INTERNATIONAL ATOVS WORKING GROUP

A Report on the Nineteenth International TOVS Study Conference

Jeju Island, South Korea

26 March - 1 April 2014

Sharing ideas, plans and techniques to study the earth's weather and climate using space-based observations

A Report on
The Nineteenth International
TOVS Study Conference

Lotte Hotel
Jeju Island, South Korea
26 March – 1 April 2014

Conference sponsored by:
Korea Meteorological Administration
ECMWF
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FOREWORD

The International TOVS Working Group (ITWG) brings together operational and research users and providers of infrared and microwave satellite sounding data. It is convened as a sub-group of the International Radiation Commission (IRC) of the International Association of Meteorology and Atmospheric Physics (IAMAP) and the Coordination Group for Meteorological Satellites (CGMS). The ITWG organises International TOVS Study Conferences (ITSCs) which have met approximately every 18 to 24 months since 1983. Through this forum, relevant experts exchange information on all aspects of the data processing and use, with a focus on inferring information on atmospheric temperature, moisture, and cloud fields. This includes evaluation of new data, processing algorithms, derived products, impacts in numerical weather prediction (NWP) and climate studies. The group considers data from all sounding instruments that build on the heritage of the TIROS Operational Vertical Sounder (TOVS), including hyperspectral infrared instruments.

This Working Group Report summarises the outcomes of the Nineteenth International TOVS Study Conference (ITSC-XIX) hosted by the Korea Meteorological Administration (KMA) on Jeju Island, South Korea, between 26 March and 1 April 2014. The ITWG Web site contains electronic versions of the conference presentations, posters and publications which can be downloaded (http://cimss.ssec.wisc.edu/itwg/). Together, these documents and web pages reflect a highly successful meeting on Jeju Island.

We wish to thank KMA for their generous hosting of the conference, and in particular the local organizing committee, especially Dr Dohyeong Kim, Dr Hyesook Lee, Dr Tae-Hyeong Oh (all KMA) and Prof BJ Sohn (Seoul National University), for leading the excellent local organization. We are also very greatful to Allen Huang, Maria Vasys, Leanne Avila and Bill Bellon (University of Wisconsin-Madison) for all their administrative and logistical support. The group was honoured to receive opening remarks by Dr Yunhwa Ko, Adminstrator of KMA and Dr David Grimes, President of WMO.

ITSC-XIX was sponsored by industry and government agencies, including ABB, EUMETSAT, NOAA/GOES-R Program Office, NOAA/JPSS Program Office, Kongsberg Spacetec, Met Office, Météo France, Orbital Systems, SCISYS, the World Meteorological Organization (WMO), and STC.

The following report encompasses an executive summary highlighting the main developments and conclusions, followed by the detailed working group reports, the conference program, and abstracts of all presentations and posters.

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Jeju Island, South Korea: 26 March – 1 April 2014

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ITSC-XIX Group Photo at Lotte Hotel
Jeju Island, South Korea

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

The nineteenth International TOVS Study Conference, ITSC-19, was hosted by the Korea Meteorological Administration (KMA) on Jeju Island, South Korea, between 26 March and 1 April 2014. 196 participants attended the Conference from 35 organizations, providing a wide range of scientific contributions. Fifteen countries and three international organizations were represented: Brazil, Canada, China, Taiwan, France, Germany, India, Japan, Norway, Russia, South Korea, Sweden, Switzerland, United Kingdom, United States, ECMWF, EUMETSAT, and the WMO. For the fourth successive meeting the number of attendees broke the record for the highest ever attendance. The Working Groups had very productive discussions and it was again encouraging to see a large number of new, younger scientists participating. This was the first time that ITWG met formally as sub-group of CGMS, and the group warmly appreciated this formal recognition, while continuing the important ties with the International Radiation Commission (IRC).

Apart from very generous support by the local hosts KMA, ITSC-19 was sponsored by industry and government agencies. The industry and government agencies included: ABB, EUMETSAT, NOAA/GOES-R Program Office, NOAA/JPSS Program Office, Kongsberg Spacetec, Met Office, Météo France, Orbital Systems, SCISYS, the World Meteorological Organization (WMO), and STC. The great success of ITSC-19 was largely thanks to the excellent work of the local organizing committee from KMA (led by Dr. Dohyeong Kim) and Seoul National University (Prof. BJ Sohn) together with the invaluable administrative and logistical support provided by Allen Huang, Maria Vasys, Leanne Avila, and Bill Bellon (University of Wisconsin-Madison Space Science and Engineering Center, SSEC).

The meeting showcased the rapid developments in the Asian region (especially Korea and China) in terms of ambitious space programs and strong progress in the use of satellite data in NWP. The characterization and use of FY-3 data, including first results from the commissioning of FY-3C, were the topic of several contributions. The group strongly acknowledged the international data provision and collaborative approach to calibration/validation activities taken by CMA. Significant progress has been made in the use of other new observations, including from ATMS and CrIS on Suomi-NPP, with both instruments now being used operationally by many NWP centers. There continues to be a strong requirement for both infrared and microwave sounders in at least three complementing orbital planes.

Critical contributions to successful data usage are the continued developments of processing packages such as the ATOVS and AVHRR Pre-processing Package (AAPP) and the Community Satellite Processing Package (CSPP). These have been further enhanced to include new data (e.g., from FY-3A/B) and new capabilities. The developments of direct broadcast packages also underpin a continued strengthening of the Regional ATOVS Retransmission Service (RARS) that uses existing or planned ground stations to process locally received data and to re-distribute it via the GTS to achieve a timeliness of 30 min or better. RARS requires a high degree of coordination between agencies and renewed efforts for a coordinated implementation and extension to more stations and other sensors are welcomed.

Following the successful launch of METOP-B, data from four hyperspectral infrared instruments are available from space for the first time, allowing unprecedented opportunities for inter-calibration and comparisons. This also fostered further research in the efficient use of hyperspectral data, for instance through principal component analysis, more sophisticated specification of observation errors and their correlations, or flexible level 2 retrieval algorithms. These developments are highly relevant for the future evolution of the global observing system, especially for hyperspectral instruments from geostationary orbit planned in Europe and China. They are also very relevant for instruments with even higher spectral resolution from polar orbit, such as IASI-NG. Dissemination strategies for the associated large data volumes continue to be a topic. The growing dataset of hyperspectral data and its stable characteristics are also increasingly attractive for climate applications.

Significant advances are being made in the treatment of cloud-affected sounding radiances in data assimilation systems, with several groups reporting positive results. Approaches range from fully taking the cloud information into account to refined cloud-clearing. Radiative transfer developments, including enhanced treatment of surface emissivity over land and sea, continue to be essential aspects, as they underpin all quantitative uses of sounding data. Adjoint sensitivity techniques are increasingly applied to summarize forecast impact in NWP, and applications emerge that use these techniques with the aim of optimizing assimilation settings such as data selection and observation errors.

Most of the meeting was organized in fourteen sessions of oral presentations and their associated poster papers. This comprised of 60 longer format oral presentations and 140 poster papers. Each poster was introduced through a short verbal summary to highlight the scientific content. The range of issues covered in oral presentations and posters included the following:

- Current, new and future observing systems;
- Operational reports from space agencies and NWP centres;
- Data assimilation applications;
- Climate applications;
- Processing software systems;
- Advanced Sounder science;
- Radiative transfer developments;
- Atmospheric chemistry and composition;
- Cloud and precipitation applications; and
- Retrieval science.

Working Groups were formed to consider six key areas of interest to the ITWG, including:

- Radiative Transfer,
- Climate,
- Data Assimilation and Numerical Weather Prediction,
- Advanced Sounders,
- International Issues and Future Systems, and
- Products and Software.

The Working Groups reviewed recent progress in the above areas, made recommendations on key areas of concern and identified items for action. These were further reviewed in a plenary session at the end of the conference. Working Group reviews and recommendations comprise an important part of the ITSC-19 Working Group Report. A summary of the key recommendations and actions arising from the conference is presented below.

Activities that had taken place since ITSC-18 in Toulouse were presented in a dedicated session of Working Group status reports. This session also reviewed progress on the Action Items and Recommendations identified by the ITSC-18 Working Groups. Many of these items formed the basis for further discussion by the Working Groups at ITSC-19. Technical sub-groups also met during ITSC-19 to discuss developments and plans concerning specific software packages, shared and in common use, and microwave frequency protection.

The conference agenda and all of the talks and many of the posters can be viewed at the ITWG Web site, located at http://cimss.ssec.wisc.edu/itwg/itsc/itsc19/program/index.html

1.2 SUMMARY OF MAJOR CONCLUSIONS

The ITSC-19 presentations, posters, Working Group meetings and discussions documented significant issues in many areas and identified areas for future activity. The full list of action items and recommendations can be found in the detailed reports from each working group. The main conclusions and recommendations are summarised below.

1. **To CGMS and satellite agencies:** the constellation of at least three polar orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), should be maintained. The overpass times of operational satellites with sounding capability (IR and MW) should be coordinated between agencies to maximize their value.
2. **To US DoD:** noting that the launch of F20 is currently uncertain, ITWG strongly recommends that SSMI/S on F20 should be flown, preferably in an early morning orbit, in support of maintaining a robust global satellite observing system.
3. **To satellite agencies:** devise plans to fill the gaps in geostationary coverage with infrared soundings.
4. **To CGMS and satellite agencies:** conduct studies to trade off benefits of spectral, radiometric, and spatial resolutions of infrared sounders considering the noise floor due to atmospheric noise and current uncertainties in spectroscopy, to enable improved spatial resolution and increased number of field of views for the next generation hyperspectral infrared sounders.
5. **To satellite agencies:** investigate the use of new microwave technology to enable future microwave sounding instruments with a field of view size closer to that provided by hyperspectral infrared sounders and the spatial resolution of future global NWP models, without compromising the noise performance.
6. **To satellite agencies:** noting that absolute calibration with on-orbit SI traceability is critical for significantly reducing uncertainties in monitoring climate trends, ITWG recommends to pursue the realization of absolute calibration missions (such as CLARREO), including considering flight opportunities on the International Space Station.
7. **To Roshydromet:** pre-processing software for L0/L1 Meteor-M data should be made available to interested users.
8. **To satellite agencies:** new operational data dissemination infrastructure should be tested at an early stage (well before launch) with simulated data.
9. **To satellite agencies:** ITWG recommends open access to new satellite data during the calibration/validation phase (particularly for all NWP centres) to help with calibration and validation.

10. **To satellite agencies:** if lossless compression does not achieve the required compression ratios (e.g., for dissemination of hyperspectral infrared data from geostationary orbit), take a conservative approach in order to mitigate information loss (e.g., by retaining as many principal components as possible), and consider providing a small subset of original radiance channels (~20) so that users can independently compare with reconstructed radiances from principal components to monitor quality of lossy compression.
11. **To satellite agencies in dialogue with users:** devise and document a mutually acceptable update strategy for the principal component basis when a principal component scores product is disseminated to users.
12. **To NWP centres:** evaluate the feasibility of assimilating observations disseminated via a PC-compressed datastream, including the use of cloudy radiances and communicate experiences to relevant data providers.
13. **To CGMS:** ITWG supports low-cost fast delivery initiatives such as RARS, and recommends reactivating the RARS Implementation Group within WMO with a broader scope to include the NOAA Direct Broadcast Real Time Network (DBRTN) and to include CrIS, IASI, ATMS, and other sounder data.
14. **To satellite agencies:** to provide email-based notification services that users can subscribe to in order to receive alerts regarding instrument issues (including approximate recovery schedules) and advance notification of changes to the data supply, combined with a searchable online archive of such notifications.
15. **To Stephen English in dialogue with the NWP WG:** to compile a list of most relevant events affecting the quality of data, e.g. calibration changes, sensor anomaly, change of operation mode, and to provide guidance on what magnitude of the event justifies a user notification .
16. **To IRC, CGMS and satellite agencies**: support for line-by-line (LBL) reference model development is of paramount importance and should be continued to ensure that users (in both operational and non-operational institutions) have access to the latest updates in LBL forward modelling.
17. **To IRC, CGMS and satellite agencies:** encourage validation and intercomparison of LBL models/spectroscopy to assess the impact of spectroscopic uncertainties and the differences between line-by-line and fast radiative transfer models.
18. **To satellite agencies:** instrument characteristics should be provided as early as possible (even approximate versions) to allow preparations for radiative transfer modelling and other evaluations. This includes in particular spectral response functions. Ultimately, detailed digitised channel system responses should be made available to allow the best-possible radiative transfer calculations.
19. **To CGMS and satellite Agencies:** conduct intercomparison studies between level 2 retrievals from hyperspectral instruments, recognising that there are now several SW packages available that utilize IASI/CrIS/AIRS data for the generation of level 2 products.
20. **To agencies involved in GRUAN:** to provide and sustain high quality in-situ observations through programs such as GRUAN. It is recommended to consider radiosonde launches matching overpass times of IASI, AIRS, etc. at least four times a month at each station under favorable conditions (clear sky). The matchups will be used to assess the quality of both the GRUAN reports and the hyperspectral infrared observations. For the satellite community the GRUAN reports will be used to validate radiative transfer models.
21. **To funding bodies of NWP centres and satellite agencies:** consider, as part of the cost of satellite programs, providing computational and personnel resources targeted at

operational NWP centres to optimise the public's return on investment from these expensive measurement systems.

1.3 FUTURE PLANS

The ITWG will continue to meet and continue to inform the infrared and microwave sounding community of the latest news and developments through its Web site (currently maintained by the University of Wisconsin-Madison/CIMSS) and via the email list (also maintained by CIMSS).

The next meeting of the ITWG will be held in Lake Geneva, Wisconsin, from 28 October to 3 November 2015. Topics of interest will include continued assessment of S-NPP, Metop and FY-3 data as well as assessment of Meghatropiques and other observations, developments in the use of sounding data in NWP, and the advancement of retrieval science and climate studies. More information about ITWG and other ITSCs may be found at: http://cimss.ssec.wisc.edu/itwg/

1.4 ACKNOWLEDGEMENTS

This report relied on the active participation of all ITSC attendees and those working group chairs. We acknowledge that writing of this report is possible only through the collective work of ITWG members. Note that most of the contents presented here are derived from the draft of the executive summary part of the ITSC-19 working group report, so some of the contents (especially action items and recommendations) are subject to change.

SUMMARY OF ACTIONS AND RECOMMENDATIONS

RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING

Action RTSP-1

Yong Chen to provide the CloudSat profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-2

Marco Matricardi to provide the ECMWF profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-3

Jean-Claude Thelen to check the availability of aircraft data observations and in-situ datasets from the UK Met Office and inform the RTSP working group Co-Chairs whether the eventual datasets can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-4

Mark Liu to provide RTSP working group Co-Chairs information on the availability of cloud optical properties data from P. Yang (infrared) and Gang Hong (microwave) and check whether these data can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-5

James Hocking to provide recent aerosol optical properties data for volcanic ash and Asian dust or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-6

RTSP working group Co-Chairs to continue the compilation of a list of available models and publish it on the RTSP-WG website (with associated links as appropriate).

Action RTSP-7

Jean-Claude Thelen to make available the reference LBL model for scattering developed at the Met Office or information about it to be hosted, or linked to, on the RTSP-WG web page.

Recommendation RTSP-1 to RT developers

The RTSP working group recommends that RT developers validate their scattering models against observations using available validation datasets.

Action RTSP-8

Marco Matricardi to communicate to the group information on the global dataset of vibrational temperatures generated at IAA and check whether it is possible for this dataset to be distributed to the wider community via a link on the RTSP-WG web page.

Recommendation RTSP-2 to RT developers

The RTSP-WG encourages RT developers to thoroughly assess the accuracy of non-LTE parameterisations used in fast RT models.

Recommendation RTSP-3 to RT developers

The RTSP-WG encourages the development of fast unapodised RT models.

Recommendation RTSP-4 to RT developers

The RTSP-WG encourages the introduction of Doppler shift effects in RT models.

Recommendation RTSP-5 to RT developers

The RTSP-WG encourages RT model developers to generalize the form of the RT equation introducing a vector formalism.

Recommendation RTSP-6 to ITWG community

The RTSP-WG encourages members of the TOVS community to exploit the capabilities offered by PC-based fast models.

Recommendation RTSP-7 to RT developers

The RTSP-WG encourages RT developers to pursue and/or continue the development of PC-based fast models.

Action RTSP-9

ITSC group members to contact RTSP-WG Co-Chairs regarding information on available sensor data.

Action RTSP-10

Paul van Delst to create a sensor acronym glossary on RTSP-WG web site.

Recommendation RTSP-8 to RTSP Co-Chairs

RTSP working group Co-Chairs to create a repository of sensor characteristics data for RT modeling community accessible via the RTSP-WP page.

Action RTSP-11

David Tobin to communicate to RTSP working group Co-Chairs the most recent specification of the AIRS spectral response function. COMPLETED (see http://asl.umbc.edu/pub/airs/srf/srfhdf.html)

Action RTSP-12

Mark Liu to check the specification of the ATMS spectral response function and communicate the relevant information to the RTSP working group Co-Chairs.

Action RTSP-13

Mark Liu to make available to the RTSP working group Co-Chairs all information regarding the spectral response function of instruments on FY-3C.

Action RTSP-14

Sung-Rae Chung to make available to the RTSP working group Co-Chairs information on the AMI spectral response function.

Recommendation RTSP-9 to sensor vendors

Sensor vendors should supply digitised channel system responses for both microwave, infrared, and visible instruments.

Recommendation RTSP-10

Instrument characteristics should be delivered as early as possible (even if not the final version – or especially so) to allow analysis of data in an RT modeling context.

Recommendation RTSP-11 to RT modelers

RT modelers are encouraged to develop surface emissivity models in the visible that include polarization.

Action RTSP-15

RTSP working group Co-Chairs to compile a list of available surface emissivity models in the visible.

Recommendation RTSP-12 to RT modelers

RT modelers should pursue the development of BRDF models for snow and ice.

Recommendation RTSP-13 to RTSP members

Members of the RTSP working group are encouraged to give feedback on the use of the CEMS community model. When applicable, this recommendation should extend to members of the TOVS community at large.

Action RTSP-16

Mark Liu to inform the RTSP working group Co-Chairs on the status of the CEMS model. Information on the CEMS model and related developments should be communicated in a timely fashion to the RTSP working group Co-Chairs who should made it available through the RTSP-WG web page.

Recommendation RTSP-14 to RT developers

The RTSP working group encourages RT developers to develop physically based emissivity models.

Recommendation RTSP-15 to RT developers

Physical models should cover as wide a range of surface types as possible.

Action RTSP-17

Xu Liu to give to RTSP working group Co-Chairs feedback on physical BDRF models.

Action RTSP-18

Mark Liu to provide to RTSP working group Co-Chairs information on infrared physical models developments.

Action RTSP-19

Fuzhong Weng to provide to RTSP working group Co-Chairs information on MW physical models developments.

Recommendation RTSP-16 to RT developers

The RTSP working group encourages RT developers to introduce an angular dependence to the land emissivity data stored in atlases.

Recommendation RTSP-17 to RT developers

The RTSP working group encourages RT developers to introduce the temperature dependence in the computation of sea surface emissivities.

Action RTSP-20

James Hocking to provide to RTSP working group Co-Chairs the empirical corrections to the refractive indices of water computed using aircraft derived data.

Action RTSP-21

Mark Liu to check whether details of the CLBL project requirements can be made available to the RTSP-WG.

Recommendation RTSP-18 to LBL model developers

LBL model developers to study the possibility of a more physically based approach to the treatment of the water vapour continuum absorption.

Action RTSP-22

Carmine Serio to provide measured continua coefficients for the far-IR and associated documentation (see Serio, C. et al 2012, JQSRT). Although this is an action from the previous conference, it was deemed important to be continued and eventually completed.

Recommendation RTSP-19 to LBL model developers

LBL model developers should pursue adopting code design that allows a more flexible approach to the use of molecular data.

Recommendation RTSP-20

The RTSP working group encourages the validation and the intercomparison of LBL models/spectroscopy to assess the accuracy of LBL computations, the impact of spectroscopic uncertainties and the differences between line-by-line and fast RT models. The members of the RTSP working group recognise this is a project that will require a large effort.

Recommendation RTSP-21

The RTSP working group encourages the use of global satellite datasets to validate LBL models.

Action RTSP-23

Mark Liu to provide feedback on the coordination of a clear sky LBL/fast RT model validation and intercomparison exercise.

Recommendation RTSP-22

The RTSP working group recommends that adequate funding is assigned to the study of the spectroscopy of atmospheric gas species relevant to NWP, Atmospheric composition and Climate applications. The RTSP working group also recommends that more emphasis should be placed on minor species which could become relevant for future applications.

Recommendation RTSP-23

Support for line-by-line (LBL) reference model development is of paramount importance and should be continued to ensure that operational centres have access to the latest updates in LBL forward modelling.

Recommendation RTSP-24 to RT developers

The RTSP working group encourages RT model developers to include a full treatment of the Zeeman effect in MW LBL models.

Recommendation RTSP-25

The group encourages the development and maintenance of visualisation packages.

Action RTSP-24

James Hocking to communicate information about how to obtain the RTTOV GUI visualisation package and link it to the RTSP-WG website.

CLIMATE

Recommendation Climate-1 to EUMETSAT

EUMETSAT to reprocess Level 1c IASI products in a shorter timeframe.

Recommendation Climate-2 to EUMETSAT

EUMETSAT to deliver inter-calibration results for IASI on Metop-A and Metop-B and a method to recalibrate one instrument to the other.

Recommendation Climate-3 to agencies

Agencies to see how scientific assessment can be taken into account at exploitation reviews and set-up procedures for quick reprocessing.

Recommendation Climate-4 to agencies

Agencies to assess the availability of data records and to make an effort to provide available data records and associated metadata, in particular instrument characteristics such as spectral response functions.

Action Climate-1

NESDIS (Lihang Zhou) to provide a focus day of AIRS and IASI data that are spectral convoluted to CrIS data.

Recommendation Climate-5 to climate community

Climate community to start analysis of PC scores of hyperspectral IR data.

Recommendation Climate-6 to agencies

Agencies shall continue to archive full definition L0 and L1.

Recommendation Climate-7

Fill and update questionnaires to enhance the ECV inventory.

Action Climate-2

WG Co-Chairs to distribute to the WG the requirements defined by the Climate community.

Action Climate-3

The WG to agree by mail exchange on the scales and other aspects of the inter-comparison.

Action Climate- 4

Nadia Smith to take the lead of the inter-comparison with help from others.

Action Climate-5

Results of the inter-comparison will be presented at the next conference.

Action Climate-6 (to everyone)

Communicate information on current reanalyses for use in climate studies.

Action Climate-7

Viju John to circulate information about maturity index and let it be put on the ITWG Climate WG website.

Recommendation Climate-8

The realization of absolute calibration missions (such as CLARREO) is further supported including flight opportunities on the ISS.

Action Climate-8

ITWG Co-Chairs to communicate Recommendation Climate-8 to CGMS.

Recommendation Climate-9

To invite RO experts to the next meeting.

Recommendation Climate-10

Provide requirements of affordable differences in absolute calibration between two instruments to industry when specifying new instruments.

Action Climate-9

Group shall try to update the Climate Group web pages.

Action Climate-10

The group shall try to summarize the current usage of TOVS/ ATOVS data for Climate studies to give more visibility on the benefits of such sounding data.

DATA ASSIMILATION AND NUMERICAL WEATHER PREDICTION

Action DA/NWP-1 on ITSC Co-Chairs

To bring recommendations 1-5, 7, 11, 14, 17 & 19 (detailed below) to the attention of CGMS.

Recommendation DA/NWP-1 to all relevant space agencies

The constellation of at least three orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), should be maintained. The overpass times of operational satellites with sounding capability (IR and MW) should be coordinated between agencies to maximize coverage (including, e.g., China, India).

Recommendation DA/NWP-2 to the Defense Meteorological Satellite Program

In support of maintaining a robust global satellite observing system, SSMI/S on F20 should be flown, preferably in an early morning orbit.

Recommendation DA/NWP-3 to Space Agencies

New operational data dissemination infrastructure should be tested at an early stage (well before launch) with simulated data.

Recommendation DA/NWP-4 to Space Agencies

There should be open access to new satellite data for all NWP centres to help with calibration and validation.

Recommendation DA/NWP-5 to funding bodies of NWP centres and space agencies

Consider, as part of the cost of satellite programs, providing computational and personnel resources *targeted at operational NWP centres* to optimise the public's return on investment from these expensive measurement systems.

Action DA/NWP-2 on NWP centres

Continue to provide information on instrument channels assimilated and their observation errors for inclusion on the NWP Working Group pages. Updates should be provided as soon as possible after changes in data usage, but at least before every conference.

Action DA/NWP-3 on NWP working group

Review NWP working group website and send comments and additions to the working group Co-Chairs, and for regional data assimilation to Roger Randriamampianina (rogerr@met.no).

Recommendation DA/NWP-6 to NWP WG members

Use the NWP WG mailing list for questions, to share new results, or to alert other centres to data problems.

Action DA/NWP-4 on NWP WG members

Send any evidence of RFI to working group Co-Chairs for inclusion on the NWP WG RFI web page and forwarding to Jean Pla.

Action DA/NWP-5 on NWP WG members

If you have estimates of revised channel characteristics resulting from post-launch diagnostics, please email these to Paul van Delst (paul.vandelst@noaa.gov).

Recommendation DA/NWP-7 to Data Providers

Agree standardized procedure for inclusion of NEdT estimates within BUFR for microwave data.

Recommendation DA/NWP-8 to Space Agencies and data providers

When designing new or modified BUFR formats, please circulate drafts to the NWP community via the NWP Working Group for feedback, prior to submission to WMO.

Action DA/NWP-6 on NWP WG Co-Chairs

Confirm SSMI/S QC flags with NRL and circulate a summary to the working group.

Action DA/NWP-7 on Fuzhong Weng

To provide at least one month of reprocessed ATMS BUFR data with reduced striping, along with documentation on methods used, and to advertise availability through WG mailing list.

Recommendation DA/NWP-9 on NWP Centres

To use the data provided by Fuzhong to assess impact of striping and to provide feedback to NESDIS.

Recommendation DA/NWP-10 to RT model developers

Ensure that DDA is used for precipitating profiles and to consider what to do in heavy rainfall areas. Encourage investigation of treatment options for frozen hydrometeors in the forward operator.

Recommendation DA/NWP-11 to Data providers

Include the azimuthal angle in BUFR for present and future centres.

Recommendation DA/NWP-12 to RT Modellers

Include treatment of wind direction in microwave emissivity models.

Action DA/NWP-8 on Météo-France

To circulate the 500 channel set for cloudy radiance analysis to WG so that GTS users can evaluate proposed new channels.

Recommendation DA/NWP-13 on Working group members

To evaluate and provide feedback to Météo-France before the beginning of September 2014.

Recommendation DA/NWP-14 on Data Providers

Consider whether this two-stream approach is a viable method for data dissemination for future systems.

Recommendation DA/NWP-15 on NWP Centres

Give feedback to data providers on this course of action.

Recommendation DA/NWP-16 to data providers

If PC compression is used to disseminate hyperspectral IR observations, a conservative approach should be taken in order to mitigate information loss (e.g., by retaining as many principal components as possible).

Recommendation DA/NWP-17 to data providers and NWP users

A mutually acceptable update strategy should be devised and documented for the dissemination of PC products.

Action DA/NWP-9 on EUMETSAT

Circulate a proposal on update strategy for IASI PC basis vectors to the working group, considering technical aspects like, for example, the length of notice period and the method for notification of changes.

Action DA/NWP-10 on NWP WG Members

Provide feedback on the above proposal.

Action DA/NWP-11 on NWP Centres

Evaluate feasibility of assimilating observations disseminated via a PC-compressed datastream, including the use of cloudy radiances, and communicate experiences to relevant data providers.

Action DA/NWP-12 on Fuzhong Weng

Produce a test dataset of one month of unapodised radiances so that they can be evaluated.

Recommendation DA/NWP-18 on NWP Centres

Consider carrying out studies to evaluate the use of unapodised radiances, noting that significant RT development may be required to do this.

Action DA/NWP-13 on NWP WG members

Express interest in ~6 monthly telecon and forward information regarding current status of CrIS assimilation to Bill Bell (william.bell@metoffice.gov.uk) by end of April 2014.

Action DA/NWP-14 on Bill Bell

Organise through NWP working group a ~6 monthly telecon to update on progress and any new findings regarding assimilation of CrIS.

Action DA/NWP-15 on working group members

Send details of bias correction schemes in use, including information on: scheme, predictors, method used to spin up (e.g., relax QC), whether there are any particular features relevant to limited area models, and whether they are interested in taking part in an intercomparison. Information to be provided to Roger Randriamampianina (rogerr@met.no) by end of July 2014, for inclusion on the NWP WG website.

Action DA/NWP-16 on Roger Randriamampianina

Consider the results of this bias correction survey in conjunction with the NWP usage tables and, by end of September 2014, circulate details of exactly what data to send for a quantitative intercomparison.

Action DA/NWP-17 on Wei Han

Evaluate whether the information on the RT group website is sufficient to provide radiometric uncertainty info needed to evaluate biases.

Action DA/NWP-18 on NWP WG Co-Chairs

Circulate a summary on the activities of the surface subgroup to working group members.

Recommendation DA/NWP-19 to satellite agencies

Provide user notification services that people can sign up to receive instrument alerts (including rough recovery schedules) and advance notification of changes to data supplies.

Recommendation DA/NWP-20 to WG members

Sign up to these notifications and feed back any issues to data providers.

ADVANCED SOUNDERS

Recommendation AS-1 to CGMS

To work with operational meteorological agencies to devise a plan to fill gaps in geostationary coverage of hyperspectral infrared sounding data.

Action AS-1

ITWG Co-Chairs to present the concern of this group to CGMS.

Recommendation AS-2 to space agencies

Pursue the development of advanced microwave sounders for geostationary satellites and pursue a demonstration of this new technology from aircraft and/or satellite.

Action AS-2

ITWG Co-Chairs to present the recommendation of this group to relevant Space Agencies (e.g., NASA, ESA, JAXA).

Recommendation AS-3 to space agencies

Conduct studies to trade off benefits of spectral, radiometric, and spatial resolutions of infrared sounders considering the noise floor due to atmospheric noise and current errors in spectroscopy.

Recommendation AS-4 to NWP Centres

Provide the results of a global nature run which has the highest possible (ideally at least 1-km) spatial resolution which can be used in simulation studies to determine the optimal trade-offs between instrument FOV size, spectral resolution, and spectral resolution for advance sounding from Polar orbit.

Action AS-3

ITWG Co-Chairs to present the concerns of this group to space agencies and operational satellite user agencies to form expert teams to conduct studies leading to the improved designs of next generation polar satellite atmospheric sounding instruments.

Recommendation AS-5 to NASA and NOAA

Form an interagency science working group to develop an optimal design for the next generation infrared sounder (evolution of CrIS) for the JPSS-2 and follow-on satellites.

Recommendation AS-6 to EUMETSAT and CNES

Re-evaluate the current design priorities for the IASI-NG considering the noise floor limiting the utility of these data posed by FOV size related cloud contamination and atmospheric and forward model noise.

Action AS-4

ITWG Co-Chairs to present the recommendation of this group to NASA/NOAA and EUMETSAT/CNES.

Action AS-5

Groups interested in high-resolution nature runs to request existing nature runs from ECMWF and NASA GMAO, and to work with these and other NWP centers to create a global high (ideally towards 1-km) resolution nature run that can be used to develop the specifications for next generation satellite sounding instruments.

Recommendation AS-7 to users

Provide, in addition to the CrIS 399 channel subset of apodized radiances, either a set of reconstructed apodized radiances or a set of PC scores for a given set of leading PCs used to reconstruct the radiances. Also consider the provision of either a set of unapodised radiances or a (smaller?) set of reconstructed unapodized radiances along with the corresponding leading PCs used to compute them.

Action AS-6

Advanced Sounders Working Group Co-Chairs to present the concern of this group to ITWG users of CrIS data.

Recommendation AS-8 to space agencies

Investigate the use of new MW technology to enable future MW sounding instruments to possess a field of view size which is closer to that provided by hyperspectral infrared sounders and the spatial resolution expected for future global NWP models, without compromising the noise performance.

Action AS-7

ITWG Co-Chairs to convey the need for higher spatial resolution MW measurements for utilization with future polar satellite hyperspectral radiances in the presence of clouds and to better approximate the resolution of future global NWP models.

Recommendation AS-9 to space agencies

Develop, test, and implement an SI Traceable radiometric standard in space as soon as feasible. Particularly, the ASWG encourages early pathfinder demonstrations of new technologies for referencing these measurements to International Standards on-orbit. As a specific example, an International Space Station flight of the new technologies developed for CLARREO with NASA Earth Science Technology Office (ESTO) support would be especially valuable for furthering a full-up mission.

Action AS-8
ITWG Co-Chairs to convey this recommendation to space agencies via CGMS.

INTERNATIONAL ISSUES AND FUTURE SYSTEMS

Recommendation IIFS-1 to ITWG community
To provide examples to the Co-Chairs (Steve English, Jérôme Lafeuille) to show where high frequency soundings proved useful.

Recommendation IIFS-2 to satellite agencies
To note the growing evidence of likely benefits from hyperspectral geostationary soundings, and where possible to work towards the provision of such instruments in plans for future geo systems.

Action IIFS-1
Steve English to request ITWG (involving NWP Group) to provide input to CGMS WG III – via Jérôme Lafeuille – for updating the CGMS Contingency Plan.

Action IIFS-2
Jérôme Lafeuille to circulate to WG members the draft ET-SUP paper describing the proposed SATURN concept (Satellite User Readiness Navigator).

Action IIFS-3
The WG members to provide feedback via Stephen English before ETSUP 17 April.

Recommendation IIFS-3 to WMO and agencies
WMO to pursue SATURN, and all agencies to actively contribute information to this portal.

Action IIFS-4
Stephen English, on behalf of ITWG and in discussion with the NWP WG, to provide list of most relevant events affecting the quality of data, e.g., calibration changes, sensor anomaly, change of operation mode, and indication of the magnitude of the event justifying a notification.

Recommendation IIFS-4 to CGMS
To implement notification process for ITWG recommended events.

Recommendation IIFS-4 to Roshydromet
To make available pre-processing software for L0/L1 Meteor-M data.

PRODUCTS AND SOFTWARE

Action PSWG-1
Nigel Atkinson and Liam Gumley to test the FY-3C software and report back to the PSWG members.

Recommendation PSWG-1 to Roshydromet

1) Provide real-time DB data and DB processing software.

2) Provide global data via a web portal.

Recommendation PSWG-2 to satellite agencies

1) Data format documentation and/or software APIs should be made available early for new datasets.
2) Portable self-describing data formats should be used where possible. CF-compliant formatting and metadata should be used where possible.

Recommendation PSWG-3 to NASA and JPSS

Provide information to the community on algorithm, software, LUT, and format changes, and comparisons between IDPS and NASA radiance products.

Recommendation PSWG-4 to JAXA

Provide routine DB data and processing software for GCOM-W1 AMSR2.

Recommendation PSWG-5 to satellite agencies

Continue to provide routine global unencrypted DB capability and accompanying processing software for both existing and new systems and sensors.

Recommendation PSWG-6 to SSEC

Create product generation software for GEO sensors including ABI, AHI, AMI via common algorithms.

Recommendation PSWG-7 to NOAA and EUMETSAT

NOAA and EUMETSAT should work together to make the DBRTN data available to the global community (e.g., via RARS and/or GTS).

Recommendation PSWG-8 to satellite agencies

Create online satellite, sensor, and processing status sites using the POES status page as a model, providing searchable archives of status information, with key events (e.g., satellite/sensor failures, noise level out of specification, etc.) clearly separated from routine events, and contact information provided.

Recommendation PSWG-9 to software and product providers (Met Office, SSEC)

Provide information on the quality and evaluation of their respective products to users.

Action PSWG-2

Nigel Atkinson and Nathalie Selbach to review the visualization package list on the PSWG webpage periodically.

Action PSWG-3

Thomas August to assemble a list of available surface emissivity validation datasets.

Action PSWG-4

Graeme Martin to contact KMA and explore the mechanism for transferring algorithms to CSPP GEO.

Recommendation PSWG-10 to KMA

Provide DB data and processing software for AMI.

Recommendation PSWG-11 to NASA, NOAA, and EUMETSAT

Continue support for funding of DB software packages.

Action PSWG-5

Liam Gumley to convey to SSEC the need to come up with a plan for continued IAPP support, perhaps under the umbrella of CSPP.

2. WORKING GROUP REPORTS

2.1 RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING

Web site: https://groups.ssec.wisc.edu/groups/itwg/rtsp

Working Group Members: Marco Matricardi (Co-Chair, ECMWF), Yong Han (Co-Chair, NOAA/NESDIS/STAR), Raymond Armante (LMD/CNRS), Pascal Brunel (MeteoFrance), Yong Chen (Univ. of Maryland), Sung-Rae Chung (NMSC), Louis Garand (Environment Canada), Su Jin Ha (KIAPS), Stephan Havemann (Met Office), James Hocking (Met Office), Nicole Jacquinet-Husson (LMD/CNRS/Univ Paris 6), Heather Lawrence (ECMWF), Quanhau Liu (Univ. of Maryland/JCSDA), Xu Liu (NASA), Jean-Claude Thelen (Met Office), David Tobin (CIMSS/SSEC/UW-Madison), Fuzhong Weng (NOAA)

2.1.1 Clouds and Aerosols

Profile and Observation Data

Collect existing profile and observation (in-situ and radiance) datasets for use in comparison, validation and training of cloudy/scattering RT models.

Action RTSP-1

Yong Chen to provide the CloudSat profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-2

Marco Matricardi to provide the ECMWF profile dataset or information about it to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-3

Jean-Claude Thelen to check the availability of aircraft data observations and in-situ datasets from the UK Met Office and inform the RTSP working group Co-Chairs whether the eventual datasets can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Optical Properties (IR and MW, spherical and non)

Collect information on existing cloud and aerosol optical properties to be used in RT models simulations.

Action RTSP-4

Mark Liu to provide RTSP working group Co-Chairs information on the availability of cloud optical properties data from P. Yang (infrared) and Gang Hong (microwave) and check whether these data can be provided or information about them to be hosted, or linked to, on the RTSP-WG web page.

Action RTSP-5

James Hocking to provide recent aerosol optical properties data for volcanic ash and Asian dust or information about it to be hosted, or linked to, on the RTSP-WG web page.

Reference RT Model for Scattering and Their Validation

List available models for generating cloud- and/or aerosol- affected radiances for use as a reference.

Action RTSP-6

RTSP working group Co-Chairs to continue the compilation of a list of available models and publish it on the RTSP-WG website (with associated links as appropriate).

Action RTSP-7

Jean-Claude Thelen to make available the reference LBL model for scattering developed at the Met Office or information about it to be hosted, or linked to, on the RTSP-WG web page.

Recommendation RTSP-1 to RT developers

The RTSP working group recommends that RT developers validate their scattering models against observations using available validation datasets.

Cloudy radiance model intercomprison

The RTSP working group agreed that the intercomparison of cloudy radiative transfer models should be pursued. However, the group also noted that this task is difficult to outline without first defining the input data sets, the particle optical properties, and a reference calculation. No action or recommendation is envisaged at this stage.

2.1.2 Fast model new features

Non-LTE

The group noted that good progress has been made in the implementation of non-LTE in fast forward models. Two items regarding the implementation of non-LTE in fast models were discussed, specifically:

- Where to get the vibration temperature profiles? (e.g. Manuel Lopez-Puertas, Istituto de Astrofisica de Andalucia (IAA))
- What are the accuracies of the current fast model parameterisations?

The following action was introduced:

Action RTSP-8

Marco Matricardi to communicate to the group information on the global dataset of vibrational temperatures generated at IAA and check whether it is possible for this dataset to be distributed to the wider community via a link on the RTSP-WG web page.

Recommendation RTSP-2 to RT developers

The RTSP-WG encourages RT developers to thoroughly assess the accuracy of non-LTE parameterisations used in fast RT models.

Unapodised radiance models for FTS sensors

Radiative transfer models to compute unapodised radiances are not currently used operationally, but their development anticipates a possible future need. It was noted that for a Principal Component based fast RT model the simulation of unapodised radiances is already available as a standard feature. This is not the case for the more conventional optical depth

based fast RT models. The group also discussed alternative methodologies to simulate unapodised radiances but these were deemed to be too computationally expensive (e.g. deapodisation requires the simulation of the full apodised spectrum). It was also noted that some clarification is needed as with regard to the convolution of the monochromatic spectra (e.g. the treatment of the band edges in the Fourier transform).

Recommendation RTSP-3 to RT developers

The RTSP-WG encourages the development of fast unapodised RT models.

Doppler shift

Neglecting Doppler (or Doppler-Fizeau) shift effects due to the Earth's rotation can lead to errors in RT model simulations.

Recommendation RTSP-4 to RT developers

The RTSP-WG encourages the introduction of Doppler shift effects in RT models.

Polarisation

The RTSP-WG recognized that the use of the scalar form of the radiative transfer equation is not adequate for specific microwave simulations. Depending on the application, the full or a reduced number of Stokes vectors is required.

Recommendation RTSP-5 to RT developers

The RTSP-WG encourages RT model developers to generalize the form of the RT equation introducing a vector formalism.

Principal Component based fast models

This RT model category includes the PC_RTTOV, PCRTM and HT-FRTM models. The RTSP-WG noted that despite the significant advantages offered in terms of computational efficiency and accuracy, the utilisation of PC-based models is seldom explored by fast RT model users.

Recommendation RTSP-6 to ITWG community

The RTSP-WG encourages members of the TOVS community to exploit the capabilities offered by PC-based fast models.

Recommendation RTSP-7 to RT developers

The RTSP-WG encourages RT developers to pursue and/or continue the development of PC-based fast models.

2.1.3 Instruments

Sensors

Sensors for which instrument characteristics are required are shown in Table 2.

New Sensors		Old Sensors	
Meteor-M	*FY-3B*	SSU	SCAMS (Nimbus-6)
EPS-NG	*IASI-NG*	PMR (Nimbus-6)	SSMR (Seasat)
MTG-IRS	*GIFTS/STORM*	HIRS (Nimbus-6)	SSM/T (DMSP)
GEOCOM-2A	*FY-3C*	VTPR (NOAA 2-5)	SSM/T-2 (DMSP)
GOES-R	*Himawari-8*	IRIS-4	
ABI	*AMI*		

Table 1: List of sensors for which instrument characteristics are required.

Action RTSP-9

ITSC group members to contact RTSP-WG Co-Chairs regarding information on available sensor data.

Action RTSP-10

Paul van Delst to create a sensor acronym glossary on RTSP-WG web site.

Recommendation RTSP-8 to RTSP Co-Chairs

RTSP working group Co-Chairs to create a repository of sensor characteristics data for RT modeling community accessible via the RTSP-WP page.

Sensor characteristics

Generating fast model coefficients for sensors requires timely delivery of sensor characteristics data to RT model developers. Satellite radiance data cannot be effectively used in either NWP or retrieval schemes if the RT model does not accurately reflect the sensor response.

The data typically required are:

- Spectral Response Functions (SRFs);
- Channel polarisations;
- Antenna temperature corrections; and
- FTS line shape or analytical model. Information on spectral sampling, and how to best handle the band edges should also be supplied.

Action RTSP-11

David Tobin to communicate to RTSP working group Co-Chairs the most recent specification of the AIRS spectral response function. COMPLETED (see http://asl.umbc.edu/pub/airs/srf/srfhdf.html)

Action RTSP-12

Mark Liu to check the specification of the ATMS spectral response function and communicate the relevant information to the RTSP working group Co-Chairs.

Action RTSP-13

Mark Liu to make available to the RTSP working group Co-Chairs all information regarding the spectral response function of instruments on FY-3C.

Action RTSP-14

Sung-Rae Chung to make available to the RTSP working group Co-Chairs information on the AMI spectral response function.

Recommendation RTSP-9 to sensor vendors

Sensor vendors should supply digitised channel system responses for both microwave, infrared, and visible instruments.

Recommendation RTSP-10

Instrument characteristics should be delivered as early as possible (even if not the final version – or especially so) to allow analysis of data in an RT modeling context.

2.1.4 Surface Properties

The group noted that at visible wavelengths, surface reflected and underwater scattered radiation over oceans can be highly polarized.

Recommendation RTSP-11 to RT modelers

RT modelers are encouraged to develop surface emissivity models in the visible that include polarization.

Action RTSP-15

RTSP working group Co-Chairs to compile a list of available surface emissivity models in the visible.

BRDF implementations for fast RT models are required for all land surface types. The working group noted the availability of the MODIS BRDF product.

Recommendation RTSP-12 to RT modelers

RT modelers should pursue the development of BRDF models for snow and ice.

The RTSP working group was informed of the development of the CEMS emissivity model.

Recommendation RTSP-13 to RTSP members

Members of the RTSP working group are encouraged to give feedback on the use of the CEMS community model. When applicable, this recommendation should extend to members of the TOVS community at large.

Action RTSP-16

Mark Liu to inform the RTSP working group Co-Chairs on the status of the CEMS model. Information on the CEMS model and related developments should be communicated in a timely fashion to the RTSP working group Co-Chairs who should made it available through the RTSP-WG web page.

Surface property physical reference models should be identified for use in validating fast RT surface property modelling. The reference models should have the following characteristics:

- Be themselves validated;
- Include angular dependence;
- Be valid on both micro- and macroscopic scales; and
- Be usable with dedicated surface property missions (e.g. SMOS, SMAP)

Recommendation RTSP-14 to RT developers

The RTSP working group encourages RT developers to develop physically based emissivity models.

Recommendation RTSP-15 to RT developers

Physical models should cover as wide a range of surface types as possible.

Action RTSP-17

Xu Liu to give to RTSP working group Co-Chairs feedback on physical BDRF models.

Action RTSP-18

Mark Liu to provide to RTSP working group Co-Chairs information on infrared physical models developments.

Action RTSP-19

Fuzhong Weng to provide to RTSP working group Co-Chairs information on MW physical models developments.

The RTSP working group noted that the RTTOV model developers are introducing an angular dependence to the land surface emissivities stored in the atlases used for the RTTOV calculations.

Recommendation RTSP-16 to RT developers

The RTSP working group encourages RT developers to introduce an angular dependence to the land emissivity data stored in atlases.

The RTSP working group discussed the dependence on temperature of the refractive indices of water. It was noted that for specific situations neglecting this effect can result in errors up to 0.2/0.3 K.

Recommendation RTSP-17 to RT developers

The RTSP working group encourages RT developers to introduce the temperature dependence in the computation of sea surface emissivities.

Action RTSP-20

James Hocking to provide to RTSP working group Co-Chairs the empirical corrections to the refractive indices of water computed using aircraft derived data.

2.1.5 Spectroscopy and line-by-line (LBL) forward models

Actively used models in this category include LBLRTM, 4A, RFM, kCARTA, and ARTS. The RTSP-WG welcomed the launch of the CLBL project (i.e., the update of LBLRTM to current FORTRAN standards and its expansion to a more modular form).

Action RTSP-21

Mark Liu to check whether details of the CLBL project requirements can be made available to the RTSP-WG.

The RTSP-WG discussed a number of issues related to the water vapour continuum absorption. Although in principle the group encourages the adoption of a more physically based approach to the treatment of the water continuum absorption, it is not yet clear whether the science is mature enough. Regarding the MT-CKD-type approach currently used in the LBL models listed above, the group noted that:

- MT-CKD-type of format for continuum coefficients allows for easy insertion into LBLRTM – which is the forward model employed by RTTOV and CRTM to generate the transmittance data used to train the regression models.
- There is a dependence of continua parameterisation on line spectroscopy so the MT-CKD-type of continua updates are not necessarily transferable to other LBL models.

Recommendation RTSP-18 to LBL model developers

LBL model developers to study the possibility of a more physically based approach to the treatment of the water vapour continuum absorption.

Action RTSP-22

Carmine Serio to provide measured continua coefficients for the far-IR and associated documentation (see Serio, C. et al 2012, JQSRT). Although this is an action from the previous conference, it was deemed important to be continued and eventually completed.

There was some discussion whether LBL models should be designed to allow their users the utilisation of line data from alternative molecular databases. For instance, for LBLRTM users it is mandatory to utilize the AER line file. The RTSP working group noted that some effort in the direction of the flexible use of line data has already been undertaken within the context of the 4A model.

Recommendation RTSP-19 to LBL model developers

LBL model developers should pursue adopting code design that allows a more flexible approach to the use of molecular data.

The RTSP working group noted that the accuracy of the forward computations carried out by LBL models should be thoroughly assessed using all available datasets. These should include global satellite datasets which cover a wide range of situations.

Recommendation RTSP-20

The RTSP working group encourages the validation and the intercomparison of LBL models/spectroscopy to assess the accuracy of LBL computations, the impact of spectroscopic uncertainties and the differences between line-by-line and fast RT models. The members of the RTSP working group recognise this is a project that will require a large effort.

Recommendation RTSP-21

The RTSP working group encourages the use of global satellite datasets to validate LBL models.

Action RTSP-23

Mark Liu to provide feedback on the coordination of a clear sky LBL/fast RT model validation and intercomparison exercise.

The RTSP working group noted that the launch of the next generation of high resolution infrared sounders offers new and exciting possibilities for the exploitation of satellite data in NWP, Atmospheric composition and Climate. Hence, it is crucial that LBL models and associated spectroscopic data are updated to the highest possible standard.

Recommendation RTSP-22

The RTSP working group recommends that adequate funding is assigned to the study of the spectroscopy of atmospheric gas species relevant to NWP, Atmospheric composition and Climate applications. The RTSP working group also recommends that more emphasis should be placed on minor species which could become relevant for future applications.

Recommendation RTSP-23

Support for line-by-line (LBL) reference model development is of paramount importance and should be continued to ensure that operational centres have access to the latest updates in LBL forward modelling.

The final LBL item discussed in the RTSP working group was about the treatment of the Zeeman effect in microwave computations. The RTSP working group acknowledged that although good progress has been made in fast RT models, there is, in some cases, still the need for a full treatment of this effect in microwave LBL models.

Recommendation RTSP-24 to RT developers

The RTSP working group encourages RT model developers to include a full treatment of the Zeeman effect in MW LBL models.

2.1.6 Visualisation Packages

The RTSP working group noted that visualisation packages for sounder data are a very valuable tool for research and training.

Recommendation RTSP-25

The group encourages the development and maintenance of visualisation packages.

Action RTSP-24

James Hocking to communicate information about how to obtain the RTTOV GUI visualisation package and link it to the RTSP-WG website.

2.2 CLIMATE

Web site: http://cimss.ssec.wisc.edu/itwg/cwsg/

Thierry Phulpin (Co-Chair, TIRSEC), Viju John (Co-Chair, EUMETSAT), Jonathan Gero (SSEC/UW-Madison), Gerrit Holl (Univ. of Toronto), Robert Knuteson (SSEC/UW-Madison), Jun Li (CIMSS/SSEC/UW-Madison), Eun-Bin Park (NMSC), Hank Revercomb (SSEC/UW-Madison), Jacola Roman (AOS/UW-Madison), Nadia Smith (CIMSS/SSEC/UW-Madison), Lihang Zhou (NOAA)

The group discussed the following topics and formulated recommendations and action items.

2.2.1 Level 1 Analyses

Some work has been started to directly use AIRS, IASI, and CrIS radiances in climate monitoring. The data series is unfortunately incomplete because of change in the data processing on one side and on the other side the continuation with IASI-B is hampered by small differences in calibration. To extend the series to include AIRS and CrIS hyperspctral radiances, work needs to be done to spectrally convolute the AIRS and IASI radiances to CrIS.

Recommendation Climate-1 to EUMETSAT

EUMETSAT to reprocess Level 1c IASI products in a shorter timeframe.

Recommendation Climate-2 to EUMETSAT

EUMETSAT to deliver inter-calibration results for IASI on Metop-A and Metop-B and a method to recalibrate one instrument to the other.

More generally when some scientific results show a deficiency in Level 1 processing of any instrument a mechanism has to be found to allow scientists to propose a method and ask for quick reprocessing.

Recommendation Climate-3 to agencies

Agencies to see how scientific assessment can be taken into account at exploitation reviews and set-up procedures for quick reprocessing.

Recommendation Climate-4 to agencies

Agencies to assess the availability of data records and to make an effort to provide available data records and associated metadata, in particular instrument characteristics such as spectral response functions.

Action Climate-1

NESDIS (Lihang Zhou) to provide a focus day of AIRS and IASI data that are spectral convoluted to CrIS data.

The issue of data compression of hyperspectral instruments was not discussed in depth. However it was pointed out that data compression could create vertical correlation. Also monitoring of PC scores is needed to check stability. The impact of instability and correlation on climate products has not been assessed. Some studies have to be carried out to study if

statistics of PC scores are fully adequate for climate monitoring and how they could be used by the climate community.

Recommendation Climate-5 to climate community

Climate community to start analysis of PC scores of hyperspectral IR data.

Recommendation Climate-6 to agencies

Agencies shall continue to archive full definition L0 and L1.

2.2.2 Level 2 Analyses

CEOS, CGMS, and WMO have developed an inventory database for ECVs (ECV-inventory.com) to describe existing climate data sets of in situ and satellite data. This will allow the users to know the existing products, their technical details and producers. This can be very useful for identifying gaps where priority must be put.

Recommendation Climate-7

Fill and update questionnaires to enhance the ECV inventory.

2.2.3 Level 3 Analyses

It is recognized that Level 3 products are necessary to the Climate Community. Appropriate spatial and temporal scales for each product are to be assessed. Uncertainties of Level 3 products (combined uncertainties from calibration, retrieval, aggregation etc.) are also required even if difficult to quantify and more studies are needed to evaluate them. It is felt important to have a 'best product,' reflecting the state-of-the-art for some ECVS which are obtained from the sounding instruments: e.g., temperature and humidity profiles.

The Climate WG proposes to undertake an inter-comparison exercise, based on the Level 2 algorithms proposed by the Products WG. Level 3 products appropriate for climates studies will be compared at various temporal and spatial scales.

Action Climate-2

WG Co-Chairs to distribute to the WG the requirements defined by the Climate community.

Action Climate-3

The WG to agree by mail exchange on the scales and other aspects of the inter-comparison.

Action Climate- 4

Nadia Smith to take the lead of the inter-comparison with help from others.

Action Climate-5

Results of the inter-comparison will be presented at the next conference.

2.2.4 Level 4 Analyses (Reanalyses)

The term L4 is used when products are obtained through multi-sensor analysis in a given space-time grid. Typically the products result from data assimilation or reanalysis. These

products are often considered as the best data for climate studies. Projects of reanalysis including all the sounding data have started or are starting. All information is welcome and must be distributed.

Action Climate-6 (to everyone)

Communicate information on current reanalyses for use in climate studies.

2.2.5 Maturity Matrix

A maturity Matrix to assess the system aspects of climate data record generation (e.g., robust and maintainable software, metadata, documentation, uncertainty characterization, access, archive, user feedback, and usage) had been proposed by Bates and Privett (2012) and has been updated by EUMETSAT and has been endorsed by major climate data record producers in Europe (e.g., ESA-CCI and EUMETSAT's satellite application facilities). It is important that users of climate data records are informed of the maturity index (the way it is defined and how to use it).

Action Climate-7

Viju John to circulate information about maturity index and let it be put on the ITWG Climate WG website.

2.2.6 Cal / Val Activities

Truth from space is urgently needed for generating climate quality datasets. Access to absolute calibration (wrt SI) in the IR (and Vis) is possible thanks to the state of the art technology like that developed for the CLARREO mission. With the postponement of the CLARREO absolute calibration mission, flying CLARREO-type instruments on the ISS is imperative. The group strongly supports such missions also including solar and RO.

Recommendation Climate-8

The realization of absolute calibration missions (such as CLARREO) is further supported including flight opportunities on the ISS.

Action Climate-8

ITWG Co-Chairs to communicate Recommendation Climate-8 to CGMS.

GPS RO delivers very accurate profiles and is very a valuable supplement to passive sounding. More attention should be given to results obtained with this technique.

Recommendation Climate-9

To invite RO experts to the next meeting.

Comparison of IASI-A and IASI-B are made possible thanks to the temporal overlap of the two satellites. The inter-calibration shows a small difference, which can generate a jump in long term time series and thus produce spurious trends. Moreover this difference is not constant and cannot be easily corrected.

If absolute calibration on the order of magnitude of 0.02 K which would be necessary to estimate inter-annual variations is very difficult to obtain, requiring inter-calibration between two instruments is a specification which should be valuable to give to industry.

Recommendation Climate-10

Provide requirements of affordable differences in absolute calibration between two instruments to industry when specifying new instruments.

2.2.7 CGMS-41 Recommendations

ITWG Climate WG strongly supports the following two recommendations made by CGMS-41:

1. Space-based climate architecture: To extend the ECV product inventory to FCDRs.
2. Space-based climate architecture: the design phase of new sensors should include an analysis of compatibility with heritage instruments.

2.2.8 The Way Forward

The number of participants in the Climate Working Group was rather small but all participants agree that the group is useful and needed. The next ITSC shall see more dedicated climate talks which should be assured by inviting key presentations early enough. The group needs to improve the presentation of its activities on the ITWG web pages.

Action Climate-9

Group shall try to update the Climate Group web pages.

Action Climate-10

The group shall try to summarize the current usage of TOVS/ ATOVS data for Climate studies to give more visibility on the benefits of such sounding data.

2.3 DATA ASSIMILATION AND NUMERICAL WEATHER PREDICTION

Web site: https://groups.ssec.wisc.edu/groups/itwg/nwp

Working group members: Andrew Collard (Co-Chair, NCEP), Fiona Smith (Co-Chair, Met Office), José Antonio Ardvéquia (CPTEC/INPE),Tom Auligné (NCAR), Bill Bell (Met Office), Niels Bormann (ECMWF), Keyi Chen (IAP, CAS), Hyoung-Wook Chun (KIAPS), Chantal Coté (EC), Helena de Azevedo (CPTEC/INPE), Fábio Diniz (CPTEC/INPE), Reima Eresmaa (ECMWF), Nadia Fourrié (Météo-France and CNRS), Wei Han (NWPC/CMA), Dirceu Herdies (CPTEC/INPE), Ken Holmlund (EUMETSAT), Tim Hultberg (EUMETSAT), Byoung-Joo Jung (KIAPS), Jeon-Ho Kang (KIAPS), Masahiro Kazumori (JMA), Min-Jeong Kim (NASA/GMAO), Christina Köpken-Watts (DWD), Eunhee Lee (NMSC/KMA), Jung-Rim Lee (KMA), Sihye Lee (KIAPS), Jinlong Li (Univ. Wisconsin), Jun Li (CIMSS/Univ. Wisconsin), Agnes Lim (Univ. Wisconsin), Magnus Lindskog (SMHI), Haixia Liu (NCEP), Qifeng Lu (NSMC/CMA), Cristina Lupu (ECMWF), Louis-François Meunier (Météo-France and CNRS), Akira Okagaki (JMA), Kozo Okamoto (JMA/MRI), Zhengkun Qin (NUIST), Roger Randrianmampianina (met.no), Indira Rani (NCMRWF), Bruna Silvera (CPTEC/INPE), Sanjeev Kumar Singh (NCMRWF), Yi Song (NOAA/NESDIS/STAR), Fuzhong Weng (NOAA/NESDIS/STAR), Yanqiu Zhu (NCEP), Xiaolei Zou (Florida State Univ.),

2.3.1 Introduction

ITSC-19 again saw a very strong contribution from the NWP community, leading to a large working group on Data Assimilation and NWP, with 44 experts from around the world. Niels Bormann was replaced by Fiona Smith as Co-Chair at this meeting. The WG would like to thank Niels for his contributions and hard work for the NWP WG over the years.

Several presentations and posters at ITSC-18 captured a range of new research developments in NWP. Highlights included:

- Initial experience with CrIS observations;
- All-sky radiance assimilation;
- Improved treatment of observation errors;
- Use of compressed hyperspectral infrared sounder observations; and
- Adjoint-based forecast sensitivity methods are increasingly used to diagnose and improve impact in data assimilation systems.

Results presented at this conference show that the assimilation of satellite sounder data in NWP continues to provide substantial forecast impact.

2.3.2 Standing Recommendations and Actions

Action DA/NWP-1 on ITSC Co-Chairs

To bring recommendations 1-5, 7, 11, 14, 17 & 19 (detailed below) to the attention of CGMS.

There were a number of recommendations and actions that had arisen from discussions at ITSC-18 that the group felt would be helpful to retain as standing items as they are likely to remain useful for the foreseeable future.

Polar Orbiting Constellation

Over the years, many observation impact experiments have demonstrated benefits from using MW and IR sounding data from three or more polar orbiting systems in NWP, compared to using data from just two orbits. An even spacing of orbits (early morning, morning, afternoon orbit) ensures the most homogeneous coverage, with benefits for forecast impact. The working group noted promising developments and plans, which may help to improve coverage in multiple orbits, in particular the Chinese FY-3 series, for which instruments from the first experimental satellites show encouraging data quality and availability. The WG sees potential in an optimized coordination of orbits between space agencies, and therefore strongly recommends international cooperation to ensure a better harmonization of orbits.

Recommendation DA/NWP-1 to all relevant space agencies

The constellation of at least three orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), should be maintained. The overpass times of operational satellites with sounding capability (IR and MW) should be coordinated between agencies to maximize coverage (including, e.g., China, India).

The group would like to recognise that good work has been done in support of this recommendation already since ITSC-18. However, whilst SSMI/S is recognised as an instrument that provides alternative sounding capability, the launch of F20 is still not confirmed. F20 would help with gap mitigation, and the WG recommends that F20 should be flown.

Recommendation DA/NWP-2 to the Defense Meteorological Satellite Program

In support of maintaining a robust global satellite observing system, SSMI/S on F20 should be flown, preferably in an early morning orbit.

Cal/val of Future Instruments

At ITSC-18, there was much discussion on the inadequacies of the distribution of test data prior to launch, and of the fact that users were unprepared for receipt of real data during Suomi NPP Cal/Val because data formats were changed. Although these issues were not discussed in detail at the working group during this meeting, the group felt that the issue was of such importance that the following recommendations should be repeated to ensure that users have adequate test data to fully prepare for future systems.

Recommendation DA/NWP-3 to Space Agencies

New operational data dissemination infrastructure should be tested at an early stage (well before launch) with simulated data.

Furthermore, NWP data has proven to be a critical resource in the Cal/Val process for new instruments.

Recommendation DA/NWP-4 to Space Agencies

There should be open access to new satellite data for all NWP centres to help with calibration and validation.

Investment to Fully Realise Potential of New Satellites in Operational Use

New satellite programs can cost hundreds of millions of Euros and yet it can take many years to learn to properly exploit the data in numerical weather prediction. Additional investment

in operational NWP (which while still expensive is only a few percent of the satellites themselves) therefore represents an efficient path for improving the cost/benefit ratio for satellite observations.

This investment should focus on improved computational resources (allowing more sophisticated models to be run and more resources for research); development of new assimilation techniques (many centres are still not running 4D assimilation systems thereby reducing the impact of observations with high temporal frequency) and improvement to the forecast models, as well as methods focused on the particular observations themselves.

Investment in operational NWP is preferred as research conducted in this paradigm from the start is more easily transferred to operational status.

It is also noted that the larger the number of operational centres able to conduct cutting-edge research, the more likely that break-throughs will be made in the use of satellite data.

Recommendation DA/NWP-5 to funding bodies of NWP centres and space agencies

Consider, as part of the cost of satellite programs, providing computational and personnel resources *targeted at operational NWP centres* to optimise the public's return on investment from these expensive measurement systems.

WG Support to NWP Community via Website and Email List

The ITSC NWP WG is recognized as an ideal forum to exchange information and inform/update NWP users about new developments, aided by Wiki-pages and a dedicated email list.

For several meetings, the survey on the use of ATOVS data has been capturing the broad developments in the assimilation of sounder data in NWP. Ahead of the ITSC-18 meeting, hyperspectral IR data were included in the survey, and the latest results posted on the NWP WG web pages. NWP centres are encouraged to share more detailed information on channel selection and observation error usage as part of this survey.

Action DA/NWP-2 on NWP centres

Continue to provide information on instrument channels assimilated and their observation errors for inclusion on the NWP Working Group pages. Updates should be provided as soon as possible after changes in data usage, but at least before every conference.

Several activities are promoted by this working group to further foster information exchange, for instance in the area of regional data assimilation, where issues such as bias correction and background error specification may require solutions that differ from the practice for global systems. A website dedicated to this is now available (see https://groups.ssec.wisc.edu/groups/itwg/nwp/regional_data_assimilation). Further input is required to make the page a useful repository.

Action DA/NWP-3 on NWP working group

Review NWP working group website and send comments and additions to the working group Co-Chairs, and for regional data assimilation to Roger Randriamampianina (rogerr@met.no).

Increased use of the NWP WG email list is also encouraged, for instance for questions regarding data usage or to alert the community of data problems.

Recommendation DA/NWP-6 to NWP WG members

Use the NWP WG mailing list for questions, to share new results, or to alert other centres to data problems.

Radio Frequency Interference

At ITSC-17, an activity was started to collect evidence from existing Radio Frequency Interference (RFI) or research into potential impacts of RFI in NWP systems. A website has been set up for this task (https://groups.ssec.wisc.edu/groups/itwg/nwp/rfi_and_nwp), including examples for Windsat, SMOS, and AMSR-E. We need to be able to document instances of RFI so that evidence can be presented to the relevant national authorities who may be able to remove offending illegal transmissions.

Action DA/NWP-4 on NWP WG members

Send any evidence of RFI to working group Co-Chairs for inclusion on the NWP WG RFI web page and forwarding to Jean Pla.

Updated Channel Characteristics

NWP systems or Simultaneous Nadir Overpass (SNO)-methods have been used to revise channel characteristics such as central pass-band frequencies for microwave instruments or spectral response functions for IR sounders. The group noted that it would be useful to collect this information at a central location, as such updates have been shown to reduce some airmass-dependent biases and therefore aid the assimilation of the affected data. The channel characteristics web-page of the RT WG seems a logical place for this, and Paul van Delst agreed to include such information.

Action DA/NWP-5 on NWP WG members

If you have estimates of revised channel characteristics resulting from post-launch diagnostics, please email these to Paul van Delst (paul.vandelst@noaa.gov).

2.3.3 Microwave Sounding Data

Noise Estimates in BUFR for Microwave Sounder Data

At ITSC-18, the WG discussed plans by EUMETSAT to disseminate instrument NEdT estimates in the BUFR level 1c products for METOP AMSU-A/MHS, information that is also now available for ATMS. At this meeting, the WG noted that this strategy is not being pursued globally, and that there is no standardized procedure for including instrument noise in BUFR across data providers.

Recommendation DA/NWP-7 to Data Providers

Agree standardized procedure for inclusion of NEdT estimates within BUFR for microwave data.

The WG also retains the following recommendation:

Recommendation DA/NWP-8 to Space Agencies and data providers

When designing new or modified BUFR formats, please circulate drafts to the NWP community via the NWP Working Group for feedback, prior to submission to WMO.

SSMI/S

At ITSC-18, a web page for sharing information on SSMI/S bias issues and QC was proposed. No material had been contributed, but a talk at this conference by Anna Booton shed much light. It was felt that Anna's conference proceedings paper would reduce the need for such a page, but that it would be good to confirm how QC flags should be used.

Action DA/NWP-6 on NWP WG Co-Chairs

Confirm SSMI/S QC flags with NRL and circulate a summary to the working group.

Striping on ATMS

NESDIS would like ATMS radiance products with striping effects mitigated to be tested by NWP centres. The method to be evaluated optimizes the number of scanlines over which the calibration is averaged, which is expected to reduce, but not eliminate, the striping. NESDIS are willing to provide these data through BUFR for an initial one month period, which may be extended to allow full evaluation of forecast impact.

Action DA/NWP-7 on Fuzhong Weng

To provide at least one month of reprocessed ATMS BUFR data with reduced striping, along with documentation on methods used, and to advertise availability through WG mailing list.

Recommendation DA/NWP-9 on NWP Centres

To use the data provided by Fuzhong to assess impact of striping and to provide feedback to NESDIS.

Cloudy Radiance Assimilation

The group noted that progress had been made in this area since the last conference. There was, however, the perception that for certain scenarios, RT accuracy still needs to be improved, for example via the inclusion of the discrete dipole approximation (DDA), and by taking explicit account of the third stokes parameter in heavy precipitation events.

Recommendation DA/NWP-10 to RT model developers

Ensure that DDA is used for precipitating profiles and to consider what to do in heavy rainfall areas. Encourage investigation of treatment options for frozen hydrometeors in the forward operator.

Microwave Emissivity

It was noted at the conference that for accurate modelling of microwave sea surface emissivity, satellite azimuth information is required to allow treatment of wind direction.

Recommendation DA/NWP-11 to Data providers

Include the azimuthal angle in BUFR for present and future centres.

Recommendation DA/NWP-12 to RT Modellers

Include treatment of wind direction in microwave emissivity models.

2.3.4 Hyperspectral Infrared Sounders

Data Dissemination for Hyperspectral Infrared Sounders

It was noted that Météo-France have produced a new set of channels for IASI to aid assimilation of cloudy radiances (of which the currently disseminated 366 channels are a subset), that could replace the current channel set distributed by GTS. In order to allow potential users to evaluate this dataset, the following actions were recorded:

Action DA/NWP-8 on Météo-France

To circulate the 500 channel set for cloudy radiance analysis to WG so that GTS users can evaluate proposed new channels.

Recommendation DA/NWP-13 on Working group members

To evaluate and provide feedback to Météo-France before the beginning of September 2014.

Data Compression for Dissemination of Hyperspectral Sounder Data

For future hyperspectral sounders (particularly geostationary imagers such as MTG-IRS) it will be challenging to losslessly disseminate all data. The working group discussed the possibility for a two-stream dissemination approach, where a low data volume stream suitable for operational assimilation would be provided with high reliability, and timeliness, combined with a lossless full resolution dataset (which can be used for research purposes) with reduced reliability and timeliness constraints. This allows significant cost-savings for the dissemination, and addresses concerns from users.

Recommendation DA/NWP-14 on Data Providers

Consider whether this two-stream approach is a viable method for data dissemination for future systems.

Recommendation DA/NWP-15 on NWP Centres

Give feedback to data providers on this course of action.

The working group appreciates that the optimal approach for production of a low volume datastream may require spectral compression through principal component analysis where a small amount of information is lost with the discarded PCs. If this is the case the working group strongly recommends that a very conservative approach is followed and does not rely on studies (theoretical or otherwise) that indicate that the information can be retained with only a small number of principal components. A small number of raw radiances could also be added to the BUFR to allow users to directly assess the quality of the compressed data for every observation.

Recommendation DA/NWP-16 to data providers

If PC compression is used to disseminate hyperspectral IR observations, a conservative approach should be taken in order to mitigate information loss (e.g., by retaining as many principal components as possible).

There was discussion on the effect of long term changes in the instrument performance and the atmospheric state (e.g., increasing CO_2) on the principal components being employed, but the group agreed there was no evidence at present that this would affect operational NWP, as this can be accounted for by updates to the PC basis vectors.

However, changes in the basis vectors would require updates to the data files required for reading the compressed data.

Recommendation DA/NWP-17 to data providers and NWP users

A mutually acceptable update strategy should be devised and documented for the dissemination of PC products.

Action DA/NWP-9 on EUMETSAT

Circulate a proposal on update strategy for IASI PC basis vectors to the working group, considering technical aspects like, for example, the length of notice period and the method for notification of changes.

Action DA/NWP-10 on NWP WG Members

Provide feedback on the above proposal.

Data Compression for Assimilation of Hyperspectral Sounder Data

If hyperspectral infrared sounder data are disseminated as a set of principal component amplitudes, the data could be assimilated at the NWP centres as either reconstructed radiances or as PC scores. Several talks and posters at this conference discussed the use of compressed observations, but some questions remain as to how this is best achieved.

Action DA/NWP-11 on NWP Centres

Evaluate feasibility of assimilating observations disseminated via a PC-compressed datastream, including the use of cloudy radiances, and communicate experiences to relevant data providers.

Use of Unapodised vs Apodised Radiances for Hyperspectral IR Sounders

As at ITSC-18, it was noted that applying an apodisation function to Band 1 CrIS data resulted in an attenuation of the amplitude of the resonance in the interferogram that corresponds to the vibrational line structure in the 15μm CO_2 band. Whilst the use of unapodised radiances is equivalent to the use of apodised radiances with a correctly defined instrument noise covariance matrix, for some assimilation systems it may be easier to test assimilation of unapodised radiances than to attempt to modify R matrices to reflect the correlations introduced through apodisation. NOAA/NESDIS can provide unapodised test datasets in BUFR. However, RTTOV and CRTM do not currently have the capability to model unapodised radiances.

Action DA/NWP-12 on Fuzhong Weng

Produce a test dataset of one month of unapodised radiances so that they can be evaluated.

Recommendation DA/NWP-18 on NWP Centres

Consider carrying out studies to evaluate the use of unapodised radiances, noting that significant RT development may be required to do this.

Impact of CrIS in NWP

CrIS data has now been available for around 18 months and is agreed to be of very good quality, but NWP centres seem to be struggling to demonstrate much impact. The group discussed ways in which results and information could be exchanged more rapidly to encourage faster adoption of useful techniques to get more benefit. It was decided that a regular teleconference between those actively working on assimilation may be a useful way to proceed.

Action DA/NWP-13 on NWP WG members

Express interest in ~6 monthly telecon and forward information regarding current status of CrIS assimilation to Bill Bell (william.bell@metoffice.gov.uk) by end of April 2014.

Action DA/NWP-14 on Bill Bell

Organise through NWP working group a ~6 monthly telecon to update on progress and any new findings regarding assimilation of CrIS.

2.3.5 Bias Correction

The group discussed bias correction of sounding data. Bias correction approaches are being investigated both for treating particular bias patterns, like for SSMIS, ATMS striping, and to generally improve bias correction schemes used in NWP. In particular there is feedback between QC and bias correction, but it is not always clear how to deal with this, and how to spin up coefficients (e.g., should QC be relaxed during spin-up phase). These issues are particularly relevant for surface-sensitive channels and cloud.

At the previous ITSC, an intercomparison exercise was proposed, but little progress had been made by this meeting. The group remains unclear on what metrics to use to compare biases, as centres use different methods and predictors. As a first step, it would be instructive for centres to share information on their bias correction schemes.

Action DA/NWP-15 on working group members

Send details of bias correction schemes in use, including information on: scheme, predictors, method used to spin up (e.g., relax QC), whether there are any particular features relevant to limited area models, and whether they are interested in taking part in an intercomparison. Information to be provided to Roger Randriamampianina (rogerr@met.no) by end of July 2014, for inclusion on the NWP WG website.

Action DA/NWP-16 on Roger Randriamampianina

Consider the results of this bias correction survey in conjunction with the NWP usage tables and, by end of September 2014, circulate details of exactly what data to send for a quantitative intercomparison.

New work at this ITSC evaluated the use of radiometric uncertainty to constrain bias corrections. However, the information required to do this for all instruments may not be available.

Action DA/NWP-17 on Wei Han

Evaluate whether the information on the RT group website is sufficient to provide radiometric uncertainty info needed to evaluate biases.

2.3.6 Surface Properties

The group noted that the surface properties subgroup did not meet at this conference.

Action DA/NWP-18 on NWP WG Co-Chairs

Circulate a summary on the activities of the surface subgroup to working group members.

2.3.7 User Notifications

There is some confusion in the working group on how to receive user notifications from data centres regarding instrument problems, and changes to data supply. The NWP WG web pages contain contact information for the agencies and some details of notification services.

Recommendation DA/NWP-19 to satellite agencies

Provide user notification services that people can sign up to receive instrument alerts (including rough recovery schedules) and advance notification of changes to data supplies.

Recommendation DA/NWP-20 to WG members

Sign up to these notifications and feed back any issues to data providers.

2.4 ADVANCED SOUNDERS

Web site: http://cimss.ssec.wisc.edu/itwg/aswg/

Working Group members: Dieter Klaes (Co-Chair, EUMETSAT), William L. Smith (*Co-Chair, SSEC/UW-Madison and Hampton Univ.*), *Chris Barnet (Science and Technology Corp.), Eric Fetzer (JPL, CA Inst. of Tech.), Chawn Harlow (Met Office), Allen Huang (CIMSS/SSEC/UW-Madison), Dohyeong Kim (NMSC), Allen Larar (NASA LaRC), Will McCarty (NASA GSFC), Stefano Migliorini (ECMWF and NCEO, Univ. of Reading), Joe Taylor (SSEC/UW-Madison), David Tobin (CIMSS/SSEC/UW-Madison), Peng Zhang (NSMC/CMA), and Dan Zhou (NASA LaRC)*

2.4.1 Introduction

This working group focuses on scientific issues affecting the optimal performance of advanced satellite sounder systems. The working group reviews the status of the development of advanced sounder systems and recommends changes pertaining to instrument specification, performance, data processing, and utilisation. For the purpose of this group, "Advanced Sounders" are defined as instruments that present significant new scientific and technological challenges and which require new methods for data processing and utilization. Thus, Advanced Sounders currently include high spectral/spatial resolution passive infrared and microwave sounders and active sensors.

2.4.2 Potential Observation Gaps in Geostationary IR Sounding

The WMO vision of the GOS in 2025 asks for a complete coverage of hyperspectral infrared sounders in geostationary orbit; current implementation plans of space agencies only partially consider an implementation. The group recognises a growing concern of potential observation gaps, particularly over America, the Pacific Ocean, and the Indian Ocean.

Recommendation AS-1 to CGMS

To work with operational meteorological agencies to devise a plan to fill gaps in geostationary coverage of hyperspectral infrared sounding data.

Action AS-1

ITWG Co-Chairs to present the concern of this group to CGMS.

2.4.3 Geostationary Satellite MW Sounding

Temperature and water vapour soundings in the microwave region in geostationary orbit have been limited through noisy receivers and antenna size. Acknowledging recent advancements in microwave receiver technology to enable sounding frequency measurements in the microwave spectral regions between 50, 118, and 183 GHz with low noise, it now appears feasible to implement a geostationary MW sounding capability (noting antenna size issues for lower frequencies).

Recommendation AS-2 to space agencies

Pursue the development of advanced microwave sounders for geostationary satellites and pursue a demonstration of this new technology from aircraft and/or satellite.

Action AS-2

ITWG Co-Chairs to present the recommendation of this group to relevant Space Agencies (e.g., NASA, ESA, JAXA).

2.4.4 Improved Sounding from Polar Orbit

Considerations for advancing polar orbiting sounding capability improvements include higher spatial resolution and denser spatial sampling to increase the likelihood of clear soundings, commensurate with finer grid size of future NWP models, as well as improvements in spectral resolution and detector signal to noise performance. With new technological developments, the employment of infrared detector arrays, which allow for higher spatial resolution at reasonable noise increase, seems feasible. It has been realized that the limitation of the use of hyperspectral radiances for sounding retrieval and model assimilation is cloud and forward model noise rather than the instrument detector noise level (i.e., the atmospheric and spectroscopy errors produce higher uncertainties in the difference between measured and calculated radiance spectra than does the instrument detector noise). Thus, the working group urges designers of next generation polar sounding systems consider these limitations in performing trade-offs between detector noise, Field-of-View size, and spectral resolution. Simulation experiments could be conducted using high spatial resolution NWP model nature runs provided by NWP centres.

Recommendation AS-3 to space agencies

Conduct studies to trade off benefits of spectral, radiometric, and spatial resolutions of infrared sounders considering the noise floor due to atmospheric noise and current errors in spectroscopy.

Recommendation AS-4 to NWP Centres

Provide the results of a global nature run which has the highest possible (ideally at least 1-km) spatial resolution which can be used in simulation studies to determine the optimal trade-offs between instrument FOV size, spectral resolution, and spectral resolution for advance sounding from Polar orbit.

Action AS-3

ITWG Co-Chairs to present the concerns of this group to space agencies and operational satellite user agencies to form expert teams to conduct studies leading to the improved designs of next generation polar satellite atmospheric sounding instruments.

Recommendation AS-5 to NASA and NOAA

Form an interagency science working group to develop an optimal design for the next generation infrared sounder (evolution of CrIS) for the JPSS-2 and follow-on satellites.

Recommendation AS-6 to EUMETSAT and CNES

Re-evaluate the current design priorities for the IASI-NG considering the noise floor limiting the utility of these data posed by FOV size related cloud contamination and atmospheric and forward model noise.

Action AS-4

ITWG Co-Chairs to present the recommendation of this group to NASA/NOAA and EUMETSAT/CNES.

Action AS-5

Groups interested in high-resolution nature runs to request existing nature runs from ECMWF and NASA GMAO, and to work with these and other NWP centers to create a global high (ideally towards 1-km) resolution nature run that can be used to develop the specifications for next generation satellite sounding instruments.

2.4.5 Apodisation of CrIS Data

CrIS was designed with a spectral resolution that is closely adapted to the CO2 line spacing. The CrIS 399 BUFR channel set is Hamming apodised. This set preserves most of the spectral information content of the full CrIS spectra but cannot be reversed to unapodised radiances. Hamming apodization does 3 things: i) localizes the SRF (i.e., removes the large side-lobes of the unapodised SRF and increases the FWHM of the central lobe by ~50%), ii) reduces the random noise in the radiances by ~40%, and iii) correlates the noise in adjacent channels by 63% and channels separated by 2 samples by 13% (NOTE: channels separated by more than 2 samples remain uncorrelated). Applications that cannot handle correlated (i.e., off-diagonal) instrument noise will not realize the full spectral potential of unapodised radiances. Most NWP users today make use of a sub-set of spectral samples and therefore will suffer from lost performance if they use adjacent apodised radiances with a diagonal instrument error covariance. Also, by using a reduced set of spectral radiances, the statistical random spectral noise reduction benefit of using the entire spectrum of radiance is lost unless Principal Component (PC) reconstructed radiances are used in place of the original radiance measurements and forward model calculations.

Recommendation AS-7 to users

Provide, in addition to the CrIS 399 channel subset of apodized radiances, either a set of reconstructed apodized radiances or a set of PC scores for a given set of leading PCs used to reconstruct the radiances. Also consider the provision of either a set of unapodised radiances or a (smaller?) set of reconstructed unapodized radiances along with the corresponding leading PCs used to compute them.

Action AS-6

Advanced Sounders Working Group Co-Chairs to present the concern of this group to ITWG users of CrIS data.

2.4.6 MW Sounder FOV size

It is desirable to use MW sounding data with hyperspectral infrared radiances for obtaining soundings in the presence of clouds. Also, global numerical models that utilize satellite data will soon have a spatial resolution which far surpasses the horizontal resolution of current MW sounding instruments.

Recommendation AS-8 to space agencies

Investigate the use of new MW technology to enable future MW sounding instruments to possess a field of view size which is closer to that provided by hyperspectral infrared sounders and the spatial resolution expected for future global NWP models, without compromising the noise performance.

Action AS-7

ITWG Co-Chairs to convey the need for higher spatial resolution MW measurements for utilization with future polar satellite hyperspectral radiances in

the presence of clouds and to better approximate the resolution of future global NWP models.

2.4.7 SI Traceable Reference Instruments for improved climate observatories

The AS working group believes that the advent of advanced climate observatories to benchmark the Earth's climate (using spectrally resolved IR and reflected solar radiances plus GPS radio-occultations like the NASA Tier 1 CLARREO Mission) could be used to cross-calibrate operational sounding instruments to SI-traceable standards which would increase their value for quantifying the climate state and decadal trends.

Recommendation AS-9 to space agencies

Develop, test, and implement an SI Traceable radiometric standard in space as soon as feasible. Particularly, the ASWG encourages early pathfinder demonstrations of new technologies for referencing these measurements to International Standards on-orbit. As a specific example, an International Space Station flight of the new technologies developed for CLARREO with NASA Earth Science Technology Office (ESTO) support would be especially valuable for furthering a full-up mission.

Action AS-8

ITWG Co-Chairs to convey this recommendation to space agencies via CGMS.

2.5 INTERNATIONAL ISSUES AND FUTURE SYSTEMS

Working Group members: Steve English (Co-Chair, ECMWF), Jerome Lafeuille (Co-Chair, WMO), Ken Carey (NOAA/ERT), Mitch Goldberg (NOAA), Allen Huang (UW/SSEC), Hoseung Lee (KMA), Hank Revercomb (UW/SSEC), Jaegwang Won (KMA), Peng Zhang (CMA)

2.5.1 Introduction

The ITSC-19 Working Group on International Issues and Future Systems convened on Saturday 29 March 2014 and discussed the following topics:

- Open issues from ITSC-18,
- Global Observing System Design:
  - Gap analysis and mitigation (www.wmo.int/oscar/space) and
  - In-orbit calibration reference standard (CLARREO-like mission),
- Access to new mission data,
- User interaction before launch (requirements for SATURN) and during operations, and
- RFI and frequency management.

2.5.2 Summary of ITSC-18 Actions and Suggested Topics for Discussion

Very good progress has been made on most actions and recommendations from ITSC-18. In particular the following items have had notable success:

- Website update,
- Direct Broadcast survey,
- FY-3 early morning orbit studies,
- FY-3 L0/L1 software,
- Himawari-8 broadcast,
- User preparedness for new data, and
- Private initiatives for new satellite data.

There remain open issues and actions with the following:

- Action IIFS-3 (ITSC-18): Notify RFI in 1400-1427 MHz band;
- Recommendation IIFS-1 (ITSC-18): Registering Direct Readout stations with the national radio frequency authorities;
- Recommendation IIFS-3 (ITSC-18): FY-3 early morning mission still to be encouraged and confirmed;
- Recommendation IIFS-4 (ITSC-18): NRT access to Meteor-M global data; and
- Recommendation IIFS-9 (ITSC-18): RARS extension to other satellite systems.

2.5.3 Global Design of the GOS, Implementation and Continuity Issues

GOS Design

There is evidence, some of it presented at ITSC-19, that availability of hyperspectral sounders from four satellites (mid morning (METOP-A and –B) and early afternoon (EOS-AQUA and S-NPP) is beneficial, for example in identifying areas at risk for tornadoes. Therefore the group recommends even more strongly implementing high frequency hyperspectral soundings in geostationary orbit. The group considered it would be helpful to collate examples where high frequency hyperspectral observations have proved useful.

Recommendation IIFS-1 to ITWG community

Provide examples to the Co-Chairs (Steve English, Jérôme Lafeuille) to show where high frequency soundings proved useful.

Recommendation IIFS-2 to satellite agencies

Note the growing evidence of likely benefits from hyperspectral geostationary soundings, and where possible to work towards the provision of such instruments in plans for future geo systems.

There followed discussion on the potential use of the INSAT-3D sounder, which should be evaluated. It is felt that real benefit of a sounder will only be fully achieved with a hyperspectral sensor but the current mission is seen as a first step in this direction.

The group also discussed whether it was desirable to encourage agencies to launch into the same orbital planes instead of spreading the missions on different orbital planes (e.g., 13:30, 15:00 Equatorial Crossing Time). The discussion was inconclusive as there are good (e.g., A-train, ECT stability required by GCOS monitoring principles) and bad aspects (less coverage, cannot try new products such as tandem winds).

Continuity

It is now anticipated that no DMSP spacecraft will fly beyond F-19 in an early morning orbit. The WG recalled the importance of ensuring continuity with some margin (two failures from a gap). Acknowledging the analysis by NOAA that the continuity between S-NPP and JPSS series is at some risk, the WG expressed concern and strongly encouraged agencies to plan satellite series with a systematic policy to re-launch when a critical mission is no longer fulfilled.

It noted that the re-launch criteria included in the current CGMS Contingency Plan (2007) http://www.wmo.int/pages/prog/sat/documents/CGMS_Contingency-Plan-2007.pdf would need to be refined and updated, especially as concerns sounding.

Action IIFS-1

Steve English to request ITWG (involving NWP Group) to provide input to CGMS WG III – via Jérôme Lafeuille – for updating the CGMS Contingency Plan.

It was also noted that the risks on the IR/MW sounding continuity increases the need for solid planning of a global RO constellation as part of a mitigation plan.

The group also noted that small mission scenarios can be envisaged as contingency measures, because they could potentially be procured quickly and cheaply to restore at least a component of the GOS (e.g. microwave sounding, RO) in the event of a gap.

Calibration Reference Standard

As part of GOS design, a reference payload such as CLARREO would (i) provide an in-orbit calibration reference and (ii) provide ultimately a climate benchmark. A pathfinder mission on the International Space Station (ISS) is a good step in this direction that will improve the value of currently operated or planned sounders. Noting that the accuracy of IASI, CrIS is estimated at the order of 0.2 K, reducing the uncertainty would reduce the time (number of decades) necessary to assess climate trends. The ITWG recommends such a mission, and encourages the community to then participate in testing and exploiting the results.

2.5.4 User Interaction Before and After Launch

Best Practices on User Preparation for New Missions

The WG was informed about the Satellite User Readiness Navigator (SATURN) portal under development by WMO in the context of a CGMS action. The aim of SATURN is to provide guidance to users to find the most current technical information on new missions. SATURN also contains a reference timeline of mission preparation, including deliverables. The WG strongly supported the concept and will provide feedback.

Action IIFS-2

Jérôme Lafeuille to circulate to WG members the draft ET-SUP paper describing the proposed SATURN concept (Satellite User Readiness Navigator).

Action IIFS-3

The WG members to provide feedback via Stephen English before ETSUP 17 April.

Recommendation IIFS-3 to WMO and agencies

WMO to pursue SATURN, and all agencies to actively contribute information to this portal.

User Interaction on Mission Status

The WG stresses the importance of getting current information to the users when any event affects the quality of data, e.g., calibration changes, sensor anomaly, change of operation mode, and indication of the magnitude of the event.

Action IIFS-4

Stephen English, on behalf of ITWG and in discussion with the NWP WG, to provide list of most relevant events affecting the quality of data, e.g., calibration changes, sensor anomaly, change of operation mode, and indication of the magnitude of the event justifying a notification.

Recommendation IIFS-4 to CGMS

Implement notification process for ITWG recommended events.

2.5.5 New Mission Data Access

GPM-Core

The group welcomed establishment of a portal allowing FTP access to data at a very early stage after the launch.

GCOM-W

The group again welcomed the early access provided to AMSR2 and it was noted that trial dissemination has now begun with EUMETCast.

FY-3

The WG acknowledged the excellent responsiveness of CMA for both provision of early data in near real time from FY-3A and 3B, and their strongly collaborative approach to instrument cal/val. This has raised the profile of FY3, which is now regarded as a key part of the GOS by

all WG members. The group welcomed news that the instruments on FY-3C are performing well, and the data will be made available as soon as possible.

METEOR-M

ITWG confirms its previous recommendation to Roshydromet to provide NRT access to global data sets from Meteor-M, including selected data sets on the GTS. In addition the WG noted the availability of information online about DB for Meteor-M, and recommended making pre-processing software available.

Recommendation IIFS-4 to Roshydromet

Make available pre-processing software for L0/L1 Meteor-M data.

MEGHA-TROPIQUES/SAPHIR

The data are said to be soon available in near-real time. The ITWG recommends implementing them on the GTS without further delay.

2.5.6 Frequency management

WMO have drafted a position paper for WRC-15. Although there are no major issues for ITWG, the group recommended that the WMO position paper be shared and brought to the attention of the national authorities in charge of frequency allocation. The group reconfirmed the old action to contact Jean Pla and notify any RFI detected in protected band.

2.6 PRODUCTS AND SOFTWARE

Web site: http://cimss.ssec.wisc.edu/itwg/sssp/index.html

Working group members: Liam Gumley (Co-Chair, SSEC, UW), Nathalie Selbach (Co-Chair, DWD), Nigel Atkinson (Co-Chair, Met Office), Jörg Ackermann (EUMETSAT), Thomas August (EUMETSAT), Leanne Avila (SSEC, UW), Anna Booton (Met Office), Rebecca Cintineo (SSEC, UW), Geoff Cureton (SSEC, UW), Tae-Myoung Kim (KMA), Hyesook Lee (KMA), Graeme Martin (SSEC, UW), Katerina Melnik (ScanEx RDC), Scott Mindock (SSEC, UW), Ashim Kumar Mitra (India Meteorological Department), Szuchia Moeller (SSEC, UW), Tom Rink (SSEC, UW), Pascale Roquet (Météo France), Simone Sievert de Costa (CPTEC/INPE), Kathy Strabala (SSEC, UW), Bomin Sun (NOAA)

2.6.1 Introduction

The scope of the Products and Software working Group has been re-defined during its meeting at the ITSC-18 and covers the following topics:

1. Both Level 1 and Level 2 satellite products,
2. Software tools and packages for generating, analyzing, and visualizing products,
3. Enabling end users to obtain or generate the products they need,
4. End user feedback and training,
5. Exchange of information for validation of products,
6. Informing the user community about requirements for future missions, and
7. Informing agencies about requirements of the users.

Discussion topics were prompted by: (i) the ITSC Co-Chairs, (ii) matters arising from the Direct Broadcast Technical Sub-group, and (iii) matters raised by group members.

2.6.2 Topics Assigned by the ITWG Co-Chairs

New Data
(Meteor-M, FY3C, Metop-B, S-NPP, Meghatropiques, commercial launches e.g. GIFTS/STORM, Iridium)

The group noted that CMA released FY-3C DB Level 1 software on March 27, 2014.

Action PSWG-1

Nigel Atkinson and Liam Gumley to test the FY-3C software and report back to the PSWG members

The group noted that the Meteor-M N2 launch is scheduled for June 2014.

Recommendation PSWG-1 to Roshydromet

3) **Provide real-time DB data and DB processing software.**
4) **Provide global data via a web portal**.

The group noted that some satellite agencies still use binary data formats.

Recommendation PSWG-2 to satellite agencies

3) **Data format documentation and/or software APIs should be made available early for new datasets.**
4) **Portable self-describing data formats should be used where possible. CF-compliant formatting and metadata should be used where possible.**

The group noted that NASA is preparing to design new algorithms, software, and data formats for Level 0 to Level 1B processing of VIIRS, CrIS, and ATMS. This has the potential to introduce confusion in the user community.

Recommendation PSWG-3 to NASA and JPSS

Provide information to the community on algorithm, software, LUT, and format changes, and comparisons between IDPS and NASA radiance products.

Real Time Data Dissemination:
RARS, Software Packages for Direct Broadcast

The group noted that GCOM-W1 has a direct broadcast capability. It would be helpful for the DB community to:

(a) have continuous access to GCOM-W1 AMSR2 data via DB to provide continuation of AMSR-E capability, and

(b) have access to software for processing the AMSR2 DB data.

Recommendation PSWG-4 to JAXA

Provide routine DB data and processing software for GCOM-W1 AMSR2.

The group noted that satellite operating agencies need to be reminded of the value of providing unrestricted DB access and software.

Recommendation PSWG-5 to satellite agencies

Continue to provide routine global unencrypted DB capability and accompanying processing software for both existing and new systems and sensors.

The group noted and supported the recent formation of the SSEC CSPP GEO project.

Recommendation PSWG-6 to SSEC

Create product generation software for GEO sensors including ABI, AHI, AMI via common algorithms.

The group noted a desire to create a climate data record of sounding products dating back to TOVS (prior to ATOVS). This was also raised in the Climate WG.

The group noted the development of the NOAA DB real-time network (DBRTN) by SSEC.

Recommendation PSWG-7 to NOAA and EUMETSAT

NOAA and EUMETSAT should work together to make the DBRTN data available to the global community (e.g., via RARS and/or GTS).

User Notification:
Best-practices for Advanced Information of Changes, Detection and Reaction to Data Problems

The group expressed a desire for better dissemination of sensor and data processing status.

Recommendation PSWG-8 to satellite agencies

Create online satellite, sensor, and processing status sites using the POES status page as a model, providing searchable archives of status information, with key

events (e.g., satellite/sensor failures, noise level out of specification, etc.) clearly separated from routine events, and contact information provided.

Future Dissemination of Hyperspectral IR Data:
Lossy Data Compression and Implications, Two-level Dissemination Concepts, Timeliness and Reliability Requirements

Regarding the dissemination of PCs and residuals the group noted that it may be better to distribute the remaining PCs. While not directly relevant to the PSWG, this topic could be investigated by another WG and/or a technical subgroup. The topic of strategy of updates for training data was also raised in the same context.

The group noted that JPSS is considering increasing the DB data rate from 15 to 30 Mbps for satellites after and including JPSS-2.

The group noted that SNPP CrIS will switch to full spectral resolution in Q4 2014. CSPP is already set to handle the FSR data (by transforming to reduced spectral resolution). NOAA has almost finished the new version of CrIS FSR calibration software and it is expected to be available in CSPP within a reasonable time after the FSR switchover.

Efficient Use of Hyperspectral IR Data:
Assimilation of PCs/Reconstructed Radiances, PCs and CDRs, PC RT Models, Level 2 Products

The group noted there are several SW packages available that utilize IASI/CrIS/AIRS for creating level 2 products. A list of software packages has been generated resulting from an action at ITSC-18 and will be made available via the PSWG software.

The group noted that the EUMETSAT Level 2 product utilizes reconstructed radiances.

Use of Sounding data in Cloudy Regions:
Accuracy of Cloudy RT in MW and IR, Assimilation/Retrieval Strategies

The group noted that EUMETSAT, NUCAPS, MIRS, and HSRTV products all include cloudy and clear retrievals.

The group noted that a cloud cleared retrieval scheme is not available in IAPP.

Validation:
Sharing and Joint Analysis of Results During Cal/Val Phase, Validation Datasets, Field Campaigns, NWP Monitoring and Assimilation, Absolute Calibration, Intercalibration

The group noted that users of DB software and products need information on the quality of the products.

Recommendation PSWG-9 to software and product providers (Met Office, SSEC)

Provide information on the quality and evaluation of their respective products to users.

Visualization Packages for Sounder Data

The group created a list of visualization packages as a result of an action from ITSC-18. The group has a requirement to keep the list up to date.

Action PSWG-2

Nigel Atkinson and Nathalie Selbach to review the visualization package list on the PSWG webpage periodically.

Infrared FOV Size: Trade-off Versus Other Characteristics

The group recommended that the Advanced Sounder working group be responsible for all work on this topic.

Case Studies to Further Improve Algorithms For Retrievals and Data Assimilation (Cloud Clearing, Surface Emissivity, Water Vapour, Other Trace Gases)

The group noted that surface emissivity validation should be explored further.

Action PSWG-3

Thomas August to assemble a list of available surface emissivity validation datasets.

2.6.3 Other Topics

The group noted that KMA is willing to provide algorithms for the CSPP GEO processing software package.

Action PSWG-4

Graeme Martin to contact KMA and explore the mechanism for transferring algorithms to CSPP GEO.

The group noted that the KMA AMI may have a DB transmission and therefore a community of DB users who may need processing software and products.

Recommendation PSWG-10 to KMA

Provide DB data and processing software for AMI.

The group noted that NOAA STAR is collecting validation data from a number of sources relevant to temperature and moisture soundings. The data are all available from the NOAA Satellite Products Validation system website (http://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/index.php). The group recommends that product users consult this website and use the data for product validation. The NPROVS+ team invites colleagues to send them their temperature and water vapor retrieval EDRs for inter-comparison with many other products that are routinely accessed and evaluated by the team.

The group noted that a continued funding support of DB packages is needed and agencies should be made aware that the need for such support has not gone away.

Recommendation PSWG-11 to NASA, NOAA, and EUMETSAT

Continue support for funding of DB software packages.

The group noted that there is still a desire to have IAPP supported and available.

Action PSWG-5

Liam Gumley to convey to SSEC the need to come up with a plan for continued IAPP support, perhaps under the umbrella of CSPP.

The group noted the following items related to EPS-SG:

1. Data format will be netCDF.
2. EUMETSAT desire for information on lessons learned from ATMS striping, including impact on higher level products. Any information should be sent to Jörg Ackermann.
3. IASI-NG and microwave sounder will not be synchronized. Remapping will be required for some applications. PSWG recommends that anyone who is concerned about this should contact Jörg Ackermann at EUMETSAT.

The group recommends that DB software providers ensure that any ancillary data required to operate the software is available in a convenient, accessible, and no cost form.

The group noted the importance of reprocessing whenever there is a major update to a product retrieval algorithm, e.g., EUMETSAT IASI L2 product. Data providers are encouraged to create consistent data records for the community, for instance for climate and scientific applications.

2.6.4 GMS High Level Priority Plan

The group agreed to circulate the CGMS HLPP and provide comments and feedback in time for the final version of the PSWG report from ITSC-19.

2.6.5 Topics and Actions from ITSC-18

The following section gives an overview on the status of the actions from the PSWG group since ITSC-18. The open actions will be followed up until ITSC-20.

Open Actions

This section gives an overview of the actions from ITSC-18 having the status “open” at the time of writing of the ITWG report.

Website

Action PSWG-1 (ITSC-18)

Decide on a solution for working group user driven content and set up logins. This is needed because the group needs to add and edit content online without needing a web admin.

Status: Open

Bill Bellon and Leanne Avila are considering a redesign of the whole ITWG web site, using a Content Management System. Other possibilities discussed were:
File sharing service (e.g., Dropbox)
User-driven forum (e.g., phpBB)
User-driven groups (e.g., Plone)
The PSWG will wait until a new CMS and website is selected, and then redesign the PSWG area of the site.

Product Validation

Recommendation PSWG-7 (ITSC-18)

Review sources of information on validation data for satellite products and ensure links are available on Working group website.

Action PSWG-11 (ITSC-18)

Review links on the validation section of the website and add any new sources of information.

Status: Open

Dependent on web site redesign (PSWG-1 from ITSC-18)

Level 1 Format Issues

Recommendation PSWG-9 (ITSC-18)

ATMS, VIIRS, and CrIS SDR calibration traceability must be improved to allow users to investigate detailed instrument performance.

Action PSWG-14 (ITSC-18)

In order to maintain a record of product provenance, create a set of guidelines for metadata to be associated with satellite products (Geoff Cureton).

Status: Open

Nathalie Selbach and Geoff Cureton are assigned to this action.

Development of Software Packages

Recommendation PSWG-11 (ITSC-18)

Collect lessons learned from working with NPP/JPSS and GOES-R algorithms and provide to NOAA/JPSS.

Action PSWG-19 (ITSC-18)

Write an "ADL Lessons Learned" document and submit to JPSS Program.

Status: Open (Graeme Martin, Ray Garcia)

Graeme Martin to write up lessons learned and recommendations in a short document as soon as possible and distribute it to the group.

Action PSWG-20 (ITSC-18)

Write a guide to "Compiling Portable Binary Code" and make available to ITWG online.

Status: Open (Graeme Martin, Ray Garcia)

To be written up by Graeme Martin as soon as possible.

Action PSWG-21 (ITSC-18)

Advertise on ITWG website and associated software package websites that users can contribute their own algorithms or software for product generation.

Status: Open (Kathy Strabala)

Kathy Strabala will add information on CSPP and IMAPP websites, and the new ITWG website.

Closed Actions

This section summarizes the outcome of the actions of the Products and Software Working Group from ITSC-18, which have been closed at the time of writing of the report for ITSC-19.

Action PSWG-2 (ITSC-18)

As part of the ITWG website redesign, the SSSP (now PSWG) web content should be reviewed for inactive or non-relevant links.

Status: Closed

The group decided that the group will start with a clean slate when the new CMS and website is ready, and will focus on providing high level links only. The group noted that Google search is more likely to provide good links than a set of static links.

Software

Action PSWG-3 (ITSC-18)

Review currently available processing systems and software packages that can be obtained by the user community, and identify gaps. This is needed so that recommendations can be made to product and software development teams to add new features.

Status: Closed

The Co-Chairs have produced an html document showing:

- Direct broadcast packages,
- Level 1 packages,
- Level 2 packages, and
- Visualisation and analysis tools.

This document will be made available on the new web site, and circulated to the WG members.

Recommendation PSWG-1 (ITSC-18)

Request that EUMETSAT investigates the feasibility of releasing the official IASI Level 2 retrieval algorithm in software form.

Action PSWG-4 (ITSC-18)

ITWG to request that IASI Level 2 software be made available.

Action PSWG-5 (ITSC-18)

Investigate how IASI Level 2 software could be made available.

Status: Closed

EUMETSAT reported that they are not able to release the package (D. Coppens). Since ITSC-18, other packages have been made available, or are planned:

1 UW's "CrIS, AIRS and IASI Hyperspectral Retrieval Software" (v1.2 of the CrIS/AIRS/IASI dual-regression retrieval software released Sep 2013)

2 NOAA's MIRS software released as part of CSPP March 2014 (Sid Boukabara) supporting ATMS, AMSU, MHS.

3 Chris Barnet is working with the CSPP project at UW to release the NUCAPS software package to the DB community. NUCAPS includes support for SNPP CrIS/ATMS, Metop IASI/AMSU/MHS, and Aqua AIRS/AMSU retrievals; planned for release in mid 2014.

Action PSWG-6 (ITSC-18)

Send request to CIMSS for continued support for IAPP for Metop-B, and investigate feasibility of adapting it for Suomi NPP.

Status: Closed

Request was sent to CIMSS and a reply received from Tom Achtor: CIMSS is continuing to support IAPP. CIMSS does not have the resources to adapt IAPP for ATMS/CrIS, but other temperature/moisture retrieval algorithms will be included in CSPP (see PSWG-4/PSWG-5 from ITSC-18). Also, see ITSC-19 poster 8p.06 by Szuchia Moeller.

The CSPP project will look into including IAPP under the CSPP umbrella.

Availability of Data

Recommendation PSWG-3 (ITSC-18)

Request that GEOMETWATCH (GMW) clarifies its policy on data and software availability and licensing. This is needed so that the user community knows what to expect from GMW data in future.

Action PSWG-7 (ITSC-18)

Forward request for information to GEOMETWATCH.

Status: Closed

Since ITSC-18 there have been various high-level discussions between EUMETSAT, NOAA, SSEC and others on the subject. (Direct request from PSWG not considered necessary). SSEC assessment at the present time is that: while high level discussions between GMW and potential STORM users have occurred and are ongoing, it is expected that (a) all users of STORM data will need to pay for the data, and (b) the processing software is likely to be restricted proprietary information.

Issues Affecting Other ITWG Working Groups

Recommendation PSWG-4 (ITSC-18)

RTTOV team to investigate improving memory usage related to the IR emissivity atlas.

Action PSWG-8 (ITSC-18)

Send technical details and examples of memory usage to RTTOV team.

Status: Closed

The information was sent to the RTTOV team. James Hocking will look at implementation for RTTOV v11. Updates to the IR land surface emissivity atlas to improve speed and memory usage have been implemented in RTTOVv11.

Recommendation PSWG-5 (ITSC-18)

CRTM to implement UWIREMIS database, as has been done for RTTOV

Action PSWG-9 (ITSC-18)

Request CRTM team to add UWIREMIS database support (Allen Huang).

Status: Closed

This is now available in CRTM.

Direct Broadcast Reception

Recommendation PSWG-6 (ITSC-18)

Working group to assemble and disseminate information on vendors for DB antenna systems and contact information.

Action PSWG-10 (ITSC-18)

Assemble a list of DB vendors, contact information, and capabilities (Liam Gumley)

Status: Closed

A list has been created and will be published on the new web site.

Recommendation PSWG-8 (ITSC-18)

ITWG members should work with NOAA STAR Sounding validation team if they have temperature and moisture products they wish to validate or compare to other products.

Action PSWG-12 (ITSC-18)

Provide NOAA contact on the PSWG web site.

Status: Closed

Information on contact person has been provided by Bomin Sun. The NOAA Satellite Products Validation system website is:
http://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/index.php. A list of persons involved in the project can be found at http://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/personnel.php

Recommendation PSWG-9 (ITSC-18)

ATMS, VIIRS, and CrIS SDR calibration traceability must be improved to allow users to investigate detailed instrument performance.

Action PSWG-13 (ITSC-18)

Investigate ways to expose or save calibration information from the RDR files.

Status: Closed

ATMS raw counts can be extracted from the "verified RDR," which can be generated by CSPP. A note has been prepared for the PSWG web site (Details can be provided by Nigel Atkinson).

Recommendation PSWG-10 (ITSC-18)

JPSS Project should investigate ways to streamline or improve data volume to reduce bandwidth needed for distribution.

Action PSWG-15 (ITSC-18)

Send request to JPSS Program Scientist for CLASS to offer optional internal HDF5 compression.

Status: Closed

- The EUMETSAT Compressed VIIRS format is now mature, and gives a 6-fold reduction compared with the original VIIRS SDR. Java conversion tool is available. The format could be adopted more widely.
- The NOAA/NESDIS IDPS is implementing gzip internal compression for SNPP HDF5 files. It will be a user-selectable option at download time from CLASS. For VIIRS SDR files (the largest files) the compression is expected to reduce data volumes by more than 50%.
- gzip internal compression is an option in CSPP, or the user can add it using 'h5repack'.

Infrared Sounder FOV Size

Action PSWG-16

Assemble the currently available studies on infrared sounder field of view size and write up a summary (Lydie Lavanant).

Status: Closed

This topic has been reassigned to the Advanced Sounder Working Group (Dave Tobin).

Visualisation and Analysis

Action PSWG-17 (ITSC-18)

Assemble a table of currently available software for visualization and analysis of satellite products.

Status: Closed

Co-Chairs have produced a table for inclusion on the PSWG web pages (see also Action PSWG-3 from ITSC-18). The list also includes links to WMO and NASA resources.

Action PSWG-18 (ITSC-18)

Create a Python cookbook for satellite products including Suomi NPP, EOS, POES, and Metop, in coordination with PyTroll developers.

Status: Closed
Geoff Cureton has created a cookbook for handling the output of the CSPP VIIRS EDR. This will be made available via the PSWG web pages.

LIST OF ACRONYMS

AAPP: Advanced ATOVS Processing Package
ABI: Advanced Baseline Imager
AHI: Advanced Himawari Imager
AIRS: Atmospheric InfraRed Sounder
AMI: Advanced Meteorological Imager (KMA)
AMSR: Advanced Microwave Scanning Radiometer
AMSU: Advance Microwave Sounding Unit
API: Application Programming Interface
ARTS: Atmospheric Radiative Transfer Simulator
ATMS: Advanced Technology Microwave Sounder
ATOVS: Advanced TIROS Operational Vertical Sounders
BRDF: Bi-directional Reflection Distribution Function
BUFR: Binary Universal Form for the Representation of meteorological data
CALIOP: Cloud-Aerosol LIdar with Orthogonal Polarization
CALIPSO: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CDR: Climate Data Record
CGMS: Coordination Group for Meteorological Satellites
CIMSS: Cooperative Institute for Meteorological Satellite Studies
CLARREO: Climate Absolute Radiance and Refractivity Observatory
CLASS: Comprehensive Large Array-data Stewardship System
CLBL: Community Line By Line
CMA: Chinese Meteorological Agency
CMIP: Coupled Model Intercomparison Projects
CNES: Centre National d'Etudes Spatiales
CrIS: Cross-track Infrared Sounder
CRTM: Community Radiative Transfer Model
CSPP: Community Satellite Processing Package
DB: Direct Broadcast
DBRTN: Direct Broadcast Real Time Network
DDA: Discrete Dipole Approximation
DISORT: Discrete Ordinate Radiative Transfer
DMSP: Defense Meteorological Satellites Program
DoD: Department of Defense (US)
DWD: Deutscher Wetterdienst (German Weather Service)
EARS: EUMETSAT Advanced Retransmission Service
ECMWF: European Center for Medium Range Weather
ECV: Essential Climate Variables
EOS: Earth Observing System
EPS: EUMETSAT Polar Satellite
EPS-NG: EUMETSAT Polar Satellite-Next Generation
ESA: European Space Agency
ESA-CCI: European Space Agency-Climate Change Initiative
ESTO: Earth Science Technology Office (NASA)
ET-SUP: Expert Team on Satellite Utilization and Products
EUMETSAT: European Organization for the exploitation of meteorological satellites
FCDR: Fundamental Climate Data Record

FOV: Field of View
FTS: Fourier Transform Spectrometer
FY-3: LEO satellite from China
GCOM-W/GCOM-W2: Global Change Observation Missions
GCOS: Global Climate Observing System
GIFTS: Geostationary Imaging Fourier Transform Spectrometer
GMW: GeoMetWatch
GOES: Geostationary Operational Environmental Satellite
GOS: Global Observing System
GPS: Global Positioning System
GRUAN: GCOS Reference Upper Air Network
GSICS: Global Space-Based Inter-Calibration System
GTS: Global Telecommunications System
GUI: Graphical User Interface
HDF: Hierarchical Data Format
HIRS: High-Resolution Infrared Radiation Sounder
HRPT: High Resolution Picture Transmission
IAA: Istituto de Astrofisica de Andalucia
IAMAP: International Association of Meteorology and Atmospheric Physics
IASI: Infrared Atmospheric Sounding Interferometer
IASI-NG: IASI- Next Generation
IDPS: Integrated Data Processing Segment
IPCC: Intergovernmental Panel on Climate Change
IR: Infrared
IRC: International Radiation Commission
ISS: International Space Station
ITSC: International TOVS Study Conference
ITWG: International TOVS Working Group
JAXA: Japan Aerospace Exploration Agency
JPSS: Joint Polar Satellite System
kCARTA: k-Compressed Atmospheric Radiative Transfer Algorithm
LBL: Line By Line
LBLRTM: Line By Line Radiative Transfer Model
LEO: Low Earth Orbit
LTE: Local Thermodynamic Equilibrium
LUT: Lookup Table
MACC: Monitoring Atmospheric Composition and Climate
MetOp: Meteorological Operational
MHS: Microwave Humidity Sounder
MODIS: Moderate-resolution Imaging Spectroradiometer
MSU-MR: Russian VIS/IR Imaging Radiometer for Meteor
MT-CKD: water vapor continuum model developed by E.J. Mlawer, D.C. Tobin and S.A. Clough, using the original CKD formulation as its foundation
MTG-IRS: Meteosat Third Generation - Infrared Radiometric Sounder
MTVZA: Russian Imaging/Sounding Microwave Radiometer
MVIRI: Meteosat Visible and InfraRed Imager
MW: Microwave
NASA: National Aeronautics and Space Administration
NEdT: Noise Equivalent Delta Temperature
NESDIS: National Environmental Satellites, Data, and Information Service

NOAA: National Oceanic and Atmospheric Administration
NPROVS: NOAA PROducts Validation System
NRL: Naval Research Laboratory
NWP: Numerical Weather Prediction
OMPS: Ozone Mapping and Profiler Suite
OPS: Operations
OSS: Optimal Spectral Sampling
PC: Principal Component
PCRTM: Principal Component-based Radiative Transfer Model
PMR: Pressure Modulator Radiometer
POES: Polar Operational Environmental Satellite
PSWG: Products and Software Working Group
QC: Quality Control
RARS: Regional ATOVS Retransmission Services
RDR: Raw Data Record
RFI: Radio Frequency Interference
RO: Radio Occultation
RT: Radiative Transfer
RTM: Radiative Transfer Model
RTTOV: Radiative Transfer for TOVS
SAF: Satellite Application Facility
SATURN: Satellite User Readiness Navigator
SCAMS: Scanning Microwave Spectrometer
SDR: Sensor Data Record
SMAP: Soil Moisture Active-Passive
SMHI: Sweden's Meteorological and Hydrological Institute
SMOS: Soil Moisture and Ocean Salinity
SNO: Simultaneous Nadir Overpass
SRF: Spectral Response Function
SSEC: Space Science and Engineering Center
SSMI: Special Sensor Microwave Imager
SSMIS: Special Sensor Microwave Imager/Sounder
SSMR: Scanning Multichannel Microwave Radiometer
SSU: Stratospheric Sounding Unit
STAR: Center for Satellite Applications and Research
STORM: Sounding & Tracking Observatory for Regional Meteorology
Suomi NPP: Suomi National Polar-orbiting Partnership
TOVS: TIROS Operational Vertical Sounder
VIIRS: Visible/Infrared Imager Radiometer Suite
VTPR: Vertical Temperature Profile Radiometer
WG: Working Group
WMO: World Meteorological Organization

ITSC-XIX AGENDA

Wednesday 26 March 2014		
8.00-8.30	Registration (continues to 15:00) Poster setup	
8.30-9.00	Welcome	Co-Chairs Mitch Goldberg, Niels Bormann
	An Overview of KMA	Dr Jae-Gwang Won (20 minutes)
	Local Arrangements	Dohyeong Kim, B.J. Sohn
	Review of agenda	Co-Chairs

9.00-9.45 Session 1a: New observations (oral presentations- 12 minutes) Chairs: Hank Revercomb and Dieter Klaes		
1.01	Yong Han	CrIS SDR Calibration and Cross-sensor Comparisons
1.02	William L. Smith	The May 2013 SNPP Cal/Val Campaign: Validation of Satellite Soundings
1.03	Lihang Zhou	Updates on the Performance of Suomi National Polar-orbiting Partnership (SNPP) Data Products

9.45-10.00 Session 1b: New observations (poster introductions - 1 minute: no visual aids) Chairs: Hank Revercomb and Dieter Klaes		
1p.01	Xin Jin	Monitoring Suomi-NPP CrIS instrument Status and Data Quality at NOAA
1p.02	Xingpin Liu	JPSS EDR Product Long-term Monitoring
1p.03	Allen Larar	The Suomi NPP airborne field campaign and preliminary NAST-I radiance results
1p.04	Hank Revercomb (for Joe K. Taylor)	Suomi NPP/JPSS Cross-track Infrared Sounder (CrIS): Calibration Validation With The Aircraft Based Scanning High-resolution Interferometer Sounder (S-HIS)
1p.05	Hank Revercomb (for David Tobin)	CrIS Radiometric Calibration: Uncertainty Estimates and Evaluations
1p.06	Yong Chen	CrIS Full Resolution Processing and Validation System (CRPVS) for JPSS
1p.07	Scott Mindock	CSPP Soumi NPP SDR 1.4

10.00-10.30 BREAK (incl. poster-viewing session 1b)

10.30-11.45 Session 1c: New observations (oral presentations- 12 minutes) Chairs: Nigel Atkinson and Allen Larar		
1.04	Fuzhong Weng	Advances in ATMS Sensor Data Record (SDR) Sciences
1.05	Zhengkun Qin	Analysis of ATMS Striping Noise from its Earth Scene Observations
1.06	Chris Barnet	Implementation of the NOAA Unique CrIS/ATMS processing

		System (NUCAPS) within the Community Satellite Processing Package (CSPP)
1.07	Bomin Sun	Procedures to Validate S-NPP Sounding Products using Conventional and Reference/Dedicated Observations,
1.08	S. Indira Rani	Simulation and Validation of INSAT-3D Imager and Sounder data at NCMRWF

11.45-12.00 Session 1d: New observations (poster introductions - 1 minute: no visual aids) **Chairs: Nigel Atkinson and Allen Larar**		
1p.08	Fuzhong Weng (for Lin Lin)	Validation of ATMS Radiance Using GPS RO and Radiosonde Data
1p.09	Simone Costa	Recent implementation and use current products and processing packages for Suomi/NPP Instruments at CPTEC/INPE
1p.10	Reima Eresmaa	Assimilation of Cross-track Infrared Sounder radiances at ECMWF
1p.11	Ana Fernandez del Rio (for Robin Faulwetter)	Assimilation of ATMS data at DWD
1p.12	Heather Lawrence	An update on the assimilation of ATMS data at ECMWF
1p.13	Fiona Smith (for James Cameron)	Assessment and assimilation of MetOp-B IASI
1p.14	Dorothée Coppens	Inter-comparison between IASI and other Multi-spectral Instruments: One Year of Dual-METOP Data

12:00-12:30	Welcome by KMA	Dr Yunhwa Ko, Administrator of KMA
	Welcome by WMO	Dr David Grimes, President of WMO
	Group Photo	

12.30-13.30 LUNCH
13.30-14.00 Poster-viewing session 1d

14.00-15.15	**Session 1e: New Observations (oral presentations - 12 minutes)**	
Chairs: Peng Zhang and Ken Holmlund		
1.09	Peng Zhang	The latest progress of FY-3C
1.10	Qifeng Lu	The data quality and performance of four FY-3 instruments for NWP
1.11	Wei Han (for Peiming Dong)	Inter-comparison of data characteristics and impact on NWP of FY-3B NPP and NOAA18 Microwave observation
1.12	Eric Péquignot (for Elsa Jacquette)	Performance status of IASI on MetOp-A and MetOp-B
1.13	Dorothée Coppens	Assessment of IASI Radiances during the SALSTICE Campaign

15.15-15.30	**Session 1f: New Observations (poster introductions - 1 minute: no visual aids)**	
Chairs: Peng Zhang and Ken Holmlund		
1p.15	Keyi Chen	Assessment of Chinese Satellite FY3A/B MWHS
1p.16	Ling Wang	Retrieval and validation of water vapor from FY3C MERSI near-infrared channels
1p.17	Pascal Brunel	Mapping CrIS field of view onto VIIRS
1p.18	Geoff Cureton	VIIRS EDR Products in the Community Satellite Processing Package (CSPP)
1p.19	Tom Rink	Analyzing VIIRS and CrIS Data with HYDRA2
1p.20	Yi Song	A BUFR and GRIB Tailoring System for NPP/JPSS and GCOM Products

15.30-16.00 BREAK (incl. poster-viewing session 1f)

16.00-16.30	**Session 2a: Processing and dissemination (oral presentations - 12 minutes)**	
Chairs: Allen Huang, Jerome Lafeuille and Ken Carey		
2.01	Liam Gumley	Recent developments with the Community Satellite Processing Package (CSPP)
2.02	Kathleen Strabala	International MODIS/AIRS Processing Package (IMAPP): Proof of the Utility of Polar Orbiter Data to Environmental Forecasters

16.30-16.45	**Session 2b: Processing and dissemination (poster introductions - 1 minute: no visual aids)**	
Chairs: Allen Huang, Jerome Lafeuille and Ken Carey		
2p.01	Nigel Atkinson	AAPP status report for ITSC-19
2p.02	Nigel Atkinson	Experiences with reception and processing of direct broadcast FY-3A and FY-3B data
2p.03	Graeme Martin	Introducing CSPP GEO: A Geostationary Satellite Data Processing Package for Direct Broadcast Users
2p.04	Dieter Klaes (for Thomas Heinemann)	EUMETSAT's global and regional services for sounder data
2p.05	Liam Gumley	NOAA Real-Time Network for Receiving and Processing Infrared and Microwave Sounder Data with Low Latency
2p.06	withdrawn	
2p.07	Su-Hyun Jung	Operational Processing of Satellite Sounding Data at NMSC
2p.08	Xiaoxu Tian	Detection of Radio Frequency Interference in Global Microwave Imager Data

16.45-17.25	**Session 3a: Future Observing Systems (Agency poster introductions - 5 min, 2 slides)**	
Chairs: Allen Huang, Jerome Lafeuille and Ken Carey		
SP.1	Jerome Lafeuille	WMO perspective
SP.2	Dieter Klaes	EUMETSAT Plans
SP.3	Kozo Okamoto	JMA and JAXA plans
SP.4	Mitch Goldberg	NOAA
SP.5	Peng Zhang	China
SP.6	Ashim Mitra	India
SP.7	Alexander Polyakov (for Alexander Uspensky)	Russia

17.25-17.40	**Session 3b: Future Observing Systems (oral presentations - 12 minutes)**	
Chairs: Allen Huang, Jerome Lafeuille and Ken Carey		
3.01	Francisco Bermudo	IASI-NG program: a New Generation of Infrared Atmospheric Sounding Interferometer

17.40-17.50	Session 3c: EPS-SG (poster introductions - 1 minute: no visual aids)	
Chairs: Allen Huang, Jerome Lafeuille and Ken Carey		
3p.01	Joerg Ackermann	EPS-SG: Overview of Mission and Products
3p.02 & 3p.03	Stéphane Rousseau	IASI-NG system overview
3p.04	Stéphane Rousseau (for Frédéric Bernard)	IASI-NG Instrument Presentation
3p.05	Javier Andrey-Andres	A step towards IASI-NG: Simulation of orbits and first impact assessment compared to IASI

19.30 Welcome dinner

Thursday 27 March 2014

08:30-09.45 Session 4a: Radiative transfer (oral presentations - 12 minutes)		
Chairs: Louis Garand and Pascal Brunel		
4.01	Nicole Jacquinet	The GEISA spectroscopic database: an key tool for atmospheric remote sensing applications
4.02	Quanhua (Mark) Liu	Community Radiative Transfer Model Updates and Applications
4.03	James Hocking	Update on RTTOV developments
4.04	Stephan Havemann	The Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC) for hyperspectral, broadband and line-by-line radiance and flux simulations
4.05	Raymond Armante (for Noelle A. Scott)	Lessons learnt from the validation of level1 and level2 hyperspectral sounders observations

09.45-10.00 Session 4b: Radiative transfer (poster introductions - 1 minute: no visual aids)		
Chairs: Louis Garand and Pascal Brunel		
4p.01	Ju-Hye Kim	Intercomparison of RTTOV and CRTM: Simulated radiances of AMSU-A and microwave scattering solver
4p.02	Pascale Roquet	A graphical user interface for RTTOV
4p.03	Cristina Lupu	Evaluation of RTTOV-11 in the IFS
4p.04	Jeon-Ho Kang	The comparison of vertical interpolation methods for the KIAPS observation processing system
4p.05	Raymond Armante	4A/OP : A fast and accurate operational forward radiative transfer model for the TIR and the SWIR

10.00-10.45 BREAK (incl. poster-viewing sessions 2b, 3c, 4b)

10.45-11.45 Session 5a: Surface studies (oral presentations - 12 minutes)		
Chairs: Kathleen Strabala and Fuzhong Weng		
5.01	Masahiro Kazumori	Use of the Ocean Surface Wind Direction Signal in Microwave Radiance Assimilation
5.02	Louis-Francois Meunier	Impact of whitecap coverage derived from a wave model on the assimilation of radiances from microwave imagers

5.03	Louis Garand	Assimilation of infrared surface sensitive channels over land and sea ice at Environment Canada
5.04	Alexander V. Polyakov	Retrieval of atmospheric profiles and surface parameters from METEOR-3M IR- and MW-sounders data

11.45-12.15 Session 5b: Surface studies (poster introductions - 1 minute: no visual aids) **Chairs: Kathleen Strabala and Fuzhong Weng**		
5p.01	withdrawn	
5p.02	Daniel Zhou	Update on IASI Emissivity Atlas
5p.03	Wei Han	The assimilation of surface-sensitive microwave sounder radiances over East Asia in GRAPES
5p.04	Fiona Smith (for Stuart Newman)	Improved use of ATOVS over land
5p.05	Heather Lawrence	Situation-dependent observation errors for AMSU-A tropospheric channels in the ECMWF forecasting system
5p.06	Stephen J. English	Prospects for assimilating more sounder radiances over snow covered surfaces
5p.07	Wen Lu	Analysis of the Third and Fourth Stokes parameters by Fully Polarimetric Microwave Radiometer Measurement over Antarctic Sea Ice
5p.08	Chunxiang Shi	Status and Plans of CMA Land Data Assimilation System (CLDAS) Project
5p.09	Lipeng Jiang	Assimilation of FY-3B Soil Moisture Products into Noah-MP Land Surface Model
5p.10	Szu-Chen Kuo	The response of vertical information content in a 3DVAR data assimilation system

12.30-13.30 LUNCH

13.30-14.00 Poster-viewing session 5b

14.00-14.45 Session 6: NWP centre reports (poster introductions - 3 minutes: 1 slide) **Chairs: Kozo Okamoto and Fiona Smith**		
NWP.1	Sangwon Joo (KMA)	Current status and plan of the satellite data assimilation at Korea Meteorological Administration
NWP.2	Akira Okagaki (JMA)	Recent developments in satellite data assimilation at JMA
NWP.3	Stephen English (ECMWF)	Recent changes in the ECMWF NWP system
NWP.4	Chantal Cote (Environment Canada)	Status of the Operational Global Deterministic Prediction System at Environment Canada
NWP.5	Roger Randriamampianina (met.no/HARMONIE)	Radiance data assimilation in HIRLAM and ALADIN consortia - Recent developments
NWP.6a, NWP.6b	Louis-Francois Meunier	Overview of the infrared radiance assimilation in the Meteo-France models/Ongoing developments on the use of microwave sounders and imagers at Meteo-France

NWP.7	Andrew Collard (NCEP)	Progress and plans for the use of radiance data in the NCEP global and regional data assimilation systems
NWP.8	Christina Köpken-Watts (DWD)	Developments in satellite data assimilation at DWD
NWP.9	William Bell (Met Office)	Overview of developments in the use of sounder data at the Met Office
NWP.10	Luis Gustavo de Goncalves (CPTEC)	Evaluation of the new Global 3DVar Operational System at CPTEC/INPE
NWP.11	Indira Rani (NCMWRF)	Real-time use of Atmospheric Sounding data at NCMRWF: Current and Future plans

Action Items from ITSC-18

Moderators: Mitch Goldberg and Niels Bormann

14.45-15.00 CGMS report (Mitch Goldberg)

15.00-15.30 Working group action items from ITSC-18 (15 minutes)

- RT (Marco Matricardi and Yong Han)
- Climate (Thierry Phulpin and Viju John)

15.30-16.00 BREAK (including poster viewing session 6)

16.00-17.00 Working group action items from ITSC-18 (15 minutes)

- NWP (Andrew Collard and Fiona Smith)
- International and Future Systems (Jerome Lafeuille and Stephen English)
- Advanced Sounders (Dieter Klaes and Bill Smith)
- Products and Software (Nigel Atkinson, Liam Gumley, Nathalie Selbach)

17.00-17.15 Technical sub-group reports and formation (5 minutes each)

Direct broadcast packages (Liam Gumley)
RARS (Jerome Lafeuille)

17.15-17.30 Working group formation

17.30-18.30 Technical Sub-Groups:

- RTTOV (James Hocking)
- CRTM (Mark Liu)
- RARS and direct broadcast packages (Jerome Lafeuille, Liam Gumley)

Friday 28 March 2014

08.30-10.15 Session 7a: Advanced IR: dissemination and assimilation (oral presentations - 12 minutes) **Chairs: Luis Gustavo de Goncalves and Andrew Collard**		
7.01	Marco Matricardi	Direct assimilation of Principal Component data for operational Numerical Weather Prediction

7.02	Fiona Smith	Improved Assimilation of Hyperspectral Sounder Reconstructed Radiances
7.03	Youngchan No	IASI channel selection for the Unified Model data assimilation system
7.04	Reima Eresmaa	Implications of observation error correlation on the assimilation of interferometric radiances
7.05	Stephanie Guedj	An Observing System Simulation Experiment to evaluate the future benefits of MTG-IRS data in a fine-scale weather forecast model
7.06	Kenneth Holmlund	Hyperspectral Infrared Sounding Missions - Future perspectives for data dissemination
7.07	Nigel Atkinson	Challenges in data compression for current and future imagers and hyperspectral sounders

10.15-10.30 Session 7b: Advanced IR: assimilation (poster introductions - 1 minute: no visual aids) **Chairs: Luis Gustavo de Goncalves and Andrew Collard**		
7p.01	Louis Garand (for Sylvain Heilliette)	Assimilation experiments using non-diagonal observation error covariances at Environment-Canada
7p.02	William Bell (for Peter Weston)	Accounting for Correlated Observation Errors in the Assimilation of High Resolution Sounder Data
7p.03	William Bell (for Peter Weston)	Assimilating IASI data into the Met Office UKV convective scale model
7p.04	Su Jin Ha	IASI quality control at KIAPS and preliminary results
7p.05	Ji-Sun Kang, Byoung-Joo Jung	IASI radiance data assimilation within KIAPS-LETKF system
7p.06	Akira Okagaki	Assimilation of AIRS and IASI radiances at JMA global NWP system
7p.07	Jun Li (for Jing Zheng)	Assimilation of Atmospheric Temperature and Moisture Soundings from AIRS for Hurricane Forecasts in regional NWP

10.30-11.00 BREAK (incl. poster-viewing session 7b)

11.00-12.00 Session 8a: Retrieval studies (oral presentations - 12 minutes) **Chairs: Bill Smith and Xu Liu**		
8.01	Thomas August	The operational IASI L2 at EUMETSAT
8.02	Antonia Gambacorta	The NOAA Operational Hyper Spectral Retrieval Algorithm: a cross-comparison among the CrIS, IASI and AIRS processing systems
8.03	Nadia Smith	An Overview of the UW Hyperspectral Retrieval System for AIRS, IASI and CrIS
8.04	Xu Liu	Explicit Retrieval of Cloud and Atmospheric Properties From CrIS, IASI and AIRS Hyperspectral Data

12.00-12.30 Session 8b: Retrieval studies (poster introductions - 1 minute: no visual aids) **Chairs: Bill Smith and Xu Liu**		
8p.01	Tim Hultberg	Use of reconstructed radiances in EUMETSAT's IASI Level 2 processor
8p.02	Thomas August (for Xavier Calbet)	Consistency validation of GRUAN sondes and IASI radiances

8p.03	Hyun-Sung Jang	Optimization of Principal Component Regression Method for Retrieving Temperature and Moisture Profiles from Infrared Hyper-Spectral Measurements over East Asia and its Use for Improving Accuracy of Physical Retrieval
8p.04	Bomin Sun	Characteristics of global conventional RAOBs and their use in satellite sounding product validation : An analysis of 3-yr NPROVS collocation data
8p.05	Robert Knuteson (for Michelle Feltz)	Using GPS Radio Occultation in the Validation of IR Temperature Sounding Profiles from CrIS, IASI, and AIRS
8p.06	Szuchia Moeller	CIMSS IAPP Retrieval Software: Updates, Application and Validation
8p.07	Jacola Roman	Assessing the Ability of IR Sounders in Detecting Extreme Weather Events and Predicting Extreme Floods
8p.08	Peng Zhang (for Hui Liu, Chunqiang Wu, Jun Li)	Simulation Test of the Atmospheric Instability Indices Regression Directly with the Hyper-spectral Interferometric Atmospheric Sounder(IAS) observation of Geostationary Meteorological Satellite
8p.09	Su Jeong Lee	Application of Artificial Neural Network for the direct estimation of atmospheric instability from a geostationary satellite imager
8p.10	Ashim K Mitra	An analysis of severe weather prediction using MODIS direct broadcast satellite data and INSAT-3D Sounder profiles receiving real-time at IMD, New Delhi
8p.11	Chian-Yi Liu	Improving the Sounding Retrievals from Synergistic Use of Hyperspectral Radiances, Surface and GNSS Radio Occultation Observations
8p.12	Jean-Claude Thelen	LW and SW atmosphere and surface retrievals in Principal Component Space from IASI, ARIES and other sensors using the Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC)
8p.13	Ramesh Singh	Evidence of Pollutants Transport from Indian sub-continent Across Himalaya Using AIRS data

12.30-13.30 LUNCH

13.30-14.00 Poster-viewing session 8b

14.00-15.15 Session 9a: Assimilation studies: clouds (oral presentations - 12 minutes) **Chairs: Stephen English and Sangwon Joo**		
9.01	Stephen English (for Alan Geer and Fabrizio Baordo)	All-sky assimilation of MHS and HIRS sounder radiances
9.02	Tom Auligne	Improved Initialization and Prediction of Clouds with All-Sky Satellite Radiances
9.03	Nadia Fourrie	New developments for the use of microphysical variables for the assimilation of IASI radiances in convective scale models
9.04	Will McCarty	Characterizing the Impact of Hyperspectral Infrared Radiances near Clouds on a Global Atmospheric Analysis
9.05	Jun Li	Handling clouds for hyperspectral infrared radiance assimilation

15.15-15.45 Session 9b: Cloud and precipitation studies (poster introductions - 1 minute: no visual aids)
Chairs: Stephen English and Sangwon Joo

9p.01	Kozo Okamoto	Two appoaches of assimilation of cloud-affected infrared radiances
9p.02	Haixia Liu	Efforts on variational cloud-clearing with CrIS data at NCEP
9p.03	Min-Jeong Kim	Development and validation of observing-system simulation experiments for all-sky microwave radiance data assimilation at NASA GMAO
9p.04	Ji-Eun Cha	Evaluation of cloud discrimination schemes for MHS brightness temperature assimilation in the KMA numerical weather prediction system
9p.05	Zhiquan Liu	Assimilation of MODIS cloudy radiances with a hybrid variational-ensemble data assimilation system for convection-permitting forecast
9p.06	Sanjeev Kumar Singh	Assimilation of cloud clear radiance of Megha Tropiques SAPHIR in NCMRWF GFST574L64
9p.07	Stefano Migliorini	All-sky assimilation of selected water vapour infrared IASI channels at ECMWF: strategy and initial trials
9p.08	Raymond Armante	Cloud properties and bulk microphysical properties of semi-transparent cirrus from IR Sounders
9p.09	Withdrawn	
9p.10	Yan Wei	Applications of spaceborne millimeter-wave radar data in analyzing typhoon structures in Western Pacific
9p.11	Ju-Hye Kim	Roles of microphysics in cloud resolving models in passive microwave remote sensing of precipitation over ocean
9p.12	Dirceu L. Herdies	Combined Scheme over the Central Andes and its Foothills

15.45-16.15 BREAK (incl. poster-viewing session 9b)

16.15-17.00 Session 10a: Assimilation studies (oral presentations - 12 minutes) **Chairs: Christina Köpken-Watts and Quanhua (Mark) Liu**		
10.01	Wei Han	Constrained variational bias correction for satellite radiance assimilation
10.02	Yanqiu Zhu	Variational Bias Correction in the NCEP Data Assimilation System
10.03	Anna Booton	An improved bias correction for SSMIS

17.00-17.30 Session 10b: Assimilation studies (poster introductions - 1 minute: no visual aids) **Chairs: Christina Köpken-Watts and Quanhua (Mark) Liu**		
10p.01	Anna Booton (for Katie Lean)	Assessment of residual biases in microwave instruments: impact of improved radiative transfer modelling for lower tropospheric AMSU-A channels and development of an improved bias correction scheme for SSMIS
10p.02	Hyoung-Wook Chun	IASI bias correction at KIAPS observation processing system
10p.03	Christina Köpken-Watts (for Olaf Stiller)	The role of observation and background errors for reconstructing localized features from non-local observations
10p.04	Niels Bormann	Situation-dependent estimates of background errors in radiance space
10p.05	Si Shen	Dimension-Reduced Projection 4DVar with Nonlinear Correction
10p.06	Bruna Barbosa Silveira	Statistical Evaluation of the Microwave Sounder Radiances Assimilation into CPTEC/INPE GSI-based Global 3DVar (G3DVar)

10p.07	Sihye Lee	Development of AMSU-A Pre-processing and Quality Control Modules at KIAPS Observation Processing System
10p.08	Byoung-Joo Jung	Assimilation of AMSU-A radiance observations within KIAPS-LETKF system
10p.09	Quanhua Liu (for Sid Boukabara)	Advanced techniques for satellite microwave data assimilation - Application to global and regional NWP
10p.10	Bormin Huang	GPU Acceleration of the WRF Model for Time-Critical Satellite Data Assimilation Applications

17.30 Icebreaker with poster-viewing of session 10b and all other poster-sessions so far

Saturday 29 March 2014

9.00-12.30	**Working Groups (with break 10:15-10:45)**
12.30-13.30	**LUNCH**
13.30-18.00	**Working groups** and/or **Activities** (details will be confirmed at meeting)

Sunday 30 March 2014

9.00-16.00	**Working groups** and/or **Activities** (details will be confirmed at meeting)
Evening	**Working groups finalise reports**

Monday 31 March 2014

8.30-9.30 Session 11a: Assimilation studies (oral presentations - 12 minutes) **Chairs: William Bell and Nadia Fourrie**		
11.01	Cristina Lupu	The impact of satellite data within the ECMWF system
11.02	Nadia Fourrie (for Vincent Guidard)	Using Forecast Senstivity to Observations to adapt IASI channel selection
11.03	Hyun Mee Kim	Estimation of satellite observation impact to numerical weather forecast using adjoint-based method
11.04	Xiaolei Zou	Satellite Radiance Assimilation in HWRF

9.30-10.00 Session 11b: Assimilation studies (poster introductions - 1 minute: no visual aids) **Chairs: William Bell and Nadia Fourrie**		
11p.01	Agnes Lim	Calibration of the Observing Simulation System Experiment (OSSE) use to assess the Impact of Geostationary Hyperspectral Data
11p.02	Fuzhong Weng	Impacts from Assimilation of Three-Orbit Satellite Radiances on Hurricane and Quantitative Precipitation Forecasts
11p.03	Helena Barbieri de Azevedo	Satellite radiances impact in the new operational CPTEC/INPE 3DVar system
11p.04	Eun-Jung Kim	Forecast Sensitivity to satellite observations in global and East-Asia

11p.05	Stephen English (for Tony McNally)	The Role of Satellite Data in the ECMWF Forecasts of Hurricane Sandy
11p.06	Withdrawn	
11p.07	Zhenglong Li	OSSE on geostationary hyperspectral infrared sounders: radiance simulation, validation and impacts on hurricane forecast
11p.08	Yu-Chi Yang	Investigation of AIRS and AMSU Sounding Products in Regional Numerical Weather Simulation
11p.09	Jinlong Li	Near real time regional satellite data assimilation system and initial evaluation
11p.10	Peng Zhang (for Shuang Xi)	Cycling Assimilation of ATOVS Microwave Sounding Observations in a Tropical Cyclone Case in 2012
11p.11	Magnus Lindskog	Use of SEVIRI radiances for handling of position errors in a limited-area data assimilation system
11p.12	Chien-Ben Chou	The impact of assimilation of microwave radiance in HWRF on the forecast over the western Pacific Ocean
11p.13	Jung-Rim Lee	The Use of COMS Clear Sky Radiance in NWP Model; CSR Product in Global Model and Clear Pixel Radiance for Local Model
11p.14	Fabio L.R. Diniz	Assessing observation impacts on CPTEC/INPE G3DVAR analysis

10.00-10.45 BREAK (incl. poster-viewing session 11b)

10.45-11.45 Session 12a: Climate (oral presentations - 12 minutes) **Chairs: Thomas August and Thierry Phulpin**		
12.01	B.J. Sohn	Use of long-term MSU/AMSU data to examine the weakening of Walker Circulation in CMIP5 climate simulations
12.02	Fuzhong Weng (for Chaeng-Zhi Zou)	Recalibration of Stratospheric Sounding Unit for Climate Reanalysis Applications
12.03	Gerrit Holl	SPARE-ICE: synergistic IWP from passive operational sensors
12.04	Nathalie Selbach	The CM SAF ATOVS tropospheric water vapour and temperature data record

11.45-11.55 Session 12b: Climate (poster introductions - 1 minute: no visual aids) **Chairs: Thomas August and Thierry Phulpin**		
12p.01	Nathalie Selbach	CHARMe: Characterization of Metadata to enable high-quality climate applications and services
12p.02	Nathalie Selbach	Climate Data Records of the EUMETSAT Satellite Application Facility on Climate Monitoring
12p.03	Nathalie Selbach	The GEWEX water vapour assessment (G-VAP) - first results from inter-comparisons and stability analysis.
12p.04	Viju John	Error characterisation of SSM/T2 radiances
12p.05	Viju John	Inter-calibration of METEOSAT IR and WV channels
12p.06	Pascal Brunel (for Paul Poli)	Assessment of the Nimbus-4 IRIS dataset (1970-1971) for use in reanalysis

11.55-12.10 Session 13a: Composition (oral presentations - 12 minutes)
Chairs: Thomas August and Thierry Phulpin

13.02	Eric Pequignot	Retrieval of atmospheric temperature, water vapour and trace gases at a vertical and horizontal kilometric resolution using an infrared tomographic imager combining nadir and limb views

12.10-12.25 Session 13b: Composition (poster introductions - 1 minute: no visual aids) **Chairs: Thomas August and Thierry Phulpin**		
13p.01	Raymond Armante (for Cyril Crevoisier)	Several decades of observation of mid-tropospheric CO2 from ATOVS, AIRS and IASI
13p.02	Raymond Armante (for Cyril Crevoisier)	A view on mid-tropospheric CH4 in the tropics: 6 years from MetOp-A/IASI
13p.03	Rebecca Cintineo	IDEA-I Air Quality Forecast Software Package: Aerosol, Ozone, and Carbon Monoxide Detection and Trajectories
13p.04	Raymond Armante (for Virginie Capelle)	Evaluation of IASI derived dust aerosols characteristics over the topical belt
13p.05	Sang-Moo Lee	Asian-dust detection over ocean from IR 11-um channel measurement
13p.06	Zhiquan Liu	A Case Study on Atlantic Tropical Cyclogenesis and Saharan Air Layer Simulated Using WRF/Chem Coupled with an AOD Data Assimilation System
13p.07	Hal Bloom (for Mark Schoeberl)	The Geostationary Remote Infrared Pollution Sounder: Measurement of the Carbon Gases from Space

12.25-13.30 LUNCH

13.30-14.00 Poster-viewing session 12b and 13b

14.00-15.15 Session 14a: Climate studies with advanced IR sounders (oral presentations - 12 minutes) **Chairs: Nathalie Selbach and BJ Sohn**		
14.01	Thierry Phulpin	A climatology of IASI radiance spectra to monitor global climate change
14.02	Raymond Armante (for Cyril Crevoisier)	Processing of Aqua/AIRS and Metop-A/IASI to study essential climate variables
14.03	Eric J. Fetzer	Variability in Eleven Years of AIRS Version 6 Observations
14.04	Robert Knuteson	Stratospheric Temperature Monitoring Using a Collocated IR/GPSRO Dataset
14.05	Hank Revercomb	Absolute Radiance Interferometer (ARI): A prototype spaceflight instrument for achieving GSICS and CLARREO goals

15.15-15.20 Session 14b: Climate studies with advanced IR sounders (poster introductions - 1 minute: no visual aids) **Chairs: Nathalie Selbach and BJ Sohn**		
14p.01	Joe K. Taylor	The University of Wisconsin Space Science and Engineering Center Absolute Radiance Interferometer (ARI): Predicted and Demonstrated Radiometric Performance

14p.02	Jonathan Gero	On-Orbit Absolute Radiance Standard for the Next Generation of IR Remote Sensing Instruments

15.20-17.00 BREAK and poster viewing for sessions 11b, 12b, 13b, 14b

19.00 Dinner, including presentation of prizes for best oral and poster presentations

Tuesday 1 April 2014

09.00-10.15 Session 15: Working Group Reports (15 minutes)

Co-Chairs: Mitch Goldberg and Niels Bormann

- RT (**Marco Matricardi**, Yong Han)
- Climate (**Viju John**, Thierry Phulpin)
- NWP (**Fiona Smith**, Andrew Collard)

10.15-10.45 BREAK

10.45-12.00 Session 15: Working Group Reports (15 minutes)

Co-Chairs: Mitch Goldberg and Niels Bormann

- Advanced Sounders (**Dieter Klaes**, Bill Smith)
- International and Future Systems (**Stephen English**, Jerome Lafeuille)
- Products and Software (**Liam Gumley**, Nigel Atkinson, Nathalie Selbach)

12.00-12.30 Session 16: Technical Sub-Group Reports (5 minutes)

Co-Chairs: Mitch Goldberg and Niels Bormann

- Direct broadcast packages (**Liam Gumley**)
- RTTOV **(James Hocking**)
- CRTM **(Mark Liu**)
- RARS (**Jerome Lafeuille**)

12.30-12.45 Closing Session

Co-Chairs: Mitch Goldberg, Niels Bormann

ITSC-XIX ABSTRACTS

Session 1a: New Observations

1.01 CrIS SDR Calibration and Cross-sensor Comparisons

Presenter: Yong Han
Authors: Yong Han

The Cross-track Infrared Sounder (CrIS) flying on the Suomi National Polar-orbiting Partnership Satellite (S-NPP) is a Fourier transform spectrometer. It provides measurements of Earth view interferograms in three infrared spectral bands at 30 cross-track positions, each with a 3x3 array of Field-of-Views. The CrIS ground processing software transforms the measured interferograms into calibrated and geolocated spectra with 1305 channels in the form of Sensor Data Records (SDRs) that cover spectral bands from 650 to 1095 cm-1 (long-wave), 1210 to 1750 cm-1 (mid-wave) and 2155 to 2550 cm-1 (short-wave) with spectral resolutions of 0.625 cm-1, 1.25 cm-1 and 2.5 cm-1, respectively. CrIS can also be operated in the full spectral resolution mode, in which the mid-wave and short-wave band interferograms are recorded with the same maximum path difference as the long-wave band (spectral resolution = 0.625 cm-1 for all three bands and a total of 2211 channels). The first part of this presentation reviews the performances of the CrIS instrument and SDR calibration algorithms, which would be useful for the users of the SDR product and processing software, both available to public. It includes (1) the Raw Data Record (RDR) and SDR data quality; (2) the SDR Instrument Line Shape (ILS) correction algorithms that remove the interferometer self-apodization effect from spectra so that the theoretical channel spectral response is a Sinc function; (3) the nonlinearity correction algorithm that removes detector nonlinear effects; and (4) the Doppler shift effect due to Earth rotation on the SDR spectral frequency. The second part of the presentation presents the results on CrIS cross-sensor calibration and comparisons. It includes (1) geolocation calibration using VIIRS channel I5 and band-to-band co-registration validation; (2) CrIS radiance comparisons with IASI (MetOp A and B) and AIRS using the SNO method; (3) CrIS performance stability assessed with VIIRS IR channels; and (4) comparisons of spectral frequency accuracy between CrIS and IASI using the Double Difference method.

1.02 The May 2013 SNPP Cal/Val Campaign: Validation of Satellite Soundings

Presenter: William Smith
Authors: W. L. Smith, A. M. Larar, H. E. Revercomb, M. Yesalusky, and E. Weisz

The NAST-I and SHIS ultra spectral interferometer sounders flew on the NASA ER-2 aircraft during the May 2013 S-NPP Calibration/Validation Campaign. The ER-2 under flew the Metop-A and -B, Aqua, and SNPP satellites, which carry the IASI, AIRS, and CrIS ultra spectral sounding instruments, respectively. Special ground truth radiosonde and surface based upward viewing ultra spectral radiance Planetary Boundary Layer (PBL) sounding observations (i.e., from the AERI and the ASSIST interferometer spectrometers) were obtained at the DOE Southern Great Plains (SGP) ARM CART-site and from a mobile ground site located in Yuma, Arizona. A common physical/statistical sounding retrieval algorithm and statistical database have been applied to the aircraft, ground-based interferometer, and satellite ultra spectral radiance data in order to use the higher spatial resolution aircraft data and higher vertical resolution surface-based interferometer PBL soundings, and radiosonde profiles, to validate the satellite sounding products. Differences between the satellite and the surface / airborne ground "truth" measurements are discussed. Special emphasis is given to validating the satellite atmospheric stability and time tendency observations made prior to the development of the devastating Moore, OK tornado on May 20, 2013.

1.03 Updates on the Performance of Suomi National Polar-orbiting Partnership (SNPP) Data Products

Presenter: Lihang Zhou
Authors: Lihang Zhou; Fuzhong Weng*; Ivan Csiszar*; Walter Wolf*; Eric Gottshall+; and Mitch Goldberg+ (*: NOAA/NESDIS/STAR; +: JPSS Program)*

Joint Polar Satellite System (JPSS) is the United States' next generation polar orbiting operational environmental satellite system. NOAA/NESDIS/STAR is taking the lead in the activities to develop, test, validate, and refine the science algorithms needed to derive user-defined products from JPSS satellites. STAR JPSS Sensor Data Record (SDR) and Environment Data Record (EDR) science teams have been formed to conduct out detailed evaluation and work on maintain and update the algorithms of the SDR and EDR products. Since the successful launch of Suomi National Polar Partnership (SNPP) satellite in October 2011, significant progresses have been made on calibration and validation of the SNPP data products. The collaborations and interactions among the SDR teams, EDR teams, and user community have been strengthened, and SNPP ATMS and CrIS SDR data are now used operationally in all major NWP centers including

NCEP, NRL, and ECMWF. To assure the quality of the products and performance of the algorithms meeting the requirements, tools for assessing and monitoring the performance of SDR and EDR products are being develop and implemented. Based on specific algorithm readiness levels, the JPSS algorithms and data product teams established a schedule of anticipated dates for the algorithms to achieve Beta, Provisional and Validated statuses. Declaring SDR/EDR product maturity is the result of a specific review of artifacts that document that the products meet a series of criteria defined for each maturity stage. By far, all the SDR products are reaching the validated maturity level; and all the EDRs have achieved Beta status. These data are now available to the public through the National Oceanic and Atmospheric Administration's (NOAA) Comprehensive Large Array-data Stewardship System (CLASS), and ready for operational evaluation. In the presentation, we will provide an overview of the latest SNPP data products' quality status and the plan forward for JPSS-1 algorithm updates.

Session 1b: New Observations

1p.01 Monitoring Suomi-NPP CrIS instrument status and Data Quality at NOAA

Presenter: Xin Jin

Authors: Xin Jin, Yong Han, Yong Chen, Likun Wang, Denis Tremblay

Since the launch of Suomi NPP satellite, we have been working on the CrIS instrument status trending and data quality monitoring at NOAA/STAR. A powerful system has been developed to facilitate these tasks. With this system, we have found and solved a lot of issues, covering the areas of instrument status, ground system performance, calibration program debugging, and etc. With all of these efforts, the operational data quality is steadily improved.

1p.02 JPSS EDR Product Long-Term Monitoring

Presenter: Xingpin Liu

Authors: Xingpin Liu, Lihang Zhou, Walter Wolf , Zhaohui Cheng, Shuang Qiu

Long term monitoring is a key function of quality assurance for the Center for Satellite Applications and Research (STAR) Joint Polar Satellite System (JPSS) Program. To track the quality of the products and performance of the algorithms, a real-time product monitoring tool is being designed and developed for the Suomi National Polar Partnership (SNPP) and JPSS Environmental Data Record (EDR) products. The real-time monitoring tool will be able to detect the products availability, as well as abnormal events, and send out notification for the anomalies. To monitor the Quality and Performance of JPSS EDR products, we need to determine: what variables are needed for near real-time product performance monitoring; how to trend the products; what are the thresholds of these variables where levels of uncertainty in the variables can be identified. The approach of the EDR long term monitoring is an extension of the product monitoring tool developed to monitor the output of STAR the Geostationary Operational Environmental Satellite R- Series Program (GOES-R) Algorithm Integration Team (AIT) framework near real-time processing, as well as the monitor system developed for the NOAA's operational NPP Data Exploitation (NDE) products. This presentation will describe in detail: determination of the monitoring methods, software architecture, and database and interface designs.

1p.03 The Suomi NPP Airborne Field Campaign and Preliminary NAST-I Radiance Results

Presenter: Allen Larar

Authors: A. Larar, W. Smith, D. Zhou, X. Liu, and J. Tian

The Suomi NPP (SNPP) satellite represents a critical first step in building the next-generation Earth observing satellite system in the US, continuing key data records that are essential for weather forecasting and climate change science. The SNPP airborne field campaign was conducted during the 6 - 31 May, 2013 timeframe based out of Palmdale, CA, and focused on under-flights of the SNPP satellite with the NASA ER-2 aircraft in order to perform cal/val of the satellite instruments and their corresponding data products. The resultant campaign dataset is intended to help better understand and benchmark and, potentially, improve the quality of associated satellite data products for subsequent research and operational data usage applications internationally. Aircraft flight profiles were designed to under-fly multiple satellites within a single sortie, when feasible, to address satellite sensor validation and cross-validation; specifically, in addition to under-flying SNPP, flight profiles were defined to also obtain data coincident with the NASA A-train (i.e. AQUA), MetOP-A, and MetOP-B satellites to enable inter-comparisons with instruments aboard those platforms (e.g. AIRS, IASI, and CrIS). An effort was made to maximize space / time coincidence of aircraft data with that from the satellite sensors, radiosondes and ground truth data sites, while observing desired meteorological and surface target scenes. The NASA / NPOESS Airborne Sounder Testbed-Interferometer (NAST-I) was one of the key payload sensors aboard the ER-2 aircraft. This presentation gives an overview of the SNPP campaign and summarizes results to

date for infrared spectral radiance inter-comparisons involving NAST-I.

1p.04 Suomi NPP/JPSS Cross-track Infrared Sounder (CrIS): Calibration Validation with the Aircraft Based Scanning High-resolution Interferometer Sounder (S-HIS)

Presenter: Hank Revercomb (for Joe Taylor)
Authors: Joe K. Taylor, D. C. Tobin, H. E. Revercomb, F. A. Best, R. O. Knuteson, R. K. Garcia, D. Deslover, and L. Borg

The Cross-track Infrared Sounder (CrIS) on Suomi NPP, launched 28 October 2011, is designed to give scientists more refined information about Earth's atmosphere and improve weather forecasts and our understanding of climate. CrIS is an infrared Fourier transform spectrometer with 1305 spectral channels, and produces high-resolution, three-dimensional temperature, pressure, and moisture profiles. These profiles will be used to enhance weather forecasting models and they will facilitate improvements to both short and long-term weather forecasting. For improved weather prediction and climate change monitoring, there is an established need for higher accuracy and more refined error characterization of radiance measurements from space and the corresponding geophysical products. This need has led to the use of direct tests of in-orbit performance, referred to as validation. Currently, validation typically involves (1) collecting high quality temporally and spatially co-located reference data from accurately calibrated airborne or ground-based instruments with traceability to absolute standards during the satellite overpass, and (2) a detailed comparison between the satellite-based radiance measurements and the corresponding high quality reference data. Additionally for future missions, technology advancements at University of Wisconsin Space Science and Engineering Center (UW-SSEC) have led to the development of an on-orbit absolute radiance reference utilizing miniature phase change cells to provide direct on-orbit traceability to International Standards (SI). The first Suomi NPP dedicated airborne calibration validation campaign was conducted May 2013 with a primary objective of providing detailed validation of CrIS radiance observations and meteorological products. During this calibration validation campaign, the NASA ER-2 aircraft instrument payload included the UW-SSEC Scanning-High resolution Interferometer Sounder (S-HIS), the NPOESS Atmospheric Sounder Testbed-Interferometer (NAST-I), the NPOESS Atmospheric Sounder Testbed-Microwave Spectrometer (NAST-M), the NASA MODIS/ASTER airborne simulator (MASTER), and the NASA JPL Airborne Visible / Infrared Imaging Spectrometer (AVIRIS). Eleven ER-2 under-flights of the Suomi NPP satellite were conducted during the campaign. This presentation will include (1) an overview of the radiance calibration approach and accuracy of the S-HIS validation data, (2) a detailed assessment of multiple under-flights, and (3) a summary assessment of the CrIS spectral radiance observations for the under-flights.

1p.05 CrIS Radiometric Calibration: Uncertainty Estimates and Evaluations

Presenter: Hank Revercomb (for David Tobin)
Authors: David Tobin, Hank Revercomb, Joe Taylor, Bob Knuteson, Dan DeSlover, Lori Borg, Graeme Martin

The Cross-track Infrared Sounder (CrIS) is the high spectral resolution spectroradiometer on the Suomi National Polar-Orbiting Partnership (NPP) satellite, providing operational observations of top-of-atmosphere thermal infrared radiance spectra for weather and climate applications. This presentation will describe the CrIS radiometric calibration uncertainty based on pre-launch and on-orbit efforts to estimate calibration parameter uncertainties, and provides example results of recent post-launch validation efforts to assess the predicted uncertainty. Pre-launch Radiometric Uncertainty (RU) estimates computed for the laboratory test environment are less than ~0.2 K 3-sigma for blackbody scene temperatures above 250 K, with primary uncertainty contributions from the calibration blackbody temperature, calibration blackbody reflected radiance terms and detector nonlinearity. Variability of the pre-launch RU among the longwave band detectors and midwave band detectors is due to different levels of detector nonlinearity. A methodology for on-orbit adjustment of nonlinearity correction parameters to reduce the overall contribution to RU and to reduce FOV-to-FOV variability is described. The resulting on-orbit RU estimates for Earth view spectra are less than 0.2 K 3-sigma in the midwave and shortwave bands, and less than 0.3 K 3-sigma in the longwave band. Post-launch validation efforts to assess the radiometric calibration of CrIS are underway; validation results to date will also be presented.

1p.06 CrIS Full Resolution Processing and Validation System (CRPVS) for JPSS

Presenter: Yong Chen
Authors: Yong Chen, Yong Han, Denis Tremblay, Likun Wang, Xin Jin, and Fuzhong Weng

The Cross-track Infrared Sounder (CrIS) on Suomi National Polar-orbiting Partnership Satellite (S-NPP) is a Fourier transform spectrometer. In normal mode (mission mode), CrIS measures the spectral bands from 650 to 1095 cm-1 (long-wave IR band, LWIR), 1210 to 1750 cm-1 (mid-wave IR band, MWIR), and 2155 to 2550 cm-1 (short-wave IR band, SWIR) with spectral resolutions of 0.625 cm-1, 1.25 cm-1 and 2.5 cm-1, respectively. It

provides a total of 1305 channels for sounding the atmosphere. CrIS can also be operated in the full spectral resolution (FSR) mode, in which the MWIR and SWIR band interferograms are recorded with the same maximum path difference as the LWIR band and with spectral resolution of 0.625 cm-1 for all three bands (total 2211 channels). NOAA intends to operate CrIS in FSR mode in the near future for SNPP and the Joint Polar Satellite System (JPSS). Up to date, the FSR mode has been commanded three times in-orbit (02/23/2012, 03/12/2013, and 08/27/2013). Based on CrIS Algorithm Development Library (ADL), CrIS full resolution Processing System (CRPS) has developed to generate the FSR Sensor Data Record (SDR). We also are developing the CrIS FSR SDR Validation System (CRVS) to quantify the CrIS radiometric and spectral accuracy, since they are crucial for improving its data assimilation in the numerical weather prediction, and for retrieving atmospheric trace gases. In this study, CrIS full resolution SDRs are generated from CRPS using the data collected from FSR mode of SNPP, and the radiometric and spectral accuracy are accessed by using the Community Radiative Transfer Model (CRTM) and European Centre for Medium-Range Weather Forecasts (ECMWF) forecast fields. The biases between observation and simulations are evaluated to estimate the FOV-2-FOV variability and sweep direction bias for clear sky over ocean. Double difference method and Simultaneous Nadir Overpass (SNO) method are also used to assess the CrIS radiance consistency with well-validated IASI. Two basic frequency validation methods (absolute and relative spectral validations) are used to access the CrIS spectral accuracy. Since CrIS SWIR band has much higher resolution than normal mode (2.5 cm-1), it makes possible to use SWIR band to assess the spectral accuracy. All three CrIS bands and 9 field of views (FOVs) are done separately for clear scenes over oceans at nadir (the 15th and 16th field of regards). Results show that CrIS SDRs from FSR have similar radiometric and spectral accuracy as those from normal mode.

1p.07 CSPP Suomi NPP SDR 1.4

Presenter: Scott Mindock
Authors: Scott Mindock, Graeme Martin, Ray Garcia, Kathy Strabala,Geoff Ceureton,Liam Gumley, Allen Huang

The Community Satellite Processing Package serves the Direct Broadcast community by providing a freely available suite of software algorithms that process Suomi NPP RDR records into SDR records. NPP ATMS, CrIS and VIIRS SDR algorithms are supported. The CSPP 1.4 release is based on the ADL 4.2 / MX 5.07.01 NPP software. CSPP SDR 1.4 incorporates new features including enhancements to the VIIRS DNB, CrIS and ATMS improvements. The algorithms now include multiprocessing support for all SDR generation, which reduces SDR processing time. Quick-look software has been enhanced to provide multi-pass capability. The poster details the new features and capabilities.

Session 1c: New Observations

1.04 Advances in ATMS Sensor Data Record (SDR) Sciences

Presenter: Fuzhong Weng
Authors: Fuzhong Weng

The Suomi National Polar-orbiting Partnership (NPP) satellite was launched on October 28, 2011 and carries the Advanced Technology Microwave Sounder (ATMS) on board. ATMS is a cross-track scanning instrument observing in 22 channels at frequencies ranging from 23 to 183 GHz, permitting the measurements of the atmospheric temperature and moisture under most weather conditions. In this report, the ATMS radiometric calibration algorithm is presented and its calibration accuracy is assessed through independent analyses of prelaunch thermal vacuum data and in-orbit measurements. It is found that the ATMS peak nonlinearity for all the channels are less than 0.5 K, which is well within the specification. For the characterization of the ATMS instrument sensitivity or noise equivalent differential temperatures (NEDT), both standard deviation and Allan variance of warm counts are computed and compared. It is shown that NEDT derived from the standard deviation is about three to five times larger than that from the Allan variance. In the ATMS sensor brightness temperature data record (SDR) processing algorithm, the antenna gain efficiencies of main beam, cross-polarization beam and side lobes must be derived accurately from the antenna gain distribution function. However, uncertainties remain in computing the efficiencies at ATMS high frequencies. Thus, ATMS antenna brightness temperature data records (TDR) at channels 1 to 15 are converted to SDR with the actual beam efficiencies whereas those for channels 16 to 22 are only corrected for the near-field side-lobe contributions. The biases of ATMS SDR measurements to the simulations are consistent between GPS RO, ARM site radiosonde and NWP data and are generally less than 0.5 K for those temperature sounding channels where both the forward model and input atmospheric profiles are reliable. From ATMS TDR data, the differences between brightness temperature observations and simulated observations are calculated based on numerical weather predictions (aka O-B). For the upper ATMS temperature sounding channels, O-B exhibits a clear striping pattern (Bormann et al.,

2013) in along-track direction. We propose to firstly use the principal component analysis (PCA) to isolate scan-dependent features such as the cross-track striping from the atmospheric signal, and then to use an Ensemble Empirical Mode Decomposition (EEMD) to extract the striping noise in ATMS Earth scene brightness temperature observations for both temperature and water vapor sounding channels. It is shown that the PC coefficient of the first PC mode, which mainly describes a scan-dependent feature of cross-track radiometer measurements, captures the striping noise. The EEMD is then applied to the PC coefficient to extract the first three high-frequency intrinsic mode functions (IMFs), which are denoted as the PC1/IMF3 noise. When the PC1/IMF3 noise is removed from the data, the striping noise is imperceptible in the global distribution of O-B for ATMS temperature sounding channels 1-16. Using the same method, it is demonstrated that the striping noise is also present in ATMS water vapor sounding channels 17-22. The magnitude of the ATMS striping noise is about 0.3 K for the temperature sounding channels and 1.0 K for the moisture sounding channels. The same technique is also applied to AMSU-A, AMSU-B and MHS. The striping noise is undetectable for AMSU-A but is present in both AMSU-B and MHS data. The cross-calibrated measurements from Microwave Sounding Unit (MSU) and Advanced Microwave Sounding Unit-A (AMSU-A) on board different NOAA polar-orbiting satellites have been extensively used for detecting atmospheric temperature trend during the last several decades. Since ATMS inherited most of the sounding channels from its predecessor of AMSU, is important to extend AMSU data records with ATMS observations. However, the ATMS field of view is different from that of AMSU. In this study, the Backus-Gilbert method is used for optimally remapping the ATMS FOVs to AMSU-A like FOVs. Differences in ATMS brightness temperatures introduced by remapping are firstly illustrated over the region of Hurricane Sandy which occurred in October 2012. Using the simultaneous nadir overpass (SNO) method, AMSU and ATMS remap observations are then collocated in space and time and the inter-sensor biases are derived for each pair of channels. It is shown that the brightness temperatures from SNPP ATMS are now well merged into the AMSU data family after remap and cross-calibration.
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1.05 Analysis of ATMS Striping Noise from its Earth Scene Observations

Presenter: Zhengkun Qin
Authors: Zhengkun Qin, Xiaolei Zou and Fuzhong Weng

The differences between brightness temperature observations and simulated observations based on numerical weather predictions, i.e., O-B, for ATMS temperature sounding channels exhibit a clear striping pattern (Bormann et al., 2013). We propose to firstly use the principal component analysis (PCA) to isolate scan-dependent features such as the cross-track striping from the atmospheric signal, and then to use an Ensemble Empirical Mode Decomposition (EEMD) to extract the striping noise in ATMS Earth scene brightness temperature observations for both temperature and water vapor sounding channels. It is shown that the PC coefficient of the first PC mode, which mainly describes a scan-dependent feature of cross-track radiometer measurements, captures the striping noise. The EEMD is then applied to the PC coefficient to extract the first three high-frequency intrinsic mode functions (IMFs), which are denoted as the PC1/IMF3 noise. When the PC1/IMF3 noise is removed from the data, the striping noise is imperceptible in the global distribution of O-B for ATMS temperature sounding channels 1-16. Using the same method, it is demonstrated that the striping noise is also present in ATMS water vapor sounding channels 17-22. The magnitude of the ATMS striping noise is about 0.3 K for the temperature sounding channels and 1.0 K for the moisture sounding channels. The same technique is also applied to AMSU-A, AMSU-B and MHS. The striping noise is undetectable for AMSU-A but present in AMSU-B and MHS data.

1.06 Implementation of the NOAA Unique CrIS/ATMS Processing System (NUCAPS) within the Community Satellite Processing Package (CSPP)

Presenter: Christopher Barnet

Authors: Chris Barnet, Mitch Goldberg, Liam E. Gumley, Antonia Gambacorta, Thomas King
The NOAA Unique CrIS/ATMS processing System (NUCAPS) is the operational retrieval system for sounding products from the Suomi National-Polar-orbiting Partnership (NPP). The retrieval methodology was originally developed by the NASA Sounding Team for sounding products from the Atmospheric Infrared Sounder (AIRS) and Advanced Microwave Sounding Unit (AMSU) instruments on the Aqua satellite. The National Oceanic Atmospheric Administration (NOAA) National Environmental Satellite, Data and Information Service (NESDIS) center for Satellite Application and Research (STAR) ported this algorithm for operational use with the Infrared Atmospheric Sounding Interferometer (IASI), Microwave Humidity Sounder (MHS), and AMSU instruments on the EUMETSAT Metop-A and Metop-B satellites and, more recently, the Suomi-NPP satellite. In the Suomi-NPP application, the NUCAPS system produces cloud-cleared radiances from the Cross-track Infrared Sounder (CrIS) field-of-regard that is co-located with the Advanced Technology Microwave Sounder (ATMS). Numerous environmental data products (EDR) are derived from the cloud cleared radiances including cloud and surface products, profiles of atmospheric temperature, moisture, ozone and other trace gases. NOAA/NESDIS/STAR has demonstrated the robust operation of this algorithm and validated the EDR products. In this presentation we will describe the implementation of NUCAPS into the Community Satellite Processing Package (CCSP). CSPP supports the Direct Broadcast (DB) meteorological and environmental satellite community through the packaging, and distribution of open source science software in over 60 countries. CSPP also supports training in local product applications. We will describe the algorithm methodology and demonstrate the capabilities of the CSPP-NUCAPS system with a focus on utilizing direct broadcast products from Aqua, Metop, and Suomi-NPP within polar applications.

1.07 Procedures to Validate S-NPP Sounding Products using Conventional and Reference/Dedicated Observations

Presenter: Tony Reale or Bomin Sun
Authors: Tony Reale, B. Sun, F. Tilley, M. Pettey, N. Nalli, D. Tobin, and C. Barnet
The NOAA Products Validation System (NPROVS) supported by JPSS and operated at NOAA NESDIS Office of SaTellite Applications and Research (STAR) provides ongoing data access, collocation and inter-comparison of multiple satellite sounding product suites against global conventional radiosondes (RAOBs). Satellite product suites include NOAA legacy operational products such as ATOVS, MiRS, IASI (MetOp-A), AIRS (Aqua), GOES, COSMIC and more recently (2012) the CrIMMS and NUCAPS from S-NPP and latest products from MeTop- B (2013). NPROVS has operated since 2008 and particularly over the past year has undergone modifications specifically in support of cal/val and algorithm development goals as defined within JPSS/STAR sounding product project. The following paper overviews the basic element of the S-NPP cal/val program and associated modifications and expansion of NPROVS to meet CrIMSS cal/val objectives. The two basic elements of the program can be separated into the Collocation Dataset and Validation components. The datasets consist of two elements, those containing conventional observations, referred to as NPROVS, and those containing special sets of Reference (ie, GCOS Reference Upper Air Network (GRUAN) and Dedicated (ie, synchronized to satellite overpass and funded by JPSS) observations, referred to as NPROVS+. Conventional datasets are global with relatively large samples whereas as the reference/dedicated are relatively few sites but highly reliable and traceable. Respective strategies for compiling collocated observations for each set and associated validation and performance characterization achieved within the context of each dataset are presented. For example, opportunities for up-scaled validation and a direct interface to satellite derived product scientific algorithm development are manifested in NPROVS+ which also provide a key component of planned Stage 1 validation of product performance justification for operational implementation. However, the large sample and more complete global coverage afforded by NPROVS offer distinct validation advantages complimentary to NPROVS+. The utilization and interplay of these two approaches to provide a complete cal/val program for S-NPP (and legacy) sounding products comprise the main theme of this paper. Examples of special results using GRUAN reference observations, including the direct use of available uncertainty estimates in satellite product assessment and the utility of NPROVS+ as a source of feedback on GRUAN performance conclude the report.

1.08 Simulation and Validation of INSAT-3D Imager and Sounder Data at NCMRWF

Presenter: S. Indira Rani
Authors: S. Indira Rani and V. S. Prasad
India's advanced weather satellite, INSAT-3D, the first geostationary sounder system over Indian Ocean was launched (located at 83°E) on 26 July 2013, for the improved understanding of mesoscale systems. INSAT-3D carries a 6 channel imager and 19 channel sounder payload. The Imager channels are in the spectral bands, Visible (Vis) (0.55 -0.75

μ), Short Wave Infra Red (SWIR) (1.55 -1.70 μ), Mid Wave Infra Red (MWIR) (3.80 - 4.00 μ), Water Vapor (WV) (6.50 - 7.00 μ), Thermal Infra Red -1 (TIR-1) (10.2 - 11.3 μ), and Thermal Infra Red -2 (TIR-2) (11.5 – 12.5 μ) with a resolution of 1km for Vis and SWIR, 4km for MWIR and TIR, and 8km for WV. The sounder channels are in the spectral bands, Short Wave Infra Red (six bands), Mid Wave Infra Red (five bands), Long Wave Infra Red (seven bands), and visible (one band) with a resolution of 10 km × 10km for all bands. The other real-time sounding data over India includes X-band direct broadcast from NOAA polar orbiting satellites (HIRS, AMSU-A/B), C-band direct broadcast from Aqua polar orbiting satellites (AIRS, AMSU-A, HSB), Eumetcast Metop satellites (IASI, AMSU-A, MHS, HIRS4), and X-band direct broadcast from NPOESS satellites (CrIS, ATMS). Along with these polar satellite soundings, INSAT-3D provides fine resolution vertical profiles over India and surrounding region. National Centre for Medium Range Weather Forecasting Centre (NCMRWF) routinely receives near-real time soundings from polar orbiting satellites, and recently started receiving INSAT-3D sounder and imager data. Simulation, Validation, and assimilation of INSAT-3D sounder and imager data is in progress at NCMRWF. Different Radiative Transfer models and Regional Atmospheric models are used to simulate the INSAT-3D sounder and imager brightness temperature. Validation of the same has been done by comparing the brightness temperature with other similar polar satellite sounder channels in the approximate spectral bands and also with model simulated brightness temperature. Detailed results will be presented during the conference.

Session 1d: New Observations

1p.08 Validation of ATMS Radiance Using GPS RO and Radiosonde Data

Presenter: Fuzhong Weng (for Lin Lin)
Authors: Lin Lin, Fuzhong Weng, Xiaolei Zou

The Suomi National Polar-Orbiting Partnership (NPP) satellite was launched on 28 October 2011 and carries the Advanced Technology Microwave Sounder (ATMS) on board. Since December 2012, the accuracy of antenna brightness temperatures (TDR) from the ATMS upper level temperature sounding channels is estimated by comparing with the simulated TDR using Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) Radio Occultation (RO) data as input to the U.S. Joint Center of Satellite Data Assimilation (JCSDA) Community Radiative Transfer Model (CRTM). It is found that the mean differences (i.e., biases) between the observed TDR and the GPS RO simulations are positive for channels 6, 10-13 with values less than 1K while negative for channels 7-9 with values greater than -0.7K. Moreover, the biases and standard deviation of channels 6-11 are stable and consistent with each other; while for channels 12 and 13 their biases increase since July 2012. This may be caused by the change made in the COSMIC retrieval algorithm at about the same time. The Southern Great Plain (SGP) Lamont station radiosonde data from July 24 to December 26, 2012 provided by U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) research campaign is utilized to validate the ATMS water vapor channels 18 to 22. It's found that ATMS observation tends to be colder than the radiosonde simulation using CRTM differed in a level within 2.3K. The correlation coefficient between observation and simulation is around 0.98. For channels 18 and 20 the bias is always smaller at night time than that at day time. On the other hand, the standard deviation is always larger at night than that at day time. The correlation coefficients of these two channels are smaller at night time than that at day time. With the high quality of COSMIC RO observations in the middle troposphere to lower stratosphere, the reliable radiosonde profiles and radiative transfer model, ATMS upper level temperature sounding channels and water vapor channels can be accurately validated.

1p.09 Recent Implementation and Use Current Products and Processing Packages for Suomi/NPP Instruments at CPTEC/INPE

Presenter: Simone Costa
Authors: Simone Costa, Jurandir Rodrigues, Valesca Fernandes, Nicolas Salvador, Luiz Barbedo

Satellite Division of the CPTEC/INPE is the Brazilian direct broadcast user of environmental and meteorological satellites. INPE start to receive continuously NPP data from its local antenna recently in October 2013. CPTEC/INPE is implementing operationally the current packages available to Suomi/NPP Instruments: IPOPP and CSPP. The aim of this paper is to present the potential use of NPP direct broadcast products and processing packages in CPTEC/INPE. Quicklook images created by AAPP using ATMS SDR files generated by CSPP and VIIRS true color image from direct reception at Cachoeira Paulista, Brazil using the IPOPP processing packages present interesting atmospheric features.

1p.10 Assimilation of Cross-track Infrared Sounder Radiances at ECMWF

Presenter: Reima Eresmaa
Authors: Reima Eresmaa, Tony McNally and Niels Bormann

Recent work on the assimilation of Cross-track Infrared Sounder (CrIS) radiances at the European

Centre for Medium-range Weather Forecasts (ECMWF) is presented. The assimilation of CrIS radiances is built upon the experience gathered from the operational assimilation of the Atmospheric Infrared Sounder (AIRS) and Infrared Atmospheric Sounding Interferometer (IASI). The focus of the assimilation is in the efficient use of cloud-free long-wave channels in wavenumber range 650-770 cm-1. As compared with the operational assimilation of AIRS and IASI, the most important difference is that some observation error correlations are explicitly taken into account. This justifies assimilation of a large number of channels adjacent in the observed spectrum and therefore allows one to partially compensate for the effect of the relatively poor spectral resolution. Additionally, observation error standard deviations are specified more aggressively than for AIRS and IASI in response to the very low instrument noise levels. A consistently positive medium-range forecast impact is achieved in both the northern and southern extratropics.

1p.11 Assimilation of ATMS data at DWD

Presenter: Ana Fernandez del Rio (for Robin Faulwetter)

Authors: Robin Faulwetter

The poster presents the assimilation of ATMS data at DWD. The variation of the observation error with field of view number (FOV) for ATMS and AMSU-A was investigated with the aid of the Desrozier method. Due to the strong nonlinear dependency of the forward model error and geolocation error on the scan angle, the ATMS observation error increases at the edges of the scanline. Since the maximum scan angle of ATMS is larger than that of AMSU-A, this effect is much more important for ATMS than for AMSU-A. Diagnostics of the FOV dependency of the observation error as well as impact experiments are presented. It is found that the FOV dependency of the observation error is crucial for ATMS. Furhermore, a quality control criterion is presented, that exploits the fact that ATMS data is superobbed before the assimilation. In regions with inhomogeneous cloud/rain signals the variation of the brightness temperature within the superobbed FOVs should be larger than in cloud/rain free regions. Potentially useful QC criteria can be formulated on the basis of the variation of brightness temperature within the superobbed FOVs.

1p.12 An Update on the Assimilation of ATMS data at ECMWF

Presenter: Heather Lawrence

Authors: Niels Bormann and Heather Lawrence

The Advanced Technology Microwave Sounder (ATMS) has been assimilated operationally at ECMWF since 26 September 2012, with a neutral to slightly positive impact on forecast scores. In this poster we present results from some refinements to the use of ATMS data, as well as provide a characterisation of the impact of ATMS in comparison to AMSU-A/MHS. One refinement is the addition of surface-sensitive ATMS data over land and sea-ice. The initial operational implementation excluded such data, and here we present results from experiments in which surface-sensitive channels were added over land and sea-ice. We use an approach that dynamically retrieves emissivity using window channel observations, similar to what is done for AMSU-A and MHS. The inclusion of the additional data results in a small further enhancement of the forecast impact of ATMS. To further compare the general forecast impact of ATMS to that of AMSU-A and MHS, we also report on assimilation experiments in the context of a depleted observing system. In a depleted system, the impact of a single instrument is much larger, allowing a better appreciation of its impact. Adding ATMS to a baseline system without polar satellite data results in a positive forecast impact that is comparable to that of one AMSU-A/MHS combination.

1p.13 Assessment and assimilation of MetOp-B IASI

Presenter: Fiona Smith (for James Cameron)

Authors: James Cameron, James Cotton, Richard Marriott

The quality of MetOp-B IASI observations has been assessed by comparing the fit for forecast background for both MetOp-A IASI and MetOp-B IASI. The bias of MetOp-B IASI is the same as that of MetOp-A IASI to less than 0.1K. The standard deviation of observed minus forecast background is up to 15% less in MetOp-B than for MetOp-A in some channels. Inter-FOV biases are smaller for MetOp-B IASI than for MetOp-A. The impact of assimilating MetOp-B IASI has been tested for two different seasons, giving positive impact in both cases. Assimilating a second IASI gives a 20% increase in the number of observations assimilated, improves the data coverage, and makes the system more robust to any interruptions in data flow. A forecast sensitivity experiments indicate that the impact per observation for MetOp-B IASI is very similar to that of MetOp-A IASI, providing evidence that MetOp-B IASI is delivering the expected impact. Observing system experiments have also been run to test the impact of reducing the spatial and temporal thinning of IASI observations. Reducing the thinning of IASI observations in the extra-tropics from 125km to 80km while simultaneously reducing the temporal thinning to 3 hours everywhere roughly doubles the number of IASI observations assimilated. This configuration is found to provide benefit in both

winter and summer experiments and is being considered for operational use.

1p.14 Inter-comparison Between IASI and Other Multi-spectral Instruments: One Year of Dual-Metop Data

Presenter: Dorothee Coppens or Bertrand Theodore

Authors: Dorothee Coppens and Bertrand Theodore

Since the launch of the second Metop platform in September 2012, two IASI (Infrared Atmospheric Sounding Interferometers) instruments are flying on the same orbit, overflying the same area with 50 minutes delay. This provides a unique opportunity to perform inter-comparisons and cross-monitoring. To do so, different methodologies have been implemented to provide complementary results giving qualitative and quantitative information on both instruments in terms of radiometric and spectral inter-calibration. This includes comparisons between the two IASI but also with other instruments covering infrared regions flying on the same platform like AVHRR and HIRS; comparisons with CrIS flying on Suomi/NPP have also been performed. We will present an overview of one year of dual Metops monitoring. Such a monitoring, besides giving us confidence that the two IASI are very well radiometrically and spectrally intercalibrated, provides a way to trace changes in the configuration of the instruments and to detect the tiny differences between them. In addition, it allowed us to emphasize some issues with the channel 5 of AVHRR/Metop-B, while comparisons with HIRS data revealed that some of its channels are not as consistent with IASI on Metop-B than on Metop-A. Comparison with CrIS is perfomed both using SNOs which occur every seven weeks and also on a daily basis using double differences. This provides useful feedbacks on the instruments: we will indeed show that they compare very well and that the non-linearity issue present in the band 1 of CrIS data has been reduced in the last version of the products.

Session 1e: New Observations

1.09 The Latest Progress of FY-3C

Presenter: Peng Zhang

Authors: Peng Zhang, Zhongdong Yang, Jinming Shi, Naimeng Lu

FY-3C is the third satellite of Fengyun 3 (FY-3) series. It was launched successfully on 23 September, 2013. As the second generation of Chinese meteorological satellite, FY-3C will replace FY-3A on the morning orbit to provide the users the continuous and homogenous observations in operation. In comparison with FY-3A and FY-3B, FY-3C inherited all the payloads which are mounted on its predecessor. In addition, there are some brand new features included. These new functions include:

1) The new payload is mounted. The GNSS Occultation Sounder (GNOS) is designed to retrieve the atmospheric temperature and moisture with Chinese Beidou and GPS signals.
2) The microwave sounding capability is improved. The Microwave Temperature Sounder (MWTS) increases its sounding channels from original 4 up to 13 while the Microwave Humidity Sounder (MWHS) increases its sounding channels from original 5 up to 15. In addition, 118 GHz Oxygen absorption bands were selected which is the first space-borne measurement to retrieve the atmospheric temperature from this band.
3) Solar Irradiation Monitor (SIM) is improved. The automatic solar tracker is added to allow the SIM to provide the more accurate measurements to the solar irradiation.

Currently, FY-3C is under the commission test. It expected the commission test will be completed at the end of February, this year. After the commission test, the data and the products will be released in operation. The users can access the FY-3C data through CMACast, Website portal, or Direct BroadCasting.

1.10 The Data Quality and Performance of Four FY-3 Instruments for NWP

Presenter: Qifeng Lu

Authors: Qifeng Lu

FY-3A, FY-3B and FY-3C, launched in May 2008, Nov 2010 and Sep 2013, are the first three in a series of seven polar orbiting meteorological satellites due to be launched by China's Meteorological Administration in the period leading up to 2020. The FY-3A/B/C payload includes four instruments of particular interest for numerical weather prediction (NWP): microwave temperature and humidity sounders, a microwave imager, and an infrared sounder. Compared to FY3A/B, the MWTS and MWHS on FY3C are improved much. The MWTS is changed with 13 channels and 90 scan pixels. The MWHS is changed to the first instrument with 8 channels at 118 GHZ and another two expanded channels at 183 GHz, leading to the new MWHS with 15 channels all in all. In FY-3 ground segment system, a subsystem to monitor the data quality and flag the bad data was developed by correlating the data quality and stability to on-orbit instrument parameters. Through this system, the observing bias currently incapable of being corrected physically were flagged to give a stable data quality. The data from four instruments dated back

to satellite launch are monitored and flagged by this system. And also the data quality and data stability were initially monitored and accessed by the standard deviation of first guess departure and its time series, through NWP fields from three centers of ERA-Interim, NCEP and CMA/T639. An analysis of first-guess departures with the flagged data has shown the data to be of good quality and good stability overall. These initial results are encouraging and build confidence that the following series of FY-3 instruments will be widely used in NWP data assimilation systems. The work also has witnessed the performance of the new monitor systems as tools for flagging the bad data for the NWP application.

1.11 Inter-comparison of Data Characteristics and Impact on NWP of FY-3B NPP and NOAA18 Microwave Observation

Presenter: Peiming Dong
Authors: Peiming Dong, Wei Han, Jiangping Huang

FY-3B and NPP are two polar orbiting meteorological satellites launched recently by China and USA, respectively. Compared to AMSUA/MHS abroad on both NOAA KLM and METOP polar orbiting satellites, MWTS/MWHS and ATMS flown on FY-3A/B and NPP are new microwave sensors in the Microwave Sounding Unit. Taking into consideration that the microwave satellite observation is the top contributor to the improvement of NWP, the investigation of these microwave satellite observation in data assimilation system has been carrying out. Inter-comparison of data characteristics and impact on NWP of FY-3B, NPP and NOAA18 microwave observation is performed. These three satellites have the similar equator crossing time. Case study result shows that NPP ATMS and NOAA AMSUA/MHS data have similar characteristics. ATMS data with noise reducing has the smallest bias of observed and simulated brightness temperature. The bias of FY-3 microwave observation, especially MWHS, is a little large. The use of these satellite microwave data all benefits the improvement of numerical weather forecast. Specially, there is a need to revise and investigate the cloud detection scheme in the performance of FY-3 and NPP microwave satellite data because that the window channel has changed significantly compared to AMSUA/MHS. Some ATMS data with large negative value of the FG-departure may be excluded by the scheme of the absolute value of the FG-departure for channel 3 proposed by ECMWF. It should be re-visited. Experiment with a length of time is being done to make the result more robust.

1.12 Performance Status of IASI on MetOp-A and MetOp-B

Presenter: Elsa Jacquette
Authors: Elsa Jacquette, Eric Péquignot, Jordi Chinaud, Claire Maraldi, Denis Jouglet, Sébastien Gaugain, Laurence Buffet, Colette Villaret, Carole Larigauderie, Jérôme Donnadille, Bernard Tournier, Claire Baque, Jean-Christophe Calvel, Dorothée Coppens

IASI (Infrared Atmospheric Sounding Interferometer) is a key element of the MetOp payloads, it is a very accurate Fourier Transform Spectrometer dedicated to atmospheric sounding that provides radiance spectra in the infrared spectral domain. The IASI program is led by the French National Space Agency CNES in cooperation with the European Meteorological Satellite Organization EUMETSAT. Under this cooperation agreement, CNES leads the development of the instruments and the level 1 processing and also operates the IASI Technical Expertise Center (TEC). The first flight model (FM2) was launched on board the MetOp-A satellite from Baïkonour on October 19, 2006 and was declared operational in July 2007. The second flight model (PFM-R) was launched on board the MetOp-B satellite on September 17, 2012 and was declared operational in April 2013. IASI TEC at CNES takes care of in-depth performance monitoring and processing parameters updating. This paper gives a status of the performances of IASI on MetOp-A and MetOp-B after 7 years and 1 year in orbit respectively. We will present the absolute radiometric calibration, and the radiometric noise and interpixel assessment. A status of IASI pixels geolocation will be presented (geometric calibration performed on ground), as well as the spectral performances. The comparison between IASI-A and IASI-B we also be presented.

1.13 Assessment of IASI Radiances During the SALSTIC Campaign

Presenter: Dorothee Coppens or Bertrand Theodore
Authors: Dorothee Coppens and Bertrand Theodore

The measurement campaign SALSTICE (Semi-Arid Land-Surface Temperature and IASI Calibration Experiment), which took place in May 2013, was a collaborative field campaign aiming, among others, at assessing the performances of IASI on Metop-B. EUMETSAT have been supporting the campaign, in particular in adjusting the operational mission planning so that IASI-B was in a special nadir view when overflowing the area in order to maximize the number of match-ups. This paper presents the results of the comparison between IASI observations and the radiance measurements performed during this campaign with the Fourier transform spectrometer ARIES (Airborne Research Interferometer Evaluation System). Nine flights have been considered from 11 to 25 May 2013, four of them

over Arizona being dedicated to land-surface processes, the others over ocean in the Gulf of California, all of them in coincidence with overpasses from one or both Metop platforms. The comparisons between both instruments, whose spectral characteristics are slightly different, have been performed into a set of spectral windows in which the effect of the instrument function is negligible. AVHRR images taken at the time of the overpass have been used in order to assess the possible presence of clouds and to assess scenes homogeneity. Some more refinements (using surface or humidity channels) have been made to provide consistent comparison. We have found that there is an overall good agreement between IASI and ARIES which agree within 1K over sea. It appeared, however, that ARIES brightness temperatures are systematically warmer than IASI ones. The comparison over land turned out to be less successful, probably hampered by the large difference in the spatial resolution of the instruments.

Session 1f: New Observations

1p.15 Assessment of Chinese Satellite FY3A/B MWHS

Presenter: Keyi Chen

Authors: Keyi Chen, Stephen English, Jiang Zhu

FY3 series have been launched since May, 2008 and the payload microwave humidity sounders (MWHS) provide vertical information of water vapor, which is critical for numerical weather prediction (NWP). Comparing with the MHS data from Metop-B, the MWHS data is found more noisy than the MHS. After MWHS data assimilated into the ECMWF forecasting system, it shows positive impact on MHS and improves the forecast scores. Also Assimilating the MWHS/FY3A and the MWHS/FY3B together, better results are shown than that only one type data is assimilated. The forecast errors start from the Tropics, spread southward and grow stronger with time, so tight quality control (QC) is suggested over tropics. These results are very encouraging that the FY3 series MWHS data could be used in NWP assimilation systems.

1p.16 Retrieval and Validation of Water Vapor from FY3C MERSI Near-infrared Channels

Presenter: Ling Wang

Authors: Ling Wang, Xiuqing Hu, Na Xu, Ling Sun

FY3C, the second-generation polar-orbiting meteorological satellite, was successful launched at the Taiyuan Satellite Launch Center, China on September 23, 2013. Water vapor is one of the operationally products provided by Medium Resolution Imager (MERSI) on board this satellite. In this paper, we present the operational algorithm for retrieving precipitable water vapor (PWV) using several MERSI near-infrared (Near-IR) channels. The operational Near-IR algorithm performs PWV retrievals globally over clear land areas and oceanic areas with Sun glint at daytime. The ratios of water vapor absorption channels near 905, 940 and 980 nm with atmospheric window channels at 865 and 1030 nm are used in this algorithm. The channel ratios partially remove the spectral surface reflectance effects and result in the atmospheric transmittance of water vapor. The column PWV amounts are derived from the atmospheric transmittance based on a Look-up Table which is pre-calculated using a radiation transfer model. The daily "pixel-based" near-IR PWV product, which is a standard MERSI level 2 data product, at the 1-km spatial resolution of MERSI, and the daily, 10-day, and monthly near-IR PWV products, which are standard MERSI level 3 products, at a 0.25Â° by 0.25Â° latitude-longitude grid globally are now routinely produced by NSMC computing facility. We present samples of PWV images and comparisons to to other satellite retrievals from MODIS and FY3A MERSI and ground-based sounding measurements.

1p.17 Mapping CrIS Field of View onto VIIRS

Presenter: Pascal Brunel

Authors: Pascal Brunel, Pascale Roquet

In order to allow the use of full resolution VIIRS imager products in conjunction with the CrIS sounder data, it is necessary to elaborate a mapping method. In the frame of the NWP-SAF AAPP software a complete CrIS/VIIRS mapping method has been established that allows to store VIIRS information in the AAPP CrIS level1d data. The CrIS field of view shape has been studied in details, deriving FOV axis regressions with satellite altitude. The CrIS center location in VIIRS data is obtained with an efficient iterative method. The mapping takes into account the VIIRS "tie bow" effect, in order to select unique VIIRS pixels in the CrIS FOV. Then, VIIRS I5, M13, M15 and M16 radiances are convolved in the CrIS FOV. They are compared to simulated VIIRS radiances from the CrIS spectrum and VIIRS spectral response functions. We observe very good agreement, biases are less that 0.3K and standard deviations below 0.5K. Any shift in the mapping gives worse results. Such careful mapping allows NWP-SAF AAPP users to accurately merge VIIRS products with CrIS data.

1p.18 VIIRS EDR Products in the Community Satellite Processing Package (CSPP)

Presenter: Geoff Cureton

Authors: Geoff Cureton, Liam Gumley, Scott Mindock, Graeme Martin, Ray Garcia, Kathleen Strabala

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) has a long history of supporting the Direct Broadcast (DB) community for various sensors, recently with the International MODIS/AIRS Processing Package (IMAPP) for the NASA EOS polar orbiters Terra and Aqua. CIMSS has continued this effort into the NPP/JPSS (previously NPOESS) era with the development of the Community Satellite Processing Package (CSPP), supporting the VIIRS, CrIS and ATMS sensors on the Suomi National Polar-orbiting Partnership (Suomi NPP) spacecraft. In time it is intended that CSPP will support GOES-R, JPSS and other geostationary and polar orbiting platforms. Here we focus on the implementation and usage of the Visible Infrared Imaging Radiometer Suite (VIIRS) Environmental Data Record (EDR) products within CSPP, which are based on the Interface Data Processing Segment (IDPS) code as implemented by Raytheon in the Algorithm Development Library (ADL). The VIIRS EDR algorithms currently available in CSPP include the Cloud Mask, Active Fires, Aerosol Optical Thickness, Sea Surface Temperature, Surface Reflectance and Vegetation Index. Each ADL sub-package consists of a binary executable and a series of configuration XML files. A series of python scripts handle ancillary data retrieval and preparation for ingest into ADL, manage algorithm execution, and provide a variety of execution options which are of utility in operational and algorithm development settings. Examples of these options, applied to operational and direct-broadcast VIIRS SDR data, are described, along with the new multiprocessing and granule yield features implemented in the CSPP VIIRS EDR v1.2 release.

1p.19 Analyzing VIIRS and CrIS Data with HYDRA2

Presenter: Thomas Rink
Authors: Tom Rink, Liam Gumley, Kathy Strabala, and W. Paul Menzel

A desktop application for analysis of satellite multispectral data has been developed using freeware to assist research and development of remote sensing applications as well as education and training of remote sensing scientists. Called HYDRA (HYper-spectral data viewer for Development of Research Applications), it provides a fast and flexible interface that allows users to explore and visualize relationships between radiances (or reflectances and brightness temperatures) and wavelength (or wavenumber) using spectra diagrams, cross sections, scatter plots, multi-channel combinations, and color enhancements on a pixel by pixel basis with full access to the underlying metadata of location and time. HYDRA can be used with multispectral (or hyperspectral) fields of data from selected instruments to display (a) pixel location and spectral measurement values; (b) spectral channels can be combined in linear functions as well the resulting images; (c) false color images constructed from multiple channel combinations; (d) scatter plots of spectral channel combinations; (e) pixels connected between images and scatter plots; (f) transects of measurements, and (g) soundings of temperature and moisture as well as spectra from selected pixels. HYDRA was initially developed for MODIS, AIRS, and AMSU. The follow-on HYDRA2 has been adapted for analyzing data from VIIRS, CrIS, and ATMS. This paper presents some examples.

1p.20 A BUFR and GRIB Tailoring System for NPP/JPSS and GCOM Products

Presenter: Yi Song
Authors: Yi Song, Thomas King, and Walter Wolf

A tailoring software system that will convert the satellite products into Binary Universal Form for the Representation of meteorological data (BUFR) and GRIdded Binary Edition 2 (GRIB2) formatted files is under development at NOAA/NESDIS/STAR. This Reformatting Toolkit will convert the products of the NPOESS Preparatory Project (NPP)/Joint Polar Satellite System (JPSS) and the Global Change Observation Mission 1st - Water (GCOM-W1) Advanced Microwave Scanning Radiometer 2 (AMSR2) into BUFR and GRIB2 files. The current toolkit development schedule consists of four phases, each adding new tailoring capabilities. In phase 1, the NPP Cross-track Infrared Sounder (CrIS) Radiances, Advanced Technology Microwave Sounder (ATMS) Radiances Visible/Infrared Imager Radiometer Suite (VIIRS) Radiances and IDPS VIIRS Sea Surface Temperature (SST) will be converted into BUFR files. In phase 2, this software system will reformat the NPP VIIRS Aerosol Optical Thickness (AOT), Ozone Mapping and Profiler Suite (OMPS) Nadir Profile (NP) and OMPS Total Column (TC) data into BUFR files. In phase 3, the NPP VIIRS Polar Winds and ACSPO Sea Surface Temperature (SST) will be converted into BUFR files, and the Global and Regional Green Vegetation Fraction (GVF) will be converted into GRIB2 files. In phase 4, this software will convert the GCOM-W1 AMSR2 Microwave Brightness Temperature, Total Precipitable Water (TPW), Cloud Liquid Water (CLW), Sea Surface Temperature (SST), Sea Surface Winds (SSW) into BUFR files and Soil Moisture (SM) into GRIB2 file, and convert NPP Ozone Limb Profile into BUFR file. Currently, the toolkit is running in the NPP Data Exploitation (NDE) system tailoring phase 1, 2 and 3 products. NDE is distributing these tailored products to the

NOAA Environmental Modeling Center (EMC) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in near real-time. The phase 4 tailoring capabilities are currently in development with a scheduled delivery in 2014. The current goal is to extend the toolkit to tailor GOES-R products. The details of this toolkit design and its products will be discussed.

1p.21 Inter-calibration Technique for IR Channels of Imaging Radiometers Onboard Electro-L and Meteor-M Satellites

Presenter: Alexander Uspensky
Authors: Uspensky A.B., Rublev A.N., Kiseleva Yu.V., Kuharsky A.V.

This poster addresses the development of inter-calibration technique for IR channels of imaging radiometers MSU-GS /Electro-L and MSU-MR /Meteor-M using data from reference instruments. The measurements in split-window channels 9, 10 of MSU-GS and 5, 6 of MSU-MR covering spectral band 10.5-12.5μm are under consideration. One of the options for reference data is SEVIRI/Meteosat-10 measurements in channels 9 and 10, i.e. GEO-to-GEO (MSU-GS) and LEO-to-GEO (MSU-MR) inter-calibration schemes can be realised. The second option is to follow GSICS recommendations and to use hyper-spectral IR sounder (AIRS/EOS Aqua, IASI/Metop) as reference instrument. In this case GEO-to-LEO and LEO-to-LEO inter-calibration schemes are being discussed. The goal of this inter-calibration is to make MSU-GS and MSU-MR measurements traceable to AIRS or IASI. As for MSU-GS instrument, the main disadvantage of GEO-to-GEO scheme is that the same pixel is viewed from different angles by MSU-GS and SEVIRI instruments. There is no direct ray matching, so MSU-GS and SEVIRI pixel zenith angles have to be taken into account. Also, it is necessary to account for the difference in spectral response functions of MSU-GS and SEVIRI channels 9, 10. The results of MSU-GS & SEVIRI data comparison over the region of interest (Indian Ocean, off the south eastern coast of Africa) demonstrates systematic biases of 2.0-3.3 K in both channels 9, 10 as well as the need for respective calibration correction of MSU-GS data. To develop GEO-to-LEO inter-calibration tool, some preliminary experiments have been carried out with inter-calibration of SEVIRI channel 9 and AIRS. In order to minimize the influence of zenith angles difference, the AIRS pixels have been selected with zenith angles close to zero. The region of interest is the Gulf of Guinea. To eliminate uncertainties related to cloud contaminated data both measured and simulated (AIRS-based) brightness temperatures TB in SEVIRI channel 9 have been sorted from minimum to maximum values. All the minimum and maximum values were discarded, so there were only ones utilised that represents cloud-free measurements. Then an inter-comparison of measured and simulated TB has been performed for 5 days in January 2013. The mean difference between both TB is found to be about 0.4K. It can be treated as SEVIRI calibration uncertainty. This methodology is currently being extended to develop MSU-GS & AIRS inter-calibration tool. It is based on the regression of coincident, collocated observations of MSU-GS and the radiance spectra measured by the AIRS convolved with the spectral response functions of MSU-GS channel 9 and 10. The results of such MSU-GS & AIRS data inter-comparison over the region of interest (Indian Ocean, near 76W) for several days in March and April 2013 are consistent with MSU-GS & SEVIRI comparison results. It shows the need for a calibration correction for MSU-GS data of the order of 2-3 K. With respect to MSU-MR instrument the LEO-to-GEO inter-calibration tool has been developed and tested. The reference instrument is SEVIRI (data in channels 9, 10). In this case the direct ray matching can be provided. The difference in spectral response functions of MSU-GS channels 5, 6 and SEVIRI channels 9, 10 has been accounted for. The results of MSU-MR & SEVIRI data comparison over the region of interest (the Gulf of Guinea) are presented.

Session 2a: Processing and Dissemination

2.01 Recent Developments with the Community Satellite Processing Package (CSPP)

Presenter: Liam Gumley
Authors: Liam Gumley, Allen Huang, Kathy Strabala, Scott Mindock, Graeme Martin, Ray Garcia, Elisabeth Weisz, Nadia Smith, James Davies, Nick Bearson

The Community Satellite Processing Package (CSPP) supports real-time processing of data from both polar and geostationary orbiting satellites. The CSPP has recently added support for new features including multi-core accelerated processing of SNPP SDR and EDR; Day/Night band stray light correction to SNPP VIIRS; dual regression statistical retrievals for CrIS/IASI/AIRS; and reprojected imagery (including true color) for SNPP VIIRS and EOS MODIS. New feature currently in testing include DB versions of the NOAA MIRS microwave and CLAVR-X imager products; the NOAA NUCAPS physical retrieval for CrIAS/IASI/AIRS; and GEOCAT retrievals for GOES imager data. This presentation will describe the features of the products available from CSPP and show examples of real-time applications.

2.02 International MODIS/AIRS Processing Package (IMAPP): Proof of the Utility of Polar Orbiter Data to Environmental Forecasters

Presenter: Kathleen Strabala

Authors: Kathleen Strabala, Liam Gumley, Hung-Lung Huang, Rebecca Cintineo, James Davies, Elisabeth Weisz, Nadia Smith, Bradley Pierce

NASA's commitment to support global operational environmental satellite users has resulted in the sponsorship of the International MODIS/AIRS Processing Package (IMAPP). This software package provides products for users of Direct Broadcast Aqua and Terra polar orbiter satellites, and has been funded continuously for more than 13 years. Since the inception of a users database in 2007, more than 1700 individuals, representing more than 70 countries have registered to download some portion of the IMAPP suite of products. That software product base now includes everything from calibration/geolocation software to Level 2 products for MODIS, AIRS and AMSR-E, as well as end-to-end applications systems such as an Air Quality Forecast package known as IDEA-I, and a complete direct broadcast Aqua and Terra processing system known as the IMAPP Virtual Appliance for MacIntosh, Linux and Windows users. Focusing on usability, reliability and robustness, the IMAPP software suite is used globally for a variety of applications, including supporting US National Weather Service Forecasters, ice identification and management, fire detection, Numerical Weather Prediction (DBCRAS), Air Quality Forecasting, and education. A variety of global environmental application examples will be presented.

Session 2b: Processing and Dissemination

2p.01 AAPP Status Report for ITSC-19

Presenter: Nigel Atkinson

Authors: Nigel Atkinson, Anna Booton, Pascal Brunel and Pascale Roquet

Version 7 of the ATOVS and AVHRR Pre-processing package (AAPP) was released in March 2012, shortly before ITSC-18. This release includes tools for processing the ATMS and CrIS instruments on Suomi-NPP. Since then there have been several update releases, adding (i) level 0 to level 1d processing of Metop-B, (ii) ingest and BUFR conversion for FY-3A/B sounders and (iii) a VIIRS cloud mask. In the near future it is planned to add VIIRS to CrIS mapping, and ingest of the new sounders on FY-3C. The current and planned AAPP capabilities will be presented. Suggestions from users for improvements or new requirements are welcome: please contact the authors or the NWP SAF Helpdesk.

2p.02 Experiences with Reception and Processing of Direct Broadcast FY-3A and FY-3B data

Presenter: Nigel Atkinson

Authors: Nigel Atkinson and Ian D. Brown

During 2013 the Met Office direct reception systems have been upgraded to acquire data from the Feng-Yun 3A and 3B satellites. The satellites broadcast in both L-band (all instruments except the imager MERSI) and X-band (MERSI only). The data are processed through the Chinese direct broadcast packages "FY3L0pp" and "FY3L1pp", to generate sensor data records (SDRs) for the various sounder and imager instruments. For imagery, it soon became apparent that the FY-3 preprocessor packages did not have a facility for updating the VIRR or MERSI visible calibration coefficients - hence the colours in the generated true-colour imagery looked very poor. However, current values for these coefficients can be obtained by downloading data samples from the CMA web portal, and these can be inserted into the various ASCII files used by the FY3L1pp package. As a subsequent step, the University of Wisconsin have adapted their reflectance correction software for use with MERSI, and this gives excellent true-colour images. The microwave sounder (MWTS, MWHS) brightness temperatures have been compared with global data from CMA that are routinely distributed via EUMETCast. FY-3B MWHS agrees very well with the global data, but FY-3A MWHS and FY-3B MWTS show some discrepancies. The discrepancies are probably due to the use of out-dated calibration coefficients in FY3L1pp. Finally, we look forward to receiving data from the new instruments on FY-3C, particularly MWTS-2 and MWHS-2. It is hoped that direct broadcast and global processing will be harmonised, and that the data will be a valuable addition to the global observing system.

2p.03 Introducing CSPP GEO: A Geostationary Satellite Data Processing Package for Direct Broadcast Users

Presenter: Graeme Martin

Authors: Graeme Martin, Scott Mindock, Liam Gumley, Allen Huang, Andrew Heidinger, Michael Pavolonis, Corey Calvert, Andi Walther

The Community Satellite Processing Package serves the Direct Broadcast community by providing a freely available suite of software to generate calibrated and geolocated sensor observations and geophysical products from raw satellite telemetry. Currently supported instruments include VIIRS, CrIS and ATMS, aboard the Suomi NPP satellite in low Earth orbit. In preparation for the launch of the geostationary GOES-R satellite, scheduled for early 2016, the CSPP team will release a software package to generate products from geostationary satellite data. The initial version

will include cloud and fog detection algorithms developed under the GOES-R Algorithm Working Group effort, and will allow Direct Broadcast users to process current-generation GOES data received on their own antennas. Future versions will include updated and additional science algorithms and will be able to process GOES-R Advanced Baseline Imager (ABI) data. Here we discuss software design considerations and project status, as well as current and future capabilities of CSPP GEO.

2p.04 EUMETSAT's Global and Regional Services for Sounder Data

Presenter: Dieter Klaes (for Thomas Heinemann)
Authors: Thomas Heinemann, Simon Elliott, Anders Meier-Sorensen, and Susanne Dieterle

EUMETSAT is well known as an operator of geo-stationary and polar orbiting meteorological satellites which carry microwave and infrared sounding instruments, such as IASI, HIRS, MHS, and AMSU-A. Future EUMETSAT satellite missions will also deliver contributions in these areas. In addition to the global data services for its own satellites and NOAA satellites in the framework of the IJPS, EUMETSAT also operates a set of 3rd party data services to distribute data from other satellite operators around the world in a comprehensive form to users in Europe, Africa, and America. These 3rd party data services already include sounder data from NOAA and FY3 satellites and will be expanded upon user request and according to data availability in the future. The EUMETSAT Advanced Retransmission Service (EARS), which started as a regional data service for sounder data from the Atlantic and Europe, now covers a large part of the Northern Hemisphere. Where possible it has been extended to include IASI data from the two METOP satellites as well as ATMS and CrIS data from Suomi-NPP, with products generated using local processing software packages. A further extension to FY3 sounders is planned for the coming years.

2p.05 NOAA Real-Time Network for Receiving and Processing Infrared and Microwave Sounder Data with Low Latency

Presenter: Liam Gumley
Authors: Liam Gumley, Bruce Flynn, Kathy Strabala, Allen Huang

As part of the Hurricane Sandy supplemental funding, NOAA has enlisted CIMSS/SSEC to set up and operate a network of direct broadcast ground stations to receive and process infrared and microwave sounder observations from polar orbiting satellites and deliver the data products to NOAA NCEP with low latency. The network will make use of dedicated ground stations operated by NOAA and CIMSS/SSEC, and will also ingest data from a network of cooperating partner stations via a collaborative data sharing arrangement. The network will receive data from Suomi NPP CrIS and ATMS; POES HIRS, AMSU, and MHS; Metop IASI, AMSU, and MHS; and FY-3 IRAS, MWTS, and MWHS. The raw satellite date (e.g., RDR or HRPT) will be ingested by CIMSS/SSEC and processed using the current versions of CSPP SDR, AAPP, and FY-3 DB software. The Level 1B/C data products will be converted to BUFR and pushed to NCEP within 15 minutes of the end of the satellite pass. NOAA operated DB stations will be located at Madison WI, Miami FL, Honolulu HI, Guam, Mayaguez Puerto Rico, Monterey CA, and Fairbanks AL. We also expect to receive data contributions from partners in the Pacific region and North America. This presentation will describe the technical details of the reception network; data processing; and expected benefit to regional NWP at NCEP.

2p.06 Updated Sounding Systems and Data Products at NOAA/NESDIS

Presenter: Awdhesh Sharma
Authors: Dr. Awdhesh Sharma

Current operational sounding systems running at the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite Data and Information Service (NESDIS) for processing the sounders data from the Cross-track Infrared (CrIS) onboard the Suomi National Polar-orbiting Partnership (SNPP) under the Joint Polar Satellite System (JPSS) program, the Infrared Atmospheric Sounding Interferometer (IASI) onboard Metop-1 and Metop-2 satellites under the program managed by the European Organization for the Exploitation of Meteorological (EUMETSAT), and the Advanced TIROS (Television and Infrared Observation Satellite) Operational Vertical Sounding (ATOVS) onboard NOAA-18 and NOAA-19 in the NOAA series of Polar Orbiting Environmental Satellites (POES). The Geostationary Operational Environmental Satellites (GOES) soundings are derived from the sounders onboard GOES West and GOES East satellites. In an effort to ensure consistent levels of service and quality assurance for these suites of products, the Office of Satellite Products and Services (OSPO) has implemented and executing new, innovative tools to better monitor performance and quality of the operational GOES and POES sounder and imager products being generated. The incorporation of these tools in both the Center for Satellite Applications and Research (STAR) and the OSPO will facilitate the joint diagnosis and resolution of problems when detected in the operational environment. This presentation will include several of these tools developed and deployed for the sounding products monitoring and data quality assurance which lead to improve the maintenance and sustainment of the Environmental Satellites Processing Center (ESPC)

processing systems. The presentation will include the discussion on the ESPC system architecture involving sounding data processing and distribution for CrIS, IASI, ATOVS, and GOES sounding products. Discussion will also include the improvements made for data quality measurements, granule processing and distribution, and user timeliness requirements envisioned from the next generation of JPSS and GOES-R satellites. There have been significant changes in the operational system due to system upgrades, algorithm updates, and value added data products and services. User requirements for GOES and POES sounder data products will also be discussed.

2p.07 Operational Processing of Satellite Sounding Data at NMSC
Presenter: Su-Hyun Jung
Authors: Su-Hyun Jung, Kwang-Jae Lee, Jeong-Sik Kim, Jae-Dong Jang, Young-Won Park and Seung-Hee Sohn
NMSC (National Meteorological Satellite Center) as one of departments of KMA (Korea Meteorological Administration) is operating COMS (Korean first geostationary meteorological satellite) and conducting foreign satellite data collection, processing, and distribution for natural disaster prevention. Currently NOAA- 18 & 19 and MetOp-A & B data are being directly received and the sounding data from them are used operationally at NMSC. KMA officially started to produce NOAA ATOVS BUFR data at Seoul in September 2006 under WMO RARS (Regional ATOVS Redissemination System) program and then NOAA receiving stations were relocated at Jincheon where NMSC was established in 2008. The new HRPT antenna was installed to receive MetOp data in December 2007. The MetOp-A ATOVS data was processed to produce L1C BUFR and disseminated them through GTS. The MetOp-B ATOVS data was done in April 2013. The acquisition frequency is up to four times a day for each satellite. The ATOVS data are used as initial inputs for Numerical Weather Prediction models as well as operational satellite analysis for daily weather analysis. In this paper, we will present about recent updated in NMSC receiving system, ATOVS data processing system, and currently being tested MetOp IASI, NPP sounding data which will be released for internal and global users.

2p.08 Detection of Radio Frequency Interference in Global Microwave Imager Data
Presenter: Xiaoxu Tian
Authors: Xiaoxu Tian, Xiaolei Zou, and Fuzhong Weng
The microwave imager observations at C-, X- and K-bands operate in unprotected frequency bands, and the natural Earth's thermal emission can be easily obscured by the signals from those active microwave transmitters over land or the geostationary satellite television (TV) signals reflected from the ocean surface. Detection of radio frequency interference in global imager data is challenging due to the presence of snow, ice sheet, cloud and precipitation, which could produce similar spectral differences as those caused by RFI. In this study, three different methods based on Principal Component Analysis (PCA) are shown to work successfully on global RFI detections in almost all Earth surface and weather conditions. Since the proposed methods can be applied to satellite radiometer data swath-by-swath and requires no training data and model simulations, it is thus applicable in an operational environment for fast data processing and data dissemination.

Session 3a: Future Observing Systems

SP.1 WMO Perspective
Presenter: Jerome Lafeuille (tbc)

SP.2 EUMETSAT Plans
Presenter: Dieter Klaes
The Poster will provide a summary update of EUMETSAT Plans for all satellite programmes and services.

SP.3 JMA and JAXA Plans
Presenter: Kozo Okamoto
Authors: Kozo Okamoto, Riko Oki, Misako Kachi, Kotaro Bessyo
JMA will launch next generation geostationary satellite "Himawari-8" in summer in 2015. JAXA is on the final stage of launching GPM-core satellite in early 2014, and developing cloud profiling radar on EarthCARE and GCOM-C. Their status and initial results will be presented.

SP.4 NOAA
Presenter: Mitch Goldberg

SP.5 China
Presenter: Peng Zhang

SP.6 India
Presenter: Ashim Mitra (tbc)

SP.7 Russia
Presenter: Alexander Uspensky (tbc)

Session 3b: Future Observing Systems

3.01 IASI-NG program: a New Generation of Infrared Atmospheric Sounding Interferometer
Presenter: Francisco Bermudo

Authors: F. Bermudo, S. Rousseau, E. Pequignot, F. Bernard,P. Veyre, C. Deniel
Further to the outstanding results of IASI in the fields of operational meteorology, air quality, atmospheric chemistry, and climate monitoring, CNES decided to develop the New Generation of the Infrared Atmospheric Sounding Interferometer (IASI-NG). With notable improvements on spectral and radiometric performances compared with the first generation. IASI NG will be a CNES contribution to the EUMETSAT Polar System Second Generation Program which aims to provide continuity of observations for weather forecasting and climate change in the 2020 to 2040 timeframe. CNES, in the frame of a cooperation with Eumetsat, will manage the development of the IASI-NG system and supply the IASI-NG flight models instruments to be flown on the Metop Second Generation satellites. This paper will present the objectives and the outlines of the IASI NG program focusing on CNES involvements in this cooperation for the development and operations of the IASI-NG instruments.

Session 3c: EPS-SG

3p.01 EPS-SG: Overview of Mission and Products

Presenter: Joerg Ackermann
Authors: Joerg Ackermann, Peter Schluessel, Dieter Klaes
The EUMETSAT Polar System – Second Generation (EPS-SG) is the follow-up system of the EPS programme. It aims to ensure continuity of the European contribution to operational weather satellite services in the mid-morning polar orbit in the timeframe of 2020 to 2040. The European Space Agency ESA develops and procures the EPS-SG Space Segment, which consists of the Metop-SG Satellites A and B series, and EUMETSAT has the overall system responsibility. In the frame of the EPS-SG development, the mission requirements for the individual observations were defined in close cooperation with a Post-EPS Mission Experts Team (PMET). For the observation missions related to atmospheric sounding, the main requirements with respect to radiometric, spectral, and geometric performances are presented. This gives a preliminary assessment of the performance of the EPS-SG Level 1 and Level 2 products that users can expect to receive for use in operational meteorology and climate monitoring. A summary of the actual status and an outlook towards future activities related to set up the product generation chains at EUMETSAT is given.

3p.02 IASI-NG ON EPS-SG : Overview of System Processing and Performances

Presenter: Eric Pequignot
Authors: E. Pequignot, S.Rousseau, F.Bernard, F.Bermudo, B. Tournier
The primary objective of the IASI-NG mission is to support Numerical Weather Prediction (NWP) at regional and global scales, atmospheric chemistry, and climatology through: - Atmospheric temperature profiles at high vertical resolution (1km down to the lower troposphere) in clear and partly cloudy air with an accuracy of 1K; - Atmospheric water vapour profiles at high vertical resolution in clear and partly cloudy air with an accuracy of 5%; - Surface temperature over sea, ice, and land surfaces (including emissivity); - Cloud parameters; - A number of atmospheric trace gases; - Stable, accurate and fully characterized hyperspectral radiances The secondary objectives of the IASI-NG mission is to reinforce pollution monitoring and air quality forecasting at global and regional scales with further trace gas measurements and the assessment of composition - climate interaction. The objective of the IASI-NG system is to fulfil EPS-SG IRS mission by providing performance twice better than for IASI for spectral resolution and twice better for radiometric noise as well ; this scenario is a significant step forward for the two decades coming after IASI, for meteorological, atmospheric chemistry and climate monitoring applications. This step forward aims at an homogeneously improved instrument, by upgrading the performance of a proven instrument (IASI). This scenario is driven by performance, while taking care of affordability. This paper gives: - a description of the processing chain from acquired interferograms on-board to spectra delivered to the end users - the main expected IASI-NG system performance budget at user level (NedT, absolute radiometric calibration, spectral coverage, spectral sampling, spectral resolution,...).

3p.03 IASI-NG System Overview

Presenter: Stéphane Rousseau
Authors: Stephane Rousseau, Frederic Bernard, Eric Pequignot, Lars Fiedler
IASI-NG is the new generation infrared hyperspectral sounder follow-on of IASI for the EPS second generation. This paper presents the IASI-NG system as part of EPS-SG system. In particular, it focuses on the impact of the operational mission on the instrument requirements, the main interfaces of the instrument with Metop-SG and the level 1 products elaboration and monitoring schemes. The instrument feasibility has been studied in the phase A in a competitive way. This paper presents the main characteristics of the selected instrument. The main challenge for IASI-NG, to reach the targeted high performance level, is the field compensation implementation. This paper presents the main innovation proposed by IASI-NG. This paper

presents also the instrument main characteristic, interfaces budget, but also the preliminary accommodation. IASI-NG aims a twice two times better compared to IASI, this papers presents the expected main performances and the preliminary radiometric and spectral calibration scheme.

3p.04 IASI-NG Instrument Presentation
Presenter: Frédéric Bernard
Authors: Frédéric Bernard, Bertrand Calvel
CNES (Centre National d'Etudes Spatiale) decide to continue the success story of IASI (Infrared Atmospheric Sounding Interferometer) by the development of the new generation of Low Earth Orbit Infrared Sounder. This paper will present the studied concept and give main characteristics of instrument. First part will focus on instrument requirements and will concentrate on performances improvement imposed by the IASI-NG mission. We will then describe the key technologies needed to fulfill the mission requirements and describe some trade off. After that, we will give a description of the studied instruments and pre-developments made with industry to demonstrate feasibility of the proposed designs.

3p.05 A step towards IASI-NG: Simulation of Orbits and First Impact Assessment Compared to IASI
Presenter: Javier Andrey-Andres
Authors: Javier Andrey-Andres, Vincent Guidard, Nadia Fourrie, Raymond Armante, Cyril Crevoisier
The hyperspectral infrared sounder IASI has already demonstrated its high capabilities for both Numerical Weather Prediction (NWP), atmospheric composition and climate studies. As the second generation of the European Polar System(ESP-SG) is being prepared, a new generation of IASI has been designed and will be on board EPS-SG: IASI-NG. IASI-NG will benefits from a increased design compared to IASI: double spectral resolution and radiometric noise decreased by a factor 2. In order to get ready to use this new instrument and to evaluate its impact on various applications, a series of simulated data has been built up. This presentation will describe the way the IASI and IASI-NG data have been simulated, as well as the selected dates. Then, from these new spectra, the first assessment studies will be described, with a specific focus on the clear cases to begin with.

Session 4a: Radiative Transfer

4.01 The GEISA Spectroscopic Database: A Key Tool for Atmospheric Remote Sensing Applications
Presenter: Nicole Jacquinet
Authors: Nicole Jacquinet, Raymond Armante, Laurent Crepeau, Noelle Scott, Alain Chedin, Cyril Crevoisier, Virginie Capelle, Cherif Boutammine, Anis Boudahoui, Laboratoire de Meteorologie Dynamique, Ecole Polytechnique, 91128 Palaiseau, France
The accuracy in the scientific exploitation of operational mission measurements heavily relies, on the quality of the spectroscopy being used in the retrieval process. In this context, the ARA/ABC(t) group at LMD develops and maintains, from now on four decades, the GEISA (Gestion et Etude des Informations Spectroscopiques Atmospheriques: Management and Study of Atmospheric Spectroscopic Information), a computer accessible database system. With the launch of high spectral resolution instruments like AIRS on board EOS-Aqua (2002), IASI on Metop-A (2006), and now on Metop-B (2012), GOSAT (2009) and Suomi NPP (2011) spectroscopic data appear to be at the root of the investigation of climate change providing an improved understanding of the different phenomena driving the atmospheric system. To take up this challenge, GEISA (1) is constantly evolving, taking into account the best available spectroscopic data. GEISA comprises, not only the line-by-line parameters database (50 molecules involved, including 111 isotopes, for a total of 3,807,997 entries, in the spectral range from 10-6 to 35,877.031 cm-1), but also two additional sub-databases: infrared and ultraviolet absorption cross-sections, microphysical and optical properties of atmospheric aerosols. GEISA as well as the 4A model(2) (4A/LMD; 4A/OP(3) co-developed by LMD and Noveltis- have become the CNES reference spectroscopic database and radiative transfer model for MetOp-A and MetOp-B, as such they are involved at CNES in the spectral calibration activities of the IASI instruments - currently recognized as a radiometric reference by the Global Space-based Inter-Calibration System (GSICS) -. GEISA is implemented on the CNES/CNRS/IPSL Ether Products and Services Centre WEB site (http://ether.ipsl.jussieu.fr), where all the archived spectroscopic data and related information can be handled through user friendly associated management software facilities. It is used on-line by more than 300 laboratories working in various domains like atmospheric physics, astronomy and astrophysics, and planetology. Due to the upcoming GEISA release (early 2014) and associated to the work in progress in the CNES-MENINGE scientific group for the future of the IASI instruments (IASI-NG) we will present the current content and planned evolution of each of the three sub-databases specifically emphasizing the quality requirements for spectroscopic line parameters when related to problems affecting the quality of the Level2 products. 1)Jacquinet-Husson

N., L. Crepeau, R. Armante, C. Boutammine, A. Chedin, N.A. Scott, C. Crevoisier, V. Capelle, C. Boonne, N. Poulet-Crovisier, et al. 2011. The 2009 edition of the GEISA spectroscopic database. JQSRT,112,2395-2445. 2) Scott, N.A. and A. Chedin, 1981: A fast line-by-line method for atmospheric absorption computations: The Automatized Atmospheric Absorption Atlas. J. Appl. Meteor., 20,556-564. 3) 4A/OP: http://www.noveltis.fr/, http://ara.abct.lmd.polytechnique.fr

4.02 Community Radiative Transfer Model Updates and Applications

Presenter: Quanhua (Mark) Liu
Authors: Quanhua (Mark) Liu, Paul van Delst, David Groff, Yong Chen, Ming Chen, Andrew Collard, John Derber, Sid-Ahmed Boukabara, and Fuzhong Weng

The Community Radiative Transfer Model (CRTM), developed at the Joint Center for Satellite Data Assimilation, operationally supports the utilization of satellite radiance data for numerical weather prediction applications. The CRTM also supports the GOES-R and JPSS/SNPP missions by enabling the necessary calibration, validation and long-term monitoring of trends. In this paper we describe enhancements associated with the latest CRTM release, v2.1.3, as well as the next planned release, v2.2.0. The enhancements include a scattering indicator approach to optimize the number of streams used for cloudy atmosphere simulations, an opaque cloud capability to enable operational cloud altitude identification, a new microwave land surface emissivity model and a new microwave sea surface emissivity model, FASTEM-5. To estimate the impact of the surface emissivity enhancements on numerical forecasts, we ran parallel experiments for a 3DVar T254 configuration. Results from these experiments indicate a neutral impact in the Northern Hemisphere and a statistically significant positive impact in both the Tropics and Southern Hemisphere. With respect to sensor verification and validation, the CRTM is used to characterize biases and noise which are important parameters for monitoring the stability and calibration accuracy of sensors. The CRTM has been used to verify the ATMS image striping for upper atmospheric channels, as well as to determine spectral shifts for hyperspectral sensors such as CrIS. Additionally, the CRTM was used to identify the root cause of the VIIRS image striping.

4.03 Update on RTTOV Developments

Presenter: James Hocking
Authors: James Hocking, Roger Saunders, Peter Rayer, David Rundle, Pascal Brunel, Jerome Vidot, Pascale Roquet, Marco Matricardi, Alan Geer, Cristina Lupu

RTTOV (Radiative Transfer for TOVS) is a fast radiative transfer model developed within the context of the EUMETSAT NWP SAF (Numerical Weather Prediction Satellite Applications Facility) and designed for use in operational NWP environments. The model allows rapid simulations of radiances for satellite infrared or microwave nadir-scanning radiometers given an atmospheric profile of temperature, variable gas concentrations, cloud and surface properties. Version 11.1 of RTTOV was released in May 2013. This version introduced a number of new features including: the capability to simulate visible/near-IR channels, a land surface bi-directional reflectance function (BRDF) atlas, new options for aerosol and cloud particles for IR scattering calculations, the capability to include a correction for non-local thermodynamic equilibrium effects for hi-res sounders, and updates to SSU coefficients to account for time-variation of cell pressure. An overview of the new capabilities will be presented along with a summary of plans for future developments.

4.04 The Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC) for Hyperspectral, Broadband and Line-by-line Radiance and Flux Simulations

Presenter: Stephan Havemann
Authors: Stephan Havemann, Jean-Claude Thelen, Anthony J Baran, Steven Wardle, Jonathan P Taylor

The Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC) has been developed and successively extended at the UK Met Office during the last eight years. During the last year the code has been completely rewritten and documented. The HT-FRTC allows very fast and exact calculations and is ideally suited for the simulation of radiances of hyperspectral sensors like IASI and MTG-IRS with thousands of channels. Efficient broadband calculations for sensors like MODIS and SEVIRI as well as high-resolution monochromatic calculations are also possible with this fast code. The code works in any part of the electromagnetic spectrum from the short-wave through the infrared to the microwave. It can be used to simulate satellite, air-borne and ground-based sensors and transmittances, radiances and fluxes can be calculated. For the simulation of scattering by clouds and aerosols (and Rayleigh scattering in the short-wave), a spherical harmonics line-by-line code has been integrated into the HT-FRTC, which is very similar to the Edwards-Slingo (ES) band code that is used for the flux calculations in the Met Office Unified Model radiation code. Alternatively Chou scaling can be used to get a fast approximation to the scattering problem. The HT-FRTC works in Principal Component (PC) space. The Principal Components represent the

transmittance/radiance/flux spectrum at a line-by-line resolution (0.001 wavenumbers), which make them independent from any sensor specifics while containing the spectral information in a very compact form. During an offline training phase, the code is trained on a wide variety of different atmospheric and surface conditions. The line-by-line training calculations are based on the most recent gaseous spectroscopy (LBLRTM 12.2). From the transmittance/radiance/flux spectra obtained during the training the Principal Components (PCs) are derived. Using a k-means clustering algorithm, a few hundred monochromatic frequencies are selected, which are then used as the predictors for the Principal Components (PC) scores. The HT-FRTC can simulate a clear-sky hyperspectral radiance spectrum for any atmosphere/surface in half a millisecond.

4.05 Lessons Learnt from the Validation of Level1 and Level2 Hyperspectral Sounders Observations

Presenter: Noelle A. Scott

Authors: N. A. Scott, R. Armante, A. Chedin, N. Jacquinet-Husson, V. Capelle, A. Feofilov, C. Crevoisier, L. Crepeau, M. Ben Sassi

Radiative transfer models, spectroscopic parameters, cloud and aerosols detection algorithms, description of the atmospheric and surface states as well as the stability of the instrument itself are among the actors entering the validation activity of Level1 and Level2 hyperspectral sounders observations. A monitoring of these various factors makes it possible: i) to reveal systematic errors potentially affecting one of them and ii) to more easily eliminate inconsistencies that may limit the usefulness of the radiances for remote sensing or assimilation. A positive feed-back of this validation activity is to be expected when the residuals (simulated minus observed values) of the brightness temperatures of each individual channels are within the instrument noise or when no ambiguity remains in the interpretation of the concurrent behavior of the different absorbers in the different spectral regions. This is the objective of the work started at LMD many years ago in particular within the frame of the NOAA/NASA Pathfinder program. Concerning IASI, it more specifically relies upon simulations and inter-comparisons of hyperspectral sounders observations (respectively, stand-alone and inter calibration approaches). In this presentation, we show how the high spectral resolution of IASI as well as its remarkable radiometric stability have helped to detect spectral signatures of errors (e.g. those related to the spectral line calculation) and to make the relevant corrections. In addition, we show how the concomitant IASI observations inherently related to its no gap (continuous) spectral scanning from 645 to 2760 cm-1, has helped to identify and disentangle the overlapping impact of different gases or of a given gas and its isotopologues: using mixing ratio profiles instead of constant values as well as using "deltaD" profiles (e.g. for H2O and HDO), leads to a noticeable improvement of the residuals bias and standard deviations. We provide the feed back of such a work on the validation tools of Level1 and Level2 products, mainly for radiative transfer models (CO2 and CH4 line mixing, line shapes, NLTE, CO2 and N2 continua temperature dependence,etc) and spectroscopy (improvement of line parameters, separation of isotopes in GEISA, etc). We also suggest an outline of future work related to the next generation sounders. More information on the LMD radiative transfer model (4A), the spectroscopic, climatic and atmospheric databases (GEISA, TIGR, ARSA) may be found at: http://ara.abct.lmd.polytechnique.fr/. For 4A/OP, see also http://4aop.noveltis.com/

Session 4b: Radiative Transfer

4p.01 Intercomparison of RTTOV and CRTM: Simulated Radiances of AMSU-A and Microwave Scattering Solver

Presenter: Ju-Hye Kim

Authors: Ju-Hye Kim, Jeon-Ho Kang, Sihye Lee, Hataek Kwon, and Jihye Kwon (All authors are from KIAPS, Seoul, Korea)

The radiative transfer for TOV (RTTOV) and the community radiative transfer model (CRTM) are fast RTMs those are used as an observation operator in numerical weather prediction. With Advanced Microwave Sounding Unit-A (AMSU-A) data, RTTOV and CRTM are compared by the first-guess (FG) departures for both clear and cloud sky conditions within the framework of Korea Institute of Atmospheric Prediction Systems (KIAPS) Observation Processing System. Without cloud condition, RTTOV produces smaller FG departures (i.e. better results) in image channels compared to CRTM over ocean. By adding cloud water and ice particles, the brightness temperature (TB) biases between CRTM simulations and the observations at 31.4 and 89 GHz channels are substantially decreased compared to RTTOV. For sounding channels, the two models are comparable in their TB calculations, but RTTOV shows slightly better FG departures in mid- and upper-tropospheric sounding channels when cloud fields are included. CRTM takes marginally longer TB calculation time. Model run times are increased by 30% when cloud fields are added to the AMSU-A simulation. The scattering computation in RTTOV is based on the two-stream Eddington approximation model which produces mean errors of less than 0.5K at the targeted microwave frequencies between 10 and 200 GHz (Bauer et al.

2006). The CRTM adopted the advanced doubling-adding (ADA) method as a scattering solver which is accurate and about 60 times faster than the doubling-adding method (Liu and Weng 2006).

4p.02 A Graphical User Interface for RTTOV
Presenter: Pascale Roquet
Authors: Pascal Brunel, Pascale Roquet
The project has decided to create a (new) graphical user interface to run the RTTOV V11 model. We have chosen to develop an interface based on Python and wxPython. This interface allows users to edit the RTTOV initial conditions (atmospheric profiles, ground parameters, etc...) run the RTTOV model efficiently (keeping coefficients in memory, possibly using multithreading) and view the results (radiances). The results of the RTTOV-K Model can also been displayed. Our poster will present the principles of this interface, and we intend to have a laptop to perform a demonstration of this software.

4p.03 Evaluation of RTTOV-11 in the IFS
Presenter: Cristina Lupu
Authors: C. Lupu and A. Geer
The latest development of the radiative transfer code (RTTOV v11) has been evaluated for use in the operational assimilation system at ECMWF. The features of RTTOV-11 discussed in this poster include alternative interpolation options and an upgrade to the coefficient files used for RTTOV. The proposed interpolation options aims to eliminate the oscillations in temperature Jacobians that results when the Rochon interpolator is used to interpolate the optical depths from coefficient to user levels in NWP models. Instead of interpolating the optical depths directly, the new attempts include log-linear interpolation (mode 3) or weighting function interpolation (mode 5). The effect of the new interpolation methods has been tested in the ECMWF system. Comparisons of the Jacobians for each AMSU-A/MetOp-A channels show that mode 5 results in very smooth Jacobians, while mode 3 does not appear to offer much benefit over the Rochon interpolator. The new interpolation options of RTTOV are evaluated through comparisons of radiative transfer simulations with RTTOV-11 using the default Rochon interpolator, and through an analysis of departure characteristics against observations. The impact on forecasts is also investigated through a series of assimilation experiments. RTTOV-11 was released with a new set of coefficient files that includes 54 levels with better-spaced vertical level structure, revised spectroscopy for all infrared sensors based on LBLRTMv12.2 and passband shifted coefficients for AMSU-A instruments. Assimilation experiments are underway to test the performance of using the new coefficient files in ECMWF system. Initial indications show that the new coefficients results in a major shock to the system in terms of biases and VarBC spinup issues. Studies are ongoing to investigate the performance of using the new coefficient files in the data assimilation context, and the latest results will be discussed in the poster.

4p.04 The Comparison of Vertical Interpolation Methods for the KIAPS Observation Processing System
Presenter: Jeon-Ho Kang
Authors: Jeon-Ho Kang, Hataek Kwon, Sihye Lee, Hyoung-Wook Chun, Ju-Hye Kim, Jung-Hyo Chae
The Korea Institute of Atmospheric Prediction Systems (KIAPS) data assimilation team has been developing the KIAPS Observation Processing System to provide optimal observations to the data assimilation system. For the bias correction (BC) and quality control (QC) of the satellite based observations, the UM model outputs which are operationally forecasted by the Korea Meteorological Administration (KMA) are used as background data. The UM background data are hybrid vertical coordinate parameter values in either theta (θ)- or rho (ρ)- levels. Pressure is present only at rho-levels and potential temperature is present at theta-levels. Therefore, the pressure values at theta-levels should be calculated by the vertical interpolation from the pressure of the immediately lower and upper rho-levels. In this study, we have tested three vertical interpolation methods which were used or are currently in use by the UM and examined the impacts of the different values of temperature, pressure, and other variables calculated by the tested methods on the departure (O-B) of AMSU-A and IASI radiances, and GPS-RO data.

4p.05 4A/OP : A Fast and Accurate Operational Forward Radiative Transfer Model for the TIR and the SWIR
Presenter: Raymond Armante
Authors: R. Armante, N.A. Scott, V. Capelle, A. Chedin, C. Burlaud, E. Bernard, C. Standfuss, B. Tournier, C. Pierangelo
4A is a fast and accurate line-by-line radiative transfer model developed and validated at LMD (Laboratoire de Meteorologie Dynamique) for the computation of transmittances, radiances and jacobians, particularly efficient in terms of accuracy and computation time. Within this frame, and with the support of the CNES (the French Space Agency), NOVELTIS has created an "operational" version of this code called 4A/OP for distribution to registered users. This version is regularly validated, updated and improved in terms of accuracy, computation time and tractability by the LMD, NOVELTIS and CNES. This software is used by several research groups and can be integrated in operational processing chains including inverse problems processing. 4A/OP,

using the most recent versions of the GEISA spectroscopic database, has the official support of CNES for radiative transfer applications in the infrared, and recently in the Short Wave InfraRed (SWIR). In particular, 4A/OP-TIR was selected by CNES as the official radiative transfer model for IASI level 1 Cal/Val and level 1 operational processing for Metop-A and Metop-B. Moreover, 4A/OP-SWIR was selected as the reference code for the French Microcarb mission and is also used by NOVELTIS for the GOSAT retrievals and l1 spectral calibration. A new version of the software is ready for distribution. After a description of 4A/OP, additional and updated capabilities (spectroscopy, scattering …) as well as a validation status using IASI level 1 and ground based TCCON observations will be presented.

Session 5a: Surface Studies

5.01 Use of the Ocean Surface Wind Direction Signal in Microwave Radiance Assimilation

Presenter: Masahiro Kazumori

Authors: Masahiro Kazumori, Stephen J. English

We developed an empirical relative wind direction (RWD) model function to represent azimuthal variations of oceanic microwave brightness temperatures of vertical and horizontal polarizations. The RWD model function was based on measurements of observed brightness temperature from the Advanced Microwave Scanning Radiometer (AMSR) and wind vector data from SeaWinds, both on board the Advanced Earth Observing Satellite - II (ADEOS-II), and Special Sensor Microwave Imager Sounder (SSMIS) first guess departure and wind vector data in European Centre for Medium-Range Weather Forecasts (ECMWF) Integrated Forecasting System (IFS). The model function was introduced to a microwave ocean emissivity model; a FAST microwave Emissivity Model (FASTEM) in a radiative transfer model for satellite radiance assimilation. Performances of the RWD model function were much more realistic than present azimuthal model functions in FASTEM for low wind speed and high frequency channels. An assimilation experiment using the RWD model function was performed in the ECMWF system. The experiment demonstrated reductions of first guess departure biases arising from modelling of the azimuthal variations in areas of high wind speed and low variability of wind direction. For example, bias reductions in ascending and descending SSMIS 19 GHz vertical polarized brightness temperature in Somali jet at the Arabian Sea were approximately 0.6 K and 0.7 K. The bias reductions were found for all assimilated microwave imager channels in a wide wind speed range. Moreover, analysis increments of specific humidity in the lower troposphere were reduced (e. g., 0.3 g kg-1 reduction at 1000 hPa in the Somali jet). We found improvements of relative humidity and temperature in short-range forecasts in the lower troposphere. The experiment results clearly showed the importance of modelling the azimuthal variation of emissivity for assimilation of microwave imager observations. The RWD model function should be included in the radiative transfer model used in the microwave radiance assimilation observation operator.

5.02 Impact of Whitecap Coverage Derived from a Wave Model on the Assimilation of Radiances from Microwave Imagers

Presenter: Louis-Francois Meunier

Authors: L-F. Meunier, S. English, and P. Janssen

The assimilation of radiances from microwave imagers, relies on an accurate representation of the surface properties in a radiative transfer model. The ECMWF IFS 4D-Var assimilation system uses the RTTOV radiative transfer model where microwave surface emissivity over oceans is computed by the FASTEM model. The ocean emissivity is influenced by the emissivity of the salted-water, the wave properties and also the whitecap coverage. It has been shown that, at large wind speeds, RTTOV exhibits an important bias for radiances from microwave imagers that could be linked to a misrepresentation of the satellite pixel fraction covered by foam. The current FASTEM whitecap fraction depends only upon the 10m wind speed. Several studies have shown that it also depends on other parameters, such as the sea state. In the IFS, the atmospheric and wave models are coupled. Therefore, a comprehensive information on the sea state is readily available to RTTOV. This capability has been used to implement a new whitecap fraction parametrisation depending upon observation time and location. Given the lack of global in situ observations of the whitecap fraction, the new parametrisation is evaluated within an assimilation experiment where the whitecap fraction estimate is used by RTTOV. Positive results are noticed regarding the first-guess departure biases but the standard deviations are slightly degraded. In order to understand these results, a retrieval of whitecap fraction has been set-up to act as a reference. The analysis of the results unveils deficiencies in other components of the FASTEM model and most likely in the foam emissivity parametrisation.

5.03 Assimilation of Infrared Surface Sensitive Channels over Land and Sea Ice at Environment Canada

Presenter: Louis Garand

Authors: Louis Garand, Surya Kanti Dutta, Sylvain Heilliette, Stephen Macpherson

Environment Canada (EC) recently initiated work toward the assimilation of hyperspectral infrared radiances sensitive to surface over land and sea ice. First assimilations cycles were conducted for July and February monthly periods using EC's global ensemble-variational analysis system (planned for mid-2014). About 140 AIRS and IASI channels are assimilated. The experiment consists in allowing the assimilation of surface sensitive AIRS and IASI channels over land and sea ice under certain conditions, essentially clear sky, relatively flat topography, and high surface emissivity. This still leaves substantial areas accepting the additional data. First results were not convincing, notably in polar areas, possibly as a result of cloud contamination. That issue, and other sensitivity experiments (e.g. surface emissivity uncertainty) are examined in the context of observing system simulation experiments (OSSE), where all currently assimilated data are simulated, then assimilated in 3Dvar mode. The nature run representing the "truth atmosphere" is that provided by ECMWF at 40 km resolution. Our approach, and most recent results obtained from the real and simulated data assimilation systems will be presented.

5.04 Retrieval of Atmospheric Profiles and Surface Parameters from METEOR-3M IR- and MW-sounders Data

Presenter: Alexander Polyakov
Authors: Polyakov A.V., Kostsov V.S., Timofeyev Yu.M., Uspensky A.B.

The installation of the advanced IR sounder IRFS-2 and the MW imager/sounder MTVZA on board the forthcoming Meteor-M N2 satellite enables the synergetic use of observed radiances for the retrieval of atmospheric temperature/humidity profiles as well as surface temperature and emissivity. Special techniques and a Science Code (SC) have been developed for inverse IRFS-2 and MTVZA data and to generate the retrieval products. Various algorithms have been realized in the SC including multiple linear regression, artificial neural networks (ANN), and physical iterative inversion. The testing of SC has been performed with simulated IRFS-2 and MTVZA measurements. Synthetic IRFS-2 spectra and MW observations were generated for a representative set of atmospheric models and surface parameters, and used the well-known LBLRTM code (for IRFS-2) and MW radiative transfer calculator (for MTVZA). The experiments were carried out for simultaneous retrieval of temperature/humidity profiles, surface temperature and emissivity. The characteristics, advantages and disadvantages of the above algorithms were analyzed by comparing error statistics of products retrieved by these various algorithms. The advantage of the ANN method is apparent when a training algorithm uses an adequate and representative sample. At the same time the pre-launch exercise with respect to IRFS-2 was carried out with an IRFS-2 proxy data set. The procedure for generating IRFS-2 proxy data from real IASI/METOP spectra is described. Comparison of IRFS-2 proxy data inversion results with ground-based measurements (on the basis of JAIVEx data) confirms their reliability. The advantages of the ANN method are demonstrated.

Session 5b: Surface Studies

5p.01 Using land surface parameter estimations to improve the assimilation of IASI data over land.

Presenter: Vincent Guidard (for Anais Vincensini)
Authors: Anais Vincensini, Vincent Guidarad, Nadia Fourrie

Infrared signal is highly impacted by surface parameters such as surface emissivity and surface temperature. The assimilation of IASI data over land generally is restricted to those channels which are not sensitive to the surface. Numerous IASI channels peaking in the middle to lower troposphere are sensitive to surface parameters, so are the window channels. In numerical weather prediction (NWP), the description of land surface temperature commonly suffers from some misrepresentations or large errors, especially over deserts, snow-covered areas and elevated regions. Moreover, in Meteo-France models, land surface emissivity is prescribed as a fixed value over the wavenumbers and the surface types, while it is well know that it varies a lot across the wavelength and the various regions of the globe. This presentation will describe how the use of land surface surface emissivity and retrieval of land surface temperature can affect the simulation of IASI brightness temperatures and improve their fit to the observed spectra. After this first step, assimilation experiments have been carried out to evaluate the impact of a proper description of surface parameters on the assimilation of IASI data over land,as well as the impact of enhanceing the channel selection over land to include surface-sensitive channels.

5p.02 Update on IASI Emissivity Atlas

Presenter: Daniel Zhou
Authors: Daniel Zhou, Allen Larar, Xu Liu, and William Smith

MetOp-A satellite was launched on 19 October 2006 and MetOp-B was launched on 17 September 2013. Two satellites fly in complementary orbits and in a sun synchronous "morning orbit" passing over the Equator at the same local time 9:30 am. MetOp-B phased 50 minutes apart from MetOp-A. Presented here are the global surface IR emissivity spectra retrieved from IASI measurements

observed from both MetOp-A and MetOp-B satellites. Inter-comparison of the emissivities obtained from MetOp-A and MetOp-B is performed to ensure the continuity of emissivity monitoring and its trend analysis. Effort on emissivity validation continues with available ground in-situ measurements and retrieval consistency check through radiative transfer model simulations. The spatial resolution of emissivity climatology atlas is now increased from 0.5 to 0.25 degrees latitude-longitude, and available to the community.

5p.03 The Assimilation of Surface-Sensitive Microwave Sounder Radiances over East Asia in GRAPES

Presenter: Wei Han
Authors: Wei Han, Peiming Dong

The assimilation of satellite microwave radiance plays an important role in the numerical weather forecast over East Asia. However, lots of surface-sensitive satellite observations are not used because of the complex surface condition over East Asia. What's more, for the Tibetan Plateau with the highest Altitude in the world, even the assimilation of those satellite data with less surface-sensitivity in general sense presents a difficult issues. To improve the assimilation of microwave sounder radiance over East Asia in GRAPES, a scheme of land surface emissivity is introduced. The land surface emissivity of those window channels is firstly retrieved from the satellite observation. The retrieval is then used in the assimilation of satellite data. It is not only the window channel takes the emissivity retrieval, but also the sounder channel near the window channel gets the retrieved emissivity. The emissivity of database is used in case of the retrieval is failed. In this report, we will introduce the analysis of the characteristics of retrieved emissivity, especially over Tibetan Plateau, together with the comparison with that of database. The impact of the land surface emissivity scheme on the simulation of satellite microwave observation, the data usage and the numerical weather forecast will also be presented.

5p.04 Improved Use of ATOVS over Land

Presenter: Fiona Smith (for Stuart Newman)
Authors: Stuart Newman, Katie Lean, T. R. Sreerekha and Bill Bell

ATOVS radiances have been assimilated directly into the Met Office 4D-Var system for some years, with demonstrable impact on forecast skill. However, to date the most extensive use of observations has been over ocean where the surface emissivity can be calculated to reasonable accuracy. Until now the higher-peaking AMSU-A temperature sounding channels 6-14 have been assimilated over land, while the more surface-sensitive channels 4 and 5 have not. We present work at the Met Office to incorporate a microwave land emissivity atlas (F. Karbou and co-workers, Meteo-France) into a 1D-Var pre-processor as a background for retrieval of emissivity and surface temperature prior to the full 4D-Var assimilation. Emissivities are retrieved for AMSU channels 1-3 and 15 (23.8, 31.4, 50.3 and 89 GHz), with the 50.3 GHz value mapped to the temperature sounding channels. We describe the implementation of this approach, including data selection and choice of background errors. Early experiments into the assimilation of AMSU-A channels 4 and 5 over land are discussed.

5p.05 Situation-dependent Observation Errors for AMSU-A Tropospheric Channels in the ECMWF Forecasting System

Presenter: Heather Lawrence
Authors: Heather Lawrence, Enza Di Tomaso, Niels Bormann, Stephen English

The Advanced Microwave Sounding Unit-A (AMSU-A) is a key satellite instrument used in numerical weather prediction systems around the world. Currently the data from AMSU-A instruments flown on 7 different satellites is actively assimilated at ECMWF, in addition to the recent ATMS instrument which includes channels with the same frequencies as AMSU-A. These instruments have been shown to have a highly positive impact on forecast scores, particularly the lower tropospheric channels which are important for weather forecasting. In order to assimilate these instruments, observation errors must be defined and these should include uncertainties due to instrument noise and uncertainties in the forward model used to convert the atmospheric temperature profile to the observed radiances. For the lower tropospheric channels, sensitive to the surface, the latter uncertainty includes surface temperature and emissivity errors as well as errors from undetected cloud and precipitation. These errors are highly situation-dependent, but currently this situation dependence is ignored in the ECMWF system and AMSU-A is assigned a constant observation error. In this paper we present a study where observation errors were allowed to vary with surface type (land, sea, sea ice, snow cover), sensitivity to the surface (surface-to-space transmittance) and the liquid water path, in order to account for emissivity and cloud/precipitation errors. We discuss the influence of the situation-dependent observation errors on observation-fit statistics and forecast impact, and investigate opportunities to extend the AMSU-A coverage as a result of the more sophisticated observation error model.

5p.06 Prospects for Assimilating More Sounder Radiances over Snow Covered Surfaces

Presenter: Stephen English
Authors: English S.J.

In the winter northern hemisphere large areas are snow covered and snow has a highly variable emissivity, depending on snow wetness, grain size, water equivalent and snow coverage. It is further complicated by vertical structure, such as refrozen layers, crust and density variation. To make matters worse the concept of a skin temperature is not well defined for many snow surfaces, because the penetration depth is significant and the temperature deep in the snow pack may be very different to the surface temperature. Unsurprisingly given these difficulties the assimilation of sounder radiances over snow has been cautious. However whilst these problems to occur they do not occur all the time. In large areas the snow may vary little from day to day, and an atlas approach, especially an updating atlas based on recent values, may be a valid approach. ECMWF have a dynamic emissivity, calculated to be consistent with the observations, and an atlas created through a Kalman filter analysis of the dynamic emissivities. Furthermore tools such as Telsem give a climatology of emissivity. In addition ECMWF have a snow analysis. Whilst solving the problem in marginal snow zones may not be practical, an approach to identify where we can assimilate sounder radiances with confidence may bring benefits. This is studied in this poster.

5p.07 Analysis of the Third and Fourth Stokes parameters by Fully Polarimetric Microwave Radiometer Measurement over Antarctic Sea Ice

Presenter: Wen Lu

Authors: Wen Lu, Shao-bo Wang, Rui Wang

WindSat is the first spaceborne fully polarimetric microwave radiometer in the world. It can measure the third and fourth Stokes parameters of the target and provide a new way for sea ice remote sensing. Future microwave sounder MIS will also be equipped with fully polarimetric channels similar to WindSat. In this paper, by using WindSat data in 2004, we studied on the brightness temperature characteristics of the third and fourth Stokes parameters over Antarctic sea ice. The regional distribution, time variation and anisotropy of the brightness temperatures were analyzed. The results showed that the brightness temperatures of the third and fourth Stokes parameters could describe the regional distribution of sea ice in a certain extent. The third Stokes parameter reflected the ice water line well in winter. The brightness temperature differences of sea water and sea ice could reach above 3K. However, in summer, brightness temperatures both of the third and fourth Stokes parameters were near 0K. We could hardly find the difference between sea water and sea ice. For time series analysis, the brightness temperatures of the third and forth Stokes parameters had correlation with sea ice concentration. In summer, because sea ice melted, the concentration decreased and the amplitude of the brightness temperature was quickly increased. In winter, the situation was the opposite. This characteristic of first-year ice was more evident than multi-year ice. For anisotropy analysis, the third Stokes parameter signal variation with azimuth was more obvious in first-year ice area than that in multi-year ice area. However, the anisotropy of the fourth Stokes parameter was weak in each area. Using these time-varying and anisotropic properties of brightness temperatures, we could distinguish first-year ice and multi-year ice.

5p.08 Status and Plans of CMA Land Data Assimilation System (CLDAS) Project

Presenter: Chunxiang Shi

Authors: Chunxiang Shi, Lipeng Jiang, Tao Zhang, Dongbin Zhang, Bin Xu, Xiao Liang and Chen Zhu

In recent years, frequent drought events have caused enormous losses. High quality space-time soil moisture products are urgent to support CMA in China drought monitoring services. Soil moisture retrieved from satellite observation or simulated from land surface models or from in-situ observations has different advantages and defections. Merging all the soil moisture information together may have the ability to obtain high quality soil moisture continuously. Therefore, CMA Land Data Assimilation System (CLDAS) Project is proposed to meet the demand of drought monitoring and other meteorological, agricultural and hydrological requirements over China. CLDAS project consists of three stages. The first stage aims to realize STMAS operation for producing forcing data; to realize operational running of CLM; to evaluate forcing and CLM's output; and to publish the operational products for users. The second stage aims to build retrospective forcing data set since 1995 over China; to develop multi-LSMs operational system; and to develop multi-satellite merged soil moisture product. The third stage aims to assimilate multi-satellite merged soil moisture; to assimilate satellite radiance or brightness temperature. The first stage of CLDAS (V1.0) has been put into operation at the end of Jun 2013 in national meteorological information center of CMA. The product coverage is 70-150E, 0-60N and the spatial resolution is 1/16 (0.0625) degree. Hourly gridded forcing data, including air temperature, pressure, humidity, wind speed, downward shortwave radiation and precipitation, are used to drive CLM in CLDAS. STMAS (Space-Time Multi-scale Analysis System) (Xie, Y., 2011) are used to combining NCEP/GFS data with regional automatic surface observation temperature (more than 30000) over China, and the result are validated using national automatic observation (more than 2400) . The result shows that the combined temperature product is closer to surface

observations than GFS product. Air pressure, relative humidity and wind speed are processed similar as temperature. The Downward shortwave radiation (DSR) is retrieved from FY-2(C-F) series geostationary meteorological satellites, operated by CMA. The DISORT method for radiation transfer calculations with the climatic data sets from the ISCCP C2 is used in the retrieval. The DSR is evaluated against ground-based observations (OBS) from 94 stations over mainland China (Jia, B., 2013). Grid precipitation is produced by merging more than 30000 rain gauge data and CMORPH product. CMA began to establish automatic soil moisture observation network since 2009. More than 2000 stations have been put into operation till now. The automatic observation network will gradually replace the human observation network which has more than 700 stations since 1981. After quality control, soil moisture observations are used to evaluate CLDAS soil moisture product.

5p.09 Assimilation of FY-3B Soil Moisture Products into Noah-MP Land Surface Model

Presenter: Lipeng Jiang

Authors: Lipeng Jiang, Chunxiang Shi, Xiao Liang, Tao Zhang, Bin Xu, Dongbin Zhang and Chen Zhu

It is widely known that soil moisture plays an important role in meteorological, agricultural and hydrological fields. Both soil moistures retrieved from remotely sensed microwave measurements and predicted from numerical models have advantages and shortcomings. Assimilation of soil moisture satellite retrievals into land surface models is considered as an effective approach to estimate soil moisture with lower errors than satellite retrievals or land surface models only. There has been a lot of research in the assimilation of near surface soil moisture retrieved from satellite sensors such as SMOS (Soil Moisture and Ocean Salinity) and AMSR-E (Advanced Microwave Scanning Radiometer – Earth Observing System). The microwave radio imager (MWRI) onboard of the Fengyun-3B satellite (FY-3B) which was launched in November, 2010 by Chinese Meteorological Administration (CMA), observes the Earth at the similar frequency with AMSR-E. We intend to assimilate MWRI soil moisture retrievals into the community Noah land surface model with multi-parameterization options (Noah-MP). The FY-3B soil moisture retrievals were firstly compared to the soil moisture product generated by Noah-MP forced by China Land Assimilation System version 1.0 (CLDAS v1.0) forcing data. To reduce the satellite-model bias, cumulative distribution function (CDF) matching was used to scale the FY-3B soil moisture retrievals to the Noah-MP outputs. Then the blended MWRI soil moisture products are assimilated into Noah-MP using an Ensemble Kalman Filter. In order to evaluate the impacts of FY-3B soil moisture product assimilation, Noah-MP with and without FY-3B soil moisture product assimilation were run separately over China forced by the CLDAS v1.0 forcing data from Jan. 2009 to Oct. 2013 with a spatial resolution of 0.0625°.In situ observations from more than one thousand automatic observation stations were used to evaluate the impacts of the assimilation of satellite retrievals.

5p.10 Typhoon Wind Structure Analysis by Assimilating ASCAT Data in GSI System

Presenter: Szu-Chen Kuo

Authors: Szu-Chen Kuo, Chian-Yi Liu, Chien-Ben Chou, Chun-Chieh Chao, Gin-Rong Liu

Most typhoons originate in the western North Pacific Ocean, where Taiwan is on the frequent typhoon tracks in the statistics. In average, Taiwan has hit by typhoon for a number approximately of six annually. To understand the wind structure will help to reduce the damage due to this natural disaster. In this research, we propose a case study that uses ASCAT data in GSI data assimilation system to explore typhoon wind structure which runs across Taiwan. Advanced Scatterometer (ASCAT) is the lastest remotely sensed surface wind instrument which carried on MetOp. ASCAT use the C-band radar to detect the backscattering from wind-roughened ocean. On the other hand, Gridpoint Statistical Interpolation (GSI) is a three dimensional variational data assimilation which uses a static background error covariance, does not reflect the flow-dependent error statistics. We also use the wind field which counting by multiple-radar synthesis method as a reference to evaluate the typhoon wind structure forecast performance. The preliminary results show that the wind structure has better pattern correlation with reference data when ASCAT surface wind is assimilated in the GSI system.

Session 6: NWP Centre Reports

NWP.1 Current Status and Plan of the Satellite Data Assimilation at Korea Meteorological Administration

Presenter: Sangwon Joo

Authors: Sangwon Joo, Yoonjae Kim, Eunhee Lee, Eun-Jung Kim, Hyun Mee Kim and B.J. Sohn

The Korea Meteorological Administration (KMA) has developed hybrid 4dVar and assimilated up to date satellite data to improve the initial condition for the Global Data assimilation and Prediction System (GDAPS). Recently, the Atmospheric Motion Vector (AMV) and Clear Sky Radiance (CSR) of Communication, Ocean Meteorological Satellite (COMS) have been assimilated in the GDAPS. They have improved the GDAPS

performance in general and the improvements are significant over the East Asia in summer. It is believed that the better performance is caused by the precise positioning of the North Pacific High which controls the weather system over the Korean peninsula during the summer time. The ATOVS, IASI, and ASCAT on board Metop-B have been assimilated since 2013 and the general performance of the global prediction is largely improved at KMA by filling the gaps between the swaths of the Metop-A data. To evaluate and monitor the impact of the satellite data on the numerical weather prediction at KMA, Forecast Sensitivity to Observations (FSO) has been developed and run in operation since 2013. The ATOVS shows the most significant observation impact among satellite sensors due to the large volume of data but the GPSRO and IASI ranked the 1st and 2nd most significant sensor respectively in terms of the impact per sounding. KMA has worked on developing the variational bias correction (VARBC) for satellite data in collaboration with the Met Office and plans to make it operation in 2015. KMA sets a high priority in assimilating more satellite data such as GOES CSR, and NPP to improve the NWP performance. To make better use of the COMS data, high resolution AMVs and CSR is tested and they will be assimilated in both global and high resolution NWP system (about 1km) in near future. The forecast sensitivity to observation error will be tested to use the satellite data properly in KMA NWP system and channels selection for the IASI data will also be improved to use more information from the hyper-spectral satellite observations.

NWP.2 Recent Developments in Satellite Data Assimilation at JMA

Presenter: Akira Okagaki

Authors: Akira Okagaki, Yuki Kosaka, Takumu Egawa, Masahiro Kazumori, Hiromi Owada, Kouji Yamashita, Masami Moriya and Yoshiaki Sato

Recent developments in satellite data assimilation at Japan Meteorological Agency (JMA) are presented. JMA has introduced various new satellite data and extensive use of existing data into global and regional data assimilation systems since the last ITSC ; MHS channel 3-5 over land, use of land surface emissivity atlas in RTTOV-10, improved assimilation of GNSS radio-occultation data, AMSR2 data from GCOM-W1, clear sky radiances and AMV from Meteosat 10, LEOGEO and AVHRR winds. Data from Metop-B are also assimilated operationally since November 2013, which has positive impacts on the global forecast model. Upgrades of global NWP system including increase of vertical resolution and expansion of model top are planned in 2014.

NWP.3 Recent Changes in the ECMWF NWP System

Presenter: Stephen English

Authors: English S.J., N. Bormann, A. McNally, A. Geer, R. Eresmaa, H. Lawrence, C. Lupu, F. Baordo, M. Matricardi

ECMWF assimilate radiances from around 20 different satellite sounders and monitor many more. The ECMWF data assimilation system performs an ensemble of 4D-var assimilations, using perturbed observations to represent uncertainty. The long term goal is to unify the ensemble data assimilation and ensemble prediction system eliminating the need for singular vectors in the latter. Satellite sounding observations have the largest impact of any data type, in part because of the very high data volume, and also due to their accuracy. The major NWP changes at ECMWF have included moving from 91 to 137 vertical levels, improvements in the physics scheme for convection (allowing peak convective rainfall to occur at the correct time of day) and tuning of the background term in the ensemble of data assimilations. The main foci in the assimilation of sounder radiances since the last ITSC have been on optimising the use of radiances in the ensemble of data assimilations; including observation errors and data screening, on introducing new data e.g. from Metop, FY3 and Suomi-NPP; on exploring improved techniques for handling cloud and surface effects on the radiances; and on more efficient assimilation of spectral information from infrared sounders (e.g. Principal Components). In this poster technical details will be given on which instruments and channels are being assimilated by ECMWF, current differences between assimilation over difference surfaces and in different cloud conditions, and details of options in the data thinning and screening, radiative transfer model used, bias correction and data monitoring systems.

NWP.4 Status of the Operational Global Deterministic Prediction System at Environment Canada

Presenter: Chantal Cote

Authors: Chantal Cote and many colleagues at Environment Canada

Many important upgrades to the operational Global Deterministic Prediction System at Environment Canada were implemented during the year 2013. SSMIS data from satellites DMSP 17 and DMSP 18 as well as RARS (Regional ATOVS Retransmission Service) data from all satellites (except AQUA and METOP-2) have been assimilated since February 2013. The time step of our data assimilation system (4D-VAR) has been reduced from 45 min to 18 min, which translates into 21 bins in a 6-h assimilation window, as opposed to 9 bins in the previous system. Likewise, the horizontal resolution of the increment has been

increased from 240x120 to 400x200 grid points. Also in February, the forecast grid spacing was decreased from 33 km to 25 km and the model hybrid vertical discretization was converted from unstaggered to staggered coordinates. With this new definition of the model levels, the stratospheric temperature structure is better resolved and the performance of the satellite bias correction scheme is greatly improved. In November new data sources were introduced, including additional CSR (Clear Sky Radiance) measurements, atmospheric motion vectors from MeteoSat10, additional ATOVS radiances and AVHRR polar winds, as well as GPS-RO and scatterometer wind retrievals from METOP-1. Our results reveal a positive impact of the above modifications compared to the previous assimilation and forecast systems for all meteorological variables. Here we will focus on forecast scores against radiosonde data for lead times of up to 5 days. A summary of data counts for assimilated observations will also be presented.

NWP.5 Use of ATOVS and IASI radiances in the HARMONIE data assimilation

Presenter: Roger Randriamampianina
Authors: Roger Randriamampianina, Magnus Lindskog, Sigurdur Thorsteinsson, Mate Mile, and Harald Schyberg

Recently, scientific work within the HIRLAM consortium is concentrating on development of limited area models (LAMs) applying the AROME and ALARO physical parametrisations, different data assimilation schemes, as well as different ensemble techniques. Here, we report the work done around radiance data assimilation, which aims to better handle data from different instruments when accounting for different LAM configurations (domain size, model top level, etc) in the variational framework. In this study we use a 3D-VAR analysis system to assimilate ATOVS (AMSU-A, AMSU-B, and MHS) and IASI (both the temperature and humidity sensitive channels) radiances. Taking into account a relatively low model top (at 10 hPa), we found out that avoiding few predictors (mainly those which are defined around and above the model top) is worth to do. Furthermore, depending on the model domain size, tuning the background error constraint applied for the variational bias correction helps to reach good convergence to the nominal bias in a relatively reasonable time. Positive impact of both the ATOVS and IASI radiances was found using different LAM configurations.

NWP.6a Overview of the Infrared Radiance Assimilation in the Meteo-France Models

Presenter: Nadia Fourrie
Authors: N. Fourrie, V. Guidard, S. Guedj, P. Moll, J.-F. Mahfouf, N. Saint Ramond

A large part of assimilated observations in the global model of Météo-France comes from infrared radiances. Since July 2013, radiances from AIRS, IASI on board Metop A and Metop B, and Cris are assimilated in the global model. The clear sky radiances from 3 geostationary satellites are also used in the analysis. The infrared radiances are also used in the mesoscale model AROME. This poster intends to give an overview of the infrared radiance usage in the French models and the status of the current developments. The relative weight of each infrared radiance type will be given and the summary of recent changes in data usage from April 2012 will be presented. For example, the number of assimilated AIRS and IASI channels has been increased with more channels in the lower troposphere and Cris channels have been added in the Météo-France models. Moreover, SEVIRI radiances are now assimilated over sea and over land with a retrieved surface temperature and an atlas of surface emissivity in the mesoscale AROME model. The information content of the various observation type is regularly computed and will be presented. In addition of the classical observing system experiments, impact of the infrared sounder assimilation is partly evaluated through the forecast sensitivity to observations, allowing to compare the relative weight of each observation types, or of each channel.

NWP.6b Ongoing Developments on the Use of Microwave Sounders and Imagers at Meteo-France

Presenter: Louis-Francois Menuier
Authors: Louis-Francois Meunier, Philippe Chambon, Jean-Francois Mahfouf

Satellite radiances from microwave instruments (sounders and imagers) are assimilated in the operational global and regional Numerical Weather Prediction models at Meteo-France (ARPEGE, ALADINs, AROME). A number of recent developments are described concerning the increase usage of microwave radiances in the operational systems since July 2013 (assimilation of new sounders Suomi-NPP/ATMS, METOP-B/AMSU-A and METOP-B/MHS, increased spatial density of AMSU-A in the regional model AROME). Despite the dominance of hyperspectral infra-red sounders in the observing system with four instruments (METOP-A/IASI, METOP-B/IASI, AQUA/AIRS, Suomi-NPP/CrIS) that represent 75 % of the total data in the global model ARPEGE, AMSU-A sounders remain the major contributor to the 24-h global forecast error reduction as diagnosed by the Forecast Sensitivity to Observations (FSO) diagnostic tool. Ongoing experiments regarding the use of the new humidity sounder SAPHIR onboard the MEGHA-TROPIQUES satellite are presented for the global ARPEGE 4D-Var system. The lack of a window

channel on this instrument has led to a new cloud detection method. Positive impacts are noticed on the humidity field in the Tropical belt for both the analyses and the forecasts.

NWP.7 Progress and Plans for the Use of Radiance Data in the NCEP Global and Regional Data Assimilation Systems
Presenter: Andrew Collard
Authors: John Derber, Russ Treadon, David Groff, Daryl Kleist, Emily Liu, Haixia Liu, Edward Safford, Paul van Delst, Yanqiu Zhu and Andrew Collard
Since the last International TOVS Study Conference in March 2012, there has been one major operational upgrade to the data assimilation system at NCEP (in May 2012) and testing has begun on the next implementation: expected in the spring of 2014. The most important component of the May 2012 upgrade was the introduction of a hybrid EnKF-3DVar data assimilation system which allows more realistic analysis increments from all observation types and resulted in significant improvement in most forecast model fields. In addition, SNPP-ATMS observations were included for assimilation with modest positive impact. An interim upgrade to the suite of assimilated observations was implemented in August 2013 which included SNPP-CrIS and AMSU-A, MHS and GRAS from MetOp-B as well as SEVIRI from MSG-3 (replacing MSG-2). The next operational upgrade will include two major components that will affect the assimilation of radiance data: The microwave sea-surface emissivity model in CRTM has been upgraded to FASTEM-5 (which has the effect of effectively removing a 2K bias seen in AMSU-A channels 1, 2 and 15). The variational bias correction scheme has been enhanced to include scan-dependence and land-surface emissivity terms plus better use of pre-conditioning and passive channels. In addition SSMIS lower atmosphere sounding channels are now assimilated (which also requires the addition of an additional two bias correction terms to account for intra-orbit biases) plus IASI from MetOp-B. Looking ahead we are continuing to work on the assimilation of cloudy radiances both in the microwave and infrared.

NWP.8 Developments in Satellite Data Assimilation at DWD
Presenter: Christina Koepken-Watts
Authors: Ch. Koepken-Watts , R. Faulwetter, O. Stiller, A. Fernandez, E. Lange, R. Gray, H. Anlauf, A. Rhodin
This overview poster describes the status of operational satellite data assimilation at DWD as well as developments in the areas of data assimilation algorithms and the use of satellite data. Additionally to an overview of the current operational use, the poster describes the developments to increase the number of instruments used (e.g. ATMS, IASI and CrIS), as well as improvements to the data use in overcast situations and over land. The status of bias correction and observation error tuning is described. A short introduction of the currently developed ensemble based data assimilation system and the new, improved numerical model, ICON is also given.

NWP.9 Overview of Developments in the Use of IR Sounder Data at the Met Office
Presenter: William Bell
Authors: James Cameron, Andrew Smith, Peter Weston, Ed Pavelin, Fiona Smith and Bill Bell
During 2013 advanced IR sounder data from two new instruments, MetOp-B IASI and Suomi-NPP CrIS, have been added to the Met Office global data assimilation system. Data quality assessments have shown the data from both instruments to be excellent and both produce improvements to forecast quality, as indicated from observing system experiments (OSEs) and forecast sensitivity to observation (FSO) diagnostics. In January 2013 an improved treatment of inter-channel error correlations was implemented for IASI, using errors diagnosed using the method of Desrozier. This increases the weight given to IASI observations in the analysis and results in measurable improvements in forecast accuracy. The inter-channel correlations result primarily from errors of representativeness resulting from horizontal scale mis-match between observations and assimilating model. The method has been applied to AIRS and CrIS and the impact assessed in a series of OSEs. Full resolution IASI data has also been assessed in the UK high resolution (2km) forecast system and the results of assimilation experiments will be presented. Finally, the treatment of cloudy radiances is being extended through an observation error model which accounts for the increase in radiative transfer model errors for channels affected by clouds. This scheme progressively inflates observation errors for those channels that are affected by clouds and allows a more aggressive use of cloudy data. Results from a 1D-Var + 1D-Var simulation study show significant reductions in analysis errors for temperature and humidity.

NWP.10 Evaluation of the New Global 3DVar Operational System at CPTEC/INPE
Presenter: Luis Gustavo de Goncalves
Authors: Luis Gustavo G. de Gonçalves, Luiz F. Sapucci, Carlos F. Bastarz, Bruna B. Silveira, Mariana Pallota, Mário F. L. de Quadro, Dirceu L. Herdies, Helena B. Azevedo, Fábio Diniz, João G. Z. de Mattos, Solange Souza, Paulo Y. Kubota

The Center for Weather Forecast and Climate Studies (CPTEC from its Portuguese acronym) from the Brazilian National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais) has replaced early 2013 its global operational PSAS data assimilation (DA) system with GridPoint Statistical Interpolation (GSI) based 3DVar (hereafter called G3Dvar).. CPTEC/INPE has been incorporating non-conventional based datasets in the PSAS system along the years (e.g. ATOVS and AIRS/AMSU retrievals, QuikScat wind, Cloud Track Wind, Total Precipitation Water from SSM-I sensors) however with little improvement in its forecast skills, mostly due to the lack of satellite radiances. Therefore, one of the main advances with the new system is the incorporation of direct satellite radiances into CPTEC/INPE operational NWP suite This work introduces the major impacts of the replacemnet of PSAS by the G3DVar in the Brazilian Global system, in particular over South America and adjacent oceans. An evaluation of the quality of forecasts with respect to underlying analyses is presented in addition to the impact from different observing systems. Special attention is given to analysis increments with respect to AMSU-A, MHS, AIRS and IASI. Additionally, a case study is presented to illustrate the differences between the two systems.

NWP.11 Real-time use of Atmospheric Sounding data at NCMRWF: Current and future plans
Presenter: Indira Rani

Session 7a: Advanced IR: Dissemination and Assimilation

7.01 Direct Assimilation of Principal Component Data for Operational Numerical Weather Prediction
Presenter: Marco Matricardi
Authors: Marco Matricardi, Tony NcNally, Niels Bormann
The ECMWF operational ECMWF 4D-Var has been adapted to allow the direct assimilation of principal component (PC) scores derived from high spectral resolution infrared sounders. The primary aim of this development is towards an efficient use of the entire measured spectrum that could not be achieved by traditional radiance assimilation. We present a system that uses 50 PC scores derived from 305 IASI channels obtained by augmenting the 191 operational IASI channels with additional surface, ozone, and water vapour channels. The new scheme has been extensively tested in a full data assimilation system that uses all operational observations (satellite and conventional). Testing over a three-month summer period suggests that the quality of the analyses produced by the assimilation of 50 IASI PCs is almost identical to that obtained when the operational 191 IASI radiances are assimilated. The verification of forecasts launched from these test analyses further confirms that there is no loss of skill from the assimilation of IASI PCs compared to that of radiances. This result is all the more important in light of the fact that while the use of PC data is currently restricted to fully clear spectra, in the operational radiance assimilation system the use of IASI data extends to channels unaffected by clouds and to fully overcast scenes. In addition, the 50 PC score system based on 305 radiances uses ~20% less computer resources (during the 4D-var minimization) compared to the system that assimilates 191 radiances. This figure represents a significant saving inside the time critical processing path for NWP centres, but could potentially be improved even further by changing the setting of the tunable accuracy of the PC based fast radiative transfer model (PC_RTTOV) used for the assimilation of PC scores. To summarise, the results obtained from the direct assimilation of IASI PC scores are extremely significant and encouraging. They demonstrate the viability of an alternative route to radiance assimilation for the exploitation of data from high spectral resolution infrared sounders in NWP. Progress in this area is very timely - at the time of writing there were four such instruments in space (IASI on METOP-A and B, AIRS on AQUA and CrIS on NPP). Work is now urgently needed to take this system forward to a stage where it can be considered as an option for the safe and efficient operational exploitation of these crucial instruments.

7.02 Improved Assimilation of Hyperspectral Sounder Reconstructed Radiances
Presenter: Fiona Smith
Authors: Fiona Smith1,2, John Eyre1, and John Remedios2
1Met Office, Exeter, UK 2University of Leicester, Leicester, UK Future dissemination of hyperspectral sounding data is likely to involve principal component (PC) compression. PC scores could be assimilated directly, or could be converted back into reconstructed radiance spectra. Simple assimilation experiments with IASI reconstructed radiances have shown that they can be successfully assimilated into NWP models with no detriment to the forecast scores. However, these experiments were conducted with unrealistic diagonal, uncorrelated observation errors that are incompatible with the full covariance matrices we now use operationally. This talk will discuss the issues surrounding the correct treatment of reconstructed radiances, in particular: the error covariances, the forward model, and channel selection. A way forward for the assimilation of

reconstructed radiances will be identified that should allow us to realise the benefit of the noise-reduction inherent in the PC compression.

7.03 IASI Channel Selection for the Unified Model Data Assimilation System

Presenter: Youngchan No

Authors: Youngchan No, Byung-Ju Sohn, Yoonjae Kim, Sangwon Joo, and William Bell

This study attempts to select IASI channels from 314 channels selected by Collard (2007) for the data assimilation, focusing on the improvement of data assimilation performance in weather forecasting with the UM model. The channel selection was performed by considering the degree of improvement of retrieved atmospheric parameters from 1 D-Var over background atmospheric parameters. In doing so IASI 200 channels were selected amongst Collard et al. 314 channels, by a means of 1 D-Var through the comparison of simulated IASI measurements with simulated background field. In addition to channels used by the UM assimilation system, channels in ozone absorption band and IASI band 3 (2000 cm-1~) were also included. Before applying newly selected channels to the UM data assimilation system, we performed the trial test of Observation Processing System (OPS) known as a quality-control process. It is found that the use of ozone channels (1014.50 cm-1~1062.50 cm-1) resulted in significantly reduced number of IASI observations passing the OPS quality control because of uncertain ozone profiles produced by UM model. Therefore selected channels over the ozone absorption band were removed from the test. In order to assess the effect of selected channels in the data assimilation system, the data assimilation performance was tested for the summer and winter period. In the O-B analysis, both temperature and water vapor in the background field appear to be substantially improved when simulated results are compared with AMSU-A and AMSU-B measured brightness temperatures in CO2 and water vapor channels.

7.04 Implications of Observation Error Correlation on the Assimilation of Interferometric Radiances

Presenter: Reima Eresmaa

Authors: Reima Eresmaa, Niels Bormann and Tony McNally

Theoretical studies show that presence of observation error correlation can benefit linear analysis, if projection of background error correlation in observation space is sufficiently small. Current operational data assimilation systems make little attempts to exploit the full potential associated to this theoretical characteristic. Instead, system design and observation selection procedures are usually based on the assumption of uncorrelated observation errors. In the special case of interferometric radiances, this unnecessarily constrains channel selections, because signal apodization is known to introduce strong inter-channel error correlations between adjacent channel pairs. To better exploit the observation error correlations in practical data assimilation, we have derived channel selections where the observation error correlation associated to signal apodization is explicitly taken into account. In the case of the Infrared Atmospheric Sounding Interferometer radiances, this approach is found to increase the theoretical information content over the operationally-used channel selection. Experiments using real radiance data suggest improved data assimilation system performance, most notably in stratosphere.

7.05 An Observing System Simulation Experiment to Evaluate the Future Benefits of MTG-IRS Data in a Fine-scale Weather Forecast Model

Presenter: Stephanie Guedj

Authors: S. Guedj, V. Guidard, B. Menetrier and J.F. Mahfouf

The primary objective of the future Meteosat Third Generation (MTG)-InfraRed Sounder (IRS) mission is to complement the current operational meteorological observing system for regional and convective-scale Numerical Weather Prediction (NWP) in Europe. The aim of this study is to assess whether the MTG-IRS instrument can have a significant beneficial impact on the operational Meteo-France AROME convective scale model. The standard way to do such a study is to carry out an Observing System Simulation Experiment (OSSE). The goal is to realistically simulate the radiance observations, a known artificial "truth" referred to the "Nature Run", and to reproduce the statistical characteristics in a real system. To do so, the specification of realistic estimates of observation errors (variance, covariance, error correlation) are crucial for the simulation and the assimilation of MTG-IRS data. In this work, we have used real radiance measurements from operational instruments as a proxy to evaluate the error characteristics that should affect forthcoming MTG-IRS measurements. Horizontal and inter-channel error correlations are diagnosed from three methods. Then, the full operational observing system is simulated from a "Nature Run" covering 3 periods of 3 months (free-run global ARPEGE forecast fields). Furthermore, preliminary synthetic MTG-IRS radiances were produced and evaluated. The simulated radiances are then assimilated into the AROME model using a 3D-Var assimilation system. Several calibration experiments have been run to mimic as close as possible a real forecasting system, by tuning mainly the satellite observation errors. The results from cycling data assimilation

and forecast with and without MTG-IRS radiances, are discussed.

7.06 Hyperspectral Infrared Sounding Missions - Future Perspectives for Data Dissemination

Presenter: Kenneth Holmlund
Authors: Kenneth Holmlund

With the advent of new satellite systems there will be a significant increase in observational data. In particular data from hyperspectral instruments will present a significant challenge on data redistribution not only in terms of volume of data to be disseminated, but also from a user perspective on data handling and processing. Several alternatives to deal with these challenges are being explored, like the use of principal component analysis of hyperspectral data to reduce the total volume, but also the distribution of only subsets of uncompressed data can be considered. Most importantly an emerging need is to enter a dialogue with the user community on refining the requirements for data redistribution, with a detailed understanding of the impact of various strategies and options on the user applications. This paper will discuss the potential impact of various redistribution approaches and introduces basic concepts for categorisation of user applications and how they map to future strategies for data services, including dissemination.

7.07 Challenges in Data Compression for Current and Future Imagers and Hyperspectral Sounders

Presenter: Nigel Atkinson
Authors: Nigel Atkinson

For current high-volume datasets such as IASI, near-real-time dissemination of the full-spectrum presents a challenge, but is nevertheless achievable within current bandwidths constraints: e.g. EUMETCast has the capacity to handle IASI data from two Metop satellites. However, this will not be the case for data from the hyperspectral sounder on Meteosat Third Generation - the MTG-IRS instrument will have an uncompressed data volume for spectra that is 30 times higher than IASI. In this presentation we will look at the principles for efficient data compression, considering lossless, near-lossless and lossy techniques. It is shown that appropriate normalisation of the spectrum (usually by the instrument noise) is a key to efficient compression - with implications for the design of level 1 data formats. EUMETSAT's compact VIIRS format is a good example of a format that has been designed with compression in mind, rather than as an afterthought. Principal Component (PC) compression is well known in the IASI community, and has the potential to separate signal and noise - though the technique has not so far been widely exploited in operations. Furthermore, PC compression is EUMETSAT's baseline for near-real-time dissemination of MTG-IRS data. Less well-known are the various options for near-lossless compression of the data - which are particularly relevant to archiving and non-real-time activities. The tradeoffs will be illustrated using simulated MTG-IRS spectra, derived from IASI. It is shown that PC-compressed MTG-IRS data is expected to have a data rate of around 1.6GB/h - slightly higher than two IASI instruments. PC residuals could be added, which would increase the data rate by a factor 3-6, depending on what level of error can be tolerated. Different products could be considered, depending on requirements for timeliness and availability.

Session 7b: Advanced IR: Assimilation

7p.01 Assimilation Experiments Using Non-diagonal Observation Error Covariances at Environment-Canada

Presenter:Louis Garand (for Sylvain Heilliette)
Authors: Sylvain Heilliette, Ping Du, Louis Garand

Model background and observation error statistics are key inputs of modern data assimilation systems used in Numerical Weather Prediction. For a long time, it was often assumed in operational context that the observation covariance error matrix is diagonal. The neglected errors correlations were, in principle, accounted for indirectly via, for example, data thinning or error inflation. In the case of radiances from vertical sounders, the advent of hyperspectral infrared sounders such as AIRS (Atmospheric Infrared Sounder), IASI (Infrared Atmospheric Sounding Interferometer) and the recently launched CrIS (Cross-track Infrared Sounder) with their thousands of channels represented an important challenge for the data assimilation community. Recently, inter-channel observation error covariances matrices were estimated for these instruments by various authors (e.g. Garand et al. 2006, Bormann et al. 2010) using different methods which gave consistent results. The purpose of this work is first the estimation of radiances observations error statistics including their inter-channel correlations and then the study of the impact of their use in a near operational context in Environment Canada's Envar global assimilation system.

7p.02 Accounting for Correlated Observation Errors in the Assimilation of High Resolution Sounder Data

Presenter: William Bell (for Peter Weston)
Authors: Peter Weston

Since January 2013 data from IASI are used with a full observation error covariance matrix within the Met Office 4D-Var assimilation scheme, accounting for correlations between channels. This

has been shown to lead to improved use of the water vapour sensitive channels and an associated improvement in forecast accuracy. The correlated observation errors were estimated using a posteriori diagnostics using data from the Met Office 4D-Var data assimilation system. The current scheme only accounts for correlated errors for IASI but results from tests to account for inter-channel correlations from other high resolution IR sounders such as AIRS and CrIS will be presented. Accounting for the correlations leads to different weights being given to observations depending on the relationship of the most correlated channels' first guess departures. Several case studies in a 1D-Var assimilation scheme will be shown to explain this behaviour. The main source of error which contributes to the inter-channel error correlations is representativeness error, which results from a scale mismatch between the observations and the model background. It is difficult to isolate and accurately quantify this source of error but there are techniques which can be used to estimate it. Results from running the 4D-Var assimilation at different model and observation resolutions will be shown.

7p.03 Assimilating IASI Data into the Met Office UKV Convective Scale Model

Presenter: William Bell (for Peter Weston)
Authors: Peter Weston

The Met Office UKV is a convective scale model at 1.5km resolution with LBCs provided by the global model (25km resolution) and forecasts are run out to 36 hours. The model is initialised 8 times per day using a 3D-Var assimilation scheme with a 3 hour window. Currently the only satellite radiances directly assimilated into this model are SEVIRI clear sky radiances from the geostationary satellite Meteosat-10 and MHS high resolution radiances from NOAA-18 & 19 and MetOp-A & B. In this paper the potential for additionally assimilating IASI will be assessed. Several tuneable aspects of the assimilation configuration will be investigated. These will include how the data are thinned with potential options being using the most homogeneous FOV of the 4 FOVs in one FOR (as used in the global) or using all 4 FOVs. In the global model IASI data are thinned to one observation per ~100kmx100km box but in the UKV the data can be used more aggressively with several thinning box sizes tested, including no thinning at all. The observation errors include contributions from scale mismatch which will be different in the UKV from the global so the errors used in the experiments will be diagnosed using a posteriori diagnostic methods and tuned as required. At the Met Office a static bias correction procedure is still used in the global model and so the performance of this same scheme will be assessed in the UKV. It is thought that the LBCs from the global model will provide all of the information on the large scale synoptic features and that any data being assimilated will only provide useful information on small scale features in the cloud and humidity fields. For this reason the channel selection for IASI will be experimented with and in particular comparing using the full 138 channel selection used in the global against just using surface and water vapour sensitive channel s which are more sensitive to smaller scale features. The effect of assimilating IASI data on the model variables in the analysis increments will be investigated and results from OSEs using a variety of potential configurations will be shown.

7p.04 IASI Quality Control at KIAPS and Preliminary Results

Presenter: Su Jin Ha
Authors: Su Jin Ha, Hyoung-Wook Chun

Radiance data needs quality control for better results of data assimilation. This study mainly investigates IASI data quality control, especially blacklisting and threshold setting at KIAPS (Korea Institute of Atmospheric Prediction Systems). After quality check to see if the data satisfy certain preconditions, the data are flagged for each condition variable in a binary manner. Quality Control on brightness temperature (TB) measurements is performed when the input data, i.e. background TBs and observed TBs, are outside the normal range or when an error occurs in the process of bias correction or calculation of the observation operator of RTTOV. When the difference between observations and forward modeled NWP background values exceeds a threshold, the data is eliminated even if the data passes the preceding procedures. A strict threshold can enhance the data quality but lower the data acceptance rate. A permissive threshold might accept more data possibly compromising the data quality. Finding an optimal threshold is critical in data preprocessing. This study investigates various methods to determine an optimal threshold and the results will be presented. To test blacklisting, we analyzed surface types and day/night monthly means and standard deviations of the background innovations of corrected observations. The monthly means of most of the ocean data evenly centered around 0.1K, while those of the land data have a comparatively large range of about 0.3 ~ -0.6 K. The preliminary results of blacklisting for one month period of November, 2012 as part of the IASI quality control at KIAPS will be presented together with the results of the threshold setting tests.

7p.05 IASI Radiance Data Assimilation within KIAPS-LETKF System

Presenter: Ji-Sun Kang and Byoung-Joo Jung
Authors: Ji-Sun Kang, Byoung-Joo Jung, Hyoung-Wook Chun, and Youngsoon Jo

Korea Institute of Atmospheric Prediction Systems (KIAPS) has successfully implemented Local Ensemble Transform Kalman Filter (LETKF; Hunt et al. 2007) data assimilation system to NCAR CAM-SE model that has fully unstructured quadrilateral meshes based on the cubed-sphere grid, known as the same grid system of KIAPS-Global Model now developing. The KIAPS-LETKF system (Kang et al., 2013) has also adopted most advanced data assimilation techniques such as an adaptive multiplicative inflation (Miyoshi, 2012), an estimation of ensemble forecast sensitivity to observations (EFSO; Kalnay et al. 2012) and proactive quality control (PQC; Ota et al. 2013). Adaptive multiplicative inflation helps avoid a spread of background ensembles collapsing (so-called a filter divergence) especially over data-rich areas, and thus ensemble forecast continues to generate a reasonable background error covariance. EFSO provides very useful information of how much and how well each observation set influences forecast errors in time and space. Furthermore, PQC can be easily performed along with EFSO, which identifies the observations causing forecast failure so that one lets the analysis reprocessed without the selected poor observations. With those promising tools in the KIAPS-LETKF system, we plan to assimilate conventional data as well as various remote sensing data such as AMSU-A, IASI, GPS RO, which an observation preprocessing team at KIAPS has processed. In this study, we will present our assimilation strategy of IASI radiance data and show preliminary results at the conference.

7p.06 Assimilation of AIRS and IASI Radiances at JMA Global NWP System

Presenter: Akira Okagaki

Authors: Akira Okagaki and Hidehiko Murata

Aiming to the operational use of the radiance data from hyper spectral infrared sounders, such as AIRS/IASI/CrIS, the assimilation method and impact of them are studied. In this study, clear-sky radiances from AIRS and IASI in the temperature sensitive-channels are assimilated. Channels sensitive to model top or surface are excluded from active assimilation. A simple cloud screening scheme using the long-wave window channels and the cloud top height estimation scheme (minimum residual method) are implemented for the clear sky radiance assimilation. These schemes employ only passive channel data to avoid erroneous interaction between cloud contamination and VarBC. Assimilation and forecast experiments are performed about one month period. The experiment results showed positive impacts on analysis and forecast accuracy especially on upper-troposphere and lower-stratosphere. Effects of upgrades of JMA global NWP system (increase of vertical resolution (60 to 100), extension of model top (0.1hPa to 0.01hPa)) in the hyper spectral infrared sounders assimilation will be presented.

7p.07 Assimilation of Atmospheric Temperature and Moisture Soundings from AIRS for Hurricane Forecasts in Regional NWP

Presenter: Jing Zheng

Authors: Jing Zheng, Jun Li, Jinlong Li and Zhiquan Liu

The objective of this study is to investigate the impacts of AIRS soundings on hurricane forecasts. By using the three-dimensional variation (3DVAR) methodology, AIRS soundings are assimilated into the Weather Research and Forecasting model (WRF). Both single field-of-view (SFOV) retrievals from UW/CIMSS and AIRS science team sounding product are tested in the assimilation. A series of cycling numerical experiments for Hurricane Ike (2008), Hurricane Irene (2011) and Typhoon Saola (2012) are conducted. The control experiments include the conventional observations. Results show improvements of hurricane track due to assimilating the AIRS temperature soundings. The potential impact of assimilating moisture information is also discussed.

Session 8a: Retrieval Studies

8.01 The Operational IASI L2 at EUMETSAT

Presenter: Thomas August

Authors: Thomas August, Tim Hultberg, Marc Crapeau, Xavier Calbet, Dieter Klaes, Rose Munro, Cathy Clerbaux, Pierre-François Coheur, Daniel Hurtmans

Geophysical parameters from the IASI instrument on Metop-A are essential products provided from EUMETSAT's Central Facility in near real time. They include vertical profiles of temperature and humidity, related cloud information, surface emissivity and temperature, and atmospheric composition parameters (CO, ozone and several other trace gases). We will present the current developments and the future evolutions of the IASI L2 processor operated at EUMETSAT forming the version 6 (v6), which release is scheduled in April 2014. In particular we will address the integration of new atmospheric composition products from ULB/LATMOS in the scope of O3M-SAF CDOP-2, with first the retrieval of CO profiles. The cloud screening has been improved too with the addition of a third detection algorithm based on artificial neural networks and independent from NWP forecasts. We will discuss here the use of concurrent cloud detection methods and the relationship between the cloudiness estimate and the sensing products yield and quality. A quality indicator is associated to the retrieved geophysical parameters in v6. Lastly, new retrieval methods for

temperature and water-vapour sounding have been developed, including joint use of micro-wave (MW) and infrared (IR) measurements. The statistical MW+IR retrieval scheme, developed for v6, takes advantage of AMSU and MHS measurements collocated with IASI L1c spectra. It allows for sounding through the clouds in most cloud contaminated IFOVs with improved performances (typically about 1K rms) as compared to the current operational IR-based partly-cloudy retrieval. The MWIR-derived temperature and humidity profiles are used to constrain the retrieval of temperature, humidity and ozone 1D-Var retrievals in clear sky. The latter are performed with reconstructed radiances from a new channel selection and a scene-dependent bias correction, which we will present as well. Initial results with the version 6 using ECMWF analyses as reference have shown that the temperature profiles are improved by 0.2 to 0.5K rms in the lower troposphere and that the precision in water-vapour profiles is increased by 30 to 50% in the boundary layer.

8.02 The NOAA Operational Hyper Spectral Retrieval Algorithm: A Cross-comparison among the CrIS, IASI and AIRS Processing Systems

Presenter: Antonia Gambacorta

Authors: Antonia Gambacorta, Chris Barnet, Walter Wolf, Thomas King, Nick Nalli, Kexin Zang, Eric Maddy, Xiaozhen Xiong, Flavio Iturbide-Sanchez, Changyi Tian, Bomin Sun, Tony Reale and Mitch Goldberg

Since February 2013, NOAA/NESDIS/OSPO has been running three hyper spectral sounding product processing systems: 1) the Atmospheric InfraRed Sounder/Advanced Microwave Sounding Unit (AIRS/AMSU) retrieval product processing system, which has been running in near-real time since 2002; 2) the Infrared Atmospheric Sounder Interferometer/ Advanced Microwave Sounding Unit/Microwave Humidity Sounder (IASI/AMSU/MHS) NOAA unique cloud-cleared radiances and trace gas product processing system, which has been running operationally since 2008; and 3) the NOAA Unique Cross-track Infrared Sounder/ Advanced Technology Microwave Sounder (CrIS/ATMS) processing system (NUCAPS), which has become operational in the Fall of 2013. The long term strategy of NOAA/NESDIS will also involve the operational processing of the future JPSS and MetOp II and III missions, spanning a total period of ~30 years of hyper spectral remote sounding data processing. The NOAA/NESDIS/STAR Operational Hyper Spectral Retrieval Algorithm is a modular architecture that was specifically designed to be compatible with multiple instruments: the same retrieval algorithm and the same underlying spectroscopy are currently used to process AIRS, IASI and CrIS data. This property is of fundamental importance in guaranteeing homogeneity across the multi-platform integrated dataset of retrieved Environmental Data Records. The CrIS instrument was launched in October 2011 and will ensure the continuity of the afternoon orbit sounding for the next decade in replacement of the AIRS instrument. The ongoing overlapping period between AIRS and CrIS will guarantee the inter-calibration between the three instruments. The combined sounding geometry of these three hyper spectral instruments (AIRS and CrIS have a 1:30pm equator crossing time; IASI has a 9:30 am equator crossing time) and the employment of the same retrieval methodology will provide an unprecedented uniform and long-term integrated database of six global atmospheric measurements per day. The full suite of retrieval products include: 1) temperature, 2) water vapor, 3) cloud cleared radiances, 4) cloud parameters, 5) trace gases (O3, CO, CH4, CO2, N2O, HNO3, SO2). Scope of this talk is a cross-comparison among the AIRS/AMSU, IASI/AMSU/MHS and CrIS/ATMS retrieval data records using the NOAA/NESDIS/STAR Operational Hyper Spectral Retrieval Algorithm. We perform a detailed analysis of the information content and statistical performance of the three retrieval systems in order to assess their level of maturity and inter-consistency.

8.03 An Overview of the UW Hyperspectral Retrieval System for AIRS, IASI AND CrIS

Presenter: Nadia Smith

Authors: Nadia Smith and Elisabeth Weisz

The University of Wisconsin (UW) retrieval system is a data processing framework designed to derive science quality data products from hyperspectral infrared radiance measurements. The system can process measurements from any infrared hyperspectral sounder of which there are currently four operational in low-Earth orbit. They are the Atmospheric Infrared Sounder (AIRS on Aqua since 2002), the Infrared Atmospheric Sounding Interferometer (IASI on Metop-A since 2006, and Metop-B since 2012) and the Cross-track Infrared Sounder (CrIS on Suomi-NPP since 2011). The UW retrieval system progresses through a series of steps, the output of which are suitable for a range of applications from now-casting to climate change assessment. The three main steps are: (i) Level 1 (calibrated radiances) to Level 2 (geophysical retrievals), (ii) Level 2 to Level 3 (uniform application-specific statistical aggregates), (iii) Level 3 to Level 4 (a description of change of over time, such a climate trends or time-tendencies). The UW retrieval framework is a multi-sensor, multi-tier system with proven accuracy and precision. In addition, it is flexible,

efficient and robust enough to function at a range of spatio-temporal scales. We will first outline updates to the retrieval algorithm and processing framework and then illustrate its value in a range of Earth system applications.

8.04 Explicit Retrieval of Cloud and Atmospheric Properties From CrIS, IASI and AIRS Hyperspectral Data
Presenter: Xu Liu
Authors: Xu Liu, Wan Wu, Allen Larar, D.K. Zhou, Yong Han, and W.L. Smith
The Cross-track Infrared and Microwave Sounder Suite (CrIMSS) was successfully launched onboard of S-NPP in October 2011. A Principal Component-based Radiative Transfer Model (PCRTM) has been developed to explore the abundant information from both the nominal and the full resolution CrIS spectra. The nominal resolution CrIS spectra have three bands with spectral resolutions of 0.625 cm-1 for long wave IR band, 1.25 cm-1 for mid-wave IR band, and 2.5 cm-1 for shortwave IR band. The full resolution CrIS data have a resolution of 0.625 cm-1 for all three bands. An optimal estimation physical retrieval method has been used to retrieve cloud, temperature, trace gases, and surface emissivity from the CrIS and ATMS spectra. Detailed comparisons of the retrieval results from both the nominal resolution and full resolution data will be given. The same algorithm has been applied to IASI and AIRS data. Examples of applying the PCRTM model to solar spectral region will be given as well.

Session 8b: Retrieval Studies

8p.01 Use of Reconstructed Radiances in EUMETSAT's IASI Level 2 Processor
Presenter: Tim Hultberg
Authors: Tim Hultberg and Thomas August
It is well known that hyper-spectral infrared radiances, like IASI measurements, can be represented by a small number of principal component (PC) scores, with almost no loss of atmospheric information. The same is true for a small subset of radiances, reconstructed from these PC scores, provided that the subset is selected in such a way that the corresponding sub-matrix of the PC's is invertible. We show how to make this selection and efficiently extract the atmospheric information in the measurements by optimal estimation retrieval based on a small subset of reconstructed radiances. A second reconstruction, using forward model PC's, is applied to the radiances in order to suppress instrument artefacts, which, although being small, do otherwise affect the retrievals negatively.

8p.02 Consistency Validation of GRUAN Sondes and IASI Radiances
Presenter: Thomas August (for Xavier Calbet)
Authors: Xavier Calbet; Marc Crapeau; Thomas August
Comparisons of observed IASI radiances with radiances calculated from SALSTICE sonde profiles and the OSS Radiative Transfer Model (RTM) are made. Some conclusions on the logistic of the measurements are discussed.

8p.03 Optimization of Principal Component Regression Method for Retrieving Temperature and Moisture Profiles from Infrared Hyper-Spectral Measurements over East Asia and its Use for Improving Accuracy of Physical Retrieval
Presenter: Hyun-Sung Jang
Authors: Hyun-Sung Jang, Byung-Ju Sohn, Jun Li, Jinlong Li, and Elisabeth Weisz
Since accuracy of physical retrieval from atmospheric sounder measurements is significantly affected by quality of initial guess, we optimized a regression retrieval method to provide high-quality initial guess field for the physical retrieval of atmospheric temperature and moisture states. In doing so, optimized statistical relationship between atmospheric states and compressed Atmospheric Infrared Sounder (AIRS) radiances was obtained by using least squares analysis of simulated radiances from four-year (2006-2009) ECMWF interim data over East Asia. Because previous study suggested that accuracy of regression retrieval highly depends on degree of atmospheric moistness and surface types, regression coefficients were obtained at geographically varying 10°×10° sub-grid box over the East Asian domain. Also seasonally changing moisture and surface conditions during the regression procedures were taken into account. Error analysis indicates that mean bias of temperature and moisture profiles retrieved from simulated radiance is close to 0 throughout the layers. RMS errors for temperature in troposphere above 850 hPa are between 1 and 2 K while retrieved moisture shows that RMS errors around 850 hPa are around 2 g/kg with a decreasing tendency with height. In comparison to the regression retrievals based on global set of training data, optimized regression retrieval for East Asia shows better results in terms of mean bias and RMS error for the given simulated radiances over the East Asian domain. In addition, accuracy of physical retrieval also is improved when optimized retrieval was used as initial guess.

8p.04 Characteristics of Global Conventional RAOBs and Their Use in Satellite Sounding Product Validation: An Analysis of 3-yr NPROVS Collocation Data
Presenter: Bomin Sun

Authors: Bomin Sun and Anthony Reale
Upper air temperature and humidity observations have been made by balloon-borne radiosonde instruments for many decades. These conventional radiosonde and dropsonde observations (RAOBs) have historically been used as a commonly accepted reference dataset in satellite sounding product validation. The NOAA Products Validation System (NPROVS) (http://www.star.nesdis.noaa.gov/smcd/opdb/poes/NPROVS.php), supported by the NOAA Joint Polar Satellite System (JPSS) in conjunction with the NPP CrIS/ATMS EDR Cal/Val program, utilizes global RAOBs as the anchor to bring together a suites of satellite atmospheric sounding products (from polar, geostationary and GPSRO) for their routine monitoring and intercomparison. This presentation provides an overview of the major characteristics of radiosonde data in the context of satellite product validation based on our several relevant publications. We summarize the accuracy of radiosonde temperature and humidity measurements, and meteorological conditions particularly of temperature inversion and moisture abrupt change that radiosondes routinely sample. We show how these characteristics are reflected in the performance evaluation of satellite products and what we need to be aware of when we use conventional RAOBs for satellite validation. We also demonstrate the overall usefulness of conventional RAOBs in satellite product validation by analyzing 3 years of NOAA IASI-RAOB collocation data collocated via NPROVS, with the aim to understand the relationship between clouds, temperature and humidity in the IASI retrievals. We discuss how such collocation data analysis can advance our understanding of the internal consistency of major components within the retrieval system and, furthermore, if major geophysical variables derived from the hyper spectral sounder represent a nominal level of maturity for application in climate monitoring. Finally, we introduce the ongoing effort within STAR NESDIS on the Suomi-NPP sounding product development and validation. By using routinely available satellite synchronized dedicated and GCOS Reference Upper Air Network (GRUAN) radiosonde data which provides measurement uncertainty, we are able to characterize in a statistically robust way the performance of the CrIS/ATMS sounding products and enhance further the improvement of retrieval algorithms.

8p.05 Using GPS Radio Occultation in the Validation of IR Temperature Sounding Profiles from CrIS, IASI, and AIRS
Presenter: Robert Knuteson
Authors: Michelle Feltz, Robert Knuteson, Henry Revercomb, Dave Tobin, and Steve Ackerman
This paper presents a general methodology for validating temperature profile retrievals from the advanced IR sounders AIRS/AMSU, IASI/AMSU, and CrIS/ATMS around the range of 10 – 300 hPa. The Cross-Track Infrared Microwave Sounding Suite (CrIMSS) uses combined observations from the Advanced Technology Microwave Sounder (ATMS) and the hyperspectral infrared Cross-track Infrared Sounder (CrIS) on the Suomi NPP satellite, the first satellite of the newly created U.S. JPSS program. The atmospheric vertical temperature profiles (AVTPs) from the CrIMSS operational product are compared to temperature profiles obtained from radio occultation (RO) from the COSMIC GPS RO network. In particular, bias, RMS, and standard deviation profile statistics will be presented for global and 30 degree latitude zones for selected time periods since launch the Suomi NPP satellite. Similar validation statistics using AIRS and IASI profile matchups with COSMIC have been created for the same space and time periods. The COSMIC GPSRO network has the spatial coverage, time continuity, and stability to provide a common reference for comparison of the sounding profile products from sensors on multiple platforms. This common temperature reference facilitates intercomparison of sounding retrieval methods and highlights differences among sensor products. In particular, the CrIMSS Mx6.3 to Mx7.1 version update will be assessed and highlighted.

8p.06 CIMSS IAPP Retrieval Software: Updates, Application and Validation
Presenter: Szuchia Moeller
Authors: Szuchia Moeller, Robert Knuteson, Elisabeth Weisz
The IAPP (International ATOVS Processing Package) was developed to retrieve profiles of atmospheric temperature and moisture, atmospheric total ozone, and other parameters including cloud properties using ATOVS radiance measurements. IAPP, which operates on NOAA-15 and later platforms, has been updated to include Metop-B. The forward model employed by IAPP is the Pressure Layered Fast Algorithm for AtmoSpheric Transmittance (PFAAST), which is developed for historical, current, and future satellite instruments such as HIRS, AVHRR, GOES sounder and imager, and most recently VIIRS on SNPP. Recent updates on PFAAST include the use of the latest version of LBLRTM (Line-by-Line Radiative Transfer Model). A summary of IAPP and PFAAST updates is provided. Furthermore, shifts in HIRS CO2 and H2O band spectral response functions have been tested for impact on IAPP retrievals. Case study results are presented from a recent validation campaign.

8p.07 Assessing the Ability of IR Sounders in Detecting Extreme Weather Events and Predicting Extreme Floods

Presenter: Jacola Roman
Authors: Jacola Roman, Robert Knuteson, and Steve Ackerman

Precipitable Water Vapor (PWV) is defined as the amount of liquid water that would be produced if all of the water vapor in an atmospheric column were condensed. It is a very useful parameter for forecasters to determine atmospheric stability and the probability of convection and severe weather, making it critical for determining the occurrence of extreme weather events. The IPCC 4th Assessment found that changes in the frequency of extreme events, such as droughts, heat waves, and floods, are expected to increase. Extreme PWV events are predicted to increase by a factor of 5-50 between 2000-2025 and 2075-2100, depending on the season and region. The Atmospheric Infrared Sounder (AIRS) on the NASA Aqua satellite was the first of a new generation of satellite sensors that provided the capability to retrieve water vapor profiles at high vertical resolution and good absolute accuracy over both ocean and land areas using the same algorithm. The operational follow-on to the AIRS is the Cross-track Infrared Sounder (CrIS) successfully launched on the Suomi NPP satellite on 28 October 2011. The CrIS, along with ATMS, will provide the U.S. component of the joint U.S./European operational weather satellite system. A long record of observations from copies of these sensors is anticipated from this new network of advanced IR sounders. Among other atmospheric observables, the NASA AIRS science team has produced a global dataset of PWV beginning in September 2002 that is approaching ten years in length. The Infrared Atmospheric Sounding Interferometer (IASI) was launched on METOP-A in October 2006 and is currently operated by EUMETSAT. IASI offers a global dataset of PWV starting in November 2007, and is anticipated to provide a long record of observations. Validation data used for this study is from the ground based GPS network (SuomiNet) and the conventional meteorological network as represented in NWP reanalysis products. This paper investigates the ability of IR sounders to retrieve PWV during extreme weather events. Additionally, a cumulative sum method will be used to examine the predictability of PWV for extreme flooding cases. Results are presented that highlight the extreme moisture during extreme flooding events through case studies, and quantify the differences and agreement between satellite retrievals and ground-based observations. In addition, the probability of extreme rain given extreme moisture will be examined.

8p.08 Simulation Test of the Atmospheric Instability Indices Regression Directly with the Geo. Interferometric Infrared Sounder (GIIRS) Observation

Presenter: Hui Liu, Chunqiang Wu, Jun Li
Authors: Hui Liu, Chunqiang Wu, Jun Li

The FengYun-4(FY-4) series geostationary meteorological satellite is the new generation of Chinese geostationary orbit meteorological satellites. The first FY-4A satellite is scheduled to be launched in 2015. The Geo. Interferometric Infrared Sounder(GIIRS) with High-spectral resolution onboard FY-4A will have a capability of continuous monitoring about the atmospheric state, the surface information and the cloud properties. Li et al (2012) show that advanced infrared sounders such as the Atmospheric Infrared Sounder (AIRS) and Infrared Atmospheric Sounding Interferometer (IASI) provide atmospheric temperature and moisture profiles with high vertical resolution and high accuracy in preconvection environments. The derived atmospheric instability indices such as convective available potential energy (CAPE) and lifted index (LI) from advanced IR soundings can provide critical information 1:6 h before the development of severe convective storms. Compared to AIRS, IASI and other advanced infrared sounders, GIIRS is insured by the 60 min repeat cycle and also up to 16km pixel resolution, providing forecasters with useful information much more frequently than the soundings available only twice daily from polar orbiting meteorological satellites. The high-spectral resolution, the broad range of spatial coverage and the high temporal resolution mean a larger amount of data, so we had to consider time of data processing. If we want to assess the pre-convective conditions and forecast convection with a sufficient lead-time, a method must be found to get timely instability indices (i.e. Total Total index, K-Index, Lifted Index and Showalter Index) from GIIRS's data. We have done a series of tests about calculating atmospheric instability indices directly, to investigate the feasibility of direct regression instability indices with IAS FY4 Sounder observation. Tests result showed that: the accuracy of atmospheric instability indices is similar no matter that calculated directly or indirectly; direct regression instability indices spent a very short time, much faster than derived indices from the atmospheric retrieval profiles; influence of noise on the accuracy of direct regression is small; and the root mean square error (RMSE) of regression with longwave channels is bigger than shortwave channels; effects of thin clouds and high clouds are different when indices are different, ice clouds affect less than water clouds.

8p.09 Application of Artificial Neural Network for the Direct Estimation of

Atmospheric Instability from a Geostationary Satellite Imager

Presenter: Su Jeong Lee
Authors: Su Jeong Lee, Myoung Hwan Ahn, Yeonjin Lee

The Advanced Meteorological Imager (AMI) which will be onboard next generation Geostationary Korea Multi-Purpose Satellite (GEO-KOMPSAT-2A) is designed to have much better spectral, temporal, and spatial resolution compared to the first generation imager. With the improvements, many new and improved value-added products are expected to be produced. Among the new products, the atmospheric instability information is considered to be an important new possibility with the pseudo sounding capability of the imager. Although its accuracy is known to be limited, its high spatial and temporal resolution could provide a significant addition for the nowcasting activities. Here, we present a preliminary result from a new algorithm which utilizes an artificial neural network (ANN) to derive the CAPE (Convective Available Potential Energy). The new algorithm derives the instability information directly from the measured brightness temperatures instead of estimating the instability from the retrieved temperature and humidity profiles from the brightness temperatures using different retrieval algorithms such as variational, statistical, or physical approaches. The ANN algorithm is expected to reduce computational time and thus to use the original high spatial and temporal resolution data. To check the feasibility of the ANN algorithm, we use brightness temperatures simulated by a radiative transfer model with the input profiles obtained from sounding instruments onboard polar orbiting satellites. We then apply the ANN algorithm to the actual SEVIRI (Spinning Enhanced Visible and Infrared Imager) observation data. During the conference, we will introduce the characteristics of the ANN algorithm and its sensitivity, the application results with the detailed performance characteristics, and plans for future activities.

8p.10 An Analysis of Severe Weather Prediction using MODIS Real-time Direct Broadcast Satellite Data Receiving at IMD, New Delhi

Presenter: Ashim Mitra
Authors: A.K MITRA and P.K KUNDU

In this study, assessing the atmospheric instability, a new index statistically computed, named here as MODIS (Moderate Resolution Imaging Spectroradiometer) profile index (MPI), using temperature and moisture profile data from real time direct broadcast (DB) receiving systems installed at three places of India Meteorological Department (IMD). The training dataset has been prepared using MODIS temperature and moisture profile from Aqua and Terra satellites over the Indian region for clear and convective weather conditions during the period of March to June 2011. The formulation of MPI and its comparison have been examined with well established traditionally used K index (KI), Lifted index (LI) and total totals (TT) index derived from radiosonde profiles of temperature, pressure and humidity. It has been observed that in most of the cases MPI has well correlated with those derived from ground truth observations. Therefore, spatially interpolated MPI can be utilized as an indicator for regional and location specific forecast over the areas where radiosonde data is not available. The results also indicated that MPI can be used as a sensitive measure for very early stages of instability developments such as thunderstorm and rainfall because no other single stability index can provide a distinct threshold value for these events. Therefore a single MPI value at a certain threshold can be treated as a stability index instead of other available indices. It is also being proposed that the inclusion of MPI as a stability parameter in physical or numerical modeling can improve accurate local severe storm predictions as a useful predictor and can also be used as diagnostic tools

8p.11 Improving the Sounding Retrievals from Synergistic Use of Hyperspectral Radiances, Surface and GNSS Radio Occultation Observations

Presenter: Chian-Yi Liu
Authors: Chian-Yi Liu, Kai-Wei Chang, Gin-Rong Liu, and Tang-Huang Lin

The spaceborne hyperspectral infrared measurement, such as the Atmospheric Infrared Sounder (AIRS) onboard NASA's Aqua satellite, has been proved that provides a great accuracy in the atmospheric thermodynamic profiling. The AIRS sounding suggests the estimation of atmospheric thermodynamic state at the accuracy of 1K per 1-km layer and 15% per 2-km layer in temperature and moisture profiles, respectively. However, the major uncertainties are raised in the atmospheric boundary layer due to the overlapping of weighting functions at several channels. Meanwhile, atmospheric thermodynamic state has great accuracy from the GNSS radio occultation (RO) retrievals. In this study, we improve the traditional physical sounding retrieval algorithm by combining the temporal- and spatial-collocated hourly surface and FORMOSAT-3/COSMIC RO observations into the sounding procedure. The preliminary result shows the sounding performance is improved when surface observation incorporates with the satellite observation. The difference reduces not only at the lowest surface level but also in the atmospheric boundary layer, when compare the retrieved profiles to radiosonde over Dongsha Islands. This will greatly help to condition

atmospheric thermodynamic state, and reduce the retrieval uncertainties from hyperspectral radiances observation.

8p.12 LW and SW Atmosphere and Surface Retrievals in Principal Component Space from IASI, ARIES and Other Sensors Using the Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC)

Presenter: Jean-Claude Thelen

Authors: Jean-Claude Thelen, Stephan Haveman

The Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC) is based on Principal Components and allows the fast simulation of hyperspectral (satellite, air-borne and ground-based) sensors. For the simulation of scattering by clouds and aerosols, a spherical harmonics line-by-line code has been integrated into the HT-FRTC code, which is very similar to the Edwards-Slingo (ES) band radiation code. The HT-FRTC has been incorporated into a one-dimensional variational (1D-Var) retrieval system that also works solely in Principal Component (PC) space. This keeps the dimensions of the matrices involved small. The solution of the full non-linear problem is achieved with an iterative Levenberg-Marquardt minimisation procedure. The variational retrieval system creates a lot of diagnostics, in addition to the solution, like the degrees of signal as a measure of information content gained. The use of PCs allows the simultaneous retrieval of the atmospheric profiles and the surface properties such as the surface emissivity and the surface temperatures, while the incorporation of the scattering code allows for retrievals in the long-wave and the shortwave. This code has been used to retrieve atmospheric and cloud parameters from IASI and from the ARIES (Atmospheric Research Interferometer Evaluation System) instrument, which flies on board of the Met Office BAe-146 research aircraft. In addition the HT-FRTC code has also been used to retrieve the surface properties from airborne/spaceborne hyperspectral imagers such as AVIRIS and Hyperion 1.

8p.13 Evidence of Pollutants Transport from Indian Sub-continent Across Himalaya Using AIRS data

Presenter: Ramesh Singh

Authors: Ramesh P. Singh

The Indo-Gangetic plains (IGP) is one of the most atmospheric polluted regions of the world, home of 900 million people. The IGP suffers with intense atmospheric pollution almost all the seasons (winter, summer, pre-monsoon and monsoon) and the pollutants move from west to east in the IGP which is like basin, with the gentle easterly slope. The movement of the pollutants depends on the meteorological conditions (wind direction, wind speed and relative humidity), the pollutants are the main cause of dense haze, fog and smog especially during the winter season. Detailed analysis of Atmospheric Infrared Sounder (AIRS) data at different locations over Indian subcontinent and across Himalaya shows contrast concentrations of trace gases and also atmospheric water vapor and relative humidity at different altitudes. These changes are attributed to the fine particles of dust and smoke which are lifted over the IGP plains and crosses the Himalaya region. The sources of atmospheric pollution and their atmospheric characteristics will be discussed in detail. The crossing of the atmospheric pollutants from Indian content is also supported from the HYSPLIT back trajectories and CALIPSO data. We will present the movement of pollutants from Indian subcontinent across Himalaya region at different altitudes and its impact on the warming of troposphere and melting of snow and glaciers of Himalaya.

Session 9a: Assimilation Studies: Clouds

9.01 All-sky Assimilation of MHS and HIRS Sounder Radiances

Presenter: Stephen English (for Alan Geer and Fabrizio Baordo)

Authors: Geer A., F. Baordo, S.J. English

Both microwave and infrared sounder radiances are sensitive to cloud. For many years a successful strategy for handling this in data assimilation has been to detect the observations affected radiatively by cloud and to not assimilate these data. There are two drawbacks to this approach. The first, obviously, is that there are large data gaps, especially for radiances sensitive to the lower troposphere and boundary layer. The second is that the data selection is biased, and strictly we should also reject data where the model state has cloud even if the observation is cloud-free. In practise this is not done, and the data assimilation risks introducing a bias through biased data sampling. This bias can be removed through automatic bias correction but it is clearly sub-optimal. Microwave imager data has been successfully assimilated through a so-called all-sky route, where instead of rejecting cloud affected data the observation operator includes a cloud model and the observation error is a function of both model and observed cloud. This creates an unbiased assimilation, and one with greater coverage. Recently it has been possible to consider extension of this approach to sounding channels. Initial work looked at microwave temperature sounding channels, because the wavelength of observation is similar to the microwave imaging channels already used. However the benefit of the additional temperature information was small. More encouraging results have been obtained applying

the technique to humidity sounding channels, especially those from microwave humidity sounders, though this required improvements in radiative transfer model accuracy for ice cloud scattering at 183 GHz. The data gives a notable positive impact not only on humidity fields, but also on wind fields. This impact is found both for cloud-free scene assimilation and the all-sky approach, but the impact is larger in the latter. The wind impact mechanism may be multi-variate relationships implicit in 4D-var, possibly including a tracer element through the dynamics. This presentation will summarise recent progress and future direction in this area.

9.02 Improved Initialization and Prediction of Clouds with All-Sky Satellite Radiances

Presenter: Tom Auligne
Authors: Tom Auligne

The initialization of cloud parameters is one of the next frontiers for improving short-term prediction skills in numerical weather prediction models. We will present the latest developments in building a capability to accurately initialize cloud microphysical parameters based on all-sky satellite radiances from multiple infrared and microwave sensors assimilated in the Weather Research and Forecasting (WRF) numerical model. The prototype uses a hybrid ensemble/variational data assimilation system with an augmented control variable for clouds, flow-dependent multivariate background errors and specific developments to address non-linearities in the observation operator and non-Gaussian error distributions related to cloud parameters. The impact of the cloud initialization on subsequent forecasts will be demonstrated.

9.03 New Developments for the Use of Microphysical Variables for the Assimilation of IASI Radiances in Convective Scale Models

Presenter: Nadia Fourrie
Authors: P. Martinet, N. Fourrie, F. Rabier, L. Lavanant, A. Gambacorta, T. Montmerle, P. Brunel, V. Guidard, Y. Bouteloup, E. Bazile

Nowadays, most data assimilated in numerical weather prediction come from satellite observations. However, the exploitation of satellite data is still sub-optimal with only 10 to 15% of these data assimilated operationally. Keeping in mind that about 80% of infrared data are affected by clouds, it is a priority to develop the assimilation of cloud-affected satellite data. The hyperspectral infrared sounder IASI has already contributed to the improvement of weather forecasts thanks to its far better spectral resolution and information content compared to previous instruments. The use of cloud-affected IASI radiances is still very complicated due to the high non-linearity of clouds in the infrared. The Martinet's PhD work suggests an innovative way to take advantage of cloud-affected radiances observed by IASI. The advanced interface RTTOV-CLD included in RTTOV using cloud microphysical properties (liquid and ice water contents, cloud fraction) from the model forecast has been evaluated [1]. The use of such radiative transfer model is necessary with the view of adding the cloud variables into the state vector of the variational assimilation system. Moreover, the potential benefit of an additional channel subset to be exploited under cloudy conditions has been studied [2]. Thanks to this new scheme, profiles of cloud water contents have been successfully retrieved from IASI cloud-affected radiances with a one dimensional variational assimilation scheme (1D-Var). The impact of these data in terms of analysis and evolution of cloud variables has been evaluated in a numerical weather prediction model. This study is the first step in evaluating the choice that has been made for the control variables used during the retrievals. A simplified one-dimensional version of the AROME model was used to run three-hour forecasts from the 1D-Var analysed profiles in order to study the capability of the convective scale model AROME to keep the cloudy increments provided by the 1d-Var. The evolution of the total cloud water content is compared when the AROME forecast is initialized with the analysis resulting from the 1D-Var or with the initial background. Promising results have shown a good maintenance of the analysis increment during more than one hour and a half of forecast. In regard to these encouraging results, a positive impact on nearcasting applications and forecasts of heavy rainfall events, which are highly coupled to cloud variables, can be expected in the future. References [1] P. Martinet, N. Fourrie, V. Guidard, F. Rabier, T. Montmerle, and P. Brunel. Towards the use of microphysical variables for the assimilation of cloud-affected infrared radiances, QJRMS, doi: 10.1002/qj.2046, 2013. [2] P. Martinet, L. Lavanant, N. Fourrie, F. Rabier, and A. Gambacorta. Evaluation of a revised IASI channel selection for cloudy retrievals with a focus on the mediterranean basin, QJRMS, DOI: 10.1002/qj.2239, 2013.

9.04 Characterizing the Impact of Hyperspectral Infrared Radiances near Clouds on a Global Atmospheric Analysis

Presenter: Will McCarty
Authors: McCarty, Will

Hyperspectral infrared measurements from modern instruments, namely the Atmospheric Infrared Sounder (AIRS), the Cross-Track Infrared Sounder (CrIS), and the Infrared Atmospheric Sounding Interferometer (IASI), are highly sensitive to the presence of clouds within a field-of-view. The Goddard Earth Observing System (GEOS)

atmospheric data assimilation system, which utilizes the Gridpoint Statistical Interpolation (GSI) algorithm, is employed at the Global Modeling and Assimilation Office (GMAO) at NASA Goddard Space Flight Center. In routine forward processing, it only considers observations that are insensitive to clouds. This screening is performed by retrieving the cloud height of an observation using a minimum residual method and then excluding channels sensitive to clouds by comparing the retrieved cloud height with their respective transmittance profiles. Certain assumptions within the minimum residual retrieval, however, can be violated in any measured spectrum affected by clouds. Specifically, there is no guarantee that the clouds will have only a single layer or that the cloud emissivity is constant in wavenumber. Additionally, the channels used in the cloud height retrieval may be suboptimal. These issues will all be evaluated under the framework of both traditional observation statistical metrics (e.g. observation departures, observation bias correction) as well as the observation impact calculations, as described in Gelaro et al. (2010). Also, intercomparisons among various sensors (e.g. AIRS and MODIS, AIRS and CloudSat/CALIPSO) will be used to further analyze the metrics investigated. This work is being performed in conjunction with an effort to expand hyperspectral infrared radiance assimilation to further assimilated cloud-affected radiances. This effort will analyze the "gray" area between clear-only infrared radiance assimilation and clear and near-opaque cloudy infrared radiance assimilation.

9.05 Handling Clouds for Hyperspectral Infrared Radiance Assimilation

Presenter: Jun Li

Authors: Jun Li, Pei Wang, Jinlong Li, Zhenglong Li, Timothy J. Schmit, and Wenguang Bai

Accurate cloud detection is very important for hyperspectral infrared (IR) radiance assimilation; a better cloud detection could reduce the data rejection and improve the radiance assimilation. Although the operational centers are using IR sounder data alone for cloud detection, the collocated high spatial resolution imager data could help sounder sub-pixel cloud detection and characterization. Besides better sounder cloud detection with collocated imager, assimilating cloudy radiances is very important in order to take full advantage of IR sounder thermodynamic information in the tropical cyclone (TC) inner core region. Usually only clear IR channels (not affected by clouds) are used in most of data assimilation systems, and cloud contaminated channels have not been used effectively due to difficulties in modeling clouds in both forecast and radiative transfer models. An optimal imager/sounder cloud-clearing technique has been developed at CIMSS (Li et al. 2005), this method can retrieve clear column radiances through combining collocated multi-band imager (e.g., MODIS) IR clear radiances and the sounder (e.g., AIRS) cloudy radiances, and no background information is needed in MODIS/AIRS cloud-clearing. Although only ~13% of the AIRS footprints are found clear, about additional 21% of the AIRS footprints can be cloud cleared successfully with MODIS. The imager/sounder cloud-clearing is similar to AMSU/AIRS cloud-clearing (Susskind et al. 2003) for deriving the clear equivalent radiances, but retains the original IR sounder spatial resolution, which is ideal for regional NWP applications. We have investigated the assimilation of IR sounder radiances by better cloud detection and cloud-clearing using AIRS/MODIS as example, for hurricane Sandy (2012) forecast experiments with WRF (Weather Research and Forecasting) as the forecast model and 3DVAR based GSI (Gridpoint Statistical Interpolation) as the analysis system. Results indicate that forecasts of both hurricane track and intensity are substantially improved when collocated high spatial resolution MODIS cloud mask is used for AIRS sub-pixel cloud detection and cloud-clearing for radiance assimilation. The techniques can be applied to process CrIS/VIIRS and IASI/AVHRR for radiance assimilation in NWP.

Session 9b: Cloud and Precipitation Studies

9p.01 Two Approaches of Assimilation of Cloud-affected Infrared Radiances

Presenter: Kozo Okamoto

Authors: K. Okamoto, A. P. McNally, W. Bell

Assimilating cloud affected infrared radiances is challenging due to its non-gaussianity, high nonlinearity and complex processes. We are working on two approaches to the assimilation: One approach is based on a single-layer opaque cloud assumption. We assimilate cloudy radiances of MTSAT imager after carefully examining the validity of this approach. Although this implementation is relatively simple and requires low computational cost, marginal impact is obtained because only partial data satisfy the assumption. The second approach is based on the "all-sky" assimilation that treats more general situations including thin, multi-layer clouds. To progress this approach, we are making preliminary investigation about the cloud effect on observation-minus-background (O-B). It is found that O-B PDF of cloudy radiances from hyperspectral sounders exhibits a near-Gaussian form by properly accounting for cloud effect using a newly developed cloud parameter. It is also shown that the O-B variability predicted by the parameter can be effectively used for cloud-dependent

observation error assignment and quality control procedure.

9p.02 Efforts on Variational Cloud-clearing with CrIS Data at NCEP

Presenter: Haixia Liu

Authors: Haixia Liu, Andrew Collard and John Derber

The variational assimilation of satellite radiance observations has contributed the forecast skill increase of the Global Forecast System (GFS) at NCEP. However, satellite observations at most of meteorologically important areas have not been used in the presence of cloud. For infrared (IR) channels, only clear-sky data has been assimilated in the Grid-point Statistical Interpolation system (GSI), the NCEP operational data assimilation system. This limits the ability to continue improving the model initial condition through assimilating radiance data over partly cloudy and cloudy regions. NCEP has begun to develop a new algorithm to use the data in partly cloudy areas by removing cloud radiative effects. In this algorithm, cloud-clearing parameters will be estimated simultaneously together with other meteorological variables within the variational framework. The preliminary results of this study using the CrIS data will be reported at the conference.

9p.03 Development and Validation of Observing-system Simulation Experiments for All-sky Microwave Radiance Data Assimilation at NASA GMAO

Presenter: Min-Jeong Kim

Authors: Min-Jeong Kim, Ron Errico, Ricardo Todling, Jianjun Jin, and Will McCarty

The NASA Goddard Earth Observing System Model, Version 5 (GEOS-5) data assimilation system combines millions of observations and a coincident short-term forecast to determine the best estimate, or analysis, of the instantaneous atmospheric state. The GEOS-5 data assimilation system integrates the GEOS-5 Atmosphere-Ocean General Circulation Model (AOGCM), which is designed to simulate climate variability on a wide range of time scales, from synoptic time scales to multi-century climate change, with atmospheric assimilation component being the Gridpoint Statistical Interpolation (GSI) atmospheric analysis developed jointly with NOAA NCEP. There has been ongoing efforts to utilize cloud and precipitation affected microwave radiance data in GSI. Changes in forward operators, quality controls, observation errors, various moisture control variables and background errors have been made in GSI to assimilate all-sky (clear+cloudy) microwave radiance data. Initially AMSU-A cloud affected microwave radiance data over cloudy region have been tested in addition to the observation data currently assimilated in the operational GSI system. It was shown that the system developed thus far showed neutral impacts using largely inflated observation errors. However, reduced observation errors aggressively changed the analyses which require thorough understanding of interactions of various components and how they are linked to the forecast impacts. However, it is difficult to interpret roles and impacts of each all-sky radiance data assimilation components on the resulting analyses because cloud and precipitation affected radiance data involve complex issues such as forward operator, moisture control variables, and non-gaussianity of error distribution, when compared to clear-sky radiance data. In this study, the behaviors of all-sky microwawe radiance data assimilation components in GSI are examined through the utilization of the GMAO's Observing System Simulation Experiment (OSSE) infractructure (Errico et al. 2012, Prive et al. 2012). OSSE experiments utilize simulated observations from a nature run which is considered as a known truth. This presentation describes OSSE setup and error tuning processes to examine all-sky microwave radiance data assimilation system in GSI. Validations of simulated observations are also presented. Finally, the impacts of various observation error models and moisture control variable choices on analysis errors are examined.

9p.04 Evaluation of Cloud Discrimination Schemes for MHS Brightness Temperature Assimilation in the KMA Numerical Weather Prediction System

Presenter: Ji-Eun Cha

Authors: Ji-Eun Cha,Dong-Bin Shin, Yoonjae Kim, Sangwon Joo

Brightness temperatures measured by the Microwave Humidity Sounder (MHS) are affected by atmospheric water vapor, cloud ice and cloud liquid water. Cloud contamination can cause additional biases between the observed brightness temperatures and simulated ones from the NWP model first guess. We have investigated statistics on the brightness temperature departures based on the different cloud detection schemes adapted in the Korea meteorological administration (KMA) numerical weather prediction system. The schemes facilitate LWP retrieval and 183GHz scattering index tests. We have also compare different schemes using liquid water thresholds and different combinations of channels. The biases have been obtained from the Unified Model background fields and METOP-B satellite observations. Results show that the bias distributions are not generally consistent for cold and warm bias regions. In order to reduce the inconsistent biases we have tested different schemes including a combined use of UM total integrated cloud liquid water and ice water.

9p.05 Assimilation of MODIS Cloudy Radiances with a Hybrid Variational-Ensemble Data Assimilation System for Convection-permitting Forecast

Presenter: Zhiquan Liu
Authors: Zhiquan Liu, Hui-Chuan Lin, and Craig S. Schwartz

MODIS infrared cloudy radiance assimilation was implemented in the NCEP Gridpoint Statistical Interpolation (GSI) data assimilation systems. Both the 3DVAR and 3D hybrid variational-ensemble (denoted as "hybrid") schemes are allowed to assimilate MODIS cloudy radiances along with other observations. Observation errors of MODIS radiance data are assigned differently for three scenarios: (1) both the model background and observations are clear; (2) both the model background and observations are cloudy; (3) the model background and observations do not agree each other in terms of cloudiness. The assimilation MODIS cloudy radiances together with conventional and GPSRO data was applied to the convection-permitting forecasts using the WRF model with a 4km horizontal resolution over the continental US. The analyses and forecasts using different assimilation schemes (3DVAR and hybrid) were compared for a case study in May 2011. The results show that the hybrid scheme is more efficient than 3DVAR to extract mesoscale information through the use of flow-dependent background error covariance formed by 50-member short-term WRF forecasts. The hybrid scheme resulted in a more coherent multivariate analysis and thus improved subsequent precipitation forecast.

9p.06 Assimilation of Cloud Clear Radiance of Megha-Tropiques SAPHIR in NCMRWF GFS T574L64

Presenter: Sanjeev Singh
Authors: Sanjeev Kumar Singh, V.S. Prasad, E.N. Rajagopal, Swati Basu

The Megha Tropiques (MT), a joint Indo-French satellite, was launched by the Indian launch vehicle, PSLV-C18 on 12 October 2011 from Satish Dhawan Space Centre, Sri-harikota, India. The main objective of this mission is to understand the life cycle of convective systems that influence the tropical weather and climate and their role in associated energy and moisture budget of the atmosphere in tropical regions. The satellite is positioned in a highly inclined equatorial plane of 20° at a height of 867 km above the Earth so as to orbit the tropical region (30°S to 30°N) nearly 14-15 times per day. It carries the four payloads i.e. Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), Sounder for Probing Vertical Profiles of Humidity (SAPHIR), Scanner for Radiation Budget (ScaRaB) and Radio Occultation Sensor for Vertical Profiling of Temperature and Humidity (ROSA). SAPHIR is a sounding instrument with 6 channels near the absorption band of water vapor at 183 Ghz. These channels provide relatively narrow weighting functions from the surface to about 10 km, allowing retrieving water vapor profiles in the cloud free troposphere. The scanning is cross-track, up to an incidence angle of 50°. The resolution at nadir is of 10 km. Previous microwave sounders are SSMT2 and AMSU-B, which are operational instruments, have 3 channels within the 183.31 GHz absorption line (at ±1, ±3 and ±7 GHz), and two window channels, at 150 and 89 GHz. These additional channels give information on the surface and near surface. The SAPHIR sounder is based on the same general principle, measuring humidity in 6 different channels located in the 183.31 ± 12 GHz Bandwidth. These radiance data contain cloud and precipitation signal. Cloud or precipitation indicates that some dynamically important weather is occurring in that region. Clouds are considered a source of noise that needed to be removed or corrected for. The forecasts of the model are sensitive to initial conditions in the regions where cloud and precipitation occur. If cloudy radiances can be properly used, potential for significant improvements in forecasts fields. Many works have been carried out to detect the cloud from radiance data. One of the studies done by Hang et al. (2005) for detecting the deep convective cloud from AMSU-B channels centered around 183.3 GHz Bandwidth. Because some of SAPHIR channels are similar to the AMSU-B channels, we have applied the method proposed in this study on SAPHIR channels to detect the deep convective cloud in the radiance. These cloud free radiances of SAPHIR are used to improve the initial conditions and subsequent forecasts of NCMRWF GFST574L64 model.

9p.07 All-sky Assimilation of Selected Water Vapour Infrared IASI Channels at ECMWF: Strategy and Initial Trials

Presenter: Stefano Migliorini
Authors: Stefano Migliorini, Alan Geer, Marco Matricardi, Stephen English

Improving the use of available satellite data has been a key goal of operational numerical weather prediction centres since the first appearance of such data. One of the current strategies to increase the information yield from satellite instruments is to try to make better use of radiance measurements in channels affected by cloud or precipitation. At ECMWF, microwave radiances from TMI and SSMIS over ocean have been directly assimilated since 2009 regardless whether they are emerging from clear sky or from cloudy or precipitating atmospheric columns. It has been shown that the resulting increase in the amount of assimilated observations and the ability to constrain the model

over cloudy areas where the model was not predicting cloud have produced statistically significant improvements in forecasts scores and better fit between model predictions and in situ measurements. It is important to note, however, that most of the forecast impact is from all-sky assimilation of water vapour sensitive microwave radiances, where the overall random, systematic and representativeness uncertainty of observations can be smaller than that associated to the forecast model uncertainty in observation space. A natural way forward is to try to assess whether similar benefits can be derived from an all-sky assimilation of infrared radiances. Radiation in the infrared, however, is much more severely affected by cloud, so that very large departures between observations and their model predictions statistically arise when radiance is measured in atmospheric window channels. Also, accurate radiative transfer calculations in cloudy conditions in the infrared require in general more sophisticated radiative transfer models. In this talk the current strategy for all-sky assimilation of satellite infrared radiances at ECMWF is discussed. First, details of the channel selection investigations that allowed us to select the IASI water vapour channels providing the largest Shannon information content in overcast conditions are discussed. Then, results from monitoring experiments comparing the fit between observations in the selected channels and their model predictions using either an accurate but computationally expensive or a less sophisticated and computationally viable radiative transfer model are presented. Finally, results from a month-long 4DVAR twin assimilation experiment with the standard operational assimilation system augmented with the selected water vapour channels from IASI either in a clear-sky of all-sky configuration are presented. Preliminary results show that a sensible choice for the total observational uncertainty over cloudy areas is key to a successful all-sky assimilation of water-vapour-sensitive satellite radiances.

9p.08 Cloud Properties and Bulk Microphysical Properties of Semi-transparent Cirrus from IR Sounders

Presenter: Raymond Armante

Authors: C. J. Stubenrauch, A. Feofilov, R. Armante, L. Crepeau

Satellite observations provide a continuous survey of the atmosphere over the whole globe. IR sounders have been observing our planet since 1979. The spectral resolution has improved from TIROS-N Operational Vertical Sounders (TOVS) to the Atmospheric InfraRed Sounder (AIRS), and to the InfraRed Atmospheric Sounding Interferometer (IASI); resolution within the CO2 absorption band makes these passive sounders most sensitive to semi-transparent cirrus (about 30% of all clouds), day and night. The LMD cloud property retrieval method developed for TOVS, has been adapted to the second generation of IR sounders like AIRS and, recently, IASI. It is based on a weighted $\chi 2$ method using different channels within the 15 micron CO2 absorption band. Once the cloud physical properties (cloud pressure and IR emissivity) are retrieved, cirrus bulk microphysical properties (De and IWP) are determined from spectral emissivity differences between 8 and 12 μm. The emissivities are determined using the retrieved cloud pressure and are then compared to those simulated by the radiative transfer model. For IASI, we use the latest version of the radiative transfer model 4A (http://4aop.noveltis.com), which has been coupled with the DISORT algorithm to take into account multiple scattering of ice crystals. The code incorporates single scattering properties of column-like or aggregate-like ice crystals provided by MetOffice (Baran et al. (2001); Baran and Francis (2004)). The synergy of AIRS and two active instruments of the A-Train (lidar and radar of the CALIPSO and CloudSat missions), which provide accurate information on vertical cloud structure, allowed the evaluation of cloud properties retrieved by the weighted $\chi 2$ method. We present results for cloud properties obtained with IASI/ Metop-A and compare them with those of AIRS and other cloud climatologies having participated in the GEWEX cloud assessment. The combination of IASI observations at 9:30 AM and 9:30 PM complement the AIRS observations at 1:30 AM and 1:30 PM local time, giving information on the diurnal cycle of clouds. References: Baran, A.J. and Francis, P.N. and Havemann, S. and Yang, P: A study of the absorption and extinction properties of hexagonal ice columns and plates in random and preferred orientation, using exact T-matrix theory and aircraft observations of cirrus, J. Quant. Spectrosc. Ra., 70, 505–518, 2001 Baran, A. J. and Francis, P. N.: On the radiative properties of cirrus cloud at solar and thermal wavelengths:A test of model consistency using high-resolution airborne radiance measurements, Q. J. Roy. Meteor. Soc.,130, 763-778, 2004.

9p.09 Retrieval of Ice Cloud Microphysical Properties Using Combined CloudSat and MODIS Measurements Based on Optimal Estimation Theory

Presenter: Yan Wei

Authors: Huang Yun-xian Han Ding Yan Wei Ye Jing

In order to get the accurate information of ice cloud microphysical properties, it combines radar reflectivity and optical depth from CloudSat and MODIS and proposes a new algorithm that is optimal estimation theory for the retrieval of ice cloud microphysical parameters. By assuming the

lognormal size distribution of cloud droplets and refining the forward physical model so as to establish functional relationships between measurements and retrieval variables, with the help of its prior information, the optimal solutions of spectral distribution parameters are obtained after iteratively calculating, then the microphysical parameters of ice cloud can be retrieved based on forward physical model, and the uncertainty can be calculated according to error propagation theory. By designing retrieval scheme and using a case data and the whole-orbit measurements, retrievals of ice cloud microphysical properties are compared with products published by CloudSat official institutions and data retrieved by using empirical algorithms. The results show that retrievals based on optimal estimation theory by using combined CloudSat and MODIS measurements are well consistent with officially released products, which makes up for the disadvantages that empirical algorithms have large error and poor expansibility and retrievals are seriously missed if measurements from single device are used, and it gives some references for the joint retrieval of ice cloud microphysical properties based on multi-sensor data. Keywords CloudSat, MODIS, ice cloud, optimal estimation theory, empirical algorithm

9p.10 Applications of Spaceborne Millimeter-wave Radar Data in Analyzing Typhoon Structures in Western Pacific

Presenter: Yan Wei
Authors: Han Ding Yan Wei Ye Jing Zhao Xian-Bin

Cloud, precipitation and thermal structure characteristics for 53 Western Pacific typhoons are comprehensively analyzed by using the CloudSat tropical cyclone crossing dataset from 2006 to 2010, and typhoons are classified as developing, mature and decaying stages according to the maximum sustained wind speed. Radar reflectivity peaks at 5km in height and where a bright band appears along the radial direction. The occurrence probability of deep convective cloud is always large while the stratocumulus has small vertical scale. Effective radius and distribution width parameter decrease as altitude increases while particle number concentration increases. Rainfall rate decreases with increasing radial distance and it's larger in July to September compared to that in other months. A warm core appears above 5km in height while below that there are a wet core and an area where relative humidity anomaly is large. At mature stage, the scope and intensity for warm core and wet core are larger than those at other stages, and an unsaturated region exists in the upper troposphere area. The atmospheric stratification is stable above 4.5km in height at each stage, below that, it's mainly instable at developing and mature stages, while it's complicated and many stable or neuter layers appear at decaying stage. Cloud profiling radar (CPR) onboard CloudSat has many detecting advantages, which can play an important role in structure analysis, model validation and landfalling track of typhoons in Western Pacific. Keywords CloudSat, typhoon, radar reflectivity, rainfall rate, atmospheric stratification.

9p.11 Roles of Microphysics in Cloud Resolving Models in Passive Microwave Remote Sensing of Precipitation over Ocean

Presenter: Ju-Hye Kim
Authors: Ju-Hye Kim (KIAPS, Seoul, Korea), Dong-Bin Shin (Yonsei University, Seoul, Korea), and Christian Kummerow (Colorado Sate University, Fort Collins, Colorado, USA)

Physically based rainfall retrievals from passive microwave sensors often make use of cloud-resolving models (CRMs) to build a priori databases of potential rain structures. Each CRM, however, has its own cloud microphysics assumptions. Hence, approximated microphysics may cause uncertainties in the a priori information resulting in inaccurate rainfall estimates. This study first builds a priori databases by combining the Tropical Rainfall Measuring Mission (TRMM) precipitation radar (PR) observations and simulations from the Weather Research and Forecasting (WRF) model with six different cloud microphysics schemes. The microphysics schemes include the Purdue.Lin (LIN), WRF Single-Moment 6 (WSM6), Goddard Cumulus Ensemble (GCE), Thompson (THOM), WRF Double-Moment 6 (WDM6), and Morrison (MORR) schemes. As expected, the characteristics of the a priori databases are inherited from the individual cloud microphysics schemes. There are several distinct differences in the databases. Particularly, excessive graupel and snow exist with the LIN and THOM schemes, while more rainwater is incorporated into the a priori information with WDM6 than with any of the other schemes. Major results show that convective rainfall regions are not well captured by the LIN and THOM schemes-based retrievals. Rainfall distributions and their quantities retrieved from the WSM6 and WDM6 schemes-based estimations, however, show relatively better agreement with the PR observations. Based on the comparisons of the various microphysics schemes in the retrievals, it appears that differences in the a priori databases considerably affect the properties of rainfall estimations. This study also includes the discrepancy of estimated rain rate from passive radiometer and active radar for two rainfall systems which have different cloud microphysics. The first one is heavy rainfall case from high cloud top (HCT) with large ice particles and the other case is strong precipitation from middle cloud top (MCT) having less ice particles. The observed characteristics from TMI and PR are compared and

sensitivity test with various a priori databases are performed. Result shows microphysics in CRMs is relatively more important in HCT case for the generation of rainfall databases which brings correct estimation of rain rate, because the scattering information from high frequency channel is effective in HCT rainfall case.

9p.12 Combined Scheme over the Central Andes and its Foothills

Presenter: Dirceu Herdies

Authors: Blacutt, L.; Herdies, Dirceu L. and Gonçalves, L. G. G.

The combined Scheme methodology is applied to merge satellite precipitation estimation data and surface rainfall data to the Central Andes which is a complex topography region. Raingauges over the Central Andes are scarce, a better approach to improve our knowledge about precipitating systems relies on an adequate combination of surface observations and satellite estimations. The present study works with the TRMM3B42 algorithm and a technique called the Combined Scheme (CoSch) that merges satellite data with surface data, in this case the Bolivian Weather Service database. When compared the TRMM 3B42 with the CoSch, known features become clear such as the moisture transport by the South American low level jet and the role of the mountainous regions to trigger convection. The resulting database is also compared with the new reanalysis NCEP/CFSR and MERRA. Interestingly the reanalysis' performance and the CoSch coincide on various features (such as seasonality, and spatial distribution of precipitation), however overestimation is still a problem for the reanalysis. The final result is an improved gridded database that allows to perform other society relevant studies.

Session 10a: Assimilation Studies

10.01 Constrained Variational Bias Correction for Satellite Radiance Assimilation

Presenter: Wei Han

Authors: Wei Han

Radiance bias correction is a very important and necessary step in the proper use of satellite observations in a data assimilation system. Variational bias correction (VarBC) is an adaptive bias corrections for satellite radiances which need to separate the observation bias from the systematic errors in the background in order to prevent the analysis from drifting towards its own climate. It shows some skill in distinguishing between the background biases and the observation biases when other unbiased observations are available and sufficient to anchor the system. When there are significant model biases and seldom unbiased observations in the assimilation process (e.g. ozone in the stratosphere), VarBC will force agreement with the biased model background. A Constrained VarBC (CVarBC) is proposed using prior knowledge of the channel in this study in order to avoid the drift of observation bias correction to the biased model background. It is some kind of regularization techniques in inverse problems. The theoretical study of this method is firstly demonstrated by a toy model and then is applied to the real case of bias correction for satellite radiance assimilation. Finally the summary and conclusions are presented.

10.02 Variational Bias Correction in the NCEP Data Assimilation System

Presenter: Yanqiu Zhu

Authors: Yanqiu Zhu, John Derber, Andrew Collard, Dick Dee, Russ Treadon, Jim Jung, George Gayno, David Groff, Paul van Delst, Jim Purser, Jeff Whiting, Bradley Ballish, Emily Liu, Daryl Kleist

Variational Bias Correction in the NCEP Data Assimilation System Yanqiu Zhu1, John Derber2, Andrew Collard1, Dick Dee3, Russ Treadon2, Jim Jung4, George Gayno1, David Groff1, Paul van Delst1, Jim Purser1, Jeff Whiting1, Bradley Ballish2, Emily Liu5, Daryl Kleist2 1 IMSG @ NOAA/NCEP/EMC, 2 NOAA/NCEP/EMC, 3 ECMWF, 4 CIMSS, 5 SRG @ NOAA/NCEP/EMC Since most data assimilation algorithms assume unbiased observations and forecast models, the observation and forecast model biases need to be removed in the data assimilation systems. Efforts have been focused on enhancing existing and developing new capabilities of the variational bias correction for the biased observations in the Gridpoint Statistical Interpolation (GSI) system at the NCEP. One major endeavor is the enhanced radiance bias correction scheme, which will be included in the next operational upgrade in the spring of 2014. The scheme replaces the original two-step procedure by a single variational step within the GSI, simplifying the operational suite. Moreover, the modified pre-conditioning speeds up the GSI minimization convergence rate, and a new adaptive background error variance for the bias coefficients enables the enhanced scheme to automatically detect any new/missing/recovering radiance data, and to quickly capture any changes in the observations and data assimilation systems. Combining with the newly built-in automatic bias initialization step, the enhanced scheme offers an advantage for retrospective and re-analysis projects. The enhanced scheme also provides an efficient way, via the newly added passive channel bias correction capability, to obtain the biases of any new satellite data that are not used but monitored for preparation for future use, such as the radiance data from SNPP satellite. Furthermore,

as the new Community Radiative Transfer Model (CRTM) development improves the microwave sea surface emissivity model, an emissivity sensitivity predictor term has been constructed to deal with the larger OmF (Observation-minus-first guess) contrast between land and sea. Another development is the variational aircraft temperature bias correction. The bias is aircraft tail number dependent, and the bias coefficients are augmented onto the existing control variable vector. Any new/obsolete tail numbers along with their bias corrections are automatically added/deleted during the assimilation period. Different choices of bias predictors with the phase of flights, aircraft vertical velocity, and pressure and the impact on the temperature analysis have been investigated. Experiment results show that different predictors selected have reduced the aircraft temperature bias, and that the fits of the analysis and first guess to the radiosonde data are improved around 250mb. With the development of cloudy radiance assimilation in GSI, how to perform bias correction for both clear-sky and cloudy radiance is yet another challenge. The bias correction strategy will also be discussed at the meeting.

10.03 An Improved Bias Correction for SSMIS

Presenter: Anna Booton
Authors: Anna Booton, William Bell
The currently operational SSMIS instruments are subject to complex orbital biases, resulting from calibration anomalies including reflector emissions and solar intrusions. To date, physically based correction techniques have only been partially successful in correcting the measured radiances. Consequently, due to the difficulty in dealing with these biases, the full potential of SSMIS to provide high quality imager data, and sounding data throughout the troposphere to mesosphere, has yet to be realised. An improved bias correction scheme is introduced for SSMIS. The scheme adopts a Fourier-based approach, whereby a complement of bias predictors comprised of Fourier components are used to parameterise the bias along the satellite track. When this compliment is extended to include higher order Fourier terms the correction is able to mitigate the orbital biases effectively. The characterisation of the orbital biases is performed for data from the DMSP F-17 and F-18 satellites. The anticipated effectiveness of scheme is ascertained through its implementation within a toy model. With the Fourier-based scheme then included within the Met Office variational bias correction system it is hoped that similar performance, meeting the stringent noise requirements on the data, will be obtained as SSMIS is assimilated in the global NWP model. The initial results are presented.

Session 10b: Assimilation Studies

10p.01 Assessment of Residual Biases in Microwave Instruments: Impact of Improved Radiative Transfer Modelling for Lower Tropospheric AMSU-A Channels and Development of an Improved Bias Correction Scheme for SSMIS

Presenter: Anna Booton (for Katie Lean)
Authors: Katie Lean, Anna Booton, William Bell and Qifeng Lu
The AMSU-A and SSMIS microwave instruments have provided valuable observations that have been assimilated in the Met Office's NWP system for many years. Presently, the bias correction scheme prior to assimilation is being reappraised: although the current method is effective in removing significant components of the bias, it is clear that residual biases still remain. In order to extract further positive impact from AMSU-A and SSMIS, improved treatment of the bias correction is developed through better understanding of the underlying physical causes and an improved approach for the bias correction scheme utilized. Improvements in the radiative transfer modelling for the lower tropospheric channels of AMSU-A (channels 6-8) have been achieved through generating more accurate estimates of the central frequencies for the channel passbands. Shifts and drifts in the centre frequencies caused by instability in the local oscillator have been diagnosed for NOAA-15, -18, -19 and Metop A. The effect of correcting for these deviations is assessed through analysis of departure statistics using the Met Office global model and assimilation experiments are used to determine the impact on the NWP system. The form and magnitude of the residual bias in AMSU-A before and after implementation of the improvements to the radiative transfer model are also investigated. SSMIS instruments suffer from complex orbital biases attributed to calibration anomalies such as reflector emissions and solar warming of the calibration target. An improved bias correction scheme that facilitates the enhanced parameterisation of the bias along the satellite track is under development. The techniques used to implement the new scheme are considered and initial results from implementing the orbital bias predictor as part of the Met Office variational bias correction scheme are discussed.

10p.02 IASI Bias Correction at KIAPS Observation Processing System

Presenter: Hyoung-Wook Chun
Authors: Hyoung-Wook Chun, Yoonjae Kim, Peter Weston and Joo-Youn Lim
Radiance bias correction for satellite data is essential for better performance of a data assimilation system. The IASI bias correction

scheme at Korea Institute of Atmospheric Prediction Systems (KIAPS) is a static method adapted from the Harris and Kelly (2001) algorithm that uses the difference of observed and simulated TBs (i.e., innovation or O-B). This scheme consists of a scan-angle component and an air-mass dependent component. The scan bias is the monthly averages of O-B TBs for each scan position subtracted by each channel mean. Most scan biases are symmetric for the scan positions. Distinct ripple marks appear along the IASI scan positions due to irregular patterns of the viewing angles. For the high peaking channels, the scan biases increase as the scan position is getting far from the nadir. On the other hand, the scan biases show an opposite pattern for the low peaking channels. The air-mass bias is parameterized by two thicknesses, i.e. 850-300 hPa, and 200-50 hPa, based on the NWP model. The slopes of the predictors and global offsets are generated by a multiple linear regression, trained on a representative sample of scan corrected O-B TBs. While the slopes of each thickness are negative values in the high peaking temperature sounding channels, they are positive for the water vapor channels. For the low peaking and window channels, the slopes are near zero and the correlation is less than 0.2, because the O-B TBs of these channels do not depend on thickness. We are currently comparing the bias correction coefficients of KIAPS, the Met Office and the Korea Meteorological Administration, and the results will be presented.

10p.03 The Role of Observation and Background Errors for Reconstructing Localized Features from Non-local Observations

Presenter: Christina Koepken-Watts (for Olaf Stiller)

Authors: Olaf Stiller

Non-local observations like, e.g., passive satellite measurements could, in principle, give accurate information about spatially localized atmospheric features if the measurements were both, sufficiently dense and accurate (i.e., observation errors need to be sufficiently small). Here the question is asked to which extent such features can be reconstructed by data assimilation (DA) methods which define the analysis state by the minimum of a quadratic cost function. More precisely, this work discusses how finite observation errors (for given background error statistics) degrade the spatial resolution of such an analysis state. For this it expands the cost function minimum into a weighted sum over pseudo inverse (PI) solutions each of which corresponds to a different subset of the available observations (i.e., only a subset of the observations is considered for each of these terms, respectively). Observation errors occur only in the weighting factors of this expansion and therefore determine the extent to which observational information is included in the analysis state. More precisely, the weighting factors of the different PIs can be written in terms of normalized observation errors and the determinant of a correlation matrix which characterizes the overlap of the corresponding observation operators. The presented mathematical results are illustrated with a simple model problem which explicitly shows how the reconstruction of a localized feature depends on observation errors as well as the observation operators' overlap. The findings of this work generally demonstrate that large observation errors do not only decrease the overall weight which the respective observations obtain in the DA process, they especially reduce the DA systems capability to obtain spatially localized information. Small observation errors are particularly important when processing strongly non-local observations as they are typically obtained from passive remote sensing measurements. These have the potential to smear out signals from localized sources over large regions in model space. Generally, observation errors have to be smaller the more the respective observation operators overlap.

10p.04 Situation-dependent Estimates of Background Errors in Radiance Space

Presenter: Niels Bormann

Authors: Niels Bormann and Massimo Bonavita

In recent years ECMWF has moved to a hybrid 4DVAR system, in which situation-dependent aspects of the background error covariance are provided based on the spread of an Ensemble of Data Assimilations (EDA). Here we present an analysis of this spread in radiance space for AMSU-A and MHS, and compare its characteristics against statistics from departures between observations and short-range forecasts. The analysis provides diagnostics of the EDA, and the results can be used for quality control decisions of radiance data. The statistics suggest that the EDA is under-dispersive, particularly over the extra-tropics, and a calibration step is required to generate estimates of background error in radiance space. Related to this, we find that the error growth in the EDA is smaller than suggested by observation departures. The estimates suggest that the size of short-term forecast errors in radiance space in the ECMWF system is well below 0.1 K for large areas of the globe for the tropospheric AMSU-A sounding channels. This is contributing input to the specification of noise requirements for future atmospheric sounding instruments.

10p.05 Dimension-Reduced Projection 4DVar with Nonlinear Correction

Presenter: Si Shen

Authors: Si Shen, Juanjuan Liu, Bin Wang

Dimension-Reduced Projection 4DVar(DRP-4DVar) is one representative approach of the

ensemble-based 4DVar methods. It uses an ensemble to define the subspace to solve 4DVar problem and also to estimate the background error covariance. What's more, it uses the statistical relationship presented by the ensemble to avoid the adjoint model, which makes it a much more economical way to implement 4DVar. However, a linear approximation is made in DRP-4DVar when projecting the analysis increments at the initial time to the simulated observation increments (i.e., observation simulated from analysis minus observation simulated from background) at observation times, which may introduce errors and limit the reduction of the cost function, especially when assimilating nonlinear observations (e.g. satellite observations). To deal with it, a nonlinear correction step is added to DRP-4DVar. In this work, this new method is implemented for the simple nonlinear model Lorenz96, as well as the original DRP-4DVar and the traditional adjoint-based 4DVar. Experiments under different situations are carried out to give a comprehensive evaluation and based on these experiments significant improvements over the original DRP-4DVar are shown. The mechanism for these improvements are also analyzed in the end.

10p.06 Statistical Evaluation of the Microwave Sounder Radiances Assimilation into CPTEC/INPE GSI-based Global 3DVar (G3DVar)

Presenter: Bruna Silveira
Authors: Bruna Barbosa Silveira, Luis Gustavo Goncalves de Goncalves, Simone Marilene Sievert da Costa

This study assesses the preliminary statistics of the Microwave Humidity Sounder (MHS/Metop-A) radiances assimilated into the Atmospheric Global Circulation Model at the Center for Weather Forecast and Climate Studies (CPTEC) a center from the Brazilian National Institute for Space Research (INPE). The global three dimensional assimilation scheme used is based on the Gridpoint Statistical Interpolation (GSI) henceforth called G3DVar. Global first guess departures from observations are calculated for January 2013, albeit particular focus over South America (SA) and adjacent oceans is given. Additionally, to a better understanding of the radiances statistics, mixing ratio fields at 00Z and 12Z synoptic times were averaged over the month and compared to ERA-INTERIM reanalysis. Preliminary results show that G3DVAR overestimates near surface (1000 hPa) air humidity over northern SA, mainly over the Amazon region, notwithstanding underestimation over the southern and western coast during the austral summer. Furthermore, negative brightness temperature (Tb) biases from channels 1, 2 and 5 are found over most of the continent, except in the Andes mountains. This could be associated to G3DVar tendency to overestimate moisture in the lower levels of the atmosphere whereas it underestimates moisture in the mid and upper troposphere. Thus, positive Tb biases are found for most channels over the Andes mountains due to its high elevation. Lastly, warm bias is observed over the oceanic regions for channels 1 and 2, and cold bias for channels 3 to 5 over the Pacific ocean close to the SA coast.

10p.07 Development of AMSU-A Pre-processing and Quality Control Modules at KIAPS Observation Processing System

Presenter: Sihye Lee
Authors: Sihye Lee, Ju-Hye Kim, Jeon-Ho Kang, and Hyoung-Wook Chun

As a part of the KIAPS Observation Processing System (KOPS), we have developed the modules for AMSU-A (Advanced Microwave Sounding Unit-A) pre-processing and quality control. The AMSU-A Level-1D radiance data were extracted using the European Centre for Medium-Range Weather Forecasts (ECMWF) BUFR (Binary Universal Form for the Representation of meteorological data) decoder. The extracted raw data then were checked for gross quality control (QC) including physical reality checks on geolocations, beam positions and observed brightness temperatures (TB) as well as blacklisting for broken channels of each satellite. Duplicate observations in a defined grid box (0.35x0.23) were eliminated using a removal score considering the distance from the grid center, surface types, reliable satellites, and cloud contamination. For a model background field, the UM forecasts with a 6-hour data assimilation window were used, and the difference of observed and simulated TBs were employed for QC and the calculation of bias correction (BC) coefficients. Before the AMSU-A BC, the initial quality checks for clear-sky radiance assimilation were performed to remove the pixels contaminated by cloud, precipitation, and sea ice. Then, scan and air-mass BC modules were developed in two steps based on 30-day innovation statistics using Harris and Kelly (2001) algorithms. The bias corrected innovations were monitored and accumulated to update the BC coefficients periodically. The final QC and thinning were performed in consideration of assimilation resolutions, and the survived AMSU-A data are finally prepared to be passed to the KIAPS data assimilation (DA) system. We plan to test the effect of different combinations of QC and BC on AMSU-A analysis increments using 1-dimensional variational assimilation (1D-Var) QC scheme.

10p.08 Assimilation of AMSU-A Radiance Observations within KIAPS-LETKF System

Presenter: Byoung-Joo Jung

Authors: Byoung-Joo Jung, Ji-Sun Kang, Youngsoon Jo, Ju-Hye Kim, Sihye Lee
Korea Institute of Atmospheric Prediction Systems (KIAPS) has successfully implemented Local Ensemble Transform Kalman Filter (LETKF; Hunt et al. 2007) data assimilation system to NCAR CAM-Spectral Element model. This model has the same grid structure on the cubed sphere as KIAPS-Global Model now developing without any singularity, and has a strong advantage on the flexibility and scalability in the future high performance computing environment. The KIAPS-LETKF system (Kang et al. 2013) has also adopted most advanced data assimilation techniques such as an adaptive multiplicative inflation (Miyoshi 2012), an estimation of ensemble forecast sensitivity to observations (EFSO; Kalnay et al. 2012) and proactive quality control (PQC; Ota et al. 2013). With those promising tools in the KIAPS-LETKF system, we plan to assimilate conventional data as well as various remote sensing data such as AMSU-A, IASI, GPS RO, which an observation preprocessing team at KIAPS has processed. In this study, we will present our assimilation strategy of AMSU-A radiance data and show preliminary results at the conference.

10p.09 Advanced Techniques for Satellite Microwave Data Assimilation - Application to Global and Regional NWP

Presenter: Sid Boukabara
Authors: Kevin Garrett and Sid Boukabara
We present recent efforts supported by the Joint Center for Satellite Data Assimilation (JCSDA) to advance and increase microwave satellite observations assimilated within the GSI analysis system used to initialize both the Global Forecast System (GFS) model and regional Hurricane WRF (HWRF) model at the National Oceanic and Atmospheric Administration (NOAA) . Specifically, the use of a 1d-variational (1dvar) preprocessor within the GSI will be discussed. The 1dvar preprocessor is applicable to current and future microwave satellite sounders and imagers including those from POES and MetOp AMSU-A and MHS, NPP/JPSS ATMS, DMSP F16-F20 SSMI/S, GCOM-W AMSR2, TRMM/TMI and GPM GMI. The capability of the 1dvar preprocessor (which applies over all-surfaces and in all-weather conditions) includes increased quality control of the microwave radiances to be assimilated, provides dynamic surface emissivity over all surfaces therefore allowing the extension of the microwave data assimilation coverage, and cloudy and rainy data assimilation through providing hydrometeor (cloud, rain, ice) information to the assimilation system. This 1dvar preprocessing increases the number and types of observations that can be assimilated. The information provided by the 1dvar preprocessor will help with the assimilation of surface sensitive channels over non-ocean surfaces as well as cloudy and rainy radiance assimilation. Advancement in the assimilation of these types of observations should have significant positive impact on both global NWP forecast and regional NWP and tropical cyclone track and intensity forecasts. Current status of the implementation of the 1dvar preprocessor in the GSI will be shown, along with examples and benefits from the quality control information it may provide, followed by discussion of its overall utility in data assimilation.

10p.10 GPU Acceleration of the WRF Model for Time-Critical Satellite Data Assimilation Applications

Presenter: Bormin Huang
Authors: Bormin Huang, Jarno Mielikainen, and Allen Huang
The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs. The inherently parallel problem of weather forecasting can be effectively solved using graphics processing units (GPUs), each with hundreds or thousands of compute cores. In this talk, we present the latest progress in our massively parallel implementation of the WRF model on NVIDIA GPUs using CUDA. This work was funded by NOAA. It is a crucial step towards more efficient and effective satellite data assimilation for time-critical environmental and weather forecast.

Session 11a: Assimilation Studies

11.01 The Impact of Satellite Data within the ECMWF System

Presenter: Cristina Lupu
Authors: Lupu C., C. Cardinali and A. McNally
In numerical weather prediction the value of a particular observing system can be assessed both in terms of its impact upon atmospheric analyses and forecasts. Understanding this impact allows the data assimilation and forecast system to be optimised to make best use of the available observations. Observation impacts have often been evaluated through OSEs experiments, in which a control analysis using all observations is compared to an analysis in which observations of interest are excluded from the assimilation. Running OSEs, while computationally very expensive to do, provides a useful measure of the impact of various observing systems. The adjoint method is an effective tool to assess the value of observations in reducing the forecast errors and the forecast impact as a result of changes in the observing system. The ECMWF currently uses this technique to assess the impact of observations on the 24-hour forecast as

measured by a global forecast error objective function, typically, the dry energy norm. More recently, the adjoint-based applications have been used for diagnosis and tuning of parameters in the observation and background error covariances in 4D-Var. In particular, the forecast sensitivity to the observation error variance can be computed and variances accordingly tuned. In this presentation, results with ECMWF 4D-Var are used to provide directions for validating experiments aimed at measuring changes in the forecast system: observation impact assessment, forecast sensitivity to error covariance weighting and a posteriori diagnosis. Results of forecast sensitivity to observation error variance are presented and their potential in reducing the forecast errors evaluated.

11.02 Using Forecast Sensitivity to Observations to Adapt IASI Channel Selection

Presenter: Vincent Guidard

Authors: Vincent Guidard, Nathalie Saint-Ramond, Nadia Fourrie

Adjoint-based techniques, such as Forecast Sensitivity to Observations (FSO) can be used to infer of any observation used in the assimilation on the reduction of 24h forecast errors. They usually are used to assess the impact of various observation system on the forecast. In this study, the contribution of every single IASI channel has been computed using a dry total energy norm. It appeared that some channels were diagnosed to have a negative impact on the forecast error reduction. Thus, assimilation trials were carried out to evaluate the impact of discarding these channels from the assimilation. The impact on forecast skills, evaluated against independent observations and analyses, agreed with FSO results. Which demonstrates the potential benefit to use FSO in support to channel selection.

11.03 Estimation of Satellite Observation Impact to Numerical Weather Forecast using Adjoint-based Method

Presenter: Hyun Mee Kim

Authors: Hyun Mee Kim, Sung-Min Kim, Sangwon Joo, and Eun-Jung Kim

An increasing number of satellite observations have contributed to the performance of numerical weather prediction. Accordingly, it is important to evaluate the impact of these observations on forecast performance. While the observing system experiment requires considerable computational resources, the adjoint-based method can evaluate the impact of all observational components at a lower cost. In this study, the effects of observations on numerical weather forecasts are evaluated by the adjoint-based method in the global and regional modeling and data assimilation frameworks. In addition, the forecast sensitivities to observation and background error covariances are investigated. The forecast sensitivity to the error covariance indicates that reducing observation error covariance and increasing background error covariance help to reduce forecast error in both frameworks. This study confirms that the adjoint-based method can be used to evaluate the observation impact in the global and regional modeling frameworks and to evaluate the background and observation error covariances. Therefore, the adjoint-based method can provide important information on the effects of observations to forecast, especially when abundant satellite observations are available. Detailed results will be presented in the conference.

11.04 Satellite Radiance Assimilation in HWRF

Presenter: Xiaolei Zou

Authors: Xiaolei Zou

This study investigates impacts of satellite microwave and infrared radiance assimilation on hurricane forecasts using the National Centers for Environmental Prediction (NCEP) Gridpoint Statistical Interpolation (GSI) data assimilation system and Hurricane Weather Research and Forecasting (HWRF) model. Satellite radiance data from the Advanced Technology Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS) onboard Suomi National Polar-Orbiting Partnership (NPP) satellite, the Advance Microwave Sounding Unit-A (AMSU-A) on board NOAA-18, NOAA-19, MetOp-A and NOAA-15, the hyperspectral Atmospheric Infrared Sounder (AIRS) onboard Aqua, and the High resolution InfraRed Sounder (HIRS) onboard NOAA-19 and MetOp-A, and are assimilated. It is firstly shown that a higher model top allows more upper-level microwave and infrared sounding channel data be assimilated into HWRF, which results in an improved atmospheric steering flow and thus the movement of tropical cyclones. It is also shown that ATMS data assimilation in HWRF results in a consistent positive impact on the track and intensity forecasts due mainly to a unique feature of ATMS. Having collocated temperature and humidity channel data, ATMS data quality control becomes much more effective than that for data from its predecessors AMSU-A and MHS. Finally, benefits of having three orbits for regional short-range forecasts are demonstrated by a set of data denial experiments with and without NOAA-15 AMSU-A data.

Session 11b: Assimilation Studies

11p.01 Calibration of the Observing Simulation System Experiment (OSSE) Use to Assess the Impact of Geostationary Hyperspectral Data

Presenter: Agnes Lim

Authors: Agnes Lim, James Jung, Allen Huang and Zhenglong Li

Higher spatial, temporal and spectral resolution will considerably enhance the information available, particularly to monitor and predict rapidly-evolving, small-scale phenomena. Such observations can be provided by hypersepctral infrared sensors placed in geostationary orbit. The Observing System Simulation Experiment (OSSE) will be used to assess the impact of geostationary hyperspectral data on a forecast system. In an OSSE, simulated observations are used as inputs into data assimilation systems. These simulated observations are drawn from a Nature Run (NR) which serves as a proxy to the real atmosphere. As OSSEs are computationally intensive, an internationally collaborative effort called the joint OSSE (Andersson and Masutani, 2010) had been formed. The Nature Run was generated by the European Centre for Medium Range Weather Forecasts (ECMWF) and had been verified by Masutani et. al, (2009). In addition, conventional and existing satellite sensors valid for the Nature run period (2005-2006) had also been simulated by NOAA/NCEP (Masutani et al, 2011) and made available to the research community through NCAR. Those data will be used in baseline experiment. We will focus on simulating the geo-hyperspectral data generated from the ECMWF Nature Run. The OSSE will be conducted using the GSI and WRF at regional scale. Prior to conducting the actual OSSE, calibration of the data assimilation system will be carried out. OSSE calibration verifies that the simulated data impact by comparing it to the real data impact. Observations types use in the calibration experiments are conventional data and satellite radiances from AMSU-A on NOAA-15 and AQUA, HIRS-3 and AMSU-B on NOAA-17 and AIRS on AQUA. Data denial experiments using both real and synthetic observations are carried out for 2 weeks and their analysis impacts are compared. Observational errors added to the synthetic observations adjusted to match the OSSE impact analysis with the real observation impact analysis. References Andersson, Erik and Michiko Masutani 2010: Collaboration on Observing System Simulation Experiments (Joint OSSE), ECMWF News Letter No. 123, Spring 2010, 14-16. Masutani, M., L.-P. Riishojgaard, R. Errico, E. Andersson, J. S. Woollen, A. Stoffelen, G.-J. Marseille, O. Reale, Y. Xie, N. Prive, T. Zhu, F. Weng, G. D. Emmitt, T. W. Schlatter, S. J. Lord, S. Greco, S. A. Wood, R. Yang, H. Sun, T. J. Kleespies, and Y. Song 2009: International collaborative Joint OSSEs,Toward reliable and timely assessment of future observing systems, Extended Abstract, The Anthony J. Hollingsworth Symposium, Phoenix, AZ, Amer. Meteor. Soc., P1.2 Masutani, M. and co authrs 2011 : Simulation of observation and calibrations for Joint OSSEs, Extended abstract, 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), Seattle, WA, Amer. Meteor.P199.

11p.02 Impacts from Assimilation of Three-Orbit Satellite Radiances on Hurricane and Quantitative Precipitation Forecasts

Presenter: Fuzhong Weng

Authors: Fuzhong Weng, Xiaolei Zou and Mitch Goldberg

This study will address the impacts of the afternoon-orbit satellite sounding data on forecasts of Gulf coast precipitation and hurricanes. Three orbits of satellite data from NOAA-15 (early morning), MetOp-A (mid-morning) and NOAA-18 (afternoon) are assimilated in Hurricane Weather Research and Forecast (HWRF)/Grid-point Statistical Interpolation (GSI) data assimilation system. The AMSU data quality control procedure used in GSI is described and also revised for eliminating the rain-affected radiances. For each of the selected cases, two pairs of data assimilation and forecasting experiments are carried out and compared with and without including AMSU data from each orbit. It is shown that an early morning orbit from NOAA-15 can cover a large data void area over continental United States and improves assimilation at 0000 UTC and 1200 UTC times whereas the PM orbit data from NOAA-18 are critical for improving the assimilation at 0600 UTC and 1800 UTC. Thus, the early morning and PM orbit satellite observations are critical for improving short-range forecasts of severe weathers over CONUS whereas the midmorning satellite sounding data from MetOp are very useful for medium range forecasts over CONUS.

11p.03 Satellite Radiances Impact in the New Operational CPTEC/INPE 3DVar System

Presenter: Helena de Azevedo

Authors: Helena Barbieri de Azevedo; Luis Gustavo Gonçalves de Gonçalves

It is noteworthy that satellite information is of utmost importance in Numerical Weather Prediction. In addition to the massive amount of remote observations produced, satellites also reach areas such as oceans, deserts and high latitudes, difficult for measurements. The Center for Weather Forecast and Climate Studies (CPTEC from its Portuguese acronym) from the Brazilian National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais) recently implemented a new three-dimensional variational data assimilation system based on the GridPoint Statistical Interpolation (GSI). The new DA scheme replaces the former operational PSAS (Physical-space Statistical Analysis System), mainly due to its capacity of ingesting a much

larger number of observations, particularly satellite radiances. In this work nine experiments were performed using the CPTEC/INPE G3DVar. CONTROL: all avaliable data at CPTEC/INPE was assimilated; NO_SAT: data used in the CONTROL but radiances; RAD: only radiosondes were assimilated; GPS: only GPS data was assimilated; SAT: only radiances were assimilated; RG: only radiosondes and GPS were assimilated; RS: only radiosondes and radiances were assimilated; GS: only GPS and radiances were assimilated; and SRG: only radiances, GPS and radiosondes were assimilated. Each experiment was taken during the month of January 2013, for up to 108 hours forecasts. These experiments show how the incorporation of radiances affect CPTEC/INPE weather prediction as well as the impact and interaction between three different types of observations. Furthermore, results show that when only GPS is assimilated there is an increase in the number of observations accepted over the Southern Hemisphere opposed to when combined GPS and radiosonde are used. Lastly, when radiances are included, there is a substantial gain in the forecasts skill. For South America, it was observed that the combination of radiosonde, GPS and radiances, showed a higher correlation when data is removed from radiances. Still, for the first hours the GPS correlation falls faster than NO_SAT, but the last hours both are equal.

11p.04 Forecast Sensitivity to Satellite Observations in Global and East-Asia

Presenter: Kim Eun-Jung

Authors: Eun-Jung Kim, Sangwon Joo, Yoonjae Kim, Dong-Joon Kim

Large amount of satellite observation data can be used in numerical weather prediction model due to the improvement of supercomputer and its impact on numerical forecast is increasing. Forecast Sensitivity to Observation (FSO) is useful tool which evaluates the impact of observations on forecast because it reduces computation costs and produces values to determine which observations improved or degraded the forecast compared to traditional observation system experiment (OSE). Forecast error in FSO is set to 24-hour global energy norm and negative value means reduction of forecast error due to the analysis state. KMA NWP system assimilates 7 satellite observation groups such as AMV, ATOVS, AIRS, IASI, CSR, and GPSRO. Impacts of these observations are investigated by using the Forecast Sensitivity to Observation (FSO) tool in the Global Data Assimilation and Prediction System (GDAPS) for summer period in 2013. In the results, over a half of the short-range forecast-error reduction is due to the satellite observations. The satellite observation impact is mainly led by Metop-A for its usage of many sensors (AMSU-A, MHS, HIRS, GRAS, IASI and ASCAT). AMSU-A, IASI and IR channel of AMV have large impacts on forecast among satellite observations. Especially, impacts of AMSU-A are the largest because AMSU-A data covers the whole globe and it is observed by 5 satellites (NOAA15, 17, 18, 19 and MetOp-A). On the other hand, GPSRO sensor has the largest impact per sounding although its data amount is small. Compared to the results for global area, impacts of satellite are little bit different in East-Asia. When using East-Asia energy norm, impacts of MTSAT and COMS (KMA) satellites are larger than when using the global energy norm because this two satellites cover the East-Asia area.

11p.05 The Role of Satellite Data in the ECMWF Forecasts of Hurricane Sandy

Presenter: Stephen English (for Tony McNally)

Authors: Tony McNally, Massimo Bonavita, Jean-Noël Thépaut and Stephen English

A number of experiments have been performed at ECMWF where different satellite observations are deliberately withheld and forecasts of the hurricane re-run. Without observations from geostationary satellites the correct landfall of the storm is still reasonably well predicted albeit with a slight timing shift compared to the control forecast. On the other hand, without polar-orbiting satellites the ECMWF system would have given no useful guidance four to five days ahead that the storm would make landfall on the New Jersey coast. Instead the hurricane is predicted to stay well offshore in the Atlantic and hit the Maine coast 24 hours later. If background errors estimated from the ECMWF Ensemble of Data Assimilations (EDA) are allowed to evolve and adapt to the depleted observing system, then some of the performance loss suffered by withholding polar satellite data can be recovered.

11p.06 Role of Different Satellite Data on the Assimilation of Typhoon Fitow

Presenter: Yan Liu

Authors: Yan Liu, Jishan Xue, Guiqing Liu

GRAPES (Global and Regional Assimilation Prediction System) is the Chinese new generation NWP system for which the pre-operational tests are being conducted currently in operational NWP centers. It can assimilate atovs, RO , cloud drift wind and scat wind et. al satellite now. This paper will present the role of different satellite data on the assimilation of typhoon Fitow.

11p.07 OSSE on Geostationary Hyperspectral Infrared Sounders: Radiance Simulation, Validation and Impacts on Hurricane Forecast

Presenter: Zhenglong Li

Authors: Zhenglong Li, Jun Li, Pei Wang, Agnes Lim, Timothy J. Schmit, Robert Atlas, Sean Casey, Bachir Annane, and Tomislava Vukicevic

High spectral resolution infrared (IR) measurements from polar orbit (LEO) satellites have been demonstrated very useful in numerical weather prediction (NWP). Although instruments, such as the Atmospheric Infrared Sounder (AIRS), the Infrared Atmospheric Sounding Interferometer (IASI) and the Cross-track Infrared Sounder (CrIS), have shown significant impacts on reducing forecast errors in global NWP, placing such an instrument in a geostationary orbit (GEO) will provide nearly time continuous three-dimensional temperature, moisture and wind profiles, which will allow substantial improvements in monitoring and predicting meso-scale severe weather events such as tropical storms. In order to quantitatively evaluate the value-added impacts by GEO hyperspectral IR instruments on weather forecasting, a regional Observing System Simulation Experiment (R-OSSE) is conducted. Current LEO and future GEO hyperspectral IR sounder radiances are simulated for Hurricane Sandy (2012) under both clear and cloudy sky conditions with a suitable nature run. The simulated GEO and LEO radiances are then assimilated in the R-OSSE forecast model, and their impacts on hurricane track and intensity forecasts are verified with nature run. The LEO hyperspectral IR sounder radiances are also compared with the real measurements to assure a realistic simulation. AIRS is assumed as the hyperspectral IR sounder in the geostationary orbit of the Geostationary Operational Environmental Satellite (GOES)-13 for R-OSSE purpose. Two different radiative transfer models are used for simulation and assimilation, respectively. A fast radiative transfer model (the University of Wisconsin Radiative Transfer Model, or UWRTM) has been developed for radiance simulation based on coupled Stand-alone AIRS Radiative Transfer Algorithm (SARTA) for molecular absorption and a cloud model accounting for cloud scattering and absorption, while the Community Radiative Transfer Model (CRTM) is used for assimilation within Gridpoint Statistical Interpolation (GSI) framework. The simulated GEO AIRS radiances are compared with the GOES-13 Imager radiance measurements, which demonstrated that the simulated GEO AIRS radiances from the natural run capture the real temporal variations reasonably well. The R-OSSE on Hurricane Sandy case indicates that GEO hyperspectral IR sounder improves track and intensity forecasts over the current existing LEO advanced IR sounders during to its high temporal resolution.

11p.08 Investigation of AIRS and AMSU Sounding Products in Regional Numerical Weather Simulation

Presenter: Yu-Chi Yang

Authors: Yu-Chi Yang(1,), Chian-Yi Liu1(2), Gin-Rong Liu1(2), and Tang-Huang Lin(2)*

The numerical weather prediction (NWP) or simulation model has been developed for decades. It has received substantial improvement in term of predictability. On the other hand, satellite observations and retrieved products may provide critical assistant over ocean than conventional observation. In particular, the combined sounding retrievals from Advanced microwave sounding unit and Atmospheric Infrared Sounder (AMSU/AIRS) suggest a high quality estimation of atmospheric temperature and moisture profiles. Meanwhile, a higher spatial resolution from single field-of-view (SFOV) of AIRS sounding was developed followed by the previous combined AMSU/AIRS product. It is believe that finer spatial resolution retrievals could retain a better gradient structure in a weather system. In this study, we propose to use combined AMSU/AIRS and AIRS SFOV soundings to evaluate the performance for introducing these two different data sets. A heavy precipitation MCS case associated with a Mei-Yu frontal system during early June 2012 in the vicinity area of Taiwan is selected to demonstrate this concept. Weather Research Forecasting (WRF) and its three-dimensional variational module (3D-Var) is used to evaluate the forecast performance due to assimilating of NASA EOS AMSU and AIRS products. The preliminary result suggests that AIRS SFOV data set have better performance over combined AMSU/AIRS when both data are selected in the same spatial coverage. However, upper levels (about 200~300 hPa levels) have negative impacts when AIRS SFOV data is applied in this case, and it is supposed due to lager retrieval uncertainties at these levels.

11p.09 Near Real Time Regional Satellite Data Assimilation System and Initial Evaluation

Presenter: Jinlong Li

Authors: Jinlong Li, Jun Li, Pei Wang, Mitch Goldberg, Tim Schmit

Although satellite data assimilation has made the significant progress in global numerical weather prediction (NWP), challenges remain on satellite data assimilation in regional NWP models. For example, due to the high temporal/spatial resolution and limited time/spatial coverage, it is generally more difficult to estimate the background error covariance and more difficult to conduct bias correction. In the fine model grid, there are often mismatches between model states and satellite observations in the rapid change environment. The mismatch could possibly either throw away the good observations or assimilate some wrong information. In addition, how to better represent the information from satellite observation and how to get value added information from satellite data into the regional NWP model still need investigations.

With these in mind, we have developed a flexible regional satellite data assimilation/forecast system for tropical storm forecast (SDAT) (see website http://cimss.ssec.wisc.edu/sdat/). As a research test-bed, SDAT will be used to study the impacts of different satellite information on high impact weather forecasting, test new ideas and new methodologies than can be potentially transferred to the operation. SDAT products can also be used directly by users, for example, through Automated Tropical Cyclone Forecast (ATCF) system that National Hurricane Center (NHC) uses. The system mainly consists of the community Gridpoint Statistical Interpolation (GSI) assimilation system and advanced Weather Research Forecast (WRF) model. In addition to assimilate regular conventional and satellite radiance data obtained from NCEP (National Centers for Environmental Prediction), the system is also able to assimilate derived products such as hyperspectral IR (infrared) soundings, total precipitable water (TPW), layer precipitable water (LPW) and atmospheric motion vectors (AMVs). To set up the system parameters, different initialization schemes, different background error covariance matrix, and different WRF model horizontal resolutions have been tested. Different satellite data impacts have also been studied based on a couple of historical cases. Since August 2013, the system has been run in real-time and displayed on-line. Preliminary forecast results show very promising on tropical cyclone prediction. Further analysis and validation are ongoing and will be presented at the conference.

11p.10 Cycling Assimilation of ATOVS Microwave Sounding Observations in a Tropical Cyclone Case in 2012

Presenter: Shuang Xi

Authors: Shuang Xi, Peng ming Dong, Peng Zhang, Dan yu Qin, Gang ma

In order to continually assimilating ATOVS sounding data to improve the regional forecasting, a cycling assimilation system was built for cycling assimilating satellite sounding data, in National Satellite Meteorology Center of CMA. In the testing experiments, NOAA 18 AMSU-a data was used to improve the forecasting of Tropical Cyclone Saola in 2012. There were 3 experiments designed in an experimental period of 120 hours: control (a natural run), cold (cold restarting with satellite assimilation and the global background driving filed every 6 hours), and cycling (warmly starting with the satellite assimilation and the forecast result from the latest 6 hours' cycle). Compared with the cold start forecasting, cycling forecasting showed advance in describing more information of the Tropical Cyclones in detail. Because not only the satellite sounding observations were added to the background, but the developing information of the tropical cyclones from the latest forecasting cycle was also reserved. As for track errors, both assimilation experiments were prior to control experiment. Especially, the cycling experiment is better than cold experiment in the first one day and third day. But in the second day, there are large errors in cycling assimilation. The reason is still under review now. The intensities of the first day and early second day in the 3 experiments are very similar to the best-track data.

11p.11 Use of SEVIRI Radiances for Handling of Position Errors in a Limited-area Data Assimilation System

Presenter: Magnus Lindskog

Authors: Tomas Landelius, Nils Gustafsson, Magnus Lindskog, Jelena Bojarova

It is hard to forecast the position of localized weather phenomena such as clouds, precipitation, and fronts. Moreover, cloudy areas are important since this is where most of the active weather occurs. Position errors, also known as phase or alignment or displacement errors, can have several causes; timing errors due to deficient model physics, inadequate model resolution, etc. Furthermore, position errors have been shown to be non-additive and non-Gaussian, which violates the error model most data assimilation methods rely on. SEVIRI radiances contain coherent information on the weather development in time and space. By comparing structures of these data with the forecast model state it is possible to get information about position errors. We use an image registration (optical flow) method to find a transformation, in terms of a displacement field, that aligns the model state with the corresponding remote sensing data. The estimated displacement field is used differently in variational and in hybrid ensemble/variational data assimilation. The novel utilization of SEVIRI data will be demonstrated and results from full scale data assimilation studies will be presented.

11p.12 The Impact of Assimilation of Microwave Radiance in HWRF on the Forecast over the western Pacific Ocean

Presenter: Chien-Ben Chou

Authors: Chun-Chieh Chao, Chien-Ben Chou, and Huei-Ping Huang

We investigated the impact of assimilating microwave radiances from the Advanced Microwave Sounding Unit-A (AMSU-A) and the Microwave Humidity Sounder (MHS) into the Hurricane Weather Research and Forecasting (HWRF) model on the forecast of typhoon tracks over the western Pacific Ocean. The assimilation of MHS observations has positive impacts on the track forecast, but the assimilation of AMSU-A leads to mixed results. In the forecast experiments, the bias correction coefficients created from the

regional model data assimilation system are found to be superior to those produced by the global modeling system, even though the background fields in both cases are derived from the global model predictions.

11p.13 The Use of COMS Clear Sky Radiance in NWP Model; CSR Product in Global Model and Clear Pixel Radiance for Local Model

Presenter: Jung-Rim Lee

Authors: Jung-Rim Lee, Yoonjae Kim, Eunhee Lee, Dong-jun Kim, In-cheol Shin

The COMS Clear Sky Radiance of WV channel data has been produced since April in 2011, and started to assimilate in global model of KMA since June 2013. The spatial resolution of COMS CSR product is about 30 km (mean brightness temperature in 7x7 pixels), and only the data whose clear fraction is 100% are used for the assimilation. The model performance after using COMS CSR data is quite improved. However, we keep monitoring the bias between CSR data and model (O-B), and plan to optimize the bias correction coefficient. Also, we are trying to use high resolution CSR (4 km pixel resolution) for Local Model of KMA (grid size is 1.5 km). We just tested the model with pre-processing module including the clear pixel radiance data. We are planning to run model and look at the performance, and the result will be presented at the conference.

11p.14 Assessing Observation Impacts on CPTEC/INPE G3DVAR Analysis

Presenter: Fabio Luiz Rodrigues Diniz

Authors: F. L. R. Diniz and D. L. Herdies

The Center for Weather Forecast and Climate Studies from the Brazilian National Institute for Space Research (CPTEC/INPE) successfully updated its operational data assimilation system with the Global 3DVar (G3DVAR). The G3DVAR generates forecasts using the Atmospheric Global Circulation Model (AGCM) developed at CPTEC/INPE and analysis using the Gridpoint Statistical Interpolation (GSI) jointly developed by NOAA, NASA, and NCAR. This system is operational at the center since January 2013 using a variety of conventional and non-conventional observations. The present work outlines the observation impacts on the analysis calculated with an observation-space approach following Todling (2013; MWR, 141, 1484-1505). Furthermore this presentation will show preliminary results of the observation impacts using a more recent version of G3DVAR capable of handling the latest components of the observing system, such as refractivity and bending angle profiles from radio occultation observations, and the radiances from the Advanced Technology Microwave Sounder. The interest of this evaluation is to corroborate for the results presented on this work, assess the quality improvements brought in using the more recent version of the system, and ensure the assimilation of all these datasets will work properly in this system once became operational at the center.

Session 12a: Climate

12.01 Use of Long-term MSU/AMSU Data to Examine the Weakening of Walker Circulation in CMIP5 Climate Simulations

Presenter: B.J. Sohn

Authors: B.J. Sohn, Euiseok Chung

There has been debate whether tropical Walker circulation weakens (or strengthens) under the global warming conditions in particular between observations and climate model simulations. Most of model simulations show weakened Walker circulation intensity when global warming progresses. Modeling community have argued that weakening trends shown in reanalysis are artifacts related to inappropriate nudging a model toward a more unstable atmosphere. We challenge this unjustified notion, with long-term MSU data by examining whether the CMIP5 model simulations are comparable to findings from MSU-derived atmospheric stability. In doing so, we remove surface influence from MSU TLT Ch2 brightness temperature to obtain the thermal structure in the lower troposphere while TTT Ch2+4 brightness temperature for slightly upper troposphere. A broad two-layer mean dry static stability is calculated from MSU brightness temperatures, and results are compared with those from CMIP5 historical simulations. It is shown that tropical distributions of 30-year mean trend of MSU-like stability from ERA-Interim reanalysis are similar to those from MSU observations, i.e. strengthened stability over the western Pacific and weakened stability over the Eastern Pacific, suggesting strengthened Walker circulation from both MSU observations and ERA-Interim reanalysis. On the other hand, ensemble mean of stability trend from CMIP5 simulations show much geographically smoothed pattern not showing any meaningful trend, due to the cancellation amongst model members, suggesting no consensus is made amongst models.

12.02 Recalibration of Stratospheric Sounding Unit for Climate Reanalysis Applications

Presenter: Cheng-Zhi Zou

Authors: Cheng-Zhi Zou

Warming of the troposphere and cooling of the stratosphere are two central features of global warming resulting from anthropogenic forcing. Although cooling of the lower stratosphere has been well documented with satellite observations from the Microwave Sounding Unit (MSU),

changes in the middle and upper stratosphere were not well understood due to a lack of well documented satellite datasets as well as other in situ observations. NOAA/STAR has recently released a well documented stratospheric temperature time series derived from the Stratospheric Sounding Unit (SSU) observations onboard historical NOAA polar orbiting satellites. The stratospheric temperature trends derived from this dataset has been compared with an earlier version developed by UK Met Office and with climate model simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5) and Chemistry-Climate Model Validation phase 2 (CCMVal2) projects. Extensive differences were found in absolute magnitudes and temporal patterns, both within and between models and observations. NOAA/STAR has recently recalibrated the SSU level-1c radiances to understand the root causes for the differences. In this talk, key factors such as cell pressure adjustment in reprocessing the SSU data and their impact on stratospheric temperature trends are discussed. Recalibration results and a newer version of SSU level-1c dataset as well as an updated SSU layer temperature time series will be released soon. Possible applications of the recalibrated level-1c data in climate reanalysis will be discussed.

12.03 SPARE-ICE: Synergistic IWP from Passive Operational Sensors

Presenter: Gerrit Holl

Authors: G. Holl, S. Eliasson, J. Mendrok, S. A. Buehler

This article presents SPARE-ICE, the Synergistic Passive Atmospheric Retrieval Experiment-ICE. SPARE-ICE is the first IWP product combining solar, infrared, and microwave radiances. By using only passive operational sensors, the SPARE-ICE retrieval can be used to process data from at least the NOAA-15 -- 19 and MetOp satellites, obtaining time series from 1998 onward. The retrieval is developed using collocations between passive operational sensors (solar, terrestrial infrared, microwave), the CloudSat radar and the CALIPSO lidar. The collocations form a retrieval database matching passive reflectances and radiances against the existing active combined radar-lidar product 2C-ICE. With this retrieval database, we train a pair of artificial neural networks to detect clouds and retrieve IWP. We show that a retrieval using solar, terrestrial infrared, and microwave performs better than a retrieval using only one or two of these techniques. The median fractional error between SPARE-ICE and 2C-ICE is around a factor 2, a figure similar to the random error between 2C-ICE IWC and in-situ measurements. A comparison of SPARE-ICE with MODIS and MSPPS indicates that SPARE-ICE performs well even in difficult conditions. SPARE-ICE is available for public use.

12.04 The CM SAF ATOVS Tropospheric Water Vapour and Temperature Data Record

Presenter: Nathalie Selbach

Authors: Nathalie Courcoux, Marc Schroeder, Nathalie Selbach

The EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) is a consortium of several European weather services. The major objective of the CM SAF is the exploitation of satellite observations to derive information on key climate variables of the Earth system. The CM SAF focuses on the atmospheric part of the Essential Climate Variables defined within the framework of the Global Climate Observing System (GCOS). Recently, CM SAF released the ATOVS (Advanced TIROS-N Operational Vertical Sounder) tropospheric water vapour and temperature data record which is available free of charge from www.cmsaf.eu. This data record consists of 13 years (1999-2011) of global water vapour and temperature daily and monthly means derived from the HIRS, AMSU-A and-B/MHS instruments flying onboard the NOAA and MetOp satellites, with up to four satellites contributing to the ATOVS data record. The product has a spatial resolution of 90kmx90km and has been processed with a fixed processing system. This system consists of the AVHRR and ATOVS Pre-processing Package (AAPP), the International ATOVS Processing Package (IAPP), an objective interpolation method (Kriging) and inter-calibration coefficients for AMSU-B. The product suite includes total precipitable water vapour, the layered integrated water vapour and the layered mean temperature in five layers, as well as the specific humidity and the temperature at six levels. The products were compared against GUAN (GCOS Upper-Air Network) radiosonde observations and against other satellite data records, with a focus on AIRS. In general the comparison results demonstrate the good quality of the CM SAF ATOVS water vapour and temperature data record. However, the evaluation also revealed that differences in sampling may strongly impact the degree of homogeneity. This can occur with the transition from single satellite observations to multi satellite observations and mainly occurs in comparison against the AIRS data record, being a single sensor product from a satellite with a stable orbit. We will outline the processing set-up, introduce the products and concentrate on the presentation of results from comparisons against GUAN radiosondes and AIRS.

Session 12b: Climate

12p.01 CHARMe: Characterization of Metadata to Enable High-quality Climate Applications and Services
Presenter: Nathalie Selbach
Authors: N. Selbach, R. Alegre, J.D. Blower, D.J. Clifford, F. Kratzenstein, P.J. Kershaw, J.P. Lewis, K. Marsh, M. Nagni
CHARMe as a GMES/COPERNICUS-project is supported by the EU-FP7 (SPACE) and is a contribution towards a European Climate Service. The project aims to link climate datasets with publications, user feedback and other items of "commentary metadata". CHARMe will help users learn from previous community experience and select datasets that best suit their needs, as well as providing direct traceability between conclusions and the data that supported them. The project applies the principles of Linked Data and adopts the Open Annotation standard to record and publish commentary information. CHARMe contributes to the emerging landscape of "climate services", which will provide climate data and information to influence policy and decision-making. This presentation will introduce the main motivation and basic ideas of the project. It will describe the selected technical approach and will give a brief overview of the system architecture.

12p.02 Climate Data Records of the EUMETSAT Satellite Application Facility on Climate Monitoring
Presenter: Nathalie Selbach
Authors: Nathalie Selbach, Petra Fuchs, Karsten Fennig, Diana Stein, Britta Thies, Jinghong Tan
The EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) generates, archives and distributes widely recognized high-quality satellite-derived products and services relevant for climate monitoring. Several data sets have already been released by CM SAF. Users have access to many parameters of the water and energy cycle based on operational satellite instruments. The time series of the climate data sets range from 8 to about 30 years. The Climate Data Records (CDR) based on polar orbiting satellites have a global coverage, while those based on geostationary satellite data have a regional coverage (METEOSAT disk). CM SAF is offering CDRs generated from ATOVS, AVHRR and SSM/I on different polar orbiting satellites as well as from the MVIRI, SEVIRI and GERB instruments onboard the METEOSAT series. These CDRs are made available via a web user interface which also allows applying post-processing procedures, such as the extraction of sub-areas or re-projection. Further climate data records will be released until the end of the current project phase (CDOP-2), covering several cloud parameters, surface albedo, radiation fluxes at top of the atmosphere and at the surface, aerosols, precipitation as well as different water vapour parameters and fluxes. These will be derived from different sensors onboard operational polar orbiting and geostationary satellites including instruments such as (A)TOVS, AVHRR (in GAC resolution), SSM/I and SSMIS, GERB, MVIRI and SEVIRI. As for the already released data sets, different areas of the globe will be covered depending on the satellite type. This presentation will give an overview of the current and planned re-processing activities at the CM SAF. It will describe the data sets as well as the user access to all CM SAF products and services.

12p.03 The GEWEX Water Vapour Assessment (G-VAP) - First Results from Inter-comparisons and Stability Analysis
Presenter: Nathalie Selbach
Authors: Marc Schroeder, Maarit Lockhoff, Lei Shi
In a Joint Letter from the Global Climate Observing System (GCOS) and the World Climate Research Programme (WCRP) the general need for coordinated international assessments of climate products was formulated. Such assessments are important mechanisms for improvements and to enhance and promote utilisation. The GEWEX Radiation Panel (GRP, renamed to GEWEX Data and Assessment Panel - GDAP) has initiated a Water Vapor Assessment in 2011, further on referred to as G-VAP. The major purpose of G-VAP is to: - Quantify the state of the art in water vapour products being constructed for climate applications, and by this; - Support the selection process of suitable water vapour products by GDAP for its production of globally consistent water and energy cycle products. The usage of products within GDAP activities essentially implies to study long-term data records. Since the start of G-VAP in 2011 two workshops have been conducted. The results of these workshops together with feedback from the first GDAP meeting were used for setting up the G-VAP assessment plan. This plan (available at www.gewex-vap.org) summarizes scope and goals of the assessement, introduces science questions and provides details on the planned technical and scientific activities. Major elements of G-VAP are: - All three parts of the GCOS Essential Climate Variables (ECV) on water vapour and their consistency are considered: Total Column Water Vapour, Upper Tropospheric Humidity as well as water vapour profiles and their related temperature profiles; - The assessment focuses on overall characteristics of participating satellite data records and reanalyses as determined from inter-comparison and comparisons against in situ observations as well as against ground-based products; - In this characterisation process the data records are not ranked according to their quality. Rather, the application areas and requirements of

the individual data records as well as the GEWEX requirements are documented; - G-VAP will provide a database that includes collocated products and validation data of sufficient quality and long-term stability to be the main repository for the current assessment. At the last G-VAP workshop in fall 2013 it was decided to assign highest priority to finalise the work on the data inventory as well as the inter-comparison, comparison to ground-based and in-situ data, stability analysis and the analysis of differences in trends using gridded data. Inconsistencies that have been observed during such analyses will be explained to the maximum extend possible. A general overview of G-VAP will be given. The focus of the presentation will be on observed inconsistencies among the long-term satellite data records as observed by the (inter-)comparisons and the stability analysis. First explanations for observed inconsistencies will be given.

12p.04 Error Characterisation of SSM/T2 Radiances
Presenter: Viju John
Authors: Viju John and Eui-Seok Chung
SSM/T-2 radiances have been assessed for their potential for monitoring of atmospheric humidity. Some anomalies are seen with the data but there are sufficient stable periods to make these data worthy of consideration for extending the microwave humidity data set back in time before the start of AMSU-B in 1998 to create more than 20 years long tropospheric humidity data set from microwave measurements. Results of comparison between SSM/T-2 radiances to in situ and other satellite data will be shown in the presentation.

12p.05 Inter-calibration of METEOSAT IR and WV Channels
Presenter: Viju John
Authors: Viju John, Rob Roebeling, Tim Hewison, Alessio Lattanzio, Joerg Schulz
We present a strategy to inter-calibrate the complete time series of Water Vapour (WV, 6.3 µm) and Infrared (IR, 11.8 µm) channel radiances from the MVIRI instrument on Meteosat First Generation and the SEVIRI instrument on Meteosat Second Generation satellites. Our initial plans were to use HIRS channels 12 and 8, respectively, as references for the inter-calibration of these channels. A systematic review of spectral conversion functions, which often dominate the errors, indicates that spectral changes of the WV channel from HIRS/2 to HIRS/3 triples the uncertainty of inter-calibrated METEOSAT WV radiances. To circumvent this issue, we now use HIRS/2, AIRS, and IASI as reference instruments and thus keeping the uncertainties due to spectral conversion similar throughout the time series.

12p.06 Assessment of the Nimbus-4 IRIS Dataset (1970-1971) for Use in Reanalysis
Presenter: Pascal Brunel
Authors: Paul Poli and Pascal Brunel
Further to the poster presented at ITSC-18 reviewing the historical satellite record pre-1979, this paper reports on work carried out with one historical radiance dataset. In 1970 and 1971, the InfraRed Interferometer Spectrometer (IRIS) operated from the Nimbus-4 satellite. Even by today's standards, this Michelson interferometer was a hyperspectral sounder, with 862 channels. It covered wavenumbers between 400 and 1600 cm-1 (or 25.00°™6.25 microns). Though without cross-scanning, this instrument predated by more than 30 years the current hyperspectral sounders such as AIRS on EOS-Aqua, IASI on Metop-A and -B, and CrIS on Suomi NPP.

The data collected by Nimbus-4 IRIS have so far not been used in global, multi-decadal, atmospheric reanalyses. Yet, these radiance data contain spectrally detailed information about our atmosphere's vertical structure and its constituents. Also, owing to the nature of the calibration problem acting on measurements of narrow spectral intervals, these radiance data have a great potential to serve as stable references in an assimilation scheme during the time period when they are available, or can be used to assess the quality of other atmospheric datasets, once the IRIS data quality has been understood and characterized.

The data from the Nimbus-4 IRIS experiment have recently been rescued from tapes by the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC). With the aid of a state-of-the-art radiative transfer model, the EUMETSAT NWP-SAF RTTOV, we revisit this radiance dataset by comparing it with ECMWF reanalyses (ERA). We find in some spectral regions (e.g., 15 microns band) that the fit to the ERA-40 reanalysis is below 2 K standard deviation in brightness temperatures.

Session 13a: Composition

13.01 Volcanic Ash and SO2 Retrievals from 30 Years of Satellite Measurements
Presenter: Fred Prata
Authors: Fred Prata, Simon Carn, Lieven Clarisse
Observations of volcanic eruptions using the TOVS/HIRS, AVHRR and TOMS satellite instruments have been available starting in 1979 and have been supplemented or replaced by new instruments with greater capabilities, such as AIRS, IASI, OMI, NPP and OMPS. An analysis of more than 30 years of archive data reveals that there is a great deal of information that can be derived on the

location and quantity of volcanic emissions into the atmosphere. Starting with the eruptions of Mt St Helens in 1980, and ending with examples from current activity, this work will show how the development of retrieval algorithms is helping to improve understanding of the role of volcanic emissions in meteorology and climate, as well as in some other disciplines. The recent suggestion that small-sized eruptions may be contributing to increases in the aerosol content at upper levels and slowing of the rate of warming of the Earth-Atmosphere system will be discussed and the contribution of satellite observations emphasized. An update to on-going climate record of upper level SO2 emissions from satellites will also be presented. Finally, a discussion of new research directions and findings concerning the transport and fate of volcanic emissions into the atmosphere will be presented.

13.02 Retrieval of Atmospheric Temperature, Water Vapour and Trace Gases at a Vertical and Horizontal Kilometric Resolution Using an Infrared Tomographic Imager Combining Nadir and Limb Views

Presenter: Eric Pequignot

Authors: E. Pequignot, J-L Bertaux, A. Hauchecorne, S. Ferron, F. Montmessin, J-L Vergely

Actual space infrared hyperspectral sounders like IASI on MetOp, AIRS on Aqua and more recently CrIS on NPP measure infrared atmospheric spectra at very high spectral resolution typically between 0.5 and 2 cm-1 and poor spatial resolution typically 10-12 km. These infrared measurements allow constraining vertically atmospheric profiles of temperature, water vapour and in a lesser extent other atmospheric gases. The design philosophy of current infrared sounders has always been to decrease the spectral resolution in order to increase the vertical resolution of temperature, water vapour and other atmospheric gas profiles. However, the improvement of the vertical resolution is not linear with respect to the improvement of the spectral resolution. There is a physical limit imposed by spectroscopy and line-shape dependency with temperature and pressure. IASI and future IASI-NG are already very close to the limit imposed by physics. It means that the improvement in terms of vertical resolution of a single channel averaging kernels or jacobians could not be very much better. The energy entering the instrument is directly proportional to its etendue (pixel solid angle x entrance pupil surface) and therefore to its size, mass and power need. These parameters are constrained by the launcher, the payload, the telemetry and the overall cost of the mission. Then for a constant energy flux entering the instrument, a trade-off between instrument noise, spectral resolution and spatial resolution is needed. That is the reason why actual infrared hyperspectral sounders have a limited spatial resolution, typically 10-12 km. Spectra are directly assimilated by NWP mid-term forecast models in order to constrain atmospheric parameters as temperature, pressure and specific humidity. In the future, they also hope to be able to constrain concentration of other atmospheric gases. The results provided by forecast models also depend on the model itself and more precisely on how the small scale convective phenomenon are solved. For now, spatial scales of about 1-2 kilometres are not explicitly solved. Assimilation of heterogeneous scenes is still also a challenge. At that time, there are no instruments that can provide measurements in order to validate atmospheric model at a kilometric scale vertically or horizontally. The instrument foreseen is called WINTI (Wild Field Infrared Tomographic Imager). It is an imager with a horizontal resolution of 1 km and about 10-20 spectral bands in the thermal infrared. Much of them are used to constrain temperature and water vapour. 3-4 bands are dedicated to chemistry (O3, CO or CH4). A mirror allows scanning along track from nadir to limb. A CNES phase 0 at system level has started in 2013. We have studied the potential of a new observation scheme based on atmospheric tomography combining nadir and limb views. It allows getting both a vertical and horizontal resolution of about 1 km. First we will define the geometry of the measurements and then the inversion scheme based on Bayesian optimal estimation. We will finally validate the concept through its ability in retrieving temperature, water vapour and trace gas profiles in some representative atmospheric conditions.

Session 13b: Composition

13p.01 Several Decades of Observation of Mid-tropospheric CO2 from ATOVS, AIRS and IASI

Presenter: Cyril Crevoisier

Authors: C. Crevoisier, N. Meilhac, A. Chedin, N. A Scott, L. Crépeau and R. Armante

Since the first retrieval of mid-tropospheric CO2 from NOAA-10/TOVS observations made by Chédin et al. (2003), the non linear inference scheme based on neural networks has been adapted to process observations from several TOVS and ATOVS instruments, and then from the hyperspectral instruments AIRS onboard Aqua and IASI onboard Metop-A. Several decades of observation can now be used to follow the long-term evolution of CO2, seasonality and growth rate. In particular, a strong asset of polar satellites comes from the possibility to retrieve mid-tropospheric CO2 columns twice a day (e.g. 9.30 am/pm for IASI). We find that, over the 20 years covered here, the difference between evening and

morning CO2 columns, hereafter referred to as Daily Tropospheric Excess (DTE), increases up to several ppm over regions affected by biomass fires, confirming the results obtained from NOAA10 TOVS observations over 1987-1991. This signal is quite robust based on its differential nature, which helps eliminating potential contaminations of the CO2 retrievals (platform drifts, potential trends, etc.). The physical mechanism linking DTE with fire emissions comes from the diurnal cycle of fire emissions associated with enhanced convection: hot convective fire plumes injects CO2 into the troposphere during the afternoon peak of fire activity, which is seen by the satellite evening passing; it is then diluted by large scale atmospheric transport, before the next satellite morning passing. The CO2 DTE shows monthly, seasonal and annual spatial patterns similar to fire products, such as CO2 emissions from the Global Fire Emission Database (GFEDv3) and burned areas from the MODIS instrument. We conclude that infrared sounders can play a fundamental role in the monitoring of CO2 and associated emissions. In particular, the DTE signal can be very useful as a quantitative proxy to constrain the analysis of current fire emissions, as well as to help reconstructing their patterns before the MODIS period by using TOVS and ATOVS instruments flying onboard the NOAA platforms since 1979.

13p.02 A View on Mid-tropospheric CH4 in the Tropics: 6 years from MetOp-A/IASI

Presenter: Cyril Crevoisier

Authors: C. Crevoisier, R. Armante, S. Massart, C. Cressot, L. Crépeau, N. Meilhac, O. Membrive, N. A. Scott, and A. Chédin

Since July 2007, monthly averages of mid-tropospheric methane are retrieved in the tropics over land and sea, by day and night, from IASI onboard MetOp-A, yielding a complete view of its geographical distribution, seasonality and long-term tendency in the mid-troposphere. Through comparisons with regular aircraft measurements of the CONTRAIL and CARIBIC programs, we will show that IASI captures well the evolution of mid-tropospheric methane with an averaged difference between collocated IASI estimates and CARIBIC measurements of 7.2 ppbv with a standard deviation of 13.1 ppbv for methane. We will show that IASI captures the trend and interannual variation f CH4, with an excellent agreement with the rate of increase measured at the surface, giving confidence in the ability of IASI to follow their evolution over the 20 years of EPS/MetOp program. We will discuss the 6-year evolution of CH4 in light of the recent evolution of surface emissions and climate conditions. Finally, we will discuss the use of IASI CH4 fields to infer the space-time distribution of methane total column and surface emissions that is currently being investigated in the framework of the MACC-II/GMES initiative and the ESA Climate Change Initiative.

13p.03 IDEA-I Air Quality Forecast Software Package: Aerosol, Ozone, and Carbon Monoxide Detection and Trajectories

Presenter: Rebecca Cintineo

Authors: Rebecca Cintineo, James Davies, Bradley Pierce, Elisabeth Weisz, Nadia Smith, and Kathleen Strabala

The Infusing Satellite Data into Environmental Applications - International (IDEA-I) software package has been developed as a part of the NASA funded International MODIS/AIRS Processing Package (IMAPP) to aid air quality forecasters in the prediction of the movement of aerosols and trace gases using direct broadcast satellite data. The initial development of IDEA came about as a partnership between NASA, NOAA and the US Environmental Protection Agency (EPA) whose defined goal was to improve air quality assessment, management and prediction. After a successful deployment of the system in the US using direct broadcast polar orbiter data, the software was ported for use by the international community. The initial release of IDEA-I uses the MODIS aerosol product (MOD04) to identify locations with a large aerosol optical depth which were used to initialize a trajectory model to forecast where the aerosols may be transported. From there, it could be determined whether they would potentially end up at heights that would affect the air quality in the boundary layer or, inversely, from where pollution may have originated. The latest release includes a separate system that uses ozone and carbon monoxide retrievals from the Aqua AIRS, S-NPP CrIS, and MetOP IASI hyperspectral sounder instruments to initialize trajectories. The products that are created can be used to help determine when and where air quality problems due to trace gases may arise and whether they are likely due to human activity or natural stratospheric intrusions. The IDEA-I software and its products will be discussed and case studies shown.

13p.04 Evaluation of IASI Derived Dust Aerosols Characteristics over the Tropical Belt

Presenter: Virginie Capelle

Authors: V. Capelle, A. Chedin, M. Simeon, C. Tsamalis, C. Pierangelo, M. Pondrom, R. Armante, C. Crevoisier, L. Crepeau, and N. A. Scott

IASI-derived monthly mean infrared (10 microns) dust aerosol optical depth (AOD) and altitude are evaluated against ground based AERONET measurements of the 500 nm coarse mode AOD and CALIOP measurements of the altitude at 38 AERONET sites within the tropical belt (30N-30S). The period covered extends from July 2007

to December 2012. The evaluation goes through the analysis of Taylor diagrams and box and whiskers plots, separating situations over sea and over land. Concerning AOD, the overall correlation for the sites over sea comes to 0.88 for 713 items (IASI and AERONET monthly mean bins). The overall normalized standard deviation is of 0.96. Over land, essentially desert, correlation is of 0.74 for 582 items and the normalized standard deviation is of 0.87. This slight but significant degradation over land most probably results from the greater complexity of the surface (heterogeneity, elevation) and, to a lesser extent, to the episodic presence of dust within the boundary layer (particularly for sites close to active sources) to which IASI, as any thermal infrared sounder, is poorly sensitive contrary to AERONET. Concerning altitude over sea, correlation is of 0.78 for 925 items and the normalized standard deviation is of 1.03. Results over land, essentially over deserts, are not satisfactory for a majority of sites. To the reasons listed above for the AOD must be added the smaller IASI signal induced by the altitude compared to the signal induced by the AOD. Site by site, disparities appear that we estimate being principally due to either the insufficient number of AERONET observations throughout the period considered, to the complexity of the situation mixing several aerosol types (case of the Persian Gulf, for example), to surface heterogeneities (elevation, emissivity, etc.), or to the use of a single aerosol model (MITR). Results using another aerosol model with different refractive indices are presented and discussed. We conclude that the present results demonstrate the usefulness of IASI data as an additional constraint to a better knowledge of the impact of aerosols on the climate system.

13p.05 Asian-dust Detection over Ocean from IR 11-um Channel Measurement

Presenter: Sang-Moo Lee

Authors: Sang-Moo Lee, and B. J. Sohn

Recently derived analytical relationship between Fresnel polarized reflectivities over the specular surface independent of surface refractive index provides opportunities of sensing surface optical properties from satellite IR measurements. This study attempts to retrieve dust distribution and proxy intensity of Asian dust over the ocean surface by using analytical relationship between decomposed polarized reflectivities from satellite-measured 11 micron brightness temperature. It has been shown that the real part of adjusted refractive index of the sea surface in clear sky is substantially different from that under dust condition. Thus it is possible to determine dust boundaries from the retrieval of adjusted refractive index. Also shown is the information of dust intensity from the IR 11 micron measurements. The developed method is applied to MODIS 11 micron channel measurements, and results indicate that one channel approach is capable of determining the dust area as well as intensity but only over ocean. It should be beneficial for the dust monitoring over the ocean in particular during the night as conventional IR approaches often result in suddenly disappearing features over the ocean.

13p.06 A Case Study on Atlantic Tropical Cyclogenesis and Saharan Air Layer Simulated Using WRF/Chem Coupled with an AOD Data Assimilation System

Presenter: Zhiquan Liu

Authors: Zhiquan Liu and Dan Chen

This study investigated the influences of dust-radiation effects on tropical cyclogenesis and the Saharan Air Layer (SAL) over the Atlantic Ocean by using the Gridpoint Statistical Interpolation 3DVAR aerosol data assimilation system coupled with the Weather Research and Forecasting/Chemistry (WRF/Chem) model. Two experiments were conducted with and without the assimilation of MODIS aerosol optical depth (AOD). One-week (from 28 August to 5 September, 2006) assimilation of the MODIS total 550 nm AOD (Deep Blue products over land and dark targeting products over ocean) retrievals significantly improves the forecast of dust outbreak and transport feature. Differences of the 180-h forecast initiated at 00 UTC 5 September from the two experiments were analyzed to investigate the dust radiation effects. The dust-radiation over mostly cloudless conditions mainly warmed the dusty air and the layer near surface through direct effects in the first three days of model simulation. In the cloudy conditions with the Meso-sclae Convective System (MCS) developing, dust semi-direct interactions through clouds induced much larger temperature increase and relative humidity decrease in the middle troposphere; thus suppressed clouds and precipitation, enhanced downward motion and resulting cold pool. Around 5 degree potential temperature decrease and 80% relative humidity decrease occurred in the middle troposphere at storm center. The enhanced downdraft stabilized the boundary layer and weakened the large-scale boundary layer convergence driving the deep, moist convection and finally caused the MCSs erosion. Due to early suppression, more ice precipitation and high clouds formed as more water ascend to freezing levels, and the greater amount of freezing water aloft released extra latent heat and invigorated the convection in peripheral region. The storm was further weakened by the bled and cooled low-level airflow caused by peripheral clouds invigoration. The dust-radiation also intensified the warmness and dryness of the SAL, which can have a feedback on the tropical cyclogenesis as well.

13p.07 The Geostationary Remote Infrared Pollution Sounder: Measurement of the Carbon Gases from Space

Presenter: Hal Bloom (for Mark Schoeberl)
Authors: Mark Schoeberl, Hal Bloom, Ryan Spackman, Science and Technology Corporation

We describe an instrument for the measurement of carbon gases and its earth remote sensing capabilities from geostationary orbit.. Carbon gases, CO, CH4 and CO2, are key components of climate change and air quality. CO, with the shortest lifetime, is produced by fires and industrial processes. It plays a role in ozone formation and is a surrogate for black carbon aerosols and smoke. CH4, is a powerful greenhouse gas produced by biogenic process, leaks from pipelines and extraction complexes, and fires. CH4 sources and sinks are highly uncertain. CO2 is also a powerful greenhouse gas, but despite years of study, its sinks are still uncertain. Using the combination of these gases we can fingerprint sources of pollution. Our instrument concept , the Geostationary Remote Infrared Pollution Sounder (GRIPS), will provide rapid temporal and high spatial resolution measurements of these carbon gases from space. The instrument is designed to quantify the concentration, sources and fluxes of these gases over the extra-polar regions from geostationary orbit. One advantage of the geostationary orbit is that more measurements in cloud free regions can be made in a few days than can be made in several weeks of low earth orbit measurements. A second advantage is that we can resolve the diurnal component of the gas concentration. This allows better tracking of plumes and identification of sources. Unlike the thermal infrared sensors on AIRS, MOPITT and IASI, GRIPS uses the near and short wave infrared to make measurements in the boundary layer, where the sources and sinks are active.

Session 14a: Climate Studies with Advanced IR Sounders

14.01 Climatology of IASI Radiance Spectra for Global Climate Change Monitoring: Results and Interpretation

Presenter: Thierry Phulpin
Authors: Thierry Phulpin, S. Gaugain and JP Gonzalez

Infrared spectra from IASI on Metop have the quality to be used in climate monitoring. As IASI and its successor are planned to fly for more than 30 year it sounds valuable to exploit its capability for estimating long term trends. The products extracted from IASI level1c routine acquisition are used to populate a climatology of the spectra at scales of months or years and at global scale. Some characteristics related to ECVs (proxies) are extracted and plotted versus time to monitor the trends of these ECV. Interannual month mean spectra are also compared to derive main trends at seasonal scale. An inversion of annual gradients has also been performed giving results very close to those obtained from NCDC statistics, confirming the pertinence of the approach. IASI also offers the possibility to monitor consistently several variables over the globe. First applications at regional scales ,e.g. the tropical ocean or the Antarctica have begun.

14.02 Processing of Aqua/AIRS and Metop-A/IASI to Study Essential Climate Variables

Presenter: Cyril Crevoisier
Authors: C. Crevoisier, R. Armante, V. Capelle, A. Chédin, N. Jacquinet-Husson, N. A. Scott, C. Stubenrauch, L. Crépeau, M. Ben Sassi, A. Bouhdaoui, A. Feofilov, N. Meilhac, M. Pondrom

Since their launch onboard Aqua in May 2002 and Metop-A in October 2006, AIRS and IASI contributes to the establishment of robust long term data records of several essential climate variables. We will focus here on 4 of them that are retrieved at LMD: (i) clouds: physical and microphysical properties; (ii) greenhouse gases: mid-tropospheric integrated content of CO2, CH4 and CO; (iii) dust aerosols: AOD, altitude, and radius; (iv) continental surface characteristics: skin temperature and spectral emissivity. We will show that with already 10 years of observations from AIRS and 6 years from IASI, and two more missions to come, hyperspectral infrared sounders have the potential to monitor the evolution of these variables on the long-term, to assess potential trends, and to detect signatures of specific climate events, such as ENSO or other sources of climate variability. All these activities rely on a processing chain of satellite observations that has been developed for many years at LMD and that includes: permanent validation and improvement of the GEISA spectroscopic database and of the radiative transfer code 4A (which are respectively the official database and code for IASI Cal/Val activities at CNES), development of dedicated cloud and aerosol detection schemes, retrieval processes, and validation activities. In particular, in close collaboration with CNES, LMD contributes to the monitoring and intercomparison of IASI radiances with companion instruments in the framework of the Global Space-based Inter-Calibration System (GSICS) of WMO. The suite of long time series of climate variables retrieved from AIRS and IASI continues to expand. Based on both their exceptional spectral and radiometric stability and their ability to characterize simultaneously several climate variables, these instruments have already demonstrated that they can and will play a major role in the monitoring and understanding of

climate evolution and variability in the coming years.

14.03 Variability in Eleven Years of AIRS Version 6 Observations

Presenter: Eric Fetzer

Authors: Eric J. Fetzer, Joao Teixeira Thomas Pagano and Bjorn Lambrigtsen

The NASA Atmospheric Infrared Sounder (AIRS) satellite instrument has provided near-continuous infrared spectral observations of the Earth since September 2002. Retrieved quantities from AIRS include detailed information about profiles of temperature and water vapor, the abundance of trace gases (ozone, methane, carbon monoxide, and carbon dioxide), and surface and cloud properties. A recently updated retrieval algorithm Version 6 (V6) shows improved performance, including more realistic trace gas variability and boundary layer structure over land, and more detailed cloud properties. V6 data processing is now complete and the entire 11-year record is publicly available. We describe the long-term characteristics of this data set.

14.04 Stratospheric Temperature Monitoring Using a Collocated IR/GPSRO Dataset

Presenter: Robert Knuteson

Authors: Robert Knuteson, Michelle Feltz, David Tobin, Daniel DeSlover, Henry Revercomb, Steve Ackerman

Climate models predict trends in stratospheric temperature due to an increase in atmospheric carbon dioxide and changes in atmospheric composition. Our ability to monitor such trends with satellite observations has improved with the addition of routine hyperspectral infrared and GPS radio occultation measurements during the last decade. Launched in 2002, the Atmospheric Infrared Sounder (AIRS) on the NASA Aqua satellite was the first of a new generation of satellite observations at high spectral resolution in the thermal infrared that provided the capability for retrieving profiles over both ocean and land areas. The high spectral resolution infrared observations achieve a new level of absolute accuracy with traceability to temperature standards pre-launch. The AIRS sensor has now measured a 10-year global dataset of IR brightness temperatures and corresponding derived temperature/water vapor vertical profiles. The operational follow-on to the AIRS is the IASI sensor on the MetOp satellites and the Cross-track Infrared Sounder (CrIS) on the Suomi NPP and subsequent JPSS satellites which will provide a long-term record of IR measurements with high absolute accuracy. Numerous spectral channels in the thermal infrared have peak emission in the stratosphere and upper troposphere. Self-calibrating observations from GPS radio occultation are available from several missions during the past decade. In particular, the GPS RO derived temperature profiles in the 300 hPa to 10 hPa range have a short traceability path that makes them a good candidate for stratospheric temperature monitoring. This paper will focus on a combined dataset of time and space coincident IR and GPS RO observations to make an assessment of the natural variability, measurement error, and sampling error associated with a joint set of coincident observations. Temperature profiles from the COSMIC program will be compared with IR channels peaking in the mid- to lower stratosphere from NASA AIRS for the five year time period 2007-2011 for selected latitude zones. The interpretation of these independent sensor measurements is an important aspect of establishing confidence in observed temperature trends in the stratosphere over the coming decades. Recent work on the comparison of IR/MW sounding retrievals to GPS RO derived dry temperature will also be reviewed and an assessment of the climate quality of current operational products will be made with regard to monitoring stratospheric temperature changes.

14.05 Absolute Radiance Interferometer (ARI): A Prototype Spaceflight Instrument for Achieving GSICS and CLARREO Goals

Presenter: Henry Revercomb

Authors: Hank Revercomb, Fred Best, Joe Taylor, Jonathan Gero, Doug Adler, Claire Pettersen, Dave Tobin, Bob Knuteson

Laboratory tests of the UW-SSEC Absolute Radiance Interferometer (ARI) sensor have demonstrated the capability to achieve 0.1 K brightness temperature accuracy (3-sigma) across much of the infrared spectrum. What really sets this achievement apart is that the ARI system includes a new set of onboard calibration verification and test technologies, which insure that its world-class accuracy is maintained following deployment in space. Development of the technologies has been supported by the NASA Earth Science Technology Office (ESTO) to further the NASA LaRC Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission, recommended as a Tier 1 mission by the National research Council (NRC) 2007 Decadal Survey. The primary goals of CLARREO are to provide an irrefutable measure of the current state of the climate and to inter-calibrate other key sensors. Although funding issues have delayed the full CLARREO mission many years, the new ARI results have brought the NASA Technical Readiness Levels for the infrared part of CLARREO up to 6, as needed to proceed with a mission. We are hopeful that an opportunity can soon be found for a spaceflight demonstration as a pathfinder for the full CLARREO mission and to serve GSICS (the Global Space-based Inter-Calibration System). Placing ARI on the

International Space Station (ISS) would be an attractive approach. The 52 degree inclination of ISS would provide many crossings of the sun synchronous Aqua, MetOp, and Suomi NPP orbits, providing excellent inter-calibration opportunities for GSICS. ISS would also provide excellent time-of-day coverage below 52 degrees latitude, allowing climate benchmark products from ARI and from the inter-calibrated operational sounders to be inter-compared. Also, the inter-calibrated sounders would provide new, higher accuracy, benchmarking products for the polar regions.

Session 14b: Climate Studies with Advanced IR Sounders

14p.01 The University of Wisconsin Space Science and Engineering Center Absolute Radiance Interferometer (ARI): Predicted and Demonstrated Radiometric Performance

Presenter: Joe Taylor

Authors: Joe K. Taylor, Henry E. Revercomb, Fred A. Best, P. Jonathan Gero, David C. Tobin, Robert O. Knuteson, Doug Adler, Claire Pettersen, Henry Buijs, Frederic J Grandmont

Spectrally resolved infrared radiances measured from orbit with extremely high absolute accuracy constitute a critical observation for future climate benchmark missions. For the infrared radiance spectra, it has been determined that a measurement accuracy, expressed as an equivalent brightness temperature error, of 0.1 K (k = 3) confirmed on orbit is required for signal detection above natural variability for decadal climate signatures. The University of Wisconsin Space Science and Engineering Center (UW-SSEC), with funding support from the NASA Instrument Incubator Program (IIP), developed the Absolute Radiance Interferometer (ARI). The ARI is designed to meet the uncertainty requirements needed to establish a spectrally resolved thermal infrared climate benchmark measurements from space. The challenge in the infrared sensor development for a climate benchmark measurement mission is to achieve this ultra-high accuracy with a design that can be flight qualified, has long design life, and is reasonably small, simple, and affordable. In this area, our design approach for the Absolute Radiance Interferometer (ARI) made use of components with strong spaceflight heritage (direct analogs with high TRL) combined into a functional package for detailed performance testing. The required simplicity is achievable due to the large differences in the sampling and noise requirements for the benchmark climate measurement from those of the typical remote sensing infrared sounders for weather research or operations. Recent testing of the University of Wisconsin Space Science and Engineering Center Absolute Radiance Interferometer has demonstrated the capability to meet the 0.1 K (k = 3) uncertainty requirement on-orbit. An overview of the instrument design and summary of the radiometric performance verification of the UW-SSEC ARI will be presented.

14p.02 On-Orbit Absolute Radiance Standard for the Next Generation of IR Remote Sensing Instruments

Presenter: Jonathan Gero

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Obtaining accurate measurements of infrared radiance from satellite instruments in space can contribute greatly to our understanding of climate change and the earth system. The long-wave forcing of the climate, the climate's response, and the long-wave feedbacks involved in that response bear characteristic signatures in a time series of thermal infrared spectra. Such a time series can provide powerful constraints for climate models by improving the representation of feedbacks. In addition an accurate time series can be used to intercompare and improve measurements from existing sounders. Signal detection above natural variability for decadal climate signatures, however, requires an uncertainty better than 0.1 K (k=3) in radiance temperature. Realizing such low uncertainty on a space-based instrument is a challenge. While the infrared sounders launched into space during the past decade, AIRS, IASI, and most recently CrIS, have been approaching this level of accuracy, the U.S. National Research Council's Decadal Survey for Earth science has called for a dedicated mission, CLARREO, to directly address these scientific and measurement objectives. The University of Wisconsin Space Science and Engineering Center, with funding support from the NASA Instrument Incubator Program, has developed the Absolute Radiance Interferometer (ARI), designed to meet the uncertainty requirements needed to establish a spectrally resolved thermal infrared climate benchmark measurements from space. This instrument employs a new concept for on-orbit verification and testing: it is capable of performing on-orbit fundamental radiometric validation, spectral characterization and calibration, and other key performance tests that are normally only performed prior to launch in thermal/vacuum testing. By verifying accuracy directly on-orbit, the instrument can provide the ultra-high confidence in data sets that are needed for societal decision making. We present the new technologies that underlie the on-orbit verification system, including on-orbit absolute calibration of the embedded blackbody cavity temperature sensors using the transient melt signatures of small quantities (<1g)

of reference materials (gallium, water, and mercury) embedded in the cavity; and on-orbit cavity spectral emissivity measurement based on a reflected radiance measurement from a broadband thermal source called the Heated Halo. Instrument testing in a vacuum environment has demonstrated end-to-end blackbody temperature measurements with uncertainties less than 45 mK (k=3) and emissivity determination with uncertainties less than 0.0006 (k=3).