

2.3 DATA ASSIMILATION AND NUMERICAL WEATHER PREDICTION

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2.3.1 Introduction

At this meeting, an increase was noted in the number of National Meteorological Services (NMS) becoming active in direct assimilation of radiances. An important number of presentations were given on the assimilation of surface sensitive channels in both the infrared and microwave regions of the spectrum including updates on the land surface modeling capabilities with both the RTTOV and CRTM models. An update on DMSP SSMIS instruments was also provided. DMSP F18 data will soon become available to users. The importance of SSMIS was noted especially in a context of a decreasing number of online SSMI and in the future AMSU-A and AMSU-B/MHS instruments.

An overview presentation on the use of MetOp IASI in NMS was also given. Many centers assimilate the radiances in both global and limited area models while the maximum number of channels assimilated remains below 200. Among those channels, at most centers, only those that sense above clouds are retained. Channels are also predominantly located in the long wave CO₂ band. Experimental testing is underway at several centers on assimilating radiances in cloudy FOVs, and some have started using these operationally. After the MetOp series, an IASI-NG instrument (phase 0 completed last year) will be included on Post-EPS. The insight into the problem of representing hyperspectral radiances with principal components has advanced. One of the main issues that remains is how to deal with clouds.

Information was also provided on the status of NPOESS and the program that will replace it, namely JPSS, to be co-operated by NOAA and NASA, and the follow-on to the DMSP mission to be operated by DoD. The audience was also informed by NOAA meeting participants of plans with respect to a follow-on mission to the highly successful COSMIC constellation (six GPS radio-occultation micro-satellites). These data have become particularly important due to their role as an anchor for the radiance bias correction of assimilation systems. The COSMIC-II program is to be shared between NOAA and Taiwan. A constellation of 12 micro-satellites is planned with increased sampling over the tropics. The target launch date is 2014.

2.3.2 NPP and NPOESS Restructuring

Heather Kilcoyne, NOAA IPO, informed the WG that a transition for the NPOESS program is underway. Segments of NPOESS are getting transferred to JPSS. JPSS is a NOAA program with NASA procuring the instruments (launch date of 2017 for JPSS1 and 2021 for JPSS2). The naming of the satellites will be J1, J2, etc... instead of C1, C2, etc. The NPP instruments are going ahead as planned. There is a cal/val team in place and a cal/val Web page is being set up but is experiencing some delays. Under the GRAVITE project, IPO has generated proxy data (based on data from the MODIS and IASI instruments) in HDF5 format to simulate NPP instruments. This data is not ITAR protected. There are no plans for changes to SafetyNet.

Action DA/NWP-1

Heather Kilcoyne (NOAA) will inform NWP WG (via mailing list) when the IPO (Integrated Project Office) cal/val Web site for NPP instruments will be up.

Recommendation DA/NWP-1 to US Department of Defense

Noting that the NPOESS program is being restructured into two separate programs, one being run by DoD and the other by NOAA/NASA known as JPSS, the WG recommends that imaging and sounding capabilities should be included on the DoD satellite, ideally including MW and IR. Furthermore, data should be free and readily accessible to the general international user community.

Recommendation DA/NWP-2 to NOAA/NASA and DoD

The short operational delivery time of the NPOESS system was an extremely attractive component of the system design. The WG recommends that the SafetyNet system (ground receiving system) is retained in the NPOESS restructuring process for both satellite programs (i.e., JPSS and DoD).

2.3.3 General Evolution of the Operational Sounding Constellation on Polar Satellites

For NWP applications, it is highly desirable to have satellites with orbits that are uniformly distributed in space. Hence the optimization of overpass times of the future LEO observation constellations should be high on the agendas of space agencies and their governing bodies. The standard data format for many NMS is the BUFR format, and all space agencies and meteorological agencies are highly encouraged to provide the data in such a format. Early warnings as a result of changes to instrument function or data processing are very beneficial to the NWP user community. Early information on future satellite missions is also important in terms of short to mid-range planning for NMS and readiness to assimilate observations as soon as possible after the satellite is launched. As weather forecast models have model tops that extend higher into the atmosphere (80-90 km), a higher abundance of instruments that sense the stratosphere and mesosphere is desirable.

Recommendation DA/NWP-3 to all relevant space agencies

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

Recommendation DA/NWP-4 to CMA

The WG recommends that CMA continues its efforts to make FY-3A data available in BUFR format to the international user community in near real time.

Action DA/NWP-2

Wei Han (CMA) will gather information on FY-3C and its instruments as well as follow-on missions and distribute this information to the WG members through the NWP WG mailing list.

Recommendation DA/NWP-5 to DoD and other space agencies

The NWP WG recommends that future microwave sensors maintain sounding capabilities of the upper stratosphere and mesosphere, in addition to tropospheric and stratospheric sounding capabilities, as is the case for SSMIS.

2.3.4 Future Systems

During the NWP WG session, Dave Ector, NOAA, provided information on plans for a follow-on mission to COSMIC. NOAA has decided to go ahead with a 12 satellite configuration for launch in 2014. Six of the satellites will have an inclination angle of around 70° and the six others will have an inclination angle of 20°. The latter is to increase the sampling in the tropics. International missions will be launched with GPS/GNSS receivers on board as secondary payloads, but most are sun synchronous and what is really needed is increased coverage in the tropics. Latency will be better than COSMIC. People interested in the ionosphere are very interested in data latency less than half an hour. NOAA and Taiwan will share the cost of the mission 50/50. The instrument will be a blackjack again but the next iteration in technology. The instrument will be able to receive GPS and Galileo signals. NASA is looking into whether GLONASS could also be added. The design of the payload is being done by NASA. Phase array antennas will be used that can point at satellites and will have increased S/N ratio. The data policy will be open. There will be around 12000 soundings a day, which will allow more sounding into hurricanes.

Currently, the space agencies of two countries, the Russian Federation and Canada, are each leading a mission in the early planning stages for quasi-geostationary observation of the Arctic (HEO). These missions would image the arctic with a more rapid refresh rate than the planned future LEO constellation.

A presentation on hyperspectral microwave instruments was given at ITSC-17. In view of the fact that microwaves are less sensitive to clouds than infrared frequencies, this type of instrument could potentially have a large positive impact on the quality of NWP forecasts.

Action DA/NWP-3

Dave Ector (NOAA) will send the report from the upcoming first meeting of the IROWG (International Radio-occultation WG) to the NWP WG members via the mailing list.

Recommendation DA/NWP-6 to satellite agencies and WMO

The geostationary and HEO (Molniya) orbit is ideal for observing the rapidly changing component of atmospheric and surface fields. The WG recommends the use of these orbits for high spectral resolution IR and/or microwave sounder/imager instruments. Ideally, if both are possible, the microwave and IR instruments should observe the same portion of the atmosphere at the same time.

Recommendation DA/NWP-7 to satellite agencies and WMO

The WG encourages further study of the benefits of hyperspectral microwave instruments.

2.3.5 Data Dissemination and Information from Satellite Agencies

Early warnings as a result of changes to instrument function or data processing are very beneficial to the NWP user community. Therefore, it is essential that good communication

(including tools) exist between data users and data providers. Early information on future satellite missions is also important in terms of short to mid-range planning for NMS and readiness to assimilate observations as soon as possible after the satellite is launched. The NWP WG welcomes the dissemination of early warnings and information through the use of its email distribution list. NWP WG members are also invited to share information on the distribution list when for instance unannounced anomalies resulting from instrument malfunction are detected or changes in data processing that may not have been announced through the agreed upon channels for instance or when in doubt (lack of clarity).

In view of the ongoing research in the use of full radiance spectra, satellite agencies should consider options to make full data sets available to users.

Action DA/NWP-4

Sid Boukabara (NOAA) will contact NESDIS to ensure that when the DMSP F18 SSMIS data (in BUFR format and processed by UPP) is available at NESDIS from FNMOC (within the next two weeks) that it is also made available for wide distribution. Furthermore, Sid will ask NESDIS to ensure that users are promptly informed of data or instrument issues.

Action DA/NWP-5

Vincent Guidard (Meteo France) and Fiona Hilton (Met Office) will revisit the selection of the EUMETSAT 314-channel subset of IASI channels. This may lead to a proposal to include further channels.

Recommendation DA/NWP-8 to EUMETSAT

The NWP WG recommends that EUMETSAT investigates lossless compression methods for the dissemination of the full IASI spectrum in the context of disseminating data from 2 or more Metop satellites.

Recommendation DA/NWP-9 to all relevant space agencies and WMO

The WG recommends that all relevant space agencies (i.e., ESA, NASA, NOAA, JMA, EUMETSAT, CMA, KMA, etc...) send information to users, including the NWP WG mailing list, about planned changes in data processing, formats, and other issues related to data as early as possible (preferably at least 6 months in advance).

EUMETSAT's User Notification Service (UNS) was noted as being a useful email and Web - based notification tool for data issues. However, the content could at times be improved. For instance, messages with no new anomalies should be removed or sent out less frequently, information about very short outages of less than about an hour are not considered useful, and in case of a data outage, further information on the reason for an outage and an expected length would be beneficial if available.

Action DA/NWP-6

European NWP WG members will inform their EUMETSAT OPS WG representatives of changes desired in the scope and format of the notifications sent through the UNS.

2.3.6 RARS

Timely delivery of data continues to be crucial for NWP. Timeliness requirements have tightened in recent years, especially for regional NWP. The Regional ATOVS Retransmission Service (RARS) has significantly improved quick delivery of data, and it continues to be vital for regional and global NWP systems with short cut-off times.

Recommendation DA/NWP-10 to WMO

The NWP WG continues to support fast delivery initiatives (RARS) with extensions wherever possible, however the WG believes that the system should continue to be low cost. At ITSC-17, it was reported that the RARS coverage is now 78%. Further extension towards global coverage is encouraged until the point is reached where further improvements are no longer cost effective.

The interaction between the RARS coordination at WMO, the RARS coordination centres, and the users was discussed. WMO would like to find out more about the status of the use of RARS by National Meteorological Services (NMS) and potentially other users, to better tailor future developments. This is done via a questionnaire to RARS users.

Action DA/NWP-7

Jerome Lafeuille (WMO) will distribute the RARS user's questionnaire to the NWP WG mailing list.

A continuing concern of the group is early information about processing changes or data anomalies. While improved efforts of some coordinating centres were noted, the potential for data problems, for instance at single RARS stations, remain due to the distributed nature of the system. Problems at a single RARS station may not be noted in the routine quality monitoring at NWP centres, and in such cases locally degraded data can potentially have a very harmful effect on analyses and forecasts. The routine station-by-station intercomparison between global and RARS data performed at the Met. Office under the NWP SAF is well suited to detect such anomalies.

Recommendation DA/NWP-11 to RARS coordination centers

The WG recommends that users be informed of processing changes and other issues regarding RARS as early as possible.

Action DA/NWP-8

Brett Candy (Met.Office) will investigate how to inform users of data anomalies noted in the intercomparison between global and RARS data performed at the Met. Office (including the possibility of an automated warning system).

2.3.7 RTTOV Users Group

The proposal to set up an RTTOV Users Group was presented to the group by Fiona Hilton (Met. Office). The idea is to have a forum that is independent of the RTTOV development group and that is primarily internet and email-based. The forum should help to establish user requirements for science developments, provide a means for exchange between users regarding technical and other usage aspects, and improve the user representation at RTTOV development meetings. The background to this is the impression that RTTOV developments are not always user-driven, and that the use or implementation of such crucial code in complex NWP systems can be an arduous task. Ideally, the forum should consist of hands-on

users of RTTOV, with a coordinator/representative who should represent the group at RTTOV development meetings.

The group responded positively to this proposal, but no volunteer for the coordination role has yet been identified.

Recommendation DA/NWP-12

The NWP WG recommends setting up an RTTOV user group, composed of members that do not actively participate in developing RTTOV software, to collect science requirements, and to establish a forum for technical and usage aspects. This group is expected to interact through internet and email.

Action DA/NWP-9

WG members will consult with their respective organizations to find prospective members of the RTTOV user group and will send an email with contact information to Fiona Hilton.

Fiona Hilton will investigate the technical options to set up such a forum. She will also prompt CRTM manager, Paul van Delst, about their experience.

2.3.8 Working Group Support to NWP Community

Evolution of the ITSC NWP WG Web Site

The Web site of the ITSC NWP WG has developed into a useful repository of information about the use of ATOVS and other sounding data in NWP, with, for instance, links to monitoring pages and contacts to data providers. Since the last ITSC meeting, Wiki capabilities have been added by Leanne Avila (SSEC), allowing easy modification of the content. Currently, only the Co-Vhairs have permission to alter the site. After some discussion, the WG decided to give all WG members permission to alter the site. Leanne Avila has been informed about this and will issue the required passwords, following an email request (with copy to the Co-Chairs). The intent of the widened Wiki-capabilities is to allow better interaction among the group between ITSC meetings (see, for example, the activities initiated below), and also to be able to better track the progress of the action items identified during the WG meetings.

Action DA/NWP-10

The NWP WG Co-Chairs will post the action items on the NWP WG wiki page and WG members will describe how action items were completed. WG members may obtain a password from Leanne Avila via email (with copy to the Co-Chairs), to be able to make changes to the Wiki page.

A questionnaire regarding the use of ATOVS data at NWP centres has been circulated before ITSC meetings by the group for some time now, in order to provide a good overview of the current status. This questionnaire was identified as an obvious candidate to use the Wiki capabilities to keep responses up-to-date.

Action DA/NWP-11

Roger Randriamampianina (met.no) will convert the ITWG ATOVS questionnaire (in word format) to wiki format and include it in the NWP WG wiki page. WG members will update their information via the wiki page. NWP WG Co-Chairs will

send a reminder to update the information at least once a year. A snapshot of the information will be taken once a year by Co-Chairs.

Action DA/NWP-12

Niels Bormann (ECMWF) will obtain a copy of Andrew Collard's ITSC-17 presentation on the IASI usage survey and include it on the NWP WG wiki page. He will also include a list of the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16.

Departure Monitoring

Routine monitoring of departure statistics between observed radiances and First-Guess equivalents is an integral part of the quality assurance for the use of sounding data at all NWP centres. Exchange of such monitoring information, via the internet, continues to be recognized as a very useful tool to diagnose performances of the data assimilation systems, and to corroborate findings in case of data problems identified at one centre. To further improve the exchange of such information, the WG made the following specific recommendations:

Recommendation DA/NWP-13 to NMS

The NWP WG recommends that detailed monitoring be available on the NMS monitoring Web sites for at least the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16 (see Action DA/NWP-12).

Recommendation DA/NWP-14 to NMS

The NWP WG recommends that monitoring Web sites be freely accessible on the internet (i.e., do not require a password).

Recommendation DA/NWP-15 to NWP WG members

NWP WG members are strongly encouraged to make use of the NWP WG mailing list, in particular to report problems with instruments.

Radiance bias correction is recognized by the group as crucial for the successful assimilation of sounding data. However, questions remain regarding the suitable choice of bias correction models and methods, the effectiveness of the bias corrections to correct observation bias (including radiative transfer), and the dangers of correcting model biases or shortcoming of quality control (e.g., signatures of cloud contamination). To address these questions, Wei Han (CMA) suggested performing an intercomparison study between global NWP centres for selected instruments/channels. This was viewed favourably by the group, as long as the required exchange of monitoring statistics is kept simple and well-defined.

Action DA/NWP-13

Wei Han (CMA) will put together a proposal for a radiance bias and bias correction intercomparison exercise. This should include specification of format to exchange relevant information and the scope of the intercomparison.

Limited-area Data Assimilation

The group discussed issues and specifics of the use of sounding data in regional data assimilation systems. These systems require their own special attention to radiance bias correction, thinning, and observation and background error specification, that often differs from the requirements of global data assimilation.

To this end, an intercomparison study was initiated at the last ITSC meeting, to study the increments resulting from assimilating a single AMSU observation in different NWP centres. Met.No, the Met Office, and SMHI participated, and the study revealed interesting differences, for instance in the spatial responses of the various systems, summarized in poster 7.22 at this ITSC meeting.

To allow better exchange of information between regional data assimilation centres and wider participation in the single-observation experiment, the WG formulated the following actions and recommendations:

Action DA/NWP-14

Roger Randriamampianina (met.no) will create a regional data assimilation page on the NWP WG wiki page. Roger will also post the poster (impact of single AMSU observation on analyses increments at three NMS) that he presented at ITSC-17 (Number 7.22) on this page.

Recommendation DA/NWP-16 to NMS

The WG recommends that other NMS also participate in the single-observation exercise (see Action DA/NWP-14) for other regions, if applicable, and that they contact Brett Candy (Met Office) and Roger Randriamampianina (met.no) to convey their results.

Action DA/NWP-15

NWP WG members involved in regional or limited area data assimilation will share their experience (experiment results, reports, papers, etc.) on bias correction procedures on the regional data assimilation Web page.

Radio Frequency Interference (RFI)

Radio Frequency Interference (RFI) from human activity (e.g., telecommunications, navigation systems, etc.) is an existing and potential threat to the use of various MW frequencies in environmental monitoring and NWP. The group supports the activities to protect relevant frequencies via the International Telecommunications Union (ITU). Following the presentation by Richard Kelley and subsequent discussions, the group discussed how best to support activities that characterize and demonstrate the effect of existing and potential RFI contamination in NWP. It was recognized that a full assessment is difficult, as it depends on the frequencies in question, the maturity of our exploitation of the data, and the nature of the contamination. It was also noted that other communities and applications may be even more directly affected by RFI (e.g., climate applications). Nevertheless, several studies and reports of RFI impact in NWP already exist, and as a starting point the group intends to establish a repository of these documents.

Action DA/NWP-16

Co-Chairs will create a section on the NWP WG wiki page which will contain examples of the existing or potential effects of RFI in NWP. Members are invited to add on this Web page any relevant impact assessments or evidence found. Nancy Baker (NRL) will provide examples to start the page.

Miscellaneous

Robust verification of forecast impact is recognized by the group as fundamental to our work. Given the variability of forecast impact by season and the considerable sampling uncertainties, significance tests on forecast impact and testing of system modifications over several seasons is seen as crucial to obtain reliable results. To establish a good practice within the NWP community, the WG made the following recommendation:

Recommendation DA/NWP-17 to the NMS and NWP community

The NWP WG recommends that forecast verification scores are displayed with error bars and indication of trial periods used.

The group also discussed how to better characterize what fraction of the overall information content contained in satellite sounding data is currently used. This discussion was prompted by a comment by Bill Smith after one of the IASI assimilation talks that less than 1% of IASI data is so far used and therefore so much more impact can be expected from using more data. The group notes that such a simple measure based merely on data counts can be misleading, and instead information content measures need to be used. Channel selection papers such as Collard (2007) usually state what percentage of information content are available in the selected channels, thus providing a more appropriate measure per spectrum. However, the spatial information content is usually not considered in these studies. A combined spatial and spectral information content analysis appears not straightforward, and the group was not in a position to formulate an action or recommendation on this issue.