Working group on Data Assimilation and Numerical Weather Prediction

The Working Group meeting was held on 18th March 2023. The attendees are listed in Appendix 1.

1. Actions from the previous meeting

The status of the actions from the previous conference can be found on the DA/NWP website: https://groups.ssec.wisc.edu/groups/itwg/nwp/action_status_tracker
Most actions were completed and standing actions can be seen in Appendix 2. The following actions were still outstanding, and were discussed during this meeting and closed:

Action DA/NWP 22-13 on WG Members : Share impact assessment results for FY-3E with the group and CMA as soon as possible after data becomes available, in particular to provide evidence for support of the early morning orbit.
(See item 6)

Action DA/NWP 23-17 on WG members to review Space Agency contacts page on the website.
(See item 10)

Action DA/NWP 23-18 on WG members: Provide impact recent LAM study references to WG co-chairs for inclusion on the website
(See item 10)

2. Recommendations from the previous conference

The DA/NWP Working Group has a long list of standing recommendations. which can be found in Appendix 3. The WG endorsed maintaining all of these recommendations.

3. Radio Frequency Interference

Regarding **Action DA/NWP- Standing 2 on DA/NWP WG members** (Send any evidence of RFI to co-chairs of the RFI Technical SubGroup), there had been little progress on this action and the group discussed several observation types that could be used to identify sources of RFI. The COWVR instrument allows a forward and aft look at the same scene which could be very helpful in identifying RFI. NRL have access to this data. A followup action is to provide more information about the COWVR instrument

Action DA/NWP 24-1 on Bill Campbell: To circulate information about the COWVR instrument and RFI detection principle to the WG.

4. CGMS HLPP

Relevant parts of the CGMS High Level Priority Plan (HLPP) were reviewed and discussed.

4.1 Microwave Sounding: Revisit Time

The current recommendation from WMO and CGMS is to have microwave sounding in 3 main orbits (early morning, morning, afternoon) plus three additional orbits. The new WMO vision for the evolution of WIGOS contains a statement that WMO recommend hourly microwave sounding data. Due to the characteristics of the polar orbit, revisit time will vary with location (polar regions would have a higher revisit time than at the equator). It could be assumed that "hourly" refers to orbits with equator crossing times separated by one hour.

Recent research including a presentation at this conference from ECMWF (Katie Lean) demonstrates that three additional orbits of microwave sounding continues to add impact to NWP, supporting the current WMO and CGMS position. Additional orbits that provide data hourly at the equator via sun synchronous orbits may not be the distribution that delivers the best value for NWP. Studies to date have not considered the impact of low-inclination orbits in conjunction with SSO and mid-inclination orbits.

The requirements for observation provision for NWP could be different depending on the physical variable associated with the type of sounding/imaging (e.g. more frequent humidity sounding could be required relative to temperature sounding). Other influencing factors are the model domain and resolution.

There are therefore some open questions which could benefit from additional studies with simulated data.

Recommendation DA/NWP 24-1 to DA/NWP WG members: Conduct simulated impact studies to establish optimal revisit times for microwave sounders in both global and regional models, in particular considering low inclination orbits, and report back at next ITSC.

4.2 Progress on extension of MW sounders over sea-ice and difficult surfaces

Discussion took place on the challenges of using more sounder information over surfaces such as sea-ice and snow. Mixed surface types in the field of view are also difficult to deal with. It was noted that several centres use, or are planning to use, dynamic emissivity retrieval. Other

approaches discussed involved using AI or other techniques to derive a fast model from a fuller descriptive model of the snow surface. There were several presentations on this topic at the conference.

ACTION DA/NWP 24-2 on WG co-chairs: Contact Steve English to obtain more information on his proposal for snow and/or sea ice emissivity ISSI project and circulate to Working Group members.

It was noted that EPS-Sterna mission with its focus on high latitudes may require a specific approach for treating sea-ice and snow. There is an EPS-Sterna workshop in April, which may highlight areas where more research is required to exploit the data.

ACTION DA/NWP 24-3 on Brett Candy: Report to WG members on any useful discussion that took place on use of microwave data over sea ice, snow or land at EPS-Sterna workshop in April 2023.

4.3 Recommendations regarding the Microwave Constellation

The WG had already discussed requirements in 2022 on the microwave constellation and it was decided that these were still relevant. The WG previously made the following recommendations which we retain at this meeting:

Recommendation DA/NWP 2022/1 to CGMS: Communicate to satellite data providers that the stability and consistency of bias and noise for individual passive radiometer instruments within a constellation of Small/CubeSats are very important for implementation. Consistency between instruments within the constellation is also critical.

Recommendation DA/NWP 2022/2 to CGMS: Communicate to satellite data providers that given Recommendation DA/NWP 2022/1, the requirement from NWP Centres for single instrument longevity within any constellation of Small/CubeSats should be a threshold of 3 years post-commissioning (below which many centres will not use the data) and an objective of 5 years (where most NWP centres will aim to use the data). If the overall mission is of long duration, the threshold for an individual satellite could be lowered to 2 years post-commissioning.

Additionally, the following recommendation applies equally to infrared and microwave data, but should be conveyed to CGMS in the context of their enquiry about NWP requirements for the microwave constellation.

Recommendation DA/NWP 24-2 to CGMS and data providers: Radiance data from new satellite instruments should be disseminated using WMO pre-approved BUFR sequences, consistent with other similar data types where possible.

It was reported at the meeting that ISRO has recently launched a humidity sounder on a small sat mission in an orbit with low inclination. A follow-on operational mission similar to the

successful SAPHIR mission is also under consideration. The WG considers humidity sounding in this orbit to be very valuable.

Recommendation DA/NWP 24-3 to Data Providers: Given the positive impact of SAPHIR on numerical weather prediction, and the uniqueness of the inclined orbit for sounding, and the lack of opportunity to use MADRAS data following its early failure, the WG supports a follow on mission that has similar or extended capability relative to SAPHIR and MADRAS in an inclined orbit.

It is increasingly likely that commercial missions will provide microwave sounding data. Due to the commercial nature there is likely to be a different relationship with the data providers, especially with regards to information about the mission which is considered intellectual property, but nevertheless is critical for assimilation of the data. An example of this is the channel SRFs. The WG is grateful to WMO for their engagement with commercial earth observation providers and recommends that this continues so that the needs of NWP are communicated.

Recommendation DA/NWP 24-4 to WMO: Continue to engage with commercial satellite providers to convey NWP requirements via industry days etc.

Action DA/NWP 24-3 on Heikki Pohjola: Share WMO best practice guide on achieving user readiness with commercial satellite providers

Recommendation DA/NWP 24-5 on CGMS and WMO members: When commercial satellite data is purchased, ensure provision to users of the necessary data and meta-data required to make use of the data in applications, as early as possible.

4.4 Timeliness requirements for Sounder observations

DBNet provides very timely observations with a goal of 20 minutes. The timeliness requirement for NWP may vary between centres as it depends on the cycling requirements of the assimilation system. For instance, if rapid update cycling is used, the requirement is for observations to be available within around 20 mins after the end of the assimilation window. It was also noted that observations at the end of the window tend to have the most impact. It was suggested that the WG gain insight into the timeliness impact through running appropriate experiments.

Action DA/NWP 24-4 on WG co-chairs: Organise a task team to perform experiments to establish the impact of data latency in both global and local assimilation systems.

5. Principal Component Compression of Hyperspectral IR observations

CGMS have requested guidance on methods for PC-compression of hyperspectral IR observations, and an update on the use of such products. The group has previously recommended that the full noise covariance matrix is used in PC-compression (Recommendation DA/NWP-Standing 5) and that working group members assess the promising hybrid compression approach with EUMETSAT IASI data (Recommendation DA/NWP 22-14). However, no feedback has been received by the WG co-chairs on any such tests. Posters on the hybrid compression approach have been presented at this conference by Tim Hultberg (EUMETSAT) & Dave Tobin (CIMSS).

ECMWF have tested the impact of a change in IASI eigenvector basis, and report that it has no impact on subsequent use of the data (Cristina Lupu), though have not examined the use of hybrid PCs. A number of centres have verified that EUMETSAT PC-compressed radiances meet their assimilation needs.

There have been no reports on the evaluation of the experimental CIMSS hybrid PC product for CrIS. WG members are encouraged to continue to evaluate hybrid PC products.

The main purpose of hybrid eigenvectors, instead of purely climatological vectors, is to enable retention of signals that are not contained within the training data, such as unusual events. Whilst this allows retention of spectral information, this is not expected to be of large impact for NWP users, since they would expect to not use observations affected by unusual events in their systems anyway, due to a lack of appropriate forward modelling. Nevertheless, the hybrid approach still seems to be the most reasonable product to meet the needs of all users.

Action DA/NWP 24-5 on Fiona Smith: Check with Tim Hultberg & Dave Tobin regarding what feedback has been received on hybrid PC-scores and report to CGMS.

Recommendation DA/NWP 24-6 on WG Members: Contact Dave Tobin for testing of hybrid PC-compressed CrIS observations

6. Hyperspectral Sounding in Early Morning Orbit

NOAA/NESDIS have requested feedback from the community on the impact of having a hyperspectral IR sounder in the early morning 5.30 AM orbit. At the previous working group meeting, an action was set (DA/NWP 22-13) to share impact assessment results for FY-3E.

No results from FY-3E HIRAS have been presented at this conference, and we therefore update the previous action with a request to provide impact assessment results to NOAA as well as CMA.

Action DA/NWP 24-6 on WG Members: Share impact assessment results for FY-3E with the working group, NOAA and CMA as soon as possible in particular to provide evidence for support of the early morning orbit.

7. Proposed switch of S-NPP CrIS to MWIR + SWIR instead of LWIR

NOAA/NESDIS have asked whether the NWP community would support a switch of S-NPP CrIS to a MWIR+SWIR configuration rather than LWIR, once NOAA-21 commissioning is complete. The group were interested to know whether the proposed change was for a permanent switch, and how long the S-NPP data would continue to be provided, given that OSPO previously indicated only 2 satellites would be processed. OSPO have now confirmed that they will continue to process S-NPP on a best endeavours basis. It is thought that the proposal to switch the bands would be permanent.

The group is interested in the concept of the 3D-winds proposed if the switch occurs, but in general adheres to the previous recommendation, made previously by a WG member consensus via email, that because of the continued impact of the LWIR from S-NPP CrIS, and a requirement for LWIR channels to perform cloud detection before use of MWIR channels, it is preferred to maintain the current configuration with S-NPP CrIS. Many WG members propose to continue assimilation of S-NPP CrIS after NOAA-21 becomes operational.

Recommendation DA/NWP 24-7 to NOAA/NESDIS: Continue provision of LWIR band on S-NPP CrIS after NOAA-21 is declared operational.

8. Imager channel cluster analysis for hyperspectral IR sounders

NOAA/NESDIS (Lihang Zhou and Likun Wang) requested feedback from the WG members on the new VIIRS cluster analysis they have produced following recommendations at previous conferences.

Feedback from ECWMF (Chris Burrows) is that the VIIRS clusters for CrIS behave identically to the AVHRR clusters for IASI, and can be used in cloud detection algorithms with the same thresholds. NCEP (Jim Jung) are also evaluating the cluster product. The EUMETSAT NWP-SAF cloud and aerosol detection software will be updated to include the use of the VIIRS cluster data

Feedback on the representation of the VIIRS clusters within the BUFR file, from ECMWF (Chris Burrows) and NCEP (Andrew Collard) is that the spectral radiance units for the clusters are inconsistent with those of the CrIS channels. This is not the case for IASI. The spectral radiance

units are $W/m^2/sr/m^{-1}$ for IASI and AVHRR clusters, $mW/m^2/sr/cm^{-1}$ for CrIS and $W/m^2/sr/\mu m$ for VIIRS Clusters. This is awkward and potentially confusing for users, though may be difficult to change in the CrIS processing change which relies on MODIS heritage for VIIRS.

Recommendation DA/NWP 24-8 to data providers: Use SI Standard units for spectral radiance in all BUFR products ($W/m^2/sr/m^{-1}$)

The working group received a request from CNES for confirmation whether clustering is required for IASI-NG and whether the algorithm needs to be consistent across instrument types.

Recommendation DA/NWP 24-9 to CNES: Cluster analysis of MetImage radiances within IASI-NG FOV is required in the IASI-NG BUFR products.

Action DA/NWP 24-7 on WG members: Provide feedback to Eric Jurado (eric.jurado@cnes.fr and copy to WG co-chairs) on proposed methodology for MetImage cluster analysis within IASI-NG FOV.

Vincent Guidard has previously proposed a map of which cluster each Met-Image pixel is in should be provided in the BUFR. It was noted that due to the large number of Met-Image pixels within each IASI-NG FOV, this represents a massive increase in data volumes. WG members were hesitant to commit to the use of such a product, but are interested to see whether it may be useful.

Recommendation DA/NWP 24-10 to EUMETSAT: Investigate whether a map of the cluster that each MetImage pixel within each IASI-NG FOV falls into could be provided as an additional auxiliary product.

9. Extension of CAMEL atlas into VIIRS era

The CAMEL emissivity atlas is noted to be very important for enabling and enhancing the use of IR sounding data over land. Maintaining an up-to-date atlas is seen as critical to meet NWP needs. Eva Borbas has reported at this conference that a new version has just been released based on 2021 climatology. The working group members would like to ensure that the CAMEL atlas is maintained beyond the lifetime of MODIS and therefore recommend that it is extended into the VIIRS era.

Recommendation DA/NWP 24-11 to Eva Borbas: Continue to update the CAMEL atlas, extending to VIIRS to ensure continuity beyond the life of MODIS

10. Working Group Matters

The group website can be found here: https://groups.ssec.wisc.edu/groups/itwg/nwp

Space Agency contacts have not been updated since the last in person conference (despite an action) and were already out of date at that time. WG members do not use this part of the website, so we propose to delete the page.

At the last conference, the WG members maintained interest in keeping the page on regional models as a useful resource for someone starting to use radiances in a LAM. The page has not been updated since the last conference but there is still interest in gathering a list of resources, and to have a science discussion on verification and validation for satellite experiments in LAM.

Action DA/NWP 24-8 on WG co-chairs: remove out of date and unused pages on WG website and update any that require it, including references on satellite data in LAM.

Action DA/NWP 24-9 on WG co-chairs: organise a science meeting on verification and validation for satellite experiments in LAM.

Regarding the NWP Working Group Survey on use of satellite sounders in NWP, the WG members had worked hard to update the survey before the conference. It remains a valuable resource that members do use between conferences. Some enhancements were suggested:

- Information regarding the use of and method for calculating error covariance matrices
- Channel use over seaice
- Information on the use of coupled systems (e.g. sea ice, SST, ozone and other chemical species)
- Cut-off times for model runs (global and local)

Action DA/NWP 24-10 on WG co-chairs: Update NWP WG survey to include changes proposed at this conference

11. Coupling NWP with other systems

Many NWP centres are moving towards the use of ancillary data from other models, and in many cases towards coupling the models together. These include various surface and chemistry models. The group had a brief discussion about how to engage with other working groups that cover these systems, in such a way that enables cross-system sharing and usage of information. The interaction with the atmospheric community and ITWG is particularly weak at the present time.

This question is more broad than the NWP Working Group, as extending the remit of the conference or encouraging members from the other communities would potentially change the scale of ITWG. Heikki Pohjola (WMO) reported that CGMS are working on future strategy for this, with an activity at WMO last week, which will likely influence the direction that this working group takes. In the meantime, the following recommendation was proposed:

Recommendation DA/NWP 24-12 to ITSC co-chairs: Organise a discussion topic for future conferences on use of coupled systems in sounder radiance assimilation

Additionally, the group discussed the remit of the working group regarding the use of imager data - IR imagers are usually considered sounders, but the visible channels are an extension well beyond TOVS capability. In general, the group is interested to discuss the use of visible channels where they are being used for or to aid in retrieval or analysis of temperature and/or humidity.

Appendix 1: List of Participants

Ahreum Lee, Andrew Collard, Asmund Bakketun, Benjamin Ruston,
Bill Bell, Bill Campbell, Brett Candy, Bryan Karpowicz,
Chawn Harlow, Chris Burrows, Christina Koepken-Watts, Hyoung-Wook Chun,
Cristina Lupu, David Rundle, David Tobin, David Duncan,
Dirceu Herdies, Emily Liu, Erin Jones, Eric Turado,
Ethel Villeneuve, Eun-Jin Kim, Fiona Smith, Haixia Liu,
Hanna Hallborn, Han-Byeol Jeong, Heikki Pohjola, Hao Hu,
Hui Christophersen, Hiroyuki Shimizu, Hongyi Xiao, Hyeyoung Kim, Indira Rani,
Isabel Monteiro, James Jung, Jana Sanchez-Arriola, Joel Mccorkel,
Jun Yang, Jonathan Mittaz, Jon Taylor, Krishna Chandramoorthy,
Kozo Okamoto, Kirsti Salonen, Liam Steele, Likun Wang,
Lingli He, Lihang Zhou, Magnus Lindskog, Mohamed Dahoui, Mate Mile,
Nadia Fourrie, Nahidul Samrat, Nancy Baker, Niama Boukachaba,
Nick Nalli, Olaf Stiller, Olivier Audouin, Olivier Coopmann,
Per Dahlgren, Reima Eresmaa, Roger Randriamampianina, Sihye Lee,
Samuel Quesada-Ruiz, Sreerekha Thonipparambil, Stefano Migliorini, Stephanie Guedj,
S. Kumar, Thomas Carrel, Thomas Deppisch, Tracy Scanlon,
Vincent Guidard, Wei Han, Xiaoyan Zhang, Yi-Ning Shi, Yanqiu Zhu

Appendix 2: DA/NWP Working Group Standing Actions

Action DA/NWP- Standing 1 on ITSC Co-chairs: To bring relevant recommendations to the attention of CGMS.
Action DA/NWP- Standing 2 on DA/NWP WG members: Send any evidence of RFI to co-chairs of the RFI Technical SubGroup - Jean Pla (jean.pla@cnes.fr), Richard Kelley (richard.kelley@noaa.gov), Stephen English (stephen.english@ecmwf.int) and Nancy Baker (nancy.baker@nrlmry.navy.mil)
Action DA/NWP- Standing 3 on DA/NWP WG members: If you have estimates of revised channel characteristics resulting from post-launch diagnostics, please email these to the radiative transfer working group chairs (Benjamin.T.Johnson@noaa.gov & Vito Gallegani <email>).

Action DA/NWP- Standing 4 on NWP centres: Continue to provide information on instrument channels assimilated and their observation errors via the working group survey spreadsheet in advance of each conference.
Action DA/NWP- Standing 5 on DA/NWP WG Members: Make suggestions and corrections to the DA/NWP Working Group website

Appendix 3: DA/NWP Working Group Standing Recommendations

Recommendation DA/NWP-Standing 1 to the Satellite Agencies: In support of maintaining a robust global satellite observing system, instrumentation to allow continued sounding of the temperature of the upper stratosphere and mesosphere (as for the SSMIS UAS channels) should be explored.
Recommendation DA/NWP-Standing 2 to funding bodies of NWP centres and space agencies: Consider, as part of the cost of satellite programmes, providing computational and personnel resources targeted at operational NWP centres to optimise the public's return on investment from these expensive measurement systems.
Recommendation DA/NWP-Standing 3 to Data providers: Include azimuthal viewing and solar angles as appropriate in BUFR for present and future instruments.
Recommendation DA/NWP-Standing 4 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.
Recommendation DA/NWP-Standing 5 to Data Providers: When using PC compression, noise normalisation should be performed using the full noise covariance matrix.
[HLPP: 4.2.6 Establish together with the user community a commonly agreed approach for retrieval of Principal Component scores and associated parameters from hyperspectral infrared data, minimising information loss including the mutually acceptable update strategy for the principal component basis and to implement such an approach in a coordinated manner.]
Recommendation DA/NWP-Standing 6 to Data Providers: If a change to data processing results in a change in brightness temperature of 0.1K or 20% of NEdT (whichever is smaller), this should be made clear in notifications to users. These notifications should be made no later than 8 weeks before the change and test data should be provided if possible.
[HLPP: 3.17 Develop best practices for operational user notifications]
Recommendation DA/NWP-Standing 7 to Data Providers: The overlap period where one satellite resource is replacing another should be chosen after consultation with the user community and should follow WMO guidelines.
Recommendation DA/NWP - Standing 8 to Data Providers: Provide NedT estimates for inclusion within BUFR for microwave data.
[HLPP 4.4.2 Agree on standardised procedures to derive NedT estimates for microwave sounders, and include such estimates in the disseminated BUFR data.]

Recommendation DA/NWP- Standing 9 to Data Providers: Make NedT estimates from microwave instruments available as time series on publicly available websites to enable monitoring of instrument health in near real time.

Recommendation DA/NWP- Standing 10 to Instrument Developers: Pre-launch calculation of NEdT should use the same algorithm as will be used in-orbit using warm target counts variability divided by the instrument gain.

Recommendation Standing 11 to Data Providers: Develop and maintain public instrument status monitoring web pages similar to the Integrated Calibration and Validation System (ICVS) from NOAA/NESDIS .