ITWG Products and Software Working Group: Report from meeting at ITSC-25

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Attendees:

Liam Gumley (SSEC) (on behalf of Graeme Martin (SSEC)) & Anna Booton (Met Office) - co-chairs

Harshitha Bhat (EUMETSAT), Hyun-sung Jang (NASA LaRC), Fiona Smith (Bureau of Meteorology), Nathalie Selbach (DWD), Sreerekha Thonipparambil (EUMETSAT), Tobiasz Górecki (IMGW), Alice Abramowicz (KNMI), Sujata Pattanayak (NCMRWF), Indira Rani (NCMRWF), John P George (NCMRWF), Srinivas Desamsetti (NCMRWF), Jean-Marie Lalande (Météo-France), Swapan Mallick (SMHI), Svetlana Akishina (St Petersburg State Uni.), Alexander Polyakov (St Petersburg State Uni.), Tomoya Urata (JMA), Mitch Goldberg (The City College of New York)

Contents:

It is noted that the group had previously been reminded of the following aims and scope of the PSWG during the "Introductions to the ITWG Working Groups" session during the first day of the conference:

- Focus on both Level 1 and Level 2 satellite data and products
- Software tools and packages for generating, analyzing, and visualizing products
- Enabling users to obtain or generate the products they need
- End user feedback
- Information exchange for validation of products
- Informing the user community about requirements for future missions; and
- Informing agencies about users' requirement

1. Introductions

The participants introduced themselves.

2. Review of actions and recommendations

Note: presentations from the PSWG 2024 "interim meeting" are linked from https://itwg.ssec.wisc.edu/pswg/

2.1 Review of Actions

Action ITSC-22-PSWG-6: Migration of the UW/SSEC/CIMSS web site to Wordpress is complete. ***Action closed*.**

Action ITSC-23-PSWG-1 regarding VIIRS cluster statistics in the CrIS FOV: Liam Gumley gave an update on (a) the new global NOAA CrIS BUFR products available via AWS (2211 channel and 431 channel BUFR files with VIIRS M13, M14, M15, M16 radiance cluster statistics for each CrIS FOV) and (b) the upcoming release of the CSPP LEO VIIRS Radiance Clusters package to generate the same BUFR files from DB data. ***Action remains open*.**

Action ITSC-23-PSWG-2 on developments in PC representation: Dave Tobin and Joe Taylor have reported the following progress:

a) NASA is developing a PCA CrIS radiance product using the EUMETSAT hybrid approach. A sample NOAA-20 product (PCA/RED) is available from GES DISC; an official product for all CrISes will be available soon.
b) A NOAA PC product for the future GeoXO/GXS sounder is in the design phase, and will follow the hybrid methodology. ***Action remains open*.**

Action ITSC24-PSWG-1 on sharing documents related to containers: documentation has been made available on the PSWG website. ***Action closed.***

Action ITSC24-PSWG-2 on porting and updating the current list of software packages to the new website: This has been completed. ***Action closed.***

2.2 Review of recommendations

The PSWG co-chairs reviewed the recommendations ahead of the conference and consulted the group in advance for feedback. In cases where the group had questions or changes, the recommendation was discussed during the meeting.

It was agreed that all the recommendations have continuing value and should be carried over. Those identified as being relevant for the foreseeable future have been promoted to standing recommendations. Recommendations were also consolidated, clarified, or broadened in scope where appropriate to retain applicability. They are re-numbered below to reflect the fact that they are now standing recommendations.

<u>Regarding software development, distribution and installation:</u>

Standing Recommendation PSWG-1: To software providers: Where possible,
a) offer the software with a choice of either pre-built binaries or source code,
b) list recommended versions of required external (OTS) libraries when supplying source code,
c) build/develop software packages in a container with a controlled environment.
(consolidates ITSC-24 PSWG recommendations 1, 2, 10)

The group noted that the Metop-SG-A1 METimage DB Level 1 processor source code is restricted due to EU export controls. End users who require the METimage DB processor to be built locally from source code are encouraged to contact the EUMETSAT NWP-SAF.

Standing Recommendation PSWG-2: To software and data providers: document the versions of APIs and readers that have been tested with your data products. (clarifies ITSC-24-PSWG recommendation 11)

Standing Recommendation PSWG-3: To software providers: software intended to be run in an operational context should only link to open source 3rd party packages (e.g. on Conda Forge). (from ITSC-24-PSWG recommendation 12)

The group noted that several agencies (e.g., CM-SAF, Meteo France) are not permitted to use versions of the Python Conda software that require a paid license. Therefore it is important to ensure that Python runtimes included with DB software are open source.

<u>Regarding Cloud technologies:</u>

Standing Recommendation PSWG-4: To software and data providers: Costs to users should be considered when migrating software and data distribution to the cloud. (from ITSC-24-PSWG recommendation 3)

Standing Recommendation PSWG-5: To software providers: Consider providing and testing software in a cloud-ready format. (from ITSC-24-PSWG recommendation 5)

Standard Recommendation PSWG-6: To software developers: Software developed for the cloud should be vendor agnostic. (clarification ITSC-24-PSWG recommendation 9)

<u>Regarding Direct Broadcast, data dissemination and data access:</u>

Standing Recommendation PSWG-7: To space agencies and data providers: Users should continue to have free access to satellite data. (from ITSC-24-PSWG recommendation 4)

Standing Recommendation PSWG-8: To space agencies: Direct broadcast should be preserved and protected, for users who require data in near-real time and/or lack adequate terrestrial access. (clarification ITSC-24-PSWG recommendation 8)

Standing Recommendation PSWG-9: To data providers: Explore the use of principal component (PC) compression to reduce the volume of hyperspectral sounder data in future geostationary direct broadcast or rebroadcast streams. (from ITSC-24-PSWG recommendation 6)

The group noted that hybrid PC compression is being considered for the NOAA GeoXO GXS mission.

<u>Regarding satellite missions / applications:</u>

Standing Recommendation PSWG-10: To space agencies: Consistency in data content and data formats between the various planned smallsat microwave missions would be highly beneficial for users. (from ITSC-24-PSWG recommendation 7)

The group noted that the ISRO Microsat-2B small satellite microwave sounder mission will generate data in HDF5 and BUFR formats.

Standing Recommendation PSWG-11: To raw data providers: In re-broadcast streams for future satellites, key metadata required to interpret the data should be sent before the data it describes, to

facilitate utilization of data in nowcasting / near-real-time applications within timeliness cut-offs (clarification ITSC-24 PSWG recommendation 13)

3. CGMS High Level Priority Plan

Several topics of relevance were selected from the CGMS HLPP guidance issued by ITWG co-chairs. The group noted progress towards these goals as shown below.

(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, minimizing information loss including the mutually acceptable update strategy for the principal component basis and to implement such an approach in a coordinated manner.

1. As previously noted, CIMSS/SSEC reported progress regarding NASA CrIS PCA product developed using EUMETSAT hybrid PC approach, and preliminary NOAA work on PC compression for future GeoXO GXS sounder. CrIS PCA/RED sample product for NOAA-21 is available at NASA GES-DISC, and will soon transition to an official product for all CrISes. GeoXO Sounder PC product is in the design phase, and will follow the EUM Hybrid methodology.
2. EUMETSAT NWP-SAF reported that the EUMETSAT hybrid PC approach is well established. It will be used for MTG-IRS (as the only format for near-real-time dissemination) and Metop-SG-A1 IASI-NG (both full spectra and PC scores will be available in NRT).
3. NWP centers reported that they have tested assimilation of reconstructed radiances with no ill effects, and that they will routinely assimilate reconstructed radiances from IRS and IASI-NG.
4. ECMWF reported they have started testing of IASI hybrid PCs in their AI-DOP model in the training dataset instead of IASI radiances.

(4.3.2) Conduct an intercomparison study between the different methods to derive level 2 data from infrared hyperspectral sounders, recognising that there are several software packages available that utilize AIRS/IASI/CrIS data.

1. NOAA Products Validation System (NPROVS) at NOAA/STAR is an enterprise products validation system. NPROVS has the capability of conducting routine monitoring and analysis of satellite sounding products by comparing them with radiosondes (global conventional, and dedicated and GRUAN radiosondes) and NWP products, and through products intercomparison. NPROVS is capable of conducting the assessment of L2 products derived from new infrared sensors or new retrieval algorithms. GRUAN has indicated they are willing to work with the community in facilitating comparisons (copied from ITSC-24 PSWG report as it remains relevant).
2. PSWG noted that both EUMETSAT and NOAA provide their IASI and CrIS Level 2 retrievals online (EUMETSAT Data Store and NOAA Open Data Dissemination, respectively). NCMRWF volunteered to compare IASI Level 2 products from EUMETSAT and NOAA over India against local RAOBS.

(4.4.1) Establish a common vocabulary and methodology with appropriate error propagation to include the errors associated with validation data (e.g. radiosonde temperature, water vapour, precipitation and winds).

1. EUMETSAT reported that error statistics are now included in the IRS Level 2 product.

(4.9) Identify AI/ML technologies for applying to the product processing and data management infrastructure and develop best practices.

1. Several groups (ECMWF, Met Office) are already converting data (e.g., BUFR) to ML-ready formats including Zarr.
2. Regarding hyperspectral infrared sounder data, it is important that the full set of channels is available for ML-training (e.g., original radiances, hybrid PC scores, or reconstructed radiances).
3. It was noted that if datasets are already in netCDF4 or HDF5 format, there are toolkits that enable Zarr-like data access without reformatting the original data (e.g., Kerchunk, VirtualiZarr).
4. It was noted that satellite data providers may need to come up with recommendations on best practise for providing data in ML-ready formats (e.g., ensuring geolocation, satellite zenith/azimuth, and solar zenith/azimuth information are included) along with appropriate metadata.

4. Update on WMO's WIGOS vision 2050 (Fiona Smith)

Fiona Smith presented an update on the WIGOS Vision 2050.

5. Plans of agencies and software providers related to new and future satellite instruments

1. NCMRWF (Indira Rani) gave a brief update on plans for new DB stations in Delhi and Chennai that will contribute to DBNet. Also noted that INSAT 3DR and 3DS are operational now. IMD would like to have support in CSPP GEO for processing imagery from INSAT 3D.
2. CIMSS/SSEC (Liam Gumley) gave a brief update on the current status of operational infrared and microwave sounders relevant to direct broadcast on Metop, JPSS, POES, FY-3, and EOS satellites. Note that global NOAA-18/19 products from NOAA will be discontinued on June 16, 2025, and end of life for POES DB is unknown at this time (the satellites will be decommissioned by end of September, 2025).
3. Anna Booton gave a brief update (provided by Hidehiko Murata) on JMA plans for Himawari-10 sounder.

6. Cloud services and cloud data distribution

EUMETSAT (Sreerekha Thonipparambil) presented an overview of the European Weather Cloud https://europeanweather.cloud/

EWC is available to EUMETSAT and ECMWF member states, and it provides cloud computing resources adjacent to the EUMETSAT and ECMWF data stores. There is a R&D call open now (closes June 30, 2025). The system utilizes Morpheus cloud management, Kubernetes container orchestration, and a Docker Container registry. Extensive online documentation and training resources are available, and support is provided by the EUMETSAT help desk. Use cases include individual user projects and large scale reprocessing.

Several members of the group have used the EWC and reported good results. They noted that users can deploy and run virtual machines and containerized software, and there is a batch job management system. The online RocketChat feature is very useful for getting help from EUMETSAT.

7. Needs and concerns of direct broadcast users

1. JMA reported that they had to add new filters to their DB antenna system to remedy problems caused by local RFI on L-band. They are willing to share the details (details have been shared with DBNet coordination group).
2. Metop-SG-A1 IASI-NG DB processing: The group noticed that IASI-NG data require significant resources for CPUs, memory, I/O for timely processing of data received via direct broadcast.

8. Status and plans of software packages for processing sounder data

Anna Booton (EUMETSAT NWP-SAF) gave a brief update on AAPP, AAPP-AWS, IRSPP and MWIPP.

AAPP - ATOVS and AVHRR Pre-processing Package
Has been developed for more than 25 years and extended to support multiple satellites

- *NOAA POES, EPS Metop, JPSS, FY-3*
- *Current version is v8.14 (Jan 2025) including support for Arctic Weather Satellite MWR*
- *v8.15 is due soon, including a bug fix for AWS*

Moving forward, AAPP will be released as a "family" of packages. After the launch of Metop SG:

- *AAPP v9 will include the traditional AAPP- supported satellites and instruments*
- *AAPP-SG v1 will support MWR (AWS), MWS and IASI-NG*
- *This should make installation easier for newer instruments. Conda based installation method is in development.*

MWIPP - Microwave Imager Pre-processor (v1.2)

- *A generic microwave imager processor – SSMIS-PP heritage*
- *Supports: SSMIS, AMSR-2, GMI, MWRI, (plus some support for MWI and ICI)*
- *Full support for MWI/ICI due autumn 2025, with AMSR-3 later*

IRSPP - Infrared Sounder Pre-processor (v1.3 Oct 2024)

- *Supports: MTG-IRS instrument (converting PC scores to reconstructed radiance)*
- *Currently tested with EUMETSAT's January 2025 test data*
- *Real data will be ~12 months after launch of MTG*

Liam Gumley (CIMSS/SSEC) gave a brief update on CSPP LEO.

- *Funded by NOAA JPSS*
- *Ready to run on 64-bit Rocky Linux 8 (source code available on request)*
- *Supported satellites and sensors include*
    - *JPSS: NOAA-21, NOAA-20 and Suomi NPP (VIIRS, CrIS, ATMS, OMPS)*
    - *Metop: Metop-B/C (IASI, AMSU-A, MHS, HIRS, AVHRR)*
    - *POES: NOAA-18/19 (AMSU-A, MHS, HIRS)*
    - *EOS: Terra and Aqua (MODIS, AIRS)*

    - *GCOM: GCOM-W1 (AMSR-2)*
    - *Fengyun: FY-3D (MERSI-2) and FY-3E (MERSI-LL)*
- *Total of 15 software packages are available.*
- *CSPP LEO now officially supports RT-STPS Level 0 decoding software, since NASA Direct Laboratory closed in June 2023.*
- *Efforts since ITSC-24 have focused on completing support for NOAA-21 across all Level 2 product generation packages (e.g., SDR, MiRS, VIIRS cloud/aerosol/volcanic ash).*
- *Upcoming releases include:*
    - *VIIRS Radiance Clusters (VIIRS radiance cluster statistics in CrIS FOV; BUFR output)*
    - *VIIRS Flood Detection with support for NOAA-21*
    - *VIIRS Land Surface Reflectance and Temperature with support for NOAA-21*
    - *VIIRS Sea Surface Temperature with support for NOAA-21*
    - *HEAP/NUCAPS atmospheric profiles with support for NOAA-21*
    - *OMPS Ozone and Sulfur Dioxide with support for NOAA-21*

9. AOB

There was no other business.

10. Follow-up discussion

In the plenary session summary of the PSWG meeting on the final day of the conference, Simon Elliott requested that the format of satellite data should follow standards recommended by the CGMS Working Group 1 (WG1): Task Group on Satellite Data and Codes, and that any issues encountered in doing so should be reported back to that working group. On 2nd July 2025, the PSWG co-chairs met with Simon, who is chair of the task group. It was agreed that a PSWG recommendation should be made to follow WG1 standards, and that issues are to be reported to the chair as needed. It was also suggested that in the future the two working groups should coordinate on common areas of interest. Links to the relevant standards will be posted to the PSWG website when available.

11. New actions and recommendations arising from ITSC-25

Action ITSC-25-PSWG-1: NCMRWF to perform a comparison of IASI Level 2 products (EUMETSAT and NOAA) vs. local RAOBs. It is noted that NCMWRF will need support from EUMETSAT and SSEC with regard to provision of the required data.

Action ITSC-25-PSWG-2: PSWG co-chairs to share information from JMA on antenna system modifications to remedy direct broadcast reception problems resulting from local radio frequency interference on L-band.

Note, **two actions remain open** from previous meetings **(refer to Section 2.1).**

Recommendation ITSC-25-PSWG-1: To satellite data and weather data providers: Noting the success of the European Weather Cloud (EUMETSAT and ECMWF), we recommend that other agencies

provide cloud computing resources to end users to facilitate adoption and exploitation of large satellite and weather datasets that are not practical to download.

Recommendation ITSC-25-PSWG-2: To satellite data providers: In light of ECMWF's recent work exploring AI/ML Direct Observation Prediction, we recommend developing, promoting, and utilizing best practises for providing (non-real-time) satellite data in formats convenient for AI/ML training (e.g Zarr, Kerchunk, VirtualiZarr), ensuring that all necessary ancillary data (e.g. zenith angles) and metadata are included.

Recommendation ITSC-25-PSWG-3: To software developers and data providers: The existing file format standards (e.g. Climate and Forecast (CF), GRIB and BUFR), as set out by CGMS Working Group 1 (WG1): Task Group on Satellite Data and Codes, should be applied, where possible, when producing data. Issues achieving this should be reported to the chair of WG1 accordingly.

In addition, **eleven new standing recommendations** were adopted **(refer to Section 2.2).**