2.6 PRODUCTS AND SOFTWARE
Web site: http://cimss.ssec.wisc.edu/itwg/pswg

Working group members: Graeme Martin (Co-Chair, SSEC/UW), Nigel Atkinson (Co-Chair, Met Office), Mathieu Asseray (Météo-France), Olivier Audouin (Météo-France), Nick Bearson (UW-Madison SSEC/CIMSS), Alessandra Monerris Belda (Bureau of Meteorology), Younousse Biaye (Université Gaston Berger), Dorothee Coppens (EUMETSAT), Geoffrey Cureton (CIMSS, UW-Madison), James Davies (SSEC, UW-Madison), Yu (Judy) Deng (Alion Science), Vincent Guidard (CNRM, Météo-France, CNRS), Liam Gumley (CIMSS/SSEC UW-Madison), Ken Holmlund (WMO), James Jung (UW-Madison), Robert Knuteson (UW-Madison SSEC/CIMSS), Agnes Lane (Bureau of Meteorology), Salvatore Larosa (CNR-IMAA), Rohit Mangla (Météo-France), Miguel-Angel Martinez (AEMET), Silke May (DWD), Paul Menzel (UW/SSEC/CIMSS), Scott Mindock (SSEC/CIMSS), Masami Moriya (JMA), Hidehiko Murata (JMA), Heikki Pohjola (WMO), Anthony L Reale (NOAA NESDIS STAR), Hank Revercomb (UW-Madison SSEC), Pascale Roquet (Météo-France), Nathalie Selbach (DWD), AK Sharma (NOAA/NESDIS), Kathy Strabala (UW-Madison/SSEC/CIMSS), Tiger Yang (UMD), Lihang Zhou (NOAA)

2.6.1 Introduction
The group was reminded of the scope of the Products and Software Working Group:
   o   Both Level 1 and Level 2 satellite products;
   o   Software tools and packages for generating, analyzing, and visualizing products;
   o   Enabling end users to obtain or generate the products they need;
   o   End user feedback and training;
   o   Exchange of information for validation of products;
   o   Informing the user community about requirements for future missions; and
   o   Informing agencies about requirements of the users.

The agenda included the following topics:
   •   Review of open actions and recommendations from ITSC-22;
   •   Status of existing software packages;
   •   New and future sensors and plans for supporting software;
   •   DBNet status and plans;
   •   Cloud services and cloud data distribution;
   •   CGMS High Level Priority Plan; and
   •   PSWG web site.

2.6.2 Review of open actions and recommendations from ITSC-21 and ITSC-22

   o   **Action PSWG21-2**: KMA and SSEC to come up with a plan to make the GK-2A software available to DB users.
       It was confirmed that Hee-Jung Kang is still the contact at KMA for any enquiries about the GK-2A software. There are no plans for SSEC to be involved with software support or distribution. Because this action is now several years old, and no changes are anticipated in the near future, it was agreed to close it.
       Action closed.

   o   **Action PSWG22-1**: Nigel Atkinson to provide Lihang Zhou with information on the VIIRS to CrIS clustering in AAPP.

VIIRS to CrIS clustering is implemented as an option in AAPP v8. The information was provided to Lihang Zhou.
Action closed.

However, the issue is not settled, as NOAA are not yet producing VIIRS radiances on the CrIS footprint as part of the operational product (even though the BUFR format has slots allocated). There does appear to be a desire from users to have this information but there are various reasons why NOAA cannot use the AAPP code. This issue has also been discussed at the NWP and Advanced Sounder working groups. A new action has been proposed:

Action PSWG-1 on PSWG co-chairs
> **To liaise with the ASWG and NWPWG co-chairs with the aim of agreeing a coordinated approach to the cluster analysis of VIIRS radiances on the CrIS footprint.**

o **Action PSWG21-4:** Nigel Atkinson to look at the CrIS PC product and compare the implementation with that used for IASI.
Lihang Zhou reported that CrIS PC products are not being generated operationally due to lack of users' requests. PC score monitoring files are being produced. Points of contact at NOAA are A K Sharma or Murty Divakarla. It was agreed to close the action.
Action closed.

There is, however, interest in PC representation for IASI, CrIS, IASI-NG and MTG-IRS, particularly the hybrid approach being introduced by EUMETSAT. This was the subject of a discussion at the Advanced Sounders Working Group. A new action has been proposed:

Action PSWG-2 on PSWG co-chairs
> **To monitor developments in PC representation, liaising with the ASWG, and report back to PSWG at the next ITSC.**

o **Action PSWG22-2**: SSEC (Scott Mindock) to work with NOAA to obtain and make available historical LUTs for VIIRS, ATMS, CrIS.
Scott Mindock reported that the CSPP team has worked with NOAA to improve the FTS LUT site. This site provides access to current and historical LUTs in the format that they were originally produced. The site does not provide historical LUTs compatible with the most recent version of project software. Some groups have successfully processed older datasets by modifying the effectivity dates of the current LUTs.

Liam Gumley suggested that anybody who is having issues with LUTs for historical data should contact the CSPP team, who would be happy to try to help.
Action closed.

o **Action PSWG22-3**: Lihang Zhou to discuss with the CLASS team whether a scripted retrieval from CLASS can be supported to allow easier access to larger/historic data amounts.

Lihang Zhou reported that discussions have been held with CLASS. Here is the response from Axel Graumann (NOAA CLASS): I have heard of users scripting access to CLASS data holdings in a roundabout way using the web interface in an automated fashion. However, users should be aware that there are limitations to the size of each order and number of daily orders one can place. Also, users must consider bandwidth capability to download large volumes of data within a 96-day lifespan of ordered files delivered to its ftp server. **Action closed.**

It was noted that CLASS is planning to move to the Cloud. The following web site describes its Big Data Program datasets:
https://www.noaa.gov/organization/information-technology/list-of-big-data-program-datasets

Nathalie Selbach reported that the CM-SAF has some experience at retrieving large amounts of data from CLASS and agreed to test the new functionality:

Action PSWG-3 on Nathalie Selbach, and others in PSWG who are able to do so To test new NOAA/CLASS access options, including cloud access, and report back to PSWG.

o **Action PSWG22-4**: Lihang Zhou to circulate a link to the NOAA 90-day rolling archive.
The archive is here: ftp://ftp-jpss.avl.class.noaa.gov. It contains a 90-day archive of a selection of Suomi-NPP and NOAA20 products. Note also that there is a tutorial linked from the CLASS home page that gives further details on data access. *Action closed.*

o **Action PSWG22-5**: PSWG co-chairs to ask EUMETSAT for an update on the feasibility of providing ASCAT processing software to DB users.
An update was received from Stefanie Linow who is in charge of ASCAT processing at EUMETSAT: "I'm aware of occasional requests to release the ASCAT L1 processor. In principle I would support this, but we have some licensing issues which prevent the distribution. For this reason, we are not planning to release the L1 ASCAT processor. I can confirm that there are plans to provide software for the local DB users for the EPS-SG instruments."
Action closed.

o **Action PSWG22-6**: PSWG co-chairs to update the group web page by next ITSC, assuming Wordpress is implemented by CIMSS as planned.
The implementation of Wordpress at CIMSS has been delayed.
Action remains open. See agenda item 8.

The group then reviewed the recommendations from ITSC-22. Many of these concern best practices and do not need to be repeated in this report. Several of them are now reflected in the new document *CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data* which is available from the Publications tab at https://www.cgms-info.org/.

Updates were provided on the following recommendations from ITSC-22:

- **Recommendation PSWG22-5** concerning test data for EPS-SG and MTG. Test data are now available from the EUMETSAT web site. We expect that more datasets will be added as the programmes progress.
- **Recommendation PSWG22-6** "when designing software, keep DB users in mind from the outset in order to minimise costs at the user end." This has been followed in ESA's Arctic Weather Satellite mission planning, see details in section 4.
- **Recommendation PSWG22-7** concerning coverage and latency of CrIS. Liam Gumley explained that CSPP SDR software requires 9 CrIS granules in order to process the central granule. Tests have been done on fewer granules (3, 5, 7) but some differences in the radiances were found with respect to global data. Therefore it has been decided not to proceed with a change until NOAA have checked the impact on products.
- **Recommendation PSWG22-8** concerning AMSR-2 L1 software for the DB community. The software is only available to NOAA partners. It was also pointed out that the DB transmission from GCOM-W1 is only switched on over certain parts of the world. Nevertheless, Kathy Strabala reported that the IMAPP team does still get requests for the AMSR-2 software. A new recommendation was proposed:

  Recommendation PSWG-1 to NOAA, JAXA and the CSPP team
  To continue exploring ways in which the AMSR-2 level 1 software and direct broadcast transmission availability could be shared with DB users.

- **Recommendation PSWG22-10** concerning protection of frequencies used in DB reception. Richard Kelley confirmed that downlink frequencies are in the scope of the newly reconstituted Technical Subgroup on frequency protection. This is currently particularly relevant to planning of SmallSat missions.

2.6.3 Status of existing software packages

CSPP LEO
Recent developments:
- GCOM-W1 AMSR-2 GAASP Microwave Retrieval Software.
- The NOAA Unique Combined Atmospheric Processing System (NUCAPS) Hyperspectral Sounding Retrieval Software is now the *Hyper-Spectral Enterprise Algorithm Package (HEAP)*.

The next version of CSPP SDR software will include support for OMPS and also preliminary support for JPSS-2 (NOAA-21). Full support for JPSS-2 will be in the second half of 2022.

All new versions will be built on 64-bit CentOS 7.

AAPP and MWIPP
These packages are being extended to support EPS-SG. More detail will be in the talk 3.01 by Nigel Atkinson.

FY-3 processors
No update from CMA, but it is expected that software will be made available to support FY-3E (due for launch in July 2021).

CSPP GEO
Information is available at https://cimss.ssec.wisc.edu/csppgeo/.

The US still does not have a hyperspectral sounder in GEO orbit, but there are proposals to include one in the next generation NOAA system.

GOES-18 is due for launch in December 2021 and will be supported in CSPP Geo software as soon as possible, anticipating an accelerated commissioning and transition to the operational GOES-West satellite.

Graeme Martin advertised the CSPP Geosphere web site: https://geosphere.ssec.wisc.edu which is running in real-time at SSEC.

IMAPP
Kathy Strabala reported that the IMAPP project has once again received funding: see https://cimss.ssec.wisc.edu/imapp/. The website and several of the software packages have been updated. The Aqua and Terra spacecraft have the potential to operate until at least 2025.

There is a new version of the IDEA-I software to produce trajectories of ozone and carbon monoxide. This now includes facilities to create animations.

MODIS level 1 software will be packaged inside a Singularity wrapper.

2.6.4 New and future sensors and plans for supporting software

NOAA-21
CSPP has been funded to support NOAA-21.

FY-3E and FY-4B
The FY-4B satellite was launched on 2nd June 2021 and it is hoped that data will be available before the end of 2021. Ken Holmlund informed the group that interested users can register to receive early access to data for FY-3E and FY-4B, at http://www.nsmc.org.cn/NSMC/project/pioneer/index.html.

EPS-SG software
Nigel Atkinson reported that software packages to process MWS, METimage, IASI-NG, MWI, ICI and SCA are being procured by EUMETSAT. They will be distributed by the NWP SAF.

We understand that source code will be available, but it is not known yet whether users will have to compile the software themselves or whether binaries will be provided. This was the subject of some discussion. Some users would like the software to be "ready to run" binaries. But other users prefer the option to build from source. Scott Mindock pointed out that distribution of only binaries constrains the processor architecture: this will not necessarily be x86 in the future. In general, any developments that make it easier for non-experts to install the software are to be commended.

Recommendation PSWG-2 to software providers
 Where possible, offer their software with a choice of either pre-built binaries or source code.

Recommendation PSWG-3 to software providers
For software that will be built from source by the user, list recommended versions of required external (COTS) libraries.

Arctic Weather Satellite (AWS)

AWS is an ESA SmallSat mission containing a microwave sounder (50 to 325 GHz). A prototype satellite is due to be launched around 2024, with a future constellation being considered. Direct broadcast planned to be available at L-band. ESA have agreed to include DB software in its mission specifications. The NWP SAF have included support for AWS software in their proposal for the next phase of the NWP SAF (CDOP-4).

GEO-XO

See https://www.nesdis.noaa.gov/GeoXO. The project is still in a planning phase and no decisions have yet been made about whether there will be direct broadcast at full resolution. Cloud distribution is being actively discussed.

2.6.5 DBNet status and plans

DBNet continues to evolve as a means of providing low-latency sounder data for NWP. Since the last ITSC, four stations have started to be set up in Africa (Kenya, Niger, Gabon, South Africa). This is an initiative of the South African Weather Service, supported by EUMETSAT. Test data are flowing from South Africa to the NWP SAF, for monitoring.

There is a move to include microwave imagers in DBNet. EUMETSAT are already distributing EARS-MWRI operationally and are planning a regional service for EPS-SG. These are rather large datasets if transmitted at full resolution; it is important to ensure that data volumes are manageable for DBNet.

It can be challenging to upgrade station hardware to support future missions. It is known that JPSS requirements are unlikely to change much in the near future, but EPS-SG is a major change from EPS and will require new hardware (e.g., demodulators). Funding can be a major issue. It is felt that technical requirements are generally understood by the system vendors, so the vendor should be the first point of call if specific information is needed (e.g., dish sizes). CGMS are well aware of these issues, so no particular recommendation is needed from PSWG at this time.

Some DBNet regions are planning a move to centralised processing in the Cloud. This was discussed further in item 6.

2.6.6 Cloud services and cloud data distribution

The costs of cloud services were discussed. Charging is generally based on server footprints, with different cloud providers having different charging structures. When considering hosted processing, users should look for efficiencies and make use of tools to analyse metrics such as disk usage. Software should not, in general, be tailored to suit a single cloud provider.

Downloading data from the cloud does incur costs, but agreements are being drawn up by e.g., NOAA and NASA to ensure that end users would not have to pay. It is important that end users continue to have free access to essential meteorological data.

EUMETSAT are setting up a pilot service in which processing is being moved to virtual machines in the same location as the data.

Recommendation PSWG-4 to agencies
> **Costs to users should be considered when migrating software and data distribution to the cloud.**

Recommendation PSWG-5 to agencies
> **Users should continue to have free access to satellite data.**

Recommendation PSWG-6 to software providers
> **To provide and test software in a cloud-ready format.**

Related to this is the issue of making use of containers, to ensure consistency of operating systems, libraries, etc., and as a first step toward running software in the cloud. This is not necessarily straightforward and there can be a steep learning curve to develop the expertise to set up containers. For some centres (e.g. Met Office) the developers do not have access to an Admin account, which limits what can be done: Singularity requires Admin privilege to create containers but not to run them, while Podman has no Admin requirement. Jim Davies reported that the CSPP team has experience of working with containers and is actively working in the area. Scott Mindock has packaged the SDR in several containers.

Action PSWG-4 on CSPP and IMAPP teams
> **To share UW/SSEC/CIMSS experiences on working with containers (Docker, Podman, Singularity), including lessons learnt, via the PSWG web site.**

The question was raised as to whether any users are reliant on Windows. Kathy Strabala confirmed that there are indeed some users who rely on Windows for processing, analysis and visualisation. The "DB Virtual Machine" is not currently working, but SSEC/UW/CIMSS plan to reinstate it soon. Jim Davies has run IDEA-I as a container inside a VM on Windows.

Action PSWG-5 on CSPP and IMAPP teams
> **To provide information on running Linux packages in Windows, via the PSWG web site.**

2.6.7 CGMS High Level Priority Plan (HLPP)
The CGMS 4-year rolling priority plan is available from the About tab at https://www.cgms-info.org/.

The items in the current CGMS HLPP that are most relevant to the PSWG were shared with the meeting. The ITWG co-chairs would like to gather information on progress against these items, as well as suggestions for new recommendations.

It was pointed out the *CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data* document referred to in Section 2 is particularly relevant to this group, and to the HLPP.

Action PSWG-6 on PSWG co-chairs
> **To provide feedback on the High Level Priority Plan and CGMS Best Practices document to ITWG co-chairs by end 2021.**

Progress was noted against the following items:
1. *2.3.2 Facilitate the transition to new LEO direct broadcast systems (JPSS, FY-3, Meteor-M, Metop-SG)*: Information related to JPSS and Metop-SG has been shared with the direct broadcast community by NOAA and EUMETSAT. Plans for software have been shared, and further presentations will be made during the course of ITSC-23.
2. *2.3.3 Advance the implementation of the CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data for operational satellites*: the Best Practices document referred to in Section 2 is particularly relevant to this group, and to the HLPP.
3. *4.3 Foster the continuous improvement of products through validation and inter-comparison through international working groups and SCOPE-type mechanisms,* and *4.3.3 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*. Tony Reale reported on the NPROVS intercomparisons, and a presentation will be made in Session 3 of the conference. Paul Menzel advertised the poster by Eva Borbas that includes the results of HIRS and MODIS comparisons from 2003 to 2013.

Action PSWG-7 on Paul Menzel and Tony Reale
> **To send a few sentences summarising their validation studies to the PSWG co-chairs, for inclusion in High Level Priority Plan feedback.**

Action PSWG-7 was completed during the conference, with input from Paul and Tony being received, see *PSWG Appendix.*

2.6.8 PSWG web site
After a delay of several years, SSEC are now in a position to look at getting Wordpress implemented for ITWG working groups. Leanne Avila is setting this up.

There is already an html document on the site related to software packages, and it was agreed that this document should be transferred to the new format and updated. The suggestion was made to include a contact for each package, where appropriate. Another important document will be the "best practices" document on cloud processing and containers (see section 6).

Action PSWG22-6 remains open, and covers the porting activity that should now be feasible between ITSC-23 and ITSC-24.

PSWG Appendix: Input received in fulfilment of action PSWG-7

From Paul Menzel

Tropospheric moisture records from HIRS, MODIS, and VIIRS plus CrIS are being compared at UW/SSEC in an ongoing effort. These include total column precipitable water vapor (TPW) as well as integrated high (UTH), mid, and low layer tropospheric precipitable water vapor that are derived using infrared spectral bands in CO_2 and H_2O absorption bands (fusion with CrIS has recently added these bands to VIIRS) plus IR window bands. A statistical regression has been developed from an atmospheric profile database that consists of geographically and seasonally distributed radiosonde, ozonesonde, and ECMWF reanalysis data. TPW and UTH are determined for clear sky radiances (and brightness temperatures, BTs) over land and ocean both day and night at 1 deg spatial resolution with monthly average values for one of four possible time periods daily (night before and after midnight and day before and after noon), compiled for the operational months of each satellite. The regression coefficients are generated using calculated synthetic radiances and the matching atmospheric profile. The regression seeks a "best-fit" atmospheric profile that is computed using least squares methods applied to actual measurements; integration over the total column yields the TPW water and integration from 400 to 10 hPa gives the UTH. The Aqua MODIS and S-NPP VIIRS equator crossing time have been maintained at 13:30 Local Time (LT); HIRS on NOAA-16, -18, and -19 cross from 14:00 to 15:00 LT during their operational lifetimes. In a poster presented by Borbas et al. at ITSC23, VIIRS plus CrIS fusion products are compared to MODIS for one year in 2017 and HIRS and MODIS are compared from 2003 to 2013.

From Tony Reale

The NOAA Products Validation System (NPROVS) has been operating at NESDIS Office of Satellite Applications and Research (STAR) since 2008. The objective was to provide a common interface for assessing operational sounding products developed at STAR (ATOVS, DMSP, MiRS) against global conventional radiosonde (and dropsonde) observations serving as a common baseline; previously each product suite included a separate system for collocation with radiosondes creating artificial (perceived) differences. NPROVS also included EUMETSAT operational soundings from IASI (MetOp-A) and GNSS Radio Occultation (RO) observations (COSMIC-1) from UCAR. In 2012, NPROVS was expanded to include hyperspectral sounding products from Aqua-AIRS (v6.1) and experimental NOAA Unique Combined Atmospheric Processing System (NUCAPS) product suites. In 2013, a major expansion to access Special Radiosondes, typically not available conventionally, including JPSS funded dedicated radiosondes (at 3 ARM sites) and "fully characterized" observations from the GCOS Reference Upper Air Network (GRUAN); referred to as NPROVS Special. An agreement between STAR and GRUAN to "reference-process" the JPSS dedicated radiosonde created the sweetest fruit for assessment, namely, the dedicated and fully characterized reference radiosonde observation. Further expansions of the product suites including Metop-B, Metop-C and COSMIC-2 followed and GNSS-RO from KOMPSAT (Korea) were integrated by 2019. Currently, over 20 product (and Test) suites are accessed across NPROVS providing "one-stop shopping" for consistent, reliable inter-comparisons of national (US) and international sounding product suites. NPROVS also includes graphical/analytical applications (JAVA) for inter-comparing and assessing (including enterprise assessment) across the multiple (user selected) satellite product suites. Graphical applications and collocation datasets (back to 2008) are available to users (binary

and netCDF), please visit our web site at
https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/.