



CGMS-44, ITWG-WP-01  
5 May 2016  
Prepared by ECWMF and  
NOAA  
Agenda Item: II/4  
Discussed in WG 2

## **Summary Report of the 29th International TOVS Study Conference (ITSC)**

The twentieth International TOVS Study Conference, ITSC-20, was hosted by the Space Sciences and Engineering Centre (SSEC) of the University of Wisconsin, Madison, USA, in Lake Geneva, Wisconsin, between 25 October and 3 November 2015. 160 participants attended the Conference from 35 organizations, providing a wide range of scientific contributions. Seventeen countries and three international organizations were represented: Australia, Brazil, Canada, China, Czech Republic, France, Germany, India, Japan, Norway, Poland, Russia, South Korea, Spain, Switzerland, United Kingdom, United States, ECMWF, EUMETSAT, and the WMO. The Working Groups had very productive discussions and it was again encouraging to see a large number of new, younger scientists participating.

The meeting benefitted from presentations about new operational satellite data from new global operational data providers, in particular China and Russia. Evaluations of data from instruments on FY-3C as well as Meteor-M N2 show promising results, with operational data usage of the FY-3C data being considered at several NWP centres. Efforts for international data provision and collaborative evaluation that builds on the international expertise were warmly welcomed and supported by the group. Within the context of a diversification of providers of polar-orbiting satellite sounding data, there is an on-going requirement for international coordination and optimisation of these activities. The group again expressed a strong requirement for both infrared and microwave sounders in at least three complementing orbital planes.

## **The International TOVS Working Group (ITWG)**

### **Summary Report of the 20th International TOVS Study Conference (ITSC)**

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## **1 Introduction**

The twentieth International TOVS Study Conference, ITSC-20, was hosted by the Space Sciences and Engineering Centre (SSEC) of the University of Wisconsin, Madison, USA, in Lake Geneva, Wisconsin, between 25 October and 3 November 2015. 160 participants attended the Conference from 35 organizations, providing a wide range of scientific contributions. Seventeen countries and three international organizations were represented: Australia, Brazil, Canada, China, Czech Republic, France, Germany, India, Japan, Norway, Poland, Russia, South Korea, Spain, Switzerland, United Kingdom, United States, ECMWF, EUMETSAT, and the WMO. The Working Groups had very productive discussions and it was again encouraging to see a large number of new, younger scientists participating.

Apart from excellent support by the local hosts, SSEC, ITSC-20 was sponsored by industry and government agencies. The industry and government agencies included: ABB, EUMETSAT, Exelis, NOAA/JPSS Program Office, JCSDA, Met Office, Météo France, Orbital Systems, SCISYS, the World Meteorological Organization (WMO), and STC. The great success of ITSC-20 was largely thanks to the excellent work of the local organizing committee from SSEC, including Allen Huang, Maria Vasys, Leanne Avila, and Jonathan Gero who also covered the essential and invaluable administrative and logistical support as usual.

The meeting benefitted from presentations about new operational satellite data from new global operational data providers, in particular China and Russia. Evaluations of data from instruments on FY-3C as well as Meteor-M N2 show promising results, with operational data usage of the FY-3C data being considered at several NWP centres. Efforts for international data provision and collaborative evaluation that builds on the international expertise were warmly welcomed and supported by the group. Within the

context of a diversification of providers of polar-orbiting satellite sounding data, there is an on-going requirement for international coordination and optimisation of these activities. The group again expressed a strong requirement for both infrared and microwave sounders in at least three complementing orbital planes. Today we are experiencing the golden age of temporal coverage from polar orbiting satellites, which includes drifting satellites such as NOAA-15, NOAA-18, and NOAA-19, which of course enhances temporal coverage. A major discussion at the conference was the potential reduction of temporal coverage over the next decade and the importance of CGMS and WMO to study this in more detail to see how to better optimize the observing system of polar-orbiting sounder satellites. Another significant concern was the lack of a sounder on the DMSP weather satellite follow-on program. Current DMSP sounders have unique mesospheric sounding channels, which are not included in other satellite programs.

Critically contributing to the successful data usage are the continued developments of processing packages such as the ATOVS and AVHRR Pre-processing Package (AAPP) and the Community Satellite Processing Package (CSPP). The developments of direct broadcast packages also underpin a continued strengthening of fast retransmission services which uses existing local ground stations to process locally received data and to re-distribute it via the GTS to achieve a timeliness of 30 min or better. Previously known as Regional ATOVS Retransmission Service (RARS), this activity is now coordinated under the DBNet initiative of WMO, providing the renewed effort of coordination called for at previous meetings. New guidelines for this service were discussed at this meeting. Also the inclusion of software to process Russian satellite data was discussed in light of the encouraging data quality from the Meteor-M N2 satellite.

Observing system experiments presented at the conference underline the critical importance of satellite sounding data for Numerical Weather Prediction. A number of avenues are pursued to further improve and extend this use. Topics are the treatment of cloud-affected sounding radiances in data assimilation systems, the extended use of data over sea-ice or land, or improved treatment of biases.

A strong over-arching science theme was renewed efforts to rigorously characterise observational uncertainties, such as arising from data processing, radiative transfer modelling, or cloud screening. This is being considered from a number of angles, through several projects in a climate context for trend detection, as part of calibration/validation activities for new satellite data, or in data assimilation for appropriate weighting of observations. The latter activities are sparked by reports from several NWP centres of significant benefits in terms of forecast impact from a more refined treatment of observational uncertainties in NWP systems.

The efficient use of hyperspectral data continues to be a topic, and efforts to increase the use of the spectral information, for instance through principal component analysis, continue to be pursued. These developments are highly relevant for the future evolution of the global observing system, especially for

hyperspectral instruments from geostationary orbit planned in Europe and China. They are also very relevant for instruments with even higher spectral resolution from polar orbit, such as IASI-NG. Also important in the very near term is the preparation by users for the full spectral resolution of CrIS on both Suomi NPP and the near future JPSS-1, scheduled for launch no later than March 2017. The full resolution will provide enhanced water vapour information and the monitoring and future assimilation of carbon monoxide.

Radiative transfer developments, including enhanced treatment of surface emissivity over land and sea, continue to be essential aspects, as they underpin all quantitative uses of sounding data.

Most of the meeting was organized in fourteen sessions of oral presentations and their associated poster papers. This comprised of 62 longer format oral presentations and 112 poster papers. Each poster was introduced through a short verbal summary to highlight the scientific content. The range of issues covered in oral presentations and posters included the following:

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

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

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

The Working Groups reviewed recent progress in the above areas, made recommendations on key areas of concern and identified items for action. These were further reviewed in a plenary session at the end of the conference. Working Group reviews and recommendations comprise an important part of the ITSC-20 Working Group Report. A summary of the key recommendations and actions arising from the conference is presented below.

Activities that had taken place since ITSC-19 in Jeju Island were presented in a dedicated session of Working Group status reports. This session also reviewed progress on the Action Items and Recommendations identified by the ITSC-19 Working Groups, and highlighted community topics of particular interest, such as the formulation of guidelines for DBNet or microwave frequency protection. Technical sub-groups also met during ITSC-20 to discuss developments and plans concerning specific software packages, shared and in common use.

A special evening session commemorated the evolution of ITWG since its inception in 1983 over the last 20 meetings, with contributions from former co-chairs and key members of the group, sharing anecdotes, but also highlighting key science mile-stones that lined the path of success of ITWG.

The conference agenda and all of the talks and many of the posters can be viewed at the ITWG Web site, located at <http://cimss.ssec.wisc.edu/itwg/itsc/itsc20/program/index.html>

## 2 Summary of major conclusions

The ITSC-20 presentations, posters, Working Group meetings and discussions documented significant issues in many areas and identified areas for future activity. The full list of action items and recommendations can be found in the detailed reports from each working group. The main conclusions and recommendations are summarised below.

**1. To CGMS and other satellite agencies:** the constellation of at least three polar orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), should be maintained. The overpass times of operational satellites with sounding capability (IR and MW) should be coordinated between agencies to maximize their value.

Noting the excellent news regarding the move of FY-3E to the early morning orbit, the group recommends to consider how the early morning orbit will be covered post FY-3E or the DMSP satellites.

When an agency has two or more satellites in the same nominal orbit (e.g. 2pm) they should be staggered by phase (as Metop). With multiple satellites from different agencies it is recommended to stagger them in ECT.

**2. To US DoD:** noting that the launch of F20 is currently uncertain, ITWG strongly recommends that SSMI/S on F20 should be flown, preferably in an early morning orbit, in support of maintaining a robust global satellite observing system.

**3. To space agencies:** the SSMIS 60 GHz upper stratospheric and mesospheric sounding capability should be continued, noting the trend for NWP models to extend higher in the stratosphere and lower mesosphere and the development of thermosphere modelling for Space Weather applications.

4. **To WMO/CGMS/other space agencies:** future programs should include the provision of high temporal frequency MW humidity sounding radiances (alongside cloud and precipitation sensitive observations).
5. **To space agencies:** ITWG recommends to develop, test, and implement an SI Traceable radiometric standard in space as soon as feasible.
6. **To space agencies and NWP centres:** noting the urgent need for realistic trade-off studies regarding the field-of-view size, instrument noise and spectral resolution of future infrared sounders, and the continued lack of a coherent analysis of these aspects, ITWG recommends dedicated studies to investigate these trade-offs in an NWP context. Such studies should also consider the effects of clouds and other geophysical uncertainties. Space agencies should consider commissioning such studies to optimize the usefulness of future infrared sounders.
7. **To WMO/CGMS:** ITWG recommends to secure full government control for observations classed as essential under WMO Res 40.
8. **To space agencies and all agencies involved in GRUAN/ARM:** ITWG recommends the provision of more GRUAN and tropical ARM sites, noting the continued need for and scarcity of ground-based reference measurements.
9. **To WMO/CGMS:** ITWG recommends to further maintain OSCAR and SATURN, noting the strong positive feedback from ITWG Members.
10. **To CGMS and other space agencies:** ITWG recommends to assign Digital Object Identifiers (DOIs) to their data sets of heritage instruments and provide these DOIs to a central portal like WMO-OSCAR.
11. **To WMO/CGMS/GSICS:** to develop best practices in pre-flight characterisation of MW sensors, and to make instrument channel characterization data for future instruments publically available.
12. **To IRC and agencies involved in radiative transfer developments:** Noting the progress made in characterising observation uncertainty for hyperspectral sounders encourage further characterisation of LBL model error and errors arising from cloud screening, with a view to considering hyperspectral sounders as an absolute reference.
13. **To NWP centres:** Consider studies into the use of physical methods as well as diagnostic methods to characterise observational uncertainties, including their correlations, to improve the assimilation of satellite radiances.
14. **To IRC and agencies involved in radiative transfer developments:** ITWG recommends the continued support of LBL model development, both the forward model software and the measurements/calculations to improve the spectroscopy.
15. **To WMO/CGMS/space agencies:** ITWG continues to support low-cost fast delivery initiatives and welcomes the DBNet initiative for renewed coordination of such activities.

16. **To Roshydromet:** Roshydromet are encouraged to release a direct broadcast processing package for the Meteor-M N2 series, including level 1 processing for the MTVZA-GY microwave imager.
17. **To satellite agencies:** ITWG recommends open access to new satellite data during the calibration/validation phase (particularly for all NWP centres) to help with calibration and validation.
18. **To WMO/CGMS/space agencies:** ITWG supports initiatives to make data from R&D and pre-operational missions available, with timeliness suitable for operational near-real-time applications (related to CGMS HLPP 2.3).
19. **To satellite agencies:** If PC compression is used to disseminate hyperspectral IR observations; a conservative approach should be taken in order to mitigate information loss (e.g., by retaining as many principal components as possible).
20. **To satellite agencies in dialogue with users:** devise and document a mutually acceptable update strategy for the principal component basis when a principal component scores product is disseminated to users. Users are encouraged to monitor reconstructed radiances in parallel to operations so that the PC update strategy can be properly tested.
21. **To funding bodies of NWP centres and satellite agencies:** consider, as part of the cost of satellite programs, providing computational and personnel resources targeted at operational NWP centres to optimise the public's return on investment from these expensive measurement systems.
22. **To the NWP community:** in support of continued efforts for frequency protection, national meteorological services should attempt to provide an assessment of the economic value of bands based on an impact assessment, as was done by the Met Office in 2005.

### 3 Future plans

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

The next meeting of the ITWG will be held in Darmstadt, Germany, 29 November – 5 December 2017. More information about ITWG and other ITSCs may be found at: <http://cimss.ssec.wisc.edu/itwg/>

### 4 Acknowledgements

This report relied on the active participation of all ITSC attendees and those working group chairs. We acknowledge that writing of this report is possible only through the collective work of ITWG members.