

## **1. EXECUTIVE SUMMARY**

### **1.1 INTRODUCTION**

The Fifteenth International TOVS Study Conference, ITSC-XV, was held near the town of Maratea in southern Italy from 4 – 10 October 2006. Around one hundred and ten participants attended the Conference and provided scientific contributions. Sixteen countries, and three international organizations were represented: Australia, Brazil, Canada, China, France, Germany, Hungary, India, Italy, Japan, Norway, Poland, Russia, Sweden, United Kingdom, United States, ECMWF, EUMETSAT and WMO. The number of attendees has remained at a consistent level over the past 3 meetings. The Working Groups had very useful discussions and it was encouraging to see a large number of new younger scientists participating. Originally it was hoped that the conference attendees would be able to learn about the launch of Europe's first polar orbiting meteorological satellite, MetOp-A, but unfortunately it was delayed until after the conference.

Most of the meeting was occupied with oral presentations and two poster sessions on a range of issues which included the following:

- Radiative transfer and surface modeling
- Climate applications
- ATOVS cloud studies
- Direct broadcast software, education and frequency protection (dedicated to Guy Rochard)
- Preprocessing and calibration
- Operational use of ATOVS
- Developments in use of ATOVS in NWP
- International Issues and Agency Status Reports
- Products from ATOVS
- MetOp Developments
- Future sensors

There were 77 oral and 50 poster presentations during the conference; the agenda is given in Appendix A. 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>.

Working Groups were formed to consider six key areas of interest to the ITWG, including Radiative Transfer and Surface Property Modelling; Use of ATOVS in Numerical Weather Prediction; Use of TOVS and ATOVS for Climate Studies; Advanced Sounders; International Issues; and Satellite Sounder Science and Products. The Working Groups reviewed recent progress in these areas, made recommendations on key areas of concern and identified items for action. Working Group reviews and recommendations comprise an important part of the ITSC-XV Working Group Report. A summary of the key points arising from the conference are listed below.

During the Conference, a session on Working Group status reports considered activities that had taken place since ITSC-XIV in Beijing. This session also reviewed progress on the Action Items and Recommendations identified by the ITSC-XIV Working Groups. Many of these items formed the basis for further discussion by the Working Groups at ITSC-XV. Several technical sub-groups also met during ITSC-XV to discuss developments and plans concerning specific software packages, shared and in common use. Brief reports on these sub-group meetings are provided in section 3.

The conference also paid tribute to Guy Rochard, a recent ITWG Co-Chair who had attended nearly every conference, who died suddenly in November 2005. A special session was dedicated to direct broadcast software, education and frequency protection, the main areas in which Guy was actively involved in his career. In addition during the conference banquet several members of the group recalled Guy's life and his major contributions to the atmospheric sounding community. He will be sadly missed by the ITWG.

## **1.2 SUMMARY OF MAJOR CONCLUSIONS**

The ITSC-XV presentations, posters, Working Group meetings and discussions documented significant issues in many areas and noted areas for future activity. In particular, it noted that:

1. The results of new observing system experiments presented at ITSC-XV demonstrate that satellite data have a large impact on weather forecast accuracy and promising new results suggest the potential for future enhancements in the use of satellite sounder and imager data. It is crucial that future instruments as a baseline maintain, and if cost effective, improve upon, the quality of AMSU and AIRS.
2. Many NWP centres are now assimilating radiances from the advanced infrared sounder, AIRS, and getting significant positive forecast impacts. The use of the warmest field of view, in the AMSU-A footprint, recommended at the last conference has replaced the centre field of view used initially.
3. The AIRS radiances assimilated are still a small fraction of those available but some efforts are underway to allow a more complete use of the AIRS data (e.g. through use of reconstructed radiances).
4. Many NWP centres are ready to assimilate IASI radiances once they become available with the help of NESDIS who have provided a simulated IASI dataset. A channel sub-set of about 300 IASI radiances has been identified for distribution to NWP centres on the GTS.
5. The number of NWP centres using level 1b ATOVS radiances in their variational assimilation systems continues to grow but there are still centres which rely on the level 2 retrievals provided by NESDIS.
6. The Regional ATOVS Retransmission Service, RARS, has been significantly developed since ITSC-XIV. The EUMETSAT EARS service has continued to expand and more NWP centres are using the EARS data. The Asia-Pacific RARS has started operations and NWP centres are already beginning to assimilate ATOVS data from this new data stream. RARS networks in S. America and Africa are being planned. The group encouraged WMO and the space agencies to continue to develop this ATOVS retransmission service as a low cost means of providing more timely ATOVS data over most of the globe.
7. The group also noted the good progress by NOAA to reduce the delay in the NOAA blind orbits for the global dataset by using the Svalbard ground station. This should become operational in early 2007.
8. An important issue for consideration is that when MODIS is retired, according to current plans, there will not be an imager in polar orbit with a channel in the water vapour band. This will degrade the accuracy of any polar satellite derived winds. Space agencies are urged to consider the best means for providing a polar orbiting imager with water vapour channels along with the conventional VIS and IR channels.
9. It was noted that the SSM/I sensor on DMSP-F15 was no longer being used by users due to the beacon interference with the 23GHz channel. A process to clean up the data was presented at the conference which should be made available to the users to allow them to assess if they can start to use data from this satellite again.
10. Considerable progress in the pre-processing of SSMIS data has been made with at least one NWP centre now able to use the sounding channels operationally. Further improvements to the pre-processing were identified during the conference. The group encouraged the SSMIS cal/val team to make the data available from DMSP-F17 as early as possible after the launch to expedite their use in operational systems.

11. A third high spectral resolution sounder workshop was held at Madison, Wisconsin, USA in April 2006 to allow a more detailed discussion of scientific issues related to advanced sounders with many eminent scientists attending. These workshops also educate and train young scientists entering the field.
12. An ITWG workshop on remote sensing and modeling of surface properties was held in Paris, France in June 2006 allowing a focused discussion on this aspect of radiative transfer in order to facilitate more use of the sounder data over land. It is planned to hold another workshop in early 2008.
13. The community software packages (i.e. AAPP and IAPP) for processing locally received ATOVS data have been upgraded to allow data to be processed from MetOp, including IASI. The updates will shortly be available for free distribution to users. This kind of ATOVS processing software has been essential in the use of ATOVS data by the meteorological community.
14. A freely available software package for processing locally received MODIS and AIRS data is being used by many countries for imagery and for Level 2 products. This IMAPP software also adds applications from AMSR-E. Future development of DB packages for MetOp-IASI, NPP and NPOESS are planned.
15. The group urged space agencies to provide documentation on data formats well before launch to allow similar community software packages to be developed for planned new satellites (e.g. FY-3 and NPP).
16. The group noted the increasing threat of RF interference in microwave imager channels as demonstrated by AMSR-E, and all members were urged to lobby their respective radio communication authorities to support protection of the imager and sounder bands.
17. A presentation on the need to foster training on remote sensing measurement systems and products to young scientists was given and the group agreed to enhance its efforts in education and training through a dedicated section of the Web site. A workshop to co-ordinate satellite meteorology training was also proposed along with the possibility of certification of some courses. Satellite provider agencies were encouraged to continue and expand their support for education and training of the next generation of remote sensing scientists.
18. It was recommended that as the NOAA-18 HIRS is not providing good data the HIRS on MetOp should be used with the new 10km field of view to allow comparisons with the 17km field of view on NOAA-17 HIRS to identify the yield of cloud free radiances. This field of view difference should be studied to consider the requirement for the field of view size for future sounders.
19. The group was pleased to note that the Integrated Program Office (IPO) has decided to put NPP into a PM ascending orbit as recommended by the ITWG at ITSC-XIV to provide continuity with Aqua/AIRS. This will help to ensure at least long term atmospheric sounder coverage in 2 orbits.
20. The time series of (A)TOVS now exceeds 27 years and the quality and number of climate products continues to grow. One sign of the importance of climate studies to society, is that there are now efforts emerging to support the routine, operational production of TOVS Climate Data Records at several centers. It was recognized that the fundamental instrument parameters of all the (A)TOVS sensors should be retained for future reprocessing efforts.
21. The group supported the continuing efforts to develop the GCOS Atmospheric Reference Observation Network (GARON) for climate with the primary objective of creating long term records of critical upper air measurements and associated error characteristics to support their continuing integration in climate applications and research.

22. The ITWG recommended that satellite agencies support the new WMO Global Space based Inter-calibration System (GSICS) to improve the accuracy of global satellite observations for weather, climate and environmental applications through an operational inter-calibration of the space component of the World Weather Watch (WWW)'s GOS and GEOSS.
23. The recent NOAA-14 pitch maneuver to investigate the calibration of the radiometers was welcomed as a useful end of life activity and may provide new information on the calibration of the sensors.
24. The group recommended studies to quantify the benefits of dual polarisation channels on conical scanning microwave radiometers for sounding channels which have significant surface contributions to assess if enhanced discrimination of surface effects is possible over the conventional cross-track scanning measurements.
25. It was recognised that high spectral resolution imaging radiometers on geostationary platforms are likely to be an important part of the future global observing system. It was recommended that a demonstration mission be conducted in the near future. GIFTS is the best current option for such a mission.
26. The group was concerned that critical climate monitoring instruments have been removed from NPOESS, specifically the loss of CrIS/ATMS in the 0530 orbit plane, removal of the limb instrument for ozone monitoring, and the Earth Radiation Budget sensors. Removal of CrIS/ATMS in the 0530 orbit seriously affects the monitoring of the diurnal cycle. The removal of ERBS breaks the climate series of a 30 year continuous climate sensor time series.

### **1.3 FUTURE PLANS**

Immediately following the ITSC-XV meeting the process for the election of the new ITWG Co-Chairs began and new Co-Chairs were elected by December 2006. This ensures that following the success of the ITSC-XV meeting in October 2006 the ITWG will continue to meet and inform the ATOVS community of the latest news and developments through its Web site currently maintained by the University of Wisconsin CIMSS and the email list server maintained by WMO.

In particular, more information suitable for education and training will be incorporated onto the Web site. A second workshop on radiative transfer modelling of the surface is planned to take place during 2008. Plans are being formulated for the next International Direct Broadcast Conference (date/time to be confirmed). EUMETSAT and CNES are hosting a workshop on the use of IASI data in Autumn 2007 which will build on the ITWG sponsored advanced sounder workshops. The links with international bodies such as the IRC, WMO and CGMS will be maintained and a report of this meeting will be made to forthcoming IRC and CGMS meetings.

In addition to this ITSC-XV Working Group Report, a Proceedings for ITSC-XV from the papers submitted will be provided to attendees and other interested persons on CD-ROM. The oral and poster presentations from ITSC-XV are already available as pdf files which can be downloaded from the ITWG Web site. The next meeting of the ITWG is planned for Spring 2008. Topics of interest will include extensive evaluation of MetOp data, initial assessment of FY-3 data and status of preparations for the NPP launch.

## **SUMMARY OF ACTIONS AND RECOMMENDATIONS**

### **RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING**

#### **Action RTSP-1**

Marco Matricardi to announce to the RTSP-WG when the new 91 level dataset is available.

#### **Action RTSP-2**

Paul van Delst to ask Yong Han (STAR/JCSDA) to provide COSPAR profile set information to the RTSP-WG Chairs.

#### **Action RTSP-3**

Paul van Delst to inquire on the availability of the IASI balloon instrument ISRF data. This information should become available from CNES (T. Phulpin, <http://smc.cnes.fr/IASI>).

#### **Action RTSP-4**

Tom Kleespies and Paul van Delst will provide most relevant links on RTSP-WG Web page related to MetOp instruments and data as they become available.

#### **Action RTSP-5**

Tom Kleespies will post the AMSU-B RFI information to the group.

#### **Action RTSP-6**

Marco Matricardi will advertise an ECMWF technical memo on LBL model spectral differences when published.

#### **Action RTSP-7**

Paul van Delst will gather information on level-to-layer conversion methodologies (including any units conversion) and software and distribute to RTSP-WG members for consideration. TL and AD modules to be included.

#### **Action RTSP-8**

Yves Rochon and Louis Garand to provide the code of the proposed new vertical interpolator: forward interpolator and mapping of Jacobians from the fast RT layering to the NWP vertical coordinates (TL/AD/Gradient). A link will be put on the RTSP-WG Website to the code (pending approval from Canadian authorities).

#### **Recommendation RTSP-1 to fast RT developers**

Perform relative comparison between models for cloudy calculations. Evaluate the accuracy of cloudy radiance models with respect to speed and complexity (e.g., how many streams are needed). Additionally perform an absolute comparison between models and measured radiances.

#### **Action RTSP-9**

Paul van Delst will distribute information to RTSP-WG members on the availability of optical property databases. More specifically documentation on the optical property databases used within the CRTM will be provided.

#### **Action RTSP-10**

Fuzhong Weng will investigate how to better assess the PC-RTM adjoint performance.

#### **Action RTSP-11**

Paul van Delst and Fuzhong Weng will investigate making the Zeeman model of Yong Han available to ITSC community.

**Recommendation RTSP-2 to fast RT developers**

Non-LTE effects should be included/parameterised in fast RT models. Progress on this issue (from the SARTA, RTTOV, CRTM teams) should be reported before the next conference.

**Recommendation RTSP-3 to NWP centers involved in hyperspectral radiance assimilation**

Document the methodologies used to speed up the hyperspectral radiance assimilation. Post that information on their monitoring Web site which is accessible to other centers. Speed estimates for standard radiance volumes should also be provided in future intercomparisons.

**Recommendation RTSP-4 to fast RT modelers**

Consider upwelling oceanic radiation (water leaving radiance) when designing the next generation of RT models that include the visible part of the spectrum.

**Action RTSP-12**

Ben Ruston to update information on the archival and documentation of sources of emissivity information in the IR and MW on a centralised site (pending NWP-SAF proposal).

**Action RTSP-13**

Ben Ruston to investigate the interest for global comparisons of land skin temperature in both the NWP and retrieval communities.

**Recommendation RTSP-5 to Co-Chairs of the second meeting on surface property modeling**

Plan the Second Workshop on Remote Sensing and Modeling of Surface Properties for the spring of 2008 (avoiding interference with ITSC-XVI). Encourage LSM investigators to attend to discuss requirements for inputs to surface emissivity models. Also encourage experts in radiometric property modeling to attend.

**Action RTSP-14**

Paul van Delst to investigate the feasibility of incorporating the PROSPECT emissivity model in the CRTM.

**Action RTSP-15**

Lihang Zhou to provide link to AIRS Science Team meeting presentations of interest on the subject of emissivity retrieval methodology and validation.

**Action RTSP-16**

Louis Garand to provide a report on surface emissivity definition for radiance assimilation at NWP centers.

**Action RTSP-17**

Louis Garand to investigate the availability of the LMD surface emissivity database at 1 x 1 degree resolution providing high spectral resolution spectra suitable for AIRS and IASI applications.

**Action RTSP-18**

Ben Ruston to provide link to soil type database for emissivity modeling.

**Action RTSP-19**

Banghua Yan to provide information on current JCSDA research and future publications on snow emissivity estimates.

**Action RTSP-20**

Paul van Delst to provide report on comparison of compact OPTRAN and RTTOV gas absorption model in CRTM.

**Action RTSP-21**

Fiona Hilton to provide link to Una O’Keefe’s report on the intercomparison between RTTOV (just cloud absorption) and DOTLRT (Discrete Ordinate Tangent-Linear Radiative Transfer) models.

**Action RTSP-22**

Stefan Buehler to provide information on datasets for cloudy/scattering RT model input.

**Recommendation RTSP-6 to RTTOV and CRTM developers**

Compare RTTOV and CRTM cloudy/scattering calculations in both the IR and MW.

**Action RTSP-23**

Nicole Jacquinet (with colleague R. Armante) to provide links to validation datasets used at LMD for AIRS and IASI and general information on Thorpex, Eaquate and IASI balloon experiments.

**Action RTSP-24**

Fiona Hilton to contact Jon Taylor about access to the Eaquate dataset on the <http://badc.nerc.ac.uk> Web site and report back to the RTSP-WG.

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**TOVS/ATOVS IN CLIMATE**

**Action Climate-1**

ITWG members led by John Bates – to activate the ITWG Climate WG Web site to provide a clearing house for datasets, current activities and plans for climate.

**Action Climate-2**

Links to assessment Web sites and references of climatologies should be added to the ITWG climate Web site (C. Stubenrauch, J. Bates, A. Kaifel).

**Recommendation Climate-1 to Space Agencies**

Space Agencies should ensure archival of all level 0 data along with any metadata for future use by the climate research and monitoring community.

**Recommendation Climate-2 to Space Agencies**

Satellite data archives must ensure the collection, retention, and provide access to complete metadata compatible with international standards (e.g., includes reference, context, provenance, and integrity information).

**Recommendation Climate-3 to agencies**

Communication channels within agencies and the international community relating to operational data reception and processing should incorporate climate requirements within an integrated GOS for NWP and climate. In turn the ITWG climate community must endeavour to tap into the appropriate information streams both locally and internationally to ensure that this happens.

**Action Climate-3**

John Bates to add to ITWG climate group Web page and act as an international focus for the provision of information regarding current and future developments to the satellite component of the GOS, and their implications. In particular to make available information relating to the status of the NPOESS project as and when publicly available.

**Action Climate-4**

The group members are asked to provide available information on future plans of satellite agencies and/or past actions helping in the interpretation of data streams to the Web page (e.g., known useful links

to Web pages or putting the information on a news page). This will need regular updates and monitoring by the group (e.g., adding information on performed satellite changes after the planned event).

**Recommendation Climate-4 to reanalysis groups**

Reanalysis groups should seek to work with the operational satellite climate centres on the optimal calibration and reprocessing of archived data sets. They also should send back to the relative operational centre any metadata obtained during or after the reanalysis.

**Recommendation Climate-5 to WMO**

ITWG strongly supports WMO for the continued efforts to develop GSICS for climate.

**Recommendation Climate-6 to NESDIS**

ITWG strongly supports NESDIS for the continued efforts to develop the GCOS Atmospheric Reference Observation Network (GARON) for climate with the primary objective of creating long term records of same-same critical upper air measurements and associated error characteristics to support their continuing integration in climate applications and research.

**Action Climate-5**

Tony Reale to collect existing data to quantify the impact and requirement for spatial and temporal coincidence of radiosonde, satellite and ground truth in-situ observations to inform GARON network operating principles.

**Action Climate-6**

ITWG to support pending programs to collect coincident satellite and radiosonde observations at ARM sites currently proposed for Aqua-AIRS (SGP, NGA and TWP; Revercomb and Tobin) and ATOVS (SGP; Reale and Lescht). Also to support analysis to quantify the requirement for spatial and temporal coincidence of radiosonde, satellite and ground truth observations in the development of GARON network operating principles. (Revercomb, Tobin, Reale, Lescht).

**Action Climate-7**

ITWG Radiative Transfer WG to provide updated knowledge on instrument characteristics Web links on the ITWG Web site.

**Action Climate-8**

ITWG Climate Group to post any information on satellite data reprocessing and sensor metadata updates on the ITWG Web site.

**Recommendation Climate-7 to reprocessing and reanalysis centres**

Provide reanalysed or reprocessed satellite data together with their metadata to the original satellite agency archiving centre.

**Recommendation Climate-8 to Satellite Agencies and to GCOS**

Ensure frequency continuity of microwave channels so that new instruments can be easily merged with MSU and AMSU data records.

**Recommendation Climate-9 to Satellite Agencies and to GCOS**

Strive for extended satellites overlap periods, for at least three years, by extension of missions beyond their nominal lifetime.

**Recommendation Climate-10 to JAXA**

The GCOM-W (Global Change Observation Mission-Winds) project should be pursued as a successor for AMSR-E data.

**Recommendation Climate-11 from John Bates to IPO through Mitch Goldberg**

The needs of the climate monitoring community for a continuous time series of sensors is to be taken into account in the planning of future satellites. The concerns of the Working Group regarding the IPO plans for NPOESS should be addressed to NOAA.

**Recommendation Climate-12 to IPO**

OMPS limb sounding capabilities should be made available on NPP and NPOESS.

**Recommendation Climate-13 to space agencies**

Future operational missions should carry high precision instruments for monitoring of climate critical gases (e.g., CH<sub>4</sub>, CO and CO<sub>2</sub>) and aerosols.

**Recommendation Climate-14 to satellite instrument providers/space agencies and to GCOS**

Work on inter-calibration and the definition of a (common) reference needs to be coordinated. The climate-user community needs access to all information concerning calibration and inter-calibration of the different sensors, both within a satellite series of a single provider and for the different polar orbiting systems.

**Recommendation Climate-15 to space agencies and to GCOS**

ITWG suggest all space agencies consider spacecraft maneuvers to investigate sensor calibration at some stage in the life of the spacecraft.

**Action Climate-9**

ITWG to thank NESDIS for the NOAA-14 pitch test and suggest this be done at some stage during the lifetime of current platforms (e.g., NOAA-15 to 18).

**Recommendation Climate-16 to EPS NRT users (National Meteorological Services)**

Prepare for the generation of IASI sub-sampled datasets (spectral, spatial, temporal) suitable for the use in climate monitoring studies from the IASI NRT data streams, and generate local archives hosting these subsets for further use.

**Action Climate-10**

ITWG members to circulate NRT planned IASI processing activities for climate (e.g., M. McCarthy for Met Office plans).

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**THE USE OF TOVS/ATOVS IN DATA ASSIMILATION/ NUMERICAL WEATHER PREDICTION (DA/NWP)**

**Recommendation DA/NWP-1 to satellite agencies**

The Working Group feels that the notification of users about significant changes to current and future observation systems has not been sufficient. For example, information concerning the turning on of the RADCAL instrument on the DMSP F-15 satellite was not communicated quickly enough to the users to react. Also the cancellation of the HES instrument was not widely advertised. Early communication of these decisions is necessary for planning and preparation by the NWP community

**Action DA/NWP-1**

All members of the Working Group to examine the mail list for missing e-mail addresses. Steve English to maintain and update the e-mail list.

**Action DA/NWP-2**

NWP WG Co-Chairs to ask developers of software packages (e.g., JCSDA and NWPSAF) to announce new software releases on the ITWG mailing list.

**Action DA/NWP-3 (open from ITSC-XIV)**

Tony McNally to provide information from the ITWG NWP survey on the ITWG NWP group Web pages and if possible to allow updating as operational systems change.

**Action DA/NWP-4**

Walter Wolf to email content and format of MODIS BUFR dataset to ITWG NWP mailing list for comment.

**Action DA/NWP-5**

Walter Wolf to provide AIRS MODIS dataset and MODIS BUFR dataset as soon as possible on NOAA server.

**Action DA/NWP-6**

NWP centres to evaluate both MODIS datasets.

**Recommendation DA/NWP-2 to SSMIS user community**

The WG encourages development and implementation of a single SSMIS data correction and selection method.

**Action DA/NWP-7**

NRL, Met Office and NESDIS to participate in and report the results of unification of operational SSMIS processing, calibration (including corrections applied going from antenna temperatures to brightness temperatures) and distribution by April 2007.

**Action DA/NWP-8**

Nancy Baker to report on DMSP-F17 cal/val and data distribution plans.

**Recommendation DA/NWP-3 to science community (also AS-6)**

The group encourages research into investigating some of the theoretical benefits of a combined microwave imager sounder (for example, it may help with assimilation over difficult emissivity surfaces) relative to the conventional cross-track scanning sounders.

**Recommendation DA/NWP-4 to NWPSAF and JCSDA.**

Continue on going collaboration on RT development and report on progress to ITWG.

**Action DA/NWP-9**

NWP WG Co-Chairs to ask Roger Saunders and Paul van Delst to circulate report to NWP WG mailing list and to present at next ITSC.

**Recommendation DA/NWP-5 to WMO**

Continue to support fast delivery initiatives (e.g., RARS), extending this where possible (e.g., Hawaii). However, the group believes that the system should continue to be low-cost. Extension of RARS towards complete global coverage is encouraged until the point is reached where further improvements are no longer cost effective.

**Action DA/NWP-10**

NWP WG Co-Chairs to bring recommendation DA/NWP-5 to the attention of WMO.

**Recommendation DA/NWP-6 to IPO**

The short operational delivery time of NPOESS data to NWP centres is an extremely attractive component of the system design. The group would like to ensure that this component be retained in the restructuring of the NPOESS program.

**Action DA/NWP-11**

John Derber to ask JCSDA and NESDIS to present recommendation DA/NWP-6 to IPO.

**Recommendation DA/NWP-7 to all satellite agencies**

Operational NWP centres to be part of the early cal/val operation for future missions and to receive near real time data before final quality of the data has been established.

**Action DA/NWP-12**

John Derber and Stephen English to ask ITWG Co-Chairs to ensure recommendation DA/NWP-7 is conveyed to all satellite agencies and operational NWP centres via appropriate international bodies (e.g., CGMS).

**Recommendation DA/NWP-8 to space agencies**

A three orbit system (ideally equally separated) of microwave and IR polar orbiting instruments has been shown to produce positive impact over a two orbit system. The group recommends consideration of a three orbit system containing state of the art microwave and IR sounders in each orbit.

**Action DA/NWP-13**

NWP WG Co-Chairs to pass recommendation DA/NWP-8 to WMO and space agencies.

**Action DA/NWP-14 (open action from ITSC-XIV)**

John LeMarshall to ensure establishment of the NPP non-GTS data distribution policy for countries outside the United States and report to the WG.

**Action DA/NWP-15**

Thomas Auligné and Tony McNally to propose a method for communicating a subset of the monitoring for IASI and set up a system for producing a Web-based display of participating centres results. The proposal will be sent to WG members for suggestions and approval through the NWP WG mailing list.

**Recommendation DA/NWP-9 to satellite agencies and WMO**

The WG encourages research and operational satellite agencies to work together towards developing the next generation of operational satellites.

**Action DA/NWP-16**

NWP WG Co-Chairs to pass recommendation DA/NWP-9 to WMO and space agencies.

**Action DA/NWP-17**

John Derber and Stephen English to ask ITWG Co-Chairs to ensure recommendation DA/NWP-9 is conveyed to all satellite agencies via appropriate international bodies (e.g., CGMS).

**Recommendation DA/NWP-10 to satellite agencies and WMO**

The geostationary orbit is ideal for observing the rapidly changing components of the atmospheric fields. The WG recommends the development of a demonstration system observing with high spectral resolution IR and/or microwave instruments. Ideally if both missions are possible the microwave and IR instruments should observe the same portion of the atmosphere at the same time.

**Action DA/NWP-18**

NWP WG Co-Chairs to pass recommendation DA/NWP-10 to WMO and space agencies.

**Recommendation DA/NWP-11 to satellite agencies and WMO**

Conical microwave imagers have a well established role in NWP which the WG wished to continue. The WG expressed concern that there could be a loss of continuity in microwave imagery in the NPOESS era.

**Action DA/NWP-19**

NWP WG Co-Chairs to pass recommendation DA/NWP-11 to WMO and space agencies.

**Recommendation DA/NWP-12 to satellite agencies and NWP centres**

The WG would like to encourage the development of an international effort directed towards improving the observing system design. The EUCOS (EUMETNET Composite Observing System) is an example. OSSEs are one tool that can be used for the observing system design problem; however, they must be done very carefully to ensure that they are unbiased and properly estimate the impact of new observing systems.

**Action DA/NWP-20**

John Derber will distribute an initial template for OSSE experiments to the WG for comment and enhancement.

**Action DA/NWP-21**

NWP WG to continue to update the NWP WG Web page with assistance of Leanne Avila.

**Action DA/NWP-22**

NWP WG Co-Chairs to review the status of the actions and recommendations in April 2007 and at regular intervals before ITSC-XVI and email a status report to WG members and ITWG Co-Chairs.

**Action DA/NWP-23**

NWP WG Co-Chairs to solicit ideas through NWP WG mailing list for WG topics 1 month prior to ITSC-XVI.

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**ADVANCED SOUNDER WORKING GROUP REPORT**

**Recommendation AS-1 to the space agencies**

It is recognised that high spectral resolution imaging radiometers on geostationary platforms would be an important part of the future global observing system. It is recommended that a demonstration mission be conducted in the near future. GIFTS is the best current option for such a mission.

**Recommendation AS-2 to data users**

The group encourages pre- and post-launch instrument characterisation and traceable calibration. Requirements for the parameters to be characterised and their required accuracy should be communicated from the users (i.e., NWP, RT modellers, climate researchers) to the data providers.

**Recommendation AS-3 to the space agencies**

Cal/Val for advanced sounders needs to be an activity which receives sufficient resources. High-altitude airborne sensors, such as those associated with the NAST and ARIES airborne sensors, and upper air reference networks need to be added to complementary data sources, such as NWP, in order to validate the radiances and derived products to the very high accuracy and precision specified by the users.

**Recommendation AS-4 to EUMETSAT/CNES**

Cal/Val efforts for IASI should focus on establishing the in-orbit performance in order that early lessons can be learned for pre-flight testing of future interferometer sounders.

**Recommendation AS-5 to the science community**

The utility of applying the SNO (Simultaneous Nadir Observation) technique for an equatorial (inclination  $<20^\circ$ ) LEO platform for the purpose of radiometric cross-calibration should be examined. Optimal orbital parameters (attitude and inclination), as well as sensor(s) type, should be determined so that recommendations for possible sensors on future equatorial satellites can be put forward.

**Recommendation AS-6 to the science community (also DA/NWP-3)**

The group encourages research into investigating some of the theoretical benefits of a combined microwave imager sounder (for example it may help with assimilation over difficult emissivity surfaces) relative to the conventional cross-track scanning sounders.

**Recommendation AS-7 to the ITWG (also SSSP-4)**

It is recommended that trade-off studies be performed to determine the optimal field of view size for the CrIS, considering existing detector noise performance and the desire to increase the density of cloud free sounding observations as a result of decreasing the field of view size. As a first step, a comparison of the yield of MetOp-1 HIRS/4 clear air data versus NOAA 17 HIRS/3 data should be conducted.

**Action AS-1 to whoever performs the above study**

Once results are available, this item should be brought before the SOAT and/or JCSDA, to determine if a recommendation to the IPO is justified (i.e., to reduce the CrIS FOV size of 14 km to 10 km or less).

**Recommendation AS-8 to the space agencies**

In order to ensure consistency of objectives and adequacy of the capabilities of various international contributions to the global observing system, it is recommended that space agencies follow the ITWG guidance on desirable radiometric measurement requirements to be met or exceeded for advanced IR sounders to be carried on future polar and geostationary orbiting satellites.

**Recommendation AS-9 to the research community and space agencies**

It is recommended that relevant organizations conduct studies to identify the capabilities of microwave sounders and develop consensus user measurement requirements for future systems. This should be done for LEO as well as GEO. It is recommended that this information be consolidated in a table similar to that presented above for the IR sounder.

**Action AS-2**

Bjorn Lambrigtsen to make a draft table summarising the requirements for microwave sounding systems.

**Recommendation AS-10 to the space Agencies**

The WMO IGEOLAB concept should be supported.

**Recommendation AS-11 to NWP Centres**

It is recognised that more efficient use of the full advanced IR sounder spectrum is desirable within NWP data assimilation. NWP centres are encouraged to consider research into the direct use of principal components and/or retrievals from advanced IR sounders in assimilation systems.

**Recommendation AS-12 to data providers**

It is noted that the use of principal components to represent advanced sounder spectra carries the danger of the loss of signals that are not properly represented in the training set. Care must be taken to ensure that data compression methods used for transmission and archiving of satellite data be lossless.

**Recommendation AS-13 to the space agencies**

Microwave sounders should be considered to always be flown with future advanced IR sounders, to provide simultaneous observations at the same time and at the same location.

**Recommendation AS-14 to the space agencies**

Future high spatial resolution imaging radiometers to be flown with advanced IR sounding instruments should possess lower tropospheric IR sounding channels to support the interpretation and enhance the utilization of advanced IR sounding spectrometer observations obtained for cloudy sky scene conditions.

**Recommendation AS-15 to the space agencies**

ITWG strongly recommends that certain elements of future operational satellite systems (e.g., the data processing, algorithm and product development system, the evaluation and validation, and the training and outreach programmes), should be led by government agencies. It is also recommended that the users of the satellite system play a key role in the definition of the characteristics of this system.

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**INTERNATIONAL ISSUES AND FUTURE SYSTEMS**

**Recommendation II/FS-1 to WMO Space Programme**

The WMO Space Programme with CGMS assistance, should continue to promote the implementation of a globally coordinated system of RARS encouraging the development of the South-American and Asia-Pacific RARS and also ensuring coverage over Africa. To extend the coverage over Africa, Gough and Marion Islands, Pretoria and Reunion HRPT stations should be considered. Honolulu and Tahiti HRPT stations should be considered to enlarge Asia-Pacific RARS coverage over the Western Pacific.

**Action II/FS-1**

WMO Space Programme to enhance user information about RARS through the WMO RARS Web site.

**Recommendation II/FS-2 to HRPT station operators**

RARS stations to upgrade HRPT stations in order to allow IASI data retransmission.

**Recommendation II/FS-3 to space agencies**

Space agencies explore the possibility of flying an upgraded AVHRR-like sensor with a water vapour channel centred near 6.7 microns on future polar satellites in order to ensure the continuity of good quality polar atmospheric motion vectors beyond Terra and Aqua.

**Recommendation II/FS-4 to satellite agencies**

Satellite agencies operating environmental polar satellites to provide or continue to provide a DB capability on their polar environmental satellite systems, and to make available in a timely manner the Direct Broadcast data processing (L0 to L1, and/or L1 to L2) software, documentation, and related training.

**Action II/FS-2**

ITWG Webmaster to expand the ITWG education Web page by linking to the international education program developer's sites and by encouraging these developers to use the ITWG education page as part of their resources and curriculum. Also to use the resources of the ITWG to help disseminate information to the international community about the education opportunities available.

**Recommendation II/FS-5 to ITWG Co-Chairs**

The ITSC-XV Working Group Report Executive Summary should encourage the satellite operators and product developers to financially support a strong education program, both within their region and internationally.

**Action II/FS-3**

ITWG members who are education material developers and providers (P. Antonelli, K. Strabala, EUMETSAT, etc.) to contact WMO Space Programme Department and the other international agencies to pursue the possibility of a certification for education programs.

**Recommendation II/FS-6 to ITWG Co-Chairs**

The ITSC-XV Working Group Report Executive Summary should encourage the organization of a workshop to bring together the scientists who are involved in environmental remote sensing education and outreach programs to present their past and present activities and to co-ordinate future initiatives.

**Recommendation II/FS-7 to NOAA and DOD**

NOAA and DOD consider options to fund reinstatement of sensors removed from NPOESS based on assessment by US and International users.

**Action II/FS-4**

M. Goldberg to NPOESS Joint Agency Requirements Group (JARG) to request the assessment of a microwave imager only solution as replacement for the CMIS, and replace the loss of soundings with ATMS in the 0530 orbit plane.

**Action II/FS-5**

M. Goldberg to IPO to assess cost savings of adding ATMS and/or CrIS in the 05:30 orbit in case of an early failure of either IASI/AMSU (10:00 orbit) or CrIS/ATMS (13:30 orbit). Cost assessment should include savings due to delaying a new launch for a single instrument failure as well as cost benefits for ensuring likelihood of having three sounders in different orbits.

**Recommendation II/FS-8 to IPO and NASA**

Consider including CERES on NPP instead of NPOESS-C1.

**Action II/FS-6**

Pete Wilczynski to provide a schedule (timetable) of availability of data format(s) for NPP/NPOESS real time Low Rate Data (LRD) & High Rate Data (HRD) as soon as practical.

**Recommendation II/FS-9 to all space agencies**

Provide expected formats of level 1b and level 2 datasets at least one year prior to launch. Establish Web sites to provide detailed information on instruments, schedule, products and formats.

**Recommendation II/FS-10 to NWP and Climate Modelling Centres**

Studies should continue to be conducted to assess the impact of corrupt data (exceeding the corresponding radiometric resolution of the passive sensor) showing the level of degradation of the NWP or climate modelling.

**Recommendation II/FS-11 to Space Agencies**

Future passive sensors should be designed to detect potential anomalies, corrupt data or interference in order to report to national Administrations and international organisations in frequency management for further action. As a matter of urgency, the frequency bands which should be considered are the following:

1400-1427 MHz	10.6-10.7 GHz	18.6-18.8 GHz	23.6-24 GHz	31.3-31.5 GHz
36-37 GHz	50.2-50.4 GHz	52.6-54.25 GHz.		

**Action II/FS-7**

Jean Pla to provide a list of existing documents addressing the use of microwave passive bands; and to produce additional documents if necessary on related topics and to contribute to the update or improvement of those existing documents with a view to disseminate corresponding information to administrations and international organizations dealing with frequency management.

**Action II/FS-8**

Jean Pla to update the ITWG Web site dealing with frequency protection (see <http://cimss.ssec.wisc.edu/itwg/groups/frequency/>)

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## **SATELLITE SOUNDER SCIENCE AND PRODUCTS**

### **Action SSSP-1**

L. Lavanant and L. Avila to

- Continue the search and solicitation of inputs for the HRPT area of the SSSP Web site using the existing survey and HRPT site list.
- Set up a tabular format to summarize HRPT sites and available information.
- Set up a mailing list of participating HRPT sites.

### **Action SSSP-2**

L. Lavanant, M. Dumont, D. Griersmith, D. Lee, N. Atkinson to update the existing EARS Web page to include information on the RARS network.

### **Recommendation SSSP-1 to EUMETSAT and NOAA/NESDIS**

A capability to routinely retain and provide retrospective access to selected portions of raw and pre-processed observations from “operational” satellites by operational centres and selected EARS / RARS facilities should be pursued.

### **Action SSSP-3**

SSSP Co-Chairs to develop and forward above recommendation to NOAA and EUMETSAT and EARS / RARS facilitators.

### **Action SSSP-4**

SSSP Co-Chairs to develop a dedicated SSSP Web site area as central location for storing and accessing such observations arising from Recommendation SSSP-1.

### **Action SSSP-5**

SSSP Co-Chairs, H. Bloom, A. Huang, N. Atkinson, D. Chaohua to request information from space agencies on processing packages for direct broadcast data and facilitate the creation of links to the information via the SSSP Web site.

### **Action SSSP-6**

A. Kaifel, P. Schlüssel, N. Atkinson, R. Saunders to

- Determine the current status of planned instrument co-registration onboard MetOp and planned NPP and NPOESS satellites.
- Define requirements for additional instrument co-registration.
- Encourage processing package providers (EUMETSAT, CIMSS) to incorporate available co-registration procedures.
- Provide information and status on SSSP Web site.

### **Recommendation SSSP-2 to CNES and EUMETSAT**

Satellite agencies are requested to provide available status information for MetOp IASI level-1 data, including during the 8-month commissioning phase (CNES) and also for AVHRR, AMSU, MHS, HIRS, ASCAT, GRAS and available level-2 products (EUMETSAT).

### **Recommendation SSSP-3 to NOAA/IPO and NSMC**

Satellite agencies are requested to provide information on the status of preparations for NPP, NPOESS and FY-3 platforms.

### **Action SSSP-7**

SSSP Co-Chairs

- Forward the above recommendations to satellite agencies and provide links to the information on the SSSP Web site.

- Include links to MetOp operational daily monitoring reports of level-1 including ASCAT and GRAS (for example from ECMWF, UKMO, NOAA and Meteo-France) after the commissioning phase.

**Action SSSP-8**

H. Bloom, D. Chaohua, N. Atkinson, A. Huang, SSSP Co-Chairs,

- Report on the strategy of ensuring local/global coherence for IMAPP (Aqua)
- Report on the strategy for NPP, FY-3 and NPOESS local/global coherence through contacts with national agencies and direct readout package developers responsible for software and data output data formats.
- Provide status and the information on the SSSP Web site.

**Action SSSP-9**

Tony Reale, Peter Schlüssel, Thomas King

- Report on the availability of processed data and products from NOAA and EUMETSAT.
- Recommend the agencies coordinate their efforts of data dissemination and validation.
- Advertise how to access MetOp global operational products and to put the information on the SSSP Web site including a tabular summary describing available products, data formats, metadata and software for reading data files.
- Put information on the SSSP Web site on disseminated product validation.

**Action SSSP-10**

Tom Kleespies, Cheng-Zhi Zou, Nigel Atkinson, Roger Saunders

- Identify source information on instrument performance characteristics for HIRS, MSU, SSU, AMSU-A, AMSU-B (including RFI) and MHS (including RFI).
- Provide access to available historical and current (in real-time) SNO data and associated corrections (metadata); and predicted (future) SNO points for selected instruments. (Note: at this time there are historical SNO points and derived inter-satellite adjustments for HIRS and MSU on a CD (perhaps only for MSU). Information on future SNO points and capability to inquire per sounder etc. are likely not routinely available but would be beneficial.)

**Recommendation SSSP-4 to NOAA, CIMSS and EUMETSAT (also AS-7)**

These agencies are encouraged to investigate the impact of the 10 km vs. 17 km field of view with respect to improved cloud detection and cloud clearing.

**Action SSSP-11 to SSSP Co-Chairs**

- Forward Recommendation SSSP-4 to respective NOAA and CIMSS scientists to investigate the impact of the higher resolution (10 km) HIRS on cloud detection and sounding products.
- Forward Recommendation SSSP-4 to EUMETSAT scientists to quantify the impact of higher resolution HIRS with coincident IASI data on MetOp.

**Action SSSP-12**

**Co-Chairs, Walter Wolf, all WG members**

- Investigate and report on opportunities and feasibility of further developing the validation areas.
- Coordinate the expansion of the designated "Validation" topic area of the SSSP Web site to provide an efficient validation tool.

**Action SSSP-13**

**SSSP Co-Chairs, all SSSP WG members**

- Solicit willing SSSP WG members to take the responsibility of selected product areas in the SSSP site.
- Solicit willing SSSP WG members to undertake a review of the overall site layout and specific topic areas and in conjunction with the Co-Chairs and Webmaster to oversee modifications.
- Activate SSSP WG mailing list to facilitate these activities and overall member interaction.