2. WORKING GROUP REPORTS

2.1 RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING

Web site: http://cimss.ssec.wisc.edu/itwg/groups/rtwg/rtwg.html

Working Group members: Louis Garand (Co-Chair), Paul van Delst (Co-Chair), Tom Kleespies, Shawn Turner, Stefan Buehler, Marco Matricardi, Nicole Jacquinet, Lihang Zhou, Banghua Yan, Martin Stengel, Jose Antonio Aravequia, Rodrigo Augusto F. de Souza, Fiona Hilton, Pascal Brunel, Benjamin Ruston, Fuzhong Weng, Adam Dybbroe

The group focused on the issues related to atmospheric radiative transfer (RT) and surface property (SP) models which are relevant for radiance assimilation as well as atmospheric and surface retrievals from infrared and microwave sounder or imager data. At ITSC-XV, the group first reviewed the actions from ITSC-XIV. The main accomplishments related to these actions were:

a) Completion of the AIRS Radiative Transfer inter-comparison with a journal article to appear in JGR.
b) A first workshop on surface property modeling was held in Paris, France (June 2006). Presentations are available from a link posted on the ITWG Web site.
c) A special issue is to appear in the Journal of Atmospheric Science in early 2007 consisting of a series of papers summarizing the progress on the modeling of radiation in cloud/precipitating atmospheres.
d) A new vertical interpolator with good Jacobian mapping characteristics between NWP and RT vertical coordinates has been developed. Code will be made available to the community.
e) Steady progress was reported at ITSC-XV on the development of new RT capabilities within the RTTOV and CRTM fast RT models.
f) A major update of the structure and contents of the RTSP-WG portion of the ITWG Web site. This included detailed information on fast and LBL models, links to surface emissivity databases, spectroscopic databases, instrument characteristics, information on adjoint coding etc.

The new action items listed below are to be completed by April 1, 2007.

2.1.1 Profile datasets

Marco Matricardi reported that a new 91 level dataset, including trace gases, to be used for training RTTOV will be available next year.

Action RTSP-1

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

The COSPAR (Committee on Space Research) dataset with upper level profile data is now available.

Action RTSP-2

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

2.1.2 Instrument characteristics

The IASI balloon instrument SRF information was advertised to the group.

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//smsc.cnes.fr/IASI).

The characteristics of the MetOp suite of instruments was discussed. General and specific information is available from:

http://www.eumetsat.int/Home/Main/What_We_Do/Satellites/EUMETSAT_Polar_System/Space_Segment/index.htm?l=en

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.

The history of the AMSU-B RFI coefficients in the on-line user guide was reviewed.

Action RTSP-5

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

2.1.3 Line by Line (LBL) modeling

There is a need to identify the spectral regions (or channels) where LBL model or spectroscopy differences would be of the greatest concern to fast RT model users.

Action RTSP-6

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

A unique spectral response function shape for all IASI channels can be used. This function will be made available on the RTSP-WG site. This is part of RTSP-4.

2.1.4 Fast RT modeling

The issue of level or layer input to fast RT models was discussed by the group.

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.

Concerning vertical profile interpolator software and its TL and AD, new methodology and software have been developed to solve the "blind level" problem, i.e. using all input levels to generate an output. There was a presentation made at ITSC-XV on this topic. A paper should appear next year in QJRMS.

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 Web site to the code (pending approval from Canadian authorities).

The issue of the accuracy of cloudy radiance modeling was raised. Future inter-comparisons of RT models should involve cloudy atmospheres. Input data for models is not easily obtainable as there are measurements of radiances, but no associated microphysics, or measurements of microphysics but no radiances. Fiona Hilton will survey the http://badc.nerc.ac.uk site to determine what measured cloudy model input data (e.g., particle size, water content) and associated measured radiances are available. Similarly, Ben Ruston will contact the IPWG at NRL to identify the availability of observed cloud microphysical parameters.

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.

Regarding the databases of particle shapes used to derive cloudy optical properties, and the associated software they will be very useful for the recommendation RTSP-1.

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.

For the new Principal Component RTMs the question of how to fairly compare the adjoint of a PC RTM with "traditional" models was discussed. This issue was raised in the Saunders *et al.* (2006) AIRS RT model inter-comparison paper.

Action RTSP-10

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

There is now consensus that the Zeeman effect at microwave frequencies for channels which have weighting functions that peak in the upper stratosphere or mesosphere should be accounted for.

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.

Improving the speed of fast RT models is important. How do we make them faster? Options are the model parameterisation, the code structure, parallelisation issues (OpenMP/MPI), hardware issues, or combinations thereof that could be improved.

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.

It was reported that fast model developers are now considering extending their models to the Visible/Near Infrared part of the spectrum.

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.

2.1.5 Surface property modeling

A discussion on the surface property modeling led to the following actions and recommendations.

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.

Bob Knuteson (SSEC/UW-Madison) and the ARM group have done an intercomparison of global surface emissivity maps retrieved from AIRS and SEVIRI data. They generally agree well but over desert there are disagreements. The RTSP-WG group should have access to these kind of studies.

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.

Information on how NWP centers define surface emissivity for the purpose of radiance assimilation is of interest to this group.

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.

Snow emissivity estimates are not yet accurate. Eric Wood (Princeton) is working on the snow emissivity problem through JCSDA (intercomparison of three models with CRTM code).

Action RTSP-19

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

2.1.6 Model intercomparisons

Action RTSP-20

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

Fast RT cloudy/scattering model comparisons were discussed. There is an NWP-SAF project to compare RTTOV against a reference. Also, details regarding the model inputs for these comparisons still need to be worked out, e.g., conversion of model inputs dominates the error in the comparisons.

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.

2.1.7 Validation datasets

Nicole Jacquinet provided an update on the availability of observational datasets for line-by-line (LBL) model validation. However, there are issues with some of these datasets, e.g.

- Access can be difficult.
- Description of the conditions of observations (e.g., ozone, CO, mixing ratio, clear/cloudy situation) and description of instrumental characteristics (e.g., ISRF, S/N ratio) are sometimes insufficiently documented.
- Atmospheric conditions do not extend to very humid atmospheres to validate the formulation of the continua for example.

More information on upcoming experiments would facilitate communication with campaign PIs to address the above issues where appropriate.

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.**

2.2 TOVS/ATOVS IN CLIMATE

Working Group members: John Bates (Co-Chair), Claudia Stubenrauch (Co-Chair), Mitch Goldberg, Anton Kaifel, Graeme Kelly, Bozena Lapeta, Mark McCarthy, Tony Reale, Masami Sakamoto, Peter Schlüssel, Nathalie Selbach, Cheng-Zhi Zou

2.2.1 Quality of existing climate records

The record length of TOVS/ATOVS now exceeds 27 years and the quality and number of climate products continues to grow. A sign of the success of these efforts, and the commitment to the importance of climate studies to society is that there are now efforts emerging to support the routine, operational production of Climate Data Records (CDRs) at several different centers.
Definitions:

- A CDR is a time series of sufficient length, consistency, and continuity to determine climate variability and change.
- Fundamental CDRs (FCDRs) are sensor data (e.g., calibrated radiances, brightness temperatures, radar backscatter) that have been improved and quality controlled over time, together with the ancillary data used to calibrate them.
- Thematic CDRs (TCDRs) are geophysical variables derived from the FCDRs, specific to various disciplines, and often generated by blending satellite observations, in-situ data, and model output.

The Global Climate Observing system (GCOS) has attempted to define requirements for CDRs by establishing a sub-set of essential climate variables in its report[1] for the ocean, atmosphere, and land. As a result, the ITWG Climate WG report should give a more complete set of references to datasets (including reprocessing), reanalyses, current activities and ongoing plans and assessments, hosted on a Web site.

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.

2.2.1.1 Assessments of climatologies

In the last years many efforts have been undertaken to produce climate records on different variables, like radiation, temperature, precipitation, cloud properties, aerosols and trace gases. Within the framework of IPCC and of GEWEX, assessments have been established to evaluate the quality of these datasets. The GEWEX precipitation assessment will be finalized by the end of 2006. GEWEX surface radiation budget, cloud and aerosol assessments are in progress.

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).

2.2.2 Plans and challenges for climate observations from satellites and relations to operational centers

2.2.2.1 Climate Operational Processing

Detecting climate change, understanding and attributing change to specific climate processes, and projecting climate impacts on the Earth system requires, among other capabilities, a long-term (many decades) consistent and comprehensive observing system. Many climate trends are small and can only be

[1] National Research Council, 2004: Climate Data Records from Environmental Satellites. National Academy Press, Washington, D. C., 150.

distinguished from short-term variability through careful analysis of long time series. Short data records or long gaps in the records can make such detection and analysis much more uncertain and costly. Projecting climate trends and impacts requires a comprehensive suite of measurements ranging from physical variables such as sea surface temperature, wind stress and water vapor to biogeochemical variables such as oceanic chlorophyll and land cover. To confidently detect small climate shifts requires instrument accuracy and stability better than generally required for weather research. While research-driven missions have revealed many of the important science issues, helped define observing requirements, and tested new technology, sustaining these observing systems without gaps is an essential component of understanding, monitoring, and predicting climate variability and change.

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).

2.2.2.2 Relations with operational centers

The satellite component of the Global Observing System (GOS) is an invaluable resource for climate. For the purposes of climate monitoring it is vital to provide strong constraints on the GOS to ensure stability and continuity of methods such that the uncertainty in the long-term data record is smaller than the subtle climate signatures to be detected. Considerable effort has gone into the calibration of historical satellite data for the generation of climate data records, but climate monitoring activities are also strongly dependent upon the near-real time processing of data and future developments to the GOS. Therefore, it is imperative that the GOS reflects the operational requirements of both NWP and climate. The climate user community requires timely information regarding proposed operational changes to satellite programs and data processing, and in turn it must communicate its requirements clearly in response to any such proposals.

A recent example with the end of life of NOAA-14 has made it clear that any future changes to the operational processing should be on the ITWG climate Web site.

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).

2.2.2.3 Reanalysis activities

It is important that the ITWG climate Web site contains details of all reanalysis efforts including documentation of any reprocessing of satellite data used and any problems with these datasets.

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.

2.2.3 Use of ancillary data in climate studies

2.2.3.1 Improved Accuracy and Calibration of Remote Sensing Measurements

In order to achieve improved calibration, the ITWG strongly recommends that satellite agencies support the new WMO Global Space based Inter-calibration System (GSICS) to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space component of the World Weather Watch (WWW)'s GOS and GEOSS. The ITWG recommends research and operational satellite agencies to establish reference measurements in space, as well as on ground and in air that will enable absolute inter-calibration (e.g., a spectrally resolving infrared radiometer). This inter-calibration system would quantitatively relate the radiances from different sensors viewing the same target to allow consistent measurements to be taken over the globe by all elements of the space-based component of the World Weather Watch's Global Observing System. In addition, it would provide the ability to retrospectively re-calibrate archived satellite data using the operational inter-calibration system in order to make satellite data archives worthy for climate studies.

Recommendation Climate-5 to WMO

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

2.2.3.2 In situ networks

Under the auspices of the Atmospheric Observations Panel for Climate (AOPC) Working Group on upper-air reference observations a report has been produced that outlines the scientific justification, principles, and station requirements for a GCOS Atmospheric Reference Observation Network (GARON) for climate. This is the result of two international workshops organised by GCOS and NOAA. Continued work in this area will be led by the AOPC Working Group and incorporate the wider community and WMO in order to implement such a network.

The complexity and magnitude of this undertaking is acknowledged, and the importance of such a program to standardize (normalize) the long-term records of evolving satellite and ground data platforms cannot be overstated. Critical areas include emphasis on the importance of providing observations which are "synchronized" with operational polar satellite overpass, and sufficient protocols to collectively manage the compilation of observations at each globally distributed GARON site.

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).

2.2.4 Requirements for climate observations from satellites

2.2.4.1 Characterization of past instruments

The recent re-analyses from ECMWF and JMA, using radiance assimilation, have identified that many similar instruments on different spacecraft often have very different biases. This is partly due to uncertainties in channel frequency and spectral response. The Climate Working Group stresses the continuing need to update knowledge of the instrument characteristics and make use of satellite nadir cross-calibration and re-analysis radiance bias corrections. There is also a need to keep this information available on the ITWG Web or links from there.

Action Climate-7

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

Various groups are reprocessing and cleaning up various satellite data records and derived products. If possible the datasets together with their metadata should be provided to the original archiving centres.

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.

Major problems identified in MSU and AMSU climate studies were related to uncertainties due to merging data records from different satellites and diurnal cycle effects. Substantial progress has been made in this area by characterisation of inter-satellite biases with the help of cross-calibration of satellite nadir observations (SNO) time series. SNO based inter-calibration algorithms have been developed and result in well-merged and well inter-calibrated MSU level 1b records for climate applications, including trend analyses and data assimilation into reanalyses. Past experience has shown that extended overlaps (up to three years) are beneficial for the cross-calibration. Remaining problems involve the merge of MSU and AMSU time series, the short overlap between subsequent satellite missions (e.g., NOAA-9 and NOAA-10), and diurnal cycle effects in the sun-synchronous time series.

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.

2.2.4.2 Continuation of Current Sensors

Consistent observations from conically scanning microwave radiometers SSM/I and AMSR-E have a critical impact on water cycle analyses and research. A continuation of those missions is very desirable.

Recommendation Climate-10 to JAXA

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

2.2.4.3 Recommendations for future sensors

The current plans for NPOESS and the available sensors onboard the satellite were discussed. The continuous availability of certain sensors/channels being of importance for climate monitoring is critical for the generation of a homogeneous climate data set based on radiances and/or retrieved products. Changes in the frequencies or even missing sensor types onboard future satellites will affect the quality of the retrieved data sets or even result in gaps in time series. The Working Group expressed its concerns on the impact of current plans for the NPOESS satellites on CDRs. A potential change in the configuration of the satellite will strongly affect the ongoing efforts of the climate community to build up a long-term satellite-based climate monitoring dataset.

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.

Instruments measuring ozone, trace gases and aerosols are required to be maintained in space for climate. At present and in the past these types are mostly on research satellites.

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., CH4, CO and CO2) and aerosols.

2.2.4.4 Calibration

The topic of inter-calibration of different satellites has been discussed previously during ITSC-XIV. The inter-calibration of different satellites is of importance for the generation of a homogeneous fundamental climate data record. Work needs to be done on the inter-calibration of different satellite platforms onboard the same satellite series (e.g., the NOAA series). In the light of the planned launch of the first EPS satellite having similar (or partially the same) sensors as the NOAA satellites, it also becomes important for the climate community to get information on the inter-calibration of the two polar-orbiting systems.

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.

The recent pitch manuever of NOAA-14 has provided the climate community with a better description of the MSU antenna pattern. This enables more accurate sensor calibration which is very important to obtain good data for climate studies.

Recommendation Climate-15 to space agencies and to GCOS

ITWG suggest all space agencies consider spacecraft manuever 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).

Climate Studies: IASI data

Hyper-spectral sounding data from the Infrared Atmospheric Sounding Interferometer (IASI) will become operationally available in 2007. IASI will provide well calibrated radiance spectra being well suited for the use in climate monitoring activities. These activities have to be well prepared, preferably before the end of the commissioning phase. One issue will be the huge data volume, of which transfer from the central archive might be a bottleneck for any reprocessing. Therefore, it would be beneficial to generate any climate data records directly from a sub-sample of the near-real-time (NRT) distribution of the IASI data for local storage and further access to such subsets. To facilitate full exploitation of the NRT products for climate studies it is necessary to provide them in a form that is compatible with the needs of climate monitoring.

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).

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

Working Group members: Steve English (Co-Chair) and John Derber(Co-Chair), Sid Boukabara, David Anselmo, Niels Bormann, Denis Blumstein, Nadia Fourrie, Thomas Auligné, Tony McNally, Nancy Baker, Chris Tingwell, Brett Candy, Kozo Okamoto, Roger Randriamampianina, Dezso Devenyi, Godelieve Deblonde, Walter Wolf, Per Dahlgren, Dirceu Herdies

2.3.1 Introduction

There were many substantive presentations at this meeting that indicated very positive results using satellite data from different instruments. The trend towards the use of level 1b sounder and imager radiances has continued with almost all centres now using or preparing to use radiances. OSEs presented at this meeting demonstrate that satellite data has an extremely important impact on weather forecasting and promising new results suggest the potential for future enhancements in the use of satellite sounder and imager data. The microwave and infrared sounding data continues to have a very large impact and it is important that future instruments as a baseline maintain, and if cost effective improve upon, the quality of AMSU and AIRS.

Since the last meeting most operational centres are now assimilating AIRS data, and several of the centres are working intensively on SSMIS data. Substantial effort has been directed towards correcting and/or flagging incorrect SSMIS data resulting from instrument problems. Use of the flagged/corrected SSMIS has given a small positive impact in the Southern Hemisphere and as a result the data has been implemented operationally at the Met Office. However, results in the Northern Hemisphere have not been as good. Further correction/screening of the data appears to be necessary.

Initial radiative transfer experiments including the effects of clouds indicate further progress has been made towards the potential future assimilation of cloudy radiances. These results indicate that radiative transfer models are now sufficiently accurate to begin the development of theoretically sound assimilation systems for clouds and precipitation. While significant progress has been made, the inclusion of clouds and precipitation remains a very difficult data assimilation problem and developments will be ongoing over at least the next 5 years.

At this ITSC meeting, there were several presentations by groups describing their development and enhancement of radiance bias correction schemes. There was an increase in the number of centres using or working towards use of variational bias correction. We believe that much of this development has been spurred by the ECMWF bias correction workshop last year. The group is supportive of the efforts directed towards this important problem.

2.3.2 Evaluation and use of TOVS/ATOVS in Data Assimilation/NWP

The use of satellite data remains very dependent on the monitoring and evaluation procedures for the satellite data. Prior to the use of the data, it is important to diagnose the significant biases between background and radiances which still remain. After implementation, monitoring is necessary to ensure that changes to the data or data assimilation system do not adversely affect the results. Many difficulties have been diagnosed and resolved by monitoring procedures. As more and more centres get involved in radiance data assimilation, better coordination of the monitoring procedures and more documentation, particularly on the bias correction method should be exchanged between the various data assimilation groups. The group continues to encourage the development and documentation of monitoring procedures as part of any centre's analysis procedure and to post monitoring results and documentation on their external Web site.

The group acknowledged the continued excellent support to users of AIRS data. The very detailed information distributed and the response to users when possible anomalies are spotted has been very helpful. The group would like to see support, similar to that provided for AIRS, for other current and future missions.

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

The Working Group noted that a new email list server has been established for exchange of information on ATOVS data quality issues and also discussion of other topics relevant to the NWP WG. The address is itwg_nwp@metoffice.gov.uk and the administrator for the list is Stephen English.

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.

The results of the ITWG survey presented at this meeting and reproduced in the Table 2.3-1 below, indicate that the NWP community still has an operational requirement for NOAA/NESDIS ATOVS data processing from instrument counts to calibrated radiances, preprocessed radiances and through to retrieved products. The group again wished to recognize the effort of Tony McNally (ECMWF) for coordinating the survey and to all centres that responded.

Table 2.3-1. Use of satellite data in operational NWP (ITWG survey of systems at 01/10/06)

Institute	**Retrievals In Global NWP**	**Retrievals in Regional NWP**	**Radiances in Global NWP**	**Radiances in Regional NWP**	**external** **WWW DATA MON**
Australia	NESDIS	NESDIS	YES-PP (1DVAR)	YES-PP (1DVAR)	
Canada (CMC)			YES – 1C (4DVAR)	YES – 1C (3DVAR)	YES (p-w)
ECMWF			YES – 1C (4DVAR)		YES
France			YES – 1C (4DVAR)	YES – 1C (3DVAR)	YES (p-w)
Germany			YES – PP (1DVAR)		YES
Hungary				YES – 1C (3DVAR)	
India	*NESDIS*				
Japan		NESDIS/JMA	YES – 1C (4DVAR)		
Korea			*YES – PP (3DVAR)*		
Spain				*YES – 1C (3DVAR)*	
Sweden				YES – 1C (3DVAR)	YES
UK			YES – 1C (4DVAR)	YES – 1C (4DVAR)	YES
USA (NCEP)			YES – 1C (3D SSI)	YES – 1C (3D GSI)	YES
USA (NRL)	NESDIS	NESDIS	YES – 1C (3DVAR)		YES

Notes
1)In the above table "1C" means that calibrated but unprocessed radiances are used. "PP" means processed radiances from NESDIS are used.

2) There is still a very limited use of tropospheric data (radiances or retrievals) over land and ice. This is true for both microwave and infrared.

3) Where both the use of radiances and retrievals are used this generally means that some part of the retrievals (such as above the model top) are used to improve the usage of the radiances.

4) The responses from each NWP centre have provided much more information than is presented here and will be made available in full to all interested parties (hopefully on the ITWG Web site).

5) Responses in italics represent a carry over from the previous survey since no response was received prior to this meeting.

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.

2.3.3 Evaluation and use of other sounding instruments in NWP

The group agreed NESDIS should be congratulated for the past activity in providing AIRS data and be encouraged to continue with the current activity to provide clear fields of view in thinned data sets available to the operational community. The group discussed options for improved exploitation of AIRS, including new datasets. It was agreed that coordination was necessary in switching from the existing operational dataset to new datasets and that more evaluation of products using MODIS for cloud detection was required. There are two datasets using MODIS data to support use of AIRS:

1. The AIRS-MODIS dataset is an AIRS spatially thinned dataset where MODIS has been used to select the field of view most likely to be cloud-free. Its format is identical to the existing AIRS warmest field of view and AIRS central field of view datasets.
2. The MODIS BUFR dataset has products derived from MODIS on each AIRS field of view e.g., standard deviation of MODIS 11micron brightness temperature.

It was also noted that more work is required on developing and testing methods which aim to allow the full spectral information to be used efficiently.

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.

The group welcomed the on-going effort on correcting SSMIS data streams but noted that at present there are several different versions with different anomaly correction methods. Bill Bell (Met Office) will visit NRL in spring 2007 with a goal of developing a single agreed best processing method.

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.

2.3.4 Forward modelling

The WG welcomed the work towards integrating RTTOV into the CRTM. This will allow good comparisons between the two systems and enhancement of both.

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.

Surface emissivity estimation remains an important problem and the activities in this area at the JCSDA and the NWPSAF are also welcomed.

2.3.5 Observing systems and real time access to data

As the use of satellite data matures, the design of observing systems, availability of data, procedures for introducing new data sources and how the data is delivered continue to be major sources of concern for operational NWP centres. The group recognizes that the inclusion of NWP early on in the preparation for AIRS data was a positive step, and encourages future satellite programs to have similar plans. For the SSMIS data the operational NWP community was not included in the early stages of the evaluation, although a productive level of cooperation was achieved at a later stage of the cal/val process.

It has been an ongoing concern of the group that a significant portion of the observations arrive too late for complete inclusion in the data assimilation systems. The operational centres are under pressure to shorten the delivery times of their forecasts to the users and thus are shortening their cut-off times for data delivery. Also, a significant increase in the use of satellite data in limited area models has been noted. These limited area systems often have shorter time requirements than global systems. Two encouraging advances have been noted. The significant improvement in the expected delivery time for the NPOESS satellites (20-30min) and the creation of the RARS (e.g., EARS, SA-RARS, AP-RARS) system should both allow a significant improvement in the availability of data. The creation of the RARS system has been particularly innovative in providing a low cost system to significantly reduce delivery times of the data. The NWPSAF currently monitors consistency of EARS data compared to NESDIS global 1B data. Similar monitoring will be desirable for the SA-RARS and AP-RARS data.

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.

The use of research satellites in operational NWP centres has been increasing. The group strongly welcomed the inclusion of research satellites in the global observing system as a very positive step forward. The availability of research data (e.g., the high spectral resolution data from AIRS) has allowed the NWP centres to develop techniques to use the data more quickly and allowing the monitoring components of the system to feed back to the instrument scientists. However, the group noted there continues to be development of satellite programs with limited or no real time access to the data.

The managers of new satellites and satellite programs have often been reluctant to allow outside users to access the data until it has been completely proven. However, NWP centres often have access to data, algorithms and monitoring capabilities which are unavailable to the satellite programs. This makes the NWP centres ideal partners in the initial evaluation process and allows them to begin early development of the infrastructure necessary to use the data.

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).

The group welcomed the continuation of the "TOVS" heritage through future missions. The group reaffirmed the statement from past meetings that the positive impact of this data on NWP will be largest if satellite agencies choose complementary overpass times which optimize the data coverage.

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.

The WG discussed data distribution for NPP and MetOp products and welcomed the developments for direct broadcast data for both satellites. Whilst the policy for GTS products is clear, the group needs more information on the policy for distribution of non-GTS products. The international distribution policy for the NPP satellite is currently unspecified.

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.

The WG considered it important that NWP centres have a system which easily allows comparison of monitoring results from various centres. Thomas Auligné has proposed and circulated a monitoring strategy for IASI to various NWP centres. Currently, several centres have agreed to adopt this strategy.

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.

2.3.6 Other data assimilation issues

The geostationary orbit is useful for observing rapidly changing features of the atmosphere. The HES IR sounder has recently been cancelled on the GOES-R platform.

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.

Observing system design is the key to having a well observed atmosphere for use in NWP. Many of the decisions concerning the observing system are often made with little or no scientific evidence. This design information is extremely important for agencies to make cost-effective well thought out decisions.

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.

2.3.7 ITWG NWP WG administration issues

The WG expressed a strong desire to provide a useful Web page under ITWG. The Working Group notes the excellent work of Leanne Avila in the establishment of the Web page.

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.

2.4 ADVANCED SOUNDER WORKING GROUP REPORT

Working Group members: Andrew Collard (Co-Chair), Allen Huang (Co-Chair), Bill Smith (Co-Chair), Paolo Antonelli, Alain Beaulne, Bill Campbell, Dong Chaohua, Zhaohui Cheng, David Crain, Mitch Goldberg, Sylvain Heilliette, Sara Hörnquist, Thomas King, Bjorn Lambrigtsen, Allen Larar, Jun Li, Yann Michel, Ed Pavelin, Eric Péquignot, Nikita Pougatchev, Filomena Romano, Stephen Tjemkes, Alexander Uspensky, Banghua Yan, Lihang Zhou

This Working Group focuses on scientific issues affecting the optimal performance of advanced satellite sounder systems. The Working Group reviews the status of the development of advanced sounder systems and recommends changes regarding to instrument specification, performance, data processing, and utilization. For the purpose of this group, "Advanced Sounders" are defined as instruments that present significant new scientific and technological challenges and which require new methods for data processing and utilization. Thus, Advanced Sounders currently include high spectral/spatial resolution infrared and microwave sounders and active sensors.

2.4.1 Geostationary Advanced Infrared Sounders

The group expressed disappointment in the cancelling of the HES geostationary advanced infrared sounder. It was noted that the operational status of the instrument resulted in extremely conservative estimates of the cost of the ground segment which in turn resulted in the project being much more expensive than a research mission would be. It was also noted that these concerns were specific to the GOES-R project and should not be interpreted as pertinent to the development of the advanced IR sounder on MTG and FY-4. It was agreed that a research mission is required to demonstrate the utility of a geostationary advanced infrared sounder and that the existing GIFTS instrument would be a good candidate to be flown in the near future.

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.

2.4.2 Calibration and Validation of Advanced Sounder Data

The need for sufficient characterisation, calibration and validation of advanced sounder observations was recognised by the group. The importance of having a traceable calibration was emphasised, both for pre- and post-launch phases. The requirements for the parameters that need to be calibrated need to be communicated from the data users to the data providers.

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.

The group noted that a variety of differing and complementary data sources are required for full validation of advanced sounders. The identification and correction of contamination in the SSMIS radiances based on NWP comparisons and a detailed knowledge of the spacecraft's orientation while in orbit was noted. Direct comparison with high-spectral resolution observations from aircraft under-flights of satellites provide valuable validation of absolute radiances, instrument line shapes, and derived products. Space agencies should provide adequate resources to allow full synergistic calibration activities.

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.

The validation of the calibration and impressive stability of AIRS instrument was noted. Cal/Val efforts for IASI should similarly concentrate on establishing the in-flight performance of the instrument to a similar degree of accuracy.

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.

A high accuracy spectrometer, in a low inclination orbit (i.e. $<20^{o}$) would have the ability to cross-calibrate all polar orbiting satellites several times per day as well as geostationary satellites in different longitudinal sectors. These cross-calibrated radiances would be useful in the determination of biases between different satellite platforms and applying single station *in-situ* calibration to the entire constellation of satellites by linking cross-calibrated radiances with high temporal frequency. This may complement the existing and planned *in-situ* calibration campaigns for many separate satellites if the radiances from several satellites can be cross-calibrated with a single 'standard' satellite.

Recommendation AS-5 to the science community

The utility of applying the SNO (Simultaneous Nadir Observation) technique for an equatorial (inclination $<20^{o}$ degrees) 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.

2.4.3 Research on the benefits of dual polarisation on microwave conical scanners

The group noted the potential benefits of dual polarisation in the surface sounding channels of SSMIS. The use of these data should be investigated and the conclusions be considered when designing future microwave sounder systems. This led to a recommendation also picked up by the DA/NWP group.

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.

2.4.4 Sounder Field-of-View issue

At ITSC-XIV, considerable discussion was held discussing the impact of the spatial resolution for the CrIS instrument being poorer than that of the current HIRS/4. It was pointed out that there was never an intent to make the CrIS horizontal resolution poorer than the existing HIRS horizontal resolution (i.e., 10 km). Previously, it was recommended that the sounding yield and accuracy of the HIRS/4 be compared with that achieved with the lower spatial resolution (17 km) HIRS/3 instrument. This task was not completed because of optical element motion induced noise on the NOAA-18 HIRS/4. It was suggested that the HIRS/4 on MetOp-1 could be used instead and this change was made to the recommendation. An action was added, requiring the results of any study to be brought before the SOAT (the IPO Sounder Operational Algorithm Team). A related recommendation (SSSP-4) and action (SSSP-11) is made in the SSSP report (section 2.6).

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).

2.4.5 Objectives and Desirable System Requirements of Advanced IR Sounders

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

2.4.5.1 Advanced IR Sounder Primary Objectives

Polar Satellite Sounding Observations: The primary measurement objective for polar satellite sounding radiance observations is to infer temperature and water vapour profiles for Numerical Weather Prediction model initialization. The radiance spectra, or the retrieved profile data, to be assimilated need not be spatially contiguous for this and simultaneous microwave observations are generally available to assist in the interpretation of cloudy hyperspectral IR sounding data.

Geostationary Satellite Sounding Observations: The primary measurement objective of geostationary satellite sounding is the observation of lower and upper tropospheric temperature and water vapour dynamics, as needed to enable the nowcasting (i.e., short-term forecasting) of hazardous weather, and the production of water vapour tracer tropospheric wind profiles, used for regional and global NWP. Spatially contiguous, above cloud, sounding observations are needed to observe the atmospheric processes associated with storm systems and for tracing cloud and altitude resolved water vapour motion winds used for NWP.

Table 2.4-1 Measurement Thresholds for Future Advanced IR Sounders

			Polar		Geostationary			
Channel cm-1	**δν cm-1**	**Purpose**	***P***	**δS[1] km**	**P**	**δt[2] min**	**δS[3] km**	**Remarks**
660-680	0.6	Strat. Temp.	1	100	-	-	-	Polar satellite only
680-800	0.6	Trop. Temp	1	15	1	30	5	Fundamental Band[4]
800-1000	0.6	T_s, H_2O, Cld	1	15	1	15	5	Fundamental Band[5] Cls, Sfc. T/Emis. & H_2O
1000-1100	0.6	O_3	1	15	3	30	5	O_3, Stratospheric Wind
1100-1590	1.2	T_s, H_2O, Aerosol/Dust	1,2	15	2,1	15	5	Water Vapor Flux Trop. Wind Profiles[6]
1590-2000	1.2	H_2O, T_s, Cld	2,1	15	1,2	15	5	Water Vapor Flux Trop. Wind Profiles[6]
2000-2200	0.6	CO, T_s, Cld	3	15	2	60	5	Trace Gas/Air Quality
2200-2250	2.5	Trop. Temp	2	15	2	15	5	Clear Ocean Day and Land/Ocean Night Utility[8]
2250-2390	2.5	Strat. Temp.	4	100	-	-	-	Night-time Utility[8]
2386-2400	2.5[9]	Trop. Temp	4	15	-	-	-	Night-time Utility[8]
2400-2700	2.5[10]	T_s, Cloud	3	15	-	-	-	Clear Ocean & Night Land Utility[8]

Table definitions: δn (spectral resolution, unapodized for the case of an FTS, assuming an instrument self apodization of less than 5%), P (priority), δt (refresh rate), δS (footprint linear resolution). The values given

are the threshold requirements with objectives being better by as much as practical from a technology and cost point of view. Priority 1 measurements are required to fulfill advanced sounding primary objectives.

[1] For cloud clearing, the highest spatial resolution is desired.
[2] Refresh rate for regional (3000 km x 3000 km) area coverage at full spectral resolution as desired for convective storm applications of the data (i.e., thermodynamic stability and water vapor flux measurement). Broader area coverage (e.g., 9000 km x 9000 km), with 30 to 60 minute refresh rates, is desired for temperature, moisture, and wind profile measurements for NWP applications, but these can be performed at lower spectral resolution (e.g., 2 x $\delta\nu$).
[3] Spatial contiguity is required to observe atmospheric dynamical processes.
[4] This band is fundamental for day/night high vertical resolution temperature profiles required for determining atmospheric constituent profile and cloud parameters from hyperspectral radiance emission measurements.
[5] High spectral resolution is needed to resolve on-line/off-line radiance determinations of surface reflectance/emissivity and to separate water vapor/cloud/dust contributions.
[6] High spectral resolution provides shortwave window observations, near the edges of these bands, as needed for cloud clearing. Either longwave (1100-1590 cm^{-1}) or shortwave (i.e., 1590-2000 cm^{-1}) sides of water vapor band can be priority 1. Having measurements covering both longwave and shortwave sides of the water vapor band will optimize the water vapor profile accuracy throughout the atmospheric column. Thus, if one side is chosen as Priority 1 then the other side becomes a Priority 2.
[7] Spectral resolution resolves CO lines and provides shortwave window observations near 2000 cm^{-1} desired for cloud clearing, surface temperature, and cloud property estimation.
[8] Reflected sunlight complicates the daytime utility of these data for cloudy sky and/or land surface conditions.
[9] A spectral resolution of 0.05 cm^{-1} is desired to resolve the contribution from in-between the absorption lines.
[10] The AIRS 2616 cm^{-1} channel, with 2.5 cm^{-1} resolution, has been found useful for cloud detection and sea surface temperature measurement.

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.

2.4.6 New Initiatives for Geostationary Sounding

At ITSC-XIV, it was recommended that studies be conducted to identify the requirements for future microwave sounders, both for polar and geostationary orbits. These studies are still required.

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.

2.4.7 International Geostationary Laboratory

The IGEOLab initiative to promote international cooperation to place and test advanced sounders (e.g., GIFTS and MW) in geostationary orbit was also noted. This initiative should be supported.

Recommendation AS-10 to the space Agencies

The WMO IGEOLAB concept should be supported.

2.4.8 Distribution and Optimal Use of Advanced Sounder Radiance Data in NWP

The current use of advanced sounder data in NWP is very conservative. The limitations are the cost of radiative transfer modelling and the transfer of large observation datasets from the satellite agencies to the NWP centres. Full use of these data requires the efficient use of all the information in a compressed form. Candidates include Principle Component (PC), reconstructed radiances, and retrievals. Investigations with reconstructed radiances are in progress, as they are most similar to the data already being assimilated. It was recognised that the use of principal components and retrievals would present much larger scientific and technical challenges to the NWP community. In choosing the optimal strategy to use, consideration must be given to the specification of the observation error covariance matrix, quality control, cloud detection and monitoring.

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.

It was noted that the use of principal components to compress advanced sounder data is fundamentally a lossy technique. For many applications the small amount of lost data may be acceptable, but it can be problematic when the principal components have been generated in such a way that the desired signals are not present. For this reason, care must be taken that for general archiving and transmission of data, the compression scheme should be lossless. Datasets with lossy compression can be distributed if they are identified as such.

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.

2.4.9 MW Sounder Deployment with Future IR Sounders

It is desirable to fly microwave sounders with future IR sounders configured in such a way as to enable simultaneous observations (i.e., collocated in space and time). Cloud-clearing will be enhanced and sub-cloud level information will be provided for spatial and temporal continuity. Such MW observations are desired to be obtained together with the observations from future advanced IR sounders.

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.

2.4.10 Imagers with Sounding Channels to Support Future IR Sounders

High spatial resolution imaging radiometers which possess one, or more, lower tropospheric IR sounding channels (e.g., MODIS) provide valuable data for cloud-clearing and for the quality control of cloud-cleared radiances from advanced IR sounding instruments. Furthermore, for the case of complex partly cloudy

scenes, where cloud clearing is unsuccessful, the imager sounding channel radiances provide valuable information for filling gaps in advanced sounder information otherwise lost below clouds. It is desirable that imaging radiometers fly with future IR sounders and that they possess sounding channels in addition to their "window" channels.

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.

2.4.11 Move to Single Contractor's Responsibility for Satellite Sounder Systems

Historically, environmental satellite systems have been developed by a partnership of government (NASA, NOAA, and EUMESAT, for example), industry and university science communities. While the technological expertise of industry is a key part of the entire system, industry is not well suited to supplying the broad perspective on the use of these future systems nor is it well suited to developing the necessary pre-launch simulations, ground data processing science algorithms, and associated data application approaches. The ITWG believes that the single contractor approach adopted by the NPOESS program, and is currently considered by NOAA for the development of the GOES-R system and any other future operational satellite systems, would tilt the resource balance so that it would undermine the ability of government to provide continuity into the future and would place much of the science community under the financial control of industry, inhibiting the science community from acting as an objective, commercially neutral, body in the development and application of future satellite systems.

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.

2.5 INTERNATIONAL ISSUES AND FUTURE SYSTEMS

Working Group members: Mitch Goldberg (Chair), Tom Achtor, Roger Saunders, Anthony Rea, Jian Liu, Marie Dumont, Kathy Strabala, Hal Bloom, Thierry Phulpin, Peter Wilczynski, Carmine Serio, Paolo Antonelli, Jean Pla

2.5.1 Regional ATOVS Retransmission Service

The Working Group noted the considerable progress made with the Regional ATOVS Retransmission Service (RARS) since the last conference. The Asia-Pacific RARS is now putting ATOVS data from Australia, Japan, China, and Korea on to the GTS providing more timely data to the NWP centres. At least one NWP centre is already assimilating ATOVS from this new source and several others are preparing to do so. The South American RARS is being set up with data becoming available in 2007. Contacts have been made with African stations to set up an African RARS but commitments need to be clarified. The group also noted the need to possibly upgrade HRPT stations to receive the MetOp IASI broadcast.

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.

2.5.2 Addition of water vapour channel to polar imager

As noted at ITSC-XIV the lack of a water vapour channel on VIIRS will seriously affect the height assignment of the polar atmospheric motion vectors (AMVs) that have been shown to be an important data source for NWP forecasts. Recognizing the high costs of modifying the VIIRS, the group considered the possibility of proposing an AVHRR-like sensor with a water vapour channel to fly on future satellites.

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.

2.5.3 Direct Broadcast

The success of environmental satellite direct broadcast (DB) has enabled users worldwide to acquire and process data for their region in real time. These DB software packages allow users to decode the raw data signal to calibrated, navigated radiances (Level 1B), and in many cases to create various products (Level 2) for environmental monitoring/evaluation, resources management/planning and weather/hazard forecasting. DB software developed through the ITWG include the ITPP for TOVS, and AAPP/IAPP for ATOVS. NASA has funded the IMAPP software package for the EOS program, including training workshops to educate users of the data and software. There are ongoing plans to support DB capabilities for MetOp IASI (AAPPv6), NPP/NPOESS (IPOPP creation) and FY-3. The Working Group also noted the success of the

Benevento, Italy, DB conference and encouraged the agencies to continue to support these valuable meetings.

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.

2.5.4 International Education Programs

There are several agencies and university groups that have developed international education programs in remote sensing and applications of environmental satellite data. Examples include the Virtual Laboratory, EUMETSAT and the University of Wisconsin-Madison CIMSS. To make potential users more aware of the opportunities and to enable coordination between education material developers, it was felt that the ITWG should assist as follows:

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.

The group discussed the importance of these education programs in training the next generation of scientists emphasizing the need for creating opportunities for students in developing countries. Also, the need for follow up to the training courses is very important to continue to engage the young scientists.

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.

The group also discussed the possibility of obtaining certification for their workshops or course materials from key agencies (e.g., WMO, NASA, NOAA, EUMETSAT). Such certification may help to secure funding for further development and presentation of course materials. This certification may also help to enable students to participate in these programs and receive credit from their agencies or universities.

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.

The group discussed the benefits of gathering together, for an international workshop, the scientists who are involved in education and outreach. The possibility of sharing information and experiences is a crucial first step to optimize the educational effort at an international level.

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.

2.5.5 NPOESS

The group is concerned that because of the recent descoping of the NPOESS payload, critical climate monitoring instruments have been removed. Specifically we are concerned that the loss of CrIS/ATMS in the 0530 orbit plane, removal of the limb instrument for ozone monitoring, and the Earth Radiation Budget sensor on future NPOESS orbits. Removal of CrIS/ATMS in the 0530 orbit seriously affects the diurnal cycle of the vertical temperature and moisture and affects climate monitoring. Removal of the ozone limb sensor degrades the resolution of the ozone profile, and the removal of ERBS from NPOESS breaks the climate series of a 30 year continuous climate sensor time series.

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.

Results presented at ITSC-XV have shown that the use of conical MW radiances in NWP models have positive impacts that are similar but not better than cross-track MW instruments. Based on this information conical sounding on a CMIS like instrument are not essential and can complicate the overall sensor design in terms of the overall cost and technical complexity. The existing NPOESS CrIMSS suite, the MetOp IASI/AMSU/MHS, and an additional early morning ATMS will provide the required sounding coverage that currently exists.

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.

NWP impact studies have shown the importance of two sounders in different orbital planes and still additional impacts from sounders in a third orbit. Since new satellite systems have fewer satellites with longer life, the impact of a failure is greatly reduced with a full complement of sounders (IR & MW) in three orbital planes. Launch of a new NPOESS satellite due to a loss of a single critical instrument (e.g., CrIS) can be delayed if a back-up exists in the 05:30 orbit.

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.

There is a risk of a gap in the CERES long-term record. This is a very important Earth Radiation Budget (ERB) dataset of climate quality.

Recommendation II/FS-8 to IPO and NASA

Consider including CERES on NPP instead of NPOESS-C1.

Documentation and distribution of NPOESS product formats well before launch is critical for both users and data reception equipment manufacturers in order to prepare or the new data. Without early delivery, a substantial delay will occur in the utilization of these high quality advanced observations and products.

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.

2.5.6 Other International Satellite Systems

Early access to data formats of other international satellite systems is critical for user readiness.

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.

2.5.7 Frequency Protection

The International Telecommunication Union, Radiocommunication sector (ITU-R) plays a vital role in the management of the radio-frequency spectrum and satellite orbits. These frequencies are finite natural resources which are increasingly in demand from a large number of services such as fixed, mobile, broadcasting, amateur, space research, meteorology, global positioning systems, environmental monitoring and communication services. ITU-R has allocated frequency bands to the passive Earth Exploration Satellite Service, EESS, for the purpose of sounding the atmosphere and surface.

The frequency bands listed in Radio Regulation (RR) N° 5.340 are unique natural resources that need to be fully protected and therefore all emissions in these bands are prohibited. Any limitation of the operation of passive sensors conducted in the satellite passive bands, especially those covered by article N° 5.340 ("All emissions are prohibited") would degrade the sensitivity of those sensors.

Experience has shown that some non exclusive EESS (passive) bands shared with other non passive services are facing high interference levels from the emissions of systems of active services in some parts of the world. Unwanted emissions from active services operating in adjacent bands may cause unacceptable interference to the EESS (passive) bands. Existing ITU-R recommendations provide performance and interference criteria for satellite passive remote sensing giving radiometric resolution and maximum interference levels. These are used in all sharing analyses with other services. Any degradation of radiometric resolution will disrupt numerical weather prediction (NWP) forecasts and climate models.

Generally the impact of radio frequency interference, RFI, within satellite passive bands is not precisely known, especially within ITU-R. In the frequency bands detailed in Recommendation II/FS-11, the question is: if the RFI is such that the interference thresholds are exceeded, what are the consequences in terms of reliability of the weather forecasting, climatology and monitoring of the environment? What happens if, for example, some EESS satellite pixels are corrupted due to non-natural emissions at 24 or 50 GHz?

The impact of potential interdependencies of interference in various passive bands is a complex issue that has not been studied thoroughly in the ITU–R including if the extent of interference in one band has any impact on measurements in another band.

Another issue is the impact of missing data, due to high levels of interference. As the data are known to be bad over the same area of the globe, they are systematically deleted from the dataset to be used.

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.

There are a number of documents addressing the usage of the microwave frequency passive bands, their scientific interest, the retrieved parameters and the technical characteristics of the corresponding passive

radiometers. These documents are available from the International Telecommunication Union, radiocommunication sector (ITU-R), WMO and other organizations. The ITU-R has adopted recommendations providing performance and interference criteria for satellite passive remote sensing (i.e., radiometric resolution and maximum interference level).

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/**)**

2.6 SATELLITE SOUNDER SCIENCE AND PRODUCTS

Web site: http://cimss.ssec.wisc.edu/itwg/groups/sssp

Working Group members: Tony Reale (Co-Chair), Lydie Lavanant (Co-Chair), Tom Achtor, Nigel Atkinson, Leanne Avila, Sid Boukabara, Dong Chaohua, Izabela Dyras, Marie Dumont, Anton Kaifel, Thomas King, Bozena Lapeta, Thierry Phulpin, Nikita Pougatchev, Elisabetta Ricciardelli, Filomena Romano, Devendra Singh, Roger Saunders, Peter Schlüssel, Rodrigo de Souza, Fuzhong Weng, Walter Wolf, Lihang Zhou, Alexander Uspensky

2.6.1 Introduction

The Working Group on Satellite Sounder Science and Products (SSSP) was formed to identify and promote international activities in the science of derived meteorological products from environmental satellite measurements. The learning environments associated with such work, both operational and research, on global, regional and local (direct readout) scales, are fundamental to improving our understanding and utility of such data in weather forecast and climate applications. They encompass a wide variety of activity, for example, the multiple parameters (temperature, moisture, precipitation, clouds, gases, etc.) produced, the different stages of scientific development and applications, and numerous opportunities for cross validation and analysis. The main goal of SSSP is to facilitate access and dissemination of this information mainly through our Web site: http://cimss.ssec.edu/itwg/sssp

The following report summarizes the topics of discussion, recommendations and action from the SSSP Working Group meetings held at ITSC-XV.

2.6.2 Information on HRPT sites

A directory of HRPT facilities that are actively receiving, ingesting, processing and archiving polar satellite data was set up on the SSSP Web site. This was recognized as a useful tool to promote interaction among ground stations and within ITWG-SSSP activities. HRPT sites are searched and solicited (see HRPT survey on Web site) and feedback and updated information received from several sites. Most recently, responses from a number of Russian sites (universities, research institutes…) and from the Chinese national meteorological institute have been collected.

A revision of the HRPT topic area format will be made to provide tabular listings of the subsets of identified sites and associated inputs received, including the satellites, instrument data, processing packages, associated measurements and products, validation, distribution and site links.

It was also agreed to set up an HRPT mailing list to facilitate the circulation of information between SSSP and HRPT sites and among HRPT sites.

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.**

2.6.3 HRPT network (EARS, RARS) information

The SSSP Web site includes information on the EARS (EUMETSAT ATOVS Retransmission Service) HRPT network. Since the last update, more HRPT sites (Lannion, Gilmore Creek…) and data retransmission (AVHRR…) capabilities have been added to the service. In parallel, the Asia-Pacific RARS (Regional ATOVS Retransmission Service) for the South Hemisphere is under development. The goal is improved access to real-time (polar) satellite observations on a regional and global scale.

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.

2.6.4 Access to HRPT raw data and processing packages for direct broadcast data

The capability to routinely obtain a limited sample (selected orbit or orbit segment) of raw (1a and 1b formats) and pre-processed (1c and 1d formats) observations as available from operational centres (NESDIS, EUMETSAT) and HRPT sites (EARS, RARS) in either 1a, 1b, 1c or 1d would be a valuable contribution for training exercises. Observations of immediate interest would include HIRS, AMSU-A and AMSU-B (also MHS), followed by AVHRR and IASI.

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.

2.6.5 Information on processing packages for direct broadcast data

Software packages to ingest and process HRPT data from existing and planned satellites are needed by the user community to create navigated, calibrated datasets. The current AAPP software allows for the processing of locally received MetOp observations up to level-1d for IASI, HIRS, AMSU and MHS and up to level-1b for AVHRR. The International MODIS/AIRS Processing Package (IMAPP) provides ground stations the capability to ingest direct broadcast data from Aqua and produce calibrated and geo-located AIRS/AMSU/HSB radiances (and selected AIRS level-2 products).

Current plans for introducing CrIS and VIIRS (from planned NPP satellites) into AAPP need to be clarified. Plans to make local processing systems from the Chinese FY-3 satellites available to the user community also needs to be clarified. Updated information as available shall be appended to the SSSP Web site.

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.

2.6.6 Instruments co-registration procedures

Procedures for co-registering the GOME and AVHRR observations with IASI data on MetOp need to be developed and made available, either inside the AAPP package (as it is done for AVHRR to HIRS) or through an independent route.

The status of planned co-registration procedures for instruments onboard future NPP and NPOESS satellites also needs to be clarified.

Action SSSP-6

A. Kaifel, P. Schlussel, 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.**

2.6.7 Current and future instrument status

The SSSP Web site currently provides operational polar satellite instrument health status for the suite of NOAA and EOS AIRS instruments via 'Satellite Health Status' and 'Level-1 Instrument Monitoring Reports' areas of the SSSP Web site. Similar information is needed for all the MetOp instruments and in particular during the planned 8-month Cal/Val commissioning phase for IASI.

Similarly, access to information on the status of preparations for near term future satellites, for example NPP, FY-3 and NPOESS is also needed to facilitate timely planning for the processing of these data.

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.**

2.6.8 Consistency between local and global packages

The coherence between local and global processing packages with respect to the scientific algorithms and output data formats is important to facilitate their simultaneous assimilation into NWP and Climate models. This has been taken into account, for example, in the development of MetOp operational and AAPP processing software for ATOVS and IASI pre-processing through level-1c data which include format interface routines (in AAPP) to convert data from the core ground segment (CGS) to AAPP formats. Similar efforts should be considered in conjunction with IMAPP (for MODIS, AMSU, AIRS) and for planned NPP, FY-3 and NPOESS processing systems.

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.**

2.6.9 ATOVS and IASI global data products from MetOp

Access to operational global MetOp data, initially for ATOVS and later for ATOVS + IASI observations, in near-real time and retrospectively, is processed by the respective operational satellite agencies (EUMETSAT and NOAA). This includes all stages of product generation for products such as atmospheric profiles, surface and cloud parameters, precipitation and trace gas concentrations. Consistent validation and comparison of the processed data and product combinations from the respective agencies should be coordinated and made available to international users and researchers (e.g., via 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.**

2.6.10 TOVS and ATOVS instrument performance

There is a need for climate activities for the recovery and documentation of available metadata records with respect to TOVS/ATOVS instruments concerning, spectral response, antenna pattern, format (i.e., 1b-level) changes, calibration corrections and systematic calibrated measurement bias, metadata. This was also noted under section 2.2.4.1 in the Climate WG.

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.)

2.6.11 Impact of HIRS sounder fov size

The ITWG was a strong proponent of decreasing the field of view of HIRS from 17 km to 10 km, which was achieved for the HIRS-4 sounder on-board NOAA-18. The scientific impact of this change on cloud detection (and also cloud and sounding products) needs to be demonstrated. Agencies such as NOAA and CIMSS that are routinely involved in the processing and validation of scientific products from operational polar satellites provide a suitable environment for such investigations.

Unfortunately, the unstable operation of the HIRS onboard NOAA-18 prevented any meaningful evaluation using this satellite. However, the 10 km resolution HIRS from MetOp can be used to measure impact with the potential for more meaningful results given the availability of concurrent HIRS and hyper-spectral infra-red data from IASI. Unfortunately, direct comparison against the lower resolution (17 km) HIRS onboard NOAA-15 and 16 are also undermined by the relatively unstable operation of HIRS on those satellites; NOAA-17 has a stable HIRS but no AMSU-A which undermines cloud detection. The Advanced Sounder WG also discussed this issue in relation to recommendations for the CrIS field of view size (see recommendation AS-7).

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.**

2.6.12 Access to validation datasets

A number of available, pending and new ideas to support user requirements for data validation were identified as candidates for inclusion in the data validation topic area of the SSSP Web site.

It was generally agreed that routine access to currently available validation datasets of collocated radiosonde, operational polar satellite and numerical weather prediction soundings as compiled by operational agencies, for example NOAA, CIMSS and EUMETSAT, would provide users with important information to validate and tune their respective scientific algorithms and applications which utilize these observations.

The SSSP Web site recently deployed a utility (see Cal /Val area) which allows users to interrogate individual collocations of such observations over an approximately one week period, in conjunction with the NOAA polar satellite operation. Procedures to routinely update these datasets and improve the user access are planned.

Validation systems to compile longer-term and expanded multi-platform validation datasets, including observations from Aqua, GOES and emerging COSMIC observations are either available or in the planning stages at NOAA.

SSSP WG discussions also led to a validation strategy, designed mainly for HRPT users, to designate a number of global target areas (mainly in the vicinity of WMO and research data facilities such as ARM and BSRN and national observatories) for which useful data describing the surface information, cloud classification (including cloud nephanalyses), ambient weather (temperature, moisture, precipitation) could be routinely collected in addition to the more routinely available satellite data and products (from global centres and EARS / RARS). Such datasets would be limited to a rolling (i.e. 30-day) period and also archived to facilitate retrospective analysis later.

Numerous cross validation datasets comparing specific products for existing (and past) operational and research satellite and ground sensors also exist across the operational and research community landscape (e.g., Vonder Haar and Forsythe comparisons of NVAP versus AIRS and ATOVS for TPW). Coordination is needed to identify suitable studies which can be accessed as a source of ongoing and / or historical validation information for users.

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.**

2.6.13 SSSP product inputs and site review

Information on scientific products as reported on the SSSP Web site have not increased much over the past two years and in some cases the existing sites no longer exist or have not been updated for several years. A letter soliciting new inputs was forwarded prior to ITSC-XV, requesting inputs from participants who have not yet registered their work, with minimal response. It was recognized during the Working Group meeting that perhaps a better way to increase product inputs would be for willing WG members to search the internet within their domain of expertise and verify that the information on the site is updated (verify / update existing links) and actively pursue new contributions.

The need for SSSP Web site review was also discussed and it was similarly recognized that a review of the site might again be more efficient if willing WG members can verify in their domain of competence that the specific topic areas of the site are efficiently structured and cohesive within the overall site structure.

Finally, it was agreed that the circulation of information between members would be facilitated through a mailing list comprised of all identified SSSP WG members, representatives of HRPT sites, ITWG representatives of the space agencies and others willing to contribute.

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.**