

A Report on The Seventeenth International TOVS Study Conference

**Asilomar State Park Conference Center
Monterey, CA, United States
14-20 April 2010**

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FOREWORD

The International TOVS Working Group (ITWG) is convened as a sub-group of the International Radiation Commission (IRC) of the International Association of Meteorology and Atmospheric Physics (IAMAP). The ITWG continues to organise International TOVS Study Conferences (ITSCs) which have met approximately every 18 months since 1983. Through this forum, operational and research users of TIROS Operational Vertical Sounder (TOVS), Advanced TOVS (ATOVS) and other atmospheric sounding data have exchanged information on data processing methods, derived products, and the impacts of radiances and inferred atmospheric temperature, moisture, and cloud fields on numerical weather prediction (NWP) and climate studies.

These Technical Proceedings available on-line bring together the papers of the scientific presentations and posters from the Seventeenth International TOVS Study Conference (ITSC-XVII) hosted by the Naval Research Laboratory at the Asilomar State Park Conference Center, Monterey, California, 14-20 April 2010. The ITSC-XVII conference report is also available which summarises the scientific exchanges and outcomes of the meeting. The ITWG Web site contains electronic versions of the conference presentations, posters and publications which can be downloaded (<http://cimss.ssec.wisc.edu/itwg/>). Together, these documents and Web pages reflect a highly successful meeting in Monterey. An active and mature community of TOVS and ATOVS data users exists, and considerable progress and positive results were reported at ITSC-XVII in a number of areas, including many related to the ATOVS system, use of IASI and AIRS measurements, and to the other current and scheduled advanced sounders.

ITSC-XVII was sponsored by industry, government agencies and a university, including the World Meteorological Organization (WMO), Meteo France, VCS Engineering, Kongsberg Spacetec AS, ABB, ITT Industries, the Met Office (UK), Raytheon, the University of Wisconsin-Madison Space Science and Engineering Center, EUMETSAT, NOAA/NESDIS/STAR, NOAA/GOES-R Program Office, Sea Space, Orbital Systems, NASA and IPO. The support of these groups is gratefully acknowledged. We wish to thank the local organizing committee from the Naval Research Laboratory, especially to Dr. Nancy Baker, Dr. Ben Ruston and NRL colleagues for their exceptional effort and talent in leading the local organization, and to Maria Vasys and Leanne Avila (University of Wisconsin-Madison) and Carine Previatti (Acquaviva Produções e Promoções) for all their administrative and logistical support.

Details of Reports and Proceedings of ITSC-XVII and from previous conferences are also available from the Web site.



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TOVS STUDY CONFERENCE (ITSC-XVII)

Monterey, CA, USA: 14 to 20 April 2010

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***ITSC-XVII Group Photo at Asilomar State Park Conference Center
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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Seventeenth International TOVS Study Conference, ITSC-XVII, was held in Asilomar State Park Conference Center, Monterey, California, USA, 14-20 April 2010. Nearly one hundred and fifty participants attended the Conference and provided scientific contributions. Twenty countries and three international organizations were represented: Australia, Brazil, Canada, China, Taiwan, Denmark, France, Germany, Hungary, India, Italy, Japan, Norway, Poland, Russia, South Korea, Sweden, Switzerland, United Kingdom, United States, ECMWF, EUMETSAT and WMO. The number of attendees at ITSC-XVII breaks the highest ever record attended at the last ITSC gathering once more. The Working Groups had very productive discussions and it was again encouraging to see a large number of new, younger scientists participating.

ITSC-XVII was sponsored by industry and government agencies and by the University of Wisconsin-Madison's Space Science and Engineering Center. The industry and government agencies included: the World Meteorological Organization (WMO), Météo France, VCS Engineering, Kongsberg Spacetec, ABB, ITT Industries, the Met Office (UK), CNES, Raytheon, EUMETSAT, NOAA/NESDIS/STAR, NOAA/GOES-R Program Office, Sea Space, ERT Inc., Orbital Systems, NASA and IPO. The support of these groups is gratefully acknowledged. The great success of ITSC-XVII can be attributed to the excellent support provided by the local organising committee from the Naval Research Laboratory and the administrative and logistical supports provided by Maria Vasys and Leanne Avila (University of Wisconsin-Madison) and Carine Previatti (Acquaviva Produções e Promoções).

Most of the meeting was occupied with nine sessions of oral presentations and their associated poster papers. Each poster paper was also allocated a 2-minute oral summary to highlight the scientific contents. The range of issues covered included the following:

- Generation and validation of meteorological and environmental products from sounder radiances,
- Atmospheric chemistry and air quality,
- Direct broadcast, preprocessing and calibration of sounder radiances (a session dedicated to the memory of Hal Woolf),
- A special Hal Woolf Memorial session as a tribute to Hal, a long time ITWG member and a dedicated scientist who has well served the international remote sensing community throughout a distinguished career,
- Atmospheric radiative transfer,
- Surface property modeling and sensing,
- Assimilation of raw measurements and derived products in NWP,
- Climate studies,
- Agency status report poster presentation,
- Future sounders and programs,
- Report on action items from ITSC-XVI, and
- Working Group Reports.

There were 101 oral presentations, 96 oral poster introductions, 17 working group and technical sub-group presentations, and more than 100 poster presentations during the

conference. The conference agenda and all of the talks and many of the posters can be viewed at the ITWG Web site, located at <http://cimss.ssec.wisc.edu/itwg/itsc/itsc17>

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

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

The Working Groups reviewed recent progress in the above areas, made recommendations on key areas of concern and identified items for action. Working Group reviews and recommendations comprise an important part of the ITSC-XVII Working Group Report. A summary of the key points arising from the conference is presented below.

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

The conference also paid tribute to Hal Woolf, an active member of the group, who died in 2009. He will be sadly missed by the ITWG.

1.2 SUMMARY OF MAJOR CONCLUSIONS

The ITSC-XVII presentations, posters, Working Group meetings and discussions documented significant issues in many areas and identified areas for future activity. In particular, 65 action items and 70 recommendations were reported by 6 working groups. Below are highlighted actions and recommendations. Highlights and recommendations from ITSC-XVII were submitted to CGMS for reporting at CGMS-38 in November 2010.

1. Recommend space agencies and NWP centers support the use of GIFTS/STORM data for research and development of hyperspectral infrared geostationary sounder products in advance of operational instruments (e.g., MTG-IRS).
2. Recommend space agencies ensure the continuation of capability for conically scanning sounders in the post DMSP era. All future such instruments should be designed with particular attention to calibration accuracy and stability.
3. In concert with the continued development of IR geo sounders, recommend the further advancement of geostationary microwave sounders.
4. Recommend the Russian Federation make the Meteor-M mission a fully contributing component of the GOS by providing the global data sets from this mission in a timely manner with all necessary ancillary information.
5. Recommend satellite agencies operating environmental polar satellites provide or continue to provide a Direct Broadcast capability on their polar environmental satellite systems, and make available in a timely manner the Direct Broadcast data processing (L0 to L1, and/or L1 to L2) software, documentation, and related training.

6. Recommend NOAA and Department of Defense (DoD) consider the use of the SafetyNet as a joint ground system ensuring timely availability of data from the JPSS and DMSP follow-on missions.
7. Noting that the NPOESS program is being restructured into two separate programs, one being run by DoD and the other by NOAA/NASA (known as JPSS,) ITWG recommends that imaging and sounding capabilities should be included on the DoD satellite, ideally including MW and IR. Furthermore, data should be free and readily accessible to the general international user community.
8. ITWG recommends that the constellation of at least three orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), is maintained. The WG recommends coordination between agencies of the overpass times of operational satellites with sounding capability (IR and MW) to maximize coverage (including, e.g., China, India).
9. The NWP WG recommends that future microwave sensors maintain sounding capabilities of the upper stratosphere and mesosphere, in addition to tropospheric and stratospheric sounding capabilities, as is the case for SSMIS.
10. The NWP WG continues to support fast delivery initiatives (RARS) with extensions wherever possible, however the WG believes that the system should continue to be low cost. At ITSC-XVII, it was reported that the RARS coverage is now 78%. Further extension towards global coverage is encouraged until the point is reached where further improvements are no longer cost effective.
11. The geostationary and HEO (Molniya) orbit is ideal for observing the rapidly changing component of atmospheric and surface fields. The WG recommends the use of these orbits for high spectral resolution IR and/or microwave sounder/imager instruments. Ideally, if both are possible, the microwave and IR instruments should observe the same portion of the atmosphere at the same time.
12. The NWP WG recommends that EUMETSAT investigates lossless compression methods for the dissemination of the full IASI spectrum in the context of disseminating data from two or more Metop satellites.
13. The WG recommends that all relevant space agencies (i.e., ESA, NASA, NOAA, JMA, EUMETSAT, CMA, KMA, etc.) send information to users, including the NWP WG mailing list, about planned changes in data processing, formats, and other issues related to data as early as possible (preferably at least 6 months).
14. The NWP WG recommends setting up an RTTOV user group, composed of members that do not actively participate in developing RTTOV software, to collect science requirements, and to establish a forum for technical and usage aspects. This group is expected to interact through internet and email.
15. The NWP WG recommends that monitoring Web sites be freely accessible on the internet (i.e., not require any password).
16. There is a critical need for a follow-on microwave imager/sounder for climate purposes because, although they were not initially intended for climate studies, they have proven hugely useful. We still look primarily to DMSP to provide such measures because of the need for LECT continuity for climate record continuity purposes. A similar imager/sounder on a post-EPS orbit would also be immensely valuable and EUMETSAT is encouraged to continue planning in this regard. Suitable representation from the climate community in the planning phase of both programs to ensure the continuity of the record is requested.
17. Satellite agencies that are considering changing the frequency or viewing geometry /resolution of heritage measures need to consider the impact on climate monitoring and particularly trend characterization.

18. Recognising that climate change may have a diurnal cycle component we recommend to CGMS that they explicitly consider the coordinated international phasing of satellites to ensure adequate sampling of the diurnal cycle.
19. Recommend EUMETSAT to pro-actively consider the multiple platform issue with consultations with NOAA, as NOAA has considerable experience in this regard. Discussions need to recognize the import to climate of the longest term record and that a non-operational platform need not be available in real-time to be useful for climate studies.
20. EUMETSAT and GSICS are urged to look pro-actively at the METOP A/B global SNO measurements opportunity to ascertain the likely validity of the global application of high-latitude-only derived SNOs for other platforms through systematic experimentation and to disseminate in the peer reviewed literature.
21. Reanalysis centers are urged to use suitable satellite Fundamental Climate Data Records (FCDRs) that have had substantial work applied for future reanalysis activities. Quality feedback information, such as data departures from existing reanalyses, should be established for the new FCDRs in order to provide further information on the quality of the observational record. Furthermore, reanalysis centers should consider whether it is more applicable to anchor future reanalyses to these globally complete and consistently processed FCDRs in preference to conventional data sources.
22. Space agencies need to recognize the importance of traceability in characterization of the fundamental measurement and to actively engage the meteorologist community throughout the process but particularly in pre-launch characterization building upon the recent BIPM-WMO meeting.
23. ITWG climate working group notes that GPS-RO in and of itself constitutes a valuable climate record. But perhaps of greater value is the cal/val it affords to the operational satellites. It is imperative that a long-term capability be retained.
24. Absolute calibration missions (such as CLARREO) should be planned to continue after CLARREO's expected lifetime and to include other spectral regions including microwave radiances, the latter recognized to be hugely challenging.
25. Recommend agencies provide and sustain high quality in-situ observations through programs such as GRUAN to improve radiative transfer models co-located in space and time. Furthermore, agencies should advertise the existence of such data to their users.
26. GSICS should continue to actively reach out to the user community to capture evolving requirements.
27. Recommend SCOPE-CM Exec panel formulate their requirements to GSICS.
28. ITWG climate WG recommend putting up an alternate AWS at DOME-C as back up for AWS8989, the latter having proven invaluable for satellite cal/val. ITWG Co-Chairs to report this issue to CGMS with the recommendation to encourage the Italian Space Agency to resume the station at DOME-C.
29. Recommend ESA strongly consider clear and unambiguous guidance on data openness and transparency from the outset of the CCI initiative to ensure that datasets created are verifiable and exhibit best practices.
30. Recommend CGMS support multiple analyses of FCDRs and TCDRs, recognising that there are many methodologically uncertain choices required.
31. Recommend CGMS to consider the potential benefits of the NWP and climate requirements approach adopted by EUMETSAT as part of the post-EPS mission planning.

32. Recommendation to reanalyses centres to provide their diurnal climatologies at hourly resolution for a suite of geophysical and radiance parameters including surface characteristics, this in support of satellite dataset construction efforts.
33. Non-LTE effects should be included/parameterized in fast RT models. Progress on this issue (from the SARTA, RTTOV, and CRTM teams) should be reported when progress is made.
34. Recommend that satellite centers consider upwelling oceanic radiation (water leaving radiance) when designing the next generation of RT models that include the visible part of the spectrum.
35. Recommend NWP centers document the methodologies used to speed up hyperspectral radiance assimilation, specifically with regards to parallelization and load balancing.
36. The SSSP WG recommends expansion in the areas of direct readout observations to areas currently not covered. EUMETSAT should provide a timetable showing the plans for a possible expansion of the Metop-A HRPT services.
37. Recommend to IPO/JPSS that a Level-2 retrieval package for IASI should be funded and made available for IASI DB users.
38. IPO/JPSS should provide timely updates on expected implementation schedules and concerns (including for IPOPP) and a recommendation to NOAA, NASA (or JPSS project management office) on the completion and distribution of the IPOPP software. IPOPP to include a BUFR conversion module.
39. Sounding science WG recommends that EUMETSAT makes calibration datasets available after concurrence with NOAA via the EUMETSAT Web site.
40. The international issues and future systems WG welcomed the plans of CMA and EUMETSAT to implement the planned IR sensors on FY-4 (by 2015) and MTG (2018) missions respectively. The WG also noted that options were being discussed by NOAA regarding a sounding capability to complement the current GOES-R and -S baseline, and strongly encouraged NOAA to pursue these investigations.
41. Recommend ITWG members review Radio Regulations (RR) No. 5.565 and its requirements for use of the spectrum in the band between 275 and 3000 GHz and make their views known to the international community.
42. There are international frequency-spectrum allocations that guide frequency band usage and delineate restrictions placed on such use. It is recognized among the environmental satellite community, however, that there are instances in which emitters are likely to cause the loss of data that is of interest to this community. An international registry of emitters would provide advance notification for future environmental satellite missions. It is proposed that a discussion of such a registry be held within appropriate (WMO, CGMS) entities. Such a registry could contain information on emitter locations, RF characteristics, duty cycles, and anticipated time frame of emitter existence. This would expand a current initiative, a much smaller scale effort named Radiofrequency Interference Survey of the Earth (RISE).
43. The International Issues and future systems WG recommends that DoD (of USA) operated polar orbiting satellite requirements be stated in terms of Satellite Data Records (SDR) rather than Environmental Data Records (EDR), in view of the needs of the NWP and climate monitoring communities for the exploitation of radiance measurements. When considering the MW sounder for the early morning orbit mission, particular attention should be paid to the requirements for calibration accuracy and stability, noting existing problems in these areas with current

conically scanning MW radiometers. The need for infrared sounding requirements for this early morning orbit mission was reiterated, in accordance with the Vision of the GOS.

44. Being aware that geostationary microwave sounding was still only envisaged as a technology and scientific demonstration mission in the WMO Vision for the GOS, the WG noted that the NASA GEOSTAR project was responding to the call for such a demonstration mission. It considered that if any trade-off needed to be made between the measurement of precipitation and the vertical temperature and moisture profile, the specific priority for microwave imagery/sounding should be on precipitation.
45. ITWG recommends CGMS to consider harmonization of the appropriate layers of the future X-Band Direct Broadcast services, for instance as concerns frequency or transmission protocols based on CCSDS standards.
46. ITWG recommends JMA to consider a broadcast service to facilitate access to Himawari-8 and -9 data, in particular for users in Pacific islands who have limited Internet connectivity.
47. ITWG recommends CGMS satellite operators to investigate the potential use of satellite-to-satellite communication (e.g., Tracking and Data Relay Satellite System, TDRSS) as a mechanism to support timely collection and redistribution of polar-orbiting satellite data in future systems.
48. A few internal action items related to ITWG community:
 - I. To obtain response functions for CrIS, FY-3 IR, COMS imager, and other new instruments.
 - II. To provide documentation of methodologies used in NWP centres to convert layer atmospheric state variables to level values.
 - III. To request Mitch Goldberg to distribute CEOS draft response to the 2010 update of the GCOS Implementation Plan for comment when ready.
 - IV. European NWP WG members to inform their EUMETSAT OPS WG representatives of changes desired in the scope and format of the notifications sent through the UNS.
 - V. NWP WG members involved in regional or limited area data assimilation to share their experience (experiment results, reports, papers, etc...) on bias correction procedures on the regional data assimilation Web page.
 - VI. ITWG Co-Chairs to create a section on the NWP WG wiki page which will contain examples of the existing or potential effects of RFI in NWP. Members are invited to add on this Web page any relevant impact assessments or evidence found.

1.3 FUTURE PLANS

The ITWG will continue to meet and continue to inform the ATOVS community of the latest news and developments through its Web site (currently maintained by the University of Wisconsin-Madison/CIMSS) and via the email list (also maintained by CIMSS). The Web site will continue to evolve to become an even more important tool for ITSC, with many new ideas proposed and endorsed at ITSC-XVI and ITSC-XVII. This could include some interactive elements to the Web site (e.g., a wiki).

The format of ITSC-XVII was similar to previous meetings, but with a significant increase in attendance resulting in significant time pressure on the agenda. At ITSC-XVII, two-minute poster introductions were followed by the poster viewing session. This format was also

applied to the five-minute oral agency status reports. A few technical sub-groups were consolidated into working groups to avoid too many parallel group meetings and too few participants. In addition, as recommended by the climate WG in ITSC-XVIII, a session specifically on analyses of overlap requirements for continuity across changes in platform or technology (e.g., HIRS2/3/4, TOVS to ATOVS, AIRS to IASA, SSMI to SSMIS) is to be considered.

The ITSC-XVII Working Group Report, and Proceedings for ITSC-XVII from the papers submitted, will be available on-line. The oral and poster presentations from ITSC-XVII are already available as PDF files that can be downloaded from the ITWG Web site. The next meeting of the ITWG is scheduled to take place in March 2012 and is to be hosted by Météo France in Toulouse, France. Topics of interest will include initial assessment of NPP, MetOp-B and FY-3B data and the development of new atmospheric chemistry missions directed at trace gas monitoring, air quality research and the advancement of climate studies. More information about ITWG and other ITSCs may be found at: <http://cimss.ssec.wisc.edu/itwg/>

1.4 ACKNOWLEDGEMENTS

This report relied on the active participation of all ITSC attendees and those working group chairs. We acknowledge that writing of this report is possible only through the collective work of ITWG members. Note that most of the contents presented here are derived from the draft of the executive summary part of the ITSC-XVII working group report, so some of the contents (especially action items and recommendations) are subject to change.

SUMMARY OF ACTIONS AND RECOMMENDATIONS

RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING

Action RTSP-1

Ben Ruston to update NWP-SAF page with the latest information of available land surface emissivity models and data for use in RT modeling.

Action RTSP-2

Following on from Action RTSP-1, Paul van Delst to notify IPWG members of the availability of the land surface emissivity model catalogue.

Action RTSP-3

Yong Han to coordinate with Weizhong Chen (NOAA LDAS contact) to start organizing this work.

Recommendation RTSP-1 to NWP-SAF and JCSDA

Ensure the future development of LBLRTM is secure.

Recommendation RTSP-2 to LBL modelers and users

Exploit all possible methodologies to validate LBL models and spectroscopy. For example: validation of LBL calculations against observations using high quality in situ data; validate using retrieved profiles to compare instrument residuals to instrument noise.

Action RTSP-4

RTSP-WG Co-Chairs to coordinate catalogue of datasets for validation:

- Target periods
- Field experiments with in situ data coincident with instrument overpasses.

Emphasis is placed on those datasets with high water vapour loading, and field campaign organizers are encouraged to pursue those conditions.

This action is in concert with recommendations made at the 2nd International IASI Conference.

The dataset catalogue will be listed on the RTSP-WG Web site.

Action RTSP-5

Stuart Newman to notify RTSP-WG when water vapour continuum model updates due to CAVIAR work become available.

Action RTSP-6

Nicole Jacquinet to report to RTSP-WG on the upcoming HITRAN conference (June 2010) in particular on spectroscopy data and modeling updates applicable to the RTSP-WG.

Recommendation RTSP-3 to NWP centres

Begin routine monitoring of cloudy and aerosol-affected radiances. This first step towards assimilation of the radiances will also provide guidance to the RT modelers.

Action RTSP-7

RTSP-WG Co-Chairs to report on what cloud model outputs are available from various centres for input to RT models.

Action RTSP-8

RTSP-WG Co-Chairs to publish on the RTSP-WG Web site methods (and software if available) to convert forecast model outputs of cloud data to those quantities required by RT models.

Action RTSP-9

Paul van Delst to notify the RTSP-WG when NPP VIIRS SRF data become publicly available (including non-US-based researchers). The NOAA IPO has already been contacted with the request.

Recommendation RTSP-4 to ITWG Co-Chairs

Contact the various space and research agencies to ask them to make instrument parameters required for fast RT modeling be made available to the RTSP-WG as soon as possible so as to allow dissemination to the interested parties.

Recommendation RTSP-5 to ITWG Co-Chairs

Contact the various space and research agencies to ask them to retain the high spectral resolution scans of microwave instrument channel responses in digital form and make those data available to the RTSP-WG as soon as possible so as to allow dissemination to the interested parties.

Action RTSP-10

Paul van Delst to contact SSEC Webmasters responsible for the RTSP-WG Web page and coordinate transitioning the current RTSP-WG Web page to the Plone groups site at SSEC. The RTSP-WG will be notified when this is completed.

Action RTSP-11

Tom Kleespies to update his TL and AD coding notes and examples on the RTSP-WG Web site.

Action RTSP-12

Paul van Delst to resolve any outstanding RTSP-WG action items from ITSC-16 by March 2011.

CLIMATE**Action Climate-1**

ITWG Co-Chairs to take action on Recommendations Climate-2, -3, -9, -10 -11, -12, -17 and -20, largely through dissemination to CGMS.

Recommendation Climate-1 to satellite agencies

There is a critical need for a follow on microwave imager/sounder for climate purposes because although they were not initially intended for climate they have proven hugely useful. We still look primarily to DMSP to provide such measures because of the need for

LECT continuity for climate record continuity purposes. A similar imager/sounder on a post-EPS orbit would also be immensely valuable and EUMETSAT is encouraged to continue planning in this regard. Suitable representation from the climate community in the planning phase of both programmes to ensure the continuity of the record is requested.

Action Climate-2

ITWG co-chairs to communicate Climate Recommendation 2 to CGMS via Mitch Goldberg of STAR/NOAA.

Recommendation Climate-2 to satellite agencies

Satellite agencies that are considering changing the frequency or viewing geometry / resolution of heritage measures need to consider the impact on climate monitoring and particularly trend characterisation. This can be easily achieved through the use of radiance simulators and climate model output that is freely available through the CMIP portal.

Recommendation Climate-3 to CGMS

Recognising that climate change may have a diurnal cycle component we recommend to CGMS to explicitly consider the coordinated international phasing of satellites to ensure adequate sampling of diurnal cycle.

Recommendation Climate-4 to ITWG Co-Chairs

Consider a session at next ITWG specifically on analyses of overlap requirements for continuity across changes in platform or technology (e.g., HIRS2/3/4, TOVS to ATOVS, AIRS to IASI, SSMI to SSMIS). With a view to promoting the appearance of such studies in the peer reviewed literature and making robustly quantified recommendations on overlaps required when the satellite technology changes and quantifying GCOS climate monitoring principles.

Action Climate-3

ITWG Co-Chairs to consider viability of Recommendation Climate-4.

Recommendation Climate-5 to EUMETSAT

EUMETSAT to pro-actively consider the multiple platform issue with consultation with NOAA who have considerable experience in this regard. Discussions need to recognise the import to climate of the longest term record and that the non-operational platform need not be available in real-time to be useful for climate.

Action Climate-4

Jörg Schulz to communicate Recommendation Climate-5 to EUMETSAT.

Recommendation Climate-6 to EUMETSAT and GSICS

EUMETSAT and GSICS are urged to look pro-actively at the METOP A/B global SNO measurements opportunity that will be afforded to ascertain the likely validity of the global application of high latitude only derived SNOs for other platforms through systematic experimentation and to write this up in the peer reviewed literature.

Action Climate-5

Jörg Schulz to communicate Recommendation Climate-6 to GSICS and EUMETSAT.

Recommendation Climate-7 to reanalysis centres

Reanalysis centres are urged to use suitable satellite FCDRs that have had substantial work applied for future reanalyses activities. Quality feedback information, such as data departures from existing reanalyses should be established for the new FCDRs to provide further information on the quality of the observational record. Furthermore, reanalysis centres should consider whether it is more applicable to anchor future reanalyses to these globally complete and consistently processed FCDRs rather than to conventional data sources.

Action Climate-6

Peter Thorne to communicate Recommendation Climate-7 through the joint GCOS/WCRP Working group on observations for reanalyses.

Recommendation Climate-8

Identify potential observational data sets that seem suitable for comparison to the CMIP5 fields for the next IPCC report. Datasets should be converted to standard grids (where possible), and to standard CF compliant NetCDF to be hosted on the Earth System Grid or similar standard, and be documented.

Action Climate-7

John Bates to communicate Recommendation Climate-8 to the SCOPE-CM executive panel. Jörg Schulz to communicate Recommendation Climate-8 to the EUMETSAT SAF network.

Recommendation Climate-9 to space agencies

Space agencies to recognise the importance of traceability in characterisation of the fundamental measurement and to actively engage the metrologist community throughout the process but particularly in pre-launch characterisation building upon the recent BIPM-WMO meeting.

Action Climate-8

Bill Bell to distribute report and presentations from the recent BIPM-WMO meeting to this working group and the ITWG Co-Chairs for their consideration.

Recommendation Climate-10

ITWG climate working group notes that GPS-RO in and of itself constitutes a valuable climate record. But perhaps of greater value is the cal/val it affords to the operational satellites. It is imperative that a long term capability be retained.

Recommendation Climate-11

Absolute calibration missions (such as CLARREO) should be planned to continue after CLARREO's expected lifetime and include other spectral regions including microwave radiances which is recognised to be hugely challenging.

Action Climate-9

Peter Thorne to distribute report from latest GRUAN meeting to the Working Group so that they are up to date.

Recommendation Climate-12

To agencies to provide and sustain high quality in-situ observations through programs such as GRUAN to improve radiative transfer models co-located in space and time. Furthermore, to advertise the existence of such data to their users.

Recommendation Climate-13 to GSICS

GSICS should continue actively reaching out to user community and capture evolving requirements.

Action Climate-10

Mitch Goldberg to communicate Recommendation Climate-13 to GSICS.

Recommendation Climate-14 to SCOPE-CM Exec panel

SCOPE-CM Exec panel to formulate their requirements to GSICS.

Action Climate-11

John Bates to communicate Recommendation Climate-14 to SCOPE-CM.

Recommendation Climate-15

To put up an alternate AWS at DOME-C as back up for AWS8989 that has proven invaluable for satellite cal/val.

Action Climate-12

ITWG Co-Chairs to communicate this to CGMS with the recommendation to encourage the Italian Space Agency to resume the station at DOME-C.

Action Climate-13

Roger Saunders to provide ESA CCI documentation to the working group members for feedback.

Recommendation Climate-16 to ESA

To ESA to strongly consider clear and unambiguous guidance on data openness and transparency from the outset to the CCI initiative to ensure that datasets created are verifiable and exhibit best practices.

Action Climate-14

Roger Saunders to feedback Recommendation Climate-16 to ESA CCI.

Recommendation Climate-17 to CGMS

To CGMS to support multiple analyses of FCDRs and TCDRs recognising that there are many methodologically uncertain choices required.

Recommendation Climate-18 to EUMETSAT

To EUMETSAT to write up the IASI / HIRS intercomparison presented at ITWG in the peer reviewed literature including an analysis as to why the channels vary in their response to the extent where such analysis is possible.

Action Climate-15

Dieter Klaes to communicate Recommendation Climate-18 to EUMETSAT.

Recommendation Climate-19 to reanalysis centres

To reanalyses centres to provide their diurnal climatologies at hourly resolution for a suite of geophysical and radiance parameters including surface characteristics in support of satellite dataset construction efforts.

Action Climate-16

Peter Thorne to communicate this through GCOS/WCRP Working Group on Observations for reanalyses.

Action Climate-17

Mitch Goldberg to distribute CEOS draft response to the 2010 update of the GCOS Implementation Plan for comment when ready.

Recommendation Climate-20 to CGMS

To CGMS to consider the potential benefits of the NWP and climate requirements approach adopted by EUMETSAT as part of the post-EPS mission planning.

Action Climate-18

Jörg Schulz to send details on the tables to NOAA for JPSS planning.

DATA ASSIMILATION AND NUMERICAL WEATHER PREDICTION**Action DA/NWP-1**

Heather Kilcoyne (NOAA) will inform NWP WG (via mailing list) when the IPO (Integrated Project Office) cal/val Web site for NPP instruments will be up.

Recommendation DA/NWP-1 to US Department of Defense

Noting that the NPOESS program is being restructured into two separate programs, one being run by DoD and the other by NOAA/NASA known as JPSS, the WG recommends that imaging and sounding capabilities should be included on the DoD satellite, ideally including MW and IR. Furthermore, data should be free and readily accessible to the general international user community.

Recommendation DA/NWP-2 to NOAA/NASA and DoD

The short operational delivery time of the NPOESS system was an extremely attractive component of the system design. The WG recommends that the SafetyNet system (ground receiving system) is retained in the NPOESS restructuring process for both satellite programs (i.e., JPSS and DoD).

Recommendation DA/NWP-3 to all relevant space agencies

The WG recommends that the constellation of at least three orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), is maintained. The WG recommends coordination between agencies of the overpass times of operational satellites with sounding capability (IR and MW) to maximize coverage (including, e.g., China, India).

Recommendation DA/NWP-4 to CMA

The WG recommends that CMA continues its efforts to make FY-3A data available in BUFR format to the international user community in near real time.

Action DA/NWP-2

Wei Han (CMA) will gather information on FY-3C and its instruments as well as follow-on missions and distribute this information to the WG members through the NWP WG mailing list.

Recommendation DA/NWP-5 to DoD and other space agencies

The NWP WG recommends that future microwave sensors maintain sounding capabilities of the upper stratosphere and mesosphere, in addition to tropospheric and stratospheric sounding capabilities, as is the case for SSMIS.

Action DA/NWP-3

Dave Ector (NOAA) will send the report from the upcoming first meeting of the IROWG (International Radio-occultation WG) to the NWP WG members via the mailing list.

Recommendation DA/NWP-6 to satellite agencies and WMO

The geostationary and HEO (Molniya) orbit is ideal for observing the rapidly changing component of atmospheric and surface fields. The WG recommends the use of these orbits for high spectral resolution IR and/or microwave sounder/imager instruments. Ideally, if both are possible, the microwave and IR instruments should observe the same portion of the atmosphere at the same time.

Recommendation DA/NWP-7 to satellite agencies and WMO

The WG encourages further study of the benefits of hyperspectral microwave instruments.

Action DA/NWP-4

Sid Boukabara (NOAA) will contact NESDIS to ensure that when the DMSP F18 SSMIS data (in BUFR format and processed by UPP) is available at NESDIS from FNMOC (within the next two weeks) that it is also made available for wide distribution. Furthermore, Sid will ask NESDIS to ensure that users are promptly informed of data or instrument issues.

Action DA/NWP-5

Vincent Guidard (Meteo France) and Fiona Hilton (Met Office) will revisit the selection of the EUMETSAT 314-channel subset of IASI channels. This may lead to a proposal to include further channels.

Recommendation DA/NWP-8 to EUMETSAT

The NWP WG recommends that EUMETSAT investigates lossless compression methods for the dissemination of the full IASI spectrum in the context of disseminating data from 2 or more Metop satellites.

Recommendation DA/NWP-9 to all relevant space agencies and WMO

The WG recommends that all relevant space agencies (i.e., ESA, NASA, NOAA, JMA, EUMETSAT, CMA, KMA, etc...) send information to users, including the NWP WG

mailing list, about planned changes in data processing, formats, and other issues related to data as early as possible (preferably at least 6 months in advance).

Action DA/NWP-6

European NWP WG members will inform their EUMETSAT OPS WG representatives of changes desired in the scope and format of the notifications sent through the UNS.

Recommendation DA/NWP-10 to WMO

The NWP WG continues to support fast delivery initiatives (RARS) with extensions wherever possible, however the WG believes that the system should continue to be low cost. At ITSC-17, it was reported that the RARS coverage is now 78%. Further extension towards global coverage is encouraged until the point is reached where further improvements are no longer cost effective.

Action DA/NWP-7

Jerome Lafeuille (WMO) will distribute the RARS user's questionnaire to the NWP WG mailing list.

Recommendation DA/NWP-11 to RARS coordination centers

The WG recommends that users be informed of processing changes and other issues regarding RARS as early as possible.

Action DA/NWP-8

Brett Candy (Met.Office) will investigate how to inform users of data anomalies noted in the intercomparison between global and RARS data performed at the Met. Office (including the possibility of an automated warning system).

Recommendation DA/NWP-12

The NWP WG recommends setting up an RTTOV user group, composed of members that do not actively participate in developing RTTOV software, to collect science requirements, and to establish a forum for technical and usage aspects. This group is expected to interact through internet and email.

Action DA/NWP-9

WG members will consult with their respective organizations to find prospective members of the RTTOV user group and will send an email with contact information to Fiona Hilton. Fiona Hilton will investigate the technical options to set up such a forum. She will also prompt CRTM manager, Paul van Delst, about their experience.

Action DA/NWP-10

The NWP WG Co-Chairs will post the action items on the NWP WG wiki page and WG members will describe how action items were completed. WG members may obtain a password from Leanne Avila via email (with copy to the Co-Chairs), to be able to make changes to the Wiki page.

Action DA/NWP-11

Roger Randriamampianina (met.no) will convert the ITWG ATOVS questionnaire (in word format) to wiki format and include it in the NWP WG wiki page. WG members will update their information via the wiki page. NWP WG Co-Chairs will send a reminder to

update the information at least once a year. A snapshot of the information will be taken once a year by Co-Chairs.

Action DA/NWP-12

Niels Bormann (ECMWF) will obtain a copy of Andrew Collard's ITSC-17 presentation on the IASI usage survey and include it on the NWP WG wiki page. He will also include a list of the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16.

Recommendation DA/NWP-13 to NMS

The NWP WG recommends that detailed monitoring be available on the NMS monitoring Web sites for at least the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16 (see Action DA/NWP-12).

Recommendation DA/NWP-14 to NMS

The NWP WG recommends that monitoring Web sites be freely accessible on the internet (i.e., do not require a password).

Recommendation DA/NWP-15 to NWP WG members

NWP WG members are strongly encouraged to make use of the NWP WG mailing list, in particular to report problems with instruments.

Action DA/NWP-13

Wei Han (CMA) will put together a proposal for a radiance bias and bias correction intercomparison exercise. This should include specification of format to exchange relevant information and the scope of the intercomparison.

Action DA/NWP-14

Roger Randriamampianina (met.no) will create a regional data assimilation page on the NWP WG wiki page. Roger will also post the poster (impact of single AMSU observation on analyses increments at three NMS) that he presented at ITSC-17 (Number 7.22) on this page.

Recommendation DA/NWP-16 to NMS

The WG recommends that other NMS also participate in the single-observation exercise (see Action DA/NWP-14) for other regions, if applicable, and that they contact Brett Candy (Met Office) and Roger Randriamampianina (met.no) to convey their results.

Action DA/NWP-15

NWP WG members involved in regional or limited area data assimilation will share their experience (experiment results, reports, papers, etc.) on bias correction procedures on the regional data assimilation Web page.

Action DA/NWP-16

Co-Chairs will create a section on the NWP WG wiki page which will contain examples of the existing or potential effects of RFI in NWP. Members are invited to add on this Web page any relevant impact assessments or evidence found. Nancy Baker (NRL) will provide examples to start the page.

Recommendation DA/NWP-17 to the NMS and NWP community

The NWP WG recommends that forecast verification scores are displayed with error bars and indication of trial periods used.

ADVANCED SOUNDERS

Recommendation AS-1 for space agencies and NWP centers

To support the use of hyperspectral geostationary imager products, such as GIFTS/STORM data, for research and development of hyperspectral infrared geostationary sounder products in advance of operational instruments (e.g., MTG-IRS).

Action AS-1

For David Crain to publicise information on data availability of the GIFTS/STORM to Advanced Sounder Working group to encourage early use of these radiances.

Action AS-2

Brian Kahn, starting from the existing WMO database containing the requirements of the World Climatological Research Program (WCRP), to survey the science community for their observational needs with respect to climate related processes and report back to the group.

Recommendation AS-2 to the research community

Review trade-off studies used to determine spectral, spatial and noise tradeoffs for determining operational advanced infrared sounder specifications with reference to optimal field of view for cloud avoidance and the use of noise reduction processing techniques and/or new detector array technology.

Recommendation AS-3 to the research community

Explore the possibility of setting up a community science working group to explore these issues.

Action AS-3

Andrew Collard to initiate discussion on how to proceed with these recommendations.

Recommendation AS-4 to space agencies

To ensure the continuation of capability for conically scanning instruments in the post DMSP era. All future such instruments should be designed with particular attention to calibration accuracy and stability.

Action AS-4

ITWG Co-Chairs to present the concern of this group to CGMS.

Recommendation AS-5

In concert with the continued development of IR geo sounders, we recommend the further advancement of geostationary microwave sounders.

Action AS-5

David Crain and Steve English to take the WMO Global Observing System Dossier on current operational systems and produce a simplified table for the Advanced Sounder Working Group report by September 2010.

Action AS-6

Advanced sounder working group to critically review the document produced above.

INTERNATIONAL ISSUES AND FUTURE SYSTEMS**Action IIFS-1**

Mitch Goldberg, Jeff Hawkins and John Bates, to communicate these recommendations to the Joint Agency Requirements Group (JARG), a holdover from the NPOESS program that will assist in the transition to the restructured programme.

Recommendation IIFS-1 to the Russian Federation

To make the Meteor-M mission a fully contributing component of the GOS by providing the global data sets from this mission in a timely manner with all necessary ancillary information.

Recommendation IIFS-2 to satellite agencies

Satellite agencies operating environmental polar satellites to provide or continue to provide a Direct Broadcast 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.

Recommendation IIFS-3 to satellite agencies

Satellite agencies operating environmental polar satellites to provide expected formats of level 1b and level 2 datasets at least one year prior to launch, and to establish Web sites to provide detailed information on instruments, schedule, products and formats.

Recommendation IIFS-4 to NOAA, NASA (or JPSS project management office)

To include a BUFR conversion module in the IPOPP software package.

Recommendation IIFS-5 to NOAA, NASA, and DoD

To confirm and implement Direct Broadcast capabilities on both the JPSS and DMSP follow-on series ensuring that environmental data from these missions are openly and freely available in near-real time, and to make the relevant ingest and pre-processing software available to the global community.

Recommendation IIFS-6 to NOAA and DoD

To consider the use of the SafetyNet as a joint ground system ensuring timely availability of data from the JPSS and DMSP-Follow-on missions.

Recommendation IIFS-7 to CGMS

To consider harmonization of the appropriate layers of the future X-Band Direct Broadcast services, for instance as concerns frequency or transmission protocols based on CCSDS standards.

Recommendation IIFS-8 to JMA

To consider a broadcast service to facilitate access to Himawari-8 and -9 data in particular for users in the Pacific Islands that have limited Internet connectivity.

Recommendation IIFS-9 to CGMS satellite operators

To investigate the potential use of satellite-to-satellite communication (e.g., Tracking and Data Relay Satellite System, TDRSS) as a mechanism to support timely collection and redistribution of polar-orbiting satellite data in future systems.

SATELLITE SOUNDER SCIENCE AND PRODUCTS**Recommendation SSSP-1**

In the interest of a more targeted focus, it is recommended to no longer support the Web site areas for “Current/Future Weather Satellite Programs” and “Operational Instrument Characteristics and Performance.” These are adequately supplied by the WMO.

Recommendation SSSP-2

The Cal/Val topic area currently provides capability for direct inter-comparison of suites of global atmospheric sounding products produced by NOAA, EUMETSAT and UCAR (GPSRO) via its link to NPROVS. This has a capability to be expanded to include products from other global centers (i.e., India ...).

Action SSSP-1

A. Reale and L. Lavanant to change Web page content according to recommendation SSSP-1 and to investigate and facilitate expansion of the Cal/Val capabilities following Recommendation SSSP-2.

Action SSSP-2

The WG Co-Chairs, Chris Down and the Webmasters (Leanne Avila, Bill Bellon) will perform the following tasks:

Investigate (formal) the user base (audience), scope and goals of the Sub Group for Satellite Sounder Science and Products Web page.

Provide feedback on the current page design and provide detail on potential upgrades to functionality, shape and design.

Determine the overall overhead for all potential changes and enhancements to the Web site.

Provide recommendations for controlling information content on products and contacts for those products.

Recommendation SSSP-3

The Web page areas “Scientific Processing packages” and “Direct Readout” should be merged into “Direct Readout and Scientific Processing Packages” including the absorption

of direct broadcast technical sub-group following the decision to absorb the technical sub group on direct broadcast packages into the SSSP WG.

Action SSSP-3

The SSSP and Direct Readout WG Co-Chairs to agree on the re-structuring/consolidation of the information of both groups.

Action SSSP-4

The WG (Anna Booton/Natalie Selbach) will present a preliminary summary of the currently available products, initially focusing on sounding and trace gases, within the Products area of the Web site. The goal is to provide users with a comprehensive technical overview detailing information such as the required input data and data formats and science.

Action SSSP-5

CIMSS (Kathy Strabala, Liam Gumley) will append a table to the technical report “Report on DB Processing Packages” that presents supported functionality in a one page summary which will be appended to the SSSP direct broadcast processing package area.

Recommendation SSSP-4 to CIMSS

To continue the support and development of IAPP in order to maintain operational use at facilities such as the Satellite Application Facility on Climate Monitoring (CM-SAF). This support should include updates, for example, that would affect the usability of the software in the case of instrument channel failure, as well as the inclusion of new sensors within the software package.

Action SSSP-6

The WG Co-Chairs to forward recommendation SSSP-4 to CIMSS.

Recommendation SSSP-5 to EUMETSAT

The SSSP WG recommends to expand the areas of direct readout observations to areas currently not covered. EUMETSAT should provide a timetable showing the plans for a possible expansion of the Metop-A HRPT services

Action SSSP-7

Jörg Ackermann and Christelle Ponsard to forward recommendation SSSP-5 to the appropriate EUMETSAT bodies and report to the WG.

Recommendation SSSP-6 to IPO/JPSS

A Level-2 retrieval package for IASI should be funded and made available for IASI DB users.

Action SSSP-8

The WG Co-Chairs should forward recommendation SSSP-6 to IPO/JPSS.

Action SSSP-9

The WG Co-Chairs will provide a post conference synopsis of product area presentations of ITSC-XVII. The WG Co-Chairs will recommend further level 2 algorithm developments where needed. Product area priorities are to be considered for

solicitation/selection of product topic areas. The results of the continuing validation will be presented at the next conference.

Action SSSP-10

Tom Achtor will conduct a survey of the WG's user community to provide a comprehensive table of available software packages for data analysis and visualization of atmospheric science data.

Recommendation SSSP-7

Product user groups should study and have input into the architecture of such processing systems for hyperspectral and active remote sensing instruments to determine their requirements for issues such as processing, IT infrastructure need, as well as methods for data acquisition or development of algorithms to better assimilate critical data from the large quantities of data that organizations may or may not be able to process in the timeframes required by operational organizations.

Action SSSP-11

AK Sharma to provide NESDIS plans to accommodate high data rates, processing and distribution systems.

Recommendation SSSP-8 to IPO/JPSS

To provide timely updates on expected implementation schedules and concerns (including for IPOP).

Action SSSP-12

To POC: Lihang Zhou should forward recommendation SSSP-8 to the responsible bodies.

Recommendation SSSP-9 to EUMETSAT

It is recommended that EUMETSAT makes the calibration datasets available after concurrence with NOAA via the EUMETSAT Web site.

Action SSSP-13

Jörg Ackermann and AK Sharma to forward recommendation SSSP-9.

Recommendation SSSP-10

It is recommended to promote WMO Web site and co-ordinate WMO and SSSP synergy for coherent and complementary information dissemination.

Action SSSP-14

L. Lavanant, A. Reale and J. Lafeuille to facilitate recommendation SSSP-10.

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), Eva Borbas, Pascal Brunel, Yong Chen, Ralph Ferraro Stephanie Guedj, Yong Han, Nicole Jacquinet, Fatima Karbou, Tom Kleespies, Sung-Yung Lee, Xu Liu, Marco Matricardi, Stuart Newman, Ben Ruston, Peter Wang, Banghua Yan

2.1.1 Introduction

Four areas were discussed in the RTSP-WG meeting at ITSC-17: issues relating to land surface emissivity modeling, line-by-line modeling, cloudy and aerosol-affected radiative transfer, and instrument spectral response characterization.

The new action items listed below are to be completed by May 2011.

Louis Garand is leaving as Co-Chair of the RTSP-WG after ITSC-17. Marco Matricardi was nominated and duly approved to replace Louis as RTSP-WG Co-Chair.

2.1.2 Land Surface Emissivity Modeling

The availability of many surface emissivity models was noted. It was suggested a catalogue of the available emissivity models and/or data be created and made available to the community, not just the ITWG. Ralph Ferraro requested (prior to the WG meeting) that the IPWG be notified of what land surface emissivity models were available for use in RT modeling.

Ben Ruston has previously catalogued land surface emissivity model via the NWP-SAF.

Action RTSP-1

Ben Ruston to update NWP-SAF page with the latest information of available land surface emissivity models and data for use in RT modeling.

Action RTSP-2

Following on from Action RTSP-1, Paul van Delst to notify IPWG members of the availability of the land surface emissivity model catalogue.

It was also noted that RT/surface emissivity modelers need to assess the current assumptions about the surface reflectivity being specular or Lambertian. At microwave frequencies, Fatima Karbou and Stephanie Guedj have compared different assumptions about the surface reflectivity ranging from specular to Lambertian, with an intermediate quasi-Lambertian assumption also, and have seen a large effect over desert and snow areas where scattering effects dominate. These differences are noticed near nadir, as expected. These data are available upon request from Fatima Karbou.

The assessment of the accuracy of land surface temperature retrievals and their comparison with analyses for certain surface types was discussed. The target areas of interest include such surface types as desert, forest, sea ice, etc. Roger Saunders pointed out that the simpler surface types, in terms of emissivity characterization, on which effort should be concentrated to increase satellite radiance data assimilation over land should be explicitly identified. Louis Garand suggested starting with geostationary retrievals to get a time series, but direct comparisons of low earth orbit retrievals should also be done.

Action RTSP-3

Yong Han to coordinate with Weizhong Chen (NOAA LDAS contact) to start organizing this work.

2.1.3 Line-by-line (LBL) Modeling

Currently, the fast RT models (RTTOV and CRTM) are all based on LBLRTM.

Recommendation RTSP-1 to NWP-SAF and JCSDA

Ensure the future development of LBLRTM is secure.

As with the land surface emissivity models, the LBL models being actively developed and in use should be catalogued, as well as which group(s) is(are) using what models.

With emphasis on the infrared region (where we have hyperspectral instruments in orbit), to assess the quality of LBL models we generally look at:

1. Accuracy of spectroscopy, and
2. Assessment of spectroscopy differences.

Recommendation RTSP-2 to LBL modelers and users

Exploit all possible methodologies to validate LBL models and spectroscopy. For example: validation of LBL calculations against observations using high quality in situ data; validate using retrieved profiles to compare instrument residuals to instrument noise.

Regarding the use of field campaign data, the links to previous and current field experiment Web sites need to be updated or verified on the RTSP-WG Web site. Additionally, there is a need to catalogue available in situ data for validation (sondes, dropsondes, rain estimates, etc.) to determine target periods where there is good independent data available (which channels should be targeted for validation?).

Action RTSP-4

RTSP-WG Co-Chairs to coordinate catalogue of datasets for validation:

- **Target periods**
- **Field experiments with in situ data coincident with instrument overpasses.**

Emphasis is placed on those datasets with high water vapour loading, and field campaign organizers are encouraged to pursue those conditions.

This action is in concert with recommendations made at the 2nd International IASI Conference.

The dataset catalogue will be listed on the RTSP-WG Web site.

Action RTSP-5

Stuart Newman to notify RTSP-WG when water vapour continuum model updates due to CAVIAR work become available.

Line mixing for trace gas molecules, such as CH₄, should be included in LBL models as soon as possible.

Action RTSP-6

Nicole Jacquinet to report to RTSP-WG on the upcoming HITRAN conference (June 2010) in particular on spectroscopy data and modeling updates applicable to the RTSP-WG.

2.1.4 Cloudy and Aerosol-affected Radiances

Regarding cloudy and aerosol-affected radiance assimilation, questions regarding requirements for RT models were raised:

1. What accuracy is required?
2. What are the computational speed requirements?
3. How to handle cloud overlap?
4. How to handle footprint non-uniformity?

The first two requirements above are difficult to answer – their inclusion in this report is to start people thinking about them. Regarding the last two questions, Marco Matricardi has addressed these issues in RTTOV-9 (ECMWF Tech. Memo 474, 2005).

Recommendation RTSP-3 to NWP centres

Begin routine monitoring of cloudy and aerosol-affected radiances. This first step towards assimilation of the radiances will also provide guidance to the RT modelers.

It was noted that the required RT model inputs for clouds (e.g., particle effective radius) are not necessarily provided by the forecast models which typically supply quantities such as cloud water, or ice, content. Documentation of techniques, and software, to perform conversions between the supplied and required variables for RT models is needed.

Action RTSP-7

RTSP-WG Co-Chairs to report on what cloud model outputs are available from various centres for input to RT models.

Action RTSP-8

RTSP-WG Co-Chairs to publish on the RTSP-WG Web site methods (and software if available) to convert forecast model outputs of cloud data to those quantities required by RT models.

2.1.5 Instrument Characterisation

The sharing of spectral response function (SRF) information between the various RT modeling groups involved in the ITWG is quite good. However, it would be preferable if the various instrument parameters required by RT modelers be made available as soon as possible (even if they are not finalized) by the instrument vendors and mission scientists and managers. The quicker RT modelers get this information, the earlier they can begin modeling

the instrument and thus minimise any delay in monitoring and assimilating the radiance data after launch.

Action RTSP-9

Paul van Delst to notify the RTSP-WG when NPP VIIRS SRF data become publicly available (including non-US-based researchers). The NOAA IPO has already been contacted with the request.

Recommendation RTSP-4 to ITWG Co-Chairs

Contact the various space and research agencies to ask them to make instrument parameters required for fast RT modeling be made available to the RTSP-WG as soon as possible so as to allow dissemination to the interested parties.

Paul van Delst brought up the relative differences seen in simulated brightness temperatures for NPP ATMS between using a boxcar response and high-frequency spectral responses digitized after measurement from scanned paper documents. It would be preferable for the high resolution measurements of microwave channel spectral response be retained in digital form and passed along to RT modelers.

Recommendation RTSP-5 to ITWG Co-Chairs

Contact the various space and research agencies to ask them to retain the high spectral resolution scans of microwave instrument channel responses in digital form and make those data available to the RTSP-WG as soon as possible so as to allow dissemination to the interested parties.

The topic of SRF data coordination was raised. Given that SRF data can be modified post-launch to address any issues or problems, it is difficult to determine whether the SRF data used in fast RT models is the current and/or best data available. Action RTSP-12 mentioned below addresses this in finalizing the action from ITSC-16.

2.1.6 Miscellaneous

The RTSP-WG Web site hosted at SSEC is not easily accessible for modification by the RTSP-WG Co-Chairs (or other group members). SSEC already offers an easier alternative to allow more interactive updates of the RTSP-WG page by the working group's members.

Action RTSP-10

Paul van Delst to contact SSEC Webmasters responsible for the RTSP-WG Web page and coordinate transitioning the current RTSP-WG Web page to the Plone groups site at SSEC. The RTSP-WG will be notified when this is completed.

Tom Kleespies indicated he would update his tangent-linear (TL) and adjoint (AD) coding class notes and examples on the RTSP-WG Web site.

Action RTSP-11

Tom Kleespies to update his TL and AD coding notes and examples on the RTSP-WG Web site.

Regarding the outstanding action items for the RTSP-WG from ITSC-16, Paul van Delst will work towards resolving (i.e., completing or deleting with explanation) any incomplete items.

Action RTSP-12

Paul van Delst to resolve any outstanding RTSP-WG action items from ITSC-16 by March 2011.

2.2 CLIMATE

Web site: <http://cimss.ssec.wisc.edu/itwg/cwsq/>

Working Group members: Jörg Schulz (Co-Chair), Peter Thorne (Co-Chair), George Aumann, John Bates, Bill Bell, Ruiyue Chen, Nathalie Courcoux, Antonia Gambacorta, Mitch Goldberg, Anton Kaifel, Richard Kelley, Dieter Klaes, Allan Larar, Xu Liu, Stephen Mango, Carl Mears, Thierry Phulpin, Roger Saunders, Martin Stengel, Dan Zhou and Cheng-Zhi Zou

2.2.1 Introduction

Satellite data contribute an increasingly influential role in monitoring climate variability and change as well as understanding climate processes. They will continue to do so in the new era of climate services as the need for increased spatial and temporal fidelity as well as global coverage in our observational datasets increases. The climate working group considered five specific areas in their discussions:

- Current satellite programs / missions still in planning stage - do they meet climate requirements? If not, what specific recommendations do we have and how can we influence them?
- Ensuring the data record - metadata, reprocessing activities, data archival - is everything as rosy as it should be?
- Cal/val activities - GSICS, GRUAN, CLARREO - are they looking like they will meet our needs? How can we most effectively influence / support them?
- Consideration of work programmes for climate research and analysis already in operation / advanced planning - are there things they should be doing that they are not? Best practices being learnt?
- Gap analysis - are there data that as a global community we should be looking at but are not? What should the priorities be and why?

It was envisaged that these five areas would cover the continuum of points participants wished to raise.

Several recommendations to CGMS arose from the discussions in the group. The submission of them is summarised in the following action for the ITWG Co-Chairs.

Action Climate-1

ITWG Co-Chairs to take action on Recommendations Climate-2, -3, -9, -10 -11, -12, -17 and -20, largely through dissemination to CGMS.

2.2.2 Current Programs / Missions in Planning

Conically scanning microwave imagers/sounders

There was substantial discussion around SSMI/S instrumentation and its use for climate applications. SSMI/S provides information on a number of societally critical parameters such as precipitation. John Bates noted that a clear need exists for an interim attempt at climate quality that lags the NWP timescale by at most a week to serve newly emerging climate services. A process to improve use of SSMI/S for such applications is currently being set up in the US in a somewhat ad hoc fashion including regular meetings (every 2-4 weeks). It will initially cover the F13-F17 suite. There are issues, in particular related to instrument characterisation, to be resolved for certain parameters and regions. Similar developments using ATOVS to provide some atmospheric parameters have been performed by the

EUMETSAT CM-SAF. It was noted that this type of climate service key requirement will increasingly need to be developed.

Discussion then turned to the long-term continuity of these increasingly critical microwave imager/sounder instruments. It was noted that 2014 is the last scheduled launch of the current instrument type and that the development and deployment of a follow-on conically scanning MIS mission was not presently assured. Following the reorganisation of the US program this is now under the sole purview of DoD and concerns were raised as to whether a microwave imager is a high priority. Also in EUMETSAT planning of Post-EPS such an instrument is in the plans but with medium to low priority and its realisation is not assured.

Recommendation Climate-1 to satellite agencies

There is a critical need for a follow on microwave imager/sounder for climate purposes because although they were not initially intended for climate they have proven hugely useful. We still look primarily to DMSP to provide such measures because of the need for LECT continuity for climate record continuity purposes. A similar imager/sounder on a post-EPS orbit would also be immensely valuable and EUMETSAT is encouraged to continue planning in this regard. Suitable representation from the climate community in the planning phase of both programmes to ensure the continuity of the record is requested.

Action Climate-2

ITWG co-chairs to communicate Climate Recommendation 2 to CGMS via Mitch Goldberg of STAR/NOAA.

Spectral Response Function Change Management and Mitigation

The atmospheric column is changing in a vertically differentiated manner. Changing of the spectral response function has two issues for climate. The first, and that dealt with typically to date, is the instantaneous stitch that must be performed to avoid an obvious jump in the series. The more insidious aspect of the fact that the long-term trends for the new and old radiative band will differ has not, in general, been dealt with to date. This will add red noise to the time series and the effect increases rather than decreases over time.

There is a clear need to characterize the likely effect of small changes in spectral response function that occur when switching instrument generation on the long-term trends. This is an issue for MSU – AMSU – ATMS. For example, multi-decadal trends calculated from HADAT2 radiosonde data using MSU channel 2 and AMSU channel 5 nadir weighting functions are different by about 10%, because the AMSU channel 5 weighting function peaks lower in the troposphere with correspondingly less stratospheric weight. A corollary to this is to archive/publish detailed spectral response functions for microwave sounders (and probably other instruments as well). (See poster 4.2).

In a similar vein, there is also a need to evaluate the efficacy of hydrometeor removal algorithms used for microwave sounders, including dependence on the size of the field of view (FOV). FOV size seems to be evolving over time as we move between instrument series. It is known that similar issues pertain to other instruments and regions of the spectrum, e.g., the HIRS series. It was noted that radiative transfer codes could be used on climate models to ascertain the likely influence of planned changes against the expected climate change signal to ascertain whether planned changes in spectral channels or viewing geometry

were likely to have a deleterious impact upon the long-term climate record long before the instrument is even manufactured.

Recommendation Climate-2 to satellite agencies

Satellite agencies that are considering changing the frequency or viewing geometry / resolution of heritage measures need to consider the impact on climate monitoring and particularly trend characterisation. This can be easily achieved through the use of radiance simulators and climate model output that is freely available through the CMIP portal.

Orbital Slots

The issue was raised that space agencies tend to use almost the same pm orbit slot and that there is a lack of an international framework to effectively manage orbital choices to maximise the global value. It is likely that for at least some aspects of the climate system an important component of the change will be changes in the diurnal cycle characteristics. Therefore there is an issue here for climate and presumably other data users where understanding change in the diurnal cycle characteristics are important.

Recommendation Climate-3 to CGMS

Recognising that climate change may have a diurnal cycle component we recommend to CGMS to explicitly consider the coordinated international phasing of satellites to ensure adequate sampling of diurnal cycle.

Temporal Instrument Overlap Requirements

There was substantial discussion around current practices and requirements for inter-satellite overlaps to assure the climate record. It was noted that these requirements were likely to be instrument specific. It was rather depressingly also noted that this discussion has been almost a standing item in climate working group deliberations for well over a decade and that generalist recommendations had been made before and there was little value to be gained in repetition. Several people pointed out that increasing overlap requirements were a substantial burden on satellite agencies. It was noted that some information on this issue exists scattered in the literature as part of larger studies, but that no systematic quantitative assessment of the impact of different overlap strategies and their fundamental value vis-à-vis the cost had been undertaken to the knowledge of participants.

Recommendation Climate-4 to ITWG Co-Chairs

Consider a session at next ITWG specifically on analyses of overlap requirements for continuity across changes in platform or technology (e.g., HIRS2/3/4, TOVS to ATOVS, AIRS to IASI, SSMI to SSMIS). With a view to promoting the appearance of such studies in the peer reviewed literature and making robustly quantified recommendations on overlaps required when the satellite technology changes and quantifying GCOS climate monitoring principles.

Action Climate-3

ITWG Co-Chairs to consider viability of Recommendation Climate-4.

It was noted that in the shorter term EUMETSAT needed to start careful consideration of how they are going to transition from METOP-A to METOP-B. It was pointed out that NOAA has considerable experience here, and one lesson learnt was that it was key to forward plan. It was recognised that only one platform can be the live platform and that the data from

the remaining platform may not be available in real time. Nonetheless this data will be incredibly valuable to EUMETSAT and the climate community and they were urged to continue METOP platforms for as long as possible even if only in substantially delayed mode.

Recommendation Climate-5 to EUMETSAT

EUMETSAT to pro-actively consider the multiple platform issue with consultation with NOAA who have considerable experience in this regard. Discussions need to recognise the import to climate of the longest term record and that the non-operational platform need not be available in real-time to be useful for climate.

Action Climate-4

Jörg Schulz to communicate Recommendation Climate-5 to EUMETSAT.

The Opportunity for Global SNO Assessments with METOP A/B

With METOP-A and METOP-B being scheduled to be less than 50 minutes apart in LECT the opportunity will exist for SNO type measures globally rather than just at the poles between two near-identically instrumented platforms. This affords a perhaps unique opportunity to assess the validity of the assumption that SNO measures can be used to infer global inter-calibration offsets. Because of the increasing importance of SNO as a fundamental technique to ascertain a long-term apparently homogeneous record working group participants felt it important to promote this analysis by EUMETSAT and GSICS partners as a high priority activity to be assured of the fundamental global validity of the SNO method.

Recommendation Climate-6 to EUMETSAT and GSICS

EUMETSAT and GSICS are urged to look pro-actively at the METOP A/B global SNO measurements opportunity that will be afforded to ascertain the likely validity of the global application of high latitude only derived SNOs for other platforms through systematic experimentation and to write this up in the peer reviewed literature.

Action Climate-5

Jörg Schulz to communicate Recommendation Climate-6 to GSICS and EUMETSAT.

2.2.3 Metadata, Reprocessing, Archival

Use of Radiances in Reanalyses

As was raised in the climate oral session, there has been a lot of work on the preparation of FCDRs under GSICS and other activities that reanalysis centres should use. The newly created FCDRs are more homogeneous than the radiance databases that are currently ingested into model-based reanalyses and would be expected to lead to more homogeneous reanalysis products as a result. More speculatively, there may also be value to use these data as an anchor data set in the reanalysis rather than the inhomogeneous and patchy radiosonde records and aircraft data that are typically used at present.

Recommendation Climate-7 to reanalysis centres

Reanalysis centres are urged to use suitable satellite FCDRs that have had substantial work applied for future reanalyses activities. Quality feedback

information, such as data departures from existing reanalyses should be established for the new FCDRs to provide further information on the quality of the observational record. Furthermore, reanalysis centres should consider whether it is more applicable to anchor future reanalyses to these globally complete and consistently processed FCDRs rather than to conventional data sources.

Action Climate-6

Peter Thorne to communicate Recommendation Climate-7 through the joint GCOS/WCRP Working group on observations for reanalyses.

Improved Access and Documentation of Observational Data Sets for the CMIP5 and the Next Intergovernmental Panel on Climate Change (IPCC) Report

There was discussion around the value of an open access CMIP type model for the distribution of observational data products. This type of model would include common standards for data and metadata as well as intermediate products. Also extremely valuable is the distribution of tools with the data that allow for format and grid, e.g., satellite product to climate model grid conversions.

There is also a need for a maturity index to differentiate between the products in as objective a manner as possible. It was noted that as climate science becomes increasingly important the expectations of openness and transparency are always increasing. It is key that we as a community meet these expectations. It was argued that to be included in the next IPCC may require such practices for a given dataset although at this stage that is largely speculative as the IPCC author team and guidance is still in the process of being formulated.

Recommendation Climate-8

Identify potential observational data sets that seem suitable for comparison to the CMIP5 fields for the next IPCC report. Datasets should be converted to standard grids (where possible), and to standard CF compliant NetCDF to be hosted on the Earth System Grid or similar standard, and be documented.

Action Climate-7

John Bates to communicate Recommendation Climate-8 to the SCOPE-CM executive panel. Jörg Schulz to communicate Recommendation Climate-8 to the EUMETSAT SAF network.

Cal / Val Activities

Working group participants agreed that cal/val efforts were key both pre-launch and during operations. They stressed that a key aspect of any successful cal/val strategy is a combination of approaches allowing for absolute certainty in characterising drift through complementary estimation. It is not a case of pick and mix and all cal/val activities have importance in ensuring the climate record from satellite measures going forwards.

Metrology Input

Bill Bell briefly outlined the outcomes of the recent BIPM / WMO meeting that took place in Geneva with a strongly international participant list. They took eight measurement areas and investigated how they ensured traceability. His main interest was in microwave sounders and imagers. Jim Anderson plugged CLARREO and the planned on orbit calibration. For MW sounders / imagers group pre-launch cal/val was felt to be the key and it was noted that the

GSICS activity would be strengthened considerably by metrologist input. It was recognised that the CEOS WG on cal/val needed to be strengthened for passive microwave measures. The meeting report will be published in May / June.

Recommendation Climate-9 to space agencies

Space agencies to recognise the importance of traceability in characterisation of the fundamental measurement and to actively engage the metrologist community throughout the process but particularly in pre-launch characterisation building upon the recent BIPM-WMO meeting.

Action Climate-8

Bill Bell to distribute report and presentations from the recent BIPM-WMO meeting to this working group and the ITWG Co-Chairs for their consideration.

GPS-RO as Fundamentally More than a Record in its Own Right

It was argued that GPS-RO constitutes more than a CDR in its own right. Because of its fundamental characteristics and the sampling pattern it can act as a reference quantity for operational satellite measures related to temperature and humidity with quasi-global coverage and covering the entire diurnal cycle. The GNSS network on which it relies will exist for a long time. There were concerns raised about the long-term GPS-RO commitment from space agencies.

Recommendation Climate-10

ITWG climate working group notes that GPS-RO in and of itself constitutes a valuable climate record. But perhaps of greater value is the cal/val it affords to the operational satellites. It is imperative that a long term capability be retained.

CLARREO-type Missions

A calibration payload precessing orbit satellite was seen as very important to climate and other applications. Concerns were raised regarding whether performance would match the expectations when in space. Particular concern was raised about noise if it is a precessing orbit as the overpasses will be short lived. It was also noted that at least initially the CLARREO payload will not carry a traceable microwave instrument and this was identified as a concern going forwards. It would be highly desirable for future calibration payloads to have such a capability.

Recommendation Climate-11

Absolute calibration missions (such as CLARREO) should be planned to continue after CLARREO's expected lifetime and include other spectral regions including microwave radiances which is recognised to be hugely challenging.

GRUAN

There was some discussion around the current status of the GCOS Reference Upper Air Network. Peter Thorne stressed the importance of engagement in the process by the satellite community to ensure that their needs were met. Participants requested an update on the current status.

Action Climate-9

Peter Thorne to distribute report from latest GRUAN meeting to the Working Group so that they are up to date.

Direct comparisons between AIRS and IASI have proven these instruments to be high quality. Such spectrally resolved infrared radiance datasets have been demonstrated to be a very powerful tool for validating weather and climate analyses by comparing simulated radiances from these analyses with measured radiances. However, the limiting factor is the accuracy of the radiative transfer model which needs highly accurate atmospheric state profiles to initially “anchor” the model to agree with the high accuracy infrared radiances.

Recommendation Climate-12

To agencies to provide and sustain high quality in-situ observations through programs such as GRUAN to improve radiative transfer models co-located in space and time. Furthermore, to advertise the existence of such data to their users.

GSICS and SCOPE-CM

Concerns were raised that GSICS need to do a better job of gathering requirements from the TCDR community to prioritise appropriately their activities. Last year there was a user meeting that led to the formulation of a formative user group and this development was welcomed. However, further efforts in this regard were encouraged by working group participants. It was noted that such communication of requirements was a two-way not a one-way process and that SCOPE-CM could do much better in communicating their fundamental requirements to GSICS.

Recommendation Climate-13 to GSICS

GSICS should continue actively reaching out to user community and capture evolving requirements.

Action Climate-10

Mitch Goldberg to communicate Recommendation Climate-13 to GSICS.

Recommendation Climate-14 to SCOPE-CM Exec panel

SCOPE-CM Exec panel to formulate their requirements to GSICS.

Action Climate-11

John Bates to communicate Recommendation Climate-14 to SCOPE-CM.

Renewal of Automatic Weather Station at DOME-C

Polar orbiting satellites provide a key climate monitoring capability. All polar satellites pass over Dome-C about eight times each day, permitting very accurate cross-validation. Automatic Weather Station (AWS) 8989 at Dome-C has produced excellent results for the relative cross-validation with AIRS and IASI data. AWS8989 has been in operation since 1998. Problems with noise and accuracy have limited the use of AWS8989 for absolute validation of IR window channels. In 2005 researchers funded by the Italian Space Agency installed an AWS a few km from AWS8989, at a location considered to be less sensitive to the potential thermal contamination due to the expansion of the facilities at Dome-C. Unfortunately the AWS failed after producing excellent data (monitored by AIRS) from 27 January 2005 through 17 November 2005.

Recommendation Climate-15

To put up an alternate AWS at DOME-C as back up for AWS8989 that has proven invaluable for satellite cal/val.

Action Climate-12

ITWG Co-Chairs to communicate this to CGMS with the recommendation to encourage the Italian Space Agency to resume the station at DOME-C.

2.2.4 Planned and Ongoing Analyses

ESA Climate Change Initiative

Roger Saunders outlined the new ESA Climate Change Initiative (CCI). The CCI is a 6-year programme with a financial budget of 75 million Euro. The concept is to reprocess ESA satellite measurements to climate quality and potentially combine them with other satellite observations for 11 ECVs (4 marine, 3 land, and 4 atmosphere). For each there will be ~2 million Euros over an initial 3 years for a consortium. Bids are currently under consideration. There will also as part of the process be a Climate Modellers User Group (CMUG). Their primary mission is to ensure it is fit for purpose for climate and reanalyses. This CMUG is running and consultation is underway. Now is the time to influence the user requirements and technical specifications of the various products. It was stressed that products would be radiances (FCDRs) as well as geophysical parameters (TCDRs). This first phase of the CCI will yield beta datasets comprising only a few years of data in some cases. Then there will be an additional 3 years for the generation of the maximum possible length time series. Concern was raised that there may not be a joined up consistency in approaches. Questions also were raised over whether a process based approach rather than ECV based approach was required.

Action Climate-13

Roger Saunders to provide ESA CCI documentation to the working group members for feedback.

Given the growing importance of climate to society openness and transparency is key as discussed in Section 2.2.3. It was felt to be useful to stress this to the CCI participants at the outset.

Recommendation Climate-16 to ESA

To ESA to strongly consider clear and unambiguous guidance on data openness and transparency from the outset to the CCI initiative to ensure that datasets created are verifiable and exhibit best practices.

Action Climate-14

Roger Saunders to feedback Recommendation Climate-16 to ESA CCI.

Need for Multiple Analyses and Characterisation of Uncertainty

It was recognised that because the historical and most present day data lacked absolute traceability that a degree of uncertainty was inevitable. The largest source of this uncertainty will be the structural uncertainty imparted through methodological choices which have no rigorous basis. To this end aims to produce one best dataset are dangerous as the chances of that dataset being absolutely accurate in its portrayal of the evolution of the climate system are infinitesimally small. There is therefore a need to produce multiple analyses which should be seen as complementary rather than redundant estimates. It was also recognised that much better efforts could be made than has historically been the case to characterise dataset uncertainties by the dataset builders. It was also noted that there may exist some datasets that

made definitively bad choices but which cannot currently be rejected because the necessary analyses to ascertain this have not been completed. This ensemble approach to dataset creation would permit such analyses.

Recommendation Climate-17 to CGMS

To CGMS to support multiple analyses of FCDRs and TCDRs recognising that there are many methodologically uncertain choices required.

Further Work on the IASI / HIRS Comparison on METOP-A

Working group participants were impressed by the presentation by Lars Fiedler of EUMETSAT on the IASI-HIRS comparison. They saw substantial value for climate applications in the approach and were keen to see it more widely publicised through a write up in the peer reviewed literature. That way the approach may be adopted or modified by others. Participants were also keen to get to the bottom of why only certain HIRS channels drifted and whether this was a real physical effect and therefore applicable to other HIRS payloads or instrument specific. Further work to write up as a peer-reviewed paper was strongly encouraged.

Recommendation Climate-18 to EUMETSAT

To EUMETSAT to write up the IASI / HIRS intercomparison presented at ITWG in the peer reviewed literature including an analysis as to why the channels vary in their response to the extent where such analysis is possible.

Action Climate-15

Dieter Klaes to communicate Recommendation Climate-18 to EUMETSAT.

Understanding Diurnal Drift Impacts More Unambiguously

Many climate datasets related to the ITWG need diurnal adjustment to reduce the effects of orbital drift when constructing long-term records. These include temperature, clouds, precipitation, UTH, and maybe even total column water vapor. Currently, many of the schemes used seem both ad-hoc and not validated. It would be very instructive to intercompare the diurnal climatologies (or other techniques) used by different groups to cope with this issue. We should also encourage the reanalysis centers to calculate and distribute their versions of diurnal climatologies for each relevant parameter.

Recommendation Climate-19 to reanalysis centres

To reanalyses centres to provide their diurnal climatologies at hourly resolution for a suite of geophysical and radiance parameters including surface characteristics in support of satellite dataset construction efforts.

Action Climate-16

Peter Thorne to communicate this through GCOS/WCRP Working Group on Observations for reanalyses.

2.2.5 Gap Analysis

Several topics were covered of which the most pertinent (in brief) were:

- We could conceivably infer a lot about cloud properties from the hyperspectral. Bearing in mind that clouds and cloud processes are a key constraint on our ability to infer climate feedbacks and therefore sensitivity efforts in this area would be useful.

- Radio frequency interference was recognised as an important issue for climate. There are two important aspects: issues of sub-detectable interference; and deletion of affected data. Both will almost undoubtedly be non-stationary in space and time. Both impact the ability to infer the true global and regional scale changes. The possibility to undertake “what if” type analyses was very briefly touched upon.
- There is likely value to an intercomparison of methods and not just final results for various CDRs. We are starting to undertake this work for MSU/AMSU.
- It was noted that CEOS was mandated to respond to the 2010 update to the GCOS Implementation Plan. Mitch Goldberg was keen to get input from this group.

Action Climate-17

Mitch Goldberg to distribute CEOS draft response to the 2010 update of the GCOS Implementation Plan for comment when ready.

For Post-EPS two sets of specifications were developed – one for NWP and one for climate. The latter is adding important requirements concerning systematic errors and long term stability which are not treated in the NWP context as their focus is only high precision matters. The view from EUMETSAT was that a consideration of such differentiated needs of NWP and climate is a mandatory step in developing mission requirements. They suggested that this process should be followed for future missions as a rule.

Recommendation Climate-20 to CGMS

To CGMS to consider the potential benefits of the NWP and climate requirements approach adopted by EUMETSAT as part of the post-EPS mission planning.

Action Climate-18

Jörg Schulz to send details on the tables to NOAA for JPSS planning.

2.3 DATA ASSIMILATION AND NUMERICAL WEATHER PREDICTION

Working Group members: Godelieve Deblonde (Co-Chair), Niels Bormann (Co-Chair), Bjarne Amstrup, Nancy Baker, Sid-Ahmed Boukabara, Bill Campbell, Brett Candy, Dave Ector, Vincent Guidard, Wei Han, Fiona Hilton, Heather Kilcoyne, Thomas King, Magnus Lindskog, Will McCarthy, Kozo Okamoto, Detlef Pingel, Roger Randriamampianina, Marc Schwaerz, Yi Song, Chris Tingwell.

2.3.1 Introduction

At this meeting, an increase was noted in the number of National Meteorological Services (NMS) becoming active in direct assimilation of radiances. An important number of presentations were given on the assimilation of surface sensitive channels in both the infrared and microwave regions of the spectrum including updates on the land surface modeling capabilities with both the RTTOV and CRTM models. An update on DMSP SSMIS instruments was also provided. DMSP F18 data will soon become available to users. The importance of SSMIS was noted especially in a context of a decreasing number of online SSMI and in the future AMSU-A and AMSU-B/MHS instruments.

An overview presentation on the use of MetOp IASI in NMS was also given. Many centers assimilate the radiances in both global and limited area models while the maximum number of channels assimilated remains below 200. Among those channels, at most centers, only those that sense above clouds are retained. Channels are also predominantly located in the long wave CO₂ band. Experimental testing is underway at several centers on assimilating radiances in cloudy FOVs, and some have started using these operationally. After the MetOp series, an IASI-NG instrument (phase 0 completed last year) will be included on Post-EPS. The insight into the problem of representing hyperspectral radiances with principal components has advanced. One of the main issues that remains is how to deal with clouds.

Information was also provided on the status of NPOESS and the program that will replace it, namely JPSS, to be co-operated by NOAA and NASA, and the follow-on to the DMSP mission to be operated by DoD. The audience was also informed by NOAA meeting participants of plans with respect to a follow-on mission to the highly successful COSMIC constellation (six GPS radio-occultation micro-satellites). These data have become particularly important due to their role as an anchor for the radiance bias correction of assimilation systems. The COSMIC-II program is to be shared between NOAA and Taiwan. A constellation of 12 micro-satellites is planned with increased sampling over the tropics. The target launch date is 2014.

2.3.2 NPP and NPOESS Restructuring

Heather Kilcoyne, NOAA IPO, informed the WG that a transition for the NPOESS program is underway. Segments of NPOESS are getting transferred to JPSS. JPSS is a NOAA program with NASA procuring the instruments (launch date of 2017 for JPSS1 and 2021 for JPSS2). The naming of the satellites will be J1, J2, etc... instead of C1, C2, etc. The NPP instruments are going ahead as planned. There is a cal/val team in place and a cal/val Web page is being set up but is experiencing some delays. Under the GRAVITE project, IPO has generated proxy data (based on data from the MODIS and IASI instruments) in HDF5 format to simulate NPP instruments. This data is not ITAR protected. There are no plans for changes to SafetyNet.

Action DA/NWP-1

Heather Kilcoyne (NOAA) will inform NWP WG (via mailing list) when the IPO (Integrated Project Office) cal/val Web site for NPP instruments will be up.

Recommendation DA/NWP-1 to US Department of Defense

Noting that the NPOESS program is being restructured into two separate programs, one being run by DoD and the other by NOAA/NASA known as JPSS, the WG recommends that imaging and sounding capabilities should be included on the DoD satellite, ideally including MW and IR. Furthermore, data should be free and readily accessible to the general international user community.

Recommendation DA/NWP-2 to NOAA/NASA and DoD

The short operational delivery time of the NPOESS system was an extremely attractive component of the system design. The WG recommends that the SafetyNet system (ground receiving system) is retained in the NPOESS restructuring process for both satellite programs (i.e., JPSS and DoD).

2.3.3 General Evolution of the Operational Sounding Constellation on Polar Satellites

For NWP applications, it is highly desirable to have satellites with orbits that are uniformly distributed in space. Hence the optimization of overpass times of the future LEO observation constellations should be high on the agendas of space agencies and their governing bodies. The standard data format for many NMS is the BUFR format, and all space agencies and meteorological agencies are highly encouraged to provide the data in such a format. Early warnings as a result of changes to instrument function or data processing are very beneficial to the NWP user community. Early information on future satellite missions is also important in terms of short to mid-range planning for NMS and readiness to assimilate observations as soon as possible after the satellite is launched. As weather forecast models have model tops that extend higher into the atmosphere (80-90 km), a higher abundance of instruments that sense the stratosphere and mesosphere is desirable.

Recommendation DA/NWP-3 to all relevant space agencies

The WG recommends that the constellation of at least three orbits (early morning, morning, and afternoon), each with full sounding capabilities (IR and MW), is maintained. The WG recommends coordination between agencies of the overpass times of operational satellites with sounding capability (IR and MW) to maximize coverage (including, e.g., China, India).

Recommendation DA/NWP-4 to CMA

The WG recommends that CMA continues its efforts to make FY-3A data available in BUFR format to the international user community in near real time.

Action DA/NWP-2

Wei Han (CMA) will gather information on FY-3C and its instruments as well as follow-on missions and distribute this information to the WG members through the NWP WG mailing list.

Recommendation DA/NWP-5 to DoD and other space agencies

The NWP WG recommends that future microwave sensors maintain sounding capabilities of the upper stratosphere and mesosphere, in addition to tropospheric and stratospheric sounding capabilities, as is the case for SSMIS.

2.3.4 Future Systems

During the NWP WG session, Dave Ector, NOAA, provided information on plans for a follow-on mission to COSMIC. NOAA has decided to go ahead with a 12 satellite configuration for launch in 2014. Six of the satellites will have an inclination angle of around 70° and the six others will have an inclination angle of 20°. The latter is to increase the sampling in the tropics. International missions will be launched with GPS/GNSS receivers on board as secondary payloads, but most are sun synchronous and what is really needed is increased coverage in the tropics. Latency will be better than COSMIC. People interested in the ionosphere are very interested in data latency less than half an hour. NOAA and Taiwan will share the cost of the mission 50/50. The instrument will be a blackjack again but the next iteration in technology. The instrument will be able to receive GPS and Galileo signals. NASA is looking into whether GLONASS could also be added. The design of the payload is being done by NASA. Phase array antennas will be used that can point at satellites and will have increased S/N ratio. The data policy will be open. There will be around 12000 soundings a day, which will allow more sounding into hurricanes.

Currently, the space agencies of two countries, the Russian Federation and Canada, are each leading a mission in the early planning stages for quasi-geostationary observation of the Arctic (HEO). These missions would image the arctic with a more rapid refresh rate than the planned future LEO constellation.

A presentation on hyperspectral microwave instruments was given at ITSC-17. In view of the fact that microwaves are less sensitive to clouds than infrared frequencies, this type of instrument could potentially have a large positive impact on the quality of NWP forecasts.

Action DA/NWP-3

Dave Ector (NOAA) will send the report from the upcoming first meeting of the IROWG (International Radio-occultation WG) to the NWP WG members via the mailing list.

Recommendation DA/NWP-6 to satellite agencies and WMO

The geostationary and HEO (Molniya) orbit is ideal for observing the rapidly changing component of atmospheric and surface fields. The WG recommends the use of these orbits for high spectral resolution IR and/or microwave sounder/imager instruments. Ideally, if both are possible, the microwave and IR instruments should observe the same portion of the atmosphere at the same time.

Recommendation DA/NWP-7 to satellite agencies and WMO

The WG encourages further study of the benefits of hyperspectral microwave instruments.

2.3.5 Data Dissemination and Information from Satellite Agencies

Early warnings as a result of changes to instrument function or data processing are very beneficial to the NWP user community. Therefore, it is essential that good communication

(including tools) exist between data users and data providers. Early information on future satellite missions is also important in terms of short to mid-range planning for NMS and readiness to assimilate observations as soon as possible after the satellite is launched. The NWP WG welcomes the dissemination of early warnings and information through the use of its email distribution list. NWP WG members are also invited to share information on the distribution list when for instance unannounced anomalies resulting from instrument malfunction are detected or changes in data processing that may not have been announced through the agreed upon channels for instance or when in doubt (lack of clarity).

In view of the ongoing research in the use of full radiance spectra, satellite agencies should consider options to make full data sets available to users.

Action DA/NWP-4

Sid Boukabara (NOAA) will contact NESDIS to ensure that when the DMSP F18 SSMIS data (in BUFR format and processed by UPP) is available at NESDIS from FNMOC (within the next two weeks) that it is also made available for wide distribution. Furthermore, Sid will ask NESDIS to ensure that users are promptly informed of data or instrument issues.

Action DA/NWP-5

Vincent Guidard (Meteo France) and Fiona Hilton (Met Office) will revisit the selection of the EUMETSAT 314-channel subset of IASI channels. This may lead to a proposal to include further channels.

Recommendation DA/NWP-8 to EUMETSAT

The NWP WG recommends that EUMETSAT investigates lossless compression methods for the dissemination of the full IASI spectrum in the context of disseminating data from 2 or more Metop satellites.

Recommendation DA/NWP-9 to all relevant space agencies and WMO

The WG recommends that all relevant space agencies (i.e., ESA, NASA, NOAA, JMA, EUMETSAT, CMA, KMA, etc...) send information to users, including the NWP WG mailing list, about planned changes in data processing, formats, and other issues related to data as early as possible (preferably at least 6 months in advance).

EUMETSAT's User Notification Service (UNS) was noted as being a useful email and Web - based notification tool for data issues. However, the content could at times be improved. For instance, messages with no new anomalies should be removed or sent out less frequently, information about very short outages of less than about an hour are not considered useful, and in case of a data outage, further information on the reason for an outage and an expected length would be beneficial if available.

Action DA/NWP-6

European NWP WG members will inform their EUMETSAT OPS WG representatives of changes desired in the scope and format of the notifications sent through the UNS.

2.3.6 RARS

Timely delivery of data continues to be crucial for NWP. Timeliness requirements have tightened in recent years, especially for regional NWP. The Regional ATOVS Retransmission Service (RARS) has significantly improved quick delivery of data, and it continues to be vital for regional and global NWP systems with short cut-off times.

Recommendation DA/NWP-10 to WMO

The NWP WG continues to support fast delivery initiatives (RARS) with extensions wherever possible, however the WG believes that the system should continue to be low cost. At ITSC-17, it was reported that the RARS coverage is now 78%. Further extension towards global coverage is encouraged until the point is reached where further improvements are no longer cost effective.

The interaction between the RARS coordination at WMO, the RARS coordination centres, and the users was discussed. WMO would like to find out more about the status of the use of RARS by National Meteorological Services (NMS) and potentially other users, to better tailor future developments. This is done via a questionnaire to RARS users.

Action DA/NWP-7

Jerome Lafeuille (WMO) will distribute the RARS user's questionnaire to the NWP WG mailing list.

A continuing concern of the group is early information about processing changes or data anomalies. While improved efforts of some coordinating centres were noted, the potential for data problems, for instance at single RARS stations, remain due to the distributed nature of the system. Problems at a single RARS station may not be noted in the routine quality monitoring at NWP centres, and in such cases locally degraded data can potentially have a very harmful effect on analyses and forecasts. The routine station-by-station intercomparison between global and RARS data performed at the Met. Office under the NWP SAF is well suited to detect such anomalies.

Recommendation DA/NWP-11 to RARS coordination centers

The WG recommends that users be informed of processing changes and other issues regarding RARS as early as possible.

Action DA/NWP-8

Brett Candy (Met.Office) will investigate how to inform users of data anomalies noted in the intercomparison between global and RARS data performed at the Met. Office (including the possibility of an automated warning system).

2.3.7 RTTOV Users Group

The proposal to set up an RTTOV Users Group was presented to the group by Fiona Hilton (Met. Office). The idea is to have a forum that is independent of the RTTOV development group and that is primarily internet and email-based. The forum should help to establish user requirements for science developments, provide a means for exchange between users regarding technical and other usage aspects, and improve the user representation at RTTOV development meetings. The background to this is the impression that RTTOV developments are not always user-driven, and that the use or implementation of such crucial code in complex NWP systems can be an arduous task. Ideally, the forum should consist of hands-on

users of RTTOV, with a coordinator/representative who should represent the group at RTTOV development meetings.

The group responded positively to this proposal, but no volunteer for the coordination role has yet been identified.

Recommendation DA/NWP-12

The NWP WG recommends setting up an RTTOV user group, composed of members that do not actively participate in developing RTTOV software, to collect science requirements, and to establish a forum for technical and usage aspects. This group is expected to interact through internet and email.

Action DA/NWP-9

WG members will consult with their respective organizations to find prospective members of the RTTOV user group and will send an email with contact information to Fiona Hilton.

Fiona Hilton will investigate the technical options to set up such a forum. She will also prompt CRTM manager, Paul van Delst, about their experience.

2.3.8 Working Group Support to NWP Community

Evolution of the ITSC NWP WG Web Site

The Web site of the ITSC NWP WG has developed into a useful repository of information about the use of ATOVS and other sounding data in NWP, with, for instance, links to monitoring pages and contacts to data providers. Since the last ITSC meeting, Wiki capabilities have been added by Leanne Avila (SSEC), allowing easy modification of the content. Currently, only the Co-Vhairs have permission to alter the site. After some discussion, the WG decided to give all WG members permission to alter the site. Leanne Avila has been informed about this and will issue the required passwords, following an email request (with copy to the Co-Chairs). The intent of the widened Wiki-capabilities is to allow better interaction among the group between ITSC meetings (see, for example, the activities initiated below), and also to be able to better track the progress of the action items identified during the WG meetings.

Action DA/NWP-10

The NWP WG Co-Chairs will post the action items on the NWP WG wiki page and WG members will describe how action items were completed. WG members may obtain a password from Leanne Avila via email (with copy to the Co-Chairs), to be able to make changes to the Wiki page.

A questionnaire regarding the use of ATOVS data at NWP centres has been circulated before ITSC meetings by the group for some time now, in order to provide a good overview of the current status. This questionnaire was identified as an obvious candidate to use the Wiki capabilities to keep responses up-to-date.

Action DA/NWP-11

Roger Randriamampianina (met.no) will convert the ITWG ATOVS questionnaire (in word format) to wiki format and include it in the NWP WG wiki page. WG members will update their information via the wiki page. NWP WG Co-Chairs will

send a reminder to update the information at least once a year. A snapshot of the information will be taken once a year by Co-Chairs.

Action DA/NWP-12

Niels Bormann (ECMWF) will obtain a copy of Andrew Collard's ITSC-17 presentation on the IASI usage survey and include it on the NWP WG wiki page. He will also include a list of the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16.

Departure Monitoring

Routine monitoring of departure statistics between observed radiances and First-Guess equivalents is an integral part of the quality assurance for the use of sounding data at all NWP centres. Exchange of such monitoring information, via the internet, continues to be recognized as a very useful tool to diagnose performances of the data assimilation systems, and to corroborate findings in case of data problems identified at one centre. To further improve the exchange of such information, the WG made the following specific recommendations:

Recommendation DA/NWP-13 to NMS

The NWP WG recommends that detailed monitoring be available on the NMS monitoring Web sites for at least the 18 IASI monitoring channels selected by Fiona Hilton after ITSC-16 (see Action DA/NWP-12).

Recommendation DA/NWP-14 to NMS

The NWP WG recommends that monitoring Web sites be freely accessible on the internet (i.e., do not require a password).

Recommendation DA/NWP-15 to NWP WG members

NWP WG members are strongly encouraged to make use of the NWP WG mailing list, in particular to report problems with instruments.

Radiance bias correction is recognized by the group as crucial for the successful assimilation of sounding data. However, questions remain regarding the suitable choice of bias correction models and methods, the effectiveness of the bias corrections to correct observation bias (including radiative transfer), and the dangers of correcting model biases or shortcoming of quality control (e.g., signatures of cloud contamination). To address these questions, Wei Han (CMA) suggested performing an intercomparison study between global NWP centres for selected instruments/channels. This was viewed favourably by the group, as long as the required exchange of monitoring statistics is kept simple and well-defined.

Action DA/NWP-13

Wei Han (CMA) will put together a proposal for a radiance bias and bias correction intercomparison exercise. This should include specification of format to exchange relevant information and the scope of the intercomparison.

Limited-area Data Assimilation

The group discussed issues and specifics of the use of sounding data in regional data assimilation systems. These systems require their own special attention to radiance bias correction, thinning, and observation and background error specification, that often differs from the requirements of global data assimilation.

To this end, an intercomparison study was initiated at the last ITSC meeting, to study the increments resulting from assimilating a single AMSU observation in different NWP centres. Met.No, the Met Office, and SMHI participated, and the study revealed interesting differences, for instance in the spatial responses of the various systems, summarized in poster 7.22 at this ITSC meeting.

To allow better exchange of information between regional data assimilation centres and wider participation in the single-observation experiment, the WG formulated the following actions and recommendations:

Action DA/NWP-14

Roger Randriamampianina (met.no) will create a regional data assimilation page on the NWP WG wiki page. Roger will also post the poster (impact of single AMSU observation on analyses increments at three NMS) that he presented at ITSC-17 (Number 7.22) on this page.

Recommendation DA/NWP-16 to NMS

The WG recommends that other NMS also participate in the single-observation exercise (see Action DA/NWP-14) for other regions, if applicable, and that they contact Brett Candy (Met Office) and Roger Randriamampianina (met.no) to convey their results.

Action DA/NWP-15

NWP WG members involved in regional or limited area data assimilation will share their experience (experiment results, reports, papers, etc.) on bias correction procedures on the regional data assimilation Web page.

Radio Frequency Interference (RFI)

Radio Frequency Interference (RFI) from human activity (e.g., telecommunications, navigation systems, etc.) is an existing and potential threat to the use of various MW frequencies in environmental monitoring and NWP. The group supports the activities to protect relevant frequencies via the International Telecommunications Union (ITU). Following the presentation by Richard Kelley and subsequent discussions, the group discussed how best to support activities that characterize and demonstrate the effect of existing and potential RFI contamination in NWP. It was recognized that a full assessment is difficult, as it depends on the frequencies in question, the maturity of our exploitation of the data, and the nature of the contamination. It was also noted that other communities and applications may be even more directly affected by RFI (e.g., climate applications). Nevertheless, several studies and reports of RFI impact in NWP already exist, and as a starting point the group intends to establish a repository of these documents.

Action DA/NWP-16

Co-Chairs will create a section on the NWP WG wiki page which will contain examples of the existing or potential effects of RFI in NWP. Members are invited to add on this Web page any relevant impact assessments or evidence found. Nancy Baker (NRL) will provide examples to start the page.

Miscellaneous

Robust verification of forecast impact is recognized by the group as fundamental to our work. Given the variability of forecast impact by season and the considerable sampling uncertainties, significance tests on forecast impact and testing of system modifications over several seasons is seen as crucial to obtain reliable results. To establish a good practice within the NWP community, the WG made the following recommendation:

Recommendation DA/NWP-17 to the NMS and NWP community

The NWP WG recommends that forecast verification scores are displayed with error bars and indication of trial periods used.

The group also discussed how to better characterize what fraction of the overall information content contained in satellite sounding data is currently used. This discussion was prompted by a comment by Bill Smith after one of the IASI assimilation talks that less than 1% of IASI data is so far used and therefore so much more impact can be expected from using more data. The group notes that such a simple measure based merely on data counts can be misleading, and instead information content measures need to be used. Channel selection papers such as Collard (2007) usually state what percentage of information content are available in the selected channels, thus providing a more appropriate measure per spectrum. However, the spatial information content is usually not considered in these studies. A combined spatial and spectral information content analysis appears not straightforward, and the group was not in a position to formulate an action or recommendation on this issue.

2.4 ADVANCED SOUNDERS

Working Group members: Andrew Collard (Co-Chair), Bill Smith (Co-Chair), Bill Bell, David Crain, Steve English, John Eyre, Nadia Fourrié, Sylvain Heilliette, Allen Huang, Brian Kahn, Bjorn Lambrigsten, Jun Li, Emily Liu, Eric Maddy, Stephen Mango, Thomas Pagano, Nikita Pougatchev, Jeffrey Puschell, Peter Schliüssel, Laura Stewart, Jonathan Taylor, Pradeep Thapliyal, Stephen Tjemkes, Banghua Yan, Vladimir Zavyolov, Daniel Zhou.

2.4.1 Introduction

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 pertaining to instrument specification, performance, data processing, and utilisation. 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.

2.4.2. Geostationary Advanced Infrared Sounders

The group notes the anticipated 2014 launch of GIFTS/STORM and recognises this as an opportunity to gain experience with geostationary hyperspectral infrared products (and in particular vector winds) in advance of the launch of MTG-IRS in 2018.

Recommendation AS-1 for space agencies and NWP centers

To support the use of hyperspectral geostationary imager products, such as GIFTS/STORM data, for research and development of hyperspectral infrared geostationary sounder products in advance of operational instruments (e.g., MTG-IRS).

Action AS-1

For David Crain to publicise information on data availability of the GIFTS/STORM to Advanced Sounder Working group to encourage early use of these radiances.

Research Community Needs

The group noted the work being pursued at the Keck Institute at Caltech/JPL to collate observing requirements from the research community and in particular those interested in investigation of atmospheric processes. Initial indications from this community indicate that they would like improved observation of the boundary layer; diurnal cycle and hydrological cycle with very high spatial resolution and global coverage. In order to communicate these requirements to the instrument community these requirements need to be refined, preferably using the three level EUMETSAT system which defines a “threshold” level (below which the measurement does not add value); “breakthrough” (which will make a significant difference to the desired goal) ; and “goal” (above which all further increases in measurement accuracy add no further value). The World Climate Research Program (WCRP) maintains a database of requirements at WMO related to observations pertinent to the observation of atmospheric processes, and this should be the starting point for further work. It is also recognised that it is not just the instruments themselves but algorithm development that is required to deliver further measurement improvements.

Action AS-2

Brian Kahn, starting from the existing WMO database containing the requirements of the World Climatological Research Program (WCRP), to survey the science community for their observational needs with respect to climate related processes and report back to the group.

Field of View Size

The group has noted that the field-of-view size for the post-EPS IASI has now been fixed at 15km. While recognising that this is a fixed specification for post-EPS, the group considers it worthwhile to continue to review the specification of this type of instrument for the benefit of other space agencies. The group recognises the trade off between field-of-view size, spectral resolution and instrument noise and encourages further investigation bearing in mind continuing scientific and technology advances. In particular, scientific advances include taking into account how clouds will be used in future retrieval and analysis systems and the effect of using noise reduction techniques (e.g., principal component analysis), particularly in the field of trace gas retrieval. Technology advances include large focal plane array technology which enables simultaneous measurements of large spatial domains with high spatial resolution and with enhanced S/N resulting from increased measurement dwell time.

Recommendation AS-2 to the research community

review trade-off studies used to determine spectral, spatial and noise tradeoffs for determining operational advanced infrared sounder specifications with reference to optimal field of view for cloud avoidance and the use of noise reduction processing techniques and/or new detector array technology.

Recommendation AS-3 to the research community

explore the possibility of setting up a community science working group to explore these issues.

Action AS-3

Andrew Collard to initiate discussion on how to proceed with these recommendations.

Recognising the Risk to Conical Scanners

The group recognises the important role of conically scanning sounders for environmental monitoring and NWP and is concerned by the possibility that these instruments will disappear from the Global Observing System, or at least be reduced in number, after the launch of DMSP-20.

Recommendation AS-4 to space agencies

To ensure the continuation of capability for conically scanning instruments in the post DMSP era. All future such instruments should be designed with particular attention to calibration accuracy and stability.

Action AS-4

ITWG Co-Chairs to present the concern of this group to CGMS.

Continued Development of Geostationary Microwave Sounders

The group noted that a microwave sounding from geostationary orbit has potential benefits to environmental monitoring and NWP and encourages the continued development of practical technological approaches for achieving this measurement capability.

Recommendation AS-5

In concert with the continued development of IR geo sounders, we recommend the further advancement of geostationary microwave sounders.

Documentation of Desired Attributes for Infrared and Microwave Sounders

It was noted that it is of benefit to those involved in designing new instruments to be able to consult information on the current suite of satellite instruments including information on the utility of the various spectral regions. A simplified table based on the WMO Global Observing System Dossier is considered to be ideal for this purpose. This document should be reviewed regularly.

Action AS-5

David Crain and Steve English to take the WMO Global Observing System Dossier on current operational systems and produce a simplified table for the Advanced Sounder Working Group report by September 2010.

Action AS-6

Advanced sounder working group to critically review the document produced above.

2.5 INTERNATIONAL ISSUES AND FUTURE SYSTEMS

Working Group members: John Eyre (Co-Chair), Jerome Lafeuille (Co-Chair), Simon Elliott, Lars Fiedler, Louis Garand, Mitch Goldberg, Liam Gumley, Jeff Hawkins, Richard Kelley, Christelle Ponsard, Stephen Tjemkes, Walter Wolf.

2.5.1 Frequency Management Issues

Achievements

The WG underlined notable achievements since ITSC-16. These included the publication of two documents, which are available by contacting Dave McGinnis (dave.mcginis@noaa.gov), Richard Kelley (richard.kelley@noaa.gov) or Jean Pla (jpla@cnes.fr):

- Draft ITU-R Report on “Identification of degradation due to interference and characterization of possible mitigation techniques for passive sensors.”
- “Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz,” a document describing passive systems for use in interference analysis for future non-passive systems.

New issues

The WG also noted the following new items of concerns:

- The Soil Moisture and Ocean Salinity (SMOS) mission of ESA which relies on an L-Band 1.4 GHz radiometer is affected in this band by RFI (point of contact: Jean Pla).
- The Soil Moisture Active Passive (SMAP) mission of NASA which will also operate an L-Band radiometer may be affected as well, however it is expected that this will be mitigated on board through the use of an agile digital detector for RFI (point of contact: Christopher Ruf, cruf@umich.edu).
- The advanced scatterometer (ASCAT) on Metop is facing RFI over land (point of contact: Dieter Klaes, dieter.klaes@eumetsat.int).

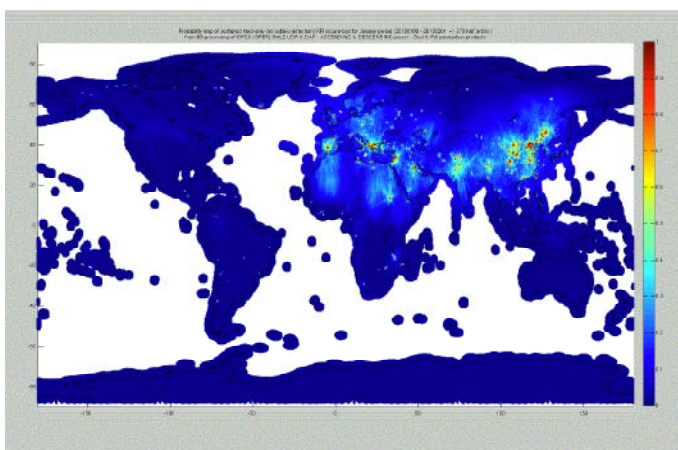


Figure IIFS-1: SMOS image of strong RFI probability.

Use of the Spectrum Above 275 GHz

An agenda item for the World Radiocommunications Conference in 2012 calls for a review and possible revision of the Radio Regulations (RR) No. 5.565, to address existing and

projected requirements between 275 GHz and 3000 GHz for the Earth Exploration Satellite Service (EESS) and Space Research Service (SRS).

It is important for ITWG membership to review its requirements for use of the spectrum in the band between 275 and 3000 GHz and make their views known to the international community. Interested members can contact dave.mcginis@noaa.gov, richard.kelley@noaa.gov, jpla@cnes.fr.

Emitter Registry

There are international spectrum allocations which guide frequency band usage and delineate restrictions placed on such use. It is recognized, however, among the environmental satellite community, that there are instances in which emitters are likely to cause the loss of data of interest to this community. An international registry of emitters would provide advance notification for future environmental satellite missions. It is proposed that a discussion of such a registry be held within appropriate (WMO, CGMS) entities. Such a registry could contain information on emitter locations, RF characteristics, duty cycles, and anticipated time frame of emitter existence. This would expand a current initiative, which is a much smaller scale effort, called Radiofrequency Interference Survey of the Earth (RISE).

2.5.2 Vision for the Space-based GOS in 2025 and Adequacy of Current Plans

The WG was briefed on the Vision for the GOS in 2025, which was finalized and adopted by the WMO Commission for Basic Systems (CBS) in April 2009 and subsequently approved by the 61st WMO Executive Council in June 2009. It is now available on line as a reference document (see: Vision for the GOS in 2025).

The Vision provides a description of both the surface and space segments of the Global Observing System as a goal to guide the evolution of this system in the coming two decades. The Vision addresses general features such as the adaptation to evolving user requirements, the integration of its various components, the expanded range of observations and parameters to be handled, the need for increased standardization, interoperability, and quality control. As concerns space-based observation, the Vision stresses the trend towards higher spatial, temporal and spectral resolutions, the need to improve data availability and timeliness, and to ensure accurate calibration and global intercalibration. The space-based component of the GOS is anticipated to increasingly rely on partnership among operational and R&D satellite operating agencies. The Vision not only foresees the continuation and enhancement of heritage missions in geostationary and in sun-synchronous orbit, but also calls for the transition to operational status of a range of missions on diversified orbit configurations that, in the past, have been only pursued with a research or demonstration purpose. These included for instance missions dedicated to the monitoring of Essential Climate Variables such as sea surface height, Earth radiation budget or atmospheric composition.

The WG noted that planned satellites in Highly Elliptical Orbit (HEO) would have advanced imagers. A limited number of water vapour and temperature channels are suitable for assimilation at high (15 minutes) temporal and spatial (2 km) resolution.

The WG highlighted and reinforced the importance of the three types of satellite sounding that are called for by the Vision:

- LEO sun-synchronous MW and hyperspectral IR observation from three orbital planes (mid-morning, afternoon, early morning),

- geostationary hyperspectral IR, and
- radio occultation (RO) sounding.

The WG reviewed the adequacy of current satellite plans with respect to these sounding missions from the mid-morning, afternoon, early morning and geostationary orbits, as well as the Radio-Occultation constellation plans.

Mid-morning and Afternoon Orbits

The WG felt confident that the morning orbit was well covered by Metop, and complemented by FY-3 that in future (FY-3E in 2014) would carry an IR hyperspectral sounder. The WG was pleased to note that ROSHYDROMET had successfully launched Meteor-M1 with a payload including MW (MTVZA) and hyperspectral IR (IRFS-2) sounders. It expected that the data from FY-3 and Meteor M satellites will be available to the community as discussed below.

As concerns the afternoon orbit, the WG noted the current redefinition of the NPOESS Program and the plan to have an NPP-based Joint Polar Satellite System (JPSS). It anticipated that the JPSS would carry a full IR and MW sounding package. It also noted the complementary plans of other agencies: for a satellite from the FY-3 series (FY-3 B, D, F) in a 14:00 Equatorial Crossing Time (ECT) orbit, and possibly the Meteor-M2 satellite at 15:30 ECT.

Early Morning Mission

As concerns the early morning orbit, the WG noted that, in the USA, requirements were still being reviewed by the Department of Defense (DOD), responsible for DMSP and the follow-on missions. As part of this review, the WG recommends that requirements be stated in terms of Satellite Data Records (SDR) rather than Environmental Data Records (EDR), in view of the needs of the NWP and climate monitoring communities for exploitation of radiance measurements.

When considering the MW sounder for this early morning orbit mission, particular attention should be paid to the requirements for calibration accuracy and stability, noting the problems in these areas with current conically scanning MW radiometers.

The need for infrared sounding requirements for this early morning orbit mission was reiterated, in accordance with the Vision of the GOS.

Action IIFS-1

Mitch Goldberg, Jeff Hawkins and John Bates, to communicate these recommendations to the Joint Agency Requirements Group (JARG), a holdover from the NPOESS program that will assist in the transition to the restructured programme.

Geostationary Infrared Hyperspectral Sounding

The WG welcomed the plans of CMA and EUMETSAT to implement such IR sensors on FY-40 (by 2015) and MTG (2018) missions respectively. The WG also noted that options were being discussed by NOAA regarding a sounding capability to complement the current GOES-R,S baseline, and strongly encouraged NOAA to pursue these investigations.

Geostationary Microwave Sounding

Being aware that geostationary microwave sounding was still only envisaged as a technology and scientific demonstration mission in the WMO Vision for the GOS, the WG noted that the NASA GEOSTAR project was responding to the call for such a demonstration mission. It considered that if any trade-off needed to be made between the measurement of precipitation and the vertical temperature and moisture profile, the specific priority for microwave imagery/sounding should be on precipitation.

Radio Occultation Sounding

The WG welcomed the setting up of a CGMS-sponsored International Radio Occultation Working Group (IROWG) that will supplement the activity of ITWG, IWWG and IPWG.

It was pleased to be informed of the recent decision of the USA and Taiwan to fund a follow-on to the very successful COSMIC mission. It noted that the new constellation would include 12 satellites able to receive GPS, GLONASS and Galileo signals. It was recalled that RO receivers are also on board of Metop and Oceansat-2, and planned for Meteor-M2 and Megha-Tropiques, and considered for other satellite missions.

2.5.3 Data Access Issues

General Recommendations

The WG reiterated the need for near-real time availability of satellite sounding data and the unique role of Direct Broadcast in the case of polar-orbiting satellites in particular. It stressed the need for detailed and comprehensive information to be made systematically available by space agencies on how to access the data in near-real time, including the description of frequencies, transmission protocols, data formats, as well as ingest and pre-processing software, and any relevant accompanying information.

The WG encouraged the Russian Federation to make the Meteor-M mission a fully contributing component of the GOS by providing the global data sets from this mission in a timely manner with all necessary ancillary information.

Recommendation IIFS-1 to the Russian Federation

To make the Meteor-M mission a fully contributing component of the GOS by providing the global data sets from this mission in a timely manner with all necessary ancillary information.

Information on data formats for new missions should be made available, in a draft form, in advance of the mission. Two recommendations were reaffirmed in this respect:

Recommendation IIFS-2 to satellite agencies

Satellite agencies operating environmental polar satellites to provide or continue to provide a Direct Broadcast 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.

Recommendation IIFS-3 to satellite agencies

Satellite agencies operating environmental polar satellites to provide expected formats of level 1b and level 2 datasets at least one year prior to launch, and to establish Web sites to provide detailed information on instruments, schedule, products and formats.

Access to NPP, JPSS and DMSP Follow-on Missions

The WG noted that in response to an action from ITSC-16, detailed information on NPP and NPOESS Satellite Data Records (SDR) and Environmental Data Records (EDR) formats had been made available and can be found on the following page:

<http://jointmission.gsfc.nasa.gov/project/science-documents.html>

which is referred to in the WMO Web site:

<http://www.wmo.int/pages/prog/sat/GOSleo.html#FutureLEO>.

The WG reiterated its support for the completion and distribution of the IPOPP software and recommended including a BUFR conversion module.

The WG also noted that the former NPOESS programme included provisions for making data openly available in near-real time from both the afternoon and the early morning orbits, and expressed its strong expectation that similar provisions would apply in the new framework of JPSS and the DMSP follow-on.

Recommendation IIFS-4 to NOAA, NASA (or JPSS project management office)

To include a BUFR conversion module in the IPOPP software package.

Recommendation IIFS-5 to NOAA, NASA, and DoD

To confirm and implement Direct Broadcast capabilities on both the JPSS and DMSP follow-on series ensuring that environmental data from these missions are openly and freely available in near-real time, and to make the relevant ingest and pre-processing software available to the global community.

The WG recalled the plans for the NPOESS SafetyNet that aimed at collecting at least 90% of the global data within 30 minutes from acquisition through a scheme of multiple data dumps to a network of 14 ground stations around the globe, viewed this concept as an efficient means to improve timely data availability. It was pleased to note that this SafetyNet was still envisaged as the main mechanism for data acquisition. The WG expected that it would apply to both JPSS and DMSP follow-on data, and possibly to other missions.

Recommendation IIFS-6 to NOAA and DoD

To consider the use of the SafetyNet as a joint ground system ensuring timely availability of data from the JPSS and DMSP-Follow-on missions.

The WG also recalled that the SafetyNet was ensuring data concentration and had to be complemented by arrangements for onward distribution to the global community.

Access to Data from FY-3 and Meteor-M Missions

The WG recalled previous actions and recommendations related to data access from FY-3 and Meteor-M missions. It was very pleased to note that the on-orbit commissioning of FY-3A had been successfully completed, and FY-3A sounding data were used by some NWP centres with significantly positive impact. Furthermore, Meteor-M1 was undergoing commissioning and had provided preliminary imagery data. Both satellites are equipped with a Direct Broadcast capability as described in the table below, with comparison with the DB characteristics of other current or planned satellites.

Table IIFS-1: Direct Broadcast characteristics of current and planned satellites.

<i>Satellite</i>	<i>Service</i>	Frequency	Data rate
NOAA-18, 19	<i>HRPT</i>	1698 or 1707 MHz	665.4 kbps
	<i>APT</i>	137.5 or 137.62 MHz	1.7 kHz
MetOp-A,B,C	<i>AHRPT</i>	1701.3 MHz (1707 MHz backup)	3.5 Mbps
	<i>LRPT</i>	137.1 MHz (137.9125 MHz)	72 kbps
Meteor-M-1,2	<i>HRPT</i>	1700 MHz	665 kbps
	<i>LRPT</i>	137.9 or 137.1 MHz	72 kbps
FY 1,D	<i>HRPT</i>	1700.4 MHz	1.33 Mbps
FY 3	<i>AHRPT</i>	1704.5 MHz	4.2 Mbps
	<i>MPT</i>	7775 MHz	18.7 Mbps
NPP	<i>HRD</i>	7812 MHz	15 Mbps
NPOESS-1,2,3,4	<i>HRD</i>	7834 MHz	20 Mbps
	<i>LRD</i>	1707 MHz	3.88 Mbps

The WG was pleased to note that transmission and data format information on FY-3A was available. However, no English translation was publicly available yet. The WG was also aware that Meteor-M Direct Broadcast was based on the CGMS HRPT/LRPT standard. In line with Recommendations 2 and 3 above, it was strongly expected that both CMA and ROSHYDROMET would pursue their efforts to provide detailed information and processing packages enabling the community to take advantage of their respective missions, and thus allowing these missions to bring a substantial contribution to the Global Observing System.

Regional ATOVS Retransmission Service

The WG noted the report provided to ITSC-17 on the implementation of the RARS, which aims at ensuring timely availability of ATOVS data to NWP centres. RARS includes three components: EUMETSAT EARS, Asia-Pacific RARS, and South-America RARS. Altogether, the 40 stations involved in RARS provide coverage for about 75% of the globe and allow availability of their sounding data worldwide over the GTS and other means within 30 minutes from acquisition. The coverage is expected to approach 80% of the globe in 2011. The WG welcomed the rapid progress of the RARS project. Considering the demonstrated benefit to NWP, WMO and the RARS contributing organizations, the WG encouraged WMO and all RARS contributing organizations to pursue the implementation of the global RARS network.

The WG welcomed the steps taken in response to ITSC-16 to consider an extension of the RARS project towards including sounding data from new missions, starting with NPP CrIS and ATMS, pending the timely availability of this data through the SafetyNet and further redistribution worldwide. It also renewed its interest for including METOP/IASI, as well as FY-3 data in the RARS.

Harmonization of Future Direct Broadcast Services

The WG recalled that Direct Broadcast from current missions was ensured in L-Band along the CGMS agreed HRPT/LRPT and HRIT/LRIT transmission standards, which are now based on CCSDS standards (Note: the CGMS standards mainly focus on the “Session” layer

and the “Transport” layer in the ISO Open Systems Interconnection (OSI) reference model, while the CCSDS standards define the “Network and “Datalink” layers). As new missions are considering dissemination of much higher data rates, mainly in X-Band, it appears that satellite operators are planning new dissemination services that in some cases do not correspond to any CGMS standard. The WG wished that future services are harmonized as far as possible to facilitate their reception by the users.

Recommendation IIFS-7 to CGMS

To consider harmonization of the appropriate layers of the future X-Band Direct Broadcast services, for instance as concerns frequency or transmission protocols based on CCSDS standards.

Dissemination of Data from Geostationary Services

The WG recalled that no Direct Broadcast was currently planned for the future Himawari-8 and -9 geostationary spacecraft of JMA that will follow the MTSAT series. The main dissemination mechanism for Himawari-8 and -9 will be via the Internet. The WG noted that in most cases data distribution from a geostationary spacecraft is not strictly Direct Broadcast since it undergoes a prior ground processing and is then redistributed; thus there are several means to ensure near-real time distribution of geostationary data, either via a transponder on the meteorological spacecraft (e.g., for current LRIT, HRIT, or future GOES-ReBroadcast) or via telecommunication satellites (e.g., with current EUMETCAst, FengYunCast services); in the latter case, data can be integrated with other data sources.

Recommendation IIFS-8 to JMA

To consider a broadcast service to facilitate access to Himawari-8 and -9 data in particular for users in the Pacific Islands that have limited Internet connectivity.

Future Dissemination Systems

Finally, the WG suggested that CGMS and satellite operators investigate the potential of satellite-to-satellite communication (e.g., Tracking and Data Relay Satellite System, TDRSS) as a mechanism to support timely collection and redistribution of polar-orbiting satellite data in future systems, since this mechanism potentially mitigates much of the expensive land receiving sites and communication infrastructure currently required to receive and disseminate global low earth orbiting satellite digital data sets in a timely manner.

Recommendation IIFS-9 to CGMS satellite operators

To investigate the potential use of satellite-to-satellite communication (e.g., Tracking and Data Relay Satellite System, TDRSS) as a mechanism to support timely collection and redistribution of polar-orbiting satellite data in future systems.

2.6 SATELLITE SOUNDER SCIENCE AND PRODUCTS

Working Group members: Tony Reale (Co-Chair), Lydie Lavanant (Co-Chair), Tom Achtor, Jörg Ackerman, Hal Bloom, Anna Booton, Zhaohui Cheng, Chris Down, Liam Gumley, Christelle Ponsard, Nathalie Selbach, AK Sharma, Kathy Strabala, Lihang Zhou.

2.6.1 Working Group Mission

The WG had a general discussion concerning the scope and focus of the WG with concurrence that the WG (through its Web site) provides a valuable contribution (one-stop shopping) but needs a more targeted focus to be more effective. Specifically, more emphasis towards the following topics is needed: a clear specification of respective product performance from global centers, requirements and users of such products, local processing capabilities using direct readout packages, routine dissemination of validation results, making available validation datasets and finally, making available ancillary (useful) datasets (atlas...) required for (or resulting from) product processing.

Recommendation SSSP-1

In the interest of a more targeted focus, it is recommended to no longer support the Web site areas for “Current/Future Weather Satellite Programs” and “Operational Instrument Characteristics and Performance.” These are adequately supplied by the WMO.

Recommendation SSSP-2

The Cal/Val topic area currently provides capability for direct inter-comparison of suites of global atmospheric sounding products produced by NOAA, EUMETSAT and UCAR (GPSRO) via its link to NPROVS. This has a capability to be expanded to include products from other global centers (i.e., India ...).

This tool can also be expanded to validation campaigns (i.e., JAIVEX, ...), special case study datasets involving “other” products/data (i.e., co-registered CALIPSO/CloudSat/AIRS data as presented at ITSC, Smith), and/or derived from local processing packages. It is also proposed to add reports from inter-comparison products/methods.

Action SSSP-1

A. Reale and L. Lavanant to change Web page content according to recommendation SSSP-1 and to investigate and facilitate expansion of the Cal/Val capabilities following Recommendation SSSP-2.

2.6.2 SSSP Web Site Maintenance

The target audience of the SSSP Web site ranges from experts in the field of satellite remote sensing to those less familiar with the jargon and acronyms normally associated with this work.

To facilitate this varied audience, the WG agreed to investigate the potential to expand on the Web page functionality allowing all users to more readily search the site contents via theme, product, instrument or experiment types, agencies and contacts.

Areas including more ease of upkeep of the Web site also to be investigated and as feasible more simplification in upkeep of page content deployed. For example, an administrator only functionality with submit fields for data entry or a system of editable text files for Web page content can be considered.

Action SSSP-2

The WG Co-Chairs, Chris Down and the Webmasters (Leanne Avila, Bill Bellon) will perform the following tasks:

Investigate (formal) the user base (audience), scope and goals of the Sub Group for Satellite Sounder Science and Products Web page.

Provide feedback on the current page design and provide detail on potential upgrades to functionality, shape and design.

Determine the overall overhead for all potential changes and enhancements to the Web site.

Provide recommendations for controlling information content on products and contacts for those products.

2.6.3 Direct Broadcast Processing Packages Technical Sub-Group Merging into SSSP

The WG agreed that the direct broadcast processing packages are a critical area of SSSP. The best interest of both, the SSSP and existing ITSC technical sub-group on direct broadcast packages is served by absorption of the technical sub group into the ITWG SSSP WG.

Recommendation SSSP-3

The Web page areas “Scientific Processing packages” and “Direct Readout” should be merged into “Direct Readout and Scientific Processing Packages” including the absorption of direct broadcast technical sub-group following the decision to absorb the technical sub group on direct broadcast packages into the SSSP WG.

Action SSSP-3

The SSSP and Direct Readout WG Co-Chairs to agree on the restructuring/consolidation of the information of both groups.

2.6.4 Products and Processing Packages Summary Tables

It was agreed that the SSSP group develops preliminary summary tables of the currently available products and direct broadcast packages.

Action SSSP-4

The WG (Anna Booton/Natalie Selbach) will present a preliminary summary of the currently available products, initially focusing on sounding and trace gases, within the Products area of the Web site. The goal is to provide users with a comprehensive technical overview detailing information such as the required input data and data formats and science.

Action SSSP-5

CIMSS (Kathy Strabala, Liam Gumley) will append a table to the technical report “Report on DB Processing Packages” that presents supported functionality in a one

page summary which will be appended to the SSSP direct broadcast processing package area.

2.6.5 Continued Support for IAPP

It was agreed that support continue for IAPP in order to maintain its operational use at facilities such as the Satellite Application Facility on Climate Monitoring (CM-SAF).

Recommendation SSSP-4 to CIMSS

To continue the support and development of IAPP in order to maintain operational use at facilities such as the Satellite Application Facility on Climate Monitoring (CM-SAF). This support should include updates, for example, that would affect the usability of the software in the case of instrument channel failure, as well as the inclusion of new sensors within the software package.

Action SSSP-6

The WG Co-Chairs to forward recommendation SSSP-4 to CIMSS.

2.6.6 Metop-A HRPT Direct Broadcast

There is currently a limited availability of Metop-A direct broadcast data due to an earlier failure of the Metop-A AHRPT side A. The root cause was heavy ion radiation, causing the failure of a component of the AHRPT Solid State Power Amplifier (SSPA). To minimize the risk of failure to the AHRPT-B unit, EUMETSAT has implemented a "partial" AHRPT service in those areas where the risk of damage from heavy ion radiation is reduced. For southbound passes, AHRPT side B will be activated for all orbits over the North Atlantic and European area, starting at around 60°N. The AHRPT will then be switched off before the spacecraft reaches the Southern Atlantic Anomaly region at around 10°N. The current switch zones are shown in the figure below.

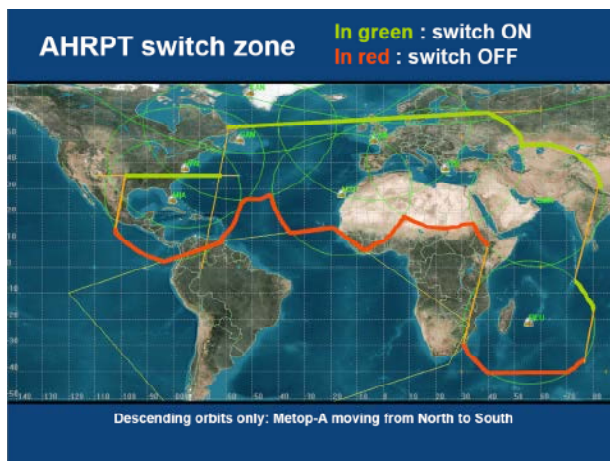


Figure SSSP-1. AHRPT switch zone for Metop-A, copyright EUMETSAT.

Recommendation SSSP-5 to EUMETSAT

The SSSP WG recommends to expand the areas of direct readout observations to areas currently not covered. EUMETSAT should provide a timetable showing the plans for a possible expansion of the Metop-A HRPT services

Action SSSP-7

Jörg Ackermann and Christelle Ponsard to forward recommendation SSSP-5 to the appropriate EUMETSAT bodies and report to the WG.

2.6.7 Metop-A/B Direct Broadcast Level-2 (IASI) Processing Package

At present there is no publicly available EDR (Level 2) retrieval package available for Metop IASI direct broadcast, and we are unaware of any plans to develop or release such a package. Since Metop is still the morning satellite for the JPSS constellation, we believe it is imperative that such a package be funded and released for Metop, since it would be extremely beneficial for local applications of NWP assimilation, weather forecasting, and environmental monitoring.

Recommendation SSSP-6 to IPO/JPSS

A Level-2 retrieval package for IASI should be funded and made available for IASI DB users.

Action SSSP-8

The WG Co-Chairs should forward recommendation SSSP-6 to IPO/JPSS.

2.6.8 Post Conference Summary of Product Presentations

WG discussion identified need for formal review and synopsis of presentation concerning derived level-2 and 3 products be made within three months after conference. Synopsis would identify product areas discussed and recommend areas of focus for future solicitations (oral poster) for next meeting

Action SSSP-9

The WG Co-Chairs will provide a post conference synopsis of product area presentations of ITSC-XVII. The WG Co-Chairs will recommend further level 2 algorithm developments where needed. Product area priorities are to be considered for solicitation/selection of product topic areas. The results of the continuing validation will be presented at the next conference.

2.6.9 Survey of Visualization Packages

Data analysis and visualization tools are used by most atmospheric scientists. There are many packages, both commercial and open source, available that provide tools and libraries for data analysis and visualization. The cost to purchase software and/or to develop useful tools can be large. Thus, a survey identifying available packages and their attributes would be a useful resource for atmospheric scientists, especially information about those tools that focus on capabilities for remote sensing data.

Action SSSP-10

Tom Achtor will conduct a survey of the WG's user community to provide a comprehensive table of available software packages for data analysis and visualization of atmospheric science data.

2.6.10 Data Rates

As hyperspectral and active remote sensing instruments are developed, product users must stay aligned with the requirements in terms of the capacity for organizations to process, assimilate, and use this data.

Recommendation SSSP-7

Product user groups should study and have input into the architecture of such processing systems for hyperspectral and active remote sensing instruments to determine their requirements for issues such as processing, IT infrastructure need, as well as methods for data acquisition or development of algorithms to better assimilate critical data from the large quantities of data that organizations may or may not be able to process in the timeframes required by operational organizations.

Also this group should coordinate recommendations on issues related to and strategies for the increasing demands to process data onboard satellites and recapture the essence of the critical data for scientific research and data assimilation.

Action SSSP-11

AK Sharma to provide NESDIS plans to accommodate high data rates, processing and distribution systems.

2.6.11 Preparations for NPP

NPP is approaching. IPO/JPSS has developed the Government Resource for Algorithm Validation Integrated Testing and Evaluation (GRAVITE) which is responsible for ongoing end to end pre-launch testing of level-1 and level 2 products. Continuous data stream testing is expected to begin during Spring (2010) and continue to launch.

Recommendation SSSP-8 to IPO/JPSS

To provide timely updates on expected implementation schedules and concerns (including for IPOP).

Action SSSP-12

To POC: Lihang Zhou should forward recommendation SSSP-8 to the responsible bodies.

2.6.12 Preparations for Metop-B

The launch of Metop-B is scheduled for April 2012. In support of currently available instrument processing packages, it is mandatory to have the calibration datasets for Metop B instruments available prior (at least one year) to launch.

Recommendation SSSP-9 to EUMETSAT

It is recommended that EUMETSAT makes the calibration datasets available after concurrence with NOAA via the EUMETSAT Web site.

Action SSSP-13

Jörg Ackermann and AK Sharma to forward recommendation SSSP-9.

2.6.13 Interface to WMO Web Site

WMO (Global Observing System Dossier) developed a Web site including similar topics on satellite product information, satellite missions and agencies (http://www.wmo.int/pages/prog/sat/index_en.html). The Web site also provides access to highly advanced reference material, for download, on satellite instrumentation characteristics and corresponding product performances (Global Observing System Dossier).

Recommendation SSSP-10

It is recommended to promote WMO Web site and co-ordinate WMO and SSSP synergy for coherent and complementary information dissemination.

Action SSSP-14

L. Lavanant, A. Reale and J. Lafeuille to facilitate recommendation SSSP-10.

3 TECHNICAL SUB-GROUP REPORTS

3.1 FREQUENCY MANAGEMENT

Summary

The spectrum management working group participated in the climate working group. They also gave a presentation summarizing frequency protection accomplishments and issues since the May 2008 ITSC meeting. Additionally the working group discussed the ITU report [RS.2165](#) Identification of degradation due to interference and characterization of possible interference mitigation techniques for passive sensors operating in the Earth exploration satellite service (passive) and displayed and discussed a poster on a preliminary draft ITU-R report on passive bands of interest to EESS/SRS from 275 to 3000 GHz.

Climate working group

Low levels of undetected RFI can add to the background signature which gets unknowingly captured in climate records. This was discussed during a meeting of the climate group and it was agreed to include wording in its report about concern of the effect of undetected RFI on overall global climate signature.

Presentation summarizing frequency protection accomplishments and issues since the May 2008 ITSC meeting

We discussed an ITU-R report on the identification of degradation due to interference and characterization of possible interference mitigation techniques for passive sensors operating in the Earth exploration satellite service. Its purpose is to discuss products from environmental satellites and the effects of RFI with a non-technical target audience. There is also a new ITU-R recommendation providing characteristics of passive sensors (RS.1861 Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz.). It lists technical data, band-by-band, for international environmental satellites – the intended audience is those performing interference studies, such as competitors for the passive spectrum and those wishing to protect it.

We also talked about three missions with frequency protection interests: Soil Moisture Ocean Salinity (SMOS), Aquarius and Soil Moisture Active Passive (SMAP). There was preliminary information about the unexpected RFI issues faced by SMOS. (N.b. these issues are now being successfully addressed by dealing with various administrations.) An important outcome from SMOS, besides the valuable scientific information is the realization that RFI, even in protected bands, is real and can lead to unexpected, expensive diversions from principle scientific missions. The Aquarius mission is interesting from a frequency protection perspective - it will have ground based RFI detection and removal. A software filter will scrub and flag the data. The flag will also indicate how much data was removed. The filter technique is similar to the asynchronous pulse blanking (after Joel Johnson) and is based on work by Chris Ruf. It does not assume a pulse-like structure for the RFI. The SMAP mission will have an L-band radar and L-band radiometer. RFI detection will be done onboard with significant oversampling in time to implement peak detection algorithm. The technique employs an agile digital detector (ADD) which has a kurtosis algorithm with sub banding to provide more robust detection when dealing with varying RFI duty cycles and power.

ITU report [RS.2165](#) Identification of degradation due to interference and characterization of possible interference mitigation techniques for passive sensors operating in the Earth exploration satellite service (passive)

This report has its target audience within ITU. Most ITU membership has no technical background in environmental remote sensing or applications. However, many do have backgrounds in rf engineering and administration and of those, many may be clueless about how their daily weather forecast, for instance, may depend upon clean, RFI-free data. The report describes passive sensing products including how they are generated and the importance of NWP. It goes on to describe product quality, including the impact of RFI on input data quality and how RFI may be identified. It concludes by addressing ITU guidance on RFI, how industry may understand RFI topics and talks to mitigating the effects of interference.

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3.2 FAST RADIATIVE TRANSFER MODEL, RTTOV

The development of the RTTOV fast radiative transfer model, part of the EUMETSAT-sponsored NWP-SAF activities is continuing. Around 350 users worldwide have received the latest version of RTTOV version 9.

One new application of RTTOV is it is now being included in an ‘observation simulator package’ (COSP) for running in climate models to compare long term trends of climate model simulations in radiance space with those measured by satellites.

The next version of RTTOV (version 10) is now well under development and is planned to be released to users early in 2011. The major enhancements of RTTOV-10 over RTTOV-9 are:

Scientific changes

- The top profile layer in RTTOV (level 0-1) can now be explicitly provided by the user. This has reduced errors in IASI high level peaking channels.
- A parametrisation of the Zeeman effect is now included for AMSU-A channel 14 and the SSMI(S) mesospheric channels.
- For high resolution IR sounders (e.g. IASI) the option of simulating principal components of the spectrum rather than the full spectrum is now possible. This provides a dramatic speed up of the computation for the entire spectrum. This option is only for clear sky radiances over the ocean at present.
- The FASTEM-3 microwave ocean surface emissivity model has been improved to FASTEM-4.
- Improved simulation of TOVS SSU radiances for reanalyses and climate applications.
- It is now possible to prescribe more than one cloud type in a given layer.
- Modules outside of RTTOV can be called to compute a more accurate land surface emissivity for infrared and microwave sounders/imagers given the lat/long and time of year. In addition an estimate of the error covariance for the emissivity is provided.

Technical changes

- Code rewritten in places to improve readability and maintenance.
- A new more flexible makefile script is supplied to compile the code
- A new test script to replace the tstrad program.

A presentation on the RTTOV-10 developments was given during the ITSC-17 conference and can be viewed on the ITWG web site under the ITSC-17 proceedings.

For your free copy of RTTOV, visit the URL below and click on ‘software requests’ in the right panel. All the documentation is available from the RTTOV web site at: <http://www.nwpsaf.org/>.

If you would like to be informed about RTTOV developments, bugs in the code, and new coefficient files you can join an RTTOV email list by sending an email to: nwpsaf@metoffice.gov.uk and requesting to be added to the list.

LIST OF ACRONYMS

AMSU: Advance Microwave Sounding Unit
ATOVS: Advanced TIROS Operational Vertical Sounders
BUFR: Binary Universal Form for the Representation of meteorological data
CAL/VAL: Calibration/Validation
CIMSS: Cooperative Institute for Meteorological Satellite Studies
CMA: Chinese Meteorological Agency
COSMIC: Constellation Observing System for Meteorology, Ionosphere and Climate
CRTM: Community Radiative Transfer Model
DMSP: Defense Meteorological Satellites Program
DoD: Department of Defense (US)
EPS: EUMETSAT Polar Satellite
EUMETSAT: European Organization for the exploitation of meteorological satellites
FNMOCC: Fleet Numerical Meteorology and Oceanography Center
FOV: Field of View
FY-3: LEO satellite from China
GLONASS: (Russian) Global Navigation Satellite System
GNSS: Global Navigation Satellite Systems
GPS: Global Positioning System
GRAVITE: Government Resource for Algorithm Validation Integrated Testing and Evaluation
HEO: Highly Elliptical Orbit
IASI: Infrared Atmospheric Sounding Interferometer
IASI-NG: IASI- Next Generation
IR: Infrared
ITAR: International Traffic in Arms Regulations
ITSC: International TOVS Study Conference
IPO: Integrated Program Office
IROWG: International Radio Occultation Working Group
ITU: International Telecommunication Union
ITWG: International TOVS Working Group
JPSS: Joint Polar Satellite System
LEO: Low Earth Orbit
Met.No: Norwegian Meteorological Institute
MetOp: Meteorological Operational
MHS: Microwave Humidity Sounder
MW: Microwave
NESDIS: National Environmental Satellites, Data, and Information Service
NMS: National Meteorological Services
NPP: NPOESS Preparatory Project
NRL: Naval Research Laboratory
NPOESS: National Polar-orbiting Operational Environmental Satellite System
OPS: Operations
RARS: Regional ATOVS Retransmission Services
RFI: Radio Frequency Interference
RTTOV: Radiative Transfer for TOVS
SAF: Satellite Application Facility
SMHI: Sweden's Meteorological and Hydrological Institute
SSEC: Space Science and Engineering Center

SSMI: Special Sensor Microwave Imager
SSMIS: Special Sensor Microwave Imager/Sounder
Met. Office: United Kingdom Met Office
UPP: Unified Pre-processor (SSMIS)
WG: Working Group

ITSC-XVII AGENDA

Tuesday 13 April 2010

15:00-19:00 Registration

19:00-22:00 Icebreaker

Wednesday 14 April 2010

8:00 Registration (continues to 15:00)

8:30-9:00 Welcome Co-chairs Allen Huang, Stephen English

An Overview Of The NRL Marine Meteorology Division Research
Nancy Baker

Local arrangements Nancy Baker, Ben Ruston

Review of agenda Co-chairs

Session 1 Generation and validation of meteorological and environmental products from sounder radiances

9:15-10:19 Session 1 Oral presentations

Chairs: Sid-Ahmed Boukabara and Jun Li

- 1.1 Sid-Ahmed Boukabara Variational Inversion of Hydrometeors Using Passive Microwave Sensors - Application to AMSU/MHS and SSMIS.
- 1.2 Jörg Ackermann Validation Aspects of Present and Future Operational Metop ATOVS/AVHRR Products.
- 1.3 Pradeep Thapliyal Development of an Algorithm for the Retrieval of Atmospheric Profiles from Infrared Sounder Onboard INSAT-3D.
- 1.4 Lydie Lavanant Towards a Better Retrieval of Fine Water Vapor Atmospheric Structures Using IASI Data.

10:20-10:40 BREAK

10:40-10:54 Session 1 Poster Presentations

Chairs: Sid-Ahmed Boukabara and Jun Li

- 1.5 Joao Teixeira Probing Trade-Wind Cumulus Boundary Layers with AIRS.
- 1.6 Lydie Lavanant Comparison of MetOp IASI Cloud Products for Cloudy Radiances Assimilation.
- 1.7 François Faijan Processing of IASI Cloudy Heterogeneous Scenes Using the AVHRR Radiances Analysis.
- 1.8 Tony Reale Demonstration Poster for the NESDIS Validation System (NPROVS).
- 1.9 Christopher Down The Australian Bureau of Meteorology Space-borne Infrared Sounder Validation Project.
- 1.10 Evan Fishbein Characterizing Sub-footprint Variability in AIRS Radiances Using MODIS.

- 1.11 Ouahid Aznay
(for Filipe Aires) Measurement and Exploitation of Multi-sensor and Multi-wavelength Synergy for Remote Sensing - Application to the Retrieval of Atmospheric Temperature and Water Vapour from MetOp.

10:54-11:42 Session 1 Oral presentations

Chairs: Sid-Ahmed Boukabara and Jun Li

- 1.12 William Blackwell Hyperspectral Microwave Atmospheric Sounding.
1.13 Lihang Zhou NPOESS Preparatory Project Validation Program for the Atmospheric Profile Data Products.
1.14 Robert Knuteson AIRS and IASI Precipitable Water Vapor (PWV) Absolute Accuracy in the Tropics, Mid-Latitudes, and Arctic

11:42-11:56 Session 1 Poster Presentations

Chairs: Sid-Ahmed Boukabara and Jun Li

- 1.15 Peter Wang Assessment of Heavy Rainfall Retrieved from Microwave Instrument in Taiwan Area.
1.16 Stephen Tjemkes Physically Based Level 2 and 3 Products Obtained
(for Paolo Antonelli) from IASI Observations Processed with UWPHYSRET.
1.17 Devendra Singh Satellite Application for Fog Detection During Day and Night Time.
1.18 Youri Plokhenko Physical Aspects of Non-Linear Analysis and Interpretation of Hyperspectral Measurements from the AIRS Radiometer.
1.19 Thomas King The NOAA Unique CrIS/ATMS Product Processing System (NUCAPS).
1.20 Brian Kahn Multi-Moment Statistics of Cloud and Moist Conserved Variables from the A-Train.
1.21 Hartmut Aumann Development of a Near Real-Time Aviation Alert System Using AIRS, Based on the Analysis of the Atmospheric Conditions at the Time of the Air France 447 Crash Using AIRS, TRMM And IASI Data.

12:00-13:00 Lunch

13:00-13:30 Break

Session 1 Generation and validation of meteorological and environmental products from sounder radiances (continued)

Chairs: Peter Schlüssel and Allen Larar

13:30-14:02 Session 1 Oral presentations

Chairs: Peter Schlüssel and Allen Larar

- 1.22 Elisabeth Weisz Updates to the IMAPP AIRS Utility Software.
1.23 Bill Smith Dual EOF Regression Surface and Atmospheric Variable Specification for Initializing Atmospheric Sounding Physical Retrieval and Direct Radiance Assimilation.

14:02-14:14 Session 1 Poster Presentations

Chairs: Peter Schlüssel and Allen Larar

- 1.24 Nikita Pougatchev AIRS v. 5 Temperature and Water Vapor retrievals characterization and error assessment.

- 1.25 Devendra Singh Status of Current and Future Satellite Program and Their Use for Agriculture Application.
- 1.26 Awdhesh Sharma Web-based Skew-T Displays of GOES and POES Operational Atmospheric Soundings Added to the NOAA/NESDIS Operation.
- 1.27 Liam Gumley Pre-Launch Evaluation of NPP/NPOESS VIIRS Atmosphere Environmental Data Records.
- 1.28 Ashim Mitra A Neural Network Approach for Temperature Retrieval from AMSU-A Measurements Onboard NOAA-15 And NOAA-16 Satellites and a Case Study During 'Gonu' Cyclone.
- 1.29 Jeff Puschell Soundings with Hyperspectral VIIRS.

Session 2: Atmospheric chemistry and air quality

14:14-14:20 Session 2 Poster Presentations

Chairs: Thierry Phulpin and Xu Liu

- 2.1 Zoltan Barcza Estimation of the carbon balance components of heterogeneous agricultural landscape using tall tower based and remotely sensed data.
- 2.2 Fiona Hilton Potential for the Use of Reconstructed IASI Radiances in the Detection of Atmospheric Traces Gases.
- 2.3 Nicole Jacquinet (for Sophie Peyridieu) Dust Aerosol Optical Depth and Altitude Retrieved from 7 Years of Infrared Sounders Observations (AIRS, IASI), and Comparison with Other Aerosol Datasets (MODIS, CALIOP, PARASOL).

14:20-15:08 Session 2 Oral Presentations

Chairs: Thierry Phulpin and Xu Liu

- 2.4 Sergey Uspensky (for Alexander Uspensky) Possibilities for Retrieving the Ozone and Trace Gases from Data of Satellite IR Sounders IRFS-2 with High Spectral Resolution.
- 2.5 Thierry Phulpin Major Results of IASI on Atmospheric Chemistry.
- 2.6 Anton Kaifel First Results on Synergistic Ozone Profile Retrieval from GOME-2 and IASI Measurements with NNORSY.

15:08-15:30 Break

15:30-16:18 Session 2 Oral Presentations

Chairs: Thierry Phulpin and Xu Liu

- 2.7 Fred Prata Retrieval of SO₂ from High Spectral Resolution Measurements: IASI and AIRS.
- 2.8 Wei Han The Assimilation of IASI Ozone Channels.
- 2.9 Hyo-Jin Han Examining Effect of Asian Dusts on the AIRS-Measured Radiances from Radiative Transfer Simulations.

Session 3: Direct Broadcast, preprocessing and calibration of sounder radiances

This session is dedicated to the memory of Hal Woolf.

16:18-17:06 Session 3 Oral presentations

Chairs: Pascal Brunel and Liam Gumley

- 3.1 Steve Swadley SSMIS Radiance Assimilation and Calibration Anomaly Mitigation.
- 3.2 Richard Kelley Draft ITU-R Rpt: Identification of Degradation Due to Interference and Characterization of Possible Mitigation Techniques for Passive Sensors.
- 3.3 Lars Fiedler IASI L0/L1 NRT Monitoring at EUMETSAT: Comparison of Level 1 Products from IASI and HIRS on Metop-A.

18:00-19:00 Dinner

19:15-21:30 Poster Viewing along with Icebreaker and remembrance of Hal Woolf

19:15-20:00 Hal Woolf Memorial Session

Chairs: Bill Smith, Paul Menzel, John Eyre, Roger Saunders, and Tom Achtor (Participating ITWG Former Co-chairs)

20:00-20:30 Session 3 Poster Presentations

Chairs: Pascal Brunel and Liam Gumley

- 3.4 Aniko Kern Real-time Processing of Direct Broadcast MODIS Data in Hungary.
- 3.5 Liam Gumley Virtual Appliance for Terra, Aqua, Metop, and POES Direct Broadcast Processing.
- 3.6 Kathleen Strabala IMAPP: Promoting the Knowledge and Use of Remote Sensing Data.
- 3.7 Ruiyue Chen Spectral and Radiometric Calibration of HIRS Using IASI on Metop Satellite.
- 3.8 Anna Booton AAPP Developments for Metop, NOAA-19 and NPP.
- 3.9 Denise Hagan Cross-Track Infrared Sounder Pre-Launch Calibration and On-Orbit Validation Plans.
- 3.10 Christelle Ponsard Evolution of the EUMETSAT Advanced Retransmission Service (EARS).
- 3.11 Richard Kelley Draft ITU-R Report: Passive Bands of Interest to EESS/SRS from 275 to 3,000 GHz.
- 3.12 Vladimir Zavyalov Using IASI Radiances to Generate Proxy Data Set to Test CrIS SDR Algorithm.
- 3.13 Yi Song A BUFR and GRIB Tailoring System for NPP/NPOESS Products.
- 3.14 Bo-Ra Kim Use of IASI Measurements to Calibrate MODIS and AMSU-B Water Vapor Channels.
- 3.15 Walter Wolf The Status of Hyperspectral Product Systems at STAR.
- 3.16 Jerome Lafeuille Status and Plans for the Global RARS Network
- 3.17 B.J. Sohn Use of Cloud Targets to Examine the Calibration Status of Satellite Visible Channels: Application to Meteosat-8/9 and MTSAT-1R.

20:30-21:30 Session 1, 2, 3 Poster Viewing

Thursday 15 April 2010

7:30-8:30 Breakfast

Session 4: Atmospheric radiative transfer

8:30-8:38 Session 4 Poster Presentations

Chairs: Paul van Delst and Marco Matricardi

- 4.1 Jonathan Taylor IASI 1dvar Using PC Radiative Transfer.
4.2 Paul van Delst ATMS NPP Preparation in the Community Radiative Transfer Model (CRTM): Spectral Response Function Analysis.
4.3 Allen Huang High-spectral Resolution Radiative Transfer Model Performance Comparison - CPU vs. GPU.
4.4 Nicole Jacquinet The GEISA Database 2009 Archive: An Assessment Of Spectroscopic Parameters through IASI Hyperspectral Remote Sensing Applications.

8:38-9:26 Session 4 Oral Presentations

Chairs: Paul van Delst and Marco Matricardi

- 4.5 Yong Han Current Status of the JCSDA Community Radiative Transfer Model (CRTM).
4.6 Roger Saunders Update on RTTOV Developments.
4.7 Stuart Newman Aircraft and Satellite Hyperspectral Measurements Investigating the Radiative Impact of Atmospheric Water Vapour.

Session 5: Surface property modelling and sensing

9:26-10:30 Session 5 Oral Presentations

Chairs: Fuzhong Weng and Fatima Karbou

- 5.1 Eva Borbas Application of the UW/CIMSS High Spectral Resolution Global IR Land Surface Emissivity Database into the RTTOV Model.
5.2 Daniel Zhou Retrieval of Hyperspectrally-resolved Surface Emissivity and Validation.
5.3 Stephanie Guedj Towards a Better Modeling of Surface Emissivity to Improve AMSU Data Assimilation over Antarctica.
5.4 Filipe Aires A Tool to Estimate Land Surface Emissivities at Microwaves Frequencies (TELSEM) for Use in Numerical Weather Prediction Schemes.

10:30-10:50 BREAK

10:50-11:08 Session 5 Poster Presentations

Chairs: Fuzhong Weng and Fatima Karbou

- 5.5 Paul van Delst Implementation of a New Infrared Sea Surface Emissivity Model in the Community Radiative Transfer Model.
5.6 Stephen English Improved Use of AIRS, IASI and AMSU-A over Land.
5.7 Stuart Newman Sea Ice Emissivities and Effective Temperatures at AMSU-B Frequencies: An Analysis of Airborne Microwave Data Measured During Two Campaigns.

- 5.8 Fred Prata Land Surface Temperature Determination from the ATSR-Family of Instruments and the Sentinel-3 SLSTR.
- 5.9 Zhaohui Cheng Infrared Land Surface Emissivity Regression Retrieval Algorithm.
- 5.10 Stephanie Guedj Towards the Assimilation of SEVIRI Observations over Land.
- 5.11 Mark Liu An Improved Fast Microwave Sea Surface Emissivity Model, FASTEM4.
- 5.12 Thomas Kleespies Footprint Matching for the Advanced Technology Microwave Sounder.
- 5.13 Sergey Uspensky Retrieving the Atmospheric Temperature/Humidity Profiles and Temperature / Emissivity of Land Surface Using the High Spectral Resolution Data from IR Satellite Sensor IRFS-2.

11:08-12:12 Session 5 Oral Presentations

Chairs: Fuzhong Weng and Fatima Karbou

- 5.14 Nicole Jacquinet (for Virginie Capelle) Infrared Continental Surface Emissivity Spectra and Skin Temperature Retrieved from IASI Observations.
- 5.15 Fuzhong Weng Improvements in Land Surface Emissivity Models for Community Radiative Transfer Model (CRTM) Applications.
- 5.16 Ralph Ferraro Utilization of Land Surface Emissivity for Precipitation Retrieval – an Obvious Linkage Between ITWG and IPWG – and Implications for GPM-era Algorithms.
- 5.17 Thomas Kleespies Modeling of Inhomogeneous Surface Properties for the Advanced Technology Microwave Sounder.

12:12-13:00 Lunch

13:00-13:30 Break

Session 6: Climate studies

Chairs: Roger Saunders and John Bates

13:30-14:18 Session 6 Oral Presentations

Chairs: Roger Saunders and John Bates

- 6.1 Paul Menzel Inferring Global Cloud Cover Properties and Trends from Thirty Years of HIRS Data.
- 6.2 Antonia Gambacorta Using Hyperspectral Sounders for Climate Applications.
- 6.3 John Bates NOAA'S Climate Data Record Project – An Update of Status and Progress.

Action items from ITSC-16

14:20-15:05 ITSC-16 Action items presented by ITSC-16 WG co-chairs

Moderators: Allen Huang and Stephen English

- Note: 15 Minutes each
 RT WG (Louis Garand)
 Climate WG (Jörg Schulz)
 NWP WG (Godelieve Deblonde)

15:05-15:30 BREAK

15:30-16:15 ITSC-16 Action items presented by ITSC-16 WG co-chairs

Moderators: Allen Huang and Stephen English

Note: 15 Minutes each

Advanced IR Sounder WG (Andrew Collard)

International and Future Systems (Jerome Lafeuille)

Satellite Sounder Science and Products (Tony Reale)

16:15-16:55 Technical sub-group reports

Moderators: Allen Huang and Stephen English

Note: 10 Minutes each

ATOVS direct broadcast packages (Liam Gumley)

RTTOV (Roger Saunders)

CRTM (Paul van Delst)

Frequency protection (Richard Kelley)

16:55-17:30 Working group formation

18:00-19:00 Dinner

19:30-21:00 Session 4 and 5 Poster Viewing

Friday 16 April 2010

7:30-8:30 Breakfast

Session 6: Climate studies

Chairs: Roger Saunders and John Bates

8:30-9:50 Session 6 Oral Presentations

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| 6.4 Baijun Tian | Vertical Moist Thermodynamic Structure of the MJO in AIRS Observations and ECMWF Interim Reanalysis |
| 6.5 Mitch Goldberg | Using Hyperspectral Infrared Radiance Global Data Sets to Validate Weather and Climate Analyses. |
| 6.6 Cheng-Zhi Zou | An Update on the NESDIS MSU/AMSU/SSU CDR Development and its Applications. |
| 6.7 Nathalie Courcoux | CM-SAF Products from ATOVS: Six Years of Operationally Produced Data (2004-2009) and First Results from the Reprocessing of ATOVS Products (1999-2009). |
| 6.8 Thomas Pagano | Natural and Anthropogenic Variability Observed in Seven Years of Data from the Atmospheric Infrared Sounder (AIRS). |

9:50-10:12 Session 6 Poster Presentations

Chairs: Roger Saunders and John Bates

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| 6.9 Eric Maddy | On the Temporal Stability of AIRS Temperature Retrievals: Trace Gas Initialization Effects. |
| 6.10 Roger Saunders | A Consistent Monitoring of Satellite Radiance Biases for GSICS. |

6.11 Nathalie Selbach	An Overview of the Operational Processing at the Satellite Application Facility on Climate Monitoring.
6.12 Mitch Goldberg	Global Space-Based Inter-Calibration System (GSICS) Sensor Intercomparisons and Corrections.
6.13 Carl Mears	A Monte-Carlo Approach to Estimating Uncertainty in MSU/AMSU Climate Data.
6.14 Eric Fetzer	Creating Long-Term Water Vapor and Temperature Records with AIRS and Other Data Sources.
6.15 Peter Thorne	GCOS Reference Upper Air Network: a Status Update.
6.16 Martin Stengel	The Intercomparison of IASI Water Vapour Retrieval Schemes under Climate Monitoring Aspects.
6.17 Nicole Jacquinet (for Claudia Stubenrauch)	Global Cloud Climatologies from Satellite-based InfraRed Sounders (TOVS, AIRS and IASI).
6.18 Eui-Seok Chung	The Radiative Signature of Increasing Carbon Dioxide Concentration in HIRS Measurements.
6.19 Ramesh Singh	Advancing and Retreat of Himalayan Glaciers Based on the Increasing Trend of Anthropogenic Activities in the Indo-Gangetic Plains.

10:12-10:40 BREAK

Session 7: Current use in NWP

10:40-10:56 Session 7 Poster Presentations

Chairs: John Eyre and Steve Swadley

7.1 Kozo Okamoto	Recent Developments in Satellite Data Assimilation at JMA.
7.2 Stephen English	Operational Status Report – UK Met Office.
7.3 Bjarne Amstrup	Status of ATOVS Usage in the DMI-HIRLAM Operational Analyses.
7.4 Detlef Pingel	Use of Satellite Radiance Data in the Global Meteorological Model of the German Weather Service (DWD).
7.5 Chris Tingwell	Operational Satellite Data Assimilation in ACCESS.
7.6 Yongsang Kim	The New NWP System at KMA and its Use of Satellite Radiance Data.
7.7 Peter Bauer	Status of Satellite Data Assimilation at ECMWF.
7.8 Wei Han	The Use of Satellite Data in Chinese New GFS.

10:56-12:00 Session 7 Oral Presentations

Chairs: John Eyre and Steve Swadley

7.9 Andrew Collard	An Overview of the Assimilation of IASI and AIRS Radiances at Operational NWP Centres.
7.10 Godelieve Deblonde	Impact Evaluation of New Radiance Data, Reduced Thinning and Higher Analysis Resolution in the GEM Global Deterministic Prediction System.
7.11 Banghua Yan	Assimilation Study of Microwave Sensor Water Vapor Sounding Channels in NCEP Global Forecast System.
7.12 Peter Bauer	Impact of Increased Satellite Data Density in Areas Most Sensitive to Forecast Error Growth.

12:00-13:00 Lunch

13:00-13:30 Break

13:30-13:52 Session 7 Poster Presentations

Chairs: John Eyre and Steve Swadley

- 7.13 Andrew Collard Prospects for the Assimilation of Advanced Infrared Sounder Radiances over Land.
- 7.14 William Campbell AMSU-A Bias Correction for COAMPS/NAVDAS.
- 7.15 Vincent Guidard Assimilation of Satellite Data over Antarctica in the Framework of the Concordiasi Campaign.
- 7.16 Vincent Guidard Evaluation of IASI Inter-Channel Observation Error Covariances.
- 7.17 Niels Bormann Of Chessboards and Ghosts: Signatures of Micro-Vibrations in IASI Monitoring in NWP?
- 7.18 Niels Bormann Assimilation of NOAA-19 Data - The Pinnacle of ATOVS Data at ECMWF?
- 7.19 Nadia Fourrie Data Impact Experiments Using IASI Observations During the Extratropical Transitions of Hurricanes Gustav, Hannah and Ike in the Atlantic.
- 7.20 Brett Candy Use of Variable Observation Errors in Radiance Assimilation.
- 7.21 Brett Candy Mesospheric Assimilation Studies with SSMIS Channels.
- 7.22 Roger Randriamampianina Radiance Single Observation Experiments Using Global and Regional Models.
- 7.23 Roger Randriamampianina The Relative Impact of Satellite Observations in the HARMONIE/Norway Regional Model

13:52-14:56 Session 7 Oral Presentations

Chairs: Dirceu Herdies and Kozo Okamoto

- 7.24 Marc Schwaerz Assimilation of IASI Radiances over Sea and Land into the Regional NWP Model COSMO-EU.
- 7.25 Vincent Guidard Impact of IASI Data Density in the Assimilation of a Convective-Scale Model.
- 7.26 Fatima Karbou Assimilation of Low Level Humidity and Temperature Observations from AMSU-A & -B over Land.
- 7.27 Marco Marticardi Preliminary Results of the Direct Assimilation of IASI Band 3 Principal Component Scores into the ECMWF NWP System.

15:00-15:30 BREAK

15:30-15:50 Session 7 Poster Presentations

Chairs: Dirceu Herdies and Kozo Okamoto

- 7.28 Dirceu Herdies Impact of TRMM Precipitation on Regional Analysis over South America.
- 7.29 John Le Marshall Improvements in NWP from Increased Use of the Information Content of Ultraspectral Observations.
- 7.30 Li Bi Impact of Satellite Surface Wind Observations on the Tropical Cyclone Track Forecasts in the NRL NAVDAS/COAMPS and NRL NAVDAS-AR/NOGAPS Mesoscale and Global Data Assimilation and NWP Systems.

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| 7.31 | Stephen Macpherson | Experiments with Increased Analysis Resolution and Satellite Radiance Data Volume in the GEM Global Deterministic Prediction System. |
| 7.32 | Peter Bauer | Direct Assimilation of All-sky Microwave Radiances at ECMWF. |
| 7.33 | Alain Beaulne | Experiments with New Data Sources in the GEM Global Deterministic Prediction System. |
| 7.34 | Fatima Karbou | Impact Studies Towards the Use of SSM/I Observations over Land in the French Global Model. |
| 7.35 | Wei Han | Bias Correction of Window Channels on Microwave and Infrared Sounders. |
| 7.36 | Bill Bell | Plans for the Assimilation of Cloudy Infrared Radiances. |
| 7.37 | Jonathan Taylor | Utilisation of IASI Data in a Cloudy Atmosphere. |

16:00-18:00 Session 6 and 7 Poster Viewing

18:00-19:15 Tom Achtor McIDAS Presentation and Demonstration.

Dinner on your own

Saturday 17 April 2010

7:30-8:30 Breakfast

9:00-12:00 Working Group Meetings

12:00-13:00 LUNCH

13:30 Open Activities

18:00-19:00 BBQ Dinner

19:30-21:00 Working groups (or as arranged by WG co-chairs)

Sunday 18 April 2010

7:30-8:30 Breakfast

Open activities.

Tour and Group dinner at Chateau Julien

Monday 19 April 2010

7:30-8:30 Breakfast

8:30-9:50 Session 7 Oral Presentations

Chairs: Tom Kleespies and Fiona Hilton

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| 7.38 | Zhiquan Liu | Radiance Assimilation over Northern High-Latitude Regions with the WRF Model. |
| 7.39 | John Eyre | Beyond Optimal Estimation: Sensitivity of Analysis Error to the Specification of Background Error. |

- 7.40 Fiona Hilton The Sensitivity of the Sub-Optimal NWP Analysis System to the Representation of Hyperspectral Data.
- 7.41 William Campbell Vertical Covariance Localization for Satellite Radiances in Ensemble Kalman Filters.
- 7.42 Niels Bormann Estimates of Spatial and Inter-Channel Observation Error Characteristics for AMSU-A and IASI and Applications in the ECMWF System.

9:50-10:20 BREAK

10:20-11:40 Session 7 Oral Presentations

Chairs: Tom Kleespies and Fiona Hilton

- 7.43 Bill Bell An Assessment of SSMIS Imager Data.
- 7.44 Jun Li Forecast of Hurricane Track and Intensity with Advanced IR Soundings.
- 7.45 Benjamin Ruston Interaction of GPS Radio Occultations with Hyperspectral Infrared and Microwave Sounder Assimilation.
- 7.46 Nadia Fourrie Impact of Advanced Sounder Cloudy Radiances in the Global Numerical Weather Prediction Arpege Model.
- 7.47 Sylvain Heilliette Infrared Cloudy Radiances Assimilation Experiments at Environment Canada.

12:00-13:00 Lunch

13:00-13:30 Break

13:30-14:18 Session 7 Oral Presentations

Chairs: Tom Kleespies and Fiona Hilton

- 7.48 Stephen Mango Emerging and Evolving Opportunities for Achieving Global Soundings for NWP and Climate Using GNSS/GPS Radio Occultation Systems.
- 7.49 Martin Stengel Assimilation of Cloud-Affected Infrared Radiances in HIRLAM 4D-Var.
- 7.50 Louis Garand Validation of Cloud Parameter Forecasts Using Infrared Hyperspectral Sounders.

14:18-15:00 Session 8: Agency status report poster presentations (5 mins)

Chairs: Mitch Goldberg and Jerome Lafeuille

- 8.1 Dieter Klaes EUMETSAT Plans
- 8.2 Thierry Phulpin CNES Programmes For Meteorology, Climate And Atmospheric Composition
- 8.3 Kozo Okamoto Agency Status Reports: JMA And JAXA
- 8.4 Sergey Uspensky Russia
- 8.5 Pradeep Thapliyal India
- 8.6 Mitch Goldberg NOAA
- 8.7 Jun Li China

15:00-15:30 BREAK

Session 9: Future sounders

15:30-15:40 Session 9 Poster Presentations

Chairs: Pete Wilczynski and Dieter Klaes

- 9.1 Louis Garand Continuous Imaging of the Arctic from the Polar Communications and Weather Mission.
- 9.2 Bill Bell Study on the Spectral and Radiometric Requirements for a European post-EPS Microwave Imaging Mission.
- 9.3 Stephen Tjemkes On the Apodisation of MTG-IRS.
- 9.4 Stephen English Evaluation of the Potential of a Geostationary IR Sounder.
- 9.5 Sergey Uspensky Development of a New Generation Meteorological
(for Alexander Uspensky) Satellites Based on Polar Orbiting Platform of “METEOR-M” Series.

15:40-16:40 Session 8 and 9 poster viewing

16:40-17:30 Working groups finalise reports

19:00 Banquet at the Aquarium

Tuesday 20 April 2010

7:30-8:30 Breakfast

Session 9: Future sounders and programs

8:30-10:06 Session 9 Oral Presentations

Chairs: Pete Wilczynski and Dieter Klaes

- 9.6 Sung-Yung Lee Activity of Sounder PEATE.
- 9.7 Peter Schlüssel Sounding Observation Missions for the Future EUMETSAT Polar System.
- 9.8 Bjorn Lambrigtsen Developing a Geosynchronous AMSU: A GeoSTAR Update.
- 9.9 Stephen Tjemkes Towards a Consolidated L2 Processor for MTG-IRS.
- 9.10 Vincent Leslie Development and Predicted Performance of the Advanced Technology Microwave Sounder for the NPOESS Preparatory Project.
- 9.11 Peter Wilczynski Global Change Observation Mission (GCOM) Data Recovery by the National Oceanic And Atmospheric Administration (NOAA) – An International Partnership to Capture Critical Operational and Climate Environmental Data Records from Space.

10:06-10:25 BREAK

10:25-11:45 Working Group reports

Co-chairs: Allen Huang and Stephen English

- RT
- Climate
- NWP
- Advanced IR Sounders
- International and Future Systems
- Satellite Sounder Science and Products

11:45-12:15 Future meetings, other events relevant to ITWG

Co-chairs: Allen Huang and Stephen English

Plans for next meeting and closing remarks

ITSC-XVII ABSTRACTS

An Overview of the NRL Marine Meteorology Division Research

Authors: Nancy Baker (Simon Chang, Pat Phoebus, Melinda Peng, Ted Tsui)

Presenter: Nancy Baker

The Marine Meteorology Division is pleased to be the local host for the 17th International TOVS Study Conference. This presentation will give a brief overview of the meteorological research activities at NRL-MRY in support of the Navy and co-located Fleet Numerical Meteorology and Oceanography Center (FNMOC). The focus will be on our use of satellite observations for NWP and real-time Naval support. Special emphasis will be placed on polar satellite assimilation with our newly operational 4D-Var system, NAVDAS-AR.

1.1 Variational Inversion of Hydrometeors Using Passive Microwave Sensors -Application to AMSU/MHS and SSMIS

Authors: S.-A. Boukabara, K. Garrett, F. Iturbide-Sanchez, W. Chen, C. Grassotti

Presenter: Sid-Ahmed Boukabara

This study presents the results of a 1-Dimensional variational algorithm which performs the inversion of hydrometeor parameters in a physically consistent fashion. The hydrometeors in question are both the liquid rain and the frozen rain (graupel ice). The algorithm is called the Microwave Integrated Retrieval System (MiRS) which uses microwave radiances from AMSU and MHS sensors onboard NOAA-18, NOAA-19, Metop-A and DMSP-F16 SSMIS as well as proxy NPP/ATMS data. It is running operationally at NOAA/NESDIS for a number of atmospheric, land and cryospheric products as well as for the integrated ice water path and surface rainfall rate. The retrieval of hydrometeors from space, is notoriously an ill-posed problem. This is because the brightness temperature measurements, depending on the sensing frequency, are a mixture of multiple signals coming from the rain itself, the ice, the suspended non-precipitating cloud droplets, the surface temperature, the surface emissivity, the atmospheric temperature and degree of humidity. The rain and ice signals themselves do not necessarily depend only on the rain or ice amounts. They also depend to various degrees on the particle size assumed, the vertical distribution, the shape, the size distribution, the density, among other

things. It is therefore challenging to solve accurately all these unknowns without constraining independently the domain of possible solutions. The physical constraints used in MiRS include:

- Using a variational technique for the inversion of all atmospheric, surface and hydrometeors parameters ensuring that the final solution fits well all brightness temperatures simultaneously. The approach consists of minimizing the constrained cost function, similar to the variational radiance data assimilation employed in Numerical Weather Prediction (NWP) models.
- Using the Community Radiative Transfer Model (CRTM) as the forward and adjoint operators for the determination of the simulated brightness temperatures as well as the Jacobians in all atmospheric conditions, including in the presence of rain and ice. MiRS can therefore physically distinguish the signal coming from ice, from rain, from other atmospheric parameters, from the surface and from skin temperature, etc. This offers a powerful way to retrieve rain and ice while at the same time accounting for secondary effects impacting the measurements, including the emissivity and the skin temperature.
- 1DVAR algorithms rely on constraint covariance matrices (composed of variances and correlations between the parameters) that force the different parameters to vary within reason during the physical retrieval. This has the added advantage of allowing to extract hydrometeor-related information from sounding channels for instance since the temperature has clearly a correlation with the presence of rain or ice.

The assessment of the results is performed by using heritage algorithms, rain gauges, ground-based radars measurements and TRMM/TMI-PR based data. It is done essentially by checking the horizontal fields (integrated and at different layers) of MiRS retrievals of liquid and frozen rain profiles. They will be assessed on a qualitative basis as well as on a quantitative basis.

1.2 Validation Aspects of Present and Future Operational Metop ATOVS/AVHRR Products

Authors: Jörg Ackermann, Rüdiger Lang, Thomas Heinemann and François Montagner

Presenter: Jörg Ackermann

The ATOVS/AVHRR instruments are flown on the current NOAA weather satellites and on Metop-A, the first of the three satellites of the EUMETSAT Polar System (EPS). Metop-A was launched on 19 October 2006. With the exception of AMSU channel 7, all sensing data from ATOVS/AVHRR onboard Metop-A are well within the nominal specifications. The validation of the Level 1 and Level 2 products is an essential prerequisite for the beneficial use of the data in numerical weather prediction and climate monitoring. Planned and present validation activities will be presented by focussing on the following aspects:

- GOME-2 vs. AVHRR channel 1 (0.63 μm). Similar to the validation of HIRS radiances using IASI, it is possible to compare AVHRR channel 1 in-band radiances against co-located measurements from the Global Ozone Monitoring Experiment (GOME-2) onboard Metop-A. Since AVHRR visible channels have no in-flight calibration, this approach might be of interest for verifying the regular updates of the AVHRR visible channels' calibration coefficients.
- MHS radiance validation. The evaluation of Simultaneous Nadir Overpasses for NOAA-19 and Metop-A was performed during the Satellite In Orbit Verification phase of NOAA-19. In particular, it helped to correct the pre-launch calibration data of the NOAA-19 MHS instrument.
- Polar cap winds from Metop-A AVHRR. Recently, a processor for calculating winds from overlapping areas of subsequent overpasses in the polar regions, has been implemented into the EPS Ground Segment. Apart of the product validation by means of prototype results, cloud top heights derived from co-located IASI measurements provide additional useful information to validate the wind height assignment.

Furthermore, an outlook on future validation aspects will be discussed: special emphasis will be given on the constellation, when two Metop satellites are operated in the same orbital plane with about 50 minutes time difference. Data from this configuration will be available, when Metop-B is launched in April 2012.

1.3 Development of an algorithm for the retrieval of atmospheric profiles from infrared sounder onboard INSAT-3D

Authors: Pradeep K Thapliyal, Munn V Shukla, Pradip K Pal and Prakash C Joshi

Presenter: Pradeep K Thapliyal

During past decade the development of sophisticated state-of-the-art mesoscale numerical weather prediction models have shown potential in the improvement of weather forecast over tropical Indian region. These models require accurate information of atmospheric temperature and humidity profiles with high spatial and temporal resolution for weather forecasting in short to medium range besides various other weather and climate applications. Currently, these data are obtained from the NOAA operational polar satellites with 1-2 days repetivity. For high temporal resolution geostationary satellites, such as GOES, are required. To improve the continuity and quality of the input atmospheric data India is planning to launch a geostationary satellite, INSAT-3D towards the end of 2010. INSAT-3D will carry an 18-channel infrared Sounder (plus a visible channel for cloud detection during daytime) along with a 6 channel Imager. The spatial resolution of INSAT-3D Sounder observation is approximately 10 km at ground. The normal mode of Sounder operation will cover 6000 km x 6000 km field of view taking approximately 160 minutes for complete coverage. INSAT-3D Sounder observations will provide vertical profiles of temperature and humidity in clear-sky conditions besides total column ozone and various other derived products. An algorithm for the retrieval of atmospheric temperature and moisture profiles along with ozone from INSAT-3D Sounder observations has been developed. A two-step approach has been adopted with nonlinear regression retrieval alongwith the forecast to be used to generate the first guess, followed by the non-linear physical retrieval to obtain the accurate profiles of temperature and humidity. The present retrieval algorithm for INSAT-3D Sounder is primarily based on the retrieval algorithms of Li et al. (2000), Ma et al. (1999), and Hayden (1988). We have also made a few efforts to improve the retrieval accuracy by fine-tuning the algorithm to the Indian tropical atmospheric conditions, besides including new nonlinear technique to improve the quality of the first guess profile in the physical retrieval routine. Results from these efforts will be presented in the conference.

1.4 Towards a better retrieval of fine water vapor atmospheric structures using IASI data

Authors: Lydie Lavanant

Presenter: Lydie Lavanant

The first results of humidity profile retrievals with IASI were much less accurate than expected from simulations done before the launch of IASI. It was discussed at different meetings (ISSWG) of whether it was possible to retrieve fine atmospheric structures from IASI data which were not present in the first guess. An intercomparison exercise of clear-sky sea retrievals performed from JAIVEx data (EUMETSAT Conf, 2009) has indicated that often the temperature and humidity retrievals compensate in ways which add incorrect structures elsewhere in the profile. This talk presents the results of a study done on Jaivex data and on a CMS dataset of coregistered radiosonde and IASI observations to understand what parameters/method can be updated in our retrieval scheme (with in mind computer calculation times of a real-time package) in order to improve the retrieval of fine water vapor structures.

1.5 Probing trade-wind cumulus boundary layers with AIRS

Authors: J. Teixeira, J. Martins, A. Santos, P. Soares, P. Miranda, V. Dang, F. W. Irion, E. Fetzer, and E. Fishbein

Presenter: Joao Teixeira

Shallow cumulus boundary layers are ubiquitous in vast areas of the Earth. Better observations of these cumulus boundary layers are essential to correctly model local and large scale circulations. Recently, the Rain in Shallow Cumulus over the Ocean campaign (RICO) tried to address some of the persisting problems in modeling this type of boundary layers from an observational perspective. It provided a comprehensive dataset that has a number of applications. In this work we used part of this dataset to validate atmospheric temperature and moisture profiles measured by the Atmospheric InfraRed Sounder (AIRS), using the V5 L2 Support product. It is shown that AIRS behaves as expected in this type of regime, independently of factors like cloud and land fractions. The high vertical resolution available through the support product is used to explore the characteristics of the planetary boundary layer, particularly its depth. Results from AIRS and RICO sondes are in good agreement, which shows that there is some potential to estimate global climatological values of boundary layer parameters from AIRS usable in applications

like validation and calibration of weather and climate prediction models, and eventually data-assimilation.

1.6 Comparison of MetOp IASI Cloud Products for cloudy radiances assimilation

Authors: Lydie Lavanant, Arlindo Arriaga, Thomas August, Sylvain Cros, Nadia Fourrié, Antonia Gambacorta, Sylvain Heilliette, Fiona Hilton, Hidenori Nishihata, Ed Pavelin, Florence Rabier, Ben Ruston, Claudia Stubenrauch

Presenter: Lydie Lavanant

IASI data for temperature and humidity sounding are now assimilated in clear conditions at many operational meteorological centres, providing good impact on forecast skill. However, a large amount of situations, more than 80% on the whole globe, are covered by clouds. All the centres began to handle these data, the first step being to detect and characterize the clouds in the footprint of the sounder. One way of investigating the limitations of a particular methodology is to perform a careful intercomparison of the results of different processing schemes for the same observations. For this study, ten different schemes are applied to a 12 hour global acquisition on 18 November 2009. This talk presents the results of the intercomparison for the cloud detection, the cloud pressure and the effective cloud amount in terms of maps, scatter plots, histograms,.. The talk also presents the impact of the cloud products accuracy on the use of cloud-affected channels in retrieval schemes.

1.7 Processing of IASI cloudy heterogeneous scenes using the AVHRR radiances analysis.

Authors: François Faijan ; Lydie Lavanant

Presenter: François Faijan

Two methods for processing of heterogeneous scenes are considered in the IASI sounder FOV for the atmospheric retrieval with use of the AVHRR radiances analysis: The first method does characterization of the cloud in terms of height, effective emissivity and coverage in the sounder ellipse. This set of cloudy parameters allows to compute IASI cloudy synthetic spectra and if the departure to the observed spectra are small enough, the cloudy observed IASI radiances are directly used in a 1Dvar cloudy scheme to retrieve the atmospheric profiles. The second method does the decomposition of the cloudy IASI spectrum in up to four spectra corresponding to homogeneous layers in the IASI FOR (Field Of Regard) and

reprojected to each individual IASI pixel. It is then possible to use each homogeneous spectrum to first determine the cloud or surface parameters and to retrieve the corresponding atmospheric profiles. In a preliminary step, the two methods will be tested on our operational North-Atlantic and Europe operational area for different days in cloudy conditions. The increase of the Degree Of Freedom in the system will be considered.

1.8 The NOAA PROducts Validation System (NPROVS) and Archive Sub-system (NARCS) for Real-time and Long-term Monitoring of Environmental Satellite Products

Authors: Anthony Reale, Michael Pettey and Bomin Sun

Presenter: Tony Reale

The National Oceanic and Atmospheric Administration/National Environmental Satellite Data and Information Service (NOAA/NESDIS) produces operational global temperature and moisture soundings from several polar-orbiting and geostationary satellites. Within the NESDIS Office of SaTellite Applications and Research (STAR), the function of centralized scientific monitoring and validation of operational atmospheric derived product systems for Advanced-TOVS (ATOVS), Atmospheric Infrared Sounder (AIRS), Microwave Integrated retrieval System (MIRS), GOES, Infrared Atmospheric Sounding Interferometer (IASI) and Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) is provided by NOAA PROducts Validation System (NPROVS) and Environmental Data and Graphical Evaluation (EDGE) analytical interface. Recently, these capabilities were enhanced through the deployment of the NPROVS ARChive Sub-system (NARCS) and associated EDGE upgrades for trend monitoring and display. The following report summarizes upgrades over the past year to the combined NPROVS and EDGE interface including the addition of new systems, parameters, analytical options and in particular the newly deployed NARCS for long term trend monitoring of the respective system performance. New products systems accessed by NPROVS include EUMETSAT IASI, MIRS from SSMIS onboard the DMSP F-16 and the recently deployed NOAA-19 satellite. This brings the total number of operational and experimental product systems accessed by NPROVS to nineteen. New parameters include drift and cloud observations from ground truth radiosondes and a number of enhanced sampling and statistical analysis options within EDGE for improved scientific analysis. A significant enhancement is the deployment of

NARCS which provides for the systematic archive of all collocated radiosonde and satellite observations routinely compiled by NPROVS and associated EDGE interface for trend analysis and display. Trend analysis and display options include a number of the features available for real-time and short term analysis plus additional capabilities specifically designed for long term trend analysis. The above work is supported by the NOAA Integrated Program Office in conjunction with CrIS/ATMS Cal/Val team activities in preparation for NPOESS level 2 product systems (2013) and pending NPOESS Preparatory Project (NPP) products in 2011. The contents of this report do not necessarily reflect any position of the United States government or the National Oceanic and Atmospheric Administration.

1.9 The Australian Bureau of Meteorology Space-borne Infrared Sounder Validation Project.

Authors: Anthony Rea and Christopher Down

Presenter: Christopher Down

The Australian Bureau of Meteorology (Bureau) is finalising the installation of a network of X-band receiving stations to provide reception capability for the next generation of meteorological satellites: NPP, NPOESS and Fengyun-3. The network will provide reception coverage over the Australian continent and surrounding oceans, and Antarctica, augmenting the current national coverage provided by the Bureau's L-band reception stations. Initially, the new ground stations will receive data from Aqua and Terra. In preparation for the provision of operational products from the next generation of satellites, the Bureau is investigating the accuracy of atmospheric soundings derived from hyperspectral instruments. To achieve this, a validation program has been designed to provide in situ data co-incident with satellite overpasses. Additional radiosondes are being launched from key sites of interest across Australia, with the launches timed to coincide with Aqua overpasses. This timing also allows comparison with MetOp data. The project will ultimately collect the over three hundred radiosonde temperature and humidity profiles, over a range of different surface types. The validation program, when complete, will provide a valuable dataset for Australian and international researchers to investigate the generation of satellite-derived atmospheric profiles and surface emissivity estimates over the Australian continent. It is hoped that, over time, the data set will lead to improvements in the quality of these products.

1.10 Characterizing sub-footprint variability in AIRS radiances using MODIS

Authors: Evan Fishbein, Mathias Schrier, Brian Kahn

Presenter: Evan Fishbein

Co-located AIRS and MODIS thermal infrared radiances are analyzed to validate spatial uniformity assumptions used in operational sounder retrieval algorithms. Retrieval algorithms used in the operational AIRS and CrIMSS retrieval algorithms assume sub-footprint uniformity. That is, adjacent footprints are composed of area-averaged combinations states and while the fractional areas of the states vary between footprints, the states themselves do not. The MODIS footprints are sorted into states using cluster analysis. The number of states and the spatial variability of the radiances within states are characterized. One of the states is identified as cloudless and from it profiles of atmospheric water vapor and temperature are derived.

1.11 Measure and exploitation of multi-sensor and multi-wavelength synergy for remote sensing - Application to the retrieval of atmospheric temperature and water vapour from MetOp

Authors: Filipe Aires, Maxime Paul, Ouahid Aznay, Catherine Prigent, Bjorn Rommen, and Marc Bouve

Presenter: Ouahid Aznay

A synergetic scheme refers to an algorithm that uses simultaneously or hierarchically the observations of two or more spectral ranges in order to obtain a more accurate retrieval than the independent retrievals put together. This study introduces first some theoretical considerations. The goal is to identify the various forms of synergy for remote sensing applications. Some simple linear models are used to introduce concepts such as additive, un-mixing, indirect or de-noising synergies. The second objective is to develop a methodology to measure the potential synergies, and to construct retrieval methods able to exploit them. Four methods are considered, the classical information content analysis, the k-Nearest Neighbors (kNN), the LINear regression (LIN), and the Neural Networks (NN). These technique are tested on a real-world application where the microwave and infrared observations from AMSU-A, MHS, and IASI instruments are used to retrieve the atmospheric profiles of temperature and water vapour. The inversion algorithms are calibrated and

tested with simulated observations, without any loss of generality, using similar theoretical assumption (same RTM, observational noise and a priori information) in order to truly compare the information content and the direct statistical retrieval approaches. These experiment will show the limitations of information content analysis to measure synergy and stress the need for other tools. Multivariate and nonlinear method such as the NN approach shows that there is a strong synergy between IR and MW for both temperature and water vapour retrieval. This type of tools should be considered in the future for the definition of new missions: The instrument characteristics should be determined not independently, sensor by sensor, but taking into account all the instruments together as a whole observing system.

1.12 Hyperspectral Microwave Atmospheric Sounding

Authors: William J. Blackwell, R. Vincent Leslie, Michael L. Pieper, Jenna E. Samra, and Chinnawat Surussavadee

Presenter: William J. Blackwell

We introduce a new hyperspectral microwave remote sensing methodology for atmospheric sounding, driven by recent advances in microwave device technology that now permit receiver arrays that can multiplex multiple broad frequency bands into more than ~100 spectral channels, thus improving both the vertical and horizontal resolution of the retrieved atmospheric profile. Global simulation studies over ocean and land in clear and cloudy atmospheres using three different atmospheric profile databases are presented that assess the temperature, moisture, and precipitation sounding capability of several notional hyperspectral systems with channels sampled near the 50-60-GHz, 118.75-GHz, and 183.31-GHz absorption lines. These analyses demonstrate that hyperspectral microwave operation using frequency multiplexing techniques substantially improves temperature and moisture profiling accuracy, especially in atmospheres that challenge conventional non-hyperspectral microwave sounding systems because of high water vapor and cloud liquid water content. Retrieval performance studies are also included that compare hyperspectral microwave sounding performance to conventional microwave and hyperspectral infrared approaches, both in a geostationary and low-earth orbit context, and a path forward to a new generation of high-performance all-weather sounding is discussed.

1.13 NPOESS Preparatory Project Validation Program for the Atmospheric Profile Data Products

Authors: Lihang Zhou, NPOESS IPO, Silver Spring, MD; H. Kilcoyne, C. Barnett, D. Gu, J. Feeley, C. Hoffman, G. Mineart, N. Baker, G. Trumbower, G. Bingham, and K. St. Germain

Presenter: Lihang Zhou

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Program, in partnership with the National Aeronautics and Space Administration (NASA), will launch the NPOESS Preparatory Project (NPP), a risk reduction and data continuity mission, prior to the first operational NPOESS launch in 2011. The Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS), collectively referred to as the Cross-track and Infrared Sounder Suite CrIMSS, are two of the instruments that make up the suite of sensors on NPP. Together, CrIS and ATMS will produce three Environmental Data Records (EDRs), the Atmospheric Vertical Temperature Profile (AVTP), Atmospheric Vertical Moisture Profile (AVMP), and the Atmospheric Vertical Pressure Profile (AVPP). The AVTP and the AVMP are both NPOESS Key Performance Parameters (KPPs). The NPOESS program, in partnership with Northrop Grumman Aerospace Systems, will execute the NPP Calibration and Validation (Cal/Val) program to ensure the data products comply with the requirements of the sponsoring agencies. The validation plans establish science and user community leadership and participation, and demonstrated, cost-effective Cal/Val approaches. This presentation will provide an overview of the collaborative datasets, techniques, and schedule for the validation of the NPP CrIMSS EDRs. EDR performance estimate matrices based on newly generated proxy data derived from AIRS and IASI as well as simulated data will be summarized and presented.

1.14 AIRS and IASI Precipitable Water Vapor (PWV) Absolute Accuracy in the Tropics, Mid-Latitudes, and Arctic

Authors: Robert Knuteson, Sarah Bedka, Henry Revercomb, Jacola Roman, Dave Tobin, and Dave Turner

Presenter: Robert Knuteson

The Atmospheric Infrared Sounder (AIRS) on EOS Aqua and the Infrared Atmospheric Sounding Interferometer (IASI) on METOP-A are the first

two sensors of a series of that will exploit high spectral resolution and broad spectral coverage of the mid-infrared to improve the retrieval accuracy of passive infrared sounding. With the addition of the Cross-track Infrared Sounder (CrIS) on NPOESS, these advanced sounders are intended to provide greatly improved vertical resolution in the measurement of atmospheric temperature and water vapor for Numerical Weather Prediction (NWP) data assimilation. The high spectral resolutions (resolving power of 1000 or more) have the added measurement advantage of providing good spectral calibration along with the good radiometric calibration provided by frequent views of high emissivity onboard blackbody and space references. The demonstrated radiometric uncertainties of the AIRS and IASI and the expected performance of CrIS are believed to be in the range of a few tenths of degrees of scene brightness temperature. This high radiometric accuracy gives promise for the accurate retrieval of atmospheric variables such as water vapor. Total column or precipitable water vapor (PWV) is a convenient measure of the absolute accuracy of water vapor soundings retrievals because it is a measurable quantity for which we have accurate ground-truth validation data. Satellite remotely sensed PWV measurements are evaluated in this paper using ground-based microwave radiometer (MWR) data at three Department of Energy Atmospheric Radiation Measurement program (DOE ARM) sites. The accuracy of the ARM MWR PWV ground truth is estimated to be between 1% and 3% (95% confidence level). For both AIRS and IASI the total column precipitable water vapor (PWV) is obtained by integrating the vertical profile of water vapor mixing ratio derived from "clear" radiances, with some important algorithmic differences. This paper provides a validation of the AIRS and IASI PWV products at three distinct climate sites over the nearly the full range of total water amounts observed on Earth (between 0.1 and 6.5 cm). Both the EUMETSAT and NOAA operational IASI retrieved products will be evaluated and compared to the AIRS science team algorithm validation results. A preliminary evaluation against ground based GPS total column water vapor products will also be presented in order to extend the validation from just the local ARM sites to a regional assessment.

1.15 Assessment of Heavy Rainfall Retrieved from Microwave Instrument in Taiwan Area

Authors: Peter K.H. Wang, Chien-Ben Chou

Presenter: Peter K.H. Wang

The satellite total precipitable water (kg/m²) is the amount of water vapor in column from the surface of the earth to space. The microwave instruments SSMI/S, AMSRE and AMSU can be used to retrieve these parameters. It could be a useful physical parameter related to the heavy precipitation. The Products of MIRS developed by NESDIS was used as indices. In order to study the cause of heavy precipitation induced by typhoon Morakot we collect the image of total precipitable water associated to all of typhoon that invade Taiwan in the recently five years from NOAA. For the monsoon season windward side area usually has heavy and a few days rainfall. The daily accumulated rainfall amount images at Taiwan area in the same period with those events also have been collected. The analysis results show that heavy precipitation of typhoon Morakot was caused by convection system of typhoon itself and abundant water vapor existing in the southwesterly induced by typhoon. And such abundant water vapor in the southwesterly maybe cause by the depress in the South China Sea .The abundant water vapor of typhoon Morakot has never been seen in the five years data. In our study show that the satellite total precipitable water image and low level water vapors are useful to observe the content of water vapor variance. The potential of 24 hours forecast of rainfall at Taiwan area by using total precipitable water and vertical water vapor distribution also have been studied. The results show that total precipitable water with prediction of weather could be useful information in this subtopic area. Product of AMSU is more efficient to morning rainfall than other instruments for higher resolution.

1.16 Physically based level 2 and 3 products obtained from IASI observations processed with UWPHYSRET

Authors: Paolo Antonelli, Hank Revercomb, Dave Tobin, Robert Knuteson, Raymond Garcia, Sarah Bedka, Eva Borbas, Paul Menzel, Fred Best, William Smith, Stephen Tjemkes, Rolf Stuhlmann, Agostino Manzato

Presenter: Stephen Tjemkes

The work presented shows the results obtained by retrieving surface and atmospheric environmental parameters from IASI observations of Earth emitted infrared energy. The list of parameters includes: vertical profiles of Temperature , Water Vapor Mixing Ratio, Carbon Dioxide, Ozone; surface emissivity and surface temperature. Level 2 products are generated using UWPHYSRET, a physically based approach which makes use of optimal estimation theory coupled with an accurate

line by line forward model (LBLRTM). The presentation: 1) introduces the theoretical basis of the inversion scheme used, along with technical implementation details; 2) presents the results obtained for different IASI overpasses in different areas over both land and ocean; 3) compares the results obtained from IASI data to those obtained by two airborne interferometers, the S-HIS and the NAST-I; 4) describes the conclusion based on the retrieval validation and assess the accuracy and the limitation of the current implementation of UWPHYSRET in deriving Level 3 products.

1.17 Satellite application for fog detection during day and night time

Authors: Devendra Singh

Presenter: Devendra Singh

The dual channel difference of satellite imagery from the two infrared window channels of low earth orbiting Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA'S Aqua and Terra spacecraft has been studied for the detection of fog. Two case studies of fog detection pertaining to day and night time have been carried out over northern India. It has been observed that improved spatial-temporal resolution of MODIS provides very useful information for monitoring fog as satellite images can provide information on the horizontal extent of the fog, which is difficult to determine from surface observations alone. A time sequence of these difference images can be used to predict fog development and dissipation.

1.18 Physical aspects of non-linear analysis and interpretation of hyperspectral measurements from the AIRS radiometer

Authors: Youri Plokhenko and W. Paul Menzel

Presenter: Youri Plokhenko

The physical interpretation of hyperspectral measurements from the AIRS spectro-radiometer in the atmospheric remote sensing is discussed. Measurement physical properties are discussed. A non-linear measurement model with a measurement vector of variable dimensionality is suggested. The primary factor affecting measurement content (measurement vector dimensionality) is spectral filtering based upon physical-statistical measurement of error detection and removal of spectral channels with abnormal error characteristics in the frame of the used measurement model. Requirement of the sufficient energy signal from the sought for physical

parameter (solution component in the stated inverse problem) affects the measurement dimensionality as well. Results of physical interpretation of AIRS hyperspectral measurement are demonstrated. The effects of non-linear physical factors are shown. The efficiency of this new modeling and processing approach is demonstrated

1.19 The NOAA Unique CrIS/ATMS Product Processing System (NUCAPS)

Authors: Thomas King, Chen Zhang, Kexin Zhang, Haibing Sun, Yi Song, Zhaohui Cheng, Antonia Gambacorta, Eric Maddy, Walter Wolf, Chris Barnett, and Mitchell Goldberg

Presenter: Thomas King

The NOAA Unique Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) Product System (NUCAPS) is under development at NOAA/NESDIS/STAR. The system will produce thinned apodized CrIS radiances, principal components of CrIS radiances, cloud-cleared CrIS radiances, and trace gas profile products for Numerical Weather Prediction (NWP) customers in near real-time. The radiance products will be available in Binary Universal Form for the Representation of meteorological data (BUFR) and network Common Data Form version 4 (netCDF4). The principal components and trace gas profile products will be available in netCDF4 format. At this time, the system components are being developed and tested with simulated CrIS and ATMS data. In addition, CrIS test BUFR data files are available to the user community. NUCAPS will be run operationally within the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Data Exploitation (NDE) Data Handling System (DHS). The thinned apodized radiances and the principal component data will be available once the NPOESS data are released (approximately 6 months after launch); the rest of the products will be released one year later. The details of the system and its products will be discussed.

1.20 Multi-moment statistics of cloud and moist conserved variables from the A-train

Authors: Brian H. Kahn, Joao Teixeira, and Eric J. Fetzer

Presenter: Brian H. Kahn

The simultaneous spatial and temporal vertical profiling of clouds, temperature and water vapor from A-train instruments such as the Atmospheric

Infrared Sounder (AIRS) and 94 GHz CloudSat radar, among others, are anticipated to be useful for evaluating and informing subgrid-scale climate model cloud parameterizations. Variance scaling spectra, as well as the variance and skewness of temperature, water vapor and derived moist conserved variables including total water, liquid water potential temperature, and equivalent potential temperature, are shown. This methodology has been extended to the ECMWF model output during YOTC, and similarities and differences between ECMWF and AIRS are highlighted.

1.21 Development of a near real-time aviation alert system using AIRS, based on the analysis of the atmospheric conditions at the time of the Air France 447 crash using AIRS, TRMM and IASI data.

Authors: Hartmut H. Aumann and Ziad Haddad

Presenter: Hartmut H. Aumann

On Monday June 1, 2009 at about 2 AM Air France flight 447 carrying 228 passengers and crew went down in the Atlantic about four hours into its flight from Rio de Janeiro to Paris. According to the Associated Press, radar contact with flight 447 was lost as its flight path entered “a thunderous zone with strong turbulence”. AIRS, the Atmospheric Infrared Sounder instrument on NASA’s Aqua spacecraft, passed over the area about one hour after the crash, a TRMM overflight was one hour and a MetOp overpass was about 3 hours before the crash. Analysis of the AIRS data shows a large cluster of Tropopause Penetrating Clouds (TPC) at the nominal crash site, the IASI data on MetOp also show a TPC cluster. Individual TPC are known to be associated with the extremely violent thunderstorms. Large clusters of TPC are characteristic of tropical depressions, although this one was not recognized as such in the forecast and subsequently dissipated. The TRMM Microwave Imager (TMI) shows an area of very heavy rain at the crash site, consistent with the AIRS observations of TPC. TPC clusters have a lifetime of many hours. Since AIRS data are available within minutes after acquisition via the direct downlink, a TPC cluster analysis can reveal the presence of dangerous thunderstorm clusters in a way which is timely for alerting the aviation community. A near real time automated detection system, which identifies TPC clusters and sends out an email message with the coordinates of suggested avoidance zones was implemented at JPL in December 2009. It is in the process of being transferred to NOAA’s operational global hazard

alert system. AIRS was launched in 2002, TRMM in 1998 and IASI in 2006.

1.22 Updates to the IMAPP AIRS utility software

Authors: Elisabeth Weisz, Hung-Lung Huang, Kathy Strabala

Presenter: Elisabeth Weisz

The latest version of the IMAPP (International MODIS/AIRS Processing Package) AIRS retrieval software provides international researchers not only with single field-of-view temperature, humidity, ozone profiles and surface parameters under all weather conditions, but also with cloud top pressure estimates in cloudy skies. In addition, a MODIS/AIRS collocation code is included in the software package, which enables the calculation of an AIRS cloud mask from the operational MODIS cloud mask product. A detailed description of the updates, a summary of the products, and their evaluation are presented.

1.23 Dual EOF Regression Surface and Atmospheric Variable Specification for Initializing Atmospheric Sounding Physical Retrieval and Direct Radiance Assimilation

Authors: William Smith Sr., Elisabeth Weisz, Stanislav Kireev, Daniel Zhou, and Jun Li

Presenter: William Smith

A dual EOF (Empirical Orthogonal Function) regression retrieval technique has been developed for the rapid extraction of cloud, surface, and atmospheric sounding parameters from hyperspectral radiance spectra. The regression specified variables are intended to be used to initialize a physical 1-d variational profile retrieval solution and/or to enable the direct assimilation of radiances into a numerical analysis/prediction model. The technique has been applied to IASI, AIRS, and NAST-I hyperspectral radiance data. The accuracy of the regression products has been validated using CloudSat/CALIPSO satellite data, ECMWF analyses, and JAIVEx dropsonde and radiosonde data sets. Examples showing the results of both the initial dual regression product and the final 1-d variational physical retrieval are shown for both global synoptic scale and regional mesoscale weather situations.

1.24 AIRS v. 5 Temperature and Water Vapor retrievals characterization and error assessment.

Authors: Nikita Pougatchev, Eric Fetzer, Evan Fishbein, and Bjorn Lambrigtsen

Presenter: Nikita Pougatchev

We present the characterization and error assessment for the AIRS v. 5 temperature and water vapor retrievals. We use dedicated radiosondes for the reference data and Validation Assessment Model as the tool for error assessment. The geographic coverage is from tropics to Alaska. In addition to the estimates of error biases and covariances we infer averaging kernels from the real measurements data.

1.25 Status of current and future satellite program and their use for agriculture application

Authors: Devendra Singh and Sanjiv Nair

Presenter: Devendra Singh

The earth observing satellite data has been very useful in monitoring of drought, flood and agriculture. We have carried out some case studies using data from these satellites for monitoring natural hazards and would be presented in the conference. Further, the current and future satellite programs of India will be presented in order to provide an overview of their applications in hydrology, weather and agriculture. The technical details and their operational real time utilization will also be discussed.

1.26 Web-based Skew-T displays of GOES and POES operational atmospheric soundings added to the NOAA/NESDIS Operation.

Author: A.K. Sharma

Presenter: A.K. Sharma

NOAA/NESDIS provides vertical atmospheric profiles of temperature and moisture soundings derived from Geostationary Operational Environmental Satellites (GOES) and Advanced TIROS (Television and Infrared Observation Satellite) Operational Vertical Sounding (ATOVS) systems onboard Polar Orbiting Environmental Satellites (POES). GOES sensors are aboard GOES-11 (West) and GOES-12 (East) and ATOVS sensors are aboard the NOAA-15, NOAA-18 and 19 series of POES and the European

Meteorological Operational satellite (MetOp-2). In an effort to ensure consistent levels of service and quality assurance for these suites of products, the Office of Satellite Data Processing and Distribution (OSDPD) is implementing and executing new, innovative tools to better monitor performance and quality of the operational GOES and POES sounder and imager products being generated. In order to provide a means of evaluating GOES and POES Soundings McIDAS (Man computer Interactive Data Access System) Meteorological Data (MD) files via the Web, the OSDPD has been producing hourly SKEW-T diagrams for over 450 sites across the U.S., Mexico, Caribbean, Western Atlantic, Eastern Pacific, and Southern Canada (including 24 hr archive) from GOES Soundings MD files. In order to leverage off the GOES capability and associated software, the OSDPD has developed POES sounder SKEW-T web pages that compliment the GOES pages over the globe. There have been significant changes in the operational system due to system upgrades, algorithm updates, and value added data products and services. User requirements for data products and services for sounders like ATOVS and IASI would help us determine the products and services required from the next generation of sounders such as Cross-Track Infrared Sounder/ Advanced Technology Microwave Sounder (Cris/ATMS) as planned for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program and the future missions of the European Organization for the Exploitation of Meteorological (EUMSAT) and GOES-R satellites. This presentation will include the discussion on the NOAA/NESDIS Environmental Satellites Processing Center (ESPC) system architecture involving sounding data processing and distribution, improvements made for data quality measurements, and web-pages for soundings products. This will also include the software developed for generating GOES and POES SKEW-T diagrams and display them via the Web site of Satellite Services Division.

1.27 Pre-launch evaluation of NPP/NPOESS VIIRS Atmosphere Environmental Data Records

Authors: Liam Gumley, Robert Holz, Steve Dutcher, Greg Quinn, Scott Mindock, Richard Frey

Presenter: Liam Gumley

Abstract not available.

1.28 A Neural Network approach for temperature retrieval from AMSU-A

measurements onboard NOAA-15 and NOAA-16 satellites and a case study during 'Gonu' cyclone

Authors: A.K. Mitra, P. K. Kundu, A. K. Sharma, and S. K. Roy Bhowmik

Presenter: A.K Mitra

Abstract A neural network (NN) technique is used to obtain vertical profiles of temperature from NOAA-15 and 16 Advanced Microwave Sounding Unit-A (AMSU-A) measurements over the Indian region. The corresponding global analysis data generated by National Center for Environmental Prediction (NCEP) and AMSU-A data from July 2006 to April 2007 are used to build the neural network training data-sets and the independent dataset of May 2007 to July 2007 divided randomly into two independent dataset for training (land) and testing (ocean). NOAA-15 and 16 satellite data has been obtained in the form of level 1b (instrument counts, navigation and calibration information appended) format and pre-processed by ATOVS (Advanced TIROS Operational Vertical Sounder) and AVHRR (Advanced Very High Resolution Radiometer) Processing Package (AAPP). The root mean square (RMS) error of temperature profile retrieved with the NN is compared with the errors from the International Advanced TOVS (ATOVS) Processing Package (IAPP). The over all results based on the analysis of the training and independent datasets show that the quality of retrievals with NN provide better results over the land and comparable over the ocean. The RMS errors of NN are found to be less than 3 °C at the surface, 0.9° to 2.2° between 700-300 hPa and less than 2°C between 300-100 hPa. It has also been observed that the neural network technique can yield remarkably better results than IAPP at the low levels and at about 200-hPa level. Finally, the network based AMSU-A 54.94-GHz (Channel-7) brightness temperature (Maximum Tb) and its warm anomaly near the center of the cyclone has been used for the analysis of 'gonu' cyclone formed over Arabian Sea during 31st May to 7th June 2007. Further, the anomalies are related to the intensification of the cyclone. It has been found that the single channel AMSU-A temperature anomaly at 200 hPa can be a good indicator of the intensity of tropical cyclone. Therefore it may be stated that optimized neural network can be easily applied to AMSU-A retrieval operationally and it can also offer substantial opportunities for improvement in tropical cyclone studies.

1.29 Sounding with Hyperspectral VIIRS

Presenter: Jeff Puschell

Abstract not available.

2.1 Estimation of the carbon balance components of heterogeneous agricultural landscape using tall tower based and remotely sensed data.

Presenter: Zoltan Barcza

Abstract not available.

2.2 Potential for the use of reconstructed IASI radiances in the detection of atmospheric traces gases

Authors: Nigel Atkinson, Fiona Hilton, Samuel Illingworth, John Eyre and Tim Hultberg

Presenter: Fiona Hilton

Principal component (PC) analysis has received considerable attention as a technique for the extraction of meteorological signals from hyperspectral infra-red sounders such as the Infrared Atmospheric Sounding Interferometer (IASI) and the Atmospheric InfraRed Sounder (AIRS). Elimination of high-order components achieves substantial bit-volume reductions for dissemination purposes, and can also be used to generate reconstructed radiances in which random instrument noise has been suppressed. To date, most studies have been in the context of Numerical Weather Prediction (NWP), in particular the analysis of temperature and humidity. This study examines the potential of the use of reconstructed radiances for chemistry applications. A major concern in the use of PC analysis for chemistry has been that the spectral features associated with traces gases may not be well represented in the reconstructed spectra, either due to deficiencies in the training set or due to the limited number of PC scores used in the radiance reconstruction. In this paper we show examples of reconstructed IASI radiances for several trace gases: ammonia, sulphur dioxide, methane and carbon monoxide. It is shown that care must be taken in the selection of spectra for the initial training set: an iterative technique, in which outlier spectra are added to a base training set, gives the best results. For the four trace gases examined, the chemical signatures are retained in the reconstructed radiances, whilst achieving a substantial reduction in instrument noise.

2.3 Dust aerosol optical depth and altitude retrieved from 7 years of infrared sounders observations (AIRS, IASI) and comparison with

other aerosol datasets (MODIS, CALIOP, PARASOL)

Authors: S. Peyridieu, A. Chedin, D. Tanre, V. Capelle, C. Pierangelo, N. Lamquin and R. Armante

Presenter: Nicole Jacquinet

Remote sensing of aerosol properties in the visible domain has been widely used for a better characterization of these particles and of their effect on solar radiation. On the opposite, remote sensing of aerosols in the thermal infrared domain still remains marginal. However, knowledge of the effect of aerosols on terrestrial radiation is needed for the evaluation of their total radiative forcing. A key point of infrared remote sensing is its ability to retrieve aerosol optical depth as well as mean dust layer altitude, a variable required for measuring their impact on climate. Moreover, observations are possible night and day, over ocean and over land. Our algorithm is specifically designed to retrieve simultaneously coarse mode dust aerosol 10 μm optical depth (AOD) and mean layer altitude from high spectral resolution infrared sounders observations. Thanks to IASI higher spectral resolution, the selection of finer channels for aerosol detection allows an even more accurate determination of aerosol properties. In this context, results obtained from 7 years (2003-2010) of AIRS/Aqua and more than 2 years (2007-2010) of IASI/Metop observations have been compared to other aerosol sensors. Compared to MODIS/Aqua optical depth product, 10 μm dust optical depth shows a very good agreement, particularly for tropical Atlantic regions downwind of the Sahara during the dust season. Comparisons with PARASOL non-spherical coarse mode product allows explaining small differences observed far from the sources. Time series of the mean aerosol layer altitude are compared to the CALIOP Level-2 products starting June 2006. For regions located downwind of the Sahara, the comparison again shows a good agreement with a mean standard deviation between the two products of about 400 m over the period processed, demonstrating that our algorithm effectively allows retrieving accurate mean dust layer altitude. A 7-year global climatology of the aerosol 10 μm dust optical depth and of the layer mean altitude has also been established, emphasizing the natural cycles of Saharan dust. Application of this method over continental surfaces, such as the Sahara desert, is currently being made possible by the retrieval of surface temperature and emissivity from IASI observations. This a priori knowledge opens the way to retrieving dust sources over land in the infrared.

2.4 Possibilities for Retrieving the Ozone and Trace Gases from Data of Satellite IR Sounders IRFS-2 with High Spectral Resolution

Authors: A.Polyakov, Yu.Timofeyev, A.Uspensky

Presenter: Sergey Uspensky

Potential errors of retrieving different atmospheric trace gases have been estimated by numerical modeling the space experiment with IRFS-2 device to be installed aboard "Meteor_M" No 2 spacecraft. If local solving operators are used, relative errors of the ozone profile retrieval on the average are ~15–30% at the 0–20 km altitudes and 10–15% in the stratosphere. In an area of the ozone maximum, relative retrieval errors are 8–10%. Potential errors of total ozone amount retrieval are 1.6–5% depending on latitude zone. Total column amount nitrous oxide and methane are retrieved with errors of 1.5–2.1% and 1.7–2.3%, respectively, depending on latitude zone.

2.5 Major results of IASI on Atmospheric chemistry

Authors: C. Clerbaux, P.F. Coheur, C. Camy Peyret, G. Dufour, D. Edwards, B. Barret, S. Massart and T. Phulpin

Presenter: Thierry Phulpin

The presentation will summarize the major results of the second international IASI conference regarding the Atmospheric composition retrieved with IASI. There are many groups working on this application and the results are very demonstrative and pretty spectacular. The main products are Ozone profile (or columns), Carbone monoxide, Methane, Carbone dioxide in the upper troposphere, nitric acid, sulphur dioxide of volcanic eruptions, and many unexpected other species like Ammonia, methanol, etc. Some intercomparisons have been performed successfully either with other satellite or instruments like Gome2, Mopitt, GOSAT, etc. and can now be considered as validated. Near real time on-going applications have started to be developed specially for the GMES Gems-MACC project or for Volcanic Ash advisory centres (VAACs). Development of assimilation in Air quality models is on going with encouraging results. Nevertheless research to continuously improve the products is still very active. The main focus remains on the improvement of profiles near the surface over land taking into account surface emissivity. There is also a strong relationship with atmospheric profiles which could foster some studies of full assimilation

to improve simultaneously temperature, humidity and trace gas profiles.

2.6 First Results on Synergistic Ozone Profile retrieval from GOME-2 and IASI Measurements with NNORSY

Authors: Anton Kaifel, Martin Felder, Roger Huckle

Presenter: Anton Kaifel

The information content of satellite measurements in the UV/VIS and in the thermal infrared (TIR) spectral regions is obviously different. UV/VIS measurements provide information mainly from the stratosphere, while TIR spectra additionally contain information about the free troposphere. With the GOME-2 and IASI instrument on MetOp there is a unique opportunity to combine spectral data from both instruments in a single retrieval scheme. However, for classical retrieval schemes based on optimal estimation (OE), such a combination in a one step retrieval is very complex to handle, and doubles the effort, because for each spectral region different forward models and spectroscopic databases are necessary. So far, if different spectral regions are used for OE-based ozone profile retrieval then the retrieval steps are performed sequentially and the results are combined, or the profile resulting from the first retrieval step is used as apriori for the second one. For a one-step ozone profile retrieval neural network based retrieval schemes like NNORSY are an ideal candidate, because no spectral forward models are necessary. This simplifies the approach because all available relevant spectral measurement data can be jointly used as input parameters for a neural network, which is then trained on available ozone profile measurement data. The resulting retrieval scheme exploits the information content of all supplied spectral input data during training. We will present first results on a novel one-step ozone profile retrieval scheme based on NNORSY GOME-2/IASI satellite data. The neural network is trained on ground based (ozone sondes) and satellite based (ACE-FTS, AURA-MLS) ozone profile measurements. Comparison of results against independent data as well as against GOME-2-only retrievals will be shown. The information gain of the NNORSY synergistic retrieval approach over single sensor retrievals in different situations and altitudes will be discussed.

2.7 Retrieval of SO₂ from high spectral resolution measurements: IASI and AIRS

Authors: Fred Prata and Lieven Clarisse

Presenter: Fred Prata

Background SO₂ gas concentrations in the atmosphere vary from less than 1 ppb to ~10 ppb with a vertical distribution with largest amounts in the boundary layer quickly falling with height, reflecting the source location near the surface. Anthropogenic emissions largely arise from industrial activities, such as lead and aluminium smelting, power station emissions and some other industrial activities. The majority of natural emissions arise from erupting volcanoes and produce orders of magnitude greater SO₂ abundances (~1 ppm), short-lived (a few weeks) events that are easily detected by appropriate infrared satellite instruments. Volcanic emissions can reach heights of 15 km or more and hence penetrate into the stratosphere, potentially causing short-term climate cooling. The emissions can also remain in the troposphere and have detrimental health effects on humans, animals and vegetation. The new high-spectral resolution sensors, IASI and AIRS, have the potential to determine the vertical locations of volcanic emissions by exploitation of the 1, 3 and 1+3 combination bands of SO₂. Here we describe the algorithms currently being used to determine SO₂ from space using IASI and AIRS high-spectral resolution measurements. We discuss these data in the context of providing information concerning volcanic hazards and also for improving our understanding of the climatic effects of volcanic aerosols on climate.

2.8 The assimilation of IASI ozone channels

Authors: Wei Han and Tony McNally

Presenter: Wei Han

This paper deals with the extraction of ozone information from IASI and begins with a brief overview of the ozone information content. Following a description of the ECMWF ozone analysis, the underlying error characteristics of the system are then evaluated using validation data from the MLS and ozone sondes. The extent to which these errors are associated with the current assimilation of UV data is assessed by deliberately withdrawing these observations. The impact of introducing the IASI infrared radiances is then tested and again the quality of the resulting ozone analysis is evaluated with MLS and ozone sondes. Finally the impact of assimilating ozone sensitive infrared radiances on the wind field through ozone advection tracing is studied.

2.9 Examining effect of Asian dusts on the AIRS-measured radiances from radiative transfer simulations

Authors: Hyo-Jin Han, Byung-Ju Sohn, Hung-Lung Huang, and Elisabeth Weisz

Presenter: Hyo-Jin Han

Radiative transfer simulations were performed in order to examine the effect of absorption and scattering of Asian dusts on the infrared radiance measured by AIRS. The RTTOV-9 model used for the simulation has been implemented with new optical properties for Asian dusts; refractive indices of mineral dust in the OPAC library and size distribution of Asian dusts retrieved from 10 years of skyradiometer measurements at Dunhuang, China. Results show that effect of Asian dusts on AIRS spectra is substantial over infrared window regions (i.e.: 3.7-4.1 μm , 8.8-9.3 μm , 10-13 μm), although the window regions are also sensitive to surface temperature, surface emissivity, and low-level atmospheric temperature. The AIRS spectral radiance measurements for the dust cases were simulated using implemented radiative transfer model, but with specification of AOT and height of dust layers obtained from CALIPSO measurements. In the simulations, surface and atmospheric temperatures are from AIRS level 2 products while surface emissivity is specified with UW/CIMSS monthly mean global infrared surface emissivity data. The comparison of simulated radiances with AIRS measurements shows a comparable quality for both clear and dusty conditions, suggesting that results can be incorporated for developing dust retrieval algorithm from hyperspectral images such as AIRS and IASI.

3.1 SSMIS Radiance Assimilation and Calibration Anomaly Mitigation

Authors: S. Swadley, G. Poe, N. Baker, B. Ruston, W. Bell, D. Kunkee and D. Boucher

Presenter: Steve Swadley

Forecast impact on both operational forecasts and assimilation experiments resulting from the assimilation of preprocessed Special Sensor Microwave Imager Sounder (SSMIS) radiances from the DMSP F-16, F-17 and F-18 satellites will be presented. Assimilation results are based upon using the NRL Atmospheric Variational Data Assimilation System-Accelerated Representer (NAVDAS-AR; an observation-space four-dimensional variational approach), together with tailored quality control and bias correction

procedures for the SSMIS data. Assimilating SSMIS UPP data results in improved forecast accuracy for both northern and southern hemispheres at a level equal to or exceeding that of the existing AMSU-A sensor impact. Observational impacts of all assimilated data are assessed using the adjoint sensitivity of the NAVDAS-AR system, and the relative observation impacts of the various satellite sounding sensor radiances by satellite and channel will be presented. The SSMIS data used herein have been preprocessed using the Unified Pre-Processor (UPP) jointly developed by the Met Office and the Naval Research Laboratory (NRL) and produced operationally at the Fleet Numerical Meteorology and Oceanography Center (FNMOC). The UPP performs first order corrections for the reflector emission biases, field-of-view induced scan non-uniformities, effects of warm-load solar intrusions, and performs spatial averaging to lower scene noise. New specialized techniques were developed to directly measure the effective surface electrical conductivity of microwave reflectors. These methods were applied to sample coupons on several microwave reflectors intended for precision space based microwave radiometers, including the remaining SSMIS reflectors. Results for the remaining SSMIS reflectors showed very low effective conductivities and indicated the likely hood of low surface electrical conductivities of the F-16 and F-17 reflectors (i.e. less than 1.0 MS/m) compared with pure aluminum (36 MS/m). Procedures to determine the electrical conductivity of the reflectors are now part of the pre-flight analysis for future SSMIS instruments. The main reflector of the recently launched third SSMIS instrument, onboard DMSP F-18, was replaced with a spare reflector having significantly higher conductivity (17-18.5 MS/m) and is expected to reduce the on-orbit reflector emission to a negligible level. Results of the F-18 SSMIS observed brightness temperatures and resulting reflector emissivity estimates will be presented.

3.2 Draft ITU-R rpt : Identification of degradation due to interference and characterization of possible mitigation techniques for passive sensors

Authors: ITU-R

Presenter: Rich Kelley

ITU-R question 243/7 asked 1 What are the range of applications and uses of passive sensors and its products? 2 What are the typical technical and operating characteristics of passive sensors that can be used for studies involving sharing and compatibility? 3 How can the degradation to passive sensor operations from all possible

interference sources be characterized? 4 Can the degradation due to interference be identified in the passive sensor and its products? 5 Are there mitigation techniques that can be employed by the passive sensors to protect their operations from degradation? A response to these questions was developed and is being sent to various administrations for adoption and dissemination. The response is contained in a report, which is focused on radio-frequency interference to radiometric measurements made by Earth exploration satellites. The natural noise floor in the bands under consideration is the data being measured. The document first discusses how the measurements are used in meteorological and climatic products. Then, it addresses the detectability of RFI and its potential impact on products. Finally, it discusses some techniques that might be used to mitigate (reduce, not eliminate) the impact from radio-frequency interference. No mitigation techniques have been identified which can be applied to the microwave sensors and their products to allow RFI without degrading their performance, reliability or availability.

3.3 IASI L0/L1 NRT Monitoring at EUMETSAT: Comparison of Level 1 products from IASI and HIRS on Metop-A

Authors: Lars Fiedler, Yakov Livschitz, Jörg Ackermann, Peter Schlüssel and Gökhan Kayal

Presenter: Lars Fiedler

The Infrared Atmospheric Sounding Interferometer (IASI) is part of the payload of Metop-A, the first of three satellites of the EUMETSAT Polar System (EPS). Metop-A was launched on 19 October 2006. The IASI instrument went alive on 26/10/2006 and generated the first interferogram on 27/11/2006. IASI L1 NRT monitoring at EUMETSAT has been started at the end of the In-Orbit Verification (SIOV) in April 2007. One part of the IASI monitoring is based on the comparison of measured and modelled IASI L1C spectra. The modelled IASI L1C radiance spectra are generated by the radiative transfer model RTIASI. To avoid uncertainties with respect to surface emissivity and reflected solar radiation, only situations over sea during night time conditions are taken into account. The cloud identification is based on cloud flags of the co-located AVHRR L1B products. Additionally, homogeneity within the IASI field of view is required; this is ensured by selecting only IASI L1C products with AVHRR radiance cluster analysis indicating population of more than 99% in one cluster. The sea surface temperature (SST) which is needed as input for RTIASI is also based on the AVHRR L1B product. Temperature, water

vapour, and ozone profiles are taken from ECWMF forecast data by selecting the nearest neighbour. Forecast data are available at 00, 06, 12, 18 h. Only co-locations within 1 h time difference are considered. This observed versus calculated radiance comparison is complemented by the comparison between the co-located measurements of IASI and HIRS flying on the same platform. IASI based HIRS pseudo channel radiances are generated by using the HIRS spectral response functions and compared with the original HIRS L1B radiance measurements. Additional information with respect to cloud cover is derived from co-located AVHRR L1B products. IASI - HIRS comparison were initially started in May 2008. However, the record has been recently extended and information from December 2007 onwards is available and will be presented. The analysis of more than 30 months of IASI L1 product quality will be shown. A very good agreement of measured and calculated IASI radiance measurements can be observed through out the observation period. The focus of this paper will be on the results from 2 years of IASI-HIRS radiance comparison. A good agreement between IASI and HIRS has been observed. However, the origin of the small IASI-HIRS bias will be presented. This will cover the period of the first IASI decontamination and the results from an investigation on the impact of the IASI instrument decontamination on the IASI-HIRS radiances will be presented.

3.4 Real-time Processing of Direct Broadcast MODIS Data in Hungary.

Presenter: Aniko Kern

Abstract not available.

3.5 Virtual Appliance for Terra, Aqua, MetOp, and POES Direct Broadcast Processing

Authors: Liam Gumley, Kathy Strabala

Presenter: Liam Gumley

Abstract not available.

3.6 IMAPP: Promoting the knowledge and use of remote sensing data

Authors: Kathleen Strabala, Liam Gumley, Allen Huang, Elisabeth Weisz, James Davies

Presenter: Kathleen Strabala

2010 marks the 10th anniversary of the existence of the NASA International MODIS/AIRS Processing Package (IMAPP). Since its inception, 28 different free packages that provide the capability for X-band reception stations that acquire NASA Aqua and Terra through direct downlink to calibrate, navigate, visualize and create science products of MODIS, AIRS and AMSR-E data have been released. In addition to software, the IMAPP project has promoted the knowledge and use of remote sensing data through the sponsorships of global direct broadcast workshops, where students learn about the instruments, products, radiative transfer and applications. To date, workshops have been held in China, Norway, South Africa (twice) and Brazil. The success of the IMAPP project can be measured by the over 600 users representing 54 countries that have registered to download software from the new IMAPP web site since it was launched in 2007.

3.7 Spectral and Radiometric Calibration of HIRS Using IASI on MetOp Satellite

Authors: Ruiyue Chen, Changyong Cao, and Likun Wang

Presenter: Ruiyue Chen

The High-Resolution Infrared Radiation Sounder (HIRS) has been widely used in numerical weather prediction and climate studies. Accurate radiance measurements from HIRS are critical for all related applications because of its impact on products at all-levels. A few studies comparing HIRS with other instruments reported biases in several HIRS channels, especially the channels that are sensitive to uncertainties in the spectral response functions (SRF). The MetOp satellite carries both the HIRS and Infrared Atmospheric Sounding Interferometer (IASI), and previous studies have showed that the IASI is well calibrated and have accurate spectral and radiometric calibration. In this study, the hyper-spectral IASI measurements in the same spectral region as that of the 19 HIRS bands are used to simulate HIRS measurements. The IASI-simulated HIRS radiance measurements are compared with co-located HIRS radiance measurements on the same spacecraft to quantify the biases at the 19 HIRS bands. A detailed analysis of the bias patterns is performed. The root causes of the biases are analyzed with recommendations in resolving these biases.

3.8 AAPP developments for MetOp, NOAA-19 and NPP

Authors: Anna Booton, Nigel Atkinson, Pascal Brunel, Philippe Marguinaud and Tiphaine Labrot

Presenter: Anna Booton

The ATOVS and AVHRR Pre-processing Package (AAPP) is a pre-processing package for the imaging and sounding instruments on the operational NOAA and MetOp satellites. The package is maintained by the EUMETSAT Satellite Application Facility for Numerical Weather Prediction (NWP SAF) and is freely available to users worldwide. AAPP can accept as input either direct-readout data (level 0, or HRPT) or level 1 data from NOAA, EUMETSAT or the Regional ATOVS Retransmission Services (RARS). AAPP version 6 has been available to users since the launch of MetOp-A in October 2006. Since ITSC-16 in 2008, support for NOAA-19 has been added, together with routine updates for NOAAs 15-18, MetOp-A and FY-1D. Several new features are planned for early 2010: (i) support for the EARS-IASI service, including BUFR encoding/decoding of IASI data in Principal Components form, (ii) new BUFR sequence for global IASI (full spectrum), with enhanced cloud information and quality control flags, (iii) MAIA version 3: a cloud mask on the AVHRR grid, and (iv) the “day 2” version of the IASI pre-processor OPS-LRS. The next major AAPP release (version 7) will provide support for the NPP satellite. It will allow the user to optimise the footprint and sampling characteristics of ATMS, as well as to map ATMS to CrIS. Input data can be in either BUFR format (e.g. global data distribution from NOAA) or in the form of Sensor Data Records from the IPOPP direct readout package.

3.9 Cross-Track Infrared Sounder Pre-launch Calibration and On-Orbit Validation Plans

Authors: Denise Hagan, Joe Predina, Gail Bingham, Gene Kratz, Denis Tremblay, Farhang Sabet-Peyman, Degui Gu, Chunming Wang, Glenn Brossus, Giovanni De Amici, Joe Hohn, Scott Farrow, Mike Plonski, Ron Glumb, Steve Wells, Lawrence Suwinski, Joseph Strong, Craig Behrens, Mark Esplin, Vladimir Zavyalov, Chad Fish, Hank Revercomb, Larrabee Strow, Heather Kilcoyne, Janna Feeley

Presenter: Denise Hagan

The Cross-Track Infrared Sounder (CrIS) together with the Advanced Technology Microwave Sounder will provide retrievals of atmospheric moisture and temperature profiles for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The CrIS is a Fourier-

transform Michelson interferometer covering the spectral range of 3.9 to 15.4 μm (650 to 2550 cm^{-1}) developed by ITT under contract to Northrop Grumman Aerospace Systems. The first deployment of the CrIS (Flight Model 1) is scheduled for 2011 on the NPOESS Preparatory Project (NPP) satellite, an early instrument risk reduction component of the NPOESS mission. The analysis and data results from comprehensive TVAC testing of the CrIS FM1 sensor demonstrate a very accurate radiometric and spectral calibration system. We describe instrument performance parameters, and the end-to-end plans and analysis tools for on-orbit verification of sensor characteristics and validation of the radiance products.

3.10 Evolution of the EUMETSAT Advanced Retransmission Service (EARS)

Authors: Christelle Ponsard, Anders Meier Soerensen, David Lee

Presenter: Christelle Ponsard

The EUMETSAT Advanced Retransmission Service (EARS) is providing data from polar orbiting meteorological satellites to more than a 1000 users with a data timeliness of 10 to 30 minutes. The currently defined services consist of EARS-ATOVS, EARS-AVHRR, EARS-ASCAT and the recently added EARS-IASI. This paper presents the latest evolutions of the four EARS services in terms of developments, end products and geographical coverage, as well as the status of the measures taken to minimise the impact on the EARS services of the Metop-A HRPT limited availability.

3.11 Draft ITU-R report : Passive bands of interest to EESS/SRS from 275 to 3 000 GHz

Authors: ITU-R

Presenter: Rich Kelley

A world radiocommunication conference (2012) agenda item calls for a review and possible revision of the Radio Regulation (RR) No. 5.565 to address existing and projected requirements between 275 GHz and 3 000 GHz for the Earth exploration-satellite service (EESS) and space research service (SRS). Information on current and planned spaceborne passive remote sensing systems was reviewed for applicable information. Scientific literature and personnel were surveyed and consulted to determine currently known frequency bands of interest. This working document presents

applicable information presented to date, recognizing that additional work is required to continue the development and refinement of these passive sensing requirements in support of updating No. 5.565 of the Radio Regulations.

3.12 Using IASI radiances to generate proxy data set to test CrIS SDR algorithm.

Authors: Vladimir Zavyalov, Mark Esplin, Gail Bingham, Chad Fish, Greg Cantwell, BJ Randall, Marc Struthers, and Xu Liu

Presenter: Vladimir Zavyalov

The Crosstrack Infrared Sounder (CrIS) is one of the key sensors now under development for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) spacecraft. The CrIS system is defined as a space-borne sensor and ground-based processing SDR (Sensor Data Records) and EDR (Environmental Data Record) algorithms. In this presentation we present our preliminary results on the development of Platinum Proxy Data Set (PDDS) to assess the performance of the CrIS SDR operational algorithm. The general purpose of the PDDS is to serve as a common base for testing of the SDR and EDR CRIMSS algorithms. SDL has developed an independent CrIS instrument model that is used to generate interferograms with CrIS-specific artifacts added. Real IASI level 1C radiance spectra are used for the input. The output of the model is in the format of the CrIS Raw Data Record (RDR) which is then fed into the SDR processing algorithm. The processed RDR from PDDS are compared with the CrIS spectra directly transformed from the high spectral resolution IASI spectra used for the input into CrIS instrument model. Example comparisons, and data issues, along with their causes, are discussed.

3.13 A BUFR and GRIB Tailoring System for NPP/NPOESS Products

Authors: Yi Song, Thomas King, Walter Wolf, and Zhaohui Cheng

Presenter: Yi Song

A tailoring software system that will convert network Common Data Form version 4 (NetCDF4) formatted files to Binary Universal Form for the Representation of meteorological data (BUFR) and GRIB2 Binary Edition 2 (GRIB2) formatted files is under development at NOAA/NESDIS/STAR. This NetCDF4 Reformatting Toolkit will produce all the tailored BUFR and GRIB2 products for the

National Polar-orbiting Operational Environmental Satellite System (NPOESS) Data Exploitation (NDE) project. NDE will make these data available to Numerical Weather Prediction (NWP) customers in near real-time. In phase I, the Cross-track Infrared Sounder (CrIS) Radiances, Advanced Technology Microwave Sounder (ATMS) Radiances, Visible/Infrared Imager Radiometer Suite (VIIRS) Radiances, Aerosol Optical Thickness (AOT), Nadir Profile and Total Column Ozone (OMPS), Sea Surface Temperature (SST) and Polar Winds will be distributed in BUFR format. The Green Vegetation Fraction will be distributed in GRIB2 format. At this time, the BUFR tables of both CrIS and ATMS radiances are completed, and their test BUFR data from the simulation data are available. The VIIRS radiance, SST, and AOT BUFR tables have been delivered to NOAA NCEP for review. The OMPS and Polar Winds BUFR tables are under development. The VIIRS radiance BUFR files containing simulated data are scheduled to be available in spring 2010. The NPOESS Preparatory Project (NPP) launch is currently scheduled for September 2011. The radiance products in BUFR format will be made available approximately 6 months after NPP launch. The details of the tool and its products will be discussed.

3.14 Use of IASI Measurements to Calibrate MODIS and AMSU-B Water Vapor Channels

Authors: Bo-Ra Kim and B. J. Sohn

Presenter: Bo-Ra Kim

We used hyperspectral IASI measurements to calibrate the 6.8 μm water vapor (WV) channel of MODIS/Terra and 183 \pm 1 GHz WV channel of AMSU-B, in conjunction with Japanese MTSAT-1R WV channel measurements. IASI information presumed to be a well-calibrated reference has been transferred to MTSAT-1R WV channel with a bias correction, which was then used as a surrogate of the IASI to calibrate the MODIS WV channel measurements. Intercomparison was made between MODIS and MTSAT-1R because the scan-time difference between MODIS and IASI makes it difficult to construct the collocated data needed for the direct comparison. Two months (June and December 2007) of data were collected and tested over the MTSAT-1R observation area (30°N–30°S, 110°E–180°). Results indicate that the MODIS WV channel is biased low up to 3 K. It is presumed that the main cause of this bias is a possible shift of the spectral response function (SRF) of the MODIS WV channel by about -11 cm^{-1} since such a shift tends to remove biases between two sensors, which seem to be dependent upon the brightness

temperature and the season. In the presentation, the ongoing study of AMSU-B WV channel calibration will be further discussed.

3.15 The Status of Hyperspectral Product Systems at STAR

Authors: Walter Wolf, Thomas King, Chen Zhang, Kexin Zhang, Antonia Gambacorta, Haibing Sun, Yi Song, Zhaohui Cheng, Eric Maddy, Chris Barnet, and Mitchell Goldberg

Presenter: Walter Wolf

Since 2002 the NOAA/NESDIS Center for Satellite Applications and Research (STAR) has built three processing systems for the generation of AIRS, IASI, and CrIS products. The primary goal of all three systems has been to generate radiances and products on a near real-time basis for Numerical Weather Prediction (NWP) centers. The AIRS product system began processing and distributing data in 2002 and STAR continues to operate and maintain this quasi-operational system. The IASI product system was delivered to operations in two phases to the NOAA/NESDIS Office of Satellite Data Processing and Distribution (OSDPD) in 2007 and 2008. CrIS products will be generated by the NOAA Unique CrIS/ATMS Product Processing System (NUCAPS) that will also be run at OSDPD. The NUCAPS system is currently nearing the end of its development phase and is nearly ready for testing. Presented here is the current status of each processing system as well as information on any recent and future updates. We also discuss important changes in the way these systems are now developed and transitioned to operations. These involve enhancements to the quality assurance process throughout the project lifecycles. Tasks included in the project lifecycles are: standardization and implementation of reviews and documentation, software reviews, requirements development/analysis, configuration management, code testing, standardization of metadata and data formats, customer involvement, and working toward common standards within NESDIS. This experience and these efforts have provided a foundation for STAR in developing systems and transitioning them to OSDPD.

3.16 RARS Global Network Status and Plans

Authors: J.Lafeuille and the RARS Implementation Group

Presenter: J. Lafeuille

The initial objective of the global network project of Regional ATOVS Retransmission Services (RARS) is to deliver Level 1c ATOVS data from at least 90% of the globe within no more than 30 minutes from acquisition, in order to serve the needs of regional and global NWP. This can be achieved with a minimum of investment in concentrating data received from a number of individual Direct Readout stations implemented throughout the world, applying common processing and coding standards, and sharing the products over the Global Telecommunications System of WMO (GTS). By January 2010, the overall coverage of the RARS network had reached 70% of the globe's surface, and further implementations were underway. The initial objective is thus nearly completed thanks to the combined efforts of:

- The EUMETSAT Advanced Retransmission System (EARS) coordinated by EUMETSAT, which involves 15 HRPT stations from Canada, Denmark, France, Greece, Norway, Oman, Russian Federation, Spain and the USA
- The Asia-Pacific RARS coordinated by the Bureau of Meteorology, Australia, with one telecommunications node in Melbourne and another in Tokyo, which involves 15 HRPT stations from Australia, China, Japan, Korea, New Zealand and Singapore;
- The South-America RARS with one coordination node in Argentina and another in Brazil, which involves 6 HRPT stations from Argentina, Brazil, and Chile.

A further objective of the RARS project is to implement such a service for advanced sounder data from NPP and NPOESS-C1, during the demonstration and early operational phases of these missions. This will involve X-band receiving stations, data selection and compression, and high bandwidth telecommunications. Requirements have been analyzed and a call is now made to operators of candidate NPP/NPOESS Direct Readout receiving stations willing to join and support this project.

See: <http://www.wmo.int/pages/prog/sat/RARS.html>

3.17 Use of cloud targets to examine the calibration status of satellite visible channels: Application to Meteosat-8/9 and MTSAT-1R

Authors: B.J. Sohn and Seung-Hee Ham

Presenter: B.J. Sohn

Examining the calibration performance of Meteosat-8/9 0.640 micron and MTSAT-1R 0.724 micron channels, three vicarious calibration

methods were employed. First a ray-matching technique was used to compare Meteosat-8/9 and MTSAT-1R visible channel reflectances with well-calibrated MODIS 0.646 micron channel reflectances. Spectral differences of the response function were taken into account for the comparison. Secondly, collocated MODIS cloud products were used as inputs to a radiative transfer model to calculate Meteosat and MTSAT-1R visible channel reflectances. In the simulation, three-dimensional effect of clouds was calculated and subtracted from the simulated reflectance in order to remove the simulation bias caused by the plane-parallel assumption. In addition, an independent method of utilizing typical optical properties for deep convective clouds (DCCs) to simulate reflectance at the selected DCC targets. Although results from three methods are not in the perfect agreement, results suggest that calibration accuracies are about 5 ~ 10% for Meteosat-8 SEVIRI 0.640 micron channel, and 4 ~ 9% for Meteosat-9 0.640 micron channel, and up to 20% for MTSAT-1R 0.724 micron channel.

4.1 IASI 1dvar using PC Radiative Transfer

Authors: Jonathan P Taylor, Stephan Havemann, Jean-Claude Thelen, Steven Wardle, Tom Emery

Presenter: Jonathan P Taylor

A fast principal component based radiative transfer code has been coupled in a 1dvar environment to retrieve profiles of temperature, water vapour and ozone along with surface temperature and spectrally resolved emissivity. Results will be presented from trials of this retrieval scheme over ocean, arable land, sea ice, snow and desert surfaces. In all cases the performance of the retrieval is validated against dropsonde data gathered by the FAAM BAe146 atmospheric research aircraft and from low level runs with this aircraft where measurements of emissivity are made using the ARIES interferometer. The talk will present the results and their sensitivity to the structure of the background error covariance matrix. The results show that it is possible to use spectral information from the water vapour and temperature sensitive channels of IASI over a wide range of land/ocean surfaces.

4.2 ATMS NPP Preparation in the Community Radiative Transfer Model (CRTM): Spectral Response Function Analysis

Authors: Paul F. van Delst, David N. Groff, William J. Blackwell, C. Lynn Chidester, Giovanni De Amici, and Steve Swadley

Presenter: Paul F. van Delst

Preparing for use of new sensors in the Community Radiative Transfer Model (CRTM) involves obtaining the instrument characterisation data such that instrument resolution transmittances can be computed for regression fitting. Typically, when preparing the CRTM for microwave sensors, the only available channel frequency data consists of central frequencies, sideband offsets, and channel bandwidths. In generating CRTM coefficients, these frequency values are used to construct "boxcar" frequency responses. These boxcar responses are then used in the convolution of monochromatic quantities such as Planck radiances or transmittances to produce such things as polychromatic correction coefficients and instrument resolution transmittances. The latter are then regressed against a set of predictors to produce the fast transmittance model coefficients used by the CRTM. In the case of the NPP ATMS, measured bandwidths are also available in the form of tables of digitised filter responses as well as digitisations of frequency response scans taken from the ATMS PFM Calibration Data Book. The radiometric impact of these different sets of ATMS filter responses will be discussed.

4.3 High-spectral Resolution Radiative Transfer Model Performance Comparison - CPU vs. GPU

Authors: Allen Huang

Presenter: Allen Huang

The computing performance of the GPU has significantly outpaced its CPU counterpart. Leveraging the combined features of general-purpose GPU supercomputing, high parallelism, high memory bandwidth (102 GB per GPU), low cost, and compact size a GPU-based high-performance radiative transfer model is studied. This paper presents the performance of the GPU-based IASI/AIRS radiative transfer model running on NVIDIA GPUs via CUDA (Compute Unified Device Architecture), the compute engine in NVIDIA GPUs for massively multi-threaded parallel computation. IASI/AIRS GPU-based forward model is demonstrated on a low-cost NVIDIA S1070 personal supercomputer with 4 Tesla GPUs (total 960 cores). The result is compared with the native INTEL multi-core CPU implementation to illustrate the significant speed-ups of computing the IASI/AIRS top of atmosphere radiance spectra gained by the newly developed GPU-based system.

4.4 The GEISA Database 2009 Archive: An Assessment of Spectroscopic Parameters through IASI Hyperspectral Remote Sensing Applications

Authors: Nicole Jacquinet, Laurent crepeau, Virginie Capelle, Noelle Scott, Raymond Armante, Alain Chedin

Presenter: Nicole Jacquinet

The successful performances of the new generation of hyperspectral sounders, like IASI, depend ultimately on the accuracy to which the spectroscopic parameters of the optically active atmospheric gases are known, since they constitute an essential input to the forward radiative transfer models that are used to interpret their observations. In this context, since its initiation in 1976, the GEISA(1) (Gestion et Etude des Informations Spectroscopiques Atmospheriques; Management and Study of Atmospheric Spectroscopic Information) computer-accessible database, is continuously developed and maintained at LMD (Laboratoire de Meteorologie Dynamique, France). The updated 2009 edition of GEISA (GEISA-09), a system comprising three independent sub-databases devoted respectively to: line transition parameters, infrared and ultraviolet/visible absorption cross-sections, microphysical and optical properties of atmospheric aerosols. In this edition, the contents of which will be summarized, 50 molecules are involved in the line transition parameters sub-database, including 111 isotopes, for a total of 3,807,997 entries, in the spectral range from 10-6 to 35,877.031 cm⁻¹. Currently, GEISA is involved in activities related to the assessment of the capabilities of IASI on board the METOP European satellite through the GEISA/IASI database (2) derived from GEISA. Since the Metop launch, in October 2006, GEISA/IASI is the reference spectroscopic database for the validation of the level-1 IASI data, using the 4A radiative transfer model(3) (4A/LMD <http://ara.lmd.polytechnique.fr>; 4A/OP co-developed by LMD and Noveltis with the support of CNES).

Highlights will be given on a selection of problems that pertains to current status of the line parameters affecting IASI hyperspectral remote sensing applications. A special effort has been given in the validation of the updated parameters and the evaluation of the subsequent impact on radiative transfer simulations. Results of comparisons "calcs-obs" based on IASI observations and 4AOP simulations will be presented. GEISA is implemented on the CNES/CNRS "Ether" Products and Services Centre WEB site (<http://ether.ipsl.jussieu.fr>), where all archived

spectroscopic data can be handled through general and user friendly associated management software facilities. More than 350 researchers are registered for on line use of GEISA.

Refs: (1) Jacquinet-Husson N., N.A. Scott, A. Chedin, L. Crepeau, R. Armante, V. Capelle, J. Orphal, A. Coustenis, C. Boone, N. Poulet-Crovisier, et al. THE GEISA SPECTROSCOPIC DATABASE: Current and future archive for Earth and planetary atmosphere studies. JQSRT, 109, 1043-1059, 2008.

(2) Jacquinet-Husson N., N.A. Scott, A. Chedin, K. Garceran, R. Armante, et al. The 2003 edition of the GEISA/IASI spectroscopic database. JQSRT, 95, 429-67, 2005.

(3) Scott, N.A. and A. Chedin, 1981: A fast line-by-line method for atmospheric absorption computations: The Automatized Atmospheric Absorption Atlas. J. Appl. Meteor., 20,556-564

4.5 Update of the JCSDA Community Radiative Transfer Model (CRTM)

Authors: Yong Han, Paul Van Delst, Fuzhong Weng, Quanhua Liu, Dave Groff, Banghua Yan, Yong Chen, and Ron Vogel

Presenter: Yong Han

The community radiative transfer (RT) model (CRTM) is developed at the US Joint Center for Satellite Data Assimilation (JCSDA) for rapid satellite radiance simulations and radiance derivative calculations under various sky and surface conditions. The model was first released publicly in 2005, and has been substantially improved and expanded since then. CRTM version 2.0 will be released in March, 2010. In this presentation, we will provide an overview of the new version with a focus on the new features. The model includes a multiple transmittance algorithm framework, which allows different transmittance algorithms to coexist. Within the framework, a new transmittance algorithm is implemented, which combines the strengths of the OPTRAN algorithm (Optical Path TRANsmittance) and the ODPS algorithm (Optical Depth in Pressure Space), currently used in the RTTOV model. In addition, special algorithms are implemented to take into account Zeeman-splitting effect for the SSMIS and AMSU-A sensors and CO₂ cell pressure leaking effect for the Stratospheric Sounding Unit (SSU). For the surface emissivity/reflectivity, a new fast Infrared emissivity model and a bi-directional reflection distribution function (BRDF) for solar reflection over sea surface are implemented. CRTM version 2 also extends the RT Solver and other modules to include components for Visible

sensors. The new version has improved computational efficiency (a factor 3 for the forward model and a factor 2 for the Jacobian model, compared to the first version) under clear sky conditions. In the presentation, we will also report on our ongoing and future work.

4.6 Update on RTTOV developments

Authors: Roger Saunders, Marco Matricardi, Peter Rayer, Alan Geer, Pascal Brunel and Philippe Marguinaud

Presenter: Roger Saunders

The fast radiative transfer model, RTTOV, which is developed by the NWP-SAF and other EUMETSAT sponsored activities, has continued to be enhanced since the release of RTTOV-9 in March 2008. Over 280 users worldwide have received a copy of the RTTOV-9 code and the number of applications is continuing to expand. In particular RTTOV-9 is now being included in an 'observation simulator package' for running in climate models to compare long term trends in models with those measured by satellites. The RTTOV-9 model is available to users free on request from the NWP SAF web site at www.nwpsaf.org. The major enhancements to be described of RTTOV-10 over RTTOV-9 are:

Scientific changes

- The top layer in RTTOV (level 0-1) can now be explicitly provided by the user.
- A parametrisation of the Zeeman effect is now included for AMSU-A channel 14 and the SSMI(S) mesospheric channels.
- For high resolution IR sounders (e.g. IASI) the option of simulating principal components of the spectrum rather than the full spectrum is now possible. This provides a dramatic speed up of the computation for the entire spectrum.
- The FASTEM-3 microwave ocean surface emissivity model has been improved.
- Improved simulation of TOVS SSU radiances
- Some improvements have been made to the RTTOV_SCATT wrapper code.
- It is now possible to prescribe more than one cloud type in a given layer.
- Subroutines outside of RTTOV can be called to compute a more accurate land surface emissivity for infrared and microwave sounders/imagers given the lat/long and time of year. In addition an error covariance is provided.

Technical changes

- Code rewritten in places to improve readability and maintenance.
- A new more flexible makefile script is supplied to compile the code (already provided with v93).
- A new test script to replace the tstrad program.

As usual it is planned to hold a RTTOV meeting during the ITSC-17 conference to allow users to provide feedback to the developers. The current plan is for RTTOV-10 to be released to the user community in October 2010.

4.7 Aircraft and satellite hyperspectral measurements investigating the radiative impact of atmospheric water vapour

Authors: Stuart M. Newman, A. Larar, W. L. Smith, K. P. Shine, I. V. Ptashnik, F. Hilton and J. P. Taylor

Presenter: Stuart M. Newman

The successful launch of the Infrared Atmospheric Sounding Interferometer (IASI), with significant improvements in forecast skill in operational weather forecasting models, demonstrates the value of hyperspectral measurements from space. However, the extension of hyperspectral data assimilation to include more channels sensitive to water vapour is an ongoing challenge. Uncertainties in the spectroscopy of water vapour, and in the formulation of the water vapour continuum, remain, and radiative transfer models require validation against observational data. The UK's Facility for Airborne Atmospheric Measurements (FAAM) BAe 146 research aircraft has been involved in two recent campaigns where the radiative impact of water vapour has been investigated. The Joint Airborne IASI Validation Experiment (JAIVEx), based in Houston, Texas, gathered a high quality data set of collocated interferometer radiances and atmospheric profile measurements in high humidity conditions. Subsequently, as an integral part of the Continuum Absorption at Visible and Infrared wavelengths and its Atmospheric Relevance (CAVIAR) project, combined ground-based and airborne measurements have been collected at midlatitudes, centred on southwest England and the Jungfraujoch research station in Switzerland. Combined, these measurements span a range of humidity conditions and allow radiative transfer models of atmospheric water vapour absorption and emission to be tested. Results from the campaigns will show the level of agreement possible between models and observations, assess recent updates to spectroscopic

line parameters, and identify regions where modelling errors persist.

5.1 Application of the UW/CIMSS high spectral resolution global IR land surface emissivity database into the RTTOV model

Authors: Borbas, E. E., B. Ruston, R. Saunders, A.D Collard, R. O. Knuteson, and A. Huang

Presenter: Eva Borbas

The calculations of upwelling infrared radiances over land with RTTOV-9 are reliant on a single emissivity value assumed to be 0.98. Recently a new IR land surface emissivity module for RTTOV has been developed by applying the UW/CIMSS high spectral resolution global IR land surface emissivity database under the EUMETSAT NWP-SAF program. The aim of this project was to provide a simple user interface which can be used with RTTOV and provide emissivity estimates for input to RTTOV and their associated error covariance for data assimilation applications. This should help in any IR forward model application including the assimilation of infrared radiances over land. In the presentation, the structure of the new IR land surface emissivity module, its evaluation with SEVIRI and IASI observations and its test in assimilation mode will be shown.

5.2 Retrieval hyperspectrally-resolved surface emissivity and validation

Authors: Daniel K. Zhou, Allen M. Larar, Xu Liu, William L. Smith, L. Larrabee Strow, Ping Yang, and Peter Schlüssel

Surface spectral emissivity derived from current and future satellites can and will reveal critical information about the Earth's ecosystem and land surface type properties, which can be utilized as a means of long-term monitoring of global environment and climate change. Surface spectral emissivity derived from satellite hyperspectral IR measurements is also crucial for achieving accurate retrievals of trace gases such as O₃, CO, CO₂, H₂O, and CH₄ which are commonly used in climate studies. In addition, the assimilation of infrared radiances in global numerical weather prediction (NWP) models also needs accurate hyperspectrally-resolved surface emissivity. Hyperspectrally-resolved surface emissivities are derived with an algorithm utilizes a combined fast radiative transfer model (RTM) with a molecular RTM and a cloud RTM accounting for both atmospheric absorption and cloud absorption/scattering. Clouds are automatically detected and cloud microphysical parameters are retrieved; and emissivity is retrieved under clear and optically thin cloud conditions. This technique separates surface emissivity from skin temperature by representing the emissivity spectrum with eigenvectors derived from a laboratory measured emissivity database; in other words, using the constraint as a means for the emissivity to vary smoothly across atmospheric absorption lines. Here we present hyperspectrally-resolved surface emissivities retrieved from IASI and validation over the Namib and Kalahari deserts.

5.3 Towards a better modeling of surface emissivity to improve AMSU data assimilation over Antarctica

Authors: *Stephanie Guedj, Fatima Karbou, Florence Rabier and Aurelie Bouchard*

Presenter: *Stephanie Guedj*

This work aims to better constrain atmospheric analyses by improving the assimilation of low-level observations over Antarctica (Concordiasi international project). Advanced Microwave Sounding Unit (AMSU) onboard polar orbiting satellites are used for temperature (module -A) and humidity (module -B) soundings. Because of Antarctica dry atmosphere and of its complex topography, the contribution of the surface to measured brightness temperature is quite

significant. Therefore, to assimilate more AMSU-A and AMSU-B microwave observations over this continent, different issues have to be dealt with. In this work, the surface emissivity issue over Antarctica is examined. In a first step, a thorough review of the use of a specular assumption to calculate emissivity from AMSU-A measurements has been undertaken. The effect of five different assumptions about the surface on retrieved AMSU emissivities has then been evaluated using one year of data: specular, lambertian and three intermediate assumptions. Simulations of brightness temperatures at AMSU sounding frequencies have been produced using a radiative transfer model. Emissivities from the five assumptions have improved simulations. The most successful schemes are found to be the lambertian scheme during the winter season and a specular or an intermediate scheme (50% specular, 50% lambertian) during Antarctica's short summer.

5.4 A Tool to Estimate Land Surface Emissivities at Microwaves frequencies (TELSEM) for use in numerical weather prediction schemes.

Authors: *Filipe Aires, Catherine Prigent, Frederic Bernardo, Carlos Jimenez, Roger Saunders, and Pascal Brunel*

Presenter: *Filipe Aires*

A Tool to Estimate Land Surface Emissivities at Microwaves (TELSEM) frequencies has been developed, for use with the Radiative Transfer TOV (RTTOV) model. Its objective is to facilitate the retrieval of atmospheric profiles over land, from satellite microwave sounders, especially the assimilation of radiances in Numerical Weather Prediction (NWP) models. TELSEM provides emissivity estimates and error covariance matrices for all land surfaces, between 19 and 100 GHz, and for all angles and linear polarizations. It is anchored to a pre-calculated monthly mean emissivity climatology derived from Special Sensor Microwave/Imager (SSM/I) observations. Tests show that it can be applied with benefits down to 5 GHz and up to 190 GHz, for atmospheric profile retrievals over land.

5.5 Implementation of a new infrared sea surface emissivity model in the Community Radiative Transfer Model (CRTM)

Authors: Paul F. van Delst, James A. Jung, and Nicholas R. Nalli

Presenter: Paul F. van Delst

The CRTM is used in the NCEP data assimilation systems to simulate satellite radiance observations. The current infrared (IR) sea surface emissivity model component of the CRTM has been in use since 2006 and is based on Wu and Smith [1997] in which surface-emitted, surface-reflected (SESR) contributions are taken into account. Recent work [Hanafin and Minnett, 2005; Nalli et al., 2008a,b] has shown that models of this type will underestimate the effective emissivity at larger zenith angles due to the quasi-specular reflection of downwelling atmospheric radiance into the sensor field-of-view. The corresponding difference between the Wu-Smith and Nalli model emissivities in the longwave IR window region (800-950cm⁻¹) is around 0.01, or 1%. For blackbody emission at typical sea surface temperatures, this is roughly equivalent to a brightness temperature error of 0.7K which, after including the reflected downwelling atmospheric radiation still amounts to a significant error of 0.5K [Wu and Smith, 1996]. A two season comparison of the two ocean surface emissivity models (Wu-Smith and Nalli) was conducted using the NCEP GDAS/GFS at the operational resolution. Improvements were noted from using the Nalli model by the increase in surface channels used over ocean along with a more consistent bias correction at the various scan angles. Improvements in the anomaly correlation statistics from using the Nalli emissivity model were also observed.

5.6 Improved Use of AIRS, IASI and AMSU-A over Land.

Presenter: Stephen English

Abstract not available.

5.7 Sea ice emissivities and effective temperatures at AMSU-B frequencies: An analysis of airborne microwave data measured during two campaigns

Authors: R. Chawn Harlow

Presenter: Stuart Newman

Satellite-based sounding of the temperature and humidity of the lower troposphere is only carried out over open sea surfaces because of large uncertainties in the surface emissivity and effective emitting temperature of other surfaces. The study of sea ice and snow surface emissivities has been the focus of two airborne campaigns carried out by the Met Office over the past decade in order to promote the assimilation of lower tropospheric sounding radiances over the Polar Regions. Presented here is an analysis of data from four flights of the FAAM BAe146 during the Feb 2008 CLPX-II campaign over the Chukchi and Beaufort Seas and three flights on the Met Office C-130 from the POLEX campaign of March 2001 over the Arctic Ocean north of Svalbard. The Microwave Airborne Radiometer Scanning System (MARSS) was present and functional during both campaigns and measures brightness temperatures at the AMSU-B and MHS wavelengths in 18 directions in the plane along track. Other instruments onboard were measuring aircraft position and height above the surface. Dropsondes were released to measure atmospheric temperature and humidity profiles. Analysis described in [1] was carried out for each MARSS footprint yielding a Lambertian emissivity and effective temperature time series for each of the seven flights discussed here. These time series are used in conjunction with nearly coincident Radarsat-1 SCANSAR imagery and (for CLPX-II) AVHRR imagery to classify the surface type. From this procedure, 23 ice types are defined including snow covered uplands, wetlands and frozen lakes, five samples of first year pack ice, six types of first year fast ice and two samples of multi-year ice. For each of these 23 ice types, Lambertian emissivity spectra at the MHS frequencies are retrieved. It is found that the emissivity difference between 157 GHz and 89 GHz (D157-89) is strongly linked to ice type. This D157-89 is highly negative for first year fast ice, less negative for first year ice, near zero for MYI and thin ice types, and positive for the frozen land sampled in this dataset. This changing behaviour in emissivity with surface type is explained in terms of differences in the snow stratigraphy and surface roughness/microtopography.

[1] R.C. Harlow, "Millimeter microwave emissivities and effective temperatures of snow covered surfaces: Evidence for Lambertian surface scattering," IEEE Trans. Geosci. Remote Sens., Vol. 37, No. 7, 1957-1970, July 2009.

5.8 Land surface temperature determination from the ATSR-family of instruments and the Sentinel-3 SLSTR

Authors: Fred Prata, Olof Zeller, Gary Corlett and John Remedios

Presenter: Fred Prata

Recent developments for determining land surface temperature (LST) from infrared broadband satellite radiometers are described. In particular we examine the operational (A)ATSR LST product and compare retrievals with ground-truth data and with other satellite products (e.g. MODIS). The operational algorithm makes use of vegetation class and static fractional vegetation cover maps as proxies for the effects of the spectral and spatial variations in infrared emissivity of the land surface. Water vapour effects are accounted for with an additional explicit dependence on column water vapour amount determined from the NVAP climatologies. Lessons learned from several years of operational data analyses have led to some significant improvements in the algorithm, which are described here. Higher spatial resolution of the land cover data from 50x50 km² to 1x1 km² provides improved LST retrievals. Water vapour climatology is also improved using the ERA40 re-analysis data, but the impact on the LST retrieval is small. The Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR) LST will utilise these improvements as well as making use of synergies with other optical instruments on board the Sentinel-3 platform. A brief discussion of the use of the longterm ATSR LST data-set, now 18 years long, for climate change studies will also be given.

5.9 Infrared Land Surface Emissivity Regression Retrieval Algorithm

Authors: Zhaohui Cheng, Haibing Sun, Walter Wolf, Fengying Sun, Mitch Goldberg, Chris Barnet and Thomas King

Presenter: Zhaohui Cheng

The land surface emissivity (LSE) varies according to soil moisture, surface coverage, view angle and soil components. STAR has calculated LSE from both AIRS and IASI using a regression retrieval. When comparing the regression emissivity to the emissivity from monthly datasets, the simultaneous emissivity retrieval algorithm developed at STAR can provide the real time surface radiance characteristics for the satellite observations; thus providing a better emissivity value for the calculations of atmosphere temperature and water

vapor profiles. The STAR LSE regression retrieval algorithm is based upon clear radiances simulated from forecast model data and an emissivity training dataset. A new emissivity training dataset is generated by combining multiple surface types with high spectral resolution lab emissivity measurements. The LSE is retrieved at 39 hinge points and may be extended to high spectral resolution with the constraint information from high spectral resolution lab emissivity measurements. The LSE retrievals from AIRS and IASI will be evaluated by comparing the regression results calculated using both the old and new coefficients. It will also be compared with the monthly UW/CIMSS global infrared land surface emissivity datasets. The results will be presented.

5.10 Towards the assimilation of SEVIRI observations over land

Authors: Stephanie Guedj, Fatima Karbou, Florence Rabier

Presenter: Stephanie Guedj

This work aims to improve the assimilation of low-level SEVIRI (Spinning Enhanced Visible and Infra Red Imager) IR (Infra-red) observations over land to better constrain atmospheric analyses in meso scale models operating at Météo-France. To date, over land surfaces, only high-peaking Water Vapour channels are operationally assimilated and IR channels are entirely rejected. The assimilation of IR observations over land is possible only if several limitations are accounted for: a reliable description of the surface emissivity, a more accurate estimation of the surface temperature and an effective bias correction scheme. Some feasibility studies have been undertaken in order to assimilate more SEVIRI observations in the ALADIN French system. The land surface emissivity was described using climatologies from the EUMETSAT Land-SAF (Satellite Application Facilities). The use of these climatologies was found very helpful in improving the RTTOV performances when simulating SEVIRI brightness temperatures (T_b) over Europe. The land surface emissivity and SEVIRI T_b were also used as input parameter in the radiative transfer model to retrieve the surface temperature (T_s) over Europe. The retrieved T_s was compared with independent T_s estimates (MODIS, Land-SAF products, ...) and was then used within the assimilation process to constrain the analysis of surface temperature. A description of the methods for emissivity/temperature retrievals will be given. An evaluation of the retrieved T_s against independent measurements will be also presented. Finally, we will give an overview of assimilation and forecast

experiment results when SEVIRI IR observations are assimilated over Europe.

5.11 An Improved FAST Microwave Sea Surface EMISSIVITY MODEL, FASTEM4

Authors: Quanhua (Mark) Liu, Steve English, and Fuzhong Weng

Presenter: Quanhua (Mark) Liu

Sea surface microwave emissivity model is crucial for radiance assimilation in supporting weather forecasting. Since the launch of the Advanced Microwave Sounder Unit in 1998, the microwave sensor data have been proven the most contributors to weather forecasting skill. The fast microwave emissivity model (FASTEM) has been used in most of numerical weather service (NWS) centers including NOAA NWS, ECMWF, and Met Office. Although FASTEM is widely used in NWP community, the model improvements at low frequencies below 20 GHz and high frequencies above 85 GHz are necessary. At low frequencies, sea water permittivity is a function of salinity that is not yet taken into account for in the FASTEM. Large bias between satellite observations and radiative transfer simulations at high frequencies has been reported. The operational microwave ocean emissivity model at the present doesn't have the capability to take account for the effect of the surface wind direction, except for a specific model for WINDSAT. The wind directional effect for vertically and horizontally polarized brightness temperatures is about 2 K, significant to radiance simulation and assimilation. In this study, we investigated the effects of permittivity models and generated a new permittivity model by using measurements for fresh and salted water at frequencies between 1.4 GHz and 410 GHz. A modified sea surface roughness model from Durden and Vescky is applied to the surface emissivity calculations. The new improved FAST Microwave Sea Surface EMISSIVITY MODEL, FASTEM4, can be used for the microwave radiance assimilation for weather forecasting and simulations in retrievals for satellite products by taking surface temperature, wind speed and direction, and salinity into account. We will use the new operational and research microwave ocean emissivity model to study the NPOESS ATMS sensor, in particular the effect of wind direction and also for the channels at high frequencies. This improved surface emissivity model will be used to examine the impact on weather forecasting.

5.12 Footprint Matching for the Advanced Technology Microwave Sounder

Authors: Thomas J. Kleespies

Presenter: Thomas J. Kleespies

In a recent paper, the author demonstrated that in order for the ATMS to have the same impact on NWP or sounding as the AMSU/MHS, there will have to be some kind of footprint matching or averaging. In that paper, a simple averaging was done of the smaller fields of view to the largest field of view at the -3dB level. In this paper, I will explore an alternative method where the smaller fields of view are convoluted with the largest fields of view at the -20dB level, which accounts for 99% of the radiation received by the sensor. This proposed method is similar to Backus-Gilbert, with the exception that no assumptions are made about the antenna pattern, such as assuming an effective Gaussian shape. The measured antenna pattern is mathematically modeled to a high degree of accuracy permitting convolution with good fidelity.

5.13 Retrieving the Atmospheric Temperature/Humidity Profiles and Temperature / Emissivity of land surface Using the High Spectral Resolution Data from IR Satellite Sensor IRFS-2

Authors: A.Polyakov, Yu.Timofeyev, A.Uspensky, S.Uspensky

Presenter: S.Uspensky

Potential errors of retrieving the atmospheric temperature/humidity profiles as well as the temperature/emissivity of land surface using the measurements of satellite IRFS-2 instrument planned to be launched aboard "Meteor_M" No2 are studied. The short description of IRFS-2 is given including the list of basic characteristics. The study has been based on developed atmospheric radiative code in IR spectral range, the representative ensemble of temperature/humidity profiles (TIGR type) and numerical experiments using the multiple linear regression method. The study has shown that the measurements of outgoing thermal radiation with the IRFS-2 allow for decreasing the uncertainties in the temperature profile from 10 K to ~1 K in the 0–50 km height layer. The temperature retrieval error increases up to 2.5 K in the near-surface atmospheric layer for all atmospheric models and up to 2–2.5 K at the 30–35 km altitudes for middle-latitude and polar atmospheric models. Vertical resolution of considered satellite method for determining the temperature profile with the IRFS-2 is 2–3 km in the troposphere. A priori uncertainty of the water vapor mixture ratio decreases by 2–5 times at

altitudes of 0–20 km. Relative humidity can be retrieved with an accuracy of no worse than 15% at the altitudes of 0.5–20 km. In the near-surface layer, the error increases up to 30%, which is caused by the peculiarities of forming the outgoing thermal IR radiation. The experiments have been carried out for simultaneous retrieval of the temperature and spectral emissivity for different land surfaces from synthetic IRFS-2 sounder data. The satellite data inversion technique is based on the use of a priori information on the spectral behavior of emissivity for various surfaces and the multiple linear-regression technique. The RMS errors for retrieved surface temperatures are shown to be equal to 0.3–0.7K depending on different solving operators. Developed method for inversion the IRFS-2 data enable to estimate the land surface emissivity with a RMS error about 0.015.

5.14 Infrared continental surface emissivity spectra and skin temperature retrieved from IASI observations

Authors: Virginie Capelle, Eric Pequignot, Alain Chedin, Noelle A. Scott

Presenter: Nicole Jacquinet

Surface temperature and emissivity spectra are variables essential for improving models of the earth surface-atmosphere interaction, retrievals of meteorological profiles, as well as cloud and aerosol characteristics. However, in most cases, they are not correctly taken into account in climate models, leading to potentially important errors in the estimation of surface energy fluxes and temperature. Satellite infrared observations offer a way to accurately estimate these variables. Here, IASI observations are interpreted in terms of monthly surface skin temperature and emissivity spectra at a resolution of 0.05 m. Following the method described in Pequignot et al., 2008 and applied to AIRS observations, for each IASI observation, an a priori estimate of the observed atmospheric temperature and water vapor profiles is first obtained through a proximity recognition within the Thermodynamic Initial Guess Retrieval (TIGR) climatological database of about 2300 representative atmospheric situations. With this information, all terms of the radiative transfer equation are then computed by using the 4A line-by-line radiative transfer model. Then, surface temperature is evaluated by using a few IASI window channels, chosen for their almost constant emissivity with respect to soil type. Emissivity is then calculated for a set of 101 atmospheric window channels distributed over the infrared spectrum. The overall infrared emissivity spectrum at 0.05 microns resolution is finally derived from a

combination of these results and of high spectral resolution laboratory measurements of various materials carefully selected within the MODIS/UCSB and ASTER/JPL emissivity libraries. The final product provided by this study is global monthly surface temperature and infrared emissivity spectra from 3.7 to 14 microns at a spatial resolution of 1° per 1°. The period covered goes from July 2007 to now.

5.15 Improvements in Land Surface Emissivity Models for Community Radiative Transfer Model (CRTM) Applications

Authors: Fuzhong Weng, Ron Vogel, Banghua Yan, and Liang Ding

Presenter: Fuzhong Weng

The Community Radiative Transfer Model (CRTM) is a critical component used in NWP systems for satellite radiance assimilation. The CRTM version 2 includes modules calculating gaseous absorption, absorption and scattering of radiation by hydrometeors and aerosols, and emission and reflection of radiation by ocean, land, snow and ice surfaces. In addition to the forward model, the corresponding tangent linear, adjoint and K-Matrix models have also been developed and included in the CRTM package for calculations of the radiance sensitivities with respect to the state variables. In this report, we will present our progresses since the ITSC-16 related to land emissivity, including 1) a dynamic computation of infrared land emissivity, 2) multi-layer snow emissivity modeling at high frequencies from dense media model, and 3) multilayer soil emissivity model for L-band simulations. Simulated radiances are compared with the measurements from several instruments.

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5.16 Utilization of Land Surface Emissivity for Precipitation Retrieval – an Obvious Linkage between ITWG and IPWG – and Implications for GPM-era Algorithms

Authors: Ralph Ferraro, Sid Boukabara, Fuzhong Weng, Nai-Yu Wang

Presenter: Ralph Ferraro

To date, the majority of the passive microwave, precipitation over land algorithms have relied on mostly empirically based methods (with physical foundation) that utilize the ice-scattering properties of precipitation sized ice particles at frequencies at or above 85 GHz. These methods mostly rely on a “first guess” that attempts to isolate this signature from the surrounding background land areas, including surfaces with similar spectral properties like snow and desert. In order to advance the retrievals into a more physically based scheme and use the full complement of measurements in the 10 – 190 GHz range (a goal of the Global Precipitation Measurement (GPM) mission and also identified as a priority research area at the 4th IPWG Workshop in October 2008), several improvements are needed to advance the current class of algorithms. Perhaps the most urgent need is the proper characterization of the underlying land surface, including the land surface emissivity. It is well recognized that the land surface emissivity community has made great strides in developing emissivity models and retrievals at microwave frequencies; yet, these have focused on the utilization of such information in NWP applications. These are not likely suitable for the wide range of conditions needed for precipitation retrievals (e.g., falling rain, falling snow, frequencies up to 190 GHz, etc.). Under the auspices of NASA’s GPM Science Team, a small study was initiated to assess the sensitivity of the precipitation algorithms to emissivity retrievals and also to gain an understanding of the variability of the emissivity estimates over similar surface types. Emissivity estimates for a 1 year period (July 2006 – June 2007) over 13 targets throughout the world were generated by several investigators and are being intercompared over time scales ranging from instantaneous to monthly (for more details, see <http://cics.umd.edu/~rferraro/LSWG.html>). The purpose of this paper is to describe this study in more detail, present some preliminary results, and engage the ITWG to further describe the needs of the international precipitation community (e.g., IPWG and GPM) and define areas of collaboration

5.17 Modeling of Inhomogeneous Surface Properties for the Advanced Technology Microwave Sounder

Authors: Thomas J. Kleespies

Presenter: Thomas J. Kleespies

The low frequency channels of the Advanced Technology Microwave Sounder have a nadir resolution of 79 km increasing to 363x151 km at edge of scan. Modern numerical weather prediction models are exceeding this resolution. Ancillary databases, such as digital elevation maps are available with a resolution of a few meters. This paper presents a method of using the measured antenna pattern of the ATMS in conjunction with a digital elevation model to perform radiative transfer over coastlines and other inhomogeneous terrain.

6.1 Inferring Global Cloud Cover Properties and Trends from Thirty Years of HIRS Data

Authors: W. Paul Menzel, Erik Olson, Bryan Baum, Robert Holz, Andrew Heidinger, Don Wylie, Darren L. Jackson, and John Bates

Presenter: Paul Menzel

The frequency of occurrence of tropospheric clouds has been extracted from NOAA/HIRS polar orbiting satellite data from 1979 onwards using CO2 slicing to infer cloud amount and height. Algorithm adjustments for instrument noise, sensor to sensor differences, viewing angle, spectral response shifts, calculated versus measured radiance biases, changing CO2 and O3 amounts, orbit drift, and investigator error have been studied. High spectral resolution infrared data from AIRS has been used to adjust spectral response functions in the recent HIRS data; Satellite Nadir Overpasses (SNO) are being used to intercalibrate the HIRS sensors before AIRS. To accommodate the thirty years CO2 increase of 335 to 385 ppm, a linear ramp with seasonal 3 ppm sinusoid has been incorporated into the radiative transfer calculations. Orbit drift (N11 & N14 drifted 3+ hrs) is mitigated by averaging daily cloud products from both am and pm sensors. CALIPSO measurements are being studied to verify the adjustments in the CO2 slicing algorithm. Some lessons learned are being documented and the next steps are to overlay the HIRS cloud properties on those derived from the AVHRR-based PATMOS-x output.

6.2 Using Hyperspectral Sounders for Climate Applications

Authors: A. Gambacorta, C. Barnet, E. Maddy, T. King, X. Liu, Z. Cheng, W. Wolf, and M. Goldberg

Presenter: Antonia Gambacorta

Hyperspectral sounding instruments have been used to produce atmospheric sounding products for the past seven years. NOAA/NESDIS/STAR has been collecting global maps of both AIRS and IASI data in preparation of temperature, water vapor, and trace gas climate studies. By exploiting the combined sounding geometry of AIRS and IASI, four daily global measurements of the atmospheric state are currently available. With the launch of the CrIS/ATMS instrument, it will be possible to obtain an unprecedented uniform and long term record of about 20 years of hyperspectral data. The higher vertical resolution and the large temporal sampling of this data set will allow for a more comprehensive investigation of unsolved key questions, such as the water vapor feedback to temperature changes and the source and sink distributions of the atmospheric trace gas components. AIRS and IASI data, along with exhaustive validation statistics, are already accessible in near real time at STAR. An overview of the technical characteristics and the scientific maturity of this data set will be given at the conference.

6.3 NOAA's Climate Data Record Project – An Update of Status and Progress

Authors: John Bates, Jeff Privette

Presenter: John Bates

NOAA is embarking on an ambitious project to routinely produce climate data records (CDRs) that are part of the list of essential climate variables of the global climate observing system. This project includes three components: 1) the production of trustworthy historical CDRs using POES and GOES observations, 2) the continuity of critical climate sensors and CDRs transitioning from NASA to NOAA (such as clouds and Earth radiation), and 3) preparing for use of the new sensors on NPP and NPOESS. In addition, we are also supporting NOAA's emerging NOAA National Climate Science and Service. The status and progress of all these activities will be presented.

As part of the NPP CDR work, NOAA's NCDC is preparing a climate raw data record to facilitate use of NPP instruments for future processing and reprocessing. We would like to engage the ITWG community in getting comments and feedback on this concept.

6.4 Vertical Moist Thermodynamic Structure of the MJO in AIRS Observations and ECMWF Interim Reanalysis

Authors: Baijun Tian, Duane E. Waliser, Eric J. Fetzer, Bjorn H. Lambriksen, and Yuk L. Yung

Presenter: Baijun Tian

Tian et al. [2006] have documented the large-scale three-dimensional moist thermodynamic structure and spatial-temporal evolution of the Madden-Julian Oscillation (MJO) using the first 2.5-year (2002-2005) high-resolution atmospheric moisture and temperature profiles from the Atmospheric Infrared Sounder (AIRS)/Advanced Microwave Sounding Unit (AMSU) on the NASA Aqua mission. Here, we re-examine the vertical moist thermodynamic structure of the MJO using the current available 7-year AIRS data (2002-2009) to test the robustness of the results of Tian et al. [2006] and their dependence of data record length, data resolution (daily versus pentad), and MJO analysis methods. We also compare the AIRS results to those from the ECMWF Interim reanalysis (ERA-Int), a new global reanalysis data set from ECMWF. The current analysis indicates that the large-scale vertical moist thermodynamic structure and spatial-temporal evolution of the MJO reported by Tian et al. [2006] are robust and independent on the AIRS data record length, AIRS data resolution, and MJO analysis methods. The MJO vertical moist thermodynamic structures from AIRS and ERA-Int data are in very good agreement although AIRS results seem to be drier in moist regions and moister in dry regions compared to ERA-Int results. These results will be a useful metric for climate model diagnostics.

6.5 Using Hyperspectral Infrared Radiance Global Data Sets to Validate Weather and Climate Analyses

Authors: Mitchell D. Goldberg, Lihang Zhou, Xingpin Liu, Zhaohui Cheng, Likun Wang

Presenter: Mitchell D. Goldberg

There is growing consensus that persistent and increasing anthropogenic emissions are increasing atmospheric temperatures, increasing sea levels, melting ice caps and glaciers, increasing the occurrence of severe weather, and causing regional shifts in precipitation patterns. Changes in these parameters or occurrences are responses to changes in climate forcing terms, notably greenhouse gases. The NASA Atmospheric InfraRed Sounder (AIRS) [Aumann et al., 2003], launched in May of 2002, is the first high spectral resolution infrared sounder

with nearly complete global coverage on a daily basis. High spectral resolution in the infrared provides sensitivity to nearly all climate forcings, responses and feedbacks. The AIRS radiances are sensitive to changes in carbon dioxide, methane, carbon monoxide, ozone, water vapor, temperature, clouds, aerosols, and surface characteristics. The AIRS data are applied to generate the first ever spectrally resolved infrared radiance (SRIR) dataset (2002- 2006) for monitoring changes in atmospheric temperature and constituents and for assessing the accuracy of climate and weather model analyses and forecasts [Goldberg, 2009]. The SRIR dataset is a very powerful climate application. Spectral signatures derived from the dataset confirmed the largest depletion of ozone over the Arctic in 2005, and also verified that the European Center for Medium Range Weather (ECMWF) model analysis water vapor fields are significantly more accurate than the analyses of the National Centers for Environmental Prediction (NCEP). The NCEP moisture fields are generally 20% more moist than those from ECMWF. Applications included computations of radiances from NCEP and ECMWF atmospheric states and comparison of these calculated radiances with those obtained from the SRIR dataset. Comparisons showed very good agreement between the SRIR data and ECMWF simulated radiances, while the agreement with NCEP values was rather poor. However, further comparisons with the SRIR dataset in 2006 found degradation in the ECMWF upper tropospheric water vapor fields due to an operational change in ECMWF assimilation /modeling procedures. This unexpected result demonstrates the importance of continuous routine monitoring. The SRIR climatology will be extended into the future using AIRS and the EUMETSAT Infrared Atmospheric Interferometer Sounder (IASI) and the NPOESS Cross-track Infrared Sounder (CrIS). The current SRIR dataset will be extended to 2009 by the end of 2010.

6.6 An update on the NESDIS MSU/AMSU/SSU CDR development and its applications

Authors: Cheng-Zhi Zou

Presenter: Cheng-Zhi Zou

NESDIS/STAR has been developing consistent, SNO (simultaneous nadir overpass) inter-calibrated radiance sensor data record (SDR) and upper air temperature thematic climate data records (TCDR) from MSU/AMSU/SSU observations for climate applications. In this talk, we will give an update on the status of the MSU/AMSU/SSU reprocessing/replication and its application activities. These include, but not limited to, a)

release of the STAR Version 1.2, recalibrated 28-year (1978-2006) MSU-only radiance SDR and its resulting upper air temperature TCDRs of mid-troposphere, upper-troposphere, and lower-stratosphere; b) SNO inter-satellite calibration results for the AMSU-A atmospheric temperature channels onboard NOAA-15 through NOAA-18 and MetOp-A; c) preliminary results on the 30-years (1978-2009) of STAR Version 2.0, merged MSU/AMSU upper air temperature TCDRs; d) application of the recalibrated MSU radiance SDRs in the new-generation of NCEP CFSR and NASA MERRA reanalyses; e) MSU trend analysis and its relationship with sea ice melting; f) bias correction analysis of the AMSU-A channels in the ECMWF-Interim reanalysis and its implications for the satellite recalibration activities; g) preliminary results on the SSU reprocessing; h) a briefing on the workshop recently held at Washington DC on Climate Data Records from Satellite Microwave Radiometry. Issues identified on the MSU/AMSU/SSU reprocessing in the workshop will be discussed.

6.7 CM-SAF products from ATOVS : six years of operationally produced data (2004-2009) and first results from the reprocessing of ATOVS products (1999-2009).

Authors: Nathalie Courcoux, Marc Schroeder, Theo Steenbergen, Joerg Schulz

Presenter: Nathalie Courcoux

The major objective of the Satellite Application Facility on Climate Monitoring (CM-SAF) is the exploitation of the satellite measurements with state of the art algorithms to derive information about key climate variable of the Earth system. The derived products focus on the atmospheric part of the "Essential Climate Variable" developed within the Global Climate Observing System (GCOS) framework. Furthermore, the CM-SAF products are tailored with respect to the need of the current and potential future users and are developed by applying the GCOS climate monitoring principles as far as possible. Concerning water vapour and temperature, the CM-SAF operationally retrieves water vapour and temperature profiles from the ATOVS observations. The CM-SAF operational processing scheme is using the International ATOVS Processing Package (IAPP) developed by the University of Wisconsin to retrieve temperature and water vapour profiles from the ATOVS observations. The output of the Global-Modell (GME) of the Deutscher Wetterdienst is used as background input to the retrieval. The retrieved products are quality controlled and a Kriging routine is applied to average and merge the results

from the different satellites. Beside the operationally retrieved products, which are disseminated with high timeliness, CM-SAF also produces data sets retrospectively. Those data sets are aimed at providing homogeneous time series that are suitable to analyse variability of Essential Climate Variables on long time periods. CM-SAF is reprocessing its ATOVS products from 1999 on, using the ERA Interim reanalysis from ECMWF (European Centre for Medium-range Weather Forecasts) as background input to the retrieval instead of the GME output. The CM-SAF ATOVS products are vertically integrated water vapour from the surface to 100 hPa, layered vertically integrated water vapour, layered mean temperature and layered mean relative humidity, the latter three for five layers, as well as temperature and water vapour mixing ratio at six pressure levels. The CM-SAF ATOVS data have a global coverage with a spatial resolution of (90 km)², and are available as monthly and daily means. The uncertainties and the number of observations are also available on pixel basis. The validation of the six years (2004-2009) of operational data against quality controlled radiosonde data is discussed (in particular the impact of the use of MetOp data from June 2009 on) and shows the high quality of the CM-SAF ATOVS products. The bias for the total precipitable water has its maximum around 1 kgm⁻², and the bias for the layered temperature is always below 1K. The first validation results of the reprocessed data set against the same quality controlled radiosonde data is shown and discussed as well, in particular the impact of the change from GME to ERA Interim on the quality and the number of observations per pixel.

6.8 Natural and Anthropogenic Variability Observed in Seven Years of Data from the Atmospheric Infrared Sounder (AIRS)

Authors: Thomas S. Pagano

Presenter: Thomas S. Pagano

The Atmospheric Infrared Sounder (AIRS) is a hyperspectral infrared instrument on the EOS Aqua Spacecraft, launched on May 4, 2002. AIRS has 2378 infrared channels ranging from 3.7 μm to 15.4 μm and a 13.5 km footprint. AIRS, in conjunction with the Advanced Microwave Sounding Unit (AMSU), produces high accuracy temperature profiles, water vapor profiles, infrared cloud height and fraction, and trace gas amounts for CO₂, CO, SO₂, O₃ and CH₄ in the mid to upper troposphere. AIRS wide swath, $\pm 49.5^\circ$, combined with a novel cloud clearing methodology enables daily global coverage for over 70% of the Earth's surface for most geophysical products. AIRS data are used

for weather forecasting, validating climate model distribution and processes, and observing long-range transport of greenhouse gases. Early in the mission, the AIRS instrument demonstrated its value to the weather forecasting community by providing better than 6 hours of improvement on the 5 day forecast. Now with over seven years of consistent and stable data from AIRS, scientists are able to examine processes governing weather and climate and look at seasonal and interannual trends with high statistical confidence. The entire 7 year data set from AIRS are collected in this work for global gridded data products of several key geophysical atmospheric variables. We also examine limitations in the Version 5 data set for trending long term climate change using retrieved geophysical parameters, while the raw radiances are indeed sufficiently stable. From this data set it is possible to identify interesting natural and anthropogenic events in Earth's atmosphere including hurricanes, biomass burning (CO plumes), inter-continental transport of carbon dioxide, ozone hole formation and stratospheric tropospheric exchange.

6.9 On The Temporal Stability of AIRS Temperature Retrievals: Trace Gas Initialization Effects

Authors: Eric S. Maddy, Chris Barnet, Murty Divakarla, Mitchell Goldberg

Presenter: Eric S. Maddy

In this study, we present an analysis of the temporal stability of 6 years of AIRS temperature retrievals under varying assumptions of trace gas species (e.g. CO₂, N₂O, etc.) concentrations. In order to quantify the effects of making various assumptions of the true and unknown trace gas concentrations we implement each assumption one at a time. Retrievals are then run on various datasets to assess the impact of the particular assumption. These separate runs are then compared against each other and also against radiosondes to see which assumption agrees best with the radiosondes temporally over the 6 year period.

6.10 A consistent monitoring of satellite radiance biases for GSICS

Authors: Roger Saunders, Brett Candy, Pete Francis and Tim Hewison

Presenter: Roger Saunders

As part of the EUMETSAT GSICS (Global Space-based Inter-Calibration System) activities to

monitor and understand the biases of the Meteosat SEVIRI, NOAA/METOP HIRS radiometers, the METOP IASI interferometer and Aqua AIRS spectrometer, a collaboration between the Met Office and EUMETSAT has been initiated. The objective is to monitor the biases of these sensors using a state of the art NWP model over at least one annual cycle and compare the biases for different sensors. Within the operational Met Office observation pre-processing environment the first guess atmospheric state (temperature, water vapour and ozone profiles and surface skin temperature), from a 6 hour forecast, is used together with a fast radiative transfer model, RTTOV, to compute radiances for the sensors at locations and times corresponding to the observations. In addition the AMSU/MHS radiances were also computed. These simulated or first guess radiances are then compared with the observed radiances and a radiance bias is computed for global and regional areas. This bias can then be studied as a function of a number of different variables such as viewing angle, time of day, location, scene radiance, total column water vapour, etc. The bias statistics can be used as an indirect comparison between pairs of different sensor observations, which can be compared with direct comparison of their collocated observations. The statistics have now been collected since the end of Nov 2008 just before there was a decontamination of the SEVIRI radiometer on Meteosat-9. An analysis of the results for the first annual cycle for 2009 will be presented together with future plans for this project.

6.11 An overview of the operational processing at the Satellite Application Facility on Climate Monitoring

Authors: Nathalie Selbach and Petra Fuchs

Presenter: Nathalie Selbach

The Satellite Application Facility on Climate Monitoring (CM-SAF) generates, archives and distributes widely recognized high-quality satellite-derived products and services relevant for climate monitoring in an operational mode. Products covering surface albedo, radiation fluxes at top of the atmosphere and at the surface, atmospheric temperature and water vapour profiles as well as vertically integrated water vapour (total, layered integrated) are derived from different sensors onboard operational geostationary and polar orbiting satellites including instruments such as ATOVS, AVHRR, GERB and SEVIRI. The products are available at a spatial resolution in the range of (15 km)² to (90 km)² on equal area grids and temporal averages ranging from daily to

monthly means. Depending on the sensors used the coverage ranges from regional (e.g., Europe, Arctic) to global. Additionally, long time-series of different atmospheric parameters are or will be generated in dedicated processing events as, for example, integrated water vapour from SSM/I, cloud and surface radiation products from AVHRR GAC data with a global coverage, or the extension of the time series of the ATOVS based products. Processing of the CM-SAF products is done at two processing centres at DWD and RMIB, respectively. The DWD processing centre also makes use of computing resources at the ECMWF. The generation of the CM-SAF products is done in separate processing environments depending on the different satellite instruments required as input. All products are archived in a central database located at DWD. The CM-SAF offers various user services, such as access to the products via a web-based interface, detailed information on products and a User Help Desk. This presentation will give an overview of the operational procedures at the CM-SAF and future plans. It will cover the processing approach as well as the user access to products and user support.

6.12 Global Space-based Inter-calibration System (GSICS) Sensor Intercomparisons and Corrections

Authors: Mitchell D. Goldberg and Xiangqian Wu

Presenter: Mitchell D. Goldberg

The Global Space-based Inter-Calibration System (GSICS) is a new international program to assure the comparability of satellite measurements taken at different times and locations by different instruments operated by different satellite agencies. Sponsored by the World Meteorological Organization and the Coordination Group for Meteorological Satellites, GSICS will inter-calibrate the instruments of the international constellation of operational low-earth-orbiting (LEO) and geostationary (GEO) environmental satellites and tie these to common reference standards. The intercomparability of the observations will result in more accurate measurements for assimilation in numerical weather prediction models, blended products from multiple sensors, construction of more reliable climate data records, and progress towards achieving the societal goals of the Global Earth Observation System of Systems. GSICS includes globally coordinated activities for pre-launch instrument characterization, onboard routine calibration, sensor inter-comparison of near-simultaneous observations of individual scenes or overlapping time series, vicarious calibration using

Earth-based or celestial references, and field campaigns. An initial strategy uses high accuracy satellite instruments, such as the NASA Moderate Resolution Imaging Spectroradiometer (MODIS) and Atmospheric Infrared Sounder (AIRS), and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) – Centre National d'Etudes Spatiales (CNES) Infrared Atmospheric Sounding Interferometer (IASI), as space-based reference standards for inter-calibrating the operational satellite sensors. Agencies participating in the program include Centre National d'Etudes Spatiales, China Meteorological Administration, EUMETSAT, Japan Meteorological Agency, Korea Meteorological Administration, NASA, National Institute of Standards and Technology, and NOAA. GSICS will provide coefficients to the user community to adjust satellite observations to a common reference. The first major deliverable is the GSICS correction algorithm for the geostationary infrared imagers. The correction adjusts the geostationary data to be consistent with IASI and AIRS. The user simply applies the correction to the original data using GSICS supplied software and coefficients. The coefficients will be a function of channel and time and will have the form $RC = a_0 + a_1RO$ where RC is the corrected radiance, a_0 and a_1 are the coefficients, and RO is the observed radiance. The coefficients for the geostationary imagers are derived from their collocations with IASI/AIRS. The Global Space-based Inter-Calibration System (GSICS) is off to a good start toward achieving its overarching goal of ensuring the comparability of satellite measurements taken at different times, by different instruments, operated by different agencies, and tying these measurements to the international system of units (SI). Eight international agencies are already participating in this program of the WMO and the Coordination Group for Meteorological Satellites. The GSICS infrastructure is in place: the GSICS Coordination Center (GCC) infrastructure at NESDIS to coordinate the inter-calibration activities, archive and disseminate results, and operate the GSICS website; the GSICS Processing and Research Centers (GPRCs), responsible for pre-launch calibration, inter-calibration of their own agency's sensors with other satellite sensors, and supporting research activities; the GSICS Research Working Group (GRWG) and GSICS Data Working Group (GDWG) to assist in the coordination, planning and implementation of GSICS research and data management activities; and the Calibration Support Segments, which are leveraged ongoing or collaborative relevant activities at other institutions, to enhance the GSICS program. At the conferences, an overview of GSICS will be presented with many examples including GEO to

LEO intercalibration and LEO to LEO intercalibration as well as examples of improved climate data records, blended products and impacts on data assimilation.

6.13 A Monte-Carlo Approach to Estimating Uncertainty in MSU/AMSU Climate Data

Authors: Carl A. Mears, Frank J Wentz, Peter Thorne

Presenter: Carl A. Mears

Combined MSU/AMSU deep layer atmospheric temperatures are of considerable interest for investigating recent climate change. For these data products to be useful, comprehensive estimates of the error must be available. Long-term datasets from MSU and AMSU are constructed by merging data from all available satellites, complicating the error structure. Sources of error include spatial temporal sampling, uncertainty in pre-merging adjustments made to account for drifting measurement times, and uncertainty merging parameters. We use a Monte-Carlo approach to produce a large set of realizations of the estimated uncertainties on the same spatial and temporal resolution as our data products. These can then be interrogated in a number of ways to find error estimates specific to the type of analysis being performed.

6.14 Creating long-term water vapor and temperature records with AIRS and other data sources

Authors: Eric J. Fetzer, Evan F. Fishbein, Thomas S. Pagano and Bjorn H. Lambrigtsen

Presenter: Eric J. Fetzer

The AIRS instrument on the NASA Aqua satellite platform has been gathering data since late August 2002. Because this data record is currently over 7 years in length, it can provide insights into a number of climate-relevant phenomena. Meanwhile, other data sources are becoming available as in situ observations are acquired and additional satellite instruments are launched. A necessary step in reaching credible scientific conclusions from any one data source is ensuring that observations from all similar data sources can be reconciled. This study addresses the challenges of creating long-term water vapor and temperature climate records with AIRS, and of merging those records with similar ones taken by other instruments.

6.15 GCOS Reference Upper Air Network: a status update

Authors: P. W. Thorne

Presenter: P.W.Thorne

Efforts to create a ground-based reference upper air network in support of climate applications continue. One of the main aims of this network is in support of satellite cal/val taken together with GSICS and CLARREO. This poster will briefly outline the most prescient developments in this endeavour from an ITWG perspective. It will concentrate upon the characterisation of errors that are traceable to absolute or relative standards drawing upon work by Franz Immler and colleagues. It will also outline new working groups that will be working on site selection and scheduling issues and I would welcome ITWG representatives on both of these groups, volunteers will be co-opted if they hang around the poster too long!

6.16 The intercomparison of IASI water vapour retrieval schemes under climate monitoring aspects

Authors: Jörg Schulz, Marc Schröder, Martin Stengel, Marc Schwärz, Roger Saunders

Presenter: Martin Stengel

Previous studies and investigations have shown the benefit of Infrared Atmospheric Sounding Interferometer (IASI) measurements for atmospheric analysis in one- and multi-dimensional analysis schemes. Beside IASIs application in NWP and Nowcasting frameworks, growing long-term records of its measurements suggest the utilization of corresponding retrieval products of atmospheric parameters for climate monitoring and subsequently, for example, for the validation of climate models.

6.17 Global Cloud Climatologies from Satellite-based InfraRed Sounders (TOVS, AIRS and IASI).

Authors: C. J. Stubenrauch, S. Cros, A. Guignard, N. Lamquin, R. Armante, A. Chédin, N. A. Scott

Presenter: Nicole Jacquinet

Satellite observations provide a continuous survey of the state of the atmosphere over the whole globe, and their record length exceeds now more than 25

years. The International Satellite Cloud Climatology Project (ISCCP), using data from a combination of geostationary and polar orbiting imagers, contributed to the understanding of numerous cloud physical processes. Due to their relatively high spectral resolution, IR vertical sounders provide reliable properties of cirrus clouds (day and night). Especially in the tropics, where the cirrus amount is abundant, ISCCP misidentifies about one third of these clouds as midlevel clouds. Therefore, IR sounders provide complementary information to ISCCP.

We present climatological averages of cloud properties as well as their regional and seasonal variation, from the TIROS-N Operational Vertical Sounder (TOVS) Path-B cloud climatology (8 years, 1987-1995) and from the AIRS-LMD cloud climatology (6 years, 2003-2008). The Atmospheric Infrared Sounder (AIRS) onboard the NASA Aqua satellite provides measurements at a much higher spectral resolution than TOVS. The LMD IR sounder cloud property retrievals are based on a weighted c^2 method using different channels around the 15 micron CO_2 absorption band. The TOVS Path-B and AIRS-LMD climatologies participate in the GEWEX cloud assessment (<http://climserv.ipsl.polytechnique.fr/gewexca>).

AIRS presents the significant advantage to be part of the A-Train, including two active instruments since 2006: the lidar CALIOP of the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission and the Cloud Profiling Radar (CPR) of the CloudSat mission. The synergy with these active instruments, which provide accurate information on geometrical cloud height and thickness as well as on the number of vertical cloud layers, has allowed to evaluate the AIRS cloud height and to develop a method to determine the cloud amount. Thus the A-Train provides a unique tool to develop a reliable cloud property retrieval and error estimation as well as more detailed studies on the vertical depth of different cloud types. Results will be presented in this session.

After the evaluation of the retrieval method, it was applied to four months (January, April, July and October 2008) of global observations from the Infrared Atmospheric Sounding Interferometer (IASI) aboard the European platform Metop. The spectral resolution is about twice as high as the one of AIRS (between 8 and 15 micron), leading to the possibility of refined cloud property retrieval. Moreover, further versions of this sensor are scheduled to be launched in the future, ensuring measurements with similar characteristics up to about 2020.

6.18 The radiative signature of increasing carbon dioxide concentration in HIRS measurements

Authors: Eui-Seok Chung and Brian J. Soden

Presenter: Eui-Seok Chung

Decadal cooling trends of observed brightness temperature of the High-Resolution Infrared Radiation Sounder (HIRS) CO₂ channels over the period of 1980-1999 are examined in conjunction with Microwave Sounding Unit (MSU) mid-tropospheric temperature channel measurements and Geophysical Fluid Dynamics Laboratory (GFDL) climate model simulations. Simulated HIRS brightness temperatures from the GFDL model with constant carbon dioxide concentration produce warming trends in consistent with the corresponding MSU observations. On the other hand, radiative simulations with time-varying carbon dioxide concentration result in distinct cooling trends, indicating that the effects of increased carbon dioxide on the HIRS radiances are more than twice as large as the effect of the tropospheric warming for the period 1980-1999. In addition, comparisons between observation and simulation suggest substantial regional variations of carbon dioxide trends.

6.19 Advancing and Retreat of Himalayan Glaciers Based on the Increasing Trend of Anthropogenic Activities in the Indo-Gangetic Plains

Authors: Ramesh P Singh

Presenter: Ramesh P Singh

The Himalayan range is one of the largest mountain chains with variable snow cover and small and large glaciers. The topography has large variability from west to east and also the physical conditions vary significantly. The snow and glaciers over the mountain show a global evidence of the changing climatic conditions that has direct and indirect impact on future climate, hydrological cycle and sea level rise. The Himalayan snow cover is source of river water for the people living in India, Pakistan, Bangladesh, Bhutan and China. The areal extent of snow cover and size of glaciers in some parts along the Himalayan belt are found to reduce, that has a great impact on the ground water resources in the region. Detailed analysis of multi sensor satellite and NCEP reanalysis data (MODIS, AIRS, OMI AURA, AMSER, NCEP reanalysis) during 2001-2009 show varying concentrations of atmospheric pollution with altitude along the

Himalayan range. The spatial and temporal variations of aerosol concentrations are controlled by the meteorological conditions, wind velocity and wind direction. The spatial variations of meteorological, atmospheric and ground parameters are found to show characteristics nature, that will be discussed in view of the sources of atmospheric pollutants and anthropogenic activities in the Indo-Gangetic plains and also its impact on the advancing and retreat of glaciers along the Himalayan range.

7.1 Recent developments in satellite data assimilation at JMA

Authors: Kozo Okamoto, Masahiro Kazumori, Toshiyuki Ishibashi, Hiromi Owada, Takumu Egawa, Hidehiko Murata and Hidenori Nishihata

Presenter: Kozo Okamoto

Recent developments in satellite data assimilation at JMA since the last TOVS meeting in May 2008 are presented. JMA introduced various satellite data in the global operational 4D-Var assimilation system: clear sky radiances from five geostationary satellites, SSMIS of DMSP-F16 and -F17, NOAA19/AMSU-A and MHS, and Metop/ASCAT ocean surface wind and GRAS refractivity. The meso-scale 4D-Var assimilation system was significantly updated in April 2009 and started assimilating GPS total precipitable water. The website is opened for real-time monitoring of radiances and AMVs : <http://qc.kishou.go.jp/>

7.2 Operational Status Report – UK Met Office

Presenter: Stephen English

Abstract not available.

7.3 Status of ATOVS usage in the DMI-HIRLAM operational analyses

Authors: Bjarne Amstrup

Presenter: Bjarne Amstrup

DMI has for a number of years used AMSU-A data in the operational DMI-HIRLAM analyses. At present AMSU-A from NOAA15, NOAA16, NOAA18, NOAA19 and Metop-A are used operationally including data over sea-ice for some. In 2009 AMSU-B from NOAA17 as well as MHS from NOAA18, NOAA19 and Metop-A became operational. We present some results from recent experiments.

7.4 Use of satellite radiance data in the global meteorological model of the German Weather Service (DWD)

Authors: Detlef Pingel

Presenter: Detlef Pingel

As many other weather centers, the German Weather Service (Deutscher Wetterdienst, DWD) uses observations of satellite sounding instruments for the purpose of numerical weather prediction. This is achieved by assimilation of the observational data into the meteorological model in the analysis step of the forecast cycle. For the DWD global model, this is accomplished by direct assimilation of radiances within a three-dimensional variational physical space analysis scheme. At present, AMSU-A data over sea from NOAA-15, NOAA-18, NOAA-19 and METOP-2 are assimilated. Preparations for the assimilation of AMSU-B and IASI data into the global model are currently under way, and first results are to be expected soon. The poster intends to overview the present state of the assimilation of satellite radiance observations in the global model of the DWD.

7.5 Operational Satellite Data Assimilation in ACCESS

Authors: Chris Tingwell, Peter Steinle, Yi Xiao, Mohar Chattopadhyay, Brett Harris and John Le Marshall

Presenter: Chris Tingwell

The Australian Community Climate and Earth System Simulator (ACCESS) provides the Australian Bureau of Meteorology with a suite of NWP systems that incorporate data assimilation and forecast model components developed by the Met Office and adapted for local use by staff of the Centre for Australian Weather and Climate Research (CAWCR). In the initial operational implementation of the ACCESS NWP suite each component of the Bureau's legacy NWP systems will have an ACCESS replacement. In particular, the global and regional forecasting products generated by the Bureau's GASP, LAPS and MesoLAPS systems will now be provided by ACCESS systems of similar horizontal domain and resolution. The ACCESS global, regional and mesoscale systems feature 4D-Var assimilation of conventional and remotely sensed observational data including satellite data not available previously to Bureau NWP systems: most importantly, radiance data from the hyper-spectral

infrared sounder AIRS and (until recently) moisture-sensitive microwave data from the SSM/I instrument; data from the IASI instrument are currently being tested. The Met Office Unified Model provides the ACCESS forecast components. As well as providing its own forecast products, each ACCESS system provides the nesting conditions for the next higher resolution ACCESS system. Much work has been devoted to the data assimilation component of ACCESS, with the success of this work being judged by comparisons of the system forecast skill with that of the Bureau's legacy operational systems. A particular focus of current work has been the optimal use of satellite data: the ability to make use of current and future sensors is seen as critical to maintaining ACCESS as a state-of-the-art NWP system. Here we will give an overview of ACCESS systems, discuss some of the issues encountered readying ACCESS for operational use in the Bureau, with an emphasis on satellite data assimilation, and show some results indicating the forecast skill ACCESS will provide. An overview of plans for future upgrades to satellite data assimilation will also be given.

7.6 The new NWP system at KMA and its use of satellite radiance data

Authors: Mr. YongSang Kim and Dr. Sang-Won Joo

Presenter: YongSang Kim

In the middle of 2010, Korea Meteorological Administration (KMA) plans to replace all the existing operational NWP system with new NWP system based on the UK Met Office UM/VAR (Unified Model/ Variational Assimilation System). The new NWP system have been developed and tested since 2008 and is currently undergoing operational trials and configuration. The main changes are the 4DVAR data assimilation system as well as main Forecast Model. We had used the 3DVAR in old NWP system but in new NWP system, we introduced the 4DVAR data assimilation system. As we used the 4DVAR system, the amount of observational data is very increased and especially satellite data such as radiance from NOAA series satellite, (ATOVS), MetOp-2 (ATOVS, IASI), Aqua (AIRS); Atmospheric Motion Vector (AMV) data from Geostationary satellites; scatterometer sea surface wind from MetOp-2 (ASCAT), ERS-2 are newly ingested. Above all the ATOVS data from several polar orbit satellites has the great impact on forecasts in our cycle NWP system. Recently using the ATOVS data fastly, we started to ingest the AP-RARS and EARS through GTS. In this presentation, I would like to introduce the new

KMA NWP system including the data assimilation system and the current status and plans about the usage of the satellite radiance data in our data assimilation system.

7.7 Status of Satellite Data Assimilation at ECMWF.

Presenter: Peter Bauer

Abstract not available.

7.8 The use of satellite data in Chinese new GFS

Authors: Wei HAN, Jishan XUE, Zhaorong ZHUANG, Yan LIU and Xueshun SHEN

Presenter: Wei HAN

The brief description and results of pre-operational trials of Chinese new generation global forecast system (GFS) are presented in this paper with stress on the use of satellite data. The new GFS is based on the global version of the unified NWP system GRAPES developed recently. The prediction model of GRAPES is non-hydrostatic in grid mesh and height based terrain following vertical coordinate with semi-implicit and semi-Lagrangian time integration scheme. The 3D variational data assimilation in GRAPES is designed to match the prediction model of GRAPES defining the same state variables in the same spatial coordinates as in the model. The digital filter initialization approach is implemented following the 3DVar analysis in order to remove the noises due to the intermittent insertions of observational data. The observational data assimilated include conventional rawinsondes and surface synoptic reports, and a variety of unconventional data such as ATOVS from NOAA series satellites and AMVs from geostationary satellites and polar satellites. One year pre-operational experiments of cyclic assimilation with 6 hour time window and 10 day forecasts initiating at 12 UTC every day have been conducted by use of archived data from Dec 1st 2006 through Nov 30th 2007. The predictions are verified not only with GRAPES analyses but with NCEP analyses as well to assess the performance of the whole GFS system. Limited by the computer resources available the spatial resolution of the experimental system is set to 1deg lat/long which is lower than the resolution of current operational system. Even with this low resolution, improvements of analyses and forecasts are evident comparing with the old system, especially in the southern hemisphere. The impact tests of different observational systems on the analysis and forecast show that the assimilation

of satellite data plays the main role in the improvement of assimilation and forecasts. However there are still obvious differences between current GFS and NCEP analyses resulting in the degradation of forecasts of the former. Further studies show that the difference in the usage of the observational data in some specific regions is a main factor responsible to the difference in the assimilations of the two systems, implying the necessity of optimization of the data screening and quality control algorithms. Some preliminary results from assimilation of FY3A microwave radiances in GRAPES GFS will also be presented.

7.9 An Overview of the Assimilation of IASI and AIRS Radiances at Operational NWP Centres

Authors: Andrew Collard, Fiona Hilton, Ed Pavelin, James Cameron, Louis Garand, Sylvain Heilliette, Vincent Guidard, Tony McNally, Reima Eresmaa, Roger Randriamampianina, Nancy Baker, Benjamin Ruston, Marc Schwaerz, John Derber, Jim Jung, Kozo Okamoto and Wei Han

Presenter: Andrew Collard

The advanced infrared sounders (infrared spectrometers observing the spectral interval between 3 and 15 microns using thousands of channels with a spectral resolution of around 1 wavenumber) IASI and AIRS have been assimilated operationally at NWP centres since the first implementation of AIRS at ECMWF in October 2003. The exploitation of the high-quality observations from these instruments has provided positive forecast impacts at a number of centres in both global and local area models. This talk will summarise the current state of operational exploitation of advanced sounder radiances. Initial implementations of these data were necessarily conservative with particular focus on the assimilation of temperature information over sea above or in the absence of cloud. Since then progress has been made with the treatment of cloud-affected radiances; with the use of data over land; and with more sophisticated treatment of humidity information. Present research and future challenges will include the continuation of more aggressive use of observations affected by cloud; increasing the number of channels used from the current 100-300, particularly in the 6-micron water band; and greater use of radiances sensitive to the surface, including polar regions. These advances will require not only improvements in the quality control, radiative transfer and bias correction of the observations but also in the NWP models themselves.

7.10 Impact evaluation of new radiance data, reduced thinning and higher analysis resolution in the GEM global deterministic prediction system

Authors: G. Deblonde, A. Beaulne, S. Macpherson, L. Garand, M. Buehner, S. Heilliette

Presenter: Godelieve Deblonde

An important upgrade of the GEM (Global Environmental Multi-scale) global deterministic prediction system is planned for implementation in June 2010. The impact on forecasts of individual components is highlighted as well as the global impact from all components together. New data sources include 150 IASI channels as well as 37 additional AIRS channels (on top of current 87), 7 channels from DMSP-16, and the 6.7 micron channel from Meteosat and JMA geostationary satellites. A unified bias correction system is introduced. The impact of these additions is shown to be clearly positive, notably in the Southern Hemisphere. As well the inner loop of the analysis resolution is increased from 240 x 120 to 400 x 200 grid points, and the thinning of radiances is reduced from 250 km to 150 km. It is shown that reduced thinning has a larger impact than increased resolution. When both are combined however, the impact is clearly significant, this in both hemispheres. Reduced thinning will be implemented while increasing the resolution will have to be delayed due to the extra computing cost. Overall, the new system is expected to improve predictability in terms of 5-day 500 hPa anomaly correlation by 6 to 12 hours depending on region. Accompanying posters describe experiments in detail.

7.11 Assimilation Study of Microwave Sensor Water Vapor Sounding Channels In NCEP Global Forecast System

Authors: Banghua Yan, Fuzhong Weng, John Derber

Presenter: Banghua Yan

Microwave humidity sounding channel measurements have been available from NOAA, Metop, DMSP, and Fengyun-3 satellites. Presently, the data from NOAA-18 - NOAA19, and METOP-A are assimilated into the NCEP Global Forecast System (GFS) and show some small positive impacts on the global medium range forecast. Lack of a significant positive impact from assimilation of water vapor sounding channels is due primarily to problem associated with prediction of water vapor

field in the GFS model as well as remaining cloud/rain-affected observations. This study will investigate the problems associated with assimilation of microwave water vapor sounding channels. First, we will improve the quality control of microwave water vapor sounding data used in the GFS. It is shown that the water vapor channels are highly affected by thick ice phase clouds and thus an ice cloud detection algorithm (Sun and Weng, 2010) will be tested in new assimilation experiments. For F16 and F17 satellites, the water vapor sounding channels are contaminated by the antenna emitted radiation and must be dealt with a specific correction algorithm as we have done for the correction of radiance anomalies in their low atmospheric temperature sounding channels (Yan et al., 2010). The SSMIS on F18 satellite which was launched in October 2009 and is now functioning very well. This new instrument and several current MHS instruments on satellites including METOP-A and FY3 offer an opportunity to characterize bias distribution of three water channels on F16 satellite.

7.12 Impact of Increased Satellite Data Density in Areas Most Sensitive to Forecast Error Growth

Presenter: Peter Bauer

Abstract not available.

7.13 Prospects for the Assimilation of Advanced Infrared Sounder Radiances over Land.

Authors: Andrew Collard

Presenter: Andrew Collard

The assimilation of radiances from the advanced infrared sounders, AIRS and IASI, has positively impacted the forecast skill of many NWP models. In most cases, radiances are either not used over land and, or channels are chosen that are unaffected by surface emission. The extension of data usage over land requires the land surface emission to be determined with sufficient accuracy. This information can be derived from the observations themselves, but will also require a priori knowledge of the surface emissivity, surface temperature and cloud fields. Quality control is also an important factor to identify regions where, for example, complex terrain make the characterisation of the surface emission less reliable. In this poster, options for the initial assimilation of advanced infrared sounder radiances over land and some initial forecast impact results are presented.

7.14 AMSU-A Bias Correction for COAMPS/NAVDAS

Authors: William F. Campbell, Keith Sashegyi

Presenter: William F. Campbell

It is generally acknowledged that showing positive impact from direct radiance assimilation is more difficult for mesoscale models than for global models. Aside from the very real difficulties in defining positive impact quantitatively and verifiably, there are statistical issues as well. For our global NWP model NOGAPS (Navy Operational Global Atmospheric Prediction System), two weeks of global radiance data were needed to produce stable bias correction coefficients for the Advanced Microwave Sounding Unit A (AMSU-A) in our 3DVar system, NAVDAS (NRL Atmospheric Variational Data Assimilation System). These coefficients depend on the underlying global model, and so are not directly useful for our mesoscale model, COAMPS. Because COAMPS is a limited area model, it takes longer to collect adequate statistics for bias correction, which is problematic if e.g. it takes longer than a season. Increasing the data density is problematic as well, because correlated error is introduced in the horizontal. Ideally we must carefully combine information on radiance bias from the global model with information from the mesoscale model to produce the best bias correction for a given region. Preliminary experiments utilizing data and predictors from both NOGAPS and COAMPS will be shown.

7.15 Assimilation of satellite data over Antarctica in the framework of the Concordiasi campaign

Authors: A. Bouchard, V. Guidard, F. Karbou, F. Rabier, S. Guedj

Presenter: V. Guidard

Concordiasi is a measurement campaign in Antarctica involving the launch of radiosoundings and stratospheric balloons. The set-up of the field campaign will be briefly described. One of the main goals of this campaign is the validation of the IASI sensor assimilation. In order to prepare this campaign, studies have been performed to improve the satellite data assimilation over high latitudes. Two types of sensors have been considered, microwave and infrared. One of the main problems associated to the microwave satellite data is the calculation of the surface emissivity. In the

meteorological model of Météo-France/ECMWF, an innovative approach based on satellite observations is used. The method, developed by Karbou (2006), improves the land surface emissivity modelling within the constraints of the 4D-VAR assimilation system. With this new calculation of emissivity, more microwave observations over land and sea ice under clear sky conditions are taken into account during the assimilations. This application has also been applied for high latitudes, after some adjustments, allowing assimilation of AMSU-A/B data over cold areas. For the infrared sensors, an additional problem is the cloud detection. The use of additional data from IASI and AIRS sensors over land and sea ice has been tested in the framework of the Concordiasi campaign. Despite of the first positive results obtained in that context, work on cloud detection and retrieval of surface properties has been continued to improve the assimilation. In particular, over the Concordia station, the available in-situ observations from the campaign helped to evaluate the bias correction and to calibrate a better retrieval using more accurate surface information.

7.16 Evaluation of IASI inter-channel observation error covariances

Authors: V. Guidard, A. Bouchard, A. Foray, W. Ohayon

Presenter: V. Guidard

IASI is an infrared hyperspectral sounder which has thousands of channels. Many Numerical Weather Prediction (NWP) centres assume that inter-channel observation error covariances are zero in their NWP software. Using Desroziers et al (2005) method, these inter-channel covariances have been computed for IASI in the framework of the French global model ARPEGE. The results which will be displayed indicate that the assumption is not valid in some parts of the spectrum. Indeed, some water vapour channels have large inter-channel observation error correlations, as well as some surface channels, for instance. This is mainly due to an overlap of the weighting functions. The statistics have been separately computed for sea and land surfaces, giving some hints on other possible sources of correlation. The resulting non-diagonal R matrix has been evaluated through 1D-VAR retrievals of temperature and humidity. The retrieved profiles are compared both to regular radiosoundings over land and coastal areas and to dropsonde data collected over the ocean during the pre-Concordiasi campaign held in the Seychelles.

7.17 Of chessboards and ghosts: Signatures of micro-vibrations in IASI monitoring in NWP?

Authors: Niels Bormann, James Cameron and Anthony McNally

Presenter: Niels Bormann

IASI data has been extensively assimilated in Numerical Weather Prediction (NWP) systems, with significant positive forecast impact. NWP systems have also been used to monitor and further investigate the data, contributing to a detailed characterisation of the performance of the instrument. Here we present a specific analysis that points to a very small instrument error that appears to be correlated with the direction of the movement of IASI's corner cube mirror. Spatial covariances of observation minus background departures have been calculated from a large sample of pairs of IASI observations. Displayed as a function of scan-line and scan-position difference between the observation pairs, the covariances show a peculiar chessboard-like pattern. The size of the pattern depends on the channel number, and can exceed 0.01 K² for some channels. The effect depends on which IASI pixel within the AMSU-A FOV is being considered, with pixels 1 and 2 showing the largest effect, whereas pixels 3 and 4 showing little to no effect. The effect has been observed in covariance statistics from ECMWF and the Met Office. The fact that spatial covariances of background errors are smooth suggests that the pattern originates from the IASI observations. The pattern appears to be correlated with the direction of the movement of the corner cube mirror of IASI. The current understanding is that it is an effect of micro-vibrations of IASI's beamsplitter, leading to so-called "ghost" features. While the effect is small and therefore of no concern to the use of the data, the analysis highlights the power of NWP to provide detailed analyses of very small aspects of instrument performance.

7.18 Assimilation of NOAA-19 data - the pinnacle of ATOVS data at ECMWF?

Authors: Niels Bormann

Presenter: Niels Bormann

For over a decade data from the ATOVS suite of instruments has provided important input to data assimilation systems for NWP. It continues to contribute substantially to today's forecast skill. Here we report on the early monitoring of NOAA-19 ATOVS data and initial assimilation trials before the operational assimilation. With data from six AMSU-A, four AMSU-B/MHS and three HIRS

instruments these experiments will make use of what is probably the largest number of ATOVS instruments we will ever have simultaneously in the ECMWF system. Early monitoring showed that overall NOAA-19 data from the three instruments performed as expected, with First Guess departure statistics comparable to those from other instruments already used in the system. Assimilation trials with adding NOAA-19 data as the sixth AMSU-A, the fourth AMSU-B/MHS and the third HIRS still show a small, but consistent positive forecast impact. This is remarkable, given the relatively large number of similar instruments already used in the system. Since these experiments have been performed, some ATOVS instruments suffered problems or showed deteriorating performance, most notably the NOAA-19 MHS, but otherwise primarily older instruments such as the NOAA-16 AMSU-A or the NOAA-17 AMSU-B. These have now been excluded from the operational assimilation system.

7.19 Data impact experiments using IASI observations during the extratropical transitions of Hurricanes Gustav, Hannah and Ike in the Atlantic

Authors: D. ANWENDER, N. FOURRIE, F. RABIER and P. ARBOGAST

Presenter: N. FOURRIE

The impact of IASI observations in the data assimilation has been tested on a 3 week period of September 2008 including 3 extra tropical transitions (ET) of tropical cyclones. Our study is dedicated to the impact that humidity sensitive infrared radiances have on the prediction of ET cases. Three experiments have been performed using the Meteo-France global model. In the first one, the observation density was enhanced by four; in the second one nine IASI channels sensitive to water vapour (WV) were added and in the third one, all IASI data were removed. The experiments have first been evaluated through global scores. The global scores in the troposphere showed an overall large positive impact of the enhanced observation density and an overall large negative impact of denying all IASI observations. The impact for the southern hemisphere is larger and statistically significant for longer forecast times than that for the northern hemisphere. Mostly the largest positive impacts for the high density and the largest negative impacts for the denial of the IASI data is seen for the humidity parameter. The additional WV channels have a weaker but also positive impact which is seen mainly for humidity in the global scores. The positive impact of the WV channels is statistically significant for shorter

forecast intervals. Furthermore, the Atlantic and European domains have been studied with the computation of the absolute errors using the total energy variable as this variable combines constituents important during ET. The absolute errors reduce remarkably for several forecasts initialized on dates around the ET events due to the additional WV channels. It can be concluded that due to the ETs high uncertainty is introduced into the numerical forecast such that the small differences in the initial conditions created by the additional WV channels lead to large forecast deviations. The additional IASI WV channels result mainly in a reduction of errors for forecasts started around the ET times. For four dates, the error variances in the background and in the analysis were diagnosed in observation space with the Desroziers et al, 2005 method. The errors in the background were better corrected at initialization time by the additional assimilation of the WV data than without them. This led to smaller errors in the analysis from which the forecasts were started. The decrease of analysis error was visible in particular in dynamical features associated with the ET events. The error reductions in the forecasts started from these analyses could be traced back to the better representation of the ET events due to the assimilation of additional WV channels. Errors were not only reduced in the vicinity of the ET events but also in features that developed further downstream under the influence of the ETs. Connections between upper level flow and surface fields were drawn to illustrate the effect of the downstream propagation of error reduction.

7.20 Use of Variable Observation Errors in Radiance Assimilation

Authors: Brett Candy, Sreerekha TR and Steve English

Presenter: Brett Candy

Until now the observation errors (the diagonal values of the Rmatrix) used within the Met Office variational assimilation scheme have been represented as a set of fixed values for a given satellite. In this study we present a generalised model to describe the total error budget for a spaceborne radiometer. The terms consist of the instrument noise, errors in modelling clear air radiative transfer, errors arising from undetected cloud in the field of view and errors arising from uncertainties in the surface emission. This latter term can be shown to be dependent on the surface to space transmittance and consequently imparts a strong scene by scene variation for near surface sounding channels. Sample results of the error estimates will be shown for AMSU and HIRS

temperature sounding channels over land and sea. Initial forecast impacts from using the new observation error model within 4D-Var will also be shown.

7.21 Mesospheric Assimilation Studies with SSMIS Channels

Authors: Brett Candy, Sana Mahmood

Presenter: Brett Candy

The top of the Met Office forecast model has recently been extended to 80km and for this new domain the SSMIS UAS channels will have a key role in the mesospheric analysis. In this study we demonstrate that the mesospheric temperatures are improved when SSMIS data is assimilated, even when the Zeeman effect is not explicitly modelled in the radiative transfer calculations. Validation is provided from independent observations provided by the microwave limb sounder and GPS radio occultations. The development version of the radiative transfer model RTTOV10 now includes a parameterisation of the Zeeman effect following the method of Han et al. It also includes a more optimal set of radiative transfer levels for modelling channels which peak at high altitude. The effect of these improvements on observation - background differences will also be presented, along with an initial look at the impact on assimilation.

7.22 Radiance single observation experiments using global and regional models

Authors: Roger Randriamampianina, Andrea Storto, Per Dahlgren and Brett Candy

Presenter: Roger Randriamampianina

According to the action (DA/NWP-15) of the ITSC-16, single observation experiments were designed with the Met Office Unified (UM) global and different regional (UM, HIRLAM, and HARMONIE) model assimilation systems. Statistical objective analysis requires the explicit specification of the observation- and background-error covariances. In this exercise, we tested the use of background error statistics, derived using different approaches: i) the largely-adopted NMC method, ii) global ensemble analyses projected forward to the short-range forecast time by the Limited Area Model itself, iii) limited-area ensemble variational assimilation and iv) limited-area ensemble variational assimilation with perturbed lateral boundary conditions. The UM (global and regional) and the HIRLAM

assimilation systems were tested with background error statistics estimated using the NMC method, while all the four above cited approaches were tested with the HARMONIE regional model.

7.23 The relative impact of satellite observations in the HARMONIE/Norway regional model

Presenter: Roger Randriamampianina

Authors: Andrea Storto and Roger Randriamampianina

The sensitivity of the forecasts to different observation groups is evaluated by comparing moist total energy norm-based cost functions within the HARMONIE/Norway regional model. We quantify the quality loss associated to each observation type. The use of a localization operator has allowed us to obtain results for the whole domain and for the area of continental Norway only, as well as for different vertical sub-regions of the atmosphere. The sensitivity of the forecasts to different observation types, especially the satellite ones, is highly dependent on the studied cases. Results show a prominent role of in-situ observations for short-range forecasts, while for medium range forecasts microwave satellite observations result in the largest impact, especially the AMSU-A channels peaking within the troposphere.

7.24 Assimilation of IASI Radiances over Sea and Land into the Regional NWP Model COSMO-EU

Authors: Marc Schwaerz, Reinhold Hess, and Christoph Schraff

Presenter: Marc Schwaerz

This work will present the impact of the assimilation of IASI data into the regional NWP model COSMO-EU of Deutscher Wetterdienst (DWD). The assimilation scheme utilized at DWD is a combination of Nudging with a 1D-VAR step (utilizing the EUMETSAT NWP SAF 1D-VAR software package). The combination of these procedures is necessary due to the fact that it is not possible to directly assimilate radiances within the nudging scheme. The implemented setup uses the bias correction scheme after Harris and Kelly (2001), the cloud detection scheme of McNally and Watts (2003), as well as the fast radiative transfer model RTTOV-9 (Version 9.3). For the usage of measurements over land a dynamic deselection of channels affected by the surface is shown. The work will present the impact differences between

using cloud free measurements only and using all measurements where the number of channels is reduced by those channels affected by clouds. In addition, the impact of including measurements over land is shown. Finally, a comparison of using additional channels of the 6.25 um water vapor band is performed.

7.25 Impact of IASI data density in the assimilation of a convective-scale model

Authors: V. Guidard, P. Brousseau, F. Rabier

Presenter: V. Guidard

Most of Numerical Weather Prediction (NWP) centres assimilate IASI data at a rather moderate density (generally 125 km) in their global NWP models. This restriction is due to both a limitation in computing resources and a moderate resolution of the final analysis increment. The assimilation of IASI data in the French convective-scale model AROME has been done in research mode for several months and should switch to operations early in 2010. Results are positive for the forecast performance, in particular for rain prediction. In this first configuration, the density of IASI data in the assimilation is the same as in the global model ARPEGE: 125 km. Nevertheless, as AROME has a mesh of 2.5 km (both for the forecast and for the assimilation), an increase of the density of IASI data in the assimilation has been explored. Impact on analyses and forecasts is described, with a particular focus on small-scale fields such as humidity. IASI has a very large number of channels compared to ATOVS-like sensors (AMSU-A, AMSU-B or HIRS). The impact of assimilating ATOVS data at a higher density in AROME is also compared to the impact of assimilating IASI data at a higher density. The effective resolution of the subsequent analysis increments will be discussed.

7.26 Assimilation of low level humidity and temperature observations from AMSU-A & -B over land

Authors: F. Karbou, F. Rabier, E. Gérard, J-P. Lafore, J-L. Redelsperger, O. Bock

Presenter: F. Karbou

Observations from satellite sensors such as the advanced microwave sounding unit-A (AMSU-A) and -B are very useful in Numerical Weather Prediction (NWP) since they provide valuable description of the temperature and of the humidity at different levels of the atmosphere. The use of these measurements in NWP has made substantial

progress but more efforts need to be devoted to assimilate many more observations over a variety of surface conditions (ocean, land, snow, ...). Feasibility studies have been undertaken at Météo-France in order to assimilate low level humidity and temperature observations from AMSU-A and AMSU-B over land. In particular, AMSU-B observations from channels 2 and 5 are systematically rejected over land. Although, these observations are informative about humidity in the low troposphere. A comprehensive set of 4 global 4D-Var assimilation and forecast experiments has been performed during the summer 2006. In addition to a control experiment, three two-month experiments have been run. The later make use of land surface emissivities dynamically retrieved at selected window channels and assimilate a selection of low level temperature and humidity observations from AMSU-A and AMSU-B over land. The assimilation of surface sensitive observations impacts key parameters of water cycle. Comparisons made using outputs of the assimilation experiments with those of the control have revealed an important change of analyzed atmospheric fields and of precipitation forecasts over parts of the Tropics and especially over West Africa. Our experiments seem to emphasize the atmosphere moistening in India, South America and in West Africa together with an atmosphere drying over Arabia and North-East Africa. The humidity change not only concerns the surface but also many levels of the atmosphere up to 500 hPa. The effect for temperature is important with cooling at surface in zones with moistening at the surface. The drying or moistening of the atmosphere are far from being negligible and have been successfully evaluated using independent TCWV measurements from the GPS AMMA network. Objective scores have also been computed and have been found positive in the Tropics for different atmospheric and surface fields.

7.27 Preliminary results of the direct assimilation of IASI band 3 principal component scores into the ECMWF NWP system

Authors: Marco Matricardi, Tony McNally

Presenter: Marco Matricardi

A new version of the RTTOV fast radiative transfer model (PC_RTTOV) has recently been developed that is able to simulate IASI principal component scores given any input atmospheric profile. Following the implementation of PC_RTTOV into the ECMWF Integrated Forecasting System, trials have been carried out where principal component scores obtained from radiances in IASI band 3 have

been directly assimilated into the ECMWF NWP system. Preliminary results of the impact on the analysed fields and forecast scores will be illustrated.

7.28 Impact of TRMM Precipitation on Regional Analysis over South America

Presenter: Dirceu Herdies

Abstract not available.

7.29 Improvements in NWP from Increased Use Of The Information Content Of Ultraspectral Observations

Authors: J. Le Marshall, J. Jung, W. L. Smith, D. Zhou, Y. Xiao, R. Seecamp, P. Lehman, C. Tingwell, B. Harris and P. Steinle

Presenter: J. Le Marshall

The volume of observational data available from ultraspectral sounders such as AIRS and IASI has resulted in carefully selected subsets of the data being used for numerical weather prediction. While use of these subsets has provided considerable improvement in analysis and numerical weather prediction capability, significant additional improvements have been demonstrated from increased use of the spatial and spectral content of the observations available from these instruments. Results from a theoretical study which demonstrate the improved accuracy of derived temperature and moisture fields, which come from the use of increased channel numbers, are noted. Also noted are assimilation results which are consistent with that study. In addition we have also summarised the considerable improvement in forecast skill potentially available from using cloudy radiances. Other important information which is contained in the ultraspectral observations, but is not transmitted currently in the limited channel BUFR messages available to NWP centres is noted. This information has been used to calculate accurate skin temperatures, surface emissivity, cloud emissivity and can also be used for other important functions such as cloud detection. Overall it is shown that although considerable benefits to numerical weather prediction had been demonstrated from the use of ultra-spectral infrared observations, there is still the potential for improvements in performance of most NWP systems through an increased use of the information content of these data.

7.30 Impact of Satellite Surface Wind Observations on the Tropical Cyclone Track Forecasts in the NRL NAVDAS/COAMPS and NRL NAVDAS-AR/NOGAPS Mesoscale and Global Data Assimilation and NWP Systems

Authors: Li Bi, Nancy Baker, Keith Sashegyi

Presenter: Li Bi

In this study, the tropical cyclone (TC) track forecasts of the Naval Research Laboratory Atmospheric Variational Data Assimilation System/Coupled Ocean/Atmosphere Mesoscale Prediction System (NAVDAS/COAMPS) and the Navy Operational Global Atmospheric Prediction System (NOGAPS) were evaluated for a number of data assimilation experiments conducted from 1 August to 30 August, 2009. To evaluate the impact of different horizontal resolutions for different types of satellite observations on the NAVDAS/COAMPS and NOGAPS TC track forecasts, several experiments were performed. The satellite observations assimilated in these experiments consisted of surface winds from WindSat and the Advanced Scatterometer (ASCAT), QuikScatterometer (QuikSCAT), Special Sensor Microwave Imager (SSM/I) wind speeds, and European Remote Sensing Satellite-2 (ERS-2) scatterometer winds. The impact of the assimilation of WindSat, ASCAT, QuikSCAT, SSM/I wind speeds and scatterometer winds on the TC position track were slightly positive through forecast length 48hr. There were no significant improvement/degradations on the TC intensity track from the assimilation of the aforementioned satellite observation types.

7.31 Experiments with increased analysis resolution and satellite radiance data volume in the GEM Global Deterministic Prediction System

Authors: Stephen Macpherson, Mark Buehner

Presenter: Stephen Macpherson

Environment Canada is currently testing an upgrade to its analysis and forecast suite planned to be implemented this summer. This includes improvements in 1) the operational Global Environmental Multiscale (GEM) model, 2) new data sources for assimilation, 3) increased 4D-Var analysis resolution, and 4) a reduction in thinning applied to satellite radiances prior to assimilation. A separate poster by Alain Beaulne (MSC) focuses on the new data sources. This poster will focus on the impact of increased 4D-Var analysis resolution and reduction in observation thinning. Impact of

increased 4D-Var analysis resolution. The global 4D-Var analysis grid resolution was changed from 240x120 T108 used in operations to 400x200 T180, with a corresponding increase in resolution for the GEM tangent-linear (TL) and adjoint (AD) models. An important operational constraint is that the higher resolution 4D-Var analysis must be available with little delay compared to the current system. Increasing the analysis resolution has a generally small but mostly positive impact. For example, a better fit to upper air wind data is obtained in the analysis, while verification of forecast geopotential height against analyses shows significant improvements in the southern hemisphere but deterioration in the tropics. The increase in TL and AD integration time is currently a major prohibitive factor for implementation, at least until computing power increases and/or the GEM TL/AD code is optimized for faster execution. Impact of reduction in observation thinning. The amount of satellite radiance data assimilated is significantly increased through a reduction in data thinning applied. In the operational system, satellite radiance data are thinned to 250 km, except for SSM/I and GOES where data are thinned to 200 km. In the tests, all radiances are thinned to 150 km resulting in a 175% increase in radiance data volume (60% for SSM/I and GOES). Tests were carried out with both the higher resolution analysis grid (see above) and the operational analysis grid. As expected, forecast improvements are greatest when reduced thinning is combined with the higher resolution analysis, but there are still some significant gains from reduced thinning alone. Improvements are most evident in the verification of forecast temperature and geopotential height fields against analyses.

7.32 Direct Assimilation of All-sky Microwave Radiances at ECMWF

Presenter: Peter Bauer

Abstract not available.

7.33 Experiments with new data sources in the GEM Global Deterministic Prediction System

Authors: A. Beaulne, L. Garand, S. Heilliette, S. Macpherson, R. Sarazzin

Presenter: Alain Beaulne

The Meteorological Service of Canada is currently testing an upgrade to the Canadian Meteorological Center analysis and forecast suite planned to be implemented this summer. This includes

improvements in 1) the operational Global Environmental Multiscale (GEM) model, 2) new data sources for assimilation, 3) increased 4D-Var analysis resolution, and 4) a reduction in thinning applied to satellite radiances prior to assimilation. A separate poster by Stephen Macpherson (MSC) focuses on the impact of increased 4D-Var analysis resolution and reduction in observation thinning. This poster will focus on the impact of the new data sources. The following data sources were added to the assimilation system: 150 channels from the IASI instrument, 37 additional high-peaking channels from the AIRS instrument, the 7 SSMI-like channels from DMS-16 SSMIS instrument, the water vapor channel from the two European and one Japanese geostationary satellites, and aircraft humidity measurements. From anomaly correlation results of one month experiments, we note a 5-day forecast improvement of 4 to 6 hours at all levels (100, 300, 500, and 850 hPa) for geopotential height in the southern hemisphere while it is mostly neutral in the northern hemisphere. Looking more specifically at the northern hemisphere, we can note with respect to the radiosondes a major reduction of the humidity bias between 150 and 250 hPa and the temperature bias between 100 and 200 hPa.

7.34 Impact studies towards the use of SSM/I observations over land in the French global model

Authors: Elisabeth GERARD, Fatima KARBOU, Florence RABIER

Presenter: Fatima KARBOU

SSM/I radiances are sensitive to total column water vapour, surface wind speed and cloud liquid water path. Because of large uncertainties about the surface (emissivity and skin temperature), the assimilation of these observations has been limited to ocean surfaces only. Benefiting from the development of new land surface emissivity schemes at Météo-France in order to allow the assimilation of AMSUA and AMSUB/MHS observations over land, these schemes have been adapted to the SSM/I radiometric characteristics. This presentation will report on different assimilation studies which have been carried out in order to extend the assimilation of SSM/I observations to land surfaces. A description of the method will be first given. Then an overview of assimilation and forecast experiments using SSM/I observations in the French global model will be presented and results commented. A focus will be made on the hydrological cycle and the information content of SSM/I data over sea and over land will be evaluated. Amongst others, issues related to the

way emissivity is assigned to the observations to be assimilated, to the adaptation of the bias correction to the surface type (land/sea) and to the observation quality control especially in the presence of rain, will be examined.

7.35 Bias correction of window channels on microwave and infrared sounders

Authors: Wei Han and Tony McNally

Presenter: Wei Han

Window channels on infrared and microwave sounders are often used to detect and reject scenes that are contaminated by cloud and / or precipitation. In its simplest form the detection may be based on a threshold test applied to observed minus clear-sky calculated radiance departures in a chosen window channel. A large departure would indicate the presence of some degree of contamination and result in the rejection of some or indeed all of the sounding channels at that particular location. Other schemes use the window channels inside a more complex multichannel cloud or rain detection algorithm. Whatever the complexity of the approach, the window channels are of central importance due to their acute sensitivity to cloud and rain - more than that of any of the other sounding channels measured by the instrument. In general the window channels (like any other channel) may be prone to systematic errors due to instrument or radiative transfer problems and, just like any other channel, require some degree of bias correction before they are used. Bias corrections are usually based upon long time averaged statistics of observed minus calculated radiance departures evaluated in clear sky conditions. However, it can be seen that there is a fundamental problem if the identification of clear sky conditions itself relies on bias corrected window channel departures. This study investigates the problem of bias correcting infrared and microwave window channels. Firstly the window channel departures will be studied in detail to look at what systematic errors may be present and require bias correction. The success of the current approach in ECMWF IFS to bias correction is evaluated and found to be problematic. It is shown that these problems are generic to infrared and microwave window channels, but for illustrative purposes the study then focuses on data from the Advanced Microwave Sounder (AMSUA) channel 4. An approach to resolve these problems based on using the mode of the departure statistics is tested in simulation and a real assimilation environment. Finally a summary and conclusions are presented.

7.36 Plans for the Assimilation of Cloudy Infrared Radiances

Authors: W. Bell, A.P. McNally and P. Bauer

Presenter: W. Bell

A scheme for the assimilation of cloud affected infrared radiances is described. The scheme follows a similar approach to that adopted for the all-sky assimilation of microwave radiances recently implemented in the ECMWF Integrated Forecasting System (IFS). In this approach the observation operator can be considered to comprise two parts: the linearised physics (LP) which generates cloud profiles per grid point from the prognostic variables and a radiative transfer (RT) model which accounts for scattering effects due to clouds in the infrared. As a first step towards a coherent treatment of clear and cloudy infrared radiances the properties of the system are assessed through inspection of the adjoint calculations for both RT and LP components for observations in typical conditions. Single observation experiments are planned to compare the performance of the system in overcast situations, where the model state is believed to be closer to the true state, with the existing treatment of cloud affected radiances. The behavior of the system is compared and contrasted with that of the microwave all-sky system.

7.37 Utilisation of IASI data in a cloudy atmosphere

Authors: Jonathan P Taylor, Stephan Havemann, Jean-Claude Thelen, Anthony Baran

Presenter: Jonathan P Taylor

A principal component based radiative transfer code has been developed that allows a full treatment of scattering by aerosols, liquid water and ice clouds. This presentation will discuss the structure of the code and the treatment of scattering by ice crystals which utilises an ensemble model of ice scattering from non-spherical particles. The performance of IASI retrievals within a 1dvar environment utilising this fast pc based radiative transfer code in the presence of cirrus clouds will be presented. The cloud properties and temperature and water vapour profile are independently verified with observations from the FAAM BAe146 atmospheric research aircraft.

McIDAS-V: A data analysis and visualization tool for environmental satellite data

Authors: Thomas Achtor, Thomas Rink, Thomas Whittaker, Jessica Staude

Presenter: Thomas Achtor

The University of Wisconsin's Space Science and Engineering Center (SSEC) has been at the forefront in developing data analysis and visualization tools for environmental satellites and other geophysical data. The fifth generation of the Man-computer Interactive Data Access System (McIDAS-V) is a java-based, open-source, freely available system for multispectral and hyperspectral researchers and algorithm developers. The software tools provide powerful new data manipulation and visualization tools to work with geostationary and polar orbiting satellite data and in the research and operational environments. McIDAS-V provides powerful and unique capabilities to support innovative techniques for developing and evaluating algorithms, visualizing data and products in 4 dimensions, and validating results. This presentation will display and demonstrate some of the capabilities of McIDAS-V to analyze and display high temporal and spectral resolution data using examples from international environmental satellites.

7.38 Radiance Assimilation over Northern high-latitude regions with the WRF model

Authors: Zhiquan Liu, Hui-Chuan Lin and Thomas Auligne

Presenter: Zhiquan Liu

Harsh environmental conditions in polar regions severely restrict the possibilities for in-situ measurement of the surface and atmospheric state. There is thus a great emphasis placed upon optimizing the exploitation of remotely sensed satellite observations. A collaborated effort is being made to conduct a 11-year (2000~2010) Arctic System Reanalysis (ASR) for better understanding Arctic weather and climate system. In the course of preparing an optimal configuration for ASR, the impact of satellite radiance data (AMSU-A, AMSU-B, MHS and AIRS) was evaluated for a winter (Dec. 2007) and a summer (Aug. 2008) month. Data assimilation system adopted is WRF-3DVAR with a 3-hourly cycling period. ECMWF's ERA-Interim global reanalysis data (80km resolution) are used as lateral boundary conditions for this regional analysis with a grid spacing of 30km. It was found that the analyses exhibit significant cold biases (up to 15 degrees) above 30hPa over central Arctic Ocean, which are believed to be associated with the radiation scheme

in the WRF model. Comparing to the experiment of assimilating only conventional observations, adding radiance data can reduce to a large extent the cold bias at high levels even though residual biases still remain. The consequence of reduced cold biases is to improve the background (3-h WRF forecast) quality and therefore allow more conventional observations entered into the data assimilation system. AIRS temperature sounding channels add additional values into the analysis over microwave sensors. However, when adding AIRS water vapor channels, much more iterations are generally needed to get analysis converged and a careful revision of the usage of those channels is under investigation. The impact of a revised WRF radiation scheme to reduce the cold biases will be also presented.

7.39 Beyond optimal estimation: sensitivity of analysis error to the specification of background error

Authors: John Eyre and Fiona Hilton

Presenter: John Eyre

Optimal estimation theory, on which most retrieval and data assimilation methods are based, assumes that the error covariances of the observations and of the a priori (background) information are known, and that they are used (at least approximately) in the retrieval/analysis procedure. In data assimilation for numerical weather prediction (NWP), background errors may be known reasonably well in the sense of global statistics. However, this can disguise substantial spatial and temporal variability. Moreover, it is possible for the overall error variance to be correct whilst the partitioning of errors between different spatial scales, e.g. between different vertical eigen-modes, is significantly incorrect. The specification of the magnitude and vertical structure of the background error covariance is crucial to the appropriate interpretation of radiance information from satellite sounders within a NWP data assimilation system. Uncertainties in the specification of error covariances are inevitable, but an improved understanding of the acceptable range of mis-specification is likely to lead to improved impact of these data in NWP. This problem is likely to be more important for advanced infra-red sounders, as we attempt to extract information on smaller vertical scales, whilst retaining the information that the NWP model often contains on sharp vertical structures. We investigate the sensitivity of analysis error to the mis-specification of background error. We first present the general theory and then apply it to the scalar case. We identify a “danger zone”, i.e. a

level of mis-specification of background error that will degrade the analysis, and quantify it as a function of the ratio of observation error to background error. We then extend this to the vertical eigen-modes of a forecast error covariance matrix and present preliminary results for the application of this approach to the assimilation of radiances from the Infra-red Atmospheric Sounding Interferometer (IASI).

7.40 The sensitivity of the sub-optimal NWP analysis system to the representation of hyperspectral data

Authors: Fiona Hilton and John Eyre

Presenter: Fiona Hilton

Satellite data are usually assimilated in the numerical weather prediction (NWP) system via variational analysis schemes based on optimal estimation theory. This theory will only give an optimal analysis if the assumed observation and background errors are correct. In practice, the analysis is sub-optimal, as observation error correlations and the synoptic dependence of background errors are usually ignored. Here, we test the hypothesis that the form of the response of the observations to changes in the atmospheric profile, in other words the shape of the Jacobian, may affect the sensitivity of the analysis to mis-specification of the background error covariance. This question is particularly relevant to the assimilation of hyperspectral data, where significant research effort has been put into the assimilation of principal components of measured spectra. Principal components have Jacobians which are very different in shape from radiance Jacobians, and are highly non-localised in the vertical. It is expected that the increased non-localisation may give rise to increased sensitivity to the mis-specification of the background error. The hypothesis is tested in a 1D-Var context with idealised Jacobian forms, and also with typical Infrared Atmospheric Sounding Interferometer (IASI) Jacobians in radiance and principal component form.

7.41 Vertical Covariance Localization for Satellite Radiances in Ensemble Kalman Filters

Authors: William F. Campbell, Craig H. Bishop, Daniel Hodyss

Presenter: William F. Campbell

A widely used observation space covariance localization method is shown to adversely affect

satellite radiance assimilation in Ensemble Kalman Filters (EnKFs) when compared to model space covariance localization. The two principal problems are that distance and location are not well defined for integrated measurements, and that neighboring satellite channels typically have broad, overlapping weighting functions, which produce true, nonzero correlations that localization in radiance space can incorrectly eliminate. The limitations of the method are illustrated in a 1D conceptual model, consisting of three vertical levels and a two-channel satellite instrument. A more realistic 1D model is subsequently tested, using the thirty vertical levels from the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Advanced Microwave Sounding Unit A (AMSU-A) weighting functions for channels six through eleven, and the observation error variance and forecast error covariance from the NRL Atmospheric Variational Data Assimilation System (NAVDAS). Analyses from EnKFs using radiance space localization are compared with analyses from unlocalized EnKFs, EnKFs using model space localization, and the optimal analyses using the NAVDAS forecast error covariance as a proxy for the true forecast error covariance. As measured by mean analysis error variance reduction, radiance space localization is inferior to model space localization for every ensemble size and meaningful observation error variance tested. Furthermore, given as many satellite channels as vertical levels, radiance space localization cannot recover the true temperature state with perfect observations, whereas model space localization can.

7.42 Estimates of spatial and inter-channel observation error characteristics for AMSU-A and IASI and applications in the ECMWF system

Authors: Niels Bormann, Andrew Collard and Peter Bauer

Presenter: Niels Bormann

Three methods are used to estimate observation errors and their correlations for clear-sky radiances from AMSU-A and IASI in the ECMWF assimilation system. The analysis is based on covariances derived from pairs of First Guess and analysis departures. The methods used are the so-called Hollingsworth/Loennberg method, a method based on subtracting a scaled version of mapped assumed background errors from FG-departure covariances, and the Desroziers diagnostic. The findings suggest that mid-tropospheric to stratospheric temperature sounding channels for IASI and all AMSU-A sounding channels show

little or no inter-channel or spatial observation error correlations, and estimates for the observation error are close to the instrument noise. Channels with stronger sensitivity to the surface show larger observation errors compared to the instrument noise, and some of this error is correlated spatially and between channels. The three methods show good consistency for these estimates. Estimating observation errors for IASI's humidity sounding channels appears more difficult. A considerable proportion of the observation error for these channels appears correlated spatially for short separation distances, as well as between channels. Observation error estimates for humidity channels are generally considerably larger than those provided by the instrument noise. The findings are being used to revise observation error and thinning scale choices in ECMWF's assimilation system. Results from trials with different thinning scales for AMSU-A and with inter-channel error correlations for IASI will be discussed.

7.43 An Assessment of SSMIS Imager Data

Authors: W. Bell, A. Geer, P. Bauer, S. Swadley

Presenter: W. Bell

Data is now available from SSMIS instruments on three DMSP platforms: F-16; F-17 and F-18, launched in October 2003, November 2006 and September 2009 respectively. F-16 and F-17 SSMIS data was found to exhibit two significant instrument biases, related to solar intrusions into the warm calibration load and reflector emission biases. Corrections are applied to correct for these effects in a Unified Pre-processor (UPP), maintained at the US Navy's Fleet Numerical Meteorology Operations Center (FNMOC). This data has been available since August 2009. The continued deterioration and imminent failure of the SSMI constellation make the assessment and exploitation of the SSMI-like imager channels (12-18) of SSMIS a high priority for ECMWF. UPP data for F16 and F17 data have been assessed through an analysis of first guess departure statistics in relation to those from other imagers currently monitored in the ECMWF system (SSMI, AMSR-E, TMI and Windsat). The data appears to be of comparable quality to the other imagers. The impact on analyses and forecast accuracy is assessed through a series of observing system experiments in which SSMIS is added to a full observing system. These experiments use the new all-sky scheme for the assimilation of imager data in clear, cloudy and precipitating regions. Background fits to other imagers are improved significantly indicating the inclusion of SSMIS

data improves the analysis total column water vapour fields.

7.44 Forecast of Hurricane Track and Intensity with Advanced IR Soundings

Authors: Jun Li, Hui Liu, Jinlong Li and Timothy J. Schmit

Presenter: Jun Li

Hyperspectral InfraRed (IR) Sounders such as Atmospheric InfraRed Sounder (AIRS) onboard NASA's Earth Observing System (EOS) Aqua platform and Infrared Atmospheric Sounding Interferometer (IASI) onboard the Europe's METOP-A satellite provide unprecedented global atmospheric temperature and moisture soundings with high accuracy and vertical resolution. The AIRS and IASI radiance measurements have been used in the global Numerical Weather Prediction (NWP) models with positive impact on weather forecasts. We also applied the full spatial resolution soundings retrieved with CIMSS Hyperspectral IR Sounding Retrieval (CHISR) algorithm from AIRS to hurricane track and intensity forecasts within a regional model - WRF (Weather Research and Forecasting). The AIRS full spatial resolution soundings were derived with a one dimension variational (1DVAR) algorithm and most of the AIRS channels were used in the sounding retrieval process. The advantages on using soundings are that (1) soundings are the physical compression of radiances, (2) currently global models use very limited water vapor channels, use of soundings may enhance the use of moisture information from advanced sounders, (3) soundings are from all channels and represent the whole AIRS/IASI information, currently global models only use ~10% of channels, and (4) for future GEO advanced sounders, it is even more important to use soundings due to large volume of data and small data latencies. NCAR (National Center for Atmospheric Research) WRF/DART (Data Assimilation Research Testbed) ensemble assimilation was performed at 36 km resolution during September 6 - 8 00UTC, 2008. NCEP (National Centers for Environmental Prediction) 1 degree global analysis was used as the initial conditions. The control run contains radiosonde, satellite atmospheric vector winds, aircraft data, ship, and land surface data, while the AIRS assimilation run was the control run plus the AIRS single field-of-view (SFOV) temperature and moisture soundings (13.5 km at Nadir). The ensemble analysis was generated every 6 hours. The study shows that the track error for Hurricane Ike is reduced by half when AIRS data were used. The hurricane intensity forecast is also improved

by 10 ~ 15 hPa when AIRS data were included. The 4-day forecasts show significant improvement on hurricane track when AIRS SFOV soundings are included. The AIRS full spatial resolution soundings also improved the forecast of rapid intensification of Typhoon Sinlaku (2008). This study demonstrates the importance of hyperspectral IR data in forecasting hurricanes.

7.45 Interaction of GPS Radio Occultations with Hyperspectral Infrared and Microwave Sounder Assimilation

Authors: Benjamin Ruston, Steve Swadley, Nancy Baker, Rolf Langland, Michael Rennie, and Hew Lewis

Presenter: Benjamin Ruston

The Navy's 4D-Var assimilation system NAVAS-AR recently has added the capability to assimilate the bending angle from GPS radio occultation. This has not surprisingly interacted with the radiances currently being assimilated into the system which include AMSU-A, SSMIS, IASI and AIRS sensors. The heritage of the NOGAPS model in the 3D-Var NAVDAS system was 30 vertical levels with the top level at 4 hPa, while the new NAVDAS-AR and NOGAPS model now uses 42 levels with a model top of 0.4 hPa. The channel selection for the hyperspectral infrared or microwave sounders was not greatly modified when the switch to the higher model top was made. Large biases of the uncorrected innovations are seen for instance in IASI channels 146-187 (681-691 cm⁻¹), SSMIS channels 22-24 and AMSU-A channels 11-13. The use of GPS-RO from COSMIC, GRAS and GRACE-A have been used to recalibrate the bias correction coefficients for the AMSU-A, SSMIS, IASI and AIRS sensors and these new coefficients are then fixed and applied to a Dec 2008-Feb 2009 stratospheric warming case to examine the ability of the sensors to better handle the warming event, and its impact on the atmospheric column downwards into the troposphere.

7.46 Impact of Advanced Sounder Cloudy Radiances in the Global Numerical Weather Prediction ARPEGE Model.

Authors: N. FOURRIE, V. GUIDARD, F. RABIER and T. PANGAUD.

Presenter: N. FOURRIE

The Atmospheric Infrared Sounder (AIRS) onboard Aqua and the Infrared Atmospheric Sounding Interferometer (IASI) onboard METOP belong to a

new generation of advanced satellite sounding instruments. They provide information with spectral resolution far exceeding that of previous sounders (HIRS). The aim of this presentation is to describe the developments performed at Météo-France to assimilate the IASI and AIRS radiances for clear and cloudy observation conditions. Indeed, cloud affected radiances used to be rejected from the ARPEGE model (90% of total observations). The under-exploitation of these sounding instruments and the fact that sensitive regions (where forecast error can rapidly grow) are often cloudy, motivated our research efforts to assimilate AIRS and IASI cloudy radiances. The assimilation of AIRS radiances affected by low clouds inside the 4D-Var assimilation scheme has been implemented in the operational configuration in February 2009. The approach is based on the use of cloud parameters, the cloud-top pressure and the net emissivity calculated offline by the cloud-characterization algorithm CO2-Slicing (Pangaud et al, 2009). These cloud parameters are then provided to the radiative transfer model RTTOV to simulate cloudy radiances from the background into the observation operator. Experiments assimilating AIRS cloud-affected radiances showed a significant positive impact on the forecast on extended periods. The positive impact of the AIRS cloudy radiance assimilation has also been studied on an interesting synoptic case, a September 2006 meso-scale mediterranean cyclogenesis. In research mode, a great part of our work deals with the improvement of the data assimilation of IASI, especially for cloudy systems. The CO2-slicing approach used to assimilate AIRS cloudy radiances is currently extended and adapted to IASI data. After the evaluation of the cloud parameters retrieved directly from the IASI observations, the impact of the additional cloudy IASI radiances in the data assimilation will be studied with global forecast scores and impact studies on Atlantic storms of January 2009.

7.47 Infrared cloudy radiances assimilation experiments at Environment Canada

Authors: Sylvain Heilliette and Louis Garand

Presenter: Sylvain Heilliette

AIRS and IASI radiances are now assimilated at most National Meteorological Services, providing high quality information on temperature and humidity. Building on this success, the next step is to extend the assimilation to cloud affected radiances, which represents a major challenge. Currently, some partial success has been achieved, meaning that the impact is neutral to weakly positive. Here we examine results of 4Dvar data

assimilation experiments in the Canadian GEM (Global Environmental Multiscale) global deterministic prediction system, where AIRS and IASI clear and cloudy radiances are assimilated. The latter are limited to nearly overcast cases with cloud tops below 250 hPa, representing an increase in data volume of the order of 10%. The control vector was expanded to include local effective cloud parameters (cloud height and fraction) for each AIRS and IASI assimilated field of view. Background values for these parameters were estimated using the CO2 slicing algorithm. Differences between analyses and forecasts resulting from clear and cloudy radiance assimilation cycles are evaluated. Analysis innovation distributions (observed minus calculated radiances from analysis) pertaining to individual channels are consistently nearly Gaussian, as hoped for. This is not always the case for all channels however, suggesting additional quality control criteria.

7.48 Emerging and Evolving Opportunities for Achieving Global Soundings for NWP and Climate Using GNSS/GPS Radio Occultation Systems

Authors: Stephen Mango, David Ector, Richard Fulton, Chris Rocken and William Schreiner

Presenter: Stephen Mango

The history of utilizing radio wave occultations observed using a space-borne platform and an earth-based or another space-based platform to probe an intervening planetary atmosphere in order to sound that atmosphere, i.e. to determine atmospheric profiles and characteristics, has been a long, but sparse, history. The technique was notably first used to sound the atmosphere of Mars in 1964-1965 using a radio source on the Mars-orbiting Mariner IV satellite whose signal was occulted by the intervening Martian atmosphere on its path to receivers on the Earth's surface [Ref. 1]; other interplanetary satellite missions sounded a planetary atmosphere using the radio occultation (RO) technique and a radio signal source on the satellite [Ref. 2]. The use of the first Global Navigation Satellite Systems (GNSS), namely the US Global Positioning System (GPS) constellation of navigation and timing satellites (at least 24 satellites), as a radio signal source to sound the Earth's intervening atmosphere utilizing the RO technique was first demonstrated with the space-borne receiver on the GPS-MET satellite mission [Ref 3]. Several following single-satellite missions sounded the Earth's atmosphere using the GPS signal sources and the RO technique – such as CHAMP, SAC-C, Ørsted, PICOSat/IOX, GRACE

(two satellites), GRAS on MetOp and then a mission with a constellation of six microsattellites, FORMOSAT-3/COSMIC, began sounding the Earth's atmosphere using RO and GPS (start April 2006). FORMOSAT-3/COSMIC [Constellation Observing System for Meteorology, Ionosphere and Climate] has clearly demonstrated significant impacts on NWP and the potential for Climate understanding [Ref. 4, 5] using a multiplicity of six RO satellites and 24-31 GPS satellites. Several nations are now planning or in the process of initializing other full, operational GNSS missions or GNSS augmentation missions which will significantly increase the potential number of signal source satellites for each RO satellite capable of receiving the varied signals. These GNSS systems include: 1.) GLONASS (Russian Federation) – 24 MEO orbit satellites, 2.) Galileo (European Union) – 30 MEO satellites, 3.) COMPASS (China) – 35 satellites including 5 GEO, 5 inclined, elliptical GSO plus 27 MEO and the GNSS augmentation systems 4.) IRNSS (India) – 7 satellites including 3 GEO plus 4 inclined, elliptical GSO and 5.) QZSS (Japan) – 3 inclined SGO satellites. The operation and sustainment of a large constellation of RO satellites capable of handling the signals from the large multiplicity of GNSS systems will provide soundings of the Earth's atmosphere with unparalleled spatial and temporal coverage. This paper will present results of analyses of such constellations of RO satellites and multiplicities of GNSS satellites and will include potential spatial and temporal coverage and the sounding performance in terms of the measurement range, uncertainty and resolution of the atmospheric and ionospheric profiles.

7.49 Assimilation of Cloud-Affected Infrared Radiances in HIRLAM 4D-Var

Authors: Martin Stengel and Magnus Lindskog

Presenter: Martin Stengel

The High Resolution Limited Area Model (HIRLAM) utilizes a 4-dimensional variational data assimilation (4D-Var) system. In the last years, this 4D-Var system has been prepared to handle infrared (IR) and microwave (MW) observation from various polar-orbiting and geostationary satellites. The latest developments were directed towards the direct assimilation of cloud-affected radiances. These radiances are believed to be very beneficial for atmospheric analysis in NWP systems, since cloudy areas are particularly 'weather-active'. To increase the exploitation of these cloud-affected radiances, an extended observation operator for satellite radiances was defined and implemented in the

HIRLAM assimilation system. Beside RTTOV, this operator additionally contains a simplified moist physics scheme. Firstly, this scheme supports a improved simulation of cloud-affected satellite radiances by modelling cloud parameters used as input to RTTOV. Secondly, the scheme and its adjoint formulation is employed to construct more accurate 'cloud-affected' Jacobians which also account for the interaction of the modelled cloud parameters and the analysis vector variables, e.g. temperature and moisture. This set-up is generally applicable to almost all IR and MW instruments within variational assimilation frameworks. Initially, we tested this methodology using the pseudo sounding channels of the Spinning Enhanced Visible and InfraRed Imager (SEVIRI). Besides assimilation increments from SEVIRI observations in clear-sky and low-level cloud conditions, additional increments of temperature, moisture, and wind were found in regions of radiance-affecting clouds using the proposed methodology. Furthermore, extended 4D-Var assimilation and forecast experiments revealed that there is a strong indication that the forecast accuracy can benefit from the assimilation of cloud-affected radiances. After a brief review of the used methodology, the general findings and calculated forecast scores of our assimilation experiments will be presented and discussed.

7.50 Validation of cloud parameter forecasts using infrared hyperspectral sounders

Authors: Louis Garand and Ovidiu Pancrati

Presenter: Louis Garand

The well known CO₂-slicing technique is used in the Canadian data assimilation system to infer cloud parameters, which allows selecting radiances unaffected by clouds. The technique was revised in terms of choice of channel pairs and identification of conditions of validity. Cloud height error biases and standard deviations were evaluated from simulated retrievals based on global model output from 6-h forecasts. Retrieved heights from real AIRS radiances compared to Calipso lidar observations yielded remarkably similar error characteristics. The model validation application is based on comparing cloud height and amount distributions derived from observed AIRS radiances with those derived from simulated radiances, both using the same CO₂-slicing code. This approach eliminates differences of definitions between model and observed quantities. It is found that in general, the model overestimates low level cloud occurrences at the expense of mid level cloud occurrences. This is the type of information useful to the modeler. The climate application is

illustrated by monthly averaged observed cloud and radiation parameters in comparison to the same variables extracted from 6-h and 12-h forecasts. A comparison with MODIS products, also based on CO₂-slicing, is presented. Finally, the improved retrieval technique resulted in a slight positive impact in data assimilation owing to improved identification of cloud free radiances.

8.1 EUMETSAT Plans

Authors: K. Dieter Klaes

Presenter: K. Dieter Klaes

This paper provides an update on the status of EUMETSAT programmes, both the current operational as well as the future programmes. EUMETSAT is currently operating the Meteosat-6/7 and the two satellites of the second generation Meteosat Second Generation as Meteosat-8 and Meteosat-9 respectively. The MSG-3/4 satellites are under storage or production respectively. MSG has been developed in co-operation between EUMETSAT and ESA. EUMETSAT also developed jointly with ESA the EUMETSAT Polar System (EPS). Metop-A, the first of a series of three satellites was launched in October 2006 and provides high quality services for three years already, the system is planned to provide operational products to the Users at least until 2012, where the launch of the second satellite Metop-B is planned. Metop-C will follow in 2016. The EUMETSAT Advanced Retransmission Service (EARS) continued its operational services and provides observations from partner HRPT (High Resolution Picture Transmission) stations. Jason-2 is EUMETSAT's first optional programme, provides operational Ocean Surface Topography information services after the successful in summer 2008. The follow on Jason-3 Programme is being prepared. EUMETSAT also works together with ESA on the preparation to operate the marine part of the GMES Sentinel-3. For the mandatory programmes preparations for Meteosat Third Generation (MTG) and Post EPS are under way and ongoing and have passed the following main milestones since the last ITSC: MTG is in Phase B, the Post EPS has passed the Mission Definition Review at the end of Phase 0. Oral or poster presentation, slight preference to Poster (will bring one anyway). Possibly a short oral summary will be needed in the International session.

8.2 CNES programmes for meteorology, climate and atmospheric composition

Authors: Thierry Phulpin, Didier Renaut and Carole Deniel, CNES.

Presenter: Thierry Phulpin

The main projects under study, in preparation or in operation which interest the ITWG are presented. A special focus will be given to SMOS results, Megha-Tropiques, expected to be launched in 2010. Also the studies of missions in phase A : IASI-NG and Minicarb, will be shortly presented.

8.3 Agency status reports: JMA and JAXA

Authors: Kozo Okamoto, Misako Kachi and Tamotsu Igarashi

Presenter: Kozo Okamoto

Current status and future plans of earth observation of JMA and JAXA are presented. JMA has been operating the Multi-functional Transport Satellite (MTSAT) -1R and is planning to replace it with MTSAT-2 in July this year. A next generation of the operational satellite (HIMAWARI-8 and -9) has been planned. JAXA's earth observation programs of US-Japan joint missions; Tropical Rainfall Measuring Mission/Precipitation Radar (TRMM/PR), NASA Aqua/Advanced Microwave Scanning Radiometer for EOS (Aqua/AMSR-E), and JAXA's satellite; Advanced Land Observing Satellite (ALOS) and Greenhouse Gases Observing Satellite (GOSAT) have been operating well. JAXA's future earth observation satellite programs have been planned and under development primarily for three focused areas of "climate changes including water cycle variation" and "global warming and carbon cycle changes", and "reduction and prevention of disasters"; - Global Change Observation Mission (GCOM) - W (water) 1: planned for launch in Japan Fiscal Year (JFY) 2011 - GCOM-C (climate) 1: planned for launch in JFY 2013 (TBD) - Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR): US-Japan joint program planned for launch in JFY 2013 - Earth Clouds, Aerosols and Radiation Explorer/Cloud Profiling Radar (EarthCare/CPR): ESA-Japan joint program planned for launch in JFY 2013 - Advanced Land Observing Satellite 2 (ALOS-2): proposed for launch in JFY2012

9.1 Continuous imaging of the Arctic from the Polar Communications and Weather mission

Authors: Louis Garand

Presenter: Louis Garand

The Polar Communications and Weather (PCW) mission will provide continuous communications and weather services in the Arctic from a constellation of two satellites in a highly elliptical Molniya orbit (inclination 63.4 degrees, apogee 39,600 km, perigee 600 km, period 12-h). The main meteorological instrument is an advanced 20-channel imager covering the spectral range 0.45-14.4 microns. The current status of the mission, planned for 2016, is presented. The mission is of interest to several countries, as PCW will provide 100 % coverage over the entire circumpolar region from 55-90 N with a refresh rate of 15 min. Orbital characteristics are illustrated. The science team uses both RTTOV and CRTM radiative transfer models to generate simulated datasets. These datasets are used to evaluate the imaging process and to test retrieval algorithms. For example wind vectors are derived from simulated radiances and compared to "truth" model winds. Since PCW imager is similar to ABI on GOES-R and the imager on MTG, common applications will be developed.

9.2 Study on the Spectral and Radiometric Requirements for a European post-EPS Microwave Imaging Mission

Authors: C. Peubey, W. Bell, P. Bauer, S. Di Michele and P. Schlüssel

Presenter: W. Bell

Planning for the follow on to the EUMETSAT Polar System (EPS) mission, currently referred to as the post-EPS mission, is currently underway. A review of user requirements has led to a shortlist of candidate instruments for the post-EPS mission. A microwave sounding (MWS) mission has been identified as a high priority and a microwave imaging (MWI) mission is still under consideration. Industrial Phase-A studies are underway. In support of these studies ECMWF are working with EUMETSAT and ESA to refine the specification of the MWI mission with respect to some key instrument parameters. Following previous studies related to channel selection and radiometric performance an ongoing study is concerned with refining: frequency drift tolerance; cross polarisation tolerance and channel selection/specification. The study also aims to develop a quantitative basis for the study of sampling strategies. The first phase of this study involved assessing the sensitivity of analysis and forecast accuracy to frequency drift. To achieve this a parameterisation of brightness temperature errors induced by frequency shift has been developed and tested in the ECMWF Integrated

Forecasting System (IFS). The impact on analyses and forecasts for specified levels of frequency drift have been determined.

9.3 On the apodisation of MTG-IRS

Authors: Stephen Tjemkes, Xavier Calbet, Paolo Antonelli, and Rolf Stuhlmann

Presenter: Stephen Tjemkes

As part of the Meteosat Third Generation preparatory programme, EUMETSAT prepares for the next generation of geostationary satellites. Among the three MTG missions foreseen, is a hyper-spectral infrared sounder. This Infrared Radiometric Sounder (MTG-IRS) observes the upwelling terrestrial radiation in two broad spectral bands with moderate high spectral resolution. A central part of the MTG-IRS are two large detector arrays. To consolidate the Level 2 Processor, a MTG-IRS science team has been formed. One of the open issues, addressed by this science team, is to understand whether there is a need to apodise the MTG-IRS observations prior to the transformation into geophysical parameters. This in principle is a fundamental trade between the potential positive and negative effects of apodisation. For instance the trade involves the possible harmonisation of the observations made by the individual detector elements, which simplifies the processing. At the other hand there is a potential information loss due to the effective reduction in spectral resolution. Also an important aspect in this trade is the capabilities of fast radiative transfer models to simulate the apodised or unapodised radiances and the associated Jacobians. During the presentation this trade related to the apodisation of the MTG-IRS observations will be discussed. The potential consequences of apodisation, for the transformation of the observations in geophysical parameters, will be illustrated using a state-of-the-art retrieval method applied to a limited number of IASI observations.

9.4 Evaluation of the Potential of a Geostationary IR Sounder.

Presenter: Stephen English

Abstract not available.

9.5 Development of a New Generation Meteorological Satellites Based on Polar Orbiting Platform "METEOR-M" Series

Authors: V.Asmus, O.Milekhin, V.Solovjev, A.Uspensky

Presenter: Sergey Uspensky

In full accordance with the Russian Federal Space Program 2006-2015 Roskosmos and Roshydromet (SRC PLANETA), as the main customers of environmental satellites, realize the development of a space observing system "METEOR-3M", including meteorological and oceanographic satellites of new generation based on several polar – orbiting platforms of "METEOR-M" type. Up to 2014 three spacecrafts of "METEOR-M" type will fly on sun-synchronized orbits (including 2 meteorological and 1 oceanographic). General information on the first satellite of this series, namely, "METEOR-M" #1 (being launched at 17 September 2009), its payload as well as on the ground segment is under discussion. Some results of commissioning phase are also presented. In particular, some problems related to the data calibration in the "transparent" channels of one of the key instruments (microwave sounder/imager MTVZA-GY) are considered.

9.6 Activity of Sounder PEATE

Authors: Sung-Yung Lee and Evan Fishbein

Presenter: Sung-Yung Lee

We will describe the activity of Sounder Product Evaluation and Test Element (PEATE) at JPL. The Sounder PEATE will support Cal/Val activity related with CrIS and ATMS on NPP platform.

9.7 Sounding observation missions for the future EUMETSAT Polar System

Authors: Peter Schluessel

Presenter: Peter Schluessel

Preparations for the future EUMETSAT Polar System (Post-EPS), which is needed from 2020 onwards, have progressed from initial gathering of user requirements towards formulation of mission requirements. The latter have been derived for a number of observation missions, to support operational meteorology, climate monitoring, atmospheric chemistry, oceanography, and other environmental services. Account has been taken to include the expected future evolution of various application areas. Most important observation missions, relevant for atmospheric sounding include, the high-resolution infrared sounding, microwave sounding, radio occultation sounding,

and nadir-viewing ultra-violet visible near-infrared shortwave-infrared sounding. A range of prioritised radiometric, spectral, and geometric requirements have been specified, given by threshold, breakthrough, and objective values that allow for instrument concepts of different levels of complexity. The mission requirements build the basis for instrument and system concept studies, being carried out by industry. Initial concepts have been elaborated, validating the mission requirements. More detailed feasibility analyses are ongoing to demonstrate possible breakthrough areas and shaping the envisaged overall payload complement for Post-EPS.

9.8 Developing a geosynchronous AMSU: A GeoSTAR update

Authors: Bjorn Lambrigtsen (Jet Propulsion Laboratory, California Institute of Technology)

Presenter: Bjorn Lambrigtsen

The Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR) is a microwave sounder under development at NASA's Jet Propulsion Laboratory (JPL) that has capabilities similar to the Advanced Microwave Sounding Unit (AMSU) sounders currently operating on NASA, NOAA and ESA low-earth-orbiting satellites – i.e. similar spatial resolution, radiometric sensitivity and spectral coverage. Microwave sounders, such as AMSU and GeoSTAR, measure the 3-dimensional structure of temperature, water vapor, cloud liquid water, precipitation and other derived parameters under a wide range of weather conditions, including full cloud cover. With a recently developed method it is also possible to measure the vertical structure of convection and precipitation when heavy convection prevents the retrieval of the standard parameters. GeoSTAR will provide these capabilities from geostationary orbit, with continuous synoptic monitoring of large portions of the visible hemisphere and a refresh cycle of 15-20 minutes. These capabilities make a geostationary sounder especially valuable as a hurricane and severe-storm observatory, but it is expected to have a significant impact on conventional numerical weather prediction as well. There are also important atmospheric and climate research applications related to the hydrologic cycle. This was recognized by the U.S. National Research Council, which recommended that a GeoSTAR-like sensor be developed for a "Precipitation and All-weather Temperature and Humidity" (PATH) mission in its recent "deadal survey" report. PATH is a "third tier" mission and may not be implemented for several years, but there is a strong possibility that GeoSTAR can be implemented as a hosted payload

in the near term, coincident with the next generation of NOAA geostationary weather satellites, the GOES-R series. The breakthrough enabling aperture synthesis concept that GeoSTAR is based on has been developed and demonstrated at JPL, largely through the NASA Instrument Incubator Program, and all key technology elements will be in place when the current IIP project is completed in 2011. A GeoSTAR space mission can then be initiated. We discuss the status of the GeoSTAR development, possible mission scenarios and some of the science applications. Copyright 2010 California Institute of Technology. Government sponsorship acknowledged.

9.9 Towards a consolidated L2 processor for MTG-IRS

Authors: Stephen Tjemkes, Xavier Calbet, Alessio Lattanzio, and Rolf Stuhlmann

Presenter: Stephen Tjemkes

As part of the Meteosat Third Generation preparatory programme, EUMETSAT prepares for the next generation of geostationary satellites. Among the three MTG missions foreseen is a hyper-spectral infrared sounder. This Infrared Radiometric Sounder (MTG-IRS) observes the upwelling terrestrial radiation in two broad spectral bands with moderate high spectral resolution. An important mission objective is the monitoring of the vertical distributions of moisture and temperature. These geophysical properties are derived from the MTG-IRS observations by the MTG-IRS Level 2 Processor. The consolidation of the physical baseline for this Level 2 Processor, the implementation of the physical baseline in a concept processor, and the application of this concept processor to a relevant proxy data is a main activity of the MTG-IRS Science Team. The poster presentation will address open issues related to the consolidation of the MTG-IRS L2 Processor, as well as the status of the concept processor and initial results.

9.10 Development and Predicted Performance of the Advanced Technology Microwave Sounder for the NPOESS Preparatory Project

Authors: William J. Blackwell and R. Vincent Leslie

Presenter: Vincent Leslie

A suite of sensors scheduled to fly onboard the NPOESS Preparatory Project (NPP) satellite in 2011 will both continue and improve the

environmental data records provided by operational and research missions over the last 40 years. The Cross-track Infrared and Microwave Sounding Suite (CrIMSS), consisting of the Cross-track Infrared Sounder (CrIS) and the first space-based, Nyquist-sampled cross-track microwave sounder, the Advanced Technology Microwave Sounder (ATMS), will provide atmospheric vertical profile information needed to improve numerical weather and climate modeling. The ability of ATMS to sense temperature and moisture profile information in the presence of non-precipitating clouds complements the high vertical resolution of CrIS. Furthermore, the ability of ATMS to sense scattering of cold cosmic background radiance from the tops of precipitating clouds allows the retrieval of precipitation intensities with useful accuracies over most surface conditions. This paper will present several assessments of the performance of ATMS and the geophysical quantities that are to be derived using ATMS measurements. Pre-launch testing of ATMS has characterized the principal calibration parameters and has enabled predictions of on-orbit performance with high levels of confidence. Planned on-orbit characterization of ATMS will further improve both the measurement quality and the understanding of various error contributions. This paper is organized as follows. First, an overview will be given of the prelaunch radiometric calibration of ATMS. Key calibration parameters will be discussed, as well as the error bars and dominant sources of uncertainty. Second, plans for on-orbit characterization of ATMS to further improve performance and reduce uncertainty will be presented. Finally, preliminary assessments of ATMS data product performance will be discussed, including vertical profile and precipitation products. The paper will compare the ATMS sensor with its heritage sensor the Advanced Microwave Sounder Unit (AMSU-A1 and A2) and Microwave Humidity Sounder (MHS). ATMS integrates three separate NOAA instruments into a single sensor, which reduced mass and power by 50% and volume by 75%. In addition, ATMS has different antenna and sampling specifications. An integral part of the CrIMSS (CrIS + ATMS) pre-launch cal/val activities is the testing of operational software that will be used to process raw data counts into scientific data products. To ensure a smooth transition after launch to the operational production of temperature, sensor, and environmental data records, pre-launch test data are passed through the software processing system to identify bugs and any unforeseen issues in the processing flow. It is important for the test data to be as authentic as possible; therefore, "proxy" data are used. The term "proxy" refers to observed data from an on-orbit sensor that are transformed spatially and spectrally to resemble, with some error, a future sensor. Atmospheric models may be

inaccurate and incomplete, and therefore data simulated using only these models will be flawed. Alternatively, proxy data derived from actual radiometric observations of the atmosphere should preserve all of the meaningful meteorological features. The prelaunch radiometric calibration of ATMS consists of Compact Antenna Test Range (CATR); thermal vacuum chamber (TVac); vibration testing; and electromagnetic and radio frequency interference testing. The antenna patterns are measured in the CATR for both the principal and co-polarization. Some patterns had four cuts, but most had two cuts. Two temperature-controlled external calibration target sets are used in the TVac to evaluate the calibration accuracy, radiometric sensitivity (NEDT), and non-linearity. This paper will present the objectives and results from the prelaunch testing. Postlaunch calibration and validation consists of four phases: activation, functional evaluation and optimization, Intensive Cal/Val (ICV), and long-term monitoring. The ICV will end approximately 180 days after launch. This paper will describe the various calibration and validation tasks in the four phases and the team responsible. Some of the tasks include calibration target stare data collection to calculate each channel's power spectral density; optimal space view selection; geolocation accuracy evaluation; RFI evaluation and mitigation; simultaneous nadir overpasses of other microwave sensors; on-orbit spacecraft maneuvers; simulation comparisons with radiosondes and numerical weather prediction models; and aircraft underflights. This paper will outline recent efforts using the NPOESS Aircraft Sounder Testbed-Microwave (NAST-M) airborne sensor to directly validate the microwave radiometers (AMSU and MHS) on several operational satellites. Comparison results for underflights of the Aqua, NOAA-16, NOAA-17, and MetOp-A satellites will be shown. Specifically, radiance-to-radiance data comparisons from two campaigns will be presented: 1) the Pacific THORpex (The Observing-system Research and predictability experiment) Observing System Test (PTOST 2003, Honolulu, HI) and 2) the Joint Airborne IASI Validation Experiment (JAIVEx 2007, Houston, TX). The paper will detail the essential techniques used to correct for the difference in altitude and view angle between the satellite and aircraft sensors. The campaigns provided critical ground truth data such as dropsondes. Our procedure for co-locating NAST-M measurements with satellite measurements will be illustrated, as well as the effect of clouds on the evaluation of window channels. The radiance-to-radiance comparisons will be evaluated against a purely simulated validation technique. We review an approach for on-orbit FOV calibration of the ATMS satellite instrument using vicarious calibration sources with high spatial frequency

content (the Earth's limb, for example). The antenna beam is slowly swept across the target of interest and a constrained deconvolution approach is used to recover antenna pattern anomalies. Additionally, we present an overview of FOV calibration exercises being considered for ATMS, which will not only help to characterize the radiometric boresight of each ATMS channel, but could also potentially identify antenna sidelobe problems affecting similar passive microwave sensors that are presently operational. Various proposed spacecraft maneuvers will be considered, with the intent to illustrate how each maneuver will help to identify and characterize possible FOV artifacts. Radiative transfer simulations that quantitatively assess the benefit of each satellite maneuver will also be presented. This work was sponsored by the National Oceanic and Atmospheric Administration under Air Force contract FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and not necessarily endorsed by the United States Government.

9.11 Global Change Observation Mission (GCOM) Data Recovery by the National Oceanic and Atmospheric Administration (NOAA) – An International Partnership to Capture Critical Operational and Climate Environmental Data Records from Space

Authors: Peter A. Wilczynski

Presenter: Peter A. Wilczynski

NOAA is creating a partnership with the Japan Aerospace Exploration Agency (JAXA) on the Global Change Observation Mission (GCOM) to provide ground station reception, processing, and distribution of Japanese satellite (GCOM-W and GCOM-C) data. The GCOM mission will provide for continuity of data important for the monitoring, modeling, forecasting and research of the atmosphere, oceans and climate. GCOM-W1 data will provide an important gap-filler to permit microwave radiometer data continuity between the termination of the NASA Aqua mission which was launched in May 2002 with a design life of 5 years, and the launch of the NPOESS C-2 spacecraft in 2016 containing the Microwave Imager/Sounder (MIS) sensor. GCOM-C will augment the data provided by the Visible Infrared Imager Radiometer Suite (VIIRS) on NPOESS to support ocean color and climate-related requirements. SGLI data will help fill the NPOESS current observation gap in the morning orbit. The NOAA Ocean Color Mitigation Plan states that GCOM-C will provide an additional Ocean Color source before the scheduled operational VIIRS-NPOESS

on C1. This data will enhance the ability of the National Weather Service (NWS) to improve their forecast models and products, and will provide ocean color data to NOAA users. NOAA is partnering with JAXA to provide data acquisition reception capabilities at the Svalbard Norway ground station, enabling JAXA the ability to downlink the satellite data from each of the 14 orbits per day. Without this improvement, JAXA will only be capable of down linking satellite information 4 times a day to the JAXA satellite site. NOAA will purchase critical ground reception hardware/software, communication links, processing and distribution services to transfer GCOM-W & GCOM-C satellite data to NOAA and JAXA by 2012. The presentation shall discuss the current status of the NOAA-JAXA partnership on the GCOM mission and will discuss prospective benefits of cooperation that includes a U.S. developed Ocean Surface Vector Winds (OSVW) instrumentation (scatterometer) flying aboard JAXA GCOM-W spacecraft, beginning with GCOM-W2.

