A report on
The Twelfth International ATOVS Study Conference

Lorne, Australia
27 February – 5 March 2002

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Report prepared by J.F. Le Marshall, D. Jasper, A. Apostolou and G. Rochard

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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). ITWG continues to organise International TOVS Study Conferences (ITSCs) which have met every 18-24 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 and moisture fields on numerical weather prediction (NWP) and climate studies.

The Twelfth International TOVS Study Conference (ITSC-XII) was held at the Cumberland Lorne Conference and Leisure Resort Centre from 27 February to 5 March 2002. This conference report summarises the scientific exchanges and outcomes of the meeting. A companion document *The Technical Proceedings of The Twelfth International TOVS Study Conference* contains the complete text of ITSC-XII scientific presentations. The ITWG web site (http://cimss.ssec.wisc.edu/itwg/) holds electronic versions of the conference presentations. Together, these documents reflect the conduct of a highly successful meeting in Lorne. An active and mature community of TOVS and ATOVS data users now exists, and considerable progress and positive results were reported at ITSC-XII in a number of areas, including many related to the new ATOVS system and to the impending Advanced Sounders.

ITSC-XII was sponsored by NASA, NESDIS, EUMETSAT, the World Meteorological Organization, the Australian Bureau of Meteorology, Météo-France ITT Industries, the Raytheon Company and Environmental Systems and Services. Their support is gratefully acknowledged. We wish to thank the local organising committee. We also thank the staff of the Cumberland for their assistance during the Conference. Finally, we acknowledge the contribution of Bureau of Meteorology Research Centre staff, particularly Agnes Apostolou, David Jasper, Terry Adair and Irene Mouzouri, who assisted with the preparation and publication of this report and the Satellite Section Staff who assisted ably in the running of the Conference at Lorne.

Dr John F. Le Marshall
Co-chair ITWG
Bureau of Meteorology Research Centre
GPO Box 1289K
Melbourne
Victoria, 3001
Australia

Dr Guy Rochard
Co-chair ITWG
Météo-France
CMS
BP 147
22 302 - Lannion Cedex
France

THE TWELFTH INTERNATIONAL TOVS STUDY CONFERENCE (ITSC-XII)

Lorne, Australia: 27 February – 5 March 2002

International TOVS Working Group (ITWG) co-chairs

Dr J.F. Le Marshall (Bureau of Meteorology Research Centre, Australia)
Dr Guy Rochard (Météo-France, Lannion, France)

Organising Committee for ITSC-XII

Dr John F. Le Marshall (Bureau of Meteorology Research Centre, Australia)
Dr Guy Rochard (Météo-France, Lannion, France)
Mr David Jasper (Bureau of Meteorology Research Centre, Australia)
Ms Margaret Hehir (Bureau of Meteorology Research Centre, Australia)

ITSC-XII participants

Thomas H. Achtor	CIMSS/SSEC Uni. of Wisc. Madison WI	USA
Myoung-Hwan Ahn	METRI, Korea Met. Admin., Seoul	Korea
Raymond Armante	LMD, Ecole Polytechnique, Palaiseau	France
Agnes Apostolou	Bureau of Meteorology, Melbourne	Australia
Stella Aura	Kenya Met. Dept., Nairobi	Kenya
Nancy Baker	Naval Res. Lab., Monterey, CA	USA
John Bates	NOAA Envir. Tech. Lab., Boulder, CO	USA
Ralf Bennartz	Univ. Kansas, Lawrence, KS	USA
Hal J. Bloom	NPOESS/IPO, Silver Spring, MD	USA
Denis Blumstein	CNES, Toulouse	France
Eva Borbas	CIMSS/SSEC, Univ. of Wisconsin	USA
Bill Bourke	BMRC, Melbourne	Australia
Francois Bouttier	CNRM, Météo-France, Toulouse	France
Pascal Brunel	CMS Météo-France, Lannion	France
Stefan Buehler	Univ. Bremen, Bremen	Germany
João Carlos Carvalho	INPE, São José dos Campos	Brazil
Narinder Chauhan	NPOESS//IPO, Silver Spring, MD	USA
Frédéric Chevallier	ECMWF, Reading, Berks	UK
Clément Chouinard	Met. Service of Canada, Quebec	Canada
Andrew Collard	Met Office, Bracknell, Berks	UK
Godelieve Deblonde	Met. Service of Canada, Dorval, Quebec	Canada
John Derber	EMC/NCEP/NOAA/NWS MD	USA
Izabela Dyras	Inst. Met. & Water Management, Krakow	Poland
Stephen J. English	Met Office, Bracknell, Berks.	UK
John R. Eyre	Met Office, Bracknell, Berks.	UK
Nadia Fourrié	Météo-France, Toulouse	France
Donald Frank	NASA DAO, Goddard SFC, Greenbelt, MD	USA
Louis Garand	Met. Service of Canada Dorval, Quebec	Canada
Albin Gasiewski	NOAA Envir. Tech. Lab., Boulder, CO	USA
Elisabeth Gérard	Météo-France, Toulouse	France
Mitch Goldberg	NOAA/NESDIS/ORA, Camp Springs, MD	USA
David Griersmith	Bureau of Meteorology, Melbourne	Australia
Songyan Gu	Nat'l Sat. Met. Ctr, Beijing	PRC

Brett A. Harris	BMRC, Melbourne	Australia
Donald E. Hinsman	World Met. Org., Geneva	Switzerland
Lee Hong	Bureau of Meteorology, Melbourne	Australia
David Howard	Bureau of Meteorology, Melbourne	Australia
Allen H.-L. Huang	CIMSS/SSEC, Uni. Wis., Madison, WI	USA
Nicole Jacquinet	LMD, École Polytechnique, Palaiseau	France
David Jasper	BMRC, Melbourne	Australia
Viju Oommen John	Inst. Envir. Physics, Univ. Bremen, Bremen	Germany
Steve Johnson	ITT-Aerospace/Comms Div. Fort Wayne IN	USA
Joanna Joiner	NASA DAO, Goddard SFC, Greenbelt, Md	USA
Sang-Won Joo	Korea Met. Admin., Seoul	Korea
Anton Karl Kaifel	Ctr for Solar En & Hydrogen Res, Stuttgart	Germany
Young-Hwa Kim	Korea Met. Admin., Seoul	Korea
Dieter Klaes	EUMETSAT, Darmstadt	Germany
Thomas J. Kleespies	NOAA/NESDIS, Camp Springs, MD	USA
Christina Köpken	ECMWF, Reading, Berks.	UK
Tomas Landelius	Swedish Met. Inst., Norrköping	Sweden
Lydie Lavanant	CMS, Météo-France, Lannion	France
John F. Le Marshall	BMRC, Melbourne	Australia
Jun Li	CIMSS/SSEC, Univ. Wis., Madison, WI	USA
Merv Lynch	Curtin Univ. of Technology, Perth, WA	Australia
Marco Matricardi	ECMWF, Reading, Berks.	UK
Larry M. McMillin	NOAA/NESDIS, Camp Springs, MD	USA
W. Paul Menzel	NOAA/NESDIS, Madison, WI	USA
Goulven Monnier	CMS, Météo-France, Lannion	France
Denis O'Brien	CSIRO Atmos. Res., Aspendale, Vic.	Australia
Kozo Okamoto	Japan Met. Agency, Tokyo	Japan
Jaan Paevere	BMRC, Melbourne	Australia
Thierry Phulpin	CNES, Toulouse	France
Mulyono Prabowo	BMG, Jakarta	Indonesia
V.S. Prasad	NCMRWF, New Delhi	India
Fred Prata	CSIRO Atmos. Res., Aspendale, Vic.	Australia
Joe Predina	ITT-Aerospace/Comms Div. Ft Wayne IN	USA
Jeffery Puschell	Raytheon St Barb. Rem. Sens., CA	USA
Florence Rabier	CNRM, Météo-France, Toulouse	France
Roger Randriamampianina	Hungarian Met. Service, Budapest	Hungary
Anthony Rea	Bureau of Meteorology, Melbourne	Australia
Tony L. Reale	NOAA/NESDIS	USA
Gail Reichert	NASA/GSFC, Greenbelt, MD	USA
Guy Rochard	CMS, Météo-France, Lannion	France
Filomena Romano	IMAAA/CNR, Tito Scalo	Italy
Herve Roquet	CMS, Météo-France, Lannion	France
Roger Saunders	Met Office, Bracknell, Berks.	UK
Harald Schyberg	Norwegian Met. Inst., Oslo	Norway
Nathaniel Servando	PAGASA, Quezon City	Philippines
Vanessa Sherlock	Met. & Rem. Sens, NIWA, Wellington	NZ
Elizabeth Silvestre Espinoza	INPE-CPTEC, São Paulo	Brazil
Devendra Singh	India Met. Dept, New Delhi	India
Sreerekha, T.R.	Inst. Env. Phys, Uni. Bremen, Bremen	Germany

Peter Steinle	BMRC, Melbourne	Australia
Graeme Stephens	Dept. Atmos. Sci, CO St. Uni., Ft Coll. CO	USA
Claudia Stubenrauch	LMD, Ecole Polytechnique, Palaiseau	France
Vince Tabor	NOAA/NESDIS/IPD, Suitland, MD	USA
Jean-Noël Thépaut	ECMWF, Reading, Berks.	UK
Chris Tingwell	BMRC, Melbourne	Australia
Bernard Tournier	NOVELTIS, Ramonville St Agne	France
Shawn Turner	Met. Serv. of Canada, Downsview, ONT.	Canada
Michael J. Uddstrom	NIWA, Wellington	NZ
Alexander B. Uspensky	SRC Planeta Roshydromet , Moscow	Russia
Paul van Delst	CIMSS-NOAA/NCEP, Camp Springs, MD	USA
Nicolas Wagneur	Met. Service of Canada, Dorval, Quebec	Canada
Phil Watts	ECMWF, Reading, Berks.	UK
Fuzhong Weng	NOAA/ NESDIS, Camp Springs, MD	USA
Gary Weymouth	Bureau of Meteorology, Melbourne	Australia
Keith Whyte	The MetOffice, Bracknell, Berks.	UK
Mike Willmott	Bureau of Meteorology, Melbourne	Australia
Jeff Wilson	Bureau of Meteorology, Melbourne	Australia
Walter W. Wolf	NOAA/ NESDIS/ORA Camp Springs MD	USA
Wu Xuebao	Nat. Sat. Met. Ctr, Beijing	PRC
Xue Jishan	Chinese Acad. Met. Science, Beijing	PRC
Zhang Wenjian	Nat. Sat. Met. Ctr, Beijing	PRC

ITSC-XII Lorne, Australia, 27 February – 5 March 2002

Members of the International TOVS Working Group at ITSC-XII

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Twelfth International TOVS Study Conference ITSC-XII was held in Lorne, Australia from 27 February – 5 March 2002. One hundred and four participants attended the Conference and provided scientific contributions. Twenty one countries, four international and many national organizations were represented: Australia, Brazil, Canada, China, France, Germany, Hungary, India, Indonesia, Italy, Japan, Kenya, New Zealand, Norway, Philippines, Poland, Russia, Switzerland, the United Kingdom, the United States of America, ECMWF, EUMETSAT, WMO, the IRC, NASA and NESDIS.

The agenda for ITSC-XI1 can be found at Appendix A. Most of the meeting was occupied with scientific presentations on a range of issues: Radiative Transfer Modelling; the application of TOVS and ATOVS data in numerical weather prediction (NWP) and climate studies; preparations for Advanced Sounders; and relevant plans of operational satellite agencies and international issues.

Section 4 of this report records the abstracts of all scientific contributions. The corresponding papers are published separately as the *Technical Proceedings of The Twelfth International TOVS Study Conference*, available through the co-chairs of the International TOVS Working Group (ITWG).

Working Groups were formed to consider five key areas identified prior to the Conference: Radiative Transfer and Surface Property Modelling; TOVS and ATOVS in Numerical Weather Prediction; TOVS and ATOVS in Climate Studies; Advanced Sounders; and International Issues Future Systems; and Satellite Sounder Science and Products. The Working Groups reviewed recent progress in these areas, made recommendations on key areas of concern and identified items for action. Working Group reviews and recommendations comprise Section 2 of this report.

During the Conference, a session on Status Reports considered summaries of allied meetings and activities that had taken place since ITSC-XI. It also reviewed progress on the Action Items identified by ITSC-XI Working Groups. Many of these items formed the basis for further discussion by Working Groups at ITSC-XII.

Several technical sub-groups met during ITSC-XII to discuss developments and plans concerning specific software packages, shared and in common use in TOVS, ATOVS and Advanced Sounder processing centres. Brief reports on these sub-group meetings are recorded in Section 3.

Overall, the meeting documented significant gains in many areas and noted areas for future activity. In particular, it noted that:

1. Considerable benefits have been demonstrated from ATOVS in NWP and other applications;

2. Continuing excellent results are being demonstrated from advanced data assimilation techniques;

3. Firm evidence continues to emerge of the utility of the TOVS/ATOVS data over land in NWP;

4. Preparations for Advanced Sounder have progressed markedly since ITSCXI.

5. Although a significant amount of work has been done since ITSC-XI in the area of radiative transfer modelling - radiative transfer modelling (including clouds), surface property modelling and calibration are areas still requiring attention;

6. The intercomparison of radiative transfer calculations is important and needs to be continued;

7. There is a continued need to emphasise climate activity and establish links with climate community;

8. NASA is to be complimented for their continued support of an advanced geostationary sounder. This sounding system provides an opportunity for operational agencies to include information from this system in the development of their plans;

9. There is a need to develop further, the interface between ITWG and the CBS of WMO;

10. The development of community software for ATOVS processing has progressed well. The free distribution of ATOVS processing software has been essential in the use of ATOVS in the meteorological community;

11. The development of community software for AIRS is proceeding well with a requirement for ingest software still outstanding. The development and distribution of this software is essential for the effective use of AIRS data in the meteorological community;

12. The requirement for near real time AIRS and MODIS data remains important;

13. The GTS/DDS bandwidth needs to be increased to carry advanced sounder data.

14. The SSMI/S will provide significant upper atmospheric observations. Access to SSMI/S data and the related data archive is important; and

15. Easy access to radiance data at NOAA/NESDIS after the transition to NPOESS needs to be established.

Conclusions and recommendations are summarised below.

1.2 CONCLUSIONS AND RECOMMENDATIONS

As a result of the activities of the Working Groups and their reports to the Conference, the following major conclusions and recommendations were adopted as a summary of the ITWG meeting at ITSC-XII. More details and specific technical recommendations and actions are given in the Sub-Groups full reports in Section 2 and the reports of the Technical Sub-Groups in Section 3.

ACTIONS AND RECOMMENDATIONS

RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING:

Atmospheric profile datasets for Radiative Transfer (section 2.1.1)

Recommendation
The next definitive LbL transmittance computation for fast RT model training should be on the AIRS 101 levels to facilitate use by all users.

Recommendation
A standard set of interpolation routines should be provided to optimally convert from level to layers (and vice versa).

Instrument characteristics required for RT modeling (section 2.1.2)

Action
T. Kleespies (NESDIS) to make HIRS and AVHRR filter response functions available to ITWG before NOAA-M launch.

P. Brunel (CMS Météo-France) to contact Tim Schmidt (CIMSS) to clarify GOES information still required (GOES-9, GOES-12).

P. Menzel (NOAA/NESDIS) to provide contact point for AQUA MODIS response functions.

R. Saunders (Met. Office, Bracknell) to raise early METEOSAT filter response function matters with EUMETSAT.

F. Weng (NEDSIS) to inform group of any information on AMSR and WINDSAT channel characteristics.

Recommendation
That instrument builders provide response functions in digital form and at the actual spectral resolution it was measured.

Recommendation
RT modelers document clearly which filter responses were used in their simulations (e.g. by including them in the output files).

Action
T. Kleespies to announce the new NOAA set of fundamental constants to the Working Group.

Line by Line (LbL) model status (section 2.1.3)

Recommendation
The EUMETSAT Line by Line intercomparison is a valuable attempt to document biases in LbL models. It should be extended to more airmass types.

Action
S. Ravindranathan (Univ. of Bremen) to provide web site on new microwave RT model inter-comparison work at Bremen University.

Action
R. Armante (LMD, Ecole Polytechnique) to provide information to the Working Group on the STRANSAC-2000 study on microwave simulations.

Fast RT models (section 2.1.5)

Action
The web site maintained by MSC on the fast model intercomparison is a valuable resource for fast model development and should be maintained at least until the next ITWG meeting. (L. Garand, AES/MSC).

Recommendation
The RT community is encouraged to continue to develop and improve fast models for new and existing sensors. It must be recognized however that NWP centers prefer to only have one RT model for all sensors in their assimilation code so new developments should be able to feed through to existing RT models in NWP Centres.

Surface Property Models (section 2.1.6)

Action
S. Ravindranathan (Univ. of Bremen) to report to the Working Group on work on surface models at Bremen.

Infrared emissivity (section 2.1.6.2)

Action
R. Saunders (Met. Office, Bracknell) to circulate to the group, a draft copy of the note composed by F. Prata (CSIRO) on issues regarding surface temperature and emissivity retrieval from satellite sounders.

Proposal for group web page (section 2.1.7)

Actions
Co-chairs to prepare a web page for the Radiative Transfer and Surface Property Modelling WG.

All ITWG members to provide links to co-chairs which can be included on the web pages.

TOVS/ATOVS DATA IN CLIMATE:

Contribution of TOVS to climate studies (section 2.2.1)

Recommendation
ITWG encourages use of satellite sounder data, including the historical TOVS/ATOVS and the next generation high spectral resolution data sets, for retrieval of column CO_2 amounts.

Recommendation
ITSC scientists are encouraged to prepare a set of comparisons of long term trends and variability from the TOVS long-term archive for specific fields. Comparisons to be prepared include temperature and moisture (Bates), clouds (Stubenrauch, Wylie-Menzel), O_3 (Kaifel), CO_2 (L. McMillin), SO_2 (F. Prata).

Relations to international climate programs (section 2.2.2)

Recommendation
An invited presentation to be given to the ITWG on IPCC results and plans at next ITSC meeting.

Recommendation
That Space Agencies/Satellite Operator reports to the next conference include the relationship of plans to the Karl principles.

Pathfinders and re-analysis (section 2.2.3)

Recommendation
Continued production of long-term TOVS climate data sets as envisioned by the NOAA/NASA Pathfinder projects with the goal of achieving a 25 year dataset 'TOVS 25'. The TOVS 25 data set would represent a best effort to use all 25 years of TOVS data for climate studies.

Calibration, validation and quality control monitoring (section 2.2.4)

Recommendation
Past and present calibration issues are currently being addressed. This is a very important activity. These issues should be fully documented, and the related data and software needs to be placed in long term archives. Further software also should be developed and shared (L. McMillin, T. Achtor, D. Klaes, J. Bates)

Action
Develop, archive and make accessible a complete audit trail of all TOVS calibration issues and their resolution (J. Bates, NOAA).

Action
T. Reale (NESDIS) and T. Achtor (CIMSS/SSEC) to compile links from the TOVS/ATOVS Data in Climate Working Group web page to sites containing calibration and validation data, including ARM CART sites, WODC/UV sites, GEWEX CEOP sites, etc.

Data access and archive (section 2.2.5)

Action
EOSDIS is the first attempt to deal with the quantum leap in data volume from the next generation environmental satellite sensors. Space agencies/satellite operators should be invited to provide a summary of their plans in relation to this experience in providing data archive and access for next generation satellite instruments (Co-chairs to CGMS).

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

Evaluation and use of TOVS/ATOVS in DA/NWP (section 2.3.2)

Recommendation (to DA/NWP Centers)
The Working Group recommends the continued exchange of monitoring results and encourages each Center to develop their own Web page to post their results. A master document linking all Web pages has been developed and will reside on the NWP SAF site with a link to the ITWG Web site at CIMMS so everyone can easily examine and compare results from other groups to theirs.

Recommendation (to DA/NWP Centers)
The Group recognizes the difficulty in implementing and validating radiance/retrieval data in a DA/NWP system and recommends that those that have prepared so-called one-observation experiment in the development of their assimilation system post them on their Web page. Since there is more than one fast RTM used, it will indirectly measure the ability of each RTM to project radiance data information onto the atmospheric state variables. Indirectly, this will also indicate what are the effective measures of background and observational error statistics used at each Center. (Action: C. Chouinard to coordinate).

Recommendation (to DA/NWP Centers)
Encourage the preparation of OSE's at various NWP Centers to be presented at the next ITWG meeting and post these results on the ITWG website.

Recommendation (to ITSC)
The Group recommends that the McNally survey summary grid be continued and posted on the ITWG Web site. When changes are made at various NWP centers on the use of data, that McNally be advised, the grid updated accordingly, and the changes be logged on the Web page. (Action: T. McNally to coordinate).

Recommendation (to NOAA/NESDIS and EUMETSAT)
The Group recommends that the data provider do quality assurance of all data, including level 1b and level 1d. The quality of the data (including e.g. navigation) should be monitored at all stages including the final stage, which may have been reformatted. The provider should attempt to identify and flag questionable or poor quality data. Data providers, e.g. EUMETSAT and NOAA/NESDIS are encouraged to use NWP monitoring results to help them in diagnosing data problems. The Group recognizes that it is easy to identify gross errors, while subtle errors are more difficult to detect. Action: V. Tabor (NESDIS), D. Klaes (EUMETSAT).

Action
Evaluate and improve the current procedures to convert antenna temperatures to brightness temperatures (NESDIS and DoD).

Action
Determine why different navigation information is being distributed in comparison with that being used in operations (V. Tabor, NESDIS).

Action
Encourage the collaboration between the local readout software developers and the data producers to minimize the differences between the global and local calibrated and navigated data (AAPP developers, space agencies).

Forward Modelling (section 2.3.3)

Recommendation
We encourage the developers of new instruments to either expand or enhance current RT code, or develop general codes applicable to all instruments and make it available.

ADVANCED SOUNDERS:

Status of plans for advanced sounding instruments (section 2.4.1)

Action
J.Eyre (Met. Office, Bracknell) to compile summary information on advanced sounders, for posting on ITWG web site.

New initiatives for geostationary sounding (section 2.4.2)

Recommendation (to CGMS)
ITWG recommends that a geostationary millimetre/sub-millimetre radiometer mission should be pursued as a technology demonstrator, with priority towards measurement of precipitation, cloud water/ice and humidity at high temporal frequency in support of nowcasting and short-range forecasting, and as a potential future contribution to the Global Precipitation Mission.

Distribution of simulated datasets for advanced sounders (section 2.4.3)

Recommendation (to CGMS)
The ITWG notes the high value of simulated AIRS data, distributed in near-real time, in assisting NWP centres to make effective preparation for real AIRS data, and it recommends that similar services should be established as part of the preparatory activities for other advanced sounders.

Action
M.Goldberg (NOAA/NESDIS/ORA) to draft short paper for CGMS describing the AIRS data simulation system and its use.

Data processing, inversion and assimilation (section 2.4.4)

Recommendation (to CGMS)
ITWG recommends that responsible agencies establish focal points to ensure that:

- ingest and pre-processing code for future advanced sounders (and their complementary imagers) is provided, in a form suitable for use with locally-received direct read-out data, and yielding output consistent with global data, and
- activities are undertaken to integrate this code into processing packages available for international distribution in a timely manner.

Recommendation (to IPO and NASA)
ITWG recommends that ingest code for NPP instruments (CrIS, ATMS and VIIRS), to be made available by IPO, should be integrated into a processing package for locally received data.

Recommendation (to NASA)
It is important that NASA continue to provide MODIS instrument status, navigation and frequently-updated calibration information in a timely manner to users and developers, to maximise the benefit of MODIS data for environmental monitoring and weather forecasting.

Recommendation (to IPO)
ITWG recommends that the user community be provided with and invited to review the draft specifications (content and format) for the raw data records (RDRs) and sensor data records (SDRs) for NPOESS/NPP instruments.

Action (H.Bloom, NPOESS/IPO)
To inform ITWG members, through the ITWG list server, of the location of draft specifications of RDRs and SDRs for NPOESS/NPP instruments.

Action (J.Eyre, via ITWG co-chairs)
To co-ordinate feedback to IPO from ITWG members on the draft specifications (content and format) for the raw data records (RDRs) and sensor data records (SDRs) for NPOESS/NPP instruments.

Recommendation
ITWG encourages research into the assimilation of cloud-affected infra-red radiances, as this may be crucial to the effective exploitation in NWP of advanced sounder data from meteorologically sensitive areas. It encourages investigation of a wide variety of methods including: (1) assimilation of cloudy radiances in "simple" cloud conditions (i.e. homogeneous, low-level clouds), and (2) assimilation of cloud-cleared radiances.

Recommendation (to NOAA)
ITWG encourages NOAA to re-examine the requirements on field-of-view size for CrIS.

Characterisation of spectral response (section 2.4.5)

Recommendations (to space agencies)
ITWG recommends that the spectral responses of advanced sounders should be characterised:

- to a level at which the associated error does not cause the total noise budget of the instrument to be exceeded,
- and, where achievable at reasonable cost, to a level at which the associated error is a negligible contribution to the total system noise.

INTERNATIONAL ISSUES AND FUTURE SYSTEMS:

Data monitoring (section 2.5.4)

Recommendation
WMO should conduct a review of its "lead centre" for data monitoring process. As a initial step in the review, WMO should characterize the scope and intent of data monitoring for its purposes. The review should then be guided by that characterization. (D. Hinsman to inform Chairman OPAG IOS for discussion by CBS Management Group, deadline 1 April 2002).

Radio frequency matters (section 2.5.8)

Action
A. Gasiewski (NOAA) and G. Rochard (CMS) to prepare a draft two page paper, to be developed through email, containing scientific justification for specific RM values for radiance observed from space. (Deadline: June 2002)

Radio occultation sounding Working Group (section 2.5.9)

Recommendation (to CGMS)
EUMETSAT should invite scientists involved in atmospheric sounding using radar occultation, in particular those participating in CHAMP, to submit a progress report for a future CGMS.

SATELLITE SOUNDER SCIENCE AND PRODUCTS:

Actions and Recommendations (section 2.6.3)

Action
Promote activity to append level 1b raw satellite observations to existing historical datasets of collocated radiosonde and TOVS and ATOVS observations, and to encourage such methods in current and planned operational systems (T. Reale, NESDIS).

Action
Write and distribute a statement asking Web Site contributors to help broaden participation by contacting others in their country / region or others in their discipline and encouraging them to contribute to the SSSP web site (T. Reale and T. Achtor).

Action
Provide information for the SSSP Web Site on NOAA data resources, availability and access information (V. Tabor, NOAA/NESDIS/IPD).

Action
Provide link(s) for the SSSP Web Site to Direct Broadcast software packages and data (T. Achtor, CIMSS.SSEC and L. Lavanant, CMS).

Action
Provide routine information for the SSSP Web Site on current operational and research instrument status (T. Reale, NESDIS).

Action
Divide SSSP Web Site contributors by research (technique) vs. operations (product) (T. Achtor, CIMSS/SSEC).

Action
Design and conduct studies in conjunction with current and planned calibration/validation experiments (e.g. DOE ARM Sites) to quantify the usefulness of conventional upper air (i.e., radiosonde, profiler, etc) data to monitor polar satellite radiometer performance, their impact on climate and weather applications, and to provide recommendations concerning long term needs for continuous, global monitoring of environmental satellite data (J. Bates, NOAA and T. Reale, NESDIS).

Action
Actively promote product validation and intercomparison studies (e.g., among product and/or software developers) (T. Reale, L. Lavanant and T. Achtor).

Action (to the SSSP)
Take an active role to identify important research topics involving current weather satellites, including topics for continued and/or expanded investigation (to be developed through interaction with other ITWG sub groups) (T. Reale, T. Achtor, and other Working Group Co-Chairs).

Action
Promote consideration of the use of gridded file product formatters in routine operational data processing at NESDIS, including time averaged (monthly) gridded files for selected, conventional data poor parameters (M. Chalfant, NEDSIS).

2. WORKING GROUP REPORTS

2.1 RADIATIVE TRANSFER AND SURFACE PROPERTY MODELLING

Working Group members: R. Saunders (Co-Chair), L. Garand (Co-Chair) with S. Gu, F. Weng, M. Matricardi, P. Van Delst, P. Brunel, T. Kleespies, F. Chevallier, L. McMillin, J. Li, N. Jacquinet-Husson, S. Turner, R. Armante, T.R. Sreerekha, V. Sherlock, S. English, G. Deblonde, C. Köpken and input from F. Prata and M. Goldberg.

This working group focuses on the issues related to atmospheric radiative transfer (RT) and surface property models which are relevant for radiance assimilation and atmospheric and surface retrievals from current and planned infrared and microwave sounder data.

2.1.1 Atmospheric profile datasets for Radiative Transfer

Radiative transfer (RT) models require a dataset of diverse profiles for training and independent validation. The group is actively using various datasets summarised here. Recent developments include the generation of the TIGR-2000 dataset at LMD, which has 2311 profiles of temperature, humidity and ozone, the latter coming from the UGAMP dataset. Humidity is extrapolated above 300 hPa. The ECMWF profile set selected from the 60 level model analyses, with fully analysed ozone consistent with the temperature and humidity fields is now available. There are 13,000 profiles on model levels with a subset of 80 selected profiles also available for RT model training. In addition to temperature, humidity and ozone there are cloud and surface variables from the model also included with each profile. This dataset is available from the RTTOV web site at: http://www.metoffice.com/research/interproj/nwpsaf/rtm

Other datasets in use are the 48 profiles from the University of Maryland Baltimore County, which are a mix of AFGL, TIGR, and NOAA profiles (contact Scott Hannon, UMBC); the Garand intercomparison set of 42 profiles selected from a larger database which uses SAGE data for upper water and ozone (contact Shawn Turner, MSC). The NOAA-88 profiles that include rocketsondes and SBUV ozone are available from Mitch Goldberg (NESDIS) and there are several versions. The older 43L TIGR-2 dataset (43 water vapour profiles) and the NOAA-88 set (34 ozone profiles) are used for RTTOV and the original 42L 32 profiles from NOAA-88 are also still in use.

The group discussed the number of levels of the profiles required for advanced IR sounder simulations. It was agreed that around 90 levels are optimum based on studies at ECMWF and the Met Office since the last meeting. However it was also felt important to agree on a standard set of levels for everybody as the line by line (LbL) transmittance calculations are so expensive. This could be the AIRS 101 levels as this would allow a sub-sampling or interpolation to any required levels for RT training.

Recommendation

The next definitive LbL transmittance computation for fast RT model training should be on the AIRS 101 levels to facilitate use by all users.

The group noted that diverse profile datasets of trace gases (i.e. CO, CH_4, N_2O, CO_2) are now in preparation at ECMWF and being used for trace gas simulations. The issue of how many profiles are needed to train a statistical regression fast RT model was raised and the general consensus was about 50 profiles are the minimum number required. The representativity of a profile set was

discussed. If the RT model can reproduce results with an independent profile set to an accuracy close to that for the dependent set then it is a reasonable assumption the dependent set is adequate. Members of the group reported problems consistently interpolating profiles on to different levels. There is a potential ambiguity relating layer integrated and level point values. Transmittance datasets should include documentation of any interpolation/integration routines so data can be used consistently.

Recommendation

A standard set of interpolation routines should be provided to optimally convert from level to layers (and vice versa).

The extrapolation of profiles to below the surface (e.g. for Antarctic profiles) was not recommended so that for training RT models the lower levels may have fewer profiles in the regression than the upper levels.

2.1.2 Instrument characteristics required for RT modeling

The group reviewed where there were new requirements or gaps in the instrument data required for RT modeling. The following is a list of the new or existing sensors where the group recognized information is still required for RT simulations:

- HIRS and AVHRR spectral response functions for NOAA-M due for launch in mid 2002.
  Action: T. Kleespies (NESDIS) to make HIRS and AVHRR filter response functions available to ITWG before NOAA-M launch.

- The AIRS channel responses will be updated 6 months after launch. L. Strow (UMBC) will make the updates available.

- GOES imager filter response functions are on a NOAA web site (except for GOES-9). Problems noted with GOES-12 should be documented.
  Action: P. Brunel (CMS Météo-France) to contact Tim Schmidt (CIMSS) to clarify GOES information still required (GOES-9, GOES-12).

- MODIS responses for AQUA are needed
  Action: P. Menzel (NESDIS) to provide contact point for AQUA MODIS response functions.

- Concerns were raised about the lack of detail in the early METEOSAT filter response functions.
  Action: R. Saunders (Met Office, Bracknell) to raise early METEOSAT filter response functions matters with EUMETSAT.

- SSMI(S) channel characteristics are documented by Barbara Burns provided after the last ITWG. Roger Saunders can distribute to ITWG on request.

- For IASI simulations note a minor change in the definition of level 1C radiances has been made (contact Marco Matricardi for details)

- AMSR and WINDSAT channel characteristics are required.
  Action: F. Weng (NESDIS) to inform group of any information on AMSR and WINDSAT channel characteristics.

Recommendation

That instrument builders provide response functions in digital form and at the actual spectral resolution it was measured.

Recommendation

That RT modelers document clearly which filter responses were used in their simulations (e.g. by including them in the output files).

NOAA have recently moved to using the latest set of fundamental constants in their processing. It was emphasized that the same set should be used in the calibration processing as in the RT model simulations.

Action

T. Kleespies (NESDIS) to announce the new NOAA set of fundamental constants to the Working Group.

2.1.3 Line by Line (LbL) model status

The status of IR LbL models used by the group is summarized below:

- GENLN2/GENLN3: new release planned but no new science, just more user friendly and Fortran 90 (contact is Dave Edwards at NCAR email:edwards@ncar.ucar.edu)

- kCARTA is being used for AIRS simulations (contact is L. Strow at UMBC email: strow@umbc.edu).

- LBLRTM: Version 6.01 is available. Some of the new features are:

  - Capability to input atmospheric profile on either altitude or pressure grid, and to output quantities on either altitude or pressure grid.
  - Capability to compute quantities for atmospheric layers which are not in local thermodynamic equilibrium (non-LTE option).
  - Update of universal constants
  - Contact is clough@aer.com

- 4A-2000: Various improvements have been made since the last meeting to be reported in a paper (contact is N. Scott at LMD email: scott@ara01.polytechnique.fr).

A report has recently been published documenting the EUMETSAT sponsored intercomparison of line by line models for IASI simulations. It is available at: http://www.eumetsat.de/en/area2/publications/tm08.pdf
The results of this study, at least for the two airmasses considered, can be used to identify parts of the infrared spectrum where model and/or spectroscopic errors are significant.

Recommendation

The EUMETSAT Line by Line intercomparison is a valuable attempt to document biases in LbL models. It should be extended to more airmass types.

For microwave LbL models:

- MPM 89/92 is used by many groups (i.e. basis for RTTOV and OPTRAN) (contact: Roger Saunders)
- MPM 97: includes updated 23.8 GHz band used at NOAA. (contact: Fuzhong Weng)
- Rosenkranz 1997: updated with a band model used at NOAA. (contact: Fuzhong Weng)
- ARTS a new model developed at Bremen Univ. which aims to be a reference model (contact: Sreerekha Ravindranathan)

There are still biases between measurements and models around the 23 GHz water vapour line. It was noted there are plans for microwave sounders at frequencies up to 500 GHz and so models will need to be able to simulate radiances at these sub-millimeter wavelengths.

Actions

S. Ravindranathan (Univ. of Bremen) to provide web site on new microwave RT model inter-comparison work at Bremen Univ.

R. Armante (LMD, Ecole Polytechnique) to provide information to the Working Group on the STRANSAC-2000 study on microwave simulations.

2.1.4 Assessment of spectroscopic databases

The performance of the new generation of high spectral resolution atmospheric sounders (e.g. AIRS, CrIS and IASI) is dependent upon the quality of the spectroscopic parameters of the active gases since these are used as input to the LbL models. The latest official releases for spectroscopic parameters are GEISA-2000 and HITRAN-2000. Nicole Jacquinet-Husson (LMD) reported on significant efforts to improve the spectroscopy for advanced IR sounders like IASI and AIRS. She commented on the development of the GEISA/IASI spectroscopic database which is an extract, in the IASI and AIRS spectral range (600-3000 cm^{-1}), and a partial update of GEISA. This work is ongoing within the ISSWG (IASI- Infrared Atmospheric Sounding Interferometer- Sounding Science Working Group), and funded by CNES/France, EUMETSAT and the E.C. Environment and Climate Program. These efforts are associated with an international collaboration for IASI required spectroscopy, notably trace gases. The current edition of GEISA is accessible freely via the ARA/LMD group web site, upon prior request for password at *nicole.jacquinet@lmd.polytechnique.fr* The GEISA/IASI spectroscopic database is available at: ftp://ara01.lmd.polytechnique.fr/pub/geisa/iasi2000 (anonymous ftp). An updated HITRAN-2000 database is available. The updates are documented at http://www.hitran.com/hitran/updates.html For the water vapour continuum, CKD 2.4, is the new standard. The EUMETSAT LbL comparison mentioned above is part of the assessment of the accuracy of these datasets.

2.1.5 Fast RT models

Status of fast models:

OPTRAN: Adapted to AIRS. Work underway to improve ozone channel simulations (see papers by McMillin, Kleespies and Van Delst in this conference proceedings).

RTTOV: Version 7 about to be released which includes AIRS and SSMI(S) simulation capability. Details in paper by Saunders et al. (this conference proceedings).

GASTROPOD: Fixed pressure level model for AIRS (see paper by Sherlock et al. in this conference proceedings).

OSS: Proprietary code developed by AER for CrIS but not yet available to RT community. Is reported to be fast and accurate. The group encouraged AER to include the IR model in the Garand comparison. Contact is Jean-Luc Moncet at AER.

MSCFAST: Implemented at MSC for use in GOES radiance assimilation. Will be adapted to AIRS. (contact Louis Garand).

3R-N: This fast model is based on neural networks and has been developed for TOVS channels at LMD (contact Raymond Armand).

Issues for fast RT models:

- Statistical models

Progress has been made on water vapour and ozone simulations for constant pressure models which for ATOVS channels now give errors well below the instrument noise. Developments are under way for other trace gases to be treated in these models. Water vapour continuum should also be treated as a separate gas from the line absorption to facilitate updates separately from the line datasets. The robustness of the simulations and proper weighting of the predictors requires further investigation. For example, channels in the center of strong lines can be difficult to simulate.

- Physical models

Updating of MSCFAST to AIRS will allow a detailed investigation of the errors versus wavelength for narrow channels. It should be noted that at least one fast physical model has been developed for MW applications (FASMPORT, Weng et al. to appear in *JAS*). This is a polarimetric 2-stream model for SSM/I, SSMI(S) and WINDSAT.

- Neural networks

The performance of these models for forward calculations is promising in terms of speed and accuracy. These models still need to be proven for Jacobian computations.

- Clouds and precipitation

Developments have been made to include cloud in fast radiance simulations. This will serve not only for NWP model validation, but also for research in the assimilation of cloudy radiances (see Chevallier et al. this conference). More work is needed to include precipitation effects in fast RT models.

- Broad channels

Broad band channels can be difficult to simulate with fast models as one central frequency is not a

good approximation for the whole channel. RTTOV for instance has errors of almost 2 K for the SEVIRI 3.9 micron channel due to this effect.

- Interferometer channels

These can have negative lobes and so have to be treated correctly for simulation. Currently only apodised radiances with very small negative side lobes have been simulated but work is planned to simulate unapodised IASI radiances.

- RT model biases

An improved understanding of RT model biases as shown by the Garand intercomparison is required. For the use of RT models in NWP data assimilation models it was noted they should be the same in both the global and regional model of each NWP centre but that different bias tuning may be required for each.

Action

The web site maintained by MSC on the fast model intercomparison is a valuable resource for fast model development and should be maintained at least until the next ITWG meeting. (L.Garand, AES/MSC).

Recommendation

The RT community is encouraged to continue to develop and improve fast models for new and existing sensors. It must be recognized however that NWP centers prefer to only have one RT model for all sensors in their assimilation code so new developments should be able to feed through to existing RT models in NWP Centres.

2.1.6 Surface Property Models

2.1.6.1 Microwave emissivity

Ocean surface

For ocean surfaces improvements in FASTEM have been made since the last meeting and this has been integrated in RTTOV-7 (see paper on FASTEM-2 evaluation at: http://www.metoffice.com/research/interproj/nwpsaf/rtm/rtm_reports.html for more details). A two scale model is under development at NESDIS by Fuzhing Weng and will be delivered to NCEP for future polarimetric sensors.

Land surface

At NESDIS the MEM (microwave emission model) has been developed and used in NCEP models. This has allowed more microwave radiances to pass the quality control tests in the assimilation. There are still problems with modeling the emissivity over melting sea-ice, multi-year snow and high topography and more work is planned at NESDIS. Work is underway at Bremen University and Sreerekha Ravindranathan will report back to the group on this work.

Action

S. Ravindranathan (Univ. of Bremen) to report to the Working Group on work on surface models at Bremen.

2.1.6.2 Infrared emissivity

Ocean surface
For the ocean surface no major developments have been made since the last ITWG. Masuda parameterisations are used at several centers (i.e. ECMWF, NCEP) and ISEM-6 (within RTTOV) which is based on Masuda (1988) and Watts et al. (1996)

Issues:

- Accuracy for large viewing angles (>60 deg) required for geostationary radiance assimilation
- Accuracy for high wind speeds. Ship borne interferometer datasets are now available for model validation from Univ. Madison (contact P. Van Delst) and Univ. Miami (contact: pminnett@rsmas.miami.edu).

Land surface
For the land surface some work is underway in order to extend the use of radiance assimilation over land. However this is a difficult problem to reduce the errors to a point where lower peaking channels can be used over land. More channels with only a small sensitivity to the land surface may be able to be assimilated with an improved representation of the land surface emissivity in NWP models.

Issues:

- The link between spectral emissivity resolution and horizontal spatial resolution is important. When averaged over large areas for satellite ifovs the spectral emissivity variation is smoothed making it difficult to use lab and/or in situ measured emissivities without appropriate smoothing.
- Emissivity mixing is *not* linear, the temperature of each element also needs to be accounted for. At night the mixing should be more linear as the temperature contrasts are reduced.
- The emissivity can vary with viewing angle particularly for bare surfaces and uniform grassland.
- Validation is important for land surface emissivity datasets developed. There are several datasets with spectral emissivities measured over different surface types (e.g. see paper by M. Lynch in this conference). In addition MODIS data is being used to improve our knowledge of the IR emissivity.

F. Prata (CSIRO) has drafted a note on issues for surface temperature and emissivity retrieval from satellite sounders.

Action

R. Saunders (Met. Office, Bracknell) to circulate to the group, a draft copy of the note composed by F. Prata (CSIRO) on issues regarding surface temperature and emissivity retrieval from satellite sounders.

2.1.7 Proposal for group web page

It was proposed the working group web page should contain:

- Contact details of WG co-chairs

Links to:

- WG reports, ITSC-XI, ITSC-XII, …
- Links to instrument characteristics for RT calculations
- Links to Line by Line model pages
- Links to fast RT model pages
- Links to surface property models
- Links to fundamental constants
- Links to relevant reports/papers

Action

Co-chairs to prepare a web page for the Radiative Transfer and Surface Property Modelling WG.

All WG members to provide links to co-chairs which can be included on the web pages

2.2 TOVS/ATOVS DATA IN CLIMATE

Working Group members: J. Bates and C. Stubenrauch (Co- Chairs) with M. Goldberg, A. Kaifel, F. Chevallier, T. Phulpin, R. Armante, W. P. Menzel, G. Stephens, M. Prabowo, V. O. John, F. Prata, S. Uppala, and L. McMillin

2.2.1 Contribution of TOVS to climate studies

The use of TOVS data for climate studies has progressed from being experimental to operational. The data sets have proven to be of high value for climate studies. These data sets have been used for regional and global temperature and upper tropospheric humidity trend studies in assessments by the Intergovernmental Panel on Climate Change (IPCC) and various World Climate Research Programs (WCRP). Cloud properties have also been proven reliable and first trend studies have been undertaken. The use of infrared sounding channels allow retrievals both day and night and are less effected by volcanic aerosols than retrievals using visible channels. Further applications of TOVS data, particularly for retrieval of column CO_2, are currently under development and appear promising.

As we eagerly anticipate the next generation of spectrally-resolving infrared sounders, it is now clear that the constellation of operational satellites will be the backbone of the long-term global observing system. A major challenge in moving to the next generation sounding systems, however, is how to maintain a seamless time series of fundamental observations during that transition. This will take a concerted effort by both the instrument scientists and the climate scientists. It will also take a long-term commitment by space agencies to provide resources to achieve the longest possible overlap of the new technology with the old technology.

The following list describes in brief detail some of the latest developments in climate products from TOVS as summarized by those participating in this conference. Further details can be found in the conference abstracts and the conference proceedings.

2.2.1.1. Temperature and water vapor

AMSU-A observations are ideal for monitoring temperature change for two very important reasons. First, microwave observations in the 50 – 60 GHz band are very insensitive to non-precipitating clouds and thereby provides near global coverage. Second, because of the high degree of linearity of microwave observations with atmospheric temperature, linear regression can be used to derive atmospheric temperature from the observed brightness temperatures. AMSU-A temperature datasets are available from NOAA/NESDIS/ORA. The record began in July 1998. The datasets are at 1x1 latitude/longitude resolution, separated into ascending and descending orbits, and averaged for daily, pentad and monthly time periods. The gridded files also include limb adjusted brightness temperatures for all AMSU-A channels, and total precipitable water and cloud liquid water over ocean. There are 40 levels of temperature, from 0.1 to 1000 mb. For additional information go to:
http://orbit-net.nesdis.noaa.gov/crad/st/amsuclimate/amsu.html

HIRS observations have been used to form a long-term climatology of upper tropospheric humidity (UTH) from late 1978 to March 1998. These data have been used to study interannual variability and long-term trends of UTH. These long-term trends are strongly positive in the deep tropics, negative in the Southern Hemisphere subtropics and midlatitudes, and of mixed sign in the Northern Hemisphere subtropics and midlatitudes. The trends are shown to be consistent with

atmospheric circulation changes observed in the past 20 years, including a tendency toward more El Niño-Southern Oscillation (ENSO) warm events and changes in transient eddy activity in the subtropics. This data set has been used in international assessments including the Intergovernmental Panel on Climate Change and in an international assessment by the World Climate Research Program.

2.2.1.2. Ozone

Due to the failure of the launch of QuickTOMS (autumn 2001) and the current problems of EarthProbe TOMS, and GOME1 on ERS2, operational total ozone column monitoring from satellite is not secure for the near future. In the framework of a nationally funded project the ZSW (Center for Solar Energy and Hydrogen Research, Stuttgart, Germany) developed a new method based on neural works (Neural Network Ozone Retrieval Scheme: NNORSY-TOVS) for reliable total ozone monitoring from NOAA-TOVS satellite data. The ZSW recently reprocessed the whole TOVS Level 1b archived data of the satellites TIROS-N, NOAA-6 to NOAA-14 starting Sept. 1979 up to now. So far NNORSY-TOVS wasn't applied to the ATOVS data of NOAA-15 and 16. The RMS on the retrieved long term TOVS total ozone column product is 9 Dobson Units (DU) for monthly mean values compared to ground measurements of Dobson and Brewer stations. This is close to the accuracy of TOMS V7 data with an RMS of about 8 DU for the same time scale. Therefore the TOVS ozone product is well suited for filling the TOMS data gap (May/1993 to July/1996) as well as for global ozone trend analyses.

NNORSY-TOVS has the following advantages:

- Total ozone retrieval can be carried out with the same accuracy also at night time, which is important for data over polar regions during the polar winter in the absence of daylight, in contrast to satellite instruments measuring the backscattered solar radiation (e.g. TOMS, GOME, SBUV).
- At present, with NOAA-14, 15 and 16 in orbit, three satellites are operational in orbit and secure the availability of daily total coverage and enables to get also information of the diurnal cycle of the total ozone column.

Future work will focus on further geophysical validation and comparison of the TOVS ozone product with other satellite ozone data (TOMS, GOME, SBUV/2) as well as the setup of a near-real-time retrieval system for the operational NOAA satellites (NOAA-14, 15 and 16) for global ozone monitoring in order to extend the long term ozone product.

2.2.1.3. Clouds

Infrared sounders on polar orbiters have been shown to have higher sensitivity to semi-transparent high thin clouds than visible and infrared window techniques. They also allow cloud property retrieval both day and night and are less effected by volcanic aerosols than retrievals using visible channels.

For the study of cloud properties, two data sets have been presented at ITSC-12:

1) University of Wisconsin has retrieved cloud properties for the period 1989 – 2001, by using the CO_2 slicing method on sampled HIRS pixels.

   Trends in HIRS cloud statistics, using the CO_2 cloud slicing method, from the last decade reveal that high clouds were stable until 1995 and then gradually decreased below 1989

levels. These decreases are mainly observed over land and especially in higher clouds; ocean cloud cover has been mostly stable. It is found that measured cloud cover trends are sensitive to the orbit overpass times; orbit drifts cause changes that cannot be attributed to decadal cloud trends. For the satellites that did not drift, NOAA 10 and 12, a significant cloud frequency decrease after 1995 is evident. A decrease in tropical cloud cover in the HIRS statistics is similar to that reported by Wielicki et al. (2002) using CERES data and by Chen et al. (2002) using ISCCP data. Such comparisons will continue and will be extended to include the full time span of the polar sounders.

2) The LMD/ARA group has retrieved cloud properties for the period 1987 – 1995, by using a weighted Ψ^2 method on cloudy HIRS radiances averaged at 1° resolution.

   The amount of high clouds ($p_{cld} < 440$ hPa) over the globe is around 30% and was stable within 1% during the observed period 1987 - 1995 which includes an El Nino event in 1987/88 and the eruption of Mt Pinatubo in 1991. High cloud amount is slightly lower in the SH midlatitudes (25%) than in the NH midlatitudes (32%). In addition to cloud height and effective emissivity, the LMD/ARA group has developed an algorithm to retrieve mean effective ice crystal diameters of medium-thick cirrus clouds. This technique takes advantage of the fact that cirrus emissivity differences between 8 and 11 microns depend on this parameter. A long-term survey of these cirrus properties is being undertaken as part of the European project CIRAMOSA (CIrrus microphysical properties and their effect on RAdiation: survey and integration into climate MOdels using combined SAtellite observations). Another activity at LMD is the intercomparison between TOVS cloud heights and those obtained by LITE, the lidar mission on the space shuttle during six days in September 1994.

2.2.1.4. Trace gasses

Important progress in retrieval of trace gas columnar abundance has been made recently. These are new research results and several investigators are planning to apply these results to the entire TOVS time series.

2.2.1.4.1. Retrieval of CO_2 from TOVS

One of the important advantages of the higher resolution sounders planned in the NPOESS era is the possibility for extracting non-traditional information from the measurements provided by these sounders. It is within this context that we describe the extent to which CO_2 may be directly retrieved from AIRS radiance data or data from similar emission-based spectrometer systems. The analyses conducted is also contrasted against the same analyses applied to ATOVS.

Investigators have shown that the retrieval of CO_2 column concentrations from high spectral resolution infrared sounders looks promising. These retrievals have high enough accuracy (approaching 2 ppmv) to be useful for CO_2 inversion studies that seek to estimate sinks and sources although the information is concentrated mainly in the free troposphere. By contrast, CO_2 information extracted from HIRS is less useful and may approach 4 ppmv accuracy under the most optimal circumstances but more generally can be expected to be at the 6 ppmv level which is just capable of resolving the annual cycle of CO_2. Investigators also have shown how retrieved CO_2 information, at the 2 ppmv level, also benefits temperatures derived from these sounders. The typical assumption of a globally constant CO_2 concentration introduces errors in temperature

retrievals that can be significantly reduced using a variable CO_2 distribution.

Plans exist to augment the data obtained by the high resolution sounders with data from spectrometers designed to measure the spectrally reflected sunlight at ultra-fine resolution in specific CO_2 absorption bands. The CO_2 measurement approach using these measurements is described in O'Brien et al. (2002) and employs radiance measurements in two carefully selected absorption bands located in the near infrared region of the solar spectrum. The complementary nature of these observations and the extent they add information on boundary layer CO_2 is currently under investigation.

2.2.1.4.2. Retrieval of SO_2 from TOVS

Approximately 7-8 Tg of sulphur are believed to be placed into the atmosphere by volcanoes each year. Most of this sulphur arrives in the form of SO_2 gas and at highly variable rates due to the nature of volcanic eruptions. It is estimated that about 30 Mt of SO_2 (~ 2 Tg of S) was emitted by the Pinatubo eruptions of June, 1991. SO_2 in the atmosphere is rapidly converted to sulphuric acid at a rate that depends on environmental temperature and the availability of water vapor. Sulphuric acid causes the stratosphere to warm and the surface to cool. SO_2 and other volcanic effluents (e.g. silicate ash) also cause radiative effects– stratospheric heating–but these are short-lived (days to weeks) and local. Nevertheless both SO_2 and ash are capable of causing changes significant radiative effects that can alter wind circulations.

Currently satellite measurements of SO_2 are made by the TOMS and GOME instruments using UV reflected light, and were also measured by the MLS on UARS. These data have variable and low spatial resolutions and, apart from the MLS, can only make daytime measurements.

The HIRS instruments are capable of measuring SO_2 in the lower stratosphere and upper troposphere through absorption of infrared radiation by $\nu 3$ band situated around 7.34 μm. TOVS has a channel that covers this region and analysis of data for several large eruptions demonstrates that TOVS can retrieve SO_2 concentrations (column) to rms accuracies of 3-6 D.U. Since TOVS provides global data and has been operational for more than 22 years, there is a potentially useful and as yet unexplored data-set of value to the climate community. The synergy of studying radiative effects and O_3/SO_2 coupling from the same data source is attractive and opens up new research avenues.

While it is extremely important to analyze the HIRS data to retrieve SO_2, HIRS data have several limitations. The broadband data are contaminated by water vapour effects and limit the retrievals to upper troposphere and lower stratosphere. These will be overcome once the high spectral resolution data of the advanced FT-IR sounders becomes available. AIRS, IASI, GIFTS and SEVIRI among others will all provide high spectral resolution data that could be used to retrieve SO_2 vertical structure and possibly provide tropospheric SO_2 estimates.

Recommendation

ITWG encourages use of satellite sounder data, including the historical TOVS/ATOVS and the next generation high spectral resolution data sets, for retrieval of column CO_2 amounts.

Recommendation

ITSC scientists are encouraged to prepare a set of comparisons of long term trends and variability from the TOVS long-term archive for specific fields. Comparisons to be prepared include temperature and moisture (Bates), clouds (Stubenrauch, Wylie-Menzel), O_3 (Kaifel), CO_2 (McMillin), SO_2 (Prata).

2.2.2. Relations to international climate programs

Satellite data sets are beginning to have a greater use in international assessments, although increased use is recommended. Notable uses occurred in the IPCC TAR for use of MSU mean layer temperature and HIRS for UTH. Research and TOVS data sets were also used as part of the WCRP Stratospheric Processes and their Role in Climate (SPARC) water vapor assessment. Satellite data sets are more extensively used in climate studies within the WCRP Global Energy and Water Cycle Experiment (GEWEX) program. In particular, the GEWEX radiation program (GRP) uses both imager and sounder data extensively in studies of global cloud, water vapor, precipitation, and earth radiation.

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU). GCOS provides an operational framework for integrating, and enhancing as needed, observational systems of participating countries and organizations into a comprehensive system focused on the requirements for climate issues. As such, GCOS provides an important point of contact for ITWG in terms of coordinating satellite sounder activities with the climate community. Details about recent GCOS activities can be found on the WMO GCOS web site.

In establishing observing systems for climate, GCOS has identified a number of basic principles that should always be followed. These derive from the so-called Karl principles (which have also been adopted by the Parties to the UN Framework Convention on Climate Change) and can be summarized as:

- ensure overlap whenever instruments are changed;
- fully document data processing methods;
- fully document station histories;
- maintain long continuous records;
- maintain calibration and validation facilities;
- wherever possible, back-up 'high-technology' systems with 'low-technology' ones;
- ensure that any new facilities fill real gaps;
- maintain effective data archive and access facilities;
- ensure there are processes to transfer systems from research to long-term stable operations;
- include GCOS needs in the initial design of networks.

These principles need to be applied to both *in situ* and satellite systems. A recent review by a USA National Research Council (NRC) Panel highlighted the following issues for the application of

satellite data for climate purposes:

- rigorous station keeping;
- overlapping observations;
- launch-on-schedule strategy;
- rigorous pre-launch and on-board calibration;
- formal production of climate products;
- web access to metadata;
- use of functioning baseline instruments on de-commissioned satellites;
- need for complementary *in situ* baseline observations;
- web access to basic climate products;
- need for network monitoring.

Recommendation

An invited presentation to be given to the ITWG on IPCC results and plans at next ITSC meeting.

Recommendation

That Space Agencies/Satellite Operator reports to the next conference include the relationship of plans to the Karl principles.

2.2.3. Pathfinders and re-analysis

Official NOAA/NASA Pathfinder project has ended but individual efforts continue and are encouraged. Since ITSC-XI, production of Path-A has continued at NASA GSFC (Susskind et al.) and processing is complete through the end of 2001. These data are being used by various investigators to study climate processes and trends, including feedback processes.

The Path-B activities (Chedin et al.) since ITSC-XI has focused on producing an extended, coherent radiosonde calibration data set using data from ECMWF and NCEP. This activity is required to provide cross-calibration data for the bias adjustment process for Path-B and should be complete by the Fall of 2002. Once that is accomplished, reprocessing of the entire TOVS data set will begin.

The ERA-40 effort is using 3-d var with TOVS 1b data. The ERA-40 effort has also had success in using the pre-TOVS instruments, the VTPRs, to extend the satellite record back to 1973. This means that we now have a 30-year record of global satellite observations that can be used for climate and global change studies.

ECMWF is currently performing the reanalysis of the global atmosphere for the period 1957-2001. ERA-40 will complement the already existing NWP reanalysis datasets: NCEP (1947-2000) and ECMWF (ERA-15, 1979-1993). In addition to the historical ground-based observations, and to a much larger extent than in ERA-15, ERA-40 makes use of the multi-channel satellite radiances through T159L60/ 3D-variational assimilation starting from the first sounding instrument VTPR in 1972 up to the present SSM/I, TOVS (MSU, HIRS and SSU) and ATOVS instruments. Cloud Motion Winds are used from 1979. Ozone information retrieved from TOMS (total ozone) and SBUV (layered ozone) is assimilated as well. The reanalyses are progressing in three streams and

currently analysed periods are 1957-1961, 1973-1975 and 1989-1996.

Surface and stratospheric analyses show major improvement compared with ERA-15. Among other positive signals, the validation of ERA-40 performed by several institutes associated to the project also indicates a better representation of tropical and extra-tropical cyclones, and better medium-range forecast performance compared with ERA-15.

Among the possible problems identified so far are higher than expected total column water vapour amounts over the tropical oceans and associated higher precipitation amounts. In addition there seems to be a slight tendency towards increased values through years 1989-1996.

Recommendation

Continued production of long-term TOVS climate data sets as envisioned by the NOAA/NASA Pathfinder projects with the goal of achieving a 25 year dataset 'TOVS 25'. The TOVS 25 data set would represent a best effort to use all 25 years of TOVS data for climate studies.

2.2.4. Calibration, validation and quality control monitoring

NOAA NESDIS is continuing efforts to address calibration issues on current and past satellites. Four issues related to calibration of the HIRS instruments are currently under investigation. These include:

1) Currently full calibration of HIRS data is accomplished every 40 scan lines. There is, however, ancillary calibration data included at the start of every scan line. NESDIS is conducting a calibration comparison study to evaluate whether using this additional calibration data leads to an improved calibration of the HIRS instruments;

2) It has been found that some satellites (notably NOAA-15 and NOAA-16) have an issue with the value at zero counts. NESDIS has a procedure to fix this problem;

3) All HIRS instruments that flew with a SSU (i.e., all HIRS instruments prior to the AMSU, except for NOAA-10 and NOAA-12) have SSU-induced noise. This noise can be significant (0.2-0.8C) and its magnitude varies from spot-to-spot and channel-to-channel. NESDIS has a process under way to attempt to correct this and apply it to the entire 1b time series;

4) The non-SSU suite HIRS instruments also have a smaller systematic noise- a process similar to 3) is under way to correct this.

Quality control efforts at numerical weather prediction centers are a very useful source of both calibration and validation information. We appreciate efforts by these centers to make such information available to users via web-based systems. It is not clear, however, that there is a procedure for the long-term archival of this information. We recommend that the long-term archive centers work with the NWP centers to establish a method for saving the important calibration and validation information derived from the assimilation systems.

In situ vertical sounding, both by the operational radiosondes and by research sondes (such as ozonesondes and research-quality water vapor sondes) is critical for satellite calibration and validation efforts. There are, however, many user communities for these data and the needs of the different user communities can conflict. For example, those who use these data for global and

regional climate studies want the launch time to remain constant in order to avoid aliasing the diurnal cycle into longer-term variability. Satellite users would prefer launch times based upon the satellite overpass time to ensure the closest match with the satellite data in time and space. Because of these conflicting needs, requests for changes in radiosonde operations to optimize their use for satellite cal/val must be precisely targeted and well supported to balance conflicts with other user needs.

NESDIS is developing a unified system for satellite validation. This system will include features such as 1) co-location of in situ data with multiple satellites, 2) storage of both the original and final corrected version of radiosonde data, and 3) co-location of radiosonde data with other in situ data types such as ACARS, buoys, GPS, etc.

The current system can be improved. Two opportunities exist for improved coordination between in situ sondes and satellite overpass times: 1) automated ship launches (Hinsman CBS) and 2) research group launches of ozonesondes and water vapor sondes.

In addition, ongoing research field programs offer another opportunity for obtaining calibration and validation data sets. These include both short-term field programs (IHOP, TOGA COARE, Vorcore, ARM IOPs, etc.) and long-term field observation programs (ARM CART sites, WODC/UV sites, GEWEX CEOP sites. etc.).

Recommendation

Past and present calibration issues are currently being addressed. This is a very important activity. These issues should be fully documented, and the related data and software needs to be placed in long term archives. Further software also should be developed and shared (L. McMillin, T. Achtor, D. Klaes, J. Bates)

Action

Develop, archive and make accessible a complete audit trail of all TOVS calibration issues and their resolution (J. Bates, NOAA).

Action

T. Reale (NESDIS) and T. Achtor (CIMSS/SSEC) to compile links from the TOVS/ATOVS Data in Climate Working Group web page to sites containing calibration and validation data, including ARM CART sites, WODC/UV sites, GEWEX CEOP sites, etc.

There is a need to develop a more formal arrangement for enquiring about, reporting and acting on past calibration issues. This arrangement requires development over the next 18 months (D.Hinsman, P.Menzel, J.Bates, L.McMillin).

2.2.5. Data access and archive

We strongly commend the efforts of the operational satellite agencies to make level 1b data sets available at low cost. We appreciate efforts by the WMO to coordinate the access and distribution of satellite data sets from research satellites. We also appreciate various national efforts for climate product processing, archiving, and distribution (such as the NASA DAACS, the French disciplinary centers ETHER for chemistry and ICARE for clouds, aerosols, and radiation).

The full archival of and access to very large data sets from research satellites, such as Terra,

remains a major challenge. In the future the operational satellite operators will face similar challenges. It is important to use the EOSDIS experience to evaluate the benefits and drawbacks of such a system for data distribution and archive.

The request from the coordination group for meteorological satellites (CGMS), that as archive centers transcribe data sets from old, difficult to use data media and formats to new and easier to use media and formats that they add some basic additional metadata to the record at that time, is commended. This metadata should include both details about the format and heritage (or audit trail) of the data as well as simple statistics computed from the data as it is being transcribed. The simple statistics should include, for a full orbit or geostationary satellite scan for each channel, the mean, standard deviation, skewness, kurtosis, maximum, minimum, total number of good observations, and total number of missing and bad observations. Such statistics are relatively easy to compute during data transcription and can be highly valuable to future users.

Action

EOSDIS is the first attempt to deal with the quantum leap in data volume from the next generation environmental satellite sensors. Space agencies/satellite operators should be invited to provide a summary of their plans in relation to this experience in providing data archive and access for next generation satellite instruments (Co-chairs to CGMS).

2.2.6. Data Utilization

There are still several issues which remain to be fully explored but of some importance for climate studies, these include; what are relative tradeoffs in using the shortwave vs longwavelength of water vapor for climate studies, and delineation of the importance of millimeter wave sounding from geosat for water cycle processes. These need to be addressed at ITWG 13.

2.2.7 Future instruments and continuity

There is an urgent need to develop the human resources necessary to take full advantage of the next generation of both research and operational satellite sounders for climate studies. We recommend that the satellite agencies in collaboration with educational institutions and national weather services develop programs such as graduate assistanceships and fellowships, post-doctoral programs, and visiting scientist programs to promote the use of the next generation satellite data.

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

Working Group members: C. Chouinard (Chair), J. Derber (Co-Chair), with N. Baker, W. Bourke, F. Bouttier, G. Deblonde, S. English, E. Gérard, B. Harris, C. Köpken, T. Landelius,, K. Okamoto, J. Paevere, V. Prasard, M. Probowo, S. Ptura, F. Rabier, R. Randriamampianina, J.Sang-Won, N. Servando, H. Schyberg, D.Singh, P. Steinle, E. Sylvestre, V. Tabor, J.-N. Thépault, C. Tingwell, M. Uddstrom, N. Wagneur, K. Whyte, J. Xue

2.3.1 Introduction

There were again many substantive presentations at this meeting that indicated very positive results using satellite data from different instruments although the impact of microwave data appears larger and easier to obtain . Very positive impact of direct assimilation of radiance was reported by still more NWP Centers that were previously using retrievals as their main source of satellite data. Some Centers that were previously using processed level-1d radiances have now started to use raw level-1b radiances with very positive results.

The WG notes that operational use of satellite data over land remains limited. Proper inclusion of the effects of surface emissivity, surface temperature, and cloud variations requires considerable development despite substantial progress in the last several years. Because of these problems, most operational Centers use channels with most of their signal above the surface or retrievals above the troposphere. There are exceptions, but even in these exceptions, the QC tends to be tighter and the weighting of the data less over land. The DAO reports positive impact for short term forecasts using 1D-var retrievals over land. The UKMO is using some lower peaking channels over limited region (Asia). ECMWF is using AMSU-A channel 5 (and above) over land and ice and NCEP in its final testing is using microwave channels over non-snow covered land.

With the release of the latest radiative transfer code (RTTOV-7) at the meeting, it is evident that the exchange of code/results and techniques between groups within the satellite community continues to be very vibrant. The use of the Internet to distribute the new radiative transfer code to users has been very efficient. Overall, the formation of the NWP SAF in Europe has had a very positive impact on satellite data user community all over the world. In the same context, the AAPP and ITPP packages used to calibrate and navigate the satellite data are now extensively used by most NWP Centers in the preparation of data for analysis. Both EUMETSAT and CIMMS have to be commended for the maintenance and distribution of such critical software that have eased the entry of NWP Centers and accelerated the work of others in relation to TOVS and ATOVS data processing.

The experimental use of AMSU-B data which had been reported at the last meeting is now used in daily analysis preparation at some NWP Centers, and others have started experimenting with positive results indicating it is only a matter of time before they implement these data. The WG encourages more studies on the use of AMSU-B to show the impact of this data in other DA/NWP systems. The bias correction procedure for AMSU-B appears to be working as well as with AMSU-A data with somewhat more difficulties apparent over continents in very dry and cold atmospheres. In the context of moisture analysis, at least three NWP Centers have added HIRS-12 moisture channel to AMSU-B with overall benefits.

Work is continuing with the use of cloudy radiance data as indicated in a number of presentations. The DAO has shown that the use cloud-cleared radiances which were so difficult in the past are

now feasible provided you can account for their correlated errors in the final analysis step. The use of satellite measured clouds in NWP remains very limited. The only use of cloud data has been the rather crude assimilation of cloud data in limited area models (UKMO, NCEP, MSC). ECMWF is beginning a project to directly assimilate cloud information through their fast RT model. The problem of properly assimilating cloud data remains unsolved and will require at least several years of development.

Several Centers indicated they have developed or are developing mesoscale models and data assimilation systems. The impact of satellite data in regional/mesoscale data assimilation systems is limited by many factors such as: incomplete use of data over land sea/ice; lateral boundary influences; low model top; background error not adequate for regional/meso scales; inadequacies in the data (e.g., clouds and vertical resolution). The WG recognizes that mesoscale data assimilation is in embryonic state and significant development is necessary. Verification of the mesoscale forecasts is difficult and inadequate. Because of the inadequacies of mesoscale DA (MDAS), the full impact of this data cannot be judged at this time. Most Centers have developed and use their MDAS to improve their QPF forecasts and are generally satisfied with improvements in only QPF.

2.3.2 Evaluation and use of TOVS/ATOVS in DA/NWP

Large biases between background and observed radiances (both level 1b and level 1d) still remain and monitoring remains a very important step in the evaluation and preparation of the satellite data for assimilation. Many difficulties have been diagnosed and resolved by monitoring procedures. The WG continues to encourage the development of monitoring procedures as part of any Center's analysis procedure and to post monitoring results on their external web site.

Recommendation (to DA/NWP Centers)

The Working Group recommends the continued exchange of monitoring results and encourages each Center to develop their own Web page to post their results. A master document linking all Web pages has been developed and will reside on the NWP SAF site with a link to the ITWG Web site at CIMMS so everyone can easily examine and compare results from other groups to theirs.

The Working Group further recognizes that the specification of background and observational errors is critical for optimal assimilation of any data type and in particular radiances. Most DA/NWP Centers have recently updated their background and observational error covariances and the Working Group encourages exchanging these results so as to better understand the impact of the a-priori statistics on TOVS data assimilation.

Recommendation (to DA/NWP Centers)

The Group recognizes the difficulty in implementing and validating radiance/retrieval data in a DA/NWP system and recommends that those that have prepared so-called one-observation experiment in the development of their assimilation system post them on their Web page. Since there is more than one fast RTM used, it will indirectly measure the ability of each RTM to project radiance data information onto the atmospheric state variables. Indirectly, this will also indicate what are the effective measures of background and observational error statistics used at each Center. (Action: C. Chouinard to coordinate).

The WG recognizes the importance of Observing System Experiments (OSE's) to quantify the impact of individual sources of data. The results of OSE's are also useful in the decision making process in agencies.

Recommendation (to DA/NWP Centers)

Encourage the preparation of OSE's at various NWP Centers to be presented at the next ITWG meeting and post these results on the ITWG website.

The results of the ITWG survey presented at this meeting and reproduced in the Table 2.3 below, indicates the NWP community still has operational requirements at various levels for NOAA/NESDIS/ATOVS data processing from level-1b through preprocessed (PP) level-1d radiances, to retrieved products.

Table 2.3. Use of ATOVS data in operational NWP. ITWG survey of systems at 01/02/2002.

Institute	Retrievals in Global NWP	Retrievals in Regional NWP	Radiances in Global NWP	Radiances in Regional NWP	WWW Data Monitoring
Australia	NESDIS (above 100)		YES - PP (via 1D-Var)		
Canada (CMC)	NESDIS (ensemble)		YES - 1b (via 3D-Var)	YES - 1b (via 3D-Var)	YES
ECMWF			YES - 1b (via 4D-Var)		YES
France			YES - PP (via 4D-Var)		
Germany (DWD)	NESDIS				
India	NESDIS				
Japan	NESDIS	NESDIS			
Korea			YES - PP (via 1D-Var)		
Sweden					
UK			YES - 1b (via 3D-Var)		YES
USA (NCEP)			YES - 1b (via 3D-SSI)	YES - 1b (via 3D-SSI)	YES
USA (NRL)	NESDIS	NESDIS			

Notes on the survey:

When questioned about systematic blacklisting of data, the most common theme is the very limited use of tropospheric data (radiances or retrievals) over land and ice. This is true for microwave and infrared.

The Working Group and data providers found this study to be very useful. Because the use and the requirement of data are rapidly changing, and in order to better serve the users:

Recommendation (to ITSC)

The Group recommends that the McNally survey summary grid be continued and posted on the ITWG Web site. When changes are made at various NWP centers on the use of data, that McNally be advised, the grid updated accordingly, and the changes be logged on the Web page. (Action: T. McNally to coordinate).

The results of the survey indicate that the majority of DA/ NWP Centers still rely upon NESDIS retrieved products and processed level-1b and level-1d data for their operational forecasting systems. The Group wishes to acknowledge this fact and support the continuing efforts of NOAA/NESDIS and EUMETSAT in their crucial role. This Inter-agency collaboration has been very beneficial. The WG wants to commend the progress at NESDIS in change notification and monitoring of the data since the last meeting.

Recommendation (to NOAA/NESDIS and EUMETSAT)

The Group recommends that the data provider do quality assurance of all data, including level 1b and level 1d. The quality of the data (including e.g. navigation) should be monitored at all stages including the final stage, which may have been reformatted. The provider should attempt to identify and flag questionable or poor quality data. Data providers, e.g. EUMETSAT and NOAA/NESDIS are encouraged to use NWP monitoring results to help them in diagnosing data problems. The Group recognizes that it is easy to identify gross errors, while subtle errors are more difficult to detect. Action: V. Tabor (NESDIS), D. Klaes (EUMETSAT).

There has been some questions raised at this meeting as to the use of uncorrected antenna temperatures of microwave instruments. The WG is concerned that biases are being introduced by the antenna correction and that users may start to use antenna temperature as if they were brightness temperatures.

Action

Evaluate and improve the current procedures to convert antenna temperatures to brightness temperatures (NESDIS and DoD)

There has been indication at this meeting that the data from central data producers may be different to that derived through AAPP, and these may be due to different calibration and navigation algorithms.

Action

Determine why different navigation information is being distributed in comparison with that being used in operations (V. Tabor, NESDIS)

Action

Encourage the collaboration between the local readout software developers and the data producers to minimize the differences between the global and local calibrated and navigated data (AAPP developers, space agencies)

In at least one presentation at this meeting, there was further evidence from sensitivity experiments that forecast errors develop in cloudy regions. This may explain the larger impact from the AMSU data when compared to the HIRS data and may have implications for future instrument design.

2.3.3 Forward Modelling

The WG is concerned with the development of RT code for new instruments. The RTM codes developed by each group (e.g. IASI/AIRS) does not follow the universal interface policy of RTTOV-6 and its predecessors. The Working Group is worried that these RTM may be difficult to use at DA/NWP Centers. The use of different RT codes in NWP for different satellites is a serious maintenance issue.

Recommendation

We encourage the developers of new instruments to either expand or enhance current RT code, or develop general codes applicable to all instruments and make it available.

2.3.4 Future platforms and real-time access to data

The WG recognizes that the preparations for AIRS were well done, and encourages future satellite programs to take the lead. The Group supports the efforts of M. Goldberg and colleagues at NOAA/NESDIS in disseminating AIRS data (decimated in several different ways) in real time BUFR format and encourages other agencies to continue to support such efforts, especially with regards to experimental data sets.

2.4 ADVANCED SOUNDERS

Working Group members: J.Eyre (Chair), M.Goldberg (Co-Chair), R.Bennartz, H.Bloom, D.Blumstein, N.Chauhan, A.Collard, N.Fourrié, D.Frank, A.Huang, S.Johnson, D.Klaes, J.Le Marshall, J.Li, L.Lavanant, M.Lynch, T.Phulpin, J.Predina, J.Puschell, F.Rabier, G.Rochard, H.Roquet, F.Romano, V.Sherlock, B.Tournier, A.Uspensky, P.Watts, W.Wolf, X.Wu, W.Zhang

2.4.1 Status of plans for advanced sounding instruments

The working group noted progress on plans for five advanced infra-red sounders: AIRS (Advanced Infrared Sounder), IASI (Infra-red Atmospheric Sounding Interferometer), CrIS (Cross-track Infrared Sounder), IRFS-2 (Infra-Red Fourier-transform Spectrometer) and GIFTS (Geostationary Imaging Fourier Transform Spectrometer). Table 2.4-1 summarizes characteristics of these instruments, and Figure 2.4-1 summarizes their planned operating periods. The characteristics of these instruments are described in more detail in the Reports of ITSC-X and ITSC-XI.

The working group also noted progress on plans for advanced microwave sounders. It proposed that comparable information on these instruments should be tabulated and made available, along with information on advanced infra-red sounders, on the ITWG web site.

Action

J.Eyre (Met. Office, Bracknell) to compile summary information on advanced sounders, for posting on ITWG web site.

2.4.2 New initiatives for geostationary sounding

Proposals have been prepared, in both the USA and Europe, to fly millimetre/sub-millimetre radiometers with sounding and imaging capabilities on geostationary satellites. To achieve required horizontal resolutions with reasonable antenna size, these instruments would use high frequencies (bands between 100 and 500 GHz), which are more sensitive to cloud and precipitation than channels used for temperature sounding from polar orbit (i.e. 50-60 GHz). However, the geostationary orbit is particularly well suited to observing time-evolving phenomena related to clouds and precipitation, which can develop rapidly and for which frequent measurements are required to support improvements in nowcasting and short-range forecasting. The working group supported the concept of an experimental mission to demonstrate this technology and suggested that priority be given to channels suited to sensing precipitation, cloud and humidity.

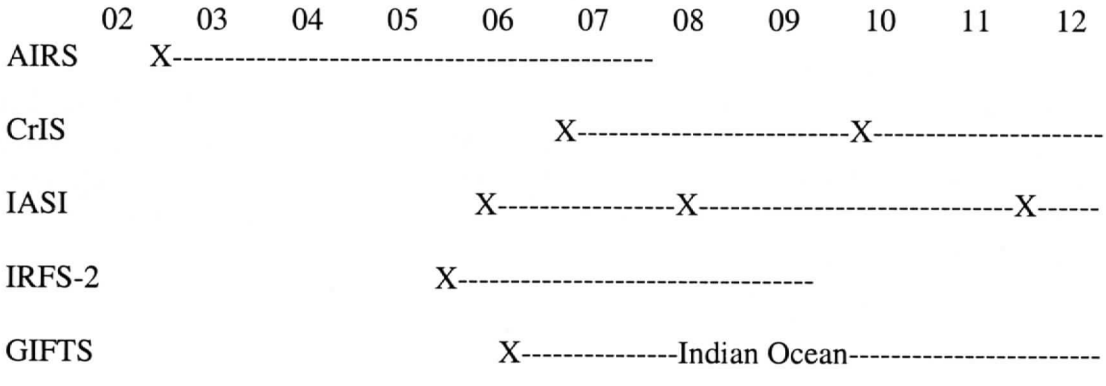
Recommendation (to CGMS)

ITWG recommends that a geostationary millimetre/sub-millimetre radiometer mission should be pursued as a technology demonstrator, with priority towards measurement of precipitation, cloud water/ice and humidity at high temporal frequency in support of nowcasting and short-range forecasting, and as a potential future contribution to the Global Precipitation Mission.

Table 2.4-1 Characteristics of Advanced Infrared Sounders

Name	AIRS	IASI	CrIS	IRFS-2	GIFTS
Orbit	705 km	833 km	824 km	850 km	Geostationary
Instrument type	Grating	FTS	FTS	FTS	FTS
Agency and Producer	NASA JPL/ LoMIRIS	EUMETSAT/ CNES Alcatel	IPO (DoD/NOAA/ NASA) ITT	Russian Aviation and Space Agency	NASA/NOAA / Navy. Space Dynamics Lab.
Spectral range (cm^{-1})	649 –1135 1217–1613 2169 –2674	Contiguous 645-2760	650 –1095 1210 –1750 2155 –2550	665 –2000	685-1130 1650-2250
Unapodized spectral resolving power	1000 – 1400	2000 – 4000	900 – 1800	2000	2000
Field of view (km)	13 x 7	12	14	35	4
Sampling density per 50 km square	9	4	9	1	144
Power (W)	225	200	86	50	255
Mass (kg)	140	230	81	45-50	60
Platform	Aqua	METOP-1,2,3	NPP and NPOESS C1	METEOR 3M N2	Geostationary
Launch date	2002	2005	2006 for NPP 2009 for C1	2005	2006

Figure 2.4-1 Advanced IR Sounder Timeline



2.4.3 Distribution of simulated datasets for advanced sounders

AIRS data, along with AMSU-A and HSB from NASA's Aqua mission, will be provided to several NWP centres in near-real time so that the utilization and impact of high spectral resolution infra-red data in NWP models can be demonstrated prior to the operational missions of IASI and CrIS. The recommendation of ITSC-XI concerning the distribution of near-real time **simulated** data for AIRS/AMSU-A/HSB had been valuable in supporting the case for this service, which was now in place and was playing an important role in allowing NWP centres to make effective preparation for the exploitation of real AIRS data, following the launch of Aqua (planned for April 2002). The meeting commended NASA and NOAA for providing this service and recommended that similar services should be established as part of the preparatory activities for other advanced sounders.

Recommendation (to CGMS)

The ITWG notes the high value of simulated AIRS data, distributed in near-real time, in assisting NWP centres to make effective preparation for real AIRS data, and it recommends that similar services should be established as part of the preparatory activities for other advanced sounders.

Action

M.Goldberg (NOAA/NESDIS/ORA) to draft short paper for CGMS describing the AIRS data simulation system and its use.

2.4.4 Data processing, inversion and assimilation

2.4.4.1 Distribution of ingest and pre-processing code

The working group reaffirmed the importance of the availability of "ingest" code (code to process raw data to level 1b data) and pre-processing code (code to process from level 1b to a point suitable for retrieval or assimilation for NWP or for other applications) to all users who intend to receive and process the raw data, **for all advanced sounders and their complementary imagers**. Instrument combinations for which this will be required (and their responsible agencies) include:

Satellite	Instruments	Agency
METOP	IASI+AMSU-A+MHS+AVHRR	EUMETSAT
Aqua	AIRS+AMSU-A+HSB+MODIS+AMSR	NASA
NPP	CrIS+ATMS+VIIRS	NASA/NOAA
NPOESS	CrIS+ATMS+VIIRS+CMIS	IPO
FY-3	MWTS+MWHS+IRAS	NSMC
Meteor-3M N2	IRFS-2+MTVZA-OK+GLOBUS	RASA/Roshydromet
GIFTS	GIFTS	NASA
GOES-R,...	ABS+ABI	NOAA

(See §2.4.6 for list of acronyms)

For global data, the global processing centres will be the responsible agencies. Plans are in place to deliver the necessary software for this purpose. However, for locally-received, direct read-out data, it will be necessary to distribute suitable ingest code to users for local implementation. This code should be compatible, in output content and quality, with equivalent code for global

processing. With the exception of EUMETSAT plans for IASI/AMSU-A/MHS/AVHRR and NASA/CIMSS plans for AIRS/AMSU-A/HSB/MODIS, plans in this area are not mature, and further developments are needed to ensure timely distribution and implementation. Without such developments, direct read-out data will not be exploited effectively.

In each case, **it will be helpful to establish, for each instrument set, a focal point** responsible for ensuring that ingest and pre-processing code is provided suitable for locally received data and yielding output consistent with global data, and that activities are undertaken to integrate this code into processing packages available for international distribution in a timely manner.

Recommendation (to CGMS)

ITWG recommends that responsible agencies establish focal points to ensure that:

- **ingest and pre-processing code for future advanced sounders (and their complementary imagers) is provided, in a form suitable for use with locally-received direct read-out data, and yielding output consistent with global data, and**
- **activities are undertaken to integrate this code into processing packages available for international distribution in a timely manner.**

The Working Group noted that plans exist to put in place ingest code for NPP instruments (CrIS, ATMS and VIIRS) on the required timeframe, but that there were no mature plans to incorporate this code into a processing package for locally received data.

Recommendation (to IPO and NASA)

ITWG recommends that ingest code for NPP instruments (CrIS, ATMS and VIIRS), to be made available by IPO, should be integrated into a processing package for locally received data.

MODIS data from Terra has provided unprecedented capabilities for observing clouds, the Earth's surface and the atmosphere. International direct broadcast users of Terra-MODIS, and in the near future Aqua-MODIS, will benefit greatly from these well-characterised data.

Recommendation (to NASA)

It is important that NASA continue to provide MODIS instrument status, navigation and frequently-updated calibration information in a timely manner to users and developers, to maximise the benefit of MODIS data for environmental monitoring and weather forecasting.

The Working Group noted progress on establishing the draft specifications for the data records for NPOESS and NPP. The Working Group reaffirmed the value of user feedback on these drafts before they are finalised.

Recommendation (to IPO)

ITWG recommends that the user community be provided with and invited to review the draft specifications (content and format) for the raw data records (RDRs) and sensor data records (SDRs) for NPOESS/NPP instruments.

Action (H.Bloom, NPOESS/IPO)

To inform ITWG members, through the ITWG list server, of the location of draft specifications of RDRs and SDRs for NPOESS/NPP instruments.

Action (J.Eyre, via ITWG co-chairs)

To co-ordinate feedback to IPO from ITWG members on the draft specifications (content and format) for the raw data records (RDRs) and sensor data records (SDRs) for NPOESS/NPP instruments.

2.4.4.2 Cloud detection and characterisation

At ITSC-XI, it was noted that advanced sounder data are most easily used in NWP when the field of view is free of cloud and when this condition can be recognised with a high degree of confidence. Accurate methods for detecting the presence of cloud are therefore very important. Approaches for improving cloud detection methods included use of coincident high-resolution imagery (e.g. AVHRR with IASI, MODIS with AIRS). ITWG therefore recommended support for the scientific and technical developments required to use coincident MODIS data to improve the cloud detection for AIRS. The Working Group noted that this recommendation had been instrumental in securing the necessary resources for this work and thanked NASA and NOAA for facilitating this work.

For NWP, observations are most important if they help to improve the analysis in "sensitive areas", i.e. regions within baroclinic zones out of which small errors in the analysis grow rapidly to become large errors in the subsequent forecast. It has previously been demonstrated that advanced infra-red sounders will be more successful than current instruments in providing information on the details on the tropospheric temperature structure that are typical in these areas, provided that the effects of cloud are not too great. Research presented at ITSC-XI and confirmed at ITSC-XII has suggested that these sensitive areas are usually cloudy, but in a significant proportion of cases only at low levels. It is therefore important that the NWP data assimilation community makes progress on the assimilation of cloud-affected radiances, and particularly those that are only affected by low cloud.

Recommendation

ITWG encourages research into the assimilation of cloud-affected infra-red radiances, as this may be crucial to the effective exploitation in NWP of advanced sounder data from meteorologically sensitive areas. It encourages investigation of a wide variety of methods including: (1) assimilation of cloudy radiances in "simple" cloud conditions (i.e. homogeneous, low-level clouds), and (2) assimilation of cloud-cleared radiances. ["Cloud-cleared" radiances are clear radiances estimated from cloud-affected radiances.]

The Working Group discussed two important advantages arising from small fields-of-view (fovs) for advanced infra-red sounders:

- to maximise the probability of obtaining clear fovs in partly cloudy areas,
- in the case of interferometric sounders, to maximise the probability of the fov being filled homogeneously (either clear or cloudy), and so to avoid noise contributions arising from artifacts in the derived spectra caused by inhomogeneities in the fov.

Recommendation (to NOAA)

ITWG encourages NOAA to re-examine the requirements on field-of-view size for CrIS.

2.4.5 Characterisation of spectral response

Accurate knowledge of the spectral response of the instrument is crucial to a correct interpretation of the data; errors in the assumed spectral response appear as errors in either the pre-processed measurements or in the forward modelling of the data. Studies have already been performed to characterise the spectral response of IASI such that the associated errors are well below instrument noise level. Studies are needed to characterise the responses of similar instruments in the same way.

Recommendations (to space agencies)

ITWG recommends that the spectral responses of advanced sounders should be characterised:

- **to a level at which the associated error does not cause the total noise budget of the instrument to be exceeded,**
- **and, where achievable at reasonable cost, to a level at which the associated error is a negligible contribution to the total system noise.**

2.4.6 Glossary of instruments

ABS	Advanced Baseline Sounder (for GOES-R+)
ABI	Advanced Baseline Imager (for GOES-R+)
AIRS	Advanced Infrared Sounder
AMSR	Advanced Microwave Scanning Radiometer
AMSU-A	Advanced Microwave Sounding Unit - A
ATMS	Advanced Technology Microwave Sounder
AVHRR	Advanced Very High Resolution Radiometer
CMIS	Conical-scanning Microwave Imager/Sounder
CrIS	Cross-track Infrared Sounder
GIFTS	Geostationary Imaging Fourier Transform Spectrometer
GLOBUS	Multi-channel scanning radiometer
HSB	Humidity Sounder - Brazil
IASI	Infra-red Atmospheric Sounding Interferometer
IRAS	Infra-red Atmospheric Sounder
IRFS-2	Infra-Red Fourier-transform Spectrometer
MHS	Microwave Humidity Sounder
MODIS	MODerate-resolution Imaging Spectrometer
MTVZA-OK	Module for atmospheric temperature and humidity sounding - oceans
MWTS	MicroWave atmospheric Temperature Sounder
MWHS	MicroWave atmospheric Humidity Sounder
VIIRS	Visible/Infrared Imager Radiometer Suite

2.5 INTERNATIONAL ISSUES AND FUTURE SYSTEMS

Working Group members: D. Hinsman (Chair), J. Bates, H. Bloom, N. Chauhan, C. Chouinard, J. Derber, J. Eyre, A. Gasiewski, M. Goldberg, D. Griersmith, S. Johnson, D. Klaes, J. LeMarshall, M. Lynch, P. Menzel, J. Puschell, T. Reale, G. Reichert, G. Rochard, A. Uspensky, J. Wilson and W. Zhang

2.5.1 Introduction

The Working Group reviewed the progress made since the last ITSC as well as issues raised during the present ITSC. It noted that almost all action items and recommendations had been accomplished and those that remained fell into seven categories: data access, data dissemination, data monitoring, equator crossing times for polar-orbiting satellites, the ITWG web site, radio frequency matters and the need for a new working group for radio occultation soundings. The Working Group noted in particular the efforts by the Co-chairs to take the necessary actions towards the completion of the recommendations and thanked them for their efforts.

It noted that the presentations by the satellite operators, as has been made at previous ITSC, were most informative and generated many useful discussions both during the presentations and afterwards. The purpose of such presentations was to allow ITSC meetings to have a comprehensive perspective of the future for satellite soundings. **Thus, the Working Group strongly encouraged the continuation of such presentation at future ITSC meetings.**

2.5.2 Data access

The Working Group was informed of the discussion at the Advanced Sounders Working Group concerning data access. It was informed that AIRS data, along with AMSU-A and HSB from NASA's Aqua mission, will be provided to several NWP centres in near-real time so that the utilization and impact of high spectral resolution infra-red data in NWP models can be demonstrated prior to the operational missions of IASI and CrIS. The recommendation of ITSC-XI concerning the distribution of near-real time simulated data for AIRS/AMSU-A/HSB had been valuable in making the case for this service, which was now in place and was playing an important role in allowing NWP centres to make effective preparation for the exploitation of real AIRS data, following the launch of Aqua. ITSC-XI had commended NASA and NOAA for providing this service and recommended that similar services should be established as part of the preparatory activities for other advanced sounders. The International Issues and Future Systems Working Group fully supported the findings by the Advanced IR Sounders Working Group and the recommendation and action it generated as recorded in the Advanced IR Sounders Working Group report.

The Working Group also noted the plans by WMO to expand the space-based component of the Global Observing System. It strongly urged that the issue of data access discussed above should also be considered by the R&D space agencies. **Since CGMS was an excellent forum for discussion and implementation of such recommendations, ITWG supported the proposal for an expansion of CGMS to include R&D space agencies contributing to the GOS and further encouraged an expanded CGMS to consider data access issues for R&D satellite missions.**

2.5.3 Data dissemination

The Working Group recalled that it had, at previous ITSCs, made recommendations to WMO to increase the capacity of the Global Telecommunications System (GTS) in order to handle not only the present volumes of satellite data and products but also the large increase in volume expected by

the end of this decade and beyond. It was pleased to note that the capacity of the GTS had been increased in some WMO regions, notably in Europe as well as between the USA and Europe, and that WMO Members should continue their efforts to implement similar system on a global basis.

The Working Group also noted the WMO initiative with regard to direct broadcast from environmental satellites. WMO was in the process of reviewing the data dissemination architecture from operational meteorological satellites and foresaw an evolution from solely direct broadcast to one that included direct broadcast to selected regional sites and alternative dissemination methods that would complement direct broadcast to meet the needs within the region. The need for the review was driven by the plans by the satellite operators to move to X-band direct broadcast which implied a near complete replacement of the present HRPT ground receiving stations worldwide. Such a replacement was felt by WMO to be unachievable. The regional sites would provide sufficient geographic coverage to meet the needs of all applications in the region. The alternative dissemination methods would include the use of Internet or Internet-like capabilities and/or commercial communications services. In acknowledging the expected massive increase in data volume, the Working Group supported the proposed WMO architecture. Furthermore, it encouraged WMO to include R&D satellite missions' dissemination in the architecture. The Working Group suggested that WMO also consider data redundancy without duplication in further developing the architecture. The Working Group noted that the ITWG had requirements for direct broadcast from environmental satellites, which were directly related to requirements for the availability of such data and the proposed WMO architecture had the potential to satisfy future ITWG requirements for data availability.

2.5.4 Data monitoring

The Working Group recalled that it had previously made recommendations related to the monitoring of satellite data and products. In noting the presentations during ITSC-12, the Working Group noted that considerable progress had been made by individual NWP centres in data monitoring. It also noted that the present WMO "lead centre" concept for data monitoring of all types was developed and implemented over 14 years ago. Since then, the monitoring of new satellite instruments as well as the availability of major improvements in Information Technologies had evolved in *an ad hoc* basis. The Working Group agreed that major NWP centres should monitor all data that are used within their system. Due to the varying types of assimilation and forecast systems found within the NWP centres, it may not be appropriate for any one centre to be expected to monitor all satellite data – including the various data levels. Thus, the Working Group proposed the following recommendation to WMO:

Recommendation

WMO should conduct a review of its "lead centre" for data monitoring process. As a initial step in the review, WMO should characterize the scope and intent of data monitoring for its purposes. The review should then be guided by that characterization. (D. Hinsman to inform Chairman OPAG IOS for discussion by CBS Management Group, deadline 1 April 2002)

2.5.6 Equator crossing times for polar-orbiting satellites

The Working Group was pleased to note the satellite operator plans for polar-orbit and that during the second half of the decade there existed the possibility for four polar-orbiting satellite series, NOAA/NPOESS, MetOp, FY-3 and Meteor 3M series. It was informed that both CMA and ROSHYDROMET had already expressed a willingness to consider moving their satellite series to the PM orbit when nearing nominal configuration. The Working Group noted that this would

provide a robust system of two satellites in both the AM and PM orbits each capable of backing-up the other. The Working Group noted that the satellite operators should strive to maintain long-term continuity of equator crossing time for their respective series while seeking to minimize any drift in the crossing time in order to maintain climatological records.

2.5.7 ITWG web site

The Working Group suggested that the ITWG web site include information related to data access for sounding instruments including relevant points of contact and metdata.

2.5.8 Radio frequency matters

The Working Group noted the importance for radio frequency allocations and protection within the International Telecommunications Union (ITU) context. With regard to passive microwave allocation and protection, the Working Group noted the need to provide scientific justification for specific RMS values for radiances observed from space. Thus, the Working Group agreed to the following action item:

Action

A. Gasiewski (NOAA) and G. Rochard (CMS) to prepare a draft two page paper, to be developed through email, containing scientific justification for specific RM values for radiance observed from space. (Deadline: June 2002)

2.5.9 Radio occultation sounding Working Group

The Working Group noted the strength of ITWG in maintaining focus as a passive sounding expert group. It recalled that CGMS 29 had requested that the ITWG take an action to investigate multi-satellite utilization for profile retrieval, specifically radio occultation with high spectral resolution infrared radiometers. At ITSC 12, a few presentations discussed the utility of radio occultation measurements for improving depiction of the tropopause location and estimation of stratospheric temperature profile beyond the information available from high spectral resolution infrared radiometers and microwave sounders. In discussing further action, the Working Group suggested that the broader community of radio occultation experts should be invited to summarize recent progress as a working paper to CGMS at their next meeting. Specifically, EUMETSAT should invite scientists participating in the CHAMP to submit such a report for a future CGMS.

Recommendation (to CGMS)

EUMETSAT should invite scientists involved in atmospheric sounding using radar occultation, in particular those participating in CHAMP, to submit a progress report for a future CGMS.

2.6 SATELLITE SOUNDER SCIENCE AND PRODUCTS

Working Group members: T.Reale and T.Achtor (Co-Chairs), with F.Weng, V. Prasad, L. Hong, E.Borbas, J.Li, S.Buehler, L.Lavanant, J.Carvalho, I.Dyras, J.Predina, E.Silvestre, M.Ahn, W.Zhang, X.Wu, M.Goldberg, F.Romano, M.Uddstrom, A.Apostolou, and D.Griersmith

2.6.1 Introduction

The Working Group on Satellite Sounder Science and Products (SSSP) was formed to promote the development and utilization of meteorological techniques and products from operational and research weather satellites for weather and climate applications. The focus is primarily on polar orbiting satellites, as they provide global coverage, although common measurements and innovative concepts on geostationary satellites are also important to this group. The goals of the SSSP are achieved by providing a central location for information dissemination and exchange related to international scientific activities, data access and validation, with the goal of enhancing communication and collaboration among and between the research and operational communities.

An important mechanism for achieving these goals is the development and maintenance of a SSSP web site, within the current ITWG web site, which provides information on operational and research satellite scientific algorithms, data sources and availability, evaluation, and contact information. In addition, the web site provides a source of ancillary information on operational and research instrumentation status, launches, and primary issues concerning the research and user community.

2.6.2 Discussion

Discussions of the SSSP Working Group at ITSC-12 focused on issues concerning the SSSP web site, including the web site structure and content, attracting additional contributors, guidelines for contributions, providing contact information on data sources and availability, and links to direct broadcast data and software packages. The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin, Madison will maintain the SSSP web site.

The SSSP Working Group will also advocate programs to promote measurement and product validation on a regional and global scale in support of current and future operational and research satellites. Programs include studies on the potential benefits of a global network of ground base observations dedicated to polar satellite instrument calibration (i.e. concurrent with satellite overpass), and the promotion of scientific algorithm, product validation and case study intercomparisons among working group members and collaborators.

The SSSP Working Group also agreed to identify and promote important research topics concerning current weather satellites for continued and/or expanded investigation to be developed through interaction with other ITWG working groups.

2.6.3 Actions and Recommendations

NOAA is acknowledged as a primary source of archived operational satellite data and is encouraged to continue to provide archived operational satellite data (level 1b through level 2) and corresponding validation data sets (i.e., data collocated with radiosondes) that are easily accessible on line, to users worldwide, and at no cost when possible, for research purposes. The data should be accessible via various search criteria (i.e. sensor name, time, location, spectral band, etc). The Satellite Active Archive (SAA) operated by the National Climatic Data Center (NCDC) is acknowledged for its outstanding contribution in this area.

In relation to these data holdings we propose:

Action

Promote activity to append level 1b raw satellite observations to existing historical datasets of collocated radiosonde and TOVS and ATOVS observations, and to encourage such methods in current and planned operational systems (T. Reale, NESDIS).

CIMSS is also commended for their initial efforts in creating the SSSP web site, and for continuing to coordinate and manage the ITWG SSSP web site. The SSSP Working Group will be responsible for recruiting contributors (with guidelines for contributions and metadata), providing contact information on data sources and availability, and providing links to direct broadcast data and software packages.

Action

Write and distribute a statement asking Web Site contributors to help broaden participation by contacting others in their country / region or others in their discipline and encouraging them to contribute to the SSSP web site (T. Reale, NESDIS and T. Achtor, CIMSS/SSEC).

Action

Provide information for the SSSP Web Site on NOAA data resources, availability and access information (V. Tabor, NOAA/NESDIS/IPD).

Action

Provide link(s) for the SSSP Web Site to Direct Broadcast software packages and data (T. Achtor, CIMSS/SSEC and L. Lavanant, CMS).

Action

Provide routine information for the SSSP Web Site on current operational and research instrument status (T. Reale, NESDIS).

Action

Divide SSSP Web Site contributors by research (technique) vs. operations (product) (T. Achtor, CIMSS/SSEC).

Ongoing programs dedicated to the global validation of operational and research satellite data are sometimes inadequate. The ITWG SSSP and Climate Sub Groups propose to advocate, initiate and promote studies to define requirements for a permanent, reliable, global ground truth validation programs in support of operational and research polar satellite observations.

Action

Design and conduct studies in conjunction with current and planned calibration/validation experiments (e.g. DOE ARM Sites) to quantify the usefulness of conventional upper air (i.e., radiosonde, profiler, etc) data to monitor polar satellite radiometer performance, their impact on climate and weather applications, and to provide recommendations concerning long term needs for continuous, global monitoring of environmental satellite data (J. Bates, NOAA and T. Reale, NESDIS).

Action

Actively promote product validation and intercomparison studies (e.g., among product and/or software developers) (T. Reale, L. Lavanant and T. Achtor).

Action (to the SSSP)

Take an active role to identify important research topics involving current weather satellites, including topics for continued and/or expanded investigation (to be developed through interaction with other ITWG sub groups) (T. Reale, T. Achtor, and other Working Group Co-Chairs).

In relation to product developers, consideration should be given to expanding the use of gridded formats to facilitate the validation, intercomparison and ultimately the use of derived products in routine NWP and climate analysis, particularly for conventional data sparse and limited accuracy parameters such as upper tropospheric temperature, upper tropospheric moisture and clouds.

Action

Promote consideration of the use of gridded file product formatters in routine operational data processing at NESDIS, including time averaged (monthly) gridded files for selected, conventional data poor parameters (M. Chalfant, NESDIS).

3. REPORTS OF TECHNICAL SUB-GROUPS

3.1 TECHNICAL SUB-GROUP ON THE ATOVS AND AVHRR PROCESSING PACKAGE (AAPP) AND THE INVERSION COUPLED WITH IMAGER (ICI)

3.1.1 Background

AAPP was a joint development of a number of European institutions, under co-ordination of EUMETSAT, for the pre-processing of HRPT direct readout data from NOAA polar orbiting satellites. AAPP produces, in a suite of processing steps, level 1b, level 1c and level 1d output files. The AAPP level 1d file is the interface to numerous Level 2 processing packages, which are used and available world wide.

AAPP has been distributed world wide by EUMETSAT and installed successfully by about 200 Users. The current version is AAPP V3.2 which includes some minor updates to the CD-version AAPP 3.0, which has been distributed in summer 2001. AAPP is now maintained and further developed by the EUMETSAT SAF for NWP and distributed by EUMETSAT to the User community as a SAF deliverable.

ICI is a Level 2 processing package and was developed and maintained by Météo-France. It is now provided and maintained as deliverable of the SAF for NWP, as AAPP. ICI is currently available in V3.0 and generates retrieved temperature and moisture profiles.

3.1.2 Bugs and Problems

During the upgrades of both packages to version 3.0 some bug-fixes have been included. V3.0 of AAPP includes all fixes to bugs reported since release of V2.0. Since the release of ICIV3.0 two bugs were reported. Solutions to the problems are reported on EUMETSAT's AAPP web-page.

http://www.eumetsat.de/en/area4/aapp/bugs.html

Three problems, which have been recognised during operation of AAPP, need attention.

1. It seems that there is a problem in the navigation of NOAA-15 and -16 data, which manifests itself in mis-location of local data or/and missing or wrong navigation (order of 10 km) of portions of lines. It was noted that the reason of this error is presently unknown. There is a need to investigate this error.

Action (EUMETSAT/NWP SAF)

To investigate this error.

Note: also action on NESDIS from NWP WG.

2. The Group noted that there is an important inconsistency between the global and local calibration of ATOVS sounding data. This has been demonstrated by Pascal Brunel's study. For AMSU-A the differences are acceptable (occasionally in the order of 0.6 K). For the HIRS data however the discrepancy is dramatic and can reach the order of several K. The difference occurs before the first and after the last calibration cycle of a local path. In AAPP the calibration coefficient is linearly interpolated. NESDIS uses the secondary mirror temperature

to provide a non-linear contribution to the calibration of global data. The coefficients are derived from global orbits of the previous day, which is not possible for locally received data. It is needed to know the shape of the calibration cycle and to establish the history of the variability of the coefficients.

Recommendation (EUMETSAT / NWP SAF) to conduct a study on this issue.

Action (S.English)

To provide monitoring information on the HIRS calibration information based on NESDIS level 1b data received at Bracknell and consistent local data.

It was noted that this effect will severely affect the planned ATOVS retransmission service, since it may make combined orbits useless for NWP.

Action (D. Klaes)

To bring this problem to the attention of the project management of the Retransmission Service.

3. It was noted from Mitch Goldberg's presentation that there is a problem in the Antenna correction for NOAA15/NOAA16. There is a need to investigate and check on the consistency of global/local processing.

Action (S. English)

To check whether Mitch Goldberg's finding look similar as the bias correction performed and to provide the information to NESDIS.
To check the antenna corrections used by AAPP for NOAA-15 and NOAA-16.

3.1.3 Information Exchange

The current scheme for the exchange of information between all involved parties was considered as sufficient.

- EUMETSAT distributes new releases (Vn.0) of AAPP on CD-ROM on an 18 month cycle basis. Temporary updates (Vn.i) are distributed via EUMETSAT's ftp-server (ftp.eumetsat.de). EUMETSAT informs the Users of new releases and updates and any other AAPP related subject via EUMETSAT's AAPP Internet Forum:

  L-AAPP@eumetsat.de

- The users can pass requests and information to EUMETSAT via EUMETSAT's User Service ops@eumetsat.de or to the AAPP helpdesk keith.wythe@metoffice.com

- The AAPP Internet Forum allows users to communicate to each other via e-mail and automatically addresses all forum participants.

It was noted that the link to the NWP SAF home page is missing on EUMETSAT's AAPP web-page.

Action (D. Klaes)

To provide this link in the AAPP Web-page.

3.1.4 New Modules

AAPP V4.0 is planned to be made available to users in February 2003. New modules anticipated:

- HIRS calibration coefficient update module (see above)
- Moonlight correction for AMSU

3.1.5 Data Visualisation

Action (all)

Web page of NWP SAF: Additional contributions are invited.

3.1.6 New Platforms

AAPP has been successfully installed on SUN, HP, SGI, DEC and IBM platforms. No new platforms were identified.

Action (A. Uspensky) (open from ITSC-XI)

Make the Windows AAPP installation available

It was noted that many new platform hardware provider do not provide F77 compilers any more with their workstations (e.g. HP). Hence a port towards F90 may be necessary. It was further noted that the NWP SAF currently assesses the effort, which would be required to do so.

3.1.7 AAPP License

Users can request a license for AAPP and ICI via EUMETSAT's web-page:

http://www.eumetsat.de/en/area4/aapp/get-aapp/get-aapp.html

http://www.eumetsat.de/en/area4/aapp/get-ici/get-ici.html

3.2 TECHNICAL SUB-GROUP ON THE INTERNATIONAL ATOVS PROCESSING PACKAGE - FURTHER DEVELOPMENT

3.2.1 General Summary

The International ATOVS Processing Package (IAPP) has been developed to retrieve the atmospheric temperature profile, moisture profile, total ozone and other parameters in both clear and cloudy atmospheres from ATOVS radiance measurements. The IAPP algorithm typically retrieves the parameters in 4 steps: 1) cloud detection and removal; 2) bias adjustment; 3) regression retrieval; and 4) nonlinear iterative physical retrieval. A publication by Li, Wolf, Menzel, Zhang, Huang and Achtor, *Journal of Applied Meteorology* (August 2000) provides details on many of the algorithms.

3.2.2 IAPP Versions 1.0, 1.1 and 2.0

IAPP v1.0 was released to the international community in April, 1999. Version 1.1, consisting primarily of small improvements and software fixes, was released in June, 2000.

A major upgrade to the IAPP, version 2.0, was released in June 2001. The IAPPv2.0 is designed to work with the AAPP (AVHRR and ATOVS Preprocessing Package) level 1-D output file. The AAPP must be acquired independently from EUMETSAT.

The IAPP currently uses radiances from HIRS-3, AMSU-A, and AMSU-B on NOAA-15, -16, and -17, preprocessed into the AAPP 1-D format, for retrieval. Ancillary data inputs for retrieval are high resolution topography (supplied), surface observations (see below) and numerical model data (see below). The user can specify retrieval coverage by latitude and longitude bounds. The IAPP performs temperature and moisture retrieval calculation on a 3x3 HIRS field of view (fov) matrix, or field-of-regard (FOR). HIRS and AMSU-A radiances are used for clear/cloudy fov determination. Depending on clouds, a HIRS + AMSU-A + AMSU-B retrieval, an AMSU-A + AMSU-B (i.e., no-HIRS) retrieval, or no retrieval is made for each FOR.

Cloud top pressure (height) and effective cloud amount are derived from the CO_2-slicing technique, if forecast profiles are available for the retrieval process. The output file is in NetCDF format. Detailed information is provided in the documentation.

Surface data in the WMO Metar format is used, if available, to improve surface condition definition. If surface observations are not available, numerical model data is used to define surface conditions, or, with neither available, window channel radiances are used to best approximate surface conditions. We strongly recommend using Metar surface information and/or NWP output to better describe surface conditions in retrieval processing.

Numerical model output can be used as a first guess field for the atmosphere and surface. Model can readily be adapted to fit into the IAPP retrieval scheme. Clearly written documentation makes this task relatively straightforward. Alternatively, a regression scheme, based on synthetic radiance calculations, can be used to provide a first guess. Detailed information is provided in the documentation.

3.2.3 Visualization

A set of powerful visualization / data manipulation tools for ATOVS and IAPP output has been created within the Man-computer Interactive Data Access System (McIDAS). Basic imaging capability is available for all bands of AVHRR, HIRS and AMSU. Any NOAA AVHRR or

ATOVS radiance value and/or IAPP field can be plotted or contoured over the imagery.

McIDAS also includes the potential to display many other types of satellite and conventional data, based on the users access to the data.

3.2.4 Obtaining IAPP

Send an email to thomas.achtor@ssec.wisc.edu requesting the current release of IAPP. He will respond with an ftp address and instructions to download the package, which is about 35 mb. If you cannot obtain the IAPP via ftp, the package on CD-ROM, can be sent, but will take a week or two longer.

3.3 INTERNATIONAL MODIS/AIRS PROCESSING PACKAGE: IMAPP

3.3.1 General

An International MODIS/AIRS Processing Package (IMAPP) has been developed for processing of EOS MODIS data for weather, climate, nowcasting, NWP, cloud properties, and radiation budget studies. Future system capabilities will encompass EOS Aqua AIRS (Atmospheric Infrared Sounder) data reception and processing. Here, we briefly address the details of system, MODIS product requirements, and expectations of the International TOVS community.

3.3.2 Background

The MODIS and AIRS instruments onboard the EOS Terra and EOS Aqua platforms provide greatly enhanced remote sensing capabilities for the observation of planet Earth. The ability to receive the data stream in a timely manner and accomplish fundamental processing to transform sensor measurements to radiances and geophysical products is a key to utilizing these data. For this purpose, the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison and other groups in the United States, along with international groups around the globe, have installed, and continue to install X-band ground stations to receive the direct broadcast data stream from the EOS Terra and EOS Aqua platforms.

3.3.3 Science Objectives

Key science products and objectives are listed below.

a) ***Cloud Mask*** A cloud detection product has been developed.
b) ***Total Precipitable Water (TPW)*** An IMAPP MODIS TPW model has been completed.
c) ***Sea Surface Temperature (SST) and Land Surface Temperature (LST)*** An IMAPP MODIS SST/LST product has been completed.
d) ***Total Column Ozone*** An IMAPP MODIS-derived total column ozone product has been completed.
e) ***Temperature Profile*** An (example) IMAPP MODIS 500 hPa temperature retrieval product has been developed.
f) ***Water Vapor*** An IMAPP MODIS water vapor product has been developed.
g) ***Surface Emissivity*** An IMAPP MODIS shortwave infrared surface emissivity product is available.
h) ***Future MODIS/AIRS Synergistic Products*** Future Synergistic Level-2 products will also be derived when both MODIS and AIRS data are available through direct broadcast of the Aqua satellite.

3.3.4 Processing Strategy

Upon reception, the direct broadcast data stream can be processed to derive calibrated, geo-located MODIS and AIRS radiances (Level-1B data). In order to conduct interdisciplinary studies with MODIS and AIRS data, the international EOS direct broadcast community and, of course, the ITWG has expressed a strong desire for a software package which uses well-established algorithms to process MODIS and AIRS data to Level-1. In addition, there are also several geophysical products (e.g. cloud mask, temperature and moisture profiles) that would directly facilitate the use of MODIS and AIRS direct broadcast data by the international science community, such as in the field of numerical weather prediction.

3.3.5 Revision History

May 1, 2002 (MODIS Level 2 v1.1) First science product release for Terra MODIS:

- This release includes the MODIS Cloud Mask (MOD35) and Cloud Top Properties (MOD06CT) algorithms. The release consists of an ancillary data extractor, a set of flat file radiance/geolocation extractors, the cloud mask software and the cloud top properties software. The extractors serve as data preprocessors for the science software packages. Production scripts exist as part of both the cloud mask and cloud top properties packages which will execute the extractors and product software in sequence. Please see the README files. The cloud mask software is updated to production version 3.1.1, whereas the cloud top properties and cloud phase software is updated to version 3.1.0.

December 3, 2001 (MODIS Level 1 v1.3) Third update for Terra MODIS:

- The calibration algorithm and lookup tables are updated to versions 3.0.0 and 3.0.0.7, respectively. This version includes calibration data for the A-side electronics on MODIS following the outage which occurred from June 15 to July 3, 2001. The calibration algorithm in IMAPP v1.3 is date sensitive, and may be used for all Terra MODIS data back to February 2000.
- The geolocation algorithm now has improved interpolation/extrapolation of ephemeris and attitude information. This prevents bad lat/lon values toward the beginning and ending sections of a pass (originally released as a patch for IMAPP v1.2 on August 31, 2001).

April 13, 2001 (MODIS Level 1 v1.2) Second update for Terra MODIS:

- Calibration algorithm and lookup tables are updated to versions 2.5.5 and 2.5.5.1 respectively, which includes calibration data for the B-side electronics on MODIS (the switch to B-side electronics occurred on 1 November 2000). The calibration in IMAPP v1.2 is date sensitive, and may be used for all Terra MODIS data back to February 2000. This version also includes a bug fix for aggregation of the 250 m and 500 m spectral bands to higher spatial resolution.
- Geolocation is significantly improved when using only the Level-0 platform ephemeris and attitude information (i.e. in near-realtime). Terrain correction is now available as an option (requires that DEM data files be installed: see the installation instructions). Definitive Terra ephemeris and attitude data are now available via FTP for input to IMAPP (see Links).
- Level-1A algorithm is more resistant to Level-0 input file anomalies. Processing now terminates gracefully if a packet with an improper length is encountered in the Level-0 input file.

November 1, 2000 (MODIS Level 1 v1.1) First update for Terra MODIS:

- Calibration algorithm and lookup tables are updated to version 2.4.3. This includes many post-launch improvements and bug fixes from the MODIS Calibration Team at GSFC
- Added support for definitive ephemeris and attitude data
- Solarisx86 is now supported on Intel Pentium platforms

May 12, 2000 (MODIS Level 1 v1.0) Initial release including the following functionality for Terra MODIS:

- Reformatting from time-ordered CCSDS Level-0 packets to Level-1A
- Geolocation for every 1000 m pixel
- Calibration for every pixel in bands 1-2, 1-7, and 1-36 at 250, 500 and 1000 m resolution respectively

3.3.6 Package Information

The IMAPP is freely available at the web address

http://cimss.ssec.wisc.edu/~gumley/IMAPP/IMAPP.html

Additional information is available from the paper "International MODIS/AIRS Processing Package - Package Information and Science Objectives" by Hung-Lung Huang, Liam Gumley, Tom Rink, and Jun Li contained in the Technical Proceedings of the Eleventh International TOVS Study Conference. It summarises differences between IMAPP and GSFC/DAAC Operational Software, Language, Data Formats used and the Supported Platforms. It describes the functions for MODIS, IMAPP, Reformatting (Level-1A), Geolocation and Calibration (Level-1B). It also describes the Level-1A File Contents, Geolocation File Contents and Level-1B File Contents are also described.

3.3.7 Summary

The IMAPP processing capabilities in terms of Level-0 to Level-1, Level-1 to Level-2 have been summarised. Package information has also been summarised. The availability of information concerning language, data format, tool kit, calibration accuracy, navigation accuracy and efficiency, internal file contents and format has also been noted. Scientific objectives of achieving Level-2 products are also outlined, and products such as cloud mask, TPW, SST/LST, total ozone column concentration, shortwave infrared surface emissivity, and sounding profiles of temperature and water vapor are noted.

The activity with IMAPP is ongoing and with continued strong support from NASA and International TOVS Working Group (ITWG), it is expected that IMAPP will continue to rejuvenate itself for the challenges of new research and operational polar orbiting satellite systems.

Acknowledgement

The IMAPP project is currently funded by NASA grant NAG5-9389.

4. ABSTRACTS OF ITSC-XII PRESENTATIONS

Validation of IAPP retrievals using DOE ARM site observations

Tom Achtor*, Wayne Feltz, Hal Woolf and Ben Howell
**CIMSS/SSEC University of Wisconsin, Madison, WI, USA*

The U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program maintains instrumentation sites in three locations; a polar site (Barrow, Alaska), a mid-latitude site (Lamont, Oklahoma) and a tropical western Pacific site (Nauru Island). These sites have an assortment of atmospheric observing instruments and launch radiosondes on a routine basis.

NOAA 15 and 16 overpass data for passes covering the three DOE ARM sites are being collected for validation studies. This study will focus on the validation of International ATOVS Processing Package (IAPP) retrieval products. Data collected from ARM and the NOAA ATOVS over a four month period will be used to validate IAPP profile retrieval data.

Recent advances to the International ATOVS Processing Package

Tom Achtor*, Jun Li and Hal Woolf
**CIMSS/SSEC University of Wisconsin, Madison, WI, USA*

A major upgrade to the IAPP, version 2.0, was released in June 2001. The IAPP works with AAPP level 1-D data, and uses HIRS/3 and AMSU –A and –B radiances for retrieval. Ancillary data inputs for retrieval include high resolution topography, surface observations and regression or numerical model first guess. The IAPP retrieves temperature and moisture vertical profiles, derived quantities, and cloud information. The output file is in NetCDF format.

IAPPv2.0 provides the user with four instrument options for retrieval: (1) AMSU-A only, (2) AMSU-A and AMSU-B, (3) AMSU-A and HIRS/3, and (4) AMSU-A, AMSU-B, and HIRS/3. The user can also specify retrieval coverage by latitude and longitude bounds. When METAR surface observations are used, the efficiency in matching the observations to radiances has greatly improved, thus decreasing the run time of the process. A summary of the IAPP methodology and example products will be provided.

Implementation of ATOVS processing package and its validation in Korea

Myoung-Hwan Ahn
MRI / KMA
Seoul, Korea

The presentation will introduce the procedure used for the operational production of ATOVS using NOAA-16 in Korea since April 2001. The preliminary validation results for a three-month period over east Asia region shows that the bias is less than 1°C and RMSE is less than 1.5°C. Several extreme cases for better and worse retrievals are analysed in detail.

The impact of data assimilation on a mesoscale model of the New Zealand region

P. Andrews, H. Oliver, X. Zheng and M. Uddstrom
National Institute of Water and Atmospheric Research
301 Evans Bay Pde
Greta Point, Wellington
New Zealand

Results from 3D VARiational data assimilation experiments with the NZ Limited Area Model (NZLAM) will be presented. The NZLAM is a regional mesoscale configuration of the Met Office (UK) Unified Model, implemented on a 324 x 324 x 38 level grid at approximately 12 km 'resolution'. The NZLAM-VAR is run as a cycling forecast-analysis system, performing a data assimilation every 3 hours, with forecasts verified using a local implementation of the Met Office VER verification system.

Initial experiments are being conducted using data supplied by the Met Office. However, as local data streams become available, they are replacing those provided by the Met Office, e.g. SST, radiosonde temperatures and winds, AMDAR, SYNOPS, buoys, ships, satellite winds, HIRS and AMSU.

A case study approach is being pursued, using the period Dec 1999 to Feb 2000, which includes events that were not well forecast by global models. Results from a number of experiments will be presented, including specification of the skill gained through mesoscale data assimilation over that provided from simply running the NZLAM in the global model (i.e. as an 'interpolator'), the impact of the forecast background error covariance

formulation employed, and some observation system impact studies.

Validation processes and results for the inverse and forward models related to IASI/AMSUs/METOP observations

R. Armante [a], N. A. Scott [a], A. Chédin [a], N. Jacquinet-Husson [a], S. Marchand [a], V. Montandon[a], F. Aires [a,b]

[a] *Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France*

[b] *Dept of Applied Physics, Columbia University, NASA/GISS, NY, USA*

The main purpose of this presentation is to contribute to the validation of operational IASI observations by estimating the errors that our neural network-based inverse and forward models introduce into the retrievals or into the simulated brightness temperatures.

So far, the techniques setting error bounds on the inferred temperature, water vapor values, ..., are developed through analyzing differences between retrieved values and "observed" values. Several types of "observed" values are here considered: one set consists in the thermodynamic description of the atmospheres as given in the TIGR 3 dataset, while the other set is based on realistic geophysical thermodynamic scenes derived from the coupling of real NOAA-16 observations and of the retrieval process (the NOAA/NESDIS retrieval ATOVS technique). Simulations of IASI spectra have been made using an IASI dedicated hyper-fast forward radiative transfer model.

We set up an integrated simulation system that creates hundreds of artificial although "realistic" IASI observations, performs hypothetical satellite retrievals for the simulated areas, and stores the results in an easily accessible format for further statistical analysis. They, in principle, give a representation of a reasonable number of geophysical scenarios: land and sea, lakes, desert areas, elevated terrains, coasts, sea ice, snow, humid and dry situations, hot and cold surface (sea and land) temperatures, clear and cloudy, high and low level clouds. Validation results will be presented for forward and inverse models.

The application of observation adjoint sensitivity to satellite assimilation problems

Nancy L. Baker

Naval Research Laboratory

Monterey, CA 93943-5502, USA

The adjoint of the NRL Atmospheric Variational Data Assimilation System (NAVDAS) is used to compute the sensitivity of the forecast error to the observations and background (and implicitly, the statistical assumptions about their respective error covariances). Observation sensitivity may be used to estimate the potential impact of satellite observations on the analysis and forecast, and to illustrate the effects of different data selection choices.

The sensitivity to an observation is largest when (1) the observations are relatively isolated or an abrupt change in observation density occurs, (2) the observations are assumed to be accurate relative to the background, and (3) the observations are located in a region with strong sensitivity of J (a cost function) to the initial temperature and wind fields.

In the present NAVDAS configuration, ATOVS brightness temperatures over land and ice are eliminated since they are more difficult to assimilate properly. This can create an abrupt change in the observation density along coastlines and ice-edge boundaries. The brightness temperatures along these boundaries contain contributions from the different surface types and have larger representativeness errors than the brightness temperatures over the open oceans. Abrupt changes in the data density also occur for the less accurate observations along the edges of the satellite scan. If the observation errors are incorrectly assumed to be spatially homogeneous, and the observations are in regions of strong sensitivity to the initial temperatures and wind fields, the sensitivity to the relatively inaccurate observations along the data-rich/data-sparse boundary will be larger than the sensitivity to the more accurate (data dense) observations. This implies that the less accurate observations have greater potential to change the forecast and influence the analysis. Increasing the assumed observation error variance decreases both the observation sensitivity and the influence of the observation on the analysis. These results highlight the importance of properly specifying the observation errors.

Variability in upper tropospheric humidity and water cycle dynamics using TOVS data

John J. Bates

NOAA Environmental Technology Laboratory

325 Broadway, Boulder, CO 80305 USA

John.J.Bates@noaa.gov

There appears to be a disconnect between the mechanisms theoretically supposed to provide water

vapor to the upper troposphere in the tropics and subtropics, and the mechanism that is most prominent in GCMs. In many GCMs, there is a strong cancellation between upper tropospheric moistening via the large-scale circulation, and drying due to compensatory subsidence from convection. A substantial net moistening effect arises from vertical transport of moisture by eddies, a mechanism that is completely ignored in most theoretical discussions.

A key region showing variability in upper tropospheric humidity (UTH) during ENSO events is the subtropical region of the North Pacific. Although this is a region of time-mean descending air in the upper troposphere, analysis of atmospheric data shows that water vapor is supplied to the upper troposphere by vertical flux within transient eddies. The transient eddy activity in this region is in turn modulated by the interaction of the tropical circulation with the midlatitude circulation. Midlatitude interactions with the tropics are greatest during boreal winter and spring when transient eddy Rossby wave activity with periods between 5 and 30 days is at a peak.

Direct assimilation of SSM/I radiances in 4DVAR

P. Bauer, G. Kelly, E. Anderson
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berks. RG2 9AX, UK
p.bauer@ecmwf.int

Since 1997, SSM/I data has been incorporated in the ECMWF assimilation system through a one-dimensional variational retrieval of water vapor path which was extended to near-surface wind speed in 1999.

With the advancement of the assimilation system the direct assimilation of radiances is preferred for the sake of computational efficiency and even more importantly due to the better description of observational errors in radiance terms. Research experiments with the operational ECMWF four-dimensional variational assimilation have been carried out introducing direct SSM/I radiance simulations employing the NWP SAF radiative transfer package RTTOV-6 and the fast sea surface emissivity model FASTEM-2. The radiance monitoring showed reduced departures between observed radiances and those simulated from the model first-guess fields. Detailed monitoring statistics are presented as well as results of the impact on the analysis in comparison to the previous parameter assimilation scheme.

Precipitation classification and analysis from the Advanced Microwave Sounding Unit (AMSU)

Ralf Bennartz
University of Kansas, Dept Physics & Astronomy, Lawrence, KS 66045, USA
and Free University of Berlin, Inst. For Space Sciences, Berlin, Germany.
bennnartz@ukans.edu
and
Anke Thoss
Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden

The Advanced Microwave Sounding Unit B (AMSU-B) provides high frequency channels at 89 GHz, 150 GHz, and around 183 GHz. Its main dedication is to provide information about the water vapor profile. In addition these channels prove useful to detect precipitation over all types of surfaces.

We have developed a precipitation classification and analysis tool for nowcasting purposes that mainly relies on the scattering signal of precipitation observed at those frequencies. This tool has originally been developed for the Baltic region. We have now extended the validation for other climate regions, especially for the Mediterranean area. We will provide a detailed assessment of the method's accuracy based on comparison of NOAA-16 AMSU data with ground-based weather radar data. In simulation studies we further examine the relative benefits of other possible channels which might be added to future satellite sensors, such as channels around the 118 GHz oxygen absorption line.

The Cross-track Infrared and Microwave Sounder (CrIMMS): a sensor suite for operational meteorological remote sensing

Hal J. Bloom
NPOESS Integrated Program Office (IPO)
NOAA/NESDIS
Silver Spring, MD, USA

The Cross-track Infrared Sounder (CrIS) and the Advanced Microwave Technology Sounder (ATMS) is a suite of critical instruments (CrIMSS) under development for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program. CrIS is an interferometric sounding sensor which measures upwelling earth radiation at very high spectral resolution and uses this data combined with data from ATMS (a 22-channel passive microwave radiometer to construct

vertical profiles of atmospheric temperature and moisture). The purpose of this paper is to focus on the instrument development status of the CrIMSS for a flight of opportunity on the NPOESS Preparatory Project (NPP) in late 2005.

As part of a suite of operational instruments to be launched in the 2009 timeframe, the Cross-track Infrared Sounder (CrIS) is a Fourier Transform Spectrometer (FTS) currently being developed for the U.S Government by ITT Aerospace. The ATMS draws its heritage directly from AMSU-A/B, but with reduced volume, mass, and power. The CrIS, combined with data from the ATMS, will provide real time radiometric data and a suite of products supporting Numerical Weather Prediction (NWP) centers around the world. The heart of the CrIS sensor is a Michelson interferometric sounder capable of sensing upwelling infrared radiances from 3 to 16 μm. The ATMS has temperature and moisture sounding capability in the 23/31, 50, 89, 150, and 183 GHz spectral range.

One of the most important technological advancements in remote sensing of temperature and moisture is the development of an advanced infrared sounder with the capability of providing very high spectral resolution in the important infrared region of the spectrum, primarily between 650 and 2700 cm^{-1}. This spectral region includes the important 4.3 and 15 μm bands for temperature soundings, the 6.3 μm band for water vapor soundings and the 9.6 μm band for ozone soundings.

The performance of the CrIS sensor is a considerable leap forward when compared to existing operational sounders, due to much improved spectral resolution and many more channels. High spectral resolution also allows the selection of temperature sounding channels that are not contaminated by water vapor lines or by emissions from other active gases and provides spectrally clean window-channels for surface measurements.

The noise equivalent radiance and noise equivalent temperature achieved in the key LW and MW bands are fairly low. Radiometric uncertainty levels are also quite good. The CrIS design, combined with data from the ATMS, is expected to yield temperature uncertainty of less than 1.0 K per 1 km layers and water vapor uncertainty of less than 15% per 2 km layers in the troposphere.

Monitoring and validation of IAPP and ICI products over Madison acquisition area

Éva Borbás[1], Thomas H. Achtor[1], Lydie Lavanant[2], W. Paul Menzel[3] and Harold M. Woolf[1]

[1]Space Science and Engineering Center, University of Wisconsin / Madison, WI, USA
[2]Météo France, SCEM, CMS, Lannion, France,
[3]NOAA/NESDIS Office of Research and Applications, Madison, WI, USA

At CIMSS/SSEC the direct broadcast NOAA16/ATOVS data are operationally and simultaneously processed by both the International ATOVS Processing Package (IAPP) version 2 developed by CIMSS/SSEC and Inversion Coupled with Imager (ICI) software version 3 developed by Météo-France. Our paper introduces a web site used for every day monitoring and validation of both software systems. For preprocessing, the AAPP (EUMETSAT) including MAIA software developed by Météo-France is used. Some temperature and humidity fields derived by the IAPP and ICI software systems and the AVIATION global NWP model analysis and their differences are displayed every day. In addition, some regional results of the ICI statistical module and the mean clear percentage cloud cover in the HIRS field of view processed by MAIA software are routinely monitored over the Madison, Wisconsin direct broadcast acquisition area.

The effect of GPS radio occultation data on radiometric profile retrievals

Éva Borbás[1], Paul Menzel[2], and Jun Li[1]

[1]Space Science and Engineering Center, University of Wisconsin / Madison,
[2]NOAA/NESDIS Office of Research and Applications,
1225 West Dayton St., Madison, WI, 53706, USA
eva.borbas@ssec.wisc.edu

While the current IR/MW remote sensing systems have limited skill for inferring temperature and moisture profiles around the tropopause and in the stratosphere, the Global Positioning System (GPS) can provide very accurate upper tropospheric and stratospheric refractivity profiles which are related to temperature and humidity through radio occultation (RO) techniques. This study uses the RO measurements to get ancillary information for radiometric retrieval around the tropopause region. The NOAA88 dataset was used to simulate ATOVS and CrIS brightness temperatures and GPS RO data.

A statistical regression was used to get temperature and humidity retrievals from the combination of these two different (radiometric and geometric) systems. In addition, some early results with CHAMP and ATOVS data will be shown.

HIRS calibration: Comparison between local AAPP and global NESDIS methods.

Pascal Brunel
Météo-France/SCEM/CMS
Lannion, France

The assimilation of locally received data in regional numerical weather prediction models requires data quality equivalent to the global ones. So the monitoring of the local data can rely on the monitoring of the global ones. HIRS calibration cycles occur only each 256 seconds and this induces difficulties in the calibration of the start and end of a local pass.

We will compare, for some cases, the approach of NESDIS calibration and what is currently done with the EUMETSAT AAPP software for local receiving stations.

Analysis of temperature and moisture profiles over Brazil using the ICI inversion model

João Carlos Carvalho[1], jcarlos@cptec.inpe.br
Lydie Lavanant[2], lydie.lavanant@meteo.fr
Nelson Jesus Ferreira[1], nelson@ltid.inpe.br
Fernando Manuel Ramos[1], fernando@lac.inpe.br

[1]Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil.
[2]Centre de Météorologie Spatiale, Lannion, France.

This study evaluates the ability of ATOVS sounders for retrieving temperature and moisture profiles for different thermodynamic regimes over Brazil. Fifteen days of NOAA-15 data (23/02/00 up to 08/03/00) were pre-processed with the ATOVS and AVHRR Processing Package (AAPP) model. The retrieval fields were obtained using the Inversion Coupled with Image (ICI) package, developed by the Centre de Météorologie Spatiale (CMS). The temperature and moisture profiles are compared with radiosonde observations and horizontal fields of temperature and moisture at 850 and 500 hPa with the ECMWF analyses.

Impact of ATOVS temperature profile on the Korean Short-Range Prediction System

Dong-Eon Chang, Yong Hee Lee , Chun-Ho Cho
Forecast Research Laboratory,
Meteorological Research Institute, KMA, Korea

The Korea Short-Range Prediction System (KSRPS) has been operating at Meteorological Research Institute to provide short-range guidance to local meteorological offices. KSRPS is based on the Korea Local Analysis and Prediction System and PSU/NCAR MM5 for analysis and prediction respectively, and the prediction cycle is initiated for every 6 hours. Since the most severe mesoscale systems, which affect the Korean peninsula, are initiated over a data-sparse region of the Yellow Sea, inputs from satellite observations such as ATOVS temperature profiles are critical to improving short-range prediction skill over Korea. In this study, the effect of assimilating ATOVS temperature products on the short-range forecast over Korea is examined. Also a dependence of ATOVS temperature profiles on background information from different numerical model products will be discussed.

NPOESS Conical Microwave Imager/Sounder: A Next-Generation Sensor

Narinder Chauhan
NPOESS/IPO, The Aerospace Corporation
8455 Colesville Road, Suite 1450, Silver Spring, MD 20910, USA
narinder.chauhan@noaa.gov

The Integrated Program Office (IPO) of the National Polar-orbiting Operational Satellite System (NPOESS) is currently engaged in developing the next-generation microwave radiometer known as Conical Microwave Imager/Sounder (CMIS). CMIS will replace the current Special Sensor Microwave/Imager (SSM/I) and its follow-on, the Special Sensor Microwave Imager Sounder (SSMIS). The first CMIS launch is currently scheduled for early 2009. The major design features of CMIS payload have just been finalized but the design for ground, telemetry and other segments is likely to be finalized in the next year. This paper discusses the CMIS sensor design, its main characteristics and the operational data products that includes about two dozen land, atmospheric and sea parameters.

The-baseline CMIS design has 'window' channels at 6.9, 10, 19, 37, 89 and 166 GHz and

'sounding' channels at 50-60, 23 and 183 GHz. It employs a dual-reflector system having a 2.2 m dish for 6.6 to 89 GHz and a smaller dish for high frequency channels. Both reflectors are oriented 180 degrees apart about the sensor spin axis. In addition, CMIS will have polarimetic capability at 10, 18 and 37 GHz, and will employ a suite of 40 Fast Fourier Transform (FFT) channels centered at 60.4347 GHz. CMIS will have a data rate of ~500 kb/s, mass of ~275 kg and will require ~340 W of power.

The CMIS sensor is the primary source for 20 of the 66 operational data products that NPOESS will be producing. Though an operational sensor, CMIS is designed to produce data products such as sea surface wind direction, soil moisture and cloud base height; products that have not been obtained operationally in the past. CMIS requirements, particularly in the areas of atmospheric profiling and ocean data products, are designed to meet challenging and operational needs of the user community. Consequently, CMIS is also likely to play an important role in improving the science of microwave remote sensing. It is also important to note that CMIS will be co-located with other sensors on the NPOESS spacecraft such as VIIRS (a visible/IR sensor), providing an excellent opportunity to develop retrieval techniques utilizing synergy of data fusion. Preliminary performance estimates for CMIS, based on simulation studies, and a description of the sensor will be presented at the meeting.

Annual and seasonal variations of atmospheric CO2, N2O and CO concentrations retrieved from NOAA/TOVS satellite observations

Alain Chedin[a], A. Hollingsworth[b], Noëlle A. Scott[a], Soumia Serrar[a], Cyril Crevoisier[a] and Raymond Armante[a]
[a] *Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaisean, France*
[b] *ECMWF, Shinfield Park, Reading, UK*

We show that atmospheric concentration variations of major greenhouse gases (CO_2, N_2O, CO) may be retrieved from observations of the National Oceanic and Atmospheric Administration (NOAA) polar-orbiting meteorological satellite series. The method relies on the analysis of the differences between the observations and simulations from a radiative transfer model using collocated radiosonde data and fixed gas concentrations as the prime input. Over the time period considered (July 1987 – September 1991), the results are in good agreement with present knowledge of the atmospheric cycles (seasonal, annual) of the gases. A reanalysis of the more than 20 years archive of NOAA observations has considerable promise for an improved knowledge of the carbon cycle.

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Annual and seasonal variations of CO2, CO and N2O observed by NOAA operational satellites

Alain Chedin[a], Soumia Serrar[a], A. Hollingsworth[b], Raymond Armante[a], and Noëlle A. Scott[a]
[a] *Laboratoire de Météorologie Dynamique, Ecole Polytechnique, France*
[b] *ECMWF, Shinfield Park, Reading, UK*

The NOAA polar meteorological satellites have flown the TIROS-N Operational Vertical Sounder (TOVS) since 1979. Using radiosondes and NOAA-10 TOVS measurements which are collocated within a narrow space and time window, we have studied the differences between the TOVS measurements and simulated measurements from the new fast, Rapid Radiance Reconstruction Network (3R-N) non-linear radiative transfer model using radiosonde temperature and humidity measurements as the prime input. The radiative transfer model also uses fixed greenhouse gas absorber amounts (CO_2, CO, N_2O) and reasonable estimates of O_3 and of surface temperature. The 3R-N model is first presented and validated. Then, a study of the differences between the simulated and measured radiances shows annual trends and seasonal variations consistent with independent measurements of variations in CO_2 and other greenhouse gases' atmospheric concentrations.

(Submitted to Remote Sensing of Environment)

Sampled databases of 60-level atmospheric profiles from the ECMWF analyses

Frédéric Chevallier
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berks. RG2 9AX, UK
f.chevallier@ecmwf.int

A major attempt to sample atmospheric profiles on a global scale, despite the high dimensionality of the problem, has been the constitution of successive versions of the Thermodynamic Initial Guess Retrieval database. Each version groups together hundreds of soundings sampled from larger databanks of observations of the atmosphere. The analyses of Numerical Weather Prediction centres provide an interesting alternative to the use of radiosonde reports, because they are homogeneous

and cover all latitudes, longitudes and days of the year. Moreover, they provide a whole set of variables consistent with each other for each profile, like layer temperature, water vapour, cloud cover and condensate, and surface characteristics. Recent developments at the European Centre for Medium-Range Weather Forecasts (ECMWF) add prognostic and assimilated ozone to the variable list.

This paper describes two diverse profile datasets from the ECMWF 40-year re-analysis. The sampling method takes temperature, specific humidity and ozone into account. The first database contains 14,293 atmospheric situations, of which the second is an 80-profile subset. Their potential applications include the validation of radiation models and statistical regressions.

Assimilation of AIRS data at the Met Office

A.D. Collard and R.W. Saunders
Met Office, Bracknell, Berks., UK

The Aqua satellite, due to be launched in 2002, will carry into orbit the AIRS spectrometer which will observe the Earth at infrared wavelengths with high spectral resolution. Theoretical studies have shown that we should expect significant improvements in the accuracy and vertical resolution of temperature and humidity retrievals when compared to those obtained using current satellite instruments. These improvements should translate into improvements in analysis and forecast fields once these radiances have been assimilated into numerical weather prediction (NWP) models.

As operational data assimilation is a time-critical process, assimilation of AIRS radiances into the Met Office's 3DVar system will require the data to be processed so that the large initial data volumes produced by the instrument itself can be reduced to manageable levels without significantly affecting the impact of the radiances. Initially this will be achieved through a combination of spatial thinning, channel selection and only using radiance channels unaffected by clouds. It is important, therefore, to either reliably reject all fields of view with significant cloud contamination or to develop strategies to extract information from AIRS radiances with clouds present. Some results of channel selection and strategies for cloud detection will be presented.

Potential of the SSM/I rain observations for 4D-Var assimilation

Frédéric Chevallier, Peter Bauer and Emmanuel Moreau
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berks. RG2 9AX, UK
f.chevallier@ecmwf.int

Numerical Weather Prediction models require accurate initial conditions and therefore rely heavily on the quality of the assimilation schemes. As known weaknesses currently affect their global analyses of humidity, additional information about the atmospheric water cycle, like rain and cloud observations, is being tentatively introduced into the assimilation schemes.

In this paper, an evaluation of the rain produced by the ECMWF forecasting system is performed based on the SSM/I radiances. Rain-retrieved products are compared to the rain simulated by the forecast model. Also a radiation model is used to generate model-equivalent SSM/I radiances that are directly compared to the observed ones. It is shown that the rain structures are well located by the ECMWF model at all latitudes. However, deficiencies are identified and discussed. Finally, prospects for the use of the rain-affected radiances in an objective data assimilation system are considered using a one-dimensional variational analysis scheme.

Potential of the ATOVS cloud observations for 4D-Var assimilation

Frédéric Chevallier and Marta Janisková
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berks. RG2 9AX, UK
f.chevallier@ecmwf.int

Radiation observations such as those from the ATOVS instrument provide information about cloud system shape and intensity. However, they are not used any more than any other cloud observation system in operational global data assimilation systems. At the European Centre for Medium-Range Weather Forecasts (ECMWF), more than half of the satellite radiances are not used by the global analysis system because they are suspected of being impacted by clouds. Studies have shown that these cloudy areas may correspond to regions where key analysis errors are located, and therefore are crucial for the quality of the forecasts.

The assimilation of cloud information in the ECMWF four-dimensional variational (4D-Var) system has been under development for several years. First, the 4D-Var physics has been developed so as to take cloud-radiation interactions into account. Second, a fast infrared and microwave radiation model and its linearised version have been designed for the computation of model-equivalent cloud-affected satellite radiances. This paper describes the strategy of this work and summarises the results obtained so far.

Recent improvements in the use of TOVS satellite radiances in the Unified 3D-var system of the Canadian Meteorological Centre

C. Chouinard, J. Hallé, C. Charette, and R. Sarrazin
Data Assimilation and Satellite Meteorology Division/CMC
MSC, Dorval, Québec, Canada

The Canadian Meteorological Centre (CMC) 3D-Var is an incremental analysis system, and is currently used by both our global and regional models with very few modifications. During the last few years, it has undergone a series of upgrades from a terrain-following coordinate, to the direct assimilation of satellite radiances and recently, the use of temperature and surface pressure data from various sources, namely radiosondes, synoptic stations and aircraft data. This has replaced our current use of geopotential heights as the main source of mass data. The quality control was subsequently upgraded to a combination background check and variational QC.

In terms of new sources of data, the use of RTOVS/ATOVS level-1d data was implemented in September 2000 and, soon after, upgraded to raw level-1b data. All the processing of the level-1b from calibration, navigation, QC, and bias control is better understood and controlled at the user end and some of the benefits of using raw data will be presented with examples. More recently, the use of lower peaking AMSU-A channels was introduced, and we now use 8 channels over water and 4 over the continents. The QC and thinning algorithms of these channels is more delicate, but the benefits are very significant, as will be shown. The use of collocated AMSU-B will now be relatively easy to introduce, and this work is underway.

In preparation for future instruments, and in particular AIRS, the direct assimilation of IR radiances from GOES and POES is under investigation. To accommodate this work, the NWP model top will be raised from 10 hPa to 0.1 hPa. Similarly, the assimilation of the higher peaking channels AMSU-A 11-14 will be possible. Tests are about to begin and preliminary results will be presented.

HRD in-situ ground system - Bridging technologies between EOS, NPP and the future

Patrick L. Coronado
Applied Information Sciences Branch
NASA – Goddard Space Flight Center
Greenbelt, MD, USA

Over the last 30 years there has been a rapid increase in the number of remote sensing satellites supporting environmental monitoring. In addition, many of these satellites have increased their number of sensors, complexity and data rates. This increase in capability and enhancements have placed a significant burden on the user community, not only to keep up with the ever changing spacecraft RF and instrument specifications, but also the handling of the exponentially increasing data volume and processing algorithms required to make the data useful to the end user. This presentation will address specific technologies developed by NASA under the NPP project, that will enable the end user to acquire and pre-process NPP and predecessor instrument data in real-time. These technologies include the Real-Time Software Telemetry Processing System which performs the function of packet processing and Level-0 formatting; NEpster, which will be a virtually distributed web tool to search and access real-time data; and science processing software that can run in either a near-real-time, direct-broadcast mode or an after-the-fact research mode. These technologies target most of the necessary steps prior to value-added image product generation. They also incorporate all instrument and spacecraft-specific formatting, encoding and configurations, thereby alleviating the end-user of this resource consuming task and development. The science processing software also processes Level 0 data to geolocated calibrated radiances, from which a number of geophysical value-added products can be generated. All of these sub-systems will function standalone and can be easily implemented into any In-Situ ground terminal. Lastly, the presentation will address NASA's public release and/or technology transfer methodology and procedures of these technologies.

Comparison of the sounding and imaging capabilities of the SSMIS and AMSU

Godelieve Deblonde
Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada, Dorval, Québec, Canada

Recently, a stand-alone 1D-Var assimilation scheme was developed to process SSMIS (Special Sensor Microwave Imager/Sounder) brightness temperatures. The development of the scheme is part of the SSMIS NWP SAF (Satellite Application Facility) activity (extension of the NWP SAF SSM/I existing software). The scheme can also process AMSU (Advanced Microwave Sounding Unit) brightness temperatures. The control variables of the 1D-Var scheme are profiles of temperature and the

natural logarithm of specific humidity, surface wind speed over the oceans and either liquid water path or profiles of total water content (total of water vapor and cloud liquid water content). The 1D-Var can process real or simulated observations and employs a version of RTTOV that includes the fast surface emissivity model FASTEM2. The 1D-Var scheme was solved using simulated brightness temperatures to compare the sounding and imaging capabilities of the SSMIS and AMSU instruments. Results of the comparison study will be presented.

Stand-Alone 1D-Var Scheme for the SSMIS, SSM/I and AMSU instruments

Godelieve Deblonde[1] and Stephen English[2]
[1]Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada, Dorval, Québec, Canada

[2]NWP Division Met Office, Bracknell, Berks., UK

A stand-alone (1D-Var) one dimensional variational assimilation scheme has been developed to process SSMIS (Special Sensor Microwave Imager/Sounder) brightness temperatures. The development of the scheme is part of the SSMIS NWP SAF (Satellite Application Facility) activity (extension of the NWP SAF SSM/I existing software). The scheme can also process AMSU (Advanced Microwave Sounding Unit) and SSM/I (Special Sensor Microwave Imager) brightness temperatures. The control variables of the 1D-Var scheme are profiles of temperature and natural logarithm of specific humidity, surface wind speed over the oceans and either liquid water path or profiles of total water content (total of water vapor and cloud liquid water content). The 1D-Var can be used to process real and simulated observations and uses a version of RTTOV that includes the fast surface emissivity model FASTEM2. The 1D-Var scheme will be described and results of several retrieval example cases will be presented.

The use of radiance data in the NCEP global and regional data assimilation systems

John C. Derber
EMC/NCEP/NOAA/NWS Camp Springs MD, USA

There have been significant changes in the use of radiance data at NCEP over the last few years. These changes have included a substantially increased volume of radiance data, an improved radiative transfer system, an improved forecast model (vertical/horizontal resolution, higher model top, improved physics), and improved quality control and bias correction techniques. These changes, along with the current status of the use of radiance data in the NCEP global and regional data assimilation systems, will be presented. In addition, current developments on enhanced radiance assimilation techniques, the use of a variety of additional sources of radiance data (e.g. AIRS, SSM/IS and geostationary imagery) and experiments to extend the usefulness of the radiance data in different situations (e.g. over land/ice) at NCEP will be discussed.

Rain rate estimation over semi-arid regions from AMSU measurements

Amy Doherty
SSEC, Univ. of Wisconsin Madison, WI 53706 USA

Rain rate estimation is important over semi-arid regions, where drought and flash flooding cause perilous conditions and make agriculture difficult. These areas have individual characteristics not taken into account by global retrieval methods. A reliable radiative transfer model is needed in order to relate the various atmospheric parameters to the observed brightness temperature. Such a model is tuned here to give good agreement with AMSU observations over the semi-arid region of Arizona. The model is used to create a look-up table of brightness temperature, instrument, surface and atmosphere characteristics. This can then be searched using Bayesian or other methods to find the most likely combination of cloud and precipitation parameters, given observations of brightness temperatures from the AMSU and other atmospheric measurements. A multichannel approach will allow a reduction in the number of independent parameters in the table.

Accurate real-time navigation of AVHRR data at high latitudes

Adam Dybbroe[#], Pascal Brunel[§], Anne Marsouin[§] and Anke Thoss[#]
[#] Swedish Meteorological and Hydrological Institute (SMHI), S-60176 Norrköping, Sweden
[§] Centre de Météorologie Spatiale, Météo-France, BP 147, 22302 Lannion Cedex, France

At CMS Météo-France, an advanced Automatic Navigation Adjustment (ANA) technique developed by Brunel and Marsouin (2000) has been used operationally since 1990 to provide highly accurate geo-located AVHRR data. ANA combines a physical image deformation model and automatic adjustment on coastal landmarks. The ANA

software has recently been made compatible with the EUMETSAT ATOVS and AVHRR processing package, AAPP, which is becoming a standard also for processing AVHRR data. In January 2000 a first ANA users workshop was held at CMS with the participation of SMHI. ANA has been installed and tested at SMHI, on locally received HRPT data, and is now running in real time in a semi-operational environment.

In our first tests at SMHI we have been running ANA without the MAIA cloud mask. This setup proved still to be able to eliminate cloudy landmarks (no land-sea mask or bad correlation) and during the summer of 2001 the results were in good agreement with those at CMS. Thus, preliminary results are promising at high latitudes. However, a clear weakness of ANA is the nighttime land-sea discrimination method (also used for twilight conditions), which uses a single Tb4-Tb5 histogram. Depending on the season, geographical area and hour of the day, this method may fail to build the land-sea mask of a viewed landmark, which reduces the number of images where the navigation can be successfully adjusted.

The high-latitude winter season with little or no daylight, snow and sea ice, and cold land and water surfaces is particularly problematic. Here we will present some initial results, and describe our plans for improving the nighttime scheme.

Precipitation estimation from NOAA/AMSU data

Izabela Dyras and Danuta Serafin-Rek
Satellite Research Department,
Institute of Meteorology and Water Management,
Kraków, Poland
Izabela_Dyras@imgw.pl

The aim of the paper is to present the actual stage of AMSU data application in the Satellite Research Department in Poland.

The data available from an Advanced Microwave Sounding Unit (AMSU) on board NOAA-16 satellites have enhanced the possibilities of the new meteorological products derivation.

The products based on AMSU data reception such as rain probability, rain rate and cloud liquid water are being prepared basing on the regression algorithms developed by Grody and Ferraro. The paper presents the work undertaken to develop the algorithm coefficients estimation for Central Europe for stratiform and convective precipitation. The comparison of the obtained results with the ground-based precipitation measurements as well as vertical humidity profiles has been performed. Results obtained are encouraging. Plans for the further verification and improvement scheme will also be presented.

ATOVS and SSM/I assimilation at the Met Office

Stephen English, Dave Jones, Andrew Smith, Fiona Hilton and Keith Whyte
Met Office, Bracknell, Berkshire, RG12 2SZ, UK.
stephen.english@metoffice.com

ATOVS radiances from NOAA-15 and NOAA-16 are assimilated directly in 3D-var. Use is made of AMSU-A, AMSU-B and HIRS (NOAA-16 only). Assimilation of satellite observations improves wind and height forecasts at altitudes below 50 hPa, both at short and medium range, even in the Northern Hemisphere, where traditionally the impact of conventional data has been larger than that of satellite data.

The impact of AMSU-B on short range humidity forecasts is also large, and some improvement persists at longer range. In order to use AMSU-B effectively it was necessary to devise a method to distinguish between thick and thin cirrus clouds. This is particularly important in quality control of the channels peaking at low altitude, and it is these channels which deliver the largest impact on forecasts. AMSU-B radiances were introduced operationally on April 18 2001. AMSU-A and HIRS from NOAA-16 also replaced MSU and HIRS from NOAA-14 on April 18. Further refinement of the use of ATOVS occurred in October 2001 with the use of fractional sea ice cover from SSM/I, ice-type from AAPP and positions of permanent ice shelves in determining microwave sea ice surface emissivity. The thinning of ATOVS also changed, with observations classed as cloud-free by AMSU but cloudy by HIRS being given preference to those classed as cloud-free by both instruments. Both changes gave small improvements. Research is continuing to improve the use of ATOVS over land and in cloudy areas. The use of SSM/I has remained largely unchanged since the initial introduction of SSM/I winds from F-13 in 1999. However winds are now assimilated from two satellites (F-13 and F-15). Experiments with assimilation of total precipitable water are showing large positive impact when used with a new formulation of the forecast model physics and dynamics. Preparation is underway for the use of SSMIS.

Use of advanced infrared sounders in cloudy conditions

Nadia Fourrié
Météo France, Toulouse, France

Studies have already shown the high potential of advanced infrared sounders such as IASI (Infrared Atmospheric Sounding Interferometer) or AIRS (Advanced InfraRed Sounder) in clear sky

conditions, but channel selections are required in order to use these data in an operational context. These studies will have to be extended to cloudy conditions. In order to address the question of cloudiness in the sensitive areas, ten FASTEX (Fronts and Atlantic Storm-Track Experiment) cases of the month of February 1997 have been studied. Sensitive areas are regions where small errors in the initial conditions can lead to strong forecast errors. Comparisons between cloud parameters deduced from the AVHRR (Advanced Very High Resolution Radiometer) observations with the MAIA (Mask AVHRR for ATOVS Inversion) and from the ARPEGE model have been performed. In particular, the cloud cover and the top level of clouds located over the sensitive area and elsewhere have been examined. Then, channel selections for advanced infrared sounders have been developed in cloudy conditions.

Plans for assimilating AQUA data at NASA's DAO

Donald Frank, Joanna Joiner, Robert Atlas and Ivanka Stajner
NASA DAO, Goddard SFC, Greenbelt, MD, USA

NASA's Data Assimilation Office (DAO) is expanding its work with TOVS to assimilate data from the advanced instruments which will fly on NASA's AQUA satellite in early 2002. The Atmospheric Infrared Sounder (AIRS), which has over 2000 channels, together with the Advanced Microwave Sounding Unit-A (AMSU-A) and the Humidity Sounder Brazil (HSB) will provide many technical challenges for data assimilation centers. One of the primary concerns is how best to subset the data in order to efficiently extract information about the Earth's atmosphere and surface. This includes static and dynamic channel selection as well as pixel thinning. The DAO is currently experimenting with simulated AIRS/AMSU/HSB radiances within the framework of our finite volume data assimilation system (fvDAS) using the OPTRAN radiative transfer code developed as part of the NOAA/NASA Joint Center for Satellite Data Assimilation. The short term goals include the assessment of the cost of processing various data subsets and preparation for near-real-time assimilation within a few months of launch. We will also discuss plans and tools for evaluating the quality of AIRS data including radiances and level 2 products from the AIRS science team.

Radiative transfer in the SAPHIR and AMSU channels in the perspective of water vapor profiles retrieval

S. Franquet [a c], N. A. Scott [a], A. Chédin [a], R. Armante [a], L. Eymard [b]
[a] Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France
[b] CETP, Vélizy, France
[c] At present on leave at RLE's Remote Sensing and Estimation Group, MIT, Cambridge, MA, USA

An approach based on neural networks is applied to retrieve atmospheric water profiles and the total precipitable water vapor content from the ATOVS system and the SAPHIR (Sondeur Atmosphérique du Profil d'Humidité Intertropicale par Radiométrie) channels. SAPHIR is planned to be on the MEGHA-Tropiques Mission. The validation of the forward model used to construct the training and generalization datasets is based on real NOAA 15 and NOAA 16 observations. Humidity retrievals from the AMSU channels are made on a global scale. Comparisons with other approaches are presented.

Assimilation of GOES imager channels at MSC

Louis Garand and Nicolas Wagneur
Meteorological Service of Canada
Dorval, P. Québec, Canada, H9P1J3

Progress has been accomplished at MSC towards the direct assimilation of GOES-East and West imager channels 2-5. Brightness temperatures are monitored every six hours, showing a regular diurnal cycle over oceans (~0.6 K in ch-4). Surface emissivity maps were constructed for all channels, with variation with viewing angle and surface wind speed over oceans. Quality control procedures, cloud detection algorithms and radiance bias correction schemes were implemented. A physical radiative transfer model, MSCFAST, is used in the assimilation process. This model is also adapted to current HIRS and future AIRS channels. Studies show that the assimilation of surface channels will in fact impact significantly on the atmospheric profile at low levels ($P > 700$ hPa), especially in the tropics. A variational estimate of surface skin temperature has been implemented. In addition, all-sky outgoing radiances can be compared to their model equivalent as well as retrieved quantities such as effective cloud height and amount. By the time of the conference, results should be available on the impact of the assimilation of GOES imager channels on NWP analyses and forecasts.

Interference Mitigation in Passive Microwave Radiometry

A.J. Gasiewski
NOAA Environmental Technology Laboratory, Boulder, CO, USA

The widespread use of microwave bands for telecommunications and other active purposes has resulted in the loss of much of the quiet spectrum previously available for passive Earth remote sensing. Although a series of bands have been allocated by the International Telecommunications Union (ITU) specifically for the passive Earth Environmental Satellite Service (EESS) and related airborne and ground-based remote sensing activities, these bands do not cover all of the necessary spectral ranges. In addition, the allocated bands provide no more than statutory protection, with absolute insurance against interference from accidental out-of-band emissions to intentional jamming being all but impractical. Means of detecting and correcting for interfering signals in passive remote sensing of natural planetary emissions are thus becoming increasingly important, particularly as requirements are identified for detecting small climate change signatures using passive microwave systems.

Interference mitigation algorithms can exploit certain common features of anthropogenic signals that cause them to be distinguishable from natural planetary emission. These features include: 1) a relative narrowbandedness, 2) an unusually high degree of slant-linear polarization, 3) an unusually high degree of polarization correlation, and 4) a high degree of directional anisotropy. We demonstrate in this paper four fundamental methods for mitigation of interference in passive microwave radiometry based on these features. The methods include: 1) sub-band diversity, 2) polarization diversity, 3) polarimetric detection, and 4) azimuthal diversity. Each of the above methods provides the possibility of detecting interference, although the first (sub-band diversity) also provides a means of correcting for interference.

Mitigation algorithms using the above techniques were developed and tested using data from the NOAA Polarimetric Scanning Radiometer C-band (PSR/C) airborne imaging system. The PSR/C was flown on the NASA P-3 aircraft as part of the 1999 Southern Great Plains experiment (SGP99), yielding the first high-resolution (~2x3 km) C-band polarimetric imagery of soil moisture variations. The data from the PSR over the area near Oklahoma City clearly show 50-70K changes in upwelling horizontally-polarized brightness temperature as the result of variations in soil moisture, although anthropogenic interference at C-band is also common. An interference correction algorithm was developed and applied to this data. The algorithm provides almost complete correction of the PSR/C imagery using only four sub-bands, along with maps of interference severity that are anticipated to be useful for a variety of subsequent applications. Results of this study and implications of mitigation techniques on the design of future airborne and spaceborne radiometers will be discussed.

The Geosynchronous Microwave (GEM) Sounder/Imager

Albin J. Gasiewski, David H. Staelin, and Bizzarro Bizzarri
NOAA Environmental Technology Laboratory Boulder, CO 80305 USA

The GEoynchronous Microwave (GEM) sensor is a new concept for continuous mapping of temperature, moisture, clouds, and precipitation. The GEM observatory will provide, for the first time, time-resolved maps of convective clouds and raincells within tropical and midlatitude hurricane cores and frontal boundaries below cirrus cover and at spatial resolutions comparable to or exceeding those of the NOAA AMSU sensors. The information from GEM will be complementary to that provided by the current and future NOAA/GOES infrared sensors and NOAA and NASA polar orbiting microwave sensors, including those planned for GPM and NPOESS. In particular, GEM will provide measurements of temperature and moisture profiles within optically opaque cirrus shields at ~50 km spatial resolution and ~15 minute imagery of precipitation within mesoscale convective systems at ~15 km resolution over the complete life cycle of a storm. A recently proposed European version (the Geostationary Observatory for Microwave Atmospheric Sounding, or GOMAS) will improve somewhat on the resolution figures through the use of a larger antenna. Additional data products are anticipated to include measurements of cirrus cloud ice content and (potentially) cloud-drift winds below cirrus layers.

GEM/GOMAS will incorporate several advanced technologies, including steerable precision surface-controlled reflectors employing linear piezoelectric actuators, micro-scanning subreflectors, composite truss and reflector structures, broadband millimeter- and submillimeter-wave radiometers, and semi-autonomous control systems using on-board processing. The ability, continually and quantitatively, to monitor precipitation and weather patterns (temperature and humidity profiles, especially above 2-5 km) through obscuring clouds on a hemispheric basis would be an enormous and

unique asset for operational nowcasting and forecasting purposes. Engineering studies have already shown that the modest size and weight of GEM permit its incorporation on GOES R+ platforms.

Ensuring consistency between AMSU-A climate temperature retrieval products from NOAA-15 and NOAA-16

Mitchell D. Goldberg and Zhaohui Cheng
NOAA/NESDIS/ORA,
5200 Auth Road, Room 810
Camp Springs, MD 20746, USA

AMSU-A temperature retrieval products are generated from both NOAA-15 and NOAA-16. The temperature retrieval algorithm is regression. Initially the regression coefficients for NOAA-15 were derived from collocated matchups of AMSU-A brightness temperatures and radiosonde observations from July–December 1998. The NOAA-16 coefficients were derived from matchups from December 2000 – March 2001 (NOAA-16 was launched in September 2000. Together, NOAA-15 and -16 provide a refresh rate of 6 hours. We found inconsistency in the tropospheric temperature retrievals with respect to expected diurnal variations when the products were examined at 6-hour intervals. We solved this problem by using synthetic regression (now the same coefficients are used for both NOAA-15 and -16) with radiance bias correction. We found that the bias adjustment for NOAA-15 and –16 were quite similar. We now have a very consistent NOAA-15 and NOAA-16 retrieval product to allow the study of diurnal variations. The approach, time series of the retrieval products, and the bias adjustment for both instruments will be presented.

AIRS radiance and geophysical products: methodology and validation

Mitchell D. Goldberg, L. McMillin, W. Wolf, L. Zhou, Y. Qu and M. Divakarla
NOAA/NESDIS/ORA,
5200 Auth Road, Room 810
Camp Springs, MD 20746, USA

The AIRS near real-time processing system generates both radiance and geophysical products. The level 1b radiance data is spectrally and spatially thinned. The complete spectra of AIRS (2378 channels) are also compressed using eigenvector decomposition.

This allows the reconstruction of all AIRS channels from 100 eigenvector coefficients (principal component scores). AIRS cloud and channel masks (specifies which channels are affected by clouds) will be provided with the radiance products. Cloud cleared radiance products are also available. With respect to geophysical retrievals, the AIRS processing system provides full resolution retrievals of temperature, moisture and ozone, surface products (skin temperature, surface emissivity) and cloud products (cloud height and fraction). Methodology and validation of the products will be presented.

Use of global ATOVS and SSM/I observations at Météo-France

Elisabeth Gérard
Météo-France, Toulouse, France

Processed NOAA-15 and NOAA-16 ATOVS radiances from NESDIS are currently being used in the four-dimensional variational (4DVar) assimilation system of ARPEGE, the global numerical weather prediction model at Météo-France; impacts on analysis and on medium-range and short-range forecasts will first be presented. The potential benefits of using ATOVS raw radiances without collocation and one-dimensional variational (1DVar) inversion are currently under investigation. Major developments in that respect concern the extrapolation of model fields above the top of the model as an input to the radiative transfer model, the optimal density of observations and quality control. Benefits of assimilating raw radiances will be assessed through medium-range forecast performances. The third panel of the presentation will deal with experimental assimilation of total column water vapour and surface wind speed over the ocean derived from the SSM/I 1DVar scheme developed at ECMWF. The model fit to other observations and the impacts of both retrieved products on analyses and forecasts will be presented.

The Cross-track Infrared Sounder: Sensor design and projected performance

Ronald Glumb and Joseph Predina
ITT Aerospace/ Communications Division
Fort Wayne IN 46801 USA

This will be a paper that describes the design of the CrIS sensor, summarizes the key sensor characteristics, discusses the current status of sensor development, and describes its projected sounding performance.

EDR algorithms for the Cross-track Infrared Sounder

Ronald Glumb, Joseph Predina, Christopher Lietzke
ITT Aerospace/ Communications Division
Fort Wayne IN 46801 USA
and
Xu Liu
Atmospheric and Environmental Research, Inc.

This will be a paper that describes the CrIS algorithms used to generate temperature, moisture, and pressure profiles, and highlights some of the new algorithm features.

Remote sensing land surface wetness by use of TRMM/TMI microwave data*

Gu Songyan, Gao Huilin, Zhu Yuanijng
Geophysical Department of Peking University
NSMC, Beijing, PRC, 100875

Water cycle analysis is the most important part of the project of GEWEX. In water cycle analysis, the land surface wetness information plays an important role. TRMM/TMI is a new kind of microwave image unit, and has a great potential application in land characteristics analysis, especially in remote sensing land surface wetness information and monitoring flood and drought situations. In our work, the wetness index analysis method was used to analyse surface wetness during the summer of 1998 over the Boyang and Tongting lake area in China, and we tried to retrieve the land surface emissivity over the same area to estimate the land surface wetness. To accomplish this, we have studied the TRMM/TMI forward characteristics first. By using the VDISORT model, we developed wetness index BWI by combining three window channels of TRMM/TMI together. According to our analysis results, the wetness BWI is sensitive with the land surface wetness changes, and has a good application in our flood classification and monitoring. In our Cal/Val test, the data of China L-SAR aboard the plane and Canadian Radar-SAR aboard the Radarsat was used, and we got a 70% to 80% Cal/Val results. At the same time, we have tried to retrieve surface microwave emissivity from TMI data. We used the emissivity product to estimate the land surface wetness and also got a good result. Our future work will be focused on investigating the possible improvements to the algorithm and extend testing of the algorithm to other regions.

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Extending 1DVAR/GASP to 0.1hPa and the Assimilation of 1C AMSU-A Data

B. Harris, W. Bourke, J. Paevere and P. Steinle
Bureau of Meteorology Research Centre
Melbourne, Vic 3001, Australia

With a view towards unifying the local and global ATOVS data assimilation schemes within the Bureau of Meteorology, the 29 level global GASP model, with a top level at 10hPa, has been extended to 50 levels with a top at 0.1hPa. This change allows the forward model calculation using RTTOV-6 to be done without extrapolation or the use of NESDIS retrievals above the top of the model. Initial experiments were performed using the NESDIS ATOVS level 1D product, incorporating both HIRS and AMSU-A from NOAA-16 and AMSU-A only from NOAA-15. The 1DVAR product was used over land above 100 hPa, with the omission of surface sensing channels interacting appropriately with the automatic information content scaling within the GASP/1DVAR system. The system performed with equal or slightly better skill in the troposphere to the existing operational system, and had a vast improvement in the stratosphere, especially in the tropics. This new configuration was then run with level 1C AMSU-A data from NOAA-15 and NOAA-16 with similar performance. The lack of water-vapour HIRS channels in the AMSU-A only experiments is expected to change the moisture content of the analysis, and this effect is currently under investigation.

Recent progress and addition of International MODIS and AIRS Processing Package

Allen Huang
CIMSS/SSEC
Univ. of Wisconsin, Madison WI, USA

The latest version of IMAPP has evolved to include MODIS SST using a GOES-type algorithm and MODIS image de-striping using wavelets. Preparation for ingesting AIRS direct broadcast data is underway. AIRS forward model calculation and its application for direct broadcast users are also under development. In this presentation we'll list the current progress and update package information to date.

Planned hyperspectral imaging and sounding research for the Indian Ocean under the GIFTS-IOMI project

Allen Huang
CIMSS/SSEC
Univ. of Wisconsin, Madison WI, USA

GIFTS-IOMI project will enable Indian Ocean hyperspectral measurements to fulfill frequent imaging and sounding products requirements for US Navy operations. In this presentation, the focus will be on the proposed basic research using simulated GIFTS-IOMI measurements. These research activities – such as NWP model generation of half-hourly mesoscale thermal dynamical/cloud sounding fields, forward modeling of radiances, sounding retrieval, water vapor tracking, cloud radiative modeling, suspended particle radiative modeling, and stability and visibility derivation – will be described.

The GEISA spectroscopic database system revisited for IASI direct radiative transfer modelling

N. Jacquinet-Husson*, N.A. Scott*, A. Chédin*, and A.A. Chursin**

*Laboratoire de Météorologie Dynamique, Ecole Polytechnique, 91128 Palaiseau, France,
**Institute of Atmospheric Optics, 634021, Tomsk, Russia
nj@ara01.polytechnique.fr

Adequate tools are required to perform reliable radiative transfer calculations to meet the needs of communities involved in understanding the atmospheres of the Earth and other planets. Accurate spectral analyses of Earth or planetary spectra observed by new generations of high spectral resolution vertical atmospheric sounders will result in an improved knowledge of their atmospheric and surface properties. The performance of instruments like AIRS (Atmospheric Infrared Sounder) in the USA, and IASI (Infrared Atmospheric Sounding Interferometer) in Europe, which have a better vertical resolution and accuracy, compared to the presently existing satellite infrared temperature sounders, is directly related to the quality of the spectroscopic parameters of the optically active gases, since these are essential input in the forward models used to simulate recorded radiance spectra. In this context, the ARA (Atmospheric Radiation Analysis) group at LMD (Laboratoire de Météorologie Dynamique, France) has developed the GEISA (Gestion et Etude des Informations Spectroscopiques Atmosphériques: Management and Study of Atmospheric Spectroscopic Information) computer accessible database system, since 1974. This early effort implemented the so-called « line-by-line and layer-by-layer » approach for forward radiative transfer modelling action. This activity is of interest to research groups dealing with direct and inverse radiative transfer studies. Currently, GEISA is involved in activities, with the purpose of assessing IASI measurements capabilities and its own database quality, within the ISSWG (IASI Sounding Science Working Group), in the frame of the CNES (Centre National d'Etudes Spatiales, France)/EUMETSAT (EUropean organization for the exploitation of METeorological SATellites) Polar System (EPS), by simulating high resolution radiances and/or using experimental data.

The contents, as well as the access and management facilities, of the Internet-accessible GEISA spectroscopic database system will be presented, in their 1997 [1] and 2001 upcoming public versions. The individual line description of GEISA-97 contains 1,336,266 entries belonging to 42 molecules (96 isotopic species) and located between 0 and 22,656 cm^{-1}. It has molecules of interest for both terrestrial and other planetary atmospheres, especially those of the Giant Planets. GEISA-97 also has a catalog of absorption cross-sections of molecules such as chlorofluorocarbons with complex spectra that are too dense for direct parameterization. Illustrations of the Web facilities of the GEISA system will be given.

For the upcoming high spectral resolution atmospheric sounders, the so-called GEISA/IASI sub-database system is being elaborated, from GEISA. Its content, which will be the spectroscopic parameters reference for IASI direct radiative transfer modelling, with enhanced spectroscopic parameters, new cross-sections and a newly issued sub-database devoted to specific aerosol data, as well, will be described.

The IASI soundings spectroscopy requirements, previously emphasized [2], will be discussed in the context of comparisons between recorded and calculated experimental spectra. Subsequent consolidated versions of GEISA and GEISA/IASI will be presented.

This work is ongoing in the frame of ISSWG projects. It is supported by CNES (GEISA/IASI project) and by the European Commission Environment and Climate Programme (VIRTEM-Validation of IASI Radiative Transfer: Experiments and Modelling- project).

References:

1. N.Jacquinet-Husson et al. (48 co-authors), JQSRT 62, 205 (1999)
2. N. Jacquinet-Husson, N.A. Scott, A .Chédin, B. Bonnet, A. Barbe, Vl.G. Tyuterev, J.P. Champion, M. Winnewisser, L.R. Brown, R. Gamache, V.F. Golovko and A.A. Chursin, JQSRT 59, 511 (1998)

Validation of a new radiative transfer model for AMSU

Viju Oommen John, S. Buehler and K. Mashrab
Institute of Environmental Physics
University of Bremen
28334 Bremen
Germany

The retrieval of atmospheric parameters from microwave satellite data requires a good forward model for the simulation of radiances and for the calculation of the Jacobians. Our study presents the validation of the recently developed ARTS (Atmospheric Radiative Transfer System) forward model by comparing it to other forward models. It was found that ARTS agrees with the CIMSS_MWLBL model (which is used as a reference model for ITWG intercomparison) within 0.05K and 0.02K for AMSU-06 and AMSU-10 respectively, 0.15K for AMSU-14 and 0.16K for AMSU-18.

Furthermore, simulated radiances based on global radiosonde data were compared to radiances measured by AMSU-A and -B.

Assimilation of cloud- and land-affected TOVS/ATOVS level 1b data at DAO

Joanna Joiner, Donald Frank, Arlindo da Silva, Mike Bosilovich, and Jon Radacovich
NASA DAO
Goddard SFC Greenbelt MD USA

Despite significant advances in the assimilation of TOVS/ATOVS data over the last decade, there are still many unresolved issues. For example, at several centers, cloud- and land-affected TOVS data are not assimilated. In this study, we show positive impacts from the use of cloud-cleared and land-affected TOVS data in the NASA Data Assimilation Office's (DAO) finite-volume Data Assimilation System (fv-DAS). We will discuss how treatment of TOVS data affects the stratosphere and tropopause in the fvDAS. We will also describe the use of TOVS data for land-surface analysis and assimilation and other developments regarding the use of TOVS data at the DAO.

ATOVS assimilation in the Met Office UK mesoscale model

Dave Jones, Richard Renshaw, Byron Chalcraft, Simon Anderson and Stephen English
Met Office, London Rd, Bracknell, Berkshire, RG12 2SZ, UK.
dave.jones@metoffice.com

The Met Office runs a limited-area mesoscale model at 12 km resolution for 48-hour weather prediction over the UK area. Apart from satellite winds and some cloud top temperature information from Meteosat IR imagery, no satellite observations are currently assimilated into this model operationally; instead they are assimilated into the global model which then feeds the boundaries of the mesoscale model. It is expected that forecasts of cloud and precipitation will be improved by the assimilation of humidity sounding channel radiances directly into the mesoscale model itself.

A real-time trial, assimilating AMSU radiances extracted from locally-received HRPT data from NOAA-15 and -16, was run in parallel to the operational runs of the UK mesoscale model during April and May 2001. The trial indicated a small negative impact on the objective skill scores used to define operational performance; however, subjective verification of cloud and precipitation forecasts against satellite imagery, surface observations and radar indicated a broadly neutral impact and in individual cases there were clear improvements to these fields.

Further analysis of the real-time trial and additional individual case study events is aimed at understanding the disappointing performance of AMSU-B in the mesoscale model. Various options to improve its impact are being explored, including alternative channel selection and changes to the quality control and error assumptions within the data assimilation system, with a view to operational implementation in 2002.

The use of ATOVS data in Korea Meteorological Administration

Sang-Won Joo
Korea Meteorological Administration
Seoul,Korea

A one-dimensional variational method has been developed to use ATOVS data in Korea Meteorological Administration (KMA). Most of the details follow the method of Eyre (1993) except calculating error covariance. In KMA, observation error is not fixed but computed from the innovation and background error covariance in radiance space. Background error is changed geographically and damping area is applied to lessen the effect of sudden changes of background error.

The 1DVAR is applied to the global data assimilation system in KMA. The forecast results using 1DVAR are compared with the operational ones for September 2001. The typhoon tracks are well forecast and the North Pacific high pressure is well positioned with the help of ATOVS data. One month accumulated root-mean-square error shows better performance of numerical forecasts with

1DVAR not only in the tropics and the Southern Hemisphere but also in the Northern Hemisphere.

NOAA-TOVS 23-year total column ozone product retrieved by neural network technique

Anton K. Kaifel and Martin D. Müller
Center for Solar Energy and Hydrogen Research
Hessbruehlstr. 21c, 70565 Stuttgart, GERMANY
anton.kaifel@zsw-bw.de

Since research has proven the ozone layer to be damaged by emissions of CFC and other gases, accurate and long-term ozone monitoring has become essential. However, localized ground measurements do not provide a global picture, while most current orbital sensors rely on solar UV backscatter and hence cannot measure during night time. Therefore, data gaps occur in common ozone products of UV satellite sensors, especially during the polar night over the Arctic and Antarctic.

Thus, a complementary method for total ozone retrievals on a global scale from NOAA-TOVS satellite data has been developed, and these are continuously available since September 1978. Therefore these data have the potential to provide a total ozone column product for more than 23 years, and this will help in understanding the role of ozone in complex middle atmospheric photochemistry, as well as critical ecological effects associated with ozone depletion induced by anthropogenic and natural processes.

A homogeneous, global ozone data set ranging from 1979 to 2001 has been created using a neural network retrieval technique. Validations with independent WOUDC ground stations yielded a day and night mean absolute error (MAE) of 12 Dobson Units (DU) for all weather conditions, including clouds. Comparisons with gridded TOMS data yielded an MAE of 10.8 DU. Further comparisons are made with the operational NOAA-TOVS ozone product as well as GOME ozone data. Also, trend analysis of the 23-year time series are compared form WOUDC ground measurements and collocated TOVS ozone data. Finally global ozone trend analyses were carried out and show different ozone depletions rates in various kinds of regions.

We will show that, compared to classical satellite sensors, the neural network-retrieved ozone is of similar accuracy. Retrieval is very fast, therefore ideally suited for real-time implementations. The neural network ozone retrieval could be adapted to other satellite instruments like IASI on the upcoming METOP mission as well as to MSG-SEVIRI, whose IR channels are quite similar to TOVS.

Improved assimilation of AMSU/HIRS/VTPR radiances in the ECMWF system

Graeme Kelly, Peter Bauer and Sakari Uppala
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire, RG2 9AX, UK
graeme.kelly@ecmwf.int

At ECMWF the operational forecasting system is continuing to be improved and with increases in computer power there will be increase in resolution. At the end of 2002 it is planned to have a forecast model with a horizontal resolution of TL 799 (25 km) and 90 vertical levels. It is also planned to increase the resolution of the 4D-Variational assimilation to TL 319 (60 km).

This improved system will require more data. Attention is being directed to use of radiances affected by cloud, land and ice. The impact of using these radiances from the HIRS and AMSU instruments will be discussed.

Currently at ECMWF a 40-year re-analysis is underway. Satellite radiances from the VTPR instruments on the NOAA spacecraft are being used from December 1972. From 1979 the NOAA spacecraft changed to the HIRS/MSU/SSU instrument set. In 1997 the new AMSU instrument was included and the SSU instrument dropped. These instruments all have very different weighting functions and the problem of satellite bias correction in the re-analysis will be discussed.

EUMETSAT Plans

K.Dieter Klaes
EUMETSAT
Darmstadt, Germany

EUMETSAT is currently developing, jointly with ESA, the Meteosat Second Generation (MSG) system and the EUMETSAT Polar System (EPS). Spacecraft from these new series will start to provide validated observations from the Earth/Atmosphere system in 2003 (MSG-1 launch planned for July 2002) and 2006 (MetOp-1 launch planned for mid 2005) respectively. There are three MSG satellites foreseen, the payload of which will be a 12 channel imager (SEVIRI – Spinning Enhanced Visible and Infrared Imager) and GERB (Geostationary Earth Radiation Budget) radiometer. The EUMETSAT Polar System is the European contribution to the US/European Initial Joint Polar System (IJPS) and will assure the morning orbit (AM) of the two-satellite system. The NOAA POES system will continue to assure the afternoon (PM) orbit. The MetOp spacecraft are foreseen within the EPS. In 2002, EUMETSAT plans to introduce the

ATOVS Retransmission Service as a pilot project, which will collect and redistribute HRPT based and AAPP processed based ATOVS products (level 1a and level 1c from HIRS and AMSU-A/B) from five HRPT stations in the Northern Atlantic/European area to Users.

The Merger of OPTRAN and RTTOV: The Best of Both Worlds

Thomas J. Kleespies
NOAA/NESDIS
Camp Springs MD 20736 USA
Thomas.J.Kleespies@noaa.gov

Informal comparisons of OPTRAN and RTTOV indicate that OPTRAN performs better with water vapor channels, while RTTOV performs better with temperature channels. The author spent the summer of 2001 as a visiting scientist at the Satellite Application Facility for Numerical Weather Prediction at the Met Office in Bracknell, England. The purpose of this work was to merge the OPTRAN and RTTOV codes. This experimental code is structured such that the treatment of each of the major absorbing species (mixed gases, water vapor, ozone) can be independently switched between the OPTRAN and RTTOV methodologies. This paper describes the brightness temperature verification results of some of these various combinations, as well as their Jacobians.

PGPLOT: Freeware graphics software useful for satellite applications

Thomas J. Kleespies
NOAA/NESDIS
Camp Springs MD 20736 USA
Thomas.J.Kleespies@noaa.gov

PGPLOT is a scientific graphing package written by T.J.Pearson of the California Institute of Technology. The package consists of simple low level routines, which can plot vectors and symbols and complex high level routines that can plot contours and images. In addition, PGPLOT features interactive routines that can accept control from devices such as a mouse. Output devices that have been implemented include black and white and color postscript, HPGL printers and plotters, a wide array of laser and ink-jet printers, GIF, and a variety of terminal and X-terminal output devices. PGPLOT is implemented on operating systems that include Solaris, UNICOS, Fujitsu, AIX, FreeBSD, HP-UX, IRIX, Linux, MacOS, VMS and Windows. This talk will outline the capabilities of PGPLOT and give an interactive presentation of some of its capabilities.

Assimilation of Geostationary Radiances within the 4DVAR System at ECMWF

Christina Köpken, Graeme Kelly, Jean-Noël Thépaut
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire, RG2 9AX, UK
Christina.koepken@ecmwf.int

In Numerical Weather Prediction, observations from geostationary satellites have, up to now, been assimilated in the form of wind vectors derived from tracking cloud and humidity features using sequences of images. However, biases and problems in assigning a height to these winds pose problems for the assimilation. This is especially the case for clear-sky water vapour winds representing the movement of a deep upper tropospheric layer. An alternative approach is to directly assimilate the radiances. This is investigated here using the four-dimensional variational assimilation (4DVAR) of ECMWF and clear-sky radiances of the METEOSAT water vapour channel provided at a spatial and time resolution of about 80 km and 1 hour, respectively.

The monitoring of the radiances reveals on average about 3K bias between the observations and the model or ATOVS measurements. To account for inaccuracies in forward radiative transfer and the calibration, a statistical bias correction based on model predictors is used. Furthermore, comparisons to the HIRS-12 and AMSUB-3 data allow for detection of a small up and downward drift of the METEOSAT radiances.

Pre-operational assimilation experiments are carried out. Results show that the analysis draws well to the METEOSAT data while the fit to other conventional observations does not degrade and an improved fit to tropical wind observations is obtained in some cases. The impact on forecast quality is slightly positive to neutral for different areas of the globe. A relatively large sensitivity of the mean increments and forecast scores to the bias correction is noted. Current research issues are an improved quality control in order to eliminate residual cloud contamination and the possibility of a routine cross-calibration using the ATOVS information. Results from the pre-operational trial

runs will be shown discussing the aspects of quality control, calibration and bias correction.

Comparison of total precipitable water derived from the NOAA/ATOVS with that derived from sunphotometer over two different locations of the North Tropical Atlantic

Konaré Abdourahamane and Yann Dehlinger
Université de Cocody, Abidjan Côte d'Ivoire,
22 BP 173 Abidjan 22
konarea@ci.refer.org

Total precipitable water is generated at 30 km spatial resolution of the HIRS instrument using the Norman Grody algorithm. The solar-column water-vapour parameter is derived from the attenuation by water vapour of near-IR solar radiation using the differential absorption techniques (Frouin et al, 1990).

A slant total water vapour content connecting photometer and Sun is measured every few minutes when the sun is present at the AERONET locations. These measurements can be compared over ocean with a slant total water vapour content computed using ICI retrievals at the same time. For this comparison, data from Barbados (13.167N; 59.5W) and Sal (16.733N; 22.935W), two flat islands located in the Atlantic ocean, were compared with neighbouring HIRS pixels over ocean.

The preliminary results obtained from the ATOVS data of Dakar and Fortaleza (NOAA reception centre) during the Equalant 1999 campaign have showed:

1) some discrepancies between the two retrievals
2) a significant spatial variance in areas less than 2°x2° for the ICI retrieval

The recent availability of the new version of the ICI will allow us to improve the ATOVS retrievals and thus to reduce the bias between the two different methods. As this work is still undergoing, hopefully a new dataset including the Abidjan NOAA reception centre data and much long period will be available soon for a better analysis of the results.

AMSU-A background errors in HIRLAM 3D-VAR

Tomas Landelius and Nils Gustafsson
Swedish Meteorological and Hydrological Institute
Norrköping, Sweden

Variational assimilation schemes require robust statistics in order to be successful. The covariance matrices of the background error, as seen through the AMSU-A observation operator, and the observation error determine the relative weights given to the background and the observations in the analysis. We study the background error standard-deviations in observation space using a Monte Carlo technique.

These results will be used in a pre-analysis screening of data where the observations are checked against the background field. Observations are accepted if the departures, normalized by the observation error and transformed background error, are less than a specified limit. Work remains to balance the relative weight given to AMSU-A observations with that given to other observation systems.

CMS Cloud processing in IASI context

Lydie Lavanant
Météo-France/SCEM/CMS
Lannion, France

Developments are ongoing at CMS/Météo-France for the processing of the future IASI interferometer sounder. This work is done in the context of a direct broadcast acquisition station and a preliminary scheme in clear conditions has already been defined.

Studies for processing cloudy spectra are underway. Their purpose is to detect and characterize the clouds, in height and cover, by processing collocated AVHRR, AMSU and IASI channels and then to select IASI channels above the cloud for retrieving the atmospheric profile in cloudy conditions.

Status on these developments and validation on a Cloudy IASI DataSet provided by EUMETSAT for a global orbit will be presented.

Studies of advanced baseline sounder for future Geostationary Environmental Operational Satellite (GOES)

Jun Li, Timothy J. Schmit,
H. –L. Huang, and W. Paul Menzel
CIMSS/SSEC Univ. of Wisconsin
Madison WI USA

The era of high-spectral-resolution radiance measurements from a geostationary perspective is approaching. The first instrument to usher in this new era is the experimental Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS), which is to be followed by an operational Advanced Baseline Sounder (ABS). The advanced sounders will have thousands of channels with widths on the order of a single wavenumber, while the current GOES Sounder

has only 18 bands with widths on the order of tens of wavenumbers. High-spectral-resolution sounder measurements from geostationary orbit will allow for monitoring the evolution of temperature and moisture structures in clear skies with high accuracy and very high vertical resolution. The current GOES sounder yields poor vertical resolutions for atmospheric temperature and moisture profiles. High-spectral-resolution sounder radiances, as well as current GOES sounder radiances, will be simulated, with instrument noise included, for a number of radiosonde profiles with varying atmospheric structures. A physical retrieval algorithm will be employed to retrieve temperature and moisture profiles with both sounders. A vertical resolution function is defined to illustrate the advantage of ABS over the current GOES sounder. In addition, retrieval and vertical resolution analyses are also performed for two prime options for ABS instrument design.

Application of wavelet analysis on stripping of MODIS multi-spectral band infrared radiance measurements

Jun Li, Zhongdong Yang,
W. Paul Menzel, and H.-L. Huang
CIMSS/SSEC Univ. of Wisconsin
Madison WI USA

MODIS measurements include striping signals for longwave infrared bands due to their being from a multi-detector sensor. The atmospheric products such as cloud properties and atmospheric temperature/moisture profiles are affected by the MODIS longwave striping signals. Wavelet Transform (WT) analysis was applied to each column of a given MODIS spectral band image. A simulation study shows the advantage of WT over the traditional Fourier Transform (FT) in removal of this kind of noise. The stripping noise is significantly reduced after application of WT analysis. Both cloudy products (cloud-top heights, cloud-top temperatures, etc.) and clear products (total precipitable water, total atmospheric ozone, atmospheric temperature, etc.) from radiance measurements before and after WT application indicate that WT analysis is an effective tool for removal of the MODIS striping noise.

Correction of Cloud Contamination on AMSU Measurements: A Modeling Study

Xiaofan Li and Fuzhong Weng

NOAA/NESDIS/Office of Research and Applications, 5200 Auth Road, Camp Springs, Maryland 20746, USA
Xiaofan.Li@noaa.gov
Fuzhong.Weng@noaa.gov

Accurate knowledge of the effects of cloud microphysics on satellite microwave sounding channel measurements is crucial for retrieval of temperature and moisture profiles in cloudy conditions. Such effects are usually unknown from observational analysis because of difficulties in obtaining cloud information such as vertical distributions of cloud hydrometeors. In this study, correction of cloud contamination on AMSU measurements is carried out using a radiative transfer simulation with cloud-resolving modeling outputs.

The 2-D cloud-resolving model includes prognostic equations for cloud contents and cloud microphysics parameterization and radiation and produces realistic vertical profiles of thermodynamic states and cloud hydrometeors. A new fast and accurate microwave radiative transfer model including scattering and polarization is applied to compute the radiances at AMSU frequencies and bandwidths based on the cloud-resolving modeling outputs.

The experiments are carried out to simulate radiances that are similar to those observed from satellite measurements. Sensitivity tests are conducted to see how sensitive AMSU radiances are to amounts and vertical structures of cloud hydrometeors. A linear regression model is developed to predict clear-sky radiances in cloudy conditions by removing the cloud contamination. The RMS error between simulated and predicted clear-sky radiances at AMSU frequencies is less than 1K and their linear correlation coefficients are larger than 0.7 which well exceeds 99% confidence level, indicating that the algorithm efficiently removes the cloud contamination from AMSU-B radiances. The correction algorithm is applied to AMSU-B measurements on board NOAA-15 and -16.

Retrieval of atmospheric and surface properties from high resolution FTIR-measured radiances

Xu Liu, Jean-luc Moncet and Richard Lynch
AER Inc.
131 Hartwell Ave,
Lexington, MA 02421
xliu@aer.com

This paper will give an overview of a physical retrieval algorithm developed at AER Inc. and its application to FTIR-measured radiances. A fast and accurate forward model, Optimal Spectral Sampling

(OSS), is used to calculate upwelling radiances. OSS is capable of modeling radiance spectra with either a localized or a non-localized instrument response function. Derivatives with respect to atmospheric and surface properties can be calculated analytically and efficiently. The OSS fast RT model is ideal for atmospheric sounding or atmospheric compensation applications. The inversion method is based on an optimal estimation algorithm. Empirical Orthogonal Functions are used to transform the atmospheric profiles into a more compact form for fast and stable inversions. The non-linearity of the radiative transfer function is taken into account in the algorithm so the inversion is very robust. The algorithm has been used to simulate the Environmental Data Record (EDR) retrieval performance for the Cross-track Infrared Sounder (CrIS). We also applied the algorithm to the NPOESS Aircraft Sounder Testbed (NAST-I) measured radiances.

An improved general fast radiative transfer model for the assimilation of radiance observations

Marco Matricardi and Frédéric Chevallier
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire, RG2 9AX, UK
m.matricardi@ecmwf.int

An improved version of the RTTOV fast radiative transfer model used operationally at the European Centre for Medium-Range Weather Forecasts (ECMWF) for the assimilation of Advanced TIROS Operational Vertical Sounder (ATOVS) radiances has been developed. This new model can compute radiances for the Atmospheric Infrared Sounder (AIRS) and reproduce line-by-line radiances and Jacobians for the surface sensing, water vapour and ozone channels of ATOVS with significantly improved accuracy. The profile-dependent predictors used by the improved model to parameterise the atmospheric optical depths are based on the approach followed by RTIASI, the ECMWF fast radiative transfer model for the Infrared Atmospheric Sounding Interferometer (IASI). To improve the accuracy of the fast model in reproducing line-by-line radiances for AIRS, modifications have been made to the predictors used in RTIASI by introducing a revised set of predictors for ozone and adding new predictors to model the water vapour continuum type absorption. To eliminate discontinuities in the water vapour Jacobians observed in RTIASI, data are now weighted prior to performing the regression.

Carbon Dioxide Retrievals from the TOVS series of satellites

Larry McMillin, Mitch Goldberg and Jiang Zhoa
NOAA/NESDIS Camp Springs MD USA

Carbon dioxide is an important greenhouse gas that is insufficiently monitored by the existing network. Satellites provide the most promising approach for global coverage. The TOVS series of satellites provide a means for obtaining measurements for the TOVS period. The approach is to use the combination of the MSU/AMSU, which respond to oxygen, with the HIRS carbon dioxide channels to measure carbon dioxide. The challenges are the level of accuracy required and the fact that both measurements are affected by water vapor to some extent. As a result, the carbon dioxide accuracy is dependent on the extent to which the water vapor effects can be removed. To help with the accuracy, a new calibration procedure has been developed and is being applied to the archived TOVS 1b data. To help with the water vapor, the water vapor channels are being used to determine areas of consistent water vapor, which will then be used to measure carbon dioxide. The approach will be presented and results will be shown.

Rapid Transmittance Studies at NESDIS

Larry McMillin, Tom Kleespies and Xiaozhen Xiong
NOAA/NESDIS Camp Springs MD USA

Several investigations concerning rapid transmittance calculations have been done. One of the more useful ones is a different way of combining the gas transmittances. Instead of calculating effective transmittances by taking ratios of gas combinations, all the transmittances are calculated for the single gases and a single correction is calculated for the combination of the multiple gases. The new approach solves several numerical problems, allows coefficients to be generated for lower atmospheric levels where an opaque gas would otherwise prevent coefficients from being generated, limits the number of line-by-line calculations needed, and can easily be extended to any number of gases. A second approach is an alternative method to account for the absorption above a layer. It involves using the previous transmittance as a predictor to replace the average pressure and temperature terms. This was desired because the Jacobians for these terms are difficult. This approach did not provide the desired accuracy, but is reported because it is an obvious alternative. A third effort involves the use of kCARTA for the

line-by-line calculations. Although kCARTA is not a line-by-line model, it gives equivalent accuracy and is faster to execute. It provides the flexibility to test alternative approaches such as changing amounts of carbon dioxide. The results of these and other studies will be presented. Taken together, with work being done by others, these approaches result in significant advances in the speed, generality, and accuracy of rapid transmittance calculations.

Progress towards an assimilation strategy for AIRS at ECMWF

A.P. McNally, N. Fourrié, M. Matricardi, J.-N. Thépaut and P. Watts
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire, RG2 9AX, UK
tony.mcnally@ecmwf.int

Preparations continue at ECMWF towards a strategy to exploit AIRS data in operational numerical weather prediction. Three main areas of development are identified: Accurate radiative transfer modeling of the AIRS radiances (including the post launch spectral characterization of the instrument), an optimal and robust channel selection for assimilation and the treatment of cloud in the AIRS field of view. This paper will examine the progress that has been made in all three areas so far and present a projected development schedule based on likely launch dates for AQUA.

A cloud detection approach for AIRS radiance assimilation

A.P. McNally and P. Watts
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire, RG2 9AX, UK
tony.mcnally@ecmwf.int

A novel approach to detect cloud in AIRS radiances is presented. The method exploits the unique spectral signature of cloud in situations where it can be distinguished from other contributions to the measured radiances, making use of accurate background information provided by a numerical weather prediction system. A combination of physical and statistical information is used to characterize the cloud signal. A key feature of the approach is that it identifies which channels are free from cloud contamination in any given field of view, providing a vital input to the channel selection procedure for assimilation.

NPP instruments and direct broadcast plans

W. Paul Menzel
Office of Research and Applications
NOAA / NESDIS
Madison, WI, USA

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) is a joint NOAA/DOC, DoD and NASA program merging the current POES and DMSP systems into a common system of polar satellites with the goal of providing meteorological, oceanographic, terrestrial, climate, space environment and other environmental data products operationally. NPOESS will produce accurate and precise long-time series of radiometric measurement data from multiple instruments on multiple platforms starting late this decade. To prepare for the new instruments and data, the USA is planning an NPOESS Preparatory Project that will demonstrate three of the NPOESS instruments as well as the associated ground data system, command and control system, and algorithms for Environmental Data Records in 2005. It is a bridge between NASA EOS era science measurements and the start of NPOESS operational capabilities. NPP provides a linkage between EOS instrumentation and the NPOESS series of instruments.

The NPP will carry the Visible Infrared Imaging Radiometer Suite (VIIRS), the Cross track Infrared Sounder (CrIS), and the Advanced Technology Microwave Sounder (ATMS). The Visible Infrared Imaging Radiometer Suite (VIIRS) features a modular design with 22 spectral bands between 0.4 and 12 microns, nadir resolution of 370 or 740 meters (depending on spectral band), advanced focal plane detector technology, mature visible and infrared calibration systems, three stage passive radiative cooler, and heritage careful risk reduction measures; it represents a significant advance in operational polar orbiting imagers. The Cross track Infrared Sounder (CrIS) is a Michelson interferometer infrared sounder that is designed to measure with high resolution and high spectral accuracy the emission of infrared radiation from the atmosphere in three bands in the spectral range from 3.9 to 15.4 microns (650 – 2550 cm^{-1}). The Advanced Technology Microwave Sounder (ATMS) has 22 spectral channels, including bands near 23, 31, 89, 166 GHz, and several near each of the 50-GHz oxygen and 183 GHz water vapor absorption bands. These three instruments continue the heritage measurements introduced by the Moderate resolution Imaging Spectro-radiometer (MODIS), Atmospheric Infrared Sounder (AIRS), and the Advanced Microwave Sounding Unit (AMSU) / Humidity Sounder Brazil (HSB).

NPP will feature an X-band direct broadcast of all data to facilitate international utilization.

HIRS observations of a decline in NH winter clouds since 1997

W. Paul Menzel[a] and Donald P. Wylie[b]
[a] *Office of Research and Applications , NOAA / NESDIS, Madison, WI, USA*
[b] *Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin -Madison, Madison, WI, USA*

Seasonal changes in semi-transparent or cirrus global cloud cover have been monitored with multi-spectral observations with the polar orbiting HIRS (High resolution Infrared Radiation Sounder) since June 1989. Trends in cloud cover, inferred from monthly averages of the HIRS cloud observation frequencies, indicate that there has been a decrease of more than 10% in the northern mid-latitudes in the winter months since January 1997. In North America and Asia, some regions show 20 to 30% decreases. Possible causes for these decreases in winter clouds mostly below 6 km are explored.

Temperature, humidity and surface emissivity retrieval experiments with IASI simulated data

G. Monnier, L. Lavanant, P. Brunel, T. Labrot, G. Rochard
Météo-France/ Centre de Météorologie Spatiale, Lannion France

The development of a stand-alone inversion algorithm for IASI data in clear conditions has been ongoing at the CMS since ITSC-XI. Several major changes, which will be described, occurred in the retrieval strategy:

- The initial guess profile is now computed on the basis of orthogonal regressions performed over a rolling profile library.
- The channels sets used in the regression computations and in the 1D-var algorithm are both selected by an iterative method based on information content.
- Surface temperature and emissivity have been introduced as retrieved variables in the 1D-var algorithm.

Typical retrieval results will be presented, together with time computation considerations. The goal of a 1K-rms for the temperature retrieval in the troposphere is reached, even near the tropopause, but not in the very first levels above the surface. Also, the contrary, the final humidity estimate rms ranges from less than 10% in tropical situations to more than 20% in polar situations. Furthermore, the accuracy of the humidity retrieval is tightly linked to the surface temperature and emissivity value and knowledge. Including surface emissivity parameters in the retrieval process will be emphasized and illustrated.

Hyperfast high spectral resolution radiance simulation with a multi-layer perceptron. Application to IASI.

V. Montandon[a], A. Chédin[a], R. Armante[a], N. A. Scott[a] , F. Aires[a,b]
[a] *Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France*
[b] *Dept of Applied Physics, Columbia University, NASA/GISS, New-York*
montandon@lmd.polytechnique.fr

An hyper-fast model for radiances was derived for the IASI instrument over the whole spectral region and for different geophysical scenarios. It is based on the education of a multi-layer perceptron trained on and applied to the subsequent versions of the TIGR data set. The results obtained by this parametric model in terms of computation time (e.g. 0.005 s per spectrum of 188 channels in CO2 band and 0.006s per spectrum of 379 channels in H2O band on IBM) and of error (maximum RMS in generalisation = 0.19 K for CO2 band and 0.49K for H2O band) should allow the requirements of a real time IASI data forward modelling to be met. Validation results will be shown.

Towards an alternative technique in upper air monitoring in Kenya

Joseph R. Mukabana
Kenya Meteorological Department Nairobi, Kenya

The taking of upper air observations of the atmosphere is crucial in the monitoring and forecasting of weather and climate of any region. The current techniques of Upper Air Observation that involve the use of radiosonde soundings are too expensive, especially for developing countries like Kenya. This has led to a great reduction in the number of active upper air stations with Kenya currently having only one operational station. It is, therefore, important to look for alternative, more viable ways of monitoring the upper reaches of the atmosphere.

In an attempt to address the above problem, the Kenya Meteorological Department (KMD), in collaboration with the Inter-Governmental Authority for Development's Remote Sensing Project (IGAD-

RSP), is engaged in research into the use of remotely sensed data in monitoring of the upper levels of the atmosphere. The strengthening of remote sensing application for early warning in food security and environmental monitoring in the IGAD sub-region is an IGAD regional project financed by the 7th European Development Fund.

The project has two main objectives, including the improvement of information systems for food security and environmental monitoring systems, and to ensure the sustainability of these systems at national and sub-regional levels. These objectives are to be achieved through enhancing the use of satellite-derived data, development of networks between relevant institutions, setting up of an environmental information system, monitoring of environmental parameters, and the building of national capacities. The national capacities will be built through holding of training workshops and the provision of tools and equipment for reception and processing of satellite-derived data.

Neural network ozone retrieval on ATOVS data

Martin D. Müller and Anton K. Kaifel
Center for Solar Energy and Hydrogen Research
Hessbruehlstr. 21c, 70565 Stuttgart, GERMANY
martin.mueller@zsw-bw.de

After having successfully applied a neural network ozone retrieval method to more than 20 years of NOAA-TOVS data, a logical step is the adaptation of this method to ATOVS. Although ATOVS does not possess additional channels in the ozone absorption band at 9.6 μm, it has the potential to retrieve temperature profiles with higher vertical resolution and accuracy than TOVS. Due to the high correlation of temperature and ozone especially in the lower stratosphere this translates into a significant information gain regarding total ozone, which concentrates in this height region. Also, the higher horizontal resolution of ATOVS helps to reduce collocation errors associated with the (point type) ground measurements used for training the neural network.

It will be shown that the higher information content in ATOVS can be exploited properly by neural networks to obtain more accurate ozone values. Some preliminary validation of ATOVS ozone retrieval results w.r.t. ground data will be presented, in addition to comparisons with NOAA14-TOVS and Earth-Probe TOMS.

Recent developments in assimilation of ATOVS at JMA

Kozo Okamoto
Numerical Prediction Division, Forecast Dept,
Japan Meteorological Agency
Tokyo, Japan

A 3-Dimensional Variational (3DVar) global analysis system started operationally at Japan Meteorological Agency (JMA) in September 2001. The 3DVar assimilates ATOVS data in form of thickness, instead of geopotential height used in the previous analysis system using an optimum interpolation method, converted from retrievals by the National Environmental Satellite Data, and Information Service (NESDIS) and the Japan Meteorological Satellite Center (MSC) retrieval.

The system for assimilating ATOVS radiance directly in the 3DVar is being developed. An ATOVS 1DVar procedure is used as a pre-processor which rejects unreliable data, removes bias components from observations with a statistical method, and selects available channels and modifies observation errors based on observation conditions such as over sea, sea-ice, land and cloud contamination. Several impact experiments are being run and show encouraging outcomes that, for instance, errors of forecasts and analyses for wind speed decrease.

Moreover other projects in progress are 1) using AMSU-B radiance, 2) improving ATOVS quality control scheme to detect cloud and rain, 3) assimilating water vapor and IR channel radiance from Geostationary Meteorological Satellite (GMS) and 4) assimilating cloud (cloud liquid water or/and cloud amount) from GMS.

The National Polar-Orbiting Operational Environmental Satellite System (NPOESS): Access to NPOESS data

John W. Overton
NPOESS Integrated Program Office (IPO)
8455 Colesville Road, Suite 1450
Silver Spring, MD 20910, USA
john.overton@noaa.gov

During the last decade, the two U.S. civilian and military systems, POES and DMSP, have evolved to use a somewhat similar spacecraft bus, but have different instrument suites. Many government studies had been conducted to assess the value of converging the two systems into a single system. Most studies recommended retaining the separate systems. A 1993 tri-agency study by DoD, NOAA,

and NASA recommended that a single converged system should replace the current separate systems.

A Presidential Decision Directive (PDD), signed in May of 1994, directed the convergence of the polar orbiting weather satellites systems into a single national system. The Integrated Program Office (IPO) within NOAA was established in October 1994 as a result of the signing of a tri-agency Memorandum of Agreement (MOA) in May 1994. The new converged system was identified as the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The IPO is staffed with representatives of NOAA, Department of Defense and NASA. This unique tri-agency office has the mission to provide a converged polar-orbiting operational, environmental satellite system that meets user community requirements. Accessibility to data is a key feature of the NPOESS mission.

All satellites will operate at a nominal 833 km altitude orbit with an inclination of 98.7 degrees (sun-synchronous) and have nodal crossing times to minimize critical revisit times. NPOESS has undertaken a far-reaching program of sensor development and satellite transition to provide complete coverage of meteorological conditions for civil, military, and scientific purposes while cutting operational costs dramatically. The program will adapt existing technology and develop new sensors.

To accomplish its mission, NPOESS satellites in three orbital planes will replace the two-satellite DMSP and POES constellations. The data will be processed into Raw Data Records (RDRs), Sensor Data Records (SDRs), and Environmental Data Records (EDRs) for use by a number of operational communities.

NPOESS delivers data to a variety of users. National and international weather, climate, hydrological, and space weather analysis and prediction centers serve the needs of billions of people worldwide. International services such as Search and Rescue Satellite-Aided Tracking (SARSAT) and ARGOS are part of the NPOESS mission.

NPOESS will provide regional data to all users in two direct broadcasts, global data within 90 minutes of observation to US Weather Centers, and global data to NOAA NESDIS's Archive System for worldwide subscription service. High Rate Data (HRD) will be broadcast using CCSDS packets at 20 Mbps at 7812 MHz or 7830 MHz. HRD will contain full resolution imagery and radiometric data from all NPOESS environmental sensors. Low Rate Data (LRD) will be broadcast using CCSDS packets at ~3.5 to 4.0 Mbps at 1702 MHz - 1710 MHz (to be resolved). LRD will contain information to produce imagery, atmospheric vertical temperature profile, atmospheric vertical moisture profile, global sea surface winds, cloud base height, cloud cover/layers, pressure and sea surface temperature.

Stored Mission Data (SMD) will be transmitted to strategically placed receiving antennas necessary to achieve a 90 minute data latency. SMD data will be transmitted using CCSDS. International users will have access to SMD via the NOAA NESDIS Archive.

Software to produce NPOESS EDRs will be made available to users through commercial vendors by the NPOESS Integrated Program Office. NPOESS will provide a continuing improvement in the accuracy of weather and climate forecasts for many years to come.

The paper will discuss the NPOESS SMD, HRD and LRD concept of operations, ground system requirements and development status. The paper will also discuss user involvement in the design and fielding of NPOESS.

IASI on board METOP : Project Status and scientific preparation.

Thierry Phulpin, François Cayla, Gilles Chalon, Vincent Cassé
CNES
Toulouse, France
D. Diebel and P. Schluessel
EUMETSAT
Darmstadt, Germany

IASI is a Michelson interferometer developed jointly by CNES and EUMETSAT, to be flown on METOP 1 to 3. It has been designed for operational meteorological soundings with a very high level of accuracy (Specifications on Temperature accuracy : 1K for 1 km and 10% for 1 km for humidity) and also for estimating and monitoring trace gases at a global scale. The main mission requirements are briefly recalled. The principles of the measurement, the instrument and the products to be delivered are shown. The schedule, the present status of the industrial development, under CNES responsibility are also presented. Future applications are prepared by an International Users group according to a Science plan jointly built up. This plan is presented with the main results already achieved and the main issues still open.

Analysis of NAST-I Measurement Characteristics

Youri Plokhenko[#] and W. Paul Menzel[&]
[#] *Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin - Madison, Madison, WI, USA*
[&] *Office of Research and Applications , NOAA / NESDIS, Madison, WI, USA*

Spatial and spectral properties of the high spectral resolution interferometer measurements from NPOESS Airborne Sounder Testbed – Infrared (NAST-I) are investigated. The second spatial differential under a fixed viewing angle of the airborne instrument is used for assessing the interferometer measurement noise. Statistical characteristics of the noise are compared with noise characteristics derived from ambient black body measurements. The second spectral differential is used to study reduction of the interferometer coherent noise. These spatial and spectral approaches to noise filtering show potential for improved utilization of the NAST–I data.

NPOESS CrIS raw data (Level 0) to sensor data (Level 1b) processing

Robert Poulin
ABB Bomem Inc.
Special Projects in Radiometry Division
Quebec, Canada
robert.h.poulin@ca.abb.com

The Cross-track Infrared Sounder (CrIS) is part of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) series of polar-orbiting spacecrafts. The CrIS *sensor* forms a key component of the larger Cross-track Infrared/Microwave Sounding Suite (CrIMSS) and is intended to operate within the context of the CrIMSS architecture.

The CrIS instrument is a Michelson interferometer infrared sounder covering the spectral range of approximately 3.9 to 15.4 microns. CrIS provides cross-track measurements of scene radiance to allow the calculation of temperature and moisture vertical distributions in the Earth's atmosphere.

We present sensor data record (SDR) level 1B algorithms that are needed on ground in order to produce meaningful data meeting all requirements of the NPOESS CrIS instrument. Level 1B data are made of geolocated, radiometrically and spectrally (spatial frequency) calibrated spectra with annotated quality indicators. CrIS SDR algorithms include, among others, radiometric calibration with phase error correction, interferometer fringe count error handling and correction of the instrument line shape (ILS) distortion.

Recent advances in utilization of ATOVS and SSM/I data in the operational global data assimilation of India.

V.S. Prasad, R.K. Paliwal,
M. Das Gupta, D. Rajan
National Center for Medium Range Weather Forecasting, Mausam Bhavan Complex, Lodhi Road, New Delhi, India

Operational Numerical Weather Prediction over the Indian subcontinent is heavily dependent on satellite data in view of the limited scope for expansion of the conventional data network to meet the input data requirements of the general circulation models. Among the range of satellite-derived products, geophysical parameters derived from ATOVS and SSM/I data has recently become available in India. An attempt is made in this study to examine the impact of these data sets on medium range forecasts over India and its neighborhood. In order to assess the impact of the said data on the Global Data Assimilation-Forecast System (GDAFS), specific forecast experiments (up to 120 h) were carried out, by including these data sets in different combinations, along with all other types of data received on GTS. The analysis and forecast fields thus generated are compared with corresponding operational archives. The impact of the data is examined in terms of various objective scores and through circulation characteristics with special emphasis on the circulation characteristics of the Indian summer monsoon.

A new method for the retrieval of upper troposphere/lower stratosphere sulfur dioxide from global long-term TOVS measurements

Fred Prata
CSIRO Atmospheric Research, PB 1, Aspendale
Victoria 3195, Australia
Fred.Prata@dar.csiro.au
John Bates &
Darren Jackson
NOAA/ Environmental Technology Laboratory,
Mail Code R/ET1A, 325 Broadway, Boulder, CO
80303, USA

Sulfur dioxide is an important gas in climate studies because once it is converted to sulfuric acid it has a strong effect on the radiative budget of the earth-atmosphere system. Tropospheric sulfur dioxide is quickly removed from the atmosphere by dry and wet deposition, but sulfur dioxide that reaches the upper troposphere or that penetrates the stratosphere has the potential to affect climate. Monitoring of SO_2 from space has been done by the TOMS instrument and more recently by GOME. These instruments sense scattered sunlight to determine SO_2 concentrations using UV absorption features between 280 and 320 nm. Until now there have been no other independent satellite measurements of this important gas.

In this paper we will outline a completely new infrared-based method for determining SO_2 in the upper troposphere and lower stratosphere. The method uses infrared absorption measurements in the strong 1361 cm^{-1} v_3-band of the SO_2 molecule. The HIRS instrument has a channel that covers this band and which has been used principally for deriving tropospheric water vapour. We will demonstrate that for SO_2 gas residing in the upper troposphere or stratosphere, the SO_2 absorption can be identified and quantified against the background atmosphere. This paper will describe the methodology, introduce the theoretical arguments and then illustrate the retrieval method using HIRS Pathfinder data for several case studies. Generally speaking, background SO_2 levels in the upper troposphere and stratosphere are low except during periods of vigorous volcanic activity. We will illustrate our TOVS SO_2 retrievals for the eruptions of Mt St Helens, El Chichon, Pinatubo, Cerro Hudson and several others. Implications of this work for climate model sensitivity studies, for monitoring hazardous volcanic clouds and for TOVS tropospheric water vapour estimation are discussed.

Impact of Channel Spectral Shape Errors on High Resolution Infrared Atmospheric Sounders

Joe Predina
ITT Aerospace / Communications Division
Fort Wayne, INB 46801
USA

Abstract: Currently under government review and will be provided when approved.

Cross Track Infrared Sounder (CrIS) Raw Data Records (RDR'S)

Joe Predina
ITT Aerospace / Communications Division
Fort Wayne, INB 46801
USA

Abstract : Currently under government review and will be provided when approved.

Variational cloud decontamination and extension to the component estimation of the IASI measurements

Pascal Prunet and Bernard Tournier
Ramonville, St Agne, France

Cloud-decontamination refers to the procedure of removing the effect of clouds from infrared measurements. This process applies on partially cloudy measured scenes, and consists in the extraction of the radiance emitted from the cloud-free portion of the instrument footprint. The retrieval of the clear components of the infrared measurements are of great importance for their use in meteorological operational systems for weather forecasting. The better correction of cloud-contaminated observations for the next generation of sounders such as IASI is essential for NWP, as they can represent about 75% of the measurements provided by infrared sounders.

This procedure can be extended to the decomposition of the measured radiance into several components, each of them corresponding to the emission of an identified physical surface involved in the measured footprint, such as clouds, sea surfaces or land surfaces. The estimation in the infrared measurement of each radiative component coming from different cloud types or from various soil types is of great interest for research applications. Understanding of the diffusion effects and radiative properties of clouds, or the cartography of terrestrial surface emissivity variability at fine scales, are major challenges for atmospheric and environmental applications.

The aim of this communication is to present the development of a variational cloud-decontamination scheme for the IASI measurements, and its extension to the decomposition of the IASI spectrum. This work was done in the context of the EUMETSAT Polar System (EPS) Programme. We use a one-dimensional variational framework (1DVAR) for the treatment of cloudy data by cloud decontamination. The extraction of a clear component spectrum is made through comparison of IASI partly cloudy adjacent pixels. The 1DVAR approach simultaneously extracts cloud-clearing parameters and information about the atmospheric and surface state from infrared measurements. The variational framework ensures that the state estimate is consistent with all available data. This IASI cloud decontamination scheme allows for complex cloud structures including multiple cloud layers with wavelength-dependent radiative properties.

The extension to the IASI measurement decomposition uses the level 1c IASI product of AVHRR radiances analysis in the IASI field of view. This product provides the classification and localisation of the different components inside the IASI footprint.

The variational IASI cloud-decontamination scheme is described, and its validation on a synthetic IASI spectra database considering various cloudy conditions is presented. The capability of the scheme to extract cloudy components is highlighted. As an illustration, the spectral correction of IASI measurement errors due to the heterogeneities of the radiative surfaces inside the footprint is presented. Finally, the potential and

some perspectives of the IASI spectrum decomposition are discussed.

Japanese Advanced Meteorological Imager: A Next Generation GEO Imager for MTSAT-1R

Jeffrey J. Puschell
Raytheon, Santa Barbara
CA 93117 USA

The Japanese Advanced Meteorological Imager (JAMI) is being developed by Raytheon Santa Barbara Remote Sensing for Space Systems/Loral as the imager subsystem for the Japanese MTSAT-1R system. JAMI is based on advanced imager technologies that have already been space qualified and flown in Raytheon-built spaceflight hardware. JAMI covers the 0.55-micron to 12.5-micron spectral region using 4 emissive bands and 1 solar reflective band. Large format arrays used in JAMI enable faster full disk coverage rate with slower scan rate. Benefits of this approach include better radiometric sensitivity, better system MTF and a longer life scanner, relative to earlier systems.

Channel selection for IASI in clear-sky conditions

Florence Rabier
CNRM, Météo-France
Toulouse, France

Advanced infrared sounders will provide thousands of radiance data at every observation location. The number of individual pieces of information is not usable in an operational NWP context, and we have investigated the possibilities of choosing an "optimal" subset of data. These issues have been addressed in the context of optimal linear estimation theory, using simulated IASI data. Several methods have been tried to select a set of the most useful channels for each individual atmospheric profile. These are two methods based on the Data Resolution Matrix (DRM), one method based on the Jacobian matrix, and one iterative method selecting sequentially the channels with largest information content. The Jacobian method and the iterative method were found to be the most suitable for the problem. The iterative method was demonstrated to always produce the best results, but at a larger cost than the Jacobian method. To test the robustness of the iterative method, a variant has been tried. It consists in building a mean channel selection aimed at optimizing the results over the whole database, and then applying to each profile this "constant" selection. Results show that this "constant" iterative method is very promising, with results of intermediate quality between the ones obtained for the optimal iterative method and the Jacobian method. The practical advantage of this method for operational purposes is that the same set of channels can be used for various atmospheric profiles.

Regional use of locally received ATOVS radiances in NWP

R. Randriamampianina* and F. Rabier†
**Hungarian Meteorological Service*
Budapest, Hungary
† CNRM, Météo-France
Toulouse, France

Our objective was to investigate the use and impact of locally received and pre-processed ATOVS radiances in the French global model, ARPEGE over Europe. The particularity of the ARPEGE model is that it uses stretched geometry emphasizing the European area with the finest resolution over France that allowed us to study the impact of locally received ATOVS data in an area of fine resolution. ARPEGE uses a four-dimensional variational assimilation scheme and assimilates pre-processed ATOVS radiances.

In the experiments runs with HIRS+AMSU-A and AMSU-A only were performed. The benefit of increased resolution data was investigated as well. The impacts of locally pre-processed ATOVS and NESDIS radiances on different range forecasts were compared at each assimilation time (00, 06, 12 and 18 UTC).

The majority of the locally pre-processed ATOVS data from NOAA-16 became available for the assimilation within a relatively short time (short cut-off: 1h50 at 00 and 12 UTC and 3h at 06 and 18 UTC) compared to those sent by NESDIS. Positive impact on the forecasts of the locally pre-processed ATOVS data compared to that of NESDIS was found in most of the cases. Assimilation of pre-processed data in Lannion, with relatively finer resolution, gave a strong positive impact on the forecast compared to the finer resolution data, pre-processed by NESDIS.

Using a new radiative transfer model to estimate the effect of cirrus clouds on AMSU-B radiances

Sreerekha T. Ravindranathan, S. Buehler, C. Emde and V.O. John
Inst of Environmental Physics
University of Bremen
PO Box 330440
28334 Bremen
Germany

The upwelling atmospheric radiation in the mm-wave spectral range is influenced by the presence of cirrus clouds. A plane parallel radiative transfer model which can take into account the effect of multiple scattering of ice particles in cirrus has been developed and is used to simulate the brightness temperature for the AMSU-B channels. The model uses an iterative procedure to solve the radiative transfer equation. The formulation of the model is such that it can easily be adapted to treat the full Stokes vector instead of just the scalar total intensity. This will allow the investigation of polarization effects by oriented non-spherical ice particles.

The presentation outlines the model and demonstrates how it is tested for convergence. Furthermore, different cirrus cloud scenarios are studied and the results are presented. The results confirm that the brightness temperature in this frequency range is greatly influenced by the cloud's microphysical properties.

ATOVS operational science status and plans

Tony Reale
NOAA/NESDIS
Office of Research and Applications
Suitland, MD., USA

The Advanced TOVS operational sounding products system operated by NESDIS has undergone several modifications over the past 18 months to improve the horizontal and vertical consistency of the global products. Specific examples of improvements are presented, for example, across coastal and ice edge (Southern Hemisphere) boundaries, in the vicinity of the tropopause, and in the upper stratosphere. These upgrades were installed through three separate operational implementations done in February, October and December (pending at this time) of 2001. Each implementation stage is discussed with expected impacts on data users. The status and plans for a new approach to compute operational soundings, including the replacement of the current library search method for determining the first guess with a statistical regression, and the integration of AMSU-B data into the ATOVS processing system (which currently uses AMSU-A, HIRS and AVHRR data), are also discussed. The motivation for the new approach is driven by NESDIS goals to provide measurement and product suites which are more suitable for global (and regional) numerical weather prediction and climate applications, and which are convergent with current direct readout processing systems (i.e. IAPP), and planned future techniques for NPOESS/METOP.

Global radiosonde and in situ upper air observations for polar satellite validation

Tony Reale
NOAA/NESDIS
Office of Research and Applications
Suitland, MD., USA

At the recent Satellite Meteorology Conference held in Madison, Wisconsin during October, 2001, the ECMWF reported that the removal of radiosonde observations from a global numerical weather prediction (NWP), in lieu of retaining polar and geostationary satellite observations (and other available insitu observations), had no impact on the global NWP performance. Concurrently, a resonating theme at the Conference concerned the need for reliable ground truth for validating satellite (particularly polar) data, and the problem of systematic errors among these data, due for example, to radiosonde differences per manufacturer, satellite radiometer drift over time, and radiative transfer calculation uncertainty. It appears that a shift in the requirement for radiosondes has occurred, from that of a dense global network of observations to support global NWP, to a smaller but more regulated network for validating satellites. The following report discusses these issues, criteria for selecting candidate radiosondes and available in situ data suitable for validating polar satellites, and the problem of validation in the upper stratosphere. A program is proposed to integrate at least a portion of the current radiosonde network (overseen by the WMO), existing CART sites, and NOAA science vessels (for example the R.V. RONALD H BROWN), in a coordinated effort to calibrate and validate operational (and research?) polar orbiting satellites (and scientific techniques). Feasibility and funding are issues!

Retrieval of cloud parameters from the new sensor generation satellite multispectral measurements.

F. Romano and V. Cuomo
Istituto di Metodologie Avanzate di Analisi Ambientale,
IMAAA/CNR, Potenza, Italy

The earth's radiation budget and climate are dependent upon cloud radiative and geometric properties. Clouds are both absorbers of outgoing longwave radiation and reflectors of incoming solar radiation. Due to their crucial role, accurate cloud proprieties knowledge is needed in order to improve climate models. A wide variety of cloud properties must be taken into account: shapes, sizes,

vertical and horizontal locations, lifetimes, numbers of liquid droplets of different sizes, numbers of ice crystals of different shapes and sizes, and more. The clouds absorb, scatter, and emit radiation in a way that is influenced by each of these properties. The effects of clouds on climate are so complicated that the leading climate models give conflicting answers regarding their impact on climate. There is even uncertainty as to whether the changes in cloud properties will amplify or diminish any surface warming that may be caused by increasing atmospheric greenhouse gases.

Satellites can not provide all the answers, but measurements of radiation from space can play a big role in helping us understand how radiation depends on cloud properties. They can also help us to identify which are the most critical cloud properties to measure. The value of satellite-based measurements is that they offer the only practical way of making cloud measurements over the entire globe. In the near future, many new satellite sensors will be available for cloud observation. They will employ multispectral measurements in the visible and infrared spectral ranges. The improvement of spatial resolution and spectral characterisations allow us to apply sophisticated retrieval procedures, which will provide new cloud products with enhanced accuracy.

The paper explores the improvements in cloud detection using microwave AMSU data and high spectral resolution IR sounder data first, then the improvements in retrieval cloud parameters. Cloud parameters (cloud top height, cloud amount and cloud emissivity) will be estimated using different approaches and different satellite data.

Using direct readout satellite imagery in a scientific outreach program: A challenge for the future

Paul Ruscher
Department of Meteorology
Florida State University
Tallahassee, FL, USA

NOAA has been providing direct readout capability to anyone interested for over thirty years, but as of the late 1980s, the program was not being used much in schools. In the United Kingdom, one study estimated that over 2,000 weather satellite receiving stations were active. In response, the EXPLORES! program was born to help schools in Florida and across the US implement direct readout technology into their classrooms. The program is still relevant today, even with high-speed Internet connectivity at schools.

For over a decade, Florida State University has been supplying direct readout hardware and software to primary and secondary schools interested in improving their use of technology in support of their earth science teaching through the EXPLORES! program. Over 230 schools in the state now have direct readout capabilities for APT (4 km polar) and/or WEFAX (8-16 km GOES). Teachers from these schools have developed a curriculum which is being adopted in schools across Florida, on CD-ROM. These teachers have clamored for more information, however, and beginning in late 2000, 15 teachers were brought on board to directly receive GVAR imagery. In 2002, they will be using HRPT imagery in a distributed mode, as well, and will be helping to design a comprehensive field experiment on the Florida sea breeze. We have plans to use LRPT imagery from the new generations of polar orbiting weather satellites, as well, in the future.

This scientific use of direct readout data has been a tremendous boost in public understanding of satellite capabilities and missions, and is an excellent model for how satellite programs of the future can transmit their mission to the general public. Such an effort is important in terms of justifying expensive equipment and programs to a sometimes sceptical general public. The public in Florida generally is supportive of satellite missions, at least in part, because of the launches which occur from Cape Canaveral. However, use of the EXPLORES! materials outside of Florida indicates their widespread acceptance and benefit.

This paper/electronic poster will serve to illustrate how the EXPLORES! program at Florida State University has evolved into a national curriculum and outreach model, which has helped NOAA on numerous occasions to enhance the use of their imagery by teachers. It also will serve as a request and challenge for instrument developers to consider the utility of (perhaps) degraded resolution imagery products to be broadcast via direct readout, whether that be in the two meter ham band, 1.7 Ghz band, or otherwise, such that it is affordable for those who are interested. Our project web site is at: http://www.met.fsu.edu/explores/

RTTOV-7: a satellite radiance simulator for the new millennium

Roger Saunders*, Marco Matricardi[†], Pascal Brunel[‡], Stephen English* and Godelieve Deblonde[§]
**Met Office, Bracknell, Berks., UK*
[†] ECMWF, Shinfield Park, Reading, Berks. RG2 9AX, UK
[‡] Météo-France, Toulouse, France
[§] Meteorological Service of Canada Dorval, P. Québec, Canada, H9P1J3

One of the essential tools to exploit satellite radiance data in an NWP model assimilation system

is a fast radiative transfer model. This includes both the forward model, which computes satellite radiances for a given profile vector and its gradient which computes the change in radiances with respect to the input profile variables. The RTTOV model has been developed for many years now and recently this has been supported as part of the EUMETSAT NWP Satellite Application Facility (SAF) activities. The last version of RTTOV (RTTOV-6) was released in March 2000 and has been distributed to over 40 users worldwide. A few developments have been made to the original RTTOV-6 release and will be mentioned briefly.

In January 2002 RTTOV-7 was released by the NWP-SAF. This has several improvements that are described in this presentation and associated posters. The main upgrades are: much improved water vapour and ozone radiance simulations, improved microwave surface emissivity model, FASTEM-2, support for AIRS, MODIS and SSM/I(S), additional RTTOV routines for simulating cloudy radiances, code rewritten in standard Fortran-90 and simpler coefficient ingest. The new model can be obtained by making a request to:

roger.saunders@metoffice.com.

Plans for RTTOV-8 are now being made and user input is welcomed.

Measurement of land surface emissivity with IASI

Peter Schlüssel
EUMETSAT, Am Kavalleriesand 31, 64295 Darmstadt, Germany
schluessel@eumetsat.de

The Atmospheric Sounding Interferometer (IASI), to be flown as part of METOP in 2005, is a multi-purpose sounding instrument that will be used for global measurement of atmospheric temperature and water-vapour as well as trace gases, cloud and surface parameters. Among the latter, the spectral emissivity of land surfaces can be measured with IASI. It allows the characterisation of the land surface and enables an accurate retrieval of land surface temperature. The spectral signature of land surfaces has been studied using random compositions of spectra from homogeneous land surfaces together with radiative transfer calculations for a globally representative set of surface-atmosphere situations. The study shows that the spectral signatures of the emissivity spectra between 3.62 and 15 μm (corresponding to the spectral domain of IASI) can be fully represented by values at 12 wavelengths, selected in highly transparent atmospheric windows. Using an EOF analysis of the IASI spectra allows for measurement of the surface emissivity at those selected wavelengths with an accuracy between 0.0035 near 13 μm and 0.0137 near 3.6 μm, which explains between 87% and 95% of the emissivity variance, respectively.

Use of ATOVS data in HIRLAM 3D-Var

Harald Schyberg, Bjarne Amstrup, Nils Gustafsson, Heikki Jarvinen
Norwegian Met. Inst., Oslo, Norway
Tomas Landelius, Magnus Lindskog, Sigurdur Thorsteinsson, Frank Thomas Tveter and Ole Vignes
Swedish Met. Inst. Norrköping, Sweden

An overview of the processing and assimilation of ATOVS data for use in the HIRLAM (High-Resolution Limited Area Model) model is given. Methods for data quality control and assumptions on error statistics are described. Assimilation of AMSU-A in the HIRLAM 3D-Var scheme has been implemented and tested on different model domains in several of the HIRLAM member countries, and a slight positive impact on the forecasts is found. The various impact studies performed are described and discussed. Finally, further developments – including use of AMSU over ice, use of AMSU-B and use of HIRS moisture channels – is discussed.

Fast radiative transfer model prediction of water vapour absorption: results from recent studies examining predictor selection and regression profile set dependencies

V. Sherlock
Met. & Remote Sensing, NIWA, Wellington, NZ

Accurate prediction of water vapour absorption has been a critical yet challenging problem for all fast radiative transfer (RT) model developments to date. Although recent fast RT model developments for the advanced sounders have given marked improvements in fast model accuracy in the 6.7 micron water vapour band, modelling water vapour absorption, particularly in line centres, remains a subject of ongoing study.

This poster examines the issues of predictor selection and predictor redundancy for two sets of predictors proposed for advanced IR sounder fast model water vapour transmittance regression schemes. Regression stability and accuracy, as determined by forward model and Jacobian fitting errors for dependent and independent profile sets, are compared for the proposed sets of predictors and subsets thereof. Dependence on the profile sets underpinning the transmittance regression sets is also examined.

Development and validation of Gastropod, a fast radiative transfer operator for the advanced infrared sounders.

V. Sherlock*, A. Collard† and R. W. Saunders†
** Met. & Remote Sensing, NIWA, Wellington, NZ*
†Met Office, Bracknell, Berks.,UK

Gastropod is a fast radiative transfer code developed to meet the requirements for a day one radiative transfer (RT) operator for AIRS (and eventually IASI) for use in variational data assimilation systems.

This presentation gives an overview of the model methodology adopted and summarises the results from line-by-line RT model validation of the Gastropod forward model and K code for dependent and independent profile sets. Issues relating to modelled variable gas absorption are described briefly here and treated in detail in the accompanying poster.

Results of the comparison of forward model and Jacobian simulations from Gastropod and the RTTOV-7 beta version AIRS fast model will also be discussed.

Comparison of error analysis in 3d-Var, for assimilation of radiances and retrievals using NOAA-14

Elizabeth Silvestre Espinoza
Instituto Nacional de Pesquisas Espaciais – INPE Centro de Previsão de Tempo e Estudos Climáticos – CPTEC Endereço:Rodovia Presidente Dutra Km, 40 Cachoeira Paulista, CEP 12630-000 São Paulo, Brazil
elizabet@cptec.inpe.br

The use of radiances in data assimilation systems can be of two forms: direct assimilation, or they may be pre-processed to retrieve geophysical parameters, like temperature or humidity for subsequent assimilation. In this work we compared, using Variational techniques, the two processes of data assimilation (Direct Assimilation and Assimilation of Retrievals) in the South Hemisphere, in the area delimited by 10°N to 35°S and 35°W to 80°W for 17 pressure levels. These techniques are implemented and compared in a three-dimensional assimilation system (3D-VAR) using simulated radiances for the channels of the NOAA-14 (HIRS, MSU and SSU) infrared-temperature profiling instruments in relation to the parameters of geopotential and mixing ratio. The analysis error patterns indicated that error analysis for direct assimilation of radiances is less than for the assimilation of retrievals, but with little difference between them. We used geopotential height and humidity at a number of points for the analysis.

Impact of ATOVS sounding in analysis in South America

Elizabeth Silvestre Espinoza[1]
João Carlos Carvalho[2]
Rosangela Cintra[3]

Instituto Nacional de Pesquisas Espaciais - INPE
Centro de Previsão de Tempo e Estudos Climáticos - CPTEC
Endereço : Rodovia Presidente Dutra Km, 40
Cachoeira Paulista, CEP 12630-000
São Paulo, Brazil

[1]elizabet@cptec.inpe.br
[2]jcarlos@cptec.inpe.br
[3]rcintra@cptec.inpe.br

The performance of the NWP models depends not only on the physical and dynamic representation of atmospheric processes, but also on initial conditions derived from observations of the real state of the atmosphere. In the Southern Hemisphere the network of conventional upper air observations is sparse, and satellite data are an alternative source for improving the specification of initial conditions. In this soundings work, ATOVS (using Inversion Coupled with Image (ICI)) has been developed at Centre de Météorologie Spatiale (CMS) of Lannion, is evaluated using analysis of the Regional Physical-space Statistical Analysis System (RPSAS) in connection with the Eta model of the Forecast Weather Center and Climatic Studies (CPTEC) from Brazil. The observations used are conventional observations (Temp, synop, ship, etc) and satellite data (NOAA-15) for the period of 23 February to 8 March 2000. The fields of the analysis are timed at 00Z and 12Z. Evaluation of the RPSAS analysis from CPTEC with and without ATOVS soundings are performed comparing the fields with NCEP and ECMWF analyses for geopotential height at the 850, 500 and 300 hPa levels.

Validation of atmospheric temperature profiles derived using a Neural Network approach from AMSU-A measurements onboard NOAA-15 and NOAA-16 satellites and their applications for tropical cyclone analysis

Devendra Singh, R.C.Bhatia, S.K.Mukherjee and Sant Prasad
Satellite Meteorology Division

India Meteorological Department, New Delhi-10003 India

The new High Resolution Picture Transmission (HRPT) reception system installed recently at IMD, New Delhi is capable of receiving real time data from sensors onboard the NOAA-K, L, M and N series of satellites. In this system, a Neural Network approach is used to retrieve the temperature profiles from AMSU-A measurements. The retrieval results are evaluated by computing the bias and root mean square (RMS) difference between retrievals and collocated radiosonde sounding profiles. Retrievals made from NOAA-16 data yield better results compared to NOAA-15 for two different seasons. The bias and root mean square errors are 1.0 - 2.0^{0}C at all levels except at the middle level of about 500 hPa where it is about 3.5^{0}C. Further, the comparison among different techniques shows that the neural network retrieval yields better results for all atmospheric levels as compared to linear regression and a non-linear physical iterative approach.

The AMSU-A measurements are also used for analysis of two recent tropical cyclones which formed in the Arabian sea in the months of May and September, 2001. The temperature anomalies were computed using AMSU-A-derived temperature profiles with NOAA-16 data. Preliminary results based on the analysis of limited data show that, in both cases, the warm core anomalies were located at about the 250 hPa level. The magnitude of warm core anomalies appears to be positively correlated with the strength of the tropical cyclone. Negative temperature anomalies, which were also observed at lower levels, appear to be caused by heavy rainfall contamination of lower AMSU-A channels (4-6). This observation can also provide useful information about the location and intensity of precipitation. The AMSU-A data appear to offer substantial opportunities for improvements in tropical cyclone analysis.

Advanced sounder capabilities – airborne demonstration with NAST-I

William L. Smith, Daniel K. Zhou, and Allen M. Larar
NASA Langley Research Center
Hampton, VA, USA

The NPOESS Aircraft Sounding Test-bed – Interferometer (NAST-I) has a spatial and spectral resolution and coverage encompassing that of all high spectral resolution sounding instruments (i.e., AIRS, IASI, CrIS, and GIFTS) which will fly aboard future research and operational satellites. The NAST-I has flown on high altitude aircraft during eight major field campaigns, obtaining high spectral resolution sounding data from which forward models and advanced retrieval algorithms planned for use with the spacecraft measurements can be verified. Furthermore, the retrievals of geophysical products from the NAST-I data provide a glimpse at what can be expected in terms of retrieval capability with these future sounders. In this presentation, NAST-I results are presented which experimentally validate the expectations of future sounding instruments both in terms of high vertical resolution meteorological sounding capability as well as for the measurement of certain atmospheric chemistry constituents. Included in the presentation is a demonstration of the capability to: (1) sound, with high vertical resolution, down to the earth's surface under clear sky conditions as well as through semi-transparent Cirrus cloud, (2) sound, with high vertical resolution, down to the tops of optically thick cloud, (3) determine the surface emissivity spectrum, the Earth's surface skin temperature, and sound the thermodynamic structure of the planetary boundary layer, over both land and sea, (4) detect aerosol absorption and account for it in the determination of surface and atmospheric variables, (5) observe mesoscale water vapor features related to convective processes and turbulence, and (6) observe the spatial distribution of tropospheric trace gases such as CO and O_3. Validation of these high spectral resolution sounder capabilities, as demonstrated with NAST-I, is provided using high spatial and temporal resolution radiosonde observations and airborne DIAL and surface based Raman LIDAR water vapor measurements.

Geostationary sounding: Current and future GOES sounders

Kent Sprunger, Chris Archer and Steve Johnson
ITT Aerospace Comms Division
Fort Wayne, IN, USA

This paper will describe the design of the current (GOES I-Q) sounders, and compare key characteristics of the current sensor to that of the planned future sensor (Advanced Baseline Sounder). It will also compare the current sounder product to the predicted ABS product

CO_2 retrievals from IR sounding measurements and its influence on temperature retrievals.

G. Stephens and R. Engelen
Dept. Atmos.Sci., Colorado State Univ., Ft Collins, CO, USA

The effects of spatial variability of the atmospheric CO_2 distribution on temperature and water vapor retrievals is described. CO_2 information content contained in present sounders as well as in future high resolution sounders is also discussed. It will be shown that the widely used assumption of constant CO_2 content introduces errors in the temperature profile up to 0.85K compared to retrievals that account for realistic variations in CO_2. It will also be shown that CO_2 information is also extractable from the high resolution spectra to be provided from AIRS and future sounders. The value of this information for carbon budget studies will be described.

Studying cirrus mean effective ice crystal sizes using satellite TIROS-N Operational Vertical Sounder (TOVS) observations

C. J. Stubenrauch[+], G. Rädel[+], F. Eddounia[+], R. Holz[+], N. A. Scott[+], D. Mitchell*
[+]*Laboratoire de Météorologie Dynamique, École Polytechnique, Palaiseau, France*
**Desert Research Institute, Atmospheric Sciences Center, NV, USA*

The Improved Initialization Inversion (3I) algorithm converts TIROS-N Operational Vertical Sounder (TOVS) observations from the NOAA polar orbiting environmental satellites into atmospheric temperature and water vapor profiles, as well as into cloud and surface properties at a spatial resolution of 1°. Within the framework of the NOAA/NASA Pathfinder Program, eight years (1987-1995) of TOVS data have been processed. Cloud-top pressure and effective IR cloud emissivity are computed from the CO_2-band radiances by a weighted ^{2} method.

Mean effective ice crystal sizes are retrieved for large-scale cirrus clouds with an IR emissivity between 0.3 and 0.85. Therefore, cloud emissivities at 8 μm and 11 μm are computed from the measured brightness temperatures, the cloud-top temperature and the surface temperature. The difference between emissivities at these wavelengths is sensitive to the mean ice crystal size of the cirrus cloud. However, the exact correlation depends on the theoretical approach to express the absorption coefficients, single scattering albedo and asymmetry parameter of ice crystals explicitly in terms of their shape and size distribution. At present, we have compared two different sets of ice crystal single scattering properties and their effect on ice crystal size retrieval: randomly oriented planar polycrystals and hexagonal columns. After different sensitivity studies we present an analysis of the spatial and seasonal distribution of mean effective ice crystal sizes of large-scale cirrus using NOAA-10 observations from 1987 to 1991. On average, effective ice crystal diameters lie between 45 and 60 μm. In winter midlatitudes, with lower humidity, mean ice crystal sizes are slightly smaller than in summer midlatitudes and in the tropics. We will also analyze effects of the Mount Pinatubo eruption. This study is part of the European project CIRAMOSA (CIrrus microphysical properties and their effect on RAdiation: survey and integration into climate MOdels using combined SAtellite observations).

Future data processing at the Information Processing Division (IPD) of the National Environmental Satellite Data and Processing Service (NESDIS)

Vince Tabor
NOAA/NESDIS
Office of Satellite, Data, Processing and Distribution
Suitland, MD, USA

Times are changing at the National Environmental Satellite Data and Information Service (NESDIS), and NESDIS is changing with the times. The future holds many challenges to be overcome in environmental satellite data processing with the upcoming launch of the National Oceanic and Atmospheric Administration (NOAA) satellites; NOAA-N, NOAA-N' and the European Organization for the Exploitation of Meteorological (EUMETSAT) satellites, Meteorological Operational Satellite METOP-1 and METOP-2. The National Polar Orbiting Environmental Satellite System (NPOESS) and NPOESS Preparatory Program (NPP) series of satellites will also bring new challenges to IPD. These changes are not limited to the type of data processed but will also spill over into the methods used. For METOP, techniques such as pipeline and parallel processing will have to be employed to meet data delivery deadlines because of the slow rate at which data will arrive at NESDIS. New and faster processors are proposed to handle the additional data volume and to speed up throughput. Completely new approaches to data processing are envisioned for the NPP and NPOESS era data processing at NESDIS. This report will cover some of the planned changes at NESDIS.

Information content and optimal channel selection for AIRS

Jean-Noël Thépaut and Nadia Fourrié
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berks. RG2 9AX, UK
jean-noel.thepaut@ecmwf.int

ECMWF is in the preparation phase for the assimilation of radiances from the advanced sounder AIRS on board AQUA, scheduled sometime in 2002. It is planned that, at day-1, the reduced radiance dataset (between 200 and 300 channels) provided by NESDIS will be assimilated.

In this paper, we try to evaluate the information content of this reduced set of channels (currently 228 simulated channels broadcast in NRT) in terms of geophysical parameters. The Information Content software developed at Météo-France in the context of IASI has been adapted to AIRS. The information content of the reduced set of AIRS channels is then compared with an optimal channel selection method (the so-called Rodgers method). The robustness of the information content to the air masses and the specification of the background error covariance matrix will be addressed. The sensitivity of the non-linear aspects of the 1DVAR retrievals will also be explored.

ATOVS 1D-VAR retrieval in the Australian region LAPS data assimilation and prediction system

C. Tingwell, B. Harris and W. Bourke
Bureau of Meteorology Research Centre
Melbourne, Australia

The use of 1DVAR retrievals of TOVS/ATOVS radiances in the Australian Bureau of Meteorology Global Assimilation and Prediction System (GASP) has produced a significant improvement in forecast skill and was implemented operationally in July 2000. This 1DVAR scheme has now been integrated with the Bureau's Limited-area Assimilation and Prediction System (LAPS), as part of an effort to unify the data assimilation component of the two systems. The 1DVAR retrievals are used over the sea and below 100 hPa and NESDIS retrievals are used to extend the first guess profiles above the top of the model (50 hPa). Several real-time assimilation and forecasting experiments have been conducted to test the impact of 1DVAR ATOVS data in the context of different assimilation strategies and we will present results that show marked gains in forecast skill.

Work is underway to test the 1DVAR system in an extended version of LAPS with an increased number of vertical levels and the model top raised to 0.1hPa, following similar extensions to GASP. This eliminates the need for NESDIS retrievals and will facilitate the use of locally received and processed ATOVS radiances whose timeliness will improve the amount of data available to the operational LAPS system. The results of experiments conducted to date will be presented.

IASI Level 0 and 1 processing algorithms description

Bernard Tournier[†] , Denis Blumstein[‡], François-Régis Cayla[‡]*
[†]NOVELTIS, Ramonville, St Agne, France
[‡]CNES, France
**present affiliation SISCLE, France*

IASI is an infrared atmospheric sounder. CNES is leading the IASI program in association with EUMETSAT and is supported by Météo-France for scientific aspects.

The instrument is composed of a Fourier transform interferometer and an associated infrared imager. The interferometer provides a spectral range from 645 cm^{-1} to 2760 cm^{-1} (3.6 μm to 15.5 μm) and a spectral resolution of 0.5 cm^{-1} (FWHM) after apodization. The sounder pixel size is 12 km (at nadir). The infrared imager allows the coregistration of IASI sounding with AVHRR images. A moving mirror with 30 scan positions provides a swath of about 2000 km (120 spectra for each 8 seconds).

The interferograms are processed by an on-board digital processing subsystem which performs the inverse Fourier transform and the radiometric calibration in order to decrease the IASI transmission rate from 45 to 1.5 Mbits/s. This part of the processing is the level 0 processing. The level 1 processing is performed on ground and produces resampled, apodized and calibrated spectra (radiometric post calibration and spectral calibration). An AVHRR radiances classification inside IASI sounder pixels is also provided.

The aim of this presentation is to describe the physical and mathematical content of the IASI level 0 and 1 processing algorithms and their architecture. It also describes the initialisation parameters required for execution of these algorithms.

Revisiting the attenuated reflected downward flux term of the radiative transfer equation

D. S. Turner
Meteorological Service of Canada
Downsview, ONT, Canada

The top-of-the-atmosphere brightness temperature for the HIRS and AIRSA instruments, with an emphasis on the attenuated reflected downward flux term, is examined. A fast line-by-line radiative transfer model is used to evaluate the radiative transfer quantities. These 'exact' calculations are compared to two models; one where the diffusivity angle equals the zenith angle and one where the diffusivity angle is constant, for forty-two diverse atmospheres.

The comparison indicates the limitations of the models. In general, the bias of the ensemble is acceptable for most clear sky situations; however, the bias develops significant zenith angle and cloud top pressure dependencies for cloudy situations, which may lead to problems.

Upgraded radiative transfer model status at NCEP/EMC

Paul van Delst
CIMSS at NOAA/NCEP
Camp Springs, MD, USA

The beta version of the upgraded Community Radiative Transfer Model (using the OPTRAN algorithm) has been released including the Forward, tangent-linear, adjoint, and K-matrix components. This presentation will briefly discuss the software design and detail the results from testing the code standalone and in the NCEP Global Data Assimilation System (GDAS). Auxillary software provided will also be mentioned.

ATOVS in the Canadian Regional Assimilation System

Nicolas Wagneur, Clément Chouinard and Judy St-James
Canadian Meteorological Center,
Meteorological Service of Canada
2121 Trans-Canada Highway, Dorval, P. Québec,
Canada, H9P 1J3

The incremental formulation of the Canadian operational 3DVAR assimilation system allows for quasi-simultaneous implementation of improvements developed for the global data assimilation in the regional framework. After the ATOVS AMSU-A channels were successfully assimilated in the new CMC global assimilation system (see presentation by Clément Chouinard), it was straightforward to do the same in our 24 km resolution regional model. A brief description of the regional spinup assimilation cycle will be presented along with significant positive impact on specific regional meteorological parameters, namely the precipitation fields.

In the process of issuing timely high resolution NWP forecasts over Canada, the timeliness, availability and coverage of data are crucial. The monitoring of level-1b data from reception to ingestion in the regional system will be presented with an eye to maximizing the volume of data.

Potential application of advanced infra red sounders on earthquake prediction and energy resources exploration

Hong-Qi Wang
START Regional Center for Temperate East Asia
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029,China

Some measurements show that methane concentrations in the atmosphere are increased prior to earthquakes in seismic areas. Because methane is an infrared absorbing gas, the variation of its concentration may cause changes of outgoing radiances at the top of the atmosphere. Through radiative transfer calculations with different spectral resolution, the effects of increasing methane concentration on the outgoing spectral radiances have been analyzed. At some frequencies in CH_4 absorption bands the outgoing radiances are sensitive to the increase of methane concentration, and the sensitivities are increased with increasing spectral resolution. Thus, the increase of methane concentration in the atmosphere in seismic areas, might be well reflected by the outgoing radiances at some properly selected frequencies. The Advanced Infra-Red Sounders (AIRS) have high spectral resolution channels in CH_4 7.66μm and/or 3.3μm, that provides the opportunity to utilize some proper channels to monitor such a phenomenon, which might be used as a kind of imminent earthquake precursor.

In the methane enrichment zones such as oil and natural gas fields, the phenomenon of large quantities of CH_4 escaping from the Earth's crust would be much more likely to occur, resulting in more significant increases in CH_4 concentrations, when these regions are located in seismic activity areas. In recent years, much attention has been paid to gas hydrates, which are ice-like solids composed of crystal cages of water molecules hosting gas molecules (usually methane), because they may represent, among others, a future energy resource. If earthquake activities happen in areas of gas hydrate sediments and could result in escaping even a small part of methane within and beneath marine gas hydrate sediments into the atmosphere, the increase of methane concentration in the atmosphere would be significant. Thus, monitoring the increase of methane concentration in the atmosphere in seismic areas with proper AIRS channels might not only be useful to impending earthquake prediction, but also be valuable in finding enrichment zones for oil, natural gas and gas hydrates on exploration of energy resources.

Advances in AMSU non-sounding products and microwave forward modeling

Fuzhong Weng
NOAA/NESDIS/Office of Research and Applications
5200 Auth Road, Rm. 601
Camp Springs, MD 20724
Fuzhong.Weng@noaa.gov

This presentation will first review the latest AMSU algorithms developed within NOAA/NESDIS for retrieving total precipitable water, cloud liquid water, precipitation, snow cover and sea ice concentration. The algorithms for total precipitable water, cloud liquid and ice water, and surface precipitation rate are all physically based and allow for using the NWP model outputs (e.g. SST and surface wind) in the retrieval. The experimental products of land emissivity and surface temperature are also recently developed for operational implementation.

Since ITSC-XI, NESDIS has also put a lot of effort into developing the fast radiative transfer model that performs best from microwave to millimeter wavelengths. Various modeling components will lead to uses of more satellite microwave sounding data from current AMSU and future sensors such as SSMIS, WindSAT and CMIS for NWP data assimilation. Progress in modeling microwave land emissivity, oceanic polarimetric emissivity and atmospheric scattering will be reported.

The ATOVS and AVHRR Processing Package current capability and future evolution

Keith Whyte*, Tiphaine Labrot[†] and Rainer[‡] Schraidt
**Met Office, Bracknell, Berks., UK*
[†]Météo-France, , Toulouse, France
[‡]EUMETSAT, Darmstadt, Germany
keith.whyte@metoffice.com

Since its inception in 1994 as a cooperative venture between various European partners, the ATOVS and AVHRR Processing Package (AAPP) has been developed in response to the needs of the international satellite data processing community, as a portable software package for Unix systems.

With the release of version 3.0 in summer 2001, a number of known problems have been dealt with, and full capability for the processing of ATOVS and AVHRR data from both NOAA15 and NOAA16 has been included. Under the auspices of EUMETSAT's Satellite Application Facility (SAF) for Numerical Weather Prediction, the maintenance, improvement and extension of AAPP is a SAF responsibility, and European meteorological agencies are continuing to cooperate in AAPP's evolution in order to meet both operational and research requirements.

The National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Mission concept and status

Peter A. Wilczynski
NPOESS Integrated Program Office (IPO)
8455 Colesville Road, Suite 1450
Silver Spring, MD 20910, USA
peter.wilczynski@noaa.gov

The NPP is a joint-agency mission intending to serve the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integrated Program Office (IPO) and the National Aeronautics and Space Administration (NASA) and their user communities. The IPO is comprised of the Department of Defense (DoD), Department of Commerce (DOC) and the NASA under the authority of the tri-agency NPOESS senior executive board, the Executive Committee (EXCOM).

The NPP provides the Earth science community with data continuity for systematic measurements in the disciplines of terrestrial and oceanic productivity, and atmospheric temperature and humidity profiles. The NPP also provides the IPO and its users a risk reduction demonstration of capabilities for critical NPOESS instruments, their associated algorithms, and NPOESS command, control, communications, and interface data processing systems, prior to the first NPOESS launch, thereby allowing lessons learned from NPP to be incorporated into NPOESS. The NPP mission is considered a bridge between the existing NASA EOS and the NPOESS programs. The mission provides continuity of climate data measurements for NASA and risk reduction for the NPOESS IPO.

The NPP spacecraft will be launched in December of 2005. NPP will operate in a sun synchronous polar orbit at an altitude of 824 km. It will have a descending node time of 10:30 am, +/- 10 minutes, with a ground track repeatability +/- 20 km, all latitudes, cross track. NPP will be built for a mission lifetime of five years. NPP will operate with three instruments: The Visible/IR Imager Radiometer Suite (VIIRS), the Cross-track Infrared Sounder (CrIS), and the Advanced Technology Microwave Sounder (ATMS) which constitutes a suite of critical instruments (CrIMSS) under development by the NPOESS IPO.

VIIRS will replace the DOC's third generation visible and infrared sensor, the Advanced Very High Resolution Radiometer (AVHRR/3), and DoD's Operational Line Scanner (OLS), flown on POES and DMSP respectively. VIIRS is under contract with Raytheon Electronics Systems, Santa Barbara Remote Sensing. The CrIS instrument is a Fourier Transform Spectrometer (FTS) currently under contract for the U.S. Government by ITT Aerospace. ATMS is a cross track scanning microwave radiometer with 22 channels. ATMS is under contract with Aerojet. CrIS and ATMS provide a single set of data products.

Satellite command and control of the NPP spacecraft will occur at the IPO Mission Management Center. All data will be stored on board the spacecraft and will be recovered on the ground at a ground station in Svalbard, Norway. NPP will have a real-time High Rate Data (HRD) link in X-Band (7750-7850 MHz). This data set will be continuously available throughout the orbit. The NPP spacecraft will be selected in April 2002.

The paper will discuss the current status of the NPP mission to include the following: Current concept of operations for NPP, spacecraft development, VIIRS/CrIS/ATMS design status, ground system development (which will include data recovery and processing) and overall project schedule.

The Virtual Laboratory for Satellite Meteorology: An opportunity for collaborative education and training

Jeff Wilson
Australian Bureau of Meteorology Training Centre
Melbourne, Victoria, Australia

Under the auspices of WMO and CGMS an international focus group has been formed to oversee the development of the WMO / CGMS Virtual Laboratory for Satellite Meteorology. The Virtual Laboratory will act as a portal for the education and training of personnel using satellite meteorology applications and data. Input from specialist groups such as the TOVS, Winds and Precipitation communities will be vital to the success of the Virtual Laboratory and the Virtual Laboratory community will offer a ready-made audience to these specialist working groups. This presentation will outline the scope of the Virtual Laboratory, highlight the progress made so far and outline possible areas of collaboration between the TOVS Working Group and the Virtual Laboratory Focus Group.

A fully operational AIRS processing and distribution system

W. Wolf[1], M. Goldberg, L. Zhou[1], Y. Qu[2], M. Divakarla[2]
NOAA/NESDIS/Office of Research and Applications (ORA); 5200 Auth Road, Camp Springs, MD 20746 USA
[1] QSS Group Inc, Lanham, MD, USA
[2] DSTI, Rockville, MD, USA

A near real-time AIRS processing and distribution system is now fully operational at NOAA/NESDIS. The AIRS orbit is created from simulated attitude and ephemeris data. The simulated orbits are used with the NCEP Aviation Model forecast data to produce atmospheric profiles at each AIRS field of view. The atmospheric profiles are run through a fast radiative transfer program to calculate the AIRS radiances along with AMSU and HSB brightness temperatures, which are subsequently used to produce temperature, water vapor and ozone retrievals. The radiances and brightness temperatures are subsampled, spatially and spectrally, and delivered to NWP centers in BUFR format. The AIRS, AMSU, and HSB radiances and brightness temperatures are matched to radiosondes and other instrument data and delivered to different scientific groups, including ORA. Details of the processing, distribution, and visualization of the AIRS products will be presented.

The status of AAPP/ICI at NSMC

Xuebao Wu, Fengying Zhang

National Satellite Meteorological Center
China Meteorological Administration
Beijing, China

Lydie Lavanant and Pascal Brunel
Centre de Meteorologie Spatiale
Météo-France
Lannion, France

Both AAPP3 and ICI3 have been implemented to process the ATOVS measurements from NOAA-16 polar-orbiting satellite. The ICI method has been used to derive vertical profiles of atmospheric temperature and humidity. In this paper we present the main characteristics of our retrieval algorithm. We also show the statistical results and their validations. A brief description of the potential use of these data in the Chinese regional numerical weather predication model will be given in this presentation.

FY-3A: progress and direct broadcast characteristics

Zhang Wenjian
CMA, China

This paper will consist of a detailed report about the satellite, instrumentation, as well as data broadcasting plans.

Land surface temperature determination from GMS-5/VISSR data with some different retrieval methods

Gao-Xiang Zhao, Hong-Qi Wang and Li-Zhi Wang
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029,China

For retrieving land surface temperature from satellite measurement data, we have proposed an algorithm to deal with the coupling problem between the land surface temperature and emissivity, which could be used to determine the land surface temperature and emissivity, simultaneously. Simulation tests show that with this algorithm, land surface temperatures could be determined rather accurately, if the atmospheric effect could be omitted. But in real situations, the atmospheric effect must be taken into consideration. In this work, the real GMS-5/VISSR data have been used to determine land surface temperatures with this retrieval algorithm and some other methods, and their accuracies are examined with in situ measurements of land surface temperature. In the procedure for retrieving land surface temperature, the atmospheric temperature and moisture profiles obtained with radiosonde and atmospheric aerosol models have been used in a forward radiative transfer calculation for making an atmospheric correction. Error analysis shows that the accuracy of our land surface temperature retrieval algorithm is mainly affected by the atmospheric correction. Quite accurate land surface temperatures can be obtained if the atmospheric correction is good, otherwise the deviations of retrieved land surface temperatures will be larger. So that if reasonably accurate atmospheric parameters are available in the atmospheric correction, acceptable accuracy of land surface temperature retrieval from real satellite measurement data could be attainable with this algorithm.

ITSC-XII Agenda

Appendix A

Wednesday 27 February 2002

10:00 – 11:00 **REGISTRATION**

11:30 – 12:30 **INTRODUCTORY SESSION (chairs Le Marshall and Rochard)**

- **Welcome**
- **Opening**
- **Presentation and discussion of agenda**

12:30 – 14:00 **LUNCH**

14:00 – 15:20 **SCIENTIFIC PRESENTATIONS**

Session 1a: TOVS/SSM (Chair: Le Marshall)

Deblonde	Comparison of the sounding and imaging capabilities of the SSMIS and AMSU	1a1
English and F. Weng	Methods for processing cloudy AMSU observations	1a2
Franquet, Scott, Chedin, Armante and Eymard	Radiative transfer in the SAPHIR and AMSU channels in the perspective of water vapor profiles retrieval	1a3
Li and Weng	Correction of cloud contamination on AMSU measurements: a modeling study	1a4

15:20 – 15:50 **BREAK**

15:50 – 17:50 **SCIENTIFIC PRESENTATIONS**

Session 1b: ATOVS/SSM(Chair: Rochard)

Reale	ATOVS operational science status and plans	1b1
Stephens and Engelen	CO2 retrievals from IR sounding measurements and its influence on temperature retrievals	1b2
Weng (Fuzhong)	Advances in AMSU non-sounding products and microwave forward modeling	1b3

Session 2a: ATOVS and TOVS in NWP (Chair: Chouinard)

Baker	The application of observation adjoint sensitivity to satellite assimilation problems	2a1
Chevallier, Bauer and Moreau	Potential of the SSM/I rain observations for 4D-Var assimilation	2a2
Derber	The use of radiance data in the NCEP global and regional; data assimilation systems	2a3

Thursday 28 February 2002

08:00 – 10:00 **SCIENTIFIC PRESENTATIONS**

Session 2b: ATOVS/TOVS in NWP (Chair: Eyre)

English, Jones, Smith, Hilton and Whyte	ATOVS and SSM/I assimilation at the Met Office	2b1
Kelly, Bauer and Uppala	Improved assimilation of AMSU/HIRS/VTPR radiances in the ECMWF system	2b2
Chouinard, Hallé, Charette and Sarazin	Recent improvements in the use of TOVS satellite radiances in the unified 3D-var system of the Canadian Meteorological Centre	2b3
Gerard	Use of global ATOVS and SSM/I at Meteo-France	2b4
Harris, Bourke, Paevere and Steinle	Extending 1Dvar/ GASP to 0.1 hPa and the assimilation of 1C AMSU-A data	2b5
Joiner, Frank, da Silva, Bosilovich and Radacovich	Assimilation of cloud- and land-affected TOVS/ATOVS level 1b data at DAO	2b6

10:00 – 10:20 BREAK

10:20 – 12:20 SCIENTIFIC PRESENTATIONS

Session 2c: ATOVS/TOVS in NWP (Chair: Menzel)

Koepken, Kelly and Thepaut	Assimilation of geostationary radiances within the 4Dvar system at ECMWF	2c1
Okamoto	Recent developments in assimilation of ATOVS at JMA	2c2
Prasad, Paliwal, Das Gupta and Rajan	Recent advances in utilization of ATOVS and SSM/I data in the operational global data assimilation of India	2c3

Session 3a: ATOVS/TOVS in climate studies (Chair: Uddstrom)

Bates	Variability in upper tropospheric humidity and water cycle dynamics using TOVS data	3a1
Chedin, Hollingsworth, Scott, Serrar, Crevoisier and Armante	Annual and seasonal variations of atmospheric CO2, N2O and CO concentrations retrieved from NOAA/TOVS satellite observations	3a2
Menzel and Wylie	HIRS observations of a decline in NH winter clouds since 1997	3a3

12:20 – 14:20 LUNCH

14:20 – 16:00 SCIENTIFIC PRESENTATIONS

Session 3b: ATOVS/TOVS in climate studies (Chair: Joiner)

Prata, Bates and Jackson	A new method for the retrieval of upper troposphere/ lower stratosphere sulfur dioxide from global long-term TOVS measurements	3b1
Goldberg	Ensuring consistency between AMSU-A climate temperature retrieval products from NOAA-15 and NOAA-16	3b2

Session 4a: Preparation for advanced sounders (Chair: Joiner)

Smith, Zhou and Larar	Advanced sounder capabilities – airborne demonstration with NAST-I	4a1
Wolf, Goldberg, Zhou, Qu and Divarkala	A fully operational AIRS processing and distribution system	4a2
Goldberg, McMillin, Wolf, Zhou, Qu and Divakarla	AIRS radiance and geophysical products: methodology and validation	4a3
Huang	Planned hyperspectral imaging and sounding research for Indian Ocean under GIFTS-IOMI project	4a4

16:00 – 16:20 BREAK

16:20 – 16:50 WORKING GROUP FORMATION

- **Radiative transfer and surface property modelling**
- **ATOVS/TOVS in climate studies**
- **ATOVS/TOVS data in NWP**
- **Advanced Infrared Sounders**
- **International issues and future systems**
- **Satellite sounder science and products**

16:50 – 17:30 POSTER INTRODUCTIONS (Chairs: Bates/ Reale)
(Introductions each 1 minute duration and maximum of one viewgraph.)

17:30 – 19:20 POSTERS

Friday 1 March 2002

08:00 – 09:30 AGENCY STATUS REPORTS (Chairs: Le Marshall / Rochard)

- **Relations with other bodies:**
  - **IRC (Smith, 5 min)**
  - **CGMS (Menzel, 5 min)**
  - **WMO (Hinsman 5 min)**
- **Reports on issues raised at ITSC - XI**
  - **Frequency protection (Rochard, 5 min)**
  - **Re-analysis at NCEP (Derber, 5 min)**
  - **Re-analysis at ECMWF (Kelly, 5 min)**
  - **Re-analysis at GSFC (Joiner, 5 min)**
  - **TOVS Pathfinder (Goldberg/ Jackson, 5 min)**
  - **Review of actions from ITSC - XI (30 min)**
- **Any other items / discussion**

09:30 – 10:10 SCIENTIFIC PRESENTATIONS

Session 4b: Preparation for advanced sounders (Chair: Kleespies)

Thepaut and Fourrie	Information content and optimal channel selection for AIRS	4b1
Collard and Saunders	Assimilation of AIRS data at the Met Office	4b2

10:10 – 10:30 BREAK

10:30 – 12:10 SCIENTIFIC PRESENTATIONS

Session 4c: Preparation for advanced sounders (Chair: Hinsman)

Frank, Joiner, Atlas and Stajner	Plans for assimilating AQUA data at NASA's DAO	4c1
Li, Schmidt, Huang and Menzel	Studies of advanced baseline sounder for future Geostationary Environmental Operational Satellite (GOES)	4c2
McNally, Fourrie, Matricardi, Thepaut and Watts	Progress towards an assimilation strategy for AIRS at ECMWF	4c3
Lavanant	CMS cloud processing in IASI context	4c4
Rabier	Channel selection for IASI in clear-sky conditions	4c5

12:10 – 14:10 LUNCH

14:10 – 15:55 SCIENTIFIC PRESENTATIONS

Session 5: Future systems – agency plans (Chair: Lavanant)

5-1: Menzel: NOAA's plans for satellites: 2001 and beyond (15 min.)

5-2: Smith: NASA's plans for future sounding systems (15 min.)

5-3: Klaes: EUMETSAT future plans (15 min.)

5-4: Zhang: Considerations on sounding instruments, future Chinese satellites (15 min.)

5-5: Uspensky: Sounding instruments, future Russian meteorological satellites (15 min.)

Session 5a: Future systems (Chair: Lavanant)

Bloom	The Cross-track Infrared and Microwave Sounder (CrIMSS): a sensor suite for operational meteorological; remote sensing	5a1
Chauhan	NPOESS conical microwave imager/sounder: a next-generation sensor	5a2

15:55 – 16:15 BREAK

16:15 – 17:00 SCIENTIFIC PRESENTATIONS

Session 5b: Future systems (Chair: Kelly)

Gasiewski	The Geosynchronous Microwave (GEM) Sounder/Imager	5b1
Glumb and Predina	The Cross-track Infrared Sounder: Sensor design and projected performance	5b2
Phulpin, Cayla, Chalon, Casse, Diebel & Schluessel	IASI on board METOP" Project status and scientific preparation	5b3

17:10 – 18:35 Presentation on software packages (Chairs: Rochard/ Le Marshall)

- **AAPP and ICI (Klaes / Whyte, Lavanant)**
- **IAPP (Achtor)**
- **RTATOV (Saunders)**
- **MODIS/AIRS/AMSU (AMSR) (Huang, Menzel)**
- **3I/3 (Armante)**

Technical subgroup formation

- **AAPP and ICI**
- **IAPP**
- **RTATOV**
- **MODIS/AIRS**
- **3I/3R**

Evening: Working Group and Technical Working Group meetings

Saturday 2 March 2002

Working Group meetings

Sunday 3 March 2002

Working Group Meetings

17:15 – 19:00 SCIENTIFIC PRESENTATIONS

Session 5c: Future systems (Chair: Goldberg)

Zhang Wenjian	FY-3A: progress and direct broadcast characteristics	5c1
Menzel	The National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP): Mission status, NPP instruments and direct broadcast plans	5c2
Coronado	HRD in situ ground system – Bridging technologies between EOS, NPP and the future	5c3
Sprunger, Archer and Johnson	Geostationary sounding: Current and future GOES sounders	5c4

Session 6a:Scientific studies and development: cloud and moisture (Chair: McMillin)

Bennartz and Thoss	Precipitation classification and analysis from the Advanced Microwave Sounding Unit (AMSU)	6a1
Gu, Gao and Zhu and Goldberg	Remote sensing land surface wetness by the use of TRMM/TMI microwave data	6a2
Dyras and Serafin-Rek	Precipitation estimation from NOAA/AMSU data	6a3

Monday 4 March 2002

08:00 – 10:00 SCIENTIFIC PRESENTATIONS

Session 6b: Scientific studies and development – cloud and moisture soundings and applications (Chair: Garand)

Romano and Cuomo	Retrieval of cloud parameters from the new sensor generation satellite multispectral measurements	6b1
Stubenrauch, Raedel, Eddounia, Holz, Scott and Mitchell	Studying cirrus mean effective ice crystal sizes using satellite TIROS-N Operational Vertical Sounder (TOVS) observations	6b2
Garand and Wagneur	Assimilation of GOES imager channels at MSC	6b3
Andrews, Oliver, Zheng and Uddstrom	The impact of data assimilation on a mesoscale model of the New Zealand region	6b4
Joo	The usage of ATOVS in Korea Meteorological Administration	6b5
Randriamampianina and Rabier	Regional use of locally received ATOVS radiances in NWP	6b6
Silvestre Espinoza	Comparison of error analysis in 3D-Var, for assimilation of radiances and retrievals using NOAA-14	6b7
Tingwell, Harris and Bourke	ATOVS 1D-Var retrieval in the Australian region LAPS data assimilation and prediction system	6b8

10:00 – 10:25 BREAK

10:25 – 12:05 SCIENTIFIC PRESENTATIONS

Session 6c: Scientific studies and development: sounders and applications (Chair: Zhang Wenjian)

Bower, Lynch and Knuteson	The validation of land surface thermodynamic properties retrieved by atmospheric sounders	6c1
Monnier, Lavanant, Brunel, Labrot and Rochard	Temperature, humidity and surface emissivity retrieval experiments with IASI simulated data	6c2
Le Marshall et al.	GIFTS IOMI high spectral temporal and spatial resolution data	6c3
Plokhenko and Menzel	Analysis of NAST-I measurement characteristics	6c4
Glumb, Predina, Lietzke and Xu Liu	EDR algorithms for the Cross-track Infrared Sounder	6c5
Fourrie	Use of advanced infrared sounders in cloudy conditions	6c6
Singh, Bhatia, Mukherjee and Sant Prasad	Validation of atmospheric temperature profiles derived using neural network approach from AMSU-A measurements on board NOAA-15 and NOAA-16 satellites and their applications for tropical cyclone analysis	6c7
Kaifel and Muller	NOAA-ATOVS 23-year total column ozone product retrieved by neural network technique	6c8

12:05 – 14:05 LUNCH

14:05 – 15:50 SCIENTIFIC PRESENTATIONS

Session 6d Scientific studies and developments – development, training and data (Chair: Saunders)

Mukabana	Towards an alternative technique in upper air monitoring in Kenya (20 minutes).	6d1
Wilson	The Virtual Laboratory for Satellite Meteorology: An Opportunity for collaborative education and training	6d2
Overton	The National Polar-Orbiting Operational Environmental Satellite System (NPOESS): Access to NPOESS data	6d3
Tabor	Future data processing at the Information Processing Division (IPD) of the National Environmental Satellite Data and Processing Service (NESDIS)	6d4
Tournier	IASI level 1 processing: in the name of CNES IASI team: Functional description of the IASI processing software (on-board level 0 processing and on-ground level 1 processing).	6d5

Wu, Zhang, Lavanant and Brunel	The status of AAPP/ICI at NSMC	6d6
Ahn	Implementation of ATOVS processing package and its validation in Korea	6d7

15:50 – 16:15 BREAK

16:15 – 17:45 SCIENTIFIC STUDIES

Session 6e: Scientific studies and developments – radiative transfer (Chair: Bates)

Saunders, Matricardi, Brunel, English and Deblonde	RTTOV-7: a satellite radiance simulator for the new millennium	6e1
Armante, Scott, Chedin, Jacquinet-Husson, Marchand, Montandon, Aires	Validation processes and results for the inverse and forward models related to IASI/ AMSUs/METOP observations	6e2
Jacquinet-Husson, Scott, Chedin and Chursin	The GEISA spectroscopic database system revisited for IASI direct radiative transfer modelling	6e3
Matricardi and Chevallier	An improved general fast radiative transfer model for the assimilation of radiance observations	6e4
McMillin, Kleespies and Xiong	Rapid transmittance studies at NESDIS	6e5
Montandon, Chedin, Armante, Scott and Aires	Hyperfast high spectral resolution radiance simulation with a multi-layer perceptron. Application to AMSU.	6e6

19:30 CONFERENCE DINNER

Tuesday 5 March 2002

08:00 – 09:15 SCIENTIFIC PRESENTATIONS

Session 6f: Scientific studies: Developments in radiative transfer (Chair: Thepaut)

Sherlock, Collard and Saunders	Development and validation of Gastropod, a fast radiative transfer operator for the advanced infrared sounders	6f1
Turner	Revisiting the downward emission term of the radiative transfer model	6f2
van Delst	Upgraded radiative transfer model status at NCEP/EMC	6f3
Whyte, Labrot and Schraidt	The ATOVS and AVHRR Processing Package: current capability and future evolution	6f4
Kleespies	The merger of OPTRAN and RTTOV: the best of both worlds	6f5

09:15 – 10:00 ITWG PLENARY: Working Group reports

10:00 – 10:25 BREAK

10:25 – 12:15
Working Group reports
Technical subgroup reports
Executive summary
Major recommendations and actions
Other business

12:30 LUNCH
13:00 CLOSE OF ITSC-XII

Poster presentations

Achtor, Feltz, Woolf and Howell	Validation of IAPP retrievals using DOE ARM site observations
Achtor, Li and Woolf	Recent advances to the International ATOVS Processing Package
Bauer, Kelly and Anderson	Direct assimilation of SSM/I radiances in 4Dvar
Borbas, Achtor, Lavanant, Menzel and Woolf	Monitoring and validation of IAPP and ICI products over Madison acquisition area
Borbas, Menzel and Li	The effect of GPS radio occultation data on radiometric profile retrievals
Brunel	HIRS calibration: Comparison between local AAPP and global NESDIS methods
Carvalho, Lavanant, Ferreira and Ramos	Analysis of temperature and moisture profiles over Brazil using the ICI inversion model
Chevallier	Sampled databases of 60-level atmospheric profiles from the ECMWF analyses
Chevallier and Janiskova	Potential of the ATOVS cloud observations for 4D-Var assimilation
Deblonde and English	Stand-alone 1D-Var scheme for the SSMIS, SSM/I and AMSU instruments
Dodge and Coronado	Weather and climate information available from EOS and NPP direct broadcasts
Doherty	Rain rate estimation over semi-arid regions from AMSU measurements
Delhinger and Lavanant	ICI3 over West Africa
Dybbroe, Brunel, Marsouin and Thoss	Accurate real-time navigation of AVHRR data at high latitudes
Grant	ASTRIUM project for future microwaves
Huang	Recent progress and addition of International MODIS and AIRS Processing Package
John, Buehler and Mashrab	Validation of a new radiative transfer model for AMSU
Jones, Renshaw, Chalcraft, Anderson and English	ATOVS assimilation in the Met Office UK mesoscale model
Kleespies	PGPLOT: Freeware graphics software useful for satellite applications
Landelius and Gustafsson	AMSU-A background errors in HIRLAM 3-D Var
Li, Yang, Menzel and Huang	Application of wavelet analysis on stripping of MODIS multi-spectral band infrared radiance measurements
McMillin and Ding	Validation studies at NESDIS
McMillin, Goldberg and Zhoa	Carbon dioxide retrievals from the TOVS series of satellites
McNally and Watts	A cloud detection approach for AIRS radiance assimilation
Poulin	NPOESS CrIS raw data (level 0) to sensor data (level 1b) processing
Predina	Impact of channel spectral shape errors on high resolution infrared atmospheric sounders
Predina	Cross-track Infrared Sounder (CrIS) raw data records (RDRs)
Prunet and Tournier	Variational cloud decontamination and extension to the component estimation of the IASI measurements
Puschell	Japanese Advanced Meteorological Imager: A next generation GEO imager for MTSAT-1R
Reale	Global radiosonde and in situ upper air observations for polar satellite validation

Rochard	Frequency protection
Sherlock	Fast radiative transfer model prediction of water vapour absorption: results from recent studies examining predictor selection and regression profile set dependencies
Silvestre Espinoza, Carvalho and Cintra	Impact of ATOVS sounding in analysis in South America
Sreerekha, Buehler, Emde and John	Using a new radiative transfer model to estimate the effect of cirrus clouds on AMSU-B radiances
Tournier	IASI level 2: NOVELTIS contribution: Spectral correction of IASI spectra due to non-homogeneous scenes and scenes decomposition into homogeneous components in an IASI FOV (cloud clearing).
Tournier, Blumstein and Cayla	IASI Level 0 and 1 processing algorithms description
Wagneur, Chouinard and St James	ATOVS in the Canadian regional assimilation system
Wang (Hongqi)	Potential application of advanced infrared sounders on earthquake prediction and energy resources exploration
Zhao, Wang and Wang	Land surface temperature determination from GMS5/VISSR data with some different retrieval methods

ITWG Mailing List

Appendix B

Dr. Véronique Achard
Département d'Optique Théorique et Appliquée
ONERA chemin de la Humiére
Palaiseau F-91761
FRANCE
(33) 1-69-93-63-65
(33) 1-69-93-63-45
achard@onera.fr

Mr. Thomas H. Achtor
CIMSS University of Wisconsin - Madison
1225 W. Dayton St.
Madison WI 53706
USA
(1) 608-263-4206
(1) 608-262-5974
tom.achtor@ssec.wisc.edu

Dr Jörg Ackermann
EUMETSAT
Am Kavalleriesand 31
D-64295 Darmstadt
Germany
49 6151 807 489
49 6151 807 838
ackermannj@eumetsat.de

Mr. Americo S. Allegrino
NOAA/NESDIS/FPDT Raytheon
E/MO1, Rm 3206, FB-4 NOAA,
5200 Auth Rd
Suitland MD 20746-4304
USA
(1) 301-967-6179
(1) 301-457-5171
americo.s.allegrino@noaa.gov

Mr. Erik Andersson
European Centre for Medium-Range Weather Forecasts
Shinfield Park
Reading Berks. RG2 9AX
UNITED KINGDOM
(44) 118-949-9627
(44) 118-986-9450
erik.andersson@ecmwf.int

Dr Hartmut H Aumann
Mail Stop 230-300
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(1) 818-354-6865
(1) 818-393-4918
hha@airs1.jpl.nasa.gov

Ms. Nancy L. Baker
Marine Meteorology Division
Naval Research Laboratory
7 Grace Hopper Ave.
Monterey CA 93943
USA
(1) 831-656-4779
(1) 831-656-4769
baker@nrlmry.navy.mil

Dr. Christopher D. Barnet
NASA Goddard Space Flight Center
Code 910.4
Greenbelt MD 20771
USA
(1) 301-286-2679
(1) 301-286-1757
cbarnet@srt.gsfc.nasa.gov

Dr. John J. Bates
R/E/CD1 NOAA/ERL
325 Broadway
Boulder CO 80303
USA
(1) 303-497-6646
(1) 1-303-497-7013
John.J.Bates@noaa.gov

Dr. Ralf Bennartz
University of Wisconsin
Atmospheric and Oceanic Sciences
1225 W Dayton St.
Madison, WI 53706
608-265-2249
bennartz@aos.wisc.edu

Dr. Wesley K. Berg
CIRES University of Colorado
Campus Box 449
Boulder
CO 80309-0449
USA
(1) 303-492-4724
(1) 303-492-2468
wkb@cdc.noaa.gov

Dr. Heiner E. Billing
Department of Meteorology
Free University of Berlin
Carl Heinrich Becker
Weg 6-10
Berlin D-12165
GERMANY
(49) 30-838-71115
(49) 30-838-71115
billing@metl06.met.fu-berlin.de

Dr. Daniel L. Birkenheuer
Forecast Research Division
NOAA/ FSL/ CIRA
325 Broadway
Boulder
CO 80303
USA
(1) 303-497-5584
(1) 303-497-7262
birk@fsl.noaa.gov

Mr. Hal J. Bloom
NOAA/NESDIS
8455 Colesville Rd
Silver Spring
MD, 20910
USA
301-713-4785
Hal.Bloom@noaa.gov

Mr. Thomas Boehm
Satellite Meteorology Department
Deutscher Wetterdienst
Kaiserleistr.
42 Offenbach D-63067
GERMANY
(49) 69-8062-2700
(49) 69-8236-1493
thomas-marian.boehm@dwd.de

Ms. Eva E. Borbas
CIMSS/SSEC
Univ. of Wisconsin
1225 W. Dayton Street,
Madison, WI 53706, USA
(608) 263-0228
eva.borbas@ssec.wisc.edu

Dr. Francois-Marie A. Breon
CDC CIRES/NOAA
325 Broadway
Boulder CO 80303-3328
USA
(1) 303-492-0257
(1) 303-497-7013
fmb@cdc.noaa.gov

Ms. Ellen B. Brown
Information Processing Division
NOAA/NESDIS
4700 Silver Hill Rd.,
Stop 9909
Washington DC 20233-9909
USA
(1) 301-457-5195
(1) 301-457-5199
ebrown@nesdis.noaa.gov

Mr Pascal Brunel
Centre de Météorologie Spatiale
Météo-France
B.P. 147
Lannion
F-22302
FRANCE
(33) 2-96-05-67-45
(33) 2-96-05-67-37
pascal.brunel@meteo.fr

Dr Barbara A. Burns
GenCorp Aerojet
1100 W. Hollyvale St.
Azusa CA 91702
USA
barbara.burns@
NorthropGrumman.com

Dr. Philippe Caille
Météo-France
42, av. Gustave-Coriolis
Toulouse
F-31057
FRANCE
(33) 5-61-07-84-55
(33) 5-61-07-84-53
philippe.caille@meteo.fr

Mr. Donald H. Ceckowski
Aerospace/Communications
Division
ITT Industries
1919 W. Cook Rd.
Fort Wayne IN 46801 USA
(1) 219-451-6010
(1) 219-451-6033
dhceckow@itt.com

Dr Moustafa T Chahine
Mail Stop 180-904
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(1) 818-354-6057
(1) 818-393-4218
moustafa.t.chahine@jpl.nasa.gov

Mr. Michael W. Chalfant
Office of Research and
Applications
NOAA/NESDIS
5200 Auth Rd
Suitland
MD 20746-4304
USA
(1) 301-457-5188 ext. 156
Fax. (1) 301-457-5171
Michael.Chalfant@noaa.gov

Dr Alain Chédin
Ecole Polytechnique
Centre Natl de la Recherche
Scientifique
Lab. de Météorologie Dynamique
Palaiseau , Cédex F-91128
FRANCE
33-1-63-33-45-33
33-1-69-33-30-05
chedin@lmd.polytechnique.fr

Dr Frédéric Chevallier
ECMWF
Shinfield Park
Reading, Berks.
RG2 9AX
UK
+44 118 949 9818
+44 118 986 9450
f.chevallier@ecmwf.int

Mr. Chien-Ben Chou
Central Weather Bureau
64 Kung-Yuan Road
Taipei 100
TAIWAN
(886) 2-2349-1256
(886) 2-2349-1259
joujb@msc.cwb.gov.tw

Dr. Clément B. Chouinard
Data Assimilation Division
Atmospheric Environment Service
2121 TransCanada Highway
Dorval Quebec H9P 1J3
CANADA
(1) 514-421-4761
(1) 514-421-2106
clement.chouinard@ec.gc.ca

Dr. Hyo-Sang Chung
Remote Sensing Research Lab.
Meteorological Research Institute
(METRI)
Korea Meteorological
Administration
460-18 shindebang-dong,
Dongjak-gu Seoul 156-720
SOUTH KOREA
(82) 2-841-2786
(82) 2-841-2787
hschung0@iris.metri.re.kr

Dr. Jean Citeau
ORSTOM-IRD/CMS
Antenne Orstom-IRD , BP 134
Lannion F-22302
FRANCE
(33) 2-96-48-00-78
(33) 2-96-05-67-37
jean.citeau@orstom.fr

Mr. John E. Clement
Raytheon/Santa Barbara Remote
Sensing (SBRS)
75 Coromar Dr., B32-20
Goleta CA 93117 USA
(1) 805-562-4017
(1) 805-562-7527
jclement@west.raytheon.com

Dr. Douglas L. Cohen
Aerospace/Communications
Division
ITT Industries
1919 W. Cook Rd.
Fort Wayne IN 46801
USA
(1) 219-451-6254
(1) 219-451-6033
dlcohen@itt.com

Dr Andrew Collard
NWP Division, Rm 330
The Met. Office
London Rd
Bracknell, Berks.
RG12 2SZ
UK
44 1344 856221
44 1344 854026
andrew.collard@metoffice.com

Prof. Vincenzo Cuomo
Istituto di Metodologie Avanzate
di Analisi
Ambientale Consiglio Nazionale
delle Ricerche
Contrada S. Loya Tito Scalo
Potenza 85050
ITALY
(39) 971-427208
(39) 30-971-427222
cuomo@unibas.it

Dr. Godelieve Deblonde
Data Assimilation & Satellite
Meteorology
Division Atmospheric
Environment Service
2121 Trans-Canada Highway
Dorval
Quebec H9P-1J3
CANADA
(1) 514-421-4774
(1) 514-421-2106
godelieve.deblonde@ec.gc.ca

Dr. Mark De Maria
CIRA Colorado State University
NOAA/NESDIS/ORA/ARAD/RA
MMT W. Laporte Ave.
Fort Collins
CO 80523-1375
USA
(1) 970-491-8405
(1) 970-491-8241
demaria@cira.colostate.edu

Dr. John C. Derber
NOAA/NWS/NCEP
World Weather Building, W/NP23
5200 Auth Rd.
Camp Springs
MD 20746
USA
(1) 301-763-8000 ext. 7230
(1) 301-763-8545
john.derber@noaa.gov

Mr. Patrick N. Dills
COMET University Corporation
for Atmospheric Research
3450 Mitchell Lane - FL3
Boulder CO 80303
USA
(1) 303-497-8339
(1) 303-497-8491
dills@ucar.edu

Dr. James Dodge
Office of Mission to Planet Earth
NASA Science Division
300 E St., SW
Washington DC 20546
USA
(1) 202-358-0763
(1) 202-358-2771
jdodge@hq.nasa.gov

Amy Doherty
SSEC
1225 West Dayton St
WI 53703
Madison, USA
608 263 3629
amyd@ssec.wisc.edu

Dr. Chaohua Dong
National Satellite Meteorological
Center
China Meteorological
Administration
Baishiqiao Road 46
Haidian District
Beijing 100081
PRC
(86) 10-6840-6327
(86) 10-6217-2724
dchua@nmsc.cma.gov.cn

Dr. Richard J. Engelen
Department of Atmospheric
Science
Colorado State University
Fort Collins CO 80523, USA
(1) 970-491-8527
(1) 970-491-3430
richard@atmos.colostate.edu

Dr. Stephen J. English
NWP/Satellite Applications
U.K. Meteorological Office
London Road
Bracknell Berkshire RG12 2SZ
UNITED KINGDOM
(44) 1344-854652
(44) 1344-854026
stephen.english@metoffice.com

Dr. Ronald M. Errico
Climate and Global Dynamics
Division
National Center for Atmospheric
Reseach
1850 Table Mesa Dr.
Boulder CO 80303, USA
(1) 303-497-1370
(1) 303-497-1700
rmerrico@ucar.edu

Dr. John R. Eyre
NWP Division
U.K. Meteorological Office
London Road
Bracknell, Berkshire
RG12 2SZ
UNITED KINGDOM
(44) 1344-856687
(44) 1344-854026
john.eyre@metoffice.com

Dr. Jennifer A. Francis
Institute of Marine and Coastal
Sciences
Rutgers University
71 Dudley Rd.
NJ 08901-8521
New Brunswick, USA
(1) 732-708-1217
(1) 732-708-3088
francis@imcs.rutgers.edu

Dr. Louis Garand
Data Assimilation and Satellite
Meteorology Division
Atmospheric Environment Service
2121 Trans-Canada Highway
Dorval P. Quebec H9P1J3
CANADA
(1) 514-421-4749
(1) 514-421-2106
louis.garand@ec.gc.ca

Dr Amadou Thierno Gaye
LPA, Ecole Superieure
Polytechnique
Dakar University
PO Box 5085 Dakar
Senegal
(+221) 825 9364
atgaye@ucad.sn

Mr. Mitchell D. Goldberg
NOAA/NESDIS
5200 Auth Rd.
Camp Springs
MD 20746, USA
(1) 301-763-8136
(1) 301-763-8108
Mitch.Goldberg@noaa.gov

Dr. Norman A. Grant
Astrium UK Limited
Anchorage Road
Portsmouth
PO3 5PU
UNITED KINGDOM
(44) 2392 70 8351
norman.grant@astrium-space.com

Dr. Norman C. Grody
NOAA/NESDIS
5200 Auth Rd.
Camp Springs
MD 20746
USA
(1) 301-763-8253
(1) 301-763-8108
Norman.Grody@noaa.gov

Gu Song yan
NSMC China
Geophysics Dept
Peking University
(86) 10 6278 7177
songyangu@hotmail.com

Dr. Brett A. Harris
BMRC
150 Lonsdale St.
Melbourne
VIC 3001
AUSTRALIA
(61) 3-9-669-4388
(61) 3-9-669-4699
b.harris@bom.gov.au

Dr. Donald W. Hillger
CIRA - Colorado State University
NOAA/NESDIS/RAMM
Foothills Campus
Fort Collins CO 80523-1375 USA
(1) 970-491-8498
(1) 970-491-8241
hillger@cira.colostate.edu

Dr. Donald Ernest Hinsman
WMO Satellite Activities
World Meteorological Organization
7 bis Ave de la Paix
Geneva CH-1211
SWITZERLAND
(41) 22-730-8285
(41) 22-734-2326
Hinsman_D@gateway.wmo.ch

Dr. Karel Hlavaty
Satellite Department
Czech Hydrometeorological Institute
Na Sabatce 17
Prague 143 06
CZECH REPUBLIC
(42) 02-4403-3289
(42) 02-4403-2442
hlavaty@chmi.cz

Dr. Allen H.L. Huang
CIMSS/SSEC
Univ. of Wisconsin - Madison
1225 W. Dayton St.
Madison WI 53706, USA
(1) 608-263-5283
(1) 608-262-5974
allenh@ssec.wisc.edu

Mr. Eiji Ikoma
Institute of Industrial Science,
3rd Dept.
University of Tokyo
7-22-1 Roppongi Minato-ku
Tokyo 106-8558
JAPAN
(81) 3-3402-6231 ext.2357
(81) 3-3423-2834
eikoma@tkl.iis.u-tokyo.ac.jp

Mr. Brian C. Jackson
Joint Office for Science Support
University Corporation for Atmospheric Research
1850 Table Mesa Dr.
Boulder
CO 80303 USA
(1) 303-497-8663
(1) 303-497-8633
bjackson@ucar.edu

Mr. Darren L. Jackson
CIRES/NOAA/CDC
325 Broadway
R/E/CD1
Boulder
CO 80303-3328, USA
(1) 303-492-0683
(1) 303-497-701
Darren.L.Jackson@noaa.gov

Mr. Steve G. Johnson
Aerospace/Communications Division
ITT Industries
1919 W. Cook Rd.
Fort Wayne
IN 46818 USA
(1) 219-451-6011
(1) 219-451-6033
sgjohnso@itt.com

Dr. Joanna Joiner
Data Assimilation Office
NASA Goddard Space Flt Center
Code 910.3
Greenbelt MD 20771
USA
(1) 301-614-6247
(1) 301-614-6297
joiner@dao.gsfc.nasa.gov

Mr. Anton Karl Kaifel
Center for Solar Energy and Hydrogen Research (ZSW)
Hessbruehlstr. 21c
Stuttgart D-70565
GERMANY
(49) 711-7870-238
(49) 711-7870-200
anton.kaifel@zsw-bw.de

Mr. Graeme Kelly
ECMWF
Shinfield Park
Reading Berks. RG2 9AX
UNITED KINGDOM
(44) 118-949-9000
(44) 118-986-9450
gkelly@ecmwf.int

Dr. Siri Jodha S. Khalsa
NSIDC University of Colorado at Boulder
1540 30th St.
Boulder CO 80309
USA
(1) 303-492-1445
(1) 303-492-2468
sjsh@kryos.colorado.edu

Dr Dongsoo Kim
Forecast Research Division
Forecast Systems Laboratory
325 Broadway
Boulder
CO 80123
USA
(1) 303-497-6725
(1) 303-497-7262
dkim@fsl.noaa.gov

Prof. Gottfried Kirchengast
Institute for Meteorology and Geophysics
University of Graz
Halbaerthgasse 1
Graz A-8010
AUSTRIA
(43) 316-380 5260
(43) 316-380 9825
gottfried.kirchengast@uni-graz.at

Dr. K. Dieter Klaes
Meteorological Division
EUMETSAT
Am Kavalleriesand 31
Darmstadt D-64295
GERMANY
(49) 6151-807-565
(49) 6151-807-838
klaes@eumetsat.de

Dr. Thomas J. Kleespies
E/RAI Room 810 WWB
NOAA/NESDIS
5200 Auth Rd.
Camp Springs
MD 20743 USA
(1) 301-763-8136 ext. 126
(1) 301-763-8108
Thomas.J.Kleespies@noaa.gov

Dr Christina Köpken
ECMWF
Shinfield Park
Reading Berks. RG2 9AX
UK
(44) 118 9499021
(44) 118 986 9450
christina.koepken@ecmwf.int

Mr. Aarno V. Korpela
NIWA
301 Evans Bay Parade
Wellington
NEW ZEALAND
(64) 4-386-0579
(64) 4-386-2153
a.korpela@niwa.cri.nz

Ms. Tiphaine Labrot
Centre de Météorologie Spatiale
Mé téo-France
B.P. 147
Lannion F-22302
FRANCE
(33) 2-96-05-67-50
(33) 2-96-05-67-37
tiphaine.labrot@meteo.fr

Dr. Bjorn H. Lambrigtsen
Jet Propulsion Laboratory
4800 Oak Grove Dr.,
MS 169-237
Pasadena CA 91109 USA
(1) 818-354-8932
(1) 818-393-4619
lambrigtsen@jpl.nasa.gov

Dr Tomas Landelius
SMHI
SE - 60176 Norrköping
Sweden
(46) 11 495 8180
(46) 11 495 8001
tomas.landelius@smhi.se

Ms. Lydie Lavanant
Centre de Météorologie Spatiale
Météo-France
B.P. 147
Lannion F-22302
FRANCE
(33) 2-96-05-67-45
(33) 2-96-05-67-37
lydie lavanant@meteo-france

Dr. Sung-Yung Lee
MS 169-237 Jet Propulsion Lab
4800 Oak Grove Dr.
Pasadena
CA 91109
USA
(1) 818-354-0645
(1) 818-393-4619
Sung-Yung.Lee@jpl.nasa.gov

Mr. Yong-Seob Lee
Remote Sensing Research Lab
Meteorological Research Institute (METRI)
Korea Meteorological Administration
460-18 shindebang-dong,
Dongjak-gu
Seoul 156-720
SOUTH KOREA
(82) 2-841-2786
(82) 2-841-2787
yslee@iris.metri.re.kr

Dr. John Le Marshall
Bureau of Meteorology Research Centre
GPO Box 1289K
Melbourne VIC 3001
AUSTRALIA
(61) 3-9669-4420
(61) 3-9669-4660
j.lemarshall@bom.gov.au

Dr. Jeff A. Lerner
Institute for Meteorology and Physics
University of Graz
Halbuerthgasse 1
Graz A-8010
AUSTRIA
Jeffrey.Lerner@fnmoc.navy.mil

Dr. Jun Li
CIMSS
University of Wisconsin - Madison
1225 W. Dayton St.
Madison
WI 53706
USA
(1) 608-2623755
(1) 608-2625974
junl@ssec.wisc.edu

Dr Mervyn Lynch
Curtin University of Technology
GPO Box U1987
Perth, WA 6001
AUSTRALIA
61 9 351 7540
61 9 351 2377
lynch_mj@cc.curtin.edu.au

Dr. Anthony McNally
European Centre for Medium-Range Weather Forecasts
Shinfield Park
Reading Berks. RG2 9AX
UNITED KINGDOM
(44) 118-949-9000
(44) 118-986-9450
t.mcnally@ecmwf.int

Dr. W. Paul Menzel
Office of Research and Applications
NOAA/NESDIS
1225 W. Dayton St.
Madison
WI 53706
USA
(1) 608-263-4930
(1) 608-262-5974 .. Fax
paul.menzel@ssec.wisc.edu

Mr. Anthony J. Mostek
Office of Meteorology at COMET
National Weather Service
3450 Mitchell Ln.
Boulder
CO 80301 USA
(1) 303-497-8490
mostek@comet.ucar.edu

Mr. Martin D. Mueller
Center for Solar Energy and Hydrogen Research (ZSW)
Hessbruhlstr. 21c
Stuttgart D-70565
GERMANY
(49) 711-7870-232
(49) 711-7870-200
martin.mueller@zsw-bw.de

Ms. Rose Munro
Eumetsat
Am Kavalleriesand 31
D-64295
Darmstad
GERMANY
Munro@eumetsat.de

Dr. George Ohring
NOAA/NESDIS
5200 Auth Rd.
Camp Springs
MD 20746
USA
(1) 301-763-8078
George.Ohring@noaa.gov

Mr. Folke Olesen
Institute for Meteorology and Climatological Research
Forschungszentrum Karlsruhe
Hermann von Helmholtz Platz 1
Eggenstein-Leopoldshafen D-76344
GERMANY
(49) 7247-82-2109
(49) 7247-82-4742
folke.olesen@imk.fzk.de

Dr. Prabodh Patel
GenCorp Aerojet
1100 W. Hollyvale St.
Azusa CA 91702
USA
(1) 626-812-2330
prabodh@NorthropGrumman.com

Prof. Pier Franco Pellegrini
Dip. Ing. Elettronica Universite di Firenze
V.S. Marta, 3 Firenze 50139
ITALY
(39) 055-479-6267
(39) 055-494-569
pelle@labtele.die.unifi.it

Dr. Marilena Perrone
Institute of Marine and Coastal Science
Rutgers University
71 Dudley Rd.
New Brunswick NJ 08901-8521
USA
(1) 732-932-7684
(1) 732-932-3036
perrone@gentoo.rutgers.edu

Charles Philpot
Dept of Earth Observation and Science – Astrium UK
Anchorage Rd
Portsmouth
PO3 5PU
(44) 0 23 9270 5476
(44) 0 9270 8683
charles.philpot@astrium-space.com

Dr. Carla Pietrapertosa
Istituto di Metodologie Avanzate di Analisi Ambientale
Consiglio Nazionale delle Ricerche
Contrada S. Loya Tito Scalo
Potenza 85050
ITALY
(39) 971-427242
(39) 971-427222
pietra@imaaa.pz.cnr.it

Mr. Robert H. Platt
EWSS GenCorp Aerojet
1100 W. Hollyvale St..
Azusa CA 91702
USA
(1) 626-812-1016
(1) 626-812-1602
Robert.Platt@aerojet.com

Dr. Youri V. Plokhenko
UCAR
1225 W Dayton St ., Room 239
Madison WI 53706
USA
(1) 608-262-7287
(1) 608-262-5974
yourip@ssec.wisc.edu

Dr. Gene A. Poe
Naval Research Lab
4555 Overlook Ave.
Washington DC
USA
(1) 202-767-3398
(1) 202-767-9194
poe@nrlmry.navy.mil

Dr. G. J. Prangsma
Satellite Data Division
Royal Netherlands Meteorological Institute
(KNMI) Wilhelminalaan 10 (P.O. Box 201)
De Bilt 3730 AE
NETHERLANDS
(31) 30-2206-453
(31) 30-2210-407
prangsma@knmi.nl

Dr. Vijapurapu S. Prasad
Department of Science and Technology
NCMRWF Mausam
BhavaneLodhi Road
New Delhi 110 003
INDIA
(91) 11-461-8216
(91) 11-469-0108
vijapurapu@yahoo.com

Dr Fred Prata
CSIRO Atmospheric Research
PMB 1
Aspendale VIC 3195
AUSTRALIA
61 3 9239 4400
61 3 9239 4444
ajp@dar.csiro.au

Joe Predina
ITT/Aerospace/Comms Division
1919 Cook Rd
PO Box 3700
Fort Wayne, IN, USA 46801
(1) 219 451 6919
(1) 219 451 6033
joe.predina@itt.com

Dr. Catherine Prigent
Observatoire de Paris
61 Av. de l'Observatoire
F-75 014 Paris, FRANCE
33 (1) 40 51 20 18
catherine.prigent@obspm.fr

Dr. James F.W. Purdom
NOAA/NESDIS
Washington DC 20023, USA
(1) 301-763-8127
James.Purdom@noaa.gov

Dr. Jeffery J. Puschell
Santa Barbara Remote Sensing
Raytheon Systems Company
75 Coromar Dr., B32/15
Goleta CA 93117 USA
(1) 805-562-7053
(1) 805-562-7767
jpuschell@raytheon.com

Dr. Florence Rabier
CNRM/GMAP M,t,o-France
42 Av G. Coriolis
Toulouse F-31057
FRANCE
(33) 5-61-07-84-38
(33) 5-61-07-84-53
florence.rabier@meteo.fr

Mr. Tony L. Reale
ORA/FPDT NOAA/NESDIS
5200 Auth Rd.
Suitland
MD 20746-4304 USA
(1) 301-457-5188 (152)
(1) 301-457-5171
Tony.Reale@noaa.gov

Dr. Markus J. Rieder
ARSCliSys Group University of Graz /
Institute for Meteorology and Geophysics
(IMG/UoG)Halbaerthgasse 1 Graz
A-8010
AUSTRIA
(43) 316-380-5263
(43) 316-380-9825
mjr@bmtlg29.kfunigraz.ac.at

Dr Rolando Rizzi
Univ. of Bologna
ADGB - Dept. of Physics
viale Berti Pichat 6/2
I-40127 Bologna,
ITALY
Tel: +39.51.630.5216
Fax: +39.51.630.5074
r.rizzi@adgb.df.unibo.it

Dr. Guy Rochard
Centre de Météorologie Spatiale
Météo-France
B.P. 147 Lannion F-22302
FRANCE
(33) 2-96-05-67-50
(33) 2-96-05-67-37
guy.rochard@meteo.fr

Dr. Filomena Romano
Istituto di Metodologie Avanzate di Analisi Ambientale
Consiglio Nazionale delle Ricerche
Contrada S. Loya Tito Scalo
Potenza 85050
ITALY
(39) 971-427266
(39) 971-427222
romano@imaa.cnr.it

Mr Johy Sakuragi
Universidade do Vale do Paraiba - UNIVAP
Laboratório de Meteorologia
Rua Paraibuna, 75 - Centro
12245-720 Sáo José dos Campos – SP, Brazil
(55) 12 322 2355
(55) 12 437 1089
jojhy@univap.br

Abdoulaye Sarr
National Met. Service of Senegal
BP 16688 Dakar-Fann
Senegal
(221) 8200780 ext 2352
(221) 825 9364
layesarr@ucad.sn

Dr. Roger W. Saunders
The Met. Office
London Rd
Bracknell, Berks. RG12 2SZ
UK
(44) 134 856295
roger.saunders@metoffice.com

Dr Peter Schluessel
EUMETSAT
Am Kavalleriesand 31
64295 Darstadt
Germany
49 6151 807 699
49 6151 807 838
schluessel@eumetsat.de

Ms. Marion Schroedter
German Remote Sensing Data Center (DFD)
German Aerospace Center (DLR)
Muenchner Strasse 20
Wessling D-82234
GERMANY
(49) 8153-28-2896
(49) 8153-28-1445
marion.schroedter@dlr.de

Dr. Axel J. Schweiger
Applied Physics Lab / Polar Science Center
University of Washington
1013 N.E. 40th St.
Seattle WA 98105 USA
(1) 206-543-1312
(1) 206-543-3521
axel@apl.washington.edu

Mr. Harald Schyberg
R&D Department
Norwegian Meteorological Institute
Gaustadalleen 30 D
(P.O. Box 43 Blindern)
Oslo N-0313 NORWAY
(47) 2296 3328
(47) 2269 6355
h.schyberg@dnmi.no

Dr Noelle Scott
Laboratoire de Météorologie Dynamique
Ecol Polytechnique
Route Départementale 36
F-91128 Palaiseau Cédex
France
33 1 6933 4532
33 1 6933 3005
scott@lmd.polytechnique.fr

Dr. Chris B. Sear
Environmental Sciences Department
Natural Resources Institute UoG
Central Avenue Chatham Kent
ME4 4TB
UNITED KINGDOM
(44) 1634-880088
(44) 1634-880066
c.b.sear@greenwich.ac.uk

Mr. Brent L. Shaw
HQ AFWA
The Aerospace Corporation
106 Peacekeeper Dr., Ste. 2N3
Offutt AFB NE 68113-4039
USA
(1) 402-291-3140
(1) 402-291-3137
brent.l.shaw@aero.org

Dr. Lei Shi
SeaSpace Corp.
9240 Trade Pl., Ste. 100
San Diego CA 92126
USA
(1) 619-578-4010
(1) 619-578-3625
lei@seaspace.com

Dr. Richard L. Slonaker
NPOESS Raytheon ITSS
4400 Forbes Blvd.
Lanham
MD 20706-4392
USA
(1) 301-794-5191
(1) 301-794-5247
Richard_L_Slonaker@raytheon.com

Mr Andrew Smith
NWP Division, Rm 330
The Met. Office
London Rd
Bracknell, Berks. RG12 2SZ
UK
(44) 1344 856902
(44) 1344 854026
andrew.smith@metoffice.com

Dr. William L. Smith
Atmospheric Sciences Competency
NASA Langley Research Center
21 Langley Blvd., Mail Stop 401
Hampton VA 23666
USA
(1) 757-864-5380
(1) 757-864-8197
bill.l.smith@larc.nasa.gov

Dr. Borislava B. Stankov
NOAA/ETL
325 Broadway
Boulder
CO 80303
USA
(1) 303-497-6707
B.Boba.Stankov@noaa.gov

Dr. Joel Susskind
NASA Goddard Space Flight Center
Code 910.4
Greenbelt MD 20771
USA
(1) 301-286-7210
(1) 301-286-1757
Joel.Susskind-1@nasa.gov

Mr. Steven D. Swadley
METOC Consulting
Marine Meterology Division
Naval Research Lab
7 Grace Hopper Rd.,Stop 2
Monterey CA 93943 USA
(1) 831-657-4781
(1) 831-656-4769
swadley@nrlmry.navy.mil

Mr. Edward V. Tabor
OSDPD/IPD NOAA/NESDIS
4700 Silver Hill Rd., Stop 9909
Washington DC 20233-9909
USA
(1) 301-457-5195
(1) 301-457-5199
Vincent.Tabor@noaa.gov

Prof. Mikio Takagi
Science University of Tokyo
2641 Yamazaki, Noda,
Chiba 278-8510, Japan
(471) 20 1750
(471) 20 1752
takagi@te.noda.sut.ac.jp

Mr. Yoshiaki Takeuchi
Numerical Prediction Division
Forecast
Department Japan Meteorological Agency
1-3-4 Oote-machi, Chiyoda-ku
Tokyo 100-8122, JAPAN
(81) 3-3212-8341 ext. 3320
(81) 3-3211-8407
takeuchi@npd.kishou.go.jp

Dr. Sumio Tamba
Center for Computer and Communications
Hirosaki University 3, Bunkyo-cho
Hirosaki Aomori 036-8561
JAPAN
(81) 172-39-3725
(81) 172-39-3722
tanba@cc.hirosaki-u.ac.jp

Mr. Raul Fritz Bechtel Teixeira
Department of Meteorology
Foundation of Meteorology and Water Resources
(FUNCEME) Avenida Bezerra de Menezes,
1900, Sao Gerardo Fortaleza,
Ceara CEP
60325-002 BRAZIL
(55) 85-287-10-11
(55) 85-287-11-65
fritz@funceme.br

Mr. Bruce H. Thomas
c/o HQ AFWA, Programs Division
The Aerospace Corporation
106 Peacekeeper Dr., Ste. 2N3
Offutt AFB NE 68113-4039 USA
(1) 402-291-3140
(1) 402-291-3137
bruce.h.thomas@aero.org

Dr Sigurdur Thorsteinsson
R&P Department
Icelandic Meteorological Office
Bustadavegur 9
R-150 Reykjavik
Iceland
(354) 5600654
(354) 5528121
siggi@vedur.is

Ms. Anke Thoss
Swedish Meteorological and Hydrological Institute
Folkborgsv. 1
Norrksping S-60176
SWEDEN
(46) 11-4958265
(46) 11-4958001
athoss@smhi.se

Dr. Stephen Tjemkes
EUMETSAT
Am. Kavelleriesand 31
Darmstadt D-64295
GERMANY
(49) 6151-807-593
(49) 6151-807-555
tjemkes@eumetsat.de

Dr Valerio Tramutoli
University of Basilicata - DIFA
CDA Macchia Rorana - 85100
Potenza
Italy
Tel. (39) 0971 427209
(39) 0971 205205
Fax. (39) 0971 427271
(39) 0971 205047
tramutoli@unibas.it

Dr. Fabio Travaglioni
Italian Meteorological Service
Piazzale degli Archivi, 34
Rome 144
ITALY
(39) 06-4986-3303
(39) 06-5924-760
cna@ecmwf.int

Dr. Nergui Tsengel
Weather Forecasting Division
Institute of Meteorology and Hydrology
Khudaldaany gudamj-5
Ulan Bator-46
MONGOLIA
(976) 1-326606
(976) 1-326611
SENGEL@rocketmail.com

Dr. David Shawn Turner
Atmospheric Environment Service
Environment Canada
4905 Dufferin Street
Downsview Ontario M3H 5T4
CANADA
(1) 416-739-4885
(1) 416-739-4221
shawn.turner@ec.gc.ca

Dr. Frank Thomas Tveter
R&D Department
Norwegian Meteorological Institute
Gaustadalleen 30 D
(P.O. Box 43 Blindern)
Oslo N-0313 NORWAY
(47) 2296 3357
(47) 2269 6355
f.t.tveter@dnmi.no

Dr. Michael J. Uddstrom
NIWA
301 Evans Bay Parade
Wellington
NEW ZEALAND
(64) 4-386-0365
(64) 4-386-2153
m.uddstrom@niwa.cri.nz

Dr. Alexander B. Uspensky
Satellite Hydrometeorology
SRC Planeta, Roshydromet,
7, B. Predtechensky per.
Moscow 123242 RUSSIA
(7) 095-255-2137
(7) 095-252-3717
(7) 095-200-4210 .. Fax
uspensky@imp.kiae.ru

Dr. Paul F. van Delst
NOAA/NCEP
5200 Auth Rd
Camp Springs
MD 20746
USA
301 763 8000 ext 7274
301 763 8545
paul.vandelst@noaa.gov

Mr. Chris S. Velden
CIMSS
University of Wisconsin - Madison
1225 W. Dayton St.
Madison WI 53706
USA
(1) 608-262-9168
(1) 608-262-5974
chrisv@ssec.wisc.edu

Dr. Hongqi Wang
START Regional Center for Temperate East Asia Institute of Atmospheric Physics
Chinese Academy of Sciences
Qi Jia Huo Zi, De Sheng Men Wai
Beijing
100029 PRC
(86) 10-62041268
(86) 10-62045230
hqwang@tea.ac.cn

Dr. Kung-Hwa Wang
Meteorological Satellite Center
Central Weather Bureau
64 Kung Yuan Road
Taipei 100
TAIWAN
(886) 2-2349-1238
(886) 2-2349-1259
peter@msc.cwb.gov.tw

Dr. David Wark
ORA NOAA/NESDIS
Washington DC 20233
USA
(1) 301-457-5435
(1) 301-457-5171
dwark@nesdis.noaa.gov

Dr. Juying X. Warner
ACD/MOPPITT
National Center for Atmospheric Research
3300 Mitchell Ln., Ste. 275
Boulder CO 80301 USA
(1) 303-497-2914
(1) 303-497-2920
juying@ncar.ucar.edu

Mr Keith W. Whyte
NWP Division
U.K. Meteorological Office
London Road
Bracknell Berks. RG12 2SZ
UNITED KINGDOM
(44) 1344 854529
(44) 1344 854026
keith.whyte@metoffice.com

Mr. Walter W. Wolf
QSS Group, Inc.
(NOAA/NESDIS)
5200 Auth Rd
Camp Springs, MD 20746
USA
301 763 8212
Walter.Wolf@noaa.gov

Mr. Harold M. Woolf
SSEC-CIMSS University of Wisconsin - Madison
1225 W. Dayton St.
Madison WI 53706 USA
(1) 608-262-0986
(1) 608-262-5974
halw@ssec.wisc.edu

Mrs Xuebao Wu
NMSC, China Meteorological Administration
No. 46 Baishiqiao Rd
Beijing 100081
China
(86) 10 6840 7027
(86) 10 6217 2724
xuebao.wu@nmsc.cma.gov.cn

Dr. Francesco Zauli
Italian Meteorological Service
Piazzale degli Archivi, 34
Rome 144
ITALY
(39) 06-9129-3421
(39) 06-9129-3421
f.zauli@meteoam.it

Dr. Wenjian Zhang
National Satellite Meteorological Center
China Meteorological Administration
Baishiqiao Road 46
Haidian District
Bejing 100081 PRC
(86) 10-6846-8537
(86) 10-6217-2724
wjzhang@nsmc.cma.gov.cn

Dr. Gaoxiang Zhao
Institute of Atmospheric Physics
Chinese Academy of Sciences
Qi Jia Huo Zi, De Sheng Men Wai,
Beijing 100029 PRC
(86) 10-6204-1317
(86) 10-6204-5230
zhaogx@ast590.tea.ac.cn

Prof. Yuanjing Zhu
The Department of Geophysics
Peking University
Beijing 100871 PRC
(86) 10-6275-1131
(86) 10-6275-1615
lwb@pku.edu.cn

ITWG related web sites

Appendix C

ITWG home page	http://cimss.ssec.wisc.edu/itwg/
AAPP	http://www.eumetsat.de/en/area4/aapp/index.html or http://www.metoffice.com/research/interproj/nwpsaf/atovs/index.html
CIMSS (Cooperative Institute for Meteorological Satellite Studies)	http://cimss.ssec.wisc.edu/
ECMWF (European Centre for Medium-Range Weather Forecasts)	http://www.ecmwf.int/
ECMWF Reanalysis	http://www.ecmwf.int/research/era/
EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites)	http://www.eumetsat.de/
FPDT-NESDIS (Operational Sounding Products)	http://poes.nesdis.noaa.gov/
JPL AIRS Project	http://www-airs.jpl.nasa.gov/
NASA Goddard Data Assimilation Office	http://polar.gsfc.nasa.gov/
NAST Aircraft Spectra, Ancillary Data, Forward Models, Visualisation Software, etc.	http://deluge.ssec.wisc.edu/~nasti/
National Centers for Environmental Prediction (NCEP)	http://www.emc.ncep.noaa.gov/
NCEP Reanalysis	http://wesley.wwb.noaa.gov/reanalysis.html
NOAA ATOVS Instrument Parameters	http://orbit-net.nesdis.noaa.gov/crad/sit/page_of_pages.html
NWP Satellite Application Facility (SAF)	http://www.metoffice.com/research/interproj/nwpsaf/

POLAR PATHFINDER SAMPLER CD	email: nside@kryos.colorado.edu web: http://www-nsidc.colorado.edu/data/nsidc-0069.html
Surface Emissivity: Atlas and Modeling	http://orbit-net.nesdis.noaa.gov/arad/ht/LANDEMS/landems.html
Surface Emissivity: ASTER Spectral library (and CD)	http://speclib.jpl.nasa.gov
TOVS Polar Pathfinders	http://psc.apl.washington.edu:80/pathp/
WMO home page	http://www.wmo.ch/