1.01. Variational Inversion of Hydrometeors Using Passive Microwave Sensors -Application to AMSU/MHS and SSMIS-^^NULL

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

This study presents the results of a 1-Dimensional variational algorithm which performs the inversion of hydrometeor parameters in a physically consistent fashion. The hydrometeors in question are both the liquid rain and the frozen rain (graupel ice). The algorithm is called the Microwave Integrated Retrieval System (MiRS) which uses microwave radiances from AMSU and MHS sensors onboard NOAA-18, NOAA-19, Metop-A and DMSP-F16 SSMIS as well as proxy NPP/ATMS data. It is running operationally at NOAA/NESDIS for a number of atmospheric, land and cryospheric products as well as for the integrated ice water path and surface rainfall rate. The retrieval of hydrometeors from space, is notoriously an ill-posed problem. This is because the brightness temperature measurements, depending on the sensing frequency, are a mixture of multiple signals coming from the rain itself, the ice, the suspended non-precipitating cloud droplets, the surface temperature, the surface emissivity, the atmospheric temperature and degree of humidity. The rain and ice signals themselves do not necessarily depend only on the rain or ice amounts. They also depend to various degrees on the particle size assumed, the vertical distribution, the shape, the size distribution, the density, among other things. It is therefore challenging to solve accurately all these unknowns without constraining independently the domain of possible solutions.
The physical constraints used in MiRS include:

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

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

1.04. Towards a better retrieval of fine water vapor atmospheric structures using IASI data^^Comparison of MetOp IASI Cloud Products for cloudy radiances assimilation

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

The first results of humidity profile retrievals with IASI were much less accurate than expected from simulations done before the launch of IASI. It was discussed at different meetings (ISSWG) of whether it was possible to retrieve fine atmospheric structures from IASI data which were not present in the first guess. An intercomparison exercise of clear-sky sea retrievals performed from JAIVEx data (EUMETSAT Conf, 2009) has indicated that often the temperature and humidity retrievals compensate in ways which add incorrect structures elsewhere in the profile.

This talk presents the results of a study done on Jaivex data and on a CMS dataset of coregistered radiosonde and IASI observations to understand what parameters/method can be updated in our retrieval scheme (with in mind computer calculation times of a real-time package) in order to improve the retrieval of fine water vapor structures.^^IASI data for temperature and humidity sounding are now assimilated in clear conditions at many operational meteorological centres, providing good impact on forecast skill. However, a large amount of situations, more than 80% on the whole globe, are covered by clouds. All the centres began to handle these data, the first step being to detect and characterize the clouds in the footprint of the sounder.
One way of investigating the limitations of a particular methodology is to perform a careful intercomparison of the results of different processing schemes for the same observations. For this study, ten different schemes are applied to a 12 hour global acquisition on 18 November 2009.

This talk presents the results of the intercomparison for the cloud detection, the cloud pressure and the effective cloud amount in terms of maps, scatter plots, histograms,.. The talk also presents the impact of the cloud products accuracy on the use of cloud-affected channels in retrieval schemes.

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

Presenter: François Faijan
Authors: François Faijan ; Lydie Lavanant
Two methods for processing of heterogeneous scenes are considered in the IASI sounder FOV for the atmospheric retrieval with use of the AVHRR radiances analysis :
The first method does characterization of the cloud in terms of height, effective emissivity and coverage in the sounder ellipse. This set of cloudy parameters allows to compute IASI cloudy synthetic spectra and if the departure to the observed spectra are small enough, the cloudy observed IASI radiances are directly used in a 1Dvar cloudy scheme to retrieve the atmospheric profiles.
The second method does the decomposition of the cloudy IASI spectrum in up to four spectra corresponding to homogeneous layers in the IASI FOR (Field Of Regard) and reprojected to each individual IASI pixel. It is then possible to use each homogeneous spectrum to first determine the cloud or surface parameters and to retrieve the corresponding atmospheric profiles. In a preliminary step, the two methods will be tested on our operational North-Atlantic and Europe operational area for different days in cloudy conditions. The increase of the Degree Of Freedom in the system will be considered.

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

Presenter: Christopher Down
Authors: Anthony Rea and Christopher Down
The Australian Bureau of Meteorology (Bureau) is finalising the installation of a network of X-band receiving stations to provide reception capability for the next generation of meteorological satellites: NPP, NPOESS and Fengyun-3. The network will provide reception coverage over the Australian continent and surrounding oceans, and Antarctica, augmenting the current national coverage provided by the Bureau's L-band reception stations. Initially, the new ground stations will receive data from Aqua and Terra.

In preparation for the provision of operational products from the next generation of satellites, the Bureau is investigating the accuracy of atmospheric soundings derived from hyperspectral instruments. To achieve this, a validation program has been designed to provide in situ data co-incident with satellite overpasses. Additional radiosondes are being launched from key sites of interest across Australia, with the launches timed to coincide with Aqua overpasses. This timing also allows comparison with MetOp data. The project will ultimately collect the over three hundred radiosonde temperature and humidity profiles, over a range of different surface types.

The validation program, when complete, will provide a valuable dataset for Australian and international researchers to investigate the generation of satellite-derived atmospheric profiles and surface emissivity estimates over the Australian continent. It is hoped that, over time, the data set will lead to improvements in the quality of these products.

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

Presenter:
Authors:

1.12. Hyperspectral Microwave Atmospheric Sounding

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

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

Presenter: Robert Knuteson
Authors: Robert Knuteson, Sarah Bedka, Henry Revercomb, Jacola Roman, Dave Tobin, and Dave Turner
AIRS and IASI Precipitable Water Vapor (PWV) Absolute Accuracy in the Tropics, Mid-Latitudes, and Arctic

Robert Knuteson, Sarah Bedka*, Henry Revercomb, Jacola Roman, and Dave Tobin

Space Science and Engineering Center, University of Wisconsin, Madison, WI, USA
*Science Systems and Applicaions, Inc. Hampton, VA

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

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

Presenter: Paolo Antonelli
Authors: Paolo Antonelli, Hank Revercomb, Dave Tobin. Robert Knuteson, Raymond Garcia, Sarah Bedka, Eva Borbas, Paul Menzel, Fred Best, William Smith, Stephen Tjemkes, Rolf Stuhlmann, Agostino Manzato
The work presented shows the results obtained by retrieving surface and atmospheric environmental parameters from IASI observations of Earth emitted infrared energy. The list of parameters includes: vertical profiles of Temperature , Water Vapor Mixing Ratio, Carbon Dioxide, Ozone; surface emissivity and surface temperature. Level 2 products are generated using UWPHYSRET, a physically based approach which makes use of optimal estimation theory coupled with an accurate line by line forward model (LBLRTM). The presentation: 1) introduces the theoretical basis of the
inversion scheme used, along with technical implementation details; 2) presents the results obtained for different IASI overpasses in different areas over both land and ocean; 3) compares the results obtained from IASI data to those obtained by two airborne interferometers, the S-HIS and the NAST-I; 4) describes the conclusion based on the retrieval validation and assess the accuracy and the limitation of the current implementation of UWPHYSRET in deriving Level 3 products.

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

Presenter: Youri Plokhenko
Authors: Youri Plokhenko and W. Paul Menzel
The physical interpretation of hyperspectral measurements from the AIRS spectro-radiometer in the atmospheric remote sensing is discussed. Measurement physical properties are discussed. A non-linear measurement model with a measurement vector of variable dimensionality is suggested. The primary factor affecting measurement content (measurement vector dimensionality) is spectral filtering based upon physical-statistical measurement of error detection and removal of spectral channels with abnormal error characteristics in the frame of the used measurement model.
Requirement of the sufficient energy signal from the sought for physical parameter (solution component in the stated inverse problem) affects the measurement dimensionality as well.
Results of physical interpretation of AIRS hyperspectral measurement are demonstrated. The effects of non-linear physical factors are shown. The efficiency of this new modeling and processing approach is demonstrated

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

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

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

1.22. Updates to the IMAPP AIRS utility software

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

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

Presenter: Nikita Pougatchev
Authors: Nikita Pougatchev, Eric Fetzer, Evan Fishbein, and Bjorn Lambritsen
We present the characterization and error assessment for the AIRS v. 5 temperature and water vapor retrievals. We use dedicated radiosondes for the reference data and Validation Assessment Model as the tool for error assessment. The geographic coverage is from tropics to Alaska. In addition to the estimates of error biases and covariances we infer averaging kernels from the real measurements data.

1.27.

Presenter:
Authors:

1.29. A Neural Network approach for temperature retrieval from AMSU-A measurements onboard NOAA-15 and NOAA-16 satellites and a case study during 'Gonu' cyclone

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

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

Presenter: Pradeep K Thapliyal
Authors: Pradeep K Thapliyal, Munn V Shukla, Pradip K Pal and Prakash C Joshi
During past decade the development of sophisticated state-of-the-art mesoscale numerical weather prediction models have shown potential in the improvement of weather forecast over tropical Indian region. These models require accurate information of atmospheric temperature and humidity profiles with high spatial and temporal resolution for weather forecasting in short to medium range besides various other weather and climate applications. Currently, these data are obtained from the NOAA operational polar satellites with 1-2 days repetivity. For high temporal resolution geostationary satellites, such as GOES, are

required. To improve the continuity and quality of the input atmospheric data India is planning to launch a geostationary satellite, INSAT-3D towards the end of 2010. INSAT-3D will carry an 18-channel infrared Sounder (plus a visible channel for cloud detection during daytime) along with a 6 channel Imager. The spatial resolution of INSAT-3D Sounder observation is approximately 10 km at ground. The normal mode of Sounder operation will cover 6000 km x 6000 km field of view taking approximately 160 minutes for complete coverage. INSAT-3D Sounder observations will provide vertical profiles of temperature and humidity in clear-sky conditions besides total column ozone and various other derived products.

An algorithm for the retrieval of atmospheric temperature and moisture profiles along with ozone from INSAT-3D Sounder observations has been developed. A two-step approach has been adopted with nonlinear regression retrieval alongwith the forecast to be used to generate the first guess, followed by the non-linear physical retrieval to obtain the accurate profiles of temperature and humidity. The present retrieval algorithm for INSAT-3D Sounder is primarily based on the retrieval algorithms of Li et al. (2000), Ma et al. (1999), and Hayden (1988). We have also made a few efforts to improve the retrieval accuracy by fine-tuning the algorithm to the Indian tropical atmospheric conditions, besides including new nonlinear technique to improve the quality of the first guess profile in the physical retrieval routine. Results from these efforts will be presented in the conference.

2.02. Potential for the use of reconstructed IASI radiances in the detection of atmospheric traces gases^^The sensitivity of the sub-optimal NWP analysis system to the representation of hyperspectral data

Presenter: Fiona Hilton^^Fiona Hilton
Authors: Nigel Atkinson, Fiona Hilton, Samuel Illingworth, John Eyre and Tim Hultberg^^Fiona Hilton and John Eyre
Principal component (PC) analysis has received considerable attention as a technique for the extraction of meteorological signals from hyperspectral infra-red sounders such as the Infrared Atmospheric Sounding Interferometer (IASI) and the Atmospheric InfraRed Sounder (AIRS). Elimination of high-order components achieves substantial bit-volume reductions for dissemination purposes, and can also be used to generate reconstructed radiances in which random instrument noise has been suppressed. To date, most studies have been in the context of Numerical Weather Prediction (NWP), in particular the analysis of temperature and humidity. This study examines the potential of the use of reconstructed radiances for chemistry applications.
A major concern in the use of PC analysis for chemistry has been that the spectral features associated with traces gases may not be well represented in the reconstructed spectra, either due to deficiencies in the training set or due to the limited number of PC scores used in the radiance reconstruction. In this paper we show examples of reconstructed IASI radiances for several trace gases: ammonia, sulphur dioxide, methane and carbon monoxide. It is shown that care must be taken in the selection of spectra for the initial training set: an iterative technique, in which outlier spectra are added to a base training set, gives the best results. For the four trace gases examined, the chemical signatures are retained in the reconstructed radiances, whilst achieving a substantial reduction in instrument noise.^^Satellite data are usually assimilated in the numerical weather prediction (NWP) system via variational analysis schemes based on optimal estimation theory. This theory will only give an optimal analysis if the assumed observation and background errors are correct. In practice, the analysis is sub-optimal, as observation error correlations and the synoptic dependence of background errors are usually ignored.
Here, we test the hypothesis that the form of the response of the observations to changes in the atmospheric profile, in other words the shape of the Jacobian, may affect the sensitivity of the analysis to mis-specification of the background error covariance. This question is particularly relevant to the assimilation of hyperspectral data, where significant research effort has been put into the assimilation of principal components of measured spectra. Principal components have Jacobians which are very different in shape from radiance Jacobians, and are highly non-localised in the vertical. It is expected that the increased non-localisation may give rise to increased sensitivity to the mis-specification of the background error.
The hypothesis is tested in a 1D-Var context with idealised Jacobian forms, and also with typical Infrared Atmospheric Sounding Interferometer (IASI) Jacobians in radiance and principal component form.

2.04. CNES programmes for meteorology, climate and atmospheric composition^^Major results of IASI on Atmospheric chemistry

Presenter: Thierry Phulpin^^Thierry Phulpin
Authors: Thierry Phulpin, Didier Renaut and Carole Deniel, CNES.^^C. Clerbaux, P.F. Coheur, C. Camy Peyret, G. Dufour, D. Edwards, B. Barret, S. Massart and T. Phulpin
The main projects under study, in preparation or in operation which interest the ITWG are presented. A special focus will be given to SMOS results, Megha-Tropiques, expected to be launched in 2010. Also the studies of missions in phase A : IASI-NG and Minicarb, will be shortly presented.^^The presentation will summarize the major results of the second international IASI conference regarding the Atmospheric composition retrieved with IASI. There are many groups working on this application and the results are very demonstrative and pretty spectacular. The main products are Ozone profile (or columns), Carbone monoxide, Methane, Carbone dioxide in the upper troposphere, nitric acid, sulphur dioxide of volcanic eruptions, and many unexpected other species like Ammonia, methanol, etc. Some intercomparisons have been performed successfully either with other satellite or instruments like Gome2, Mopitt, GOSAT, etc. and can now be considered as validated. Near real time on-going applications have started to be developed specially for the GMES Gems-MACC project or for Volcanic Ash advisory centres (VAACs). Development of assimilation in Air quality models is on going with encouraging results. Nevertheless research to continuously improve the products is still very active. The main focus remains on the improvement of profiles near the surface over land

taking into account surface emissivity. There is also a strong relationship with atmospheric profiles which could foster some studies of full assimilation to improve simultaneously temperature, humidity and trace gas profiles.

2.06. Retrieval of SO2 from high spectral resolution measurements: IASI and AIRS^^Land surface temperature determination from the ATSR-family of instruments and the Sentinel-3 SLSTR

Presenter: Fred Prata^^Fred Prata

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

Background SO2 gas concentrations in the atmosphere vary from less than 1 ppb to ~10 ppb with a vertical distribution with largest amounts in the boundary layer quickly falling with height, reflecting the source location near the surface. Anthropogenic emissions largely arise from industrial activities, such as lead and aluminium smelting, power station emissions and some other industrial activities. The majority of natural emissions arise from erupting volcanoes and produce orders of magnitude greater SO2 abundances (~1 ppm), short-lived (a few weeks) events that are easily detected by appropriate infrared satellite instruments. Volcanic emissions can reach heights of 15 km or more and hence penetrate into the stratosphere, potentially causing short-term climate cooling. The emissions can also remain in the troposphere and have detrimental health effects on humans, animals and vegetation. The new high-spectral resolution sensors, IASI and AIRS, have the potential to determine the vertical locations of volcanic emissions by exploitation of the ν1, ν3 and ν1+ν3 combination bands of SO2. Here we describe the algorithms currently being used to determine SO2 from space using IASI and AIRS high-spectral resolution measurements. We discuss these data in the context of providing information concerning volcanic hazards and also for improving our understanding of the climatic effects of volcanic aerosols on climate.^^Recent developments for determining land surface temperature (LST) from infrared broadband satellite radiometers are described. In particular we examine the operational (A)ATSR LST product and compare retrievals with ground-truth data and with other satellite products (e.g. MODIS). The operational algorithm makes use of vegetation class and static fractional vegetation cover maps as proxies for the effects of the spectral and spatial variations in infrared emissivity of the land surface. Water vapour effects are accounted for with an additional explicit dependence on column water vapour amount determined from the NVAP climatologies. Lessons learned from several years of operational data analyses have led to some significant improvements in the algorithm, which are described here. Higher spatial resolution of the land cover data from 50x50 km2 to 1x1 km2 provides improved LST retrievals. Water vapour climatology is also improved using the ERA40 re-analysis data, but the impact on the LST retrieval is small. The Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR) LST will utilise these improvements as well as making use of synergies with other optical instruments on board the Sentienl-3 platform. A brief discussion of the use of the longterm ATSR LST data-set, now 18 years long, for climate change studies will also be given.

2.08. Dust aerosol optical depth and altitude retrieved from 7 years of infrared sounders observations (AIRS, IASI) and comparison with other aerosol datasets (MODIS, CALIOP, PARASOL)

Presenter: S. Peyridieu

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

Remote sensing of aerosol properties in the visible domain has been widely used for a better characterization of these particles and of their effect on solar radiation. On the opposite, remote sensing of aerosols in the thermal infrared domain still remains marginal. However, knowledge of the effect of aerosols on terrestrial radiation is needed for the evaluation of their total radiative forcing. A key point of infrared remote sensing is its ability to retrieve aerosol optical depth as well as mean dust layer altitude, a variable required for measuring their impact on climate. Moreover, observations are possible night and day, over ocean and over land.

Our algorithm is specifically designed to retrieve simultaneously coarse mode dust aerosol 10 µm optical depth (AOD) and mean layer altitude from high spectral resolution infrared sounders observations. Thanks to IASI higher spectral resolution, the selection of finer channels for aerosol detection allows an even more accurate determination of aerosol properties.

In this context, results obtained from 7 years (2003-2010) of AIRS/Aqua and more than 2 years (2007-2010) of IASI/Metop observations have been compared to other aerosol sensors. Compared to MODIS/Aqua optical depth product, 10 µm dust optical depth shows a very good agreement, particularly for tropical Atlantic regions downwind of the Sahara during the dust season. Comparisons with PARASOL non-spherical coarse mode product allows explaining small differences observed far from the sources. Time series of the mean aerosol layer altitude are compared to the CALIOP Level-2 products starting June 2006. For regions located downwind of the Sahara, the comparison again shows a good agreement with a mean standard deviation between the two products of about 400 m over the period processed, demonstrating that our algorithm effectively allows retrieving accurate mean dust layer altitude.

A 7-year global climatology of the aerosol 10 µm dust optical depth and of the layer mean altitude has also been established, emphasizing the natural cycles of Saharan dust.

Application of this method over continental surfaces, such as the Sahara desert, is currently being made possible by the retrieval of surface temperature and emissivity from IASI observations. This a priori knowledge opens the way to retrieving dust sources over land in the infrared.

3.00. SSMIS Radiance Assimilation and Calibration Anomaly Mitigation

Presenter: Steve Swadley

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

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

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

Presenter: Lars Fiedler
Authors: Lars Fiedler, Yakov Livschitz, Jörg Ackermann, Peter Schlüssel and Gökhan Kayal
The Infrared Atmospheric Sounding Interferometer (IASI) is part of the payload of Metop-A, the first of three satellites of the EUMETSAT Polar System (EPS). Metop-A was launched on 19 October 2006. The IASI instrument went alive on 26/10/2006 and generated the first interferogram on 27/11/2006. IASI L1 NRT monitoring at EUMETSAT has been started at the end of the In-Orbit Verification (SIOV) in April 2007.

One part of the IASI monitoring is based on the comparison of measured and modelled IASI L1C spectra. The modelled IASI L1C radiance spectra are generated by the radiative transfer model RTIASI. To avoid uncertainties with respect to surface emissivity and reflected solar radiation, only situations over sea during night time conditions are taken into account.
The cloud identification is based on cloud flags of the co-located AVHRR L1B products. Additionally, homogeneity within the IASI field of view is required; this is ensured by selecting only IASI L1C products with AVHRR radiance cluster analysis indicating population of more than 99% in one cluster. The sea surface temperature (SST) which is needed as input for RTIASI is also based on the AVHRR L1B product.
Temperature, water vapour, and ozone profiles are taken from ECWMF forecast data by selecting the nearest neighbour. Forecast data are available at 00, 06, 12, 18 h. Only co-locations within 1 h time difference are considered.

This observed versus calculated radiance comparison is complemented by the comparison between the co-located measurements of IASI and HIRS flying on the same platform. IASI based HIRS pseudo channel radiances are generated by using the HIRS spectral response functions and compared with the original HIRS L1B radiance measurements. Additional information with respect to cloud cover is derived from co-located AVHRR L1B products. IASI - HIRS comparison were initially started in May 2008. However, the record has been recently extended and information from December 2007 onwards is available and will be presented.

The analysis of more than 30 months of IASI L1 product quality will be shown. A very good agreement of measured and calculated IASI radiance measurements can be observed trough out the observation period.

The focus of this paper will be on the results from 2 years of IASI–HIRS radiance comparison. A good agreement between IASI and HIRS has been observed. However, the origin of the small IASI-HIRS bias will be presented.

This will cover the period of the first IASI decontamination and the results from an investigation on the impact of the IASI instrument decontamination on the IASI-HIRS radiances will be presented.

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

Presenter: Liam Gumley
Authors: Liam Gumley, Kathy Strabala

3.06. Spectral and Radiometric Calibration of HIRS Using IASI on MetOp Satellite

Presenter: Ruiyue Chen

Authors: Ruiyue Chen, Changyong Cao, and Likun Wang

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

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

Presenter: Denise Hagan

Authors: Denise Hagan, Joe Predina, Gail Bingham, Gene Kratz, Denis Tremblay, Farhang Sabet-Peyman, Degui Gu, Chunming Wang, Glenn Brossus, Giovanni De Amici, Joe Hohn, Scott Farrow, Mike Plonski, Ron Glumb, Steve Wells, Lawrence Suwinski, Joseph Strong, Craig Beh

The Cross-Track Infrared Sounder (CrIS) together with the Advanced Technology Microwave Sounder will provide retrievals of atmospheric moisture and temperature profiles for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The CrIS is a Fourier-transform Michelson interferometer covering the spectral range of 3.9 to 15.4 μm (650 to 2550 cm-1) developed by ITT under contract to Northrop Grumman Aerospace Systems. The first deployment of the CrIS (Flight Model 1) is scheduled for 2011 on the NPOESS Preparatory Project (NPP) satellite, an early instrument risk reduction component of the NPOESS mission. The analysis and data results from comprehensive TVAC testing of the CrIS FM1 sensor demonstrate a very accurate radiometric and spectral calibration system. We describe instrument performance parameters, and the end-to-end plans and analysis tools for on-orbit verification of sensor characteristics and validation of the radiance products.

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

Presenter: Vladimir Zavyalov

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

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

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

Presenter: Bo-Ra Kim

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

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

3.16. RARS Global Network Status and Plans

Presenter: J. Lafeuille

Authors: J.Lafeuille and the RARS Implementation Group

The initial objective of the global network project of Regional ATOVS Retransmission Services (RARS)is to deliver Level 1c ATOVS data from at least 90% of the globe within no more than 30 minutes from acquisition, in order to serve the needs of regional and global NWP. This can be achieved with a minimum of investment in concentrating data received from a number of individual Direct Readout stations implemented throughout the world, applying common processing and coding standards, and sharing the products over the Global Telecommunications System of WMO (GTS).

By January 2010, the overall coverage of the RARS network had reached 70% of the globe's surface, and further implementations were underway. The initial objective is thus nearly completed thanks to the combined efforts of:

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

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

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

4.00. IASI 1dvar using PC Radiative Transfer^^Utilisation of IASI data in a cloudy atmosphere

Presenter: Jonathan P Taylor^^Jonathan P Taylor
Authors: Jonathan P Taylor, Stephan Havemann, Jean-Claude Thelen, Steven Wardle, Tom Emery^^Jonathan P Taylor, Stephan Havemann, Jean-Claude Thelen, Anthony Baran
A fast principal component based radiative transfer code has been coupled in a 1dvar environment to retrieve profiles of temperature, water vapour and ozone along with surface temperature and spectrally resolved emissivity. Results will be presented from trials of this retrieval scheme over ocean, arable land, sea ice, snow and desert surfaces. In all cases the performance of the retrieval is validated against dropsonde data gathered by the FAAM BAe146 atmospheric research aircraft and from low level runs with this aircraft where measurements of emissivity are made using the ARIES interferometer. The talk will present the results and their sensitivity to the structure of the background error covariance matrix. The results show that it is possible to use spectral information from the water vapour and temperature sensitive channels of IASI over a wide range of land/ocean surfaces.^^A principal component based radiative transfer code has been developed that allows a full treatment of scattering by aerosols, liquid water and ice clouds. This presentation will discuss the structure of the code and the treatment of scattering by ice crystals which utilises an ensemble model of ice scattering from non-spherical particles. The performance of IASI retrievals within a 1dvar environment utilising this fast pc based radiative transfer code in the presence of cirrus clouds will be presented. The cloud properties and temperature and water vapour profile are independently verified with observations from the FAAM BAe146 atmospheric research aircraft.

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

Presenter: Allen Huang
Authors: Allen Huang
The computing performance of the GPU has significantly outpaced its CPU counterpart. Leveraging the combined features of general-purpose GPU supercomputing, high parallelism, high memory bandwidth (102 GB per GPU), low cost, and compact size a GPU-based high-performance radiative transfer model is studied.

This paper presents the performance of the GPU-based IASI/AIRS radiative transfer model running on NVIDIA GPUs via CUDA (Compute Unified Device Architecture), the compute engine in NVIDIA GPUs for massively multi-threaded parallel computation. IASI/AIRS GPU-based forward model is demonstrated on a low-cost NVIDIA S1070 personal supercomputer with 4 Tesla GPUs (total 960 cores). The result is compared with the native INTEL multi-core CPU implementation to illustrate the The significant speed-ups of computing the IASI/AIRS top of atmosphere radiance spectra gained by the newly developed GPU-based system.

4.04. Update of the JCSDA Community Radiative Transfer Model (CRTM)

Presenter: Yong Han
Authors: Yong Han, Paul Van Delst, Fuzhong Weng, Quanhua Liu, Dave Groff, Banghua Yan, Yong Chen, and Ron Vogel
The community radiative transfer (RT) model (CRTM) is developed at the US Joint Center for Satellite Data Assimilation (JCSDA) for rapid satellite radiance simulations and radiance derivative calculations under various sky and surface conditions. The model was first released publicly in 2005, and has been substantially improved and expanded since then. CRTM version 2.0

will be released in March, 2010. In this presentation, we will provide an overview of the new version with a focus on the new features. The model includes a multiple transmittance algorithm framework, which allows different transmittance algorithms to coexist. Within the framework, a new transmittance algorithm is implemented, which combines the strengths of the OPTRAN algorithm (Optical Path TRANsmittance) and the ODPS algorithm (Optical Depth in Pressure Space), currently used in the RTTOV model. In addition, special algorithms are implemented to take into account Zeeman-splitting effect for the SSMIS and AMSU-A sensors and CO2 cell pressure leaking effect for the Stratospheric Sounding Unit (SSU). For the surface emissivity/reflectivity, a new fast Infrared emissivity model and a bi-directional reflection distribution function (BRDF) for solar reflection over sea surface are implemented. CRTM version 2 also extends the RT Solver and other modules to include components for Visible sensors. The new version has improved computational efficiency (a factor 3 for the forward model and a factor 2 for the Jacobian model, compared to the first version) under clear sky conditions. In the presentation, we will also report on our ongoing and future work.

4.07. Aircraft and satellite hyperspectral measurements investigating the radiative impact of atmospheric water vapour^^Sea ice emissivities and effective temperatures at AMSU-B frequencies: An analysis of airborne microwave data measured during two campaigns

Presenter: Stuart M. Newman^^Stuart M. Newman
Authors: Stuart M. Newman, A. Larar, W. L. Smith, K. P. Shine, I. V. Ptashnik, F. Hilton and J. P. Taylor^^R.Chawn Harlow
The successful launch of the Infrared Atmospheric Sounding Interferometer (IASI), with significant improvements in forecast skill in operational weather forecasting models, demonstrates the value of hyperspectral measurements from space. However, the extension of hyperspectral data assimilation to include more channels sensitive to water vapour is an ongoing challenge. Uncertainties in the spectroscopy of water vapour, and in the formulation of the water vapour continuum, remain, and radiative transfer models require validation against observational data.

The UK's Facility for Airborne Atmospheric Measurements (FAAM) BAe 146 research aircraft has been involved in two recent campaigns where the radiative impact of water vapour has been investigated. The Joint Airborne IASI Validation Experiment (JAIVEx), based in Houston, Texas, gathered a high quality data set of collocated interferometer radiances and atmospheric profile measurements in high humidity conditions. Subsequently, as an integral part of the Continuum Absorption at Visible and Infrared wavelengths and its Atmospheric Relevance (CAVIAR) project, combined ground-based and airborne measurements have been collected at midlatitudes, centred on southwest England and the Jungfraujoch research station in Switzerland. Combined, these measurements span a range of humidity conditions and allow radiative transfer models of atmospheric water vapour absorption and emission to be tested. Results from the campaigns will show the level of agreement possible between models and observations, assess recent updates to spectroscopic line parameters, and identify regions where modelling errors persist.^^Satellite-based sounding of the temperature and humidity of the lower troposphere is only carried out over open sea surfaces because of large uncertainties in the surface emissivity and effective emitting temperature of other surfaces. The study of sea ice and snow surface emissivities has been the focus of two airborne campaigns carried out by the Met Office over the past decade in order to promote the assimilation of lower tropospheric sounding radiances over the Polar Regions.

Presented here is an analysis of data from four flights of the FAAM BAe146 during the Feb 2008 CLPX-II campaign over the Chukchi and Beaufort Seas and three flights on the Met Office C-130 from the POLEX campaign of March 2001 over the Arctic Ocean north of Svalbard. The Microwave Airborne Radiometer Scanning System (MARSS) was present and functional during both campaigns and measures brightness temperatures at the AMSU-B and MHS wavelengths in 18 directions in the plane along track. Other instruments onboard were measuring aircraft position and height above the surface. Dropsondes were released to measure atmospheric temperature and humidity profiles.

Analysis described in [1] was carried out for each MARSS footprint yielding a Lambertian emissivity and effective temperature time series for each of the seven flights discussed here. These time series are used in conjunction with nearly coincident Radarsat-1 SCANSAR imagery and (for CLPX-II) AVHRR imagery to classify the surface type. From this procedure, 23 ice types are defined including snow covered uplands, wetlands and frozen lakes, five samples of first year pack ice, six types of first year fast ice and two samples of multi-year ice. For each of these 23 ice types, Lambertian emissivity spectra at the MHS frequencies are retrieved. It is found that the emissivity difference between 157 GHz and 89 GHz (D157-89) is strongly linked to ice type. This D157-89 is highly negative for first year fast ice, less negative for first year ice, near zero for MYI and thin ice types, and positive for the frozen land sampled in this dataset. This changing behaviour in emissivity with surface type is explained in terms of differences in the snow stratigraphy and surface roughness/micro-topography.

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

5.01.
Presenter:
Authors:

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

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

The CRTM is used in the NCEP data assimilation systems to simulate satellite radiance observations. The current infrared (IR) sea surface emissivity model component of the CRTM has been in use since 2006 and is based on Wu and Smith [1997] in which surface-emitted, surface-reflected (SESR) contributions are taken into account.

Recent work [Hanafin and Minnett, 2005; Nalli et al., 2008a,b] has shown that models of this type will underestimate the effective emissivity at larger zenith angles due to the quasi-specular reflection of downwelling atmospheric radiance into the sensor field-of-view. The corresponding difference between the Wu-Smith and Nalli model emissivities in the longwave IR window region (800-950cm-1) is around 0.01, or 1%. For blackbody emission at typical sea surface temperatures, this is roughly equivalent to a brightness temperature error of 0.7K which, after including the reflected downwelling atmospheric radiation still amounts to a significant error of 0.5K [Wu and Smith, 1996].

A two season comparison of the two ocean surface emissivity models (Wu-Smith and Nalli) was conducted using the NCEP GDAS/GFS at the operational resolution. Improvements were noted from using the Nalli model by the increase in surface channels used over ocean along with a more consistent bias correction at the various scan angles. Improvements in the anomaly correlation statistics from using the Nalli emissivity model were also observed.

5.08. Infrared Land Surface Emissivity Regression Retrieval Algorithm

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

The land surface emissivity (LSE) varies according to soil moisture, surface coverage, view angle and soil components. STAR has calculated LSE from both AIRS and IASI using a regression retrieval. When comparing the regression emissivity to the emissivity from monthly datasets, the simultaneous emissivity retrieval algorithm developed at STAR can provide the real time surface radiance characteristics for the satellite observations; thus providing a better emissivity value for the calculations of atmosphere temperature and water vapor profiles. The STAR LSE regression retrieval algorithm is based upon clear radiances simulated from forecast model data and an emissivity training dataset. A new emissivity training dataset is generated by combining multiple surface types with high spectral resolution lab emissivity measurements. The LSE is retrieved at 39 hinge points and may be extended to high spectral resolution with the constraint information from high spectral resolution lab emissivity measurements. The LSE retrievals from AIRS and IASI will be evaluated by comparing the regression results calculated using both the old and new coefficients. It will also be compared with the monthly UW/CIMSS global infrared land surface emissivity datasets. The results will be presented.

5.12. Footprint Matching for the Advanced Technology Microwave Sounder^^Modeling of Inhomogeneous Surface Properties for the Advanced Technology Microwave Sounder

Presenter: Thomas J. Kleespies^^Thomas J. Kleespies
Authors: Thomas J. Kleespies^^Thomas J. Kleespies

In a recent paper, the author demonstrated that in order for the ATMS to have the same impact on NWP or sounding as the AMSU/MHS, there will have to be some kind of footprint matching or averaging. In that paper, a simple averaging was done of the smaller fields of view to the largest field of view at the -3dB level. In this paper, I will explore an alternative method where the smaller fields of view are convoluted with the largest fields of view at the -20dB level, which accounts for 99% of the radiation received by the sensor. This proposed method is similar to Backus-Gilbert, with the exception that no assumptions are made about the antenna pattern, such as assuming an effective Gaussian shape. The measured antenna pattern is mathematically modeled to a high degree of accuracy permitting convolution with good fidelity.^^The low frequency channels of the Advanced Technology Microwave Sounder have a nadir resolution of 79 km increasing to 363x151 km at edge of scan. Modern numerical weather prediction models are exceeding this resolution. Ancillary databases, such as digital elevation maps are available with a resolution of a few meters. This paper presents a method of using the measured antenna pattern of the ATMS in conjunction with a digital elevation model to perform radiative transfer over coastlines and other inhomogeneous terrain.

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

Presenter: Virginie Capelle
Authors: Virginie Capelle, Eric Pequignot, Alain Chedin, Noelle A. Scott
Surface temperature and emissivity spectra are variables essential for improving models of the earth surface-atmosphere interaction, retrievals of meteorological profiles, as well as cloud and aerosol characteristics. However, in most cases, they are not correctly taken into account in climate models, leading to potentially important errors in the estimation of surface energy fluxes and temperature. Satellite infrared observations offer a way to accurately estimate these variables. Here, IASI observations are interpreted in terms of monthly surface skin temperature and emissivity spectra at a resolution of 0.05 m.

Following the method described in Pequignot et al., 2008 and applied to AIRS observations, for each IASI observation, an a priori estimate of the observed atmospheric temperature and water vapor profiles is first obtained through a proximity recognition within the Thermodynamic Initial Guess Retrieval (TIGR) climatological database of about 2300 representative atmospheric situations. With this information, all terms of the radiative transfer equation are then computed by using the 4A line-by-line radiative transfer model. Then, surface temperature is evaluated by using a few IASI window channels, chosen for their almost constant emissivity with respect to soil type. Emissivity is then calculated for a set of 101 atmospheric window channels distributed over the infrared spectrum. The overall infrared emissivity spectrum at 0.05 microns resolution is finally derived from a combination of these results and of high spectral resolution laboratory measurements of various materials carefully selected within the MODIS/UCSB and ASTER/JPL emissivity libraries. The final product provided by this study is global monthly surface temperature and infrared emissivity spectra from 3.7 to 14 microns at a spatial resolution of 1° per 1°. The period covered goes from July 2007 to now.

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

Presenter: Ralph Ferraro
Authors: Ralph Ferraro, Sid Boukabara, Fuzhong Weng, Nai-Yu Wang
To date, the majority of the passive microwave, precipitation over land algorithms have relied on mostly empirically based methods (with physical foundation) that utilize the ice-scattering properties of precipitation sized ice particles at frequencies at or above 85 GHz. These methods mostly rely on a "first guess" that attempts to isolate this signature from the surrounding background land areas, including surfaces with similar spectral properties like snow and desert. In order to advance the retrievals into a more physically based scheme and use the full complement of measurements in the 10 – 190 GHz range (a goal of the Global Precipitation Measurement (GPM) mission and also identified as a priority research area at the 4th IPWG Workshop in October 2008), several improvements are needed to advance the current class of algorithms. Perhaps the most urgent need is the proper characterization of the underlying land surface, including the land surface emissivity.

It is well recognized that the land surface emissivity community has made great strides in developing emissivity models and retrievals at microwave frequencies; yet, these have focused on the utilization of such information in NWP applications. These are not likely suitable for the wide range of conditions needed for precipitation retrievals (e.g., falling rain, falling snow, frequencies up to 190 GHz, etc.). Under the auspices of NASA's GPM Science Team, a small study was initiated to assess the sensitivity of the precipitation algorithms to emissivity retrievals and also to gain an understanding of the variability of the emissivity estimates over similar surface types. Emissivity estimates for a 1 year period (July 2006 – June 2007) over 13 targets throughout the world were generated by several investigators and are being intercompared over time scales ranging from instantaneous to monthly (for more details, see http://cics.umd.edu/~rferraro/LSWG.html).

The purpose of this paper is to describe this study in more detail, present some preliminary results, and engage the ITWG to further describe the needs of the international precipitation community (e.g., IPWG and GPM) and define areas of collaboration

6.01. Using Hyperspectral Sounders for Climate Applications^^NULL

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

6.04. Vertical Moist Thermodynamic Structure of the MJO in AIRS Observations and ECMWF Interim Reanalysis

Presenter: Baijun Tian

Authors: Baijun Tian, Duane E. Waliser, Eric J. Fetzer, Bjorn H. Lambrigtsen, and Yuk L. Yung
Tian et al. [2006] have documented the large-scale three-dimensional moist thermodynamic structure and spatial-temporal evolution of the Madden-Julian Oscillation (MJO) using the first 2.5-year (2002-2005) high-resolution atmospheric moisture and temperature profiles from the Atmospheric Infrared Sounder (AIRS)/Advanced Microwave Sounding Unit (AMSU) on the NASA Aqua mission. Here, we re-examine the vertical moist thermodynamic structure of the MJO using the current available 7-year AIRS data (2002-2009) to test the robustness of the results of Tian et al. [2006] and their dependence of data record length, data resolution (daily versus pentad), and MJO analysis methods. We also compare the AIRS results to those from the ECMWF Interim reanalysis (ERA-Int), a new global reanalysis data set from ECMWF. The current analysis indicates that the large-scale vertical moist thermodynamic structure and spatial-temporal evolution of the MJO reported by Tian et al. [2006] are robust and independent on the AIRS data record length, AIRS data resolution, and MJO analysis methods. The MJO vertical moist thermodynamic structures from AIRS and ERA-Int data are in very good agreement although AIRS results seem to be drier in moist regions and moister in dry regions compared to ERA-Int results. These results will be a useful metric for climate model diagnostics.

6.05. An update on the NESDIS MSU/AMSU/SSU CDR development and its applications^^NULL

Presenter: Cheng-Zhi Zou^^NULL
Authors: Cheng-Zhi Zou^^NULL
NESDIS/STAR has been developing consistent, SNO (simultaneous nadir overpass) inter-calibrated radiance sensor data record (SDR) and upper air temperature thematic climate data records (TCDR) from MSU/AMSU/SSU observations for climate applications. In this talk, we will give an update on the status of the MSU/AMSU/SSU reprocessing/replication and its application activities. These include, but not limited to,: a) release of the STAR Version 1.2, recalibrated 28-year (1978-2006) MSU-only radiance SDR and its resulting upper air temperature TCDRs of mid-troposphere, upper-troposphere, and lower-stratosphere; b) SNO inter-satellite calibration results for the AMSU-A atmospheric temperature channels onboard NOAA-15 through NOAA-18 and MetOp-A; c) preliminary results on the 30-years (1978-2009) of STAR Version 2.0, merged MSU/AMSU upper air temperature TCDRs; d) application of the recalibrated MSU radiance SDRs in the new-generation of NCEP CFSR and NASA MERRA reanalyses; e) MSU trend analysis and its relationship with sea ice melting; f) bias correction analysis of the AMSU-A channels in the ECMWF-Interim reanalysis and its implications for the satellite recalibration activities; g) preliminary results on the SSU reprocessing; h) a briefing on the workshop recently held at Washington DC on Climate Data Records from Satellite Microwave Radiometry. Issues identified on the MSU/AMSU/SSU reprocessing in the workshop will be discussed.^^NULL

6.08. Natural and Anthropogenic Variability Observed in Seven Years of Data from the Atmospheric Infrared Sounder (AIRS)

Presenter: Thomas S. Pagano
Authors: Thomas S. Pagano
The Atmospheric Infrared Sounder (AIRS) is a hyperspectral infrared instrument on the EOS Aqua Spacecraft, launched on May 4, 2002. AIRS has 2378 infrared channels ranging from 3.7 um to 15.4 um and a 13.5 km footprint. AIRS, in conjunction with the Advanced Microwave Sounding Unit (AMSU), produces high accuracy temperature profiles, water vapor profiles, infrared cloud height and fraction, and trace gas amounts for CO2, CO, SO2, O3 and CH4 in the mid to upper troposphere. AIRS wide swath¸ ±49.5°, combined with a novel cloud clearing methodology enables daily global daily coverage for over 70% of the Earth's surface for most geophysical products. AIRS data are used for weather forecasting, validating climate model distribution and processes, and observing long-range transport of greenhouse gases.
Early in the mission, the AIRS instrument demonstrated its value to the weather forecasting community by providing better than 6 hours of improvement on the 5 day forecast. Now with over seven years of consistent and stable data from AIRS, scientists are able to examine processes governing weather and climate and look at seasonal and interannual trends with high statistical confidence. The entire 7 year data set from AIRS are collected in this work for global gridded data products of several key geophysical atmospheric variables. We also examine limitations in the Version 5 data set for trending long term climate change using retrieved geophysical parameters, while the raw radiances are indeed sufficiently stable. From this data set it is possible to identify interesting natural and anthropogenic events in Earth's atmosphere including hurricanes, biomass burning (CO plumes), inter-continental transport of carbon dioxide, ozone hole formation and stratospheric tropospheric exchange.

6.11. An overview of the operational processing at the Satellite Application Facility on Climate Monitoring

Presenter: Nathalie Selbach
Authors: Nathalie Selbach and Petra Fuchs
The Satellite Application Facility on Climate Monitoring (CM-SAF) generates, archives and distributes widely recognized high-quality satellite-derived products and services relevant for climate monitoring in an operational mode. Products covering surface albedo, radiation fluxes at top of the atmosphere and at the surface, atmospheric temperature and water vapour profiles as well as vertically integrated water vapour (total, layered integrated) are derived from different sensors onboard operational geostationary and polar orbiting satellites including instruments such as ATOVS, AVHRR, GERB and SEVIRI. The products are available at a

spatial resolution in the range of (15 km)² to (90 km)² on equal area grids and temporal averages ranging from daily to monthly means. Depending on the sensors used the coverage ranges from regional (e.g., Europe, Arctic) to global. Additionally, long time-series of different atmospheric parameters are or will be generated in dedicated processing events as, for example, integrated water vapour from SSM/I, cloud and surface radiation products from AVHRR GAC data with a global coverage, or the extension of the time series of the ATOVS based products.
Processing of the CM-SAF products is done at two processing centres at DWD and RMIB, respectively. The DWD processing centre also makes use of computing resources at the ECMWF. The generation of the CM-SAF products is done in separate processing environments depending on the different satellite instruments required as input. All products are archived in a central database located at DWD. The CM-SAF offers various user services, such as access to the products via a web-based interface, detailed information on products and a User Help Desk.
This presentation will give an overview of the operational procedures at the CM-SAF and future plans. It will cover the processing approach as well as the user access to products and user support.

6.13. Creating long-term water vapor and temperature records with AIRS and other data sources

Presenter: Eric J. Fetzer
Authors: Eric J. Fetzer, Evan F. Fishbein, Thomas S. Pagano and Bjorn H. Lambrigtsen
The AIRS instrument on the NASA Aqua satellite platform has been gathering data since late August 2002. Because this data record is currently over 7 years in length, it can provide insights into a number of climate-relevant phenomena. Meanwhile, other data sources are becoming available as in situ observations are acquired and additional satellite instruments are launched. A necessary step in reaching credible scientific conclusions from any one data source is ensuring that observations from all similar data sources can be reconciled. This study addresses the challenges of creating long-term water vapor and temperature climate records with AIRS, and of merging those records with similar ones taken by other instruments.

6.16. The intercomparison of IASI water vapour retrieval schemes under climate monitoring aspects

Presenter: Martin Stengel
Authors: JÃ¶rg Schulz, Marc SchrÃ¶der, Martin Stengel, Marc SchwÃ¤rz, Roger Saunders
Previous studies and investigations have shown the benefit of Infrared Atmospheric Sounding Interferometer (IASI) measurements for atmospheric analysis in one- and multi-dimensional analysis schemes. Beside IASIï¿½s application in NWP and Nowcasting frameworks, growing long-term records of its measurements suggest the utilization of corresponding retrieval products of atmospheric parameters for climate monitoring and subsequently, for example, for the validation of climate models.

6.17. The radiative signature of increasing carbon dioxide concentration in HIRS measurements

Presenter: Eui-Seok Chung
Authors: Eui-Seok Chung and Brian J. Soden
Decadal cooling trends of observed brightness temperature of the High-Resolution Infrared Radiation Sounder (HIRS) CO2 channels over the period of 1980-1999 are examined in conjunction with Microwave Sounding Unit (MSU) mid-tropospheric temperature channel measurements and Geophysical Fluid Dynamics Laboratory (GFDL) climate model simulations. Simulated HIRS brightness temperatures from the GFDL model with constant carbon dioxide concentration produce warming trends in consistent with the corresponding MSU observations. On the other hand, radiative simulations with time-varying carbon dioxide concentration result in distinct cooling trends, indicating that the effects of increased carbon dioxide on the HIRS radiances are more than twice as large as the effect of the tropospheric warming for the period 1980-1999. In addition, comparisons between observation and simulation suggest substantial regional variations of carbon dioxide trends.

7.00. Recent developments in satellite data assimilation at JMA^^Agency status reports: JMA and JAXA

Presenter: Kozo Okamoto^^Kozo Okamoto
Authors: Kozo Okamoto, Masahiro Kazumori, Toshiyuki Ishibashi, Hiromi Owada, Takumu Egawa, Hidehiko Murata and Hidenori Nishihata^^Kozo Okamoto, Misako Kachi and Tamotsu Igarashi
Recent developments in satellite data assimilation at JMA since the last TOVS meeting in May 2008 are presented. JMA introduced various satellite data in the global operational 4D-Var assimilation system: clear sky radiances from five geostationary satellites, SSMIS of DMSP-F16 and -F17, NOAA19/AMSU-A and MHS, and Metop/ASCAT ocean surface wind and GRAS refractivity. The meso-scale 4D-Var assimilation system was significantly updated in April 2009 and started assimilating GPS total precipitable water. The website is opened for real-time monitoring of radiances and AMVs : http://qc.kishou.go.jp/^^Current status and future plans of earth observation of JMA and JAXA are presented.

JMA has been operating the Multi-functional Transport Satellite (MTSAT) -1R and is planning to replace it with MTSAT-2 in July this year. A next generation of the operational satellite (HIMAWARI-8 and -9) has been planned.

JAXA's earth observation programs of US-Japan joint missions; Tropical Rainfall Measuring Mission/Precipitation Radar (TRMM/PR), NASA Aqua/Advanced Microwave Scanning Radiometer for EOS (Aqua/AMSR-E), and JAXA's satellite; Advanced Land Observing Satellite (ALOS) and Greenhouse Gases Observing Satellite (GOSAT) have been operating well.

JAXA's future earth observation satellite programs have been planned and under development primarily for three focused areas of "climate changes including water cycle variation" and "global warming and carbon cycle changes", and "reduction and prevention of disasters";
- Global Change Observation Mission (GCOM) - W (water) 1: planned for launch in Japan Fiscal Year (JFY) 2011
- GCOM-C (climate) 1: planned for launch in JFY 2013 (TBD)
- Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR): US-Japan joint program planned for launch in JFY 2013
- Earth Clouds, Aerosols and Radiation Explorer/Cloud Profiling Radar (EarthCare/CPR): ESA-Japan joint program planned for launch in JFY 2013
- Advanced Land Observing Satellite 2 (ALOS-2): proposed for launch in JFY2012

7.01. Data impact experiments using IASI observations during the extratropical transitions of Huricanes Gustav, Hannah and Ike in the Atlantic^^IMPACT OF ADVANCED SOUNDER CLOUDY RADIANCES IN THE GLOBAL NUMERICAL WEATHER PREDICTION ARPEGE MODEL.

Presenter: N. FOURRIE^^N. FOURRIE
Authors: D. ANWENDER, N. FOURRIE, F. RABIER and P. ARBOGAST^^N. FOURRIE, V. GUIDARD, F. RABIER and T. PANGAUD.

The impact of IASI observations in the data assimilation has been tested on a 3 week period of September 2008 including 3 extra tropical transitions (ET) of tropical cyclones. Our study is dedicated to the impact that humidity sensitive infrared radiances have on the prediction of ET cases. Three experiments have been performed using the Meteo-France global model. In the first one, the observation density was enhanced by four; in the second one nine IASI channels sensitive to water vapour (WV) were added and in the third one, all IASI data were removed.

The experiments have first been evaluated through global scores. The global scores in the troposphere showed an overall large positive impact of the enhanced observation density and an overall large negative impact of denying all IASI observations. The impact for the southern hemisphere is larger and statistically significant for longer forecast times than that for the northern hemisphere. Mostly the largest positive impacts for the high density and the largest negative impacts for the denial of the IASI data is seen for the humidity parameter. The additional WV channels have a weaker but also positive impact which is seen mainly for humidity in the global scores. The positive impact of the WV channels is statistically significant for shorter forecast intervals.

Furthermore, the Atlantic and European domains have been studied with the computation of the absolute errors using the total energy variable as this variable combines constituents important during ET. The absolute errors reduce remarkably for several forecasts initialized on dates around the ET events due to the additional WV channels. It can be concluded that due to the ETs high uncertainty is introduced into the numerical forecast such that the small differences in the initial conditions created by the additional WV channels lead to large forecast deviations. The additional IASI WV channels result mainly in a reduction of errors for forecasts started around the ET times.

For four dates, the error variances in the background and in the analysis were diagnosed in observation space with the Desroziers et al, 2005 method. The errors in the background were better corrected at initialization time by the additional assimilation of the WV data than without them. This led to smaller errors in the analysis from which the forecasts were started. The decrease of analysis error was visible in particular in dynamical features associated with the ET events.

The error reductions in the forecasts started from these analyses could be traced back to the better representation of the ET events due to the assimilation of additional WV channels. Errors were not only reduced in the vicinity of the ET events but also in features that developed further downstream under the influence of the ETs. Connections between upper level flow and surface fields were drawn to illustrate the effect of the downstream propagation of error reduction.^^The Atmospheric Infrared Sounder (AIRS) onboard Aqua and the Infrared Atmospheric Sounding Interferometer (IASI) onboard METOP belong to a new generation of advanced satellite sounding instruments. They provide information with spectral resolution far exceeding that of previous sounders (HIRS). The aim of this presentation is to describe the developments performed at Meteo-France to assimilate the IASI and AIRS radiances for clear and cloudy observation conditions.

Indeed, cloud affected radiances used to be rejected from the ARPEGE model (90% of total observations). The under-exploitation of these sounding instruments and the fact that sensitive regions (where forecast error can rapidly grow) are often cloudy, motivated our research efforts to assimilate AIRS and IASI cloudy radiances. The assimilation of AIRS radiances affected by low clouds inside the 4D-Var assimilation scheme has been implemented in the operational configuration in February 2009. The approach is based on the use of cloud parameters, the cloud-top pressure and the net emissivity calculated offline by the cloud-characterization algorithm CO2-Slicing (Pangaud et al, 2009). These cloud parameters are then provided to the radiative transfer model RTTOV to simulate cloudy radiances from the background into the observation operator. Experiments assimilating AIRS cloud-affected radiances showed a significant positive impact on the forecast on extended periods. The

positive impact of the AIRS cloudy radiance assimilation has also been studied on an interesting synoptic case, a September 2006 meso-scale mediterranean cyclogenesis.

In research mode, a great part of our work deals with the improvement of the data assimilation of IASI, especially for cloudy systems. The CO2-slicing approach used to assimilate AIRS cloudy radiances is currently extended and adapted to IASI data. After the evaluation of the cloud parameters retrieved directly from the IASI observations, the impact of the additional cloudy IASI radiances in the data assimilation will be studied with global forecast scores and impact studies on Atlantic storms of January 2009.

7.04. Use of satellite radiance data in the global meteorological model of the German Weather Service (DWD)

Presenter: Detlef Pingel
Authors: Detlef Pingel
As many other weather centers, the German Weather Service (Deutscher Wetterdienst, DWD) uses observations of satellite sounding instruments for the purpose of numerical weather prediction. This is achieved by assimilation of the observational data into the meteorological model in the analysis step of the forecast cycle. For the DWD global model, this is accomplished by direct assimilation of
radiances within a three-dimensional variational physical space analysis scheme. At present, AMSU-A data over sea from NOAA-15, NOAA-18, NOAA-19 and METOP-2 are assimilated. Preparations for the assimilation of AMSU-B and IASI data into the global model are currently under way, and first results are to be expected soon.
The poster intends to overview the present state of the assimilation of satellite radiance observations in the global model of the DWD.

7.05. The new NWP system at KMA and its use of satellite radiance data

Presenter: YongSang Kim
Authors: Mr. YongSang Kim and Dr. Sang-Won Joo
In the middle of 2010, Korea Meteorological Administration (KMA) plans to replace all the existing operational NWP system with new NWP system based on the UK Met Office UM/VAR (Unified Model/ Variational Assimilation System). The new NWP system have been developed and tested since 2008 and is currently undergoing operational trials and configuration. The main changes are the 4DVAR data assimilation system as well as main Forecast Model. We had used the 3DVAR in old NWP system but in new NWP system, we introduced the 4DVAR data assimilation system. As we used the 4DVAR system, the amount of observational data is very increased and especially satellite data such as radiance from NOAA series satellite, (ATOVS), MetOp-2 (ATOVS, IASI), Aqua (AIRS); Atmospheric Motion Vector (AMV) data from Geostationary satellites; scatterometer sea surface wind from MetOp-2 (ASCAT), ERS-2 are newly ingested. Above all the ATOVS data from several polar orbit satellites has the great impact on forecasts in our cycle NWP system. Recently using the ATOVS data fastly, we started to ingest the AP-RARS and EARS through GTS. In this presentation, I would like to introduce the new KMA NWP system including the data assimilation system and the current status and plans about the usage of the satellite radiance data in our data assimilation system.

7.08.

Presenter:
Authors:

7.11. Impact evaluation of new radiance data, reduced thinning and higher analysis resolution in the GEM global deterministic prediction system

Presenter: Godelieve Deblonde
Authors: G. Deblonde, A. Beaulne, S. Macpherson, L. Garand, M. Buehner, S.Heilliette
An important upgrade of the GEM (Global Environmental Multi-scale) global deterministic prediction system is planned for implementation in June 2010. The impact on forecasts of individual components is highlighted as well as the global impact from all components together. New data sources include 150 IASI channels as well as 37 additional AIRS channels (on top of current 87), 7 channels from DMSP-16, and the 6.7 micron channel from Meteosat and JMA geostationary satellites. A unified bias correction system is introduced. The impact of these additions is shown to be clearly positive, notably in the Southern Hemisphere. As well the inner loop of the analysis resolution is increased from 240 x 120 to 400 x 200 grid points, and the thinning of radiances is reduced from 250 km to 150 km. It is shown that reduced thinning has a larger impact than increased resolution. When both are combined however, the impact is clearly significant, this in both hemispheres. Reduced thinning will be implemented while increasing the resolution will have to be delayed due to the extra computing cost. Overall, the new system is expected to improve predictability in terms of 5-day 500 hPa anomaly correlation by 6 to 12 hours depending on region. Accompanying posters describe experiments in detail.

7.15. Vertical Covariance Localization for Satellite Radiances in Ensemble Kalman Filters^^AMSU-A Bias Correction for COAMPS/NAVDAS

Presenter: William F. Campbell^^William F. Campbell
Authors: William F. Campbell, Craig H. Bishop, Daniel Hodyss^^William F. Campbell, Keith Sashegyi

A widely used observation space covariance localization method is shown to adversely affect satellite radiance assimilation in Ensemble Kalman Filters (EnKFs) when compared to model space covariance localization. The two principal problems are that distance and location are not well defined for integrated measurements, and that neighboring satellite channels typically have broad, overlapping weighting functions, which produce true, nonzero correlations that localization in radiance space can incorrectly eliminate. The limitations of the method are illustrated in a 1D conceptual model, consisting of three vertical levels and a two-channel satellite instrument. A more realistic 1D model is subsequently tested, using the thirty vertical levels from the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Advanced Microwave Sounding Unit A (AMSU-A) weighting functions for channels six through eleven, and the observation error variance and forecast error covariance from the NRL Atmospheric Variational Data Assimilation System (NAVDAS). Analyses from EnKFs using radiance space localization are compared with analyses from unlocalized EnKFs, EnKFs using model space localization, and the optimal analyses using the NAVDAS forecast error covariance as a proxy for the true forecast error covariance. As measured by mean analysis error variance reduction, radiance space localization is inferior to model space localization for every ensemble size and meaningful observation error variance tested. Furthermore, given as many satellite channels as vertical levels, radiance space localization cannot recover the true temperature state with perfect observations, whereas model space localization can.^^It is generally acknowledged that showing positive impact from direct radiance assimilation is more difficult for mesoscale models than for global models. Aside from the very real difficulties in defining positive impact quantitatively and verifiably, there are statistical issues as well. For our global NWP model NOGAPS (Navy Operational Global Atmospheric Prediction System), two weeks of global radiance data were needed to produce stable bias correction coefficients for the Advanced Microwave Sounding Unit A (AMSU-A) in our 3DVar system, NAVDAS (NRL Atmospheric Variational Data Assimilation System). These coefficients depend on the underlying global model, and so are not directly useful for our mesoscale model, COAMPS. Because COAMPS is a limited area model, it takes longer to collect adequate statistics for bias correction, which is problematic if e.g. it takes longer than a season. Increasing the data density is problematic as well, because correlated error is introduced in the horizontal. Ideally we must carefully combine information on radiance bias from the global model with information from the mesoscale model to produce the best bias correction for a given region. Preliminary experiments utilizing data and predictors from both NOGAPS and COAMPS will be shown.

7.16. Evaluation of IASI inter-channel observation error covariances

Presenter: V. Guidard
Authors: V. Guidard, A. Bouchard, A. Foray, W. Ohayon

7.21. Use of Variable Observation Errors in Radiance Assimilation^^Mesospheric Assimilation Studies with SSMIS Channels

Presenter: Brett Candy^^Brett Candy
Authors: Brett Candy, Sreerekha TR and Steve English^^Brett Candy, Sana Mahmood

Until now the observation errors (the diagonal values of the Rmatrix)
used within the Met Office variational assimilation scheme have been represented
as a set of fixed values for a given satellite.
In this study we present a generalised model to describe
the total error budget for a spaceborne radiometer. The terms consist of the
instrument noise, errors in modelling clear air radiative transfer,
errors arising from undetected cloud in the field of view and errors arising from uncertainties
in the surface emission. This latter term can be shown to be dependent on the surface to
space transmittance and consequently imparts a strong scene by scene variation
for near surface sounding channels.

Sample results of the error estimates will be shown for AMSU and HIRS temperature sounding channels
over land and sea. Initial forecast impacts from using the new observation error
model within 4D-Var will also be shown.^^The top of the Met Office forecast model has recently been extended to 80km and for this
new domain the SSMIS UAS channels will have a key role in the mesospheric
analysis. In this study we demonstrate that the mesospheric temperatures are improved when SSMIS
data is assimilated, even when the Zeeman effect is not explicitly modelled in the radiative
transfer calculations. Validation is provided from independent observations provided by the microwave
limb sounder and GPS radio occulations.

The development version of the radiative transfer model RTTOV10
now includes a parameterisation of the Zeeman effect following the method of Han et al.

It also includes a more optimal set of radiative transfer levels for modelling channels which peak at high altitude. The effect of these improvements on observation - background differences will also be presented, along with an initial look at the impact on assimilation.

7.25. Assimilation of IASI Radiances over Sea and Land into the Regional NWP Model COSMO-EU

Presenter: Marc Schwaerz
Authors: Marc Schwaerz, Reinhold Hess, and Christoph Schraff
This work will present the impact of the assimilation of IASI data into the regional NWP model COSMO-EU of Deutscher Wetterdienst (DWD). The assimilation scheme utilized at DWD is a combination of Nudging with a 1D-VAR step (utilizing the EUMETSAT NWP SAF 1D-VAR software package).The combination of these procedures is necessary due to the fact that it is not possible to directly assimilate radiances within the nudging scheme.

The implemented setup uses the bias correction scheme after Harris and Kelly (2001), the cloud detection scheme of McNally and Watts (2003), as well as the fast radiative transfer model RTTOV-9 (Version 9.3). For the usage of measurements over land a dynamic deselection of channels affected by the surface is shown. The work will present the impact differences between using cloud free measurements only and using all measurements where the number of channels is reduced by those channels affected by clouds. In addition, the impact of including measurements over land is shown. Finally, a comparison of using additional channels of the 6.25 um water vapor band is performed.

7.26. Assimilation of low level humidity and temperature observations from AMSU-A & -B over land

Presenter: F. Karbou
Authors: F. Karbou, F. Rabier, E. Gérard, J-P. Lafore, J-L. Redelsperger, O. Bock
Observations from satellite sensors such as the advanced microwave sounding unit-A (AMSU-A) and -B are very useful in Numerical Weather Prediction (NWP) since they provide valuable description of the temperature and of the humidity at different levels of the atmosphere. The use of these measurements in NWP has made substantial progress but more efforts need to be devoted to assimilate many more observations over a variety of surface conditions (ocean, land, snow, ...). Feasibility studies have been undertaken at Météo-France in order to assimilate low level humidity and temperature observations from AMSU-A and AMSU-B over land. In particular, AMSU-B observations from channels 2 and 5 are systematically rejected over land. Although, these observations are informative about humidity in the low troposphere.

A comprehensive set of 4 global 4D-Var assimilation and forecast experiments has been performed during the summer 2006. In addition to a control experiment, three two-month experiments have been run. The later make use of land surface emissivities dynamically retrieved at selected window channels and assimilate a selection of low level temperature and humidity observations from AMSU-A and AMSU-B over land.

The assimilation of surface sensitive observations impacts key parameters of water cycle. Comparisons made using outputs of the assimilation experiments with those of the control have revealed an important change of analyzed atmospheric fields and of precipitation forecasts over parts of the Tropics and especially over West Africa. Our experiments seem to emphasize the atmosphere moistening in India, South America and in West Africa together with an atmosphere drying over Arabia and North-East Africa. The humidity change not only concerns the surface but also many levels of the atmosphere up to 500 hPa. The effect for temperature is important with cooling at surface in zones with moistening at the surface.

The drying or moistening of the atmosphere are far from being negligible and have been successfully evaluated using independent TCWV measurements from the GPS AMMA network. Objective scores have also been computed and have been found positive in the Tropics for different atmospheric and surface fields.

7.29.

Presenter:
Authors:

7.30. Impact of Satellite Surface Wind Observations on the Tropical Cyclone Track Forecasts in the NRL NAVDAS/COAMPS and NRL NAVDAS-AR/NOGAPS Mesoscale and Global Data Assimilation and NWP Systems

Presenter: Li Bi
Authors: Li Bi , Nancy Baker, Keith Sashegyi
In this study, the tropical cyclone (TC) track forecasts of the Navel Research Laboratory Atmospheric Variational Data Assimilation System/Coupled Ocean/Atmosphere Mesoscale Prediction System (NAVDAS/COAMPS) and the Navy Operational Global Atmospheric Prediction System (NOGAPS) were evaluated for a number of data assimilation experiments conducted from 1 August to 30 August, 2009. To evaluate the impact of different horizontal resolutions for different types of satellite observations on the NAVDAS/COAMPS and NOGAPS TC track forecasts, several experiments were performed. The satellite

observations assimilated in these experiments consisted of surface winds from WindSat and the Advanced Scatterometer (ASCAT), QuikScatterometer (QuikSCAT), Special Sensor Microwave Imager (SSM/I) wind speeds, and European Remote Sensing Satellite-2 (ERS-2) scatterometer winds. The impact of the assimilation of WindSat, ASCAT, QuikSCAT, SSM/I wind speeds and scatterometer winds on the TC position track were slightly positive through forecast length 48hr. There were no significant improvement/degradations on the TC intensity track from the assimilation of the aforementioned satellite observation types.

7.33. THE INCLUSION OF HUMIDITY ESTIMATES FROM THE AIRS/AMSU SENSOR AND BRAZILIAN GROUND-BASED GNSS NETWORK INTO THE CPTEC/INPE GLOBAL DATA ASSIMILATION SYSTEM

Presenter: Luiz Fernando Sapucci
Authors: Luiz Fernando Sapucci

The AIRS/AMSU (Atmospheric Infrared Sounder/Advanced Microwave Sounding Unit) aboard the AQUA satellite has been used as the main source of humidity information in the PSAS (Physical-space Statistical Analysis System) - the operational data assimilation system at the Center for Weather Forecasting and Climate Studies of the Brazilian National Institute for Space Research (CPTEC/INPE). The impact of AIRS/AMSU values is significant over continental regions where surface measurements are scarce, such as the Amazonian region, where the assimilation of IWV values from the AIRS/AMSU sensor shows a tendency to reduce the known overestimation of precipitation in short-range forecasts. However, since the AQUA satellite passes over South America at 0600 and 1800 UTC, this creates a gap in temporal resolution at 0000 and 1200 UTC, where the present distribution of radiosondes over the South America is not dense enough to characterize the global distribution of the humidity appropriately. Thus, other data sources should be included. In recent years the density of the Brazilian Network for Continuous GNSS Monitoring (RBMC) has been increased significantly, with the number of ground-based GNSS receivers from this network doubling in the last two years. With continued investment by Brazilian agencies in support of ongoing research, the number of receivers available over Brazilian territory should double again over the next years, reaching a total of 150. These investments have also been applied to the acquisition of meteorological sensors and data transmission systems. One aim of these research projects is the continuous monitoring of integrated water vapor (IWV) in real time to improve numerical weather prediction in Brazil. The IWV values from some GNSS receivers are used in this work as an additional source of humidity in the data assimilation system at the CPTEC-INPE. The main aim of this work is to investigate the joint contribution of humidity values from GNSS receivers and AIRS/AMSU in the improvement of the quality of the analyses and forecasts obtained. In order to assess the impact of these data on the performance of CPTEC/INPE's assimilation system, several experiments are being carried out in which the humidity values from AIRS/AMSU sensor and GNSS receivers are assimilated separately and simultaneously. Other studies by the data assimilation group at CPTEC/INPE are in progress, such as the inclusion of radioccultation GNSS profiles and the operationalization of the Local Ensemble Transform Kalman Filter method in collaboration with the University of Maryland (USA). Additional studies will be necessary for the future integration of all these developments, which will contribute to CPTEC/INPE's ability to generate improved forecasts over South America.

7.38. An Assessment of SSMIS Imager Data^^Plans for the Assimilation of Cloudy Infrared Radiances^^Study on the Spectral and Radiometric Requirements for a European post-EPS Microwave Imaging Mission

Presenter: W. Bell^^W. Bell^^W. Bell
Authors: W. Bell, A. Geer, P. Bauer, S. Swadley^^W. Bell, A.P. McNally and P. Bauer^^C. Peubey, W. Bell, P. Bauer, S. Di Michele
and P. Schlüssel

Data is now available from SSMIS instruments on three DMSP platforms: F-16; F-17 and F-18, launched in October 2003, November 2006 and September 2009 respectively. F-16 and F-17 SSMIS data was found to exhibit two significant instrument biases, related to solar intrusions into the warm calibration load and reflector emission biases. Corrections are applied to correct for these effects in a Unified Pre-processor (UPP), maintained at the US Navy's Fleet Numerical Meteorology Operations Center (FNMOC). This data has been available since August 2009. The continued deterioration and imminent failure of the SSMI constellation make the assessment and exploitation of the SSMI-like imager channels (12-18) of SSMIS a high priority for ECMWF. UPP data for F16 and F17 data have been assessed through an analysis of first guess departure statistics in relation to those from other imagers currently monitored in the ECMWF system (SSMI, AMSR-E, TMI and Windsat). The data appears to be of comparable quality to the other imagers. The impact on analyses and forecast accuracy is assessed through a series of observing system experiments in which SSMIS is added to a full observing system. These experiments use the new all-sky scheme for the assimilation of imager data in clear, cloudy and precipitating regions. Background fits to other imagers are improved significantly indicating the inclusion of SSMIS data improves the analysis total column water vapour fields.^^A scheme for the assimilation of cloud affected infrared radiances is described. The scheme follows a similar approach to that adopted for the all-sky assimilation of microwave radiances recently implemented in the ECMWF Integrated Forecasting System (IFS). In this approach the observation operator can be considered to comprise two parts: the linearised physics (LP) which generates cloud profiles per grid point from the prognostic variables and a radiative transfer (RT) model which accounts for scattering effects due to clouds in the infrared. As a first step towards a coherent treatment of clear and cloudy infrared radiances the properties of the system are assessed through inspection of the adjoint calculations for both RT and LP components for

observations in typical conditions. Single observation experiments are planned to compare the performance of the system in overcast situations, where the model state is believed to be closer to the true state, with the existing treatment of cloud affected radiances. The behavior of the system is compared and contrasted with that of the microwave all-sky system.^^Planning for the follow on to the EUMETSAT Polar System (EPS) mission, currently referred to as the post-EPS mission, is currently underway. A review of user requirements has led to a shortlist of candidate instruments for the post-EPS mission. A microwave sounding (MWS) mission has been identified as a high priority and a microwave imaging (MWI) mission is still under consideration. Industrial Phase-A studies are underway. In support of these studies ECMWF are working with EUMETSAT and ESA to refine the specification of the MWI mission with respect to some key instrument parameters. Following previous studies related to channel selection and radiometric performance an ongoing study is concerned with refining: frequency drift tolerance; cross polarisation tolerance and channel selection/specification. The study also aims to develop a quantitative basis for the study of sampling strategies. The first phase of this study involved assessing the sensitivity of analysis and forecast accuracy to frequency drift. To achieve this a parameterisation of brightness temperature errors induced by frequency shift has been developed and tested in the ECMWF Integrated Forecasting System (IFS). The impact on analyses and forecasts for specified levels of frequency drift have been determined.

7.41. Beyond optimal estimation: sensitivity of analysis error to the specification of background error

Presenter: John Eyre
Authors: John Eyre and Fiona Hilton

Optimal estimation theory, on which most retrieval and data assimilation methods are based, assumes that the error covariances of the observations and of the a priori (background) information are known, and that they are used (at least approximately) in the retrieval/analysis procedure. In data assimilation for numerical weather prediction (NWP), background errors may be known reasonably well in the sense of global statistics. However, this can disguise substantial spatial and temporal variability. Moreover, it is possible for the overall error variance to be correct whilst the partitioning of errors between different spatial scales, e.g. between different vertical eigen-modes, is significantly incorrect. The specification of the magnitude and vertical structure of the background error covariance is crucial to the appropriate interpretation of radiance information from satellite sounders within a NWP data assimilation system. Uncertainties in the specification of error covariances are inevitable, but an improved understanding of the acceptable range of mis-specification is likely to lead to improved impact of these data in NWP. This problem is likely to be more important for advanced infra-red sounders, as we attempt to extract information on smaller vertical scales, whilst retaining the information that the NWP model often contains on sharp vertical structures.

We investigate the sensitivity of analysis error to the mis-specification of background error. We first present the general theory and then apply it to the scalar case. We identify a “danger zone”, i.e. a level of mis-specification of background error that will degrade the analysis, and quantify it as a function of the ratio of observation error to background error. We then extend this to the vertical eigen-modes of a forecast error covariance matrix and present preliminary results for the application of this approach to the assimilation of radiances from the Infra-red Atmospheric Sounding Interferometer (IASI).

7.49. Interaction of GPS Radio Occulatations with Hyperspectral Infrared and Microwave Sounder Assimilation

Presenter: Benjamin Ruston
Authors: Benjamin Ruston, Steve Swadley, Nancy Baker, Rolf Langland, Michael Rennie, and Hew Lewis

The Navy's 4D-Var assimilation system NAVAS-AR recently has added the capability to assimilate the bending angle from GPS radio occultation. This has not surprisingly interacted with the radiances currently being assimilated into the system which include AMSU-A, SSMIS, IASI and AIRS sensors. The heritage of the NOGAPS model in the 3D-Var NAVDAS system was 30 vertical levels with the top level at 4 hPa, while the new NAVDAS-AR and NOGAPS model now uses 42 levels with a model top of 0.4 hPa. The channel selection for the hyperspectral infrared or microwave sounders was not greatly modified when the switch to the higher model top was made. Large biases of the uncorrected innovations are seen for instance in IASI channels 146-187 (681-691 cm-1), SSMIS channels 22-24 and AMSU-A channels 11-13. The use of GPS-RO from COSMIC, GRAS and GRACE-A have been used to recalibrate the bias correction coefficients for the AMSU-A, SSMIS, IASI and AIRS sensors and these new coefficients are then fixed and applied to a Dec 2008-Feb 2009 stratospheric warming case to examine the ability of the sensors to better handle the warming event, and its impact on the atmospheric column downwards into the troposphere.

8.00. EUMETSAT Plans

Presenter: K. Dieter Klaes
Authors: K. Dieter Klaes

This paper provides an update on the status of EUMETSAT programmes, both the current operational as well as the future programmes. EUMETSAT is currently operating the Meteosat-6/7 and the two satellites of the second generation Meteosat Second Generation as Meteosat-8 and Meteosat-9 respectively. The MSG-3/4 satellites are under storage or production respectively. MSG has been developed in co-operation between EUMETSAT and ESA. EUMETSAT also developed jointly with ESA the EUMETSAT Polar System (EPS). Metop-A, the first of a series of three satellites was launched in October 2006

and provides high quality services for three years already, the system is planned to provide operational products to the Users at least until 2012, where the launch of the second satellite Metop-B is planned. Metop-C will follow in 2016. The EUMETSAT Advanced Retransmission Service (EARS) continued its operational services and provides observations from partner HRPT (High Resolution Picture Transmission) stations. Jason-2 is EUMETSAT's first optional programme, provides operational Ocean Surface Topography information services after the successful in summer 2008. The follow on Jason-3 Programme is being prepared. EUMETSAT also works together with ESA on the preparation to operate the marine part of the GMES Sentinel-3. For the mandatory programmes preparations for Meteosat Third Generation (MTG) and Post EPS are under way and ongoing and have passed the following main milestones since the last ITSC: MTG is in Phase B, the Post EPS has passed the Mission Definition Review at the end of Phase 0.

Oral or poster presentation, slight preference to Poster (will bring one anyway). Possibly a short oral summary will be needed in the International session.

9.02. On the apodisation of MTG-IRS^^Towards a consolidated L2 processor for MTG-IRS

Presenter: Stephen Tjemkes^^Stephen Tjemkes
Authors: Stephen Tjemkes, Xavier Calbet, Paolo Antonelli, and Rolf Stuhlmann^^Stephen Tjemkes, Xavier Calbet, Alessio Lattanzio, and Rolf Stuhlmann
Title: On the apodisation of MTG-IRS

Presenter: Stephen Tjemkes1
Co-authors: Xavier Calbet1, Paolo Antonelli2, and Rolf Stuhlmann1
1): EUMETSAT, Eumetsat Allee 1, Darmstadt, Germany
2): SSEC, Wisconsin, USA

As part of the Meteosat Third Generation preparatory programme, EUMETSAT prepares for the next generation of geostationary satellites. Among the three MTG missions foreseen, is a hyper-spectral infrared sounder. This Infrared Radiometric Sounder (MTG-IRS) observes the upwelling terrestrial radiation in two broad spectral bands with moderate high spectral resolution. A central part of the MTG-IRS are two large detector arrays.

To consolidate the Level 2 Processor, a MTG-IRS science team has been formed. One of the open issues, addressed by this science team, is to understand whether there is a need to apodise the MTG-IRS observations prior to the transformation into geophysical parameters. This in principle is a fundamental trade between the potential positive and negative effects of apodisation. For instance the trade involves the possible harmonisation of the observations made by the individual detector elements, which simplifies the processing. At the other hand there is a potential information loss due to the effective reduction in spectral resolution. Also an important aspect in this trade is the capabilities of fast radiative transfer models to simulate the apodised or unapodised radiances and the associated Jacobians.
During the presention this trade related to the apodision of the MTG-IRS observations will be discussed. The potential consequences of apodisation, for the transformation of the observations in geophysical parameters, will be illustrated using a state-of-the-art retrieval method applied to a limited number of IASI observations.^^Title: Towards a consolidated L2 processor for MTG-IRS

Presenter: Stephen Tjemkes1
Co-authors: Xavier Calbet1, Alessio Lattanzio2, and Rolf Stuhlmann1
1): EUMETSAT, Eumetsat Allee 1, Darmstadt, Germany
2): MakaluMedia, Darmstadt, Germany

As part of the Meteosat Third Generation preparatory programme, EUMETSAT prepares for the next generation of geostationary satellites. Among the three MTG missions foreseen is a hyper-spectral infrared sounder. This Infrared Radiometric Sounder (MTG-IRS) observes the upwelling terrestrial radiation in two broad spectral bands with moderate high spectral resolution.

An important mission objective is the monitoring of the vertical distributions of moisture and temperature. These geophysical properties are derived from the MTG-IRS observations by the MTG-IRS Level 2 Processor. The consolidation of the physical baseline for this Level 2 Processor, the implementation of the physical baseline in a concept processor, and the application of this concept processor to a relevant proxy data is a main activity of the MTG-IRS Science Team.

The poster presentation will address open issues related to the consolidation of the MTG-IRS L2 Processor, as well as the status of the concept processor and initial results.

9.07. Sounding observation missions for the future EUMETSAT Polar System

Presenter: Peter Schluessel
Authors: Peter Schluessel

Preparations for the future EUMETSAT Polar System (Post-EPS), which is needed from 2020 onwards, have progressed from initial gathering of user requirements towards formulation of mission requirements. The latter have been derived for a number of observation missions, to support operational meteorology, climate monitoring, atmospheric chemistry, oceanography, and other environmental services. Account has been taken to include the expected future evolution of various application areas. Most important observation missions, relevant for atmospheric sounding include, the high-resolution infrared sounding, microwave sounding, radio occultation sounding, and nadir-viewing ultra-violet visible near-infrared shortwave-infrared sounding. A range of prioritised radiometric, spectral, and geometric requirements have been specified, given by threshold, breakthrough, and objective values that allow for instrument concepts of different levels of complexity. The mission requirements build the basis for instrument and system concept studies, being carried out by industry. Initial concepts have been elaborated, validating the mission requirements. More detailed feasibility analyses are ongoing to demonstrate possible breakthrough areas and shaping the envisaged overall payload complement for Post-EPS.

9.09. Development and Predicted Performance of the Advanced Technology Microwave Sounder for the NPOESS Preperatory Project

Presenter: Vincent Leslie
Authors: William J. Blackwell and R. Vincent Leslie

A suite of sensors scheduled to fly onboard the NPOESS Preparatory Project (NPP) satellite in 2011 will both continue and improve the environmental data records provided by operational and research missions over the last 40 years. The Cross-track Infrared and Microwave Sounding Suite (CrIMSS), consisting of the Cross-track Infrared Sounder (CrIS) and the first space-based, Nyquist-sampled cross-track microwave sounder, the Advanced Technology Microwave Sounder (ATMS), will provide atmospheric vertical profile information needed to improve numerical weather and climate modeling. The ability of ATMS to sense temperature and moisture profile information in the presence of non-precipitating clouds complements the high vertical resolution of CrIS. Furthermore, the ability of ATMS to sense scattering of cold cosmic background radiance from the tops of precipitating clouds allows the retrieval of precipitation intensities with useful accuracies over most surface conditions.

This paper will present several assessments of the performance of ATMS and the geophysical quantities that are to be derived using ATMS measurements. Pre-launch testing of ATMS has characterized the principal calibration parameters and has enabled predictions of on-orbit performance with high levels of confidence. Planned on-orbit characterization of ATMS will further improve both the measurement quality and the understanding of various error contributions. This paper is organized as follows. First, an overview will be given of the prelaunch radiometric calibration of ATMS. Key calibration parameters will be discussed, as well as the error bars and dominant sources of uncertainty. Second, plans for on-orbit characterization of ATMS to further improve performance and reduce uncertainty will be presented. Finally, preliminary assessments of ATMS data product performance will be discussed, including vertical profile and precipitation products.

The paper will compare the ATMS sensor with its heritage sensor the Advanced Microwave Sounder Unit (AMSU-A1 and A2) and Microwave Humidity Sounder (MHS). ATMS integrates three separate NOAA instruments into a single sensor, which reduced mass and power by 50% and volume by 75%. In addition, ATMS has different antenna and sampling specifications.

An integral part of the CrIMSS (CrIS + ATMS) pre-launch cal/val activities is the testing of operational software that will be used to process raw data counts into scientific data products. To ensure a smooth transition after launch to the operational production of temperature, sensor, and environmental data records, pre-launch test data are passed through the software processing system to identify bugs and any unforeseen issues in the processing flow. It is important for the test data to be as authentic as possible; therefore, "proxy" data are used. The term "proxy" refers to observed data from an on-orbit sensor that are transformed spatially and spectrally to resemble, with some error, a future sensor. Atmospheric models may be inaccurate and incomplete, and therefore data simulated using only these models will be flawed. Alternatively, proxy data derived from actual radiometric observations of the atmosphere should preserve all of the meaningful meteorological features.

The prelaunch radiometric calibration of ATMS consists of Compact Antenna Test Range (CATR); thermal vacuum chamber (TVac); vibration testing; and electromagnetic and radio frequency interference testing. The antenna patterns are measured in the CATR for both the principal and co-polarization. Some patterns had four cuts, but most had two cuts. Two temperature-controlled external calibration target sets are used in the TVac to evaluate the calibration accuracy, radiometric sensitivity (NEDT), and non-linearity. This paper will present the objectives and results from the prelaunch testing.

Postlaunch calibration and validation consists of four phases: activation, functional evaluation and optimization, Intensive Cal/Val (ICV), and long-term monitoring. The ICV will end approximately 180 days after launch. This paper will describe the various calibration and validation tasks in the four phases and the team responsible. Some of the tasks include calibration target stare data collection to calculate each channel's power spectral density; optimal space view selection; geolocation accuracy evaluation; RFI evaluation and mitigation; simultaneous nadir overpasses of other microwave sensors; on-orbit spacecraft maneuvers; simulation comparisons with radiosondes and numerical weather prediction models; and aircraft underflights.

This paper will outline recent efforts using the NPOESS Aircraft Sounder Testbed-Microwave (NAST-M) airborne sensor to directly validate the microwave radiometers (AMSU and MHS) on several operational satellites. Comparison results for

underflights of the Aqua, NOAA-16, NOAA-17, and MetOp-A satellites will be shown. Specifically, radiance-to-radiance data comparisons from two campaigns will be presented: 1) the Pacific THORpex (THe Observing-system Research and predictability experiment) Observing System Test (PTOST 2003, Honolulu, HI) and 2) the Joint Airborne IASI Validation Experiment (JAIVEx 2007, Houston, TX). The paper will detail the essential techniques used to correct for the difference in altitude and view angle between the satellite and aircraft sensors. The campaigns provided critical ground truth data such as dropsondes. Our procedure for co-locating NAST-M measurements with satellite measurements will be illustrated, as well as the effect of clouds on the evaluation of window channels. The radiance-to-radiance comparisons will be evaluated against a purely simulated validation technique.

We review an approach for on-orbit FOV calibration of the ATMS satellite instrument using vicarious calibration sources with high spatial frequency content (the Earth's limb, for example). The antenna beam is slowly swept across the target of interest and a constrained deconvolution approach is used to recover antenna pattern anomalies. Additionally, we present an overview of FOV calibration exercises being considered for ATMS, which will not only help to characterize the radiometric boresight of each ATMS channel, but could also potentially identify antenna sidelobe problems affecting similar passive microwave sensors that are presently operational. Various proposed spacecraft maneuvers will be considered, with the intent to illustrate how each maneuver will help to identify and characterize possible FOV artifacts. Radiative transfer simulations that quantitatively assess the benefit of each satellite maneuver will also be presented.

This work was sponsored by the National Oceanic and Atmospheric Administration under Air Force contract FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and not necessarily endorsed by the United States Government.

10. McIDAS-V: A data analysis and visualization tool for environmental satellite data

Presenter: Thomas Achtor
Authors: Thomas Achtor, Thomas Rink, Thomas Whittaker, Jessica Staude

The University of Wisconsin's Space Science and Engineering Center (SSEC) has been at the forefront in developing data analysis and visualization tools for environmental satellites and other geophysical data. The fifth generation of the Man-computer Interactive Data Access System (McIDAS-V) is a java-based, open-source, freely available system for multispectral and hyperspectral researchers and algorithm developers. The software tools provide powerful new data manipulation and visualization tools to work with geostationary and polar orbiting satellite data and in the research and operational environments. McIDAS-V provides powerful and unique capabilities to support innovative techniques for developing and evaluating algorithms, visualizing data and products in 4 dimensions, and validating results. This presentation will display and demonstrate some of the capabilities of McIDAS-V to analyze and display high temporal and spectral resolution data using examples from international environmental satellites.

Presenter:
Authors: