ITSC-13 ORAL PRESENTATIONS ABSTRACTS

SESSION 1

The assimilation of AMSU-B radiance data in the Canadian Meteorological Centre global data assimilation system: their difficulties relative to the assimilation of AMSU-A radiances.

Presenter: Clement Chouinard

C. Chouinard and J. Hallé
Meteorological Service of Canada

The assimilation of AMSU-A data is now used routinely at most national NWP Centres, and their impact, as demonstrated at most Centres, is now recognized as the most important source of data in the SH and in some systems, it represents the most important source of data in the NH.

AMSU-A radiances are ideal data for any assimilation system, and particularly for a variational system such as the Canadian Meteorological Centre (CMC) 3D-var. The radiative transfer model required to simulate AMSU-A radiance from an atmospheric state vector is a linear operator which depends mainly on the atmospheric temperature. Consequently, the impact of a radiance datum will impact mostly the temperature profile and not the moisture. On the other hand, the radiative transfer for AMSU-B is a complex nonlinear operator which depends strongly on moisture and temperature, consequently a radiance datum will apply a correction in both these fields. Background error statistics of temperature and moisture then become important critical parameters controlling the flow of radiance information to the atmospheric temperature and moisture profiles.

A series of tests prepared with AMSU-B radiances will highlight the difficulties with the data and how these were resolved in order to positively impact on all analysis variables. It will be shown that the quality control (QC) and the data selection are critical, and how small differences in a problematic atmospheric profile can lead to major differences in the simulated radiance using RTTOV-7. These large differences between simulated and observed then produce large corrections to the initial guess temperature and humidity of the 3D-var. When all difficulties were resolved, the impact of AMSU-B data on the analyses and forecasts were very significant as will be demonstrated from 2-month summer and winter assimilation cycles. The impact on moisture are very large improving precipitation forecasts up to and beyond 4 days. The use of AMSU-B radiance data was implemented in the 3D-var at CMC on June 19, 2003.

Current status and future plans for assimilation of passive microwave measurements at the Met Office

Presenter: Stephen English

Stephen English, Andrew Smith, Fiona Hilton, William Bell, Brett Candy and Nigel Atkinson
Met Office, United Kingdom.

The use of passive microwave instruments such as AMSU and SSM/I is now well established at the Met Office, both for global and regional NWP. In this paper current operational use of ATOVS and SSM/I data will be summarised. Results from recent pre-operational trials will be presented, including results using data from three satellites, use of RTTOV-7 and a new bias correction scheme. Work has been continuing on use of ATOVS over land. It is being found that providing detailed first-guess information for emissivity is having little impact, and effort is focusing on robust methods for analysing emissivity in 1D-var. Work has also begun on comparing model NWP background fields of ice and liquid water with passive microwave measurements. For an in-depth analysis of the use of AMSU in mesoscale assimilation see the paper by Candy et al.

The major scientific challenges facing us for processing future passive microwave systems such as CMIS will be examined, and work underway to test and develop the necessary science will be presented.

Use of satellite radiances in the operational ECMWF system

Presenter: Graeme Kelly

Graeme Kelly
ECMWF, United Kingdom

Currently 70 million satellite radiances are presented to the operational 4D-VAR analysis at ECMWF and about 3.5 million radiances are used in the 4D-VAR minimisation. The paper will summarise the calculations of surface emissivity and the screening for cloud and rain for each sensor. Also the assimilation and forecast impact from the sensors HIRS, AMSUA, AMSUB, and SSMI will also be discussed.

Use of ATOVS raw radiances in the operational assimilation system at Météo-France

Presenter: Elisabeth Gérard

Elisabeth Gérard, Florence Rabier, Nadia Fourrié, Delphine Lacroix
Météo-France/CNRM/GMAP, Toulouse, France

The use of raw radiances became operational at Météo-France on 22nd of October 2002 and the use of NOAA-17 data in addition to NOAA-15 and NOAA-16 data on 17th of December 2002. Only AMSUA data have been used in the operational model as a first step.

The purpose of this presentation is to document the developments associated with the operational modifications to follow: improvement of the precipitation mask for a better usage of AMSUA data, use of HIRS data and use of locally received Lannion and EARS AMSUA data in addition to the currently used NESDIS/Bracknell data in short cutoff time analyses where largest impact is expected. Results of Observing System Experiments will also show the benefit of AMSUA data in our operational model.

Development of 3D Variational Assimilation System for ATOVS Data in China

Presenter: Xue Jishan

Xue Jishan, Zhang Hua, Zhu Guofu, Zhuang Shiyu
Chinese Academy of Meteorological Sciences

Zhang Wenjian, Liu Zhiquan, Wu Xuebao, Zhang Fenyin
National Satellite Meteorological Center, China

In order to alleviate the problem of sparseness of conventional observational data in some key areas for numerical weather prediction, a new 3D variational data assimilation system (GRAPES-3Dvar) with stress on effective usage of satellite data has been developed. This is a grid point analysis system. Recursive filter or spectral transformation is used for preconditioning of control variables during minimization of cost function depending on the domain of analysis (either limited area or global). The forward observational operator and its tangent linear and ajoint for satellite irradiances are adopted from the software package RTTOV developed by ECMWF. A bias correction scheme for input irradiances data is also developed. At present only AMSU-A and AMSU-B data over the oceans are used to avoid the influences of inaccurate computation of surface emissivity and erroneous first guess in higher levels. In addition to satellite irradiances and conventional rawinsonde observations, satellite derived winds from geostationary satellite and surface winds from QUIKSCAT are also ingested by the assimilation system. The results of preliminary experiments are very encouraging. In the experiments with typhoon cases, the use of ATOVS microwave irradiances from NOAA-16 obviously improves the numerical prediction of both track and intensity of the typhoon. Further investigation shows that without satellite information, the large scale flow pattern are usually poorly defined due to the lack of observations and some bogus model must be adopted for defining the inner structure of the typhoon. The assimilation of satellite irradiances results in better analyses of both the inner structure of the typhoon and the large scale environment. The latter is crucial for the prediction of the track and the former is an important factor determining if the typhoon will develop or decay. The wind information is also an important complementary data source, especially for reducing the positioning error of the typhoon in the analyses. The assimilation of irradiances at microwave channels over land and at infrared channels will be tested in the near future with new scheme of surface emissivity to be introduced. The assimilation system will also be tested in the operational environment.

Operational use of the ATOVS radicances in global data assimilation at the JMA

Presenter: Masahiro Kazumori

Masahiro Kazumori, Kozo Okamoto, Hiromi Owada

In the presentation, current status of the direct assimilation of ATOVS radiances at the Japan Meteorological Agency (JMA) and the results of some experiments are shown.

Since 1982, JMA had operationally used the temperature profile retrieved by NOAA/NESDIS. As the accuracy of humidity product is not sufficient, only temperature and thickness had been used. There was few observed information of atmospheric humidity in JMA global analysis: JMA uses only radio-sonde-observed humidity profiles and statistically derived profiles from Geostationary Meteorological Satellite (GMS-5) brightness temperature. Since 3D-Var data assimilation system was introduced in the operational global analysis system, ATOVS radiance assimilation has been being developed. As cycle experiments showed many good results, it became operational in 28 May 2003. In the experiments, level 1D ATOVS radiances data are assimilated directly in place of retrievals, and the statistical humidity retrievals from GMS-5 were

discontinued. Moreover new cumulus parameterization scheme of global model was jointly used.

The direct assimilation of ATOVS data expanded moisture observation coverage and improved the analyzed quality of temperature field and humidity, which will lead to higher performance of the prediction globally. The experiments have demonstrated positive impacts on forecast skills for the geopotential height at 500 hPa in the southern hemisphere and in the tropical region. The forecast scores of the temperature at 850 hPa, wind speed at 250 hPa and sea level surface pressure were similarly good. The improvement of short-term forecast was remarkable. The temperature profiles in the upper stratosphere and the global humidity field in the troposphere were also improved. The initial fields of temperature and humidity showed higher accuracy verified against radio-sonde observation and the total precipitable water from SSM/I. And better results on the typhoon track prediction and the global monthly mean 24-hour rainfall were also found out.

Though JMA has achieved considerable progress in ATOVS data assimilation, some un-preferable features are seen: anomalous change of temperature at some levels in the stratosphere and the excessive concentration of rainfall in 6-hour forecast. To solve these problems, we continue to carry out some experiments and improve the global model and bias correction scheme of ATOVS brightness temperature. Moreover, we are going to assimilate ATOVS Level 1B and SSM/I data operationally in 2003 and a preparation on AIRS data assimilation is proceeding.

Locally Received and Processed ATOVS Radiances in the Australian Region LAPS Data Assimilation and Prediction System

Presenter: Christopher Tingwell

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

The use of 1DVAR retrievals of ATOVS radiances in the Australian Bureau of Meteorology Local Assimilation and Prediction System (LAPS) has produced a modest improvement in forecast skill over that obtained with NESDIS retrievals and represents an important step towards the unification of the data assimilation schemes employed by the Bureau's local NWP system (LAPS) and global system (GASP). The 1DVAR retrieval scheme was implemented in the 29-level operational LAPS system in September 2002, with 1DVAR retrievals used over the sea and below 100 hPa. NESDIS retrievals are used to extend the first guess profiles above the top of the model (50 hPa).

An extended 50-level version of LAPS, with the model top raised to 0.1 hPa and nested within a similarly extended GASP, is being used to test the 1DVAR assimilation of locally received ATOVS radiances, processed via the AAPP package. The timeliness of local reception and processing should improve the amount of ATOVS data available to the LAPS system which, operationally, employs an early data cut-off. The vertical extension of both models eliminates the need for NESDIS retrievals and promises a fully
unified local/global data assimilation system able to handle radiance data, whether received and processed locally or sent from overseas centres via the GTS, equivalently. The results of experiments conducted to date will be presented.

Enhanced use of radiance data in NCEP data assimilation systems

Presenter: John Derber

John C. Derber, Paul VanDelst, XiuJuan Su, Xu Li, and Russ Treadon
NOAA/NWS/NCEP/EMC, Camp Springs, MD, USA

Since ITSC-12, there have been significant changes in the use of radiance data at NCEP. These changes include the improvement and standardization of the radiative transfer system, new surface emissivity formulations, enhanced data selection algorithms, improvements in the quality control, reformulated bias correction techniques, refined data assimilation techniques, improved forecast models and the inclusion of new data sources. These changes will be briefly described with an emphasis on investigations directed towards testing of three new data sources. These data sources (EOS AIRS and AMSU-A, GOES imager, and AVHRR imager) each present different challenges and have different strengths. The EOS data have required the development of the capability of using large numbers of channels into the data assimilation systems. The inclusion of this capability has driven several changes to the radiative transfer calculations and quality control procedures. The inclusion of the GOES imager data was primarily directed towards the improvement of the definition of the upper level moisture fields. The use of these data has presented unique quality control problems. To begin development of enhanced surface temperature analyses, we have also begun evaluating the use of AVHRR imager data. These data have shown significant potential for improving the specification of the sea surface temperature

within our analysis system. Data impact experiments for these three data sets will be presented.

Recent Improvements in Temperature and Moisture Profiles using NOAA Satellites AMSU data and their impact on NWP model over Indian region

Presenter: Devendra Singh

Devendra Singh, Y. V. Rama Rao, and R. C. Bhatia
India Meteorological Department
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India Meteorological Department, New Delhi receives and process NOAA TOVS and ATOVS data in real time. The physical and neural network approaches have been used to retrieve atmospheric temperature and moisture profiles from NOAA-16 satellite AMSU data over Indian region. The earlier training data set based on global data only for two seasons used in neural network technique has been replaced by new training data set based on regional data over land and ocean for all the seasons. The new training data set has improved the temperature and moisture profiles accuracy retrieved using neural network approach compared to physical method. The detail validation and inter comparisons of temperature and moisture profiles have also been carried out with ECMWF analysis over sea and land separately for different seasons for the year 2002-2003. The performance of neural network technique is found to be superior compared to physical method.

Recently, temperature and moisture profiles retrieved from NOAA-16 ATOVS data over Indian region have been used in regional NWP model for the impact study. The operational NWP system of India Meteorological Department is based on a Limited Area Analysis and Forecasting System (LAFS), which consists of real time processing of data received on Global Telecommunications System (GTS), objective analysis by 3-D multivariate optimum interpolation (OI) scheme and a multi-layer primitive equation model. Several experiments were performed using temperature and moisture profiles retrieved from NOAA-16 ATOVS data. The preliminary studies reveal that these additional data have a positive impact on geopotential height and rainfall prediction of the limited area model. A case study pertaining to monsoon over India has also been worked upon using the same data. The results will be presented in detail during the workshop.

Dynamic inference of background error correlation between surface skin and air temperature

Presenter: Louis Garand

Louis Garand, Mark Buehner and Nicolas Wagneur
Meteorological Service of Canada

One neglected component of background vertical error correlations necessary for data assimilation is that between surface skin and air temperature. This component is of interest, in particular, for the assimilation of radiances which are sensitive to the surface, as it impacts on the retrieved boundary layer structure. One difficulty is that this correlation, most often strong, can also be weak or even negative depending on the meteorological situation. Here, we explore the avenue of mapping globally this correlation using an ensemble of forecasts valid at the same time from differences of each member with the ensemble mean. This method appears very promising as it uses flow dependent background error syatistics. An impact study involving the assimilation of infrared window channels of the GOES imager will be presented.

SESSION 2

First results of the assimilation of AIRS data in METEO-FRANCE NWP model

Thomas Auligne

Thomas Auligne, Florence Rabier, Meteo-France, CNRM/GMAP
Lydie Lavanant, Meteo-France, CMS
and Mohamed Dahoui, DNM Morocco

A subset of channels from AIRS (Atmospheric InfraRed Sounder) aboard AQUA satellite is provided operationally by NOAA/NESDIS to NWP centres. Studies have been carried out to assimilate this data in the METEO-FRANCE NWP suite. They require good monitoring and bias correction of the observations. The impact of the early assimilation of AIRS on numerical weather forecast is presented.

Infra-red radiances are contaminated by clouds in most cases. Therefore, there is a need for a cloud detection scheme. We focus on the McNally and Watts method that has been validated in a comparison study by Lavanant and Dahoui. In order to take more advantage of the available data, the assimilation of cloudy radiances is studied, using a radiative transfer model in cloudy conditions (RTTOV-Cld). Results from monitoring and 1D-Var assimilation experiments are shown.

The assimilation of AIRS radiance data at ECMWF

Presenter: Tony McNally

Tony McNally, Phil Watts, Jonathan Smith, Richard Engelen,
Graeme Kelly, and Jean-Noel Thepaut

A limited amout of radiance data from the AIRS instrument on AQUA are assimilated into the ECMWF operational analysis/forecasting system. The key elements of the assimilation system will be described (e.g. cloud detection and handling of systematic errors) and the results of impact experiments performed prior to operational implementation will be presented. Finally the areas currently under development will be discussed together with some plans for the future.

Assimilation of AIRS radiances into the Met Office's Global NWP Model.

Presenter: Andrew Collard

Andrew Collard (Met Office), Roger Saunders (Met Office), James Cameron (Met Office), Yoshiaki Takeuchi (JMA), Brett Harris (BoM), John Eyre (Met Office) and Lisa Horrocks (Met Office).

The Atmospheric Infrared Sounder (AIRS), launched on NASA's polar-orbiting Aqua satellite in May 2002, is the first in the next generation of high spectral resolution infrared sounders. These advanced sounders are designed to measure atmospheric temperature and humidity with much better vertical resolution than has previously been possible from satellite instruments. With 2378 channels in the 3.7-15.4 micron range, perhaps the greatest challenge presented by AIRS is the efficient assimilation of measured radiances into NWP models for maximum benefits in improved temperature and humidity profiles.

A subset of 324 AIRS channels has been received in near-real time at the Met Office since October 2002. We use a 1D-Var pre-processing step to perform quality control, variational cloud detection, channel selection, bias correction and monitoring. Our routine data monitoring provides comparisons of AIRS radiances with Met Office 6-hour forecast fields: results and selected spectra are updated daily on the WWW. 3D-Var is then used to assimilate clear fields-of-view into the Met Office NWP model. We will provide an overview of the processing system in place at the Met Office. Areas for future improvement and first results from assimilation trials will be discussed.

A Model Based Bias Correction Scheme for AIRS at the Met Office

Presenter: Brett Harris

Brett Harris[1], Andrew Collard[2], Roger Saunders[2] and James Cameron[2].
[1]Bureau of Meteorology Research Centre, Melbourne, Australia
[2]The Met Office, Bracknell, United Kingdom

The Atmospheric Infrared Sounder (AIRS) is a high resolution spectrometer with 2378 channels in the range of 640 – 2700 cm^{-1} of the infrared spectrum. The instrument is onboard NASA's AQUA earth observing satellite launched on 4 May 2002. The Met Office receives brightness temperatures for a subset of 324 channels, in near real-time, from NESDIS. The radiances are then passed through a cloud detection algorithm, to determine the clear soundings. The RTTOV-7 forward model is used to simulate background radiances from the Met Office NWP system. As for ATOVS, the observed minus background radiances have systematic biases, which must be removed before the radiances may be assimilated in a variational data assimilation system. In this study, a model based bias correction scheme, based on the Harris and Kelly (2001) approach, is used with various combination of background predictors, to find the optimal combination which removes the biases, both globally and locally for a small subset of channels. The results of various predictor combinations for different channels will be presented.

Use of MODIS imager data to help dealing with AIRS cloudy radiances

Presenter: Lydie Lavanant

Mohamed Dahoui*, Lydie Lavanant**, Florence Rabier***, Thomas Auligne***
* Moroccan Meterological Service
** Météo-France/DP/CMS/R&D
*** Météo-France/CNRM/GMAP

The atmospheric Infrared Sounder (AIRS) was launched in May 2002 on board the AQUA platform. This new high spectral resolution instrument provides 2378 channels covering the spectral range between 3,7 mm to 15 mm. Even with a much lower spectral resolution, the impact of ATOVS data on numerical weather prediction forecasts is positive and consistent. Consequently it is anticipated that

additional positive impact will occur with the successful exploitation of AIRS data.

For the time being, in most operational analysis systems, the assimilation of the satellite radiances is limited to the cloud-free pixels. This is mainly due to the deficiencies in the representation of clouds processes within atmospheric models. As a consequence clouds are considered as a source of noise and any unfiltered cloud affected pixels could have a large detrimental impact on the quality of NWP products. It is then crucial to be confident in the quality of the cloud detection schemes used in the assimilation systems. Several approaches are used to detect and characterize clouds from AIRS radiances. Most algorithms are based on threshold techniques and radiative transfer calculations. The main goal of this study is to the different cloud-detection/characterization schemes, applied to AIRS data, by using the MF/CMS cloud detection scheme based on collocated MODIS imager data. Four AIRS cloud-detection schemes have been tested: the NOAA/NESDIS, ECMWF schemes for the cloud detection and the CO2-slicing and Minimum Local Emissivity Variance (MLEV) methods that make cloud detection and characterization.

Previous AIRS cloud information is then used to allow the retrieval of the atmospheric profile in cloudy conditions from AIRS/AMSU channels. In this study, only low-level cloud situations are considered. The cloud top pressure and effective cloud amount are used as background or first guess of the 1DVar method.

Status on the development and validation on a 10 days dataset in North Atlantic of mapped MODIS/AIRS observations collocated with ECMWF NWP forecast profiles are presented.

Potential of high density observations on Numerical Weather Prediction: A study with simulated observations

Presenter: Zhiquan Liu

Zhiquan LIU, National Satellite Meteorological Center, Beijing, China
and Florence RABIER, Centre National de Recherches Météorologies, Toulouse, France

The skill of numerical weather prediction depends to a large extent upon the quantity of globally available observations. Especially for high density observations, only a fraction of observations is used in current assimilation systems. In this presentation, the potential of high density observations is studied in a practical 4DVAR assimilation context. Two individual meteorological situations are used to examine the impact of different observation densities on the analysis and the forecast. A series of observing-system simulation experiments (OSSEs) are performed. Both direct observations (temperature and surface pressure) and indirect observations (radiance), with uncorrelated and correlated errors, are simulated. In general, it is verified that a small reduction (increase) of the initial error in the sensitive area can produce a considerable improvement (degradation) of the targeted forecast. In particular, the results show that increasing the observation density for the uncorrelated-error case can generally improve the analysis and the forecast. However, for correlated observation error and using a diagonal observation error covariance matrix in the assimilation, increasing the observation number in such a way that the error correlation between two adjacent observations becomes greater than a threshold value (around 0.2), will degrade the analysis and the forecast. In any case, it would seem that artificially increasing the observation error would allow to use dense observations even if their error is spatially correlated.

The Use of AMSU data in the Met Office Mesoscale Model

Presenter: Steve English (for Brett Candy)

Brett Candy, Stephen English, Richard Renshaw & Bruce Macpherson

Following on from the positive benefit of using AMSU radiance information in the Met Office Global Model we have recently investigated the use of such data in the Met Office UK Mesoscale Model. In this paper we shall give an overview of the implimentation of AMSU radiances into the Mesoscale Model data assimilation scheme and highlight some problems encountered regarding consistency with existing observational types that are used outside of the variational framework. A general problem regarding the assessment of impact for a new data type in a model with a small domain is the ability to obtain reliable statistics of forecast change. In this paper we attempt to address this by two methods, firstly by running an impact study for an extended period encompassing several weather types and secondly by validating precipitation forecasts using the UK weather radar network.

Use and impact of satellite data in th NZLAM-VAR mesoscale model

Presenter: Vanessa Sherlock

V. Sherlock, P. Andrews, A. Korpela, H. Oliver and M. Uddstrom.
NIWA, Wellington, New Zealand.

We provide a summary of the current use of satellite data in the NZLAM-VAR mesoscale model for the New Zealand region. The accuracy of forecasts using global and mesoscale models are presented for a one month case study period. Results from mesoscale model runs without and with data assimilation are compared, and the impact of assimilation of ATOVS data is examined specifically. Future developments are described briefly.

Prospects for All-Weather Microwave Radiance Assimilation

Presenter: Albin Gasiewski

Albin J. Gasiewski[1], Alexander Voronovich[1], Bob L. Weber[2], Boba Stankov[1], Marian Klein[3], Reginald J. Hill[1], and Jain-Wen Bao[1]

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Microwave radiometric data from satellite sensors is an extremely valuable source of information for temperature and moisture profiling and radiance assimilation over regions that are either cloud-free or covered by mostly thin non-scattering clouds. However, regions for which assimilation of microwave data would be most valuable include frontal zones where rapidly evolving heavy cloud cover and/or precipitation is present. Although scattering at microwave band above ~50 GHz can be strong in such regions the ability to probe deeply using microwaves can still provide important information on the amount and type of hydrometers and latent heating profiles. Time-resolved observations of cloud and precipitation dynamics can facilitate further inference of moisture and heat fluxes.

Direct radiance assimilation provides an optimal framework by which to utilize such information, however, the use of microwave data in radiance assimilation for all weather conditions remains limited due to several factors, including: 1) the need to rapidly and accurately compute the incremental response functions over heavy clouds and precipitation, and 2) time-sampling limitations of polar-orbiting microwave sensors, 3) microphysical precipitation process model limitations, including lack of appropriate error covariance models, and 4) fast and self-consistent assimilation update techniques. While each of these obstacles is formidable, we discuss in this talk potential solutions currently under study. Specifically, we demonstrate a new discrete-ordinate technique for rapid numerical calculation of the incremental brightness temperature profiles (Jacobian) for a layered scattering atmosphere. Applying this method to simulated data using the MM5 mesoscale atmospheric model of NCAR for Hurricane Bonnie (1998) we illustrate the potential for satellite microwave observations to be used to “lock” the state of a numerical weather model onto observed precipitation dynamics. Both low-Earth orbiting and geosynchronous microwave radiance fields are considered, and ramifications for the prospects of such all-weather assimilation using the proposed Global Precipitation Mission (GPM) and Geosynchronous Microwave (GEM) Sounder/Imager systems are discussed.

Dust Storm Mornitoring and Quantitative Prediction Experiment with NWP in Northeast Asian

Presenter: Dong Chaohua

DONG Chaohua

From spring to early summer, dust storms frequently occur in Northeast Asian (in some places throughout the year). Northern China was seriously affected by the dust storm and dust weather system in spring. These dust storm and dust weather systems are generally generated in the droughty and part droughty area of middle latitudes, which just have a rare vegetation coverage, as strong winds entrain large quantities of dust particles into the atmosphere and carry them over large distances downstream. These dust storms have a severe impact upon the air quality in regions downwind of the dust sources. The real-time monitor and prediction of dust storms therefore are highly desirable as a meteorological service to the public.

Payload of meteorological satellites has several spectral regions locating at visible, near infrared, infrared and microwave bands. So the satellite sensors can receive reflection, emission and absorption from the observed targets, such as aerosol, clouds, and earth’s surface. Based on different spectrum performance, the geophysical parameters can be obtained.

As the meteorological satellites have a wide monitoring scale, good time frequency and spatial resolution, high precision, it is the most effective way for monitoring dust storms. A 24_hour operational dust storm monitoring system by using both geostationary and polar orbiting satellite data was established in NSMC/CMA on March 1, 2001. With this system, we can dynamically monitor dust storm, analyze dust storm sources and transport paths, as well as calculate dust storm influencing range and aerosol strength.

The form of dust storm is a very complicated physical process, such as atmospheric movement, type of land surface, dust emission etc. The prediction model of dust activities must involve the key processes of dust emission, dust transport and dust deposition. It requires the coupling of the dust emission scheme with an atmospheric model, supported by other modules and adequate land-surface parameter, i.e., the establishment of an integrated modeling system.

In order to test the integrated modeling system, a joint working group in which the scientists are from the different parts, suth as the CMA, the Chinese Academy of Science and City university of Hong Kong, China, did 24, 48 and 72hr forecasts of Northeast Asian dust events for march and April, 2002. The results are validated with synoptic records from the meteorological network and dust concentration measurements at 12 stations in China, Japan and Korea. The predicted spatial patterns and temporal evolution of dust events and the predicted near-surface dust concentrations are found to agree well with the observations. The successive forecasts of near surface dust concentration for the 10-day period between 15 and 24 March 2002 are compared with observations. It demonstrates that the modeling system well predicted the spatial distributions and temporal evolutions of all dust events in this period of time.

We have determined the total dust emission, total dust deposition and total dust load for the entire domain of simulation and have found that the total dust emission is on average 11.5 $x10^6$ tn day^{-1} (maximum 65.7 $x10^6$ tn day^{-1}); total dust deposition is 10.8 $x10^6$ tn day^{-1} ((maximum 51.4 $x10^6$ tn day^{-1}) and total dust load is 5.5 $x10^6$ tn with a maximum of 15.9 $x10^6$ tn.

NOAA's Satellite and Information Stewardship Program and Plans

Presenter: Mitch Goldberg (for John Bates)

John Bates, Chief Remote Sensing Applications Division,
National Climatic Data Center, NOAA/NESDIS

NOAA/NESDIS is implementing a concept of a stewardship umbrella for its new and old satellite data sets and for the processing of satellite data for climate. The elements of this stewardship program include:

1. Careful monitoring of observing system performance for long-term applications
2. Generation of authoritative long-term records through validation of the calibration process, reprocessing, product generation and the blending of *in situ* and satellite measurements
3. Provide state of the environment information for decision makers and place the current state in its historical context
4. Archive and access to fundamental measurements, products and metadata
5. Data rescue for past satellite data sets

This talk will provide an overview of NESDIS progress and plans for stewardship.

Fast passive microwave radiative transfer in precipitating clouds: Towards direct radiance assimilation

Presenter: Ralf Bennartz

Ralf Bennartz
Atmospheric and Oceanic Sciences
University of Wisconsin, Madison, Wisconsin, USA

Tom Greenwald
Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin, Madison, Wisconsin, USA

Andrew Heidinger
NOAA/NESDIS

Peter Bauer
ECMWF

Radiative transfer models for global data assimilation purposes have to fulfill stringent requirements in terms of computation speed, memory usage, and accuracy. In a new project supported by the Joint Center for Satellite Data Assimilation (JCSDA) we investigate different options for fast radiative transfer models in the microwave spectral range. The work aims at preparing for the assimilation of observed radiances of current and future passive microwave satellite sensors into NCEP's Global Data Analysis System (GDAS) under cloudy and precipitating conditions. In precipitating situations, scattering by large particles becomes important and must be

adequately considered in the radiative transfer. We will give an outline on the status of the development and test of the fast microwave radiative transfer models for clouds and precipitation and show results of Monte-Carlo simulations that illustrate the number of scattering events experienced by a photon for different types of precipitation and different frequencies.

Variational Cloud and Rainfall Data Assimilation at ECMWF

Presenter: Tony McNally for Frédéric Chevallier

Frédéric Chevallier, Peter Bauer, Angela Benedetti, Marta Janiskova, Philippe Lopez, Emmanuel Moreau, Adrian M. Tompkins

4D-Var assimilation schemes assume the linearity of their forward model in the vicinity of prior information and consequently do not properly handle variables that have fine temporal and spatial scales compared to the forward model. Hence cloud- and rain- affected satellite radiances are discarded from numerical weather prediction 4D-Var systems despite the critical need of observations within the cloudy regions.

To circumvent that limitation, a '1D-Var+4D-Var' approach has been developed at ECMWF, where 4D-Var assimilates 1D-Var retrievals of temperature and moisture profiles in rain-affected areas. The 1D-Var method is applied either to rain-rate retrievals obtained from satellite observations or directly to satellite brightness temperatures. This paper will present the methodology and will describe the meteorological impact on the forecast system.

Further, we suggest the possibility of assimilating some of the satellite radiances directly in 4D-Var further to achieving improvements in the modelling of clouds: for instance the 6.3 microns channel on-board all the geostationary satellites. The ECMWF 4D-Var system is being modified so as to assimilate such observations and first results may be presented.

Contribution of POLDER to water vapour observation

Presenter: Michèle Vesperini

Michèle Vesperini
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The POLDER instrument onboard ADEOS (Nov 1996 – June 1997) provided the first opportunity to apply the two-channel ratio technique in the near infrared to retrieve atmospheric water vapor content at the global scale. It revealed very valuable data over continents, where radiosonde measurements are very sparse and where inversion of InfraRed and microwave measurements is very unprecise due to surface emissivities. The total column water vapor content (TCWV) is retrieved in clear-sky conditions from two channels located beside and in an H2O gaseous absorption band (respectively 865 and 910 nm). Assuming that the surface reflectance variation is small between these two close bands, the 910 to 865 nm reflectance ratio is a function of the atmosphere transmission which is related to the water vapor content. The second POLDER mission onboard ADEOS-2 launched late 2002, will use an updated retrieval algorithm. The relation between TCWV and reflectance ratio is parameterized with a polynomial fit, whose coefficients are determined by using SSM/I TCWV collocated observations over ocean. Spectral variations of the land surface reflectivity are accounted for by a correction factor using the atmospheric window 765 and 865 nm reflectances. Water vapor retrieval are performed for all clear-sky pixels over land and for clear-sky and specular reflexion (glint) situations over ocean. Comparisons with meteorological analyses showed large discrepancies over Africa and southern America. Differences appear mainly off the maximum intensity of the ITCZ showing a problem of the forecasting system in positioning the convectiveactivity when not forced by appropriate observations.

Assimilation of AMSU-A Microwave Radiances with an Ensemble Kalman Filter

Presenter: Herschel Mitchell

Herschel L. Mitchell, P.L. Houtekamer, Gerard Pellerin, Mark Buehner, and Bjarne Hansen
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The ensemble Kalman filter (EnKF) is a 4-d data assimilation method. On the one hand, it is an approximation to the standard Kalman filter that improves as the ensemble size increases; on the other hand, it is a nonlinear extension of the standard Kalman filter. The EnKF is well-suited for parallel computation and, on today's computers, can be run at resolutions that can yield operationally interesting results. An interesting aspect of the EnKF is that it does not require tangent linear or adjoint operators either for the forecast model or for the (forward) interpolation operators from the model state to the observations.

An EnKF has been developed to provide initial conditions for the Canadian Meteorological Centre (CMC) operational medium-range ensemble prediction system. The EnKF is currently undergoing pre-operational testing. It uses a version of the CMC operational forecast model having a global 240x120 grid and 28 levels in the vertical. Many different types of meteorological observations, including microwave radiances from the AMSU-A instrument on the NOAA polar orbiters, are assimilated by the EnKF. At the present time, the EnKF relies on the quality control and bias correction procedures performed by the CMC operational 3-d variational (3d-Var) analysis for these latter observations. For the calculation of simulated radiances from a model state vector, the EnKF (like the operational 3d-Var procedure) uses the RTTOV radiative transfer model developed by the NWP Satellite Application Facility.

The way in which the AMSU-A radiances are assimilated in the EnKF will be described. Results showing their overall impact will be presented and compared with corresponding results for the operational 3d-Var procedure.

A Research of Four-dimension Variational Data Assimilation with ATOVS Clear Data

Presenter: Ma Gang

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Satellite vertical sounding data, which represent the three-dimension distribution of atmospheric state at that time, are based on infrared and microwave observations of meteorological satellite. Nowadays more and more deducing atmospheric parameters from satellite vertical sounding data and other satellites data are applicated in numerical weather forecast. In order to use as many as these data high spatial resolution, a four-dimension data assimilation scheme is developed to introduce them into a numerical weather prediction model. Then the quality of model's initial field is therefore improved. And the model physical parameters such as wind and water vapor become more rational.

In this paper a variational assimilation method is used. In this method, a MM5 mesoscale model and its adjoint model that are used as dynamic restriction. As well as conventional sounding data, ATOVS radiance data from satellite and retrieved air temperature and water vapor profiles from ATOVS data are introduced into our system by an observational operator and its adjoint operator simultaneously. While the initial variables (approximate atmospheric situation) in the model domain are given, upwelling-radiance on the top of atmosphere for each channel of ATOVS will be calculated by the integral of a fast radiation transfer model (RTTOV). Therefore the ATOVS data are integrated into the four-dimension mesoscale variational data assimilation system for both analyzing and forecasting. Then a more precise initial model input and thus a more accurate forecast can be obtained by these coherent variables of atmospheric situation.

In order to check the impact of ATOVS data on model forecast, data from T106 and ATOVS during 19-26, July, 2002 are used. First we get the impact from the initial model field only with the conventional sounding data variational assimilation on the predicted atmospheric state and the temporal and spatial precipitation distribution. Then the ATOVS clear-radiance is introduced into the assimilation system to get the impact on the model prediction. At last the impact of retrieved profile from ATOVS data is performed. To confirm these impacts we design three tests. At first we assimilate the model initial filed only with air temperature and no atmospheric moisture; and in the second test the assimilation of the model initial fields only with the moisture and without air temperature is proved to have positive effect on the simulated precipitation. In the last one both the air temperature and water vapor from ATOVS clear-radiance is assimilated to see how it improves the model prediction.

Impact of the assimilation of MSG/SEVIRI radiances in a mesoscale NWP model

Presenter: Thibaut Montmerle

Thibaut Montmerle and François Bouttier (Météo-France)
(This work is financed by Alcatel Space)

In the context of high-resolution weather forecasting, the high horizontal and temporal resolutions of measurements performed by geostationary satellites are an asset compared to polar satellites, despite their weaker spectral and vertical resolutions. The SEVIRI radiometer onboard MSG (Meteosat Second Generation) provides a complete set of radiance observations in the visible and the infrared spectrum every 15 min with an approximate spatial resolution of 3 km over Europe. Those measurements therefore

seem to be particularly well adapted for weather prediction at convective-scale, since they allow continuous access to information about the variation rates of temperature and humidity fields in space and time.

In order to quantify the impact of the assimilation of SEVIRI radiances in the mesoscale analysis of those meteorological quantities, the ALADIN model and its variational assimilation scheme have been used. ALADIN is an operational limited area NWP model coupled with the global model ARPEGE developed at Météo-France, that uses a horizontal resolution of 10 km and a stretched vertical grid composed of 41 levels. In its research version, a 3D-Var analysis can be applied in order to assimilate different kinds of meteorological observations. Radiances observed by 8 channels of SEVIRI radiometers in the infrared and water vapor absorption spectrum have been assimilated in this framework. All the radiances that have not been contaminated by clouds are taken into account, and a bias correction scheme has been applied.
A noticeable positive impact has been observed in the analysis of the vertical structure of the specific humidity in the middle troposphere. The poor vertical resolution of the channels that are sensitive to temperature variations implies however a very weak reduction of the error in the analysis of this quantity. 24 hours prediction that have been undertaken from this analysis shows more realistic cloud cover patterns in the mid and high troposphere than the prediction performed without any data assimilation. It is also showed that these results are highly dependent on the formulation of the background error covariance matrix (or B matrix) that allows to filter and spread spatially the information contained in the radiances. To maximize their potential effect during the assimilation step, the B matrix should indeed take into account the vertical stratification of the forecast errors of the humidity field which are the errors that spatial instruments should strive to observe. Different formulations and their effect on the analysis of the humidity field and on the forecast are presented here.

Impact of the ATOVS data on the Mesoscale ALADIN/HU Model

Presenter: Roger Randriamampianina

Roger Randriamampianina and Regina Szotak

At the Hungarian Meteorological Service for the last few years we have been investigating the three-dimensional variational (3D-Var) data assimilation technique in the limited area model ALADIN (ALADIN/HU).

Our main objective is to change the so-called dynamical adaptation (that takes initial file from the French global model ARPEGE) that is recently in operational use, to a 6-hour data assimilation cycling. Other important task is to use as more observations as possible. Data from radiosonde and surface observations are already prepared for data assimilation. At present, we are investigating the use of data from aircraft (AMDAR) and satellite (ATOVS) observations. Two resolutions (80 and 120km) are considered in the study of the impact of ATOVS data.

We got promising results when assimilating ATOVS data at both resolutions.

SESSION 3

Preparations for NOAA-N and N'

Presenter: Thomas Kleespies

Thomas. J. Kleespies
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Camp Springs, MD 20746

NOAA-N is presently scheduled for launch in the summer of 2004. This satellite will carry somewhat different instrumentation from the NOAA-KLM series. The Microwave Humidity Sounder will replace the Advanced Microwave Sounding Unit-B. The MHS has some different frequencies from the AMSU-B. The High Resolution Infrared Sounder/3 will be replaced by the HIRS/4, which has a smaller field of view. This paper will discuss these changes and some changes to the level 1B processing at NOAA/NESDIS that will accompany the launch of NOAA-N. It will also discuss some of the planned On-orbit Verification activities for NOAA-N and review some results of the successful OV for NOAA-17.

Operational High Resolution Infrared Radiation Sounder Calibration Algorithms and Their Effects on Calibration Accuracy

Presenter: Pubu Ciren (for Changyong Cao)

Changyong Cao

The High Resolution Infrared Radiation Sounder (HIRS) calibrates once every 40 scan-lines using a blackbody and space view. As a result, the calibration coefficients between the calibration cycles have to be interpolated. In the history of operational HIRS calibration, several interpolation methods have been used and unfortunately,

depending on which method is used, these algorithms can produce HIRS level 1b radiance data with significant differences in scene brightness temperature. Although the effect on weather applications is relatively small, it is significant for long term climate studies where high calibration accuracy is required. In this study, the operational HIRS calibration algorithms are evaluated, and sample test data sets are analyzed to quantify the effects. A new algorithm is proposed to reduce the calibration biases caused by the previous calibration algorithms.

SESSION 4

Status of RTTOV-7 and plans for RTTOV-8

Presenter: Roger Saunders

Roger Saunders, Stephen English, Peter Rayer (Met Office),
Pascal Brunel (MeteoFrance),
Frederic Chevallier and Marco Matricardi (ECMWF)

The fast radiative transfer model, RTTOV-7, was released in Feb 2002 and has since been distributed to many users worldwide. The capabilities of RTTOV-7 will be recalled and some statistics on its use will be presented. The next update to RTTOV is RTTOV-8 planned for release in early 2004. The main technical and scientific upgrades to RTTOV-8 will be described.

NCEP infrared sea surface emissivity model

Presenter: John Derber (for Paul van Delst)

Paul van Delst
CIMSS@NOAA/NCEP/EMC

An infrared sea surface emissivity model for use in the NCEP Global Data Assimilation System (GDAS) has been completed. The model is based on fitting specific sensor channel emissivities derived from high resolution sea surface emissivities computed using the Wu-Smith model. The emissivity fit accuracy and the impact on radiative transfer calculations and GDAS statistics will be discussed.

A New Microwave Snow Emissivity Model

Presenter: Fuzhong Weng

Fuzhong Weng and Banghua Yan
Joint Center for Satellite Data Assimilation

This study presents a new microwave snow emissivity model which is empirically derived from satellite retrievals and ground-based measurements. This model produces a variety of snow emissivity spectra at microwave frequencies according to snow types. As part of this model, an algorithm is also developed to classify snow type using the Advanced Microwave Sounding Unit (AMSU) measurements at 23.8, 31.4, 50.3, 89 and 150 GHz. It is shown that the global snow emissivity simulated with this model agrees well with that retrieved from satellite measurements.

The 2003 Edition of the GEISA spectroscopic database system for the second generation vertical sounders radiance simulation

Presenter: Nicole Jacquinet-Husson

N. Jacquinet-Husson, N.A. Scott, A. Chédin, K. Garceran, R. Armante
LMD, Ecole Polytechnique, 91128 Palaiseau, FRANCE,

The **GEISA** (**G**estion et **E**tude des **I**nformations **S**pectroscopiques **A**tmosphériques: Management and Study of Atmospheric Spectroscopic Information) computer accessible database system, in its former 1997 and 2001 versions, has been updated in 2003 (GEISA-03). It is developed by the ARA (Atmospheric Radiation Analysis) group at LMD (Laboratoire de Météorologie Dynamique, France) since 1974. This early effort implemented the so-called « line-by-line and layer-by-layer » approach for forward radiative transfer modelling action.
The GEISA 2003 system comprises three databases with their associated management softwares:

- a database of spectroscopic parameters required to describe adequately the individual spectral lines belonging to 42 molecules (96 isotopic species) and located in a spectral range from the microwave to the limit of the visible. The featured molecules are of interest in studies of the terrestrial as well as the other planetary atmospheres, especially those of the Giant Planets.
- a database of absorption cross-sections of molecules such as chlorofluorocarbons which exhibit unresolvable spectra.
- a database of refractive indices of basic atmospheric aerosol components.

Illustrations will be given of GEISA-03, data archiving method, contents, management softwares and Web access facilities at: http://ara.lmd.polytechnique.fr

The performance of instruments like AIRS (Atmospheric Infrared Sounder; http://www-airs.jpl.nasa.gov) in the USA, and IASI (Infrared

Atmospheric Sounding Interferometer; http://smsc.cnes.fr/IASI/index.htm) in Europe**,** which have a better vertical resolution and accuracy, compared to the presently existing satellite infrared vertical sounders, is directly related to the quality of the spectroscopic parameters of the optically active gases, since these are essential input in the forward models used to simulate recorded radiance spectra. For these upcoming atmospheric sounders, the so-called GEISA/IASI sub-database system has been elaborated, from GEISA. Its content, will be described, as well.
This work is ongoing, with the purpose of assessing the IASI measurements capabilities and the spectroscopic information quality, within the ISSWG (IASI Sounding Science Working Group), in the frame of the CNES (Centre National d'Etudes Spatiales, France)/EUMETSAT (EUropean organization for the exploitation of METeorological SATellites) Polar System (EPS) project, by simulating high resolution radiances and/or using experimental data. EUMETSAT will implement GEISA/IASI into the EPS ground segment.

The IASI soundings spectroscopic data archive requirements will be discussed in the context of comparisons between recorded and calculated experimental spectra, using the ARA/4A forward line-by-line radiative transfer modelling code in its latest version.

An Alternate Approach to Modelling the Reflected Downward Flux Term

Presenter: David Shawn Turner

D.S. Turner
Meteorological Service of Canada

Most current fast forward models simulate the attenuated reflected downward flux as the attenuation of the reflection of a downward radiance evaluated along a path defined by the secant of a mean emergent angle, the diffussivity factor. Models assume the diffusivity factor to be constant or the secant of the satellite zenith angle, and assume that the spectral mean of the RDF term can be decomposed into the product of the specral means of its components. This article considers the inadequacies of these assumptions and proposes an alternate method for evaluating this term.

Infrared radiative transfer modeling using the Optimal Spectral Sampling (OSS) method

Presenter: Jean-Luc Moncet

By Jean-Luc Moncet, Gennadi Uymin, Xu Liu and H. Snell

The OSS method is a simple and flexible approach to radiance modeling originally developed for the real-time processing of NPOESS/CrIS data. OSS-based models have been produced for the airborne NAST-I and AIRS instruments as well as for microwave sensors. The monochromatic treatment of the radiative transfer in OSS confers the ability to directly model non-positive ILS (such as interferometric functions) and to accommodate different observer altitudes (for airborne applications). In addition, it greatly simplifies the computation of analytical Jacobians and makes it possible to model scattering effects in an accurate and computationally efficient way. An overview of the theoretical basis and examples of applications of the OSS method will be presented. More details will be given in a companion poster.

Spectral surface emissivity for use in assimilation of IR radiance data over land

Presenter: Malgorzata Szczech-Gajewska

Malgorzata Szczech-Gajewska, IMWM, Krakow, POLAND
Florence Rabier, Meteo-France, Toulouse, France

The interest of the usage of the very high spectral resolution satellite measurements, as from AIRS or IASI instruments, over land will certainly be growing in the next few years. Preparatory studies have begun with the creation of appropriate "climatological" maps for surface spectral emissivity (SSE), based on new Ecoclimap (Masson et al.2002) vegetation and land cover types and infrared SSE values from spectral libraries (MODIS, ASTER and JPL) compiled with the ones modelled by Snyder et al. (1998). Separated emissivity maps were created for 18 wavebands in the infrared spectral range and for each month. The final maps were validated with MODIS channel 31 and 32 land surface emissivity products based on the split-window method. Currently new SSE is tested in the radiative transfer model RTTOV7 with HIRS channel 8 and AIRS data.

Atmospheric Spectroscopy with AIRS: Validation of the AIRS Forward Model

Presenter: L. Larrabee Strow

L. Larrabee Strow

The high spectral resolution radiances measured with the Atmospheric Infrared Sounder (AIRS) launch on

NASA's AQUA platform in May 2002 are providing a unique data set for improving our understanding of atmospheric emission spectra, which will hopefully lead to improved weather and climate products without the need for empirical tuning of these products. We have compared radiances observed with AIRS to radiances computed from ECMWF analysis/forecast products, and computed from a wide range of radiosonde measurements recorded coincident with an AIRS overpass. Our analysis of these results concentrate on clear, night, ocean conditions where the surface emissivity should be well known, and the detection of cloud-free fields-of-view is most accurate. We now have a dataset that includes large numbers of nominally clear observations over many months, allowing accurate statistical analysis, at least for the ECMWF comparisons. Results assessing the accuracy of various formulations for the water vapor continuum will be discussed, both in the atmospheric windows and inside the strong water band centered at 6.7 microns. In addition we will present analysis of the validation of the temperature sounding channels that are influenced by carbon dioxide emission.

Validation of Satellite AIRS LST/LSE Products Using Aircraft Observations

Presenter: Robert Knuteson

Robert Knuteson, Brian Osborne, Henry Revercomb, and David Tobin
University of Wisconsin, Madison, Wisconsin

William Smith
NASA Langley Research Center, Hampton, VA

Weather satellites have shown positive impact on forecast models for data collected over the world's oceans. However, the use of weather satellite data over land areas has been limited. One of the problems faced by users of broadband infrared measurements is the inability to separate the effect of land surface temperature (LST) from natural variations in land surface emissivity (LSE). A new generation of infrared sounders has been developed for obtaining improved profiles of atmospheric temperature, water vapor, and trace gas concentrations. A characteristic of these advanced sounders is the use of spectrometers with nearly continuous coverage of the 8-14 micron infrared window region with resolving powers of 1000 or greater. These high spectral resolution sounders have the advantage of being able to resolve individual absorption lines of water vapor and carbon dioxide and thereby provide a number of transparent "microwindows" that require a smaller atmospheric correction than broad-band instruments. In addition, it has been recognized that high spectral resolution infrared observations have another important advantage over broad band measurements in that they allow an effective surface temperature to be determined simultaneously with an effective land surface emissivity. A method for emissivity – temperature separation using high spectral resolution infrared observations will be presented using data from the NASA Atmospheric InfraRed Sounder (AIRS) satellite instrument. The satellite measurements will be compared with subpixel observations at high spectral resolution from a high altitude aircraft over a ground truth site in North Central Oklahoma, USA. The techniques used in this analysis have implications for the future operational use of data from the NPOESS CrIS and the METOP IASI sensors.

Advances in the Use of Super Channels for Processing High Spectral Resolution Satellite Measurements

Presenter: Larry McMillin

Larry McMillin and Yong Han, NOAA/NESDIS.

High spectral resolution instruments provide the resolution necessary to optimize the vertical resolution of the measurements. They also provide a very large number of channels, and processing all the channels is beyond the processing capabilities of current computers. As a result, various procedures are used to decrease the processing burden. These are using a subset of channels, using eigenvectors, and using super channels. Using a subset does not take advantage of the noise reduction that is possible. Using eigenvectors is difficult because current rapid transmittance algorithms cant be applied. These leaves the super channel approach as the one solution that can use all the information and make the calculations rapidly. The super channel approach consists of picking channels that have similar spectral properties and averaging them. To obtain the speed benefits, two parts are required. These are a fast radiative transfer model, and a Planck calculation. These have been done for broad band instruments such as HIRS, but super channels differ in that the wavelength intervals are wider than a typical broad band instrument and the fact that discrete wavelengths are selected. The solutions that have been applied to AIRS data will be presented and the information content will be compared to the original data.

RTIASI-4 - An improved version of the ECMWF fast radiative transfer model for the Infrared Atmospheric Sounding Interferometer

Presenter: Marco Matricardi

Marco Matricardi, ECMWF, Reading, UK

An improved version of RTIASI, the ECMWF fast radiative transfer model for IASI, has been developed with EUMETSAT. The new version of the model, RTIASI-4, features a number of significant upgrades. Regression coefficients are generated from a database of line-by- line transmittances that uses the year 2000 version of the HITRAN molecular database and the number of gases included in the line-by-line computations has been increased to include HNO3, CCL4, OCS and CF4. The accuracy of radiance computation has been improved by dividing the atmosphere into 89 fixed pressure layers that extend from 1050 to 0.005 hPa. To improve the prediction of the water vapour optical depths, a single algorithm for water vapour has been introduced with the data being weighted prior to performing the regression and the computation of the optical depth due to the water vapour continuum absorption has been performed using a separate fast transmittance model. RTIASI-4 also features a revised set of predictors for ozone. As a result, a significant reduction of the fast model fitting errors in the 6.7 μm water vapour band and in the 9.8 μm ozone band has been achieved. Including CO, CH4, N2O and CO2 as profile variables has also enhanced the capability of the model that can be exploited for environment related studies to be carried out at ECMWF. The radiative transfer equation used in RTIASI-4 includes the effect of solar radiance reflected over a land or water surface. For the case of solar radiance reflected over a land surface, the reflecting surface is treated as a perfect diffuser following the Lambert law whereas for a full-gravity-capillary wave surface the reflective characteristics of the surface are described by the Gaussian-Joint North Sea Wave project model. Finally, in RTIASI-4 the viewing angle of the detector and the zenith angle of the sun are converted into a local path angle that varies with altitude because of the curvature of the Earth and its surrounding atmosphere.

SESSION 5

Comparison of the CMC analyzed fields of Integrated Water Vapour with those retrieved from the SSM/I

Presenter: David Anselmo

David Anselmo and Godelieve Deblonde
Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada

On June 19th, 2003 the Canadian Meteorological Centre (CMC) began assimilating AMSU-B brightness temperatures and GOES-9 radiances in its 3D-Var global data assimilation system. These new satellite data join the AMSU-A brightness temperatures that are already assimilated (Channels 3-10 over the oceans) at CMC since June 7th, 2001. To prepare for the assimilation of SSM/I (Special Sensor Microwave Imager) brightness temperatures, the CMC analyzed IWV (Integrated Water Vapor) fields are evaluated by comparing them with SSM/I retrieved IWV. Two comparisons are performed. Firstly, SSM/I IWV fields are compared against analyzed fields to measure the impact of assimilating AMSU-A Channel 3 (50.3 GHz) which has a non-negligible humidity dependence. Analyses prior to the addition of AMSU-B and GOES data are used for this purpose. Two assimilation cycles are executed: one assimilating AMSU-A Channels 3-10 and the other only Channels 4-10. Secondly, SSM/I IWV is compared with analyzed fields of IWV that are derived with and without the additional AMSU-B and GOES data over the same period. The results of these two comparisons will be presented.

The AMSU Observation Bias Correction and Its Application on 1-Dvar Retrieval Scheme and Typhoon monitoring

Presenter: Kung-Hwa Wang

Kung-Hwa Wang, Chien-Ben Chou
Central Weather Bureau, Taipei, Taiwan

The Advanced Microwave Sounding United-A (AMSU-A) on NOAA series after NOAA-15 is the new generation of microwave sounders for providing information on the vertical profiles of atmospheric temperature and humidity. Since most of AMSU channels have beam position-dependent bias, therefore it is crucial to remove such bias for providing useful profiles of atmosphere. The measurement errors are estimated from the differences between satellite observations and the simulated satellite observations which were obtained from a radiative transfer operator with 12-hours forecasts as their input. The measurement errors estimated in this way will contain the forecast error of 12 hours forecast. The NMC method assume that the statistics of difference between forecasts at different ranges valid at the same time are the representative of forecast error statistic. The differences used in NMC method have been transfer to brightness temperature in each AMSU channels with the radiative transfer operator. This data can be used to obtain the value of 12 hours forecast error in

brightness temperature for each AMSU channels. So that the effect from the 12 hours forecast errors in each AMSU channels can be removed when the measurement errors are estimated as mentioned above. In this study, we carefully examined the AMSU beam near Taiwan area. A bias correction method which concerns about the beam position-dependent bias and the effect of 12 hours forecast error used on the regression equations has been built. A data reitrieval method based on one-dimensional variational schemed has also been developed. Through the comparison of the retrieved profiles and the background fields, we found that the method worked well near Taiwan area. Even with quite accurate background fields, the retrieved profiles profiles have show positive impact to improve the fields, The result show that the improvement made in the retrieval scheme over background error is about 0.45K in the temperature profiles above 780 hPa. So as the temperature anomalous of typhoon is improved.

Level 1B Products from the Atmospheric Infrared Sounder (AIRS) on the EOS Aqua Spacecraft

Presenter: Thomas Pagano

Thomas S. Pagano
Jet Propulsion Laboratory, California Institute of Technology
Pasadena, CA

The Atmospheric Infrared Sounder (AIRS) was launched May 4, 2002 on the EOS Aqua Spacecraft. AIRS is the first high spectral resolution infrared imaging sounder with 2378 infrared channels ranging from 3.7 - 15.4 microns and a spectral resolution of 1200. A discussion of the objectives of the AIRS experiment including requirements on the data products is given. We summarize the instrument characteristics including sensitivity, noise and spectral response and preflight calibration results leading to the estimate of the calibration accuracy. We show the in-flight behavior and stability of the instrument and steps taken to mitigate the effects of icing and radiation effects. Indications are that the radiometric accuracy of AIRS is better than 0.2K for all frequencies at a scene temperature of 250K, and stability better than 0.2K as well. Spectral stability is shown to be better than 2ppm of the center frequency. The Level 1B calibration algorithm will be presented as well as the results of in-flight stability and sensitivity measurements.

AIRS Retrieval System

Presenter: Sung-Yung Lee

By Sung-Yung Lee, Evan Manning, and Ed Olsen,
Jet Propulsion Laboratory,
Pasadena, California.

The AIRS Team Leader Facility at JPL is developing software to process AIRS data. The software will be run at NASA GSFC DAAC in Greenbelt Maryland. The retrieval algorithm, which generates atmospheric and surface parameters from radiance products, is called the Unified Team Algorithm. Many science team members are responsible for various parts of the retrieval algorithm. They test their software at their home institution and integrate it into the AIRS level 2 software. Major software changes to the Unified Team Algorithm are reviewed by the science team.

The AIRS project has the goal of temperature retrieval accuracy of 1K in 1 km thick layers in the troposphere. For water vapor profiles, the accuracy goal is 10% relative accuracy in 2 km thick layers in the troposphere. We are also planning to retrieve surface and cloud parameters as well as minor gases like O3, CH4 and CO.

JPL is preparing to deliver the first working version of the level 2 software in July 2003.. The output from this version will be released to the public in August. Many AIRS products from this provisional version of retrieval software will be presented.

Atmospheric Soundings of Temperature, Moisture and Ozone from AIRS

Presenter: Mitch Goldberg

M.D. Goldberg, C.D. Barnet, L. McMillin, L. Zhou
M. Divakarla, W. Wolf
NOAA/NESDIS/STAR, Camp Springs, MD, USA

The Atmospheric InfraRed Sounder (AIRS) is the first of a new generation of high spectral resolution infrared sounder with 2378 channels measuring outgoing radiance between 650 cm-1 and 2675 cm-1. The improved vertical resolving power of the AIRS is expected to greatly improve the accuracy of temperature and moisture soundings. AIRS soundings of atmospheric temperature, moisture and ozone are being generated in near real-time at NOAA/NESDIS. These products are currently being validated, and distribution of these retrievals to the community is expected by the end of 2003. The soundings are compared with radiosondes, model analyses and NOAA-16 retrievals. Both the algorithms and the validation results are discussed in detail.

The next advanced sounders to be processed at NESDIS will be the Infrared Atmospheric Sounding

Interferometer (IASI) and the Cross-track Infrared Sounder (CrIS). If launch schedules are maintained, IASI and CrIS radiance and sounding products are expected no earlier than 2006 and 2007, respectively. Our plans for providing IASI and CrIS products are also discussed.

AIRS Real-Time Sounding Profile Retrieval for IMAPP (International MODIS/AIRS Processing Package) Users

Presenter: Elisabeth Weisz

Elisabeth Weisz, Hung-Lung Huang, Jun Li, Suzanne Seemann, Eva Borbas, Liam Gumley;
Cooperative Institute for Meteorological Satellite Studies,
University of Wisconsin-Madison, U.S.A

The high-spectral-resolution Atmospheric Infrared Sounder (AIRS) is part of the core payload of NASA's Earth Observing System (EOS)-Aqua platform. AIRS, together with the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder Brazil (HSB), provides measurements of atmosphere, clouds, land and ocean surface properties with high accuracy.

Current work at CIMSS includes the development of a real-time processing algorithm to retrieve atmospheric temperature and humidity profiles in the troposphere and lower stratosphere as part of the International MODIS/AIRS Processing Package (IMAPP). The first version of the clear statistical retrieval approach includes the use of a training database accounting for viewing angle, surface emissivity, surface skin temperature, surface pressure, and forward model bias. The global training dataset utilizes single window channel classification procedure providing six classes of regression coefficient sets to optimize retrieval performance. To identify clear scenes 1km-MODIS cloudmask has been adapted for AIRS footprints. We present retrieval methodology, and discuss associated aspects including training database setup, noise characterization/filtering, channel selection, and synthetic principal component regression. Results are discussed by means of performance and error characterizations.

We anticipate the first release of this processing algorithm before the ITSC-XIII.

Current Results from AIRS/AMSU/HSB

Presenter: John Blaisdell

Joel Susskind(a), Christopher D. Barnet(b), John M. Blaisdell(c),
Lena F. Iredell(c), Fricky Keita(c), Louis C. Kouvaris(c)

(a) NASA Goddard Space Flight Center
(b) NOAA/NESDIS
(c) Science Applications International Corproation

AIRS was launched on EOS Aqua on May 4, 2002, together with AMSU-A and HSB, to form a next generation polar orbiting infrared and microwave atmospheric sounding system. The primary products of AIRS/AMSU/HSB are twice daily global fields of atmospheric temperature-humidity profiles, ozone profiles, sea/land surface skin temperature, and cloud related parameters including OLR. The sounding goals of AIRS are to produce 1 km tropospheric layer mean temperatures with an rms error of 1K and layer precipitable water with an rms error of 20%, in cases with up to 80% effective cloud cover. Pre-launch simulation studies indicated that these results should be achievable. Minor modifications have been made to the pre-launch retrieval algorithm now that a full year of data has been collected, and these recent modifications are discussed. Sample fields of parameters retrieved from AIRS/AMSU/HSB data are presented and validated as a function of retrieved fractional cloud cover. As in simulation, the degradation of retrieval accuracy with increasing cloud cover is small. Select fields are also compared to those contained in the ECMWF analysis, done without the benefit of AIRS data, to demonstrate information the AIRS can add to that already contained in the ECMWF analysis.

First global measurement of mid-tropospheric CO2 from NOAA polar satellites : The tropical zone

Presenter: Soumia Serrar

A. Chédin, S. Serrar, N.A. Scott, C. Crevoisier, R. Armante
Laboratoire de Météorologie Dynamique, Institut Pierre-Simon Laplace,
Ecole Polytechnique, 91128 Palaiseau, France

Mid-tropospheric mean atmospheric CO2 concentration is retrieved from the observations of the NOAA series of polar meteorological satellites, using a non-linear regression inference scheme. For the four years of the present analysis (July 1987 - June 1991), monthly means of the CO2 concentration retrieved over the tropics (20N-20S) from NOAA-10 show very good agreement with recent in situ observations (properly equipped commercial airliners). The annual trend inferred corresponds to the known increase in the concentration of CO2 as a

result of human activities. Also, the impact of El Nino Southern Oscillation (ENSO) events is clearly seen and confirms in situ observations or model simulations. A rough estimate of the method-induced standard deviation of these retrievals (resolution of 15x15° and one month) is of the order of 3.6 ppmv (around 1%). The coming analysis of the almost 25 years of NOAA archive should contribute to better an understanding of the carbon cycle.

Mid-tropospheric CO_2 retrieval in the tropical zone from AIRS observations

Presenter: Cyril Crevoisier

Cyril Crevoisier, Alain Chédin, Sylvain Heilliette, Noëlle A. Scott,
Soumia Serrar and Raymond Armante

The new 2378 channel high spectral resolution NASA/Aqua/Atmospheric Infrared Sounder (AIRS) launched in May 2002 is used to retrieve mean concentration of atmospheric carbon dioxide (CO_2). A reduced set of AIRS channels, presenting a high sensitivity to variations of the atmospheric CO_2 and reduced sensitivities to variations of other atmospheric components, and well covering the mid-troposphere (from 700 hPa to the tropopause), is first selected using the Optimum Sensitivity Profile (OSP) method (Crevoisier *et al* 2003). A cloud elimination procedure based on AIRS and Atmospheric Microwave Sounding Unit (AMSU) observations is then performed to detect clear fields of view. The resulting AIRS and AMSU measurements, the latter being not sensitive to CO_2 variations, are used in a neural network inference procedure. This non-linear regression scheme has already proved its efficiency in the retrieval of mid-tropospheric CO_2 from NOAA polar satellites (Chédin *et al* 2003). The first results obtained with AIRS give hope to improve the accuracy of the retrieval. Maps of monthly mean mid-tropospheric CO_2 concentration are finally obtained for a few months in the tropics [20S;20N].

Validation of AIRS Retrievals

Presenter: Bjorn Lambrigsten (for Eric Fetzer)

By Eric J. Fetzer, Edward T. Olsen, Luke L. Chen, Denise Hagan, Evan Fishbein, and Frederick W. Irion,
Jet Propulsion Laboratory, California Institute of Technology

The Atmospheric Infrared Sounder (AIRS) spectrometer and companion instrument the Advanced Microwave Sounding Unit have operated simultaneous since 31 August 2002. Collocated observations from the Humidity Sounder for Brazil were also available until 5 February 2003. Geophysical products are generated from directly observed radiances using a retrieval algorithm that is an integral part of the observing system. Retrieved products include cloud cleared radiance, surface temperatures, cloud properties, profiles of temperature and water vapor, and column and profile abundances of ozone and other trace gases. These quantities are being validated by comparison with observations taken in situ and by other satellite sensors. Retrievals are also compared with general circulation model reanalyses. All retrieved products are scheduled for public release in August 2003. Validation analyses for this data release are limited to open ocean conditions in the latitude band from 40 S to 40 N, however. The AIRS retrieval algorithm is scheduled for update in February 2004, and the associated products will be validated over the entire 40 S to 40 N band, including nighttime land. Subsequent releases will address increasingly complex observing conditions, including daytime land and polar conditions. We describe here the validation of cloud cleared radiances, sea surface temperatures, profiles of water vapor and temperature, and ozone. Comparisons are currently being made with assimilation model reanalyses, operational buoys and radiosondes, and dedicated radiosondes and ozonesondes. Results are presented for retrievals over ocean, appropriate to the August data release. Some preliminary comparisons over land are also shown.

Validation of Atmospheric InfraRed Sounder (AIRS) Spectral Radiances with the Scanning High-resolution Interferometer Sounder (S-HIS) aircraft instrument

Presenter: Hank Revercomb

Henry E. Revercomb, David C. Tobin, Robert O. Knuteson, Fred A. Best,
William L. Smith*, Paul van Delst, Daniel D. LaPorte, Scott D. Ellington, Mark W.Werner, Ralph G. Dedecker, Ray K. Garcia, Nick N. Ciganovich, H.Benjamin Howell, and Steven Dutcher

University of Wisconsin-Madison, Space Science and Engineering Center
1225 West Dayton Street, Madison Wisconsin, 53706
* NASA Langley Research Center

The ability to accurately validate high spectral resolution IR radiance measurements from space using comparisons with aircraft spectrometer

observations has been successfully demonstrated. The demonstration is based on a 21 November 2002 under-flight of the AIRS on the NASA Aqua spacecraft by the S-HIS on the NASA ER-2 high altitude aircraft and resulted in brightness temperature differences approaching 0.1K for most of the spectrum!

Aircraft comparisons of this type provide a mechanism for periodically testing the absolute calibration of spacecraft instruments with instrumentation for which the calibration can be carefully maintained on the ground. This capability is especially valuable for assuring the long-term consistency and accuracy of climate observations, including those from the NASA EOS spacecrafts (Terra, Aqua and Aura) and the new complement of NPOESS operational instruments. The validation role for accurately calibrated aircraft spectrometers also includes application to broadband instruments and linking the calibrations of similar instruments on different spacecraft.

Both the AIRS and the S-HIS calibrations are expected to be very accurate (formal 3-sigma estimates are better than 1 K brightness temperature for a wide range of scene temperatures), because high spectral resolution offers inherent advantages for absolute calibration and because they make use of high emissivity cavity blackbodies as onboard radiometric references. AIRS has the added advantage of a cold space view, and the S-HIS calibration has benefited from the availability of a zenith view from high altitude flights on the Proteus aircraft. The S-HIS has also benefited from calibration techniques developed over many years in conjunction with the original HIS aircraft instrument and with the Atmospheric Emitted Radiance Interferometer (AERI) instruments developed for the DOE ARM Program. The absolute radiometric calibration is traceable to NIST, and in the future, we plan to check the calibration directly by inter-comparison to a NIST-maintained sensor (the TXR radiometer).

It is expected that aircraft flights of the S-HIS and its close cousin the NPOESS Atmospheric Sounder Testbed (NAST) will be used to check the long-term stability of AIRS over the life of the mission.

Validation Studies Using NAST-Interferometer Field Measurements

Presenter: Allen Larar

Allen M. Larar[a], William L. Smith[a], Daniel K. Zhou[a], and Stephen Mango[b]
[a]NASA Langley Research Center, Hampton, VA 23681
[b]NPOESS Integrated Program Office, Silver Spring, MD 20910

The Integrated Program Office (IPO) developed and supports high-altitude aircraft flights of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Airborne Sounding Testbed (NAST) as part of risk mitigation activities for future NPOESS sensors. The NAST-Interferometer (NAST-I) is a high spectral and spatial resolution (0.25 cm^{-1} and 0.13 km nadir footprint per km of aircraft altitude, respectively) cross-track scanning (2 km swath width per km of altitude) Fourier Transform Spectrometer (FTS) observing within the 3.7 – 15.5 micron spectral range. NAST-I infrared spectral radiances are used to characterize the atmospheric thermodynamic state and provide information on radiatively active trace gases (e.g. O_3 & CO), clouds, and the terrestrial surface during experimental campaigns. These direct and derived NAST-I data products greatly contribute toward instrument and forward model pre-launch specification optimization and will enhance post-launch calibration/validation activities for the Cross-track Infrared Sounder, CrIS, to fly on NPP and NPOESS (as well as for other advanced atmospheric spaceborne sensors). In this paper we address some of the challenges associated with validating infrared spectral radiances obtained from such high spectral resolution remote sensing systems. This will include comparison of NAST-I infrared spectral radiances measured during recent field experiment campaigns with other radiance measurements as well as radiance calculations performed using Line-by-Line (LBL) and "Fast" forward radiative transfer models based on independent, nearly-coincident observations of atmospheric state.

Validation and Comparison of S-HIS and NAST-I Retrievals for THORPEX 2003

Presenter: Paolo Antonelli

Paolo Antonelli, Hank Revercomb, Robert Knuteson, Dave Tobin, and Steve Dutcher
University of Wisconsin, Madison, Wisconsin
William Smith and Daniel Zhou
NASA Langley Research Center, Hampton, VA

The Scanning High-resolution Infrared Sounder (S-HIS) and the NPOESS Aircraft Sounding Test-bed Interferometer (NAST-I) have flown simultaneously on the same platform during the *2003 THORPEX Observing System Test* campaign. Both the instruments are Michelson interferometers and possess very high spectral and spatial resolution. The results of several airborne missions exploited in the past years have shown that the absolute accuracy of the spectral radiances measured with these

instruments is excellent. This paper aims to take advantage of the simultaneous observations collected by the two instruments to show: a) the relative spectral accuracy, b) the differences in the noise levels between the two instruments c) the differences in the vertical and horizontal structure of the retrieved temperature and water vapor fields.

Validation of Satellite AIRS Retrievals With Aircraft NAST-I Observations – Implications for Future Satellite Sounding Capabilities

Presenter: William Smith

William Smith and Daniel Zhou
NASA Langley Research Center, Hampton, VA
Paolo Antonelli, Hank Revercomb, Robert Knuteson, and Allen Huang
University of Wisconsin, Madison, Wisconsin

The airborne NPOESS Aircraft Sounding Test-bed Interferometer (NAST-I) has flown on numerous flights under the Aqua satellite in order to validate AIRS radiance measurements and profile retrievals. The NAST-I is an excellent AIRS airborne validation tool since it possesses very high spectral and spatial resolution. The results of these airborne missions have shown that there is excellent absolute accuracy of the spectral radiances measured with the NAST-I and AIRS instruments. However, the vertical resolution of the derived profile is shown to be highly dependent on the "effective" noise level of the spectrum used for the retrieval process. The "effective" spectrum noise level is a function of the single spectral sample radiance measurement noise, the number of spectral channels used for the retrieval, and the number of spatial samples averaged to produce the final profile result. For the NAST-I aircraft instrument, the effective spectrum noise level is extremely small after reducing the horizontal linear resolution to that of the satellite AIRS instrument (i.e., ~14 km for AIRS as opposed to ~2km for NAST-I) and as a result its relatively large spectral range and high spectral resolution (i.e., NAST-I possess nearly four times the number of spectral channels as does the AIRS). Retrieval results for various spectral and spatial resolutions are shown to demonstrate the dependence of retrieved vertical profile resolution on the effective spectrum noise levels. For example, it is shown that spatial averaging of the AIRS data, which increases signal to noise, can be used to improve the vertical resolution of the retrieved profiles. Implications for future METOP IASI, NPP/NPOESS, and EO-3 GIFTS spectral resolution, spatial resolution, and instrument noise characteristics are discussed.

Effects of GPS/RO refractivities on IR/MW retrievals

Presenter: Éva Borbás

Éva Borbás [1], W. Paul Menzel [2], Jun Li [1], and Harold M. Woolf [1]
[1]Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin/Madison
[2]NOAA/NESDIS Office of Research and Applications

We examined whether the GPS/RO measurements of the tropopause region are able to improve tropospheric profile retrievals from IR and MW radiometric measurements with the ATOVS (Advanced TIROS Operational Vertical Sounder) on current NOAA polar orbiting satellites and with the future high spectral resolution infrared measurements from the Cross-track Infrared Sounder (CrIS) planned for the NOAA Polar Orbiting Environmental Satellite Suite (NPOESS).

First a simulation study will be presented wherein a statistical regression is used to get temperature and moisture retrievals from the combination of the ATOVS (CrIS) brightness temperatures and GPS/RO refractivity data. The ATOVS/CrIS and GPS/RO combination is found to yield tropospheric profiles in better agreement with those from radiosondes than profiles inferred from either system alone. A sensitivity test was also performed to investigate how large GPS/RO refractivity errors can be and still improve the radiometric temperature or moisture retrievals. Second, the associated study conducted with real GPS/RO (CHAMP) and sounder (ATOVS) data will also be shown.

SESSION 6

The sounding instruments on second generation of Chinese national meteorological satellites FY-3

Presenter: Dong Chaohua (for Wenjian Zhang)

Wenjian ZHANG
National Satellite Meteorological Center, China Meteorological Administration,
Beijing 100081, P.R. CHINA

FY-3 is the second generation of Chinese national polar-orbiting meteorological satellite series. According to the current plan, the year 2006-2010 is the FY-3 Research and Development (R&D) phase with two satellites and followed by operational phase with five satellites. The FY-3 series will be equipped with both sounding and imaging payload, enabling more powerful observations, with the main objectives of providing global sounding of 3-

dimensional thermal and moisture structures of the atmosphere parameters to support global and regional numerical weather prediction, providing global imaging to support short range weather forecasting and real time monitoring of meteorological/hydrological disasters and surface environment anomaly, as well as providing necessary data for deriving important geophysical parameters to support researches on global change and climate change.

In partnership with the China Aerospace Science and Technology Corporation (CASC), the first satellite of this series, FY-3A satellite, is scheduled to be available in 2006. Now the FY-3A and associated instruments are under manufacturing. FY-3A will carry more than ten remote sensing instruments and four of them related to atmospheric sounding. These instruments are: Infrared atmospheric sounder, Microwave atmospheric temperature sounder, Microwave atmospheric humidity sounder and Ozone profiler. This paper will give a brief introduction to the FY-3A, including the manufacturing progress of the satellite platform, the manufacturing progress FY-3A instruments, as well as the planning of FY-3 ground segment.

India Meteorological Department Report

Presenter: Devendra Singh (for R. C. Bhatia)

An update on the India Meteorological Department.

Scientific Research Center "Planeta" Report

Presenter: Alexander Uspensky

An update on the Scientific Research Center "Planeta."

EUMETSAT Plans

Presenter: Dieter Klaes

K. Dieter Klaes
EUMETSAT, Darmstadt, Germany

EUMETSAT is currently developing, jointly with ESA the EUMETSAT Polar System (EPS) and commissioning the first Meteosat Second Generation Satellite(MSG-1). MSG-1 has been successfully launched in 2002 and will start to provide validated observations from the Earth/Atmosphere system end of 2003. Three MSG satellites are foreseen, the payload of which will be a 12 channel imager (SEVIRI=Spinning Enhanced Visible and Infrared Imager) and a GERB (Geostationary Earth Radiation Budget) radiometer, a fourth one is planned. The EUMETSAT Polar System is the European contribution to the U.S./European Initial Joint Polar System (IJPS) and will assure the morning orbit (AM) of the two- satellite system. The NOAA POES system will continue to assure the afternoon (PM) orbit. The Metop spacecraft will provide imagery and sounding information, with innovative capabilities. The launch of the first Metop satellite is planned for September 2005. Three Metop spacecraft are foreseen within EPS.

Update about Frequency Protection: Results of WRC 2003 and SFCG 23… What to do now?

Presenter: Guy Rochard

Guy Rochard
Meteo-France

This paper will report on results from the WRC 2003 and SFCG 23 meetings. Additional information about frequency protection can be found on these web sites:

http://cimss.ssec.wisc.edu/itwg/groups/frequency/
and
http://guy.rochard.free.fr/meteo/

NESDIS ATOVS Operational Sounding Products Processing and Distribution

Presenter: A. K. Sharma

A. K. Sharma
NOAA/NESDIS
Washington DC 20233

Since 1979 the National Oceanic and Atmospheric Administration National Environmental Satellite, Data, and Information Service (NOAA/NESDIS) has been providing the operational sounding products from the polar orbiting satellites continuously with a suite of infrared and microwave radiation sounder measurements, and derived temperature and moisture sounding products on a global scale. NOAA's primary mission for sounding data products represents a unique source of global, atmospheric, weather information, with a demonstrated positive impact on Numerical Weather Prediction (NWP) forecasts. Current polar orbiting satellites provide measurements from the HIRS/3, AMSU-A and AMSU-B sounder instruments on board NOAA-15, NOAA-16 and NOAA-17. Advanced TIROS (Television and Infrared Observation Satellite) Operational Vertical Sounding (ATOVS) sounding products from NOAA-15 were operationally

implemented by NESDIS in April 1999 and AMSU-B processing was delayed until May 2000. NOAA-16 and NOAA-17 were made operational in March 2001 and October 2002 respectively. There are over 500,000 soundings made every day from the ATOVS on aboard NOAA-15, 16 and 17 series of Polar Orbiting Environmental Satellites (POES). Monitoring sounding data products generation systems on a 24 hours basis is important. A web-based user interface has been developed and implemented for monitoring the products generation systems. Quality of the data products and timeliness for processing and distribution are extremely important factors in designing the operational systems at the NESDIS. This presentation will include the discussion on the improvements on the quality and timeliness and the operational changes required by the systems to accommodate the future instruments data processing such as pipeline processing for granules instead of orbits. The processing changes required for the upcoming launches of the NOAA satellites NOAA-N and NOAA-N' and the European Organization for the Exploitation of Meteorological (EUMETSAT) satellites, Meteorological Operational Satellite (MetOp)-1 and MetOp-2 will be discussed. Re-hosting of operational systems from a slower processor CRAY machine to a faster processor IBM machine will also be discussed.

NESDIS ATOVS Operational Sounding Products

Presenter: Tony Reale

Tony Reale
NOAA/NESDIS
Washington DC 20233

The National Oceanic and Atmospheric Administration, National Environmental Satellite Data and Information Service (NESDIS) operates a fleet of civilian, polar orbiting environmental satellites which provides users and researchers with a suite of operational atmospheric and environmental data. The current operational configuration consists of three polar satellites, NOAA-15, 16, and 17, each deploying the Advanced TIROS Operational Vertical Sounder (ATOVS) instrument configuration. ATOVS consists of the 15-channel Advanced Microwave Sounding Unit-A (AMSU-A), the 5-channel AMSU-B, the 20-channel High-resolution Infrared Radiation Sounder (HIRS/3), and the 6-channel Advanced Very High Resolution Radiometer (AVHRR/3).

The following report summarizes the current status of the operational ATOVS (and AMSU-B) instruments and derived sounding products distributed by NESDIS to national and international users. This is done through a brief review of instrument health, the scientific processing algorithms, statistical results, and a series of examples of data requests (on a global and regional scale) that have been received from the user community over the past 18 months. It is through such requests and feedback back from users that NESDIS is able to gauge the usefulness of these data, the scope of the information they provide and areas of concern. For example, the application of derived soundings for arctic polar winter cases, tropical moisture, and global temperatures in the middle and upper stratosphere are just a few examples of user requests received and discussed. Ongoing internal review by NESDIS scientists has also resulted in a number of interesting cases, for example, during the recent winter period (2003), the weather pattern over a large portion of the United States featured a persistent lower level inversion associated with cold air overridden by warm moist air from the Gulf of Mexico and South Atlantic, and an associated signature error characteristic in the derived sounding products. Such features represent one of the foremost challenges for satellite meteorologists as they are essentially invisible to the current generation of satellite atmospheric radiometers, yet can be reliably identified through comparisons against short-term numerical weather prediction forecasts.

The report concludes with a discussion of derived satellite product error characteristics, how the current scientific algorithms meet (or not) the current user requirements in this area for the variety of numerical weather prediction and climate applications these data entertain, and how future upgrades planned by NESDIS during the Year 2004 (including significant advances in scientific validation) will better meet these needs. Also discussed is the role of the radiosonde network in defining error characteristics, their explicit use in "tuning" the scientific algorithms to derive products, current strengths and weaknesses, and how future plans to dedicate a small global network of reference sondes to provide ground truth coincident with polar satellite overflights could better meet the needs of numerical weather prediction and climate application users.

Further development of the ATOVS and AVHRR Processing Package (AAPP) including an initial assessment of EARS radiances

Presenter: Nigel Atkinson

Nigel Atkinson and Keith Whyte (Met Office),
Tiphaine Labrot (Météo-France)

The various changes to AAPP for the recent V4.0 release will be discussed. These include rationalisation of the documentation, Fortran90

compatibility and the addition of code to detect and correct for occurences of the moon in the AMSU-A space view. The requirements for AAPP V5.0 will be examined, in particular the changes necessary for processing NOAA-N data. Finally the future of AAPP in the Metop era will be addressed.

Examples of the implementation of AAPP in an operational setting, particularly the routine processing of data from the Eumetsat ATOVS Retransmission Service (EARS), will be included.

The National Polar-orbiting Operational Environmental Satellite System: Future U.S. Operational Earth Observation System

Presenter: Hal Bloom

By Hal J. Bloom and
Peter Wilczynski

Over the last decade, the tri-agency Integrated Program Office (IPO), comprised of the National Oceanic and Atmospheric Administration (NOAA), the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA), has been managing the development of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS will replace the current military and civilian polar-orbiting environmental satellites. The IPO, through its Acquisition and Operations (A&O) contractor, Northrop Grumman, will begin in 2009 to launch NPOESS spacecraft into three orbital planes to provide a single, national system capable of satisfying both civil and national security requirements for space-based, remotely sensed environmental data.

In 1997, the IPO initiated a robust sensor risk reduction effort that was focused on early development of the critical sensor suites and algorithms necessary to support NPOESS. In 2001, preliminary design efforts were completed for the last of five critical imaging/sounding instruments for NPOESS. Three of these sensors are scheduled to fly on the joint NASA/IPO NPOESS Preparatory Project (NPP) mission in 2006. Early flight-testing of instruments will reduce development risk and demonstrate and validate global imaging and sounding instruments, algorithms, and pre-operational ground processing systems prior to delivery of the first NPOESS spacecraft.

To meet user-validated requirements for 55 geophysical parameters, NPOESS will deliver global Stored Mission Data (SMD) to four U.S. centers for processing and distribution, with 95% of the data being delivered in less than 28 minutes from the time of collection. Global SMD will be down-linked to 15 globally distributed ground stations at Ka-band frequencies and will be the complete, full resolution data set containing all sensor data and auxiliary data necessary to generate all NPOESS Environmental Data Records. NPOESS spacecraft will also simultaneously broadcast two types of real-time data to suitably equipped ground stations. The NPOESS High Rate Data broadcast (X-band frequencies) will be a complete, full resolution data set and is intended to support users at regional hubs. The NPOESS Low Rate Data broadcast (L-band frequencies) will be a subset of the full data set and is intended for U.S. and worldwide users of remote/mobile field terminals.

The advanced technology visible, infrared, and microwave imagers and sounders that will fly on NPOESS will deliver higher spatial and temporal resolution atmospheric, oceanic, terrestrial, climatic, and solar-geophysical data, enabling more accurate short-term weather forecasts and severe storm warnings, as well as serving the data continuity requirements for improved global climate change assessment and prediction.

SESSION 7

Preparations for the Geostationary Imaging Fourier Spectrometer

Presenter: William Smith (for John Le Marshall)

J. Le Marshall, L. Leslie,R. Seecamp,A.Rea, B. Choi and M. Dunn

Not available.

Characteristics of Land and Atmospheric Parameters Over Indian Sub-continent

Presenter: Ramesh Singh

Ramesh P. Singh
Department of Civil Engineering
Indian Institute of Technology
Kanpur – 208 016, India

Indian sub-continent is divided into three major geological regions. These three geological regions are characterized by different types of rocks and soils and have different types of vegetation covers. Detailed analysis of SSM/I, IRS P4 OCEANSAT MSMR, ERS and AVHRR data have been carried out over Indian sub-continent. The microwave remote sensing response is very much dependent on the land cover, types of land covers, physical parameters of the land cover and also atmospheric

parameters. In the present paper, microwave response of different geological regions of India will be presented. The microwave response (in terms of brightness temperature and emissivity) show strong inter-annual variability over different geological regions of India. Different regions of India show different types of emissivity and moisture content. The surface topography is found to show strong scattering due to which the ERS data is found to be very sensitive with the surface topography. The effect of season on active and passive microwave remote sensing response will be discussed over different geological regions. Efforts have been made to quantify the influence of atmosphere on microwave response.

Retrieving Infrared Land Surface Emissivity With AIRS Observations

Presenter: Xuebao Wu

Xuebao Wu [1], Jun LI [2], Yuanjing Zhu [1], Paul Menzel [2] and Wenjian Zhang [3]

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[2] *CIMSS/SSEC/UW-Madison,USA*

[3] *National Satellite Meteorological Center, Beijing, China*

This report reviews briefly the characteristics of high spectral resolution observations. The paper describes the use of EOS-Aqua AIRS measurements over China to characterize the surface properties important for IR thermal emission. Infrared rapid transmittance model is used for the sensitivity study of surface parameters and the atmospheric parameters from lower troposphere. An experiment is carried out to retrieve the land surface emissivity and temperature. The MLEV (Minimum Local Emissivity Variance) retrieval method is implemented in this study. The atmospheric profiles of the ECMWF NWP model are utilized to simulate the satellite measurements. Preliminary retrieval results are given out.

Surface effects in hyperspectral infrared measurements from the AIRS instrument of the Aqua satellite

Presenter: Youri Plokhenko

Youri Plokhenko[#] and W. Paul Menzel[&]

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The surface emissivity (SE) variations cause measurable changes in infrared radiances. To improve the accuracy of vertical temperature-moisture profiles retrieved from AIRS sounder infrared measurements, the surface emissivity must be accounted for in the solution of the inverse problem. The accuracy of atmospheric parameters retrieved from IR measurements depends on the measurement accuracy and accurate definition of measurement model. The associated inverse problem based upon the numerical solution of the radiative transfer equation (RTE) is ill posed. Disregarding the spectral-spatial variations of SE in the RTE magnifies the errors. Different types of surface cover, with different surface optical properties and extremely high spatial and temporal variations, restrict the use of a priori estimates of SE. The direct evaluation of SE is an effective approach for modeling. A model accounting for the surface reflection and an algorithm of solution are presented. The solution includes the surface emissivity, the surface temperature, and the temperature-moisture profile. The RTE equation is solved using method of least squares in coordinate descent on basis of a Gauss-Newton numerical schema. Results of SE estimation are demonstrated. The SE estimates over land show significant spectral-spatial variability. Accounting for the emissivity positively changes the atmospheric temperature-moisture profiles estimate.

Characterization of troposphere and land surface properties from CMIS

Presenter: Alan Lipton

Jean-Luc Moncet and Alan Lipton
AER Inc.

The NPOESS Conically-scanning Microwave Imager/Sounder (CMIS) will provide polarimetric measurements in the range 6-183 GHz. CMIS will combine capabilities of AMSR, WindSat and SSMIS, in that it will enable the retrieval of soil moisture, ocean surface wind direction, and mesospheric temperature, in addition to the more traditional microwave land/surface environmental variables. The combination of sounding and imaging channels on the CMIS instrument will be exploited to enhance both surface and lower atmosphere characterization and maintain physical consistency between the atmosphere and surface variables. In particular, the presence of vertically and horizontally polarized channels near 23 GHz and in window regions, together with the presence of sounding

channels, will open the door to significant advances in assimilation or retrieval of lower atmosphere data over land. In addition, there are plans to quantify the impact of incorporating the information provided by VIIRS and CrIS, on the same platform, on the system performance over land and on the EDR quality control.

SESSION 8

Advanced TOVS (ATOVS) Cloud Products Using HIRS/3 and AMSU-A Measurements

Presenter: Michael Chalfant

Michael W. Chalfant
Office of Research and Applications / NESDIS / NOAA, Washington DC

Franklin H. Tilley
ITSS Division / Raytheon Corporation, Lanham MD

The National Oceanic and Atmospheric Administration (NOAA) , National Environmental Satellite Data and Information Service (NESDIS) currently produces a suite of operational quality cloud products from the Advanced TIROS Operational Vertical Sounder (ATOVS) system using the High-resolution Infrared Radiometer Sounder (HIRS/3) and Advanced-Microwave Sounding Unit (AMSU-A) instruments onboard the NOAA polar orbiting satellites. These global products include Cloud Top Temperature, Cloud Top Pressure and Cloud Amount, in support of NESDIS commitment to improve Short Term Warnings and Forecasts. The ATOVS cloud products are dependent upon the generation of accurate temperature and moisture retrievals for both the generation of a correction for the attenuation of radiances above the cloud tops as well as the determination of cloud top pressure.

The ATOVS cloud products are generated using the CO_2 Slicing technique, at each HIRS/3 Field-of-View (FOV). These products are also output to 1 X 1 degree gridded fields, for ascending and descending orbital passes and separated into Total, High, Medium and Low pressure layers, where the parameters are calculated as a function of the Effective Cloud Fraction. The ATOVS cloud products, at the sounding location are being archived and distributed via AWIPS, to NWS field forecast offices. Two cloud product statistical tables are generated globally and updated daily on the NESDIS web site, for comparison with other cloud product systems as well as assessing the performance of the ATOVS cloud product system.

The ATOVS cloud products have been undergoing extensive evaluation by NESDIS and National Weather Service (NWS) personnel for possible use in regional and global Numerical Weather Prediction (NWP) forecasts. Comparisons of the ATOVS Cloud products with several other cloud product generation systems such as the ATOVS temperature retrieval Cloud Mask; the AVHRR/3 based CLAVR-x and UK Meteorological Office s Clear Fraction; GOES and the USAF RTNEPH, have resulted in substantial improvement in the coverage of retrieved marine stratus plus providing for an independent quantative verification of the ATOVS cloud parameter values. This paper describes the algorithms for deriving these cloud products as well as the scientific and system upgrades which have resulted in significant increases in both cloud product accuracy and coverage.

Cloud Parameters from a Combination of Infrared and Microwave Satellite Measurements

Presenter: Filomena Romano

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Clouds are both absorbers of outgoing longwave radiation and reflectors of incoming solar radiation. Due to their crucial role, the knowledge of the horizontal and vertical distribution and the optical properties of globally distributed clouds are of fundamental importance to the understanding of the radiation and heat balance, weather and climate of the earth and the atmosphere. Measurements of radiation from space can play a big role in helping us to understand how radiation depends on cloud properties. They can also help us to identify which are the most critical cloud properties to measure. The goodness of satellite-based measurements is that they offer the only practical way of making cloud measurements over the entire global. In the next future, many of new satellite sensors will be available for cloud observation. The improvement of spatial resolution and spectral characterisations allow us to apply sophisticated retrieval procedure, which will provide new cloud products with enhanced accuracy.

Although radiometers have been used to derive cloud cover, study of the quantitative estimate of the vertical cloud composition and structure by means of passive remote satellite sounding has been extremely limited because of the complexity of the cloud interactions with the radiation field of the atmosphere. Since clouds are practically opaque in

the infrared sounding frequencies and since the majority of the clouds are transparent in the microwave regions, it would appear that a proper combination of infrared and microwave measurements could be useful and significant data to determine the cloud coverage, the vertical cloud structure and composition in all weather conditions.

In this paper we wish to demonstrate the feasibility of utilizing a combination of infrared and microwave sounding data for the estimation of the cloud parameters. Theoretical calculation are used to examine the spectral characteristics of microwave (AMSU) and infrared brightness temperature values for non-precipitating clouds in order to improve the retrieval of cloud parameters.

Cirrus microphysical properties from TOVS observations

Presenter: Gaby Rädel

G. Rädel , C. J. Stubenrauch, and F. Eddounia
CNRS/IPSL, Laboratoire de Météorologie Dynamique, Ecole Polytechnique, France

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

We already retrieved the mean effective ice crystal sizes (D_e) for large-scale cirrus clouds with an IR emissivity between 0.3 and 0.85 by using their dependance on the difference between cloud emissivities at 8 µm and 11 µm for NOAA10 data. Look-up tables were constructed assuming homogeneous clouds of 1km thickness, consisting of randomly oriented planar polycrystals (*Rädel et al., 2003*). In addition the ice water path (IWP) is determined from the emissivity at 11 µm and the retrieved D_e. We find that on average effective ice crystal diameters lie between 30 and 60 µm and ice water paths lie between 20 and 35 g/m^2, depending on season and latitude.

Correlations between these micro- and macrophysical properties and the state of the atmosphere, as described by the ECMWF ERA-40 reanalysis, have been established by collocating the two data sets. A parameterization of D_e as function of wind and water vapour content, as well as cloud top temperature and ice water path from TOVS will be presented.

This study is part of the European project CIRAMOSA (CIrrus microphysical properties and their effect on RAdiation: survey and integration into climate MOdels using combined SAtellite observations).

Rädel, G.; Stubenrauch, C. J.; Holz, R.; Mitchell, D. L.: *Retrieval of effective ice crystal size in the infrared: Sensitivity study and global measurements from TIROS-N Operational Vertical Sounder*, J. Geophys. Res. Vol. 108 No. D9, 10.1029/2002JD002801, 2003.

Synergistic Cloud Clearing and Cloud Property Retrieval Using Aqua Sounding and Imaging Infrared Measurements

Presenter: Hung-Lung (Allen) Huang

Hung-Lung Huang[1], Kevin Baggett[1], Elisabeth Weisz[1], Jun Li[1], and William L. Smith[2]
[1]Cooperative Institute of Meteorological Satellite Studies, University of Wisconsin – Madison
[2]Langley Research Center, NASA

High spectral resolution (~0.5 cm-1) infrared sounding and high spatial resolution (~1 km) infrared imaging measurements on board the NASA EOS Aqua satellite provide an unprecedented opportunity to characterize the full clear and cloudy sounding and cloud property retrieval capability that no single instrument has been able to achieve, up to now.

The Atmospheric Infrared Sounder (AIRS) has single field of view resolution at sub satellite point (i.e. nadir) of about 14 km. The clear sounding sampling probability is less than 10%. It requires the use of infrared measurements from multiple AIRS field of views and co-located microwave measurements to improve the yield of high performance clear sounding retrieval. Unfortunately, this procedure reduces the spatial resolution (from one single to 3 by 3 field of views, for example) and is also limited by the inhomogeneity (different types, phases, and heights) and contrast (difference of cloud fraction within each field of view) of the clouds within the processing footprint.

As part of International MODIS and AIRS Processing Package (IMAPP), AIRS sounding and cloud property retrieval will be demonstrated by the fusion of 1-km MODIS infrared radiances with the derived cloud mask and phase products. We will present the details of this synergistic procedure, performance of the cloud cleared radiances and the associated sounding and cloud property retrievals.

Characteristics of the Cloudy Atmosphere Observed the Atmospheric Infrared Sounder (AIRS)

Presenter: Evan Fishbein

By Evan Fishbein, Luke Chen and Sung-Yung Lee
[1]Jet Propulsion Laboratory, California Institute of Technology

The Atmospheric Infrared Sounder (AIRS) derives surface and profiles quantities under partial cloudy conditions by estimating the clear sky component of the observed radiances. The procedure uses microwave and infrared radiances to provide independent estimates of the clear component. It also assumes variability at scales less than 50 km occurs only in the cloudy component. We are validating both the assumptions and results of the procedure. We compare clear sky radiances produced from forecasts with those from our algorithms. We compute the spatial coherency of the cloudy component and are examining its daily and seasonal variability.

Synergistic use of high spatial resolution imager and high spectral resolution sounder for atmospheric and cloud retrievals

Presenter: Jun Li

***Jun Li*[*], *Timothy, J. Schmit*[@], *Fengying Sun*[*], *W. Paul Menzel*[@]**

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High spatial resolution imager and high-spectral resolution sounder radiance measurements from geostationary orbit will allow for monitoring the evolution of atmospheric profiles and clouds. Advanced baseline imager (ABI) and Hyperspectral Environmental Suite (HES) on GOES-R in 2012 and beyond will provide enhanced spatial, temporal and vertical information for atmospheric soundings and clouds operationally. ABI provides better information on cloud types and phase with high spatial resolution, while HES provides better information on cloud-top and emissivity. Combination of data from both instruments will provide improved cloud property retrievals than that from either alone. The Moderate-Resolution Imaging Spectroradiometer (MODIS) and Atmospheric Infrared Sounder (AIRS) measurements from EOS Aqua platform are used for the atmospheric and cloud property retrievals. The retrievals from combination of MODIS and AIRS data are compared with retrievals from either MODIS or AIRS alone, as well as the forecast analysis, to demonstrate the advantages on the atmospheric and cloud retrieval using combined high spatial and spectral imaging and sounding radiance measurements.

Estimates of the dynamics of volcano eruption column using real-time AVHRR

Presenter: Ignacio Galindo

Ignacio Galindo

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The physical properties of eruption plumes are studied for the eruption of Popocatépetl volcano which occurred on July 19, 2003 at 9:20 local time coincident with the NOAA-15 satellite pass. Computations are made using the AVHRR brightness temperature and radiance data obtained from the plume and the nearby environment. The results show besides the distribution of mass and the energy of the plume the thermal flux and the variation of velocity with height in the eruption column and the variation of the radial expansion velocity with radial distance according with Sparks (1986) and others. We believe that the introduction of AVHRR data into these calculations produces more reliable results.

SESSION 9

Diagnosing the Global Energy-Water Cycle with Satellite Observations

Presenter: William Rossow

William B. Rossow

As part of the World Climate Research Program, the Global Energy and Water Experiment (GEWEX) is, as its name suggests, attempting to diagnose the atmospheric energy-water cycle and its variations. Note that this cycle is central to determining the climate's sensitivity (feedbacks) to forced changes and plays a role in determining unforced climate variations by connecting all of the other components of the climate system. To achieve this, the GEWEX

Radiation Panel (GRP) is working to assemble a complete diagnostic dataset that describes the main components of the energy-water cycle and its weather-scale variations over a period of a few decades to support research on these topics. Some of these datasets are ready now and appear to be of useful accuracy, some exist but their accuracy is not well known and some do not exist at all. The rationale for assembling this data collection and a summary of the current status will be presented. Since these data are now being used for climate research, the GRP is proposing that a careful assessment of their quality be carried out to: (1) set the stage for re-processing (if needed) to improve quality, (2) provide a better understanding of these data when used for analyses of the energy-water cycle and (3) to support the next IPCC assessment, which will focus on water. Given the expertise in the ITWG, GRP proposes to partner with ITWG for the assessment of satellite-based tropospheric water vapor data products. It might make sense for this task to be combined with a complete assessment of tropospheric and surface temperature measurements from satellites as well.

Use of radiances data in ERA-40

Presenter: Graeme Kelly

Graeme Kelly
ECMWF, United Kingdom

At ECMWF a re-analysis has been completed using all available satellite and conventional data from 1967 to 2002. A reduced resolution version of the ECMWF operational IFS system (3D-VAR at 60 levels and horizontal resolution of TL 159 (120 km) was used for the data assimilation system. The use of satellite radiances started with VTPR radiances in 1973 and radiances were used directly in the assimilation from VTPR, HIRS, MSU, SSU, and AMSU. SSMI radiances where input to a pre-processing 1D-VAR and the retrieved products of total precipitable water and wind speed were then assimilated in the 3D-VAR analysis. Some of the difficulties that arose with the satellite data during the re-analysis discussed. The re-analysis was highly successfully but it is clear that further re-analyses could be further improved with the knowledge obtained from ERA40 about the performance of the satellite sensors.

The use of MSU in climate change studies

Presenter: Peter Thorne

Peter Thorne, Simon Tett, & David Parker
Hadley Centre for Climate Prediction and Research, Met Office, UK

We briefly summarise our recent research using two independently produced MSU climate timeseries.

We illustrate the use of MSU products in attempts to resolve the observed discrepancy between a significant surface warming and little tropospheric temperature change within the tropics over the satellite period. This is contrary to climate model predictions of increasing warming aloft under anthropogenic forcings. We use MSU data both to inform and to test our hypothesis that this disagreement occurs because tropical tropospheric temperature evolution on climate timescales is a two-boundary problem with both surface and stratospheric constraints.

We also show how MSU data can be usefully used to inform us as to the potential causes of recent climate change. Space-time global optimal detection studies using a climate-model yield significant both natural and anthropogenic climate change signals within tropospheric MSU timeseries. This result is shown to be insensitive to the choice of MSU dataset within the mid to upper troposphere. For stratospheric temperatures our analyses imply that the model significantly overestimates the response - most likely because it has too much ozone reduction in comparison to recent observations.

Climate variability and change of tropical tropospheric humidity as observed by HIRS

Presenter: Mark McCarthy

Mark McCarthy[1] & Ralf Toumi[2]
[1]Hadley Centre of Climate Prediction and Research, Met Office, UK
[2]Imperial College, London, UK

We review some of our results from analysing the Upper Tropospheric Relative Humidity (UTRH) product of J.Bates et al. (2001) from the High Resolution Infra-Red Sensor (HIRS) for the period 1979-98

The only mode of interannual variability that can be identified in the HIRS record are UTRH variations following patterns of anomalous convection associated with El Nino and the Southern Oscillation (ENSO). We describe the seasonal pattern of this variability and show that extremes in UTRH during the northern hemisphere winter of an ENSO event are dominated by regional changes in tropospheric temperatures. Atmosphere-ocean dynamics coupled with the seasonal cycle in UTRH can result in

regional UTRH anomalies during the following summer season. We further discuss the importance of being able to simultaneously diagnose temperature and humidity products in climate research, and radiosonde data are used to highlight differences in temperature-humidity relationships over a range of space and time scales.

The HIRS dataset contains significant regional trends characterised by increasing humidity over Africa, the West Indian ocean and the Amazon, and decreasing humidity over the southern hemisphere convergence zones and subtropics. We show that changes in ENSO, or a simple intensification of the Hadley circulation are inadequate to describe these observations, a number of alternative scenarios are discussed, including the suitability of the current version of the HIRS dataset for trend analysis.

The results are presented with comparison to those produced by the atmosphere only model HadAM3 forced with observed SSTs for the same period.

Plans for a Collocated Radiosonde and Satellite Upper Air Network (SUAN)

Presenter: Tony Reale

Tony Reale
NOAA/NESDIS
Washington DC 20233

The problem of absolute scientific calibration and validation of polar satellite radiometers, and the lack of a dedicated global program to provide such data since the onset of the TOVS operational series satellites in 1979, has resulted in a serious problem concerning the identification and removal of systematic bias and uncertainty in the long-term record of satellite data. This has turned out to be a major problem particularly for climate applications where such errors or jumps in the long term record of measurements and/or derived products can easily overwhelm the sensitive climate signals being sought, as well as for shorter term numerical weather prediction (NWP) applications for which such differences can introduce measurements bias and/or increased noise mitigating their impact.

Over the past year or so several user groups from the climate, NWP and satellite community have recognized this inherent weakness and have recommended that the requirements for the global radiosonde network be expanded to include polar satellite scientific calibration and validation. During January, 2003, the **NOAA Council on Long-term Climate Monitoring (CLTCM)** forwarded several carefully worded recommendations for establishing a small network of reference radiosondes coincident with overflying (polar) satellites for absolute calibration of global atmospheric temperature and moisture, citing the specific need for long-term planning to obtain accurate global temperature and moisture measurements via integrated global observing systems which include redundant data platforms.

Later in March, 2003, a **"Workshop to Improve the Usefulness of Operational Radiosonde Data"** was held at the National Climatic Data Center (NCDC) in Asheville, North Carolina. Recommendations from this diverse group of radiosonde users and experts from the NWP, climate and satellite community formally recognized that the requirements for global radiosondes clearly extend to the satellite community, citing the need for absolute scientific calibration of satellite measurements, products and scientific algorithms (i.e., radiative transfer fast codes) against "reference" radiosondes. Similar to CLTCM, the Workshop recommend that a small network of global (reference) radiosondes coincident with operational (and research) polar satellite overpass be established. However, the Workshop went on to recommend basic guidelines for selecting candidate sites, for example, that selected sites not interfere with established climate records and NWP requirements for synoptic observations. The group also noted the problem of radiosonde measurement errors, their association with the various radiosonde instrument types, changes that have occurred over time, and the potential importance of past and future collocations with satellite overpass to resolve these errors. Finally the Workshop recommended that the International TOVS Study Conference be consulted in setting up this Satellite Upper Air Network (SUAN).

The following report summarizes activities over the past several months to establish a preliminary network of candidate SUAN sites, including site selection based on previous climate and NWP requirements, the radiosonde type flown and adequate global distribution.

SESSION 10

GeoSTAR – A New Approach for a Geostationary Microwave Sounder

Presenter: Bjorn Lambrigsten

Bjorn Lambrigtsen
Jet Propulsion Laboratory

The Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR) is a microwave atmospheric sounder, with capabilities similar to those of the AMSU-A/B system, and is intended for deployment in geostationary orbit – where it will complement future infrared sounders to enable all-weather temperature and humidity soundings. It also has the capability of mapping rain rates, and it can be deployed in medium earth orbits as well. GeoSTAR is based on spatial-interferometric principles and uses a stationary array of a large number of individual receivers to synthesize a large aperture and achieve the required spatial resolution, an approach that has significant advantages over conventional real-aperture systems – such as full-disk scanning with no moving parts. GeoSTAR will implement the same tropospheric sounding channels as AMSU-A (temperature) and AMSU-B (humidity) and will achieve an initial spatial resolution of 25-50 km. Future versions will have significantly higher spatial resolution. The required technology is currently being developed at the Jet Propulsion Laboratory and other collaborating organizations, under NASA's Instrument Incubator Program, and a ground based demo system will be ready in 2005.

NPOESS VIIRS sensor design and performance

Presenter: Jeffrey Puschell

Carl F Schueler, Jeffery J. Puschell, J. Edward Clement, et al.
Raytheon Santa Barbara Remote Sensing

Not available…

Overview of the CrIMSS (CrIS/ATMS) retrieval algorithm

Presenter: Xu Liu

Xu Liu and Jean-Luc Moncet,
AER, Inc

AER is the retrieval algorithm developer for the Cross Track Infrared and Microwave Sounder Suite (CrIMSS), which will fly onboard of NPP and NPOESS platforms. The infrared component of the CrIMSS is an interferometer-based Cross-Track Infrared Sounder (CrIS). The microwave component is an Advance Technology Microwave Sounder (ATMS). The radiative transfer forward model uses an innovative parameterization, which models both radiances and weighting functions accurately and efficiently. The inversion algorithm uses a physical retrieval method to retrieve atmospheric and surface properties from both microwave and infrared sensors. Different strategies for dealing with clouds will be discussed. Some results of applying the CrIMSS algorithm to real data will be presented.

IASI on Metop : an Advanced Sounder for Operational Meteorology and Climate studies.

Presenter: Thierry Phulpin

T.Phulpin, G. Chalon and D. Blumstein
Centre National d'Etudes Spatiales, 18 avenue E. Belin, 31401 Toulouse cedex 9 – France

IASI is a new generation infrared vertical sounder developed jointly by CNES and EUMETSAT that will be embarked on METOP 1 to 3. It has been designed for operational meteorological soundings with a very high level of accuracy (Specifications on Temperature accuracy : 1K for 1 km and 10 % for humidity) and also for estimating and monitoring trace gases on a global scale. The IASI system includes the 3 instruments, a data processing software integrated in the EPS ground segment and a technical expertise centre (TEC) implemented in CNES Toulouse.
The instrument is composed of a Fourier transform spectrometer and an associated infrared imager. The optical configuration is based on a Michelson interferometer and the interferograms are processed by an on-board digital processing subsystem, which performs the inverse Fourier transforms and the radiometric calibration. The infrared imager co-registers the IASI soundings with AVHRR imager (AVHRR is another instrument on the Metop satellite).The first flight model has just been delivered by the prime Alcatel to be integrated in the next months on METOP 1. Its radiometric performances are compared to its specifications.

The operational software for level 1 and level 2 is currently under development respectively under CNES and Eumetsat responsibility. The Level 1 processing is devoted to deliver to end users very well calibrated and located radiance spectra. Its functions and parameters will be established , monitored and updated by the TEC. A calibration/validation plan to ascertain level 1 data quality has been defined.
Based on actual current instrument performances, simulations performed in the framework of

preparatory studies by the IASI sounding study working group (ISSWG) show that with the current assimilation or inversion techniques, mission requirements are met.

The Operational IASI Level 2 Processor

Presenter: Peter Schluessel

Peter Schluessel
EUMETSAT

The operational IASI (Infrared Atmospheric Sounding Interferometer) Level 2 processor will be part of the EPS (EUMETSAT Polar System) Core Ground Segment). Starting with Level 1c data the IASI Level 2 processor generates vertical profiles of temperature and humidity, ozone columns of deep layers, and columnar amounts of carbon monoxide, nitrous oxide, and methane, as well as surface temperature, surface emissivity, cloud amount, cloud height, and cloud phase. The processor not only makes use of IASI data but also utilises information from the companion instruments AVHRR (Advanced Very High Resolution Radiometer), AMSU-A (Advanced Microwave Sounding Unit A), and MHS (Microwave Humidity Sounder), as well as Level 2 products from the Advanced TIROS Operational Vertical Sounder (ATOVS).

The processor functionality can be broadly broken down into three parts, the pre-processing, the cloud-detection, and the retrieval step. In the pre-processing all data are checked for availability and are validated against valid thresholds and co-located with IASI by interpolation or nearest match-up. Land-sea mask and surface topography distribution are generated for each IASI instantaneous field of view (IFOV) and weighted with the corresponding point spread function. Depending on user-configuration and data availability a number of cloud detection tests are executed, based on IASI data alone, or using IASI in combination with AVHRR and/or ATOVS. The AVHRR scenes analysis is used to determine cloud amount, cloud height distribution, and the number of cloud formations within an IASI IFOV. Different retrieval types are foreseen. In the cloud-free case the parameters to be derived are temperature and water-vapour profiles, ozone amounts in deep layers, columnar amounts of carbon monoxide, methane, and nitrous oxide, surface temperature, and surface emissivity at different wavelengths. In cloudy situations, the number of retrieved parameters can change according to cloud amount and user choice. It is foreseen that parameters are derived above clouds only, or in case of low cloud amounts, that a cloudy retrieval or a variational cloud clearing is performed. The retrieval techniques implemented are statistical retrievals based on EOF regression and artificial neural network methods for the first retrieval, and a variational Marquardt-Levenberg method employing IASI super-channels and/or AMSU-A and MHS channels. The result from the first retrieval can constitute the final product, or it can be fed as initial guess into the simultaneous iterative retrieval. The final product will be accompanied by a compressed error covariance matrix.

Joint Temperature, Humidity, Ozone, and SST Retrieval from IASI Sensor Data

Presenter: Marc Schwaerz

Marc Schwaerz and Gottfried Kirchengast,
Institute for Geophysics, Astrophysics, and Meteorology (IGAM), Graz, Austria

The IASI (Infrared Atmospheric Sounding Interferometer) instrument will be part of the core payload of the METOP series of polar-orbiting operational meteorological satellites currently prepared for EUMETSAT (first satellite to be launched in 2005). Compared to existing operational satellite radiometers, this high spectral resolution instrument allows significantly improved accuracy and vertical resolution of retrieved temperature and humidity profiles, and also delivers ozone profiles and sea surface temperature (SST). Applications like numerical weather prediction and climate change and variability studies (e.g., of the El Nino phenomenon) will benefit from these improvements. The aim of our data analysis preparation is eventual utilization of the retrieved data for climatological purposes, in particular for simultaneously monitoring climatic changes in the thermal structure of the atmosphere, in upper troposphere moisture, in stratospheric ozone, and in SST.

We discuss a joint retrieval algorithm of temperature, humidity, ozone, and SST (more precisely, the latter is the surface skin temperature of the ocean), which we developed based on optimal estimation methodology and which we carefully tested under realistic conditions (using high resolution ECMWF analysis fields). The algorithm contains in a first step an effective and fast channel selection method based on information content theory, which leads to a reduction of the total number of IASI channels (> 8400) to about 3 % only (~250), which are subsequently used in the retrieval processing. We show that this reduction is possible without any performance decrease compared to using many more (order 1000) channels. The clearly improved performance of the joint algorithm compared to more specific retrieval setups is exemplified as well. Finally, the application of the algorithm to AIRS

(Advanced Infrared Sounder) data, a next step planned, is addressed.

SIRAS-G, The Spaceborne Infrared Atmospheric Sounder:
The potential for high-resolution infrared imaging spectrometry from geosynchronous orbit

Presenter: George Aumann (for Thomas Kampe)

Thomas U. Kampe
Ball Aerospace & Technologies Corp., Boulder Colorado, USA

Thomas S. Pagano
NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

The Spaceborne Infrared Sounder for Geosynchronous Earth Orbit (SIRAS-G) represents a new approach to infrared imaging spectrometry suitable for Earth observation from geosynchronous orbit. SIRAS-G, selected for development under NASA's 2002 Instrument Incubator Program (IIP-4), is an instrument concept with lower mass and power requirements than contemporary instruments while offering enhanced capabilities for measuring atmospheric temperature, water vapor, and trace gas column abundances in a compact package. SIRAS-G utilizes grating spectrometers to provide the high spectral resolution, building off the experience of AIRS. The SIRAS-G concept is adaptable to airborne, low-Earth orbit and geosynchronous deployment. The flight instrument concept is designed to measure infrared radiation in 2048 spectral channels with a nominal spectral resolution ($\Delta\lambda/\lambda$) of between 700 and 1100. SIRAS-G employs a wide field-of-view hyperspectral infrared optical system that splits the incoming radiation to four separate grating spectrometer channels. Combined with large 2-D focal planes, this system provides simultaneous spectral and high-resolution spatial imaging. In 1999, the SIRAS team built and tested SIRAS spectrometer No. 4 (12.3 – 15.4μm) under NASA's Instrument Incubator Program (IIP-1). SIRAS-G builds on this experience with a goal of producing a laboratory demonstration instrument including the scan assembly, telescope, a single spectrometer channel, focal plane and active cooling subsystem. In this paper, we describe planned development activities, including the fabrication and testing of the demonstration instrument. Performance predictions for several candidate future scientific missions are presented and the potential benefits to science retrievals due to enhanced spatial resolution are discussed.

Introduction of the Hyperspectral Environmental Suite (HES) on GOES-R and beyond

Presenter: Jun Li (for T. Schmit)

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The Hyperspectral Environmental Suite (HES) on GOES-R in 2013 will provide high spatial (better than 10 km), high temporal (better than 1 hour), high spectral resolution (single wavenumber), measurements with rapid coverage rate for observing the evolution of atmosphere and clouds. The HES has been expanded to include other capabilities for environmental monitoring of the ocean and land. HES, together with the Advanced Baseline Imager (ABI), will provide visible, near-infrared and infrared radiance measurements for improving weather monitoring and forecasting. The requirement for HES disc sounding (DS) and severe weather/meso-scale (SW/M) modes are introduced in this talk, and various simulations are carried out to demonstrate the superiority of HES over the current GOES sounder system. Atmospheric Infrared Sounder (AIRS) measurements are also used for the HES performance studies.

ITSC-13 POSTERS
ABSTRACTS

POSTER SESSION A: THURSDAY

A01: Advanced TOVS (ATOVS) Cloud Products Using HIRS/3 and AMSU-A Measurements

Presenter: Michael Chalfant

Michael W. Chalfant
Office of Research and Applications / NESDIS / NOAA, Washington DC

Franklin H. Tilley
ITSS Division / Raytheon Corporation, Lanham MD

The National Oceanic and Atmospheric Administration (NOAA) , National Environmental Satellite Data and Information Service (NESDIS) currently produces a suite of operational quality cloud products from the Advanced TIROS Operational Vertical Sounder (ATOVS) system using the High-resolution Infrared Radiometer Sounder (HIRS/3) and Advanced-Microwave Sounding Unit (AMSU-A) instruments onboard the NOAA polar orbiting satellites. These global products include Cloud Top Temperature, Cloud Top Pressure and Cloud Amount, in support of NESDIS' commitment to improve Short Term Warnings and Forecasts. The ATOVS cloud products are dependent upon the generation of accurate temperature and moisture retrievals for both the generation of a correction for the attenuation of radiances above the cloud tops as well as the determination of cloud top pressure.

The ATOVS cloud products are generated using the CO_2 Slicing technique, at each HIRS/3 Field-of-View (FOV). These products are also output to 1 X 1 degree gridded fields, for ascending and descending orbital passes and separated into Total, High, Medium and Low pressure layers, where the parameters are calculated as a function of the Effective Cloud Fraction. The ATOVS cloud products, at the sounding location are being archived and distributed via AWIPS, to NWS field forecast offices. Two cloud product statistical tables are generated globally and updated daily on the NESDIS web site, for comparison with other cloud product systems as well as assessing the performance of the ATOVS cloud product system.

The ATOVS cloud products have been undergoing extensive evaluation by NESDIS and National Weather Service (NWS) personnel for possible use in regional and global Numerical Weather Prediction (NWP) forecasts. Comparisons of the ATOVS Cloud products with several other cloud product generation systems such as the ATOVS temperature retrieval Cloud Mask; the AVHRR/3 based CLAVR-x and UK Meteorological Office's Clear Fraction; GOES and the USAF RTNEPH, have resulted in substantial improvement in the coverage of retrieved marine stratus plus providing for an independent quantative verification of the ATOVS cloud parameter values. This paper describes the algorithms for deriving these cloud products as well as the scientific and system upgrades which have resulted in significant increases in both cloud product accuracy and coverage.

A02: Meteorological Products Generation Using Combined Analysis of ATOVS and AVHRR Data

Presenter: Izabela Dyras

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The satellite observations in different waveband ranges provide the important information on the state of the atmosphere that is used for weather analysis and forecast. Combining these data into one system encounters problems due to the data various range as well as temporal and spatial resolution. On the other hand such system is a useful tool for the data analysis and presentation.

The paper presents the progress in the cloud analysis on NOAA AVHRR images as well as in algorithms allowing the retrieval of various parameters from NOAA AMSU data in the Satellite Research Department, Institute of Meteorology and Water Management in Poland. The combined analysis maps are created and then disseminated via Intranet to the regional forecasting offices. Such satellite maps enhance the ability to diagnose the meteorological parameters e.g. precipitation using satellite imagery.

The prepared meteorological products for Poland include several thematic layers such as precipitation intensity and range, convective clouds' detection, Total Precipitable Water estimation. A case study from 12th of August, 2002 will be included to present the system's functionality.

The GIS technology is used for preparation and visualisation of the products and allow to overlay data derived from various other sources including ground measurements, NWP analysis and forecast, lightning system, geographical data and administrative boundaries.

A03: Multi-spectral rain-rate retrieval from AMSU and AVHRR

Presenter: Aarno Korpela

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We have previously described the development of NIWA ATOVS Collocation Archive (NACA) at ITSC-X and ITSC-XI. The archive collocates AMSU level 1d AAPP data and AVHRR locally derived products with Doppler weather radar data, at high spatial accuracy (1 km) and temporal resolution (7.5 min), preserving information at sub-AMSU instantaneous field of view scale. The relationship between AMSU observations and rain-rate, including beam-filling effects is investigated through analysis of the NACA archive, identifying rain signatures. For the development of rain retrieval algorithm, those AMSU-B ifovs that contain no precipitation are used to derive a relationship between the 89 and 150 GHz data in the absence of scattering. Scattering index can then be defined as the difference between the modelled (scatter free) 150 GHz brightness temperature and the measured 150 GHz brightness temperature. Rain-rate scattering algorithm from NACA is based on rain signal in the scattering index. By combining the AMSU data with the AVHRR derived within-ifov cloud data, characterizing the rain processes, it is possible to further refine the accuracy of the scattering index method, leading to rain-rate retrievals with $R^2 > 0.69$. The details of the method and validation results will be presented, demonstrating the capability of the combined microwave, infrared, and visible rain-rate algorithm to produce spatially accurate rainfall estimates of value in nowcasting, rain-process studies, and the identification of radiative contaminants in the observations used in numerical weather prediction models (e.g. the New Zealand Limited Area Model, NZLAM-VAR).

A04: A Research of Four-dimension Variational Data Assimilation with ATOVS Clear Data

Presenter: Ma Gang

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Satellite vertical sounding data, which represent the three-dimension distribution of atmospheric state at that time, are based on infrared and microwave observations of meteorological satellite. Nowadays more and more deducing atmospheric parameters from satellite vertical sounding data and other satellites data are applicated in numerical weather forecast. In order to use as many as these data high spatial resolution, a four-dimension data assimilation scheme is developed to introduce them into a numerical weather prediction model. Then the quality of model's initial field is therefore improved. And the model physical parameters such as wind and water vapor become more rational.

In this paper a variational assimilation method is used. In this method, a MM5 mesoscale model and its adjoint model that are used as dynamic restriction. As well as conventional sounding data, ATOVS radiance data from satellite and retrieved air temperature and water vapor profiles from ATOVS data are introduced into our system by an observational operator and its adjoint operator simultaneously. While the initial variables (approximate atmospheric situation) in the model domain are given, upwelling-radiance on the top of atmosphere for each channel of ATOVS will be calculated by the integral of a fast radiation transfer model (RTTOV). Therefore the ATOVS data are integrated into the four-dimension mesoscale variational data assimilation system for both analyzing and forecasting. Then a more precise initial model input and thus a more accurate forecast can be obtained by these coherent variables of atmospheric situation.

In order to check the impact of ATOVS data on model forecast, data from T106 and ATOVS during 19-26, July, 2002 are used. First we get the impact from the initial model field only with the conventional sounding data variational assimilation on the predicted atmospheric state and the temporal and spatial precipitation distribution. Then the ATOVS clear-radiance is introduced into the assimilation system to get the impact on the model prediction. At last the impact of retrieved profile from ATOVS data is performed. To confirm these impacts we design three tests. At first we assimilate the model initial filed only with air temperature and no atmospheric moisture; and in the second test the assimilation of the model initial fields only with the moisture and without air temperature is proved to have positive effect on the simulated precipitation. In the last one both the air temperature and water vapor from ATOVS clear-radiance is assimilated to see how it improves the model prediction.

A05: Variational retrievals within the summertime eastern Pacific environment using ATOVS with the COAMPS™ mesoscale forecast system

Presenter: Nancy Baker

Grant A. Cooper[123], Nancy L. Baker[2], and Philip A. Durkee[3]

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A one-dimensional variational (1DVAR) retrieval scheme has been used to investigate the complex relationship between satellite-derived information and *a priori* constraint. Specifically, we investigate the ability of the Advanced TIROS Operational Vertical Sounder (ATOVS) to contribute information within the summertime eastern Pacific (EPAC) environment to a mesoscale numerical weather prediction system (the Coupled Ocean – Atmosphere Mesoscale Prediction System (COAMPS™) and the Naval Research Laboratory (NRL) Atmospheric Variational Data Assimilation System (NAVDAS)).

Analyses of information content and theoretical retrieval performance show that, when treated optimally, significant humidity and temperature information can be derived from ATOVS infrared and microwave retrievals within the clear and cloudy sky summertime EPAC environment. A study of theoretical retrieval error sensitivity to representative EPAC background state vector elements and associated errors was also conducted to establish the *a priori* elements critical for successful 1DVAR retrievals.

1DVAR profile temperature and humidity retrievals were generated using both simulated and actual ATOVS observations constrained by the COAMPS 6-hr forecasts and a synoptically relevant background error covariance matrix. The time period of interest coincides with the Dynamics and Chemistry of Marine Stratocumulus (DYCOMS) Phase II field study. The 1DVAR results are consistent with the theoretical information content study and indicate that these satellite observations can provide information that, when used in concert with a reasonable first-guess background (i.e., from COAMPS), reduce the retrieval error and adjust the retrieval within the shallow boundary layer toward the designated "true" profile.

The generally good agreement between theoretical retrieval errors and the error statistics calculated using non-linear Newtonian iteration demonstrates consistency and reliability of the NRL 1DVAR retrieval scheme.

COAMPS is a trademark of the Naval Research Laboratory.

A06: The Assimilation of Satellite Observations for the U.S. Navy's Operational Forecast Models

Presenter: Nancy Baker

Nancy L. Baker[*1], Clay Blankenship[1], Bill Campbell[1], Rolf Langland[1], Steve Swadley[2]

Scientists at the Marine Meteorology Division of the Naval Research Laboratory have recently developed a new three-dimensional variational system NAVDAS (NRL Atmospheric Variational Data Assimilation System). NAVDAS is slated to replace the multivariate optimum interpolation analysis system this fall for both the global and mesoscale atmospheric forecast models run operationally at the U.S. Navy's Fleet Numerical Meteorology and Oceanography Center.

NAVDAS is designed to assimilate a variety of satellite observations, including visible and infrared cloud-tracked and water vapor winds, scatterometer winds, radiances or retrievals for polar orbiting sounders, and the Special Sensor Microwave Imager (SSM/I) surface wind speed and total precipitable water. In addition, the adjoints of global forecast model (NOGAPS) and NAVDAS are used to compute the sensitivity of the forecast error to the observations and to the assigned observation error, and to estimate the impact of the observations on the forecast error. These statistics may be used to tune NAVDAS.

This presentation will describe assimilation details and results from AMSU-A and AMSU-B radiance assimilation tests. Observation impact statistics compiled from several months of assimilation/adjoint runs will also be presented and discussed. Finally, results from data assimilation runs where the observation usage has been modified as suggested by the adjoint calculations are presented.

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2. METOC Consulting, Monterey, CA

A07: Long-Term Temperature Time Series Constructed from "Morning" Satellites

Presenter: Mitch Goldberg

M.D. Goldberg and Zhaohui Cheng
NOAA/NESDIS/STAR, Camp Springs, MD, USA

There has been much debate about the magnitude of decadal temperature trends in the mid troposphere derived from the MSU. Temperature trends from Christy and Spencer, and Wentz et al. at RSS are derived by combining all observations from "morning" and "afternoon" satellites to a given local time. In addition to computing offsets between the different satellites (i.e. intercalibration), special attention is needed to account for the drift in the equator crossing times (i.e. changes in the diurnal cycle), which can be quite large for the "afternoon" satellites. These adjustments of course are not perfect and will result in uncertainty in the trends. Our approach is to avoid these adjustments by constructing MSU/AMSU time series from "morning" satellites (NOAA-10 , NOAA-12 and NOAA-15). The drift of the morning satellites is very small (within 1 hour) and can be ignored completely when constructing ocean-only time series. Another feature of using "morning" satellites is that the data can be separated into ascending and descending orbits allowing time series to be generated for two nominal local times – 7:30 AM and 7:30 PM. We find that the trend at 7:30 AM is larger than 7:30 PM. Details of our methodology and results for different regions are discussed.

A08: Progress towards a climate-quality data set from MSU channel 1.

Presenter: Carl Mears

Carl A. Mears, Matthias C. Schabel, and Frank J. Wentz
Remote Sensing Systems
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Climate monitoring research using the MSU and AMSU instruments has focused on direct measurements of the middle troposphere and lower stratosphere using MSU channels 2 and 4, and their (nearly) corresponding channels on AMSU[1,2] as well as indirect measurements of the lower troposphere obtained by differencing measurements from different incidence angles to obtain the synthetic '2LT' channel[1]. Analysis of MSU channel 1, which has a atmospheric vertical weighting function that peaks near the surface, is complicated by the large contribution of surface emission to the measured brightness temperatures. Over land, the extraction of a climate quality data set may be impossible due to the large diurnal cycle in surface temperature, as well as large changes in surface emissivity as soil moisture, vegetation extent, and snow cover on a variety of time scales. Over the ocean, the situation is significantly better, since the oceanic emissivity is both lower and much better characterized. In this presentation, we summarize our progress towards a climate quality data set over the oceans. We are currently using our comprehensive ocean surface model (which we also use to retrieve ocean surface winds from SSM/I, TMI and AMSR) to remove the effects of surface emission from the MSU channel 1 data, and CCM3 model output to remove the effects of the diurnal cycle.

1. Christy, J.R., et al., "Error Estimates of Version 5.0 of MSU/AMSU Bulk Atmospheric Temperatures." Journal of Atmospheric and Oceanic Technology, 2003. In Press.
2. Mears, C.A., M.C. Schabel, and F.J. Wentz, "A reanalysis of the MSU channel 2 troposperic temperature record." Journal of Climate, 2003. In Press.

A09: Comparison of AMSU-B Brightness Temperature with Simulated Brightness Temperature using Global Radiosonde Data

Presenter: Viju Oommen John

By V. O. John, S. A. Buehler, and M. Kuvatov, IUP, University of Bremen, Germany

We present a comparison of brightness temperature measured by AMSU to radiative transfer model calculations based on radiosonde data. The forward model used is the stable version of the Atmospheric Radiative Transfer Simulator(ARTS), a general purpose radiative transfer model which can handle many different remote sensing instruments in the millimeter to infrared spectral region. The atmospheric profiles used are the Met Office - Global Radiosonde Data taken from the British Atmospheric Data Centre (BADC). The comparison is done for 82 stations from 15 European countries, the countries participating in COST Action 723.

As the forward model ARTS has already been validated against AMSU brightness temperatures using high resolution radiosonde data from Lindenberg which is a reference station for German Weather service(DWD), the main aim of this comparison is to check the quality of the radiosonde data from the different stations. The poster will present the methodology of the comparison, final results of the forward model validation, and how the quality check is made for the radiosonde stations.

A10: The ITWG Web Site: Creating a Useful Forum for the Community

Presenter: Leanne Avila

Leanne Avila
CIMSS/University of Wisconsin-Madison

Following the election of the new co-chairs, Roger Saunders and Tom Achtor, maintenance of the ITWG web site was transferred to the webmaster at CIMSS (home institution of Tom Achtor – http://cimss.ssec.wisc.edu/itwg/). Working closely with the co-chairs, the new ITWG webmaster undertook the task of redesigning the site to create not only a more aesthetically pleasing page, but also to create a more useful forum for the ITWG community. News and Highlights have been added to provide a more dynamic element to the site. Numerous updates, including practical information, regarding this ITSC conference have been posted to the ITWG web site to encourage users to continue to visit. We will continue to find ways to enhance the usefulness of the site with input from the community.

A11: The International ATOVS Processing Package (IAPP)

Presenter: Tom Achtor

Thomas Achtor, Jun Li, and Hal Woolf
Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin-Madison

The International ATOVS Processing Package (IAPP) has been developed to retrieve the atmospheric temperature profile, moisture profile, total ozone and other parameters in both clear and cloudy atmospheres from ATOVS radiance measurements. The IAPP algorithm retrieves the parameters in 4 steps: 1) cloud detection and removal; 2) bias adjustment; 3) regression retrieval; and 4) nonlinear iterative physical retrieval. A publication by Li, Wolf, Menzel, Zhang, Huang and Achtor, *Journal of Applied Meteorology* (August 2000) provides details on the algorithms. This poster will describe in detail the ITPP processing technique with examples of output products. Information on how to obtain the ITPP is also available.

A12: Software Packages for Direct Broadcast Data Processing of EOS MODIS and AIRS/Microwave Radiances

Presenter: Tom Achtor

Allen Huang, Thomas Achtor, Liam Gumley
Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin-Madison

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison, USA, has a long history of software development to acquire and process radiances measurements from polar orbiting and geostationary weather satellites. Since 1983, CIMSS has worked with the International TOVS Working Group (ITWG) to create the International TOVS/ATOVS Processing Packages (ITPP/IAPP). CIMSS has also worked with NASA and the Earth Observing System (EOS) direct broadcast community to create the International MODIS/AIRS Processing Package (IMAPP). This paper describes these software packages and their products.

INTERNATIONAL MODIS/AIRS PROCESSING PACKAGE (IMAPP)

Within the NASA Earth Observing System (EOS) program, a direct broadcast capability was created for MODIS and AIRS radiance measurements. The NASA Earth System Enterprise provided support to the University of Wisconsin CIMSS to develop processing software for MODIS and AIRS. The objective is to develop a software package for international distribution which allows any ground station capable of receiving EOS direct broadcast data to produce a suite of geophysical products in near real-time (within 1 hour of satellite overpass). This objective will allow NASA to directly involve the international community in the use and validation of EOS data sets.

The International MODIS/AIRS Processing Package (IMAPP) allows any ground station capable of receiving direct broadcast from Terra or Aqua to produce calibrated and geolocated MODIS or AIRS radiances (Level 1), along with a select group of science products (Level 2). IMAPP is derived from the operational MODIS processing software developed at NASA GSFC, and is modified to be compatible with direct broadcast data.

The most recent version of IMAPP MODIS Level-1 software supporting Terra and Aqua (v1.4) was released to the international EOS direct broadcast community in September 2002. The initial release of IMAPP MODIS Level 2 science products occurred in May 2002, and the current version (v1.4) was released in September 2003. The MODIS Level 2 products currently include cloud mask, cloud top properties, and atmospheric profiles, using the same science algorithms as the operational NASA versions. However a simplified input/output interface allows the software to run on all supported IMAPP

platforms, and also allows both IMAPP and NASA MODIS Level-1B HDF formats to be used as input.

IMAPP is supported on the following UNIX platforms and operating systems:
SGI MIPS, IRIX 6.5
Sun Ultra, SunOS 5.7
IBM RS/6000, AIX 4.3
HP PA-RISC, HP-UX B.10.20
Intel Pentium, Linux 2.2.12-20 (with gcc)
Intel Pentium, Solaris x86 2.5.1 (with gcc)
The IMAPP source code distribution is at:
http://cimss.ssec.wisc.edu/~gumley/IMAPP/

The MODIS cloud mask indicates the probability that a given view of the earth surface is unobstructed by clouds or optically thick aerosol, and whether that clear scene is contaminated by a shadow. The cloud mask is generated at 1000 and 250 meter spatial resolution. It is more than a simple yes/no decision. The cloud mask includes four levels of confidence indicating whether a pixel is clear (bits 1 and 2) as well as the results from different spectral tests. An individual confidence flag is assigned to each single-pixel test and is a function of how close the observation is to the threshold. The individual confidence flags are combined to produce the final cloud mask flag for the output file. The algorithm is further divided into several conceptual domains (e.g. daytime ocean) according to surface type and solar illumination. Each domain defines a processing path through the algorithm, which in turn defines the spectral tests performed and associated thresholds. Different cloud conditions are detected by different tests. Spectral tests which find similar cloud conditions are grouped together. The groups are arranged so that independence between them is maximized (Ackerman, et. al., 1998)

The MODIS cloud top properties algorithm retrieves cloud top pressure, temperature, effective emissivity, and thermodynamic phase. The CO_2 slicing algorithm (pressure, temperature, emissivity) uses the differences in longwave infrared (> 13 microns) cloud absorption, while the phase algorithm component utilizes differences in ice and water absorption between 8 and 12 microns. Utilizing the 8-11 micron and 11-12 micron brightness temperature differences, cloud phase can be discerned based upon the magnitude of the differences (Frey, et. al., 1999).

The MODIS atmospheric profiles algorithm retrieves vertical profiles of temperature and moisture, total column water vapor and ozone, and surface skin temperature. The algorithm is regression-based and uses clear-sly radiances measured by MODIS in day and night conditions over land and water. The regression coefficients are derived from a fast radiative transfer model with input profiles obtained from a global database of radiosonde measurements of temperature, moisture, and ozone (Seemann, et. al., 2003).

AIRS/AMSU/HSB Level-1 processing software is undergoing final beta testing at CIMSS in preparation for release in November, 2003. Combined MODIS/AIRS retrieval algorithms are being prototyped and tested. They will be available in a later release.

During the next year of IMAPP activities, the following work is planned:
Port new MODIS Level 2 science products to IMAPP including SST, Land Surface Reflectance, Aerosol Optical Depth, Cloud Optical Properties, Snow/Ice Detection
Release first version of AIRS/AMSU/HSB Level-1 processing software (in conjunction with NASA JPL).
Release AIRS Level 2 retrieval algorithm for combined AIRS/MODIS observations.

References:

Ackerman, S. A., K. I. Strabala, W. P. Menzel, R. A. Frey, C. C. Moeller, and L. E. Gumley, 1998: Discriminating clear sky from clouds with MODIS. *J. Geophys. Res.*, 103, D24, 32141-32157.
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Seemann, S. W, J. Li, W. P. Menzel, and L. E. Gumley, 2003: Operational Retrieval of Atmospheric Temperature, Moisture, and Ozone from MODIS Infrared Radiances. *J. Appl. Meteorol.*, 42, 1072-1091.

A13: Re-examining the Requirements on Field-Of-View Size for CrIS

Presenter: Hung-Lung Allen Huang

Hung-Lung Huang, Richard Frey, CIMSS,
University of Wisconsin-Madison,
W. L. Smith, Langley Research Center, NASA,
and H. Bloom, Integrated Program Office, NOAA

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) is expected to become a vital part of the long-term global earth-atmosphere observing system. The NPOESS's advanced infrared sensor, the Cross-track Infrared Sounder (CrIS) will provide most of the atmospheric profile information on temperature and water vapor, under both clear and cloudy conditions, for the next twenty years.

One of the recommendations of the advanced sounders group within the International TOVS Working Group (ITWG) at 12th International TOVS Study Conference (ITSC) states, "ITWG encourages NOAA to re-examine the requirements on field-of-view size of CrIS". It is this recommendation that provides the motivation for the work presented here.

Currently the CrIS field-of-view (FOV) size requirement is set at approximately 14 km at satellite nadir view. The current Atmospheric InfRared Sounder (AIRS), aboard NASA's polar-orbiting EOS–Aqua satellite, has a 13.6 km nadir FOV. At this FOV size, using AIRS as an example, more than 90% of measurements will be cloud contaminated and major processing efforts will involve not only time consuming cloud detection and cloud clearing, but will also degrade measurement performance (higher data noise) and lose valuable spatial resolution.

Theoretically, a finer spatial resolution (smaller FOV size) will enable improved sounding through broken clouds. In this paper we use sounding and imaging data from NPOESS' surrogate, AIRS and MODIS, to demonstrate that a smaller CrIS FOV can achieve improved sounding performance and also reduce processing demands. Based on our findings we will be recommending a 8 km or smaller CrIS FOV (at satellite nadir) to the advanced sounder working group during the 13th ITSC meeting.

A14: MODIS Cloud Mask: Results and Validation

Presenter: Steve Ackerman

S.A. Ackerman[1], R. Frey[1], W. P. Menzel[2], K. Strabal[1], C. Moeller[1], J. Key[1], L. Gumley[1] and D. Tobin[1]

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Clouds are a crucial component in all meteorological and climate models. MODIS makes it possible to improve upon the existing remote sensing studies by identifying clouds more reliably with a multi-spectral approach at high spatial resolution. The MODIS Cloud Mask aims to minimize the potential errors in retrieval algorithms resulting from cloud contamination by labeling every pixel of data as either *confident clear*, *probably clear*, *uncertain*, or *cloudy*. Cloud masking from the MODIS observations are produced routinely and distributed to the earth system scientists. .

The MODIS cloud mask classifies each pixel as either *confident clear*, *probably clear*, *uncertain*, or *cloudy*. The cloud mask algorithm (Ackerman et al, 1998) uses a series of threshold tests to detect the presence of clouds in the instrument field-of-view. Designed to operate globally during the day and night, the specific tests executed are a function of surface type, including land, water, snow/ice, desert, and coast, and solar illumination. Each cloud detection test returns a confidence level that the pixel is clear ranging in value from 1 (high confidence clear) to 0 (low confidence clear). Tests capable of detecting similar cloud conditions are grouped together and a minimum confidence is determined for each group as follows:

$$G_{j=1,N} = \min[F_{i,j}]_{i=1,m},$$

where F_i is the confidence level of an individual spectral test, m is the number of tests in a given group, and N is the number of groups (e.g. five). The final cloud mask (Q) is then determined from the product of the results from each group,

$$Q = \sqrt[N]{\prod_{i=1}^{N} G_j} .$$

This approach is clear-sky conservative in the sense that if any test is highly confident that the scene is cloudy ($F_i = 0$), the final clear sky confidence is 0. The four confidence levels included in the cloud mask output are: (1) *confident clear* ($Q > 0.99$); (2) *probably clear* ($Q > 0.95$); (3) *uncertain* ($Q > 0.66$); and (4) *cloudy* ($Q \leq 0.66$). For many regions of the globe, the *uncertain* classification can be considered *probably cloudy*. For comparison with the expert analysis, confident clear and probably clear are considered clear pixels and the uncertain and cloudy confidences are labeled as cloudy.

The paper will present the latest updates to the MODIS cloud mask, results from this cloud detection algorithm, and along with validation using ground based, aircraft and other satellite instruments.

A15: Measurements of Stratospheric Volcanic Aerosol Optical Depth from NOAA/TOVS Observations

Presenter: Clémence Pierangelo

Clémence PIERANGELO[1], Alain CHEDIN[1], Patrick CHAZETTE[2]
[1]LMD-IPSL, Palaiseau, France,[2]LSCE-IPSL, Gif-sur-Yvette, France

We show that infrared optical depth of stratospheric volcanic aerosols produced by the eruption of Mount Pinatubo in June 1991 may be retrieved from the observations of the High resolution Infrared

Radiation Sounder (HIRS-2) onboard the polar meteorological satellites of the National Oceanic and Atmospheric Administration (NOAA).

Evolution of the concentration in time and in space, in particular the migration of the aerosols from the tropics to the Northern and Southern Hemispheres are found consistent with our knowledge of the consequences of this eruption. The method relies on the analysis of the differences between the satellite observations and simulations from an aerosol-free radiative transfer model using collocated radiosonde data as the prime input. Thus, aerosol optical depths are retrieved directly without making assumptions about the aerosol size distribution or absorption coefficient.

A reanalysis of the almost 25 years archive of NOAA/TIROS-N Operational Vertical Sounder (TOVS) observations has considerable promise for an improved knowledge of the atmosphere loading in volcanic aerosols.

A16: Retrieving dust aerosol optical depth and altitude using AIRS data

Presenter: Clémence Pierangelo

Clémence PIERANGELO, Alain CHEDIN, Cyril CREVOISIER, Sylvain HEILLIETTE, Raymond ARMANTE, Claudia STUBENRAUCH, Noëlle A. SCOTT
LMD-IPSL, Palaiseau, France

We show that the recently launched Advanced InfraRed Sounder (AIRS) is able to retrieve both the optical depth and the altitude of dust aerosols over ocean. The very high resolution of AIRS channels (about 1cm-1) requires a line-by-line radiative transfer code, and the presence of the aerosol requires to consider scattering effects. Therefore, we developed a radiative transfer code coupling a line-by-line model (Automatized Atmospheric Absorption Atlas : 4A) and a discrete ordinate method (DISORT). Simulations show that the decrease in brightness temperature may reach 10 K for some channels. This effect increases with the aerosol optical depth and altitude of the layer. As these variations depend on the channel considered, we aim at retrieving both the altitude and the optical depth, using a well-chosen subset of ten to twenty channels and Look-up-Tables. Dust events over the ocean have already been detected and first retrievals will be presented at the time of the meeting. Further studies are being undertaken to retrieve separately dust loading and spectral infrared optical depths. Through the variations of spectral infrared optical depths, we should improve our knowledge of the spectroscopy and chemical composition of the dust aerosol.

A17: A Fully Operational Near Real-Time AIRS Processing and Distribution System: Level 2 Products

Presenter: Walter Wolf

W. Wolf(1), M. Goldberg(2), and L. Zhou(1)

(1) QSS Group Inc, Lanham, MD, USA
(2) NOAA/NESDIS/STAR, Camp Springs, MD, USA

A near real-time AIRS/AMSU/HSB processing and distribution system is fully operational at NOAA/NESDIS/STAR. Level 1B radiances and brightness temperatures have been distributed to Numerical Weather Prediction Centers since October, 2002. These data have been placed into BUFR format and distributed through the NOAA CEMSCS server. The AIRS Level 2 products, temperature, water vapor, ozone, and surface products, are planned to be released to the public during late summer or early fall of 2003. NOAA plans to place the Level 2 products into BUFR format and distribute this data to the user community. Details of the data formats, along with the processing and distribution of the AIRS products will be presented.

A18: Application of Principal Component Analysis to Near Real-Time AIRS Channel Monitoring, Data Compression, Noise Filtering, and Atmospheric Retrievals

Presenter: Lihang Zhou

L. Zhou (1), M. Goldberg(2), and W. Wolf(1)

(1) QSS Group Inc, Lanham, MD, USA
(2) NOAA/NESDIS/STAR, Camp Springs, MD, USA

The Atmospheric InfraRed Sounder (AIRS) is the first high spectral resolution infrared sounder that provides accurate atmospheric soundings at high vertical resolution. Principal component analysis (PCA) has been used as an effective tool to store the information from the 2000 plus AIRS channels in a compressed format. AIRS individual channels can be reconstructed with minimal signal loss, using about 80 eigenvectors. A web site has been developed where the quality of the AIRS reconstructed radiances can be monitored in conjunction with the individual channel quality information. Details on the application of PCA to AIRS data, including the

generation and application of eigenvectors, the use of PCA for data compression, quality control, noise filtering and estimation, and the PCA monitoring web site will be presented. The use of PCA for the regression retrieval of atmospheric parameters, such as temperature, moisture and ozone profiles, and surface skin temperature, surface emmisivity, etc., will also be discussed.

A19: First Comparison of Radiances Measured by AIRS/AQUA and HIRS/NOAA-17

Presenter: Pubu Ciren

Pubu Ciren, QSS GROUP Inc. Maryland, U.S.A.
and Changyong Cao, NOAA/NESDIS/STAR, U.S.A.

The operational High Resolution Infrared Radiation Sounder (HIRS) has been flown on all NOAA satellites for more than two decades. An independent and objective evaluation of its calibration accuracy is highly desirable for both weather and climate applications. The Atmospheric Infrared Sounder (AIRS) onboard the recently launched AQUA satellite, with hyper-spectral resolution covering most of the HIRS spectral channels, provides such a unique opportunity for evaluating the calibration accuracy of HIRS. In this study, we present for the first time the comparisons of radiances measured by HIRS with those convolved from coincidental AIRS measurements on both collocated pixel level and grid level. The study is based on publicly released AIRS data from March to July, 2003. Preliminary results, including agreements and discrepancies between the measurements from these two instruments are presented.

A20: On the use of Planck-weighted transmittances in RTTOV

Presenter: Pascal Brunel

P. Brunel, F. Chevallier, D.S. Turner and M. Szyndel

Several fast radiative transfer models including RTTOV assume that the Planck function does not depend on wave number when integrating over the width of a satellite filter function. This approximation is less valid for wide spectral bands, like the Meteosat water vapour channel. In the operational weather centres, that error is partly corrected downstream in a bias-correction scheme.

This paper presents an alternative approach, where the model regression predicts convolved transmittances that are weighted by the Planck function. The method is applied to RTTOV. Results are presented comparing the performance of the model to reference line-by-line computations and to real satellite observations.

A21: A comparison of RTTOVSCATT and ARTS with AMSU-B observations using Met Office mesoscale model short range forecasts of ice water profiles

Presenter: Stephen English

T. R. Sreerekha, Claudia Emde, Stefan Buehler,
Univ. of Bremen, Germany and

Una O'Keeffe, Stephen English
Met Office, United Kingdom.

Modelling of emission from liquid water and precipitation has made significant progress in recent years, but the errors of scattering models for ice clouds are not well documented. In this paper the ability of two independent models, ARTS and RTTOVSCATT to simulate AMSU-B is examined. RTTOVSCATT uses a simple delta-Eddington solution to the radiative transfer equation, , whereas ARTS uses a successive order of scattering method in discrete ordinates, with a full treatment of polarisation. NWP background fields of temperature, humidity, cloud water and ice are taken from very short range forecasts (less than six hours) of the Met Office mesoscale model. These are colocated in time and space to the AMSU-B measurements for a number of case studies. Initial results are encouraging with similar broadscale features in the ARTS simulations and AMSU-B observations, although very large ice crystals need to be assumed to be present in significant numbers to explain the magnitude of observed brightness temperature depression for AMSU-B. The poster will present latest results of the intercomparison.

A22: How good are current emissivity models?

Presenter: Stephen English

Stephen English
Met Office, United Kingdom

It is generally agreed that assimilation of radiances which are sensitive to the surface (ocean, land, ice) requires knowledge of surface emissivity. This can either be provided by a model relating emissivity to geophysical variables, or an atlas of emissivity itself at relevant frequencies. But how good does this emissivity need to be? How does this match up to current model performance (and how do we validate this)? What implications does this have for use of ATOVS in NWP? In this poster an analysis of emissivity errors derived from AMSU observations

(compared to NWP background) will be presented, using RTTOV/Fastem. It is concluded that Fastem-1 has an surface brightness temperature error equivalent to an error in emissivity of 1.5% over the ocean, which is not good enough to extract useful temperature information from AMSU channels 4 and 5, except near the edge of the scan. The major sources of error are discussed. A similar analysis is shown for other surface types.

A23: Two fast forward radiative transfer models dedicated to the AIRS instrument and comparison to AIRS observations.

Presenter: Cyril Crevoisier (for Sylvain Heilliette)

Sylvain Heilliette, Alain Chedin, Noëlle Scott, Raymond Armante and Cyril Crevoisier
Laboratoire de Météorologie Dynamique
Ecole Polytechnique- 91128 Palaiseau Cedex (France)

The launch of the high spectral resolution Advanced Infrared Sounder (AIRS) on board of EOS-Aqua opens promising perspectives for remote sensing applications as the improvement of temperature and water vapor profile retrieval or retrieval of greenhouse gases (CO_2, N_2O and CH_4 for example). The availability of a forward radiative transfer model is the key to all these applications. Fast line-by-line models like the Automatized Atmospheric Absorption Atlas (4A) model are able to produce accurate results but remain too slow for the treatment of huge amount of data from this new instrument. In order to fill this gap, we have developed two hyperfast codes devoted to the simulation of a reduced set of 324 AIRS channels distributed by NESDIS. These two models rely on the availability of the TIGR-AIRS dataset of brightness temperatures, transmission functions, temperature and gas mixing ratio analytical Jacobians, calculated for all the atmospheric situations of the TIGR thermodynamic database using our fast line-by-line model 4A. The first model is based on a multilayer perceptron trained using supervised learning techniques on the TIGR-AIRS database as the learning set. The second model is based on thermodynamic profile pattern recognition in the TIGR database and linearization of the radiative transfer equation. Computation time is of the order of 0.02 sec/atmosphere for the neural network approach and of 0.2 sec/atmosphere for the pattern recognition approach. The advantages and drawbacks of these two different approaches are presented. As an example of application, we show bias calculations between real AIRS observations and simulated brightness temperatures using ECMWF analyses and radiosonde measurement as input thermodynamic profiles.

A24: Intercomparison of fast radiative transfer models for AIRS simulations

Presenter: Roger Saunders

Roger Saunders, Met Office,
Jean-Luc Moncet (AER) and
Vanessa Sherlock (NIWA)

Since the launch of Aqua in May 2002 several fast radiative transfer models have been developed to rapidly compute AIRS radiances and their jacobians for data assimilation and retrieval applications. At the Workshop on Sounding from High Spectral Resolution Infrared Observations at Madison, Wisconsin on 6-8 May 2003 it was agreed to set up an intercomparison under the ITWG of RT models which can simulate AIRS radiances. This paper presents some initial results from at least 3 models. Both forward model computations for all AIRS channels and calculations of Jacobians for a selection of AIRS channels will be presented. It is hoped that more models will be included in the intercomparison in time.

A25: Observation of Solar radiation reflected by land surfaces from the GOES-8 sounder IR spectral measurements over continental USA

Presenter: Youri Plokhenko

Youri Plokhenko[#] and W. Paul Menzel[&]

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The quantitative estimation of temperature and moisture vertical profiles is based upon the numerical solution of the radiative transfer equation (RTE). The associated inverse problem is ill posed. The accuracy of atmospheric parameters retrieved from IR measurements depends on the measurement accuracy and accurate definition of the measurement model.

The effect of surface emissivity (SE) on IR broad band spectral measurements (GOES-8) is discussed. SE variations cause measurable changes in infrared radiances. Disregarding the spectral-spatial variations of SE in the RTE magnifies the errors. Different types of surface cover, with different surface optical properties and extremely high spatial and temporal variations, restrict the use

of a priori estimates of SE. A model accounting for SE and an algorithm of solution are presented. The solution includes SE, the surface temperature, and the temperature-moisture profile. Results over land (continental USA) are discussed. Spatial-temporal distributions of SE estimates in longwave and shortwave spectral bands are presented.

For daytime the solar reflected component in the 3.8 –4.6μ band (5 channels) is estimated for cloud free conditions using a priori SE estimates (nighttime) and surface temperature, atmospheric temperature-moisture profiles estimates derived from spectral measurements in longwave band 6.5-7.5μ (3 channels) and 11-14.7μ(8 channels). A ratio of the bi-directional reflection function for a 1-hour time increment (variable solar angle under fixed satellite measurement geometry) for each pixel of the measurement matrix (195*315) is estimated. The temporal-spatial analysis of the bi-directional reflection function ratio indicates a significant anisotropy in the spatial-angle distribution of surface reflection for broad band spectral measurements with spatial averaging about 900–2500 km*km: forward scattering is significantly larger than back scattering; scattering is an increasing function of solar altitude angle in the back plain and a decreasing function of solar altitude angle in the forward plain.

Results show that in satellite remote sensing the applicability of the Lamberthian surface to model the downwelling IR flux reflection of real land surface will be very limited.

A26: Estimation of Coupling Between Mobile Vehicular Radars and Satellite Radiometers

Presente: Albin Gasiewski

Albin J. Gasiewski and Valery U. Zavorotny
NOAA Environmental Technology Laboratory, Boulder, CO USA

It has recently been proposed by the automotive industry that wideband vehicular collision avoidance radar be developed at a frequency centered at approximately 24 GHz. Coupling of emissions from such radar systems into passive microwave satellites can impart significant interference to earth remote sensing applications in the bands between 22 and 27 GHz, and in particular in the 23.6-24.0 band allocated on a primary basis to the passive Earth Exploration Satellite Service (EESS) [1]. One of the most obvious coupling mechanisms between mobile vehicular radar and a satellite radiometer is reflection of the main lobe of the radar by another directly-illuminated vehicle toward the main lobe of the radiometer. Since vehicular radars will commonly illuminate another close-in leading vehicle it is believed that such scattering scenarios will be commonplace.

In order to estimate the interference from a collection of such vehicular radars to a passive microwave satellite (such as the NOAA AMSU or future NPOESS ATMS and CMIS sensors) we performed both numerical simulations to determine the system coupling coefficient C_{sm}, defined as ratio of the angular power density at the radiometer for the reflected beam to the main lobe angular power density on the axis of the vehicular radar. The single reflection mechanism taken into account is that from the rear window of the leading vehicle, suspected to be the primary element that would provide interference at the angles of the radiometer receiving antenna.

The cases we consider show that reflection of radiation from vehicular radars from the rear windows of automobiles can impart a significant degree of coupling (-10 to -20 dB) with space-borne radiometers. Additional scattering can be expected from other nearby objects such as trees and the tilted roofs of buildings. Discussed will be the expected impact on satellite radiometry for weather and climate observation.

References [1] A. J. Gasiewski, W. Wiesbeck and C. S. Ruf, "Impact of mobile radar and telecommunications systems earth remote sensing in 22-27 GHz range," *Technical Assessment by the IEEE GRSS Technical Committee on Frequency Allocation in Remote Sensing (FARS)*, April, 2002.

A27: Geosynchronous Microwave Observation System Simulation

Presenter: Albin Gasiewski

Albin J. Gasiewski[1], Boba Stankov[1], Alexander Voronovich[1],
Bob L. Weber[2], Marian Klein[3], and Jai-Wen Bao[1]

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[2] Science and Technology Corporation and NOAA/ETL, Boulder, CO, USA
[3] University of Colorado/NOAA-CIRES, Boulder, CO, USA

Passive microwave sounding and imaging from geosynchronous orbit was first studied in the mid-1970's, although initial proposals using microwave channels at ~183 GHz and lower frequencies required prohibitively large antennas. In 1992 it was proposed that submillimeter-wavelength channels could be used for many of the sounding and cloud/precipitation imaging applications that

previously were believed to require the use of microwave channels. The capabilities of submillimeter-wave channels for precipitation imaging were further demonstrated in 1994 using airborne imagery of clouds at the 325 GHz water vapor band. These studies suggested that the antenna costs for geosynchronous microwave precipitation imaging and temperature and moisture sounding can be significantly reduced while retaining good spatial resolution by using key submillimeter-wavelength water vapor and oxygen bands. Accordingly, the current Geosynchronous Microwave (GEM) Sounder/Imager concept is based on a ~2-3 meter center-fed reflector antenna and fast-scanning subreflector. An alternate concept for gesynchronous microwave sounding and imaging (GeoSTAR) has been proposed based on synthetic aperture techniques, and would ostensibly be able to provide similar resolution using bands at 50-56 and 183 GHz.

In this poster we illustrate a means for assessing the precipitation retrieval capabilities of GEM vis-à-vis GeoSTAR using an observation system simulation for a landfalling hurricane event (Hurricane Bonnie, August 1998). The system simulations are based on 6-km resolution, 50-level microphysical cloud data obtained from MM5 model runs for Hurricane Bonnie using the Reisner five-phase microphysical cloud model. A unique fast forward radiative transfer model based on the discrete-ordinate (DO) method and incorporating both scattering effects and fast calculation of the Jacobian of the forward transfer model is used to compute observed brightness temperature fields and their derivatives. Discussed will be the accuracy of rain rate and cloud liquid and ice water content retrievals.

A28: Japanese advanced meteorological imager (JAMI): design, characterization and expected on-orbit performance

Presenter: Jeffrey Puschell

Jeffery J. Puschell et al.
Raytheon Santa Barbara Remote Sensing

The Japanese Advanced Meteorological Imager (JAMI) was developed by Raytheon and delivered to Space Systems/Loral as the Imager Subsystem for the Japanese MTSAT-1R system. Detailed characterization tests show JAMI meets all MTSAT-1R requirements with margin using a compact, efficient instrument architecture.

A29: Optimization and evaluation of interpolated ATMS and CMIS data

Presenter: John Galantowicz

John Galantowicz, Alan Lipton, and Jean-Luc Moncet
AER Inc.

Interpolation of microwave sensor data is needed both to create effective footprint shapes that match other channels and sensors (e.g., ATMS to Crosstrack Infrared Sounder, CrIS, field-of-regard) and to collocate sample centers. In many cases--for example, when the interpolation increases footprint size relative to the native sensor footprint--the process may also produce composite samples with lower effective radiometric noise than the sensor. Optimal interpolation methods like those derived from the Backus-Gilbert approach provide various mechanisms through which the user tries to control the composite sample effective shape, location, and noise properties. It is left to the user, however, to judge the qualities of the results and use them to make the necessary trade-offs regarding spatial sampling and radiometric noise. Using results from footprint matching exercises for CMIS (Conical Microwave Imager Sounder) and ATMS (Advanced Technology Microwave Sounder), we will describe techniques for defining this trade-space and evaluating composite sample spatial and radiometric qualities. Considerations include sub-resolution horizontal scene variability and spatial noise, vertical profile retrieval resolution, geolocation accuracy, and the costs of artificial resolution enhancement.

POSTER SESSION B: FRIDAY

B01: An operational AVHRR cloud top temperature and height retrieval and its validation

Presenter: Adam Dybbroe

Adam Dybbroe (SMHI), Sauli Joro (FMI), Aarno Korpela (NIWA), Anke Thoss (SMHI)

Within the Eumetsat Satellite Application Facility (SAF) project to support Nowcasting and Very Short Range Forecasting (NWCSAF) SMHI has developed algorithms and software to extract four cloud and precipitation products from AVHRR data. A cloud top temperature and height (CTTH) product from polar satellite data is useful in aviation forecasting and in the early warning of thunderstorm development. But in addition to Nowcasting the AVHRR CTTH will also be used for climate applications through the Climate Monitoring SAF.

The CTTH is derived in both opaque and semi transparent cloudiness. The opaque retrieval assumes the cloud to be black and is using a colocated NWP

model profile and forward radiative transfer model calculations to compensate for absorption above the cloud. The semi-transparency retrieval uses a histogram correction method using the AVHRR 11 and 12 micron window channels, based on the work of Inoue (1985) and Derrien et al. (1988).

The objective validation of satellite derived cloud top height is a challenging task. Direct measurements require expensive measurement campaigns using aircrafts, and are thus scarce. In addition the often used ground based remote sensing techniques as provided by Lidars usually have difficulty detecting high thin cirrus and also requires the cloudfield to be single layered.

In our attempt to objectively validate the NWCSAF AVHRR based CTTH retrieval we have used operational radar data from a network of C-band weather radars over Finland, capable of giving reliable estimates of the height of ice clouds, including thin cirrus. A significant advantage of weather radars are their good areal coverage (at least in Scandinavia) and their high temporal and spatial resolution. Weather radars provide the possibility for a large validation dataset, and data can be collocated in time and space with the satellite data with a high accuracy avoiding the necessity for critical assumptions to account for possible deviations.

B02: An AMSU-HIRS-AVHRR data extraction and re-mapping tool

Presenter: Adam Dybbroe

Adam Dybbroe, Anders Henja, Anke Thoss and Karl-Göran Karlsson (SMHI)

A software tool, the AMSU-HIRS-AVHRR mapping library (AHAMAP), to read and re-map AMSU, HIRS, and AVHRR level 1 data of the NOAA satellites have been developed at SMHI. AHAMAP is coded in C and Python. It reads AMSU-A, AMSU-B and HIRS data following the AAPP level 1c format, AVHRR data in AAPP level 1b format, as well as AVHRR data from the archive of NOAA Local Area Coverage (LAC) data of both the old and new (KLM series) NOAA satellites.

Upon extraction of the satellite data, AHAMAP is able to re-map the data to a user defined map projection. AHAMAP performs the calibration and navigation of the satellite data, using only the calibration and navigation information appended in the level 1 data files. The earth mapping is done using the Cartographic projection library version 4 (PROJ.4) originally written by Gerald Evenden of the USGS.

As the AAPP AVHRR level 1b and the NOAA LAC data only provides positional (longitude and latitude) information for every 40th pixel in the scanline, and for every 20th scanline in the case of AAPP, much interpolation and extrapolation is needed. We employ 3rd order lagrangian interpolation and 5th order lagrangian extrapolation.

The high level interpreted programming language Python provides an easy user interface, where the extraction, interpolation/extrapolation and re-mapping of channel data and sun- and satellite viewing angles can be done in only three lines of code:

```
>>> import avhrr
>>> this=avhrr.avhrr('hrpt.l1b') # Level 1b data read
>>>
that=this.build_all('southsweden',{'channels':range(5)
,'azimuth':1,'solar':1,'satellite':1}) # Interpolcation
and remapping
>>>
that.data[3].data[0,0]*that.info['ir_gain']+that.info['ir
_intercept'] # Ex: channel 4 Tb value of upper left
corner of area
255.26
```

AHAMAP is licensed under the GNU Lesser Library General Public License (http://www.gnu.org) and can be obtained from SMHI by emailing one of the authors.

B03: The ATOVS and AVHRR Product Processing Facility for EPS

Presenter: Dieter Klaes

Dieter Klaes, Jörg Ackermann, Rainer Schraidt, Tim Patterson, Peter Schlüssel, Pepe Phillips, Arlindo Arriaga, and Jochen Grandell

The ATOVS/AVHRR Product Processing Facility (PPF) of the EPS (EUMETSAT Polar System) Core Ground Segment comprises the Level 1 processing of the data from the ATOVS sounding instruments AMSU-A, MHS and HIRS/4, and the imager AVHRR/3 into calibrated and navigated radiances. A second component includes the level 2 processing, which uses as input the level 1 products of the aforementioned instruments. The specification of the PPF is based on two well-known and well-established software packages, which have been used by the international community for some years: The AAPP (ATOVS and AVHRR Pre-processing Package) and ICI (Inversion Coupled with Imager). The PPF is able to process data from instruments flown on the Metop and NOAA satellites. For the level 1 processing of the sounding instruments' data

(HIRS, AMSU-A and MHS), the basic functionality of AAPP has been kept; however, the individual chains for each instrument have been separated and additional functionality has been integrated. For HIRS a global calibration, as performed by NOAA/NESDIS today, has been included. For AMSU-A and MHS the moon contamination of the calibration space view can be corrected for. Additional functionality has also been included in the AVHRR processing. In particular, an enhanced navigation by landmark processing has been implemented to ensure accurate geo-location. Additionally, the PPF can digest and process the global AVHRR data either at full pixel resolution (1 km at nadir), which is the nominal mode for the Metop processing, or at the reduced resolution of the NOAA/GAC (Global Area Coverage) data (about 4 km resolution at nadir). For the level 2 processing the ICI had to be modified to include the most recent improvement in fast radiative transfer modelling as included in the RTTOV-7. As a first step towards the realisation of the PPF a prototype has been generated for the purpose to help specifying the details of the PPF, and for verification of the latter by generation of reference and test data. The prototype is able to process HRPT data, GAC data from the NOAA satellite active archive (SAA), and also Local Area Coverage (LAC) data. GAC data processing means that the processing of whole orbits is possible. Current work is aimed to assess the quality of the Level 2 retrievals and to generate reference test data for the operational PPF.

B04: ATOVS Operational Products and the Satellite Upper Air Network (SUAN)

Presenter: Tony Reale

Tony Reale
NOAA/NESDIS
Washington DC 20233

The current configuration of NOAA operational polar satellites consists of NOAA-15, 16, and 17, each deploying the Advanced TIROS Operational Vertical Sounder (ATOVS) instrument configuration. ATOVS which consists of the 15-channel Advanced Microwave Sounding Unit-A (AMSU-A), the 5-channel AMSU-B, the 20-channel High-resolution Infrared Radiation Sounder (HIRS/3), and the 6-channel Advanced Very High Resolution Radiometer (AVHRR/3). The following poster summarizes the current status of the operational ATOVS (and AMSU-B) derived sounding products distributed by NESDIS to national and international users. This is done through a brief review of the scientific processing algorithms, statistical results, and a series data cases based on requests that have been received from the user community over the past 18 months. Planned upgrades of the scientific algorithms and products to better meet current and future user requirements particularly in the areas of numerical weather prediction and climate are also presented.

One of the major areas of concern for users that has evolved with the more widespread use of these data particularly is the problem of absolute scientific calibration and validation of polar satellite radiometers and derived products, and the lack of a dedicated global program to provide such data. This has resulted in a serious problem concerning the identification and removal of systematic bias and uncertainty in the long-term record of satellite data, as well as with the current data measurements being received. Over the past year or so several user groups from the climate, NWP and satellite community have acknowledged this problem and have recommended that the requirements for the global radiosonde network be expanded to include a subset or radiosondes coincident with satellite overpass. Such groups include the **NOAA Council on Long-term Climate Monitoring (CLTCM)** in January 2003, and later in March a "**Workshop to Improve the Usefulness of Operational Radiosonde Data"** was held at the National Climatic Data Center (NCDC) in Asheville, both forwarding specific recommendations for establishing special radiosonde sites to provide reference radiosondes coincident with overflying (polar) satellites for absolute scientific calibration of global satellite measurements, atmospheric temperature and moisture, and associated scientific algorithms. The poster concludes with a summary of recent activities to establish a preliminary network of candidate Satellite Upper Air Network (SUAN) sites.

B05: Working Group for Satellite Sounding Science and Products (SSSP)

Presenter: Tony Reale

Tony Reale
NOAA/NESDIS
Washington DC 20233

Lydie Lavannant
Meteo-France/DP/CMS
Lannion, France

Leanne Avila
CIMSS
Madison, WI

At the 11th International TOVS Study Conference (ITSC-XI, Budapest, 2000), the Working Group (WG) on Satellite Sounder Science and Products

(SSSP) was formed to promote the importance and continued development of scientific techniques for deriving environmental products from operational (and research) weather satellites. The focus of the WG is mainly on polar orbiting satellites (given their global coverage), but combined polar and other (i.e., GOES, GPS) platforms are also of interest. The primary objective is to facilitate better communication and collaboration among scientists within the international research and operational communities by providing a central location for information dissemination and exchange, thus creating a forum for addressing scientific algorithms and products from operational and research weather satellites, and to promote scientific exchange among the international group of researchers and product developers.

One action of the ITWG/SSSP was to create a new SSSP web site now available through the ITWG web site (http://cimss.ssec.wisc.edu/itwg/sssp/) to serve as the focal point for promoting correspondence and comparisons among scientists working in the product derivation area. The site provides users the opportunity to register their work by actively seeking scientific product developer inputs to register their work by providing to us a brief summary (or abstract), associated graphic, and web site link (if available). Topics for contributions include Products and Science (ie, soundings, wind, clouds...Level 1,2,3...), Scientific Processing Packages (ie, AAPP, OPTRAN, 1DVAR, etc), Satellite Instrument Health, and Direct Broadcast issues.

The longer term goals of the WG/SSSP will be to report to the ITWG on the current status of derived products and scientific algorithms, the progress made since the last ITSC meeting, perceived areas of strengths and weaknesses, and recommended actions.

The following poster presents the SSSP web site, current contribution and ongoing issues.

B06: Satellite-based Precipitation Analysis in Support of Nowcasting Applications

Presenter: Ralf Bennartz

Ralf Bennartz
Atmospheric and Oceanic Sciences
University of Wisconsin, Madison, Wisconsin, USA

Anke Thoss, Adam Dybbroe, Daniel B. Michelson
Swedish Meteorological and Hydrological Institute (SMHI)
Norrköping, Sweden

Within the framework of EUMETSAT's Nowcasting Satellite Active Facility (SAF) new satellite-based applications for nowcasting and very short range forecasting are being developed. We describe a method to remotely sense precipitation and classify its intensity over water, coasts, and land surfaces. This method is intended to be used in an operational nowcasting environment. It is based on data obtained from the Advanced Microwave Sounding Unit (AMSU) onboard NOAA-15/16/17. Each observation is assigned a probability of belonging to four classes: precipitation-free, risk of precipitation, precipitation between 0.5 and 5 mm/h and precipitation higher than 5 mm/h. Since the method is designed to work over different surface types, it relies mainly on the scattering signal of precipitation-sized ice particles received at high frequencies.

With the successful launch of Meteosat Second Generation (MSG) additional opportunities in precipitation nowcasting arise from the combination of multispectral MSG observations with polar orbiting passive microwave sensors. We will present first results of precipitation classifications using combined AMSU/MSG-SEVIRI observations.

B07: Monitoring Climate Change using Satellites: Lessons from the MSU.

Presenter: Peter Thorne

Simon Tett & Peter Thorne

Hadley Centre for Climate Prediction and Research, Met Office, UK

Monitoring climate change from an in situ network is difficult due to instrument changes, random errors, and other inhomogeneities. Doing so from satellites is much more difficult. Experience with in-situ networks implies that for observational error to be neglected it should be less than 10% of the expected climate signal. Errors of more than about 50% are too large to sensibly validate model predictions. An error analysis of deep-layer temperatures produced by University of Alabama, Huntsville (UAH) from the MSU instruments flown on several operational weather satellites shows that the largest contribution to observational error for the 21-year trend arises from inter-satellite bias adjustment. However, uncertainties in the corrections arising from the temperature of the instrument were non-negligible.

Recently Remote Sensing Systems (RSS) have produced an alternative analysis to that of UAH. Differences between the two for the "MT" product exceed their respectively estimated error bounds and arise mainly from differences in the corrections for instrument body temperature

associated with NOAA-9. The availability of two independently produced versions permits study as to the sensitivity to processing choices. Clearly for other products this may not be possible so it is important that we fully investigate the causes of differences to learn lessons for future climate satellite applications.

These findings support the recommendations of several published reports (e.g. NRC2001) which address the use of satellite data for climate research:

(1) Satellite overlaps should be a minimum of two years in length, implying ``launch-on-schedule'' rather than ``launch on failure''
(2) instruments require extensive and better pre-launch calibration at a level which can support climate trend evaluation for example to avoid corrections for the instrument body temperature
(3) on-board monitoring of instrumentation
(4) minimal east-west spacecraft drift to avoid aliasing the diurnal cycle
(5) maintenance of spacecraft altitude with on-board propulsion.

If since 1979 AMSU instruments had been flown with two-year overlaps, an instrument lifetime of five years and stable orbits then the error in tropical deep-layer temperatures would be about 0.02 K/decade. This is a considerable reduction in the approximate error of 0.1 K/decade from the instruments actually flown.

B08: Ongoing and planned activities in the usage of ATOVS AMSU A/B in the HIRLAM 3DVAR system at SMHI

Presenter: Per Dahlgren

Per Dahlgren
SMHI, Sweden

AMSU-A radiances over sea are soon to be operationally assimilated at SMHI.
The effects of more carefully selected data for bias correction are therefore important to study. One of our plans is to select bias correction data in the vicinity of soundings only. A further development in the use of AMSU-A data is to assimilate radiances over ice and land. Due to the importance and the non linear properties of surface skin temperature and surface emissivity, we will perform tests where these variables are included in the control vector. We also plan to use AMSU-B in our 3DVAR. So far, we have only done a literature survey in the matter. The first practical experiments are planned to the autumn of 2003.

B09: Use of ATOVS in the DMI-HIRLAM regional weather model

Presenter: Jakob Grove-Rasmussen

Jakob Grove-Rasmussen, DMI, and
Bjarne Amstrup (bja@dmi.dk), DMI

For years the positive impact of (A)TOVS measurements in global weather models has been well established, but the usefullness of the data in regional short range models has not been fully exploited.

The aim of this study is to explore the impact of AMSU-A data from NOAA16 and NOAA17 on the DMI-HIRLAM (Danish Meteorological Institute - HIgh Resolution Local Area Model), covering Europe, North America and the Atlantic Ocean. This study has become more relevant with the established EARS (EUMETSAT ATOVS Retransmission System) which enables the EUMETSAT member countries to receive ATOVS data within 30 minutes of observation over a large fraction of the DMI-HIRLAM region.

B10: Use of ATOVS data for operational atmospheric correction and surface irradiance calculations

Presenter: Marion Schroedter

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The German Remote Sensing Data Center (DFD) processes TOVS and ATOVS temperature and water vapour profiles on a routinely basis for all NOAA passes received by its facilities in Oberpfaffenhofen. TOVS profiles are retrieved with ITPP5.21 and ATOVS profiles with a combination of AAPP3.0 and IAPP2.0. All data sets are made available within the frame of the ISCU World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT, http://wdc.dlr.de).

From these level 2 data, value added products like gridded water vapour vertical column maps over Europe are generated operationally for different times of the day.

European maps of water vapour column are used at DFD mainly for atmospheric correction of remote sensing sensors measuring in the Visible and Near-Infrared like NOAA-AVHRR, IRS-LISS, Landsat7-ETM, and MODIS.

A new application serving the renewable energy industry is currently under development in the EC funded HELIOSAT-3 project: Solar irradiances are calculated from measurements of the SEVIRI instrument onboard the Meteosat Second Generation satellite. The retrieval of spectrally resolved products and the separation into the direct and diffuse radiation is aimed at. These data will be used for an optimized siting of concentrating solar thermal power plants and performance checks of solar energy systems. To describe atmospheric extinction, water vapour measurements from ATOVS are used during the development phase. Later it is aimed at using MSG derived water vapour directly, but ATOVS will still be used for quality checks and cross-comparisons.

B11: Simultaneous determination of continental surface emissivity and temperature from NOAA-10/HIRS observations. Analysis of their seasonal variations

Presenter: Soumia Serrar

A. Chédin, E. Péquignot, N. A. Scott, S. Serrar

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Continental surface infrared emissivity strongly depends on the frequency and on the type of the surface. Emissivity values as low as 0.7 may be observed around 8-10 µm or, at shorter wavelengths around 4 µm, particularly over desert regions. Satellite observations are very sensitive to emissivity variations, up to 0.5 K in brightness temperature at 11 µm for a variation as small as 0.01 of the emissivity. An accurate and coherent (simultaneous) determination of surface temperature and emissivity is essential to greatly improving the estimation of the longwave surface energy budget and, consequently, improving the performance of surface-atmosphere interaction models. Based on a space-differential approach and a non-linear regression inference method, 4 years of NOAA-10 observations (July 1987 to June 1991) over northern Africa (5N-30N and 20W-60E) have been interpreted in terms of surface emissivity at three wavelengths (channel 8 at 11.1 µm, channel 10 at 8.3 µm, and channel 18 at 4 µm) and surface temperature. Maps at the resolution of 1°x1° and one month will be shown. Time series of zonal means bring into evidence important seasonal variations. They are compared to time series of precipitations and Normalized Difference Vegetation Index (NDVI).

B12: A Comparison of AVHRR and HIRS Global Cloud Types

Presenter: Michael Pavolonis

Michael J. Pavolonis, CIMSS/SSEC/UW and
Andrew K. Heidinger, ORA/NOAA/NESDIS

In this study, global-scale radiometric cloud types from an extended version of the Clouds from AVHRR (Advanced Very High Resolution Radiometer) (CLAVR-x) software suite will be examined as they relate to low, mid, and high level cloud amounts derived from High Resolution Infrared Radiation Sounder (HIRS) measurements. The CLAVR cloud types include warm liquid water clouds, supercooled water clouds/mixed phase clouds, opaque ice clouds, non-opaque ice clouds, and multi-layered clouds. Monthly frequencies for each cloud type will be shown for the months of January and July. Of particular interest are regions containing multiple cloud layers since the presence of cloud overlap can greatly alter the retrieval of cloud top height and hence the derived low, mid, and high cloud amounts from the HIRS data. The cloud overlap algorithm employed in CLAVR has been shown to be capable of accurately classifying regions of cloud overlap on a global-scale.

B13: Comparison of IAPP and ICI Sounding Products at CIMSS

Presenter: Harold Woolf

Harold M. Woolf, Eva Borbas, Jun Li, Thomas Achtor,
Cooperative Institute for Meteorological Satellite Studies
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Lydie Lavanant and Guy Rochard
Meteo-France, SCEM, CMS, Lannion, France

The International ATOVS Processing Package (IAPP) and its predecessor, the International TOVS Processing Package (ITPP), have been developed at SSEC/CIMSS to retrieve atmospheric temperature and moisture profiles and other parameters in both clear and cloudy atmospheres from (Advanced) TIROS Operational Vertical Sounder (ATOVS/TOVS) radiance measurements. The software has been run operationally for NOAA TOVS and/or ATOVS Global Area Coverage data and direct broadcast (DB) data since the early 1990's. Meanwhile, another ATOVS/TOVS DB processing package, called Inversion Coupled with Imager (ICI), was developed by Meteo-France.

At SSEC/CIMSS the DB ATOVS data have been processed operationally in near real-time by both IAPP and ICI, since February 2001. The products are monitored on a daily basis and validated on the web site

http://cimss.ssec.wisc.edu/iapp_ici/

The poster will present comparisons, in both graphical and numerical forms, of the products of the two software packages.

B14: Influence of the first guess on mesoscale IAPP retrievals

Presenter: Harold Woolf

Harold M. Woolf, Wayne F. Feltz, and Thomas H. Achtor

The International ATOVS Processing Package (IAPP) has been run operationally since early 2002 for small areas (approximately +/- 4 degrees of latitude and longitude) centered on the Atmospheric Radiation Measurement (ARM) program Clouds and Radiation Testbed (CART) sites at Lamont, Oklahoma (36.6N 97.5W); Barrow, Alaska (71.3N 156.8W); and Nauru (0.5S 166.9E). These sites are customarily denoted Southern Great Plains (SGP); North Slope of Alaska (NSA); and Tropical Western Pacific (TWP), respectively. The retrievals are done twice, using (1) the built-in regression guess, and (2) profile information obtained from the National Centers for Environmental Prediction (NCEP) Aviation Model global analysis-forecast system.

Because of the extensive amount and variety of instrumentation operating at the SGP site, there is ample "ground truth" available, making it an ideal location for evaluation of retrieval methodology.

The poster will present comparisons of retrievals made with and without numerical weather prediction (NWP) first-guess information, and independent estimates of atmospheric state obtained from other sensors at the site.

B15: Operational Assimilation of GOES Water Vapor Imager Channel at MSC

Presenter: Nicolas Wagneur

Nicolas Wagneur and Louis Garand
MSC, Dorval, Quebec, Canada

The assimilation of radiance imager data at 6.7 micron (channel 3) was made operational in the Canadian Meteorological Center global 3Dvar analysis system in June 2003. The MSCFAST (Garand, 1999) physical radiative transfer model is used as forward operator. This addition was made concurrently with new AMSUB data. The improvement of adding independently GOES imager channel 3 on moisture analysis and forecasts is shown.

The monitoring suite of data treatment shows stable cardiograms of innovations. Also geographical maps of monthly averages of innovations show no viewing angle bias problems. These data are to be implemented in regional system as the new main frame computer will become operational. Work is under way in order to include recently activated GOES-12 satellite.

B16: Global maps of microwave land surface emissivities for weather forecast

Presenter: Frédéric Chevallier

Catherine Prigent, Frédéric Chevallier, Peter Bauer and Jean-Noel Thépaut

Significant uncertainties still affect the estimation of microwave surface emissivity over land and hamper the assimilation of surface-sensitive microwave channels. Several approaches are being investigated for AMSU-A and are presented. On the one hand, top-down methods estimate the emissivity based on independent (i.e. not assimilated) satellite measurements, for instance SSM/I data over land or past data. On the other hand, bottom-up approaches are based on land surface and surface emissivity modelling. These various methodologies are discussed and results in the ECMWF assimilation system are presented.

B17: RTTOV_SCATT, a fast radiation model that includes scattering at microwave frequencies

Presenter: Frédéric Chevallier

Emmanuel Moreau, Peter Bauer and Frédéric Chevallier

For simulating the radiative transfer in clouds and precipitation for large data volumes, a radiation model has been developed based on the fast modeling framework RTTOV. Multiple scattering contributions are implemented through the Eddington's second approximation. This poster describes the model and illustrates its validation. Based on ECMWF model cloud and precipitation profiles a relative comparison of RTTOV_SCATT and of a doubling-adding model reveals that apart

from situations with excessive amount of snow (snow paths > 1kg/m2) both models agree within radiometer noise, i.e, within 0.5K. An intercomparison with radiative transfer codes from independent research groups also reveals the good performance of the model. However the treatment of subgrid-scale cloud variability is identified as an important source of uncertainty.

B18: An Improved OPTRAN Algorithm

Presenter: Yong Han

Yong Han, Larry M. McMillin, Yoshihiko Tahara, Thomas J. Kleespies,
Xiaozhen Xiong, and Paul van Delst

Presented here is an improved algorithm for the fast and accurate transmittance-calculation procedure, optical path transmittance (OPTRAN). This algorithm combines two techniques developed separately at the NOAA NESDIS and NCEP and implemented in OPTRAN version 7 and 8, respectively. The first technique applies a correction term to account for the differences between the total transmittances averaged over spectral response function (SRF) and the transmittances that are the product of the SRF-averaged transmittances of individual gases. The correction term is estimated from a given atmospheric state in a similar way as that to predict transmittances for each gas. The motivation for developing the technique is to eliminate the use of the effective transmittances, a technique difficult to apply in situations when transmittances are estimated for four or more gases. The second technique is developed in order to reduce the number of regression coefficients used to predict the transmittances. It is especially useful for hyper-spectral sensors, such as AIRS, for which the number of coefficients is reduced to 183,106 from 4,280,400 in the previous versions. The technique applies a polynomial function with the gas amount as a dependent variable to estimate the vertical variations of the coefficients, rather than having a separate set of regression coefficients for each vertical layer. We will present some technique details of how the two techniques are implemented in the new algorithm, and the results of the algorithm validations against both dependent and independent data sets.

B19: Infrared radiative transfer modeling using the Optimal Spectral Sampling (OSS) method

Presenter: Jean-Luc Moncet

Jean-Luc Moncet, Gennadi Uymin, Xu Liu and H. Snell

The OSS method is a simple and flexible approach to radiance modeling originally developed for the real-time processing of NPOESS/CrIS data. OSS-based models have been produced for the airborne NAST-I and AIRS instruments as well as for microwave sensors. The monochromatic treatment of the radiative transfer in OSS confers the ability to directly model non-positive ILS (such as interferometric functions) and to accommodate different observer altitudes (for airborne applications). In addition, it greatly simplifies the computation of analytical Jacobians and makes it possible to model scattering effects in an accurate and computationally efficient way. An overview of the theoretical basis and examples of applications of the OSS method will be presented. More details will be given in a companion poster.

B20: Preliminary validation of the CrIMSS (ATMS/CrIS) retrieval algorithm

Jean-Luc Moncet

Jean-Luc Moncet, Xu Liu and Richard Lynch
AER, Inc.

Pre-NPP tuning and validation of the NPOESS/CrIS algorithm involves testing activities on real data from the AMSU/AIRS instruments on the EOS/AQUA platform. The future CrIS algorithm is being adapted to regularly process data from AIRS. Preliminary results of this validation effort will be presented. Key areas investigated includes removal of cloud effects and quality control of temperature and moisture profile EDRs.

B21: Cloud characteristics and channel selection for IASI radiances in the meteorological sensitive areas

Presenter: Florence Rabier

Nadia Fourrié and Florence Rabier, Météo-France, CNRM/GMAP

The cloudiness in simulated IASI (Infrared Atmospheric Sounding Interferometer) pixels deduced from AVHRR (Advanced Very High Resolution Radiometer) satellite imager is studied more especially in the meteorological sensitive areas during FASTEX (Front and Atlantic Storm Track Experiment). It is found that few clear AVHRR observations are located in the IASI pixels in these regions, which are covered by high -level and low-level clouds. The IASI channel selection is then studied in the context of the sensitive areas for the pixels with low-level clouds. The Entropy Reduction

(ER) method of Rabier et al (2002) which was previously studied in a general context is compared with two other channel selection methods using selection criteria based on the adjoint sensitivity: the sensitivity to observation and the so-called Kalman Filter sensitivity. It is found that even though the "sensitive" methods give slightly better results than the ER one, this latter performs quite robustly and at a lower computational cost. The robustness to the specification of the background error covariance matrix is then studied. It is shown that the channel selection based on the ER method is particularly robust to this specification but the analysis step itself requires an accurate determination of the background error covariance matrix. In addtion it is shown that an independently computed constant channel set gives comparable results to the optimal channel set.

B22: Application of an objective error variance tuning method to satellite radiances observational errors

Presenter: Florence Rabier

Bernard Chapnik, Gérald Desroziers, Florence Rabier, Météo-France, CNRM/GMAP
and Olivier Talagrand, Laboratoire de Météorologie dynamique

Desroziers and Ivanov (2001) have proposed an objective variance tuning algorithm based on an optimality diagnosis in a variational data assimilation framework. In this poster, some interesting properties of this method are provided, an application of the algorithm to the tuning of satellite radiance observational error are shown and discussed.

References

G. Desroziers and S. Ivanov. Diagnosis and adaptive tuning of information error parameters in a variational assimilation. Quart. J. Roy. Meteor. Soc., 127:1433-1452, April 2001.

B23: Can a statistical regression be a valuable tool for advanced IR-sounders data inversion?

Presenter: Alexander Uspensky

A.B.Uspensky, S.V.Romanov***

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The paper summarizes the performance characteristics of statistical regression approach for the inversion of advanced IR-sounders data or, in other words, for the retrieval of atmospheric temperature (T), humidity (q), ozone concentration (Q) profiles. The new-generation space-borne IR-sounders on board future operational satellites (IASI/MetOp, CrIS/NPOESS, IRFS/Meteor) will provide high resolving power (0.25 – 0.6 cm^{-1}) spectral radiance measurements of continuous or quasi-continuous coverage from 3.7 (5.0) to 15.5 μm. Because of highly increased satellite data volume and large number of sought variables the application of traditional inversion methodology, in particular, "physical" inversion algorithms or standard regression technique may cause significant problems. The authors have developed and examined statistical regression algorithms for the retrieval of atmospheric T-, q-, Q- profiles from IASI measurements that are capable to give rather accurate results at a "reasonable" cost. The proposed retrieval algorithms are constructed on the basis of linear statistical eigen-vector regression that have been refined through the introduction of generalized empirical orthogonal functions both in measurement and state spaces. Contrary to other approaches the "optimal" number of predictor and predictand variables is specified "theoretically" using the consistency check between data information content and compression ratio. The problem of compilation the representative training datasets is considered from the point of view of sampling effects reducing and selection the limited numbers of profiles. A simulation study has been performed to demonstrate the capabilities of proposed techniques in the retrieval of T-, Q – profiles from synthetic IASI measurements. The application of developed algorithms enables to achieve the reasonable accuracy of T-, Q- profile retrievals as well as to reduce slightly the mean RMS errors (defined via averaging over atmosphere layers) comparing to standard eigen-vector regression .

B24: A System Design for Storing, Archiving, and Retrieving Hyperspectral Data

Presenter: Ralph Dedecker

Ralph G. Dedecker, Tom Whittaker, Ray K. Garcia, Robert O. Knuteson
University of Wisconsin-Madison, Space Science and Engineering Center

Hyperspectral data and products derived from instrumentation such as AIRS, CrIS, GIFTS and HES will impose storage and data retrieval requirements that far exceed the demands or earlier generation remote sensing instrumentation used for atmospheric science research. Efforts at the University of Wisconsin - Space Science and Engineering Center

(UW-SSEC) are underway to develop a new architecture designed to address projected real time and research needs.

The large volume of data collected and products produced from hyperspectral instrumentation will require large distributed storage devices employing several servers. The hardware infrastructure must be implemented to allow component augmentation, replacement, and maintenance without undue demands to modify user applications. User applications will need tools to simplify the location of data files. User data selection facilities for retrieving specific information from storage devices for calibration, analysis, instrument inter-comparison, or reference purposes will also be necessary due to of the large data volume and standardized data formats and data delivery schemes will be important.

This poster will outline a prototyped infrastructure for data archiving and cataloging, data storage, metadata search and query, and retrieved data delivery schemes to be utilized for real time operations and by research users.

B25: Potential use of IASI for volcanic clouds detection and monitoring

Presenter: T. Phulpin

T.Phulpin and M. Dana, Centre
National d'Etudes Spatiales, 18 avenue E. Belin,
31401 Toulouse cedex 9 – France

Volcanic emissions and resulting stratospheric aerosols are acknowledged to have a strong effect on climate. They msut be detcetd and monitored routinely on a global scale. Volcanic clouds are also a danger for aeronautics and are for this reason monitored through a global operational system widely based on satellite data. GOES, AVHRR, HIRS and TOMS are currently used in the Volcanic Ash Advisory Centers (VAAC). Current techniques for volcanic cloud monitoring allow with a relatively good reliability detection, sizing and mass estimate of aerosol. But composition and altitude retrieval remain difficult. AIRS and MODIS data now available are also bringing some useful information. The Infrared spectrometer IASI (onboard METOP in 2005) which will provide continuous spectra from 660 to 2740 cm-1 exhibits characterisics potentially interesting for tracking volcanic clouds. A simulation based on 4A radiative transfer model show that IASI combined with AVHRR will permit to dicriminate ice clouds, ash and sulfate aerosols, to determine accurate SO2 column, and have a good estimate of the SO2 level.

B26: The Infrared Ozone Retrieval Algorithm for NPOESS-OMPS

Presenter: (for Hilary E. Snell)

Hilary E. Snell, Edward J. Kennelly and Courtney J. Scott (AER, Inc.)
Juan Rodriguez, Quinn Remund and Roger Scarlotti (Ball Aerospace)
Jack Larsen (Raytheon ITSS)

The Ozone Mapping and Profiler Suite (OMPS) was the first sensor suite selected to fly on the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) spacecraft. OMPS consists of a UV-visible limb-viewing sensor and a UV nadir-viewing sensor. OMPS will also use data from another NPOESS sensor, the Cross-Track Infrared Sounder (CrIS), to provide total column ozone measurements primarily under nighttime conditions. This poster will provide an overall description of the OMPS with emphasis on the design and capabilities of the IR ozone retrieval algorithms.

B27: Update about Frequency Protection: Results of WRC 2003 and SFCG 23… What to do now?

Presenter: Guy Rochard

Guy Rochard
Meteo-France

This poster will report on results from the WRC 2003 and SFCG 23 meetings. Additional information about frequency protection can be found on these web sites:

http://cimss.ssec.wisc.edu/itwg/groups/frequency/
and
http://guy.rochard.free.fr/meteo/

B28: Tropospheric CO Observed with NAST-I: Retrieval Algorithm, First Results, and Validation

Presenter: Daniel Zhou

Daniel K. Zhou[*], William L. Smith[*], Jun Li[†], and Stephen A. Mango[‡]

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A methodology of retrieving tropospheric CO from remote sensed infrared (IR) spectral data has been developed. Tropospheric CO profiles, together with the thermodynamic properties, are determined using a three-stage approach that combines the algorithms of physical-based statistical eigenvector regression, simultaneous non-linear radiance inversion, and CO enhancement physical iterative retrieval. The NPOESS Airborne Sounder Testbed-Interferometer (NAST-I) aboard a high altitude aircraft with a spectral coverage of 650-2700 cm^{-1} and a spectral resolution of 0.25 cm^{-1} has been successfully collecting the data during many field campaigns. The retrieval methodology is described and demonstrated by simulations. Detailed CO retrieval error analyses based on NAST-I instrument and the retrieval uncertainties of the other parameters are discussed. Results from several NAST-I field campaigns are presented including those from observations over the western Pacific Ocean made in conjunction with airborne truth atmospheric chemistry profiles. Retrievals from both simulations and measurements illustrate that tropospheric CO profile can be obtained from remote sensed IR spectral data (such as NAST-I data) with accurate thermodynamic properties.

B29: Observations of dust emission/absorption by AIRS

Presenter: L. Larrabee Strow

L. Larrabee Strow

The impact of atmospheric dust on the high spectral resolution radiances observed with the Atmospheric Infrared Sounder (AIRS) will be presented. We have observed dust absorption/emission and scattering for a number of large dust events originating in the Sahara, the Gobi desert, and in Syria. In addition, we have observed large dust clouds emitted by the Mt. Etna eruption. The semi-continuous high-spectral resolution radiances recorded by AIRS may allow automated detection of dust contamination in the AIRS spectra, which may be important for both data assimilation of AIRS radiances for forecasting applications and for production of climate products with AIRS. Using a scattering version of the AIRS forward model, we have determined the dust cloud optical depths and mean particle sizes for several of these events. Intercomparisons with MODIS observations of these events will also be presented.