A41A MC: Hall D Thursday 0830h

Chemical and Dynamical Data Assimilation II

Presiding: **W Lahoz,** University of Reading**; R Swinbank,** Met Office

A41A-0013 0830h POSTER

The Met Office 3D-VAR stratosphere-troposphere data assimilation system

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In November 2000, a new stratosphere-troposphere data assimilation system was implemented at the Met Office. The new system uses a 3-D variational analysis scheme, and replaces the system based on the Analysis Correction scheme which was originally implemented in October 1991. In conjunction with the change of assimilation method, the stratospheric system now also includes the direct assimilation of radiance measurements from the TOVS and ATOVS instruments, rather than temperature retrievals. The model configuration was changed to use a new set of 40 levels; the tropospheric levels are now the same as in the standard operational 30-level global forecast model but there are additional levels in the stratosphere and lower mesosphere. It is anticipated that such a set of levels will allow improvements to the assimilation of satellite soundings. Further research will be carried out to assess the benefits of the additional stratospheric levels with the intention of extending the standard global model when computer resources permit.

A41A-0014 0830h POSTER

The NERC Data Assimilation Research Centre and Envisat

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The NERC Data Assimilation Research Centre (DARC), a Centre of Excellence in Earth Observation, has been recently set up in the UK. DARC is a distributed centre, with participation from the universities of Reading, Oxford, Cambridge and Edinburgh, and the Rutherford Appleton Laboratory. It has strong links with the UK Met Office, and with European data assimilation groups.

One of the remits of DARC is the exploitation of research satellite data (e.g. from ESA's Envisat, due to be launched in November 2001). This presentation will describe the participation of DARC in the Envisat programme. This participation involves: (1) the calibration/validation of Envisat data using an NWP assimilation system, and (2) the production of 4-d quality-controlled datasets of temperature, ozone and water vapour from Envisat using an NWP assimilation system.

URL: http://darc.nerc.ac.uk

A41A-0015 0830h POSTER

Monitoring of MLS Measurements for Ozone Data Assimilation

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The ozone data assimilation system at the NASA Goddard Space Flight Center Data Assimilation Office (DAO) has operationally provided near real time global three dimensional analyzed ozone fields since December 1999 Presently, the system assimilates both total column ozone and profile measurements from the NOAA-16 SBUV/2 instrument into an off-line transport model using a physical space statistical analysis scheme (PSAS).

Recently, this system was modified to investigate a possible impact from including MLS profile observations. Over a period from December 13, 1991 to March 1, 1992 the system assimilated both NOAA 11 SBUV/2 profile measurements and TOMS total column measurements. Short term ozone forecasts were produced and compared to MLS observations. The resulting observed-minus-forecast (O-F) residuals were studied regionally (by both latitude bands and pressure levels) in order to explore the potential impact of MLS observations on the assimilation and sensitivity to the UARS yaw maneuver and other instrument and algorithm characteristics. In addition, MLS profiles were compared to nearest neighbor SBUV and analysis profiles.

In the tropics, analyzed ozone values tend to be too high from 1-3 hPa and too low from 10-20 hPa. MLS measurements in these regions tend be lower and higher (respectively) than forecast ozone values. This indicates that assimilating MLS measurements may improve analysis results in these areas. Further, nearest neighbor profile comparisons in the southern high latitudes indicate that laminar features present in the analysis, but not present in SBUV measurements, are also present in MLS measurements. This, together with the availability of MLS measurements in polar night regions indicates that assimilating MLS measurements may improve analyzed ozone values in high latitudes.

URL: http://dao.gsfc.nasa.gov/pages/ozone_assim.html

A41A-0016 0830h POSTER

Effects of the nudging for atmopsheric field and total ozone on simulated ozone distribution

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Restoring forces to observed values are applied as nudging for atmospheric field of wind and temperature, and for total ozone in the 3-d chemical transport model, and their effects are investigaed. The dynamical module is a general circulation model, which uses a triangular truncation at the maximum wavenumber 45 and has 45 layers from the surface up to the mesopause (0.01 hPa). In the chemical module, there are 40 species or families, in which 26 and 14 species are, respectively, transported and in photochemical equilibrium. Chemical reaction includes 23 photolytic reactions, 59 gas phase reactions, 5 heterogeneous reactions on polar stratospheric clouds and 2 heterogeneous reactions on sulfate aerosols. Chemical species are transported with a semi-Lagrangian scheme of cubic interpolation. Control run is made without nudging, while experiment runs use nudgings of atmospheric field and/or total ozone.For atmospheric field nudging, Japan Meteorological Agency (JMA) objective analysis data of wind and temperature are used while for total ozone nudging TOMS data is used. Experiment run A uses both the atmospheric nudging and ozone nudging, and experiment B uses atmospheric nudging alone. It is found through the comparison that model errors in the tropospheric ozone yield, when the ozone nudging is used, crucial errors in the stratospheric ozone.

A41A-0017 0830h INVITED POSTER

Moisture analysis in atmospheric data assimilation

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Similar to atmospheric ozone and other constituents, model-based assimilation of moisture observations is especially challenging in view of the lack of useful error estimates. This is true for the observations as well as for the model predictions that are used as background estimates in the assimilation. Compared to, for example, the mass field, the distribution of atmospheric moisture is more strongly affected by mesoscale systems, and depends on nonlinear physical processes that are not well resolved by today's general circulation models. Errors in model predictions of the moisture field can be quite large, involving the deformation and displacement of large-scale features, and poor representation of small-scale sources and sinks. Most models exhibit systematic errors, e.g., a tendency to be too dry in the lower Tropical troposphere, but these biases vary with season and location. The usual assumptions about model errors invoked in data assimilation (zero-mean, stationary white noise) clearly do not apply for atmospheric moisture.

We will describe a number of innovative features of the analysis scheme in development at NASA's Data Assimilation Office (DAO), which represent an attempt to deal realistically with the complex nature of the moisture errors. The first of these consists of a sequential bias estimation scheme, designed to remove the model bias from the background estimates used in the assimilation. This effectively eliminates time-mean errors in the moisture analyses with respect to radiosonde observations, and results in a significant reduction of the drift in subsequent forecasts.

Second, we carefully considered the choice of variable to be used in the calculation of the moisture analysis. Our primary criterion is that the analysis variable should be reasonably homogeneous in space, in order to facilitate covariance modeling. The moisture analysis should be, as much as possible, robust to the misspecification of error estimates. This is especially important for the assimilation of satellite measurements (such as total precipitable water), since the spatial distribution of the moisture analysis increment due to the assimilation of an integrated moisture-related observation will be entirely determined by the presumed error covariances. We briefly review some of the problems with the variables that have traditionally been used for atmospheric moisture analysis, such as specific humidity, its logarithm, and relative humidity. Our proposed choice of variable is defined by a background-dependent transformation of specific humidity. We will show results of experiments performed at the DAO with the Physical-space/Finite-volume Data Assimilation System (fvDAS) that clearly demonstrate a positive impact of this choice.

Finally, having addressed these issues, we feel prepared to attempt to further improve the description of moisture errors by modeling the three main dynamic effects on the error covariances in the assimilation cycle: (1) advection of initial errors, (2) error growth due to model defects, and (3) error reduction due to the incorporation of observations. We will formulate simple representations of each of these effects, which are intended to be incorporated in the moisture error covariance specification of the fvDAS.

A41A-0018 0830h POSTER

Assimilation of Sea Surface Salinity in a Tropical OGCM : a Twin Experiment Approach

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Observing ocean surface salinity by satellite is a challenging issue for next years'oceanographic activities. It is motivated by the active role of salinity that is now well recognized in ocean dynamics and ocean/atmosphere exchanges. This is particularly evident in the case of the ENSO phenomenon in the tropical Pacific Ocean. Improvements of numerical simulations and predicitions will mean that salinity observations must be taken into proper account in conjunction with temperature and altimetric data. The sensitivity of a primitive equation model of the tropical Pacific Ocean to Sea Surface Salinity (SSS) is studied through the use of a data assimilation technique in the rather academic "twin experiment" context. The data assimilation technique used, the SEEK filter, is derived from the conventional Kalman filter theory. We will explain why such a sophisticated technique is necessary. Indeed, an empirical method such as the newtonian relaxation method, used in the same conditions, fails to constrain both the observed (surface) variable and the other components of the state vector. Within the experimental context used, the assimilation of SSS data with the SEEK filter is able to constrain most of the model variables linked with the SSS signal. SSS information in particular appears relatively successful in restoring zonal velocity, which is an important variable in fresh pool migration, and in simulating a barrier layer in the convergence zones. The final analysis errors remain minor and stable over time. This is widely true when simulating satellite SSS observations based on the GODAE criteria (0.2 psu error, 200km, 10 days), which shows the potential of these observations. To extend these results to a real context, the problems of

model-data bias and unknown error covariances must be addressed as they are actually a strong limitation in assimilation performance when assimilating any real data set.

A41A-0019 0830h POSTER

High Frequency Polar Waves in the Middle Atmosphere as seen in a Data Assimilation System

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High frequency waves in the polar vortex have been observed since the 1980's and are believed to be created by instabilities in the vortex winds. These eastward propagating waves consist of zonal waves 1 through at least 4 all moving at approximately the same phase speed, so that when wave 1 has a four day period, wave 2 will have a 2 day period, and so on. These waves are generally referred to as the 4-day wave because the wave 1 component is often dominant and is easily resolved by daily observations. However, past studies have shown that the 2-day, wave 2 component can be larger than the 4-day, wave 1 component at certain times and locations. This study examines the winter southern hemisphere vortex of 1998 using four times daily output from a data assimilation system to focus on the polar 2-day wave and its relation to the 4-day wave.

The data assimilation system products are from a test version of the finite volume data assimilation system (fvDAS) being developed at Goddard Space Flight Center (GSFC). The fvDAS has many new features and improvements that help in polar wave analysis, including a general circulation model with accurate advection near the poles and an analysis system that interactively assimilates satellite radiance observations. Ozone products are also available from the GSFC ozone assimilation system.

Results show that the polar 2-day wave dominates during July 1998 at 65S. The vertical structure of the 2-day wave shows only one peak with westward phase tilt with height above the peak and eastward phase tilt with height below the peak. This differs from the more poleward 4-day wave that tends to have two out of phase peaks in the vertical. The 2-day wave is somewhat faster than 2 days during July 1998 with a period closer to 1.6 days and an average amplitude for the month of over 2.5 K. Results for potential vorticity and ozone also show the 2-day wave consistent with the temperature signal. The 2-day wave represents a major source of ozone variation in this region.

A41A-0020 0830h POSTER

An Analysis of Various Kalman Filtering Techniques for Thermospheric Species Data Assimilation

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To determine the propagation parameters of high-frequency radio, an accurate forecast of the ionosphere is desirable. Until recently, obtaining a real-time and precise description of neutral atmospheric composition has acquired less consideration in comparison to other parameters such as ionospheric and neutral density. However, forecasting the ionosphere, especially during geomagnetic storm times, is strongly dependent on perturbations in the neutral composition. Because of this coupling between the ionosphere and neutral atmospheric chemistry, accurate knowledge of the neutral composition is critical in forecasting the ionosphere. The more accurate description of the neutral atmospheric composition is then used to supplement input parameters for ionospheric modeling.

In the research presented here, data assimilation techniques are applied to more accurately determine the neutral atmospheric species. The neutral atmospheric species are measured using remote sensing airglow data from polar orbiting spacecraft. Data is assimilated and noise from this data is reduced using filtering techniques in combination with a state propagation model. Methods for ingesting satellite data, predicting the state of the neutral atmosphere in the future, and filtering the data are investigated and then used simultaneously, utilizing the benefits of each, to reproduce the neutral atmospheric composition.

Since data assimilation techniques have enormous computational requirements for global forecasting, a significant amount of study is required to decrease the computation time while not decreasing accuracy. In this presentation, various methods are tested and compared in speed and accuracy in recreating a simulated data set and are documented as a benchmark for data assimilation of the neutral atmospheric composition as well as for other similar global systems.

A41A-0021 0830h POSTER

Data Assimilation with the Canadian Middle Atmosphere Model

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A three-dimensional variational (3D-var) data assimilation scheme has been developed for the Canadian Middle Atmosphere Model (CMAM) in order to provide further insight into the model's errors and to provide a platform for the design and testing of satellite instruments targeting the middle atmosphere. CMAM is a 65-level (90 km) General Circulation Model of the troposphere-stratosphere-mesosphere capable of producing a realistic ozone climatology and QBO-like oscillations. Because CMAM has fully interactive chemistry, radiation and dynamics, the assimilation of ozone and other species is planned and may help to diagnose the interplay between these three processes. The 3D-var scheme has been adapted from the Canadian Meteorological Centre's operational weather forecasting system primarily by raising the lid, changing the vertical coordinate, adding analysis variables and developing new statistics. A preliminary set of background-error statistics have been estimated from CMAM climatology and are compared to statistics used by the operational Canadian weather forecast model. Results of the initial validation of the CMAM/3D-var system involving conventional meteorological observations from the troposphere and lower stratosphere, supplemented by middle atmosphere ozone and temperature data from satellite instruments such as TOMS and MLS, are also presented. Future plans include the assimilation of other chemicals and other sources of satellite data.

A41A-0022 0830h POSTER

Model Simulations of CO2 Transport Using Assimilated Meteorological Fields

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The numerical simulation of CO2 transport (and other tracers such as CO, CH4, and biomass burning tracers) in the atmosphere is required to determine the fate of anthropogenic source gases. Estimation of the CO2 exchange between the ocean surface, the terrestrial biosphere, and the atmosphere is of first-order importance to understanding the global carbon cycle and the processes that are most crucial in determining the atmospheric CO2 concentration. Forward transport simulations have been conducted using two-dimensional, time-dependent grids of average surface fluxes (from TRANSCOM) and three-dimensional wind data from a prototype data assimilation system (FV-DAS) run by the Goddard Data Assimilation Office. The objective is to better understand the contribution of meteorological variability to changes in CO2 and other constituents. By accurately accounting for meteorological variability, through use of assimilated winds, we hope to better characterize the distribution of surface sources and sinks (and chemistry where applicable). With assimilated meteorology such chemistry/transport runs provide the basic framework to analyze existing (and proposed) measurement data on a point-by-point, real-time basis. We compare with measured CO2 concentration gradients on a daily, seasonal, regional, and interhemispheric basis to examine the consistency of sources, sinks, and transport formulation. We will also examine the inter-annual variability of atmospheric CO2 due to atmospheric circulation changes using longer runs with assimilated winds.

A41B MC: Hall D Thursday 0830h

Advances in Aerosol Science and Technology III

Presiding: **T A Cahill,** DELTA Group-University of California, Davis**; P B Kelly,** University of California, Davis

A41B-0023 0830h POSTER

The Center for Aerosol Research (AEROCENTER)

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The newly established Center for Aerosol Research (AEROCENTER) located at the NASA/Goddard Space Flight Center in Greenbelt MD is dedicated to fostering interdisciplinary research in all aspects of aerosol science. AEROCENTER will be an incubator for innovative new analysis of existing data and ideas for new space missions. The plan is to tap and harvest ideas from a broad international and interdisciplinary science community and to incorporate these ideas into NASAs aerosol research effort for understanding and predicting the aerosol effect on climate and the environment. In order to achieve this goal the center aims to host several established and developing scientists for a period of 3-6 months each year. AEROCENTER will also develop a new technical infrastructure that will integrate the present aerosol research activities and data resources of GSFC/Greenbelt and GSFC/GISS, increase efficiency in the use of NASA remote sensing data, and increase the involvement of a larger national and international scientific community. The center aims to institutionalize and extend the present knowledge base within NASA into a national resource for the education and research communities.

URL: http://aerocenter.gsfc.nasa.gov

A41B-0024 0830h POSTER

AERONET POLARIZATION MEASUREMENTS

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Since 1995, a polarized version of the CIMEL sunphotometer is operated on a number of AERONET sites. Those polarized AERONET sunphotometers provide daily measurements of the linear polarization in the principal plane, in addition to the standard solar transmission and total radiance measurements. The polarized version of the instrument is equipped with