JCSDA Quarterly

No. 20, September 2007

Joint Center for Satellite Data Assimilation • 5200 Auth Road • Camp Springs • MD • 20746 *Editor: George Ohring*

NOAA……..NASA……..US Navy……..US Air Force *Web-site: www.jcsda.noaa.gov*

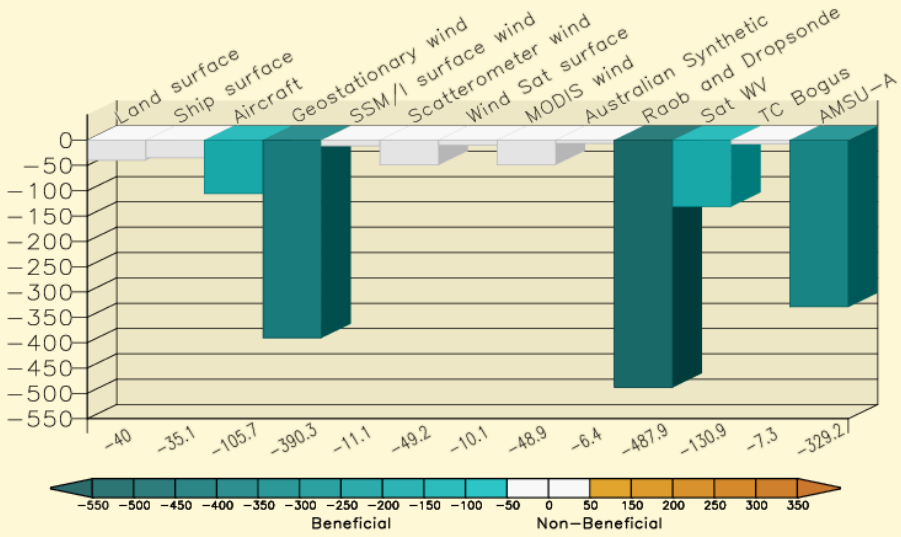
News in This Quarter

Science Update

Observation Impact Monitoring With a Data Assimilation Adjoint

In numerical weather prediction (NWP), there is an increasing need to develop and apply methods for monitoring the impact and value provided by atmospheric observations used in data assimilation. It is recognized that larger amounts of satellite observations are of benefit to NWP yet, from a diagnostic perspective, it can be difficult and computationally expensive to quantity the relative value of the many types of data that are assimilated. For example, when many channels from an infrared sounder are assimilated, what is the relative benefit, in terms of forecast skill, provided by each of these channels? An adjoint-based method can efficiently be used to answer these types of questions, by providing quantitative information about the impact of all observations assimilated by an operational NWP system.

One-Year Observation Impact Sum



Impact of observation types in NAVDAS-NOGAPS summed from 23 Sept 2006 - 23 Sept 2007. The impact (vertical scale, J kg^{-1}) represents reduction of 24h global forecast error. This plot is based only on observations used for the 0000 UTC analyses.

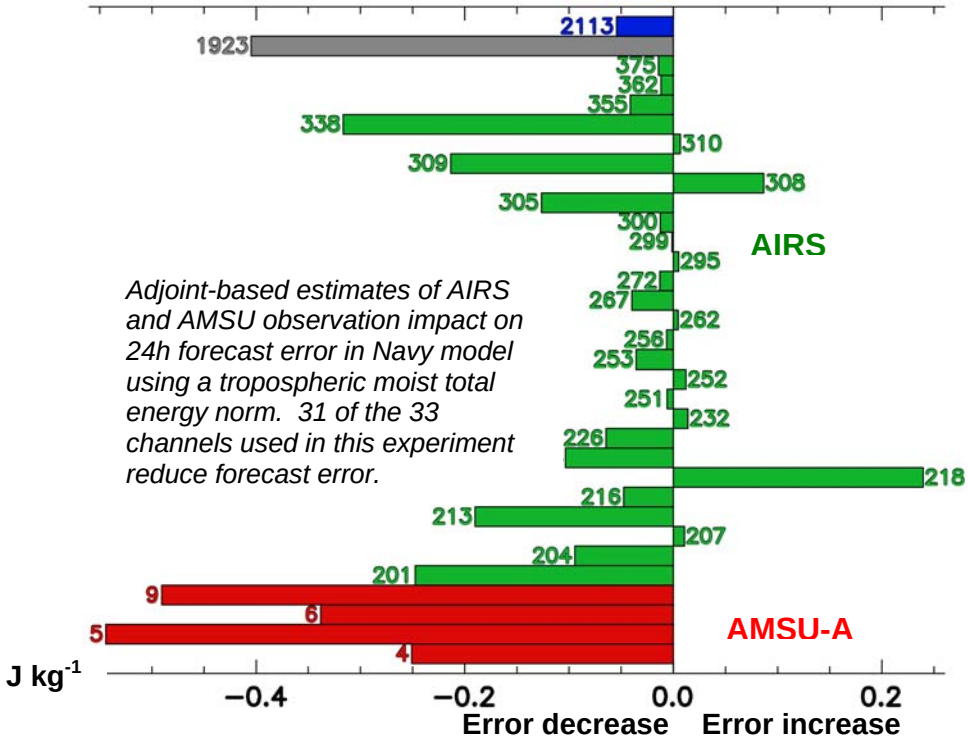
The derivation of adjoint-based observation impact estimates is described by Langland and Baker (Tellus, 2004). This technique provides the separate forecast impact of *every assimilated observation.* The calculation requires adjoint versions of the forecast model and the data assimilation procedure. We quantify the impact of observations in terms of their contribution to the difference between forecast error norms on an analysis and a background trajectory, whose initial conditions are separated by six hours. The computational cost of producing the observation impact information using the adjoint system is about the same as a single re-run of the regular analysis and forecast model. It should be noted that this method evaluates the impact of all observation data simultaneously, in contrast to conventional data-denial studies that estimate the forecast impact for subsets of observations that are withheld from (or added to) the analysis.

Currently, at the Naval Research Laboratory– Fleet Numerical Meteorology and Oceanography Center, adjoint-based observation impact is computed once per day for the 0000 UTC operational run of the Navy's global assimilation/forecast model using vertically-integrated (surface to ~250hPa), moist energy-weighted global 24h forecast error as a cost function. The observation impact information is used to make decisions for quality control and to help decide which aspects of the data assimilation procedures may need improvement – for example, the observation error statistics or bias correction. Typically, the most useful information is provided in summaries of observation impact results compiled for several weeks, to provide a representative statistical sample. A web page has been developed at NRL-Monterey to display observation impact results
http://www.nrlmry.navy.mil/ob_sens/obsens_main_od.html

Observation impact information is also being used at NRL in a research mode to address other data assimilation issues, including channel selection for new satellite instruments such as the AIRS, as illustrated in the accompanying figure.

We have also developed and tested observation impact in a 4D-Var context with the adjoint of the assimilation system using an accelerated representer method. A new project, starting in FY08, and funded in part by JCSDA, will compare observation impact in the Navy, GMAO, and Canadian operational global assimilation and forecast systems.
(Rolf Langland, Nancy Baker, Ben Ruston, NRL-Monterey, Ronald Gelaro, NASA-GMAO)

Impact of AIRS and AMSU Channels



Adjoint-based estimates of AIRS and AMSU observation impact on 24h forecast error in Navy model using a tropospheric moist total energy norm. 31 of the 33 channels used in this experiment reduce forecast error.

International Items

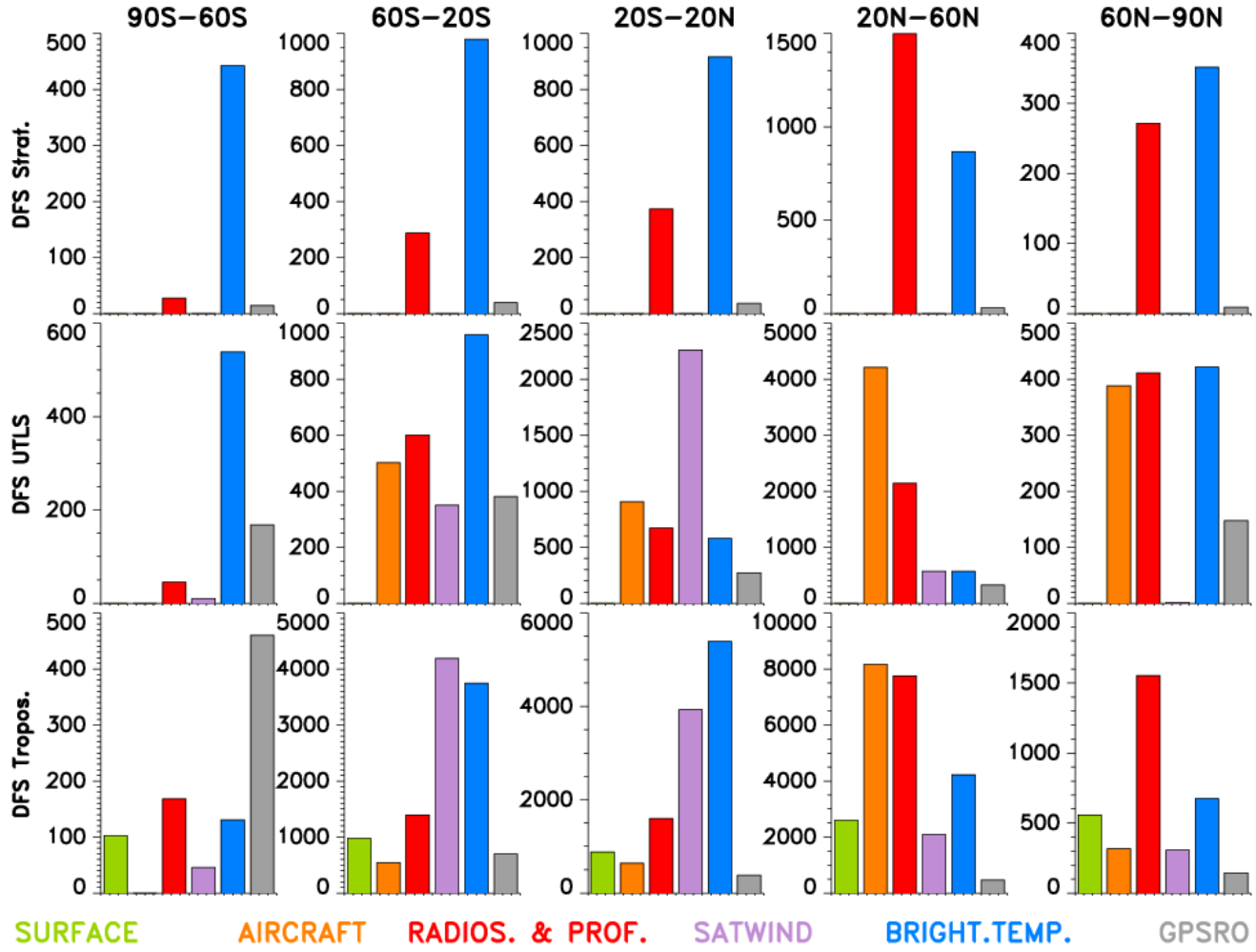
Satellite Data Assimilation at Meteo-France

Important improvements achieved at Météo-France in global forecasting since the year 2000 are largely due to the the implementation of a variational assimilation, the insertion of new satellite data types, and the increase in the data quantity used as well as the way the satellite information is assimilated.

Since June 2000, the operational data assimilation system of Météo-France has used a Four-Dimensional Variational scheme (4DVAR), performed on 6h time windows. As of September 2007, the 4DVAR scheme provides the initial state of a global spectral forecasting model called “ARPEGE” run four times a day (maximum forecast range: 102h) with a T358 horizontal resolution (linear grid), 46 levels in the vertical and a variable horizontal resolution obtained from a stretching factor of 2.4 (enabling a 23 km grid resolution over France, decreasing to 132 km at the antipode). The 4DVAR increments are computed at a lower horizontal resolution (T149). By the beginning of 2008, the different resolutions are likely to be increased to T538 and 60 levels for the ARPEGE model, and T224 for the 4DVAR increments. Since July 2005, Météo-France also operates a 3DVAR assimilation (6h cycling) to initialize a limited-area model called “ALADIN-FRANCE” which covers an area of about 3000 km x 3000 km around France at 9 km horizontal resolution and 46 vertical levels (this will soon be increased to 60 levels, similar to ARPEGE).

Variational assimilation in general is a good algorithmic framework for an efficient use of satellite data of different kinds. Since 2000, an increasing number of satellite data has been used operationally in the global 4DVAR, and significant progress has been achieved in the quality of the forecast. In 2005, most of the data already used in the global ARPEGE 4DVAR were also introduced in the ALADIN 3DVAR, with a somewhat smaller impact, due to the geographical position of the ALADIN-France area, over western Europe, where the relative weight of conventional terrestrial observations is larger.

Importance of Different Observing Systems in Meteo-France 4DVAR Analyses



The numbers of degrees of freedom for signal (DFS) – a measure of the importance of an observing system - in the Météo-France 4DVAR analysis, as a function of observation data-type for five zonal regions and for three altitude bands (Tropos. - below 9 km altitude, UTLS - between 9-16 km altitude, and Strat. - above 16 km altitude). Note the different scales. Surface data from SYNOP, SHIP, Buoys and GPS Zenith total delays are in green, AIRCRAFT data are in orange, Radiosonde and profiler data are in red, satellite winds from geostationary satellites, scatterometers and polar MODIS winds are in purple, radiance brightness temperature from ATOVS, AIRS and SSM/I instruments are in blue, GPS radio-occultation data are in grey.

The accompanying figure shows the weights of the various data-types in constraining the global analysis as of September 2007. The degrees of freedom for signal (DFS) indicate the importance of each observing system in the various regions. As expected the Northern mid-latitude troposphere is well covered by conventional observations (radiosondes and aircraft), while the stratospheric analysis relies primarily on brightness temperatures collected by satellite sounders. In that respect, data from the AMSU-A instrument have been assimilated under the form of raw brightness temperatures added the end of 2002. HIRS and AMSU-B temperatures were added later on (end of 2003, and October 2004, respectively) as well as similar data from the NASA Eos-AQUA satellite, and very recently from the European MetOp satellite (5 September 2007). Since September 2006, the SSM/I data have been assimilated, as well as a subset of channels from the hyperspectral infra-red sounder AIRS onboard the NASA Eos-AQUA satellite. One particular type of satellite data has been assimilated in the ALADIN 3DVAR, and not in the global ARPEGE 4DVAR: some fine-resolution radiances from the

SEVIRI instrument of MSG (Meteosat Second Generation). Different types of satellite winds (cloud winds or water vapor winds) have been used for a long time at Météo-France, long before the variational technique was implemented. In June 2006, the MSG winds were used for the first time to replace the previous Meteosat 7, and MODIS winds over the poles (from the polar orbiting satellites NASA Eos-AQUA and TERRA) were introduced in the ARPEGE 4DVAR. The accompanying figure indicates that these data have a strong influence on the upper-tropospheric analysis in the tropics. Scatterometer winds from the QuikSCAT satellite were introduced in October 2004, and complemented very recently by the ERS-2 winds (5 September 2007).

It is worth highlighting the recent developments in GPS applications at Météo-France. On September 5th 2007, GPS radio-occultation measurements in the form of bending angles from 8 satellites were introduced in the global 4DVAR: 6 FORMOSAT-3/COSMIC satellites, plus GRACE-A and CHAMP. The assimilation experiments performed in Fall 2006, Spring and Summer 2007 showed a very significant impact of this new data type on the forecast skill for almost all the meteorological fields and all the expected areas, especially on the Southern hemisphere. The accompanying figure illustrates the importance of GPS radio-occultation measurements in constraining the analysis in the high southern latitudes where very few other observations with high vertical resolution are available. Another type of GPS data was introduced one year before (September 2006), and is now used in both the ARPEGE and ALADIN systems: these are the Zenith Total Delays (ZTDs) provided by several networks of GPS receiving stations in Europe available on the Global Telecommunication System through the EUMETNET GPS water vapor program.

Our future efforts in satellite data assimilation will be geared towards the full use of the MetOp instruments (GRAS, IASI, and ASCAT), the implementation of a variational bias correction for all brightness temperature sounding data, and a global increase in the number of pieces of information actually assimilated. Later on (planned for 2009), Meteo-France will start assimilating the Doppler lidar horizontal line-of-sight wind measurements from the ADM-Aeolus demonstration mission of the European Space Agency (ESA). Significant work is being conducted at Meteo-France, in collaboration with ESA, ECMWF, and KNMI to prepare for processing and using this new data type.
(Jean Pailleux, Florence Rabier, Paul Poli, Meteo-France)

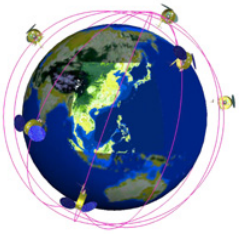
Wind Lidar Update

Approximately 25 U. S. and European scientists and lidar specialists attended the 28th meeting of the Working Group on Space-Based Lidar Winds (Lidar Working Group), held in Snowmass, Colorado, July 17 -20, 2007. The meeting highlights included: presentations/discussions on the plans for upcoming wind lidar airborne campaigns, a report on the 15th Atmospheric Dynamics (ADM) Advisory Group meeting and recommendations on US – European collaborations, and a discussion of the potential US response to the ESA ADM calibration/validation announcement of opportunity, expected in the Fall 2007. The next Lidar Working Group meeting is scheduled for February 5 - 8, 2008, in Monterey, California.
(Wayman Baker, JCSDA)

Planning continues for the THORPEX Pacific – Asian Regional Campaign (T-PARC) that will take place during August – October 2008 (tropical cyclone, extra-tropical transition components) and January – March 2009 (winter component). The National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration are key supporters of T-PARC. A planning Workshop for T-PARC and Collaborating Experiments will be held in Princeville, Kauai, Hawaii, 4-6 December 2007; for further details, see: http://www.ucar.edu/na-thorpex/PARC.html

The Thorpex Interactive Grand Global Ensemble (TIGGE) is an archive of global ensemble forecasts, collected at three facilities located at NCAR, ECMWF, and the Chinese Meteorological Administration. The archives are maintained in support of THORPEX-related research activities and opened earlier this year. Currently up to 73 forecast fields are available at 6-hrly output frequency out to 16 days from five international forecast centers. By the end of 2007, forecast data from up to 10 centers are expected to become available. For further details, see: http://tigge.ecmwf.int/ or http://tigge.ucar.edu/home/home.htm
(Zoltan Toth, NOAA/NCEP)

Cosmic Corner



Parallel runs with and without COSMIC data are being analyzed at the JCSDA in order to evaluate the impact of COSMIC and to further improve the performance of the system when assimilating GPS observations of refractivity. The experiments are evaluated for different seasons to fully understand the assimilation of this new data type. The JCSDA is preparing to test the assimilation of CHAMP and GRACE GPS radio-occultation observations and plans to incorporate these data into operations in the near future..

The UCAR COSMIC Data Analysis and Archive Center (CDAAC) has recently experienced a drop in the number of occultations (currently processing ~1200 per day) due to several reasons: (1) communication with one of the satellites is lost, (2) solar panels of another satellite are stuck and (3) another satellite is operating with only one solar panel. UCAR/CDAAC is working on solving all these issues. Only one of the six satellites is still at the lower ~700 km altitude orbit. UCAR/CDAAC has updated the processing software and higher quality retrieved GPS radio occultation profiles are expected. In addition, the number of levels in the COSMIC files has increased from 200 to 300 (from 40 km to 60 km). However, NCEP is not assimilating observations above 30 km in its global data assimilation system.

Several workshops and meetings on GPS are taking place during the month of October in Boulder, CO. UCAR is holding the Second Formosat-3/COSMIC Data Users workshop on October 23-24, followed by a meeting on "Future Missions and New Technologies" on October 24-25. The UCAR COSMIC retreat will take place during October 25-26. At about the same time, NOAA is holding a a workshop in Boulder on the Applications of GPS/Global Navigation Satellite System (GNSS) in NOAA (October 24-25).
(Lidia Cucurull, JCSDA/NCEP & UCAR)

In Memoriam
Dr. Anthony (Tony) Hollingsworth: 1943 – 2007

It is with great sadness that we announce the sudden death of Tony Hollingsworth, a giant in the fields of Numerical Weather prediction and exploitation of satellite observations. Tony passed away on Sunday 29th July, 2007, while on holiday in his native and much-loved Ireland. He was 64 years old.

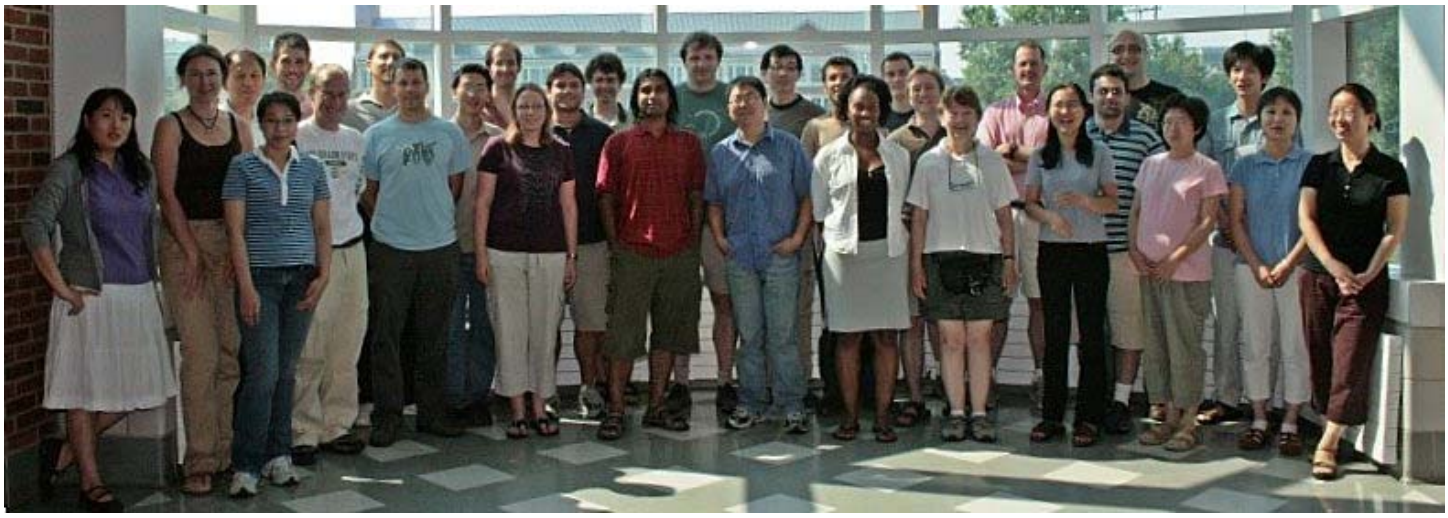
Tony began his career working as a forecaster in the Irish Meteorological Service, from which he took leave to carry out Ph.D. studies at M.I.T. After a spell at the Department of Atmospheric Sciences of Oregon State University, he returned to Europe to take up a research position in the UK Universities' Atmospheric Modeling Group at the University of Reading. He joined ECMWF on 1st March 1975, and was the Center's longest serving Staff Member. In his time he worked on virtually every aspect of numerical weather prediction, heading in turn the Physical Aspects Section and the Data and Model Divisions of the Research Department. He was appointed Head of Research in 1991 and Deputy Director in 1995. He stepped down from these latter positions on reaching his sixtieth birthday, but eschewed retirement to lead the Europe-wide GEMS environmental monitoring project, an activity he pursued with vision and dedication to the very end.

Tony was also an important player on a wider international stage, fostering extensive collaboration with EUMETSAT, ESA and space agencies worldwide, and working in support of the World Climate Research Program, the Global Climate Observing System, the US National Academy of Sciences and the American Meteorological Society. He was a recipient of the Jule G. Charney Award of that Society, and a D.Sc. of the University of Cork for his contributions to numerical weather prediction.

We have lost a great scientist, colleague and friend, and our thoughts are with Tony's wife, son and daughter at this sad time.

(Adrian Simmons, ECMWF)

JCSDA Training Workshop on Applications of Remotely Sensed Observations in Data Assimilation



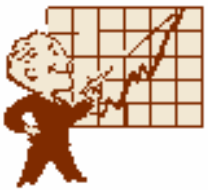
Data assimilationists of the future with Workshop Director, Prof. Eugenia Kalnay (eyeglasses hanging).

As a result of increases in computational capabilities, the availability of large amounts of useful observational data, and the development of powerful assimilation techniques, the major forecast centers of the world (e.g., NCEP, ECMWF, UKMO, GMAO, NRL, and Meteo-France) have made significant strides in satellite data assimilation. But the actual number of scientists at these centers making this all possible can be counted on the fingers of one's hands. Unfortunately, while the need for scientists trained in satellite data assimilation is increasing, there is no commensurate output of such scientists by the universities. As an initial step toward entraining more students into the field of satellite data assimilation, the JCSDA sponsored a workshop on **Applications of Remotely Sensed Observations in Data Assimilation** at the University of Maryland, July 23-August 10, 2007. The workshop was jointly organized by the Earth System Simulation Interdisciplinary Center (ESSIC) and the Atmospheric and Oceanic Science Department (AOSC) of the University. The applicants included graduate students nearing completion of their Ph.D. thesis and early career postdoctoral scientists. Sixty students applied and 15 were selected; an additional 15 participated at their own expense. The students heard lectures in remote sensing, data assimilation, radiative transfer, and prediction models. Lecturers represented a broad variety of institutions: University of Maryland, NOAA, NASA, Navy, ECMWF, Oregon State University, Lamont-Doherty Earth Observatory, Colorado State University, and Simpson Weather Associates. In addition to lectures, students participated in exercises and numerous group discussions during the two-week period. Copies of the lectures may be viewed at http://www.jcsda.noaa.gov/meetings_WARSO2007.php

Outlook for Next Quarter

Upcoming Events

- **JCSDA Management Oversight Board Meeting, Camp Springs, MD, Date TBD**
- **1st International IASI Conference, Anglet, France, 13-16 November 2007, http://smsc.cnes.fr/IASI/A_conference.htm**
- **JAS Special Issue on Papers from JCSDA Workshop on Assimilation of Satellite Observations of Cloud and Precipitation in NWP Models, November 2007**



JCSDA Seminars

9/19/07	Peter (Kung-Hwa) Wang	Meteorological Satellite Center, Taiwan	Typhoon parameters using AMSU/AMSR-E data
10/24/07	Lars Peter Riishojgaard	Director, JCSDA	The JCSDA: A progress report
11/15/07	Ron Gelaro	NASA GSFC/GMAO	Assessing the impact of observations in the NASA GEOS-5 atmospheric data assimilation system