

## News in This Quarter Science Update

### Assimilation of Cloud Properties

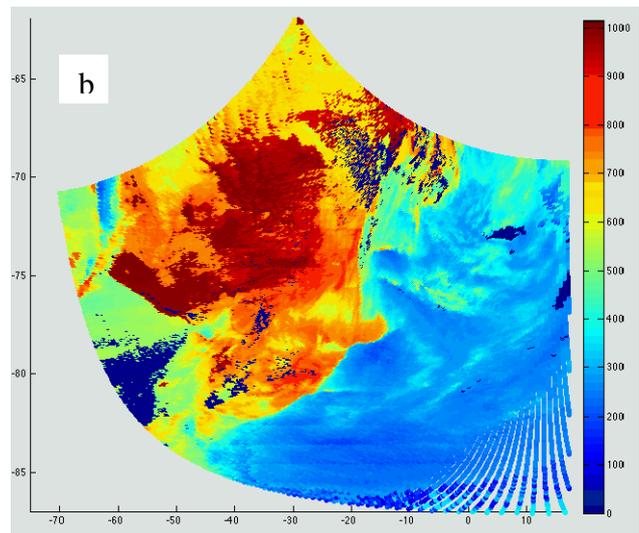
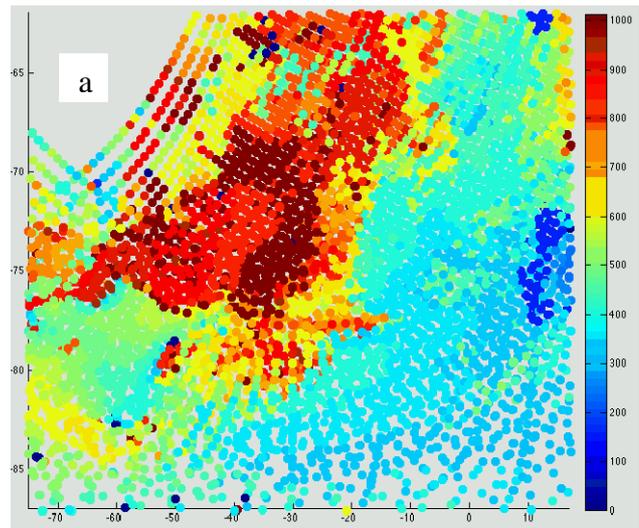
The National Center for Atmospheric Research (NCAR) is leading the developments for the Air Force Weather Agency (AFWA) next generation cloud analysis system. The AFWA Coupled Analysis and Prediction System (ACAPS) aims at designing a coherent data assimilation system where the hydrometeors are updated jointly with the dynamical variables.

Current developments in the ACAPS Project focus on building a robust and efficient 4D-Var data assimilation at cloud-resolving scales, based on the Grid-point Statistical Interpolation (GSI) system and the Advanced Research Weather Research and Forecasting (WRF-ARW) model. The Adjoint code of WRF-ARW is being coupled to the GSI framework and enriched with linearized microphysical parameterizations.

In parallel, the choice of a proper control variable for the cloud properties is being studied. Some of the desired properties are a Gaussian distribution of the errors, the “retrievability” from the observations, a simple relation to the model prognostic variables, and the ability to model background errors covariances. As a starting point, we plan to address the latter with an ensemble of model forecasts through a hybrid variational/ensemble data assimilation implementation.

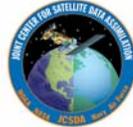
The assimilation of cloud and rain-contaminated satellite radiances is a central element to build a global cloud analysis capability. The large background departures and non-linearities in the cloudy radiative transfer need particular attention. A pre-processing step, where the cloud vertical extent is retrieved independently for every pixel through a simple linear observation operator (see figure), is considered as an option to bring the analysis first-guess closer to the observations. This approach will be expanded to include the expertise from 1D-Var retrievals of cloud properties in the assimilation.

In September 2009, an International Workshop on Cloud Analysis was held in Boulder, Colorado to discuss the scientific issues associated with the assimilation of cloud properties. All presentations and discussion topics are available at: [http://www.mmm.ucar.edu/events/09\\_clouds/](http://www.mmm.ucar.edu/events/09_clouds/)



**Maps of Cloud Top Pressure (in hPa) a) retrieved from the departures between AIRS observations and the model background with a linear cloudy radiance operator, and b) from NASA MODIS Level 2 retrievals for a single granule over the high southern latitudes.**

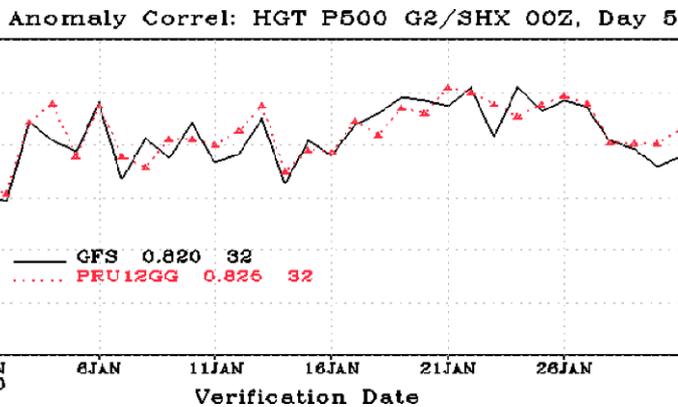
(Tom Auligne, National Center for Atmospheric Research)



## NCEP Implements Assimilation of Additional GPS Radio Occultation Observations

NOAA's National Centers for Environmental Prediction (NCEP) initiated assimilation of GPS Radio Occultation (RO) observations from the GRACE-A and METOP-A missions into its operational Global Data Assimilation System on 2 March 2010, resulting in slight increases in forecast skill in the Southern Hemisphere.

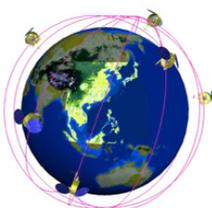
Archiving of GRACE-A data at NCEP began in May 2008, and GRAS data (the GPS RO receiver on METOP-A) a couple of months later, in July 2008. Observations from both satellites have been monitored in NCEP's operational system since March 2009. The positive impact of adding GRACE-A and GRAS into the operational observing system for the last parallel test is shown in the figure. Overall, including these two satellites slightly increases model skill (mass and wind fields) in the Southern Hemisphere, with average anomaly correlation for 5-day 500-mb geopotential height forecasts increasing for 0.820 to 0.825. Forecast impact in the Northern Hemisphere was neutral for this period. GRACE-A adds ~100-150 profiles/day and GRAS ~550 profiles/day to the ~1,000-1,500 profiles/day provided by the COSMIC RO satellites for initializing the forecasts.



**Time series of the 5-day anomaly correlation score for the 500-mb geopotential heights in the Southern Hemisphere for the operational model (GFS without GRAS and GRACE-A) and pru12GG (GFS with GRAS and GRACE-A).**

(Lidia Cucurull, JCSDA)

## Cosmic Corner:



The Coordination Group for Meteorological Satellites (CGMS) has created a fourth permanent Working Group: the International Radio Occultation Working Group (IROWG), co-sponsored by CGMS and the World Meteorological Organization (WMO).

The IROWG will focus on the exchange of experiences in the exploitation of Radio Occultation data, in particular for operational use. Two co-chairs have been designated: David Ector (NOAA) and Axel Von Engel (EUMETSAT).

The first workshop of the International Radio Occultation Working Group (IROWG) will take place September 10-11, 2010, in Graz, Austria, immediately following the joint Climate Workshops of the Occultations for Probing Atmosphere and Climate (OPAC)-4 & EUMETSAT'S GRAS-Satellite Applications Facility (SAF). OPAC is a forum for everybody interested in atmospheric remote sensing by occultation methods and/or the use of occultation data in atmospheric physics, chemistry, and meteorology, this time with special focus on climate applications.

Additional information about the IROWG Workshop can be found at: <http://www.uni-graz.at/opac2010/>

(Lidia Cucurull, JCSDA)



## Recent Ensemble Kalman Filter Results

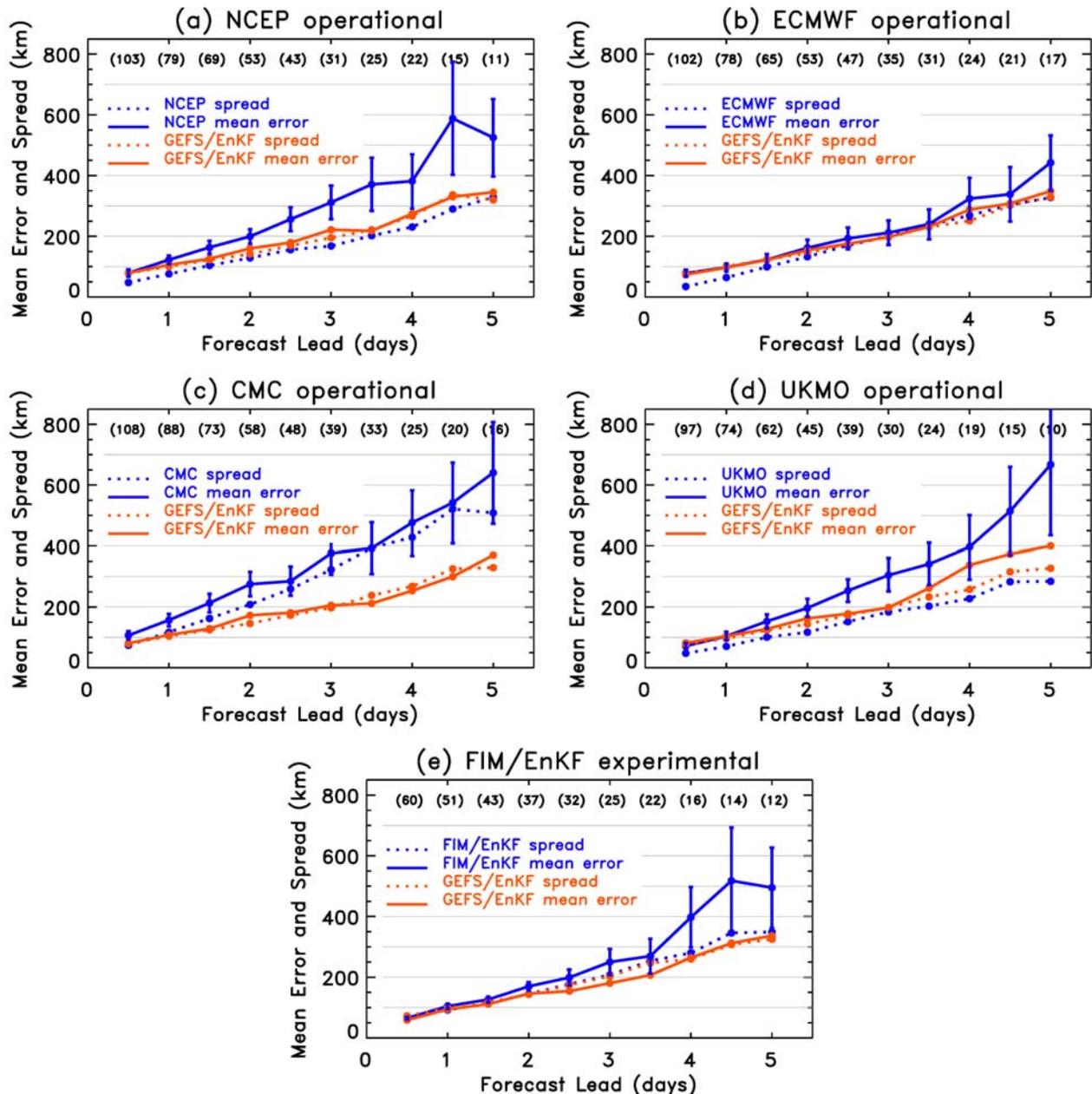
NOAA ESRL Physical Sciences Division scientists continue their experimentation with an ensemble Kalman filter (EnKF) developed with NOAA THORPEX funds. Recently, a global EnKF was run using 60 members and a T382 L64 version of the NCEP Global Ensemble Forecast System (GEFS). The full operational data stream assimilated into the NCEP Grid Point Statistical Interpolation (GSI) was used, plus "TCVitals" estimated observations of the minimum central pressure of the tropical cyclones. 20-member ensemble forecasts were generated from the GEFS/EnKF, plus from the ESRL "FIM" model, the global, Flow-following, finite-volume Icosahedral grid Model (fim.noaa.gov). Tropical cyclone track forecasts were examined from late July to early October 2009, including all basins. The figure on the next page shows the track errors and ensemble spreads for the experimental T382 GEFS/EnKF relative to operational forecasts from NCEP (T126L28 resolution, GSI control initial condition plus ensemble-transform perturbations). The figure also shows comparisons with the ECMWF operational system, the Canadian Meteorological Centre (CMC) operational system, the UK Met Office operational system (UKMO), and the FIM experimental ensemble system. The GEFS/EnKF is competitive with the ECMWF system and generally more skillful than the other systems, and the spread and error are generally consistent with one another in the GEFS/EnKF ensemble, a desirable property.

Based upon this and other positive evidence from recent EnKF and EnKF/variational hybrid experiments, NCEP/EMC, NASA/GMAO, ESRL/PSD, and the University of Oklahoma recently inked an agreement to



bring the EnKF to EMC for consideration as input to a hybrid variational/ensemble data assimilation scheme (HVEDAS). Over the next few months, the EnKF will be evaluated against the NCEP operational global ensemble system (at comparable resolutions). If the EnKF proves similar in performance or superior, the EnKF will be used in the coming years as input to the HVEDAS, with development in 2010 and 2011, extensive testing in 2011, parallel testing in 2012, and an intended implementation in the June of 2013.

For more information, contact Jeff Whitaker ([Jeffrey.s.whitaker@noaa.gov](mailto:Jeffrey.s.whitaker@noaa.gov)) or Tom Hamill ([tom.hamill@noaa.gov](mailto:tom.hamill@noaa.gov)).



Comparison of global average track forecast errors and average spread between the experimental GEFS/EnKF and (a) the NCEP operational ensemble system, (b) the ECMWF operational ensemble system, (c) the CMC operational ensemble system, (d) the UK Met Office operational ensemble system, and (e) the experimental FIM/EnKF ensemble system. Numbers in parentheses on top on each panel indicate the sample size at a particular forecast lead, i.e., the number of matched paired forecasts between the GFS and the model in question. Dashed lines indicate spread, solid lines indicate error. Error bars indicate the 5<sup>th</sup> and 95<sup>th</sup> percentiles of a resampled block bootstrap distribution.

(Tom Hamill, NOAA/ESRL)



## My Participation in a Data Assimilation Course via Video – Conference

(Min-Jeong Kim, JCSDA)



As multiple sources of observational data emerge, scientists with various backgrounds, such as radar remote sensing and satellite remote sensing, collaborate on data assimilation. Before joining the JCSDA, I studied precipitation retrieval algorithms using radar and passive microwave measurements for my Ph. D. thesis. I did not take a data assimilation class simply because they were not directly related to my thesis topic.

After joining JCSDA, I faced various challenges: learning new terminologies, refreshing my knowledge of fundamental dynamics, and deciphering complicated codes. I felt the need to systematically learn data assimilation many times when I listened to the discussions among data assimilation experts, and I never had that chance until now. I was delighted when I was given an opportunity to take a graduate course on data assimilation that is being taught by Professor Xiaolei Zou at Florida State University (FSU) within World Weather Building. These lectures were initially made accessible to us in a teleconference format, which has now been switched to a video-conference format. About ten people from NOAA/NESDIS and several from the University of Wisconsin's Cooperative Institute for Mesoscale Meteorological Studies and NASA's Marshall Space Flight Center have been attending the classes on a regular basis. During each class, students can ask questions remotely, hear questions asked by FSU students, and obtain answers from the professor either instantly in the classroom or through emails. Homework and term projects are assigned. I found the class extremely beneficial as it emphasizes the basic concepts while covering a wide range of practical topics. The course materials are delivered in simple terms so that they are easy to understand. The course outline is as follows:

1. Introduction
2. Theory of statistic estimate

3. Interpolation, Statistical implications of least-square fit
4. Filtering
5. Successive corrections and optimal interpolation
6. Adjoint
7. Adjoint sensitivity analysis in NWP
8. 3D-Var, 4D-Var, and EnKF Methods
9. Minimization
10. Traditional vortex bogusing techniques
11. 4D-Var vortex bogusing techniques
12. Quality control of satellite radiance observations
13. Use of radiance adjoint for model verification
14. 1D-Var retrieval of satellite radiances
15. GPS RO data
16. Quality control of GPS RO observations
17. GPS RO assimilation
18. Cloudy profiles from GPS ROs
19. TOMS total ozone data for hurricane prediction
20. Radar observations within hurricanes

Many of us at NESDIS find inspiration from Prof. Zou's lectures and gain deeper understanding of what we do at work related to data assimilation.

## A Note from the Director



*I'm pleased to be able to report that we are back on track with our external research program and that we are wrapping up the selection process for the FY 2010 Federal Funding Opportunity administered by NOAA/NESDIS on behalf of the Joint Center. We had a very good turnout of*

*proposals and look forward to the results the projects will be bringing us once they get underway.*

*During the one-year hiatus in the external research program brought upon us by an unexpected shortage of funding provided by our sponsors, we in the JCSDA management team took the opportunity to review the results of all the projects funded during the first seven years of existence of the Joint Center. One of our conclusions was that while many of the projects had provided interesting results with potential future applications, we would clearly have liked to see a larger proportion of the projects leading to operational implementation within the systems of one or more of the JCSDA partners. It was also quite clear to us that much of the blame was to be placed on our own side, and not necessarily on the funded investigators. An issue that we have struggled with since the inception of the Joint Center is the very limited amount of computer resources available to us. One of the consequences of this is that we have been largely unable to provide suitable test environments in terms*



of both hardware and software even to those investigators who may have had a sincere interest in having their ideas and algorithms tested in a “quasi-operational” setting. We are working aggressively to try to rectify this with help from both NASA and NOAA, and I am hopeful that an eventual successful solution to this will help substantially increase the likelihood of success for future JCSDA projects.

In about one month from now we will be hosting our annual JCSDA Science Workshop and I hope to see as many of you there as possible – whether you are externally or internally funded, working on “in-kind” contributions at one of our partners, or perhaps simply interested in what the Joint Center is up to. To a large extent due to the positive feedback we received from many of you, we have decided to go back to last year’s venue, the South Campus of University of Maryland Baltimore County.

Later this spring it is time for another milestone for the Joint Center: For the first time we will be hosting an event jointly with our friends and colleagues from Europe, namely the ECMWF/JCSDA Workshop on Assimilating Satellite Observations of Clouds and Precipitation into NWP Models, taking place in Reading, UK June 15-17. I think that between our two institutions we have been able to put together a quality program, and I hope that this will turn out to be the beginning of more extensive collaboration as well as a larger visibility for the Joint Center also outside the country.

Lars Peter Riishojgaard, Director, JCSDA

## Outlook for Next Quarter

### Upcoming Events

#### ECMWF - JCSDA Workshop on Assimilating Satellite Observations of Clouds and Precipitation into NWP Models



The European Center for Medium Range Weather Forecasting (ECMWF) and the U.S. Joint Center for Satellite Data Assimilation (JCSDA) are organizing a Workshop on Assimilating Satellite Observations of

Clouds and Precipitation into NWP Models, to be held on June 15 - 17, 2010, at ECMWF in Reading, UK. The outcome of this Workshop is expected to be specific recommendations/plans to advance the assimilation of

cloud/precipitation observations in operational NWP models. These recommendations will be directed at ECMWF and JCSDA, as well as other NWP centers and the relevant scientific communities.

*The Problem:* To date, assimilation of satellite measurements has focused on the clear atmosphere. But satellite observations in the visible, infrared, and microwave provide a great deal of information on clouds and precipitation as well as the clear regions above the clouds. The issue is how to use this information to improve the initialization of cloudy and precipitating atmospheric regions in NWP models. Since clouds and precipitation often occur in sensitive regions for forecast impacts, such improvements are likely necessary for continuing significant gains in weather forecasting.

*Background:* The workshop is a follow-up to a similar workshop that the JCSDA sponsored in 2005. That workshop covered the three main topics related to assimilating observations in cloudy/precipitating regions: satellite observing capabilities, modeling radiative transfer and cloud/precipitation formation, and data assimilation. The papers presented at the 2005 workshop were published as a Special Section of the Nov. 2007 issue of the Journal of Atmospheric Sciences.

#### Workshop set-up:

- 1¾ days for presentations, 1¼ day for working groups followed by a plenary session.
- Introduction will include brief summary of 2005 workshop.
- Workshop sessions will cover current status of cloud/precipitation assimilation in NWP, satellite observations, radiative transfer modeling, cloud and precipitation modeling, and special issues related to data assimilation of cloud/precipitation-affected observations.
- Invited presenters will be tasked to present status and issues/solution that can be addressed in working groups and not to present well-known results.
- Three working groups will run in parallel and each group will include experts in observations, modeling, and data assimilation. Each group will devise an implementation plan across disciplines. The final report will merge individual reports into one consistent document.
- Selected papers will be submitted for a special issue of the Quarterly Journal of the Royal Meteorological Society; publication in ECMWF Proceedings (and online) in any case. A short workshop summary will be submitted to AGU’s EOS.
- Participation by invitation

The workshop website is at:

[http://www.ecmwf.int/newsevents/meetings/workshops/2010/Satellite\\_observations/index.html](http://www.ecmwf.int/newsevents/meetings/workshops/2010/Satellite_observations/index.html)



## Eighth Annual JCSDA Science Workshop



The eighth annual Science Workshop of the Joint Center For Satellite Data Assimilation (JCSDA) will take place May 4-5, 2010 in Halethorpe, Maryland, at the University of Maryland at Baltimore County (UMBC). The purpose of the JCSDA Science

Workshop is to review the ongoing and planned scientific development sponsored by the JCSDA, and to plan and coordinate future efforts. The JCSDA has the following six scientific priority areas: (1) Radiative transfer, (2) Clouds and precipitation, (3) Advanced instruments, (4) Land data assimilation, (5) Ocean data assimilation and (6) Air quality data assimilation. The JCSDA supports scientific development work in these areas with proposal-based, internally directed funds (JSDI) as well as with external grants awarded via a competitive Federally Funding Opportunity (FFO) open to the broader scientific community. In addition, JCSDA individual partners undertake their own research that overlaps with JCSDA objectives. It is important that all these efforts be complementary and coordinated. The JCSDA science workshop aims at facilitating this coordination. At the JCSDA Science Workshop, JCSDA Principal Investigators will report on progress on their projects and participate in discussions about the status and plans of the Joint Center. The first circular of the science workshop can be found at the JCSDA web site (<http://www.jcsda.noaa.gov/>). In this circular, you will find general information on meeting address, registration, lodging near UMBC and instructions for oral and poster presentations. If you would like to attend, or for additional information, contact [Sid.Boukabara@noaa.gov](mailto:Sid.Boukabara@noaa.gov). (Sid Boukabara, JCSDA)

## First Community Gridpoint Statistical Interpolation (GSI) Data Assimilation System Tutorial Class



Registration is now in progress for the 1st Community Gridpoint Statistical Interpolation (GSI) Data Assimilation System tutorial on June 28 - 30, 2010 at the National

Center for Atmospheric Research Foothills Laboratory, Boulder, Colorado.

The GSI system is a unified variational data assimilation

system currently part of the operational Global Forecast System and North American Mesoscale Model and will be part of the Weather Research and Forecasting Rapid Refresh system, which is slated to replace the Rapid Update Cycle run at NOAA/NCEP in 2010.

This tutorial will be the first community tutorial hosted jointly by NOAA/NCEP/ Environmental Modeling Center (EMC) and the NOAA-AFWA-NSF-FAA Developmental Testbed Center (DTC). It will be a three day venture (half day optional) with both lecture and hands-on sessions. The lecturers are invited from various GSI development/support teams, including NOAA/NCEP/EMC, NASA/Global Modeling and Assimilation Office, NOAA/Global Systems Division, NCAR/Mesoscale and Microscale Meteorology Division and DTC, and will provide first-hand information on the GSI system.

Due to the constraints of physical space and computers, a maximum of 40 participants can be accommodated for the tutorial. For tutorial Information and on-line registration, please visit: [http://www.dtcenter.org/com-GSI/users/tutorials/gsi\\_tutorial\\_2010.2.php](http://www.dtcenter.org/com-GSI/users/tutorials/gsi_tutorial_2010.2.php)

For more information regarding the GSI model, please visit: <http://www.dtcenter.org/com-GSI/users/index.php>

Registration fees: \$300.00 for both lectures and hands-on sessions (including print-out, shuttle, lunch and break refreshments)

Important Dates:

5 March 2010: Registration Opens

After 25 May 2010: No refunds for cancellation

(Hui Shao, JCSDA)



## JCSDA Seminars

JCSDA seminars are generally held on the third Wednesday of each month in Room 707 of the World Weather Building. Presentations are posted at

<http://www.jcsda.noaa.gov/JCSDASeminars.php> prior to each seminar. Off-site personnel may view and listen to the seminars via webcast and conference call. A complete listing of past and future seminars is at the above web-site. Seminars during the next Quarter are listed on the following page.



<i>Date</i>	<i>Speaker</i>	<i>Affiliation</i>	<i>Title</i>
<i>TBD</i>	Steve Goodman	NOAA GOES-R Program Senior Scientist	The GOES-R Geostationary Lightning Mapper (GLM) and Opportunities for Assimilation of the Data into NWP Models
<i>Tuesday, May 19, 2010</i>	Ricardo Todling	NASA/GSFC Global Modeling and Assimilation Office	Tentative Title: The GMAO Data Assimilation System: Status and Future Directions
<i>TBD</i>	Florence Rabier	Meteo France	Data Assimilation at Meteo-France
<i>June 2010 (Date TBD)</i>	Tom Auligne	NCAR	Recent Developments on the Assimilation of Cloudy Radiances with WRF

Editor's Note: Unsolicited articles for the JCSDA Quarterly Newsletter are encouraged as are suggestions for seminar speakers or topics. Please send them to [George.Ohring@noaa.gov](mailto:George.Ohring@noaa.gov).