## News in This Quarter
Science Update

Preparing the NCEP GDAS/GFS for Atmospheric Motion Vectors Derived from the Future GOES-R Advanced Baseline Imager (ABI)
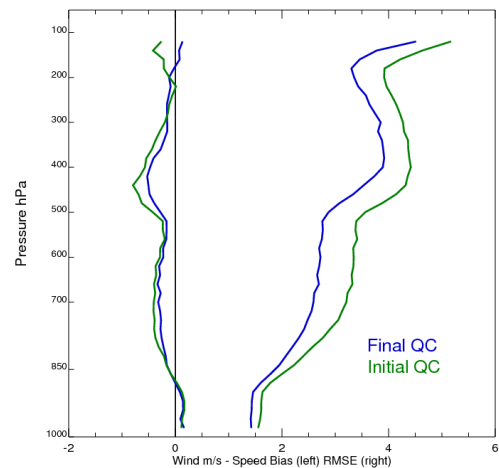
A new Atmospheric Motion Vector (AMV) nested tracking algorithm has been developed for the Advanced Baseline Imager (ABI) to be flown on NOAA's future GOES-R satellite [Bresky et al., 2012]. This algorithm is very different from the AMV algorithm used operationally at NOAA/NESDIS today. The new AMV algorithm was designed to capture the dominant motion in each target scene from a family of local motion vectors derived for each target scene. Capturing this dominant motion is achieved through use of a two-dimensional clustering algorithm that segregates local displacements into clusters. The dominant motion is taken to be the average of the local displacements of points belonging to the largest cluster. This approach prevents excessive averaging of motion that may be occurring at multiple levels or at different scales which may lead to a slow speed bias and a poor quality AMV. A representative height is assigned to the dominant motion vector through exclusive use of cloud heights [Heidinger & Pavolonis, 2009 and Heidinger et al., 2010] from pixels
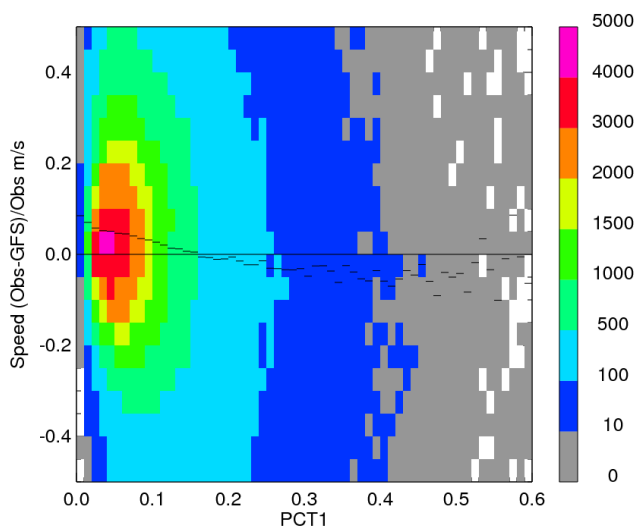
belonging to the largest cluster. This algorithm has been demonstrated to significantly reduce the slow speed bias associated with winds at upper levels, something that is commonly observed in AMVs derived from satellite imagery. Given the significant improvement in quality we have observed with AMVs derived from this new AMV algorithm, we are hopeful that future GOES-R AMVs will positively impact the accuracy of NCEP GFS forecasts.

To support this outcome, the investigation of the GOES-R AMVs impact on the NCEP GFS has begun before launch with the use of proxy data. Using satellite imagery provided by Meteosat's Spinning Enhanced Visible & InfraRed Imager (SEVIRI), AMV data has been generated for determining quality control procedures as well as evaluating the implementation in the NCEP GFS. Several parameters available from the nested tracking algorithm have been examined as candidate quality control parameters. One parameter PCT1, a measure of the cluster standard deviation divided by the distance the cluster traveled between images, has shown some skill in predicting AMV departure from the GFS background. The normalized speed departure and PCT1 values are shown in a density plot (Figure 1) for the month of June 2012. The AMVs associated with the cirrus cluster type have a positive mean speed departure for the smallest values of PCT1 while the mean departure becomes negative for large values of PCT1. Note that this density plot does not include AMVs which failed to meet traditional quality control measures using Quality Indicator and Expected Error. Trimming the tails of the PCT1 distribution by adding this parameter to the quality control procedure allows the removal of a small number of AMVs which fall outside the range of typical PCT1 values.

Figure 1. *Density plot of normalized AMV speed departure from GFS background and the nested tracking parameter PCT1 for cirrus clusters in June 2012. The black line at each PCT1 bin shows the mean speed departure value. AMV number in the x/y bin range from 0 to 5000.*

Figure 2. *Vertical profiles of speed bias (GFS-AMV) and wind vector difference RMSE for IR AMVs with respect to the GFS analysis for June 2012. Initial QC represents results using the current GOES AMV observation error. Final QC represents results with a 25% reduction in observation error.*

To estimate the impact of the addition of GOES-R AMVs to the observing system on the GFS analysis state and forecast skill, an experiment suite was constructed to include two seasons for both the experiment which includes GOES-R AMV proxy data and the control which does not use AMVs from SEVIRI. The pre-implementation version of the Hybrid Ensemble Kalman Filter GDAS/GFS was selected for this study. Initial results from the first season, May-July 2012, revealed an observation minus analysis wind vector difference RMSE which is not ideal for the ABI Channel 14 infrared AMVs. The large RMSE for the GOES-R AMVs indicates the quality control is too lenient and/or the specified observation error is too large. Tuning experiments, which varied the AMV observation error within the GDAS/GFS, showed a positive response by the wind vector difference RMSE for all 4 AMV types when the error was reduced. Repeating the first season run with the AMV error set at 75% of current GOES AMV observation error has lowered the vector difference RMSE (Figure 2). Also included in the new summer season run is the application of a log normal vector difference threshold to replace the current wind component departure check. Analysis of the AMVs impact is underway and initial results indicate the GOES-R AMV data are behaving as expected in the NCEP GDAS/GFS.

(Sharon Nebuda and Dave Santek, CIMSS; Jim Jung, CIMSS/JCSDA; Jaime Daniels, NOAA/STAR; Wayne Bresky, IMSG).

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Nowcasting of Clouds Based on Multiple Infrared Satellite Sensors

The initialization of clouds in Numerical Weather Prediction (NWP) models is a difficult problem that has recently received increased scrutiny. Current data assimilation methods are challenged by the high spatio-temporal variability of clouds, strong non-linearities in the radiative transfer calculation, and non-Gaussian error distributions. Furthermore, even with the new generation of satellite sensors, clouds are fundamentally under-observed and the initialization process needs to rely on ancillary information to determine the non-observed cloud variables. However, the usual balance equations defined at synoptic scale are not applicable for convection-permitting scales and model balance via ensembles of forecasts is affected by systematic model errors. For these reasons, NWP prediction is usually outperformed by simple advection methods in the first hours of forecast (*i.e.* nowcasting).

We propose a novel approach for cloud nowcasting based on multiple infrared satellite sensors, using a simplified version of the Weather Research and Forecasting (WRF) model and data assimilation. The fundamental piece of the system is the Multivariate Minimum Residual (MMR) scheme proposed by Auligné [2013a,b]. This scheme starts by comparing satellite infrared radiance observations with their equivalents from a numerical model using the Community Radiative Transfer Model (CRTM). The WRF data assimilation system is used to compute the departures between the observations and their model equivalent. These departures are calculated for multiple channels sensitive to different altitudes in the atmosphere. The MMR scheme then solves a variational problem for every satellite field-of-view individually and retrieves a cloud profile (similarly to a 1DVar approach). The retrieval process is fast and properly constrained due to the simple representation of the cloud via a vertical stack of thin, opaque blackbody clouds. The control variable is hence reduced to the cloud fraction at every vertical level. The MMR scheme has been implemented successfully for several satellite infrared instruments onboard polar-orbiting and geostationary platforms, including AIRS, IASI, CrIS, MODIS, GOES-Imager, and GOES-Sounder. A validation of the results has been conducted with synthetic and real data, inter-comparison between instruments, and independent observations such as CloudSat [Xu et al., 2013].

The next component of the nowcasting system is the interpolation of the cloud columns from the satellite fields-of-view to the model grid points. Our current prototype involves procedures to account for the size of the fields-of-view, which depends on the scan angle. Specific procedures are also used to combine optimally the information from sounders (with high vertical accuracy but low horizontal resolution) and imagers (with low vertical accuracy and high horizontal resolution). These procedures are perfectible, yet they produce reasonable results. The resulting product is a three-dimensional gridded field of cloud fraction that fits precisely the measurements for a combination of infrared satellite instruments.
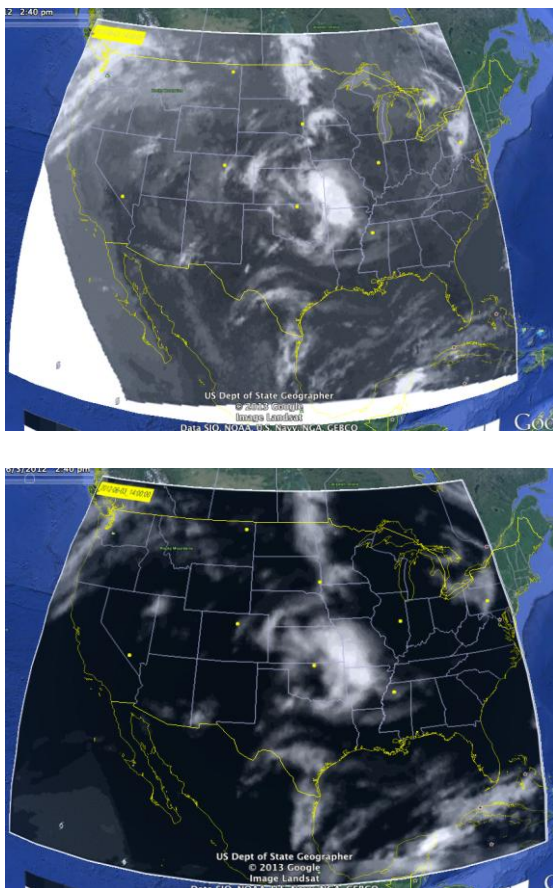
The forecasting component of the system is constructed via the WRF dynamical core. This provides dynamical transport and diffusion of clouds over time. Technically, the WRF model is run without any physics, treating the 3-dimensional gridded cloud fraction as a dynamical tracer. This approach is faster than a full NWP model implementation while preserving acceptable skills for short-term forecasts in situations without significant changes in the cloud thermodynamical structure.

The last component of the cloud nowcasting system is the implementation of a rapid-update cycling (currently every
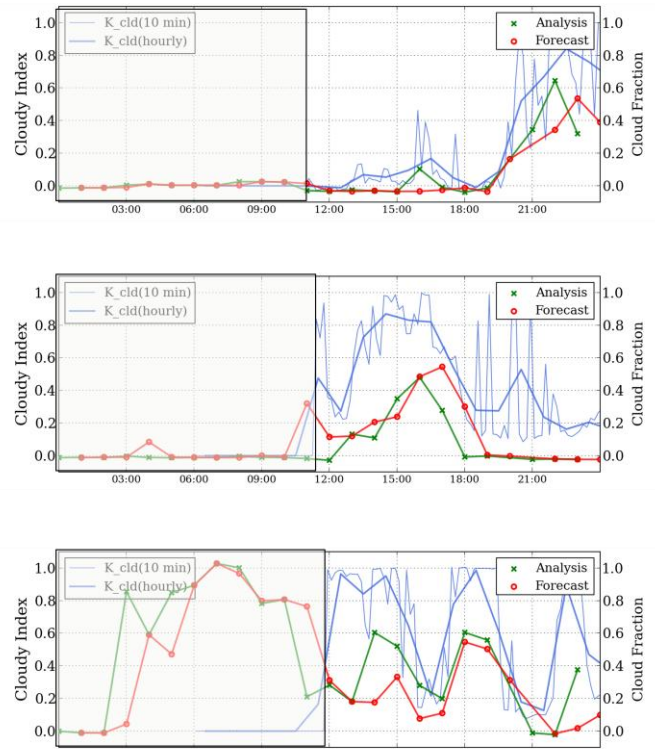
hour). In observation-rich areas, new information is overwriting the latest forecast whereas unobserved regions remain unchanged. This procedure ensures that the system is always using the most recent information. The age of the information is recorded and transported in time (as an additional tracer) to allow for optimal combination of forecast data with new observations. Each updated state becomes in turn the initial point for a new forecast, which will not suffer from the usual model spin-down problems since clouds are treated as tracers and they do not interact with the model physics.

Figure 1 provides a visual validation of a 1-hour forecast at 15km horizontal resolution compared with GOES-Imager observations. Figure 2 overlays time-series of the analyzed and forecasted clouds with a cloud attenuation index derived from surface irradiance observations at three SURFRAD stations located in the mid-western United States. Globally the model properly represents the clouds but it misses the

high temporal variability, which is associated with sub-grid scale clouds. This prototype will now be ported to the Gridpoint Statistical Interpolation (GSI) system and tested at higher resolution in a near-real-time environment.

Figure 2. *Timeseries of instantaneous (light blue) and 10-min averaged (dark blue) cloud attenuation derived from global solar horizontal irradiance observations at three SURFRAD stations. The model analysis and 1-h forecast of total column cloud fraction are represented in green and red respectively. Night-time information is covered with a grey box.*

(Tom Auligné, NCAR)

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Figure 1. *Top) Observations from GOES-imager (channel 4 minus channel 2) for June 3rd, 2012 at 13:45 UTC. Bottom) Model 1-hour forecast of total column cloud fractions at 14:00 UTC. The yellow dots correspond to the locations of SURFRAD stations.*

Development Efforts

A New Community Multi-purpose Formatting Toolkit for BUFR Encoding

Many data assimilation applications, such as the Gridpoint Statistical Interpolation (GSI), utilize environmental satellite data sets encoded in the Binary Universal Form for data Representation (BUFR) format. At many Numerical Weather Predication (NWP) centers, BUFR data is delivered or generated in near-real time to meet operational priorities and then archived for both reanalysis and research-to-operations (R2O) activities. In many cases however, the broader R2O community does not have adequate access to the archived BUFR data necessary to carry out the development and improvement of data assimilation systems. To increase and enhance access as well as provide added value to the satellite data needed by researchers, the JCSDA has supported an effort to consolidate all available BUFR encoder/decoders into a single, flexible utility called the Community Multi-purpose Formatting Toolkit (CMFT).

The Center worked closely with its partners to gather all existing codes and BUFR tables. Therefore, the CMFT tool includes the capability to encode data from more than 20 satellite sensors into BUFR in the exact format expected by the NOAA operational models, namely GSI. Table 1 shows a list of the supported satellite sensors. Additionally the CMFT tool can create data tanks and dumps of any time window (e.g. ±3 hours of forecast run time) to meet both global and regional NWP requirements.

Table 1. List of satellite sensor data supported by the CMFT tool.

CMFT Supported Sensors			
AMSU-A	MLS	OSCAT	MSU
AMSU-B	TMI	ASCAT	SSMI EDR
MHS	Super TMI	SEVIRI	SSMI SDR
SSMI/S	ATMS	AVHRR	GOES SST
HIRS3/ HIRS4	CrIS	WINDSAT EDR 68	POES SST
OMI	GPSRO	AMSRE	VIIRS

The architecture of the CMFT software package facilitates quick implementation in any R2O environment. All necessary libraries (e.g. BUFRLIB, W3, HDF5, etc.) are contained within the package and versions are consistent with all reader software. The codes and libraries may be compiled with gfortran or Intel after a simple configuration file modification and the 'make' command.

Running the CMFT tool can be done through different modes of operation to meet the various needs of the research community. The most straightforward method to run the CMFT is through a JAVA Graphical User Interface (GUI), shown in Figure 1. The GUI allows the user to select exactly the satellite data to encode in BUFR ad-hoc. Once the selections are made, the user can execute the generated processing (bash) scripts through the GUI to generate the BUFR data. Alternatively, the user may generate the scripts from the JAVA GUI or use example scripts provided with the software package, and execute them via a command line or a cronjob. This may be the desired mode, for example, if the user requires BUFR files from satellite data downloaded from a direct broadcast site.
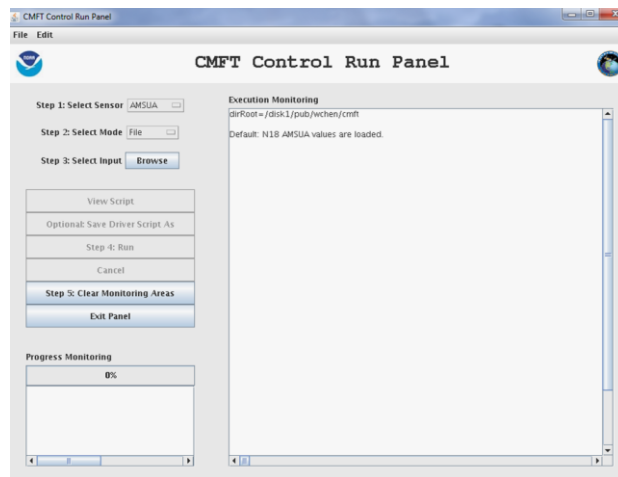
Figure 1. The CMFT GUI interface displaying the Control Panel.

The modular design of the CMFT tool allows for easy extension to future satellite data, such as from GCOM-W AMSR2. Another future capability will be an extension which allows for the BUFRization of synthetic or proxy data to support Observing System Simulation Experiments (OSSEs). The CMFT tool is freely available from the JCSDA. For more information, please contact Kevin Garrett (Kevin.Garrett@noaa.gov).

(Kevin Garrett, JCSDA; Wanchun Chen, NOAA/STAR)

CRTM Update

The latest releases of the Community Radiative Transfer Model (CRTM), versions 2.1 through v2.1.3, incorporate a number of improvements over the previous operational release, v2.0.5. These changes include new science as well as functional changes to allow users access to existing computational results.

Microwave Sea-Surface Emissivity Model
The biggest change from v2.0.x to v2.1.0 was the implementation of the FASTEM4/5 microwave sea surface emissivity model. FASTEM5 is the default and FASTEM4 [Liu et al., 2011] can be selected by specifying the appropriate data file during CRTM initialization. The previous model, a combination of FASTEM1 [English and Hewison, 1998] and a low frequency model [Kazumori et

al., 2008], can still be invoked via the options input to the CRTM functions.

Tests of the FASTEM5 microwave sea surface emissivity model, via CRTM v2.1.1, in the NCEP Global Data Assimilation System produced a neutral to slightly negative impact on forecast skill. Additionally, a wind speed dependence remained in the CRTM brightness temperatures compared to observations for the surface-sensitive microwave channels.

As explained in Liu et al. [2011], since FASTEM2, "the total atmospheric transmittance is used in a correction factor to the reflectivity for the accounting of angular-dependent downward radiation." The development of this capability in FASTEM2 is described in Deblonde [2000]. While this capability was implemented in CRTM v2.1 and v2.1.1, the application of the reflectivity correction was not activated. This correction was activated in clear-sky calculations in v2.1.2.
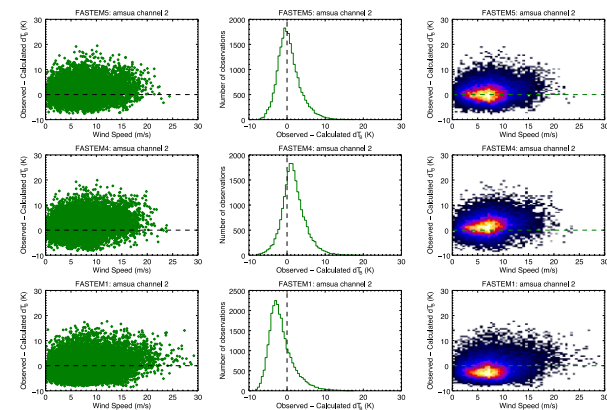
An indication of the CRTM brightness temperature differences between the FASTEM5/4/1 microwave sea surface emissivity models for AMSU-A channel 2 (NOAA-15 through MetOp-A) are shown in Figure 1.

Microwave Land-Surface Emissivity Model

The microwave land emissivity model now uses more information about the surface characteristics, specifically soil and vegetation types as well as the leaf area index (LAI), to compute the emissivity.

Non-LTE for Hyperspectral Infrared Sensors

A model to correct daytime radiances for the non-LTE effect in the shortwave infrared channels has been implemented [Chen et al., 2013]. Currently the correction is applied only to the hyperspectral infrared sensors: AIRS (Aqua), IASI (MetOp-A/B), and CrIS (Suomi-NPP).
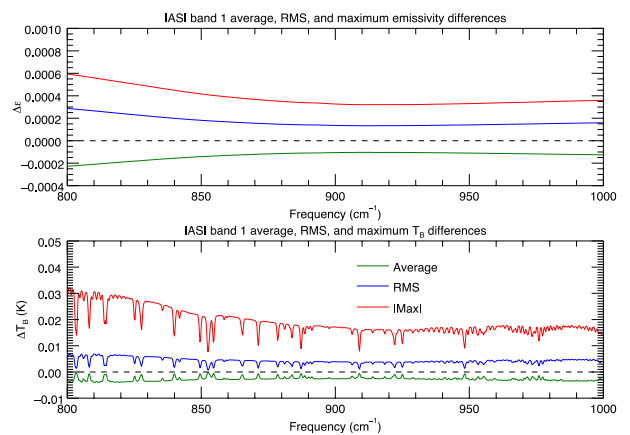
SOI Radiative Transfer Algorithm

A Successive Order of Interaction (SOI) radiative transfer (RT) algorithm [Heidinger et al., 2006] has been implemented and can be selected for use via the options input to the CRTM functions. The default RT solver remains the Advanced Doubling-Adding (ADA) algorithm [Liu and Weng, 2006].

Infrared Sea-Surface Emissivity Model Data

The infrared sea surface emissivity model (IRSSEM) interpolates look-up-table (LUT) data as a function of zenith angle using a weighted quadratic method. For individual frequencies in the Nalli emissivity data (see Nalli et al. [2008a] and Nalli et al. [2008b]) there is a sharp dropoff as a function of zenith angle. Interpolation of data close to this dropoff produced artifacts exacerbated by the wide angular spacing of the emissivities. Decreasing the zenith angle spacing of the emissivity data to 1° minimizes these interpolation artifacts.

In addition to decreasing the zenith angle spacing, the updated Nalli emissivity data was derived using the "varMinT" technique (see equations 29 and 30 in Nalli et al. [2008a]), as opposed to the minimum RMS technique of the original data (see equations 31 and 32 in Nalli et al. [2008a]). These two approaches are very similar but do produce slightly different results, particularly at higher zenith angles.

To quantify the differences in changing to the updated Nalli emissivities, the CRTM forward model was run for a randomized set of zenith angles from -60° to 60° for 32703 model profiles over ocean, using the MetOp-A IASI Band 1 transmittance coefficients. The average, RMS, and absolute maximum differences seen in the emissivities and the brightness temperatures are shown in Figure 2.

Figure 1. GSI single-cycle run (2013012700) results for AMSU-A channel 2 (with QC) comparing use of FASTEM5 (top panels), FASTEM4 (middle panels), and FASTEM1 (bottom panels). The data plots are, from left to right, simple scatterplot, simple histogram, and 2-D density map (brighter color indicates higher point density).

Figure 2. The average, RMS, and absolute maximum differences between the Nalli model emissivities (top) and associated computed brightness temperature (bottom) for the longwave window in band 1 of the MetOp-A IASI. The CRTM forward model computations used 32703 model profiles over ocean for a randomized set of zenith angles from -60° to 60°.

Several new functions have been implemented to increase the flexibility of CRTM application, including channel subsetting, selecting the number of streams for radiative transfer calculation, and a user-selectable switch to turn on and off scattering calculations for clouds and aerosol.

Other new science updates, functionality, and interface changes are detailed in the CRTM User Guide found at ftp://ftp.emc.ncep.noaa.gov/jcsda/CRTM/REL-2.1.3.

(Paul van Delst, JCSDA)

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Other News

2013 Joint DTC-EMC-JCSDA GSI Tutorial and Workshop Recap

The 2013 Joint DTC-EMC-JCSDA Gridpoint Statistical Interpolation (GSI) Tutorial and Workshop were held on August 5-8, 2013 at the NOAA Center for Weather and Climate Prediction (NCWCP), College Park, Maryland. It was the first time that the GSI Tutorial and Workshop were held at the new NOAA facility and the first time the DTC, EMC and JCSDA hosted these GSI outreach events as a joint effort. This marked the third annual GSI Tutorial and the second GSI Workshop since the GSI became a community model in 2009.

The GSI Tutorial was a three day class on August 5-7, 2013, with 11 hours of lectures and 6 hours of hands-on sessions. A tremendous effort was made by the GSI partners to make this event happen. NOAA provided the facility and computers for the tutorial, NCAR provided computing resources and servers for practical sessions, the NCWCP helpdesk provided onsite facility support, and JCSDA provided additional logistical support to the DTC. Forty-nine students from the United States and several other countries/regions participated in this tutorial. The lectures covered GSI basics as well as specific topics for advanced users. Invited lecturers and practical session instructors from several GSI development/support teams, including seven from EMC, JCSDA and NESDIS, one from NASA/GMAO, one from NCAR/MMM and three from DTC (affiliated with NOAA/ESRL or NCAR/RAL), provided first-hand information on the GSI system. Dr. Kayo Ide from the University of Maryland was invited as a guest speaker to give a general talk on the fundamentals of data assimilation. While past GSI tutorials were geared toward regional applications, running GSI in global applications was introduced for the first time in both the lectures and practical sessions. GSI tutorial materials and photos are available at http://www.dtcenter.org/com-GSI/users/docs/index.php.

The GSI Workshop was a one-day event hosted on August 8, 2013. The workshop was geared for both beginner and advanced data assimilation users, and was intended for users to share their experience on data assimilation efforts. Speakers were invited from different organizations and universities to cover the latest development and applications of GSI, as well as other advanced data assimilation techniques. Lectures were followed by a discussion session. Seventy-one registered participants attended the GSI Workshop, 50 onsite and 21 through remote access. Slides presented at the GSI Workshop are available at http://www.dtcenter.org/com-GSI/users/docs/index.php.

(Hui Shao, JCSDA/DTC)

Participants at the 2013 Joint DTC-EMC-JCSDA GSI Tutorial and Workshop at the NOAA Center for Weather and Climate Prediction, College Park, MD August 2013.

A Note from the Director

The newsletter comes to you with a bit of a delay this time. The good news is that we are back from the forced hiatus of many JCSDA activities due to the shutdown of the federal government for part of October. The bad news is that the shutdown means that not all of our activities have progressed as much as we would have liked to see. For instance, the much-needed upgrades of our two computers, JIBB and S4, are still being worked, but it now looks unrealistic that we will be able to roll out the upgraded platforms this fall as originally intended.

The Hurricane Sandy projects mentioned in the last issue of this newsletter are also still taking shape, and this is yet another area where we would have liked to be a bit further ahead at this time. However, we are getting there, and not all the news is bad. On the positive side, it now looks as if we will be spending some of the funds on fostering a closer collaboration between the JCSDA partners across agency boundaries, something that has always been a very high priority for us.

At this time, we are about three months away from the Second JCSDA Symposium that will be held during the 2014 AMS Annual Meeting in Atlanta. We started on a high note with our first Symposium in Austin last January, which included a high-profile panel and lunch-time events to feature the interagency nature of the JCSDA and the role of the Joint Center seen through the eyes of the agency executives. This year we are focusing more on the scientific and technical aspects of the work, and we have therefore decided to devote all our time slots to scientific presentations from JCSDA-funded investigators and other collaborators. The response to our call for papers has been very strong, as you will see from the strength of both the oral program and of the sizeable poster session included in next year's edition of the Symposium. We look forward to seeing many of you at the event in Atlanta.

Finally, it is with sorrow that we say farewell to one of our colleagues in the JCSDA Executive Team, Michele Rienecker, who left her position as JCSDA Associate Director when she retired from her position with NASA at the end of September to return to her native Australia. Michele had been the Head of the Global Modeling and Assimilation Office at Goddard since its inception in 2002, and she was a tireless advocate for the GMAO effort throughout her tenure. Under her leadership, GMAO became a major contributor to JCSDA and to the national data assimilation effort as a whole. Michele also helped put Goddard squarely on the map in the areas of reanalysis and data impact studies, both areas that were largely outside her own sphere of interest and experience when she took over the reins of the newly established office. Truly a series of remarkable accomplishments, and we will miss Michele's relentless ambition also on behalf of the Joint Center and her ever-present critical sense. Please join me in thanking Michele for her service, and in wishing her a long and happy retirement! However, on a more positive note, we now get to welcome Ron Gelaro as the new NASA Associate JCSDA Director. Ron is among the pioneers of one of the modern ways of looking at data impact, namely via the so-called FSO diagnostics, and he has also been active in predictability research. Ron, we welcome you and we look forward to working with you in the future!

Lars Peter Riishojgaard, Director, JCSDA

Upcoming Seminars			
Date	Speaker	Affiliation	Title
Nov 20, 2013	Clara Draper	NASA Goddard Space Flight Center GMAO/GESTAR	Assimilation of Land Surface Skin Temperature Observations into the GEOS-5 Atmospheric Modeling and Assimilation System
Feb 26, 2014	Min-Jeong Kim	NASA Goddard Space Flight Center GMAO/GESTAR	Cloud and Precipitation Assimilation Activities at the JCSDA

Upcoming Seminars

JCSDA seminars are generally held on the third Wednesday of each month at the NOAA Center for Weather and Climate Prediction, 5830 University Research Court, College Park, MD. 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. Audio recordings of the seminars are posted at the website the day after the seminar. If you would like to present a seminar contact Kevin.Garrett@noaa.gov

Upcoming seminars are listed above. Check:
http://www.jcsda.noaa.gov/JCSDASeminars.php
for updates.

Career Opportunities

CIRA/JCSDA Visiting Scientist Program Announcement

In coordination with the National Oceanic and Atmospheric Administration (NOAA), the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University is accepting applications to a Visiting Scientist Program (VSP) to support the activities of the Joint Center for Satellite Data Assimilation (JCSDA). The VSP seeks to stimulate collaboration and idea exchange between science partners toward advancing the use of satellite observations in weather, climate and environmental analysis and prediction. Applicants are encouraged to propose ideas that resonate with the understood challenges and current research fronts of satellite data assimilation. Selected candidate(s) will interact closely with a team of scientists at the NOAA Center for Weather and Climate Prediction in College Park, MD. Application deadline: December 31, 2013. Review of applications will begin in January 2014 and may continue until the position(s) is/are filled. For complete position description and qualification requirements, visit https://www.cira.colostate.edu/personnel/employment_opportunities/requisition.php?id=75. Please submit proposals outlining specific research and prospective partners, along with a current CV, budget requirements, and list of three

references to the attention of Human Resources Manager at the following email address: cira_hr@mail.colostate.edu. References will not be contacted without prior notification of candidates. Please put your last name and 13-132 in the subject line of the e-mail. Colorado State University conducts background checks on all final candidates. CSU is an EO/EA/AA employer.

NOAA/NESDIS/STAR, JCSDA

The Center is currently seeking qualified candidates for positions on the Directed Research Team (DRT) to work on high priority data assimilation projects, with focuses on passive microwave radiance, geostationary radiance, and Atmospheric Motion Vector (AMV) assimilation. These positions are full-time, contract positions with Riverside Technology, Inc. and located at the NOAA Center for Weather and Climate Prediction in College Park, MD. Descriptions of available opportunities can be found at http://www.jcsda.noaa.gov/careers.php

NOAA/NWS/EMC

I. M. Systems Group is currently seeking qualified candidates to fill a variety of positions at the NOAA Environmental Modeling Center (EMC) related to the improvement of the NOAA operational data assimilation system and forecast models. These positions are located at the NOAA Center for Weather and Climate Prediction in College Park, MD. A list of opportunities is available at: http://www.imsg.com/index.php/careers/current-opportunities