JOINT CENTER FOR SATELLITE DATA ASSIMILATION

NO. 48, FALL 2014

JCSDA Quarterly

NOAA | NASA | US NAVY | US AIR FORCE

NEWS IN THIS QUARTER

JCSDA PARTNER ACTIVITIES TOWARD THE ASSIMILATION OF GLOBAL PRECIPITATION MEASUREMENT MISSION OBSERVATIONS

Overview of the Global Precipitation Measurement Mission

The Global Precipitation Measurement (GPM) mission's Core satellite, launched on February 27, 2014, is well designed to estimate precipitation from 0.2 to 110 mm/hr and to detect falling snow. Knowing where and how much rain and snow falls globally is vital to understanding how weather and climate impact both our environment and Earth's water and energy cycles, including effects on agriculture, freshwater availability, and responses to natural disasters. GPM is a joint NASA-JAXA mission.

The design of the GPM Core Observatory is an advancement of the Tropical Rainfall Measuring Mission (TRMM)'s highly successful rain-sensing package. The cornerstone of the GPM mission is the deployment of a Core Observatory in a unique 65° non-Sun-synchronous orbit to serve as a physics observatory and a calibration reference to improve precipitation measurements by a constellation of eight or more dedicated and operational U.S. and international passive microwave sensors. The Core Observatory carries a Ku/Ka-band Dual-frequency Precipitation Radar (DPR) and a multi-channel (10–183 GHz) GPM Microwave Radiometer (GMI). The DPR will provide measurements of 3-D precipitation structures and microphysical properties, which are key to achieving a better understanding of precipitation processes and improving retrieval algorithms for passive microwave radiom-

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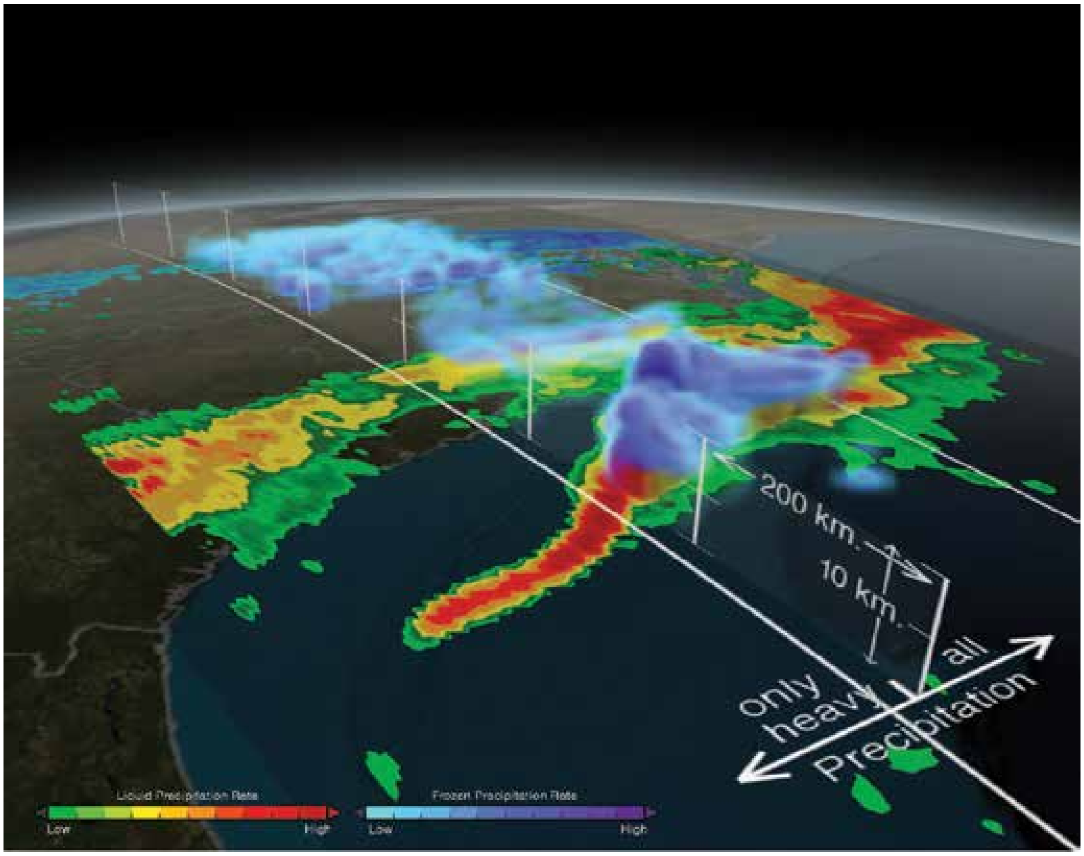

Figure 1. *This image, from March 17, 2014 (just 18 days after GPM's launch), combines data from GPM's Dual-frequency Precipitation Radar (DPR) and GPM Microwave Imager (GMI) and shows the southern extent of the storm off the coast of South Carolina. Inside the storm over the Atlantic Ocean, precipitation was frozen at high altitudes in the cloud before melting into rain near the surface. Inland, the temperatures were below freezing all the way down to the surface, allowing the formation of shallow, low-level (i.e., nimbostratus) clouds capable of producing snow. GMI views an area nearly four times as wide as DPR. The GPM Core Observatory GMI anchors partner satellite data to provide next-generation uniform estimates of precipitation everywhere on Earth every 3 hours. To learn more about GPM, visit www.nasa.gov/gpm.*

eters. The combined use of DPR and GMI measurements will place greater constraints on possible solutions to radiometer retrievals to improve the accuracy and consistency of precipitation retrievals from all constellation radiometers. Furthermore, since light rain and falling snow account for a significant fraction of precipitation occurrence in middle and high latitudes, the GPM instruments extend the capabilities of the TRMM sensors to detect falling snow, measure light rain, and provide, for the first time, quantitative estimates of microphysical properties of precipitation particles.

GPM's data products are released from NASA's Precipitation Processing System (PPS) in near real time: GMI products within 1 hour of collection and DPR products within 3 hours of collection. As a science mission with integrated application goals, GPM is designed to (1) advance precipitation measurement capability from space through combined use of active and passive microwave sensors, (2) advance the knowledge of the global water/energy cycle and freshwater availability through better description of the space-time variability of global precipitation, and (3) improve weather, climate, and hydrological prediction capabilities through more accurate and frequent measurements of instantaneous precipitation rates and time-integrated rainfall accumulation.

(Gail Skofronick-Jackson, NASA/GSFC, GPM Project Scientist)

GPM Data Assimilation Status and Plans: Update from NASA/GMAO

Scientists at the Global Modeling and Assimilation Office (GMAO) at NASA Goddard Space Flight Center are investigating the assimilation of Global Precipitation Mission (GPM) Microwave Imager (GMI) radiance measurements. Current efforts are expanding the all-sky (clear, cloudy, and precipitating) data assimilation methodology under development in the GSI system while also determining how the system is reacting to the assimilation of only clear-sky observations. The ultimate goal is to routinely assimilate these data to improve weather forecasts including severe storms and hurricanes as well as to improve global cloud and precipitation analyses.

The all-sky methodology has been implemented and extended to use GMI radiances. Since the observations have sensitivity to both clouds and precipitation, the existing infrastructure in the GSI has been extended to be more directly compatible with the GEOS-5 system. First, the GEOS-5 moist physics have been linearized and implemented as part of the GSI solution. Second, the analysis has been extended to include cloud ice and liquid as control variables. These directly relate to the prognostic cloud variables of the GEOS-5 model as well as the linearized physics.

Initial results have focused on a test case using Hurricane Arthur, which reached hurricane status on July 3, 2014, and was the first Atlantic hurricane to be observed by the GPM Core Observatory satellite. The normalized 37 GHz polarization difference, which anti-correlates to observed cloud liquid water path, is shown in Figure 1a. By comparing the observations to the modeled cloud water in Figure 1b, it is seen that in multiple regions of the Gulf, clouds are either displaced or missing. Also, it is seen that the model underestimates the liquid cloud amount in Hurricane Arthur, located off the

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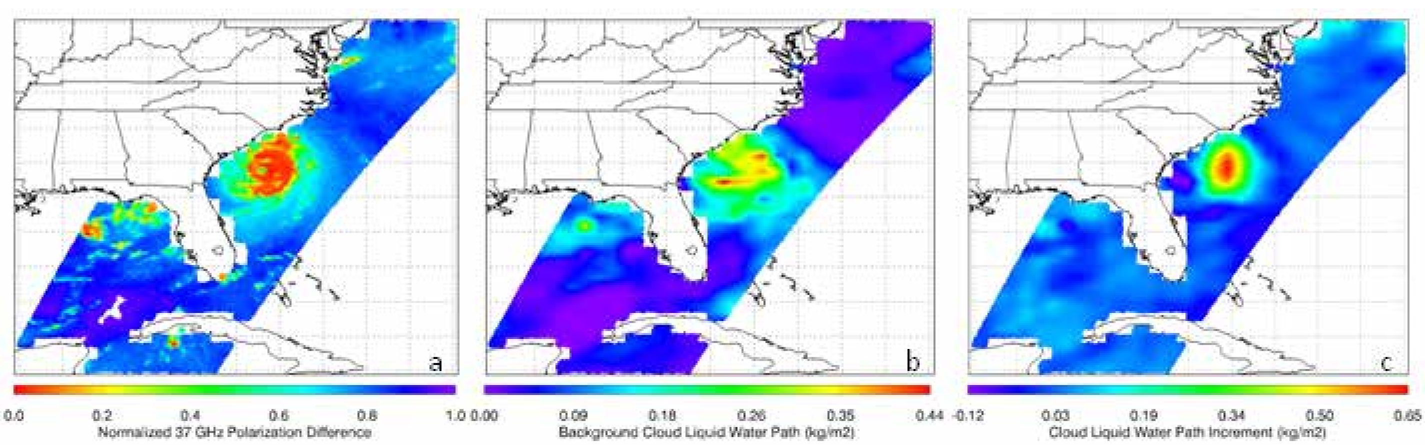

Figure 1. *The (a) normalized polarization difference of the GPM/GMI 37 GHz bands, (b) background cloud liquid water path, and (c) corresponding analysis increment of cloud water projected into cloud liquid water path space for the GPM orbit observing Hurricane Arthur at analysis time 1200 UTC on 3 July 2014.*

coast of South Carolina. By incorporating the GMI radiances under all-sky conditions, it is seen in Figure 1c that the analysis is indeed moving toward the observations via the generation of clouds in the analysis increment of cloud water. While this is only a single case, further investigation is ongoing to ensure that these increments are done in a manner that is physically consistent with the mass and wind fields.

Additionally, the reaction of the system to the clear-sky measurements from GMI and the TRMM Microwave Imager (TMI) is being considered. This effort has found that these observations have a net drying effect, which is resulting from a skewed distribution of the difference between the observations and the background fields. This has led to a reevaluation of quality-control procedures that have been extended from heritage microwave imagers.

With the convergence of these efforts and further advancements in data assimilation methodology (e.g., 3D/4D Variational/Ensemble Hybrid systems, advances in observation error modeling), the GMAO is on the verge of being able to routinely assimilate these observations in real time. Deliverables including read routines and BUFRization tools have been coordinated with and delivered to JCSDA partners.

(Will McCarty, Min-Jeong Kim, and Jianjun Jin, NASA/GMAO)

GPM Data Assimilation Status and Plans: Update from NOAA/NESDIS/STAR

Efforts are currently ongoing at the NOAA/NESDIS Center for Satellite Applications and Research (STAR) to assimilate Global Precipitation Mission (GPM) Microwave Imager (GMI) brightness temperatures in the NOAA Global Forecast System (GDAS/GFS). Working collaboratively with the NASA Global Modeling and Assimilation Office (GMAO), the capability to convert GMI data to BUFR format has been developed. For our purposes, we are choosing to work with the GMI L1C-R brightness temperature dataset which provides co-registered observations from both low- and high-frequency channels. This allows for the assimilation system, in this case the Gridpoint Statistical Interpolation (GSI), to use the full spectrum of observations simultaneously for improved quality control (QC). Since the GMI is to be used as the reference for cross-calibration of other GPM constellation sensors, no calibration is performed while creating the GMI 1C-R dataset.

The extension of the GSI for assimilation of GMI observations will occur in two phases. Phase 1, currently underway, will focus on assimilating observations in clear-sky and over-ocean only. We have begun assessments of the GMI brightness temperature bias and observation error by integrating the data within our newly developed Community Observation Assessment Tool (COAT). The COAT allows for the comparison of observed brightness temperatures with those simulated with GFS background fields and the Community Radiative Transfer Model (CRTM). It also provides a sandbox for de-

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veloping components for QC and precipitating and non-precipitating cloud detection/retrieval, which could be transferred to the GSI. New water and ice cloud retrievals have been implemented, and assessment of observation errors is in progress. At the same time, in coordination with GMAO, all plumbing in GSI to allow assimilation of GMI brightness temperatures has been completed, and initial experiments utilizing heritage QC routines (from SSM/I) are underway (see Figure 1). Once the QC and filtering has been optimized and tailored to GMI, experiments will be run to assess the impact on GFS forecasts.

Phase 2 will extend the assimilation of GMI observations to all-sky and all-surfaces. The key component for this capability may reside in the 1DVAR preprocessing algorithm currently being integrated within the GSI. The Multi-Instrument Inversion and Data

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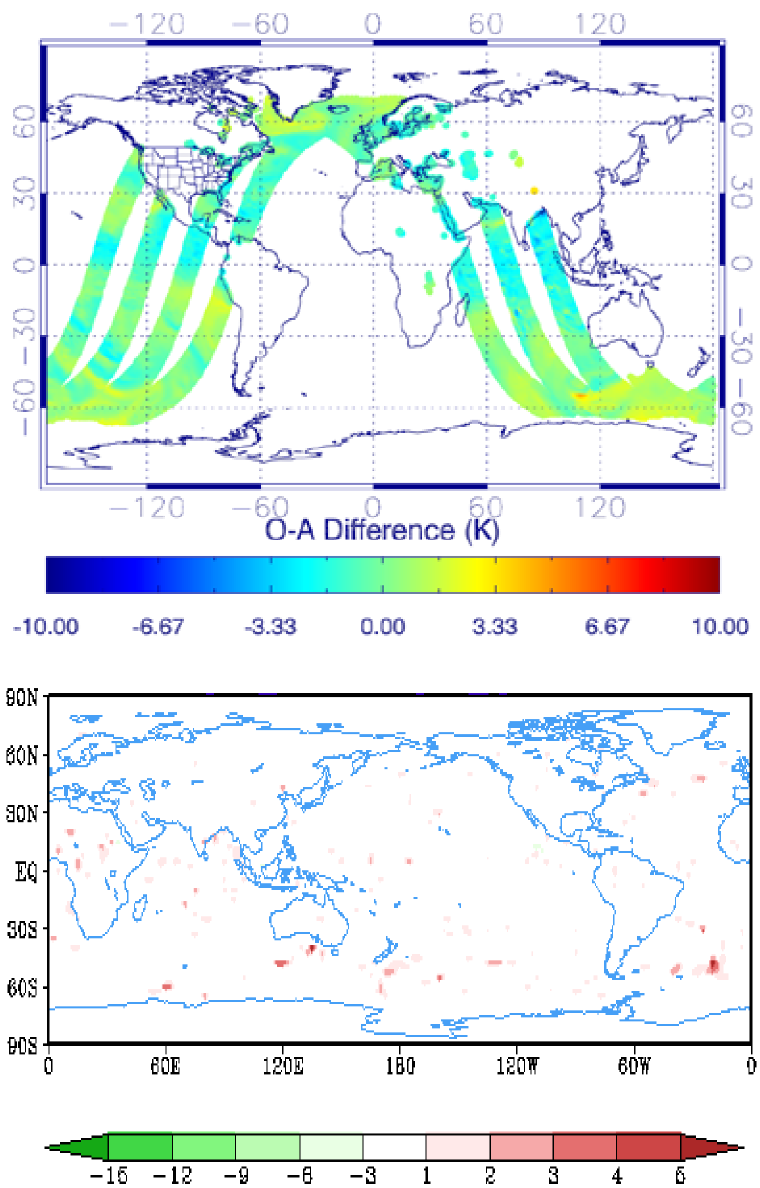

Figure 1. *Difference of O-A with and without assimilation of GPM GMI in the GDAS (top) and forecast difference in U wind component field (m/s) with and without assimilation of GPM GMI at Day 2.*

Assimilation Preprocessing System (MIIDAPS) will provide geophysical (surface and atmospheric state) and QC variables to the GSI assimilation system. For example, the 1DVAR minimization accounts for both hydrometeors and surface emissivity in the state vector, to better characterize the observations or linearize hydrometeor control variables before they are assimilated. MIIDAPS has already been extended to GPM GMI and shows some promising results.

(Erin Jones and Kevin Garrett, RTi/JCSDA)

Utilizing GPM/TRMM Radar for Analysis Weather Forecasting: Report from NOAA/OAR/ESRL

Utilizing GPM/TRMM radar reflectivity data for weather forecasting may indeed be pushing the limits of these observations, but this project at the NOAA Earth System Research Laboratory (ESRL) aims to determine their utility in this novel application. Two critical questions quickly became apparent. First, is the relative small areal coverage of the radar swath, especially when working with the dual-frequency footprint of a 150km width, large enough to have an influence in global or regional modeling? Second, will the data availability latency be too large with respect to model assimilation cycle times?

Simply testing these ideas with proxy TRMM data has proven to be a formidable task. TRMM radar data are used here as a GPM Ku band proxy. This constrains the geographical case study region to TRMM's latitudinal coverage of ~35° N and S of the equator. A major task is transforming space-scanned volumes into the 3D model Cartesian grid. This transform is unique for every satellite overpass over the domain owing to the scan geometry of the instrument, and the altitude and trajectory of the orbit with respect to model coordinates. Unlike a 2D field such as rain rate, here scan angle, scan range, and satellite motion will map radar volumes uniquely into the Cartesian grid for every overpass in the horizontal and vertical. To solve this problem for case-study work, we have been working with NASA for the software and orbital information to enable the transform.

Concerning data availability latency, GPM, unlike TRMM, will offer reflectivities with under 6h latency, putting these within the realm of real-time use, if not for the assimilation used to initialize forecast runs then potentially for the assimilation used for a first guess for subsequent model runs.

It was decided the initial test could be best accomplished by starting at storm scale and seeing if an impact was observable. The objective is to identify a storm case that falls within TRMM coverage area over CONUS that is long-lived enough to study it with a forecast model, in this case WRF with a 1km resolution, initialized with variational LAPS, an assimilation system under development at the Global Systems Division at ESRL. An initial case has been identified (see Figure 1), in which the storm persists for

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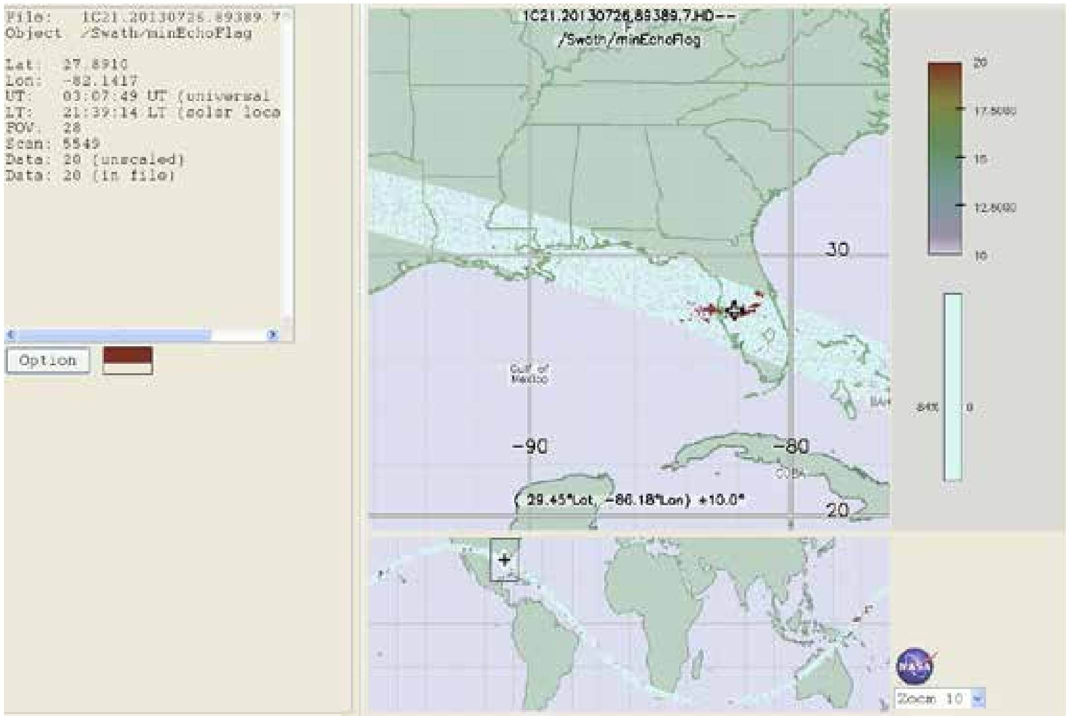

Figure 1. *Map of the minEchoFlag from the TRMM 1C21 dataset showing the presence of a convective storm over Central Florida on July 26, 2013 at ~03 UTC, our current case study. The swath contains the full storm, with part of the convective line extending westward into the Gulf of Mexico. The crosshairs in the large image, centered over the storm, correspond to the geographic coordinates and times shown in the panel at the upper left of the display.*

more than 10 hours while remaining within the model domain, and was well captured by a TRMM overpass. Can the proxy GPM data add value comparable to conventional radar? If it can in a small-scale case as this, we would anticipate it will provide similar impact to a global model as would conventional ground-based radar data, with only the swath width being the major constraint.

We are currently working on the data transform to the Cartesian grid, and putting the ancillary data together for the defined WRF forecast. The grid is a 750x750 horizontal Lambert projection with 42 vertical levels, 1km true, centered over Central Florida. We plan to run 3 WRF runs—one with no radar, one with space radar, and one with ground-based radar—and compare the forecast performance of each with respect to the evolving reflectivities as observed by ground radar.

In addition to this Florida case, we are looking to obtain another case, for which there is minimal ground-based radar available. Ideally the Rocky Mountain west would be perfect, but TRMM does not cover those latitudes. Recently Hurricane Odile has provided a tropical system that has progressed to the west Texas area that is normally dry and is poorly covered by ground-based radar. This might potentially become a second case to study even though validation might prove difficult.

(Dan Birkenheuer, Yuanfu Xie, and Kirk Holub, NOAA/ESRL)

GPM Assimilation Plans at NRL

The envisioned implementation plan for the Global Precipitation Mission (GPM) Microwave Imager (GMI) sensor at Naval Research Laboratory-Monterey with regard to data assimilation for Numerical Weather Prediction (NWP) is similar to that of an SSM/I and MHS. The imager channel near the water-vapor absorption line at 23.8 GHz along with the 18.7 and 37 GHz channels, all at vertical polarization, can be used to estimate the Integrated Water Vapor (IWV) in the atmospheric column. Currently, the IWV products are assimilated from the remaining operational SSM/I and SSMI/S sensors. The direct assimilation of these channels continues to be an option, but has not been moved to a high priority at present. However, direct radiance assimilation of the 183.31 +/- 7 and +/- 3 GHz, and potentially the two polarizations at 166.0 GHz, would be strongly considered. Operationally, the Navy Atmospheric Variational Data Assimilation System–Accelerated Representer (NAVDAS-AR) run at Fleet Numerical Meteorology and Oceanography Center (FNMOC) assimilates similar 183 GHz channels from the MHS, SSMI/S, and ATMS sensors. It is expected that there would be efforts dedicated to augment these channels with those from the GPM GMI. Lastly the Navy Coupled Ocean Data Assimilation (NCODA) system, which produces a sea-temperature and ice analysis, will use the GMI data primarily to produce sea ice concentration and edge analyses in the winter hemisphere as the tropical orbit will limit this sensor's coverage of sea ice.

(Ben Ruston, NRL)

Unsolicited articles for the JCSDA Quarterly Newsletter are encouraged as are suggestions for seminar speakers or topics. Please send them to Kevin.Garrett@noaa.gov.

OTHER NEWS

JCSDA 2015 Federal Funding Opportunity

The Fiscal Year 2015 Federal Funding Opportunity (FFO) for JCSDA external grants on Research in Satellite Data Assimilation for Numerical Environmental Prediction is now available on the U.S. Government website grants online. The direct link to the opportunity may be found under:

http://www.grants.gov/web/grants/view-opportunity.html?oppId=269230

The priorities in FY15 are:

1. Fundamental scientific improvements to the Community Radiative Transfer Model (CRTM). Projects in this category will be expected to identify actual and recognized shortcomings in the CRTM. Coordination with the CRTM technical team is suggested.

2. Tackle the issue of bias error characterization of satellite data, in cloudy and rainy conditions. This issue is considered critical

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in the proper handling of cloud and rain-impacted radiances in data assimilation systems.

3. Optimization of the assimilation of DMSP SSMI/S data. Projects selected in this category will be expected to be complementary to existing projects funded under other programs.

4. Assimilation of GPM sensors (passive and active). Projects in this category are encouraged to design scientific techniques, modules that could be applied generically to similar sensors (such as GCOM-W AMSR2).

5. Accelerate GOES-R data assimilation readiness (data such as radiances, AMVs, etc.) from both ABI and GLM sensors. Projects selected in this category will be expected to be complementary to existing projects funded under other programs and use real data as proxy to GOES-R from GOES and Himawari-8 satellites.

6. Optimization of the SNPP sensors data assimilation (ATMS, CrIS, VIIRS, OMPS) in preparation for the assimilation of data from JPSS sensors. Projects selected in this category will be expected to be complementary to already funded projects funded under other programs.

Total funding is anticipated to be approximately $500,000 per year. Individual annual awards in the form of grants or cooperative agreements are expected to range from $90,000 to $150,000. It is anticipated that three to five awards will be made. Project duration will be 1–2 years, with funding for multi-year projects contingent on satisfactory progress in prior years and funding availability. Full proposals are due by January 15, 2015. Proposers should follow application and submission directions spelled out in the FFO call.

(Sid Boukabara, JCSDA)

MEETING REPORTS

2014 Summer Community GSI Tutorial

The Fifth Community GSI Tutorial was held on July 14–16, 2014, at the NCAR Foothills Laboratory in Boulder, Colorado. This event is one of the outreach events hosted by the Developmental Testbed Center (DTC) in collaboration with the major GSI development teams providing operational capabilities to the research community. It has become a primary training resource for both operational and research users, providing essential knowledge on how to execute and further develop GSI.

This tutorial was a three-day venture with invited lectures and practical hands-on sessions. The lectures were designed to cover both GSI fundamental topics, including compilation, running, and diagnostics, as well as advanced topics in pre-processing, radiance and radar data assimilation, hybrid techniques, and GSI infrastructure. The invited lecturers and practical session instructors were invited from major GSI development and support teams, including NCEP/EMC, NASA/GMAO, NOAA/

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Participants of the 5th Community GSI Tutorial held in Boulder, CO from July 14-16, 2014.

ESRL, NCAR/MMM, and the DTC (affiliated with NOAA/ESRL or NCAR/RAL). The guest speaker from the university community this year was Dr. Milija Zupanski from Colorado State University. The tutorial attendance reached maximum capacity with 41 students from the United States and international communities.

The presentations and lectures of the GSI tutorial are posted at:

http://www.dtcenter.org/com-GSI/users/docs/index.php

For more information on the GSI system and its community support, please visit: http://www.dtcenter.org/com-GSI/users/index.php

(Hui Shao, JCSDA/DTC)

PEOPLE

Welcome Aboard, Mohar Chattopadhyay

Mohar Chattopadhyay joined Atmospheric and Environmental Research (AER) at NOAA/ NESDIS/STAR as a senior staff scientist in July 2014 to work on assimilation of cloudy radiances in support of JCSDA. She moved with her family to the United States in April 2014 from Melbourne, Australia, where she was working for Commonwealth Scientific and Industrial Research Organisation (CSIRO) on regional climate modeling and tropical cyclogenesis in the South Pacific region. Prior to that she was part of the Australian Bureau of Meteorology's data assimilation team assimilating SSM/I and HIRS data in the Bureau's 4DVar scheme. Mohar earned her Ph.D. in Atmospheric Science from the University of Canterbury, Christchurch, New Zealand, and also worked in the NZ MetService as a mesoscale modeler. Mohar is a keen gardener who likes to go for long walks, practice her music and read books when not at work.

CAREER OPPORTUNITIES

Further information on career opportunities listed here may be found at http://www.jcsda.noaa.gov/careers.php

NOAA

The National Oceanic and Atmospheric Administration, Center for Satellite Applications and Research (NOAA/STAR) is currently seeking qualified candidates in support of the JCSDA. Successful candidates will join the Directed Research Team (DRT) to work on high priority data assimilation projects, with focuses on assimilation of passive and active microwave radiance data, geostationary radiance data, and Atmospheric Motion Vectors (AMVs), as well as support current efforts on Observing System Simulation Experiments (OSSEs) and the Community Radiative Transfer Model (CRTM) development. These are full-time, permanent positions with Riverside Technology, Inc., Atmospheric and Environmental Research, Inc., the University of Maryland, or Colorado State University, and are located at the NOAA Center for Weather and Climate Prediction in College Park, MD.

NOTE FROM THE DIRECTOR

I hope everyone has enjoyed the summer of 2014, which for the Washington, DC, area was one of the most pleasant in recent memory. (The hope is that we won't pay for it dearly in the coming winter!)

The first order of business of this note is to congratulate two of the JCSDA partner agencies on their recent successful satellite launches: The U.S. Air Force having successfully deployed its DMSP F19 satellite (with SSMI/S onboard) in April 2014, and NASA having launched the Global Precipitation Mission (GPM) core observatory in February 2014. The release of the F19 data is imminent as of the writing of this note, while NASA released its GPM level-2 data on July 30, 2014. One of the major objectives of the JCSDA is of course to accelerate and optimize the use of satellite data in operational systems, and we are glad that robust coordination of activities between JCSDA partner scientists from the start (JCSDA was an early adopter of the GPM data) has led to significant progress being made in the testing and assimilation of these data. This newsletter, you might have noticed, is focusing on this effort, and should provide you a good overview of this progress.

On a somehow related note, the exotically named Hurricane Sandy projects aimed at improving the assimilation of certain satellite data (namely the Atmospheric Motion Vector (AMV) winds, the cloud- and rain-impacted radiances, and the geostationary infrared radiances) are all continuing to make progress and are starting to bear fruit, and we hope to be reporting on these projects in the near future, perhaps in one of these newsletters. These JCSDA projects, funded by NOAA's satellite data gap mitigation initiative, involve experts from different JCSDA partners and from academia. The executive team has recognized the necessity to coordinate more closely the AMV assimilation activities, and consequently a JCSDA Satellite Winds Working Group (SWWG) has been established, co-chaired by Dr. Jaime Daniels (NESDIS) and Dr. Pat Pauley (NRL). Thank you Jaime and Pat for stepping in to make this coordination happen.

On the High Performance Computing (HPC) front, the JIBB supercomputer, after being fully upgraded, continues to play a critical role in the JCSDA efforts, and no one

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is making better use of this upgrade than the OSSE project. This important effort helps examine objectively the potential impacts of hypothetical sensors on NWP skills. The sensors being considered are a hyperspectral infrared sensor on a geostationary platform, an alternative constellation of radio occultation sensors, and a microwave sensor on a geostationary platform. The JIBB's sister machine, the S4 supercomputer, has also been upgraded recently and its full release to all users was announced in July 2014. S4 is an essential component of the wider O2R environment that the JCSDA is establishing for the mutual benefit of the research community and the JCSDA operational partners. An upcoming publication is being worked on to highlight the achievements made possible by the S4 resources.

Before I close this note, I want to remind you of the Third Symposium on the Joint Center for Satellite Data Assimilation at the AMS Annual Meeting in Phoenix, Arizona, on January 4–8, 2015. The deadline for submission is behind us, and the program is finalized, but we hope to see many of you at the meeting. It is one of our main venues where we get a pulse of the research activities in satellite data assimilation and perhaps influence our future activities.

Take care,
Sid Boukabara (Acting Director, JCSDA)

SCIENCE CALENDAR

UPCOMING EVENTS

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.

JCSDA SEMINARS			
DATE	**SPEAKER**	**AFFILIATION**	**TITLE**
10 November, 2014, 2 p.m.	Thomas Nehrkorn and Ross Hoffman	AER	Correction for Position Errors in Variational Data Assimilation
21 January, 2015, 2 p.m.	John McCormack	NRL	TBD
MEETINGS OF INTEREST			
DATE	**LOCATION**	**WEBSITE**	**TITLE**
4-8 January, 2015	Phoenix, AZ	https://ams.confex.com/ams/95Annual/webprogram/3JCSDASYMP.html	3rd Symposium on the JCSDA 95th Annual Meeting of the AMS