JOINT CENTER FOR SATELLITE DATA ASSIMILATION

NO. 53, WINTER 2016

JCSDA Quarterly

NOAA | NASA | US NAVY | US AIR FORCE

doi:10.7289/V50C4SS7

NEWS IN THIS QUARTER

SCIENCE UPDATE

SMAP Data Assimilation at the GMAO

The NASA Soil Moisture Active Passive (SMAP) mission (Entekhabi et al. 2010) has been providing L-band (1.4 GHz) passive microwave brightness temperature (Tb) observations since April 2015. These observations are sensitive to surface (0-5 cm) soil moisture. Several of the key applications targeted by SMAP, however, require knowledge of deeper-layer, "root zone" (0-100 cm) soil moisture, which is not directly measured by SMAP. The NASA Global Modeling and Assimilation Office (GMAO) contributes to SMAP by providing Level 4 data, including the Level 4 Surface and Root Zone Soil Moisture (L4_SM) product, which is based on the assimilation of SMAP Tb observations in the ensemble-based NASA GEOS-5 land surface data assimilation system (Reichle et al. 2015). The L4_SM product offers global data every three hours at 9 km resolution, thereby interpolating and extrapolating the coarser-scale (~40 km) SMAP observations in time and in space (both horizontally and vertically). Since October 31, 2015, beta-version L4_SM data have been available to the public from the National Snow and Ice Data Center (NSIDC; http://nsidc.org/data/smap) for the period March 31, 2015, to near present, with a mean latency of ~2.5 days.

The land surface model component of the assimilation system, the NASA GEOS-5 Catchment land surface model (Koster et al. 2000), is driven with observations-based surface meteorological forcing data, including precipitation (Reichle and Liu 2014), which is the most important driver for soil moisture. The model also encapsulates knowledge of key land surface processes, including the vertical transfer of soil moisture between the surface and root zone reservoirs. The radiative transfer model to simulate L-band brightness temperatures was calibrated using observations from the Soil Moisture and Ocean Salinity mission

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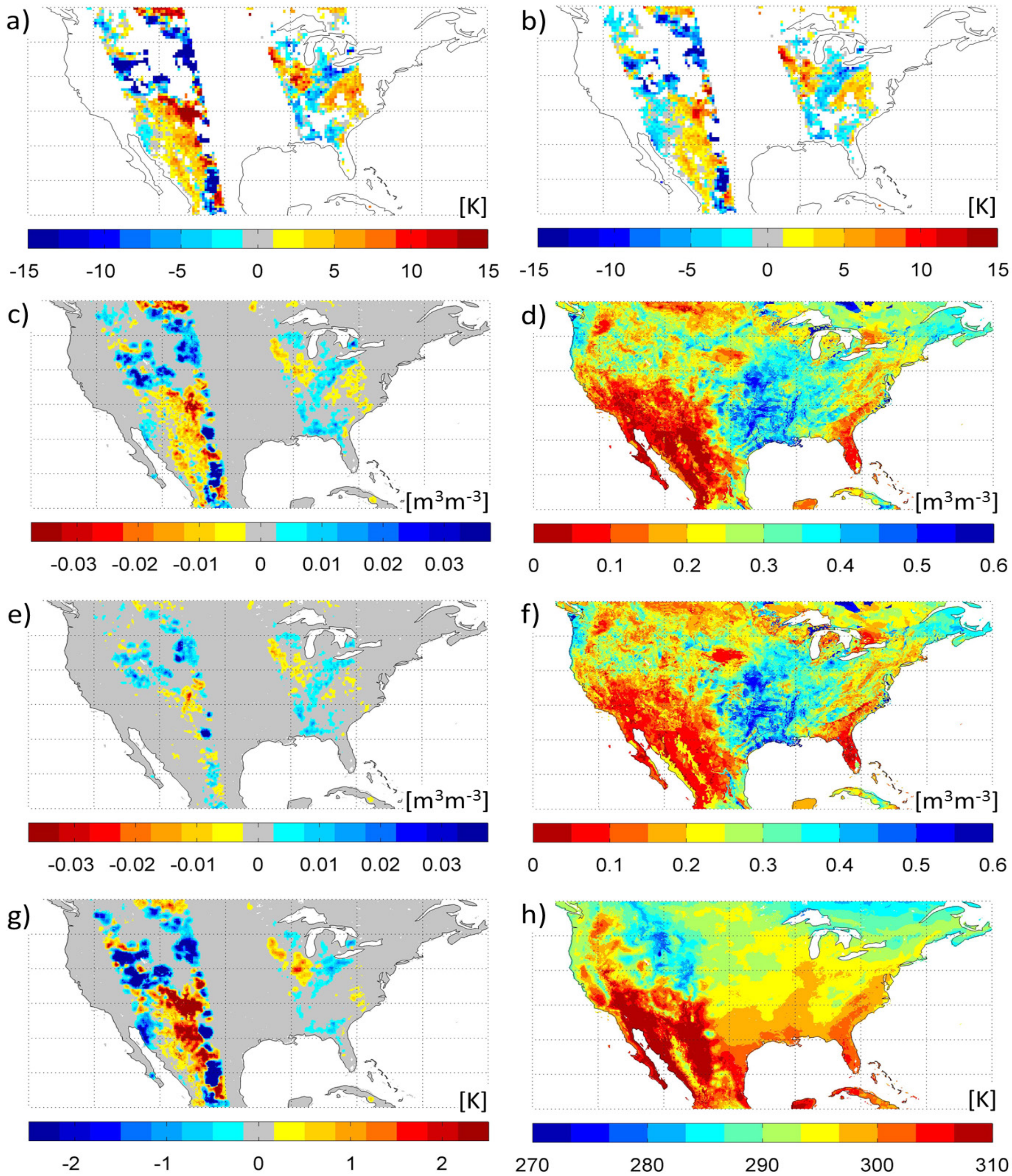

Figure 1. *L4_SM analysis for 29 May 2015, 0z. The top row shows O-F Tb residuals for (a) H-pol and (b) V-pol. Analysis increments are shown for (c) surface soil moisture, (e) root zone soil moisture and (g) surface soil temperature. The resulting analysis fields are shown for (d) surface soil moisture, (f) root zone soil moisture and (h) surface soil temperature.*

(De Lannoy et al. 2013). The horizontally distributed ensemble Kalman filter update step considers the respective uncertainties of the model estimates and the observations.

The quality of the L4_SM product is assessed against in situ measurements from watersheds with locally dense sensor networks and continental-scale sparse networks (Reichle et al. 2015). These comparisons indicate that the current beta version of the L4_SM data product meets the mission accuracy requirement, which is formulated in terms of the ubRMSE: the RMSE after removal of the long-term mean difference. For the period March 31 to October 25, 2015, the overall ubRMSE of the 3-hourly L4_SM surface soil moisture at the 9 km scale is 0.037

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m^3/m^3. The corresponding ubRMSE for L4_SM root zone soil moisture is 0.024 m^3/m^3. Both of these metrics are well within the 0.04 m^3/m^3 ubRMSE requirement.

The assessment of the L4_SM product further includes a global evaluation of the internal diagnostics from the assimilation system, including statistics of the observation-minus-forecast (O-F) residuals and the analysis increments (Reichle et al. 2015). The instantaneous soil moisture and soil temperature increments are within a reasonable range and result in spatially smooth soil moisture analyses (Figure 1). The O-F Tb residuals exhibit only small biases on the order of 1-3 K between the (rescaled) SMAP Tb observations and the L4_SM model forecasts, which indicates that the assimilation system is largely unbiased (Figure 2a). The average (RMS) magnitude of the O-F residuals is 5.7 K, which reduces to 2.6 K for the observation-minus-analysis (O-A) residuals (not shown), reflecting the impact of the SMAP observations on the L4_SM system.

Finally, the standard deviation of the *normalized* O-F residuals measures the consistency

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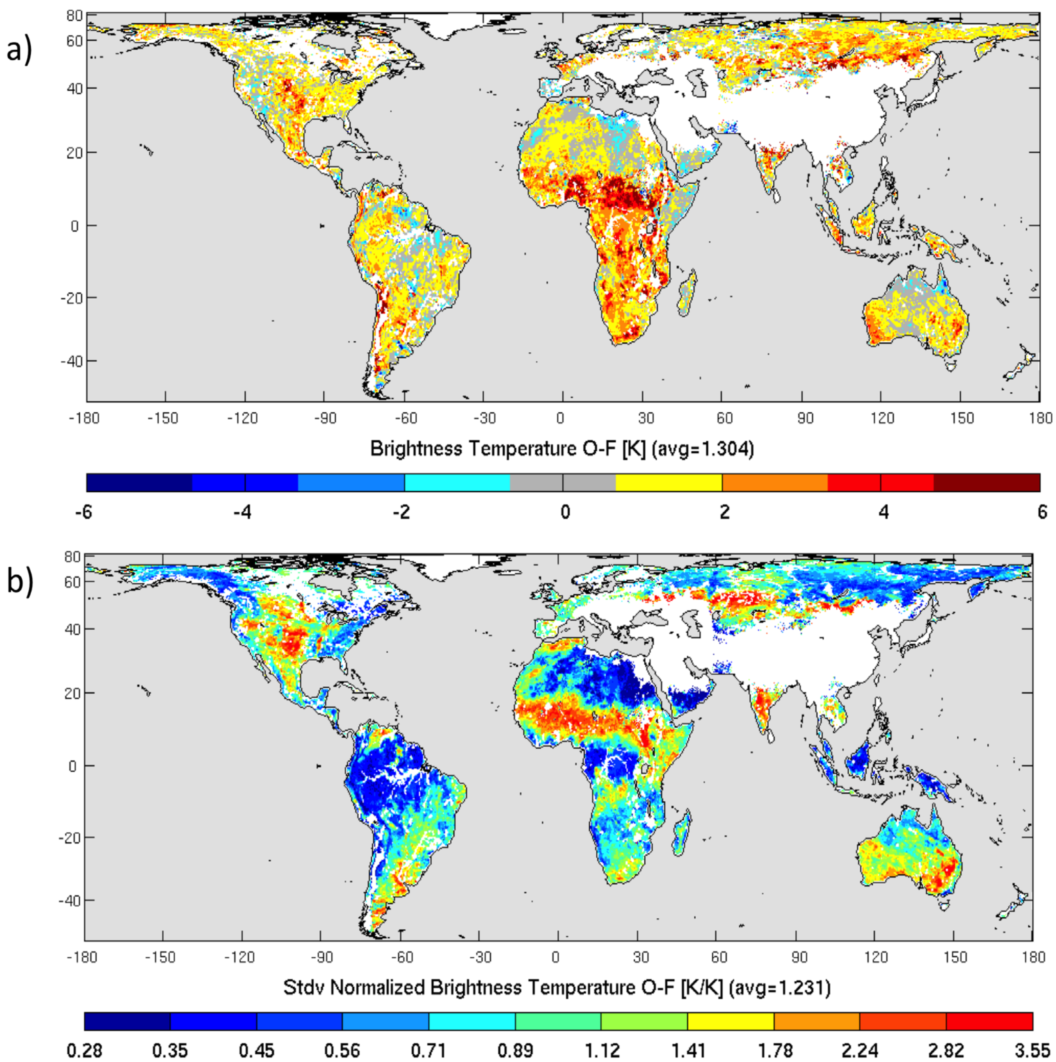

Figure 2. *(a) Mean O-F Tb residuals from the current beta-version L4_SM algorithm for 11 Apr 2015, 0z, to 25 Oct 2015, 0z. (b) Same as (a) but for the standard deviation of the normalized O-F Tb residuals.*

between the expected (modeled) errors and the actual errors. Specifically, the O-F residuals are normalized within the standard deviation of their expected total error, which is composed of the error in the observations (including instrument errors and errors of representativeness) and errors in the brightness temperature model forecasts. The parameters that determine the expected error standard deviations are key inputs to the ensemble-based L4_SM assimilation algorithm. If they are chosen so that the modeled errors are fully consistent with the actual errors, the metric should be unity. If the metric is less than one, the actual errors are overestimated by the assimilation system, and if the metric is greater than one, the actual errors are underestimated. Averaged globally, the time series standard deviation of the normalized O-F residuals is 1.2 K/K and close to unity (Figure 2b). Regionally, however, the metric deviates considerably from unity, which indicates that the L4_SM assimilation algorithm either over- or underestimates the actual errors that are present in the system.

Several limitations of the beta-version L4_SM data product and science algorithm calibration will be addressed prior to the release of the validated data product scheduled for 2016. Planned improvements include revised land model parameters, revised error parameters for the land model and for the assimilated SMAP observations, and revised surface meteorological forcing data for the operational period and the underlying climatological data. Nevertheless, the current beta version of the L4_SM product is sufficiently mature for release to the larger science and application communities.

R. Reichle, G. De Lannoy, Q. Liu, and J. Ardizzone (NASA GMAO)

Acknowledgments

The authors gratefully acknowledge the contributions by many SMAP project team members and Calibration/Validation (Cal/Val) Partners at the Goddard Space Flight Center, Jet Propulsion Laboratory, NSIDC, and several universities and agencies. Computational resources are provided by the NASA High-End Computing Program through the NASA Center for Climate Simulation.

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The Implementation of NEMS GFS Aerosol Component (NGAC) Version 2: Global Aerosol Forecasting at NCEP Using Satellite-Based Smoke Emissions

Atmospheric aerosols are suspended particulate matter in the atmosphere (e.g., mineral dust, smoke, sea salt, sulfates) which impact Earth's climate, human health, and economy. To predict the distribution of atmospheric aerosols as a component of the NOAA Environmental Modeling System (NEMS), the NOAA/NWS National Centers for Environmental Prediction (NCEP) partnered with the NASA Global Modeling and Assimilation Office (GMAO) and NOAA/NESDIS Center for Satellite Applications and Research (STAR) in developing a NEMS Global Forecast System (GFS) Aerosol Component (NGAC) (Lu et al. 2010, 2013).

Development of a global aerosol forecast system provides a first step toward an aerosol data assimilation capability at NCEP. The overarching goals for developing the global aerosol forecasting and data assimilation capabilities include: (1) to improve weather forecasts and climate predictions by taking into account aerosol effects on radiation and clouds; (2) to enhance the use of satellite observations by properly accounting for aerosol effects during the assimilation procedure; (3) to provide aerosol dynamic boundary conditions for regional air quality prediction models; and (4) to provide global aerosol products to meet stakeholder needs such as UV index, ocean productivity, solar energy production, visibility, and sea surface temperature (SST) retrievals.

The NGAC consists of two key modeling components: (1) the Global Spectral Model (GSM) within the NEMS architecture and (2) the online aerosol module based on Goddard Chemistry Aerosol Radiation and Transport (GOCART) model (Colarco et al. 2010). NGAC Version 1.0 has been providing 5-day dust forecasts at 1°x1° resolution on a global scale, once per day at 0000 Coordinated Universal Time (UTC), since September 2012. This article describes the upcoming NGAC upgrade (NGAC V2), slated for operational implementation in early 2016.

With support from JCSDA, the NCEP-STAR-GMAO team developed a near-real-time (NRT) smoke-emission product on a glob-

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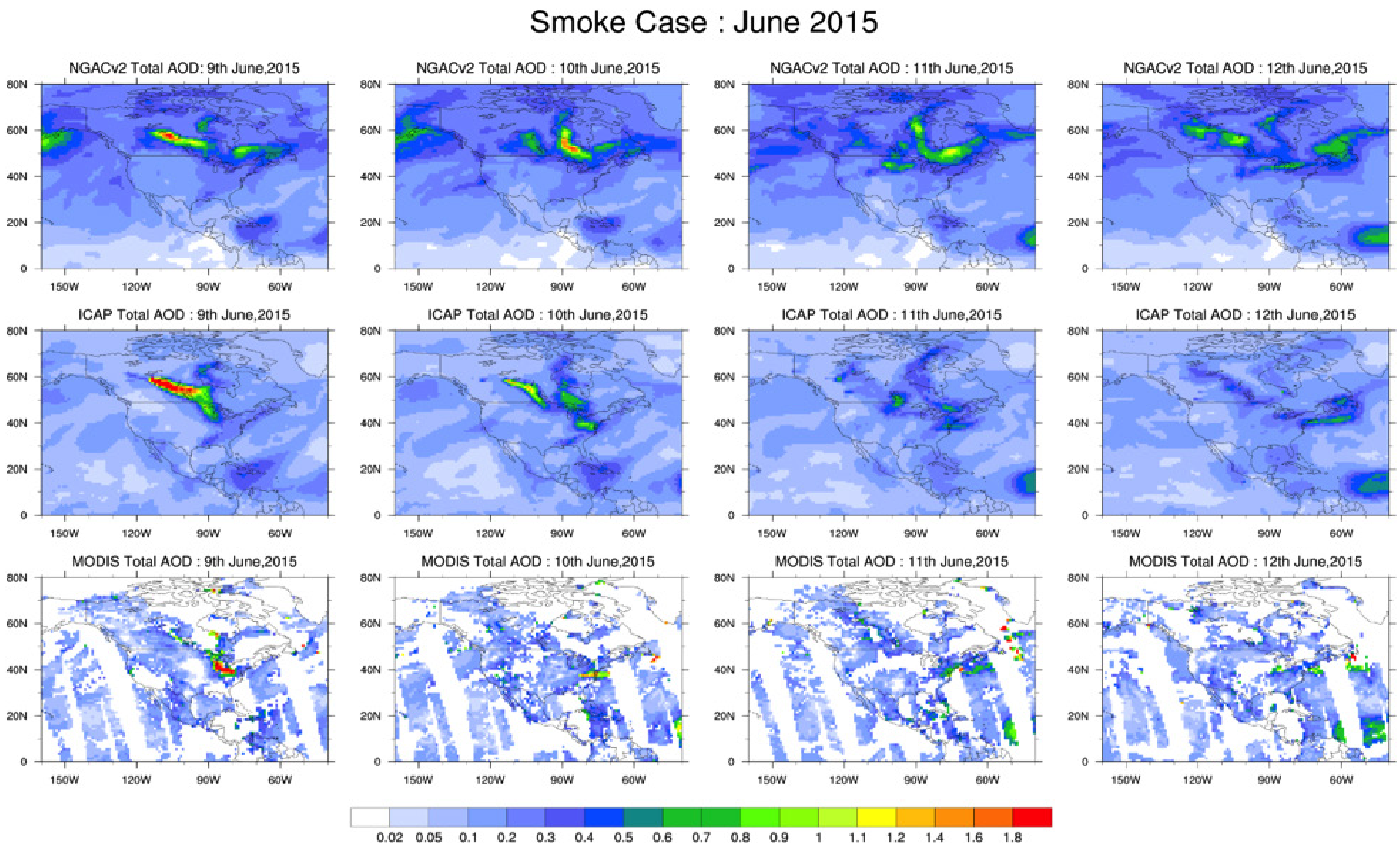

Figure 1. *Total AOD from NGAC V2 (top panels), the ICAP MMEs (middle panels), and MODIS (bottom panels) during June 9-12, 2015.*

al scale. Specifically, smoke emissions are blended from STAR's Global Biomass Burning Emission Product (GBBEP) from a constellation of geostationary satellites (Zhang et al. 2012) and GSFC's Quick Fire Emissions Data Version 2 (QFED2) from polar orbiting sensors (Darmenov and da Silva 2015). The resulting emission dataset, GBBEPx, became operational at NESDIS in June 2015, providing global emission fluxes for CO2, CO, OC, BC, PM2.5, and SO4 daily. A parallel (pre-operational) NRT data feed to NCEP has been established and the parallel NGAC V2 system has been running since July 2015.

The production of GBBEPx smoke emissions enables NCEP to upgrade NGAC for multi-species aerosol forecasts (including dust, sea salt, sulfate, and carbonaceous aerosols). Figure 1 shows elevated aerosol optical depth (AOD) stretching from Canada to the Great Lakes region and the mid-Atlantic region during June 9–12, 2015. The increase in AOD corresponds to widespread fire activity in Canada with effects across the continent throughout the period. AOD simulated by NGAC V2 is consistent with the International Cooperative for Aerosol Prediction Multi-Model Ensemble (ICAP-MME, Sessions et al. 2015) as well as observations from the space-borne Moderate Resolution Imaging Spectrometer (MODIS) sensor. Note the ICAP-MME is generated from the aerosol forecasts from GMAO, NRL, ECMWF, and JMA.

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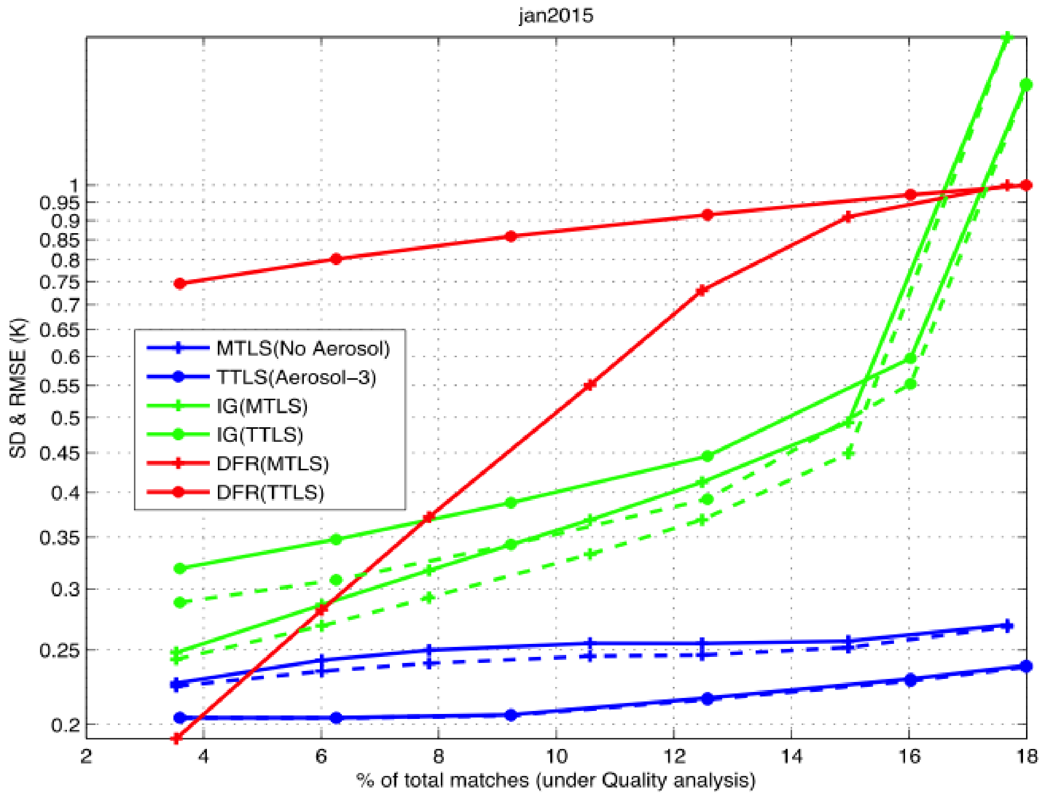

Figure 2. *Comparison of retrieval accuracy (blue lines) and algorithm sensitivity (Degrees of Freedom in Retrieval, red lines) of MTLS (crosses) without aerosol and Truncated Total Least Squares (solid circles) using aerosol optical depth in the state vector for MODIS-Aqua data for January 2015. Evaluation is done against iQuam buoy data. Initial Guess (IG) SST accuracy (green lines) is also shown.*

The implementation of NGAC V2 will provide a full suite of two-dimensional (2-D) and three-dimensional (3-D) aerosol products for various downstream applications. An example is presented here (Figure 2) and is focused on exploring and refining the use of aerosol information in physical deterministic retrievals of SST. NGAC 3-D aerosol predictions are used as input to the Community Radiative Transfer Model (CRTM), along with Global Forecast System (GFS) profiles of humidity and temperature. Aerosol column density (ACD) of all aerosols was then included in the state vector for the MODIS-Aqua SST retrieval.

Additional channels available for MODIS, combined with a three-element reduced-state vector, offer the prospect of testing a variant of the Truncated Total Least Squares (TTLS) approach. A comparison between results for the two-component [SST, total column water vapor (TCWV)] Modified Total Least Squares (MTLS, Koner et al. 2015) algorithm and three-component [SST, TCWV, ACD] state vectors is shown in Figure 2. It can be seen that the RMSE (dashed standard deviation lines in Figure 2) is improved noticeably when ACD is a retrieved parameter. A further consequence of including ACD in the state vector is that algorithm sensitivity is significantly improved. This is demonstrated by the increase in the degree of freedom in retrieval (DFR) values to 0.75 and above. Fully demonstrating this will require more accurate validation data.

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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.

MEETING REPORTS

Third Joint JCSDA-ECMWF Workshop Highlights Progress and Challenges for Assimilating Cloud and Precipitation-Affected Satellite Observations

The Third Joint JCSDA-ECMWF Workshop on Assimilating Satellite Observations of Clouds and Precipitation into NWP Models took place from December 1-3, 2015, and was hosted by the JCSDA at the NOAA Center for Weather and Climate Prediction in College Park, MD. It followed previous workshops in 2005 and 2010. The decision to hold a third workshop was prompted by a recommendation from the International Precipitation Working Group.

The workshop brought together 98 participants representing the JCSDA partners from the United States, which includes three National Oceanic and Atmospheric Administration (NOAA) line offices, the U.S. Navy and Air Force, and the National Aeronautics and Space Administration (NASA), along with international NWP centers including ECMWF, the U.K. Met Office, Météo-France, and the Japan Meteorological Agency, as

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Participants of the Third Joint JCSDA-ECMWF Workshop on Assimilating Satellite Observations of Clouds and Precipitation into NWP Models.

well as representatives from academia and the private sector.

The workshop was divided into three main themes: forecast model developments; data assimilation methodology; and observations and radiative transfer.

Regarding model development, there was a call for more interaction between scientists working on cloud and rain assimilation and those developing improved model components, especially in the physics part. The meeting noted examples where this has worked very well at ECMWF, for example in relation to the treatment of supercooled water.

In the data assimilation discussions, it was appreciated how much progress has been made since the last meeting in 2010. It was observed that uncertainty in the physics both of the model and the observation operators could be modeled more accurately in ensemble methods than is currently the case.

The workshop noted with interest proposals for future active instruments as well as enhanced infrared capabilities from geostationary orbit. However, participants also expressed concern about the lack of future provision of microwave imagers and longer-term plans for active sensors.

The workshop recognized that improvements are still needed in the characterization of scattering parameters and their associated uncertainty. It encouraged JCSDA and ECMWF to engage with a workshop on scattering databases to be held in Bologna, Italy, from October 3-7, 2016, hosted by CNR-ISAC and jointly sponsored by the GEWEX, CloudSat and GPM missions.

Finally, the workshop recognized the need for improved access to tools to simulate cloud-affected observations. This could be achieved, for example, through the integration of improved operators for visible and active observations into models such as CRTM and RTTOV, and through tools such as the NWPSAF radiance simulator, which may facilitate the evaluation of the significance of model changes for observation assimilation.

Noting the rapid rate of developments in this area in the last five years and also noting the growing number of centers now actively involved in related research and development, it was proposed to break with the previous five-year cycle for these meetings and to hold the next joint workshop at ECMWF in around three to four years' time.

All oral and poster presentations can be found on the JCSDA website:
http://www.jcsda.noaa.gov/meetings_JointEC-JC_Wkshp2015_agenda.php

Co-chairs,
Thomas Auligné (Director, JCSDA)
Stephen English (ECMWF)

PEOPLE

Meet Dr. Melinda Peng

Dr. Melinda Peng joined the JCSDA Management Oversight Board (MOB) as the Naval Research Laboratory (NRL) representative in May, 2015, following Dr. Simon Chang's retirement. Dr. Peng currently heads the NRL Marine Meteorology Division (MMD) Atmospherics Dynamics and Prediction Branch in Monterey, CA, and brings to the JCSDA MOB her experience gained from more than 30 years of sustained contributions to the science of meteorology, and in particular to operational numerical weather prediction (NWP).

Over the course of her career, Dr. Peng has been the principal investigator for many diverse projects in global NWP modeling, tropical cyclone genesis and prediction, and high-impact weather. As a senior scientist, she developed and implemented new components for the Navy's global and mesoscale NWP systems—the Navy Operational Global Atmospheric Prediction System (NOGAPS) and Coupled Ocean-Air Mesoscale Prediction System (COAMPS). Most recently she led the NRL multi-year research and development program to develop and transition to operations the new NAVGEM (NAVy Global Environmental Model), which replaced NOGAPS in 2013.

Dr. Peng has served as the Navy's lead in several national partnerships and various community-wide committees and boards, including the Earth System Prediction Capability (ESPC), the National Unified Operational Prediction Capability (NUOPC), the U.S. THORPEX Executive Committee (USTEC), the Hurricane Forecast Improvement Program (HFIP), and the High Impact Weather Prediction Project (HIWPP).

Dr. Peng's many significant contributions to the atmospheric sciences have been recognized over the years. She was elected as a fellow of the American Meteorological Society in 2012. She led the NRL NAVGEM team that was presented the Department of the Navy Acquisition Excellence Award for Technology Transition in the 2012. In 2013 she was named one of the Dr. Delores M. Etter Top Navy Scientists and Engineers of the Year for her contributions to Navy science and technology and research and development. Dr. Peng was a key member of the development team for COAMPS for Tropical Cyclone (COAMPS-TC), the Navy's tropical cyclone prediction system, which won the Office of Naval Research Bisson Prize for Naval Technology Achievement for 2014. Dr. Peng is also a recipient of the 2016 Excellence in Science and Technology Award from the University of Albany Alumni Association.

Dr. Peng earned her B.S. in Atmospheric Physics from National Central University in Taiwan. Following 2 years as a meteorologist with Taiwan's Civil Aviation Bureau, she came to the United States, where she earned M.S. degrees in Atmospheric Science and Computer Science and a Ph.D. in Atmospheric Science from the State University of New York at Albany. Upon graduation, she accepted a lecturer position with the Department of Land, Air and Water Resources at the University of California-Davis. In 1983 she joined the Department of Meteorology at the Naval Postgraduate School (NPS) in Monterey, CA, where she served successively as National Research Council postdoc-

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toral fellow, adjunct research professor, and research associate professor for the next 13 years. Concurrently she served as the principal consultant for the Modernization and NWP Project at the Central Weather Bureau in Taiwan for 10 years. She left NPS in 1996 to accept a position with the NRL MMD Mesoscale Modeling Section and was appointed as head of the Atmospherics Dynamics and Prediction Branch in 2008. Dr. Peng also served a 2-year detail as a National Science Foundation program director in the Large-Scale Dynamics Section, Atmospheric Science Division, in Arlington, VA.

Dr. Peng has actively mentored numerous scientists throughout her career; formally as a postdoctoral research advisor, thesis advisor, or Ph.D. committee member; and informally as a senior scientist and NRL branch head. She maintains active collaborations with scientists at many universities and government laboratories, both nationally and internationally. A prolific author and in-demand speaker, she has more than 80 peer-reviewed publications and more than 100 conference presentations to her credit.

Welcome, Dr. Mahdi Maghrebi

Dr. Mahdi Maghrebi has joined Atmospheric and Environmental Research, Inc. (AER) at NOAA/NESDIS/STAR as a scientific programmer in support of JCSDA. Dr. Maghrebi received his Ph.D. in Civil Engineering with an emphasis in Environmental Engineering from the State University of New York at Buffalo. Prior to joining AER, he was a postdoc associate at Catholic University of America, in Washington, DC. His primary focus is on the implementation of a field alignment (or displacement correction) algorithm in the Gridpoint Statistics Interpolation (GSI) application for data assimilation. The field alignment algorithm, which has been already implemented in Weather Research and Forecasting (WRF-DA) model, corrects for position errors in the background fields. In his spare time, Mahdi enjoys outdoor activities such as fishing, hiking, and camping.

Welcome, Mitchell Weiss

Mitchell Weiss joined the JCSDA Directed Research Team at NOAA/NESDIS/STAR as a contractor for Riverside Technology, Inc., in early November 2015. In the position of a scientific programmer, Mitch's primary responsibility and focus will be on providing programming support for the Data Fusion and O2R/R2O tasks.

Mr. Mitchell received a B.S. in Meteorology in 1980 from the State University of New York at Oneonta and an M.S. degree in Atmospheric Science from Colorado State University in 1983. After completing his master's, he moved to the Washington, DC, area and began work as a government contractor on a variety of NOAA- and NASA-based projects. His most notable work to date occurred from 1995 to 2012, as a senior scientist for the Meteorological Development Labora-

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tory (MDL) at NOAA headquarters in Silver Spring, MD, where his focus was on developing statistical model guidance for aviation-related meteorological variables. More recently, Mitch was a programmer analyst for a trade association based in Washington.

In his free time, Mitch enjoys the outdoors, hiking, softball, day trips, and activities with his family.

CAREER OPPORTUNITIES

Opportunities in support of JCSDA may be found at http://www.jcsda.noaa.gov/careers.php as they become available.

NOTE FROM THE DIRECTOR

Happy 2016 everyone! The year started on a fast pace with the AMS Annual Meeting in New Orleans, where the Fourth AMS Symposium on the Joint Center for Satellite Data Assimilation (JCSDA) took place. A more in-depth summary will be available in the next *JCSDA Quarterly Newsletter*, but there is no spoiler in saying the 2016 edition of this symposium was a great success, thanks in particular to the sustained efforts of Jim Yoe.

For those living in the DC Metro area, the recent "snowmaggedon" event is a bitter reminder of the socioeconomic value of accurately predicting extreme events. There is no doubt in my mind that the great work from JCSDA partners over the years has contributed to efficiently assimilating satellite observations in operational systems, which in this case resulted in tremendous value in terms of public safety and economic savings. We need to ensure that everybody—especially those who hold the purse strings for research and development—recognizes the importance of satellite data assimilation for extreme events, and this is why we are setting up the JCSDA Observing System Assessment Standing Capability (JOSASC). The main goal is to provide on-demand capability to compute the impact of observations on forecast for particularly impactful events. My main interests are a) to formulate the problem in order to obtain statistically significant results and therefore scientifically sound answers, and b) to assess how these after-the-fact studies can be used to improve our operational data assimilation procedures.

A natural application of the JOSASC is to assess the impact of future and potentially interesting new observations. This type of study, often referred to as Observing System Simulation Experiments (OSSEs), is an area where the JCSDA is strongly involved and will continue to play a key role in the future, particularly with the noticeable emergence of commercial satellite data.

Since we are discussing future systems, JCSDA is co-organizing, with the National Center for Atmospheric Research (NCAR), a joint workshop in March on the Blueprints for Next-Generation Data Assimilation Systems. This workshop is expected to provide input from experts about the planning of a) gradual convergence of existing data assimilation systems and b) the development of next-generation data assimilation architecture.

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You can now mark your calendars: The 14th JCSDA Workshop on Satellite Data Assimilation will convene at the CSUMB Moss Landing Marine Laboratories in Moss Landing, CA, beginning May 31 at noon and concluding June 2 at 5 p.m. This setting at California State University, Monterey Bay (CSUMB), should allow participants to travel without trimming personal time. The event is a nice opportunity to highlight the importance of our partners outside the Beltway, and we are particularly grateful to the Naval Research Laboratory in Monterey for working as our local coordinator for the occasion.

Thomas Auligné
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 Erin.Jones@noaa.gov.

MEETINGS OF INTEREST

DATE	LOCATION	WEBSITE	TITLE
14–16 March, 2016	Saint Martin d'Hères, France	http://cimss.ssec.wisc.edu/itwg/groups/rtwg/meetings/sfcem/2016/	Fourth Workshop on Remote Sensing and Modeling of Surface Properties
11–14 April, 2016	Espoo, Finland	http://www.microrad2016.org/	14th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment
10–13 May, 2016	Shanghai, China		WMO 6th Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction
31 May–2 June, 2016	Moss Landing, CA		JCSDA 14th Technical Review Meeting & Science Workshop on Satellite Data Assimilation