National Aeronautics and Space Administration

NASA Short-Term Prediction Research and Transition Center

2013 SPoRT Annual Report

Snow coating ground in Jackson County, Alabama.

Preface

This past year has been a very successful year for SPoRT as measured by the number of successful transitions of research products to operational end users, the large number of peer-reviewed publications being accepted for publication, and a broader community recognition of SPoRT being the “place to go” for help transitioning research and experimental products to operations. While the number of new end users collaborating with SPoRT has grown over the past year, SPoRT continues to have very strong interactions with existing partners at both Weather Service Forecast Offices and NOAA National Centers.

This Annual Report provides a comprehensive update on the many of the SPoRT accomplishments over the last year. I am very appreciative of the efforts of Mr. Jonathan Case who exhibited strong leadership in guiding the development of the report and assisted me as technical editor for all the articles. This report is as much a reflection of the SPoRT team’s individual professional accomplishments as it is those of the SPoRT project in general.

Gary Jedlovec

SPoRT Project Lead

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Executive Summary

Over the past decade, the SPoRT program in Huntsville, AL has established itself as a leader in the research-to-operations community for transitioning unique NASA and NOAA satellite products, modeling and data assimilation techniques, and nowcasting tools to operations. The SPoRT program continued its successful paradigm during 2013, expanding on its suite of unique products, building additional collaborations and partnerships, and conducting innovative research to address specific weather forecast challenges and benefit operational activities in the NOAA/NWS and the disaster response community. SPoRT maintained a significant presence in satellite Proving Ground (PG) activities for the GOES-R program to demonstrate future capabilities of the Geostationary Lightning Mapper (GLM) and the Advanced Baseline Imager (ABI). Involvement with the JPSS PG has led to successful transitions and assessments of the VIIRS instrument from the Suomi-NPP satellite for situational awareness, and research to improve disaster-mitigation strategies. Both reflectance and radiance Day Night Band (DNB) imagery and red-green-blue (RGB) composites were transitioned to provide an equivalent nighttime visible satellite capability, and improve the diagnosis of nocturnal cloud cover and city lights.

Numerous lightning and satellite datasets were added to the current suite of products disseminated by SPoRT to help address specific forecast challenges of its partners and end-users. With the inclusion of four networks in Colorado, Houston, Langmuir, and West Texas, real-time total lightning data are now being provided to a dozen NWS Weather Forecast Offices (WFOs) and NCEP offices across the country, including the Aviation Weather Center (AWC) and Storm Prediction Center (SPC). A national mosaic of Pseudo-GLM (PGLM) data was assessed and improved through collaborations with AWC and SPC. A suite of AMSR-2 passive microwave products from the Naval Research Laboratory (NRL) was added to support the GOES-R Tropical PG efforts with the NCEP National Hurricane Center (NHC). To aid in the identification of stratospheric air intrusions that lead to strong non-convective wind events associated with mid-latitude cyclones, a total ozone anomaly product from the Atmospheric InfraRed Sounder (AIRS) was developed for the NCEP Weather Prediction Center (WPC) and Ocean Prediction Center (OPC) to be used alongside the total column ozone and air mass RGB products. The SPoRT "POES-GOES" hybrid suite (insertion of polar orbiting data atop GOES imagery) was enhanced with a spectral difference product for detecting low clouds and fog. The POES-GOES hybrids use POES data from both MODIS and VIIRS to produce ABI-like resolution products within the polar-orbiting swath. New products were transitioned to Alaska WFO partners, highlighted by the inclusion of the 2-km SPoRT sea surface temperature (SST) at the Alaska Ice Desk. The transition of the SPoRT SST provided a 60% reduction in the time required to generate public SST charts, thereby enabling the Alaska Ice Desk to meet the NOAA Arctic Vision and Strategy directive of daily SST graphics instead of the nominal twice-weekly production.

Numerical modeling and Data Assimilation (DA) activities in 2013 continued to use open-source community/operational models (i.e., Weather Research and Forecasting [WRF] model and NOAA/NWS Environmental Modeling System [EMS]) and NASA research systems (i.e., NASA Unified-WRF [NU-WRF] model and Land Information System [LIS]) to address specific forecast challenges of SPoRT partners. Experiments with the assimilation and bias correction of AIRS hyperspectral profile retrievals using the operational NCEP/Environmental Modeling Center (EMC) Gridpoint Statistical Interpolation (GSI) DA system are ongoing to address forecast challenges of (1) atmospheric rivers impinging on the U.S. West Coast and Alaska south coast, and (2) tropopause folds and stratospheric intrusions leading to strong non-convective wind events. A standardized set of dynamic scripts was developed to facilitate DA research with the GSI package to benefit SPoRT projects, as well as others collaborating with SPoRT in modeling and DA activities. Another scripting package was developed and transitioned to select partner WFOs to enable seamless model verification using the Model Evaluation Tools (MET) software. Through automated data acquisition and execution, the SPoRT-MET scripts promote a more standardized approach toward assessing local model performance and the contributions of real-time SPoRT initialization datasets (i.e., SPoRT SST, real-time LIS land surface data, and daily MODIS green vegetation fraction) without the need for forecasters to learn the intricacies of MET. Additionally, SPoRT is developing DA capabilities in LIS using retrieved soil moisture swaths from the European Space Agency's Soil Moisture and Ocean Salinity satellite, as a proving-ground type of effort in preparation for the upcoming NASA Soil Moisture Active-Passive (SMAP) mission. As such, SPoRT is now officially recognized as an Early Adopter for the SMAP mission.

All products continue to be supported in applicable end-user decision support systems (DSS). These DSS consist of legacy AWIPS, AWIPS II (which represents one of the main thrusts of the current SPoRT DSS efforts), and N-AWIPS. SPoRT provided continuity of its products from AWIPS to AWIPS II, and exhibited community leadership in developing AWIPS II capabilities for research datasets via the Experimental Products Development Team (EPDT).

During 2013, SPoRT hosted collaborative EPDT workshops, in which training was provided on the development of AWIPS II "plug-ins" and participants wrote code for their own projects through hands-on applications. SPoRT received an official AWIPS Test Authorization Note approval for the use of its total lightning plug-in at NWS WFOs. A plug-in was also developed for a Total Lightning Tracking Tool (TLTT), which allows users to track total lightning trends in specific convective cells. The TLTT was evaluated at the Hazardous Weather Testbed's Experimental Warning Program (EWP) in May, receiving positive initial feedback. SPoRT has also been developing a common Web and mobile platform architecture to enable the delivery of satellite and model data to a variety of platforms, using a Web Mapping Service (WMS). The WMS framework was extended to provide data to the NWS Damage Assessment Toolkit (DAT) to support disaster recovery and assist in storm surveys.

The SPoRT transition paradigm is the cycle of matching products and capabilities to forecast challenges, providing appropriate training, and collaboratively assessing products in an operational testbed environment to determine if the products are sufficiently mature for wider distribution. Following this model, SPoRT paired specific products to new partners in the NWS Alaska Region and WFO in San Juan, PR. A collaboration with the Geographic Information Network of Alaska (GINA) is enabling the use of "virtual machines" at the University of Alaska – Fairbanks for SPoRT product generation using data from the GINA Direct Broadcast receiving station. This strategy will, in turn, reduce product delivery latency and make SPoRT-provided products more operationally relevant in Alaska. To assist in monitoring drought and flood potential, the SPoRT real-time LIS land surface simulations were transitioned to AWIPS II at the NWS Huntsville, AL WFO through a modification of AWIPS II configuration files and exploitation of pre-existing AWIPS II data-ingest routines, thereby avoiding the development of a plug-in that would require special approval. SPoRT continued its extensive efforts in appropriate end-user training through the development of (1) three new modules for total lightning applications, (2) LIS introduction and applications modules, (3) laminated front-and-back "quick guides" for numerous satellite products, (4) "micro" lesson on RGB imagery, (5) GOES-R Convective Initiation module, and (6) RGB imagery training to the NHC. Numerous product assessments were conducted during 2013 for both new and existing products, using a Likert-type scale to determine the level of perceived utility of the product on the forecaster's decision-making process for a given forecast challenge. These assessments spanned a wide-range of products (GOES-R PG, CIRA Layered Precipitable Water, RGB imagery, POES-GOES hybrid suite, VIIRS Day-Night Band (DNB) radiance and reflectance) and geographical distribution of end-users (Alaska, U.S. West Coast, Rocky Mountains Front Range, Southeastern U.S., and Puerto Rico). Additionally, several external assessments were facilitated by SPoRT, in particular to support the EWP and the AWC Summer Experiment.

Lastly, SPoRT completed a disasters feasibility study through funding provided by NASA Applied Sciences. The feasibility study focused on high-impact weather events occurring from 2011 to 2013 as a means for quantifying tornado intensity through satellite products, and developing a prototype interface for inclusion of high-resolution NASA, NOAA, and commercial satellite data within the NOAA/NWS DAT. During 2013, the SPoRT "Disasters Team" provided support to NWS and NASA for several high-impact events, including the Moore, OK EF-5 tornado on 20 May and Super Typhoon Haiyan that devastated the Philippines in November. A VIIRS DNB "black-out" product was developed to analyze the power outages associated with the Moore, OK tornado and Haiyan impact on Tacloban City. Several other very high-resolution satellite data sources were also explored, including ASTER 15-m false color depictions, 5-m true color imagery from the ISERV instrument aboard the International Space Station, and DigitalGlobe Worldview 0.5-m commercial imagery of the Washington, IL EF-4 tornado. The analysis of these high-resolution satellite datasets were greatly facilitated by the new SPoRT Visualization and Collaboration Laboratory (VCL) — a 750-square foot facility with an accompanying 14' × 6' video wall, centrally located around SPoRT staff offices. The video wall consists of a 3 × 4 array of 1920 × 1080 pixel high-definition monitors powered by a high-end gaming computer, and features the use of the Scalable Adaptive Graphics Environment (SAGE) windowing and media control software to provide an interactive, multi-tasking environment. The combination of the video wall with SAGE supports interactive meetings, collaborations, seminars, and data analysis that optimize the efficiency and productivity of every-day SPoRT activities. Additionally, external and simultaneous video conferencing capabilities are enabled by two strategically-located cameras, a desktop computer, and the Vidyo™ software developed for government applications. The VCL was utilized for the GOES-R PG satellite liaison technical interchange meeting hosted by SPoRT in November, and will support future transition activities for years to come.

Introduction

The NASA Short-term Prediction Research and Transition (SPoRT) Center is an end-to-end research-to-operations activity focused on the development and applications of unique high-resolution multispectral observational data from NASA and NOAA satellites, advanced modeling and data assimilation techniques, and nowcasting tools to improve short-term weather forecasts. The year 2013 has seen many exciting accomplishments within the SPoRT program, including expansion of data products that support new collaborating partners (an updated map of partners is given in Figure 1).

This annual progress report highlights the most significant accomplishments and developments in SPoRT during 2013. The report structure follows that of the SPoRT core functions. Highlights are presented in the area of SPoRT products (section 1), modeling and data assimilation research (section 2), decision support systems (section 3), transition training and assessments (section 4), disaster response (section 5) and information technology developments (section 6), followed by references. SPoRT continued its presence in satellite Proving Ground (PG) programs, including the Geostationary Operational Environmental Satellite-R series (GOES-R) PG, GOES-R visiting scientists proposals, and Joint Polar Satellite System (JPSS) PG activities. Highlights in each of these areas are presented within the upcoming sections in the appropriate context. The Appendices provide summaries of SPoRT team structures and personnel, products and partnerships, publications and conference

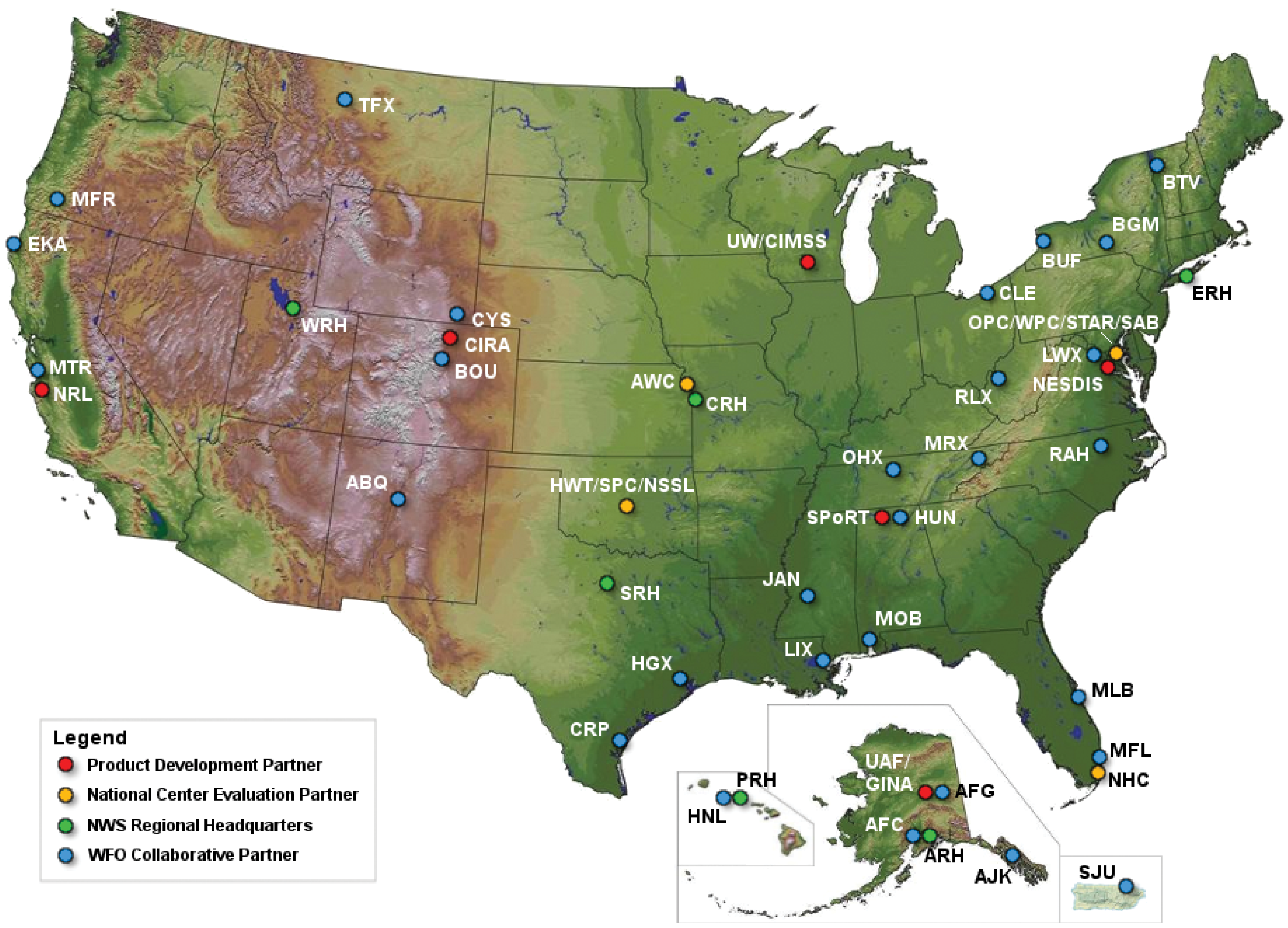

Figure 1. Map of SPoRT collaborative partners, effective January 2014.

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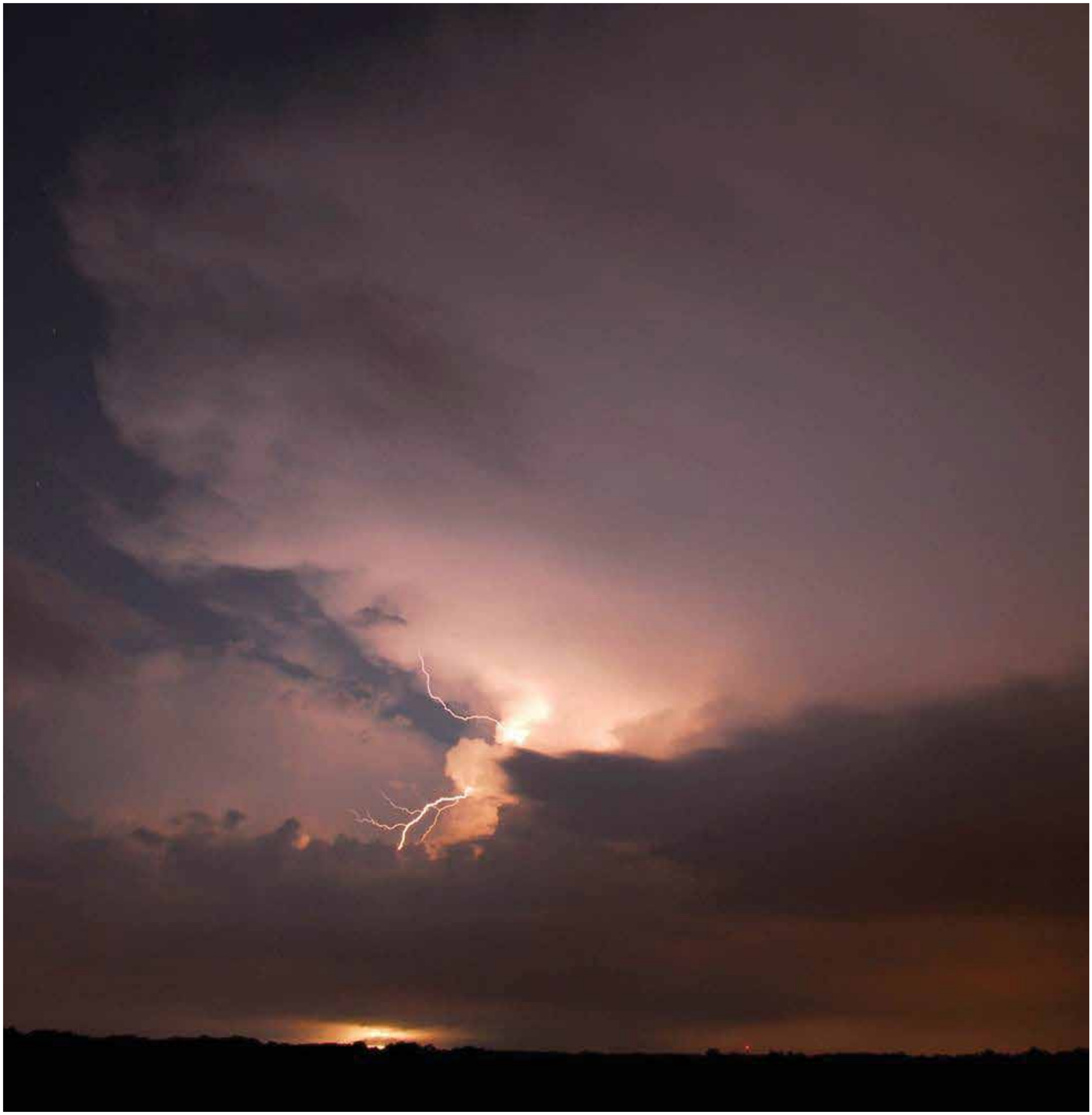
SPoRT Products



Lightning near Harvest, Alabama.
(Image copyright Kevin M. McGrath, mcgrathimages.com. Used with permission.)

The year 2013 has been ambitious for the SPoRT Products team, having actively engaged in new collaborations for both core and satellite Proving Ground (PG) work. This has led to expanded collaborations with existing partners, data providers, as well as new product suites. The following sub-sections highlight many of the noteworthy activities during 2013.

Total Lightning Activities

Access to additional lightning network data

SPoRT celebrated its 10th anniversary of providing total lightning data to the Huntsville, AL (HUN) National Weather Service (NWS) Weather Forecast Office (WFO) this past spring. Since that initial collaboration, SPoRT has expanded the provision of real-time total lightning data to a dozen WFOs and National Centers for Environmental Prediction (NCEP) offices across the country. This effort has been made possible by establishing strong collaborations with four additional, non-NASA lightning mapping array (LMA) systems this year. These systems include the Colorado LMA (Colorado State/New Mexico Tech), Houston LMA (Texas A&M/New Mexico Tech), Langmuir Lab LMA (New Mexico Tech), and the West Texas LMA (Texas Tech University). The first three networks support several collaborative WFO partners (Albuquerque, NM; Boulder, CO; Cheyenne, WY; Houston, TX; and the Spaceflight Meteorology Group [SMG]) as well as NCEP National Center partners (Aviation Weather Center [AWC] and Storm Prediction Center [SPC]). Beyond these new collaborations, arrangements were established to have access to the new Central Florida LMA at the Kennedy Space Center, and the Wallops Island LMA at NASA's Wallops Flight Facility when these come online in 2014. A third arrangement will initiate collaborations with Georgia Tech University and the Atlanta, GA LMA that will also come online in 2014. These activities have been further bolstered by the acceptance of a trip to meet with several NOAA/NWS Center Weather Service Units (CWSUs) to expand the use of total lightning to aviation-centric operations as part of the GOES-R Visiting Scientist Program (VSP).

Collaboration with Emergency Managers

SPoRT began a project with the Morristown, TN WFO earlier this year to evaluate the use of North Alabama LMA data at the Chattanooga/Hamilton County, TN emergency operations center. The project was recommended by the Morristown, TN NWS WFO to coordinate with emergency managers. During the summer SPoRT provided a Google Earth-formatted, real-time Web display of total lightning data for use by the emergency managers. Centered on Chattanooga, TN, the display used SPoRT's Geostationary Lightning Mapper (GLM) demonstration product, namely the pseudo-GLM (PGLM). The initial goal was for training and familiarization with the PGLM flash extent density. A follow-up meeting in November confirmed the initial success and interest in these data. The discussions focused on ways to improve the Web display as well as aim for a more formal assessment during Spring 2014.

National Center collaborations

In 2012, SPoRT began providing the PGLM mosaic product to the NCEP AWC and SPC as part of a GOES-R evaluation and partnership. Unlike the products provided to local WFOs that use only a single LMA network, the PGLM mosaic contains real-time data from every LMA available to SPoRT (eight networks as of December 2013) to address the operational needs of the National Centers versus that of WFOs. The local WFOs have a far smaller operational domain than either National Center partner. As such, a single LMA (if available) will generally be sufficient for the WFO. SPC has responsibilities for the Conterminous United States (CONUS) while the AWC includes the SPC domain as well as large portions of the Atlantic and Pacific basins. Given this major difference in operational domains, the National Centers require the use of every LMA available in their domain. The WFOs primarily use LMA data operationally for nowcasting, short-term, and warning decision support forecasting. AWC and SPC, with their larger operational domain focus more on convective development, storm intensity, and convective location with respect to flight corridors.

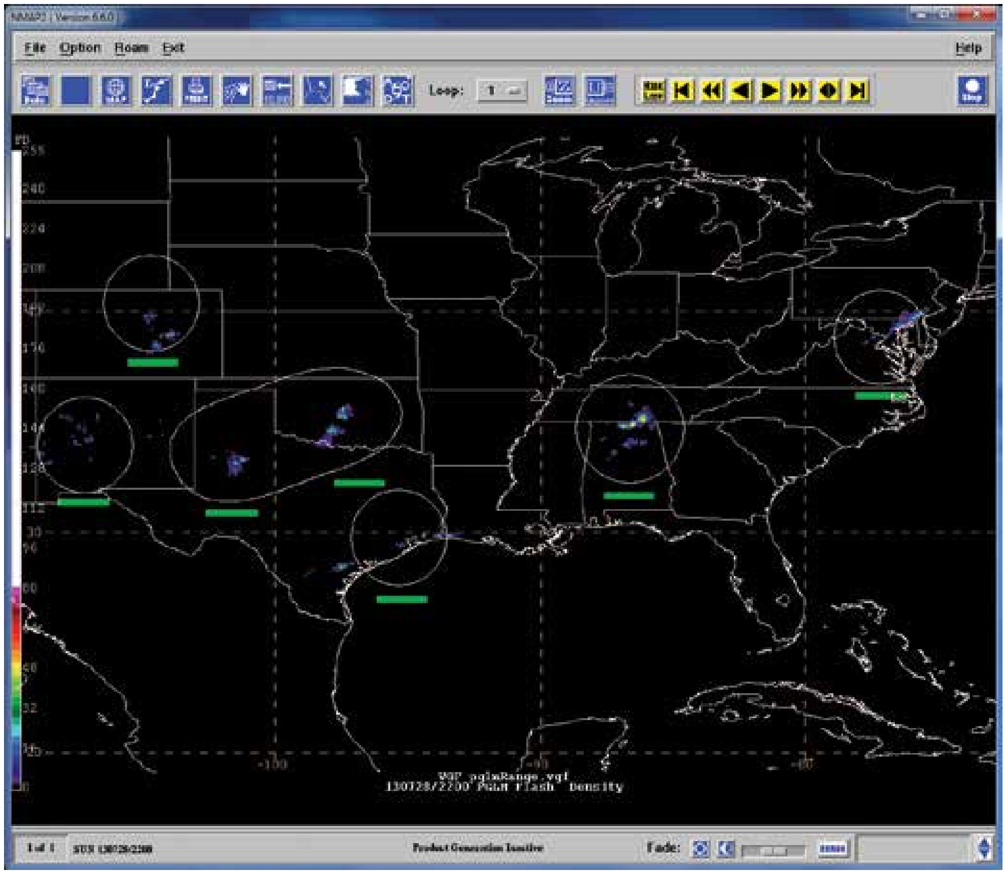


Figure 2. An example of the PGLM mosaic display in N-AWIPS for AWC and SPC. This display includes the updated color curve, range rings, and network status bars.

After the initial evaluation, SPoRT coordinated with the AWC's GOES-R satellite liaison to make improvements to the product, which resulted in three major enhancements (a sample display of the enhanced product in the National Center-Advanced Weather Interactive Processing System [N-AWIPS] is shown in Figure 2). First, the product's color bar display was revised to provide greater fidelity. Second, the range rings for each individual LMA were updated to improve visibility in the N-AWIPS display. These rings show the effective range with each LMA network, although some detection beyond this effective range is still possible. Lastly, a network status bar was added consisting of a simple green-yellow-red status to indicate whether a network is active or inactive. This enables forecasters to easily determine if a network is observing no lightning or suffering from a data outage. The PGLM mosaic is now routinely available to operations at AWC, with transition efforts in progress for SPC.

Passive Microwave Products

To support the GOES-R Tropical PG, collaborations continued with the Naval Research Laboratory (NRL) to transition numerous passive microwave products to the NCEP National Hurricane Center (NHC) in Miami, FL. SPoRT helped facilitate the transition of these data into NHC's local decision support system, N-AWIPS. This effort continued in 2013, using passive microwave data from various Defense Meteorological Satellite Program instruments such as the Special Sensor Microwave Imager, Special Sensor Microwave Imager/Sounder, as well as passive microwave data from the Tropical Rainfall Measuring Mission (TRMM) satellite. SPoRT has coordinated with NRL to obtain the data from the Advanced Microwave Scanning Radiometer-2 (AMSR-2; follow-on instrument to AMSR-E). This year, SPoRT successfully ingested the AMSR-2 data and began providing single channel and Red-Green-Blue (RGB) AMSR-2 composites along with the suite of other passive microwave products. In addition to observing rain rates, the passive microwave data are often used to investigate tropical cyclone structure. According to Mark DeMaria, "The use of passive microwave imagery within N-AWIPS was one of the more significant events at the NHC in recent years."

AIRS Ozone and Anomaly Products

In 2012, SPoRT began generating an Atmospheric Infrared Sounder (AIRS) total column ozone product. The AIRS total column ozone product has been used in tandem with the Moderate Resolution Imaging Spectroradiometer (MODIS) air mass RBG imagery by forecasters at the NCEP Weather Prediction Center (WPC) and Ocean Prediction Center (OPC) to aid in the identification of stratospheric air and potential vorticity anomalies for forecasting cyclogenesis and strong non-convective wind events (see the numerous blog posts on this application at <http://nasasport.wordpress.com/>. The air mass RGB uses a total of four infrared channels to characterize moisture, cloud cover, and synoptic-scale features associated with air masses. By combining these channels, the air mass RGB product can help identify stratospheric intrusions, which can be enhanced with comparisons to the AIRS ozone product. In June 2013, SPoRT expanded the AIRS products to include an ozone anomaly product.

The ozone anomaly product shows the percentage departure from climatology. This value is based on a global mean climatology derived from the Microwave Limb Sounder integrated ozone profiles constructed by Ziemke et al. (2011). Since elevated total column ozone values could be within the climatological range, the anomaly product was created to determine whether high ozone values are representative of anomalous stratospheric air intrusions. The anomaly product enables forecasters to better pinpoint stratospheric intrusions with the knowledge that air can be classified as stratospheric when ozone values are 25% greater than climatology (Van Haver et al. 1996). Values of 100% are equal to climatology, while values greater than (less than) 100% are above (below) climatology. A color table was constructed so that values representative of stratospheric air are shaded blue (≥ 125% of climatology). The example in Figure 3 compares the MODIS air mass RGB, total column ozone, and ozone anomaly product from 26 June 2013.

The initial version of the ozone anomaly product was well received. However, feedback from Michael Folmer (the satellite liaison at WPC, OPC, NCEP Satellite Analysis Branch [SAB], and the Tropical Analysis and Forecast Branch [TAFB] of NHC) indicated a limitation of the current product format. The ozone anomaly was produced as an "image" file for use in N-AWIPS. This meant that the ozone anomaly could not be overlaid on the airmass RGB composite, which also was an image file. SPoRT addressed this concern by converting the ozone anomaly into a gridded product. The anomaly product allows our National Center partners to overlay the ozone anomaly with the airmass RGB and fuse the strengths of each.

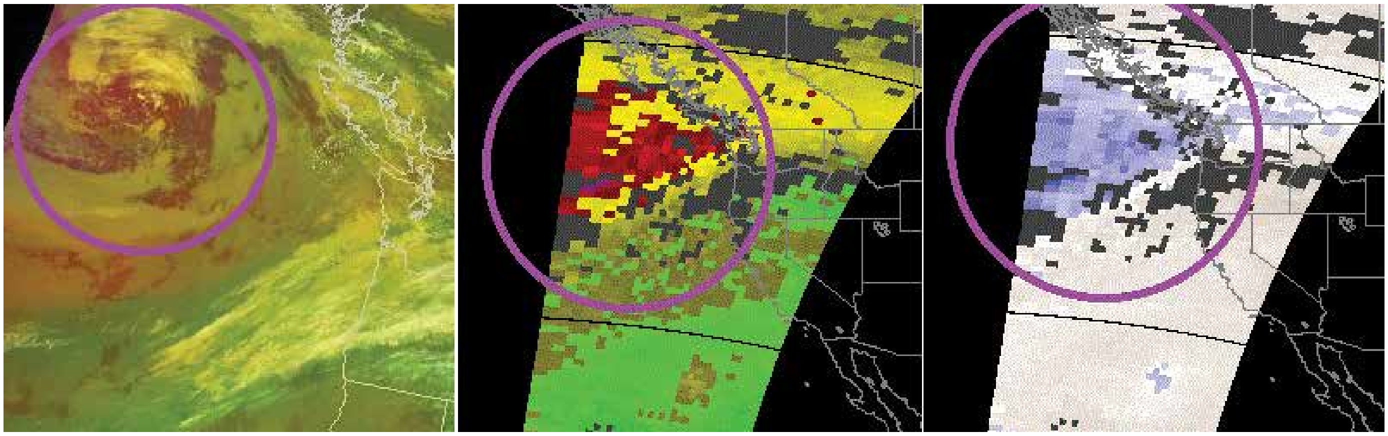


Figure 3. Example display from N-AWIPS of three products to help identify stratospheric air intrusions and potential vorticity anomalies to forecast cyclogenesis and strong non-convective wind events, consisting of the MODIS air mass RGB (left), AIRS ozone (center), and AIRS ozone anomaly (right). The circled region highlights an area with high potential vorticity (left), high concentration of ozone (center), and ozone concentrations more than 125% of climatology, confirming a stratospheric air intrusion.

POES-GOES Hybrid Suite

The Polar Orbiting Environmental Satellite (POES)-GOES hybrid product suite originated in 2009 to address forecaster concerns with using polar-orbiting MODIS data. Forecasters preferred the high temporal resolution of geostationary satellite data, especially since it was impractical to loop the infrequent swaths of MODIS imagery. Due to this limitation, the MODIS imagery was not being used to its full potential. The solution was to use GOES imagery as a background image and when appropriate polar orbiting data were available, insert the higher-resolution polar data swaths on top of the GOES image. Once designed, the process became the preferred way to visualize a number of polar-orbiting products from both MODIS and the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor aboard the Suomi-NPP satellite. This process has resulted in the hybrid suite becoming a core SPoRT product now supporting both the GOES-R and JPSS PGs. In 2013, a spectral difference fog and low-cloud detection image was added to the hybrid product suite. The fog and low-cloud hybrid consists of GOES spectral difference imagery combined with the POES night-time microphysics RGB composite from both MODIS and VIIRS. This combination allows forecasters to observe, side-by-side, current GOES capabilities (spectral difference) with the future GOES capabilities (night-time microphysics RGB). The suite of hybrid products has turned out to be quite helpful with PG activities, as described below.

CIRA Layered Precipitable Water Product

SPoRT has been funded to support the Colorado Institute for Research in the Atmosphere (CIRA) to transition and assess the Layered Precipitable Water (LPW) product. This has built off the collaborative relationship CIRA and SPoRT established with the older blended total precipitable water product. Originally developed by Stan Kidder and John Forsythe at CIRA, the refinement, transition, and evaluation was a funded collaboration via the NASA Research Opportunities in Space and Earth Science (ROSES). The LPW product is based on microwave observations and observed precipitable water in discrete layers: surface-850 mb, 850-700 mb, 700-500 mb, and 500-300 mb. A total column precipitable water product is also available. LPW is derived from the Microwave Integrated Retrieval System using data from NOAA-18, NOAA-19, Metop-A, Defense Meteorological Satellite Program's F-18, and AIRS version 6 retrievals via the NASA Land Atmospheric Near real-time Capability for EOS system. With nearly global coverage, the swath information in LPW is updated every three hours. LPW has been evaluated for its use to aid precipitation forecasts and estimates by promoting improved diagnosis of atmospheric rivers, moisture plumes, and overall distribution of moisture in the vertical, especially in data-poor regions (such as upstream from land based radars). Details of the forecaster assessments conducted during 2013 are provided in the Transition, Training, and Assessments section.

2013 Proving Ground Activities: GOES-R and JPSS

The SPoRT program continues as an active and funded partner with both the GOES-R and JPSS Proving Grounds. Both activities are focused on engaging the end user community to assess, evaluate, and ultimately incorporate new technologies into operations. GOES-R and JPSS PG activities are highly synergistic, particularly in the realm of assessing the POES-GOES hybrids and RGB composites that fuse information from multiple spectral channels into a single product. However, each has its own unique features. In the GOES-R arena, SPoRT has been involved with several activities, including total lightning (in preparation for the GLM), the POES-GOES hybrid suite (in preparation for the Advanced Baseline Imager [ABI]), as well as collaborating with other product developers (e.g., the University of Alabama in Huntsville [UAH] GOES-R Convective Initiation [CI] and the National Environmental Satellite Data and Information Service [NESDIS] Quantitative Precipitation Estimate [QPE] products). The JPSS PG has primarily focused on incorporating products from the VIIRS instrument aboard the Suomi-NPP satellite. Many of SPoRT's JPSS PG activities have focused on utilizing the Day-Night Band (DNB), which is unique to the VIIRS instrument. The various PG activities include direct collaborations and evaluations with WFO and National Center partners. In addition, SPoRT continues to serve as subject matter experts with external evaluations, ranging from total lightning to supporting UAH in their transition of the GOES-R CI product. These activities included participation in the Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) in Norman, OK and the AWC Summer Experiment in Kansas City, MO. The sub-sections below indicate to which PG each effort belongs.

GOES-R Convective Initiation (GOES-R)

Another product at the EWP, AWC Summer Experiment, and participating with the OPG was the UAH GOES-R CI product (Mecikalski and Bedka 2006). Much like the PGLM, the GOES-R CI product has been evaluated at the EWP for several years. The SPoRT program does not produce the GOES-R CI, but supports UAH in transitioning and displaying the product. Originally, the GOES-R CI used a series of satellite parameters to generated a yes/no forecast on what particular satellite cells would undergo initiation (radar echoes of 35+ dBZ) within the next 1-2 hours. Since its original implementation, the product has undergone extensive improvement. The GOES-R CI continues to use numerous satellite observed variables but now incorporates model background data. This combination has resulted in the CI product generating a true probabilistic forecast of CI, responding to forecaster evaluations of the past two years. SPoRT continues to support the UAH team in transitioning this product to end users for further evaluations.

NESDIS Quantitative Precipitation Estimate (GOES-R)

Given the successful collaboration with the UAH team in aiding the transition of the GOES-R CI product, NESDIS requested SPoRT's guidance with their QPE product (Kuligowski 2002). The NESDIS QPE product uses data from GOES satellites, specifically IR channels as well as microwave data from the TRMM Microwave Imager (TMI) and the Microwave Humidity Sounder on NOAA-18, -19, and METOP-A. Rainfall rates can be inferred from IR information alone, particularly for convective clouds. However, the microwave channels have an advantage over IR in that they can examine the varying ice and droplet size within the clouds, rather than just the cloud tops. From these microphysical characteristics a more accurate estimate of rain rate can be produced. Given the non-geostationary nature of these observations, the microwave data are used to calibrate the more frequently-available IR-derived rain rates. Being based primarily on GOES, it is usable in either the GOES-East or GOES-West fields of view, although specific domains were created to support SPoRT partners. The product has a 4-km spatial resolution and updates every 15 minutes. The QPE algorithm generates products in accumulation intervals of 1, 3, 6, 12, and 24 hours as well as three- and seven-day accumulations. The primary evaluation of QPE has focused on its utility to estimate precipitation in data-poor regions, such as offshore and remote land locations. In 2013, the NESDIS QPE was assessed by NWS partners on the U.S. West Coast, Alaska, and San Juan, PR. The results of the assessment are detailed in the Transition, Training, and Assessment section.

Visit by the Satellite Liaisons (GOES-R and JPSS)

SPoRT invited the six satellite liaisons to meet in Huntsville, AL on 12-14 November 2013. The liaisons represented the NOAA/NWS Alaska Region, AWC, OPG, SPC, the Warning Decision Training Branch, and WPC/OPC/SAB/NHC. The liaisons represent their respective organizations, primarily in support of GOES-R activities, but also the JPSS PG with the launch of Suomi-NPP. The goal of the visit was face-to-face discussions with the liaisons. SPoRT had the opportunity to demonstrate its activities and capabilities. Likewise, each liaison presented the roles and responsibilities at their specific locations. This provided two distinct outcomes: first, the science sharing allowed all participants to better understand the capabilities of the other as well as enabling the satellite liaisons to outline their goals for future collaborations; secondly, since the liaisons coordinate directly with several SPoRT partners, this meeting was the equivalent of a site visit to each location as the liaisons were able to clearly outline the goals, needs, and interests of the institutions they supported. The visit will set the stage for SPoRT and the satellite liaisons to build stronger collaborations as the end-user community prepares for the GOES-R era. The first steps will occur in early 2014 with the initial SPoRT-satellite liaison coordination call that was arranged during the visit. This will help guide SPoRT activities in several collaborations, including the upcoming HWT EWP in Norman, OK in May 2014.

New products for Alaska (GOES-R and JPSS)

The SPoRT program continued to expand its Outside the Conterminous United States (OCONUS) activities during 2013, particularly with new partners in Alaska, addressing the recommendation set forth by the 2012 Science Advisory Committee. Several products, such as the POES-GOES hybrid suite and the RGB composites, were transitioned to help address various forecasting challenges in Alaska. The SPoRT sea surface temperature composite was transitioned to the National Weather Service's "Ice Desk" where its incorporation into operations has resulted in a significant time savings to the forecasters preparing sea ice forecasts (Figure 4). SPoRT has also partnered with the University of Alaska in Fairbanks Geographic Information Network of Alaska (GINA), a direct broadcast location for MODIS and VIIRS data. In order to reduce product generation latency, the two organizations established data processing on local "virtual machines" at GINA. This accomplishment eliminated the need to transfer direct broadcast data first to SPoRT for product generation, and then back to GINA for dissemination to the Alaska WFOs. The goal is to have this capability fully transitioned to GINA in 2014.

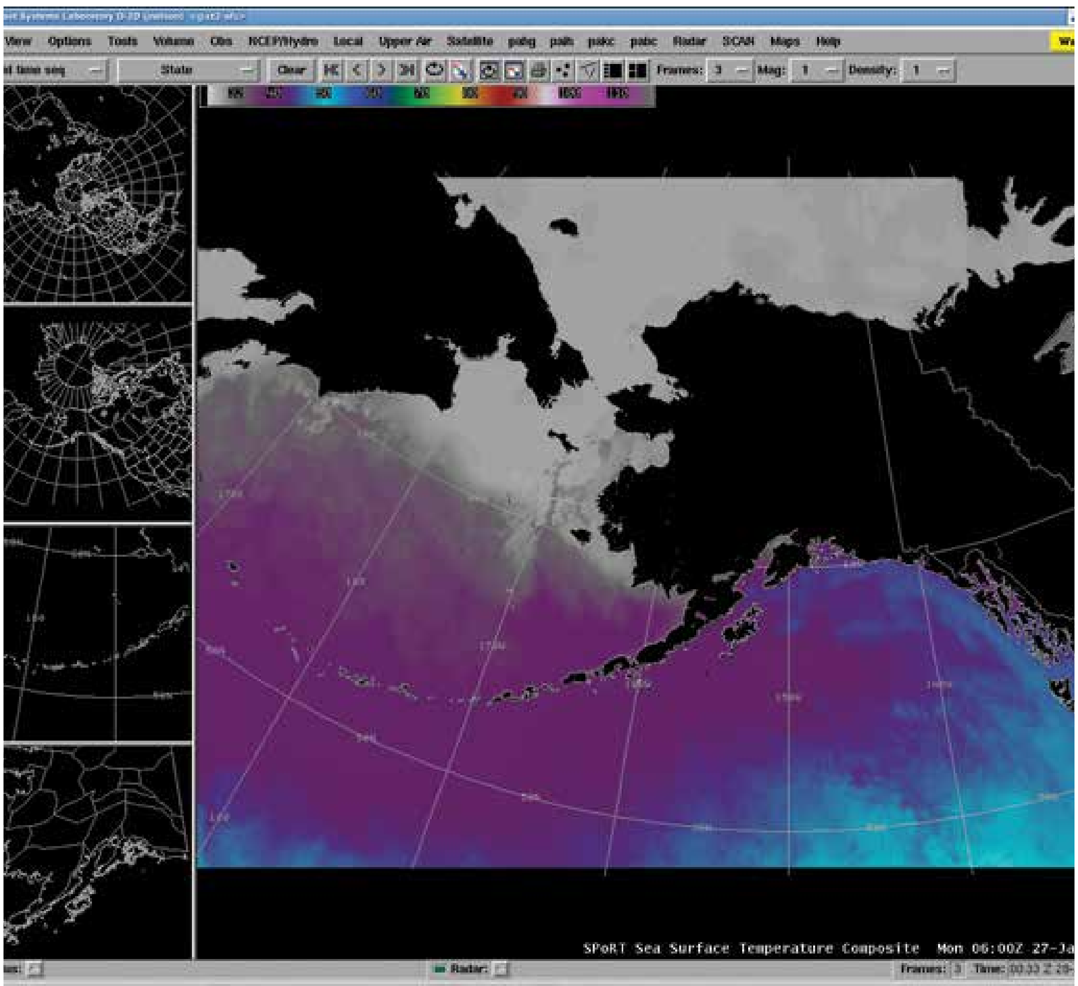


Figure 4. A sample image of the SPoRT SST composite product in AWIPS as used by Alaska WFOs and the Alaska Ice Desk.

VIIRS Day-Night Band Products (JPSS)

One of the most unique components of the JPSS PG is the effort with the VIIRS DNB data. Four separate products have been created based on the radiance and reflectance output from the DNB sensor. The radiance is based on raw, low-light observations, while the reflectance is based on normalized low-light observations for a given amount of moonlight. In addition, the radiance and reflectance imagery can be combined into an RGB composite. Both RGBs use the DNB for the red and green components while the VIIRS 11 mm thermal channel provides the blue component. Given the sensitivity of the DNB to reflected moonlight, the RGB products use the thermal IR channel to infer the cloud height, while retaining the high-resolution texture and cloud type. Figure 5 provides an example of the new DNB radiance RGB over New Mexico. City lights, ice and snow, and lightning are depicted as yellow. Low-level clouds are denoted by yellow shades with thicker clouds being a brighter yellow. Mid-to-high, thick clouds are blue shades to white in appearance. Lastly, mid-to-high thin clouds are blue shades. Both of the VIIRS DNB RGBs, along with the more traditional RGBs such as the night-time microphysics, were evaluated as part of the JPSS evaluation with Front Range partners (Albuquerque, NM; Boulder, CO; Cheyenne, WY; and Great Falls, MT) and are discussed further in Section 4.

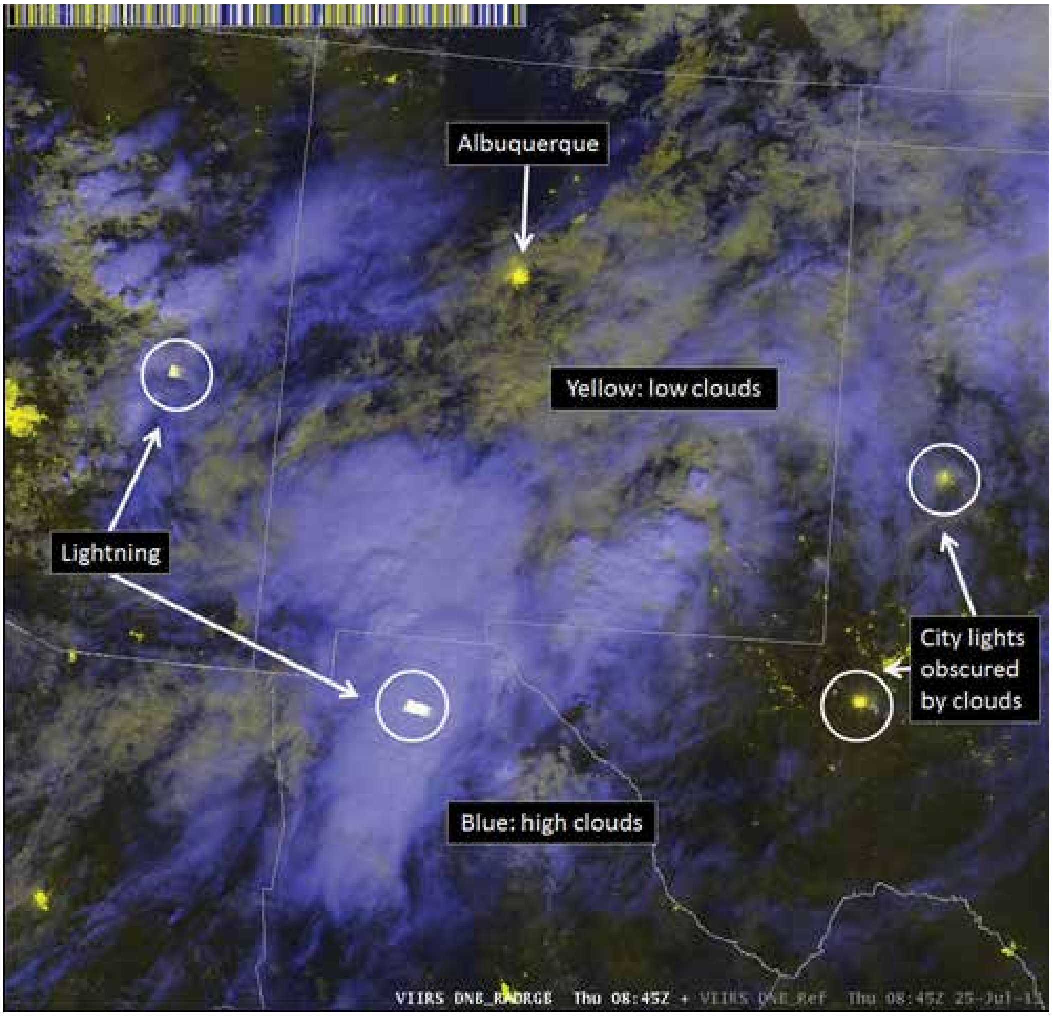
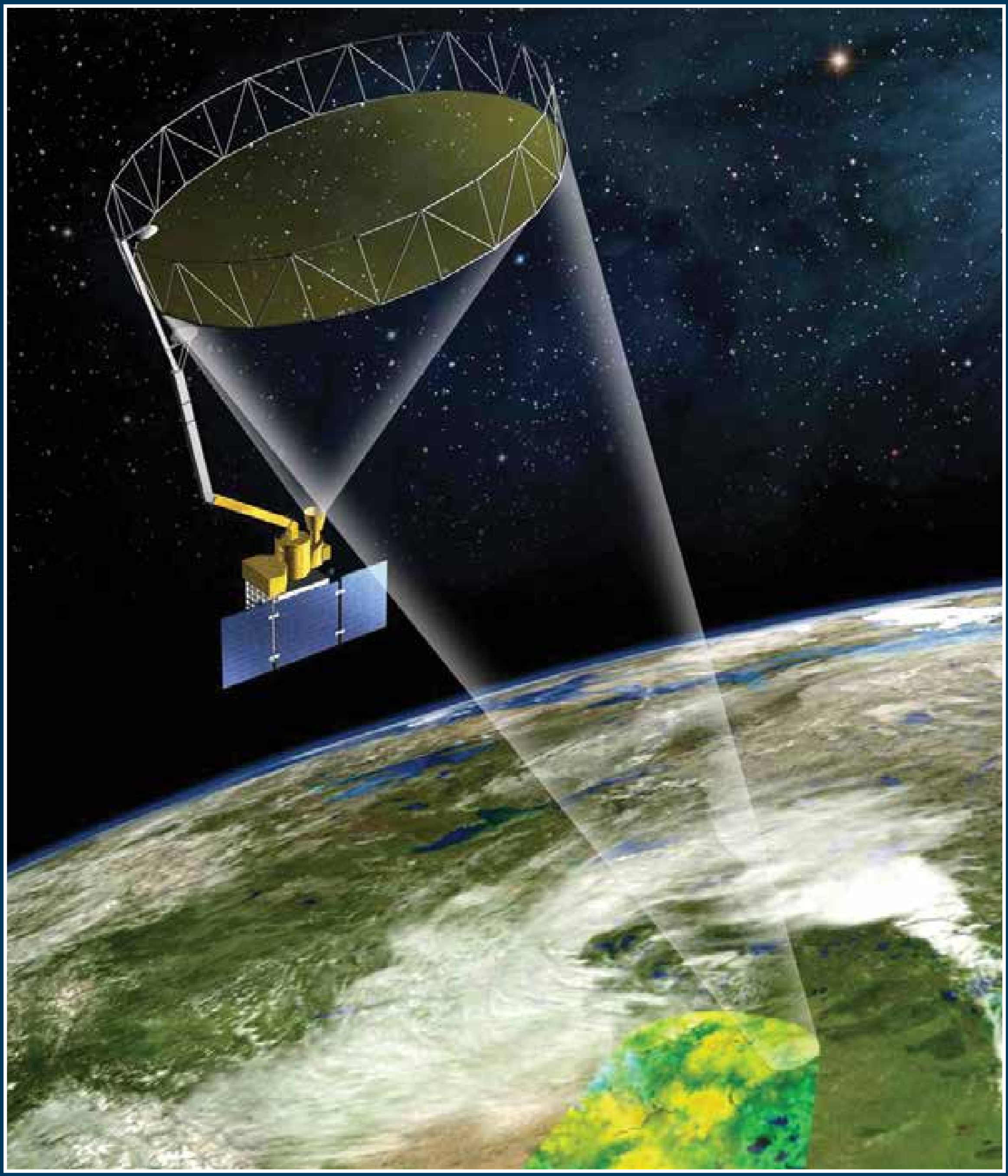


Figure 5. An annotated example of the VIIRS DNB radiance RGB composite taken over New Mexico and encompassing WFO Albuquerque's county warning area at 0845 UTC 25 July 2013. The image shows how the RGB composite distinguishes between high (blue) and low (yellow) clouds as well as showcasing other VIIRS DNB capabilities. These include observing city lights, identifying where city lights are obscured by cloud cover, and occasionally observing lightning flashes.

2

Modeling and Data Assimilation



Artistic rendition of upcoming NASA Soil Moisture Active-Passive spacecraft.
(Image credit: http://smap.jpl.nasa.gov/multimediagallery/)

During 2013, the SPoRT Modeling and Data Assimilation team has focused on enhancing its areas of expertise while also working to incorporate upcoming NASA instrumentation into its current capabilities. SPoRT has been a community leader in the assimilation of retrieved profiles from hyperspectral IR sounders and regional land surface modeling through applications of the NASA Land Information System. Additionally, SPoRT has developed and transitioned capabilities to enable our partners and collaborators to test new datasets in operational systems and quantitatively evaluate the impact of those new datasets. The following section highlights ongoing efforts and new collaborations that have arisen in the past year.

Assimilation of Hyperspectral IR Retrieved Profiles

SPoRT is a community leader in assimilation of retrieved profiles from hyperspectral IR sensors (e.g., AIRS, the Infrared Atmospheric Sounding Interferometer [IASI], and CrIS). The assimilation of hyperspectral IR profiles work was expanded in 2013 to include new assimilation techniques, forecast challenges, and partners. Below are highlights of these activities.

Atmospheric rivers and bias correction

The assimilation of AIRS profiles was conducted on an eastern Pacific domain to improve analyses and forecasts of atmospheric rivers, with a goal of generating a near-real-time enhanced 3D moisture analysis that could be used by West Coast WFOs and WPC/OPC for diagnosing the location, extent, and magnitude of atmospheric rivers. Atmospheric rivers are narrow tongues of enhanced low-level water vapor and precipitation that propagate from the Intertropical Convergence Zone northeastward, often impacting the West Coast of North America, among other areas. When these moisture-laden plumes interact with the steep orography along the West Coast, heavy precipitation often occurs which can lead to severe flooding and landslides. Since atmospheric rivers typically include significant cloud cover, the NCEP Global Forecast System (GFS) model, which assimilates AIRS radiances in cloud-free areas only, may not fully capture these features. In contrast, the assimilation of AIRS retrieved profiles of temperature and moisture is being tested to determine whether the retrieved profiles in partly cloudy regions can improve the resulting analyses. In regions where clouds are located, the portion of the profile above the cloud top is assimilated, with the goal of providing an enhanced view of atmospheric river features.

Blankenship et al. (2013) showed that assimilation of AIRS retrieved profiles of temperature and moisture can resolve the atmospheric river as a narrower feature, but there was an overall systematic drying trend in the analyses using AIRS. Data assimilation algorithms are generally designed for use with unbiased observations (Dee 2005). In some cases biases can be ignored, but often the impact on model analyses is significant. In an effort to reconcile these biases between the model and observation (retrievals), recent work has focused on developing a technique to bias-correct the AIRS retrieved profiles. Figure 6 shows mean profiles of specific humidity and temperature for both AIRS retrievals and the WRF model background (from a run without AIRS profile assimilation). These plots also show the correlations between the model background and the observations. These results are from a single model run on 10 Mar 2011 over western North America and the eastern North Pacific. The background and AIRS-retrieved temperatures are well correlated, with low bias, indicating little need for temperature bias correction. Moisture biases are very small in lower layers but in the upper troposphere, biases are substantial. At layers above 150 mb, the observations have little skill (as evidenced by low correlations) due to poor instrument sensitivity, so these observations are not assimilated. This leaves an intermediate region between roughly 500 mb and 200 mb where the retrievals have useful information, but a large bias relative to the model background.

Based on these results, a layer-by-layer regression-based linear bias correction was developed for moisture retrievals so the structure of the observations may be imparted to the model without changing the model climatology. Similar techniques are commonly used in operational assimilation of brightness temperatures in weather forecast models (Eyre 1992; Harris and Kelly 2001). The bias-corrected retrieved specific humidity in the right panel of Figure 7 more closely match the magnitudes of the background field (without AIRS profile assimilation), given by the better color correspondence between the background shading (model) and the colored crosses (observations). This bias correction enables the assimilation algorithm to more optimally incorporate information from both the background and observations. Research is now focused on validating the model forecasts with bias correction, and comparing to results without bias correction. Additionally, the need for different bias corrections based on model domain and season will be investigated.

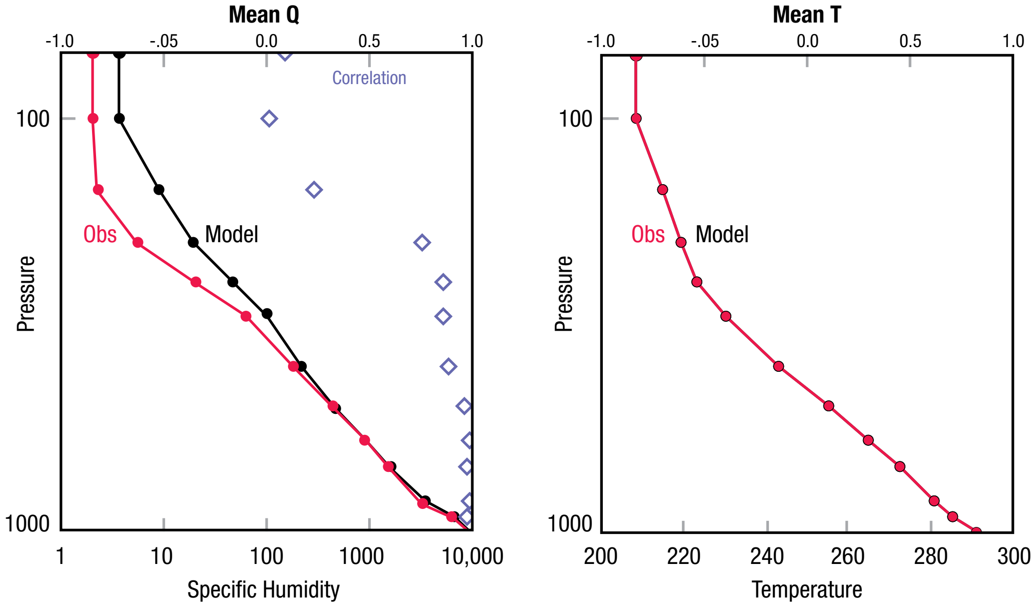


Figure 6. Model (black) and observed (red) mean profiles of specific humidity (left panel, mg kg^{-1}) and temperature (right, K), with correlations (upper scale) marked by blue diamonds.

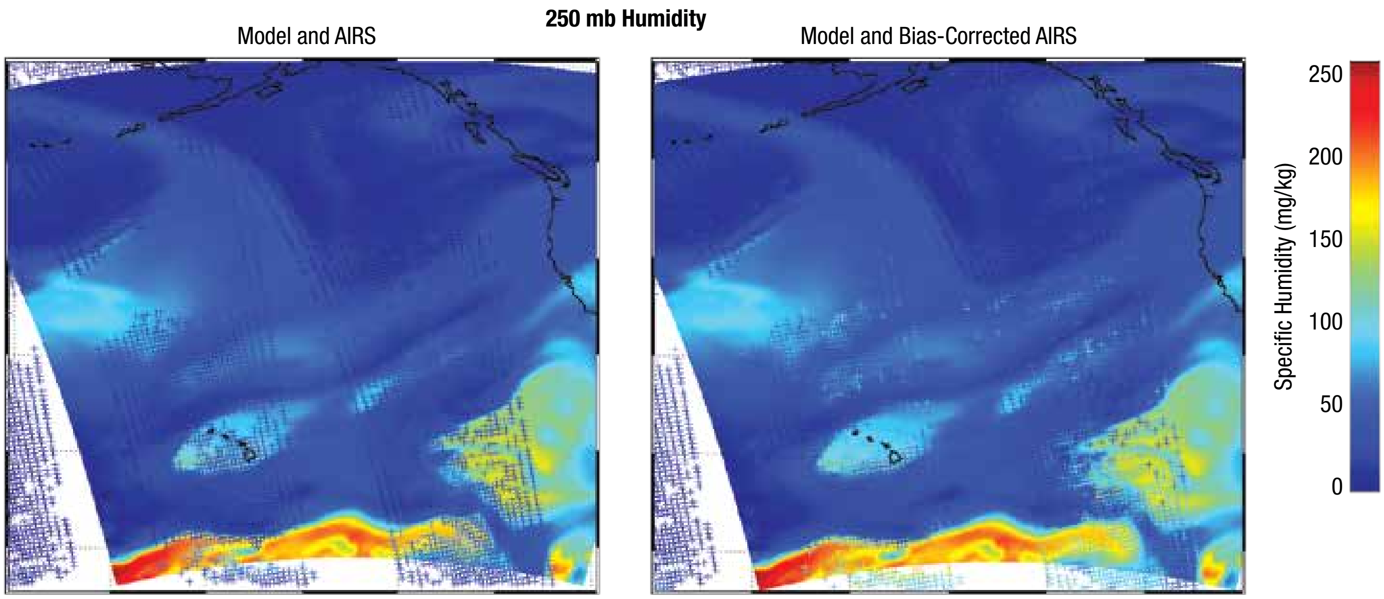


Figure 7. Model background (continuous field) and AIRS retrievals (small crosses) of 250-mb specific humidity (mg kg^{-1}) over the North Pacific for uncorrected (left), and bias-corrected AIRS retrievals (right).

Non-convective high wind events

In recent years, satellite data assimilation has improved skill in forecasting extratropical cyclones; however, errors still remain in forecasting the position and strength of extratropical cyclones and the tropopause folding process associated with these storms. Often, extratropical cyclones result in low-level high winds near the center of the storm that are not associated with convection, but rather with stratospheric air descending in the tropopause folding regions. The goal of this study was to determine the impact of assimilating satellite temperature and moisture retrieved profiles from hyperspectral IR sounders (i.e., AIRS, Cross-track Infrared and Microwave Sounding Suite [CrIMSS], and IASI) on the model representation of the tropopause fold and an associated near-surface high-wind event.

The hypothesis being tested is that the assimilation of hyperspectral IR profiles will result in a better representation of the temperature and moisture characteristics of the descending stratospheric air, which, in turn, will improve model representation of tropopause folds and associated near-surface high winds. Two experiments were conducted to test this hypothesis: (1) a control that contained all of the satellite (except for hyperspectral IR radiances) and conventional observations assimilated by operational regional DA systems, and (2) an experiment that assimilated all of the aforementioned observations plus retrieved profiles from AIRS, IASI, and CrIMSS. Cycled Weather Research and Forecasting (WRF) model simulations initialized at each cycle with a Gridpoint Statistical Interpolation (GSI) analysis were used for each set of forecasts for an extratropical cyclone event near the U.S. East Coast from 9 February 2013.

Since surface and especially upper-air observations are spatially and temporally limited, the model results were compared to the limited domain 13-km Rapid Refresh (RAP) and 32-km North American Regional Reanalysis (NARR). Although model analyses and reanalysis do not represent the true state of the atmosphere, they are a close approximation due to advanced data assimilation techniques. Because the RAP domain did not cover the extent of the low pressure system and the coarser NARR analyses were similar to RAP, the NARR was used in the results. Tropopause folds can be identified by model potential vorticity (PV; defined as the product of absolute vorticity and static stability). Figure 8 shows a series of model cross-sections taken across the southern side of the storm, where non-convective winds were around 35 m s^{-1} near the surface. The control run overestimated the tropopause temperature in the region of stratospheric air over the Mid-Atlantic States. The tropopause fold in the control simulation (Figure 8b) had a different shape than that depicted by the NARR (Figure 8a) and RAP; however, the experimental run more closely resembled the shape of the NARR and RAP tropopause fold (Figure 8c). Even though the shape was similar, the experimental run overestimated the magnitude of the PV anomaly compared to the magnitude depicted by both the NARR (Figure 8d) and RAP analyses. Even though model depiction of the PV anomaly differed between the control and experiment, it was

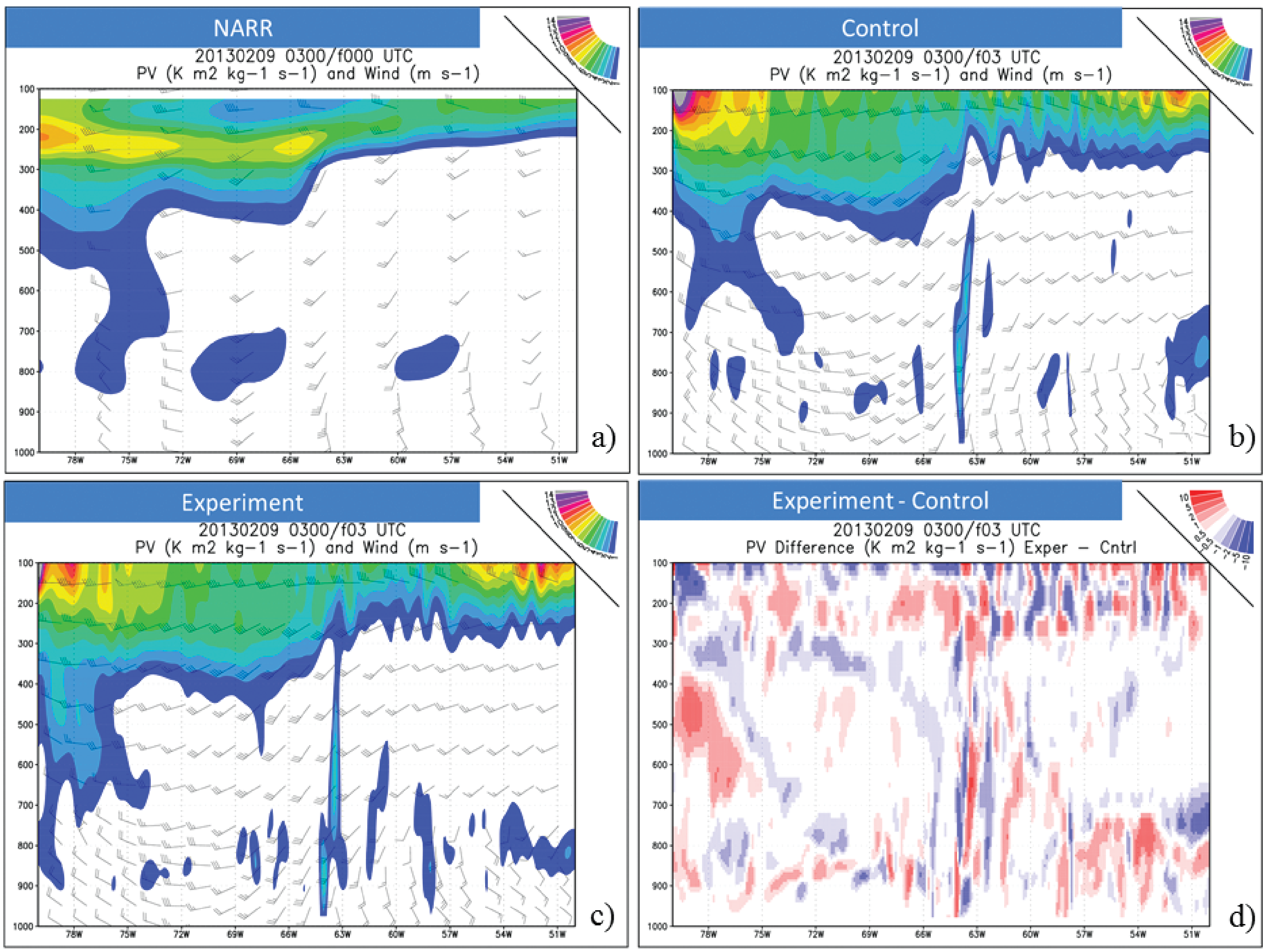


Figure 8. Cross sections of analyzed/simulated potential vorticity (shaded) and isobaric winds (barbs), valid 0300 UTC 9 February 2013 for (a) NARR, (b) 3-h forecast from 0000 UTC 9 February Control WRF Simulation, (c) 3-h forecast from 0000 UTC 9 February Experiment WRF Simulation, and (d) potential vorticity difference for Experiment minus Control.

found that changes in low-level static stability had a greater impact on changing the surface wind field. The magnitude of the experimental winds more closely resembled the NARR and RAP analyses but the location was displaced (not shown). Overall, the assimilation of hyperspectral IR profiles changed the representation of temperature characteristics of stratospheric air and the shape of the tropopause fold to more closely resemble model analyses, but had little impact on moisture characteristics in upper-level dry regions.

These experiments assimilated hyperspectral IR profiles in the entire atmospheric column, so, while encouraging, the results are inconclusive as to whether the positive impact on the surface wind fields are related to changes to the upper-level dynamics or thermal gradients near the surface. Ongoing work focuses on assimilating profiles only at upper levels to isolate the upper-level dynamic changes from any lower-level thermal changes.

Southern Region Modeling Collaboration

SPoRT has an ongoing modeling collaboration with the NWS Southern Region WFOs at Mobile, AL (MOB), Houston, TX (HGX), and Huntsville, AL (HUN). The forecast challenge for this phase of the project is primarily warm-season CI and precipitation forecasts. The collaboration has led to the incorporation of SPoRT surface initialization datasets (sea surface temperatures, Land Information System [LIS; Kumar et al. 2006; Peters-Lidard et al. 2007] soil moisture and temperature data, and daily MODIS Green Vegetation Fraction [GVF; Case et al. 2014]) into the real-time local model runs at each office. Additionally, a set of scripts has been developed to run the Model Evaluation Tool (MET) software to generate verification statistics based on the local model output from the WRF Environmental Modeling System (EMS; Rozumalski 2013) framework. A prototype of the verification scripts was transitioned to each office as well as the NWS Eastern Region Headquarters, and has been refined based on feedback from each office.

Initial composite verification results from numerous case days during summer 2012 (Medlin et al. 2012) indicated that both a control experiment (NCEP GFS-based initialization with no SPoRT data) and the operational WRF (GFS with SPoRT data) exhibited a consistent under-prediction of precipitation coverage. It was hypothesized that due to sensitivity of the planetary boundary layer (PBL) to the use of the SPoRT surface initialization datasets, there may be a more optimal set of PBL schemes as well as microphysics options that would produce better forecasts with higher-resolution surface features. To determine this optimal physics configuration for using SPoRT data, SPoRT ran a simulation matrix consisting of eight microphysics by three PBL schemes for both the control and operational configurations for a single case study each from the WFO MOB and HGX EMS model runs. The results were examined both qualitatively through the use of an 8-by-3 display of model output for select variables, and quantitatively through the use of the SPoRT-MET scripts. In addition, an assessment of the run-time performance of each physics combination was conducted to determine the practicality of running a specific configuration in real time by a WFO with limited computational resources.

Preliminary results indicate that substantial complexity and variability exists between different physics combinations in terms of simulated CI and especially accumulated precipitation. The MOB case had more widespread convection and better overall simulations than the HGX case, which featured very sparse, weaker precipitation coverage. In the MOB case, most SPoRT-initialized matrix members initiated convection at the correct time and locations when compared to validating radar reflectivity imagery, whereas the control run delayed CI and tended to place it in the wrong locations (not shown). Differences in the Heidke Skill Score (HSS) verification statistic for 10 mm $(3\ h)^{-1}$ accumulated precipitation support the improved accuracy of CI in the SPoRT-initialized runs. Figure 9 shows the differences in HSS by forecast hour for the Mellor-Yamada-Janjic (MYJ) PBL parameterization option with all eight microphysics schemes. Most microphysics members in the SPoRT runs had HSS about 0.1 to 0.3 higher than in the control runs during the period of CI/active convection (forecast hours 13-17 in Figure 9). Similar verification results occurred with the two other PBL schemes in combination with the eight microphysics options (not shown). Since these results are derived from only a single case study, control and SPoRT simulation matrix runs are being conducted for several additional cases for both WFO MOB and HGX from summer 2012.

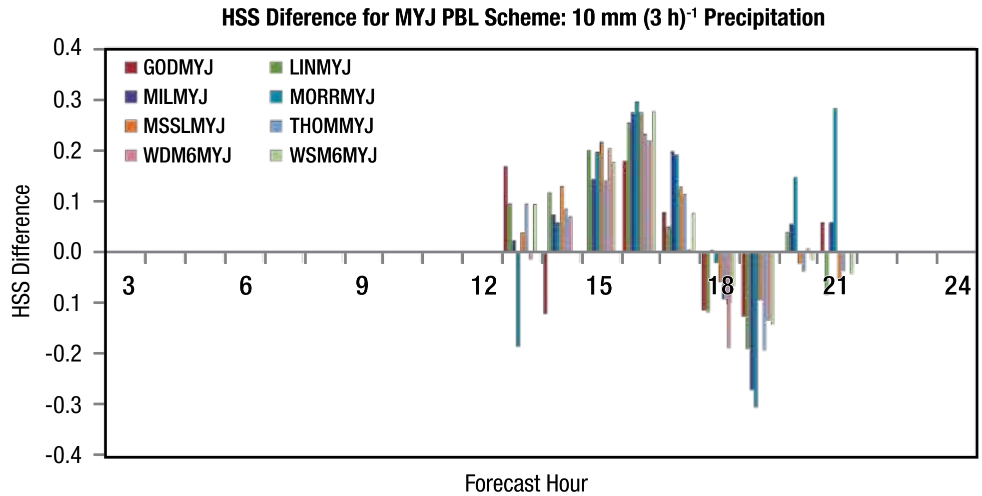


Figure 9. Difference in the Heidke Skill Score (HSS) verification statistic for 10 mm $(3\ h)^{-1}$ accumulated precipitation threshold as a function of forecast hour for the eight microphysics schemes run in conjunction with the Mellor-Yamada-Janjic (MYJ) PBL parameterization. Results are shown from the 3 July 2012 WRF physics matrix case study from the MOB WFO forecast domain.

SPoRT-SERVIR Modeling Collaboration

SPoRT has maintained a collaboration with the NASA SERVIR project to enhance weather modeling capabilities at select SERVIR international locations. SPoRT first configured the WRF model for the Central American and Caribbean regions (i.e., “Mesoamerica”) to upgrade the legacy modeling system run at Panama using the MM5 model. This past year, the primary focus was to develop a modeling solution for the Kenya Meteorological Service (KMS) to enhance weather forecast capabilities in eastern Africa.

Mesoamerica runs using cloud computing resources

This effort involved initializing the WRF model with the 2-km SPoRT SST product, increasing the horizontal resolution over the legacy MM5 runs, and generating proof-of-concept model verification statistics. With the help of personnel from NASA Ames Research Center, the Mesoamerica real-time WRF runs were implemented onto a cloud computing architecture. The Mesoamerica WRF runs have been maintained on the NASA Ames Code I Private Cloud during the past year, with model output being sent to a Web page for display and analysis. In late 2013, Ames staff aided SPoRT with the transition of the modeling configuration and automation scripts to the Amazon Elastic Cloud Computing system. Ongoing research is examining ways to improve efficiency of the system and to understand future costs for users of a cloud-based WRF modeling system. Model outputs will also be migrated to a Web mapping service for viewing and dissemination.

Kenya Meteorological Service modeling activities

For the KMS-WRF experiment, a modeling domain was configured for daily control and experimental runs on a 12-km/4-km nested domain using one of SPoRT’s weather-in-a-box clusters. Forty-eight hour forecasts are being generated each day in real time, initialized at 0000 UTC. The experimental WRF run is first produced in real-time and uses GFS model initial/boundary conditions along with a land surface initialization from LIS runs generated over eastern Africa. The LIS data consist of offline Noah land surface model (LSM) simulations on a 0.03 degree grid (~3 km) forced by NCEP Global Data Assimilation System (GDAS) analyses and 8-km NCEP Climate Prediction Center Morphing technique (CMORPH) half-hourly precipitation analyses. The LIS was designed to provide improved, higher-resolution land surface initialization fields to the WRF runs, compared to initializing with 0.5-degree GFS model land surface grids. After completion of the experimental WRF runs, the control WRF simulation is made which uses all initial and boundary conditions from the GFS model grids. The real-time daily KMS-WRF simulations were implemented on 1 October and a set of control and experiment forecasts is being collected to generate verification statistics and determine how the inclusion of LIS initialization can improve model skill scores over the GFS-initialized WRF control runs. Future efforts will further enhance the model configuration by incorporating the real-time NESDIS VIIRS GVF product (Vargas et al. 2013) into both the LIS and WRF runs, after it becomes publicly available.

Soil Moisture Assimilation

Soil moisture is an important variable for weather prediction, particularly in the warm season, because it governs the flux of water vapor into the atmosphere through evapotranspiration. Soil moisture has applications in numerical weather prediction, drought monitoring, flood prediction, and public health applications such as extreme heat, and water- and vector-borne diseases. SPoRT has been developing the capability to assimilate soil moisture retrievals from the Soil Moisture and Ocean Salinity (SMOS) satellite into the NASA LIS for the Noah LSM. SMOS is a polar orbiter launched by the European Space Agency in November 2009. It carries an L-band (1.4 GHz) microwave radiometer which is used to retrieve the soil moisture content in the near-surface layer. SMOS has a resolution of 35-50 km and an absolute accuracy of 4% with measurements made twice daily in most mid-latitude locations (European Space Agency 2002).

In a test run, SMOS retrievals were assimilated into version 3.2 of the Noah LSM in an Ensemble Kalman Filter run with eight ensemble members, initialized with a 30-day spin-up including state perturbation, forced by GDAS analyses. Figure 10 shows some preliminary results from tests of SMOS data assimilation in LIS. The retrievals show areas of wetter soil moisture in southern Canada near the Great Lakes and also in southern Illinois (Figure 10b). Both of these areas are much wetter in the 0300 UTC LIS-Noah assimilation output (Figure 10c) compared to the LIS-Noah output prior to assimilation (Figure 10a), showing that the assimilation successfully modified the model field to more closely match the "observations." There are also some drier areas where the assimilation decreased the soil moisture, such as in the Carolinas and Florida.

The SMOS data assimilation methodology is undergoing testing and refinement in several areas. The LIS structure includes several user-defined parameters which govern the Ensemble Kalman filter assimilation, such as settings for frequency, magnitude, and covariance structure of state, observation, and forcing perturbations. The quality control for SMOS retrievals will also be evaluated, including flags for radio-frequency interference, precipitation, frozen surface, and heavy vegetation.

In 2013, SPoRT was officially recognized as an Early Adopter for the NASA Soil Moisture Active-Passive (SMAP) mission. The techniques developed for the assimilation of SMOS soil moisture retrievals will therefore be used to facilitate the swift implementation of assimilating soil moisture retrievals from the SMAP satellite, scheduled for launch in November 2014 as of this writing. SMAP includes both an L-band radiometer similar to the SMOS radiometer, and an active radar. The radar retrievals will have a lower accuracy (6% vs. 4%) but be produced at a much higher resolution of ~1-3 km (Kim et al. 2012). A blended radar/radiometer product is expected to combine the accuracy of the radiometer with the resolution of the radar. These combined retrievals at 9-km resolution (Entekhabi et al. 2012) will enable a better representation of soil moisture fields for the various regional real-time LIS runs at SPoRT, as described in the next sub-section. Pre-launch SMAP data will be made available in January 2014, and these data will be used to develop the necessary modules for assimilating the data into LIS, initially in the NCEP Noah LSM. All three SMAP products will be tested, as differences in latency, full-orbit availability, and quality may affect data assimilation results.

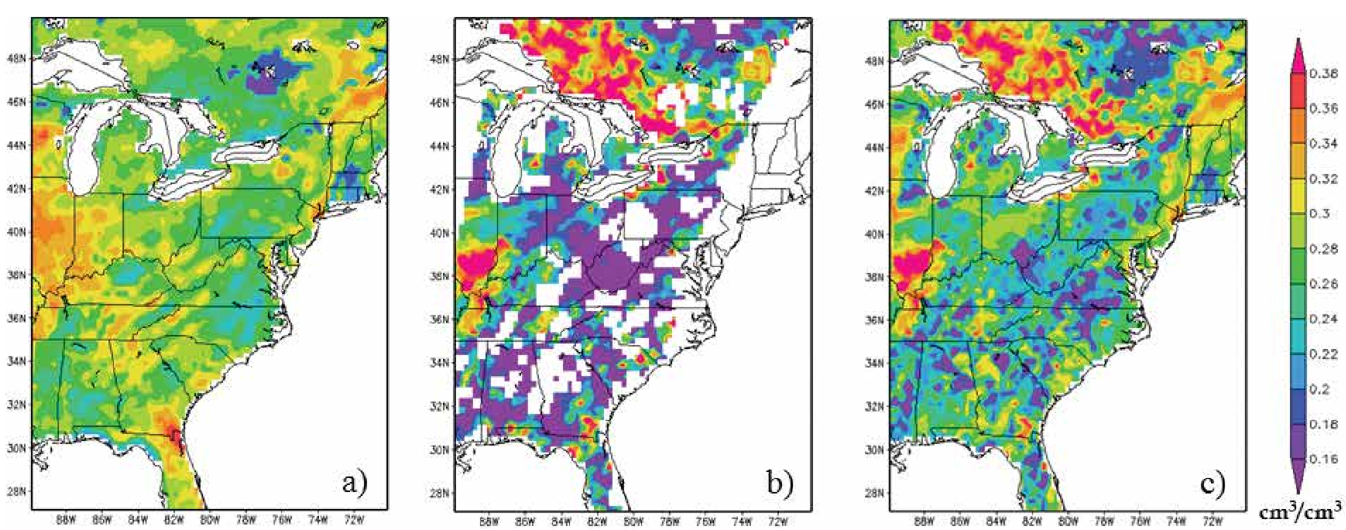


Figure 10. a) 0-10 cm modeled soil moisture at 0000 UTC 5 Jun 2013 prior to assimilation. b) SMOS retrieved surface soil moisture valid at 2300 UTC 4 June 2013. c) 0-10 cm modeled soil moisture at 0300 UTC 5 Jun 2013, after assimilation.

Other Activities and Collaborations

Dynamic data assimilation scripts

As part of an effort to align more closely with the NCEP Environmental Modeling Center (EMC), SPoRT developed a set of dynamic scripts that mimic the cycled WRF/GSI system used for the operational EMC North American Mesoscale model. These scripts are open source and easily transferred between scientists working with SPoRT and external collaborators. As new data assimilation and modeling capabilities are developed, these scripts will be tested in this operational data assimilation system. The long-term vision for the use of these scripts is to unify data assimilation activities at the National Space Science and Technology Center (NSSTC) in Huntsville, AL under a common data assimilation system (i.e., GSI) to make research more relevant to the operational community.

MODIS Cloud Top Pressure for AIRS Radiance Quality Control

A project funded by the Joint Center for Satellite Data Assimilation concluded that cloud-top designation associated with quality control procedures within GSI may not provide the best representation of cloud top pressure in partly cloudy regions (CTP; Zavodsky et al. 2013). Because this designated CTP determines which channels are cloud-free and, thus, available for assimilation, ensuring the most accurate representation of CTP is imperative to obtaining the greatest impact from satellite radiances. Any errors in the calculated CTP that are used to quality control radiances within GSI may limit the amount of data assimilated in the vertical, thereby limiting the positive impact on regional forecasts (e.g., McCarty et al. 2009). Figure 11 demonstrates this concept for a single swath of AIRS radiances compared to CTP from MODIS. The region in the upper-right part of the swath (green circle) is where GSI has properly quality-controlled the radiances and not many more radiances could be assimilated. At the bottom-right part of the swath (red circle), the quality control places the clouds too high (compared to MODIS) resulting in a reduced number of assimilated lower troposphere radiances that could add valuable information to the analysis.

As part of ongoing work on this topic, a technique was developed to improve the quality of the CTP designation within the GSI in an effort to increase the number of assimilated radiances. This technique involves "swapping" the CTP calculated from the radiances within GSI with CTP from the high-resolution MODIS. The impact on the operational system will be examined by comparing analysis increments and numerical forecasts generated using the operational (i.e., AIRS-only CTP) technique with the MODIS CTP swapping technique.

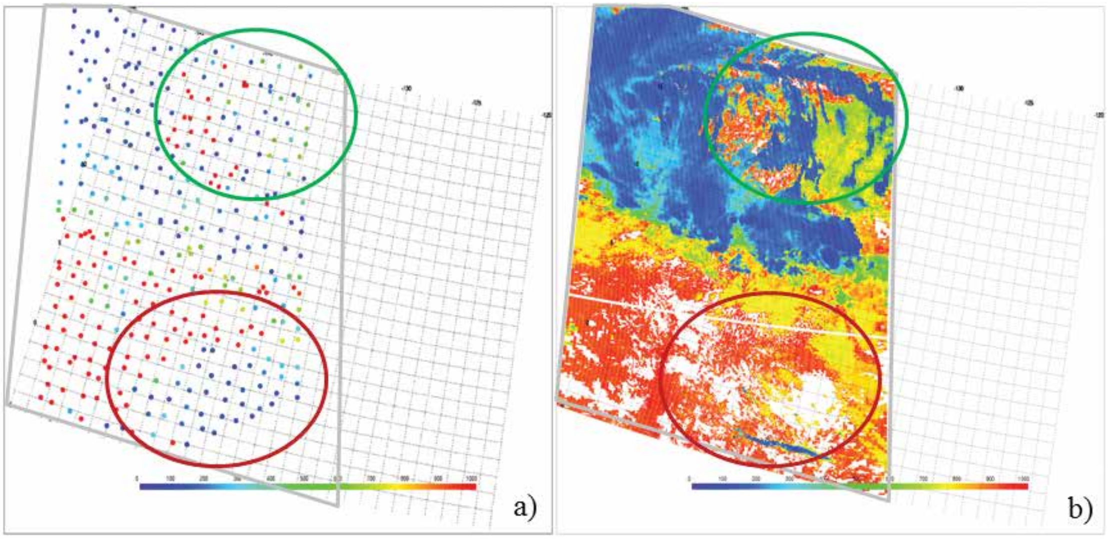


Figure 11. a) AIRS-only quality control currently used by GSI to determine clear channels in radiance data, and b) the corresponding MODIS CTP (right) showing regions where swapping in MODIS CTP would lead to additional high-quality assimilated radiances.

SPoRT-LIS and domain expansion using MRMS precipitation

A real-time SPoRT-LIS application has been running the Noah LSM in an offline capacity in recent years over a southern and eastern U.S. region. The offline LIS integrates the Noah LSM with surface input provided by atmospheric and precipitation analyses, currently the North American Land Data Assimilation System-phase 2 (NLDAS-2), GDAS, and the NCEP Stage IV hourly precipitation product. The output from LIS has been used for different types of applications: (1) situational awareness, such as drought monitoring and assessing flood potential, and (2) initializing local models with more representative, high-resolution land surface fields. The output from the real-time LIS was successfully transitioned to AWIPS II at the NWS HUN WFO to aid in situational awareness applications.

To broaden the potential user-base for real-time applications, an additional LIS-Noah run was implemented to cover the entire CONUS on a 0.03-degree grid. The new LIS uses the National Severe Storms Laboratory's Multi-Radar Multi-Sensor high-resolution precipitation product, generated on a 0.01-degree grid over the CONUS. The CONUS-LIS run sets the stage for local modeling, situational awareness applications, and future assessments with SPoRT partners outside of NWS Southern Region.

NASA Unified-WRF project with Goddard Space Flight Center

A four-year project was awarded in May to Co-Investigators from the NASA Goddard Space Flight Center and SPoRT for the proposal titled "Advancing Coupled Land-Atmosphere Modeling with the NASA-Unified WRF via Process Studies and Satellite-Scale Data Assimilation." This project builds on the successful development and application of the NASA Unified-WRF (NU-WRF) modeling system, with the goal of integrating and enhancing existing land and atmospheric data assimilation capabilities to advance regional-scale coupled land-atmosphere modeling. SPoRT's involvement is to conduct land surface data assimilation experiments using L-band soil moisture data from both the SMOS and future SMAP missions, as well as develop capabilities for incorporating real-time vegetation data from VIIRS. In addition to the soil moisture data assimilation efforts described earlier in this section, a module was developed and tested in LIS to incorporate the daily global VIIRS GVF product developed by NESDIS. Each of these capabilities will be invoked to conduct modeling and land data assimilation research of recent high-impact events such as the U.S. extreme drought and heat from the 2011 and 2012 summers, and to advance international modeling collaborations in conjunction with NASA SERVIR.

Operational AMU WRF

Another ongoing collaboration involves work with the Applied Meteorology Unit (AMU) at the Cape Canaveral Air Force Station, FL to produce an operational NWP model in support of launch operations at the Kennedy Space Center and Wallops Island. The AMU is focused on very high-resolution modeling (nested grids of 1-km over launch sites) and incorporating SPoRT datasets into their model. The AMU operational model uses the GSI/WRF scripts developed by SPoRT, mentioned earlier in this section. As part of this collaboration, AMU is also incorporating SPoRT surface datasets including the real-time LIS, MODIS GVF, and 2-km SST product.

3

Decision Support System (DSS)

Low-precipitation supercell thunderstorm near Ft. Cobb, Oklahoma.
(Image copyright Kevin M. McGrath, mcgrathimages.com. Used with permission.)

One of the SPoRT core functions is to deliver products to the end-user's DSS. Over the last year, SPoRT has focused significant efforts on providing continuity as the NWS transitions to AWIPS II, along with building for a flexible future delivery system to support more end-users. The following sections discuss the work in these two areas.

AWIPS II Development/EPDT

SPoRT has been developing AWIPS II "plug-ins" to maintain continuity for its products as the NWS transitions to AWIPS II. Currently SPoRT has an LMA plug-in being tested and evaluated at NWS offices. In addition, several other plug-ins are in development and will be tested in 2014.

Total Lightning Tracking Tool (TLTT)

In 2013, the HWT incorporated SPoRT's total lightning ingest and display plug-in for AWIPS II. This enabled the PGLM product to be provided for the seven ground-based LMAs that were available at the time for evaluation. The inclusion of the SPoRT AWIPS II plug-in facilitated the first-ever evaluation of the SPoRT/Meteorological Development Laboratory (MDL) Total Lightning Tracking Tool (TLTT). The TLTT has been the highest-priority request by operational forecasters since total lightning was first transitioned to operations in 2003 to WFO Huntsville. Forecasters have requested the ability to observe a time series plot of total lightning, which has been difficult or extremely time consuming to perform in the past. The TLTT takes advantage of the ability to write custom plug-ins within AWIPS II in order to create this functionality. The TLTT is a small piece of a larger moving trace tool in development by MDL.

The initial feedback, along with that of the PGLM products, was very positive. Forecasters were impressed with the information the PGLM could provide and the possibilities of the TLTT. The overall consensus with the TLTT was that it was extremely valuable conceptually. The major criticism was that it had difficulty in its implementation. As an example, the TLTT display was often difficult to activate and the display was cluttered for very slow-moving storms. All of this feedback has been taken into account and the revised TLTT will be evaluated in 2014 at the HWT EWP. Additionally, SPoRT submitted a proposal to the Operations Proving Ground (OPG) that was accepted and the TLTT will be one of the key OPG evaluations in 2014. The revised TLTT has more features of the full MDL tool and can create time series plots of most gridded and radar data sets.

Spring 2013 EPDT Training Workshop

Back in 2012, SPoRT formed the Experimental Products Development Team (EPDT) to focus on creating advanced display capabilities for the use of experimental research data in the AWIPS II environment. In 2013, SPoRT conducted training associated with EDPT both through bi-weekly conference calls and through two workshops held in Huntsville, AL. The EPDT is coordinated by SPoRT team member and former NWS employee, Jason Burks, and is jointly funded by NASA and NOAA.

In preparation for the first EPDT workshop, the team began holding biweekly conference calls. These conference calls used desktop sharing to help establish a base level of development knowledge in the AWIPS II architecture and

Figure 12. Spring 2013 EPDT Meeting in Huntsville, AL.

prepare members to have an effective workshop. During 12-14 March 2013, SPoRT hosted the first EPDT workshop in Huntsville at the NSSTC (Figure 12). During the three-day workshop, participants were taught how to integrate a sample dataset into AWIPS II through the development of plug-ins. The workshop covered writing plug-ins to ingest and display the data along with how to avoid common pitfalls encountered during development. The workshop combined lectures with hands-on exercises to enhance the participants' learning. In addition to AWIPS framework topics, the workshop included invited talks on topics such as NWS AWIPS II software governance and future use of the NWS Virtual Lab for AWIPS II development. The feedback provided from the workshop indicates that it was a resounding success and has advanced both EPDT members and the NWS in developing software to enable visualization of unique datasets within the AWIPS II architecture.

Fall 2013 EPDT Code Sprint

SPoRT hosted a three-day EPDT code sprint in Huntsville on 24-26 September 2013. During the code sprint, sub-groups of EPDT members extended their knowledge of AWIPS II by developing projects in the AWIPS II architecture. The code sprint workshop enabled the members to develop code useful to their own projects, along with the community as a whole by advancing their knowledge. The group developed projects such as extending the AWIPS II RGB displays to support recipes, tracking meteogram, Meteorological Phenomena Identification Near the Ground (mPing) display, and mini Environmental Data Exchange (EDEX). All of these projects made significant progress during the code sprint and continued the participants' learning through real-world, hands-on applications of concepts previously learned during the Spring 2013 workshop. The projects developed during this workshop will continue to be advanced and will help to extend the AWIPS II platform to address the needs of the meteorological community. The first EPDT group continues to hold bi-weekly conference calls and plans to have a follow-on workshop in Spring 2014. Based on the success of the first group of participants in the EPDT program, SPoRT will begin training a second group in Spring 2014. The second EPDT group will be taken through the same course as the first group and extend the reach of AWIPS II development to more participants. The initial training workshop for the second group will be held in March 2014.

Common Web/Mobile Development platform for NASA Earth Science Data

SPoRT has been developing an architecture that will enable the delivery of science data, such as satellite imagery and model data, to various decision support platforms using a Web Mapping Service (WMS), consisting of both a server and client framework (Figure 13). The server allows for easy ingest of geospatial data including geospatial imagery and publishes the data via an open geospatial standard. The WMS can be easily integrated within a DSS without additional effort. The client framework provides a base for developing mobile and Web applications. The base makes development of mobile and Web clients easier and more flexible. This framework has enabled SPoRT to respond to disasters more easily while supporting current users and providing new imagery seamlessly. The development of this technology was funded by a partnership between the NASA Marshall Space Flight Center (MSFC) Office of Strategic Analysis and Communications, SPoRT, SERVIR and the MSFC Science Innovation Fund. SPoRT began ingesting real-time MODIS true color products and has since expanded the products offered through this system. The system was demonstrated as part of the MSFC Innovation and Technology Exposition held on 12 September 2013 (Figure 14). The demonstration included an Android tablet version of the mobile client developed on the client framework.

The WMS framework was extended to provide data directly to the NWS Damage Assessment Toolkit (DAT). After severe weather occurs, the NWS performs storm surveys of the damage. SPoRT was funded through a NASA ROSES 2011 A.33 Earth Science Applications in Disasters proposal to examine the feasibility and application of tornado damage detection algorithms using remote sensing imagery to assist the NWS in streamlining the storm survey process. The framework was extended to provide delivery of imagery to the DAT and was demonstrated during the Washington, IL Tornado in November 2013. The WMS framework has enabled SPoRT to respond more quickly to disaster events and provide its imagery to a wider audience. More details on the Disaster Response project are given in Section 5.

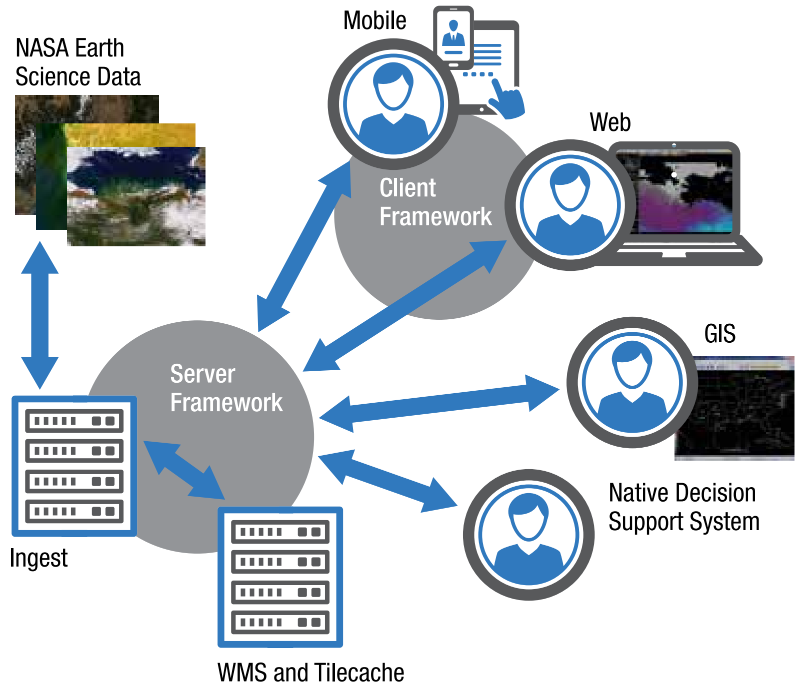


Figure 13. Architectural diagram of the Common Web/Mobile Platform.

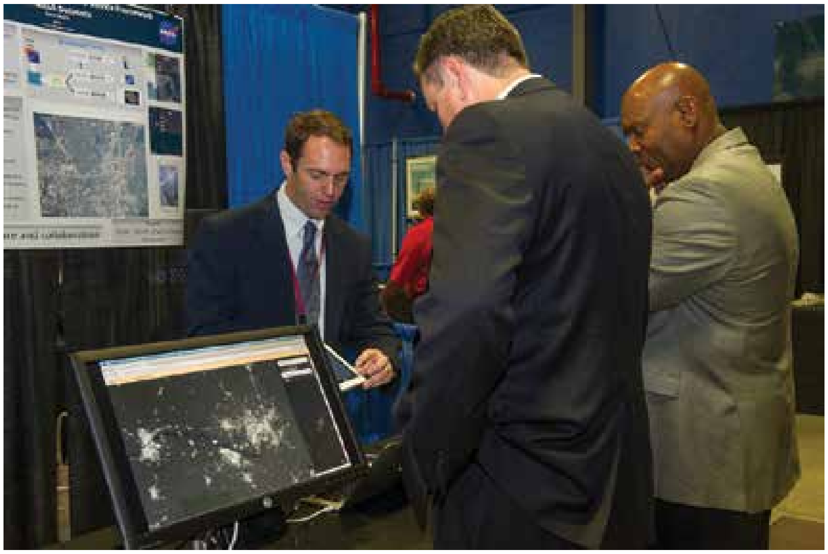


Figure 14. Mr. Jason Burks (left) from SPoRT demonstrates the Common Web Mapping and Mobile Device Framework for NASA Datasets to Center Director Patrick Scheuermann (middle), and Office of Strategic Analysis and Communications Director Bobby Watkins (right).

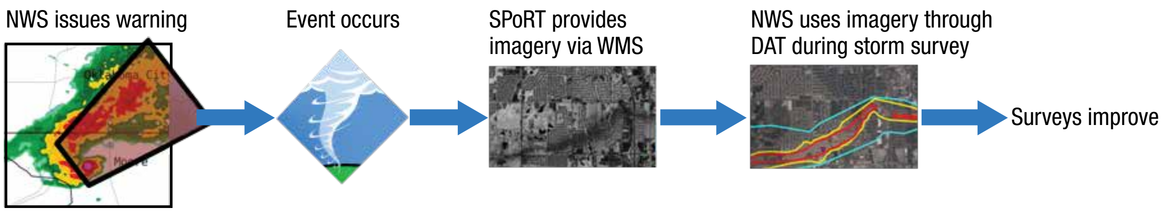


Figure 15. NWS storm survey process using the DAT along with SPoRT imagery.

4

Transition Training and Assessments

Rime ice coats Monte Sano near Huntsville, AL.
(Image copyright Eugene W. McCaul, Jr., stormshooter.com. Used with permission.)

As part of its core functions, SPoRT seeks to transition unique NASA products and capabilities to those users providing services that protect life and property of the general public. The transition paradigm is the cycle of matching products/capabilities to user forecast challenges, providing product training to users, collaboratively assessing the product in an operational testbed, and then deciding if the product is ready for wide usage or whether it requires further development. The following is a description of the products transitioned to users in 2013 and the training and assessment activities associated with those products.

Transition Activities

Expanded collaborations with Alaska Region and GINA

High-latitude users in Alaska expanded activities with SPoRT in 2013 through establishing a base menu within their display system, ingesting additional products and imagery, and participating in product assessments for short, intensive periods of 6 to 8 weeks. As in previous years, the GOES-R and JPSS Proving Ground OCONUS annual meeting in June was attended by SPoRT. After this meeting separate visits by additional staff were made to all Alaska WFOs, the Pacific/Alaska River Forecast Center, the Alaska Ice unit, and the NOAA Tracking Station at Gilmore Creek. The three Alaska WFOs have found value in the POES-GOES hybrid suite imagery (i.e., longwave and shortwave IR, water vapor, and visible channels). In much of Alaska, the GOES imagery footprint is much larger than its native resolution due to the high viewing angle. The POES-GOES hybrid inserts the polar-orbiting MODIS (from EOS Terra and Aqua platforms) and VIIRS (from Suomi-NPP) into the GOES images, when available. The result is an animation sequence where GOES imagery provide continuity and the unique NASA polar-orbiting imagery provide improved interpretation of cloud and land surface features. Without the POES-GOES hybrid suite, multiple displays would be needed and many users would not be fully aware of the polar-orbiting imagery availability and value.

Visits to the WFOs built on this success and began the integration of RGBs into the Alaska product suite. A standardized suite of RGBs was established and SPoRT staff provided training and demonstrated their utility to individuals during the visits and via asynchronous distance learning modules. At the start of December 2013, Alaska forecasters participated in an assessment of night-time microphysics RGB imagery to aid aviation products related to differentiating low clouds and fog, as well as analysis of mid- and upper-level cloud structures. Other groups, such as the Alaska Ice Desk in Anchorage started using the SPoRT SST composite to more efficiently create SST charts for the public. In some cases, the use of the SST composite provided a 60% reduction in required production time of the public SST charts. The use of the SPoRT SST has enabled the Alaska Ice Desk to meet the NOAA's Arctic Vision and Strategy directive of a daily SST graphic instead of the current twice-weekly production.

GINA continues to work with SPoRT to provide access and processing resources for MODIS and VIIRS data over Alaska for transition to WFOs. Due to the time required to download, process, and send hybrid and RGB imagery from Alaska sources to operational users, GINA suggested the use of 'virtual machines' (VM) on UAF hardware for SPoRT product generation using data from their local Direct Broadcast receiving stations. A VM is a software implementation of a computer that executes code just like a physical machine. These new VMs with local GINA data sources will reduce product delivery latency and make SPoRT-provided products more operationally relevant. Given the limitations of geostationary data and the more frequent views of polar-orbiting satellites at high latitude, the transition of unique NASA data and capabilities in 2013 has been very successful. SPoRT is well-positioned for continued growth and expansion in the Alaska region in areas of RGB and passive microwave imagery.

Expanded collaborations to WFO San Juan, PR

The NWS WFO in San Juan, PR (SJU) examined a number of satellite products, including MODIS and VIIRS RGBs. The SJU satellite focal point provided feedback on the utility of various RGB products in the Puerto Rico domain related to the detection of African dust. SJU also participated in a summer assessment of NESDIS GOES-R QPE and CIRA LPW, in which five forecasters completed 42 formal feedback surveys and provided additional feedback to product developers. Through SPoRT's transition efforts in its GOES-R PG work, the QPE developer was made aware of several operational limitations of the product that are to be addressed in subsequent versions of the product. SPoRT's role as the bridge between research and operations was well demonstrated through this new SJU collaboration in 2013. SJU also provided detailed blog posts of operational examples for the benefit of the operational community as a whole, via the Wide World of SPoRT blog site. Given the SJU forecast priorities of heavy precipitation and convection, SPoRT will continue to engage forecasters with GOES-R QPE and will look to expand future collaborations to involve the GOES-R CI product and the use of SPoRT-LIS for input to local model runs at SJU. In addition, plans began in 2013 for a Direct Broadcast station to be placed in San Juan that will allow SPoRT to better provide RGB imagery specific to SJU needs over the western and central Atlantic region.

Lightning plug-in ATAN approved for AWIPS II

SPoRT has developed proficiency with the NWS's new decision support and visualization system, AWIPS II, to ensure that collaborations with WFO partners continue as they transition to this new system. One of the first products to be evaluated for transition to AWIPS II was the LMA, for which an AWIPS II plug-in was developed as discussed in the 2012 SPoRT Biennial Report. During 2013, SPoRT coordinated with the AWIPS II program office to have the plug-in tested for an AWIPS Test Authorization Note (ATAN). The ATAN certifies that the plug-in is approved for use in an operational AWIPS II system at a WFO. This approval was received in early Spring of 2013 and allows SPoRT partners with AWIPS II to use LMA data operationally (Figure 16). By the end of 2013, the ATAN was approved for partners in Huntsville, AL, Houston, TX, and the Spaceflight Meteorology Group. Additionally, the Boulder, CO office has been approved and will begin installation of the plug-in during early 2014.

Land Information System available to WFO Huntsville in AWIPS II

The real-time SPoRT configuration of the NASA LIS provides output of surface fluxes and subsurface soil temperature and soil moisture. These fields have been used by collaborating NWS WFOs for diagnosing summertime CI, assisting drought/flood outlooks, and initializing land surface variables for local model runs. The Huntsville WFO has used LIS output via the SPoRT Web site for operational applications to analyze the potential for flooding, and they have used it as a tool to provide input to the U.S. Drought Monitor. During 2013, the Huntsville WFO transitioned to the AWIPS II ingest and display system. AWIPS II has built-in utilities for decoding model gridded fields in the Gridded Binary-2 (GRIB2) format. SPoRT began placing LIS files in this format on the Local Data Management system for ingest and use by the Huntsville WFO. With instructions developed by SPoRT, the Huntsville WFO was able to modify AWIPS II configuration files in order to display LIS surface and sub-surface fields without the implementation of supplemental data-ingest code (i.e., "plug-ins"), which would have required a series of NWS approvals. The combination of LIS output with other native datasets, such as radar-estimated precipitation, will be a powerful combination in a single display frame for analysis of precipitation events for assessing future flood potential. Plans are being developed to conduct a LIS assessment during 2014 with select SPoRT partners already upgraded to AWIPS II.

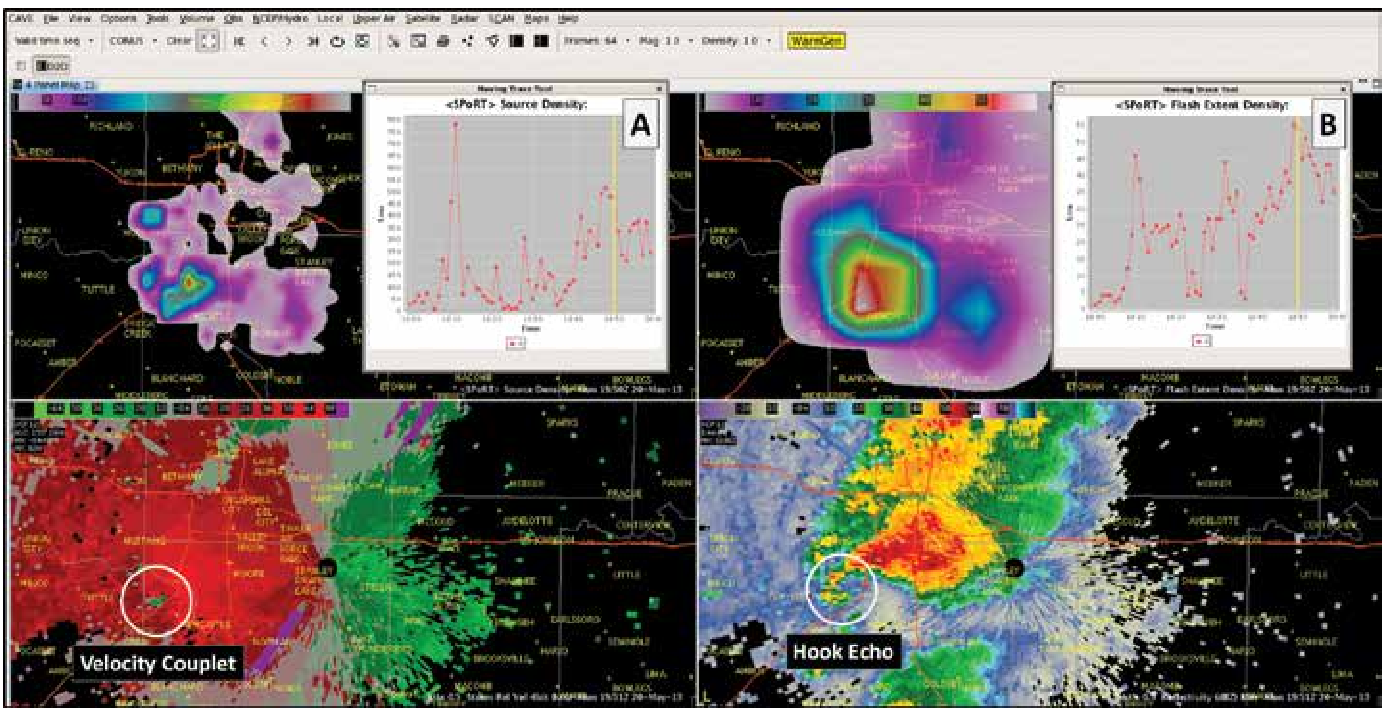


Figure 16. AWIPS II display of source density (upper left) and PGLM flash extent density (upper right), as depicted by SPoRT's LMA plug-in at 1950 UTC, six minutes prior to the formation of the Moore, OK EF-5 tornado on 20 May 2013. Corresponding 0.5° radar storm relative velocity (lower left) and 0.5° radar reflectivity (lower right) are shown, as well as the time-series output from SPoRT's Total Lightning Tracking Tool for the source density (inset A) and PGLM flash extent density (inset B). The time-series plots show the initial lightning jump that occurred at 1910 UTC. The yellow vertical bar in both insets is the current time being displayed in AWIPS II.

Training

Total Lightning Applications module

Total lightning was a major component of training activities in 2013 with three specific modules released. Much of this content highlighted several new collaborations that initiated in 2012 and continued into 2013, along with SPoRT's core lightning activities. The HWT EWP used SPoRT's ingest and display plug-in for AWIPS II, which required an update to the 2012 PGLM training module. More importantly, the SPoRT/MDL Total Lightning Tracking Tool was demonstrated. Training on the use of this new tool was included in the PGLM module for the HWT. SPoRT also supported AWC and SPC partners with a National-Center-specific total lightning module. Since the National Centers still use N-AWIPS and have a different operational focus than local forecast offices, it was necessary to spin off a supporting module to address the National Centers' large-scale needs and forecast concerns. This module directly supported SPoRT's efforts to bring the PGLM into operations at the AWC to aid in aircraft routing activities near thunderstorms.

The WFO partners will soon have a new module to support their own operations. The original total lightning training focused on the basics to familiarize forecasters to the total lightning concept. This latest module is a series of operational examples, many of which were submitted by the forecasters themselves for inclusion. The module is subdivided into three components as the amount of content was too much for a single, 15-minute training. The module subsections focus on lightning safety, traditional severe weather uses, and unusual cases. Each subsection is self-contained and no more than 20 minutes in length. The module has been submitted for inclusion in the NOAA Learning Management System and will be available to forecasters well ahead of the 2014 spring convective season.

NASA LIS Introduction and Real-time Applications module

The overall goal of the LIS training module is to enable collaborating partners to apply real-time output to aid in situational awareness in the areas of drought monitoring and assessing flood potential. Content for this training was developed jointly between SPoRT and the NWS Huntsville WFO. With the addition of a CONUS-scale LIS domain and the transition of LIS output into AWIPS II, there could be numerous potential users in 2014. To provide end-users with a primer on the LIS, the content focuses on a high-level overview of the NASA LIS and real-time simulations, the configuration of LIS static and dynamic forcing data sets, how to view the data in AWIPS II displays, and example applications of LIS from the Huntsville WFO operations examining hydrometeorological processes related to flooding and drought monitoring. Future applications may include the use of LIS output to assess wild fire potential.

Quick Guide training approach and development

To help the operational user during their shift duties, SPoRT has used a "Quick Guide" method for various products. These two-sided, single-sheet references provide an easy way for end-users to be reminded of the important points for a given product. The Quick Guides help a user recall some of the details that they received from other more robust training (e.g., E-learning modules, teletraining, etc.). Several Quick Guides were created in 2013 covering the following topics:

- QPE and LPW,
- VIIRS instrument,
- VIIRS imagery and Day-Night Band (including an RGB version of DNB),
- GOES-R Convective Initiation,
- Several RGB imagery products (air mass, night-time microphysics, and dust),
- Total Lightning, and
- AIRS total ozone and anomaly products.

Micro-lesson on RGB imagery

Training for operational users was created for the night-time microphysics RGB composite applied to diagnosing cloud types, in particular differentiating fog from low clouds. The RGB imagery is shown in the module to assist in determining cloud thickness and temperature in addition to the particle phase and size (Figure 17). This combined information allows one to deduce the cloud type and height for aviation forecast responsibilities. The audio narration is a brief summary of teletraining that had been delivered to end-users prior to product evaluations, and runs approximately 8 minutes in length (hence the "micro-lesson" title). Both MODIS and VIIRS are used to create the night-time microphysics RGB imagery as a proxy to future GOES-R/-S capabilities. The module also discusses the VIIRS instrument DNB sensor that detects reflected moonlight. These types of micro-lessons are application-based and short enough for operational users to complete or reference during a normal shift. SPoRT has taken this training approach with topics such as total lightning, CI, and specific RGB training for high-latitude users. See the SPoRT Training page <http://weather.msfc.nasa.gov/sport/training/> for a complete listing.

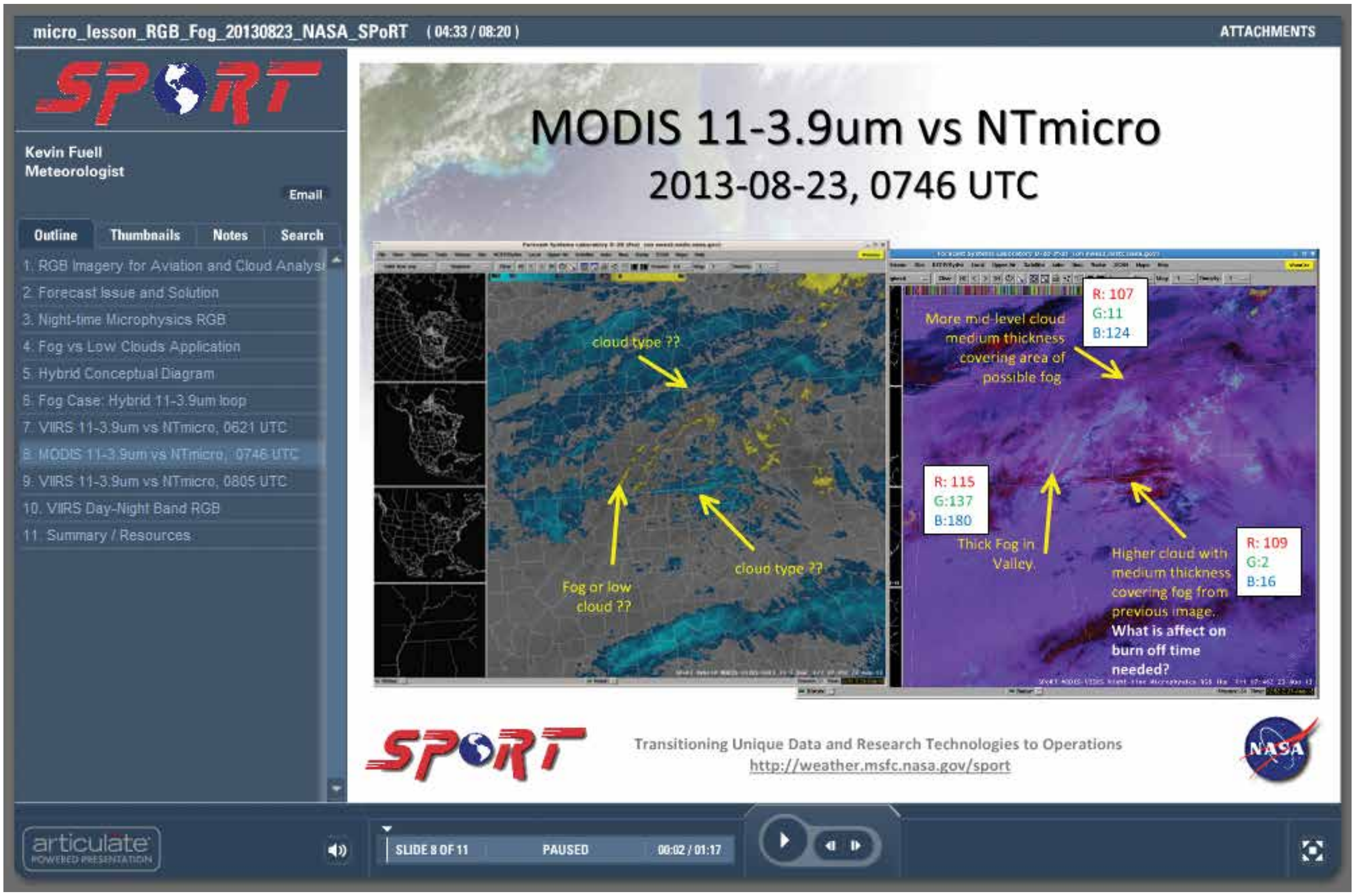


Figure 17. Example of Web-based, self-paced training developed to support transition and assessment of RGB imagery from MODIS and VIIRS. This eight minute "micro-lesson" reviews some specific utilities of the night-time microphysics RGB, the Hybrid LEO/GEO 11-3.9µm product, and the VIIRS Day-Night Band RGB to help improve fog and low cloud analysis for aviation forecast product requirements.

GOES-R CI module

A new recorded training module was produced for the modified GOES-R CI product, in collaboration with the UAH product development team. The 13-minute module describes the new probabilistic version of the product and educates users on the inclusion of the Rapid Refresh model forecast fields and snow identification from National Snow and Ice Data Center to the CI algorithm. The use of software to combine audio and presentation materials allows SPoRT to easily update training as the transition cycle results in improved versions of existing products. This module was quickly developed in early Spring 2013 and subsequently used at this year's HWT EWP, AWC Testbed, and for SPoRT assessments. The module is complemented by a single page, double-sided Quick Guide to be used in the operations area as a brief training summary.

RGB Imagery Training to NHC

As part of its GOES-R PG activities, SPoRT continued to participate with CIRA to provide GOES-R proxy products to NHC. SPoRT has played a key transition role to enable products from both groups to be efficiently delivered and viewable in the N-AWIPS decision support system used at NHC. RGB products from SEVIRI were initially supplied to NHC in 2012 to aid in examining the environment surrounding tropical cyclones and help diagnose potential influences in development or decay. SPoRT staff also attended the 2012 WMO Workshop on RGBs where European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) personnel and other attendees provided insights to RGB applications. In 2013, experts from EUMETSAT's training staff collaborated with SPoRT to develop several tropical cyclone case studies from the 2012 season as well as individual examples from the last decade of SEVIRI operations. Via a GOES-R Visiting Scientist Program award, SPoRT staff traveled to NHC to meet with EUMETSAT staff to deliver in-class training to NHC/TAFB staff regarding the day-time microphysics and convective storms RGB imagery as well as the DNB RGB product suite from VIIRS. Several hours of lecture and discussion were provided over a two-day visit. NHC's use of SEVIRI products from SPoRT over the central and eastern Atlantic offers a valuable training tool for the future capabilities of GOES-R/S.

SPoRT-Led Product Assessments During 2013

As part of the transition from research to operations, SPoRT conducts assessments of new and experimental products. Products to be evaluated by end-users are from within SPoRT projects or collaborations with external partners. First, the product is matched with a user group with a high-priority forecast challenge that can be improved through the transition of this product. Then a specific time period is identified for the assessment corresponding with when the forecast challenge is most active or at its greatest impact. For example, the night-time microphysics RGB imagery has the potential to better differentiate fog from low clouds compared to traditional spectral difference imagery. Fog and low clouds occur most frequently in the Autumn months for inland NWS Southern Region WFOs, and tend to occur later for the coastal WFOs. Therefore, SPoRT conducted two separate assessments with these groups in 2013, in addition to several other product assessments.

As part of the GOES-R PG, the GOES-R QPE was provided to West Coast users in the Spring to assess its value during heavy precipitation events related to atmospheric rivers of moisture originating from the tropics. Alaska users also evaluated the QPE to test its ability to quantify high-latitude, shallow precipitation events that typically occur in late summer. Lastly, the San Juan, PR WFO evaluated QPE because of their limited radar coverage and to test the product in a more convective environment where it was originally intended. In all QPE assessments, the CIRA LPW was included as a complementary product to improve the 3-dimensional atmospheric moisture content analysis.

Other assessments included the evaluation of RGB imagery to detect nocturnal hazards to aviation. Users along the Rocky Mountains Front Range evaluated RGB and DNB imagery from VIIRS in the Summer to analyze smoke from fires as well as fog and blowing dust events. Most of the forecaster recommendations expressed an interest in having these data available more regularly. While more VIIRS instruments are planned in future JPSS satellites, the current lone instrument does demonstrate broad support among the respondents for several of the VIIRS products, such as the two above and the traditional long- and shortwave IR imagery. This in its own right is valuable feedback as it shows how the JPSS PG is supporting the demonstration of future GOES-R products via current operational polar-orbiting satellites. VIIRS also nicely complements the operational capabilities of the older MODIS instruments already supporting the GOES-R PG.

Because of its long period of night in winter, Alaska users also evaluated the night-time RGB imagery for cloud and aviation forecast challenges and compared these to traditional GOES imagery, which tend to have low resolution at this high latitude. Also a part of the GOES-R PG assessment work is the GOES-R CI product. Several NWS Southern Region offices continued their collaborations with SPoRT by testing the newest version of this product which they have had a role in improving through feedback during past assessments (i.e., completing the loop of operations to research).

User feedback during an assessment is captured via an online form using a Likert-type scale that asks for input on the value of a given product in meeting a forecast need. Typically, the scale uses “very small,” “small,” “some,” “large,” and “very large” as choices regarding the perceived impact or value to the end-user. Additional questions ask users to identify how the product was applied compared to legacy methods. User comments can be added to the feedback form and often serve as a start to collaborative interaction and discussions between product developers and end-users.

A summary of the SPoRT-led assessments conducted for numerous satellite products is presented in Table 1. The table provides a high-level summary of the feedback and recommendations acquired during each of the assessment periods. The information gathered during the assessments will be used to continue improving the products if determined necessary. The sub-sections that follow provide additional details and insight into the SPoRT-led assessments for the various products listed in Table 1.

Table 1. SPoRT-led satellite product assessments conducted during 2013. Product abbreviations used in the first column are as follows: QPE = Quantitative Precipitation Estimate; LPW = Layered Precipitable Water; NTmicro = Night-Time microphysics; DNB Rad & Refl = Day-Night Band Radiance and Reflectance.

Product(s)	WFO Partner(s)/Region(s)	Dates	Highlights of feedback and recommendations
GOES-R QPE/ CIRA LPW	Eureka & Monterey, CA Medford, OR	1 Mar – 30 Apr	• **GOES-R QPE**: Inaccurate estimation due to complex terrain. Often underestimated along coast; overestimated in mountainous terrain • **CIRA LPW**: Often used to confirm model data; not much impact in forecast process despite users having high confidence in its accuracy
GOES-R QPE/ CIRA LPW	Fairbanks, Anchorage, and Juneau, AK San Juan, PR (SJU)	15 Jul – 15 Sep	• **GOES-R QPE**: Underestimated precipitation for many events, esp. in SJU; forecasters learned biases and product still had utility • **GOES-R QPE**: Inconsistent performance in Alaska for shallow precipitation systems • **CIRA LPW**: High value and impact according to user feedback. Alaska used it for precipitation forecasts during atmospheric river events and SJU used it to track tropical waves • Recommended the use of a cloud-type product to reduce precipitation in cirrus cloud areas • Recommended an adjustment based on influence of topographic features and wind
RGB Imagery: *NTmicro, Dust, DNB Rad & Refl* **Single Channel**: *11µm, 3.9µm, DNB Rad & Refl*	Boulder, CO Albuquerque, NM Cheyenne, WY Great Falls, MT	1 Jul – Aug 31	• NTmicro and DNB Radiance were favored products • NTmicro RGB had greatest utility for fog and low cloud analysis related to aviation issues • DNB Radiance and RGB were valued for cloud level and fire hot-spot analysis • DNB reflectance usage limited by stray light issues • Recommended coloring to distinguish fires from ground-based sources of light emissions in DNB • Recommended further product development with DNB for smoke detection at night
GOES-R CI probabilistic algorithm	Miami, & Melbourne, FL, Huntsville, AL Corpus Christi, TX Albuquerque, NM	1 Sep – 31 Oct	• Forecasters noticed inconsistent behavior between GOES East and West CI algorithm: Solution is subsequently being worked by developers • User feedback: Newest version of CI product resulted in decreased false alarms, increased probability of detections, and better situational awareness of the convective environment
RGB Imagery: *NTmicro, DNB Rad & Refl, Hybrid POES-GOES, 11-3.9µm imagery*	**NWS SR inland WFOs**: Huntsville, AL, Nashville and Knoxville, TN Raleigh, NC, Great Falls, MT Albuquerque, NM	15 Jul – 31 Oct	• Found improved value to diagnose cloud types compared to traditional single-channel imagery • Two-thirds of users indicated that fog and low clouds could be differentiated by NTmicro RGB • 60% of users had "some" to "large" impact to aviation forecasts even though MODIS and VIIRS swaths were infrequently available • NTmicro RGB was unexpectedly applied to analyzing clouds producing low-level precipitation not indicated by radar reflectivity
RGB Imagery: *NTmicro, DNB Rad & Refl, Hybrid POES-GOES 11-3.9µm imagery*	**AK/WS WR WFOs**: Anchorage, Fairbanks, and Juneau, AK, Medford, OR **NWS SR coastal WFOs**: Miami and Melbourne, FL Mobile, AL, Slidell, LA Corpus Christi and Houston, TX	1 Dec 2013 – 31 Jan 2014	• Most reviews indicated the NTmicro influenced their Aviation (i.e., TAFs) forecast product and over 50% saw "large" to "very large" impact to their operations by examining the imagery • VIIRS DNB RGB had mixed utility for users • Most comments focused on improved cloud height and structure analysis with NTmicro RGB • NTmicro RGB helped distinguish fog from low clouds more than hybrid 11-3.9µm imagery • Users commented on desire for geostationary-based instruments with similar capabilities (MODIS and VIIRS demonstrate future GOES-R products) • Recommended to derive categorical display of clouds/other features from RGB imagery

CIRA LPW/GOES-R QPE: U.S. West Coast

SPoRT's assessment of NESDIS GOES-R QPE and CIRA LPW with its West Coast WFO partners occurred during March and April. These products were assessed by forecasters in the NWS Eureka, Medford, and Monterey WFOs with a focus on atmospheric river events. For the NESDIS QPE product, forecasters examined QPE in 1-, 3-, 6-, and 24-hour accumulation intervals for flood guidance. Based on feedback, the complex terrain led to inaccurate estimations of rainfall and a somewhat predictable, but unquantifiable, orography-induced bias. Precipitation was often underestimated by the NESDIS QPE along the coast and overestimated within the mountainous terrain; however, there was a below-average number of atmospheric river events during the evaluation, thereby limiting conclusions.

For the LPW portion of the assessment, forecasters had high confidence in the accuracy of LPW, and often used LPW either to confirm model initialization of 3-dimensional moisture or to adjust short-term forecasts of precipitation. Ultimately, users indicated that LPW initially had "very small" to "some" impact on their forecasting process; however, new application methods or derived products are likely needed before wider distribution to the operational community. User feedback to product developers at CIRA will influence the next version of the LPW product to be examined in 2014.

CIRA LPW/GOES-R QPE: Alaska and San Juan, PR

A second assessment of the NESDIS GOES-R QPE and CIRA LPW took place from 15 July to 15 September, involving the Alaska Region and the San Juan, PR WFO, with a goal of determining how these experimental products might improve precipitation forecasts in data-sparse and off-shore regions. The forecast offices involved in the assessment contributed to 77 surveys, several emails with specific examples of both products, and four operational examples posted to the Wide World of SPoRT blog.

Forecasters generally indicated for most events that CIRA LPW had a "large" impact on their forecast process in SJU and "some" impact on their forecast process in AK; however, during an atmospheric river event in AK, forecasters said the CIRA LPW had a "large" impact. The NESDIS GOES-R QPE seemed to underestimate precipitation for many events in SJU, although forecasters adjusted to the bias over time and stated that the product still had "some" to "large" utility despite the underestimates. In Alaska, the GOES-R QPE did not exhibit a consistent bias and tended to miss shallow precipitation systems. These errors likely led to Alaska forecasters stating that it provided "small" to "some" utility.

VIIRS Night-time Assessment: Rocky Mountains Front Range

An assessment of the VIIRS night-time products was conducted with SPoRT's Front Range partners from 1 July to 1 September 2013, which included the four WFOs at Albuquerque, NM, Boulder, CO, Cheyenne, WY, and Great Falls, MT. The assessment was primarily in support of the JPSS PG; however, some components can be of use to the GOES-R PG as well, specifically the RGB imagery and high-resolution IR imagery. The assessment focused on night-time application products and was intended for evaluation during the fire-weather season. Since the fire season was not active during the assessment, the goals of the assessment shifted more toward the night-time utility of the evaluated imagery including a combination of four single channel (3.9-µm and 11-µm infrared; VIIRS DNB radiance and reflectance) and four RGB products (dust and night-time microphysics RGBs; RGB composite of both radiance and reflectance of the DNB channel).

The assessment indicated broad support of two particular products; the DNB radiance product (and its RGB variant) and the night-time microphysics RGB composite. The DNB radiance product was most used for its high-resolution detection of fire hot spots, supplementing the traditional 3.9-µm imagery. This high-resolution product was very useful as it gave forecasters a more accurate picture of the eventual burn scar, which can be a crucial piece of information in determining the risk of future flash-flood events due to the lack of vegetation. The radiance product was typically preferred to the reflectance product because the radiance could be used more often. The DNB reflectance is created through a normalization of the DNB radiance by the available moonlight. During July and August when the available moonlight is low (based on moon phase and elevation angle), stray light from the sun falsely provides high values of radiance. Normalizing the large radiance by the small available moonlight results in a large reflectance value and a saturated image with washed-out cloud and ground features.

Besides enabling the detection of hot-spot locations, the DNB radiance product helped qualitatively assess fire growth, and provided some guidance on the presence of cloud cover by inspecting the amount of obscuration of city lights. Assessment respondents recommended that the city lights be denoted by a different color than the fire hot spots. The second product that received wide support was the night-time microphysics RGB. This was by far the most popular product for assessing cloud type and cloud features. Discussions with forecasters, however, indicated that training is required to have the night-time microphysics RGB used more widely in operations, due to the complexity of the images.

GOES-R CI: Southern Region WFOs

The UAH GOES-R CI product was assessed during an intensive evaluation period with five SPoRT-partner WFOs (Miami, Melbourne, Huntsville, Corpus Christi, Albuquerque). The GOES-R CI algorithm was revised this past year to include a more robust statistical method that compares the current cloud growth event to “training” datasets of similar, historical events. Hence, the algorithm output is a probabilistic value of CI. The product was available for both the GOES East and West satellites, offering full CONUS coverage. SPoRT’s role in this transition from researcher (UAH) to end-user (forecaster) ensured timely delivery of the GRIB2 files to HWT EWP participants for use in AWIPS II.

The intensive evaluation period with WFOs occurred from 1 September through 31 October 2013. The offices included in the assessment represented a wide variety of convective environments, especially in the fall season. Information received and disseminated to the developers has been essential in the continued improvement of the CI algorithm. In previous years, this type of direct forecaster feedback has resulted in incremental changes to the algorithm from a binary yes/no to a “Strength of Signal” product, and in 2013 to a fully statistical methodology that produces a probability of CI that is self-calibrating. According to user-feedback, the probabilistic product resulted in decreased false alarms, increased probability of detections, and better situational awareness of the convective environment. Feedback indicated a low bias in CI probability over the GOES-West domain that the developers are working to improve for 2014. Plans are currently underway to have a larger assessment in the spring of 2014, when the convective season is at its peak.

RGB Analysis for Aviation and Clouds

Inland NWS Southern Region WFOs

Nearly all NWS WFOs have the challenge of providing forecasts for local airport locations. A significant problem for aviation forecasting is the diagnosis of low clouds and fog that cause ceilings and low visibility. As part of the GOES-R and JPSS PGs, SPoRT conducted an evaluation of several RGB products for select inland NWS Southern Region WFOs from 15 September to 31 October. During this period, inland WFOs in the southeastern U.S. tend to have a higher occurrence of ceiling and visibility restrictions due to fog and/or low clouds. The Huntsville, Nashville, Morristown/Knoxville, and Raleigh WFOs participated as well as two WFOs on the Front Range: Albuquerque and Great Falls. The products examined were the MODIS and VIIRS night-time microphysics and VIIRS DNB RGB imagery. These were compared to traditional 11-3.9 µm difference imagery in the POES-GOES hybrid product.

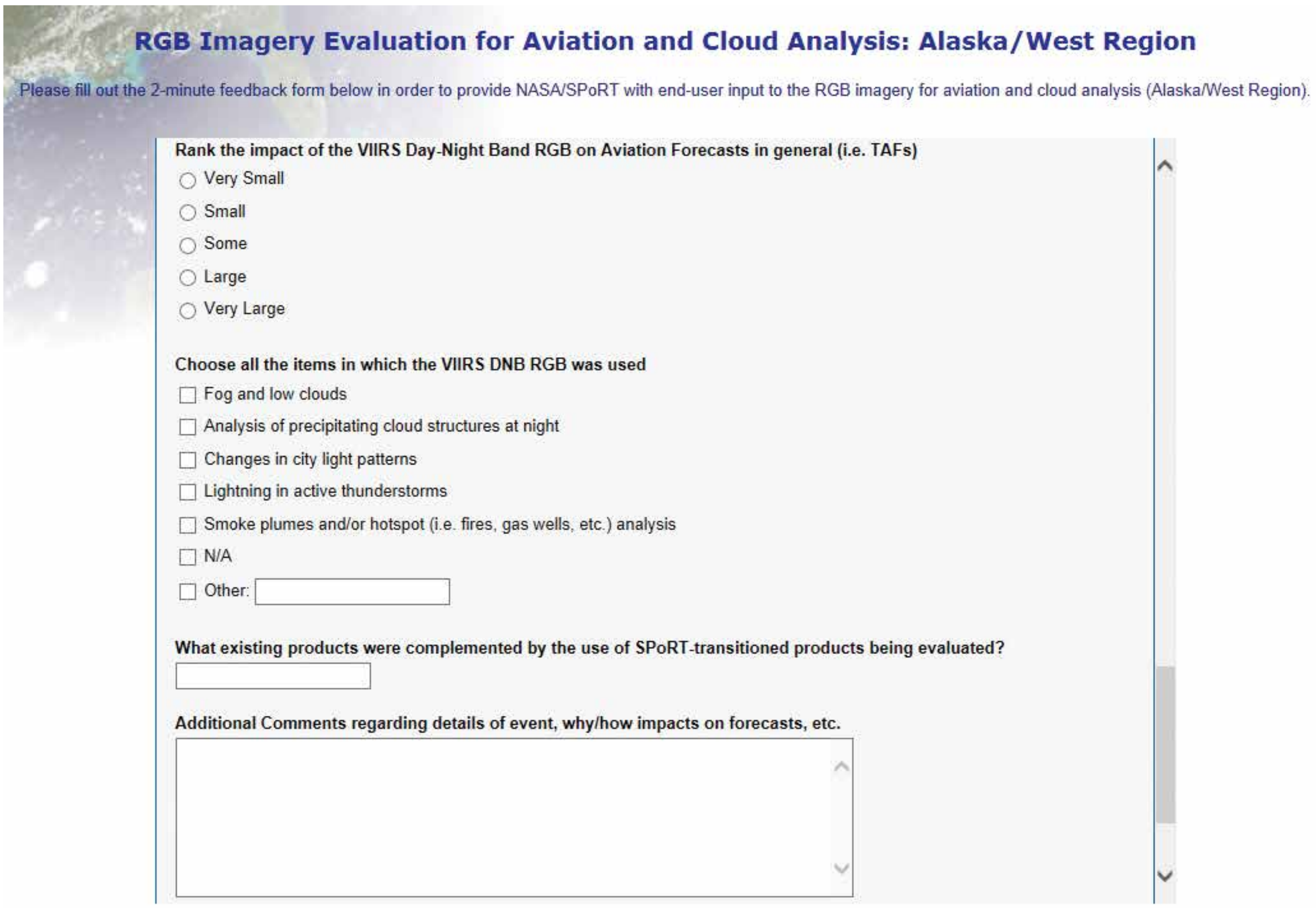
Nearly 50 official feedback submissions were received, with approximately two-thirds of users ranking the night-time microphysics as having “some” to “very large” impact to aid in differentiating fog from other cloud types. Forecasters only had swath imagery from MODIS and VIIRS for these RGB products, yet 60% indicated there was “some” to “large” impact to aviation forecasts by having these data available. The Great Falls and Albuquerque WFOs found a new application of the night-time microphysics RGB by diagnosing shallow precipitation systems occurring far away from radar sites and below the lowest radar scan. By engaging users during the evaluation, SPoRT was able to create solutions to reduce the latency of product delivery, assist users with RGB color interpretation, and explore details of color change due to microphysical particle size.

NWS Southern Region Coastal

In early winter, the frequency of low clouds and fog peak for coastal WFOs in the NWS Southern Region. So beginning in December, SPoRT began its assessment of RGB imagery (in particular the night-time microphysics RGB) for aviation forecasting with NWS Southern Region coastal WFOs using the same methodology described above for inland WFOs. Preliminary feedback indicated added value by applying the night-time microphysics RGB to more easily diagnose cloud heights and types compared to single-channel imagery. Limited passes from polar-orbiting satellites in the southern CONUS, however, reduced the overall value of the product and limited the opportunities for the forecaster to become familiar with this new type of satellite imagery.

Alaska and Northwestern CONUS WFOs

High-latitude partners in the northwestern CONUS and Alaska (Medford, OR; Anchorage, Fairbanks, and Juneau, AK) also expressed interest in these products to help differentiate fog from low clouds. These WFOs were thus added to the Southern Region Coastal assessment that began in December. In addition to the benefit of higher resolution over the stretched GOES foot print, more frequent night-time passes of polar-orbiting satellites allow these RGB products to have a greater potential impact at high-latitude locations. SPoRT conducted teletraining for both groups prior to the start of the assessment and created specific high-latitude versions of the asynchronous training module and Quick Guides for the RGB imagery in this assessment. A portion of the feedback form for Alaska and the Western Region participants is shown in Figure 18. Preliminary user assessments of the RGB imagery from MODIS and VIIRS indicate that these products helped to delineate high- and low-cloud features and at times can differentiate fog from low clouds, especially in coastal areas. However, at temperatures of -20°C or less, the night-time microphysics RGB is less effective due to noise in the shortwave IR channel at these temperatures; hence, an alternative RGB product will need to be explored to meet this aviation forecast challenge at very cold temperatures.



RGB Imagery Evaluation for Aviation and Cloud Analysis: Alaska/West Region

Please fill out the 2-minute feedback form below in order to provide NASA/SPoRT with end-user input to the RGB imagery for aviation and cloud analysis (Alaska/West Region).

Rank the impact of the VIIRS Day-Night Band RGB on Aviation Forecasts in general (i.e. TAFs)

- Very Small
- Small
- Some
- Large
- Very Large

Choose all the items in which the VIIRS DNB RGB was used

- Fog and low clouds
- Analysis of precipitating cloud structures at night
- Changes in city light patterns
- Lightning in active thunderstorms
- Smoke plumes and/or hotspot (i.e. fires, gas wells, etc.) analysis
- N/A
- Other:

What existing products were complemented by the use of SPoRT-transitioned products being evaluated?

Additional Comments regarding details of event, why/how impacts on forecasts, etc.

Figure 18. Portion of online form used by Alaska and Western Region forecasters to submit feedback during assessment of night-time RGB imagery from MODIS and VIIRS. Multiple choice and Likert-type scale questions are used to obtain input regarding product value and application. Some open space is provided for users to provide additional details regarding their operational experience with the product.

External Assessments Facilitated by SPoRT During 2013

In addition to leading several assessments of SPoRT core and various Proving Ground products, the SPoRT team participated in other external evaluations. The most well-known are the Spring EWP hosted by the HWT in Norman, OK and the Summer Experiment hosted by AWC in Kansas City, MO. The HWT EWP seeks to place new products/technologies in front of NWS forecasters for intensive evaluation in a real-time environment that is isolated from the public. The AWC Summer Experiment is designed to enhance AWC forecasting operations and capabilities by exposing forecasters to new data sets, tools, displays, and potential product evolution. This is done by bringing together AWC forecasters with external collaborators including NCEP centers, the FAA, academia, private industry, and product developers. In each Experiment, the warning environment occurs in real-time, yet all warnings that are issued remain internal to the testbed environment. In this way, the products being highlighted can be learned, utilized, and evaluated prior to full operational implementation.

SPoRT has primarily contributed to these and other external assessments with subject matter experts, training materials, and providing various satellite products (e.g., RGB imagery, POES-GOES hybrids, etc.), total lightning, and AIRS derived products. AWIPS II visualization plug-ins and tools were provided by SPoRT to aid other GOES-R PG partners, such as UAH with the GOES-R CI, to transition their products for assessment by both HWT attendees and WFO forecasters. SPoRT also provided the capability to display various GOES-R and JPSS PG products within N-AWIPS for use at National Centers. The PGLM Flash Density and GOES-R CI products were transitioned for use by AWC forecasters during the Summer Experiment, and a suite of RGB imagery products from the MSG SEVIRI instrument were provided to NHC for the GOES-R Tropical PG demonstration conducted by CIRA. Lastly, SPoRT provided VIIRS DNB imagery in N-AWIPS format to NHC over the western Atlantic to aid in tropical cyclone analysis. Table 2 highlights the assessments in which SPoRT was involved that were led by external collaborators.

Table 2. SPoRT-supported product assessments during 2013 led by external collaborators.

Product(s)	Assessment Lead/Users	Dates	Highlights of feedback and recommendations
PGLM Flash Density, Total Lightning Tracking Tool, GOES-R CI	**Lead**: HWT EWP **Users**: Forecasters attending HWT Spring Experiment	1 May – 30 Jun	• PGLM and lightning jumps provided insight to storm development and potential severe weather • Total Lightning Tracking Tool was conceptually well received but several adjustments were recommended to improve real-time functionality • 84% of forecasters noted the probability of the cloud objects increased in regions of observed CI; 52% stated product would add “some” or “large” value to their operations; primary criticism involved how product was displayed, i.e., “confetti nature” of display
PGLM Flash Density Mosaic, GOES-R CI	**Lead**: AWC **Users**: AWC Forecasters at “Summer Experiment”	1 – 31 Aug	• PGLM found useful to identify strengthening convection; can be used to improve convective SIGMETs, adjust flight tracks, and will be vital to identify convection in data sparse regions • GOES-R CI provided increased confidence in areas of developing/decreasing convection; display was noted to be noisy due to using larger regional to CONUS domains
CIRA GOES Sounder: Air Mass RGB **SEVIRI RGB Imagery**: *Air Mass, Dust, Natural Color, Day Microphysics, Convective Storms* *VIIRS DNB*	**Lead**: CIRA **Users**: NHC Forecasters at TAFB and Hurricane Specialist Unit	1 Aug – 31 Oct	• CIRA GOES Sounder Air Mass RGB imagery provided added value in assisting the analysis of cyclones transitioning from tropical to extratropical, but color range was noted to be small • Users became comfortable with the Air Mass, Dust, and Natural Color RGBs to diagnose environment surrounding tropical cyclones; these added value to forecasting change in cyclone intensity based on environmental interactions/influence • Recommended further experience and training cases to diagnose cyclone via Day Microphysics and Convective Storms RGBs * Cloud structure analysis at night improved via application of VIIRS DNB, but was limited by data coverage and frequency

5

Disaster Response

Tornado near Enid, Oklahoma.

(Image copyright Kevin M. McGrath, mcgrathimages.com. Used with permission.)

NASA Applied Sciences: Disasters Feasibility Study

Following the severe weather outbreak of 27 April 2011, SPoRT analyzed a variety of satellite data sets to support partnering NWS WFO colleagues in response to the storms. SPoRT provided single channel, red-visible wavelength reflectance data and short-term changes in reflectance as a product useful for identifying damage scars oriented from southwest to northeast along tornado damage tracks. Similarly, true color imagery following the event helped to identify tracks of the most significant tornadoes. In addition to MODIS imagery, SPoRT acquired higher spatial resolution (15 m) Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery and produced false color composites that were useful in identifying the damage tracks, including minor adjustments to the ground surveys performed by the NWS WFOs in Huntsville, AL and Birmingham, AL.

These activities were timely, as the NASA ROSES solicitations in late 2011 were looking for Applied Sciences projects focused on the use of NASA and other data sets in support of disaster mitigation, assessment, and response. SPoRT submitted a proposal entitled “Enhancement of the NWS Storm Damage Assessment Toolkit (DAT) with Earth Remote Sensing Data,” which was selected as a one-year feasibility study with a goal of incorporating NASA, NOAA, and commercial satellite data products within the NOAA/NWS DAT. The DAT is an application designed for handheld smartphones and tablets, which allows storm survey meteorologists to acquire photos of damage, estimate damage intensity, and use the aggregated observations to define the tornado track and assign the maximum damage category. The feasibility study focused on case study analyses of the 27 April 2011 tornadoes and other high-impact events that occurred in 2011, 2012, and 2013 as a means of quantifying our ability to detect tornadoes of varying intensity among the satellite products available, and to develop a prototype methodology and interface for the inclusion of imagery within the DAT.

During the feasibility study phase, a variety of satellite image datasets were successfully integrated within the DAT, in collaboration with in-kind support from NOAA/NWS programmers responsible for developing a satellite access interface. This data integration was made possible through the establishment of a WMS (as described in Section 3), which allows for rapid tiling and dissemination of data on demand while preserving the highest resolution imagery. The feasibility study also supported two NASA summer interns and a graduate student at the University of Alabama in Huntsville. Summer intern Rachel Dryden extended the application of satellite data to severe weather events by examining vegetation damage resulting from a significant, widespread hail event. Her results corroborated earlier findings in a similar event analyzed by Molthan et al. (2013). Summer intern Tony Cole subjectively identified tornado damage tracks across Alabama that were visible in MODIS and ASTER imagery, and that work was extended by graduate student Jordan Bell to include Landsat-7 observations. The team concluded that the majority of strong to violent tornadoes (Enhanced Fujita (EF) scale EF-2 or greater) can be detected by ASTER, Landsat-7, and/or MODIS, and that detectability improves with increases in spatial resolution (Bell et al. 2014, submitted).

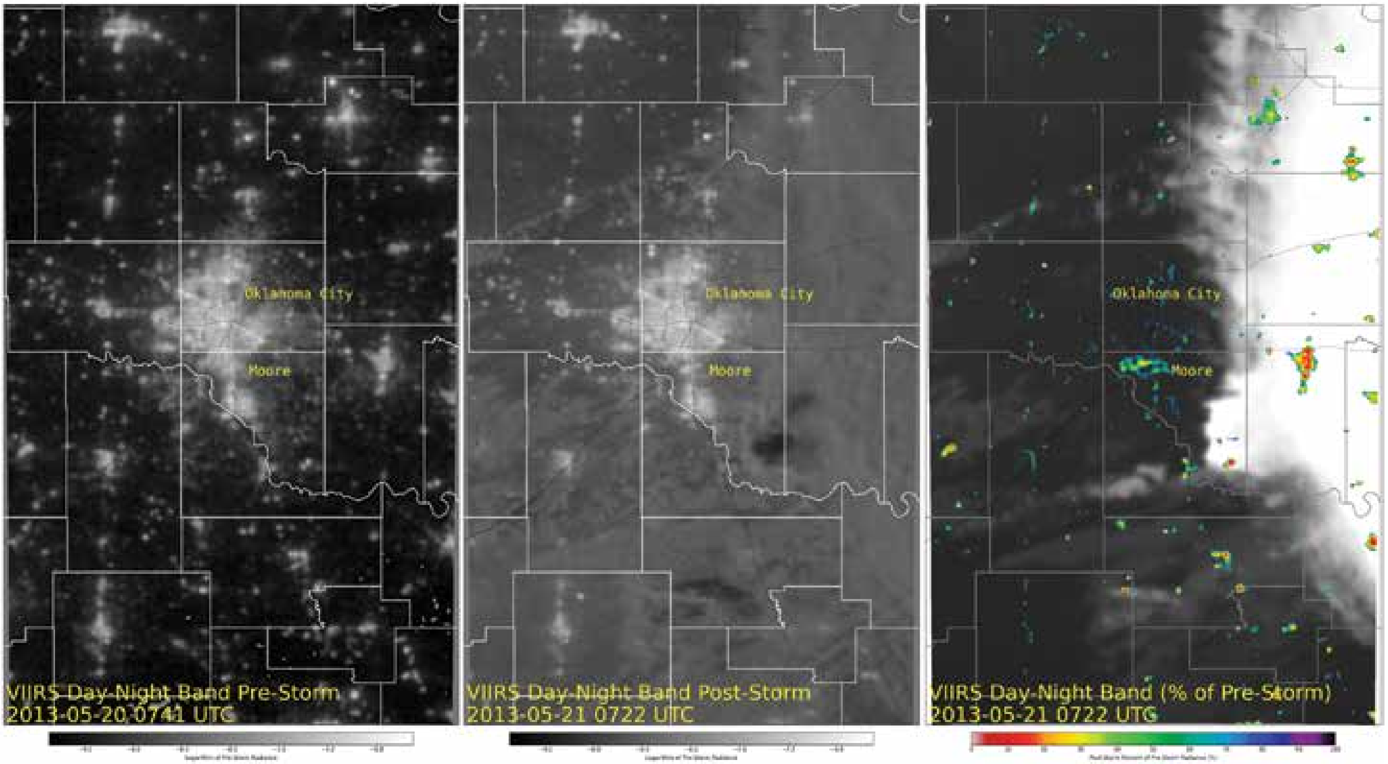


Figure 19. Examples of VIIRS DNB imagery over Moore and Oklahoma City, OK prior to the severe weather event (left), immediately following the event (center), and a percentage of normal estimate based upon a difference between the two (right). In the right panel, the outage area over cloud-free Moore is apparent, while other decreases are noted in cloudy areas across Oklahoma. Grayscale infrared cloud-top temperatures identify the clouds associated with the departing mesoscale convective system.

Response to Significant Events

SPoRT provided support to NWS colleagues and the NASA Applied Sciences Program for several high-impact disaster events in 2013. Following the Moore, OK EF-5 tornado on 20 May 2013, a VIIRS DNB "black-out" product (e.g., Molthan and Jedlovec 2013) was applied by differencing pre- and post-storm imagery that immediately identified power outages associated with the tornado that tracked across the Moore community (Figure 19). A variety of techniques continue to be explored to facilitate the creation of a DNB baseline composites in addition to time-series analyses of city lights or other, more statistically robust differencing techniques and cloud clearing useful in confirming power outage areas.

Following use of the VIIRS DNB, an analysis of several other satellite data sets was conducted to evaluate their utility in identifying the damage area, and the usefulness of the data in monitoring longer-term recovery. The SPoRT Disasters team acquired imagery from ASTER to provide a 15-m false color depiction of the damage scar and partnered with the SERVIR Project at MSFC to acquire data from the International Space Station (ISS) SERVIR Environmental Research and Visualization System (ISERV), which provides true color imagery at approximately 5-m resolution over requested areas. The team tested dissemination of these data sets within the DAT as a precursor to future near real-time applications.

Disaster applications also included analysis of areas affected by Super Typhoon Haiyan that impacted the Philippines in November 2013. Continuing the use of the DNB, the SPoRT Disasters Team produced a change in light product that highlighted the areas of extensive damage and loss of infrastructure, such as the Tacloban City area and other cities along the track of Haiyan as it continued to the northwest (Figure 20). Finally, the SPoRT Disasters team analyzed high spatial resolution commercial imagery from the DigitalGlobe Worldview, a panchromatic sensor at approximately half-meter resolution that identified damage to structures from the Washington, IL EF-4 tornado, as well as visible "swirls" or scars in fallow fields where dirt was disrupted by the tornadic circulation (Figure 21). These early results have been demonstrated as applications of data within the DAT to further support feasibility study activities. Early interactions with and feedback from NWS colleagues in a variety of partner WFOs have encouraged the team to continue their work toward new products that will help to objectively determine hail or tornado damage areas via satellite products. The SPoRT Disasters team submitted a proposal for a follow-on NASA/ROSES Disasters: Feasibility to Decisions award in late 2013, supporting a three-year series of activities and continued DAT integration beginning in early 2014.

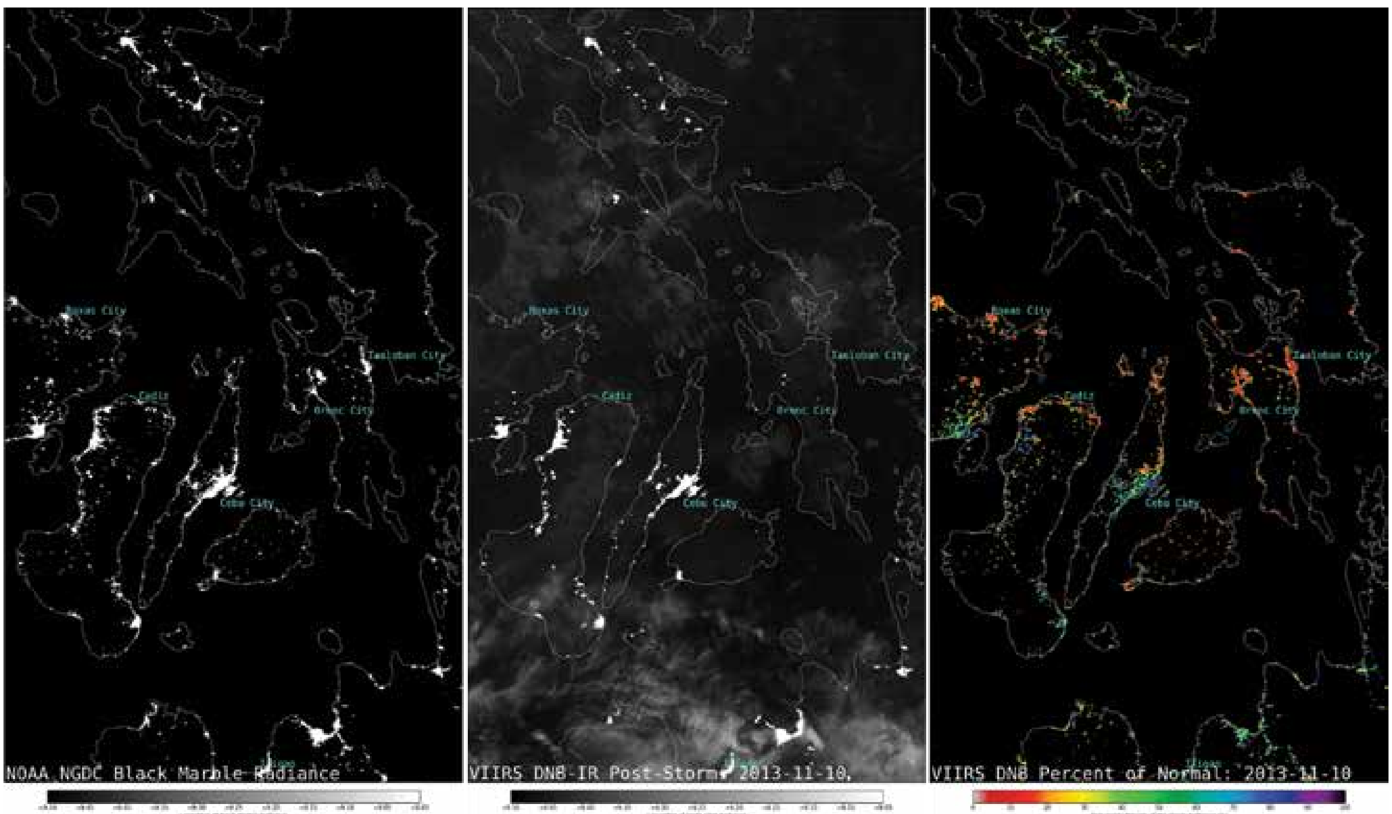


Figure 20. Decreases in light across the Philippines following Super Typhoon Haiyan. (left) Typical DNB radiance as shown in the NASA/NOAA VIIRS "Black Marble" composite, averaged over select days of cloud-free data in 2012. (center) Combination of VIIRS DNB imagery following the storm, along with infrared imagery used to identify cloud cover. (right) Differencing of the post-storm and Black Marble composite, identifying numerous power outages following the storm.

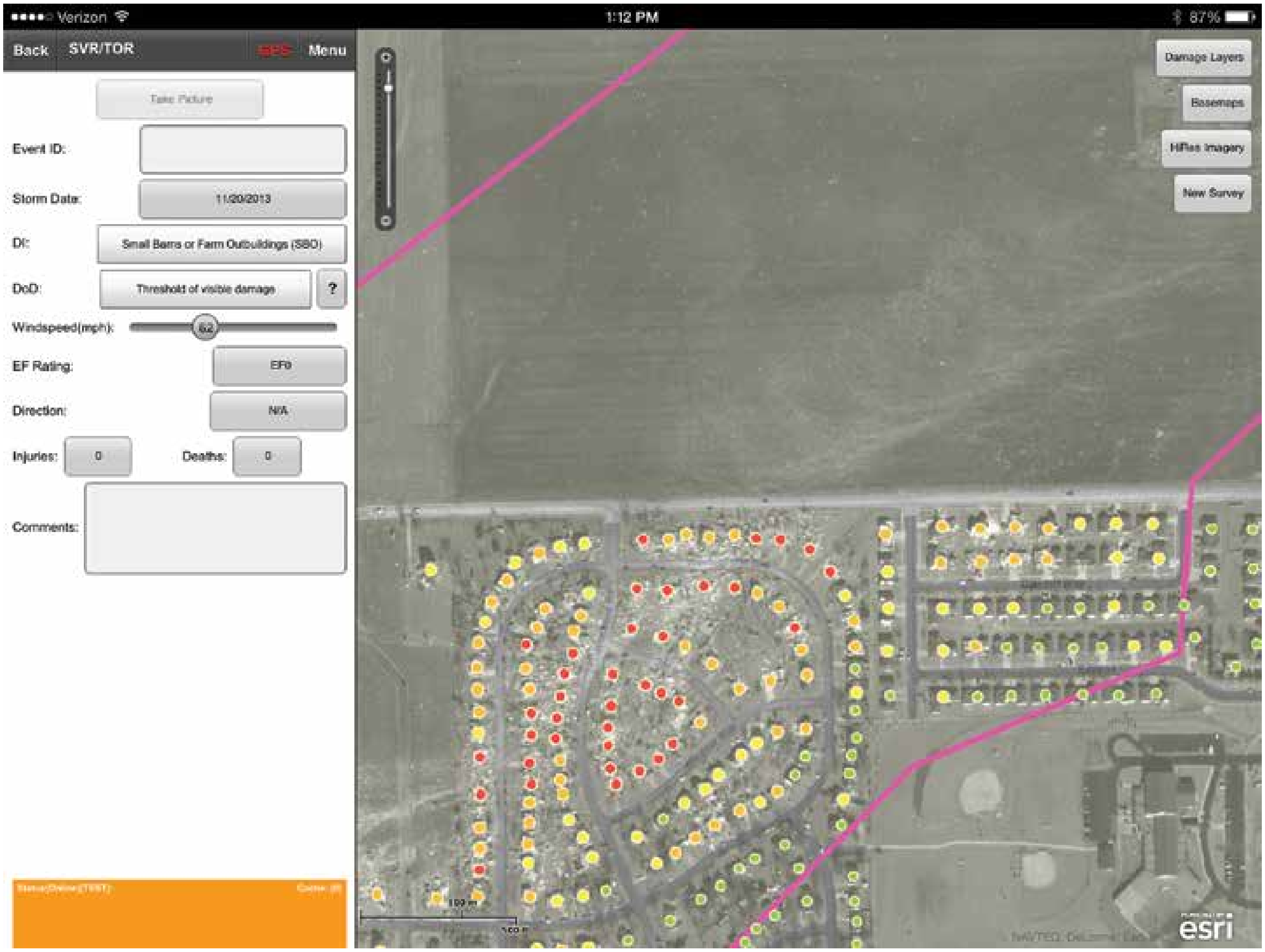


Figure 21. Example of high-resolution imagery and analysis incorporated within the DAT. Imagery is provided by the DigitalGlobe Worldview panchromatic band at approximately 0.5-m spatial resolution, zoomed out to show a neighborhood in Washington, IL that was damaged by the EF-4 tornado. Subjective damage assessment performed by the imagery is shown as a color code ranging from no visible damage (green) to light (yellow), moderate (orange), and severe damage (red). Swirl-shaped scars in the adjacent field were produced by the tornado circulation.

6

Information Technology Developments

Launch of GPM satellite at Tanegashima Space Center.

(Image Credit: NASA/Bill Ingalls)

SPoRT Video Wall as a Scientific Analysis and Collaboration Tool

A new Visualization and Collaboration Laboratory (VCL) was created during the last year to enhance ongoing scientific analysis at SPoRT, and expand collaborations. The 750 square-foot VCL is conveniently located adjacent to the team's office space and includes a 14' × 6' video wall, video conferencing capability, comfortable seating for casual discussions, or reconfiguration options for conference room, workshop, or seminar seating. The video wall consists of a 3 × 4 array of 1920 × 1080 pixel thin bezel high-definition video monitors physically integrated into the 14' × 6' display. The display is powered by a single Alienware Aurora gaming computer with a second-generation Intel Core 4.1-GHz processor, 32-GB memory, and an AMD Fire Pro W600 video card with six mini display port connections. Mini display-to-dual DVI cables are used to connect the computer directly to the 12 individual video monitors.

The open-source Scalable Adaptive Graphics Environment (SAGE; Renambot et al. 2004) windowing and media control software is used to provide an interactive, multi-tasking user interface to the video wall for the display of high-resolution satellite imagery, videos, graphics, and text files. SAGE was developed by the Electronic Visualization Lab (EVL) of the University of Illinois at Chicago as part of the National Science Foundation-funded OptiPuter Project. The EVL has turned over the day-to-day support of user community to Vadiza <http://www.vadiza.com>. Vadiza provides software, services and technical support for SAGE users around the world. The National Science Foundation has renewed the funding for EVL to focus exclusively on leading-edge innovations that use virtual reality and Big Data techniques. The site <https://groups.google.com/forum/#!forum/sagecommons> is an active google forum dedicated to the SAGE community looking to share ideas and ask questions.

The content stored on the host computer (i.e., SAGE server) and manipulation of the various display windows is under the control of any user running SAGE PC, Mac, or Linux compatible client "pointer" software. This allows multiple users to open, position, and resize numerous display windows containing scientific data and graphics files simultaneously from wired or wireless network connections anywhere in the VCL. Clients can also share their individual "desktops" with the host computer using TightVNC and SAGE desktop software displaying content as a window on the video wall (Figure 22).

External video conferencing capabilities are enabled on a standard desktop computer using two Sony EVI-HD7V cameras strategically positioned in the VCL. The output from the video conferencing computer is fed to the SAGE server via a direct video feed between a Black Magic video capture card in the video conferencing and SAGE server computers. Video card software is used to route video output to the SAGE software for display as a window on the video wall.

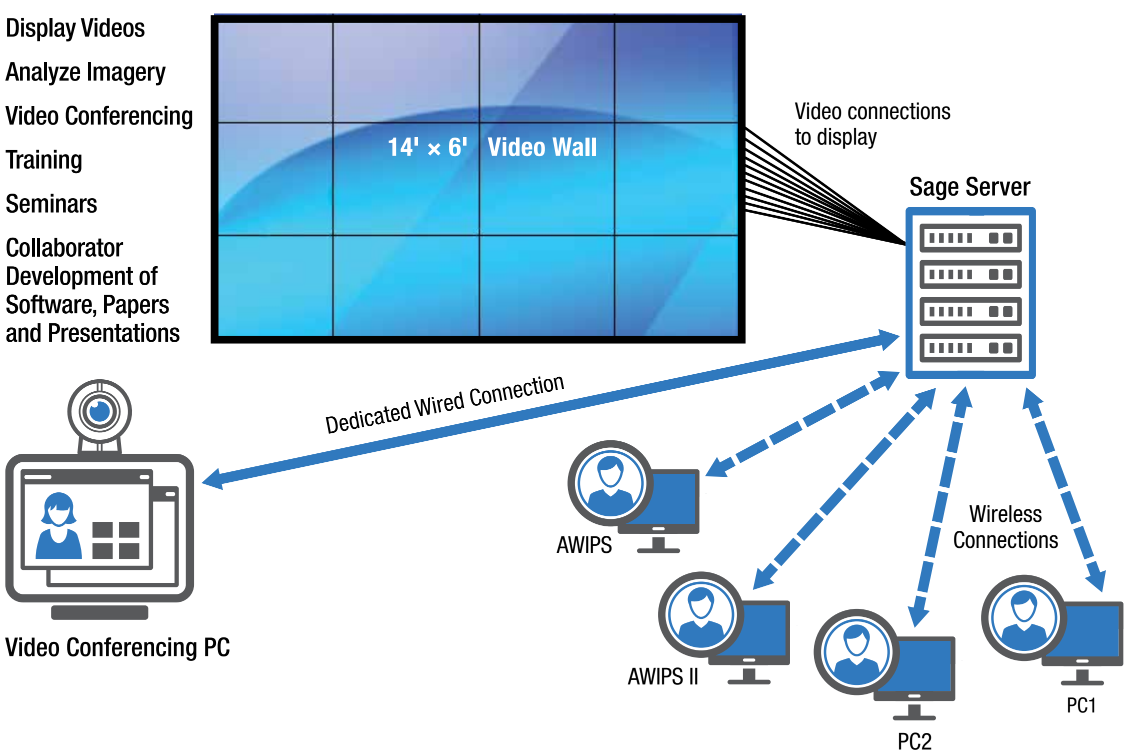


Figure 22. Conceptual diagram of the SAGE video wall interaction with multiple users for group viewing.

The Vidyo™ software developed for government applications (Vidyo 2014) works seamlessly to connect with anyone, anywhere using equipment they already have. The Vidyo™ Portal provides a secure Web-based environment which enables users to manage their contacts and room settings to connect easily with remote collaborators for face-to-face communication with the click of a mouse button. Remote users can join a meeting by downloading VidyoDesktop™ client software (Vidyo.com 2013). The client makes it easy for people to join the meeting room from anywhere using their own devices, over wired or wireless networks. A client application for mobile devices can be downloaded from the App store and Google Play.

Examples of Video Wall Usage

The video wall is in regular use by the SPoRT team for seminars, internal and external training, virtual workshops, collaborative partner meetings, collaborative software development, and scientific data analysis. The flexible furniture arrangement of the room allows seminar seating for over 30 attendees, on-sight training for up to 18 participants, and conference room seating for up to 16 individuals. SPoRT hosted the second EPDT workshop and the GOES-R PG Satellite Liaison technical interchange meeting during Fall 2013 in the VCL. The fourth SPoRT Collaborators Workshop will be held virtually in February 2014 using the video conferencing capabilities of the VCL. External attendees will have remote video conferencing connections via Web-cams and using Vidyo™ software to transmit and receive audio and video displays of other participants and those participating in the SPoRT VCL. The VCL Vidyo™ display is hosted as a window on the SAGE video wall (Figure 23).

In this way, a more productive exchange of technical information, including interactive feedback and discussion, will facilitate better learning for all participants.

The video wall is also used daily as a visual media for SPoRT group meetings. The video wall facilitates visual sharing of science updates and serves as a common development/projection location for sharing of meeting notes and actions. It is also extensively used for collaborative software, presentation, and proposal development, the analysis of high-resolution scientific data for product development, and in support of disaster applications (Figure 23). For example, the large screen display enables the SPoRT Disaster Response team to validate storm radar signatures with actual damage characteristics based on before and after satellite imagery, and facilitates collaborative discussion (both internally and externally) of improvements to disaster response. SPoRT ingests and processes many very large and high-resolution data sets for product generation on small-monitor workstations, typically with a 1920 × 1080 resolution graphics card (or about 2 × 107 pixels) on a 24" or 27" monitor. The analysis of large-image data (often containing greater than 109 pixels) by an individual scientist is limited in this typical workstation configuration. The video wall enables these products to be easily displayed in a collaborative environment for a more thorough analysis. The video wall can display natively 2 × 108 pixels and the SAGE software allows for roam and zoom capabilities to display any portion of the data set quickly to a large group. This capability is especially important when the timely analysis of high-resolution satellite data is needed to support product development, evaluation, and disaster applications.

Figure 23. SPoRT-VCL video wall demonstrating the Vidyo™ conferencing capability in conjunction with displaying a high-resolution satellite image of damage from the 20 May 2013 Moore, OK EF-5 tornado.

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Appendix A. SPoRT Work Groups and Participating Team Members

The members of each SPoRT Work Group are listed in Table A1 below. In many instances, the same representative appears in more than one Work Group to foster cross-collaboration between groups.

Table A1. List of SPoRT Work Groups and participating team members in each group.

Work Group	Participating Team Members
SPoRT Leadership Team	**Dr. Gary Jedlovec (NASA MSFC, SPoRT PI), lead** Mr. Kevin Fuell (UAH) Dr. Andrew Molthan (NASA MSFC) Mr. Matt Smith (UAH) Dr. Geoffrey Stano (ENSCO, Inc.) Mr. Bradley Zavodsky (NASA MSFC) Mr. Jason Burks (NASA MSFC)
Modeling and Data Assimilation	**Mr. Bradley Zavodsky (NASA MSFC), lead** Dr. Emily Berndt (NASA Post-doctoral scientist) Dr. Clay Blankenship (USRA), Mr. Jonathan Case (ENSCO, Inc.) Mr. Nicholas Elmer (SPoRT/UAH graduate student) Dr. Aaron Naeger (UAH) Ms. Jayanthi Srikishen (USRA)
Product Development/Maintenance	**Dr. Geoffrey Stano (ENSCO, Inc.), lead** Dr. Bob Atkinson (USRA) Dr. Emily Berndt (NASA Post-doctoral scientist) Mr. Kevin Fuell (UAH) Mr. Frank LaFontaine (Raytheon) Ms. Anita LeRoy (UAH) Mr. Kevin McGrath (Jacobs) Dr. Andrew Molthan (NASA MSFC) Dr. Aaron Naeger (UAH) Mr. Matt Smith (UAH) Mr. Kristopher White (NWS HUN/NASA MSFC)
Decision Support Systems	**Mr. Matt Smith (UAH), lead** Mr. Jason Burks (NASA MSFC) Mr. Kevin McGrath (Jacobs)
Transition, Training, and Assessments	**Mr. Kevin Fuell (UAH), lead** Mr. Jonathan Case (ENSCO, Inc.) Mr. Frank LaFontaine (Raytheon) Ms. Anita LeRoy (UAH) Ms. Lori Schultz (UAH) Mr. Matt Smith (UAH) Dr. Geoffrey Stano (ENSCO, Inc.) Mr. Kristopher White (NWS HUN/NASA MSFC)
Disaster Response	**Dr. Andrew Molthan (NASA MSFC), lead** Mr. Jordan Bell (SPoRT/UAH graduate student) Mr. Jason Burks (NASA MSFC) Mr. Kevin McGrath (Jacobs) Ms. Lori Schultz (UAH)
Information Technology	**Mr. Kevin McGrath (Jacobs), lead** Mr. David Cross (NSSTC IT Support) Ms. Rita Edwards (NSSTC IT Support) Ms. Jayanthi Srikishen (USRA) Mr. Bradley Zavodsky (NASA MSFC)

Appendix B. Complete List of SPoRT Products

SPoRT continues to maintain its core suite of MODIS satellite products and model initialization fields for use by its operational end-users. The product list has grown substantially this past year with the inclusion of additional products from Suomi-NPP. Table B1 summarizes the suite of SPoRT products, details on the products, and the forecast challenge(s) that each product helps to address.

Table B1. SPoRT product suite provided to end-users.

Instrument/Product	Forecast Challenge (Domains)
MODIS (Terra and Aqua)	**(CONUS, Alaska)**
Imagery (visible, 3.9, 6.7, 11 µm)	Improved situational awareness
Suite of RGB products (true, false color snow, air mass, night & day-time microphysics, dust)	Cloud structure, visibility obstructions, snow-cover extent, atmospheric structure
Fog/low cloud (11-3.9 µm)	Improved situational awareness
NDVI/Green Vegetation Fraction (GVF)	Improved NWP model initialization and forecasts
AIRS (Aqua)	**(CONUS)**
Carbon monoxide, ozone imagery and anomaly	Fires, air quality, storm dynamics, stratospheric intrusions
Total Lightning Data (ground-based)	**(North AL, DC, Central FL, OK, West TX, CO, Langmuir)**
Source/flash density	Severe weather, ltg safety, impact-based decision support
Combined Instrument Products	**(Northern Hemisphere – Atlantic & Pacific basins)**
Multi-sensor SST/Great Lakes LST/ice mask composite	Coastal processes, lake-effect precipitation; Improved NWP model initialization and forecasts
CIRA Blended TPW/Layered PW	Moisture mapping, atmospheric rivers, precipitation
HMS/FIRMS fire/burn area	Smoke, reduced visibility, localized flooding
GOES	**(CONUS, Alaska)**
Sounder air mass RGB	Storm dynamics, improved situational awareness
GOES-R Proxy Products	**(CONUS, Alaska)**
Pseudo GLM product suite	Severe weather, lightning safety, impact-based decision support **(total lightning nests)**
POES-GOES hybrid imagery (visible, 3.9, 6.7, 11 µm)	Improved situational awareness **(CONUS, Alaska)**
POES-GOES Hybrid RGB suite	Improved situational awareness **(CONUS, Alaska)**
NESDIS Quantitative Precipitation Estimates	Precipitation mapping **(CONUS, Alaska)**
GOES-R Convective Initiation (CI) algorithm	CI, precipitation mapping **(GOES-East & West)**
JPSS Proxy Products (Suomi-NPP)	**(CONUS, Alaska)**
VIIRS imagery (visible, 3.9, 11 µm)	Improved situational awareness
Suite of VIIRS RGB products (true color, air mass (w/CrIS), night & day-time microphysics, dust)	Cloud structure, visibility obstructions, storm dynamics
VIIRS DNB (low light) – radiance, reflectance, RGB	Improved situational awareness
SEVIRI	**(Atlantic basin)**
RGB products (air mass, dust, Saharan Air Layer)	Tropical storm forecasting, storm dynamics
Passive Microwave	**(Atlantic & Pacific basins)**
TMI 37(V/H), 85(V/H), composite	Precipitation monitoring, storm dynamics
SSMI/S 37(V/H), 85(V/H), 91(V)	Precipitation monitoring, storm dynamics
SSMI/S RGBs – 37/85, 37PCT	Precipitation monitoring, storm dynamics
AMSR-2 18/37/89, 37PCT	Precipitation monitoring, storm dynamics
Miscellaneous	**(CONUS and global)**
Land Information System (LIS) – soil moisture	drought/flood monitoring; Improved NWP model initialization and forecasts **(SE CONUS/CONUS)**
WindSat – Ocean Surface Wind Vectors (OSWV)	Improved situational awareness over oceans **(global)**

Appendix C. Product Suites at SPoRT Collaborating Partners

The tables below summarize the SPoRT product suites that are developed and disseminated to the collaborating entities listed. The information pertains to the collaborating product development partners (Table C1), National Center evaluation partners (Table C2), and NWS Regional Headquarters (Table C3), according to the map given in Figure 1.

Table C1. List of Product Development Partners and the suite of products provided to SPoRT.

Product Development Partner	Product Suite Provided
NOAA/NESDIS – National Environmental Satellite, Data, and Information Service	GOES data, Meteosat SEVIRI NESDIS QPE, Snowfall rate
NRL – Naval Research Laboratory	Passive microwave, WindSat
UAF/GINA – University of Alaska - Fairbanks/Geographic Information Network of Alaska	MODIS and VIIRS data
UW/CIMSS – University of Wisconsin – Madison/Cooperative Institute for Meteorological Satellite Studies	MODIS and VIIRS data
UW/CIMSS – University of Wisconsin - Madison/Cooperative Institute for Meteorological Satellite Studies	MODIS data, VIIRS data

Table C2. List of National Center Evaluation Partners and the suite of products obtained from SPoRT.

National Center Evaluation Partner	Product Suite Obtained
AWC – Aviation Weather Center	GOES-R CI, PGLM
HWT/SPC/NSSL – Hazardous Weather Testbed/Storm Prediction Center/National Severe Storms Laboratory	GOES Sounder air mass, GOES-R CI, PGLM, WRF Lightning Forecast Algorithm
NHC – National Hurricane Center	Passive Microwave, RGBs
OPC/WPC/SAB – Ocean Prediction Center, Hydro-meteorological Prediction Center, Satellite Analysis Branch	AIRS Ozone, MODIS, Passive Microwave, RGBs, VIIRS

Table C3. List of NWS Evaluation Regions and the suite of products obtained from SPoRT.

NWS Evaluation Region	Product Suite Obtained
Alaska Region Headquarters	NESDIS QPE, SPoRT Hybrids, SPoRT SST, WindSat
Central Region Headquarters	RGBs, Total Lightning, SPoRT SST (Great Lakes)
Eastern Region Headquarters	MODIS, RGBs, SPoRT Hybrids, SPoRT SST, VIIRS data, Total Lightning
Pacific Region Headquarters	NESDIS QPE, SPoRT SST
Southern Region Headquarters	CIRA Blended TPW, GOES-R CI, LIS, MODIS, MODIS vegetation, RGBs, SPoRT Hybrids, SPoRT SST, Total Lightning, VIIRS
Western Region Headquarters	CIRA Layered PW, MODIS, NESDIS QPE, RGBs, SPoRT SST, VIIRS, WindSat

Appendix D. SPoRT Publications and Presentations in 2013

Peer-reviewed journal publications:

Goodman, S. J., R. J. Blakeslee, W. J. Koshak, D. Mach, J. Bailey, D. Buechler, L. Carey, C. Schultz, M. Bateman, E. McCaul Jr., and G. Stano, 2013: The GOES-R Geostationary Lightning Mapper (GLM). Atmos. Res., 125-126, 34-49.

Jedlovec, G., 2013: Transitioning Research Satellite Data to the Operational Weather Community: The SPoRT Paradigm. Geoscience and Remote Sensing Newsletter, March, L. Bruzzone, editor, Institute of Electrical and Electronics Engineers, Inc., New York, 62-66.

Merceret, F. J., T. P. O'Brien, W. P. Roeder, L. L. Huddleston, W. H. Bauman III, and G. J. Jedlovec, 2013: Transitioning research to operations: Transforming the "valley of death" into a "valley of opportunity". Space Weather, 11, 1-4.

Molthan, A. L., J. E. Burks, K. M. McGrath, and F. J. LaFontaine, 2013: Multi-Sensor Examination of Hail Damage Swaths for Near Real-Time Applications and Assessment. J. Operational Meteor., 1 (13), 144-156. Available online at http://www.nwas.org/jom/articles/2013/2013-JOM13/2013-JOM13.pdf

Molthan, A., and G. Jedlovec, 2013: Satellite observations monitor outages from Superstorm Sandy. Eos, Trans. Amer. Geophys. Union, 94 (5), 53-54.

Ralph, F. M., J. Intrieri, D. Andra Jr., R. Atlas, S. Boukabara, D. Bright, P. Davidson, B. Entwistle, J. Gaynor, S. Goodman, J.-G. Jiing, A. Harless, J. Huang, G. Jedlovec, J. Kain, S. Koch, B. Kuo, J. Levitt, S. Murillo, L. P. Riishojgaard, T. Schneider, R. Schneider, T. Smith, and S. Weiss, 2013: The emergence of weather-related test beds linking research and forecasting operations. Bull Amer. Meteor. Soc., 94, 1187-1211.

Zavodsky, B. T., J. L. Case, C. B. Blankenship, W. L. Crosson, K. D. White, 2013: Application of next-generation satellite data to a high-resolution, real-time land surface model. Earthzine, J. Kart, editor, Institute of Electrical and Electronics Engineers. Available online at http://www.earthzine.org/2013/04/10/application-of-next-generation-satellite-data-to-a-high-resolution-real-time-land-surface-model/

Zavodsky, B. T., A. L. Molthan, and M. J. Folmer, 2013: Multispectral Imagery for Detecting Stratospheric Intrusions Associated with Mid-Latitude Cyclones. J. Operational Meteorology, 1 (7), 71-83. Available online at http://www.nwas.org/jom/articles/2013/2013-JOM7/2013-JOM7.pdf

Conferences, Symposia, Workshops, Newsletters and Meetings:

Bell, J. R., J. E. Burks, A. L. Molthan, and K. M. McGrath, 2013: Development of WMS capabilities to support NASA disasters applications and app development. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, IN11B-1519.

Berndt, E. B., B. Zavodsky, G. J. Jedlovec, N. J. Elmer, 2013: Impact of the assimilation of hyperspectral infrared retrieved profiles on Advanced Weather and Research model simulations of a non-convective wind event. 38th National Weather Association Annual Meeting, Charleston, SC, P2.7. Available online at http://www.nwas.org/meetings/abstracts/display.php?id=1862

Berndt, E. B., B. Zavodsky, A. Molthan, and G. J. Jedlovec, 2013: The use of red green blue air mass imagery to investigate the role of stratospheric air in a non-convective wind event. 38th National Weather Association Annual Meeting, Charleston, SC, P2.8. Available online at http://www.nwas.org/meetings/abstracts/display.php?id=1861

Blankenship, C. B., B. T. Zavodsky, G. J. Jedlovec, G. A. Wick, and P. J. Neiman, 2013: Impact of AIRS thermodynamic profiles on precipitation forecasts for atmospheric river cases affecting the western United States. Preprints, Ninth Symp. on Future Operational Environmental Satellite Systems, Austin, TX, Amer. Meteor. Soc., P291. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper214490.html

Burks, J. E., 2013: Common web mapping and mobile device framework for display of NASA real-time data. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, GC13C-1092.

Calhoun, K. M., D. E. Bruning, D. M. Kingfield, S. D. Rudlosky, C. W. Siewart, T. Smith, G. T. Stano, and G. J. Stumpf, 2013: Forecaster use and evaluation of PGLM data at the NOAA Hazardous Weather Testbed and GOES-R Proving Ground. Preprints, Ninth Symp. on Future Operational Environmental Satellite Systems, Austin, TX, Amer. Meteor. Soc., TJ30.2. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper223893.html

Case, J. L., S. V. Kumar, R. J. Kuligowski, and C. Langston, 2013: Comparison of four precipitation forcing datasets in Land Information System simulations over the Continental U.S. Preprints, 27th Conf. on Hydrology, Austin, TX, Amer. Meteor. Soc., P69. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper214457.html

Colle, B., A. L. Molthan, R. Yu, D. Stark, S. E. Yuter, and S. W. Nesbitt, 2013: Evaluation of Model Microphysics Within Precipitation Bands of Extratropical Cyclones. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, H33E-1404.

Folmer, M. J., K. Bedka, J. R. Walker, S. Goodman, S. D. Rudlosky, G. T. Stano, B. Reed, J. M. Sienkiewicz, D. R. Novak, J. Kibler, A. Orrison, and H. D. Cobb III, 2013: GOES-R product demonstrations at HPC, OPC, SAB, and TAFB. Preprints, Ninth Symp. on Future Operational Environmental Satellite Systems, Austin, TX, Amer. Meteor. Soc., P312. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper219228.html

Goodman, S. J., R. J. Blakeslee, W. Koshak, D. Mach, J. Bailey, D. Buechler, L. Carey, C. J. Schultz, M. Bateman, E. W. McCaul Jr., and G. T. Stano, 2013: The GOES-R Geostationary Lightning Mapper (GLM): A new eye on lightning. Preprints, Ninth Symp. on Future Operational Environmental Satellite Systems, Austin, TX, Amer. Meteor. Soc., TJ30.1. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper215803.html

Jedlovec, G. J., 2013: SPoRT: Transitioning NASA and NOAA Experimental Data to the Operational Weather Community. Preprints, Third Conference on Research to Operations, Austin, TX, Amer. Meteor. Soc., 6.3. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper216108.html

Jedlovec, G., J. Srikishen, R. Edwards, D. Cross, J. D. Welch, and M. R. Smith,, 2013: Scalable Adaptive Graphics Environment (SAGE) software for the visualization of large data sets on a video wall. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, IN33C-06.

Molthan, A. L., K. K. Fuell, F. J. LaFontaine, K. M. McGrath, and M. Smith, 2013: Current and Future Applications of Multispectral (RGB) Satellite Imagery for Weather Analysis and Forecasting Applications. Preprints, Ninth Symp. Future Operational Environmental Satellite Systems, Austin, TX, Amer. Meteor. Soc., P290. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper213833.html

Molthan, A. L., J. E. Burks, K. M. McGrath, and J. R. Bell, 2013: Near Real-Time Applications of Earth Remote Sensing for Response to Meteorological Disasters. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, IN14A-05.

Ramachandran, R., H. Conover, M. McInery, A. Kulkarni, H. M. Goodman, B. T. Zavodsky, S. Braun, and B. Wilson, 2013: Curated data albums for hurricane case studies. Preprints, 11th Conf. on Artificial and Computational Intelligence and its Applications to the Environmental Sciences, Austin, TX, Amer. Meteor. Soc., P277. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper214095.html

Smith, M., K. M. McGrath, and J. E. Burks, 2013: AWIPS II applications development – A SPoRT perspective. Preprints, 29th Conf. on Environmental Information Processing Technologies, Austin, TX, Amer. Meteor. Soc., 7A.3. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper216227.html

Smoot, J. L., G. Jedlovec, and B. Williams, 2013: Climate Variability and Impact at NASA's Marshall Space Flight Center. AGU Fall Meeting, San Francisco, CA, American Geophysical Union, GC13C-1092.

Stano, G. T., J. A. Sparks, S. J. Weiss, and C. W. Siewert, 2013: Fusing total lightning data with Aviation Weather Center and Storm Prediction Center Operations during the GOES-R Visiting Scientist Program. Preprints, Sixth Conf. on Meteorological Applications of Lightning Data, Amer. Meteor. Soc., Austin, TX, P724. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper215183.html

Stano, G. T., B. Carcione, K. D. White, and C. J. Schultz, 2013: Low topped convection and total lightning observations from north Alabama. Preprints, Sixth Conf. on Meteorological Applications of Lightning Data, Amer. Meteor. Soc., Austin, TX, 6.4. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper215193.html

White, K. D., and J. L. Case, 2013: The utility of real-time NASA Land Information System data for drought monitoring applications. Preprints, 27th Conf. on Hydrology, Austin, TX, Amer. Meteor. Soc., P33. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper220182.html

White, K. D., G. T. Stano, and B. Carcione, 2013a: An Investigation of North Alabama Lightning Mapping Array Data and Usage in the Real-Time Operational Warning Environment During the March 2, 2012 Severe Weather Outbreak in northern Alabama. Preprints, Sixth Conf. on Meteorological Applications of Lightning Data. Austin, TX, Amer. Meteor. Soc., 6.5. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper223418.html

White, K. D., G. T. Stano, and B. Carcione, 2013b: Utility of north Alabama lightning mapping array data and implementation strategies in AWIPS II. National Weather Association 38th Annual Meeting, Charleston, SC, Natl. Wea. Assoc., P1.33.

Zavodsky, B., E. Berndt, C. Blankenship, and K. Fuell, 2013: Recent Activities with AIRS Level-2 Profile Data at the SPoRT Center. 2013 Spring AIRS Science Team Meeting, Pasadena, CA.

Zavodsky, B., J. Srikishen, 2013: Using AIRS Profile Information to Better Assimilate AIRS Radiances in GSI, 11th Joint Center for Satellite Data Assimilation Workshop, College Park, MD. Available online at http://www.jcsda.noaa.gov/documents/meetings/wkshp2013/dayThree/Zavodsky_JCSDA_Workshop_final.pdf

Zavodsky, B. T., J. Srikishen, and G. J. Jedlovec, 2013: Evaluation of the Impact of Atmospheric Infrared Sounder (AIRS) radiance and profile data assimilation in partly cloudy regions. Preprints, Special Symp. on Joint Center for Satellite Data Assimilation, Austin, TX, Amer. Meteor. Soc., J4.5. Available online at https://ams.confex.com/ams/93Annual/webprogram/Paper213152.html

Appendix E. 2013 SPoRT Awards

In 2012, SPoRT established a series of annual awards to recognize outstanding contributions of SPoRT partners to the SPoRT mission. The “Satellite Champion of the Year” award is given to an individual at a National Center or Weather Forecast Office for their outstanding efforts to integrate experimental data into their office operations. Without liaisons who serve as local advocates for the various satellite data and products, the transition of unique research data to the operational community would be a lot more difficult. The “Collaborative Partner of the Year” award recognizes a group or office for their extraordinary efforts in demonstrating the utility of experimental products in WFO operations. Offices that step up as a team to evaluate and use these products are vital to the success of the SPoRT program. The “Blog Post of the Year” award recognizes individuals who have made repeated efforts to disseminate the utility of SPoRT products to the broader user community through the Wide World of SPoRT blog <http://nasasport.wordpress.com/>.

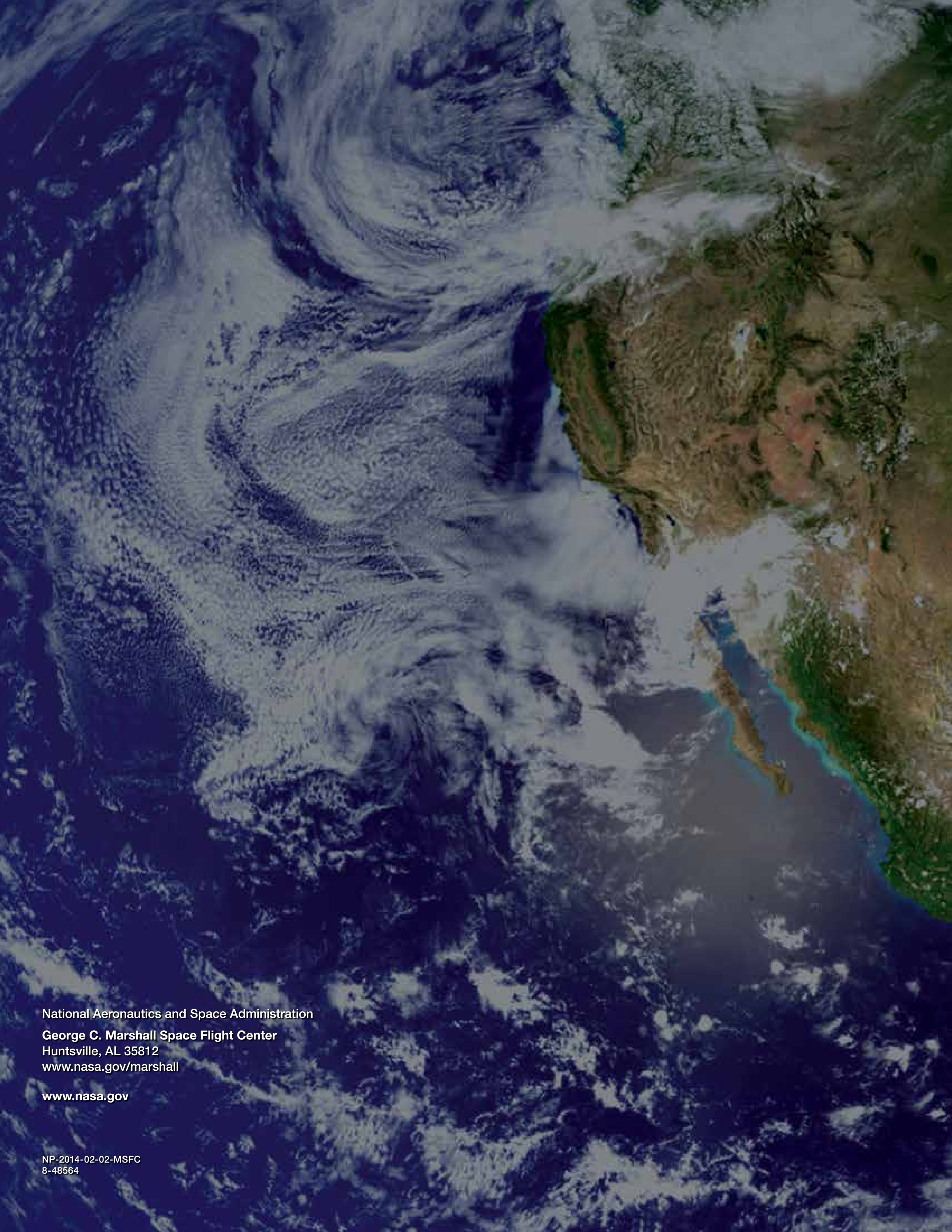
The 2013 recipients are:

- **Amanda Terborg**, CIMSS/SSEC, AWC, Kansas City – Satellite Champion of the Year
- **San Juan, PR WFO** – Collaborative Partner of the Year
- **Luis Rosa**, Forecaster, San Juan, PR WFO – Blog Post of the Year, for the post titled “Tropical Rain Brings Historic Rain to San Juan, Puerto Rico”
- **Geoffrey Stano**, ENSCO, SPoRT Liaison, Huntsville, Alabama – Blog Post of the Year, for the post titled “Total Lightning Perspective of the Moore, Oklahoma Supercell”

Our congratulations to all of these award recipients!

Appendix F. Acronyms and Abbreviations

ABI	Advanced Baseline Imager
AIRS	Atmospheric InfraRed Sounder
AMSR-2	Advanced Microwave Scanning Radiometer-2
AMU	Applied Meteorology Unit
ARSC	Arctic Research Supercomputer Center
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AWIPS	Advanced Weather Interactive Processing System
CI	Convective Initiation
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CONUS	Conterminous United States
CrIMSS	Cross-track Infrared and Microwave Sounding Suite
CrIS	Cross-track Infrared Sounder
CTP	Cloud Top Pressure
DAT	Damage Assessment Toolkit
DNB	Day-Night Band
DSS	Decision Support System
EF	Enhanced Fujita tornado scale
EMC	Environmental Modeling Center
EMS	Environmental Modeling System
EOS	Earth Observing System
EPDT	Experiment Products Development Team
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GDAS	Global Data Assimilation System
GFS	Global Forecast System
GINA	Geographic Information Network of Alaska
GLM	Geostationary Lightning Mapper
GOES	Geostationary Operational Environmental Satellite
GPM	Global Precipitation Measurement
GSI	Gridpoint Statistical Interpolation
GVF	Green Vegetation Fraction
HSS	Heidke Skill Score
HWT	Hazardous Weather Testbed
IASI	Infrared Atmospheric Sounding Interferometer
IR	Infrared
ISERV	ISS SERVIR Environmental Research and Visualization System
ISS	International Space Station
JCSDA	Joint Center for Satellite Data Assimilation
JPSS	Joint Polar Satellite System
KMS	Kenya Meteorological Service
LIS	Land Information System
LMA	Lightning Mapping Array
LPW	Layered Precipitable Water
LSM	Land Surface Model
MODIS	Moderate Resolution Imaging Spectroradiometer
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
N-AWIPS	National Centers-AWIPS
NCEP	National Centers for Environmental Prediction
NDVI	Normalized Difference Vegetation Index
NESDIS	National Environmental Satellite Data and Information Service
NHC	NCEP National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NSSTC	National Space Science and Technology Center
NWP	Numerical Weather Prediction
NWS	National Weather Service
OCONUS	Outside the CONUS
OPC	NCEP Ocean Prediction Center
OPG	Operations Proving Ground
PG	Proving Ground
PGLM	Pseudo Geostationary Lightning Mapper
POES	Polar Orbiting Environmental Satellite
PV	Potential Vorticity
PW	Precipitable Water
QPE	Quantitative Precipitation Estimate
RGB	Red-Green-Blue
ROSES	Research Opportunities in Space and Earth Sciences
SAB	Satellite Analysis Branch
SAC	Science Advisory Committee
SAGE	Scalable Adaptive Graphics Environment
SEVIRI	Spinning Enhanced Visible and IR Imager
SMAP	Soil Moisture Active-Passive
SMOS	Soil Moisture and Ocean Salinity
SPC	NCEP Storm Prediction Center
SPoRT	Short-term Prediction Research and Transition
SST	Sea Surface Temperature
Suomi-NPP	Suomi-National Polar-orbiting Partnership
TAFB	Tropical Analysis and Forecast Branch
TLTT	Total Lightning Tracking Tool
TPW	Total Precipitable Water
TRMM	Tropical Rainfall Measuring Mission
UAH	University of Alabama in Huntsville
VCL	Visualization and Collaboration Laboratory
VIIRS	Visible Infrared Imaging Radiometer Suite
WFO	Weather Forecast Office
WMS	Web Mapping Service
WPC	Weather Prediction Center
WRF	Weather Research and Forecasting



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