GOESR3 Periodic Reporting

Reporting Period: July 2018 – December 2018
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Project Title: GOES-R Water Cycle Products & Services to Support the National Weather Service
Project Number: 309

Executive Summary

The Cooperative Institute for Climate and Satellites at the University of Maryland (CICS-MD), in conjunction with its NOAA/NESDIS/Center for Satellite Applications and Research (STAR)/Cooperative Research Programs (CoRP)/Satellite Climate Studies Branch (SCSB) partner, will support the Geostationary Operational Environmental Satellite - R Series (GOES-R) Risk Reduction Program (GOES-R3) through this proposal focused on research and development (R&D) of water cycle products that will serve multiple users at NOAA’s National Weather Service (NWS). The primary topical areas include: precipitation, land surface hydrology, water quality and high impact weather. The R&D will exploit the new capabilities from baseline and future products of the GOES-R satellite, mainly measurements (or proxies of them) from the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). In particular, measurements from the Himawari-8, rapid scan operations of current GOES satellites and ground lightning networks will be exploited to advance water cycle products. The targeted end users within NWS include the National Water Center (NWC), the Weather, Ocean and Tropical Prediction Centers (WPC, OPC and TPC) and the NWS Pacific Regions, where collaborations are already underway. Additionally, synergy and exploitation of Joint Polar Satellite System (JPSS) products will also be included in this project, in particular, direct broadcast (DB) data which will greatly reduce data latency and offer a greater potential of fusion with GOES-R data. The advantage of reduced latency from DB data has been demonstrated by the NESDIS Snowfall Rate product that was evaluated at NWS Weather Forecast Offices (WFOs) over the past few years. Finally, the SCSB/CICS-MD Satellite Proving Ground will be used to test the new products in a near-real time capability and form the basis for testbed activities with the NWS users.

Progress toward Milestones

This project started in FY16 (July 1, 2016) and is in its third year; spending has been behind as planned for a variety of reasons, therefore, we are requesting a one-year no-cost extension (June 30, 2020) and will focus on tasks 4 – 7 are reported on below.

1. Workshop with NWS and NOS stakeholders to define project priorities (Previously Completed):

In order to determine project priorities as we move ahead in this multi-year project, we met with members of the NWS/Office of Water Prediction (OWP) on October 19, 2016, to describe to them the current project (as proposed) and potential new topics (as outlined in the proposal) to get their input as to their priorities. Brian Cosgrove represented the interests of NWS/OWP and was joined by Dave Kitzmiller and Yu Zhang from OWP; Cosgrove gave a nice overview of the current/future needs of satellite products at OWP. Topics presented by the project team included:
• Review of ongoing activities in support of NWS and of potential interest to NWS – Scott Rudlosky and Patrick Meyers
• Improved precipitation rates for the NWS Pacific Region – Nai-Yu Wang
• Advancement of LEO snowfall rate retrievals – Huan Meng
• Water quality – Christopher Brown
• Global flood estimate and forecasting using satellite precipitation and hydrological models – Bod Adler and Huan Wu
• High resolution remote sensing of evapotranspiration (ET) and soil moisture – Chris Hain
• Global snowdepth and water equivalent estimations using satellite and in-situ data – Cezar Kongoli

The first two topics are tasks that are now completed; of the other activities presented, OWP had the most interest in the snowfall rate and the ET/soil moisture projects. Next of interest was the water quality and global flood activities. The snowfall rate task was started in January 2018, and is ongoing, and the Water Quality task started in July 2018. Both are reported on later in this report.

2. OCONUS Rain Algorithm for NWS Pacific Region – (Previously completed)

This task was carried out by CICS-MD research scientists Nai-Yu Wang, Yalei You, and Patrick Meyers. The project examines lightning-convection-rainfall relations and develops an approach to integrate the lightning information into geostationary IR rain algorithms for the Pacific region. IR and water vapor channels from Advanced Himawari Imager (AHI) on Himawari-8, and GLD 360 ground lightning flash rates are used. The resulting test product shows some benefit of the lightning data in the convective part of the storm systems in the Pacific Ocean region.

Major accomplishments:

1. Examine lightning-cloud-rain relationships with AHI/Himawari-8 and GLD360 lightning flashes

Results show that lightning frequency is a good proxy to separate storms of different intensity, identify convective cores and convective rain area, and screen out false convective core signatures indicated by clod IR cloud top temperature. The lightning-cloud-rainfall relationships derived provide insights into the best approaches for rain estimation and provide the lightning-rainfall quantitative relations to potentially be used. Specifically, the lightning information has been shown to be useful to aid identification of convective cores in thick anvils missed by the IR technique, eliminate misidentified convective cores, and correctly define convective rainfall volume. These will be key uses of the lightning information as part of a geosynchronous rain estimation technique.

2. Develop a rain estimation technique to take advantage of lightning information potential, using AHI/Himawari-8 and GLD360 data

A satellite rainfall estimation technique is developed to combine infrared and lightning information to estimate convective and stratiform precipitation over Pacific Ocean. Lightning information is coupled with a modified IR-based Convective/Stratiform Technique (CST) for ocean (CST-ocean) and produces a lightning-enhanced CST (CSTL) for Ocean (CSTL-ocean). Both the CST-ocean and CSTL-ocean are then applied to the training (2015) and independent (2016) datasets. In general, this study shows some improvement over the IR rainfall estimates (rain area and intensity) by adding lightning information. The CST can generally catch the heavy (convective) rain regions, while CSTL further identifies convective areas that are missed by CST and removes convective cores that are incorrectly defined by CST.

Previous results showed that various combinations of the AHI hold promise in some oceanic convective zones than simple IR temperature gradient information. This task concluded at the 4th Quarter of 2017.
We’ll further investigate this multi-channel information in the coming years if additional funding is available.

**Recent Development:** Issues with the loop heat pipe on the GOES-17/West have led us to re-evaluate whether a GLM-only rainfall intensity product could prove valuable. Examples of the gridded GLM products have been sent to Bob Kuligowski for initial evaluation. STAR/UMD scientists also plan to interrogate the gridded GLM products alongside both satellite and radar measures of precipitation intensity to begin developing a demonstration product. Future reports will provide updates on this activity.

3. **ProbSevere for Ocean Regions (Initial tasks completed, efforts refocused during this period)**

Although activities laid out in the initial proposal have been completed/closed, collaborations continued with the ProbSevere development team. Our efforts focused on integrating the emerging GLM gridded products into the ProbSevere framework. It’s envisioned that this topic will be an ongoing activity beyond the scope of this project.

Several gridded GLM products have been integrated into ProbSevere, however initial results were mixed. The direct relationships expected between lightning intensity and thunderstorm severity (i.e., lightning jump) were not found to be robust. This leads to the initial conclusion that combinations of GLM fields will be needed to adequately detect lightning jumps. Our team stands ready to evaluate the vast datasets that are presently being created in the ProbSevere development environment.

Our initial focus in this effort was on the ability for the GLM to identify and track storm features. There are now two complementary efforts pursuing this topic. NASA/SPoRT and OU/CIMMS continue to advance the tracking of storm features using combined lightning/radar/satellite fields. This work has the potential to feed directly into the MRMS/ProbSevere implementation. STAR/UMD and Texas Tech University continue to pursue the definition of GLM storm features using only GLM information. These efforts leverage the high temporal update frequency of the GLM in an attempt to routinely identify GLM storm features. A GLM storm feature ID is envisioned as a future gridded product. It seems most likely that the tracking of these storm features will be left to post processing.

4. **Develop enhanced snowfall rate (SFR) product through ABI propagation (updated this reporting period)**

The goal of this project during this period is to use ABI IR data to propagate the snowfall rate (SFR) product (Kongoli et al., 2015, 2018; Meng et al., 2017; Ferraro et al., 2018).

a) **Data and Method**

The SFR product is propagated using the morphing technique. The GOES-R ABI channel 13 (10.3 μm) band is a clean infrared longwave window band. It is recommended that forecasters default to the 10.3 μm for subjective cloud identification and classification (Lindsey et al., 2012). Cloud moving vector (CMV) is determined by calculating the spatial lag correlation between two consecutive channel 13 images. The calculated maximum spatial lag correlation corresponds to the cloud shift which is then used to compute the velocity field. To increase accuracy, all calculation is performed on the GOES-R original grid with 2km resolution. In addition, a microwave (MW) Field-Of-View (FOV) is represented by a rectangular plane instead of a single point during propagation. This approach effectively overcomes the divergence issue. Figure 1 shows two channel 13 images at 15 minutes apart and overlaid with the calculated CMV. The CMV field shows southeasterly moving cloud system, especially in the region with lower IR observations (in blue). The calculated CMV is consistent with the shift of the cloud structures.

b) **Result**
Once the CMV is determined, it can be used to propagate the SFR product. The procedure is shown in the following case study (Figure 2). The S-NPP SFR swath at 2017-04-14 07:10Z and the NOAA-19 swath at 08:29Z on the same day are used in this study. Only the region with SFR greater than 1 mm/hr is presented to focus on the main portion of the storm. Seven consecutive channel 13 images were utilized to derive CMV at 15-min interval. The S-NPP SFR field was then propagated with the series of CMV to the time of the NOAA-19 overpass, i.e. about 80-min later. Figure 2 reveals that the most prominent change in the storm is the southeasterly advection in the southern portion of the system while little movement occurs in the northern region. The pattern of the propagated S-NPP SFR field (Fig. 2(c)) agrees very well with that of the NOAA-19 (Fig. 2(d)). This result demonstrates the effectiveness of this morphing technique. Some differences between the two SFR images are also noted. Since no inter-calibration has been performed on the S-NPP and NOAA-19 SFR products, the differences in the SFR magnitude in some regions may be due to the algorithm differences. Since no snowfall detection is applied in this propagating scheme, it may cause more snowfall being present downstream where the environmental conditions do not favor snowfall.

c) Future plan

The calculation of moving vector is time-consuming and needs to be optimized for operational production. Adding a model-based snow detection algorithm will improve the accuracy of snowfall propagated to downstream. In addition, cross-calibration between the SFR products from different satellites will be beneficial.

d) References


5. Smokey Mountain Rain Gauge Network (Updated this reporting period)

A specialized rain gauge network, co-sponsored by the GOES-R program, was examined and compared with satellite rainfall products, including the GOES-R baseline algorithm, SCaMPR (Self-Calibrating Multivariate Precipitation Retrieval). This data set, maintained by Professor Doug Miller of the Univ. of North Carolina-Asheville, is located in western NC and TN, in the Smokey Mountains. It’s intended to examine orographic rainfall. The task is being led by Ralph Ferraro and Brandon Bush (Univ. of...
Maryland, Atmospheric and Oceanic Sciences (AOSC) undergraduate student). Additionally, AOSC student Jackson Hill, has developed tools to co-locate and validate daily satellite rainfall estimates, including SCaMPR, with the Community Collaborative, Rain, Hail and Snow Network (CoCoRaHS). A poster on this work was presented at the Ninth Workshop of the International Precipitation Working Group (IPWG-9) which was held in Seoul, Korea during November 5-9, 2018 (see Figure 3). Details of the workshop can be found at [http://www.isac.cnr.it/~ipwg/meetings/seoul-2018/Seoul2018.html](http://www.isac.cnr.it/~ipwg/meetings/seoul-2018/Seoul2018.html).

The work has been insightful and demonstrates that algorithm performance varies by synoptic situation; there are instances of relatively good agreement between satellite and surface observations and also cases where the satellite misses rain entirely or produces false alarms. As a follow on, a meeting is planned with the investigators of the networks – Ana Baros (Duke Univ.) and Doug Miller – to discuss sustainment of the network and pilot studies to be performed.

6. New AWIPS Capabilities (New this reporting period)

As part of the CICS-SCSB Satellite Proving Ground and Training Facility, we are bringing in new satellite products for internal use and also for testing at national centers located in College Park, MD, as well as the National Water Center in Tuscaloosa, AL. During this reporting period, progress has been made on having the River Flood product (which we are obtaining from CIMSS), the SMOPS soil moisture product, and the CMORPH rain product generally ready for use.

During the next reporting period, we plan on using these products to examine ongoing flooding episodes in the CONUS and Alaska.

7. Retrieving Ocean Color Products from GOES-R Series ABI Observations (Updated this reporting period)

The objective of this project is to develop a technique and algorithm to retrieve chlorophyll concentration from Advanced Baseline Imager (ABI) sensor onboard the Geostationary Operational Environmental Satellite (GOES) -R series platforms. Our approach is to pair estimates of chlorophyll concentration derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi National Polar-orbiting Partnership (SNPP)/Joint Polar Satellite System (JPSS) with ABI observations, and then develop a chlorophyll algorithms from these observations using ABI data. Work performed during this initial stage of the project was primary preparative and involved a lot of literature review and conceptual thinking to lay the foundation of algorithm development. Below we discuss our finished work in details and outline future steps.

a) Data coverage

We examined the data coverage for VIIRS and ABI data. The SNPP and JPSS carrying VIIRS are polar-orbiting satellites with global coverage. The SNPP VIIRS was launched on October 28, 2011, and became operational on January 12, 2012. The JPSS-1 (NOAA-20) was launched on November 18, 2017 and became operational on May 30, 2018.

The GOES-R was launched on November 19, 2016, and reached geostationary orbit at test location (-89.5° longitude) on November 29, 2016 when it was renamed GOES-16. GOES-16 began drifting on November 30, 2017, arrived at its operational location of -75.2° longitude on December 11, 2017, and resumed operations on December 18, 2017 when the satellite was declared GOES-East. During the drift, GOES-16's five main instruments (ABI, GLM, SUVI, SEISS, and EXIS) was turned off and placed in safe or diagnostic mode, and all data collection was disabled. To summarized, the full disk of GOES-16 is centered at -89.5° between November 29, 2016 and November 30, 2017, and at -75.2° after December 18, 2017, with a ~17-day gap of data between the test and operational periods.
The GOES-S was launched on March 1, 2018 and reached the same test location on March 12, 2018 when it was renamed GOES-17. On October 24, 2018, GOES-17 began drifting and arrived at its final operational location of -137.2° longitude (designated for GOES-West) on November 13, 2018. GOES-17 did not transition to operations as NOAA’s GOES West until February 12, 2019. The long delay was associated with an issue in its cooling system which did not start properly. Due to the cooling failure, infrared and near-infrared imaging was only possible 12 hours per day. The issue affects 13 of the infrared and near-infrared channels on the instrument. Fortunately, no other sensors of the satellite were affected, so the visible channels for chlorophyll retrieval are unaffected. In summary, GOES-17 full disk is centered at -89.5° between Mar 12 and October 24, 2018, and at -137.2° after November 13, 2018 with a ~20-day data gap.

b) Spectral bands

We evaluated the spectral bands available on ABI and compared them with VIIRS bands. The spectral bands available on VIIRS and ABI relevant for water property evaluations are compared in Table 1. For chlorophyll retrieval in open ocean waters, the ABI sensor lacks a key green band around 550 nm, making it unfit for applying the classical “blue-green” band ratio algorithms. In addition, there is only one near-IR band (C3) available for atmospheric correction, as opposed to two bands (M6 and M7) available in VIIRS, making it difficult to extrapolate the atmospheric contribution of signals to visible bands. However, these challenges do not exclude the potential of using ABI for chlorophyll retrieval because of the following considerations. First, reflectance at the ABI blue band (C1) varies more with chlorophyll than that at the red band (C2), and therefore it is possible to detect chlorophyll signal based on the contrast between the two bands. Second, the ABI C3 band in the near-IR is similar to VIIRS M7 band, and with some assumptions, it is possible to use it as a basis for conducting atmospheric correction, either explicitly or implicitly. In summary, the ABI has a basic set of bands essential for chlorophyll remote sensing.

Table 1. Visible and near-IR spectral bands on VIIRS and ABI relevant for water property retrievals. The wavelengths denote the approximate central wavelengths ± 50% full width at half maximum (FWHM). VIIRS bands highlighted in green are used for chlorophyll calculation in the “OC3” (O’Reilly et al., 1998) and “CI” (Hu et al., 2012) algorithms. Bands highlighted in yellow are used for VIIRS atmospheric correction.
c) Considerations to match up ABI and VIIRS data

We put considerable thought into the matchup between ABI and VIIRS pixels. To overcome the challenges caused by the lack of bands on ABI, special care has to be taken when matching up and comparing ABI and VIIRS data. For the purpose of this project, the matchup is not in a radiometric sense, such as requiring the ABI and VIIRS viewing at identical angles towards a pixel or using the deep convective clouds with near-Lambertian reflectance property as a viewing target so that difference in viewing geometry no longer matters. Instead, we will match up ABI and VIIRS pixels based only on coincident time and location. This does not mean, however, that the viewing geometry of the two sensors are irrelevant. These parameters are critical and will be added to the ABI-VIIRS matchup dataset, and will be taken into account when constructing the ABI chlorophyll algorithm. Specifically, these parameters include the solar zenith, solar azimuth, ABI viewing zenith, ABI viewing azimuth, VIIRS viewing zenith, and VIIRS viewing azimuth angles (Table 2). These parameters are important because the upwelling water-leaving light-field is anisotropic, because of the need to mask out pixels contaminated by sun glint, and because the atmospheric thickness from the satellite remote-sensing standpoint depends on the solar and sensor zenith angles.

We have identified methods to calculate these solar and sensor geometry parameters. The solar angles can be calculated with a Python package, Pysolar (pysolar.readthedocs.io). VIIRS viewing angles can be calculated with another Python package, Pyorbital (pyorbital.readthedocs.io). These packages have been installed and tested on my computer. The ABI data are given in angular coordinates and can be converted into viewing angles using formulas given by Soler and Eisemann (1994). The latitude/longitude coordinates for ABI pixels can be calculated from radians using formulas given in section 5.1.2.8.1 in the GOES-R Product Definition and Users’ Guide (PUG) Volume 3 (https://www.goes-r.gov/resources/docs.html).

<table>
<thead>
<tr>
<th>Table 2: Comparison of sensor viewing geometry between VIIRS and ABI.</th>
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<tbody>
<tr>
<td>VIIRS</td>
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<tr>
<td>Scan angle (from sensor)</td>
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<tr>
<td>Zenith angle (from ground)</td>
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<tr>
<td>Azimuth angle (from ground)</td>
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<tr>
<td>Geometry stability</td>
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</table>

d) Preliminary data analyses

We have downloaded ABI data and VIIRS data for test purposes. We obtained 4 days (2017059–2017062) of GOES-16 ABI full-disk L1b data at C1, C2, and C3 bands from NOAA CLASS server (ftp.bou.class.noaa.gov). VIIRS-SNPP L2 data during the same period of time covering the GOES-16 full-disk region (-170.8° – -8.2° longitude, -81.3° – 81.3° latitude, for GOES-16 at the test location) were also downloaded. The ABI and VIIRS netcdf4 data file structures were examined using Python. A visualization of an ABI full disk is shown in Fig. 4.
The ABI full-disk L1b data are large with a data volume of ~50 G per day when all three bands are included. The ABI full-disk goes through light and dark cycles everyday. During the light cycle, the majority of the full disk is illuminated by the sun; during the dark cycle, the full disk is mostly covered by darkness. Since VIIRS overpass time is close to local solar noon, the download volume can be cut by half if we only download the data during the light cycle which. The VIIRS nominal equator-crossing local time is 13:30 ±10 min. Considering a VIIRS orbital period of 101.5 min, data collected between 13:00 and 1:00 GMT (for GOES-16 at test location) will cover all VIIRS overpasses. This will still generate large amount of data even after a significant reduction of data. To cope with the large data volume, we will select one day per month in 2018 to get a representative development dataset after the test data analyses is finished. An external hard drive of 4 Terabyte has been ordered to store the data.

e) Next steps

The following four remaining tasks will be accomplished this coming year:

1. Match up daily VIIRS ocean color observations with coincident ABI observations including all sensor and solar geometry data, and obtain a comprehensive training dataset with VIIRS chlorophyll, L2 flags, and various sensor and solar geometry parameters.
2. Analyze empirical relationships between the VIIRS-derived chlorophyll data and ABI radiometric measurements.
3. Use deep learning algorithms to build an algorithm to retrieve chlorophyll concentration from ABI L1b data.
4. Apply the algorithm to ABI data and compare with VIIRS chlorophyll maps obtained for the same time period.

f) References


<table>
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<tr>
<th>Project Milestones</th>
<th>Milestones (CY)</th>
<th>(Expected) Outcome</th>
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<tr>
<td>Workshop with NWS and NOS stakeholders to define project priorities</td>
<td>Completed in 4Q 2016</td>
<td>Priority areas were developed, however, only a few can be accomplished with current funding levels.</td>
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<tr>
<td>Complete development, testing and validation of OCONUS GOES-R rain rate algorithm utilizing lightning information</td>
<td>Completed in 4Q 2017</td>
<td>Demonstration that there is some potential to improve IR based rainfall algorithm with ground-based lightning.</td>
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<tr>
<td>Complete development and testing of lightning advection rain rate algorithm over CONUS that also exploits LEO DB</td>
<td>Completed/refocused during 2Q 2018</td>
<td>New GLM AWIPS products developed, tested and being rolled out to NWSFO’s for operational use.</td>
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<tr>
<td>Develop ProbSevere training database over ocean; perform testing at OPC and NWS Pacific Region</td>
<td>Completed/refocused during 2Q 2018</td>
<td>Lead to collaborations that promote the proper use of the GLM in the ProbSevere framework</td>
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<tr>
<td>Develop enhanced SFR product through ABI propagation; perform testing at NWC, WPC, SPC and NWSFO</td>
<td>2Q 2020</td>
<td>Experimental use across NWS; inclusion into NESDIS EPPS; SCAMPR; CMORPH</td>
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<tr>
<td>Utilize the Smoky Mountain and CoCoRaHS rain gauge networks to validate satellite rainfall products</td>
<td>4Q 2019</td>
<td>Determine the performance of SCAMPR, CMORPH, others in orographic conditions and across the CONUS</td>
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<tr>
<td>Complete the development of a GOES-16 ABI and S-NPP/NOAA-20 VIIRS data base for use in water quality product</td>
<td>3Q 2020</td>
<td>A prototype empirical water quality suite of products from GOES-R series satellites.</td>
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**Plans for Next Reporting Period**

The plans for the next six months include:

1. Using actual GOES-16 GLM AWIPS products continue to examine relationships between GOES-16 ABI, GLM and LEO microwave measurements from S-NPP and N20 ATMS, GCOM-W1 AMSR-2 and GPM GMI observations. Additionally, expand the AWIPS capability to include emerging PGRR products (both GOES and JPSS).

2. Continue to exploit GOES wind vectors to interpolate MW derived SFR in between LEO overpasses.

3. Continue to exploit the Smoky Mountain gauge network to look for possibilities to improve the SCaMPR algorithm in complex terrain.

4. Continue learning AI techniques and building a database of GOES-16 ABI and S-NPP / NOAA-20 VIIRS data that will be used to form empirical algorithms in order to generate empirical water quality products from GOES-R series measurements.

5. Explore the concept of GLM storms and the potential for a GLM-only rainfall intensity product

**Additional Information**

1. Interaction with operational partners –
   - CICS scientists continue to participate in the Satellite training team weekly meetings, helped coordinate GLM training efforts, and developed the GLM training quick guides.
Meet regularly (in person and remotely) with the NWS/Office of Water Prediction to describe GOES-R (and JPSS) satellite products that are ripe for validation of the National Water Model parameters.

- Regular tag ups with NWS (Silver Spring) TOWR-S team/AWIPS technical staff.
- Engagement with NWS/CMOPRH precipitation team
- Developed and maintain a NWS Virtual Lab community for the GLM (https://vlab.ncep.noaa.gov/web/geostationary-lightning-mapper)

2. Conference/workshop participation –

- Oral presentation entitled “Geostationary Lightning Mapper Performance” by Rudlosky and Koshak (but presented by Pat Meyers, CICS-MD) at the 99th AMS Annual Meeting, January 6-10, 2019, Phoenix, AZ.

3. Funding concerns – As previously mentioned, spending has been less than expected, so we are requesting a one-year no-cost extension and complete the project on June 30, 2020.

4. Outside project publicity –

- CICS scientists produced many social media posts on the GLM. For example, a video tweeted 3 days before GOES-S/17 launch was viewed over 15,000 times within 24 h. CICS has become the main source of GLM imagery for the NOAA/NESDIS communications teams.

5. Journal articles:


Figure 1: Examples of GOSE-R channel 13. The time interval is 15 minutes. The overlay moving vector is calculated using morphing method.

Figure 2: SFR morphing result. (a) The SFR initial location overlaying with moving vector; (b) the GOES-R channel 13 with moving vector; (c) The morphing result with 80 minutes propagation period; (d) The corresponding N19 SFR observation.
Validation of Satellite Precipitation Estimates over the Continental United States using Unique Rain Gauge Data Sets

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1. Introduction

Validation of satellite precipitation estimates is an ongoing challenge. Exploitation of “specialized” data sets can provide a first order evaluation of algorithm performance in regions where conventional data is limited or even non-existent. In this study, we examine some initial use of two such data sets over the continental United States (CONUS).

2. Gauge Data #1 – CoCoRaHS

The Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) is a non-profit, community based, network of volunteers who measure and report rain, hail and snow in their backyards. Individuals and family volunteers of all ages and all walks of life are the foundation of the CoCoRaHS network. Many students also participate through their schools. CoCoRaHS reports 24-hr precipitation totals, typically from 7 am – 7 am each day. The only requirement is the purchase of a low cost (~$20 USD) rain gauge. On-line training is provided; each region also has volunteer coordinators who can also offer on-site set up and training. The data are available on-line.

3. Gauge Data #2 - GSMNP

The Great Smoky Mountains and Pigeon Basin (GSMNP) high-resolution rain gauge network, developed by Duke University and maintained by the UNC-Ashville, includes 44 tipping bucket rain gauges deployed during 2007-2009 at mid to high elevations (from 1150m to 1920 m) along exposed ridges in the western part of the state of North Carolina in the Southern Appalachians in locations where no previous rainfall observations were ever made, and where complementary existing observations are available at low elevations. This is a region of orographic rain and periodic severe flooding. Every rain gauge is visited every two-three months for regular maintenance, data collection and scheduled recalibration. Quality control of collected data is performed for each rain gauge, where flags are added to any questionable data.

4. Satellite and Radar Rainfall Data

24 hour satellite rainfall data sets were obtained from Bob Kuligowski (NESDIS/STAR) and the CICS-MD IPWG Validation Web Site3. The data sets analyzed included:

- SCAMPR - Self-Calibrating Multivariate Precipitation Retrieval
- CMORPH - CPC Morphing technique
- MRMS - Multi-Radar/Multi-Sensor System

Simple co-location methods (e.g., nearest satellite observations to gauge locations) were employed.

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https://www.ncl.noaa.gov/projects/meri/

5. Results – GSMNP and SCAMPR

The SCAMPR rainfall estimates were evaluated over the GSMNP domain for GOES-15 for 24-hour periods during seven months during 2017. Some general findings include:

- The performance of SCAMPR varies from region to region (W, C and E)
- Missed precipitation by SCAMPR are most likely associated with warm rain processes
- Overestimation by SCAMPR are most likely due to persistent cold cloud tops

6. Results – Radar, Satellite and CoCoRaHS

- The CoCoRaHS and MRMS fields are in general agreement
- CMORPH and SCAMPR vary considerably
  - In many instances, CMORPH agrees better with surface reports

7. Summary & Future Plans

This pilot (and ongoing study) is exploiting “specialized” surface rain gauge data sets over the CONUS to validate satellite-based precipitation products. Preliminary results suggest that these surface data sets can provide “another piece of information” to algorithm developers and product users. In the next phase of the activity, which is centered around students as a form of outreach, education, and training, will focus on quantitative evaluation, using the IPWG validation protocol tools.

Acknowledgements – We would like the GOES-R3 Program and Center for Satellite Applications and Research (CSAR) of NOAA/NESDIS for supporting this activity. Additionally, we want to thank the University of Maryland/CICS-M, University of North Carolina - Asheville, and Duke University for their contributions to the analysis and maintaining the GSMNP network and providing the data sets for this study.

Figure 3. Poster entitled “Validation of Satellite Precipitation Estimates over the Continental United States using Unique Rain Gauge Data Sets” that was presented at the Ninth Working Group meeting of the International Precipitation Working Group.
Figure 4. An example of GOES ABI full disk at band C1 with 1-km resolution obtained around 18:16 UTC, Feb 28, 2017. The bright spot at the center is due to sun glint.