

## GOESR3 Final Report

**Reporting Period:** July 2017 – June 2020 (full 3-year period)

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**Project Title:** Integration of GOES-R/ABI data in Flood Mapping Software for Flood Monitoring and Forecasting

**Project Number:** 402

### *Executive Summary*

With the support of GOES-R3 from FY17-19, we've successfully integrated the GOES-16&17/ABI data in the flood mapping software and developed the ABI flood mapping software for river forecasters, decision-makers and other users to use the ABI flood products in their flood operations. The project work in FY17-19 can be summarized as follows:

#### **1. Development of the ABI flood detection algorithms**

Based on the framework of the VIIRS flood detection algorithms, we successfully developed the ABI flood detection algorithms with new improvements and adjustments. The key improvements and adjustments include:

**1) ABI data correction:** A data correction method has been developed to stabilize the reflectance in the ABI visible, near infrared and short-wave infrared channels during daytime. Although the method still shows some problems in the early morning and late afternoon, it performs well during daytime and guarantees the overall performance of the ABI flood product.

**2) Improvement on the flood detection under sun-glint contamination:** A sun-glint look-up table is applied to mask sun-glint contamination region. Water detection and water-fraction retrieval algorithms are specially developed for sun-glint contaminated water in the ABI images.

**3) Improvement on the minor flood detection algorithm:** The minor flood detection algorithm has been improved by applying land cover types for both water detection and cloud detection, which helps improve the flood detection capability significantly for the 1-km ABI images.

Other improvements and adjustments include new training of the decision trees for ABI images, adjustments to the cloud shadow and terrain shadow removal algorithm to match with the 1-km spatial resolution of the ABI imagery, ancillary dataset derivation and updates such as ABI 1-km water mask and so on.

#### **2. Development of the ABI flood mapping software**

During FY17-19, the ABI flood mapping software has been developed. The software include three modules:

**1) ABI data projection and flood detection module:** This module is used to project the ABI CONUS and full-disk images in the ABI visible channel (500-m spatial resolution), near infrared channel, short-wave infrared channel and thermal infrared channel into regional images at 1-km spatial resolution.

Based on the projected images, the module further detects floods by using the developed ABI flood detection algorithms and produces 5-m or 10-m flood datasets in hdf4 formats.

**2) ABI composition module:** This module is used to composite the ABI 5-m or 10-m flood maps into hourly flood maps and daily flood maps. Through the composition process, the composited flood maps derive the maximal clear-sky coverage during the composition period. The daily composited flood maps have the maximal clear-sky coverage during a day.

**3) Image display module:** This module is used to generate ABI flood maps in png, geotiff, shapefile and AWIPS-II formats.

### **3. Integration of the GOES-17/ABI data into the ABI flood mapping software**

Besides GOES-16/ABI data, the GOES-17/ABI data has also been integrated in the ABI flood mapping software to generate the GOES-17/ABI flood maps, which makes up for the deficiency in spatial resolution of GOES-16/ABI in the west coastal region.

### **4. Expand the ABI flood product to all the mid-low latitude regions in America**

The ABI flood product was originally designed to cover CONUS only. With the test in other regions, the product has been expanded to cover the entire America mid-low latitudes between 50.5°S and 50.5°N. The ABI flood products are now produced routinely in the SSEC-UW/Madison using the ABI re-broadcast downlink. All these products are distributed to the AWIPS-II system. Since 2020, the ABI flood products are also distributed through the GEONETCast-Americas for agencies of other countries in Central and South America to use the ABI flood products in their operations.

### **5. Development of the archive system and interface for archiving and downloading of the ABI/AHI/VIIRS flood products**

With the support from both the GOES-R3 and JPSS PGRR programs, an archive system has also been developed to archive and distribute the ABI, AHI, and VIIRS flood products and for users to download the historic data. The archive system includes a database and a web interface (<https://jpsfflood.gmu.edu>). The framework of the system is based on Google Map API. The ABI daily composite flood products in mid-low latitudes of America (images and datasets) are all archived since Oct. 2019. Additionally, another ftpsite and interface is also set up for users to download the latest 30-day ABI data in SSEC/UW-Madison: <ftp://floodlight.ssec.wisc.edu>.

### **6. Experimental trial to apply the ABI flood products in the downscaling model**

The developed ABI 1-km flood products are also experimentally applied in the downscaling model to help determine the floodwater under cloudy conditions in the VIIRS images. Currently, this work is still on-going.

## ***Final Year Milestones (FY19) and Project Deliverables***

In FY-19, the milestones include two aspects: development of the downscaling model and development of the archive system.

**1. Development of the downscaling model:** Currently, we have made some breakthroughs on the downscaling techniques. The downscaling model can be used to generate 30-m flood maps using the VIIRS 375-m flood products in the CONUS now. During the downscaling process, the ABI 1-km flood

products are mainly used to determine the floodwater under cloudy conditions in the VIIRS flood products as planned. We are also working on downscaling the ABI 1-km flood products to the 30-m flood products directly.

**2. Development of the archive system:** The archive system has already been developed and applied in archiving the VIIRS/ABI/AHI flood products as well as data downloading.

Project deliverables include:

**1) Project documents:** user guide, software introduction and semi-annual reports.

**2) Software modules:** All the three modules have been delivered, run and maintained routinely in SSEC/UW-Madison.

**3) ABI flood products:** The ABI flood products have been routinely produced and distributed through AWIPS-II system and GEONETCast-Americas.

**4) Archive system:** The archive system has been run and maintained routinely to archive the VIIRS/ABI/AHI flood products and for users to download the products.

**5) Workshops and journal papers:** Three workshops, two conference presentations, two journal papers and one book chapter have been completed related to this project.

### ***Discussion of operational transition readiness for any project outcomes***

Although there are still some issues existing in the current ABI flood products, the operational transition readiness of this product is quite high. The software has been run routinely since Dec. 2018 firstly in the CONUS and then since Nov. 2019, the geographic range has been expanded in the entire mid-low latitudes of America. Preliminary evaluation and validation have shown consistent performance mostly. The major issues lie in two aspects:

**1. Data correction method:** The current data correction method doesn't work very well during early mornings and late afternoons, especially in early mornings, which results in less water detection result in early morning than in other time periods.

**2. Challenges of water detection with existence of thin clouds:** The cloud detection of the ABI flood product is self-supported. Some thin clouds may not be detected very well, resulting in lower quality of water detection in this situation. In the ABI flood maps, the low quality of water detection may cause some inconsistency of flood detection occasionally.

Once these two issues are fixed in FY-20, the product can be transitioned to operations with good performance and confidence.

### ***Additional Information***

#### **1. Interaction with operational partners**

We attend monthly telecons organized by the JPSS Program Office, and communicate with NWS's River Forecast Centers on the progress and the issues we meet during the ABI development. We communicate with the GOES-R Program on the issues existing in the ABI imagery. We work with GONETCas-Americas to provide flood products for rebroadcast on their network.

#### **2. Conference/workshop participation**

### 1) Workshops:

- Li, Sanmei and Straka, W. Satellite-based Flood Mapping to Support Flood Forecasting and Mitigation. Significant Hazards Satellite Applications Short Course, 29 September 2019 Joint Satellite Conference. American Meteorological Society, Boston, MA, 2019.
- Li, Sanmei and Straka, W. Use of Satellites in Analyzing Heavy Precipitation in the Caribbean and Midwest Flooding from 2019. From GOES-R and JPSS Satellite Data to Disaster Response: Every Decision Counts, 12 January 2020. 2020 AMS Annual Meeting. American Meteorological Society, Boston, MA, 2020.
- Li, Sanmei, Introduction to the Global GEO-LEO Flood Mapping System. CEC workshop, Mexico City, Nov. 15, 2019

### 2) Conference presentations and posters:

- Li, Sanmei, Sun, Donglian. Application of GOES-16/ABI Imagery in Flood Detection to Improve Flood Mapping Capability, Pecora&ISRSE conference, Baltimore, MD, Oct. 09, 2019
- Li, Sanmei, Mitchell Goldberg, Donglian Sun, William Sjoberg and Dan Lindsey, Contributions of GEO-LEO Satellite Imagery in Flood Mapping for Flood Forecasting and Monitoring, AGU, San Francisco, 2019

### 3. Outside project publicity

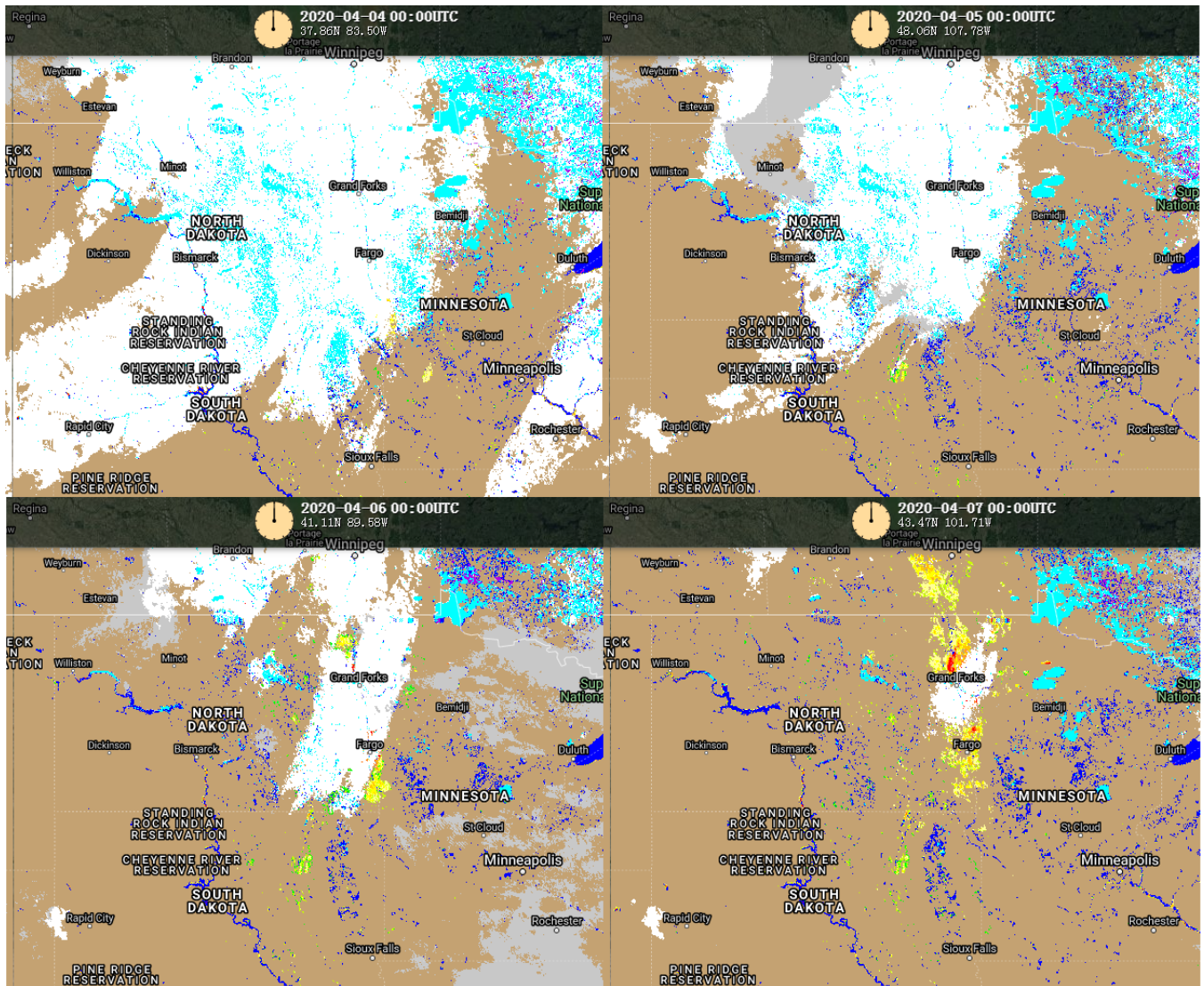
The ABI flood products have been used by NWS, FEMA and agencies in other countries in Central and South America. The following are some blogs and news links related to the ABI flood products:

- <https://satelliteliaisonblog.com/2020/04/14/application-example-applying-satellite-imagery-to-nws-grand-forks-flood-operations/>
- Geonetcast new product blog: <https://geonetcast.wordpress.com/2020/05/14/noaa-leo-geo-flood-mapping-products-are-now-available-on-gnc-a-rebroadcast/>
- Where Is the Floodwater? FEMA's Floodwater Fraction Map Products Web App, FEMA Response Geospatial Office, June 29, 2020

### 4. Journal articles

- Mitchell D. Goldberg, Sanmei Li, Steve Goodman, Daniel T. Lindsey, William Sjoberg and Donglian Sun. Contributions of Operational Satellites in Monitoring the Catastrophic Floodwaters due to Hurricane Harvey. Remote Sensing, 10 (8), 1256, 2018.
- Mitchell D. Goldberg, Sanmei Li, Daniel T. Lindsey, William Sjoberg, Lihang Zhou and Donglian Sun. Mapping, Monitoring, and Prediction of Floods Due to Ice Jam and Snowmelt with Operational Weather Satellites, Remote Sens. 2020, 12, 1865; doi:10.3390/rs12111865

**Key Graphics**



The ABI flood maps from April 04 to 07, 2020 recorded the continuous progress of the major snowmelt flood along the Red River in Minnesota, which provided river forecasters with important situational awareness for river forecasting