GOESR3 Periodic Reporting

Reporting Period: July 2018 – December 2018 (1st half of FY18 funding cycle)

Team Lead: Sanmei Li Donglian Sun
Team Members: Sanmei Li Donglian Sun

Project Title: Integration of GOES-R/ABI data in Flood Mapping Software for Flood Monitoring and Forecasting
Project Number: 402

Executive Summary

Overall Status: **Green**

	Green [1] (Controlled)	***Yellow*** [2] (Caution)	***Red*** [3] (Critical)	**Deviation Summary**[4]
Budget	☒	☐	☐	
Schedule	☒	☐	☐	
Scope	☒	☐	☐	

[1] *Project is within budget, scope and on schedule.*
[2] *Project has deviated slightly from the plan but should recover*
[3] *Project has fallen significantly behind schedule, is forecast to be significantly over budget, and/or has taken on tasks that are out of scope.*
4Details of deviations provided in subsequent section of report

Milestone	**Approved Schedule**	**Start Date**	**Forecasted Completion**	**Actual Completion**	**Status**
Milestone Title					
Algorithm improvements and integration to flood mapping software	July 2017	July 01, 2018	Dec. 31, 2018	Dec. 31, 2018	Completed
Algorithm and software performance test, evaluation and improvements	July 2017	July 01, 2018	Dec. 31, 2018	Dec. 31, 2018	Completed
Delivery of version 1.0 ABI flood mapping software	July 2017	July 01, 2018	Dec. 31, 2018	Dec. 31, 2018	Completed
Website development	July 2017	July 01, 2018	July 31, 2020		In progress

Note: Bold milestones are key external project deliverables

Status Definition: Green (will meet schedule), Yellow (milestone will be delayed), Red (milestone cannot be met on current path)

Progress toward FY17 Milestones

1 Improve the GOES-R flood detection algorithms

1.1 Improve the ABI minor flood detection algorithm

The minor flood detection algorithm we used for VIIRS data does not show good performance even with the threshold adjustments to fit the spatial resolution of the ABI imagery. Thus, the algorithm has been further modified for steady performance and better detection capability on minor to moderate floods. In the VIIRS algorithm, a potential minor-floodwater pixel is determined by comparing its reflectance and NDVI with the average reflectance of the determined dry land. Because the coarser spatial resolution of ABI imagery, the difference between a potential flood pixel and the surrounding dry land is much smaller than that in VIIRS imagery. When smaller thresholds are applied, although more flood pixels could be picked up, more dryland pixels are counted in. To fix this issue, land cover types are considered in the comparison. A potential flood pixel is determined by comparing its reflectance and NDVI with the average reflectance of the neighbouring dry land pixels with the same land cover types. Considering the spectral difference of land cover types, the thresholds are set for each land cover type accordingly. The global land cover dataset we used was outdated, so we updated the land cover dataset with the 2017's VIIRS global land cover dataset. With this modification, the minor flood detection capability of ABI imagery has been improved substantially. From the algorithm performance test, most minor to moderate flood water pixels with water fractions larger than 15% in ABI imagery can be detected successfully.

1.2 Sun-glint contaminated water fraction retrieval

The existing VIIRS flood algorithms only consider minor to moderate sun-glint contamination over ocean surface. However, over inland water surface especially in low latitudes, sun-glint contamination is very common in ABI imagery. To fix this issue, the detection algorithm on the sun-glint contaminated ocean surface has been transitioned to inland water surface to determine minor to moderate sun-glint contaminated inland water surface. Because the surface reflectance of sun-glint contaminated water surface in the short-wave infrared channel becomes much higher, the DNNS method for water fraction retrieval cannot be directly applied in water fraction retrieval of this water type. Thus, a histogram method is applied by searching dry land pixels and neighboring sun-glint contaminated water pixels to retrieve water fractions based on the linear combination model. With the improvement, although the result is still slightly underestimated due to the difficulty to find the water pixels with the exact same sun-glint contamination, it looks much more reasonable and continuous in the time series of 5-minute ABI flood maps during a day.

Fig. 1 presents a before-and-after comparison example on water fraction retrieval of the sun-glint contaminated water surface. Fig.1 (left) is an ABI false-color image on Aug. 11, 2018 14:50 (UTC), in which most water surface is moderately contaminated by sun glint. In the ABI flood maps (Fig. 1 (mid) and Fig. (right)), most of the sun-glint contaminated water pixels are picked up. With the DNNS method, the water fractions are substantially underestimated in Fig.1 (mid). By separating the water type from other water types and applying a histogram method, the water fractions are more reasonable in Fig. 1 (right).

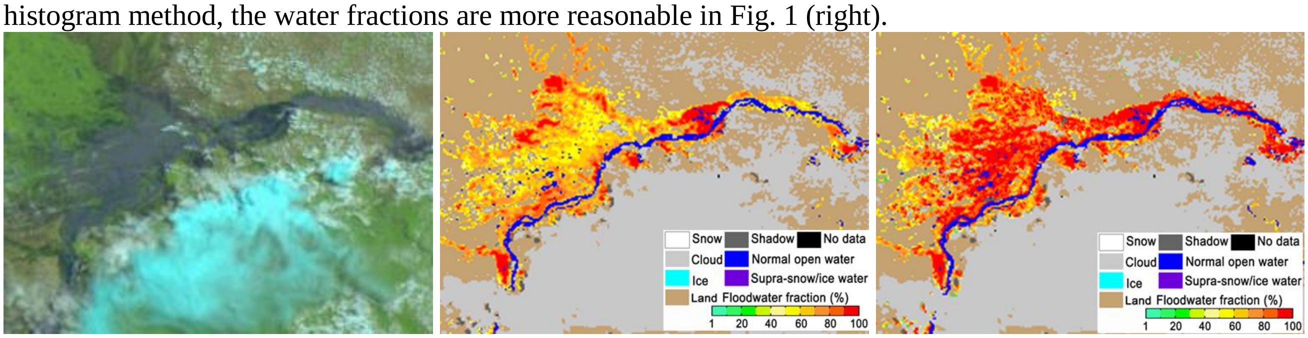

Fig. 1 Before-and-after comparison on water fraction retrieval of sun-glint contaminated water surface (left: ABI false-color image; mid: ABI flood map without considering sun-glint contamination; right: ABI flood map with considering sun-glint contamination)

1.3 Cloud and cloud shadow test with ABI operational clear-sky mask

Currently, there is an operational ABI clear-sky mask for determination of cloud and cloud shadows. We tested this operational product and tried to apply it in the ABI flood process for cloud and cloud shadow detection. However, the current clear-sky mask does not show very accurate results over snow/ice and water surface. Somehow, it turns to be too strict over water surface, resulting in much more cloud cover over lakes and river valleys. After comparison with the results of the ABI flood maps without ABI operational clear-sky mask, we decide to go without ABI operational clear-sky mask until a more mature operational clear-sky mask is available. All the interfaces to the operational clear-sky mask have been kept in the software. Once the operational clear-sky mask becomes steadier, it can be easily integrated in the algorithms.

Fig.2 shows a comparison example between the current operational clear-sky mask and the ABI flood map. Fig. 2 (left) is an ABI false-color image, in which the Salt Lake is clear-sky for flood mapping. In the ABI flood map (Fig. 2 (mid)), the Salt Lake is detected as mostly clear-sky, but in the ABI operational clear-sky mask (Fig. 2 (right)), it shows as mostly cloudy. It is hard to tell which one is correct. There might be some very thin cloud over the Salt Lake. However, for flood mapping, clear-sky coverage is very crucial and the algorithms are designed to ignore very thin clouds in order to detect the floodwater as most as possible.

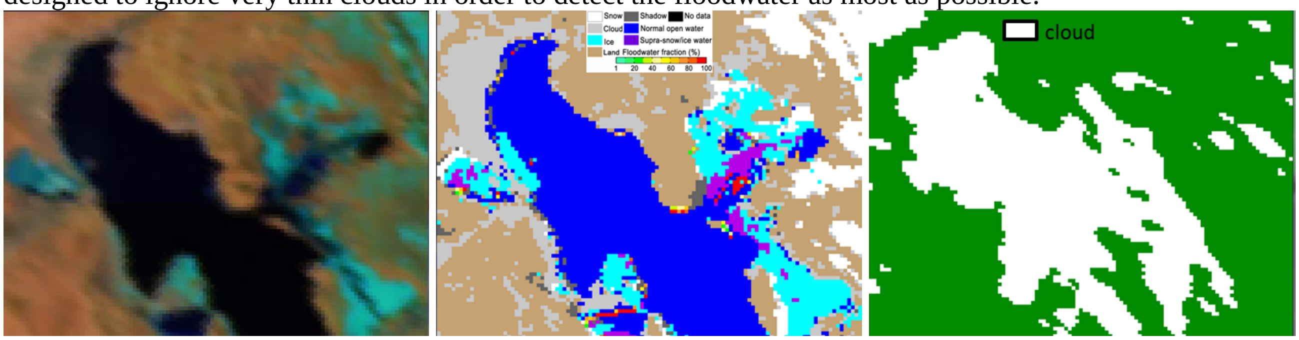

Fig. 2 Comparison between ABI flood map and ABI operational clear-sky mask on cloud detection (left: ABI false-color image; mid: ABI flood map; right: ABI operational clear-sky mask)

2 Algorithm and software performance test, evaluation and improvements

We did algorithm and software performance test with data year around in the CONUS. From May 2017 to October 2018, for each month, at least two-day 5-minute ABI data were collected and chosen for the test. Datasets in South America were also collected to test the algorithm and software performance. Each 5-minute flood map has been visually inspected with the corresponding ABI natural-color image. Some maps were also compared with the same-day VIIRS results and Landsat-8 OLI images and SAR images. From the test results, both the algorithm and software show steady performance and can be used for routine process.

3 Development of the rolling composition module

After discussion with GOES-R program and JPSS Program, the routine ABI flood maps are not updated every 5 minutes. Instead, it is updated every hour using a rolling composition method. The rolling composition means at each hour during daytime, the generated ABI flood map is composited from all the previous 5-minute flood maps on the same day. At the end of a day, the final map is actually a daily composition from all the 5-minute flood maps on that day. Figure 3 shows the process of ABI rolling composition. At 23:00 (UTC), the flood map is the composited results of ABI flood maps from 13:00 (UTC) to 23:00 (UTC).

The rolling composition does not simply accumulate all the flood pixels in each 5-minute flood map. Because some cloud shadows cast by thin clouds are not removed completely, and some ice clouds are easily confused with snow cover, two indices were included to filter residual cloud shadows and snow/ice cover.

$$P_w = \frac{N_w}{N_l + N_w} \quad (1)$$

$$P_s = \frac{N_s}{N_s + N_l + N_c} \quad (2)$$

Where, P_w is the probability of a floodwater pixel, P_s is the probability of a snow/ice pixel, N_w is the observing times of floodwater, N_l is the observing times of clear-sky land or normal water, N_s is the observing times of snow/ice, N_c is the observing times of cloud cover.

If $P_w \geqslant 0.3$, it is defined as a floodwater pixel in the daily composited flood map.
If $P_s \geqslant 0.1$, it is defined as a snow/ice pixel in the daily composited flood map.

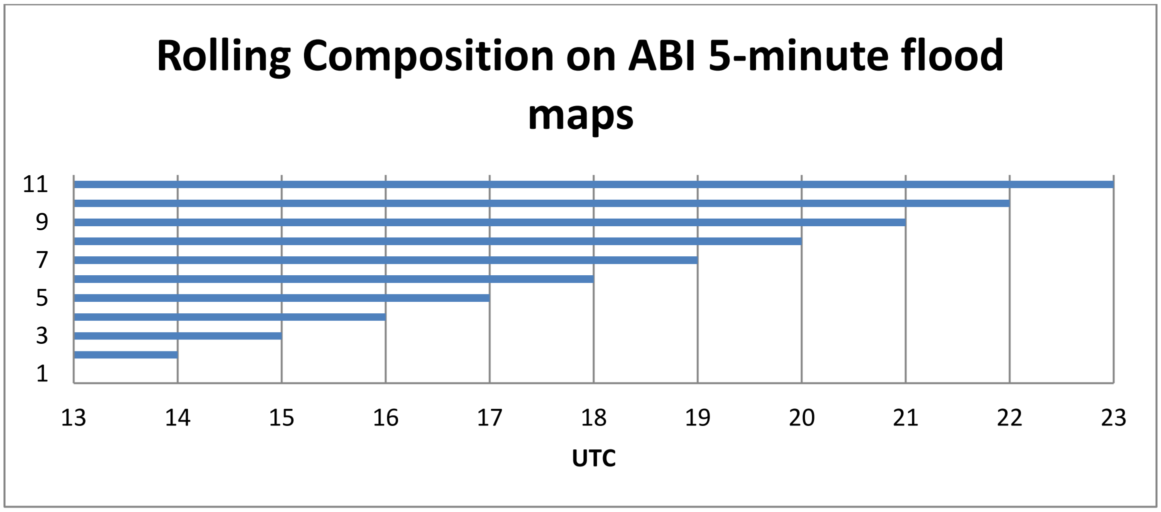

Fig. 3 Sketch of rolling composition for ABI 5-minute flood maps

4 Release of ABI software version 1.0

In December 2018, we released the version 1.0 ABI flood mapping software. Documents to introduce the products and software were prepared. The documents and software have been delivered to the GOES-R Program and the collaborative group in CIMSS for routine process. The near real-time ABI flood maps have been distributed through AWIPS-II for RFCs to load and posted to SSEC's Real Earth for public access. Hourly ABI flood maps can be browsed via the link: http://realearth.ssec.wisc.edu/?products=River-Flood-ABI-hourly, and daily ABI flood maps can be browsed via the link: http://realearth.ssec.wisc.edu/?products=River-Flood-ABI. Fig. 4 shows a sample rolling composited ABI flood map from 11:00 to 17:00 (UTC) on Mar. 05, 2019 in Real Earth.

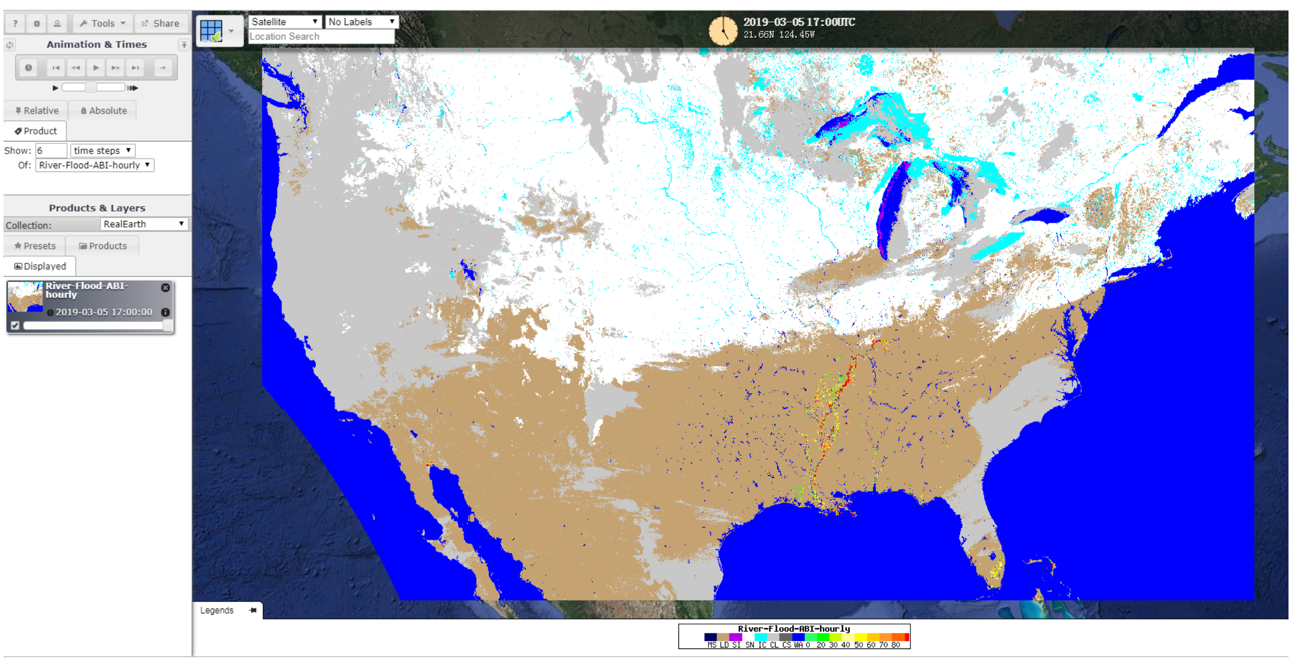

Fig. 4 ABI hourly composited flood map in the CONUS on Mar. 05, 2019

5 Near real-time response to flood events with the experimental GOES-R/ABI flood maps

The ABI flood maps have been applied in near real-time response to flood events including flood in North Carolina due to hurricane Florence, flood in Florida due to hurricane Michael, flood in Texas in Oct. 2018 and flood in the Midwest in Sep. 2018. Flood maps were sent to FEMA and RFCs for their applications during those flood events. Fig. 5 presents a flood map on Sep. 18, 2018 during the period of hurricane Florence.

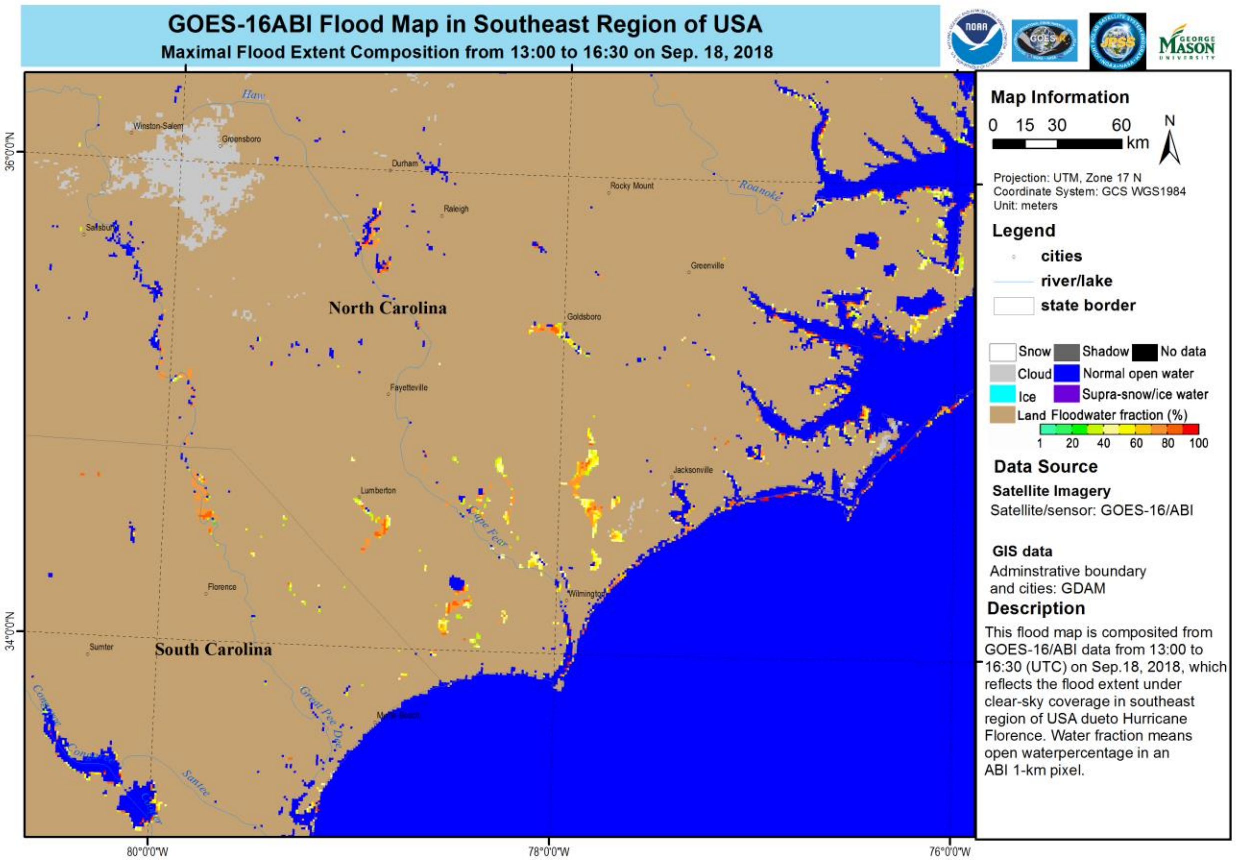

Fig. 5 GOES-16/ABI flood map on Sep. 18, 2018 in southeast of USA due to hurricane Florence

6 Website development

A website is under development to display ABI flood maps for public access. The website is designed based on Google Earth APIs and will display ABI and VIIRS flood maps for public users to browse and download the near real-time flood maps. The framework of the website has been finished. Currently, the website is still under development.

Plans for Next Reporting Period

1 Continue to evaluate the ABI flood product

We will continue to evaluate the ABI flood product to see whether there are any critical issues. The ABI flood maps will be compared with the VIIRS results and other images from Landsat and SAR. Communications will be made with RFCs to see whether there are any issues for them to use the product. Improvements will be made to fix the potential issues from the evaluation results.

2 Downscale the ABI 1-km flood products

We will start the development by applying the ABI flood products in the downscaling model together with the VIIRS results to generate high-resolution flood products.

3 Applications of the ABI flood product

We will continue to use the ABI flood products for near real-time flood events response from FEMA, RFCs and International Disaster Charter.

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 also communicate with the GOES-R Program on the issues existing in the ABI imagery.

2. **Conference/workshop participation**

None.

3. **Outside project publicity**

None.

4. **Journal articles**

None.

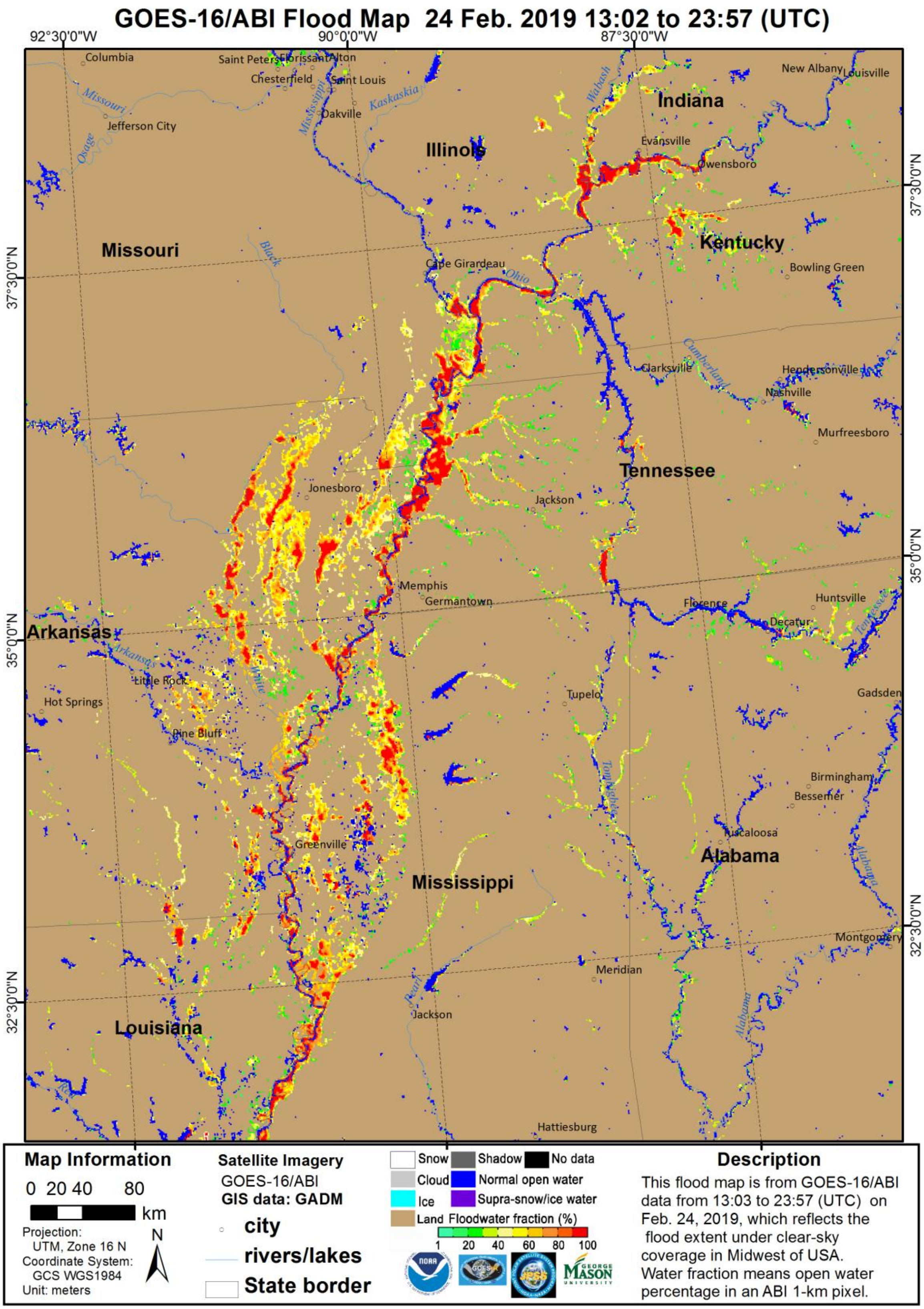

Fig. 6 GOES-16/ABI flood map in Midwest on Feb. 24, 2019 shows the extensive flooding over the Mississippi River Valley