Near Real-Time Use of Optical Remote Sensing and Synthetic Aperture Radar for Response to Central U.S. Flooding in Late April-Early May 2017

Jordan R. Bell[1], Lori A. Schultz[1], Madeline Jones[2], Andrew Molthan[3], Scott A. Arko[4], Kirk Hogenson[4], Franz J Meyer[4]

[1]Earth System Science Center, University of Alabama in Huntsville, Huntsville, AL, [2]New Light Technology Inc./FEMA, Washington D.C., [3]NASA Marshall Space Flight Center, Huntsville, AL, [4]Alaska Satellite Facility, University of Alaska Fairbanks, Fairbanks, AK

IN31C-0094

Introduction

- Satellite remote sensing provides a large scale view at areas impacted by disasters, especially in widespread flooding events.
- A constellation of NASA, NOAA, commercial and international partner satellites provide a wide array of information in varying wavelengths, spatial resolutions and repeat cycles.
- Effort to focus on optical remote sensing (VIS, NIR, IR) are often thwarted by widespread cloud cover, especially in flooding events.
  - Storm systems (tropical or extratropical) can bring cloud cover that can linger for several days

Optical vs SAR Remote Sensing

- Optical systems passively receives thermal emissions or reflected components from the object they are observing, while synthetic aperture radar (SAR) allows for penetration through most clouds and precipitation, varying with wavelength.
- SAR systems also penetrate through dense vegetation canopy, depending on wavelength. Allows for through-cloud observations of floods and other severe weather damage.
- Backscattering mechanisms depend upon the surface that is being sampled:
  - Smooth surfaces like undisturbed water can appear dark (low dB)
  - Vegetation orientation impacts dB return from various polarizations.

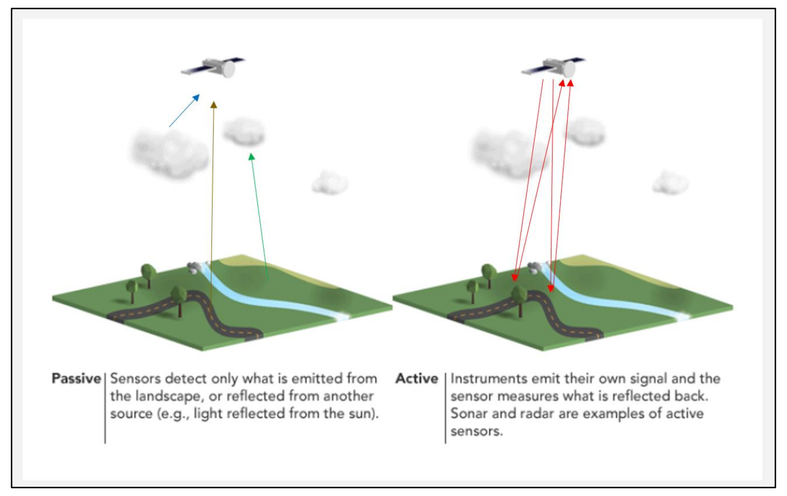

Figure 1. Comparison of passive and active remote sensing. This figure courtesy of NASA ARSET training module on Synthetic Aperture Radar.

Collaborations with Alaska Satellite Facility

- The Alaska Satellite Facility (ASF) at the University of Alaska Fairbanks is the NASA Distributed Active Archive Center (DAAC) specializing synthetic aperture radar processing and archiving. The DAAC is part of the Earth Science Data and Information System (ESDIS) Project based at Goddard Space Flight Center.
- ASF maintains an archive of the European Space Agency's Copernicus Sentinel 1A and 1B satellites. Sentinel 1A/1B are two C-Band instruments that provide a 12 day repeat cycle of most places on Earth. In addition to the Sentinel 1 data, ASF also has archived data from ALOS-1, ERS-1 & 2 and UAVSAR.
- ASF and Marshall Space Flight Center (MSFC) have been working together to better connect SAR data and products with decision makers, especially in disaster response.
- In order to expedite the processing and reduce latency of the date, ASF designed a collaboration tool, that helps with prototyping tools and recipes that use SAR imagery.
- The Hybrid Pluggable Processing Pipeline (HyP3) provided ASF a way to process Sentinel 1 data during the floods and pass that data off to MSFC, who in-turn generated flood products for government agencies such as the Federal Emergency Management Agency (FEMA) during their response.

Late April/Early May 2017 Flooding Response with FEMA

- In late April 2017, a storm system brought several days of heavy rain to portions of Missouri that caused rivers to swell and begin flooding.
- Collaborations with ASF provided several products to be used to during the response to this flooding event
  - RTC-Radiometrically terrain corrected images are corrected for SAR geometry and radiometry.
  - Change detection product identifies change between two images that meets a certain threshold.
  - False color composite allows for rapid, visual identification of key features and potential changes in those features.
- FEMA used these products to help with their modeling and analysis of infrastructure impacted and potential damage replacement costs.

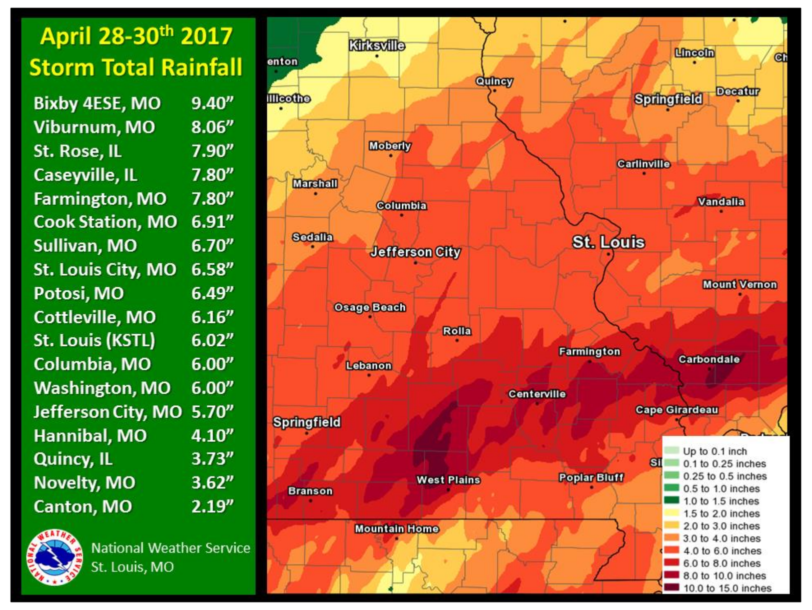

Figure 2. Three day rainfall totals across portions of Missouri that caused widespread flooding. Image is courtesy of the NOAA/National Weather Service-St. Louis.

May 2017 River Flood Crest Summary

Meramec River

Location	May 2017	Record	Previous Record
Steelville	28.70'	**28.70' (2017)**	27.22' 07/27/1998
Sullivan	36.52'	**36.52' (2017)**	33.50' 08/01/1915
Pacific	33.05'	33.42' (2015)	
Eureka	46.11'	**46.11' (2017)**	46.06' 12/30/2015
Valley Park	43.31'	44.11' (2015)	
Arnold	45.62'	47.26' (2015)	

Big River

Location	May 2017	Record	Previous Record
Byrnesville	30.02'	30.20' (1915)	

Figure 3. Several river gauges and their readings during this flooding event. Image is courtesy of the NOAA/National Weather Service-St. Louis.

Figures 4-10: ASF DAAC 2017, contains modified Copernicus Sentinel data 2017.

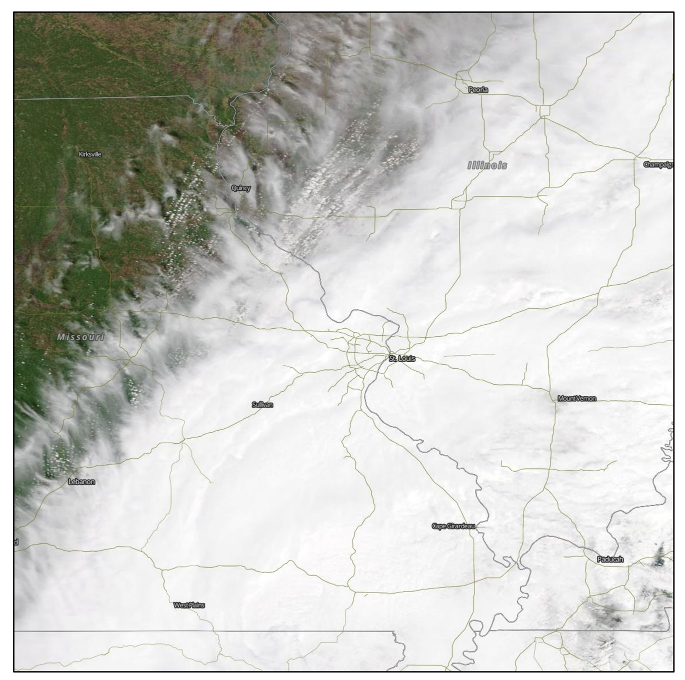

Figure 4. Terra MODIS true color image from 4 May 2017 showing expansive cloud shield over portions of Missouri where flooding was located.

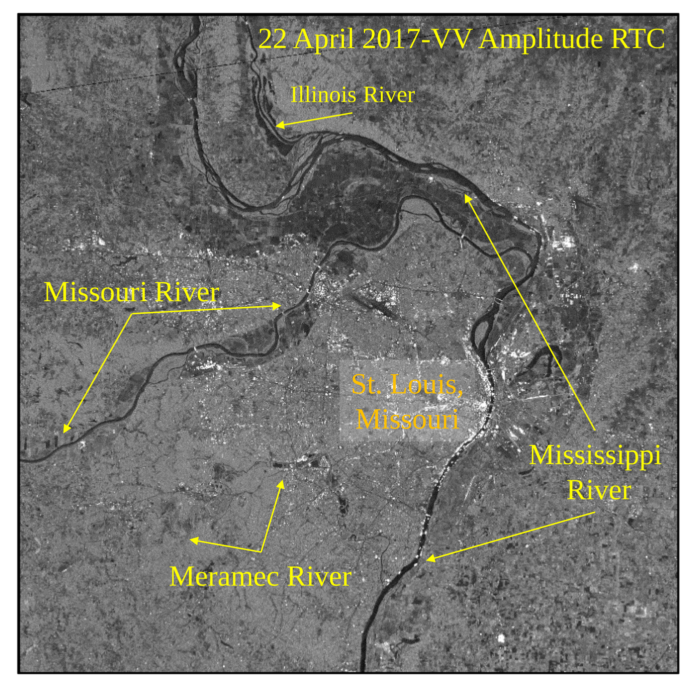

Figure 5. Sentinel 1A dB radiometrically terrain corrected (RTC) image acquired on 22 April 2017. The image was acquired by ESA and processed using the HyP3 system at ASF.

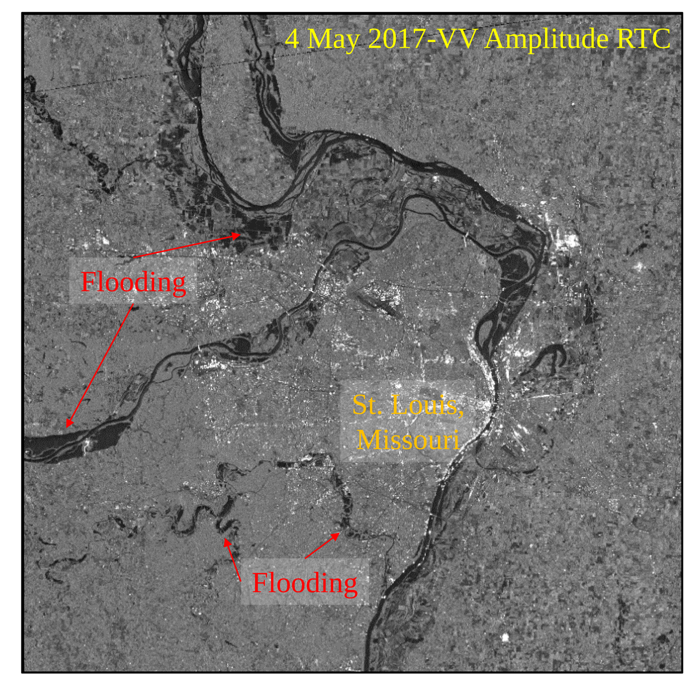

Figure 6. Sentinel 1A dB radiometrically terrain corrected (RTC) image acquired on 4 May 2017. This image show considerable amount of flooding around the rivers.

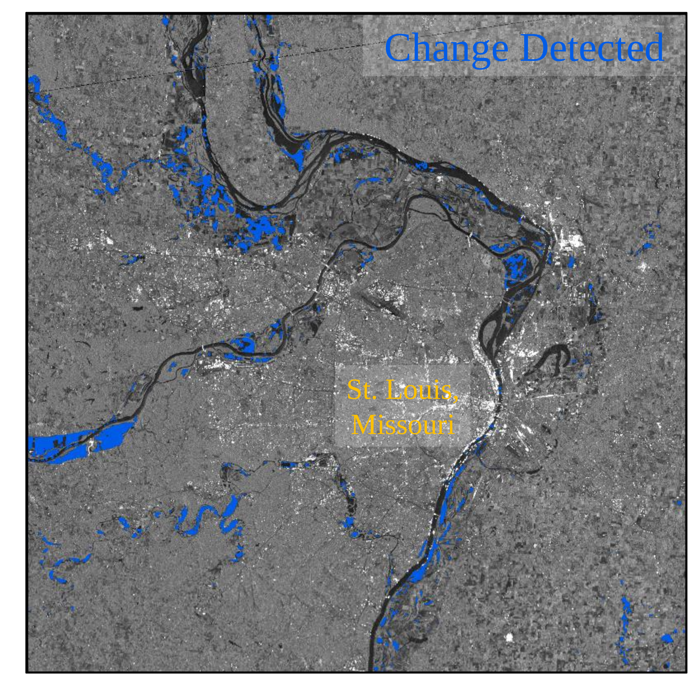

Figure 7. Using data from a before (Fig. 5) and after (Fig. 6), ASF has developed a change detection tool for HyP3 which identifies areas of significant change (flooding) between the two scenes.

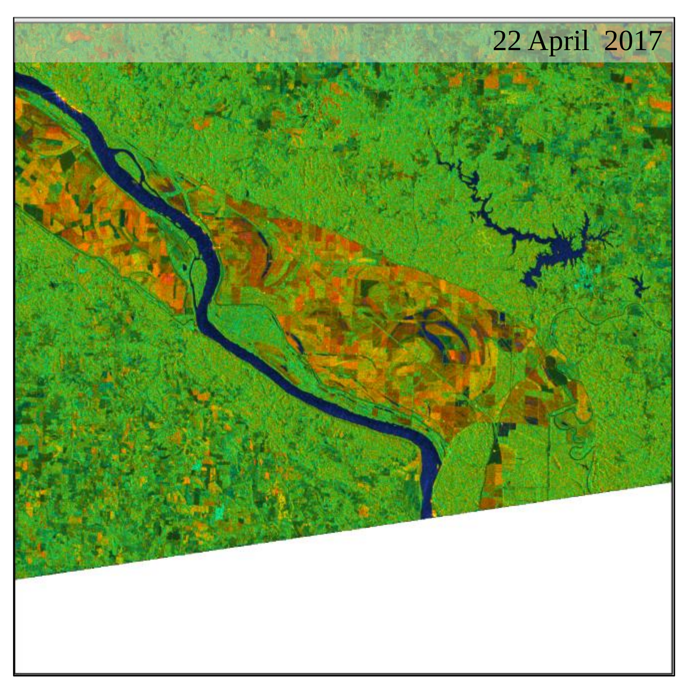

Figure 8. Sentinel 1A RGB composite from 22 April 2017 located just north of Grand Tower, IL. The flood plain on fields near the river are shown in orange/brown, while the surround vegetation is green.

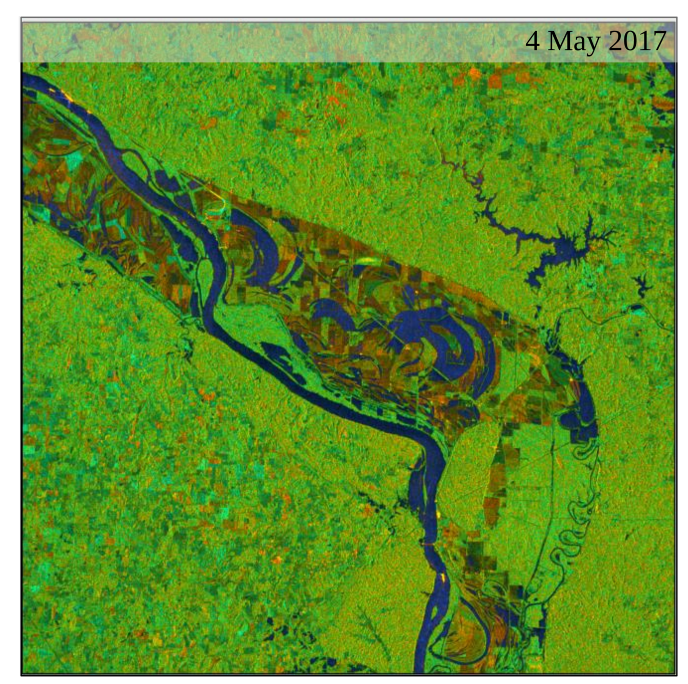

Figure 9. Sentinel 1B RGB composite from 4 May 2017 after the heavy rains caused flooding. Water appears blue while the wet flood plain/fields are shown in dark brown.

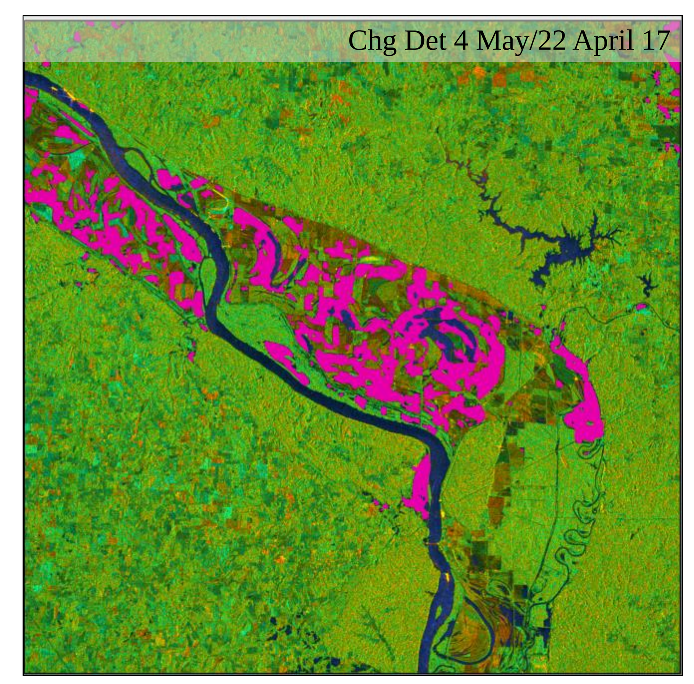

Figure 10. Sentinel 1 change detection product (pink) overlaid on the RGB composite from the 4 May 17. The ChgDet product shows where the area is more wet from the rains than in April, likely flooding.

Figure 11. SPOT6 true color RGB from 5 May 2017. The SPOT true color RGB after skies cleared. Although a day later, the water is still apparent, coinciding with the ChgDet and RGB images.