NOAA Water Team Meeting

The Earth Systems Integration Board — WATER TEAM

April 19, 2023
2:30 - 4:00 PM EST

Google Meet

Call-in Number: 304-760-9735

PIN: 335 996 813#

AGENDA

2:30 ET	Welcome; WWC Strategy Recap
2:40 ET	**Flood Inundation Mapping | *Water Availability, Quality, and Risk Output 2*** Sean Helfrich
3:20 ET	**Droughts | *Extreme Events and Cascading Hazards Output 7*** Veva Deheza
3:55 ET	Upcoming Water Team Meetings

The Weather, Water, and Climate Strategy

Developed by the ESIB with input from all Line Offices and 100+ SMEs, the WWC Strategy was published to noaa.gov in October 2022. It reflects an integrated Earth systems approach, and directly supports CRN and the NOAA and DOC Strategic Plans.

Organized around 6 Societal Challenges

- ★ Extreme Events and Cascading Hazards
- ★ Coastal Resilience
- ★ The Changing Ocean
- ★ Water Availability, Quality, and Risk
- ★ Effects of Space Weather
- ★ Monitoring and Modeling for Climate Change Mitigation

Outcomes and Outputs to be achieved in the next 5 years

- ★ Outcomes describe high level science and service innovations to be achieved in collaboration with partners
- ★ Outputs are the specific and necessary actions the agency will take to achieve the 5-year outcomes

Weather, Water, and Climate Strategy
FY 2023-2027

NOAA NESDIS Flood Inundation Mapping (FIM) products

NOAA POC: Sean Helfrich

Josef Kellndorfer, Mitch Goldberg, Sanmei Li, Qingyuan Zhang, Xinyi Chen, Qing Yang, William Straka, Christopher Jackson, Tyler Ruff, Shawn Carter, Bill Sjoberg, and Frank Monaldo.
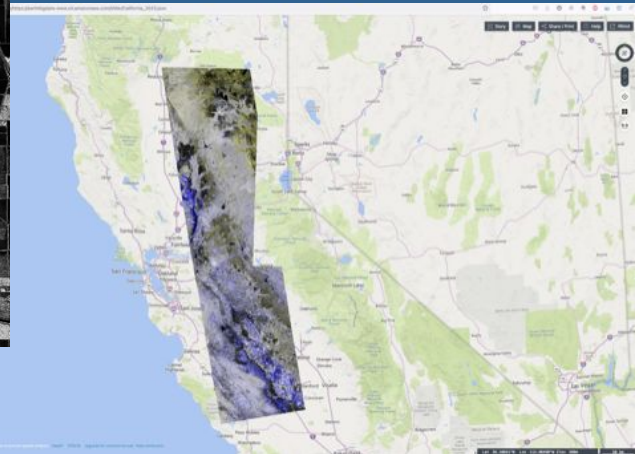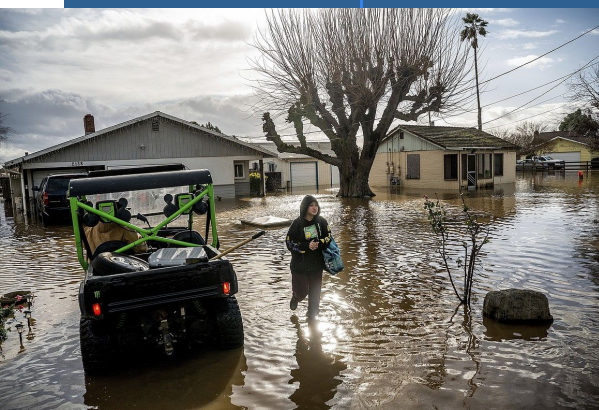
NOAA Water Team Meeting – April 19, 2023

NOAA Flood / Coastal Inundation Mapping Development Products

- **VIIRS Flood Detection - US** (3 products)
  - *NWS NRT; NWS Daily Composite; NWS 5-day Composite*
- **VIIRS Flood Detection - Global** (3 products)
  - *Global NRT; Global Daily composite; Global 5-day Composite*
- **Synthetic Aperture Radar (SAR) (1 Product)**
  - *(Sentinel 1, RadarSat Constellation Mission (RCM), RadarSat 2, ALOS 4 (2023), and NISAR (2023)*
- **ABI US Flood Detection Products** (2 products)
  - *Hourly Composite; Daily Composite*
- **Blended Flood Detection - VIIRS/ABI and VIIRS/SAR** (2 products)
- **Flood Depth - Downscaled VIIRS Flood Depth, SAR Flood Depth, and Blended VIIRS/SAR** (3 Products)

VIIRS / ABI Flood Mapping Test Portal
https://realearth.ssec.wisc.edu/#

- Online visualization page : https://www.ssec.wisc.edu/flood-map-demo/flood-products/
- Links to the single flood products:
  - VIIRS real-time flood maps: http://floods.ssec.wisc.edu/?products=RIVER-FLDglobal
  - VIIRS daily composites: https://floods.ssec.wisc.edu/?products=RIVER-FLDglobal-composite1
  - VIIRS 5-day composites: http://floods.ssec.wisc.edu/?products=RIVER-FLDglobal-composite
  - ABI Daily composites: http://floods.ssec.wisc.edu/?products=River-Flood-ABI
  - AHI Daily composites: http://floods.ssec.wisc.edu/?products=RIVER-FLD-AHI
  - Joint VIIRS/ABI: http://floods.ssec.wisc.edu/?products=RIVER-FLD-joint-ABI
  - Joint VIIRS/AHI: http://floods.ssec.wisc.edu/?products=RIVER-FLD-joint-AHI
- Also available on RealEarth App (available for Android and Apple)

- The flood products via Web Mapping Service (via Real Earth) and FTP are available

- Note that these products are not supported 24/7 but do have a high reliability of uptime.
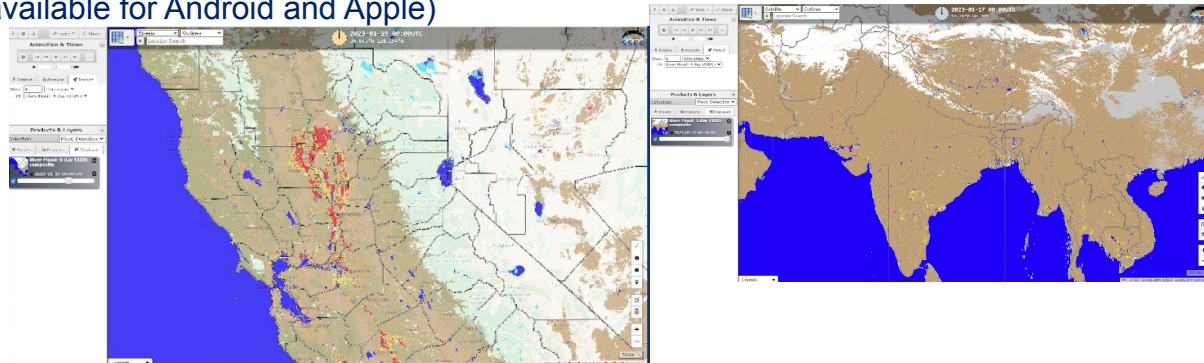
# Lists of VIIRS/ABI/AHI Flood Products

Products	Spatial resolution	Availability	Coverage	Production latency	Description
Suomi-NPP &NOAA-20/VIIRS near real-time flood product	375m	2-3 daytime passes for each satellite	Global land between 80°S and 80°N	Available 3 hours after pass	Daytime-only flood extent in water fractions (open water percentage in a satellite pixel)
Suomi-NPP &NOAA-20/VIIRS daily composited flood product	375m	Once per day	Global land between 60°S and 75°N	All tiles available by 1030Z	
Suomi-NPP &NOAA-20/VIIRS 5-day composited flood product	375m	Once per day	Global land between 60°S and 75°N	All tiles available by 1030Z	
GOES-16&17/ABI flood product	1-km	Every hour	Land in America (135° W ~ 17° W, 50.5°S ~ 50.5°N)	every hour	
Himawari-8&9/AHI flood product	1-km	Every hour	Land in East Asia and Oceania (90° E ~ 180° E, 47.5°S ~ 50.5°N)	every hour	
Joint VIIRS/ABI flood product	375m~1km	Once per day	Land in America (135° W ~ 17° W, 50.5°S ~ 50.5°N)	Available at 07Z	
Joint VIIRS/AHI flood product	375m~1km	Once per day	Land in East Asia and Oceania (90° E ~ 180° E, 47.5°S ~ 50.5°N)	Available at 18Z	

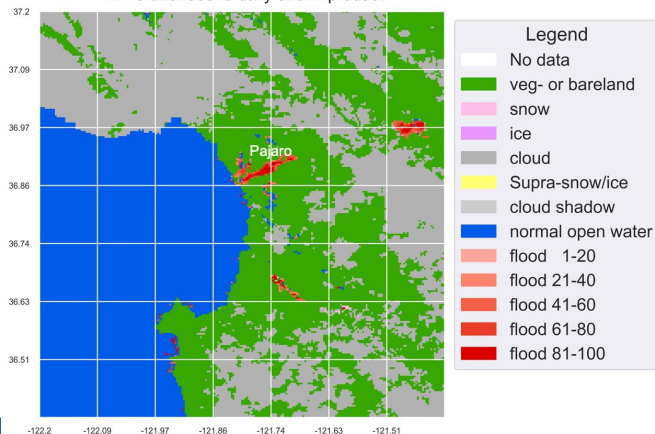# VIIRS daily floodwater extent products

VIIRS d20230308 daily 375 m product
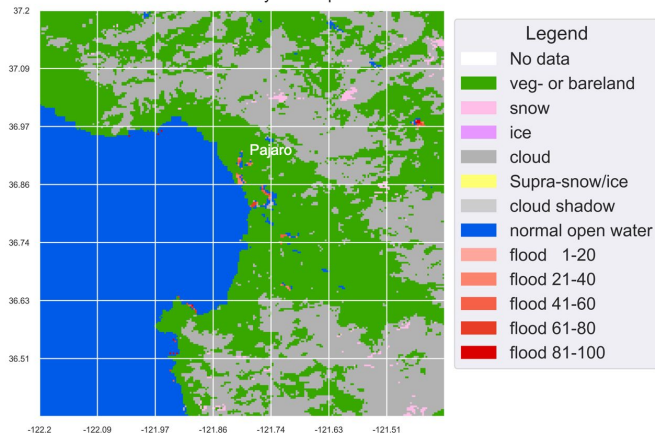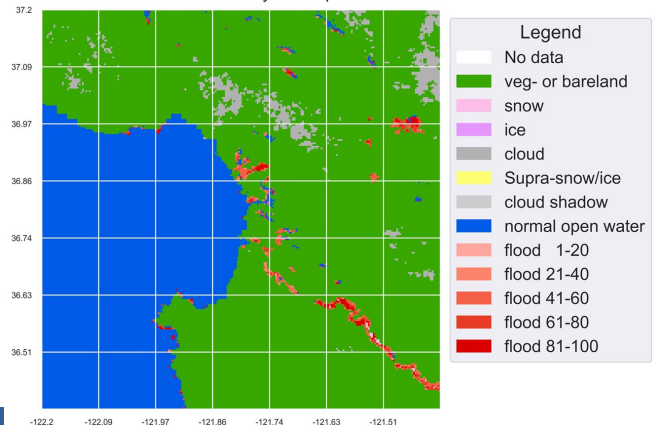
VIIRS d20230311 daily 375 m product
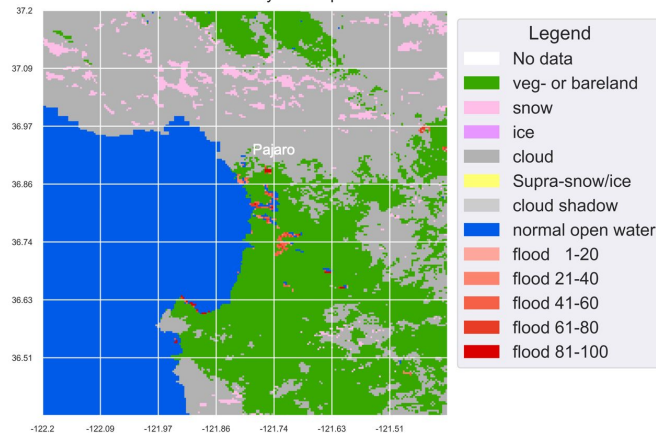
VIIRS d20230313 daily 375 m product
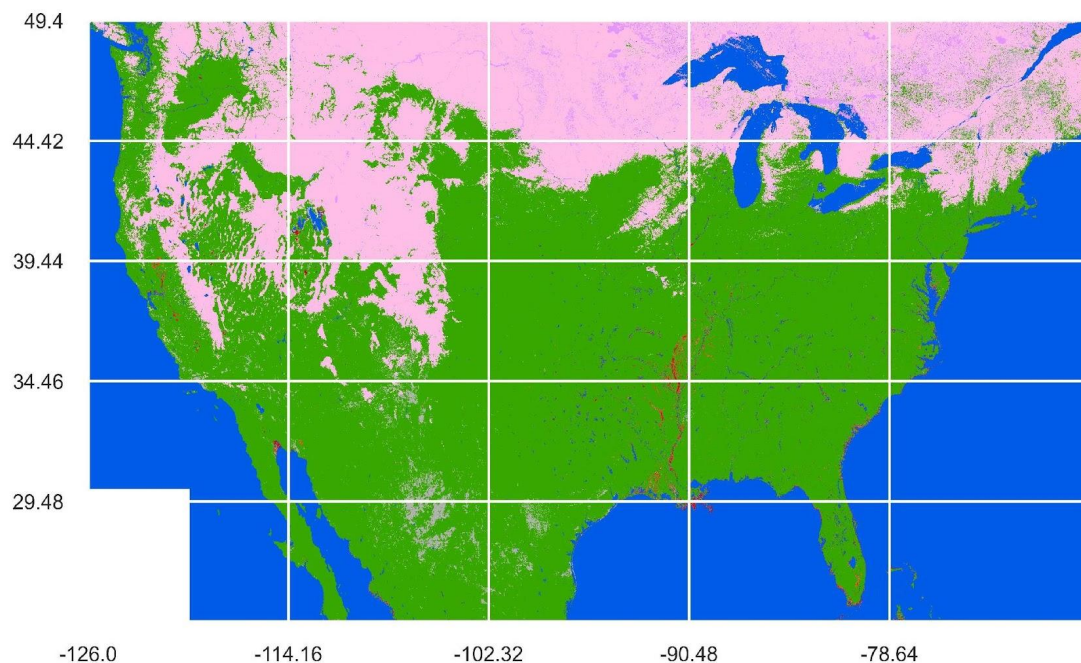
VIIRS d20230315 daily 375 m product

Pajaro levee leaking

Pajaro flooding

Salinas River now flooding

VIIRS 5 Day Composite floodwater Fraction products

VIIRS d20230317-20230321 5-day 375 m product

Legend

- No data
- veg- or bareland
- snow
- ice
- cloud
- Supra-snow/ice
- cloud shadow
- normal open water
- flood   1-20
- flood 21-40
- flood 41-60
- flood 61-80
- flood 81-100

Annual Composite Flooding from VIIRS FIM

- Monthly and annual composition in 2018 and 2020.
    - Monthly results: https://floods.ssec.wisc.edu/?products=VIIRS-Flood-Month-ObvTimes
    - Annual results: https://floods.ssec.wisc.edu/?products=VIIRS-Flood-Annual-ObvTimes
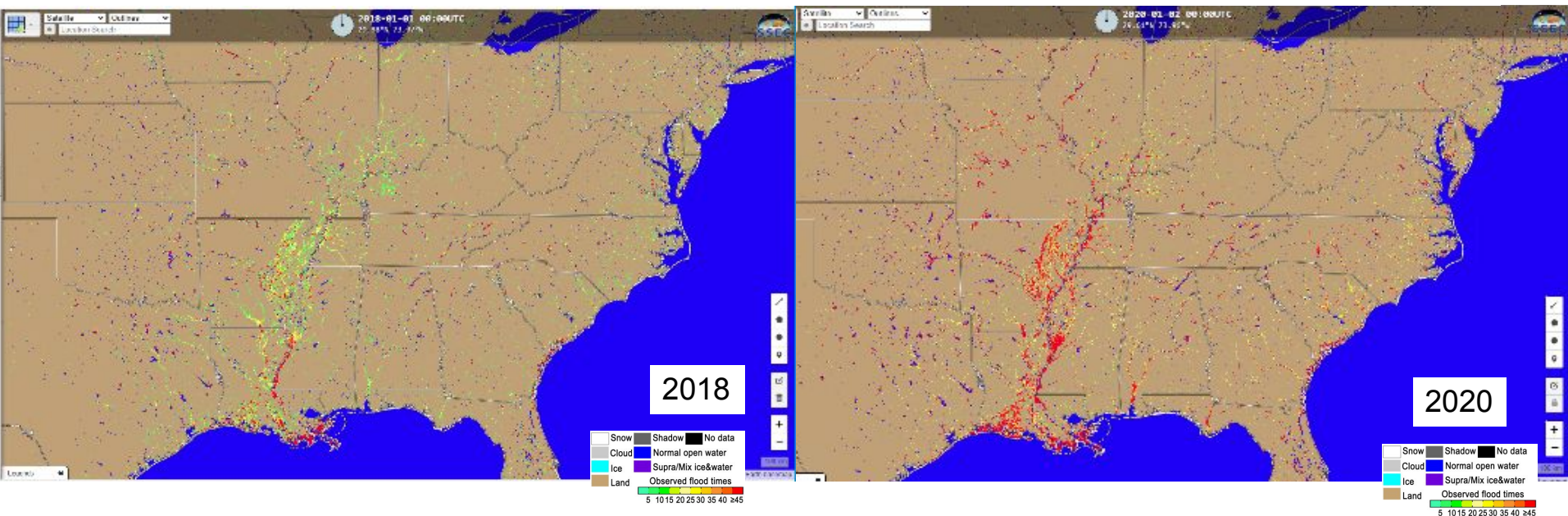
Colors from green to red represent different total observed flood times in 2018, and warmer colors indicate more frequent floods occurring in 2018. Red color means flood times ≥ 45.

Downscaling VIIRS Flood Extents

- Due to the need for street and local level flood monitoring, NOAA is testing generate finer-scale VIIRS and ABI Flood Extent
  - spectral unmixing water fractions
 - downscaling using DEM data

Unmixed VIIRS pixel

50 % land

50 % water

375 m

Locate water fraction in pixel

VIIRS pixel footprint on DEM or historical flood map

50 % land

50 % water

375 m
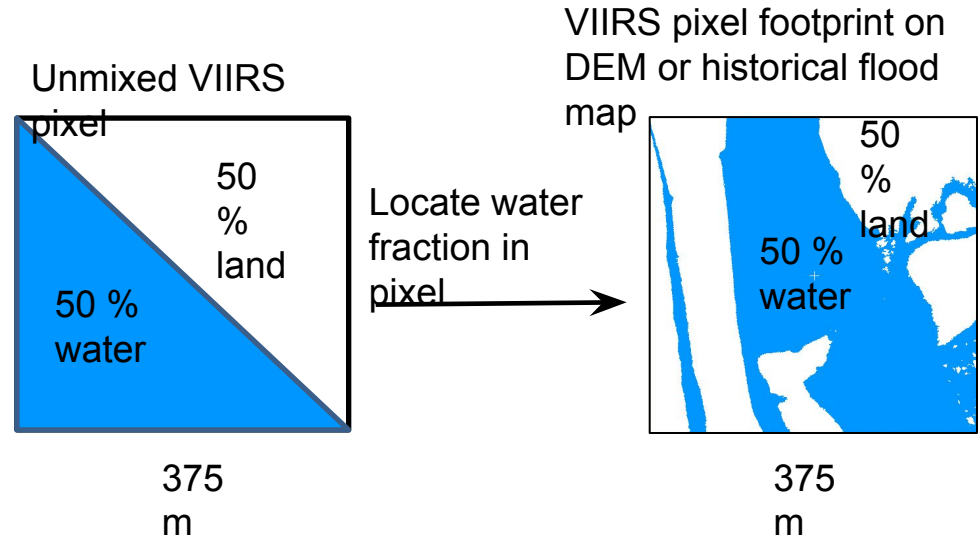
Currently, JPSS provides daily (unmixed) water fractions at a global scale, while generation of downscaled extents and flood depths is semi-operational over selected sites
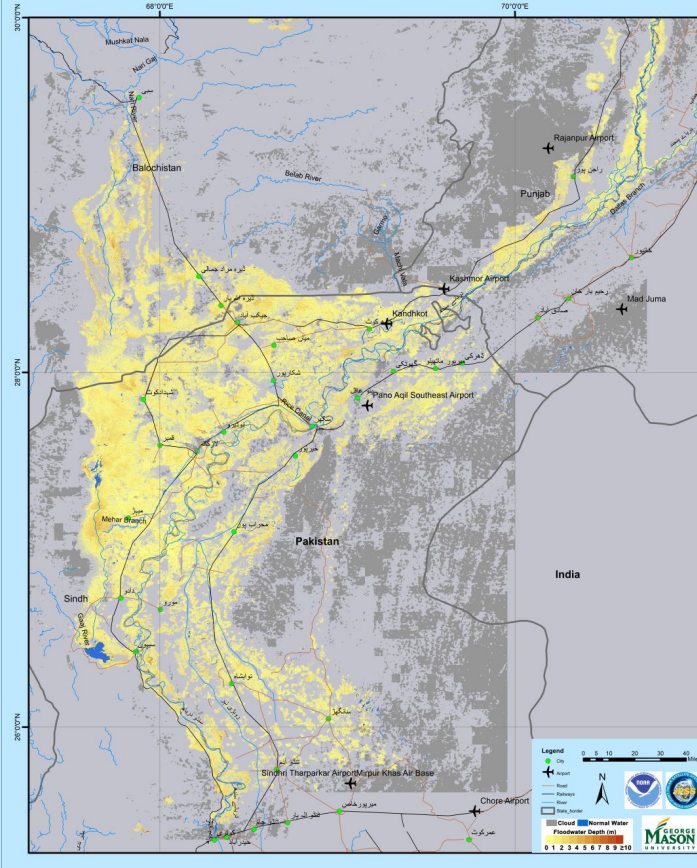
By integrating SAR data, can we improve VIIRS water fraction estimates? Can different DEM data and downscaling techniques be used to improve downscaled flood extents?

Suomi-NPP&NOAA-20/VIIRS 30m Floodwater Depth Map
in Pakistan on Aug. 27th, 2022
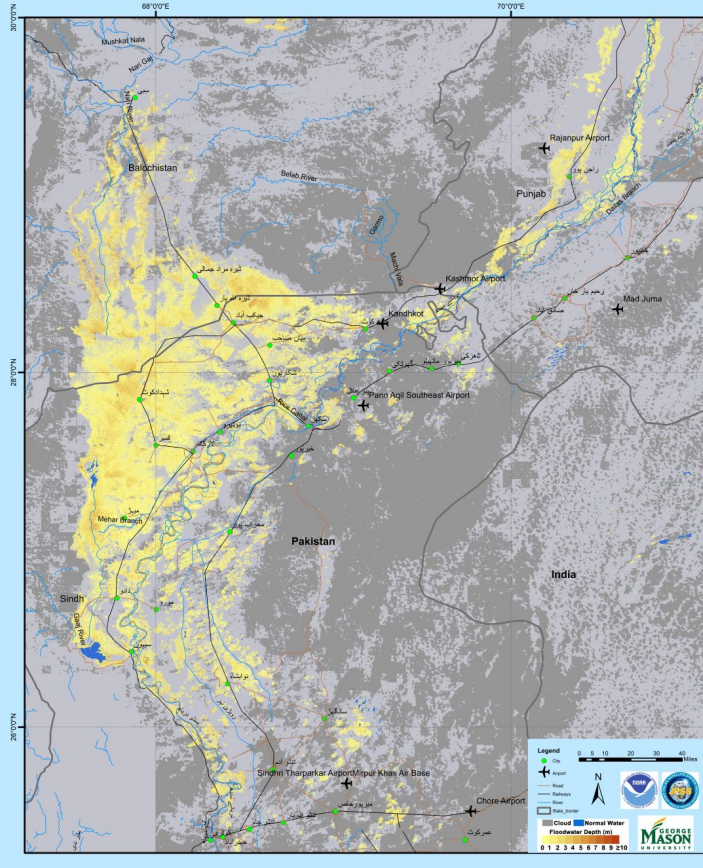
Suomi-NPP&NOAA-20/VIIRS 30m Floodwater Depth Map
**in Pakistan on Aug. 28th, 2022**

A paper from Sanmei Li et al (**A Downscaling Model for Derivation of 3-D Flood Products from VIIRS Imagery and SRTM/DEM**) has been accepted for publication in ISPRS Journal of Photogrammetry and Remote Sensing.

VIIRS downscaled 30-m floodwater depth maps in Pakistan on Aug. 27 and Aug. 28, 2022

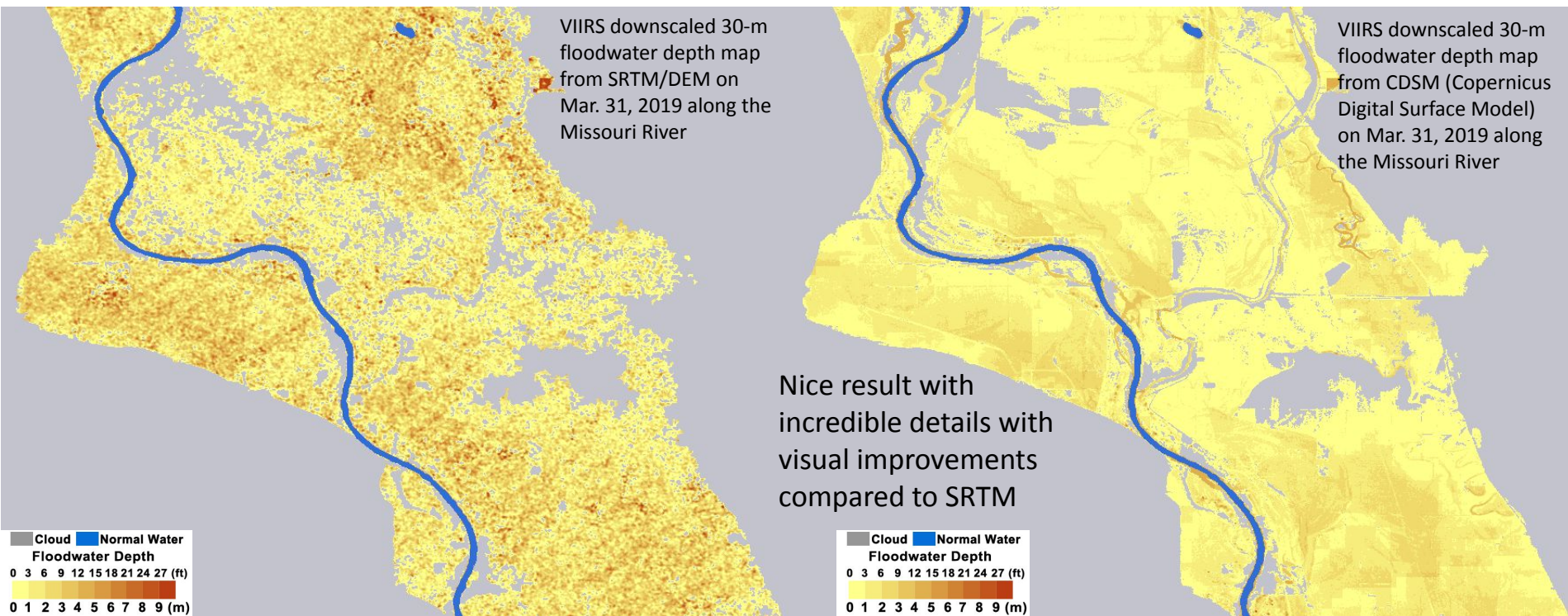NOAA National Environmental Satellite, Data, and Information Service

VIIRS Flood Support During March 2023 California Floods
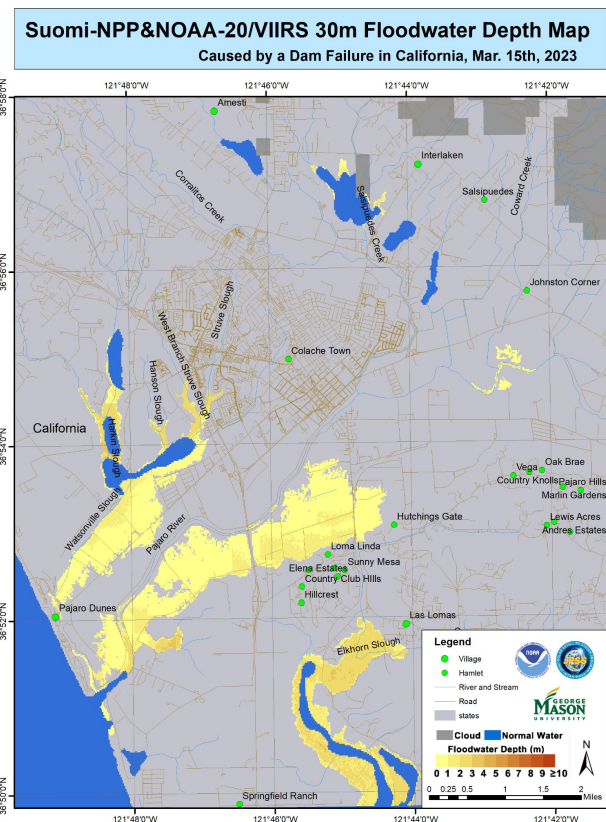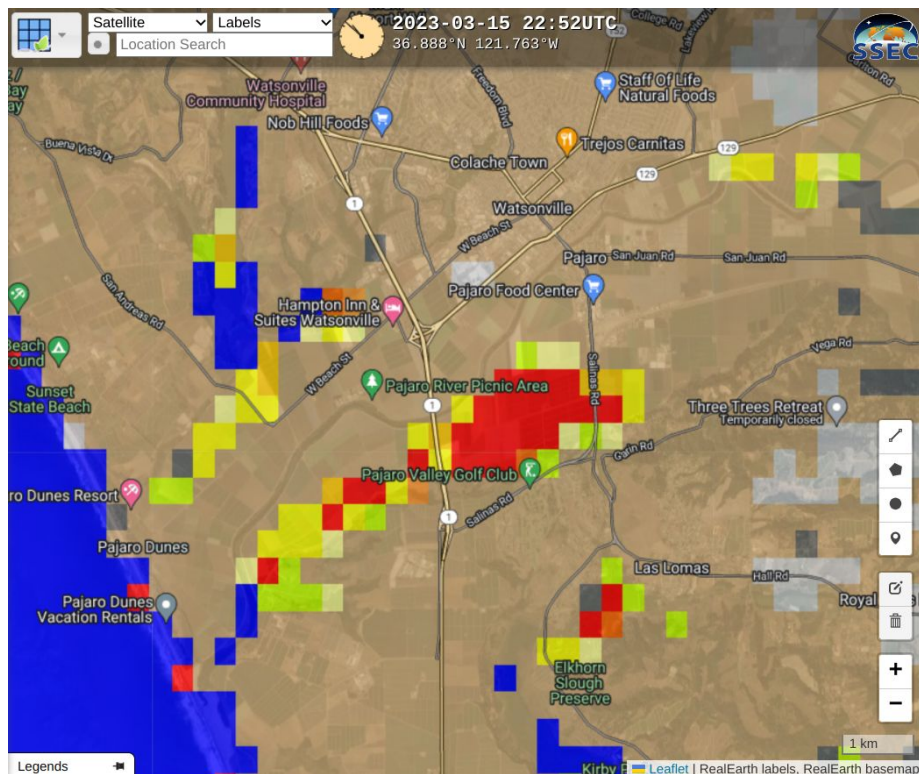
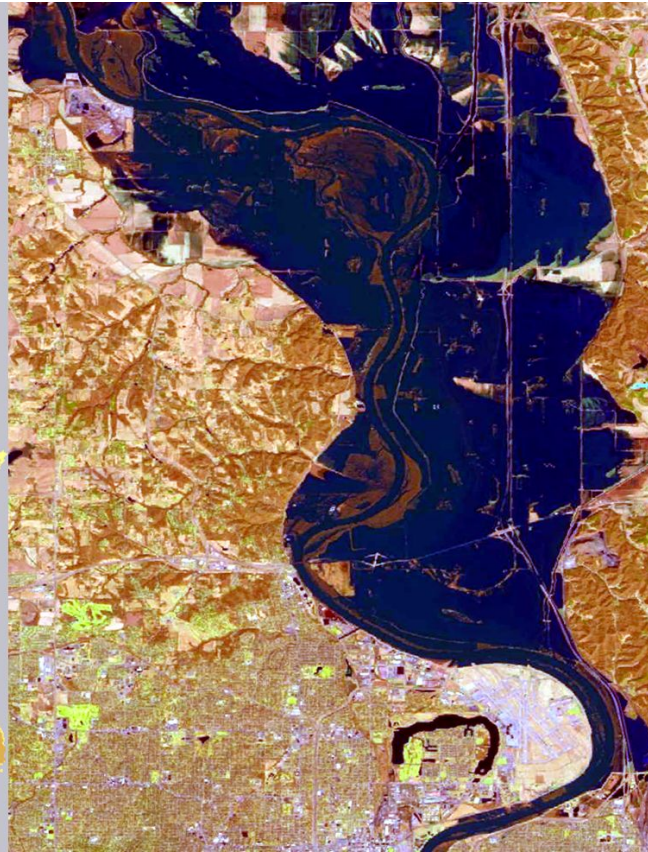VIIRS 375m Flood Fraction and downscaled 30-m floodwater depth maps over Pajaro, CA on Mar 15, 2023
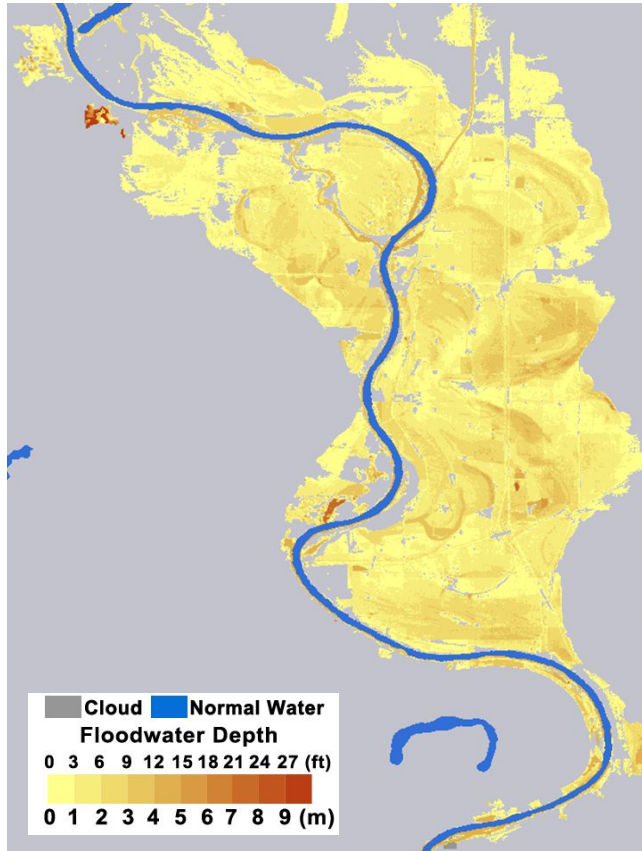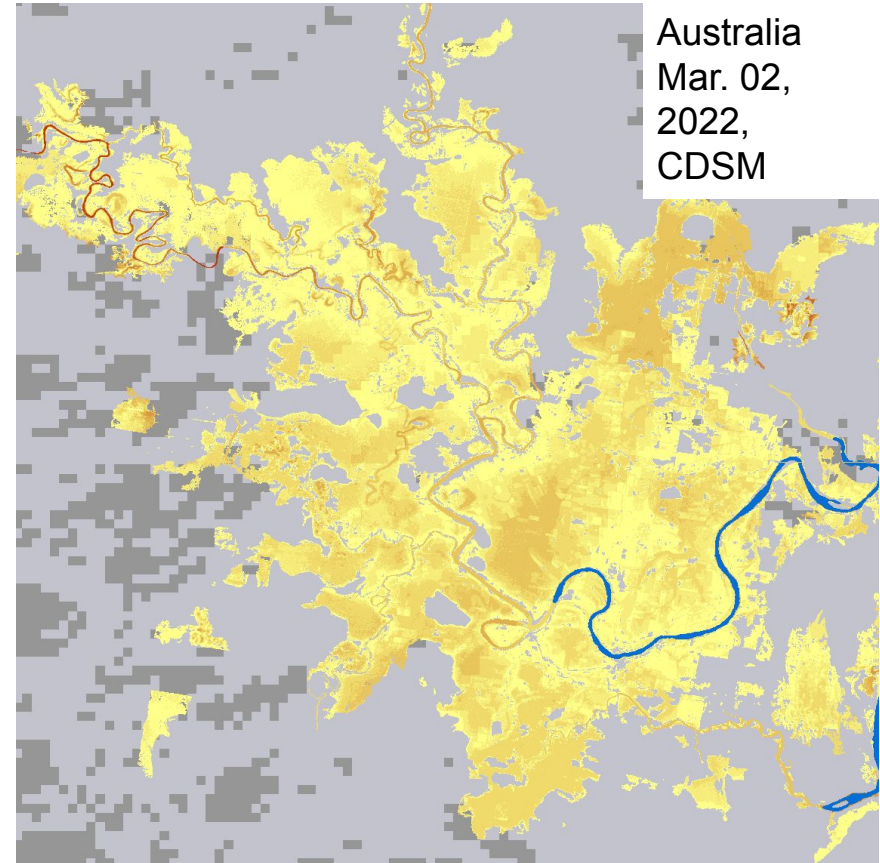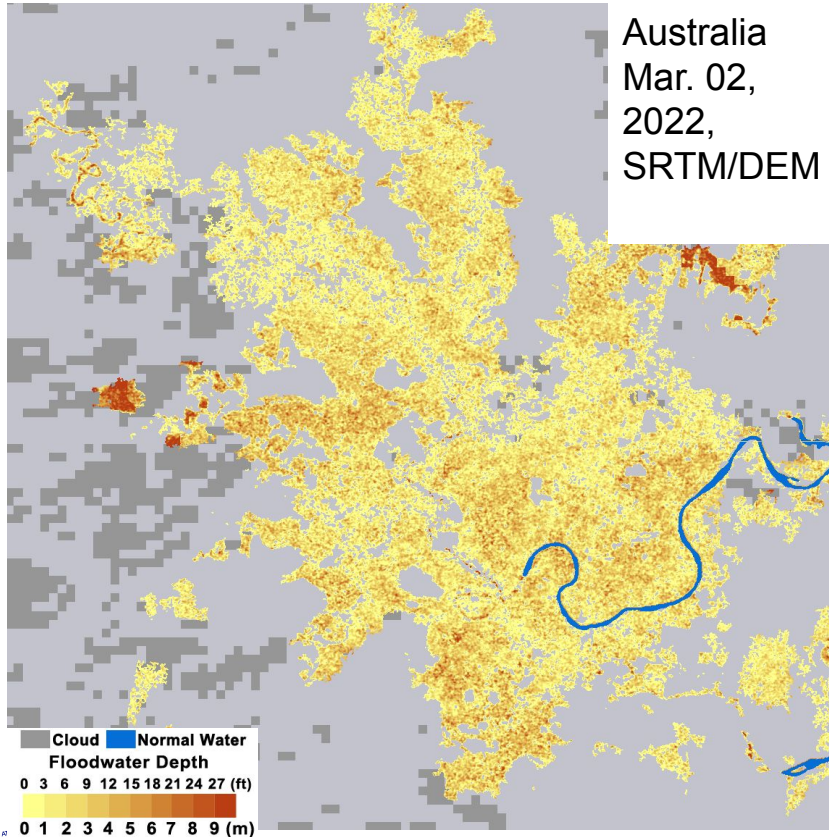
Updating the DEM used in VIIRS Flood Depth

VIIRS downscaled 30-m floodwater depth map from SRTM/DEM on Mar. 31, 2019 along the Missouri River

VIIRS downscaled 30-m floodwater depth map from CDSM (Copernicus Digital Surface Model) on Mar. 31, 2019 along the Missouri River

Nice result with incredible details with visual improvements compared to SRTM

Cloud   Normal Water
Floodwater Depth
0 3 6 9 12 15 18 21 24 27 (ft)

0 1 2 3 4 5 6 7 8 9 (m)

Cloud   Normal Water
Floodwater Depth
0 3 6 9 12 15 18 21 24 27 (ft)

0 1 2 3 4 5 6 7 8 9 (m)

Updated VIIRS 30m Flood Depth – Nebraska Flooding

VIIRS downscaled floodwater depth map with CDSM on Mar. 21, 2019


Sentinel-2 on Mar. 21, 2019

Cloud | Normal Water

Floodwater Depth

0 3 6 9 12 15 18 21 24 27 (ft)

0 1 2 3 4 5 6 7 8 9 (m)

Updated VIIRS 30m Flood Depth – Australia Flooding

Australia
Mar. 02,
2022,
SRTM/DEM

Australia
Mar. 02,
2022,
CDSM

Cloud Normal Water
Floodwater Depth
0 3 6 9 12 15 18 21 24 27 (ft)
0 1 2 3 4 5 6 7 8 9 (m)

General SAR Characteristics

- Active microwave – Day-Night Independent
  - L-band (23 cm)
  - C-band (5 cm)
  - X-band (2 cm)

- Not obscured by clouds and rain

- Swath widths from 240 to 400 km

- Resolutions from 1 to 50 m.

- Geolocation to within a pixel for modern SARs

- Ability to apply signal polarizations

- Measurement of phase and magnitude of a signal -> interferometry, coherence, backscatter metrics
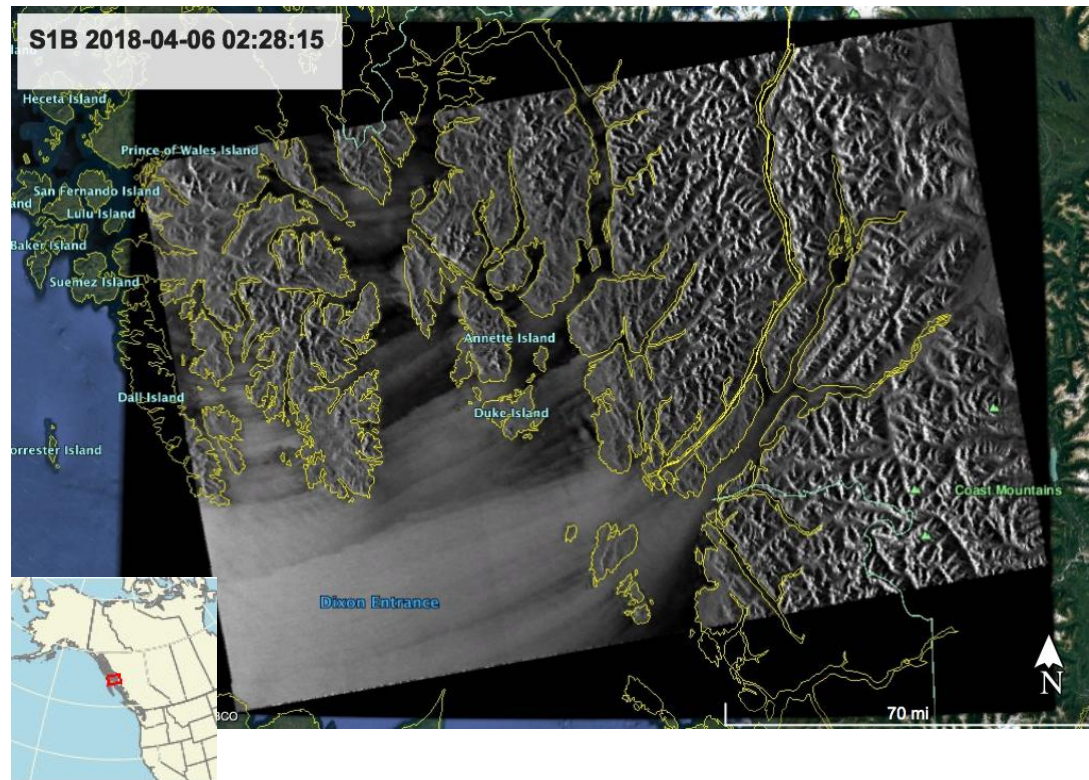
Current and Planned SAR Missions available to NOAA

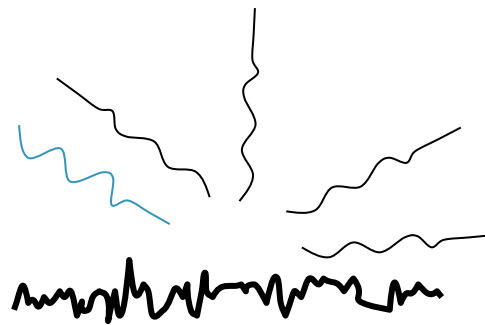| Satellite	Agency	Band	Polarization	Available Period	Availability	Deliver Time
Sentinel-1A	ESA	C	Single, Dual	2014-Present	Free	NRT
Sentinel-1B	ESA	C	Single, Dual	2016-Dec 2022	Free	NRT
Sentinel-1C	ESA	C	Single, Dual	Launch in 2023	Free	NRT
Sentinel-1D	ESA	C	Single, Dual	Launch in 2024	Free	NRT
ALOS-2	JAXA	L	Full	2014-present	Approved RA	Delay
ALOS-4	JAXA	L	Full	Launch in 2021	Working on Data Agreement with JAXA and NASA	Unknown
RADARSAT-2	CSA	C	Full	2007-present	Purchase	NRT
RADARSAT Constellation	CSA	C	CP	2020-Present	Free – Working on End User Agreement with CSA	NRT
NiSAR	NASA	L	Full	To be launched in 2024	Yes	Future

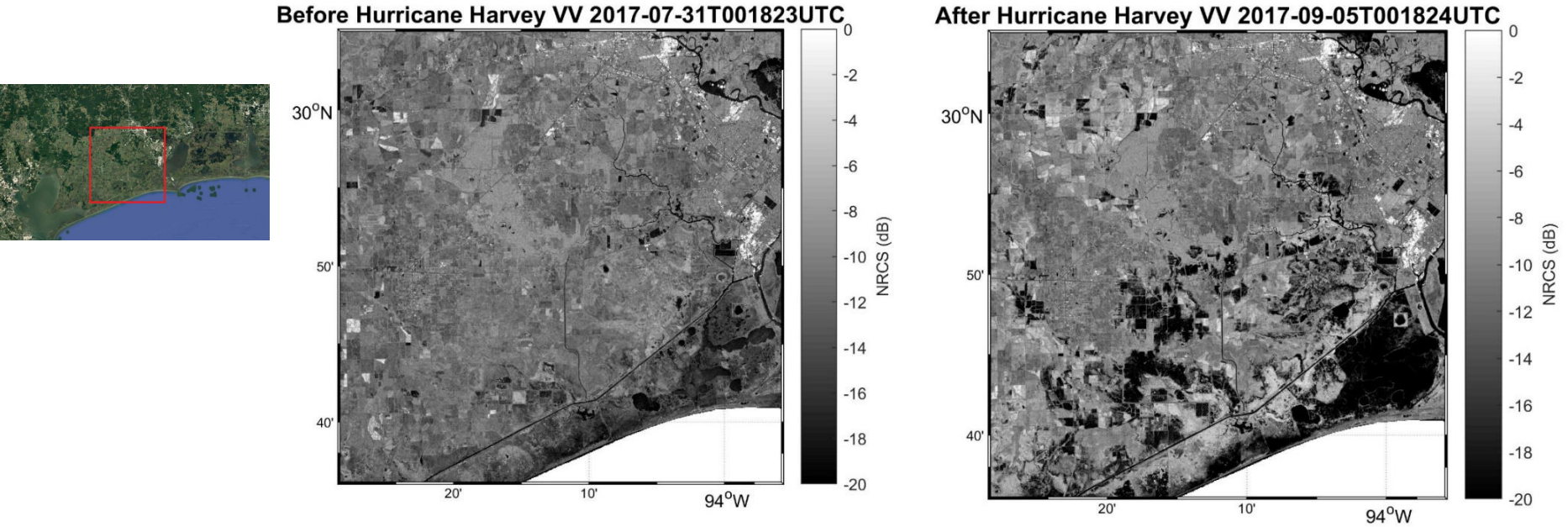**Specular scattering from a smooth surface: Most of the energy is reflected away.**
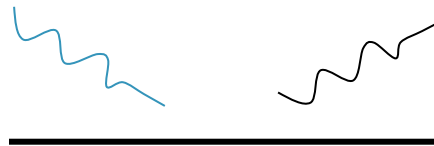
Diffuse Scattering from a rough surface: Energy is reflected in all directions.

*The rougher the surface the greater the backscatter, the brighter the SAR image.*

What about floods?

Before Hurricane Harvey VV 2017-07-31T001823UTC

After Hurricane Harvey VV 2017-09-05T001824UTC

Flat water surfaces act as reflectors and absorbers of microwaves at most SAR frequencies, so the SAR transmissions never return as backscatter to the sensor. When there is a large drop in the backscatter over land from one image from a previous date, this Is typically associated with floods.

Sentinel-1 C-Band Time Series: Red River
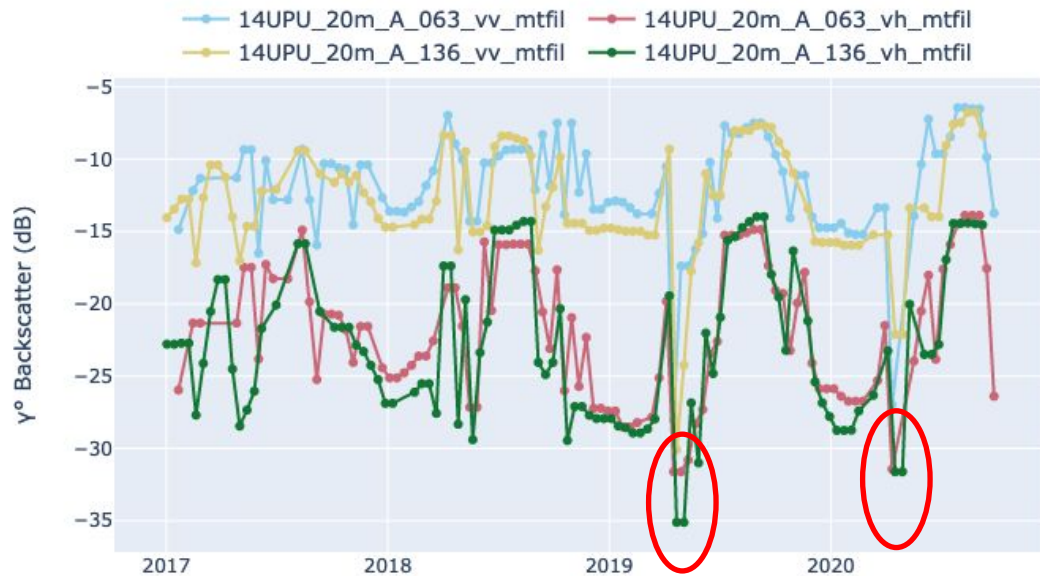
NOAA's NRT Flood Mapping Characterization

In order to test backscatter over flood areas, the performance SAR Flood Mapping Algorithms and demonstrate the algorithms to customers; STAR in collaboration with Earth Big Data developed a SAR Flood testing portal.

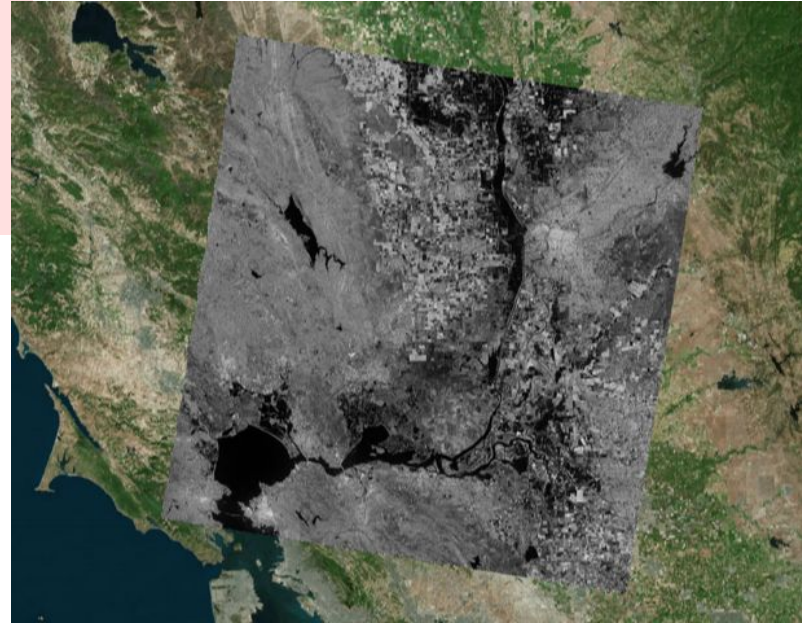Daily automated Sentinel-1 processing of all pilot regions to add to time series data stacks

Check for new available scenes at NASA DAAC

Process new available scenes with restitute precision orbit

Automated updates of MGRS tiles at
http://remotesensing.earth

RGB Flood maps for California Support:

https://data.amerigeoss.org/ameriterria/#clean&proxy/_60s/https://earthbigdata-www.s3.amazonaws.com/titiler/California_2023.json
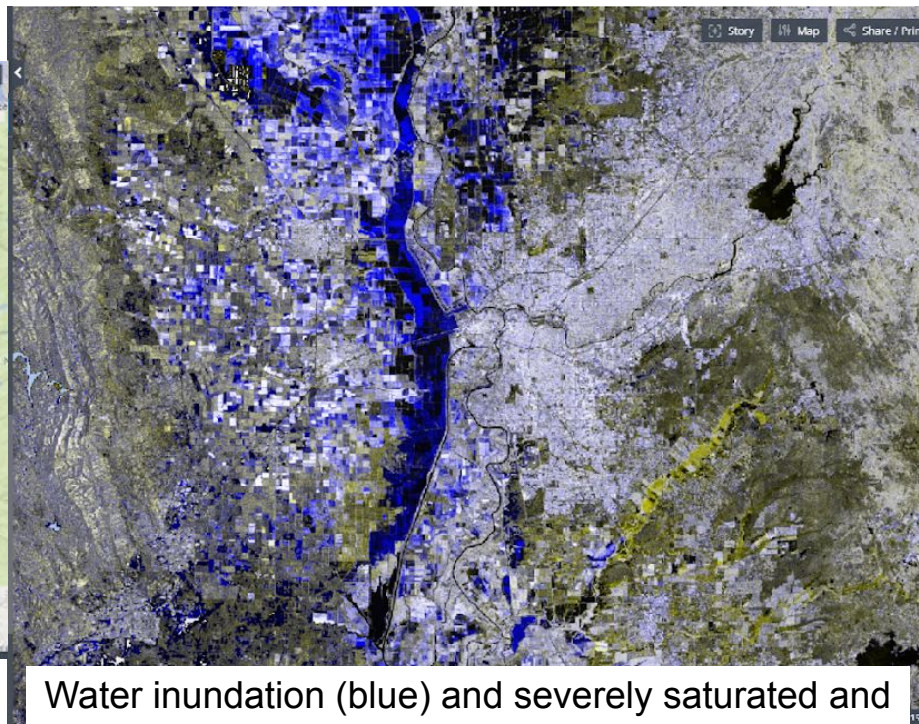
SAR RGB Flood Maps – Sacramento, CA

High Resolution RGB Sentinel (RadarSAT 2 (VV,VH)
Flood enhanced imagery Jan 14 2023
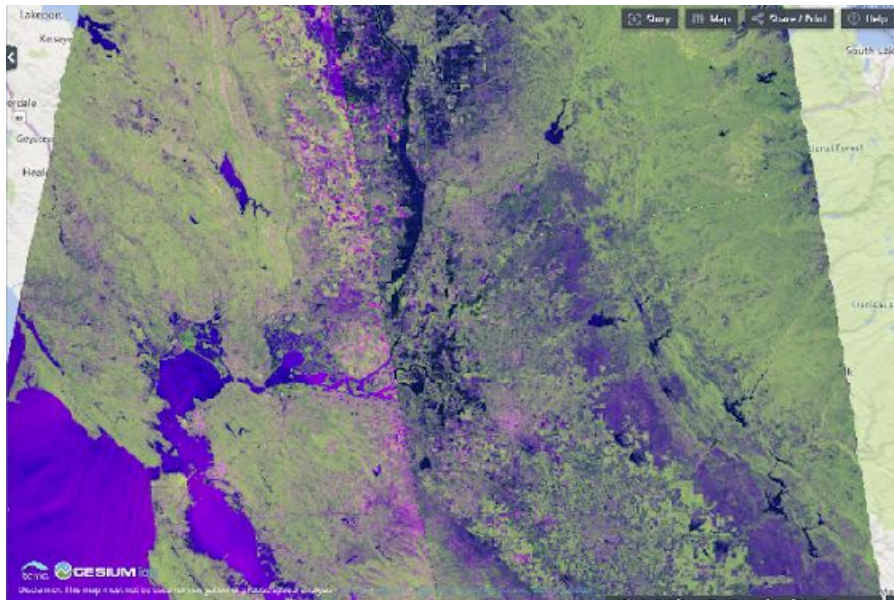
High Resolution RGB RS2 + S1a Flood
enhanced imagery Jan 14 2023

Water inundation (blue) and severely saturated and
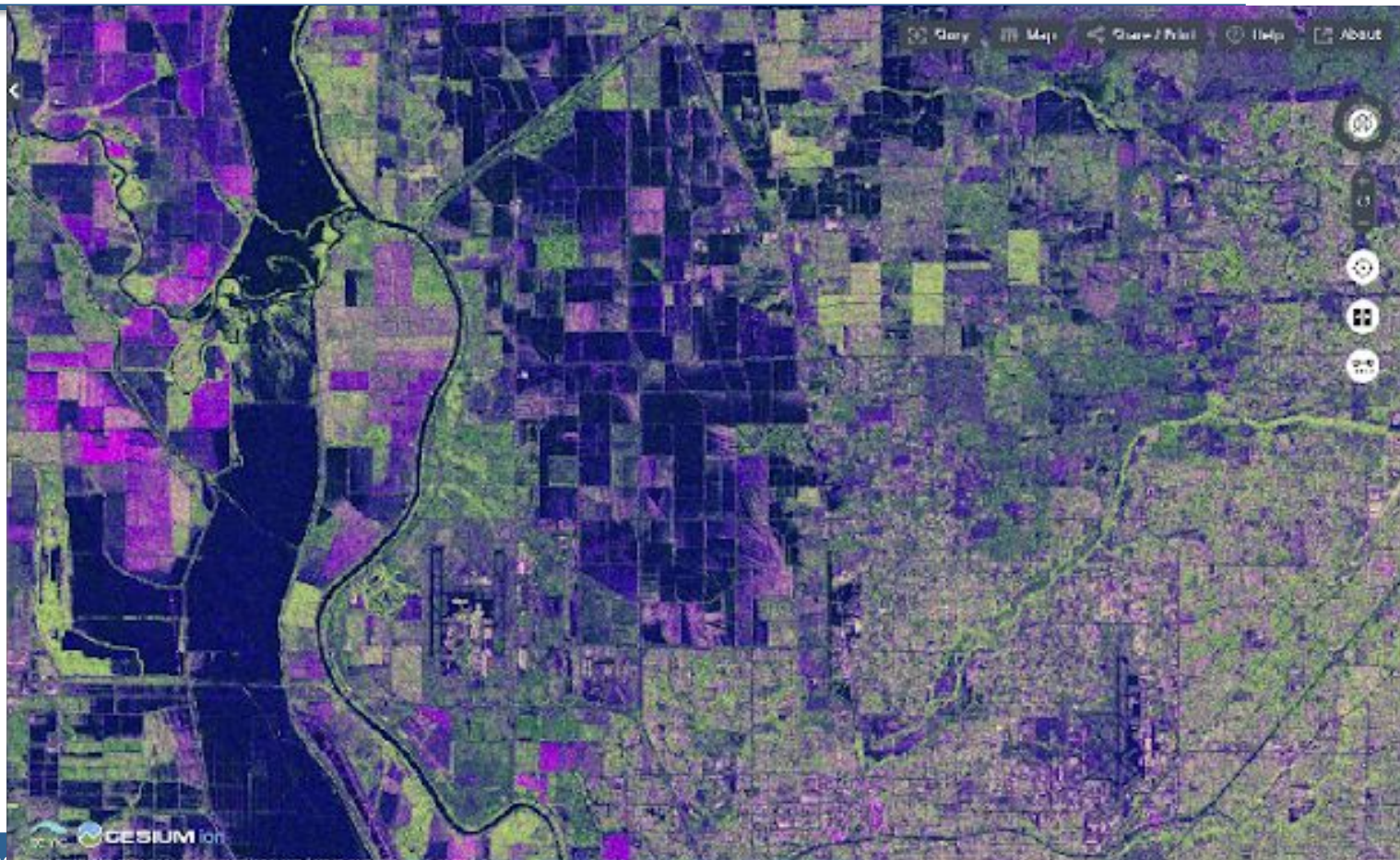water under heavy canopy (purple colors)

Water inundation (blue) and severely saturated and
water under heavy canopy (yellow colors)

SAR RGB Flood Maps – North of Sacramento, CA

Water inundation (blue) and severely saturated and water under heavy canopy (purple colors)

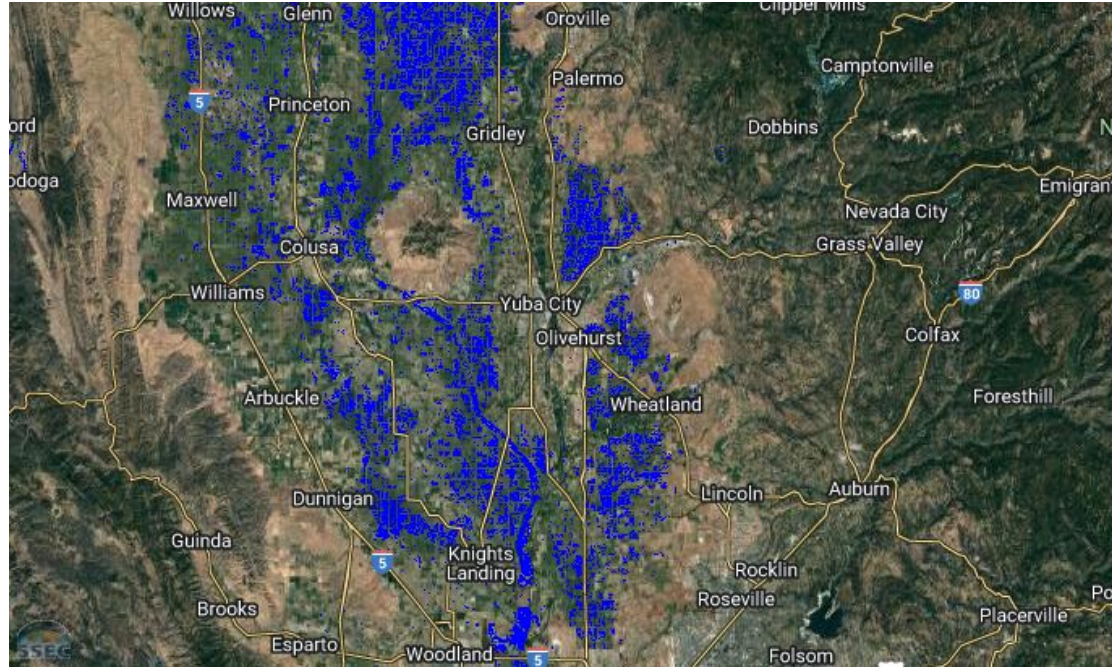This is 5m resolution SAR, allowing for detailed flood mapping.

NWS Flood Analysis based on Sentinel 1 Images

National Water Center is able to use SAR Flood Inundation Map (FIM) using Sentinel 1a from Jan 11, 2023. This product uses a single day for preflood baseline conditions to determine where backscatter has declined substantially using an Al Unet Algorithm.
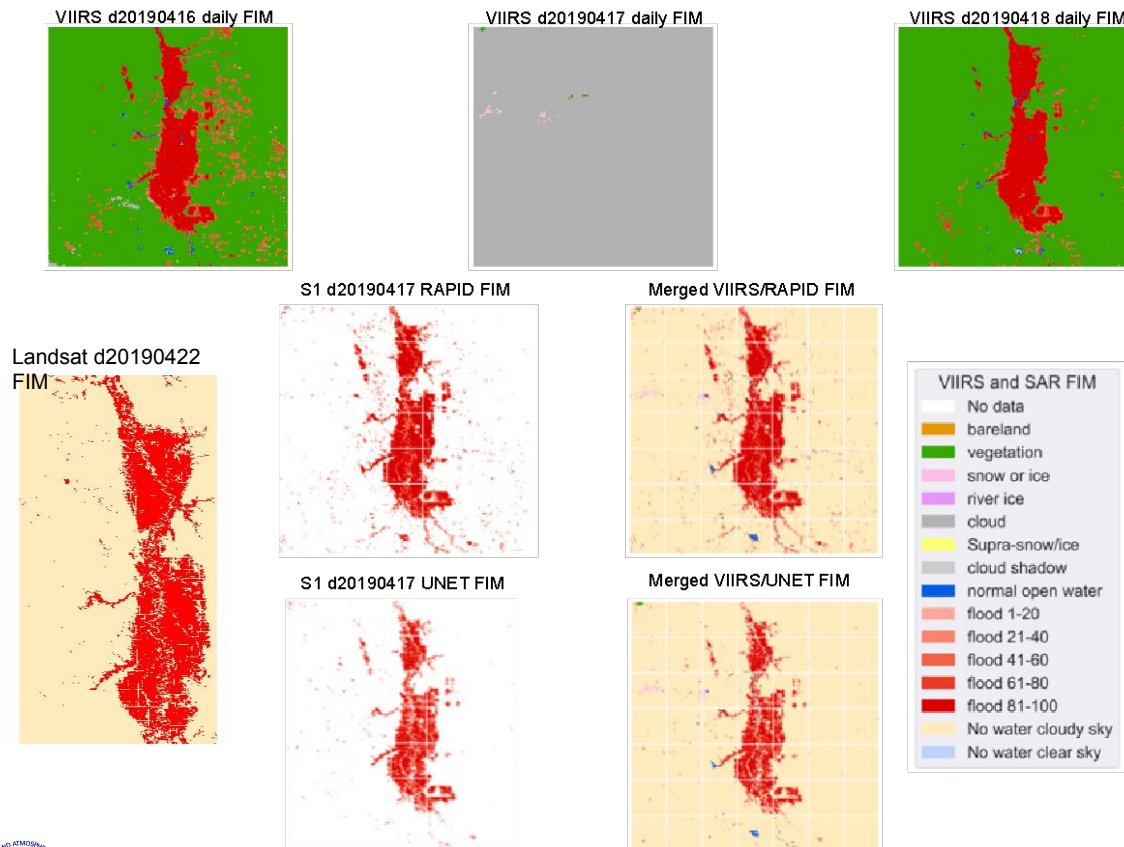
The pluvial ponding in the agricultural region of the Sacramento and San Joaquin Valleys is still very extensive.

While the UNet Flood takes only a few minutes to generate, the algorithm has mixed results in many cases.

# Machine Learning SAR Flood Detection

VIIRS d20190416 daily FIM

VIIRS d20190417 daily FIM

VIIRS d20190418 daily FIM

Landsat d20190422 FIM

S1 d20190417 RAPID FIM

Merged VIIRS/RAPID FIM

S1 d20190417 UNET FIM

Merged VIIRS/UNET FIM

VIIRS and SAR FIM

- No data
- bareland
- vegetation
- snow or ice
- river ice
- cloud
- Supra-snow/ice
- cloud shadow
- normal open water
- flood 1-20
- flood 21-40
- flood 41-60
- flood 61-80
- flood 81-100
- No water cloudy sky
- No water clear sky

- NOAA is testing performance of 2 Machine Learning algorithms (Liu et al UNET, Shen et al RAPID) for flood detection in the Red River.

- UNET excludes "permanent" water from the flood prediction, while RAPID includes "permanent" water.

- The Sentinel 1b overpass on April 17 was cloudy preventing VIIRS observations, but VIIRS flood observations on April 16 & 18 were collected allowing for a general comparison. VIIRS is 375m resolution, while the SAR products are 30m resolution.

- The 30m Landsat observation on April 22, is the closest date to the SAR overpass. Conditions by that date show the migration of the water downstream (north) and may not be suitable for direct validation, but can be applied to understand ML algorithm differences.

- **More testing is needed, but for April 17, the RAPID algorithm appears better aligned with VIIRS and LandSat.**
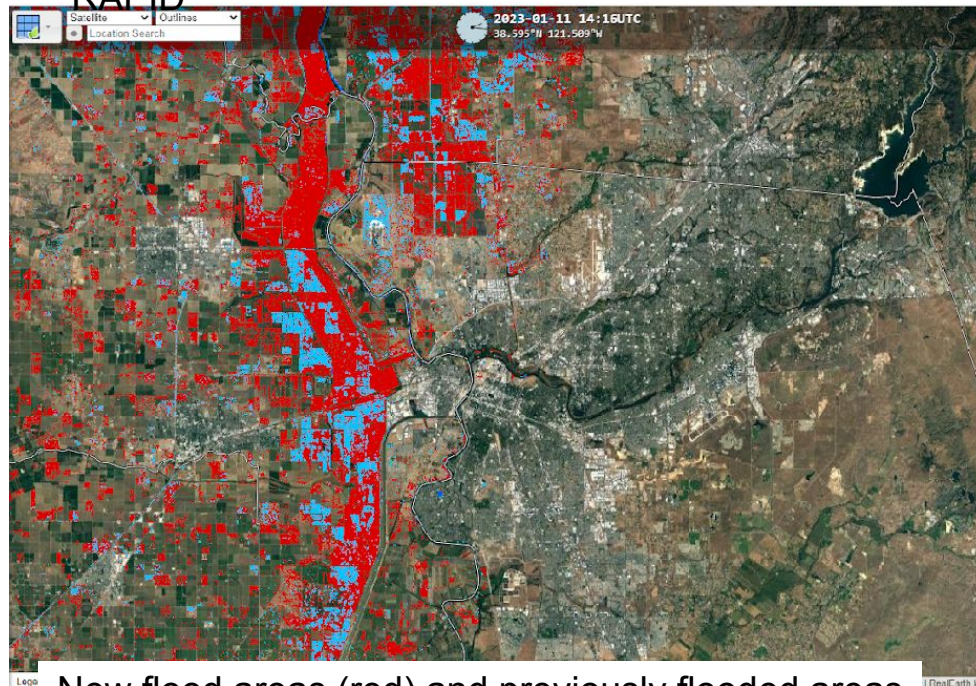
SAR RGB Flood Maps – Sacramento, CA Jan 11 2023

High Resolution RGB Flood enhanced imagery
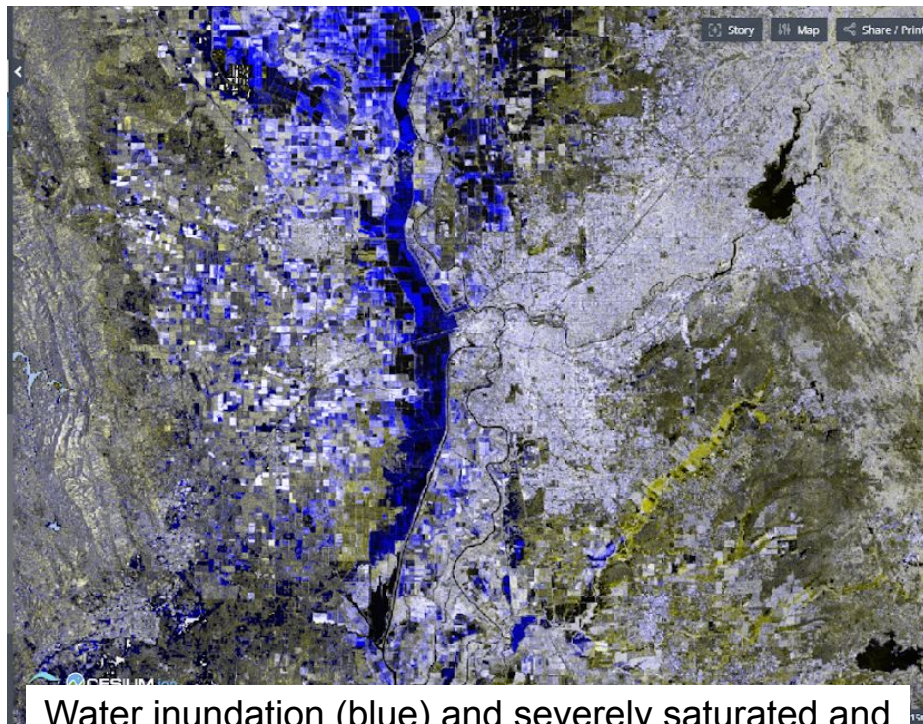
High Resolution Flood Extent Change from RAPID

Water inundation (blue) and severely saturated and water under heavy canopy (yellow colors)

New flood areas (red) and previously flooded areas (light blue)

NOAA's Developmental SAR Flood Mapping – Northern CA

NOAA is developing a new SAR based flood mapping algorithm. This algorithm will allow for detailed flood maps to be generated within minutes after an identified flood. Evaluation data is being provided to National Water Center and NOAA RFOs.

Jan 11, 2023

Jan 13, 2023
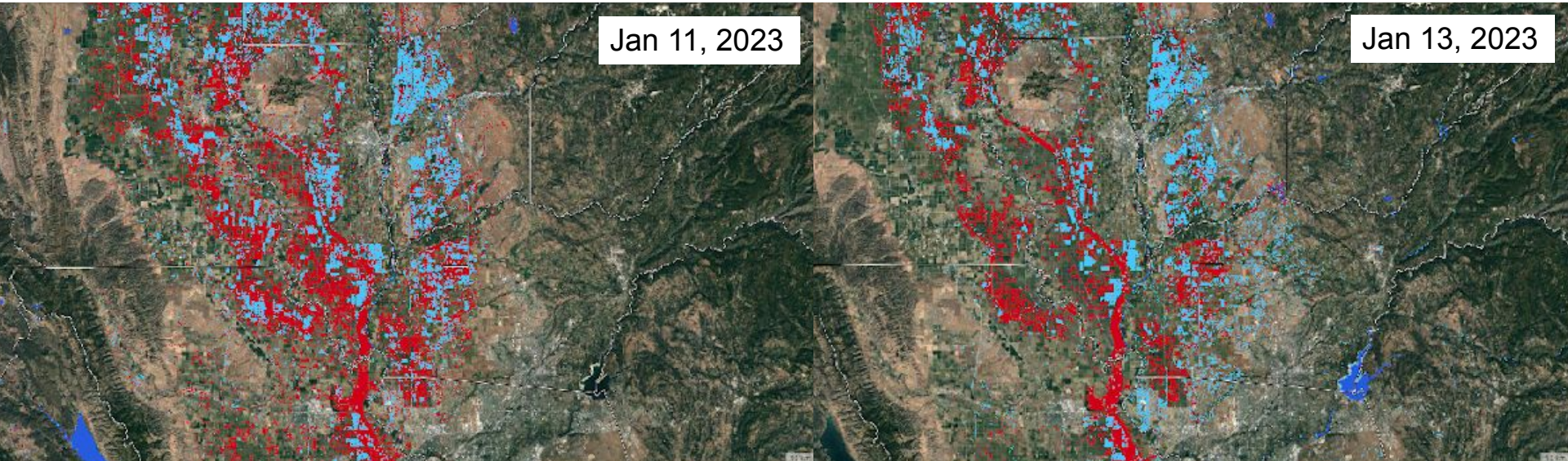
New flood areas (red) and previously flooded areas
(light blue)

Floods vs Irrigated Crops in California

irrigated croplands as pre-flood water

Dry Sentinel-1 VV 11/14/22

Planet 11/14/22
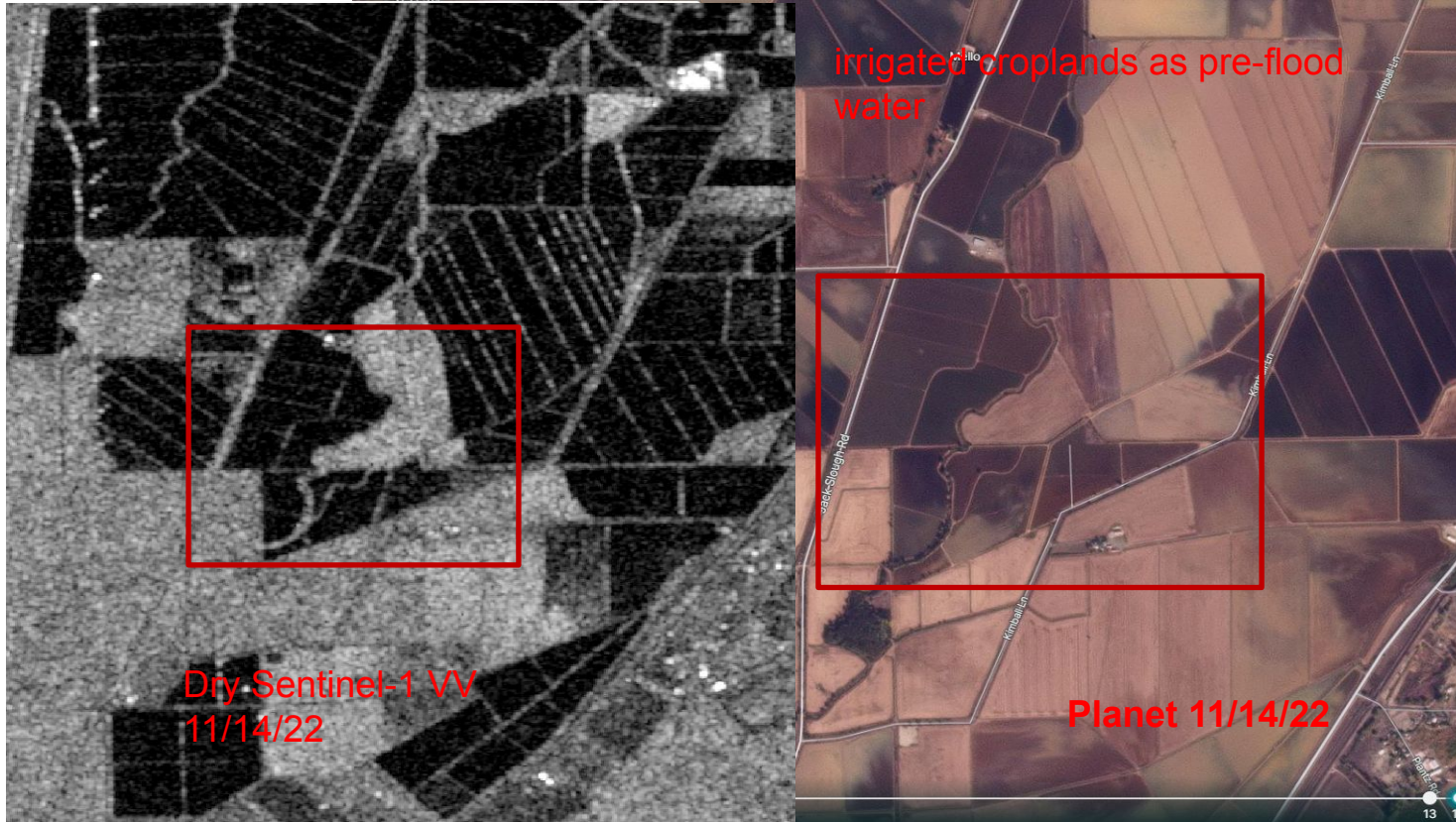
One of the challenges with SAR and Optical Flood Detection is discrimination of intentional flooding for agriculture or land management and weather related floods.

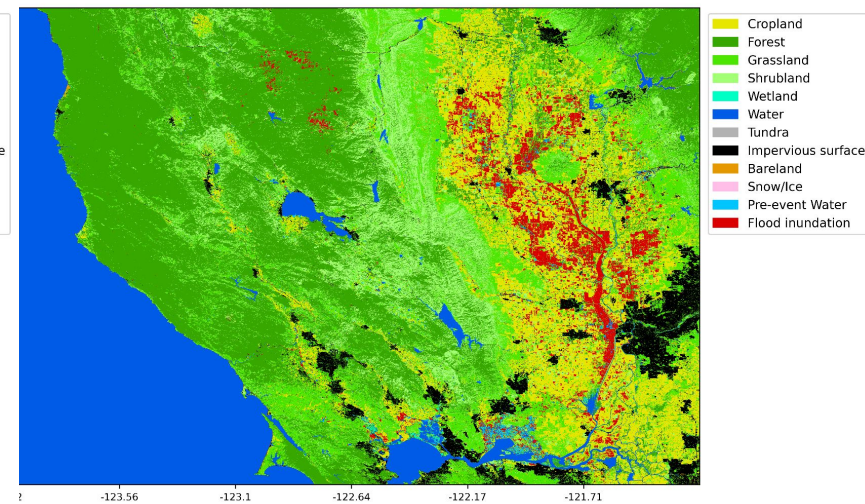# SAR Automated Flood Change Detection Maps to remove irrigation

Before labeling irrigated
croplands as pre-flood water
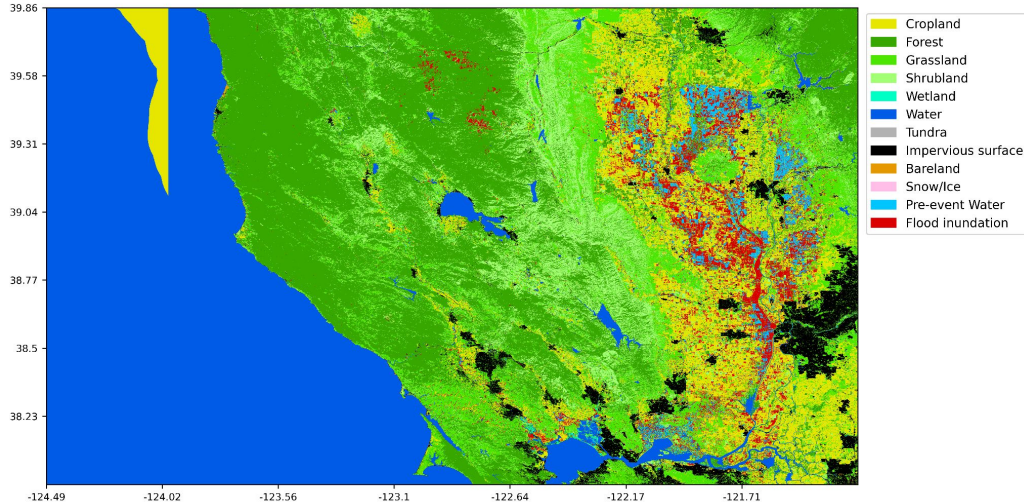
After labeling irrigated
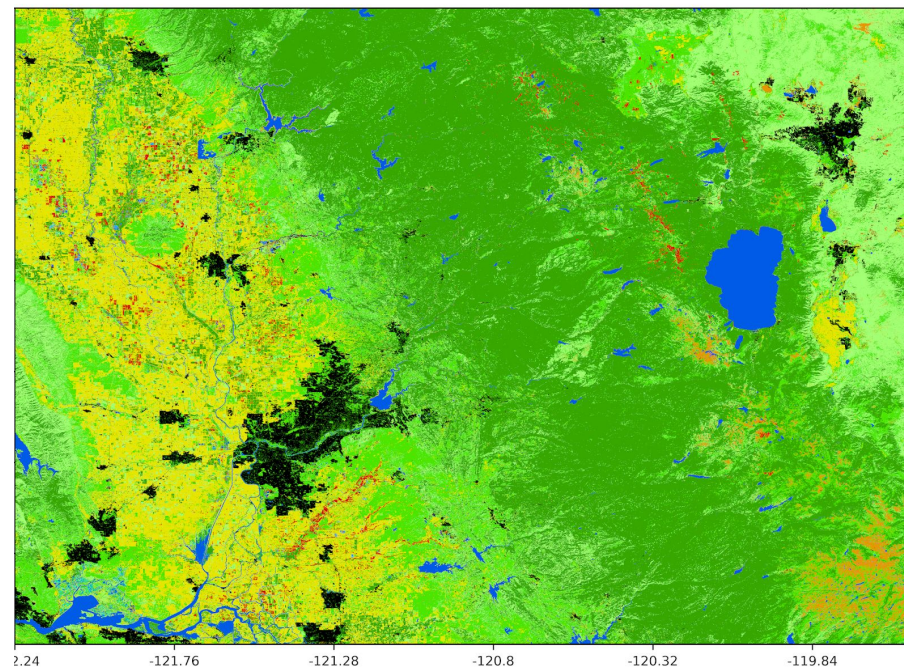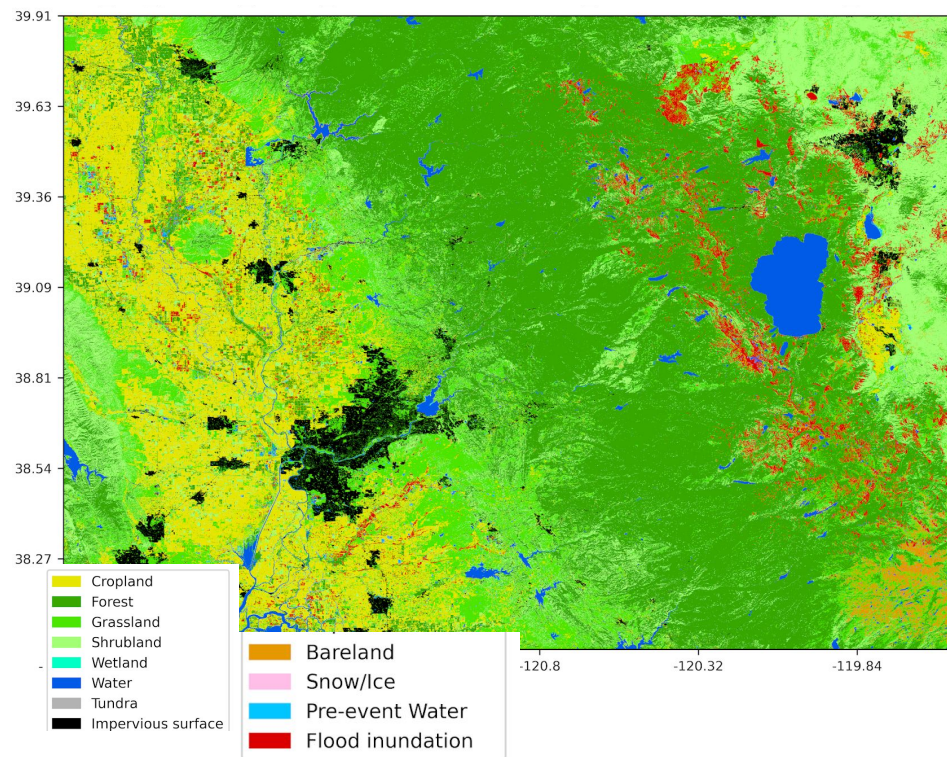croplands as pre-flood water

New flood areas (red) and previously flooded areas
(light blue)

2023-01-01 California flood RAPID SAR FIM snow removal test using VIIRS

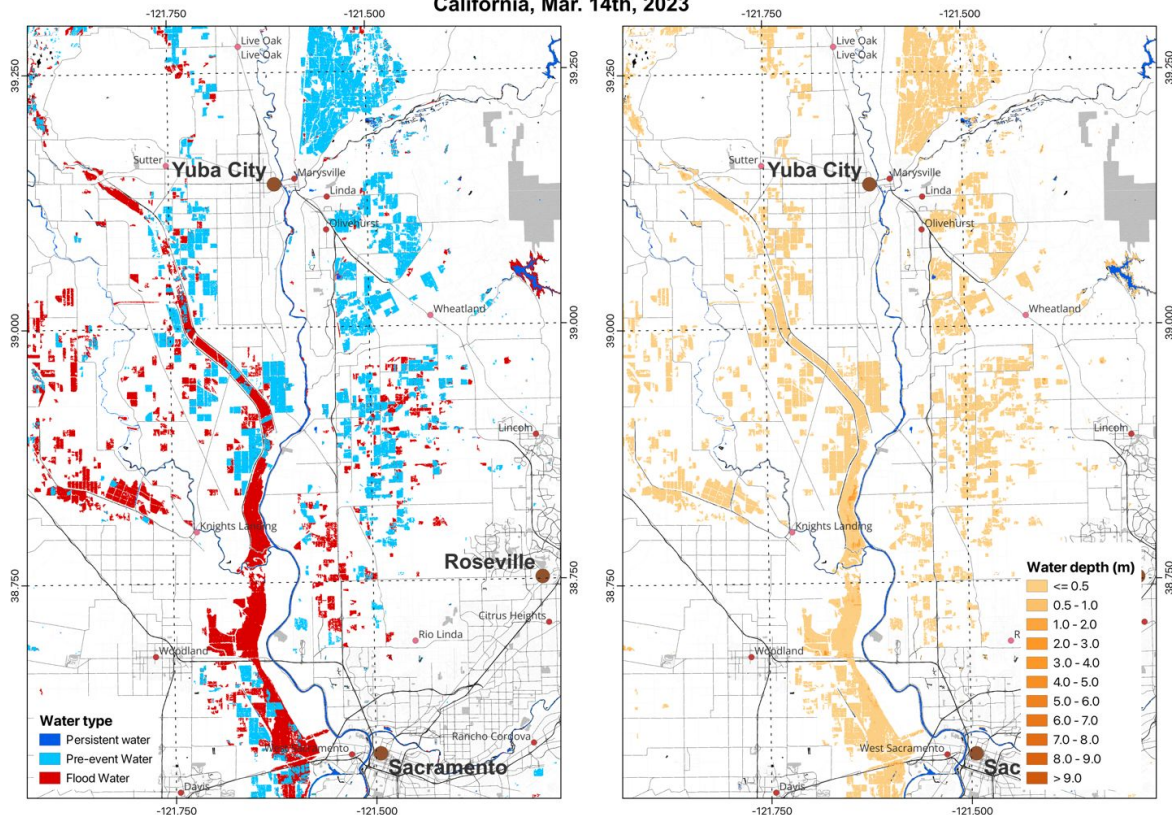Before snow pixel removal

After snow pixel removal

Legend:
- Cropland
- Forest
- Grassland
- Shrubland
- Wetland
- Water
- Tundra
- Impervious surface
- Bareland
- Snow/Ice
- Pre-event Water
- Flood inundation

New SAR flood extent and depth products

RAPID-based Sentinel-1 30 m Floodwater Extent and Depth Maps
California, Mar. 14th, 2023

# Cloud Production Support for Current Red River of the North

- ## Provision of updated GeoJSON for RFO quick ingest
  - https://earthbigdata-www.s3.amazonaws.com/presigned-urls-geojson/RCM/RCM_RTCCOG_urls.geojson?AWSAccessKeyId=AKIAJFTC5FRGKQV5C5KQ&Signature=q929oMn%2Fkb0OslQBjLAA0n34d6w%3D&Expires=1767880761
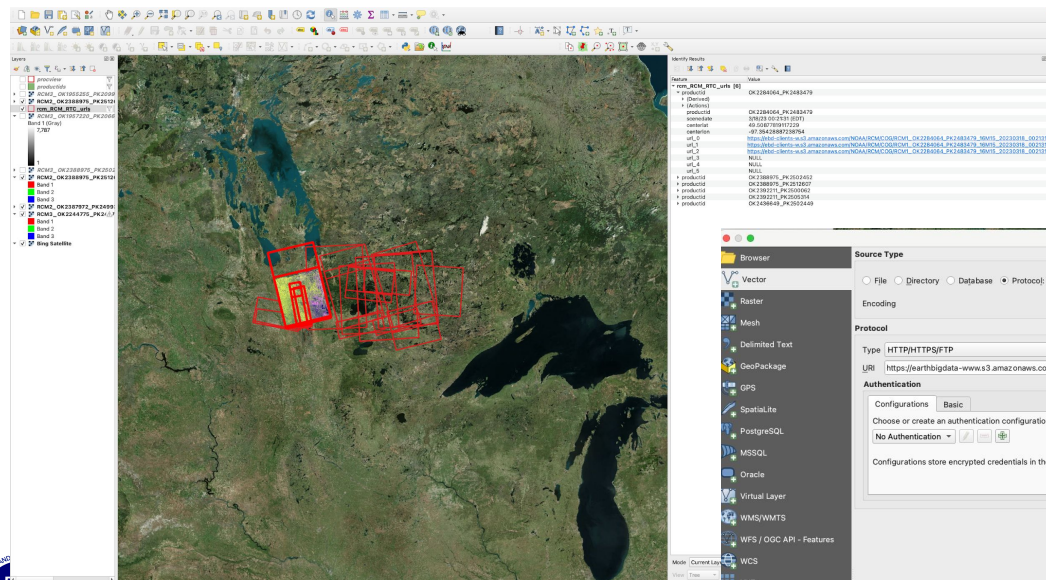
- Productid
- Scenedate
- Beammodetype
- Centerlat / centerlon
- Urls for the 16-bit amplitude and HEQ
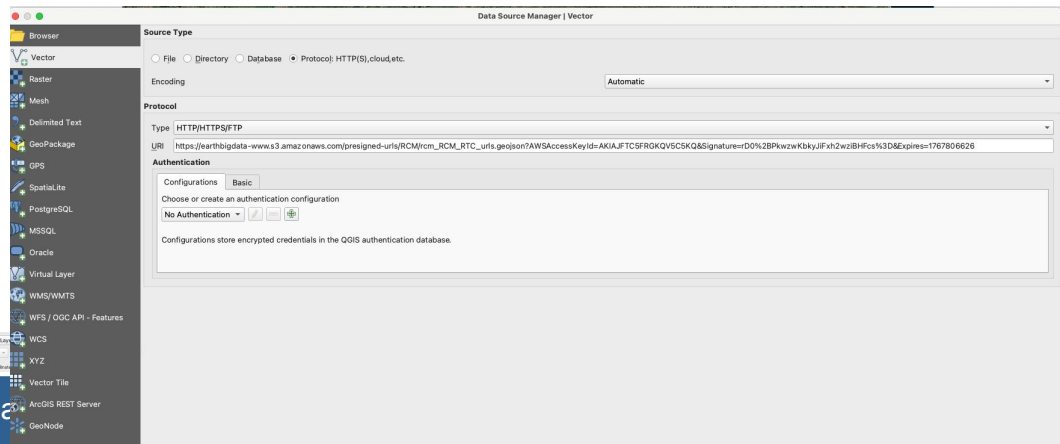
Histogram Equalized AmeriGEOSS Visualization - Red River of the North
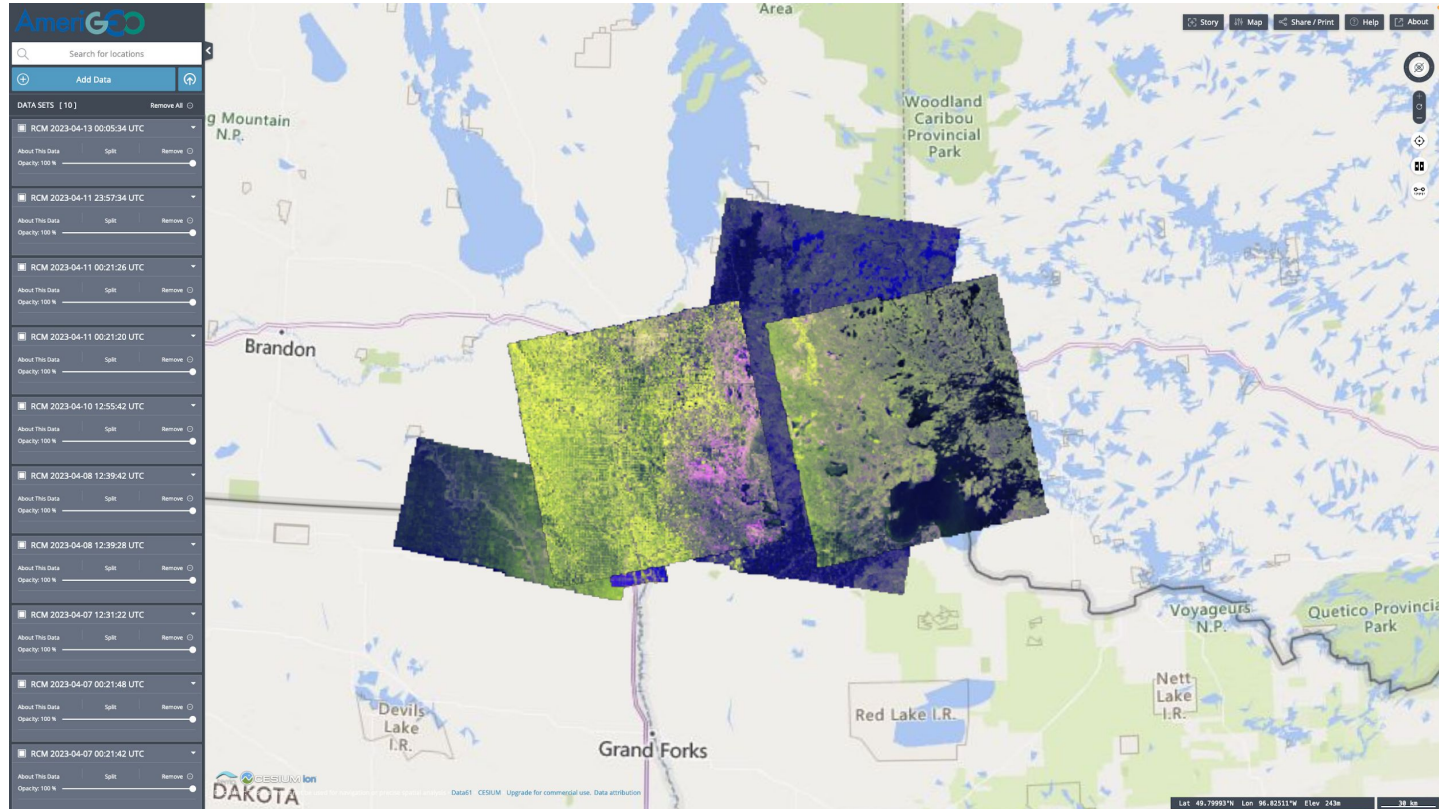
Ongoing and Future Work for 2023

- Continue evaluation and validation of SAR flood algorithms
- Working to combine use of multi-SAR satellites (RCM, RS2, Sentinel 1) to provide consistent flood maps.
- Improve snow and irrigation removal from SAR flood signal
- Improve flood mapping from SAR in urban areas and under dense canopies
- SAR Flood Depth
- Institute automated triggers for flood events
- Import all production into cloud
- Integrate SAR into same Real Earth Environment as VIIRS and GOES Products (https://floods.ssec.wisc.edu/)
- Generate historical inundation maps and frequencies for validation and downscaling
- Examine temporal changes for coastal inundation and impacts on periodic flooding

Next Meeting: May 17, 2023