Current and Future NOAA Global Flood Inundation Mapping Systems and other satellite derived products for the Arctic

William Straka - Presenter

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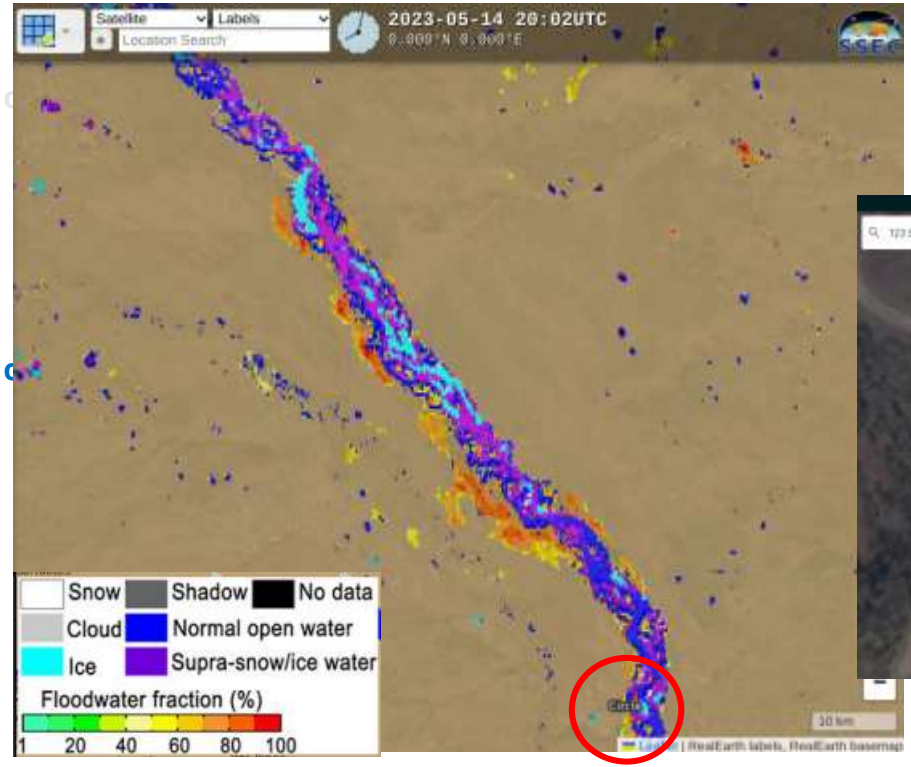
William Straka is a researcher with the Cooperative Institute for Meteorological Satellite Studies (CIMSS), where he has been working for over 18 years. He currently works as a liaison, including assisting in training, to the US National Weather Service, including APRFC during Alaska Spring Breakup season

Acknowledgements: Sanmei Li (GMU), Mitch Goldberg (CCNY/CESSRST, former NOAA NESDIS Chief Scientist), Sean Helfrich (NOAA/NESDIS) and the stakeholders who provide invaluable feedback as well as many others!

2023 Spring Breakup in Review

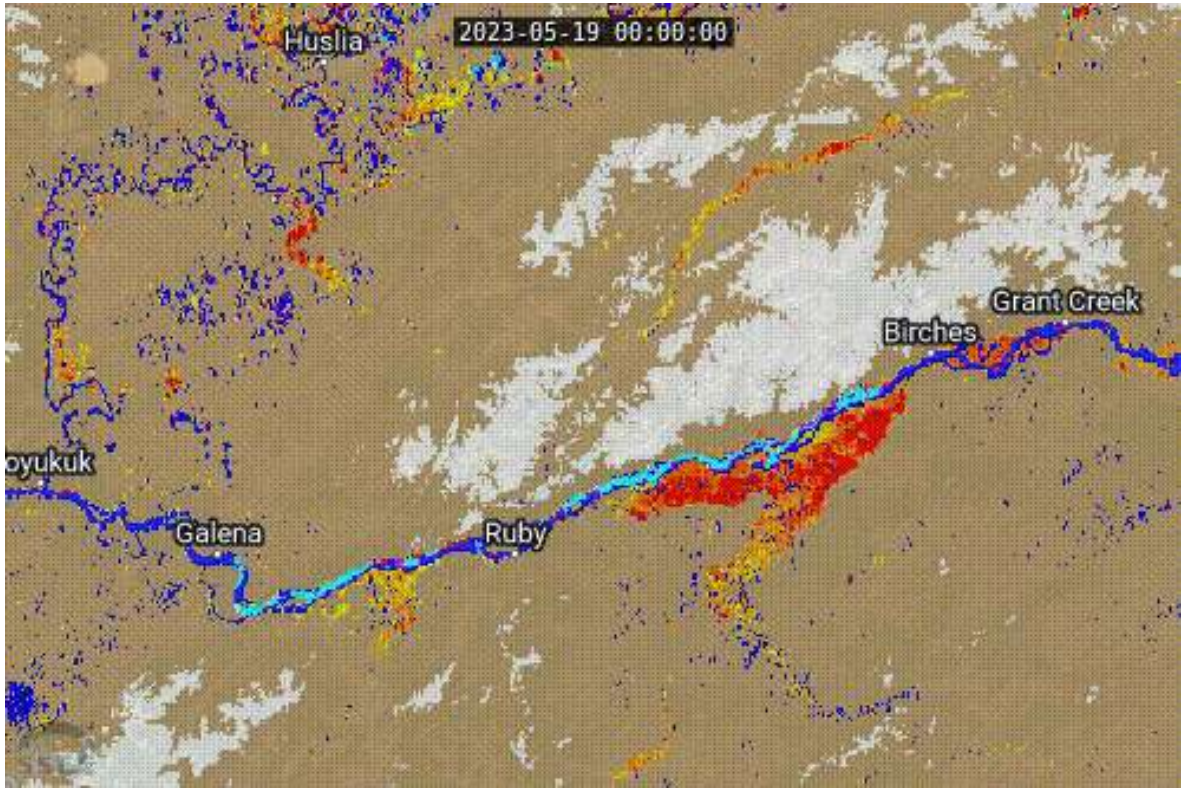
NWS Alaska Region

Timeline of Events

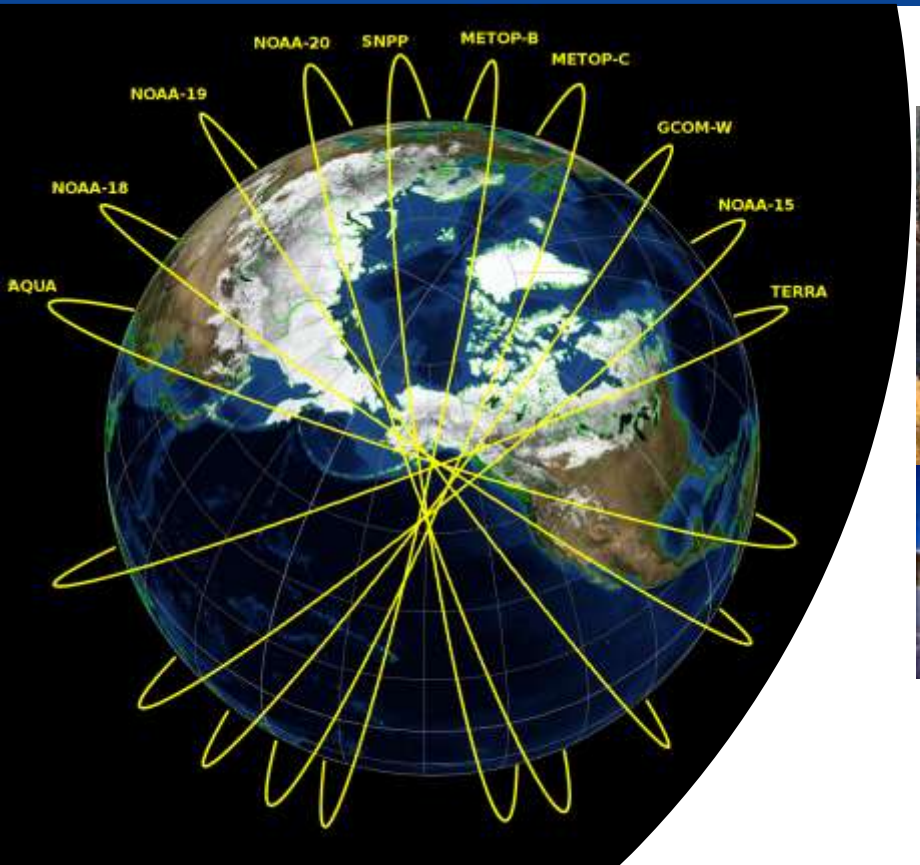


Stranded ice in Circle from Planet.com imagery - May 14th.

“Non-hazard” flooding that became hazardous during 2023 Alaska Breakup season



High repeat of satellite data in the Arctic



UAF-GINA & NESDIS Facilities

rage
e Arctic
terior AK

Near real-time processing stacks in Alaska delivering products worldwide **within 15 minutes** EO overpass

GINA: Keeping Data Close to the Customers

High repeat of satellite data in the Arctic

- Acquisition plans of the RADARSAT Constellation Mission

Optical and SAR Flood products
With help from

Sean Helfrich (NESDIS), Sanmei Li (GMU), Vincent Decker (NRCan), Mitchell Goldberg (CCNY, Former NESDIS Cheif Scientist, Qingyuan Zhang (UMD), Qing Yang (UW- Milwaukee), and Xinyi Shen (UW- Milwaukee)

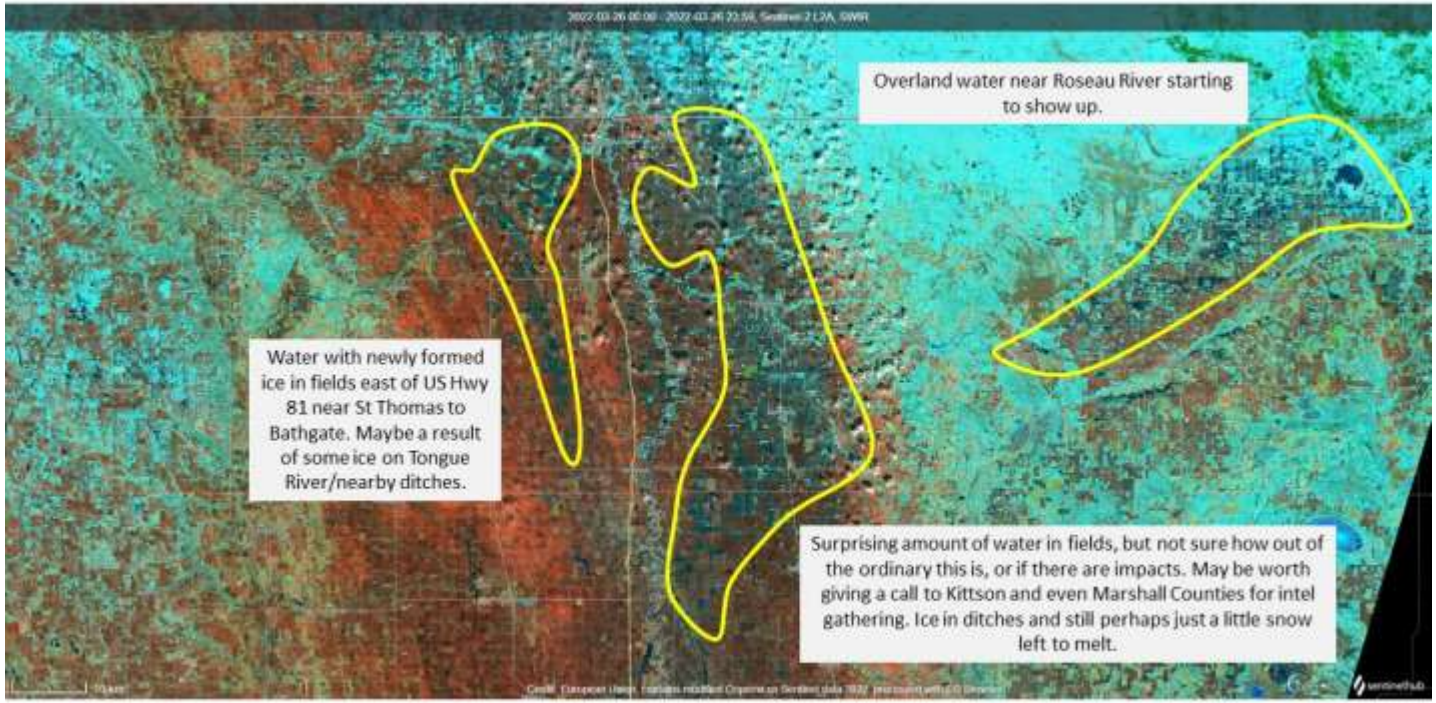
SATELLITE INFORMATION USED FOR Decision Support

- Optical imagery (RGBs)
  - Good for qualitative, high resolution, analysis
  - Limited to daytime and cloud free conditions
  - Good to observed “downstream” impacts from storms.
    - Ex - “Lake Oslo” breeze

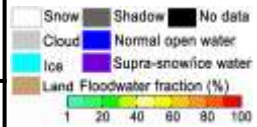
- Flood Extent product
  - Good for quantitative extent impacts
  - Optical
    - Limited to daytime and cloud free conditions.
    - Lower resolution (1 km for ABI, 375 m for VIIRS flood products, 30 m for downscaled VIIRS)

  - SAR
    - High spatial (5-10 m resolution)
    - Limited repeat cycle, even with higher refresh from RCM
    - Limited swaths and availability

Sentinel-2 RGB Example



List of VIIRS/ABI Flood Products

Products	Spatial resolution	Availability	Coverage	Production latency	Description
Suomi-NPP, NOAA-20, NOAA-21 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[1]	Daytime-only flood extent in water fractions (open water percentage in a satellite pixel)
Suomi-NPP, NOAA-20, NOAA-21 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, NOAA-21 VIIRS 5-day composited flood product*	375m	Once per day	Global land between 60°S and 75°N	All tiles available by 1030Z	
GOES-E/W(ABI) flood product *	1-km	Every hour	Land in America (135° W ~ 17° W, 50.5°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 18Z	

* - Currently operational at NOAA
\+ - Transitioning to operations

[1] - Latency from direct broadcast is ~10-20 minutes from satellite overpass (CONUS & AK only)

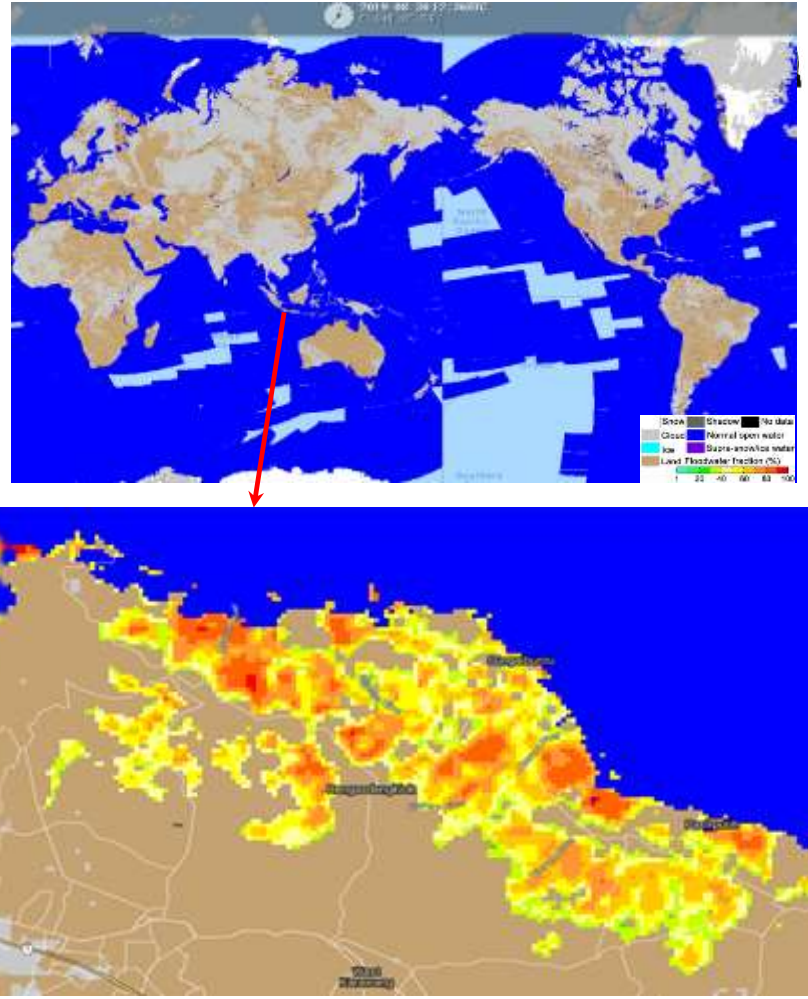
VIIRS NRT *Flood Product*

The VIIRS 375-m Flood Product, is a near real-time product derived from daytime VIIRS imagery from Suomi-NPP, NOAA-20 and NOAA-21.

The VIIRS Flood Map reflects the current flood status at the time of the overpass along with additional information on the weather and land conditions.

Suomi-NPP, NOAA-20 and NOAA-21 are low earth orbiting satellites, which means only two daytime observations can be derived per day over a given Region of Interest (ROI) with a ~50 min interval.

Observations are taken ~2-3pm local solar time. The latency of the product is about 3 hours after a pass is complete.

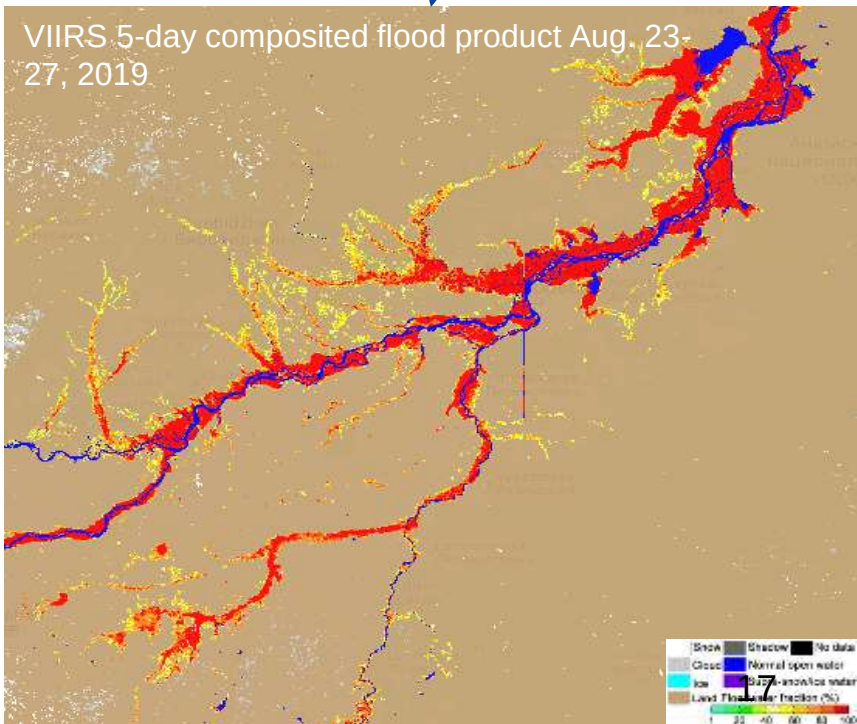


VIIRS Composited *Flood Products*

The VIIRS Composited Flood Products are used to filter out cloud cover through a maximal water-fraction composition process and thus derive the maximal flood extent during a flood event from the VIIRS NRT flood maps from the JPSS satellites

The routinely global VIIRS Composited Flood Products include daily composited flood product and 5-day composited flood product.

The composition process is done by dividing the global land into 136 AOIs.

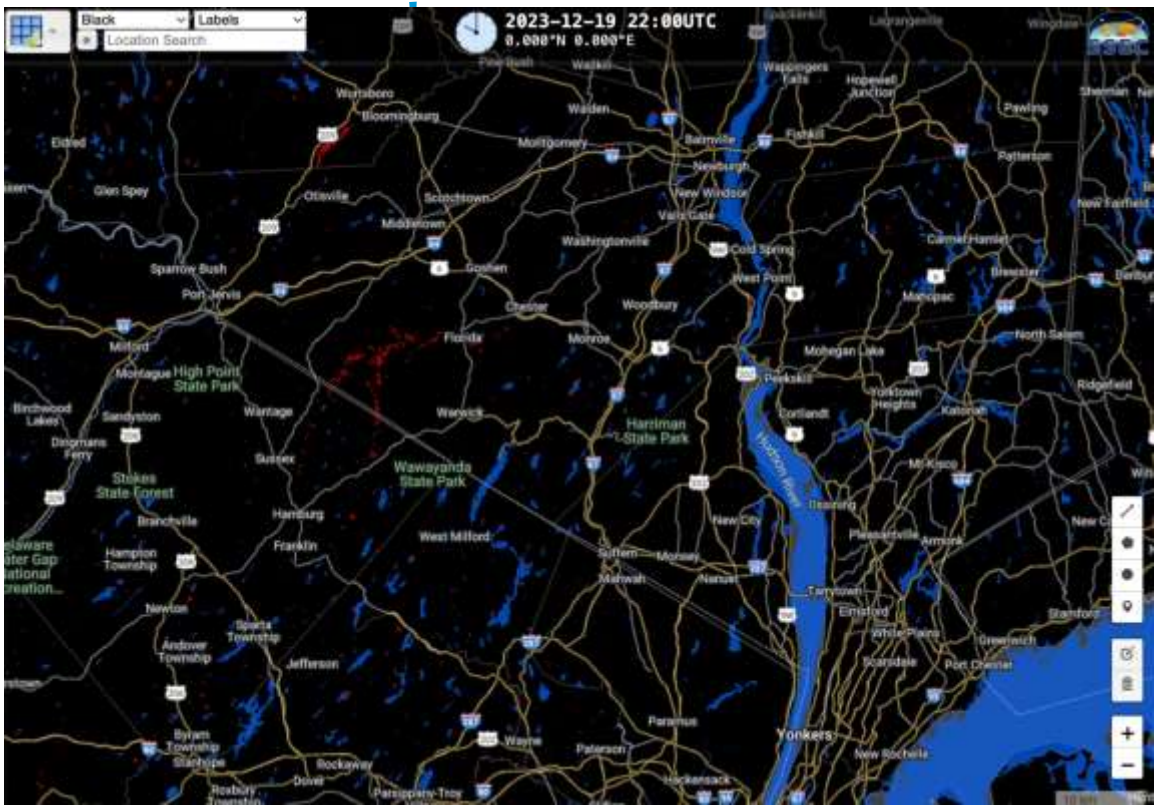


SAR FLOOD PRODUCTS

- The Synthetic Aperture Radar (SAR) imagery is a very high-resolution flood mapping, though at lower temporal resolution, is able to see flooding even during times of extended cloud cover or nighttime that frequently occurs during flooding and inhibits optical flood detection.

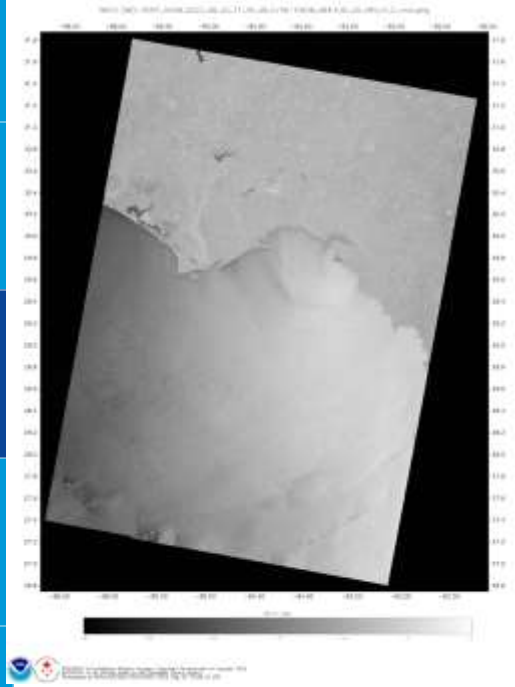
- There are multiple satellite missions (Sentinel-1, Radar Constellation Mission, JAXA's ALOS satellites, etc). By combining these we can help get more frequent observations

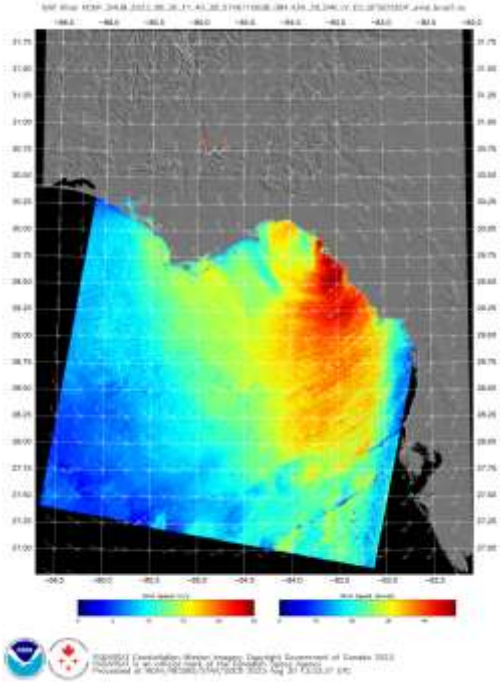
PreOperational/Developmental - NOAA SAR Flood



https://floods.ssec.wisc.edu/?products=C-band-VV-VH-dual-pol.75,C-band-VV-VH-dual-pol-m.75&center=41.250451272341486,-74.20372009277345&zoom=10&width=1127&height=807&basemap=wb&labels=google&view=leaflet&collection=Flood%20Detection&timeproduct=C-band-VV-VH-dual-pol&timespan=-6t&animationspeed=50

Hurricane Idalia





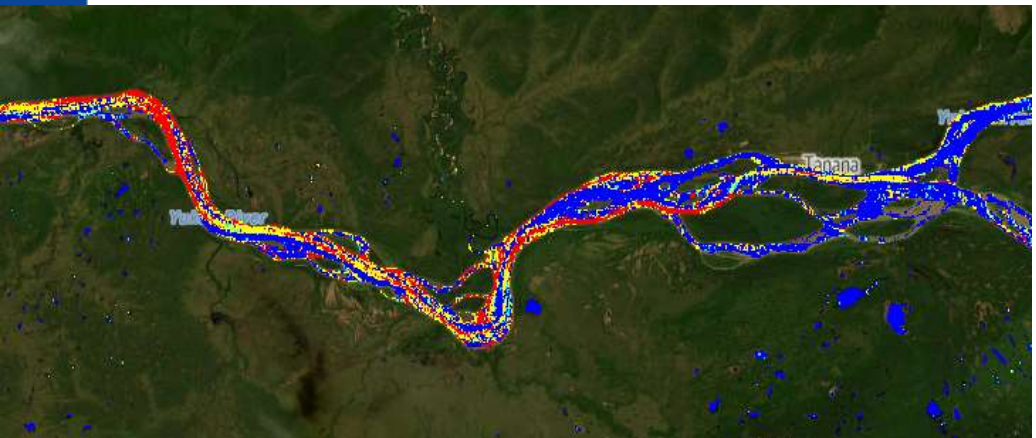
Under Development

PreOperational/Developmental

Downscaled VIIRS Product: The VIIRS 375-m floodwater fraction products to 30-m 3-D flood products are currently being run routinely globally. Currently the downscaling uses the CDSM DEM, an example shown and will be tested, before transition to operations.

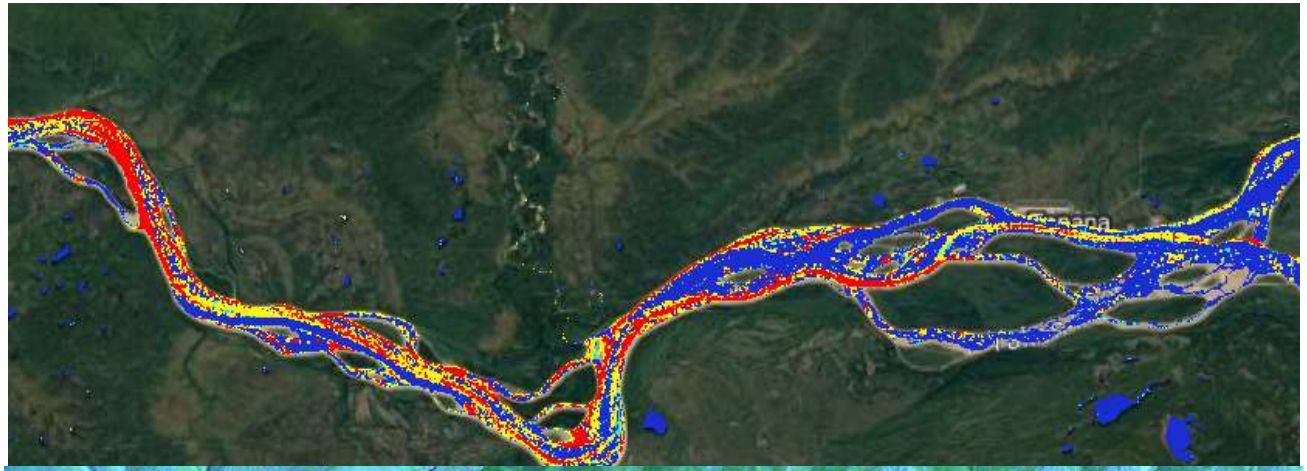
River Ice Products
Slides from the National Water Center

National Water Center
Synthetic Aperture Radar River Ice Surveillance (SARRIS)

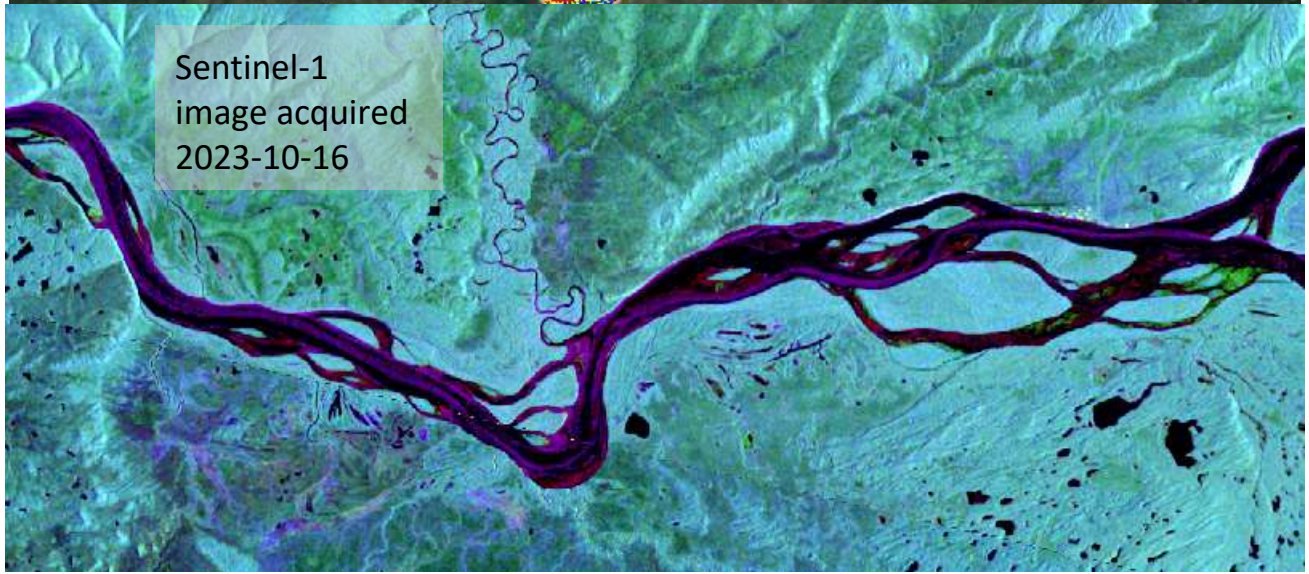


SARRIS Overview

- River ice classification using Sentinel-1 Synthetic Aperture Radar
- SAR provides day/night nearly all weather imaging capabilities
- Relatively fast processing (9 image swath in about 1 hour)



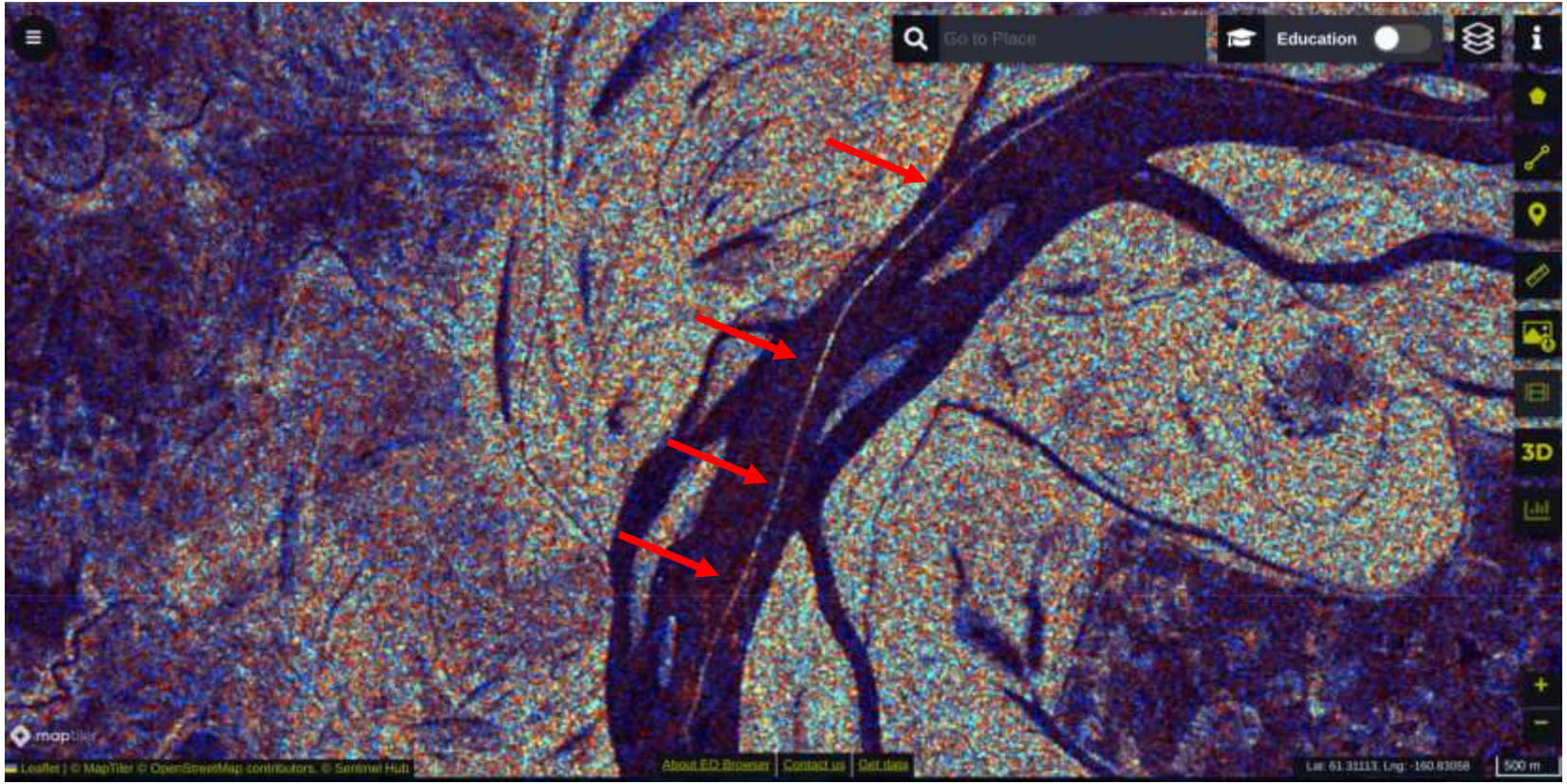
Open Water
Smooth Ice
Fractured Ice
Jumbled Ice



Multi-temporal False Color Image

Red - Current VV
Blue - Current VH
Green - Reference VV

River ice trail Detection



20 Feb 2023 - 23:59 - Sentinel-1

Examples and applications

2023 Spring Breakup in Review

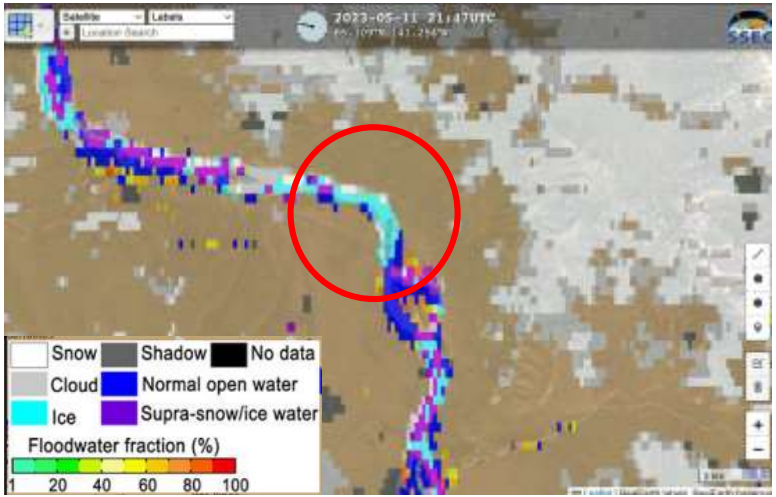
NWS Alaska Region

Timeline of Events

May 12

Moderate flooding in Eagle

Ice jam forms downstream, moderate flooding with damage to seawall, flooding roads, and damage to several structures.

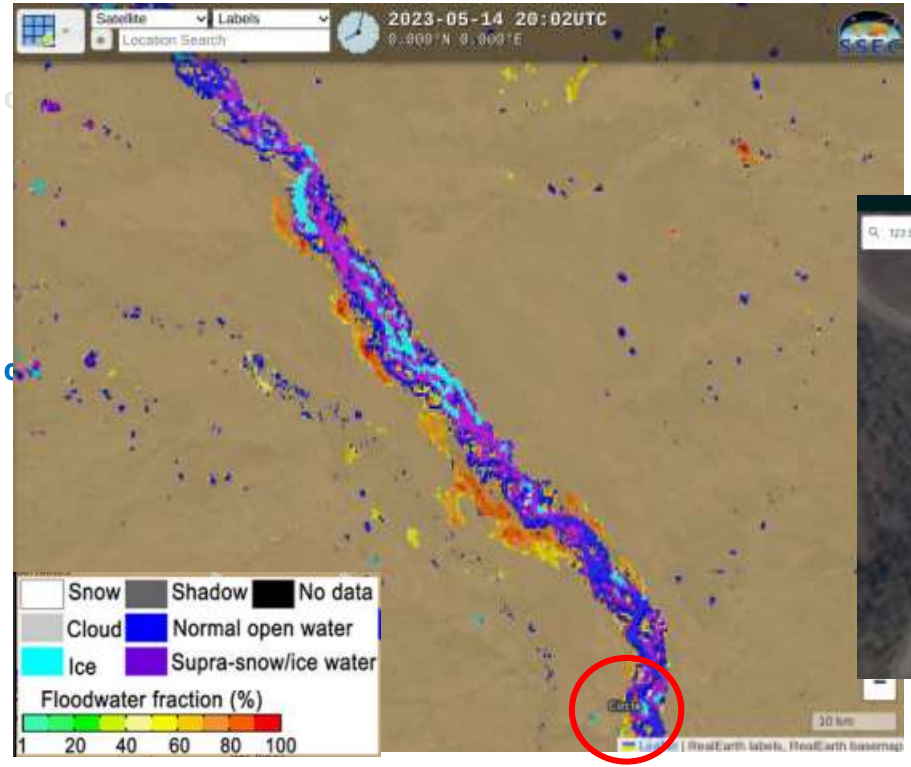


Clockwise from top right: seawall damage on Front St on May 13th; aerial view of Mission Rd between Eagle and Eagle Village on May 13th; DOT crews removing ice and repairing washouts along Mission Rd on May 18th.

2023 Spring Breakup in Review

NWS Alaska Region

Timeline of Events



Stranded ice in Circle from Planet.com imagery - May 14th.

2023 Spring Breakup in Review

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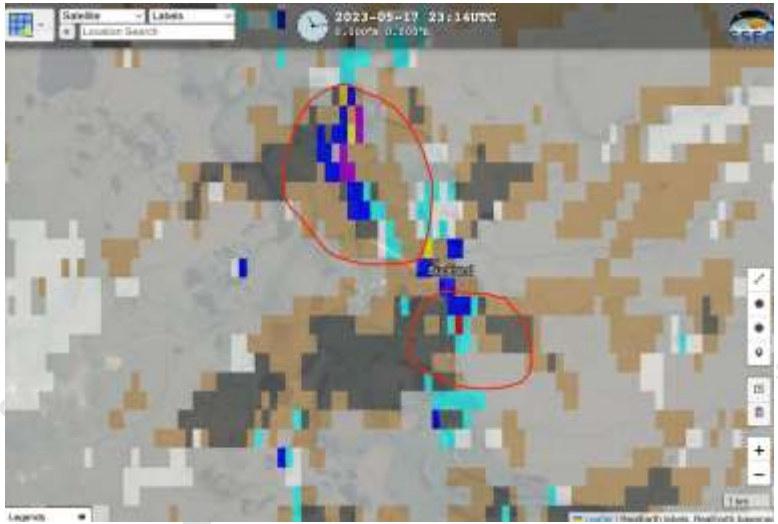


May 17

Flooding of Buckland

Multiple ice jams on the Buckland River causes significant flooding to nearly 80% of community. Roads inundated with water; water under or surrounding homes and structures.

Ice Jam Downstream of Buckland - May 17th.

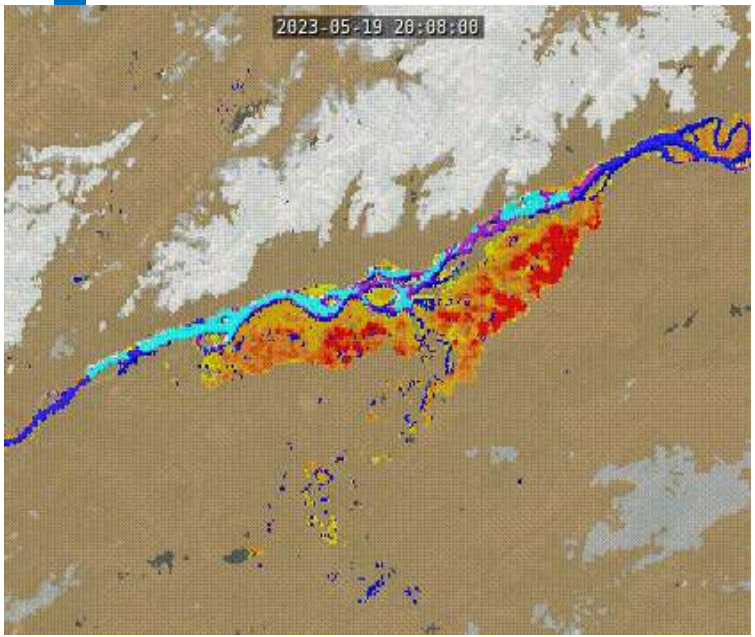
2023 Spring Breakup in Review

Timeline of Events

May 19-20 continued

Large ice jam on Yukon River

A large ice jam upstream causing significant out of bank flow, with flooding along Kokrine Hills/Bible Camp and Nowitna River.



Large ice jam ~50+ miles long at Big Eddy on the Yukon River (upstream of Ruby, AK) - May 18th.

Significant flooding at Bible Camp near Big Eddy on the Yukon River - May 18th.

2023 Spring Breakup in Review

NWS Alaska Region

Timeline of Events

May 22-26 continued

Prolonged flooding in Russian Mission

Yukon River ice jam downstream of Russian Mission causes a week long flooding event. Several homes and runaway damaged

May 27-29

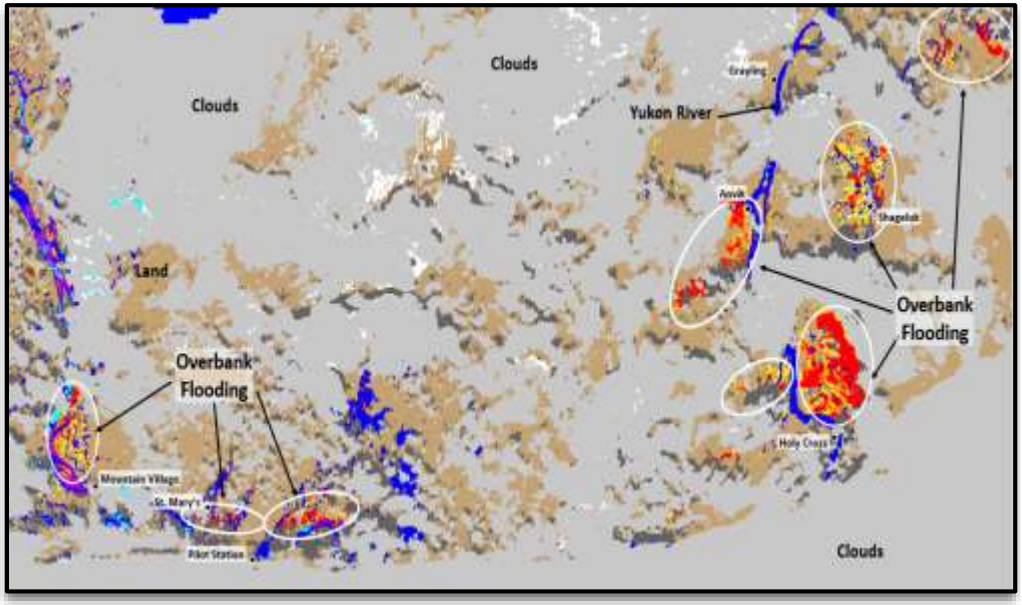
Yukon Delta Flooding

Yukon River breakup front moves downstream to the delta flooding Emmonak, Alaskuk, and Nunam Iqua.

May 27-29 continued

Backwater and overflow

Backwater from previous Yukon River ice jams and upstream snowmelt causes widespread overbank flooding of lowlands from Mountain Village to Grayling.



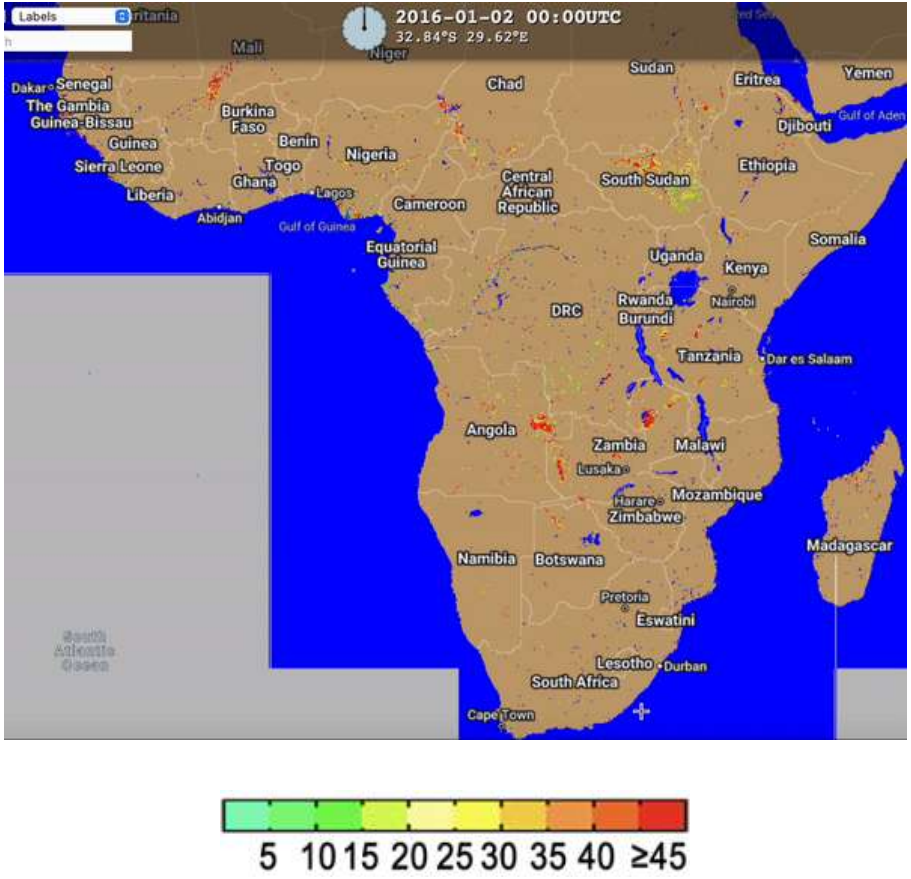
VIIRS Imagery showing the extent of out of bank flow and flooding (yellow/orange/red) across the lower Yukon River - May 28th.

Satellites as a *tool to assess* ***flood risk***

By utilizing derived flood maps, one can create a global or regional assessment of the number of days a given area is flooded for a given year (or longer time period).

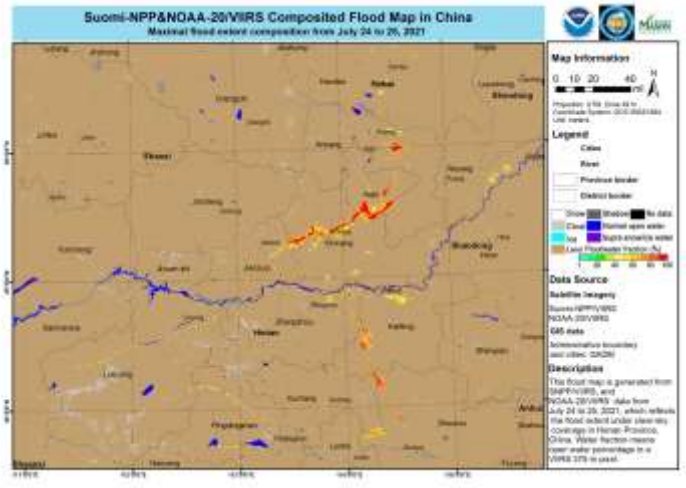
This can help assess where the most flood prone regions are and help with flood mitigation/preparedness efforts

Currently NOAA has the VIIRS daily and 5-day flood maps for (2012-2020) to begin this effort, which is freely available to users for analysis.

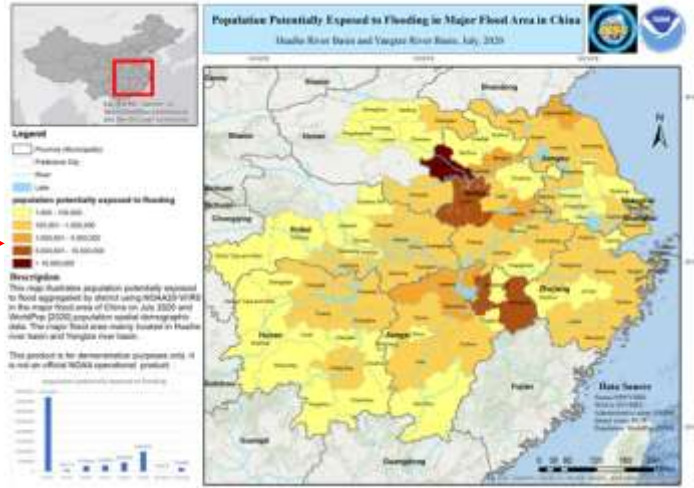


Tying satellite data and socio-economic information together

Population or other socio-economic database

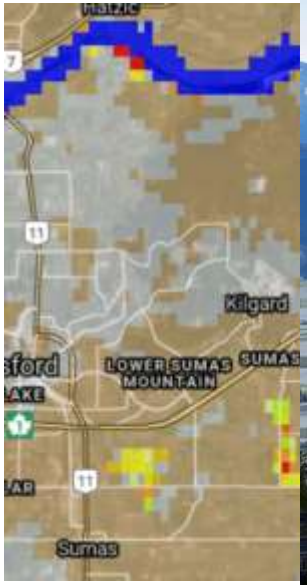


ArcGIS or similar application



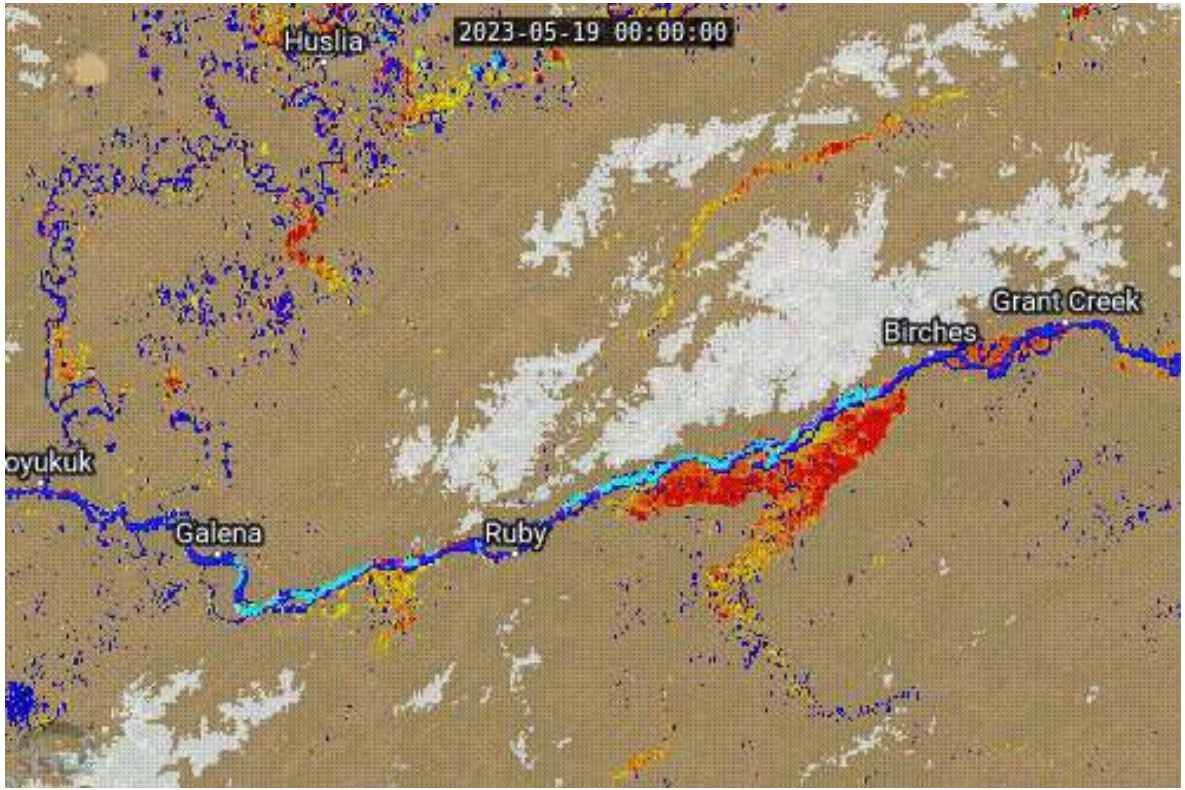
Li, S.; Goldberg, M.D.; Sjoberg, W.; Zhou, L.; Nandi, S.; Chowdhury, N.; Straka, W., III; Yang, T.; Sun, D. Assessment of the Catastrophic Asia Floods and Potentially Affected Population in Summer 2020 Using VIIRS Flood Products. *Remote Sens.* **2020**, *12*, 3176. https://doi.org/10.3390/rs12193176

https://cimss.ssec.wisc.edu/satellite-blog/archives/43303



November 17, 2021. (Photo by Don MacKinnon / AFP via Getty Images)

Identification of upstream flooding that affects downstream communities during 2023 Alaska Breakup season



Example of how the optical flood products

- As data becomes available from near-realtime data from GINA (east to west), communities can see what is happening upstream along the rivers in addition to inter-village reports and the APRFC RiverNotes dashboard.

- The 1 and 5 day composites can provide a daily look at the end of the day to see where flooding is occurring, possible flooded marsh/tundra is located and where ice is along the river

- Remember that the all of the flood products are produced during **daytime and cloud-free conditions only**, thus the products will not be updated overnight

CIRA's Aviation Website for custom cross-sections

- https://aviation.cira.colostate.edu
- Various user interface functions based on user feedback
  - User-selectable path
  - A layer feature for icing/turb (PIREPs)
  - Product evaluation/User feedback
  - ***User quick guide*** and documents

- Extended to CO[illegible] addition
- Add **smoke data** model) with smc
- Oregon Wildfire Respon[illegible] Episodes and Air Quality and Health guidelines by NOAA GSL

Summary

- The NOAA Flood products are being used by the Alaska Pacific River Forecast Center during spring break up season and can be used by the public to monitor flood conditions upstream of their location

- There is a SAR based river-ice only product, SARRIS product from NWC, which is useful in identifying ice conditions.

- Interaction with FEMA, US National Weather Service, River Forecast Centers and the National Water Center as well as the communities are important in knowing what to provide the users for satellite based flood monitoring and how the product is performing

Accessibility information

Online

- Online visualization page : https://www.ssec.wisc.edu/flood-map-demo/flood-products/

- Links to the single flood products:
  - VIIRS real-time flood maps for Alaska: https://tinyurl.com/5n75563a

  - VIIRS daily composites: https://tinyurl.com/msnzeyf3

The flood products via Web Mapping Service (via Real Ea re available

Note that these products are not supported 24/7 but do have a high reliability of uptime.