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Satellite-Derived Flood Product and *Its Implementation* in **Impact-Based Forecast** and **Warning Services**

Presented by William Straka III (CIMSS/SSEC, NOAA/JPSS) & Rion Suaib Salman (BMKG)

Acknowledgements: Sanmei Li (GMU), Mitch Goldberg (CCNY/CESSRST, former NOAA NESDIS Chief Scientist), and the stakeholders who provide invaluable feedback

Acknowledgements:

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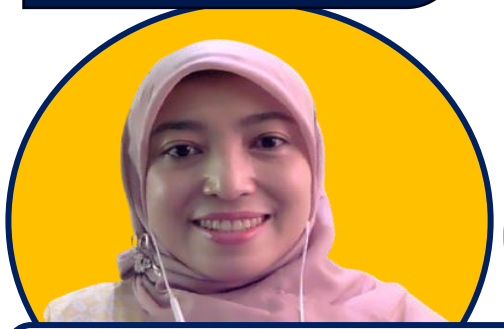

FACILITATORS

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William Straka

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 as well as US and international emergency response stakeholders such as BMKG on the NOAA Flood Products.

Rion S. Salman

Rion works at Indonesia Agency for Meteorology Climatology and Geophysics (BMKG) as a weather observer and forecaster. Furthermore, he has been working 10 years and his area responsibility is in Maluku Province. Currently, he also become the EOTEC DevNet Asia Oceania Region Community of Practice task team meeting from Indonesia, and he also contributed to satellite skills and knowledge for operational meteorologists document that developed by WMO.

OUTLINE

- Introduction to the NOAA Global Flood Products
- NOAA Global Flood Product Data + algorithms
- Utilization of Existing Flood Product Generating Tools of the NOAA Global Flood Product
- Product Generation and Application of Satellite-Derived Flood Products for IBFWS

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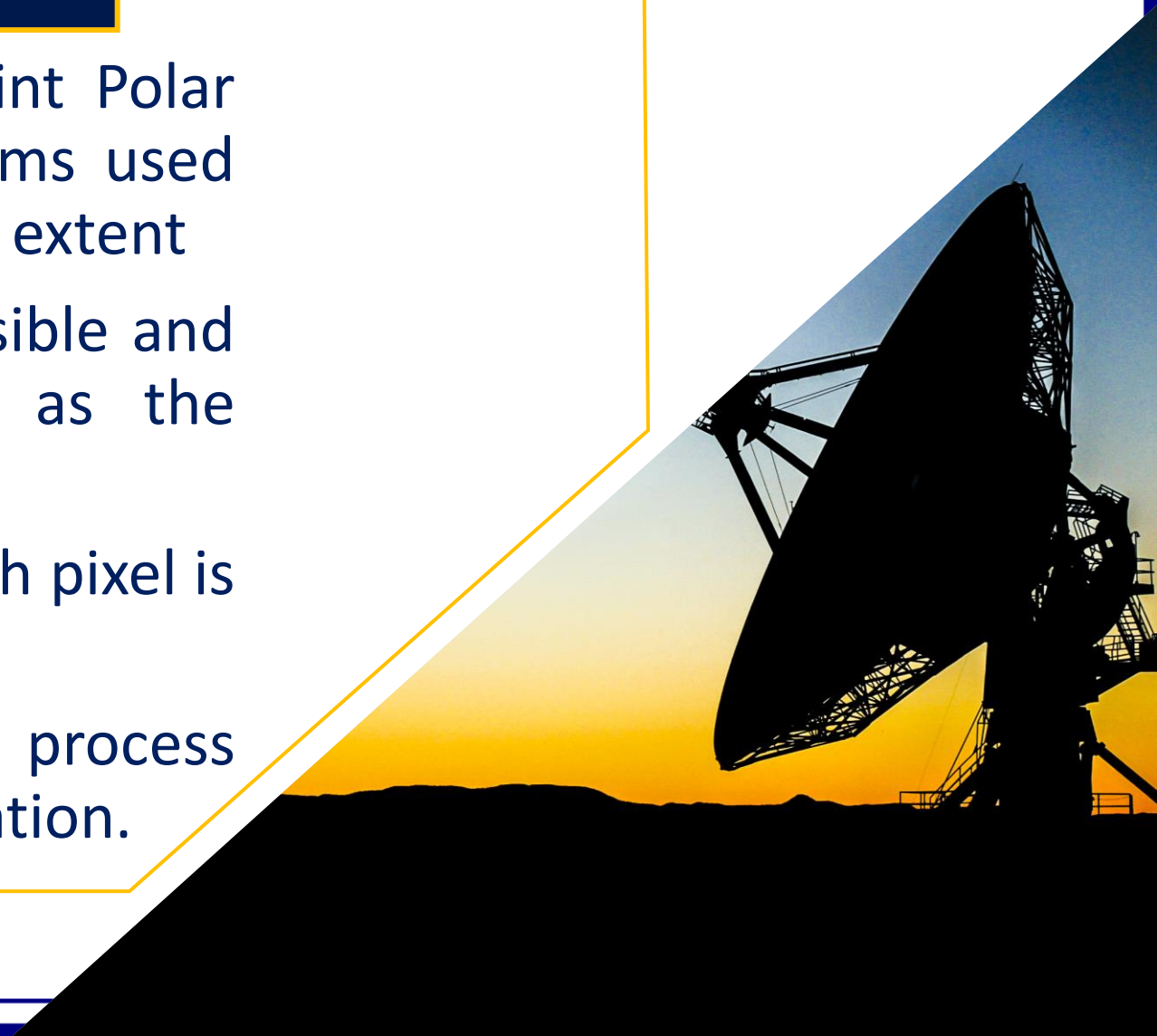
Flood Products *Overview*

- The VIIRS and AHI flood products provide flood areal extent and can be used for situational awareness.
- On a daily basis, the joint VIIRS/AHI flood product provides the best coverage in regions covered by AHI.
- Under clear-sky conditions in the VIIRS and AHI images, the VIIRS flood product is recommended for use because of its more accurate floodwater details.
- The AHI flood maps filter out clouds using a multiple composition process. This means that they may be able to provide flood extent in regions which are cloudy during the two daytime VIIRS overpasses. In this case, the ABI and AHI flood maps may be used for flood mapping with spatial resolution at about 1 km instead of 375 meters.

Flood Products Overview (cont.)

- Both the geostationary (AHI) and Joint Polar Satellite System (JPSS) Flood algorithms used the same basic process to derive flood extent
- The algorithm uses input from the visible and shortwave infrared bands as well as the thermal bands as inputs.
- Through a series of decision trees, each pixel is classified as one of several values
- More information on the algorithm process will be mentioned in the next presentation.



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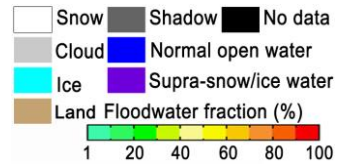
Flood Products Overview (cont.)

- The actual output of the VIIRS flood product is a netCDF file. These files are converted to pngs, geoTIF and Shape output files via a python code for distribution.
- The data is also available to view on the web and via WMS services

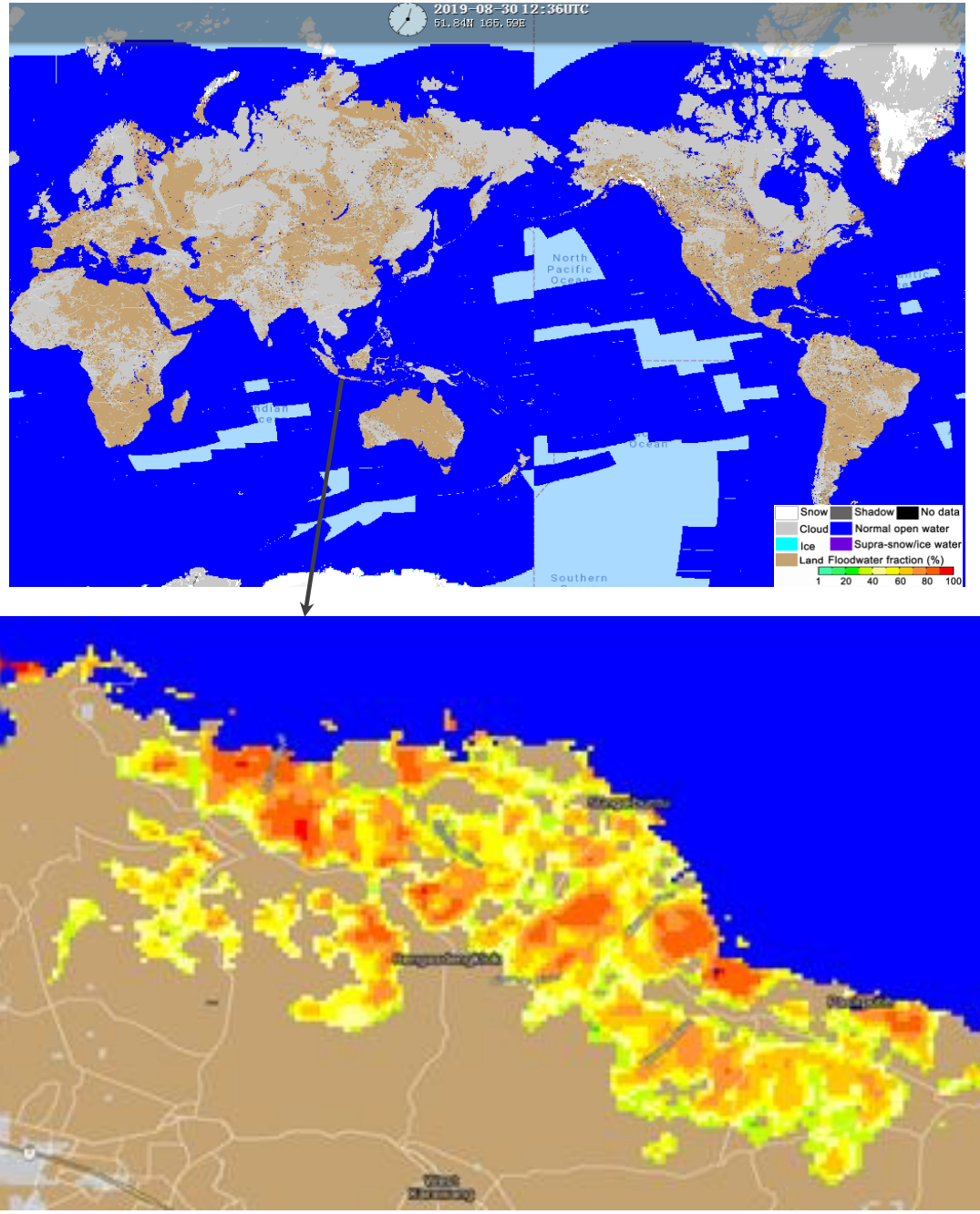
Lists of VIIRS/AHI Flood Products

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	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	
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/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	

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

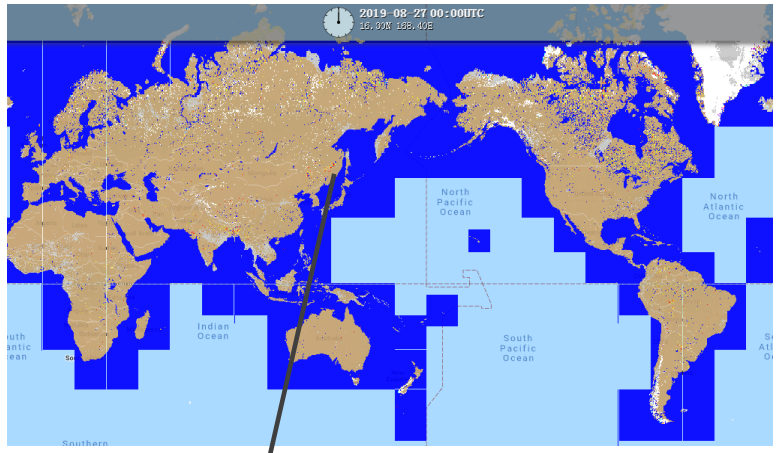
VIIRS NRT *Flood Product*

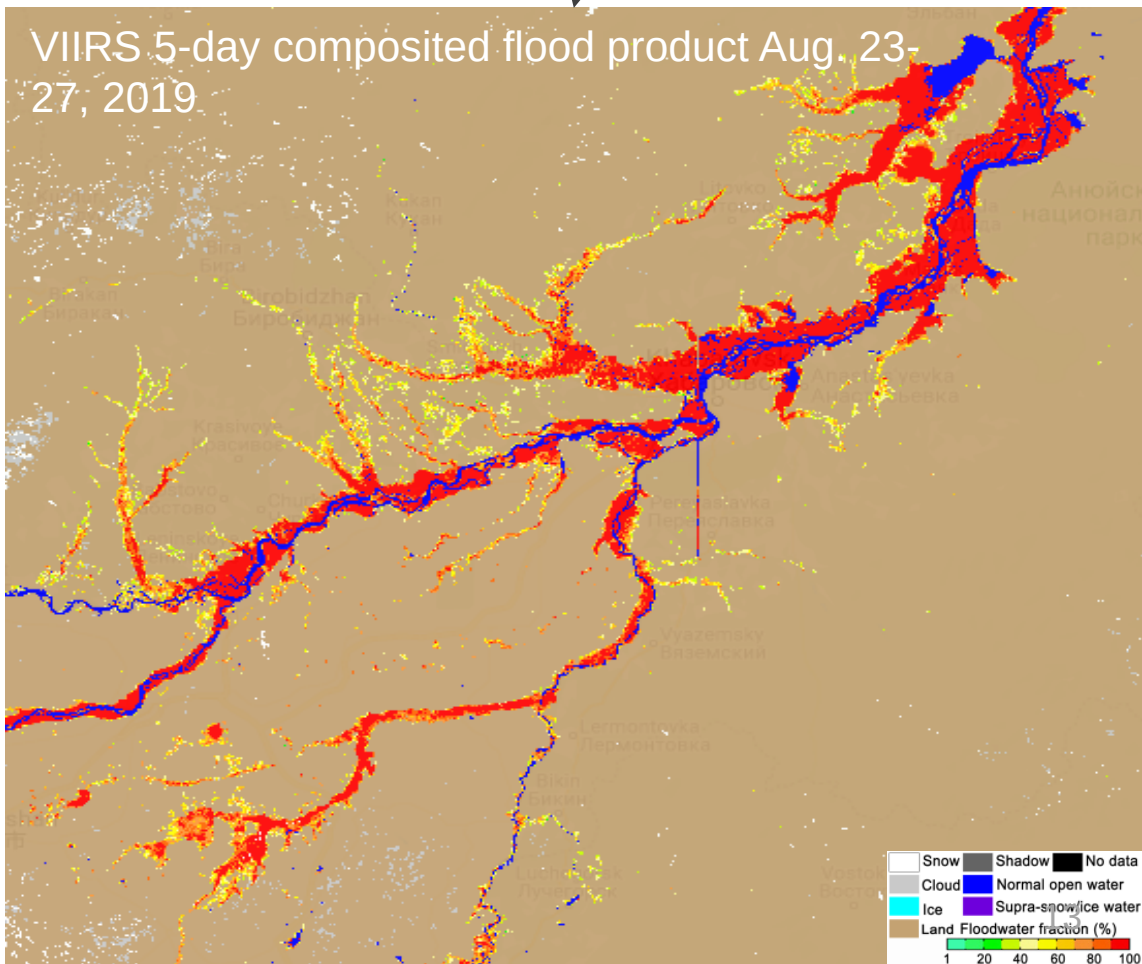
- The VIIRS 375-m Flood Product, is a near real-time product derived from daytime VIIRS imagery from Suomi-NPP, NOAA-20 and NOAA-21.
- The VIIRS Flood Map reflects the current flood status at the time of the overpass along with additional information on the weather and land conditions.
- Suomi-NPP, NOAA-20 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*

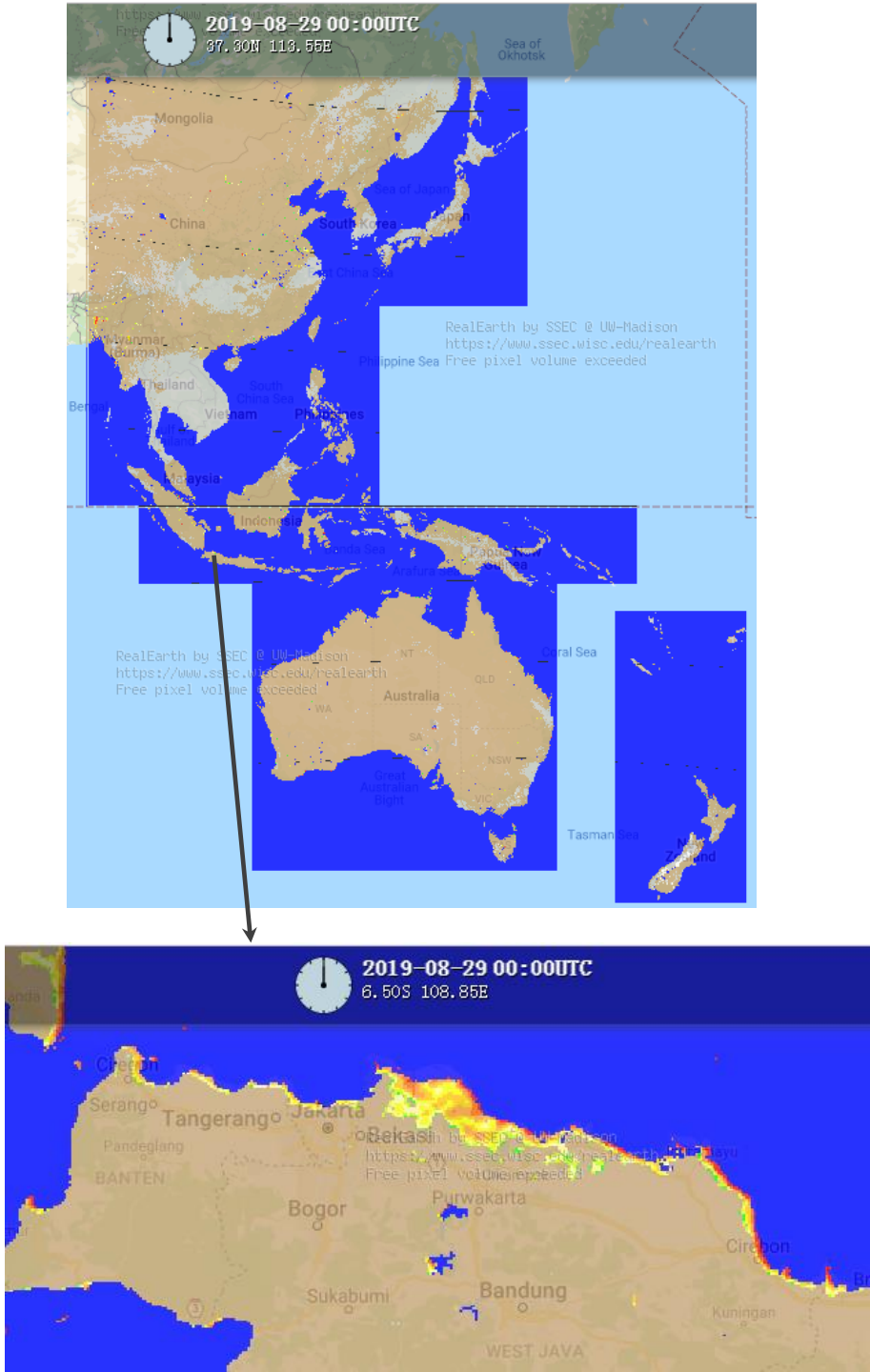
- The VIIRS Composited Flood Products are used to filter out cloud cover through a maximal water-fraction composition process and thus derive the maximal flood extent during a flood event from the VIIRS NRT flood maps from the JPSS satellites
- The routinely global VIIRS Composited Flood Products include daily composited flood product and 5-day composited flood product.
- The composition process is done by dividing the global land into 136 AOIs.





AHI Flood *Product*

- The AHI Flood Product is a rolling composited result based on the 10-minute AHI flood maps with hourly updates. Each hourly-updated flood map shows the average flood water fractions from the first 10-minute flood map to the latest one.
- At the end of a day, the AHI Flood Map is a daily flood composite, and shows the flood extent under the daily maximal clear-sky coverage (example shown right).
- Data from AHI is acquired using the Himawari Cloud to STAR and then provided to CIMSS for processing.



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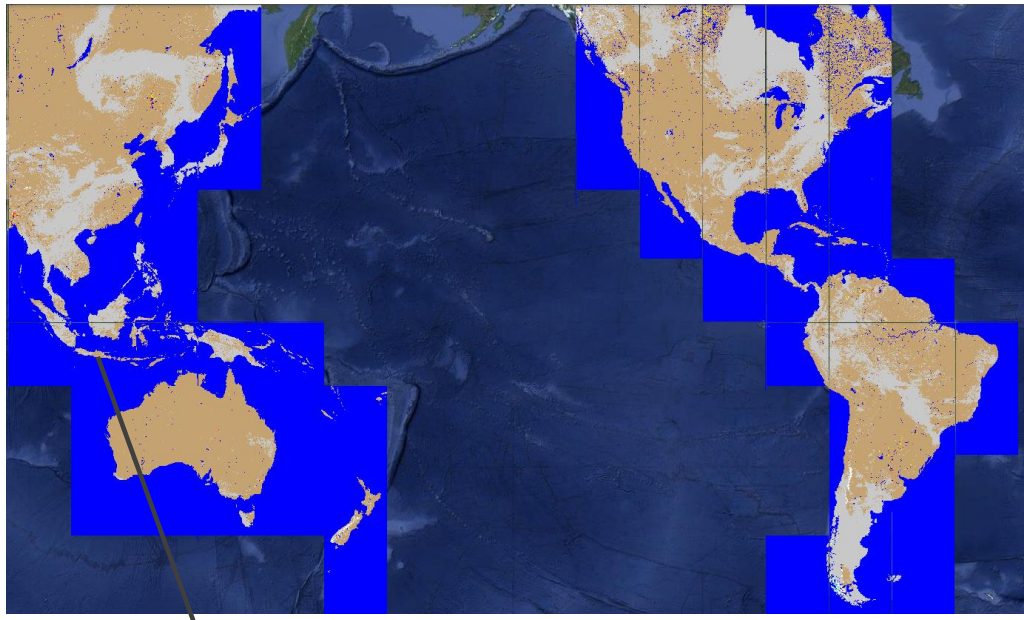
Joint **VIIRS/ABI/AHI** *Flood Products*

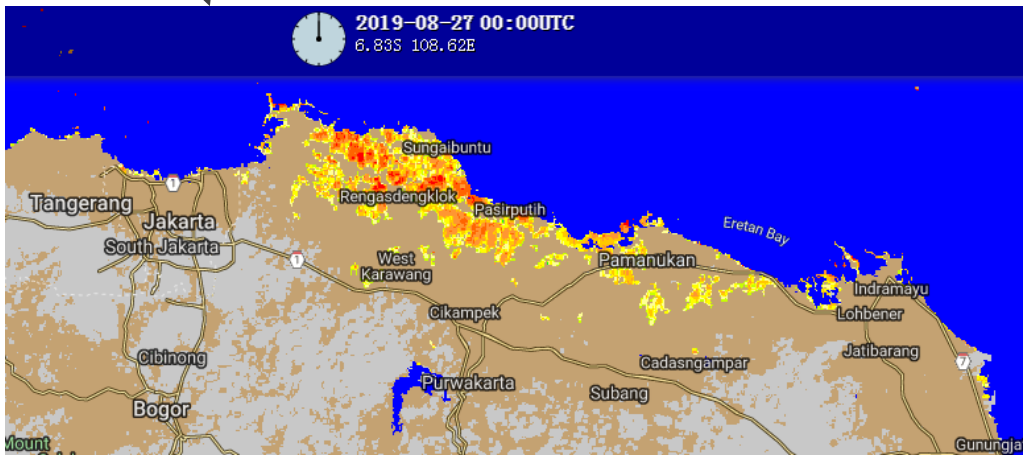
- The joint VIIRS/ABI or VIIRS/AHI Flood Products blend the daily flood detection results from VIIRS, ABI and AHI. It is based on the VIIRS 375-m daily composited flood maps, and uses the 1-km ABI or AHI daily clear-sky detection results to fill the gaps of clouds and cloud shadows in the VIIRS maps.

- Thus, it shows the flood extent under the maximal clear-sky coverage derived from ABI or AHI during daytime, and keeps the more accurate floodwater details from VIIRS.

- **IMPORTANT NOTE - The current Joint VIIRS/ABI or VIIRS/AHI Flood products are currently being operationalized, but being run in NRT at CIMSS. Also, the 1-km ABI/AHI flood water fractions have not been fully fused with the VIIRS results, so the resolution of the current products vary from 375m to 1km.**

Aug. 27, 2019





The global land is divided into **136 AOIs** for the **VIIRS** composition ***process and data archive***.

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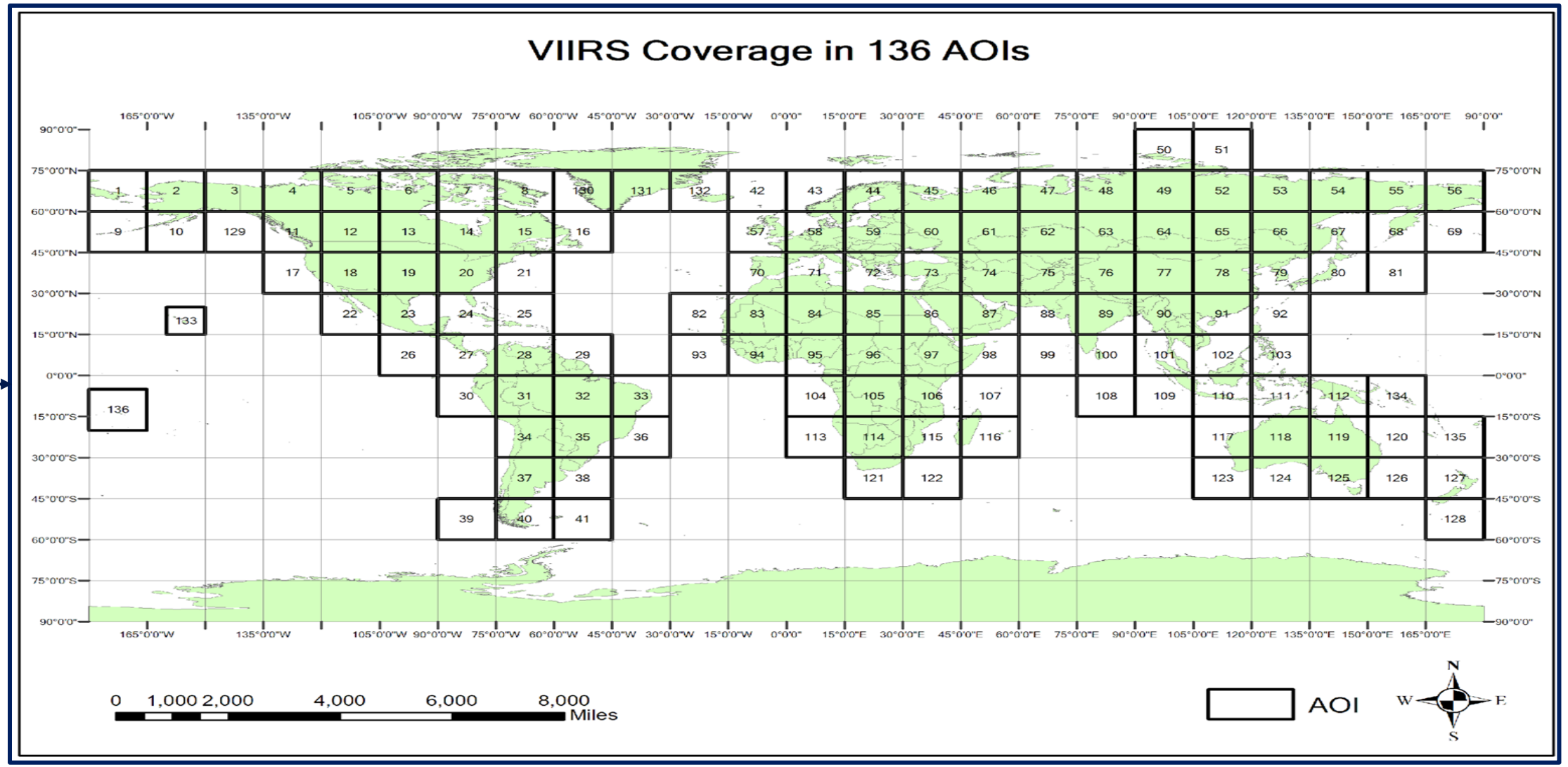

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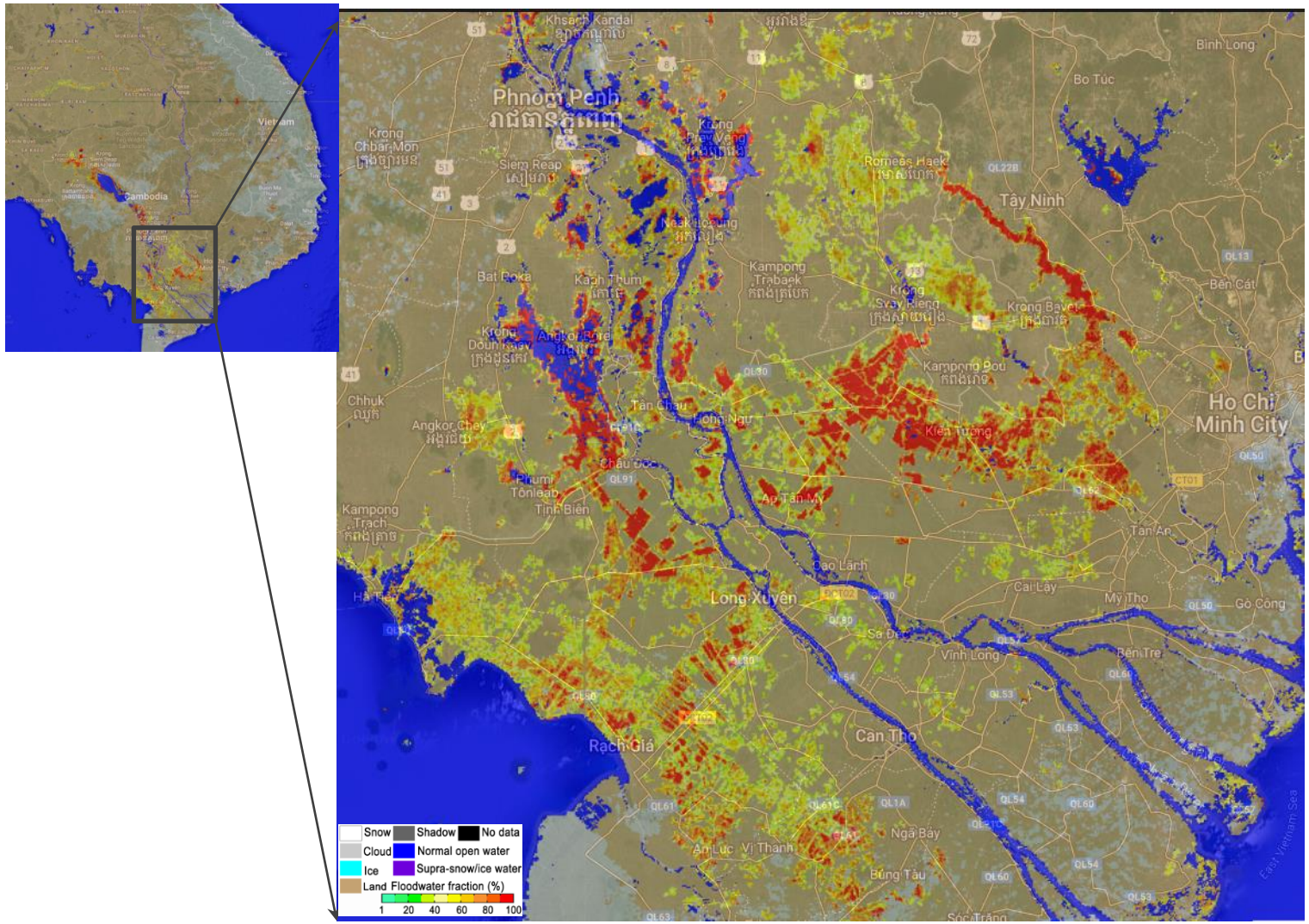
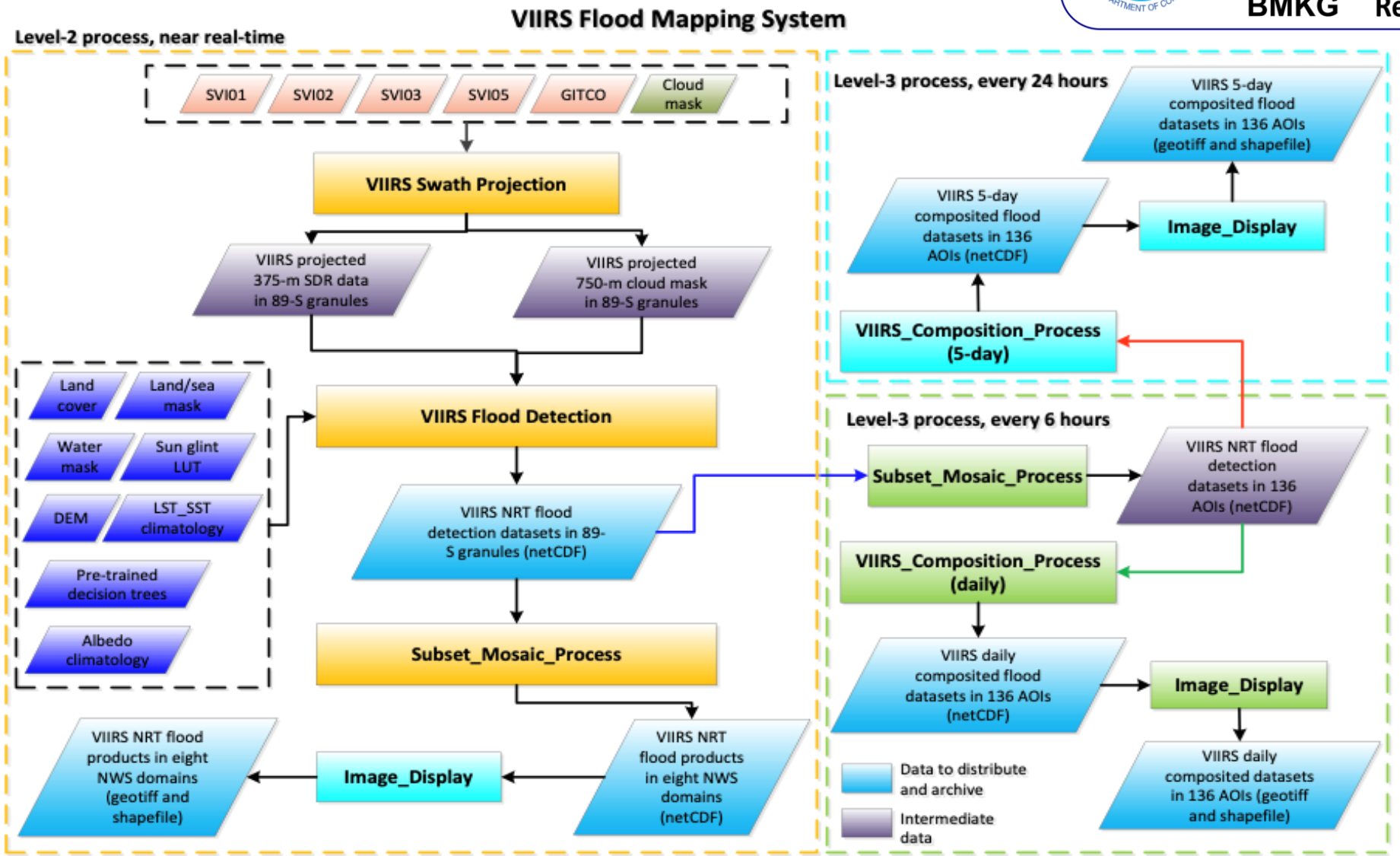
Example case – **Mekong Delta flooding, 3 Dec 2021**



Bands used by NOAA Flood Product

Channels used by the NOAA VIIRS Flood Product

VIIRS Band	Central Wavelength (µm)	Band Explanation	Spatial Resolution (m) @ nadir
M1	0.412	Visible/ Reflective	750 m
M2	0.445		
M3	0.488		
M4	0.555		
M5	0.672		
M6	0.746	Near IR	
M7	0.865		
M8	1.240	Shortwave IR	
M9	1.378		
M10	1.61		
M11	2.25		
M12	3.7	Medium-wave IR	
M13	4.05		
M14	8.55	Longwave IR	
M15	10.76		
M16	12.01		
DNB	0.7	Visible / Reflective	750 m across full scan
I1	0.64	Visible / Reflective	375 m
I2	0.87	Near IR	
I3	1.61	Shortwave IR	
I4	3.74	Medium-wave IR	
I5	11.45	Longwave IR	

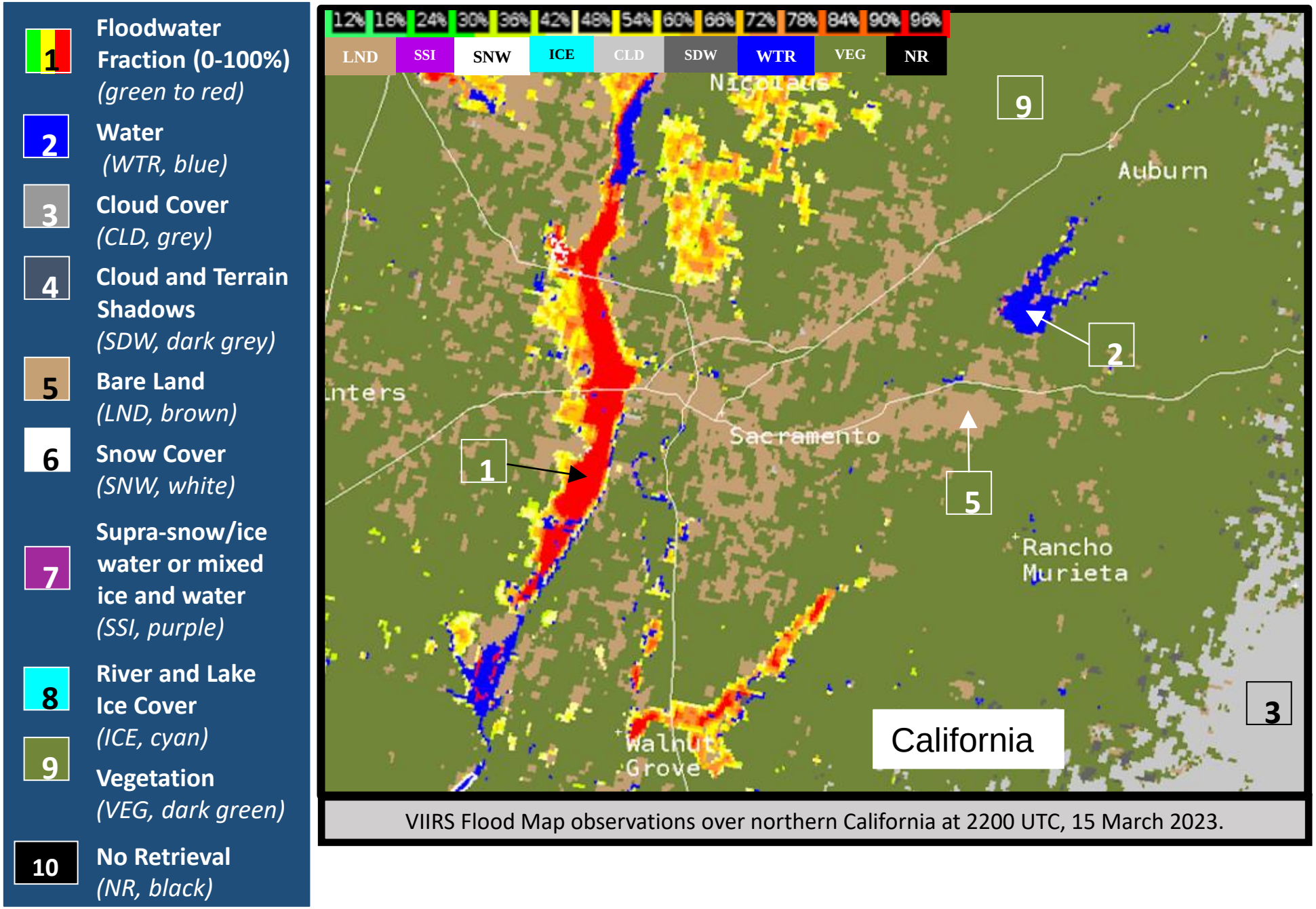

VIIRS Flood Mapping System
Level-2 process, near real-time
SVI01
SVI02
SVI03
SVI05
GITCO
Cloud mask
VIIRS Swath Projection
VIIRS projected 375-m SDR data in 89-S granules
VIIRS projected 750-m cloud mask in 89-S granules
Land cover
Land/sea mask
Water mask
Sun glint LUT
DEM
LST_SST climatology
Pre-trained decision trees
Albedo climatology
VIIRS Flood Detection
VIIRS NRT flood detection datasets in 89-S granules (netCDF)
Subset_Mosaic_Process
VIIRS NRT flood products in eight NWS domains (geotiff and shapefile)
Image_Display
VIIRS NRT flood products in eight NWS domains (netCDF)
Level-3 process, every 24 hours
VIIRS 5-day composited flood datasets in 136 AOIs (geotiff and shapefile)
VIIRS 5-day composited flood datasets in 136 AOIs (netCDF)
Image_Display
VIIRS_Composition_Process (5-day)
Level-3 process, every 6 hours
Subset_Mosaic_Process
VIIRS NRT flood detection datasets in 136 AOIs (netCDF)
VIIRS_Composition_Process (daily)
VIIRS daily composited flood datasets in 136 AOIs (netCDF)
Image_Display
VIIRS daily composited datasets in 136 AOIs (geotiff and shapefile)
Data to distribute and archive
Intermediate data

Cloud Detection and *cloud/terrain* **shadow**

- Cloud detection is performed operationally by the operational VIIRS cloud mask, but the algorithm can run without it by utilizing the three reflective channels and, NDVI, NDSI, NDWI and the 11.45µm channel to do cloud masking. Note that this also helps determine if a pixel is snow or not.
- The shadowed area from clouds and terrain is typically darker than the non-shadowed area because of less irradiance, which makes it look alike floodwater in optical satellite imagery.
- The cloud shadow is geometrically constructed using the relationship among the sun, satellite, cloud. The other thing that is done is to consider the parallax of the pixels
- Similarly, terrain, such as valleys, etc, can form shadows as well. In order to do this, the surface roughness is needed to help differentiate between the terrain and shadowed pixels.

Determination of **water fraction retrieval**

- Water fractions represent flood extent more accurately than water/no water masks.
- The NOAA Flood product retrieves water fractions for supra-veg/bare land floodwater, which is the most common flood type, to derive more accurate flood extent.
- The calculation uses a linear combination model based on multispectral linear mixture theory is the general way for sub-pixel fraction retrieval in optical satellite imagery (Sheng et al, DeFries et al., and Jiang et al.).



VIIRS Flood Map observations over northern California at 2200 UTC, 15 March 2023.

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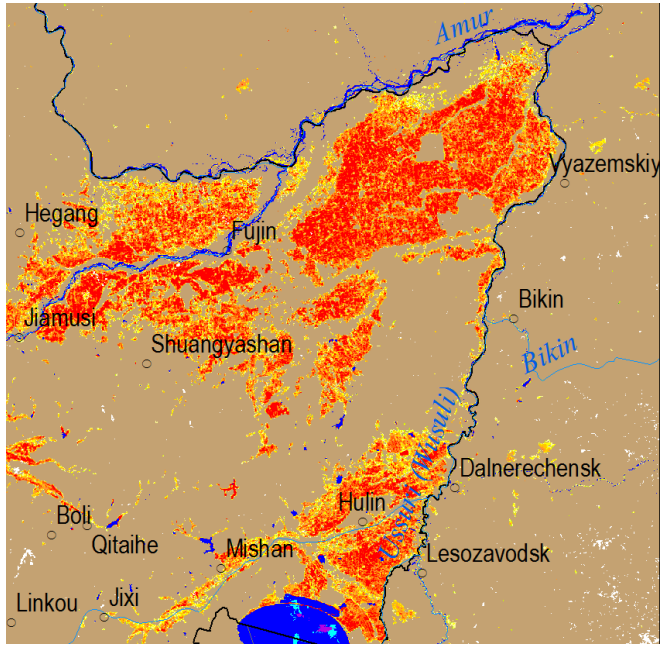
Issues to be aware of

- **Agricultural-related flooding:** Some flooding water shown in the VIIRS flood maps may not be any hazard-related flooding, but from agriculture-related activities such as rice paddy planting and aquaculture. However, flooding in this area could result downstream flooding depending other conditions.

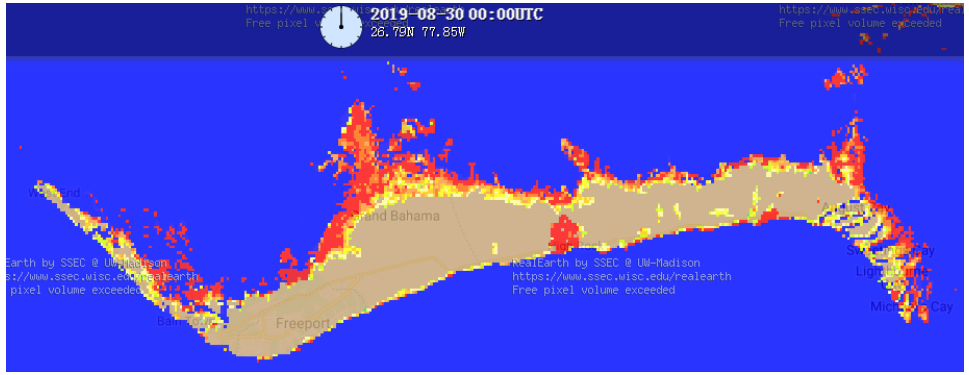
- **Tides and Marsh lands:** In some regions especially coastal areas, consistent flooding may be detected in the flood maps. These floods are mostly caused by the tides or occur over marsh lands, which do not pose any large scale social impact, though they can pose localize impacts (ex. rough roads.

- **Water reference map:** The water reference map encompasses permanent water bodies such as lakes and reservoirs. However, as new hydrological projects are build, the water reference map must be updated.

- **Solar Eclipses:** For granules that are flagged as an “eclipse”, the flood product will not be produced.

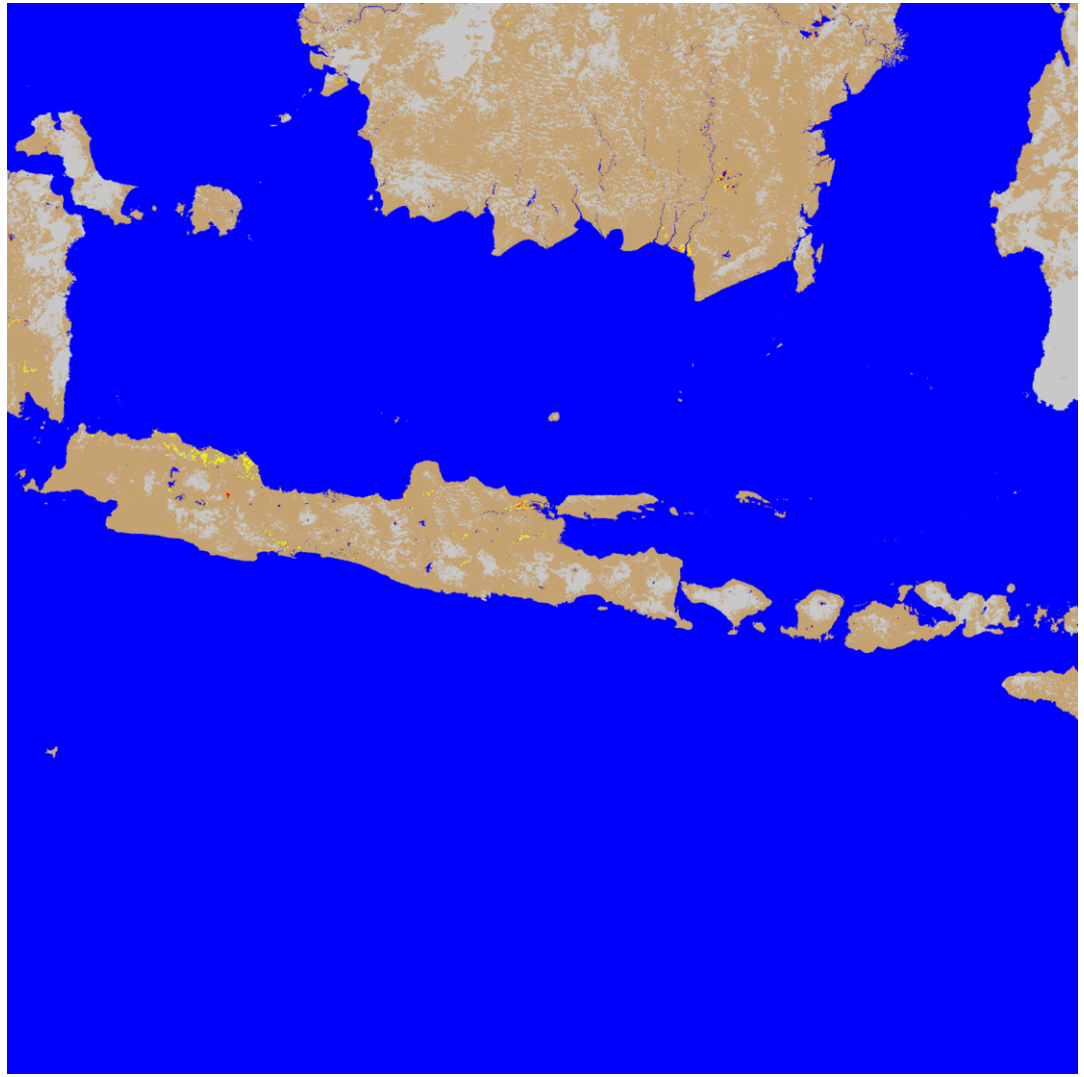


The widespread flooding water in the northeast of China from May 03 to 09, 2018 was not hazard-related flooding, but the “flooded” rice paddy areas during planting season.

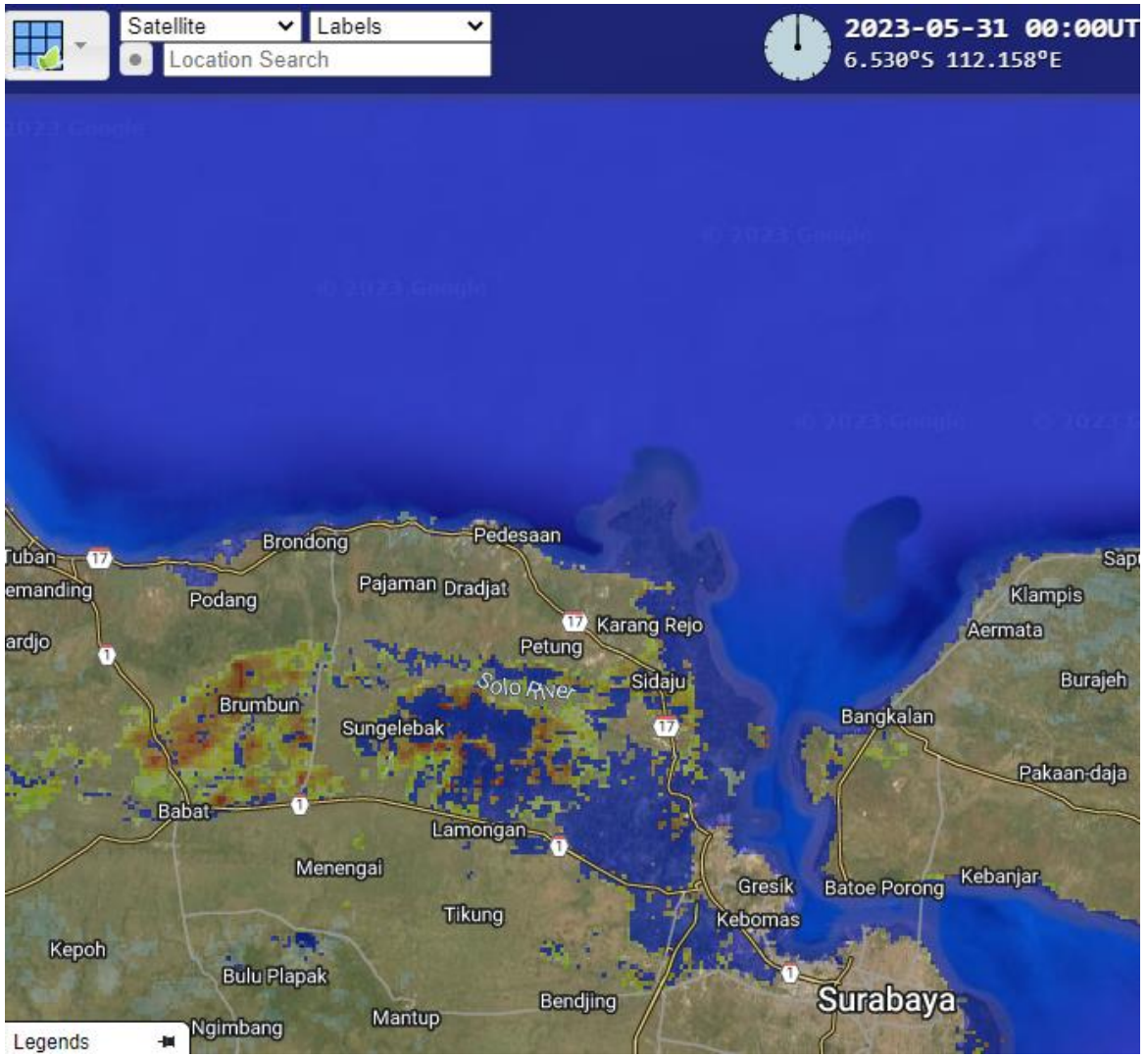


Flooding caused by the tides in Great Bahamas is a natural phenomenon.

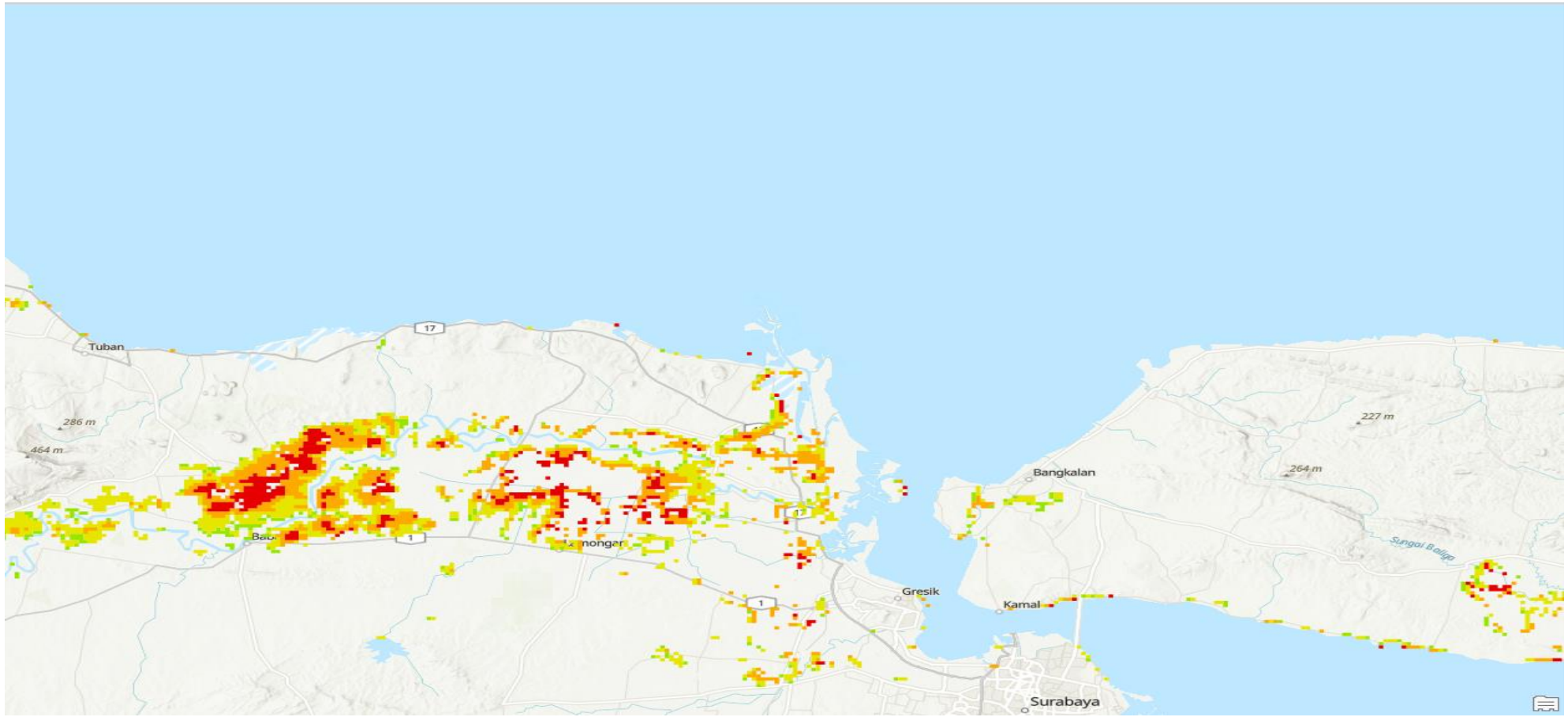
PNG



GeoTif displayed in web viewer



Combining all the layers into one image using ArcGIS



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Natural Resources Canada | Ressources naturelles Canada
Canada

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NATIONAL WEATHER SERVICE

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Example of how the products can be used **during the day**

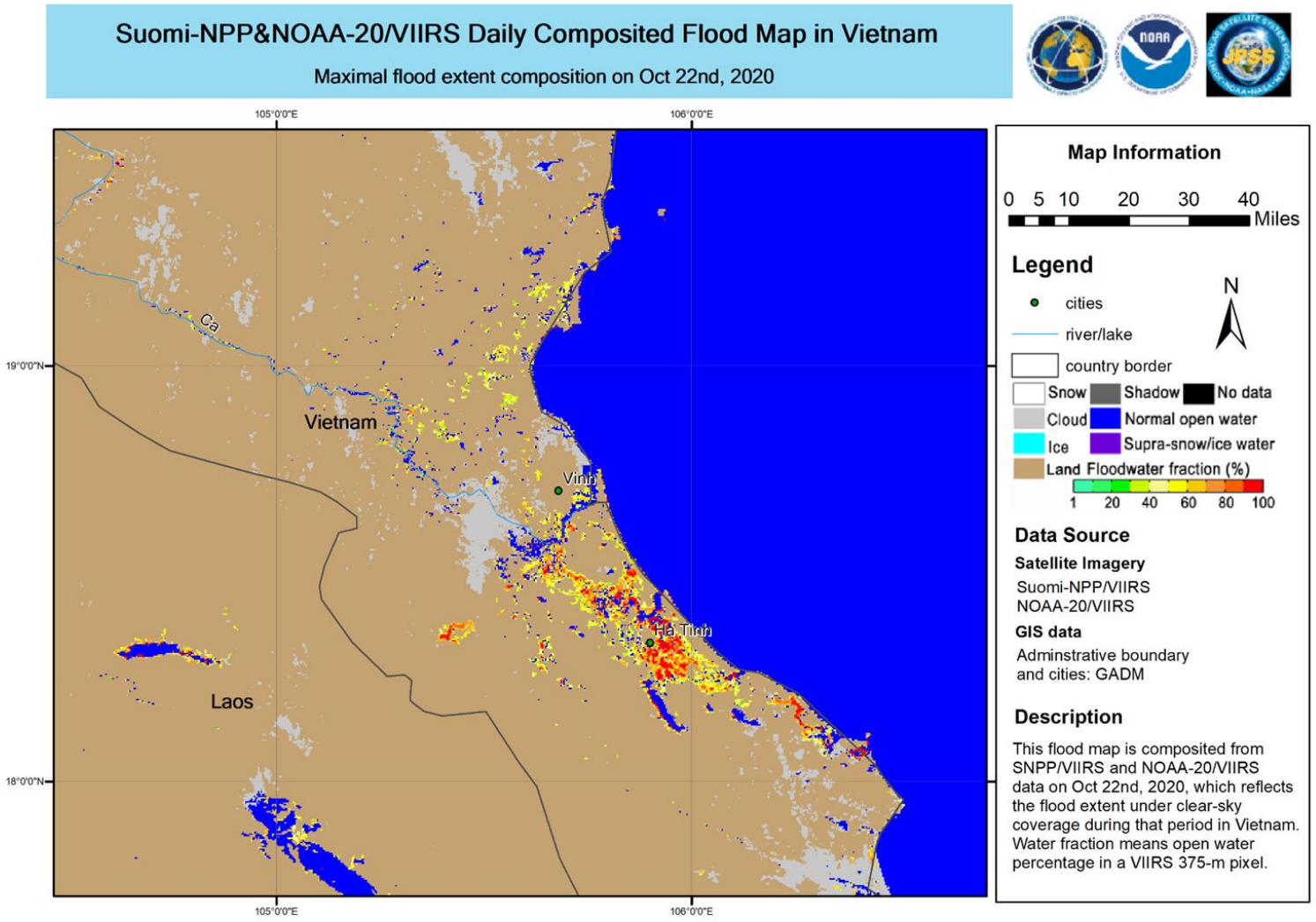
- The ABI/AHI flood maps are available from the early morning to the late afternoon, and thus are recommended for use during the periods when VIIRS flood products are unavailable.
- Once the high resolution (**375 m**) flood product from VIIRS become available (3-4pm local solar time over a given region, assuming DB availability), assessments can be revised using finer and more accurate details of the flood extent, depending on cloud cover over ROI at time of S-NPP and NOAA-20 passes.
- When available, the Joint VIIRS/ABI or VIIRS/AHI Flood products are highly recommended for an initial evening assessment, since they provide the best coverage from ABI or AHI and the more accurate floodwater details from VIIRS.
- When it is always partially cloudy during a period, the VIIRS daily or 5-day composited flood products are also recommended for use as they filter out the cloud cover through a maximal water-fraction composition process and can reflect the maximal flood extent during a day or the latest five days.
- Remember that the all of the flood products are produced during **daytime only**, thus the products will not be updated overnight

Example cases – Vietnam, 16 October 2020

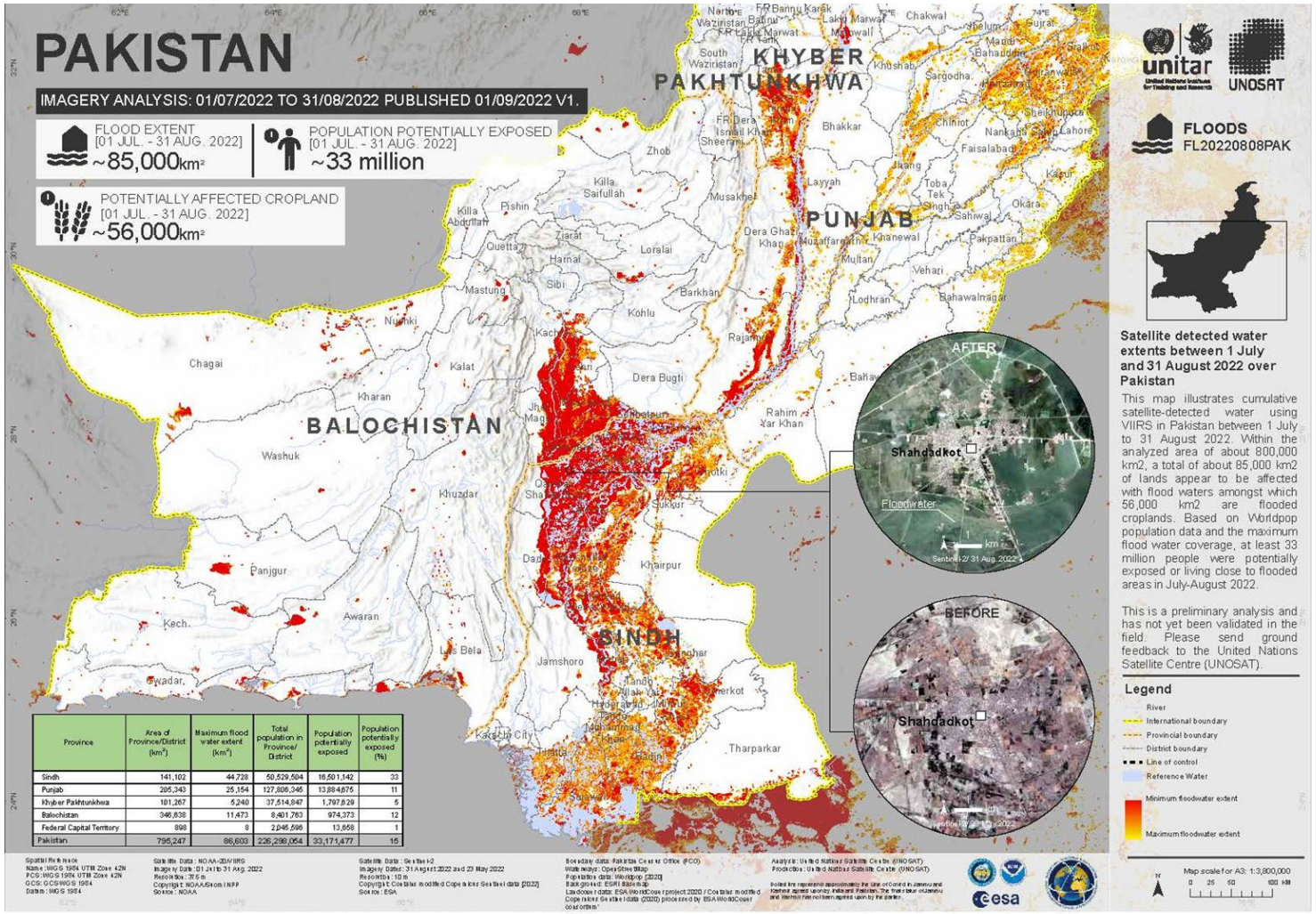
- Tropical storms have brought heavy rainfall and high wind speeds causing severe flooding across Vietnam's central provinces. At least 23 people have been killed and 14 people are reported missing.

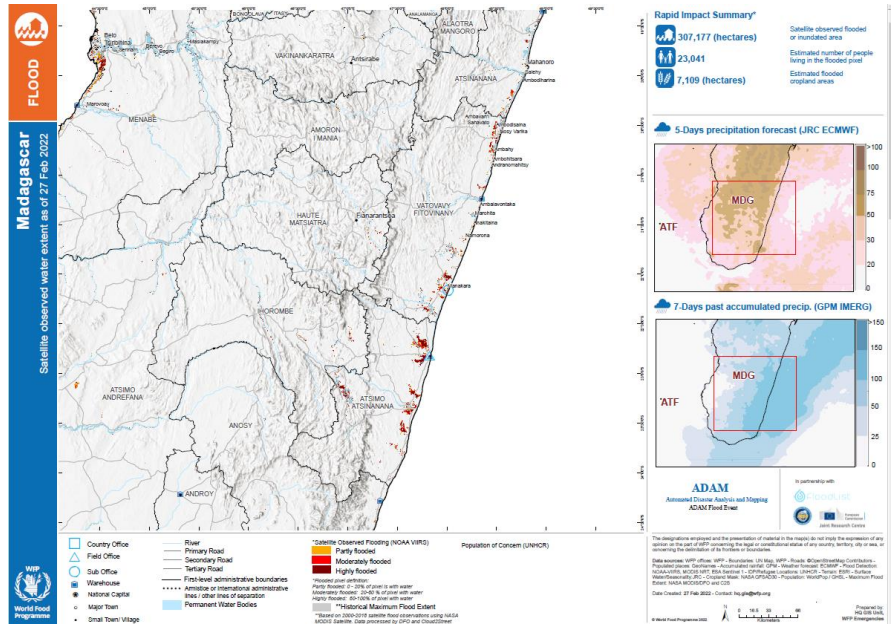
- Local authorities have evacuated 46,000 people from the worst affected areas. Over 100,000 homes have been flooded. The national disaster management authority also reported damage to roads and bridges and over 584 hectares of crops are inundated.

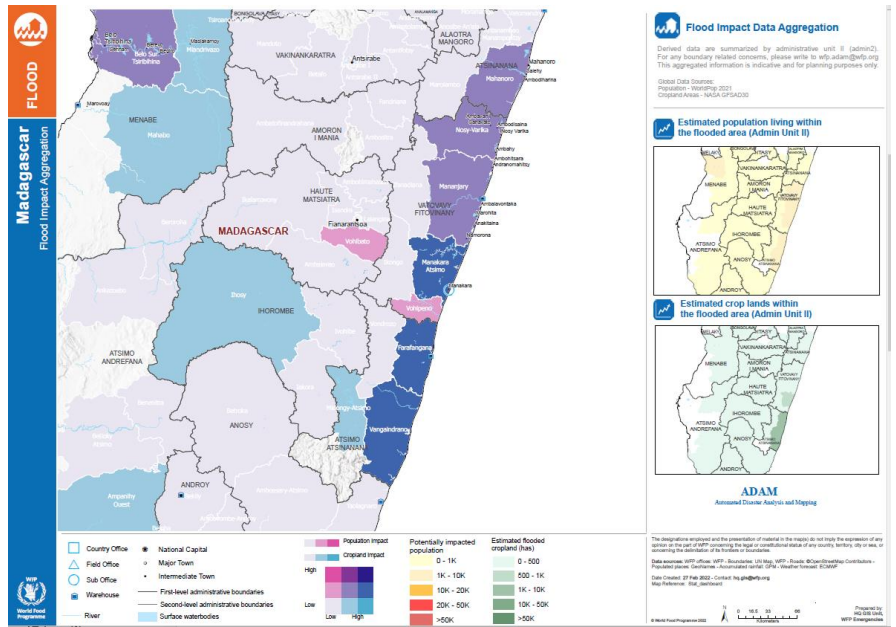
- https://disasterscharter.org/web/guest/activations/-/article/flood-large-in-viet-nam-activation-680-



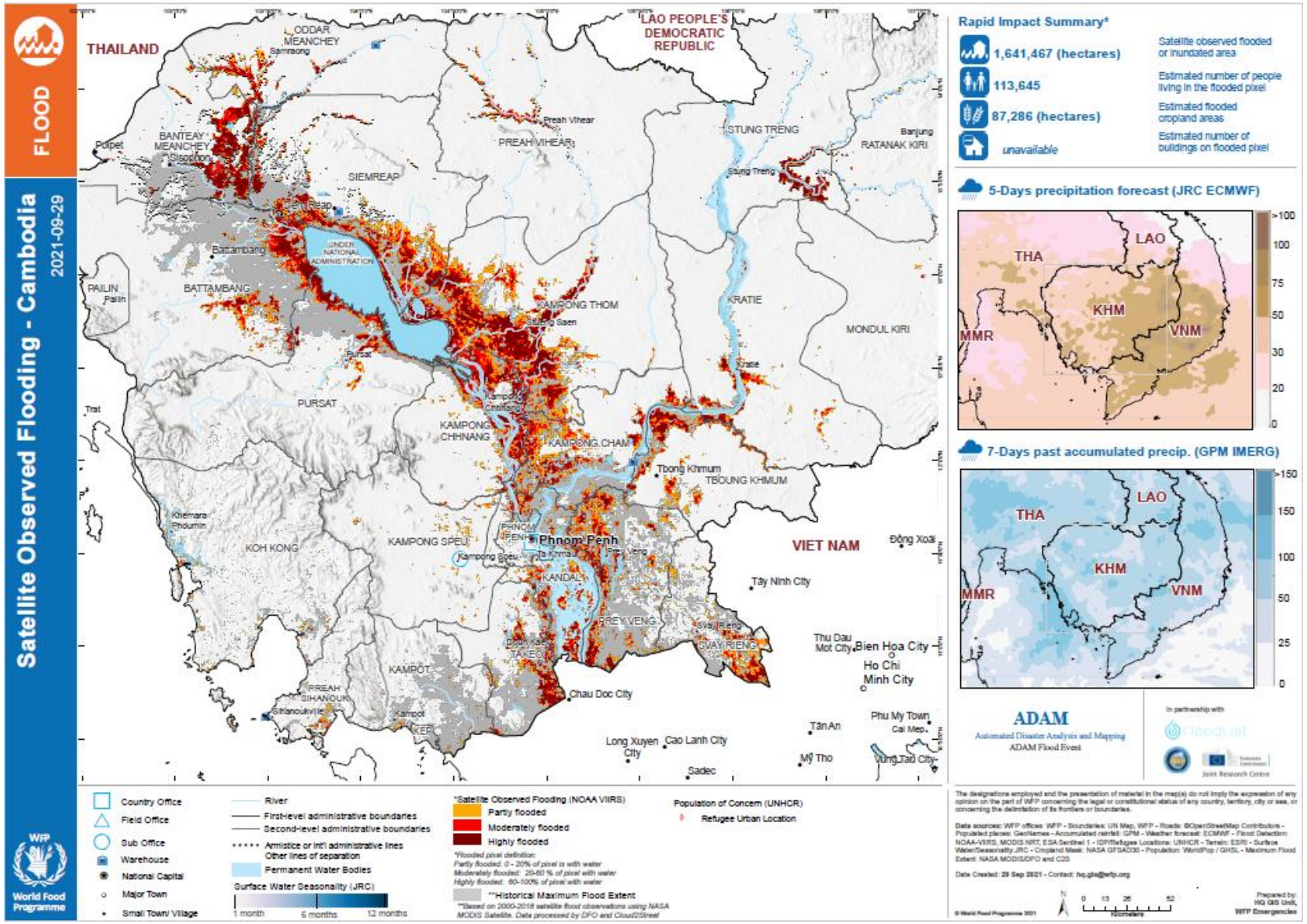
Example cases – International Charter/WFP





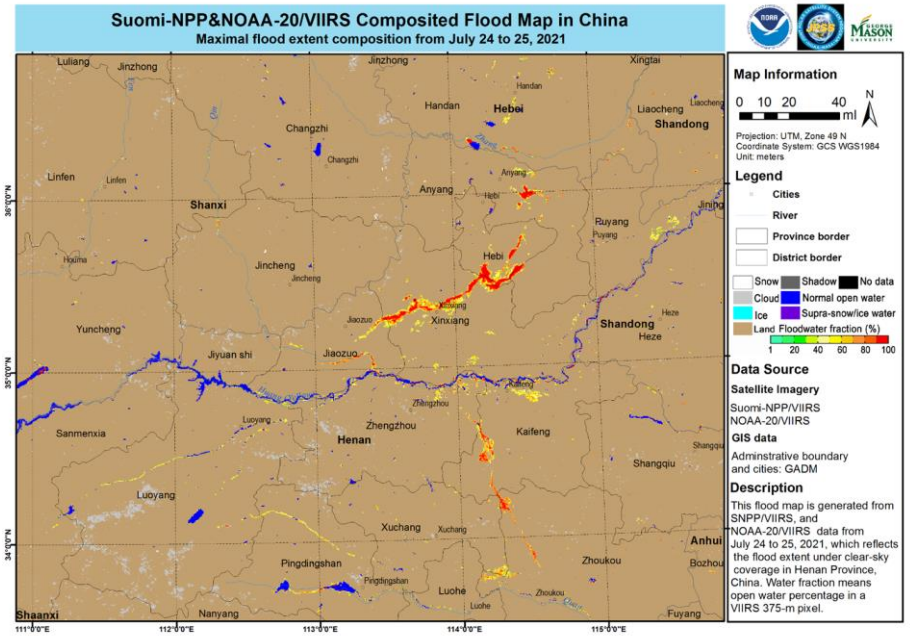


Example case – World Food Programme

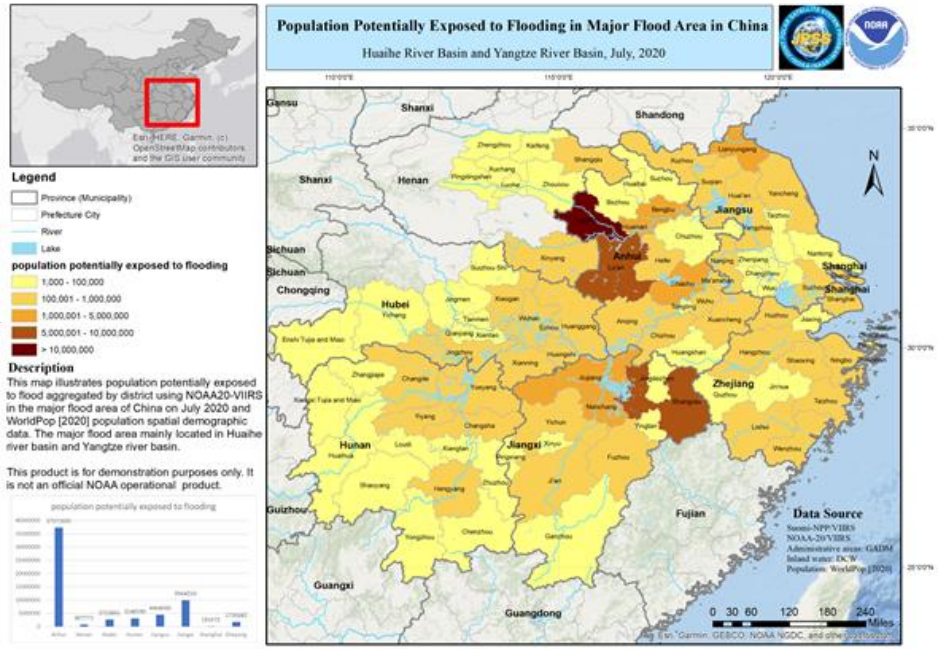


Tying satellite data and socio-economic information together

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

Example cases **–** Australia Bureau of Meteorology

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Australian Government
National Situation Room

NSR Dashboard: Severe Weather – WA
Information current as at 0600 hrs AEDT, 2 February 2023
For further enquiries – NSR: 1300 243 222

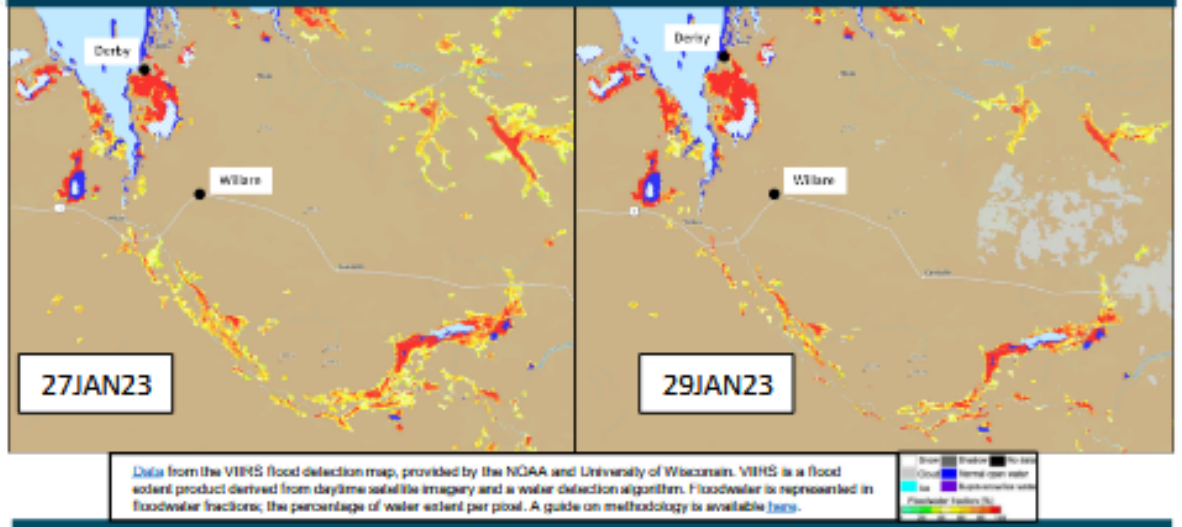
3

Updates in RED
All times AEDT unless otherwise stated

CURRENT SITUATION – WA

- Showers and thunderstorms are expected over the Kimberley today, 02FEB23, adjacent North Interior, Pilbara, Gascoyne and northern Central West district.
- Thunderstorm activity will continue over the Kimberley for most of the week.
- River level rises are expected at Fitzroy Crossing, with a MINOR flood warning current for the Fitzroy River. MINOR flooding is occurring at Noonkanbah. [13]
- The WA Government has enacted an Emergency Situation Declaration for the Shires of Broome and Derby, West Kimberley. This provides additional powers under the *Emergency Management Act 2005* (WA) to access commercial and non-governmental assets for emergency response, search and rescue, and relief operations. The declaration has been extended and is scheduled to expire at 1800 hrs AWST 09FEB23. [1]
- The DFES State Operations Centre remains activated in response to ex-Tropical Cyclone Ellie which has been designated a Level 3 incident (protracted in nature and significant impact on the routine functioning of the community and infrastructure). [2]
- As at 01FEB23, Defence has approximately 275 personnel across aviation, general duties, logistics and coordination support, including three planners. [3]
- Since 06JAN23, Defence aircrafts have transported 421 tonnes of emergency relief supplies and 1068 passengers. [3]
- At the request of DFES, Defence aircrafts continue to transport evacuated residents back to their home

KIMBERLEY REGION SATELLITE-DERIVED FLOOD EXTENT – 27-29JAN23



WA Statistics: 03JAN23 to 02FEB23

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 derived optically based VIIRS daily and 5-day flood maps for (2012-2020) to begin this effort, making it freely available to users for analysis.

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Download the *Data*

Quick Guide of Flood Products

- Real Earth Website: https://realearth.ssec.wisc.edu/?products=RIVER-FLD-AHI.75,RIVER-FLD-joint-AHI.75,RIVER-FLDglobal-composite1.-100,RIVER-FLDglobal-composite.75,RIVER-FLDglobal&center=10,120&zoom=4&basemap=streets&labels=-&timespan=-5d&timestep=1d
- Visit JPSS (amazon aws) link: https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/
- Visit FTP: https://www.ssec.wisc.edu/flood-map-demo/ftp-link/ftp-link-ahijoint/
- Set your AOI. For example: Vietnam's AOI (090, 091, and 120).
- Knowing the flood area (the city or river name)
- JPSS link (2012 – 2020) – Floodwater fraction layer (00-100%).
- Ftp-link (the last ten days) – all layer of floodwater fraction. Recommended – Download each day.

FTP Link & JPSS

FTP link

For larger dowloads, use an ftp or http tool and search
ftp://floodlight.ssec.wisc.edu/joint/*AHI.***
or
https://floodlight.ssec.wisc.edu/joint/*AHI.***

Satellite: ○ VIIRS ○ ABI ○ AHI ◉ JOINT
File type: ○ GeoTiff ○ Shapefile
Region: ○ VIIRS_ABI ◉ VIIRS_AHI
Area Of Interest:
○ 064 ○ 065 ○ 066 ○ 067 ○ 077 ○ 078 ○ 079 ○ 080 ○ 090 ○ 091
○ 092 ○ 101 ○ 102 ○ 103 ○ 109 ○ 110 ○ 111 ○ 112 ○ 117 ○ 118
○ 119 ○ 120 ○ 123 ○ 124 ○ 125 ○ 126 ○ 127 ○ 128 ○ 134 ○ 135

RIVER-FLD-joint-AHI_20230621_000000.part135.force.tif
RIVER-FLD-joint-AHI_20230621_000000.part134.force.tif
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RIVER-FLD-joint-AHI_20230621_000000.part123.force.tif
RIVER-FLD-joint-AHI_20230621_000000.part120.force.tif

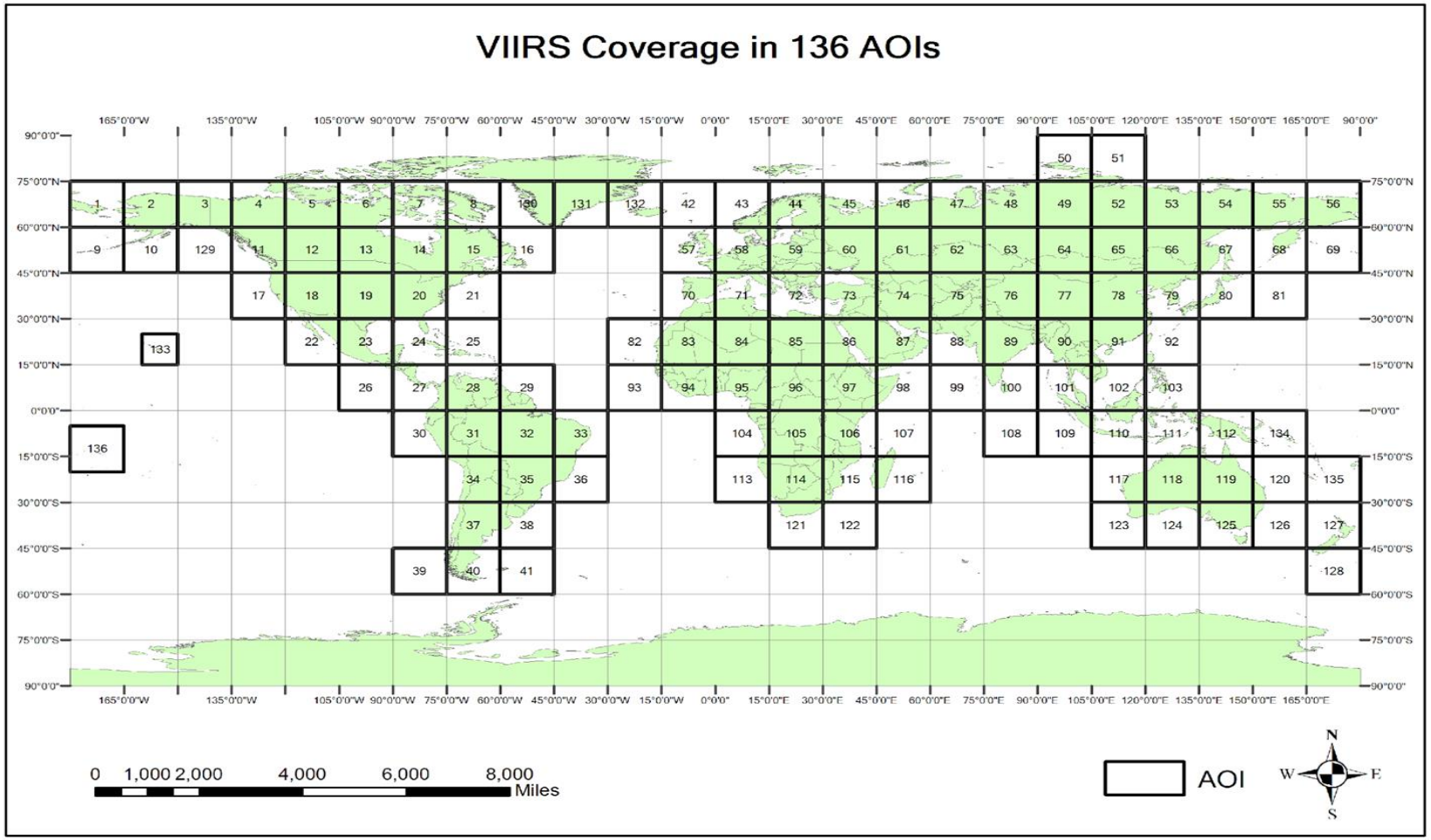
AWS S3 Explorer | noaa-jpss / JPSS_Blended_Products / VFM_5day_GLB / ShapeZIP | Hide folders? | Folder | Bucket

Show 100 entries | Search:

Object	Last Modified	Timestamp	Size
2012/			
2013/			
2014/			
2015/			
2016/			
2017/			
2018/			
2019/			
2020/			

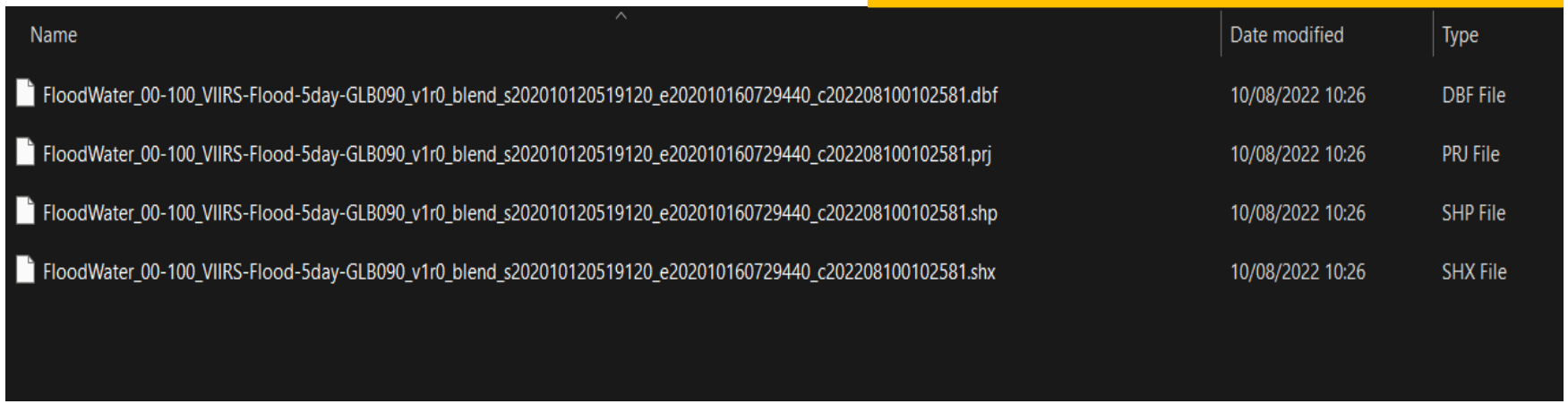
Showing 1 to 9 of 9 entries | Previous | 1 | Next

Area *of Interest*

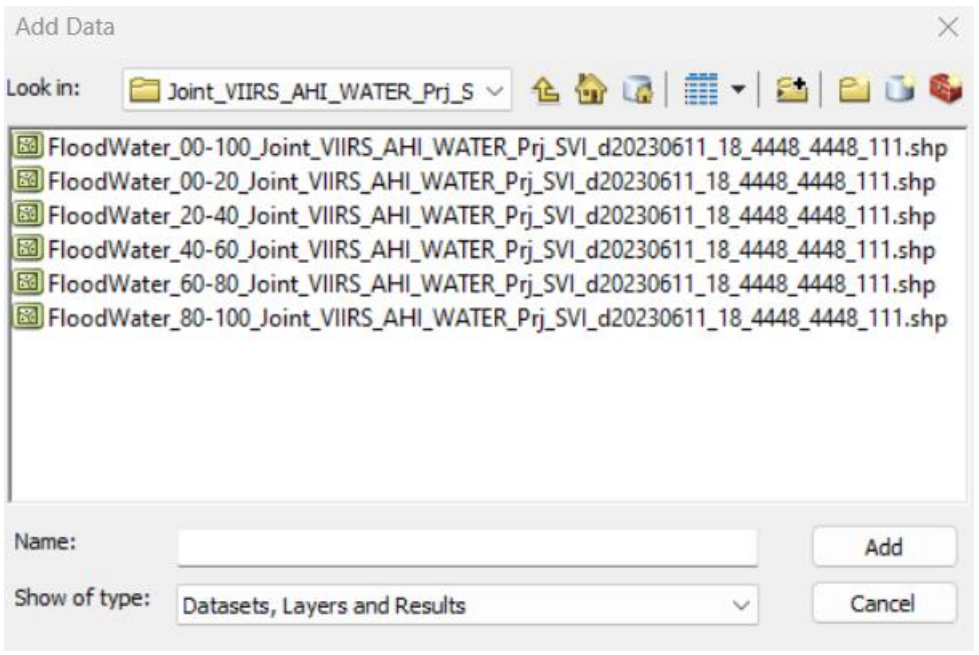


Data *Format*

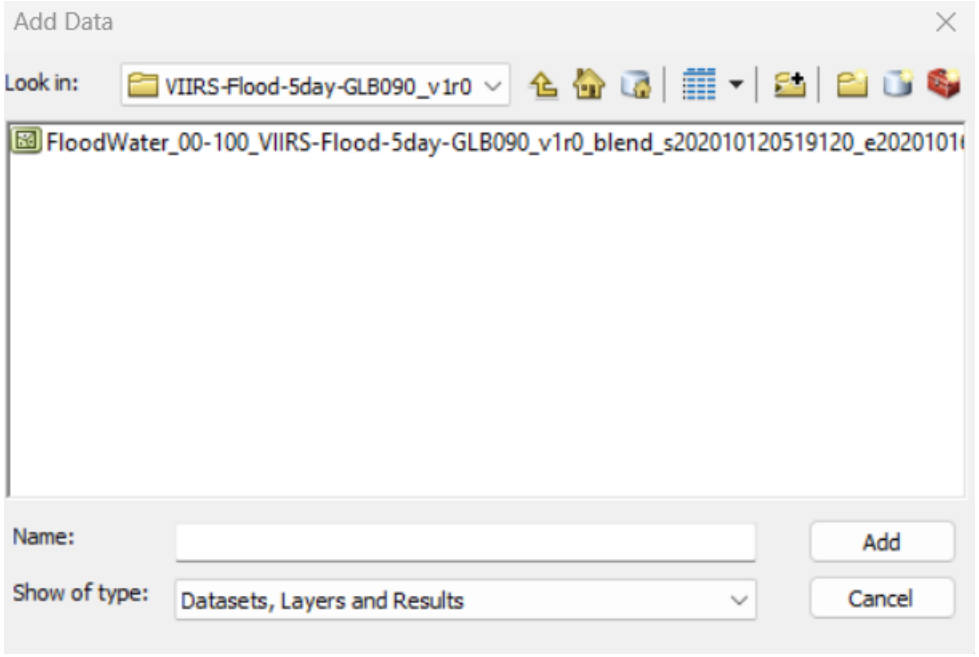
Shapefile Data



Data from FTP link (open in ArcGIS)



Data from JPSS (open in ArcGIS)



Display *the Data*

Using the ArcGIS

- Many tools in ArcGIS
- The arc Toolbox for advanced analysis.
- Spatial analyst tool, Analysis tool, and Multidimensional tool.

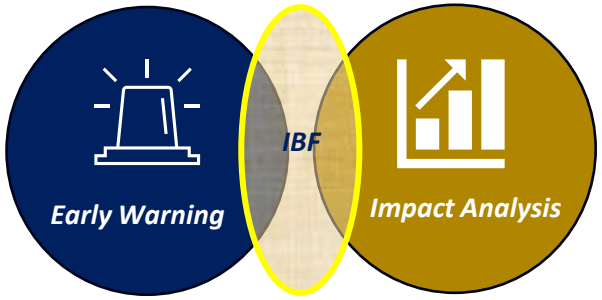
Impact & Response

Weather Forecast

Not enough to prevent people from a **Natural Disaster**

What we need? Impact ***analysis*** *from each* **region**

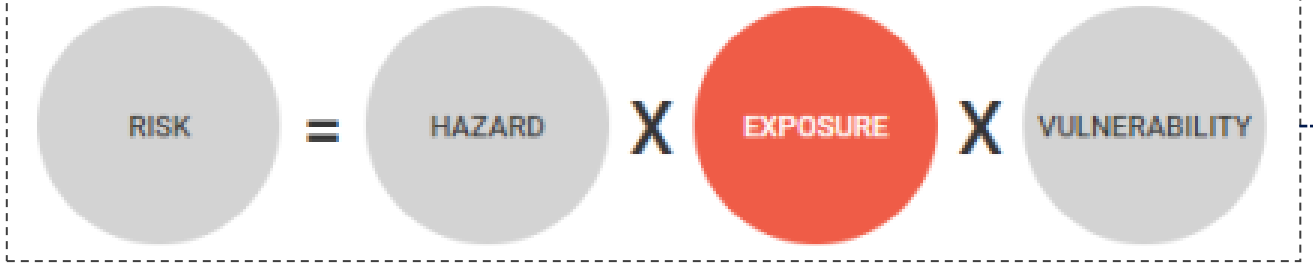
Considering on **impact** *and* ***how stakeholder*** will response it

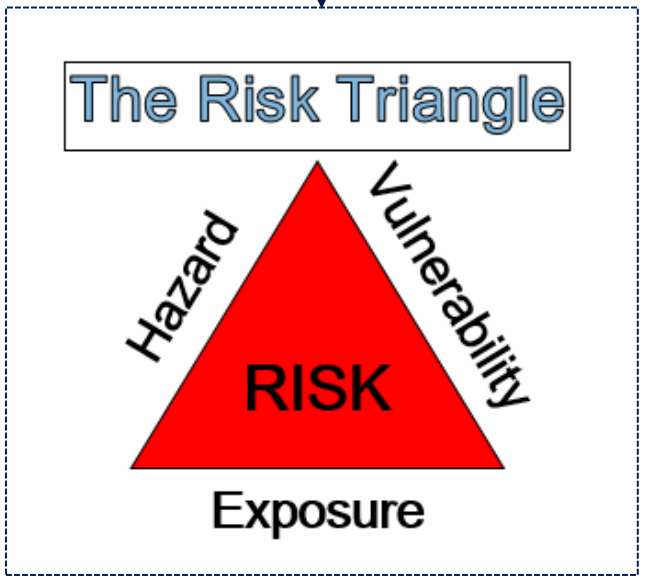


Climate Change

Impact-based Forecast (IBF)

Solution





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Impact & Response Table (15 June 2021), *Full Support from Regional Disaster Management (BNPB)* Maluku Province.


Focus Group Discussion (FGD)
Penyusunan Matriks Risiko Bencana Banjir dan Tanah Longsor
dalam Implementasi Impact-based Forecast dan Warning Services
di Kota Ambon
Ambon, 23 - 24 Agustus 2023


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SAFETY FIRST


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Not only *point area*
Teluk Ambon
Sirimau
Ambon
Nusaniwe
Bandara Pattimura
Leitimur Selatan
Leihitu Barat
Leihitu
Maluku Tengah
Salahutu
Polygon as a result directly from *stakeholders* in Ambon City. They drew the flood prone area

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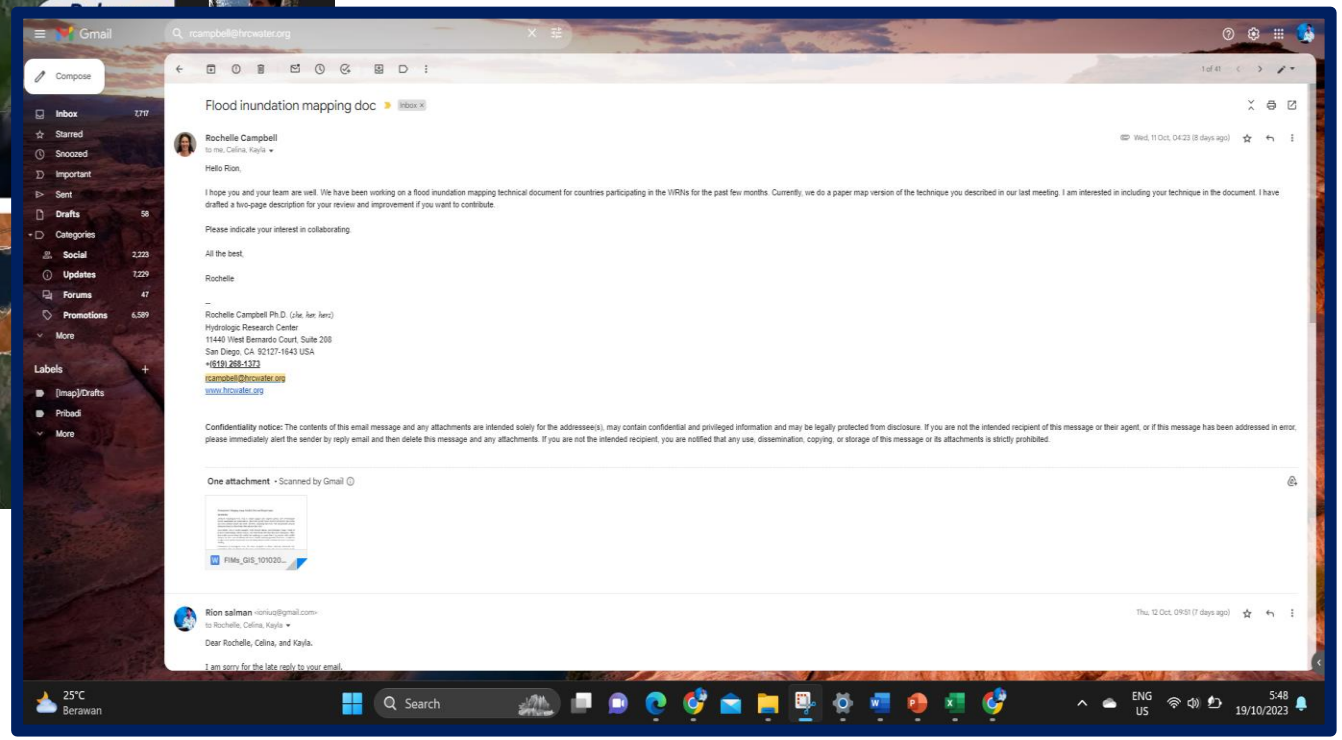
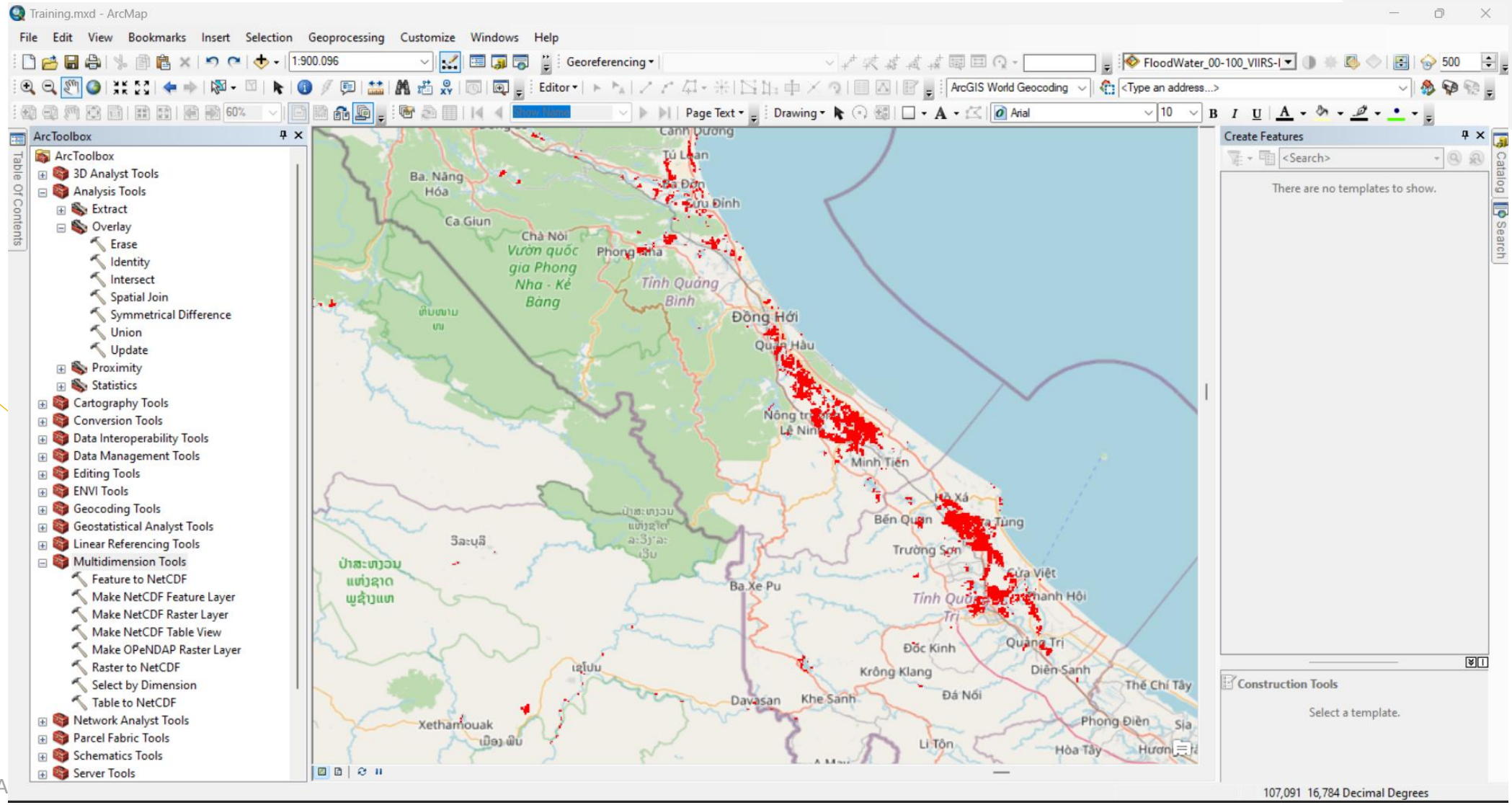
Meeting with Weather-Ready Nation (WRN) on 28 September 2023

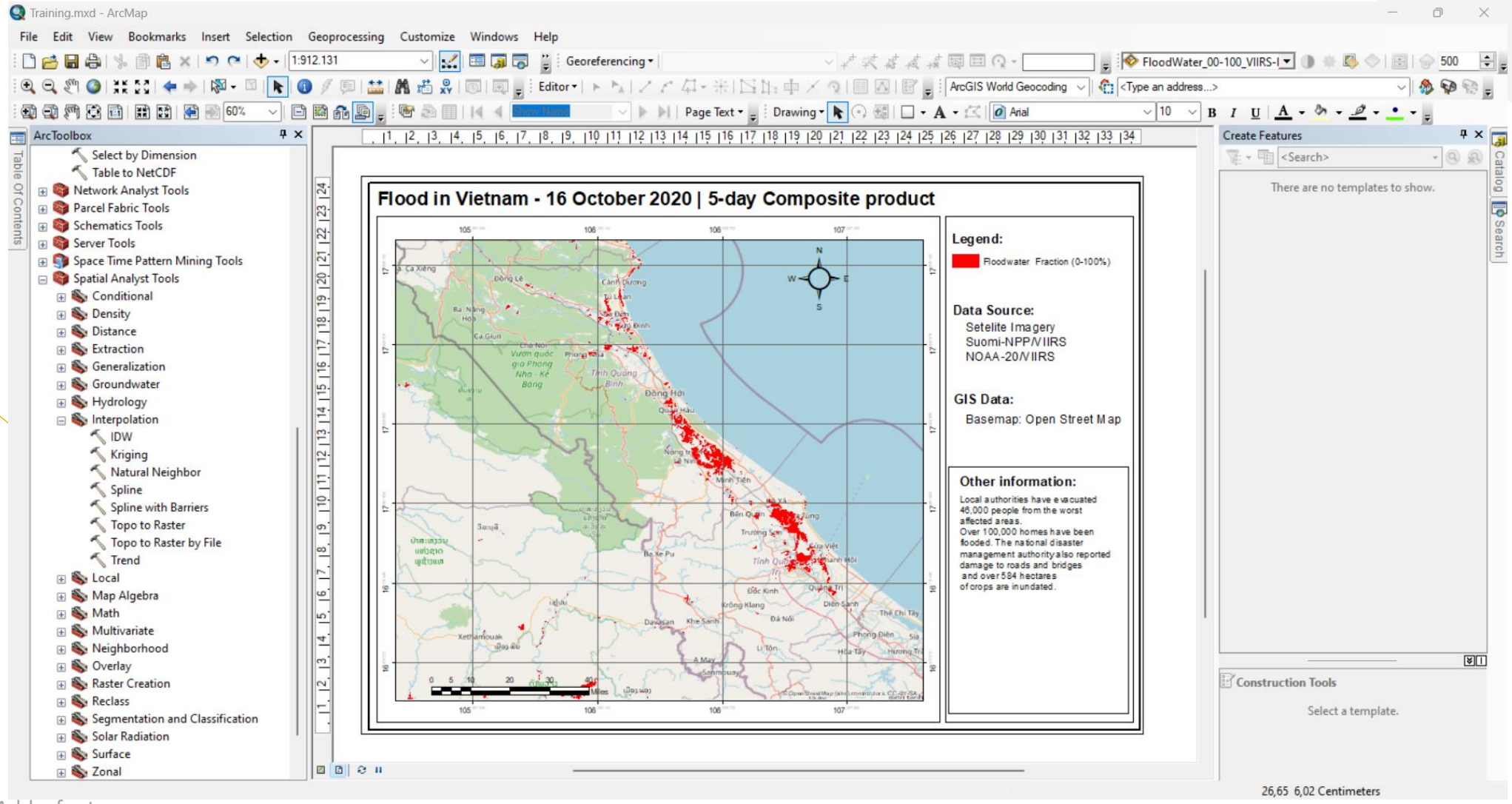
Future work with WRN: Joint Paper



ArcGIS


Training.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
ArcToolbox
3D Analyst Tools
Analysis Tools
Extract
Overlay
Erase
Identity
Intersect
Spatial Join
Symmetrical Difference
Union
Update
Proximity
Statistics
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
ENVI Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Feature to NetCDF
Make NetCDF Feature Layer
Make NetCDF Raster Layer
Make NetCDF Table View
Make OPeNDAP Raster Layer
Raster to NetCDF
Select by Dimension
Table to NetCDF
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Create Features
There are no templates to show.
Construction Tools
Select a template.
Đồng Hới
Minh Tiến
Bến Quan
Trường Sơn
Ba Xe Pu
Đốc Kinh
Krông Klang
Đá Nổi
Diên Sanh
Quảng Trị
Davasan
Khe Sanh
Xethamouak
Phong Điền
Hòa Tây
107,091 16,784 Decimal Degrees

ArcGIS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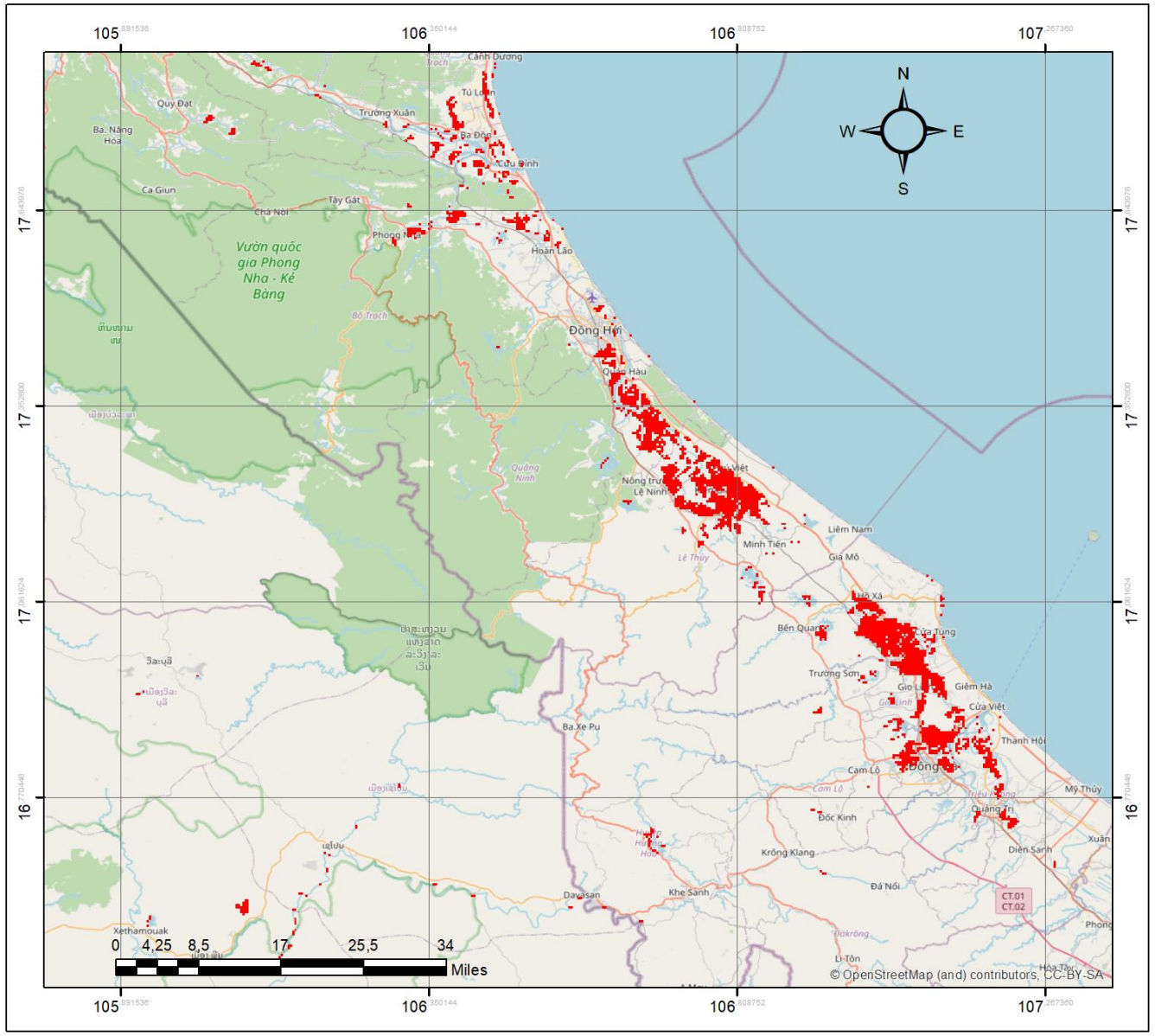
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
IDW
Kriging
Natural Neighbor
Spline
Spline with Barriers
Topo to Raster
Topo to Raster by File
Trend
Local
Map Algebra
Math
Multivariate
Neighborhood
Overlay
Raster Creation
Reclass
Segmentation and Classification
Solar Radiation
Surface
Zonal
Flood in Vietnam - 16 October 2020 | 5-day Composite product
Legend:
Floodwater Fraction (0-100%)
Data Source:
Setelite Imagery
Suomi-NPP/VIIRS
NOAA-20/VIIRS
GIS Data:
Basemap: Open Street Map
Other information:
Local authorities have evacuated 46,000 people from the worst affected areas.
Over 100,000 homes have been flooded. The national disaster management authority also reported damage to roads and bridges and over 584 hectares of crops are inundated.
Create Features
There are no templates to show.
Construction Tools
Select a template.
26,65 6,02 Centimeters

Result

Flood in Vietnam - 16 October 2020 | 5-day Composite product



Legend:

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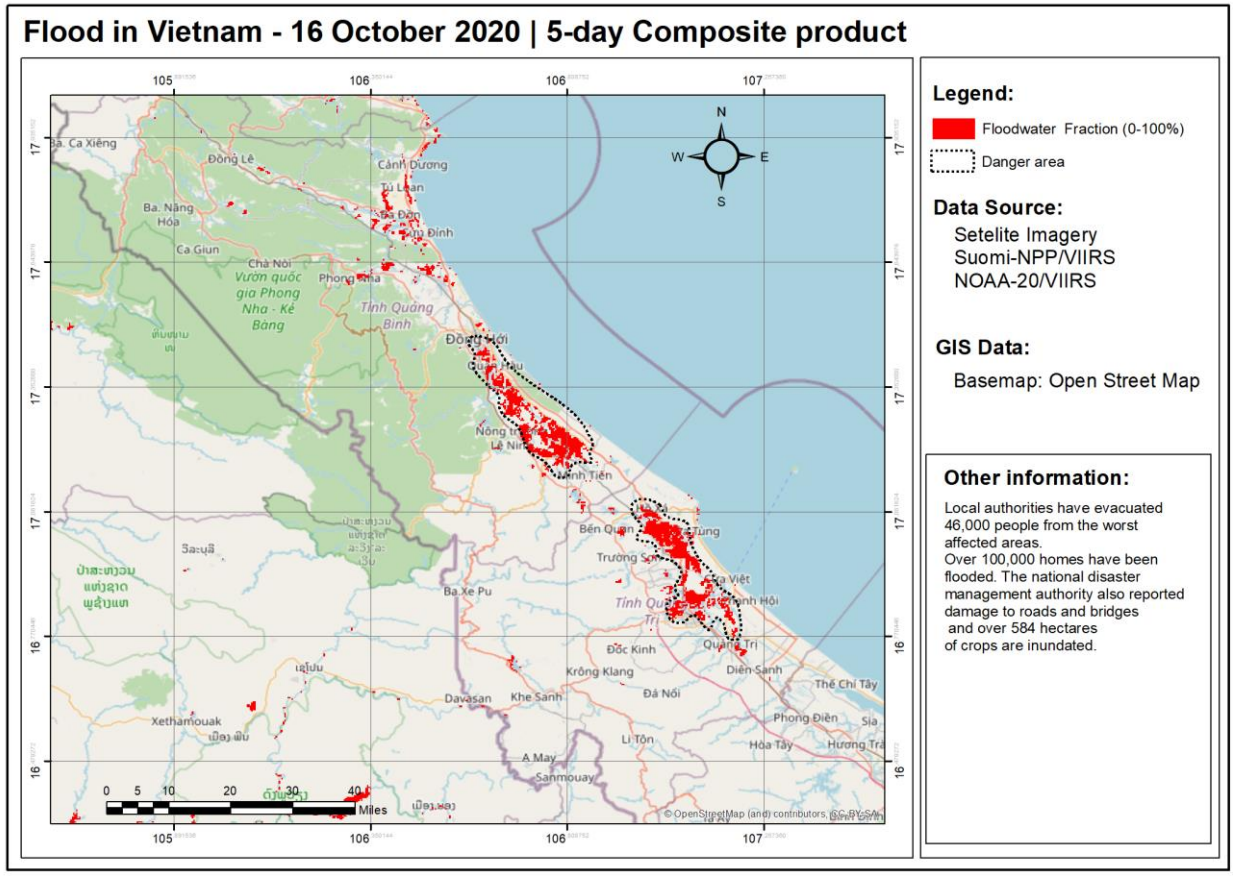
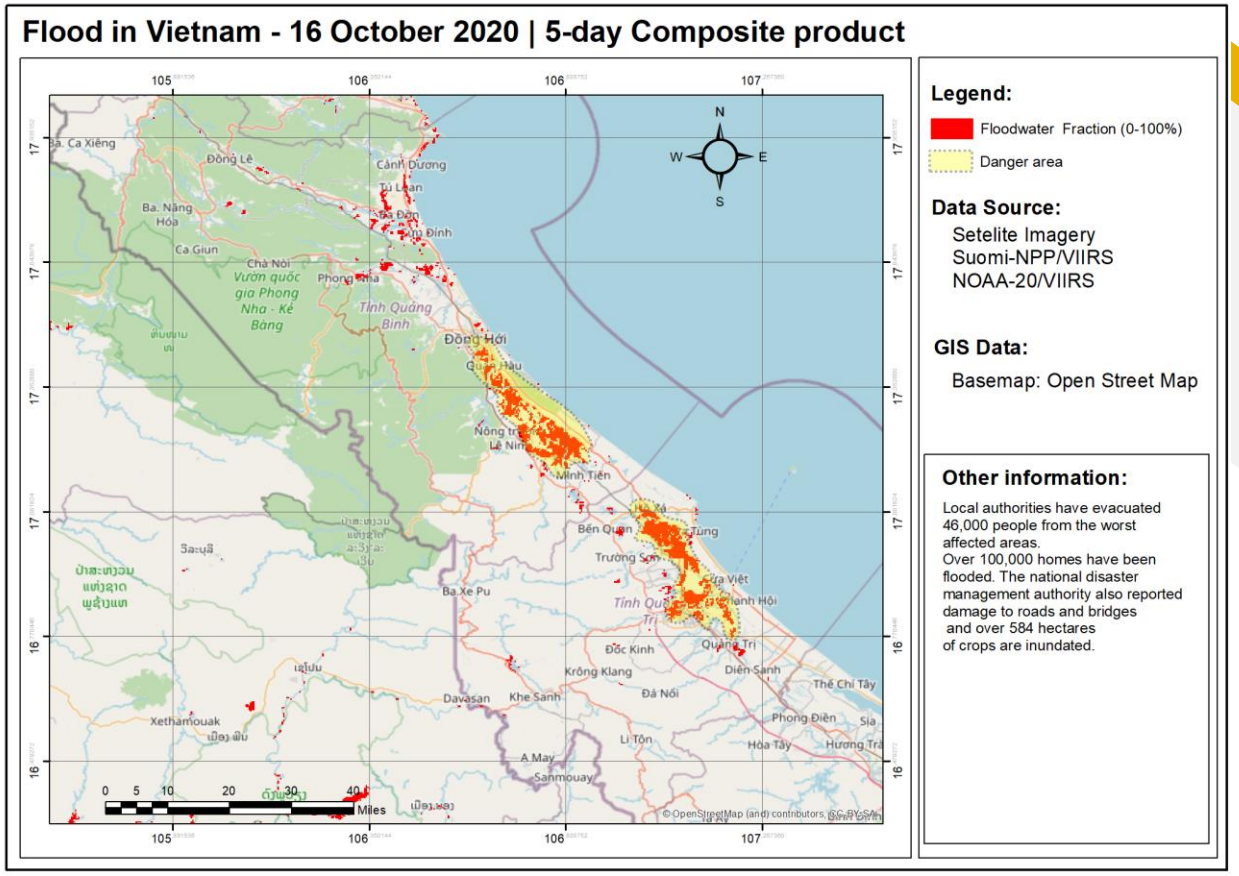


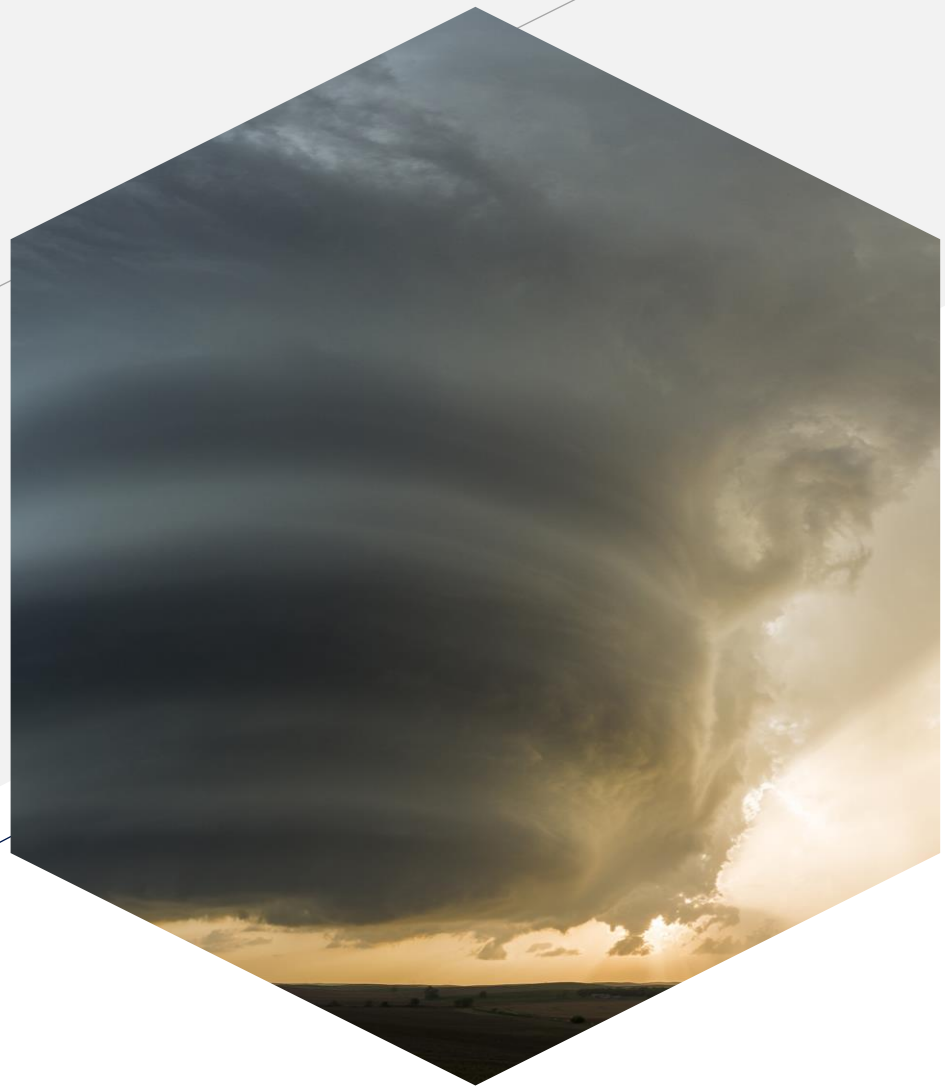


"Keep it simple but cover all aspects"

Case ***Study***

1. Dina – Indonesia
2. Guile Saligo – Philippines
3. Vanessa – Cameroon
4. Kahlan – Oman
5. Doni - Indonesia

“Practice Time”



Thank *You* | Terima ***Kasih***

Willian Straka (*Trainer*) & Rion S. Salman (*Co-Trainer*)

william.straka@ssec.wisc.edu | rion.salman@bmkg.go.id

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