



13th Asia-Oceania Meteorological Satellite Users' Conference

AOMSUC-13

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









Satellite-Derived Flood Product

Trainers BIO:



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 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.

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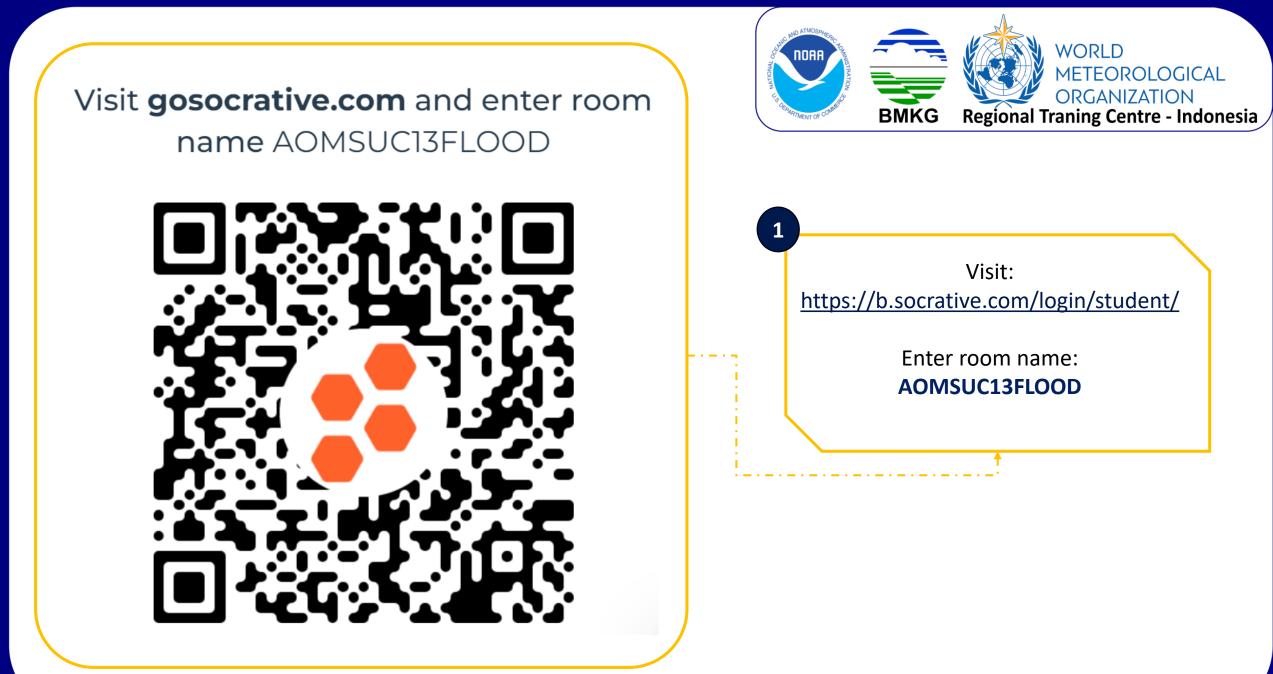
OUTLINE

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





1. What do you know about **satellite-derived flood** products? Could you mention them or do you have **experience** with it?





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.

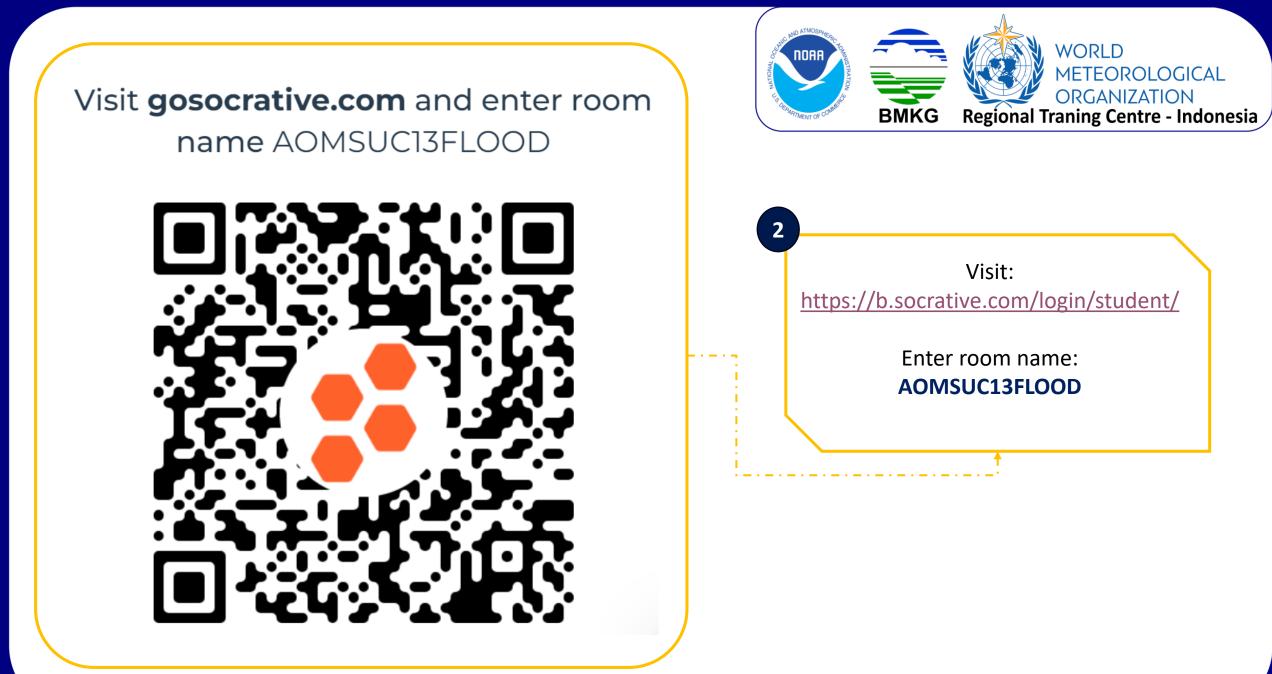
Flood Products Overview (cont.)



- 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.



NOAA GLOBAL FLOOD PRODUCT





2. What is the original file output of VIIRS flood product?

- a) Polygon
- b) GeoTIF
- c) Shapefile
- d) NetCDF



Satellite-Derived Flood Product ¹¹



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

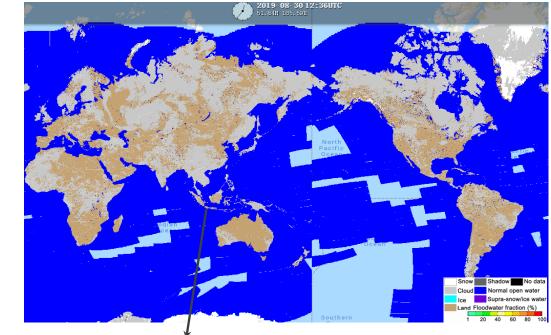
Lists of VIIRS/AHI Flood Products

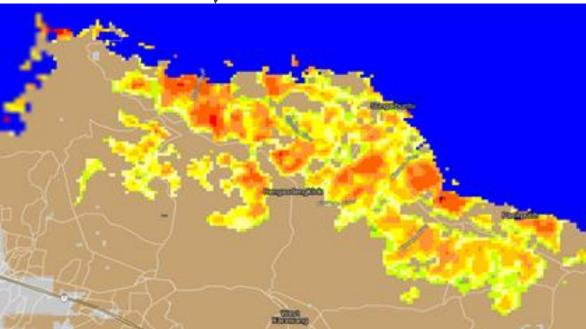
Products	Spatial resolution	Availability	Coverage	Production latency	Description
Suomi-NPP, NOAA-20, NOAA- 21 VIIRS near real-time flood product*	375m	2-3 daytime passes for each satellite	Global land between 80°S and 80°N	Available 3 hours after pass	Daytime-only flood extent in water
Suomi-NPP, NOAA-20, NOAA- 21 VIIRS daily composited flood product*	375m	Once per day	Global land between 60°S and 75°N	All tiles available by 1030Z	fractions (open water percentage in
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	a satellite pixel)
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	Snow Shadow No data Cloud Normal open water Ice Supra-snow/ice water Land Floodwater fraction (%)
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	1 20 40 60 80 100

* - Currently operational at NOAA+ - Transitioning to operations

VIIRS NRT Flood Product

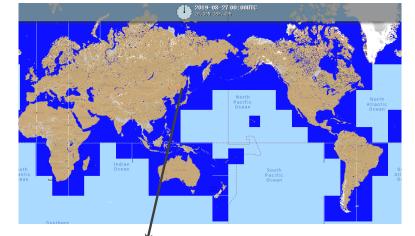
- The VIIRS 375-m Flood Product, is a near real-time product derived from daytime VIIRS imagery from Suomi-NPP, NOAA-20 and NOAA-21.
- The VIIRS Flood Map reflects the current flood status at the time of the overpass along with additional information on the weather and land conditions.
- Suomi-NPP, NOAA-20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

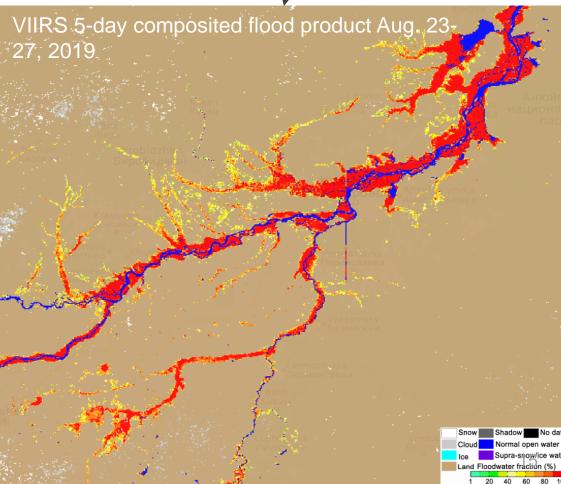




VIIRS Composited *Flood Products*

- 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.



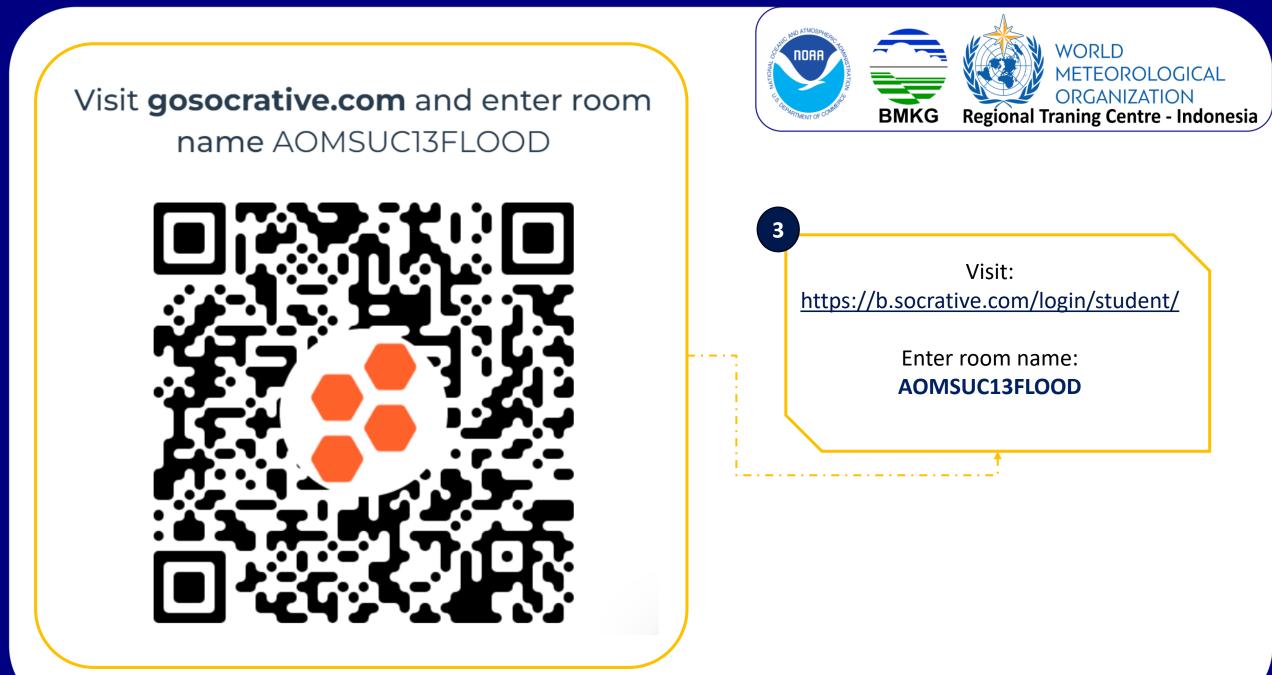


AHI Flood Product

- 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.









3. Regarding the AHI Flood Product, how does the map show flood water?

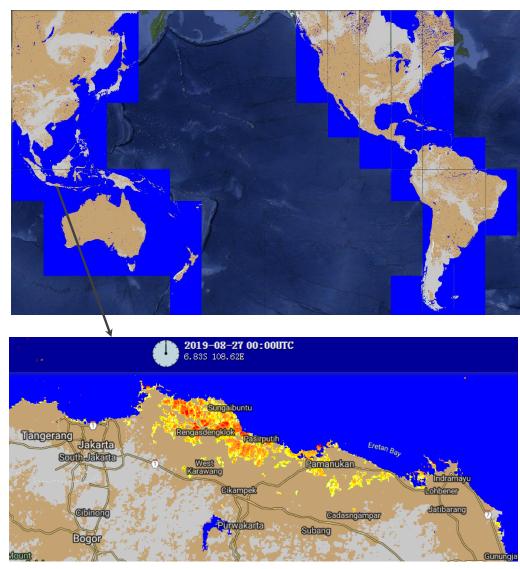
- a) Each minute
- b) Daily average
- c) Average from (first 10-minute to the latest one)
- d) Annually



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 clearsky 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.

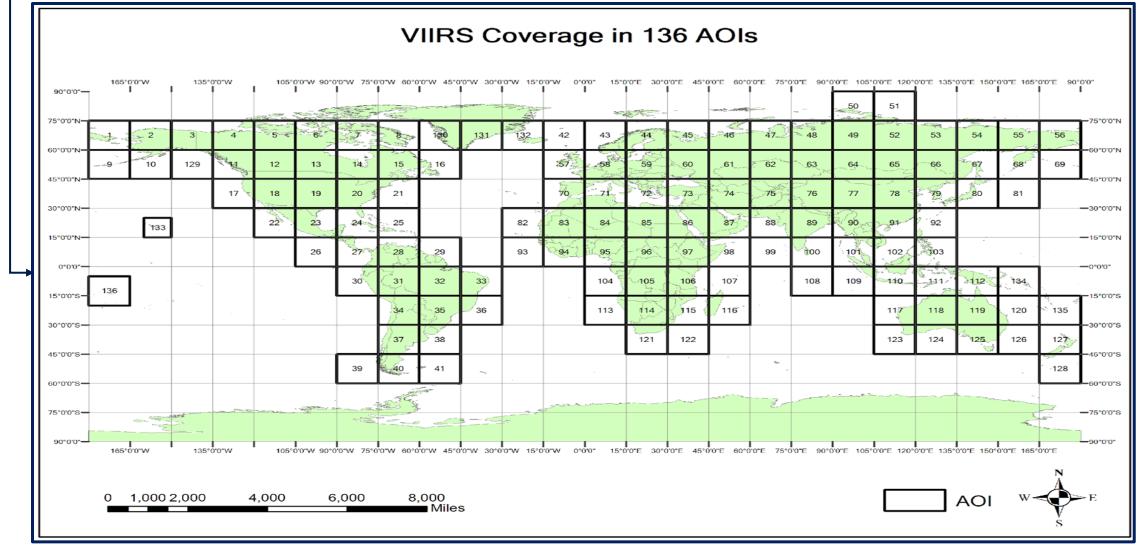
Aug. 27, 2019



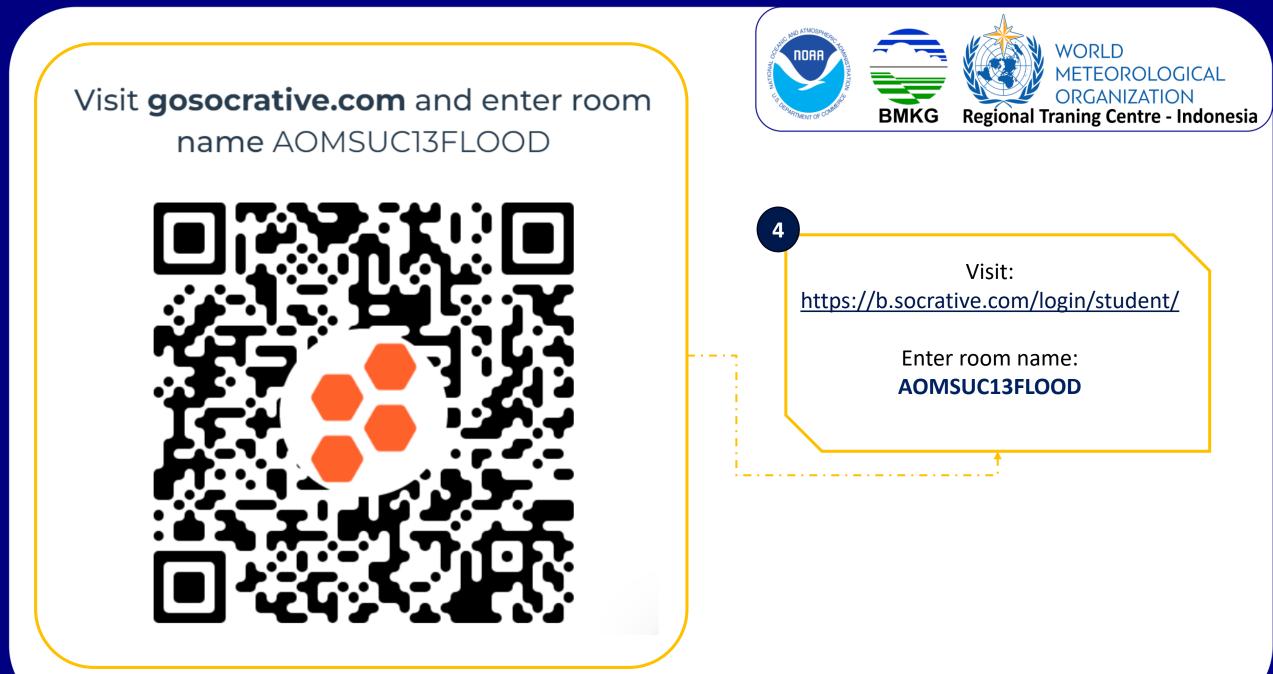
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The global land is divided into **136 AOIs** for the VIIRS composition *process and data archive*.





NOAA GLOBAL FLOOD PRODUCT

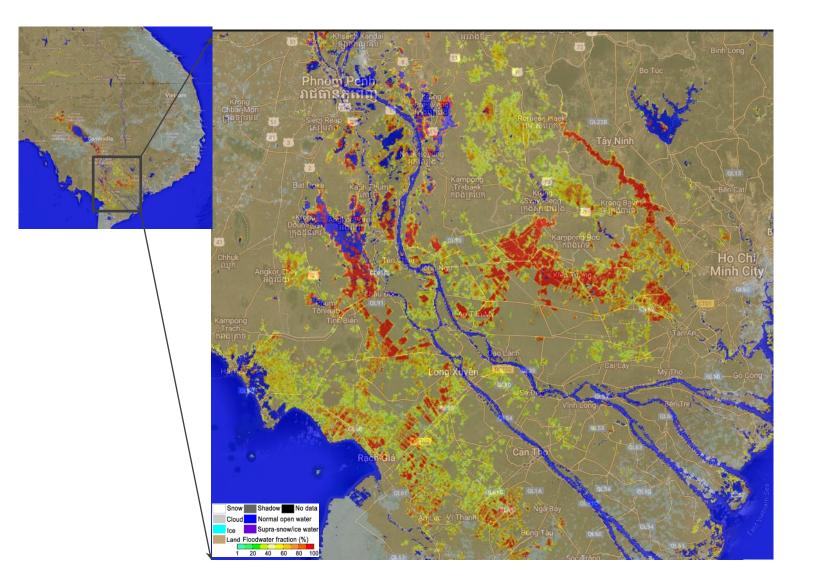




4. How many AOIs of VIIRS coverage? a) 125 b) 365 c) 136 d) 112



Example case – Mekong Delta flooding, 3 Dec 2021





Bands used by NOAA Flood Product

Channels used by the NOAA VIIRS Flood Product

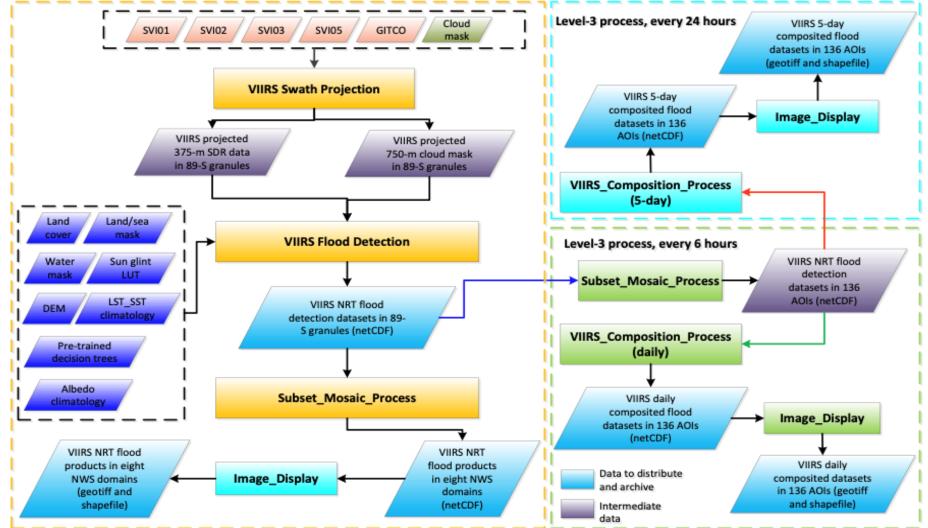
VIIRS Band	Central Wavelength (µm)	Band Explanation	Spatial Resolution (m) @ nadir	
M1	0.412			
M2	0.445	Visible/		
M3	0.488	Reflective		
M4	0.555	Reflective		
M5	0.672			
M6	0.746	Near IR	750 m	
M7	0.865			
M8	1.240			
M9	1.378	Shortwave IR		
M10	1.61	Shortwave IX		
M11	2.25			
M12	3.7	Medium-wave IR	-	
M13	4.05	Wedduin-wave in		
M14	8.55			
M15	10.76	Longwave IR		
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		
I 4	3.74	Medium-wave IR		
I5	11.45	Longwave IR		

-IMPACT-BASED FORECAST



VIIRS Flood Mapping System





NOAA GLOBAL FLOOD PRODUCT



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.).



Fraction (0-100%) (green to red)



3

4

5

6

7

Water (WTR, blue)

Floodwater

Cloud Cover (CLD, grey)

Cloud and Terrain Shadows (SDW, dark grey)

Bare Land (LND, brown)

Snow Cover (SNW, white)

Supra-snow/ice water or mixed ice and water (SSI, purple)



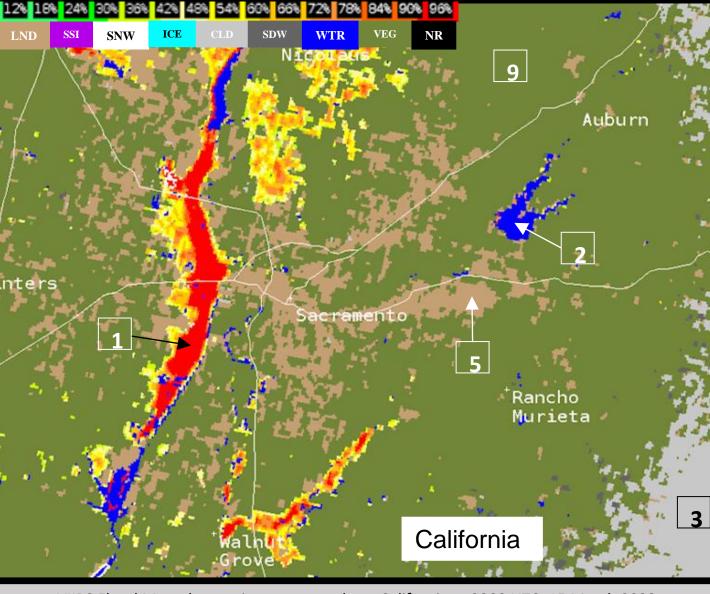
9

River and Lake Ice Cover (ICE, cyan)

Vegetation (VEG, dark green)

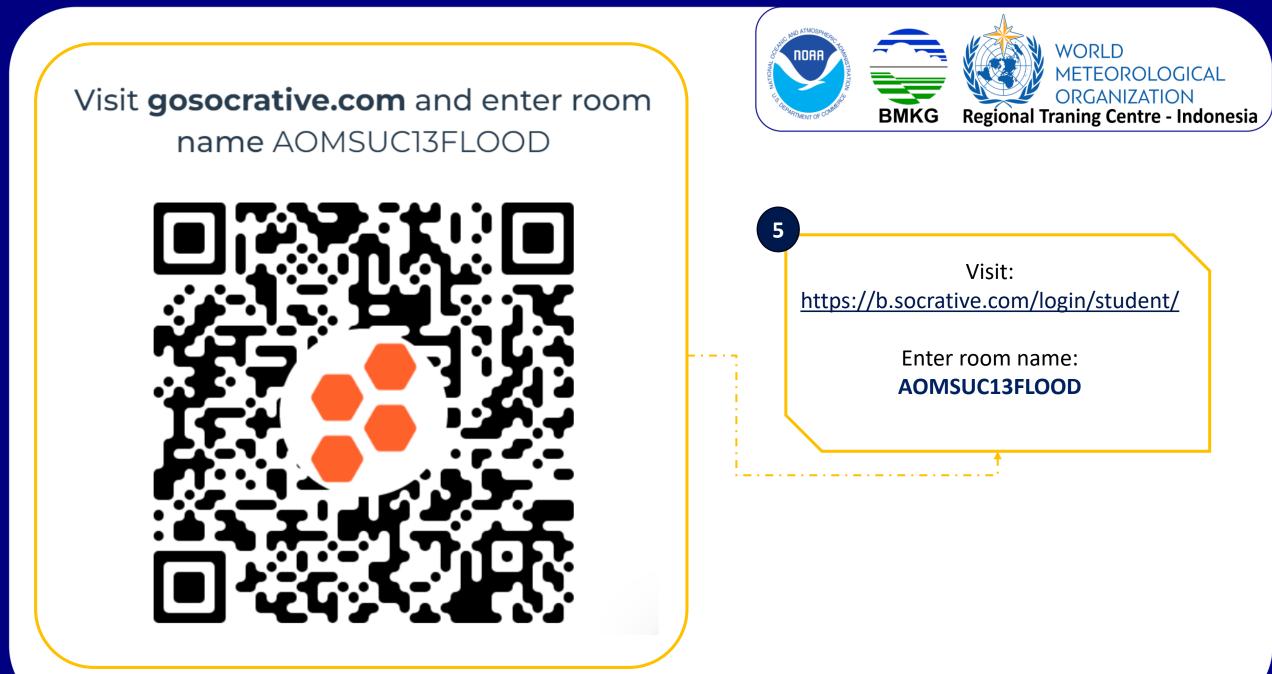
No Retrieval

(NR, black)



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

10

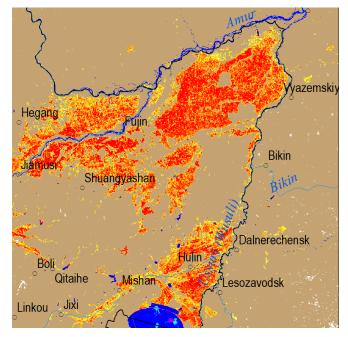




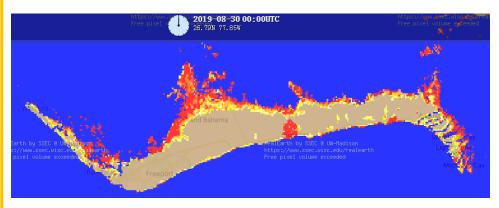
5. What is the color of interpretation to describe *vegetation and bare land*?
a) Blue and grey
b) white
c) Dark green and brown
d) Purple and yellow

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.

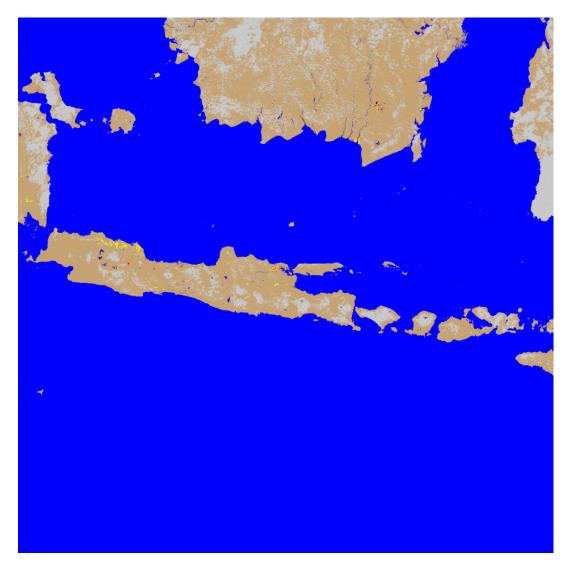


The widespread flooding water in the northeast of China from May 03 to 09, 2018 was not hazardrelated flooding, but the "flooded" rice paddy areas during planting season.

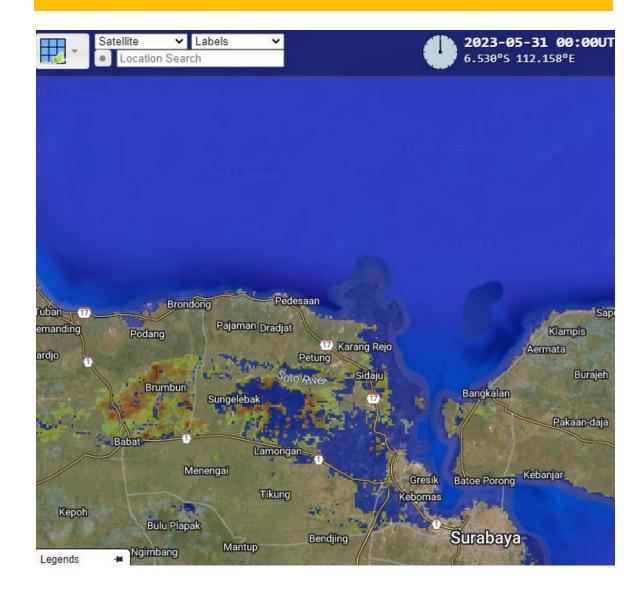


Flooding caused by the tides in Great Bahamas is a natural phenomenon.



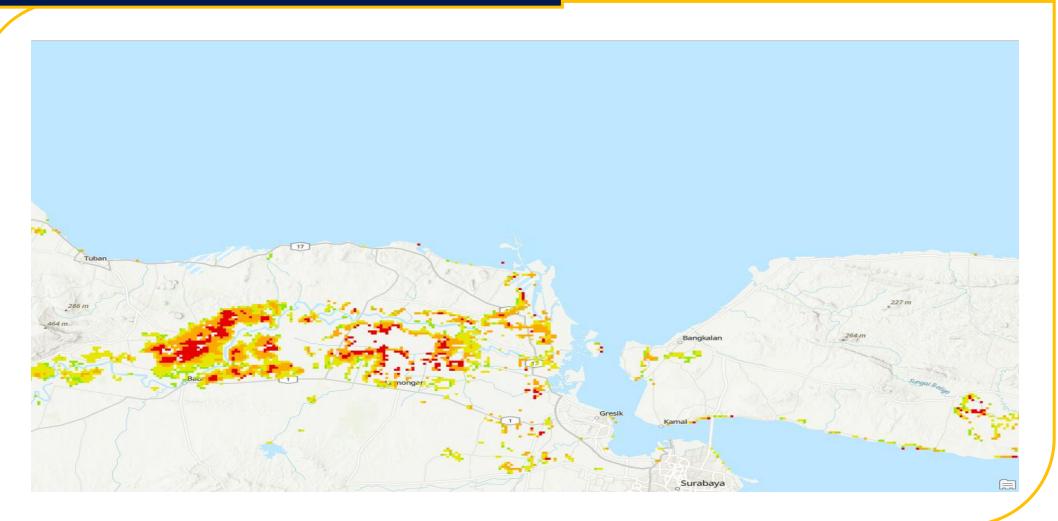


GeoTif displayed in web viewer





Combining all the layers into one image using ArcGIS



Satellite-Derived Flood Product

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International and US Users





The Committee on Earth Observation Satellites





World Food Programme









Natural Resources **Ressources naturelles** Canada Canada











NOAA GLOBAL FLOOD PRODUCF



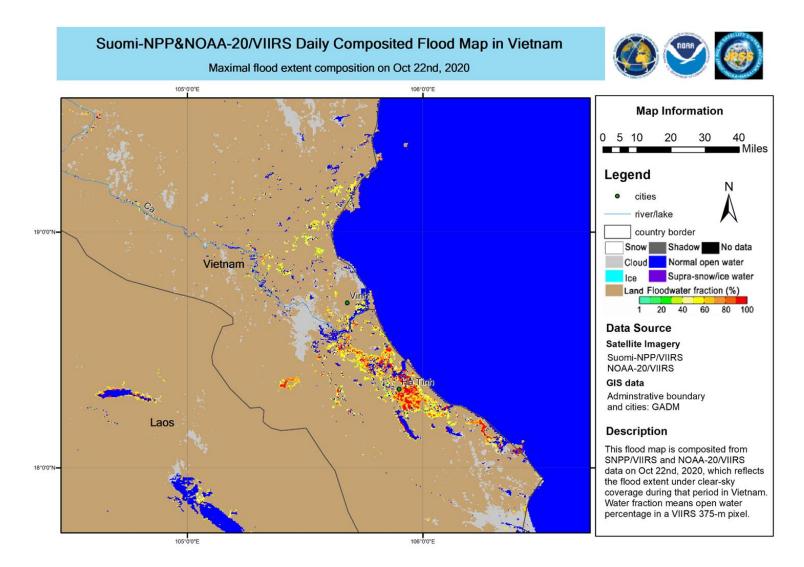
Example of how the products can be used **during the day**

- 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

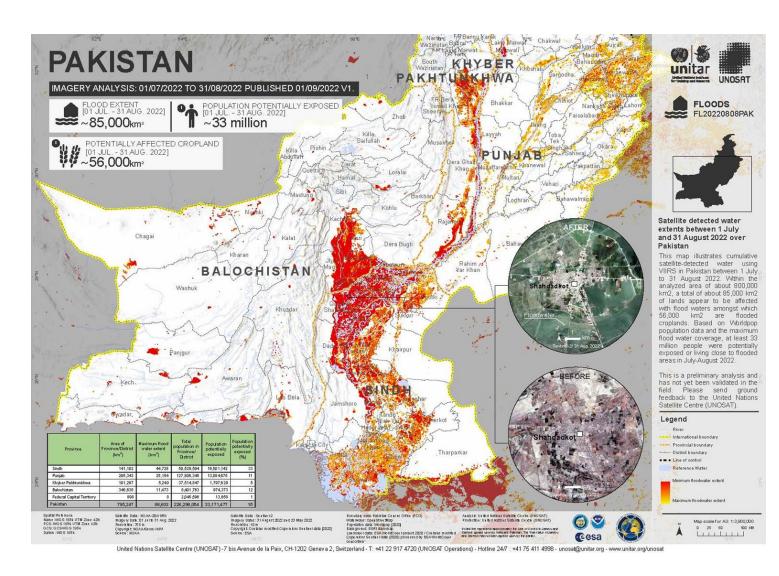
NOAA GLOBAL FLOOD PRODUCT

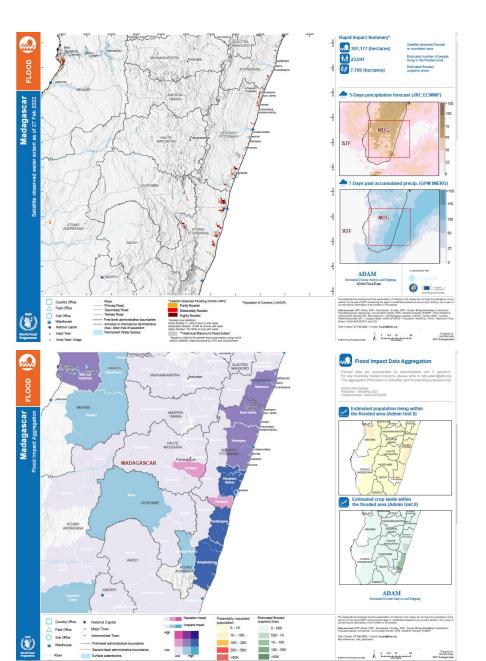
Example cases – Vietnam, 16 October 2020

- 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/a ctivations/-/article/flood-large-in-vietnam-activation-680-

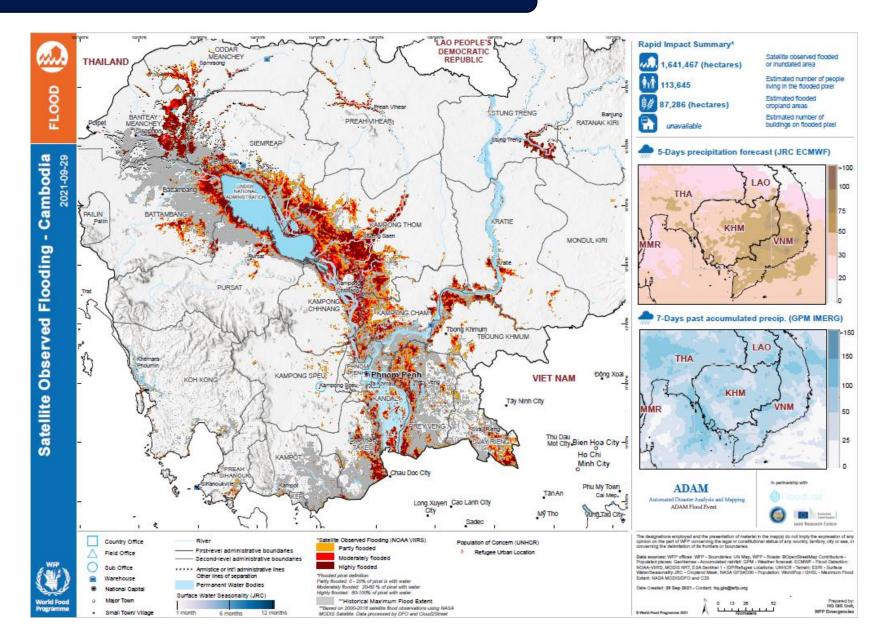


Example cases – International Charter/WFP

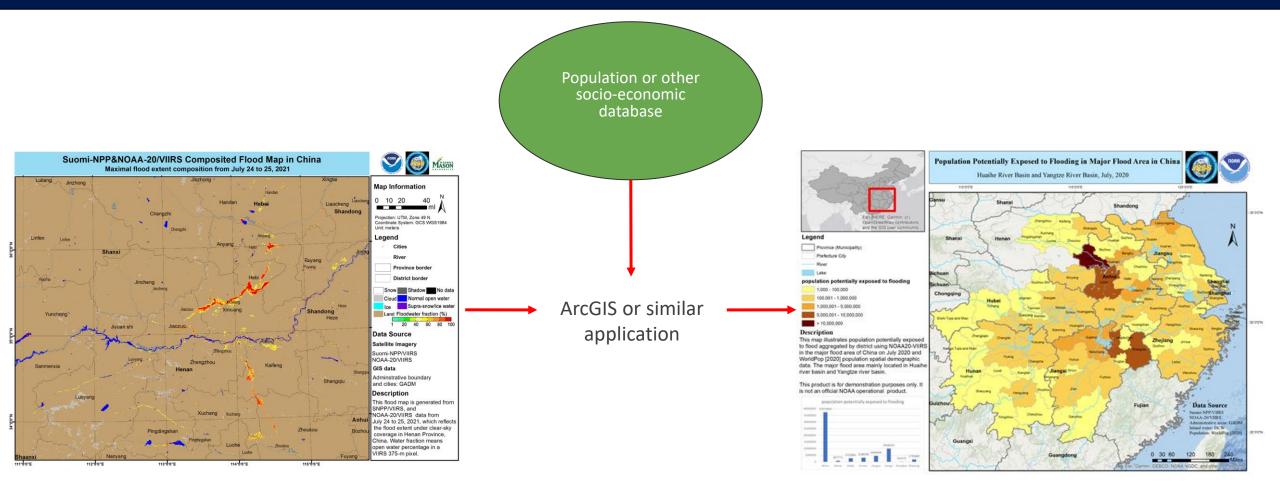




Example case – World Food Programme

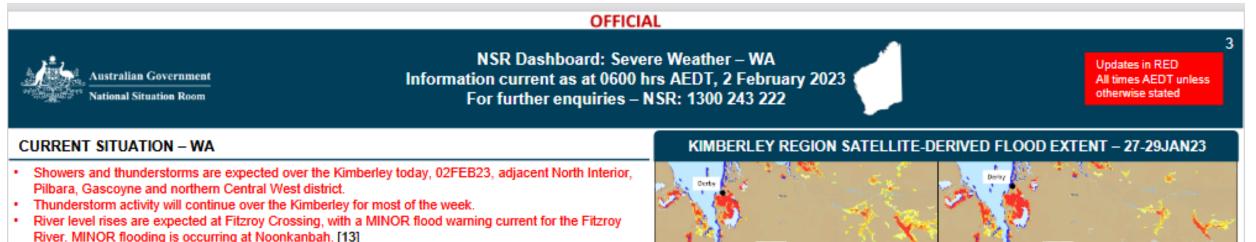


Tying satellite data and socio-economic information together



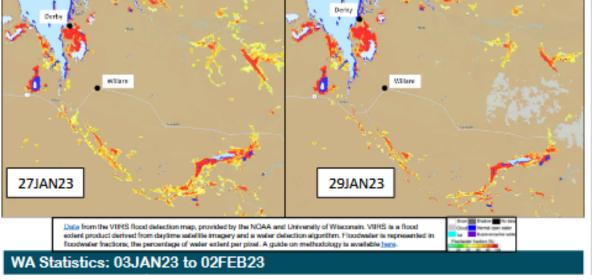
Li, S.; Goldberg, M.D.; Sjoberg, W.; Zhou, L.; Nandi, S.; Chowdhury, N.; Straka, W., III; Yang, T.; Sun, D. Assessment of the Catastrophic Asia Floods and Potentially Affected Population in Summer 2020 Using VIIRS Flood Products. *Remote Sens.* **2020**, *12*, 3176. https://doi.org/10.3390/rs12193176

Example cases – Australia Bureau of Meteorology



- 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 DEEC. Defense aircrafts continue to transport sussuand residents back to their home



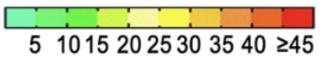
Satellites as a tool to assess flood risk

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.







Download the Data

Quick Guide of Flood Products

- Real Earth Website: <u>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-composite1.-100,RIVER-FLDglobal¢er=10,120&zoom=4&basemap=streets&labels=-& ×pan=-5d×tep=1d
 </u>
- Visit JPSS (amazon aws) link: <u>https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/</u>
- Visit FTP: <u>https://www.ssec.wisc.edu/flood-map-demo/ftp-link/ftp-link-ahijoint/</u>
- 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: O VIIRS O ABI O AHI O JOINT File type: O GeoTiff O Shapefile Region: O VIIRS_ABI O VIIRS_AHI Area Of Interest: 064 065 066 067 077 078 079 080 090 091 092 0101 0102 0103 0109 0110 0111 0112 0117 0118 0119 0120 0123 0124 0125 0126 0127 0128 0134 0135

RIVER-FLD-joint-AHI 20230621_00000.part135.force.tif RIVER-FLD-joint-AHI 20230621_000000.part134.force.tif RIVER-FLD-joint-AHI 20230621_000000.part128.force.tif RIVER-FLD-joint-AHI 20230621_000000.part126.force.tif RIVER-FLD-joint-AHI 20230621_000000.part126.force.tif RIVER-FLD-joint-AHI 20230621_000000.part124.force.tif RIVER-FLD-joint-AHI 20230621_000000.part123.force.tif RIVER-FLD-joint-AHI 20230621_000000.part123.force.tif RIVER-FLD-joint-AHI 20230621_000000.part123.force.tif

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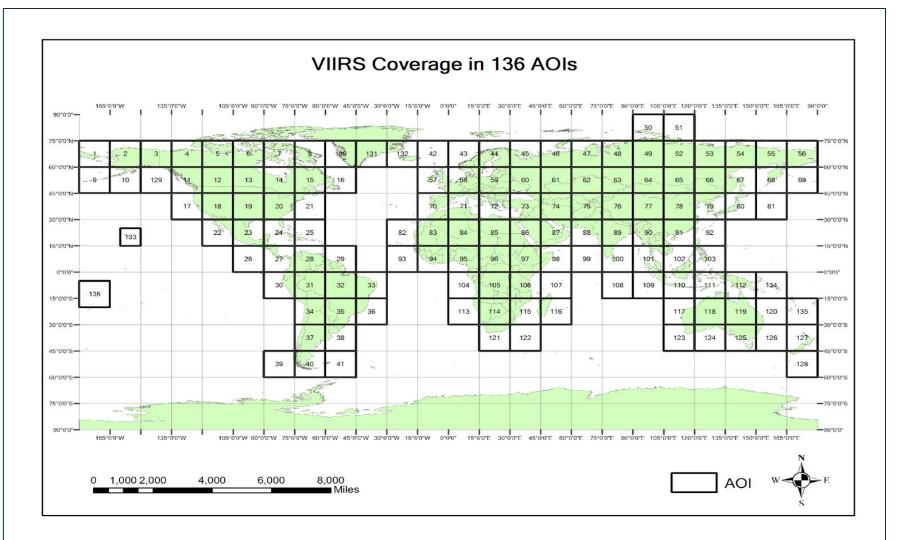


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nowing 1 to 9 of 9 entries					F	revious 1 I	Next

Satellite-Derived Flood Product ⁵

Area of Interest





NOAA GLOBAL FLOOD PRODUCT

Data Format

Snap	efile Data		
Name		Date modified	Туре
FloodWater_00-100_VIIRS-Flood-5day-GLB090_v1r0_blend_s202010120519120_e202010160729440_c202208100102581	.dbf	10/08/2022 10:26	DBF File
FloodWater_00-100_VIIRS-Flood-5day-GLB090_v1r0_blend_s202010120519120_e202010160729440_c202208100102581	.prj	10/08/2022 10:26	PRJ File
FloodWater_00-100_VIIRS-Flood-5day-GLB090_v1r0_blend_s202010120519120_e202010160729440_c202208100102581	.shp	10/08/2022 10:26	SHP File
FloodWater_00-100_VIIRS-Flood-5day-GLB090_v1r0_blend_s202010120519120_e202010160729440_c202208100102581	.shx	10/08/2022 10:26	SHX File
FloodWater_00-100_VIIRS-Flood-5day-GLB090_v1r0_blend_s202010120519120_e202010160729440_c202208100102581	.shx	10/08/2022 10:26	SHX File

Changefile Date

6	Data from FTP link (oper	n in ArcGIS)
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Add Data Look in: VIIRS-Flood-5day-GLB090_v1r0 Image: Control Name: Control Name: Control Datasets, Layers and Results Image: Control Datasets, Layers and Results Image: Control Image: Control Datasets, Layers and Results Image: Control Image: Control

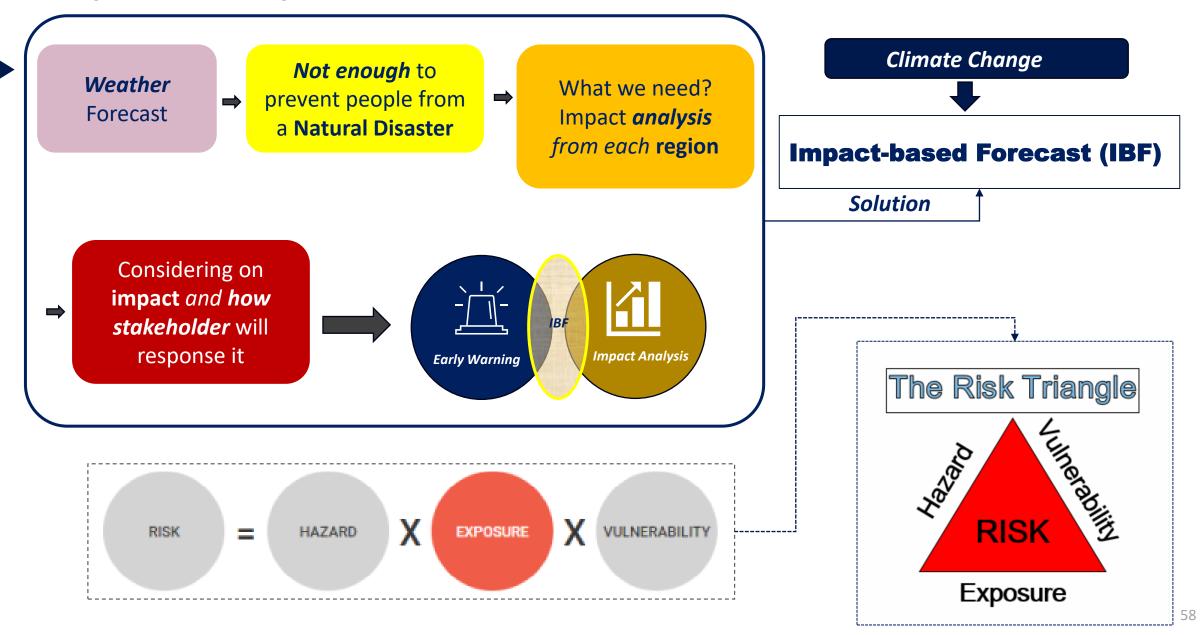
Add a footer

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









-IMPACT-BASED FORECAST



















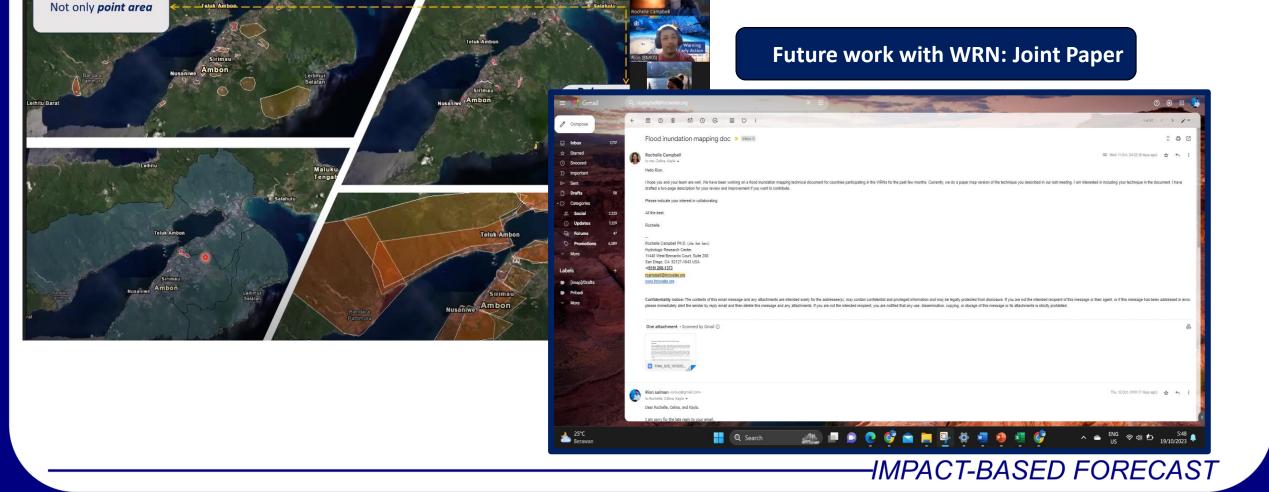








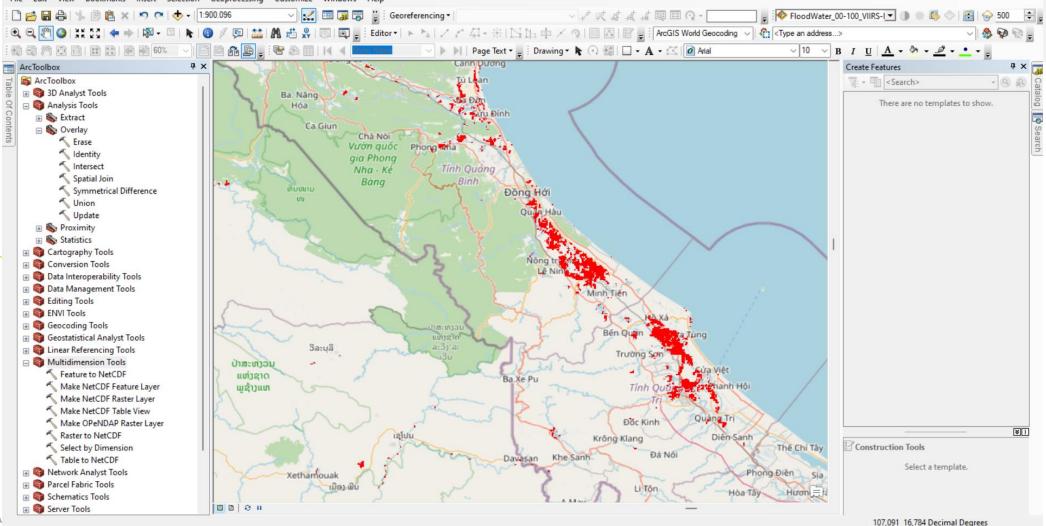
Meeting with Weather-Ready Nation (WRN) on 28 September 2023



ArcGIS

🔇 Training.mxd - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help



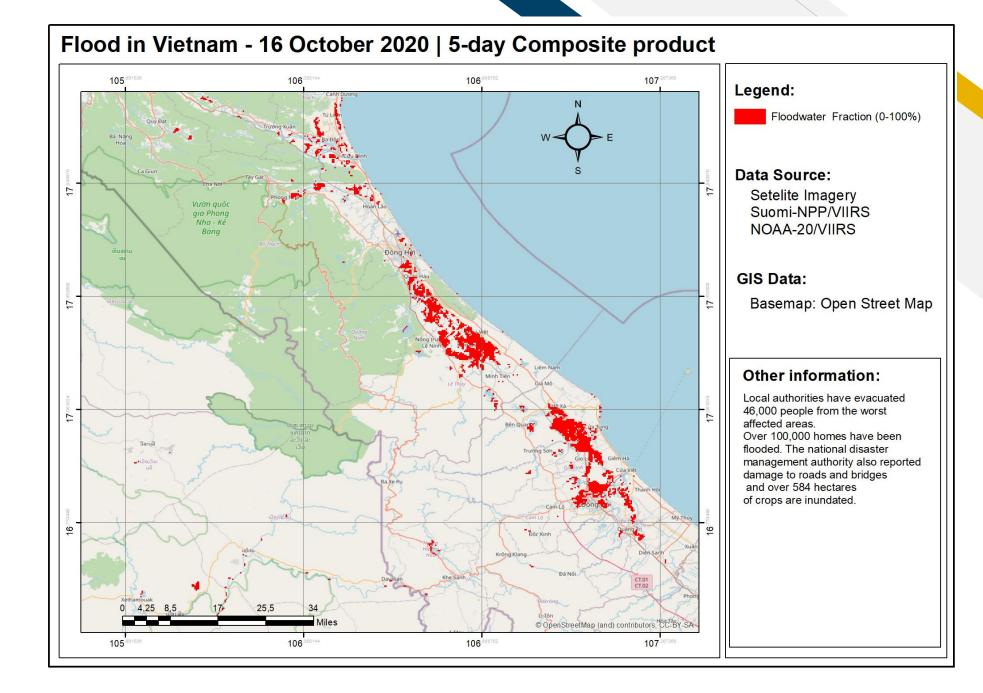
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ArcGIS

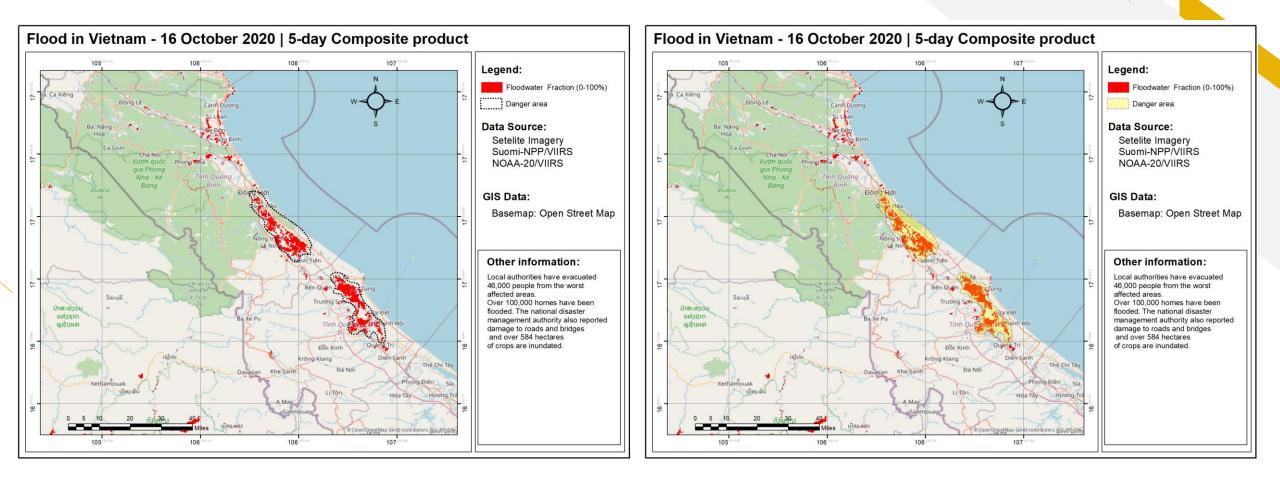
Training.mxd - ArcMap o X File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help] 🖕 🕪 FloodWater_00-100_VIIRS-I 💌 🌗 👋 🗔 🗸 🖾 🇊 🖓 🍹 Georeferencing • ~ ↓ 於 尊 尊 尊 圖 回 ♂ -🗋 🚰 🔚 🚔 | % 📄 🖺 🗙 🔊 🥐 🚸 🗸 1:912.131 500 ≑ 📮 🛗 🕅 猶 🕺 🔟 🔍 👘 🗐 💭 🕫 Editor 🔹 ト 🍡 📝 🎢 🖓 🖓 🔆 🖓 👘 🖄 🖄 👘 🖉 🤉 🗄 ArcGIS World Geocoding 🗸 🥀 (Type an address...> 🏇 🖗 😨 🖕 🔍 🔍 🖑 🥥 । 💥 🖸 🔶 🔶 2 - 12 k () 🗸 🕒 📓 🖓 🔄 👷 🖓 🐘 | | 4 4 🔤 🗤 1000 🗸 🗸 🕨 | 19 age Text 🗸 🚽 Drawing 🖡 🕤 🐼 | 🗆 – A – 🖄 🖉 Arial ᡚ 🚭 🐖 🕄 🛅 🗰 😫 🚰 影 60% \vee 10 \vee B I U A \cdot \wedge \cdot \square \cdot \bullet ArcToolbox 4 × 🗖 Ψ× Create Features Select by Dimension Search> - 0 2 Table to NetCDF There are no templates to show. Retwork Analyst Tools 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Flood in Vietnam - 16 October 2020 | 5-day Composite product -1 Parcel Fabric Tools Search Schematics Tools 105 108 Legend: + Server Tools 🗄 🌍 Space Time Pattern Mining Tools Floodwater Fraction (0-100%) 🖃 🌍 Spatial Analyst Tools Đồng Lê 🗄 🇞 Conditional Data Source: 🕀 🇞 Density Setelite Imagery 🕀 🇞 Distance Suomi-NPP/VIIRS 🗄 🍆 Extraction NOAA-20/VIIRS 🕀 🇞 Generalization 🕀 🇞 Groundwater GIS Data: Hydrology 🖃 🍆 Interpolation Basemap: Open Street Map S IDW Kriging Natural Neighbor Other information: Spline Local authorities have evacuated Spline with Barriers 46,000 people from the worst Topo to Raster affected areas. <u>ത</u>` Over 100.000 homes have been Topo to Raster by File ປາສະຫງວາ fooded. The national disaster <u>∞</u> ແຫ່ງຊາດ management authority also reported Trend ເມຂ້າວແຫ damage to roads and bridges 16. 17. and over 584 hectares 🗄 🍆 Local of crops are in undated. Doc Kin 🗄 🍋 Map Algebra 🗄 🍋 Math 5 DANO 🗄 🍆 Multivariate 4. 🗉 🇞 Neighborhood Hda Tay ω. ¥1 🕀 🍋 Overlay 🕀 🇞 Raster Creation Construction Tools 2 🕀 🍋 Reclass Select a template. 🛞 🇞 Segmentation and Classification 🗄 🍆 Solar Radiation 🗄 🍆 Surface 000 🗄 🍆 Zonal

26,65 6,02 Centimeters

Result

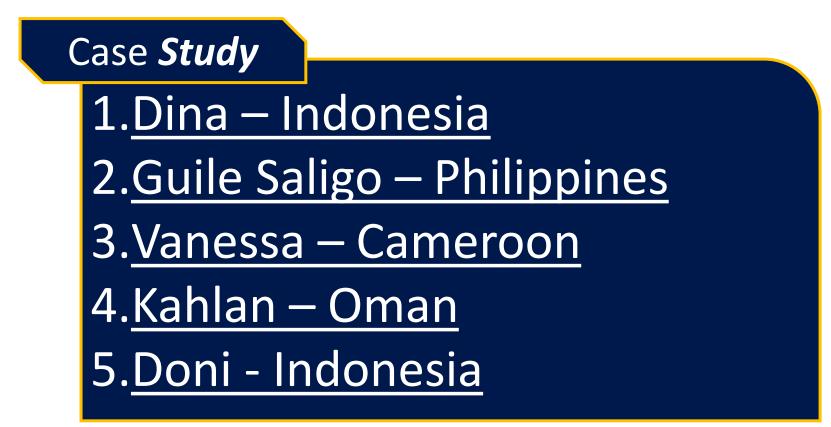


Result



"Keep it simple but cover all aspects"







"Practice Time"





Thank You | Terima Kasih

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

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