Mapping the Impacts of Typhoon Goni in Camarines Sur

Geomatics for Environment and Development

MANILA OBSERVATORY

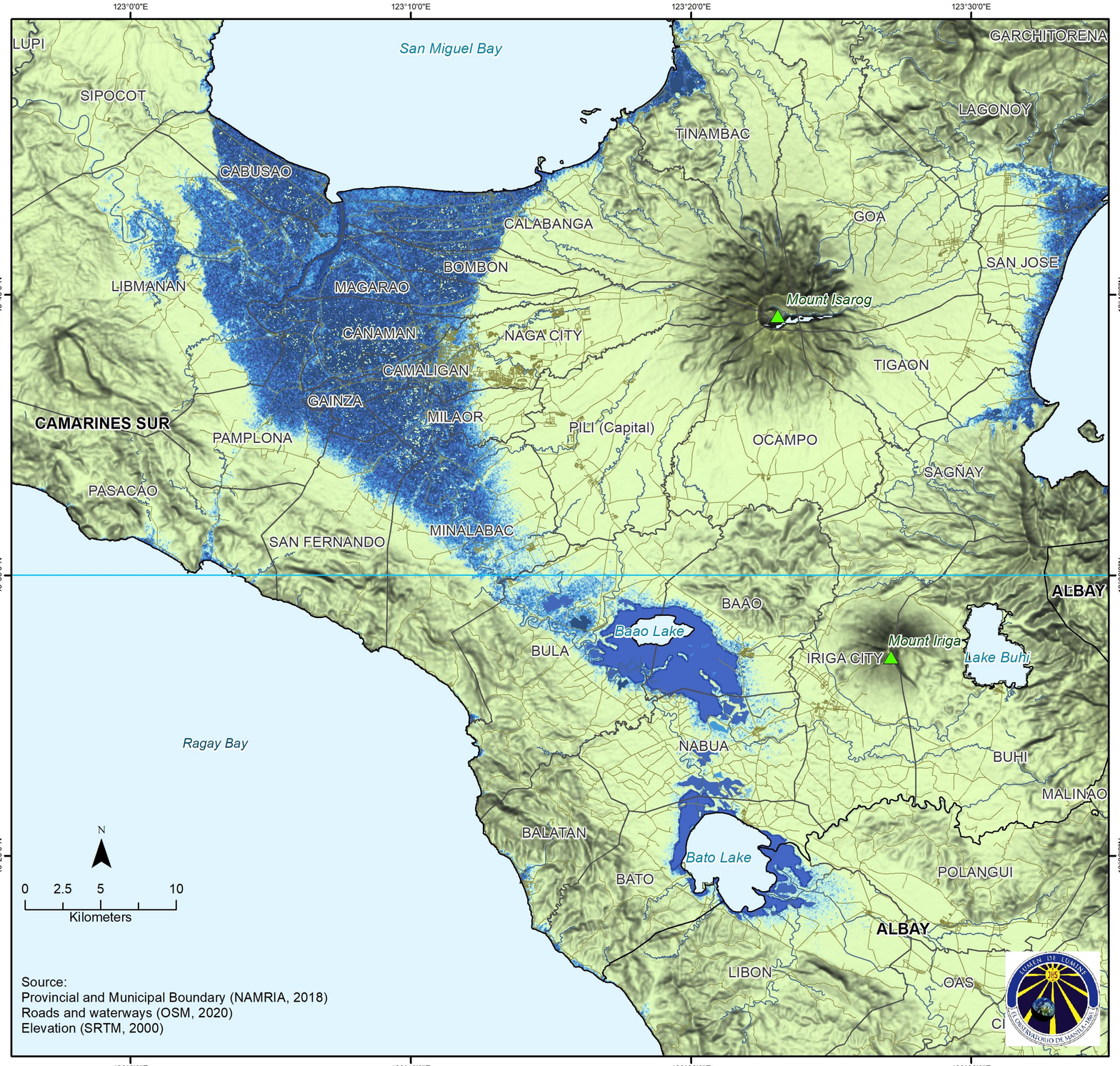
November 9, 2020

Summary

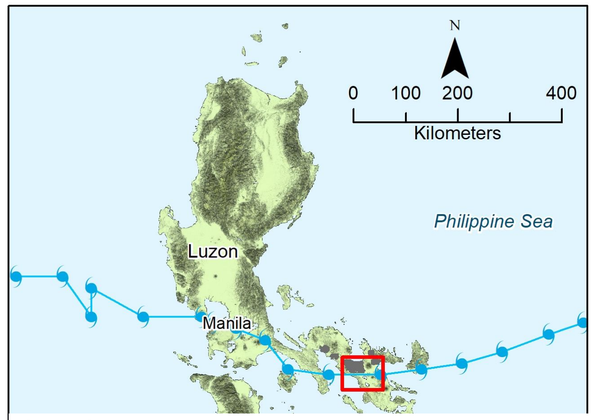
- Low-lying municipalities (with elevation of less than 10 meters above sea level) were flooded (flood extent was estimated to be **295 km^2**) due to rainfall exceeding 150 mm during the onslaught of Typhoon Goni.
- Roughly **200,000 people or 10%** of the province's population were estimated to be flooded.
- Buildings in different parts of the province were damaged. The typhoon damaged a total of more than **10,000 houses**.
- **281 km^2** of land for annual crops were flooded.

Low-lying Areas in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



Source:
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)
Elevation (SRTM, 2000)



Legend

- Typhoon Goni Track
- Waterways
- Roads
- Provincial Boundary
- Municipal Boundary

Low Elevation Coastal Zones (m.a.s.l.)

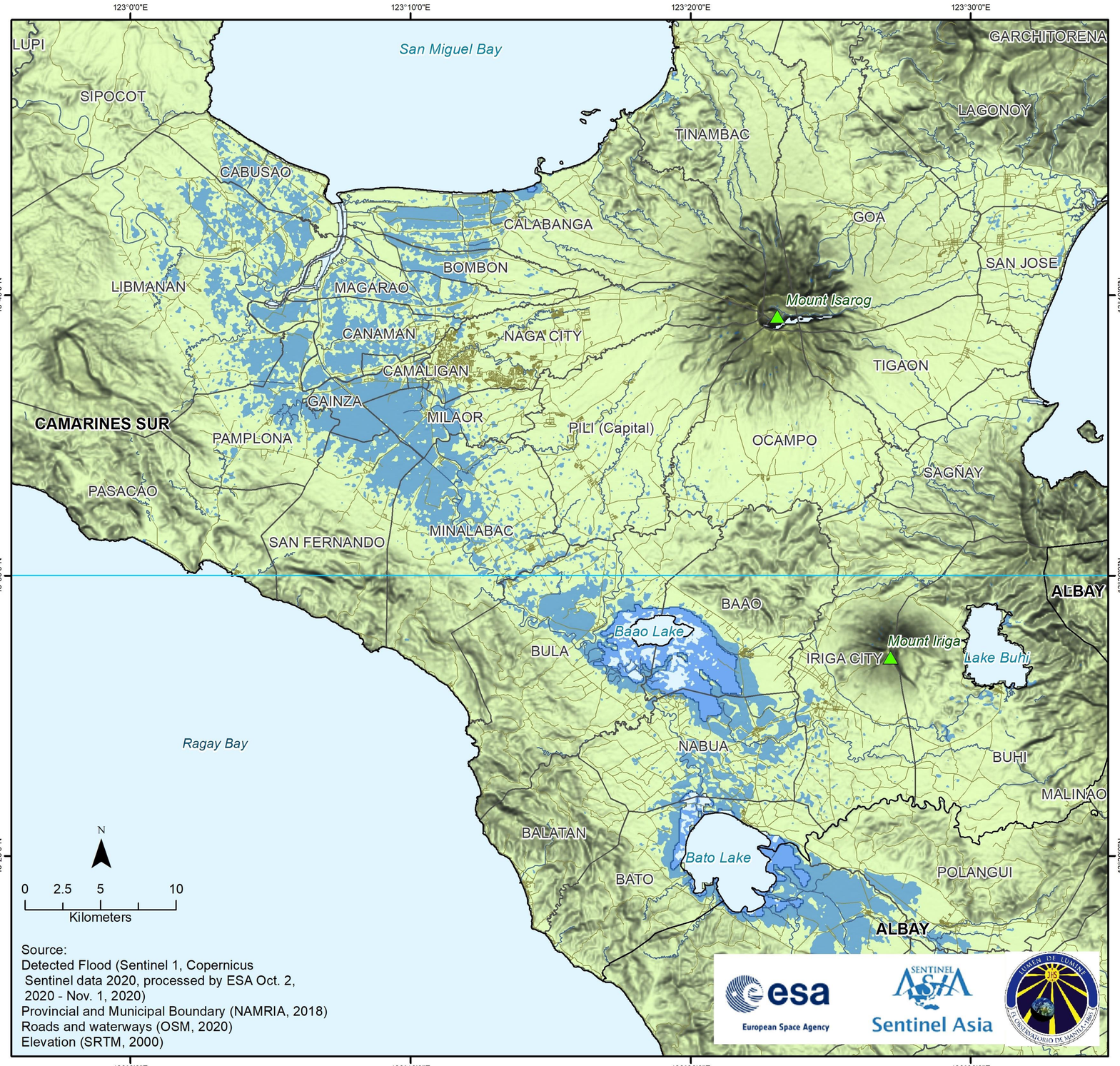
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10

Low-lying municipalities:

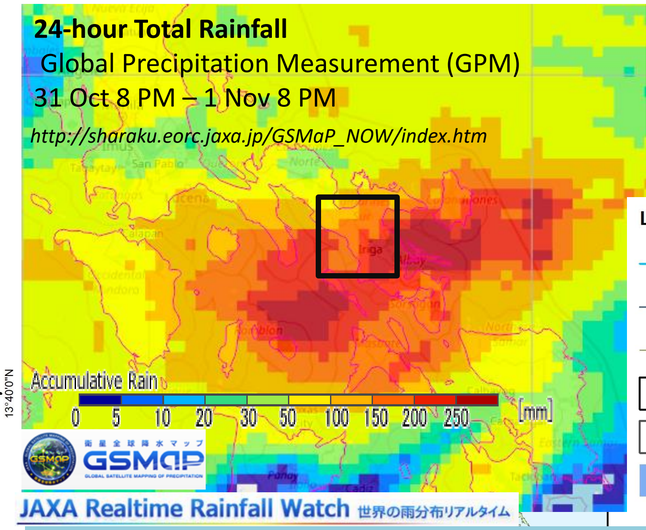
Libmanan	Baao	Sagñay
Minalabac	Garchitorena	Pasacao
Calabanga	Pamplona	Camaligan
Bula	Milaor	Sipocot
Canaman	Nabua	Presentacion
Lagonoy	San Fernando	Balatan
Siruma	San Jose	Tigaon
Magarao	Bombon	Lupi
Tinambac	Gainza	Iriga City
Ragay	Del Gallego	Goa
Caramoan	Bato	Pili
Cabusao	Naga City	

Flooded Areas in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESA Oct. 2, 2020 - Nov. 1, 2020)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)
Elevation (SRTM, 2000)



Legend

- Typhoon Goni Track
- Waterways
- Roads
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

- *Highlighted in **blue** are the observed flooded areas in Camarines Sur (**295 km²**) after >150 mm of rain due to Typhoon Goni on Nov. 1, 2020.*
  - *Flood extent was detected by thresholding the difference of pixel values of Sentinel-1 SAR image taken on Nov. 1, 2020 and Oct. 2, 2020 in Google Earth Engine.*
  - *Please note that flood extent could be underestimated in urban areas due to complex backscattering over built surface.*
  - *Note also that **no ground validation** was done for this map.*

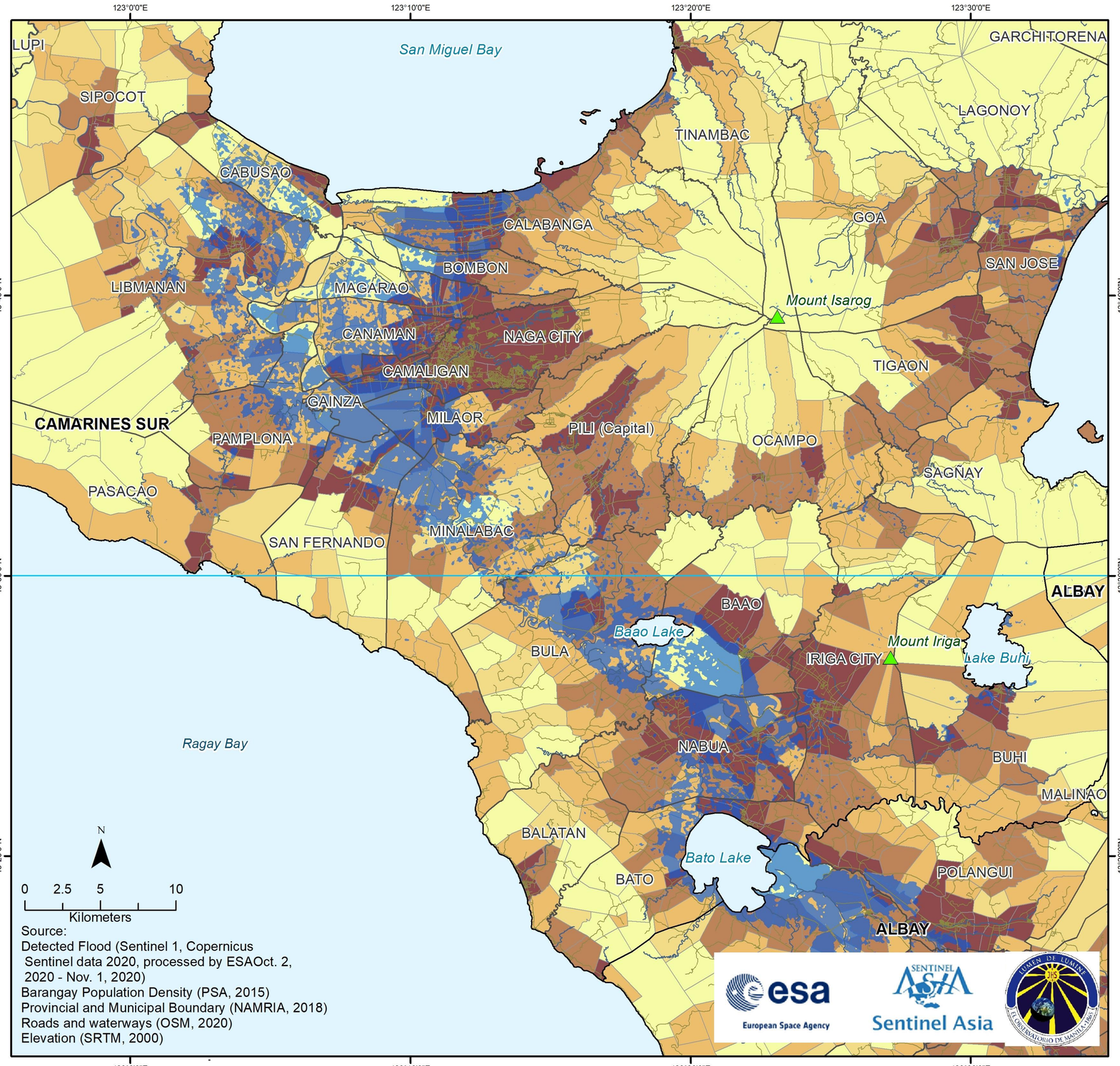
30 Flooded municipalities in Camarines Sur

Libmanan	*Milaor*	*Iriga City*	*Tinambac*
Bula	*Gainza*	*Buhi*	*Sagňay*
Minalabac	*San Fernando*	*Pili*	*Pasacao*
Nabua	*Bato*	*Camaligan*	*Tigaon*
Canaman	*Magarao*	*San Jose*	*Goa*
Baao	*Cabusao*	*Naga City*	*Balatan*
Calabanga	*Ocampo*	*Lagonoy*	*Sipocot*
Pamplona	*Bombon*		

- SAR – Synthetic Aperture Radar

Flooded Population in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



Legend

- Typhoon Goni Track
- Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

Barangay Population Density (person per sq.km.)

- 21 - 200
- 200 - 250
- 250 - 500
- 500 - 1,000
- 1,000 - 42,885

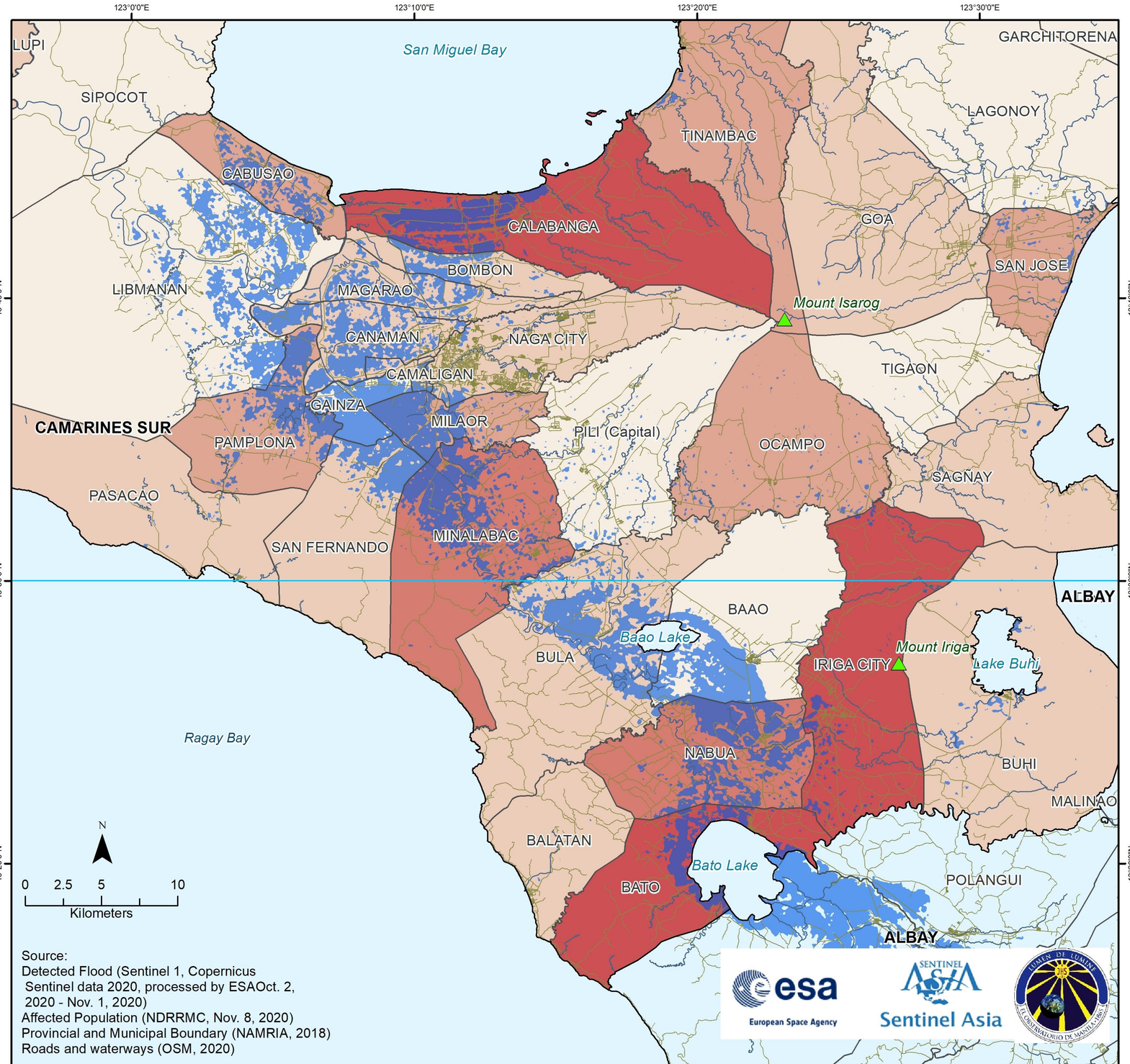
Estimated Population in Flooded Municipalities

- Roughly **200,000 people or 10%** of Camarines Sur's population were flooded.
- This estimation is based on the detected flooded area and PSA's barangay population data of 2015.
- **More than 10,000 residents** were flooded in **Nabua, Calabanga, Bula, Libmanan, Milaor, Canaman, Minalabac, and Baao.**
- *Please note that due to the limitation of flood detection over urban areas using SAR images, the flooded population in urbanized cities like Naga City might be underestimated.*

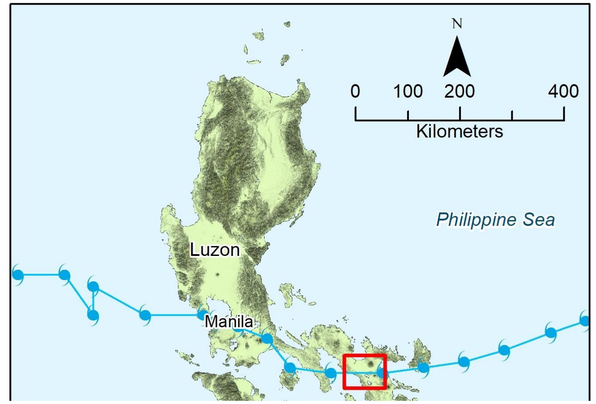
- PSA – Philippine Statistics Authority
- SAR – Synthetic Aperture Radar

Affected Population in Camarines Sur as of Nov. 8, 2020

Typhoon Goni (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESAOct. 2, 2020 - Nov. 1, 2020)
Affected Population (NDRRMC, Nov. 8, 2020)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)



Legend

- Typhoon Goni Track
- Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

Affected Population
Nov. 8, 2020

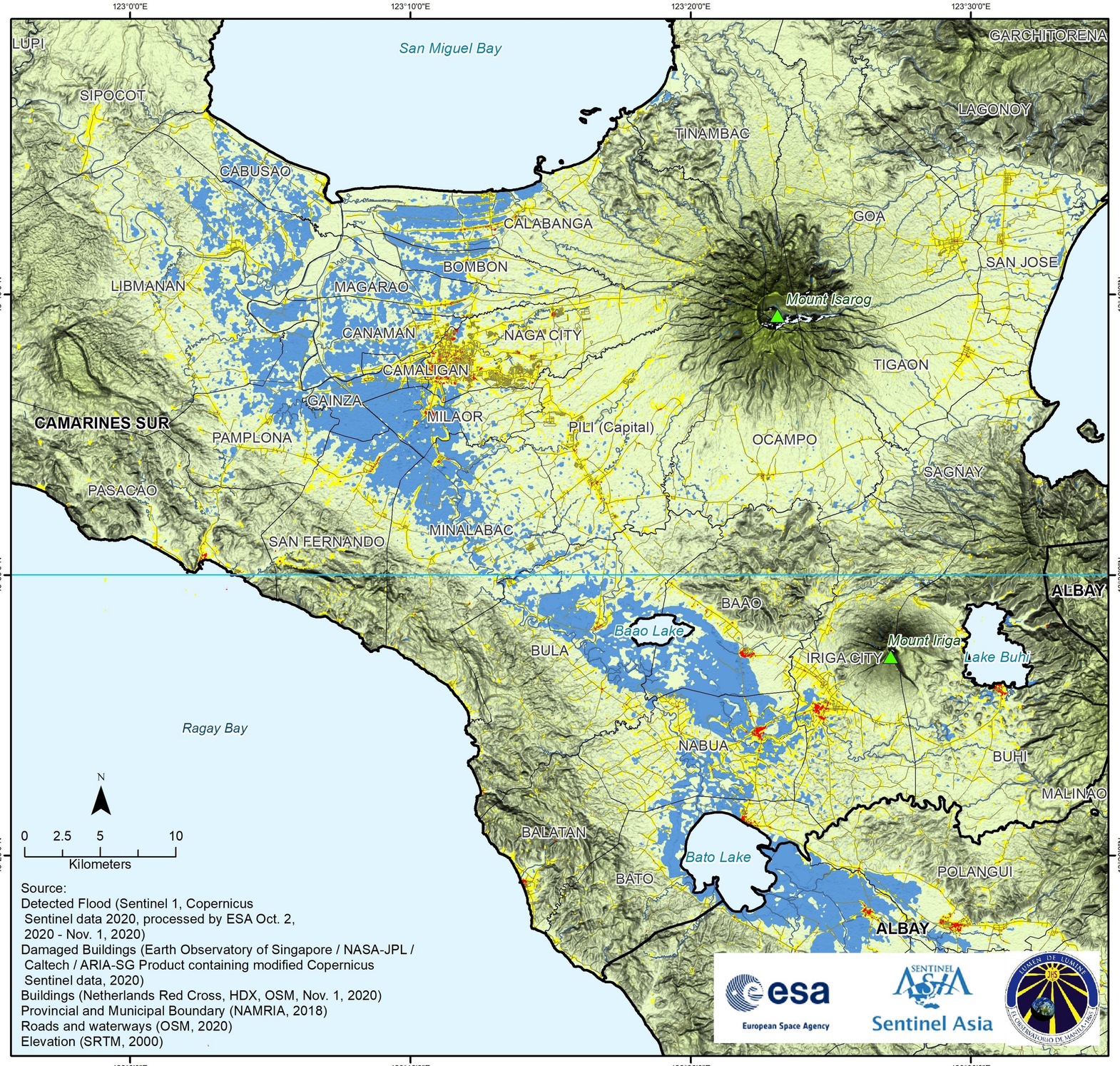
- 0 - 1,000
- 1,001 - 3,000
- 3,001 - 6,000
- 6,001 - 10,000
- 10,001 - 34,216

- NDRRMC reported that Goni affected a total of **159,722** persons in Camarines Sur.
- **Iriga City, Bato, Calabanga, Siruma** have the highest number of affected population (>10,000 persons).

- NDRRMC – National Disaster Risk Reduction and Management Council

Damaged Buildings in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESA Oct. 2, 2020 - Nov. 1, 2020)
Damaged Buildings (Earth Observatory of Singapore / NASA-JPL / Caltech / ARIA-SG Product containing modified Copernicus Sentinel data, 2020)
Buildings (Netherlands Red Cross, HDX, OSM, Nov. 1, 2020)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)
Elevation (SRTM, 2000)

Legend

- Typhoon Goni Track
- Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Buildings
- Detected Flooding
- Possible Building Damage

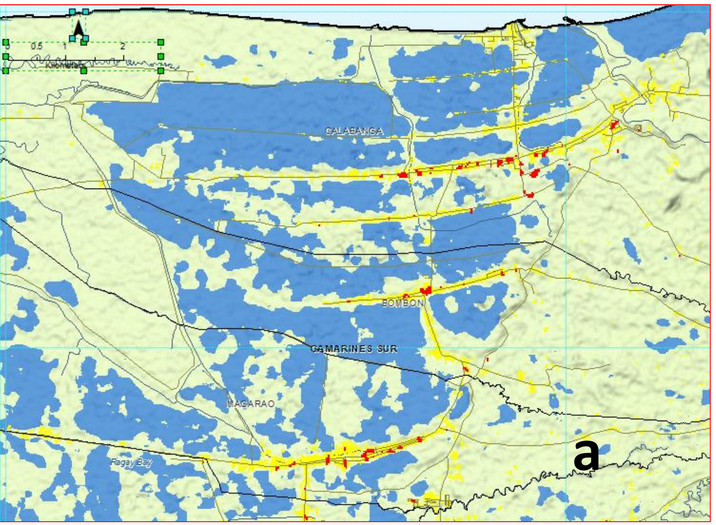
- Highlighted in yellow are the location of buildings and in red the possible location of building damage due to inundation and strong winds of Typhoon Goni.
- NDRRMC reported a total of **13,718 damaged houses** of which **3,042 were totally damaged** and **10,674 were partially damaged**.

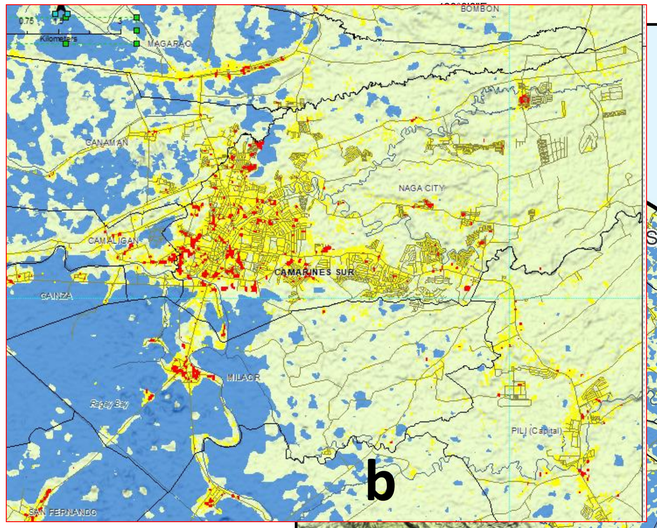
- Building locations were merged from OSM data and AI predictions on Bing Map images from Netherlands Red Cross for typhoon Goni.
- Damaged areas were detected using synthetic aperture radar data of Sentinel-1 of European Space Agency by ARIA-SG team of Earth Observatory of Singapore (EOS) in collaboration with NASA-JPL and Caltech.
- *Please note that **no ground validation** was done for this data.*

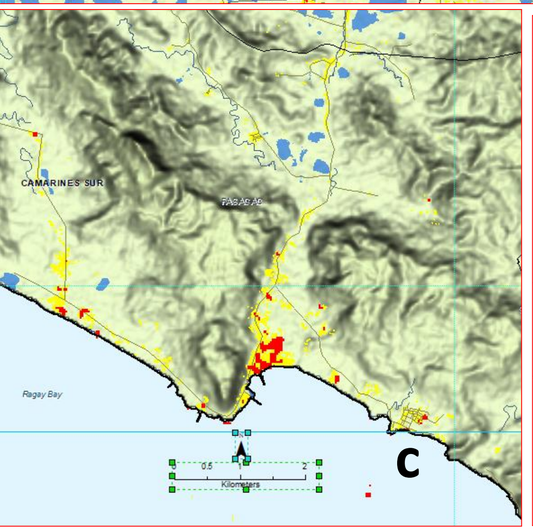
- NDRRMC – National Disaster Risk Reduction Management Council
- OSM – Open Street Map
- AI – Artificial Intelligence
- NASA - National Aeronautics and Space Administration
- JPL – Jet Propulsion Laboratory

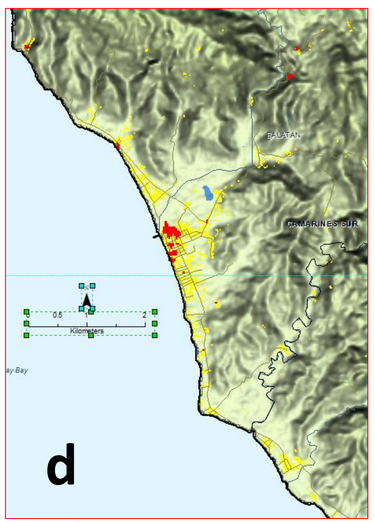
Damaged Buildings in Camarines Sur

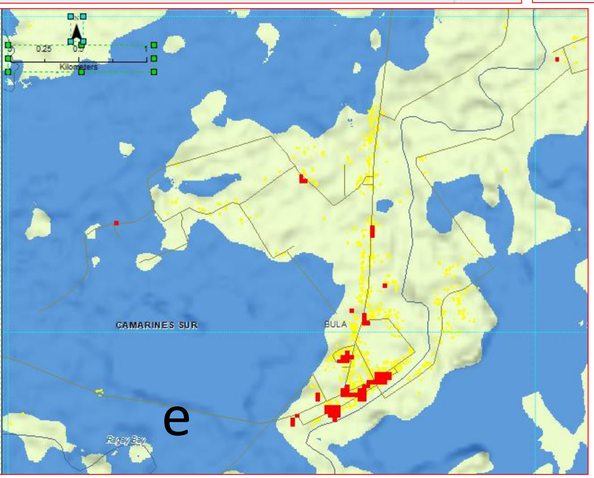
Typhoon Goni (Nov. 1, 2020)

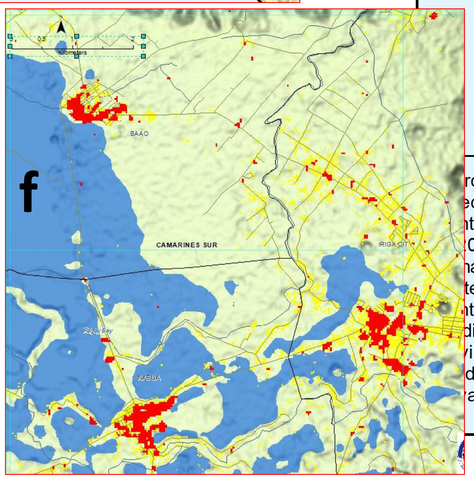


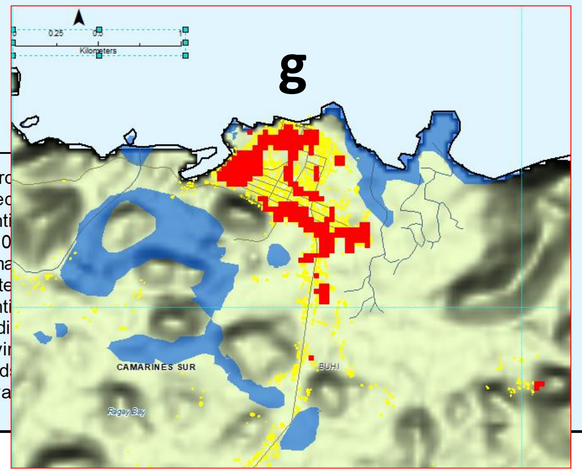






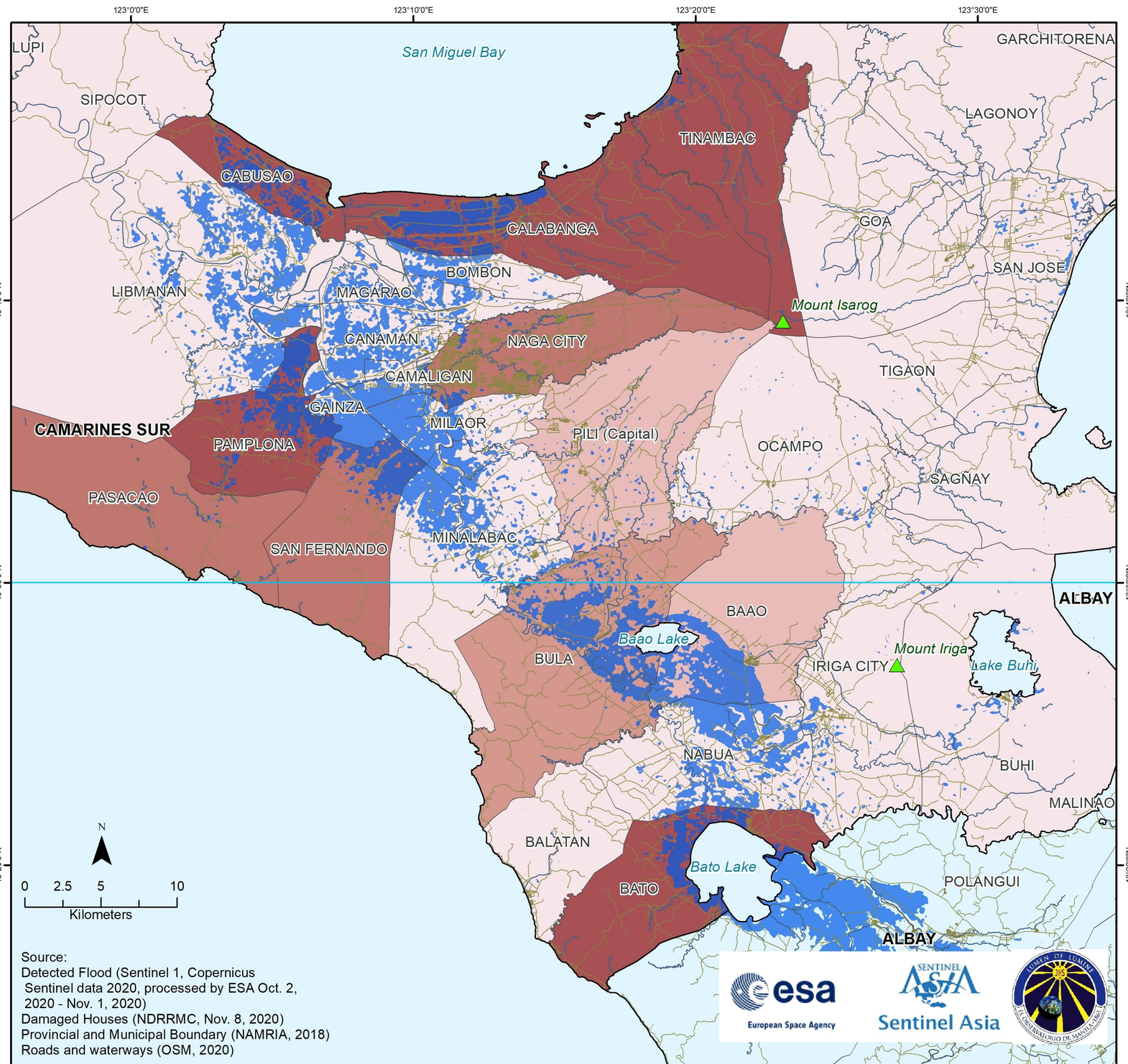




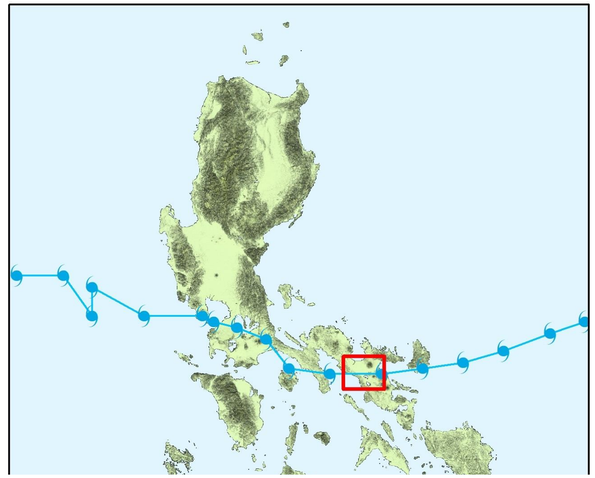


Damaged Houses in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESA Oct. 2, 2020 - Nov. 1, 2020)
Damaged Houses (NDRRMC, Nov. 8, 2020)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)



Legend

- Typhoon Goni Track
- Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

Damaged Houses
Nov. 8, 2020

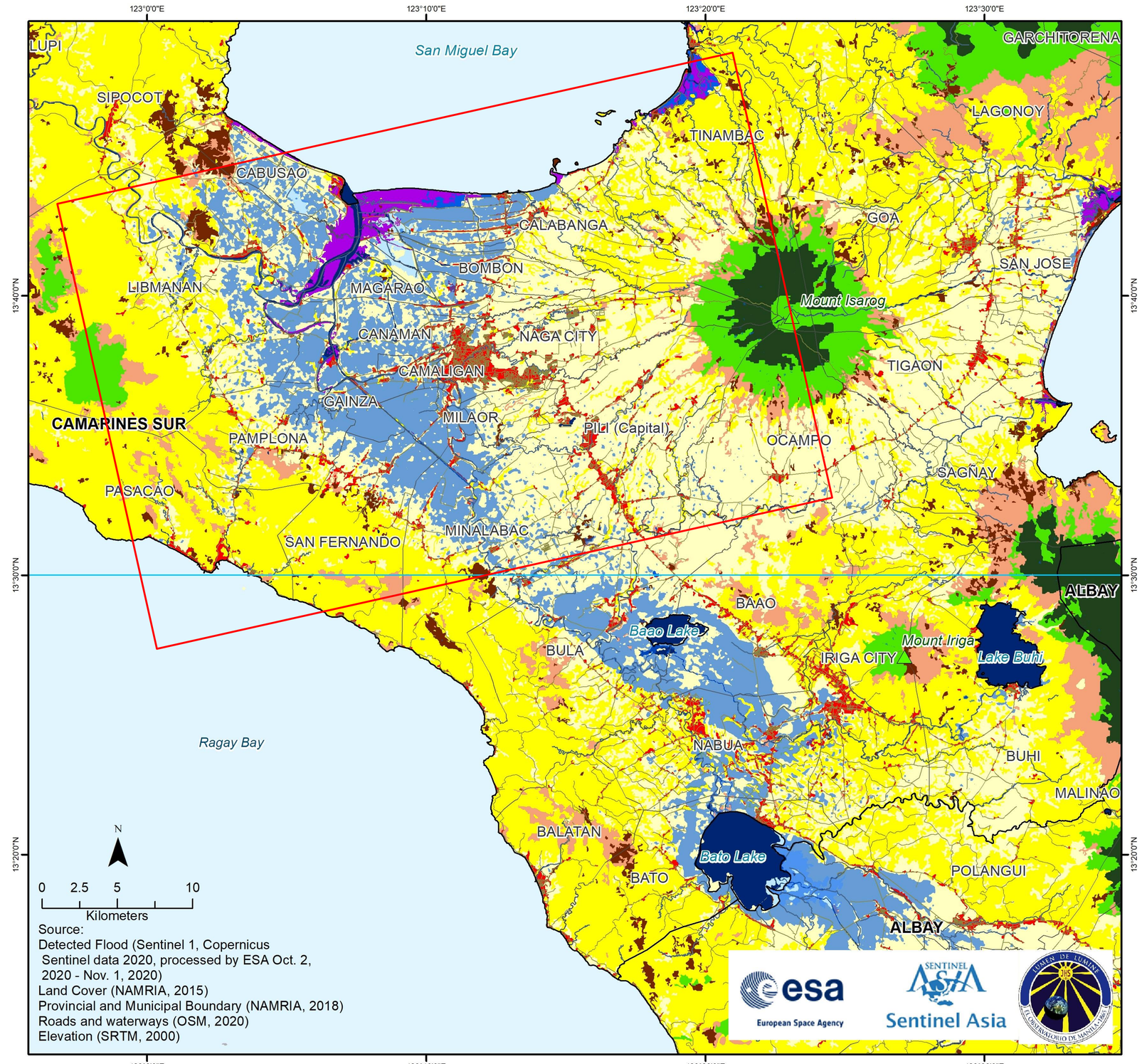
- 0
- 1 - 250
- 251 - 300
- 301 - 800
- 801 - 5,910

- NDRRMC reported that Goni damaged a total of **13,716 houses in Camarines Sur**.
- **Bato, Calabanga, and Tinambac** have the highest number of damaged houses (>1,000 houses).

- NDRRMC – National Disaster Risk Reduction and Management Council

Affected land cover in Camarines Sur

Typhoon Goni (Nov. 1, 2020)



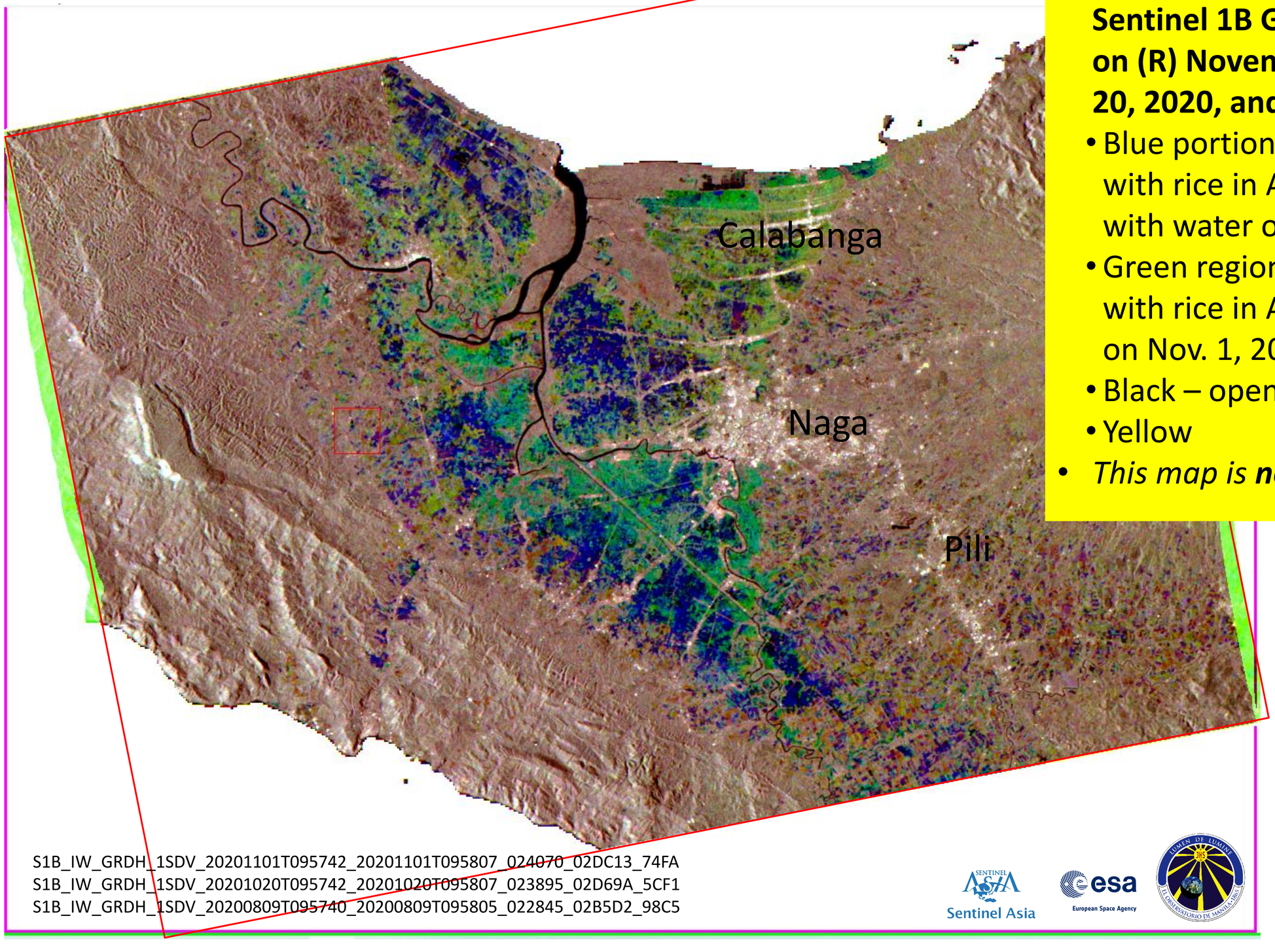
Legend

- Typhoon Goni Track
- Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

Land Cover (2015)

- Annual Crop
- Brush/Shrubs
- Built-up
- Closed Forest
- Fishpond
- Grassland
- Inland Water
- Mangrove Forest
- Marshland/Swamp
- Open Forest
- Open/Barren
- Perennial Crop

- Based on this map, flooding affected **281 km² of annual cropland, 3.9 km² of perennial cropland, and 1.5 km² of built-up area in the province**.
  - Note that the land cover data used was 5 years old and that flood detection from radar images tends to be underestimated.
- Aside from the agricultural damage caused by floods, crops were also damaged due to strong winds.



- **Multi-temporal RGB composite of Sentinel 1B GRDH IW images captured on (R) November 1, 2020, (G) October 20, 2020, and (B) August 9, 2020.**
  - Blue portions show the fields planted with rice in August that was covered with water on Oct. 20, 2020.
  - Green regions show the fields planted with rice in August that was flooded on Nov. 1, 2020 due to Typhoon Rolly.
  - Black – open water
  - Yellow
- *This map is **not ground validated.***

S1B_IW_GRDH_1SDV_20201101T095742_20201101T095807_024070_02DC13_74FA
S1B_IW_GRDH_1SDV_20201020T095742_20201020T095807_023895_02D69A_5CF1
S1B_IW_GRDH_1SDV_20200809T095740_20200809T095805_022845_02B5D2_98C5

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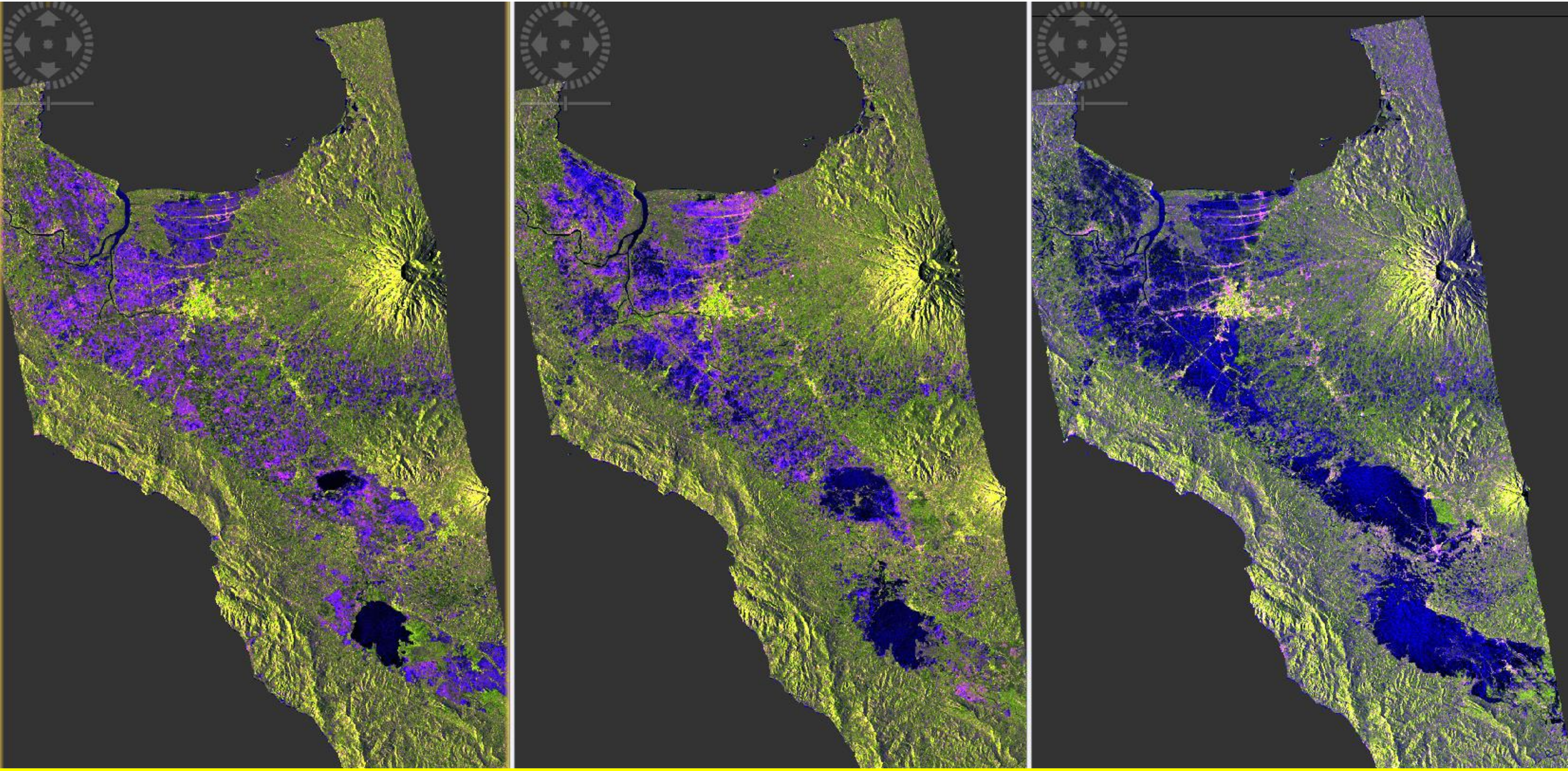
- RGB – Red Green Blue
- GRDH – Ground Range Detected High Resolution (10x10 m)
- IW – Interferometric Wide Swath Mode



- **Sentinel 1 SAR images captured on August 9, 2020, October 20, 2020, and Nov. 1, 2020 to show the change in agricultural land**
  - **Pink – potentially rice field**
  - **Blue – surface water**

S1B_IW_GRDH_1SDV_20201101T095742_20201101T095807_024070_02DC13_74FA
S1B_IW_GRDH_1SDV_20201020T095742_20201020T095807_023895_02D69A_5CF1
S1B_IW_GRDH_1SDV_20200809T095740_20200809T095805_022845_02B5D2_98C5

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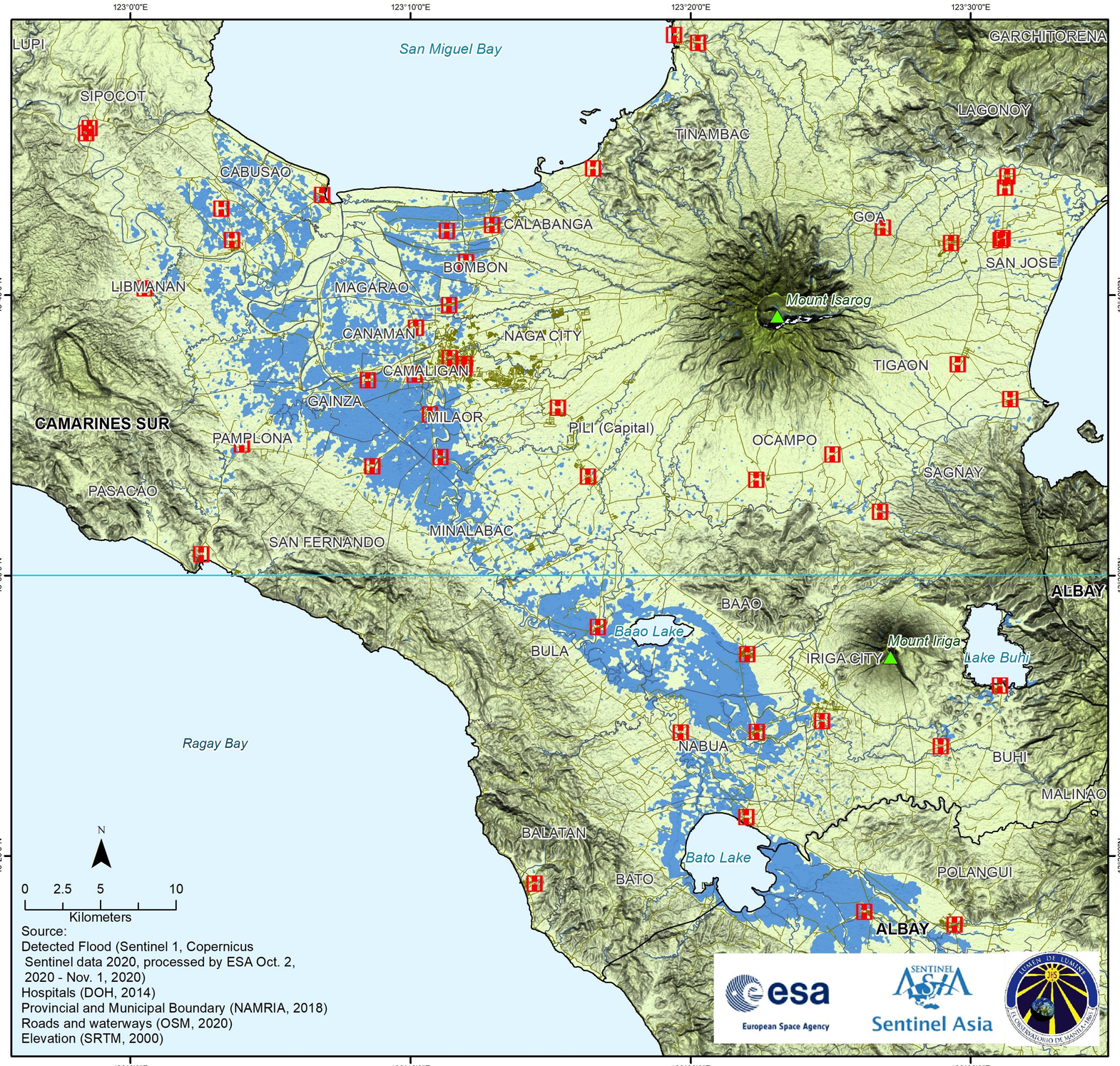
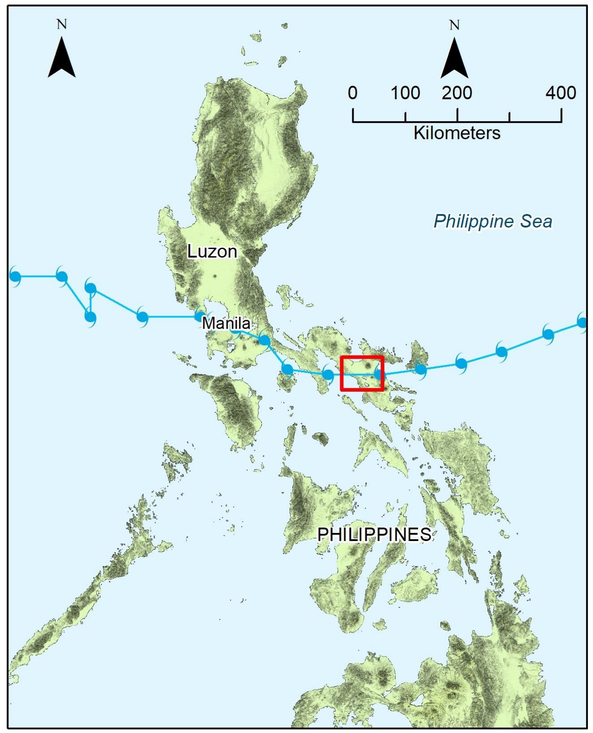
esa European Space Agency

CAMARINES SUR Typhoon Goni Hospitals and Detected Flood (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESA Oct. 2, 2020 - Nov. 1, 2020)
Hospitals (DOH, 2014)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and waterways (OSM, 2020)
Elevation (SRTM, 2000)



Legend

- Hospitals
- Typhoon Goni Track
- Roads
- Waterways
- Detected Flooding
- Provincial Boundary
- Municipal Boundary

European Space Agency

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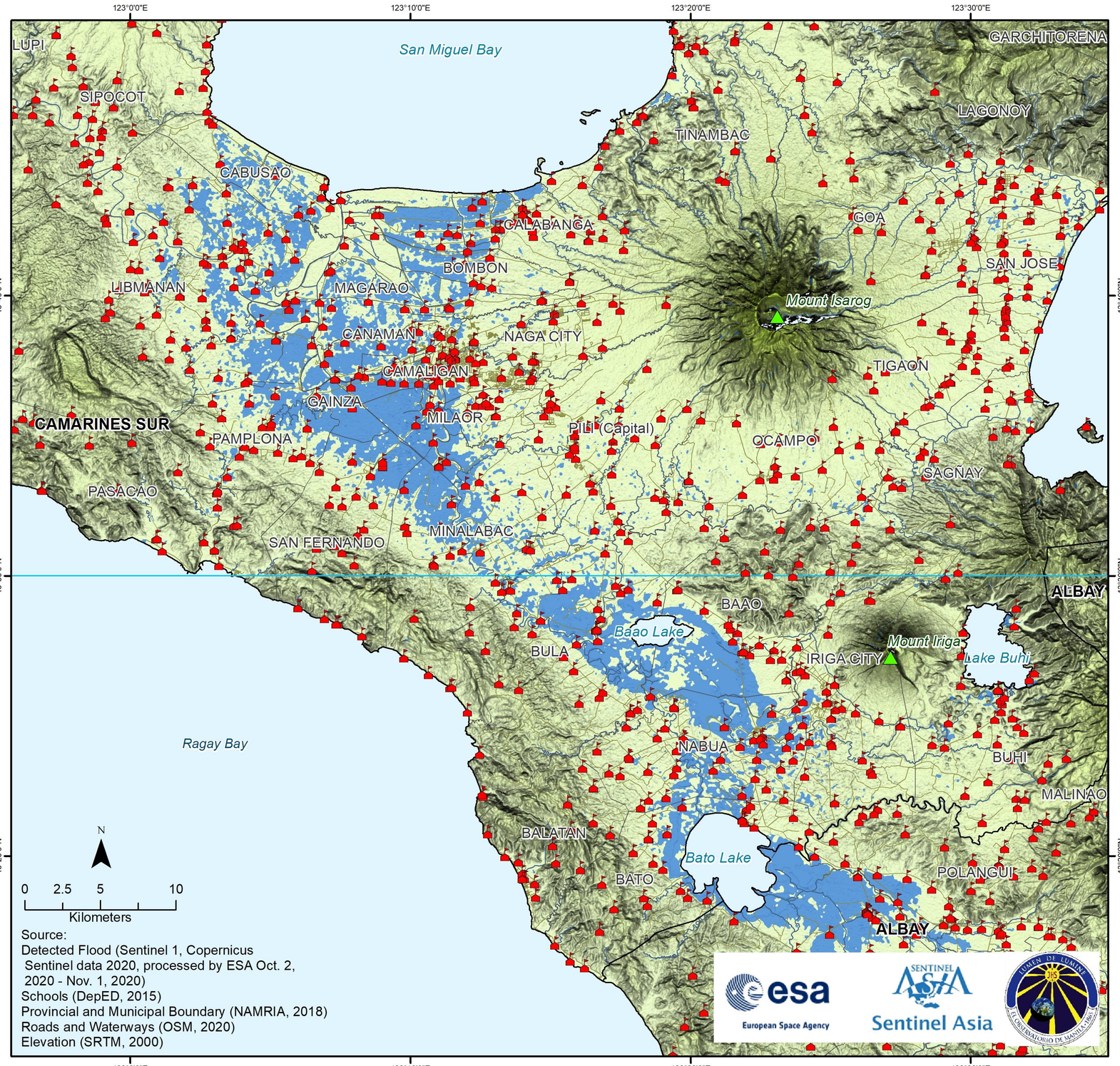
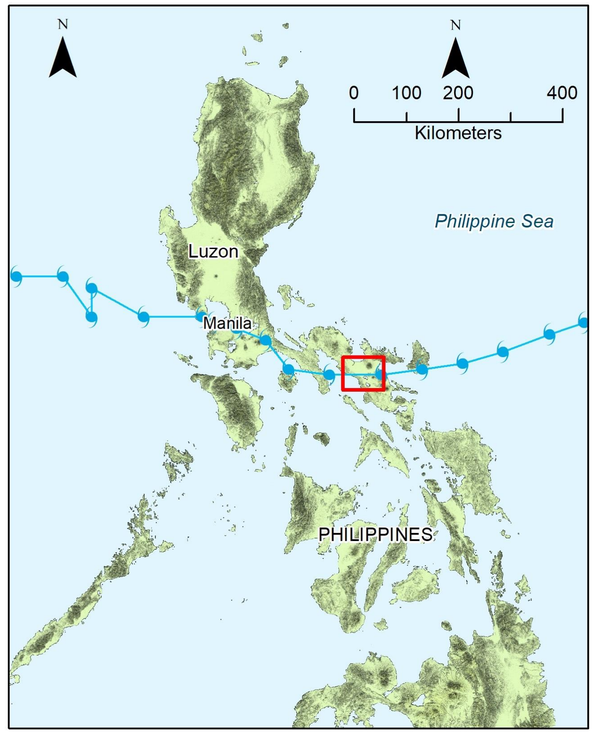
CAMARINES SUR Typhoon Goni Schools and Detected Flood (Nov. 1, 2020)



Source:
Detected Flood (Sentinel 1, Copernicus Sentinel data 2020, processed by ESA Oct. 2, 2020 - Nov. 1, 2020)
Schools (DepED, 2015)
Provincial and Municipal Boundary (NAMRIA, 2018)
Roads and Waterways (OSM, 2020)
Elevation (SRTM, 2000)

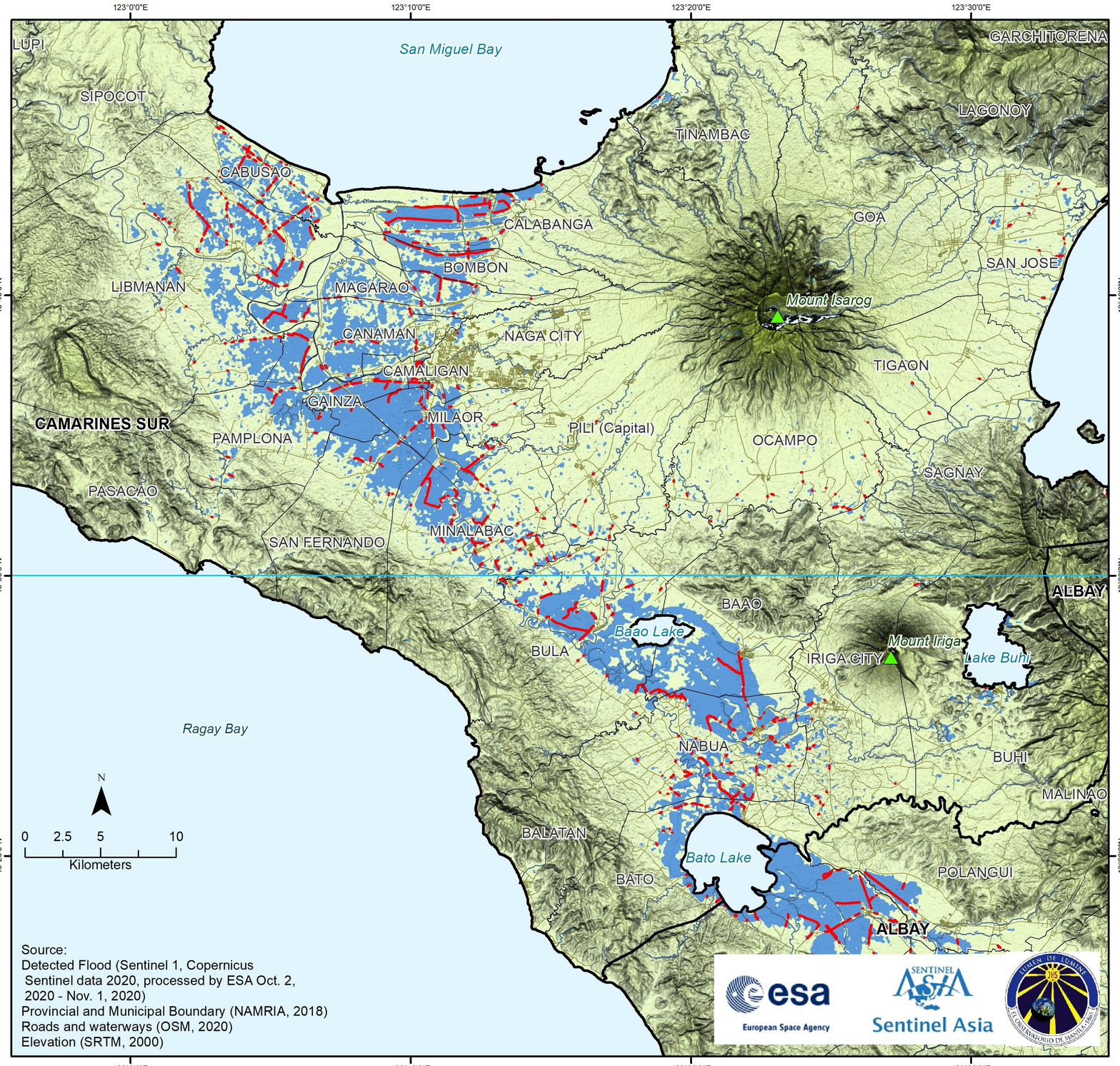


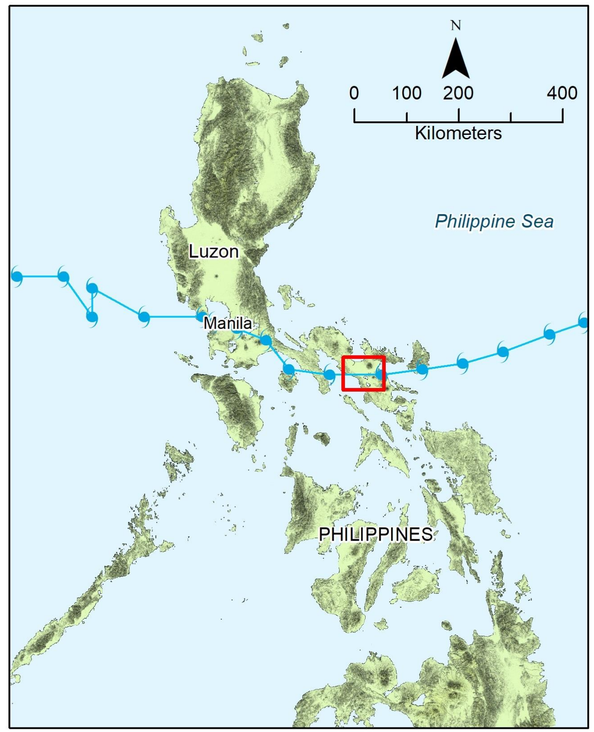
Legend

- Schools
- Typhoon Goni Track
- Roads
- Waterways
- Detected Flooding
- Provincial Boundary
- Municipal Boundary

Typhoon Goni (Nov. 1, 2020)

CAMARINES SUR Typhoon Goni Flooded Roads (Nov. 1, 2020)





Legend

- Typhoon Goni Track
- Roads
- Flooded Roads
- Waterways
- Provincial Boundary
- Municipal Boundary
- Detected Flooding

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For queries, requests, comments, suggestions, please email manila@observatory.ph