

Mapping the Impacts of Tropical Depression Dujuan (Auring) in the Eastern Visayas and Caraga Region

Geomatics for Environment and Development (GED) Laboratory

MANILA OBSERVATORY

March 5, 2021

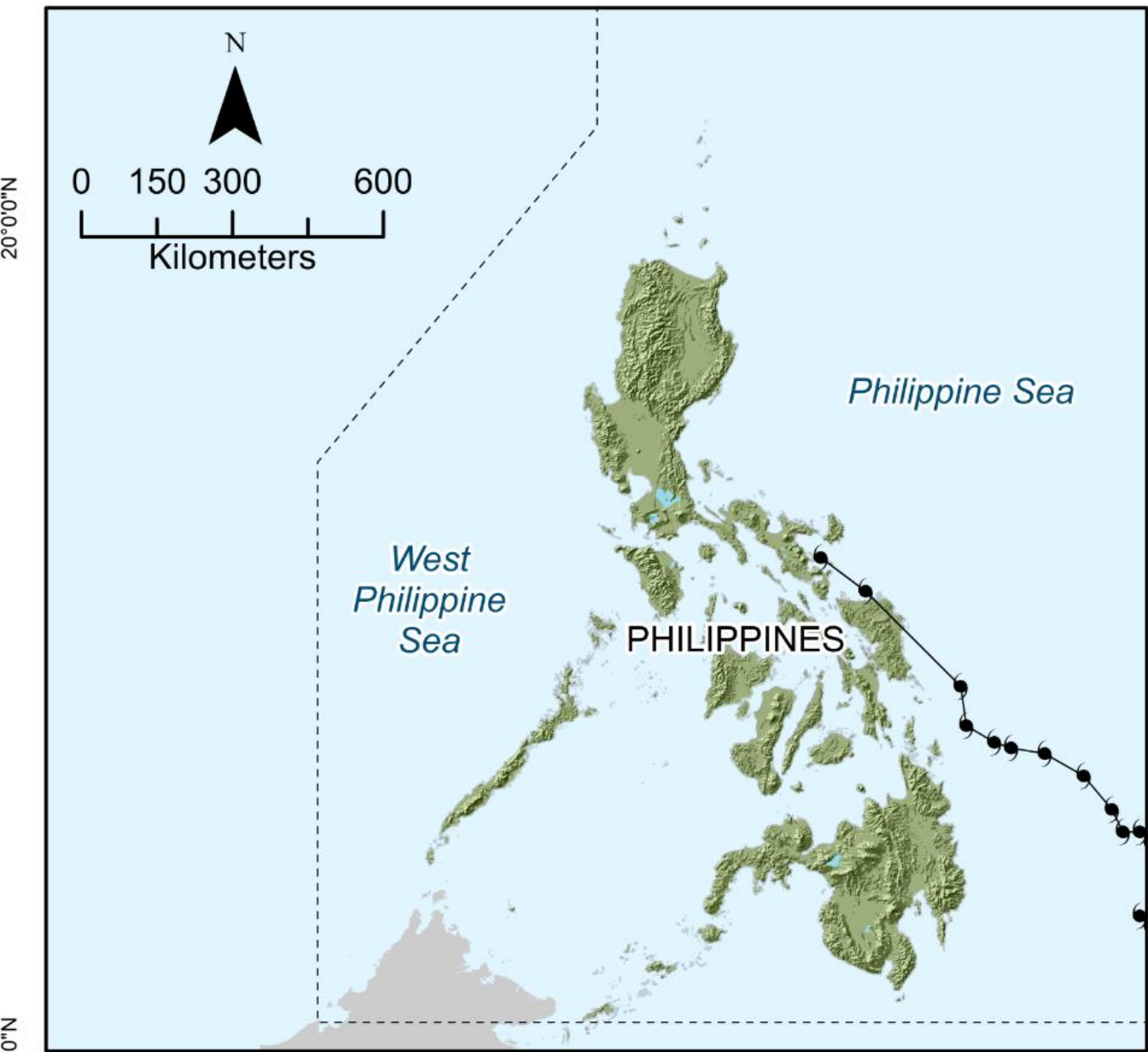
Summary

- Several areas in Southern Philippines experienced accumulated 24-hour rainfall exceeding 150 mm during the onslaught of Tropical Depression Auring on Feb. 20-22, 2021.
- Multi-temporal Synthetic Aperture Radar images detected flooding in the municipalities of San Miguel, Tago and Tandag City in the province of Surigao del Sur.
- Generated maps show affected population as well as flooded infrastructure and land cover by TD Auring.




Tropical Depression 'AURING' Track over the Philippines



Source:
Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
Elevation (SRTM 30 meters, 2000)



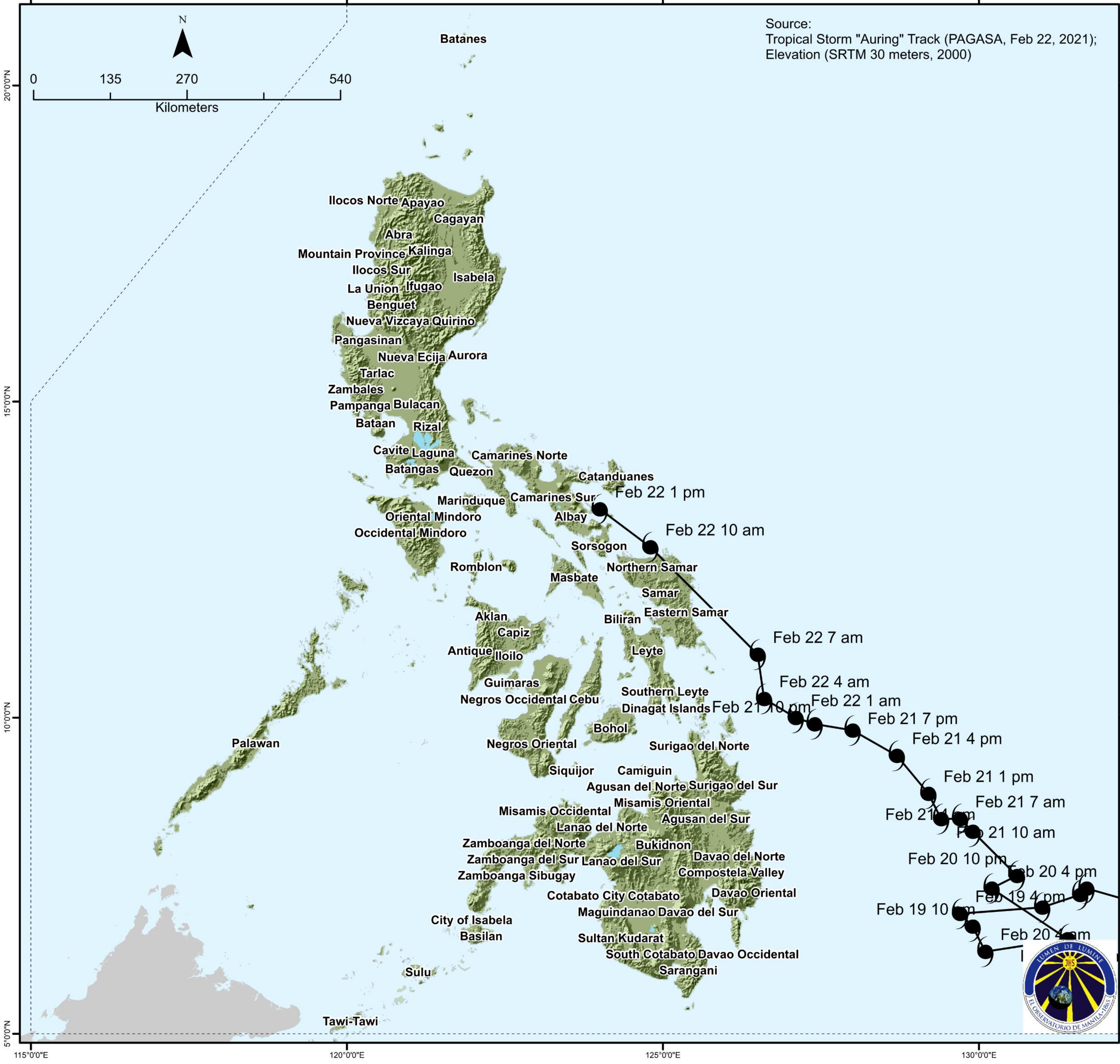
Legend

-  Tropical Depression (TD)
-  TD Auring Track
-  Philippine Area of Responsibility

Dujan or 'Auring' entered the Philippine Area of Responsibility (PAR) at 10:00 am of Feb. 17, 2021 as a "Tropical Storm". It made landfall on Feb. 22, 2021 at 9:00 am over Batag Island, Laoang, Northern Samar.

Tropical Depression (TD) 'Auring' (NDRRMC Situation Report No. 04)

- Based on the **forecast track and intensity**, it remained a tropical depression (TD) and considerably weakened as it traversed the Dinagat Islands - Homonmon Island areas.;
- Maximum sustained winds: 45 km/h near the center; and
- Gustiness: 55 km/h, moving West Northwestward at 15 km/h.



Tropical Depression 'Auring' Rainfall over Southern Philippines (February 21-22, 2021)



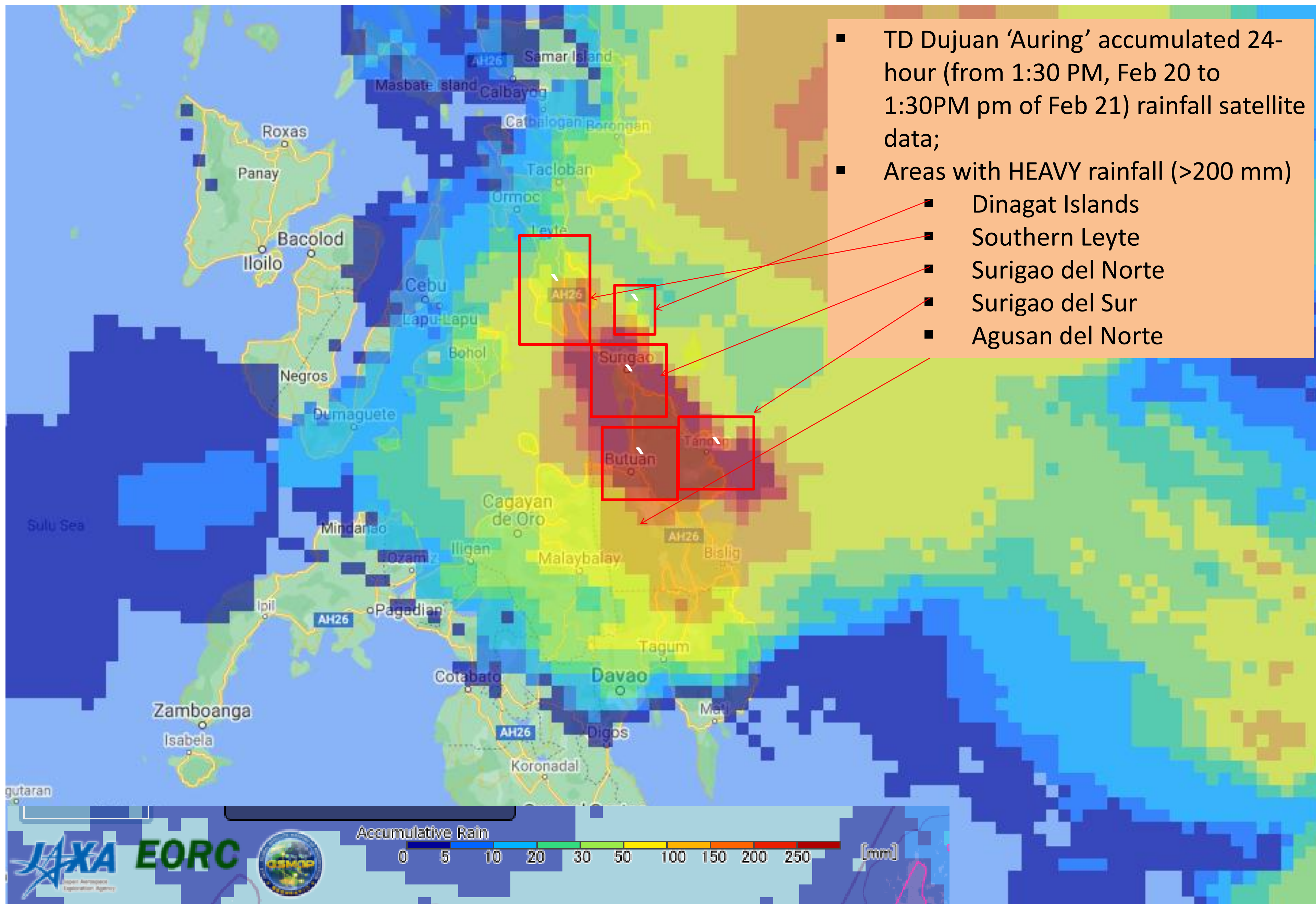
JAXA GLOBAL RAINFALL WATCH 世界の雨分布速報

日本語

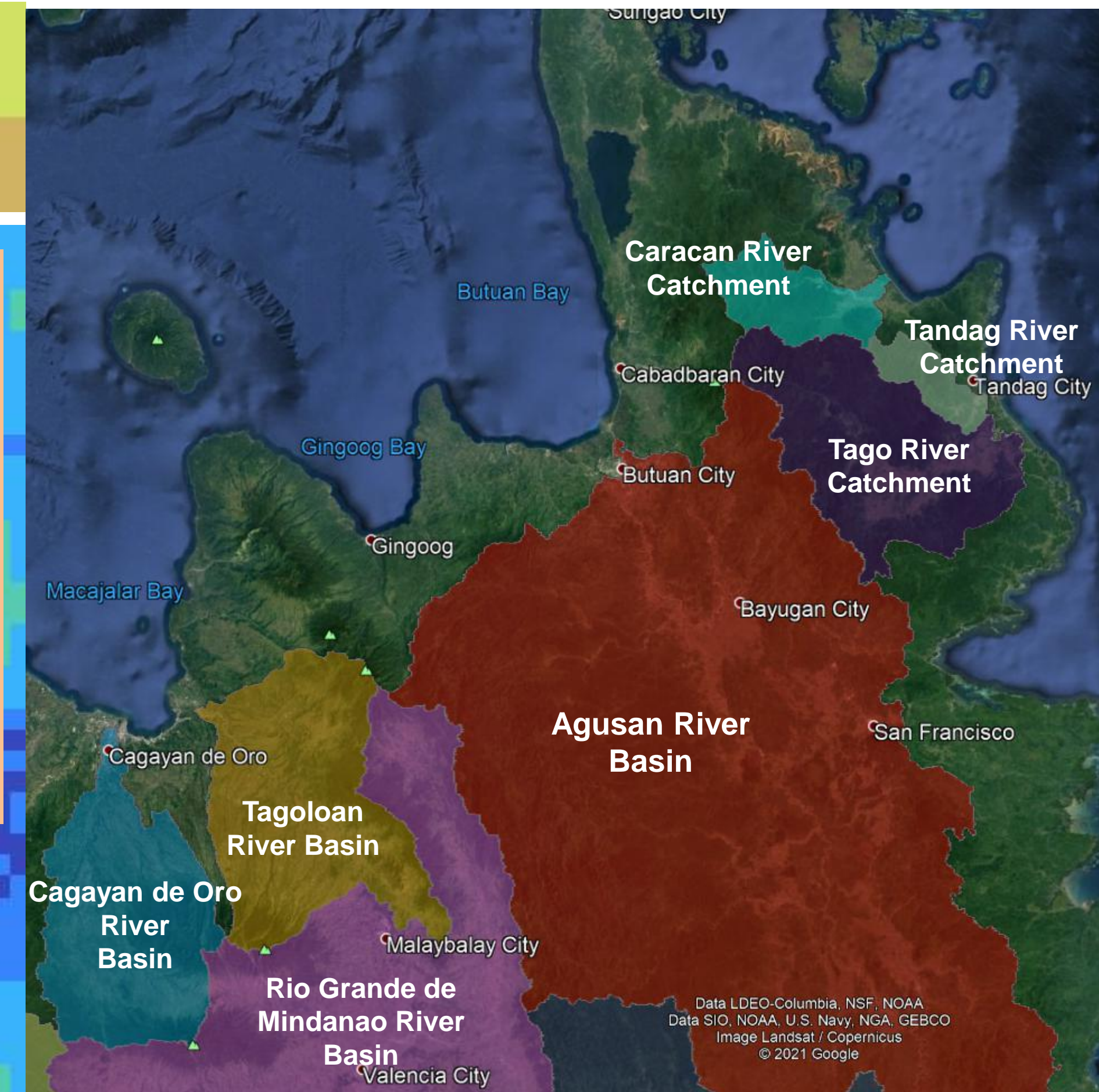
Last Update: 22 Feb 2021 14:48:45 UTC



JAXA Global Rainfall Watch (GSMaP) 2021.02.21 13:00(JST)
<https://sharaku.eorc.jaxa.jp/GSMaP/index.htm>



- TD Dujan 'Auring' accumulated 24-hour (from 1:30 PM, Feb 20 to 1:30PM pm of Feb 21) rainfall satellite data;
- Areas with HEAVY rainfall (>200 mm)
 - Dinagat Islands
 - Southern Leyte
 - Surigao del Norte
 - Surigao del Sur
 - Agusan del Norte



Affected River Basins and Principal Watersheds:

- Agusan River Basin
- Rio Grande de Mindanao River Basin
- Cagayan de Oro River Basin
- Tagoloan River Basin
- Tago River Watershed
- Tandag River Catchment
- Caracan River Catchment

Image Source: Google Maps

18 Major River Basins & Principal River Basins in the Philippines



Tropical Depression 'Auring' Rainfall over Central and Southern Philippines (February 21-22, 2021)

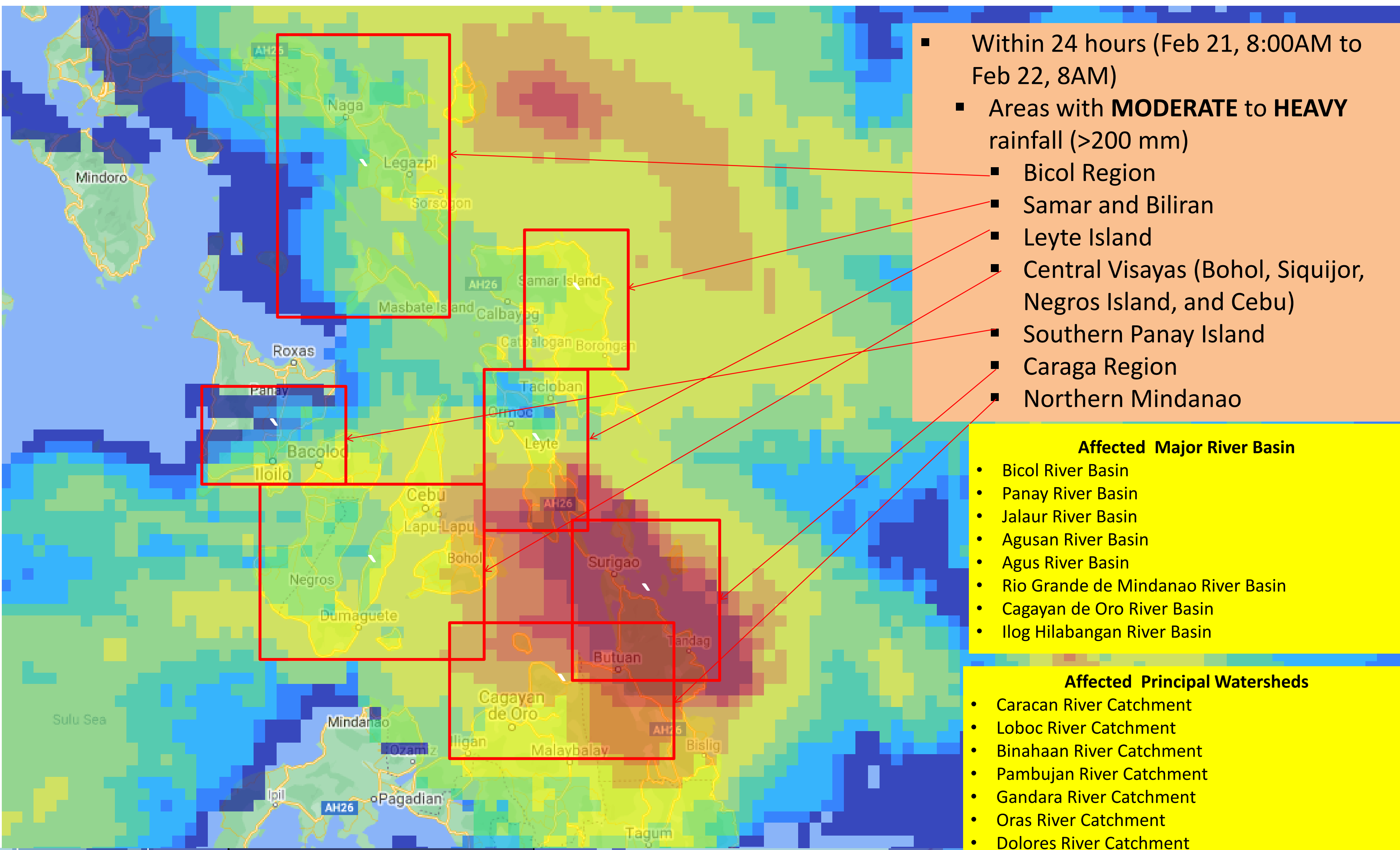


JAXA GLOBAL RAINFALL WATCH 世界の雨分布速報

日本語 Last Update: 22 Feb 2021 14:48:45 UTC



JAXA Global Rainfall Watch (GSMaP) 2021.02.22 08:00(JST)
<https://sharaku.eorc.jaxa.jp/GSMaP/index.htm>



- Within 24 hours (Feb 21, 8:00AM to Feb 22, 8AM)
 - Areas with **MODERATE** to **HEAVY** rainfall (>200 mm)
 - Bicol Region
 - Samar and Biliran
 - Leyte Island
 - Central Visayas (Bohol, Siquijor, Negros Island, and Cebu)
 - Southern Panay Island
 - Caraga Region
 - Northern Mindanao

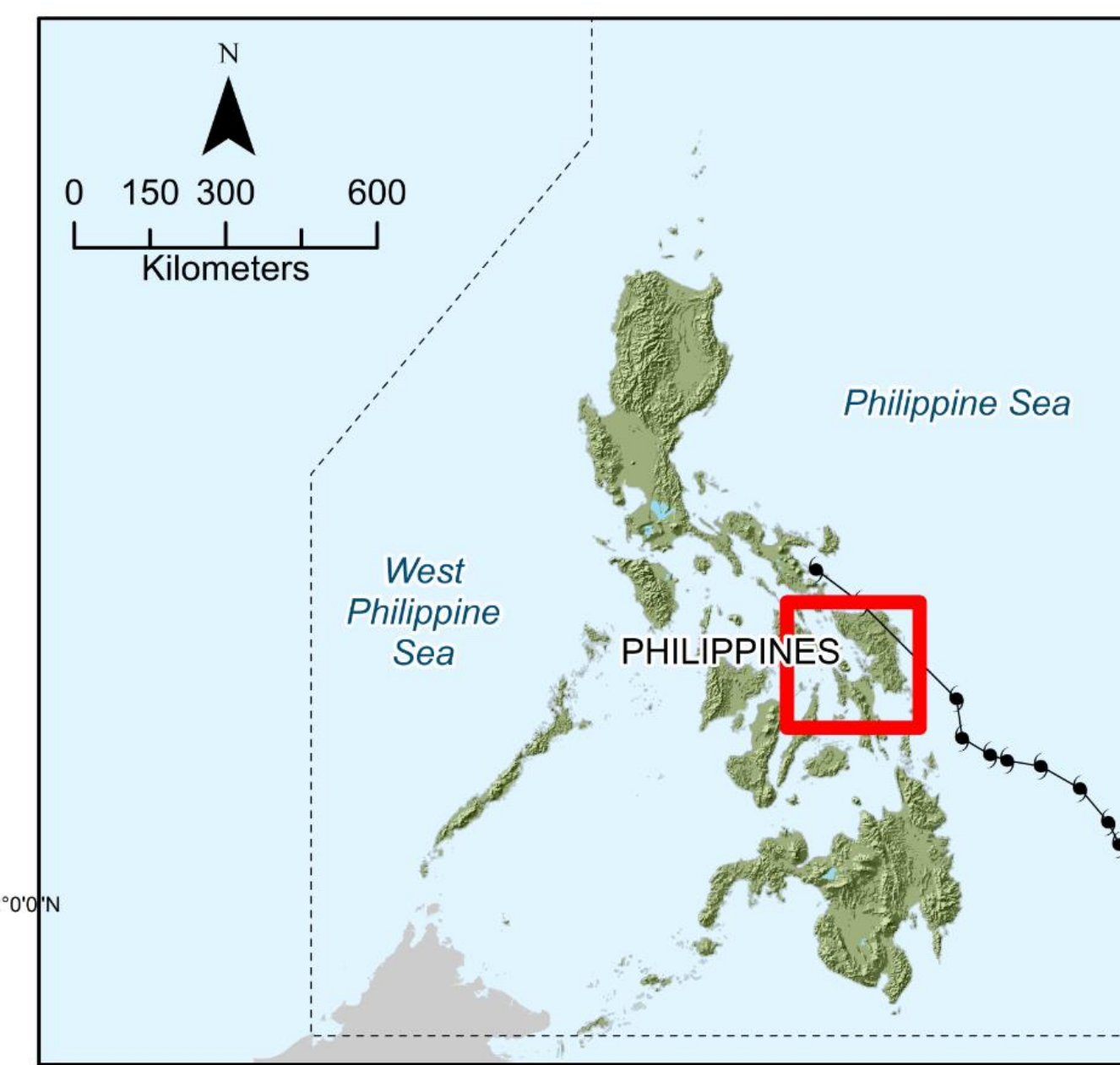
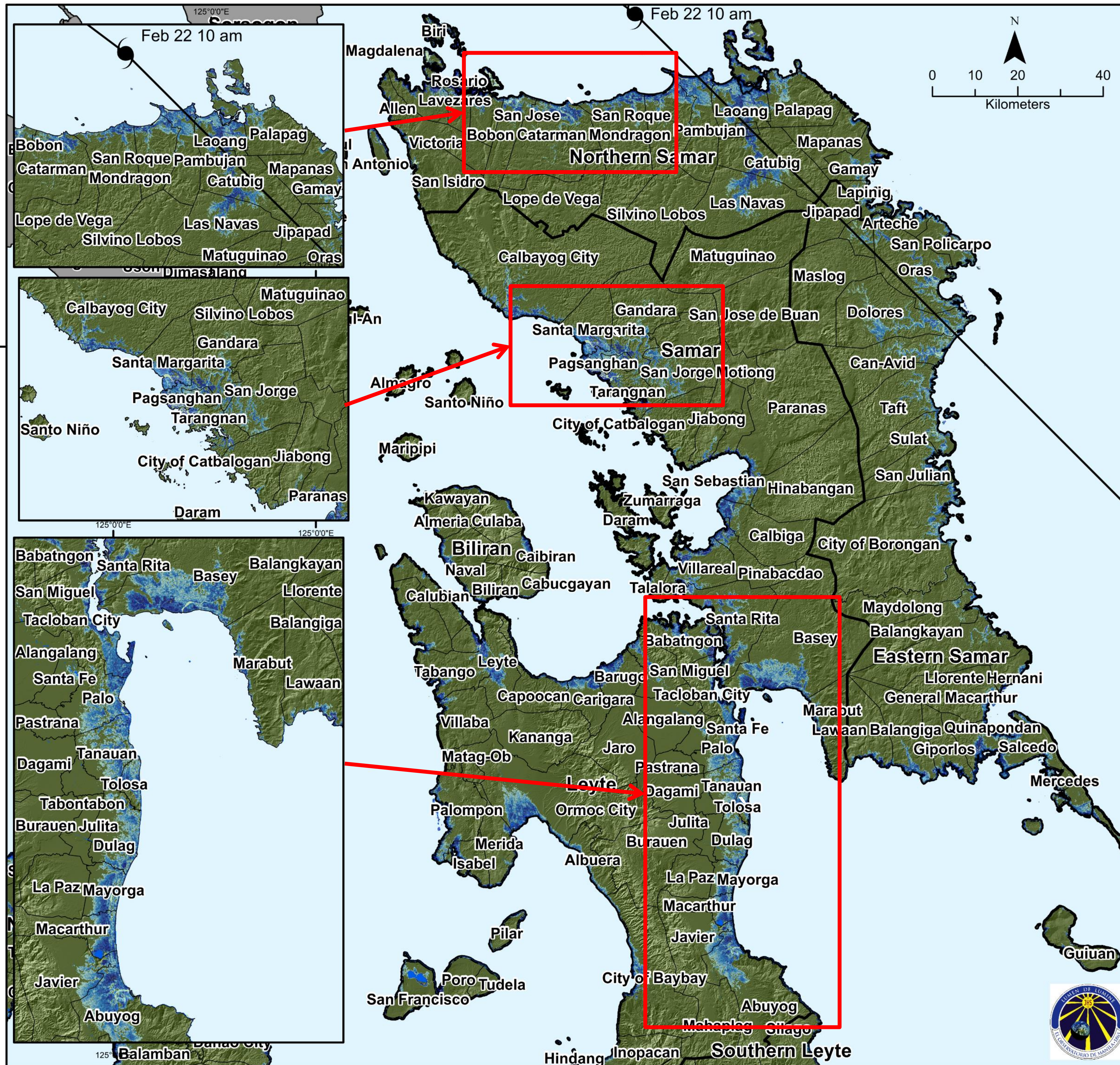
- Affected Major River Basin**
- Bicol River Basin
 - Panay River Basin
 - Jalaur River Basin
 - Agusan River Basin
 - Agus River Basin
 - Rio Grande de Mindanao River Basin
 - Cagayan de Oro River Basin
 - Ilog Hilabangan River Basin

- Affected Principal Watersheds**
- Caracan River Catchment
 - Loboc River Catchment
 - Binahaan River Catchment
 - Pambujan River Catchment
 - Gandara River Catchment
 - Oras River Catchment
 - Dolores River Catchment
 - Tagoloan River Basin
 - Tago River Watershed
 - Tandag River Catchment



Image Source: Google Maps
 18 Major River Basins & 3 Principal River Basins in the Philippines

Low-Lying Areas in Eastern Visayas



Legend

- Tropical Depression (TD)
- TD Auring Track
- Municipal Boundary
- Provincial Boundary

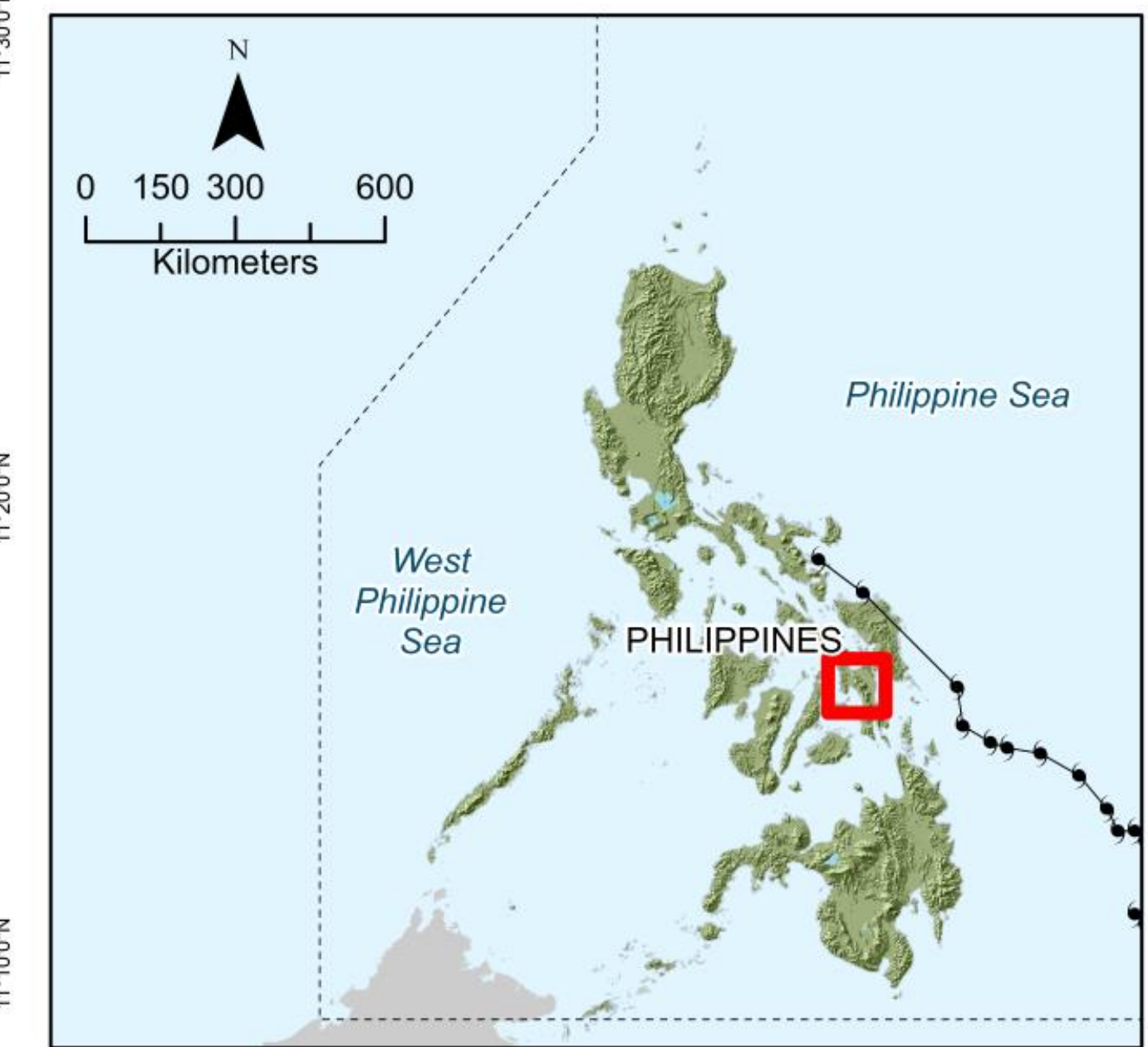
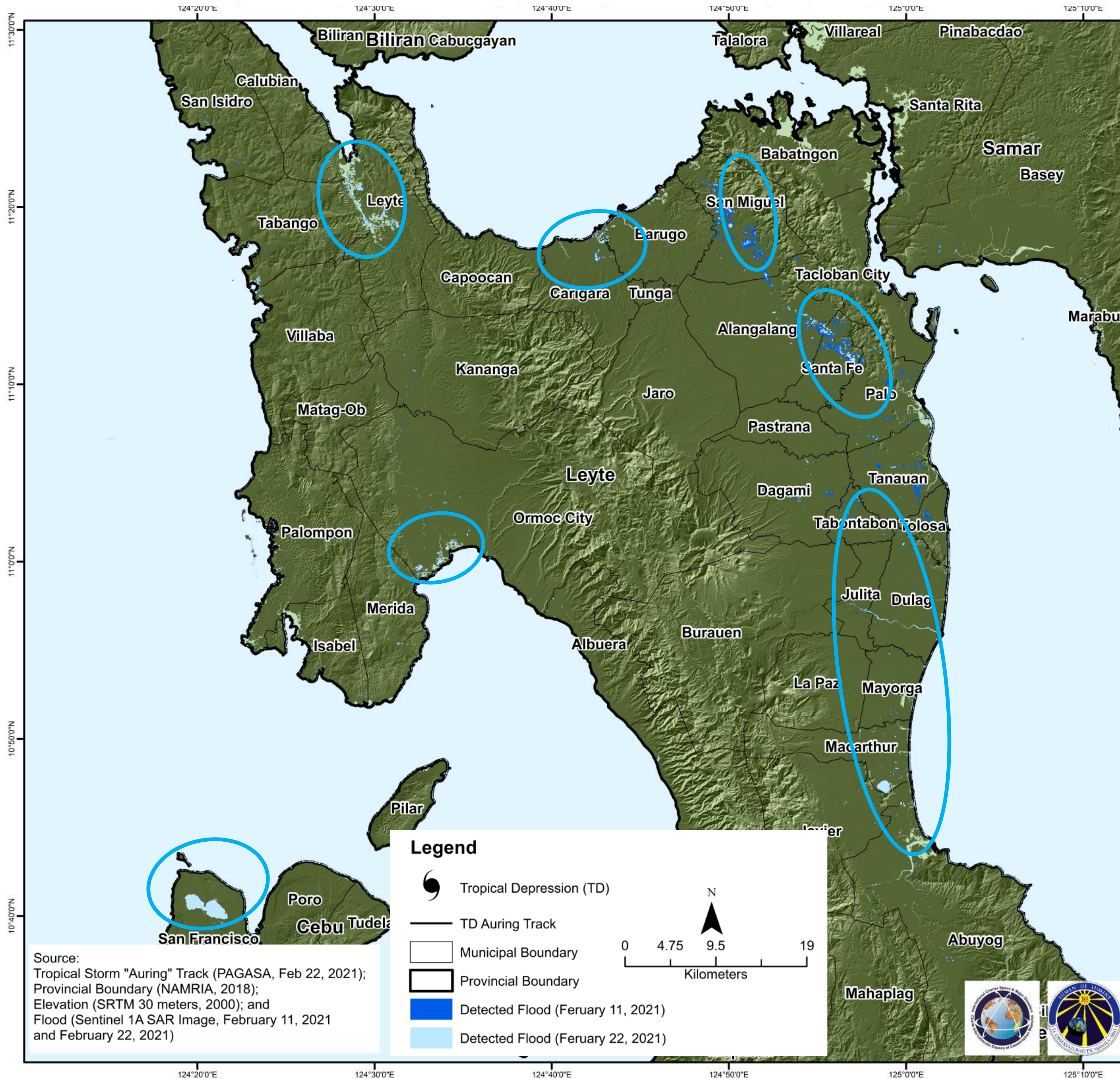
Low Elevation Coastal Zones (meters above sea level)

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Source: Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021); Provincial Boundary (NAMRIA, 2018); and Elevation (SRTM 30 meters, 2000)

LOW-LYING CITIES/ MUNICIPALITIES		
NORTHERN SAMAR	SAMAR	LEYTE
• Laoang	• Calbayog City	▪ Leyte
• San Roque	• Sta Margarita	▪ Barugo
• Pambujan	• Pagsanghan	▪ San Miguel
• San Jose	• Catbalogan City	▪ Tacloban City
• Catarman	• San Sebastian	▪ Santa Fe
• Lavezares	• Villareal	▪ Palo
• Rosario	• Basey	▪ Anauan
• Gatubig	• Hinabangan	▪ Tolosa
• Las Navas	• Galbiga	▪ Dulag
	• Sta Rita	▪ Mayorga
		▪ Mcarthur
		▪ Abuyog
		▪ Ormoc City

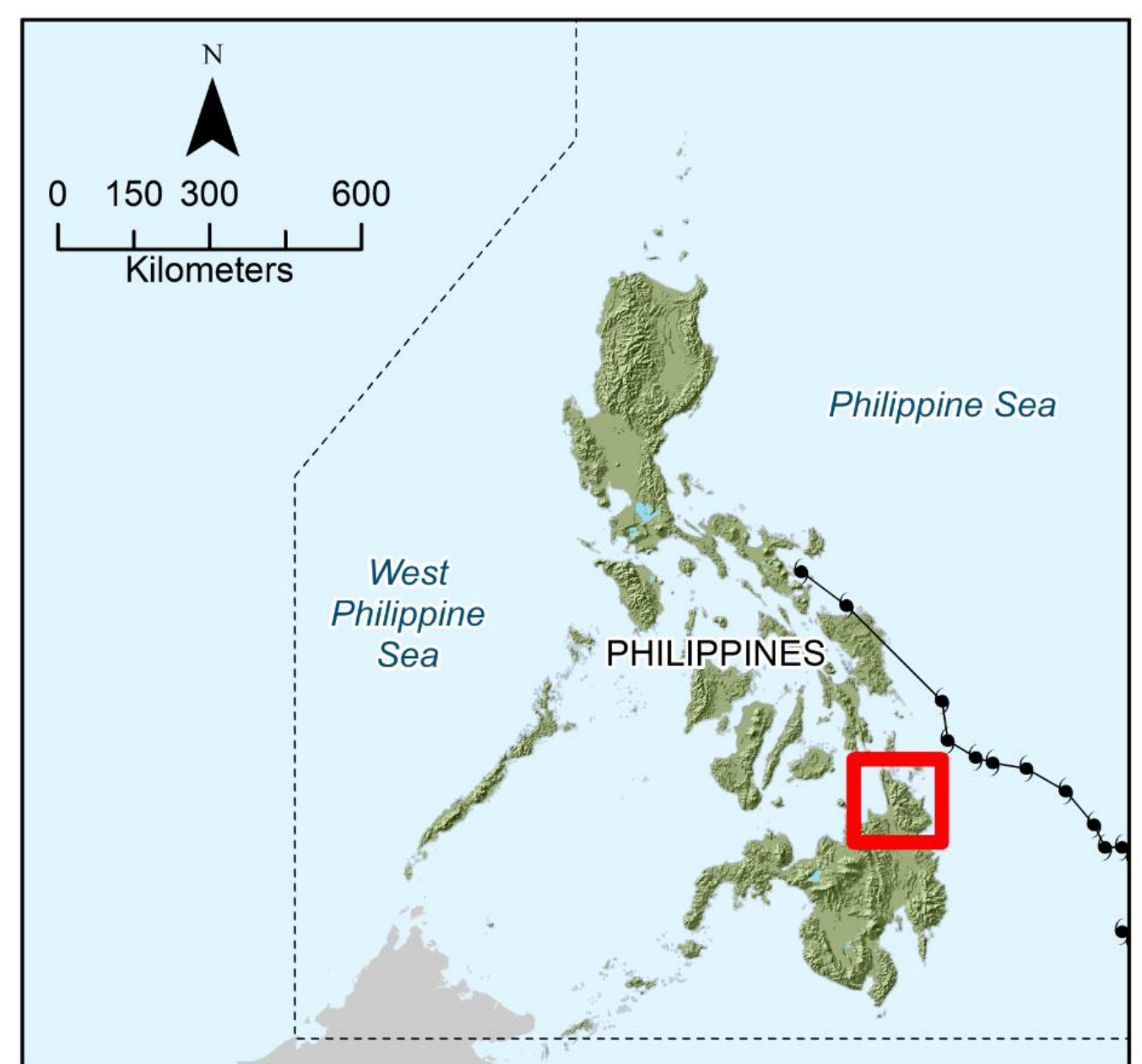
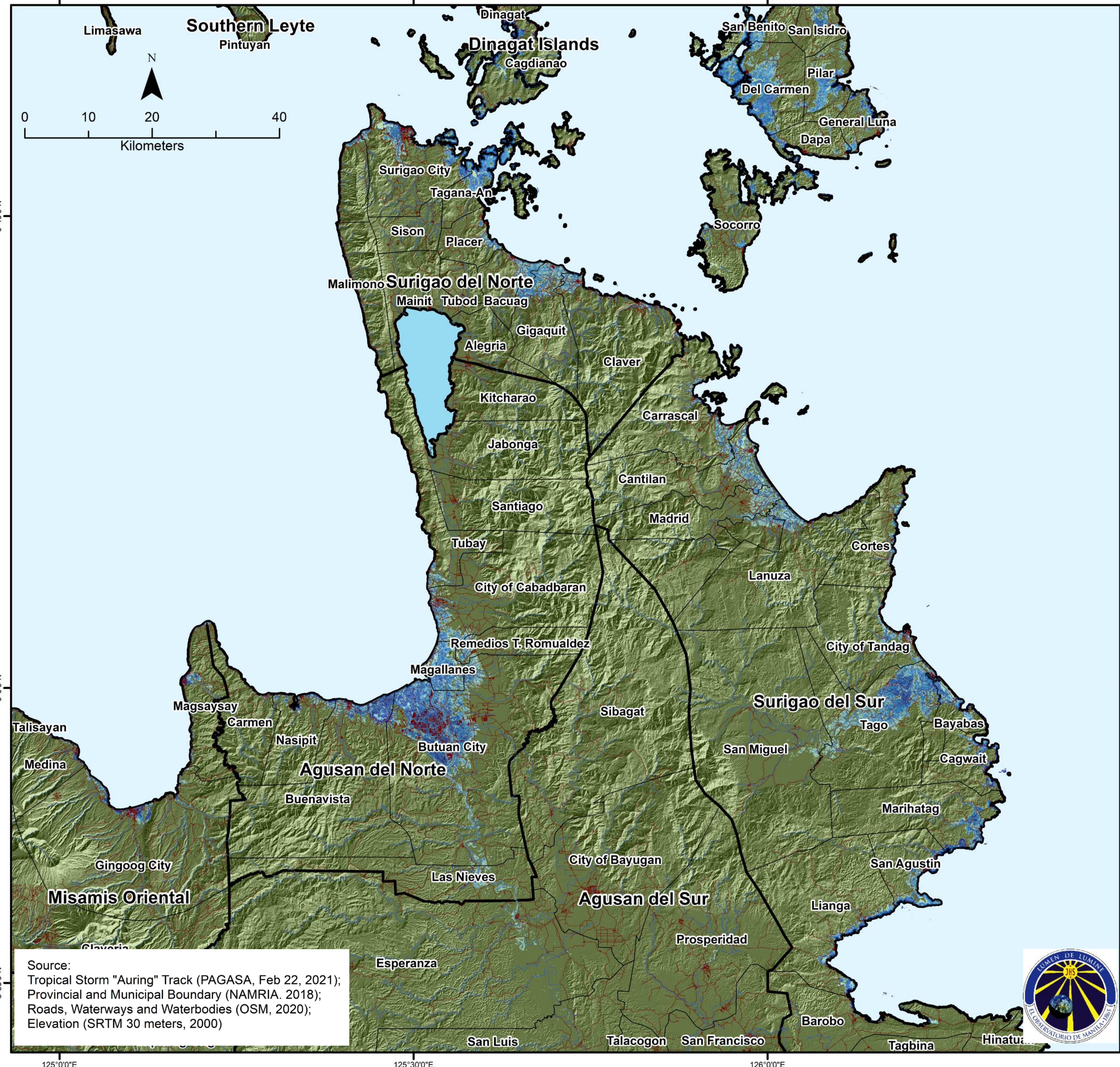
Detected Flood in Central Philippines (Sentinel 1A Images, February 22, 2021)



- Highlighted in **blue** are the observed flooded areas in Leyte Island after >150 mm of rain due to Tropical Depression 'Auring' on Feb 22, 2021.
 - Flood extent was detected by thresholding the difference of pixel values of Sentinel-1 SAR image taken on Feb 11, 2021 and Feb 22, 2021.
 - 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.
- SAR – Synthetic Aperture Radar

- ### Flooded municipalities in Leyte
- Ormoc City
 - Leyte
 - Carigara
 - San Miguel
 - Alangalang
 - Sta Fe
 - Tanauan
 - Tolosa
 - Macarthur

Low-Lying Areas in Caraga Region



Legend

- Tropical Depression (TD)
 - TD Auring Track
 - Roads
 - Waterways
 - Waterbodies
 - Municipal Boundary
 - Provincial Boundary
- | Low Elevation Coastal Zones (meters above sea level) | |
|--|--------|
| | 1 - 2 |
| | 3 - 4 |
| | 5 - 6 |
| | 7 - 8 |
| | 9 - 10 |

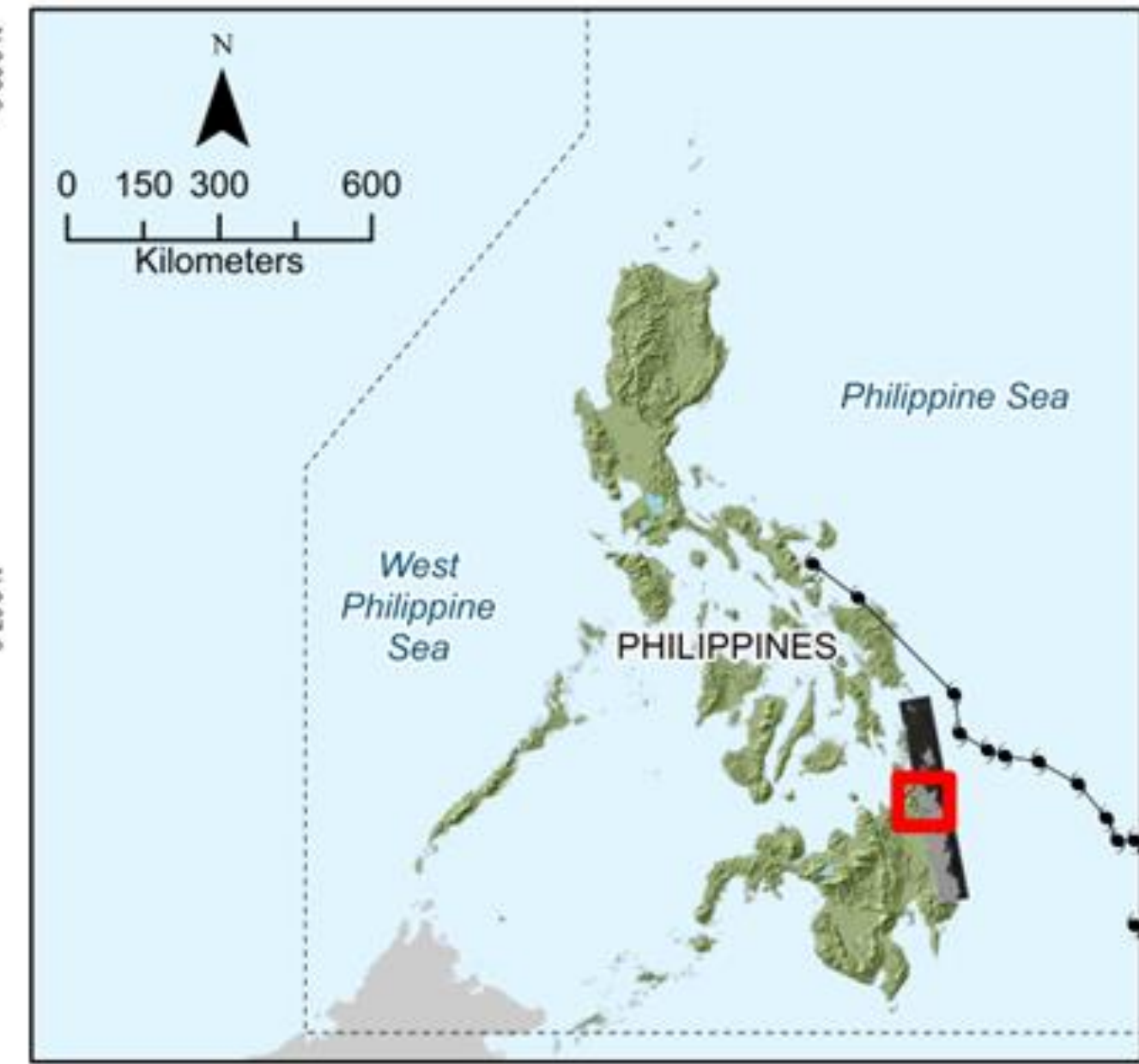
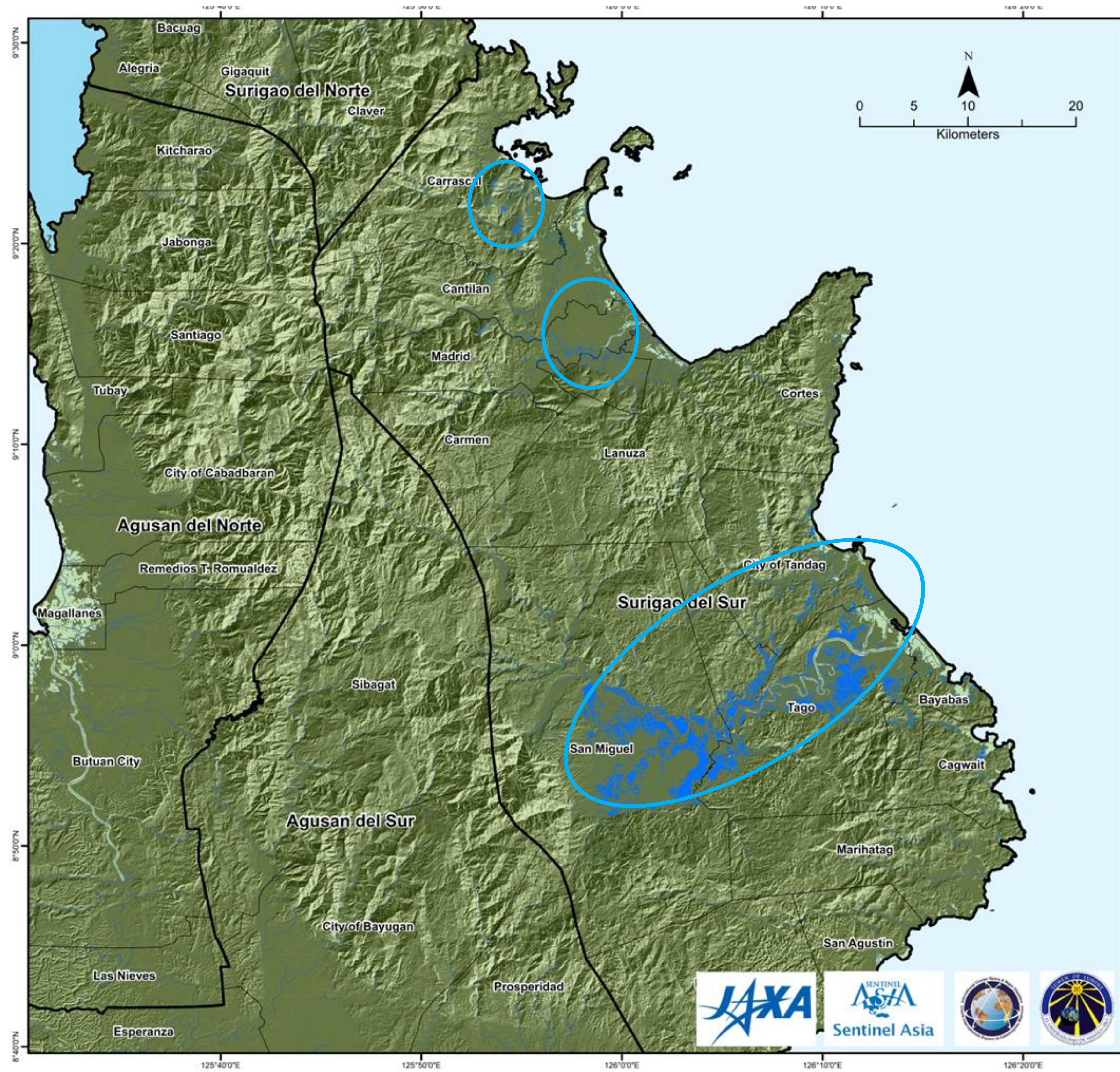
LOW-LYING CITIES/ MUNICIPALITIES

- | AGUSAN DEL NORTE | SURIGAO DEL NORTE | SURIGAO DEL SUR |
|-------------------------|------------------------------|-----------------|
| ▪ Butuan City | ▪ Surigao City | ▪ Carrascal |
| ▪ Magallanes | ▪ Tagana-An | ▪ Cantilan |
| ▪ Buenavista | ▪ Gigaquit | ▪ Madrid |
| ▪ Remedios T. Romualdez | ▪ Del Carmen, Siargao Island | ▪ Carmen |
| ▪ Cabadbaran City | | ▪ Tandag City |
| | | ▪ Tago |

Source:
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial and Municipal Boundary (NAMRIA, 2018);
 Roads, Waterways and Waterbodies (OSM, 2020);
 Elevation (SRTM 30 meters, 2000)



Detected Flood in Surigao del Sur (ALOS-2 Images, April 11, 2019 and February 25, 2021)



Legend

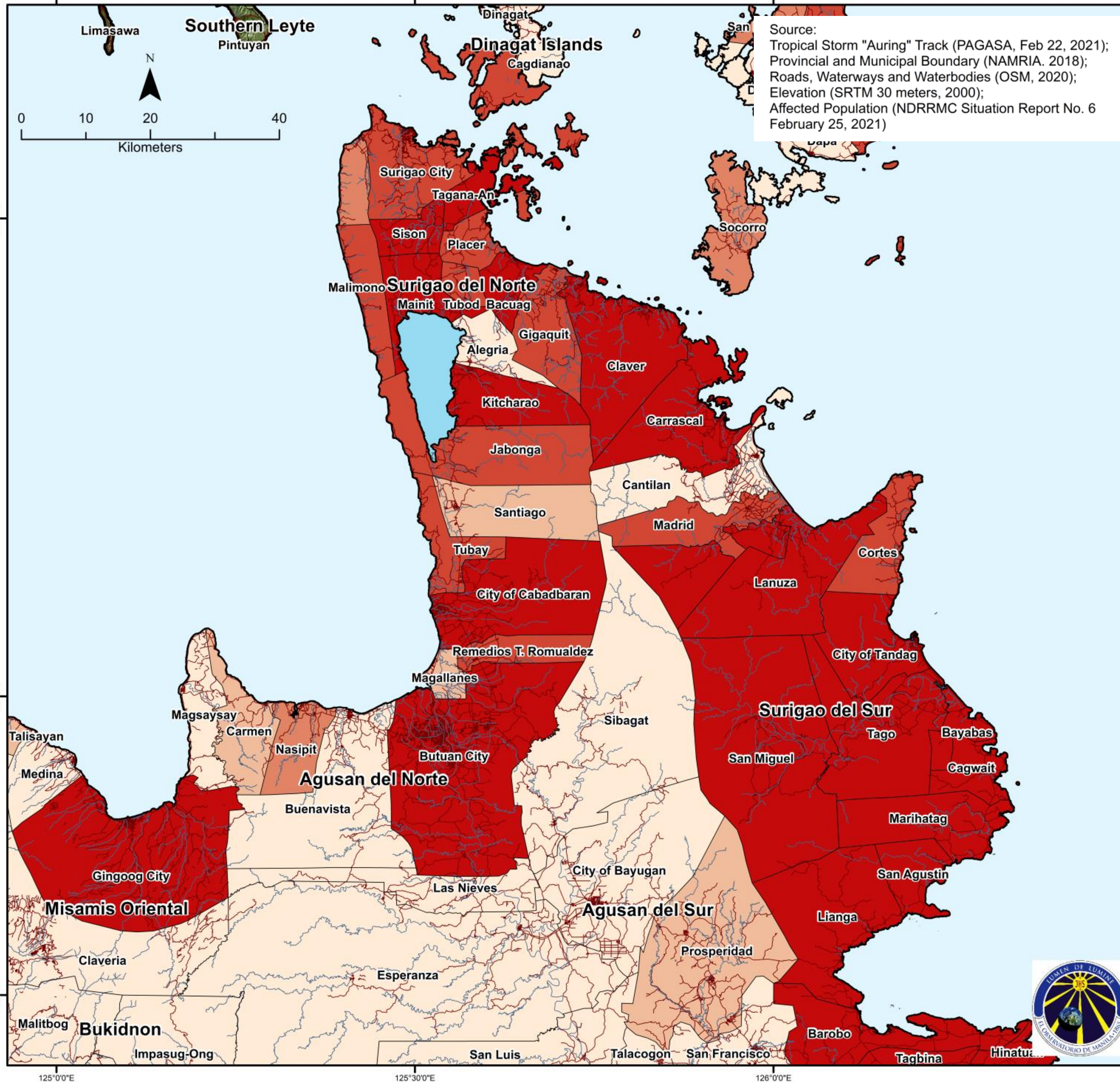
- Tropical Depression (TD)
- TD Auring Track
- Roads
- Waterways
- Waterbodies
- Municipal Boundary
- Provincial Boundary
- Detected Flood (February 25, 2021)

Source:
Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
Provincial and Municipal Boundary (NAMRIA, 2018);
Roads, Waterways and Waterbodies (OSM, 2020);
Elevation (SRTM 30 meters, 2000)
Flood (JAXA ALOS-2 PALSAR-2, April 11, 2019 and
February 25, 2021)

- Highlighted in **blue** are the observed flooded areas in San Miguel, Tago, and Tandag City in Surigao del Sur (**71.58 km²**) after >200 mm of rain due to Tropical Depression 'Auring' on Feb 21, 2021.
- Flood extent was detected by thresholding the difference of pixel values of ALOS-2 PALSAR-2 images taken on April 11, 2019 and Feb 25, 2021.
- 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..



Affected Population in Caraga Region, as of February 25, 2021 (8:00AM)



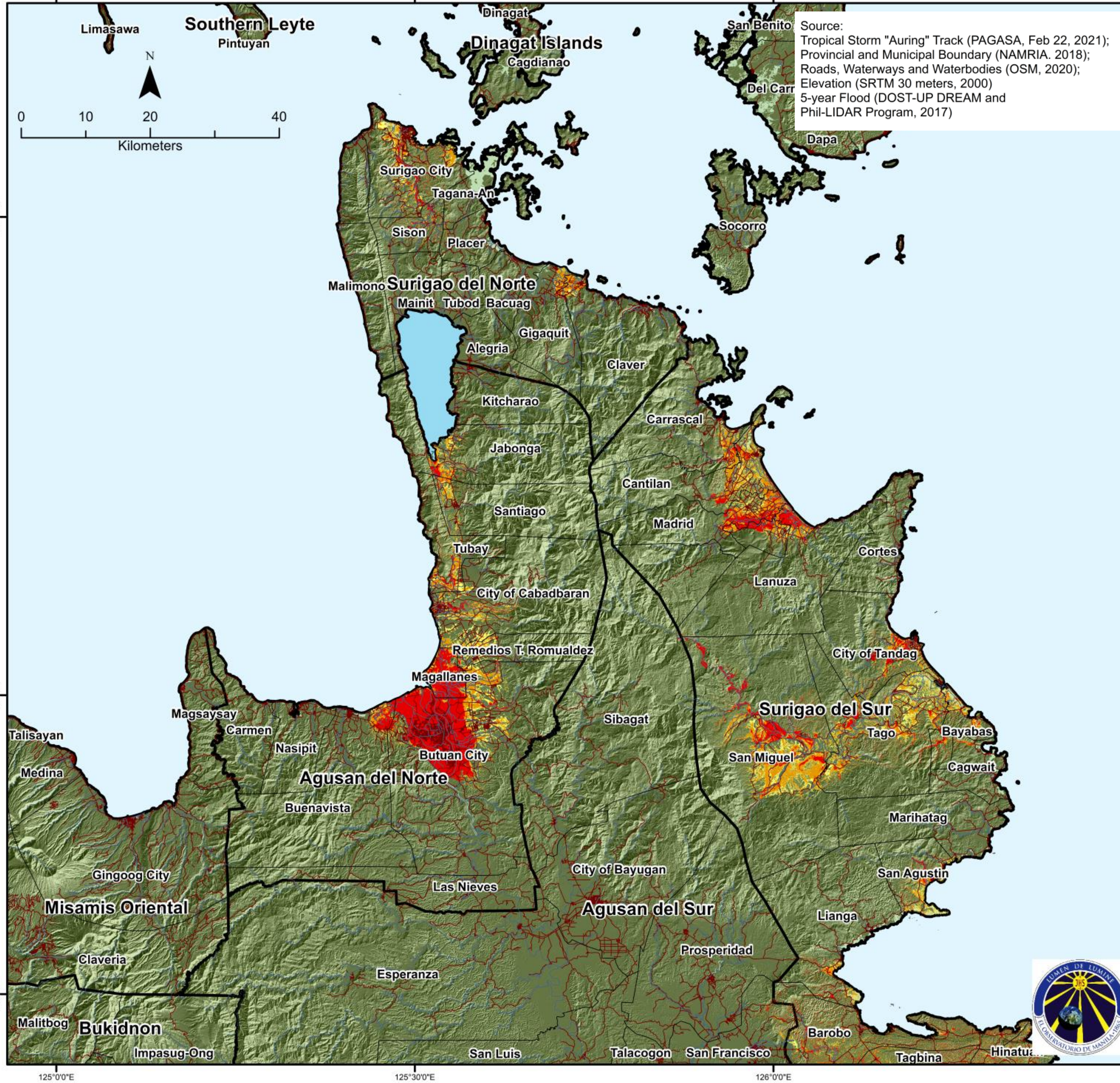
Legend

- Tropical Depression (TD)
 - TD Auring Track
 - Roads
 - Waterways
 - Provincial Boundary
 - Municipal Boundary
 - Waterbodies
- | Affected Population | |
|---------------------|--------------|
| February 25, 2021 | |
| | 0 |
| | 1 - 150 |
| | 151 - 600 |
| | 601 - 2500 |
| | 2501 - 20872 |

- NDRRMC reported that Tropical Depression 'AURING' affected a total of **190,789 persons** in Caraga Region.
- **3,187 persons** were affected in Dinagat Islands.
- **14,352 persons** were affected in Agusan del Norte.
- **6,125 persons** were affected in Agusan del Sur.
- **35,131 persons** were affected in Surigao del Norte.
- **131,994 persons** were affected in Surigao del Sur

• NDRRMC – National Disaster Risk Reduction and Management Council

5-year Flood in Caraga Region



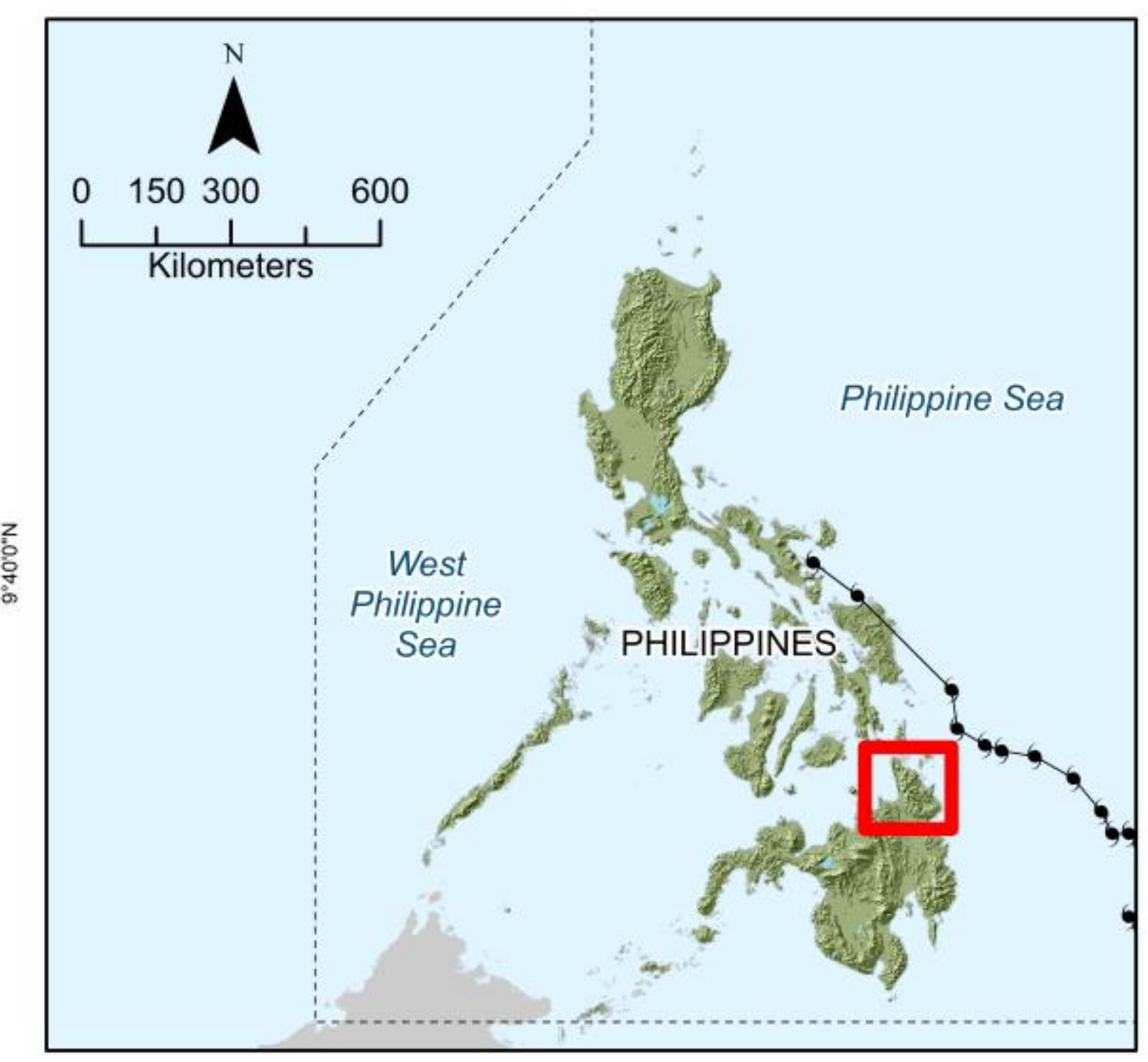
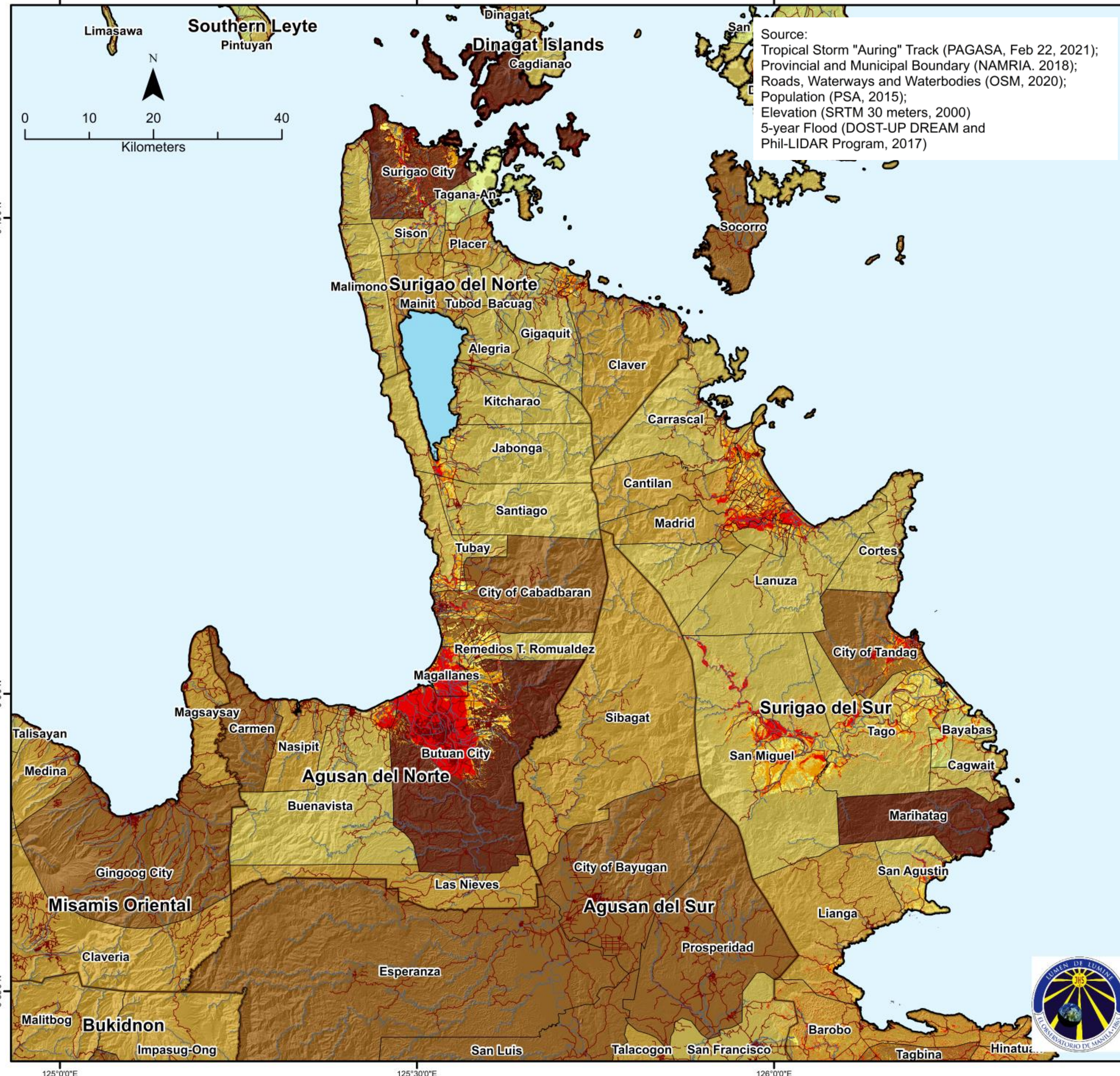
Legend

- Tropical Depression (TD)
 - TD Auring Track
 - Roads
 - Waterways
 - Municipal Boundary
 - Provincial Boundary
 - Waterbodies
- 5-year Flood Model**
- Hazard Level**
- Low (0.1 m to 0.5 m)
 - Moderate (0.5 m to 1.5 m)
 - High (>1.5 m)

Top 25 Cities and Municipalities with High Hazard level (ranked based on area of high flood hazard level per municipality/city):

- | | | |
|-------------|--------------|-----------------|
| Butuan City | Bislig City | Cabadbaran City |
| San Miguel | Tandag City | Sison |
| Tagbina | Surigao City | Tubay |
| Magallanes | Lanuza | Jabonga |
| Hinatuan | Buenavista | San Agustin |
| Bnarobo | Tubajon | Carrascal |
| Tago | Cantilan | Bayabas |
| Madrid | Carmen | Liang |
| | | Loreto |

Population Exposed to 5-year flood in Caraga Region

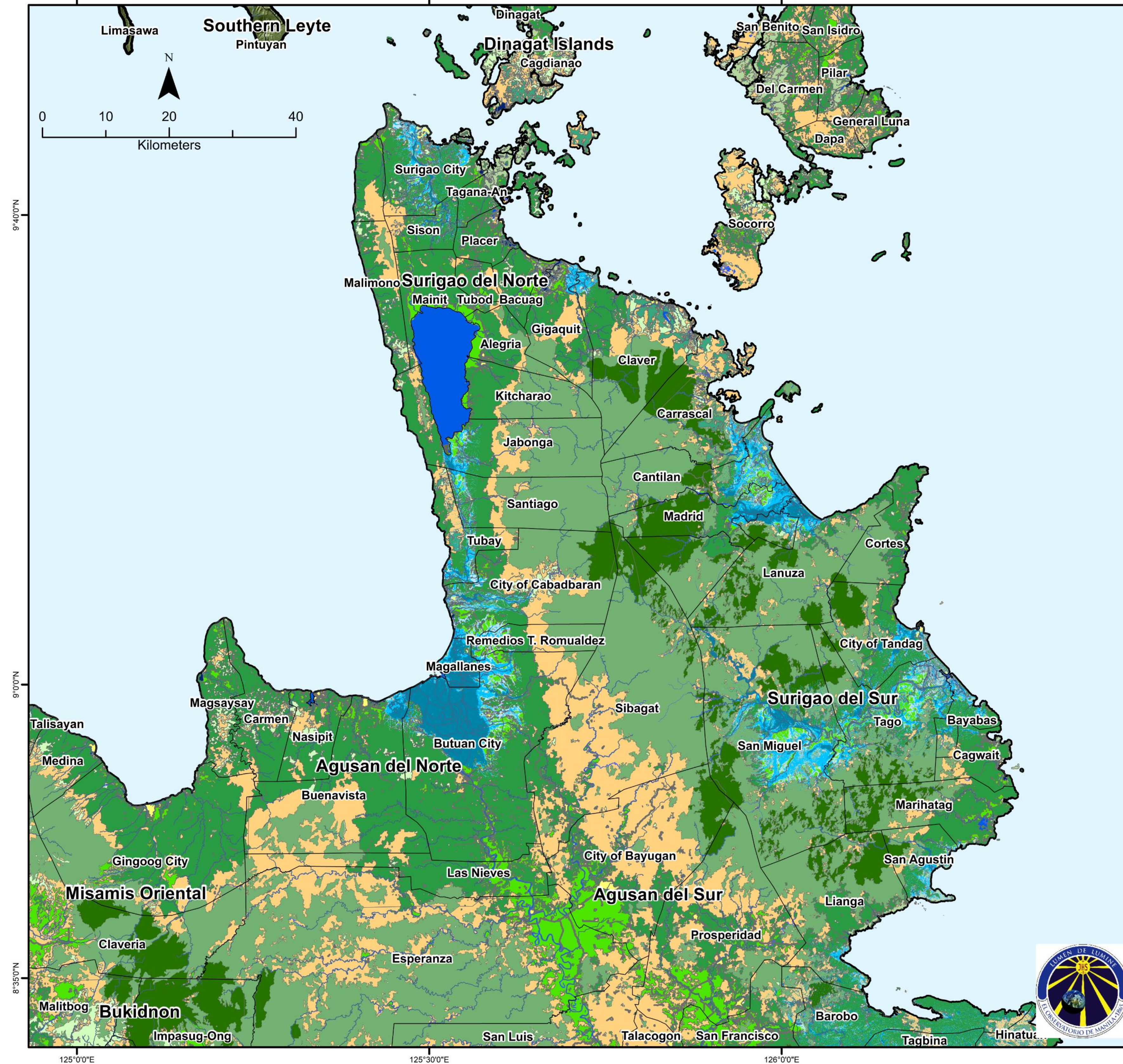


Legend

	Tropical Depression (TD)	5-year Flood Model
	TD Auring Track	hazard level
	Roads	Low (0.1 m to 0.5 m)
	Waterways	Moderate (0.5 m to 1.5 m)
	Municipal Boundary	High (>1.5 m)
	Provincial Boundary	Population
	Waterbodies	(per municipality)
		0 - 10,000
		10,001 - 25,000
		25,001 - 50,000
		50,001 - 125,000
		125,001 - 2,936,116

- Top Cities and Municipalities with High Population (more than 1 Million people)**
- Butuan City
 - Marihatag
 - Surigao City
 - Bayugan City

Land Cover Exposed to 5-year Flood in Caraga Region



Legend

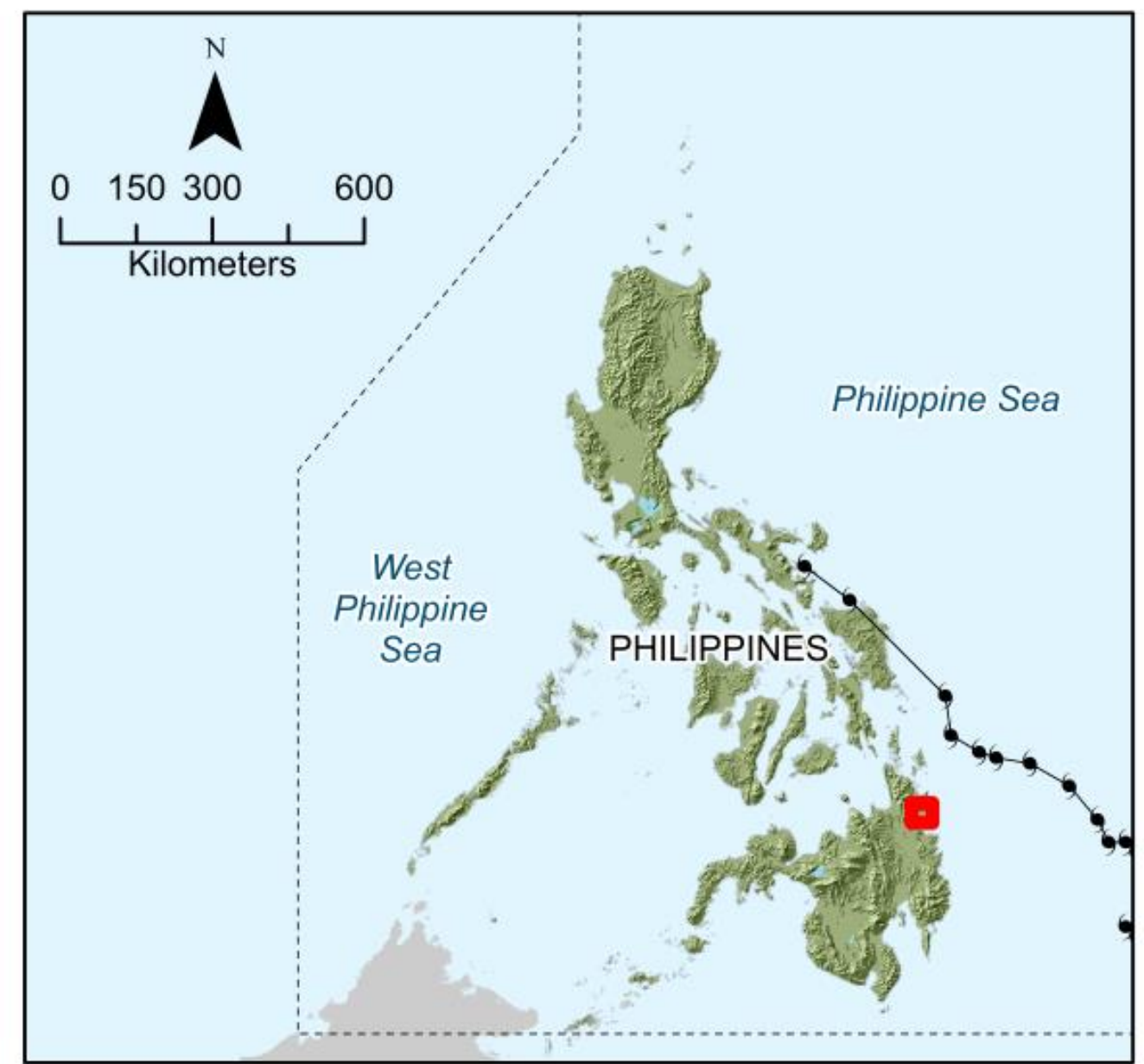
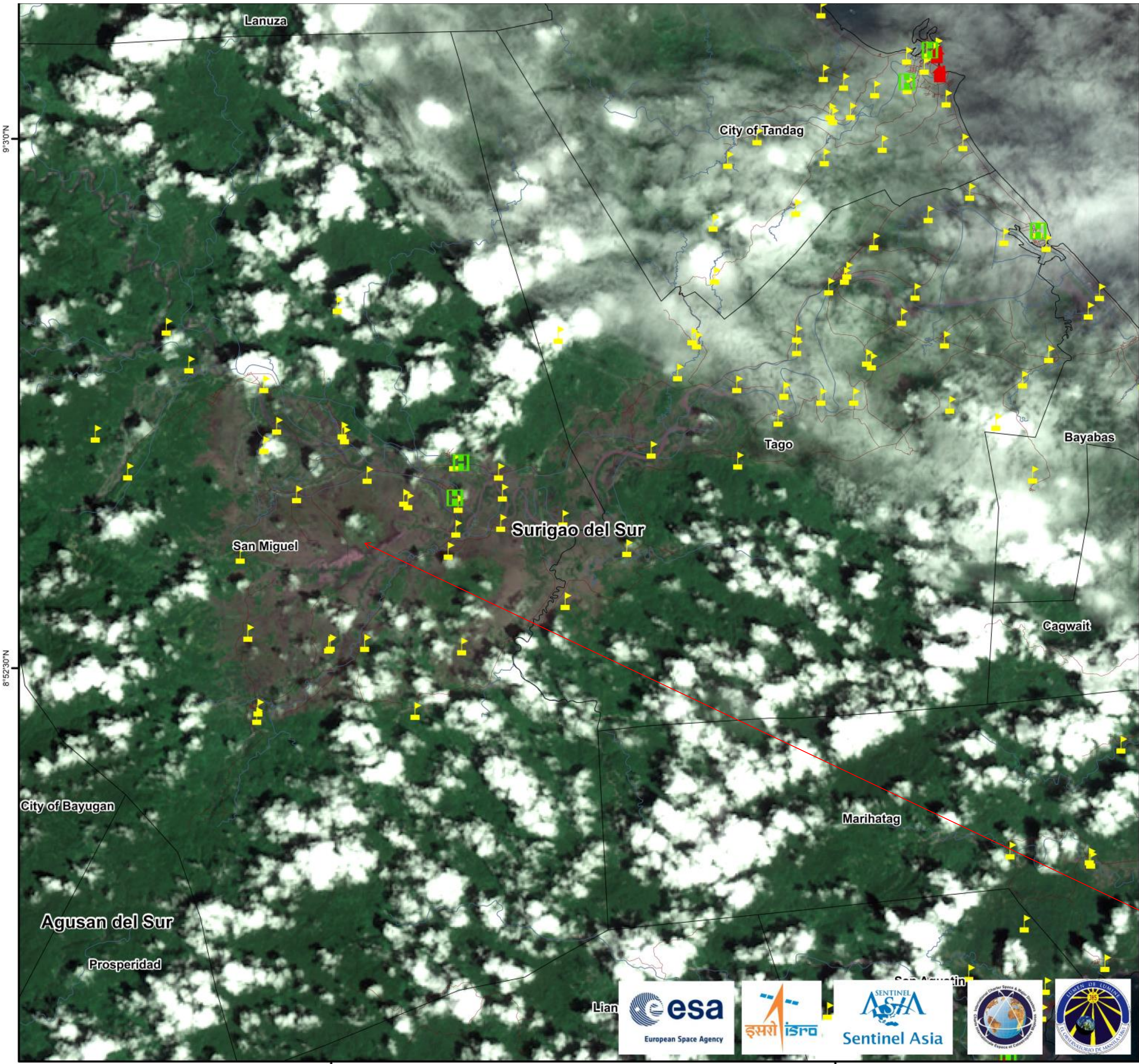
- | | | | |
|--|--------------------------|--|-----------------|
| | Tropical Depression (TD) | | Perennial Crop |
| | TD Auring Track | | Annual Crop |
| | Roads | | Brush/Shrubs |
| | Waterways | | Built-up |
| | Municipal Boundary | | Open Forest |
| | Provincial Boundary | | Closed Forest |
| | | | Fishpond |
| | | | Grassland |
| | | | Inland Water |
| | | | Mangrove Forest |
| | | | Marshland/Swamp |
| | | | Open/Barren |

5-year Flood Model

- hazard level**
- Low (0.1 m to 0.5 m)
 - Moderate (0.5 m to 1.5 m)
 - High (>1.5 m)

Source:
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial, Municipal Boundary and Land Cover (NAMRIA, 2018/2015);
 Roads, Waterways and Waterbodies (OSM, 2020);
 Elevation (SRTM 30 meters, 2000);
 5-year Flood (DOST-UP DREAM and Phil-LIDAR Program, 2017)

Tropical Depression (TD) Auring True Color Composite of Sentinel-2 (February 25, 2021) in San Miguel, Tago and Tandag City, Surigao del Sur.



Legend

	Tropical Depression (TD)		Hospital
	TD Auring Track		Places of Worship
	Roads		School
	Waterways		
	Waterbodies		
	Municipal Boundary		
	Provincial Boundary		

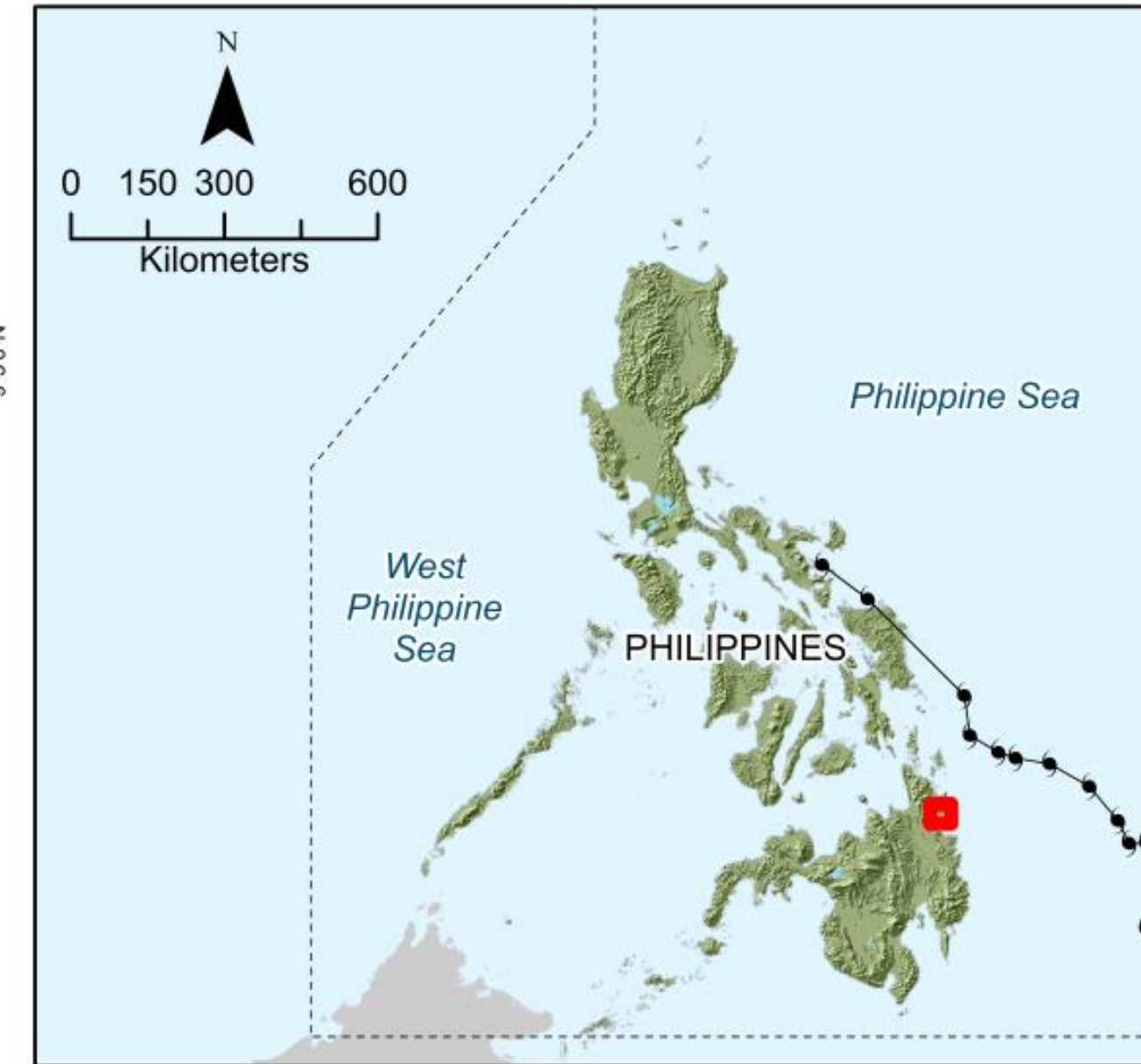
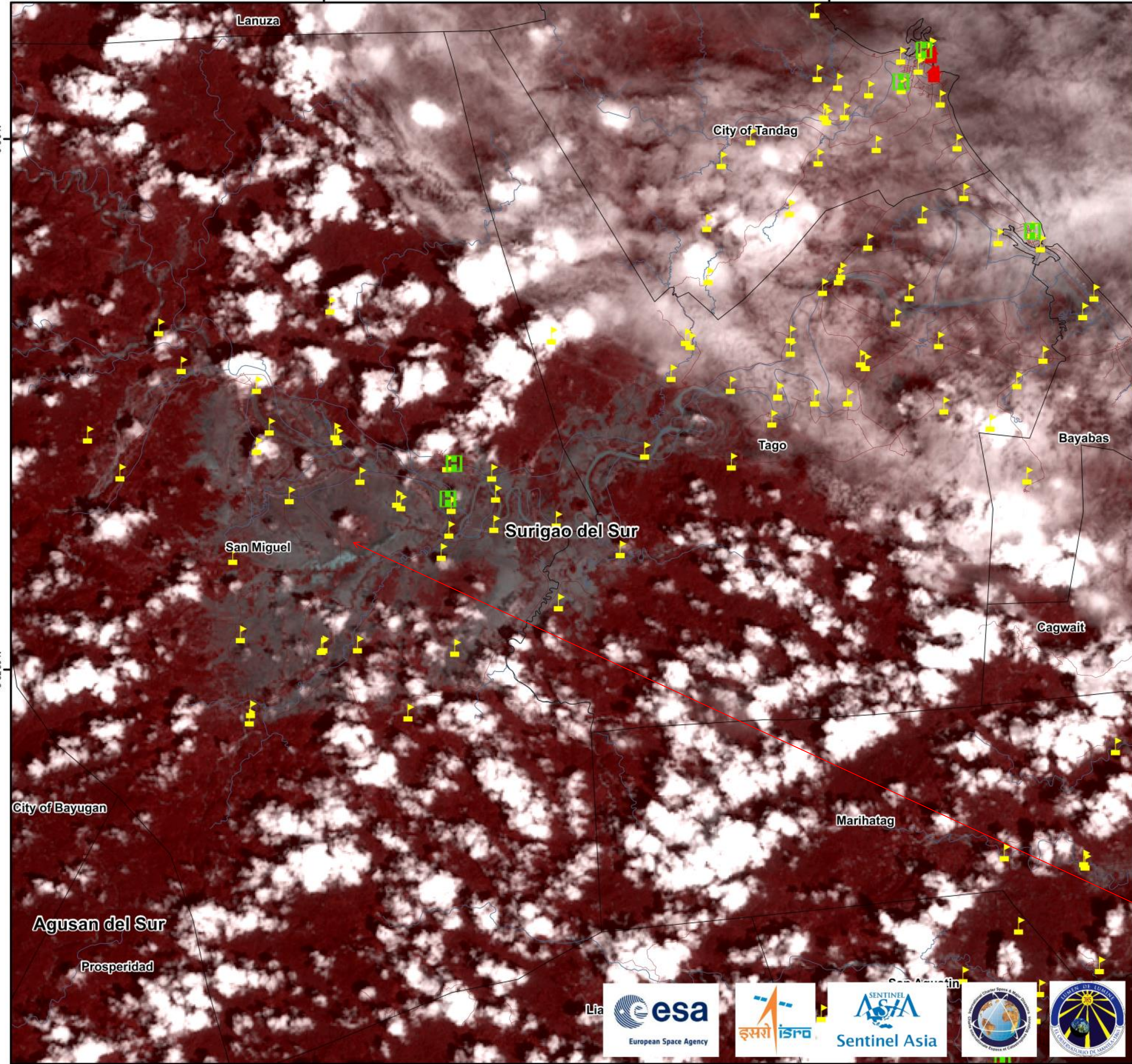
0 1.75 3.5 7
Kilometers

Source:
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial and Municipal Boundary (NAMRIA, 2018);
 Roads, Waterways, Places of Worships and Waterbodies (OSM, 2020);
 Elevation (SRTM 30 meters, 2000);
 RESOURCESAT_2A February 25, 2021 Indian Space
 Research Organization (ISRO);
 Hospital (DOH, 2014); and
 School (DepEd, 2015)

• This true color composite map shows flooded areas in San Miguel, Tago and Tandag City in Surigao del Sur on February 25, 2021.. The light brown areas are the muddy flood waters.

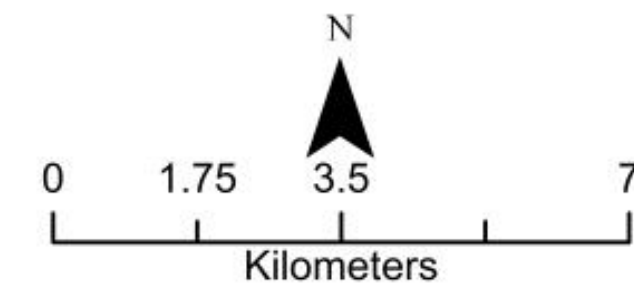


Tropical Depression (TD) Auring False Color Composite of Sentinel-2 (February 25, 2021) in San Miguel, Tago and Tandag City, Surigao del Sur.



Legend

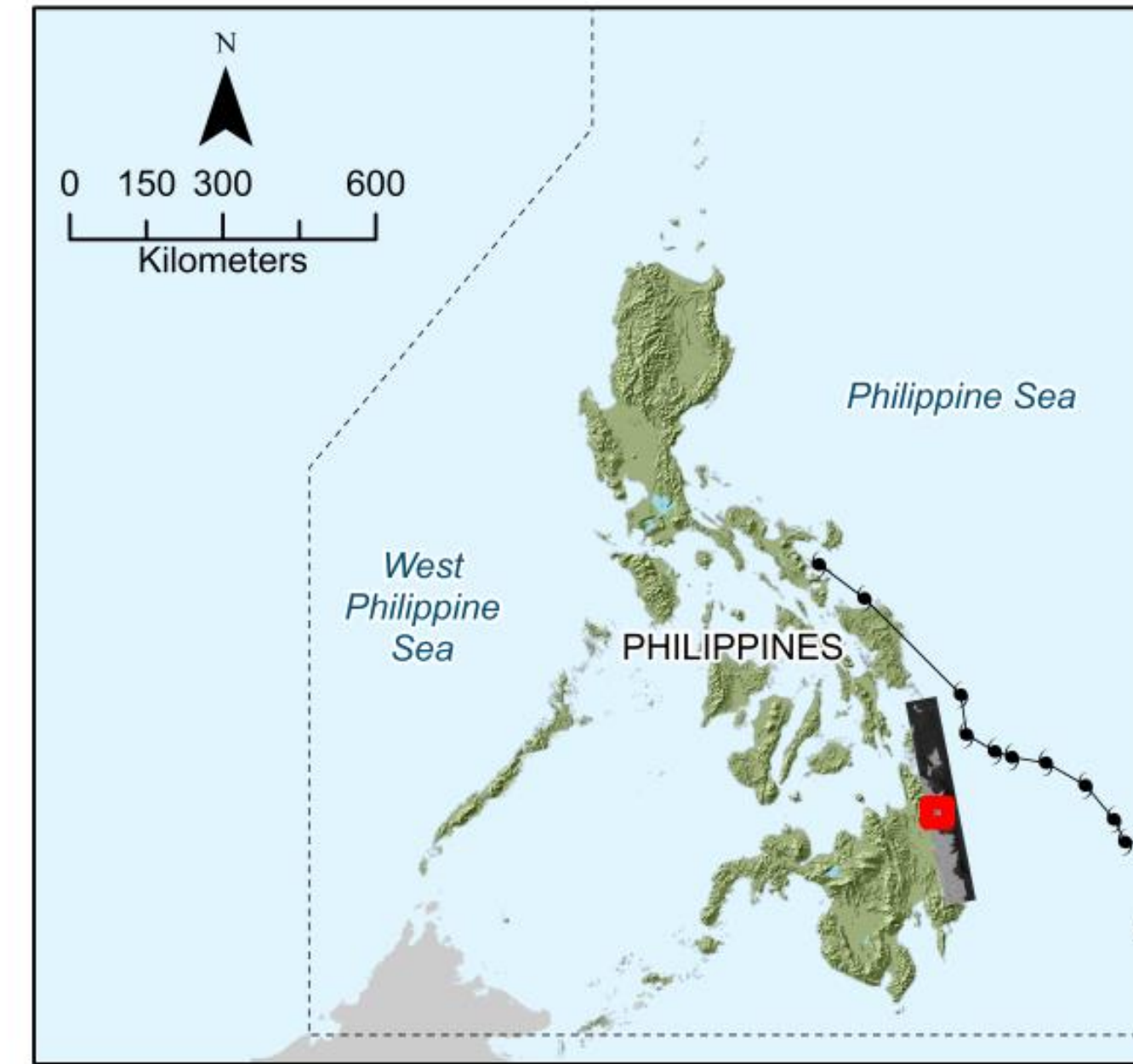
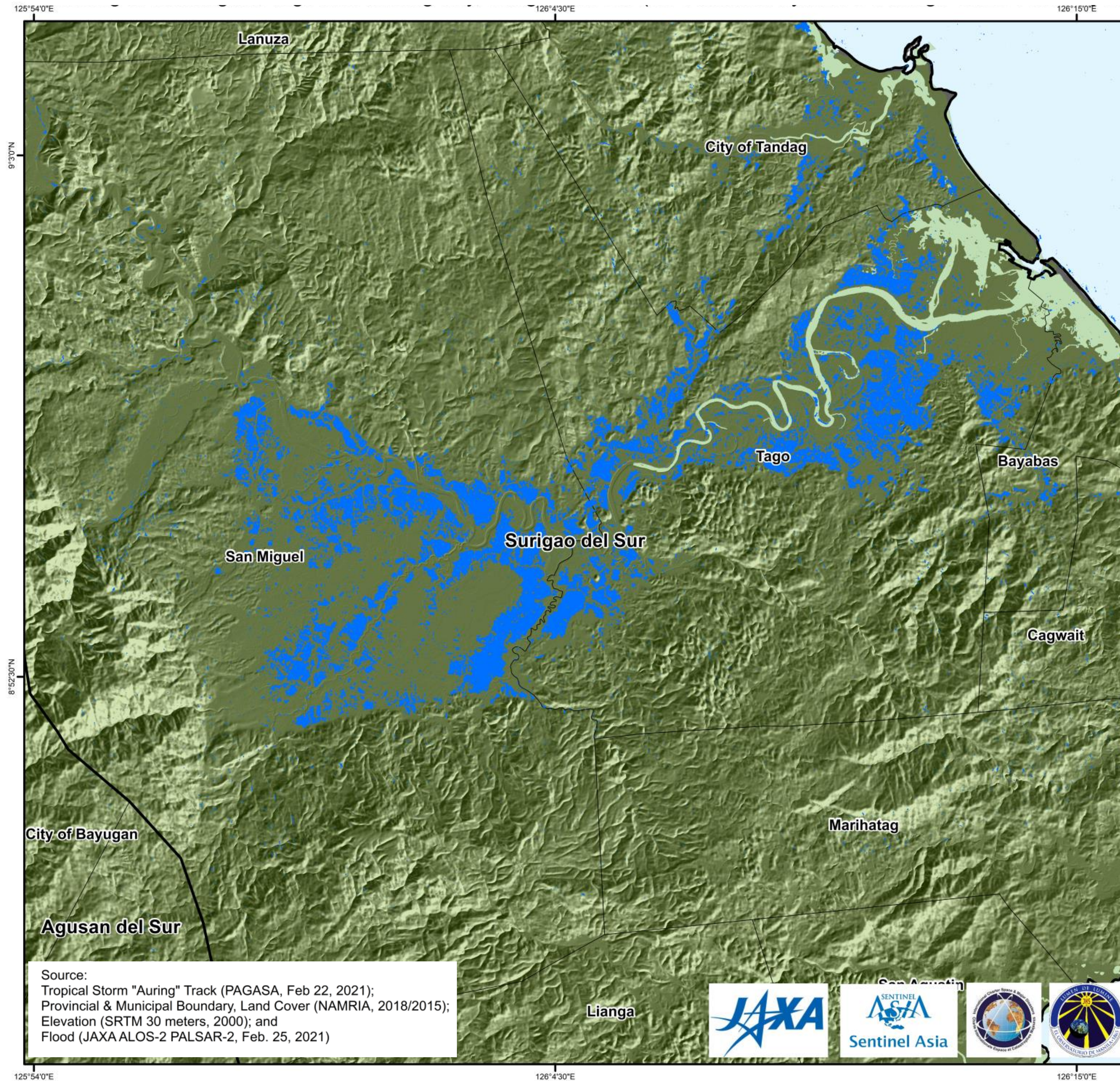
- Tropical Depression (TD)
- TD Auring Track
- Roads
- Waterways
- Waterbodies
- Municipal Boundary
- Provincial Boundary
- Hospital
- Places of Worship
- School








Source:
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial and Municipal Boundary (NAMRIA, 2018);
 Roads, Waterways, Places of Worships and Waterbodies (OSM, 2020);
 Elevation (SRTM 30 meters, 2000);
 RESOURCESAT_2A February 25, 2021 Indian Space
 Research Organization (ISRO);
 Hospital (DOH, 2014); and
 School (DepEd, 2015)

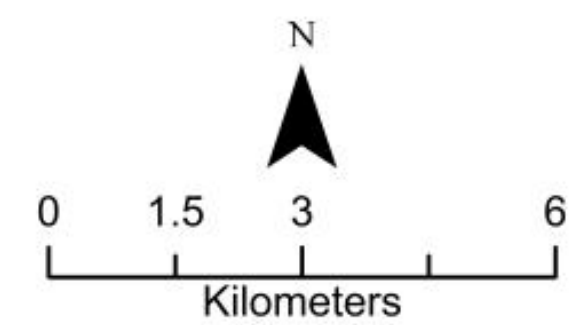
- This false color composite map shows flooded areas in San Miguel, Tago and Tandag City in Surigao del Sur on February 25, 2021. The dark brown areas are the muddy flood waters.

Detected Flood in San Miguel, Tago and Tandag City Surigao del Sur (February 25, 2021)



Legend

-  Tropical Depression (TD)
-  TD Auring Track
-  Municipal Boundary
-  Provincial Boundary
-  Detected Flood (Feb 25, 2021)

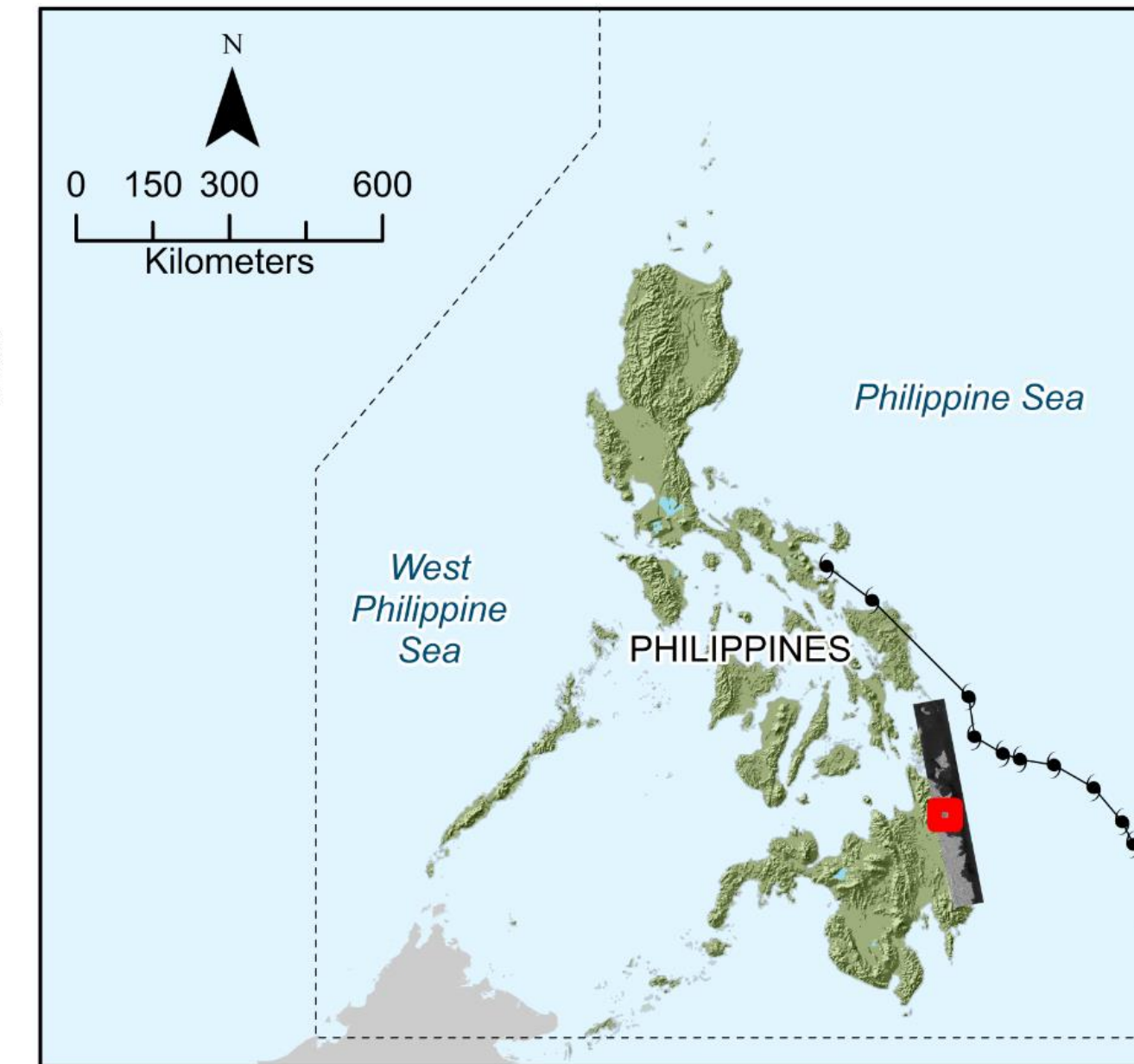
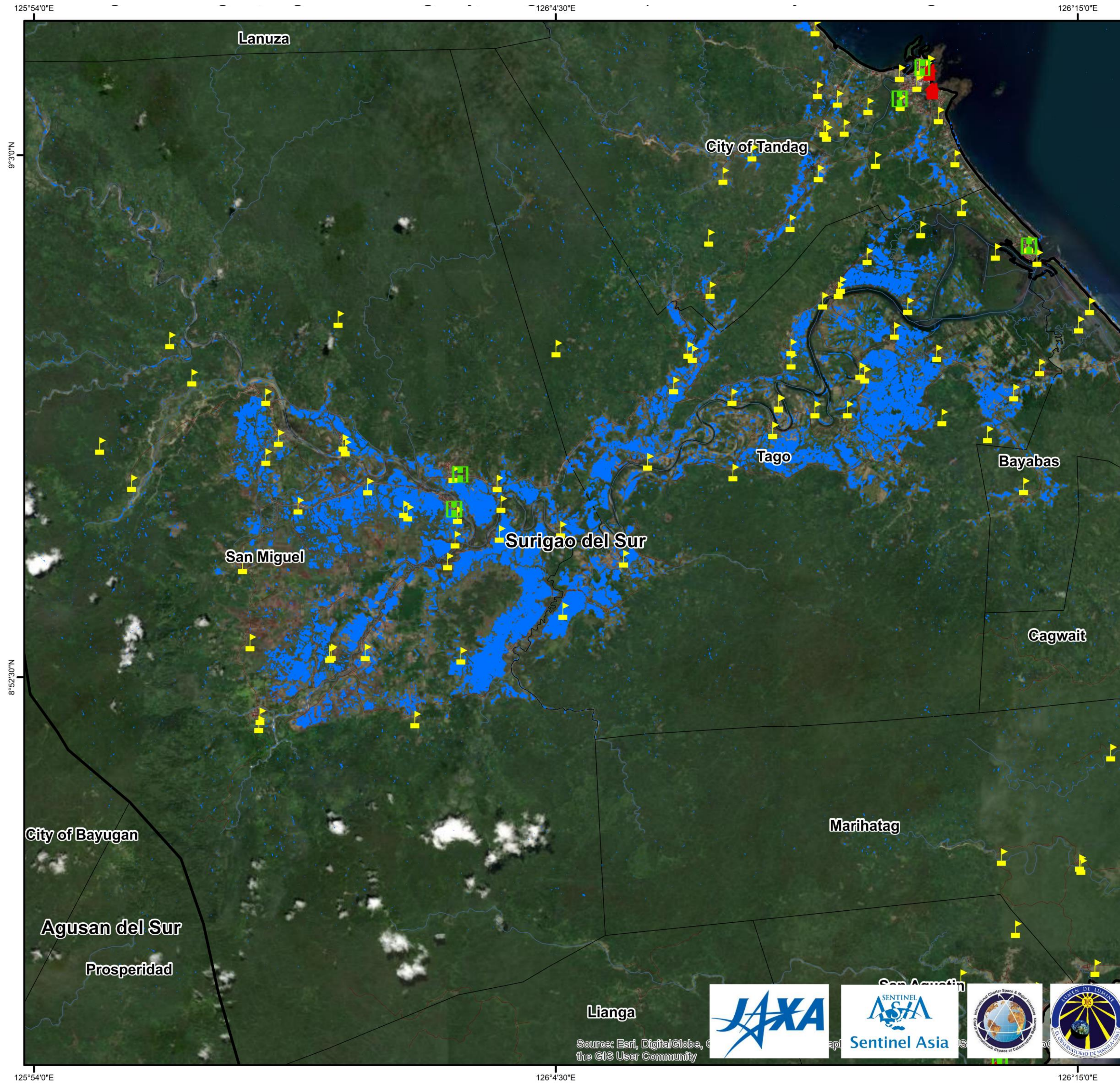


Source:
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial & Municipal Boundary, Land Cover (NAMRIA, 2018/2015);
 Elevation (SRTM 30 meters, 2000); and
 Flood (JAXA ALOS-2 PALSAR-2, Feb. 25, 2021)



- Highlighted in **blue** are the observed flooded areas in San Miguel, Tago and Tandag City in Surigao del Sur (**71.58 km²**) after >200 mm of rain due to Tropical Depression 'Auring' on Feb 21, 2021.
- Flood extent was detected by thresholding the difference of pixel values of ALOS-2 PALSAR-2 image taken on April 11, 2019 and Feb 25, 2021.
- 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.

Detected Flood in San Miguel, Tago and Tandag City Surigao del Sur (February 25, 2021)



Legend

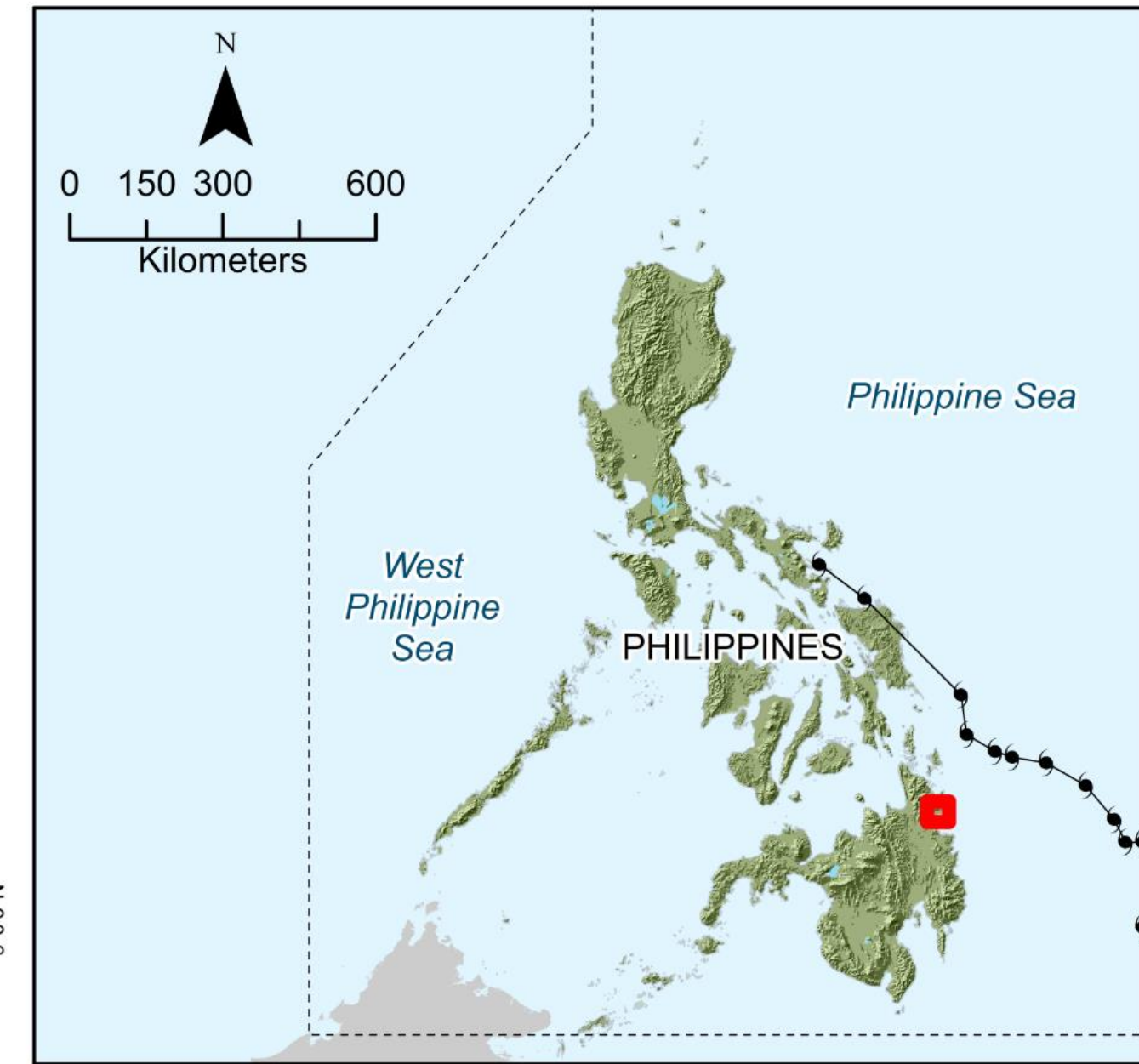
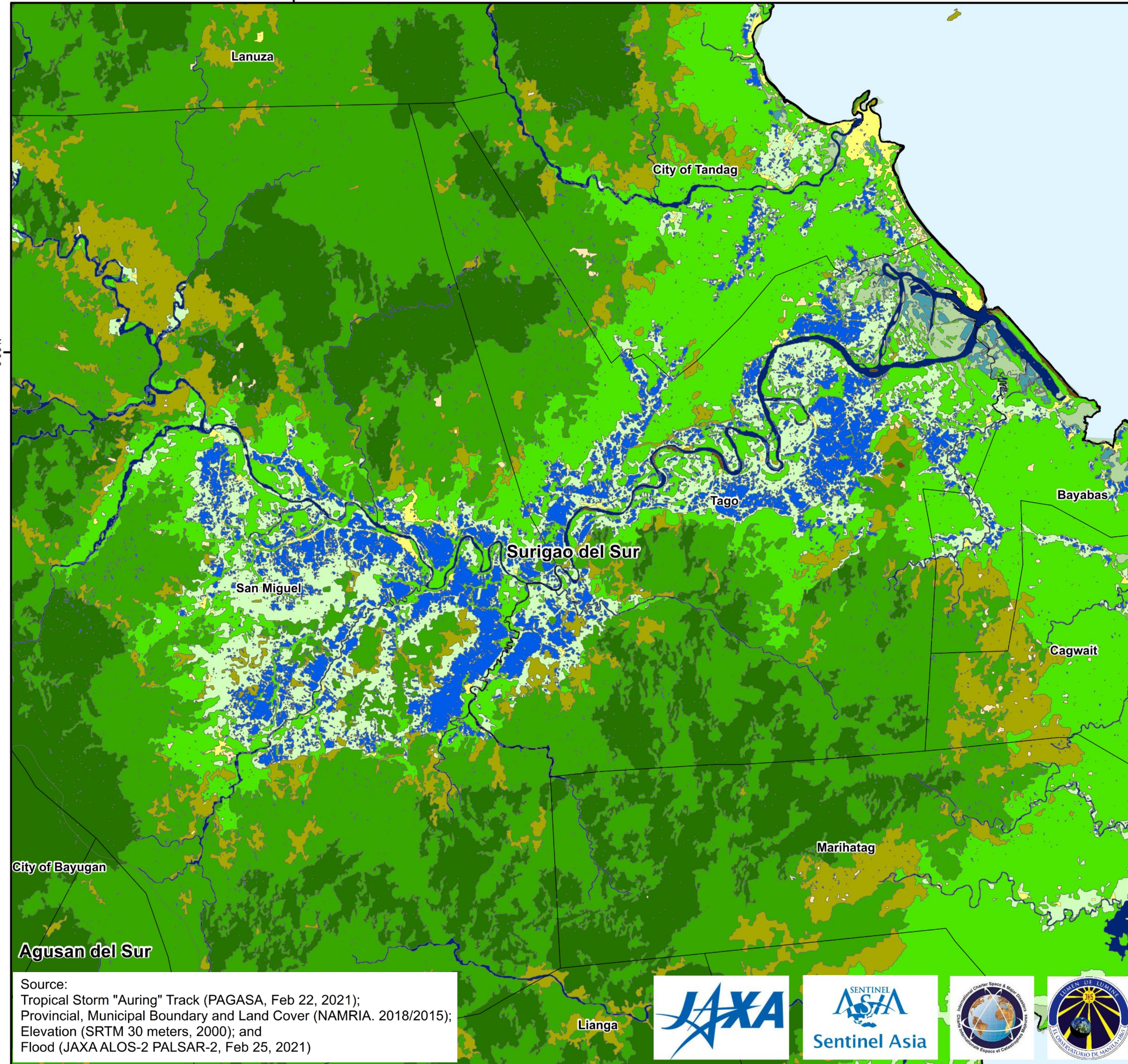
- Tropical Depression (TD)
- TD Auring Track
- Waterways
- Roads
- Municipal Boundary
- Provincial Boundary
- Detected Flood (Feb 25, 2021)
- Hospital
- Places of Worship
- School

Source:
 Basemap (ESRI, 2020)
 Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
 Provincial & Municipal Boundary, Land Cover (NAMRIA, 2018/2015);
 Roads, Waterways, Places of Worships and Waterbodies (OSM, 2020);
 Elevation (SRTM 30 meters, 2000); and
 Flood (JAXA ALOS-2 PALSAR-2, Feb. 25, 2021)
 Hospital (DOH, 2014); and
 School (DepEd, 2015)

Flooded areas (blue) in relation to lifeline facilities

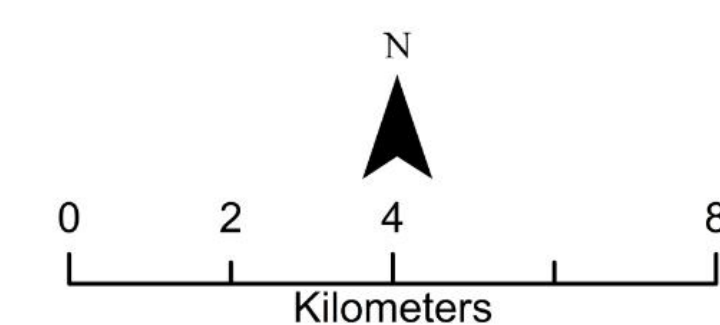
- **San Miguel (35.45 km²);**
- **Tago (31.46 km²); and**
- **Tandag City (4.67 km²).**

Affected Land Cover in San Miguel, Tago and Tandag City, Surigao del Sur



Legend

- | | | | |
|--|-------------------------------|--|-----------------|
| | Tropical Depression (TD) | | Annual Crop |
| | TD Auring Track | | Brush/Shrubs |
| | Municipal Boundary | | Built-up |
| | Provincial Boundary | | Closed Forest |
| | Detected Flood (Feb 25, 2021) | | Fishpond |
| | | | Grassland |
| | | | Inland Water |
| | | | Mangrove Forest |
| | | | Marshland/Swamp |
| | | | Open Forest |
| | | | Open/Barren |
| | | | Perennial Crop |



- Based on this map, flooding affected **68.56 km² of annual cropland, 5.02 km² of open forest, 4.45 km² of perennial cropland, and 0.21 km² of built-up area in the San Miguel-Tago-Tandag City area.**
- Note that the land cover data used was 5 years old and that flood detection from radar images tends to be underestimated.
- Damage to agriculture was Php21,437,542 in Caraga Region. Rice damage in Surigao del Sur amounted to Php15,306,442. (NDRRMC Sitrep No. 06, 24 February, 8:00 AM)

Source:
Tropical Storm "Auring" Track (PAGASA, Feb 22, 2021);
Provincial, Municipal Boundary and Land Cover (NAMRIA, 2018/2015);
Elevation (SRTM 30 meters, 2000); and
Flood (JAXA ALOS-2 PALSAR-2, Feb 25, 2021)



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