

# TROPICAL STORM SENDONG

Manila  
Observatory  
([www.observatory.ph](http://www.observatory.ph))

together with

Xavier University  
Dr. Ando Siringan,  
MSI



$$\text{RISK} = f(\text{HAZARD}, \text{EXPOSURE}, \text{VULNERABILITY})$$

RISK

Likelihood of  
harm, loss,  
disaster

Risk  
Lexicon

HAZARD

Physical impact of  
disturbance

EXPOSURE

Elements affected  
by hazard

VULNERABILITY

Susceptibility,  
capacity to  
prepare, absorb,  
& recover from  
hazard



# TROPICAL STORM SENDONG

Max Wind Speed  
(JTWC/1-min avg):

**100 km/hr**

24 hours total rainfall  
PAGASA Lumbia  
Station:

**180mm**



<b>NAME</b>	<b>YEAR</b>	<b>HIGHEST WIND SPEED</b>	<b>DEATHS</b>	<b>DAMAGE (Php B)</b>
Rosing	1995	260	936	11
Reming	2006	320	754	5
Frank	2008	172	938	13
Nitang	1984	220	1363	4
Uring	1991	95	5101	1
Pepeng	2009	120	492	27
Ondoy	2009	85	464	11
<b>Sendon g</b>	<b>2011</b>	<b>~100</b>	<b>~1000+</b>	<b>-</b>



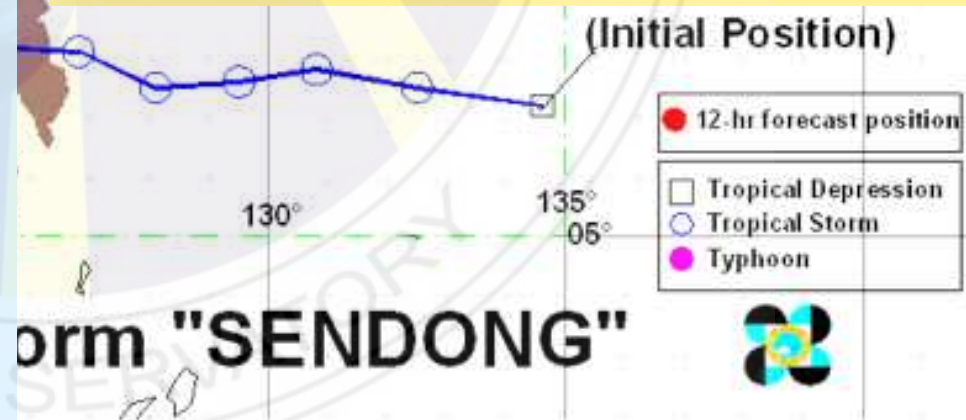
# TROPICAL STORM SENDONG

What is  
**180mm**  
OF TOTAL  
RAINFALL FOR  
A DAY?

Max Wind Speed  
(JTWC/1-min avg):  
**100 km/hr**

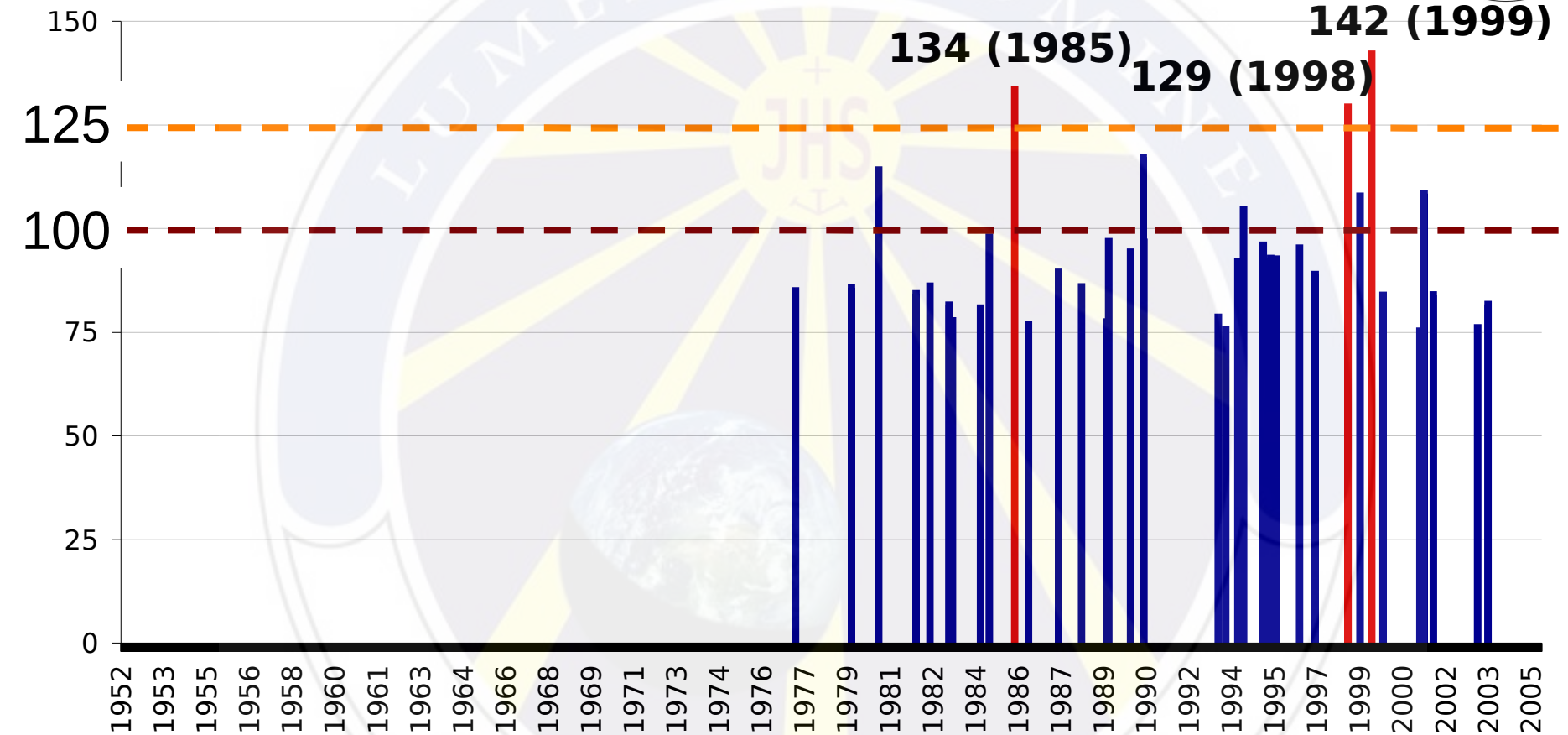
24 hours total rainfall  
PAGASA Lumbia  
Station:  
**180mm**

Ondoy:  
Total 1 day  
rainfall =  
**~370mm**





# Lumbia PAGASA Station (Rainfall mm/day)



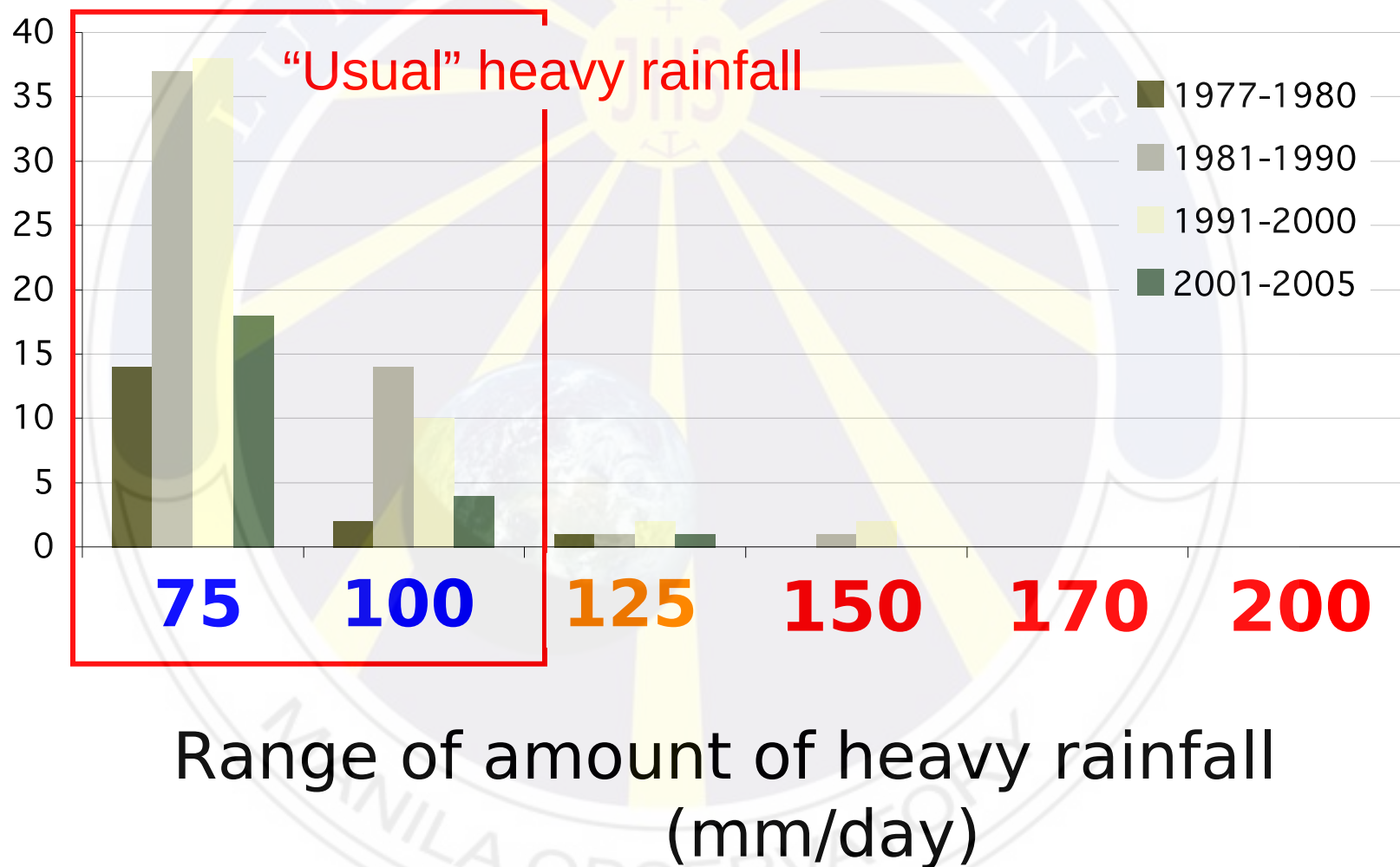
From 1977-2005 (29 years), daily rainfall that is greater than 125mm in Lumbia, Cagayan de Oro happened only three (3) times.





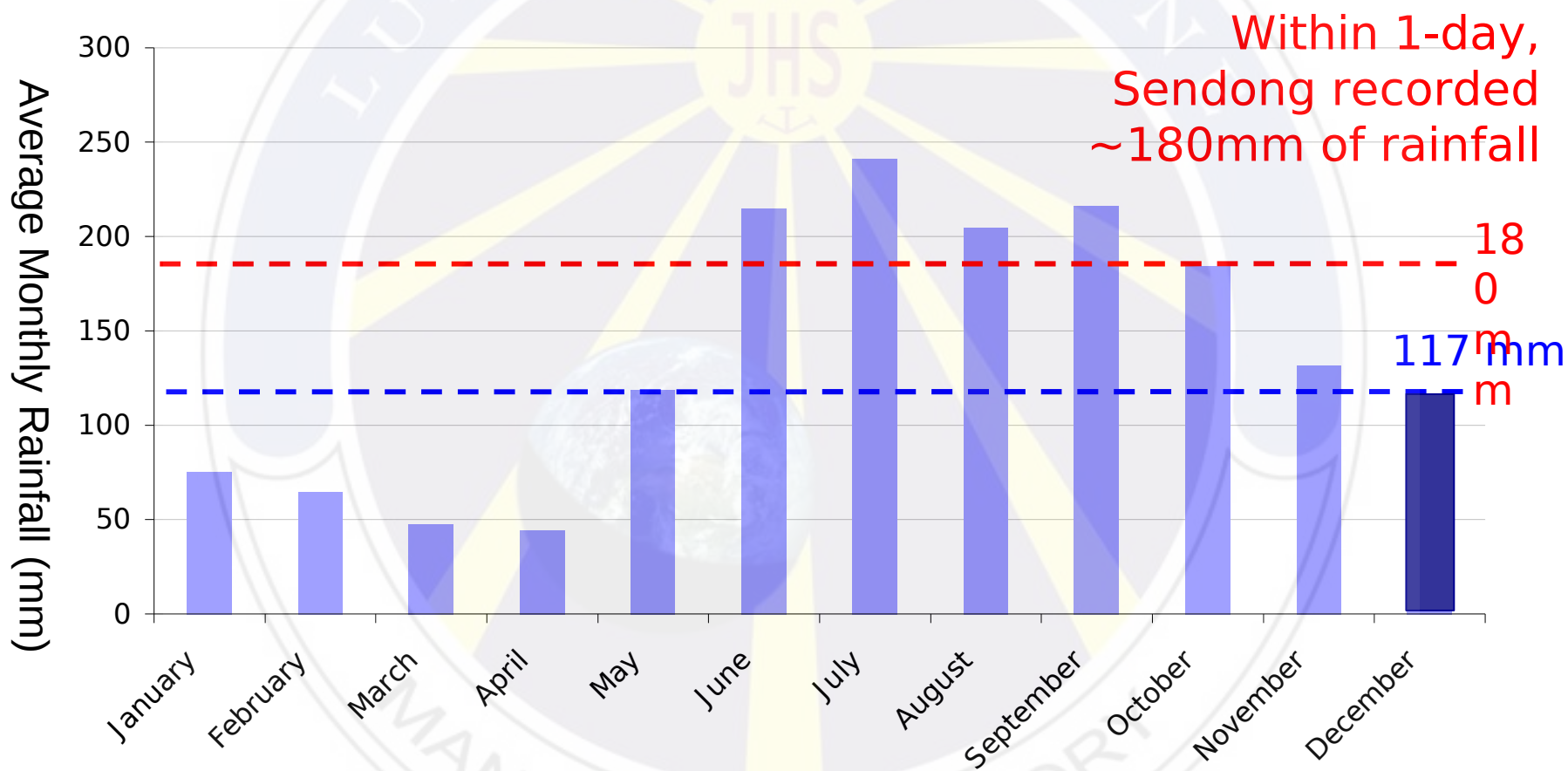
# PAGASA Lumbia Station Rainfall Distribution

How often it happens





# Average Monthly Rainfall in Lumbia Station (1977-2005)







# Information Available:

- 1) **Ground Observations**  (Rain Amount)
- 2) Satellite Data
- 3) Archived Information

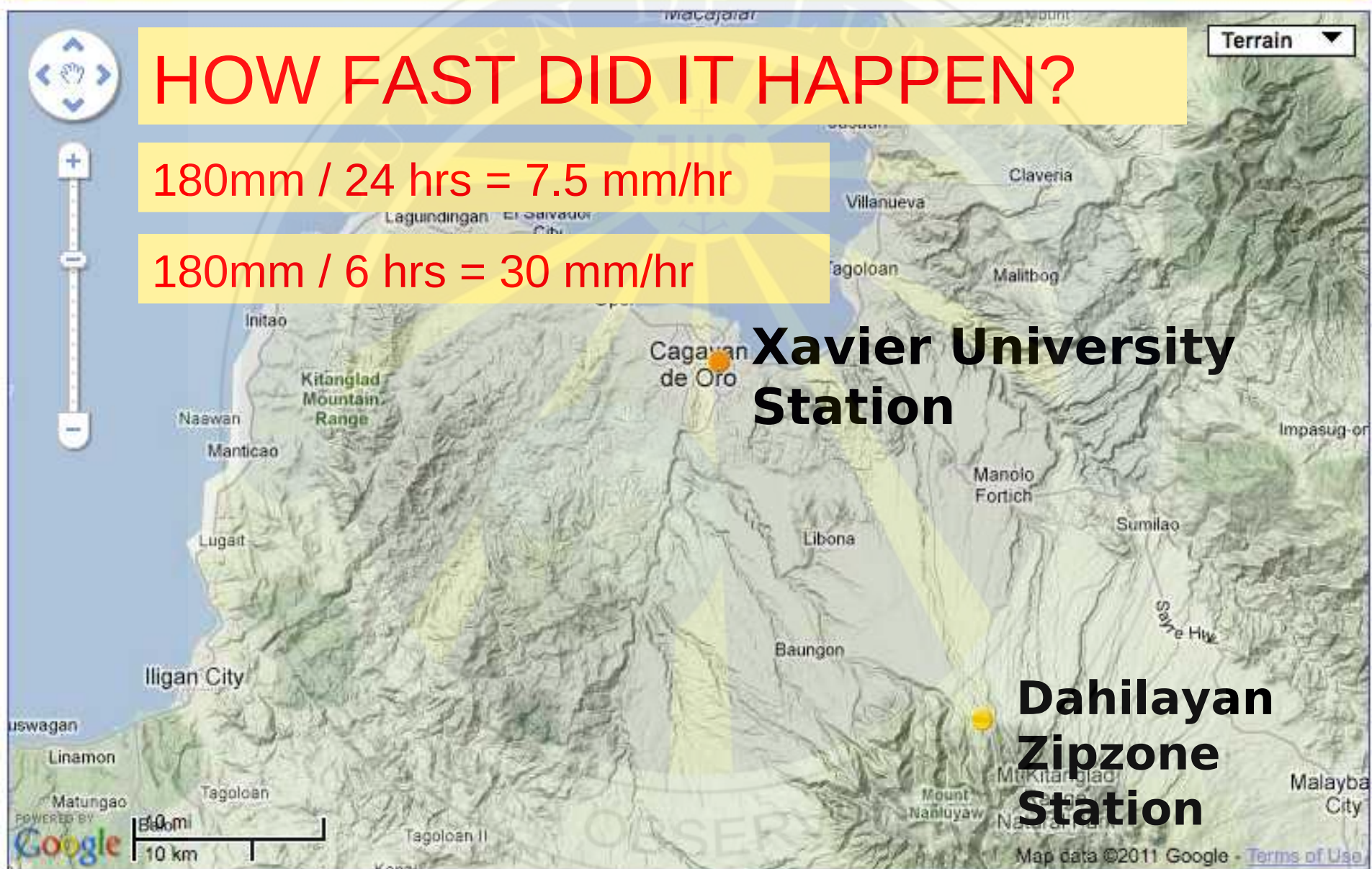
# HOW FAST DID IT HAPPEN?

$180\text{mm} / 24 \text{ hrs} = 7.5 \text{ mm/hr}$

$180\text{mm} / 6 \text{ hrs} = 30 \text{ mm/hr}$

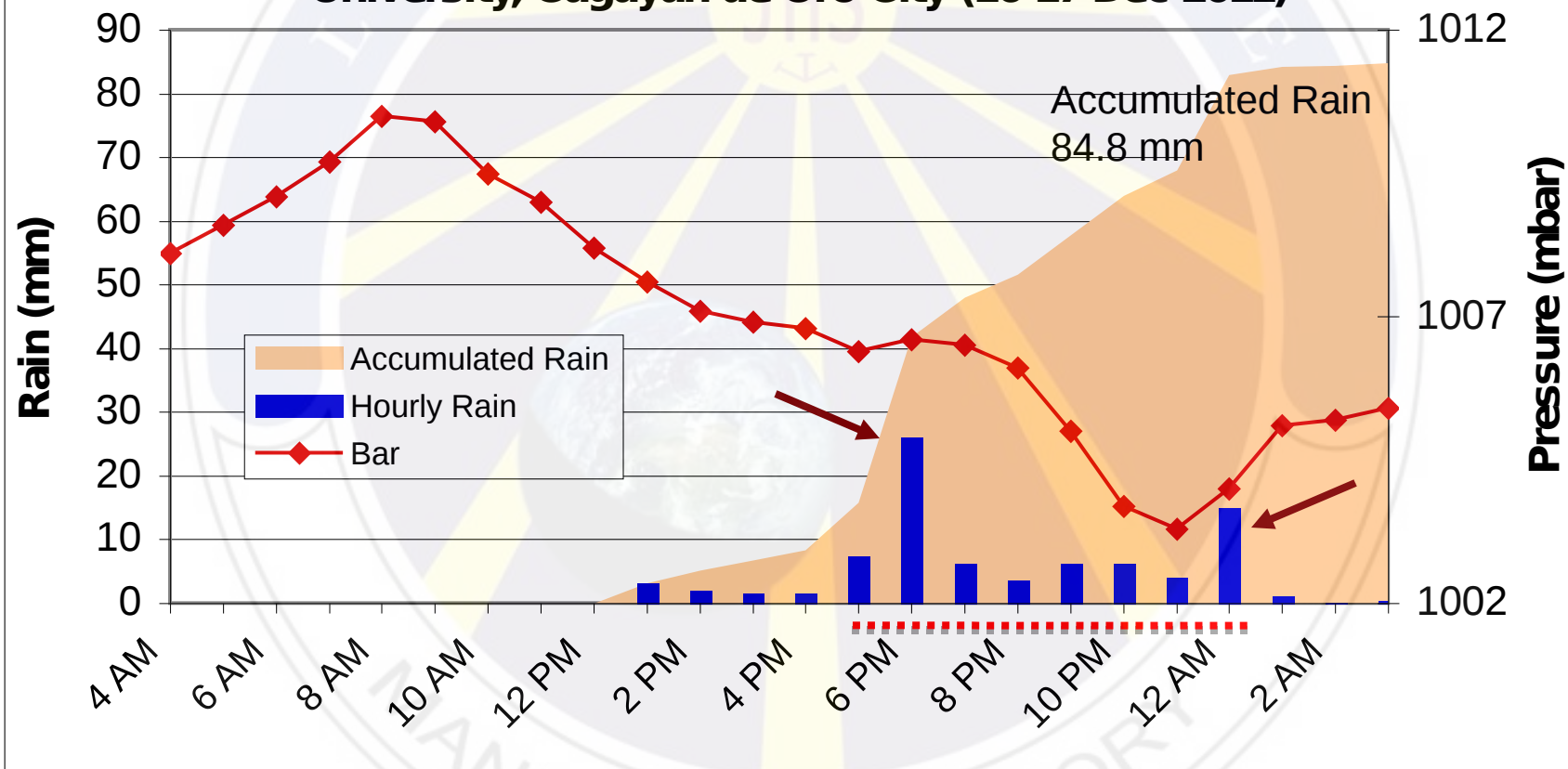
**Xavier University  
Station**

**Dahilayan  
Zipzone  
Station**

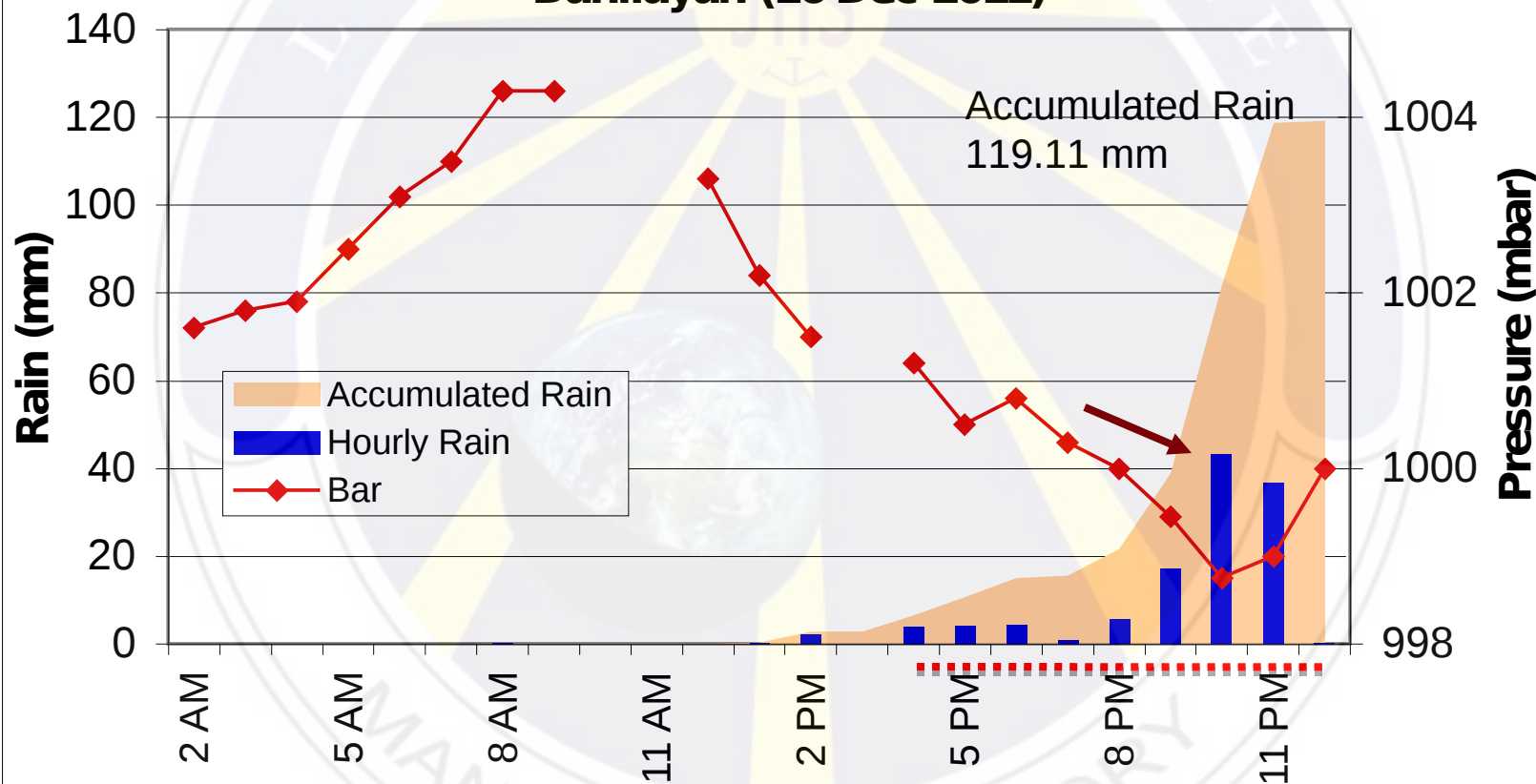




## Hourly Accumulated Rainfall and Average Pressure in Xavier University, Cagayan de Oro City (16-17 Dec 2011)

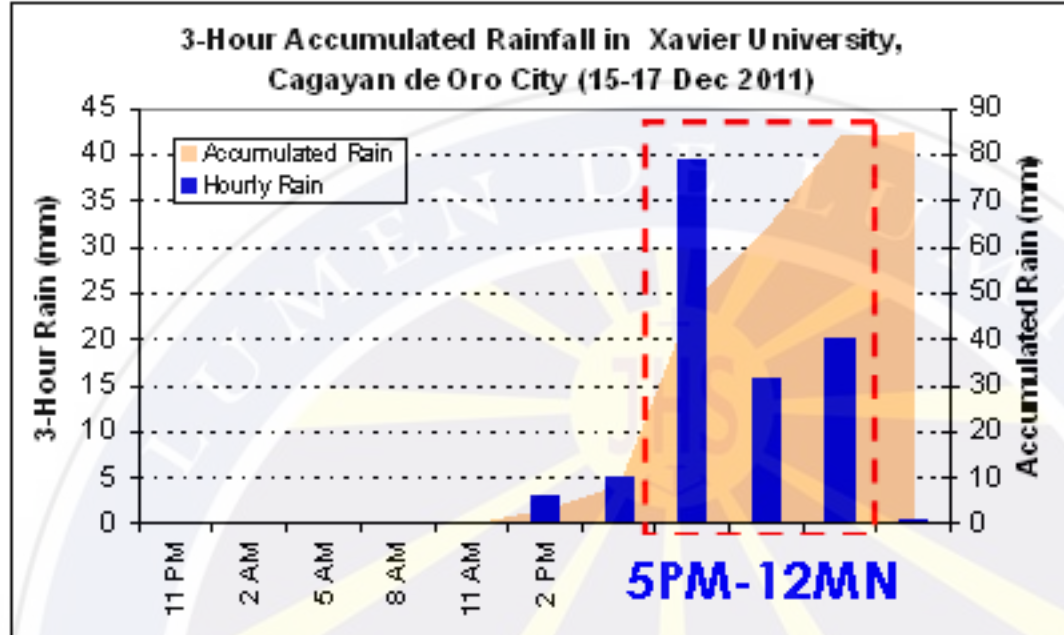


## Hourly Accumulated Rainfall and Average Pressure in Dahilayan (16 Dec 2011)

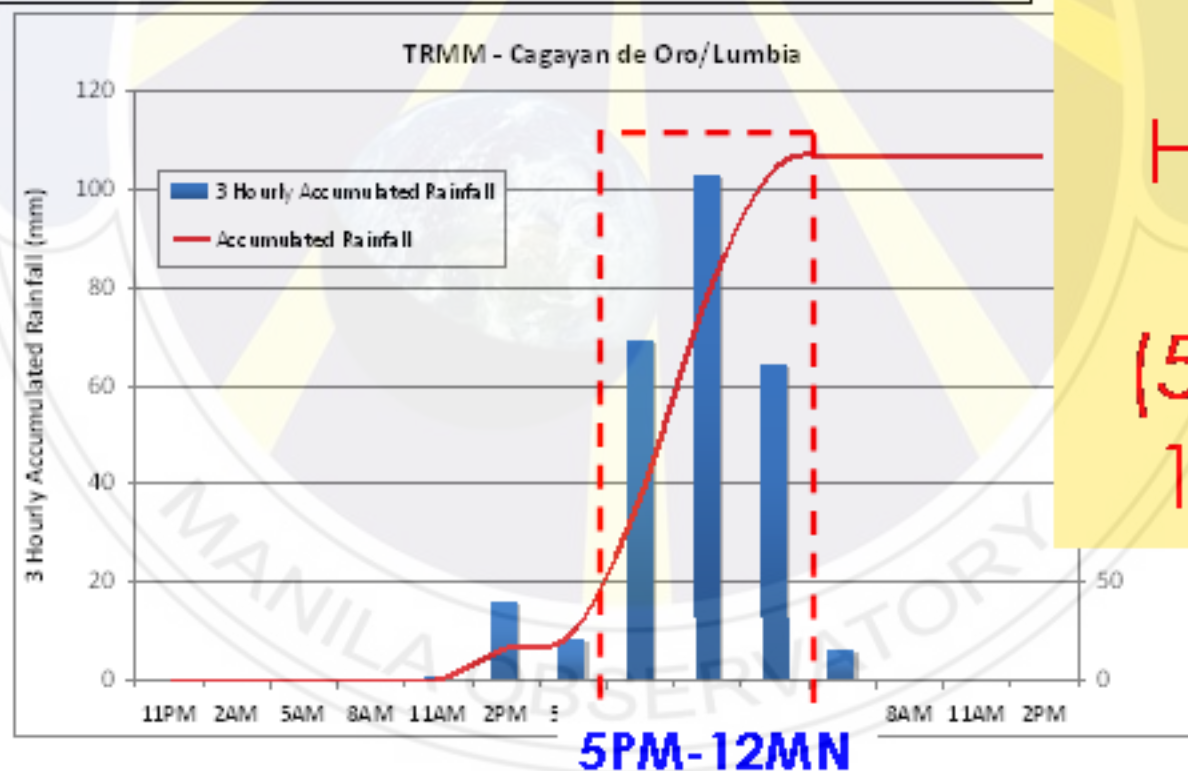




Ground  
station



Satellite-  
based  
rainfall



HEAVY  
RAINFALL  
WITHIN  
~ 6-7  
HOURS  
(5PM to  
12MN)



# Information Available:

1) Ground Observations

2) **Satellite Data**

- (Rain Amount)
- (Progression of Typhoon and Rain)
- (Flood: from Rain, Footprint)

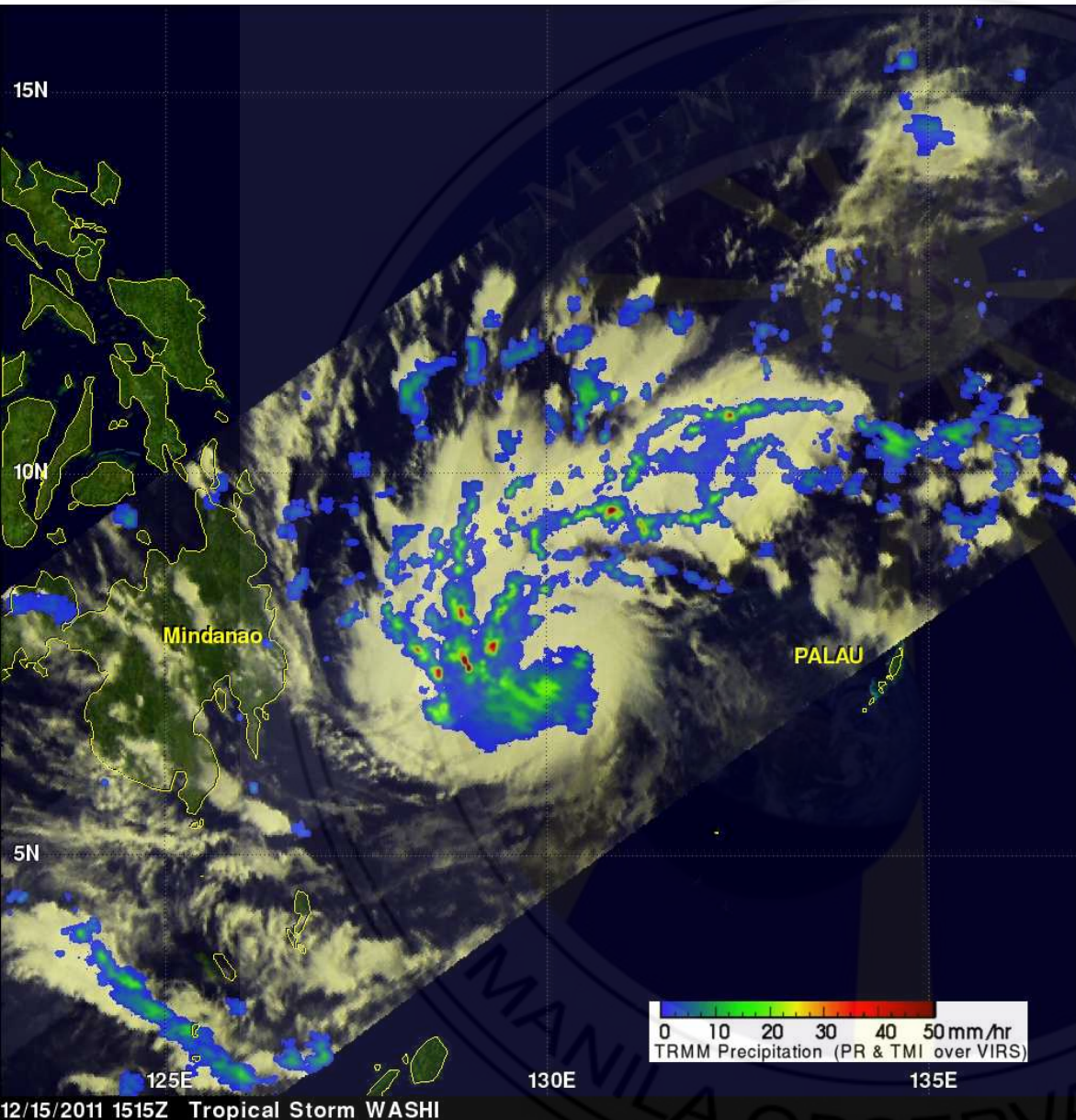
3) Archived Information



**HOW DID IT PROGRESS?**

**3 HOURLY  
ACCUMULATED RAINFALL**

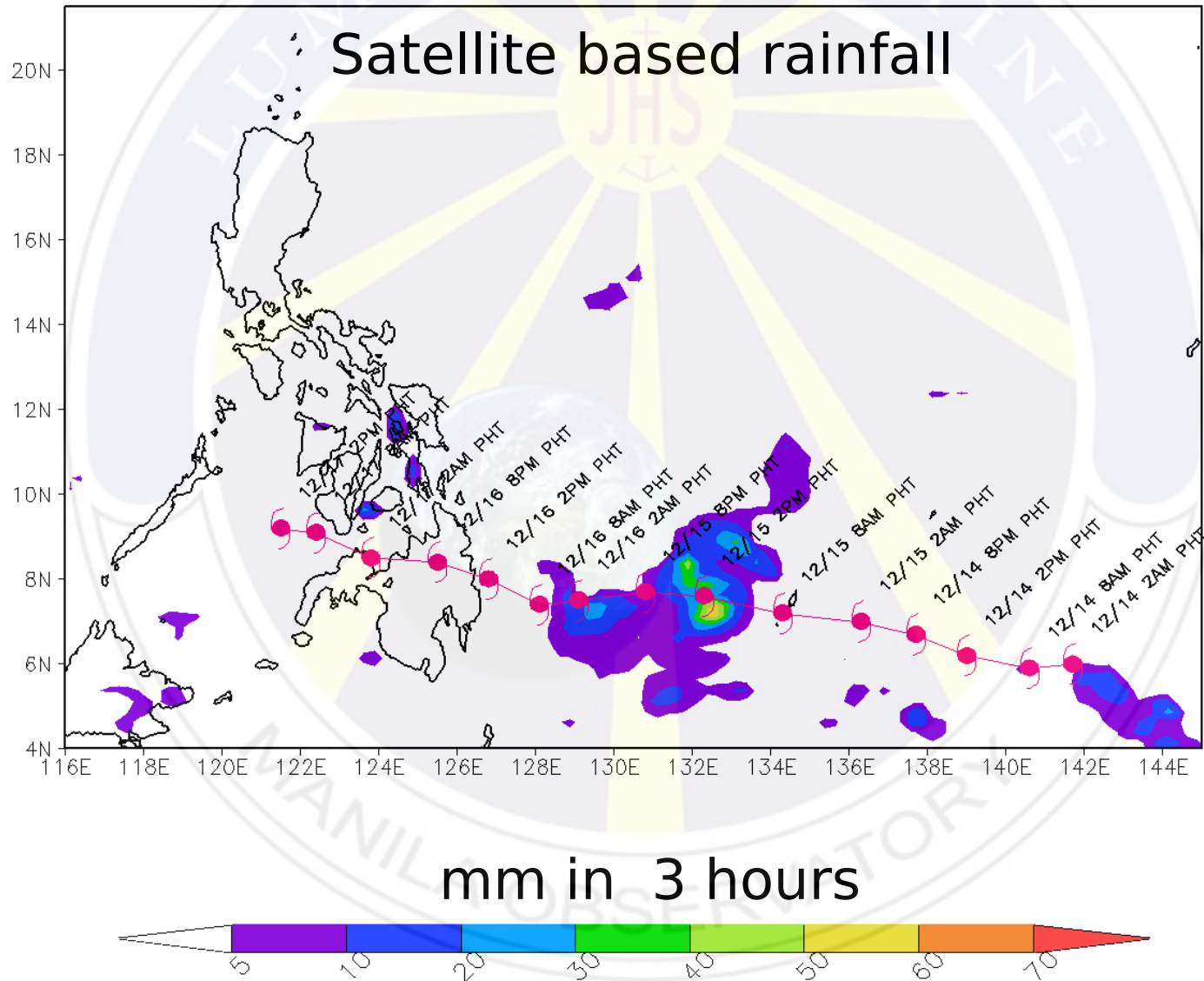




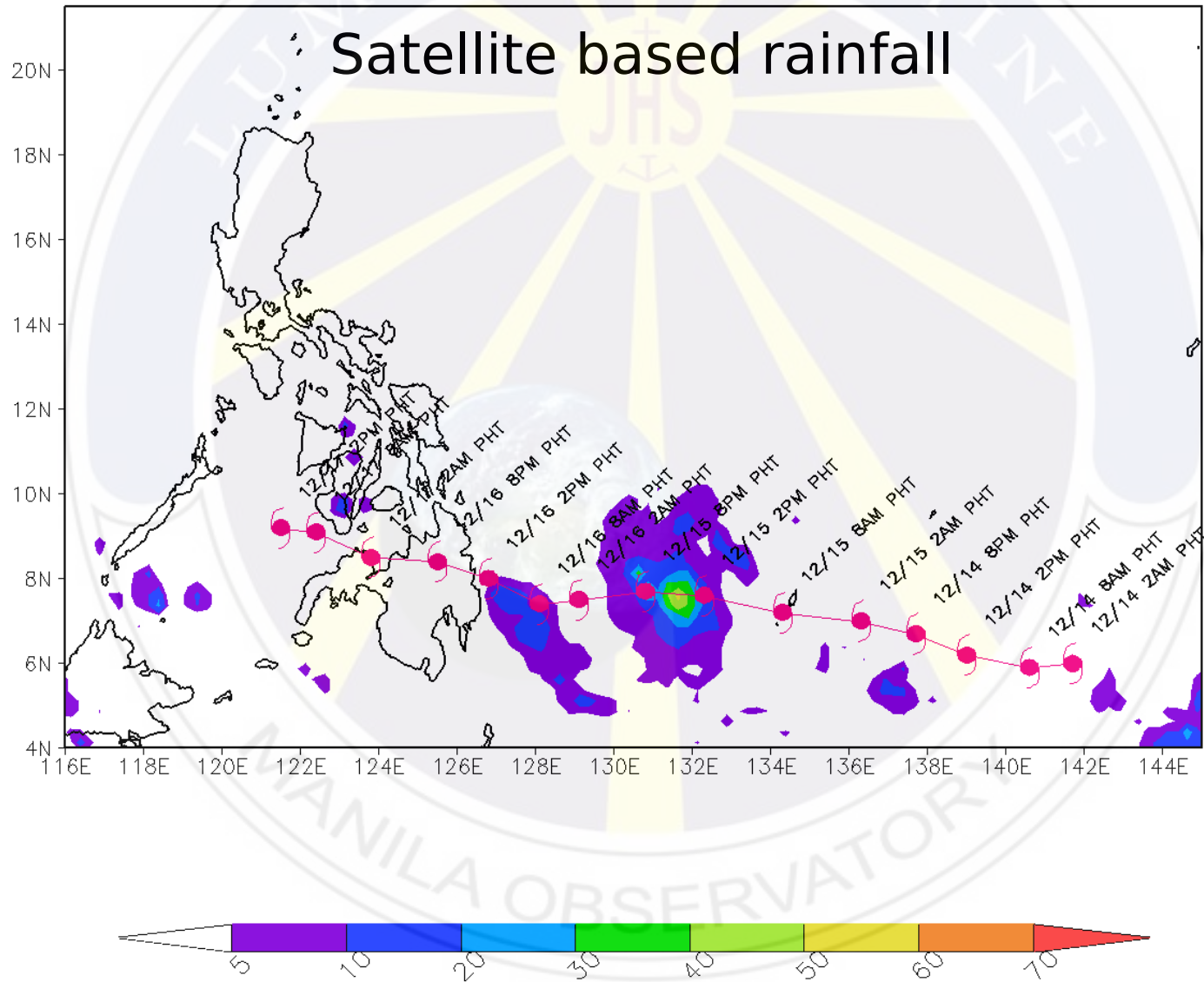
*"TRMM provided a "top down" **rainfall analysis** of Tropical Storm Washi on **Dec. 15**. Light to moderate rainfall (green and blue) was falling throughout the storm a **rate between 20 to 40 mm per hour**. There were **more areas of heavy (red) rainfall** around the center of the storm than on the previous day.*

*Credit: SSAI/NASA, Hal Pierce"*

# DEC 15 11AM - 2 PM

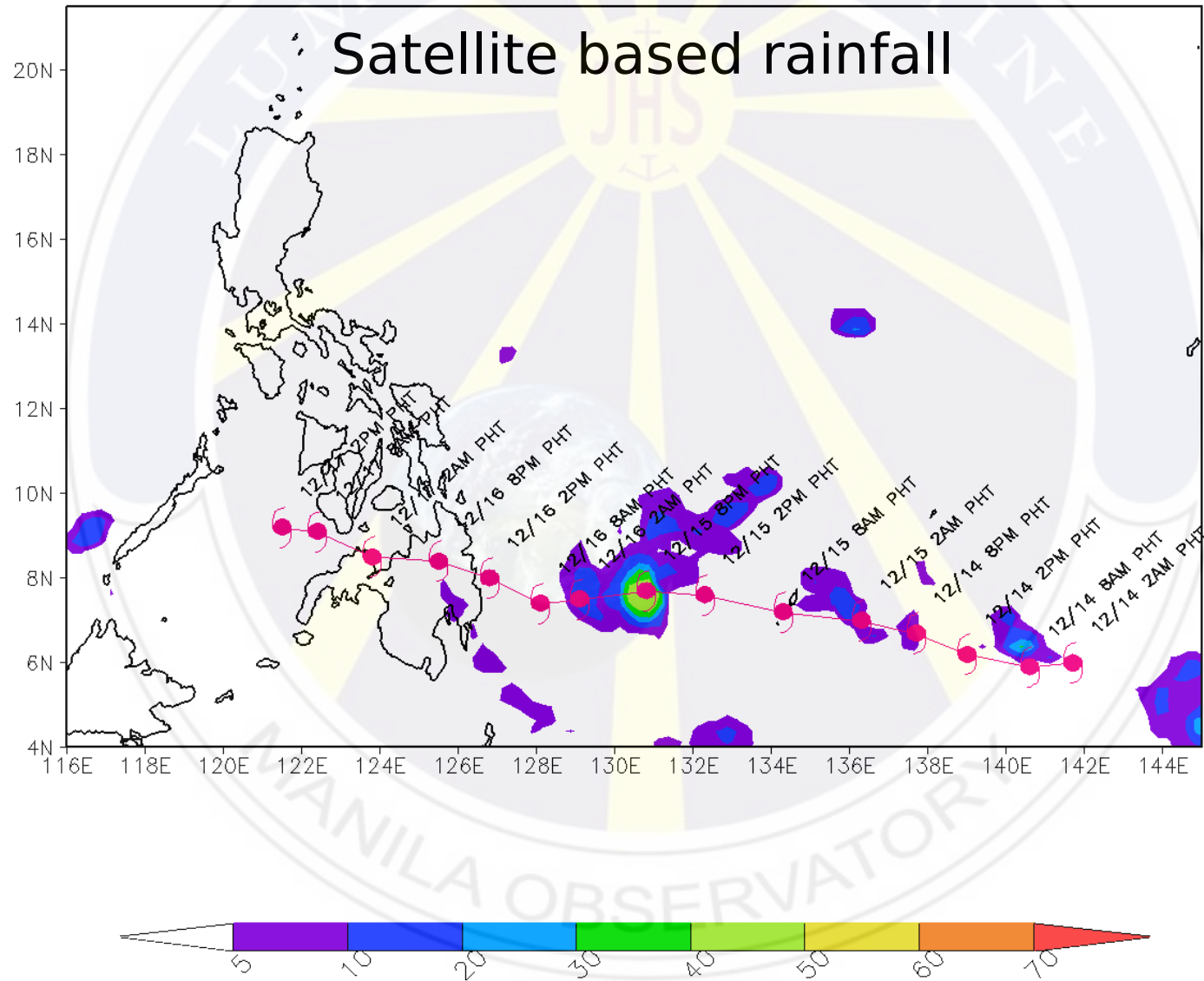


# DEC 15 2PM - 5 PM

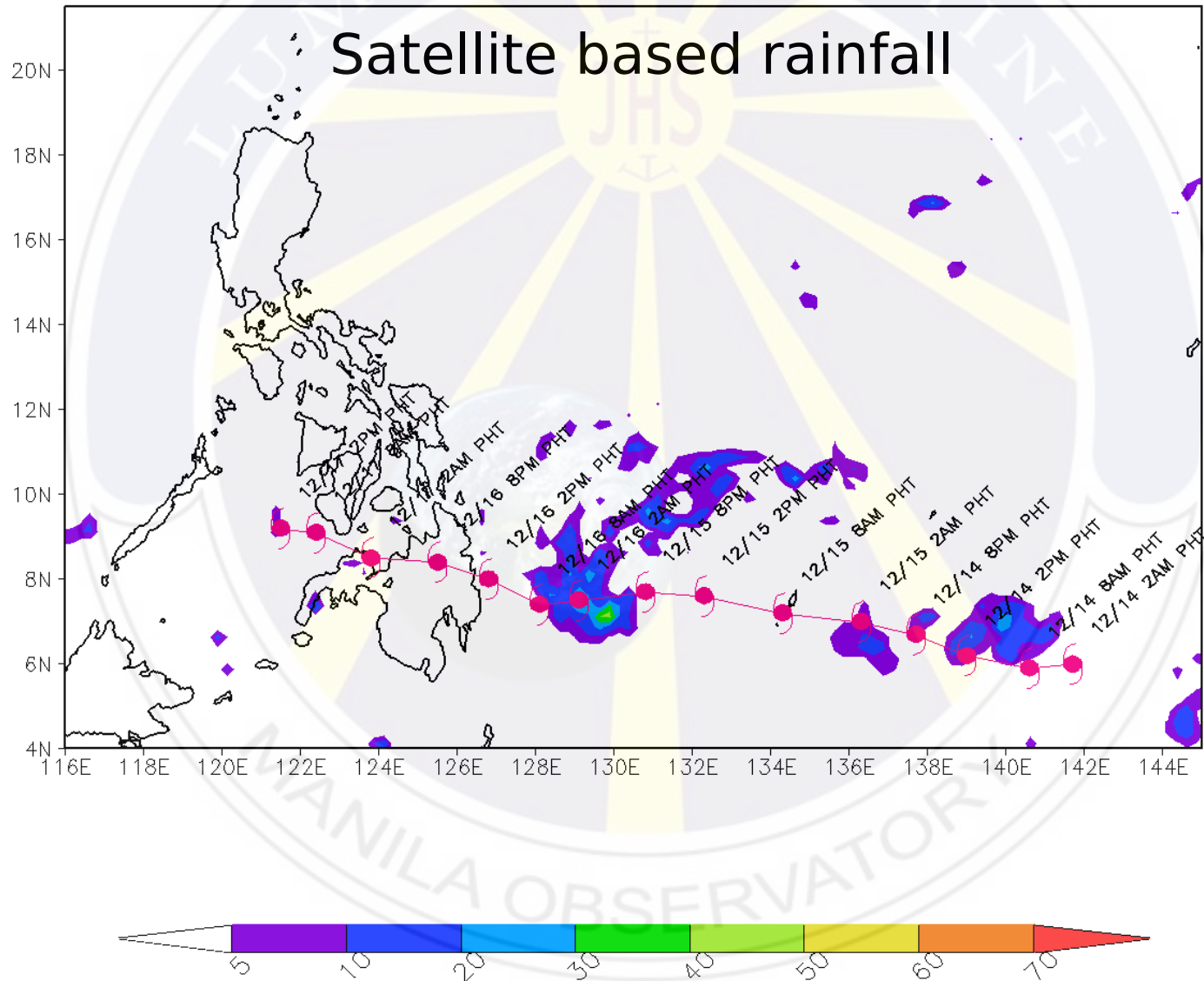




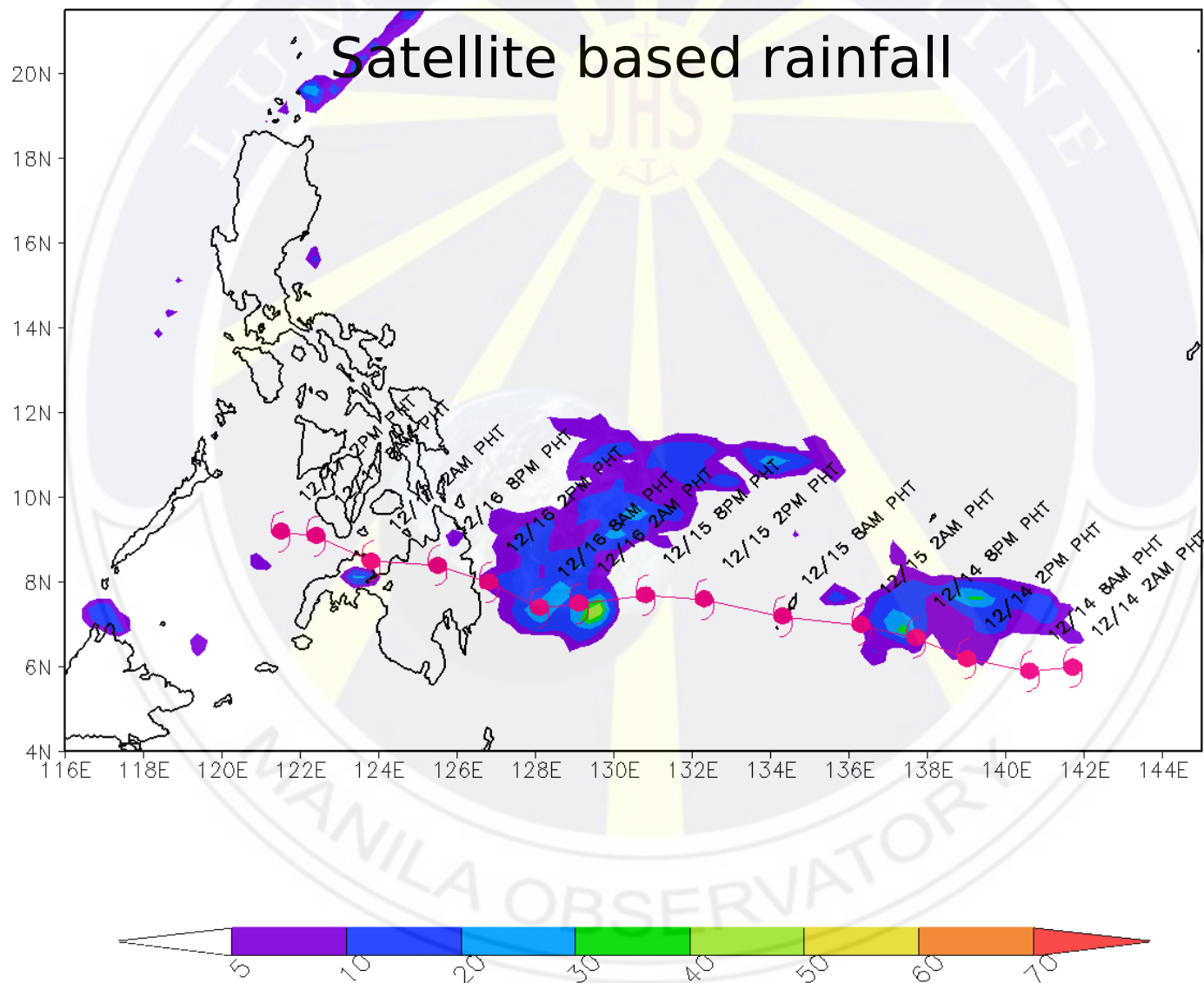
# DEC 15 5PM - 8 PM



# DEC 15 8PM - 11 PM

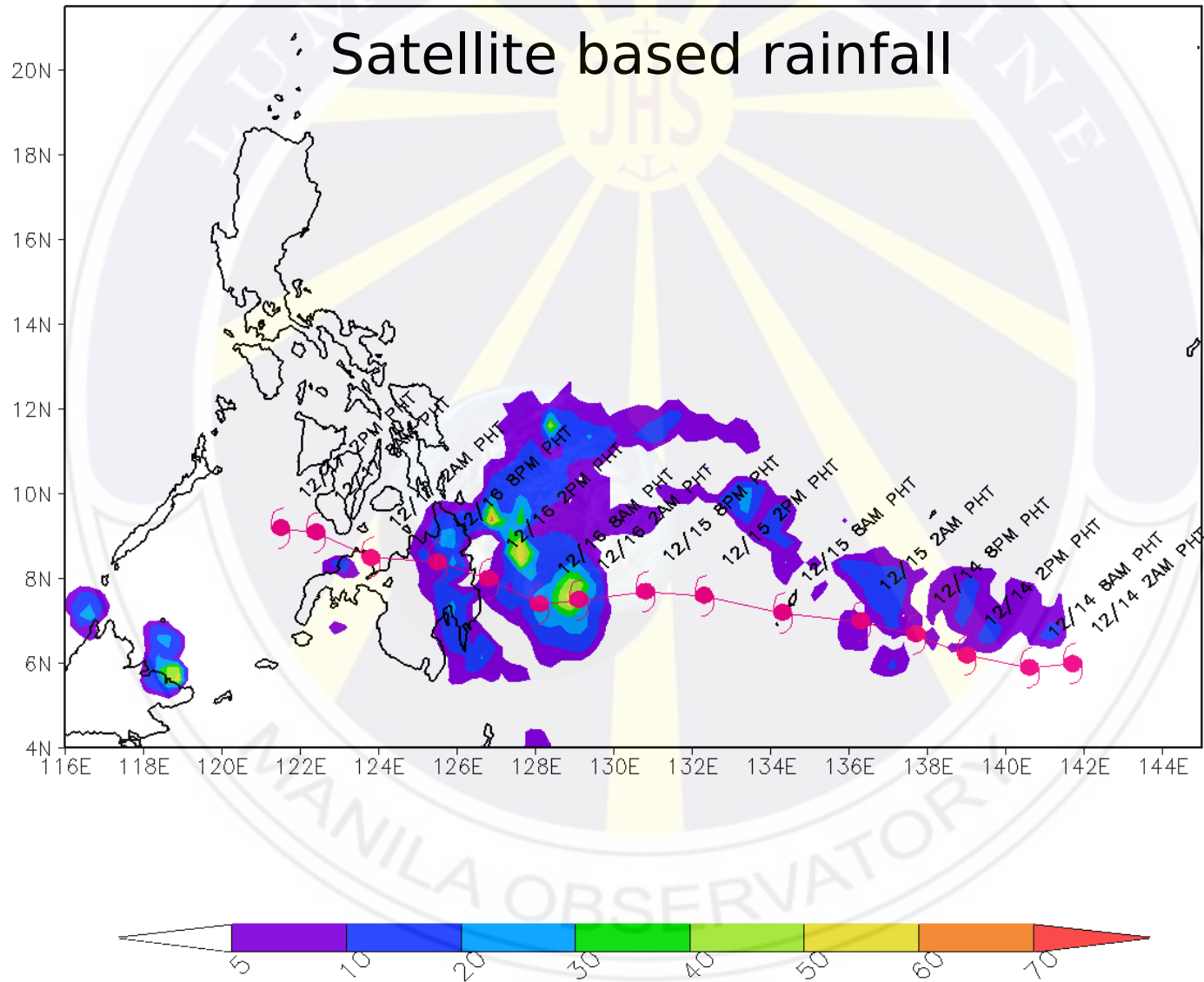


# DEC 15, 16 11PM – 2 AM

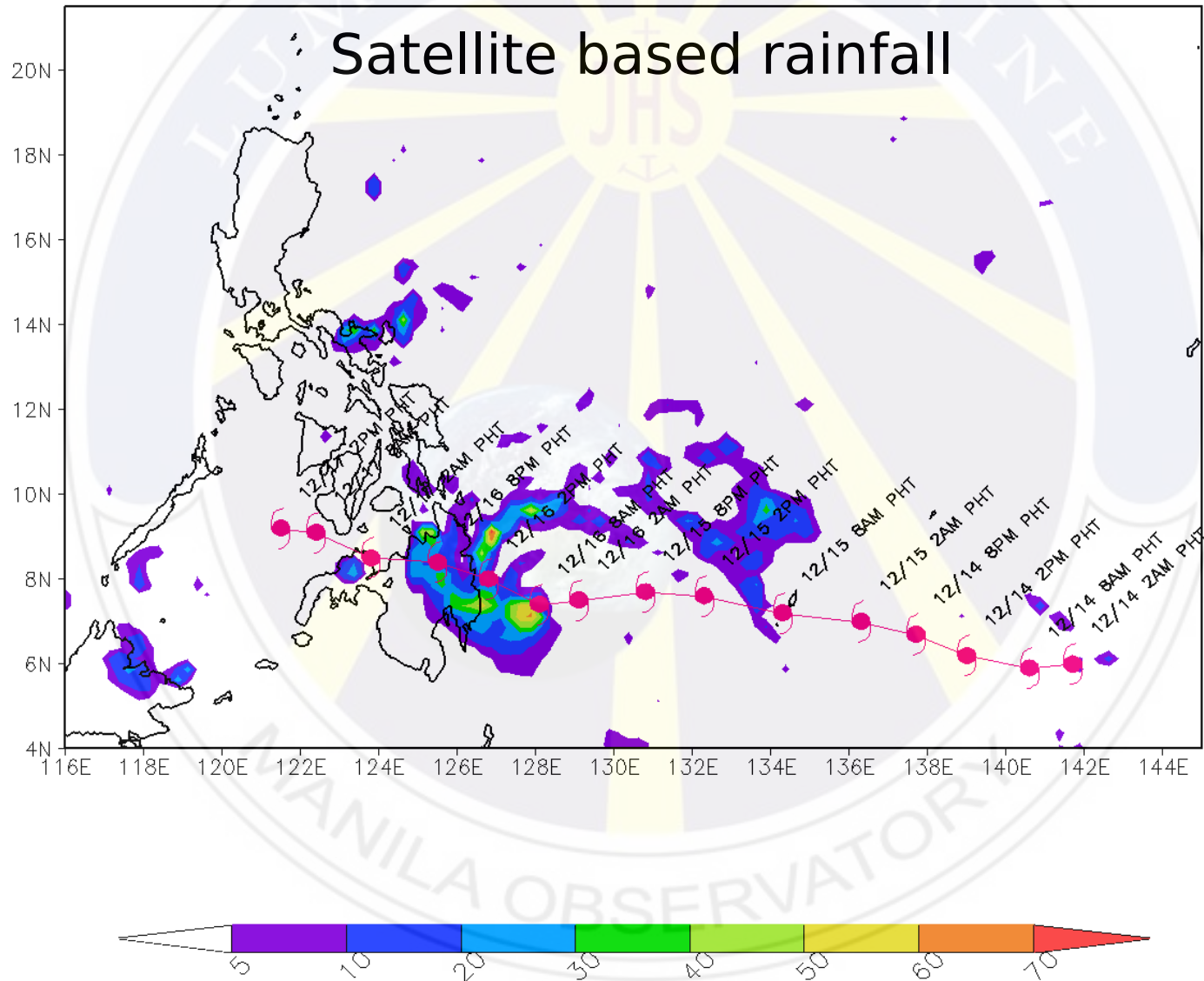




# DEC 16 2 AM – 5 AM

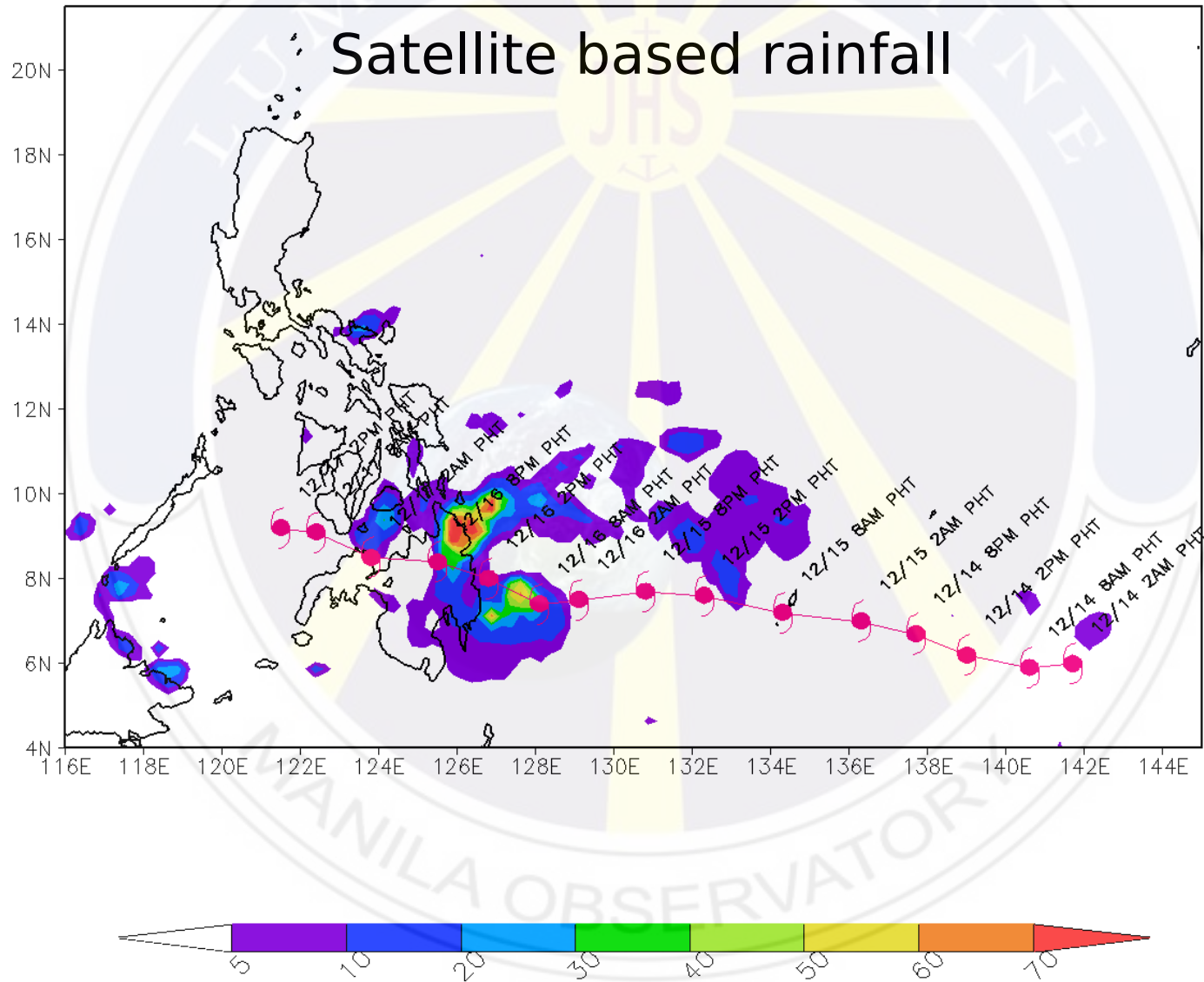


# DEC 16 5 AM – 8 AM



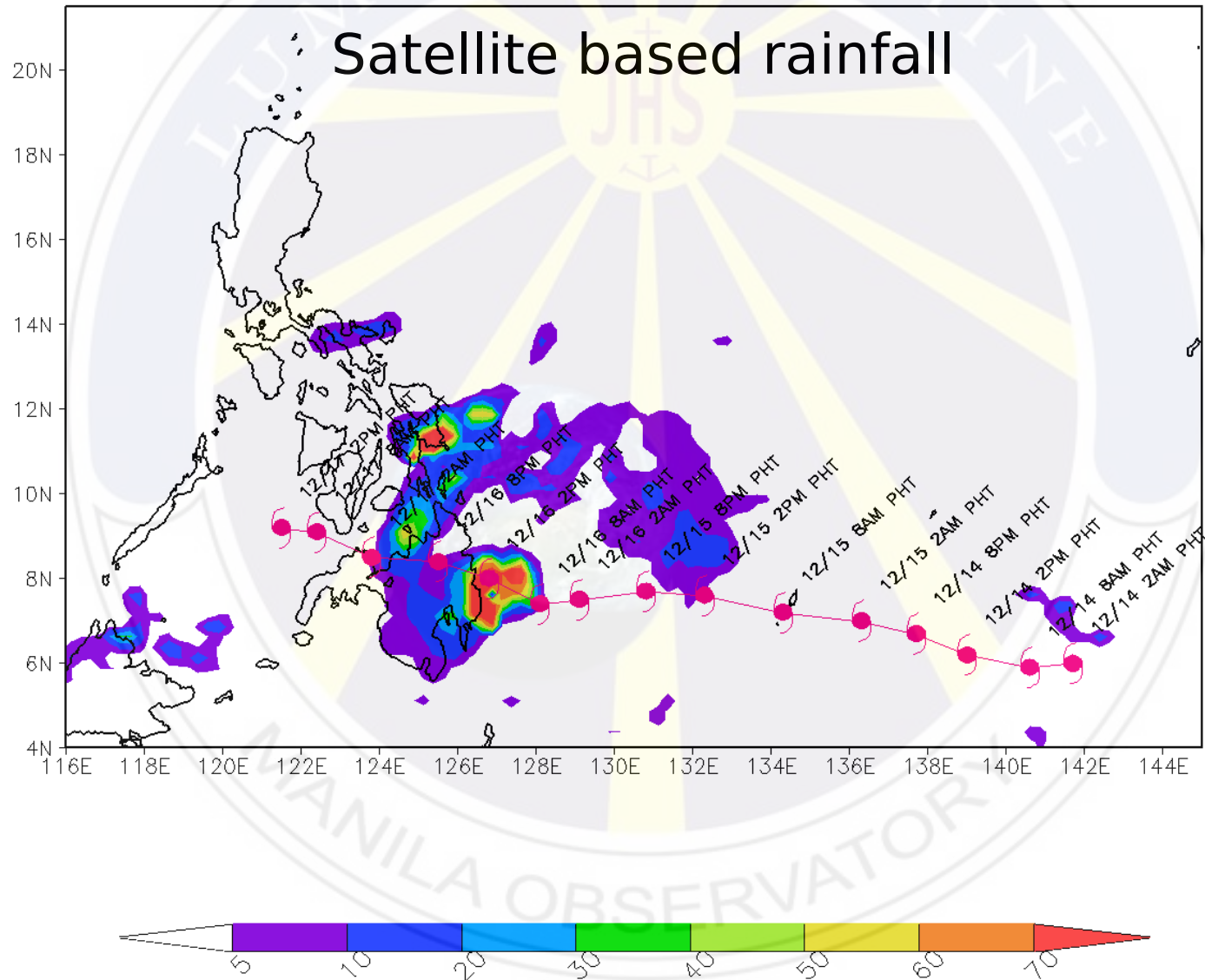
# DEC 16

## 8 AM - 11 AM

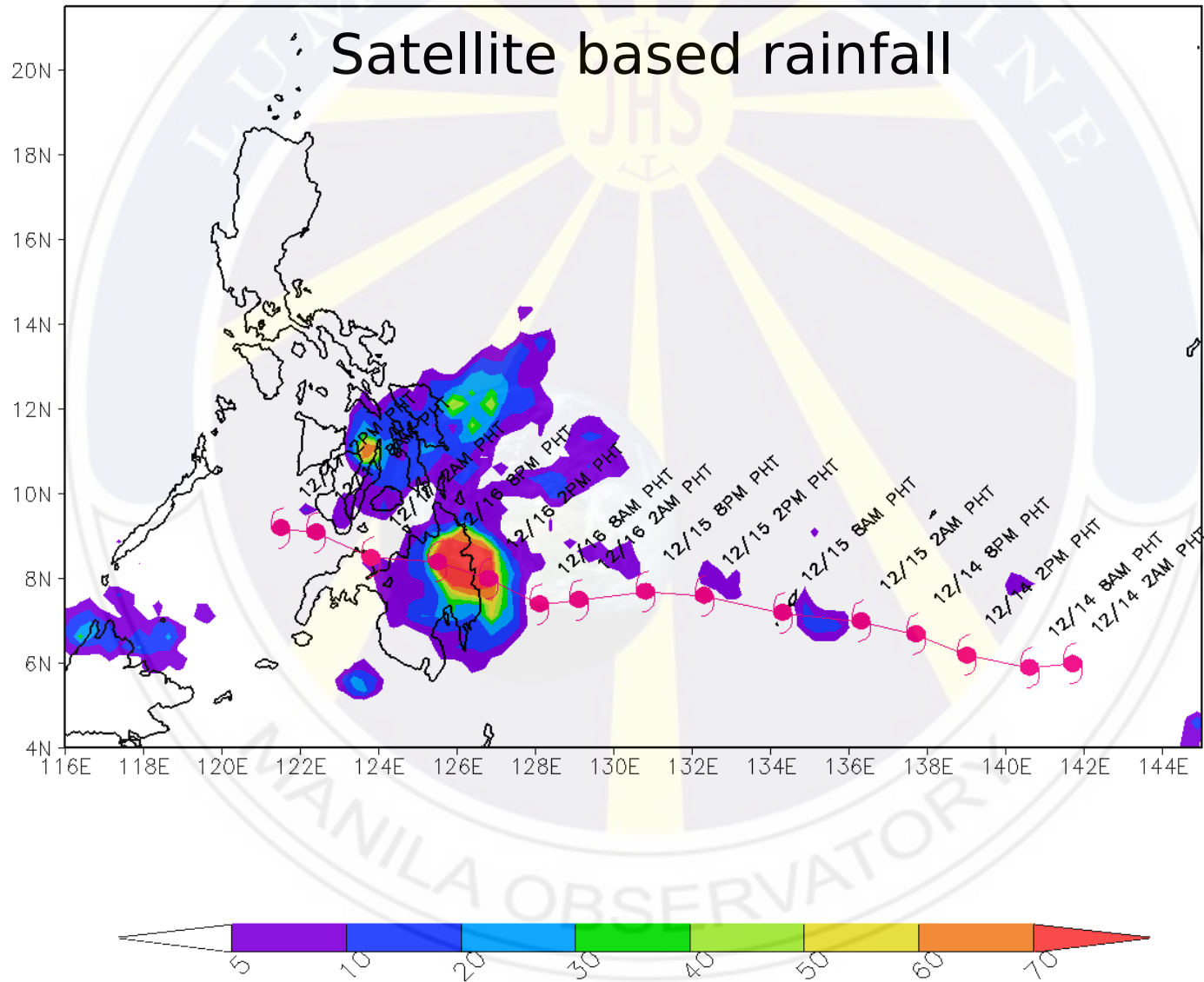




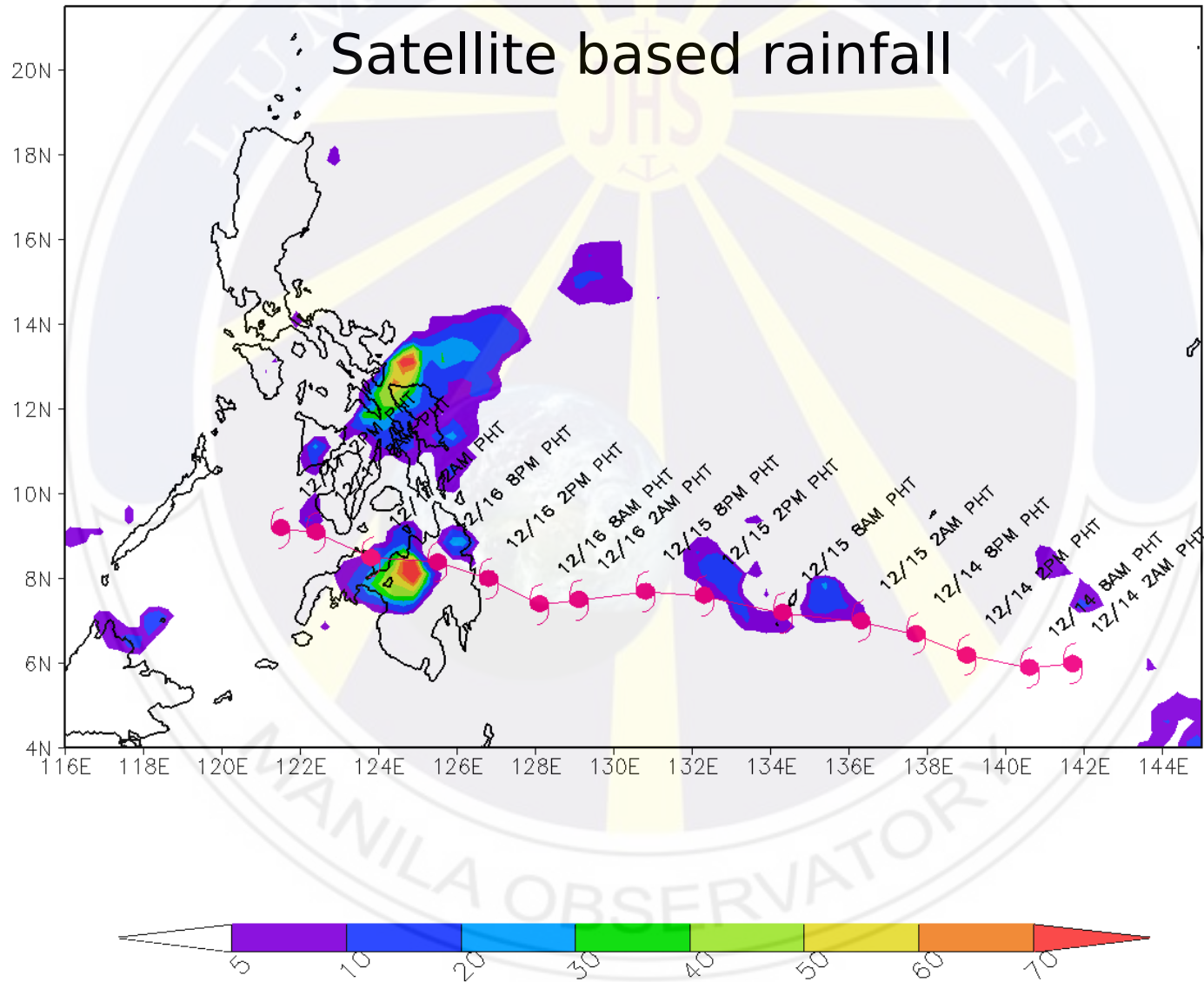
# DEC 16 11 AM – 2 PM



# DEC 16 2 PM – 5 PM

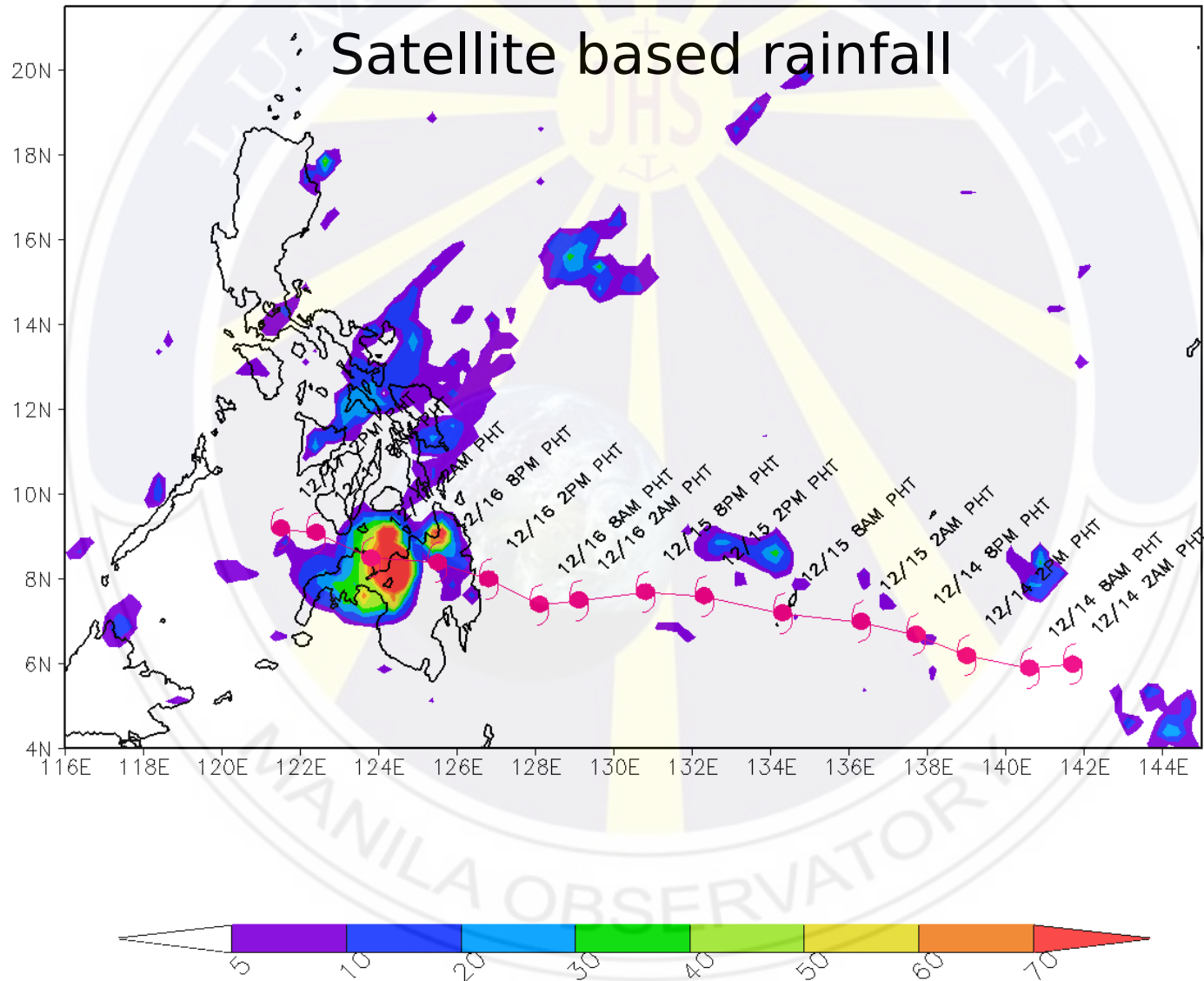


# DEC 16 5 PM – 8 PM

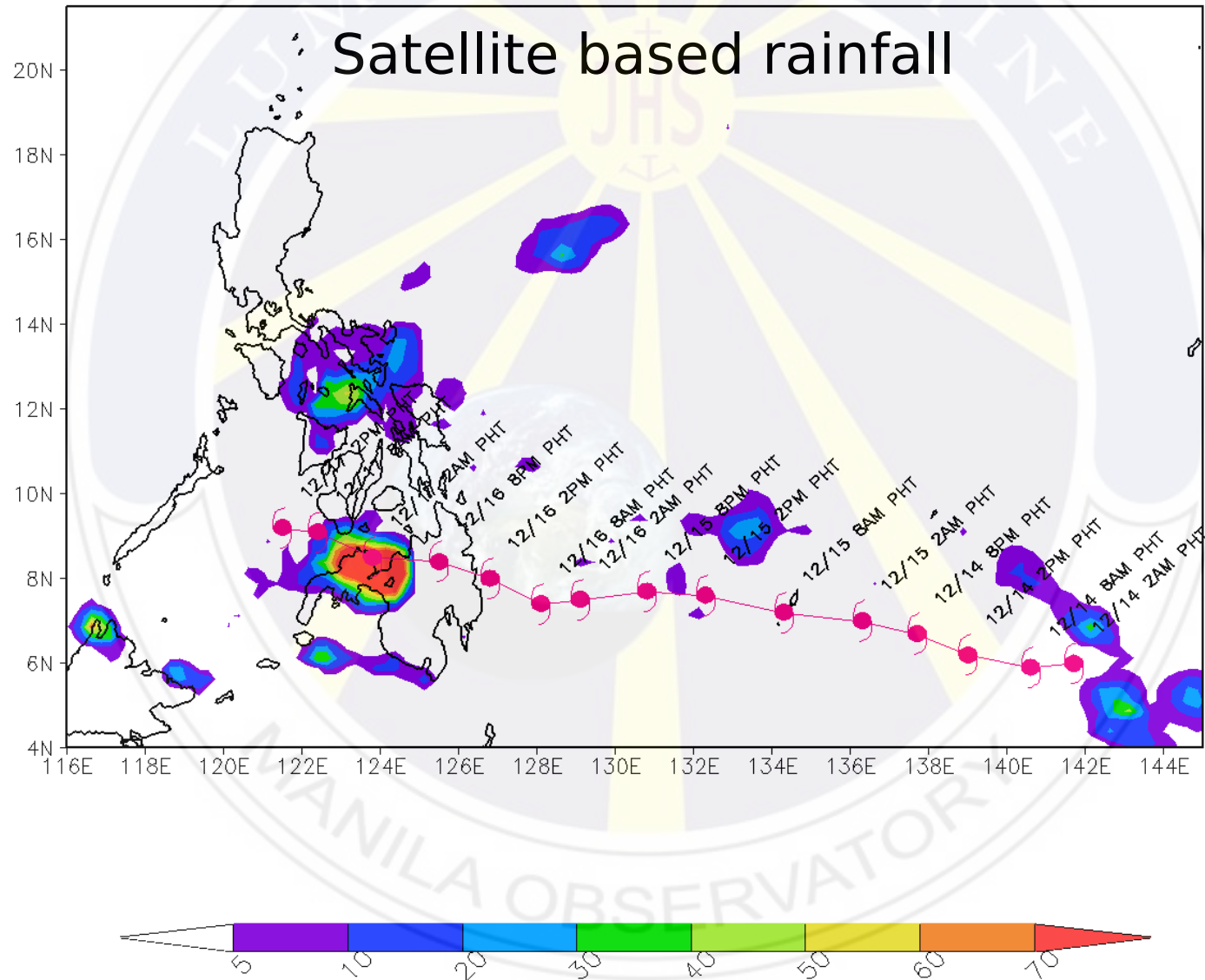




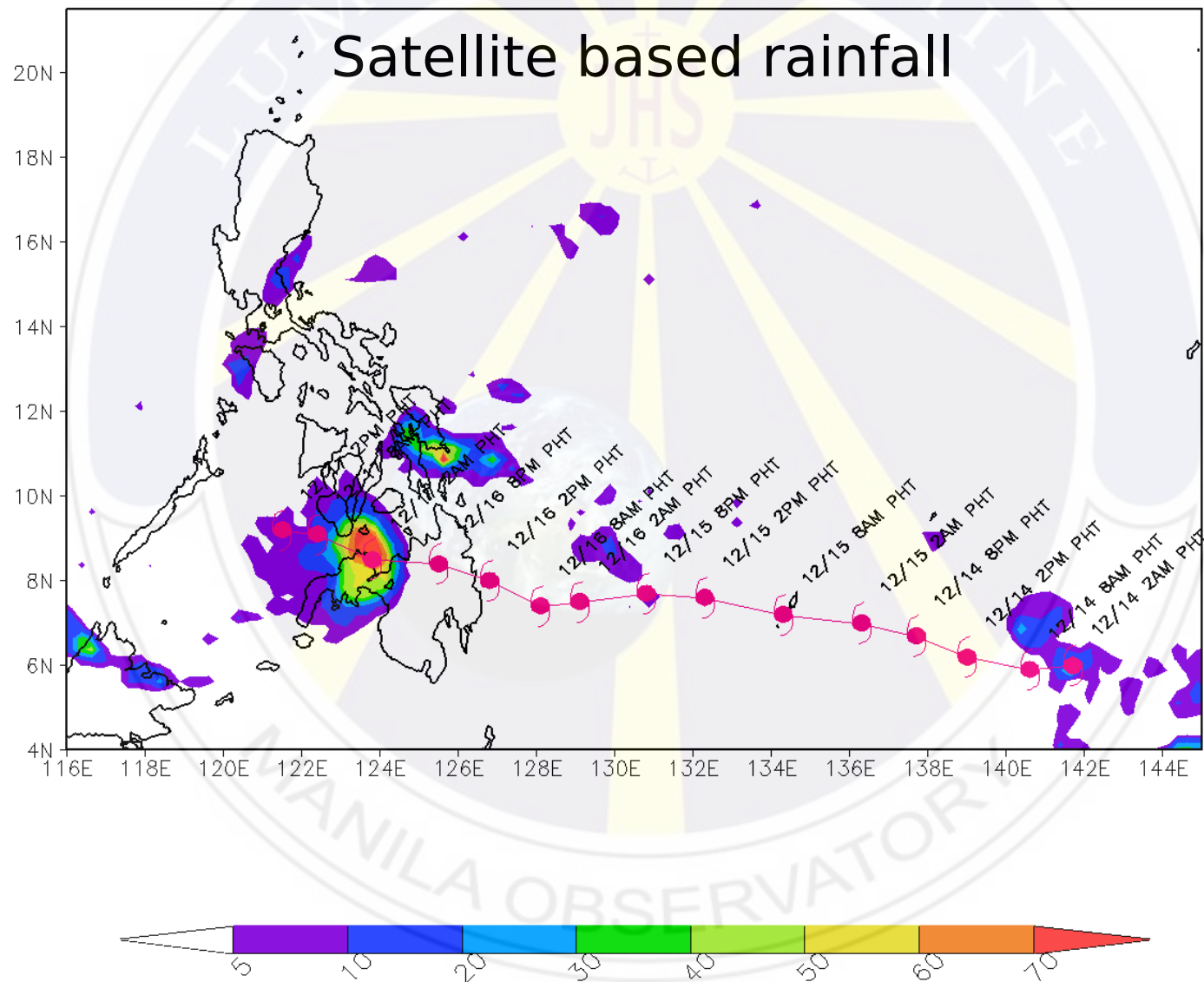
# DEC 16 8 PM – 11 PM



# DEC 16, 17 11 PM – 2 AM



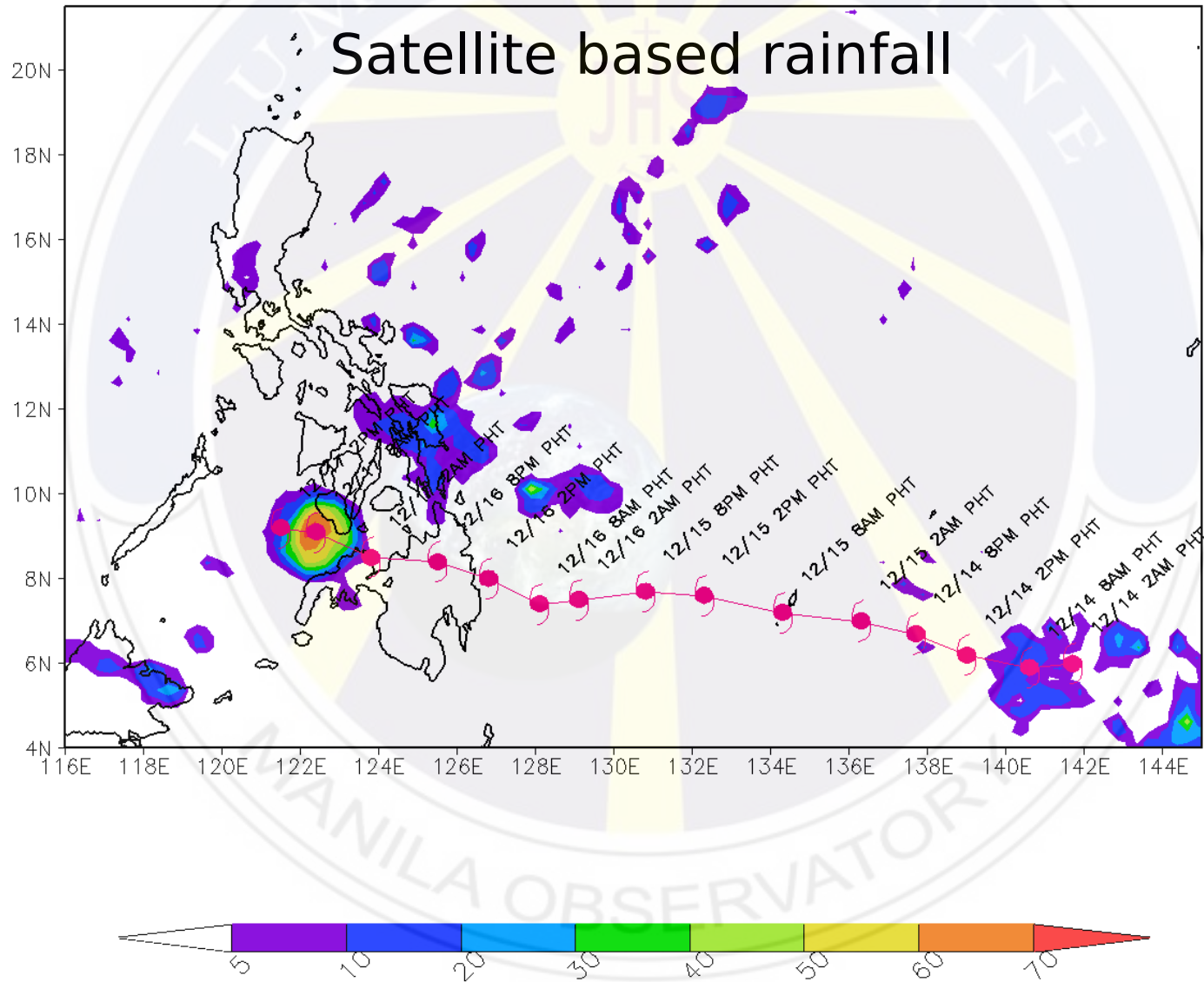
# DEC 17 2 AM – 5 AM



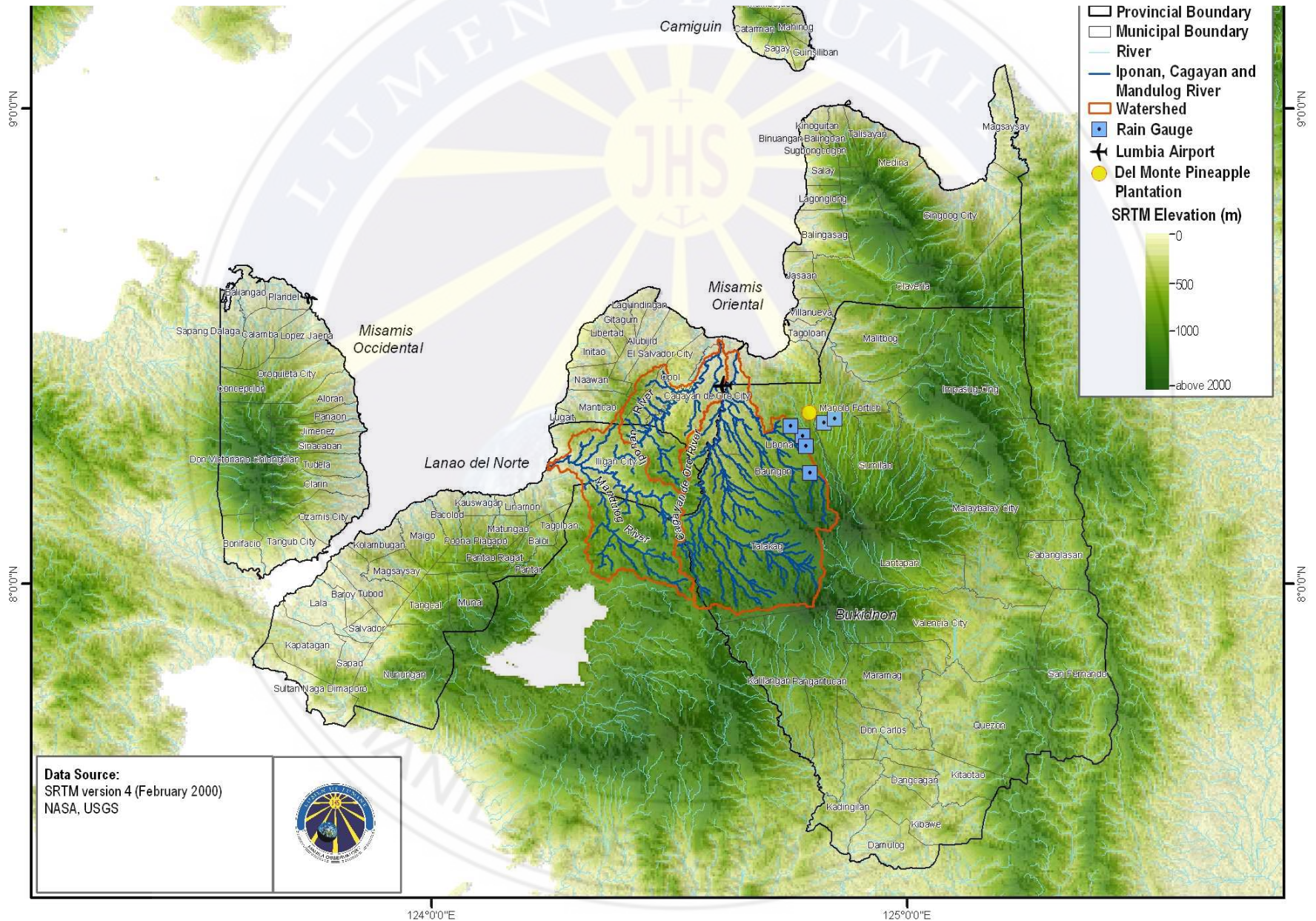


# DEC 17

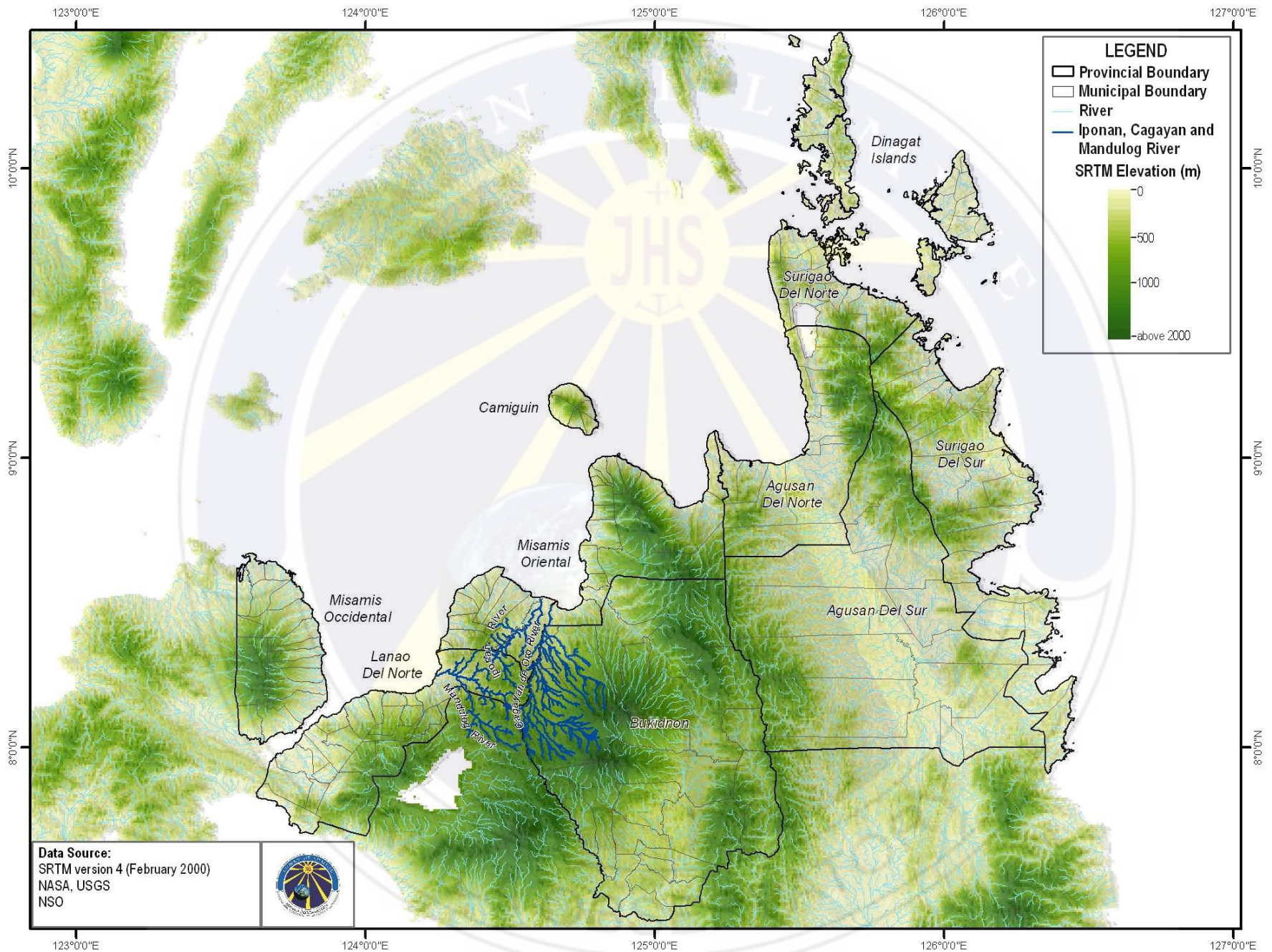
## 5 AM – 8 AM



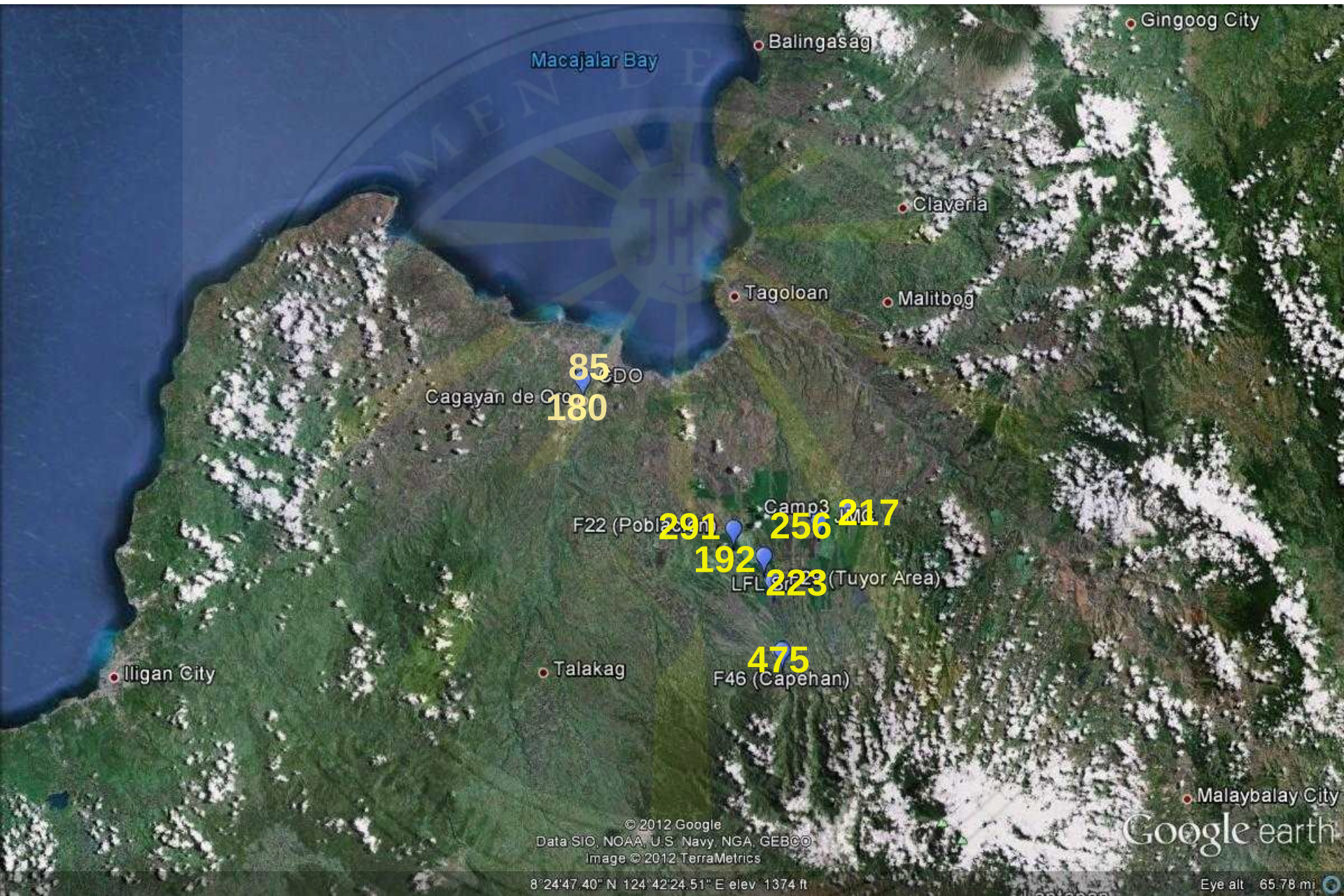
# Northern Mindanao, Region 10, Elevation (based on SRTM 90m data)











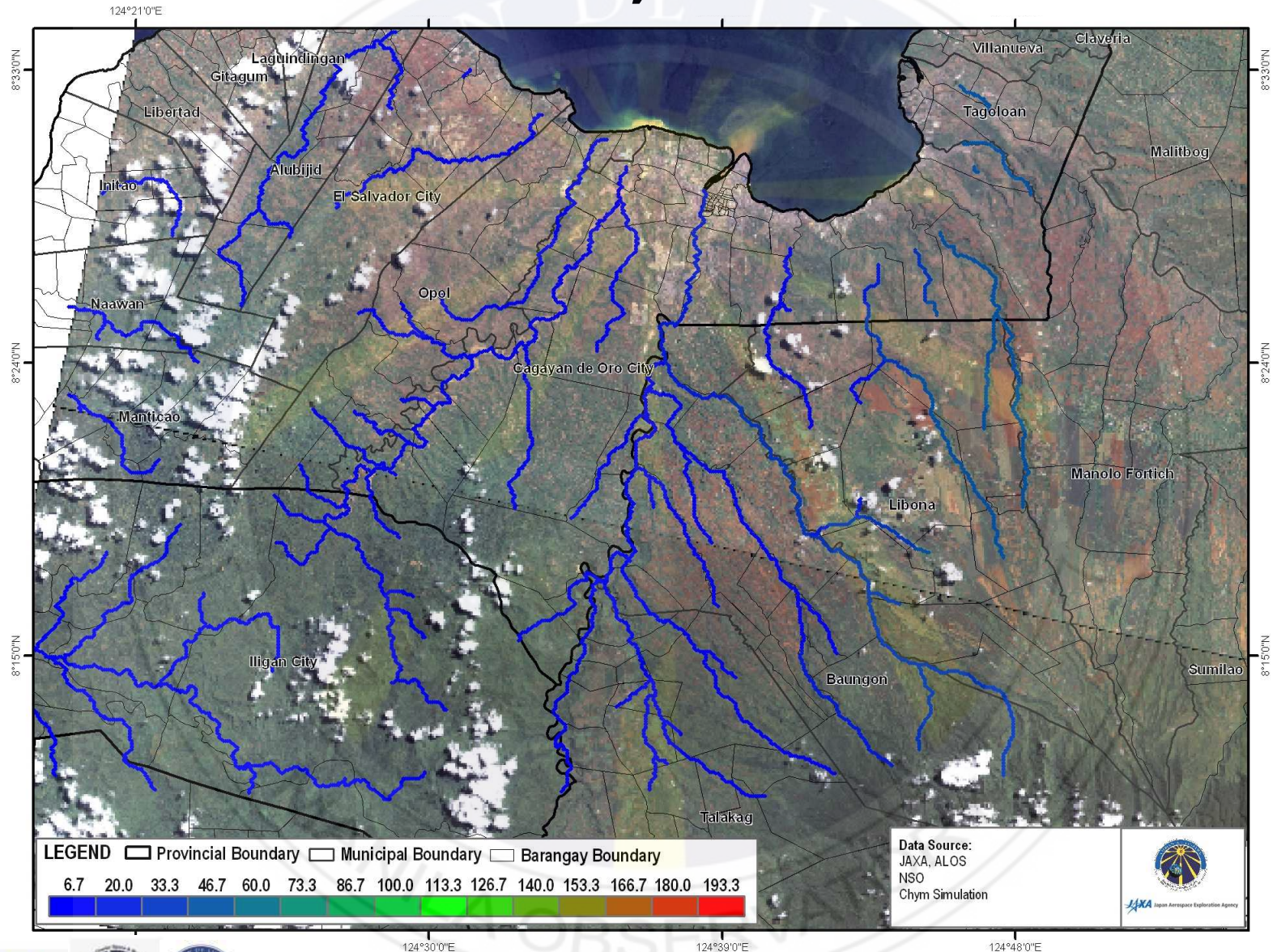




# RAINFALL → FLOODING

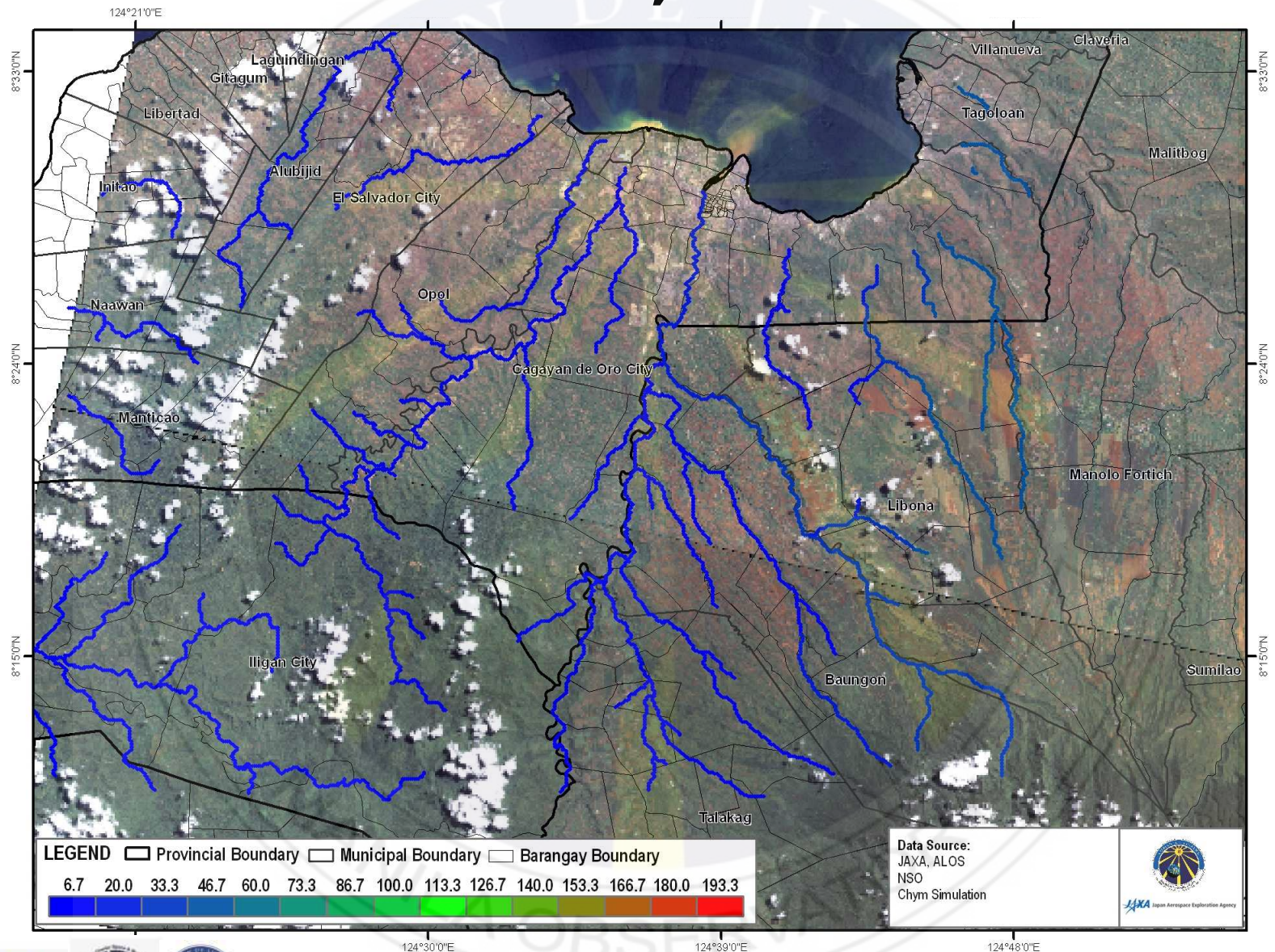
## EARLY WARNING FLOOD MODELING PRELIMINARY RESULTS

# Dec 16, 12 NN



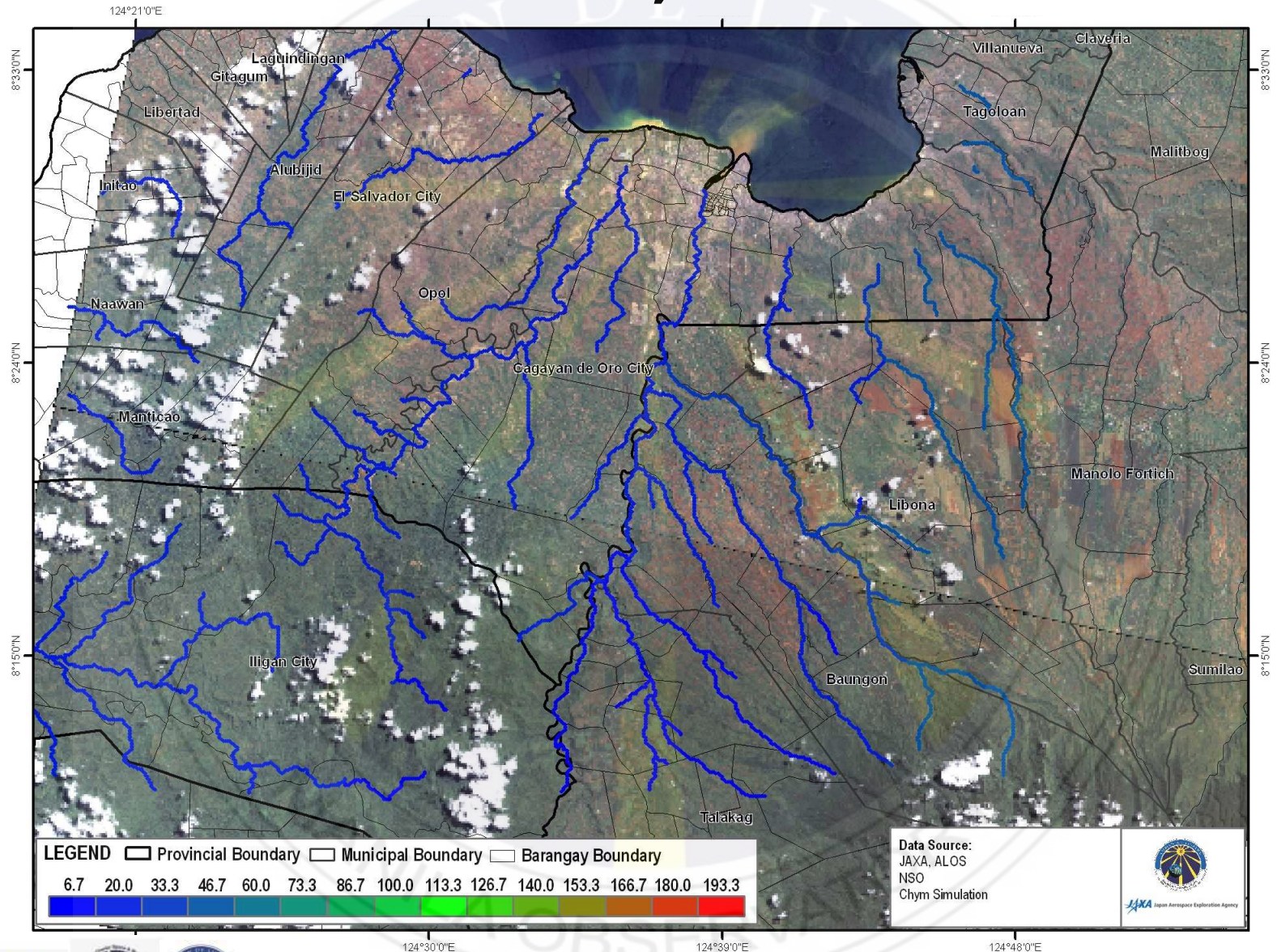


# Dec 16, 1 PM



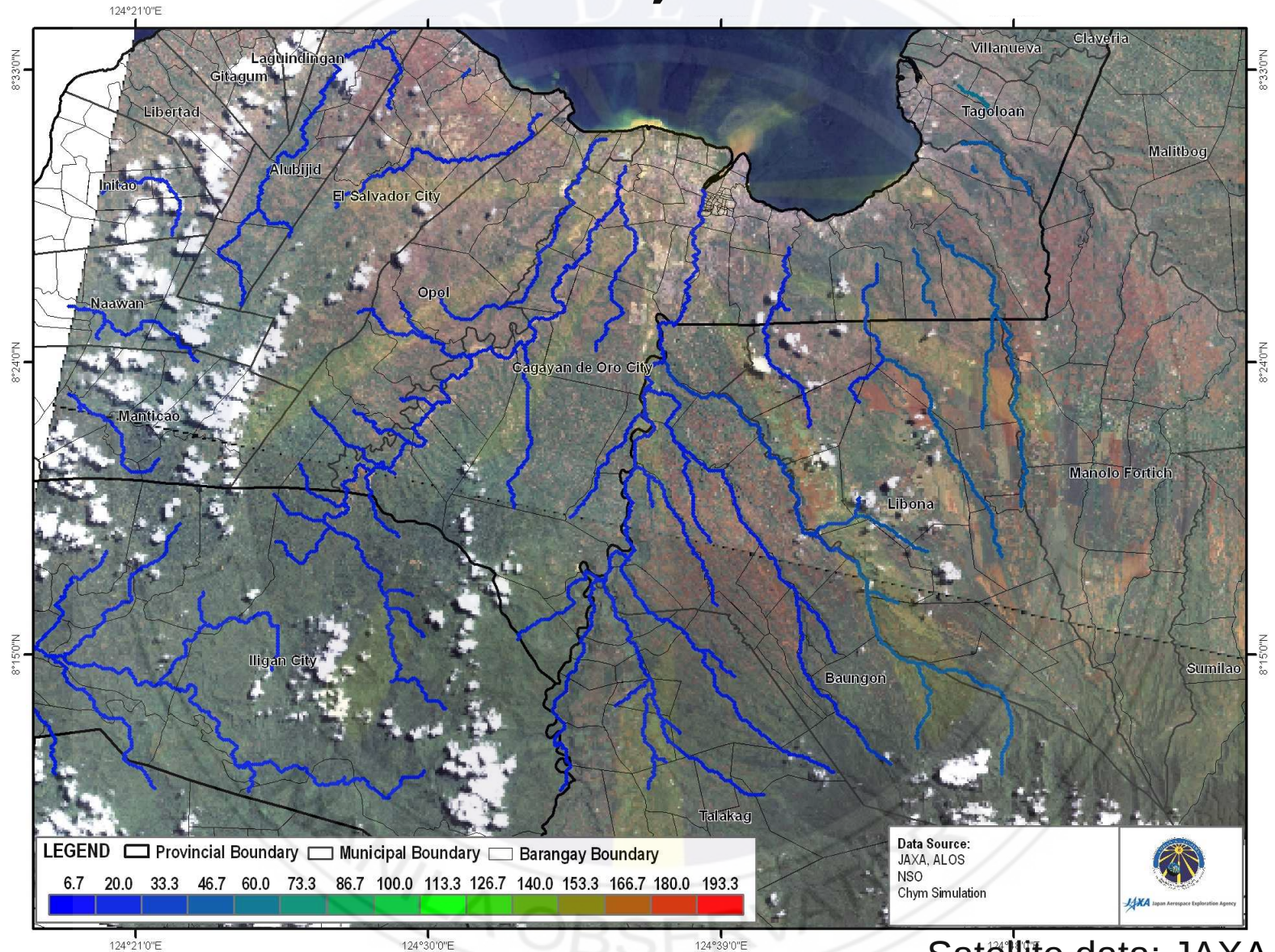


# Dec 16, 2 PM





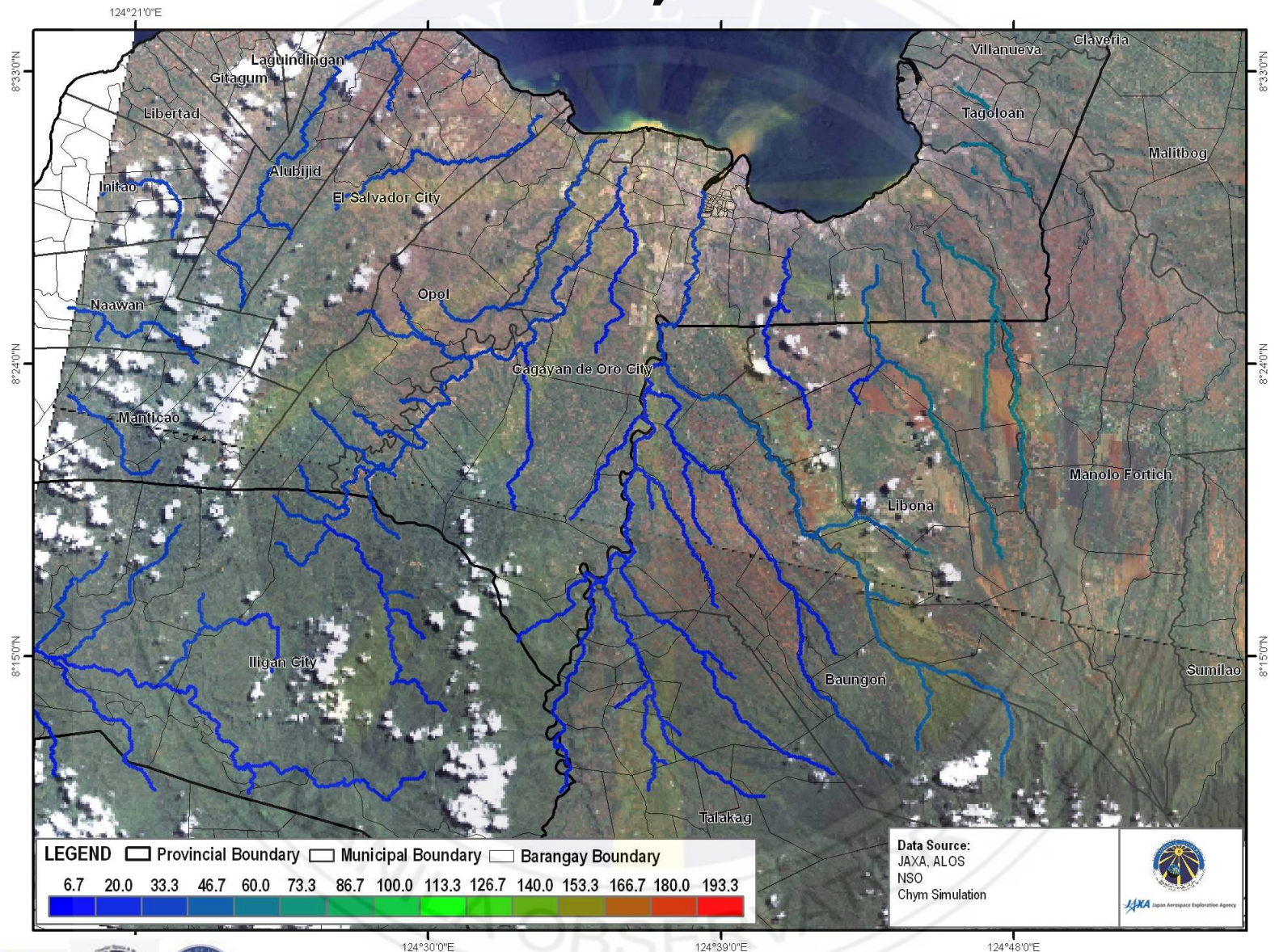
# Dec 16, 3 PM



Satellite data: JAXA, ALOS  
Barangay Boundaries: NSO

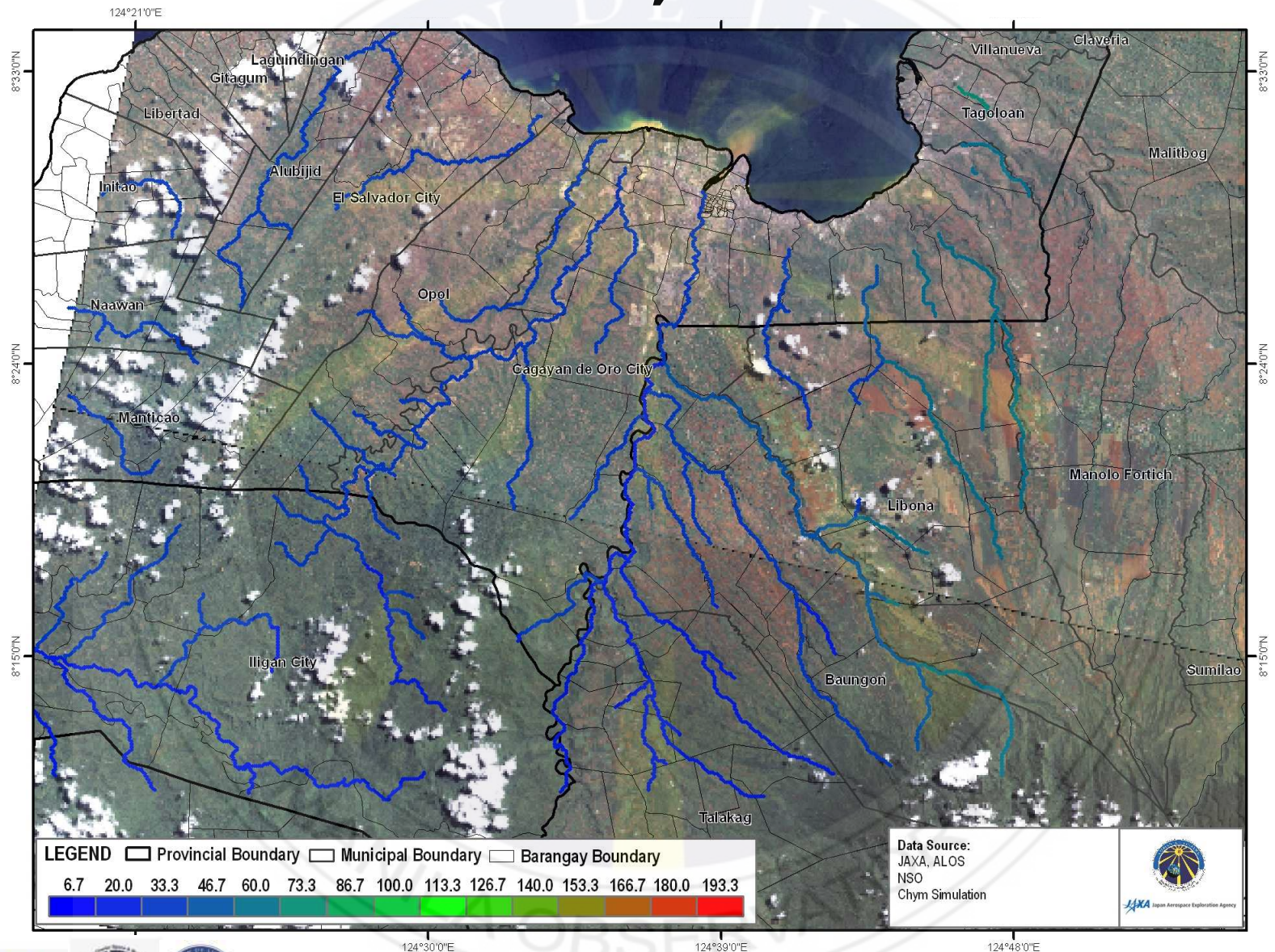


# Dec 16, 4 PM



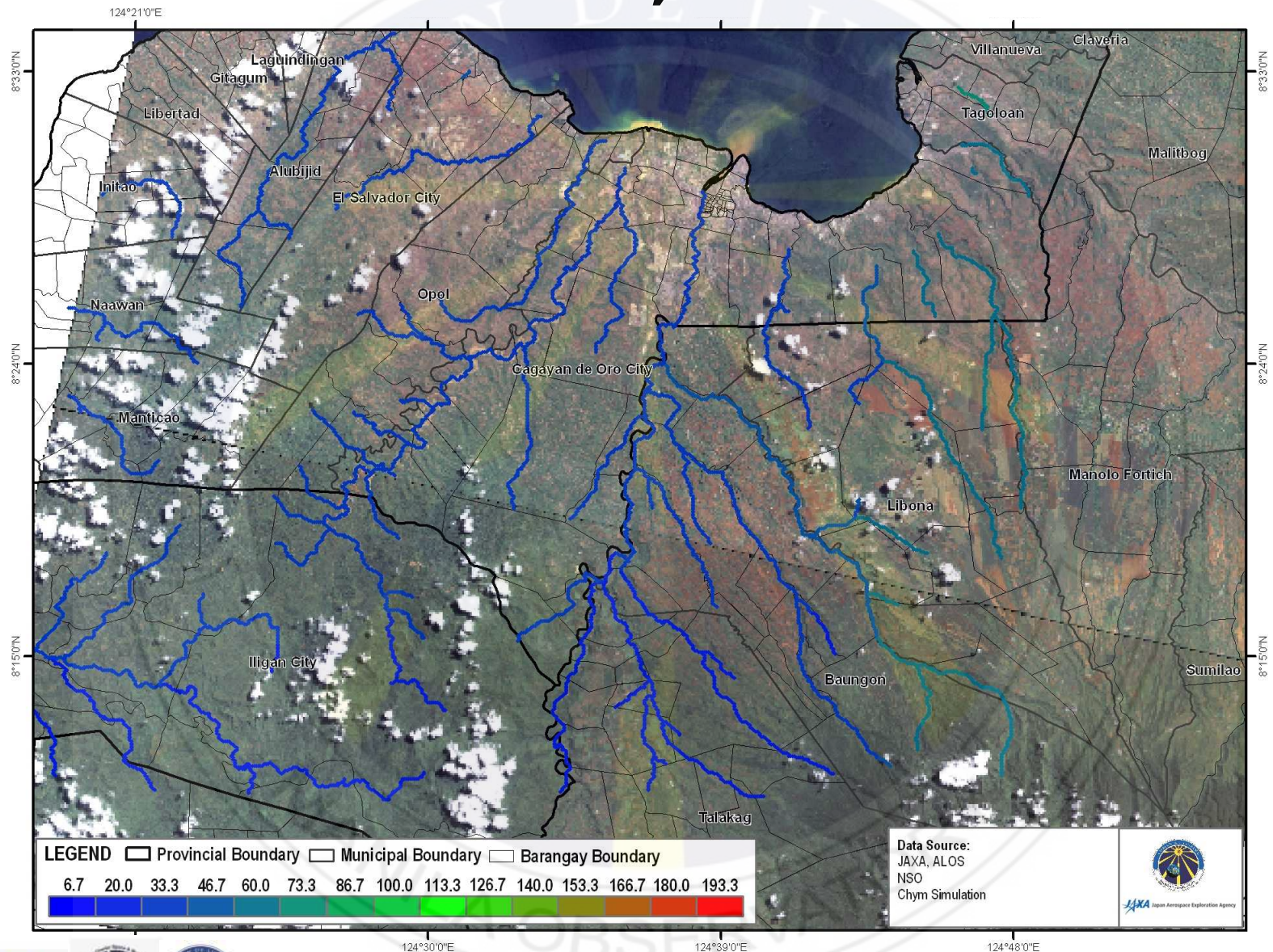


# Dec 16, 5 PM



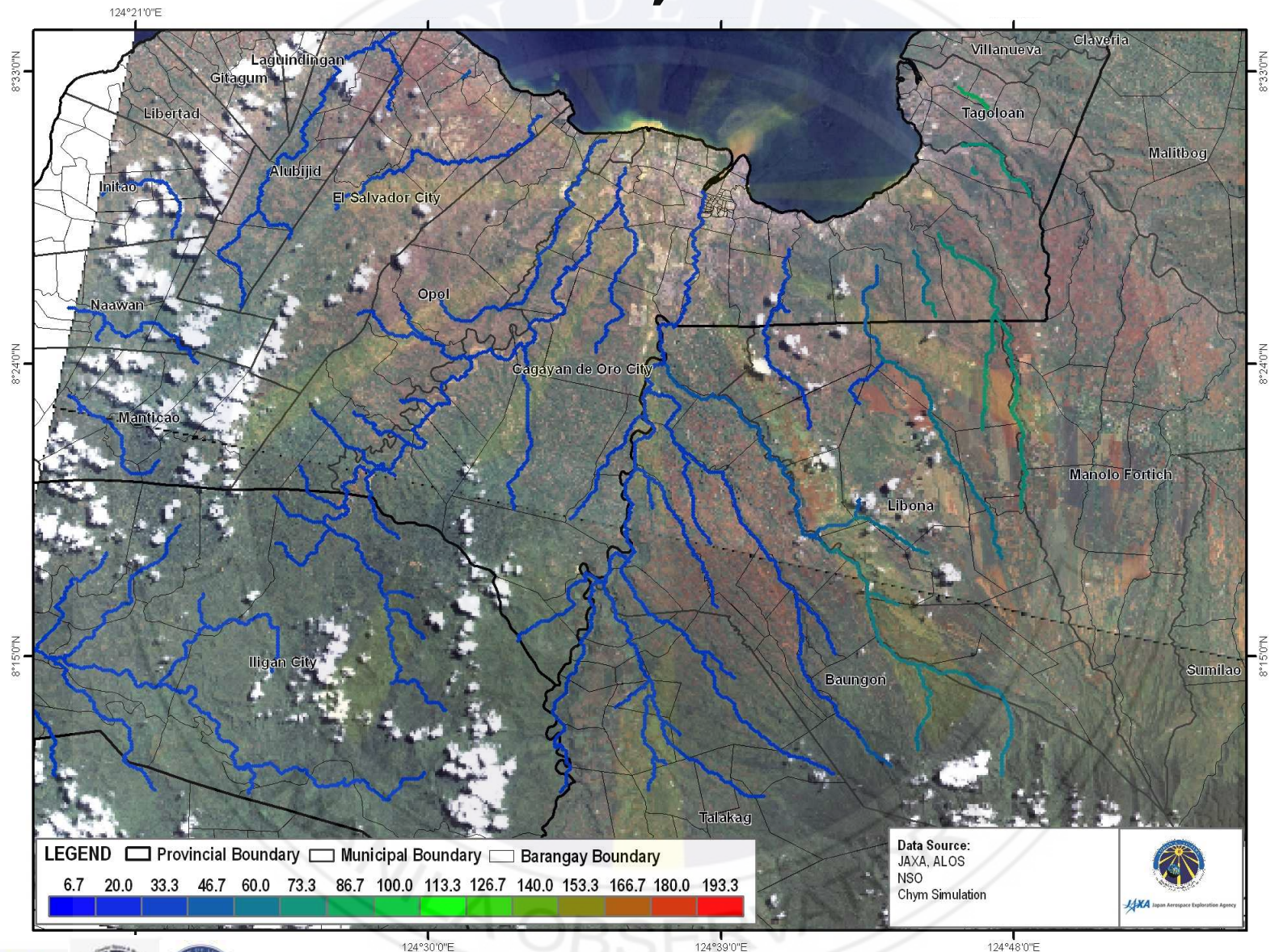


# Dec 16, 6 PM



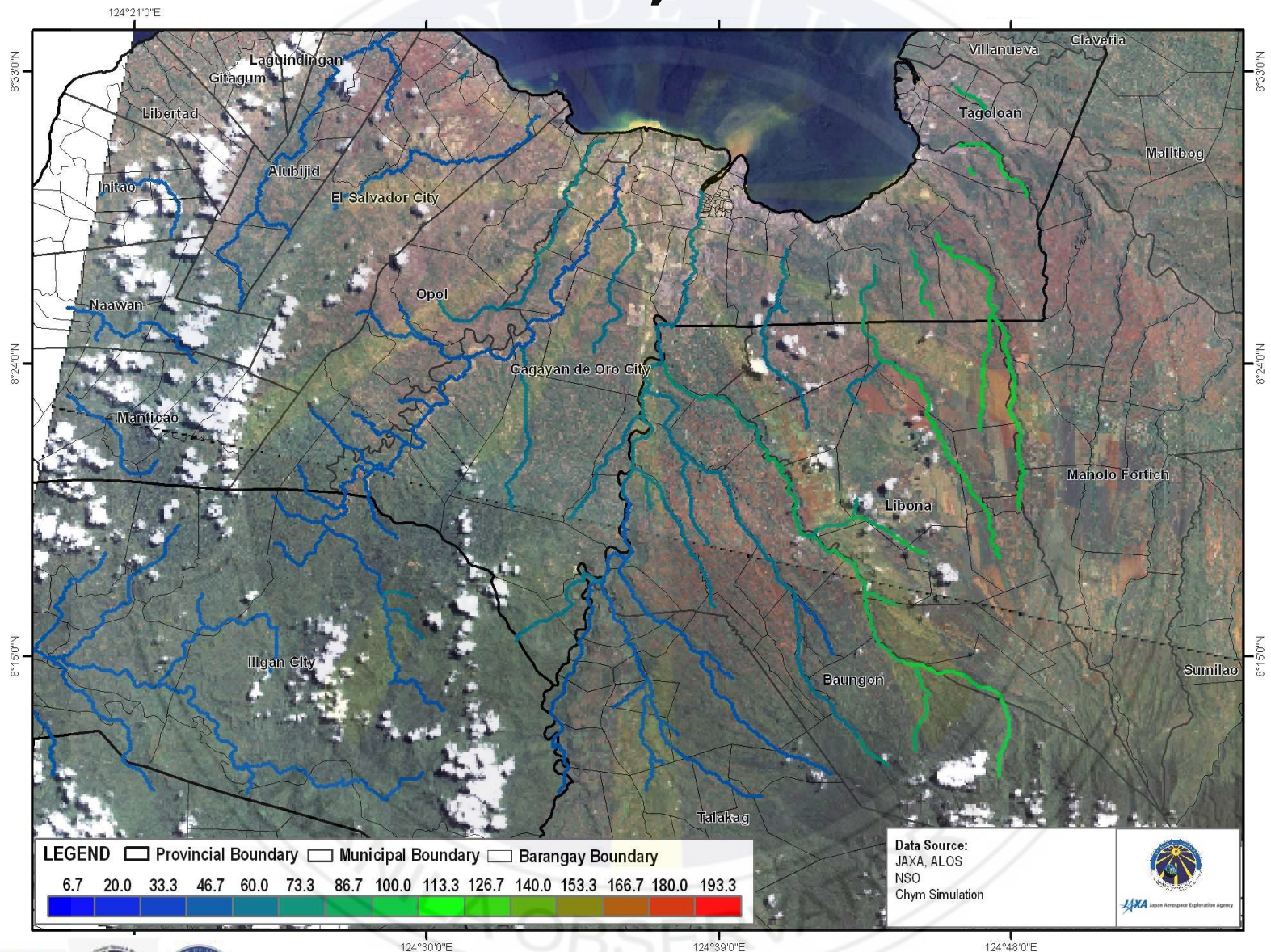


# Dec 16, 7 PM



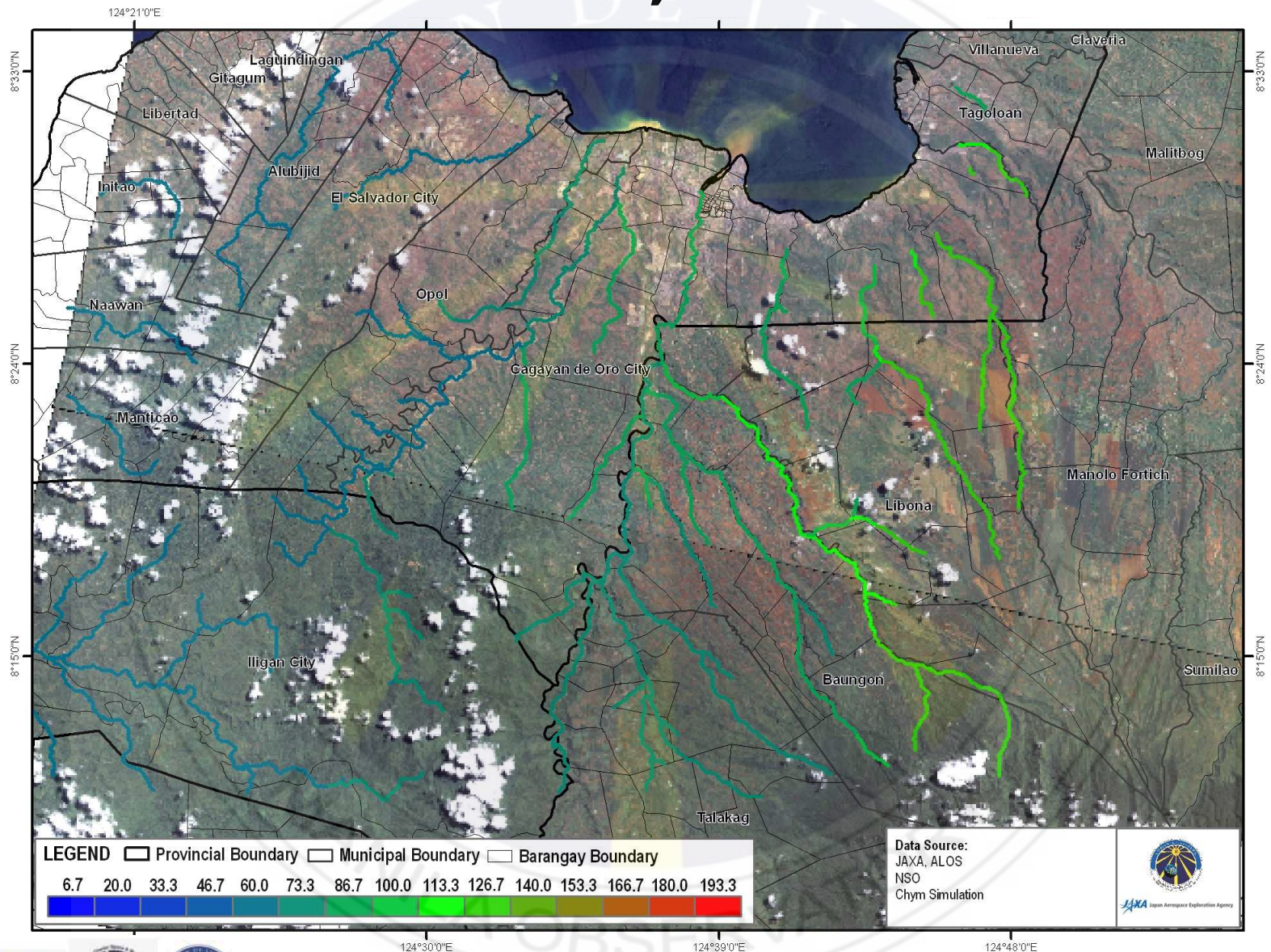


# Dec 16, 8 PM



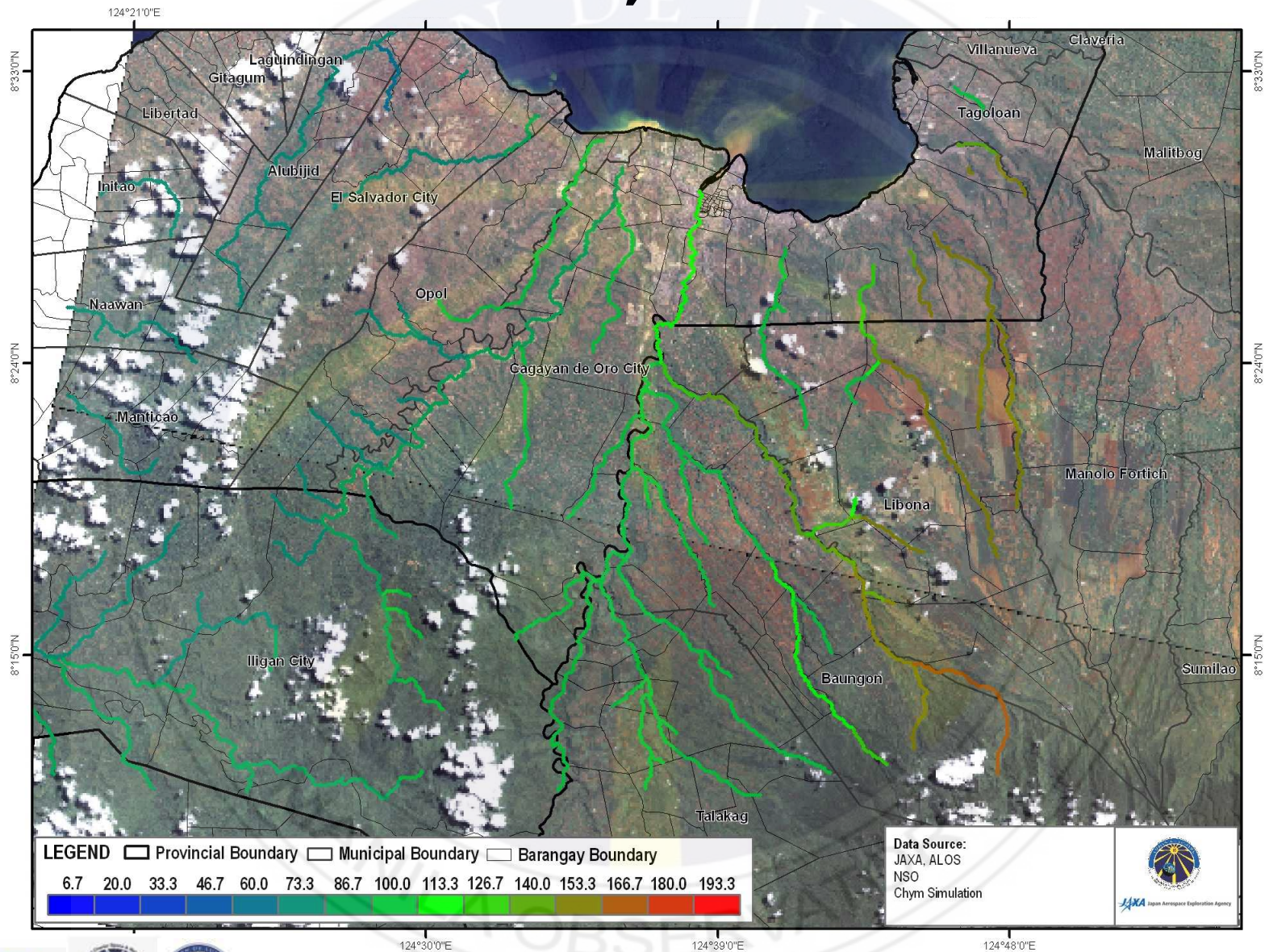


# Dec 16, 9 PM



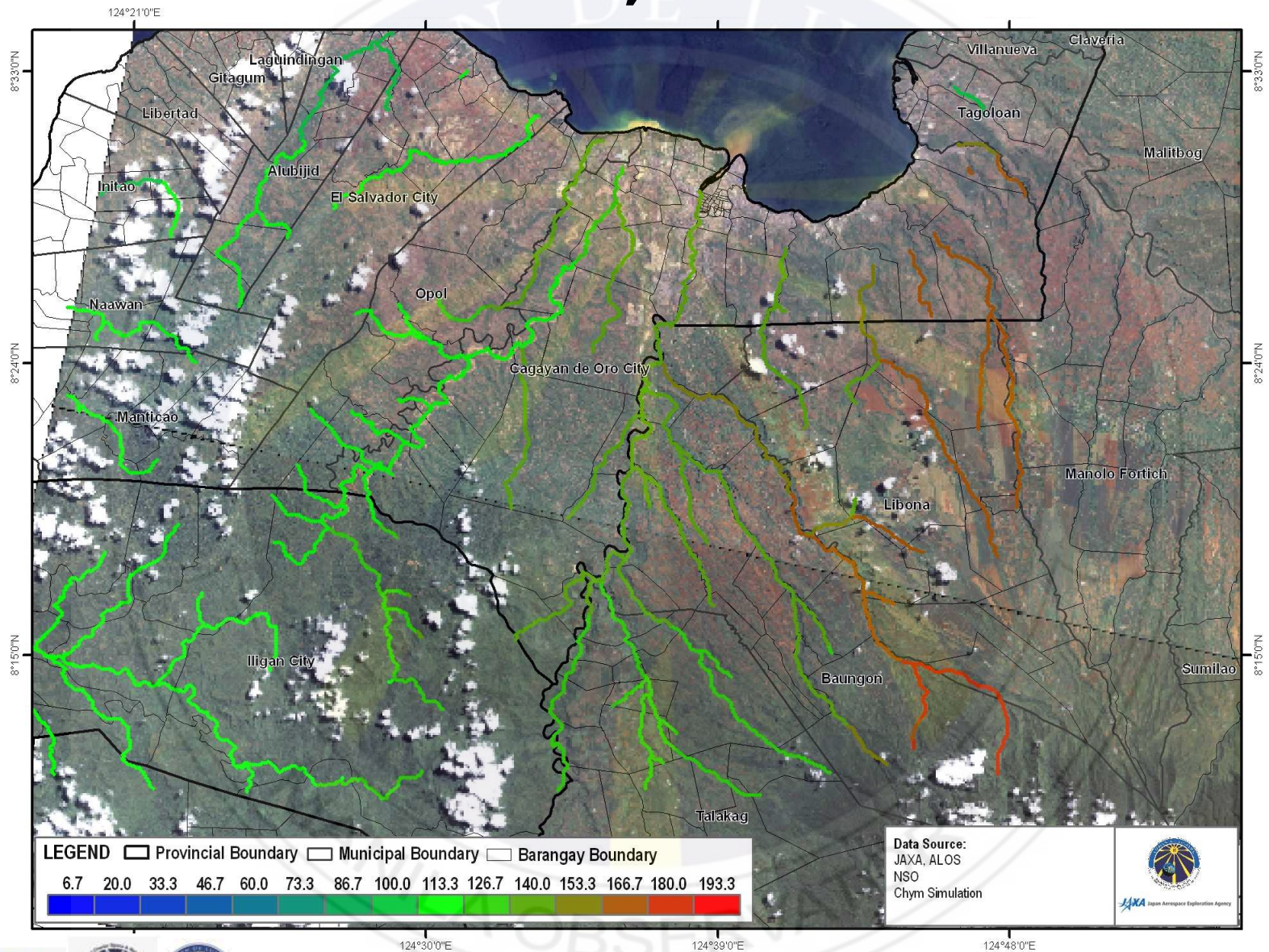


# Dec 16, 10 PM



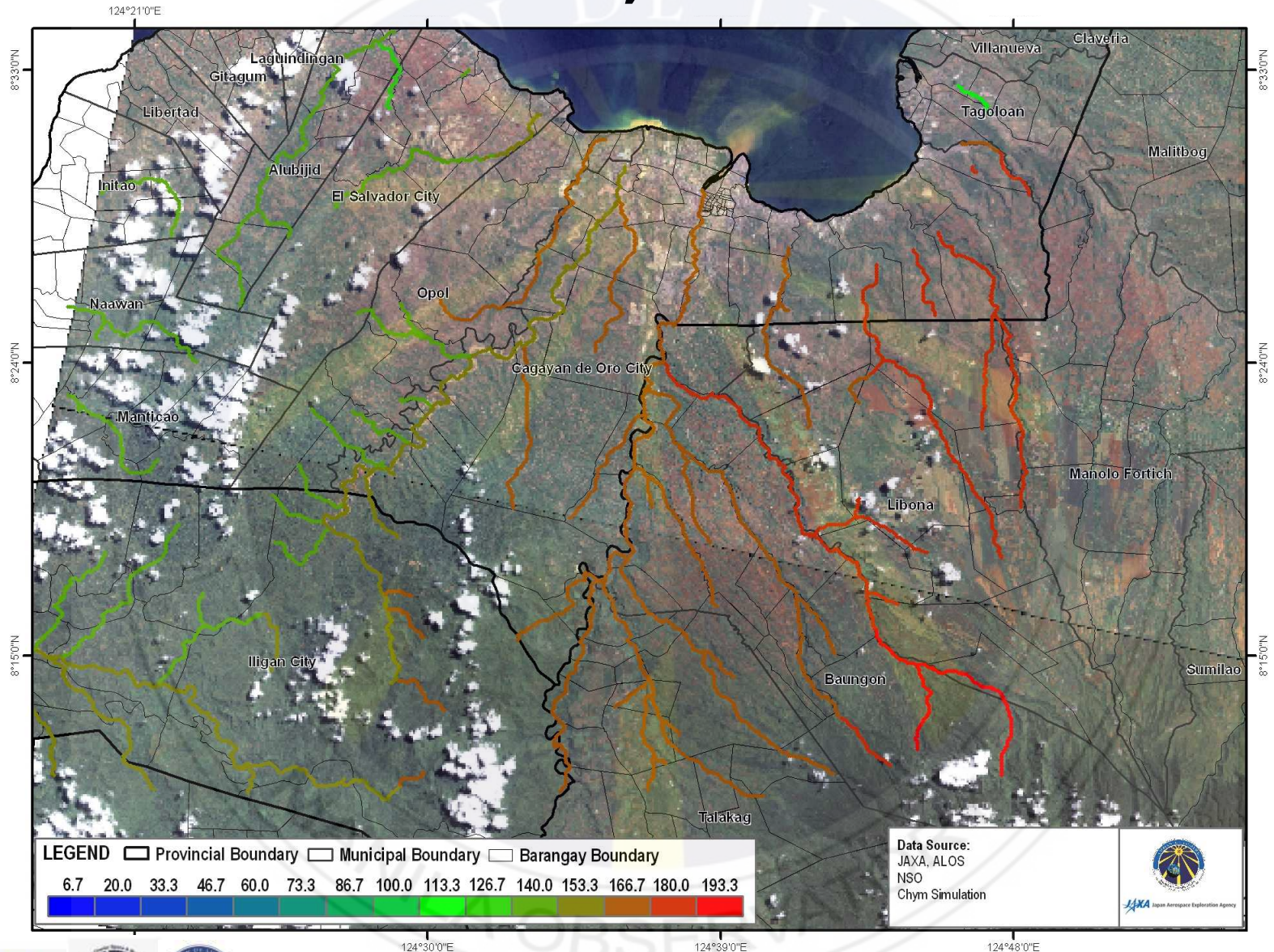


# Dec 16, 11 PM



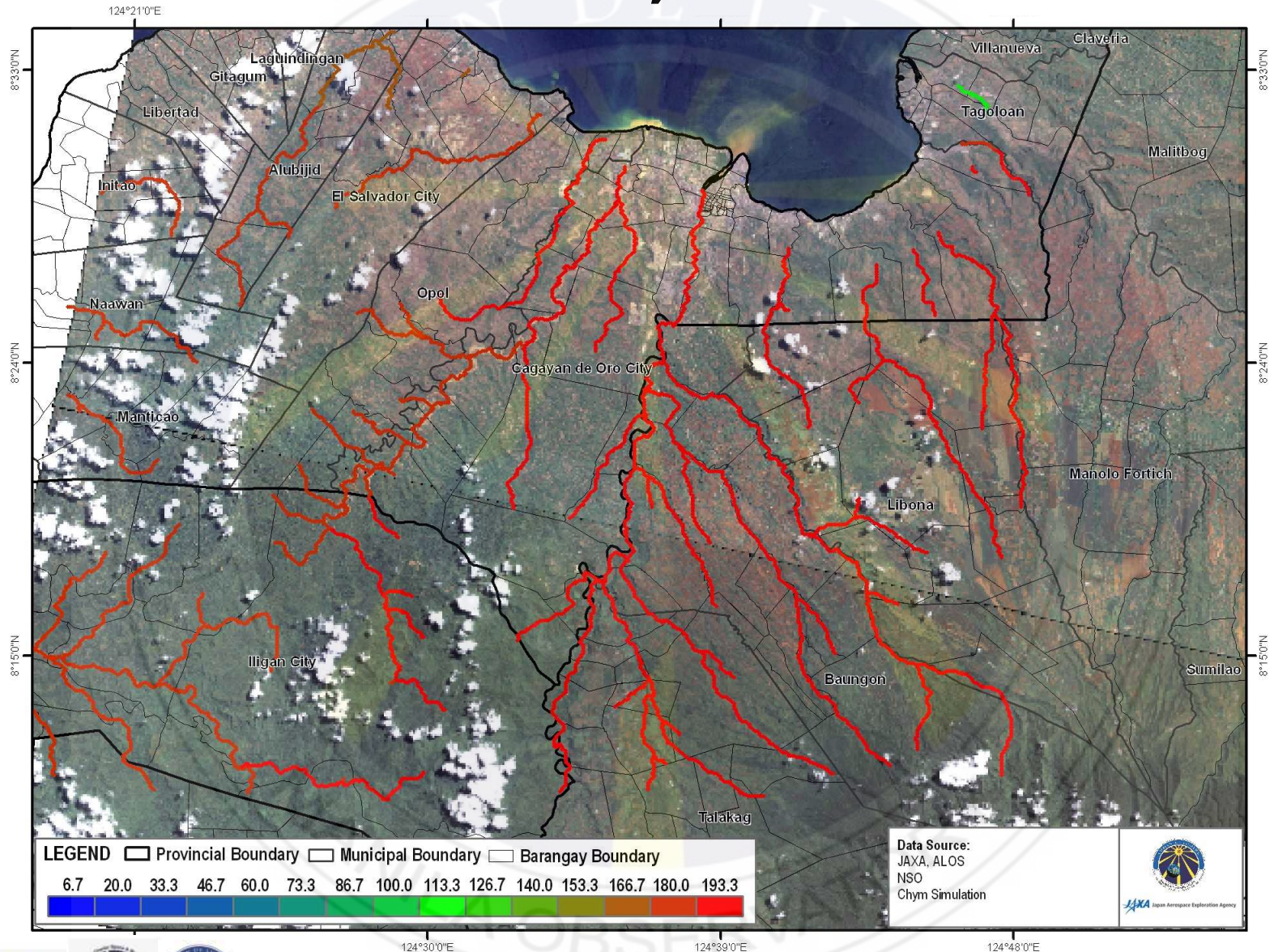


# Dec 16, 12 MN



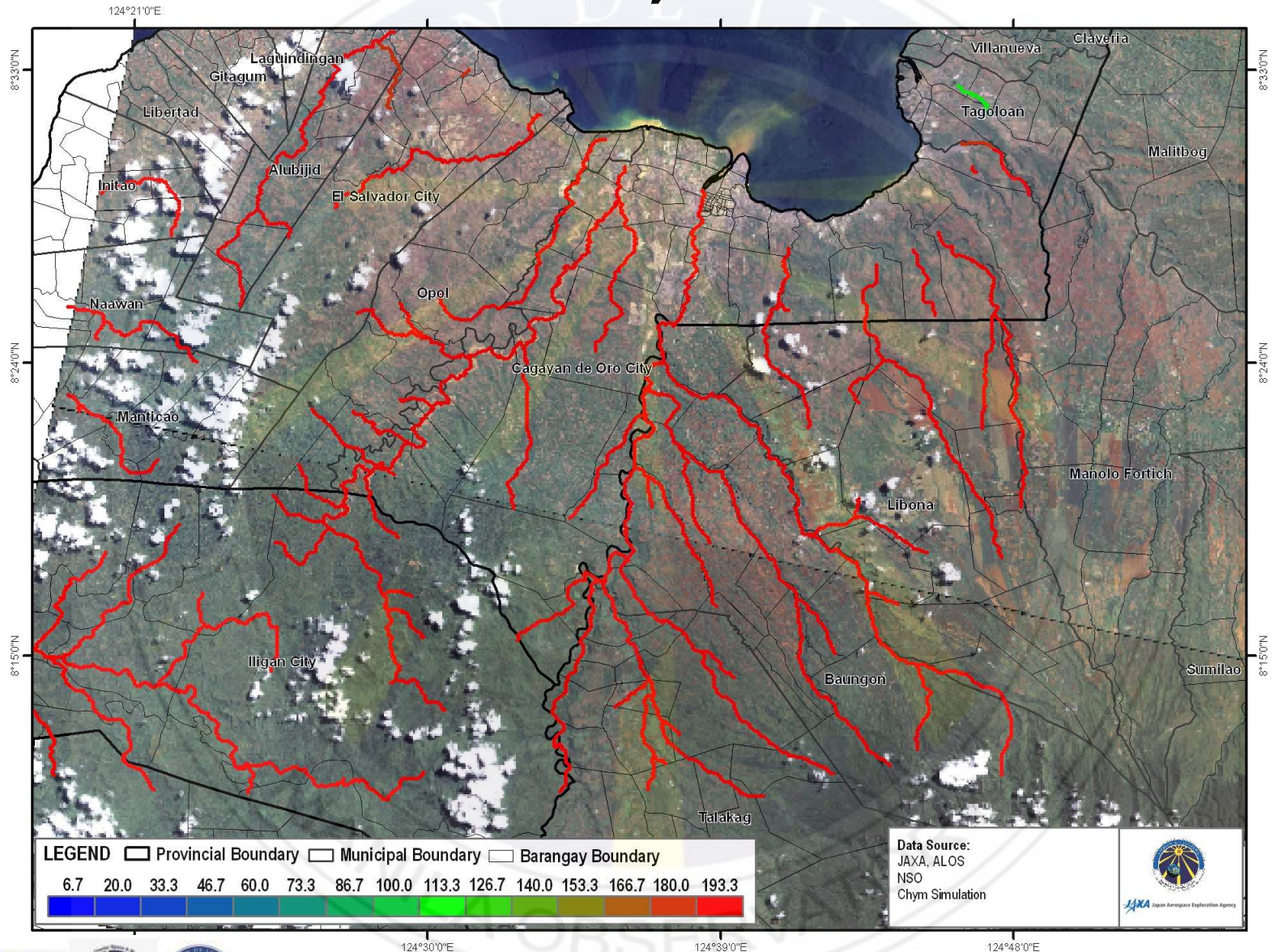


# Dec 17, 1 AM





# Dec 17, 2 AM

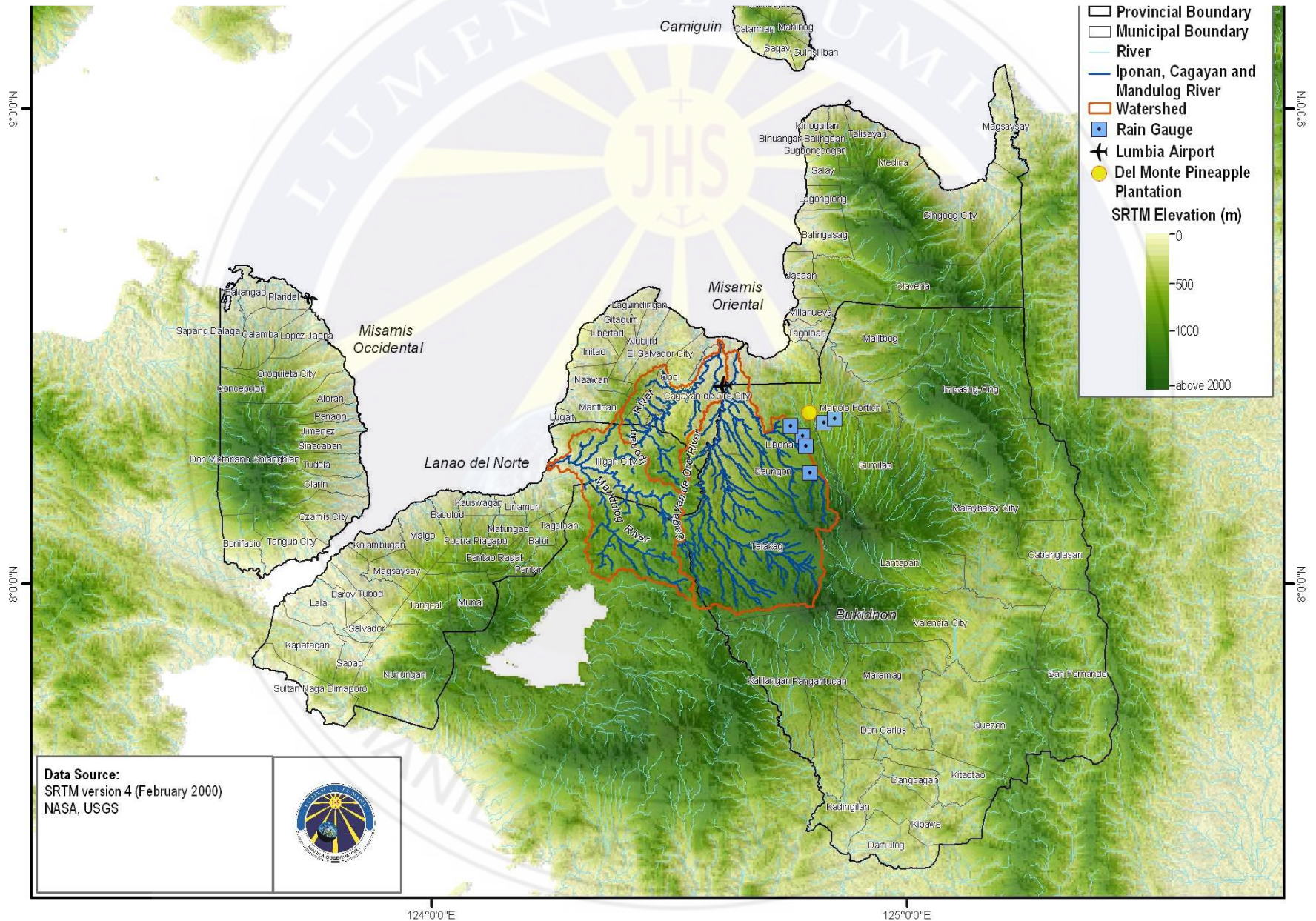


**EXPOSURE**





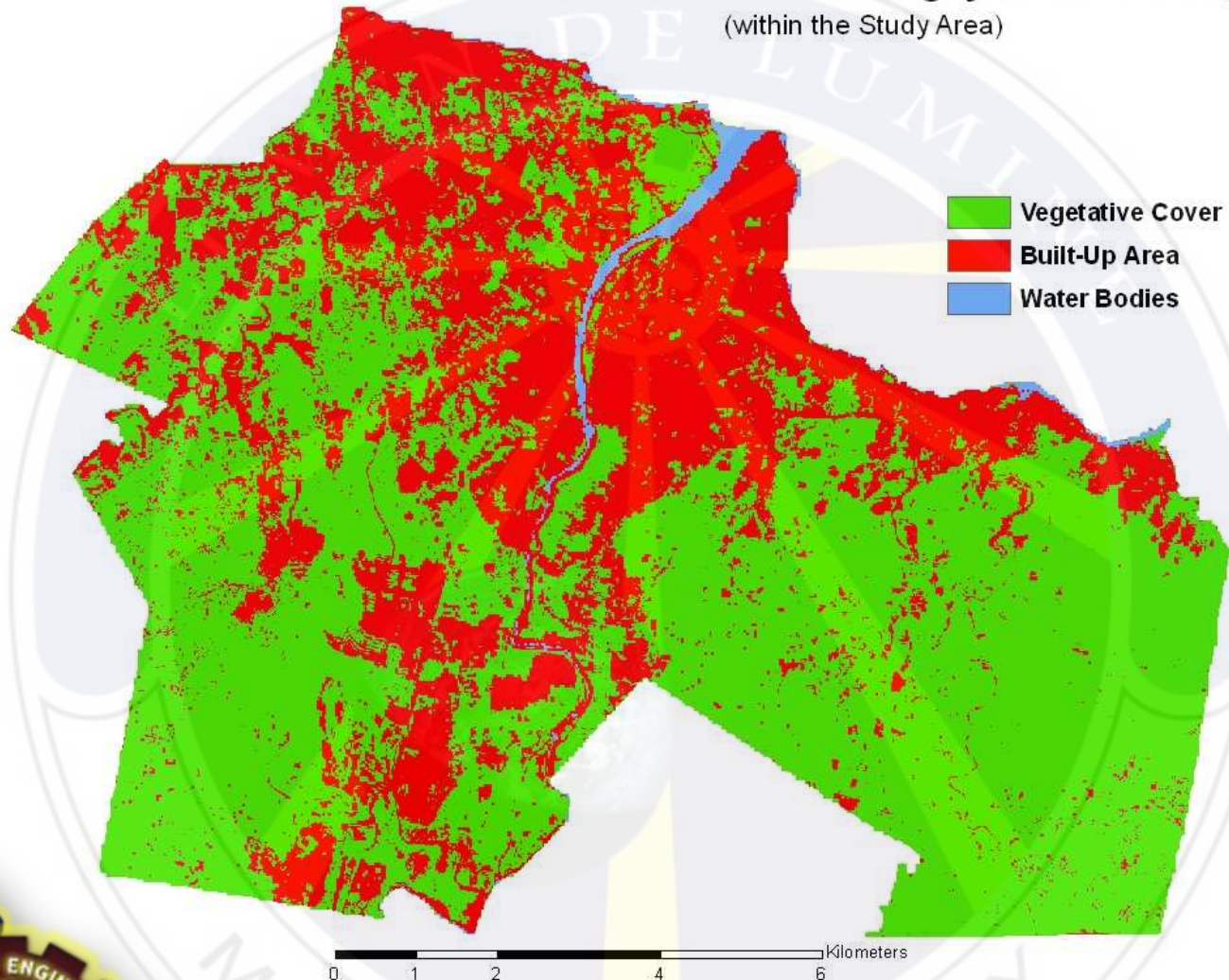
# Northern Mindanao, Region 10, Elevation (based on SRTM 90m data)





compliments of:  
MSabines

## 2005 Land Use/Cover in Cagayan de Oro City (within the Study Area)



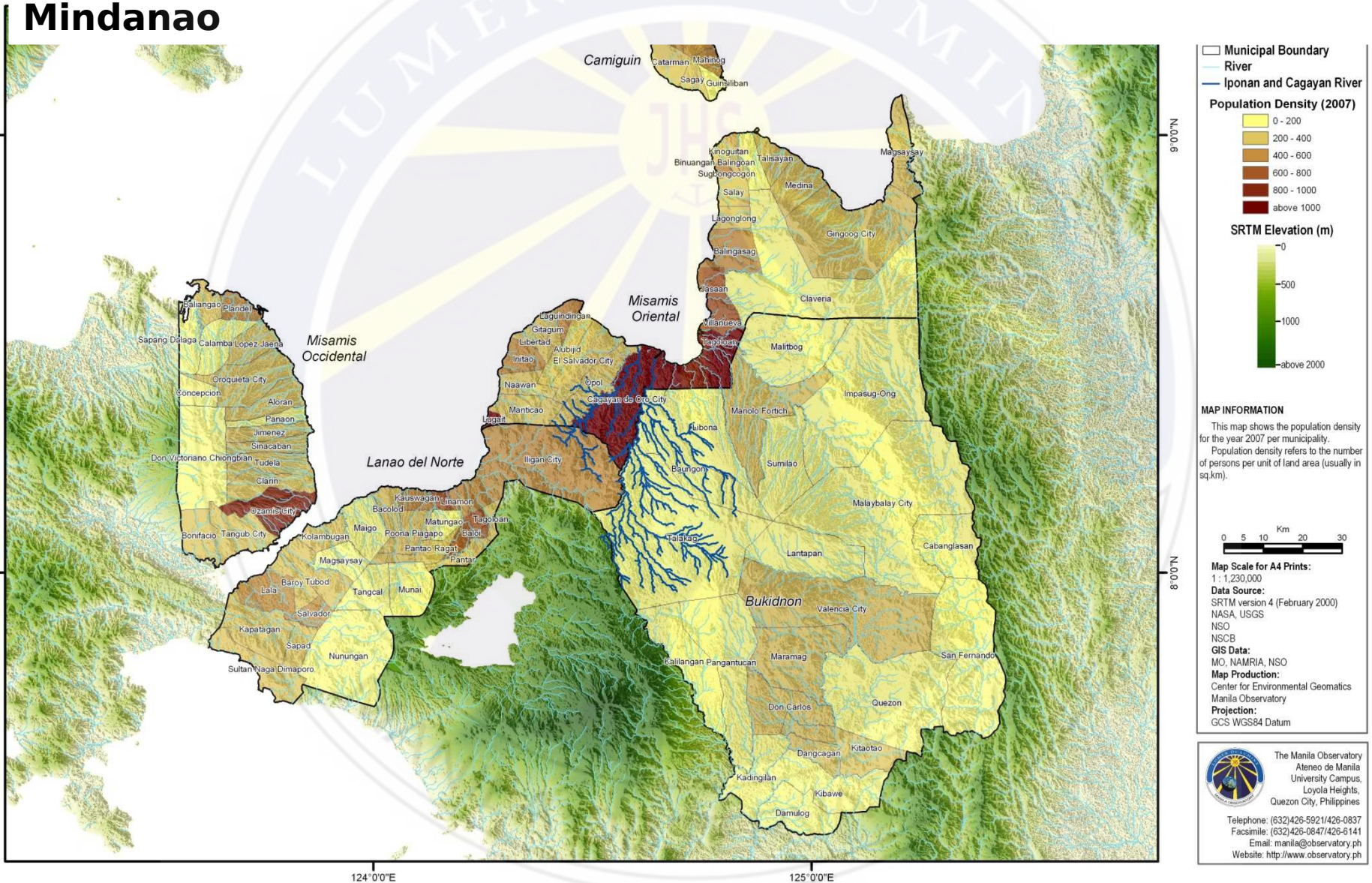
Source: SPOT taken 2005



Slide Courtesy of XU, XU ERC



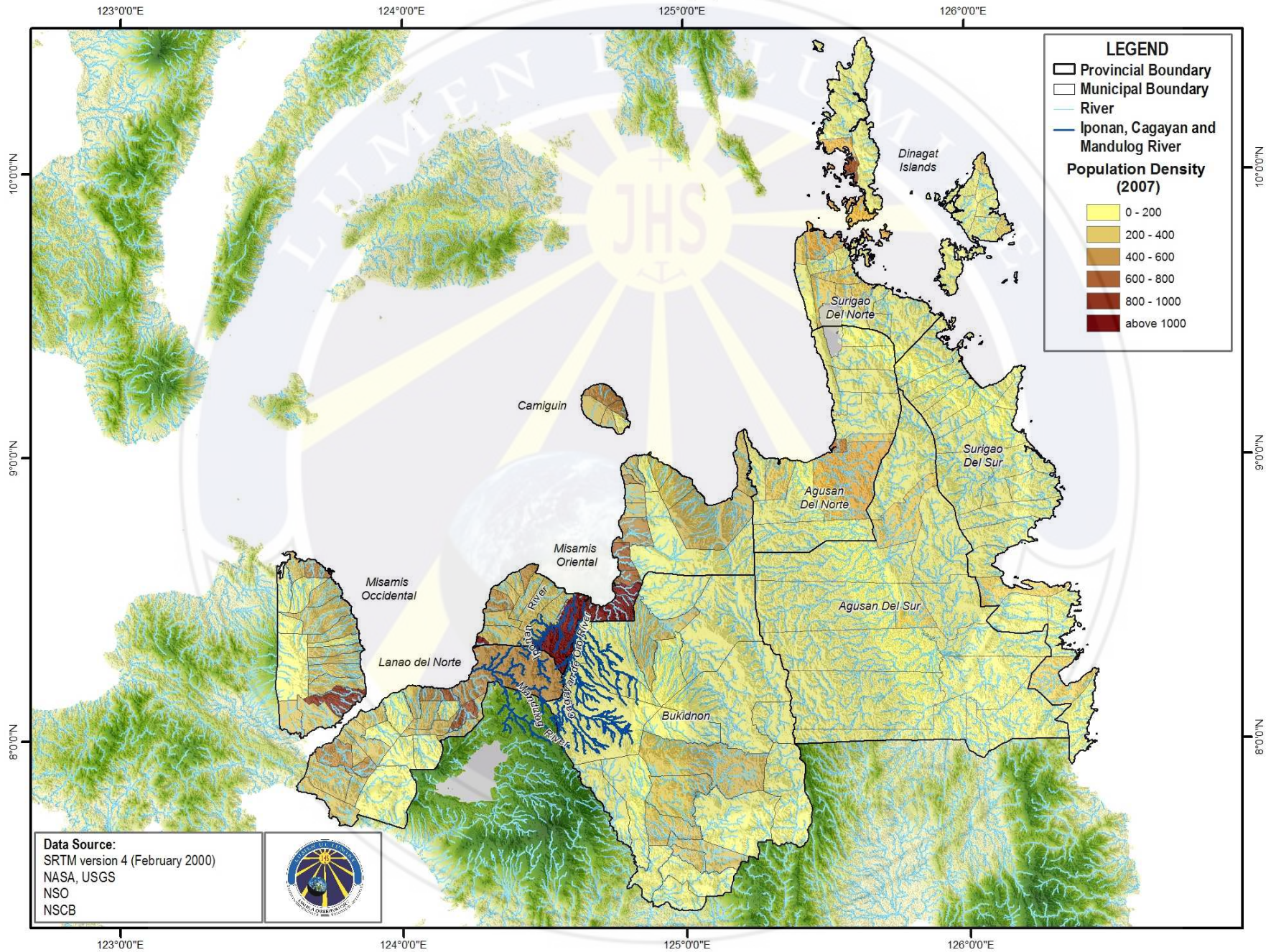
# Cagayan de Oro City has the highest population density by municipality/city for Misamis Oriental and the rest of Northern Mindanao





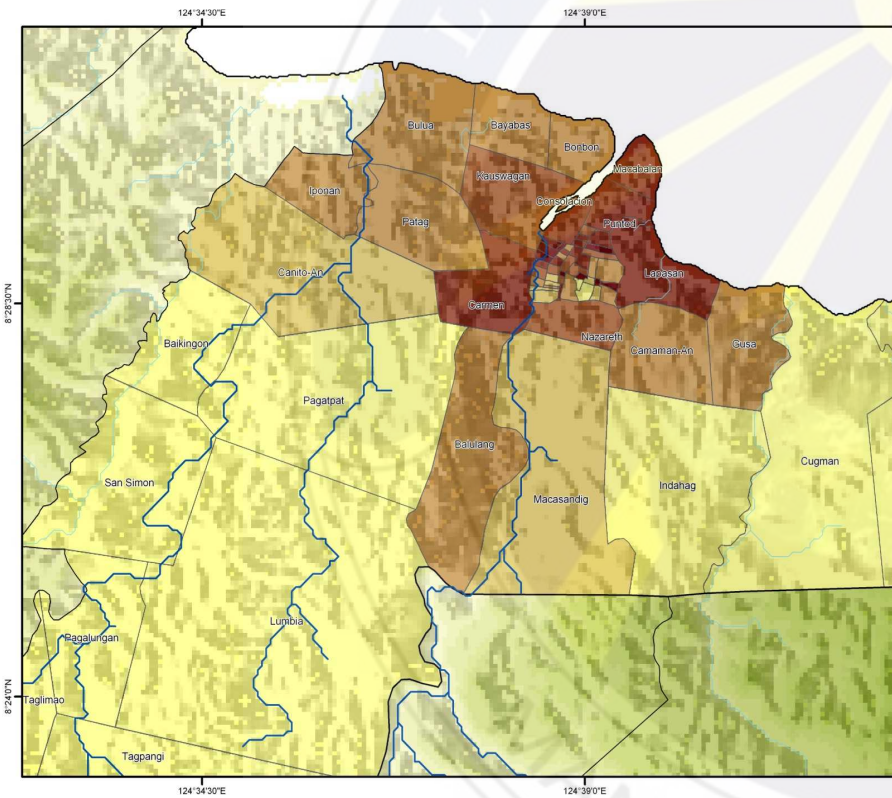
# CARAGA and Region 10

## Population Density (2007)

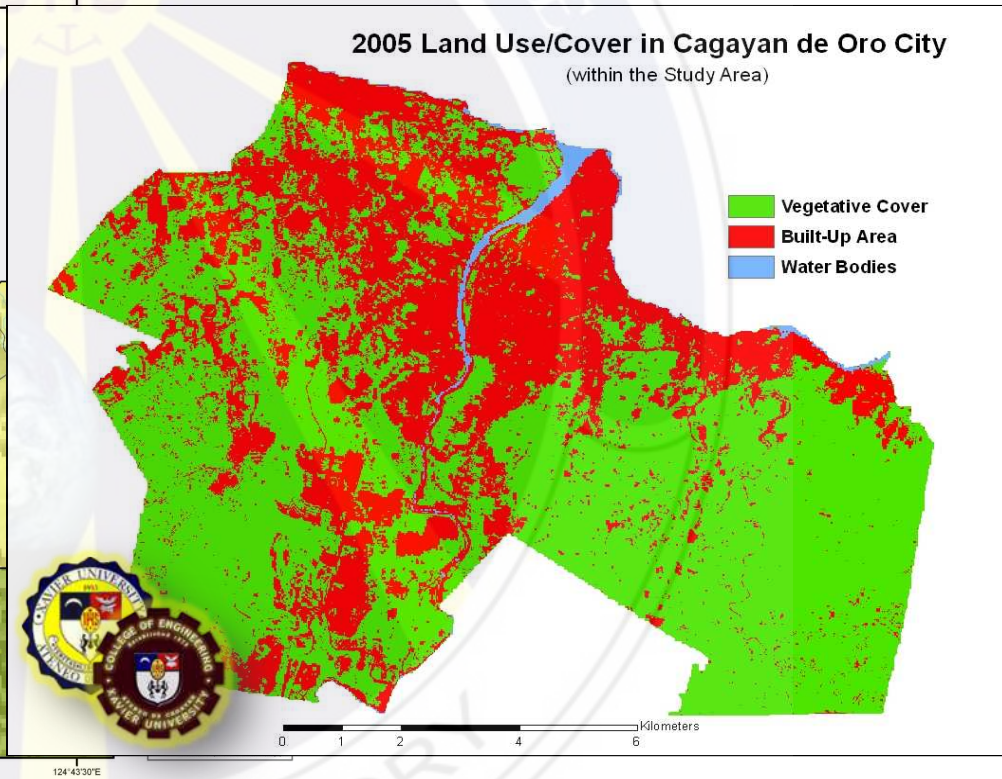




## 2007 POPULATION DENSITY

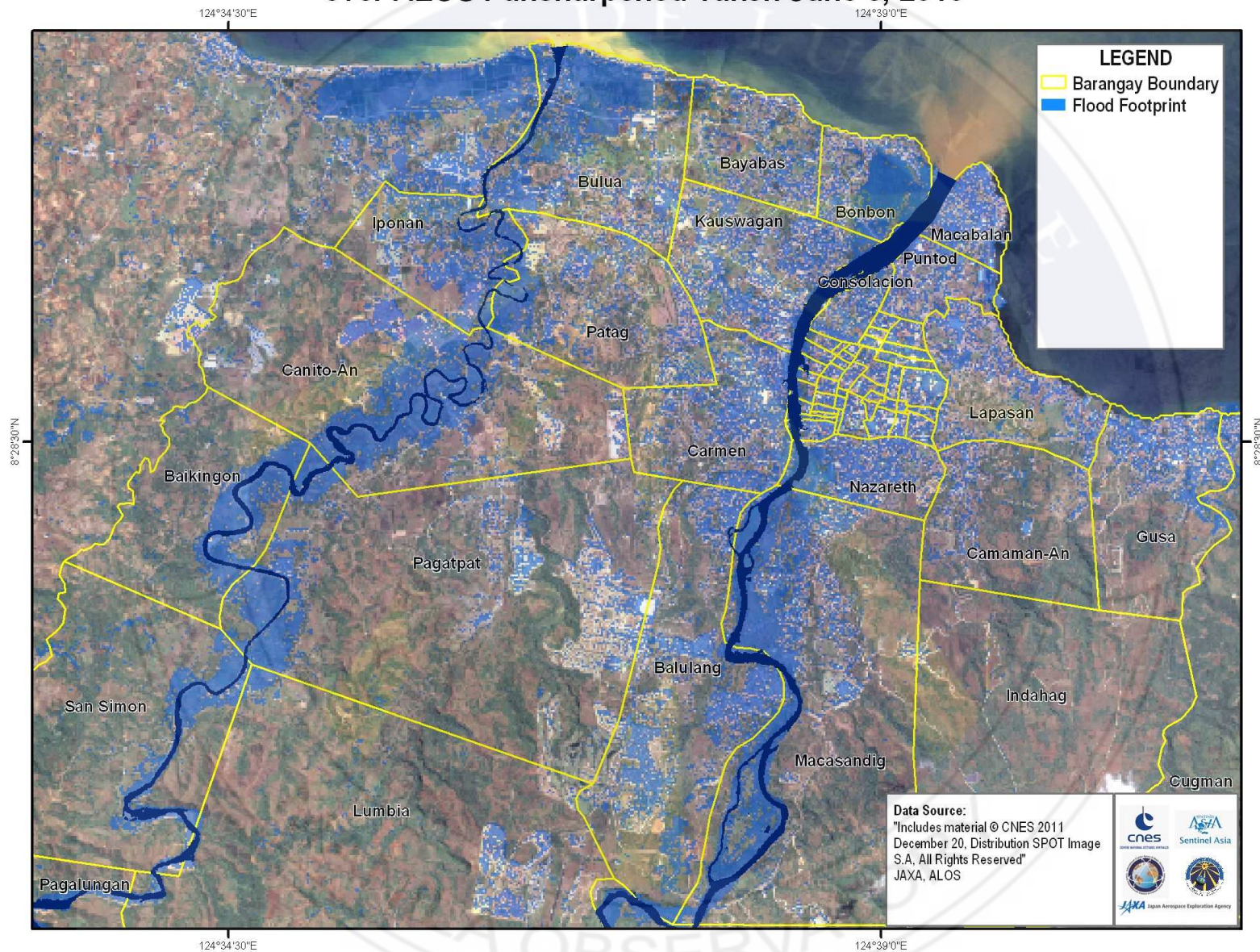


## 2005 LAND USE



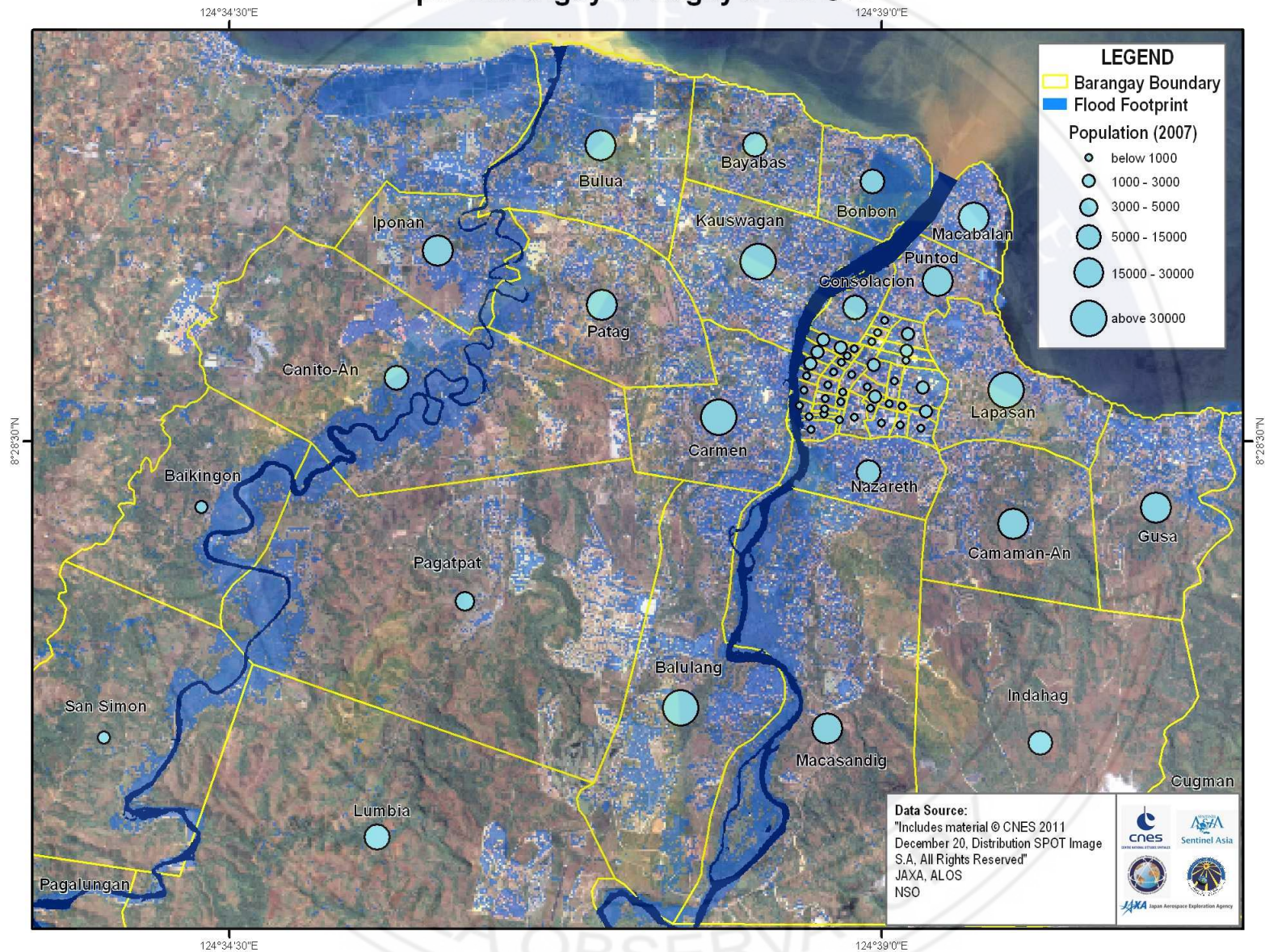


# Flood Footprint Extracted from SPOT4 taken December 20, 2011 over ALOS Pansharpened Taken June 5, 2010



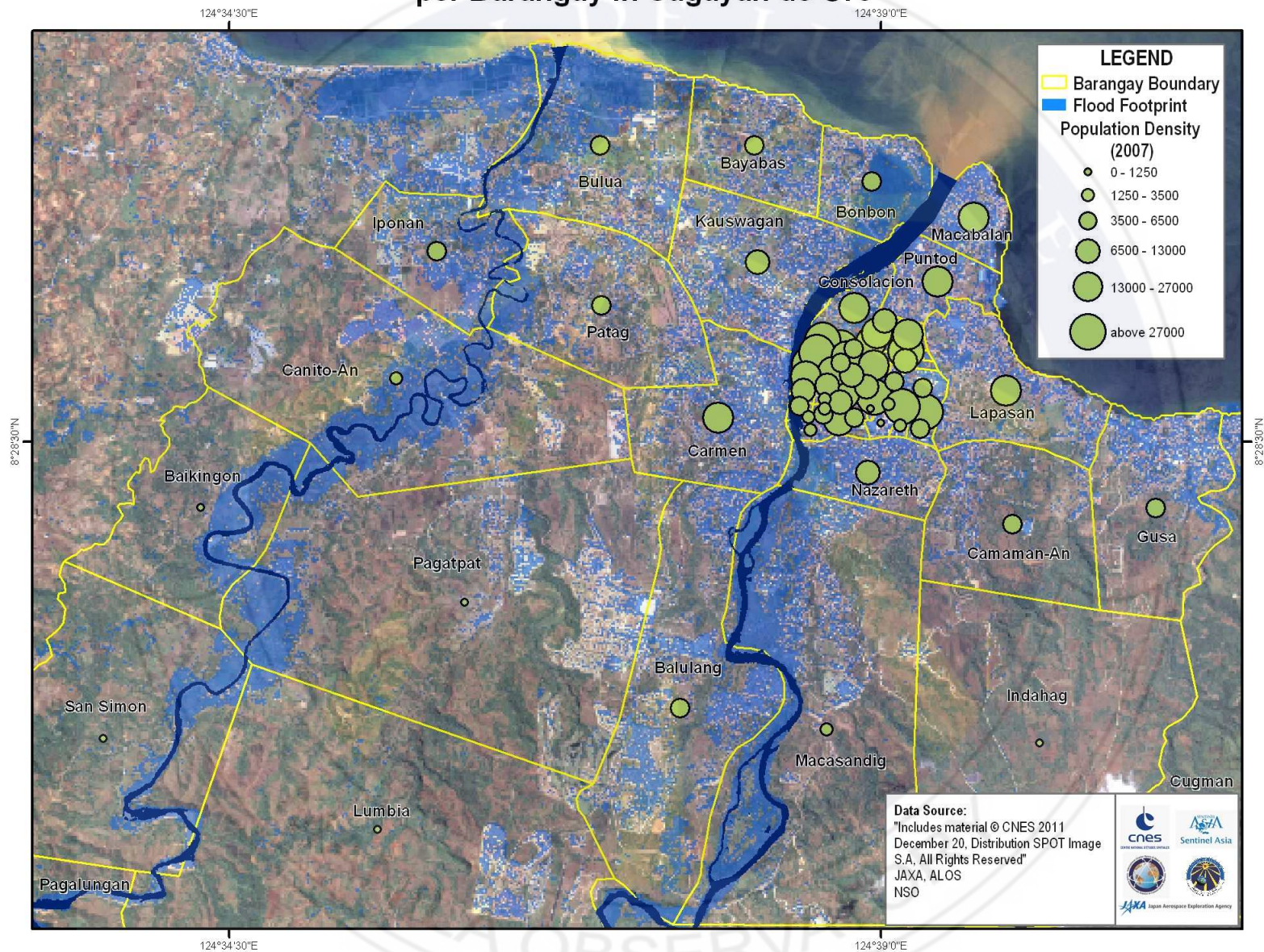


# Flood Footprint and Population (2007) per Barangay in Cagayan de Oro



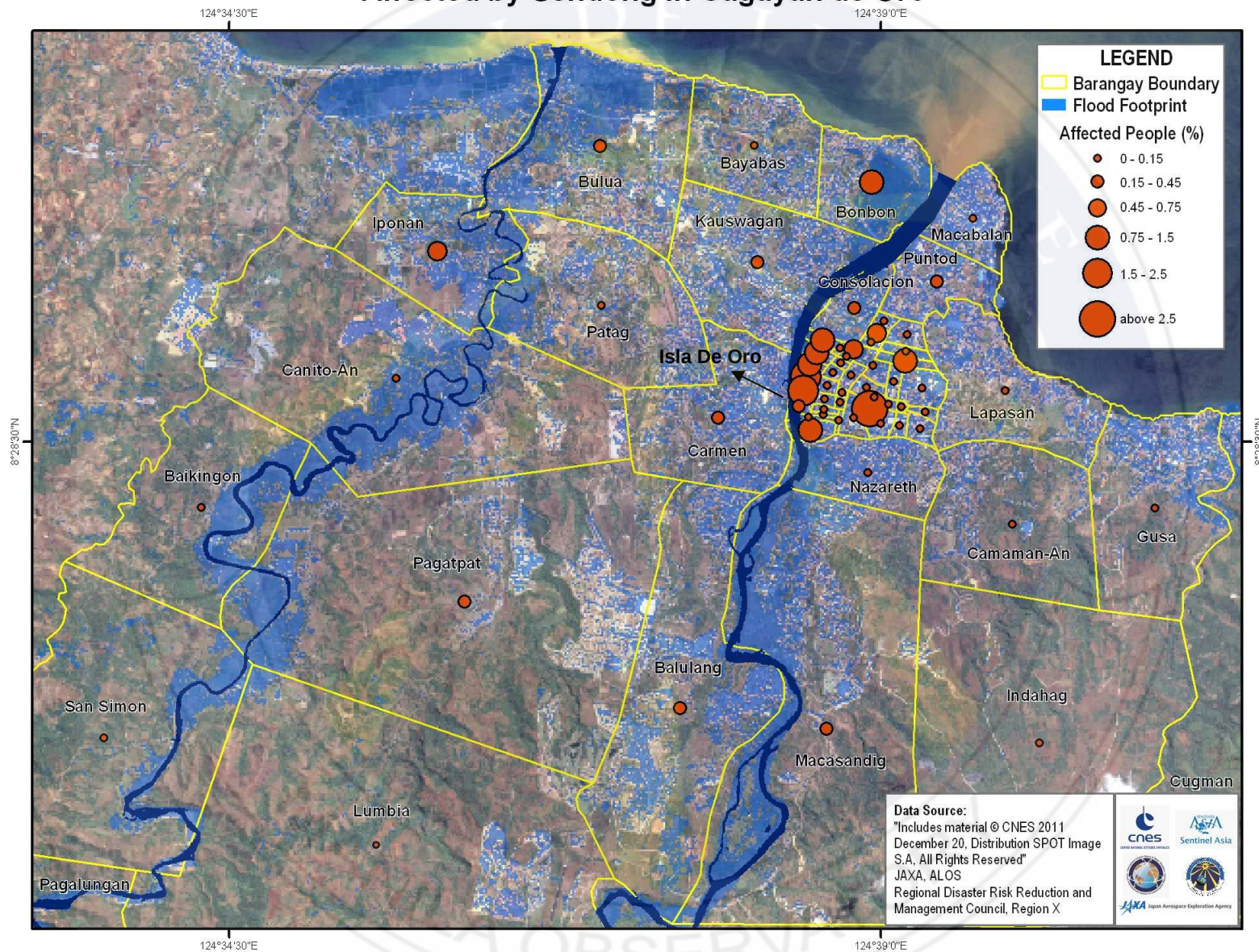


# Flood Footprint and Population Density (2007) per Barangay in Cagayan de Oro





# Flood Footprint and Percentage of People per Barangay Affected by Sendong in Cagayan de Oro





# Information Available:

1) Ground Observations

2) Satellite Data

3) **Archived Information**

(Social Demographics)

(Typhoon tracks, Climate)

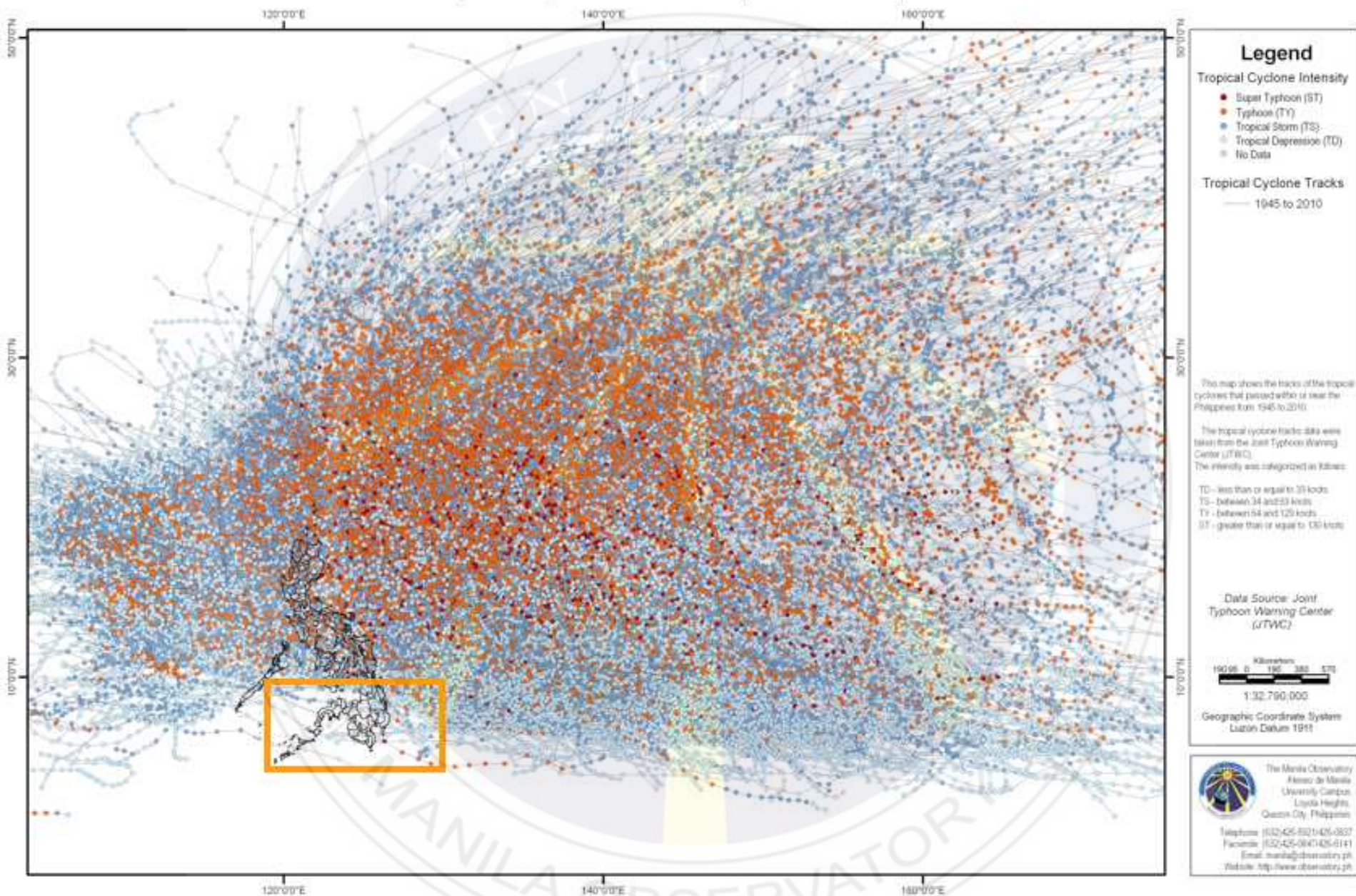




**AWARENESS ON HISTORICAL  
INFORMATION**

**DO TYPHOONS PASS  
THROUGH MINDANAO??**

# Tropical Cyclone Tracks (1945 - 2010)



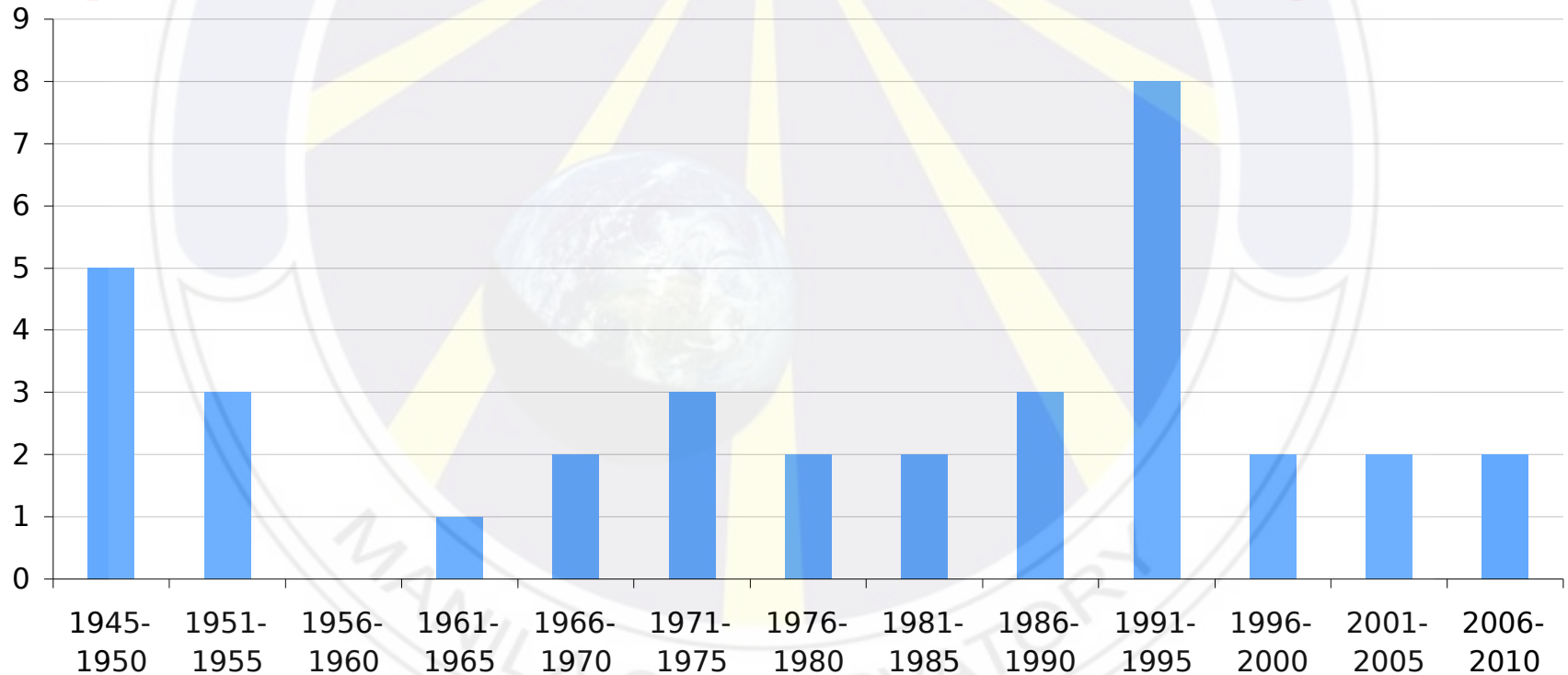


Number of typhoons that make landfall in Mindanao  
from 1945-2010 (BARS are EVERY 5 YEARS)

**35 typhoons in the last 65 years**

**6 typhoons in the last 15 years**

Number of typhoons



# Typhoons trajectories identified by Selga for 18

**~ 21 typhoons in 17 years  
passed through Mindanao**



Ap



May

June

July

August

September

October

November

December





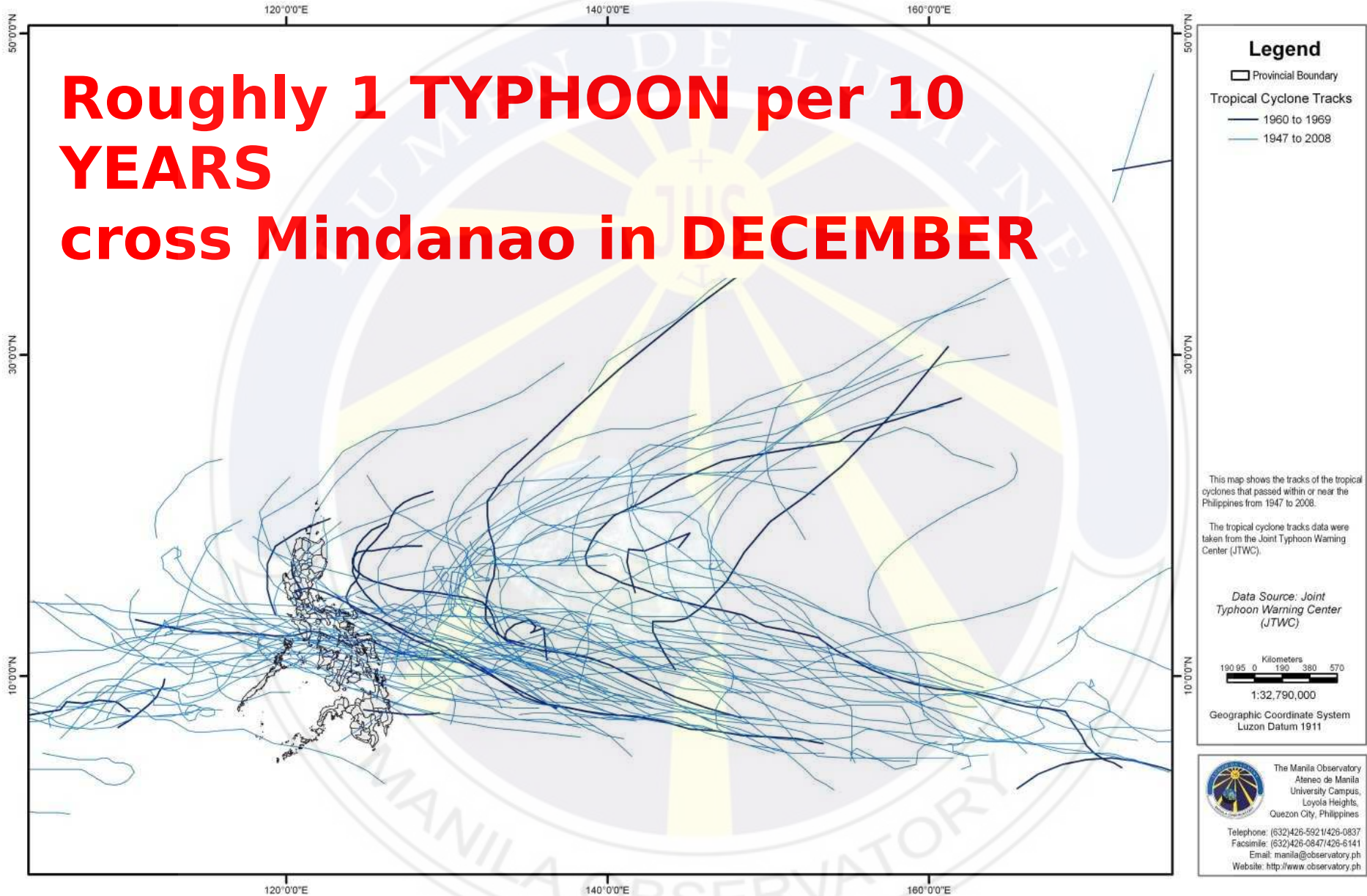
**AWARENESS ON HISTORICAL  
INFORMATION**

**DO TYPHOONS PASS  
THROUGH MINDANAO??**

**IN DECEMBER??**

## Tropical Cyclone Tracks from 1960 to 1969 in December

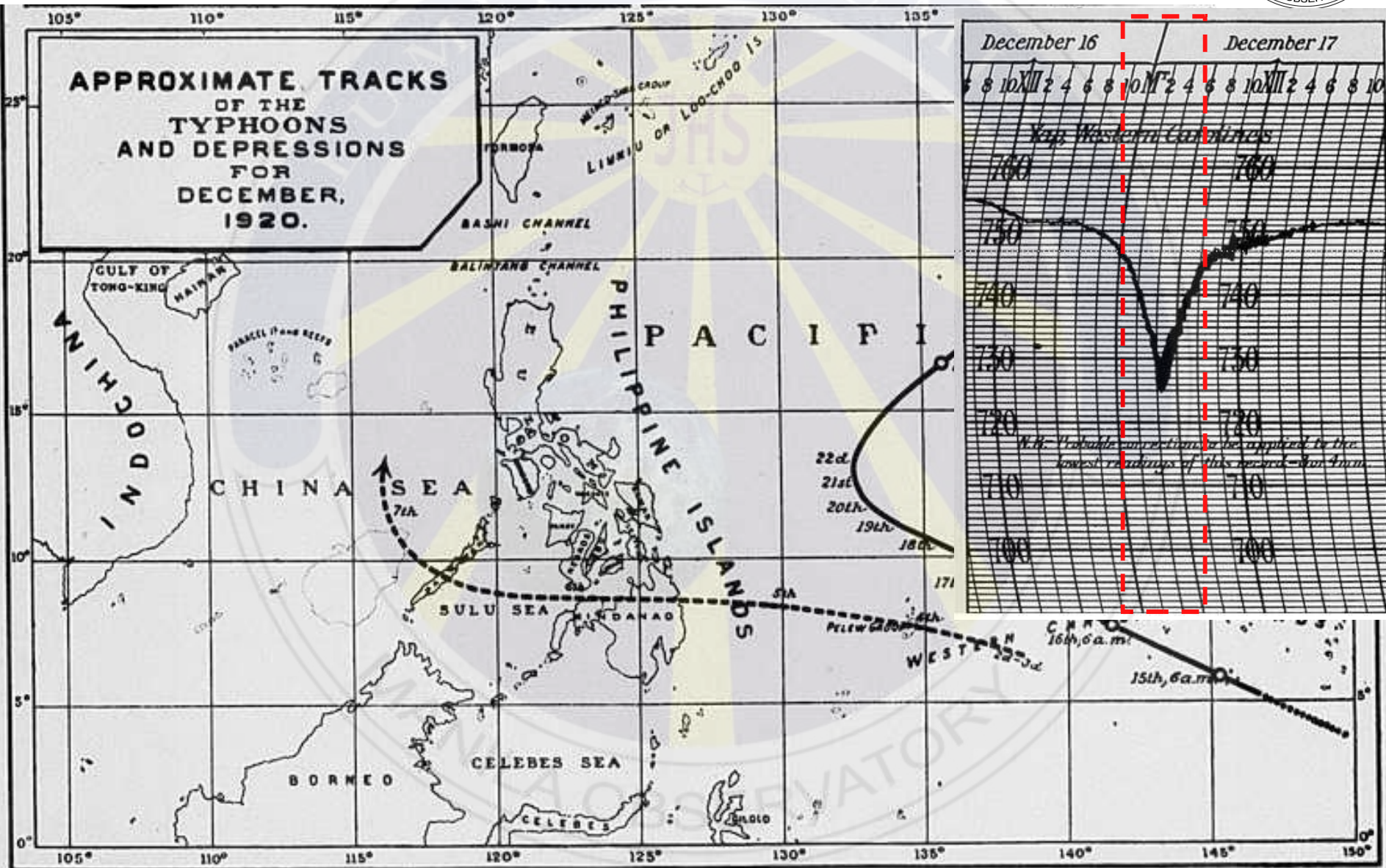
**Roughly 1 TYPHOON per 10 YEARS  
cross Mindanao in DECEMBER**





# DECEMBER 16-17, 1920

## Lowest pressure at ~4am



**APPROXIMATE TRACKS  
OF THE  
TYPHOONS  
AND DEPRESSIONS  
OF  
DECEMBER, 1930.**



**DECEMBER  
1930**



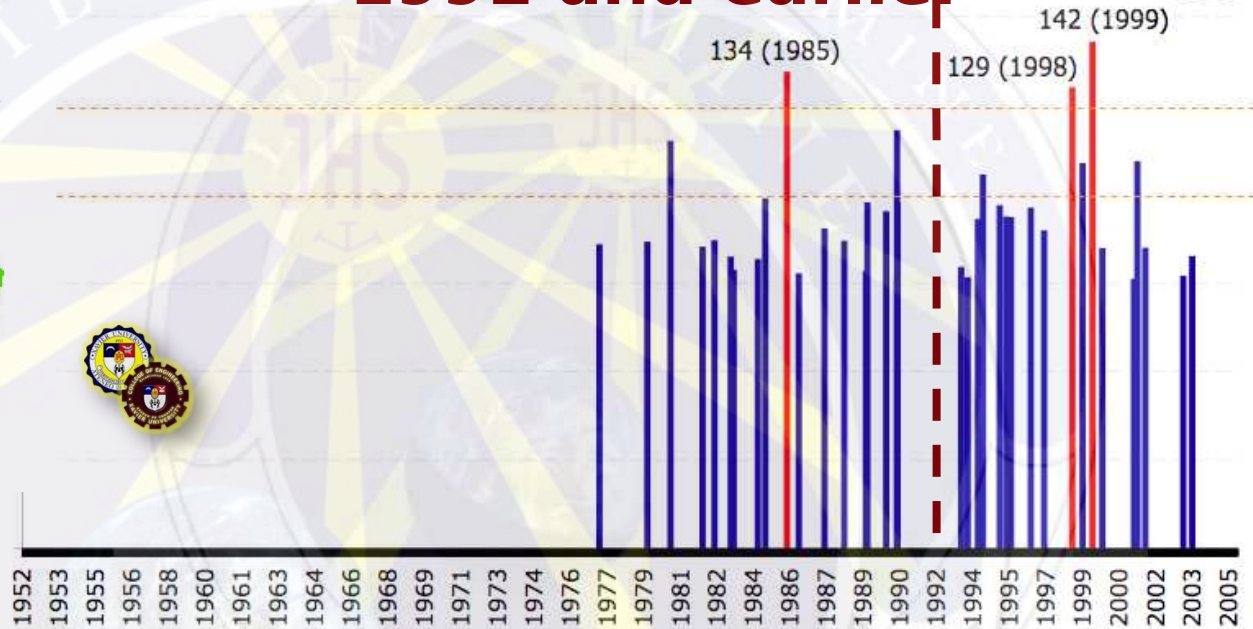
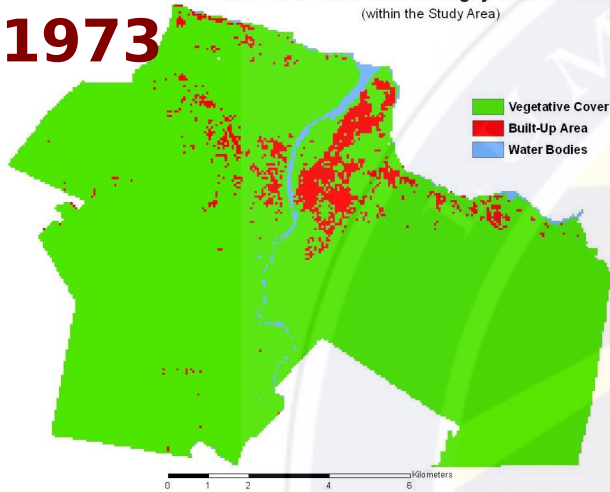
# Lumbia PAGASA Station (Rainfall mm/day)



## 1992 and earlier

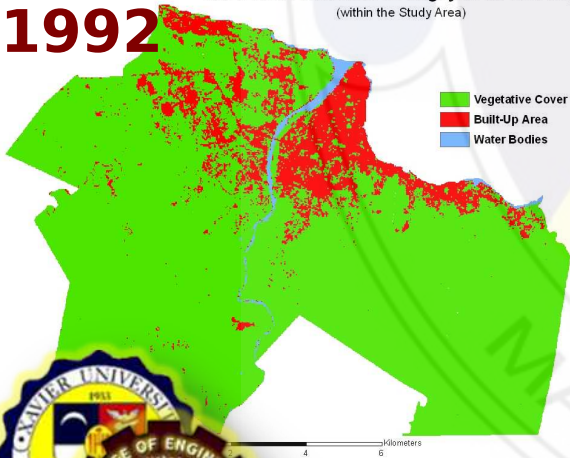
1973

1973 Land Use/Cover in Cagayan de Oro City  
(within the Study Area)



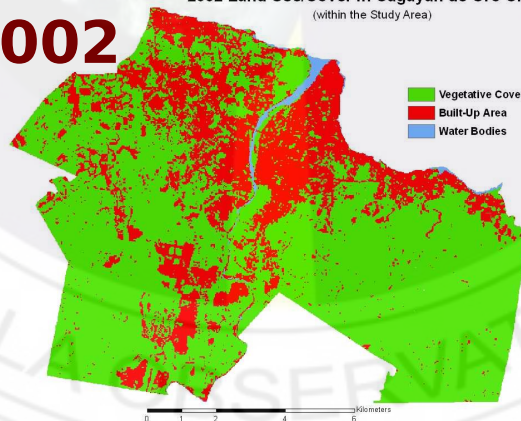
1992

1992 Land Use/Cover in Cagayan de Oro City  
(within the Study Area)



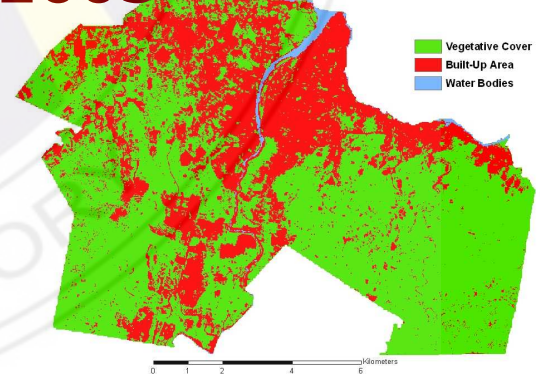
2002

2002 Land Use/Cover in Cagayan de Oro City  
(within the Study Area)



2005

2005 Land Use/Cover in Cagayan de Oro City  
(within the Study Area)



Land use figures courtesy of XU ERC





# Valuable contributions to this analysis come from:

Faye Cruz

Julie Dado

Emil Gozo

Raul Dayawon

Genie Lorenzo

Fernando Siringan

Toni Loyzaga

Celine Vicente

Gemma Narisma

Xavier University

Many thanks to Engr. Elpidio Paras for providing  
the data at the Dahilayan Adventure Park.



# Information Available:

- 1) Ground Observations
- 2) Satellite Data
- 3) Archived Information





What we are working on now:

1) Setting up more weather stations with local thresholds (around Phils, Manila)

2) Near real time data assimilation

3) Integrating info for public's use (bagyo page)