*AOMSUC-12 Training*
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# Introduction to Rainfall Nowcasting Using Satellite Images

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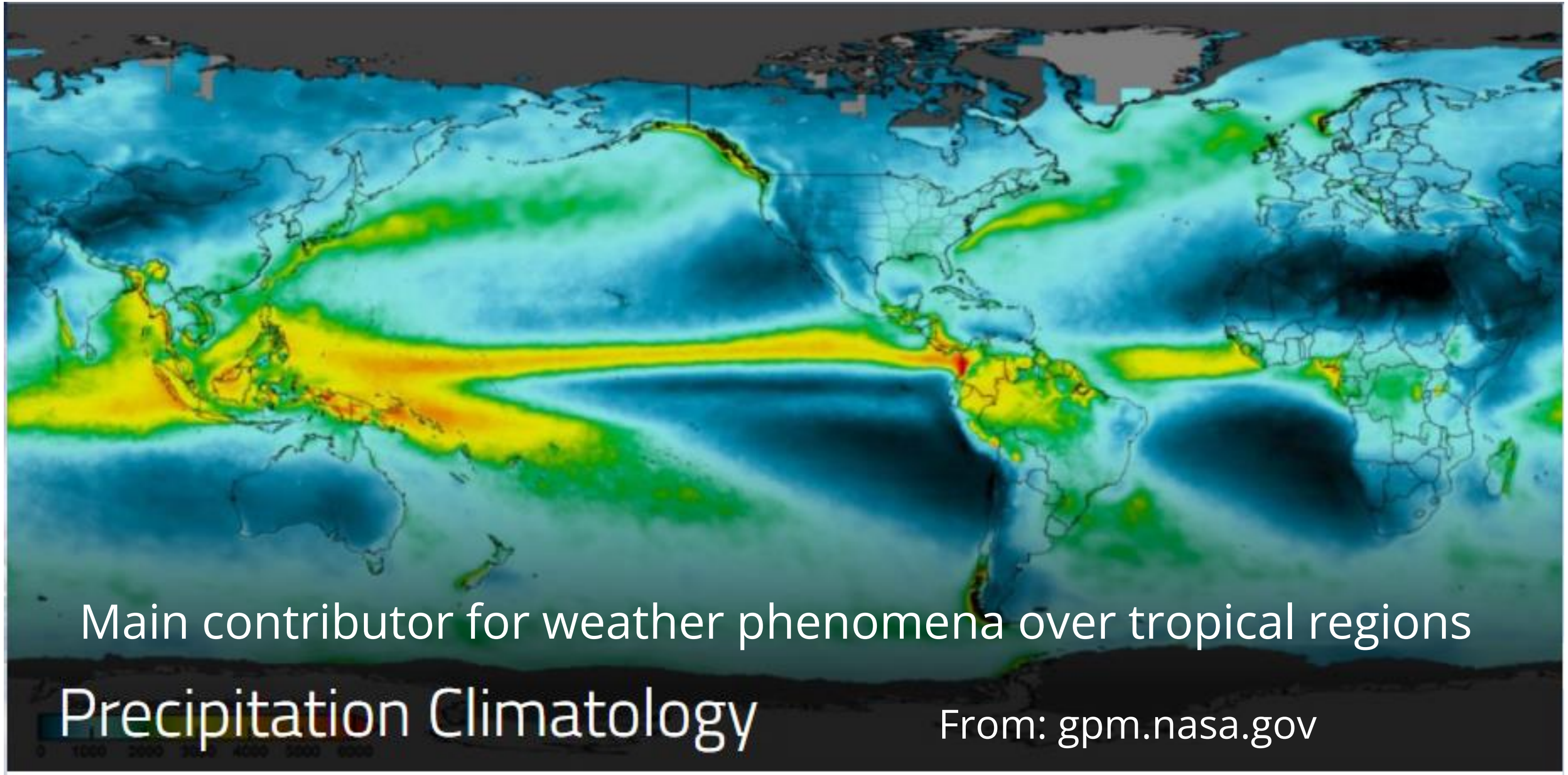
# Outline for today

1. Introduction
2. WMO definition of Nowcasting
3. Satellite measurement
4. IR-VIS Precipitation
5. Nowcasting Methods
6. Rainfall Estimation
7. Limitation
8. Satellite Parallax Correction
9. RGB for Nowcasting
10. Case Study
11. Summary

# Intro: Rainfall in the Tropics



# Intro: Heavy Rainfall

**Heavy rainfall due to extreme weather condition may cause natural hazards such as floods and landslides.**

**Providing the information of this rainfall event is essential**

# Nowcasting

- **Definition** : Forecasting with local detail over a period from the 0 to 6 hours ahead
- **Tools** : radar, satellite, ground observational data, NWP
- **Target** : Mesoscale and local scale weather (usually storm)
- **Output** : warning the public of hazardous, high-impact weather including tropical cyclones, thunderstorms and tornadoes which cause flash floods, lightning strikes and destructive winds

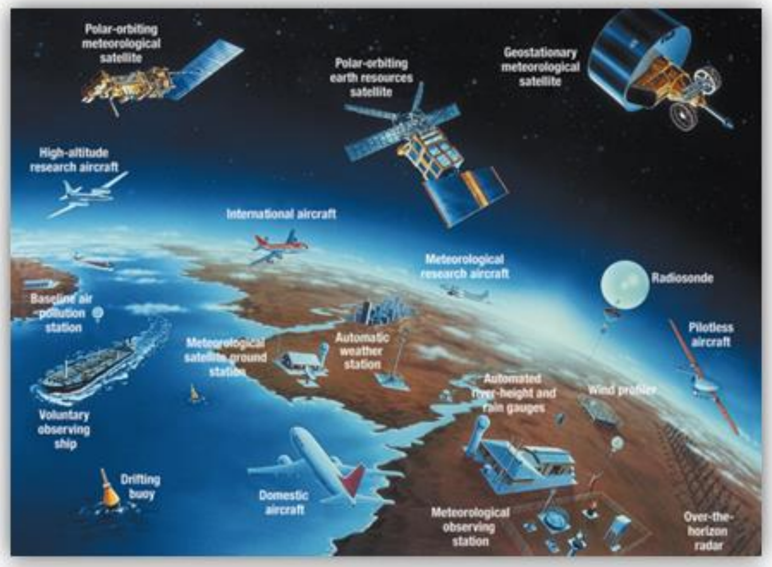
(WMO)

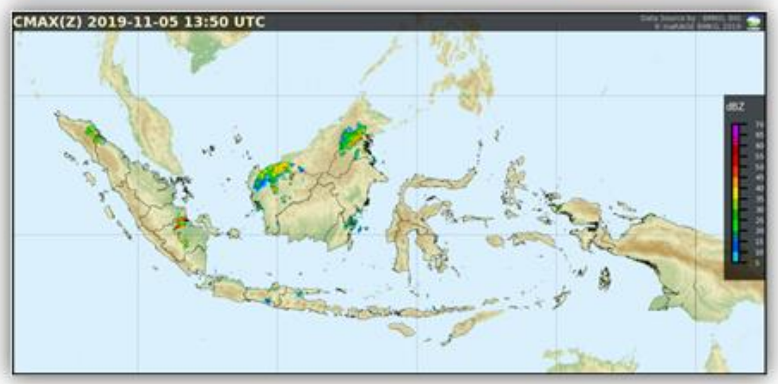
# Why Satellite?

•Rain Gauge data are available on land only (densely populated area).

•Radar is effective tool for observing precipitation, but high cost and limited to maximum range detection (about 300 km).

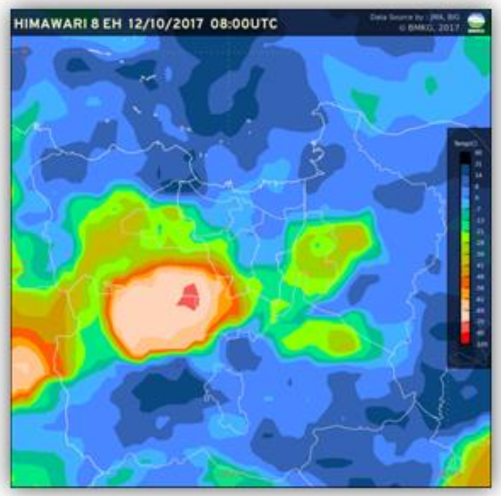
•**Most of geostationary meteorological satellite data can be accessed freely and available for global coverage with short time interval observation.**



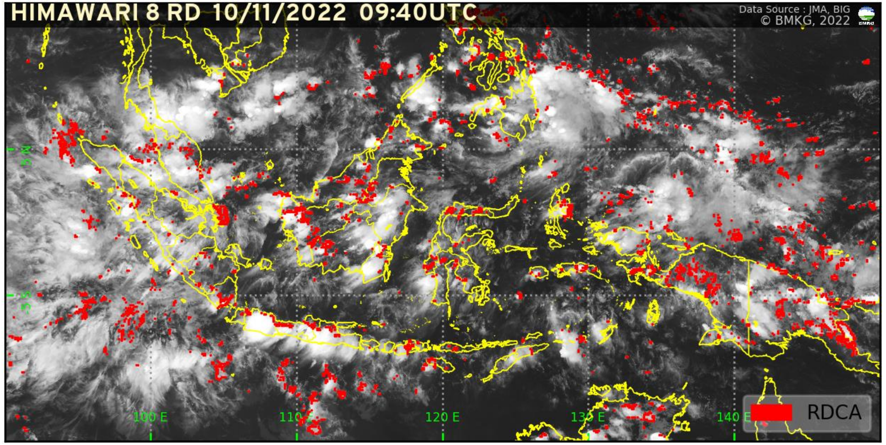



# IR-VIS-precipitation

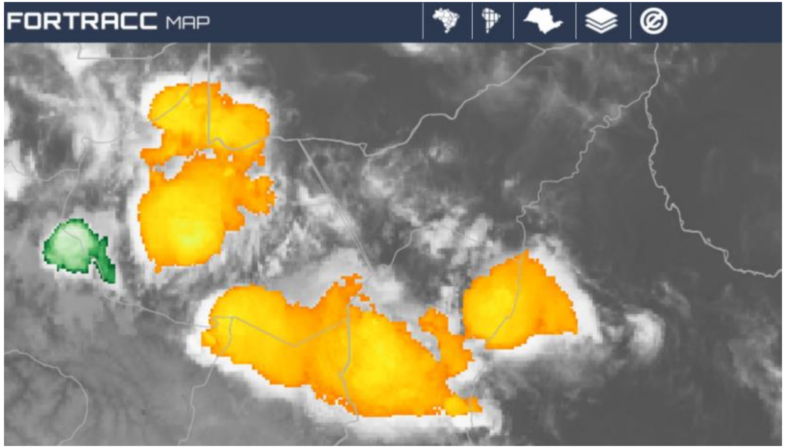
- Satellite infers precipitation indirectly from emitted infrared radiation and reflectance by clouds.
- **IR:** Lower IR brightness temperature means higher cloud top.
- **VIS:** Higher cloud albedo means the more droplets and/or ice crystals it contains and the deeper it tends to be.
- Better to combine both for cirrus removal.

# Nowcasting Methods using Satellite




Rapidly Developing Cumulus Area (RDCA)
Developed by JMA

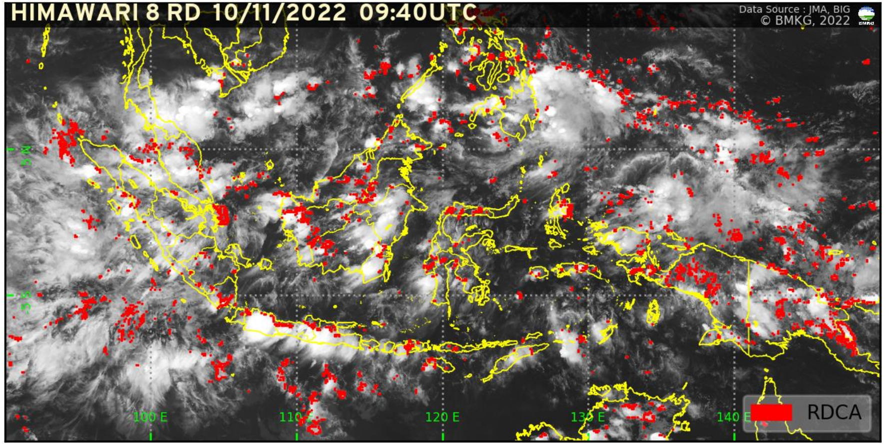



Forecast and Tracking the Evolution of
Cloud Clusters (ForTraCC)

Rapidly Developing Cumulus

Cloud Tracking

# Rapidly Developing Cumulus Area (RDCA)




Extract detection candidate area (removes clear region and thin cloud area)

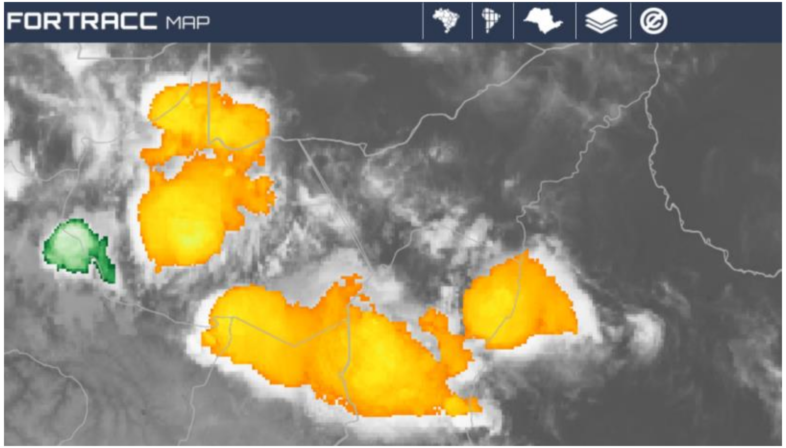
↓

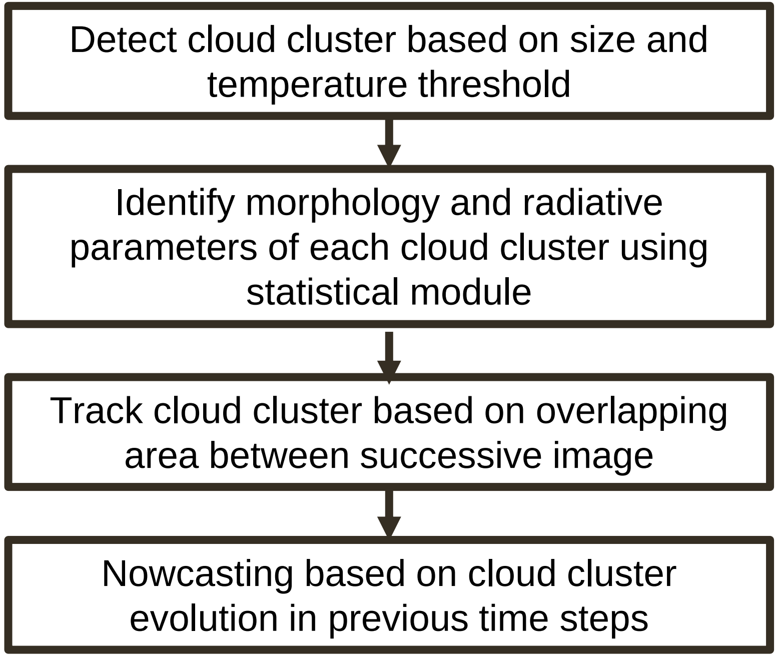
Calculate detection parameters (11 parameters)

↓

Calculate prediction index (based on 11 parameters) and decision process

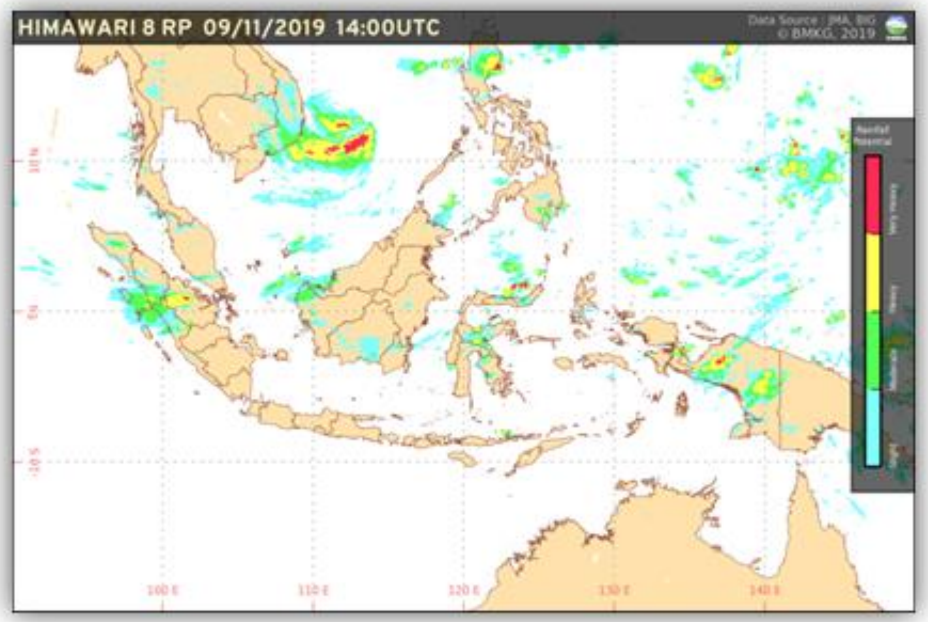
# Forecasting and Tracking the Evolution of Cloud Clusters (ForTraCC)

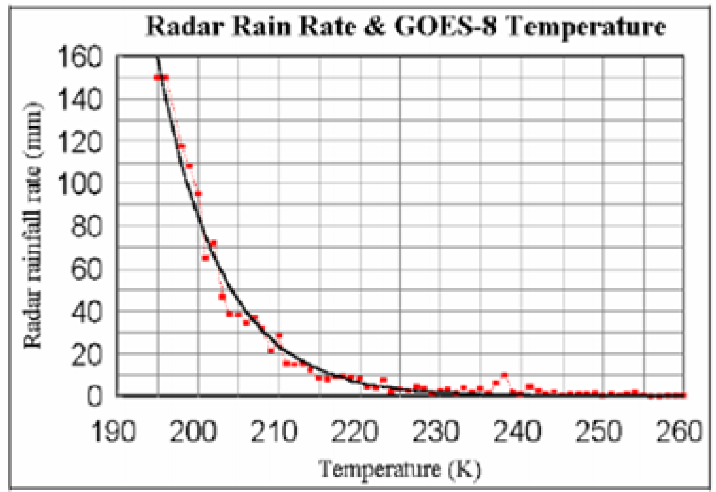


# Rainfall Estimation

Various techniques have been developed to estimate rainfall from visible and/or infrared (IR) radiation




- Vicente et al (1998) :

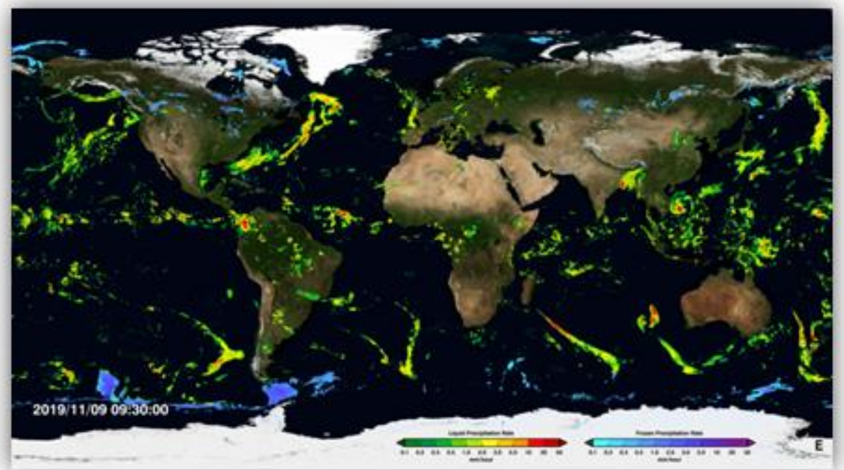
$$R = 1.1183 \times 10^{11} \times \exp(-3.6382 \times 10^{-2} \times T^{0.5})$$

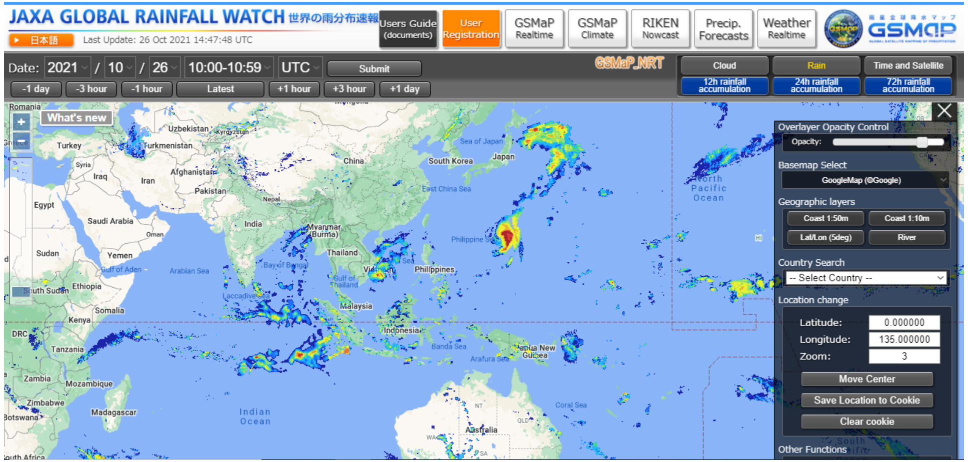
# Precipitation Estimation

Below are rainfall estimation based on satellite products which inferred not only from IR but also microwave radiation from polar satellites

**Integrated Multi-satellitE Retrievals for GPM (IMERG)**

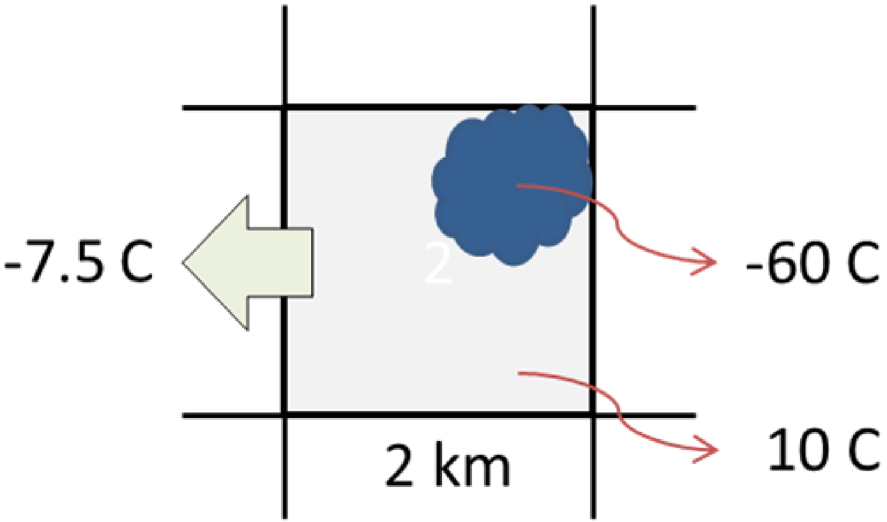
**Global Satellite Mapping of Precipitation (GSMaP)**



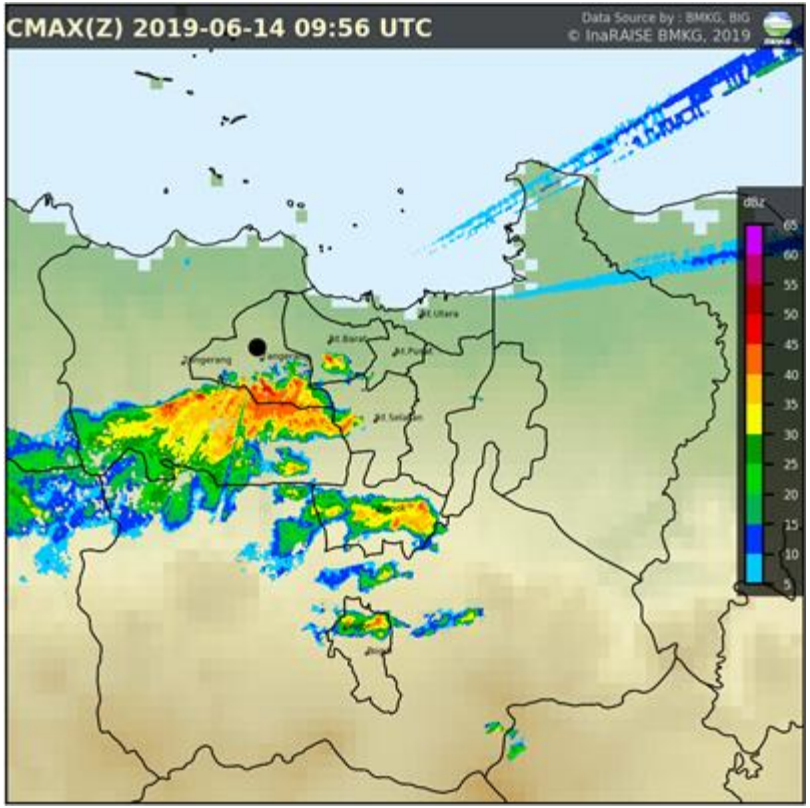
# Limitation

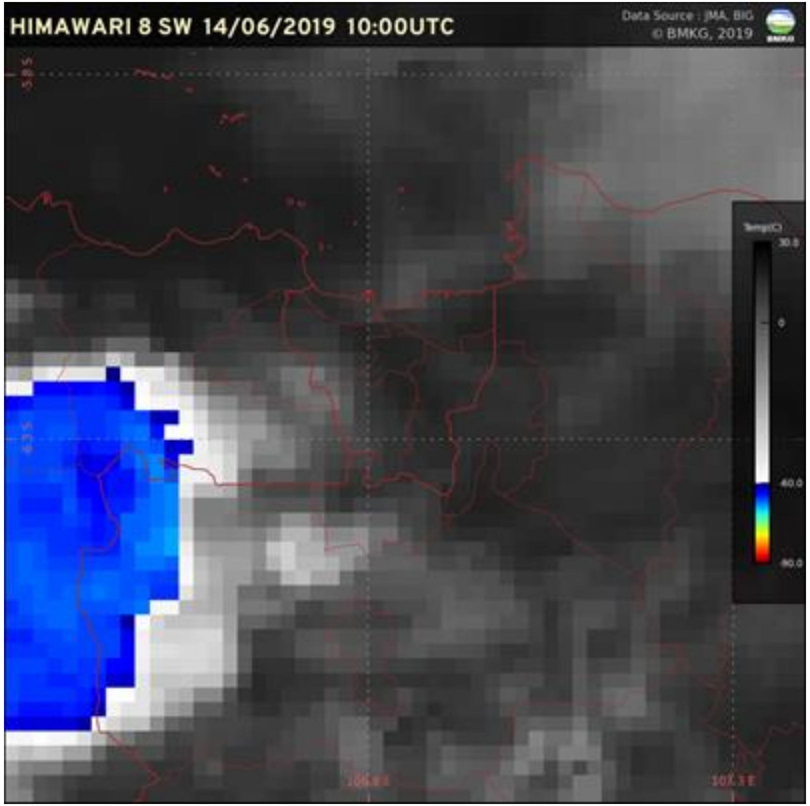
- Cirrus filtering is difficult due to absence of visible imagery at night
- Short convective cloud lifetime
- Sub-grid cumulonimbus
- Slanted view for higher latitude
- Data latency



# Satellite Parallax Correction

***Rainfall shift under top of Cumulonimbus (height: 15km) around 20 km to east***



# Satellite Parallax Correction

A : Apparent Top Cloud Location

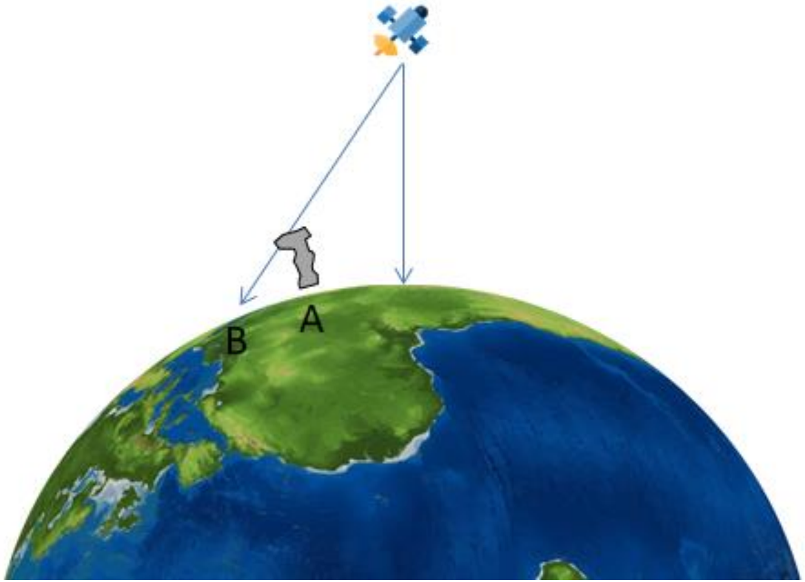
B : Actual Top Cloud Location

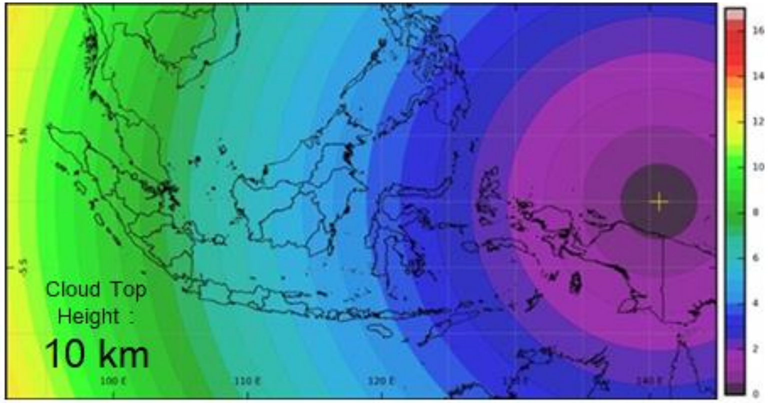
Distance A-B : Parallax

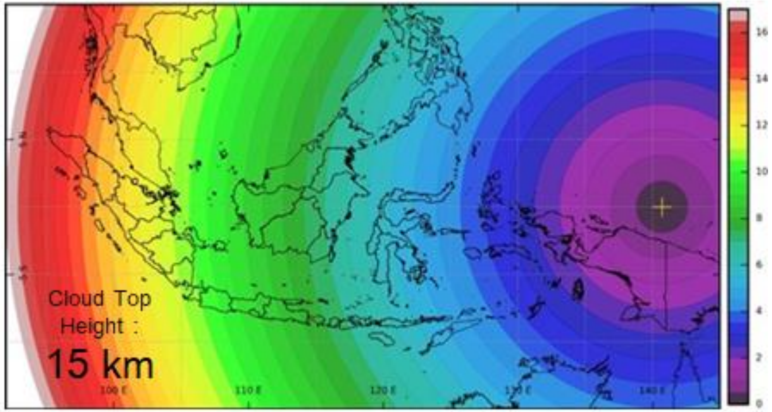
Depends on :

-Cloud top height

-Cloud distance from subsatellite point



# Question (1)

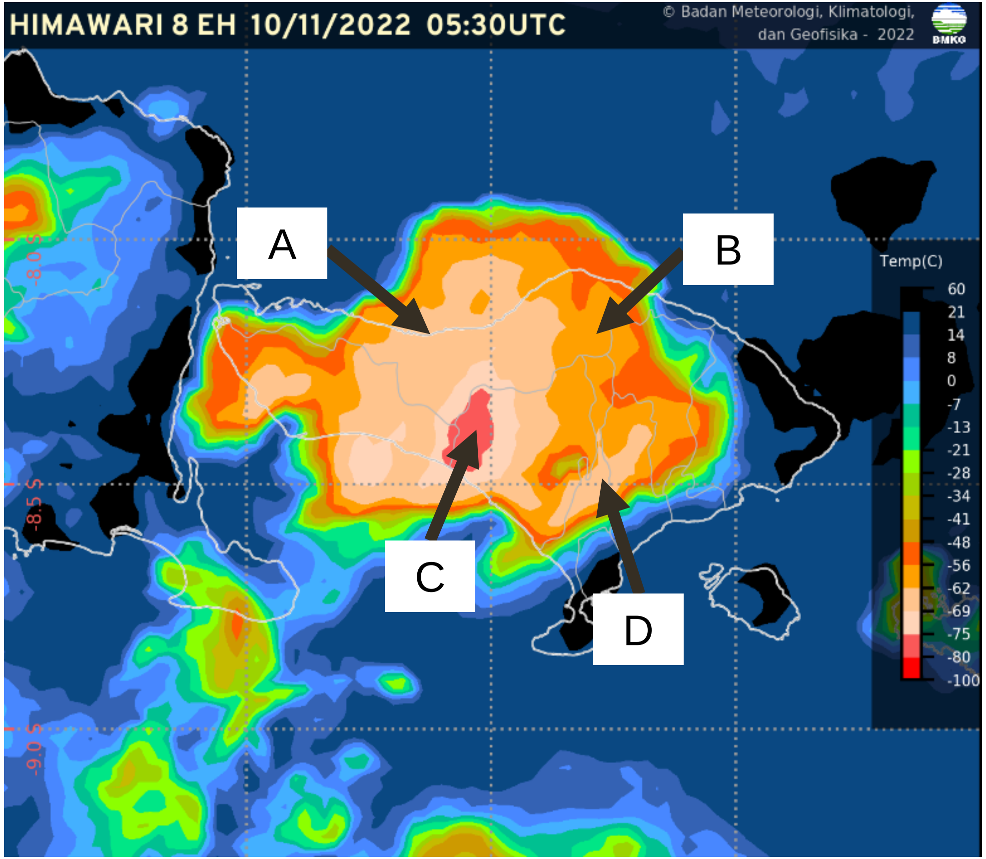
Which area has the highest potential for heavy rainfall?

a)A

b)B

c)C

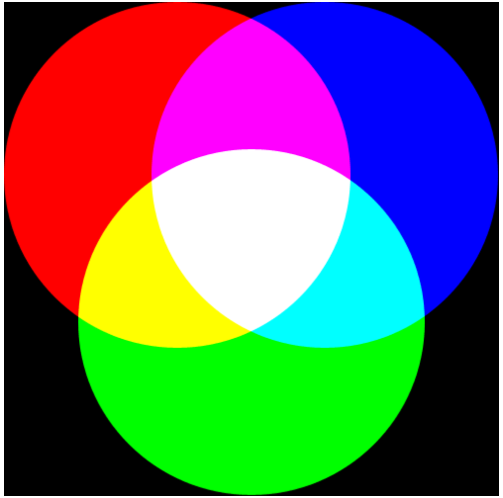
d)D

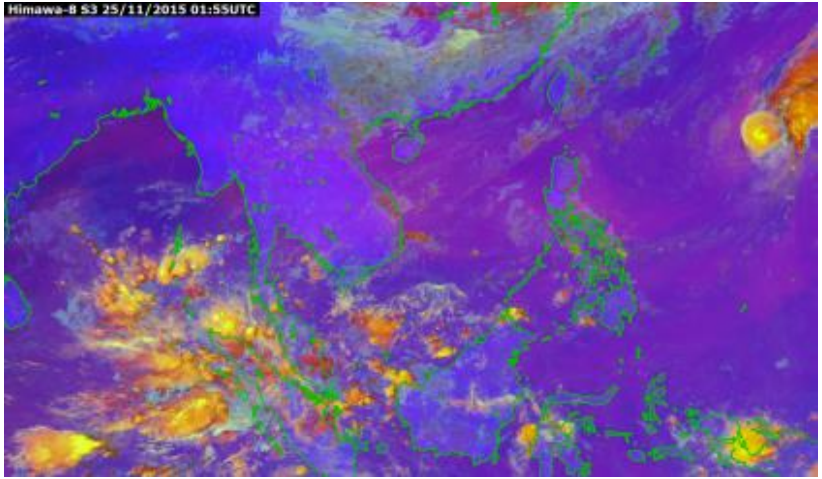


# RGB Composite

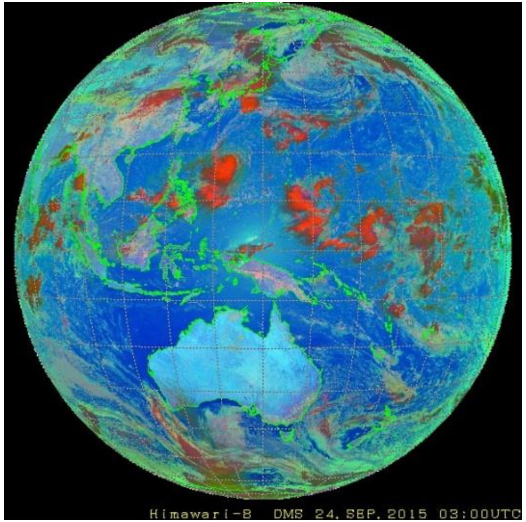
Composite of **Red (R)**, **Green (G)**, and **Blue (B)** with specific intensity creates specific color. Intensity of each color range from 0 to 255.

R(255) + G(100) + B(0) = **Orange**
R(255) + G(0) + B(255) = **Purple**

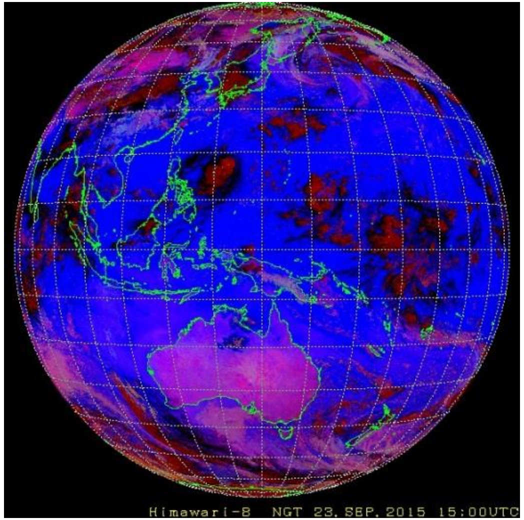




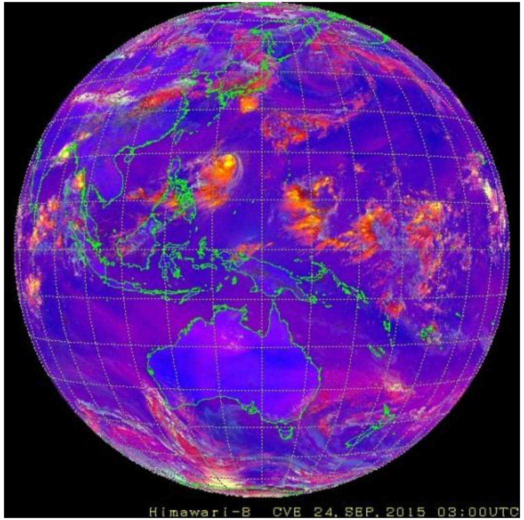
# RGBs for Nowcasting (Himawari-8)




Day Microphysics



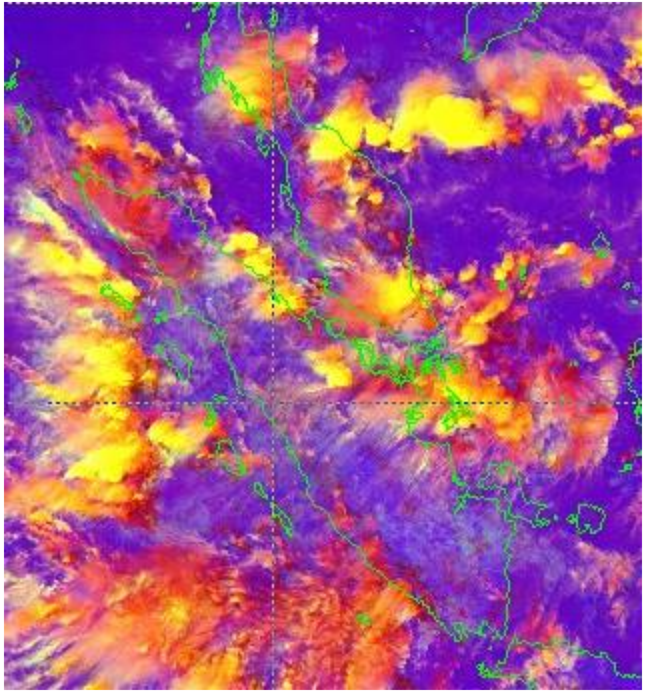

Night Microphysics




Day Convective Storm

http://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php?area=fd_

# Day Convective Storm RGB



**Red** : 7.3 – 6.2 μm
**Green** : 10.4 – 3.9 μm
**Blue** : 0.64 – 1.6 μm

Intensity of **Red** is calculated by subtracting brightness temperature (BT) of 7.3 μm with BT of 6.2 μm

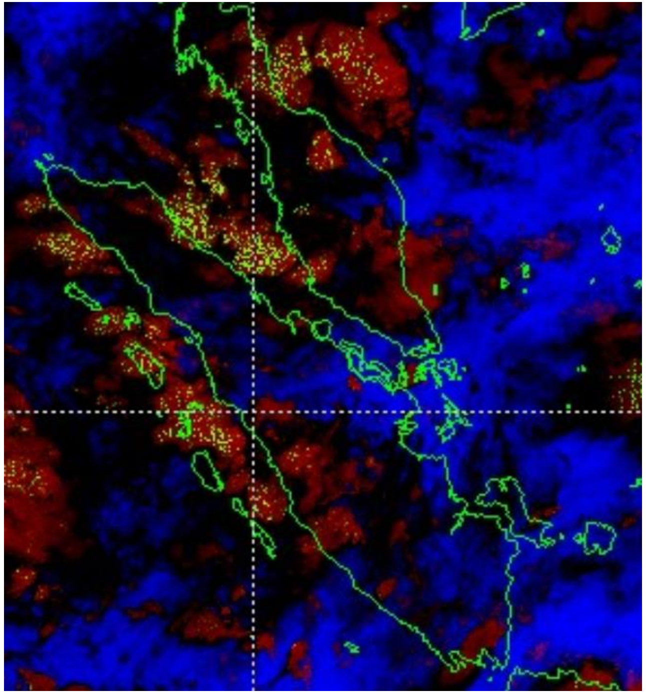
When it comes to nowcasting a thunderstorm, we're looking for **bright yellow color** on the image.



Cumulonimbus cloud with strong updraft

High-level cloud with ice particles

# Night Microphysical RGB



**Red** : 12.4 – 10.4 μm
**Green** : 10.4 – 3.9 μm
**Blue** : 10.4 μm

Intensity of **Blue** is calculated based on the brightness temperature 10.4 μm

Very cold, thick, high-level cloud

# Question (2)

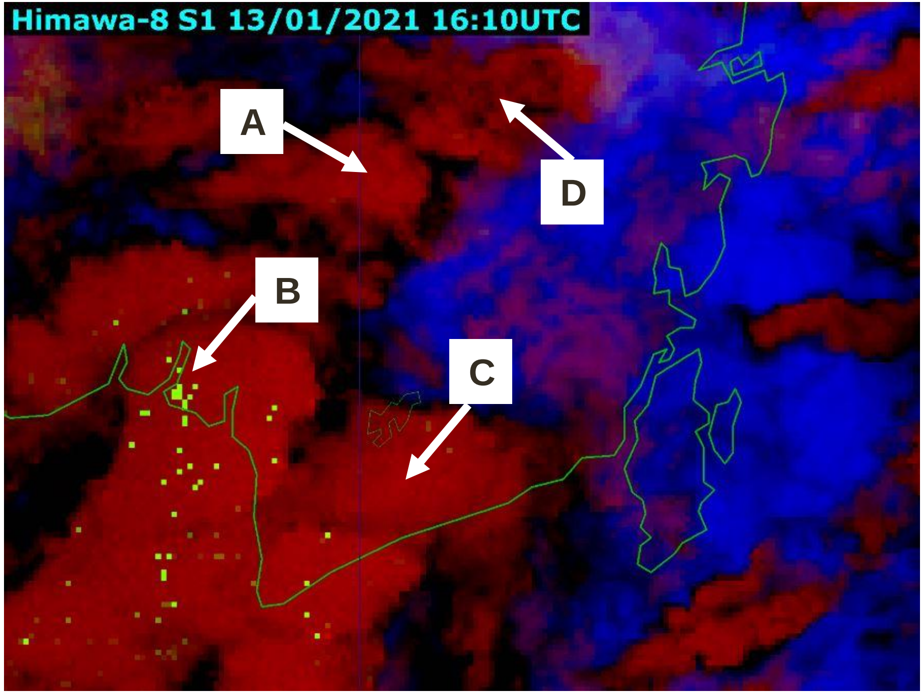
Which area has the highest potential for heavy rainfall?

a)A

b)B

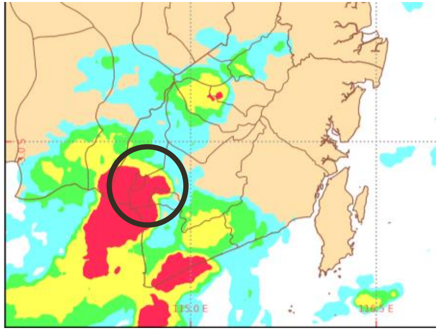
c)C

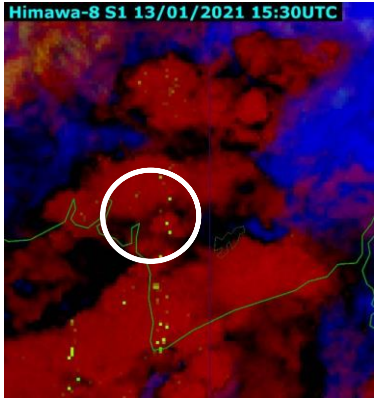
d)D

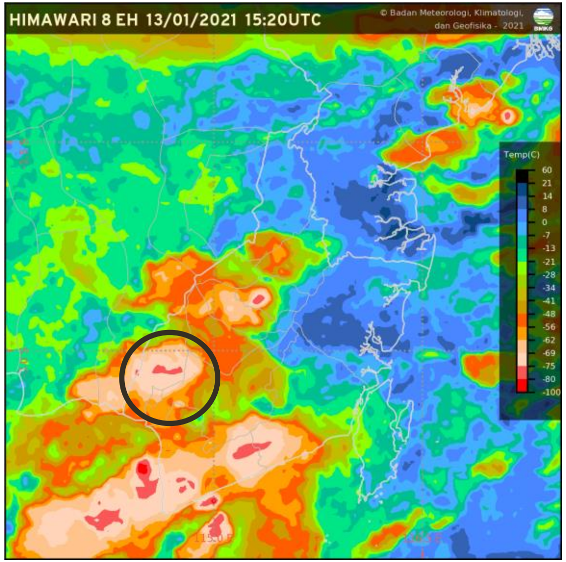


# Case Study of Heavy Rainfall

- **Date and Time** : January 13th 2021, 15-21 UTC (night in local time)
- **Location** : Banjarmasin, South Kalimantan, Indonesia
- **Total Rainfall** : 165 mm
- **Impact** : Flooding



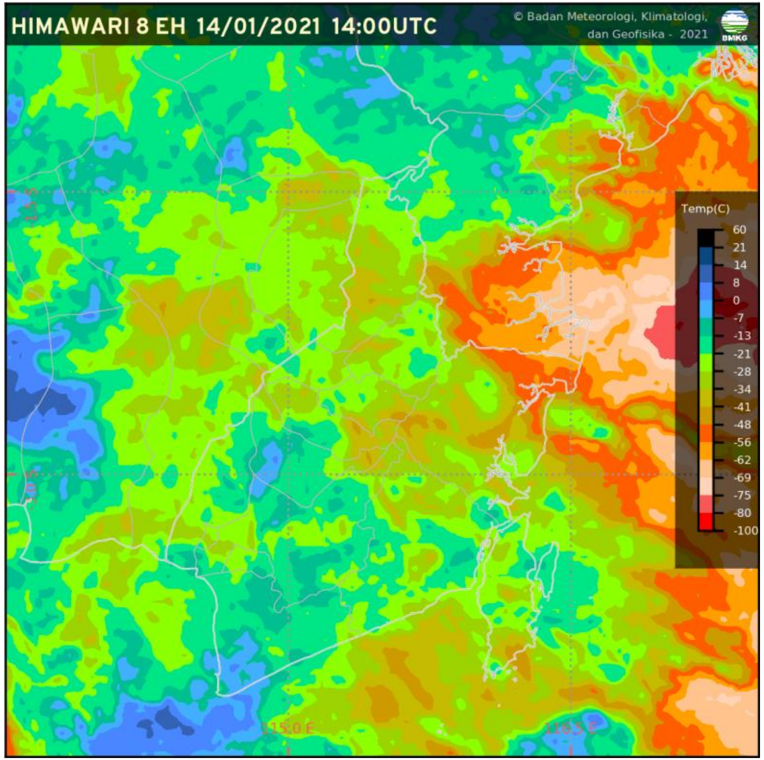


# Case Study of Mesoscale Convective System

- **Date and Time** : January 14$^{th}$ 2021, 14-19 UTC (night in local time)
- **Location** : South Kalimantan, Indonesia

- Two **Mesoscale Convective System** (MCS) moving to the west (from sea to land)
- Lead time for nowcasting up to 4 hours



# Summary

1. When radar observations are not available, doing local analysis using both infrared and visible image of satellite are helpful to find mesoscale and local scale convective rainfall.
2. Carefully issuing local warning based on heavy rainfall interpretation on satellite image due to parallax error.
3. Various rainfall estimation satellite products can be used to fulfill the gap in scarce ground observations (e.g. GSMaP, IMERG). Microwave satellite data was of limited use, showing only the large scale precipitation.
4. Rapidly developing cumulus, cloud tracking, and RGB composite are several methods for nowcasting using satellite.


thank you