AOMSUC-10 Training
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BMKG

Introduction to Nowcasting using Satellite Data and Products: Precipitation examples

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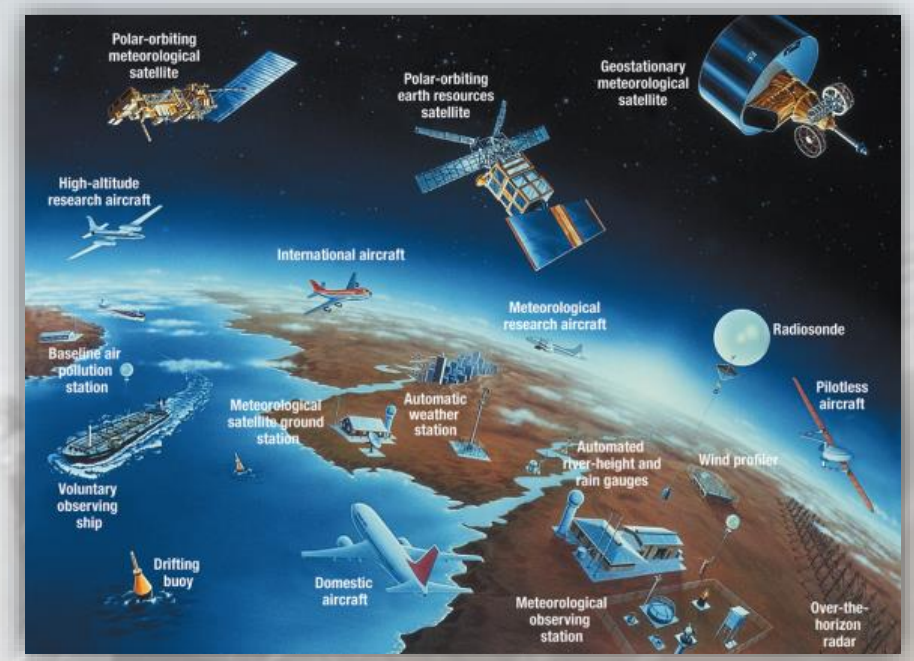
Nowcasting

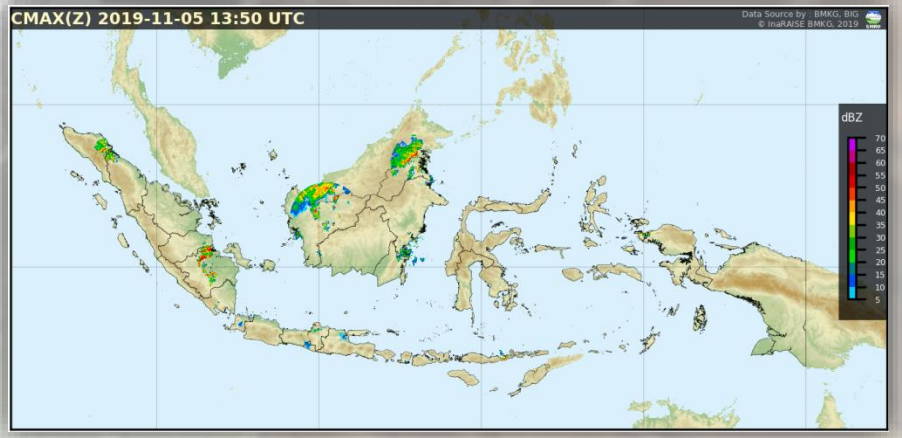
- **Definition** : Forecasts obtained by extrapolation for a period of 0 to 6 hours ahead
- **Tools** : radar, satellite and ground observational data
- **Target** : small features such as individual storms
- **Output** : warning the public of hazardous, high-impact weather including tropical cyclones, thunderstorms and tornados which cause flash floods, lightning strikes and destructive winds

(WMO)

Why Satellite?

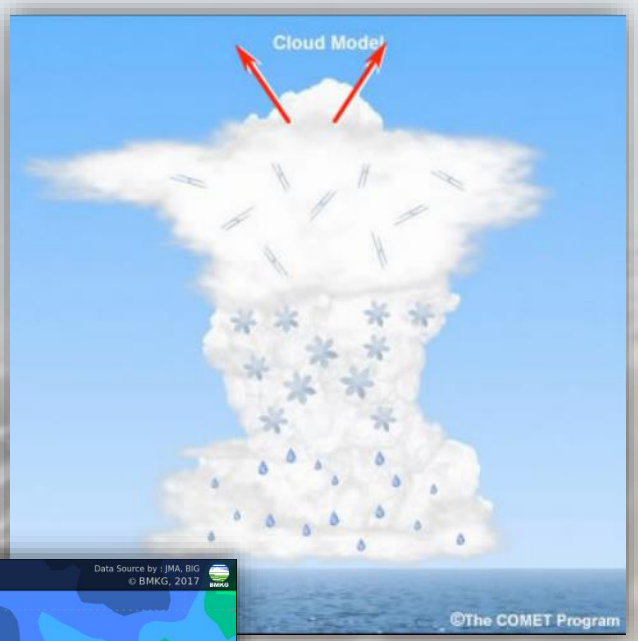
- Raingauge data are available on land only (densely populated area)
- Radar is effective tool for observe precipitation, but high cost and limited to maximum range detection (about 300km)
- Most of geostationary metorological satellite data can be accessed freely and available for global coverage with short time interval observation

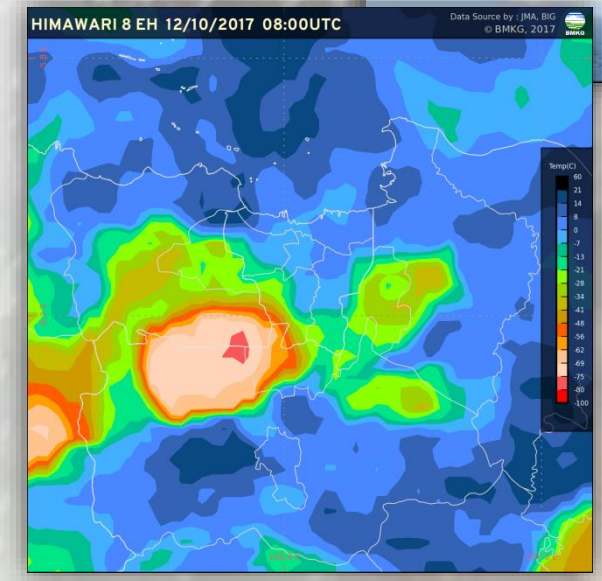




IR-VIS-Precipitation

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

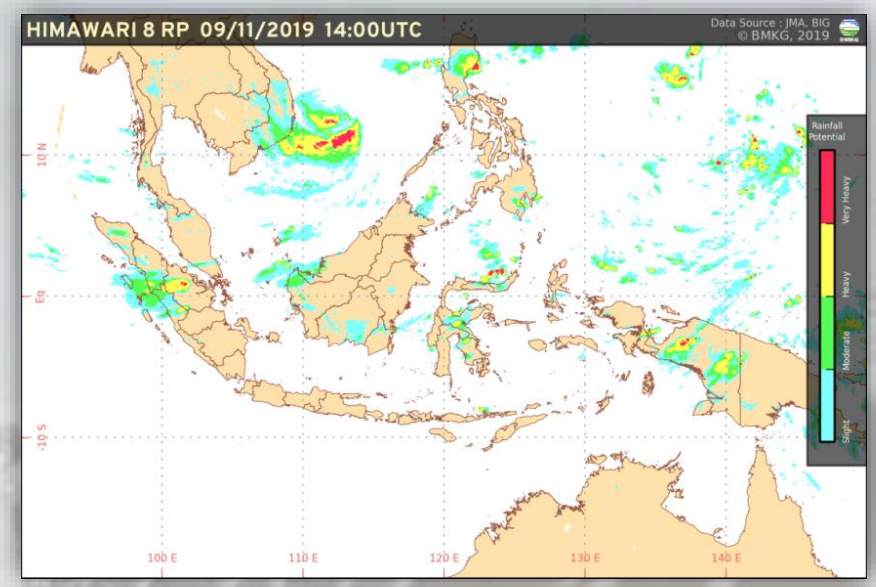


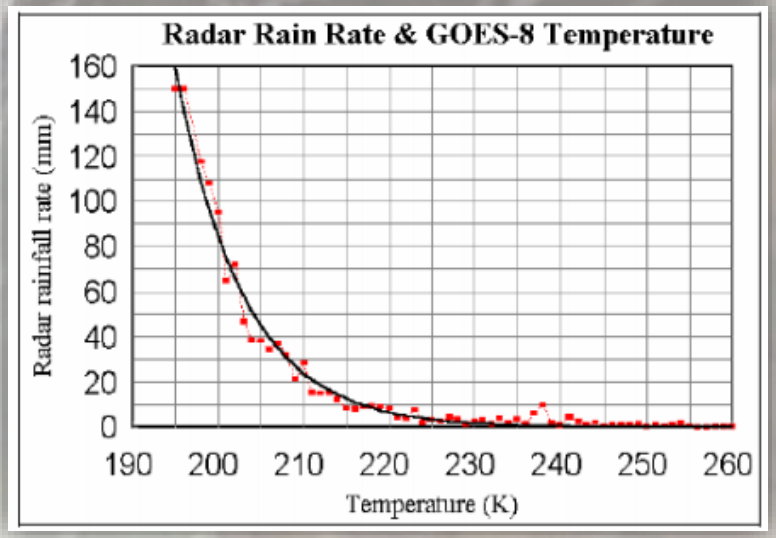


Precipitation Estimation

- Various techniques have been developed to estimate rainfall from visible and/or infrared (IR) radiation
- Vicente et al (1998) :

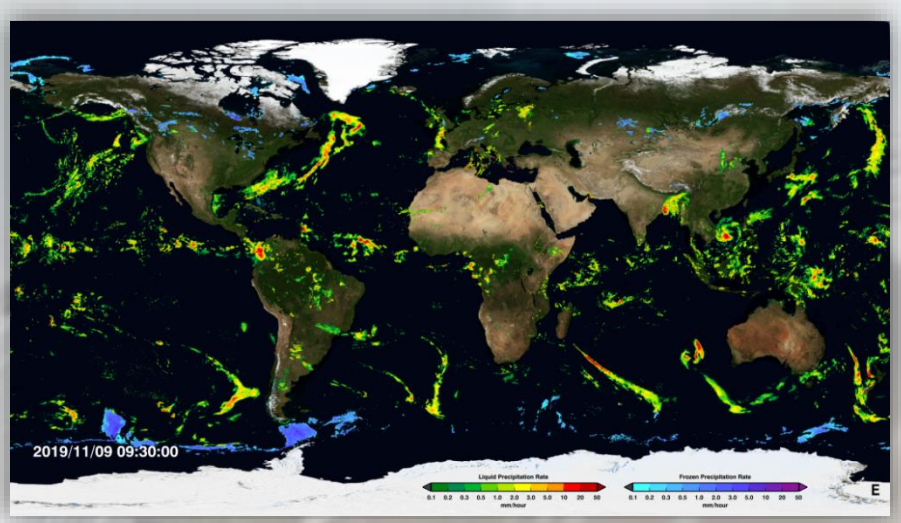
$R = 1.1183 \times 10^{11} \times \exp (- 3.6382 \times 10^{-2} \times T^{0.5})$

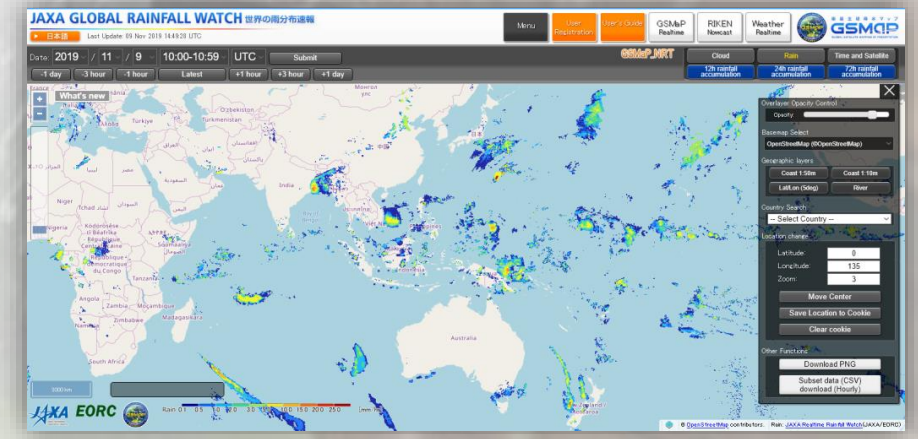




Precipitation Estimation

- IMERG and GSMaP are rainfall estimation based on satellite products which inferred not only from IR but also microwave radiation from polar satellites



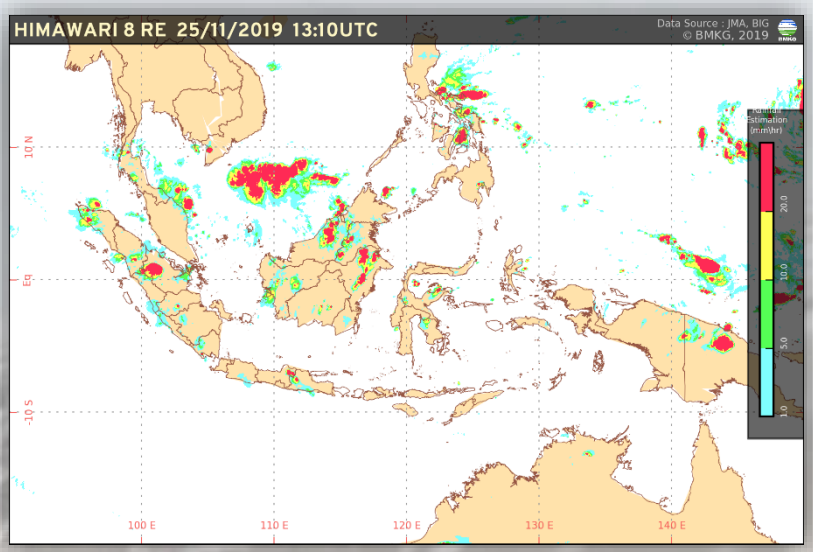


Socrative Question (1)

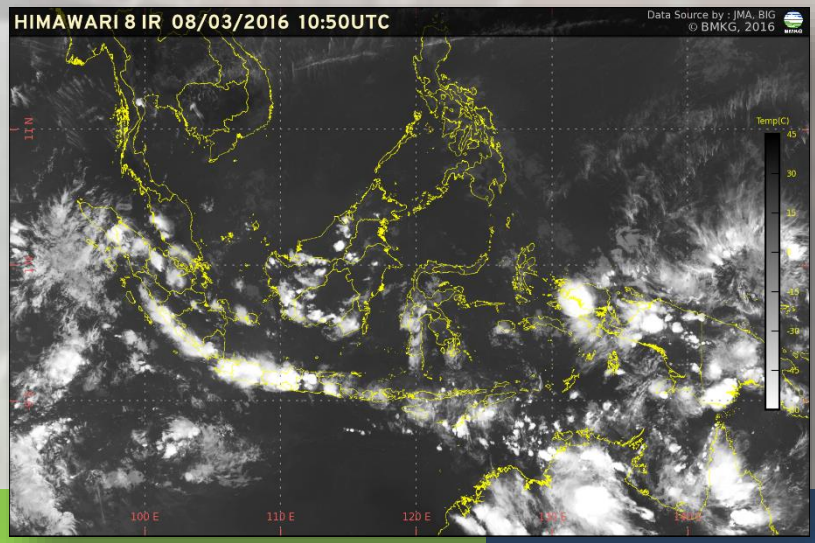
- Have you used rainfall estimation product derived from infrared/microwave satellite data?

a) Yes
b) No
c) I have used it, but prefer doing rainfall analysis from reflectance/brightness temperature image

Rainfall Estimation Product

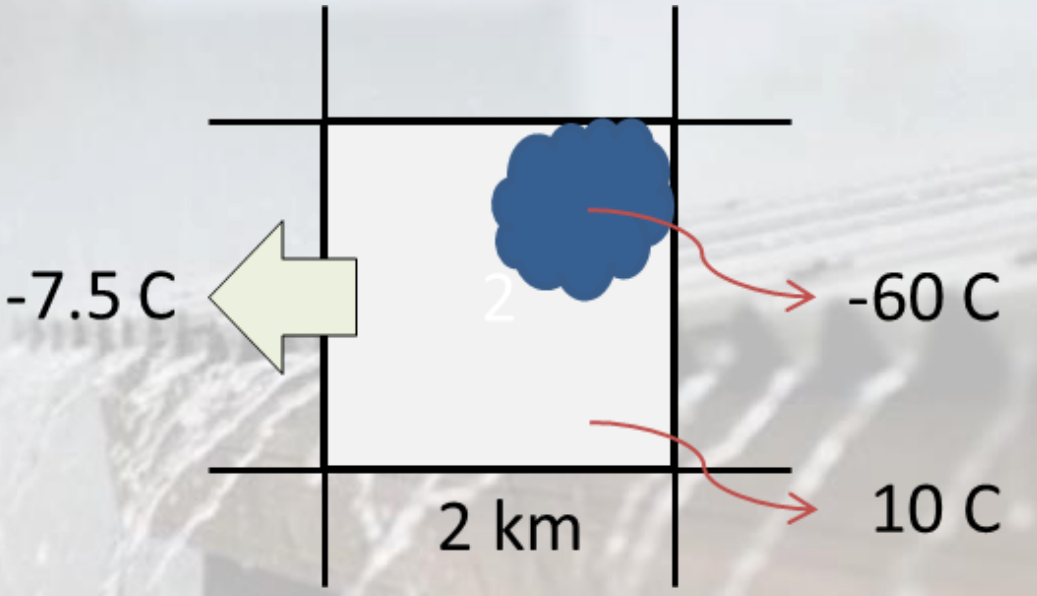


Brightness Temperature Infrared



Limitation

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

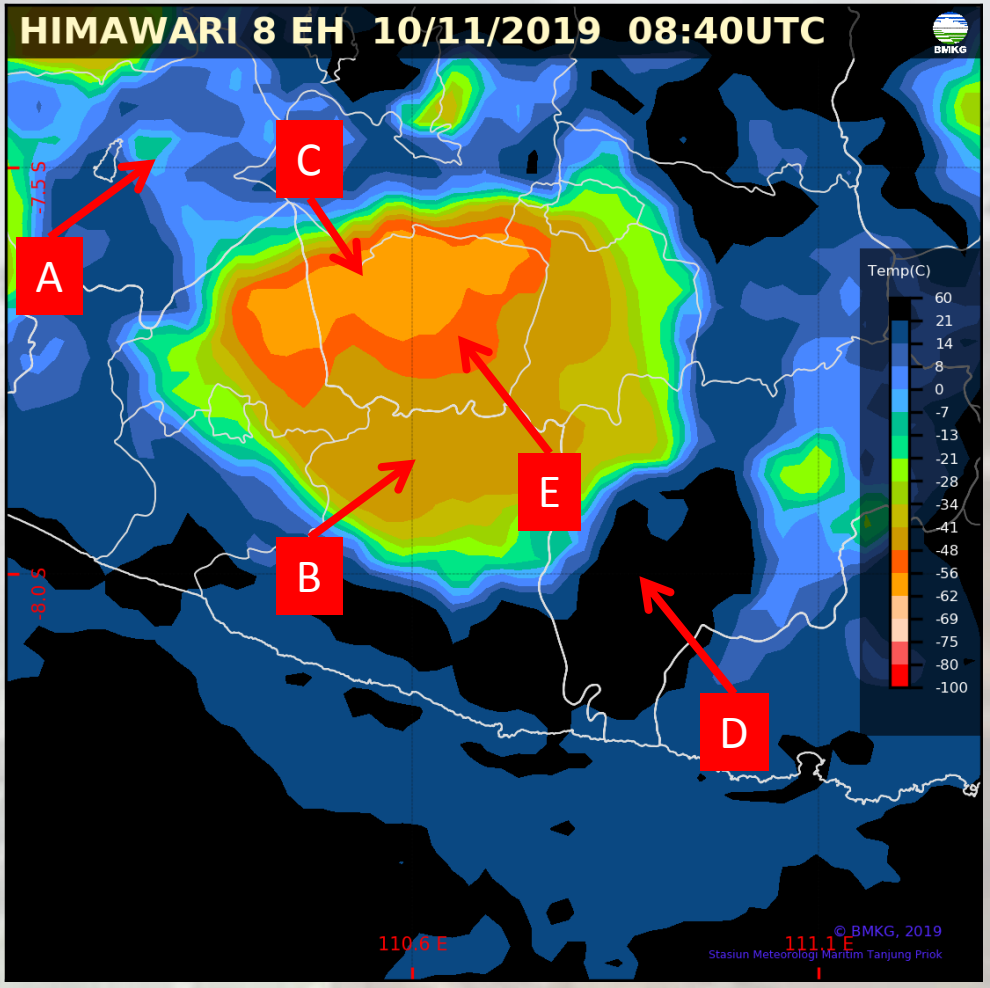


Socrative Question (2)

Which areas has the highest potential for heavy rainfall?

a) A
b) B
c) C
d) D
e) E

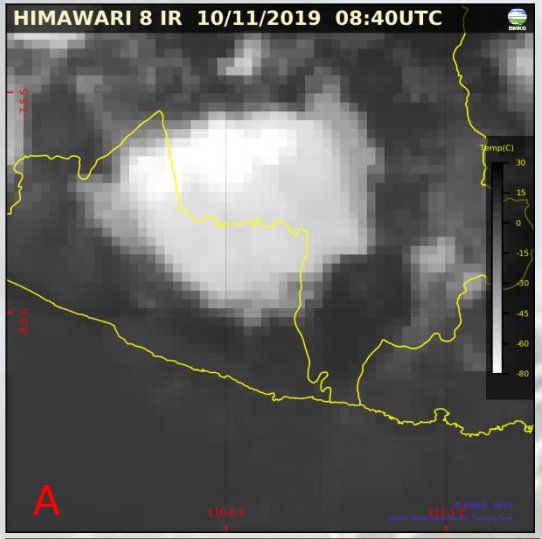
Enhanced Infrared Image

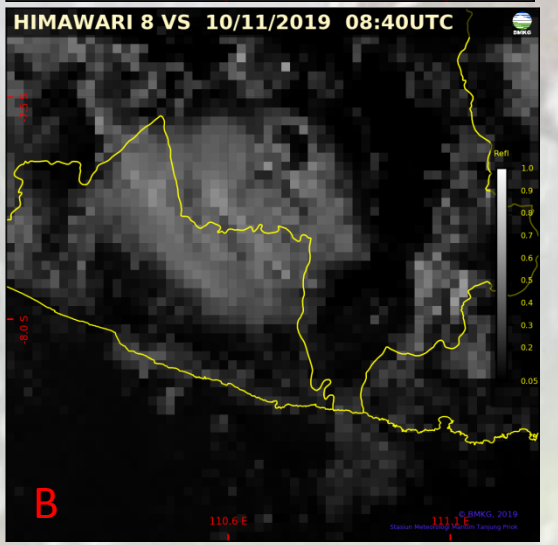


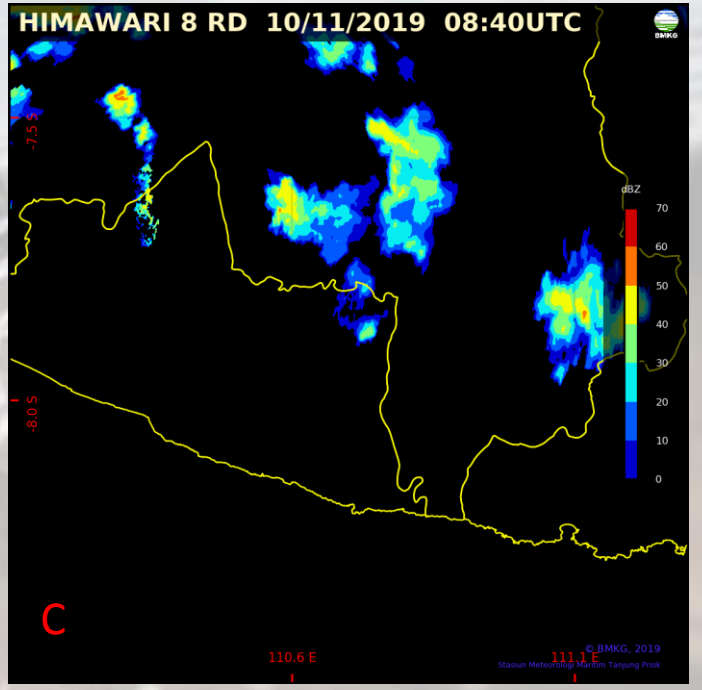
Convective Cloud

Stratiform rainfall :
- Continous
- Small drops
- Uniform

Convective rainfall :
- Short duration
- Heavy and large drops
- Varies



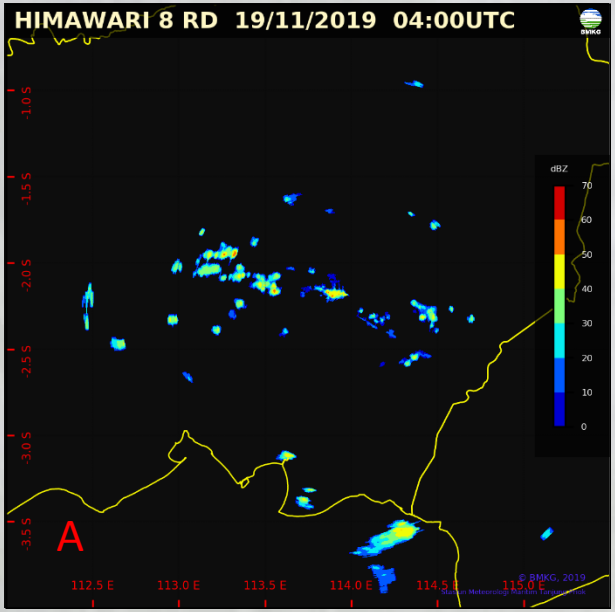


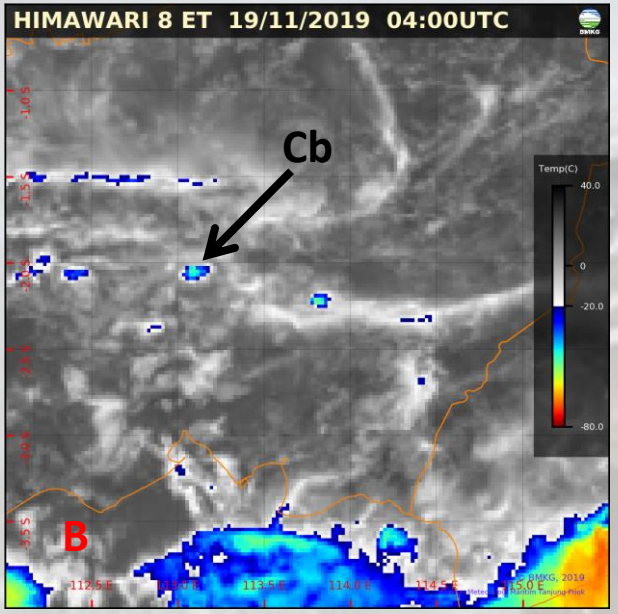


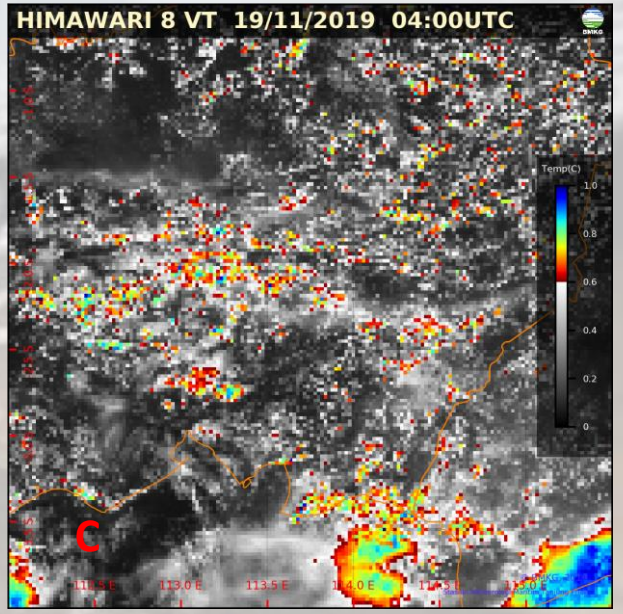
A Himawari-8 B13 (IR)
B Himawari-8 B03 (VS)
C C-Band Radar Reflectivity

Local Convective Cloud

Local convective rainfall cells (diameter : 2-3 km) are detected in radar image.







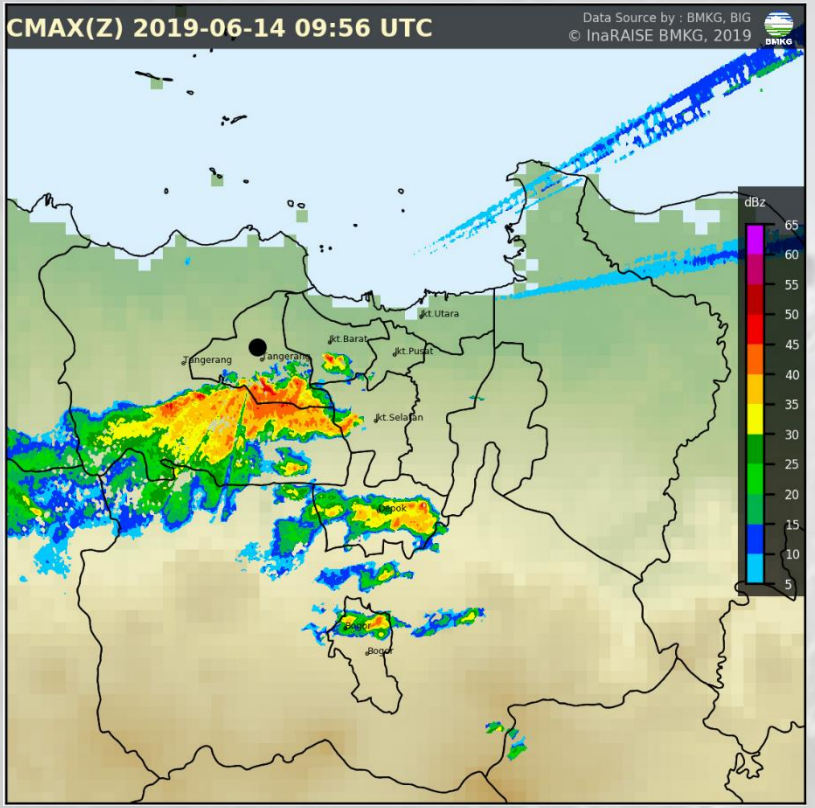
Statistic at Cb cell
medium-heavy rainfall (30-60 dBZ) :

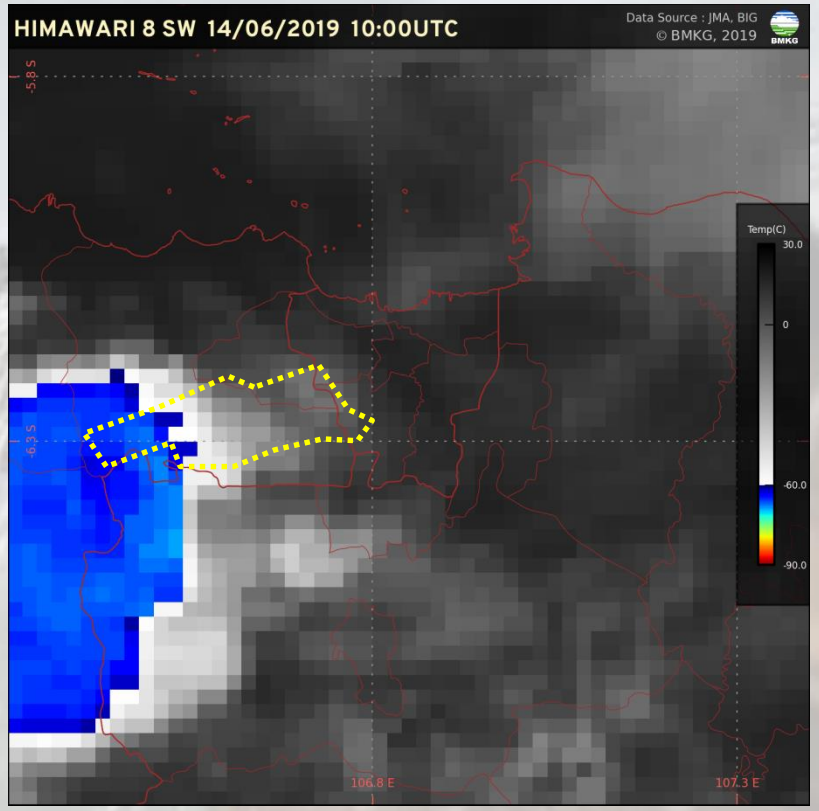
19/11/2019 03:57UTC		
Max. :	6.7°C	(2.0000S 113.2000E)
Min. :	-46.0°C	(2.0400S 113.0800E)
Ave. :	-26.6°C	
Dev. :	14.0°C	
Tot. :	33	IR

19/11/2019 03:57UTC		
Max. :	0.918	(2.0600S 113.1000E)
Min. :	0.129	(2.0000S 113.2000E)
Ave. :	0.673	
Dev. :	0.172	
Tot. :	33	VS

A Himawari-8 B13 (IR Enhanced)
B Himawari-8 B03 (VS Enhanced)
C C-Band Radar Reflectivity

Satellite Parallax Correction

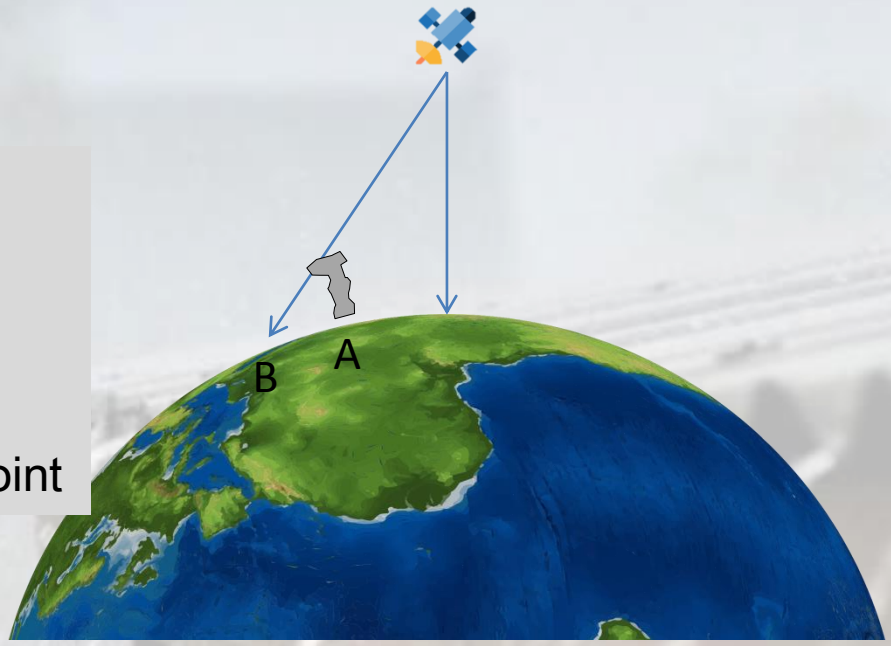


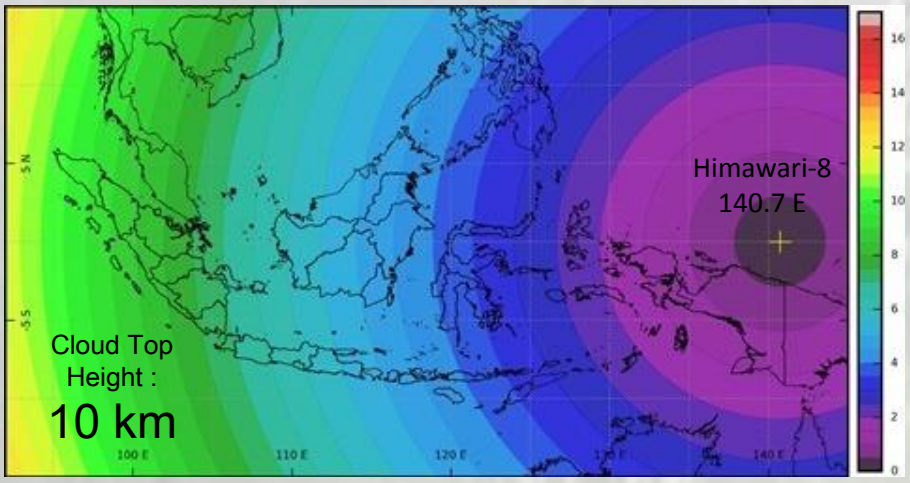


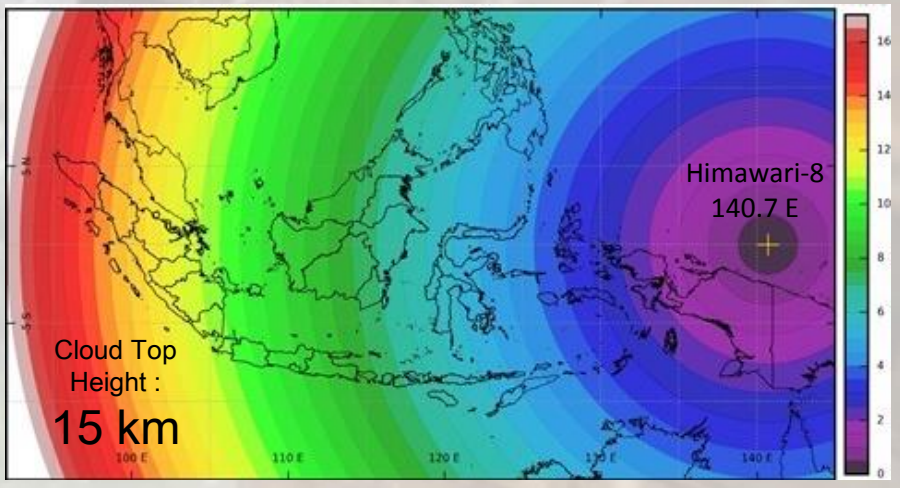
Rainfall shift under top of Cumulonimbus (height: 15km) around 20 km to east

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

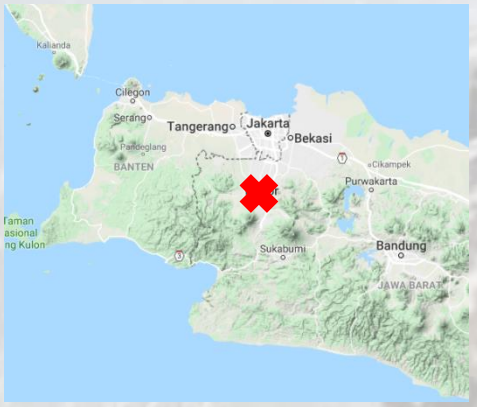


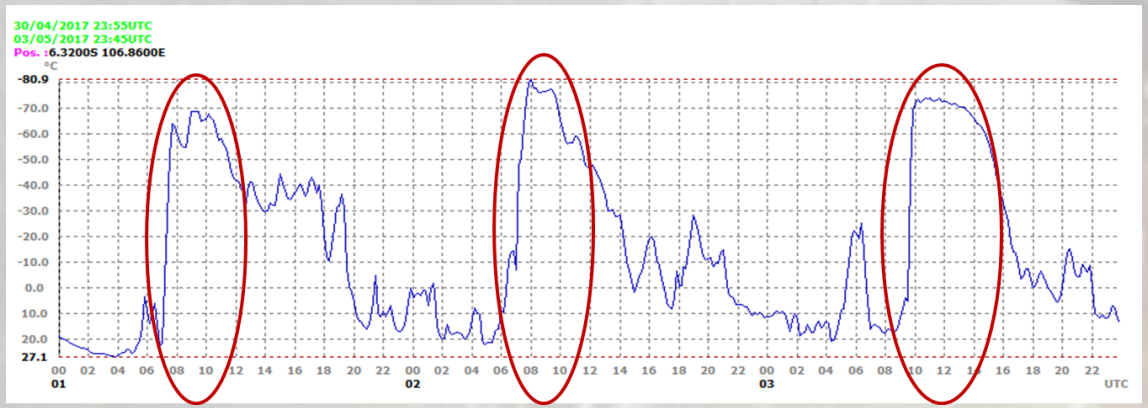


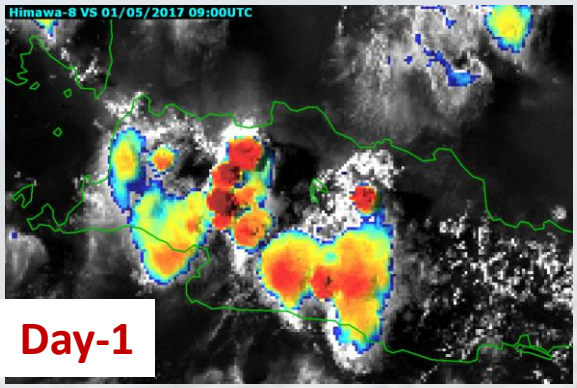


Diurnal Circulation

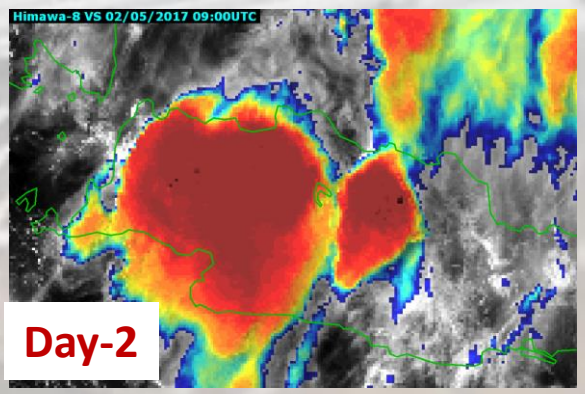
Oceanic deep convection tends to reach its maximum in the early morning and continental convection generally peaks in the late afternoon



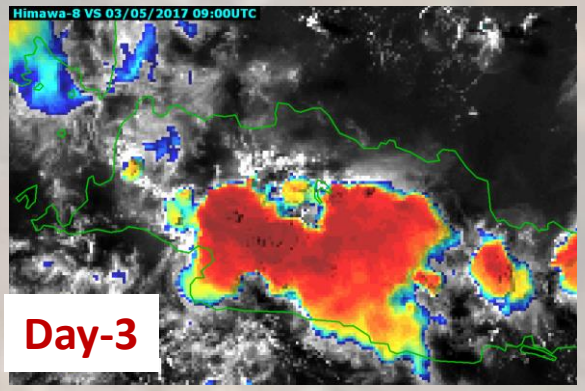




Day-1



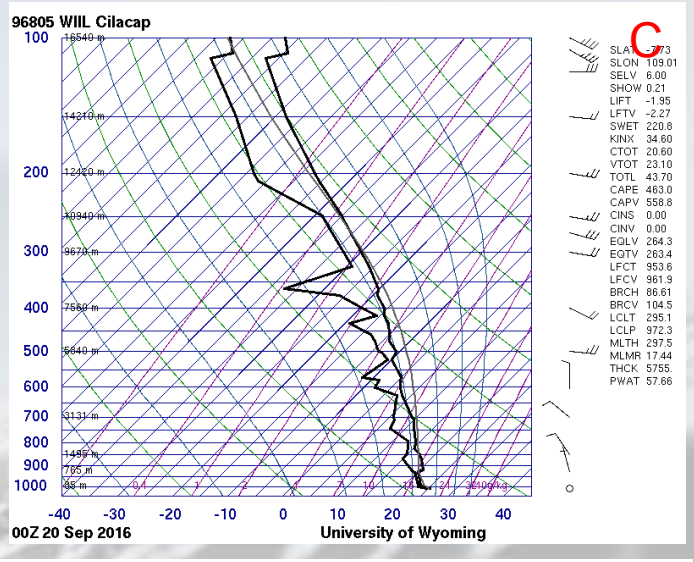
Day-2

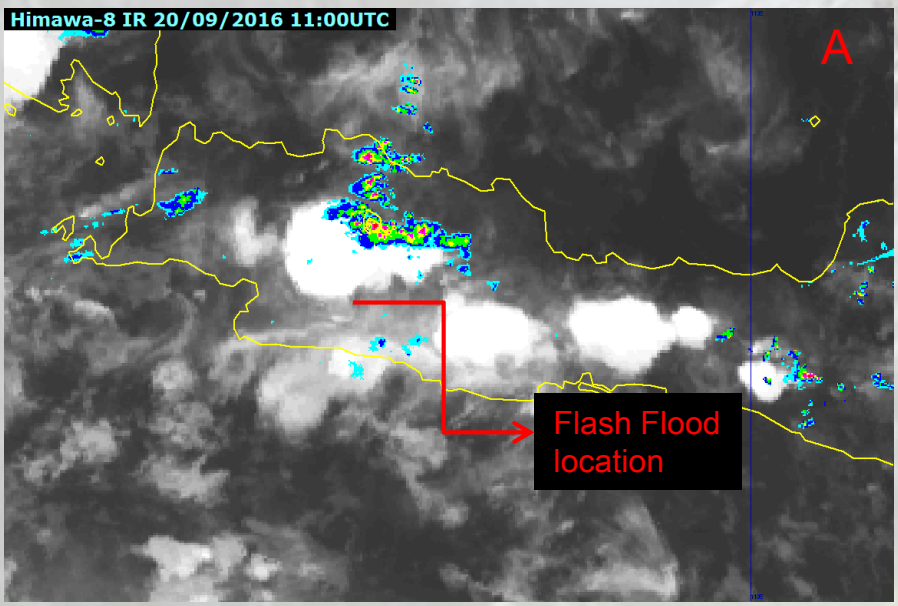


Day-3

Heavy Rainfall

Heavy rain from 20 September caused a landslide and flash flooding in parts of West Java,and it reported as the worst affected with 33 people killed, 20 missing, and over 6,000 homeless.

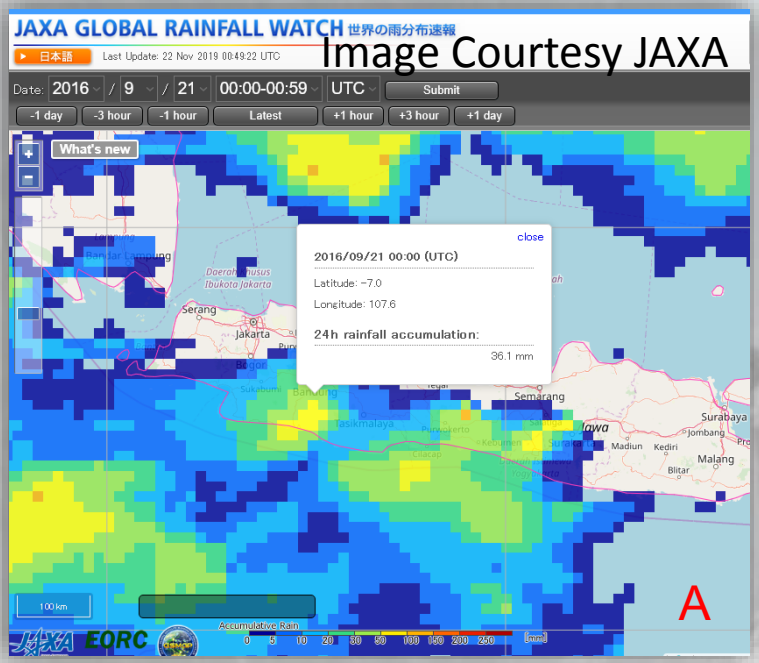




RAINFALL STATION	Sub-District	B Rainfall (mm/day) 20 September 2016
Perkebunan Papandayan	Cikajang, Garut	255
Bayongbong	Bayongbong, Garut	140
Paseh	Paseh, Sumedang	127
Cisaruni	Cikajang, Garut	110
Rancakalong	Rancakalong, Sumedang	104
Conggeang	Conggeang, Sumedang	102

A Composite Radar Reflectivity and Himawari IR
B Stations with 24 hour precipitation > 100mm
C Radiosonde 00 UTC (KI 34.6)

Heavy Rainfall



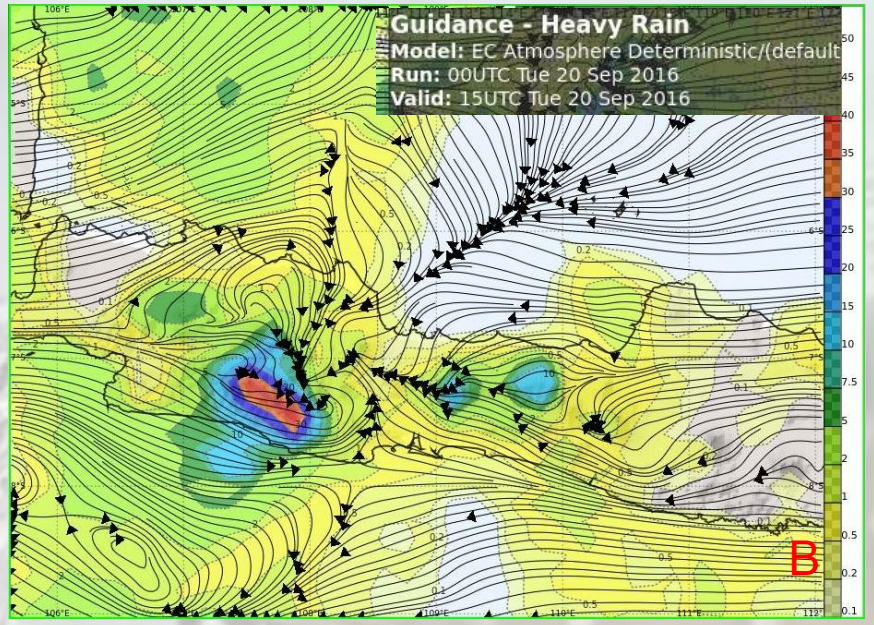
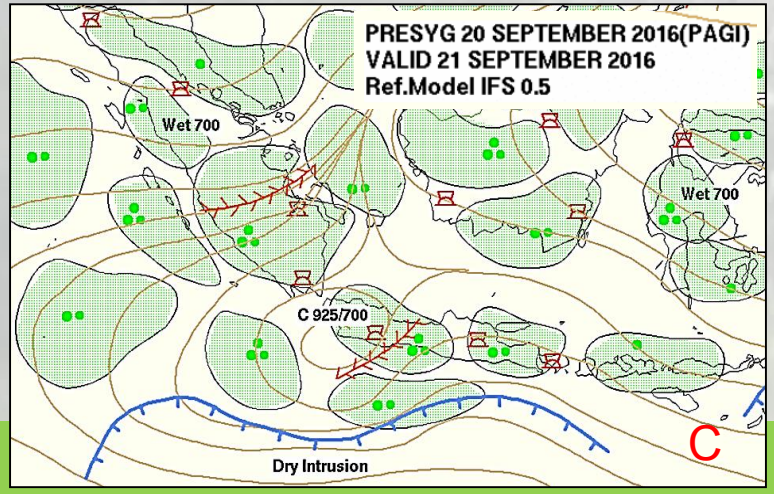


Image Courtesy BoM



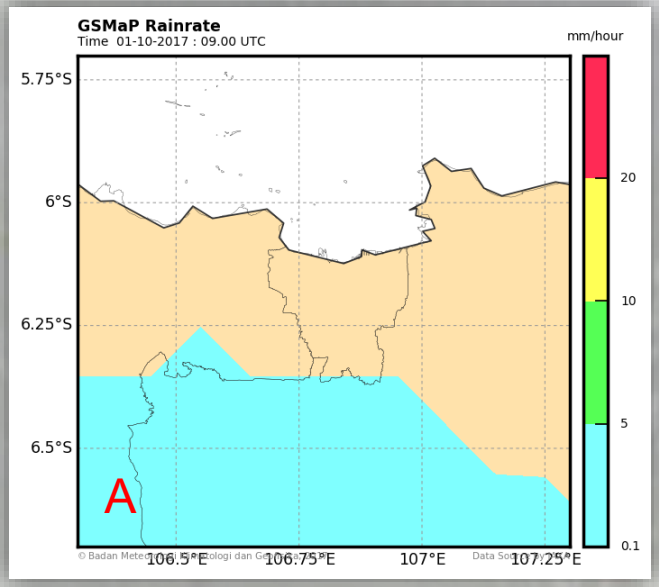
A GSMaP 24hr Accumulation
B EC Deterministic (Gradient wind + Precipitation)
C Sig Weather Chart

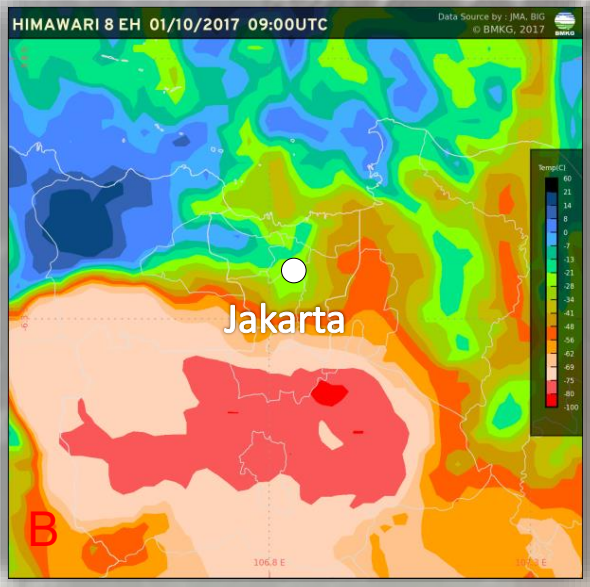
Hail Precipitation

Hail event at South of Jakarta
(01 Oct 17 09UTC)

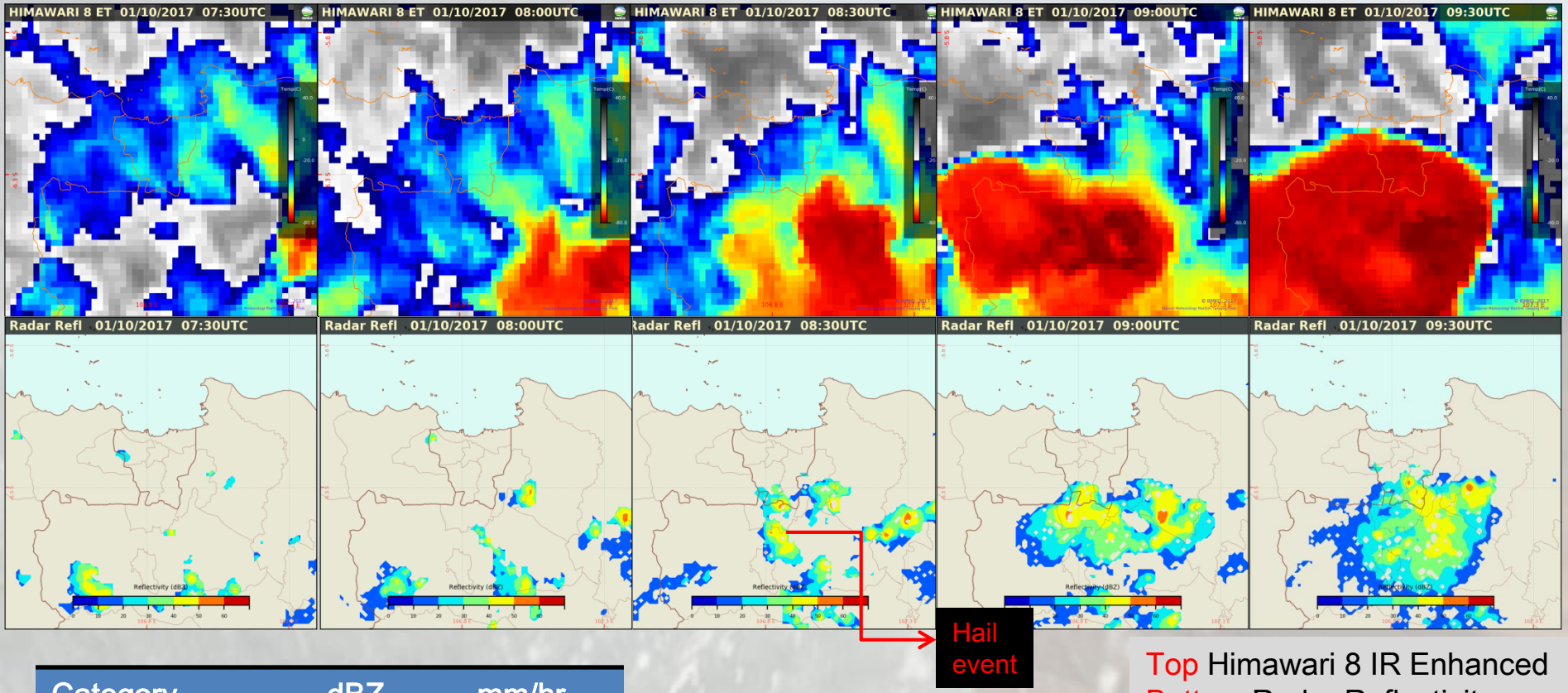
GSMaP product used to locate distribution of heavy rainfall. However at the event time, only slight rain is detected over south of Jakarta. It is a bit difficult to see small scale heavy precipitation at GSMaP due to its spatial resolution.

A GSMaP NRT
B Himawari-8 B13 (IR Enhanced)
C C-Band Radar Reflectivity





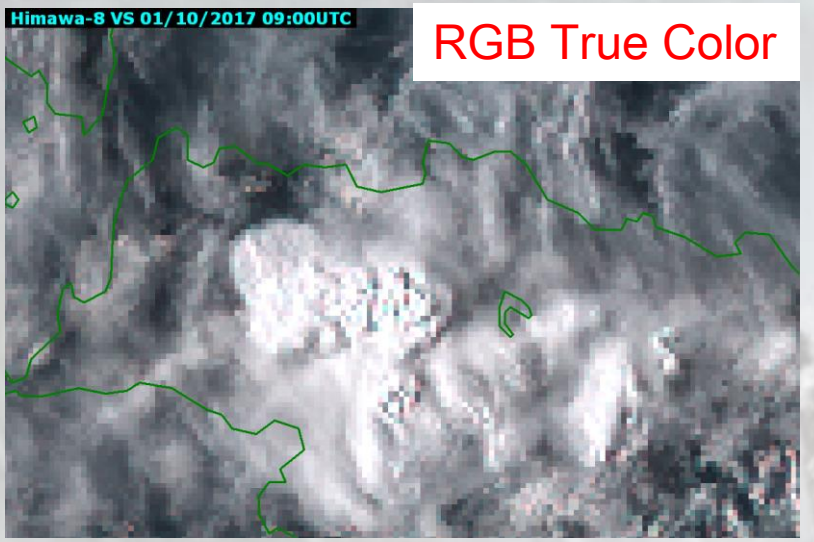
Hail Precipitation

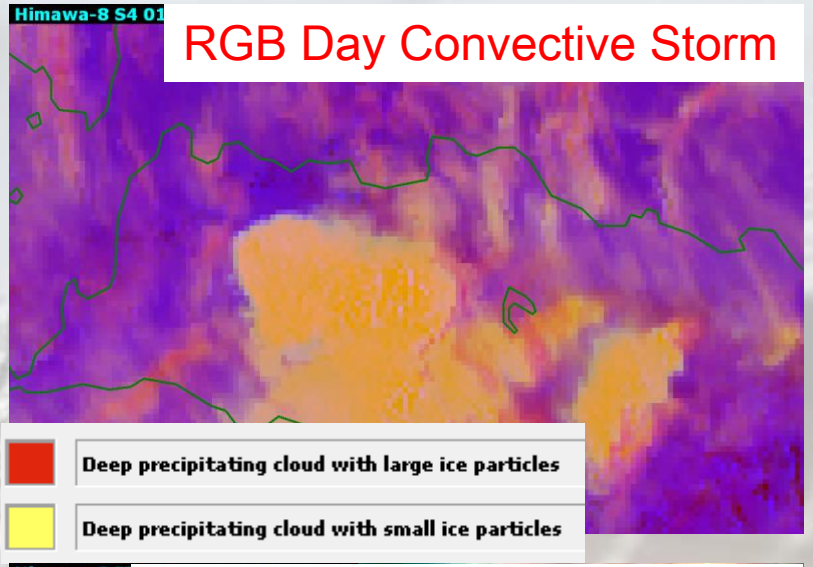


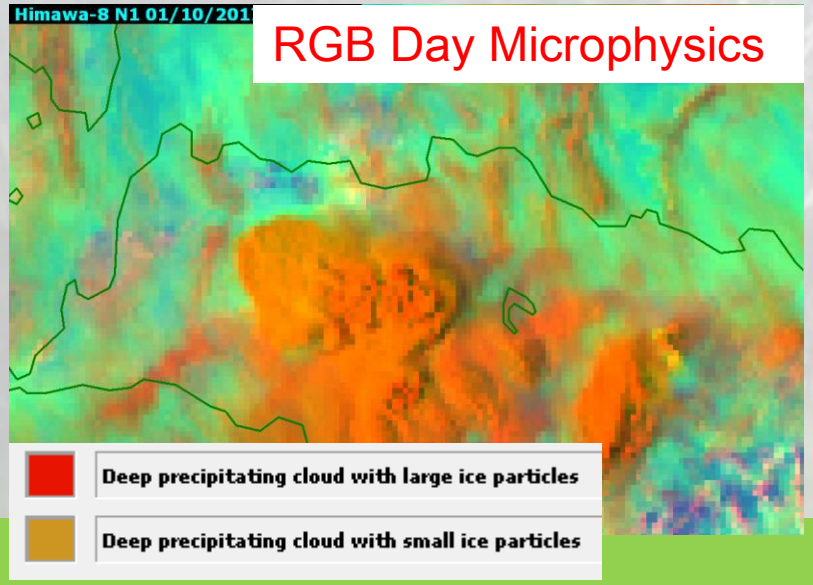
Top Himawari 8 IR Enhanced
Bottom Radar Reflectivity

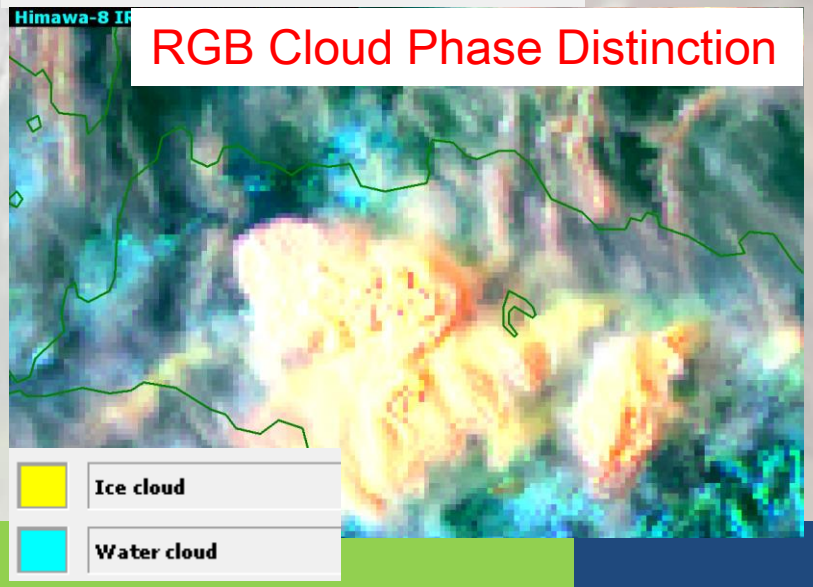
Category	dBZ	mm/hr
Slight Rain	30-38	1-5
Mod Rain	38-48	5-10
Heavy Rain	48-58	10-20
Very heavy Rain	>58	>20

Hail Precipitation









Socrative Question (3)

- What satellite product do you prefer to monitor the thunderstorms (heavy rain/hail) over western Java?

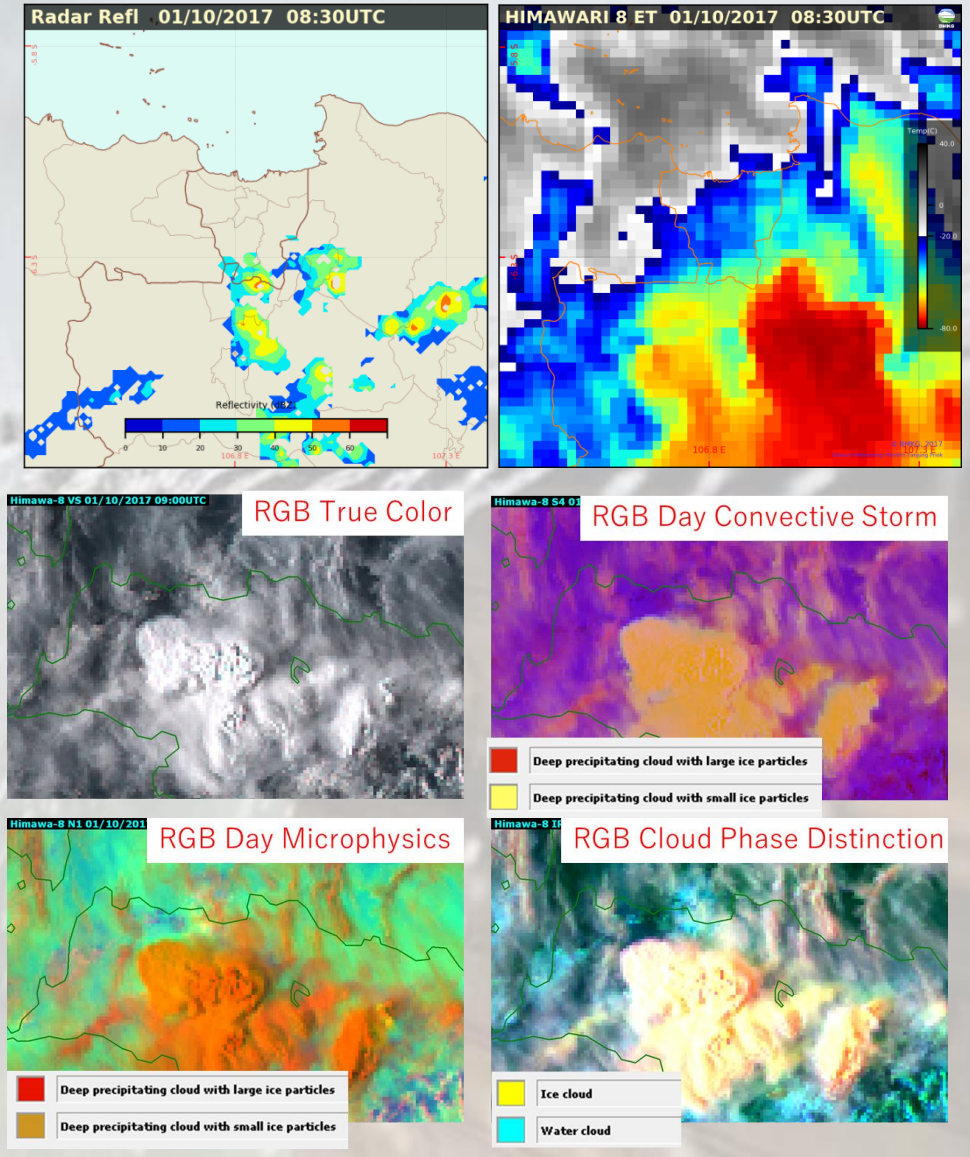
a) IR Enhanced

b) RGB True Color

c) RGB Day Convective Storm

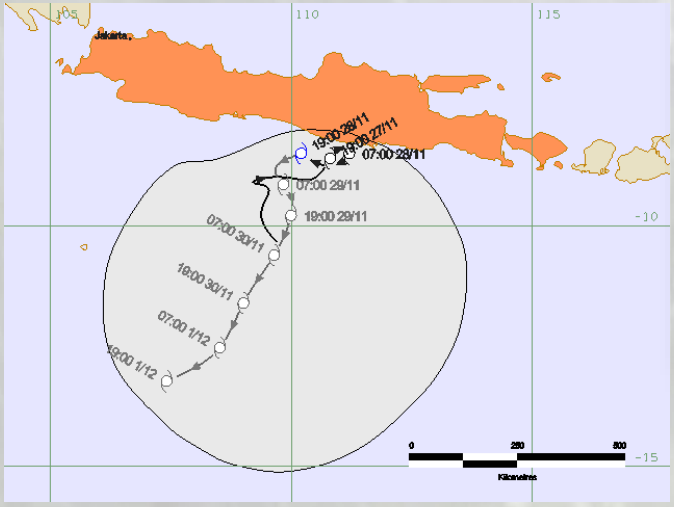
d) RGB Day Microphysics

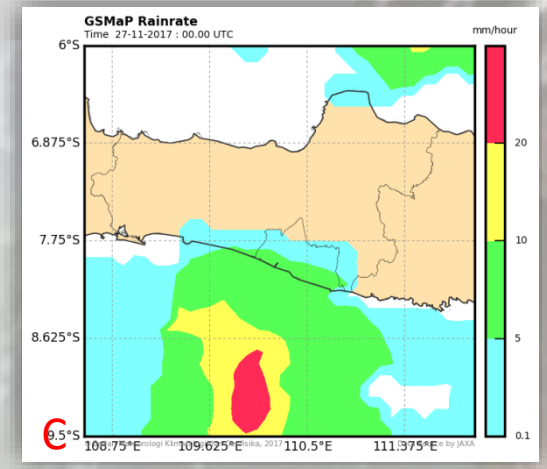
e) RGB Cloud Phase Distinction

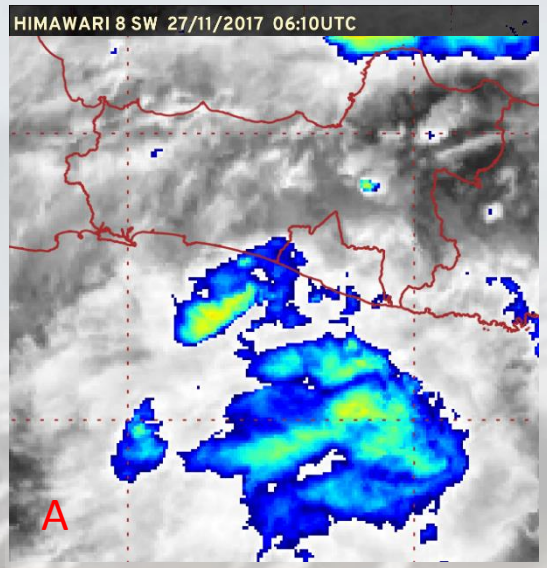


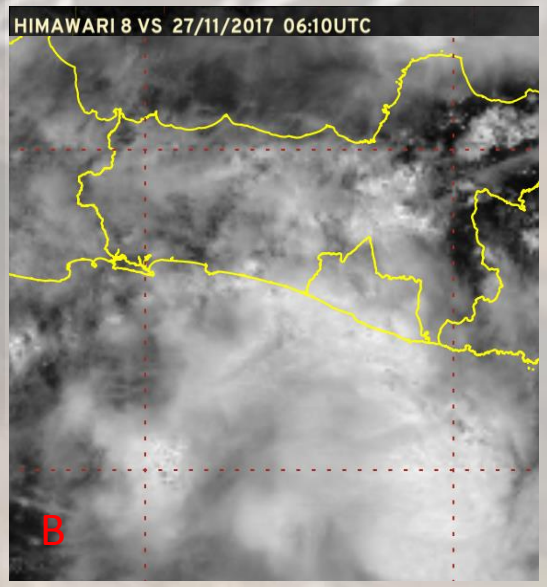
Tropical Cyclone

Tropical Cyclone Cempaka was a tropical cyclone that impacted the island of Java and Bali, Indonesia in November 2017. Although it did not make landfall and only developed to a category 1 cyclone, Cempaka managed to cause 41 deaths with more than 20,000 people evacuated and around US$83.6 millions in damages









A Himawari-8 B13 (IR)
B Himawari-8 B03 (VS)
C GSMaP NRT

Tropical Cyclone

GPM Satellite

KaPr

Target : Weak rainfall and snowfall

Swath : 125 km

KuPr

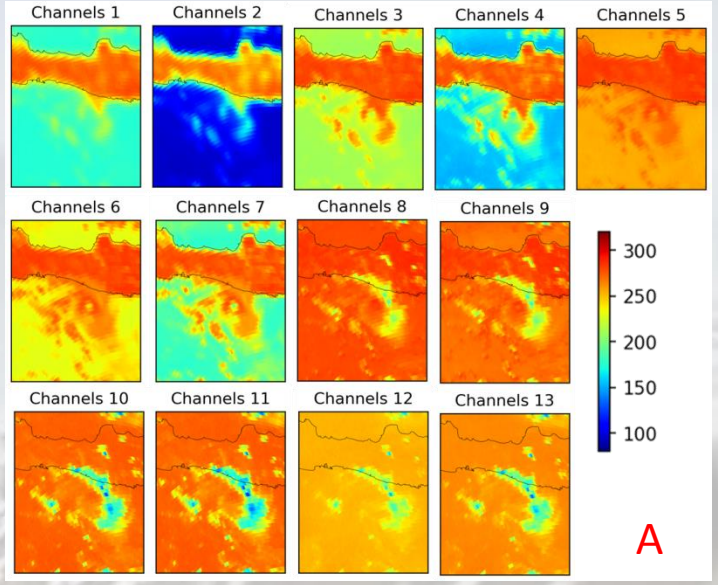
Target : Heavier Rainfall

Swath : 245 km

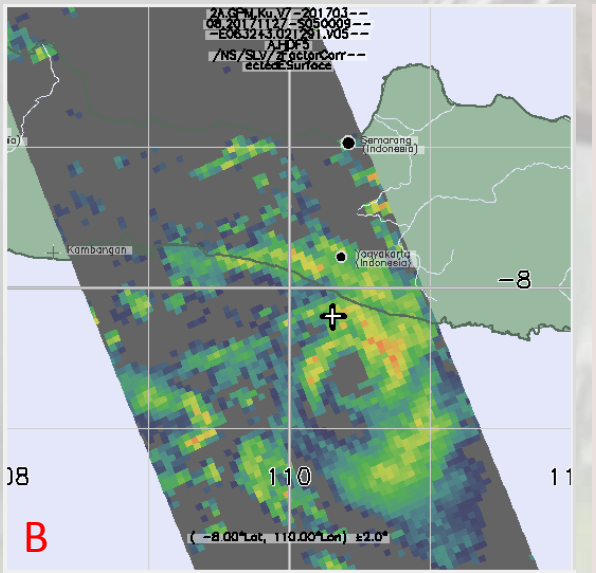
GMI

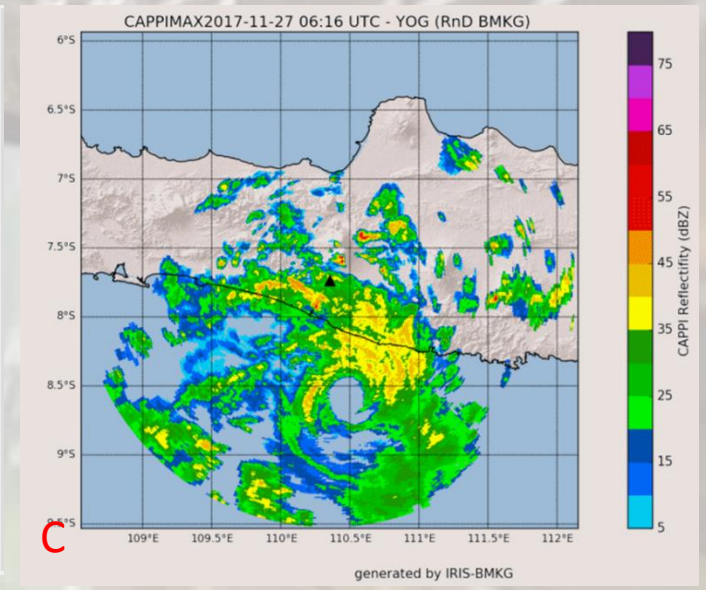
Multi Channels : 13 (9 TMI + 4 Channels)

Swath : 850 km



Near Real Time Viewer :
https://storm.pps.eosdis.nasa.gov/storm/cesium/GPMNRTView.html

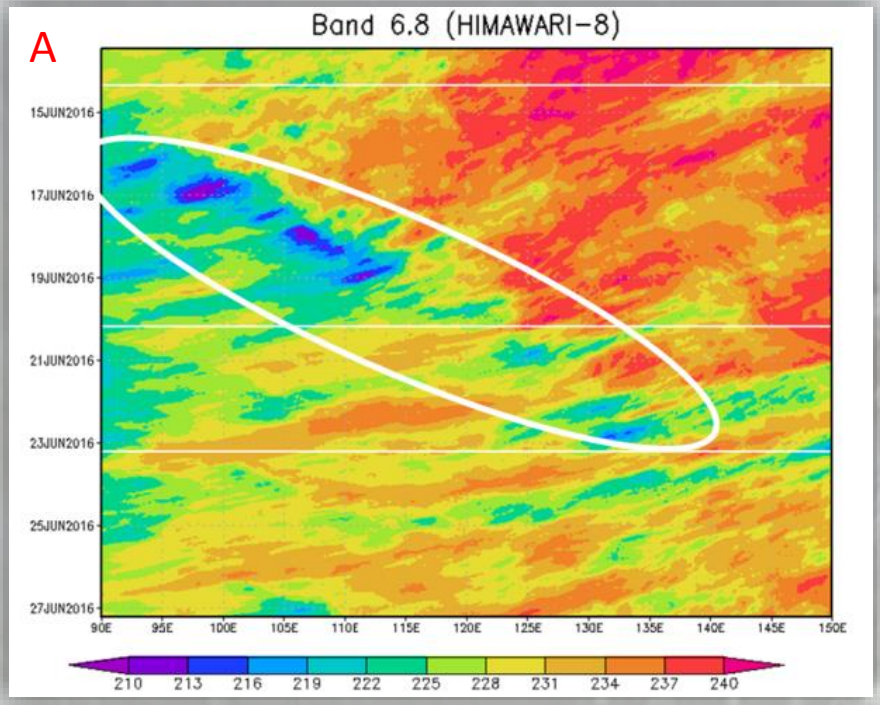


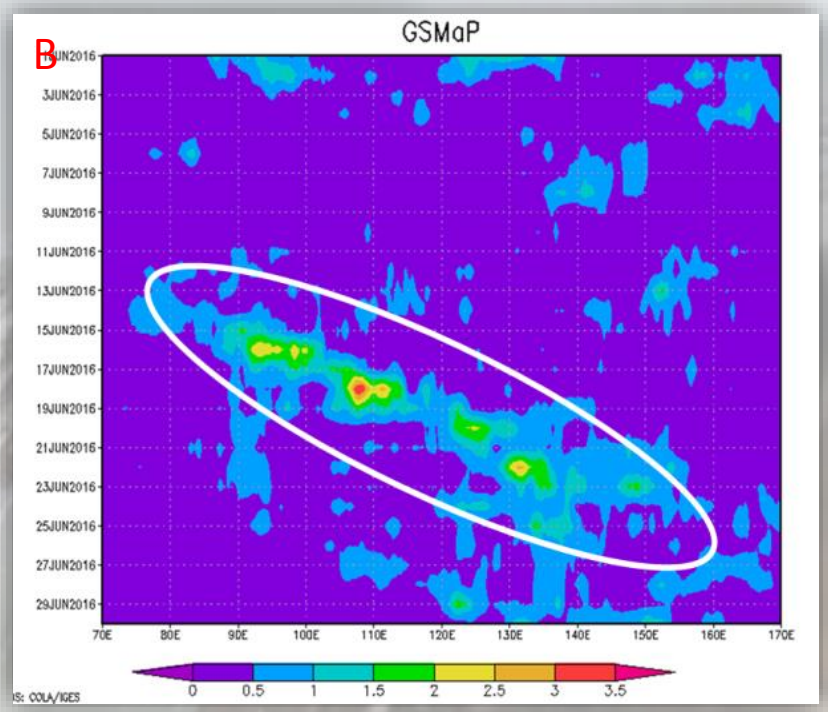


A GPM (GMI)
B GPM (DPR-Ku)
C C-Band Radar Reflectivity

MJO Propagation

A Himawari-8 Water Vapor
B GSMaP NRT





Because most tropical rainfall is convective, and convective cloud tops are very cold (emitting little longwave radiation), the MJO is most obvious in the variation of brightness temperature measured by an infrared sensor.

Summary

- If radar observations are not available, doing local analysis using both infrared and visible image are helpful to find very small convective rainfall.
- Carefully issuing local warning based on heavy rainfall interpretation on satellite image due to parallax error
- NWP products can also used for nowcasting
- Various rainfall estimation satellite products can be used to fullfill gap in scarce ground observations (e.g. GSMaP, IMERG). Microwave satellite data was of limited use, showing only the large scale precipitation.
- The development of MCS, Cyclone, and MJO, which triggering very heavy rainfall and could causing hydro meteorological hazard can be predicted using satellite