香港天文台
HONG KONG OBSERVATORY

# SATELLITE-BASED ANALYSIS & NOWCASTING

WMO Severe Weather Forecasting Programme (SWFP)
Regional Sub-programme for Southeast Asia (SWFP-SeA)
Training Desk and Study Visit for Cambodia
(Ha Noi, 19 - 23 May 2025)


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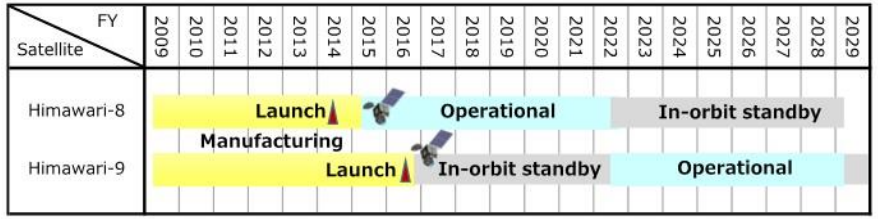
# JMA Himawari-8/9

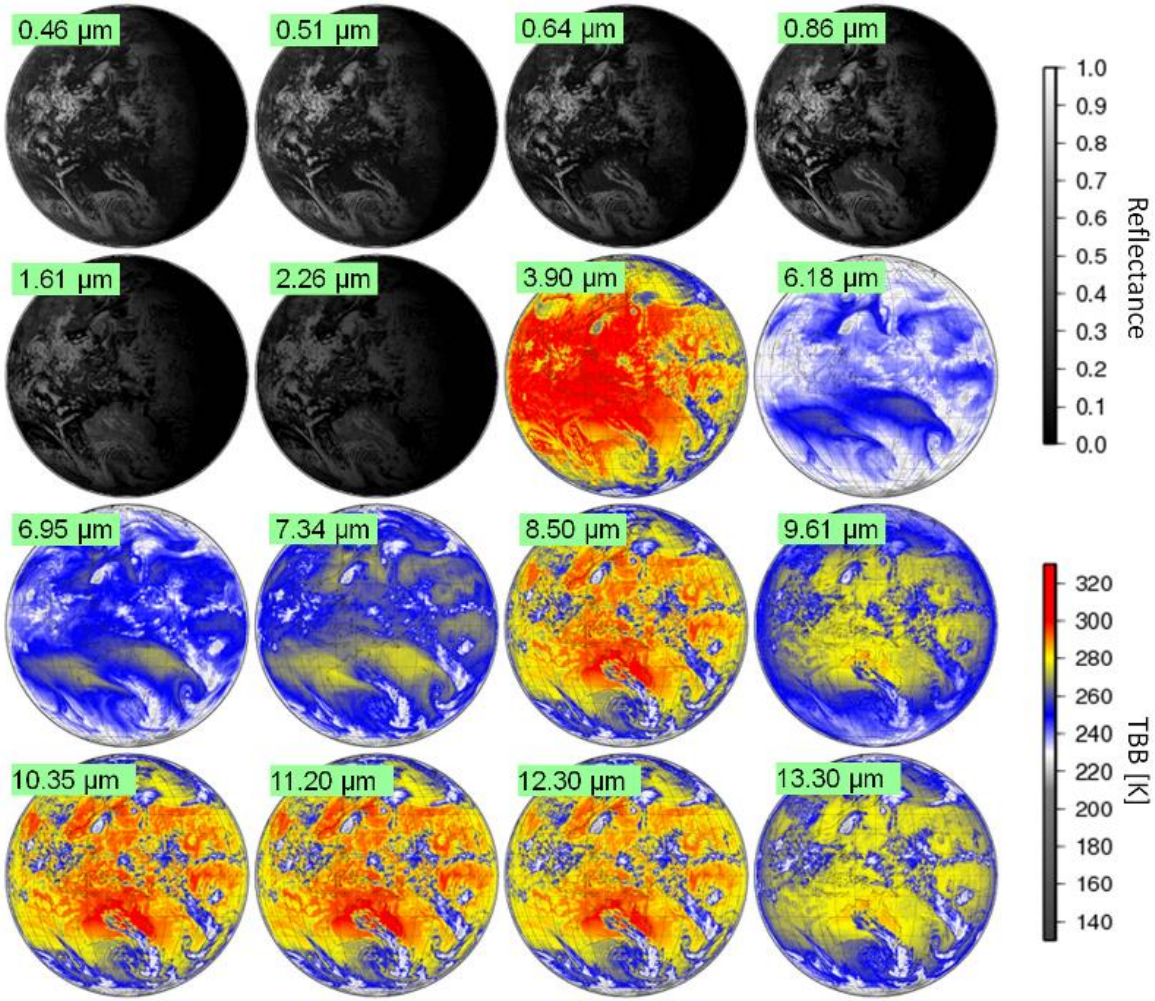



## 16 Bands of AHI (Advanced Himawari Imager)


| MTSAT Channels | Band | | | Wavelength [μm] | Spatial Resolution | |
|---|---|---|---|---|---|---|
| VIS | 1 | V1 | Visible | 0.46 | 1 km | RGB band composited |
| | 2 | V2 | | 0.51 | 1 km | |
| | 3 | VS | | 0.64 | 0.5 km | |
| | 4 | N1 | Near Infrared | 0.86 | 1 km | Aerosol |
| | 5 | N2 | | 1.6 | 2 km | Water cloud and Ice cloud |
| | 6 | N3 | | 2.3 | 2 km | Size of the cloud droplet |
| IR4 | 7 | I4 | Infrared | 3.9 | 2 km | Fog, Hot spot (Forest fire) |
| IR3 (WV) | 8 | WV | | 6.2 | 2 km | Water vapor |
| | 9 | W2 | | 7.0 | 2 km | |
| | 10 | W3 | | 7.3 | 2 km | |
| | 11 | MI | | 8.6 | 2 km | $SO_2$ (Sulfur dioxide) |
| | 12 | O3 | | 9.6 | 2 km | $O_3$ (Ozone) |
| IR1 | 13 | IR | | 10.4 | 2 km | Atmospheric Windows |
| | 14 | L2 | | 11.2 | 2 km | |
| IR2 | 15 | I2 | | 12.3 | 2 km | |
| | 16 | CO | | 13.3 | 2 km | $CO_2$ (Carbon dioxide) |

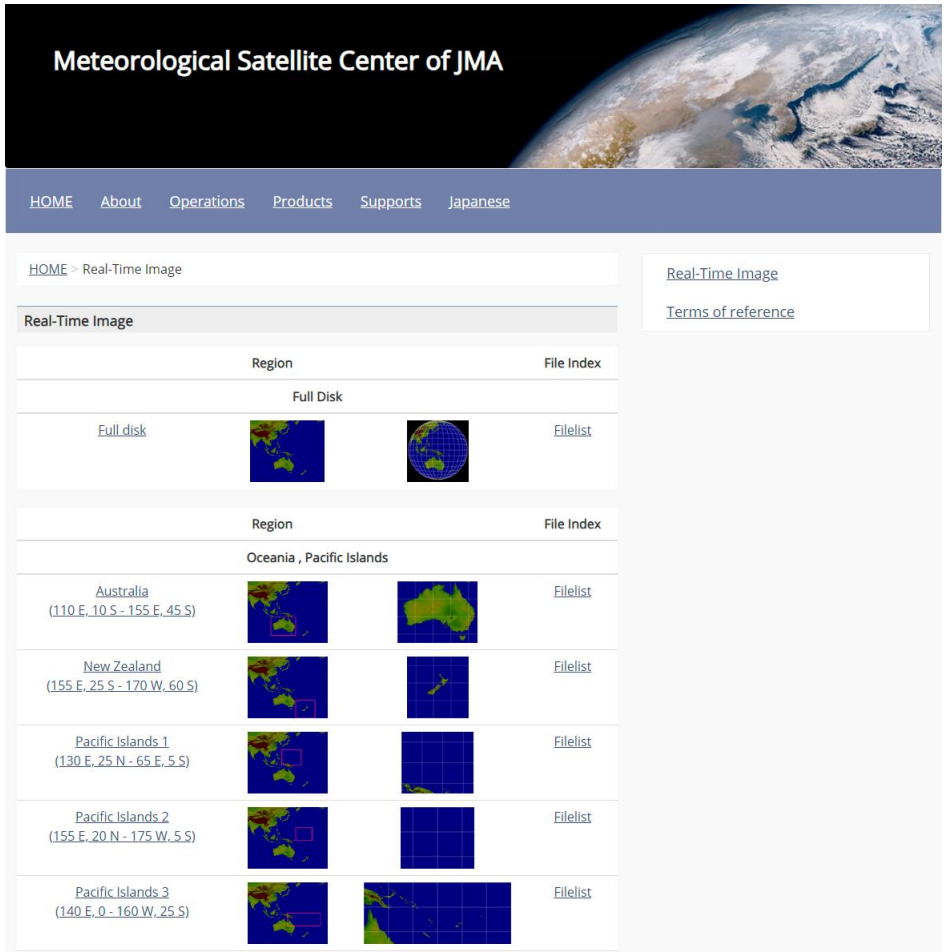
http://www.jma.go.jp/jma/jma-eng/satellite/

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 μm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 μm | | | vegetation, aerosol G | |
| 3 | 0.64 μm | 0.68 μm | 0.635 μm | low cloud, fog R | |
| 4 | 0.86 μm | | 0.81 μm | vegetation, aerosol | Near Infrared |
| 5 | 1.6 μm | | 1.64 μm | cloud phase | |
| 6 | 2.3 μm | | | particle size | |
| 7 | 3.9 μm | 3.7 μm | 3.92 μm | low cloud, fog, forest fire | Infrared |
| 8 | 6.2 μm | 6.8 μm | 6.25 μm | mid- and upper level moisture | |
| 9 | 6.9 μm | | | mid- level moisture | |
| 10 | 7.3 μm | | 7.35 μm | mid- and lower level moisture | |
| 11 | 8.6 μm | | 8.70 μm | cloud phase, SO2 | |
| 12 | 9.6 μm | | 9.66 μm | ozone content | |
| 13 | 10.4 μm | 10.8 μm | 10.8 μm | cloud imagery, information of cloud top | |
| 14 | 11.2 μm | | | cloud imagery, sea surface temperature | |
| 15 | 12.4 μm | 12.0 μm | 12.0 μm | cloud imagery, sea surface temperature | |
| 16 | 13.3 μm | | 13.4 μm | cloud top height | |



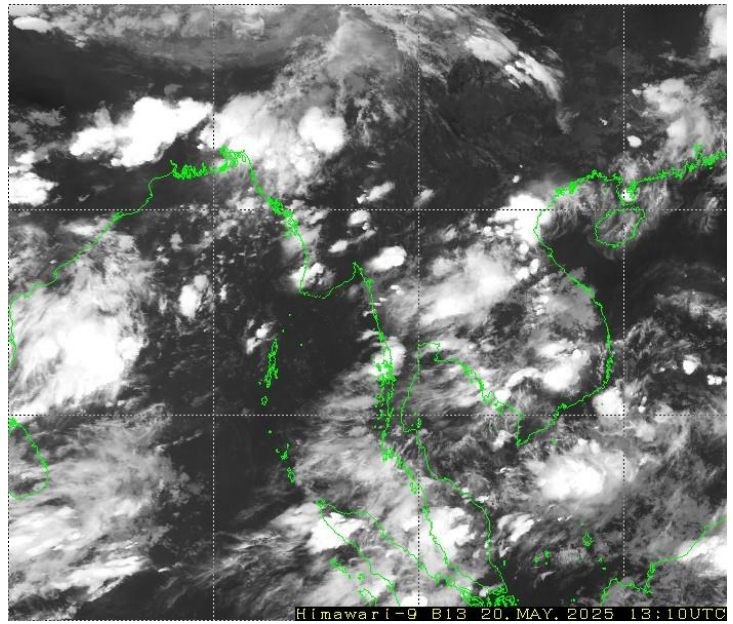
# Himawari Real-time Image

https://www.data.jma.go.jp/mscweb/data/himawari/



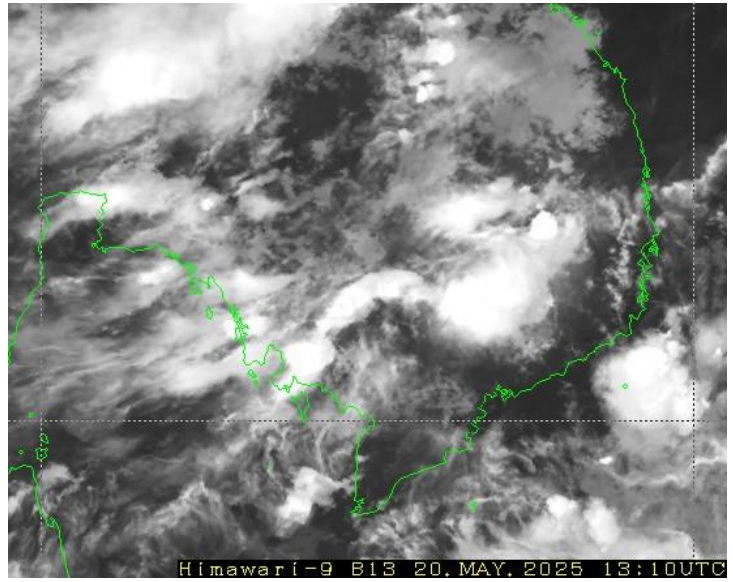

**Southeast Asia 1**

https://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php?area=se1

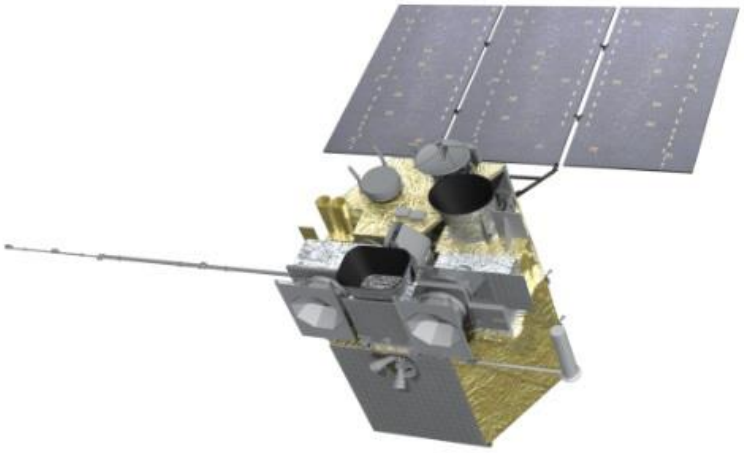



**Hi-res Asia 1**

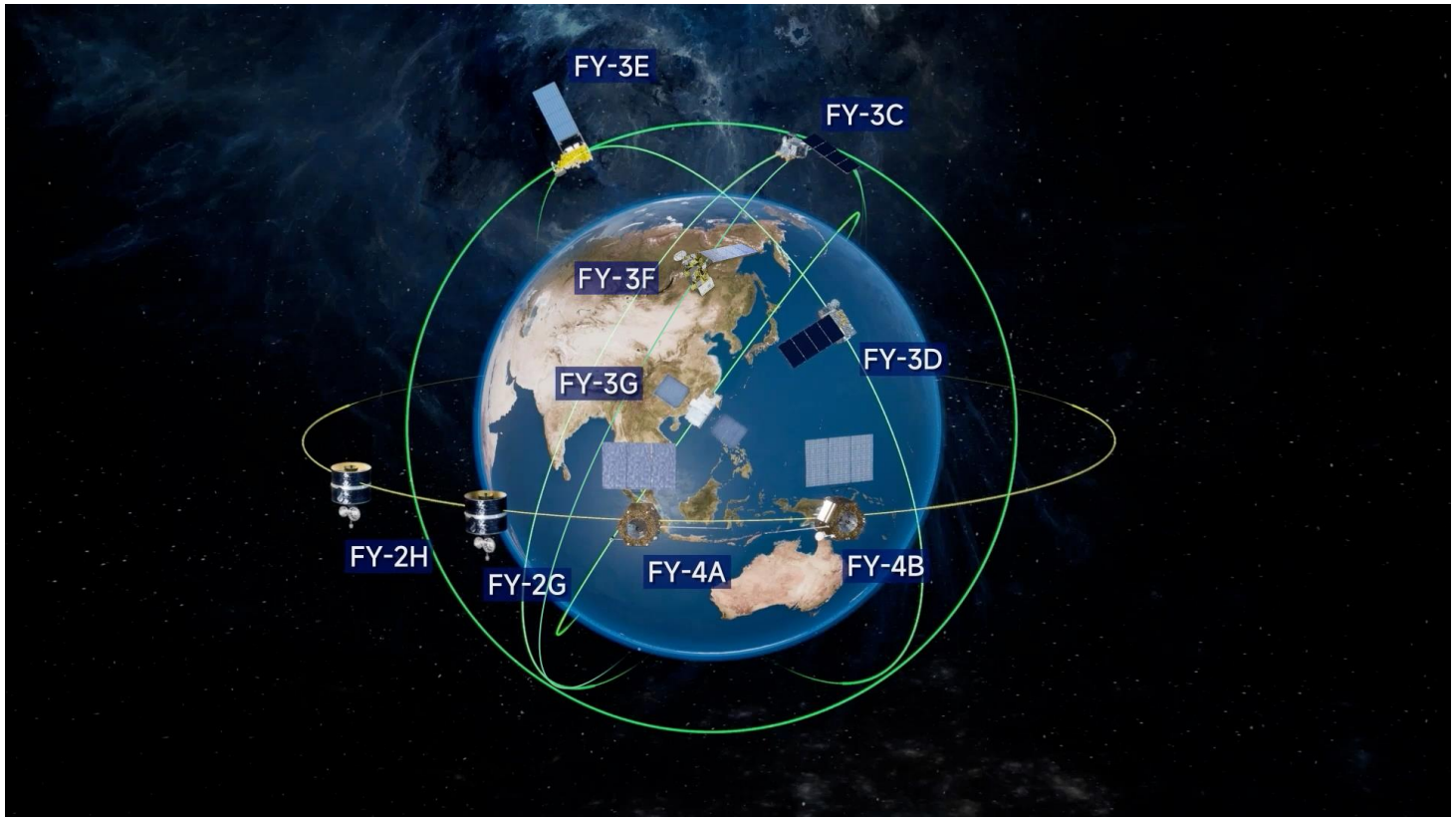
https://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php?area=ha1



# CMA Fengyun 4 (FY-4A and FY-4B)




https://www.nsmc.org.cn/nsmc/en/home/index.html



# FY-4 Advanced Geostationary Radiation Imager (AGRI)

## FY-4A (14 channels)

| Channel | Type | Central wavelength | Band | SNR or NEΔT @ specified input | Spatial resolution | Main purpose |
|---|---|---|---|---|---|---|
| 1 | Visible & Near-Infrared | 0.47μm | 0.45 ~ 0.49μm | S/N≥90 @ ρ=100% | 1km | Aerosol |
| 2 | | 0.65μm | 0.55 ~ 0.75μm | S/N≥200 @ ρ=100% | 0.5~1km | Fog, cloud |
| 3 | | 0.825μm | 0.75 ~ 0.90μm | S/N≥200 @ ρ=100% | 1km | Vegetation |
| 4 | Short-wave Infrared | 1.375μm | 1.36 ~ 1.39μm | S/N≥90 @ ρ=100% | 2km | Cirrus |
| 5 | | 1.61μm | 1.58 ~ 1.64μm | S/N≥200 @ ρ=100% | 2km | Cloud, snow |
| 6 | | 2.25μm | 2.1 ~ 2.35μm | S/N≥200 @ ρ=100% | 2~4km | Cirrus, aerosol |
| 7 | Mid-wave Infrared | 3.75μm | 3.5 ~ 4.0μm (high) | NEΔT≤0.7K @ 300K | 2km | Fire |
| 8 | | 3.75μm | 3.5 ~ 4.0μm (low) | NEΔT≤0.2K @ 300K | 4km | Land surface |
| 9 | Water vapor | 6.25μm | 5.8 ~ 6.7μm | NEΔT≤0.3K @ 260K | 4km | High level water vapor |
| 10 | | 7.1μm | 6.9 ~ 7.3μm | NEΔT≤0.3K @ 260K | 4km | Middle level water vapor |
| 11 | Long-wave Infrared | 8.5μm | 8.0 ~ 9.0μm | NEΔT≤0.2K @ 300K | 4km | Water vapor, cloud |
| 12 | | 10.7μm | 10.3 ~ 11.3μm | NEΔT≤0.2K @ 300K | 4km | Surface temperature |
| 13 | | 12.0μm | 11.5 ~ 12.5μm | NEΔT≤0.2K @ 300K | 4km | Surface temperature |
| 14 | | 13.5μm | 13.2 ~ 13.8μm | NEΔT≤0.5K @ 300K | 4km | Cloud thickness |

Source: https://www.nsmc.org.cn/nsmc/en/instrument/AGRI.html

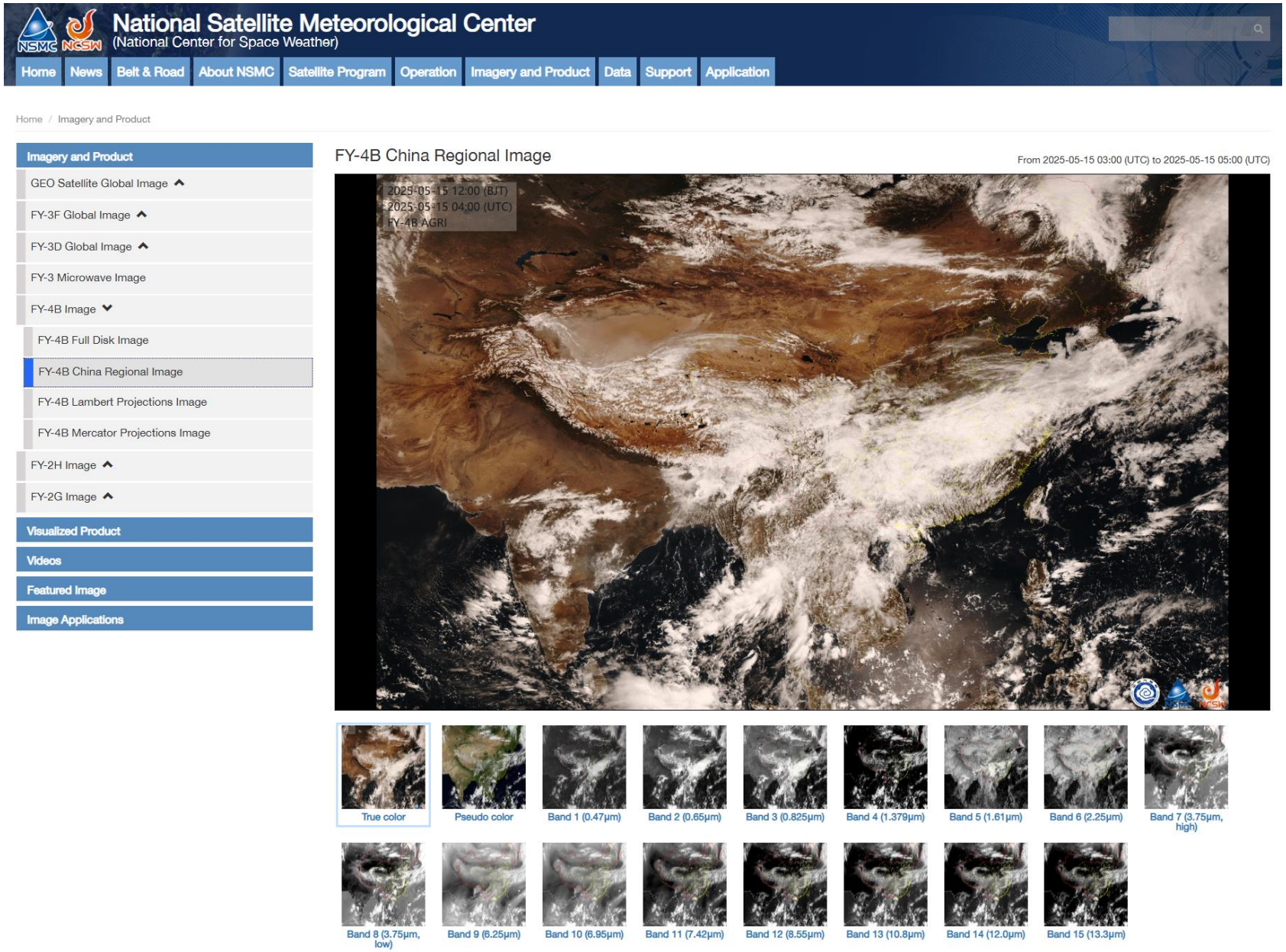
## FY-4B (15 channels)

| Band | Center wave length (μm) | Band width (μm) | Spatial resolution(km) | Sensitivity/SNR | | Main purpose |
|---|---|---|---|---|---|---|
| 1 | 0.47 | 0.45~0.49 | 1 | S/N≥90(ρ=100%) | | Aerosol |
| 2 | 0.65 | 0.55~0.75 | 0.5 | S/N≥150(ρ=100%)@0.5km | S/N≥3(ρ=1%)@1km | Fog, cloud |
| 3 | 0.825 | 0.75~0.90 | 1 | S/N≥200(ρ=100%) | S/N≥3(ρ=1%) | Vegetation |
| 4 | 1.379 | 1.371~1.386 | 2 | S/N≥120(ρ=100%) | S/N≥2(ρ=1%) | Cirrus |
| 5 | 1.61 | 1.58~1.64 | 2 | S/N≥200(ρ=100%) | S/N≥3(ρ=1%) | Cloud, snow |
| 6 | 2.25 | 2.10~2.35 | 2 | S/N≥200(ρ=100%) | S/N≥2(ρ=1%) | Cirrus, aerosol |
| 7 | 3.75 | 3.50~4.00(high) | 2 | ≤0.7K(315K) | | Fire |
| 8 | 3.75 | 3.50~4.00(low) | 4 | 0.2K(300K) | 2K(240K) | Land surface |
| 9 | 6.25 | 5.80~6.70 | 4 | 0.2K(300K) | 0.9K(240K) | High level water vapor |
| 10 | 6.95 | 6.75~7.15 | 4 | 0.25K(300K) | 0.9K(240K) | Mid level water vapor |
| 11 | 7.42 | 7.24~7.60 | 4 | 0.25K(300K) | 0.9K(240K) | Low level water vapor |
| 12 | 8.55 | 8.3~8.8 | 4 | 0.2K(300K) | 0.4K(240K) | Cloud |
| 13 | 10.80 | 10.30~11.30 | 4 | 0.2K(300K) | 0.4K(240K) | Surface temperature |
| 14 | 12.00 | 11.50~12.50 | 4 | 0.2K(300K) | 0.4K(240K) | Surface temperature |
| 15 | 13.3 | 13.00~13.60 | 4 | 0.5K(300K) | 0.9K(240K) | Cloud and water vapor |

An additional band (Bands 9-11) in FY-4B to better resolve mid-level and low-level water vapour

# FY-4B Imagery

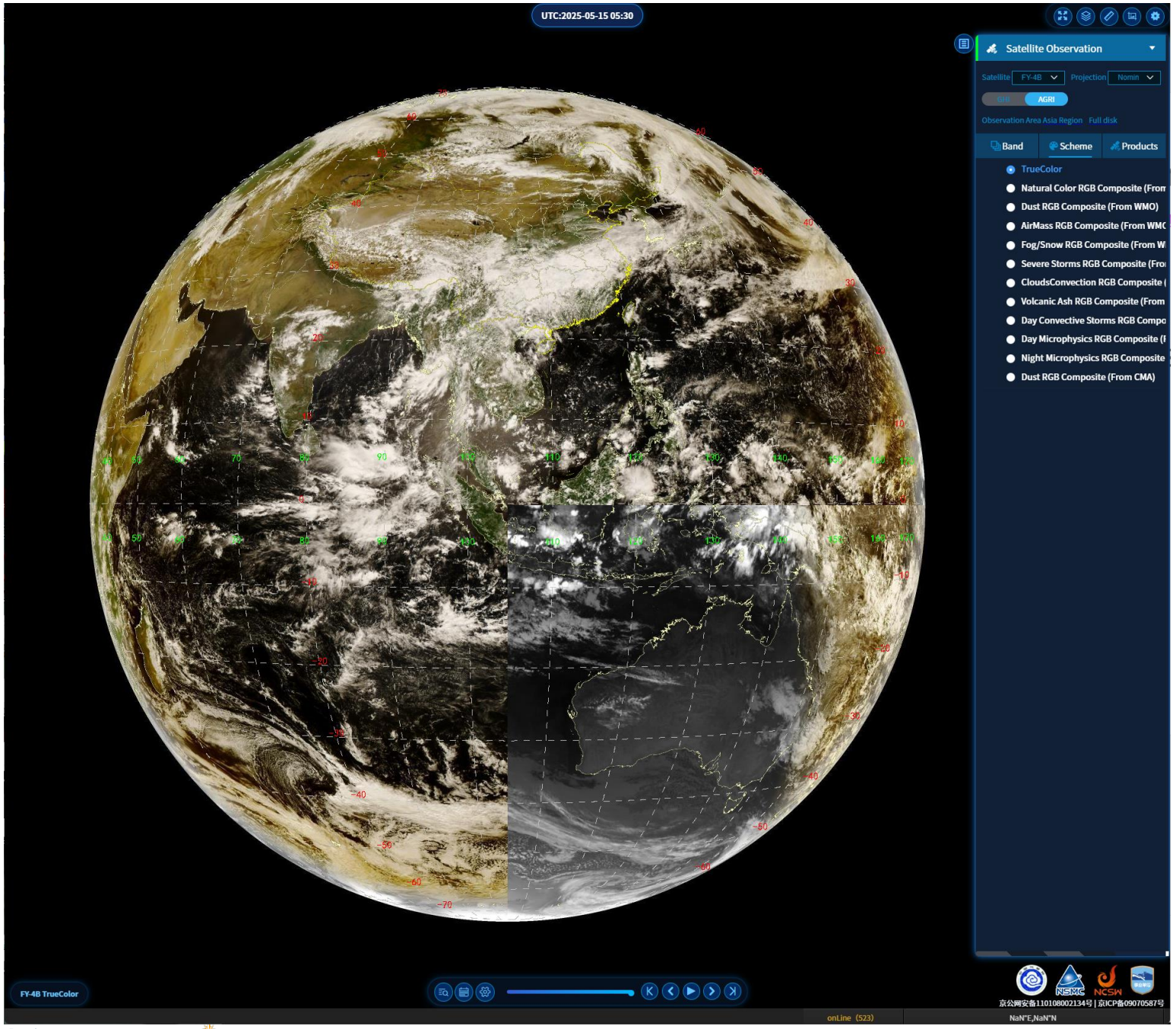
https://www.nsmc.org.cn/nsmc/en/image/index.html?id=FY4B_AGRI_IMG_REGI_GCLR_GLL



# Fengyun Satellite Weather Application Platform (SWAP)

http://rsapp.nsmc.org.cn/geofy/en/

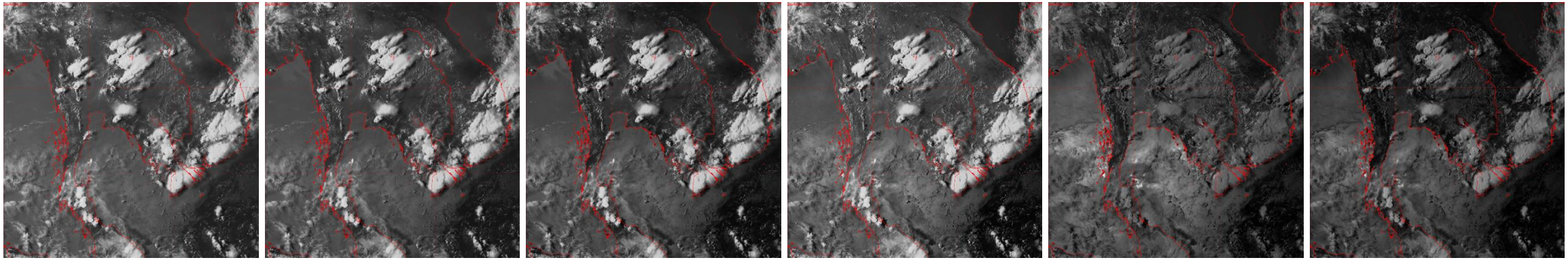
A web-GIS interactive display of FY4B (and FY4A / FY2H) images



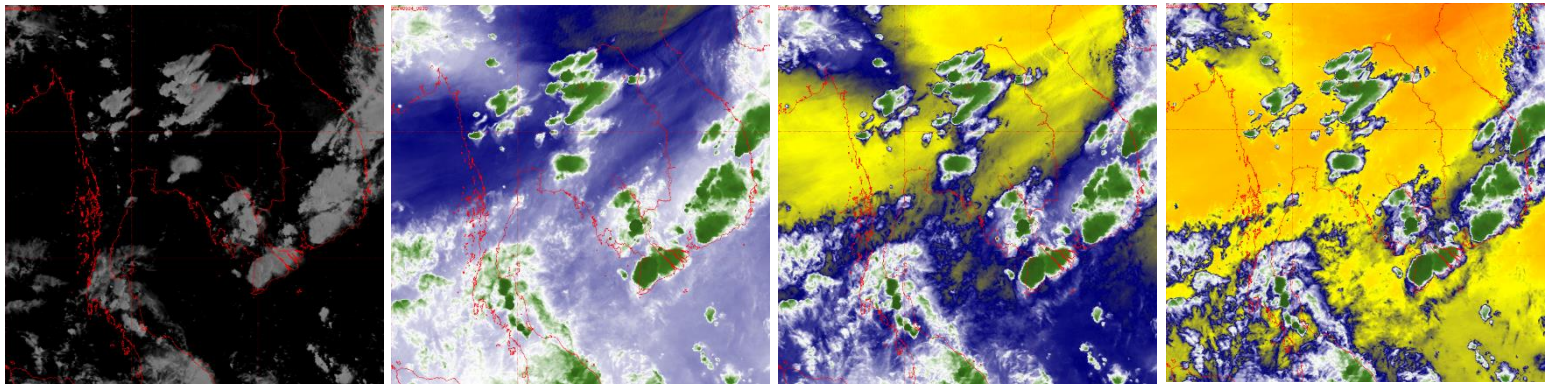
# Using multi-spectral satellite images in weather monitoring

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 µm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 µm | | | vegetation, aerosol G | |
| 3 | 0.64 µm | 0.68 µm | 0.635 µm | low cloud, fog R | |
| 4 | 0.86 µm | | 0.81 µm | vegetation, aerosol | Near Infrared |
| 5 | 1.6 µm | | 1.64 µm | cloud phase | |
| 6 | 2.3 µm | | | particle size | |
| 7 | 3.9 µm | 3.7 µm | 3.92 µm | low cloud, fog, forest fire | |
| 8 | 6.2 µm | 6.8 µm | 6.25 µm | mid- and upper level moisture | |
| 9 | 6.9 µm | | | mid- level moisture | |
| 10 | 7.3 µm | | 7.35 µm | mid- and lower level moisture | |
| 11 | 8.6 µm | | 8.70 µm | cloud phase, SO2 | Infrared |
| 12 | 9.6 µm | | 9.66 µm | ozone content | |
| 13 | 10.4 µm | 10.8 µm | 10.8 µm | cloud imagery, information of cloud top | |
| 14 | 11.2 µm | | | cloud imagery, sea surface temperature | |
| 15 | 12.4 µm | 12.0 µm | 12.0 µm | cloud imagery, sea surface temperature | |
| 16 | 13.3 µm | | 13.4 µm | cloud top height | |

Band01 (0.46 μm) Band02 (0.51 μm) Band03 (0.64 μm) Band04 (0.86 μm) Band05 (1.6 μm) Band06 (2.3 μm)



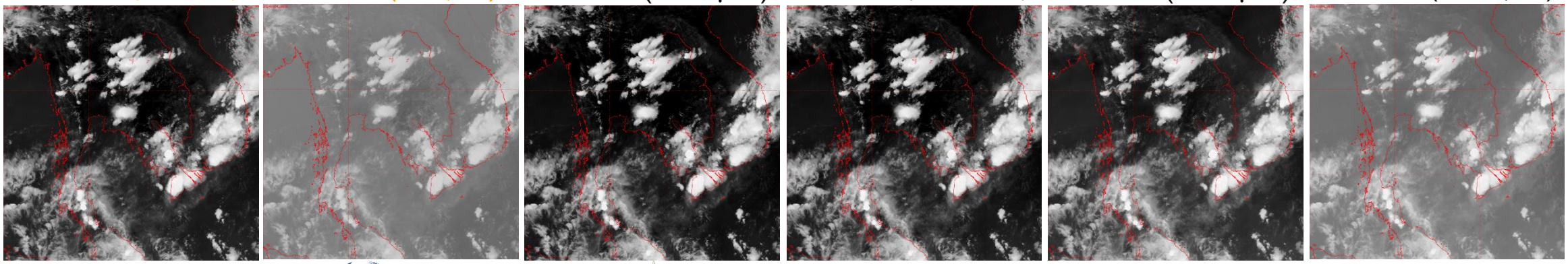
Band07 (3.9 μm) Band08 (6.2 μm) Band09 (6.9 μm) Band10 (7.3 μm)



**2024-05-04**

**08:30 UTC**

Band11 (8.6 μm) Band12 (9.6 μm) Band13 (10.4 μm) Band14 (11.2 μm) Band15 (12.4 μm) Band16 (13.3 μm)



# Use and Interpretation of Satellite RGB Imagery for Severe Weather Nowcasting

# RGB Composite Imagery

- What is RGB technique?
  - To derive various information of cloud characteristics by colorizing and composing different channels of satellite imagery

  - Advantage:
    - simple process by composition of real-time images to create RGB product on-the-fly
    - various information derivable by RGB image
    - “natural texture” of single channel images can be retained in RGB product

# JMA MSC Himawari RGB Quick Guides







## Himawari RGB Quick Guides

### Outline

Himawari RGB Quick Guides provide basic summaries on the use of RGB composite imagery.

They are designed simply with front and reverse sides for ease of printing and lamination. A total of 18 Quick Guides are provided in relation to SATAID software to facilitate daily work.

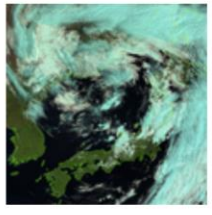
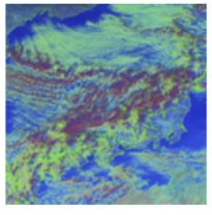
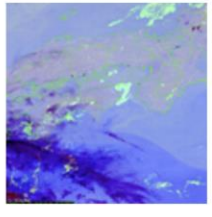
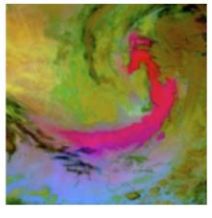
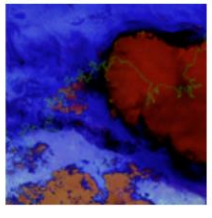
Guides contain information on:

1. Main application(s), benefits and limitations
2. Typical cases
3. Color interpretation
4. RGB recipe (RGB composition: combinations of imagery assigned to the three primary colors with recommended thresholds) and related specifications

### Himawari RGB Quick Guides

Click on an RGB name or image to download the relevant content.

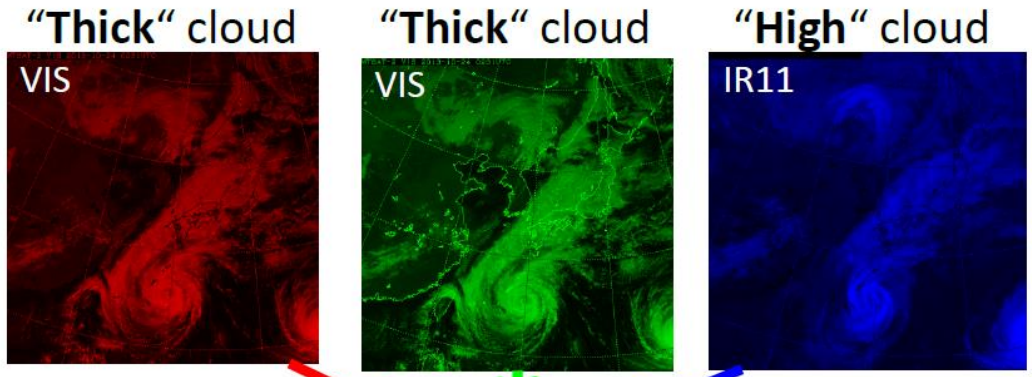
#### WMO-recommended schemes

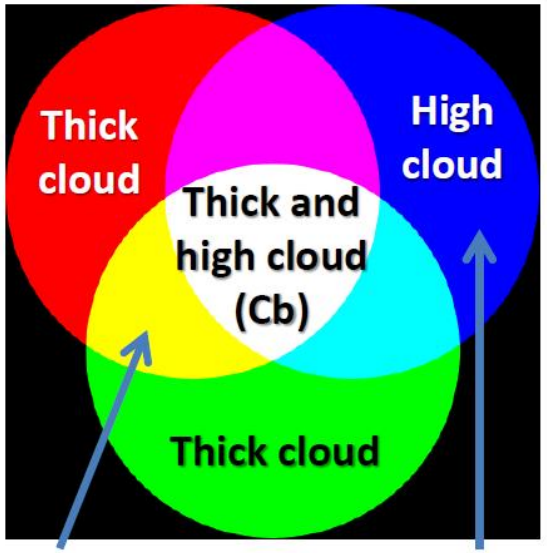
| | | |
|---|---|---|
|  Natural Colors |  Day Snow-Fog |  Day Microphysics |
|  Night Microphysics |  Dust |  24-hour Microphysics |

# Example of RGB product (1) – False Color Imagery

## RGB composite

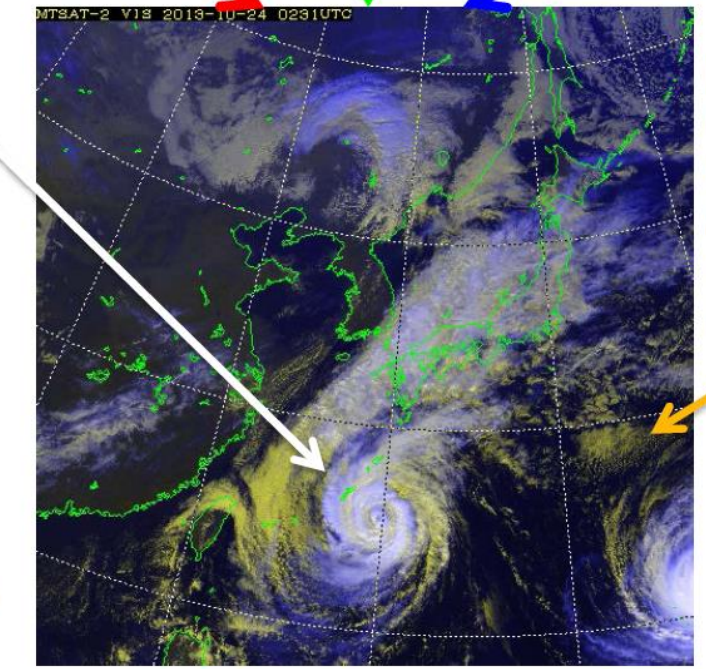
Thick and high cloud (Cb) areas appear white!



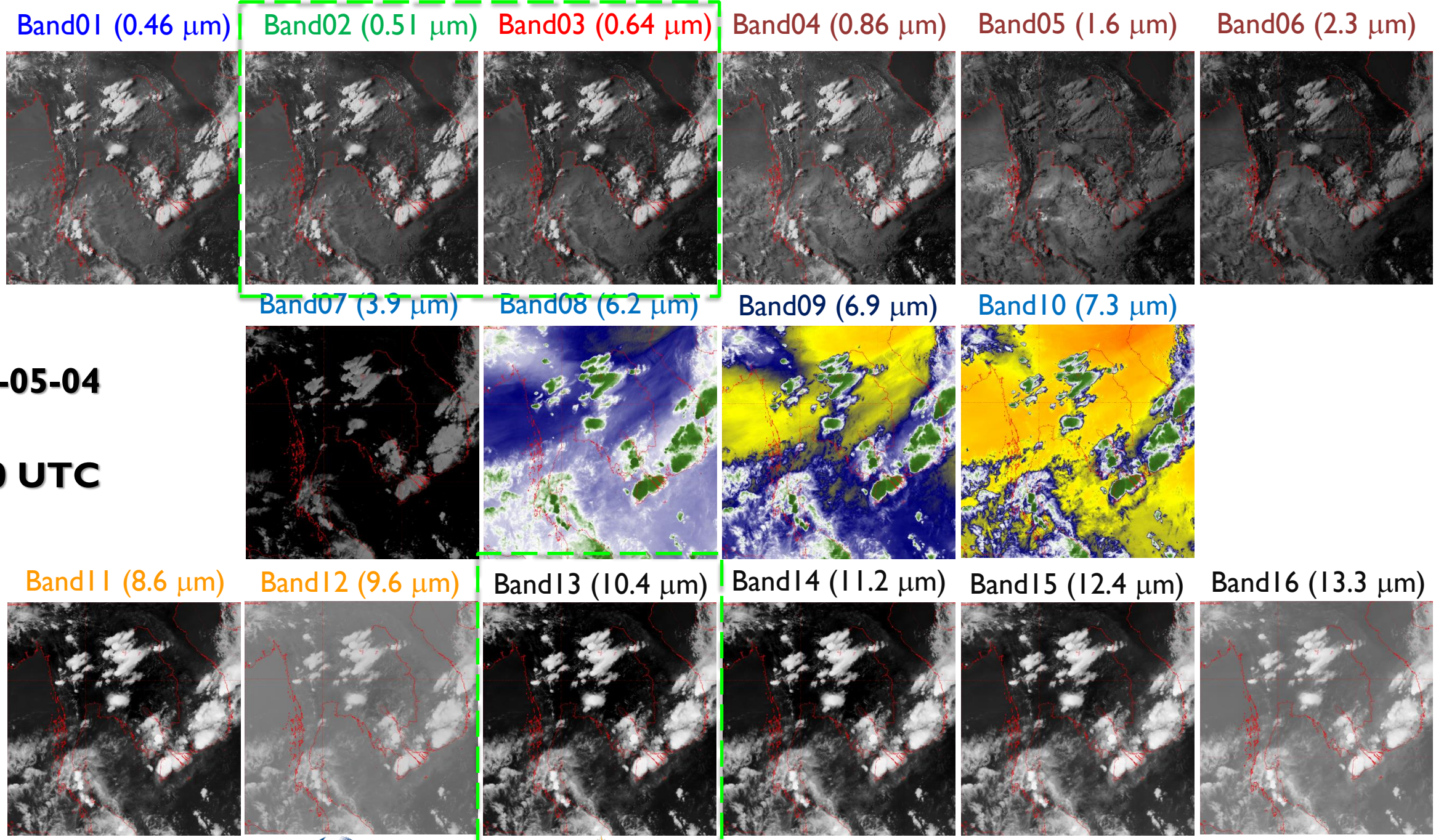




Thick but not high cloud (Low level clouds)

High but not thick cloud (Cirrus)

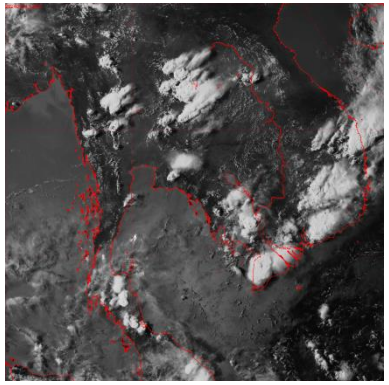


If you want to focus on the low level clouds, look at the yellow area.

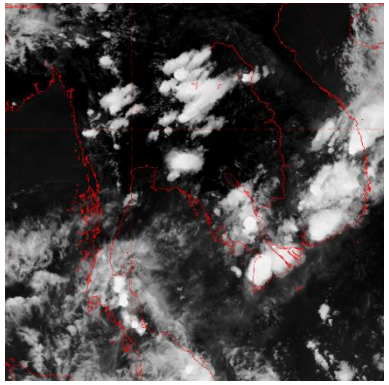

Band01 (0.46 μm)
Band02 (0.51 μm)
Band03 (0.64 μm)
Band04 (0.86 μm)
Band05 (1.6 μm)
Band06 (2.3 μm)
Band07 (3.9 μm)
Band08 (6.2 μm)
Band09 (6.9 μm)
Band10 (7.3 μm)
2024-05-04
08:30 UTC
Band11 (8.6 μm)
Band12 (9.6 μm)
Band13 (10.4 μm)
Band14 (11.2 μm)
Band15 (12.4 μm)
Band16 (13.3 μm)

# 2024-05-04 08:30 UTC

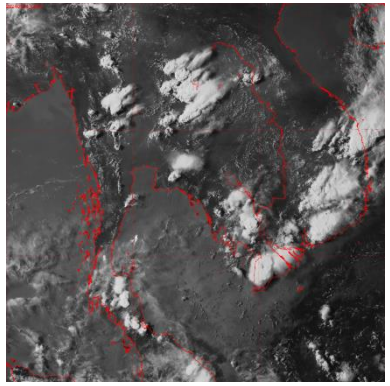
Band03 (0.64 μm)

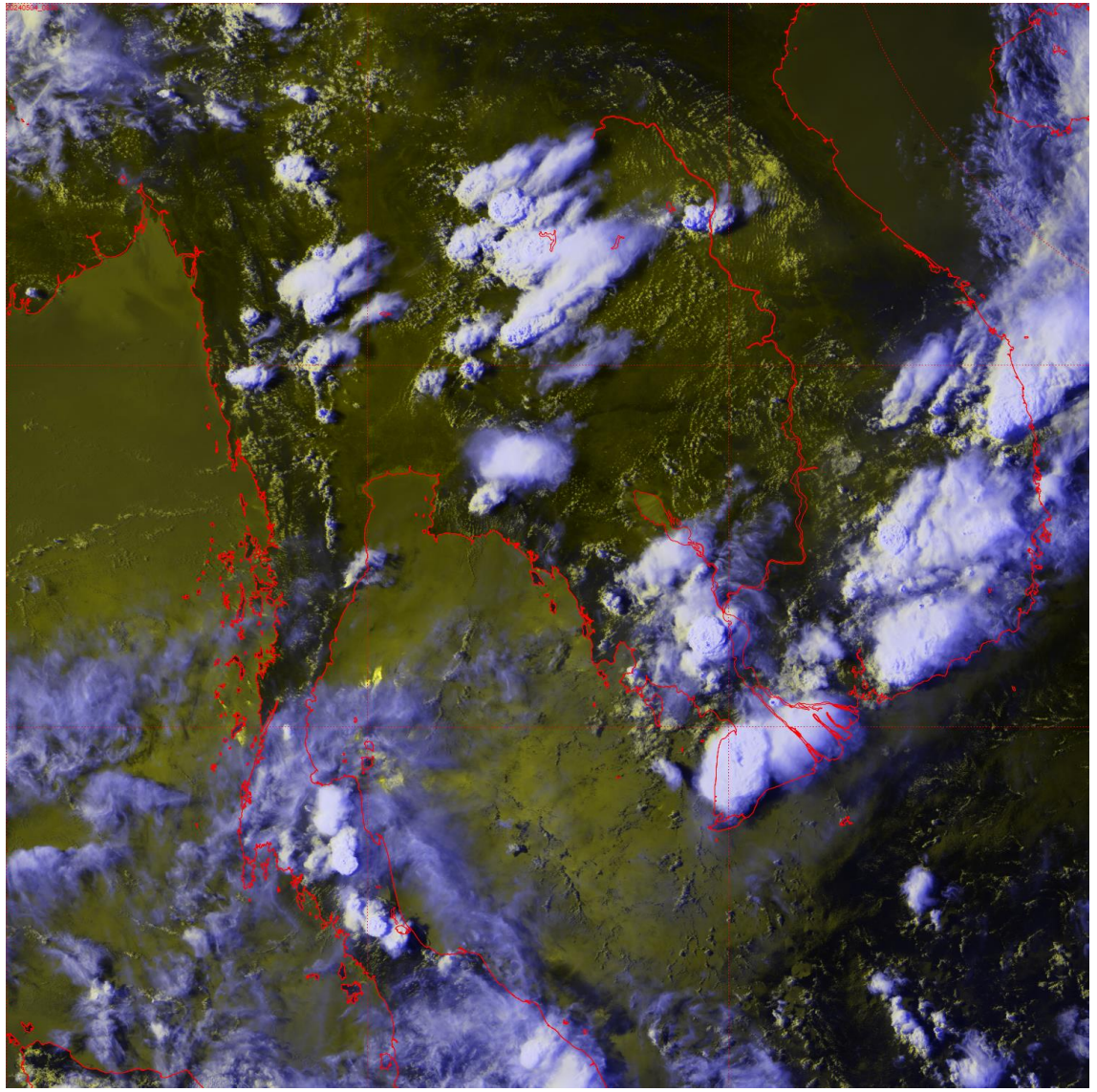


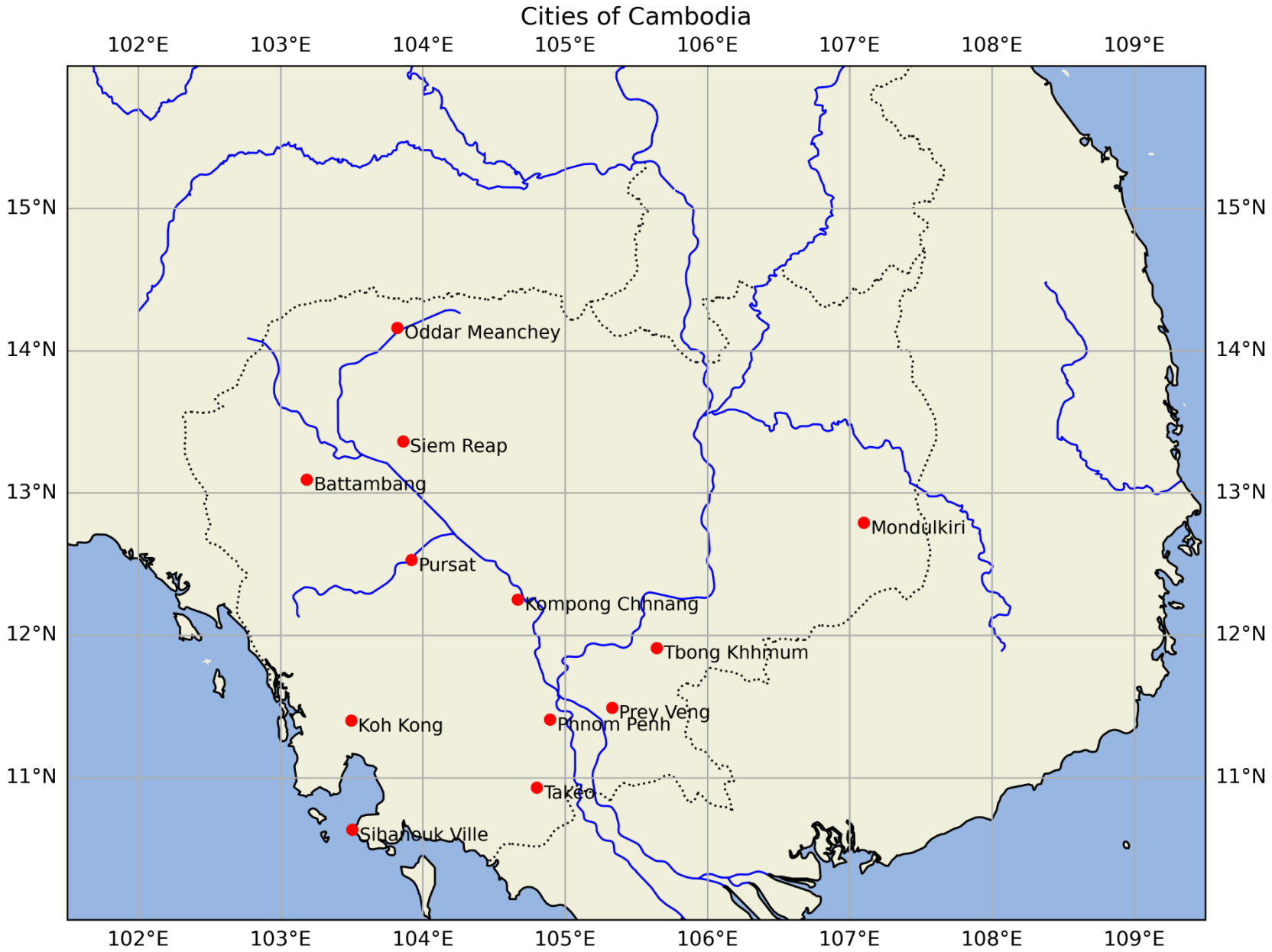
Band13 (10.4 μm)



Band02 (0.51 μm)

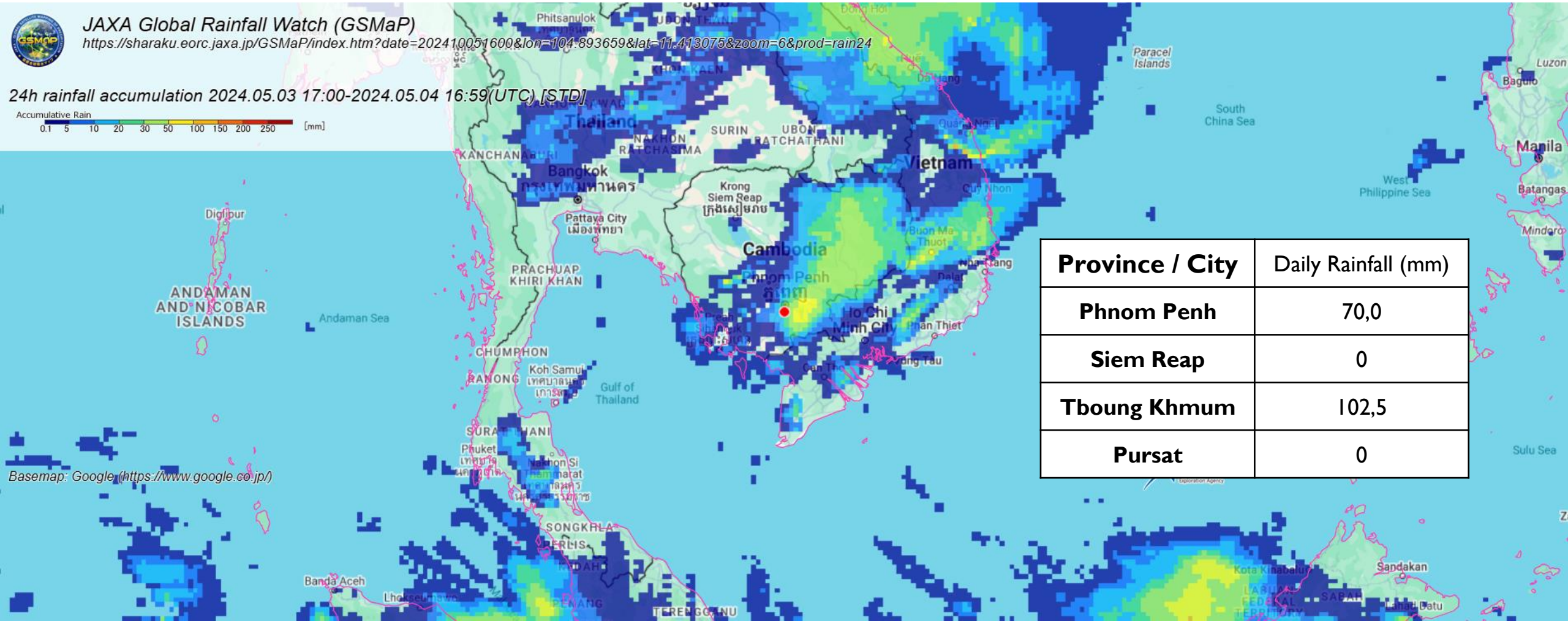





Cities of Cambodia
102°E
103°E
104°E
105°E
106°E
107°E
108°E
109°E
15°N
14°N
13°N
12°N
11°N
Oddar Meanchey
Siem Reap
Battambang
Pursat
Kompong Chhnang
Mondulkiri
Tbong Khhmum
Prey Veng
Phnom Penh
Koh Kong
Takéo
Sihanouk Ville

# JAXA Global Rainfall Watch (https://sharaku.eorc.jaxa.jp/GSMaP/index.htm)

## 24 hours accumulated rainfall at 17:00 UTC 4 May 2024




| Province / City | Daily Rainfall (mm) |
|---|---|
| **Phnom Penh** | 70,0 |
| **Siem Reap** | 0 |
| **Tboung Khmum** | 102,5 |
| **Pursat** | 0 |

0.1 5 10 20 30 50 100 150 200 250 (mm)

# RGB Composite Imagery

| Band | Himawari-8/ AHI | MTSAT-2/ IMAGER | Physical Properties | Natural Color | Day Microphysics | Night Microphysics | Day Snow-Fog | Day Convective Storm | Dust | Airmass |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.47 µm | | vegetation, aerosol B | | | | | | | |
| 2 | 0.51 µm | | vegetation, aerosol G | | | | | | | |
| 3 | 0.64 µm | 0.68 µm | low cloud, fog R | X | | | | X | | |
| 4 | 0.86 µm | | vegetation, aerosol | X | X | | X | | | |
| 5 | 1.6 µm | | cloud phase | X | | | X | X | | |
| 6 | 2.3 µm | | particle size | | | | | | | |
| 7 | 3.9 µm | 3.7 µm | low cloud, fog, forest fire | | X | X | X | X | | |
| 8 | 6.2 µm | 6.8 µm | upper level moisture | | | | | X | | X |
| 9 | 6.9 µm | | mid- and upper level moisture | | | | | | | |
| 10 | 7.3 µm | | mid- level moisture, SO2 | | | | | X | | X |
| 11 | 8.6 µm | | cloud phase, SO2 | | | | | | X | |
| 12 | 9.6 µm | | ozone content | | | | | | | X |
| 13 | 10.4 µm | 10.8 µm | cloud imagery, information of cloud top | | X | X | | X | X | X |
| 14 | 11.2 µm | | cloud imagery, sea surface temperature | | | | | | | |
| 15 | 12.4 µm | 12.0 µm | cloud imagery, sea surface temperature | | | X | | | X | |
| 16 | 13.3 µm | | cloud top height | | | | | | | |

# JMA MSC Himawari RGB Quick Guides







## Himawari RGB Quick Guides

### Outline

Himawari RGB Quick Guides provide basic summaries on the use of RGB composite imagery.

They are designed simply with front and reverse sides for ease of printing and lamination. A total of 18 Quick Guides are provided in relation to SATAID software to facilitate daily work.

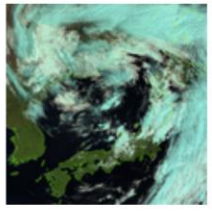
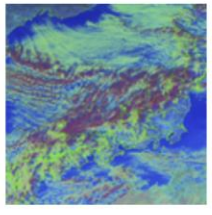
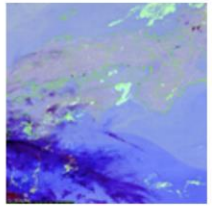
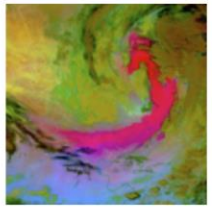
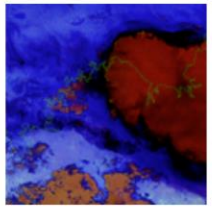
Guides contain information on:

1. Main application(s), benefits and limitations
2. Typical cases
3. Color interpretation
4. RGB recipe (RGB composition: combinations of imagery assigned to the three primary colors with recommended thresholds) and related specifications

### Himawari RGB Quick Guides

Click on an RGB name or image to download the relevant content.

#### WMO-recommended schemes

| | | |
|---|---|---|
|  Natural Colors |  Day Snow-Fog |  Day Microphysics |
|  Night Microphysics |  Dust |  24-hour Microphysics |

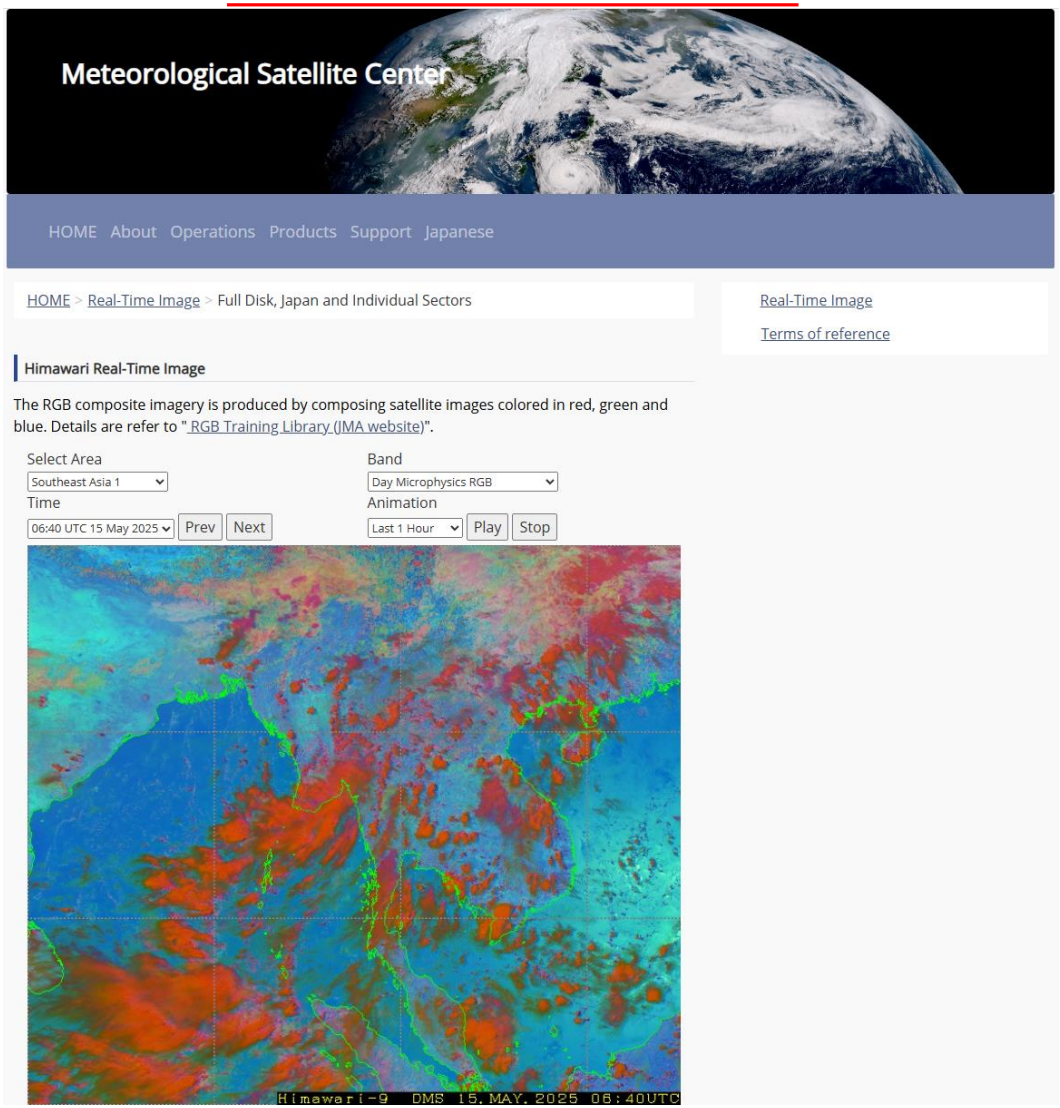
# Online resources

- Himawari Real-Time Image (including RGB products)
  - https://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php
  - Select **"Southeast Asia 1"** or **"Hi-res Asia 1"**

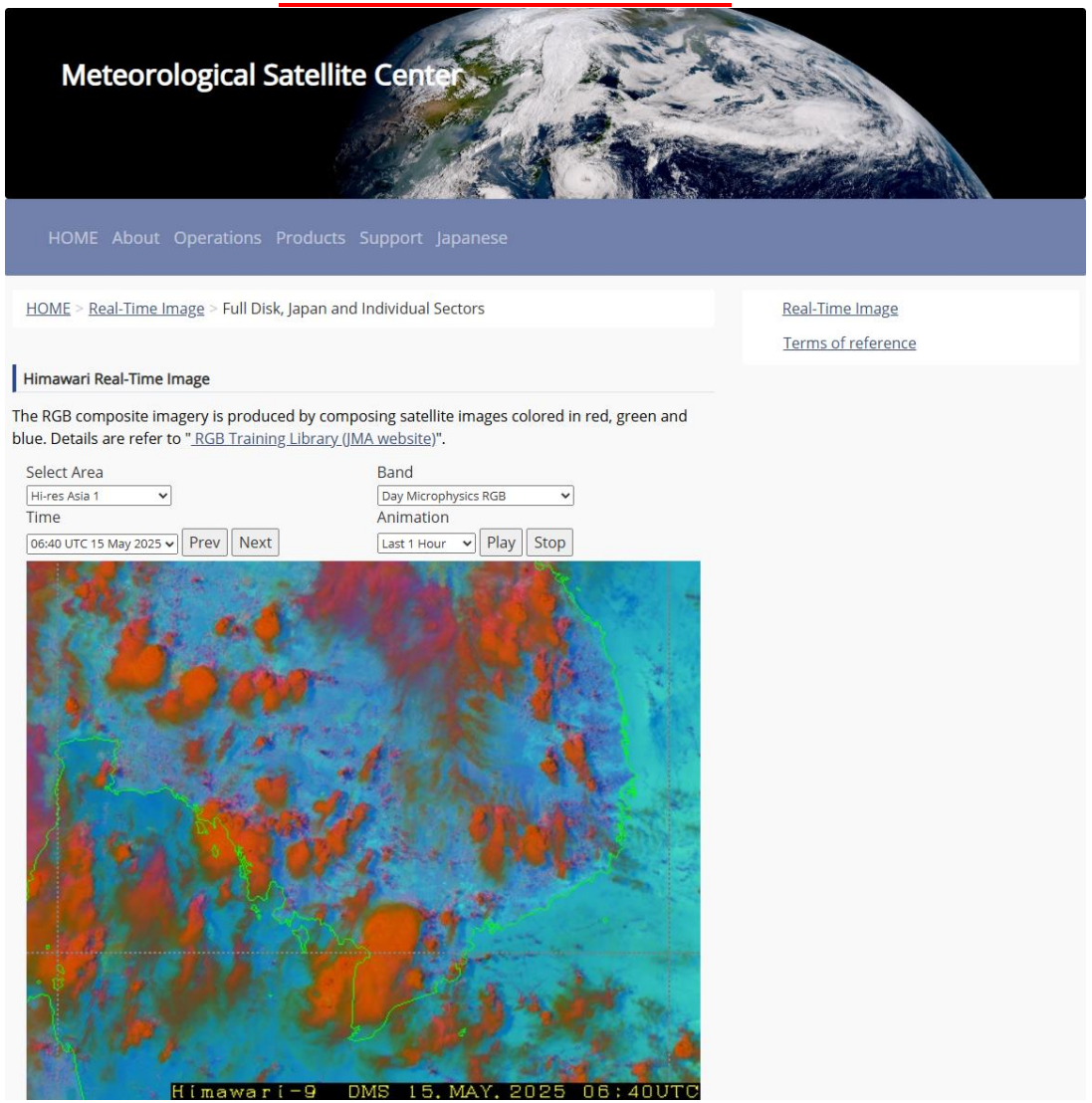
- Reference on RGB product
  - https://www.data.jma.go.jp/mscweb/en/product/product.html
  - https://www.jma.go.jp/jma/jma-eng/satellite/VLab/RGB_QG.html
  - Introduction to Himawari-8 RGB Composite Imagery

https://www.data.jma.go.jp/mscweb/data/himawari/sat_img.php

## "Southeast Asia 1"




## "Hi-res Asia 1"



# (1) Natural Color RGB

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 μm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 μm | | | vegetation, aerosol G | |
| 3 | 0.64 μm | 0.68 μm | 0.635 μm | **low cloud, fog** R | |
| 4 | 0.86 μm | | 0.81 μm | **vegetation, aerosol** | Near Infrared |
| 5 | 1.6 μm | | 1.64 μm | **cloud phase** | |
| 6 | 2.3 μm | | | particle size | |
| 7 | 3.9 μm | 3.7 μm | 3.92 μm | low cloud, fog, forest fire | Infrared |
| 8 | 6.2 μm | 6.8 μm | 6.25 μm | mid- and upper level moisture | |
| 9 | 7.0 μm | | | mid- level moisture | |
| 10 | 7.3 μm | | 7.35 μm | mid- and upper level moisture | |
| 11 | 8.6 μm | | 8.70 μm | cloud phase, SO2 | |
| 12 | 9.6 μm | | 9.66 μm | ozone content | |
| 13 | 10.4 μm | 10.8 μm | 10.8 μm | cloud imagery, information of cloud top | |
| 14 | 11.2 μm | | | cloud imagery, sea surface temperature | |
| 15 | 12.3 μm | 12.0 μm | 12.0 μm | cloud imagery, sea surface temperature | |
| 16 | 13.3 μm | | 13.4 μm | cloud top height | |

These channels have reflection characteristics for land/ sea surface conditions (such as snow/ ice covered area , vegetation) respectively.

RGB "Natural Colors" scheme

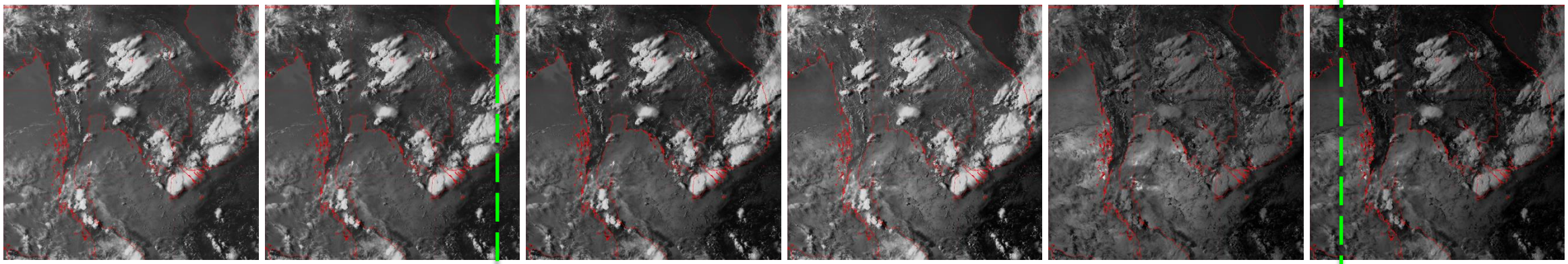
(RGB : B05/B04/B03)

R : B05(N2 1.6) Range : 0 ~ 100 [%] Gamma : 1.0

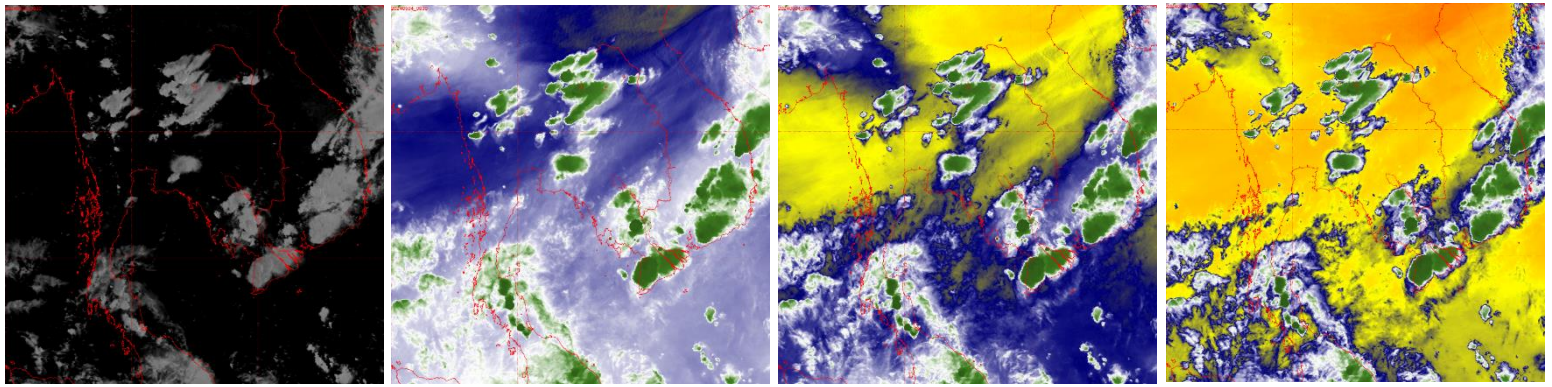
G : B04(N1 0.86) Range : 0 ~ 100 [%] Gamma : 1.0

B : B03(VS 0.64) Range : 0 ~ 100 [%] Gamma : 1.0

Band01 (0.46 μm) Band02 (0.51 μm) Band03 (0.64 μm) Band04 (0.86 μm) Band05 (1.6 μm) Band06 (2.3 μm)



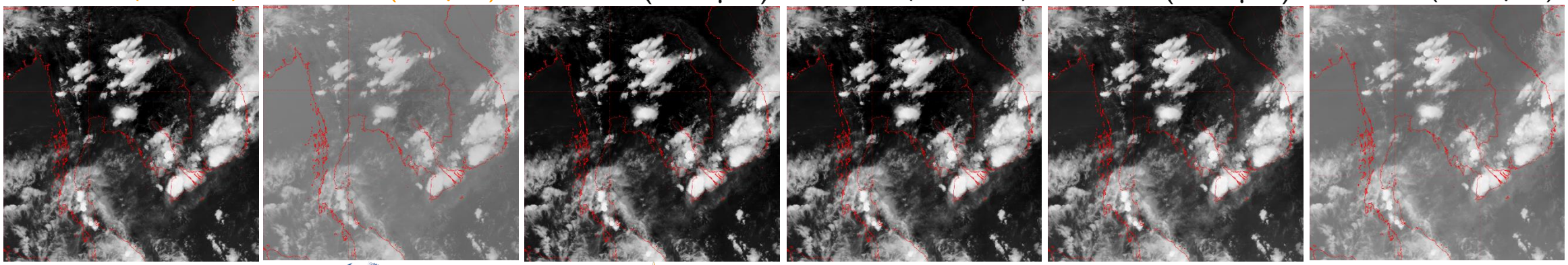
Band07 (3.9 μm) Band08 (6.2 μm) Band09 (6.9 μm) Band10 (7.3 μm)



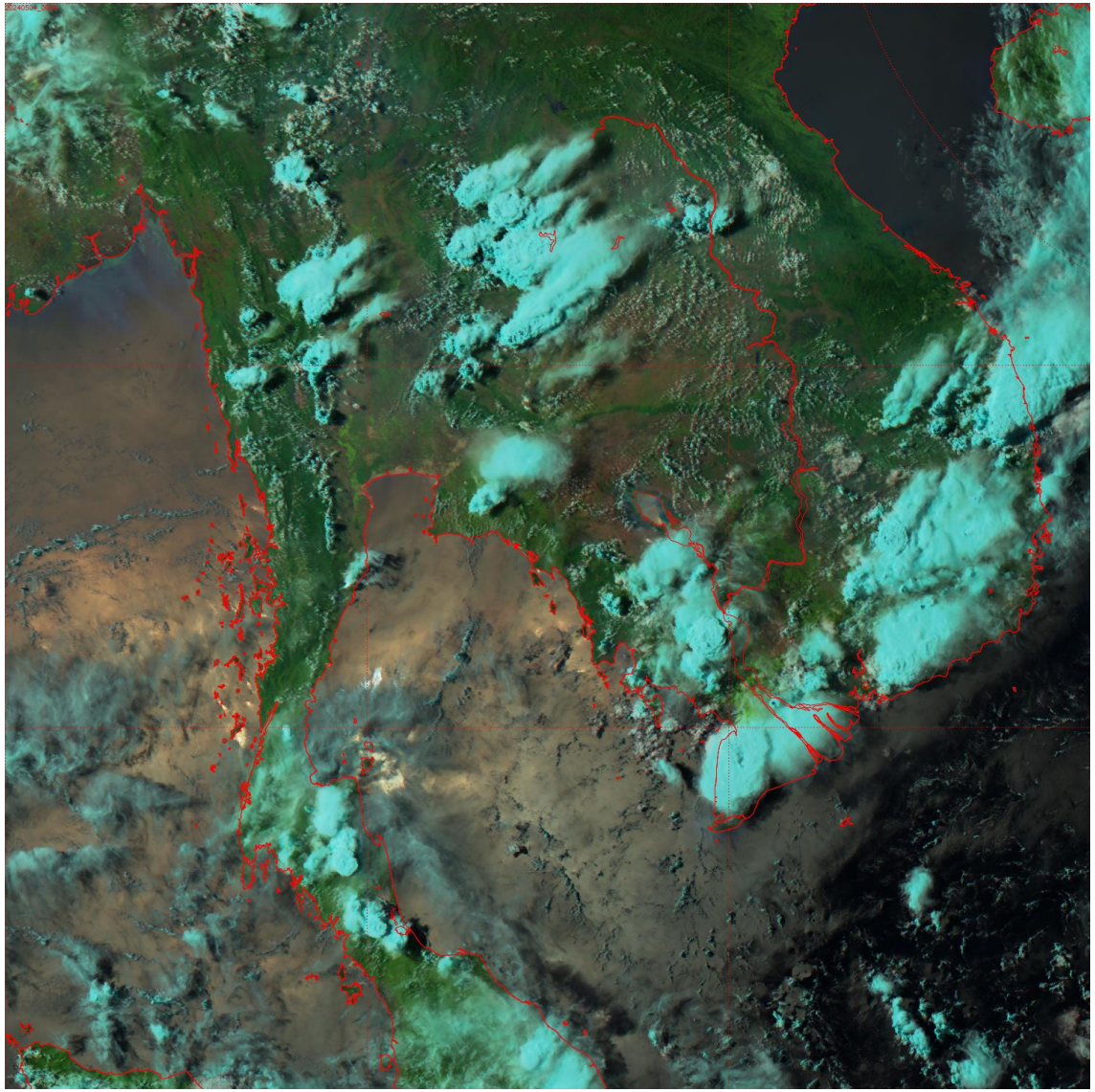
**2024-05-04**

**08:30 UTC**

Band11 (8.6 μm) Band12 (9.6 μm) Band13 (10.4 μm) Band14 (11.2 μm) Band15 (12.4 μm) Band16 (13.3 μm)



# 2024-05-04 08:30 UTC



High-level ice clouds

Low-level water clouds

Ocean | Vegetation | Desert | Snow

# (1) Natural Color RGB

- Main applications:
  - Identification of surface characteristics (vegetation, bare soil and snow) and ice / water clouds

- Benefits:
  - Stratification of high-level ice clouds and low-level water clouds
  - Quick and intuitive identification of surface characteristics

- Limitation:
  - Only daytime
  - Similarity of colour of high-level ice cloud and snow-/ice-covered surfaces
  - Cyan areas may represent contributions from both ice and water cloud with large droplets due to contribution from band05 (1.6 μm)

# (2) Day Convective Storms RGB

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 µm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 µm | | | vegetation, aerosol G | |
| 3 | 0.64 µm | 0.68 µm | 0.635 µm | **low cloud, fog** R | |
| 4 | 0.86 µm | | 0.81 µm | vegetation, aerosol | Near Infrared |
| 5 | 1.6 µm | | 1.64 µm | **cloud phase** | |
| 6 | 2.3 µm | | | particle size | |
| 7 | 3.9 µm | 3.7 µm | 3.92 µm | **low cloud, fog, forest fire** | Infrared |
| 8 | 6.2 µm | 6.8 µm | 6.25 µm | **mid- and upper level moisture** | |
| 9 | 7.0 µm | | | mid- level moisture | |
| 10 | 7.3 µm | | 7.35 µm | **mid- and upper level moisture** | |
| 11 | 8.6 µm | | 8.70 µm | cloud phase, SO2 | |
| 12 | 9.6 µm | | 9.66 µm | ozone content | |
| 13 | 10.4 µm | 10.8 µm | 10.8 µm | **cloud imagery, information of cloud top** | |
| 14 | 11.2 µm | | | cloud imagery, sea surface temperature | |
| 15 | 12.3 µm | 12.0 µm | 12.0 µm | cloud imagery, sea surface temperature | |
| 16 | 13.3 µm | | 13.4 µm | cloud top height | |

The phase and size of cloud particles distinction can be revealed from these **differences**.

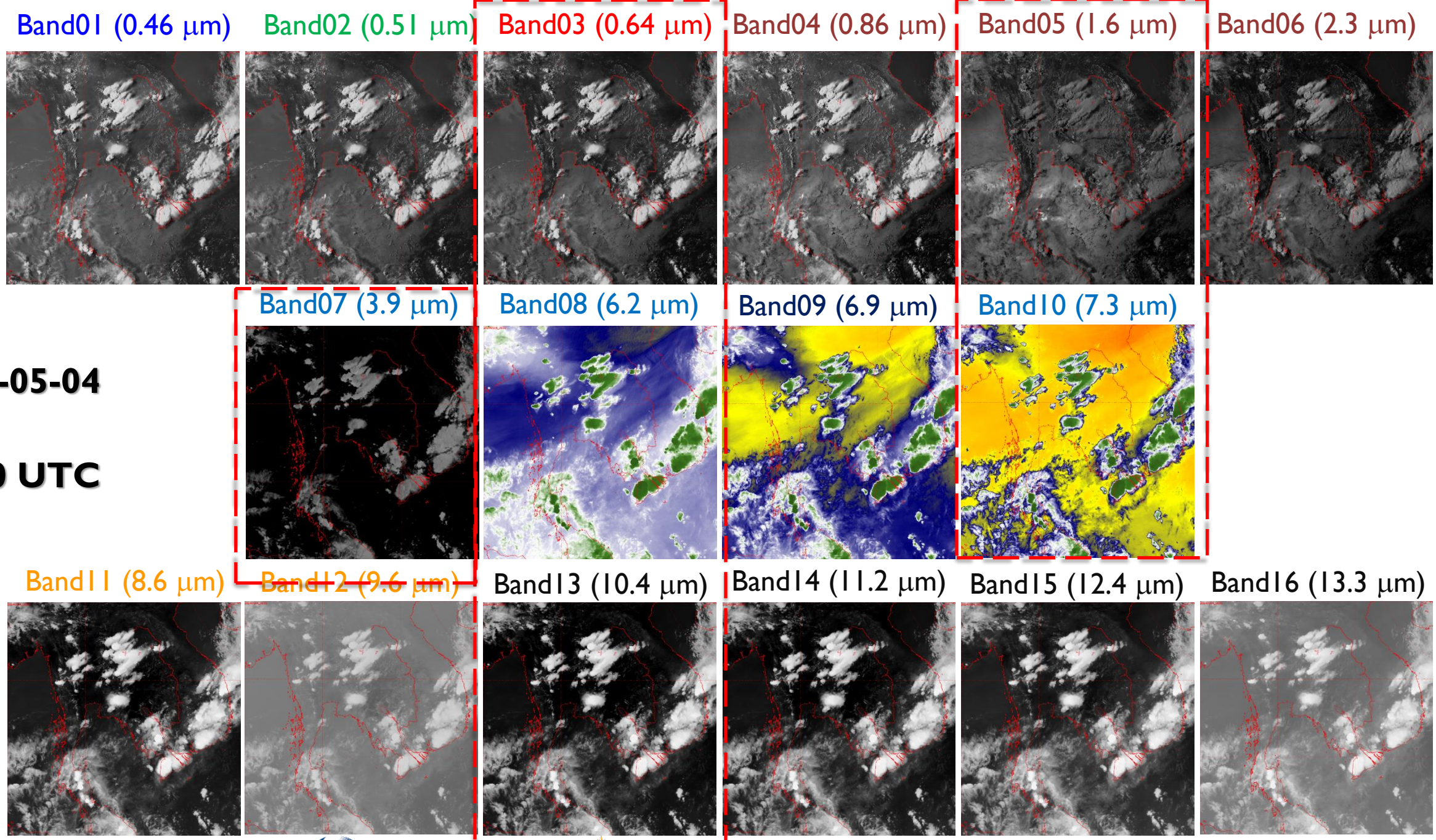
RGB "Day Convective Storms" scheme

(RGB : B08-B10/B07-B13/B05-B03)

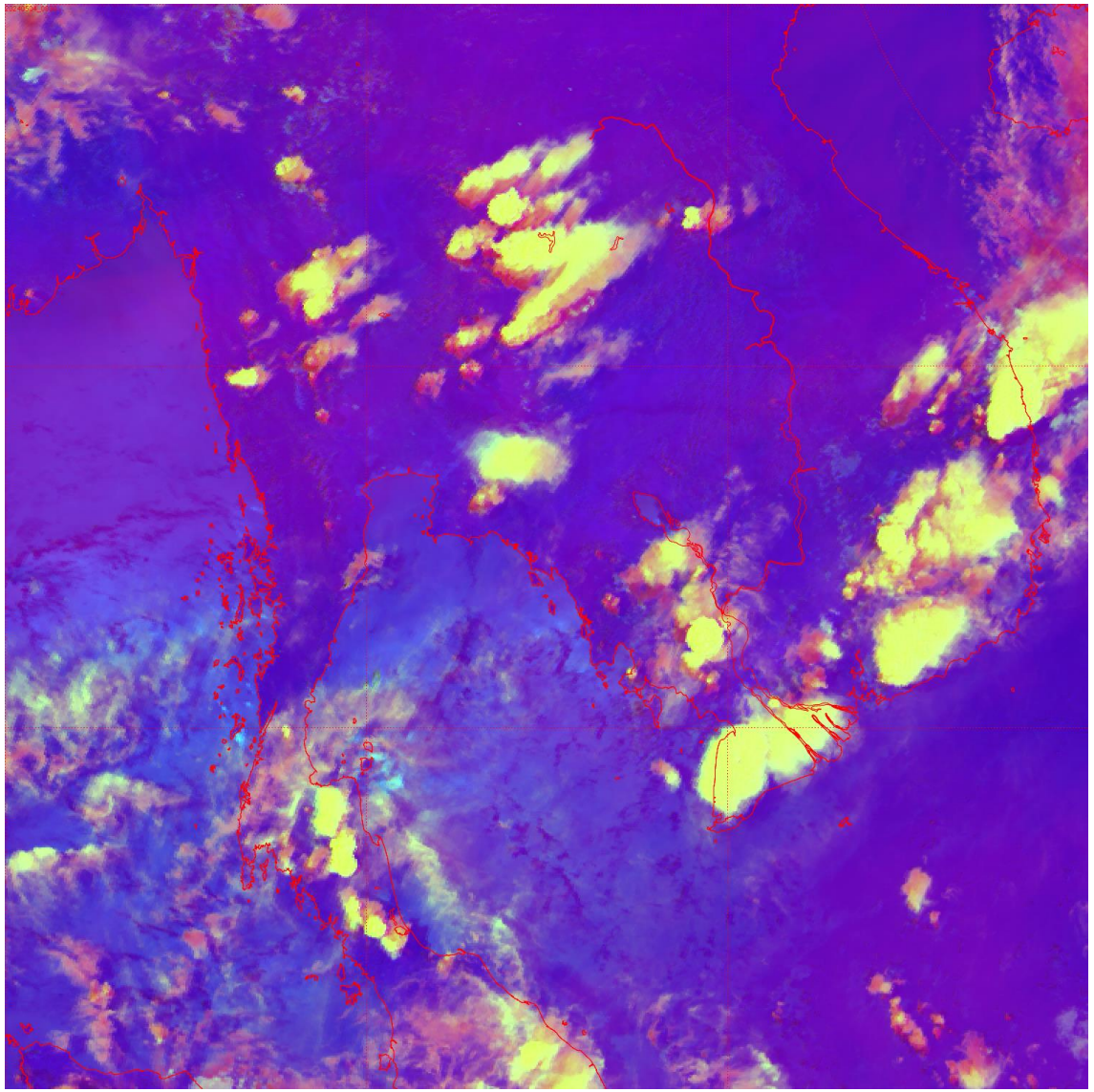
R : B08(WV6.2) – B10(WV 7.3) Range: -35 ~ 5 [K] Gamma: 1.0

G : B07(I4 3.9)-B13 (IR10.8) Range: -5 ~ 60 [K] Gamma: 0.5

B : B05(NIR1.6)-B03(VIS0.6) Range: -75 ~ 25 [%] Gamma: 1.0


Band01 (0.46 μm)
Band02 (0.51 μm)
Band03 (0.64 μm)
Band04 (0.86 μm)
Band05 (1.6 μm)
Band06 (2.3 μm)
Band07 (3.9 μm)
Band08 (6.2 μm)
Band09 (6.9 μm)
Band10 (7.3 μm)
2024-05-04
08:30 UTC
Band11 (8.6 μm)
Band12 (9.6 μm)
Band13 (10.4 μm)
Band14 (11.2 μm)
Band15 (12.4 μm)
Band16 (13.3 μm)

# 2024-05-04 08:30 UTC



**Deep precipitating cloud**

- High level cloud
- Large ice particles
- Precipitation not necessarily reaching the ground

**Deep precipitating cloud**

- High level cloud
- Small ice particles
- Cb cloud with strong updraft and severe weather **OR**
- thick, high-level lee cloudiness with small ice particles

**Thin cirrus cloud**

- Large ice particles

**Thin cirrus cloud**

- Small ice particles

Ocean | Land

# (2) Day Convective Storm RGB

- Main applications:
  - Identification of high-level cloud tops and/or small ice particles conducive to severe / significant convection with strong updraft

- Benefits:
  - Distinctive yellow patterns denoting cumulonimbus (Cb) clouds with strong updraft and severe weather

- Limitation:
  - Only daytime
  - Less clear for low-level clouds and surface conditions
  - Possible mixed with other high-level clouds (e.g. lee side of mountainous ranges) leading to reduced clarity for convective clouds

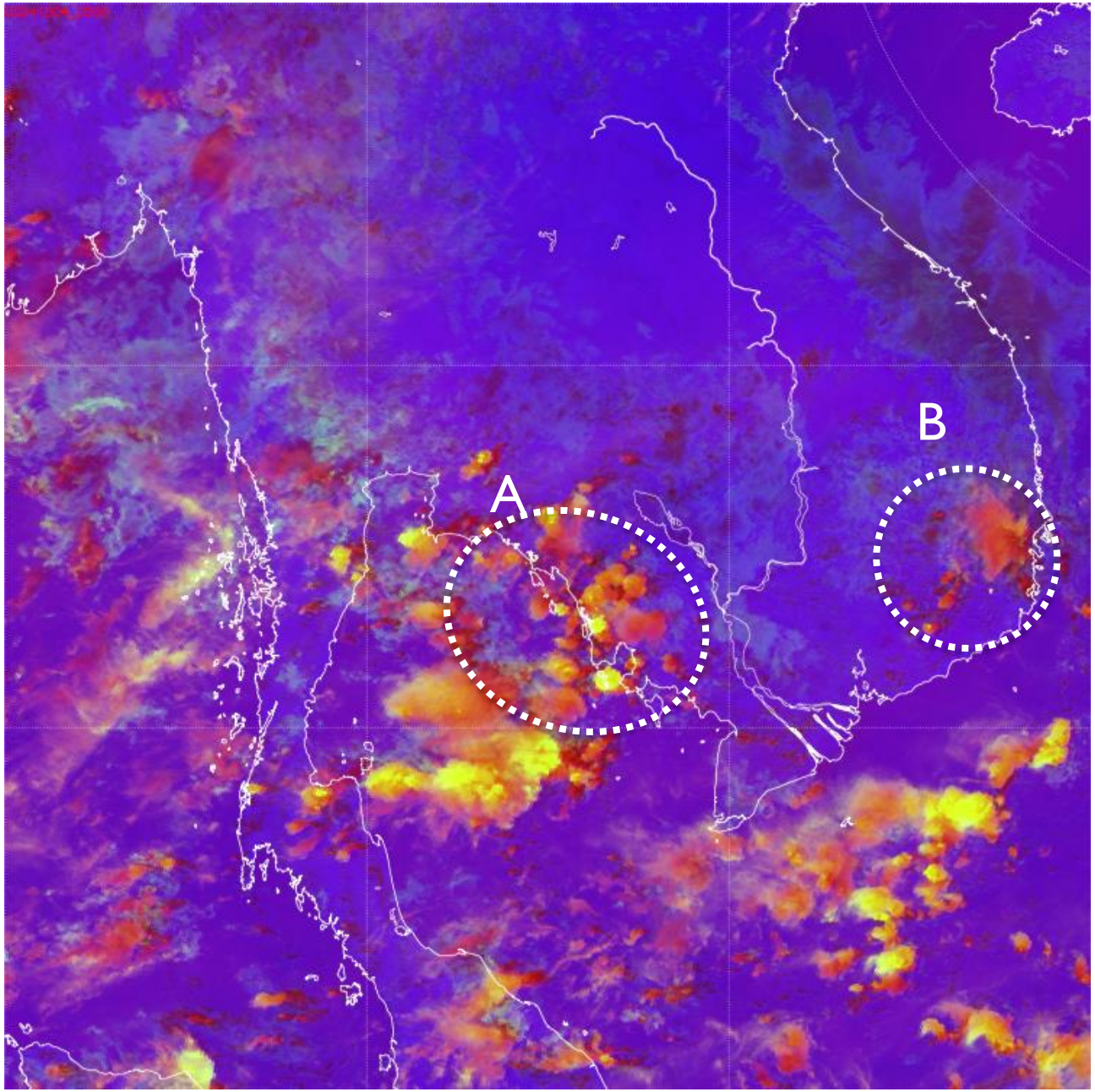
# Exercise 1

## 2024-10-04 05:00 UTC

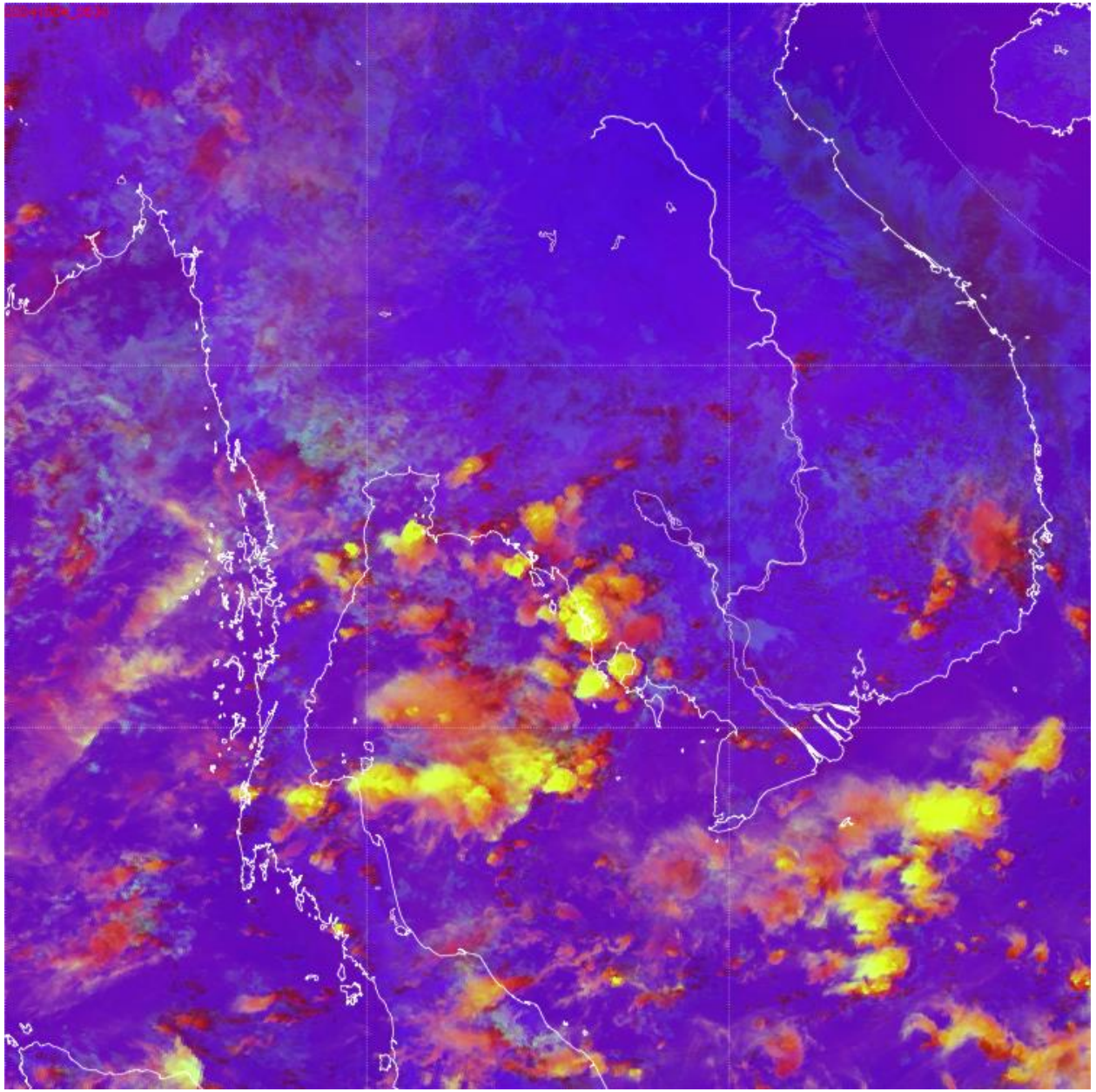
1. What types of clouds are present in A and B?

2. Referring to the images in the next 2 pages, identify the development of the clouds in A, and nowcast for the following 1-2 hours.

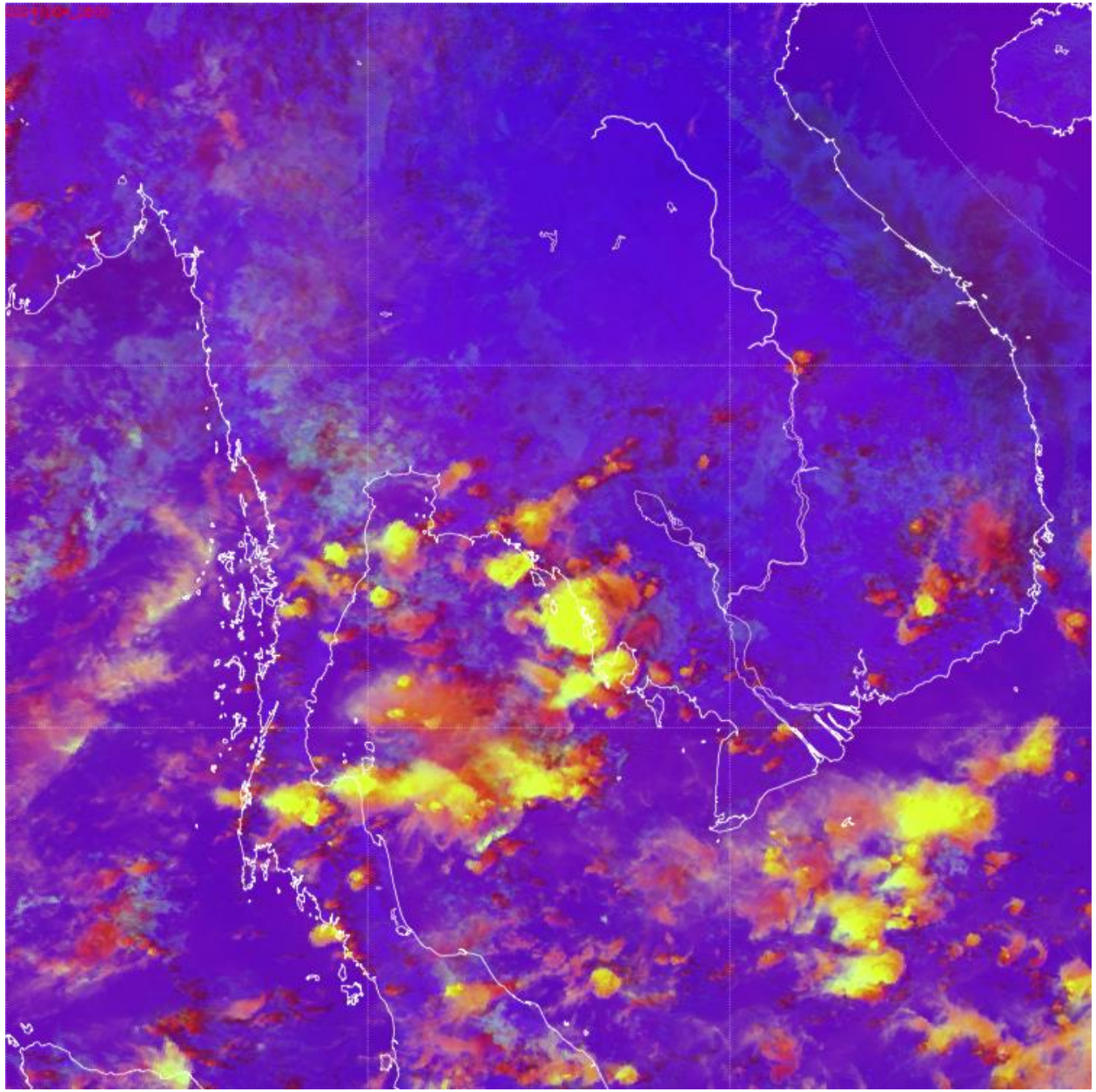
3. Would you expect any new convective developments in or near provinces / cities such as Phnom Penh and Prey Veng ?



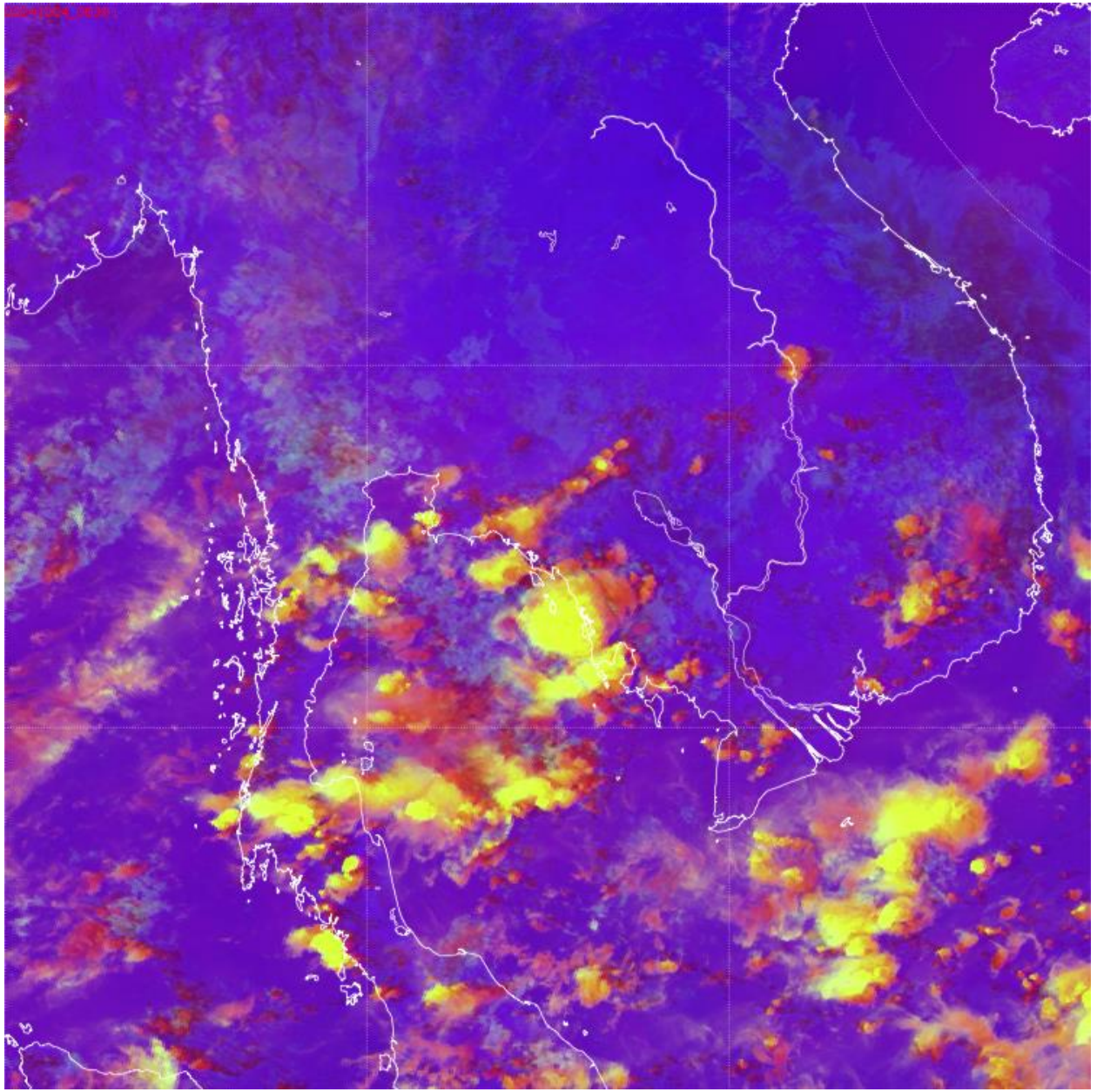
2024-10-04 05:30 UTC



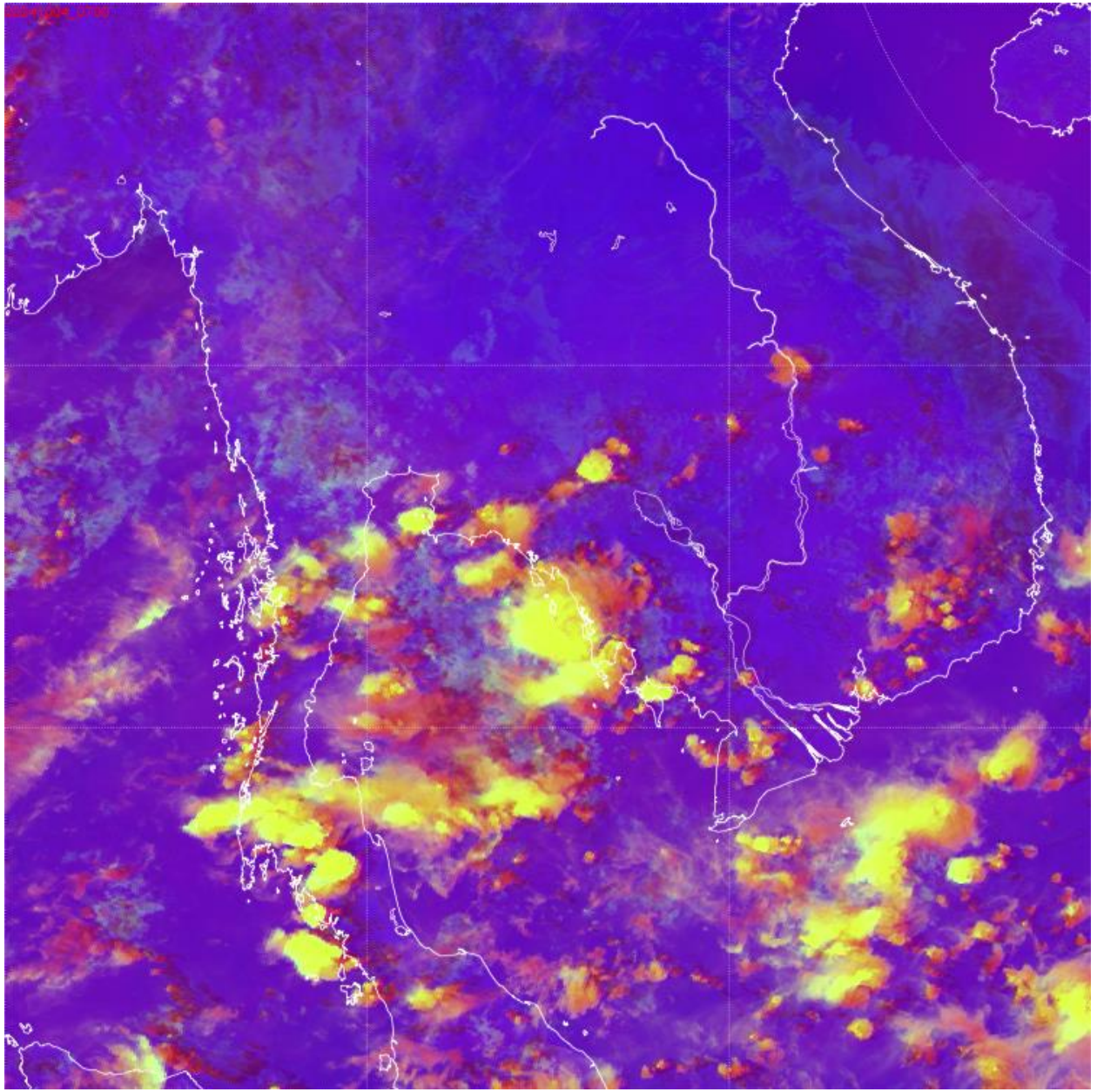
2024-10-04 06:00 UTC



2024-10-04 06:30 UTC



2024-10-04 07:00 UTC



香港天文台
HONG KONG OBSERVATORY

WMO

# (3) Day Microphysics RGB

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 μm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 μm | | | vegetation, aerosol G | |
| 3 | 0.64 μm | 0.68 μm | 0.635 μm | low cloud, fog R | |
| 4 | 0.86 μm | | 0.81 μm | vegetation, aerosol | Near Infrared |
| 5 | 1.6 μm | | 1.64 μm | cloud phase | |
| 6 | 2.3 μm | | | particle size | |
| 7 | 3.9 μm | 3.7 μm | 3.92 μm | low cloud, fog, forest fire | Infrared |
| 8 | 6.2 μm | 6.8 μm | 6.25 μm | mid- and upper level moisture | |
| 9 | 6.9 μm | | | mid- level moisture | |
| 10 | 7.3 μm | | 7.35 μm | mid- and lower level moisture | |
| 11 | 8.6 μm | | 8.70 μm | cloud phase, SO2 | |
| 12 | 9.6 μm | | 9.66 μm | ozone content | |
| 13 | 10.4 μm | 10.8 μm | 10.8 μm | cloud imagery, information of cloud top | |
| 14 | 11.2 μm | | | cloud imagery, sea surface temperature | |
| 15 | 12.4 μm | 12.0 μm | 12.0 μm | cloud imagery, sea surface temperature | |
| 16 | 13.3 μm | | 13.4 μm | cloud top height | |

B04 – high reflectivity for snow/ice covered area and clouds (sea surface looks dark); reflection characteristics vary with phase and size of cloud particles (smaller particle has higher reflectivity)

B07 – 3.9 micron image has reflection characteristics depending on phase and size of cloud particles – useful to distinguish cloud layer and convective clouds, etc. (smaller particle has higher reflectivity)

B13 – atmospheric window channel, with whitish (darker) areas corresponding to low (higher) brightness temperature – i.e. high-level cloud and developed Cbs (clouds on lower levels)

## RGB "Day Microphysics" scheme

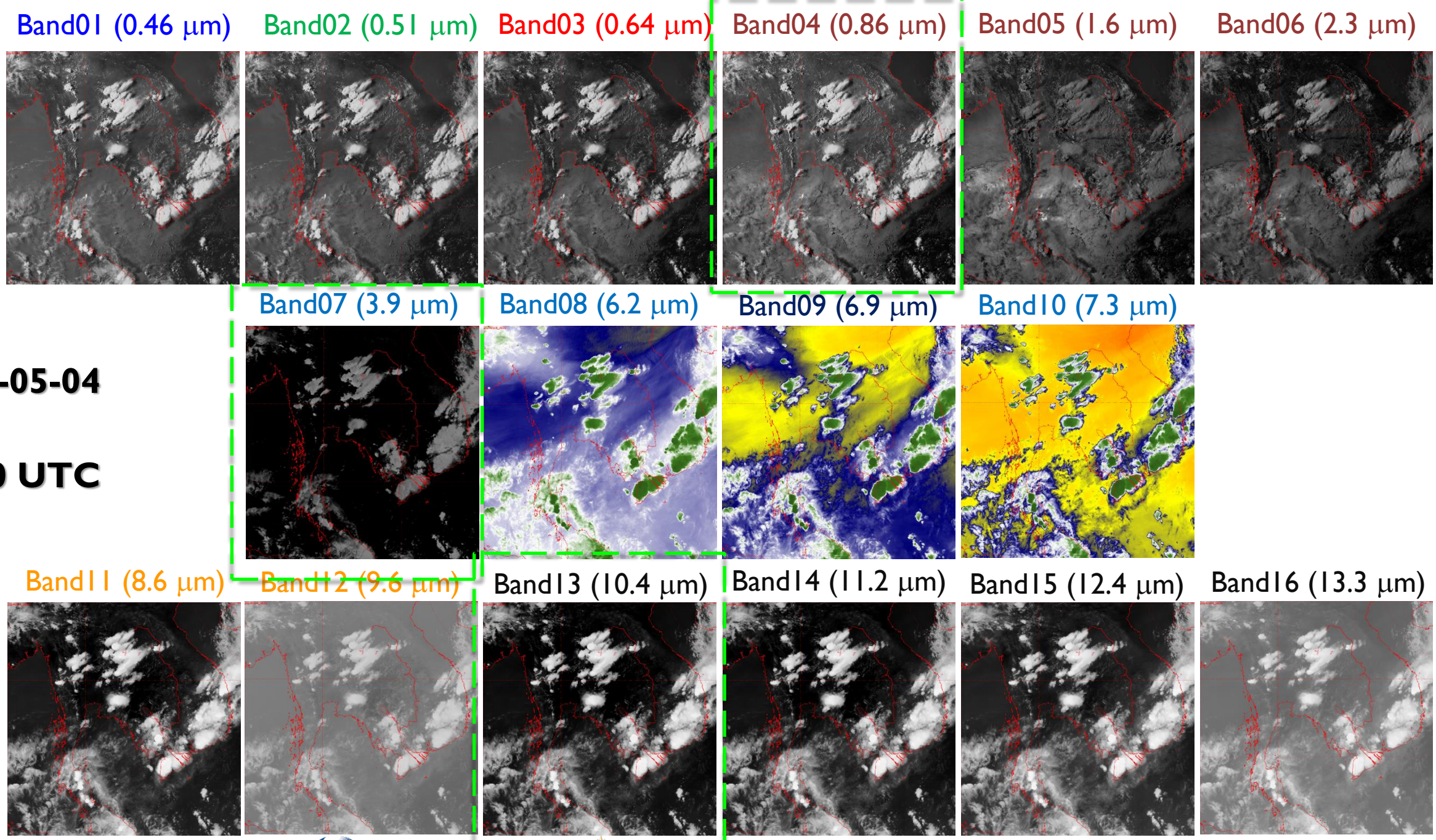
(RGB : B04/B07/B13)

R : B04(NIR0.86) Range: 0 ~ 100 [%] Gamma: 1.0

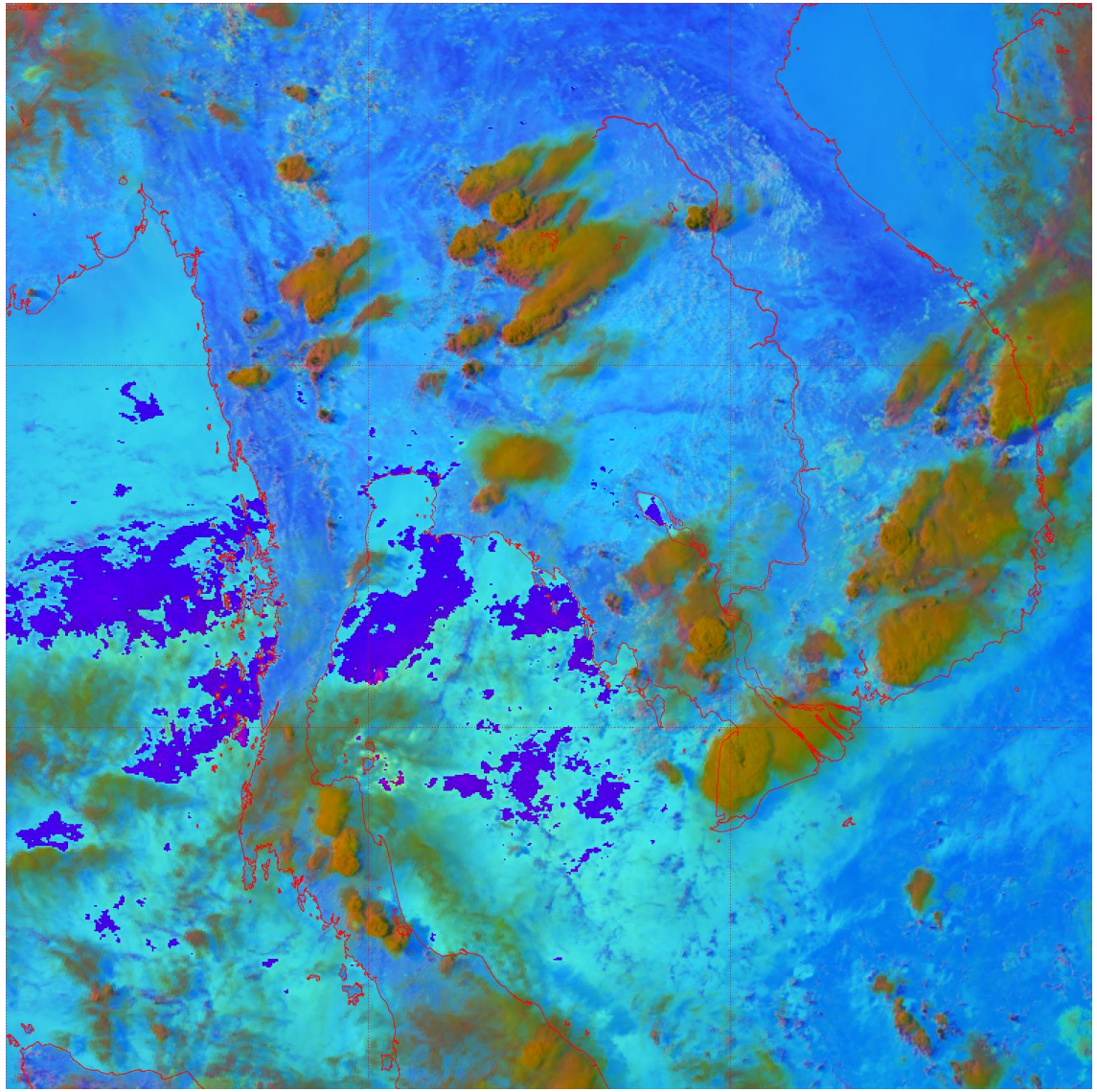
G : B07(I4 3.9) Range: 0 ~ 60 [%] Gamma: 2.5 (Summer)

Range: 0 ~ 25 [%] Gamma: 1.5 (Winter)

B : B05(IR10.4) Range: 203 ~ 323 [K] Gamma: 1.0 (reverse)


Band01 (0.46 μm)
Band02 (0.51 μm)
Band03 (0.64 μm)
Band04 (0.86 μm)
Band05 (1.6 μm)
Band06 (2.3 μm)
Band07 (3.9 μm)
Band08 (6.2 μm)
Band09 (6.9 μm)
Band10 (7.3 μm)
2024-05-04
08:30 UTC
Band11 (8.6 μm)
Band12 (9.6 μm)
Band13 (10.4 μm)
Band14 (11.2 μm)
Band15 (12.4 μm)
Band16 (13.3 μm)

# 2024-05-04 08:30 UTC



## Colour interpretation for Day Microphysics RGB

| Color | Interpretation |
|---|---|
| | Deep precipitating cloud (precipitation is not necessarily reaching the ground) - bright, thick, large ice particles, cold cloud |
| | Deep precipitating cloud (Cb cloud with strong updrafts and severe weather)* - bright, thick, small ice particles, cold cloud<br>*or thick, high-level lee cloudiness with small ice particles |
| | Thin Cirrus cloud (large ice particles) |
| | Thin Cirrus cloud (small ice particles) |
| | Super-cooled, thick water cloud - bright, thick, small droplets |
| | Super-cooled, thick water cloud - bright, thick, large droplets |
| | Super-cooled thin water cloud with large droplets |
| | Super-cooled, thin water cloud with small droplets |
| | Thick water cloud (warm rain cloud) - bright, thick, large droplets |
| | Thick water cloud (no precipitation) - bright, thick, small droplets |
| | Thin water cloud with large droplets |
| | Thin water cloud with small droplets |
| | Ocean |
| | Vegetation |
| | Desert/Fire (Hot spot) |
| | Snow/Ice |

# (3) Day Microphysics RGB

- Main applications:
  - Provide a complex cloud analysis, distinguish ice from water phase, and to provide information on cloud top particle size, temperature and cloud optical thickness.
  - Monitor the development of convection, fog and low clouds

- Benefits:
  - Good colour contrast between ice and water clouds, especially for water clouds with small droplets and snow on ground
  - Provides information on cloud particle size, optical thickness and cloud top temperature. Orange colour indicates the presence of small ice crystals on top of cumulus clouds.
  - Detection of super-cooled water clouds and wildfires.

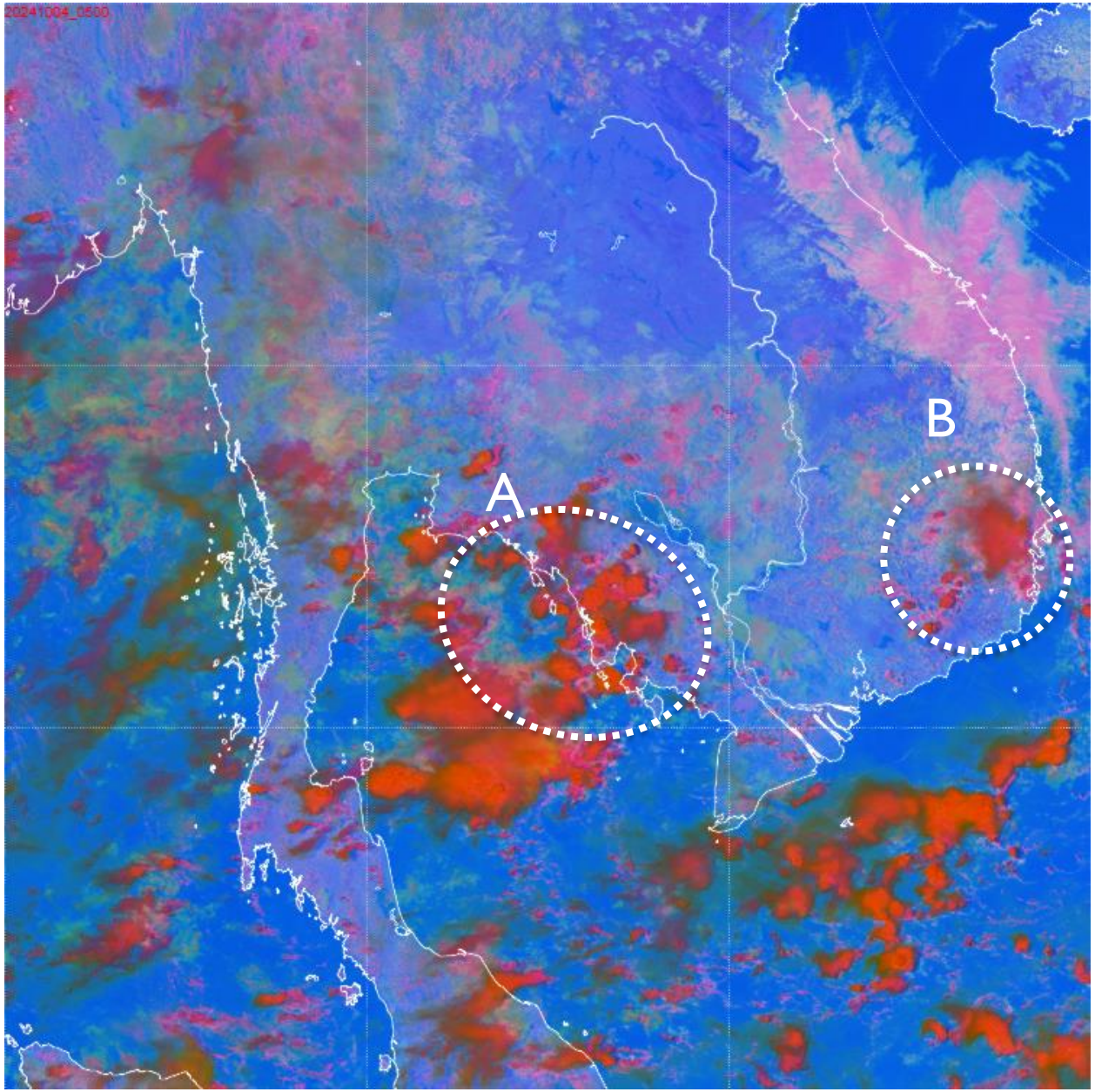
- Limitations:
  - Only daytime
  - Pixel colour fades during dawn/dusk when the sun's angle is low
  - Many colour shades – needs practice for proper interpretation

# Exercise 2

2024-10-04 05:00 UTC

1. Identify types of clouds in A and B?

2. How do they compare with your results using Day Convective RGB?



# (4) Night Microphysics RGB

| Channel | Himawari-8/ -9 | MTSAT-1R/-2 | MSG | Physical Properties | |
|---|---|---|---|---|---|
| 1 | 0.46 μm | | | vegetation, aerosol B | Visible |
| 2 | 0.51 μm | | | vegetation, aerosol G | |
| 3 | 0.64 μm | 0.68 μm | 0.635 μm | **low cloud, fog** R | |
| 4 | 0.86 μm | | 0.81 μm | **vegetation, aerosol** | Near Infrared |
| 5 | 1.6 μm | | 1.64 μm | **cloud phase** | |
| 6 | 2.3 μm | | | particle size | |
| 7 | 3.9 μm | 3.7 μm | 3.92 μm | low cloud, fog, forest fire | Infrared |
| 8 | 6.2 μm | 6.8 μm | 6.25 μm | mid- and upper level moisture | |
| 9 | 6.9 μm | | | mid- level moisture | |
| 10 | 7.3 μm | | 7.35 μm | mid- and upper level moisture | |
| 11 | 8.6 μm | | 8.70 μm | cloud phase, SO2 | |
| 12 | 9.6 μm | | 9.66 μm | ozone content | |
| 13 | 10.4 μm | 10.8 μm | 10.8 μm | cloud imagery, information of cloud top | |
| 14 | 11.2 μm | | | cloud imagery, sea surface temperature | |
| 15 | 12.4 μm | 12.0 μm | 12.0 μm | cloud imagery, sea surface temperature | |
| 16 | 13.3 μm | | 13.4 μm | cloud top height | |

This RGB is effective to distinguish clouds with high cloud top (such as Cb) and fog or low-level clouds because the difference of 3.9 micron is included in this scheme.

RGB "Night Microphysics" scheme

(RGB: B15-B13 /B13-B07/B13)

R : B15(IR2 12.3) - B13(IR 10.4)

Range: -4 ~ 2 [K] Gamma : 1.0

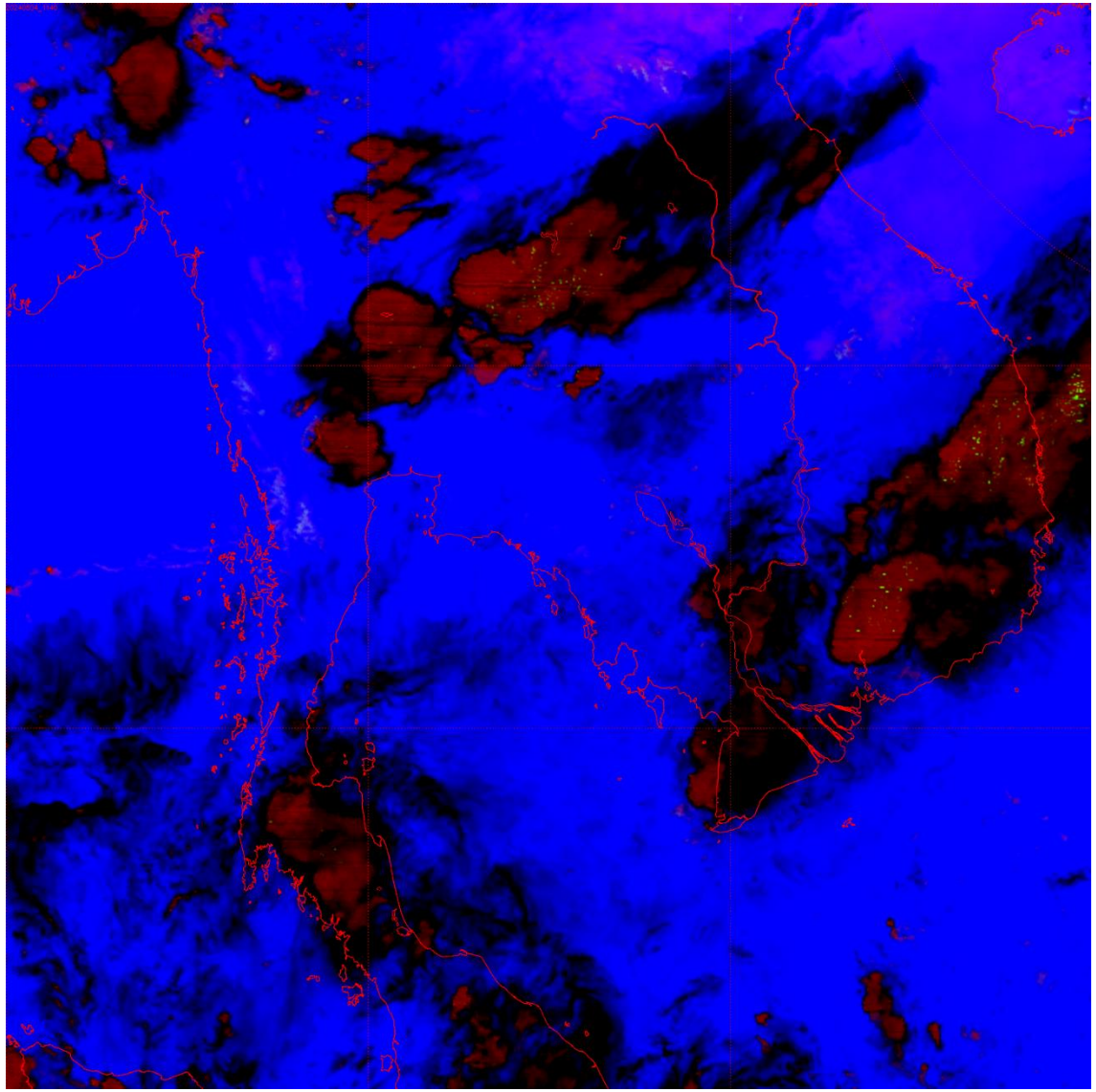
G : B13(IR 10.4) - B07(IR4 3.9)

Range : 0 ~ 10 [K] Gamma : 1.0

B : B13(IR 10.4)

Range : 243 ~ 293 [K] Gamma : 1.0

# 2024-05-04 11:40 UTC

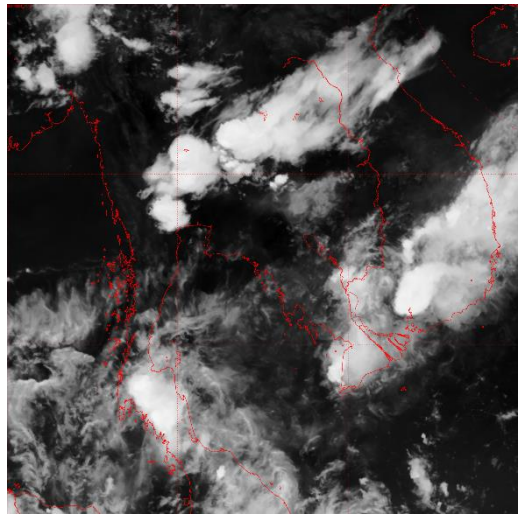


## Interpretation of colors for "Night Microphysics"

| | | |
|---|---|---|
| Cold, thick, high-level cloud | Very cold (< -50° C), thick, high-level cloud | Thin Cirrus cloud |
| Thick, mid-level cloud | | Thin, mid-level cloud |
| Low-level cloud (high latitudes) | | Low-level cloud (low latitudes) |

| Ocean | Land |
|---|---|

IR1 (B13) image



# Interpretation of colors for "Night Microphysics"

Cold, thick, high-level cloud

Very cold (< -50° C), thick, high-level cloud

Thin Cirrus cloud

Thick, mid-level cloud

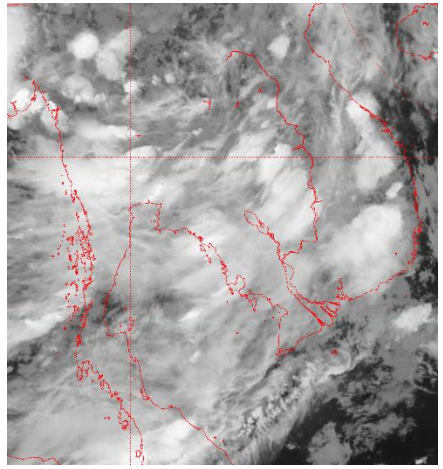
Thin, mid-level cloud

Low-level cloud (high latitudes)

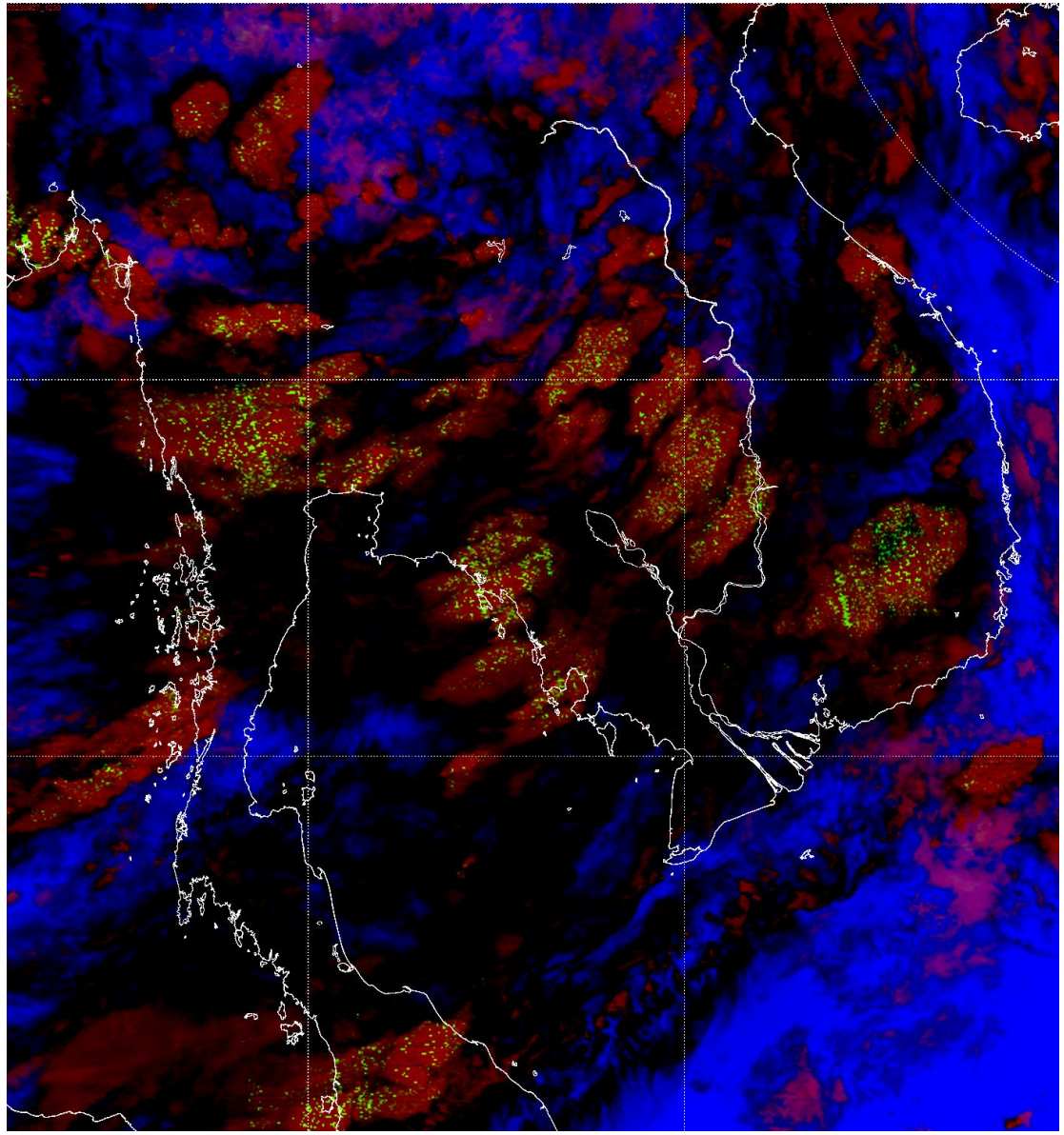
Low-level cloud (low latitudes)

Ocean | Land

IR1 (B13) image



## 2023-09-27 12:30 UTC



# (4) Night Microphysics RGB

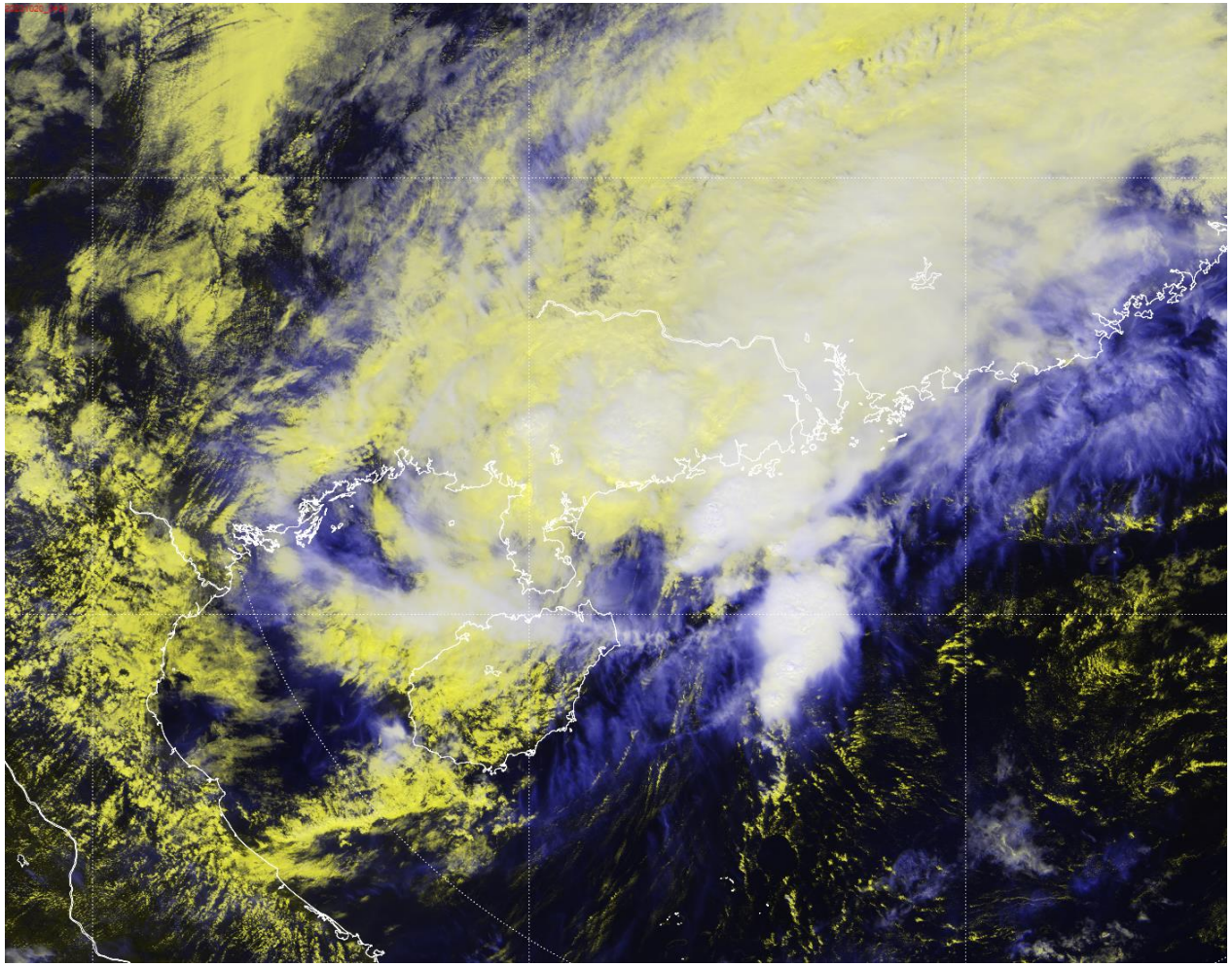
- Main applications:
  - Cloud analysis and detection of fog / low clouds during nighttime

- Benefits:
  - Good contrast between water cloud (fog / log clouds) and cloud-free surfaces
  - Effective for nighttime cloud analysis
  - Useful for identifying fire hotspots

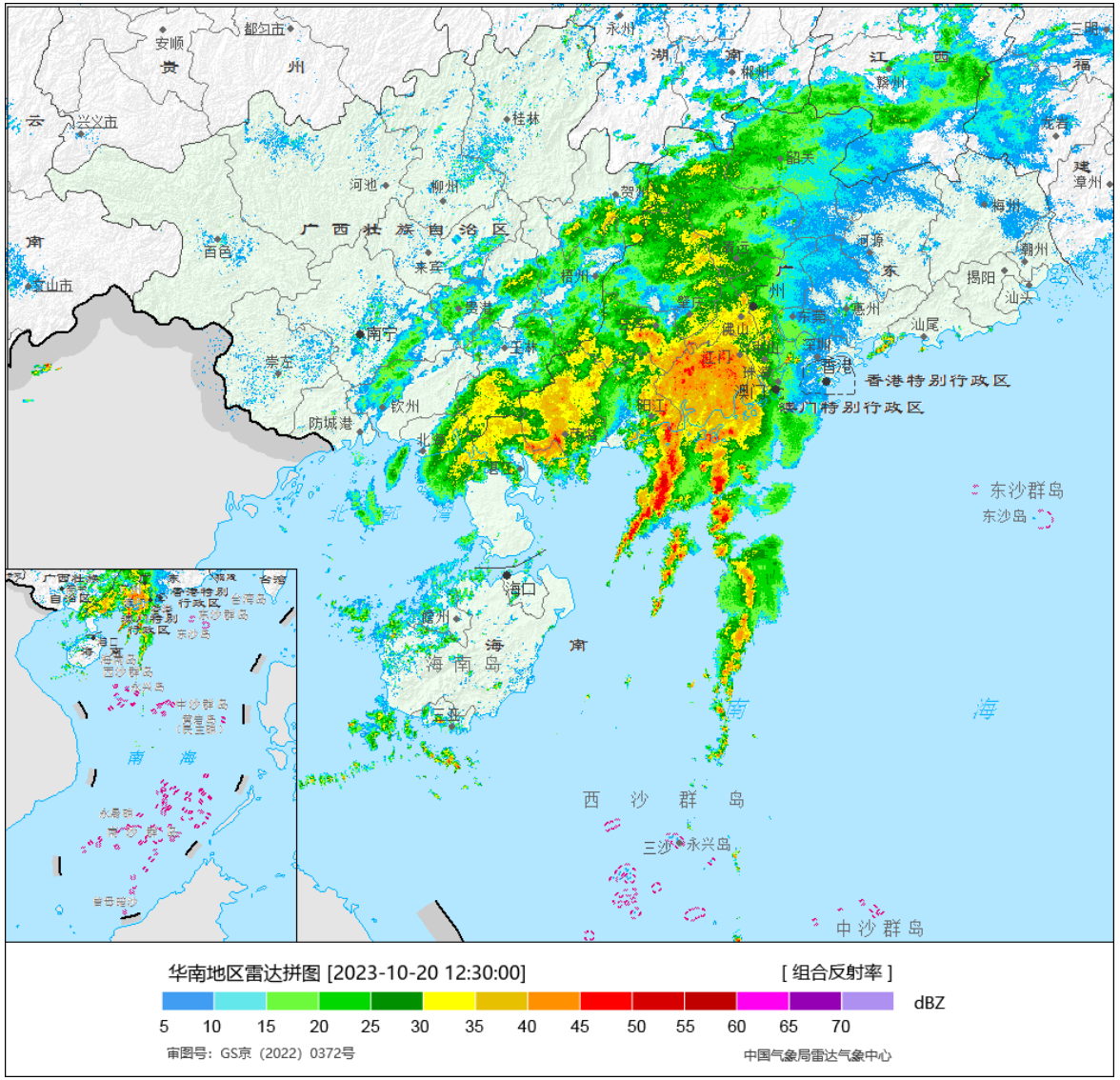
- Limitations:
  - Good for nighttime only (all clouds appear magenta during daytime)
  - Ambiguity to differentiate fog from low-clouds only from Night Microphysics RGB
  - Fog / low clouds may appear mixed with surface thermal conditions (i.e. diurnal / latitudinal and seasonal variations)

# Comparing RGB imagery with radar observation

# 2023-10-20 04:30 UTC

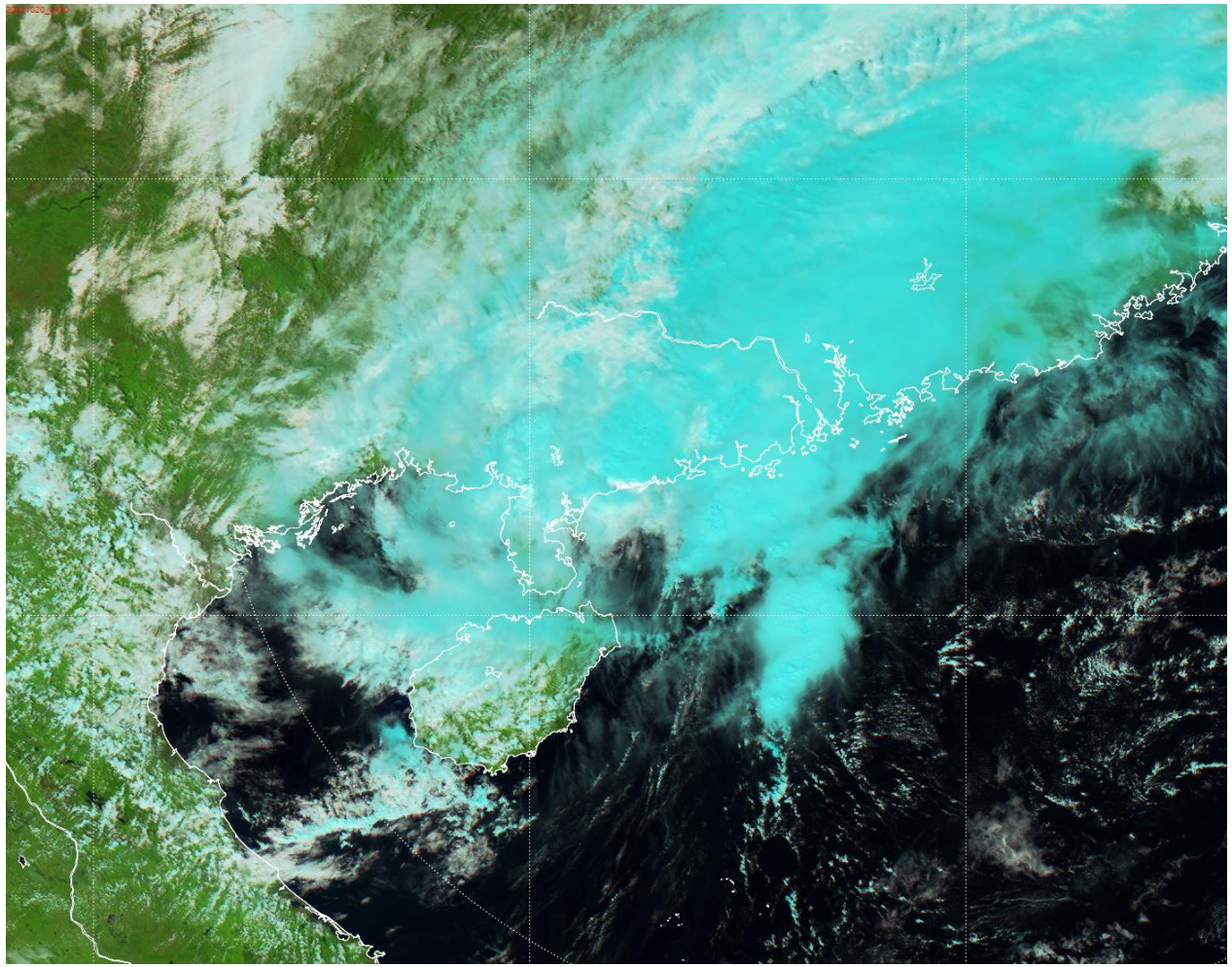


False Colour

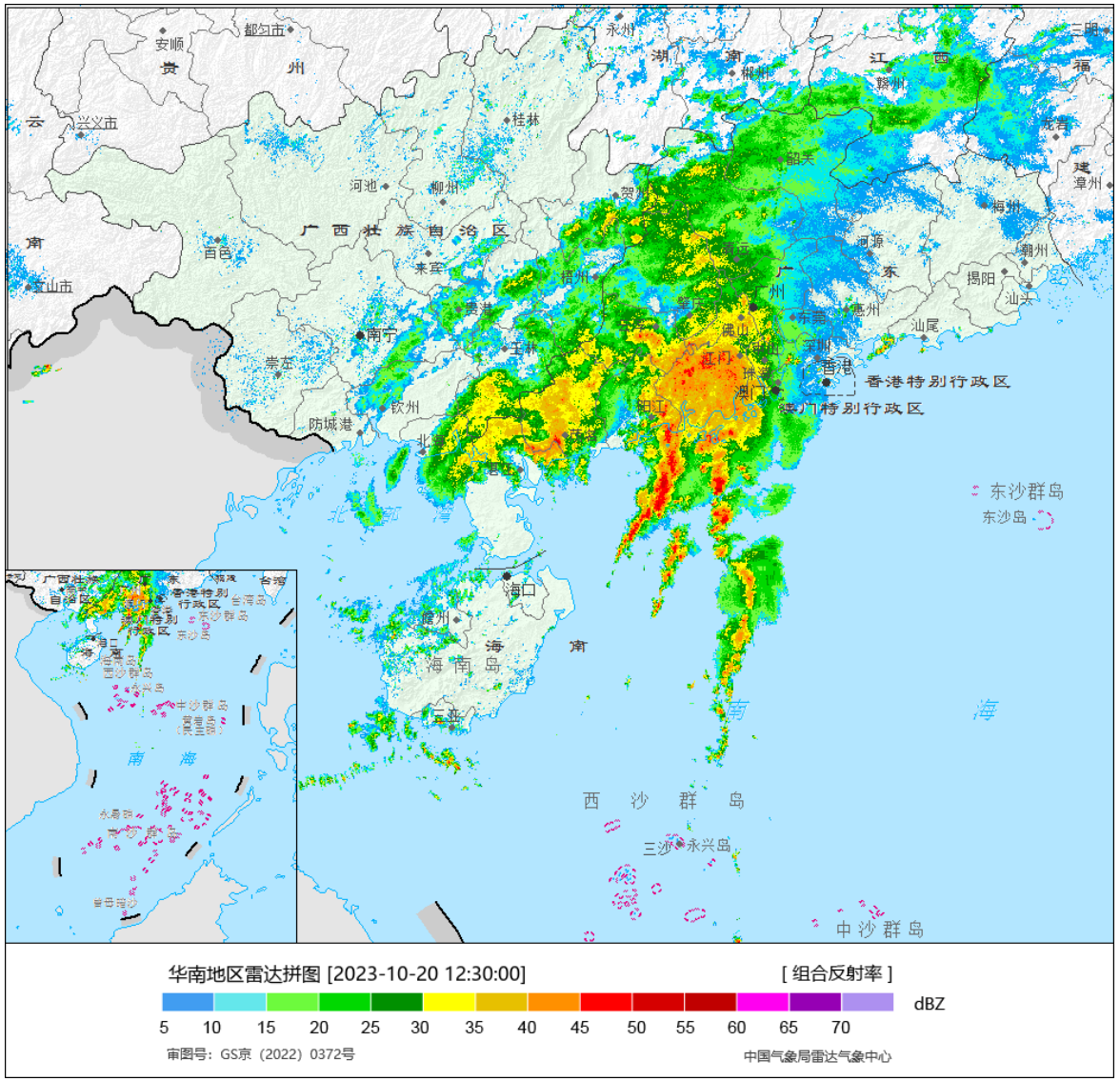



Credit: CMA

# 2023-10-20 04:30 UTC

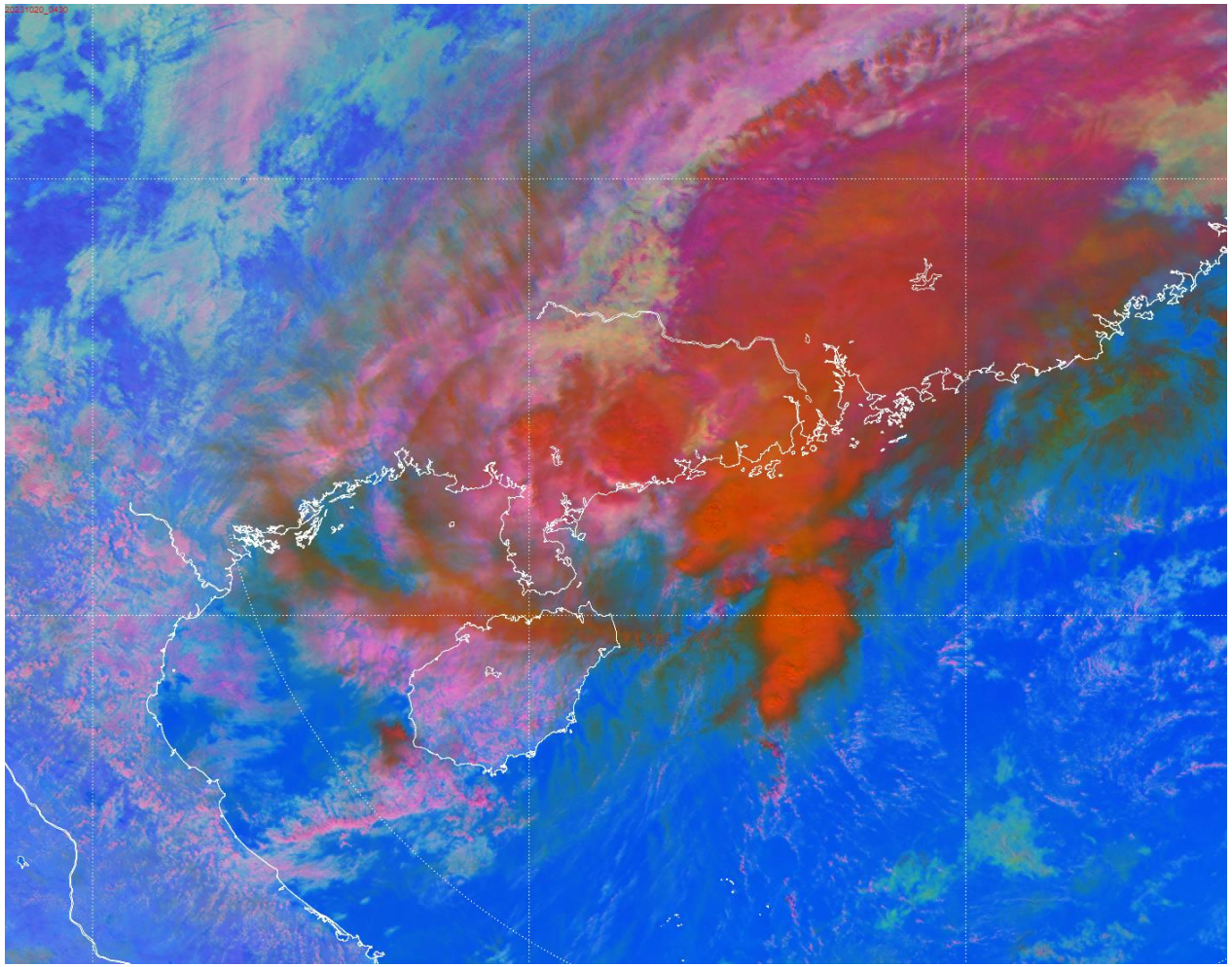


Natural Colour

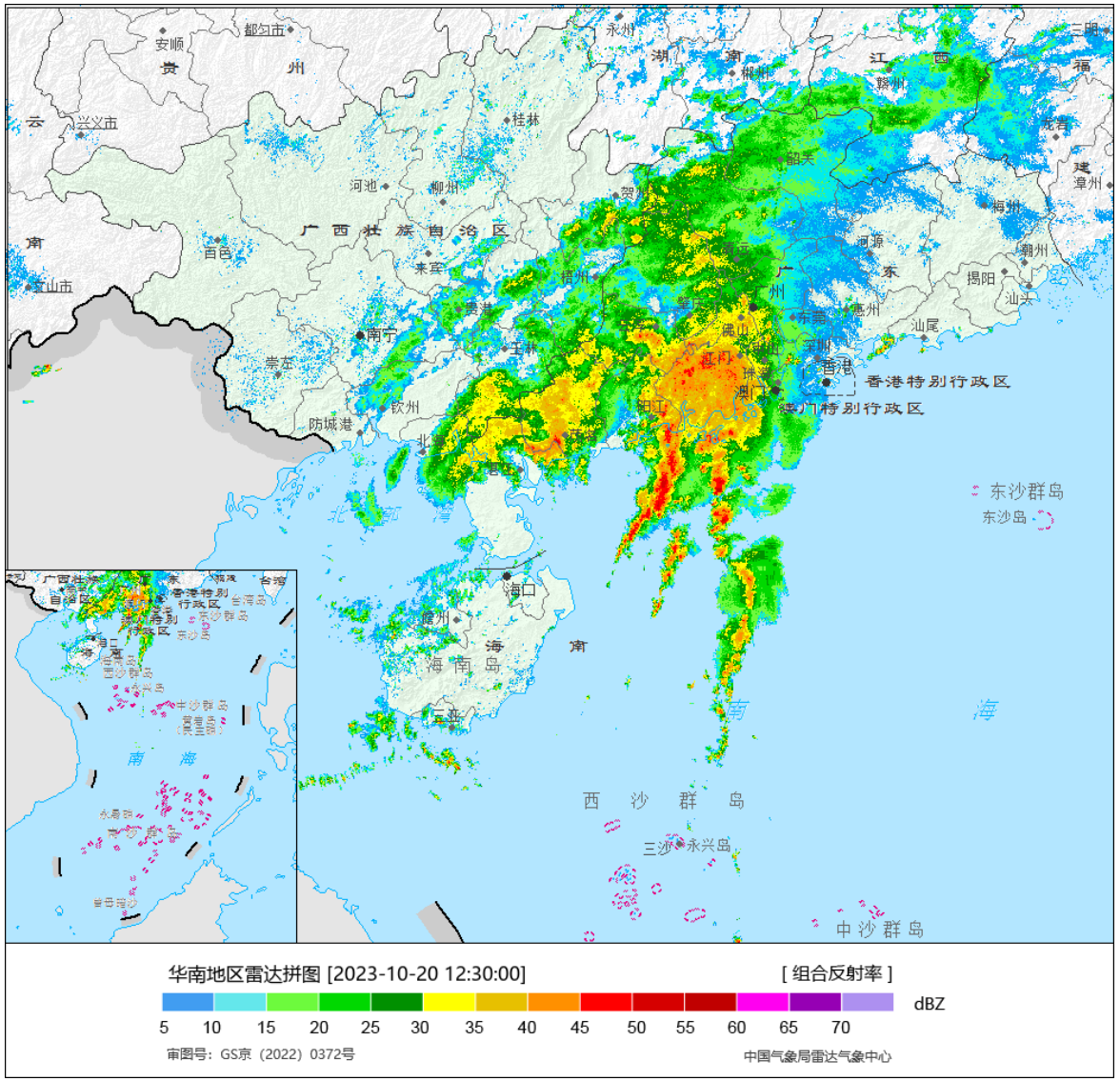



Credit: CMA

# 2023-10-20 04:30 UTC

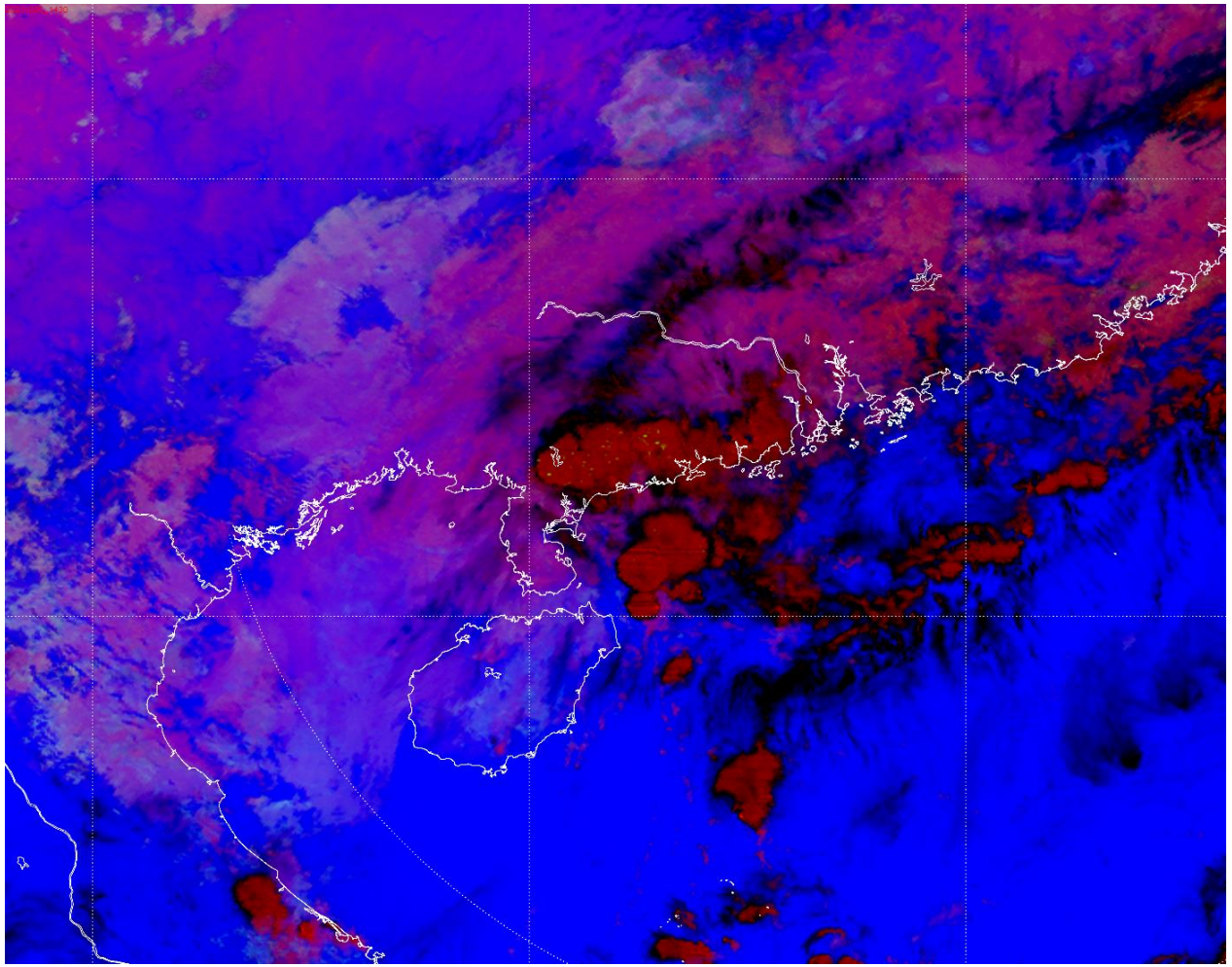


Day Microphysics

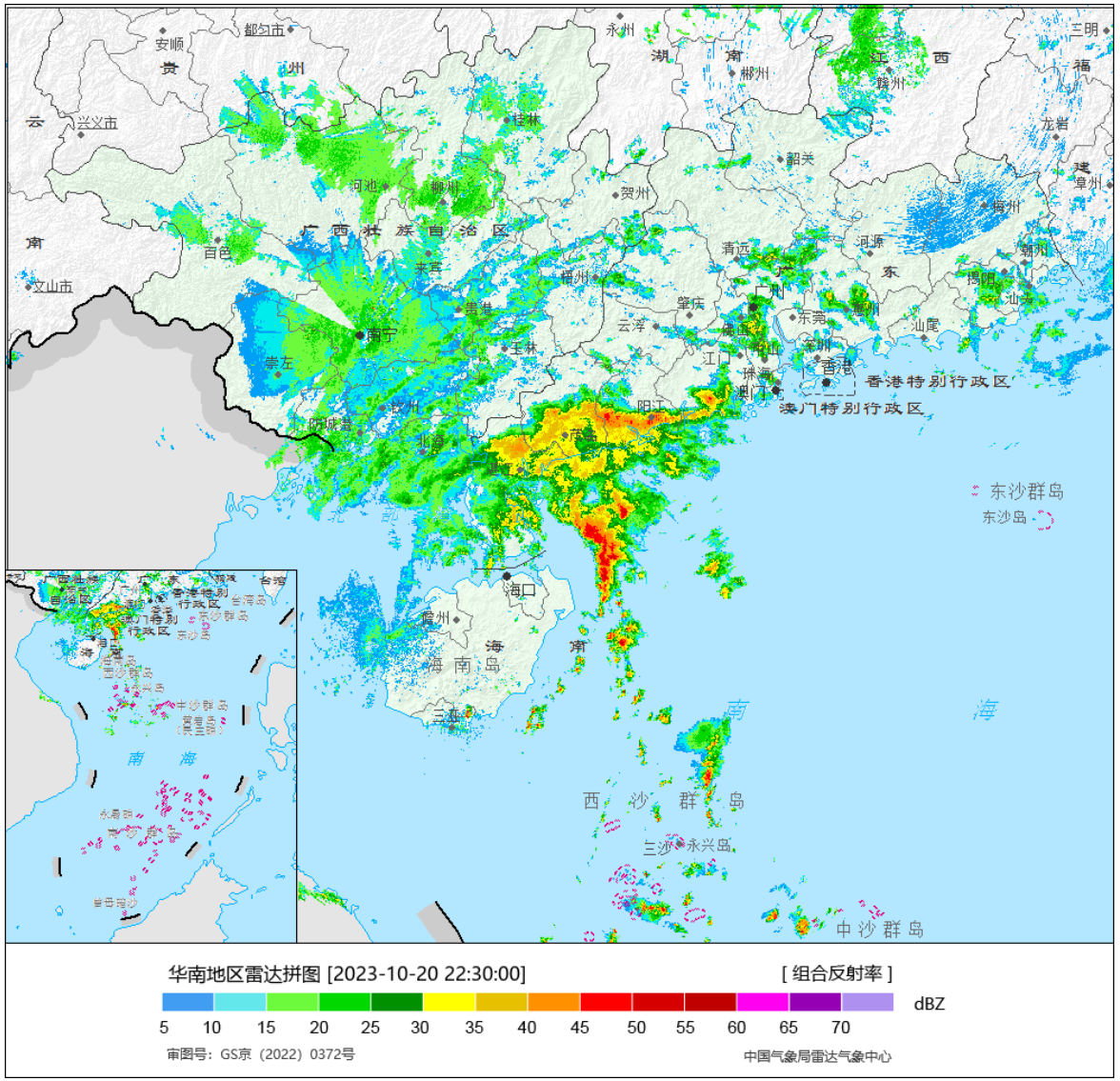



Credit: CMA

# 2023-10-20 14:30 UTC



Night Microphysics



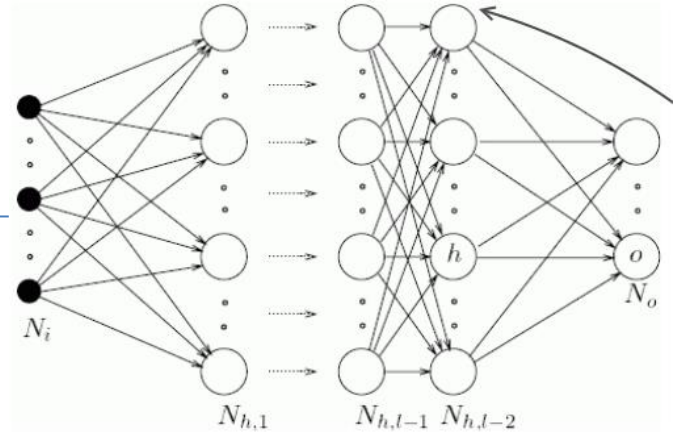

Credit: CMA

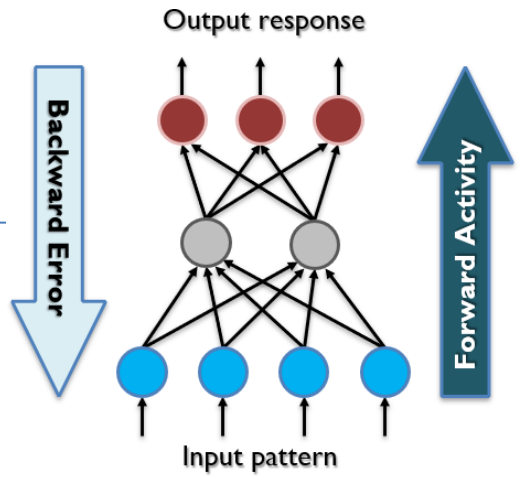
# Artificial Intelligence / Machine Learning in Satellite Analysis and Nowcast Products

# Multi-layer perceptron artificial neural network (MLPANN)

- Features of MLPANN:

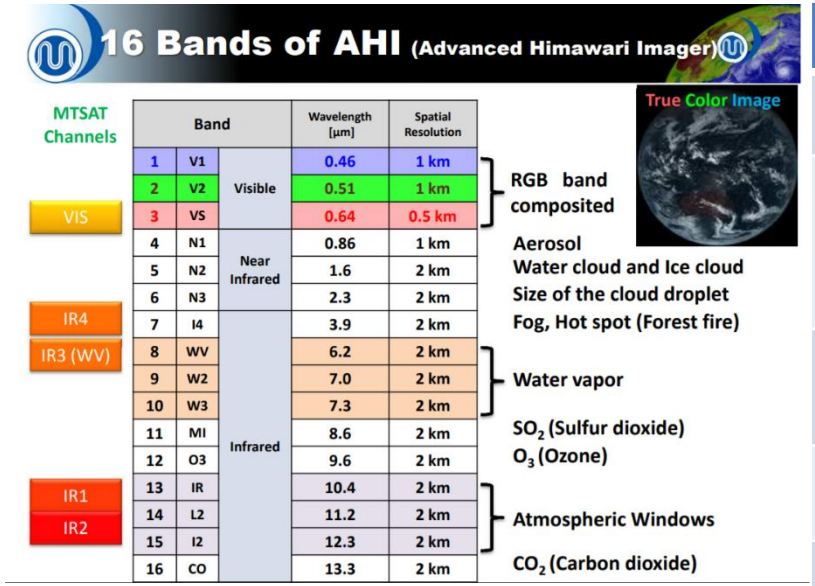
| | |
|---|---|
| Neural Network Architecture | Deep neural networks |
| Training Algorithm | Backpropagation |
| Learning Strategy | Supervised learning |



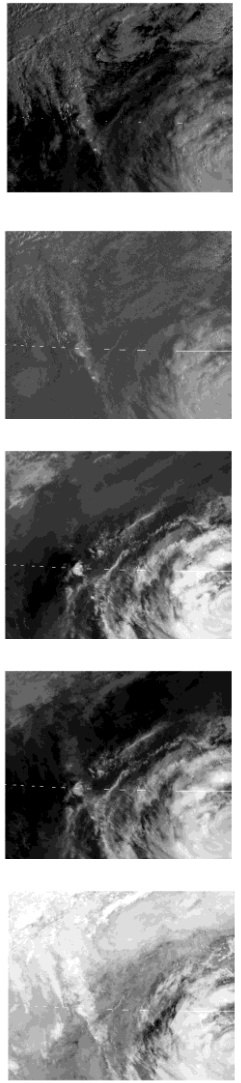




Two-step procedure in backpropagation network – activity from input pattern flows forward through the network while the error flows backward to adjust the weights.

# Machine Learning Satellite Retrieved Reflectivity

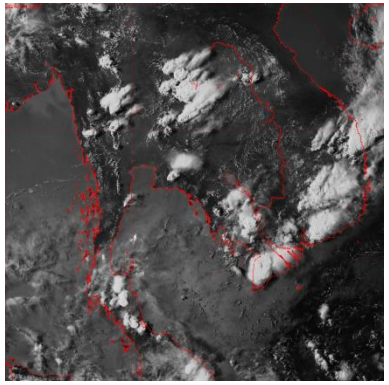



| Input | Description |
|---|---|
| B03 (VIS0.64) | VIS0.64. Reflectivity of B03 depends on optical thickness. Thick cloud are displayed in white. |
| B05 (NIR1.6) - B04 (N1 0.86) | Difference between NIR1.6 and N1 0.86. B04 has high reflectivity for snow/ice covered area and clouds, sea surface looks dark. Reflection characteristic of B05 depends on the phase and size of cloud particles. On difference image, thick clouds with large ice particles are displayed in black (dark), low clouds and land/sea surface look whitish (bright) |
| B08 (WV6.2) - B10 (W3 7.3) | Difference between WV6.2 and W3 7.3. On difference image, thick clouds with high cloud are displayed in white, low clouds and thin Ci are indistinct. |
| B13 (IR10.4) | IR10.4, Atmospheric window band, available for 24 hours. High-level clouds and developed Cbs appear in white, mid-level cloud appear in bright gray. |
| B13 (IR10.4) - B15 (I2 12.3) | Difference between IR 10.4 and I2 12.3. Absorption by water vapor of B15 is slightly larger than that of B13. On difference image, thick cloud and low-level cloud contribute to rather grey color, high-level cloud contributes bright color. |
| Equinox day diff. | Indication of different Season |

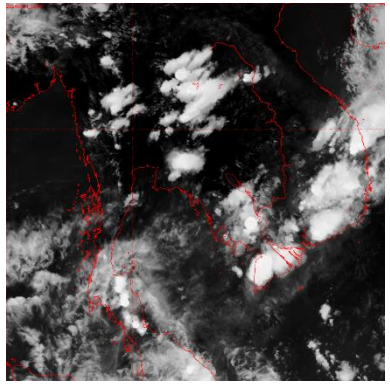


# 2024-05-04 08:30 UTC

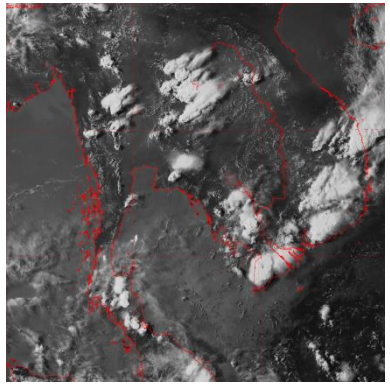
Band03 (0.64 μm)

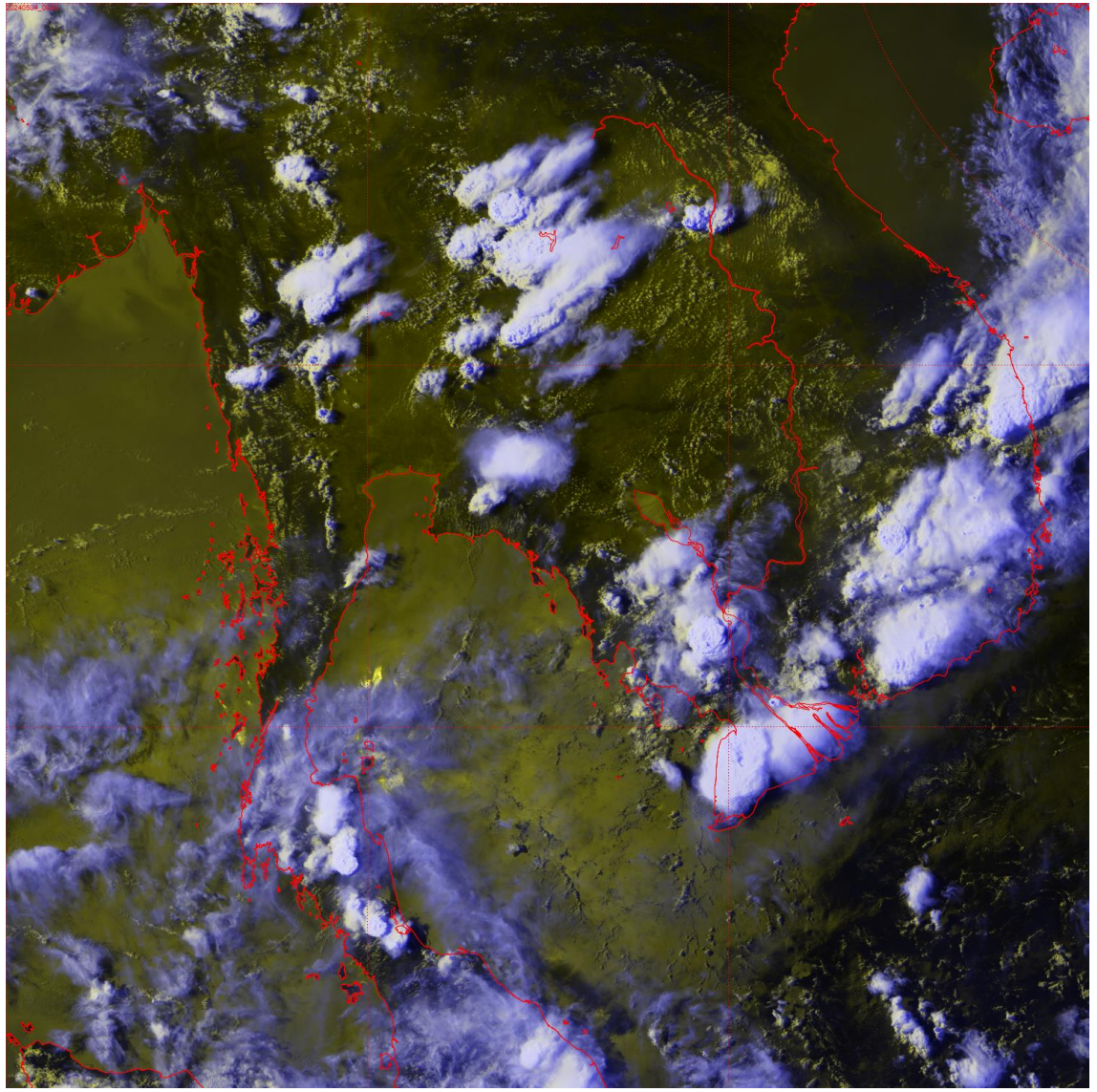


Band13 (10.4 μm)

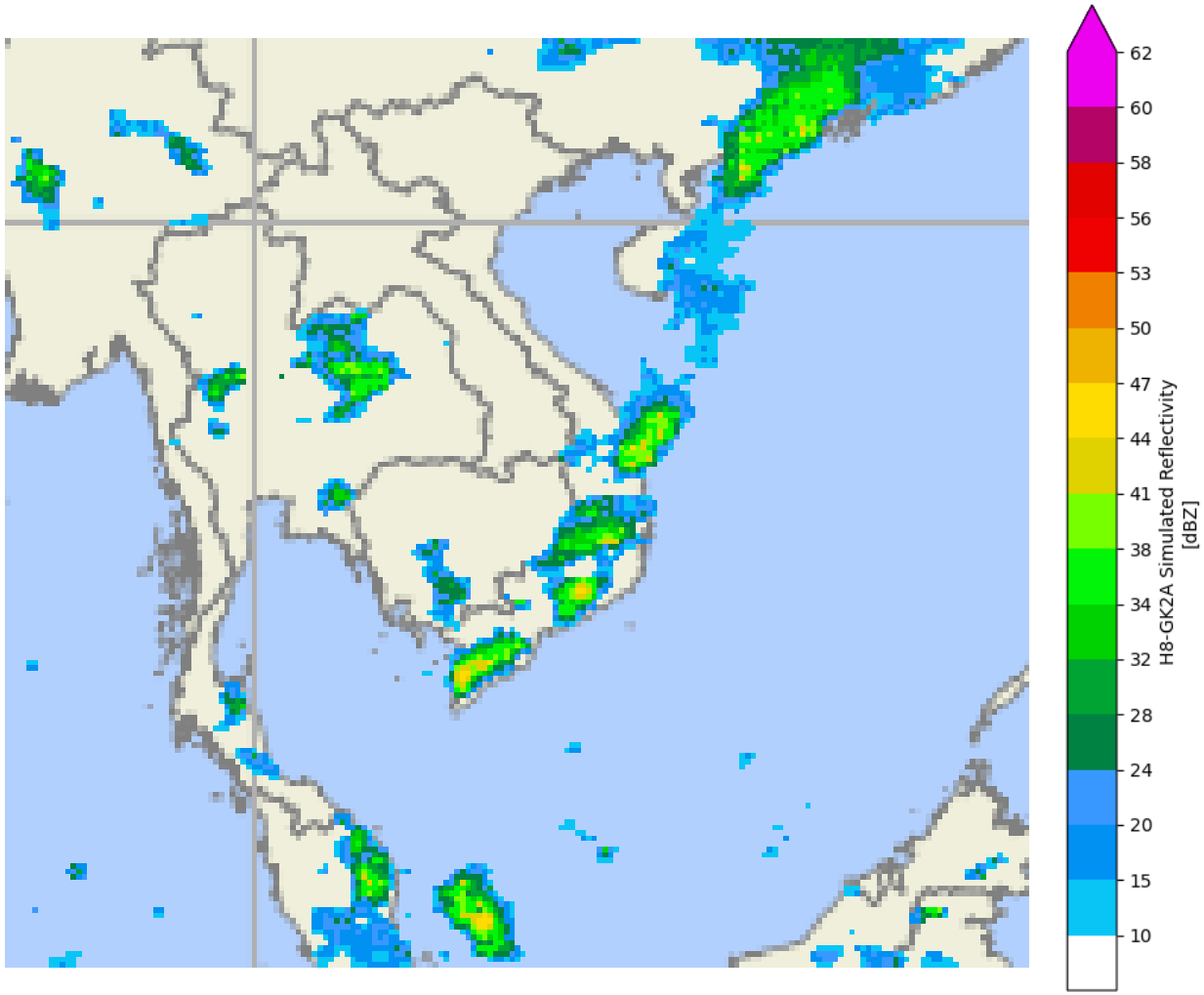


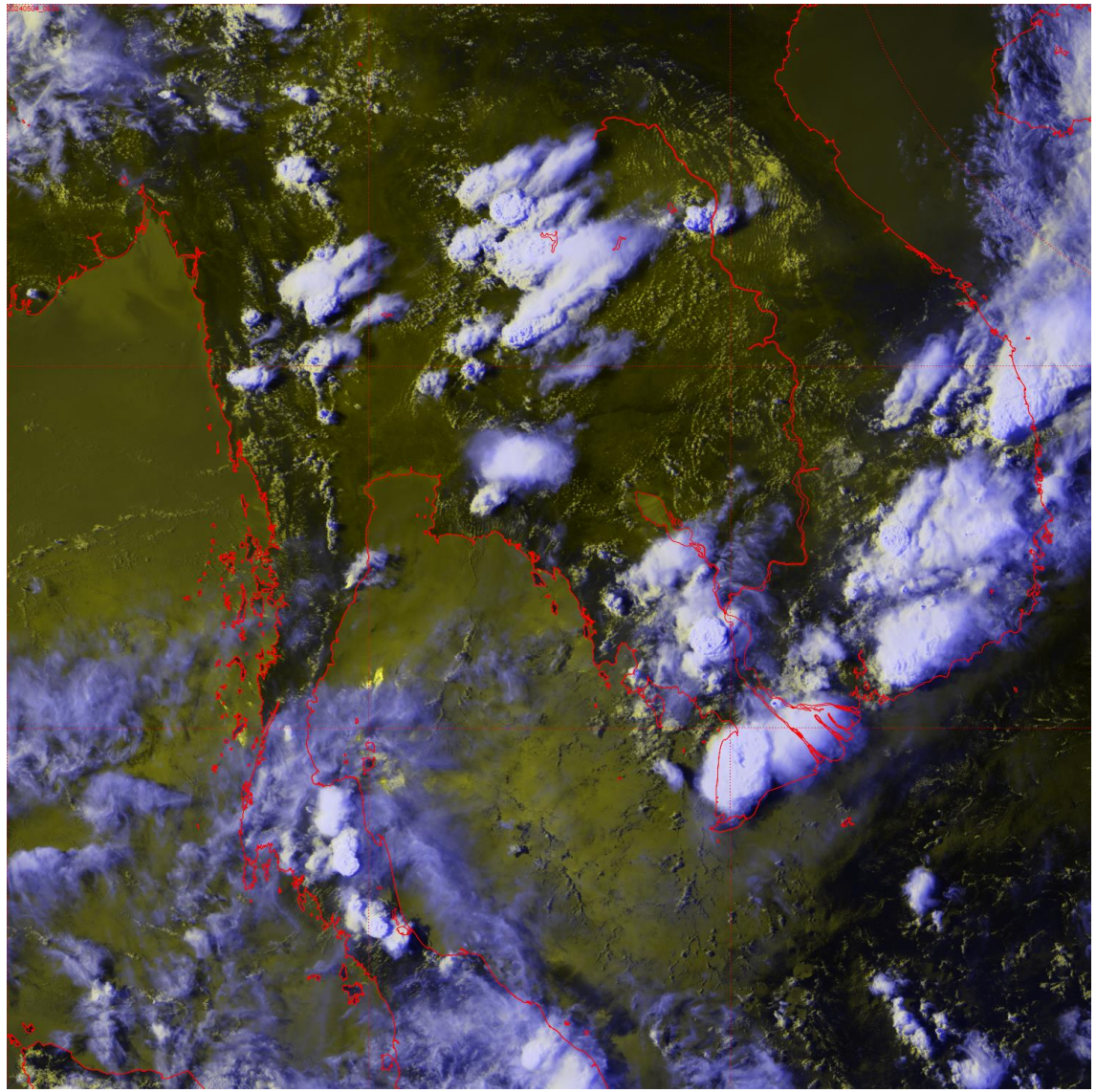
Band02 (0.51 μm)





# 2024-05-04 08:30 UTC



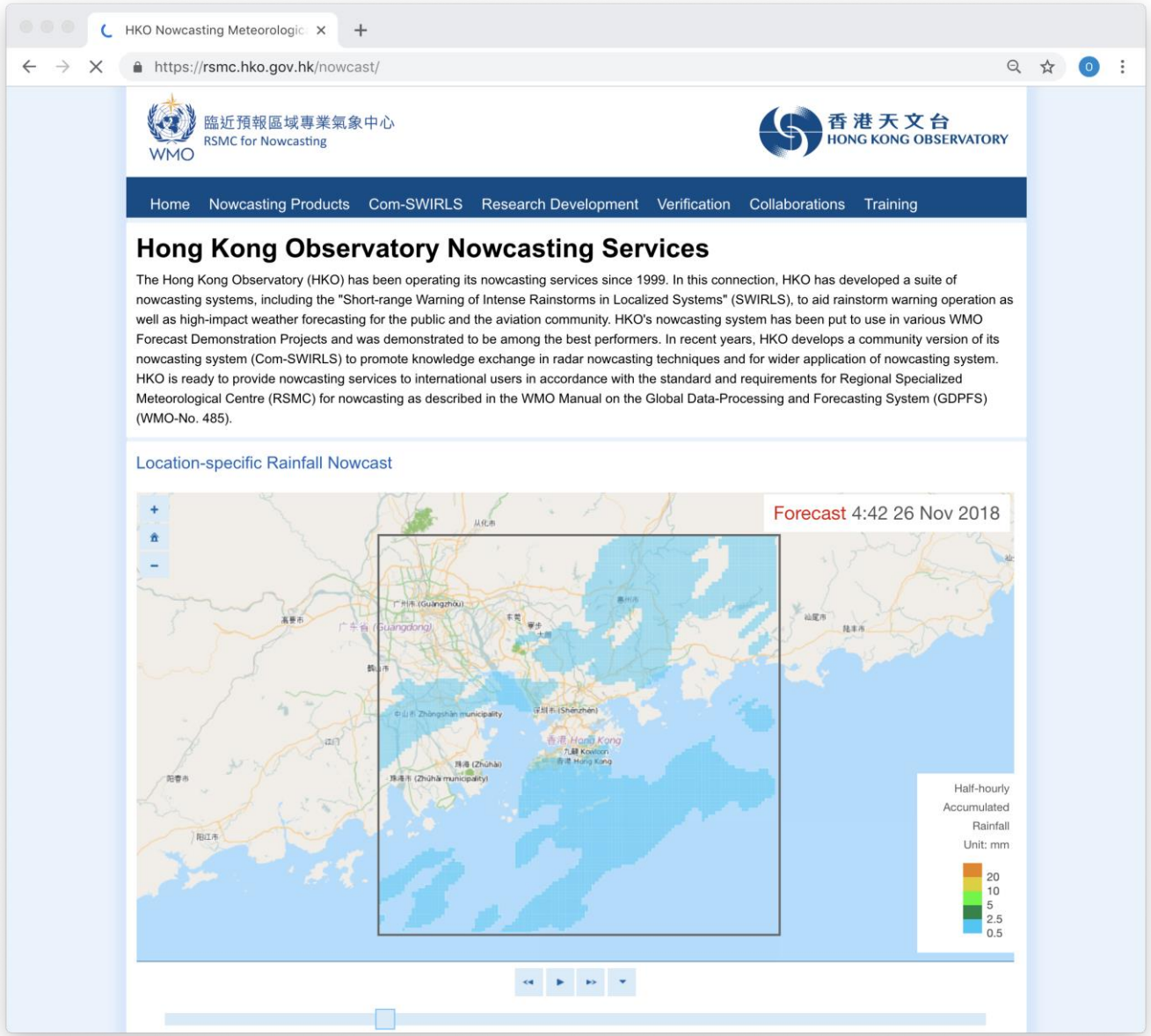



WORLD METEOROLOGICAL ORGANIZATION

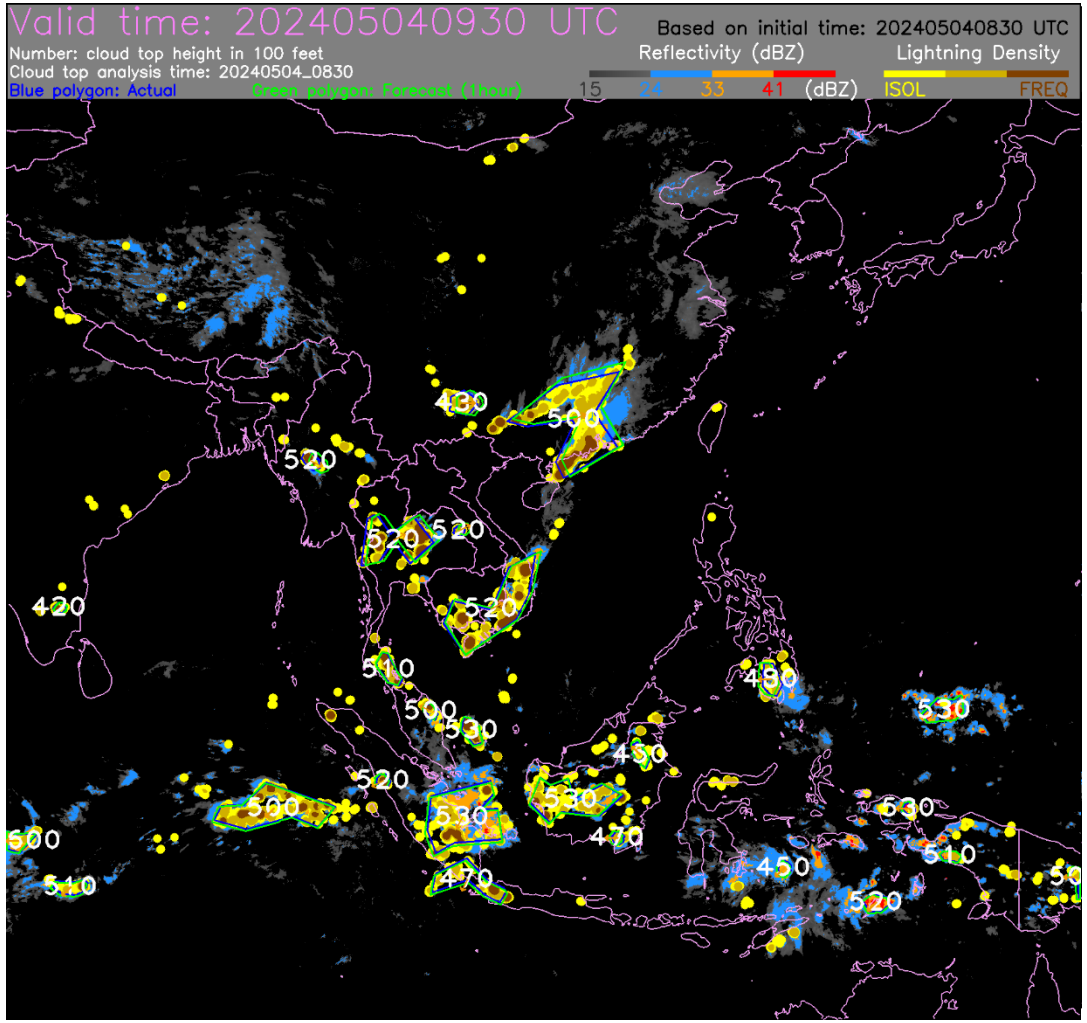
臨近預報區域專業氣象中心
RSMC for Nowcasting
WMO

香港天文台
HONG KONG OBSERVATORY

# Website: https://rsmc.hko.gov.hk/



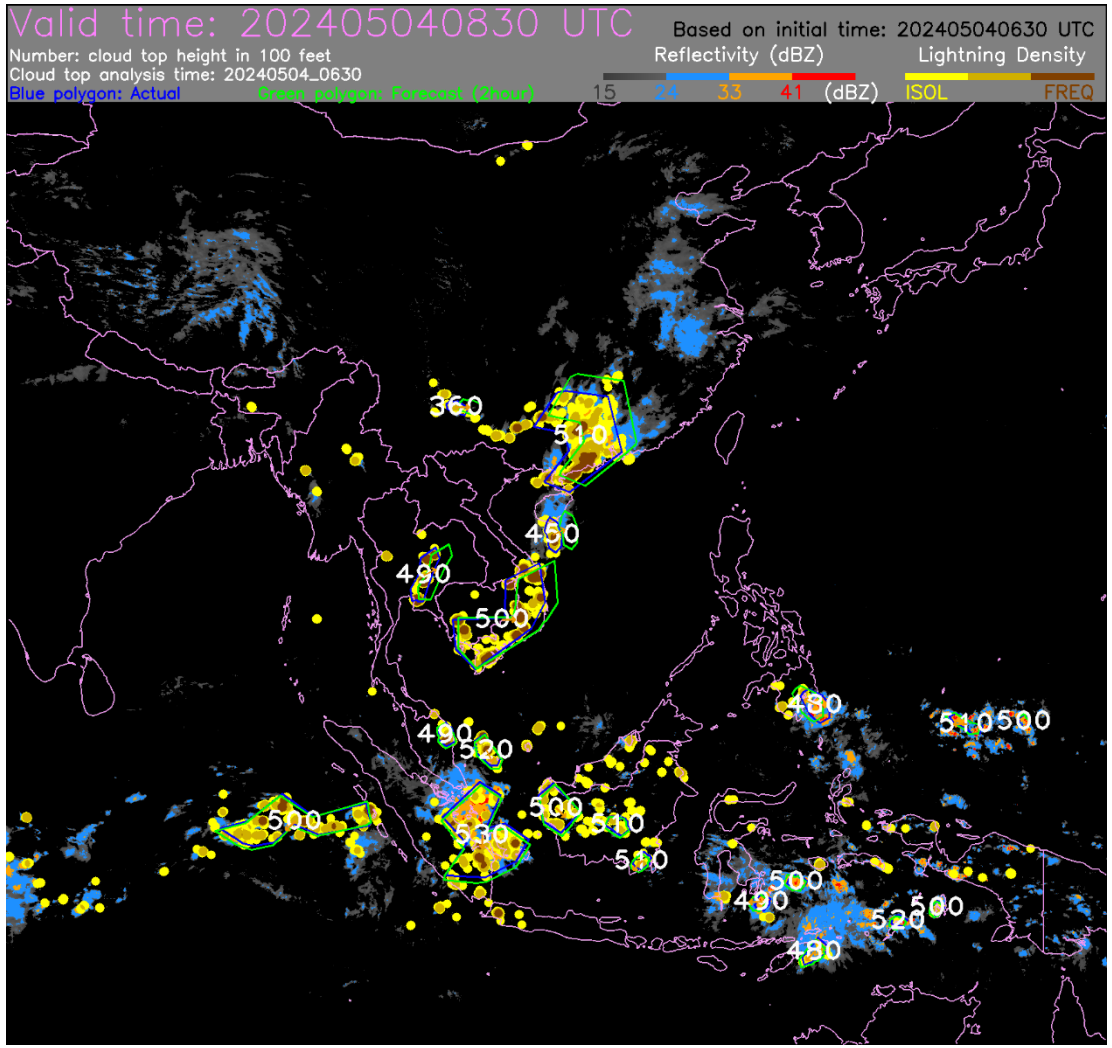

Significant Convection Nowcast over East Asia

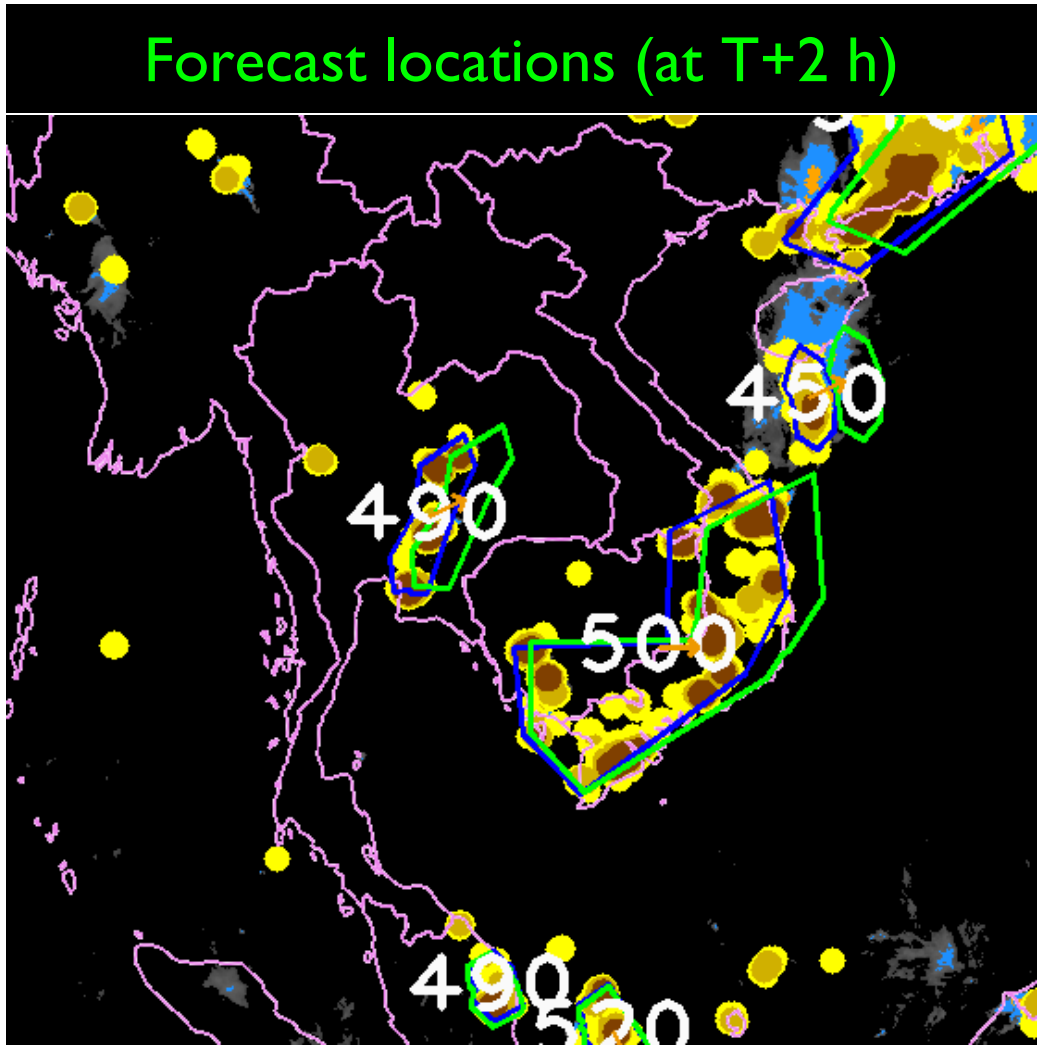



Significant convection nowcast at the fourth hour (in UTC) using retrieved reflectivity (blue ≥24 dBZ, orange ≥33 dBZ and red ≥41 dBZ) from Himawari-8 data and updated every 10 minutes. Lightning counts are marked in yellow (sparse) to brown (dense) with green polygons on areas with high reflectivity or dense lightning.

# Significant Convection Nowcast (1-6 hr) using Himawari-9 ML retrieved reflectivity

**Initial time: 2024-05-04 06:30 UTC**

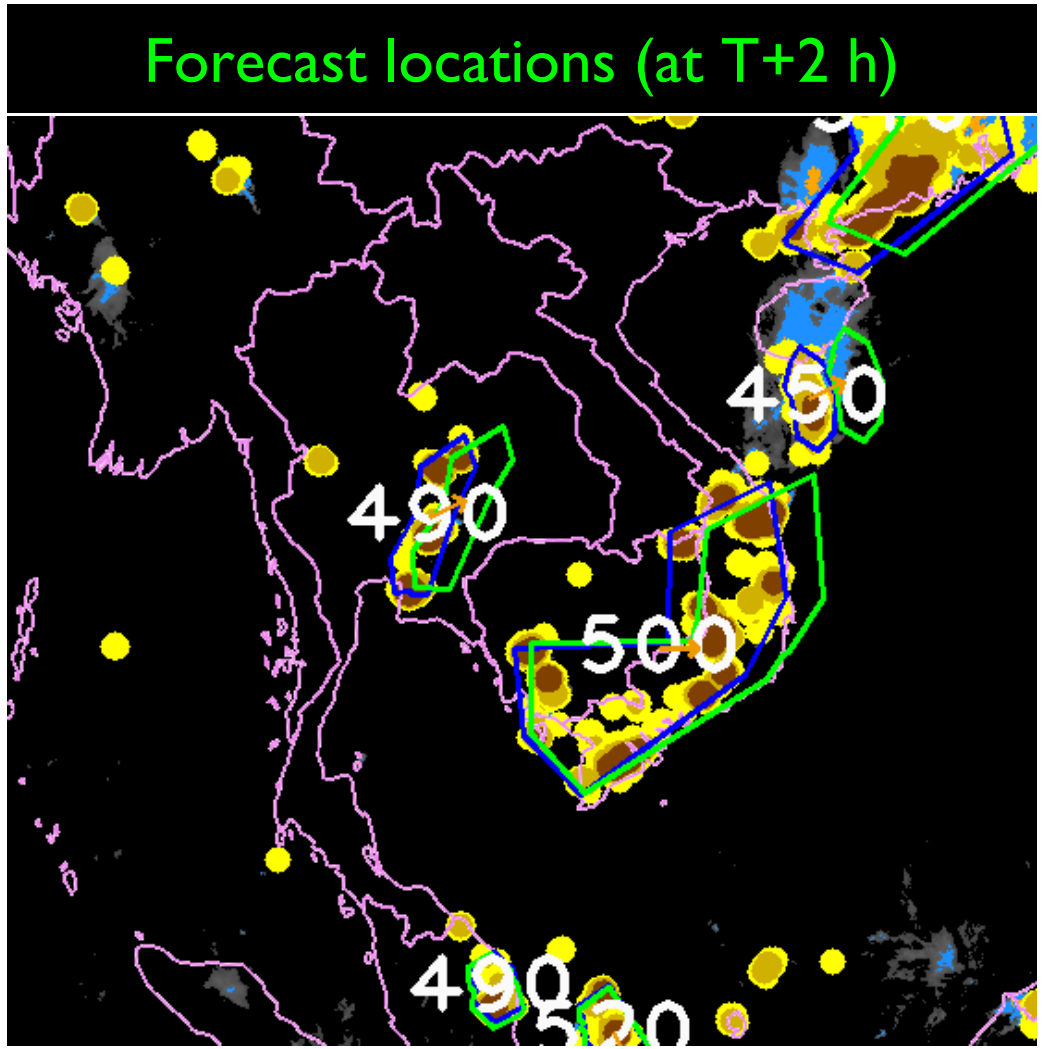


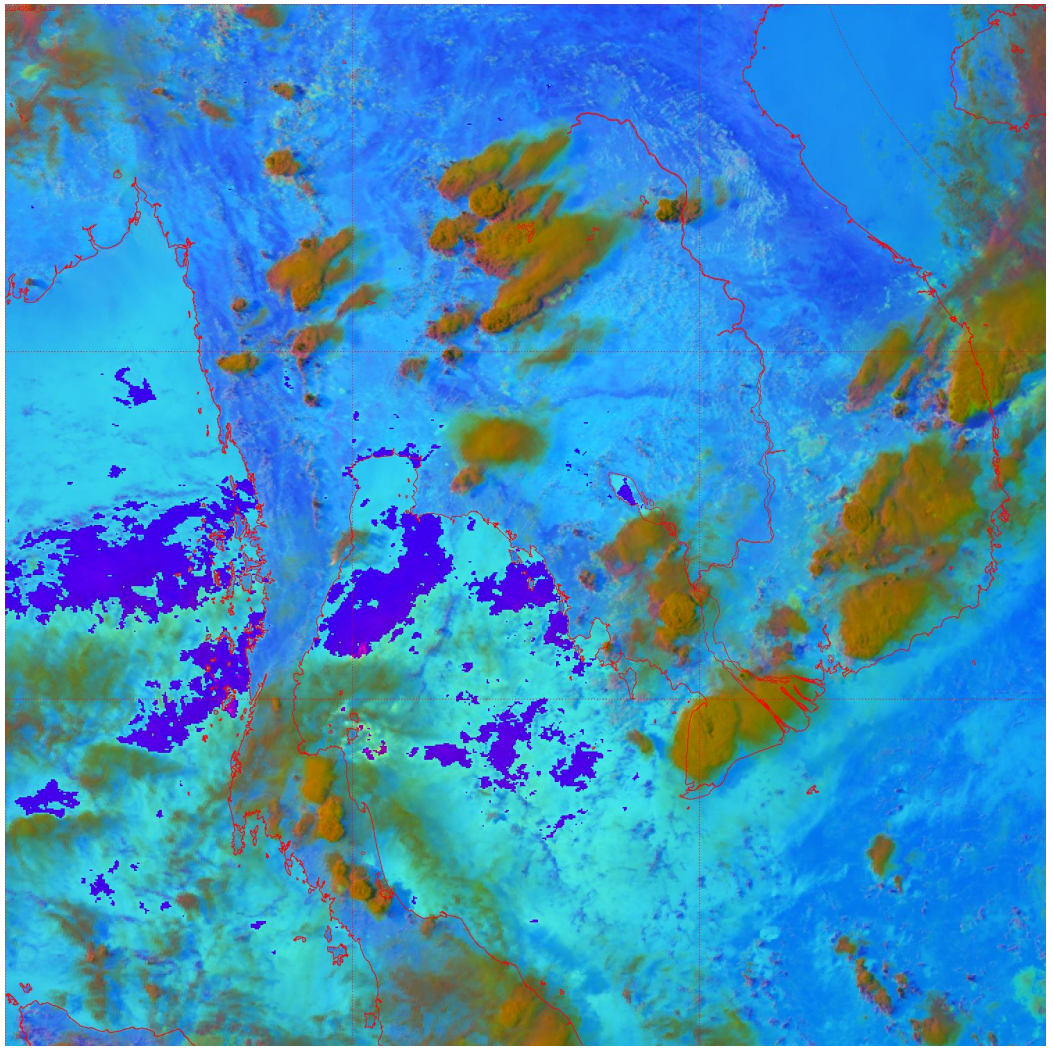



# 2024-05-04 08:30 UTC

Colour interpretation for Day Microphysics RGB

| Color | Interpretation |
|---|---|
| | Deep precipitating cloud (precipitation is not necessarily reaching the ground) - bright, thick, large ice particles, cold cloud |
| | Deep precipitating cloud (Cb cloud with strong updrafts and severe weather)* - bright, thick, small ice particles, cold cloud<br>*or thick, high-level lee cloudiness with small ice particles |



# Summary

- Resources of online satellite products for analysis of convective weather
- Principle of RGB techniques
  - False color (visible + infrared)
  - Natural Color
  - Day Convective Storm
  - Day Microphysics
  - Night Microphysics
- Machine learning retrieved (simulated radar) reflectivity from Himawari multi-spectral imagery
- RSMC Nowcasting website showing nowcast of significant convective areas up to the next 6 hours

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HONG KONG OBSERVATORY

# Thank you very much

## Q&A