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HONG KONG OBSERVATORY

APPLICATION OF GK-2B GEMS OBSERVATION TO MONITOR THE ENVIRONMENT OVER SOUTHERN CHINA

AOMSUC-15 and FYSUC-2025 (28 – 30 October 2025)

Qingdao, Shandong Province, China

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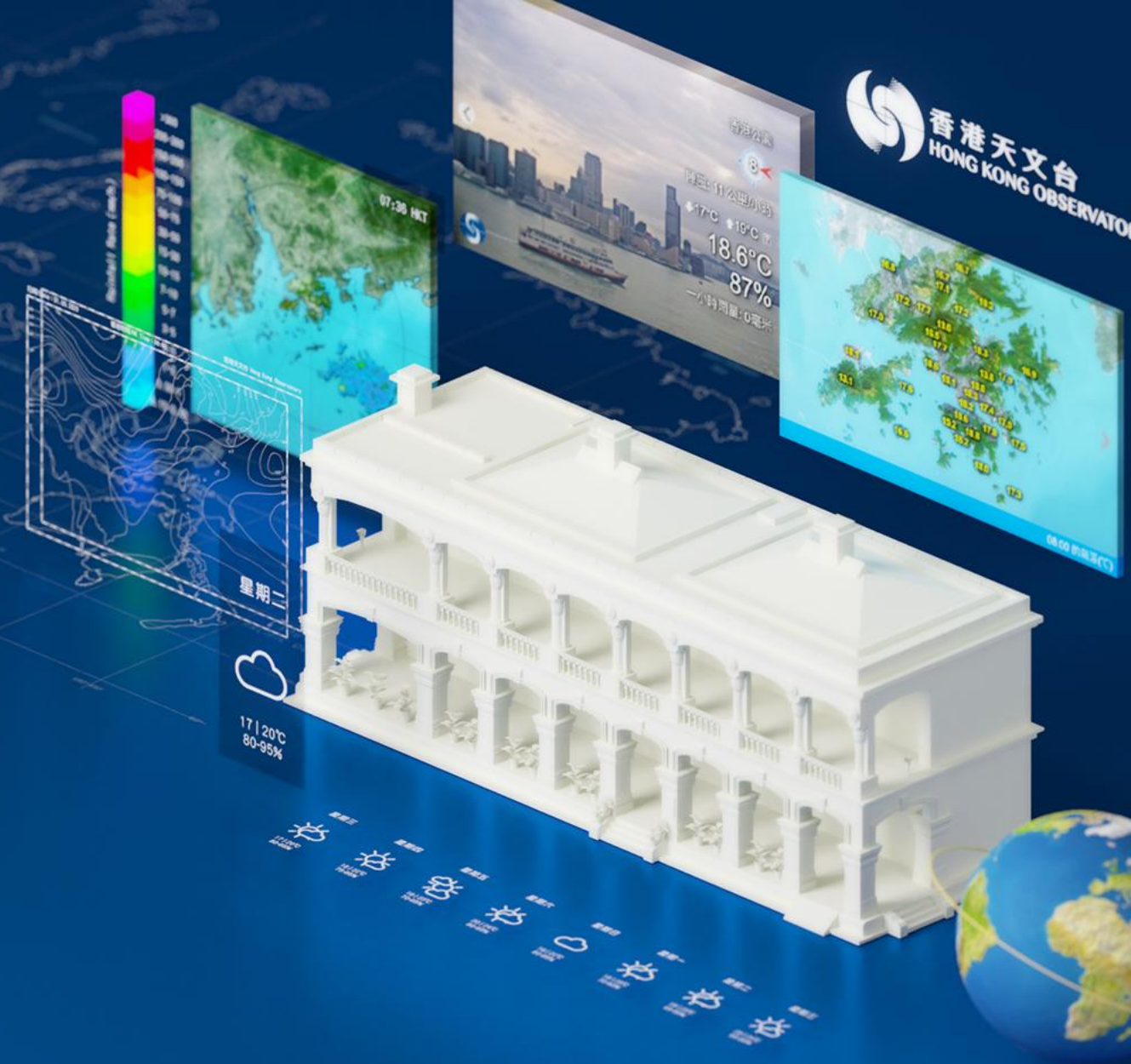


INTRODUCTION

SATELLITE USAGE AT HKO

Geostationary satellites

Mostly using the following satellites:

- Himawari-8/9
- Fengyun-4B
- GEO-KOMPSAT-2A

Usages:

- Satellite imageries (Visible, Infrared, Water Vapour channels…)
- L2 products: rainrate, AOD, Precipitation Water Vapour…

Polar-orbiting satellites

- Direct reception: Aqua, JPSS, Fengyun-3, etc.

Usages:

- Satellite imageries (including microwave)
- L2 products: SO2 concentration at different altitudes.

INTRODUCTION

QUESTION IN DAILY FORECAST AND MONITORING

- Besides tropical cyclones and rainstorms, some phenomena also requires forecast and monitoring, e.g. local visibility
- Cause: Fog/Mist? Sand/Dust?
- Existing Products: Dust RGB (qualitative only)? AOD products?

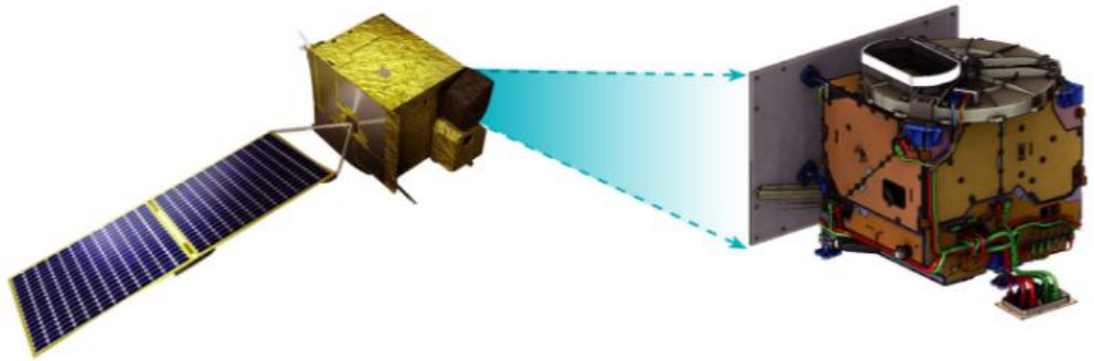
- Difficulties:
  - Types and Qualities of GEO satellites products
  - Limited temporal resolution and observation coverage of LEO satellites
- Other satellites/instruments to support Environmental Monitoring?

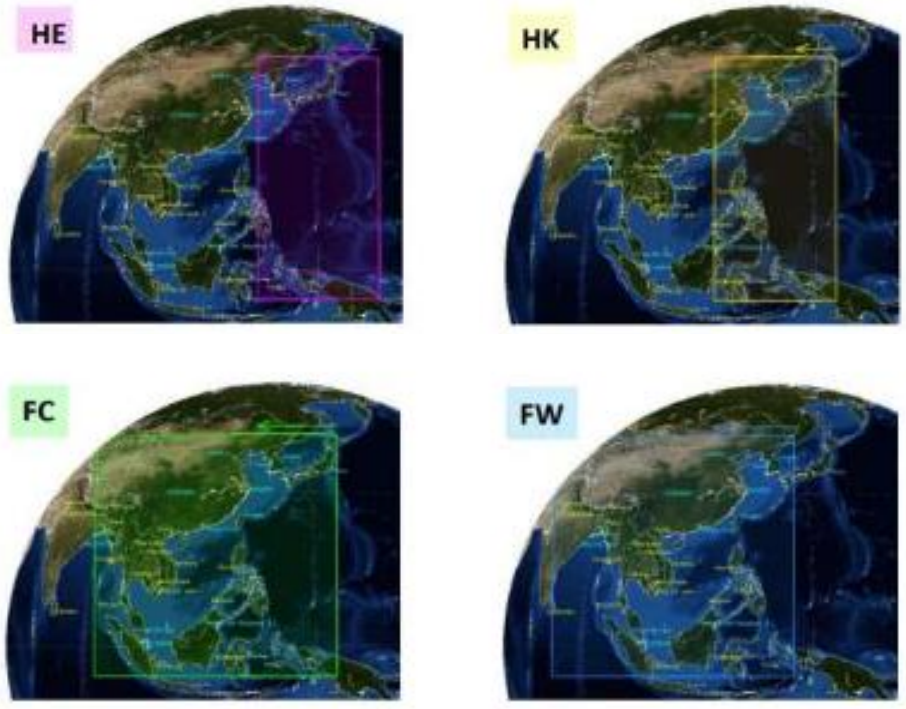
INTRODUCTION

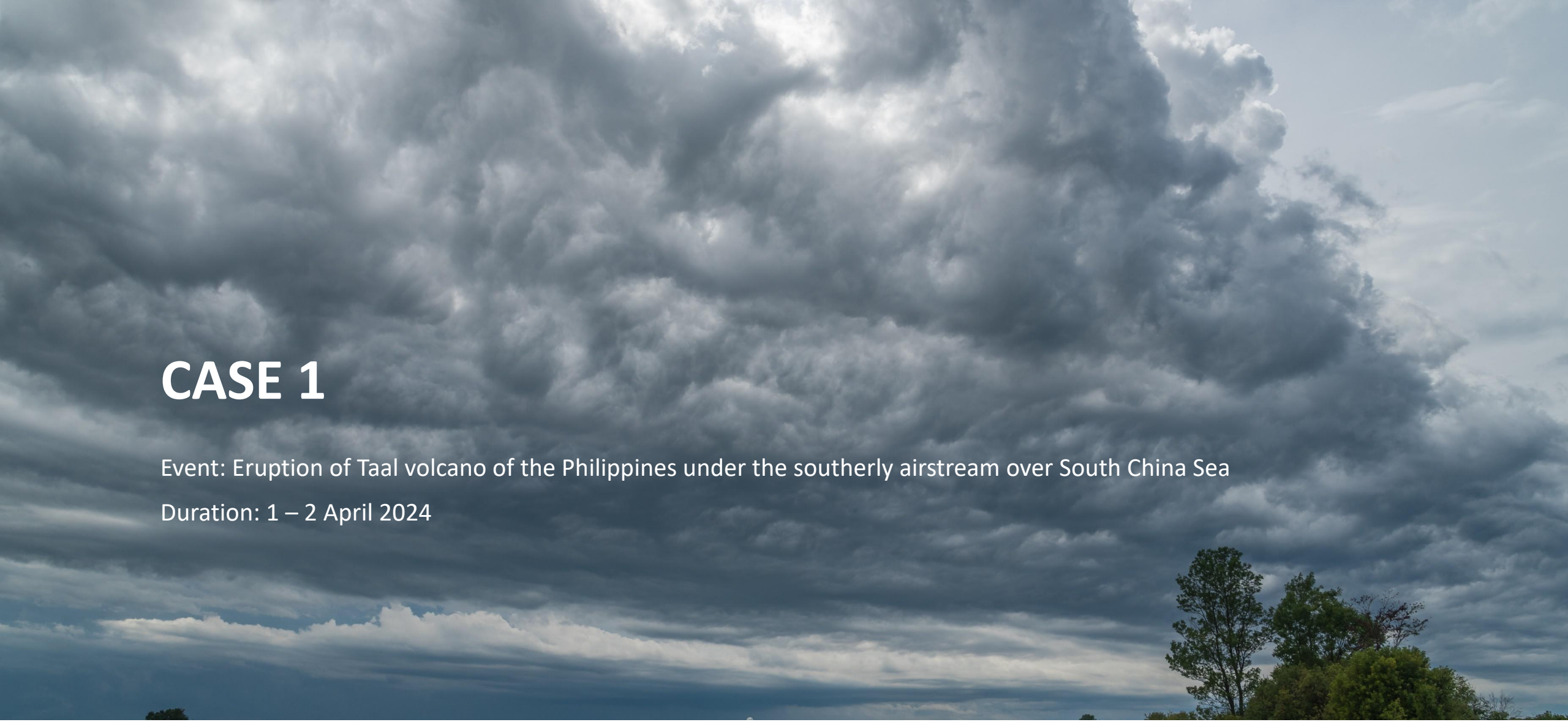
GK-2B GEMS

- Satellite: GEO-COMPSAT-2B (GK-2B)
- Instrument: Geostationary Environmental Monitoring Spectrometer (GEMS) [UV/VIS grating imaging spectrometer, range 300-500 nm]
- Institute: National Institute of Environmental Research (NIER) of Korea
- Scanning Strategy: Hourly observation during daytime over East Asia
- Products: AOD, concentration of SO2, surface PM2.5, PM10, etc.

- **HKO access to GEMS data since late 2023**
- **Useful in environmental monitoring and analysis. Two cases follow.**







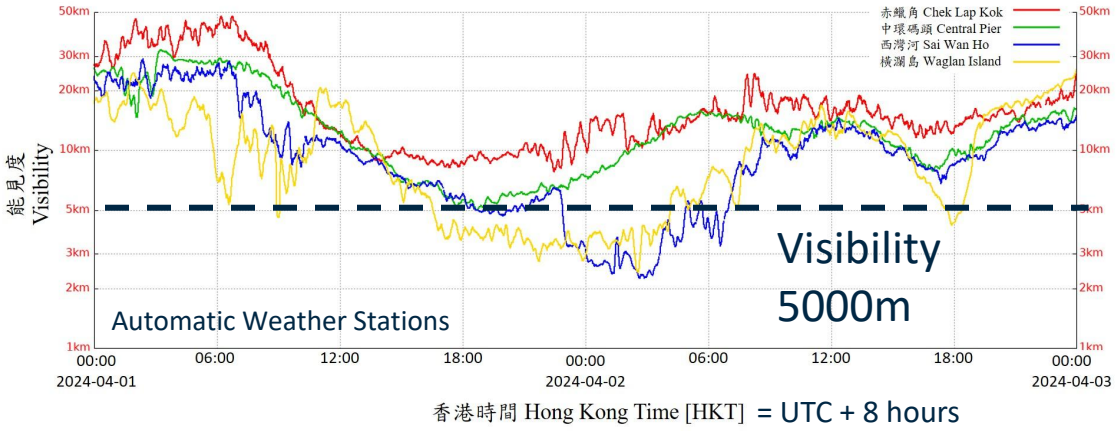
CASE 1

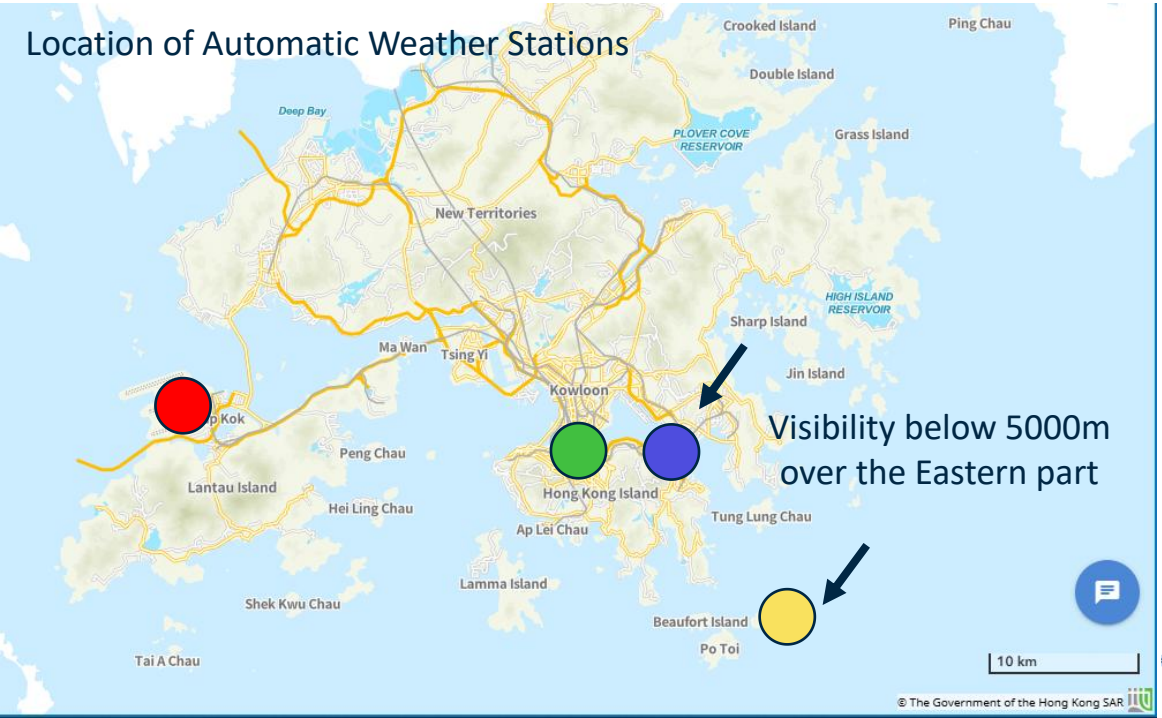
Event: Eruption of Taal volcano of the Philippines under the southerly airstream over South China Sea

Duration: 1 – 2 April 2024

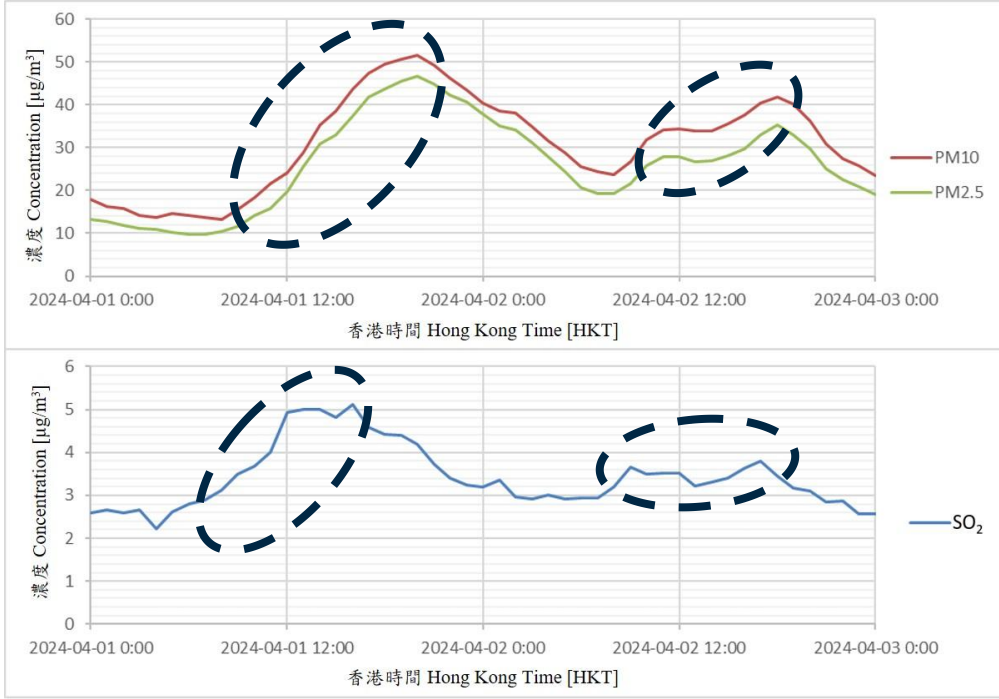
CASE 1: TAAL VOLCANO

GROUND OBSERVATIONS

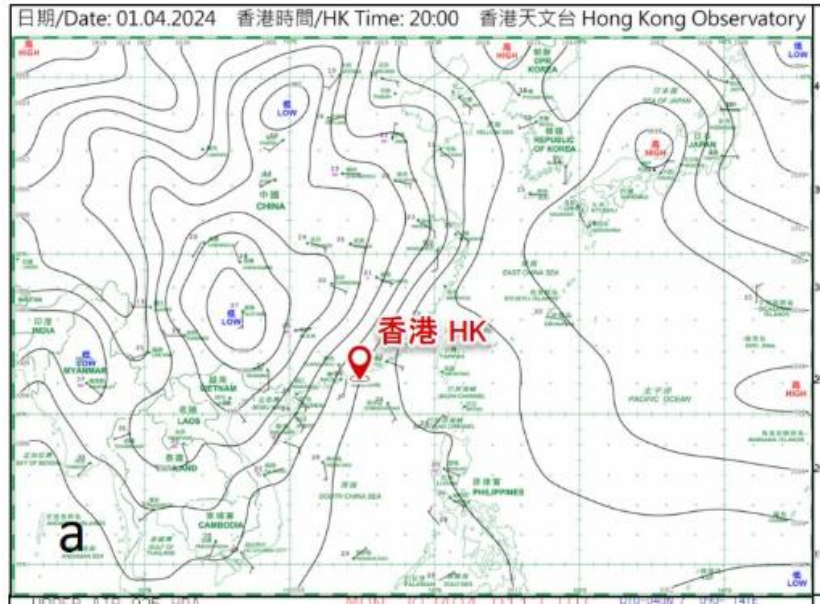




Rise of concentration of PM2.5, PM10 and SO2 in Hong Kong (Air quality monitoring stations)



Synoptic Pattern
Southerly airstream
from South China Sea



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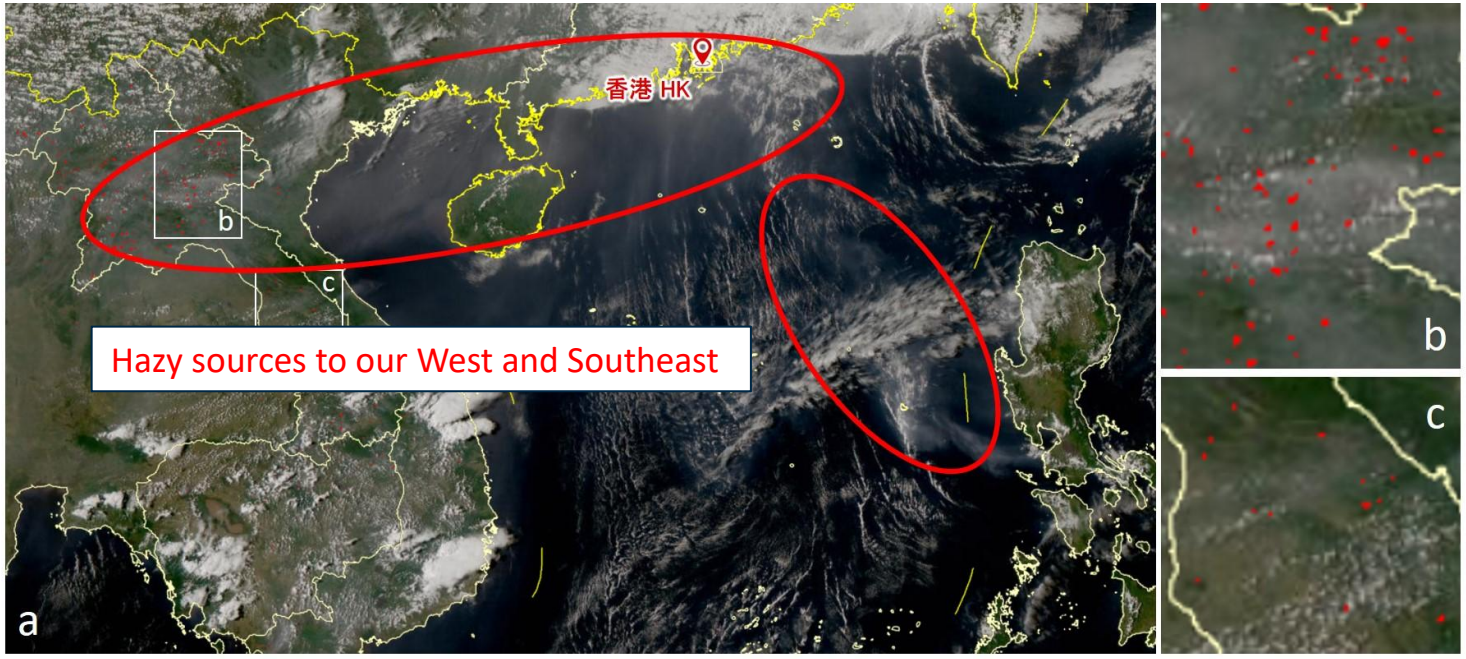
CASE 1: TAAL VOLCANO

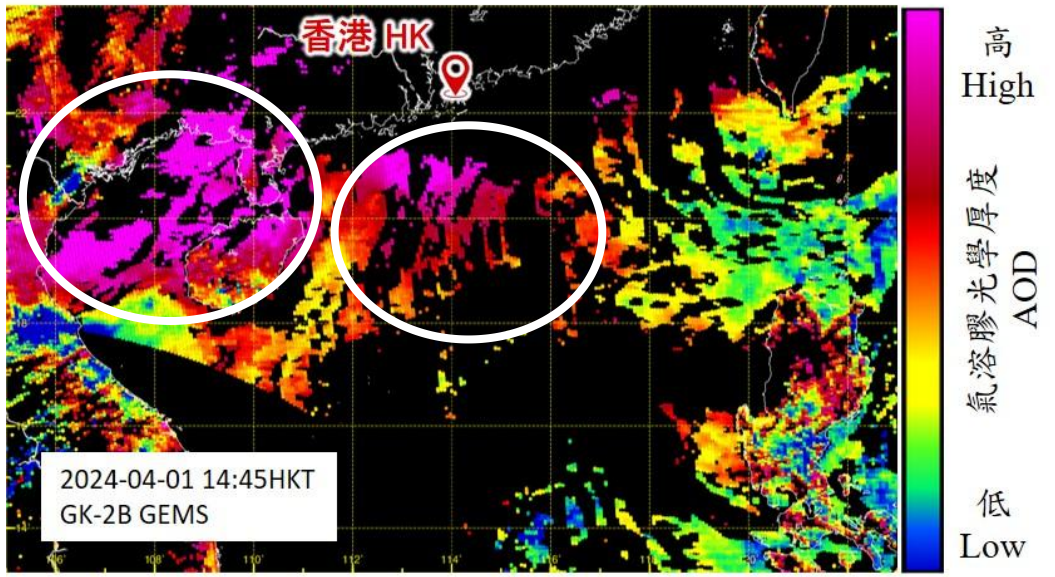
SATELLITE OBSERVATIONS

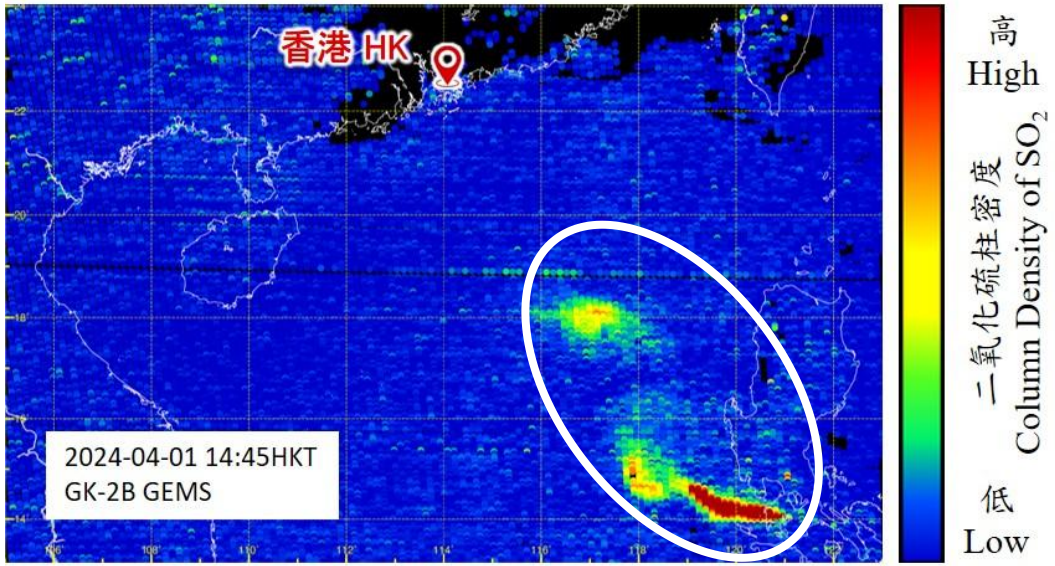


FY-4B True Color
1600HKT (0800UTC), 1 April 2024

Red dots indicates hot spots
e.g. seasonal biomass burning over Indo-China Peninsula

Image source: SWAP of NSMC/CMA



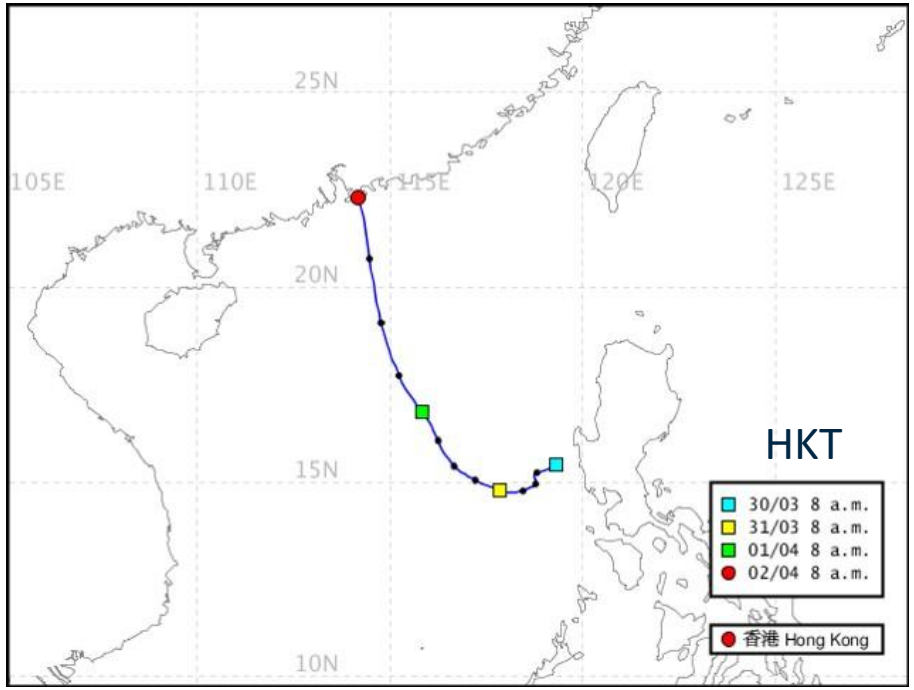


GK2B GEMS Observation

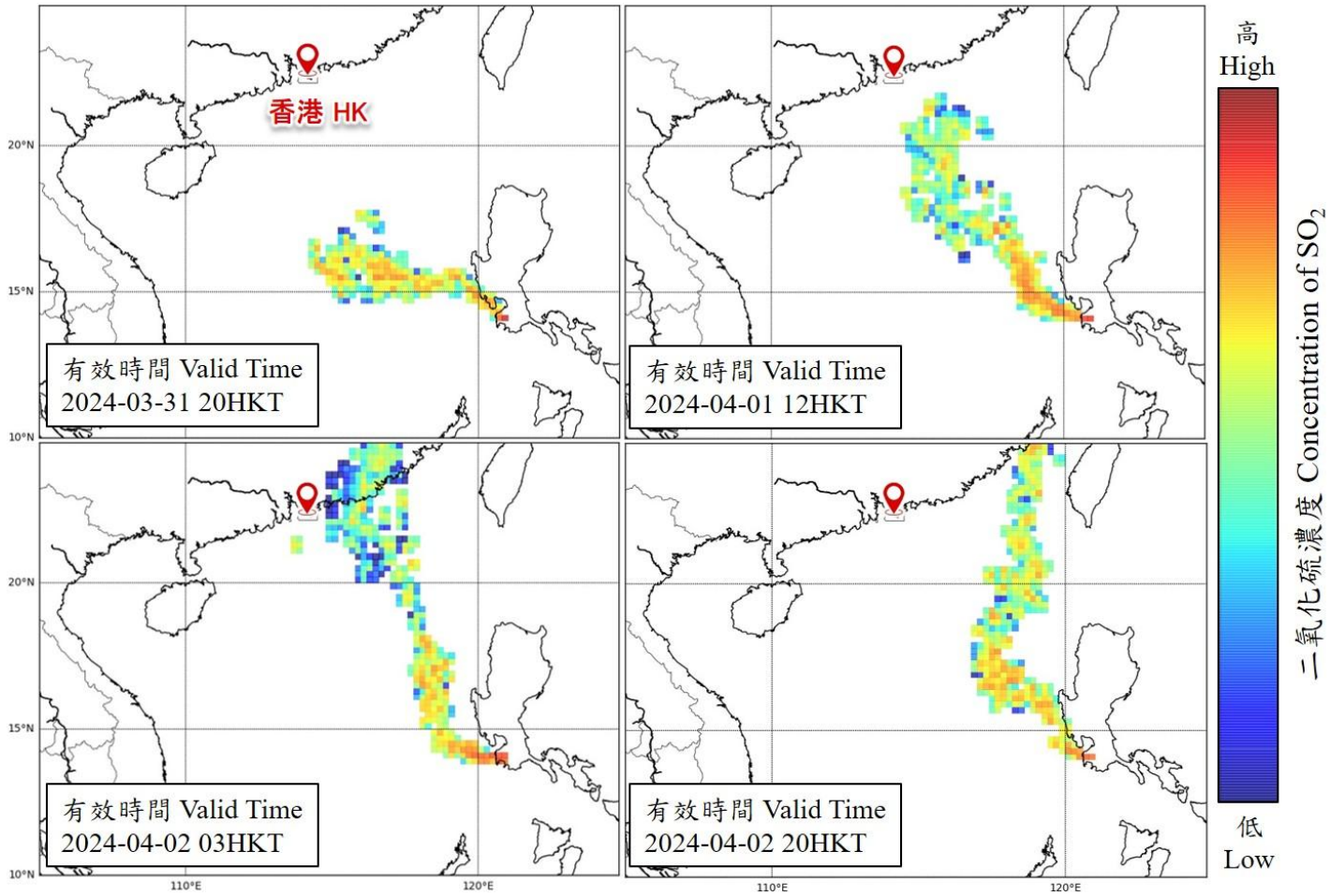
- High AOD regions to our West and South (similar to FY4B True Colour)
- **Source of SO2** only to our Southeast (originated from Taal Volcano)

CASE 1: TAAL VOLCANO

TRACING THE SOURCE



3-day backward trajectory analysis
(dating back from 08:00 HKT on 2 April 2024)

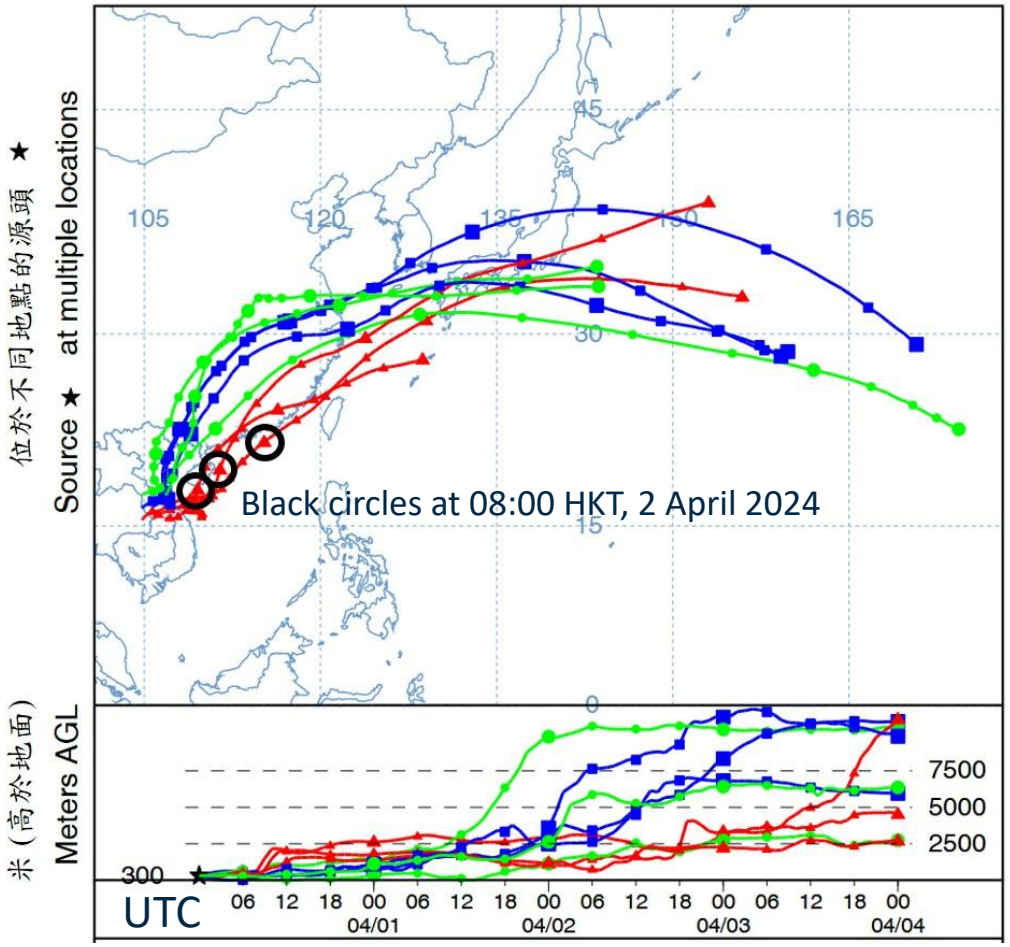


Dispersion model “FLEXPART” was used based on a hypothetical SO2 concentration source to evaluate if the SO2 plume could reach the south China coastal areas after releasing from Taal Volcano.

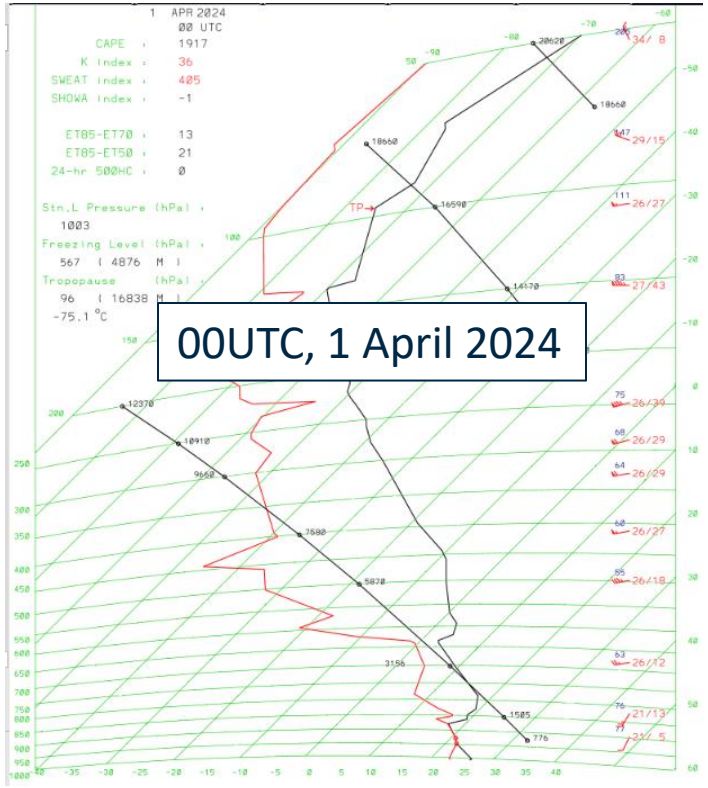
Low surface visibility was likely induced by the eruption of Taal Volcano.
Dispersion model result also explains the larger impact to the **eastern part** of Hong Kong

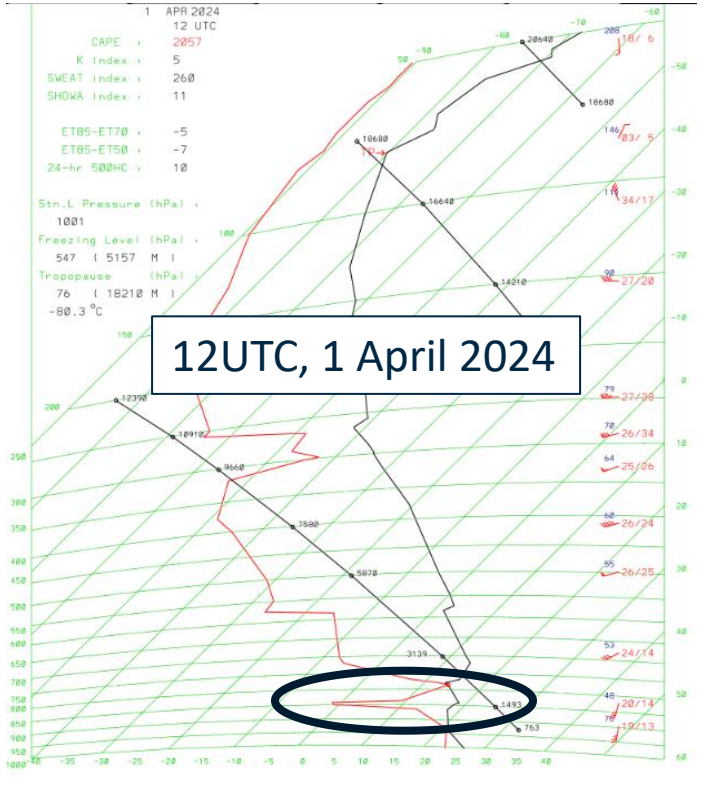
CASE 1: TAAL VOLCANO

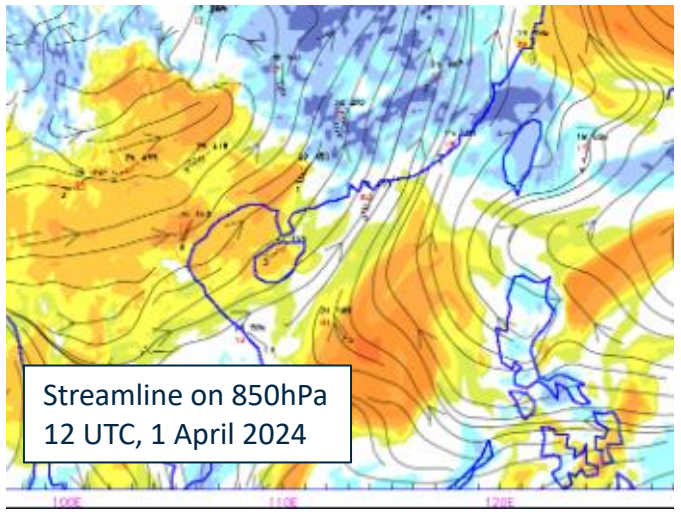
IMPACT FROM THE WEST?



4-day forward trajectory analysis
(starting from 08:00 HKT on 31 March 2024)







Biomass burning activities over Indo-China Peninsula brought impact to upper-air (850hPa).
Significant drop of dew point in Tephigram at 12UTC, 1 April 2024

CASE 1: TAAL VOLCANO

MORE REFERENCES

- Hong Kong Observatory's Blog
  A rare event on 1-2 April 2024: reduced visibility in Hong Kong under southerly winds (Link)
- Lin, C., Yu, J.Z., Lee, E. *et al.* Mysterious air pollution in south China linked to volcanic emissions from the Philippines. Commun Earth Environ **6**, 86 (2025).
  https://doi.org/10.1038/s43247-025-02073-y
  (Development of a real-time chemical-wind index to identify the occurrence of air pollution associated with volcanic emissions)

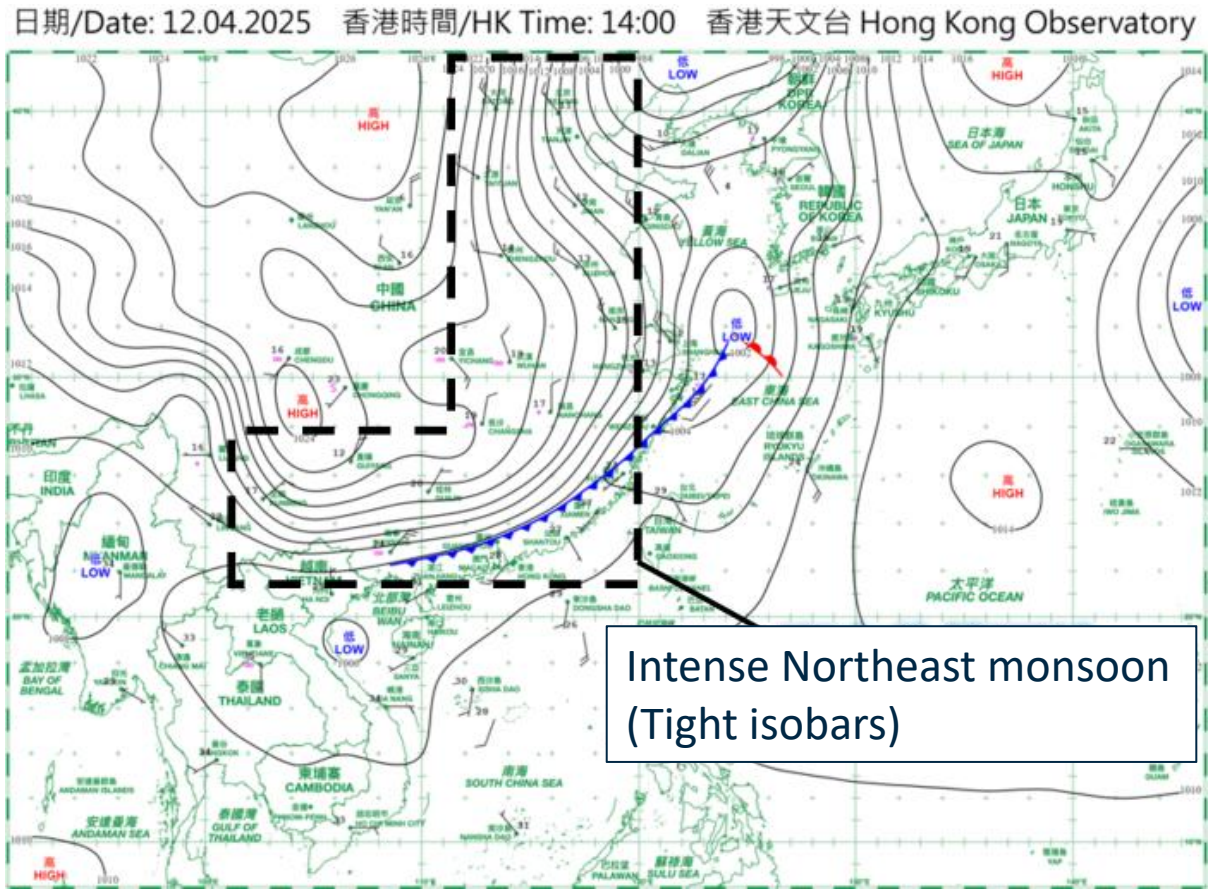
CASE 2

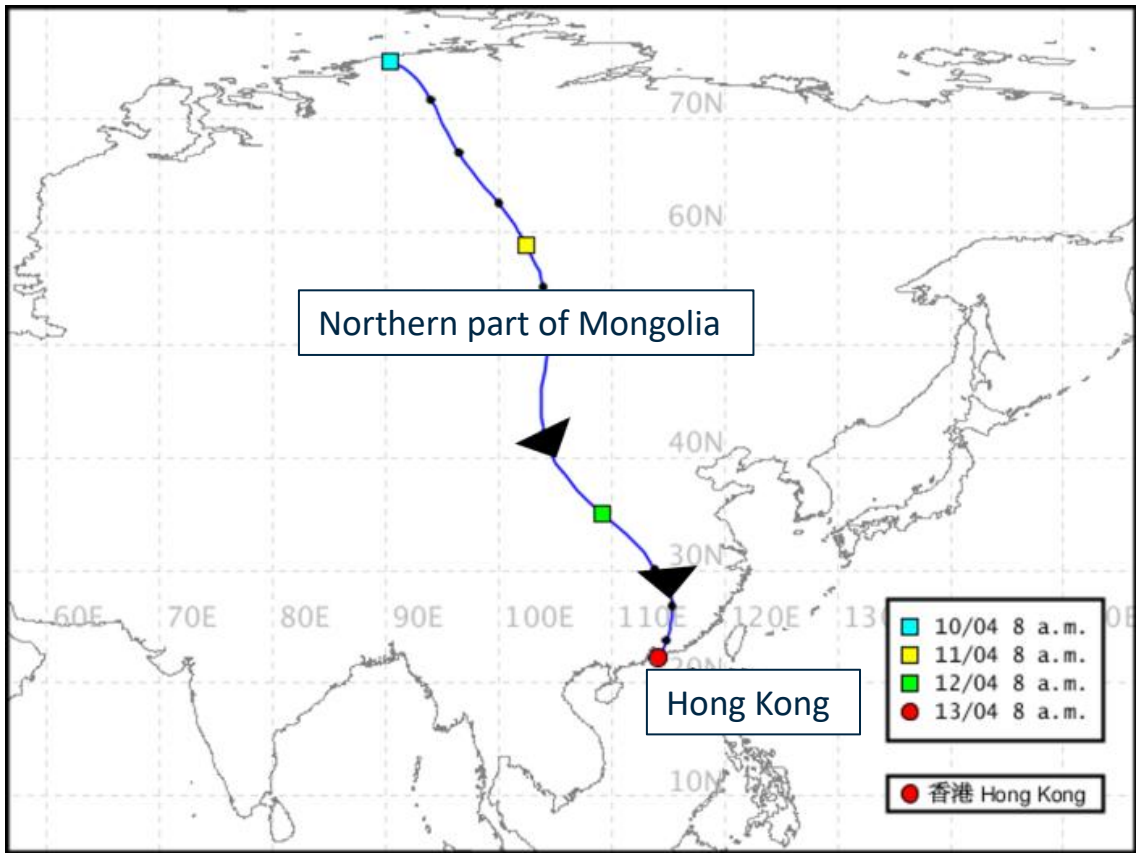
Event: Sand/Dust storm originated from northern China and Mongolia under an intense northeast monsoon

Duration: Mid April 2025

CASE 2: SAND/DUST

SYNOPTIC ANALYSIS





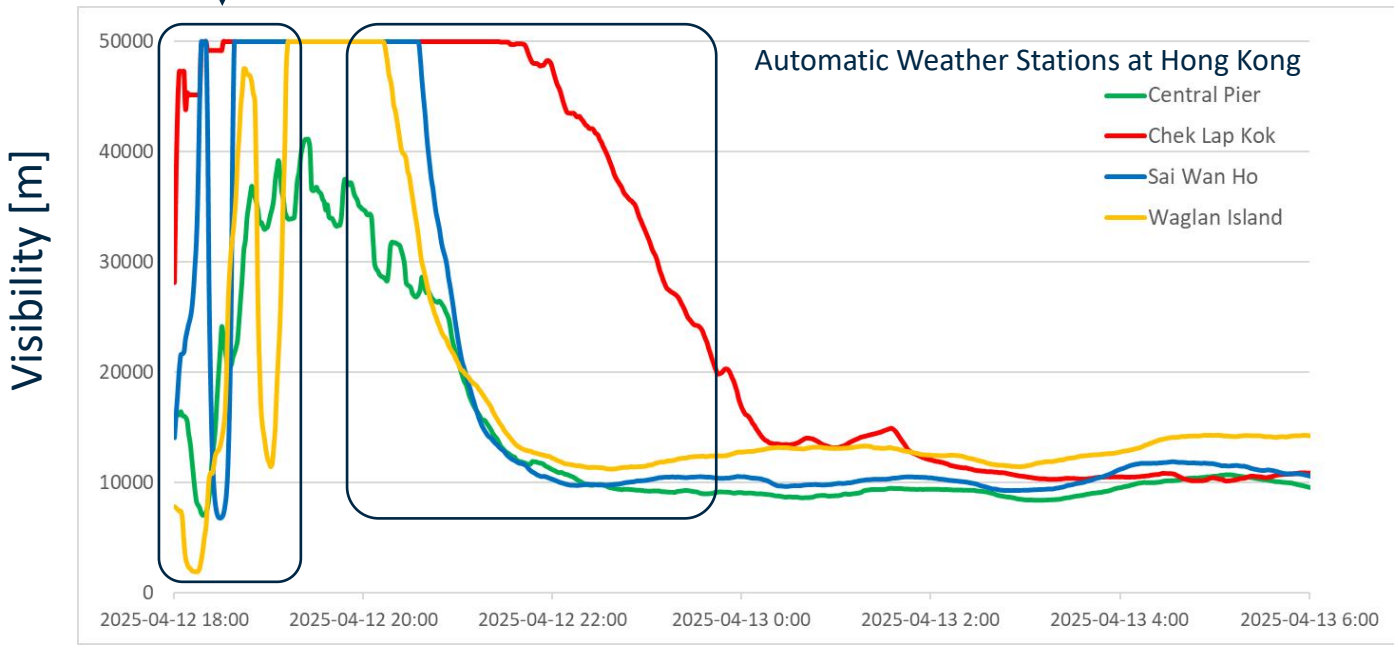
CASE 2: SAND/DUST

GROUND OBSERVATIONS

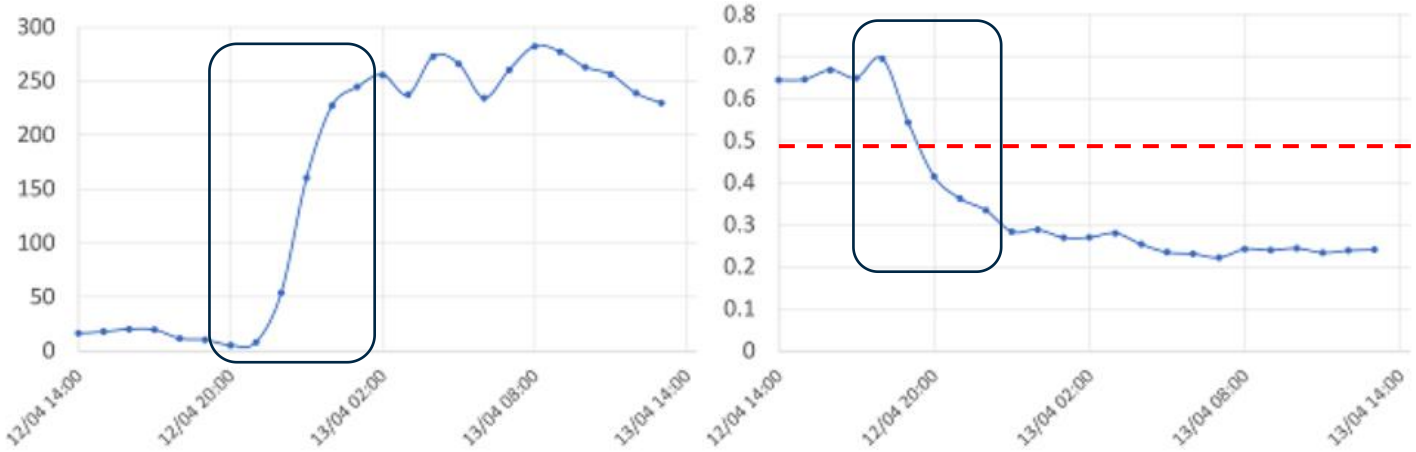
00UTC (left), 12UTC (right) on 12 April 2025 Sand/dust

Due to precipitation

Arrival of Sand/Dust at night of 12 April 2025
(Gradual drop of visibility)



Hong Kong Time



HKT

0.5
Indicator for Identifying Atmospheric SandDust in Hong Kong
https://www.meteorology.org.hk/bulletin/Vol21.1_2011.pdf

Measurement of an air quality monitoring station
(Left) Concentration of PM10 [µg/m3]
(Right) Ratio PM2.5/PM10

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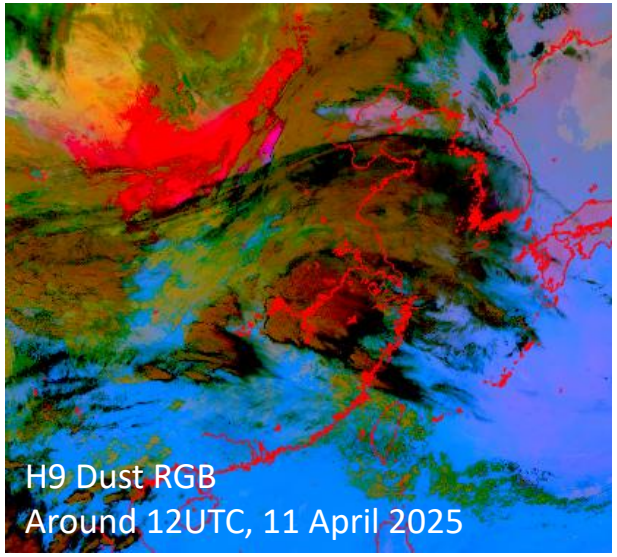
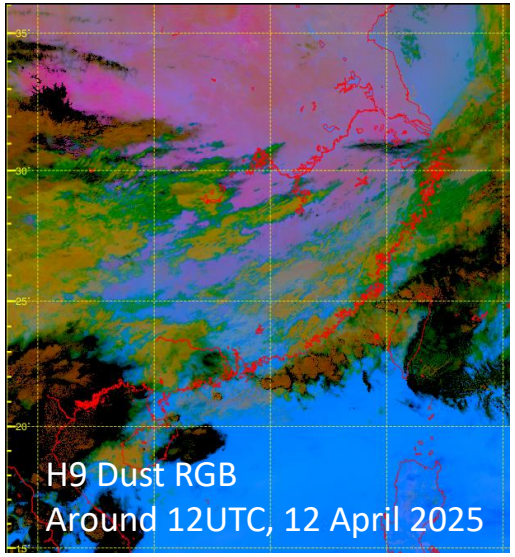
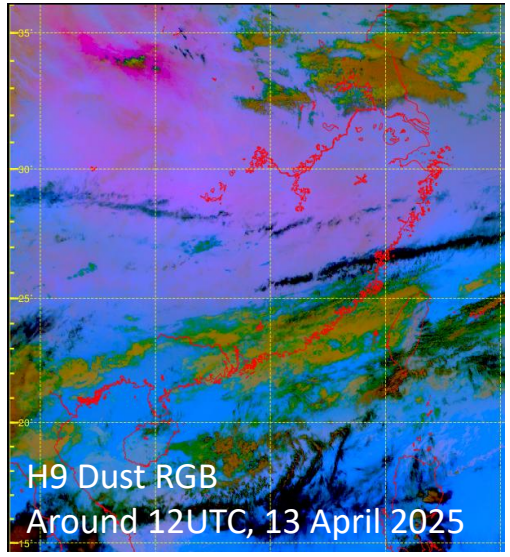
CASE 2: SAND/DUST

SATELLITE OBSERVATIONS

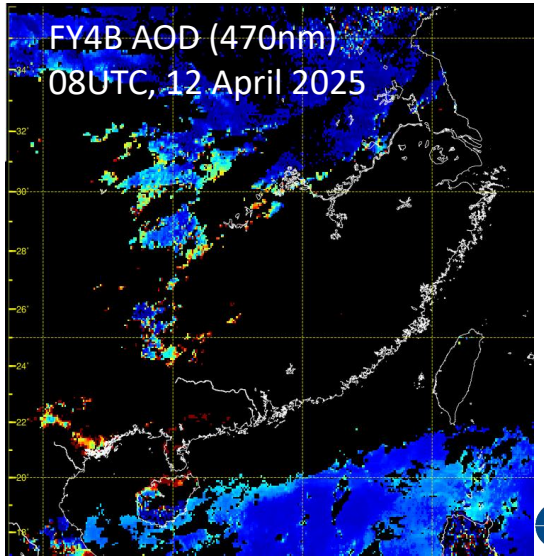


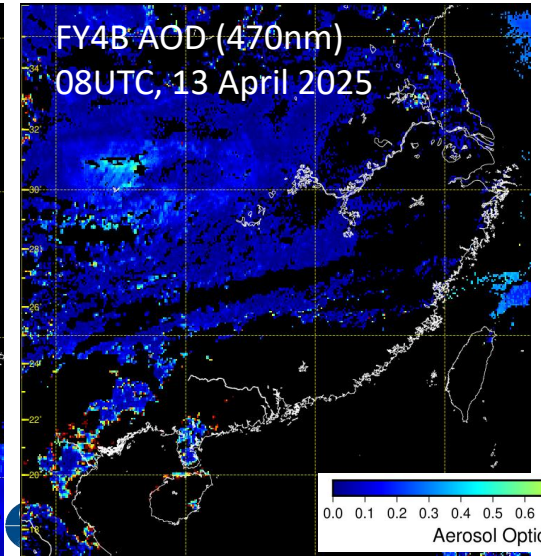


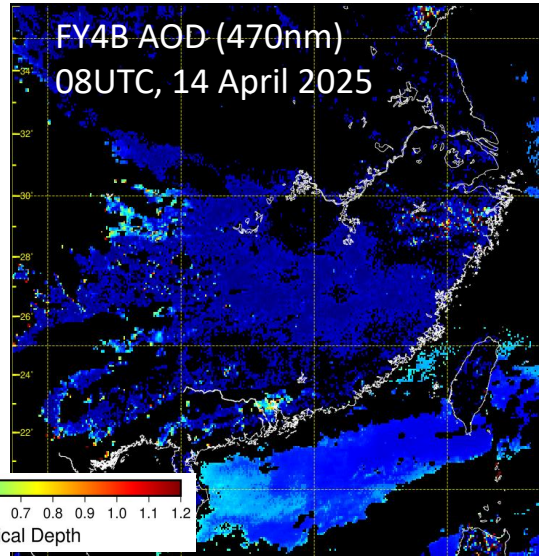


Strong signal in Dust RGB when Sand/Dust were over Northern part of China
But it weakened over Southern China

No clear signal on FY-4B AOD

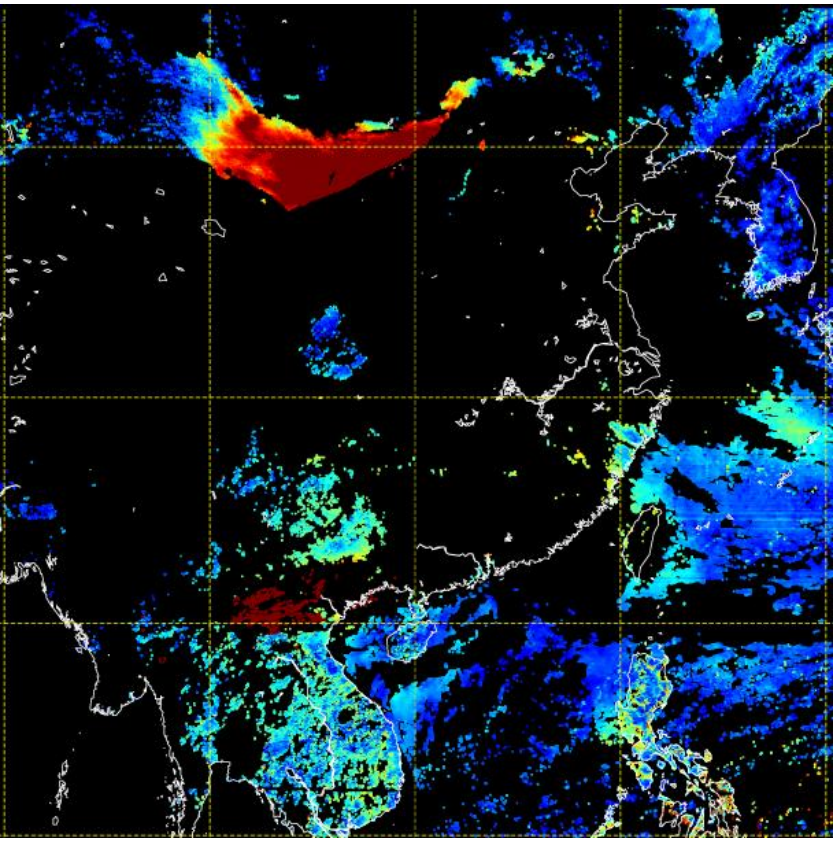


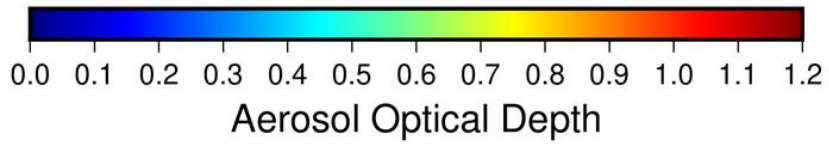




CASE 2: SAND/DUST

GK2B GEMS OBSERVATIONS (0745UTC, 11 APRIL 2025)





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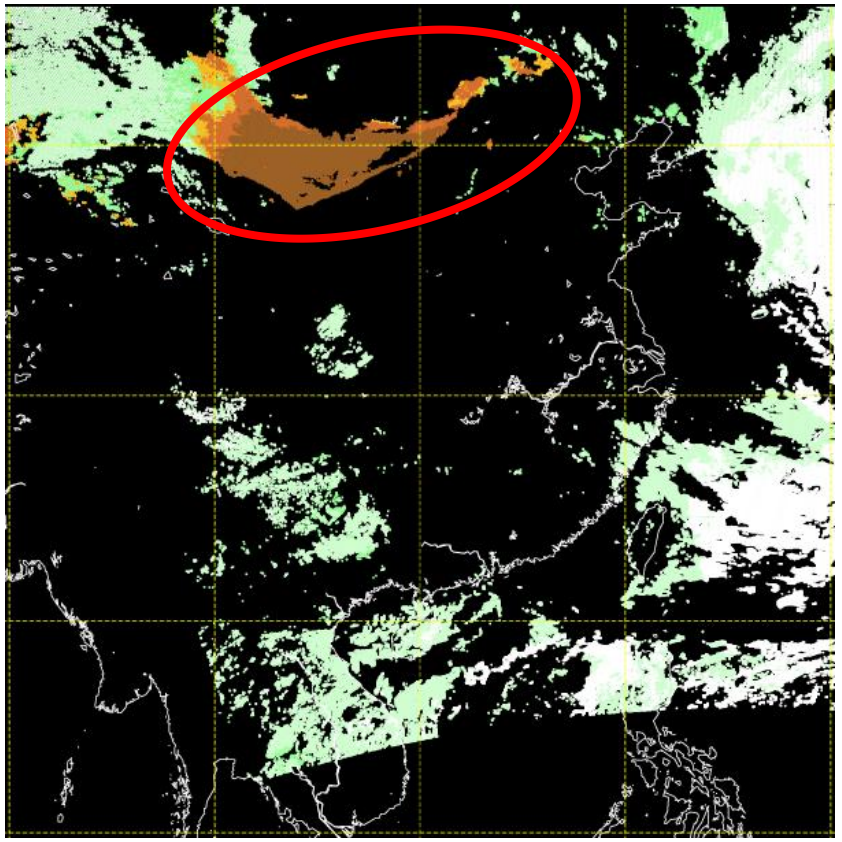
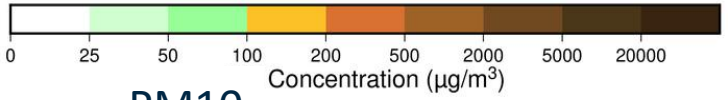
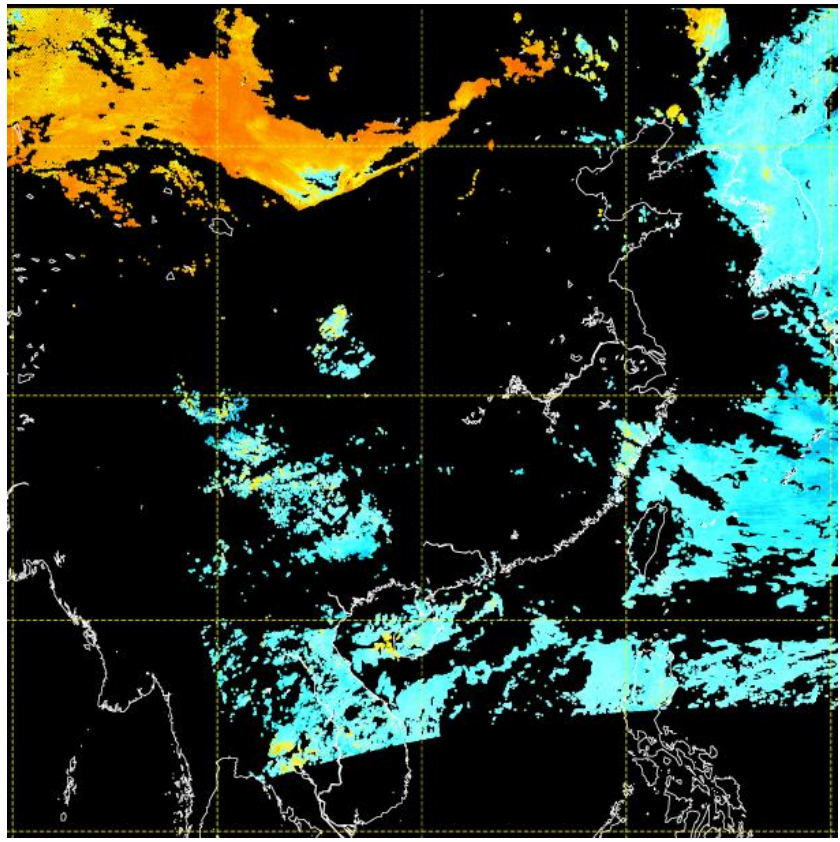
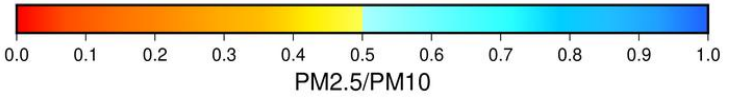




PM10





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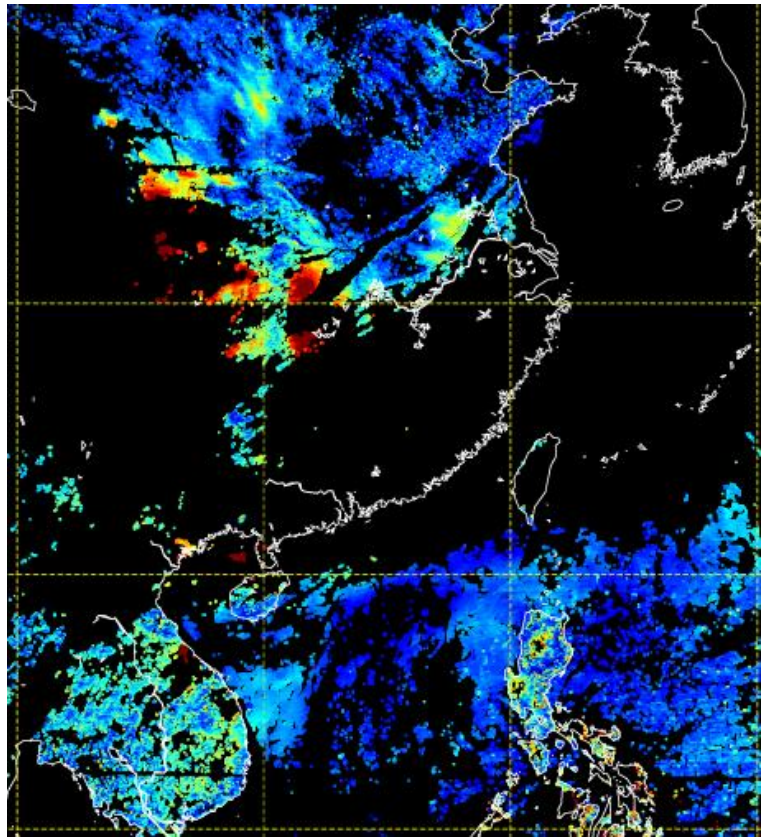
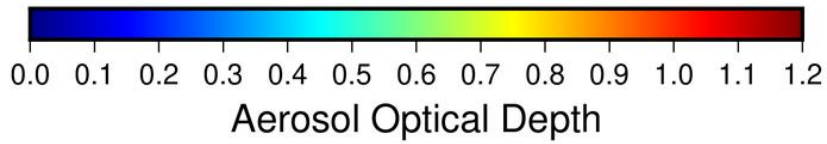
CASE 2: SAND/DUST

GK2B GEMS OBSERVATIONS (0745UTC, 12 APRIL 2025)





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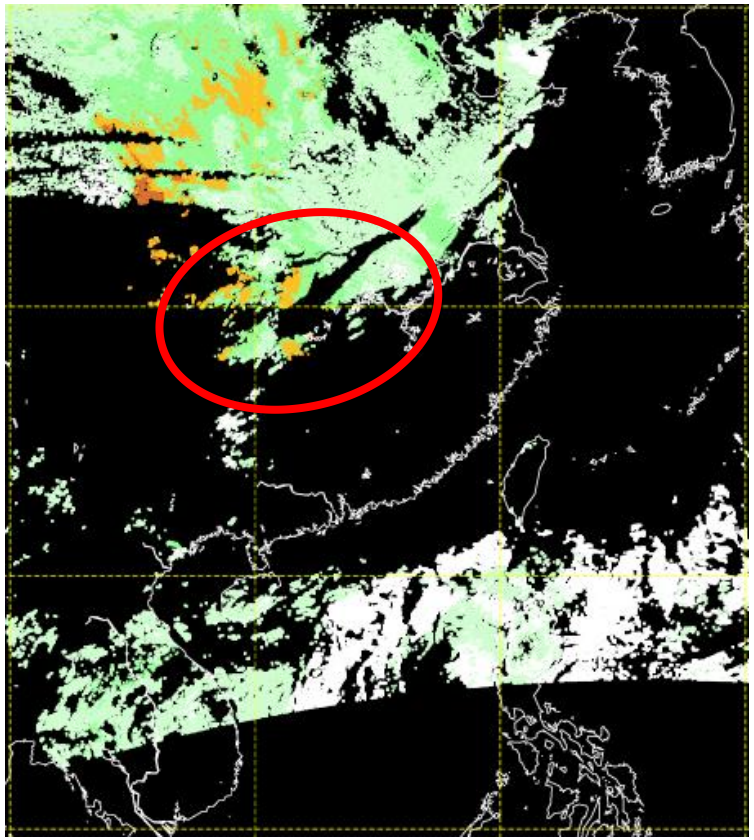

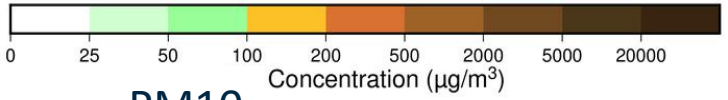

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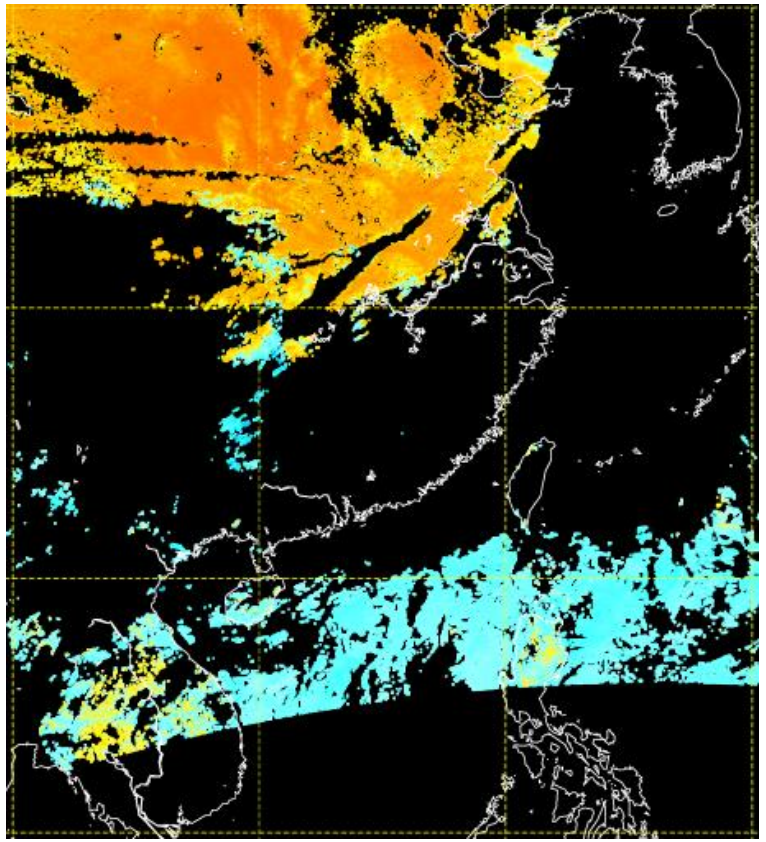

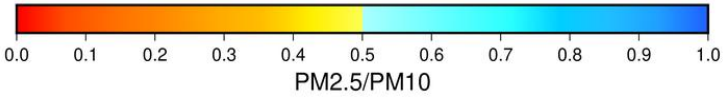

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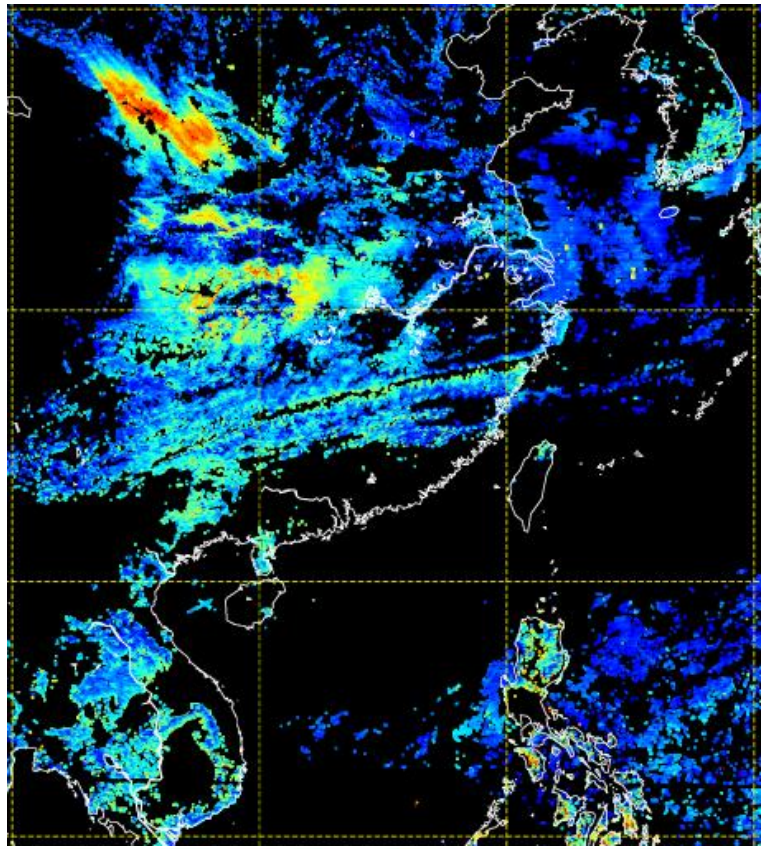
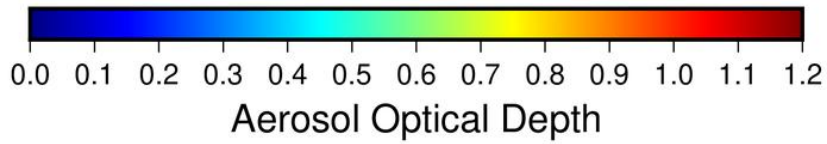
CASE 2: SAND/DUST

GK2B GEMS OBSERVATIONS (0745UTC, 13 APRIL 2025)





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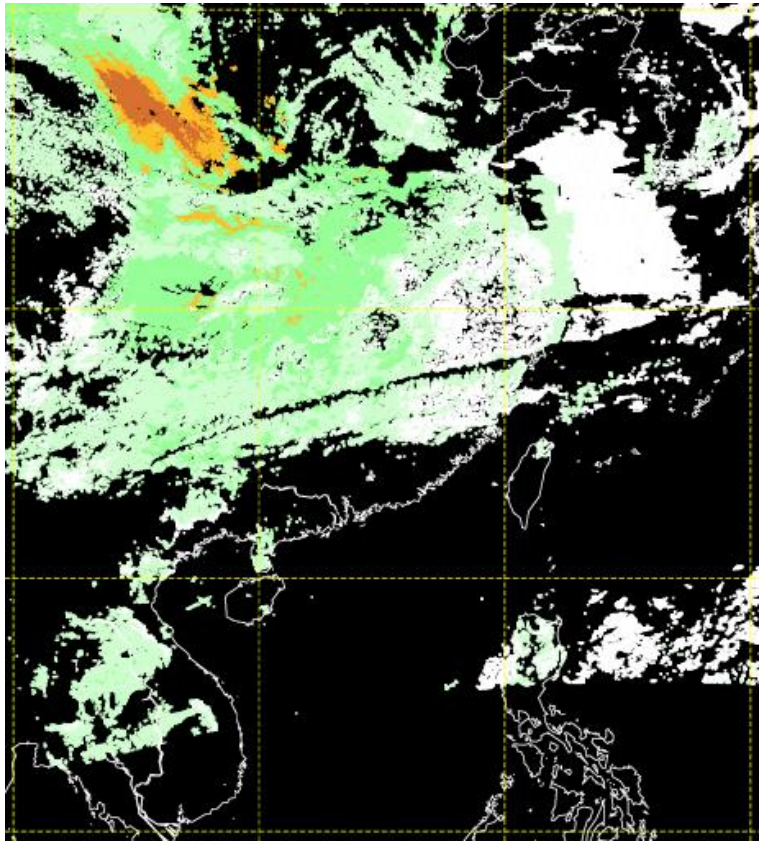

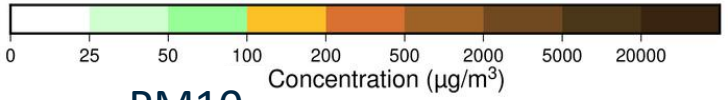

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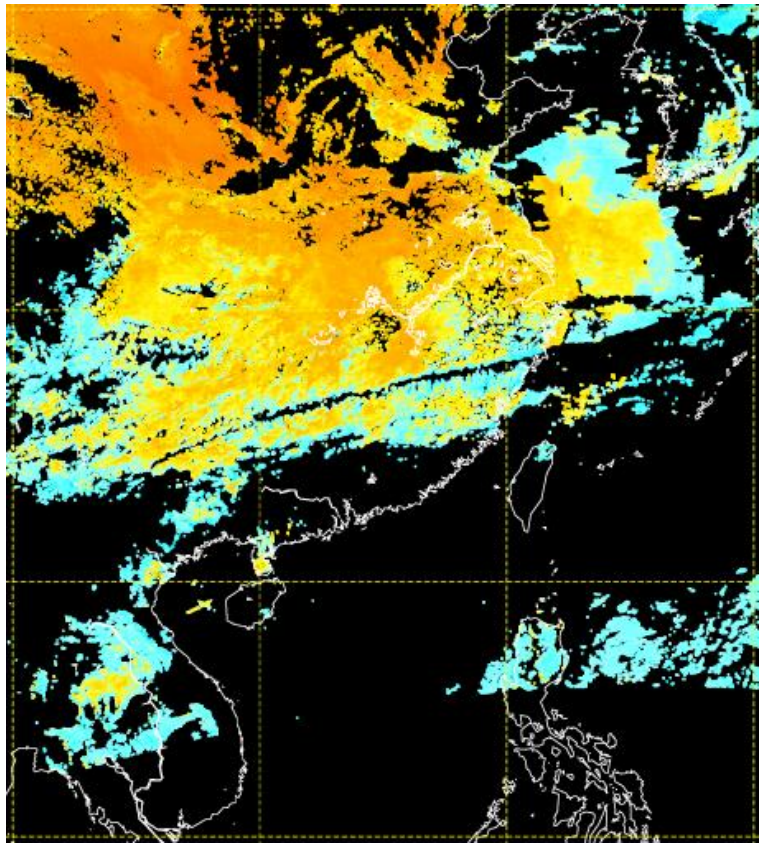

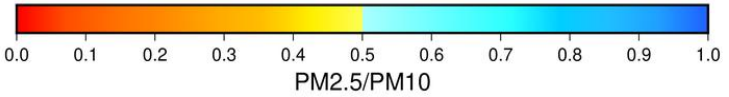

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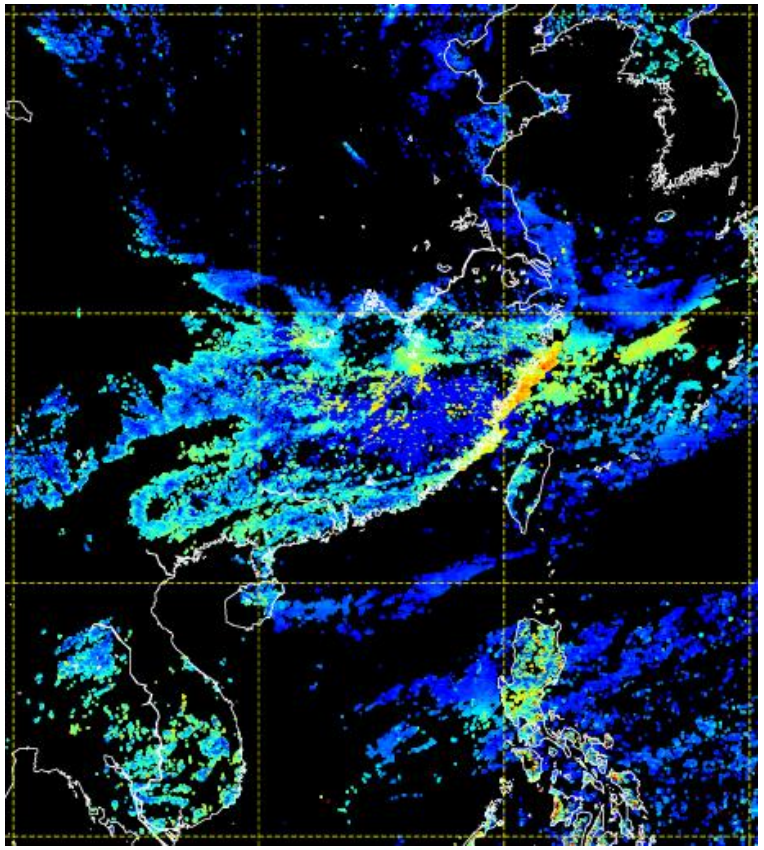
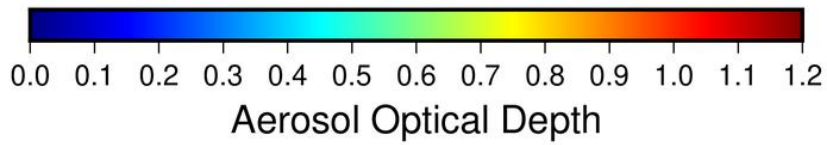
CASE 2: SAND/DUST

GK2B GEMS OBSERVATIONS (0745UTC, 14 APRIL 2025)





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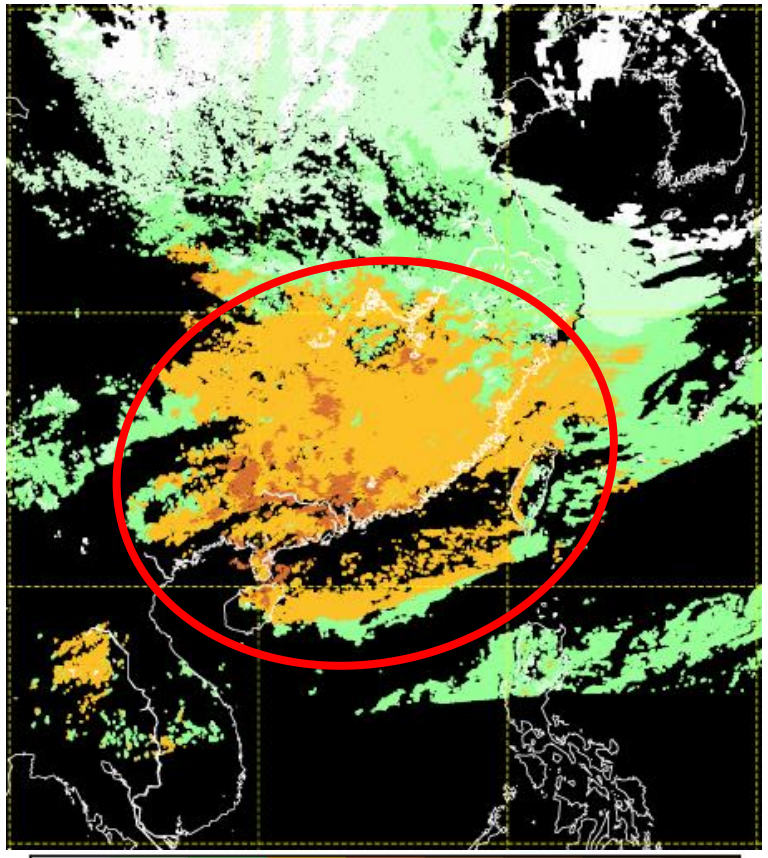
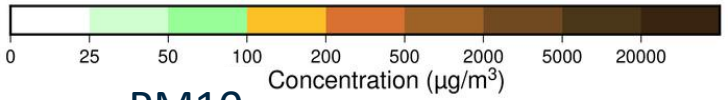
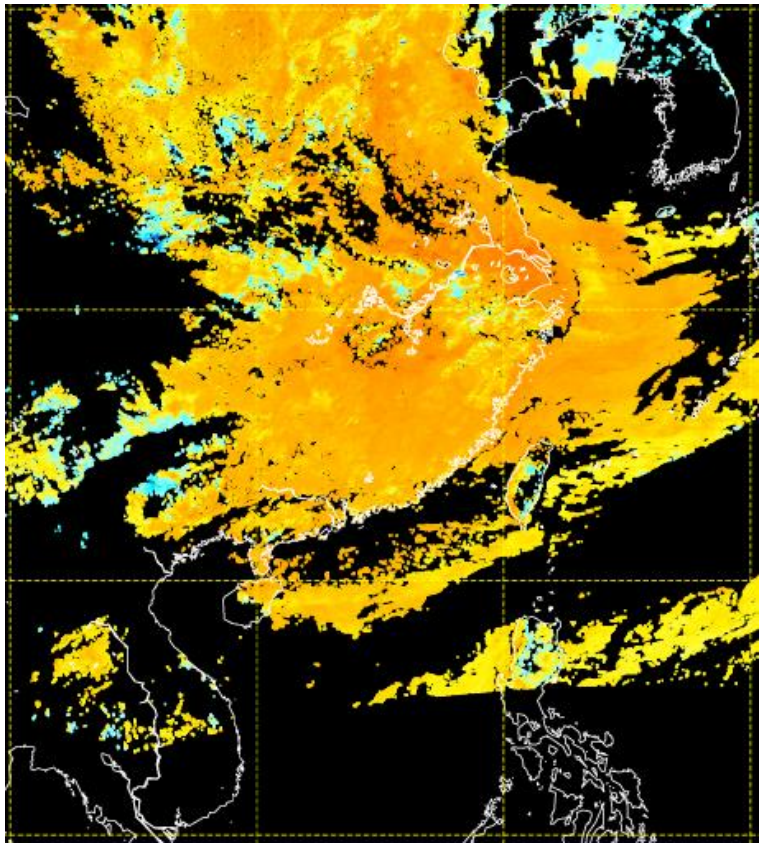
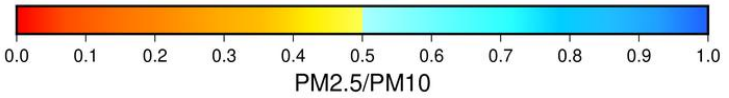




PM10





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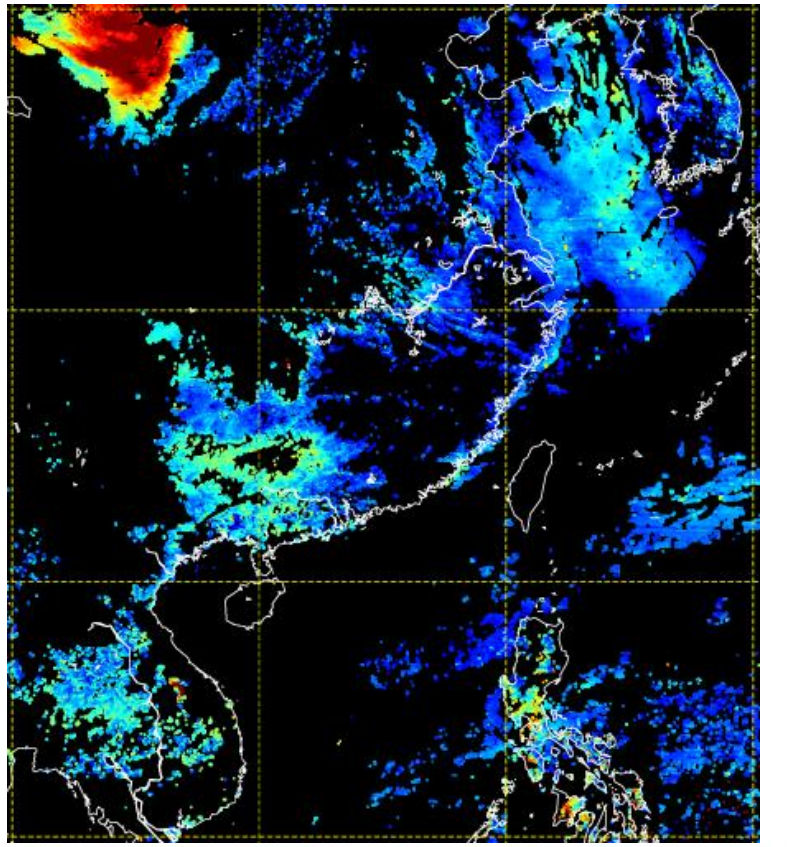
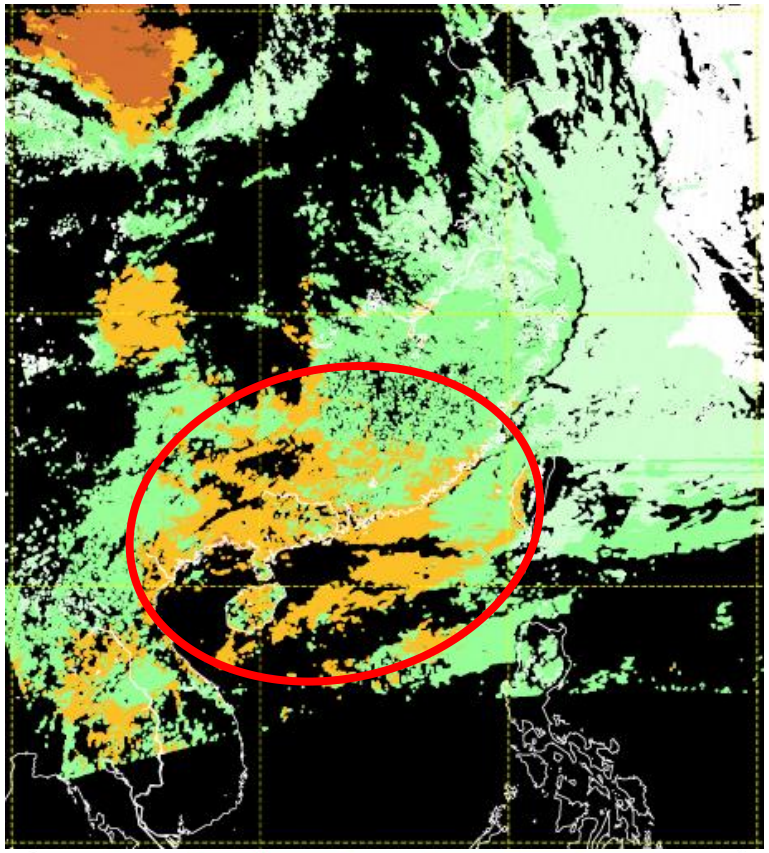
CASE 2: SAND/DUST

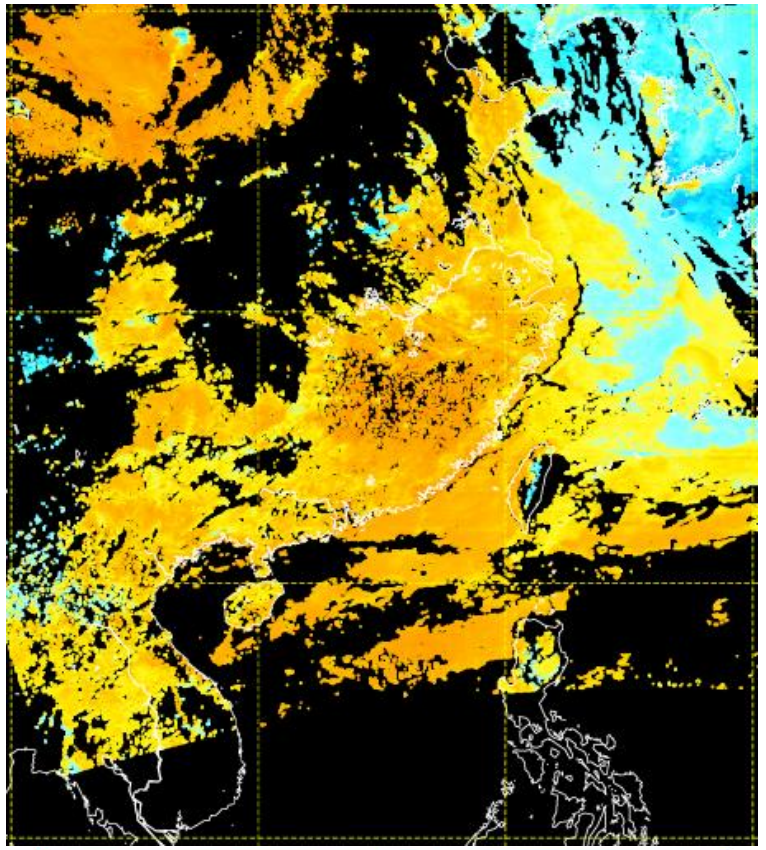
GK2B GEMS OBSERVATIONS (0745UTC, 15 APRIL 2025)



(550nm)



PM10



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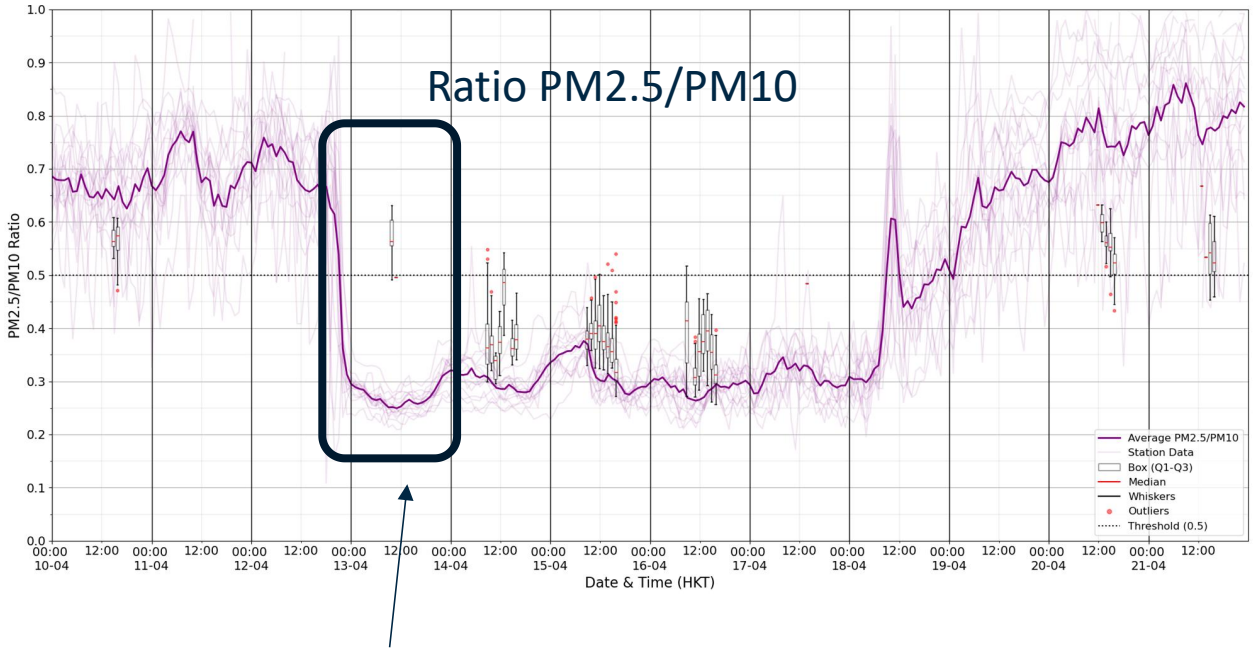
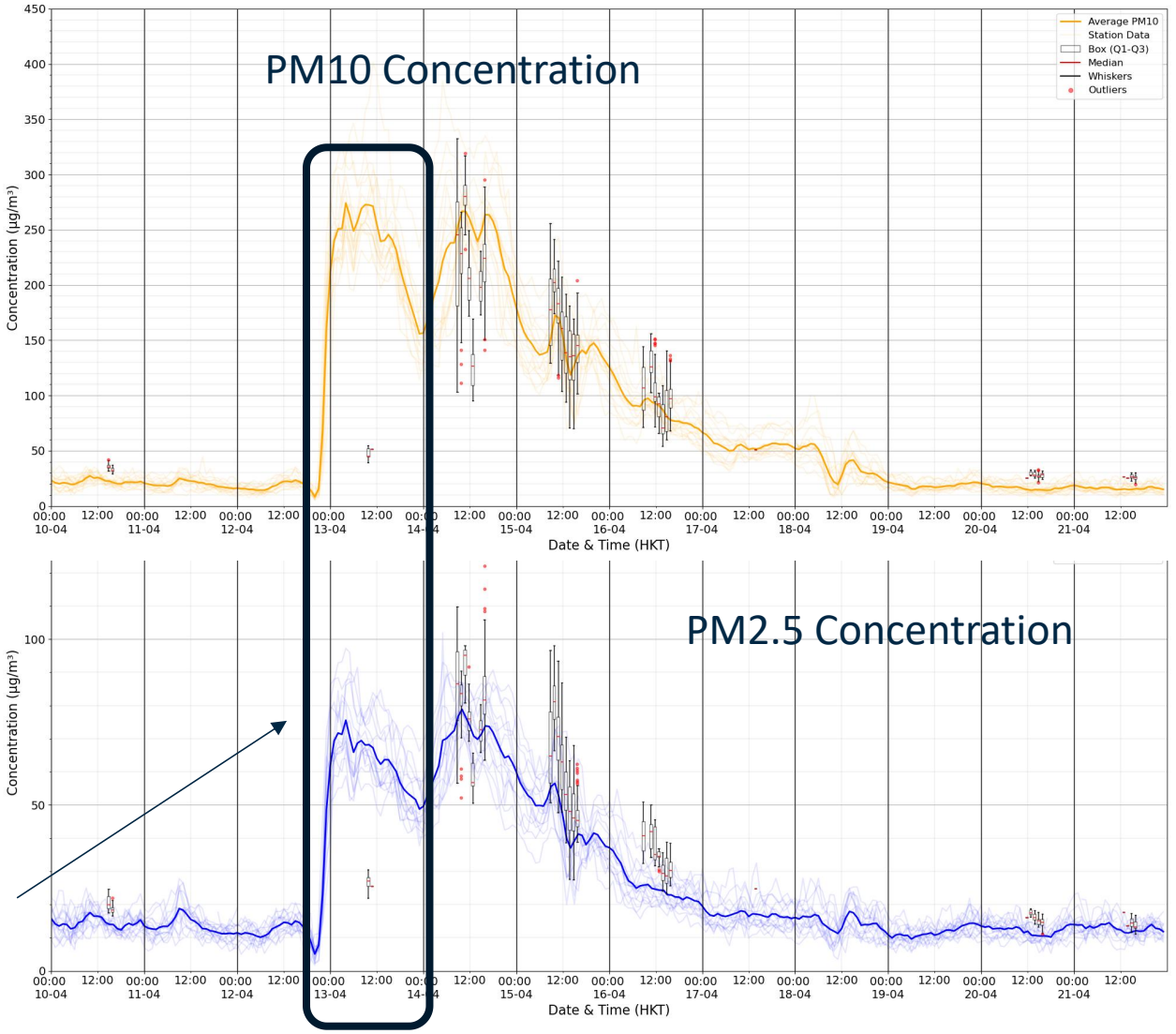
CASE 2: MID APRIL 2025

GK2B GEMS V.S. GROUND STATIONS





Observation data was on low side or missing during the episode
Perhaps recalibration of algorithm was being handled

Box-Whiskers plots: GK2B GEMS data around Hong Kong
Lines: General Air Quality Monitoring Stations (Thick line shows the mean)
The data matches with each other well

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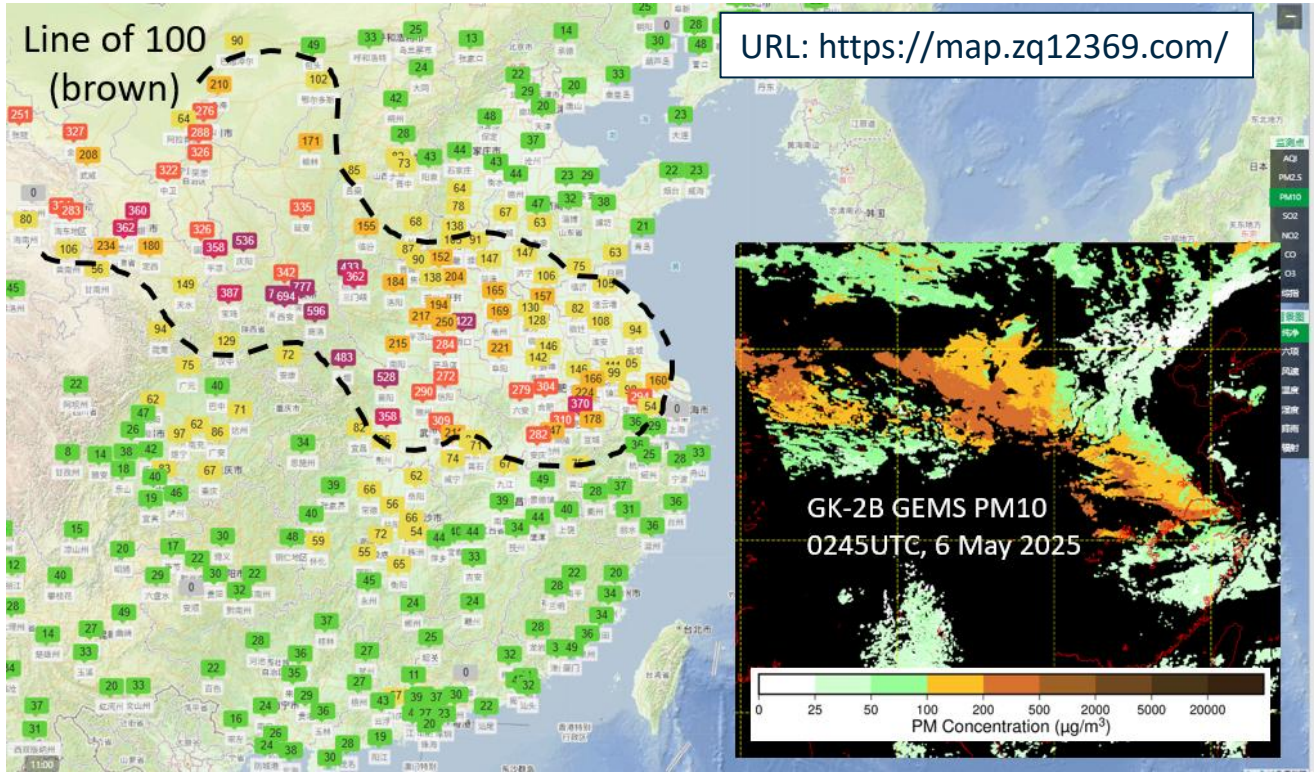
CONCLUSIONS

GK2B GEMS

- AOD signal clearer than conventional GEO satellite products
- Hourly update of data during daytime (win LEO)
- Extensive observation domain (win LEO)
- Directly support environmental monitoring, e.g. compare L4 products (Surface concentration of PM10 and PM2.5) with ground measurement
- Forecasters do not need to mentally convert the high AOD into surface visibility issue.



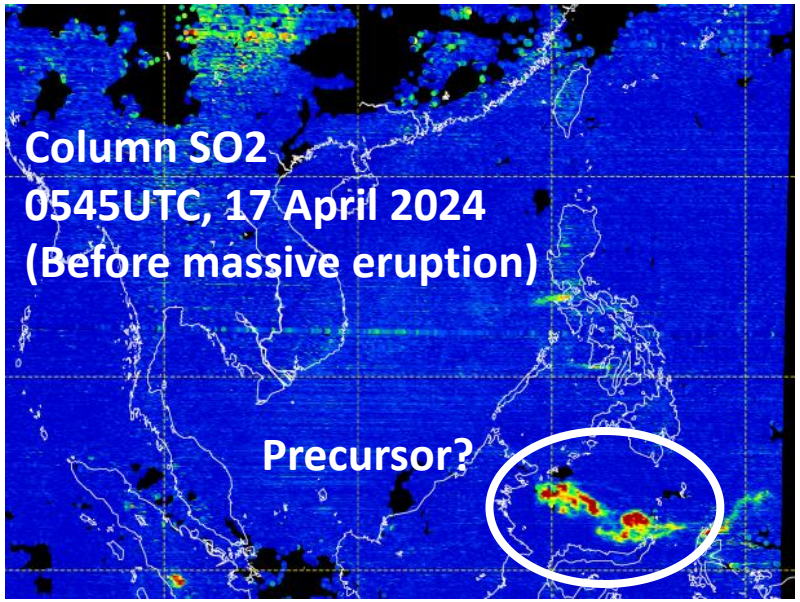
Comparison between GK2B GEMS and Ground stations

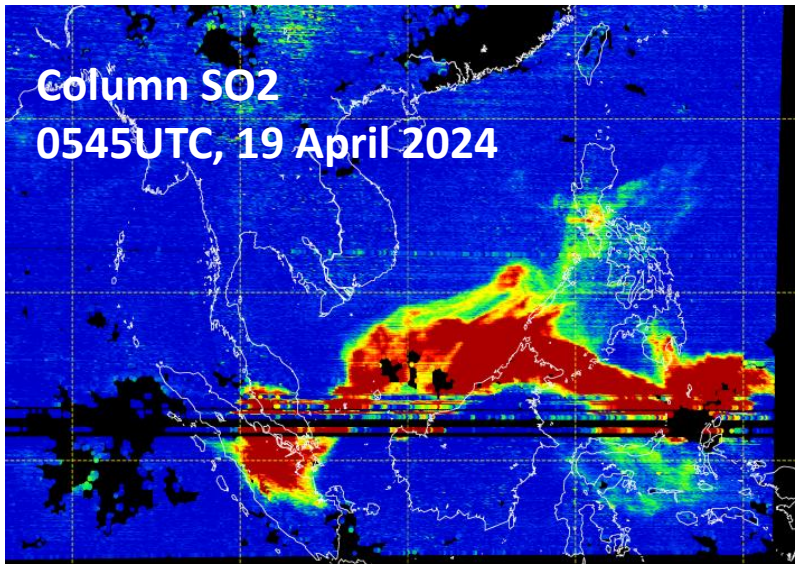
POTENTIAL APPLICATIONS

- Monitoring of volcano activities
- Support aviation community (like the spread of SO2)

Mount Ruang spewed lava and and ash on April 17, seen from Sitaro, North Sulawesi. It also triggered lightning in the ash cloud -- a common phenomenon in powerful volcano eruptions. Center for Volcanology and Geological Hazard Mitigation/AFP/Getty Images

Eruption of Ruang volcano of Indonesia (Night on 17 April 2024)
https://edition.cnn.com/2024/04/23/climate/indonesia-volcano-eruption-weather-impact/index.html

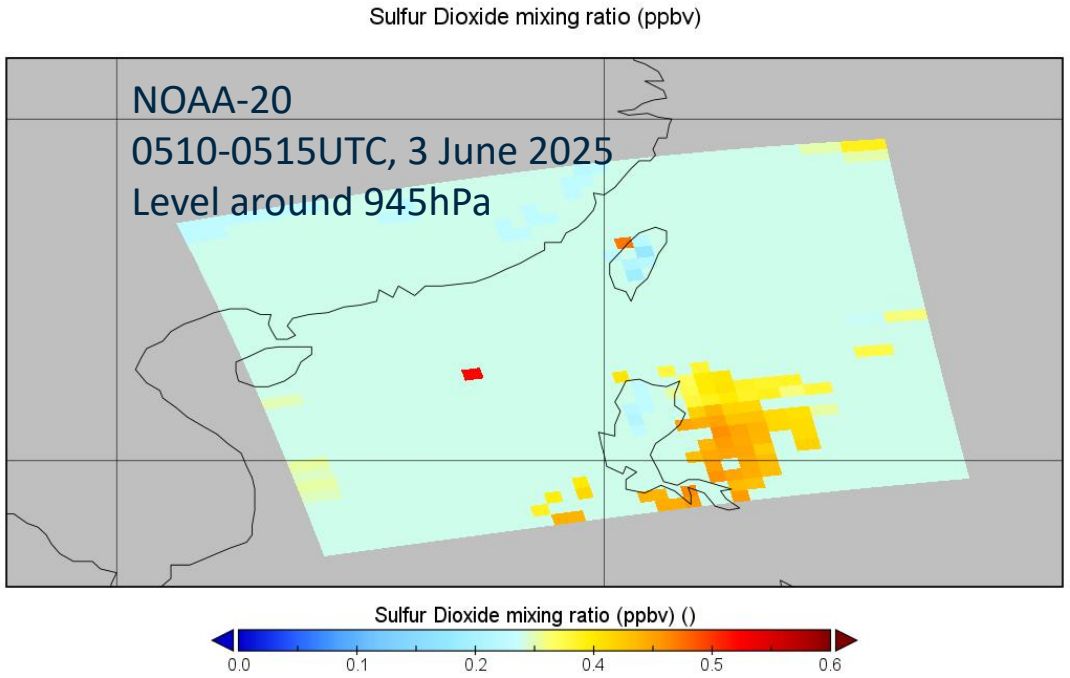




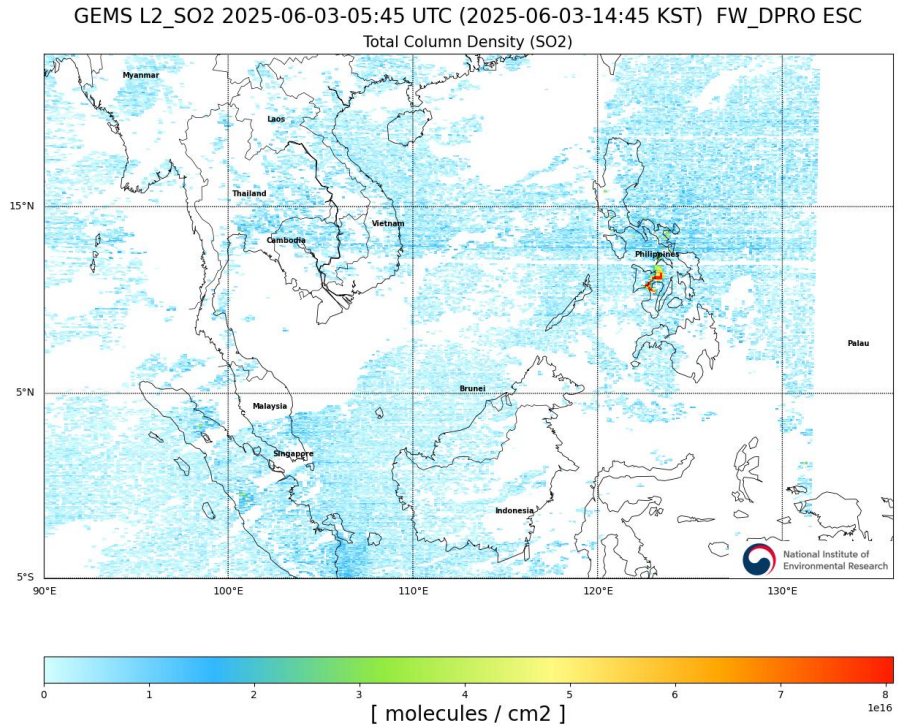
POTENTIAL APPLICATIONS

- Together with information derived from polar-orbiting satellites, concentration of SO2 at **different altitude** could be provided as an aviation weather services.

Eruption of Kanlaon volcano of the Philippines (early-June 2025)



Processing result from satellite direct broadcast data



Column SO2
0545UTC, 3 June 2025

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