EarthCARE/MSI Level-2 Algorithms: Description and Synergistic Analysis Plan with MSI and CPR

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Introduction

- Clouds exert an important influence on the *water* and *energy* balances and process, thus, more observations are required for understanding of *cloud lifecycle*.
  - *e.g. Randall et al. (1984) pointed out that a mere 4% increase of the Earth's area covered by low-level clouds, compensates for a projected 2–3 K rise in global temperature due to a doubling of* CO_2.

- We have long history of the passive sensing of clouds, using the NOAA, ADEOS-2, TRMM, Terra/Aqua, GCOM-C, and Geostationary satellites …

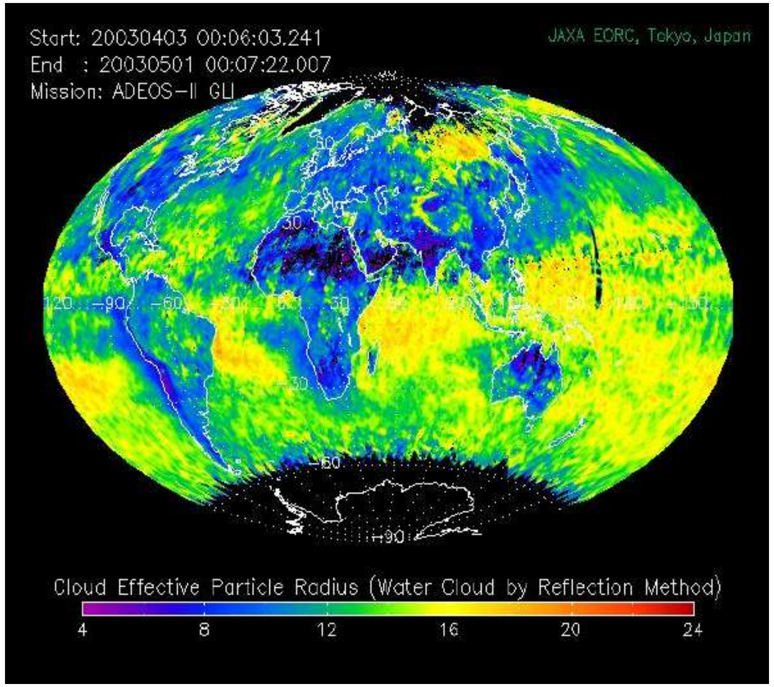
- Recently, active sensing open the door toward better understanding of clouds, in terms of cloud evolution process.

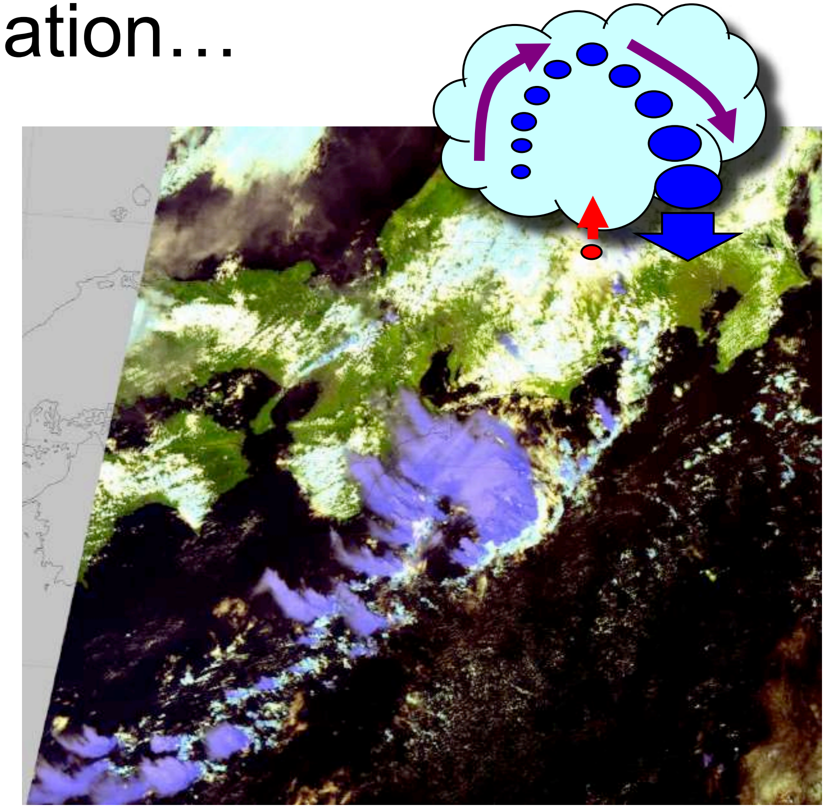
Directions of the cloud research

- Long term record → climate change study

  AVHRR, MODIS, VIIRS, GLI, SGLI, Geostationary…
- 3-D observation → cloud evolution process

  CloudSat, Calipso, EarthCARE, + Passive sensors
- Observation + Model simulation…





Strategy of cloud observation

GCOM-C 2017-

Satellite Observations

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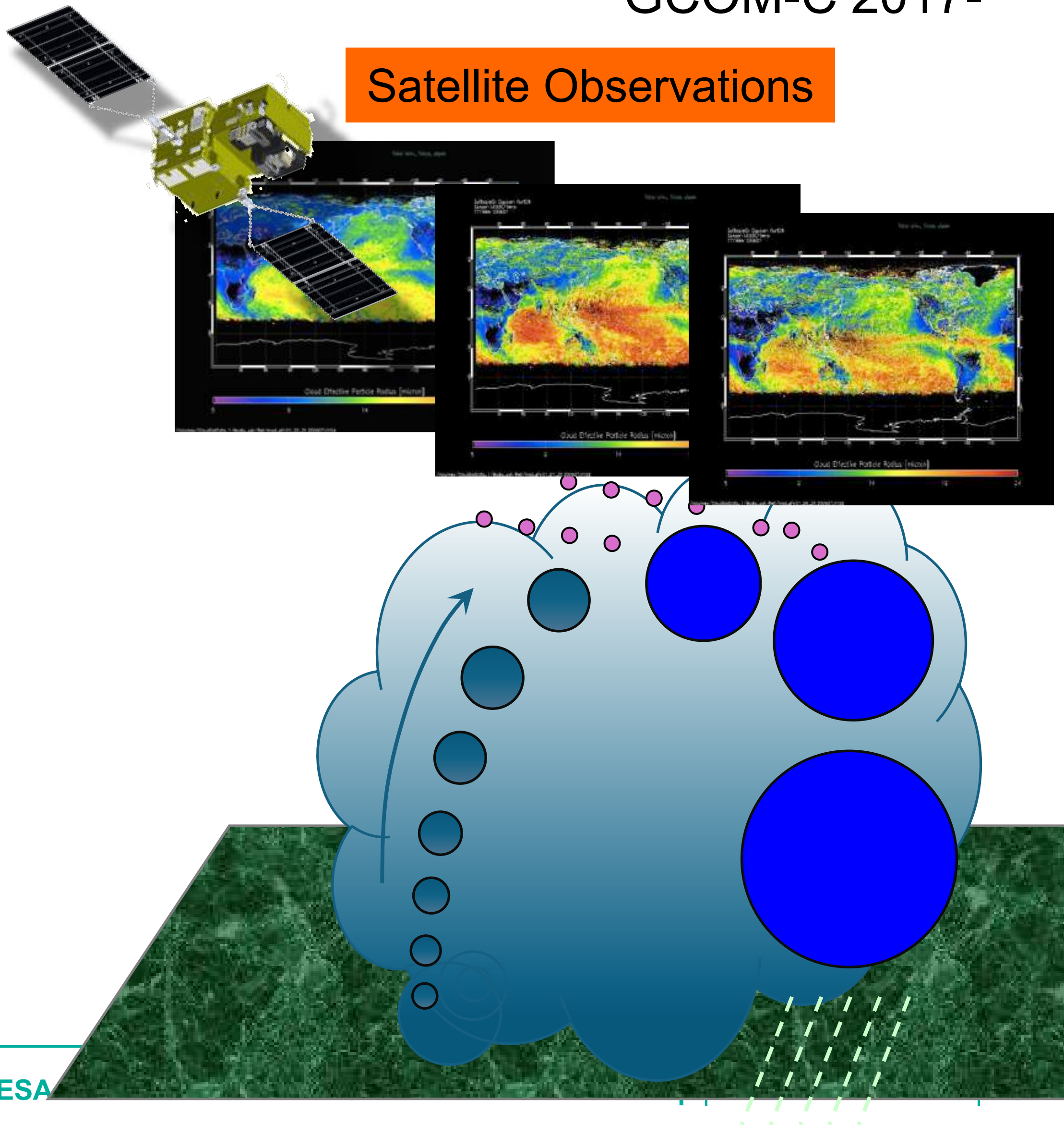
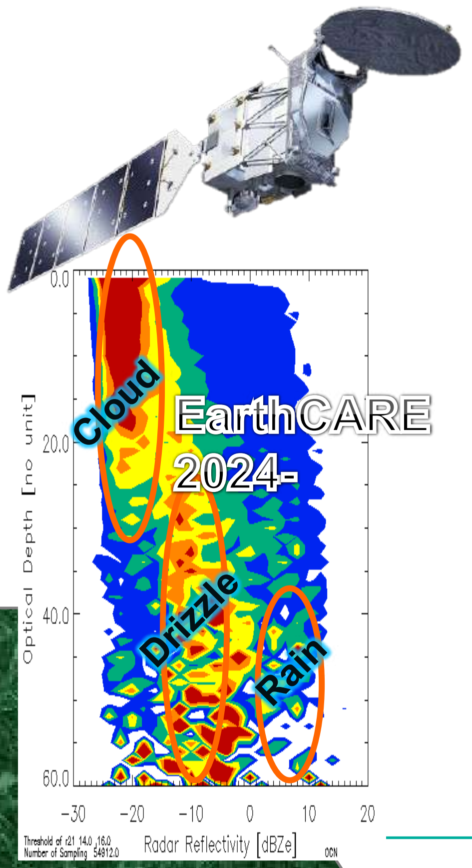
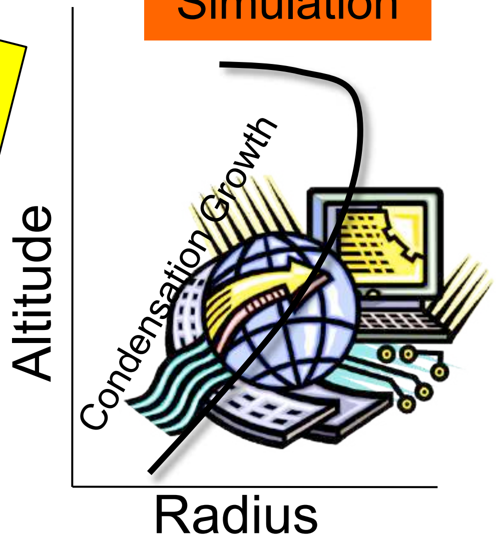
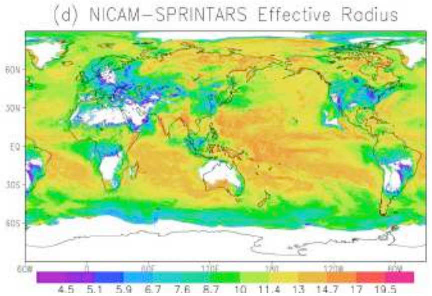




Bin-method Simulation



Comparison between Satellite vs Models.



MSI, Cloud product process

MSI/L1 data

↓

Calculate the cloud flag and Cloud phase using **CLAUDIA**

↓

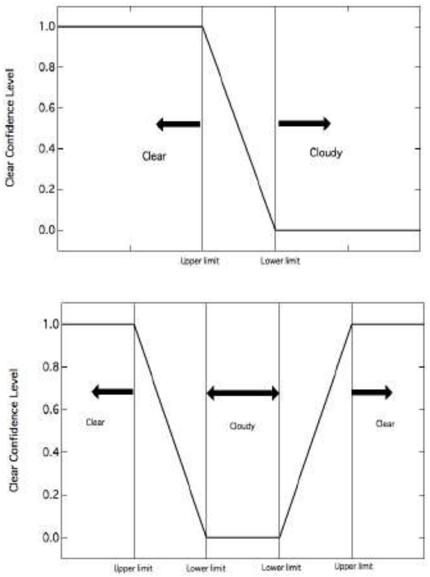
Day Water	**Day Ice**
Calculate the COT, CDR, CTT using the 3ch method of **CAPCOM**	Calculate the COT, CDR CTT, using the 3ch method of **CAPCOM**
↓	↓
COT, CDR, CTT	COT, CDR, CTT

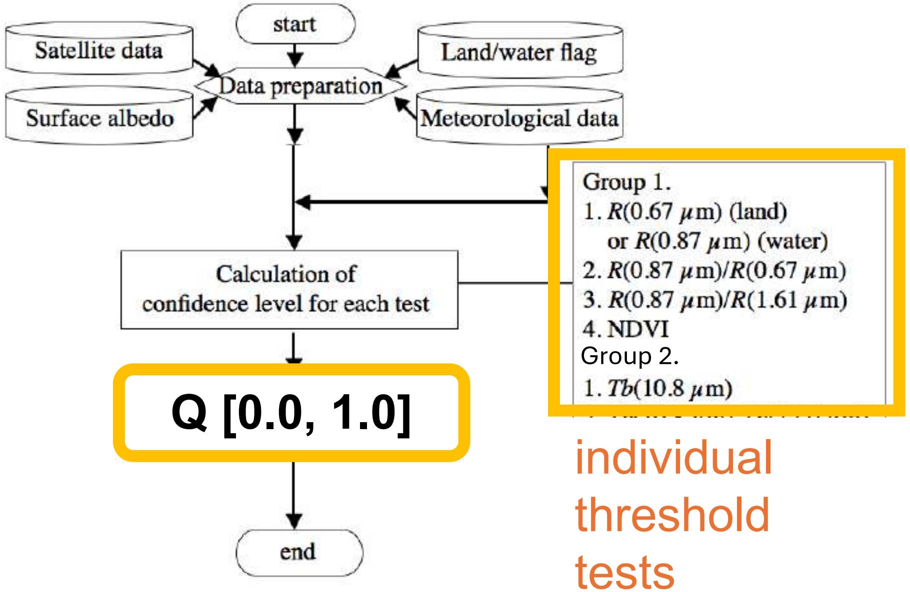
CLAUDIA algorithm (for cloud flags)

- 5 individual threshold tests
- Merge into a Clear Confidence Level (CCL) **Q [<u>0.0</u>, <u>1.0</u>]**

Cloudy

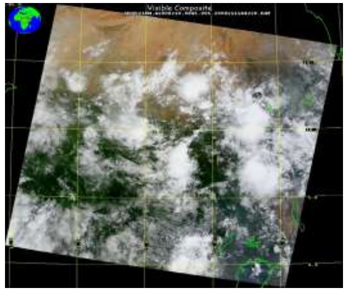
Clear

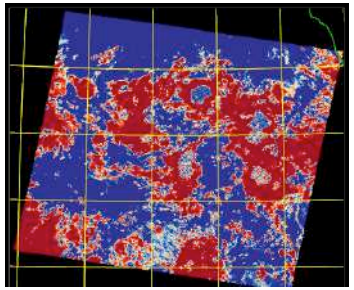




individual threshold tests

- A similar concept with the MODIS standard algorithm (MOD06) but designed for a neutral decision, less bias to cloudy or clear.
- Used for GCOM-C/SGLI, Himawari/AHI and the EarthCARE/MSI

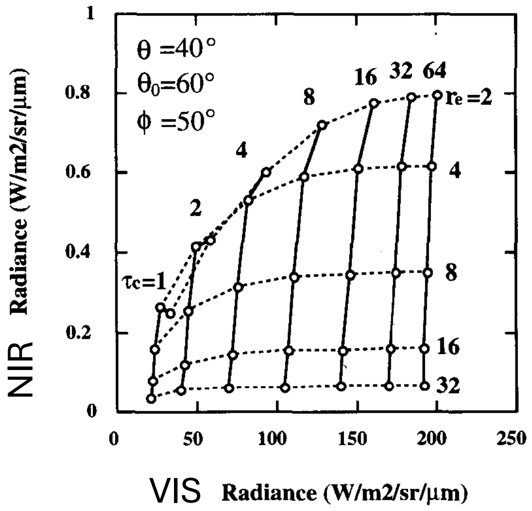




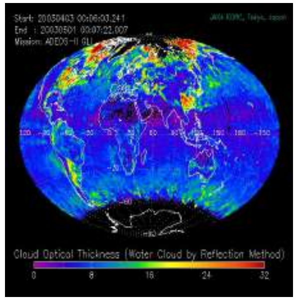
Ishida, H., and T. Y. Nakajima, 2009: Development of an unbiased cloud detection algorithm for a spaceborne multispectral imager. Journal of Geophysical Research-Atmospheres, 114, doi:10.1029/2008JD010710.
Nakajima, T. Y., T. Tsuchiya, H. Ishida, and H. Shimoda, 2011: Cloud detection performance of spaceborne visible-to-infrared multispectral imagers. Applied Optics, 50, 2601-2616

CAPCOM algorithm (for cloud properties)

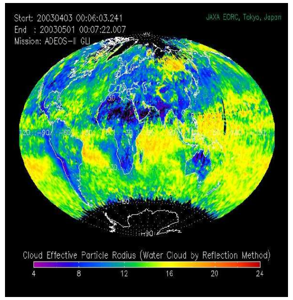
- Based on the Nakajima-King diagram (VIS band, NIR band)
- Newton method for finding the best solution
- Used for Midori-II/GLI, GCOM-C/SGLI, TANSO/CAI, Himawari/AHI and the EarthCARE/MSI

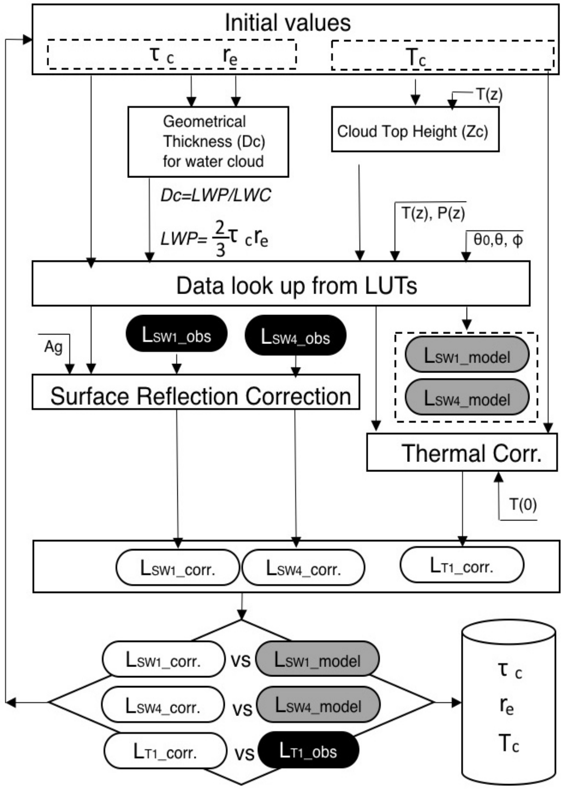


COT



CDR



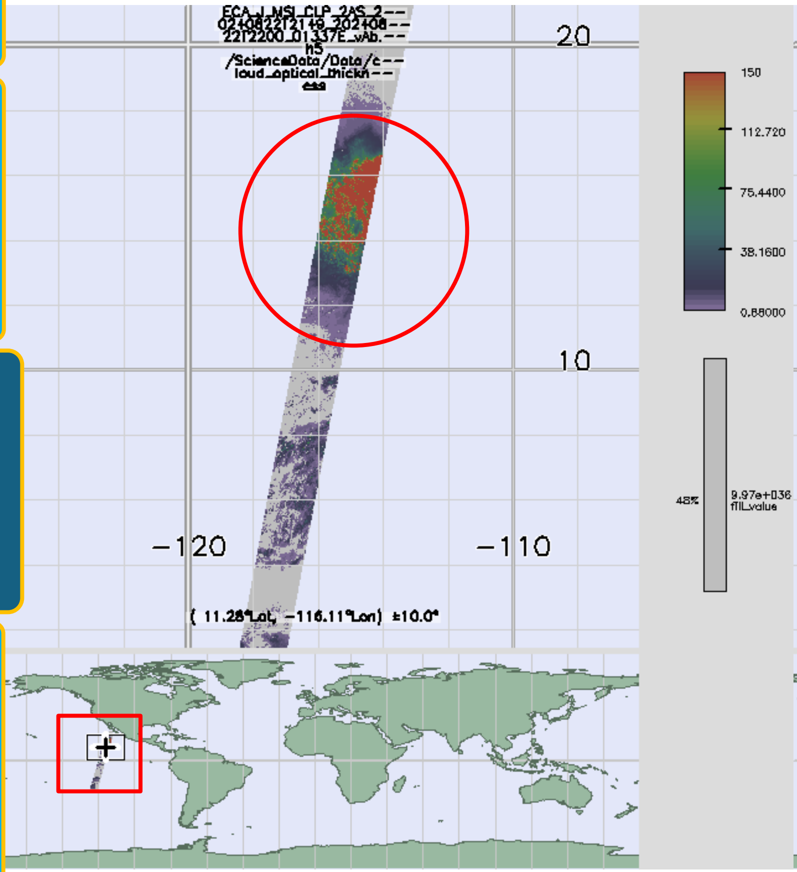


- Retrieval accuracy (by simulation)

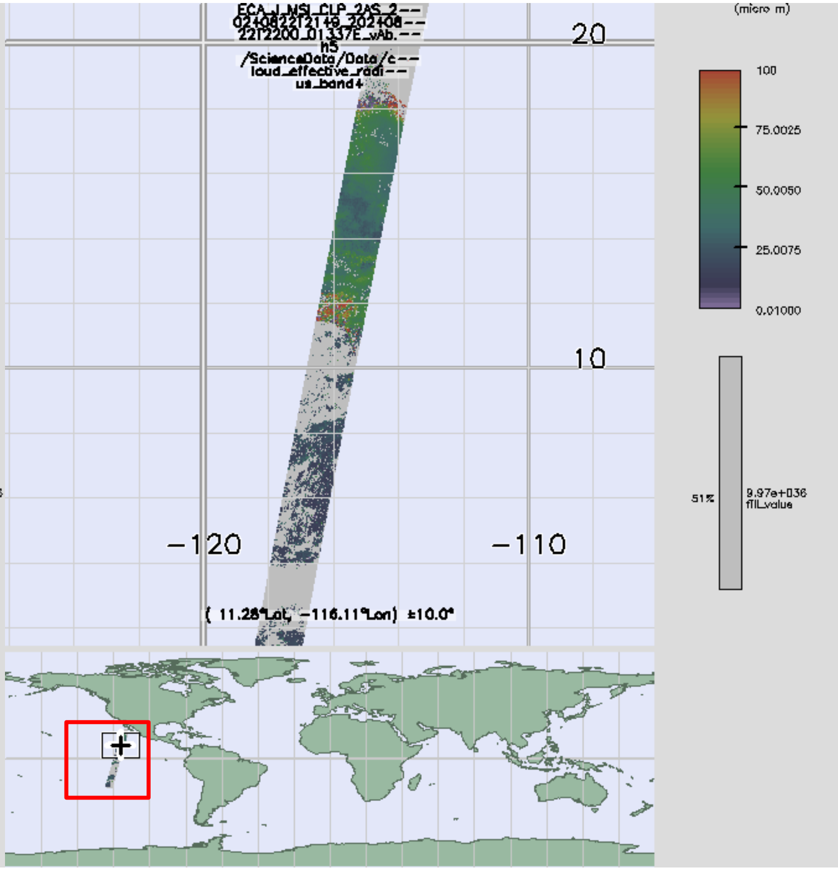
Less than 1 % and 3 % for COT and CDR when COT=16, CDR=16µm.

Nakajima, T. Y., and T. Nakajima, 1995: Wide-area determination of cloud microphysical properties from NOAA AVHRR measurements for FIRE and ASTEX regions. Journal of the Atmospheric Sciences, 52, 4043-4059.
Kawamoto, K., T. Nakajima, and T. Y. Nakajima, 2001: A global determination of cloud microphysics with AVHRR remote sensing. Journal of Climate, 14, 2054-2068.

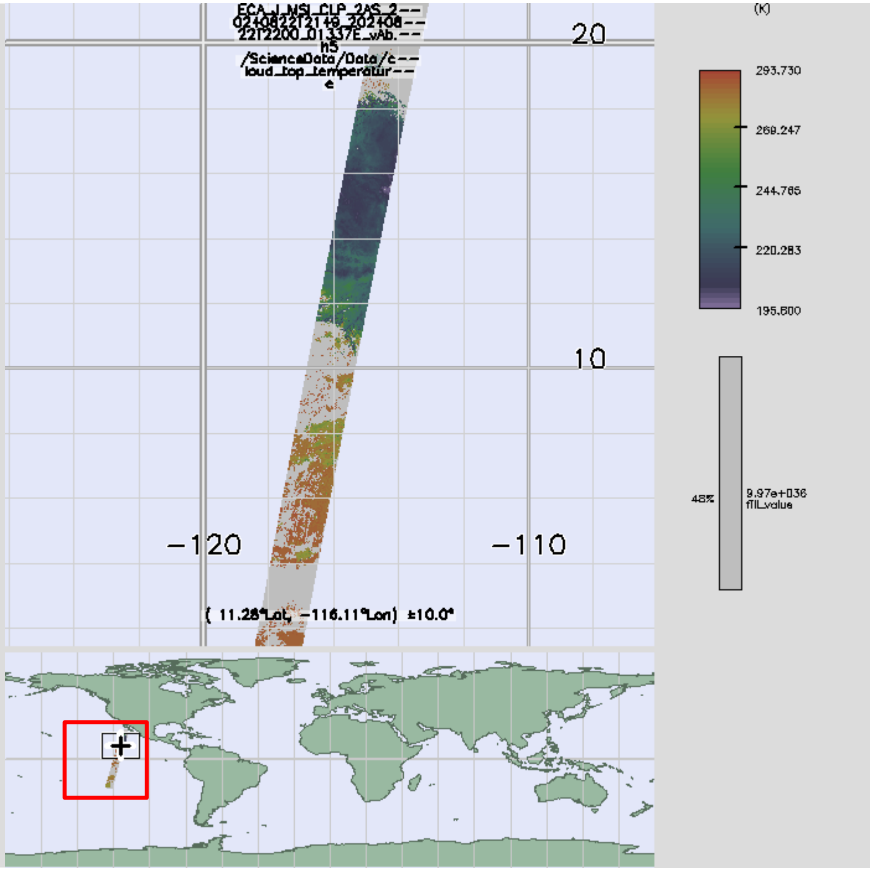
MSI L2a Cloud Product



Cloud Optical Thickness (COT)



Cloud Droplet Radius (CDR) (band4=2.2μm)

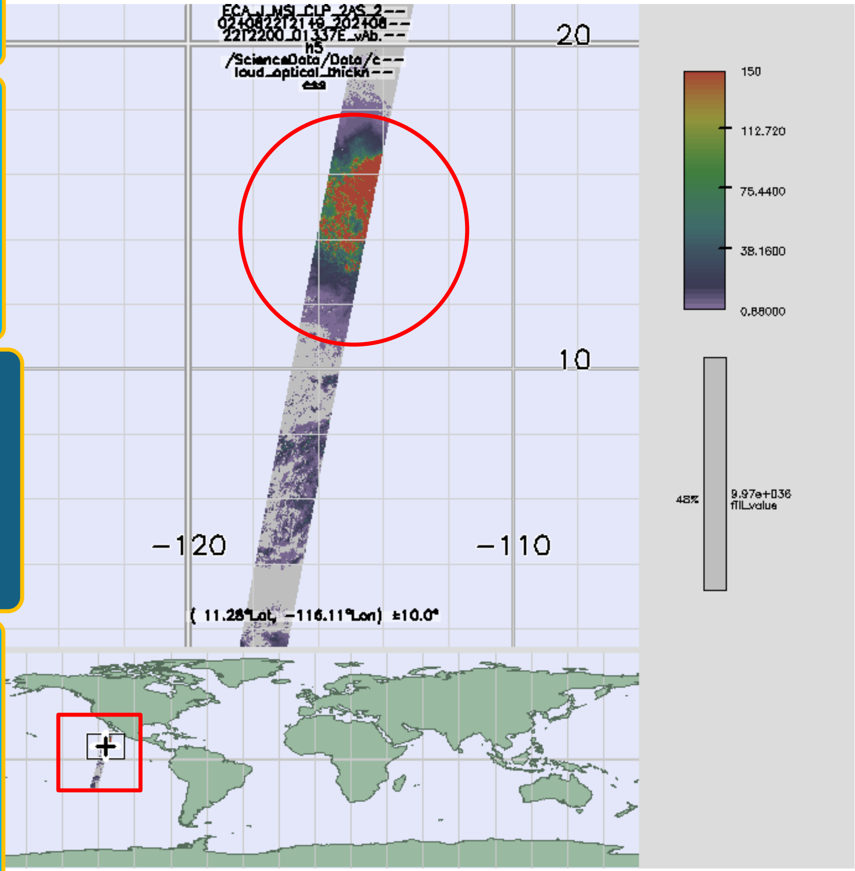


Cloud Top Temperature (CTT)

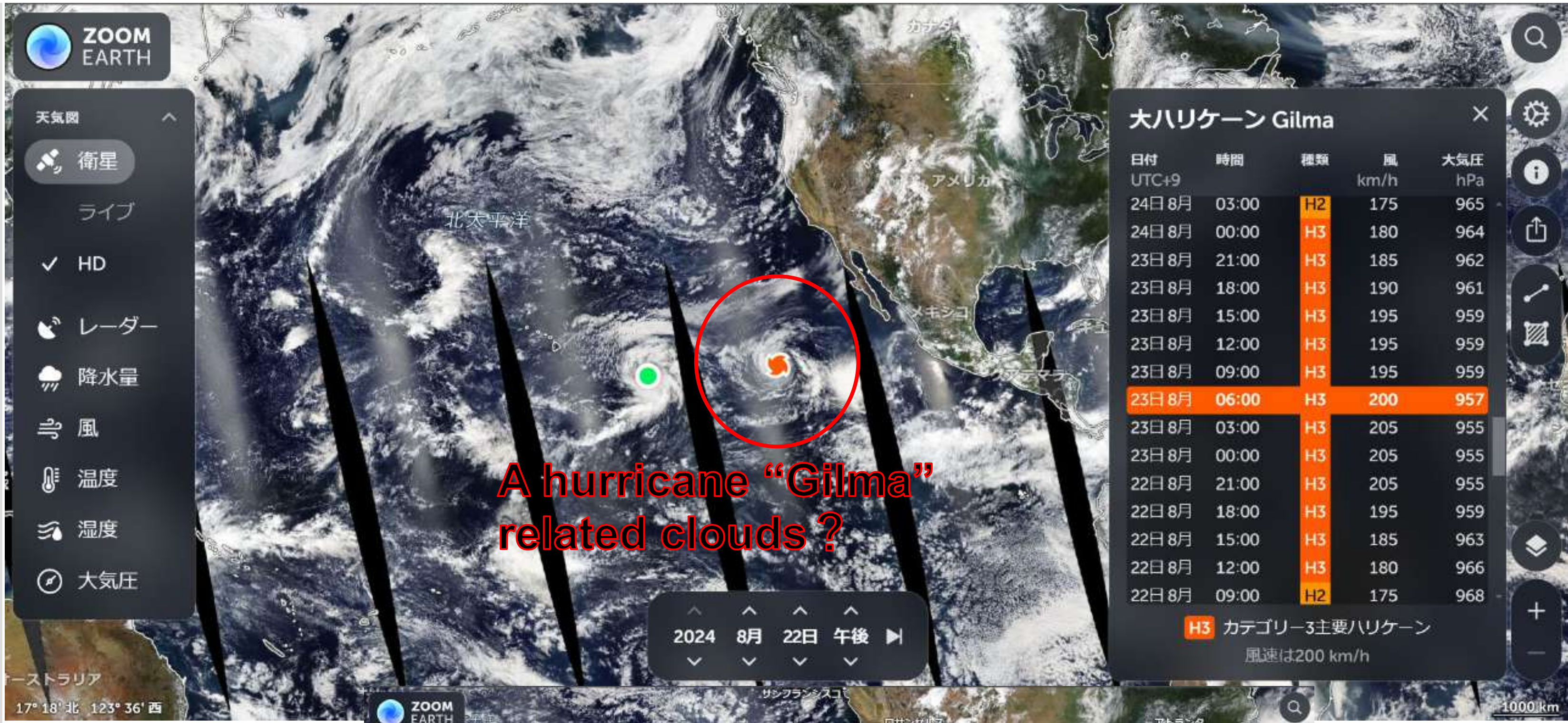
A Real MSI Data 21:49-22:00（UTC）, Aug. 22, 2024

ECA_J_MSI_CLP_2AS_20240822T2149_20240822T2200_01337E_vAb.h5

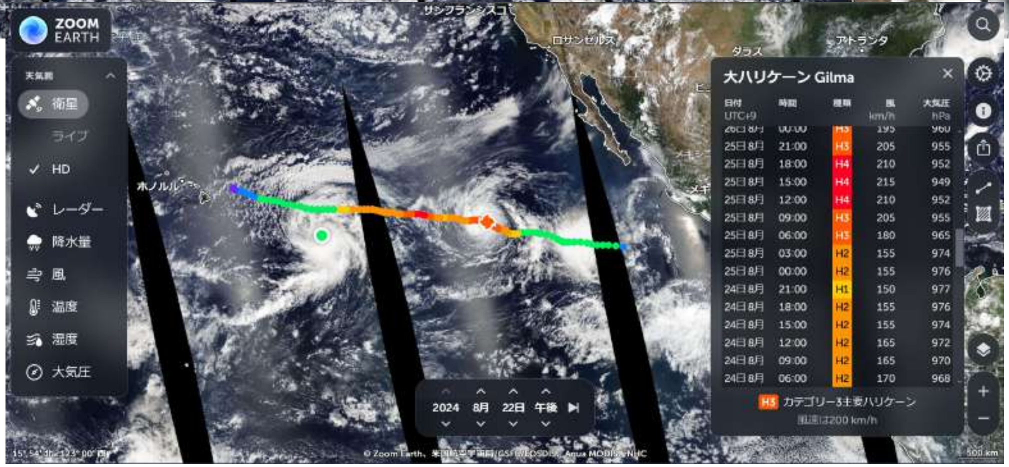
MSI L2a Cloud Product



Cloud Optical Thickness (COT)

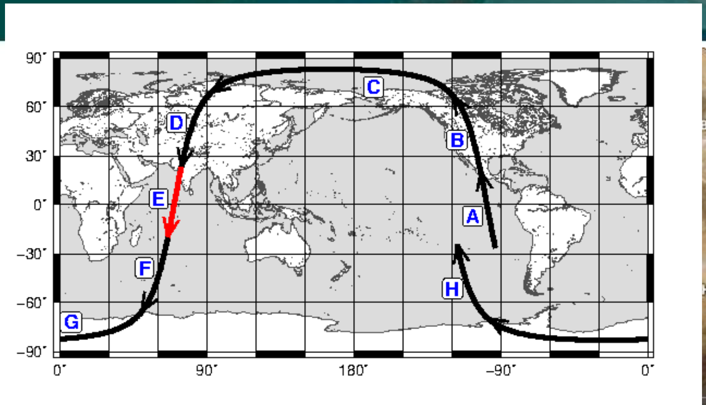


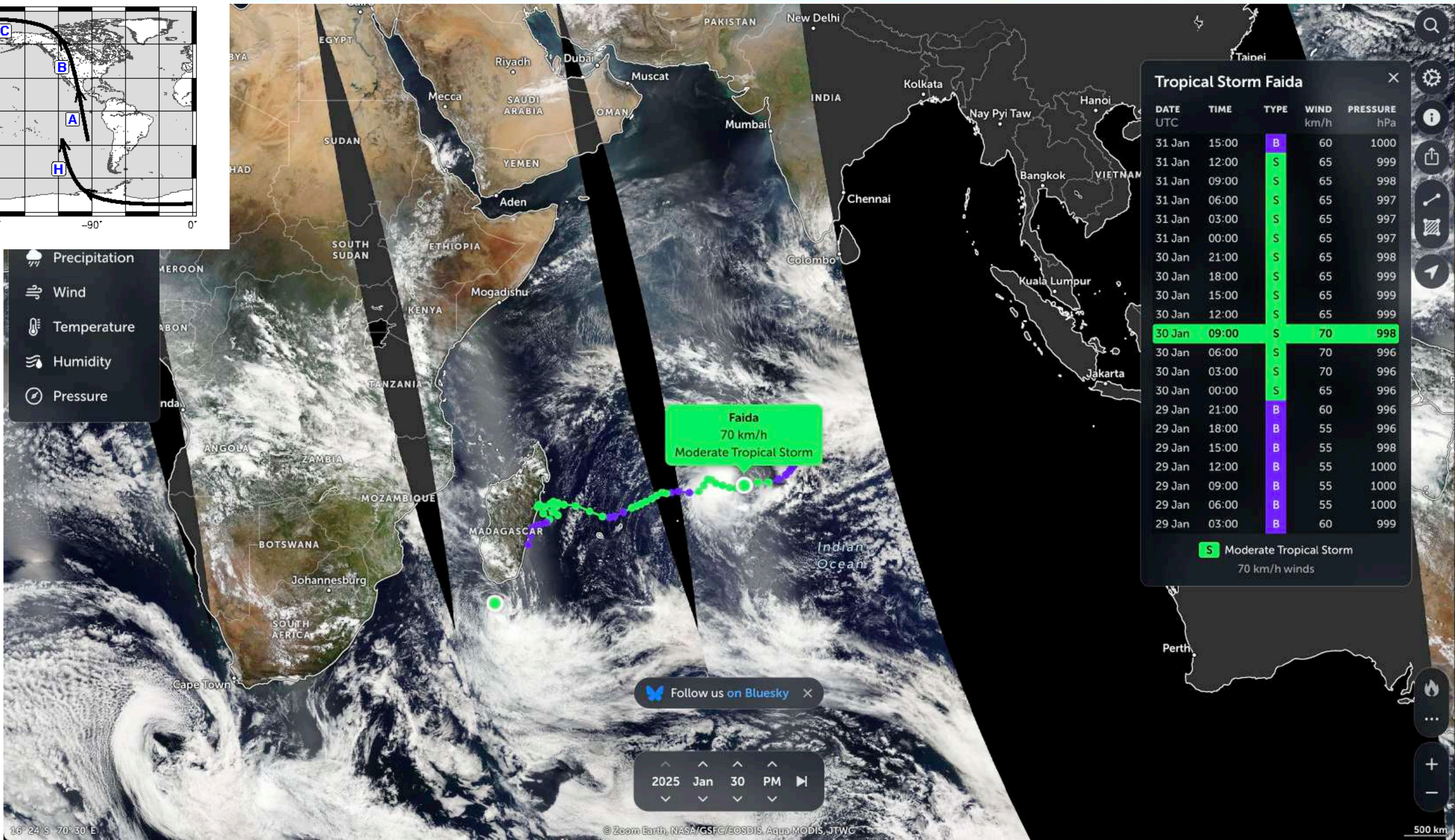
21:49-22:00（UTC）, Aug. 22, 2024



https://zoom.earth/storms/gilma-2024/

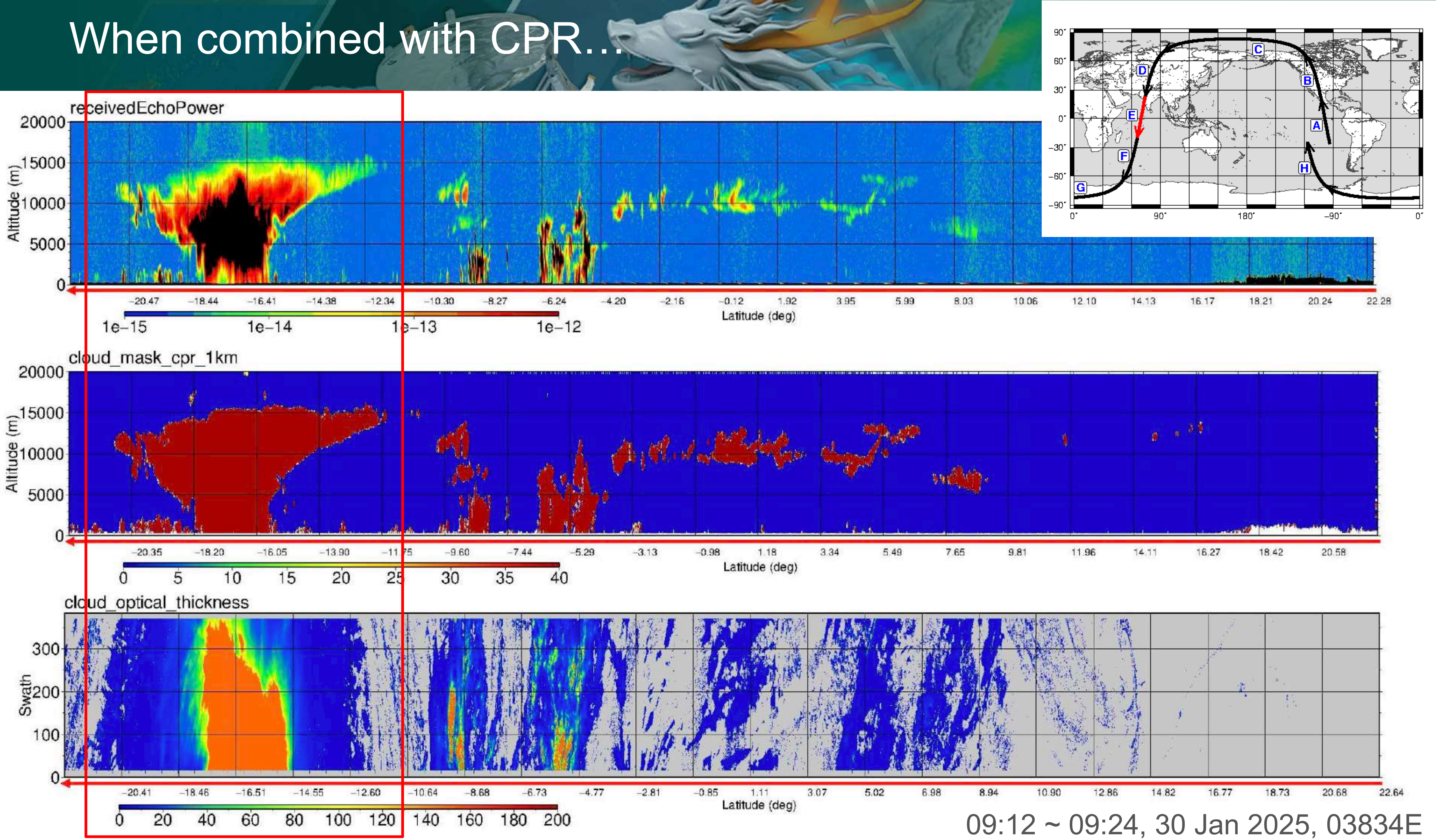
When combined with CPR…





https://zoom.earth/storms/faida-2025/

When combined with CPR…

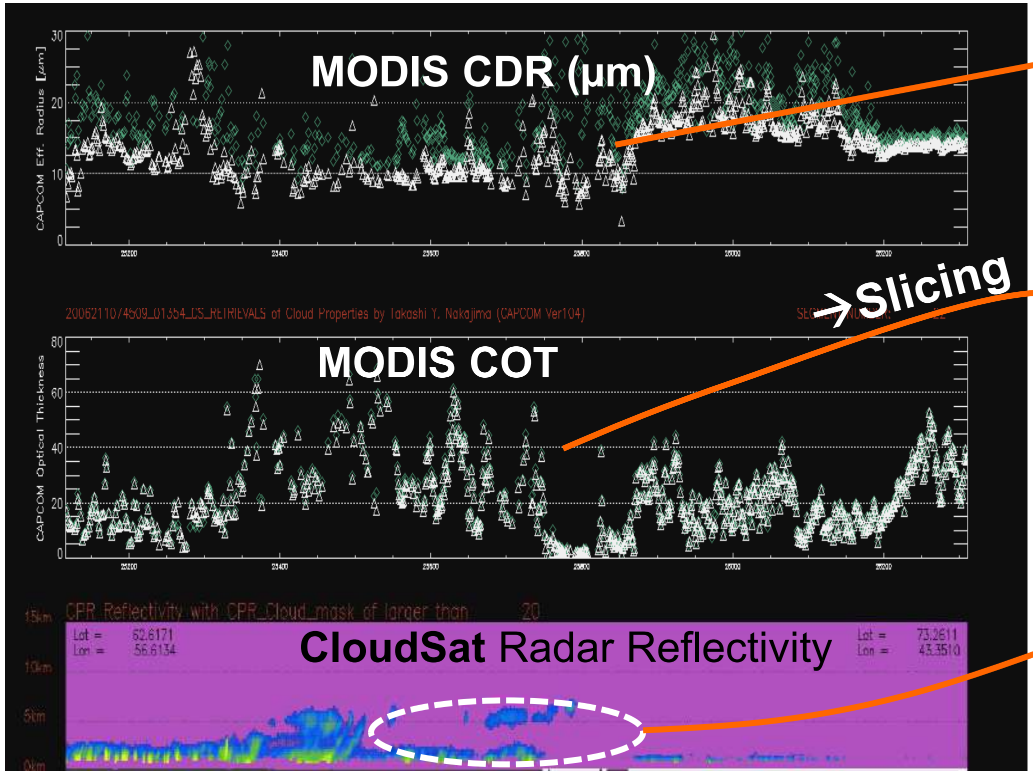


09:12 ~ 09:24, 30 Jan 2025, 03834E

To do in future

New visualization of the radar reflectivity, CFODD (Contoured Frequency by Optical Depth Diagram)

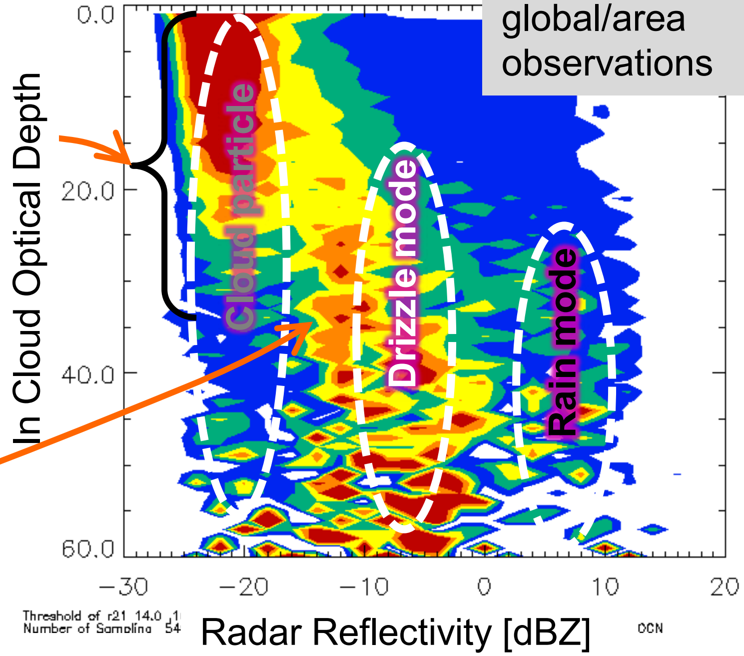
A-Train flight direction →



A case of,

14μm<CDR<16μm

Gathering global/area observations



Nakajima, T. Y., K. Suzuki, and G. L. Stephens, 2010: Droplet growth in warm water clouds observed by the A-Train. Part II: A Multi-sensor view. J. Atmos. Sci., 67, 1897-1907.

Introduction

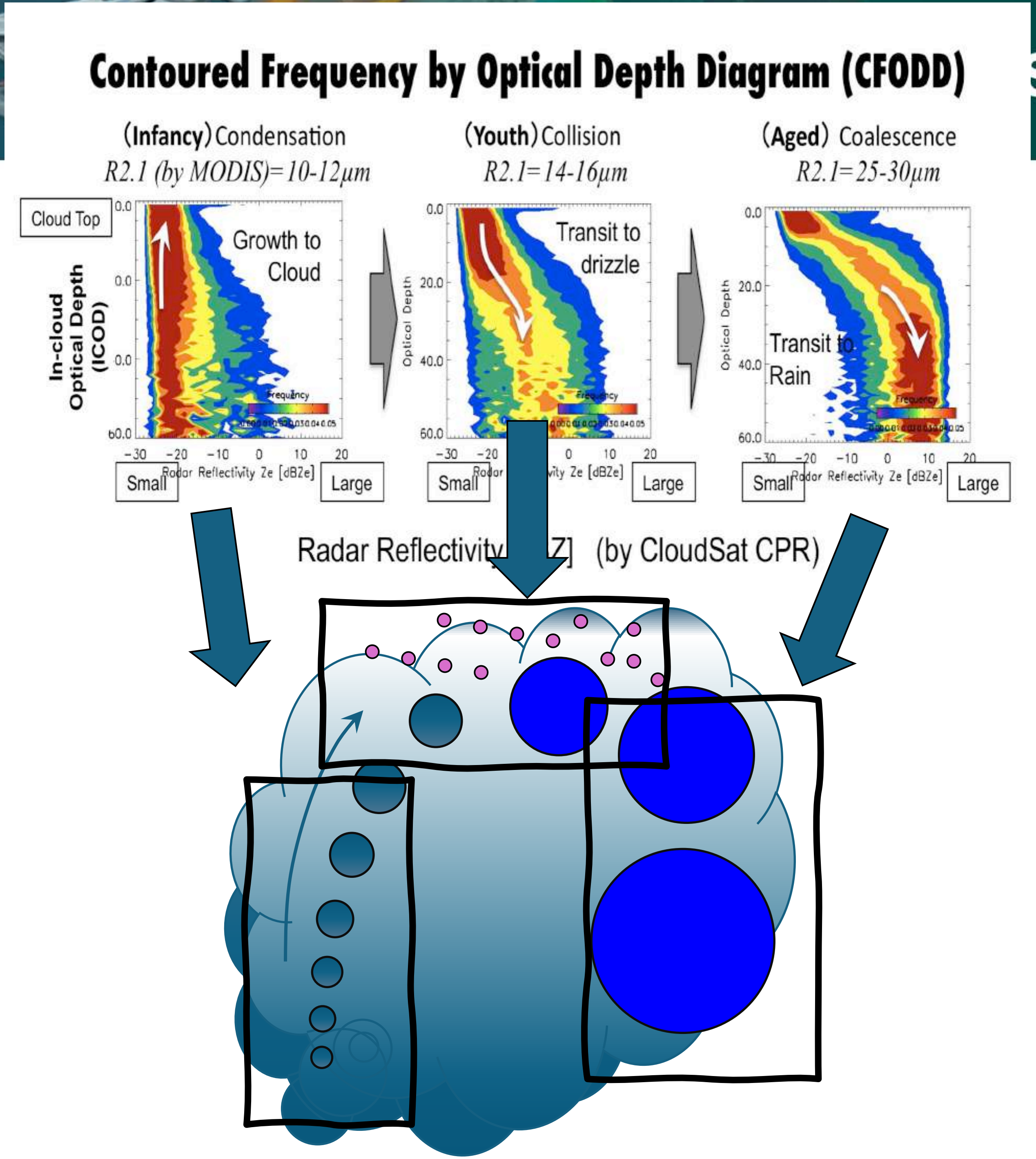
Strategy

Algorithm

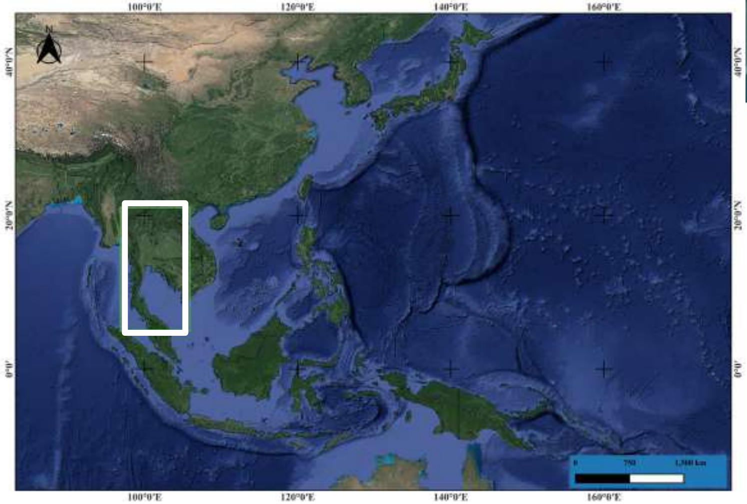
CFODD

Summary

Visualizing Cloud Evolution from space, CFODD



Difference of the CFODD in Thailand, La Niña and El Niño



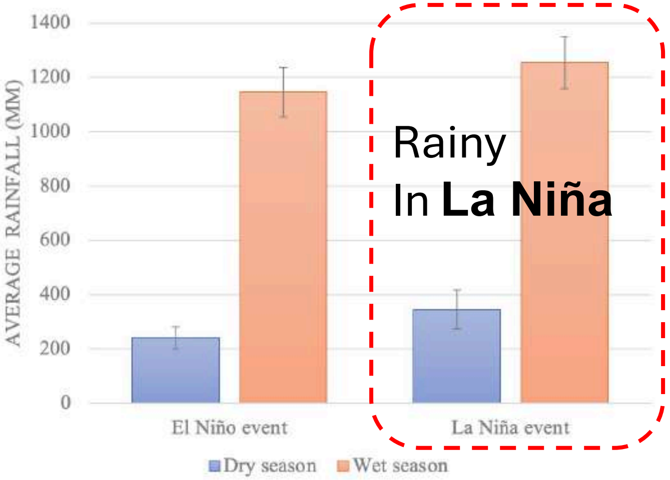


Fig. 3. Average rainfall divided into two distinct periods, dry season and wet season, each spanning 6 months. The error bars represent the variation in monthly rainfall within each period, influenced by ENSO phases from 1991 to 2022.

Panuwong Wongnim, Minrui Wang, and Takashi Y. Nakajima, 2024: Investigation of characteristics of warm clouds in Thailand under different climate patterns with contoured frequency by optical depth diagrams and ground-based meteorological data, *JMSJ*, **102**(6)

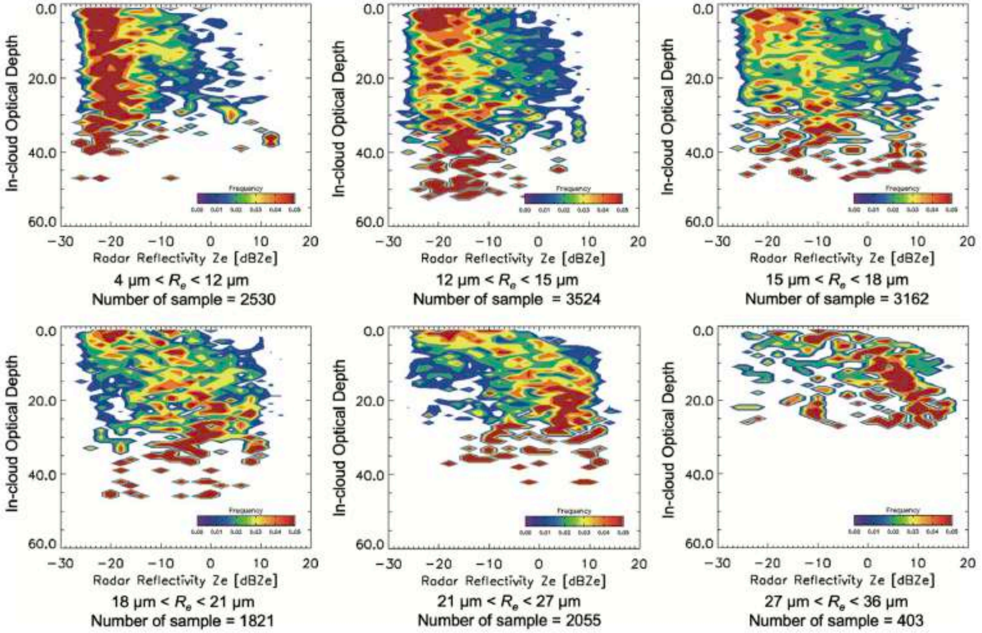


Fig. 9. CFODDs classified by R_e with threshold values between 4 μm and 36 μm for Thailand under El Niño phase.

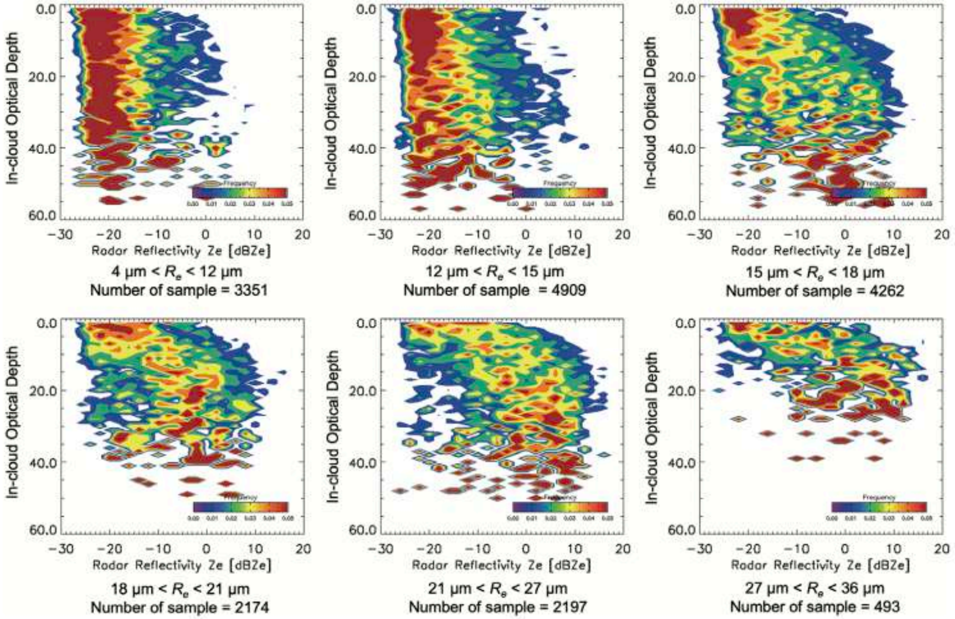


Fig. 8. CFODDs classified by R_e with threshold values between 4 μm and 36 μm for Thailand under La Niña phase.

During **El Niño** event (=less rain)

During **La Niña** event (=rainy)

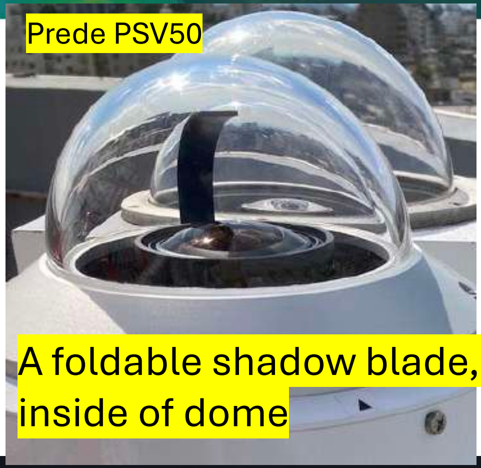
Summary

JAXA esa

- ☐ Clouds exert an important influence on the *water* and *energy* balances and process; thus, more observations are required for understanding of *cloud lifecycle*.
- ☐ Need more observations of clouds from satellites for
  - generating cloud climatology database
  - investigating cloud evolution process
- ☐ The CFODD presents
  - cloud evolution process, clearly.
  - useful for model evaluations.

  Need data longer than 1-2 years for generating the CFODDs.
- ☐ A Doppler capability of the EarthCARE/CPR improves our understanding of cloud evolution process.
- ☐Validation of MSI cloud products have started. More efforts are needed.

A New SkyCamera system at Shibuya Campus



Thanks for your attention