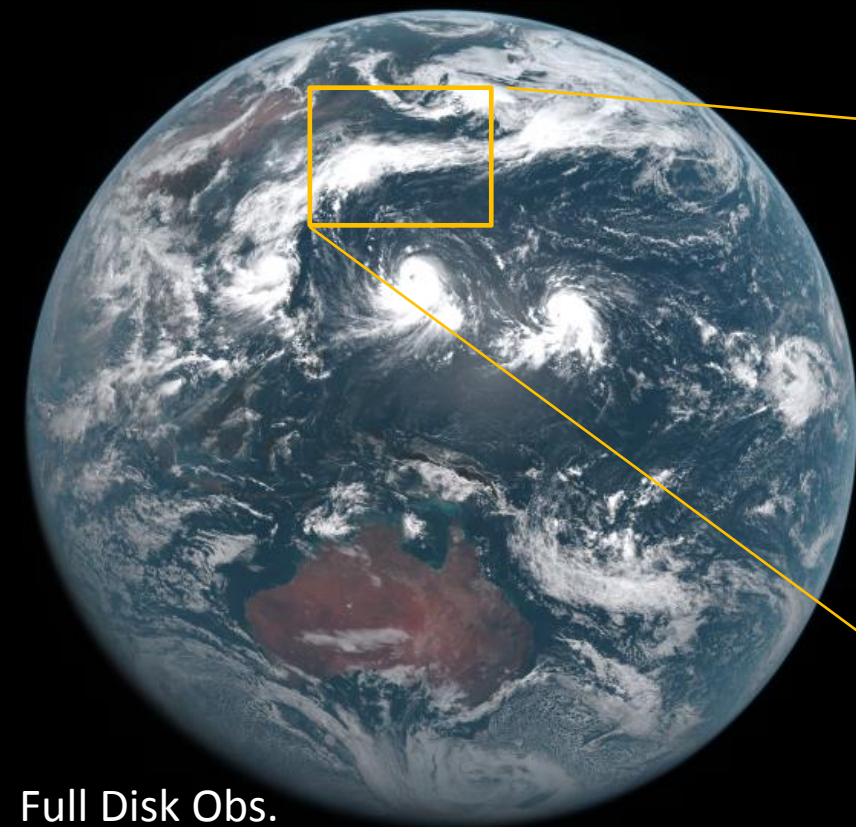
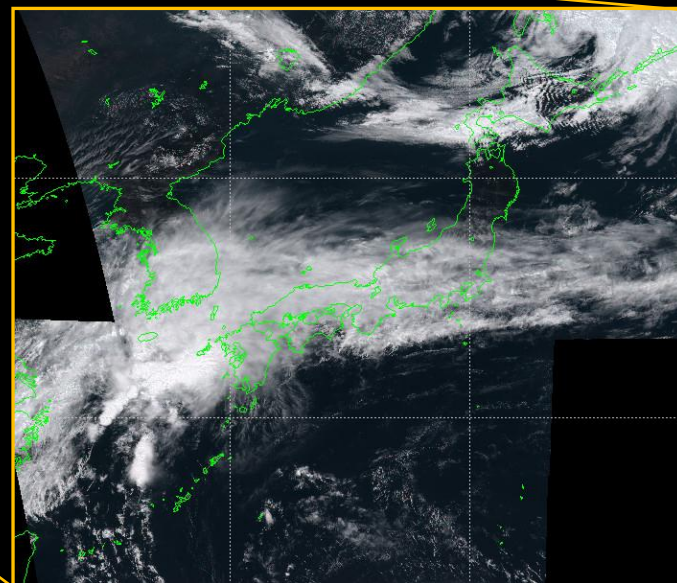


Detection of rapidly developing cumulus areas from Himawari-8 data



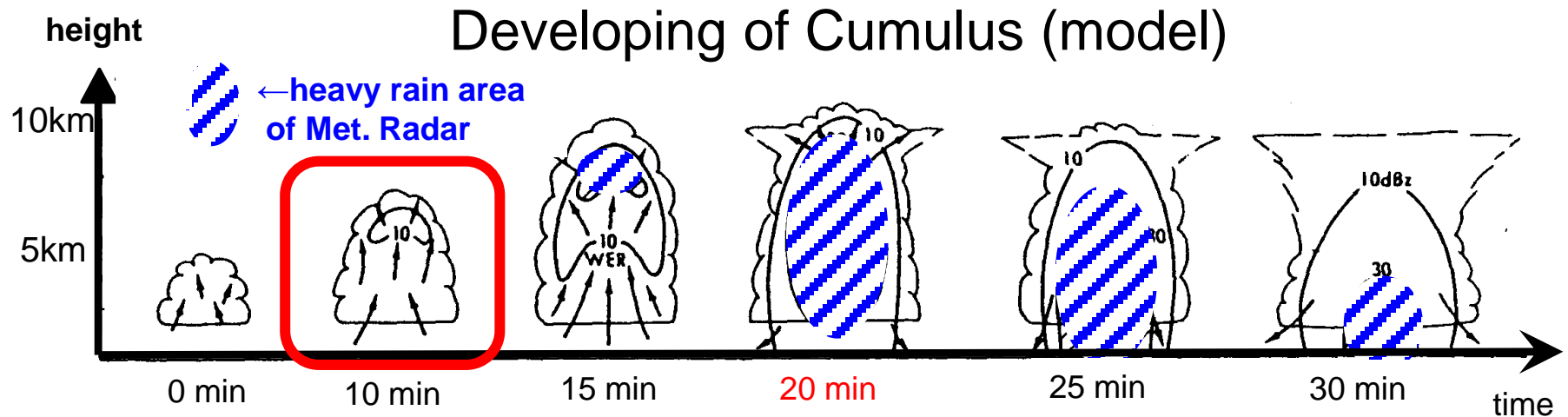
Full Disk Obs.



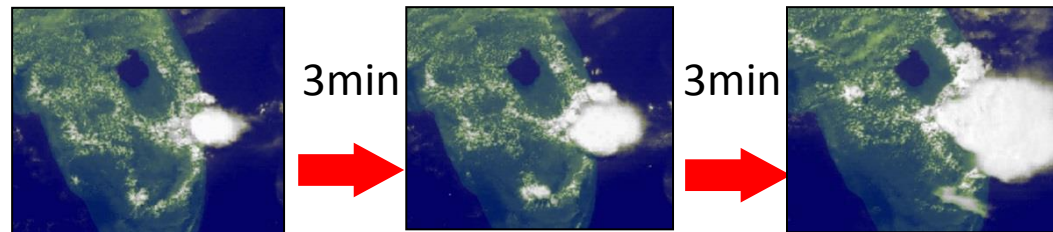
Japan & Vicinity Obs. At 02:00 UTC on 7th July 2015

Hiroshi SUZUE
Meteorological Satellite Center,
Japan Meteorological Agency

Developing Cumulus and Radar Echo



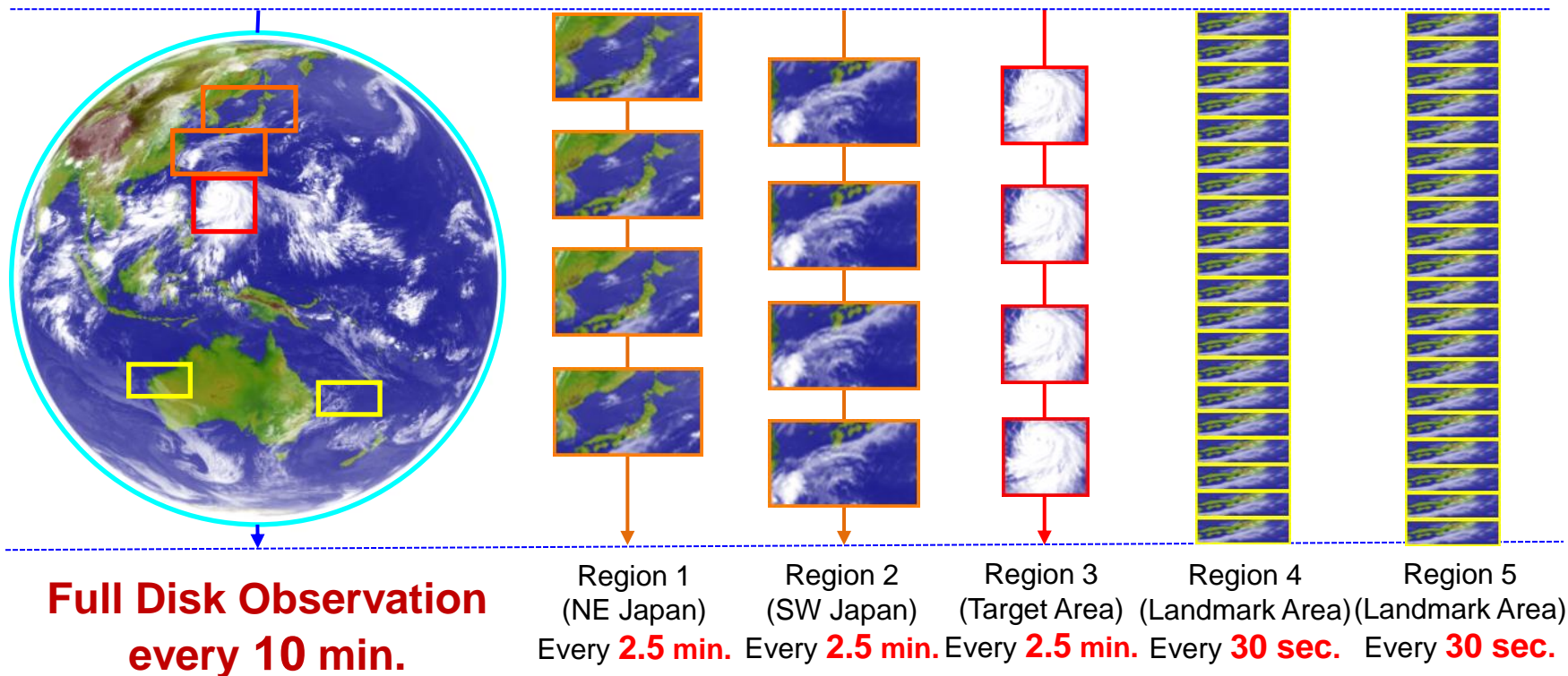
Chisholm, A. J. and Renick, J. H. (1972) [traced and added]



If we can detect cumulus that is growing rapidly,
we get to know thunderstorm coming earlier
than the radar !

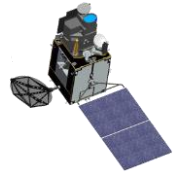
**Prepare for
thunderstorm!**

Himawari-8/9 AHI observations in 10 minutes observing cycle



Spectral Bands

Himawari-8/9 Imager (AHI; Advanced Himawari Imager)



cf.
MTSAT-2
Bands



VIS
0.68 μm

IR4
3.7 μm

IR3
6.8 μm

IR1
10.8 μm

IR2
12.0 μm

| Band | | Spatial Resolution | Central Wavelength | Physical Properties |
|------|---------------------|--------------------|--------------------|---|
| 1 | Visible (VIS) | 1 km | 0.47 μm | vegetation, aerosol |
| 2 | | | 0.51 μm | vegetation, aerosol |
| 3 | | 0.5 km | 0.64 μm | Vegetation, low cloud, fog |
| 4 | Near Infrared (NIR) | 1 km | 0.86 μm | vegetation, aerosol |
| 5 | | 2 km | 1.6 μm | cloud phase |
| 6 | | | 2.3 μm | particle size |
| 7 | Infrared (IR) | 2 km | 3.9 μm | low cloud, fog, forest fire |
| 8 | | | 6.2 μm | mid- and upper-level moisture |
| 9 | | | 6.9 μm | mid-level moisture |
| 10 | | | 7.3 μm | mid- and lower-level moisture |
| 11 | | | 8.6 μm | cloud phase, SO ₂ |
| 12 | | | 9.6 μm | Ozone content |
| 13 | | | 10.4 μm | cloud imagery, information of cloud top |
| 14 | | | 11.2 μm | cloud imagery, sea surface temperature |
| 15 | | | 12.4 μm | cloud imagery, sea surface temperature |
| 16 | | | 13.3 μm | cloud top height |

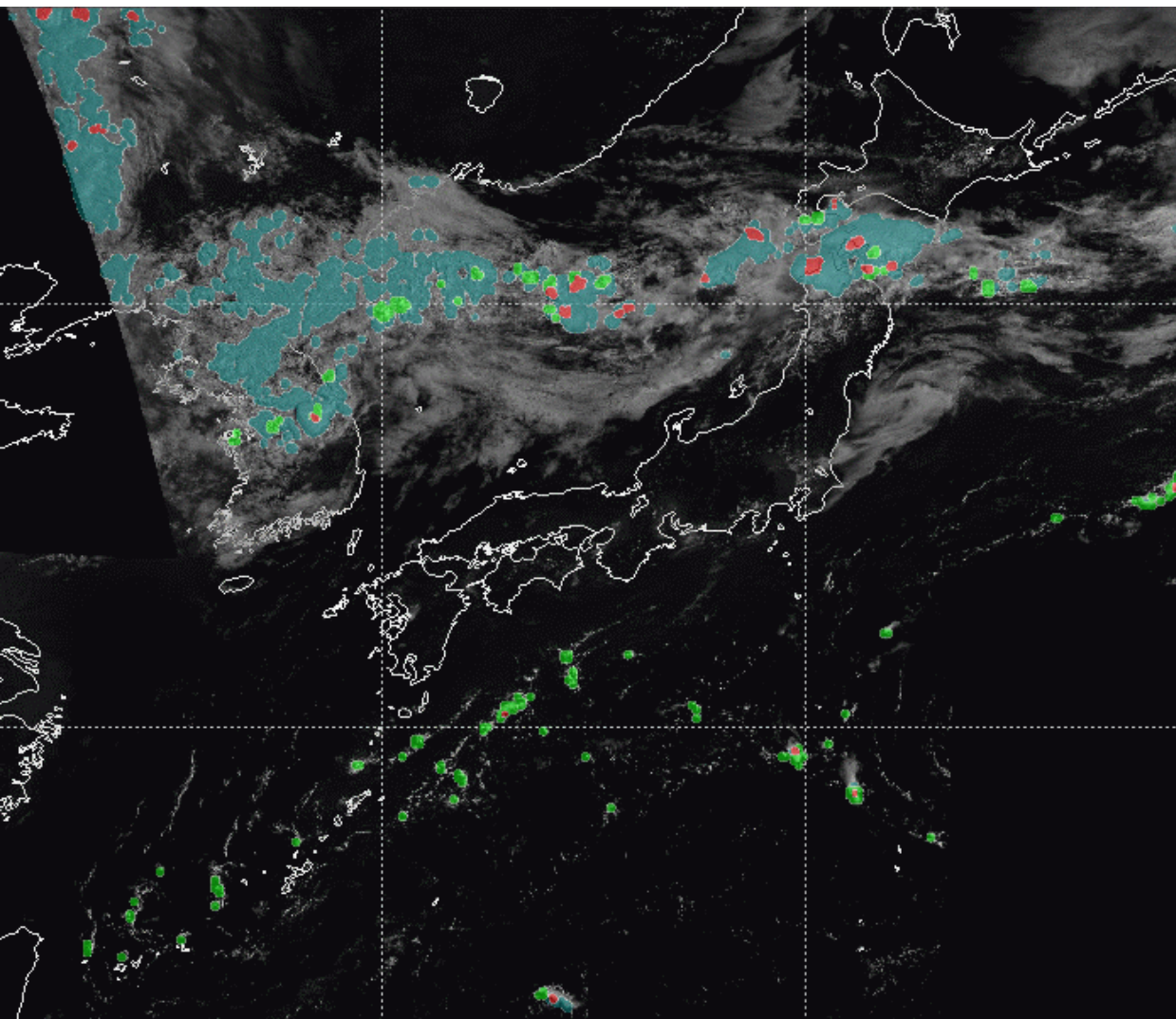
3 Visible Bands

Addition of NIR Bands

Increase of WV Bands

Increase of TIR Bands

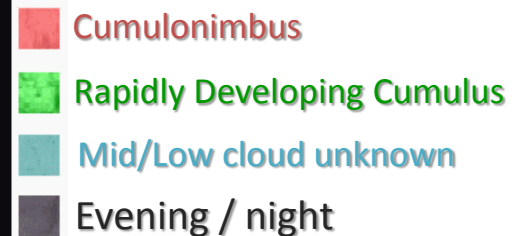
Convective Cloud Information (2nd Aug. 2015)



Convective
Cloud
Information

2015-08-02
000000 UTC
090000 JST

- RDCA product detects **rapidly developing cumulus** with thunder and **area of disturbance to occur in near future**.
- RDCA detection
 - Only daytime in summer
 - Lead time : about 25 mins.



Convective Cloud Information

● Rapidly Developing Cumulus Area (RDCA)

- ✓ Developing cumulus
- ✓ Current/Future disturbance is expected
- ✓ Detect only in daytime

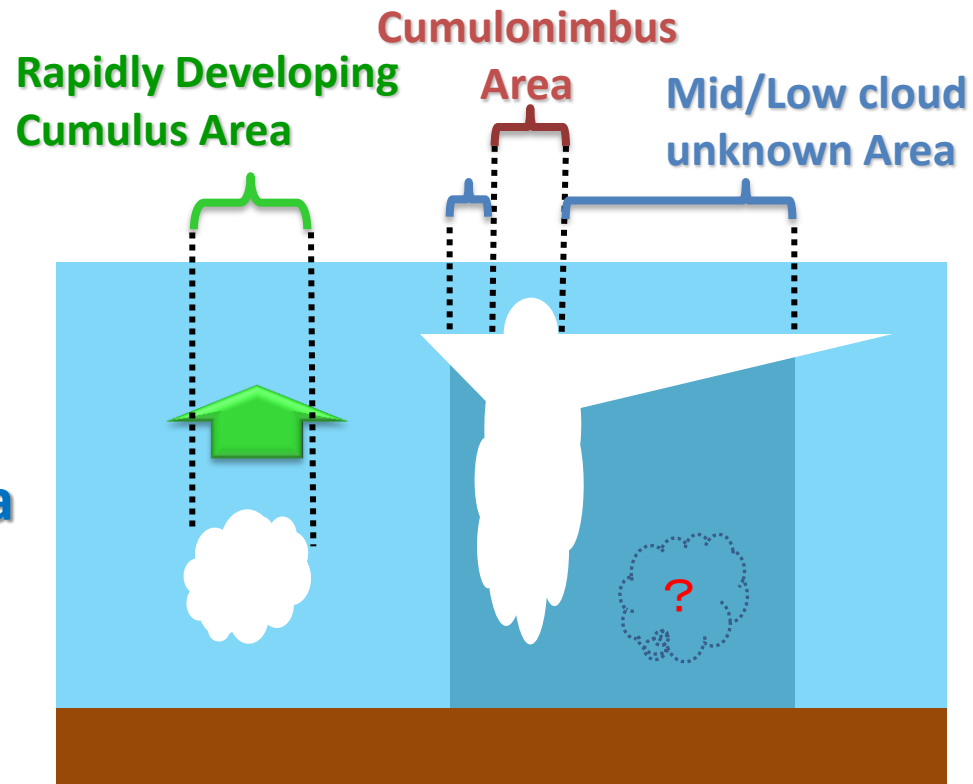
To detect expected sever weather earlier than Radar signals!

● Cumulonimbus Area

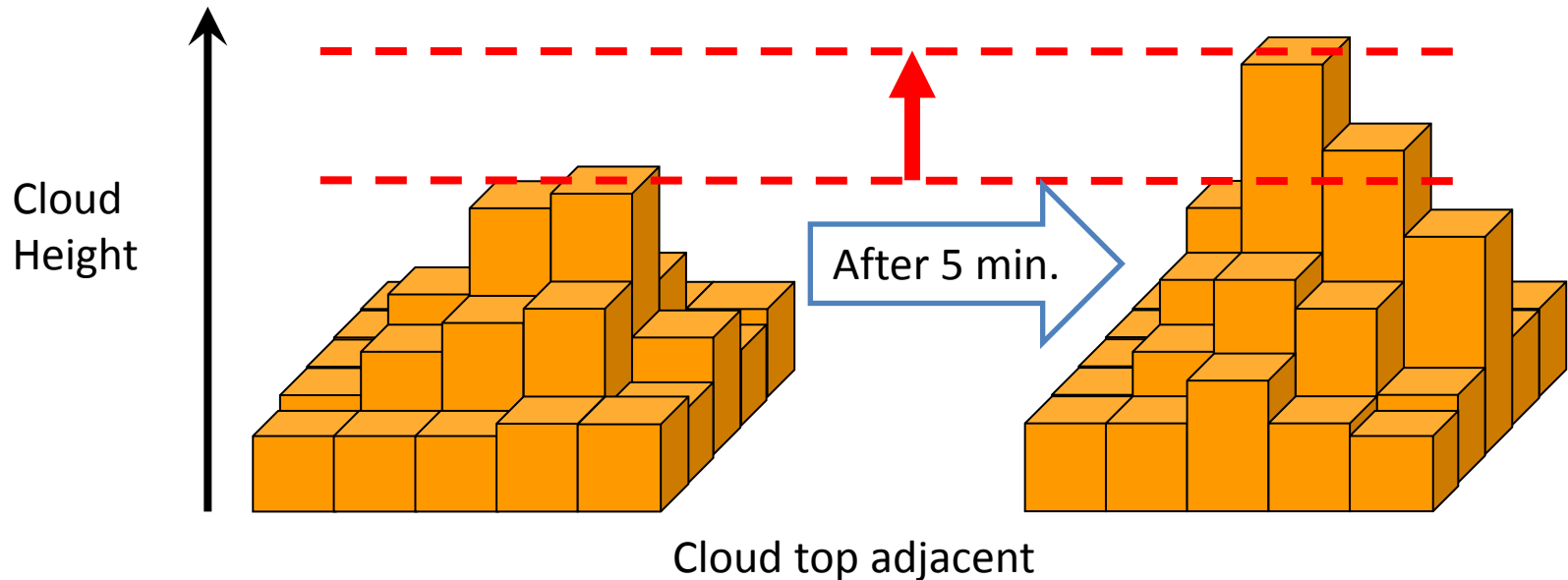
- ✓ A round top, except for anvil cirrus
- ✓ Strong upward flow is expected

● Mid/Low Cloud Unknown Area

- ✓ Anvil cirrus
- ✓ Anvil cirrus hides clouds below



Concept of RDCA detection



Developing cumulus →

- **Cloud Top is higher**

Brightness temperature is getting low.

- **Roughness of Cloud Top is getting large**

Contrast between light and dark is getting clear.

e.g. Difference of reflective intensity is increasing in visible image.

RDCA : Detection Parameters

| No. | Detection Parameter | Main object |
|-----|--|--|
| 1 | VIS (0.64 μ m) | Extracting thick cloud (preprocessing) |
| 2 | BT difference 10.4 μ m – 12.4 μ m | Rejection of thin cirrus (preprocessing) |
| 3 | VIS (0.64 μ m): Max – Average in target space | Detection of roughness which is observed at developing cloud top |
| 4 | VIS (0.64 μ m): Standard Deviation in target space | |
| 5 | IR (10.4 μ m) BT: Min – Average in target space | |
| 6 | IR (10.4 μ m) BT: Standard Deviation in target space | |
| 7 | Temporal changing of VIS (0.64 μ m) average value | Presumption of developing level of cloud |
| 8 | Temporal changing of IR (10.4 μ m) BT average value | |

Constant Parameters

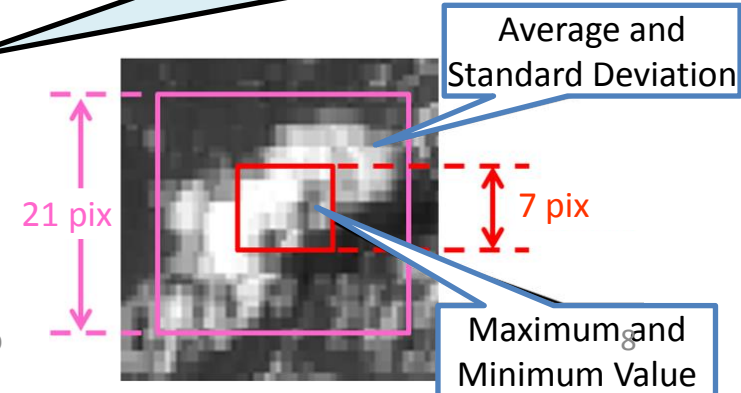
- Estimated for cloud mask

Constant Parameters

- Estimated from single image

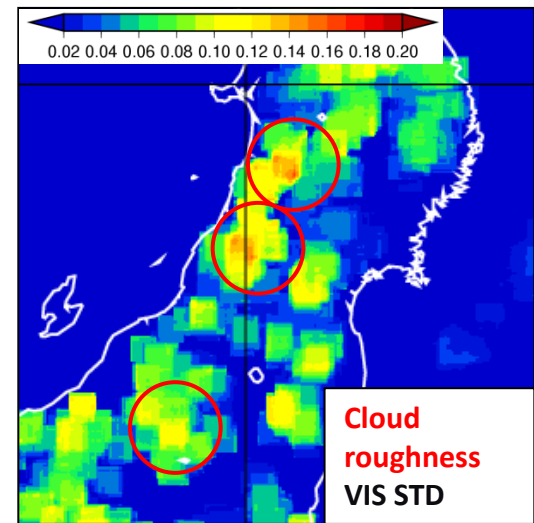
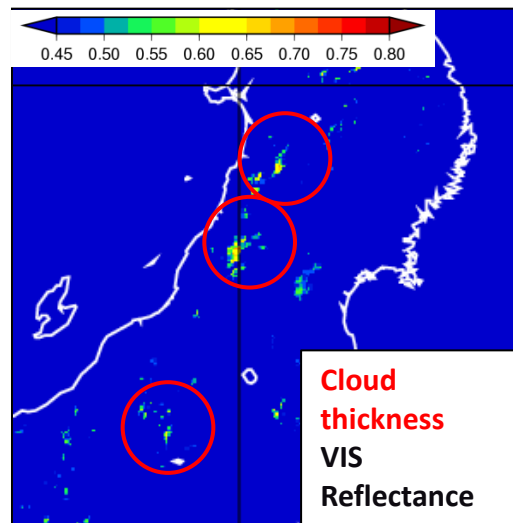
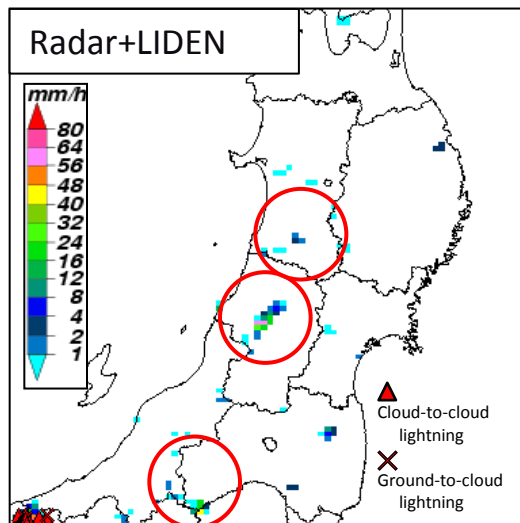
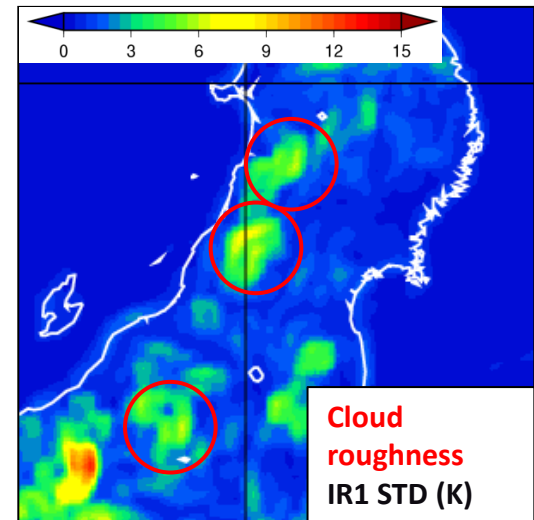
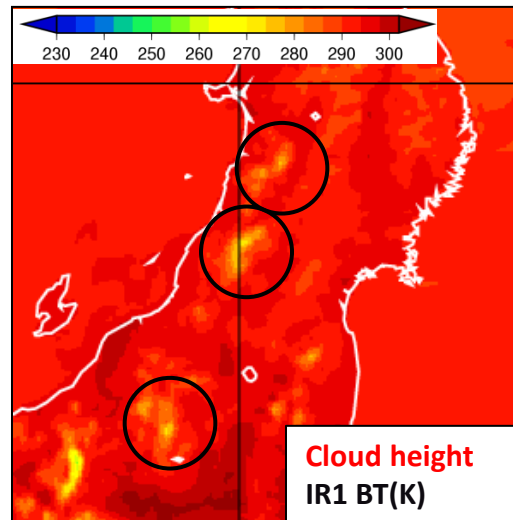
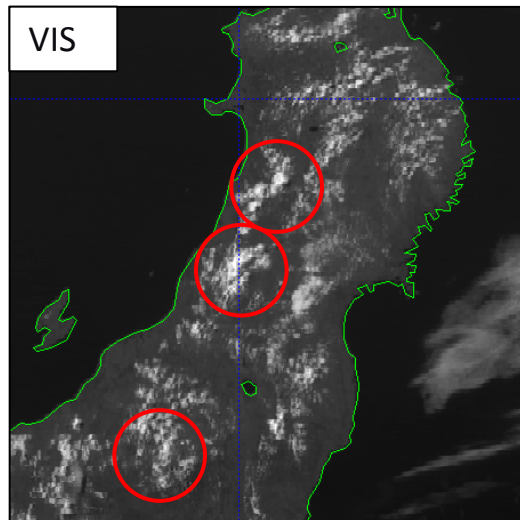
Dynamically Changing Parameters

- Estimated temporal changing between 2 images in 5 minutes
- Considering cloud motion



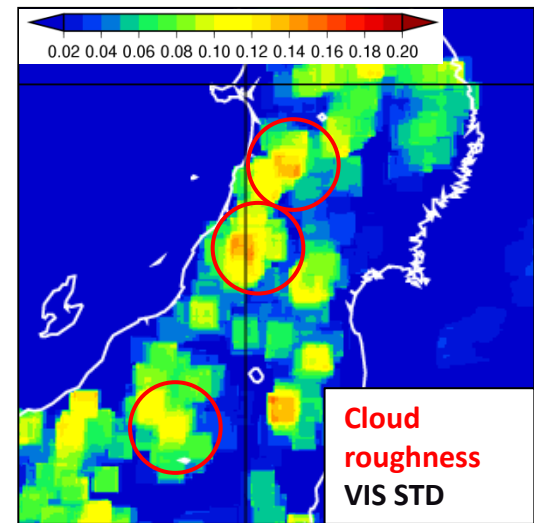
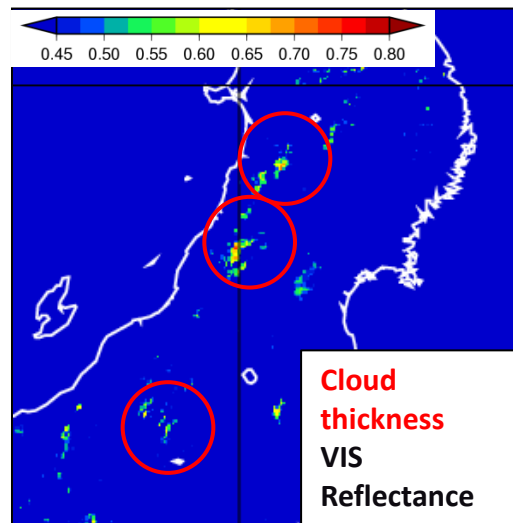
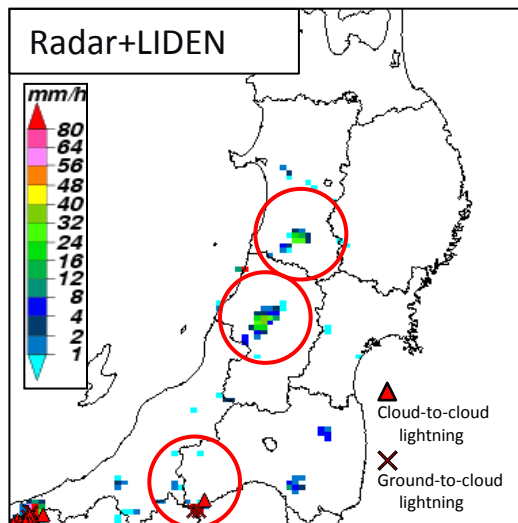
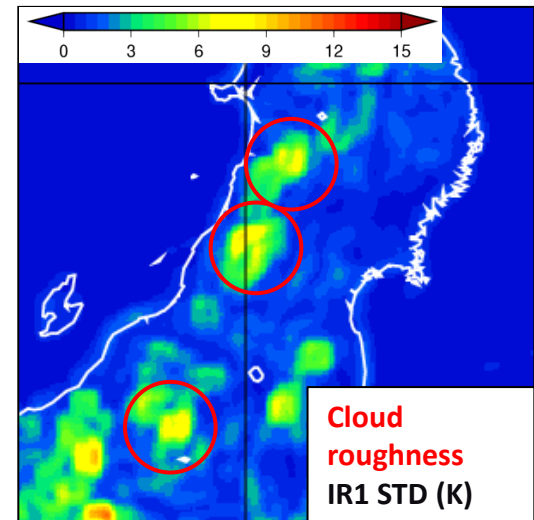
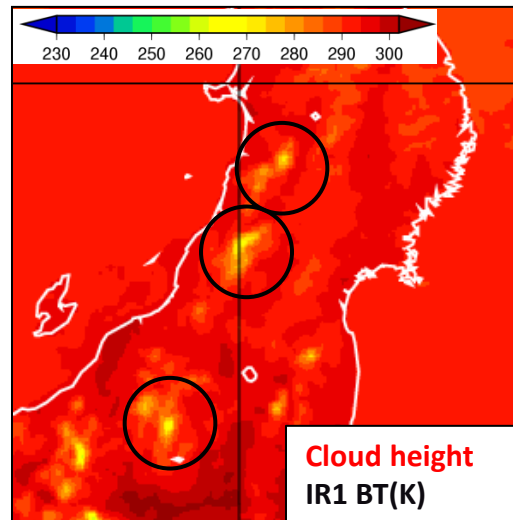
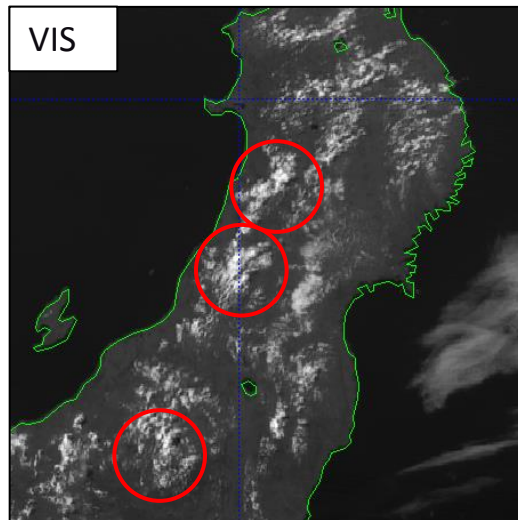
Cloud Height, Thickness and Roughness

04:20UTC



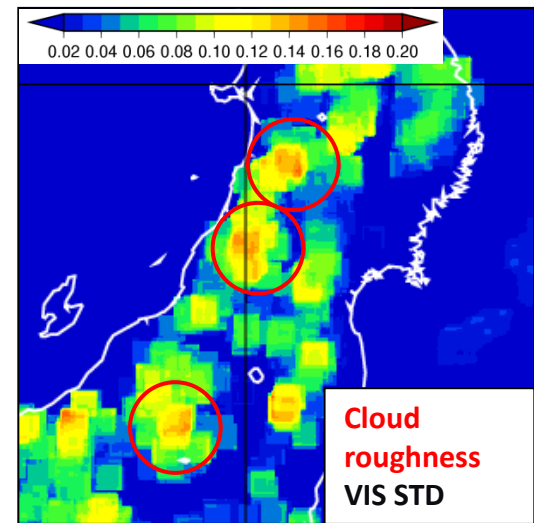
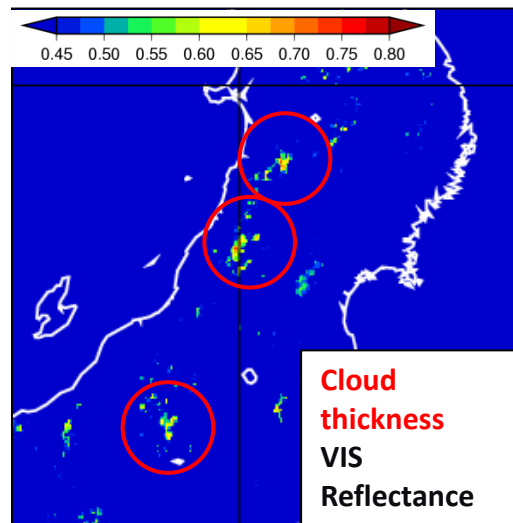
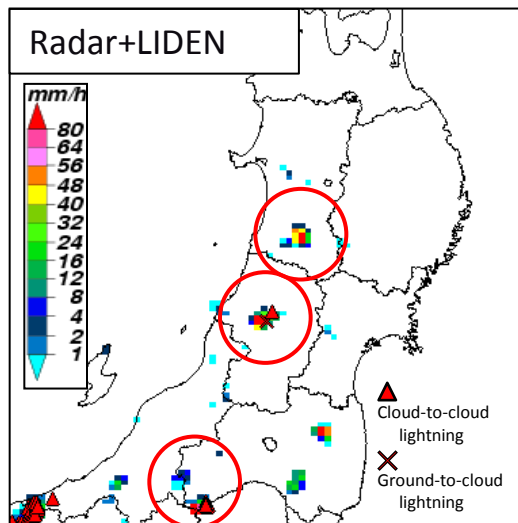
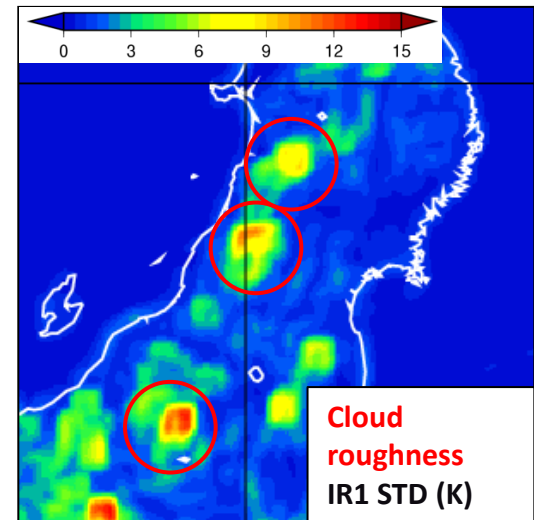
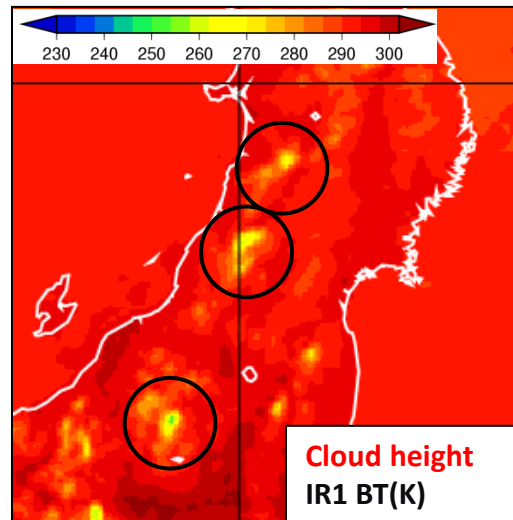
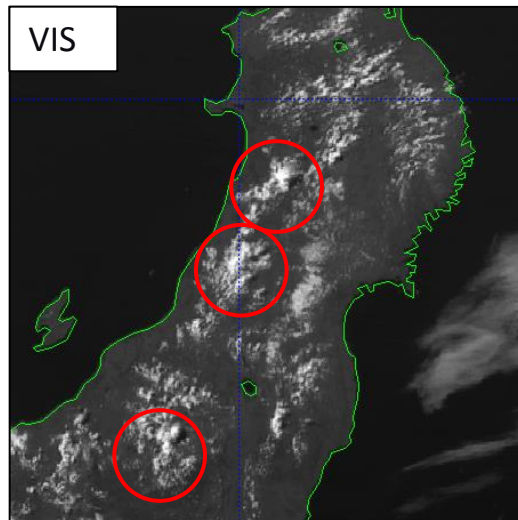
Cloud Height, Thickness and Roughness

04:30UTC



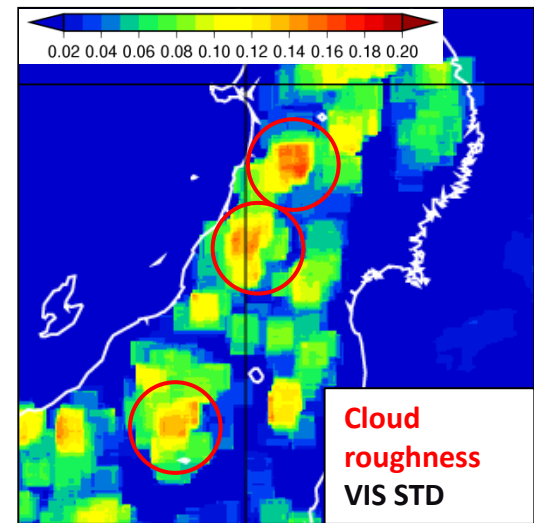
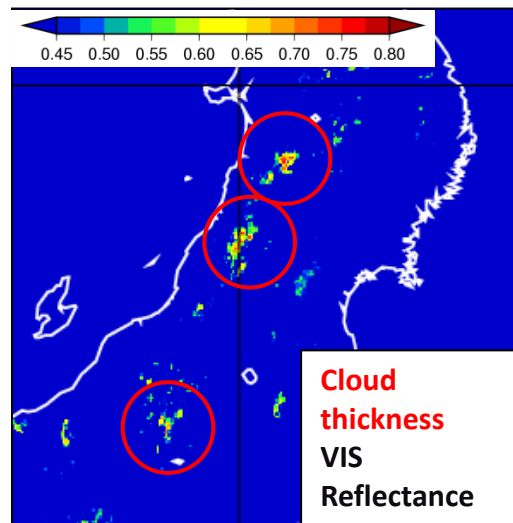
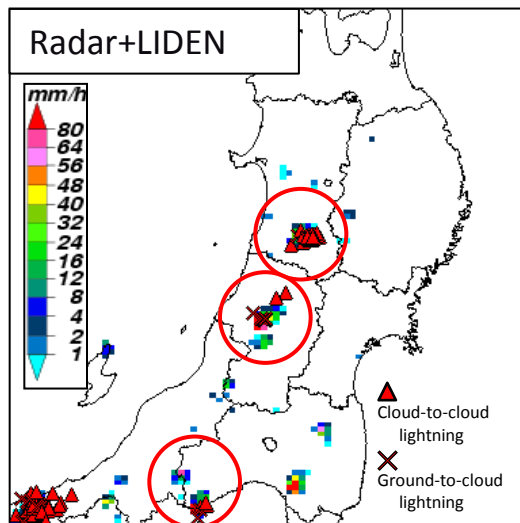
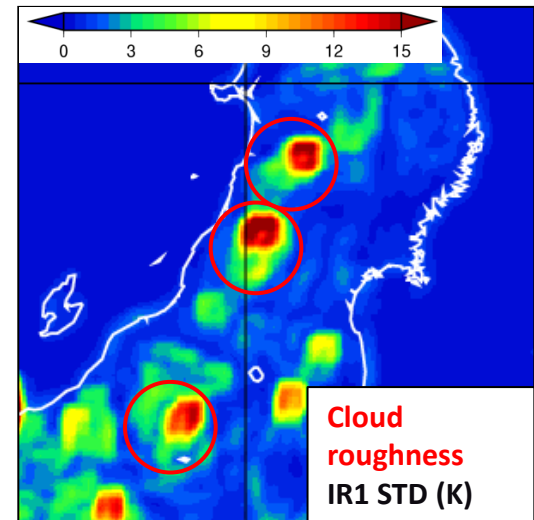
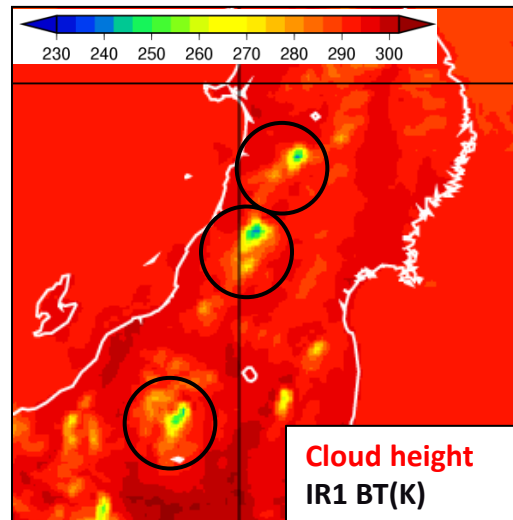
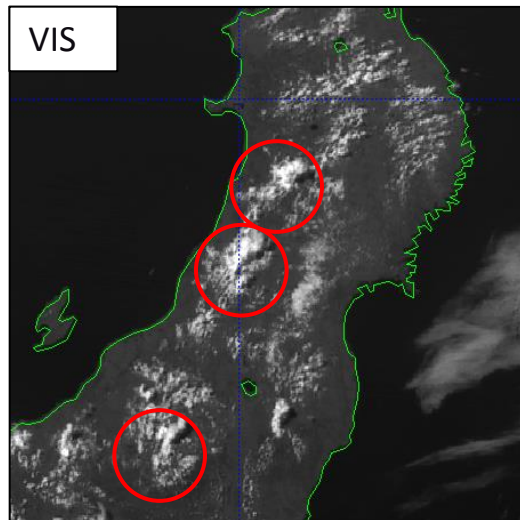
Cloud Height, Thickness and Roughness

04:40UTC



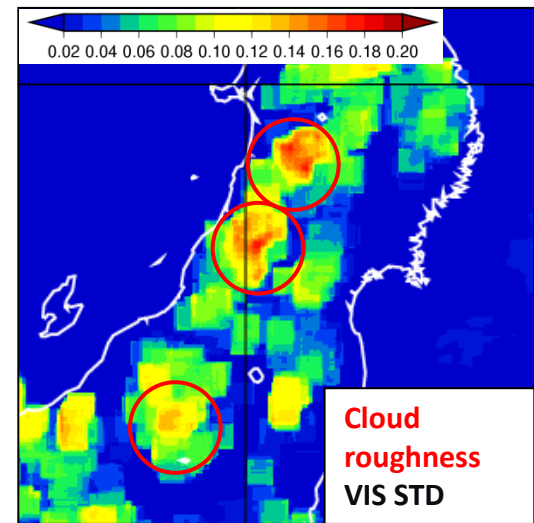
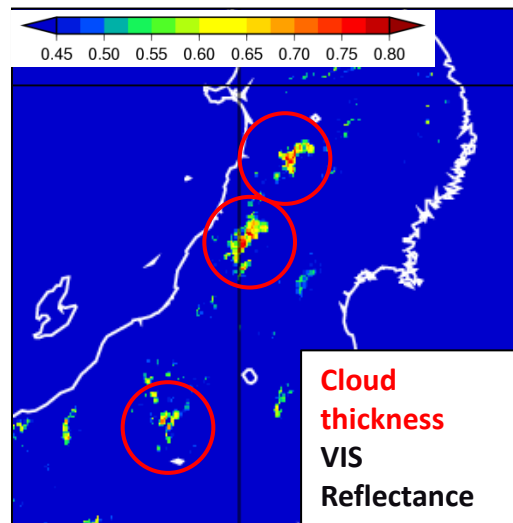
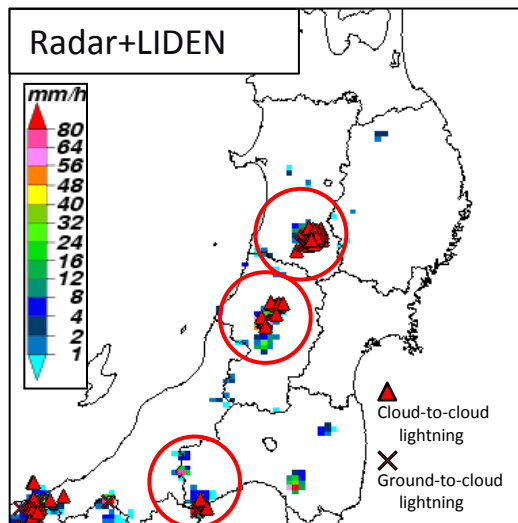
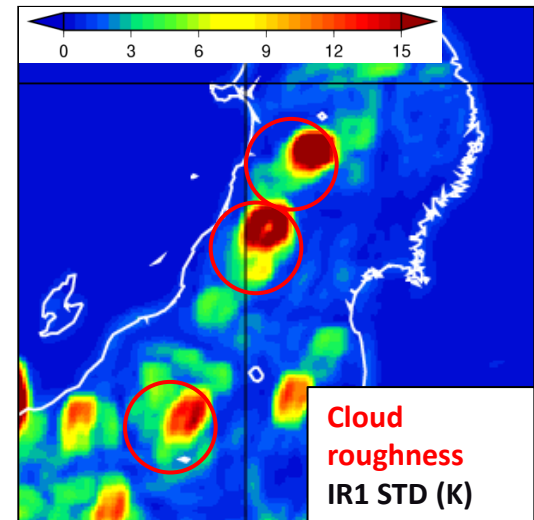
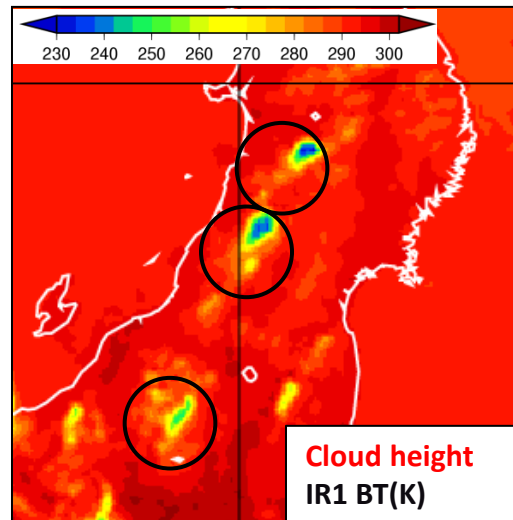
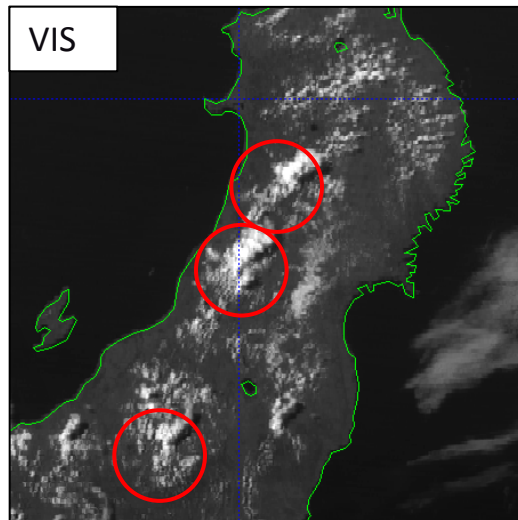
Cloud Height, Thickness and Roughness

04:50UTC

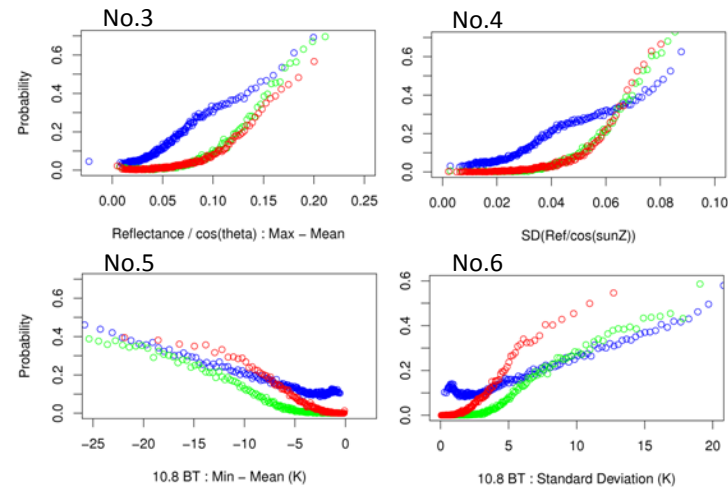


Cloud Height, Thickness and Roughness

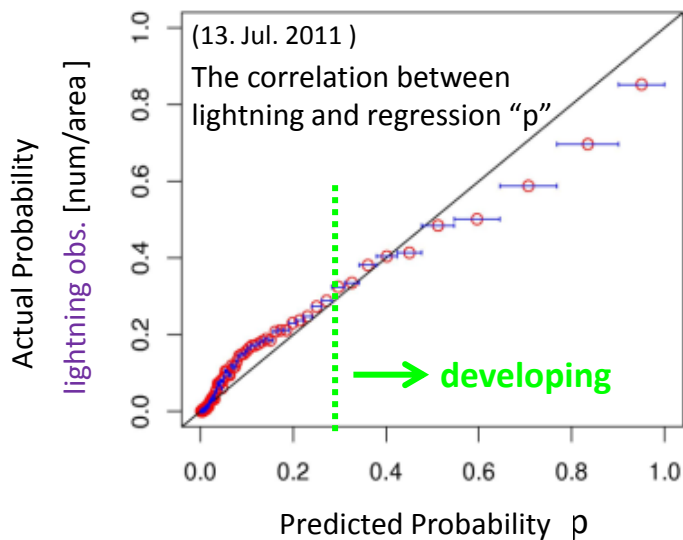
05:00UTC



RDCA : Decision process



Three class parameters;
 ○: <250K, ○: 250~273.15K, ○: >273.15K



Logistic Regression Model

$$p = \frac{1}{1 + \exp \left\{ - \left(a_0 + \sum_i a_i x_i \right) \right\}}$$

Probability
(forecast)

Detection
parameters

Coefficients a_i are determined by the logistic regression model when lightning occurs within 60 minutes after observed variable x_i .

=> High "P" area is decided as RDCA

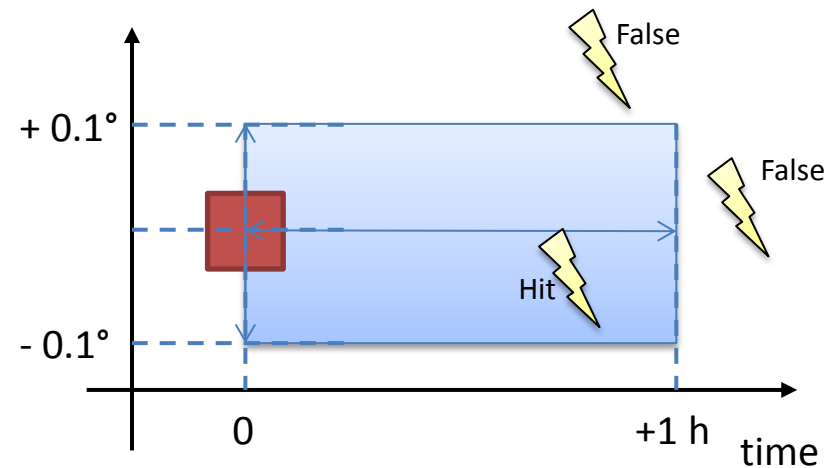
RDCA : Setting and evaluation

RDCA product

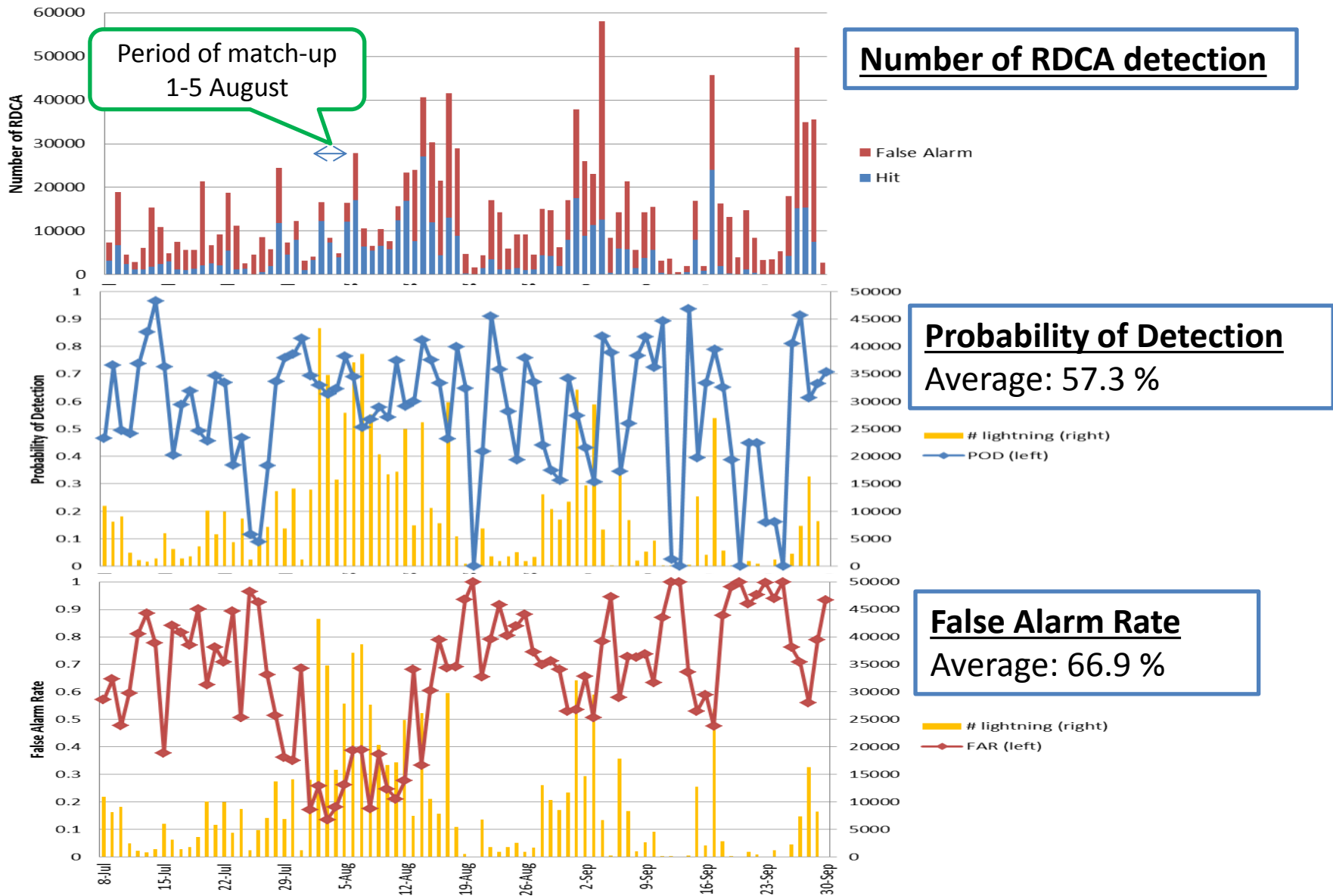
- Spatial resolution: 0.01° square grid (Both VIS & IR)
- Data refresh rate : 5 minutes
- Parameters handled with 3 classes by IR (BT: $<250\text{K}$, $250 \sim 273.15\text{K}$, $>273.15\text{K}$)
- RDCA spatial resolution: **0.1° grid** (Possibility is calculated on 0.01° grid)

Match-up/Evaluation data

- Data: Lightning detection (CG/CC)
- Hit: thunder stroke within $\pm 0.1^\circ$ and **1 hour** corresponding to target grid (RDCA: evaluation, VIS/IR: match-up)



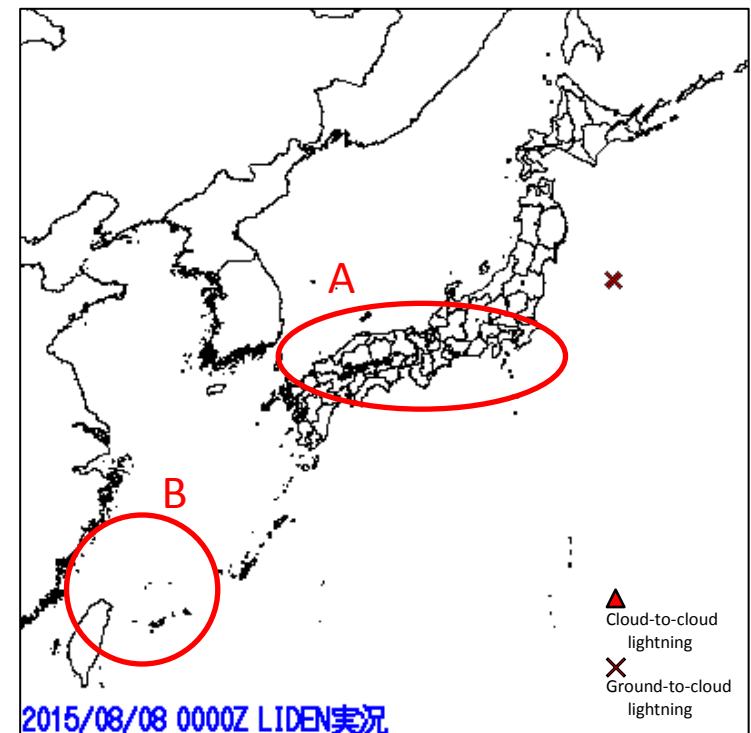
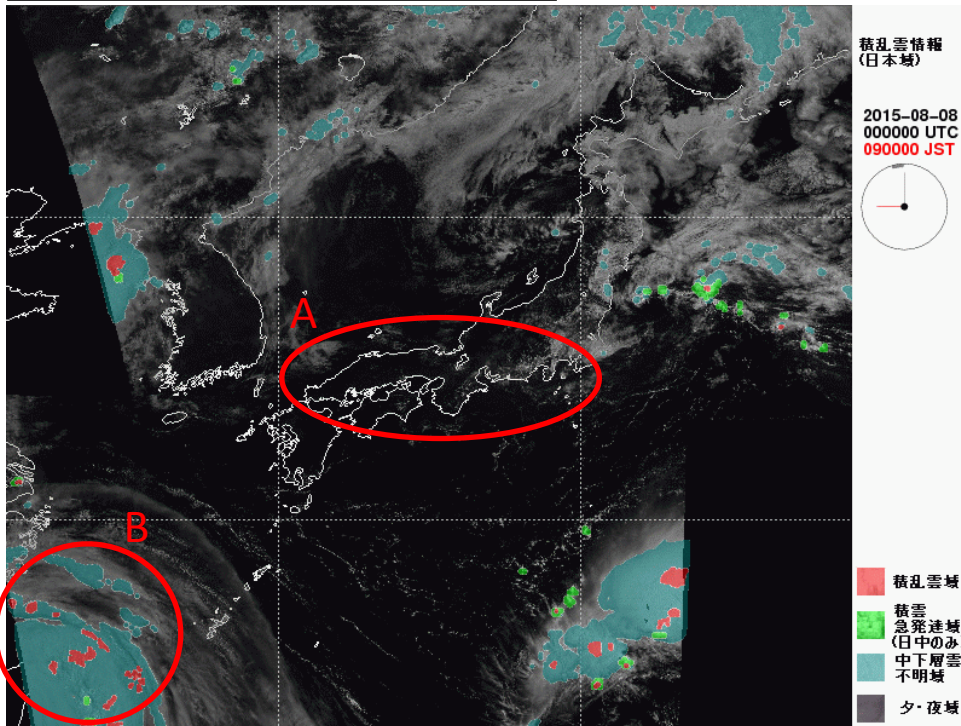
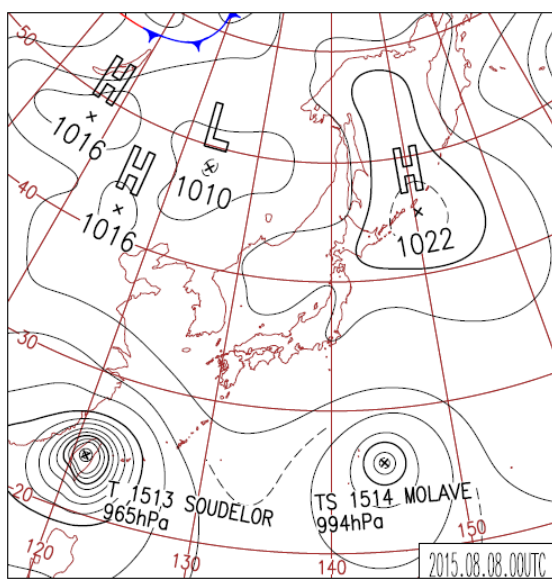
RDCA : Detection accuracy in 2015



Characteristics of RDCA

(8 Aug. 2015)

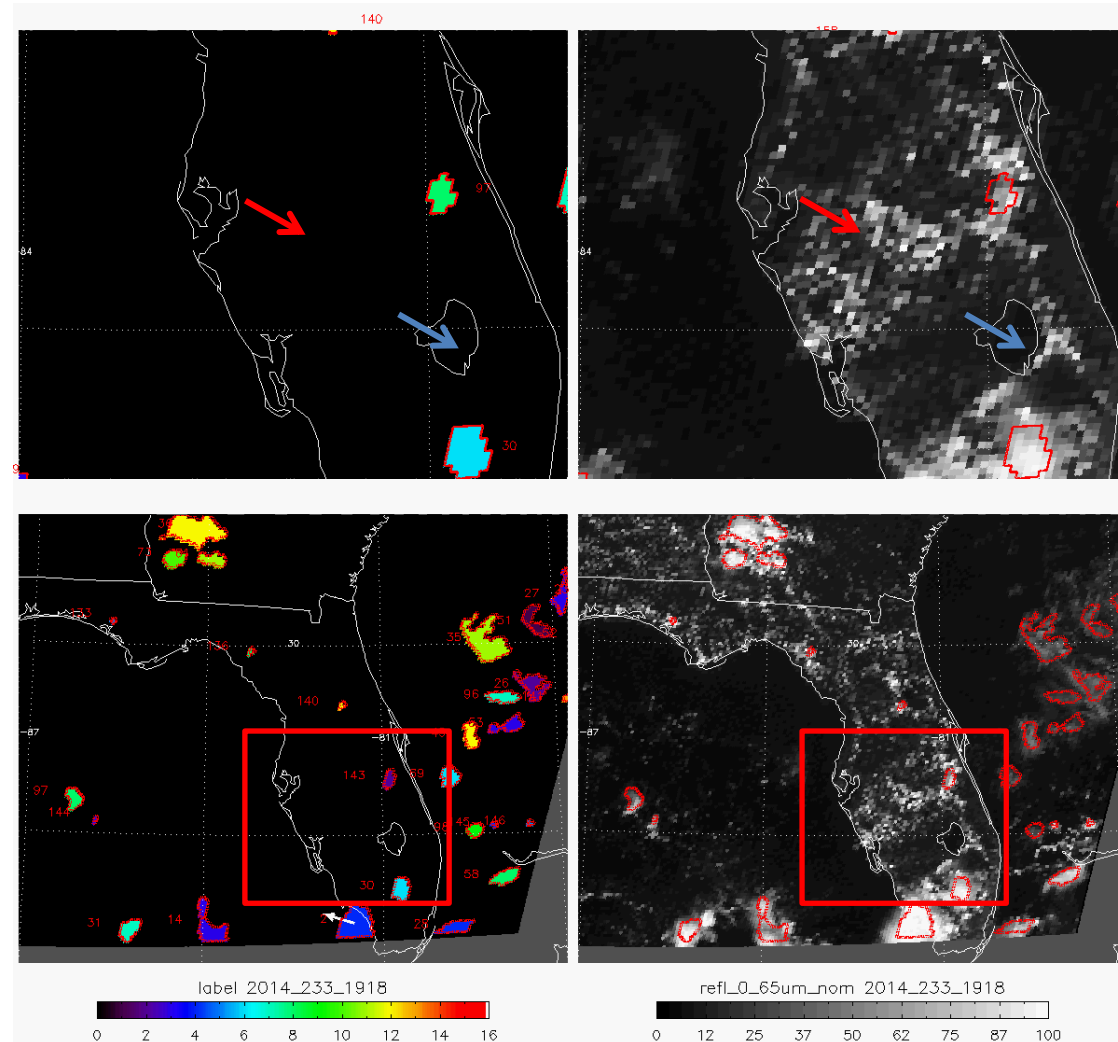
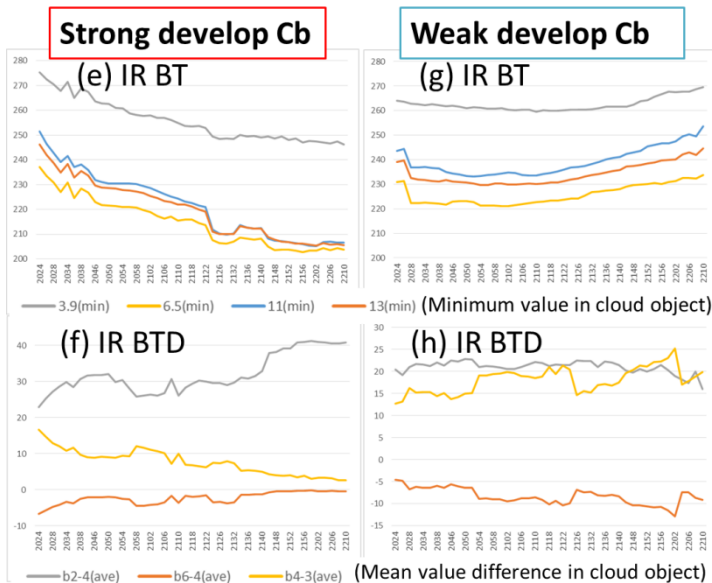
- The isolated Cb cloud can be detected with high accuracy by RDCA product (A : heat lightning area)
- The detection accuracy is low for middle or high clouds that shield low clouds (B : typhoon area)



Future Work : cloud object tracking

Cloud object tracking (COT)

- Tracking cloud object from infant Cb to mature Cb
- Data: GOES-14 SRSOR
11um top of tropopause emissivity
- 1-3 minutes refresh data have a good performance of COT



A sample of COT over the Florida Peninsula on 21 Aug. 2014

Summary/Future Plans

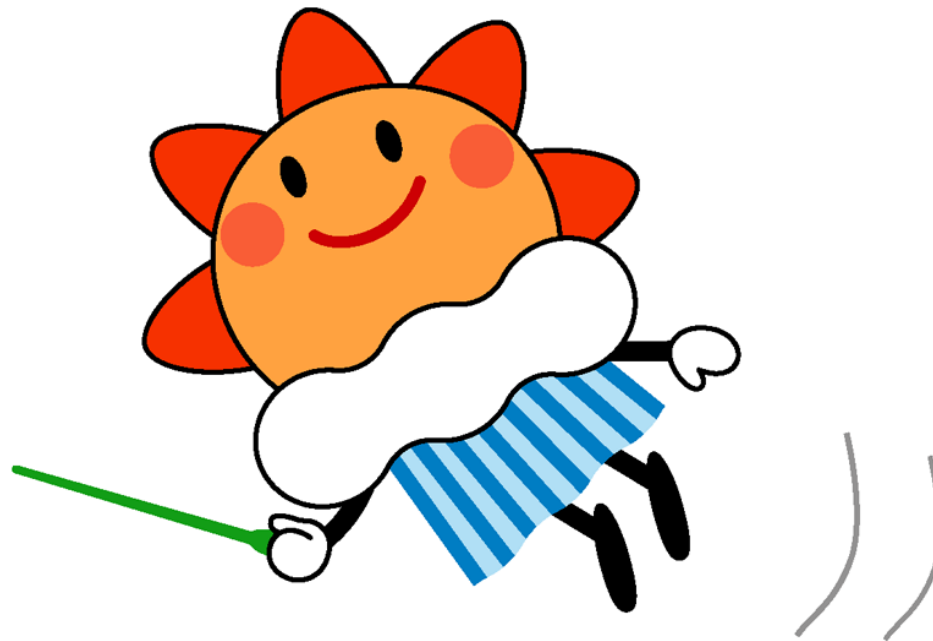
Summary

- This product utilizes only two bands (VIS; $0.64\mu\text{m}$ and one IR; $10.4\mu\text{m}$). Currently, the operation implements during daytime in summer.
- The evaluation/match-up is utilized of lightning detecting (LIDEN)
- RDCA has many points to be improved (e.g. evaluation data, cloud movement, cloud mask and using other data related to convection)

Future Plans

- Detection of RDCA all day in all seasons
- Domain extension using full disk observation data
- Update of the RDCA detection algorithm (e.g. cloud object tracking)

Thank you for your kind attention



JMA mascot "Harerun"