Himawari-8 current applications and future development

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Outline

- Overview of Himawari-8/9 AHI and its products
  - *Improved Resolutions*
  - *Advantages of High Observation Frequency*
  - *Operational Products developed at MSC/JMA*
- Detection of Rapidly Developing Cumulus Area (RDCA)
  - *Algorithm*
  - *Case Studies*
- Future Plans
- Summary

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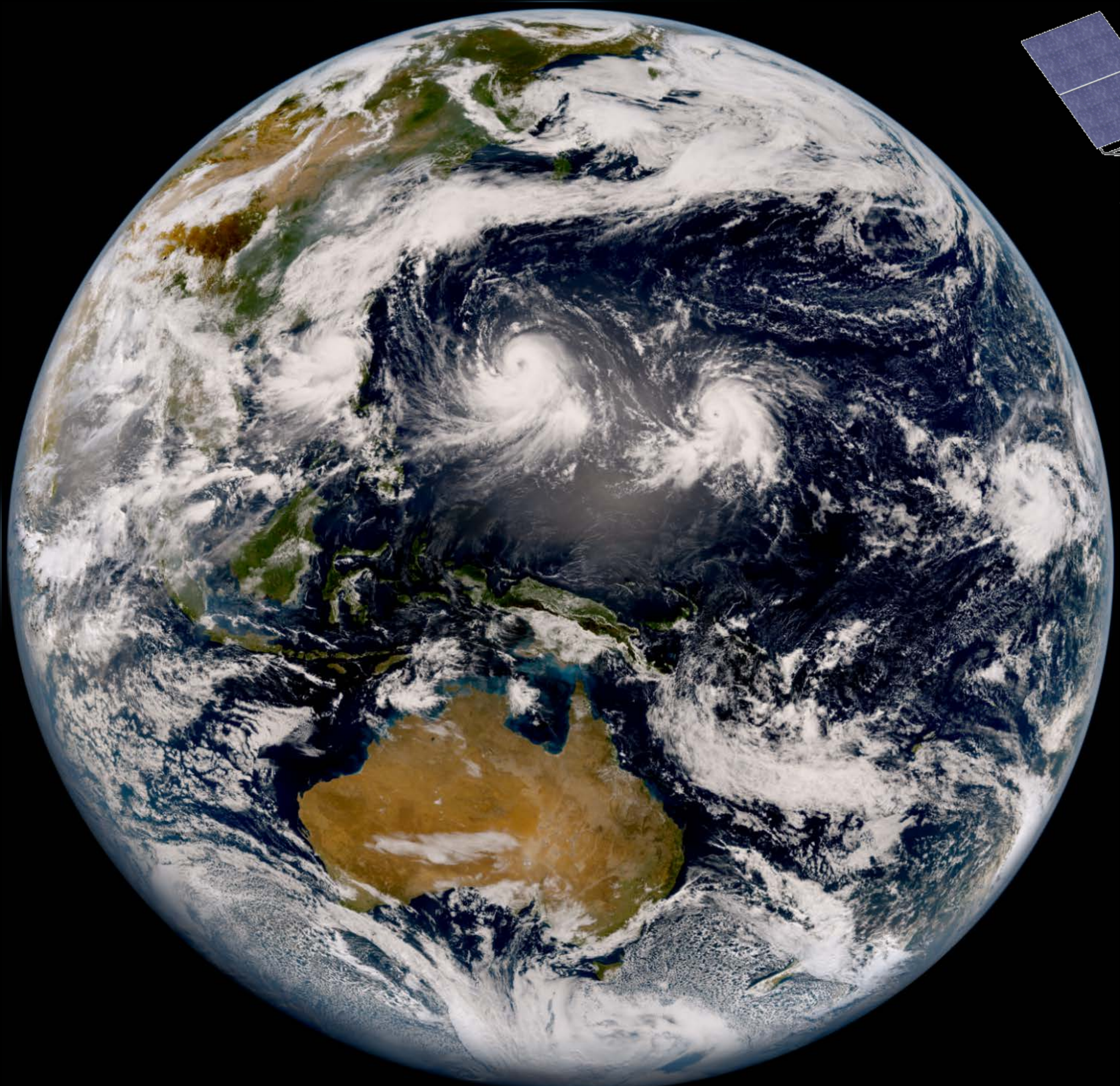
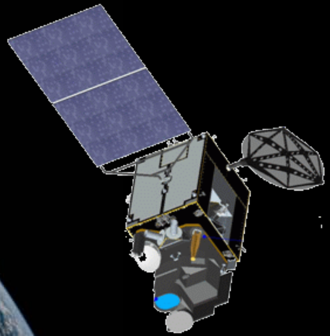
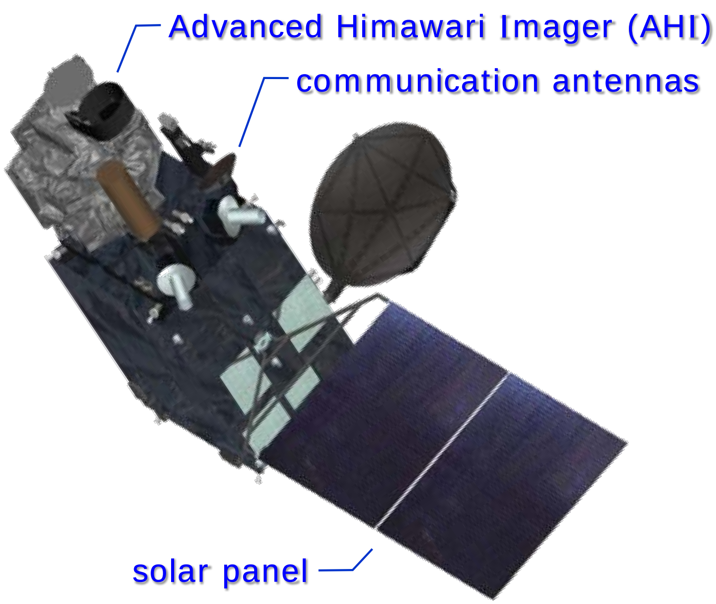
Himawari-8 began operation at 02:00 UTC on 7th July 2015.



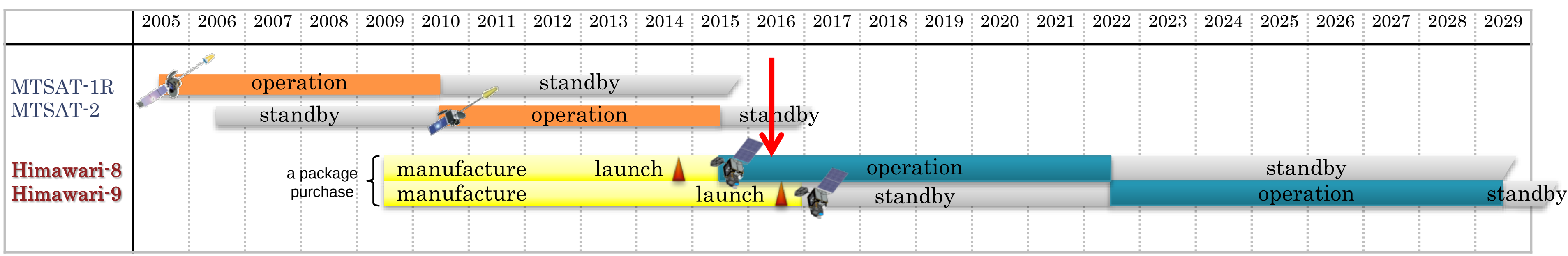


Outline of Himawari-8/9



Geostationary position	Around 140.7° E
Attitude control	3-axis attitude-controlled geostationary satellite
Communication	1) Raw observation data transmission Ka-band, 18.1 - 18.4 GHz (downlink)
	2) DCS International channel 402.0 - 402.1 MHz (uplink) Domestic channel 402.1 - 402.4 MHz (uplink) Transmission to ground segments Ka-band, 18.1 - 18.4 GHz (downlink)
	3) Telemetry and command Ku-band, 12.2 - 12.75 GHz (downlink) 13.75 - 14.5 GHz (uplink)

Himawari-8 began operation on 7 July 2015, replacing the previous MTSAT-2 operational satellite



Improved Resolutions

Spatial

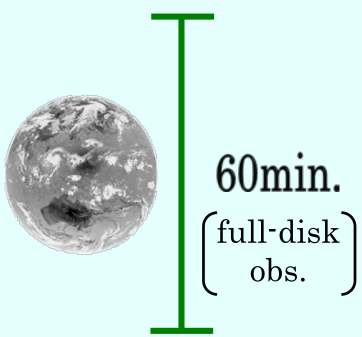
At sub-satellite point

MTSAT-1R / 2	Himawari-8 / 9
VIS 1 km IR 4 km	VIS 0.5/1 km IR 2 km

Temporal

Observation Frequency

MTSAT-1R / 2

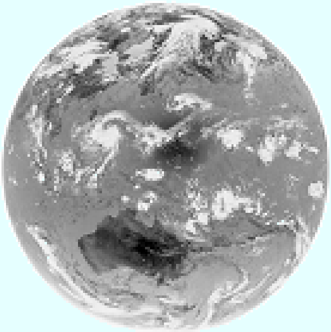


Himawari-8 / 9

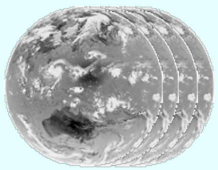
Spectral

MTSAT-1R / 2

VIS 1 band



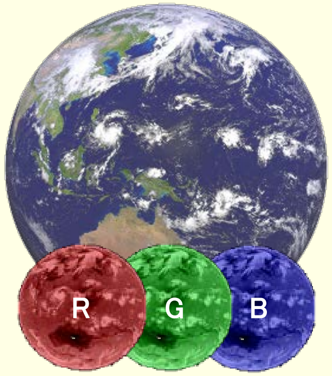
IR 4 bands



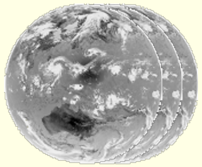
5 bands

Himawari-8 / 9

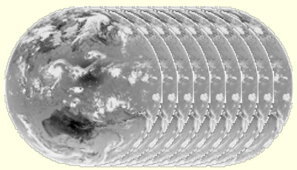
VIS 3 bands



NIR 3 bands



IR 10 bands



16 bands

MSC/JMA

Spectral Bands

Himawari-8/9 Imager (AHI)

Band		Spatial Resolution	Central Wavelength	Physical Properties
1	Visible	1 km	0.47 μm	vegetation, aerosol
2			0.51 μm	vegetation, aerosol
3		0.5 km	0.64 μm	low cloud, fog
4	Near Infrared	1 km	0.86 μm	vegetation, aerosol
5		2 km	1.6 μm	cloud phase
6			2.3 μm	particle size
7	Infrared	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, SO2
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

cf. MTSAT-2 Bands

- VIS 0.68 μm
- IR4 3.7 μm
- IR3 6.8 μm
- IR1 10.8 μm
- IR2 12.0 μm

3 Visible Bands

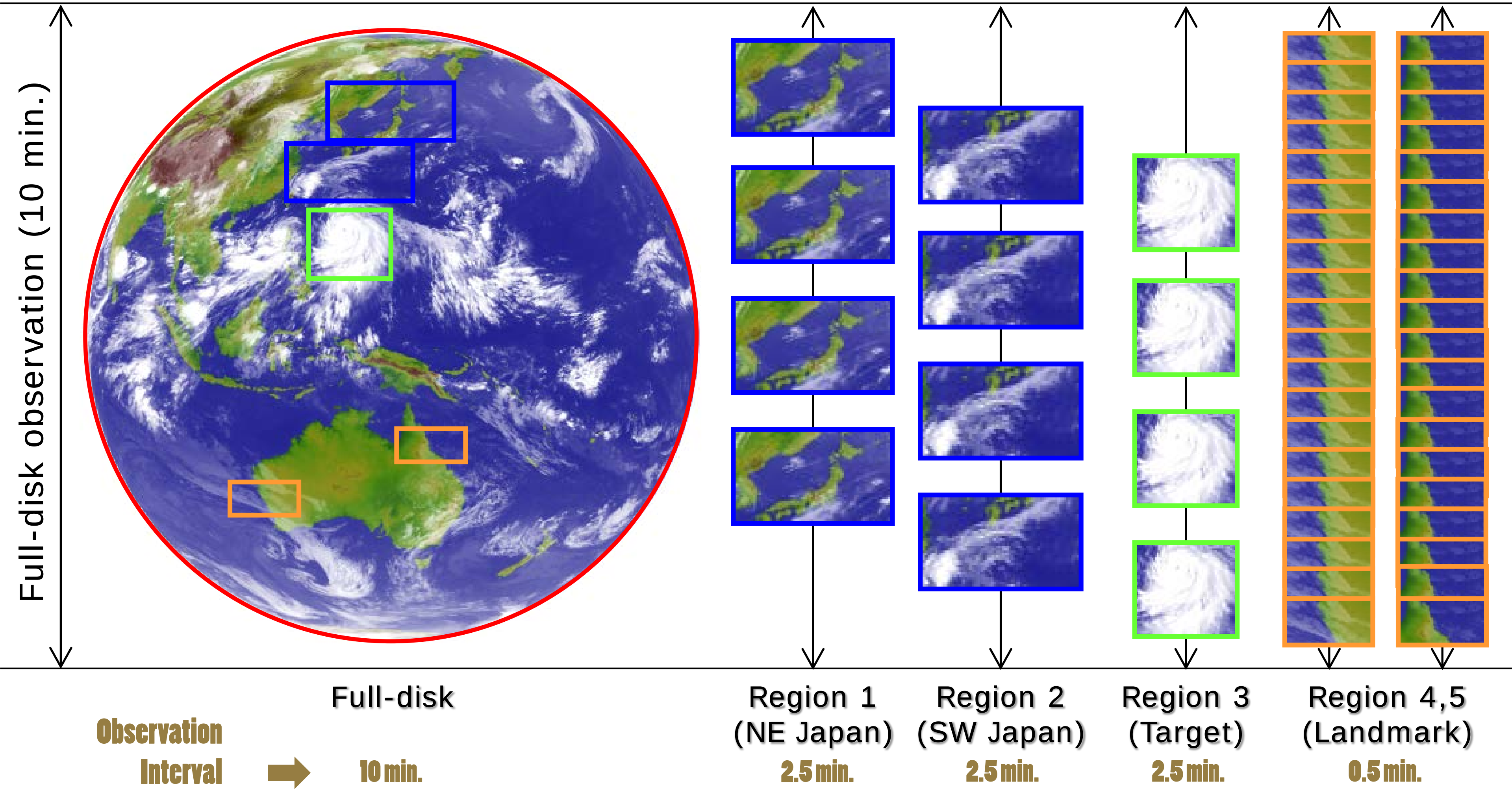
Addition of NIR Bands

Increase of WV Bands

Increase of TIR Bands

More Flexible Regional Observation

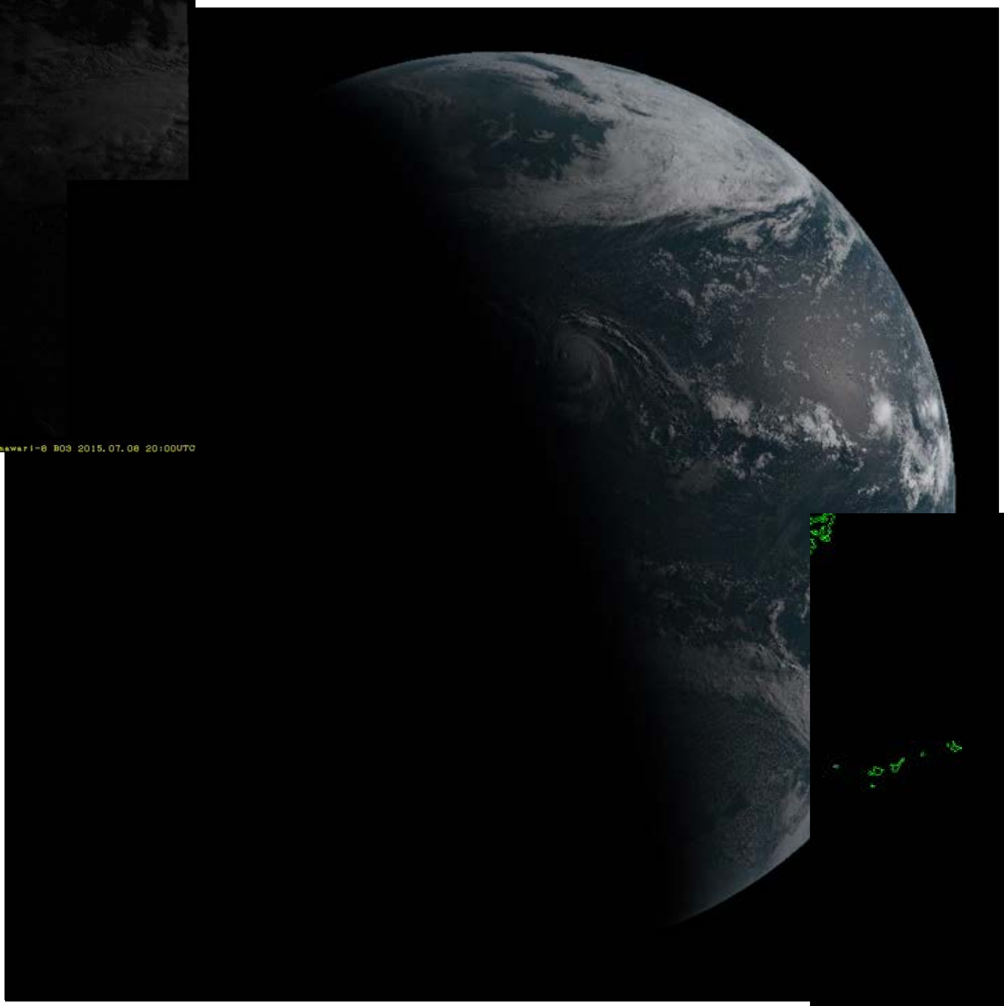
- Several types of regional observations can be performed during 10 minutes of full-disk observation.



Observation modes and intervals

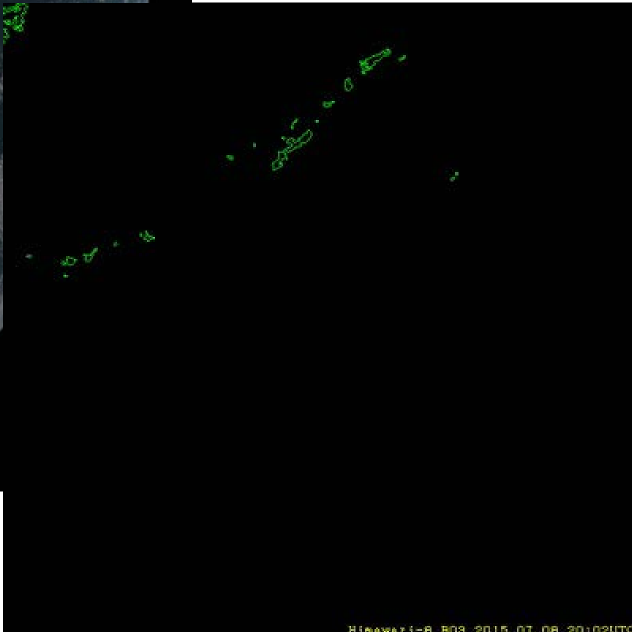
July 9-10, 2015

Japan & Vicinity Obs.
2.5 min.



Full Disk Obs. 10 min.

Targeted Area obs.
2.5 min.

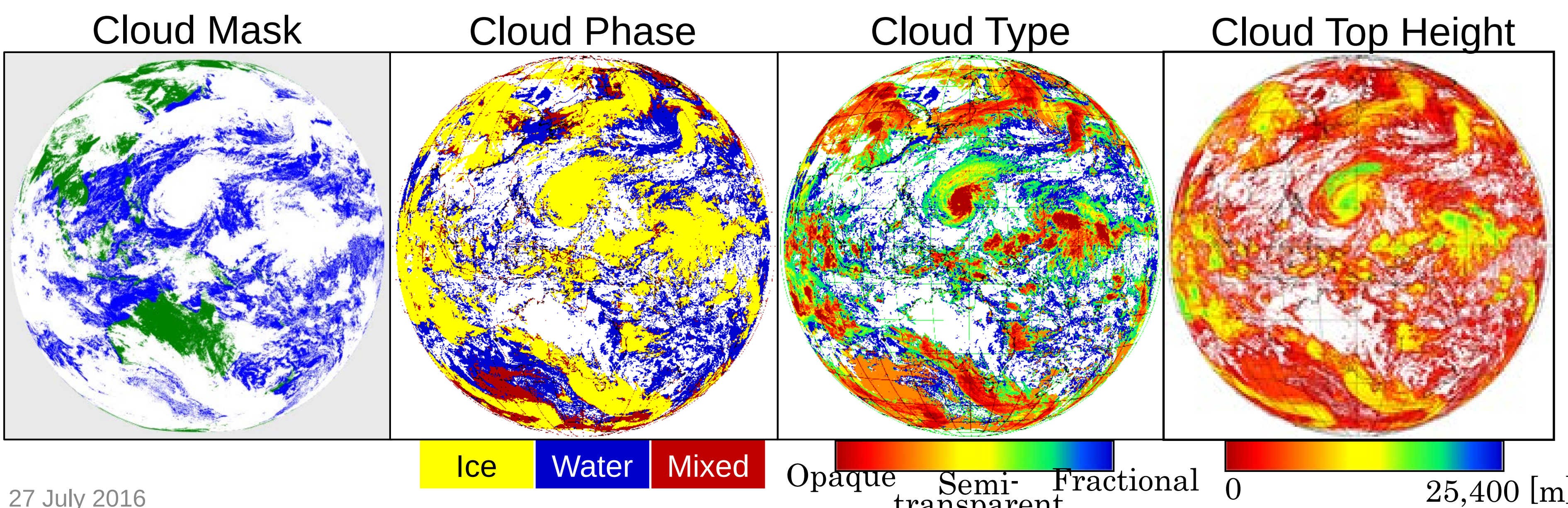


Himawari-8 Level-2/3 Products

Fundamental Cloud Product

- Basically referring to the NWC-SAF's ATBDs for MSG/SEVIRI
- Adapted to AHI by JMA (in-house codes at JMA)
- For other AHI Level-2/3 products developed at MSC/JMA

Derived parameters	Cloud Mask, Cloud Phase/Type, Cloud Top Height (Including Top Press. and Top Temp.)
Projection	Normalized Geostationary Projection (same as HSD)
Spatial resolution	2km@SSP (same as HSD for infrared bands)
Temporal resolution	Hourly

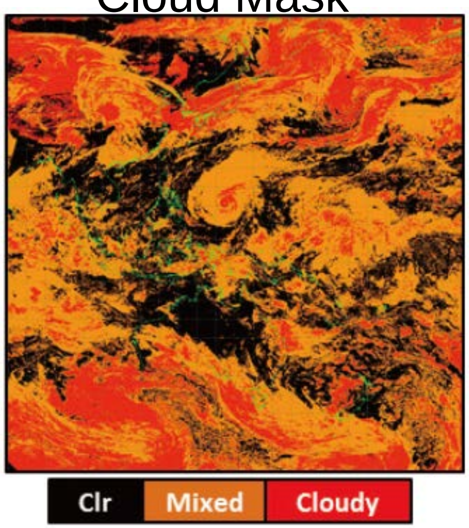


High-resolution Cloud Analysis Information(HCAI)

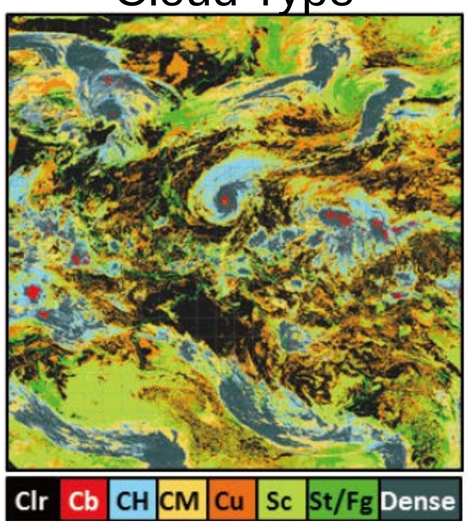
- Produced from FCP via projection conversion
- Reproduced Cloud Type for cloud monitoring
- Provided to foreign NMHSs as well as domestic users

Derived parameters	Cloud Mask, Cloud Type, Cloud Top Height, Snow Ice Mask
Projection	Lon/Lat grid
Spatial resolution	0.02 degree x 0.02 degree
Temporal resolution	Hourly

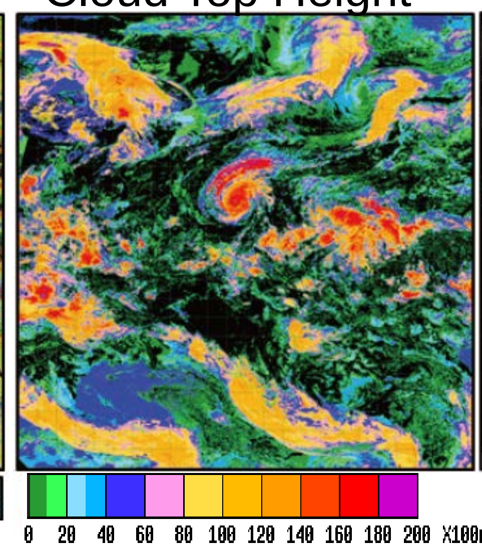
Cloud Mask



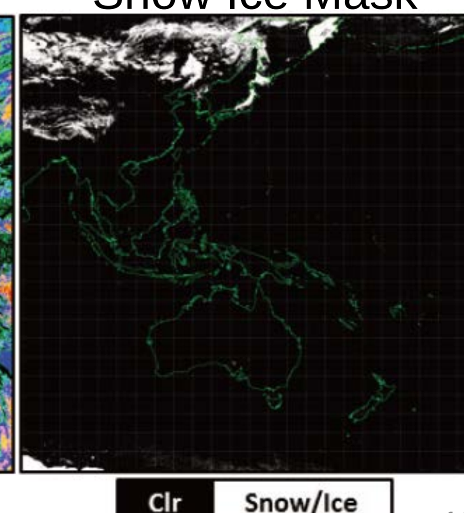
Cloud Type



Cloud Top Height



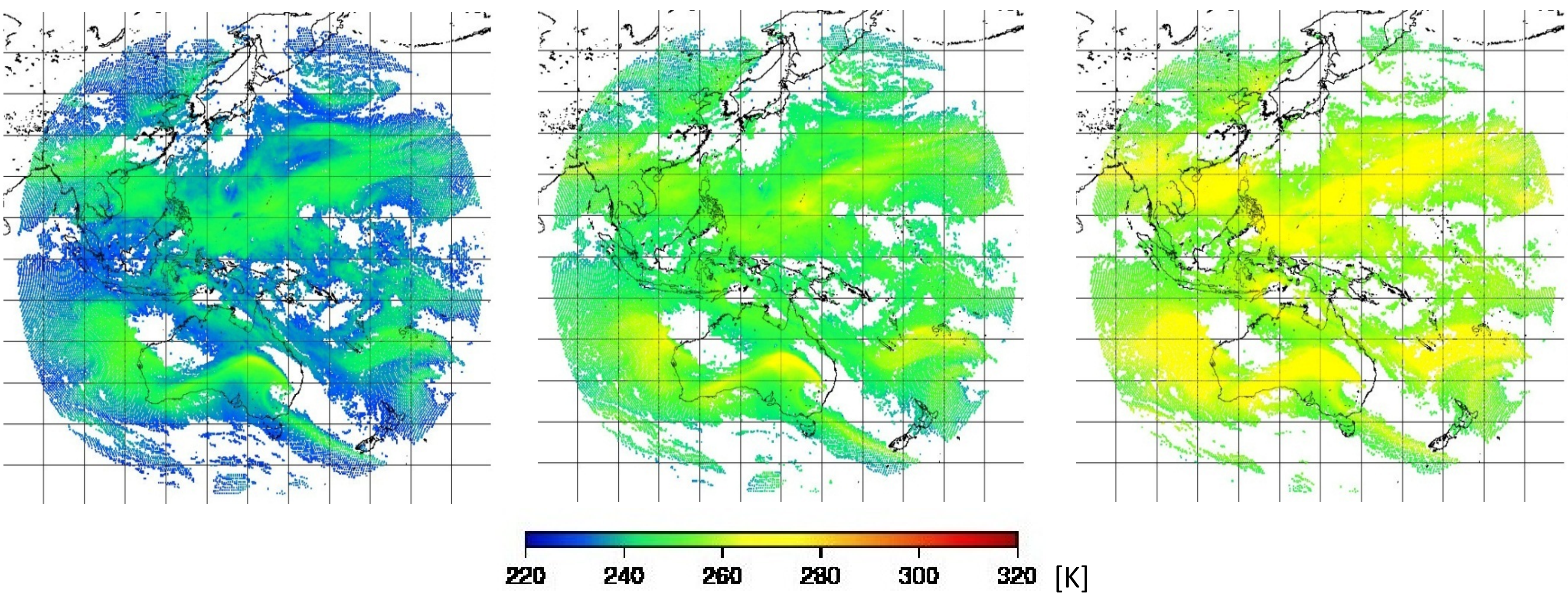
Snow Ice Mask



Clear Sky Radiances (CSRs)

- Area averaged clear sky radiance and brightness temperature
- Provided to NWP users
- Specifications:
  - All IR bands (3.9, 6.2, 6.9, 7.3, 8.6, 9.6, 10.4, 11.2, 12.4, 13.3 μm)
  - Full disk, Hourly produced
  - Spatial resolution (size of area for averaging): 16 x 16 pixel (IR) (32 x 32 km @SSP)

Band #8 (6.2 um) | Band #9 (6.9 um) | Band #10 (7.3 um)



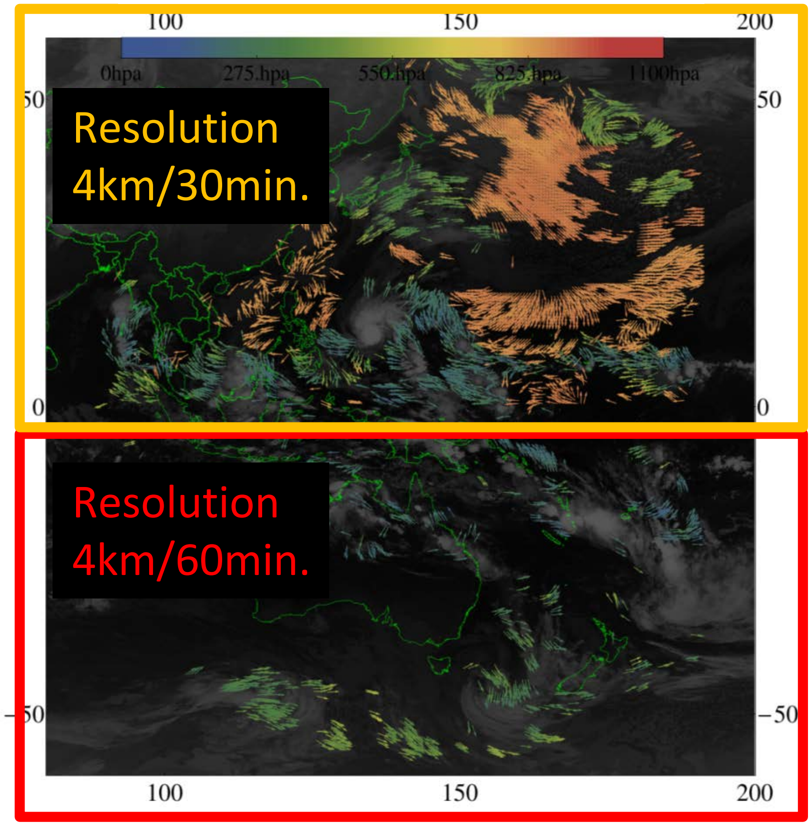
0300 UTC 20 April 2015

MSC/JMA

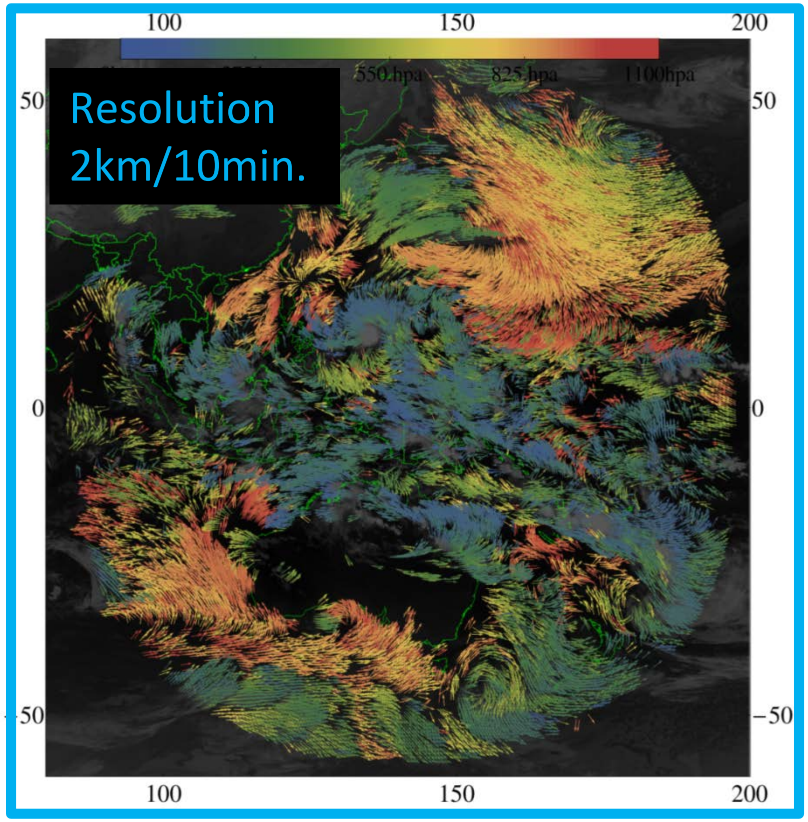
Atmospheric Motion Vectors (AMVs)

- A new algorithm was developed for AMVs detection based on an optimal estimation method
- Provided to NWP users

MTSAT-2 AMVs (QI > 60)



Himawari-8 AMVs (QI > 60)

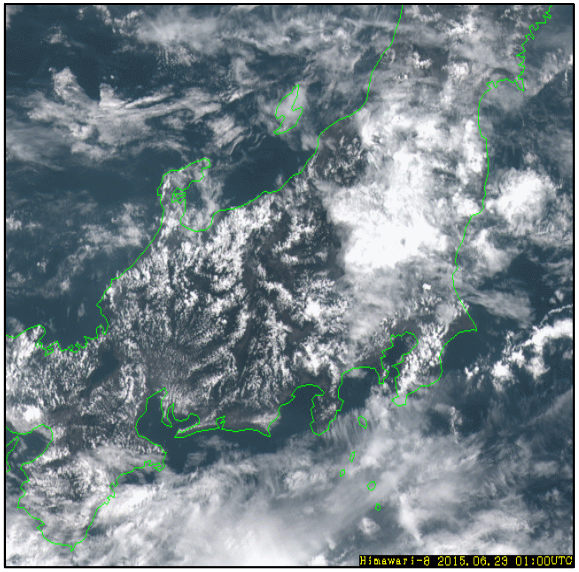


Colder color : upper level wind
Warmer color : lower level wind

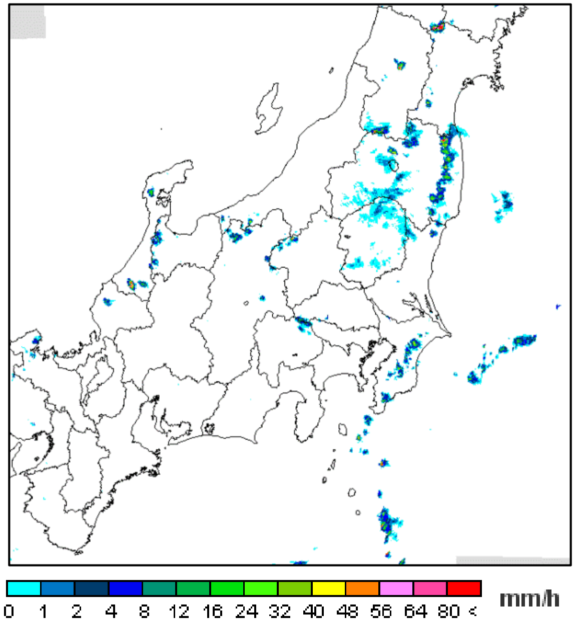
1700 UTC 14 Jan. 2015

Detection of Rapidly Developing Cumulus Area

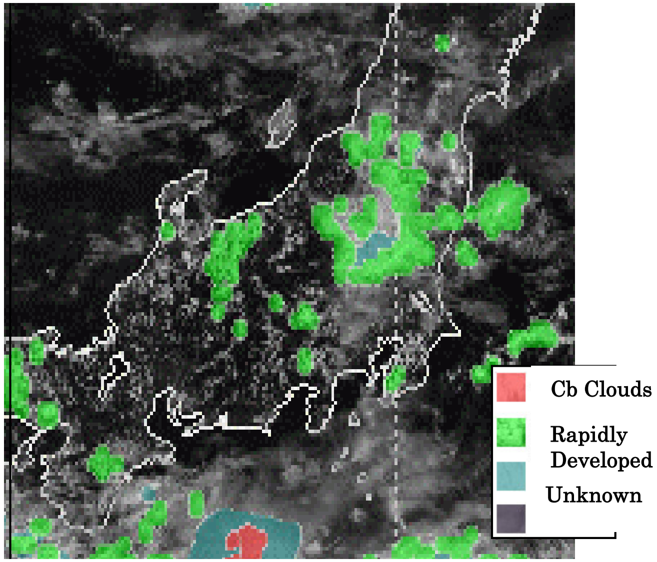
Himawari-8 Imagery



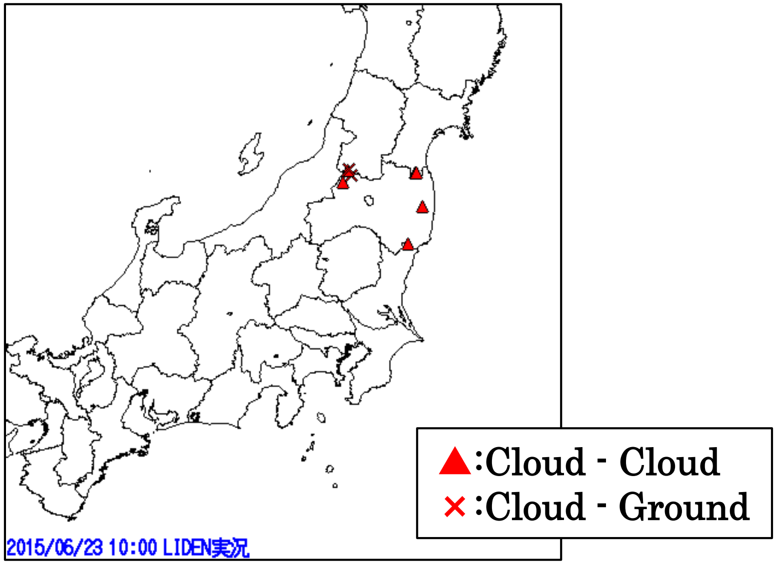
JMA's Weather Radar System



Convective Cloud Information



JMA's Lightning Detection Network (LIDEN)



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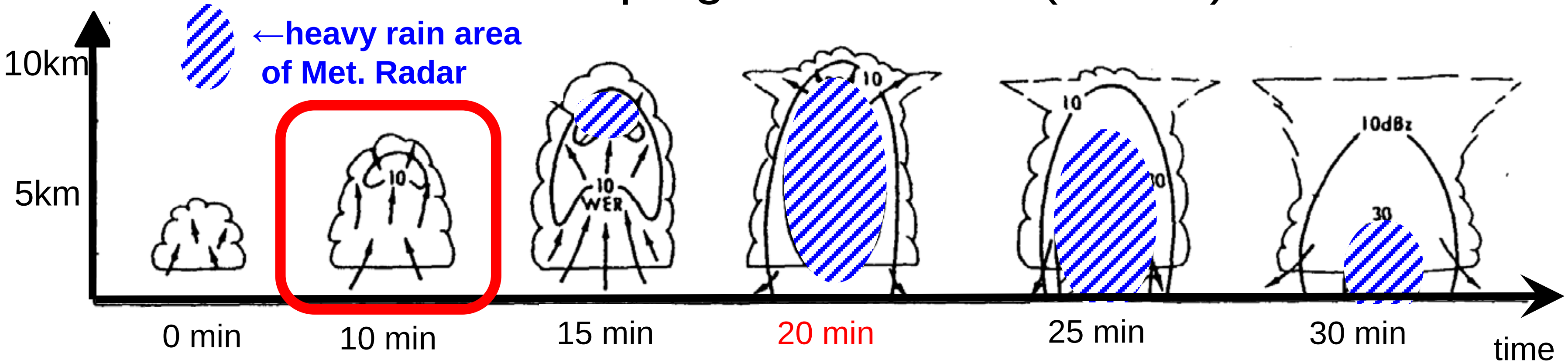
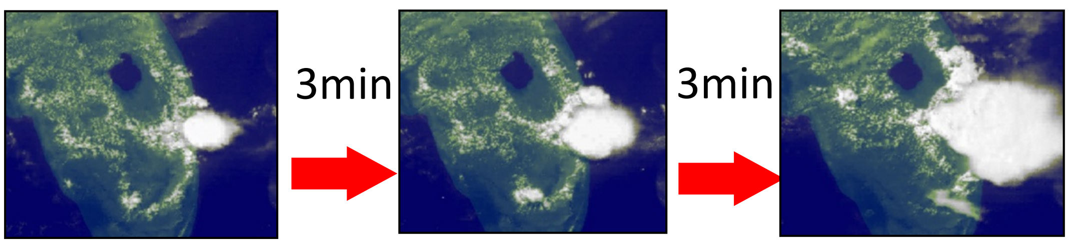
Developing Cumulus and Radar Echo

Developing of Cumulus (model)



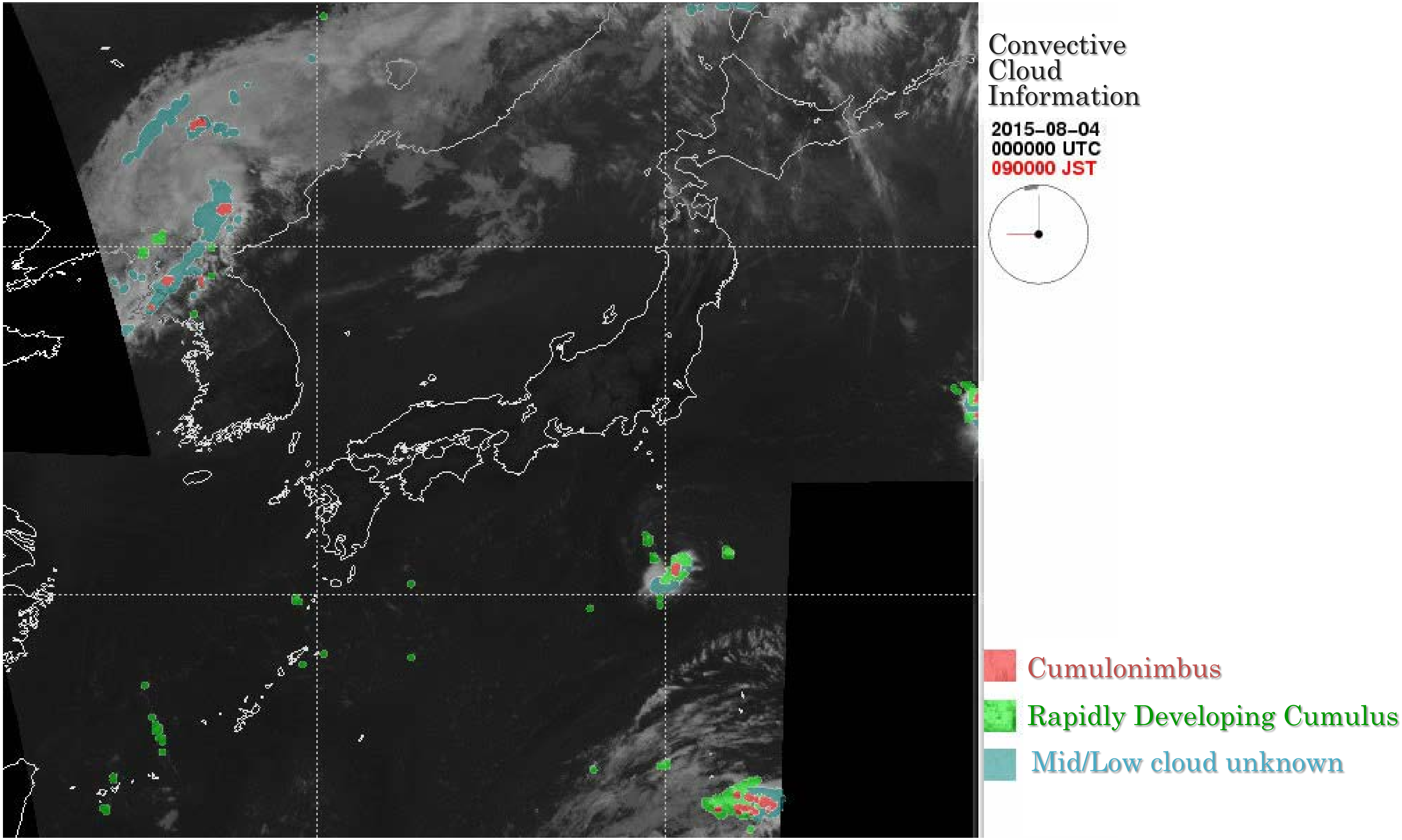
Chisholm, A. J. and Renick, J. H. (1972) [traced and added]



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

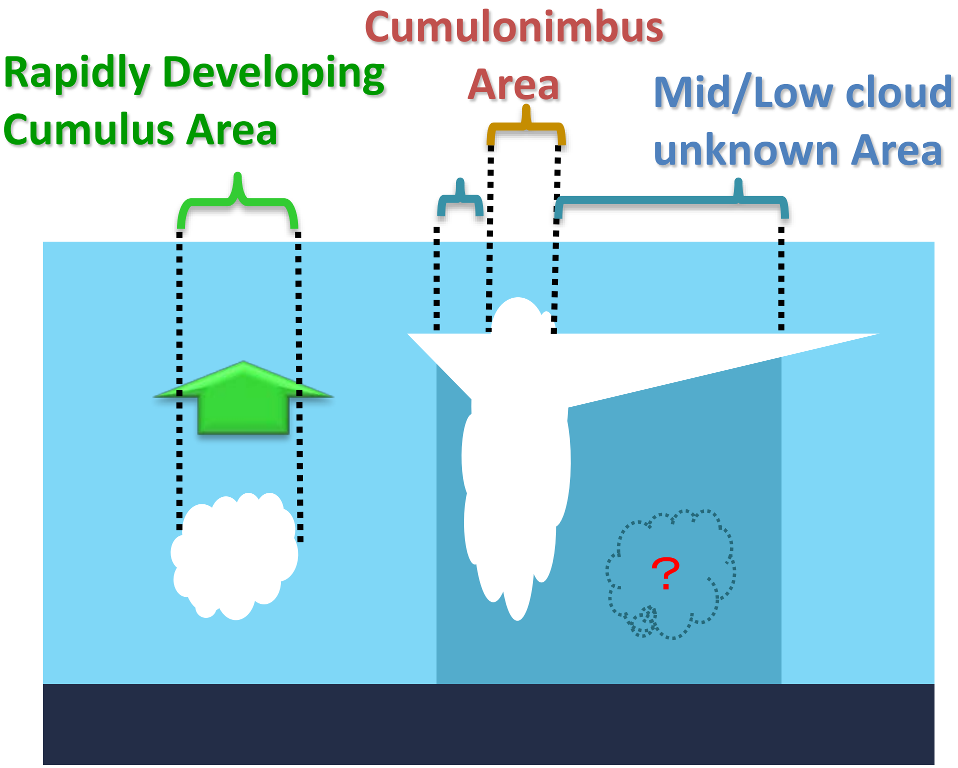
Prepare for thunderstorm!

RDCA Product

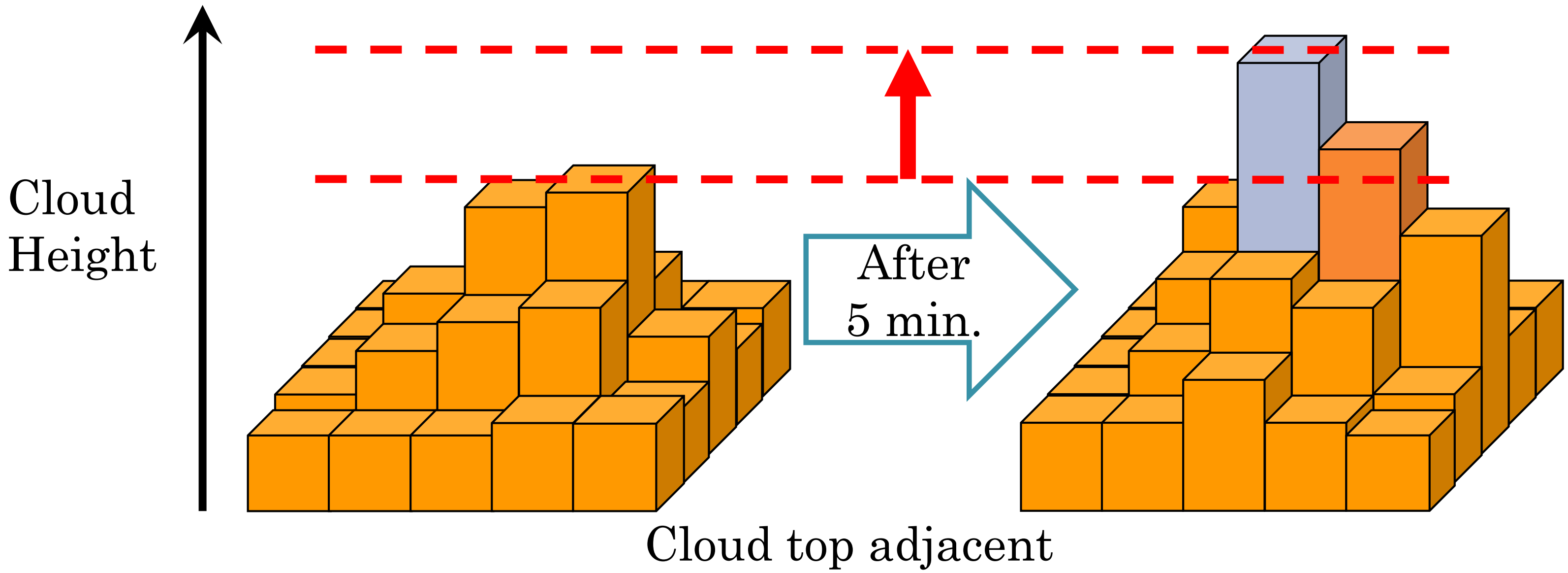


RDCA Product

- **Rapidly Developing Cumulus Area (RDCA)**
  - ✓ Developing cumulous
  - ✓ Current/Future disturbance is expected
- **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 increases

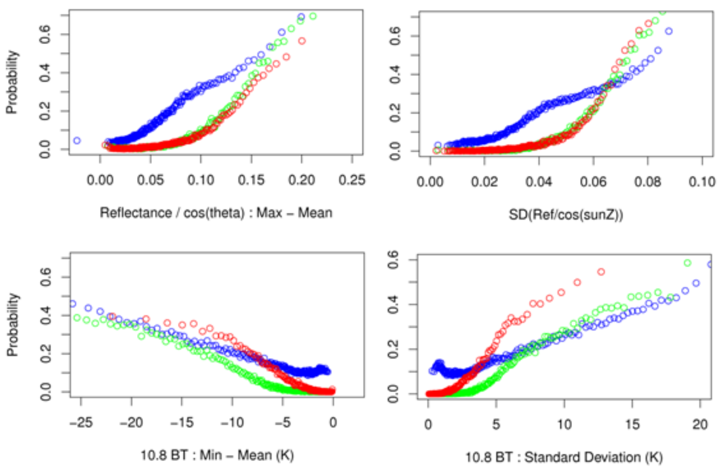
  Contrast between light and dark is getting clear.

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

- Cloud microphysical parameters change

  Ice particles are produced near cloud top

RDCA : Decision Process



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

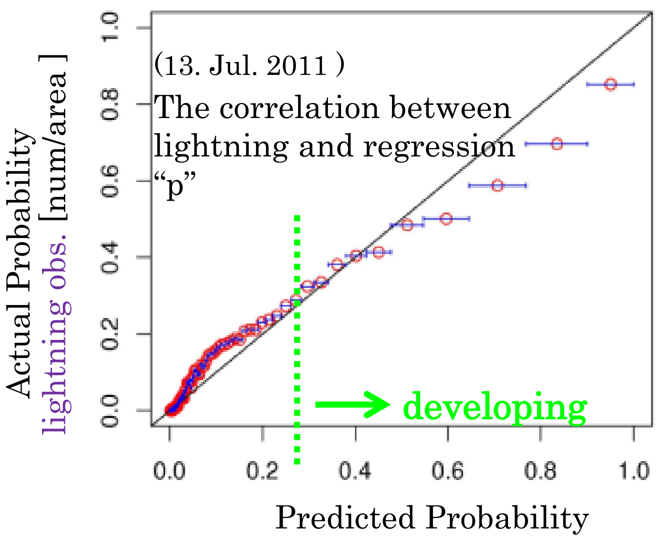
Logistic Regression Model

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

Probability (forecast)

Detection parameters

Coefficients $\boldsymbol{a_i}$ are determined by the **logistic regression model** when lightning occurs within 60 minutes after observed variable x_i .

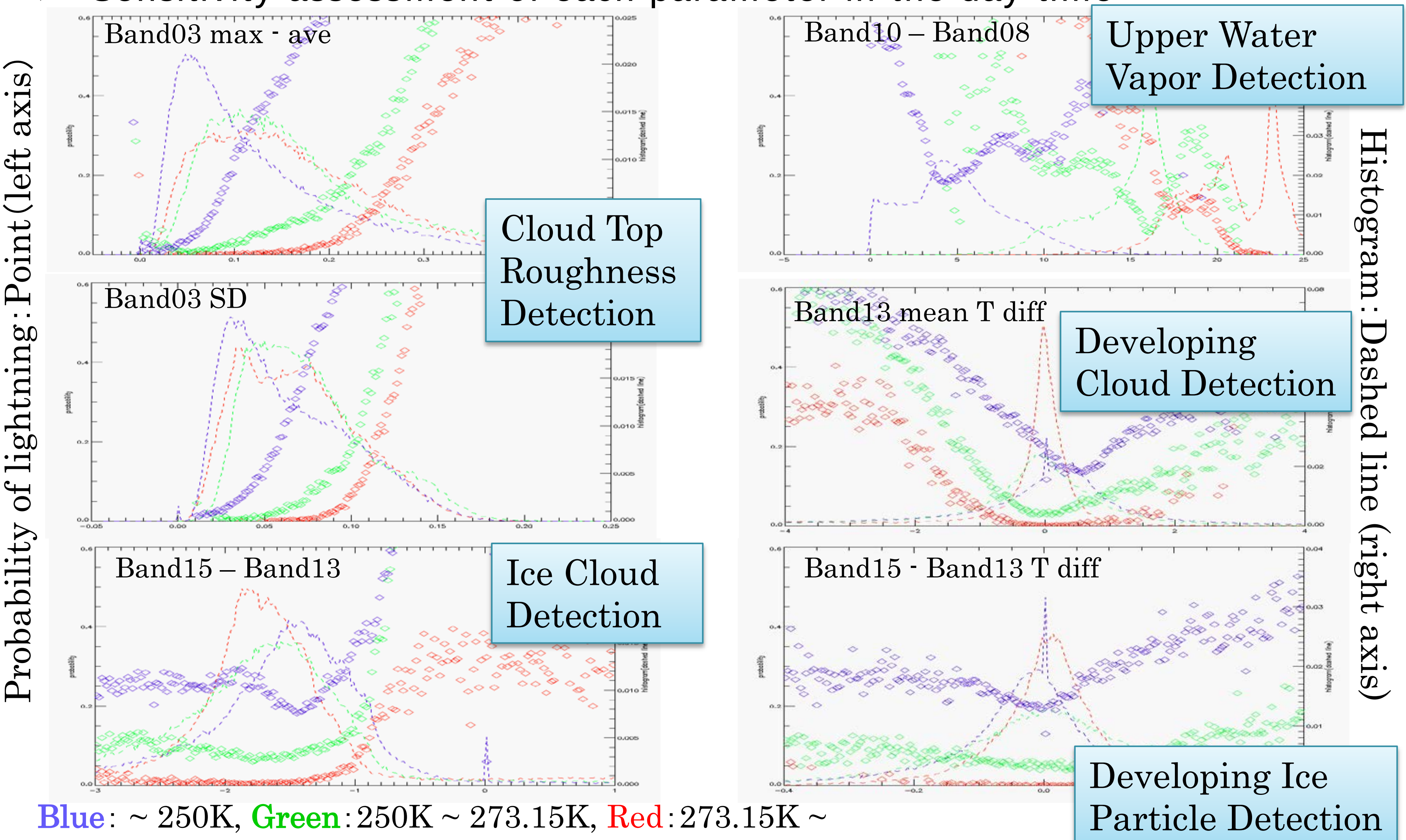


=> High "P" area is decided as RDCA

➢ RDCA detection parameters

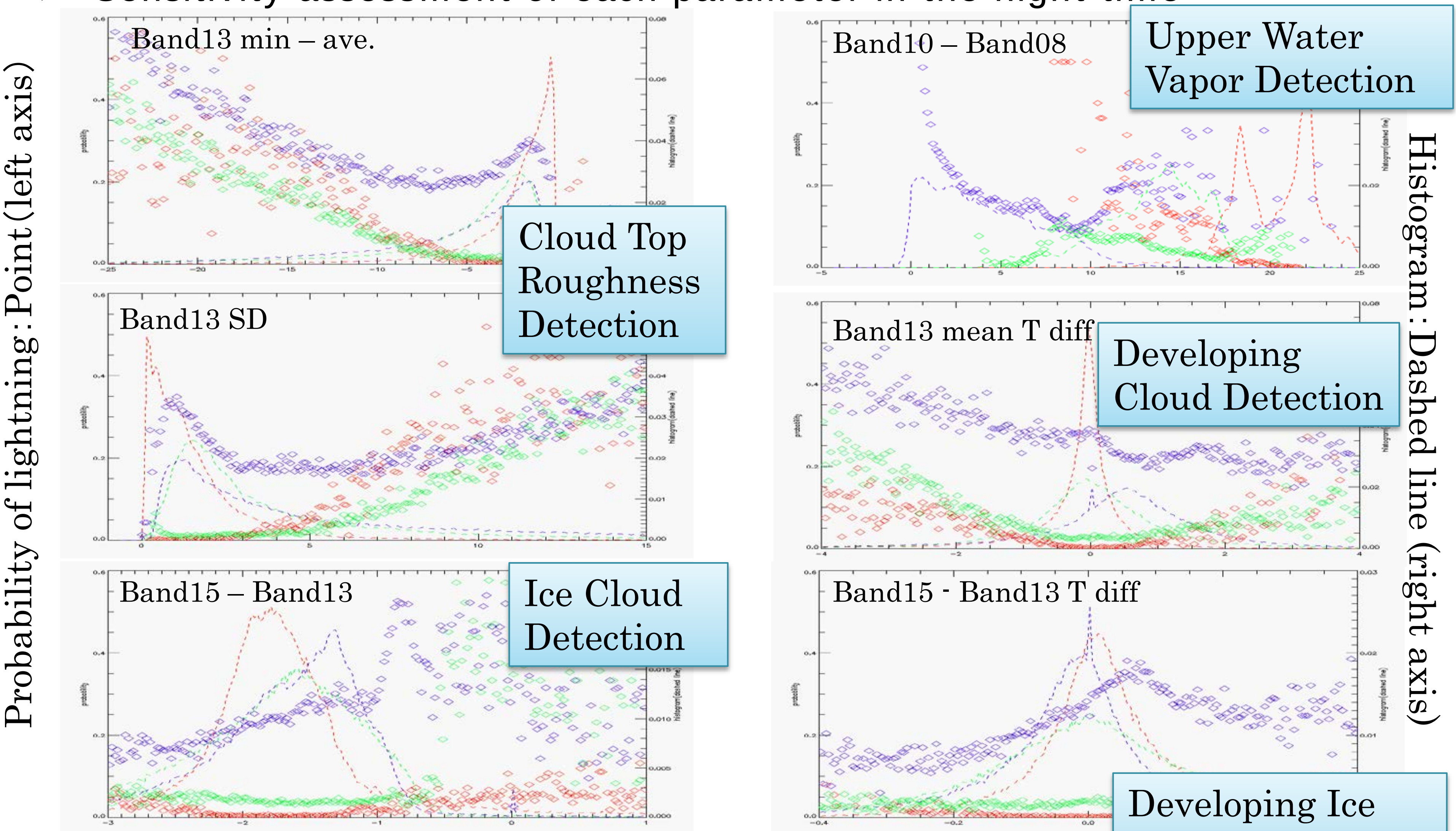
	Detection Parameter	Main Objective	
Only day time	B03(0.64µm):Max-Ave.*[2]	Cloud Top Roughness Detection	One Scene Parameters
Only day time	B03:Standad Deviation*[2]	Cloud Top Roughness Detection	One Scene Parameters
	B13(10.4µm):Min.-Ave.	Cloud Top Roughness Detection	One Scene Parameters
	B13:Standard Deviation	Cloud Top Roughness Detection	One Scene Parameters
New	B16(13.3µm)-B13	Ice Cloud Detection	One Scene Parameters
New	B08(6.2µm)-B13	Ice Cloud Detection	One Scene Parameters
New	B15(12.4µm)-B13	Ice Cloud Detection	One Scene Parameters
New	B11(8.6µm)-B13	Ice Cloud Detection	One Scene Parameters
New	B10(7.3µm)-B08	Water Vapor Detection above Cloud Top	One Scene Parameters
Only day time	Temporal Variation of B03 Average Value*[2]	Developing Cloud Detection	Time Change Parameters
	Temporal Variation of B13 Average Value	Developing Cloud Detection	Time Change Parameters
New	Temporal Variation of B11-B13 Average Value	Developing Ice Particle Detection	Time Change Parameters
New	Temporal Variation of B15-B13 Average Value	Developing Ice Particle Detection	Time Change Parameters

- Sensitivity assessment of each parameter in the day time



Blue : ~ 250K, Green : 250K ~ 273.15K, Red : 273.15K ~

- Sensitivity assessment of each parameter in the night time

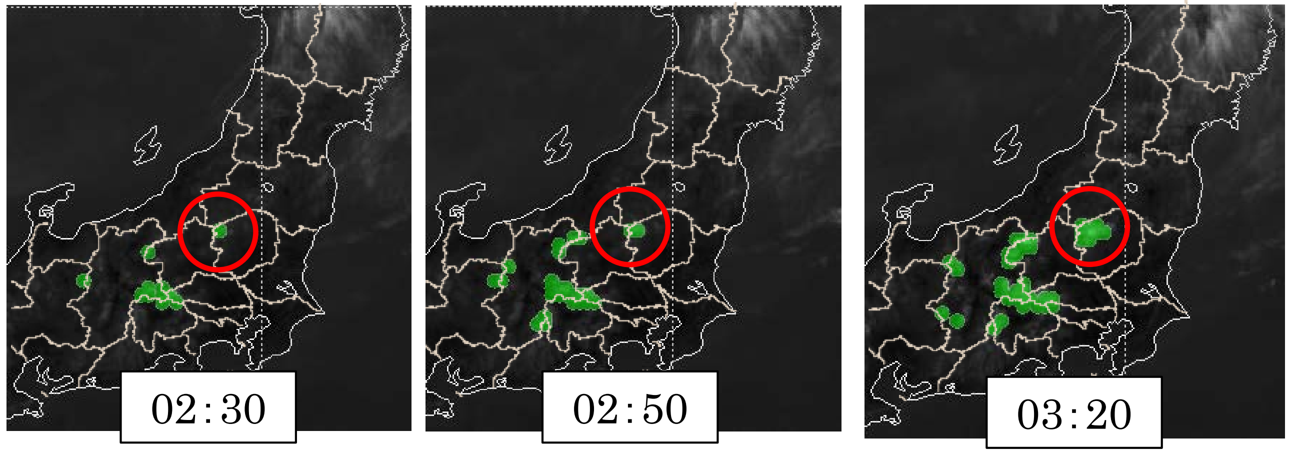


Blue : ~ 250K, Green : 250K ~ 273.15K, Red : 273.15K ~

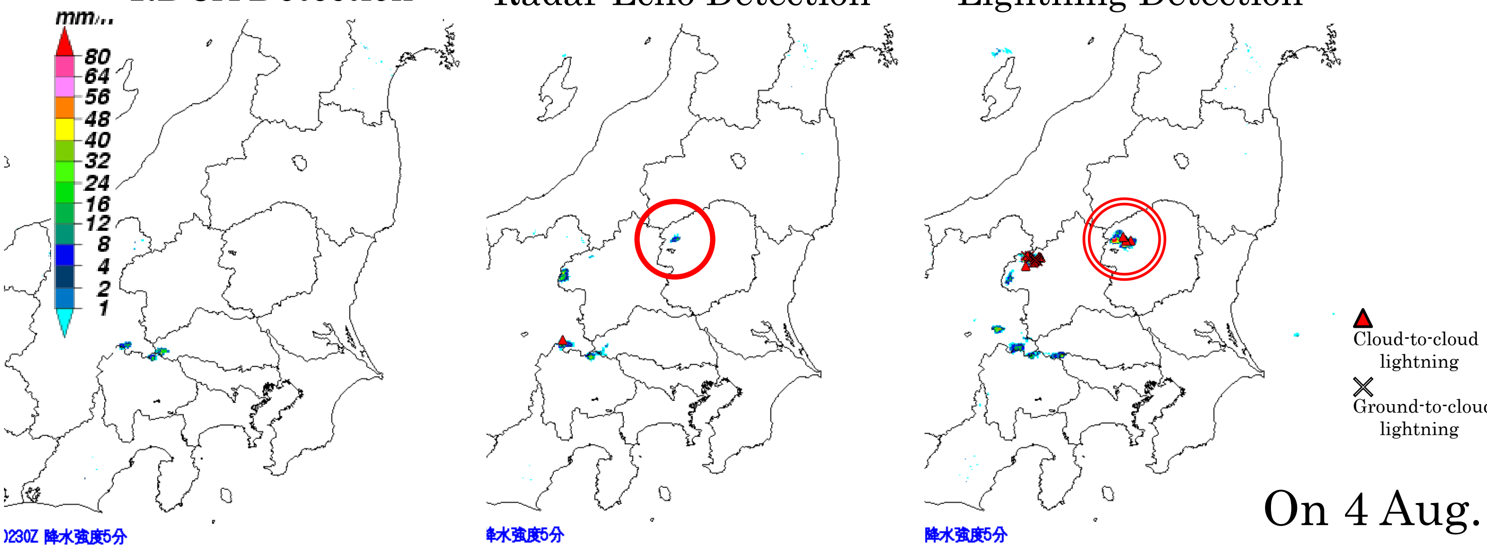
Case Study (1)

- ➢ Early detection of convective cloud with lightning

→ RDCA product can detect developing cumulus earlier than a radar echo.

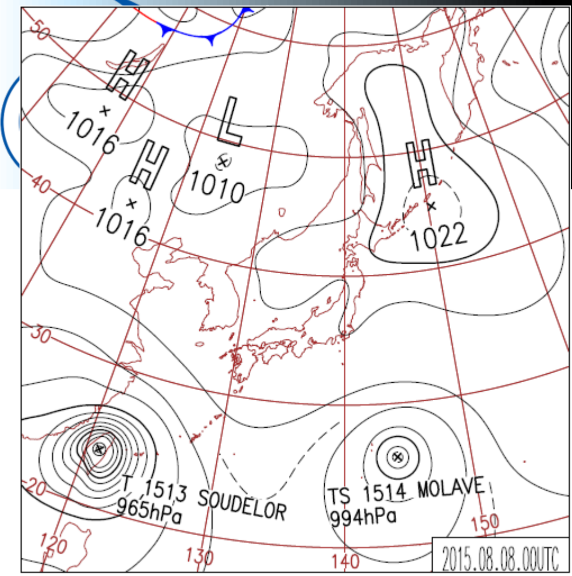


RDCA Detection | Radar Echo Detection | Lightning Detection

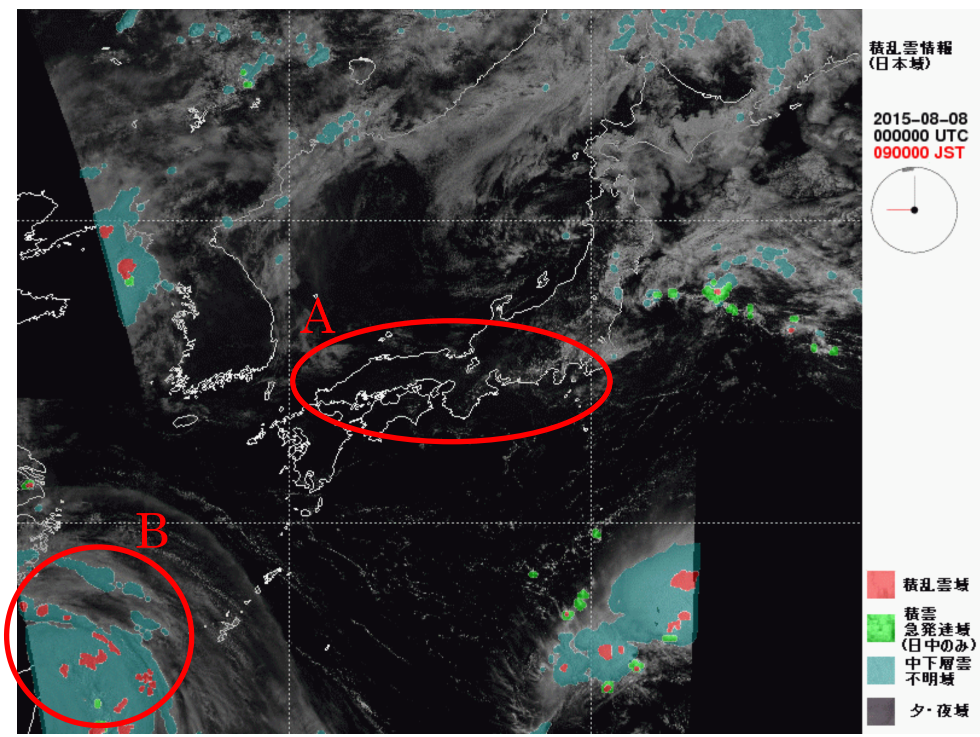


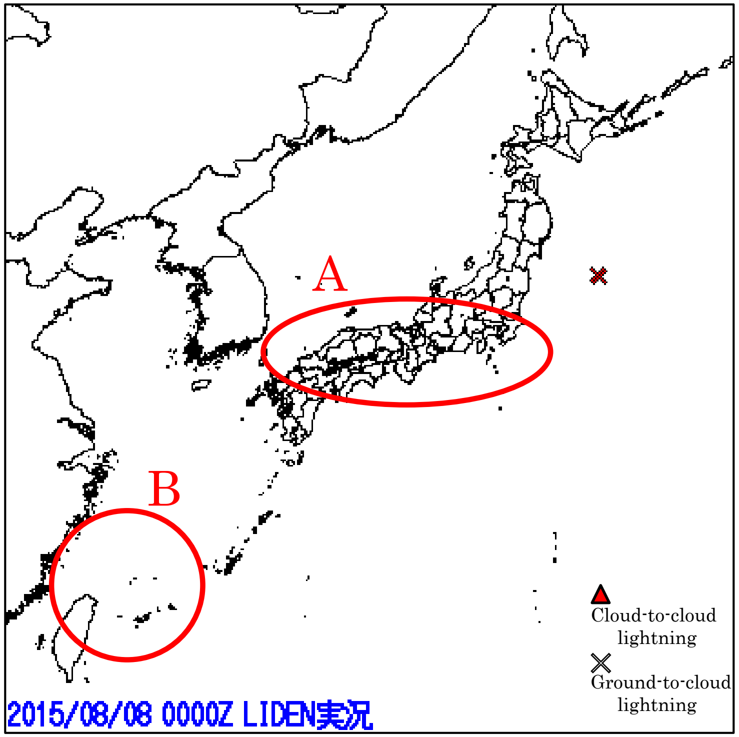
On 4 Aug. 2015

Case Study (2)



- 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)

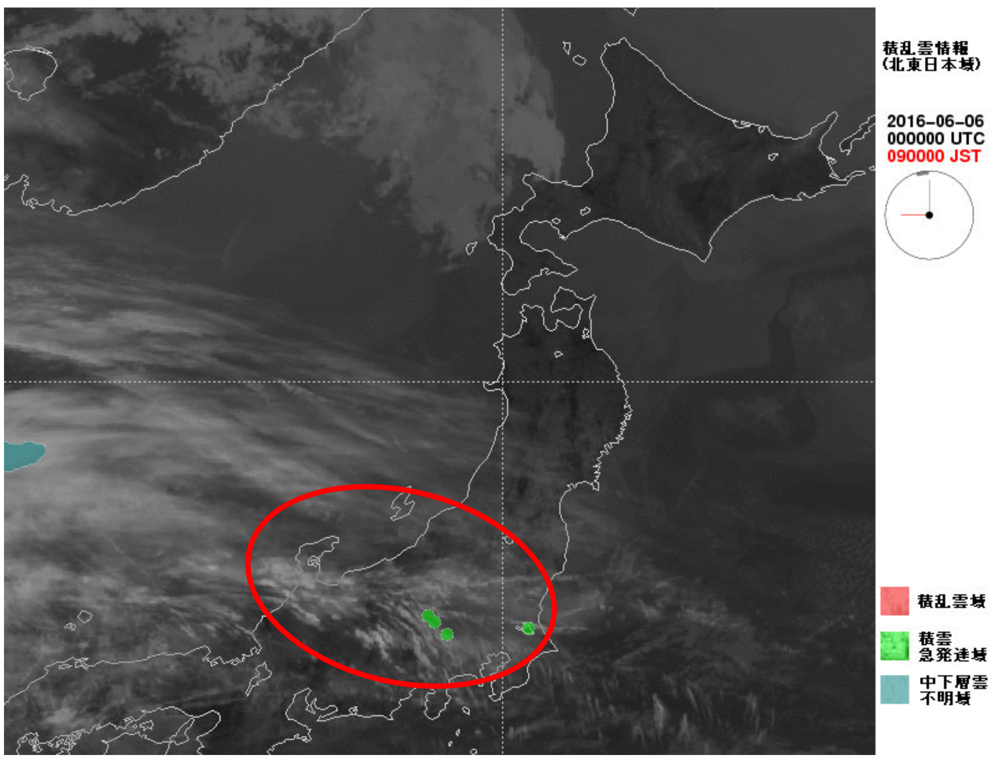


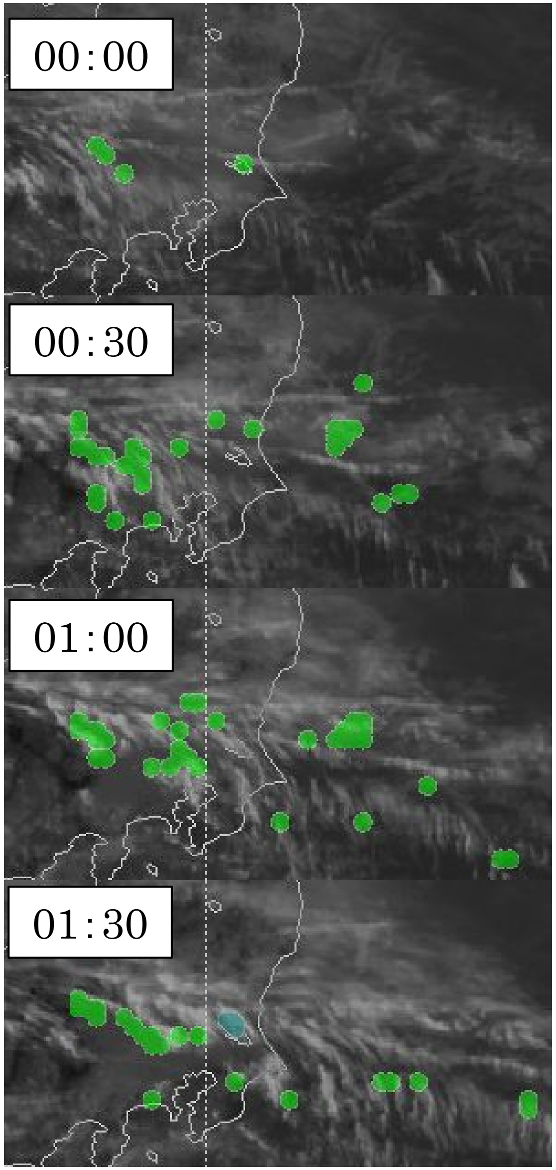


On 8 Aug. 2015

Case Study (3)

➢ False detection due to passing upper clouds
→ Brightness temperature seems to decrease rapidly because upper clouds pass over lower clouds



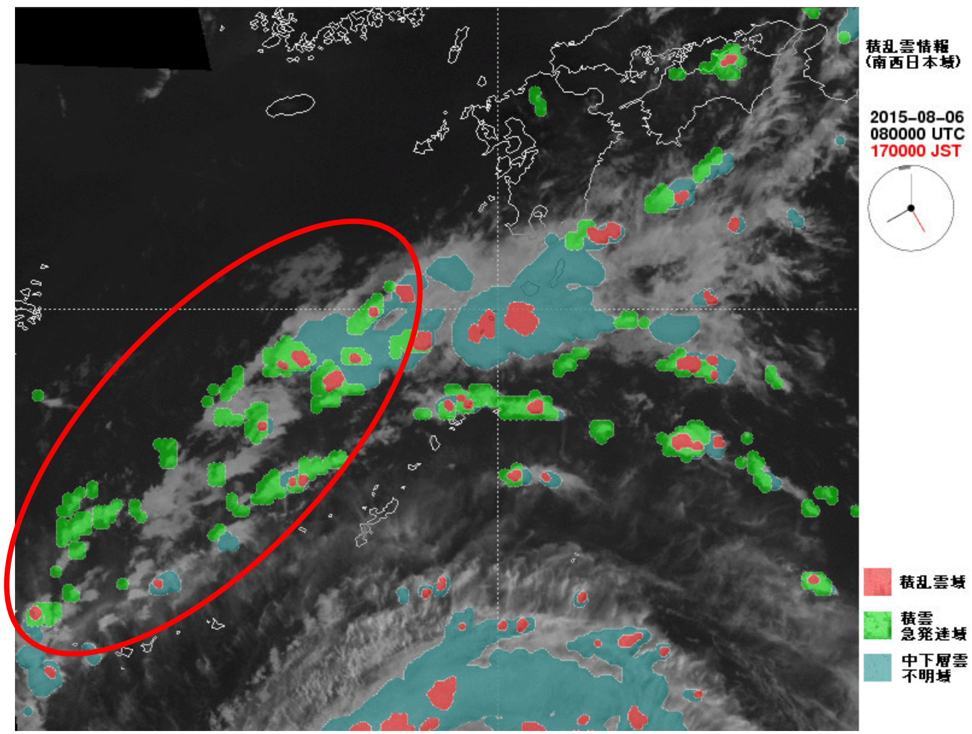


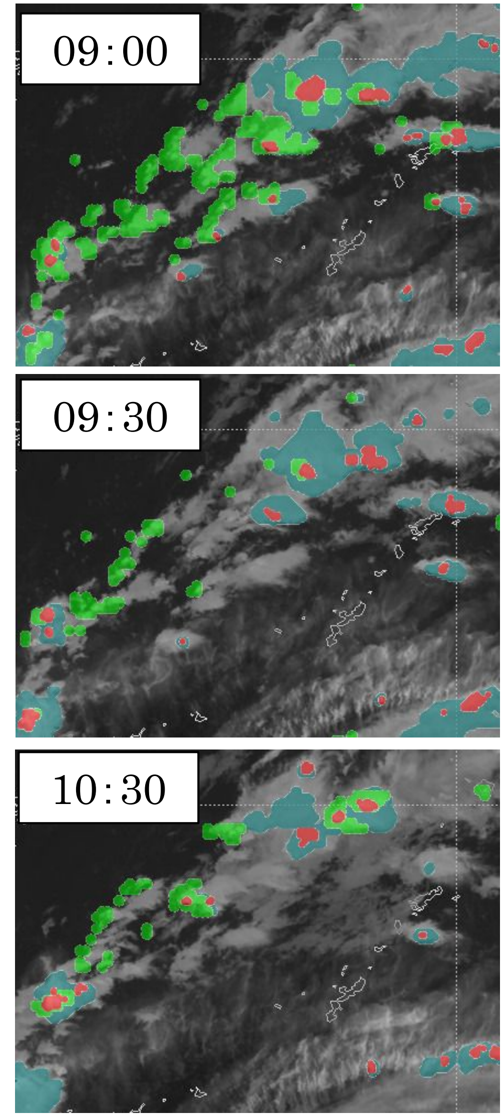
On 6 June 2016

Case Study (4)

➢ Decrease in the number of the RDCA detection at night

→ Detection parameters of visible band are not used at night





On 6 Aug. 2015

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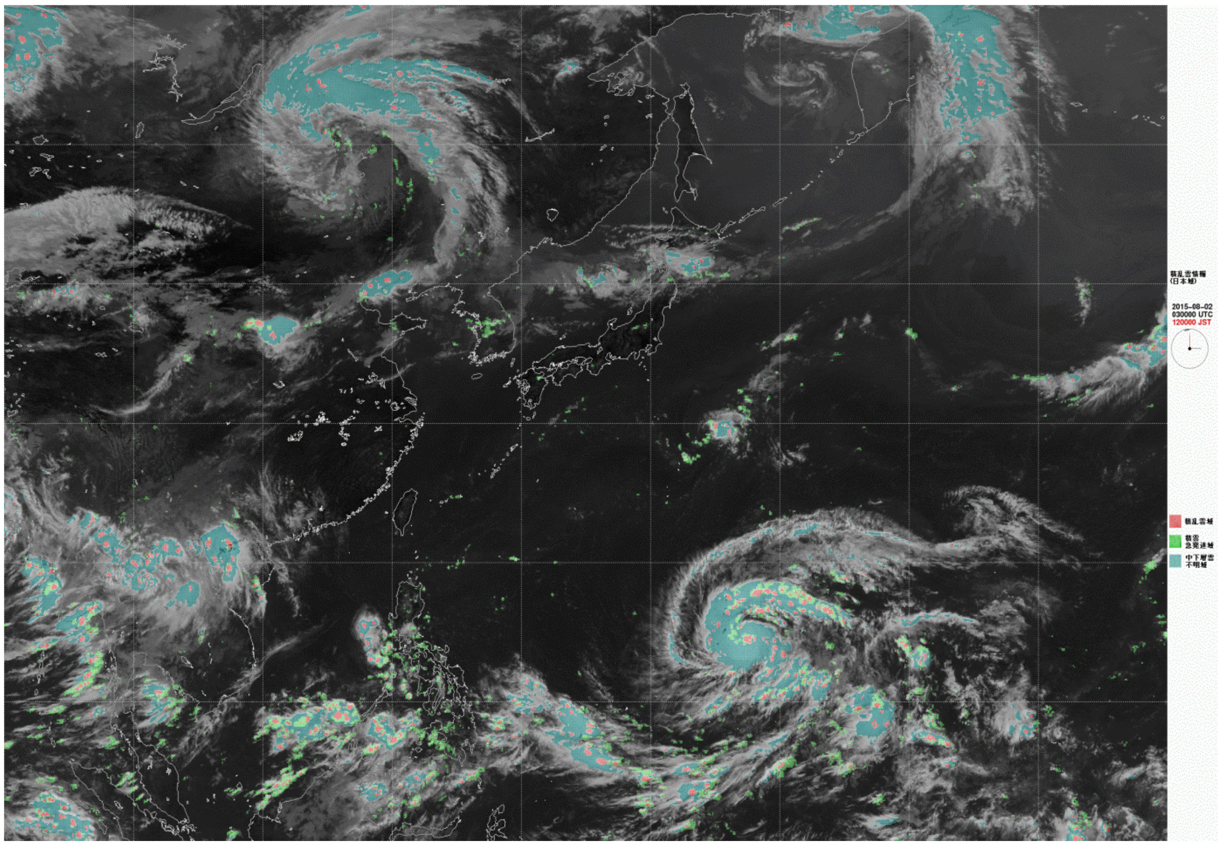
Future Plan

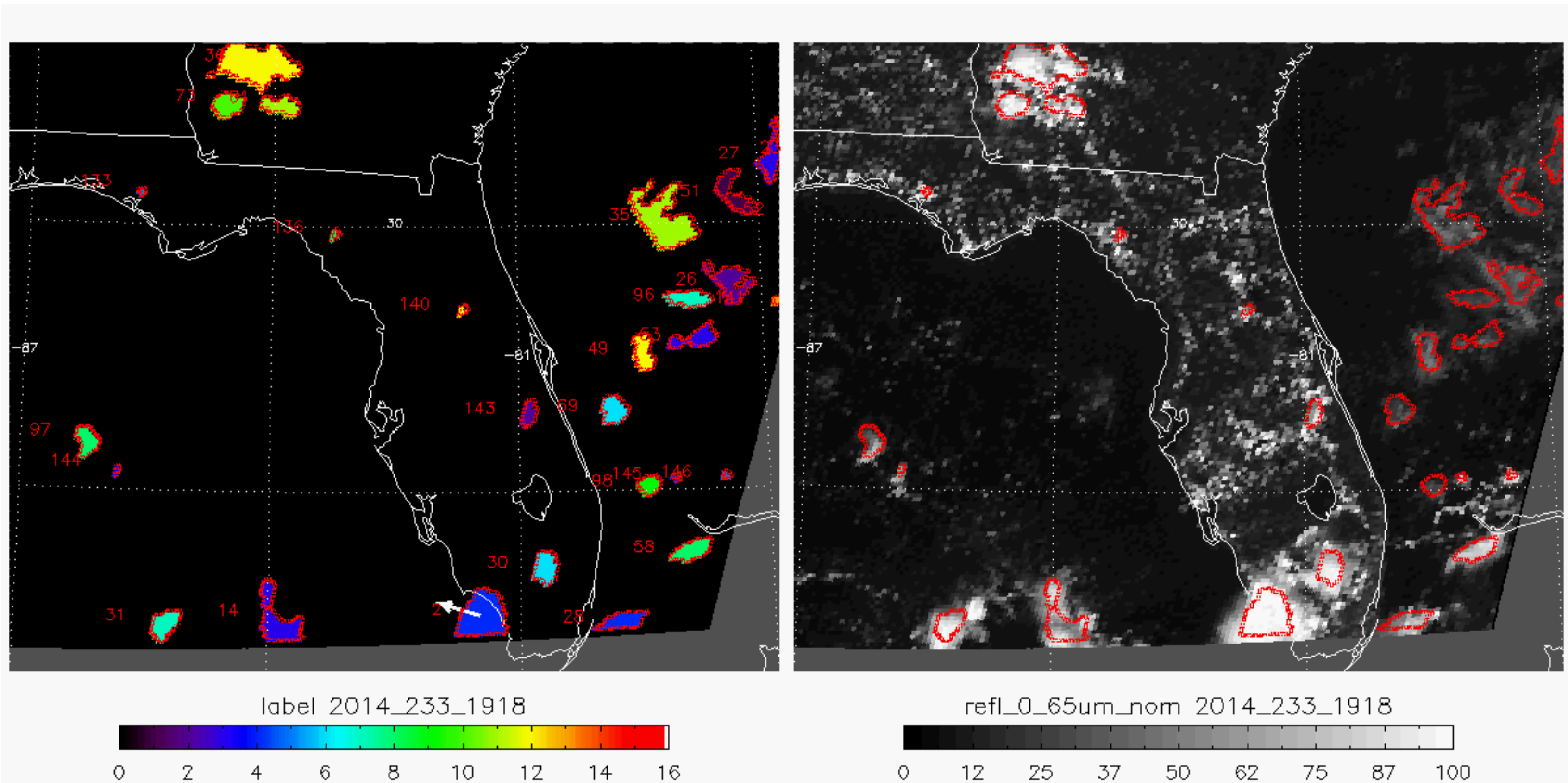
- Domain extension of the RDCA product using Himawari-8/AHI Full Disk observation data for safety and air traffic control over Asia and Western Pacific regions



Sample of extended domain RDCA product

Future Plan

- Improvement of the RDCA detection algorithm (e.g. cloud tracking)



Sample of cloud object tracking

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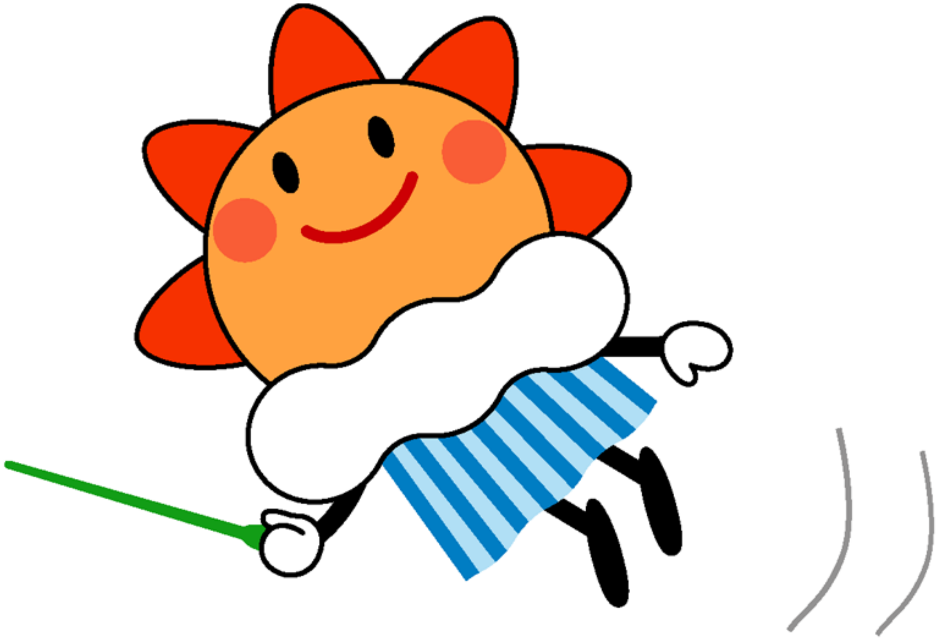
Summary

- **Improved Observation Function by Himawari-8/AHI**
  - ✓ *High-resolution and high-frequency observation using multiple bands enables to capture server weather phenomena*
  - ✓ *Many products have been developed using AHI observation data*
- **Detection of Rapidly Developing Cumulus Area**
  - ✓ *Statistical method is used for rapidly developing cumulus detection*
  - ✓ *RDCA product has been operational all day using multiple observation bands data*
- **Future Plans**
  - ✓ *Domain extension of the RDCA product*
  - ✓ *Improvement of the RDCA detection algorithm*

Thank you for your kind attention



JMA mascot character
“Harerun”