Detection of convective overshooting tops using Himawari-8 AHI, CloudSat CPR, and CALIPSO data

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Contents

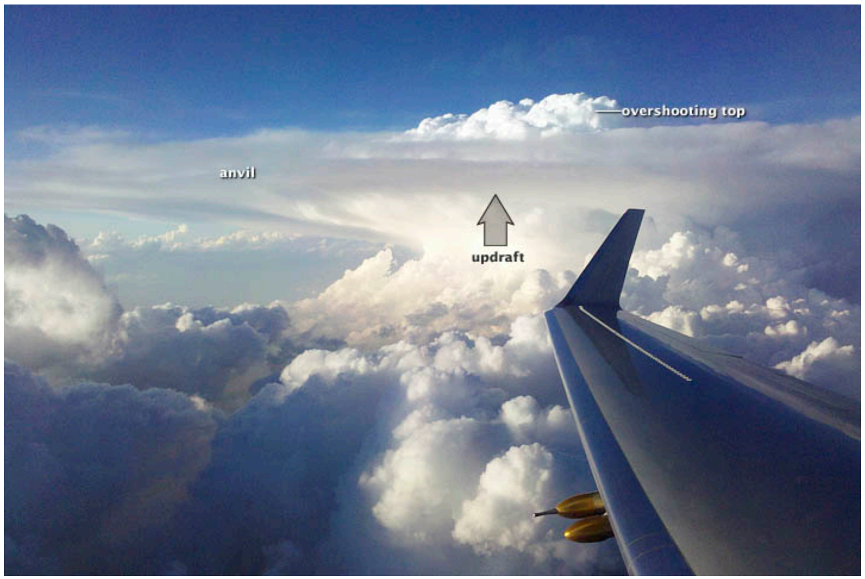
Intelligent Remote sensing and geospatial Information Systems

ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY 2009

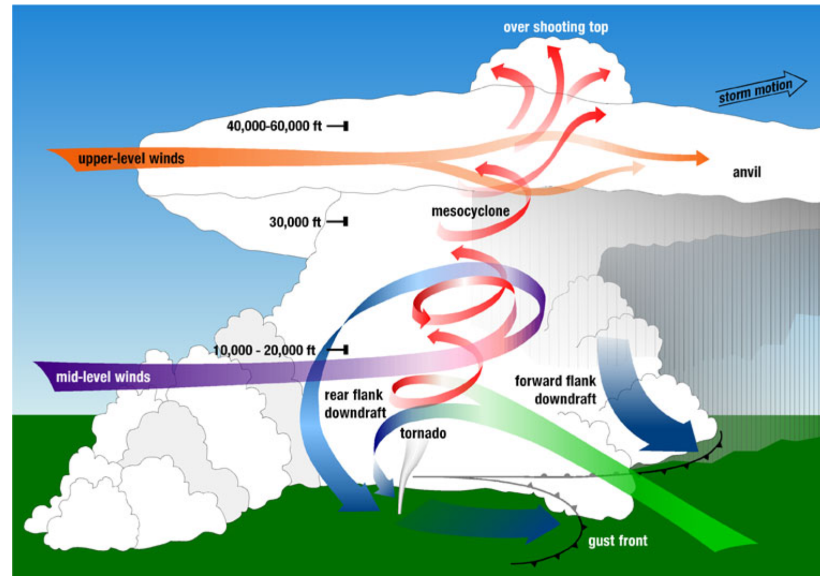
Introduction

Overshooting Tops (OT): "a domelike protrusion above a cumulonimbus anvil, representing the intrusion of an updraft through its equilibrium level"

[American Meteorological Society's *Glossary of Meteorology*]



NASA Earth Observatory image



Importance of research on overshooting top

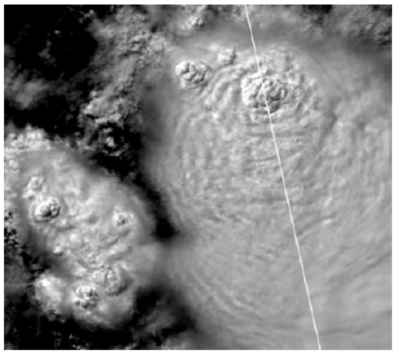
- Cumulonimbus clouds with OT can cause severe weather conditions such as ground lightning, large hail, strong winds, and heavy rainfall, significantly influencing in-flight and ground aviation operations.
- The accurate detection of OT is important for inclement weather, lightning, and aircraft turbulence.

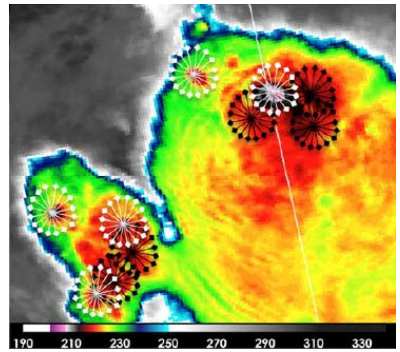
Introduction

Existing method of detecting OT IRW-Texture vs. WV-IRW BTD

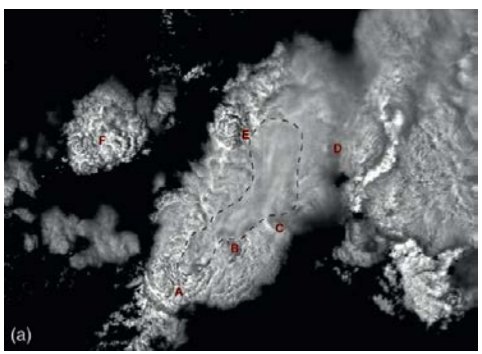
MODIS 0.25km Visible image | **MODIS Infrared channel image**

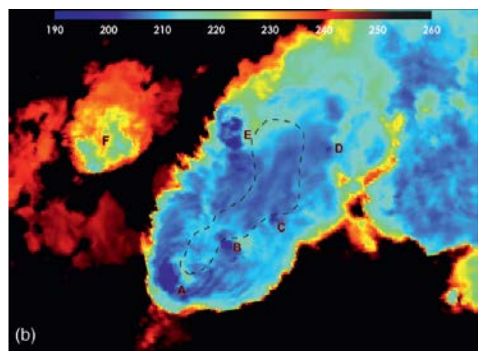
IRW-texture method

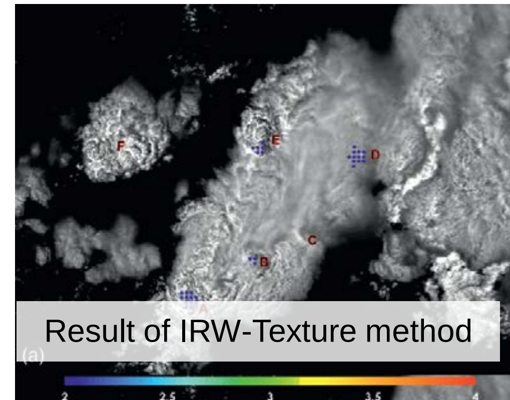


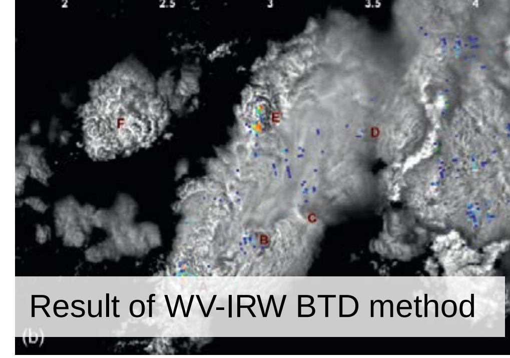


WV-IRW BTD method







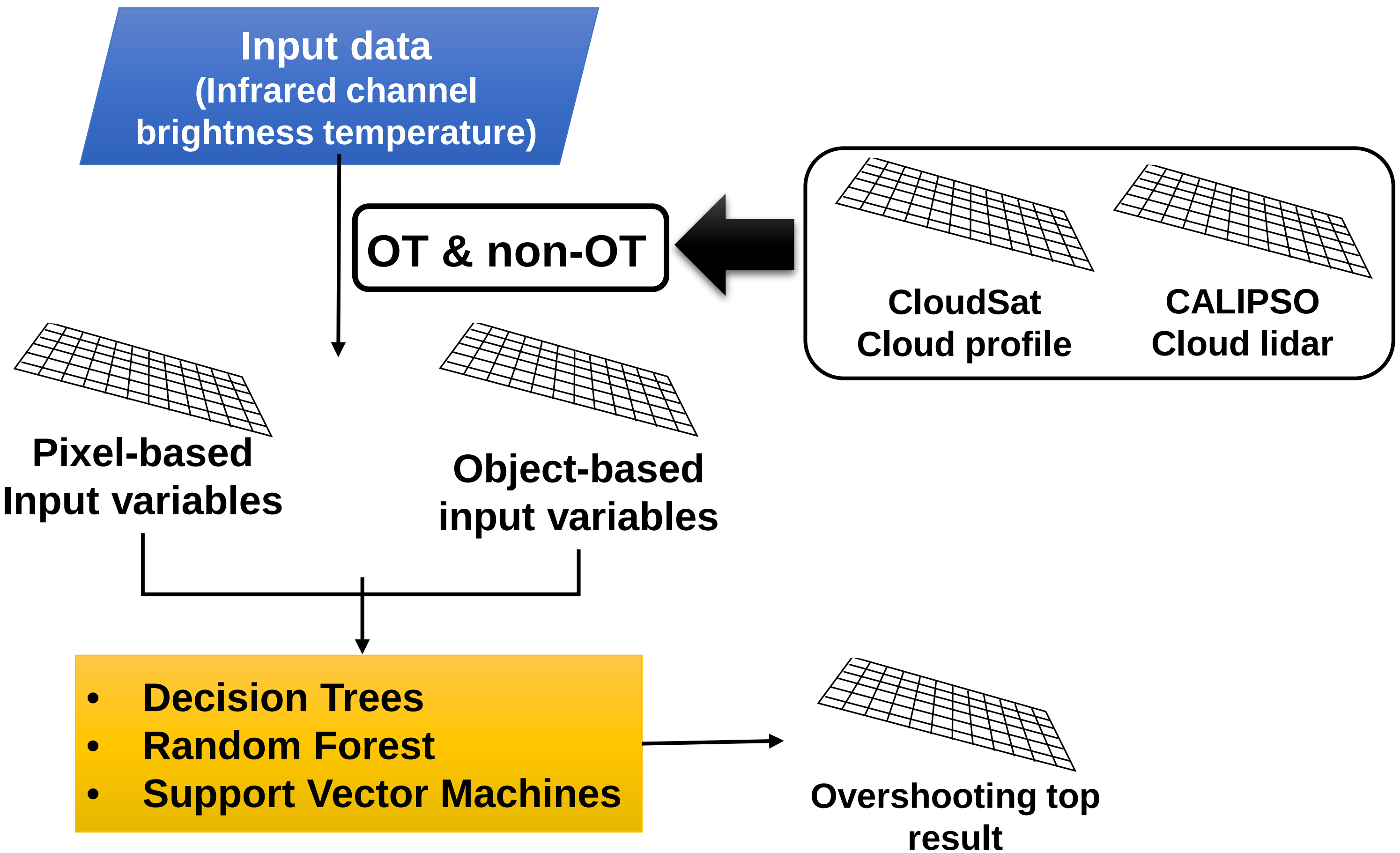


Bedka et al. 2010 (JAMC)

- **IRW-Texture method**: as it uses gradients (i.e. texture) in brightness temperature, it is called "IRW-texture". The method identifies a group of pixels with about 15 km in diameter and brightness temperatures significantly colder than the surrounding anvil cloud.
- **WV-IRW BTD method**: it uses the difference of brightness temperatures between water vapor and infrared channel.

Research methods

Flow diagram of detecting overshooting top algorithm



Research methods

◆ Data used in OT detection algorithm

❖ Satellite data

Satellite/Sensor	Channel information	Period	Spatial res.
Himawari-8 Advanced Himawari Imager (AHI)	Infrared 10.4 μm (Band 13)	June 2015	2 km

❖ Ancillary data (reference data)

Satellite/Sensor	Used data	Period	Spatial resolution
CloudSat Cloud Profiling Radar (CPR)	Cloud Geometrical Profile (2B-GEOPROF)	June 2015	Vertical res.: 480 m Swath: 1.3 km
CALIPSO lidar	Cloud lidar profile	June 2015	Vertical res.: 60 m Horizontal res.: 5 km

Research methods

◆ Data used in OT detection algorithm

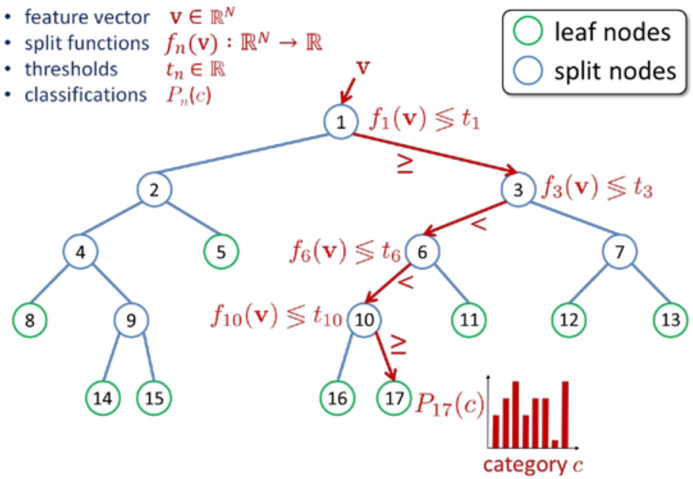
❖ Used input data

Sensor	Analysis method	Used variables	Period	Spatial res.
Himawari-8 AHI	Pixel-based	● 10.4 μm channel brightness temperature	June 2015	2 km
		● 10 min. before 10.4 μm channel brightness temperature		
		● 10.4 μm channel average and standard deviation (Moving window size (MWS) = 5, 7, 11)		
		● Difference of 10.4 μm channel brightness temperature and 10 min. before one (MWS = 1, 3, 5)		
	Object-based	● Object-based variables (a total of 13 variables) - Area, asymmetric, compactness, mean, 10 min. before mean, radius of the major/minor axis, roundness, skewness, 10 min. before skewness, STD(standard deviation), 10 min. before STD, width		

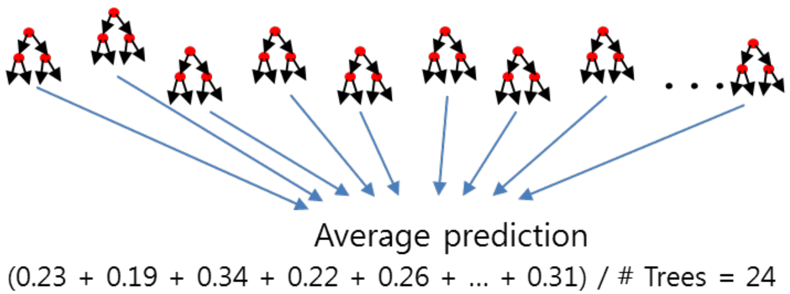
Research methods

❖ Machine learning methods used for detection of OT

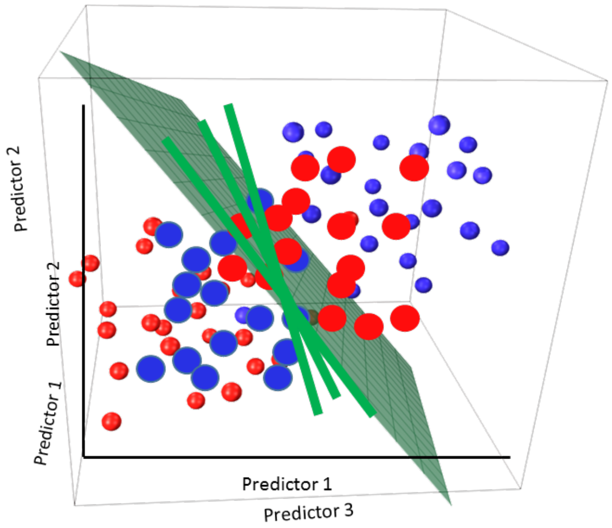
Decision Trees (DT)



Random Forest (RF)
(Ensemble of several decision trees)



Support Vector Machines (SVM)

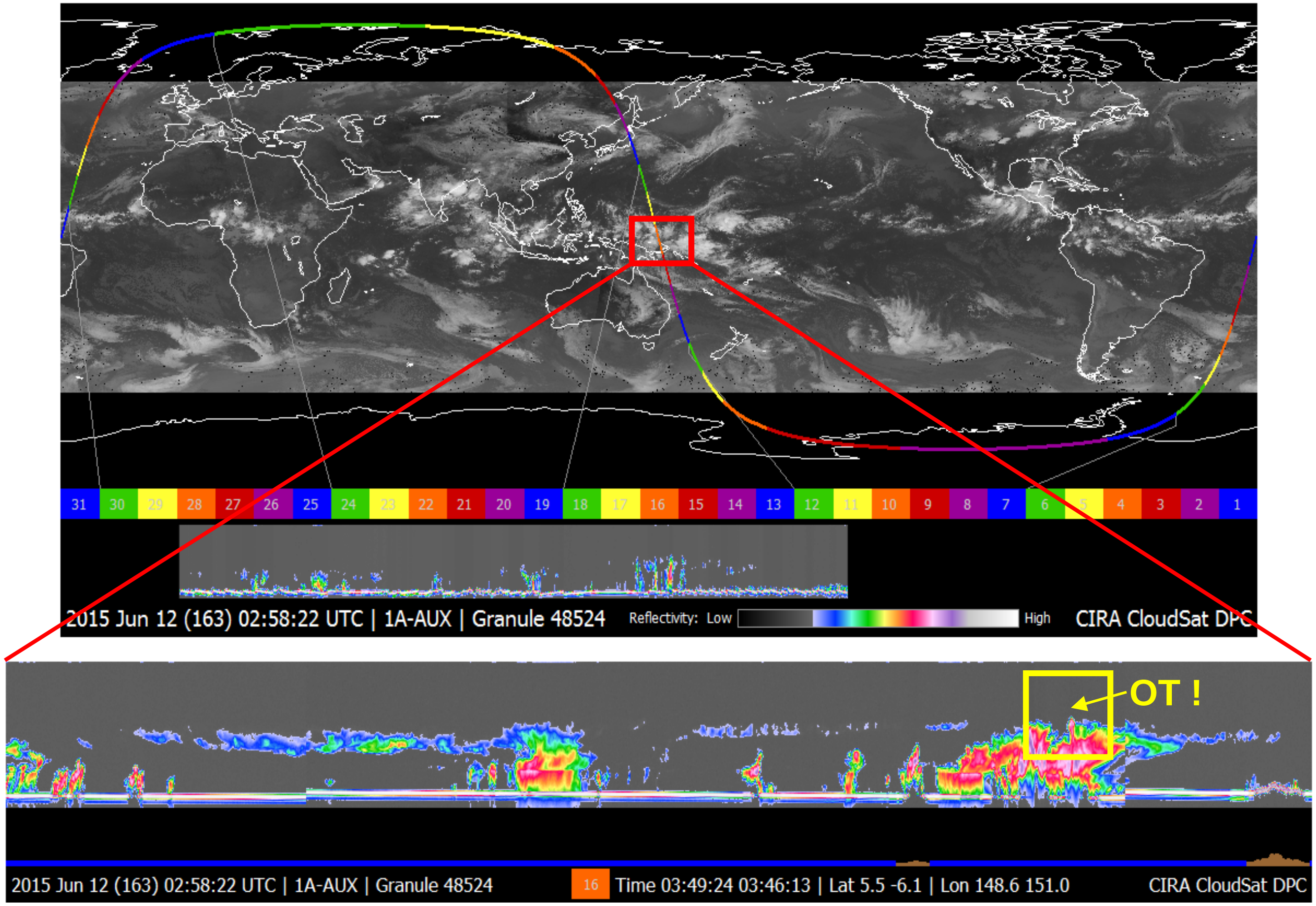


Research results

◆ **Construction of OT cases using CloudSat and CALIPSO data & Sampling for OT and non-OT region**

❖ **Construction of OT cases using CloudSat CPR data**

At about 03:50 June 12, 2015

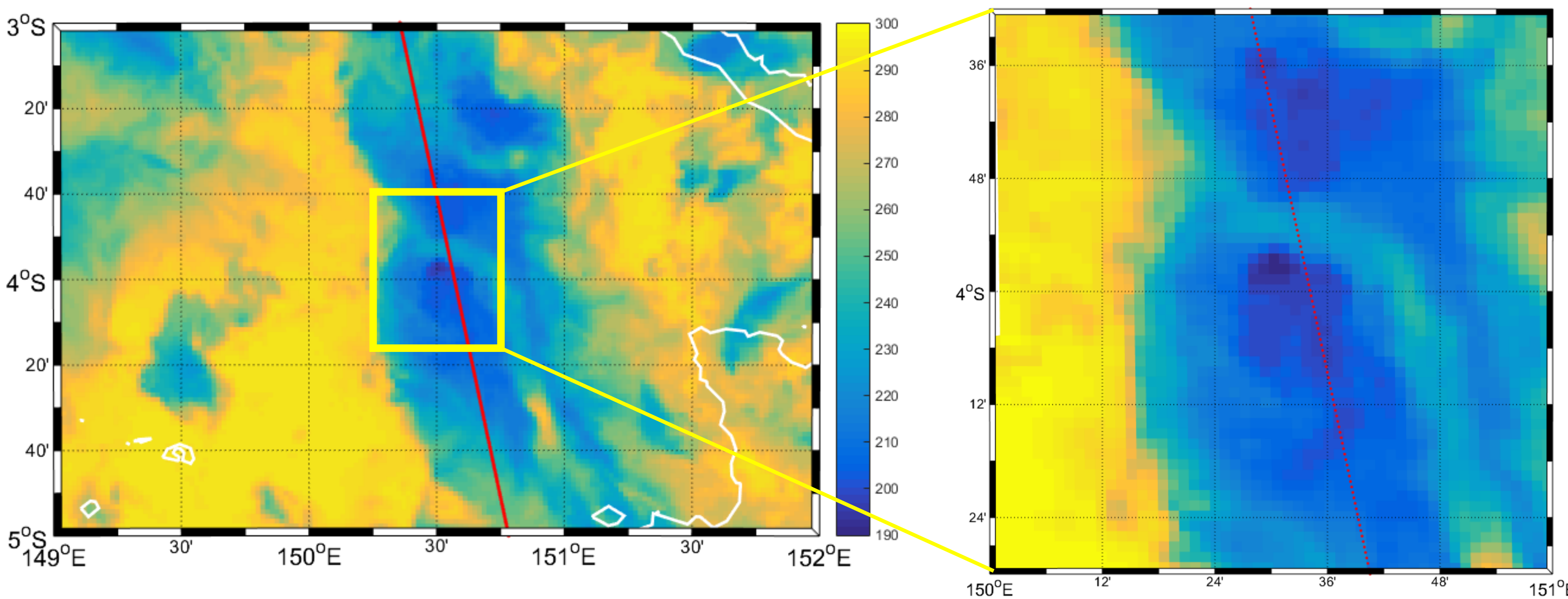


Research results

◆ **Construction of OT cases using CloudSat and CALIPSO data & Sampling for OT and non-OT region**

❖ **Construction of OT cases using CloudSat CPR data**

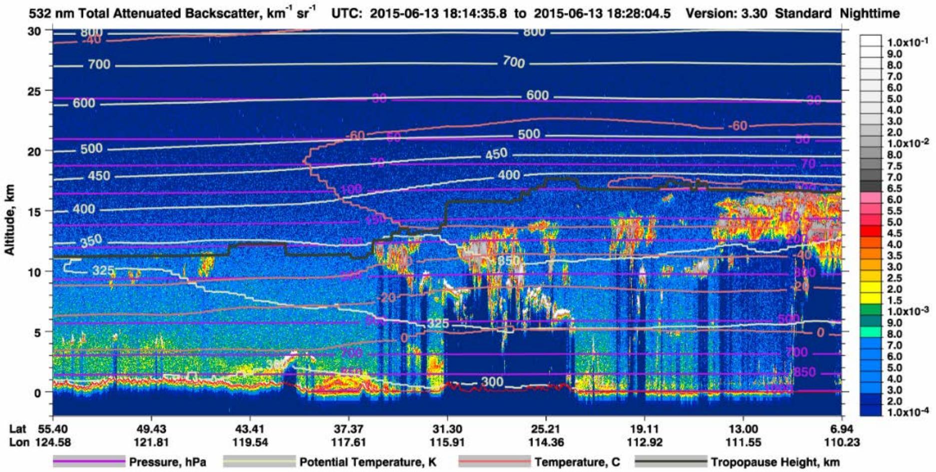
Himawari-8 image
at about 3:50 June 12, 2015

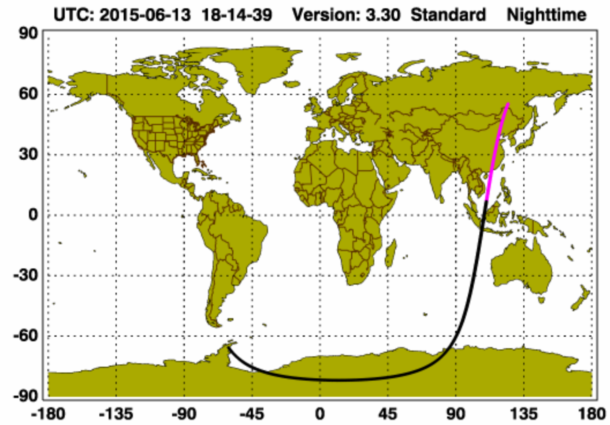


◆ **Construction of OT cases using CloudSat and CALIPSO data & Sampling for OT and non-OT region**

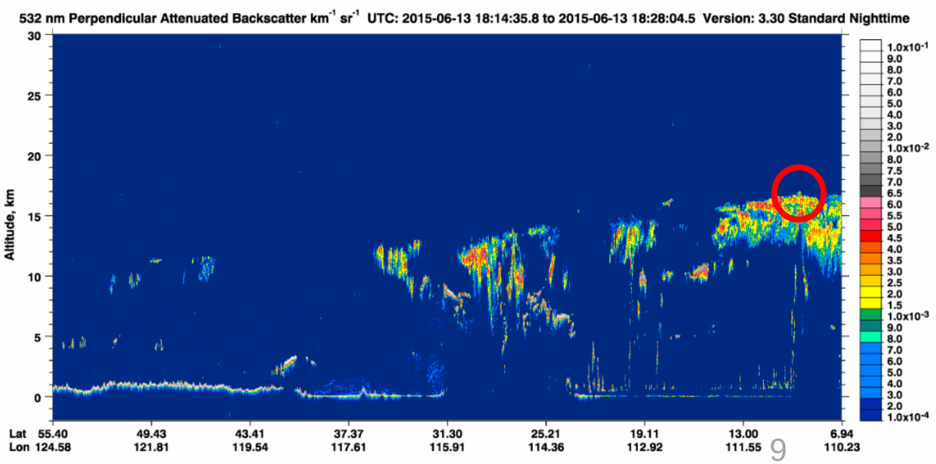
❖ **Construction of OT cases using CALIPSO data**

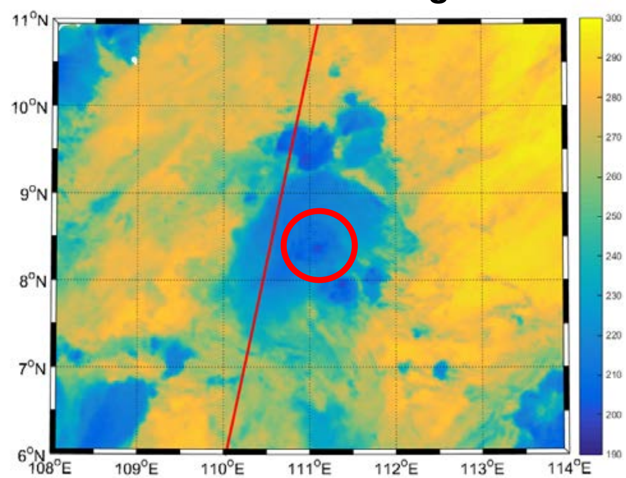
At about 18:20 June 13, 2015





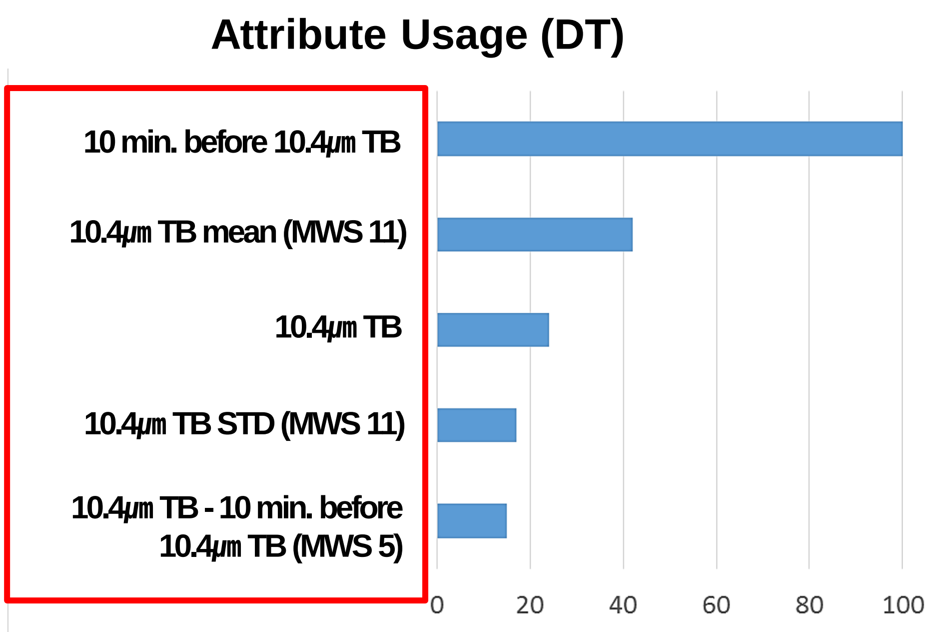
Himawari-8 image

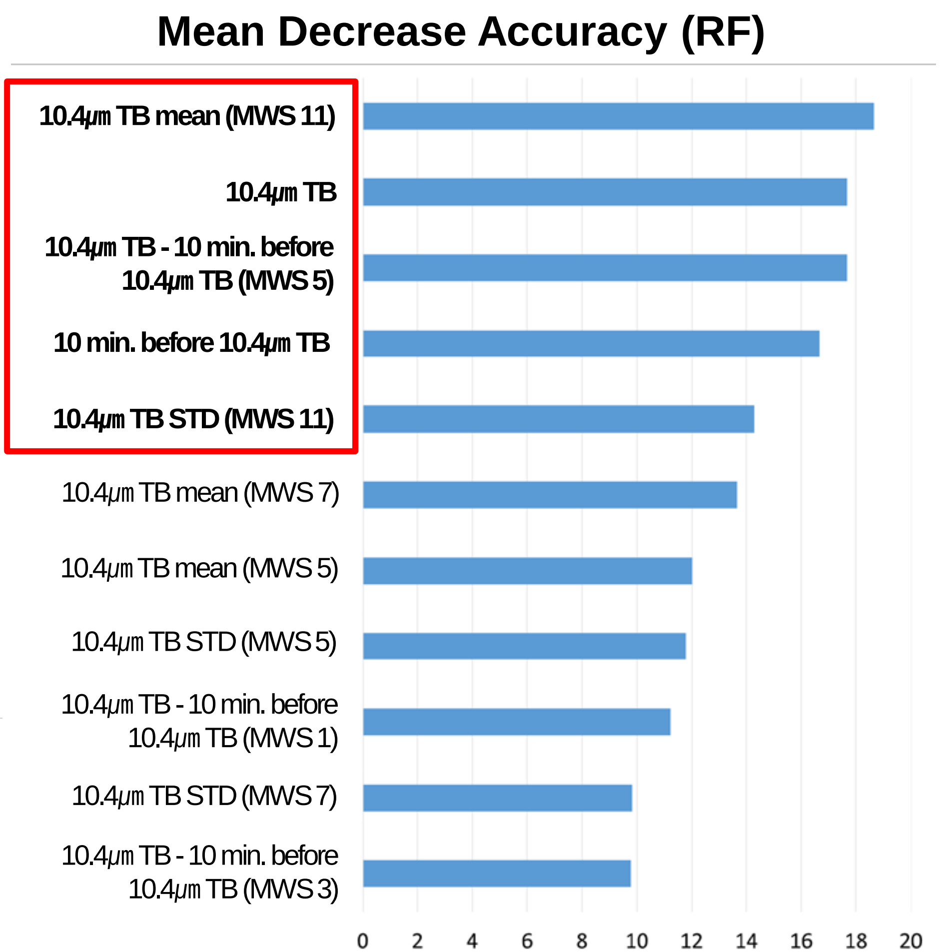




◆ **Inter-comparison of machine learning results (decision trees, random forest, support vector machines)**

❖ Pixel-based OT detection result – Variable importance of DT & RF

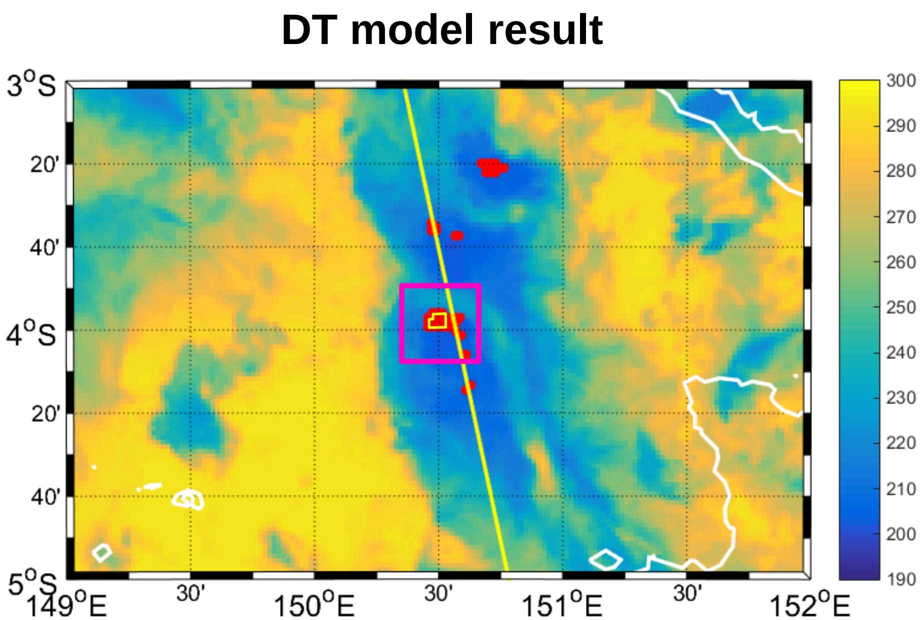


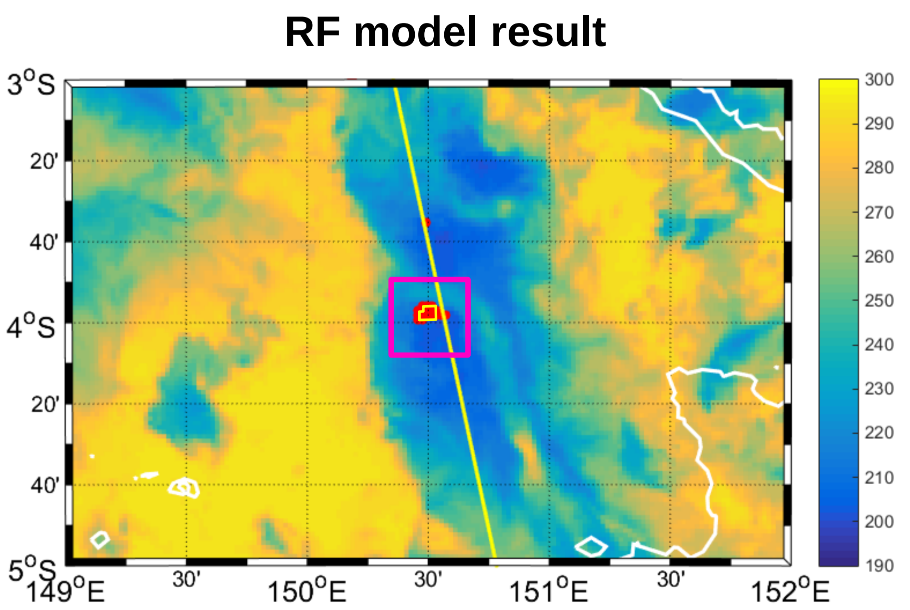


Research results

- **Inter-comparison of machine learning results (decision trees, random forest, support vector machines)**
  - **Pixel-based OT detection result – Qualitative validation using Himawari-8 image for DT & RF model result**

Himawari-8 image at about 3:50 June 12, 2015





Yellow line: a track of CloudSat passing through OT occurrence region

OT occurrence region identified by CloudSat

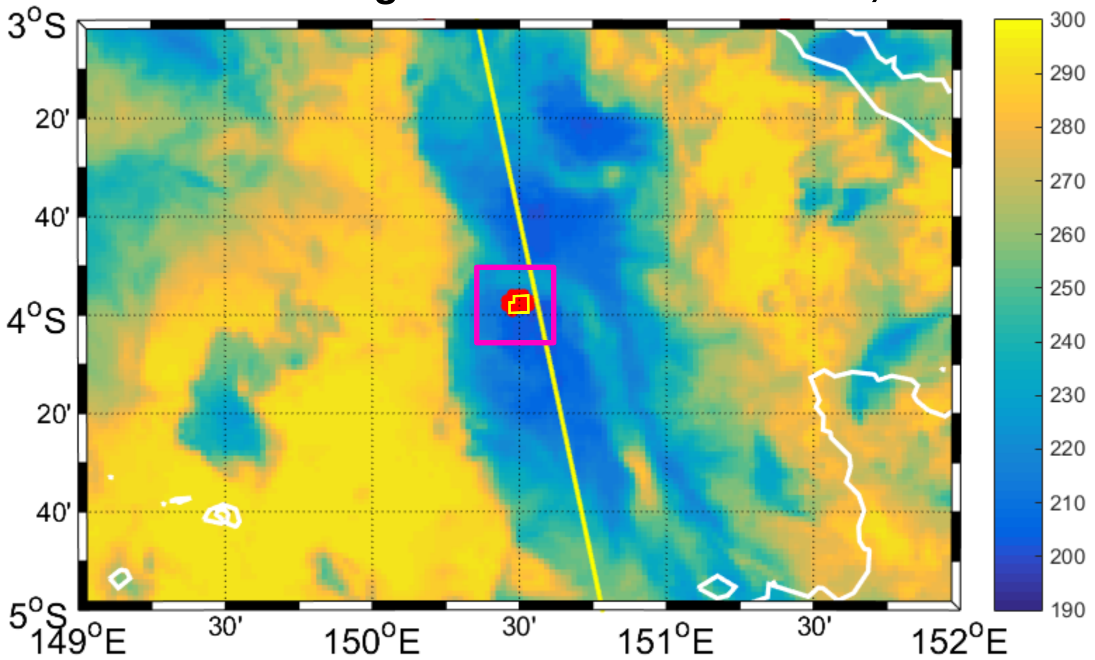
Location of OT delineated by visual interpretation

Research results

- **Inter-comparison of machine learning results (decision trees, random forest, support vector machines)**
  - **Pixel-based OT detection result – Qualitative validation using Himawari-8 image for SVM model result**

SVM model result

Himawari-8 image at about 3:50 June 12, 2015



Yellow line: a track of CloudSat passing through OT occurrence region

OT occurrence region identified by CloudSat

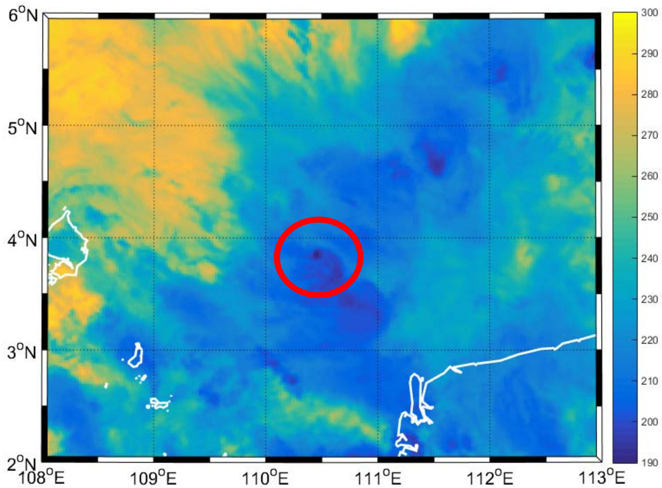
Location of OT delineated by visual interpretation

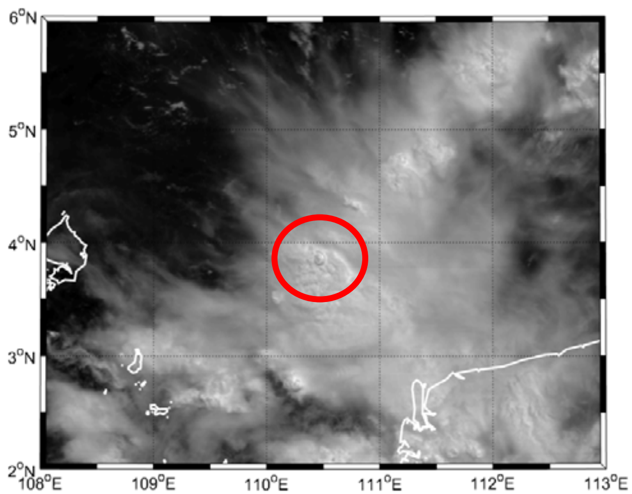
Research results

◆ Detection of object-based OT detection

❖ Construction of OT cases based on visual interpretation

At about 3:10 June 12, 2015





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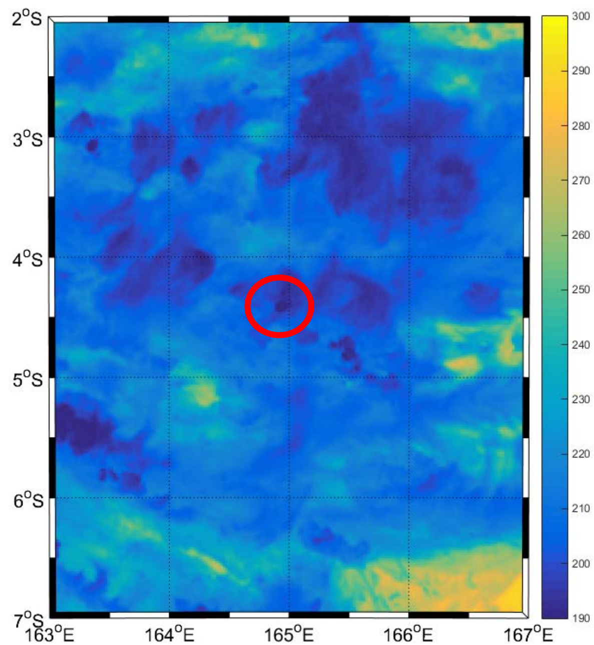
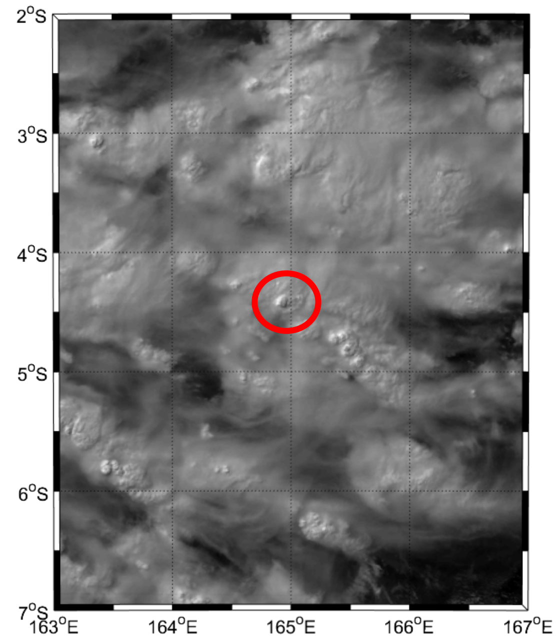
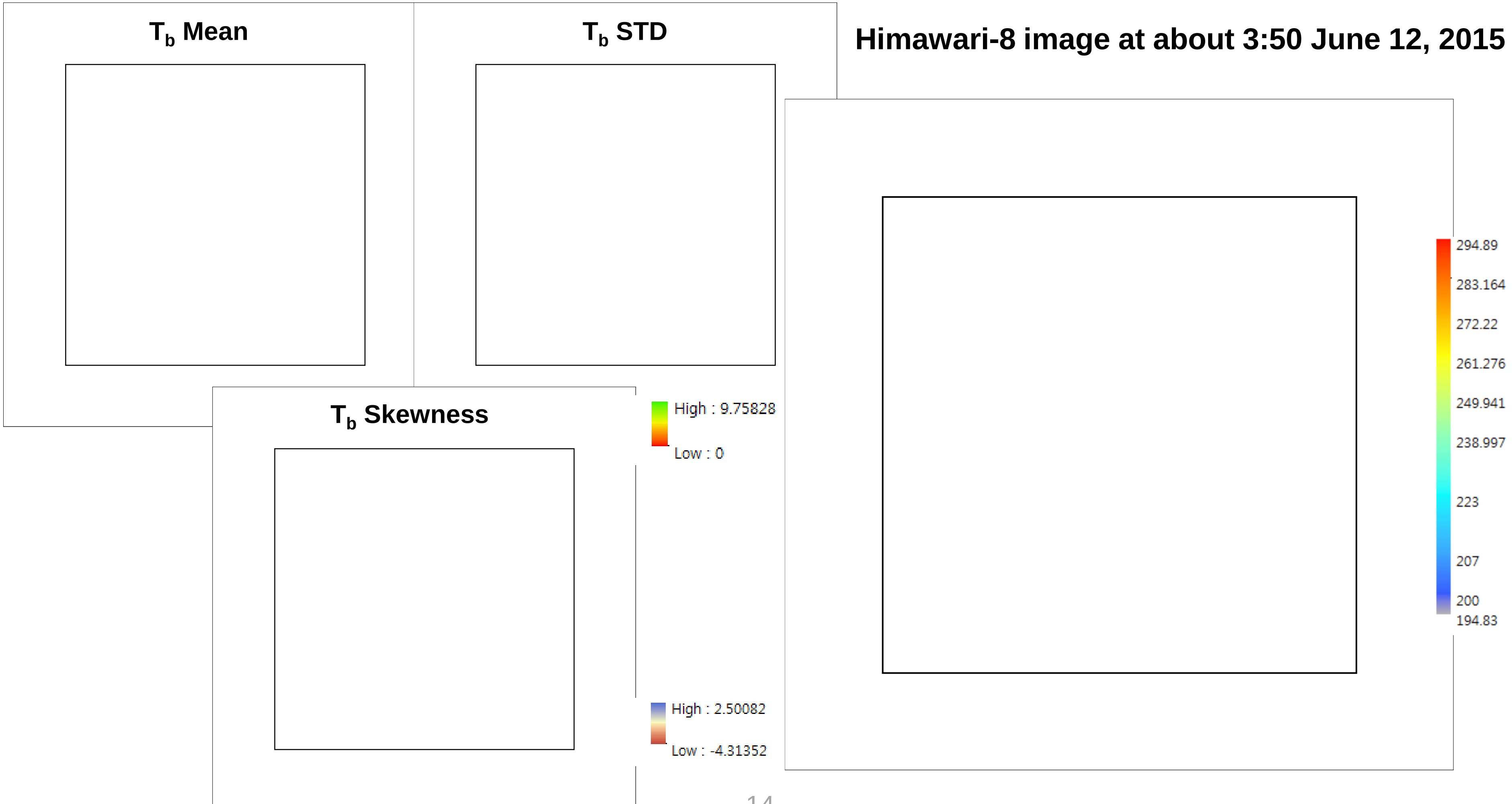




Detection of object-based OT detection

❖ Result of segmentation for input variables using e-Cognition software

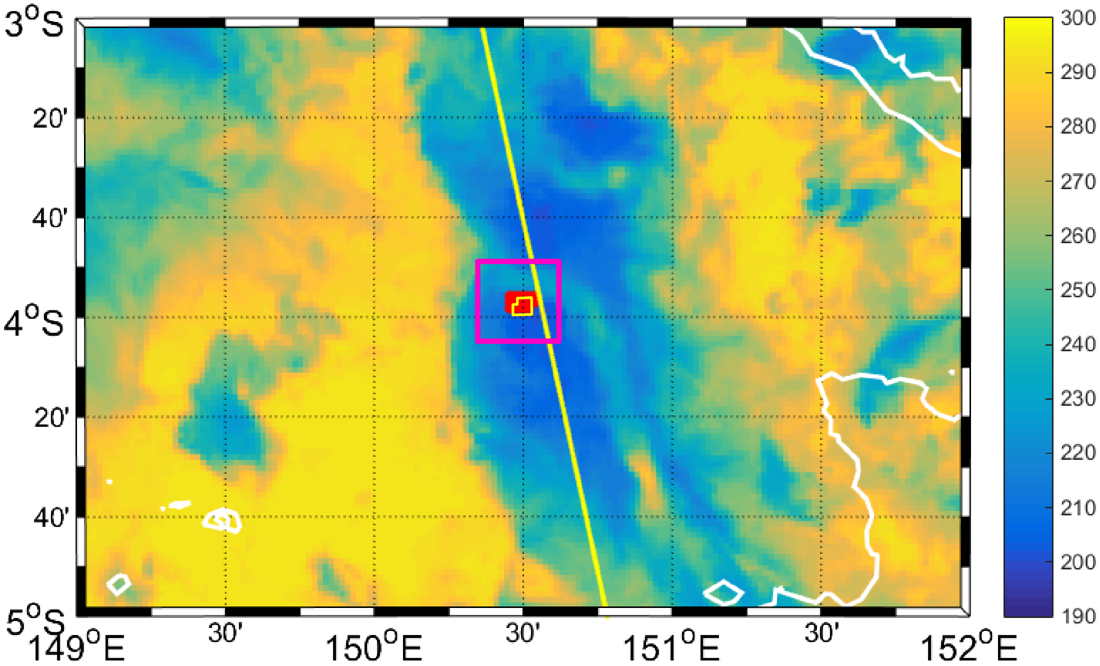


Research results

◆ Detection of object-based OT detection

❖ SVM result

Himawari-8 image at about 3:50 June 12, 2015



Yellow line: a track of CloudSat passing through OT occurrence region

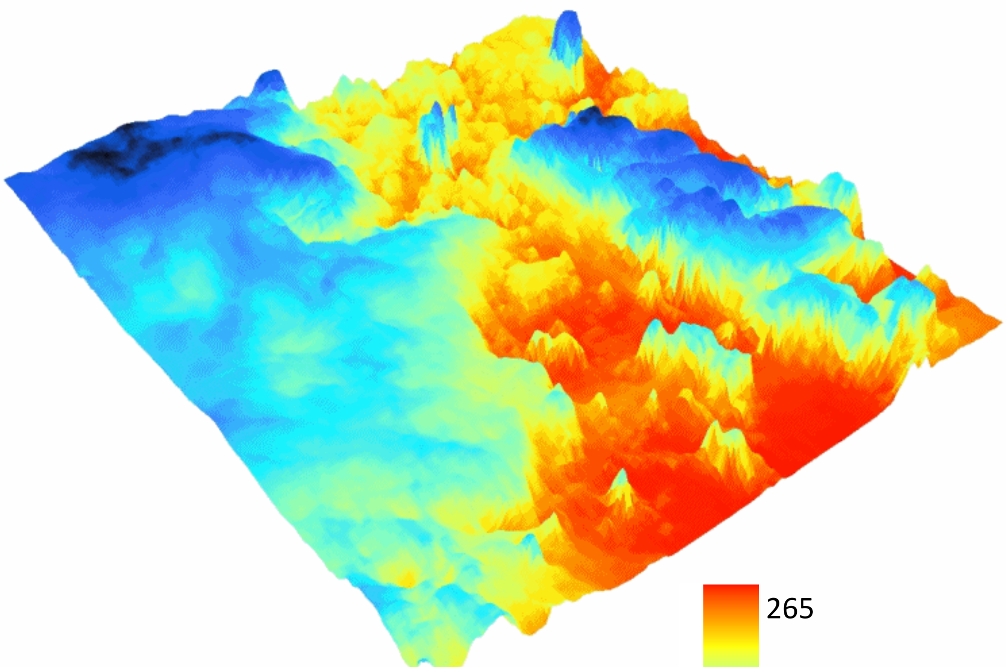
OT occurrence region identified by CloudSat

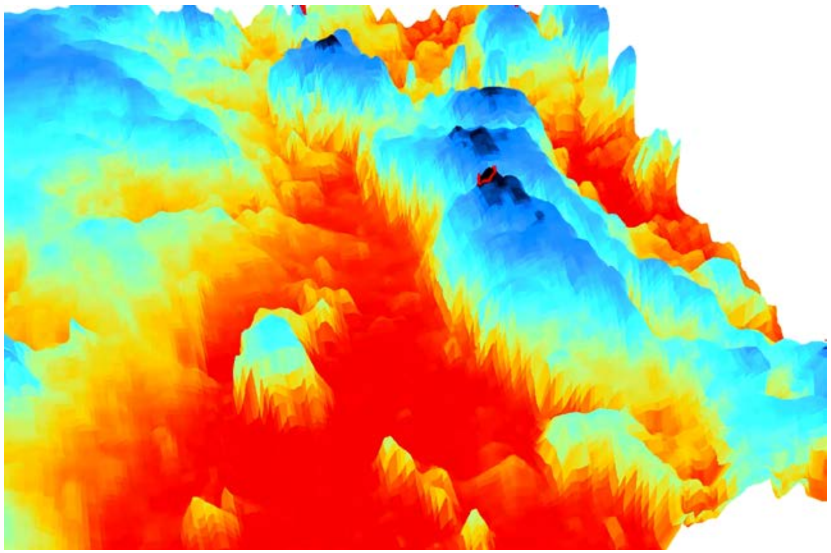
Location of OT delineated by visual interpretation

◆ **Detection of object-based OT detection**

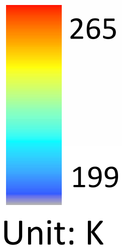
❖ **Animation of RF result**

Himawari-8 image at about 3:50 June 12, 2015





2015.06.12 2:50



OT occurrence region identified by CloudSat

Summary and future studies

- The result of OT detection using machine learning methods (decision trees, random forest, support vector machines) presented the best performance in SVM model based on qualitative validation for both pixel and object-based analysis.
- According to the information of variable importance from DT and RF model, average and standard deviation of brightness temperature (WMS 11), brightness temperature, difference of 10.4 μm channel brightness temperature and 10 min. before one (WMS 5), 10 min. before brightness temperature were identified as important variables for detection of OT in common.
- SVM model showed similar results for object and pixel-based OT detection results.

Further research

- To find OT reference data with satellite image and CloudSat and CALIPSO data so as to add more OT cases in training dataset and perform qualitative/quantitative validation with more OT cases for reliable OT algorithm.
- To develop day/night OT detection algorithm.
- To compare between machine learning approach and existing algorithm qualitatively and quantitatively.

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- NOAA NESDIS center for satellite applications and research, ATBD, Flight Icing Threat, Version 1.0

Questions?!

Thank you

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