Satellite-based overshooting tops detection methods: comparison and validation

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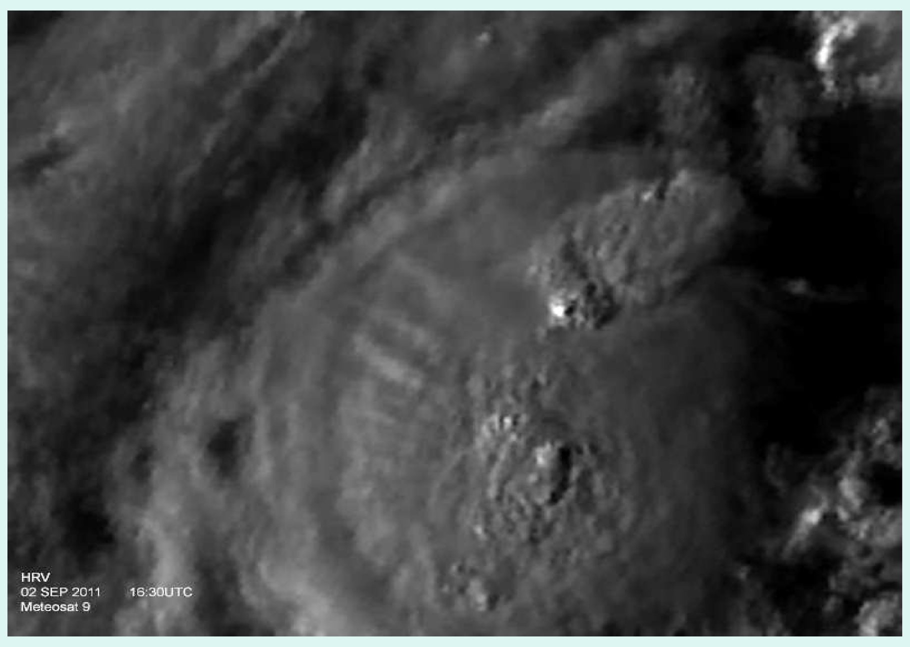
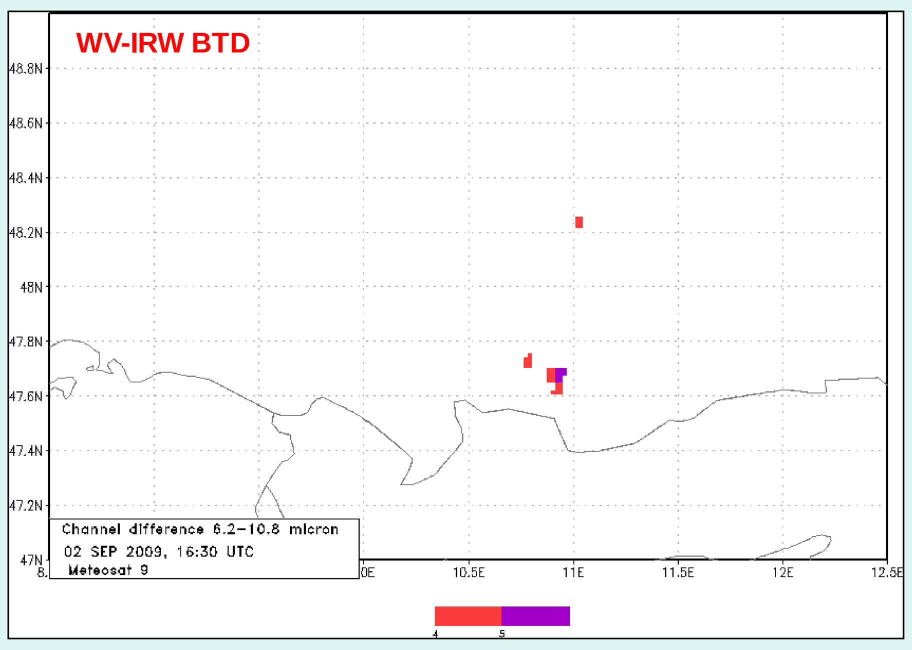
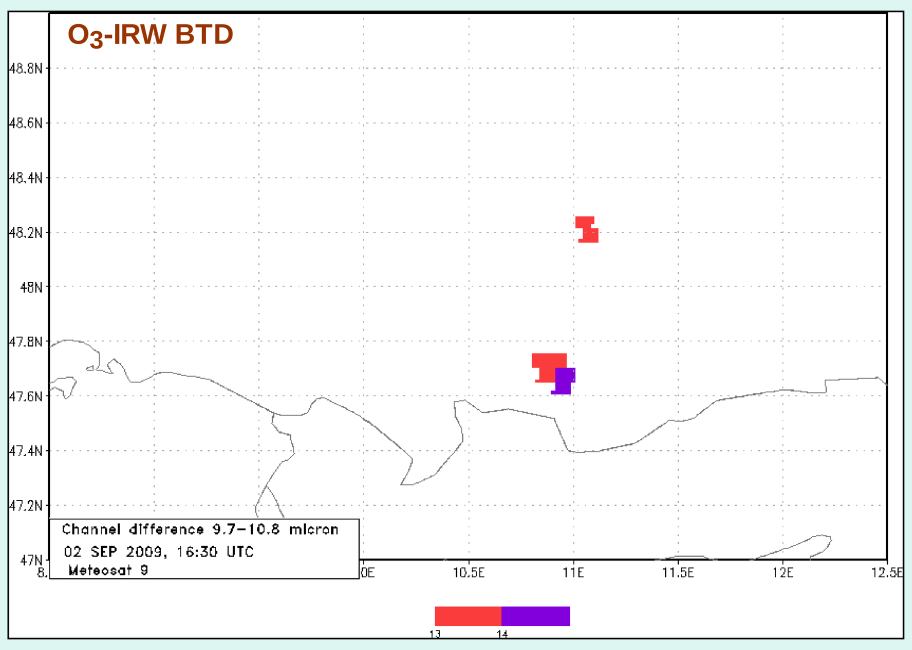
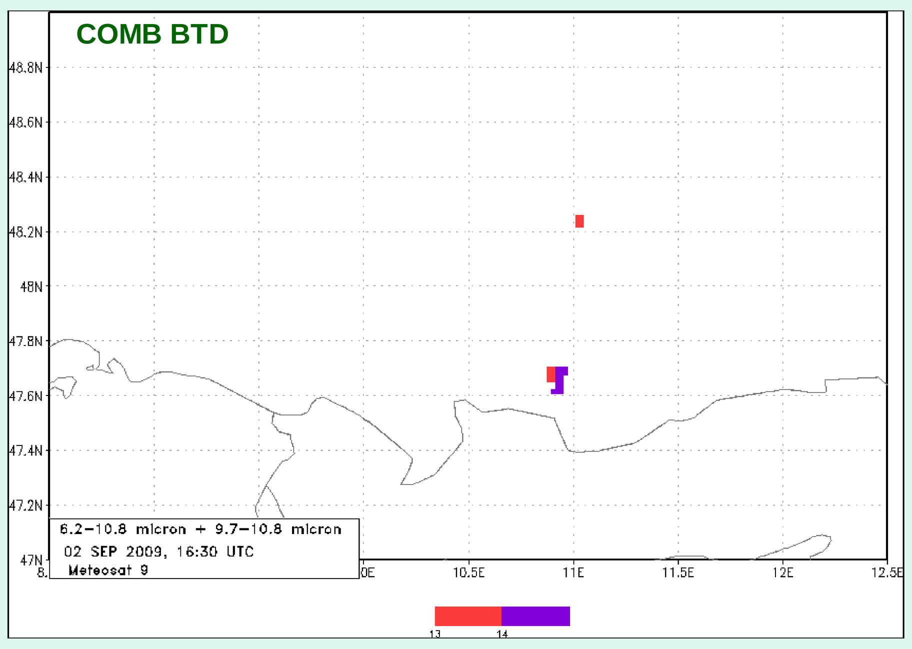
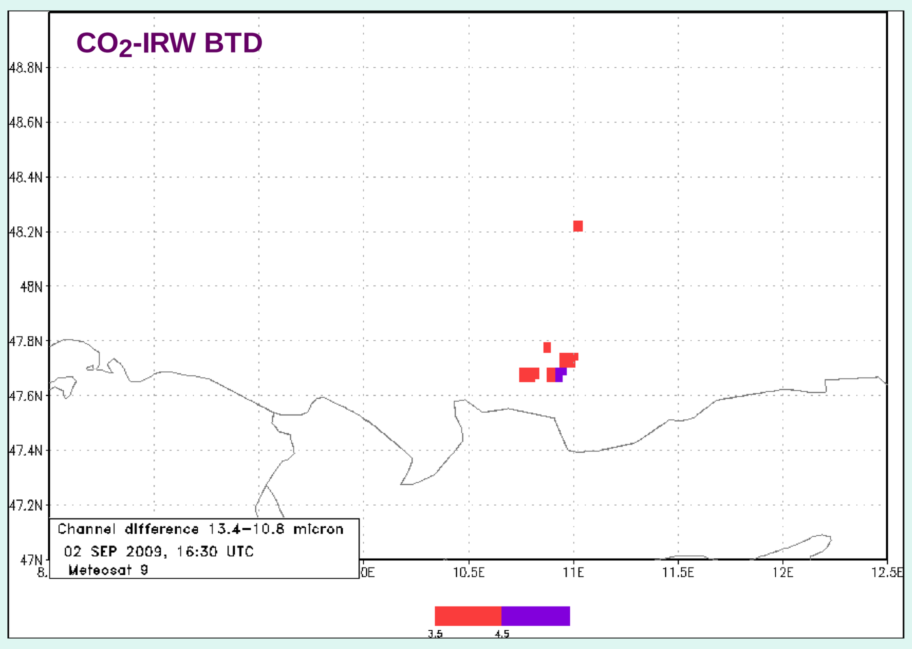
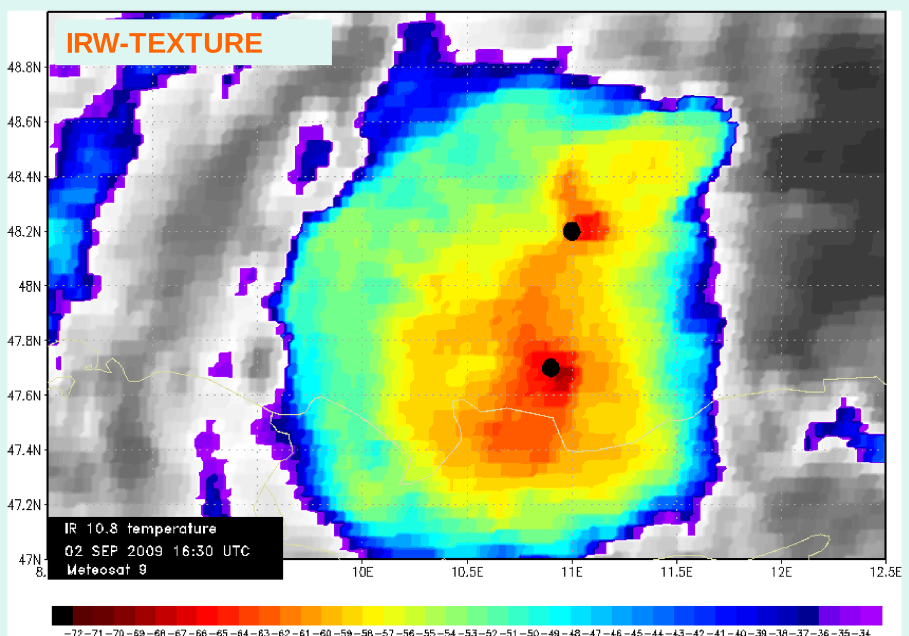












INTRODUCTION

An overshooting convective cloud top (OT) is a dome-like protrusion above a cumulonimbus anvil, often penetrating into the lower stratosphere. OTs can be most easily identified in the high-resolution visible channel imagery as the lumpy textured appearance, however only during day-time. In the 10.8 µm infra-red window (IRW) channel, available during both day and night, a small cluster of very cold brightness temperatures can indicate that an OT is present. The aim of this investigation is to compare the results of several different satellite–based OT detection methods and to validate their ability to locate very deep convective clouds and possible overshooting.

Cb cloud over Africa with cirrus anvil and overshooting tops. Source: ISS, Nasa

COMPARISON OF THE OT DETECTION METHODS

- Four brightness temperature difference methods (BTD) are used:
  - 6.2 µm - 10.8 µm (WV-IRW)
  - 9.7 µm - 10.8 µm (O_3-IRW)
  - 13.4 µm - 10.8 µm (CO_2-IRW)
  - combination (COMB) of WV-IRW and O_3-IRW BTD
- Each BTD method includes two criteria, one for the IRW brightness temperature and the other for BTD:

BTD	Threshold	
WV-IRW	IRW brightness temperature < 215 K	> 4 K
CO2-IRW		> 3.5 K
O3-IRW		> 13 K
COMB		> 4 K & > 13 K

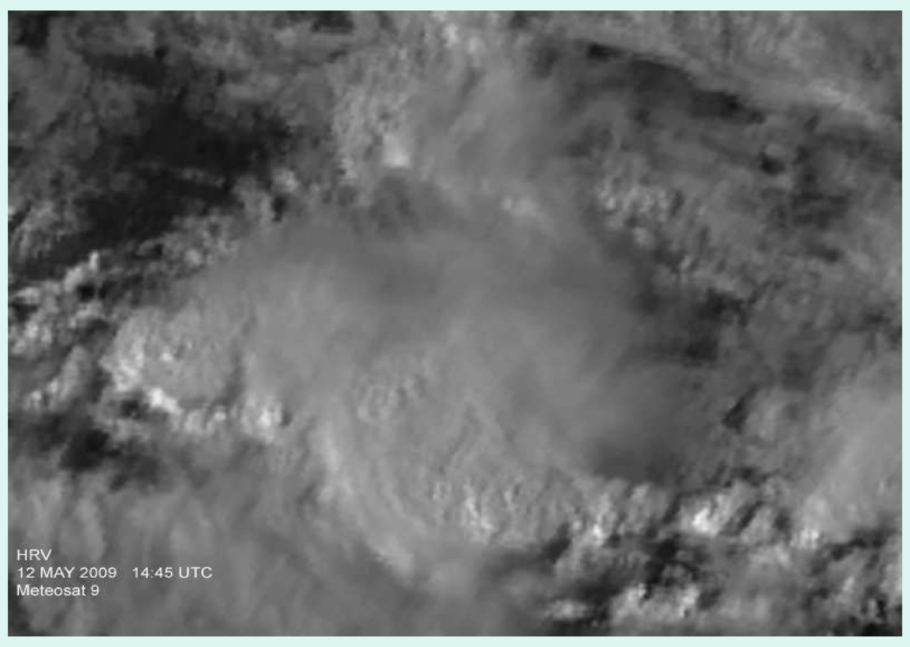
- **WV-IRW BTD** is one of the most commonly used methods for detecting OTs. It is appropriate for day/night OT detection. Since OT often protrudes into the lower stratosphere, the area where temperature increases with height, water vapor at that height is warmer than the cloud top, which makes the BTD positive. This method shows a significant number of false alarms, especially in the region of the cirrus plume.

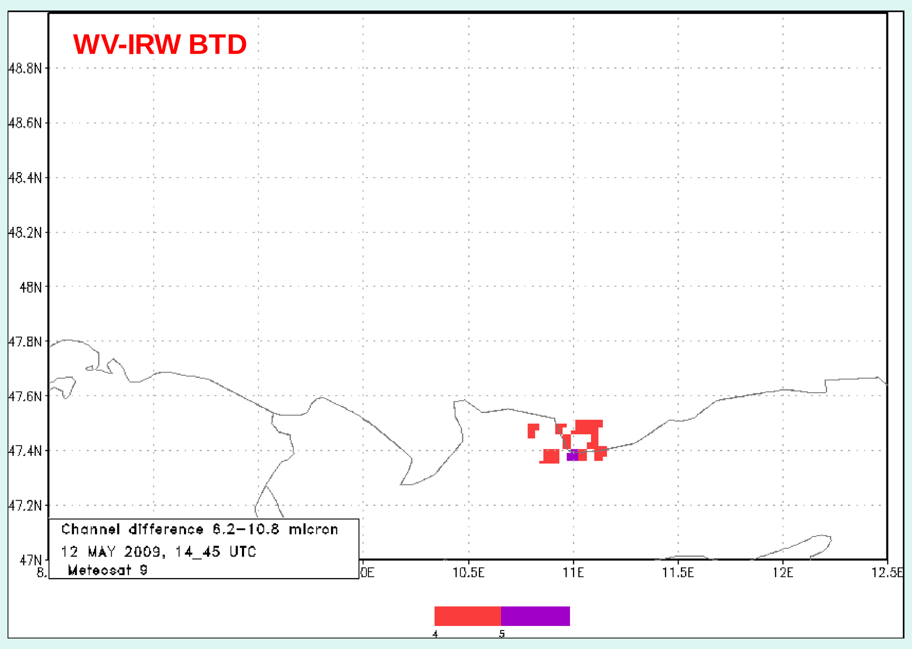
- **O_3-IRW BTD** shows positive signatures for the deep convective clouds. Values greater than 13K are generally located within the region of the most intense convection in the IR and HRV satellite images, but they occupy too large area to exclusively represent OTs, especially in May (example on the right) and June. Ozone concentration varies seasonaly, reaching the highest values in spring and the lowest in autumn over the mid-latitudes. Therefore, in spring, values >14K seem to be located within the region of the most intense convection, better corresponding to the pixels detected by the other BTD methods.

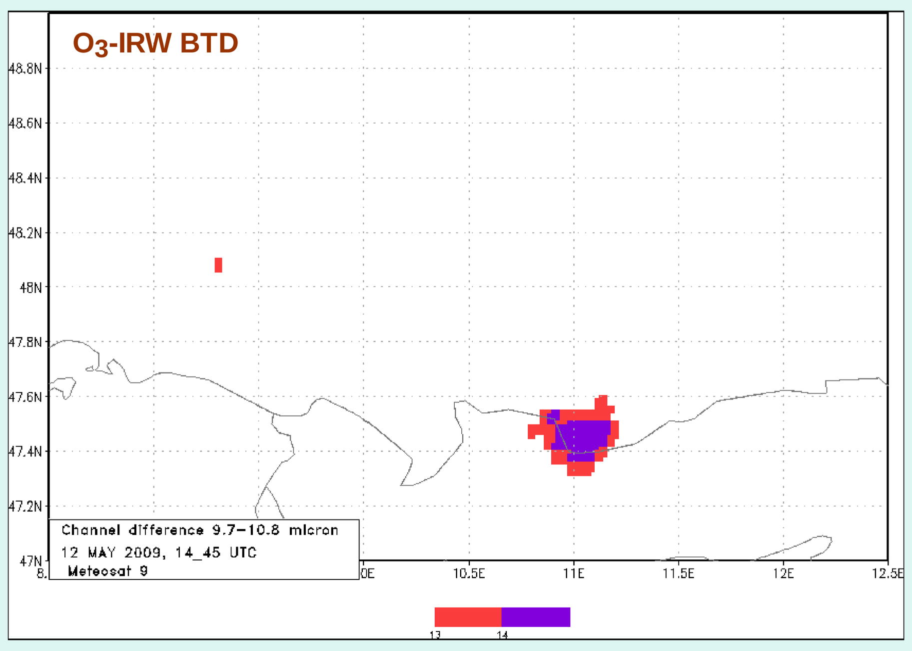
- **COMB BTD** method is developed in order to use the ability of both WV and O_3 channel data to identify significant cloud tops. This method shows the smallest number of false alarm.

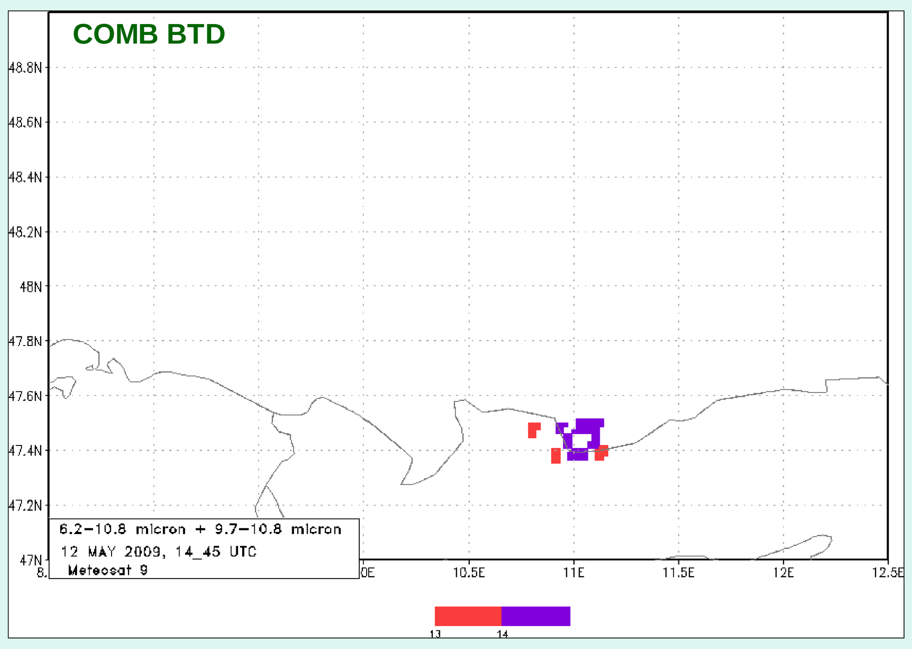
- **CO_2-IRW BTD** is frequently used for determining the height of the opaque clouds. The reason is that with higher cloud tops the absorption effect of CO_2 gets smaller, making the BTD of the CO_2 and IRW channel close to 0 or positive, in case of very deep convective clouds. This method shows similar properties as the O_3-IRW BTD method.

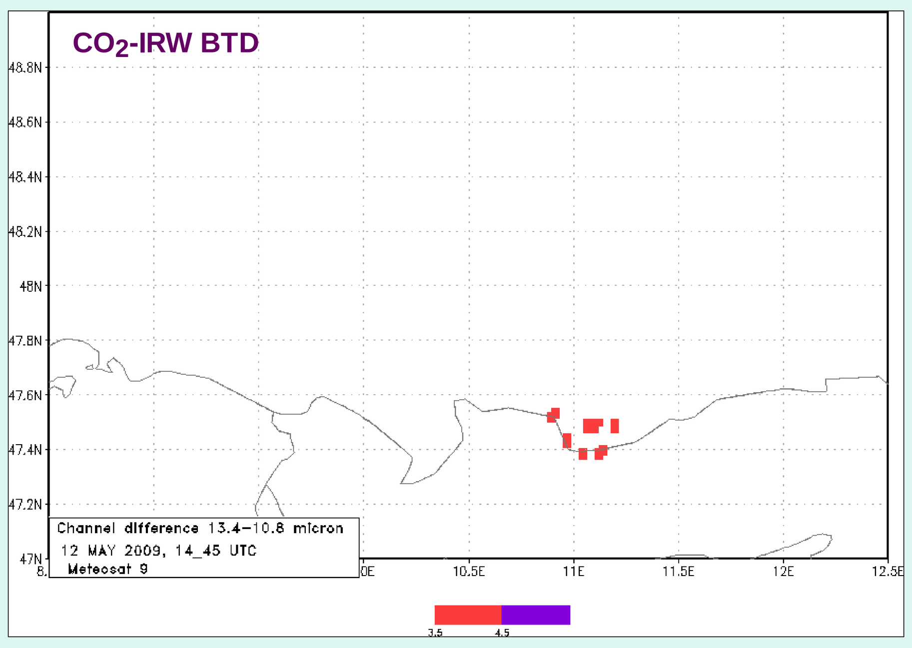
- **IRW-TEXTURE** is a more complex method, including a combination of infrared channel brightness temperatures and their spatial gradients, a numerical weather prediction model tropopause temperature forecast and OT size criteria to identify OTs during both day and night at their proper spatial scale. Locations of the OTs detected by the IRW-TEXTURE method are marked by black dots on the enhanced IR images left and right.

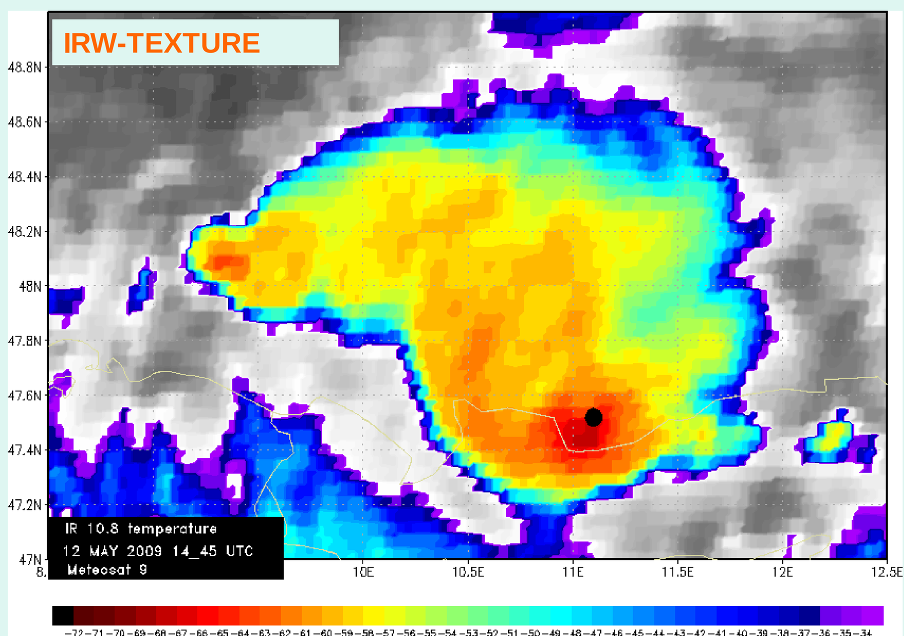












CONCLUDING REMARKS

All four investigated BTD methods indicate deep and very intense convection but not necessarily overshootings. In most cases, especially in May, pixels meeting defined criteria are too widely dispersed to exclusively represent OTs. This suggests the need to adapt the criteria especially in case of O_3-IRW BTD method which should have criteria depending on the seasonal variation of the ozone concentration. IRW- texture method sometimes detects thin cirrus cloud as OT. The work is still in progress. The results of detection for all five satellite based OT detection methods will be compared with the High Resolution Visible (HRV) satellite images during daytime in order to validate each method.

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