ADACS Sky Mining Hackathon 2018

Instructions for the “Looking the other way” challenge

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Goal

Protection of telescope and personnel from severe weather at the remote Murchison Radio Observatory MRO by way of providing a very short term forecast of severe convective activity

Weather detection in the sticks

- MRO (Murchison Radio Observatory) is about 600km NNE of Perth
- Remote telescope site is outside BoM radar coverage
- Often nobody at the site
- The best we have is quasi real-time satellite imagery from Japanese Himawari 8 satellite

Satellite data – fast and furious overview

- Himawari 8 (JMA's geostationary weather satellite) images entire earth once every 10 minutes.
- This occurs in 10 horizontally scanned sectors across the globe with a few regions of interest interspersed at 2.5 minute intervals just to keep things interesting.
- At 7m30s after starting the full earth scan, the sector where the MRO site is located is being scanned.
- Thus e.g.: The 10:30 UT scan in fact shows the MRO site at 10:37:30.
- The data for every scan is downlinked to Japan straight after completion (and while the full earth scans are in progress), which takes about 5 minutes.

Satellite data – fast and furious overview

- From Japan, the data go to BoM via dedicated fiber link. This takes about 2 minutes.
- BoM uploads them to our supercomputer file system at NCI in Canberra, adding a minimal 1 minute or so of further delay.

As a result of all this:

- The data become available 8 minutes after the sector scan completes.
- The minimum data delay therefore is **8 minutes**, the maximum **18 minutes**.

It is therefore important to be able to extrapolate from the available data!

An even faster and furiouser meteo primer

- Weather takes place in the troposphere. This typically goes to about 11km altitude at MRO latitudes and ends with the tropopause, on top of which lies the stratosphere, a region of relatively calm winds, little vertical motion, and an inversed temperature gradient.
- Severe convective developments are characterized by very strong updrafts, resulting in CB (cumulonimbus) cloud, aka thunderstorms.
- If updrafts inside the CBs is strong enough, the upper end pokes into the stratosphere.
- This is known as an **Overshooting Top**

An even faster and furiouser meteo primer

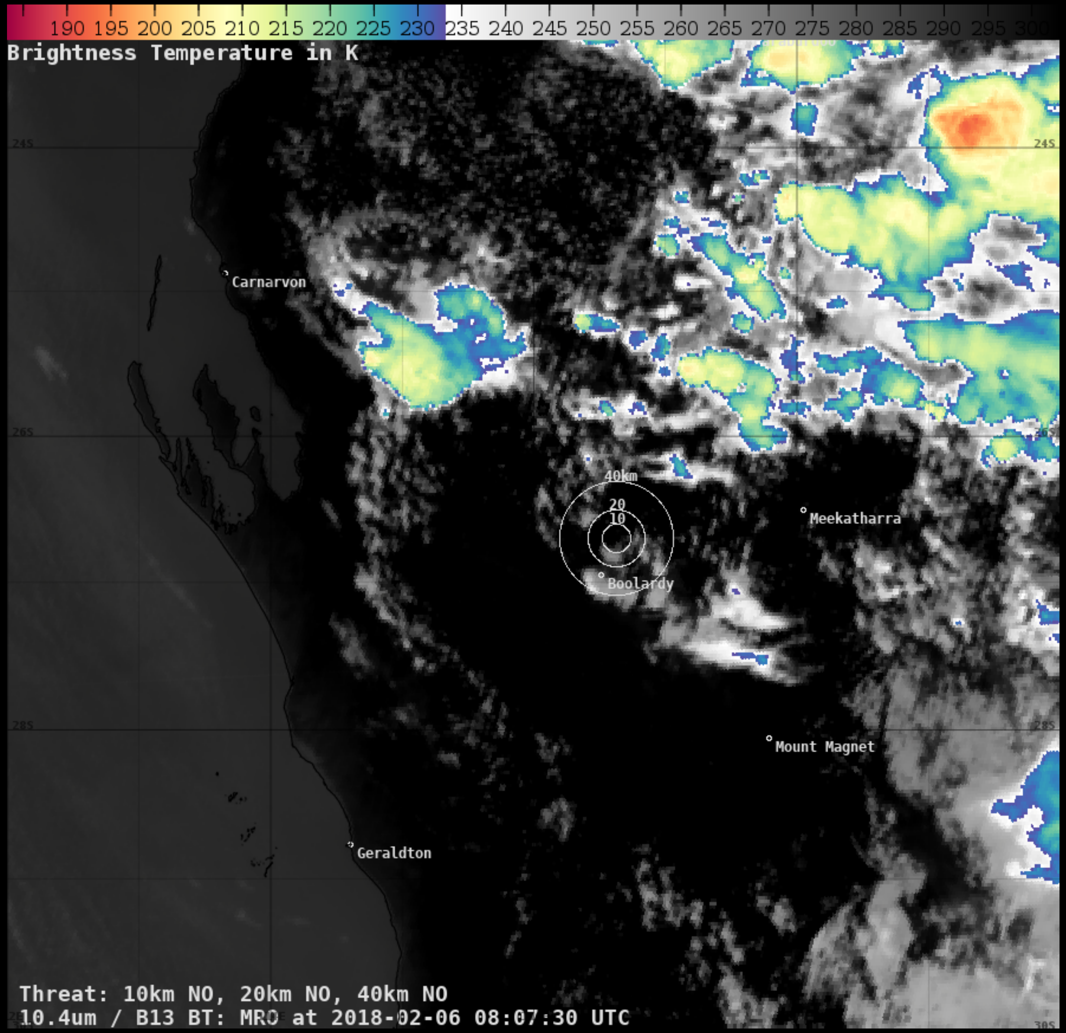
- The weather satellite looks at earth in 16 different spectral bands
- This allows to visualize and detect a variety of physical processes
- We are particularly interested in illustrating:
  - Temperature of the clouds (because that allows us to infer how high up their tops are)
  - Any overshooting tops (because that allows us to determine where severe convective developments are taking place)

An even faster and furiouser meteo primer

- Temperature of the clouds is best seen in band 13, a thermal infrared channel. Using false colour images we can highlight cloud top temperatures.
- In the following example, the colour scale on the B13 images is set to BW for temperatures above -41C, and to colour scale below. It is generally accepted that temperatures below -41C are indicative of convective cloud

B13 image example

- Highlights cloud
- Blue – yellow – red colour scheme indicates cooler temperatures. Red would be indicative of a thunderstorm
- Occasionally however, thinner cirrus cloud can also be detected, which would lead to false detections
- Doesn’t match the severity of a storm necessarily.
- Not a perfect match to detect severe weather

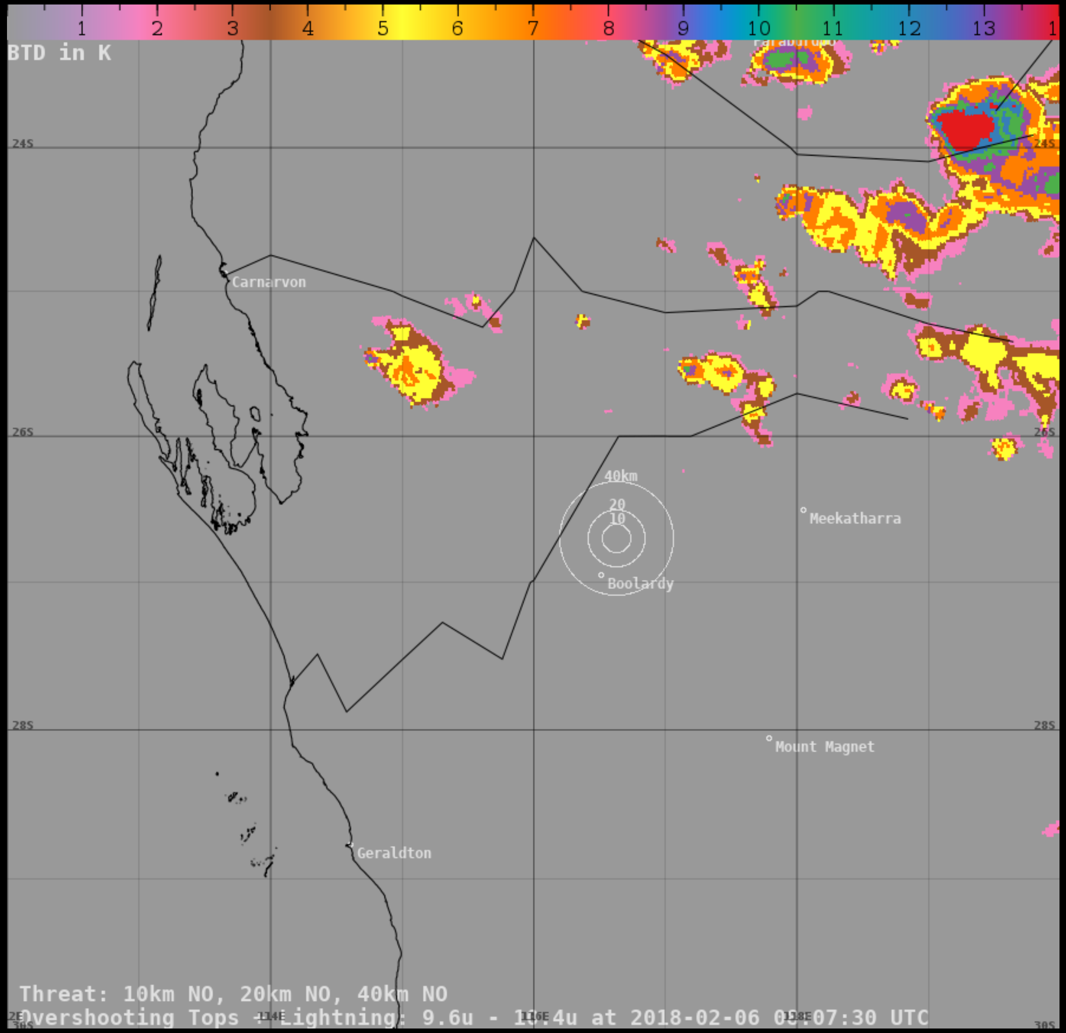


An even faster and furiouser meteo primer

- It has been shown however that forming a difference between two channels, the ozone detection and the thermal infrared, rather reliably shows severe weather developments.
- These plots are showing Overshooting Tops, which is the top of cumulonimbus cloud with sufficient energy to poke into the stratosphere layers, causing a **brightness temperature excess** in the difference between the channels.
- The larger the brightness temperature excess, the more severe the storm

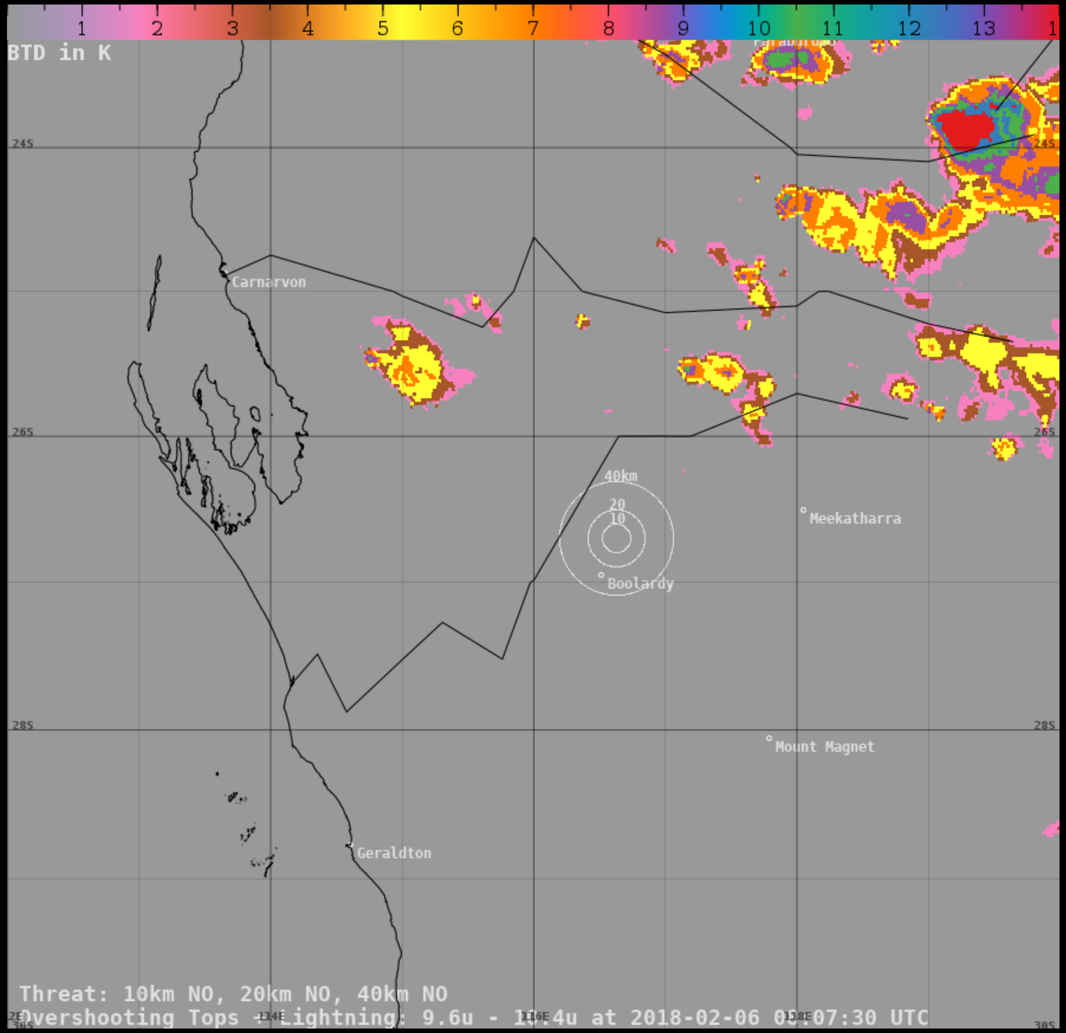
Overshooting tops image example

- The same time as in the B13 image
- Shows BTD (brightness temperature difference) between the O3 and Thermal IR channels.
- Is limited in these plots to a scale of 0 – 14K
- Excesses of more than 5K are considered severe



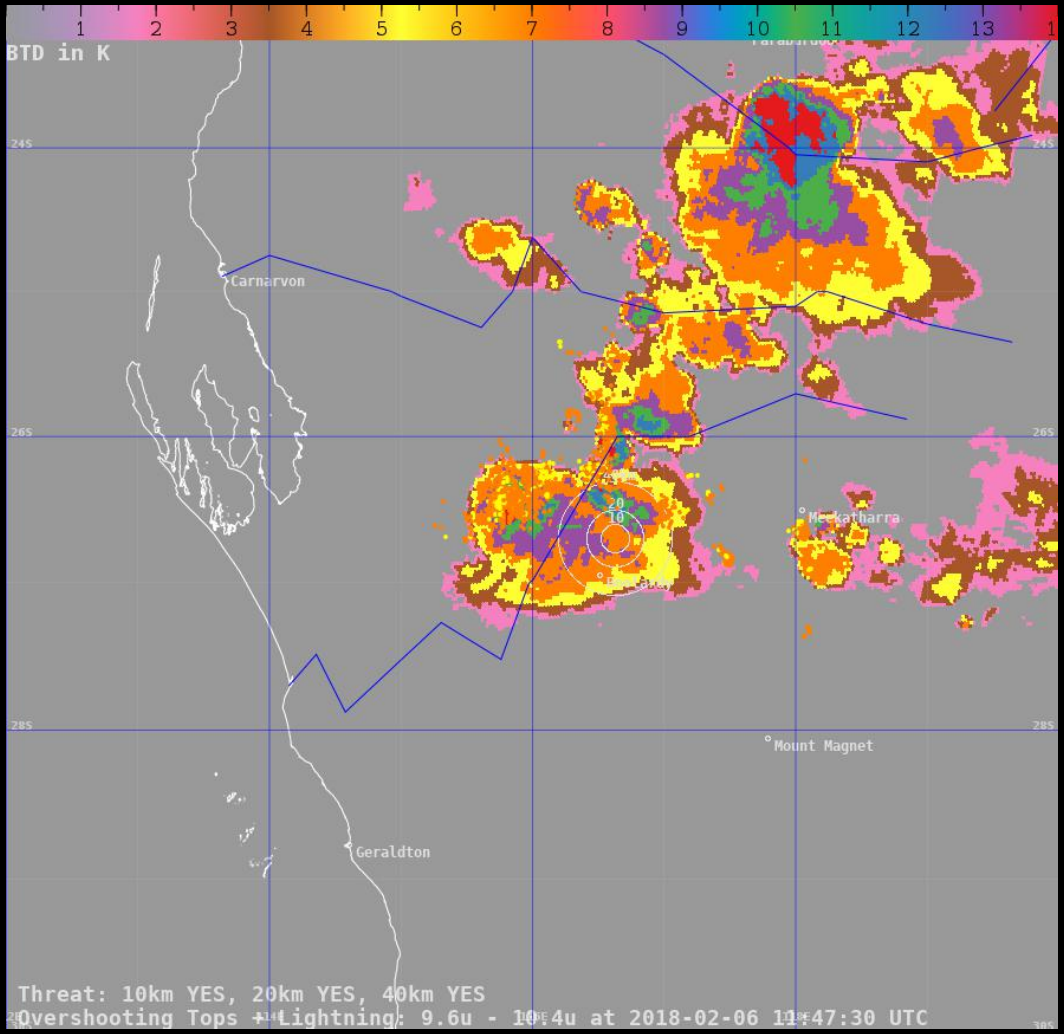
Together now

- Blinking the images you can see which of the storm systems in the images are likely to produce severe gust, lightning, and hail.



Time series

- Watching the overshooting tops develop over time then gives us an idea of the growth of CB cloud in the area.
- We want to extrapolate from these developments and predict the very near future (T+30m, T+60m) using naïve extrapolation in both growth and position.



The challenge

- The challenge, should you choose to accept it, is to write a python code that
  - Identifies overshooting tops / individual cells from the overshooting tops data
  - Predicts naively (based on the previous few frames) the position and extent of the overshooting tops areas at T+30m and T+60m

Technical Details

- The example data range available to work with is 2018-02-06 00:00 to 2018-02-16 23:50
- You can run the code ~/bin/OT_O3-IR_MRO.py YYYY MM DD HH MM to obtain the image for the given time/date, remember to offset the time by 7m30s – if you want to plot the 20:30 image, you'd call: ~/bin/OT_O3-IR_MRO.py 2018 2 6 20 37 or it won't find the data.
- You can access the raw data (i.e. the temperature excesses) in the data array data = mro_scn['B12'] - mro_scn['B13'] on line 72 in the code. Note that the data array is rotated 90 degrees: x = latitude, y = longitude.
- The winning contribution will be able to issue a warning 30 minutes prior to the MRO core site becoming affected by an overshooting tops area.
- **Make sure you keep copies of your code on your own machines! The hackathon.inside.net virtual machine will be deleted right after the hackathon has ended. It was made available through the generous support of NCI staff in Canberra!**