

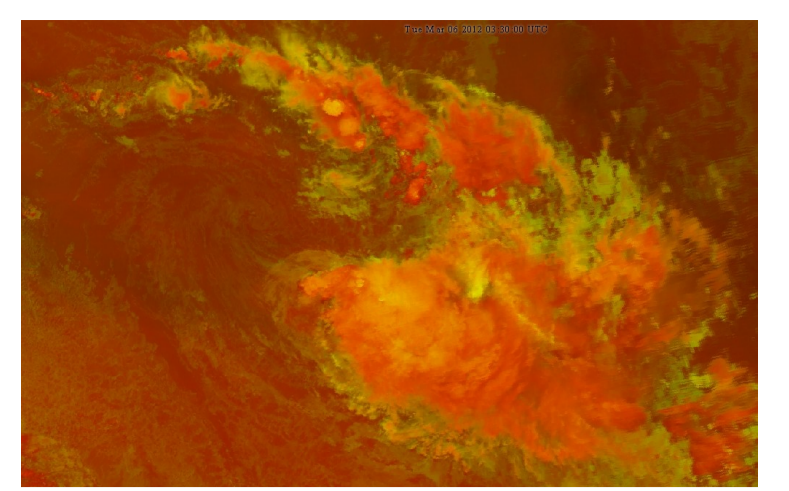


Adapting multi-channel MODIS (Moderate Resolution Imaging Spectroradiometer) Satellite Imagery to the detection of severe storms for use in Bureau Operations

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The next generation of Japanese geostationary satellites (Himawari 8/9) will carry an improved imager supporting the effective use of multi-spectral red-green-blue (RGB) enhanced imagery. In preparation, the Bureau of Meteorology (Bureau) is working on adopting EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) multi-spectral image enhancement algorithms, developed for Meteosat Second Generation (MSG) satellite data. The necessary data for the Australian region is sourced from the Moderate-Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's AQUA and TERRA polar orbiting platforms, which provides a superset of the planned Himawari 8/9 spectral bands.

Development work includes extending the Bureau's satellite data processing systems to produce multi-spectral images, as well as making use of the increased spatial resolution of MODIS data to improve forecasting and "nowcasting" capabilities. To evaluate progress, the multi-spectral enhancements are assessed against complementary data sets, such as Numerical Weather Prediction (NWP) model data, surface-based observations, radar observations and current single band imagery and associated products.

The new multi-spectral enhancements provide an effective training opportunity for forecasters in preparation for Himawari 8/9 data. This results in the added challenge of making the new products easily accessible, which has led to the development of an innovative web-based data viewer, which provides geographic and temporal browsing capabilities of the various satellite data products.

Severe Storm Composite RGB

For this paper we are concentrating our attention on the Severe Storm RGB composite algorithm. This product is a day time enhancement used to identify and localise severe storms with significant updraft and overshooting tops.

The EUMETSAT recipe defined for the enhancement is:

| Beam | Channel | Range | Gamma | Gamma2 |
|-------|-----------------|--------------|-------|--------|
| Red | WV6.2 - WV7.3 | -30K to 0K | 1.0 | 1.0 |
| Green | IR3.9 - IR10.8 | 0K to +55K | 0.5 | 1.0 |
| Blue | NIR1.6 - VIS0.6 | -70% to +20% | 1.0 | 1.0 |

The water vapour channel difference attributed to the red channel is used to locate the areas of extended moisture columns associated with severe storms, while the infra-red channel difference attributed to the green channel is used to highlight the presence of small ice cloud particles

Tuning the Severe Storm RGB to MODIS and Australasian landscape and weather

The EUMETSAT multispectral imagery algorithms are optimised for the European continent and weather patterns. Australia and its surrounding Asian and Pacific Island countries have very different soil and vegetation types, and differing weather.

Not only do we need to consider the differences in what the satellite views, but also the instrument differences. The MODIS imager has differences in the channel central peaks, particularly the SEVIRI's 6.2µm versus the MODIS 6.7µm, as well as differences in calibration and bandwidth. The imager on Himawari 8/9 will also have differences to contend with.

This study will compare severe storm events from both the Northern Hemisphere and Southern Hemisphere from both the SEVIRI and MODIS imagers. We will investigate and quantify the channel differences and how those differences affect the multispectral imagery algorithms.

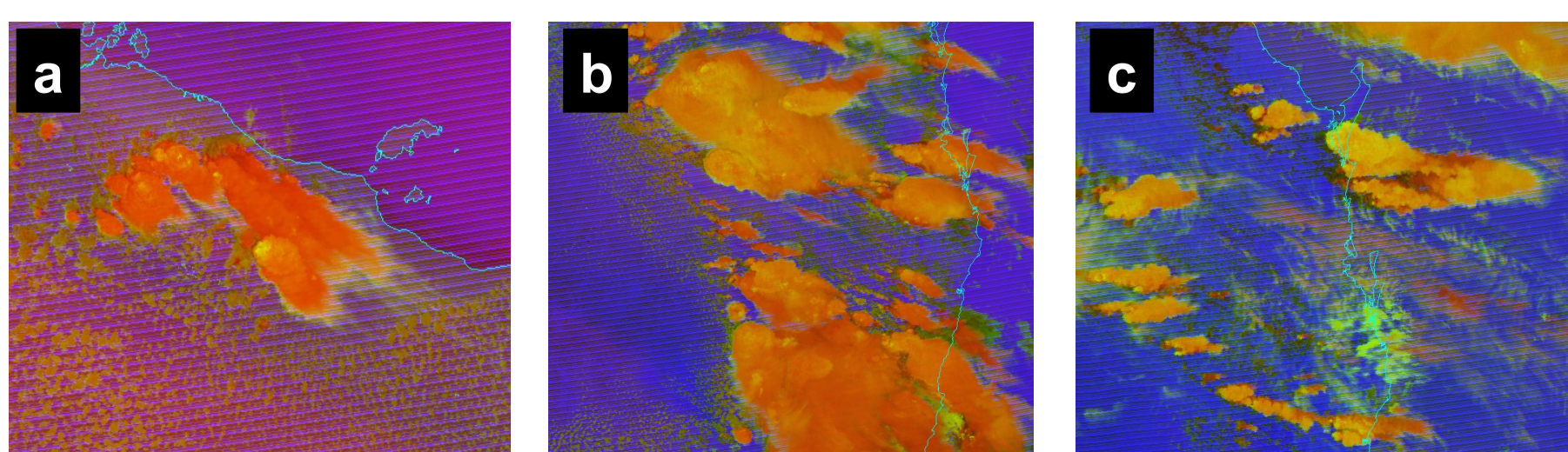
Severe storms in Australia

For this study we will extend the work on severe storm analysis based on MODIS and SEVIRI instruments².

For this study we have twelve well recognised severe storm cases to analyse with the MODIS instrument. The storms cover the length and breadth of Australia, from the top of Queensland down to Melbourne, and from Western Australia to the east coast.

Preliminary investigation has revealed distinct differences between cases. Clear yellow within red, panel a), bright yellow but spread across cloud top, panel c) and mixtures, panel b).

Possible causes are; location, timing, and more likely the lifecycle signatures of severe storms.



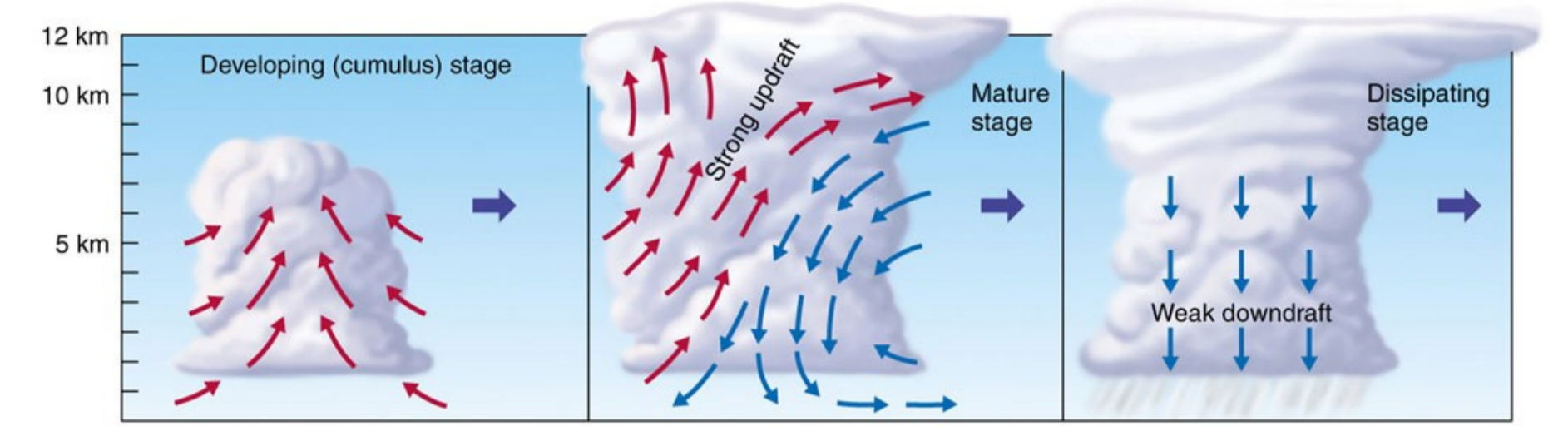
Relating the imagery to radar signatures of severe storm lifecycle

To clarify if the lifecycle of severe storms provides the differences we see in the sample set, we compare the timing of the MODIS imagery with signatures from the nearest weather watch radar.

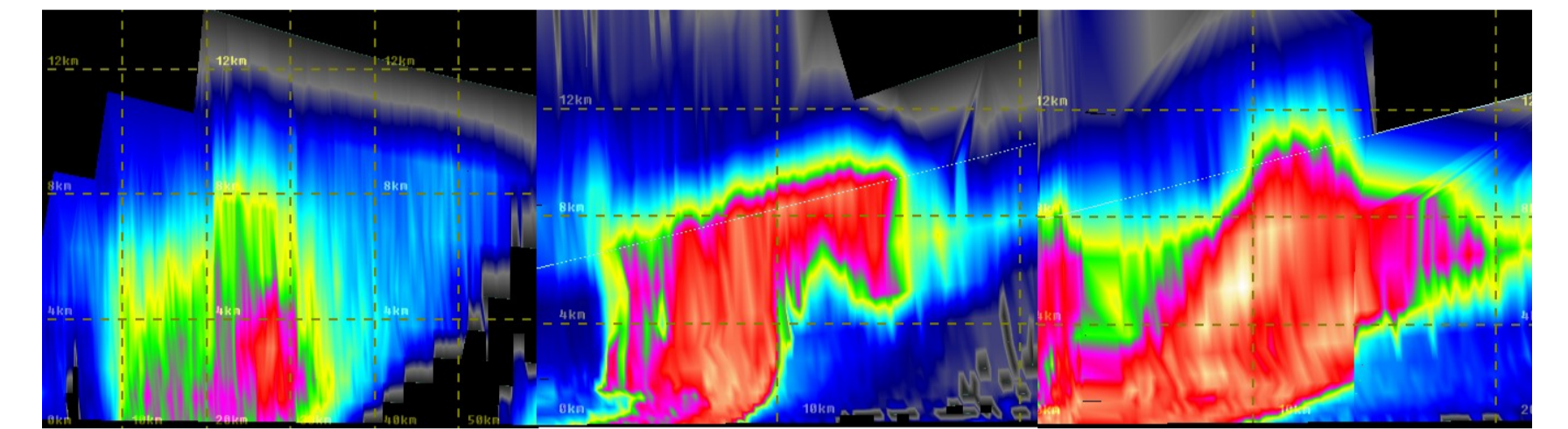
s-band radar is sensitive to atmospheric moisture, particularly rain or larger water coalescence.

The image right shows a simplified schematic of the lifecycle of a severe storm with the comparative radar moisture signatures.

The left pane shows the development stage with the beginnings of the updraft winds. The centre shows the strong updraft making an overshooting top with heavy rain. And the right pane shows the dissipation stage with extended heavy rain across the storm.



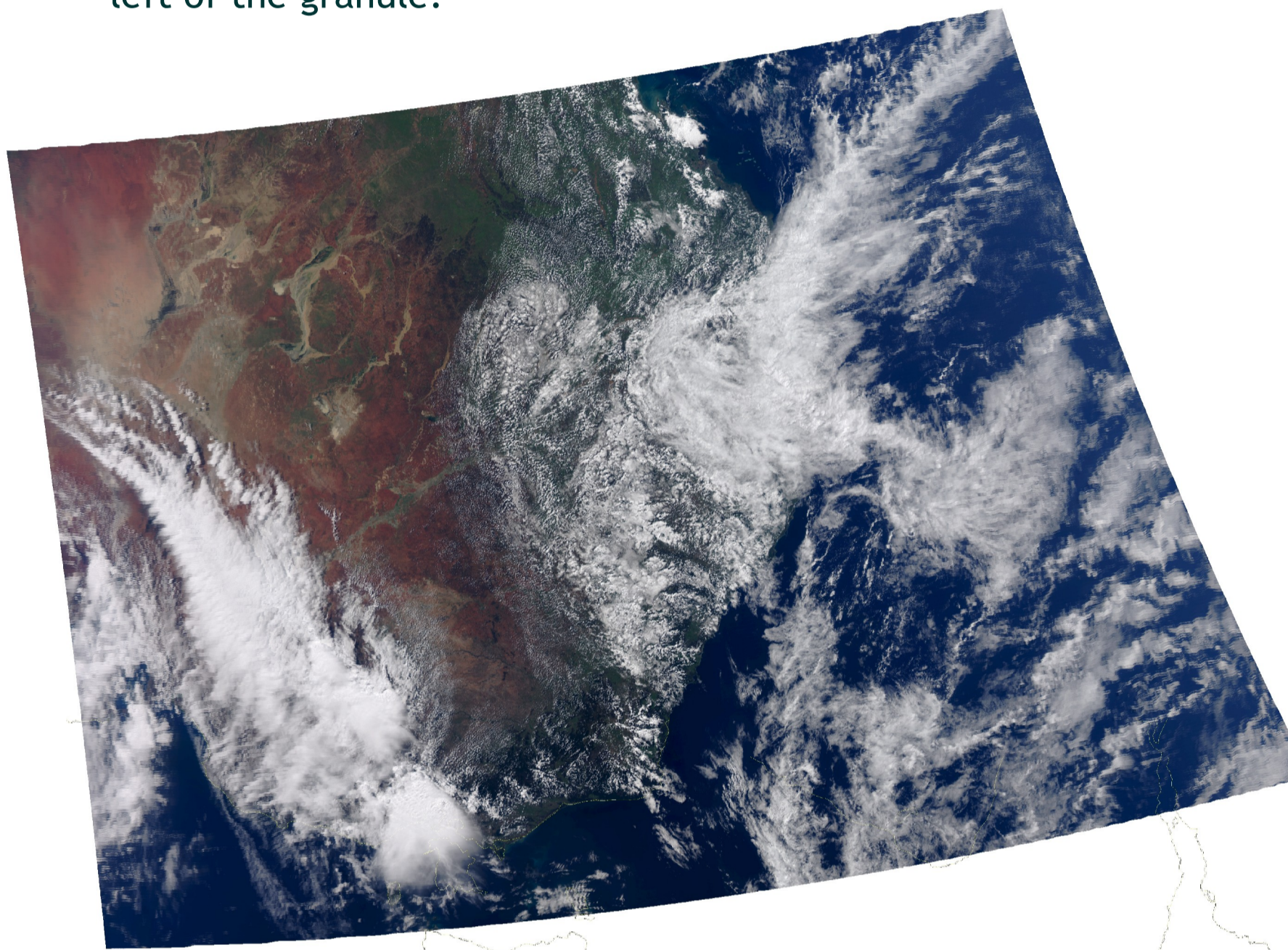
http://www.geog.ucsb.edu/~joel/g110_w08/lecture_notes/thunderstorm/thunderstorm.html



Analysis of a Severe Storm case study, 6th March 2010 Melbourne hail storm

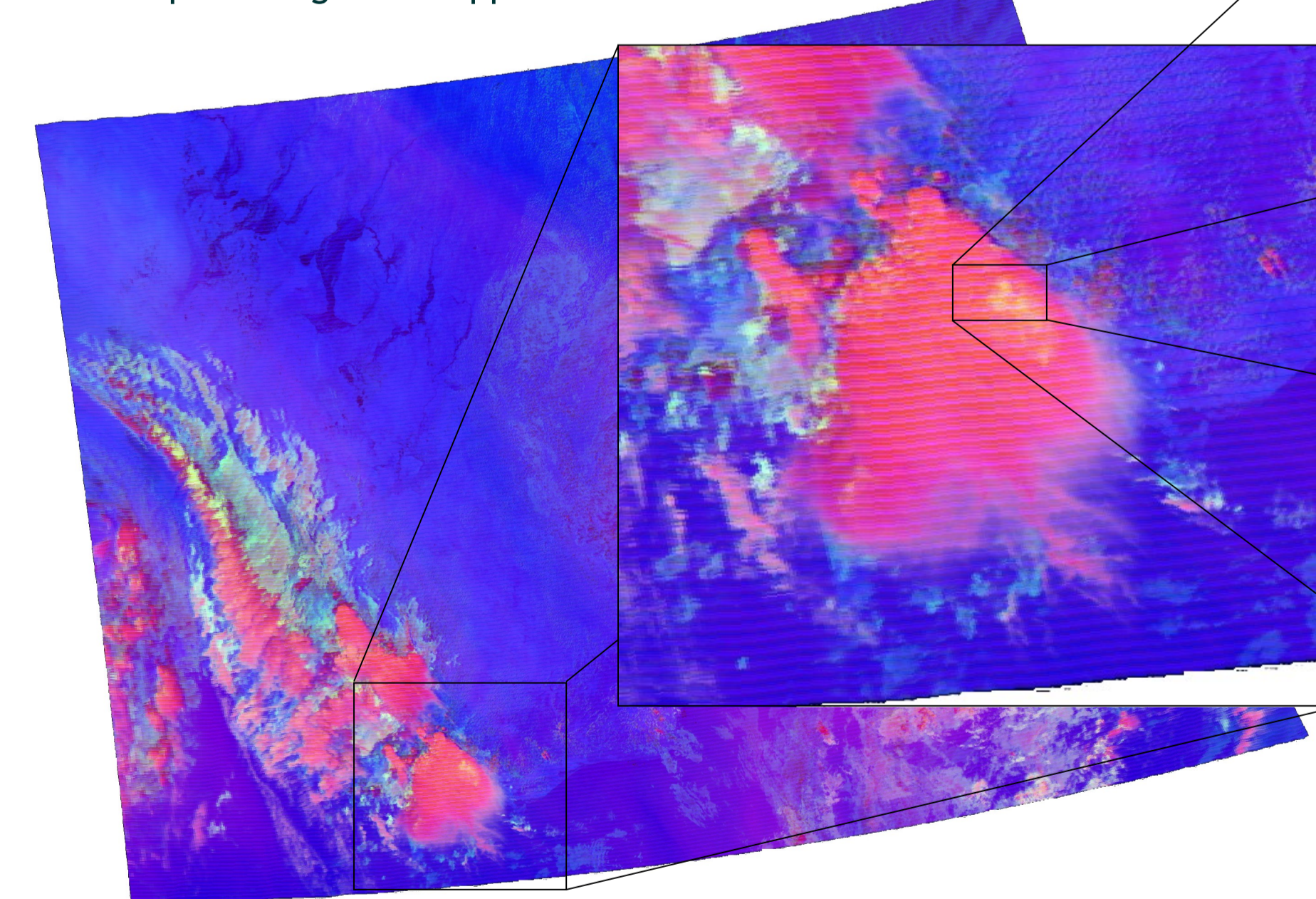
A severe hail storm was recorded in Melbourne Australia on the 6th March 2010. The storm lasted several hours from midnight through to 0430 UTC. The storm struck the Melbourne metropolitan area approximately 0230 UTC.

Below is a six minute MODIS granule composite visible RGB from the 6th March 2010 0400 UTC. Victoria and Melbourne are located lower left of the granule.

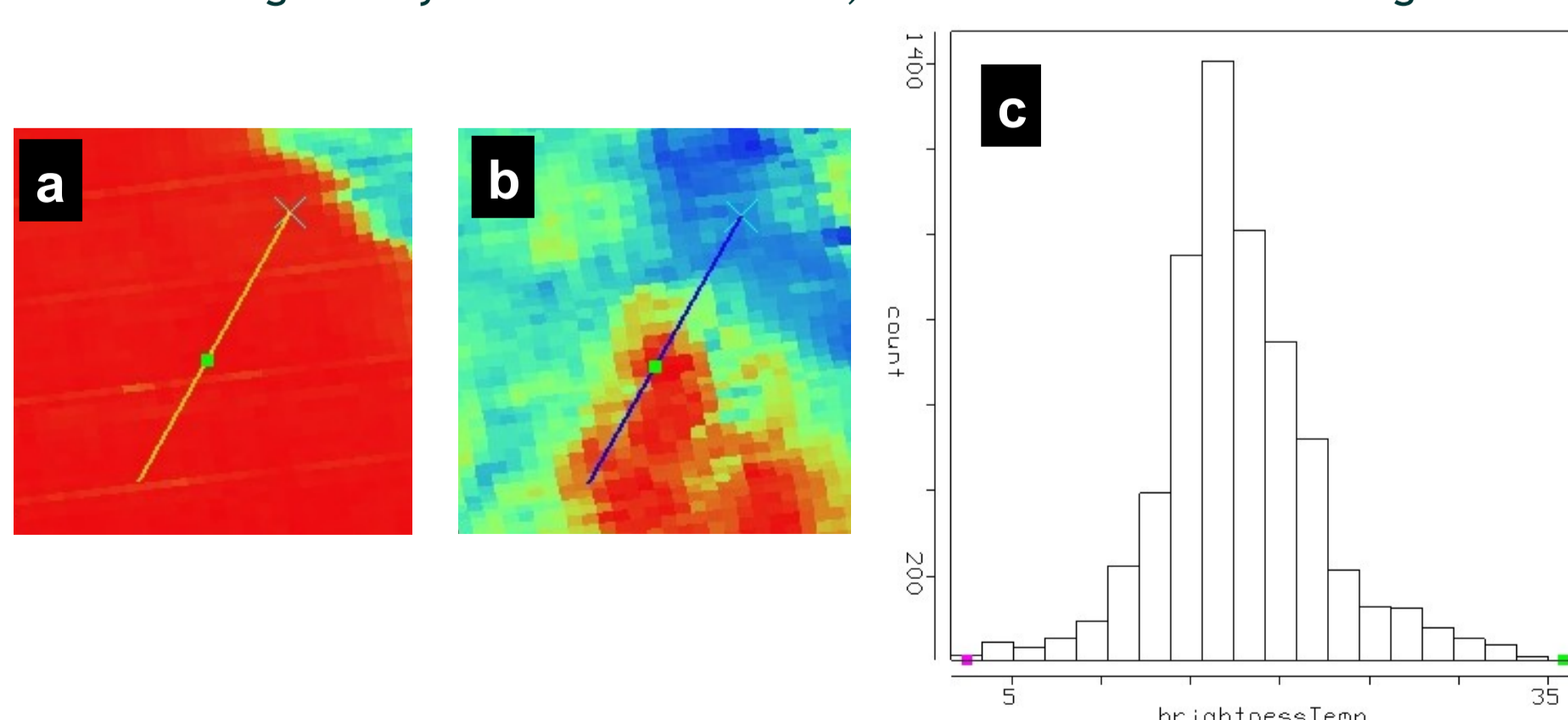


We can clearly see the cloud band associated with the trough between the high on the western flank and the low on the east flank. The wind direction over Melbourne was from the north west.

Below is the same six minute MODIS granule with the Severe Storm RGB composite algorithm applied.



An overshooting top inherent to severe storms is well defined by the composite. The intense yellow indicates the overshooting top in the larger body of thick level cloud, the red colour surrounding.



In these panels we compare the same transect as that in the images right. Panel a) is the 6.7µm - 7.2µm combination attributed to the red channel in the Severe Storm RGB, panel b) is the 3.97µm - 11µm attributed to green.

The histogram, panel c), shows the cross section in panel b). The maximum brightness difference here is 35K, hence we have changed the -5K to 60K to -5K to 40K for the Severe Storm RGB above.

In the series of diagrams below we have equivalent radar and MODIS imagery.

We have a patch of intense reflections on the order 70dBZ. Panel c) shows the same scale area as the intensification in panel a) with the MODIS visible red channel 1 250m resolution imagery. The cross section in panel a) is represented in panel b) as averaged volumetric reflectivity across the fourteen vertical beam angles available to the radar, where left to right represents the cross section low to high.

Panel b) shows three components of the severe storm lifecycle; the left half to approximately 12km is indicative of the dissipation phase of storms where the upwelling vertical winds have reduced and the moisture forms heavy large droplet rain which the radar sees as intense reflections. The "grim reaper" signature which is indicative of strong vertical winds that pull the moisture upwards and reduce the size of the moisture particles which shows as virtually no reflectivity overtopped by strong reflections of the upwelling velocity reduces high in the storm and the moisture again coalesces. The third interesting zone is in between the two intense areas where the top down view shows evidence of minor a cyclonic wind.

In panel c) we see the light grey smooth band surrounding an area of brighter and darker disturbances associated with higher level dynamic cloud.

