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Bureau of Meteorology

# EUMeTrain Environment Week

## Making use of Weather Satellites for Bushfire Monitoring within Australia

Mike Willmott  
Senior Meteorologist  
Bureau of Meteorology  
(Volunteer Country Fire Authority)



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# A bit about the presenter (Mike Willmott)

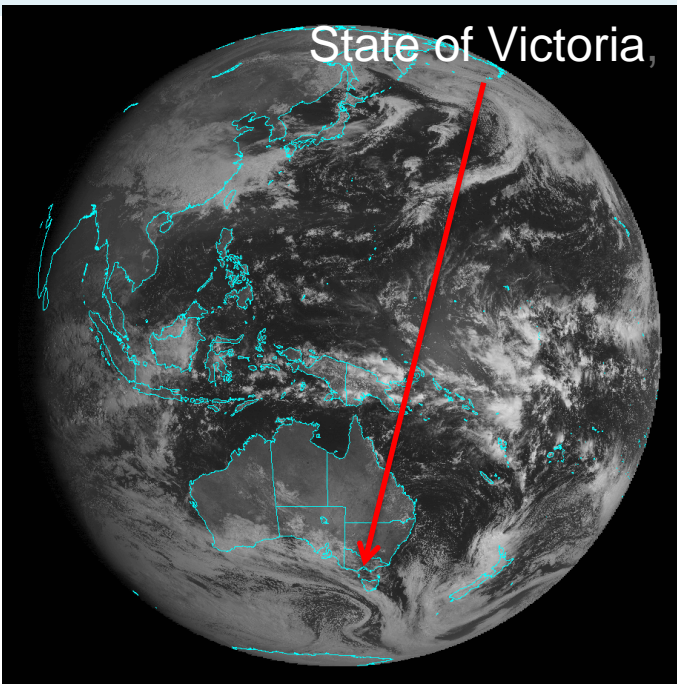


Image: from MTSAT-2 (JMA)



Image: from Google Earth



Image: from Mike's wife, Deb

Mike Lives on the beautiful Mornington Peninsula and works in Docklands (Melbourne)

Mike has worked for the Australian Bureau of Meteorology for over 41 years!

Mike has also been a volunteer firefighter with the Country Fire Authority for over 36 Years!



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# Outline

- History
- Satellite Imagery
  - 3.5 $\mu\text{m}$  v 10.5 $\mu\text{m}$
- Fires within Australia (Emphasis on SE Australia)
- Sentinel and eMap
- Preparedness Response and Recovery



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# History

- The Bureau has been ingesting satellite data since 25 December 1963 (Mainly photographic imagery)
- Geostationary Meteorological Satellite made available (GMS-1 from Japan Meteorological Agency) in 1977
- First LEO Satellite received by the Bureau which had more than two channels (Vis and IR) was NOAA-8 in 1983
- McIDAS (SSEC) introduced within the Bureau in 1987 providing the ability to manipulate satellite data
- First operational use of Weather Satellites for bushfire monitoring in 1997
- Ad hoc approach to hot spot monitoring for the fire agencies
- Partnership with Geoscience Australia to provide data for "Sentinel"
- Himawari 8 – ten minute data, 16 channels, better spatial resolution (2km)



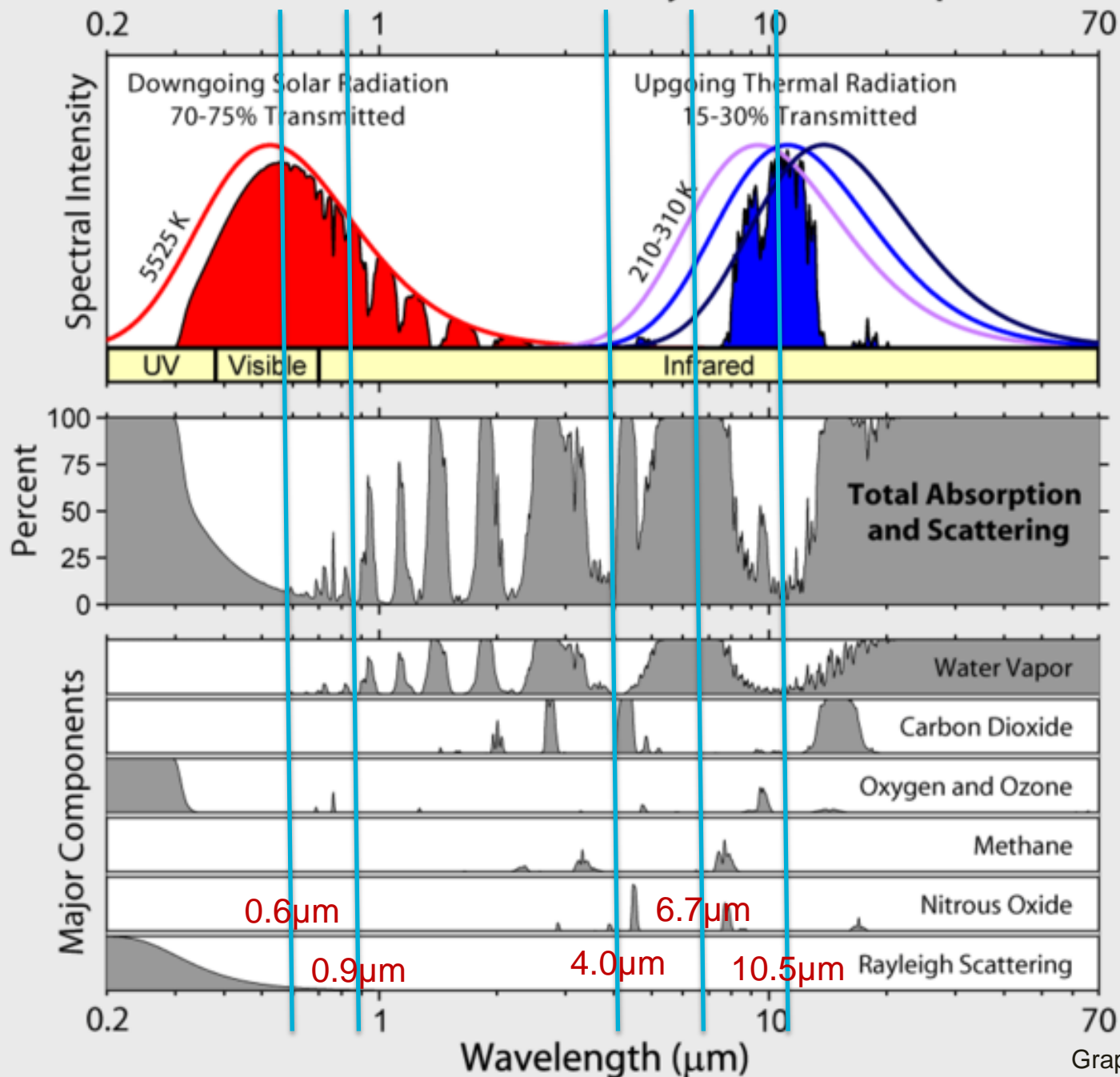
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First image received in Australia from TIROS-VIII

# Radiation Transmitted by the Atmosphere





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# NOAA-8 (1983)

First satellite ingested by the Bureau with AVHRR instrument

Detailed characteristics:

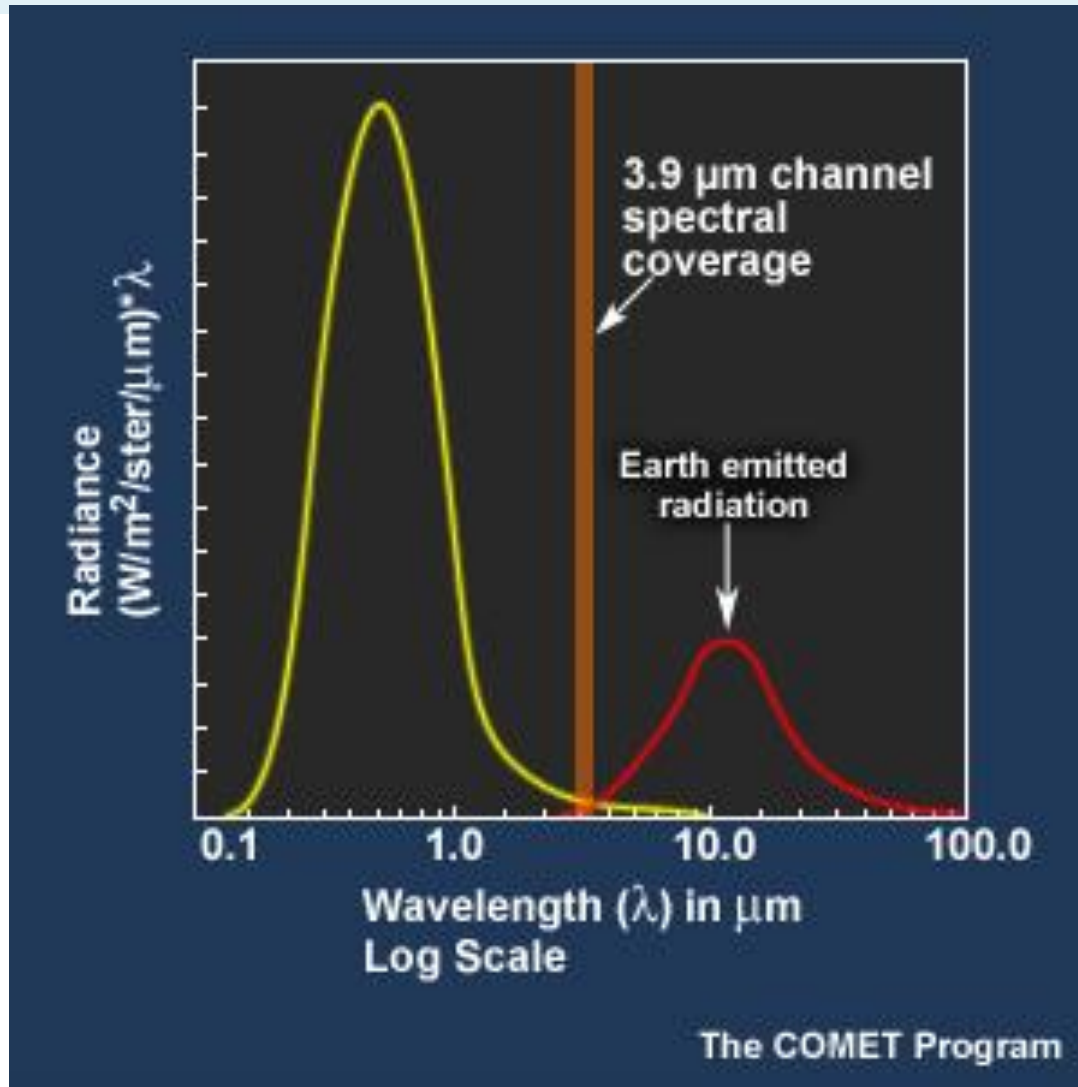
Central wavelength	Spectral interval	SNR or NE $\Delta$ T @ specified input
0.615 $\mu\text{m}$	0.55 - 0.68 $\mu\text{m}$	9 @ 0.5 % albedo
0.912 $\mu\text{m}$	0.725 - 1.10 $\mu\text{m}$	9 @ 0.5 % albedo
3.74 $\mu\text{m}$	3.55 - 3.93 $\mu\text{m}$	0.12 K @ 300 K
11.0 $\mu\text{m}$	10.5 - 11.5 $\mu\text{m}$	0.12 K @ 300 K



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# Why 3.5 $\mu\text{m}$ channel?



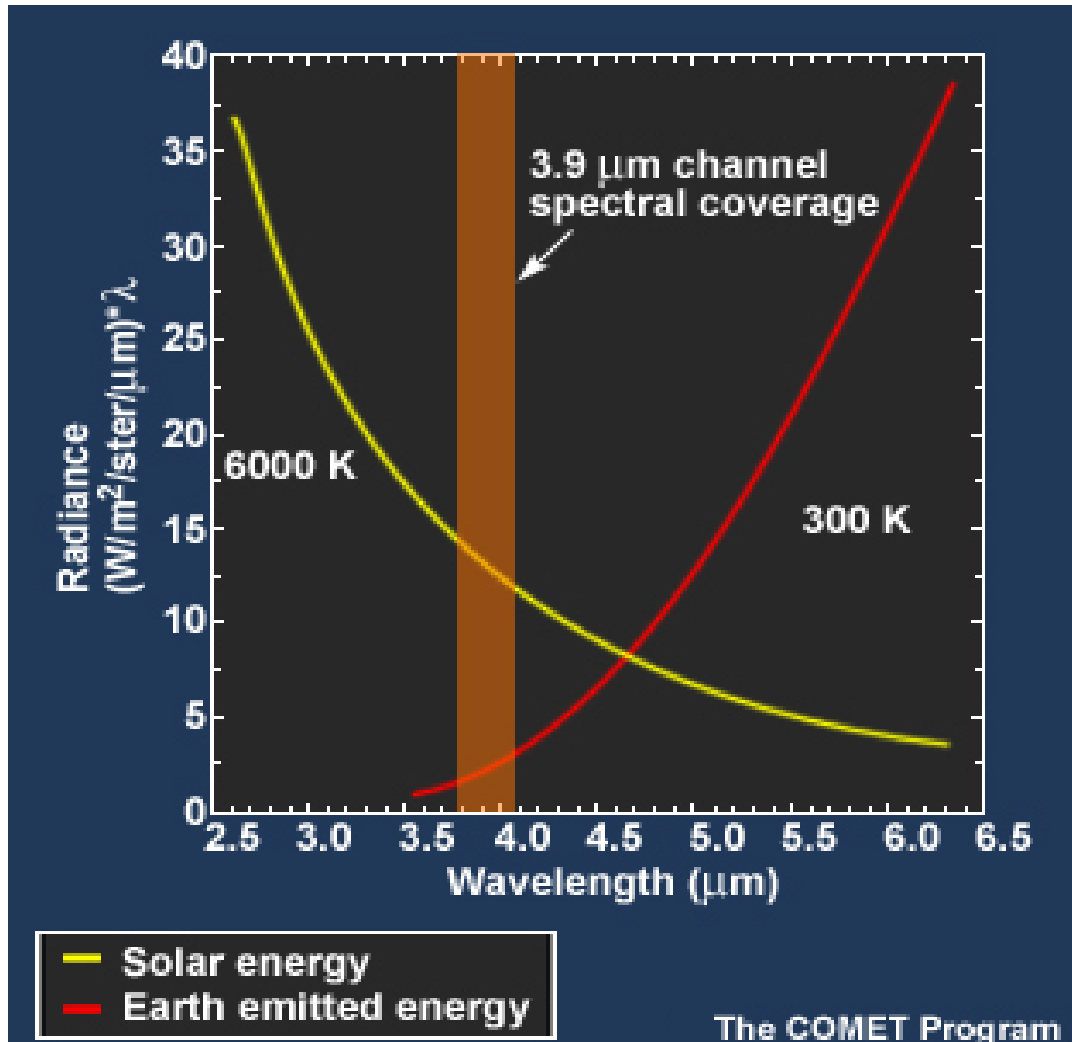




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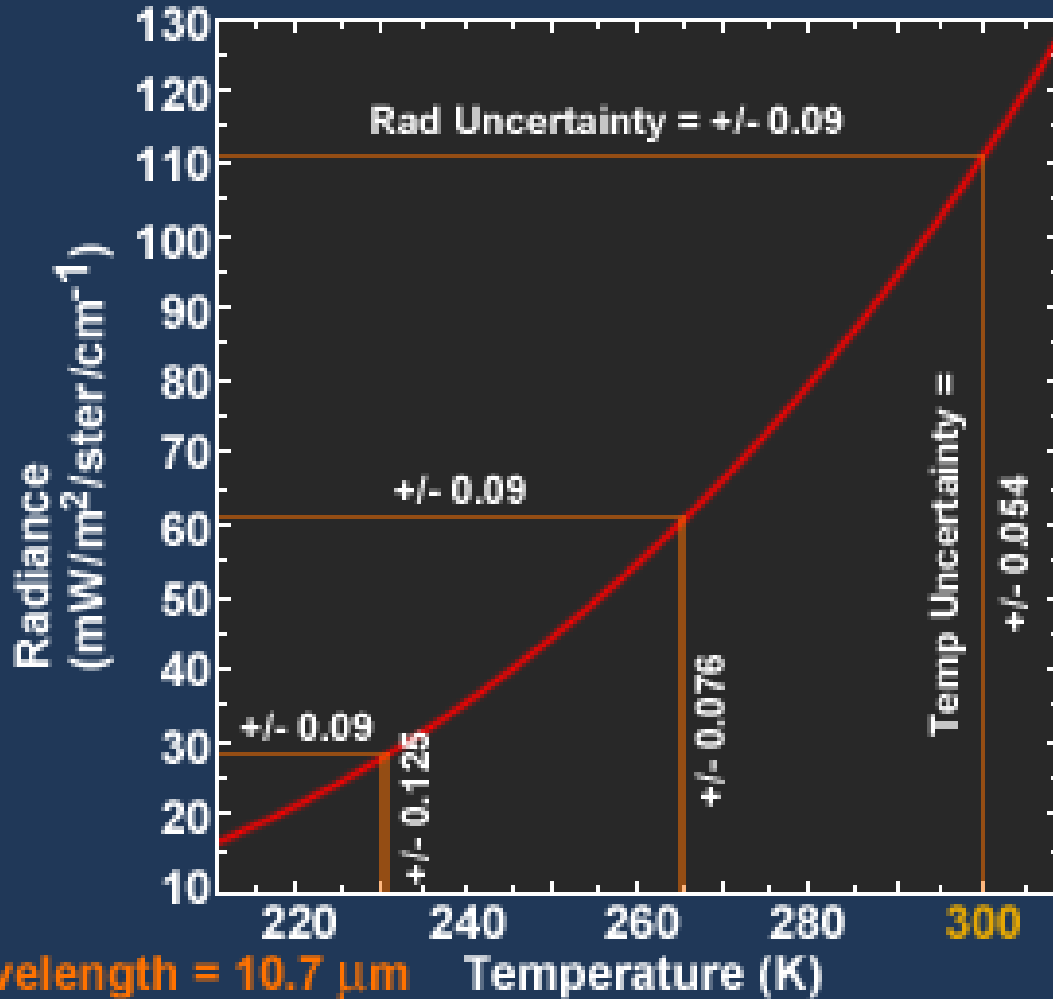
Bureau of Meteorology

# Why 3.5 $\mu\text{m}$ channel?



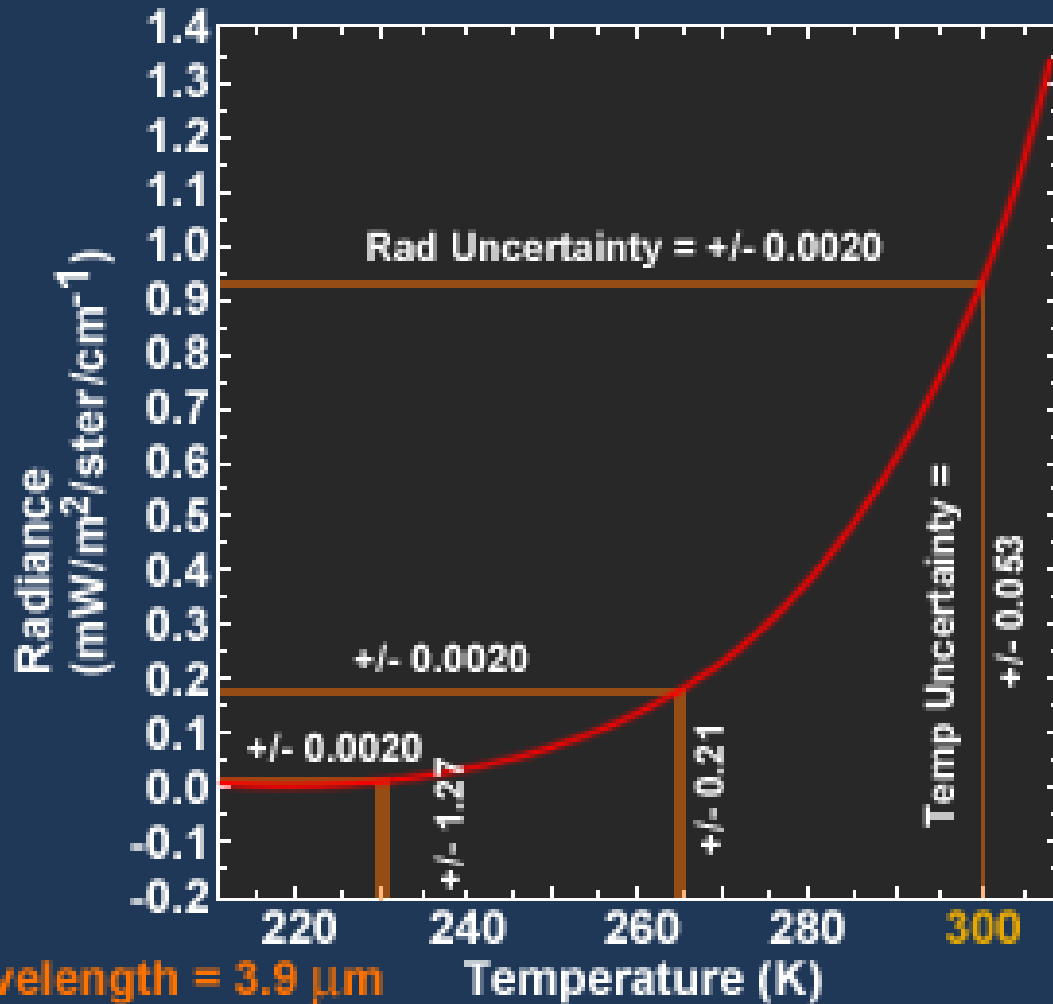


# 3.5 $\mu\text{m}$ vs 10.5 $\mu\text{m}$ channel





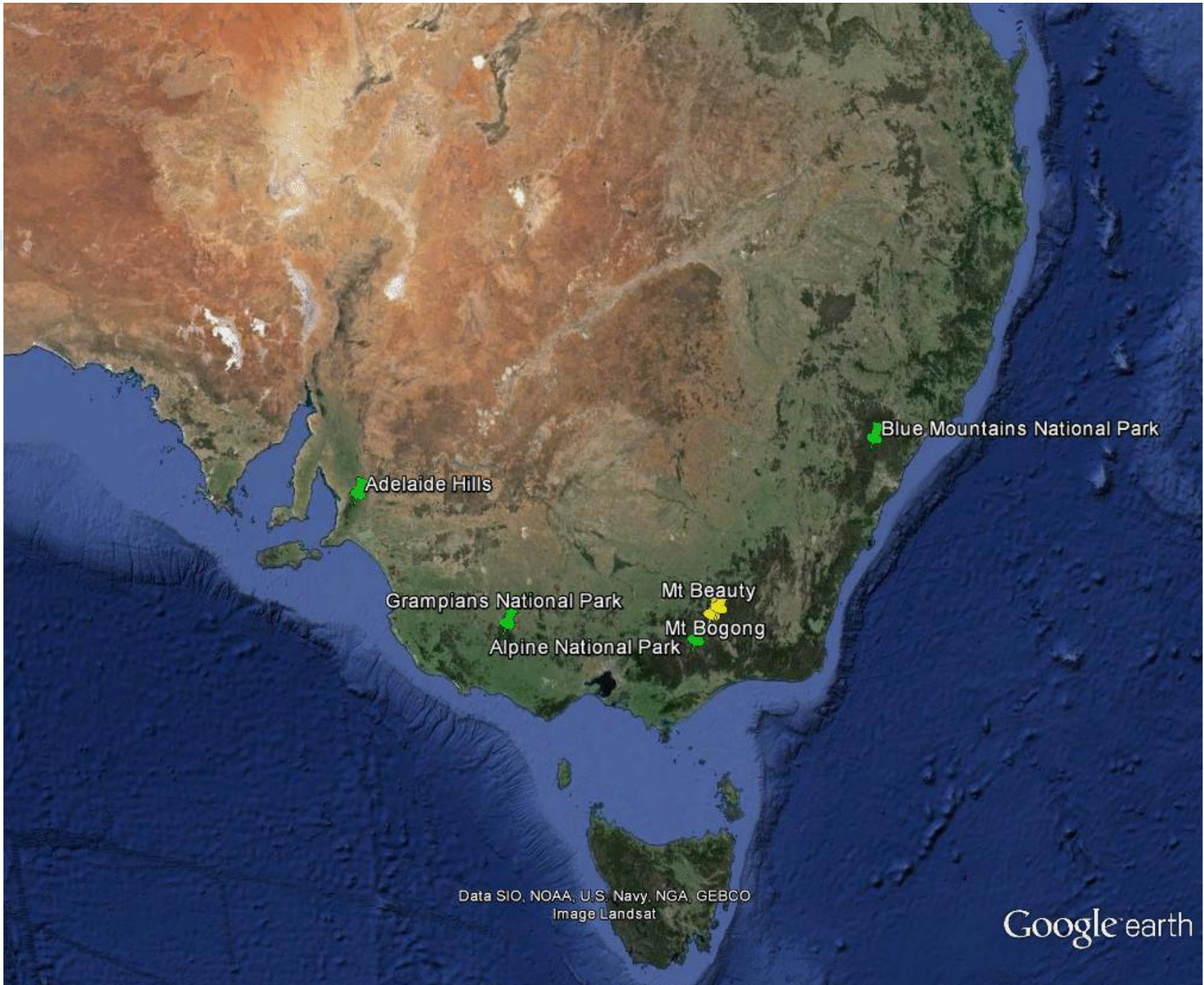
# 3.5 $\mu\text{m}$ vs 10.5 $\mu\text{m}$ channel





Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image Landsat

Google earth



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image Landsat

Google earth



Mt Bogong

Mt Beauty

Alpine National Park

Image Landsat

Google earth



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# Typical Wilderness Area - Mt Beauty (NE Victoria - Dry sclerophyll forest)



Photo: [travelvictoria.com.au](http://travelvictoria.com.au)



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# Typical Wilderness Area - Mt Bogong (NE Victoria - Dry sclerophyll forests)









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# Typical Wilderness Area



Photo: [couriermail.com.au](http://couriermail.com.au)



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# Wilderness





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# Wilderness



Photo: abc.net.au



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# Consequences

- **Five deadliest Australia bushfires on record**
  - Bushfires are ranked according to the number of fatalities.
    1. **Black Saturday (VIC), 7-8 Feb 2009 - 173 fatalities**
    2. **Ash Wednesday (VIC, SA), 16-18 Feb 1983 – 75 fatalities**
    3. **Black Friday (VIC), 13-20 Jan 1939 – 71 fatalities**
    4. **Black Tuesday (TAS), 7 Feb. 1967 – 62 fatalities**
    5. **Gippsland fires and Black Sunday (VIC), 1 February-10 March 1926 – 60 fatalities**



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# Consequences



Photo :taken by Jake Valance of Bushfire at Kinglake (HeraldSun Readers witness gallery)



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# Urban Rural Interface Canberra Fires (2003)



Photo: [canberrabushfires.com.au](http://canberrabushfires.com.au)



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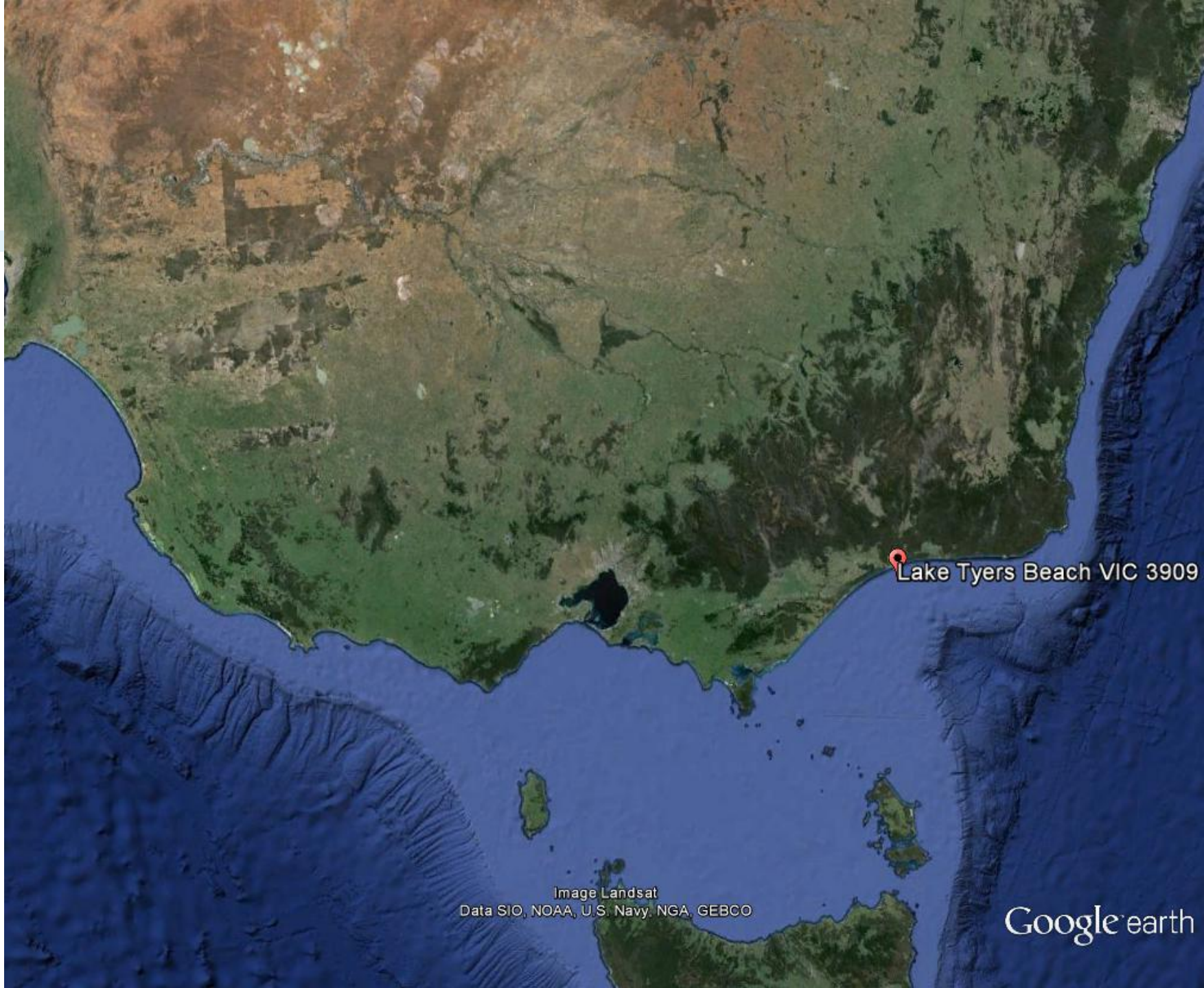
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# Urban Rural Interface Canberra Fires (2003)



Photo: abc.net.au

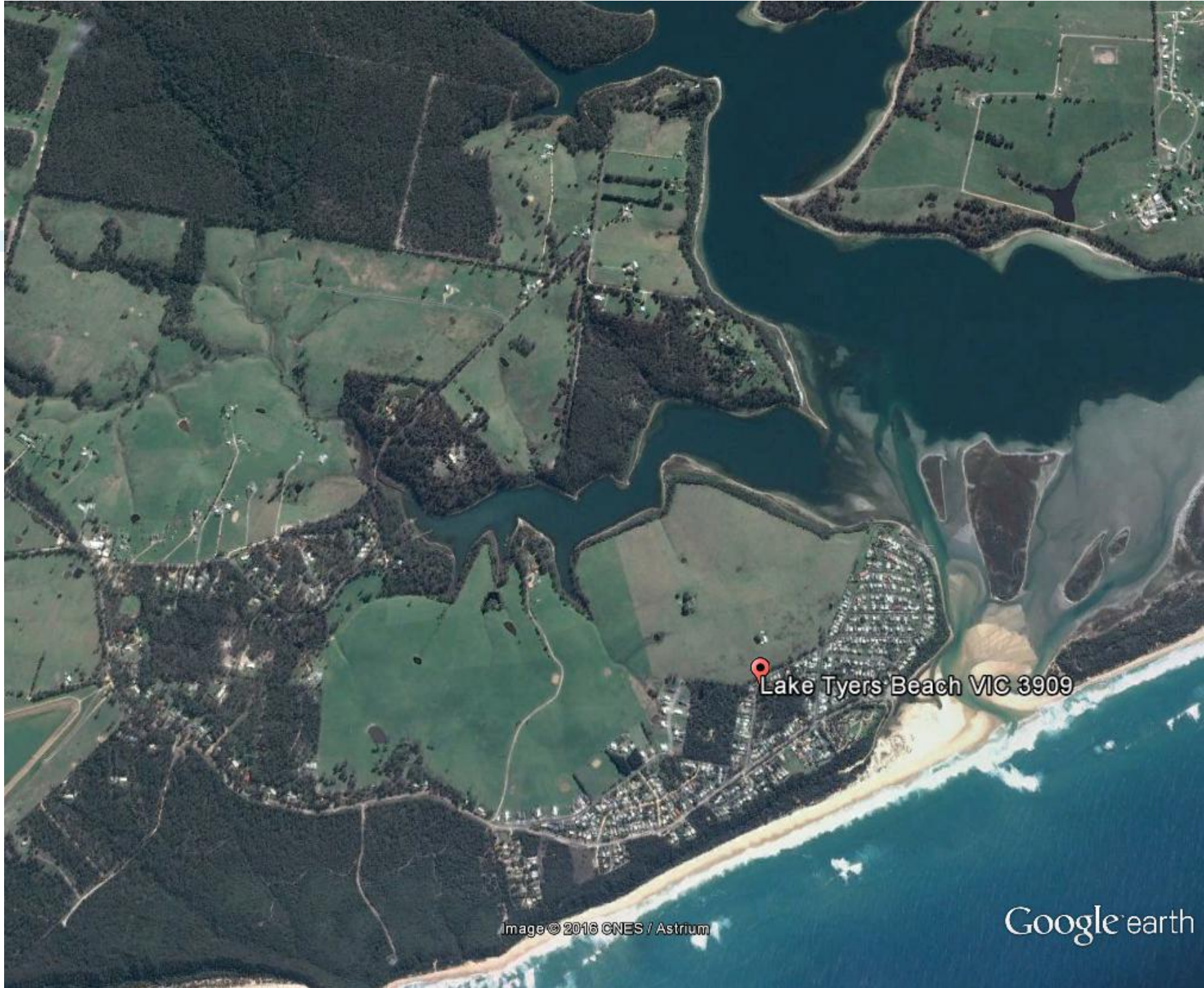




Lake Tyers Beach VIC 3909

Image Landsat  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth



Lake Tyers Beach VIC 3909



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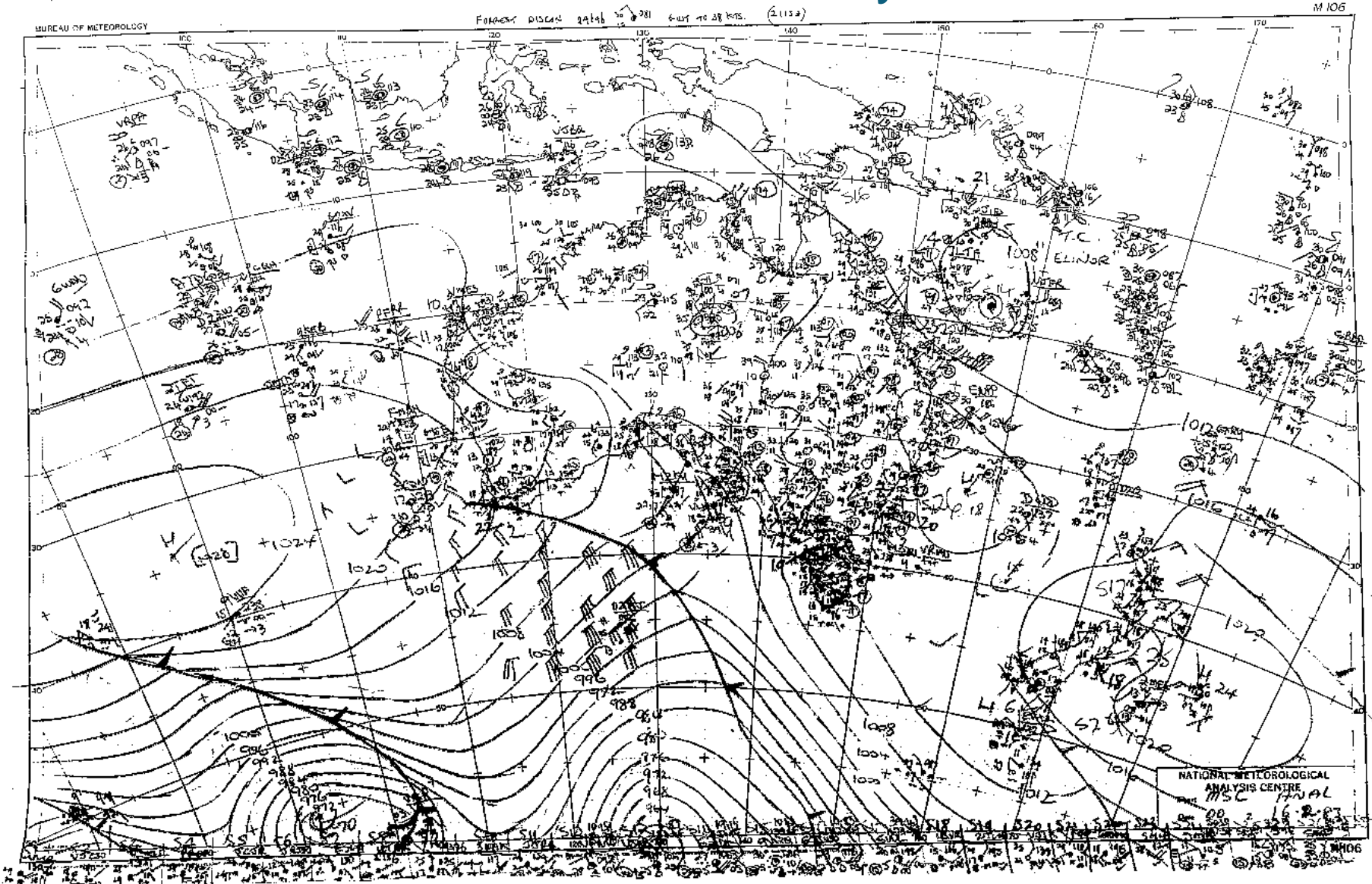


*(Photo: Frank Flynn, Lake Tyers Beach)*

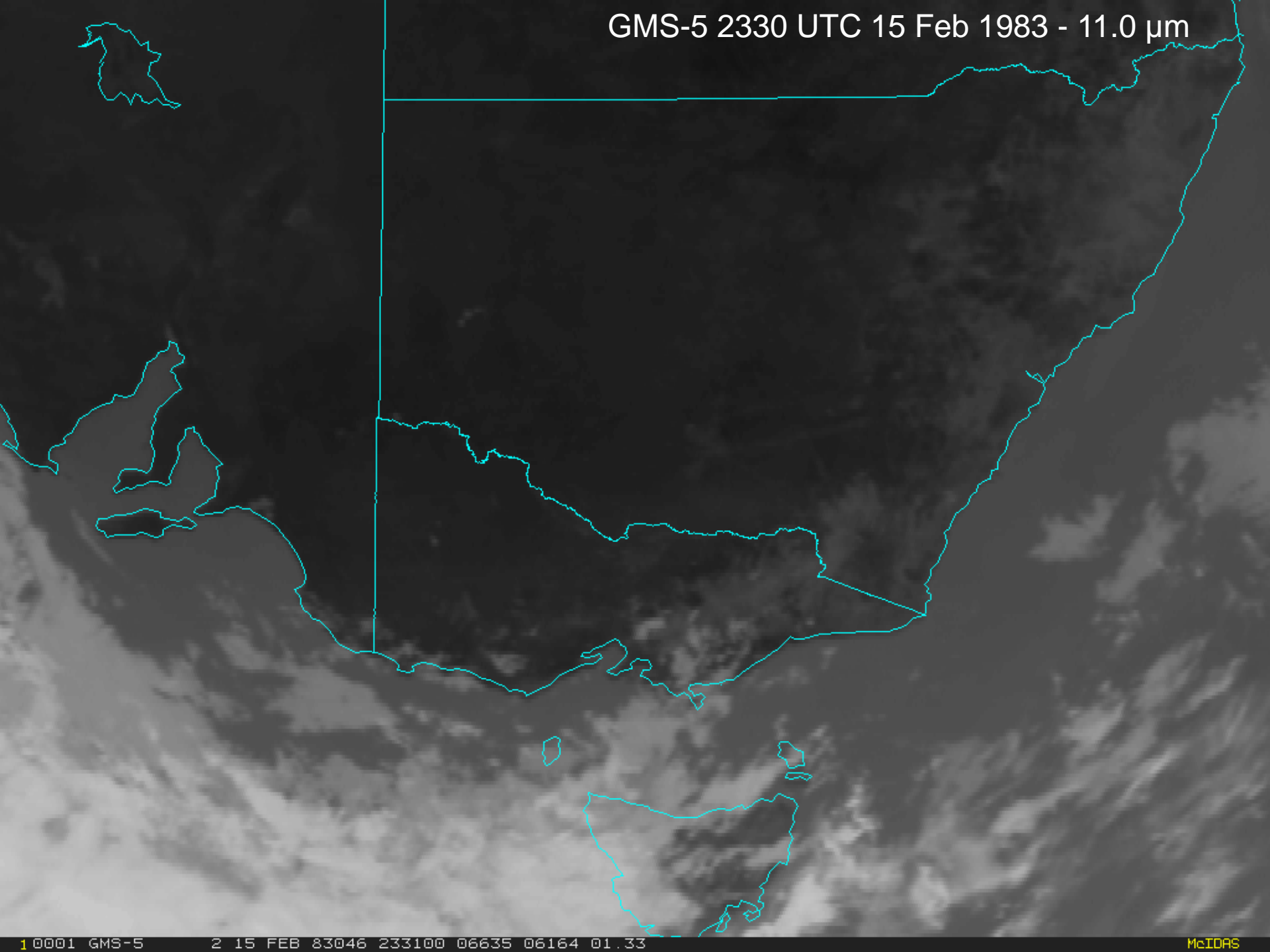


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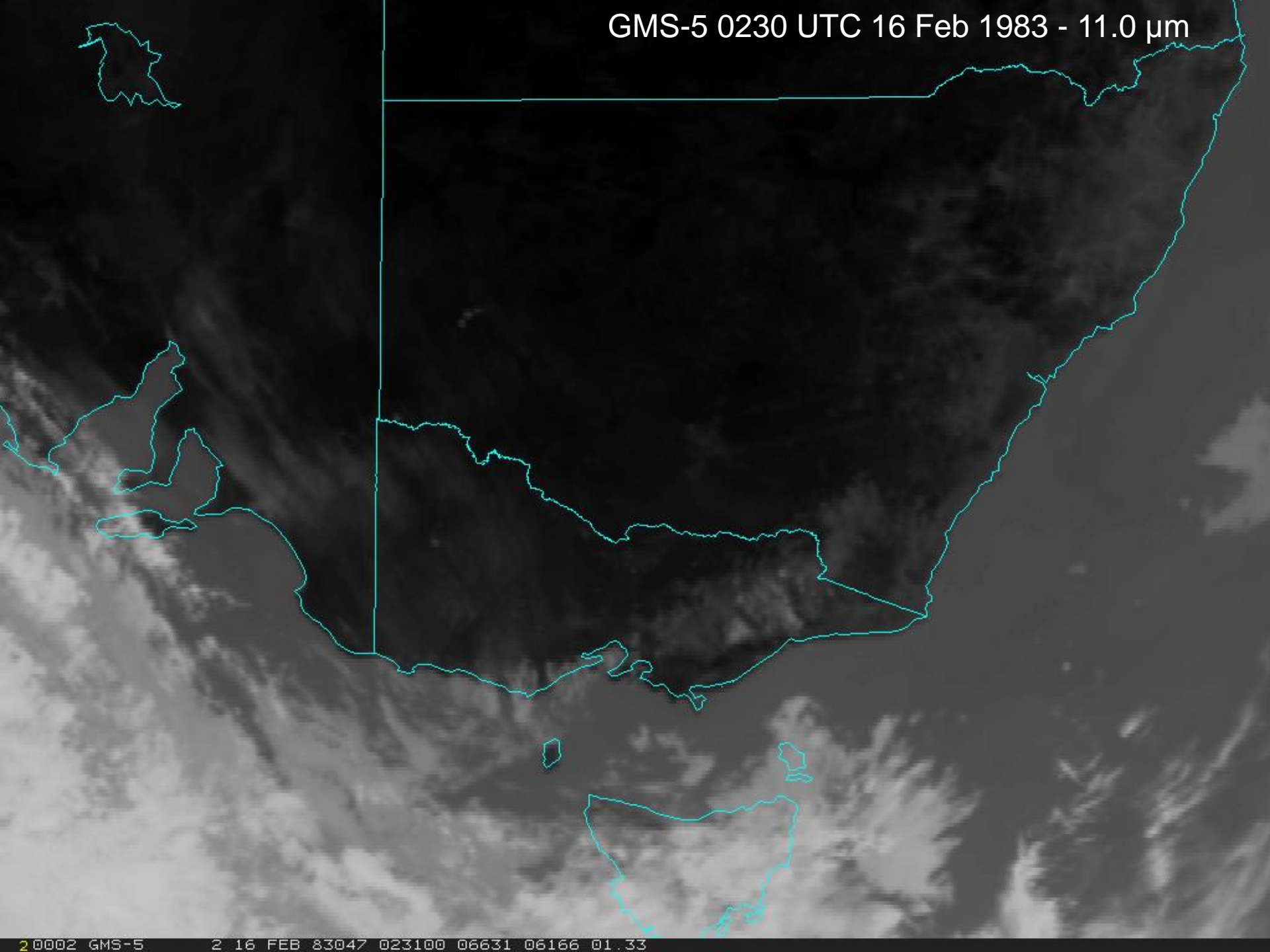
# Worst Fire Day in SE Australia's History 16 February 1983



GMS-5 2330 UTC 15 Feb 1983 - 11.0  $\mu\text{m}$

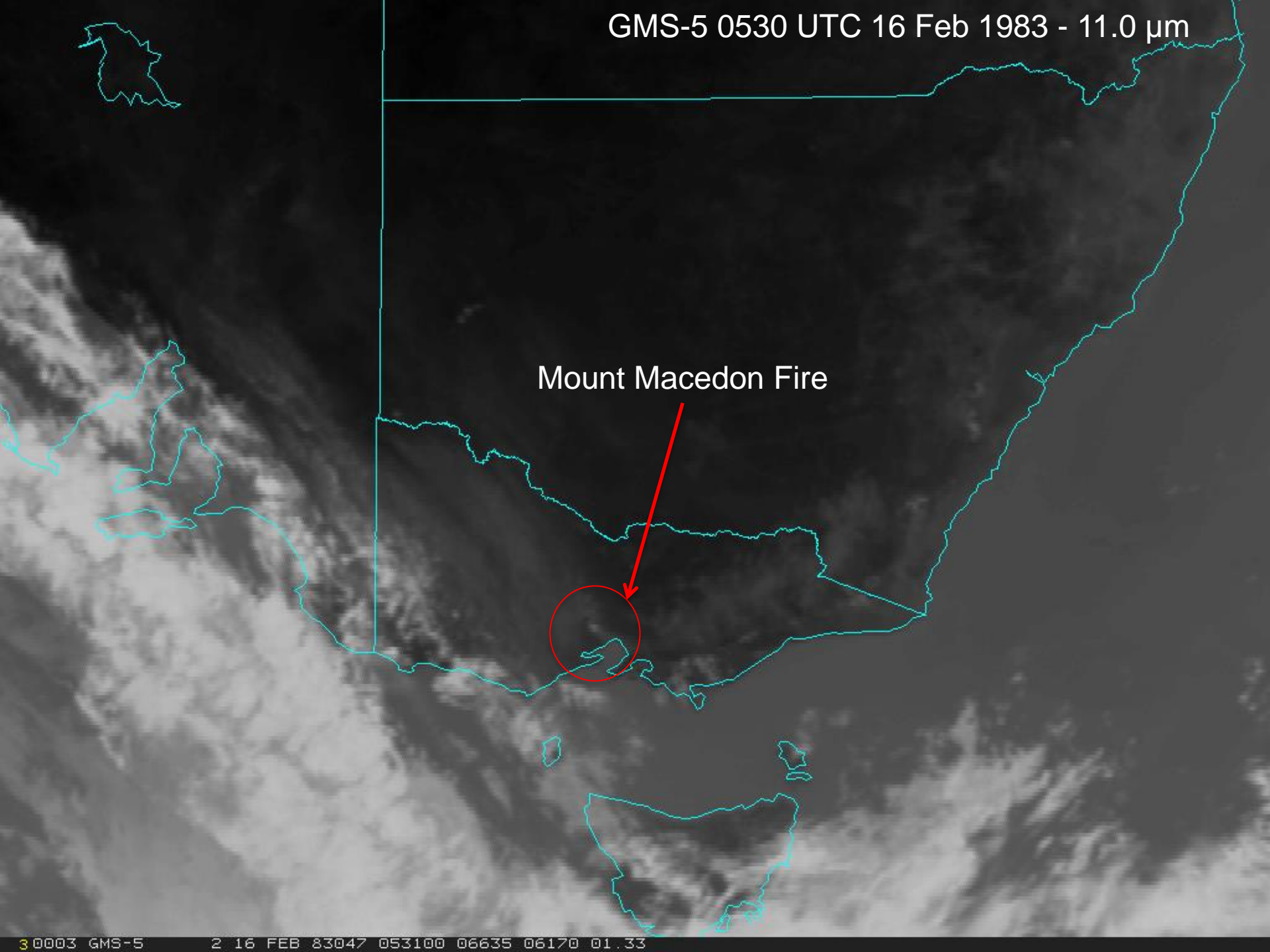


GMS-5 0230 UTC 16 Feb 1983 - 11.0  $\mu\text{m}$

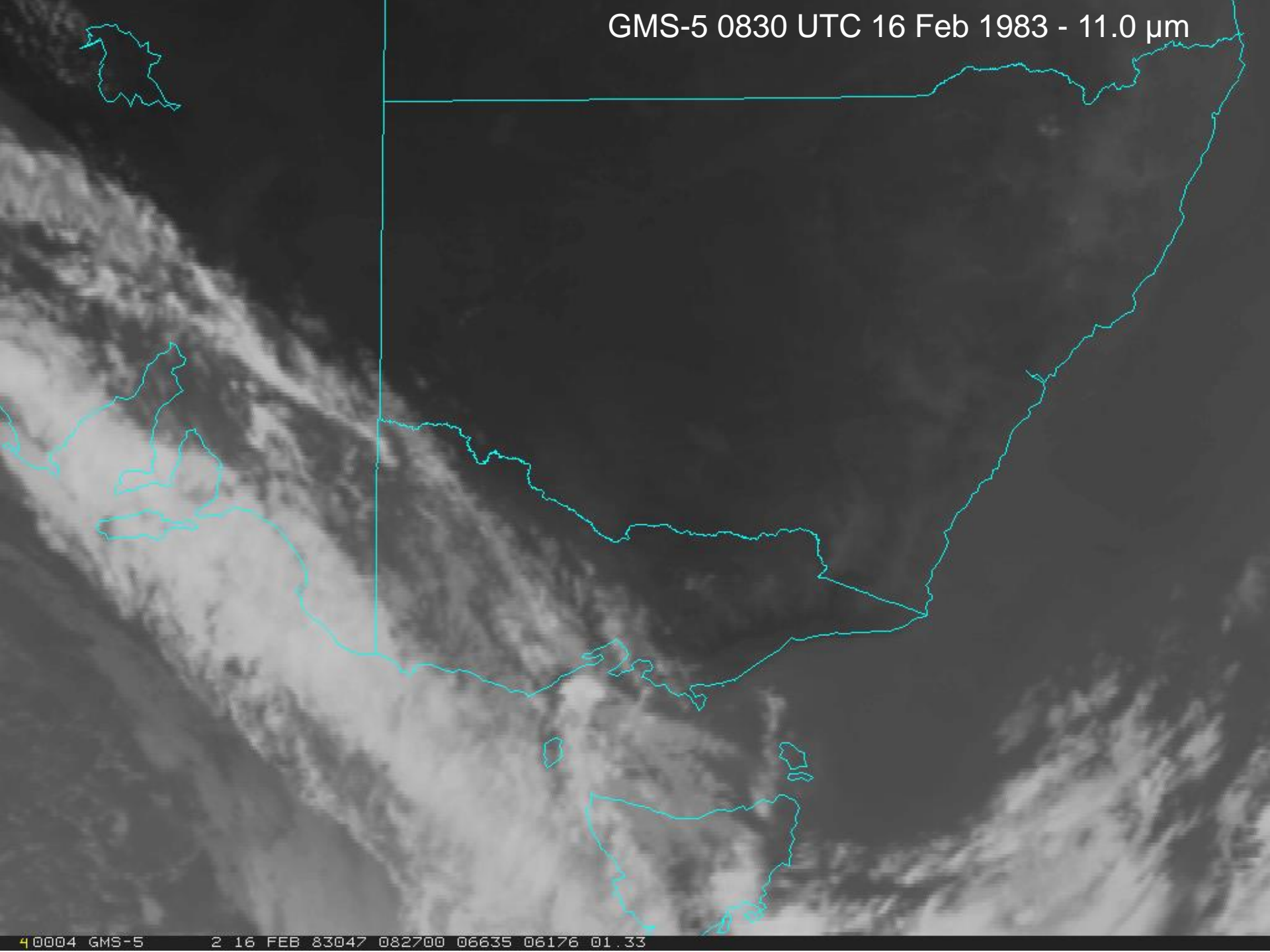


GMS-5 0530 UTC 16 Feb 1983 - 11.0  $\mu\text{m}$

Mount Macedon Fire



GMS-5 0830 UTC 16 Feb 1983 - 11.0  $\mu\text{m}$



40004 GMS-5 2 16 FEB 83047 082700 06635 06176 01.33

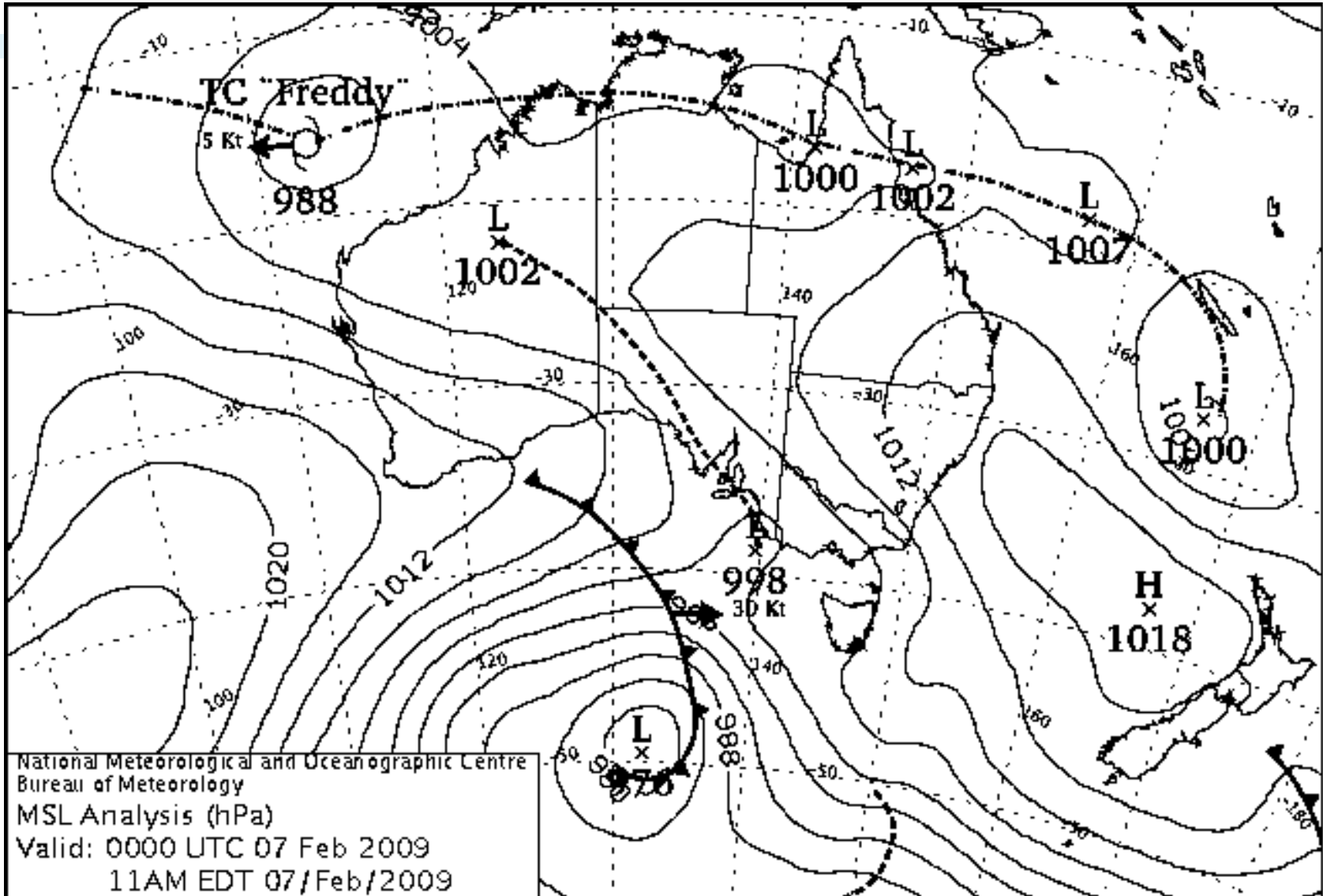




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# Worst Fire Day in SE Australia's History 7 February 2009

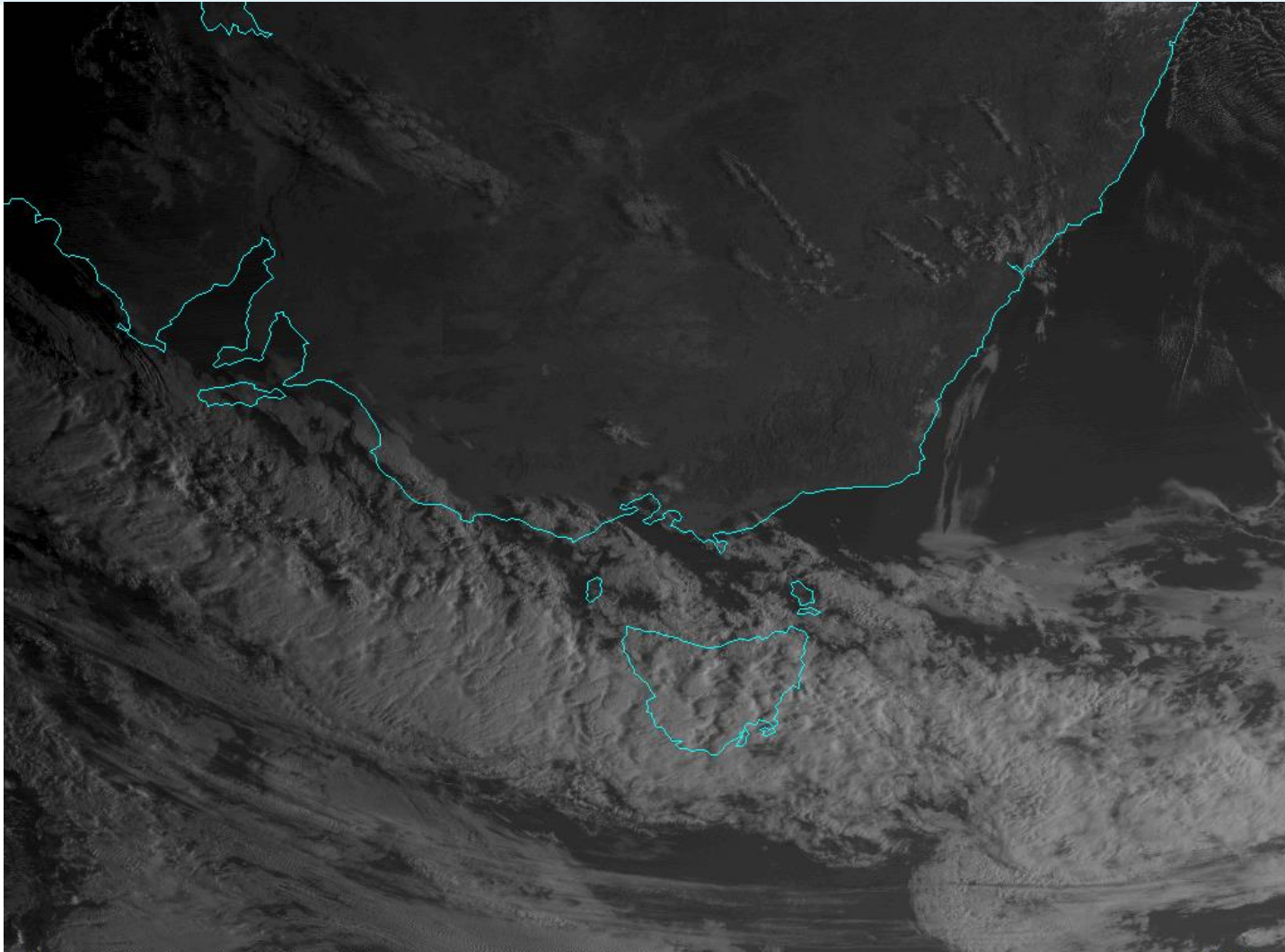




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# Black Saturday MTSAT-1R (0.55 $\mu\text{m}$ )

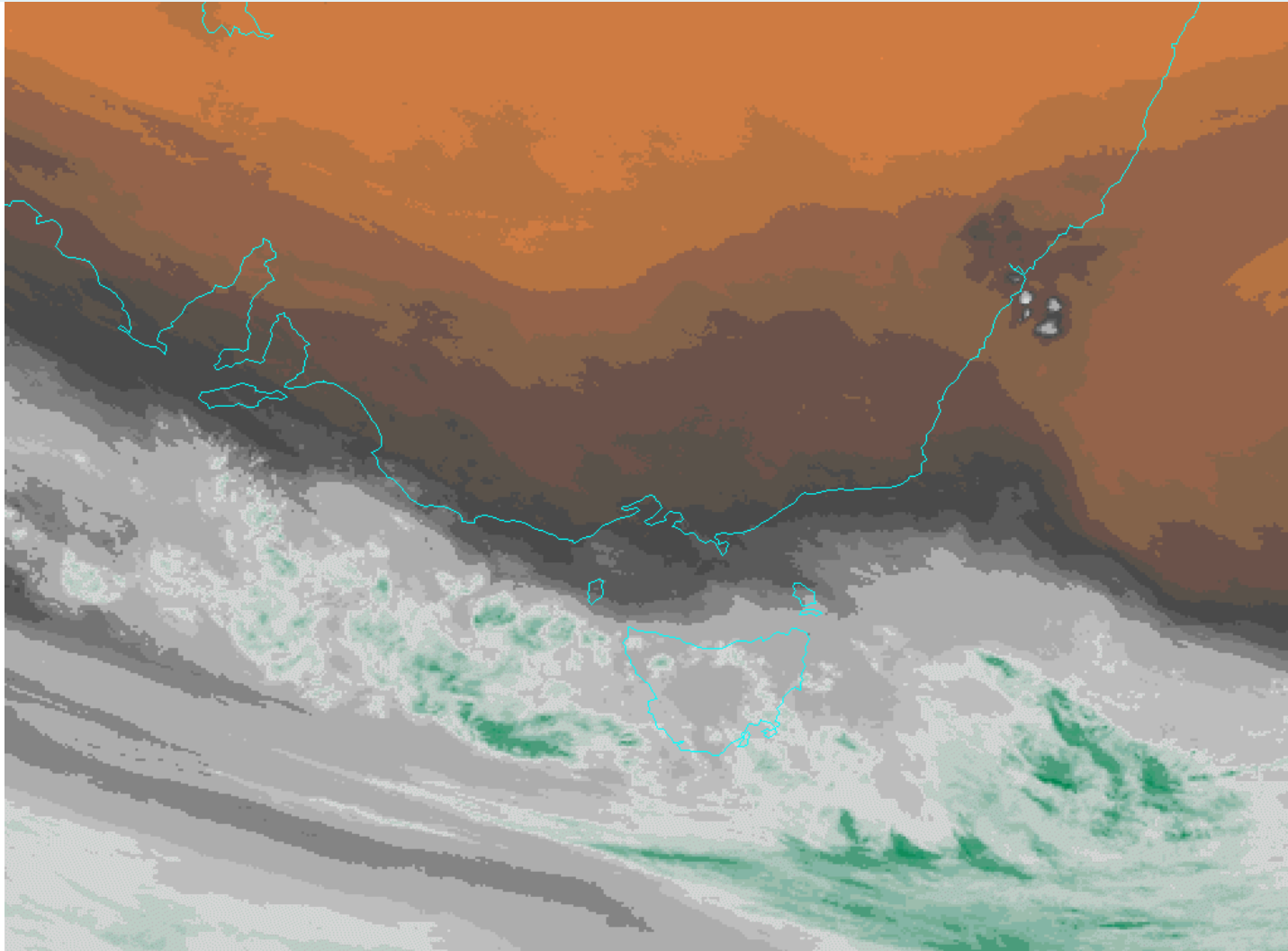




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# Black Saturday MTSAT-1R (6.7 $\mu$ m)

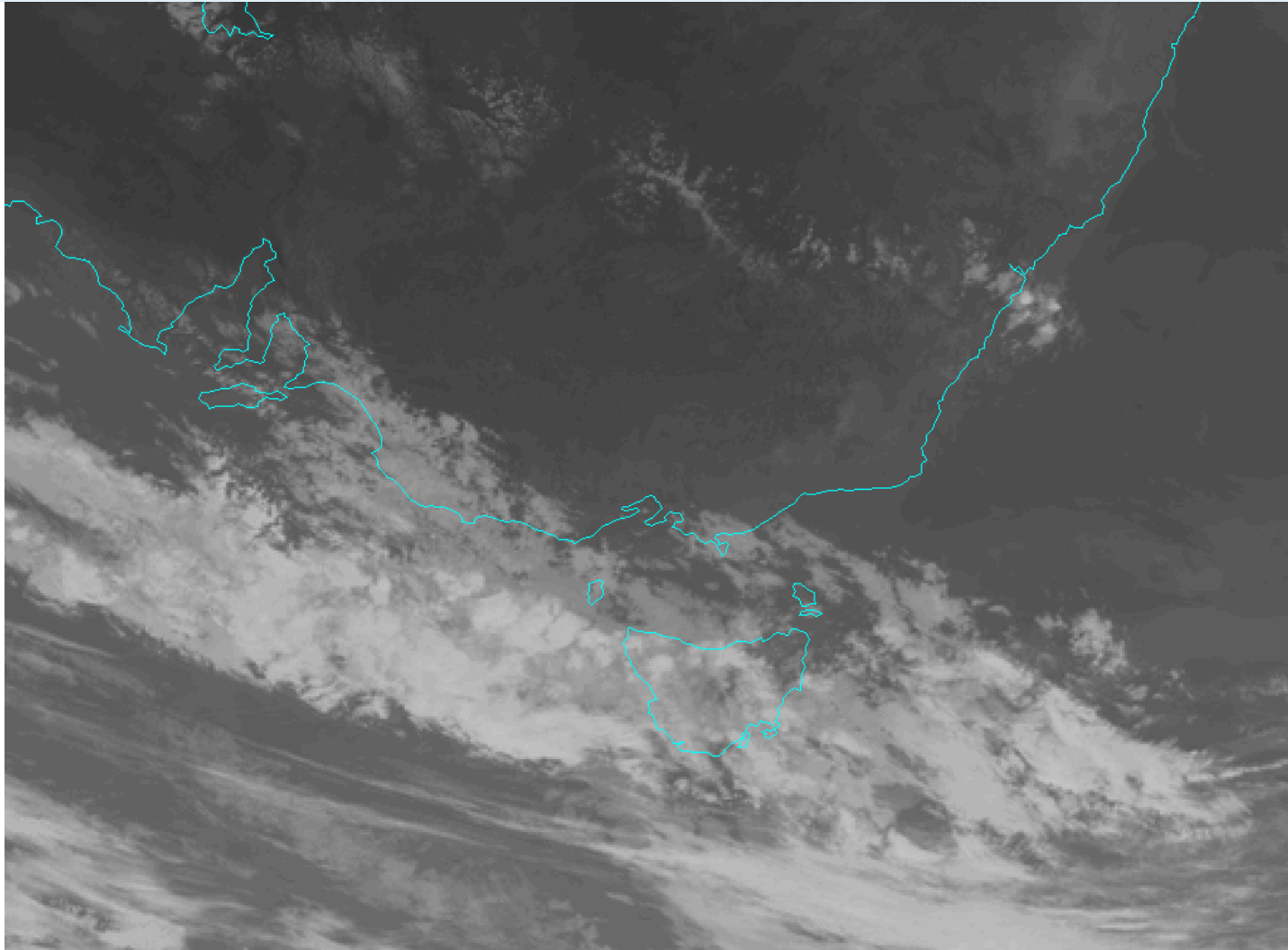




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# Black Saturday MTSAT-1R (10.5 $\mu\text{m}$ )

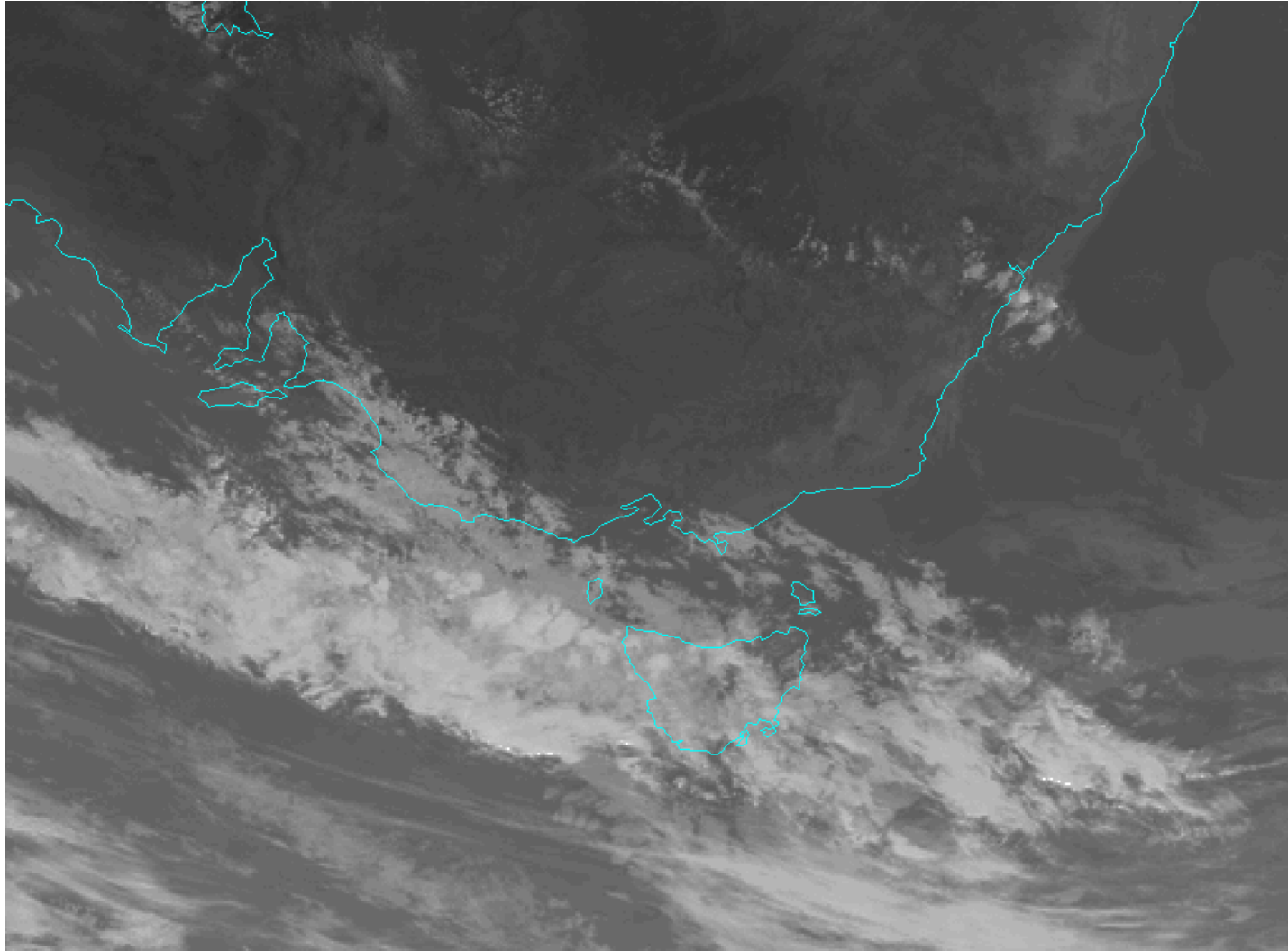




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# Black Saturday MTSAT-1R (3.7 $\mu$ m)



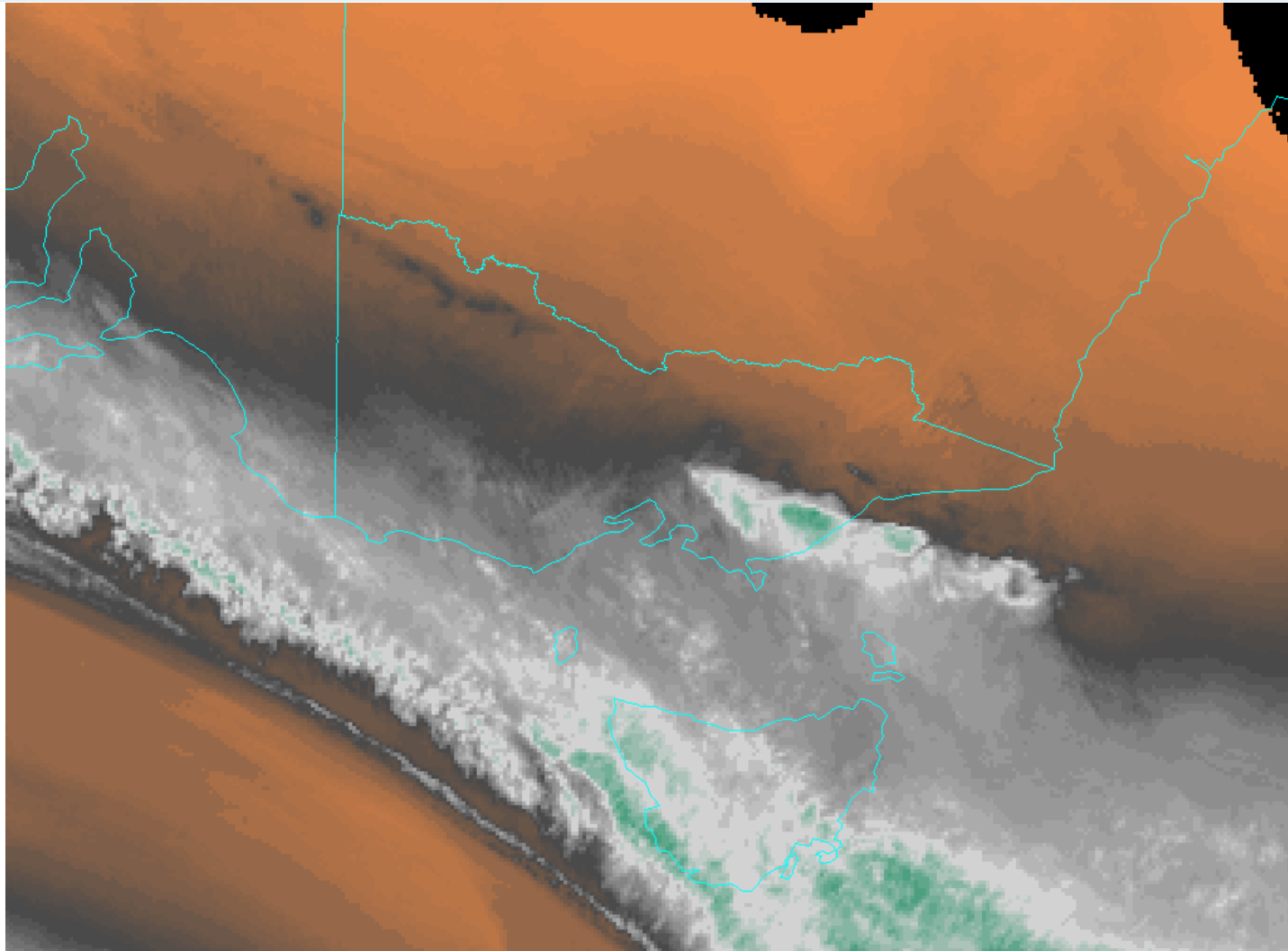


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# Black Saturday MTSAT-1R (6.7 $\mu$ m)

## 7 Feb 2009 - 09:30 UTC



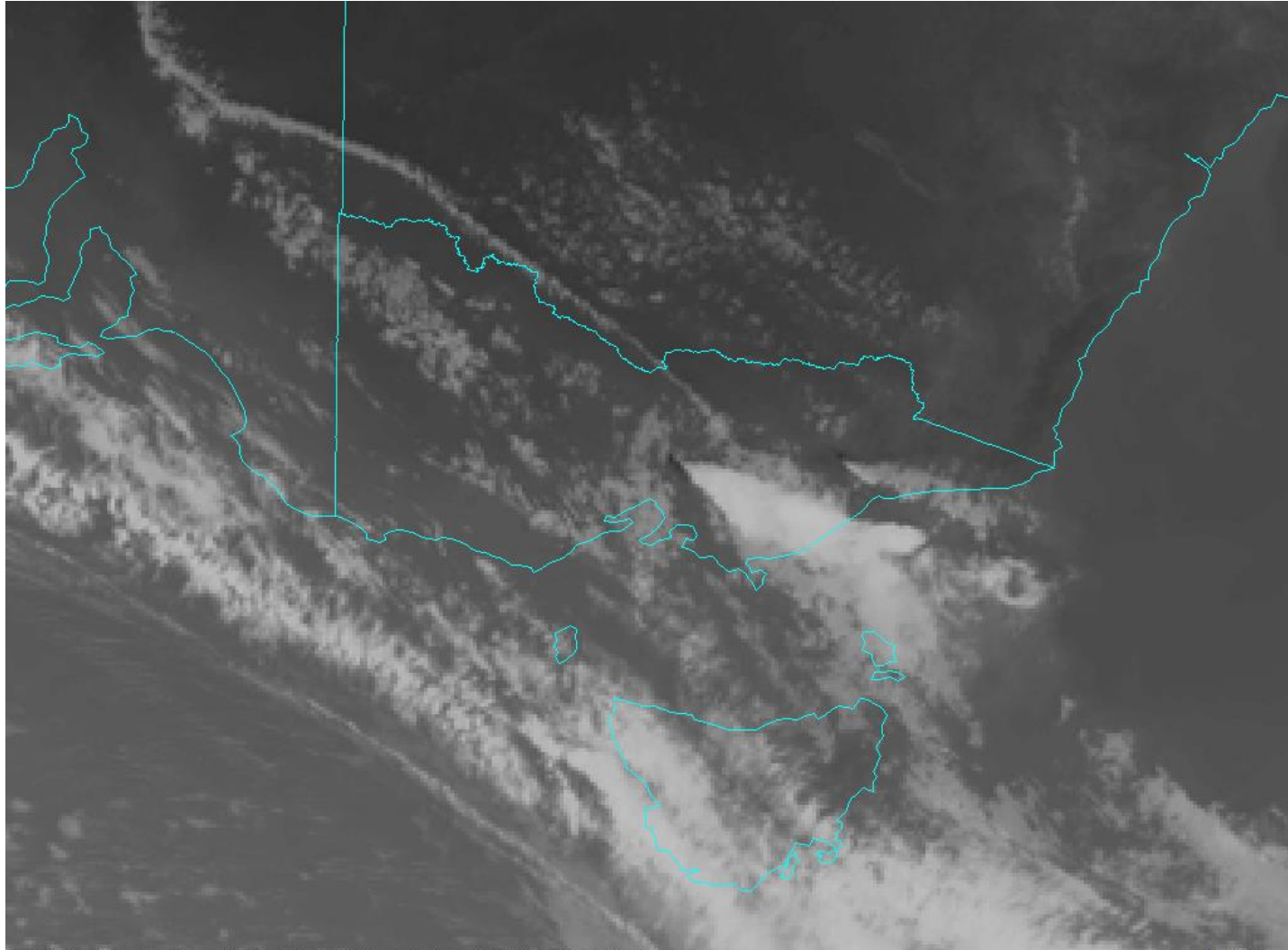


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# Black Saturday MTSAT-1R (10.5 $\mu$ m)

## 7 Feb 2009 - 09:30 UTC



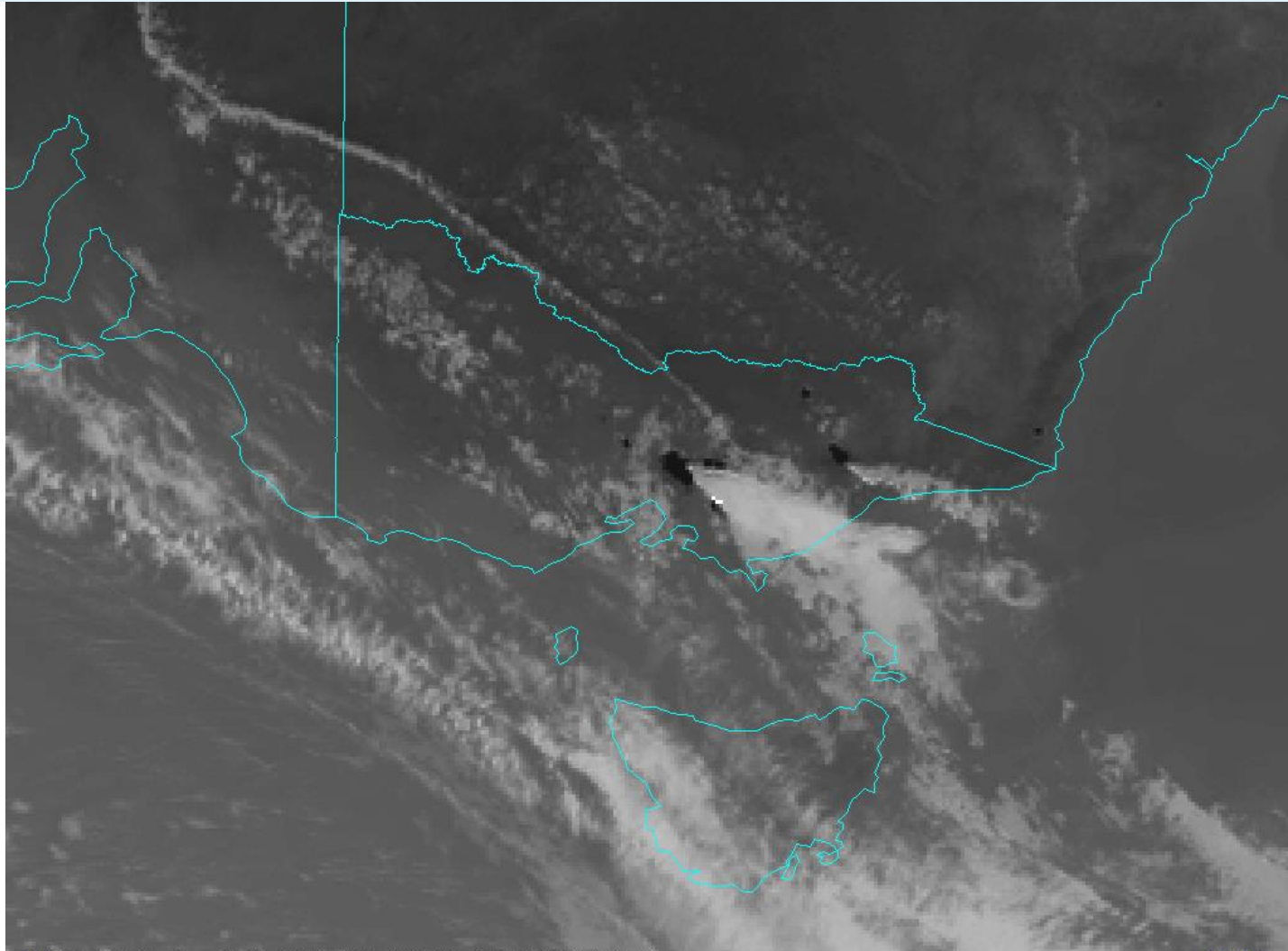


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# Black Saturday MTSAT-1R (3.7 $\mu$ m)

## 7 Feb 2009 - 09:30 UTC







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# Black Saturday 7 Feb 2009



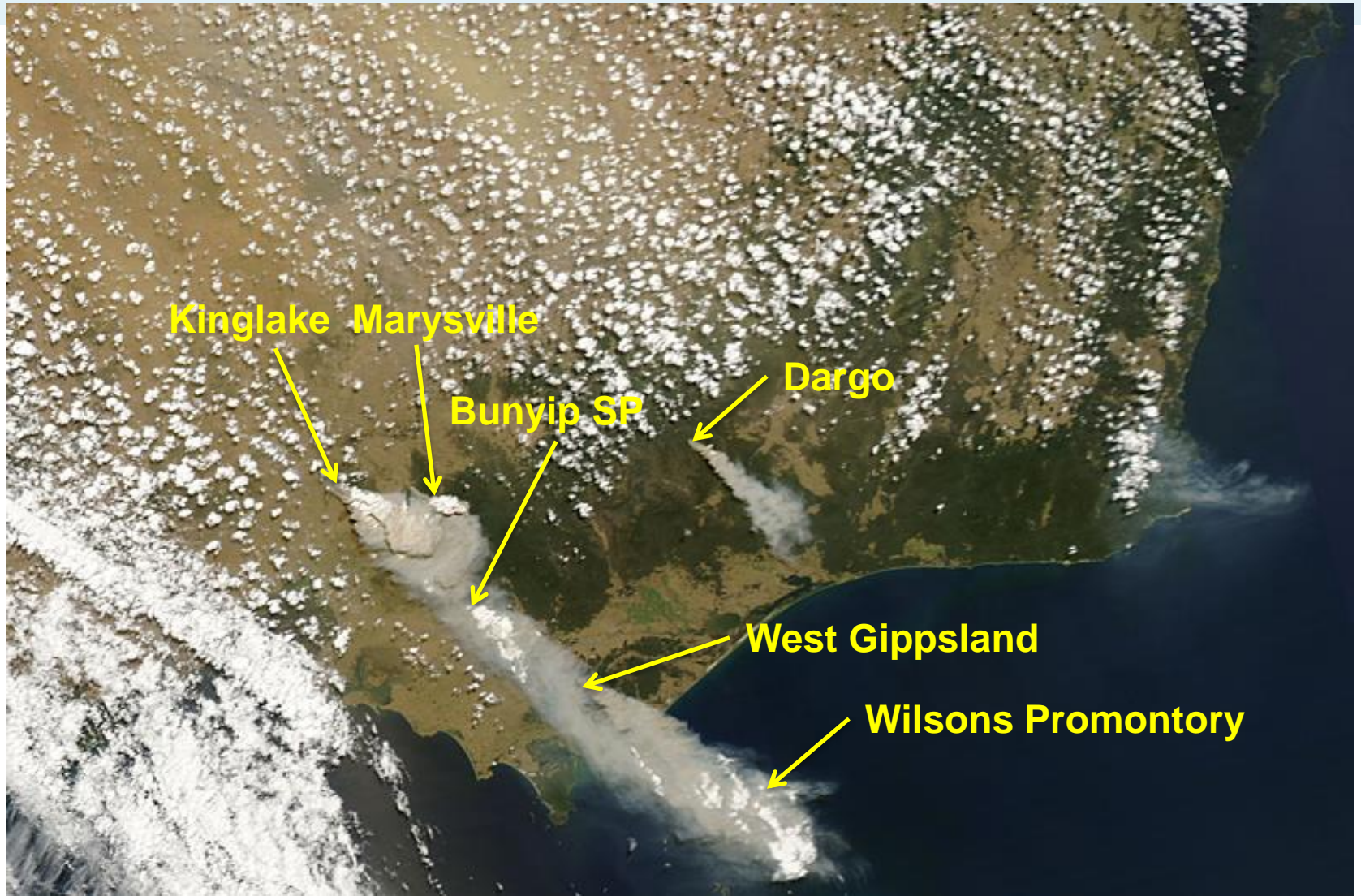
Graphic: wikipedia.org



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# MODIS "Rapidfire" Image (Aqua)





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# Emergency Management Cycle

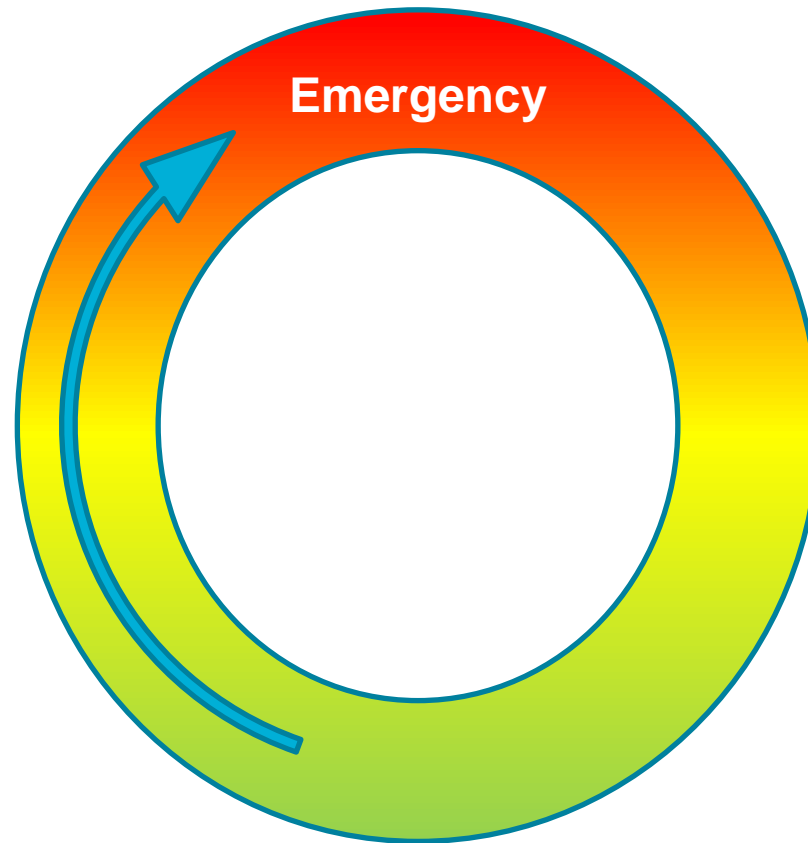




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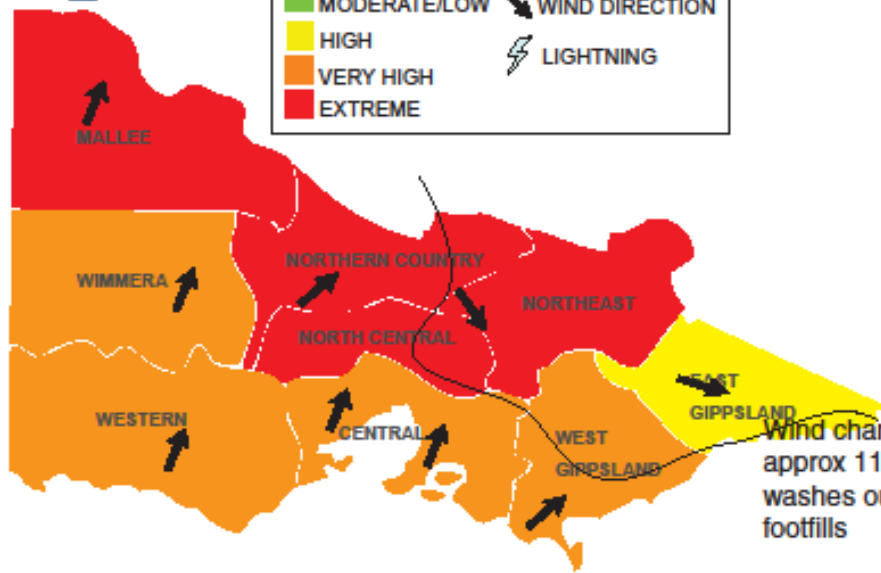
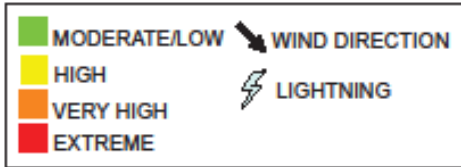
# Preparedness





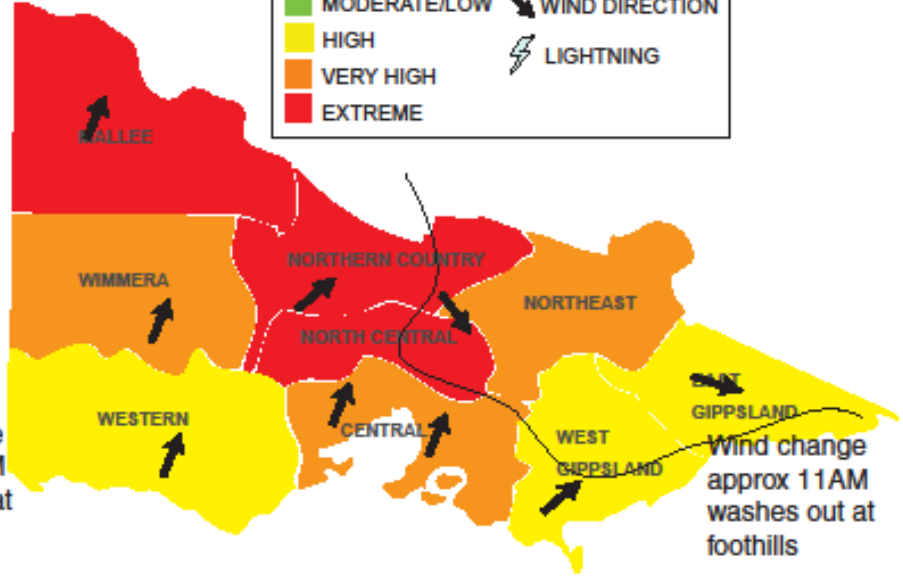
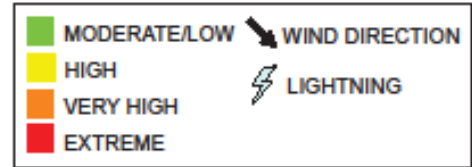
# THURSDAY 5 FEBRUARY 2009

## Forest Fire Danger Rating (FFDR)



Wind change approx 11AM washes out at foothills

## Grassland Fire Danger Rating (GFDR)



Wind change approx 11AM washes out at foothills

### Fire Danger

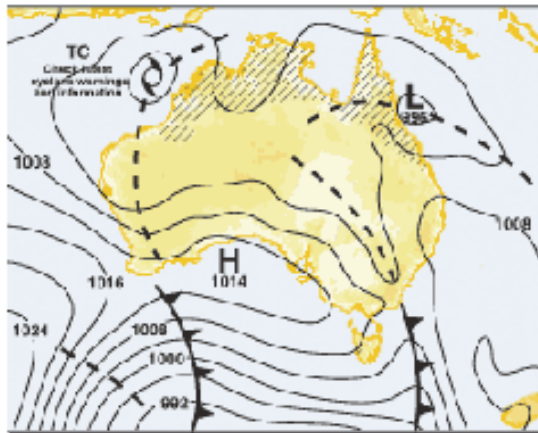
Generally reaches extreme across the north due to hot drier conditions inland ahead of the weak trough. Note, north of the Divide and through central areas the peak in GFDR may occur late morning /early afternoon - just before maximum temperature time.

### Lightning

Lowest chance day for thunderstorms - any convection is more likely to be over into southern NSW.

### Precipitation

Nil.



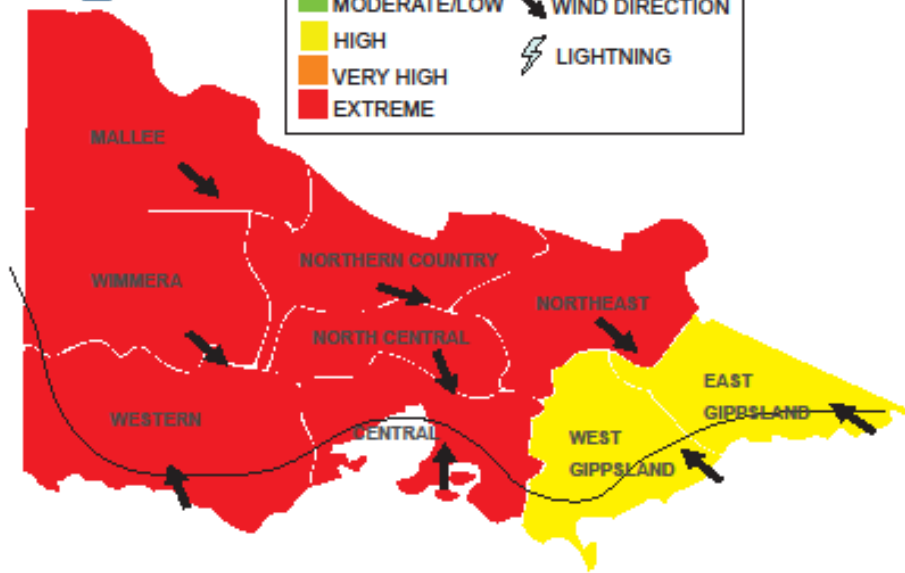
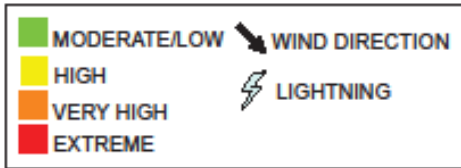
### Synoptic pattern

The trough over NSW and eastern Victoria pushes further east as a cold front moves through Bass Strait dragging the trough with it. The airstream over Victoria becomes southwest to southerly from the west. Instability is expected in the northeast. The airmass remains hot in the north but becomes cooler in the south. Note, models look fairly consistent with change timing but if the change is slower more locations in the west will have higher ratings.

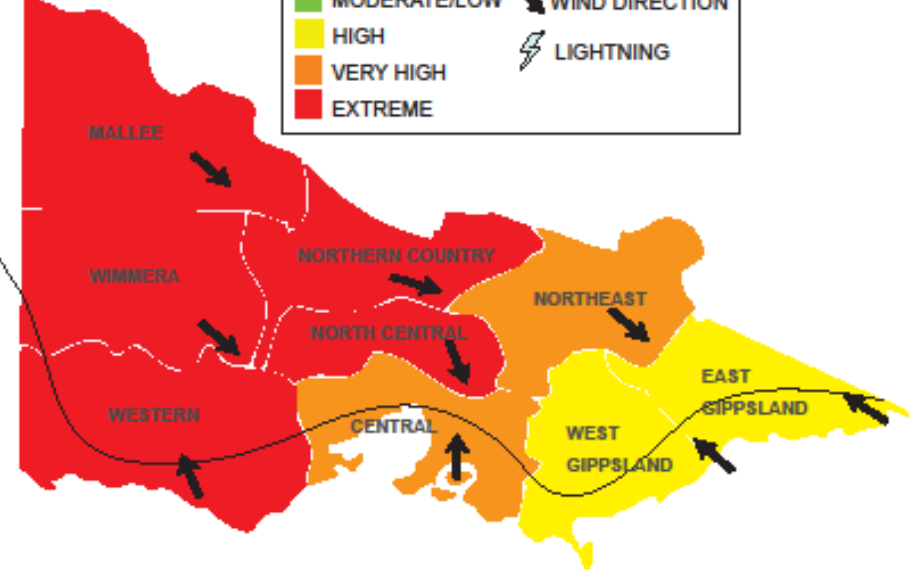
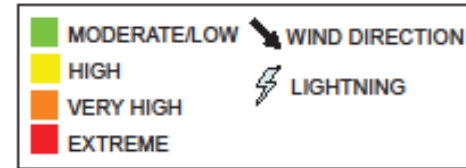


FRIDAY 6 FEBRUARY 2009

**Forest Fire Danger Rating (FFDR)**



**Grassland Fire Danger Rating (GFDR)**



**Fire Danger**

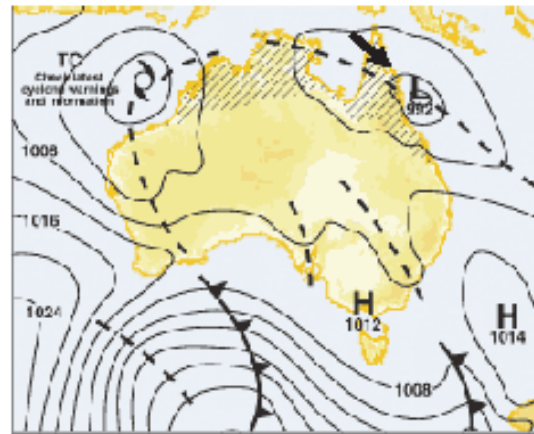
Winds in the upper levels will freshen with central and elevated areas in the west seeing fresh northerly winds around 30-45km/hr. The winds result in GFDR reaching a peak in the north and central earlier than max temp, however remainder including FFDR will reach peaks in late afternoon.

**Lightning**

Nil.

**Precipitation**

Nil.



**Synoptic pattern**

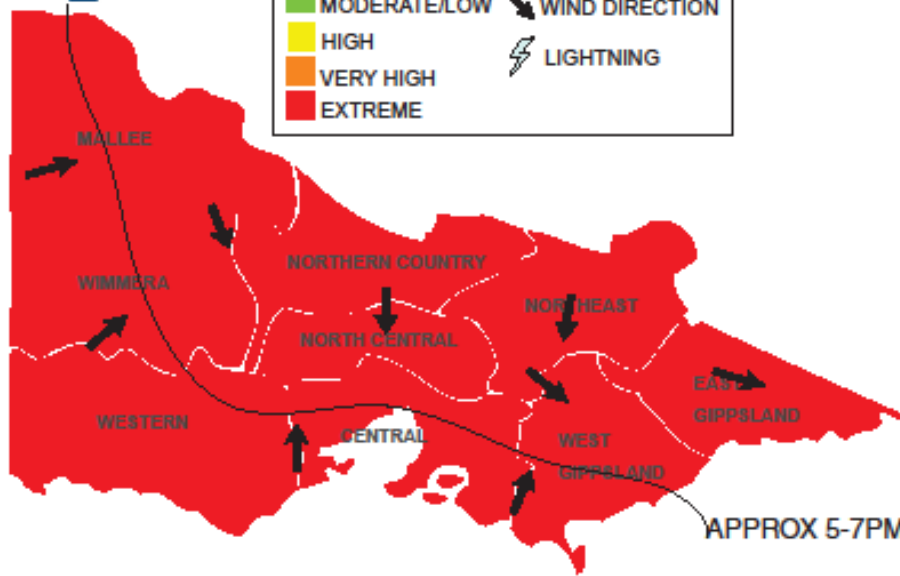
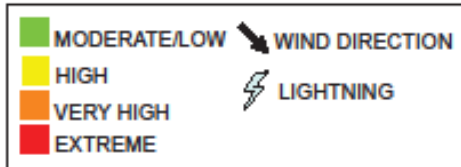
High pressure system moves into the Tasman sea as a developing frontal passage moves into the Southern Ocean. Winds will start to shift around to the northwest by afternoon. Weak prefrontal trough will develop along the coast again and in the far west before stalling overnight. The drier continental air will continue to migrate into northern Victoria resulting in very warm to hot in the north temperatures and drying in the afternoon.



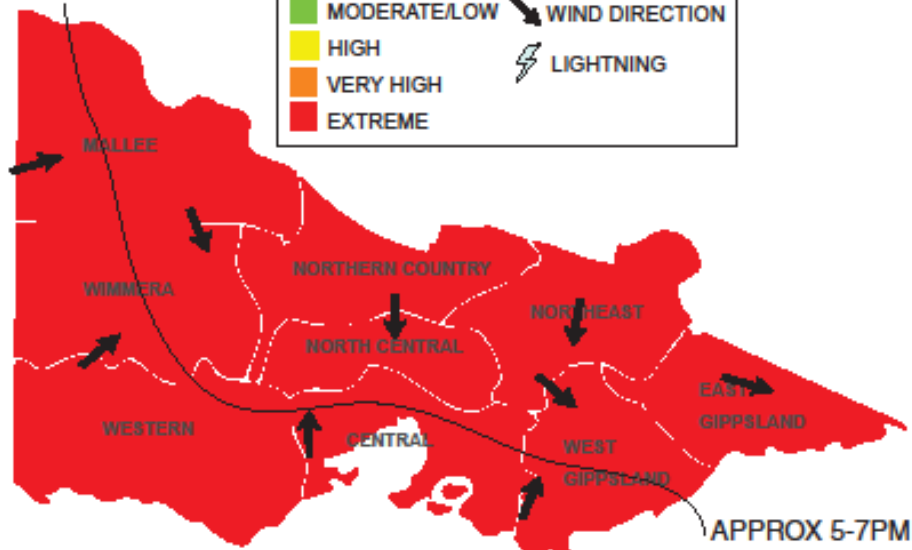
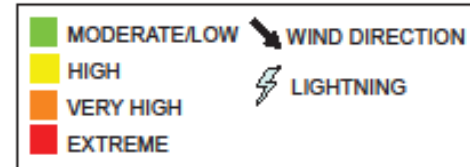
SATURDAY 7TH FEBRUARY 2009

CRITICAL Extreme Fire Weather spike day

Forest Fire Danger Rating (FFDR)



Grassland Fire Danger Rating (GFDR)



Fire Danger

Fire danger will be extreme in both forest and grass due to the strong winds, low RH and temperatures in the 40s. Both FFDI and GFDR above 50 will be reached in the morning - from 7am onwards, with ratings above 80 by late morning. Poor relative Humidity recovery overnight due to warm overnight temps.

Lightning

Unlikely but low prob (less 5%) with change, and possible with any fire induced pyricumulus.

Precipitation

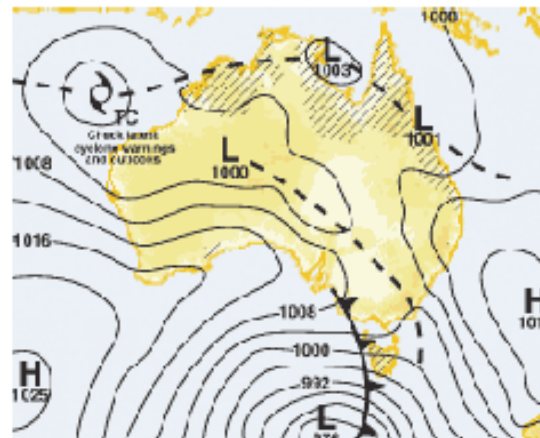
Scattered showers developing WELL behind change.

NOTE, INITIALLY DRY GUSTY SOUTHWEST CHANGE

Information provided for internal briefing purposes within the Integrated Emergency Coordination Centre and not to be used for any other purpose or distributed without permission.

Synoptic pattern

The cold front developing in the Southern Ocean will catch up on a prefrontal trough that impacts on the western half the state during the afternoon. Ahead of the frontal passage strong hot dry northwesterly winds will impact on the state, including the east, with central and elevated areas seeing winds above 50km/hr - gusts reaching up to 100 km/hr, in the morning to afternoon, before cooler but strong southwesterly winds push through, with scattered showers well behind. Timing of the change may vary, so areas impacted the most may differ depending on the change timing.



Department of Sustainability and Environment

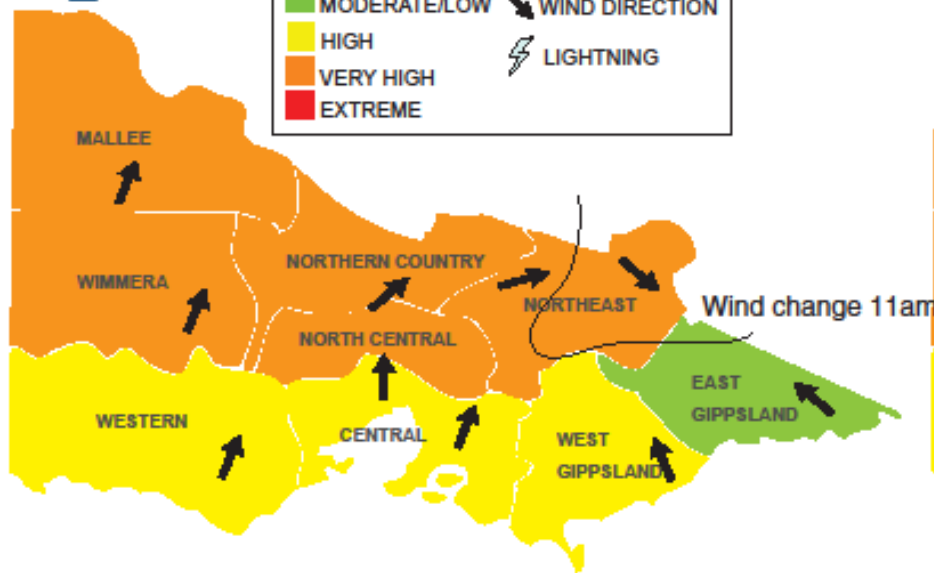
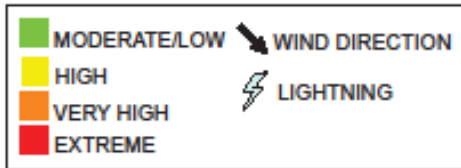


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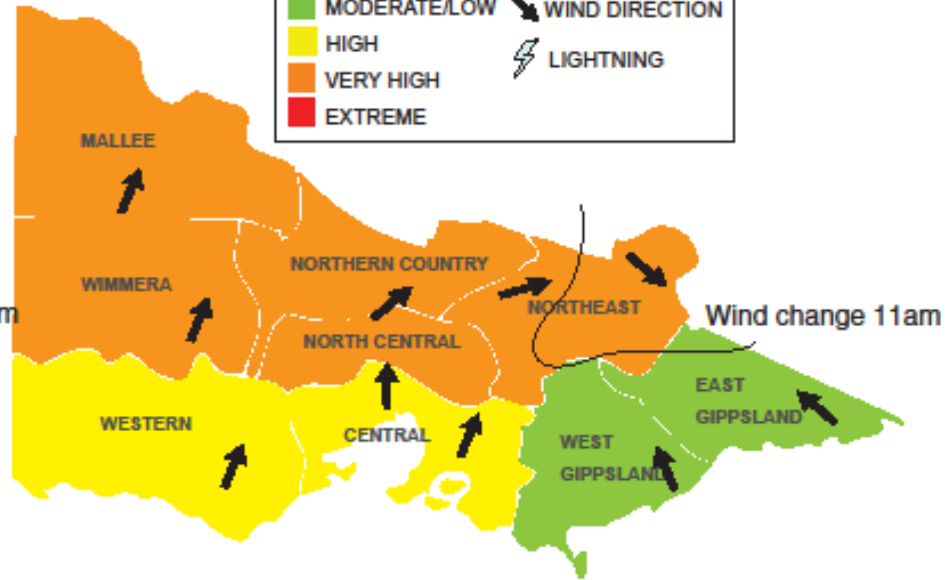
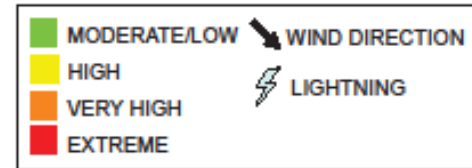


# SUNDAY 8TH FEBRUARY 2009

## Forest Fire Danger Rating (FFDR)



## Grassland Fire Danger Rating (GFDR)



### Fire Danger

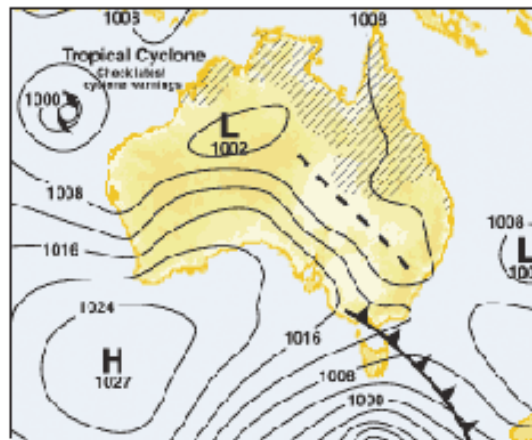
Very high generally in the north with dry air and fresh wind speeds. Moderate to high in the south with RH a little higher due to cooler temperatures. Temps still high in far northeast.

### Lightning

Nil.

### Precipitation

Scattered showers on and south of the ranges. Totals not exceeding 5-10mm locally in the eastern Alpine, even less elsewhere..



### Synoptic pattern

The cold front has a lot of depth to it and should have pushed across most of Victoria early in the day with much cooler conditions extending throughout along with relatively fresh southerly winds. Maximum temperatures will be 10-15 degrees less than the previous day, and therefore Relative humidity will be higher as well. Scattered showers expected, mainly on and south of the dividing range

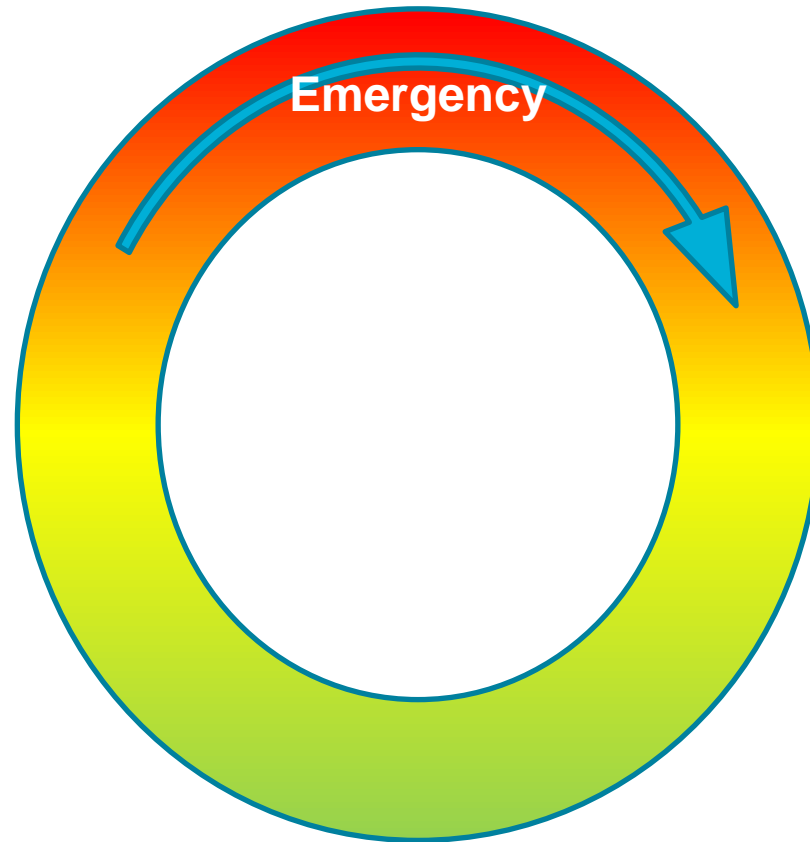




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# Response





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# Response





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# Response



Photo: [www.sbs.com.au](http://www.sbs.com.au)



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# Response





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# Response



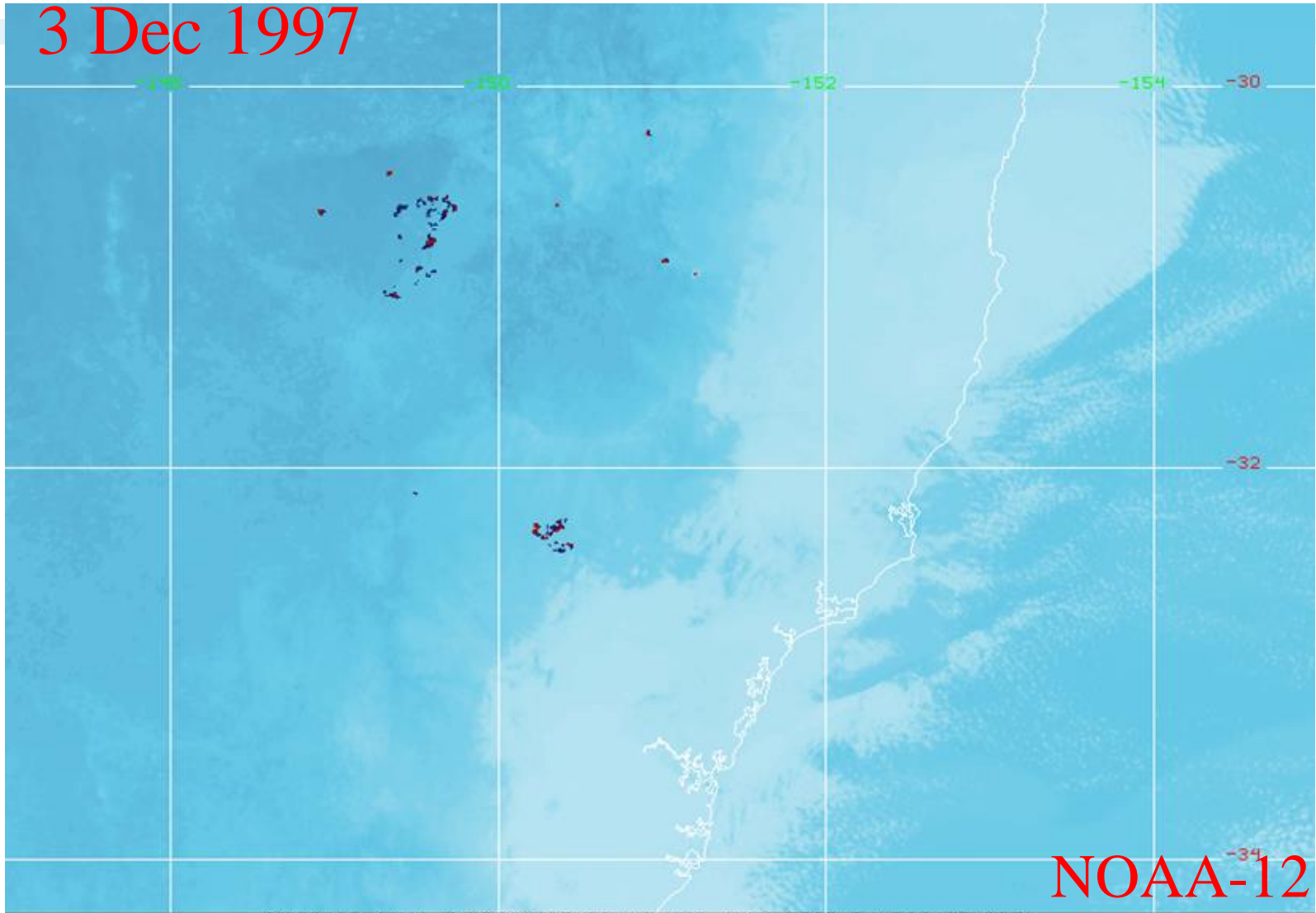
Photo:theaustralian.com



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# Monitoring Hot Spots

3 Dec 1997



NOAA-12 CH-4 3 DEC 1997 08:16 UTC (HOT SPOT T4>280 T3>305)



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# Sentinel

The screenshot displays the Sentinel Hotspots web application. The browser address bar shows the URL <http://sentinel.ga.gov.au/#/main>. The page title is "Sentinel Hotspots". The navigation menu includes "Home" and "Sentinel Hotspots". The main content area features a map of Australia and surrounding regions, including Indonesia, Papua New Guinea, and New Zealand. The map is overlaid with numerous hotspots, represented by colored icons (red, orange, yellow, purple) indicating different time intervals. A legend at the top of the map area defines these intervals: "Last 0 - 2 hours" (red), "Last 2 - 6 hours" (purple), "Last 6 - 24 hours" (orange), "Last 24 - 48 hours" (yellow), and "Last 48 - 72 hours" (orange). The map also shows geographical labels such as Java Sea, Banda Sea, Arafura Sea, Timor Sea, Solomon Sea, Coral Sea, Tasman Sea, Great Australian Bight, and New Zealand. The current coordinates are displayed as Lat -21.912°, Long 142.413°. The page footer includes copyright information and a Creative Commons Attribution (CC BY) license.



# Sentinel

The screenshot displays the Sentinel Hotspots web application. The browser address bar shows the URL <http://sentinel.ga.gov.au/#/main>. The page title is "Sentinel Hotspots". The navigation menu includes "Home" and "Sentinel Hotspots". A search bar is present with the text "Populated place search". The main content area features a map of Victoria, Australia, with various hotspots marked by icons of different colors and sizes. The legend indicates the following categories:

- Last 0 - 2 hours (Red icon)
- Last 2 - 6 hours (Purple icon)
- Last 6 - 24 hours (Orange icon)
- Last 24 - 48 hours (Yellow icon)
- Last 48 - 72 hours (Light Green icon)

The map shows a high density of hotspots in the western and central regions of Victoria, particularly around Melbourne and Geelong. The interface also includes a "Quick Links" dropdown, a "Prod V:1.5.2" version indicator, and a "20 km" scale bar. The footer contains copyright information and a Creative Commons BY license.





# Sentinel

The screenshot displays the Sentinel Hotspots web application. The browser address bar shows the URL <http://sentinel.ga.gov.au/#/main>. The page title is "Sentinel Hotspots". The navigation menu includes "Home" and "Sentinel Hotspots". A search bar for "Populated place search" is visible. The main content area features a "Hotspot Legends" bar with five categories: "Last 0 - 2 hours" (red), "Last 2 - 6 hours" (purple), "Last 6 - 24 hours" (orange), "Last 24 - 48 hours" (yellow), and "Last 48 - 72 hours" (green). The map shows a satellite view of a region in Australia, with several hotspots marked by colored icons. The map includes labels for locations such as Gilderoy, Powelltown, Piedmont, Noojee, Neerim North, Neerim Junction, Neerim, and Neerim East. A scale bar indicates 2 km. The map data is attributed to Google Imagery and TerraMetrics. The footer contains copyright information and a Creative Commons BY license.

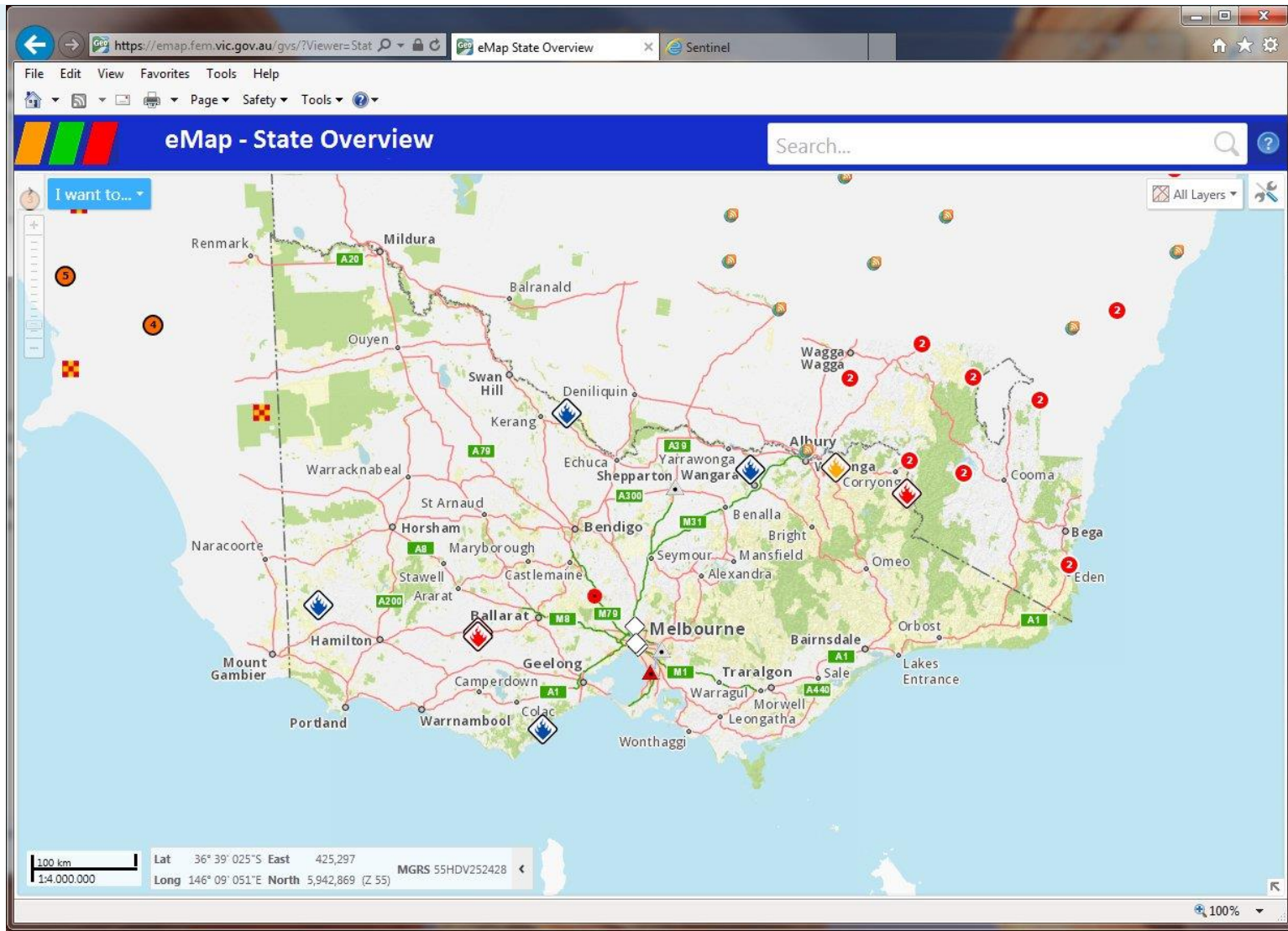
Hotspot Legends: Last 0 - 2 hours Last 2 - 6 hours Last 6 - 24 hours Last 24 - 48 hours Last 48 - 72 hours

Hotspots Last Acquired: 2016-04-04 19:02 UTC Updated: 2016-04-04 22:50 UTC | MODIS Mosaic Last Acquired: 2016-04-04 05:17 UTC Updated: 2016-04-04 23:21 UTC

Copyright Disclaimer Privacy Accessibility Information Publication Scheme Freedom of Information Sentinel Feedback

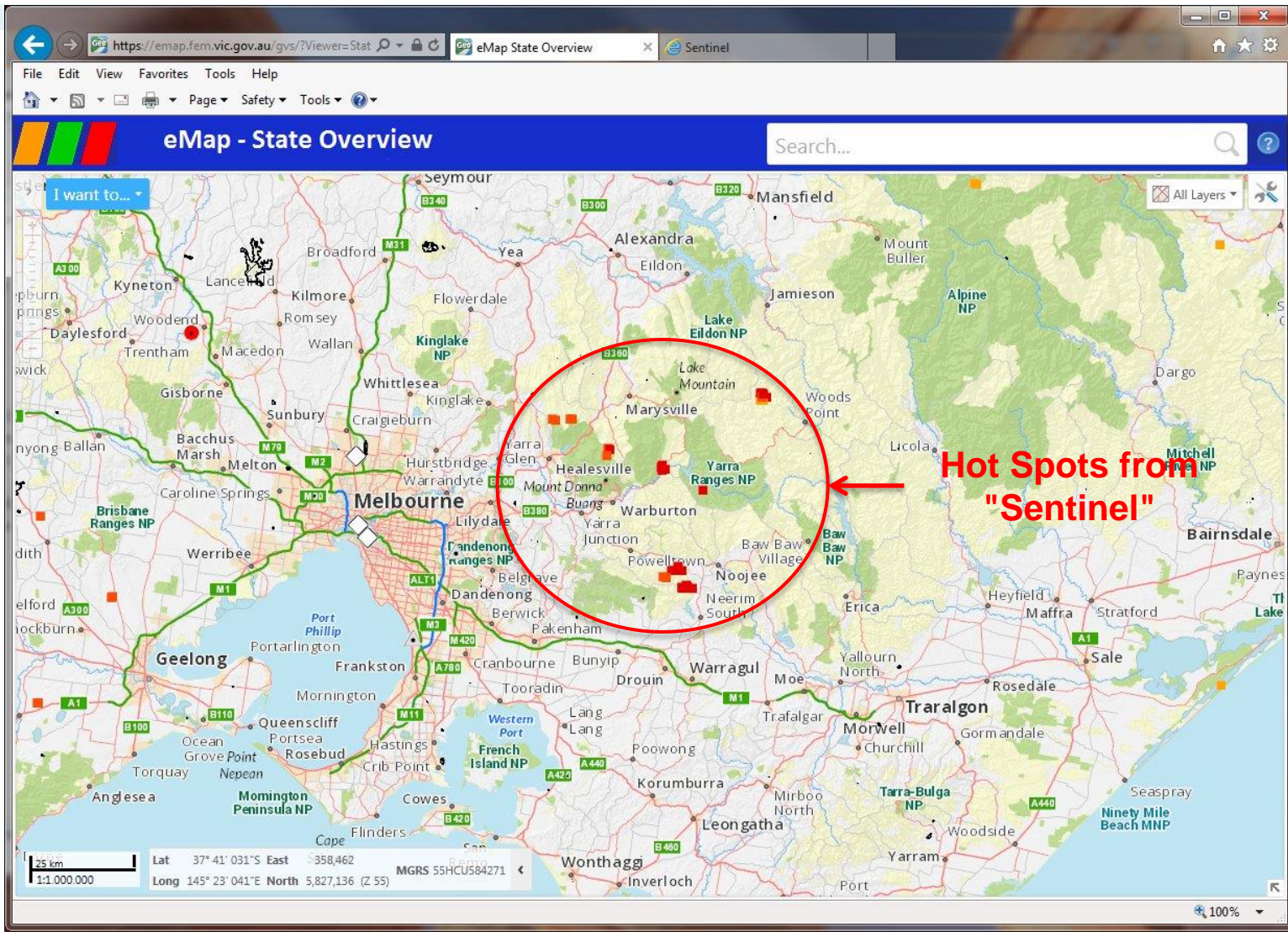


# Emergency Map (eMap)





# Emergency Map (eMap)





# Emergency Map (eMap)

The screenshot shows the eMap State Overview web application. The browser address bar displays the URL: <https://emap.fem.vic.gov.au/gvs/?Viewer=Stat>. The page title is "eMap - State Overview". The map area shows a topographic view of a region in Victoria, Australia, with various geographical features, roads, and administrative boundaries. Key locations and features include:

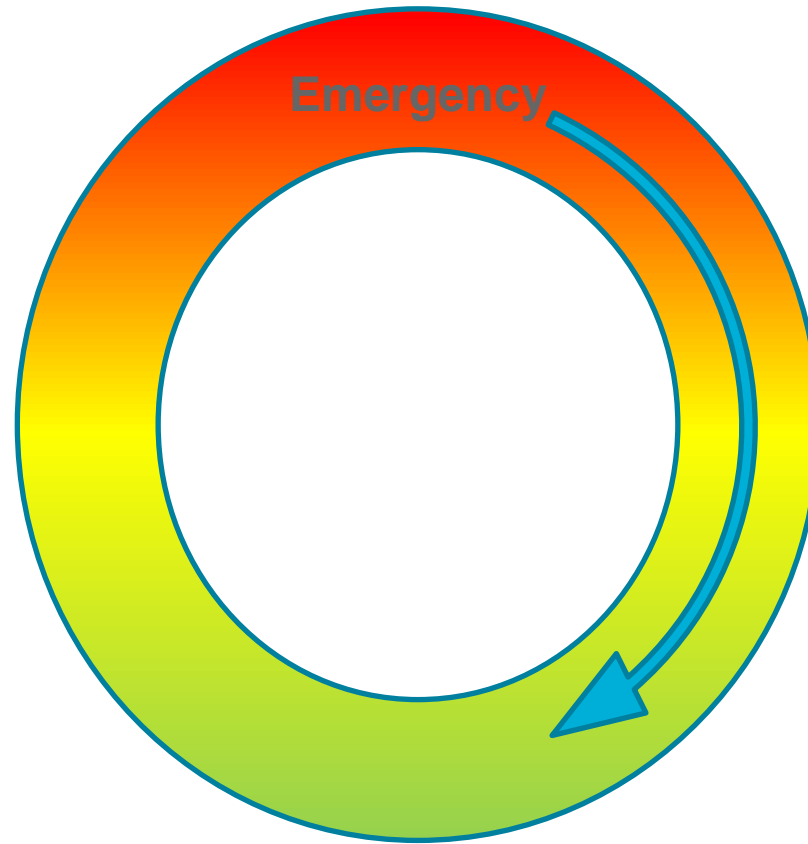
- Geographical Features:** Pioneer Creek, Falls Creek, Salin Creek, Lovely Creek, Black Butte Creek, Tarago River, and the La Trobe River.
- Roads:** Pioneer Creek Middle Black Tk, Pioneer Creek Rd, Falls Creek Rd, Limberlost Rd, Spion Kopje Tk, Black Butte Creek Tk, Tarago Rd, and various other roads.
- Administrative Boundaries:** Baw Baw, Whites Corner, Limberlost, Gentle Annie, Neerim, and Neerim Junction.
- Search Bar:** Located at the top right with the text "Search...".
- Scale Bar:** Located at the bottom left, showing 1 km and 1:50,000.
- Coordinates:** Lat 37° 54' 003" S East 403,433' Helio, Long 145° 54' 006" E North 5,804,610 (Z 55), MGRS 55H DU034046.



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# Recovery





# AVHRR/3 (NOAA-17, 18, 19)

Detailed characteristics:

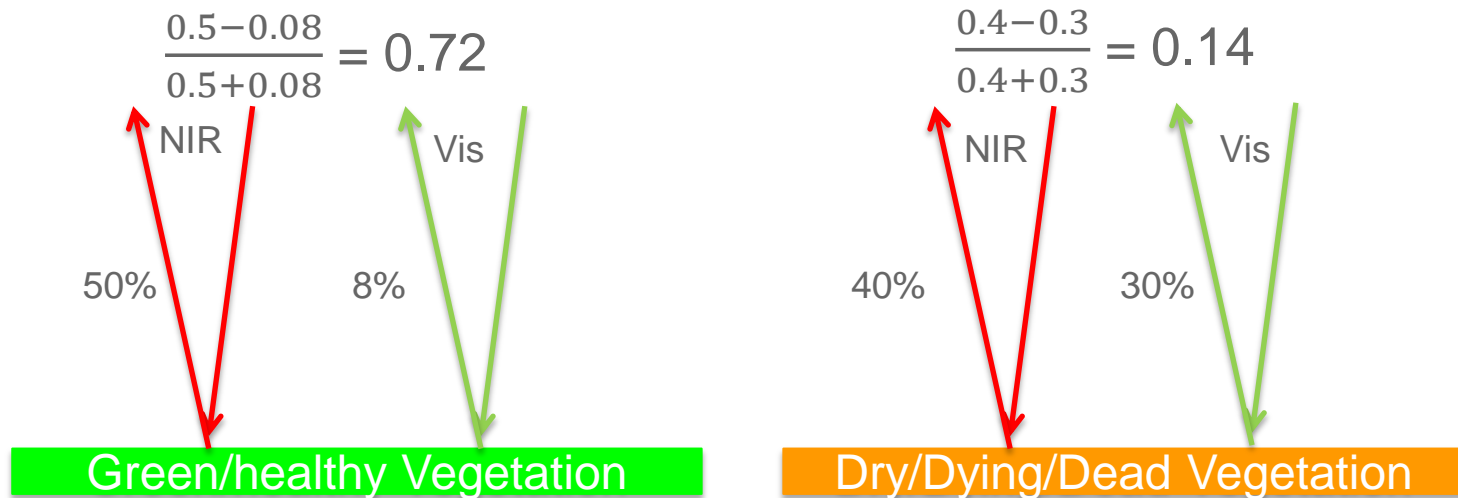
Central wavelength	Spectral interval	SNR or NE $\Delta$ T @ specified input
0.630 $\mu\text{m}$	0.58 - 0.68 $\mu\text{m}$	9 @ 0.5 % albedo
0.862 $\mu\text{m}$	0.725 - 1.100 $\mu\text{m}$	9 @ 0.5 % albedo
1.61 $\mu\text{m}$	1.58 - 1.64 $\mu\text{m}$	20 @ 0.5 % albedo
3.74 $\mu\text{m}$	3.55 - 3.93 $\mu\text{m}$	0.12 K @ 300 K
10.8 $\mu\text{m}$	10.3 - 11.3 $\mu\text{m}$	0.12 K @ 300 K
12.0 $\mu\text{m}$	11.5 - 12.5 $\mu\text{m}$	0.12 K @ 300 K



# Normalised Difference Vegetation Index (NDVI)

Calculated from Visible and Near Infrared radiances  
(0.630  $\mu\text{m}$  and 0.862  $\mu\text{m}$  for NOAA satellites)

$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$

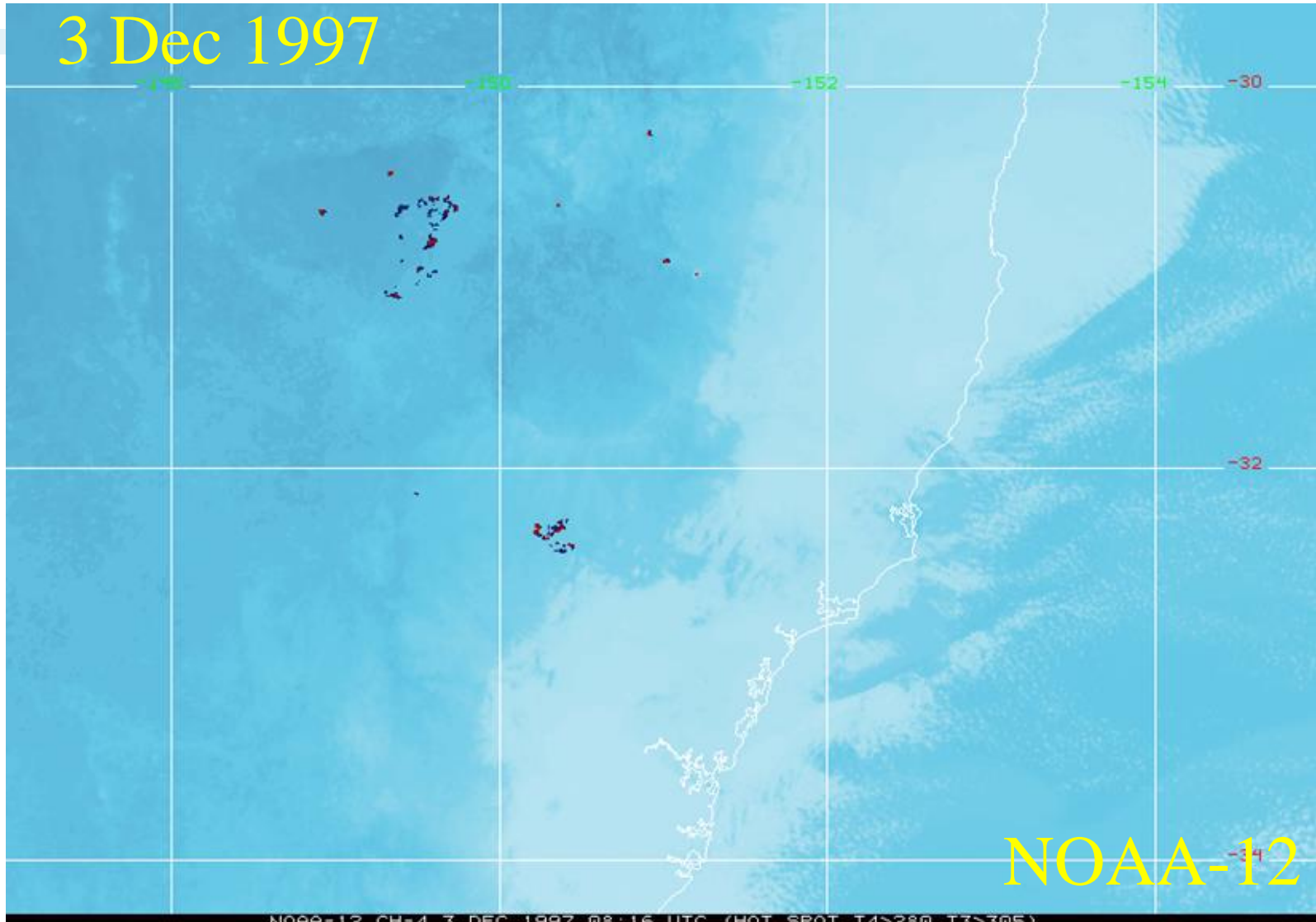




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# Monitoring Hot Spots and Fire Scars





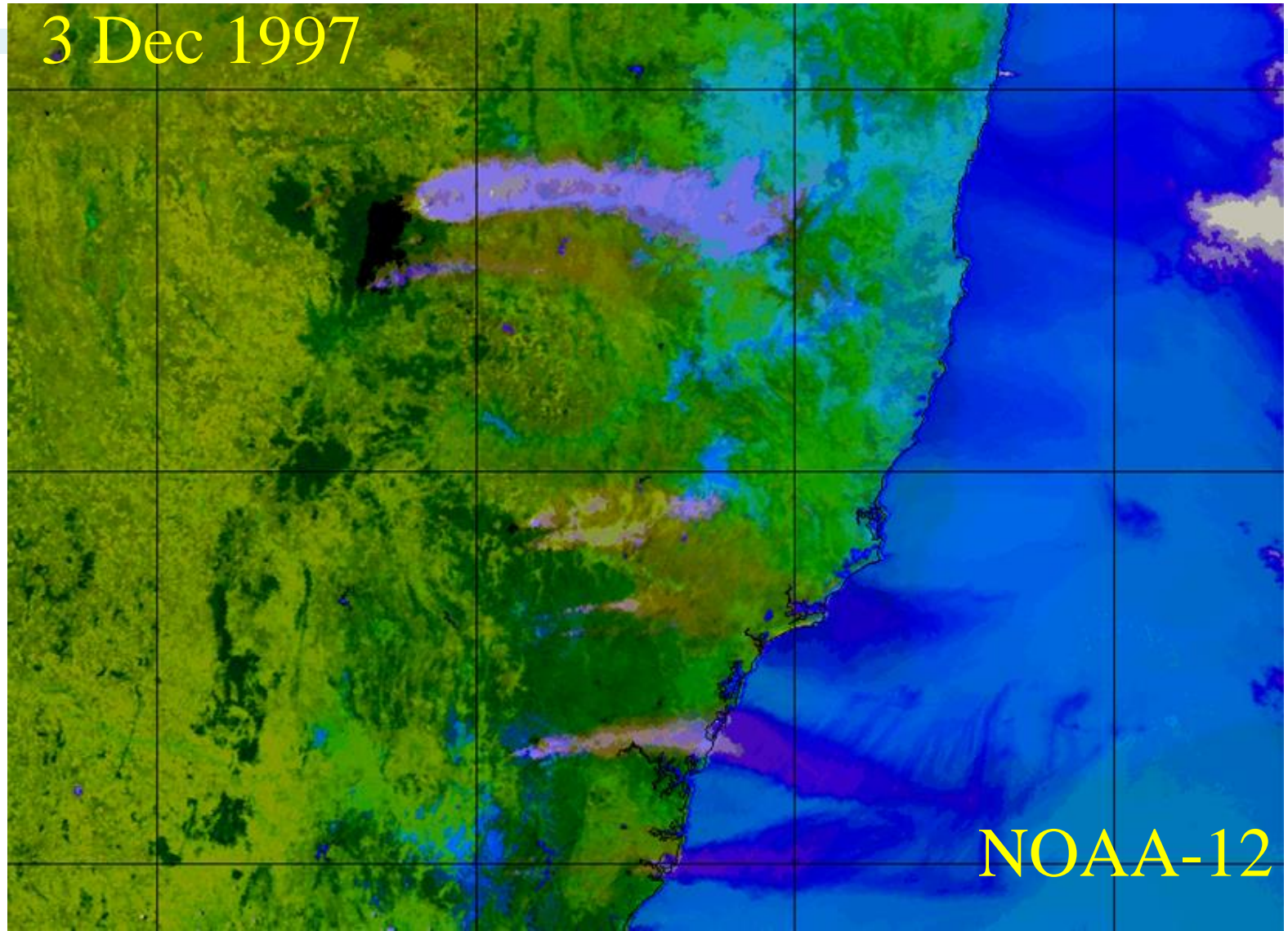


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# Monitoring Hot Spots and Fire Scars

3 Dec 1997



NOAA-12



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# Regrowth – recovery





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# Regrowth – recovery Epicormic shoots





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# Regrowth – recovery Epicormic shoots



# Specification of “Himawari-8/9” Imager (AHI)

as of HIMAWARI-8/9

Band	Central Wavelength [μm]	Spatial Resolution
1	0.43 - 0.48	1Km
2	0.50 - 0.52	1Km
3	0.63 - 0.66	0.5Km
4	0.85 - 0.87	1Km
5	1.60 - 1.62	2Km
6	2.25 - 2.27	2Km
7	3.74 - 3.96	2Km
8	6.06 - 6.43	2Km
9	6.89 - 7.01	2Km
10	7.26 - 7.43	2Km
11	8.44 - 8.76	2Km
12	9.54 - 9.72	2Km
13	10.3 - 10.6	2Km
14	11.1- 11.3	2Km
15	12.2 - 12.5	2Km
16	13.2 - 13.4	2Km

RGB  
Composited  
Color Image

1.3 μm for GOES-R

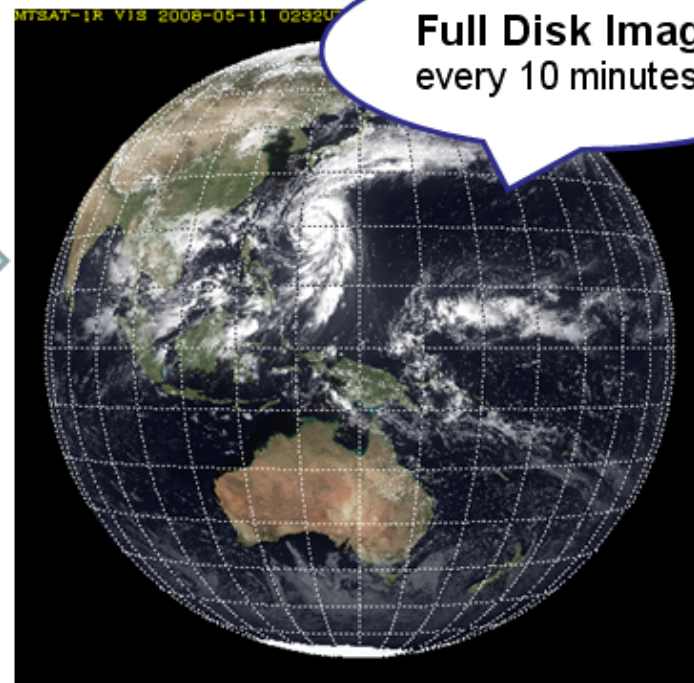
Water  
Vapour

SO<sub>2</sub>

O<sub>3</sub>

Atmospheric  
Windows

CO<sub>2</sub>



Full Disk Image  
every 10 minutes

Band	Central Wavelength [μm]	Spatial Resolution
1	0.55 - 0.90	1Km
2	3.50 - 4.00	4Km
3	6.50 - 7.00	4Km
4	10.3 - 11.3	4Km
5	11.5 - 12.5	4Km

as of MTSAT-1R/2

X: MSG



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# Summary

- Bushfires are part of the Australian Ecology
- The Urban/Rural Interface will always be an issue
  - Most fatalities occur within these areas
- Weather Satellite Data are used for
  - preparation of fire weather forecasts (predominantly 0.55  $\mu\text{m}$ , 3.4  $\mu\text{m}$ , 6.7  $\mu\text{m}$  and 10.5  $\mu\text{m}$  bands)
  - monitoring fire hot spots (using 3.7  $\mu\text{m}$  and 10.5  $\mu\text{m}$ )
  - monitoring fire scars and regrowth (using 0.63  $\mu\text{m}$  and 0.86  $\mu\text{m}$  bands)
- Himawari 8 data will be extremely useful to assist in bushfire monitoring of hot spots, fire scars and regrowth within Australia



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# Satellite Image Acknowledgements

- I would like to acknowledge the organisations that made the direct ingestion of satellite data by the Australian Bureau of Meteorology possible so that they could be used within this presentation:
  - Japan Meteorological Agency (GMS-5, MTSAT-1R)
  - National Oceanic and Atmospheric Administration (NOAA-8, NOAA-12)
  - National Aeronautical and Space Administration (TIROS-VIII, Aqua, Terra)



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Thank you...

# Questions?

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