bushfire CRC

FOEHN-LIKE WINDS AND OTHER EXTREME DRYING EVENTS

THE HIGHFIRE RISK PROJECT

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Introduction

- Foehn winds occur in connection with many mountainous regions and have been linked with elevated wildfire risk, e.g. Santa Ana winds in southern California, the north foehn in Switzerland and foehn winds in New Zealand and parts of Asia.

- Very little is known about foehn winds and their effect in Australia

- Observationally, foehn-like conditions are characterised by:

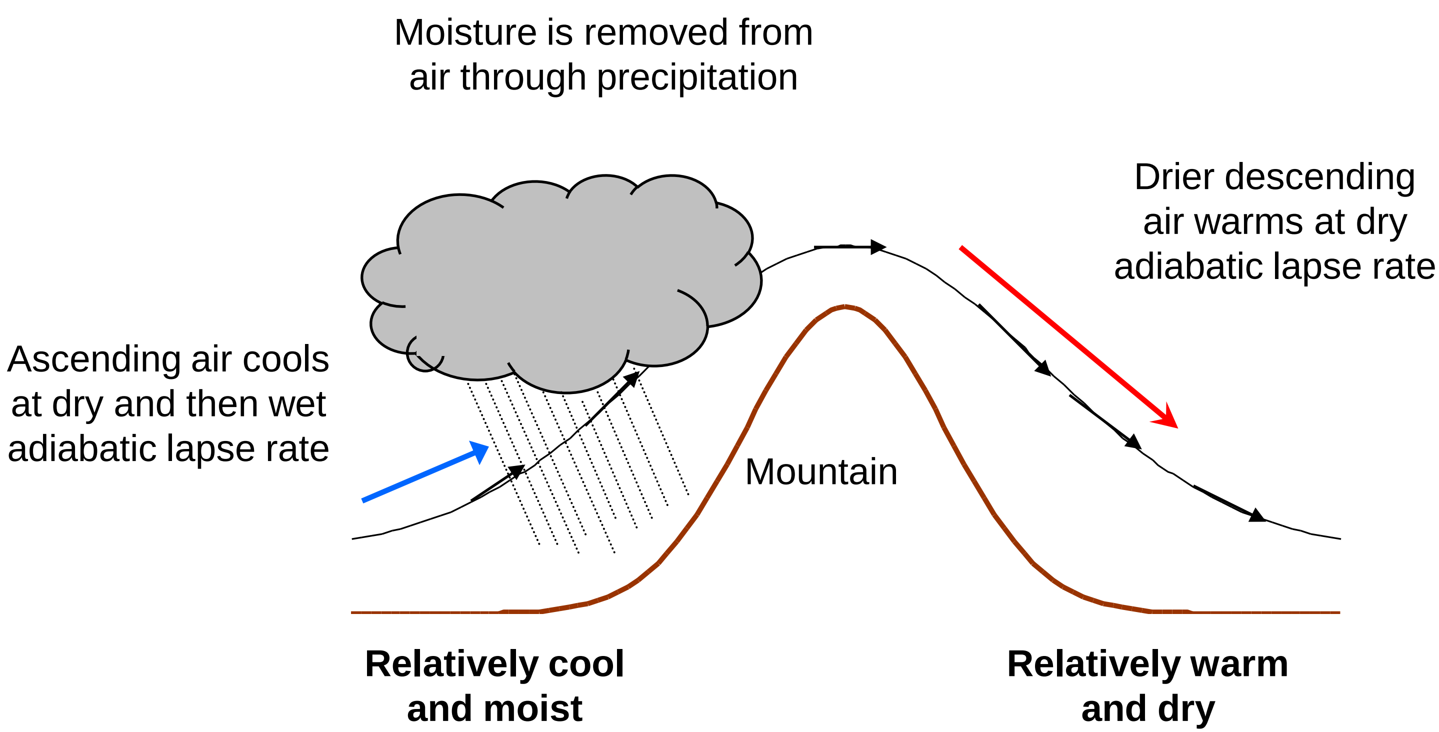
  a. Surface winds blowing from the mountains

  b. An abrupt rise in air temperature in the lee of the mountains, and

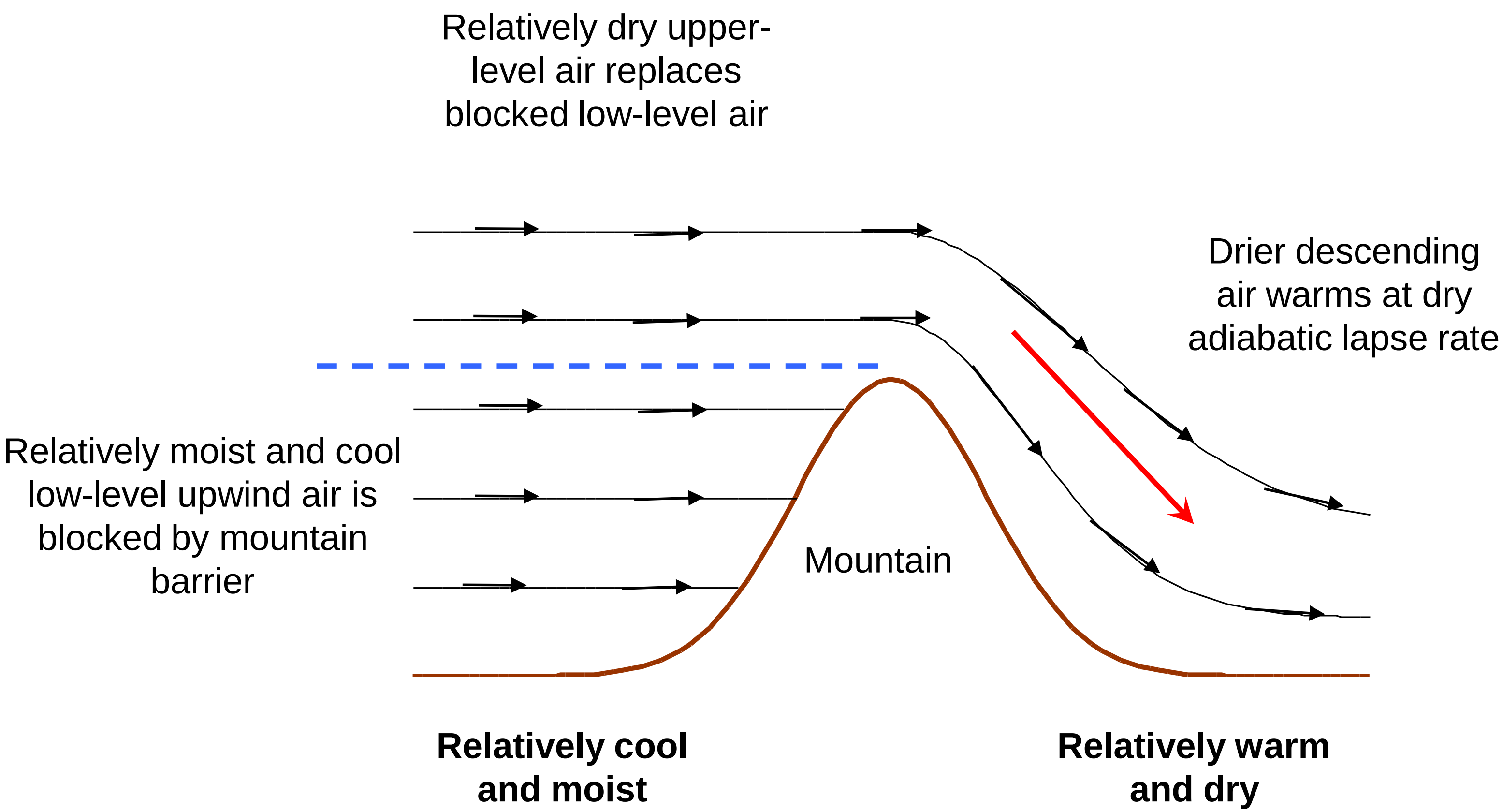
  c. An accompanying reduction in atmospheric moisture

Genuine foehn occurrence, however, is attributed to two mechanisms:

A. Thermodynamic foehn mechanism

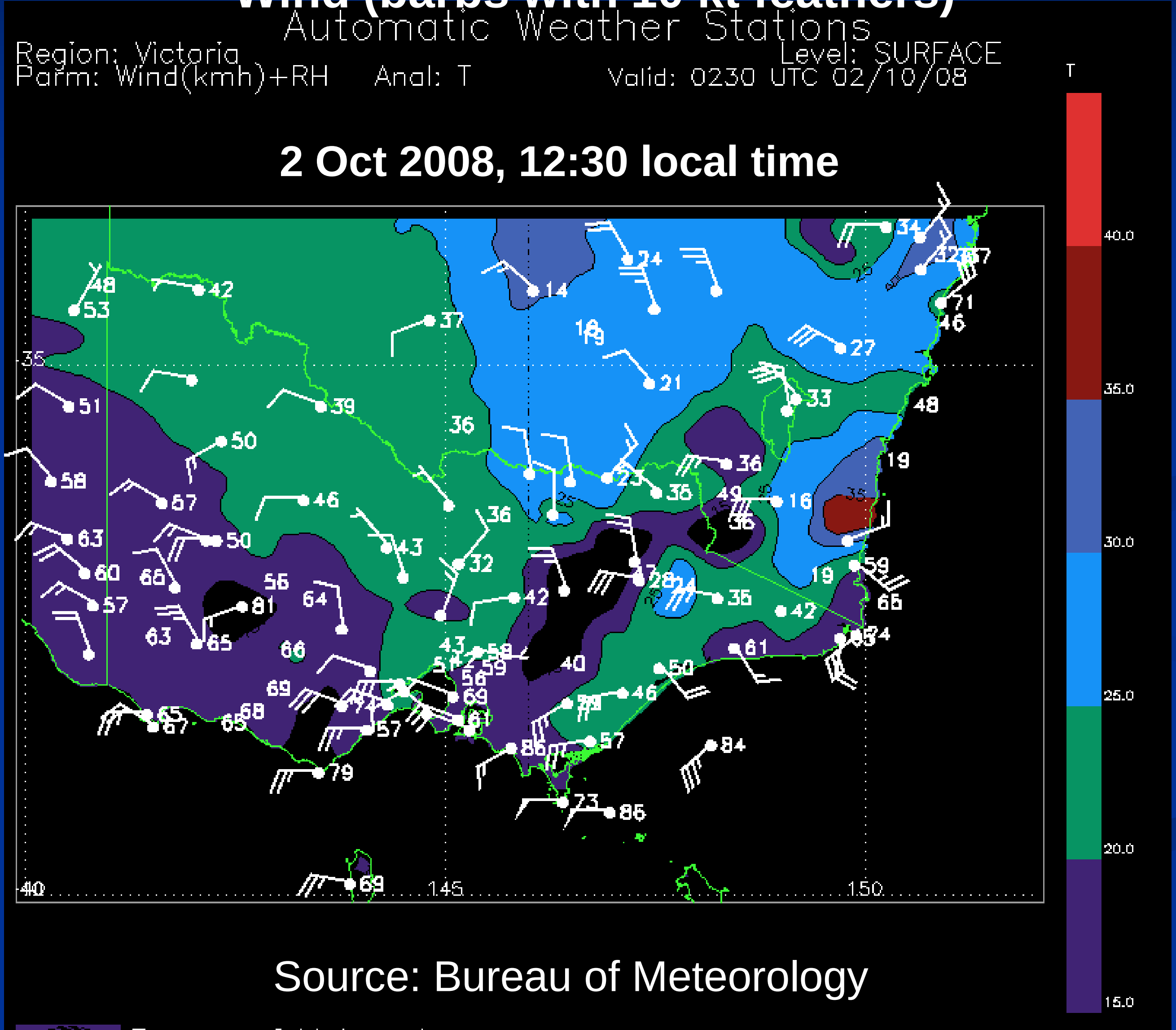


B. Mechanical or “blocking” foehn mechanism



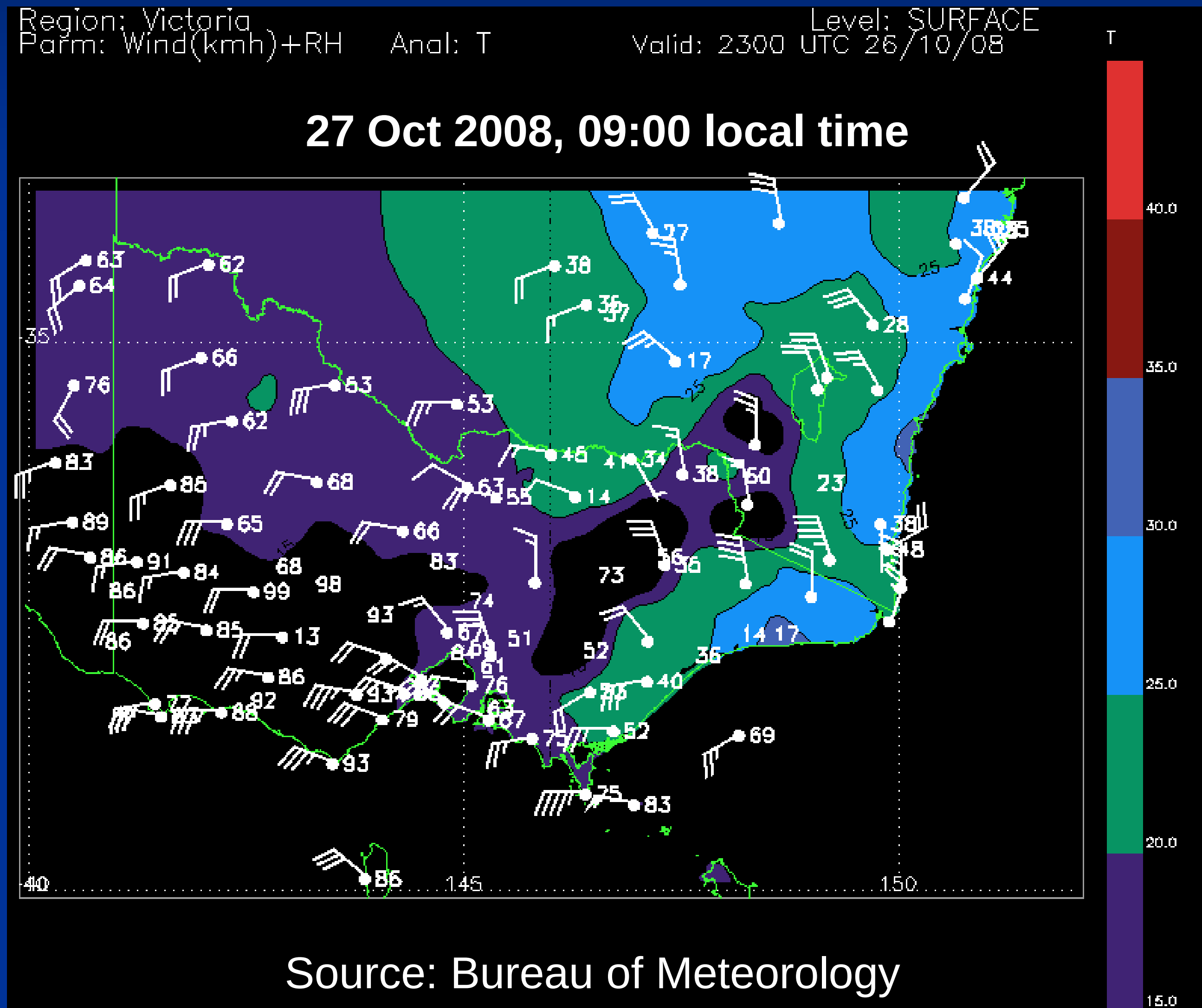
Foehn-like conditions

Temperature (coloured), Relative Humidity (number) and Wind (barbs with 10 kt feathers)



Foehn-like conditions

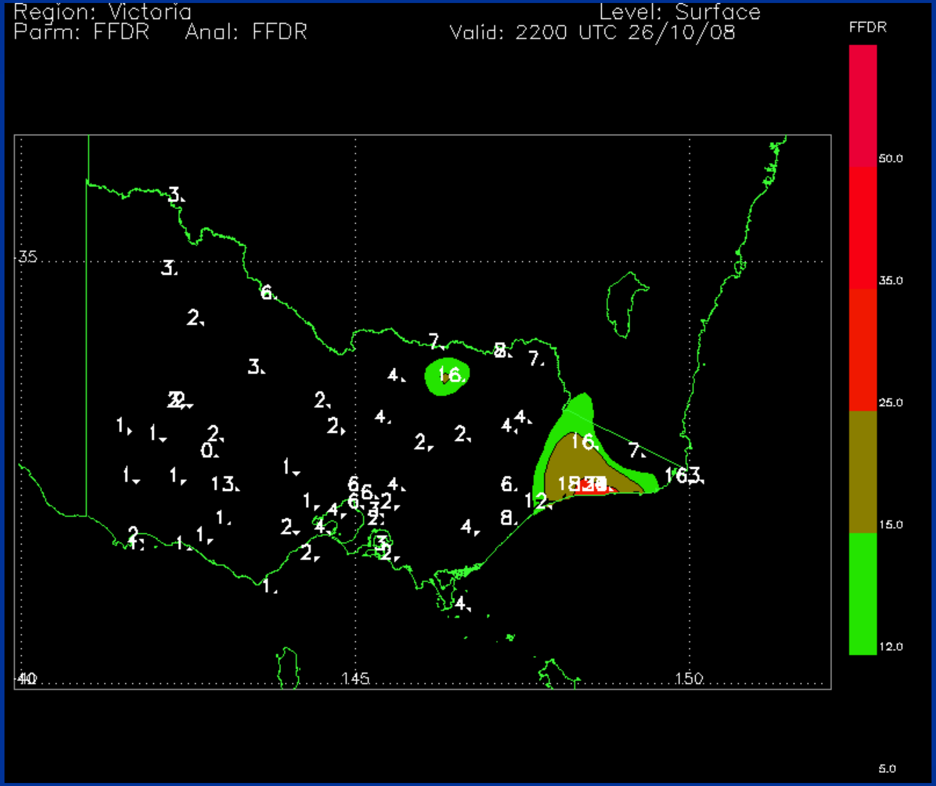
Temperature (coloured), Relative Humidity (number) and Wind (barbs with 10 kt feathers)



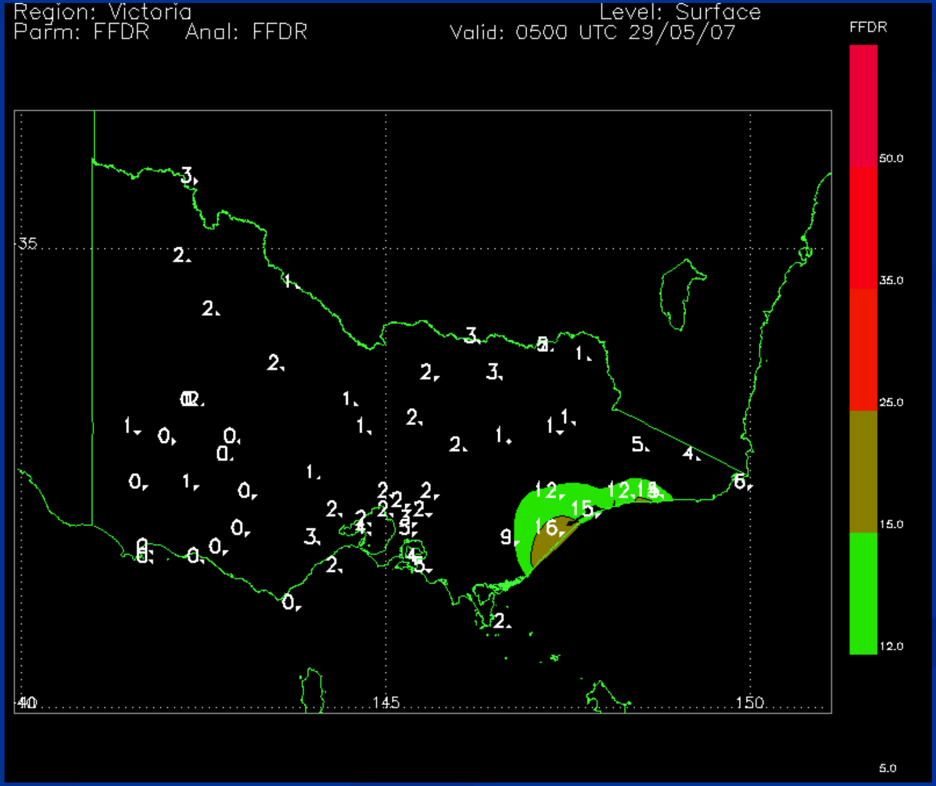
Foehn-like conditions

McArthur Mk 5 Forest Fire Danger Rating

27 Oct 2008, 08:00 local time



29 May 2007, 15:00 local time

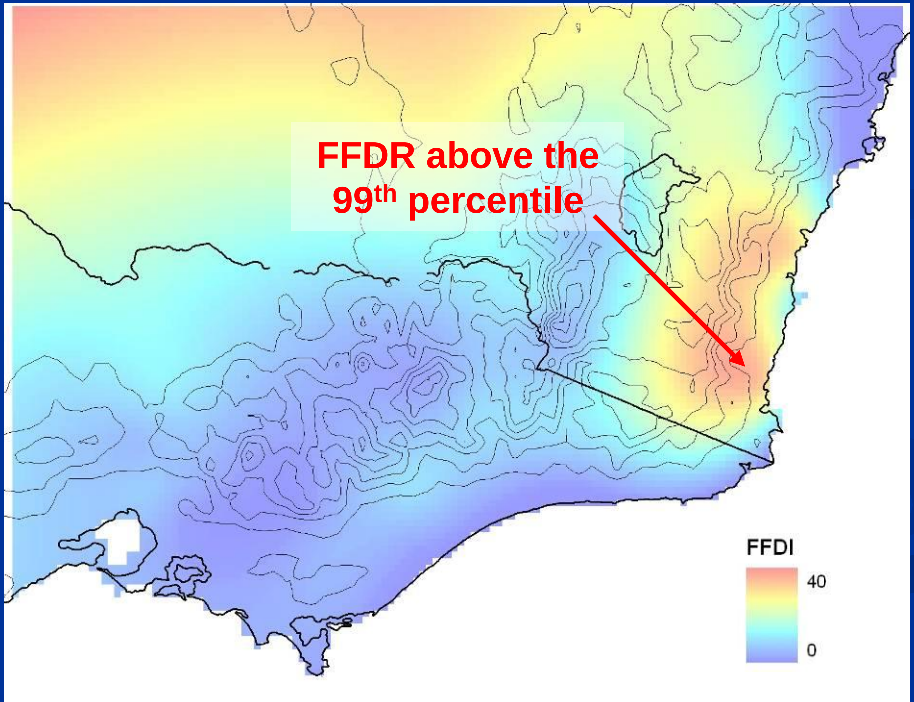


Source: Bureau of Meteorology

Research

We combined spatiotemporal analysis of fire weather observations with numerical weather prediction modelling to investigate the effects of foehn winds on fire danger levels and the atmospheric processes that result in them.

Foehn-like occurrences consistently resulted in fire danger levels that were statistically anomalous, i.e. above the 95th percentile of climatological values



27 Oct 2008, 15:00 local time

Foehn conditions at Moruya, NSW

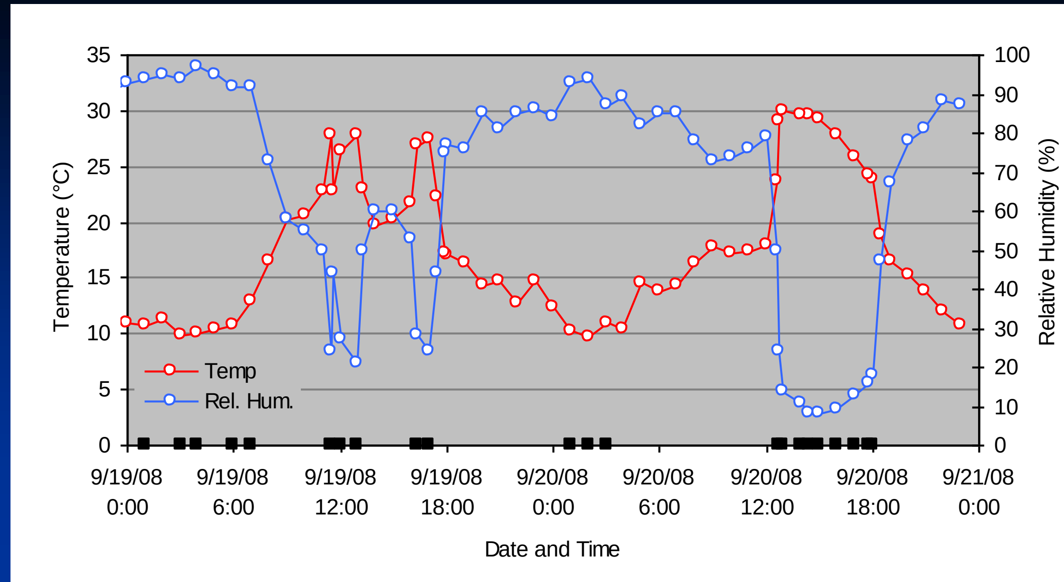
19-20 September 2008

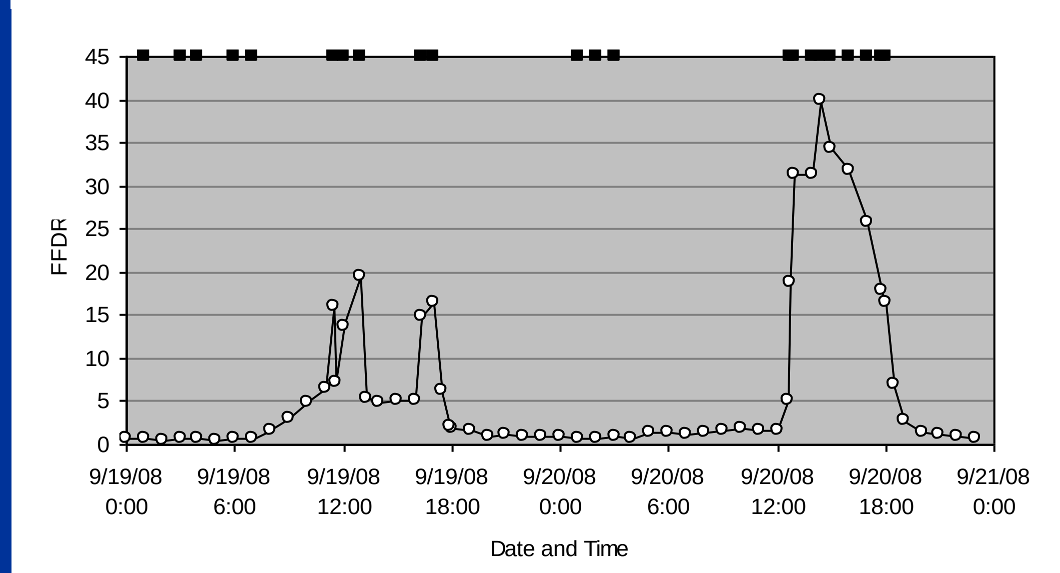
Changes in fire weather conditions are abrupt and significant, e.g.

20/9/08	12:00	13:00
Temp	18°C	30°C
RH	79%	14%
FFDR	1.6	31

Winds were gusting 40-50 km/h during the periods of interest

All this amounts to a 20-fold increase in fire danger levels in an hour!





The black squares in the figures indicate times when Moruya was in the lee of the ranges

Foehn conditions at Bega, NSW

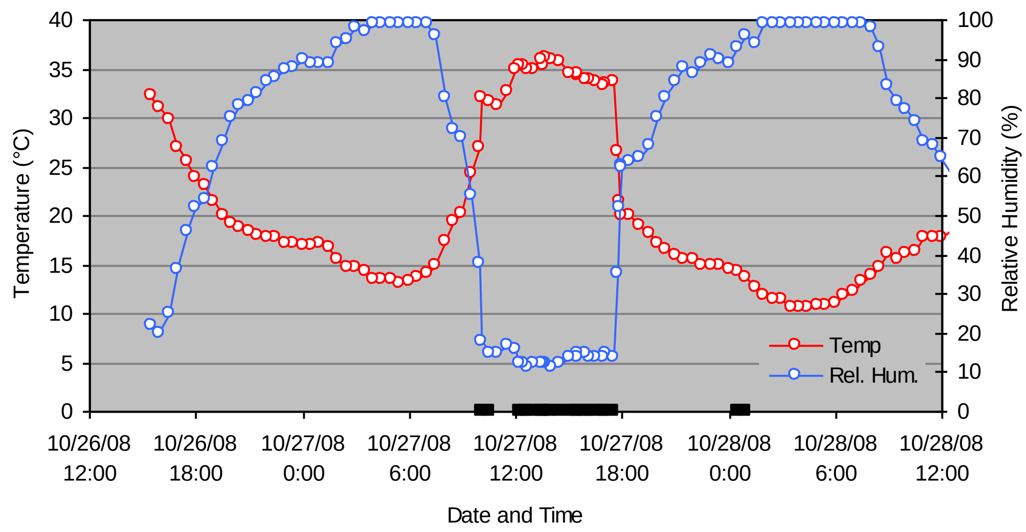
27 October 2008

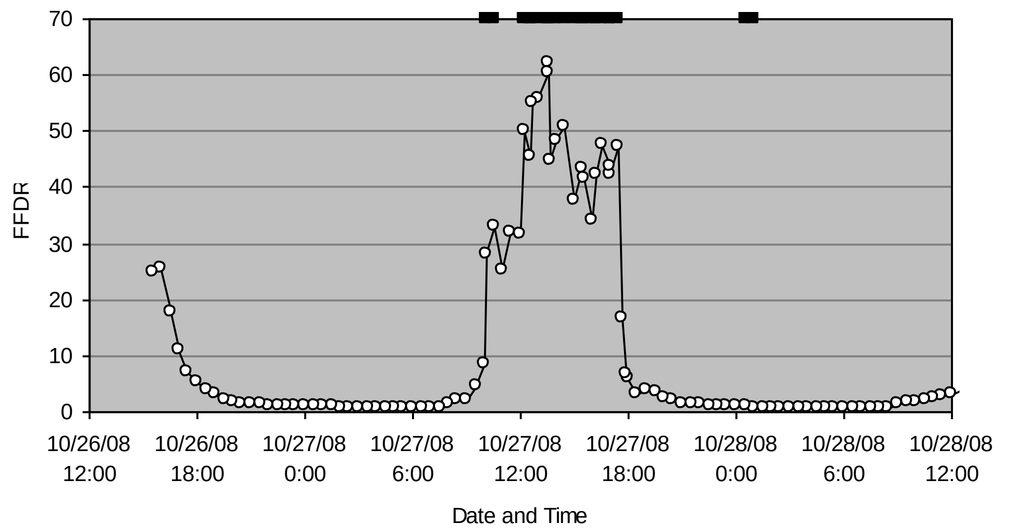
Changes in fire weather conditions are again abrupt and significant, e.g.

27/10/08	09:30	10:06	12:14
Temp	24°C	32°C	35.3°C
RH	55%	18%	12%
FFDR	4.5	28.2	50.1

Winds were gusting 50-60 km/h

This amounts to a 6-fold increase in fire danger levels in 36 minutes. Fire danger ultimately reached extreme (severe) levels.





The black squares in the figures indicate times when Bega was in the lee of the ranges

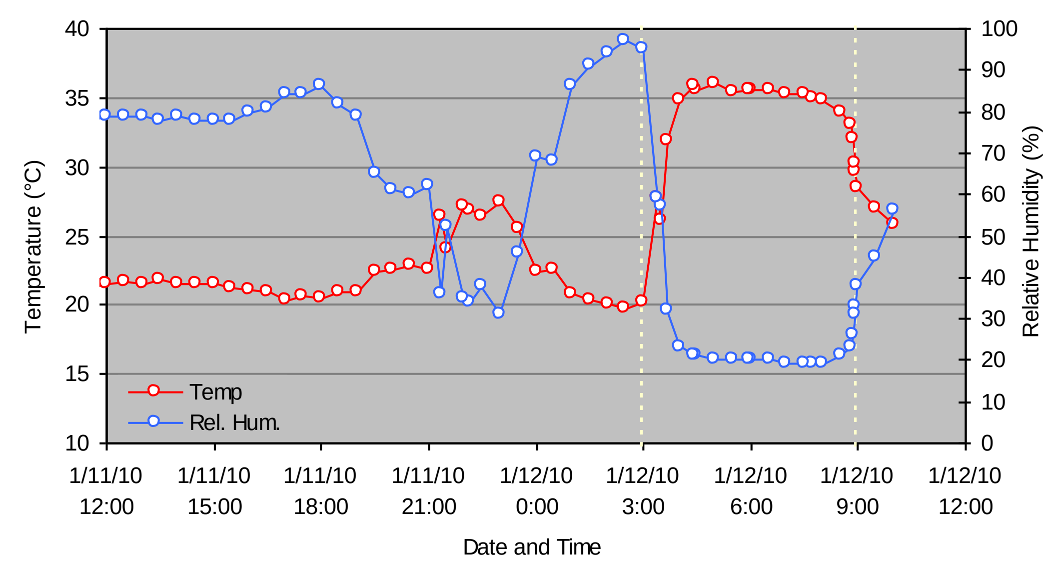
Foehn (?) conditions at Wilson's Prom., VIC

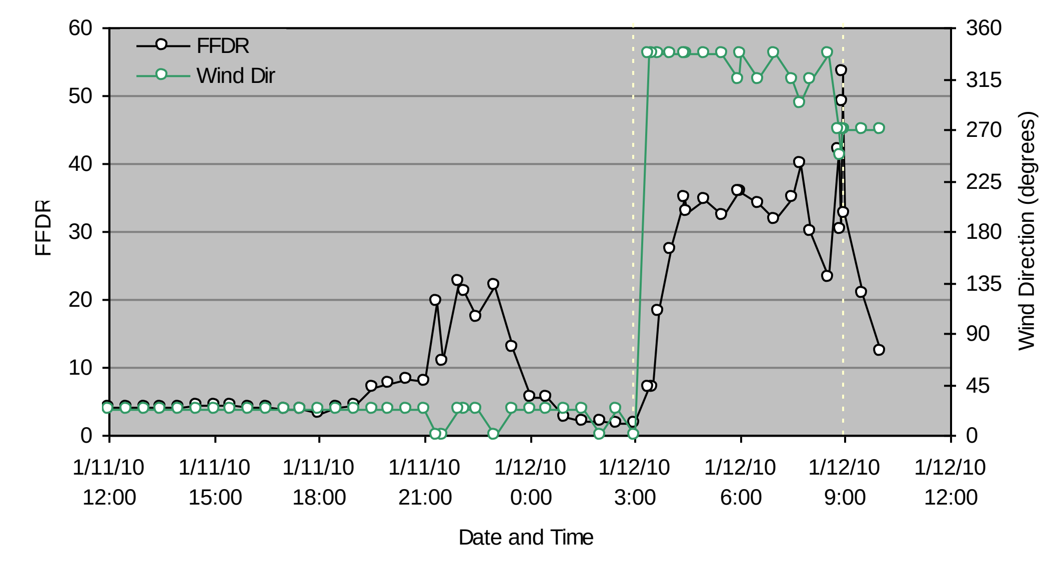
12 January 2010

Changes in fire weather conditions are again abrupt and significant, e.g.

12/01/10	03:00	04:00
Temp	20°C	35°C
RH	95%	23%
FFDR	1.7	27.4

This amounts to a 16-fold increase in fire danger levels in an hour, and all in the early morning when fire behaviour would normally expected to be mild!



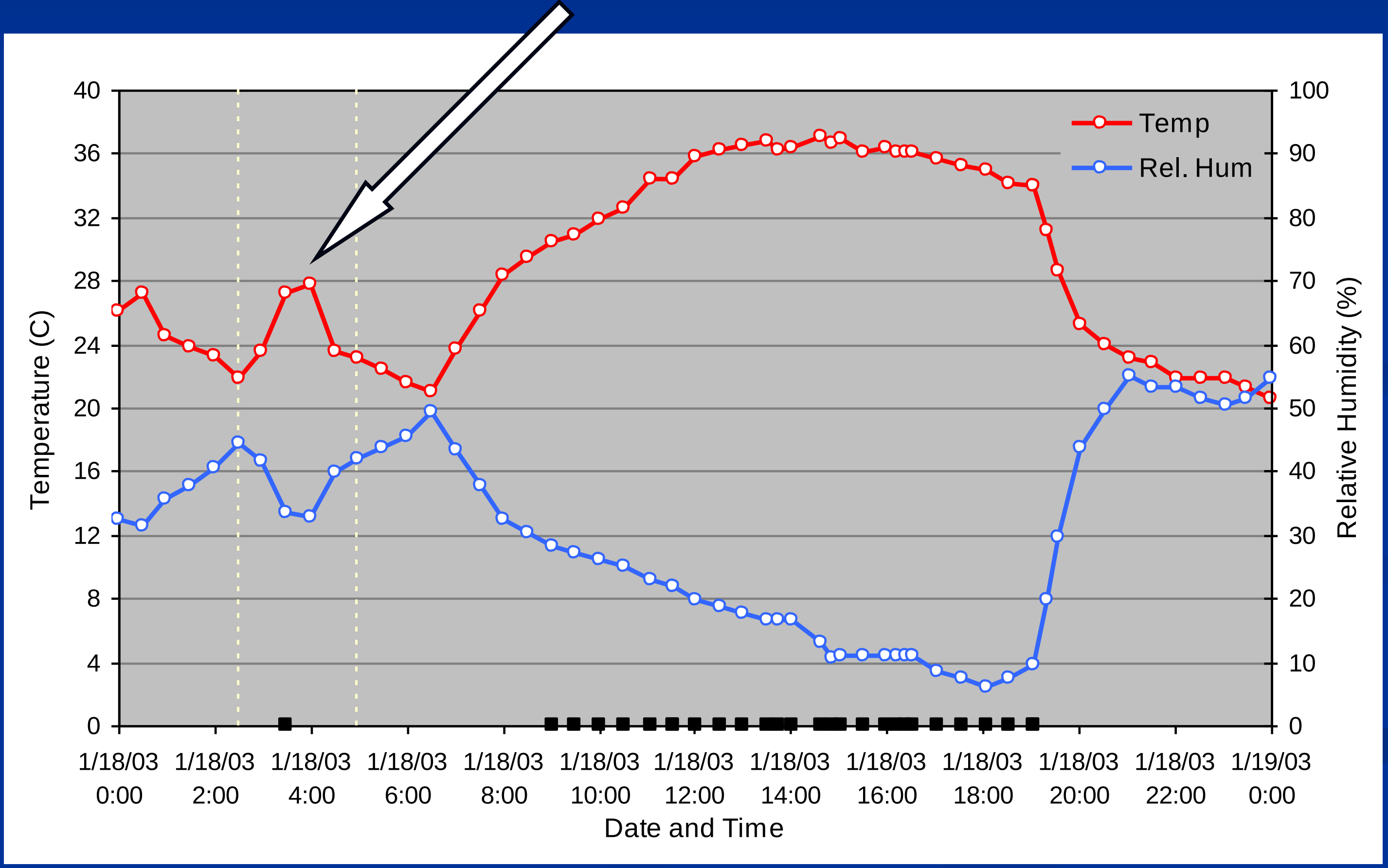


Wind gust increased to 40-60 km/h, but average wind speed decreased → increased turbulence!

18 January 2003 - Canberra

In the early morning (02:00-03:30) of 18 January 2003 temperature rose 6°C, while relative humidity fell by 12%.

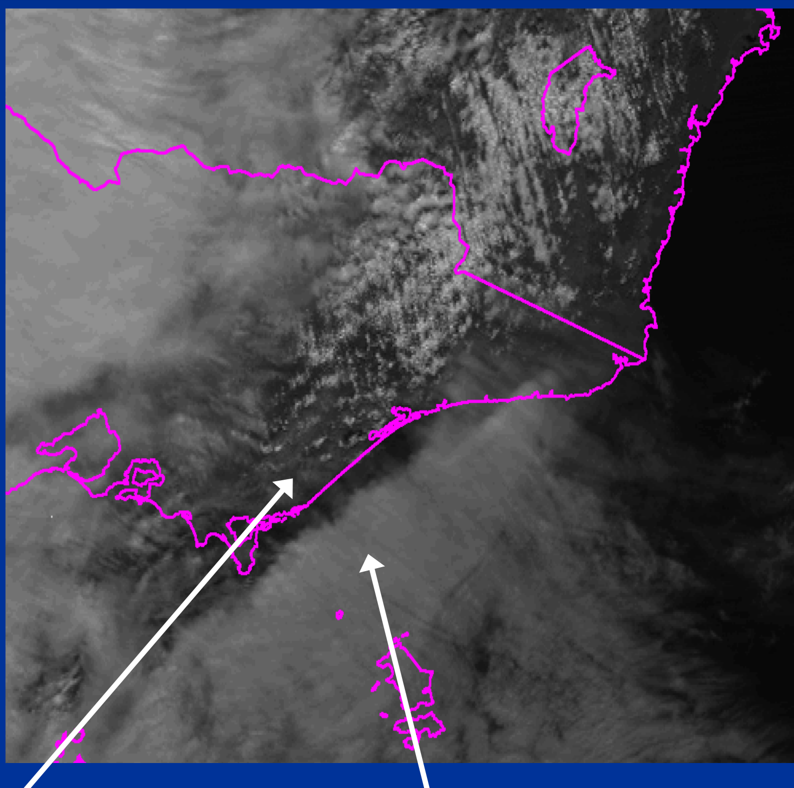
Possible foehn...?



NWP Modelling (using MesoLAPS 0.05° resolution)

29 May 2007

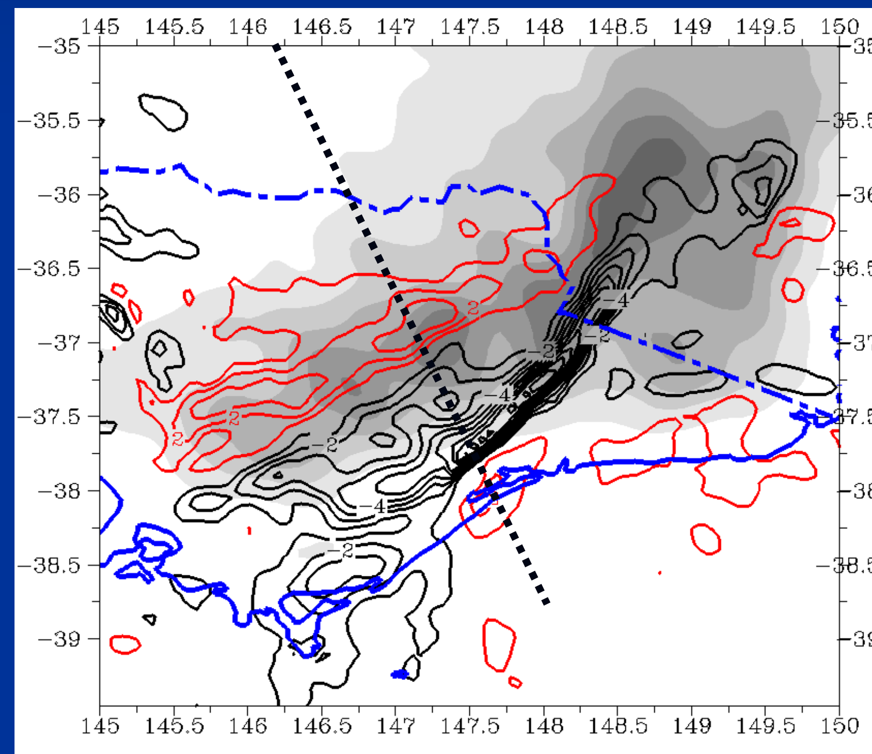
Visual band satellite image taken at 12:33, 29 May 2007



Foehn Gap

Foehn Arch

MesoLAPS output showing vertical movement of upper air at 500 hPa level ≈ 5 km altitude



Red contours indicate descending air, black contours ascending air.

NWP Modelling

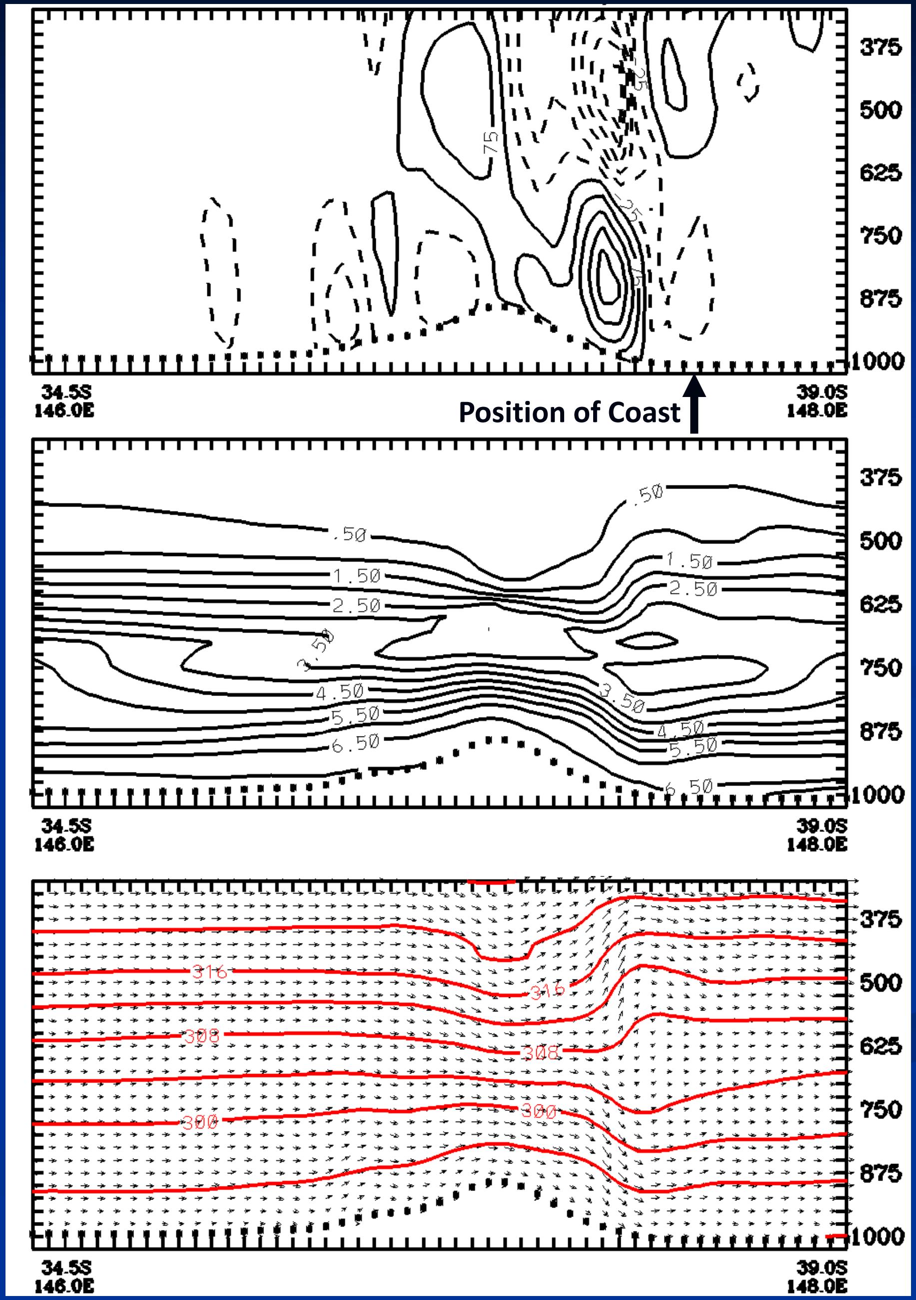
(MesoLAPS 0.05° resolution)

29 May 2007

Vertical velocity: solid contours indicate downward moving air, dashed contours indicate upward moving air (hPa/hr)

Mixing ratio: the amount of water vapour relative to the amouint of dry air (g/kg)

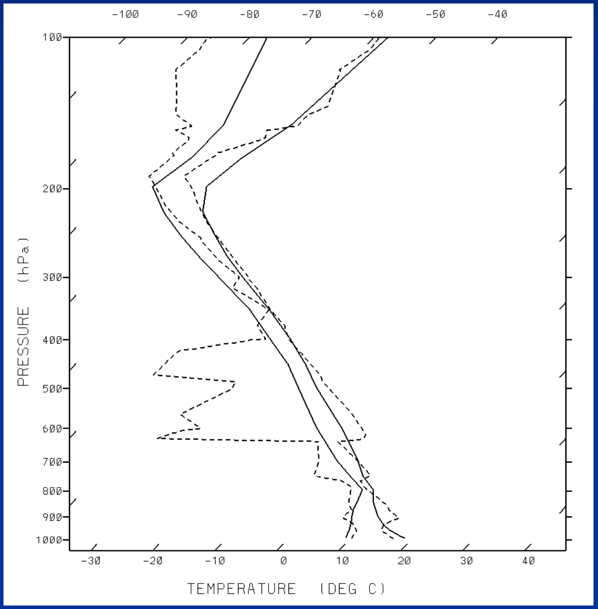
Streamlines and wind vectors: Streamlines are lines of constant potential temperature (K), wind vectors indicate strength and direction of the flow.

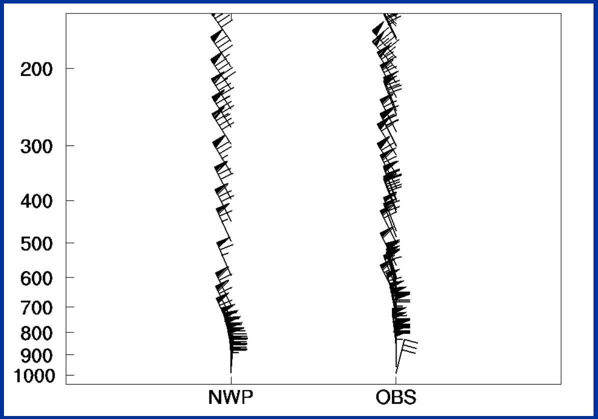


NWP model validation

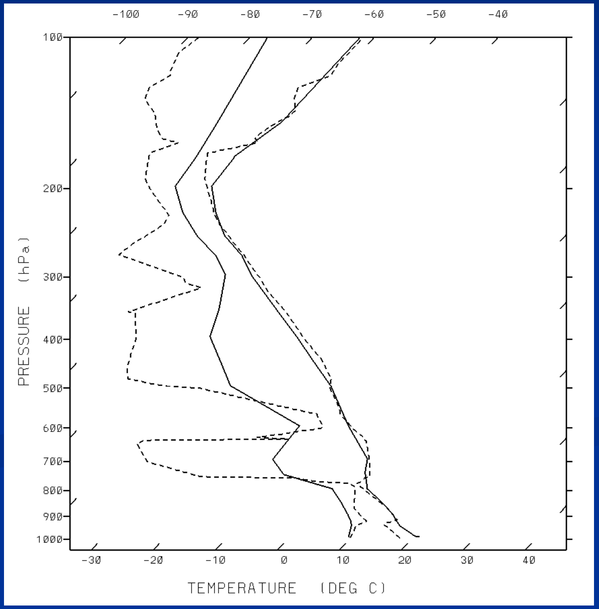
10:00, 29 May 2007

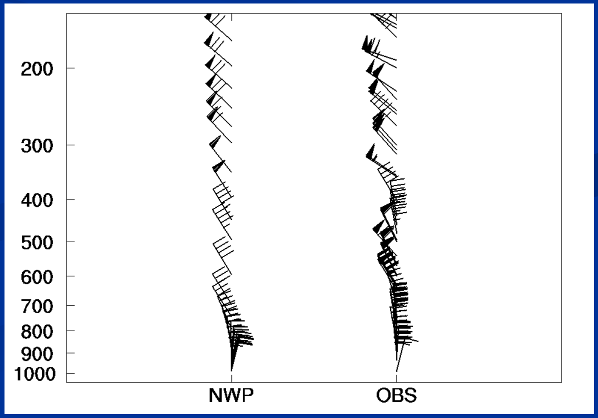
Melbourne





Wagga Wagga





MesoLAPS does a good job modelling temperature but a poor job of modelling dewpoint

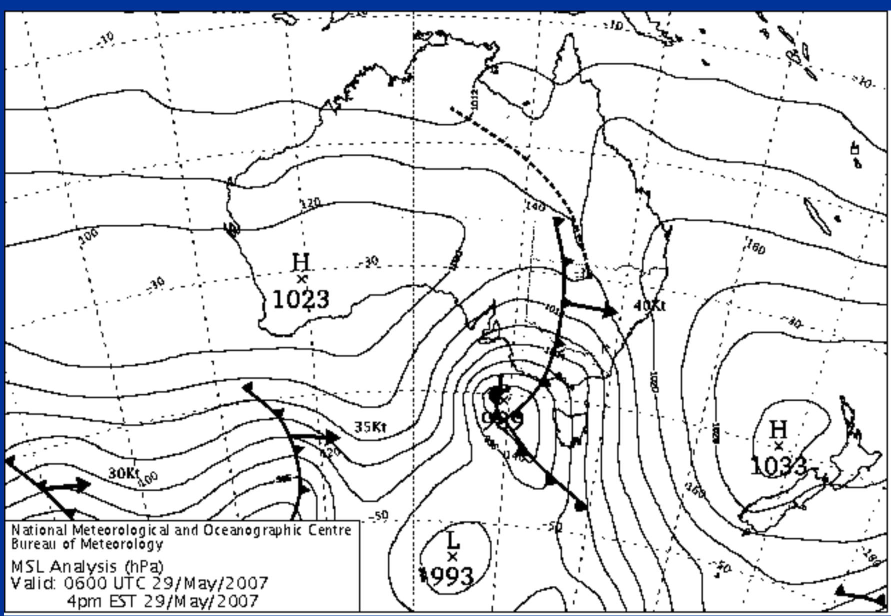
MesoLAPS does a pretty good job modelling wind speed and direction

Synoptic precursors to foehn occurrence

Foehn events were found to occur in connection with the passage of low pressure cells and troughs

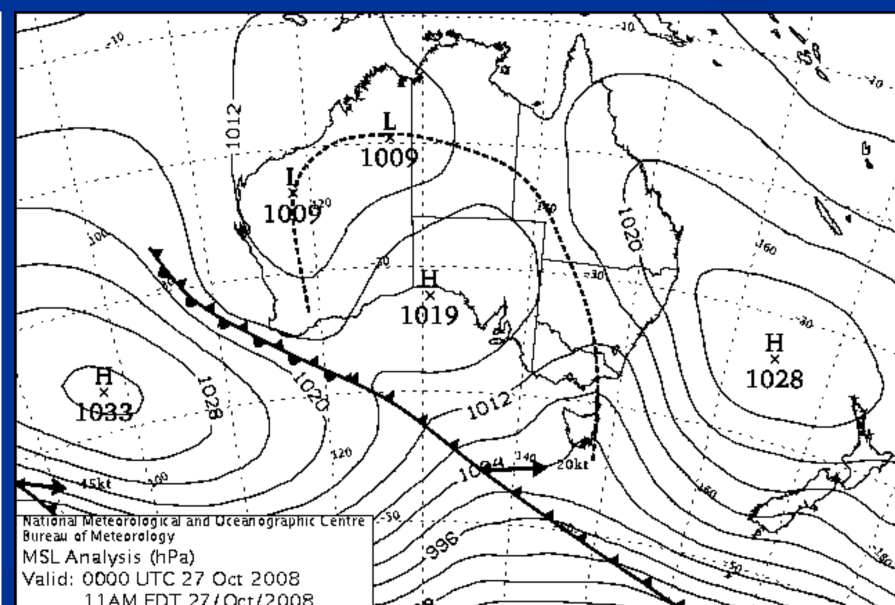
29 May 2007

A low pressure cell moves across the Bight causing winds to blow across the topography

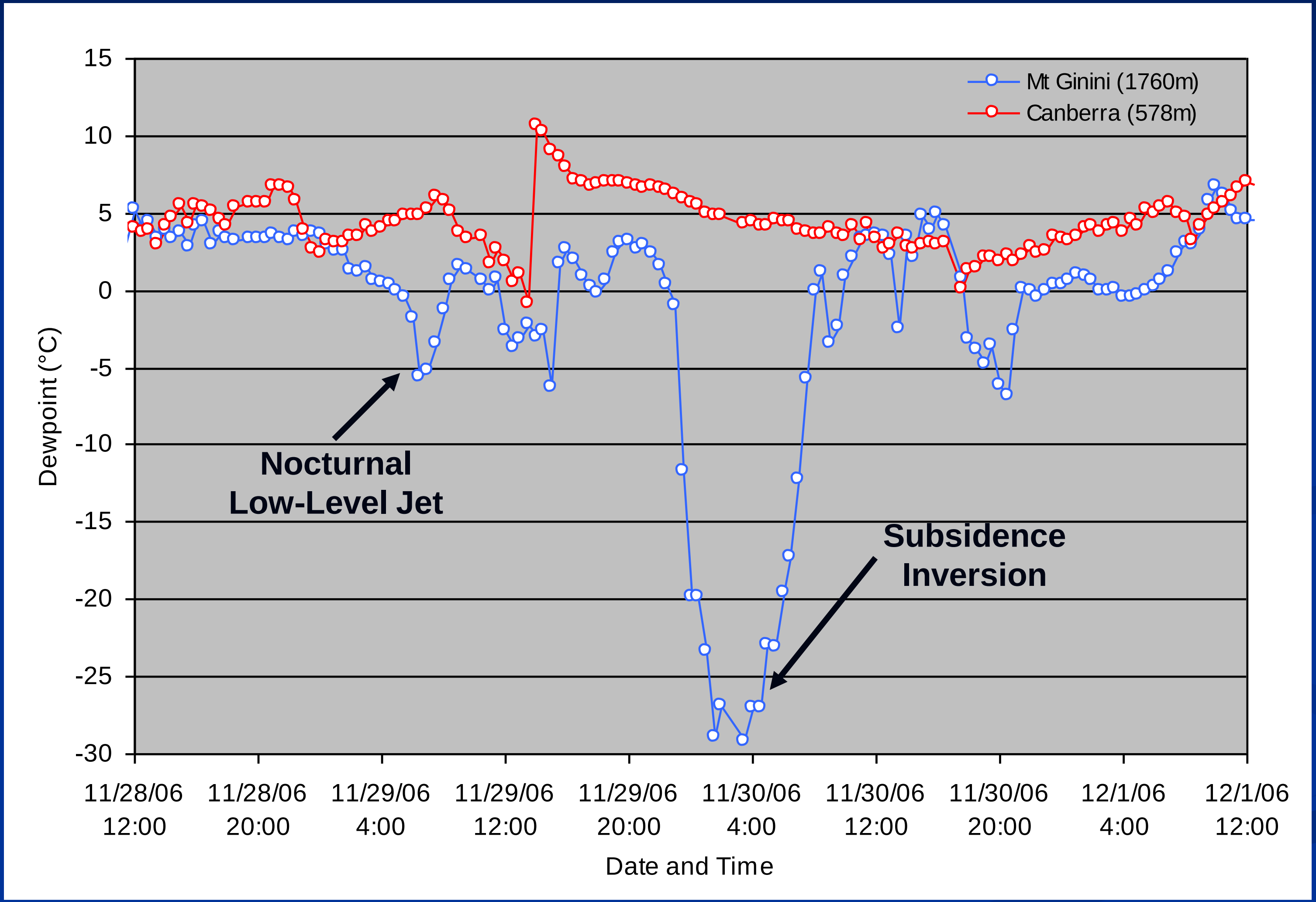


27 October 2008

A trough moves across SE Australia causing winds to blow across the topography

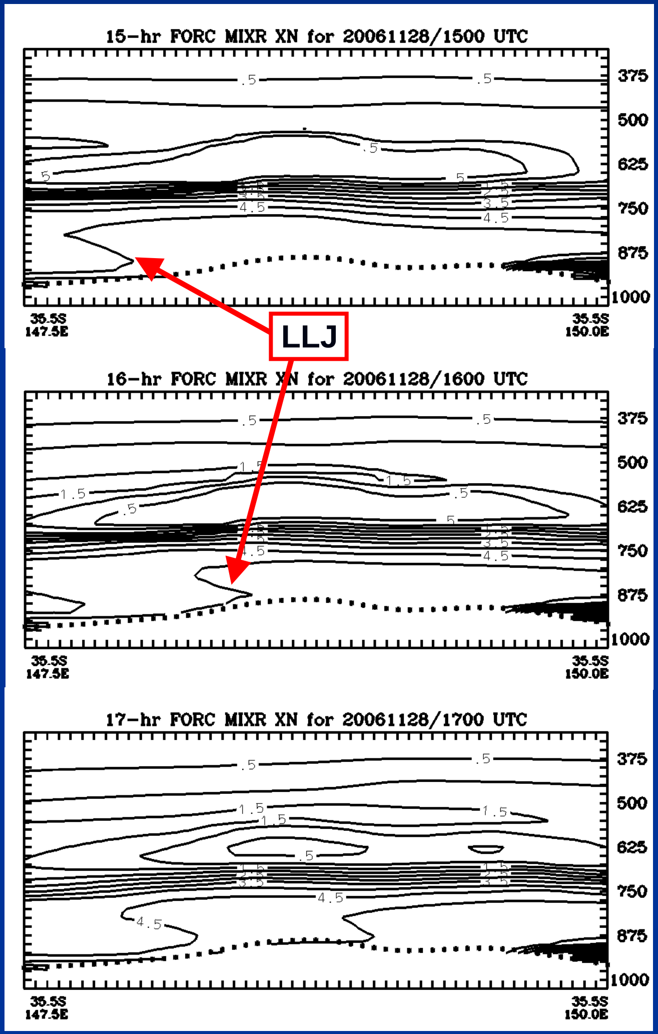


Other extreme drying events…



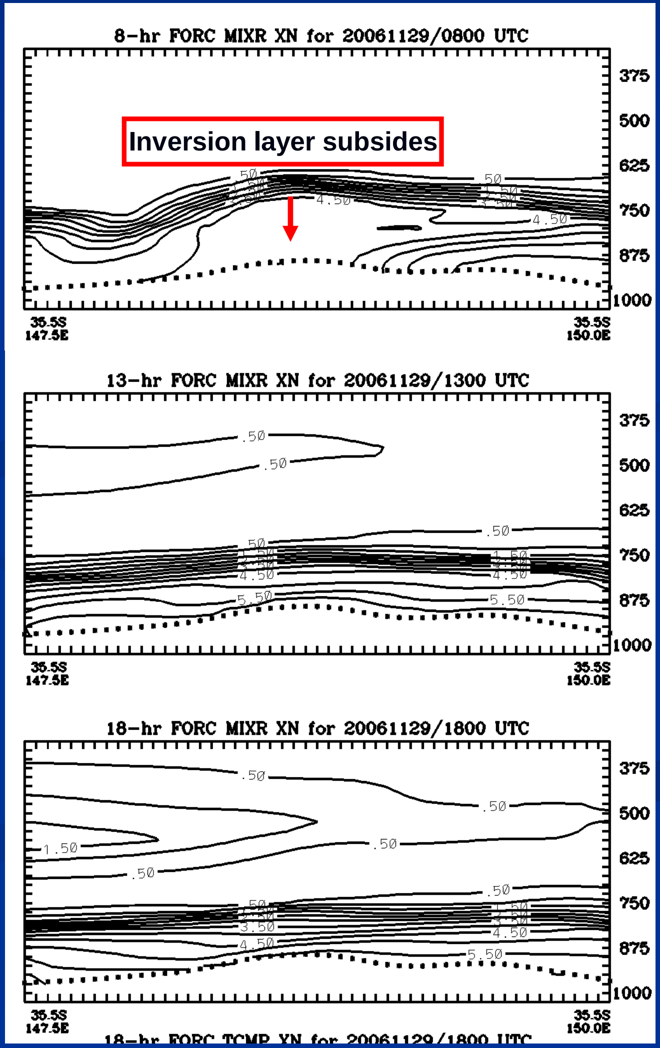
Other extreme drying events…

A nocturnal low-level jet (moving W to E) brings drier air nearer to the surface



MesoLAPS output

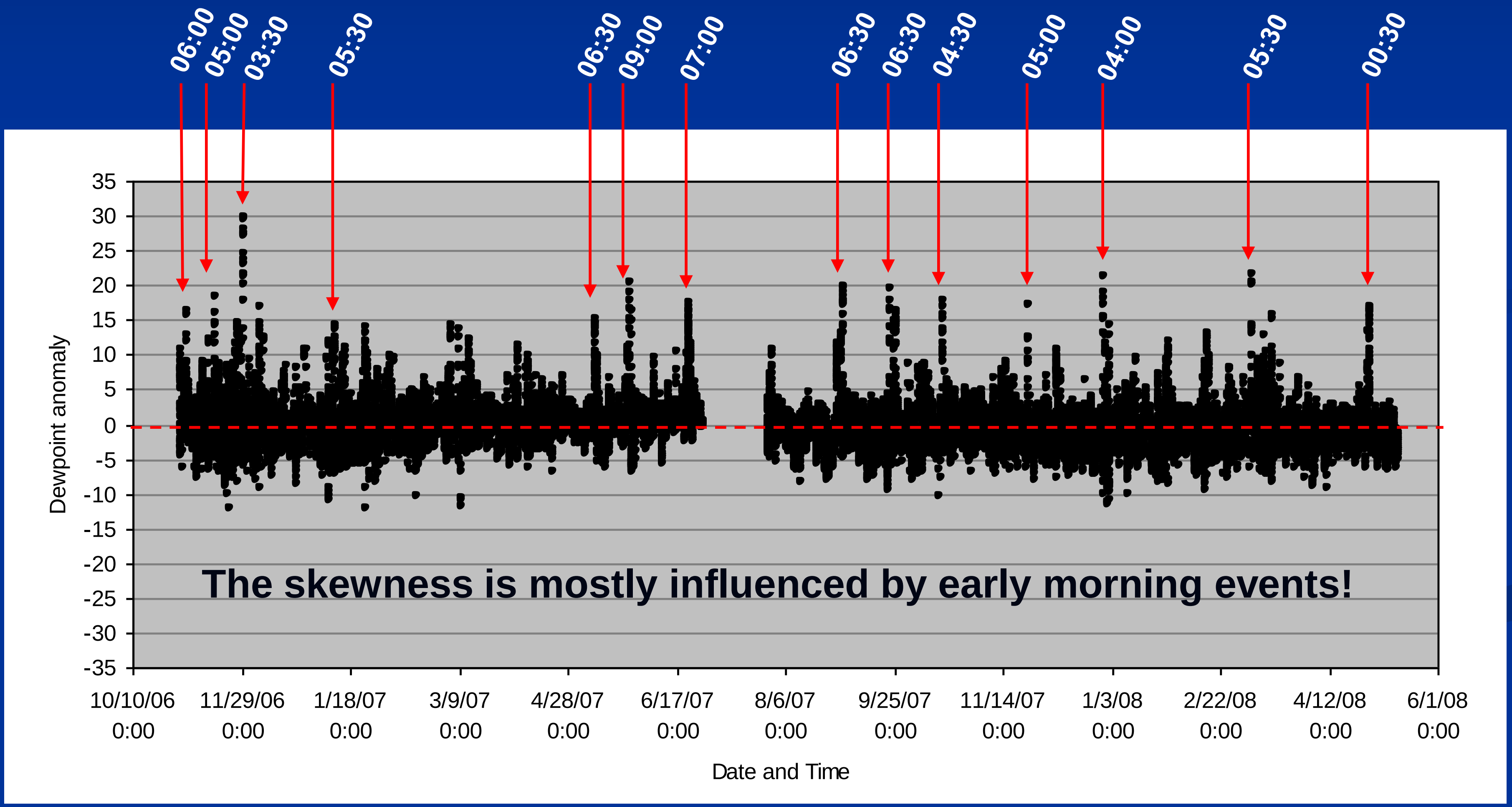
A subsidence inversion intersects topography, exposing it to the very dry air above the inversion



Other extreme drying events…

Difference in lowland and high-country dewpoint, expressed as anomaly (i.e. difference from average). The lowland site is Canberra (578 m), the high-country site is Mt Ginini (1760 m)

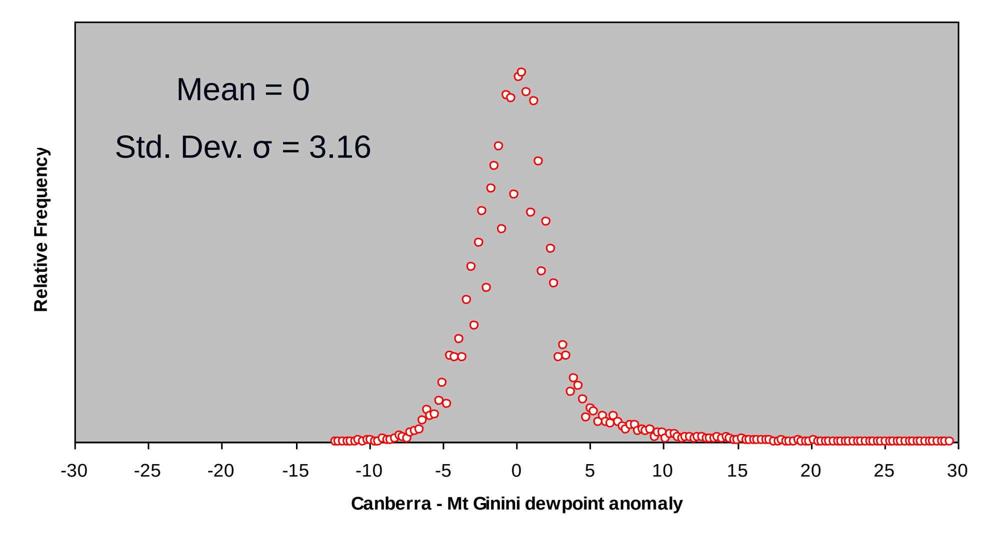
Distribution is positively skewed: Skewness = 1.3



Other extreme drying events…

Calculations indicate that for the Canberra-Mt Ginini station pairing dewpoint anomalies will occur with the following frequencies

Anomaly	Significance level	Occurrence frequency
> 2σ = 6.3°C	Approx. 95%	0.22 per day i.e. one event every 4.5 days
> 3σ = 9.5°C	Approx. 99%	0.11 per day i.e. one event every 9 days



Implications

• The research confirms foehn winds do occur over SE Australia and shows that they can result in abrupt localised changes in FFDR, which can reach anomalous levels (i.e. above the 95th percentile of climatological values).

• The onset of foehn conditions can easily increase fire danger levels by a factor of ten or more within an hour.

• Regions affected include the Sydney basin, the south coast of New South Wales and the Gippsland region, though similar effects could be expected at other regions located in the lee of significant topography.

Implications

- The research also has a number of implications for fire suppression operations and fire crew safety. For example, hourly updates of weather variables by personnel in the field may be insufficient given that foehn occurrence can cause significant changes in FFDR over sub-hourly time intervals

- The high-country can experience significantly drier conditions when compared to low-land stations, particularly in the early morning. Careful monitoring of weather conditions is required.

- A significant drying event can be expected in the high-country (above about 1500m) on one in about every 4-9 days. This means that campaign fires in the high-country are very likely to be affected by such an occurrence!

Some relevant peer-reviewed HighFire Risk Publications

Sharples, J.J. Mills, G.A., McRae, R.H.D., Weber, R.O. (2010) Elevated fire danger conditions associated with foehn-like winds in southeastern Australia. *Journal of Applied Meteorology and Climatology,* in press. doi:10.1175/2010JAMC2219.1

Sharples, J.J. Mills, G.A., McRae, R.H.D., Weber, R.O. (in prep.) Dewpoint anomalies in the Australian high country and their implication for bushfire risk management.

McRae, R.H.D., Sharples, J.J. (in prep.) The thermal belt in an Australian bushfire context.

Sharples, J.J., McRae, R.H.D., Weber, R.O., Mills, G.A. (2009) Foehn-like winds and fire danger anomalies in southeastern Australia. *Proceedings of the 18th IMACS World Congress and MODSIM09*. 13-17 July, Cairns.

Sharples, J.J., McRae, R.H.D., Weber, R.O., Gill, A.M. (2009) A simple index for assessing fuel moisture content. *Environmental Modelling and Software*, 24, 637-646.

Sharples, J.J., McRae, R.H.D., Weber, R.O., Gill, A.M. (2009) A simple index for assessing fire danger rating. *Environmental Modelling and Software*, 24, 764-774.

Sharples, J.J. (2009) An overview of mountain meteorological effects relevant to fire behaviour and bushfire risk. *International Journal of Wildland Fire*, 18, 737-754.

Sharples, J.J. (2008) Review of formal methodologies for wind-slope correction of wildfire rate of spread. *International Journal of Wildland Fire* 17, 179-193.


THANKS!