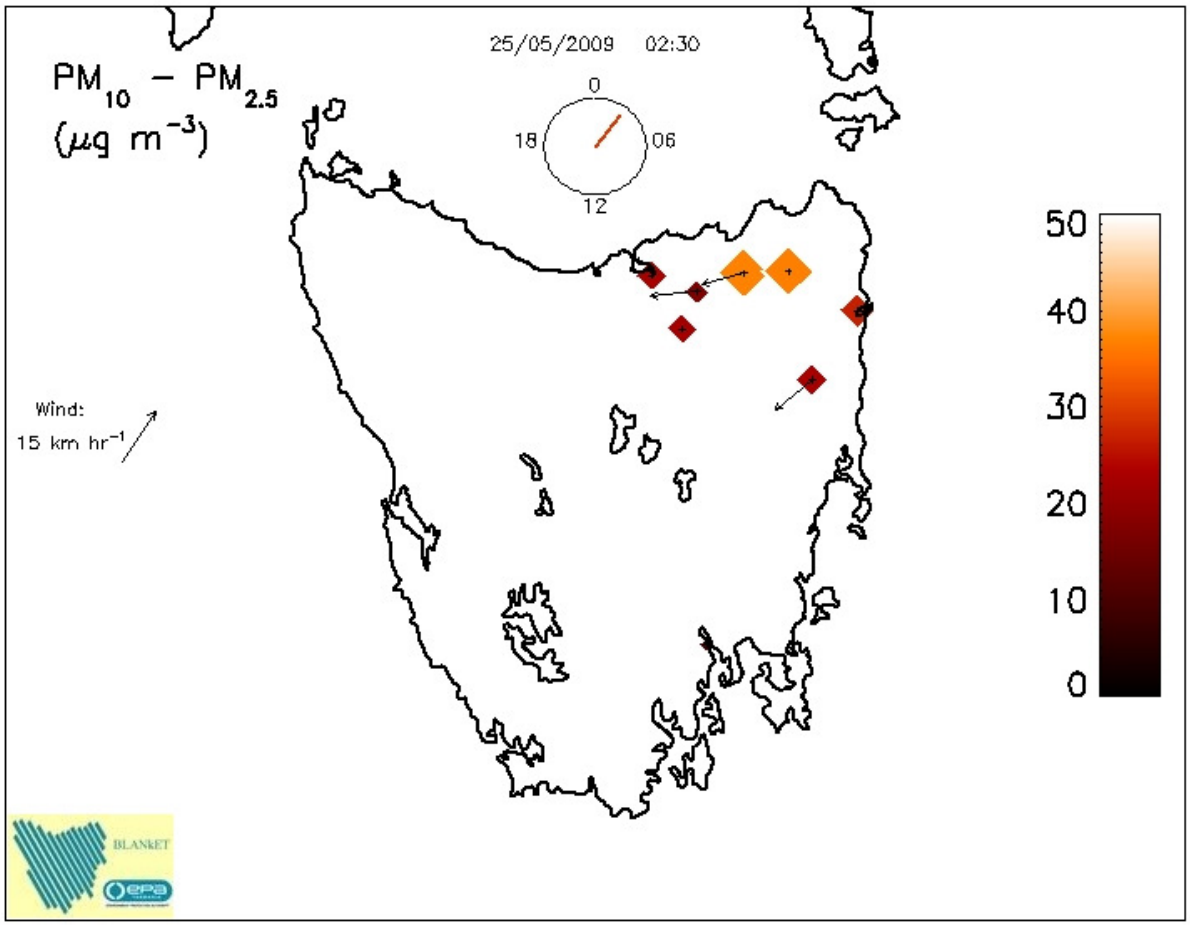
BLANkET[1] Technical Report - 4
A multi-day event in the PM_{10}-$PM_{2.5}$ signal measured in the North-East Tasmanian BLANkET stations – sea-salt aerosol

November 2009



Data visualisation of the late May 2009 PM_{10} event seen in the BLANkET data. Station locations are marked by small black crosses overplotted with red diamonds. The colour and size of the diamond represents the size of the PM_{10}-$PM_{2.5}$ signal (i.e. the coarse fraction of PM_{10}). Wind vectors are shown for the BLANkET stations. High levels of coarse particles were seen for several days during an interval of moderately strong easterly winds. The image shows the situation for 02:30 AEST on the 25th of May 2009.

[1] Base-Line Air Network of EPA Tasmania

Summary: In late May 2009 the five newly commissioned BLANkET air monitoring stations in the north-east of Tasmania recorded an extended interval of high PM10 signals over several days commencing late on the 23rd of May. Simultaneously measured $PM_{2.5}$ levels were mostly low during this time. Hence, according to these data, the high PM_{10} levels appeared to be due to particles in the range from 2.5 µm to 10 µm in size, i.e. in the coarse part of the PM_{10} fraction, demonstrating that the event was not due to wood smoke. (Smoke particles are below 1 µm in aerodynamic diameter.) Data from independent stations showed some remarkably consistent time-variations. The event ended suddenly in the early hours of the 26th of May when a cold front crossed the state and rain fell at most stations.

During the event there was a clear correlation between the size of the PM_{10}-$PM_{2.5}$ signal and relative humidity at each station.

Analysis of the data indicates the likely origin of the elevated signals were sea-salt aerosols.

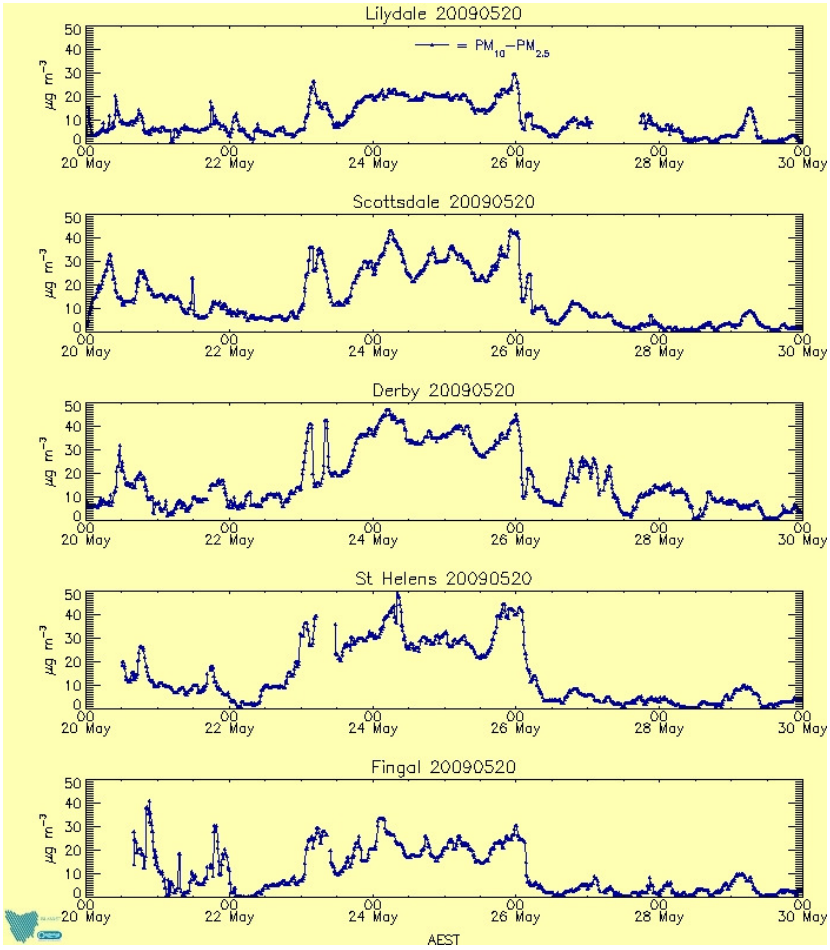


Figure 1 - PM_{10} - $PM_{2.5}$ against date for late May 2009 for the five north-east Tasmania BLANkET stations

Introduction: In late May 2009 the five newly commissioned BLANkET air monitoring stations in the north-east of Tasmania recorded an extended interval of high PM10 signals over several days commencing late on the 23rd of May. Simultaneously measured $PM_{2.5}$ levels were mostly low during

this time. The high PM_{10} levels therefore appeared to be due to particles in the range from 2.5 µm to 10 µm in size, i.e. in the coarse part of the PM_{10} fraction. This demonstrates that the event was not due to wood smoke. Data from independent stations showed some remarkably consistent time-variations. The event ended suddenly in the early hours of the 26th of May when a cold front crossed the state and rain fell at most stations. Figure 1 shows the basic data for this event for the five north-eastern Tasmanian stations, plotting $PM_{10} - PM_{2.5}$ against date, using a 2-hour median filter to show the underlying variation more clearly.

The eastern-most stations exhibited the biggest effect in the PM_{10} - $PM_{2.5}$ signal. For example St Helens, Derby and Scottsdale stations recorded peak $PM_{10} - PM_{2.5}$ levels near 40 to 50 µg m^{-3}, while at Lilydale station (the westernmost BLANkET station) $PM_{10} - PM_{2.5}$ peaked near 30 µg m^{-3}. At Fingal, the southern-most station, $PM_{10} - PM_{2.5}$ also peaked near 30 µg m^{-3}. Figure 2 shows the current Tasmanian air monitoring stations. The BLANkET stations are shown by black triangles.

Figure 2 - Tasmanian air monitoring stations, May 2009. The BLANkET stations are: LD = Lilydale; SC = Scottsdale; DE = Derby; SH = St Helens; FI = Fingal.

This report discusses the event and the probable causes.

General comments: The top panel of Figure 3 below shows both PM_{10} and $PM_{2.5}$ for Lilydale station from station commissioning on the 6th of May to the end of May 2009. Lilydale station is located about 800 metres down a small valley from Lilydale township, and receives domestic woodsmoke from the town on calm cold nights when a drainage flow is established. The lower panel of Figure 3 shows meteorological data measured at the air station.

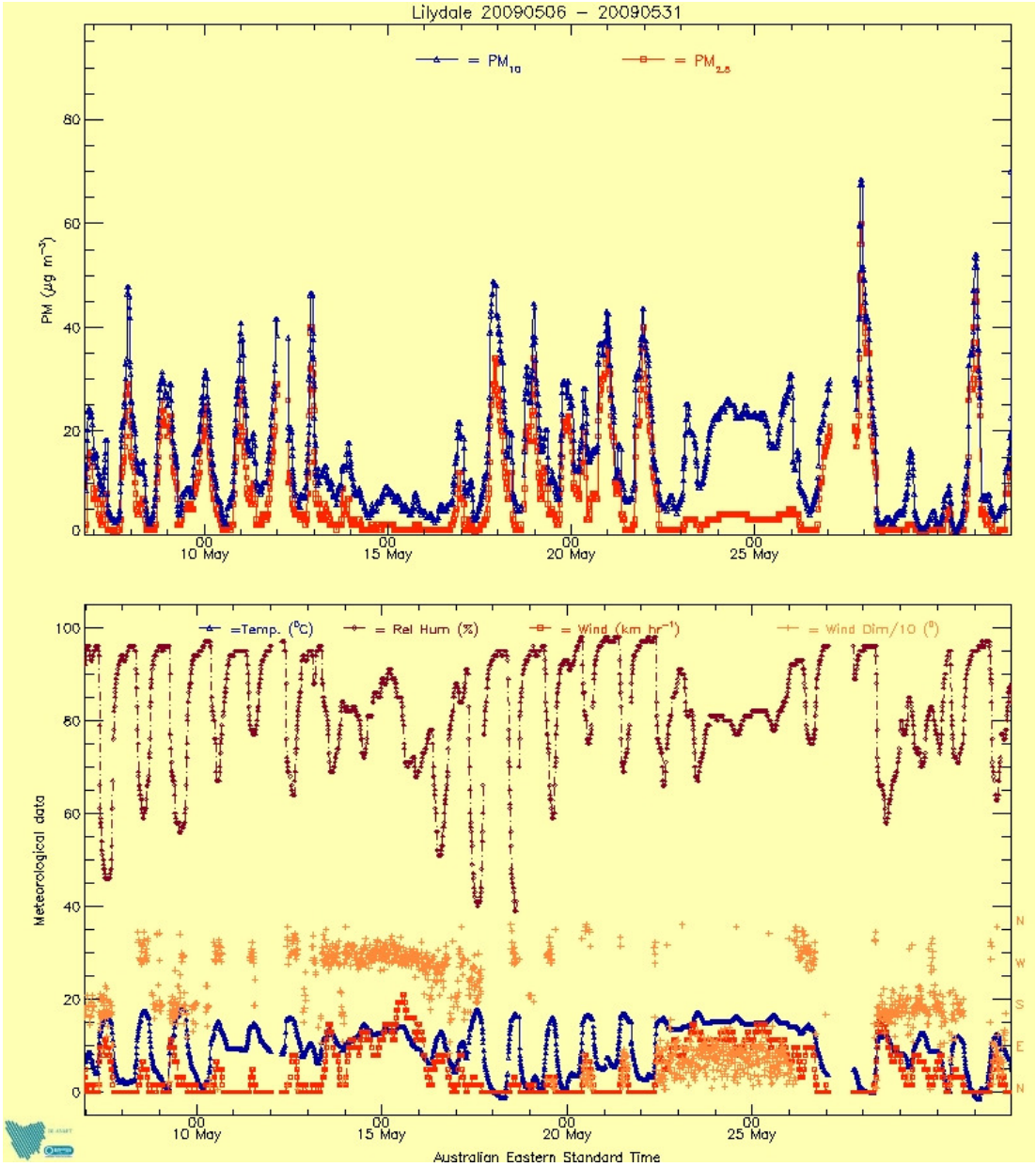


Figure 3 - Lilydale BLANkET station, air quality and meteorological data, 6th to 31st of May 2009

In general, woodsmoke dominates both the $PM_{2.5}$ and PM_{10} measurements, as shown by the close agreement between these two quantities. The late May event, where PM_{10} was significantly greater than $PM_{2.5}$, clearly stands out as unusual. From the meteorological data, this event occurred during a prolonged interval of moderate (10 to 15 km hr^{-1}) east to north-easterly winds. Synoptically, a high pressure system was nearly stationary to the east of Tasmania over most of this interval. (See the appendix for Bureau of Meteorology surface analysis pressure charts for this time.)

Figure 4 shows data from the Scottsdale BLANkET station from station commencement on the 13th of May to the 31st of May. Scottsdale station is located on a hill about 1 km to the south of the town, and is generally not subject to woodsmoke from the main residential area, although occasionally a local smoke plume can have a short term effect (as seen late on the 18th of May). Hence, $PM_{2.5}$ levels

are significantly lower at this station than at Lilydale. The high PM_{10} and low $PM_{2.5}$ signals in late May again occur during an interval of moderate east to north-easterly winds.

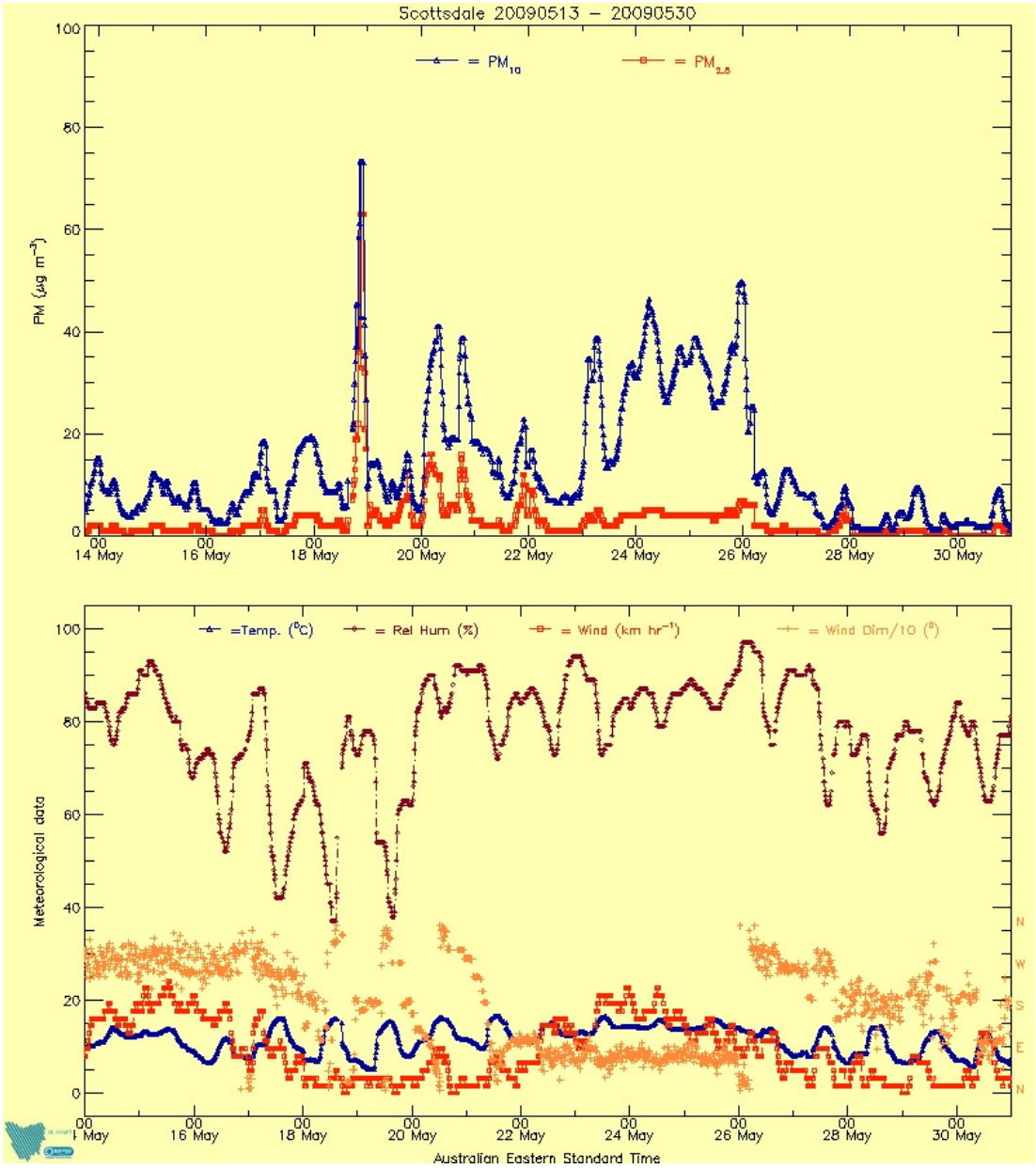


Figure 4 - Scottsdale BLANkET station, air quality and meteorological data, 13th to 31st May 2009

The general appearance of the late May event at the other three stations is similar to that shown for Lilydale and Scottsdale. Figure 1 showed $PM_{10} – PM_{2.5}$ for the five north-east Tasmanian BLANkET stations. Figure 5 repeats these data but also includes data from a DRX operating at the Hobart air station (lower panel). There is evidence for a similar but smaller event in the Hobart data.

How the BLANkET stations measure aerosols: The BLANkET stations are equipped with Dustrak DRX optical particle counters. Sample air is drawn into a chamber and illuminated by pulsed laser light. Small particle in the air scatter light to a detector. More particles in the sample air means that more scattering occurs. The BLANkET DRXs were field calibrated in Hobart by comparing their output with

that from a PM_{10} TEOM (a gravimetric technique) and an older style dustrak which was itself earlier calibrated against gravimetric $PM_{2.5}$ air sampler. The DRX calibration therefore relates the optical properties of a given aerosol to its mass. Hence the DRXs were effectively calibrated against the aerosols usually present in Hobart. These are likely to be sea-salt and dust aerosols in the coarse part of PM_{10}, and smoke in the $PM_{2.5}$ part. The conversion from optical scattering counts to a mass concentration for the field DRX instruments deployed in the field is necessarily dependent on the validity of these calibration factors.

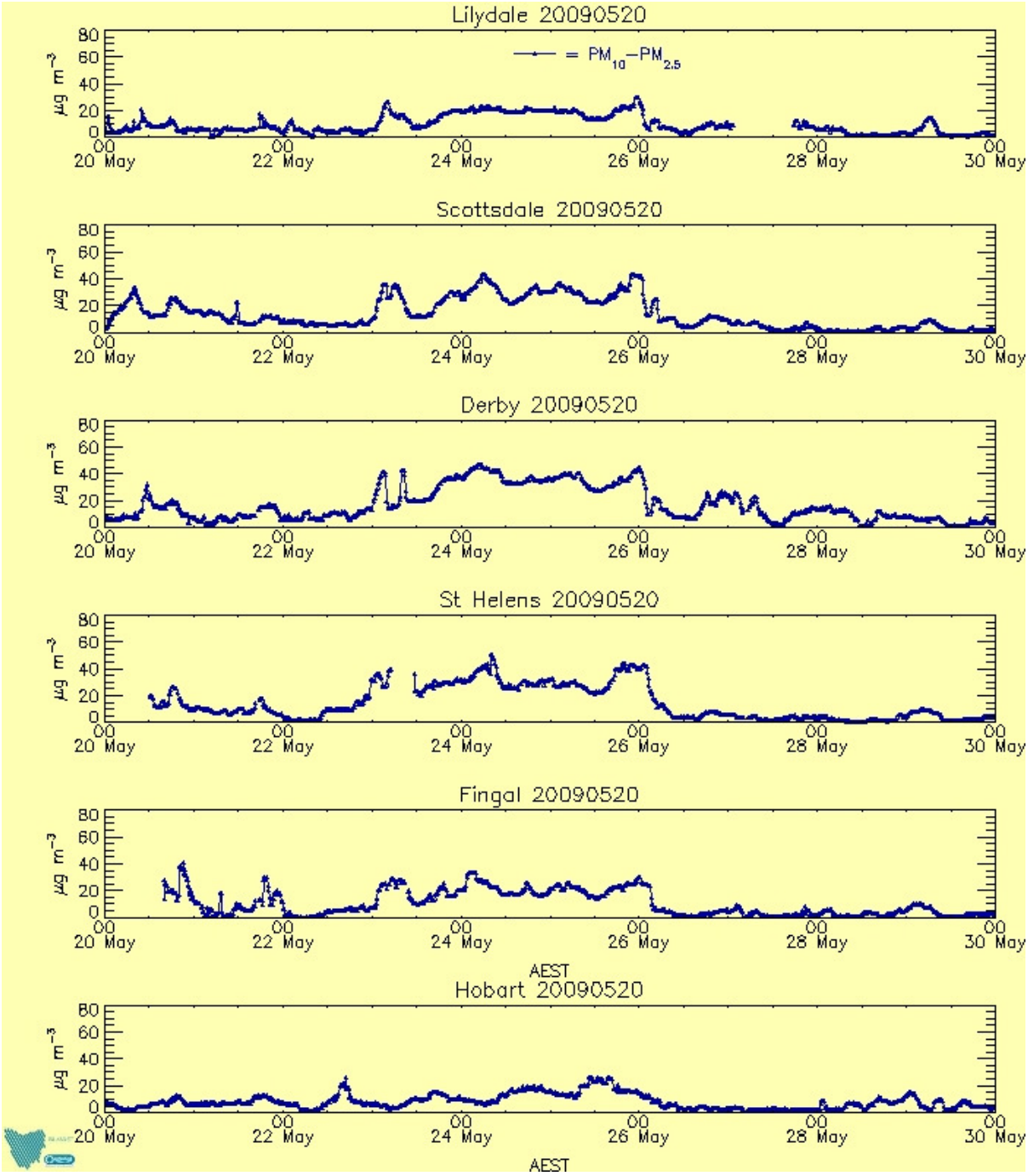


Figure 5 - PM_{10} - $PM_{2.5}$ against date for late May 2009 for the five north-east Tasmania BLANkET stations as well as from a DRX dustrak located in Hobart

Figure 6 compares the Hobart (New Town) DRX $PM_{10} - PM_{2.5}$ data and the 24-hourly $PM_{10} - PM_{2.5}$ measurements at New Town derived from two co-located low-volume air samplers (which independently measure PM_{10} and $PM_{2.5}$ by a gravimetric method). The gravimetric $PM_{10} - PM_{2.5}$ data are shown as red upright crosses. The raw DRX data are shown as the dotted line, with day averages shown as blue squares. There is a very good measure of agreement between the gravimetric and optical data.

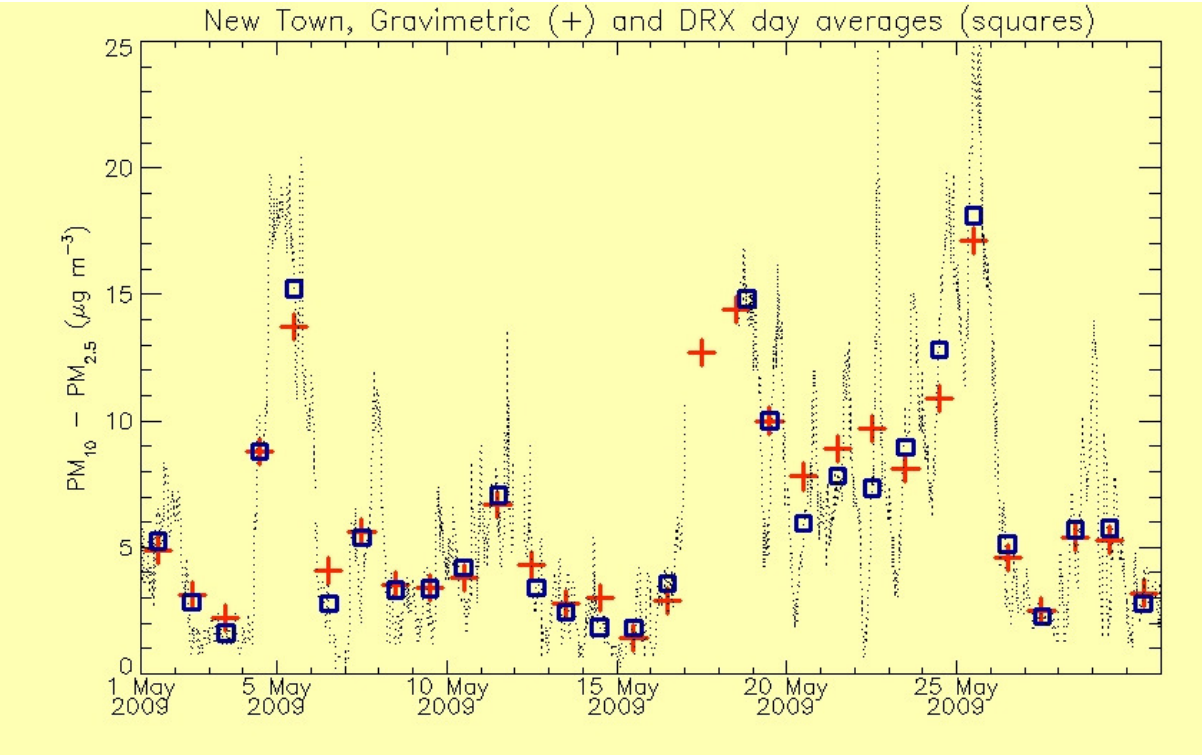


Figure 6 - Comparison of gravimetric (red upright crosses) and day-averaged optical (dustrak DRX, as used in the BLANkET stations, blue squares) $PM_{10} - PM_{2.5}$ data from Hobart, May 2009. The source (10-minute) DRX data are also shown as the dotted line.

However, there is a possibility that the high signals in the coarse part of PM_{10} seen in late May 2009 in the north-east BLANkET stations may have resulted from the presence of a different aerosol to those usually seen, perhaps one that gives a greater scatter for its mass than seen at Hobart, and hence invalidating the scattering-to-mass calibration.

Evidence against this possibility comes from data collected at the Rowella air station (on the lower Tamar River), located to the west of the BLANkET stations. This station is equipped with PM_{10} and $PM_{2.5}$ TEOM (gravimetric) instruments. Rowella also recorded the start of the event seen in the BLANkET data, but, unfortunately, was shutdown for scheduled maintenance late on the 25th of May while the event was still in progress. The closest BLANkET station to Rowella is Lilydale, about 25 km away in an east-south-east direction. Comparing the data from Rowella and Lilydale (Figure 7) shows the PM_{10} - $PM_{2.5}$ signals at these two stations are very similar in size, suggesting that the DRX scatter-to-mass calibration appears unlikely to be greatly in error.

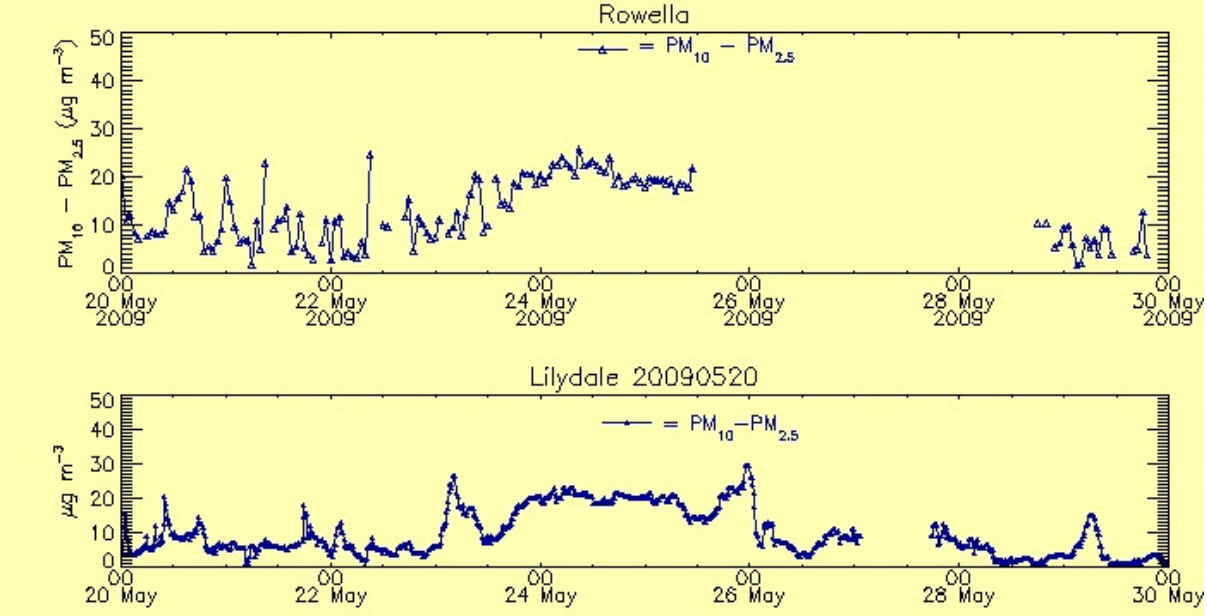


Figure 7 - Top panel: TEOM PM_{10} - $PM_{2.5}$ data from Rowella; Lower Panel: DRX Dustrak PM_{10} - $PM_{2.5}$ data from Lilydale, 25 km ESE from Rowella

Additionally, as noted above, a similar but smaller increase in the Hobart DRX PM_{10}-$PM_{2.5}$ data was also seen in late May. These DRX data correlated well with the gravimetric data obtained at Hobart (as shown in Figure 6).

The context: The PM_{10} – $PM_{2.5}$ event seen in the BLANkET data in late May was noticeably unusual (e.g. as shown in the above Figures), however, at that time the stations had been operating for less than one month. It is of interest to compare the gravimetric data for May 2009 from the major air stations at Hobart, Launceston, George Town, and Rowella, as shown in Figure 8, with the BLANkET data. Data from the first three listed stations come from low-volume air samplers, the Rowella data are day-averaged TEOM values.

All stations show elevated PM_{10} – $PM_{2.5}$ levels around the 23rd to 25th of May when the north-east Tasmanian BLANkET stations recorded the PM_{10} – $PM_{2.5}$ event. However, the four stations shown in Figure 8 also show moderately elevated PM_{10} – $PM_{2.5}$ levels from around the 16th of May onwards, as well as a possible, brief, event around the 4th or 5th of the month. Inspection of the entire datasets for Hobart, George Town, and Launceston reveal that episodes of elevated PM_{10} – $PM_{2.5}$, while not common, are not unprecedented. In this context, the late May event does not appear so unusual, particularly at the stations of George Town and Hobart, which are the two stations closest to the coasts. (While Rowella is only about 10 km south-east of George Town, Launceston is about 45 km south-east of George Town.)

While George Town, Launceston, and Hobart all have local industrial and other sources of PM_{10} particles, the general correlation over a wide spatial scale suggests a natural source. As the signals are larger at the near-coastal stations, it is suspected the source may be sea-salt aerosols.

In this view, the late May PM_{10} – $PM_{2.5}$ event seen in the north-east BLANkET stations is only unusual in that sea air was able to reach these stations due to the moderately strong east to north-easterly

winds, whereas under calm conditions, or for westerly or north-westerly winds, the sea-salt laden air either can't penetrate to the stations or is deposited en route over the Tasmanian mainland.

General background on sea-salt aerosols: Sea salt aerosols range in size from less than 0.2 µm to over 200 µm in effective diameter, with a distinct maximum in number density below 2 µm. However, more than 90% of the mass is contained in giant particles having a median mass diameter between 2 and 20 µm (R. Chester, *Marine Geochemistry*). These large particles dominate the deposition of sea-salts, even though they are present in the air in relatively low numbers.

Atmospheric sea-salt concentration over the ocean varies exponentially with wind speed for winds between 5 and 35 m s^{-1} (around 20 to 125 km hr^{-1}). At lower wind speeds the concentration falls off rapidly because few bubbles form under these conditions.

Near Tasmania, at 15 metres above the ocean surface, sea-salt concentrations average 15 to 20 µg m^{-1} in summer and 20 to 25 µg m^{-1} in winter.

The late May peak $PM_{10} – PM_{2.5}$ levels from the north-east BLANkET stations were around 40 to 50 µg m^{-3}(based on the scatter-to-mass calibration discussed above). The elevated $PM_{10} – PM_{2.5}$ signals were seen during an interval of moderate to strong east to north-east winds. The event ended early on the 26th of May when a cold front with rain crossed the state.

The May 2009 $PM_{10} – PM_{2.5}$ data from the Tasmanian air stations do not appear inconsistent with the known properties and observed concentrations of sea-salt aerosol. Additionally, it is known that sea-salt aerosols are present in Launceston's air (Keywood et al., 2000, *J. Air & Waste Management Assoc.*, vol. 50, pp 418-427). It is suggested that a satisfactory and reasonable explanation of the late May event is from the landward transport of sea-salt aerosols from the ocean to the east of Tasmania, driven by the moderate to strong synoptic east-north-easterly winds.

Could the late May '$PM_{10} – PM_{2.5}$ event' be due to widespread dust? Dust particles can be similarly sized to sea-salt aerosols and hence could also give an enhanced signal in the PM_{10} fraction with little or no increase in $PM_{2.5}$. A large dust event was seen in the BLANkET data in mid September 2009 (see separate report on this event). In this September event the dust visible on satellite images, and was deposited on the ground over a large area of northern and eastern Tasmania. The event was widely reported in the Tasmanian media. This dust storm originated in the north-east of South Australia. The dust was carried to the south coast of mainland Australia, then through Bass Strait to the Tasman Sea.

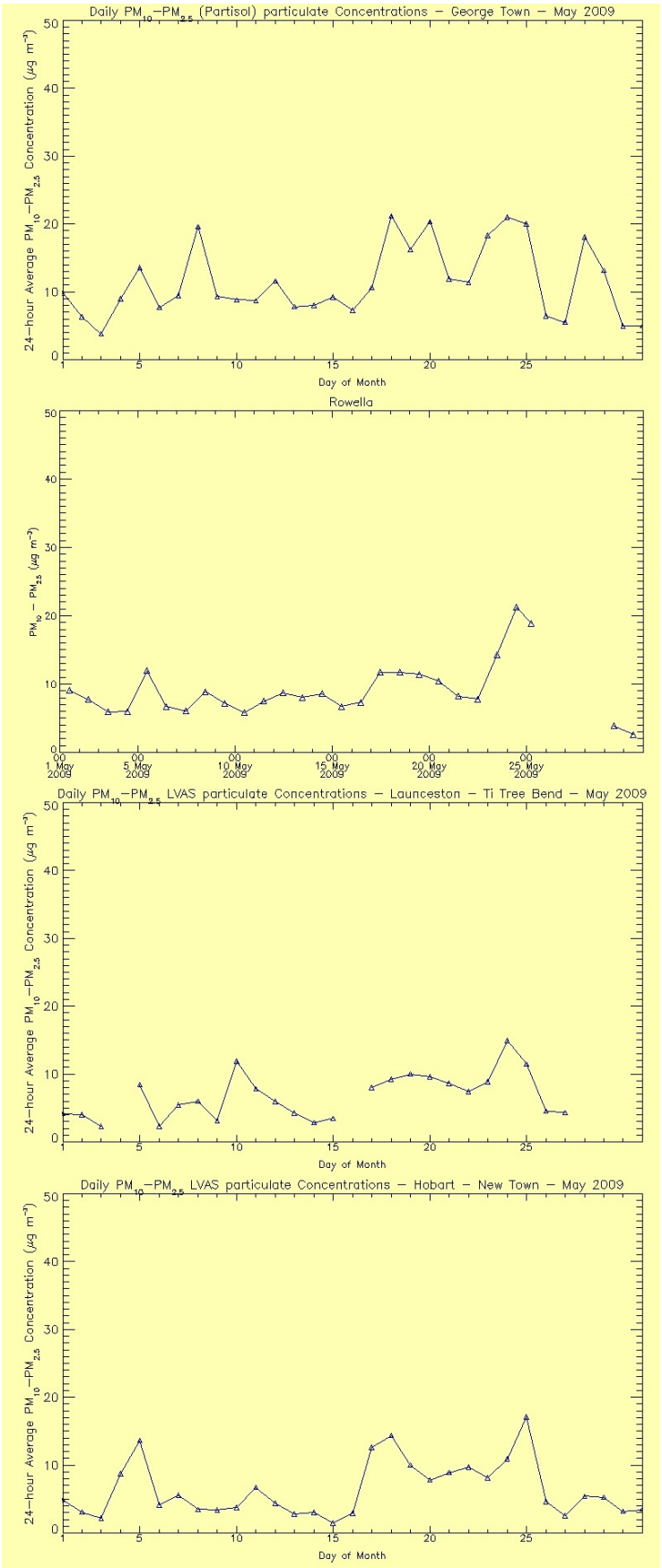


Figure 8 - Gravimetric PM_{10} - $PM_{2.5}$ for (top to bottom) George Town, Rowella, Launceston, and Hobart, May 2009

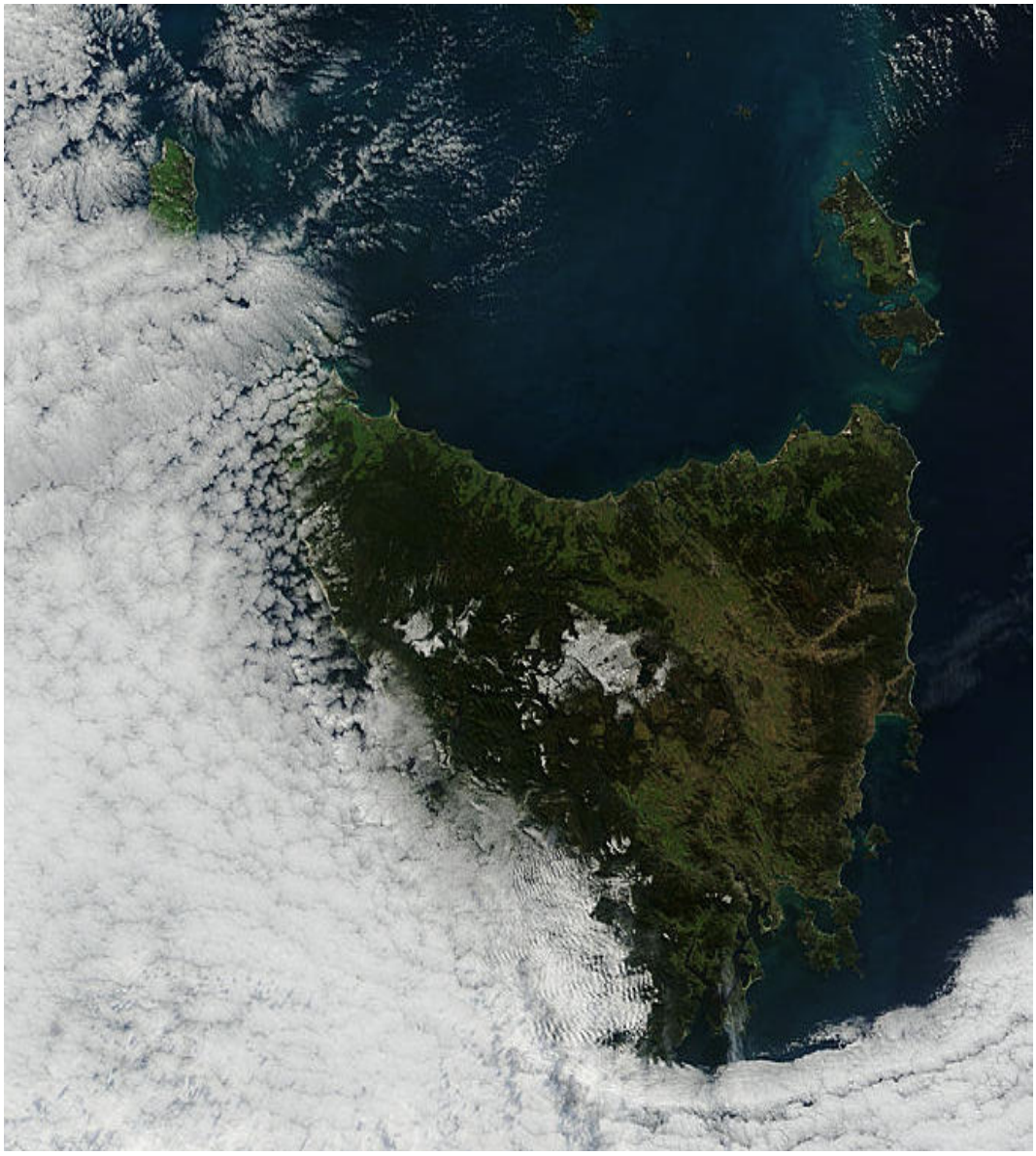


Figure 9 - MODIS image of Tasmania for the 18th May 2009

Satellite images from the late May interval (22nd to 26th of May) show a generally high level of cloud cover. However a MODIS image from the 18th of May, shown in Figure 9, shows clear skies over the eastern half of Tasmania. A detailed MODIS image of north-eastern Tasmania (not shown) shows no indication of widespread dust. On this day elevated $PM_{10} - PM_{2.5}$ levels were recorded at both George Town (20 µg m^{-3}) and Hobart (14 µg m^{-3}), while Rowella and Launceston were also moderately high (near 10 µg m^{-3}). Wind speeds at both George Town and Hobart were low on this day, mostly below 2 m s^{-1} so that it was unlikely there was any locally raised dust.

The most likely source for any significant amount of airborne dust reaching Tasmania is the Australian hinterland. For the late May event, it is considered unlikely that dust could be brought to the north-east BLANkET stations from an easterly direction for several days.

Relative Humidity correlation: Sea-salt aerosols are known to increase in size with increasing local relative humidity. The Lilydale $PM_{10} - PM_{2.5}$ data for the 23rd to the 25th of May (i.e. during the middle part of the event) are plotted against relative humidity in Figure 10. Apart from the small number of high humidity - low $PM_{10} - PM_{2.5}$ points (which occurred right at the start of the event), the data appear well correlated. The other BLANkET stations show similar patterns during the event. The correlation may arise as a result of the dependence of aerosol growth (and hence size) with local relative humidity.

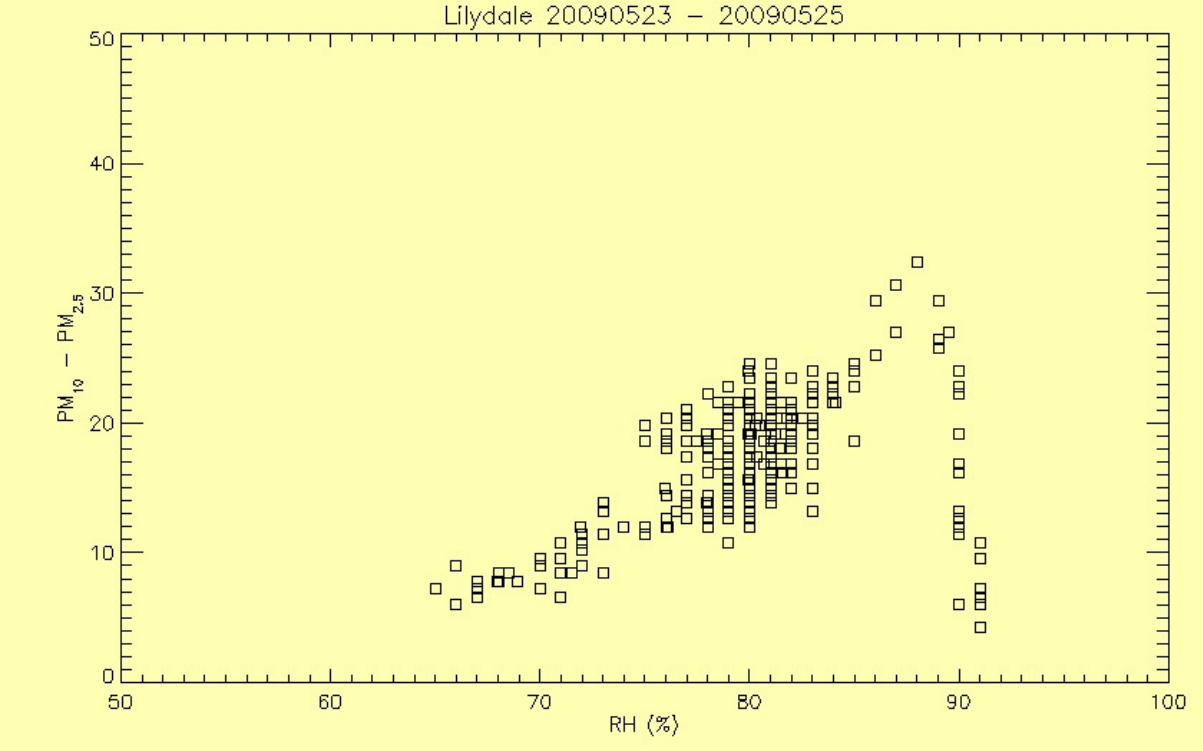


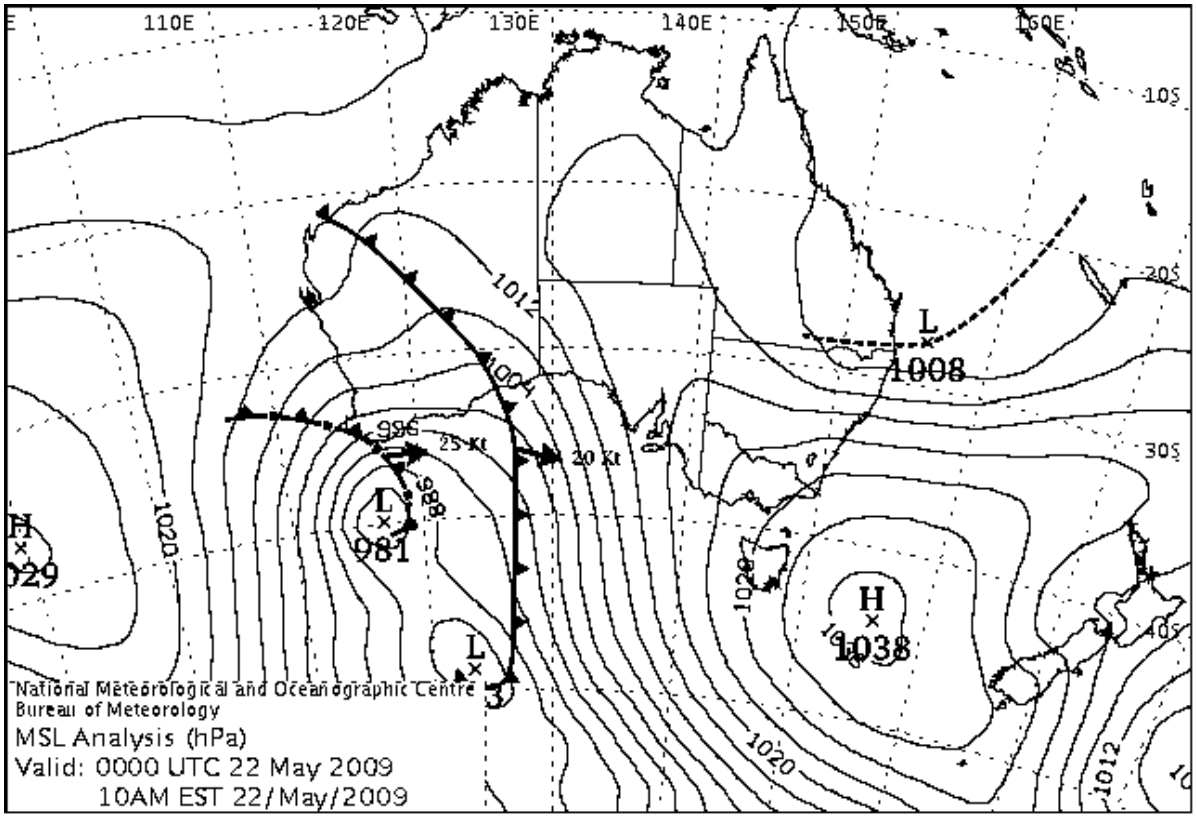
Figure 10 - Lilydale BLANkET data, 23rd to 25th May 2009, showing $PM_{10} - PM_{2.5}$ versus relative humidity

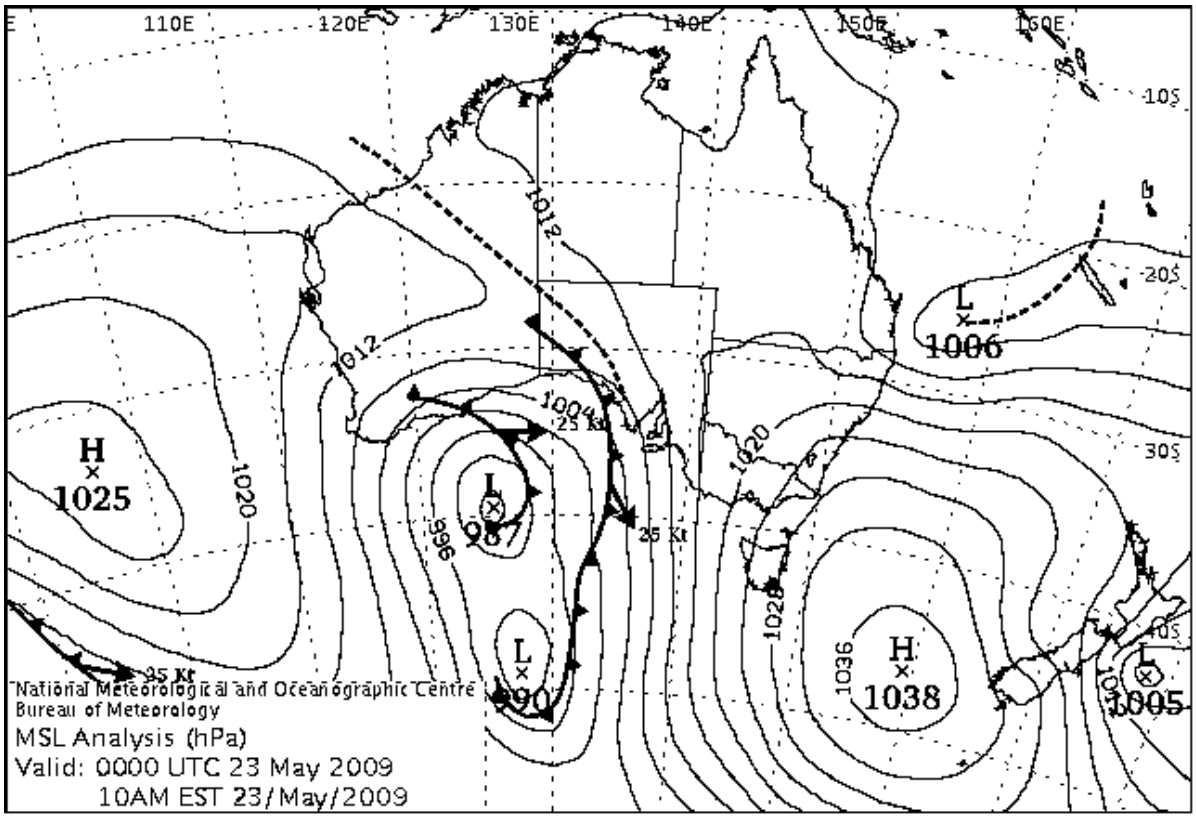
Summary: The increase seen in PM_{10} concentrations with little or no increase in $PM_{2.5}$ concentrations in the north-east Tasmanian BLANkET air stations in late May 2009 corresponded to an interval of moderate to strong east-north-easterly winds. Similar increases in $PM_{10} - PM_{2.5}$ were seen at this time in gravimetric data from the major Tasmanian air stations located at George Town, Rowella, Launceston and Hobart. Inspection of the data from the major air stations indicated that such PM_{10} - $PM_{2.5}$ events, were not uncommon, albeit mostly they are present at a more moderate level. Since the BLANkET stations commenced operation in May 2009 intervals of strong easterly winds have been infrequent. However, similar events have been seen in subsequent data.

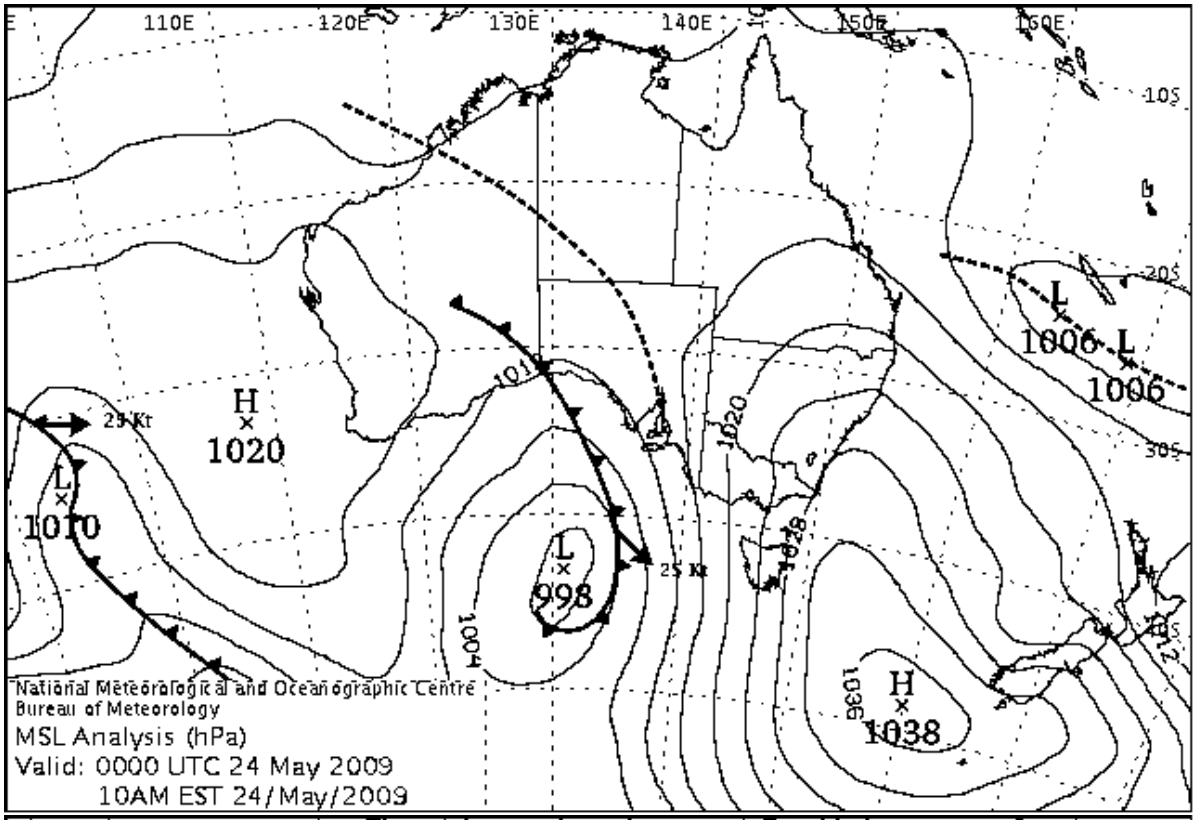
These data rule out smoke as being the aerosol that gave rise to the observed signal, given that smoke aerosols are mostly well below 1 µm in aerodynamic diameter. It appears more probable that the BLANkET stations detected sea-salt aerosols being carried from the ocean to the east of Tasmania on the moderately strong east-north-easterly winds.

Report complied by John Innis.

Appendix: Bureau of Meteorology analysis charts, 22nd to 27th May 2009.



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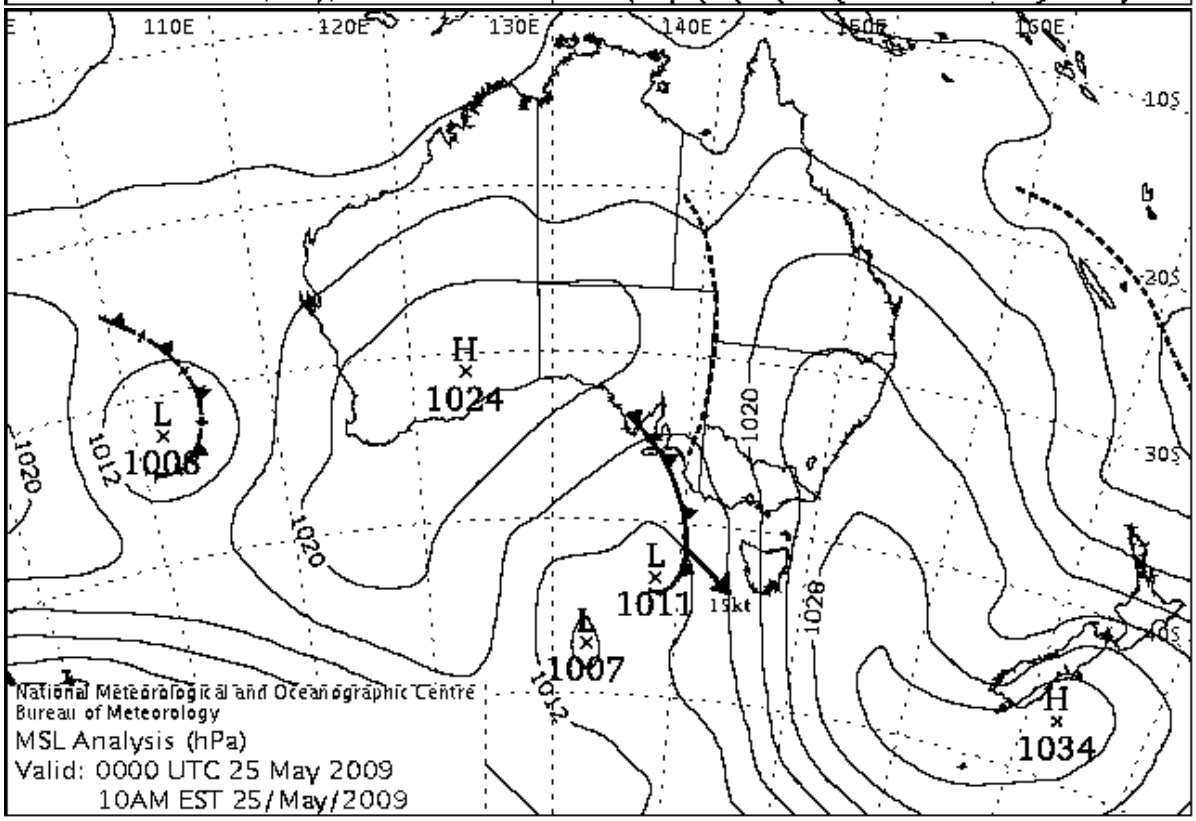
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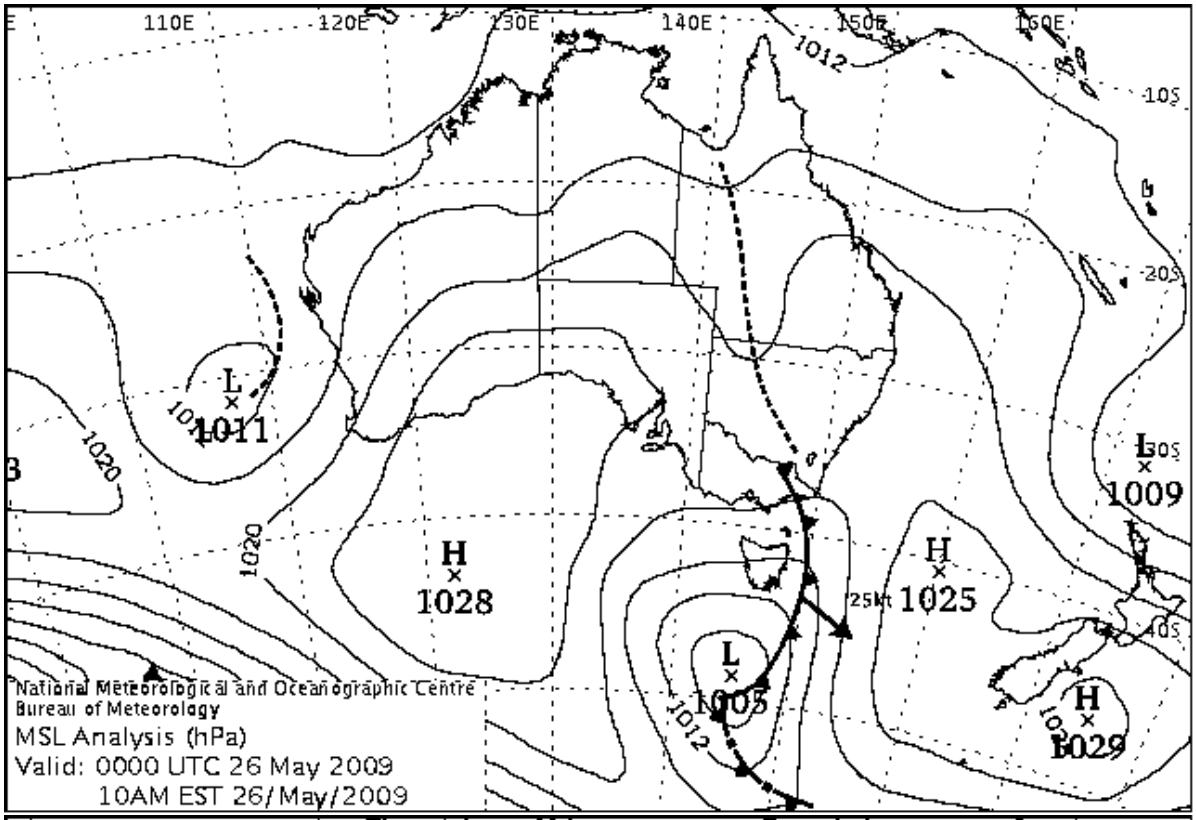
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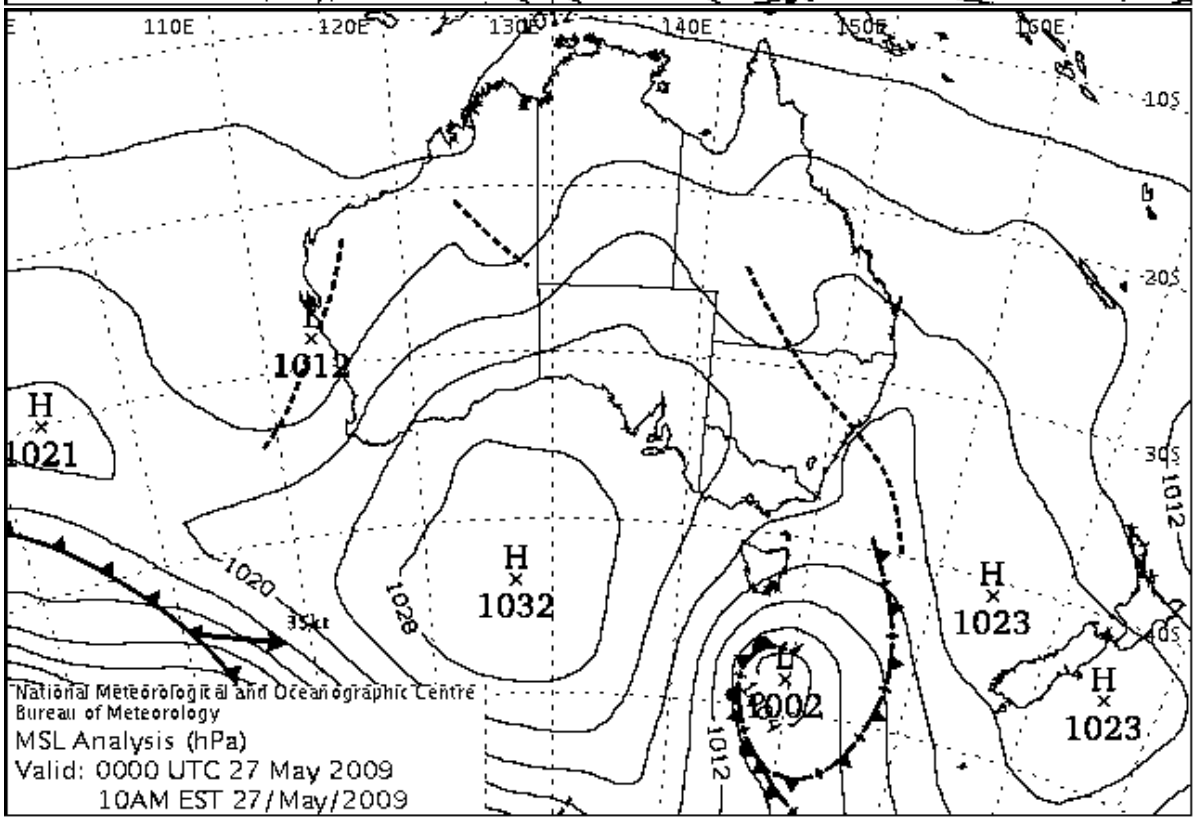
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