BLANkET[1] Technical Report 29

Smoke in northern Tasmania from a west coast planned burn, 15th October 2014, and notes on the prevailing wind systems : *'Turn right at the Tamar'*

Air Section, EPA Division, April 2015

Figure 1: A view towards Exeter under smoke in the middle Tamar Valley, taken on the late afternoon of the 15th of October 2014 from Bradys Lookout. Exeter air station recorded a peak $PM_{2.5}$ level near 150 μg m^{-3} soon after the photograph was taken. The smoke originated at a burn at Temma on the upper west coast of Tasmania, moved across the north of the state into Bass Strait, then was carried up the Tamar to Launceston on a north–west wind. The photograph was submitted to the EPA by a member of the public.

[1]Base–Line Air Network of EPA Tasmania

Context of the BLANkET reports

BLANkET (Base–Line Air Network of EPA Tasmania) reports are compiled using BLANkET and other Tasmanian air quality data, as well as data from other sources. The topics and events chosen for these reports are selected for one or more of the following reasons: Scientific interest – for example if the event demonstrates a principle or principles of general value in understanding smoke movement and dispersal in the Tasmanian context; Well-documented events – such as if the event is captured by two or more stations and hence provides general information on smoke movement; General public interest – this includes large–scale or other smoke events that have generated comment at the time or are of intrinsic public interest for other reasons; Annual reports and in-depth analysis of smoke surveys.

1 Summary

A number of BLANkET air monitoring stations across the north–west of Tasmania and in the Tamar region recorded an elevation in $PM_{2.5}$ levels on the afternoon and evening of the 15th of October 2014. Unusually elevated $PM_{2.5}$ concentrations lasted up to several hours at some stations, and peaked at several hundred micrograms per cubic metre. Analysis of these data combined with satellite imagery and other information identifies the source as a planned burn, of total area 6100 ha, that took place at Temma on the west coast of Tasmania on the 14th and 15th of October. Using information supplied by the burn agency, and other data, a calculation of down–range $PM_{2.5}$ concentrations is shown to be reasonably consistent with the observed levels.

The smoke moving across north–west Tasmania on the 15th of October 2014 generally moved on a westerly wind into southern Bass Strait, and then entered the Tamar valley, and was carried to Launceston on a north–west wind. This general transport of smoke from the west coast into Bass Strait and then up the Tamar valley to Launceston has been documented in several instances in the past. A brief analysis of the prevailing wind systems in northern Tasmania suggests that around a quarter of the time, south–westerly and westerly winds in the the far north–west of Tasmania occur at the same time as north–westerly winds in the Tamar. Several mechanisms are identified as giving rise to this pattern of prevailing winds. Under these particular circumstances smoke from burns in the northwest and upper west coast of Tasmania can be, and has been seen to be, transported to the Tamar valley.

Contents

2 Air Quality data

2.1 BLANkET station data

The EPA Division's BLANkET network of monitoring stations collect indicative air quality data from many regions of Tasmania. On the afternoon and evening of the 15th of October 2014 smoke levels (measured as $PM_{2.5}$) substantially above normal were recorded across northern Tasmania. A plot of the $PM_{2.5}$ data from selected northern BLANkET stations are shown as a stacked plot in Figure 2.

Smoke is first seen at Wynyard near 14:30 AEST on the 15th of October, co–incident with a wind direction change from north–westerly to westerly as noted below, and slightly later, near 15:00 AEST, at Emu River (5 km south of Burnie). Smoke moved through the two Ulverstone stations[2] from 15:50 AEST, and then to Devonport at 16:00 AEST. Smoke reached George Town at 17:00 AEST and was carried up the Tamar, through Exeter, to Launceston arriving just before 19:00 AEST. Lilydale station also recorded elevated smoke on this evening, possibly more that may be expected for that time of year from local woodheaters alone.

The approximate peak (10–minute data) $PM_{2.5}$ levels in μg m^{-3} at the stations were - Wynyard: 300; Emu River: 550; West Ulverstone: 130; Ulverstone: 80; Devonport: 420; George Town: 270 (one point); Exeter: 150; Ti Tree Bend: 100; South Launceston: 100.

Table 1 gives the day–averaged $PM_{2.5}$ levels for selected stations for the 15th of October 2014. The day–averaged $PM_{2.5}$ for Wynyard for the 16th of October 2014 is just above the National Environmental Protection Measure $PM_{2.5}$ 24–hour advisory reporting standard of 25 μg m^{-3}. The table also shows the number of instances where hourly–averaged $PM_{2.5}$ was over 25 μg m^{-3} on the 15th–16th of October 2014. The Tasmanian Department of Health and Human Services (DHHS) automatically issues a health alert for susceptible people[3] when the hourly–averaged $PM_{2.5}$ is above 25 μg m^{-3}.

The other northern Tasmanian stations at Smithton, Sheffield, Westbury, Hadspen, Longford, Perth, Campbell Town, and over the north-east at Scottsdale, Derby, St Helens, and Fingal, did not record elevated $PM_{2.5}$ on the 15th–16th of October. The absence of significantly elevated $PM_{2.5}$ levels in the Sheffield, Westbury, Hadspen, Longford and Perth station records is important for the data interpretation to be discussed below.

[2] A temporary station was operating in Ulverstone, in addition to the station at West Ulverstone

[3] The DHHS advises that people at higher risk of health problems from exposure to air pollution include those with heart disease, chronic lung diseases such as asthma, chronic bronchitis and emphysema, infants, people aged over 65 years, and those with long-term medical conditions. Together these groups comprise about 20% of the Tasmanian population. However, there is wide variation in the response to air pollution and the risk of health problems depends on each individual's overall health status and the severity and duration of pollution exposure. An hourly–averaged $PM_{2.5}$ air quality notification threshold of 25 μg m^{-3} is a precautionary level for the more vulnerable people in the community. See http://www.dhhs.tas.gov.au/peh/alerts/air for further information.

Station	Day–averaged $PM_{2.5}$ (μg m^{-3}) 15th Oct 2014	Number of hours $PM_{2.5} > 25$ μg m^{-3} 15–16 Oct 2014
Wynyard	**25.1**	6
Emu River	15.1	2
West Ulverstone	5.8	2
Ulverstone	7.1	0
Devonport	13.0	1
George Town	11.3	2
Exeter	11.6	2
Ti Tree Bend	9.8	2
South Launceston	11.3	3

Table 1: Summary of air quality data for selected northern Tasmanian BLANkET stations.

Individual plots of the particle and meteorological data collected at a number of stations in northern Tasmania during the interval 15 Oct 2014 until 16 Oct 2014 are shown in Figures 3 to 10.

The top panels of these plots show the air quality data. Particle concentrations are given in micrograms per cubic metre (in short form this is written as μg/m^3, or μg m^{-3} in scientific notation). PM_{10} is shown as the blue line and symbols and $PM_{2.5}$ is shown as the red square symbols in the air quality plots. $PM_{2.5}$ is a better indicator of smoke than is PM_{10}. $PM_{2.5}$ values below 5 μg m^{-3} signify very clear air.

The lower panels of these plots show the meteorological data of external (air) temperature, relative humidity, wind speed and wind direction. Wind speed is given in kilometres per hour (km/hr, or km hr^{-1} in scientific notation). Wind direction is given in degrees. Zero degrees is a north wind, 90 degrees is an east wind, 180 degrees is a south wind, and 270 degrees is a west wind. Wind direction is divided by 10 before being plotted, so a wind direction of 18 units on the plot means 180 degrees, or a wind from the south.

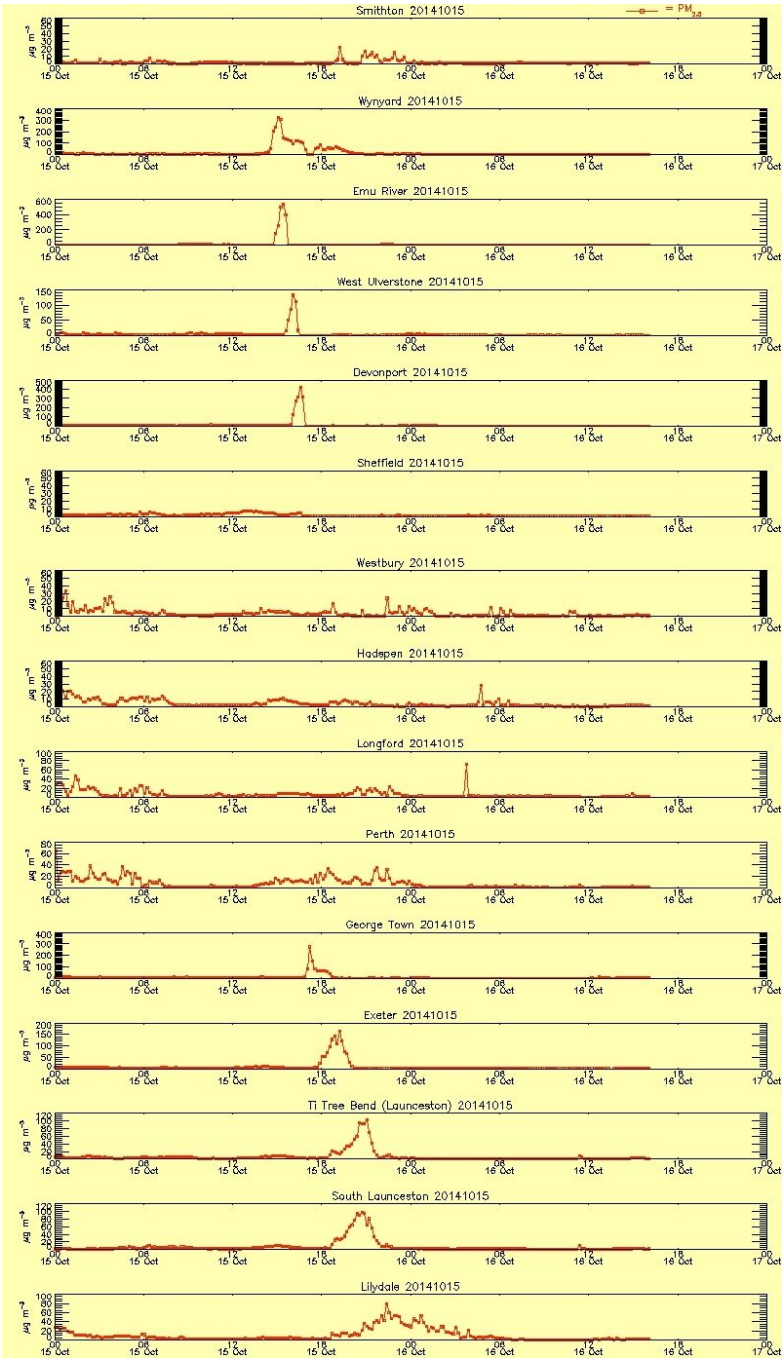


Figure 2: A plot of smoke concentrations detected by the BLANkET air monitoring network at stations located in northern Tasmania during the period 15 Oct 2014 until 16 Oct 2014.

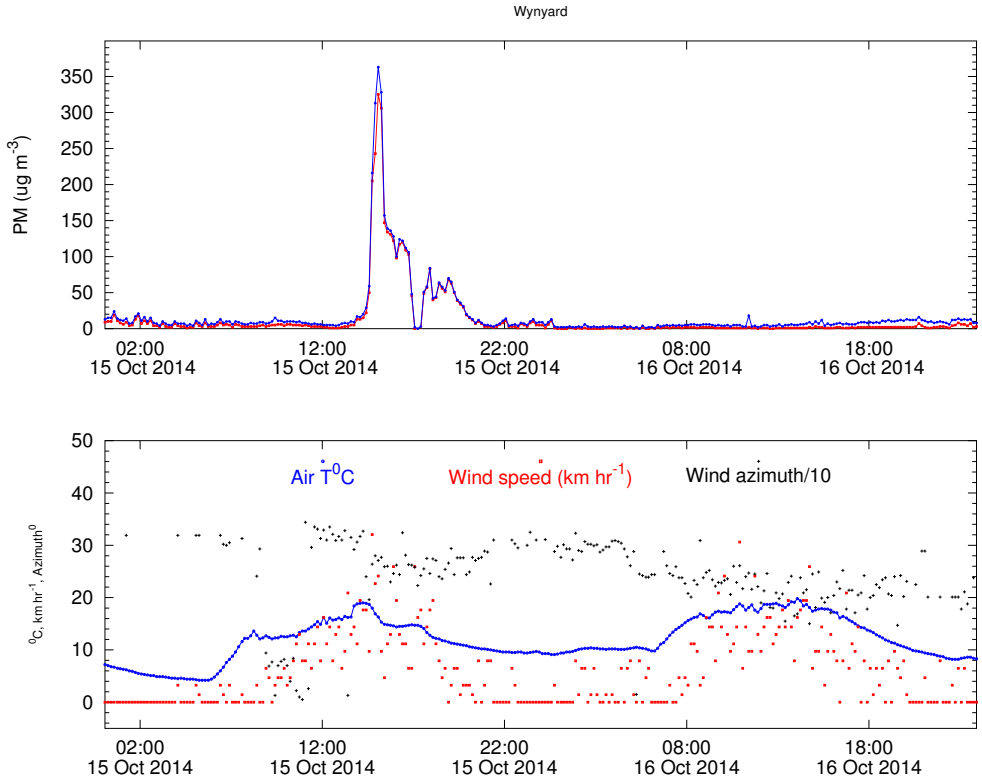


Figure 3: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at Wynyard, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

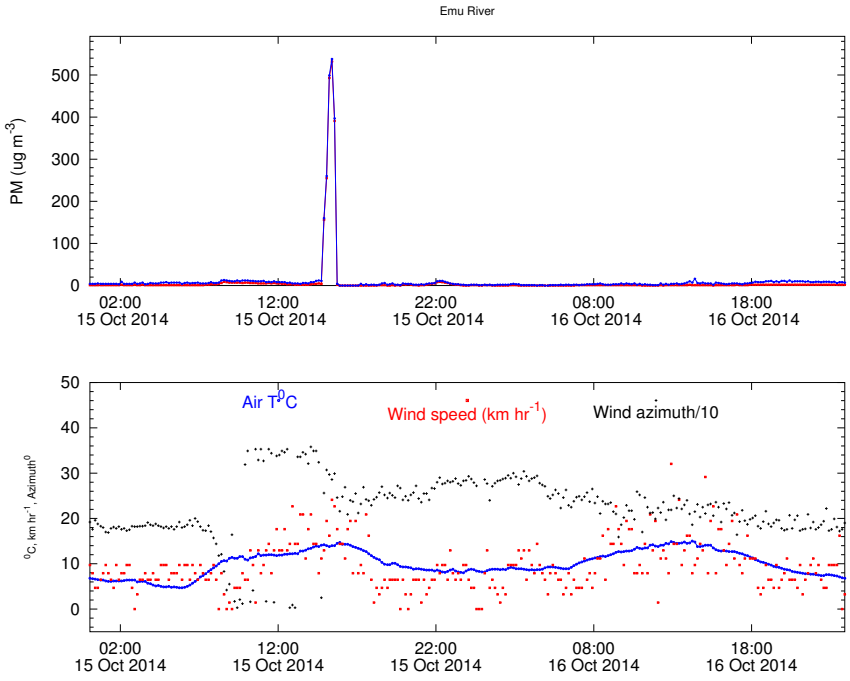


Figure 4: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at Emu River, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

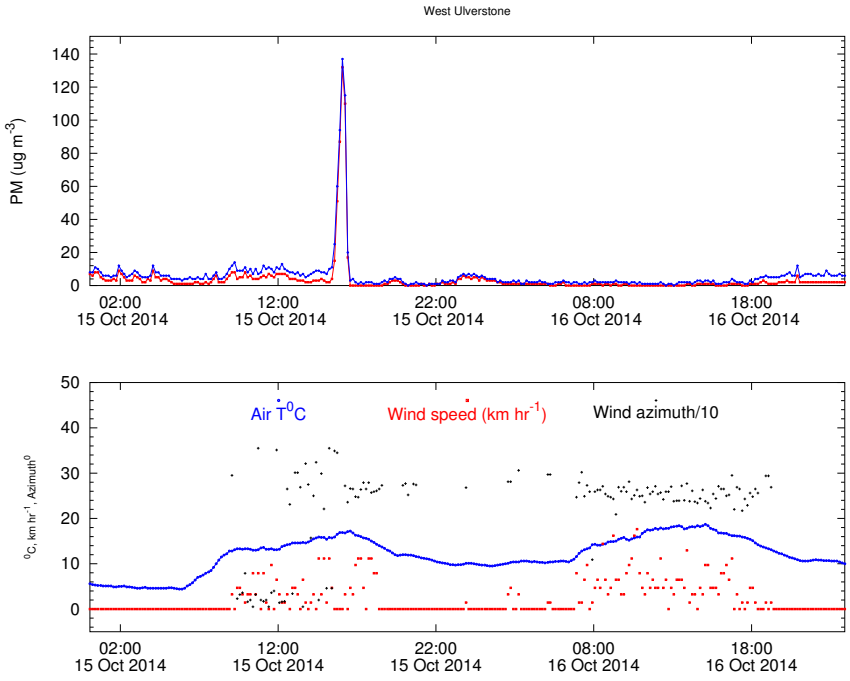


Figure 5: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at West Ulverstone, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

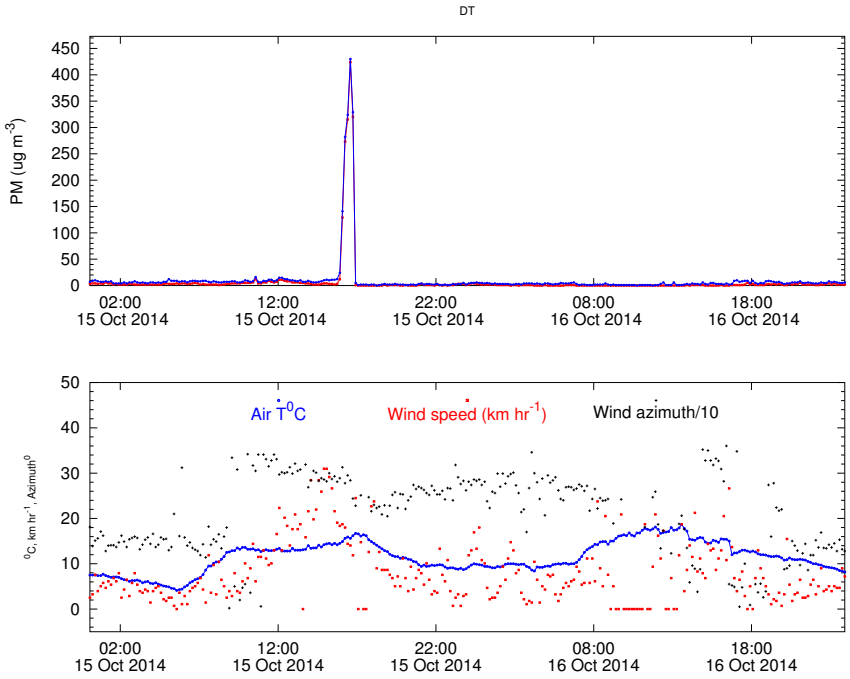


Figure 6: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at Devonport, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

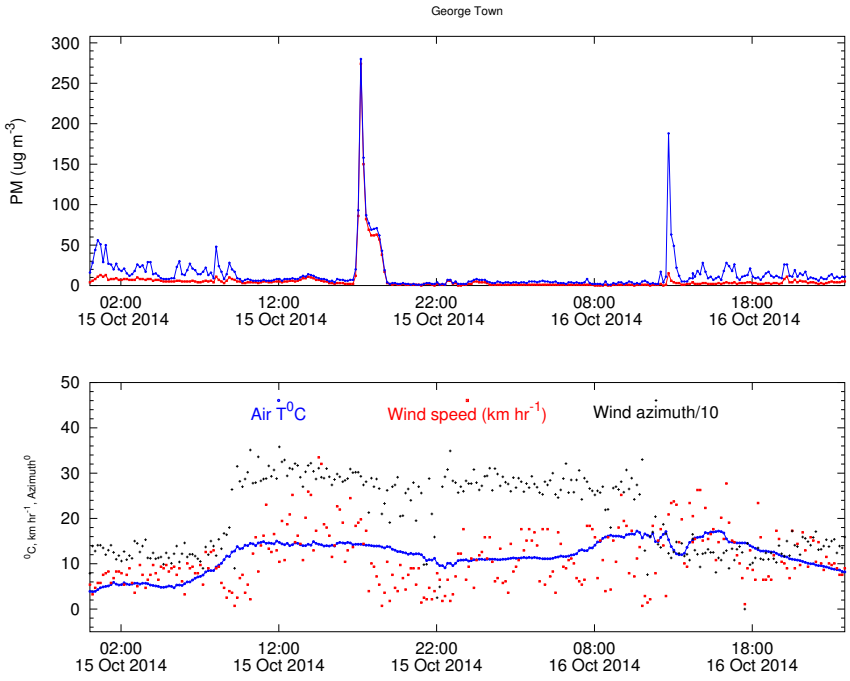


Figure 7: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at George Town, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

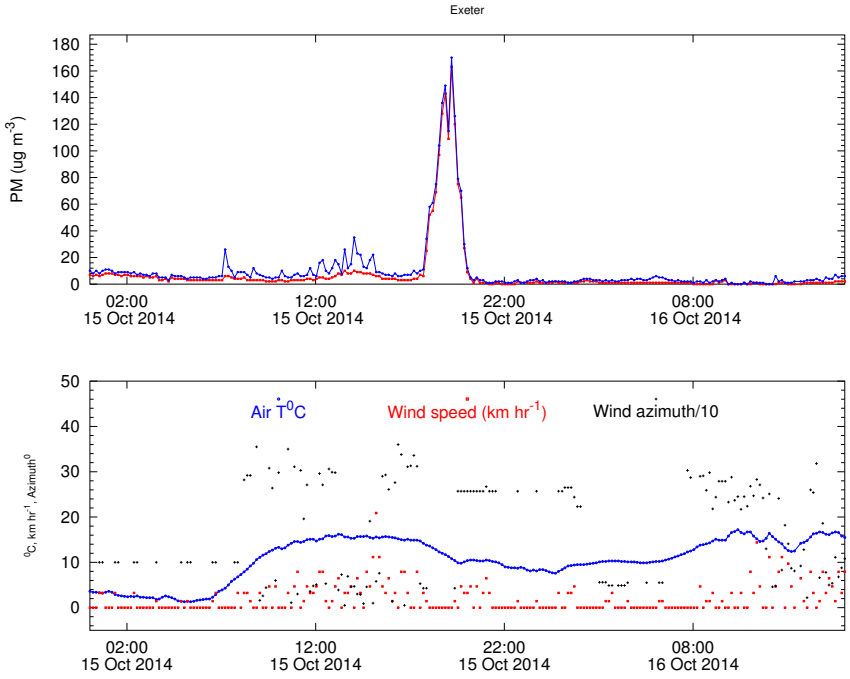


Figure 8: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at Exeter , during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

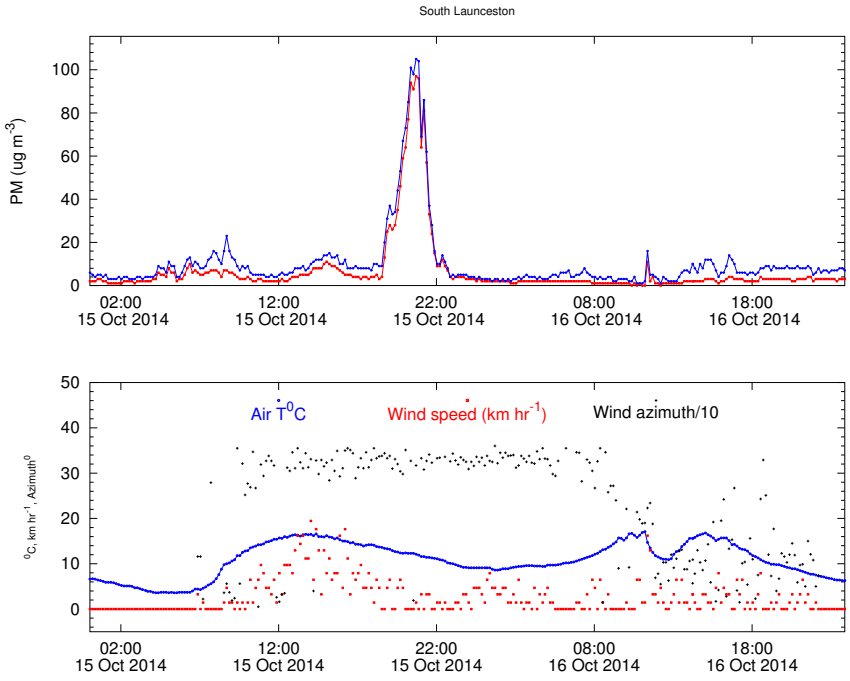


Figure 9: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at South Launceston, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

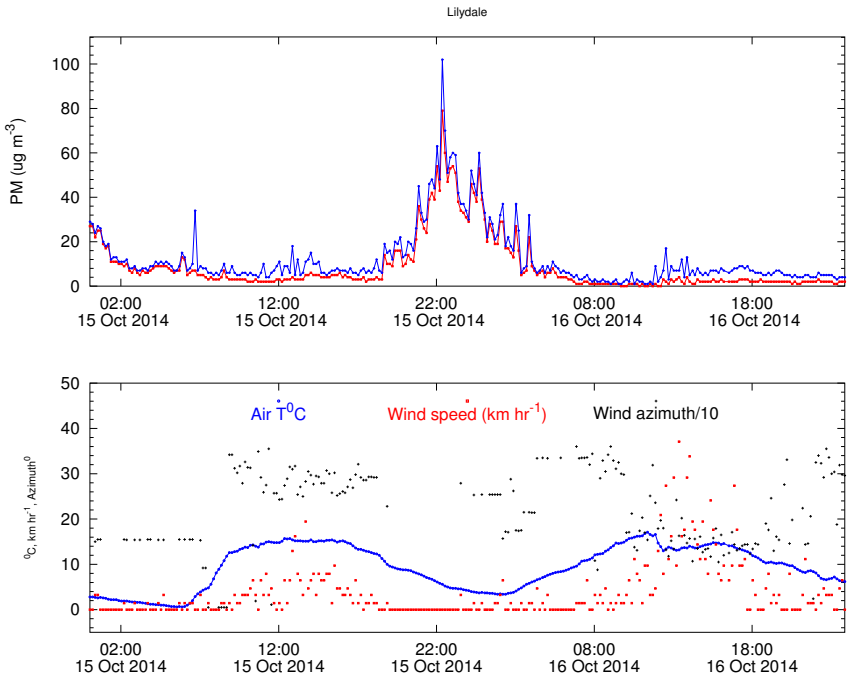


Figure 10: A plot of smoke concentrations (upper panel) and meteorological conditions (lower panel) measured by the BLANkET Air Monitoring Station at Lilydale, during the interval 15 Oct 2014 until 16 Oct 2014. In the upper panel $PM_{2.5}$ data are shown in red. PM_{10} are shown in blue.

2.2 Data visualisation

Figures to show visual representations of the network data from northern Tasmania as snapshots of $PM_{2.5}$ from the 3rd of January. The instantaneous value of $PM_{2.5}$, in μg m^{-3} , is shown by the size and colour of the diamond symbol at the station location. Wind direction and speed is indicated by the arrow. The spatial structure in the wind field (e.g. as noted in the caption in Figure 14) is of relevance for the later discussion.

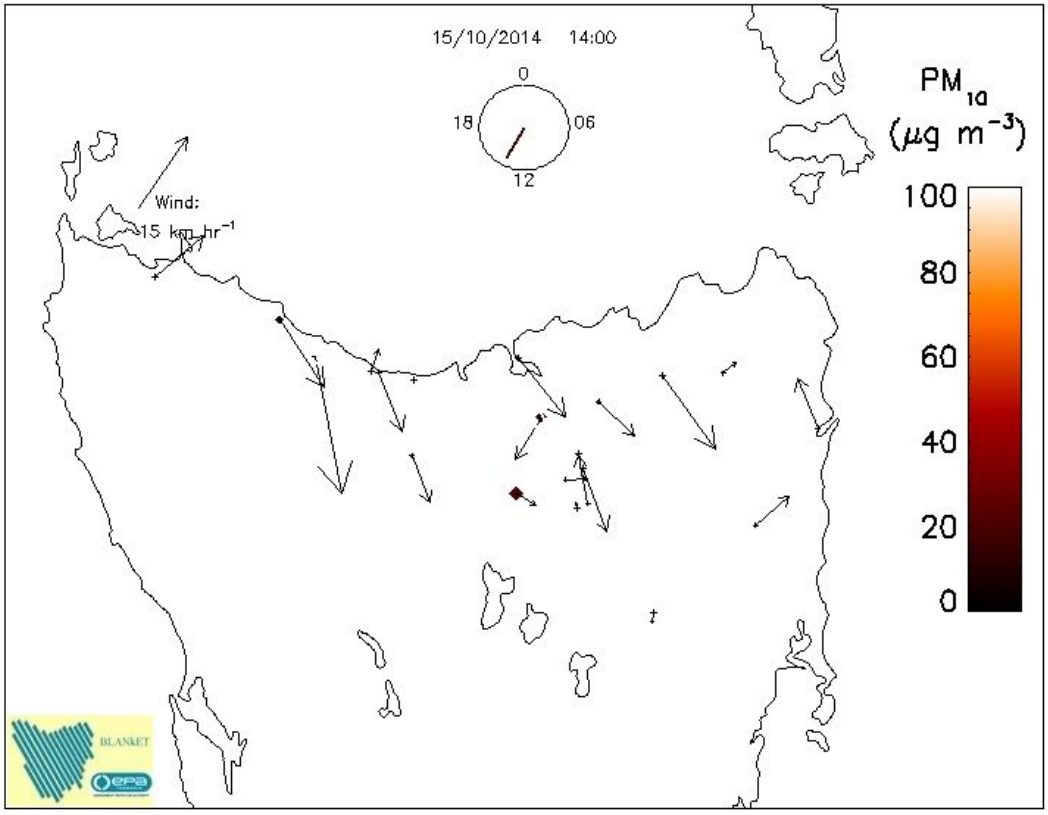


Figure 11: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 14:00 AEST on the 15th of October 2014 for the north of Tasmania. The instantaneous value of $PM_{2.5}$ is shown by the size and colour of the diamond symbol at the station location. Wind direction and speed is indicated by the arrow. The image shows the situation shortly before smoke first reached Wynyard station in the northwest of the state. The wind at Wynyard and over most of north–central Tasmania is northwesterly, but it is southwesterly at Smithton.

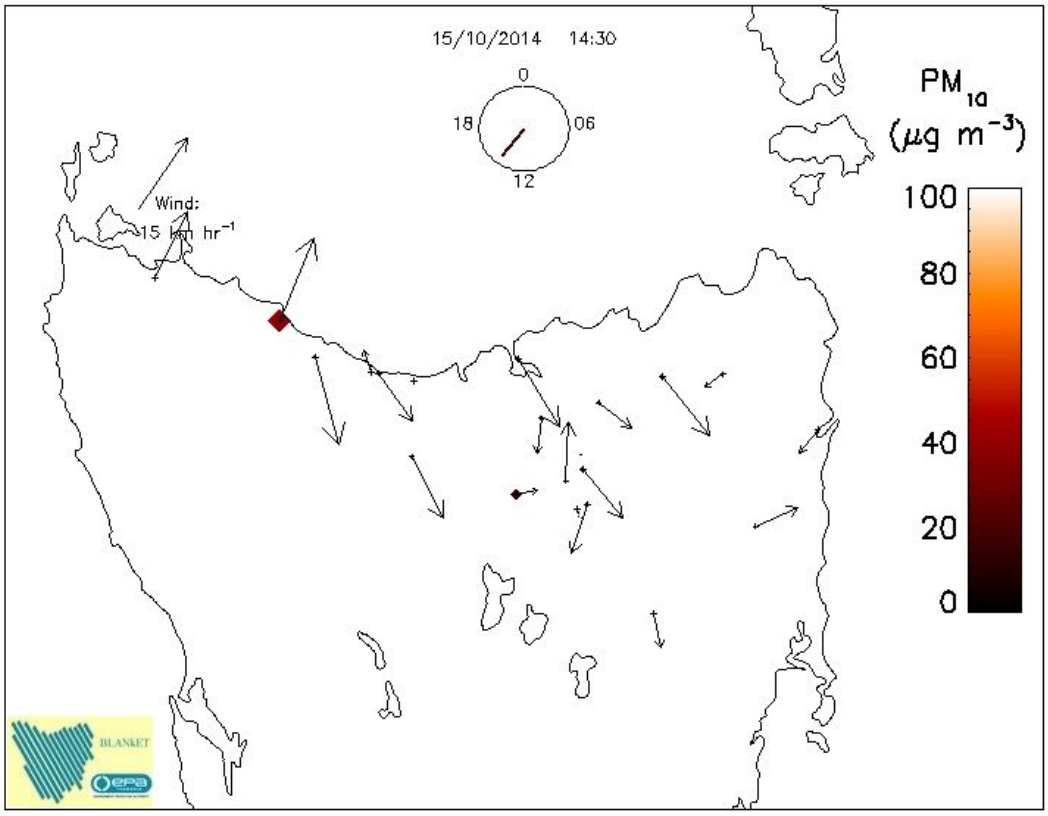


Figure 12: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 14:30 AEST on the 15th of October 2014 for the north of Tasmania. Smoke has now reached Wynyard station on a southwest wind.

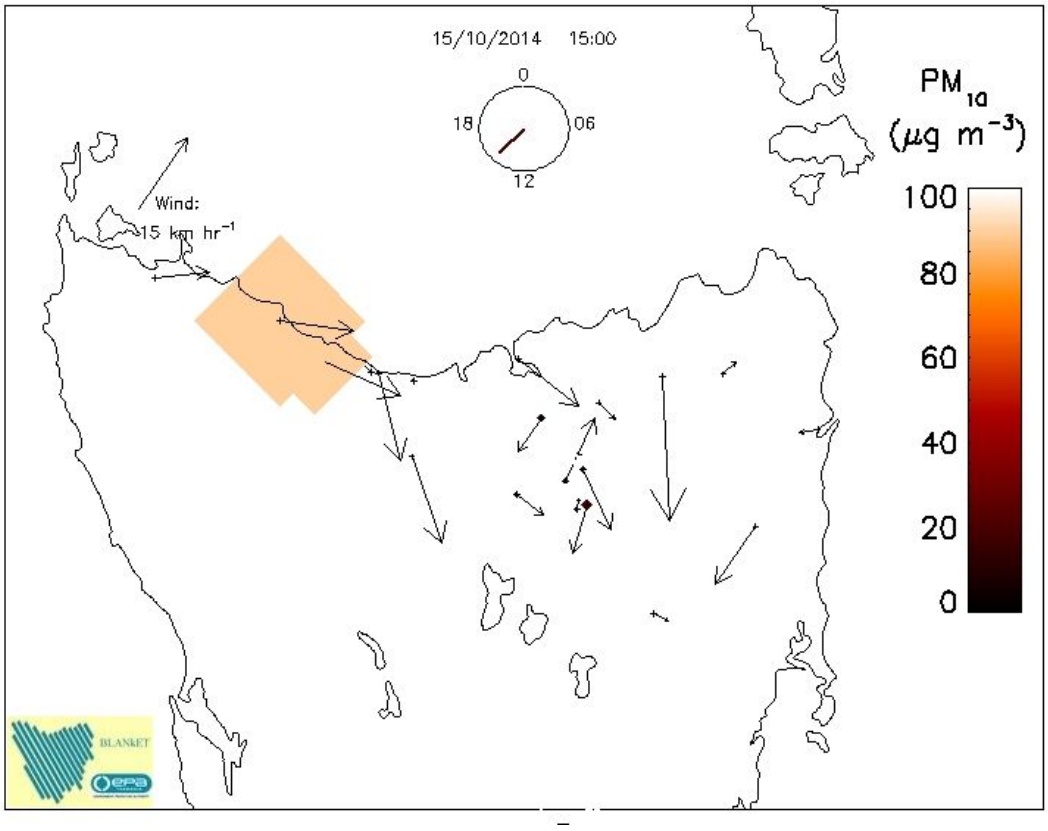


Figure 13: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 15:00 AEST on the 15th of October 2014 for the north of Tasmania. Smoke is present at Wynyard and Emu River stations.

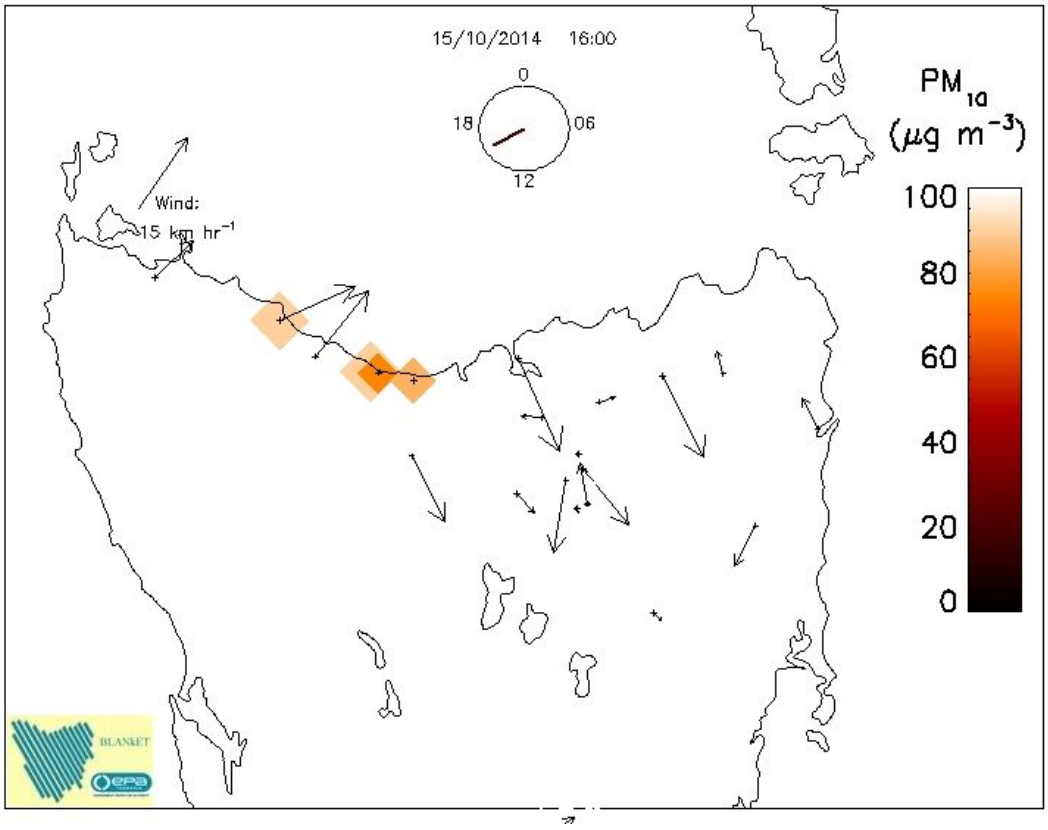


Figure 14: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 16:00 AEST on the 15th of October 2014 for the north of Tasmania. The smoke has reached to Ulverstone and Devonport. Note that the winds are southwesterly along the northwest coast of Tasmania, but have remained northwesterly over much of the north–central and northeast of Tasmania.

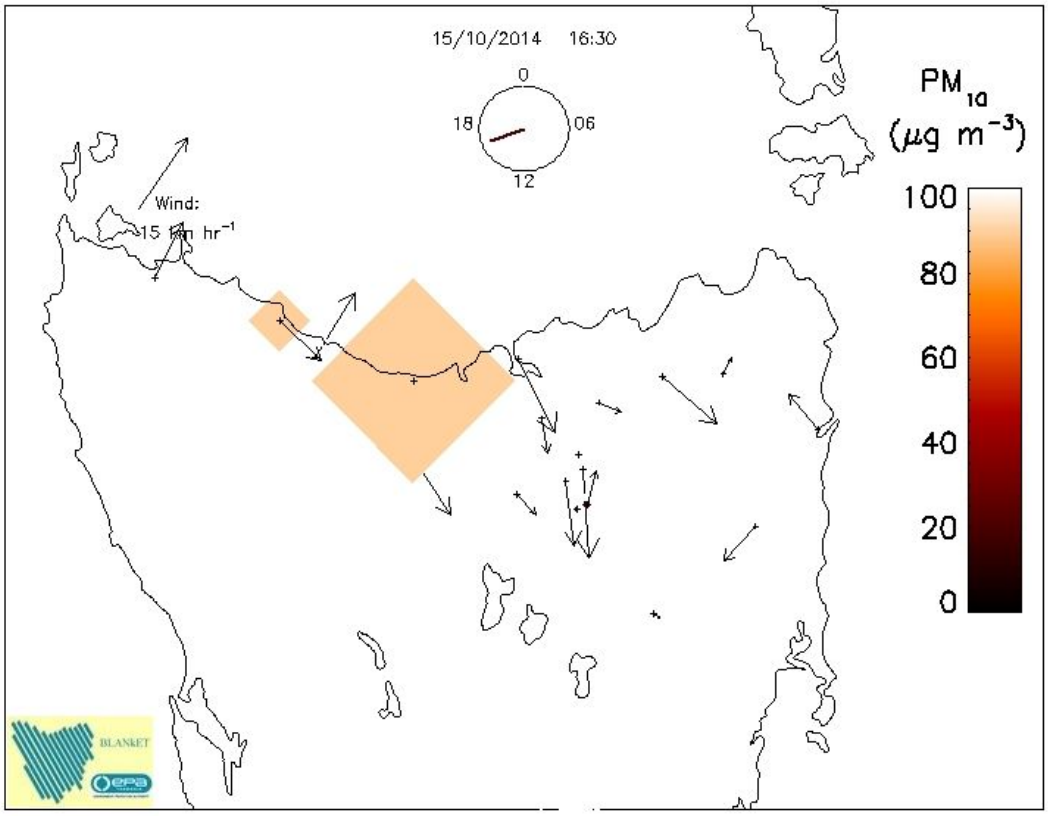


Figure 15: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 16:30 AEST on the 15th of October 2014 for the north of Tasmania. The smoke concentration at Devonport is at the recorded peak.

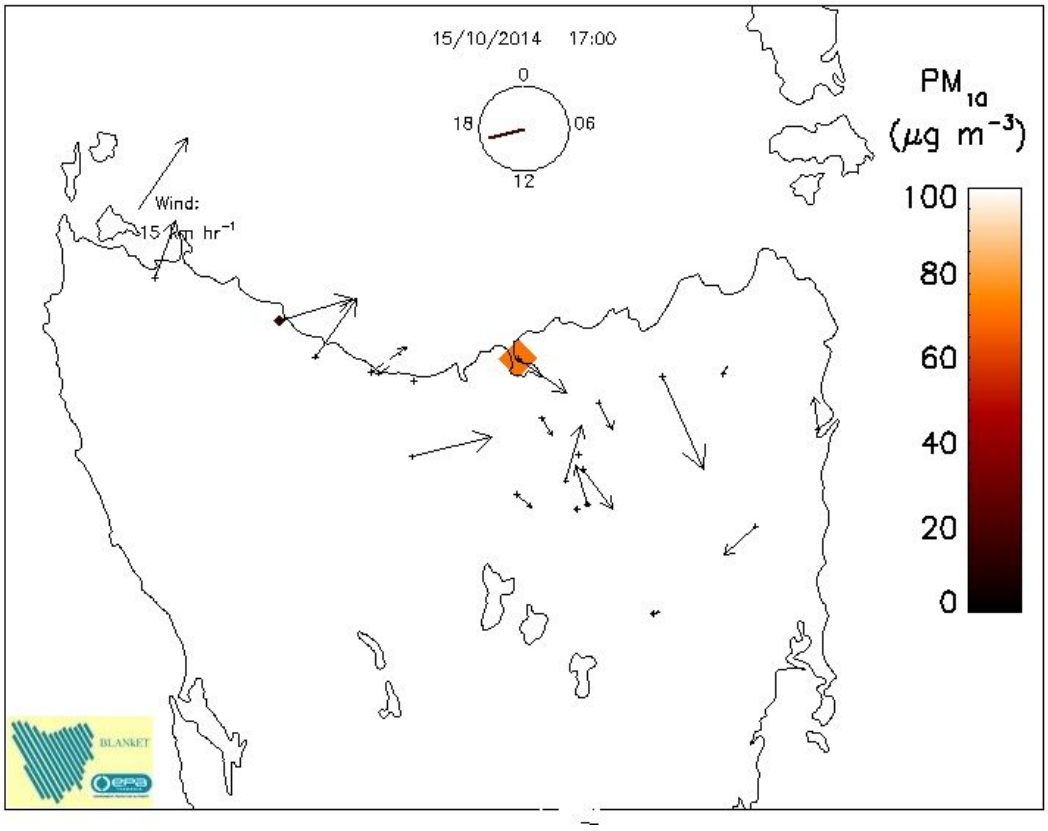


Figure 16: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 17:00 AEST on the 15th of October 2014 for the north of Tasmania. The smoke has reached George Town at the mouth of the Tamar.

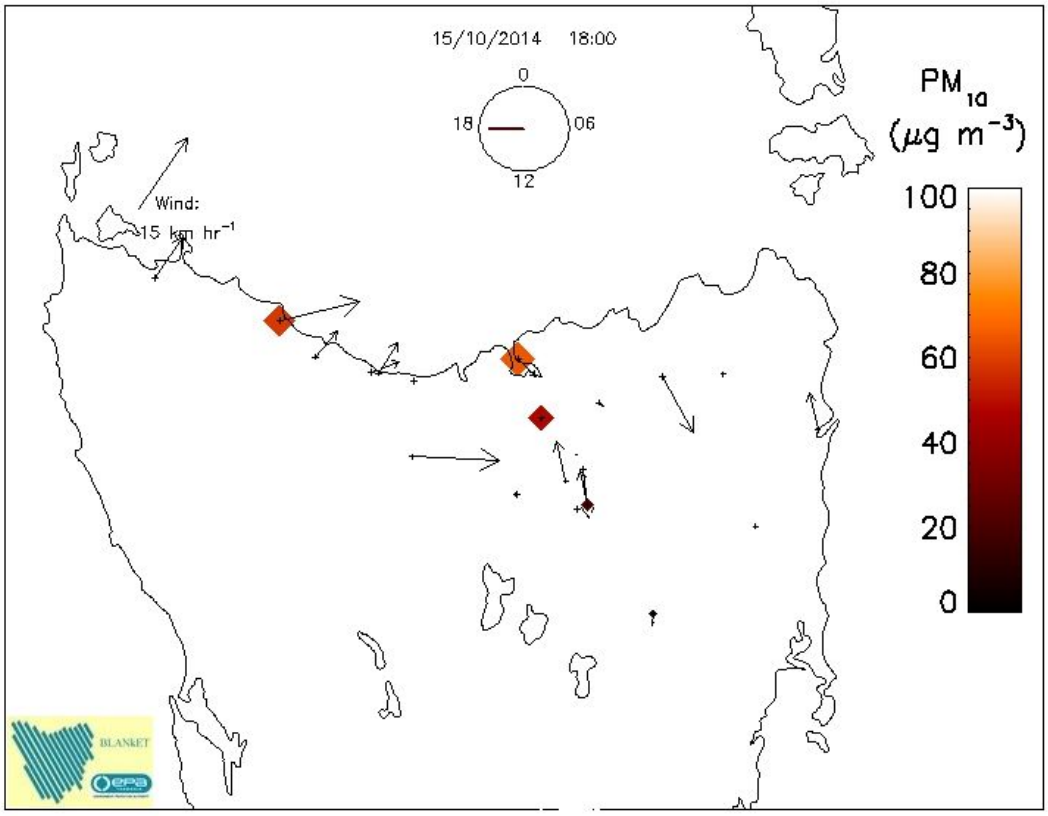


Figure 17: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 18:00 AEST on the 15th of October 2014 for the north of Tasmania. The smoke has reached Exeter in the middle Tamar.

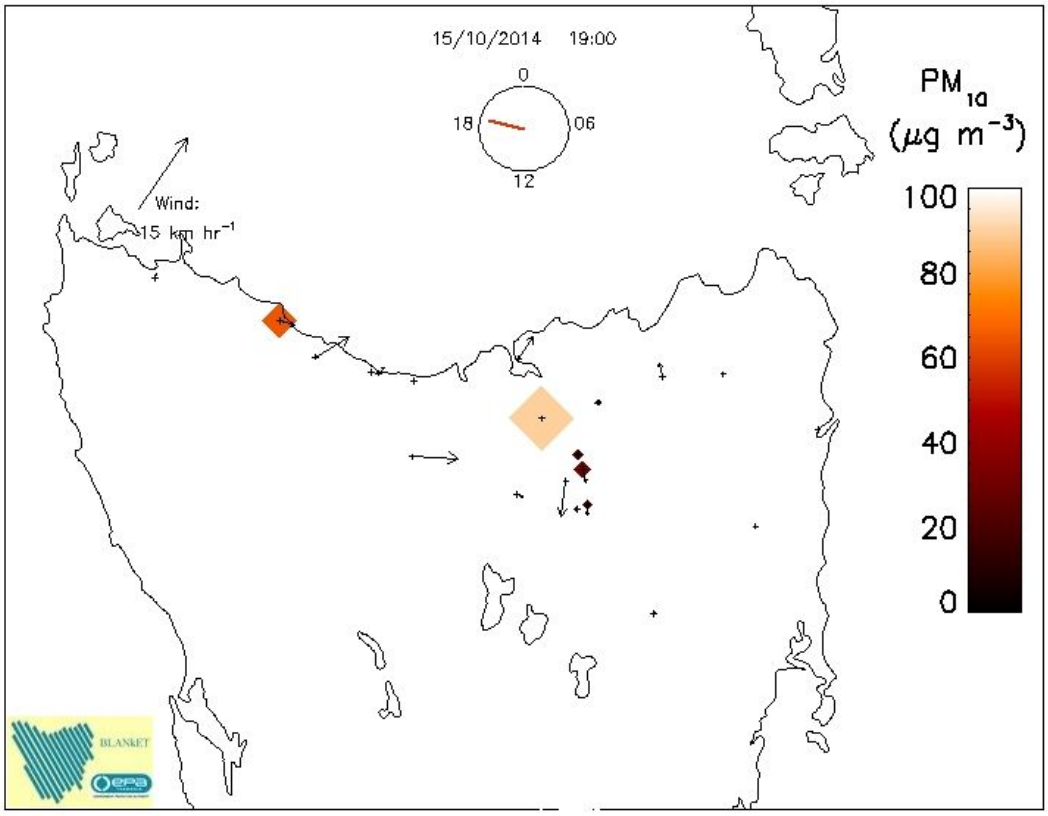


Figure 18: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 19:00 AEST on the 15th of October 2014 for the north of Tasmania. Smoke is being recorded at the Launceston stations.

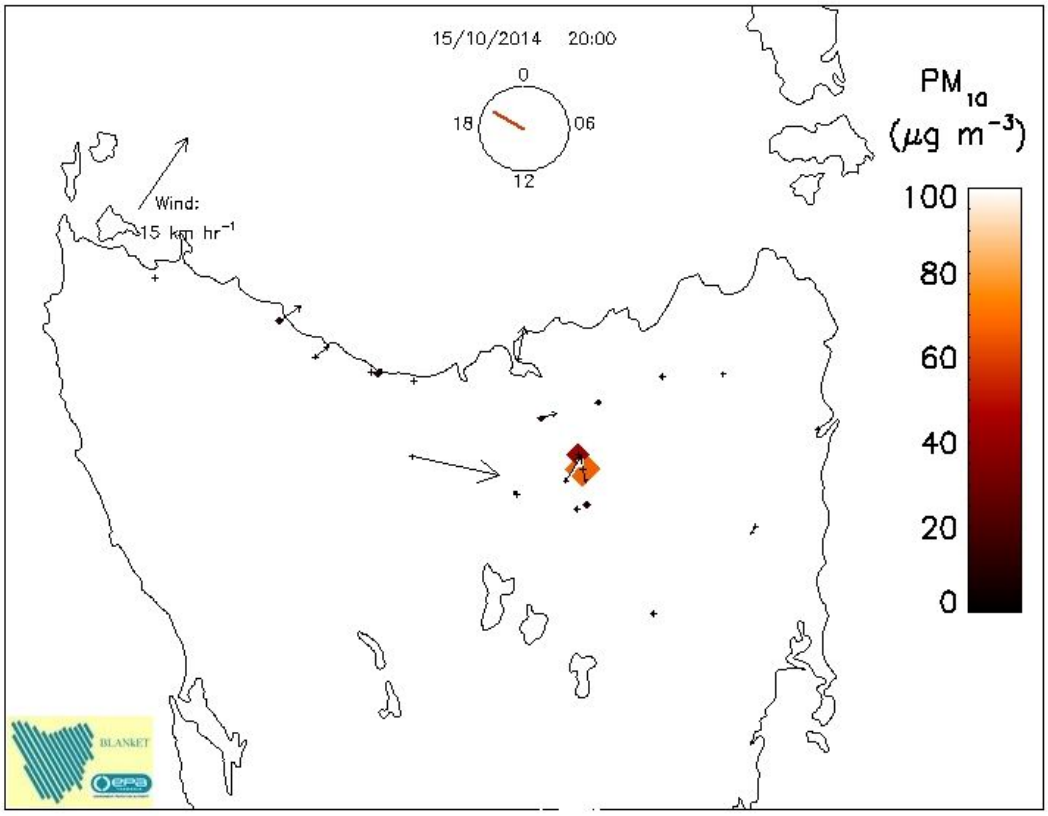


Figure 19: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 20:00 AEST on the 15th of October 2014 for the north of Tasmania. Smoke has cleared the lower and middle Tamar stations.

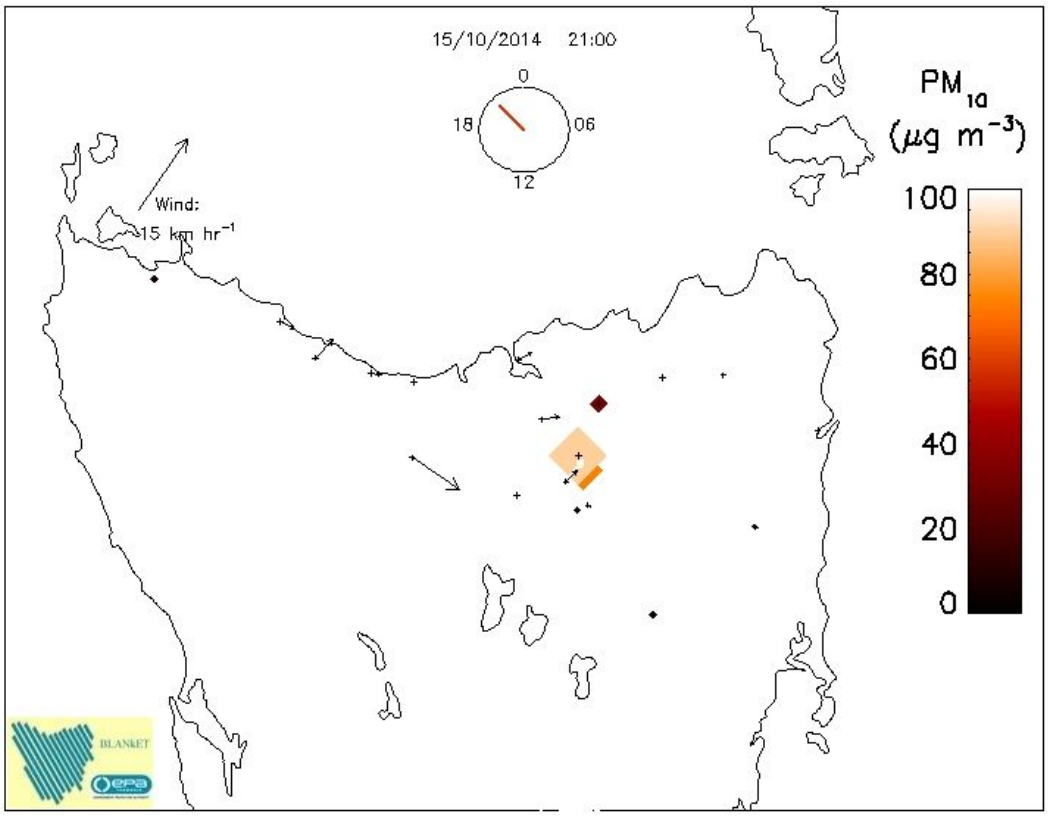


Figure 20: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 21:00 AEST on the 15th of October 2014 for the north of Tasmania. Lilydale station (northeast of Launceston) is showing elevated $PM_{2.5}$.

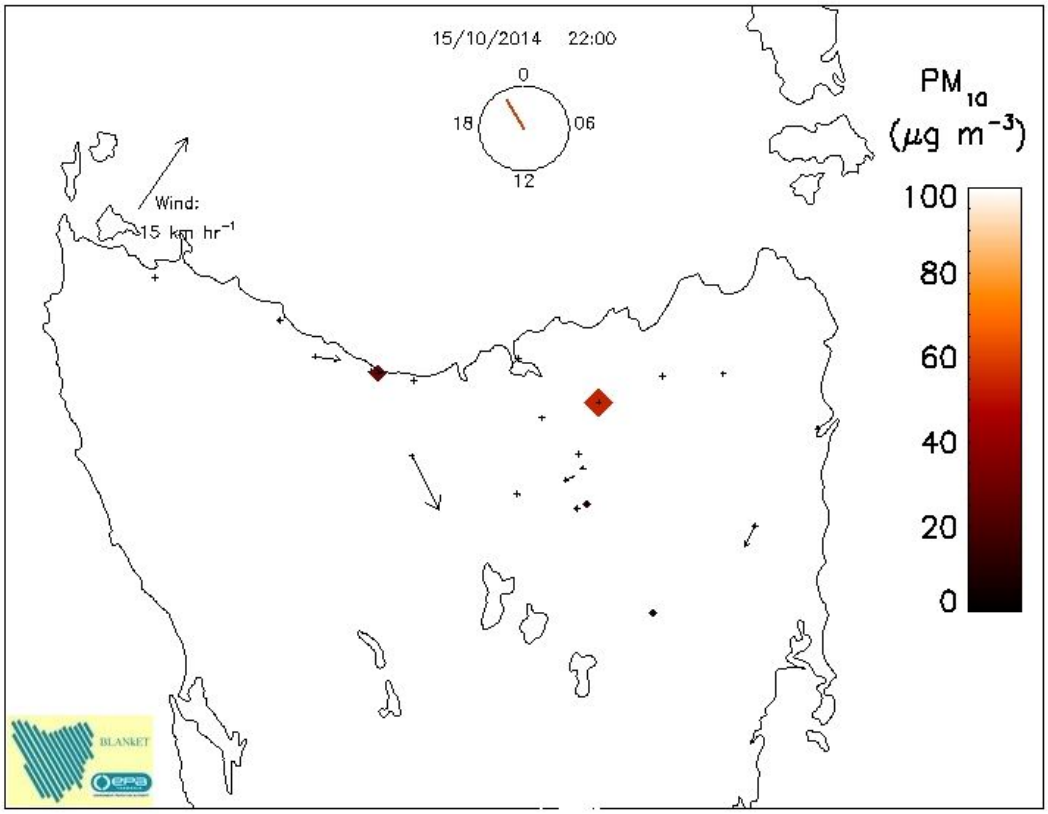


Figure 21: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 22:00 AEST on the 15th of October 2014 for the north of Tasmania. $PM_{2.5}$ at Lilydale is still elevated. There is a small increase in $PM_{2.5}$ at Perth, due south of Launceston.

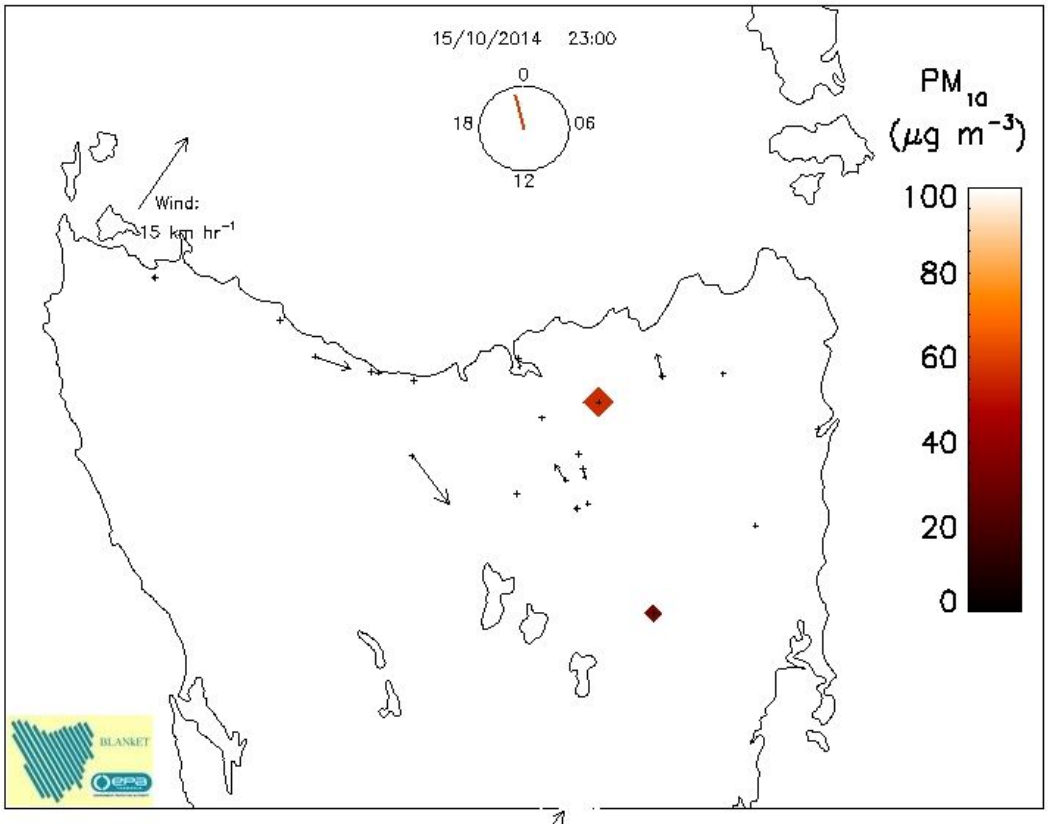


Figure 22: Spatial visualisation of BLANkET station $PM_{2.5}$ time-series data for 23:00 AEST on the 15th of October 2014 for the north of Tasmania. There is now a small increase in $PM_{2.5}$ at Campbell Town, in the northern midlands of Tasmania. This may have arisen from local sources, but a contribution from the smoke seen across the north of Tasmania cannot be ruled out.

3 Satellite Images

The MODIS Aqua image from the afternoon of the 14th of October 2014 (i.e. the day before smoke was recorded over the northwest and Tamar regions), is shown in Figure 23. A large smoke plume is visible in the northwest of the state originating from a burn on the west coast of Tasmania. Another plume is visible over Bass Strait near the mouth of the Tamar originating from a separate source. Smithton station recorded the passage of a smoke plume commencing at 18:00 until approximately to 20:00 AEST on the 14th of October. The peak 10–minute $PM_{2.5}$ recorded was just over 50 μg m^{-3} . These data are shown in the upper panel of Figure 24.

Figure 23: A Modis Aqua satellite image of northern Tasmania from the afternoon of the 14th of October 2014. A large smoke plume is visible in the northwest of the state originating from a burn on the west coast of Tasmania. Another, separate, plume is visible over Bass Strait near the mouth of the Tamar. Smithton station recorded the passage of a smoke plume commencing at 18:00 until approximately to 20:00 AEST on the 14th of October. The peak 10–minute $PM_{2.5}$ was just over 50 μg m^{-3} .

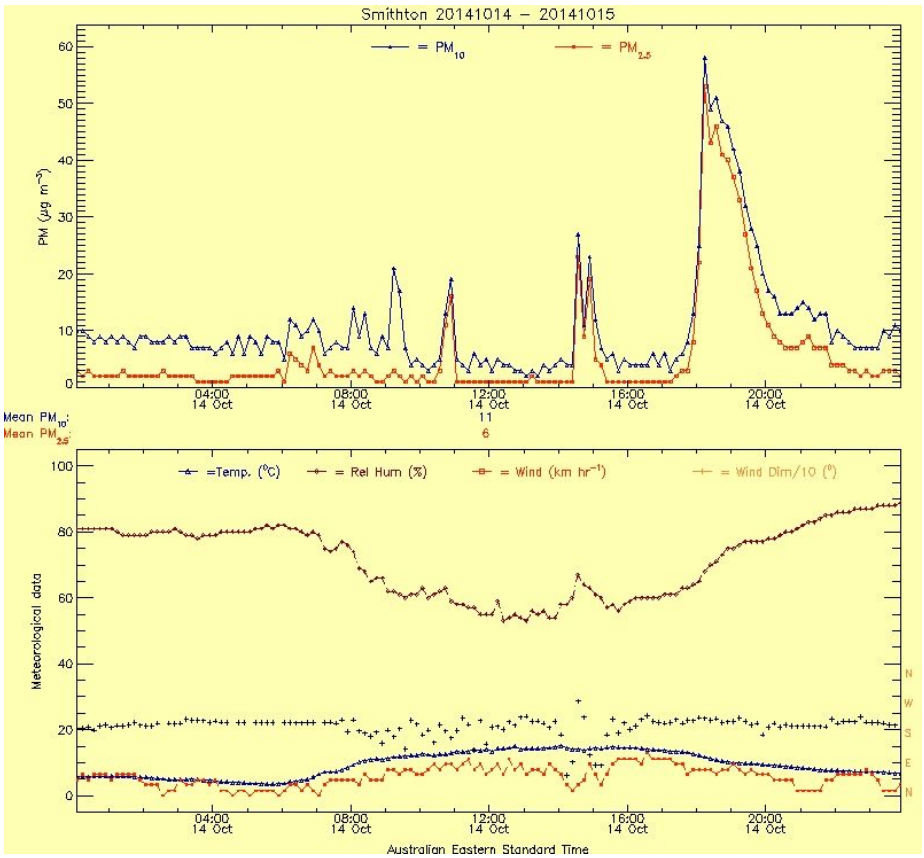


Figure 24: Data from Smithton BLANkET station, 14th October 2014. Top panel: $PM_{2.5}$ (red symbols) and PM_{10} (blue symbols) 10–minute data. Lower panel: Meteorological data. Smithton station recorded the passage of a smoke plume commencing at 18:00 until approximately to 20:00 AEST on the 14th of October. The peak 10–minute $PM_{2.5}$ was just over 50 μg m^{-3} . The wind was from the south over this interval.

The MODIS Terra image of northwest Tasmania from the morning of the 15th of October is shown in Figure 25. The red polygon on the west coast is an infrared hotspot derived by the NASA Rapidfire analysis, and coincides with the location of origin of the plume seen on the 14th October MODIS Aqua image. A faint smoke plume (labelled) is moving to the northeast from the hotspot.

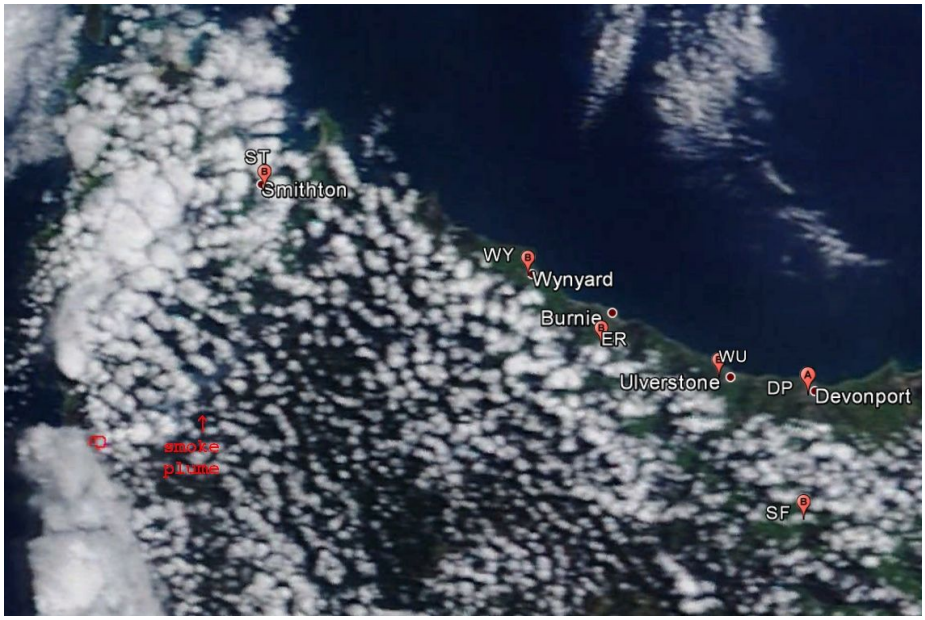


Figure 25: Detail of northwest Tasmania from the MODIS Terra image obtained on the morning of the 15th of October 2014, displayed in Google Earth. Air station locations are shown by the red balloon icons. The red polygon on the west coast is an infrared hotspot derived by the NASA Rapidfire analysis. A faint smoke plume (labelled) is moving to the northeast from the hotspot.

The MODIS image obtained from the Modis Aqua satellite at 15:00 AEST on the afternoon of 15 Oct 2014 is shown in Figure 26. Air station locations are shown by the red ballon icons. A large plume of smoke is visible between Smithton (ST) and Wynyard (WY). This image is a composite of two satellite passes. The left–hand section is from an overpass near 15:00 AEST (16:00 summer time), while the right–hand section was from near 13:30 AEST. The right–hand edge of the plume consequently appears cut off in this composite image.

A further partial satellite image of northern Tasmania from near 16:00 AEST (17:00 summer time) is available from the AVHRR satellite. This is shown as a false colour image[4] in Figure 27. Although there is some difficulty distinguishing

[4]The image has been reconstructed from one visible light image (shown as blue) and two near–infrared images (representing green and red).

Figure 26: A composite Modis Aqua satellite image of northern Tasmania obtained from overpasses between 13:30 and 15:00 AEST, on the 15 Oct 2014, displayed in Google Earth. Air station locations are shown by the red balloon icons. A large plume of smoke is visible between Smithton (ST) and Wynyard (WY) stations.

smoke and cloud in this false–colour image, the smoke plume has appeared to move eastwards over north Tasmania and into coastal Bass Strait.

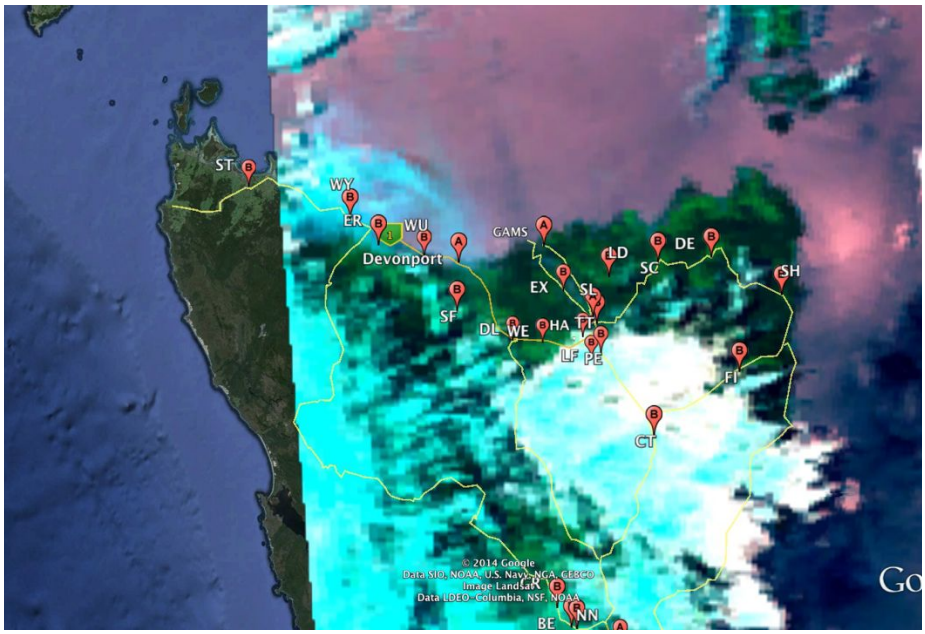


Figure 27: An AVHRR satellite image showing part of northern Tasmania collected at 16:00 AEST, on the 15th of October 2014, displayed in Google Earth. Air station locations are shown by the red balloon icons.

4 Bureau of Meteorology surface pressure charts, 15th October 2014

Bureau of Meteorology surface pressure charts for 10:00 h and 16:00 h AEST for the 15th of October are shown in Figures 28 and 29 respectively. The 10:00 h AEST chart shows a high–pressure system centred over South Australia, a low–pressure system in the Tasman Sea, and a cold front south of the Bight approaching Tasmania from the west.

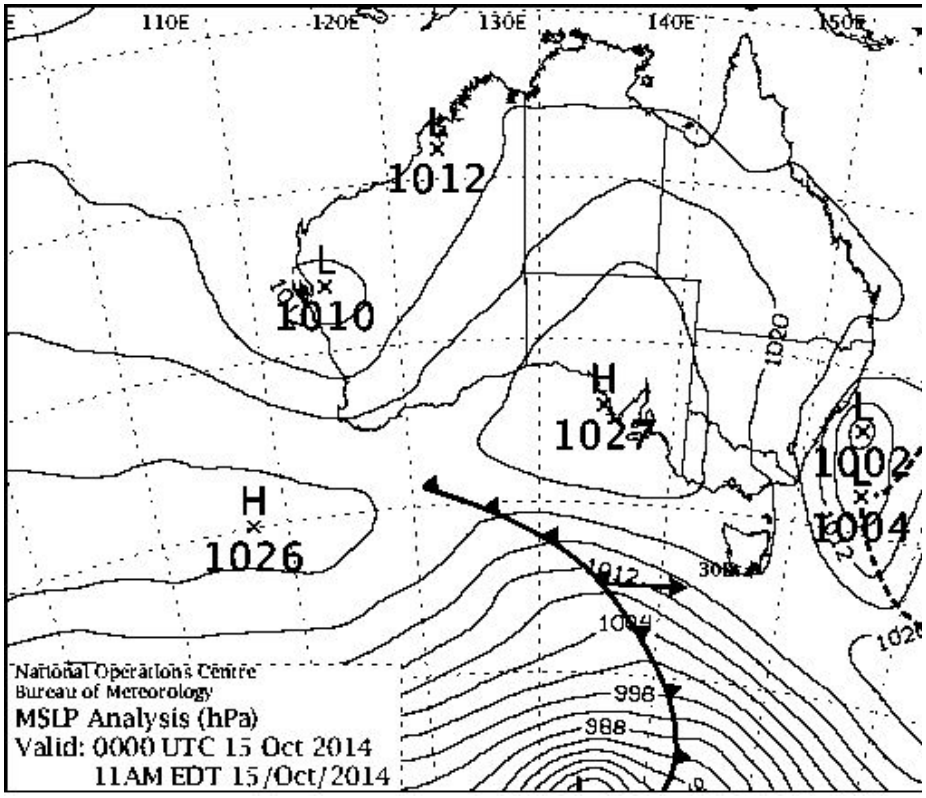


Figure 28: Detail from the surface pressure chart from the Bureau of Meteorolgy for 00 UT (10:00 h AEST, or 11:00 EDT) on the 15th of October 2014.

The 16:00 h AEST chart shows the front has moved closer to Tasmania. The isobar extending over northern Tasmania is clearly distorted. This appears to be an example of a formation of a pressure ridge on the windward side of Tasmanian's western mountains. Associated with this is the formation of a lee trough of the leeward side of the mountains. This process is discussed further is a later section (see in particular Figure 39). In a well–defined westerly flow a small–scale low–pressure system can form in central or eastern Tasmania. The spatial patterns in the wind systems seen in northern Tasmania on the afternoon

of the 15th of October 2014 are consistent with the lee trough/small–scale low pressure system that results from the pressure ridge formation.

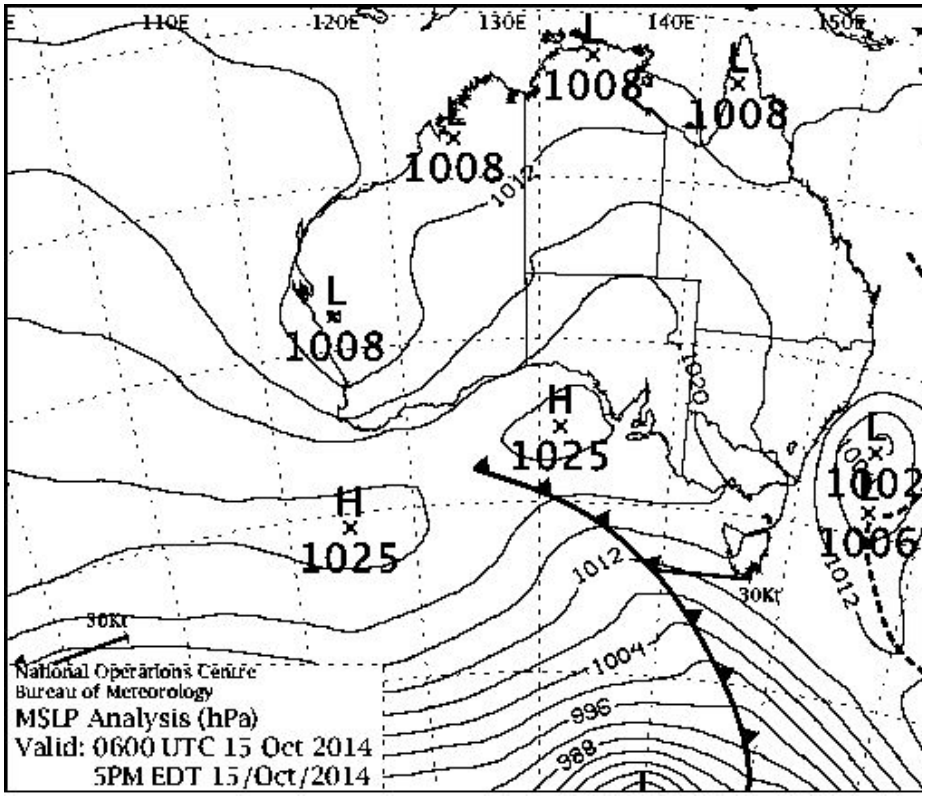


Figure 29: Detail from the surface pressure chart from the Bureau of Meteorolgy for 06 UT (16:00 h AEST, or 17:00 EDT) on the 15th of October 2014.

5 Planned burns registered with the Tasmanian Fire Service, 14th October 2014

Figure shows the planned burns registered with the Tasmania Fire Service (TFS) on the 14th of October 2014. Registration of burns is not compulsory outside the fire permit interval. Hence Figure 30 may not show all all burns that occurred in Tasmania on this day. Burns marked in red are those registered as having ignition times on the 14th of October. A large burn, of 1300 ha, conducted by the Parks and Wildlife Service is shown at Temma on the west coast. This burn coincides with the origin of the smoke plume on the satellite images shown above. A 200 ha burn at Flowery Gully in the Tamar may have been the origin of the smoke seen north of the Tamar mouth in Figure 23.

6 The source – a planned burn on the west coast

The smoke plumes seen in the satellite images given above for the 14th and 15th of October appears to have originated near the location of a burn undertaken by the Parks and Wildlife Service (PWS) near Temma.

Information on burns undertaken by the Parks and Wildlife Service (PWS) are recorded on the PWS website[5]. PWS burns conducted in autumn are also recorded on the CSMS of the FPA.

The PWS site noted a burn at Arthur River, of 1300 ha, was underway from the 14th of October. The website listed the burn as still in progress on the 16th of October.

The *Advocate* newspaper carried an on–line article late on the 15th of October 2014 reporting on smoke over northern Tasmania on that day. In this article a PWS spokesperson was quoted as saying the 1300 ha burn ignited on the 14th of October (a Tuesday) had grown to 6000 ha on the 15th of October, but was now contained. The *Advocate* article identified this burn as the source of smoke in Burnie and Latrobe. An extract of this article is shown in Figure 31.

Information later supplied to the EPA Division by the PWS recorded that the decision to continue the burn on the 15th of October was taken after the burn on the 14th had extended beyond the originally planned boundaries in several locations. Hence a controlled burn operation was commenced to burn the extended area to safe limits.

Given the known size and location of the burn, the satellite imagery, and the information reported in the *Advocate* article as sourced from the PWS, it seems clear that the smoke recorded in the northwest and Tamar stations on the 14th of October 2014 originated from the Temma River PWS burn.

[5] http://www.parks.tas.gov.au/index.aspx?base=908.

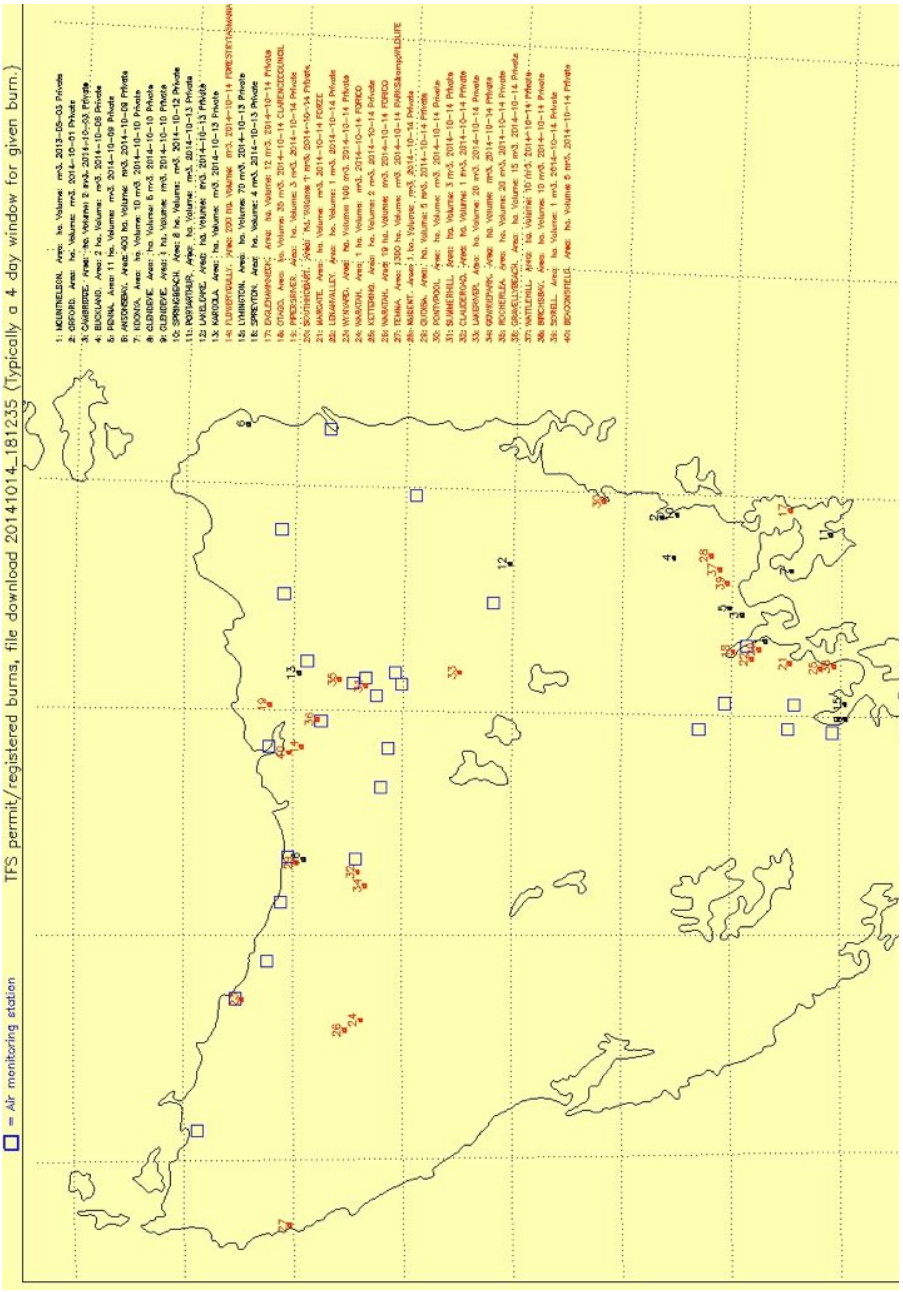


Figure 30: Planned burns registered with the Tasmania Fire Service, at 19:00 on the 14th of October 2014. Burns marked in red had reported ignition times on the 14th of October. A burn of 1300 ha by the Parks and Wildlife Service is listed at Temma on the west coast. This burn coincides with the origin of the smoke plume on the satellite images shown above.

Smoke blankets Coast as burn-off quadruples

By MARK ACHESON Oct. 15, 2014, 10:28 p.m.

BIG STINK: A Tasmania Parks and Wildlife Service hazard reduction burn at Temma was the cause of thick smoke in Burnie yesterday afternoon. Picture: Stuart Wilson.

A HAZARD reduction burn on the West Coast quadrupled in size yesterday causing smoke to blanket the Coast as far as Latrobe.

The fire was lit by Tasmania Parks and Wildlife Service personnel at midday on Tuesday, about 10 kilometres east of Temma.

It was intended to burn 1300 hectares of remote bushland but reached 6000 hectares.

Tasmania Parks and Wildlife service manager fire operations Adrian Pyrke said the burn-off was meant to finish on Tuesday, but had to be taken out of its boundaries yesterday.

Figure 31: Extract from an on–line article from the *Advocate* newspaper, late on Wednesday, the 15th October 2014.

7 Smoke calculations

A calculation of approximate downwind smoke concentrations can be made using `r`udi_plume, an arithmetical representation of a smoke plume. The method is based on a small number of simplifying assumptions and principles. The aim is not to provide a rigorous physical and mathematical description of a smoke plume and its evolution, but to provide a tool to explore the smoke concentrations that may result from various scenarios of fuel–loading, burn times, wind conditions, and so on.

The principles and assumptions used in the `r`udi_plume program are described in BLANkET Technical Report 26[6]. In brief, at program run the burn parameters of area, fuel–loading, particle emission factor, smoke ceiling, wind speed, duration of the main flaming phase, cone angle of the plume, and a burn decay time–constant can all be specified. The rate of fuel consumption during the flaming phase of burning is assumed constant – hence the rate of smoke production during this interval is also constant. The plume is calculated at sequential 30–minute time steps. The time–series of the hypothetical $PM_{2.5}$ concentrations on the plume centre–line at a given down–wind range is also calculated.

The parameters used in the calculation are given in Table 2, and refer to the burning conducted on the 15th of October 2014. Information supplied by the PWS assisted in determining some of these parameters, all of which are estimated quantities. The area of 4000 ha is an estimate of the burn on this day, based on the fact that more than 1300 ha were burnt on the 14th of October, and the total burn over the two days was near 6000 ha. The fuel–loading of 8 t per hectare was estimated given the PWS information that it was 11 to 14 years since the area was previously burnt, and with reference to Marsden–Smedley et al. [7]

The particle emission factor of 0.020 kg kg^{-1} is an estimated value, chosen to be twice as high as 'real–world' woodheater emission rates. The smoke ceiling of 400 m is also an estimate based on what could be reasonable.

The ignition time of 09:30 AEST and the total flaming time of 6 h is derived from PWS information that ignition took place after 10:30 (summer time) and the fire was considered safe by 16:00 (summer time). The wind speed of 5.5 m s^{-1} (20 km hr^{-1}) is representative of the wind speed measured at the northwest stations during the smoke onset. The cone angle of 25° is based on the appearance of the smoke plume on the MODIS image shown in Figure 26.

The calculation assumes the wind direction is constant. This is not in general the case, and it was not the case over northern Tasmania for the burn on the 15th of October. The calculation is not physically realistic in this sense, but it does provide a measure of guidance for smoke concentrations downwind of the burn.

A 'snapshot' of the hypothetical plume, 7 hours after ignition, is shown in

[6] BLANkET Techical Report 26, appendix D, http://epa.tas.gov.au/epa/blanket-reports

[7] Tasforests, vol 11, pp87–107, 1999, *Buttongrass moorland fire-behaviour prediction and management.*

Parameter	Value
Area	4000 ha
Fuel–load	8 t/ha
Emission factor	0.020 kg/kg
Smoke ceiling	400 metres
Decay time–constant	5000 seconds
Total flaming–time	6 hours
Wind speed	5.5 m/s
Cone angle	25°
Ignition time	09:30 AEST (10:30 EDT)

Table 2: Parameters for the `rudi_plume` calculation for the Temma burn plume calculation. The values shown are based on information received from the PWS or are estimated from other information, as detailed in the text.

Figure 32. The calculated plume–centre–line concentrations at a range of 100 km from the burn is shown in Figure 33. In this case the calculation has been carried to 15 hours from ignition. Smoke reaches this location, 100 km downwind of the burn, near 15:00 AEST, with a concentration near 420 μg m^{-3}. On the 15th of October 2014, the Emu River station, 5 km south of Burnie, showed a brief elevation of $PM_{2.5}$ just near 15:00 AEST, with a peak near 500 μg m^{-3}. Emu River is 100 km from the area of the Temma burn. The fact it was only a brief interval of elevated $PM_{2.5}$ at Emu River appears to be due to the passage of the smoke plume across the station, as shown by the systematically varying wind direction in the lower panel of Figure 4. Had the wind direction been more constant over this time the duration of the smoke impact at Emu River, and consequently at nearby locations, may have been more extended.

The calculation can be extended in time to include longer ranges downwind. Smoke reached George Town, 180 km from the burn, near 17:00 AEST, some 7.5 hours after the postulated 09:30 AEST ignition. The average wind speed, assuming straight line motion would need to be near 24 km hr^{-1} (near 6.5 m s^{-1}). The wind speed measured at George Town on the afternoon of the 15th of October ranged from near 10 to 30 km hr^{-1}. It is possible the wind speed over coastal Bass Strait (e.g. from Devonport to George Town) may have been slightly higher. The calculated smoke concentration at George Town, using the burn parameters noted above but with a wind speed of 24 km hr^{-1}, is near 200 μg m^{-3}, which overestimates the mean level but is comparable to the peak level measured at George Town on the day.

It is reiterated that the calculations presented here are for guidance only, but indicate that large downwind smoke concentrations were a likely consequence of the burn.

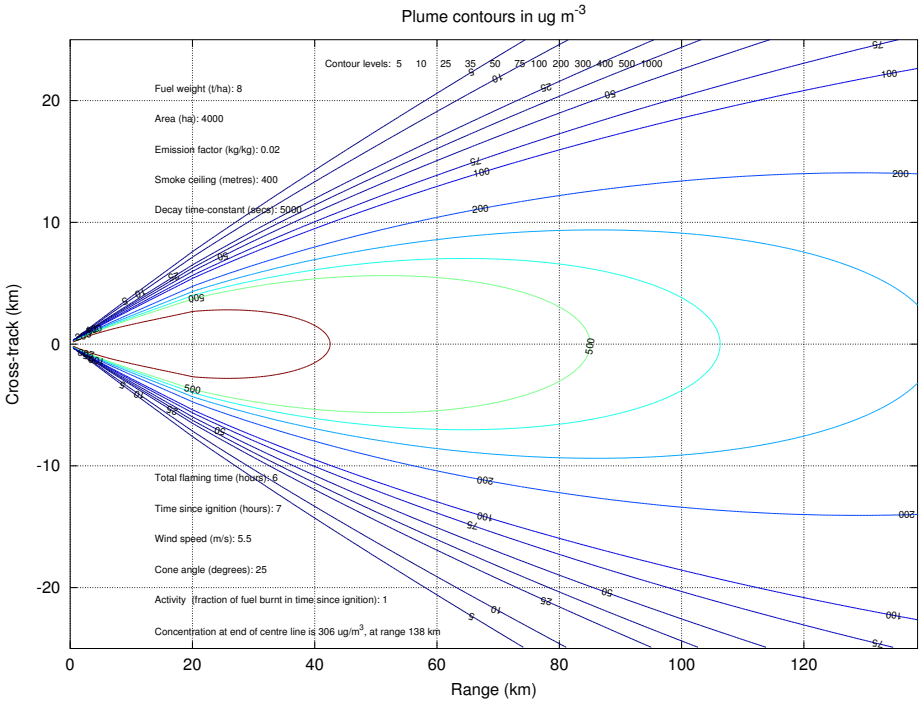


Figure 32: A plot of calculated, hypothetical, smoke concentrations from rudi_plume using the parameters in Table 2. The hypothetical plume is shown in a two–dimensional representation 7 hours after ignition.

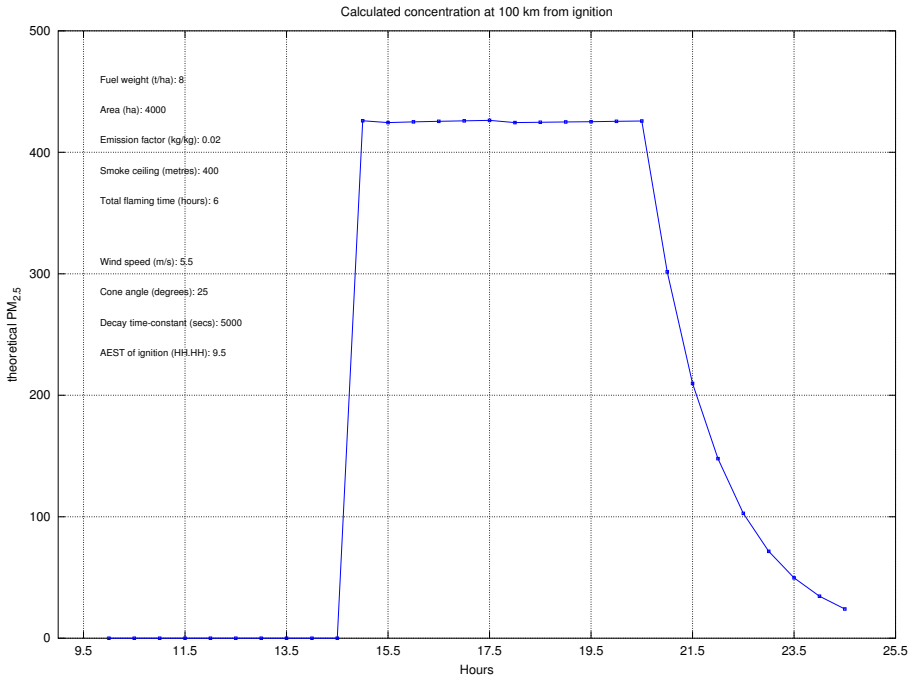


Figure 33: A plot of calculated, centre–line smoke concentrations from `rudi_plume` for a location at plume centre 100 km downwind of the burn with burn parameters as listed in Table 2. The calculation also assumes a constant wind direction during the time interval shown.

8 A note on prevailing wind regimes in northern Tasmania – implications for smoke movement in northern Tasmania

The movement of smoke from the west coast burn, in this instance at Temma, to the northwest coast, over southern Bass Strait towards George Town at the mouth of the Tamar and upriver to Launceston is in many ways similar to a number of previously noted examples. This section explores the similarities and the possible interpretation in terms of the prevailing wind systems over northern Tasmania.

8.1 Evidence from smoke movement from west and northwest Tasmania into north–central Tasmania and the Tamar Valley

Some instances of smoke initially moving eastwards from the west coast area of Tasmania to the mouth of the Tamar then upriver will be described here.

8.1.1 March 2008: Smoke from the Heemskirk bushfire reaching to Launceston

In March 2008 a large bushfire burnt for several days on the west coast of Tasmania. On the 18th of March the ABC news reported the fire had burnt 17,000 hectares and was still going. The MODIS Terra image for the morning of the 18th of March 2008 if shown in Figure 34. Smoke from the Heemskirk bushfire (source under cloud) initially moved to the northeast, before turning to the southeast, under a northwest wind, over the Tamar area.

This bushfire predates the establishment of the BLANkET network from May 2009 onwards. However the Ti Tree Bend air station was operational. $PM_{2.5}$ data from Ti Tree Bend for February–May 2008 are shown in Figure 35. Two data streams are shown: Red squares are from a reference (gravimetric) low–volume air sampler, and upright crosses are day–averages from an 8520 dustrak[8]. The highest $PM_{2.5}$ values in this interval occured on the 18th of March, and were ascribed to smoke from the Heemskirk fire. High values in the few days preceding the 18th of March were also likely from the same fire.

[8]The good agreement between the reference gravimetric sampler data and the dustrak provided an important foundation for the development of the BLANkET network.

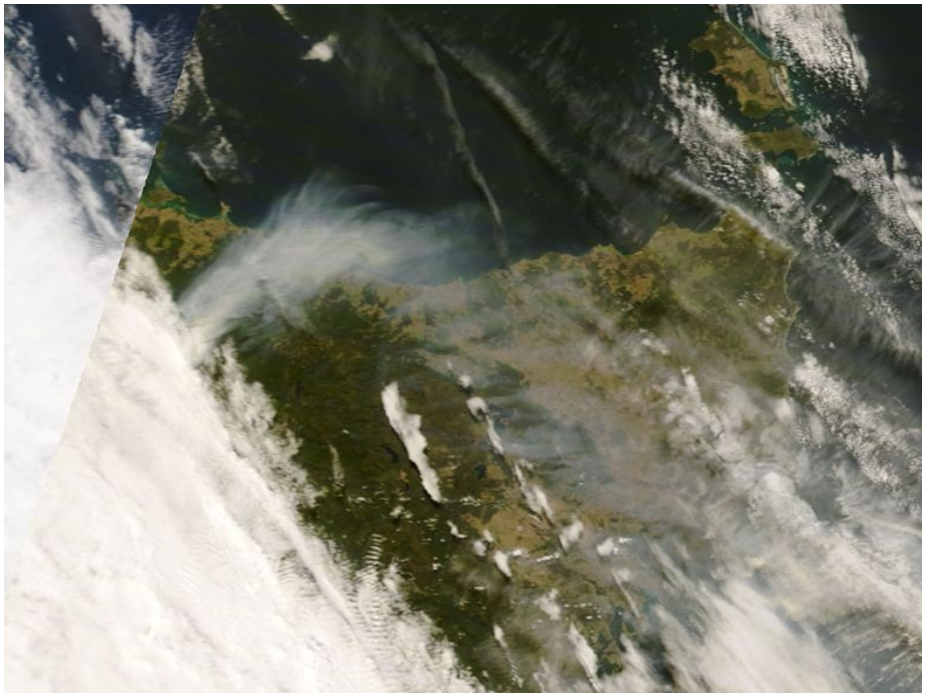


Figure 34: MODIS Terra image of northern Tasmania from the morning of the 18th of March 2008. Smoke from the Heemskirk bushfire (under the cloud, on the upper west coast of Tasmania) initially moved to the northeast to Bass Strait, before encountering a northwest wind and moving over north–central Tasmania.

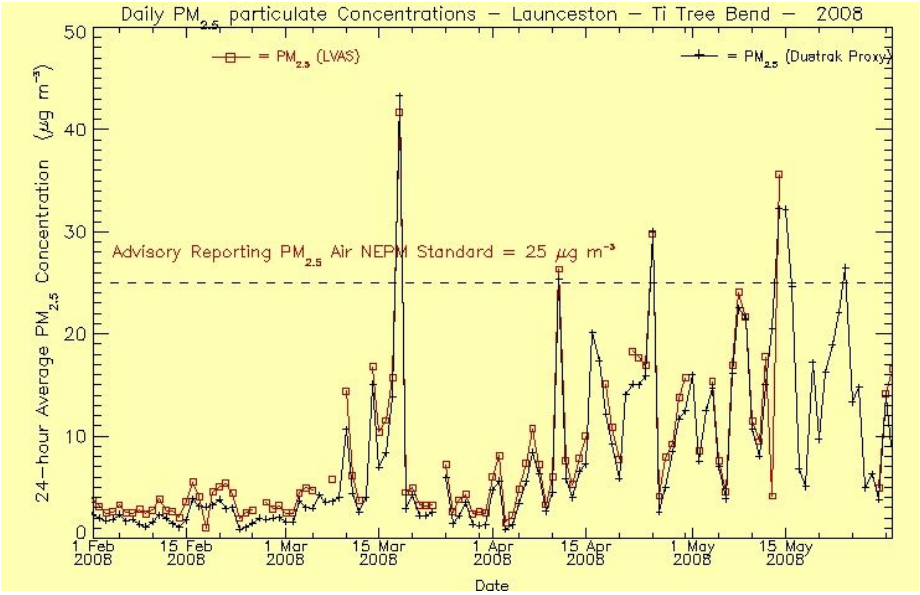


Figure 35: Daily values of $PM_{2.5}$ data from Ti Tree Bend air station, February to May 2008. Two data streams are shown: Red squares are from the reference low–volume air sampler, and upright crosses are day–averages from an 8520 dustrak.

8.1.2 20th October 2010: Smoke from a burn near Sheffield moved to Bass Strait then turned south and entered the Tamar

On the 20th of October 2010 smoke from a burn at Stoodley (near Sheffield) was seen to move northeasterly to Bass Strait, then turn southerly and entered the Tamar. A MODIS satellite image, processed by GeoSciences Australia Sentinel project, is shown in Figure 36. Data from George Town station are shown in Figure 37. The smoke arrived at George Town on a northerly wind. The circumstances of this burn and the subsequent smoke movement were discussed in BLANkET Technical Report 11.

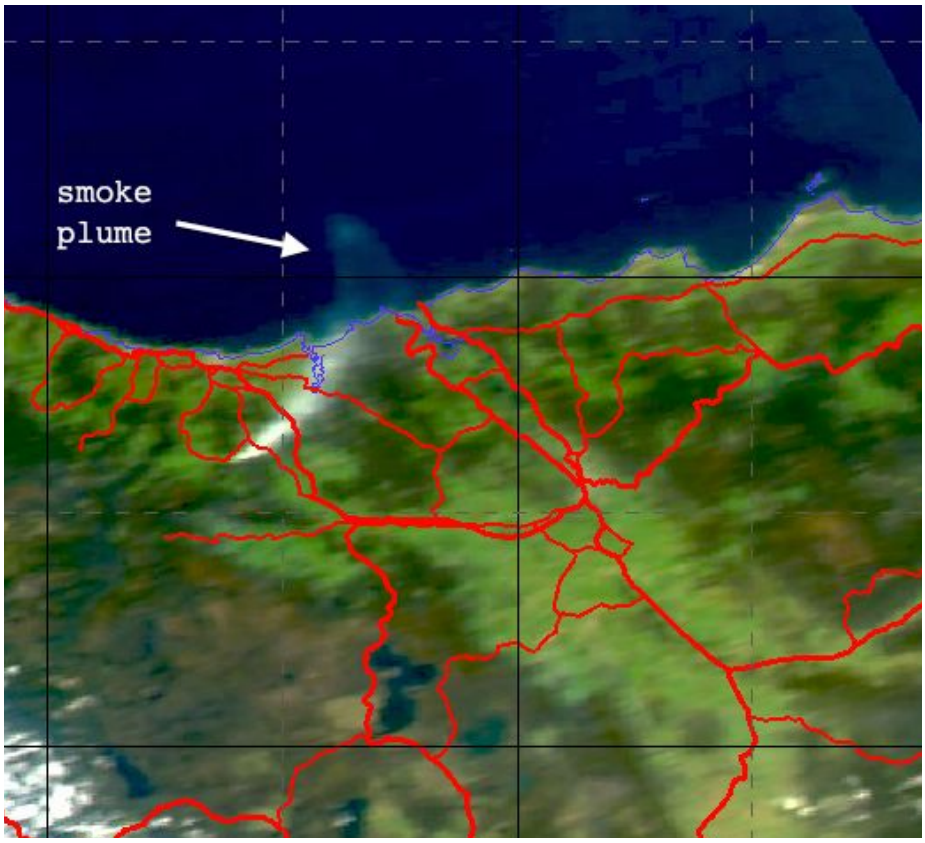


Figure 36: MODIS Aqua image of northern Tasmania processed by GeoSciences Australia, from the afternoon of the 20th October 2010. Smoke from a burn at Stoodley, near Sheffield, moves into Bass Strait then turns to the south and enters the Tamar.

As noted in BLANkET Technical Report 11, during the afternoon of the 20th of October 2010 there was a clear distortion of the pressure isobar over Tasmania. The Hobart BoM office noted this as a relatively common occurrence

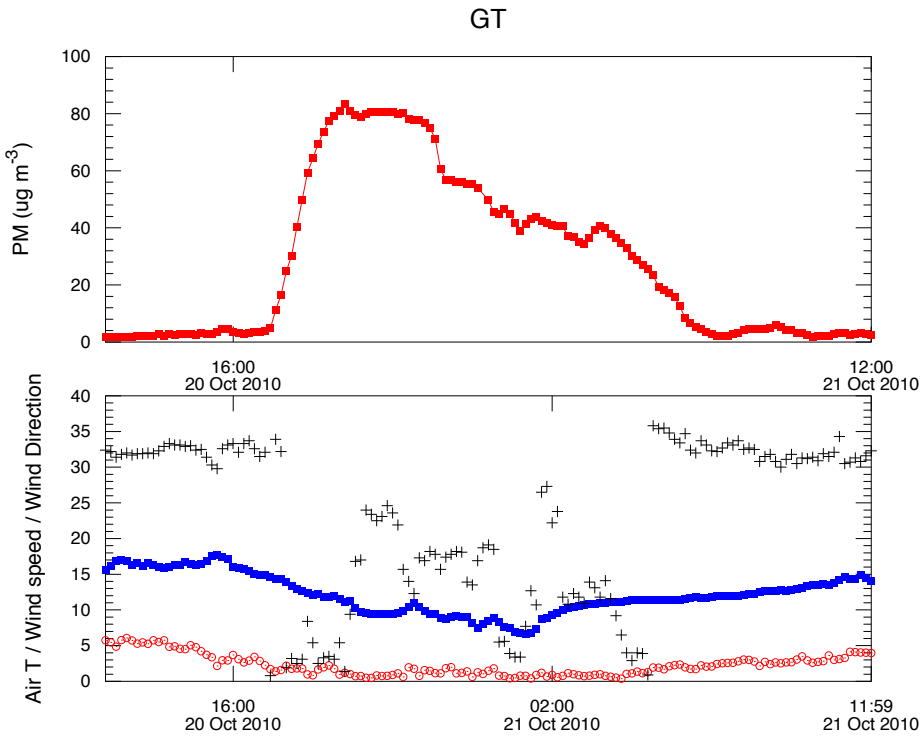


Figure 37: Data from George Town station, 20th–21st October 2010. Top panel: Time–series of $PM_{2.5}$. Lower panel: Meteorological data. Blue symbols: Air temperature (in C). Red circles: Wind speed (km hr^{-1}). Upright crosses: Wind direction (divided by 10 to fit the axes). The onset of elevated $PM_{2.5}$ co–incided with a wind change from north–west to a more northerly to north–east flow.

over Tasmania, and arises from a ridge of high pressure produced over the western mountains by westerly winds, with a corresponding lee trough that forms over central or eastern Tasmania. The Hobart BoM concluded that on the 20th of October 2010 the trough was intensive enough to produce a small low–pressure system, centred near Sheffield, which dissipated later in the day. The wind speed and directions at Emu River, West Ulverstone, Sheffield and Exeter on the afternoon of the 20th of October 2010 are shown schematically in Figure 38 and appeared consistent with circulation around the leeward low–pressure system near Sheffield identified by BoM analysis.

An illustration of a low–pressure system resulting from a lee trough is given in the Bureau of Meteorology publication 'Wind, waves, weather – Tasmania', Boating Weather Series, December 2000. This figure is reproduced here as Figure 39. On the afternoon of the 20th of October 2010 the leeward low–

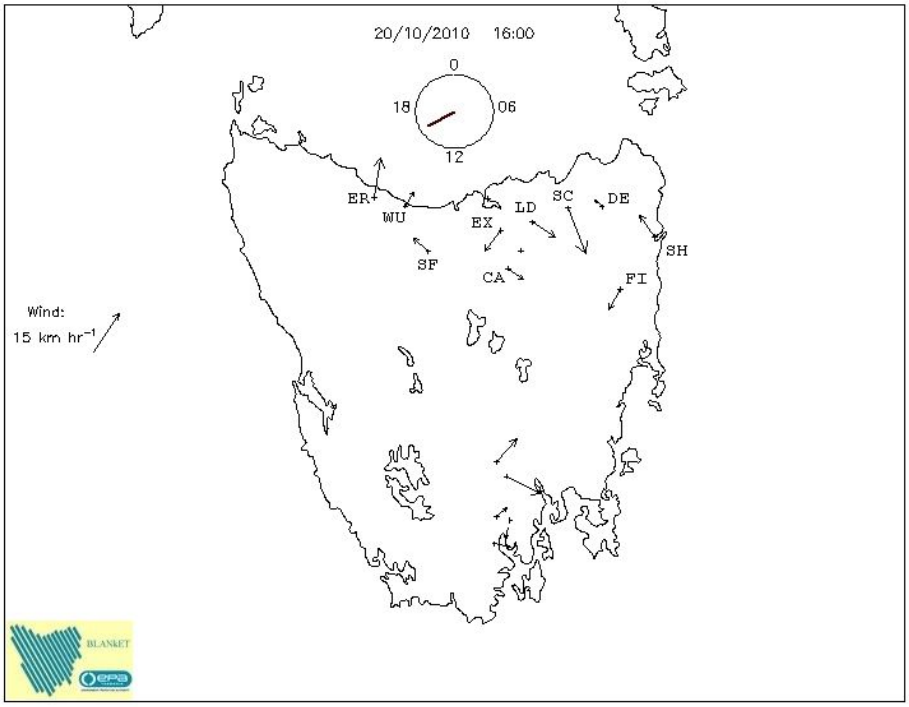
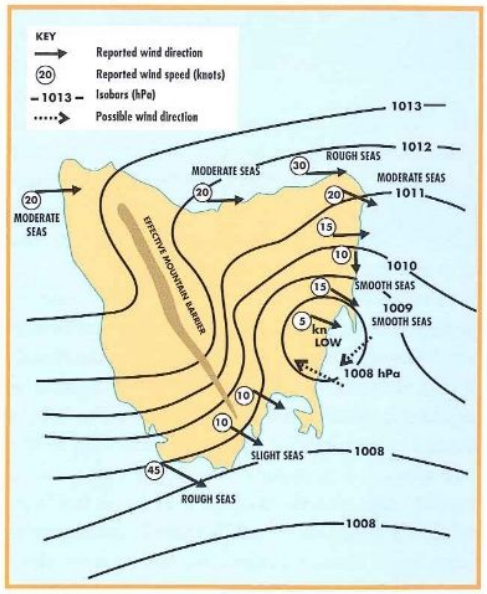


Figure 38: Wind directions at the BLANkET stations from 16:00 AEST on the afternoon of the 20th October 2010.

pressure system formed in north–central Tasmania, near Sheffield, and not over the central east coast as shown here.

Lee troughs: When air flows over a mountain range, a pressure ridge can occur on the windward side of the range, with a pressure trough forming on the lee side. In a well-defined westerly airstream a low pressure trough – or even a closed low circulation – can form on the lee side of Tasmania's mountain barrier. Usually the greater the speed of the airstream, the further leeward the trough will be displaced. This development is of considerable interest to east coast fishermen since it can create an area of relatively light winds on the east coast in a westerly airstream although winds in the south and near Banks Strait in the northeast may be stronger. The lee trough can occur at any time of the year, unlike the heat low.



Example of lee trough and low development.

Figure 39: Schematic of the formation of a windward pressure ridge over Tasmania's western mountains and corresponding lee trough/low–pressure system. From the Bureau of Meteorology publication 'Wind, waves, weather – Tasmania', Boating Weather Series, December 2000. On the afternoon of the 20th of October 2010 the leeward low–pressure system formed in north–central Tasmania, near Sheffield, and not over the central east coast as shown here.

8.1.3 28–29 March 2011: Northwest planned burn smoke reaching the Tamar via Bass Strait

On the 28th of March 2011 several relatively large planned burns (each of several tens of hectares in size) were ignited in the far northwest of Tasmania. The burns and the subsequent smoke movement were described in detail in BLANkET Technical Report 19, but a brief summary is given here. The MODIS Aqua image from the afternoon of the 28th of March 2011 is given in Figure 40. Blue arrows mark the direction of travel of smoke plumes and hence the local wind directions. The wind is southwesterly in the northwest of the state, but northwesterly in the Tamar region. As was described in BLANkET Technical Report 19, the cloud pattern, such as seen over Bass Strait reaching to the north–east coast of Tasmania, is suggestive of winds eddying around the north–west coast and western mountains. The wind pattern, shown by the smoke movement indicated by the blue arrows, is consistent with this appearance.

Later on the 28th of March, near 21:00 AEST, the general wind pattern seen earlier is still present, as shown in the night–time thermal infrared image from the AVHRR satellite. This is presented in Figure 41. Smoke plumes from several burns in the far northwest of the state are seen to move northeastwards before turning to the south and reaching the Tamar region. Smoke is not normally so prominent on the thermal infrared images, but in this case it appears there was a marked temperature contrast between the smoke and underlying land and ocean.

The $PM_{2.5}$ data records from the Tamar show a smoke plume moved across these stations overnight on the 28th–29th, as shown in Figure 42. The northwest air stations of Smithton, Wynyard, Emu River, West Ulverstone, and Sheffield showed only slightly elevated $PM_{2.5}$ on this night.

As was discussed in BLANkET Technical Report 19, the Bureau of Meteorology inferred that a weak and spatially small low pressure system formed over the mid northwest coast on the evening of the 28th of March 2011 following the dissipation of a ridge of high pressure that had extended westwards from a cell centred to the east of Tasmania. Air circulation around this low pressure system gave rise to the observed wind pattern.

Figure 40: MODIS Aqua image from the afternoon of the 28th of May 2011. Blue arrows mark the direction of travel of smoke plumes and hence the local wind directions.

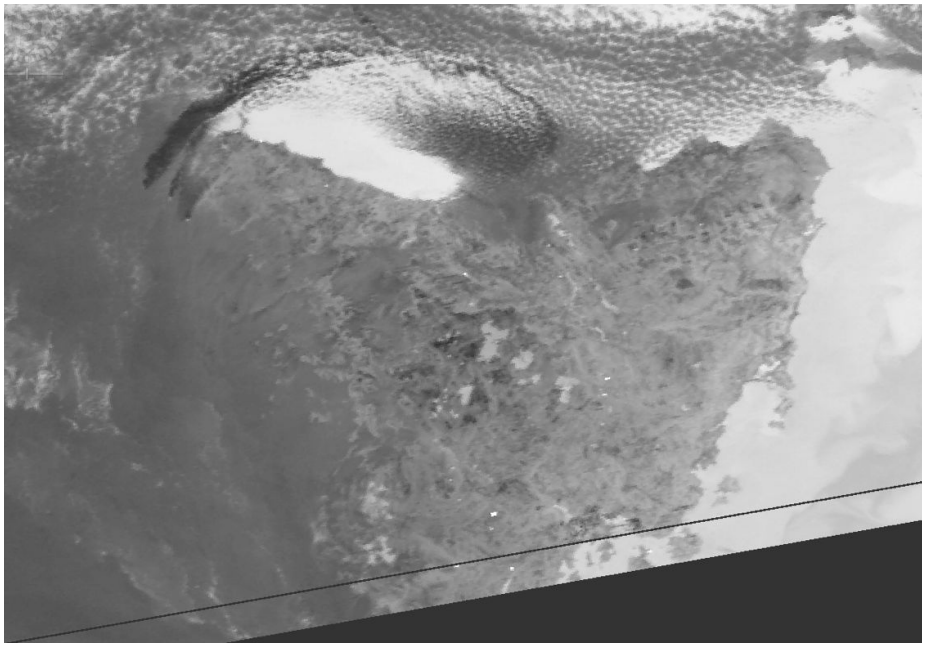


Figure 41: AVHRR thermal infrared view of northern Tasmania from 21:00 AEST on the 28th of March 2011. Smoke plumes from several burns in the far northwest of the state appear to move northeastwards before turning to the south and reaching the Tamar region.

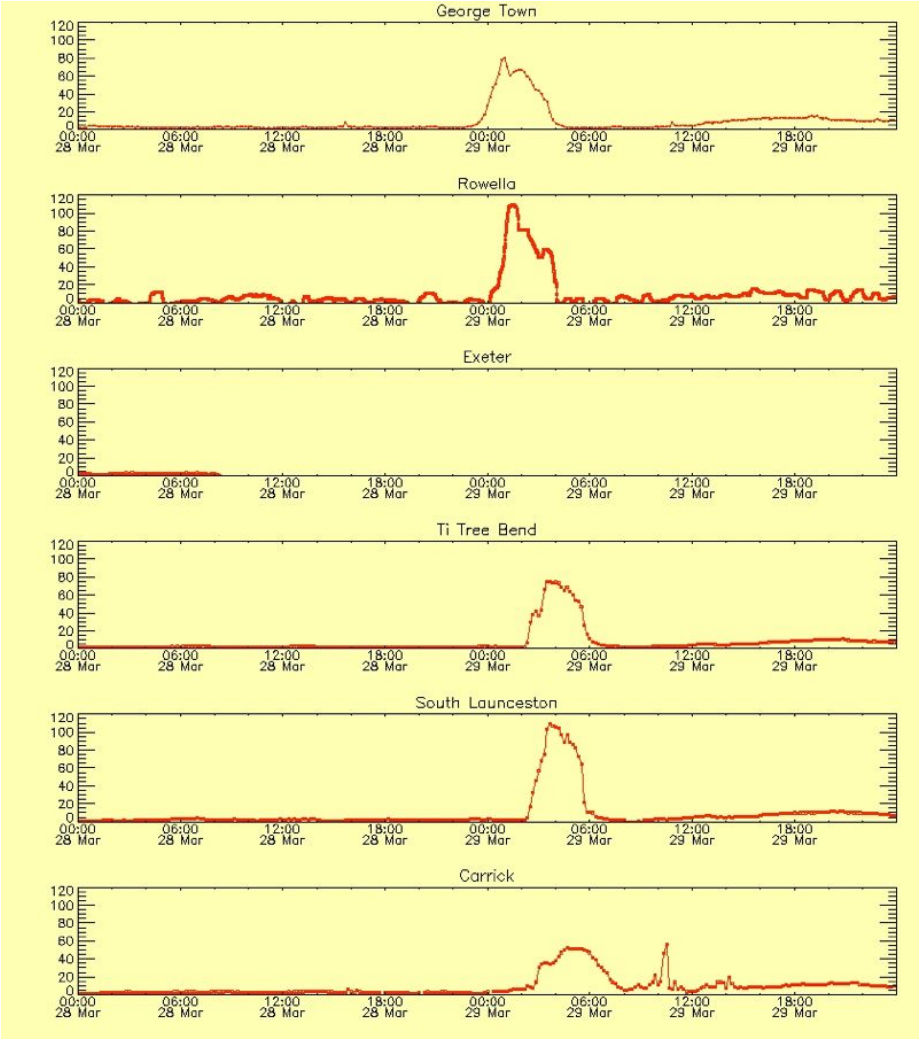


Figure 42: $PM_{2.5}$ data from the air stations in the Tamar region for 28–29 March 2011. Exeter station suffered an instrumental failure on the 28th of March.

8.1.4 8th October 2013 – Smoke from west coast burns reaching the Tamar

On the 8th of October smoke was recorded across the northwest air stations, and, subsequently, into the 9th of October in the Tamar and South Esk air stations. Elevated $PM_{2.5}$ was not recorded at Sheffield, due south of Devonport, or at Deloraine further east. The circumstances of the burns which occurred in the far northwest on this day, and a detailed analysis was given in BLANkET Technical Report 26. The smoke appeared to enter the Tamar and lower South Esk valley regions on a northerly to northwesterly wind, with smoke first appearing at George Town then sequentially at Exeter and Launceston. The analysis indicated it was likely that the west coast burns contributed to the recorded smoke. The absence of elevated $PM_{2.5}$ levels at Sheffield and Deloraine is evidence that the smoke moved into Bass Strait on a westerly wind, then subsequently turned southwards to move to the Tamar and South Esk regions.

The surface pressure charts for the afternoon and evening of the 8th of October 2013 show evidence for a pressure ridge over north–western Tasmania.

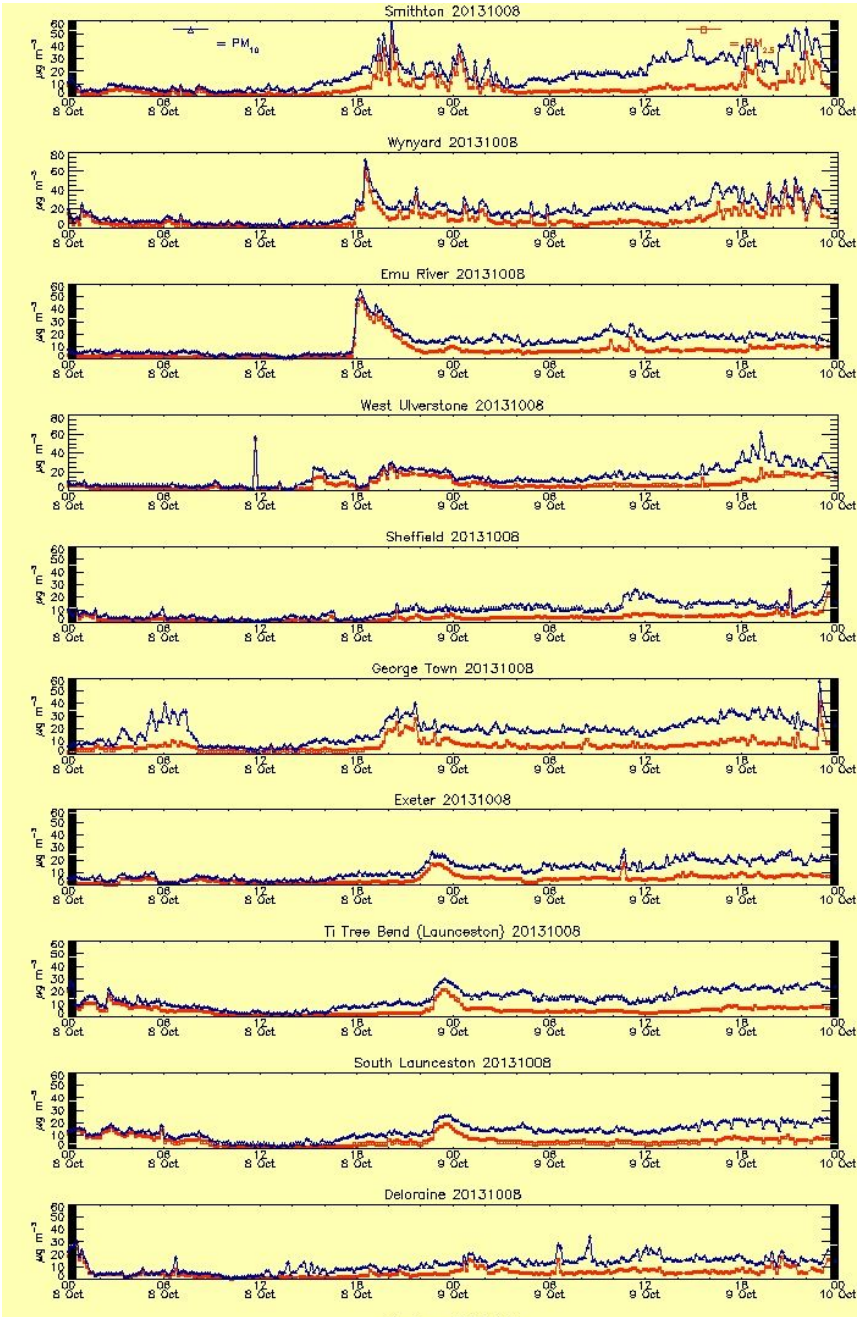


Figure 43: $PM_{2.5}$ data from selected northern Tasmanian air stations for 08–09 October 2013. Smoke entering the Tamar first appeared at George Town then sequentially at Exeter and Launceston. Smoke was recorded at the northwest coast stations of Wynyard, Emu River, and West Ulverstone, but not at the inland stations of Sheffield and Deloraine.

8.2 Wind roses

Wind roses have been produced using data from the Tasmanian air stations, and are shown for some selected northern stations in Figures 44 to 49 for the calendar year of 2013[9]. The wind rose is a graphical representation of wind direction and wind speed for a station, and provides a means of visualising the prevailing wind conditions. Wind directions are given in the usual meteorological sense that a wind direction of, for example, 180° means a wind from the south. The sector lengths are given as a percentage of the total data set. A measured wind speed of zero is taken as 'calm', but it should be noted that the mechanical anemometers used in the BLANkET stations have a stall speed of up to 0.5 m s^{-1}. Hence the stations are likely to report 'calms' under very–light wind conditions.

8.2.1 Smithton, far northwest coast

The wind rose for Smithton, presented in Figure 44, shows a dominance of southwest winds. Some of this may arise from katabatic–type flows down the Duck River valley in cold weather, as well as from possible topographical steering of south to west winds by the valley. The Duck River valley near Smithton is however relatively broad, shallow, and open. The BLANkET station is located on moderately open ground, but there are two buildings within 10 metres. Consequently some local effects influencing the measured wind direction may be possible.

The general prevalence of southwesterly winds at Smithton is however also seen in data from other weather stations in the near vicinity. The Bureau of Meteorology website provides summary information for Tasmanian meteorological stations, including many no longer operational[10]. A (manual) weather station operated at Grant Street, Smithton (on the southern fringe of the town) from April 1962 to October 1997. The wind rose for 3 p.m. from these data also shows a clear dominance of southwesterly winds, as seen in the BLANKET station wind rose plot (Figure 44). The 9 a.m. wind rose for the Grant Street site shows similar features to the 3 p.m. rose, although the southwesterly wind is not as dominant as at 3 p.m.

The Bureau of Meteorology website also has wind roses from a station at Smithton aerodrome (for 1996 to 2010). The 9 a.m. wind rose shows a dominance of southerly and southwesterly winds. The 3 p.m. wind rose shows dominant southwesterly and westerly winds. Southwesterly winds are also dominant at Stanley, approximately 20 km northeast of Smithton, and are a significant component at Redpa, approximately 40 km southwest of Smithton. These plots are also given in Appendix A.

8.2.2 Wynyard, northwest coast

Figure 45 shows the wind rose for Wynyard. The dominant winds are from the west, although easterlies are also reasonably prominent. The anemometer and

[9] Wind roses for a given station for other years are very similar.

[10] Wind rose plots for several northwestern Tasmanian sites are given in Appendix A.

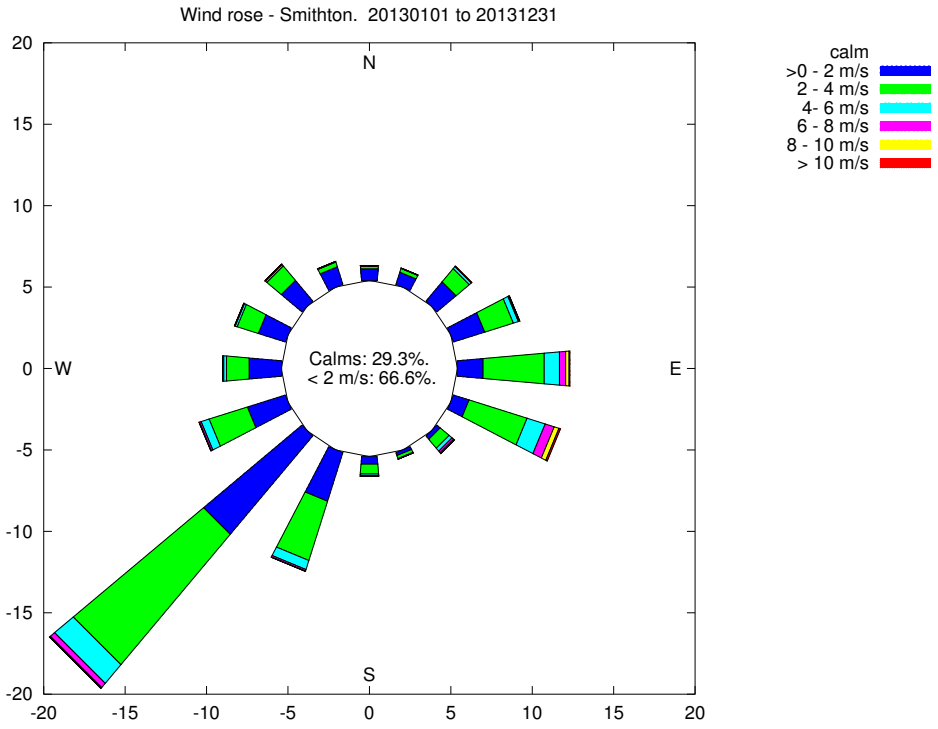


Figure 44: Wind rose for 2013 for Smithton.

wind vane at Wynyard are mounted on a building above the roof line, and should provide a reasonably valid representation of local wind speed and direction.

The Wynyard BLANkET station wind rose is similar in appearance to wind roses for Preolenna station, approximately 20 km southwest of Wynyard (operated 1971–1994), available from the Bureau of Meteorology website and given in Appendix A.

8.2.3 Emu River, 5 km south of Burnie, northwest coast

Figure 46 shows the wind rose for Emu River station. Emu River station is in an isolated area and is expected to be well removed from local interfering effects on the wind measurements. Westerly and easterly winds are often seen. Of interest is the marked southerly wind. This is the signature of a katabatic wind which is a well documented feature[11] in the Emu River data record during cool, synoptically calm, weather.

[11] See BLANkET Technical Report 17.

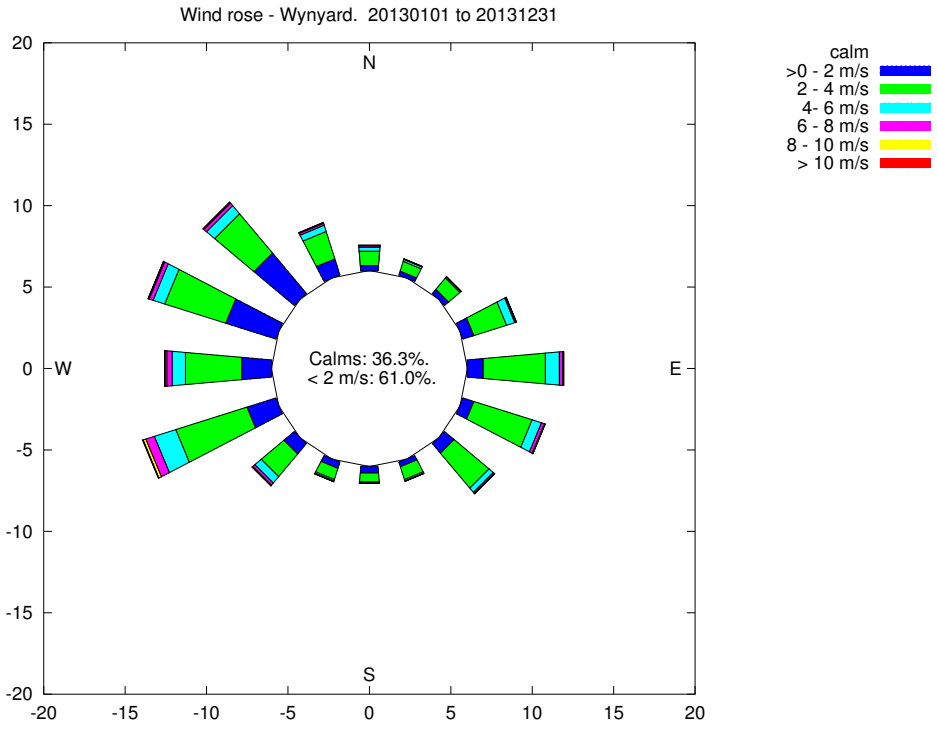


Figure 45: Wind rose for 2013 for Wynyard.

8.2.4 Sheffield – 20 km inland from Devonport, mid–northwest coast

Figure 47 shows the wind rose for Sheffield station. The dominant winds are clearly from the west and northwest.

8.2.5 George Town – mouth of the Tamar River, mid north coast

Figure 48 shows the wind rose for George Town. There are significantly fewer calms than for the other stations presented here The dominant winds are westerly and west–northwesterly. The southeast winds represent a down–river flow in the Tamar valley.

8.2.6 South Launceston – upper Tamar River

Figure 49 shows the wind rose for South Launceston. The dominant wind is northwesterly, which is effectively up the Tamar River. South Launceston station is approximately 85 metres above sea–level. The other Launceston air station is Ti Tree Bend, located approximately 3.5 km northwest of South Launceston, but at only 5 m elevation. Winds at Ti Tree Bend show a larger percentage

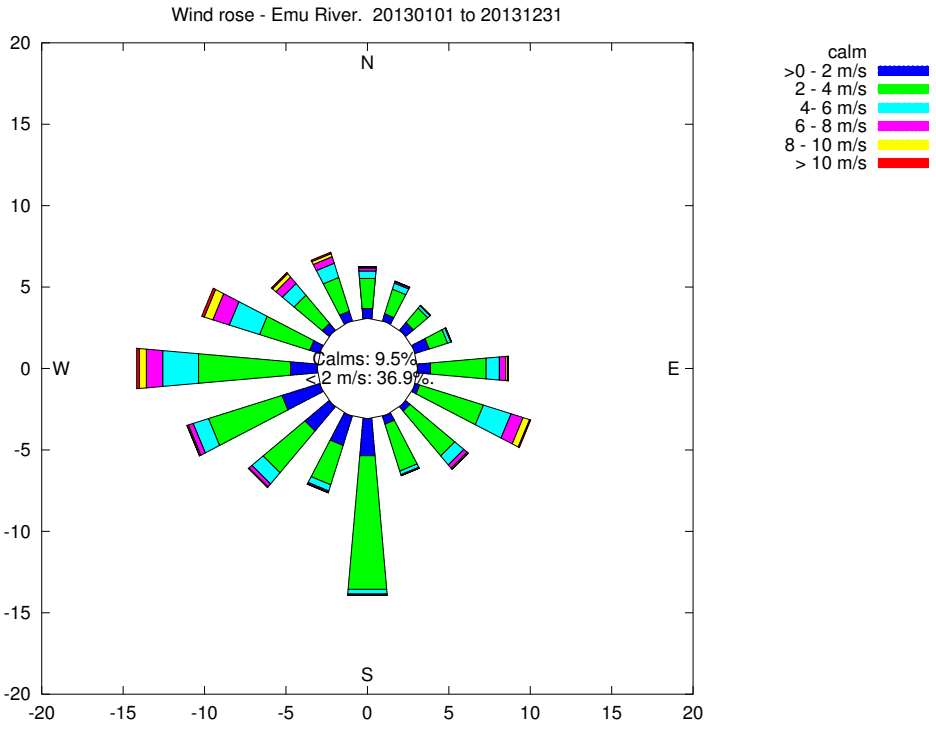


Figure 46: Wind rose for 2013 for Emu River.

of south and east winds (which mostly occur in cold weather) than are seen at South Launceston. The occurrence of vertical stratification of wind flows in the Tamar Valley at Launceston was noted in BLANkET Technical Report 10 (pp 44–47).

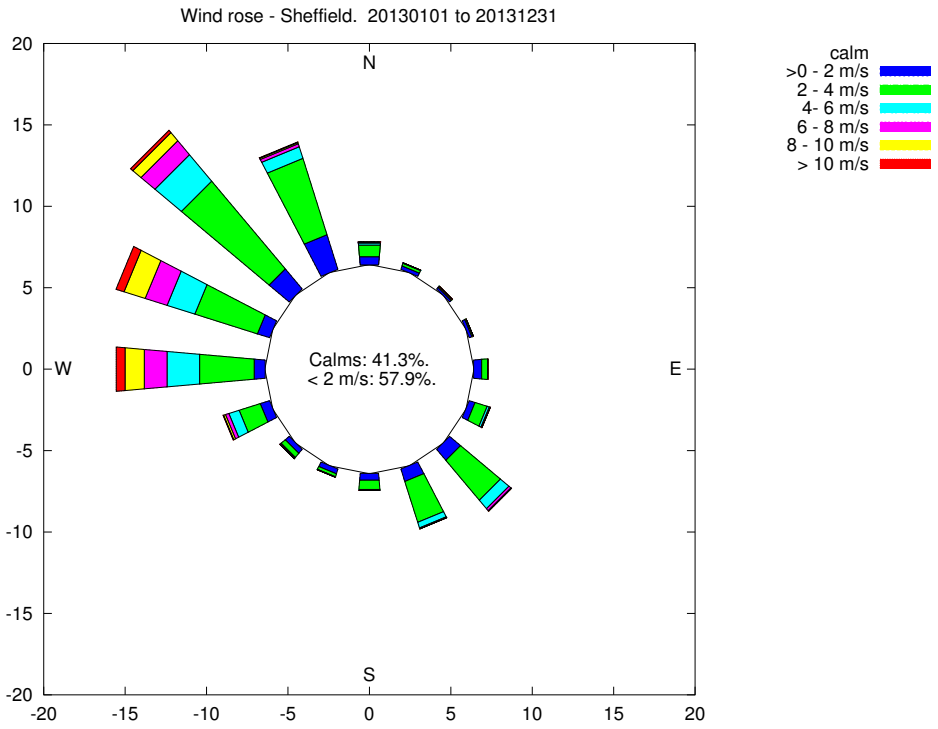


Figure 47: Wind rose for 2013 for Sheffield.

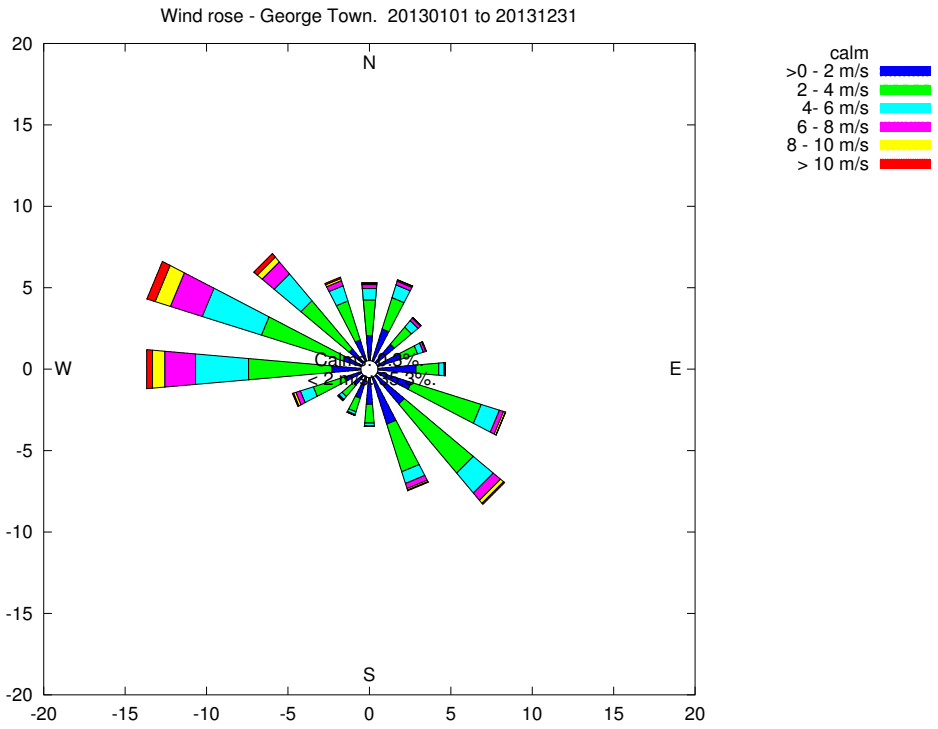


Figure 48: Wind rose for 2013 for George Town.

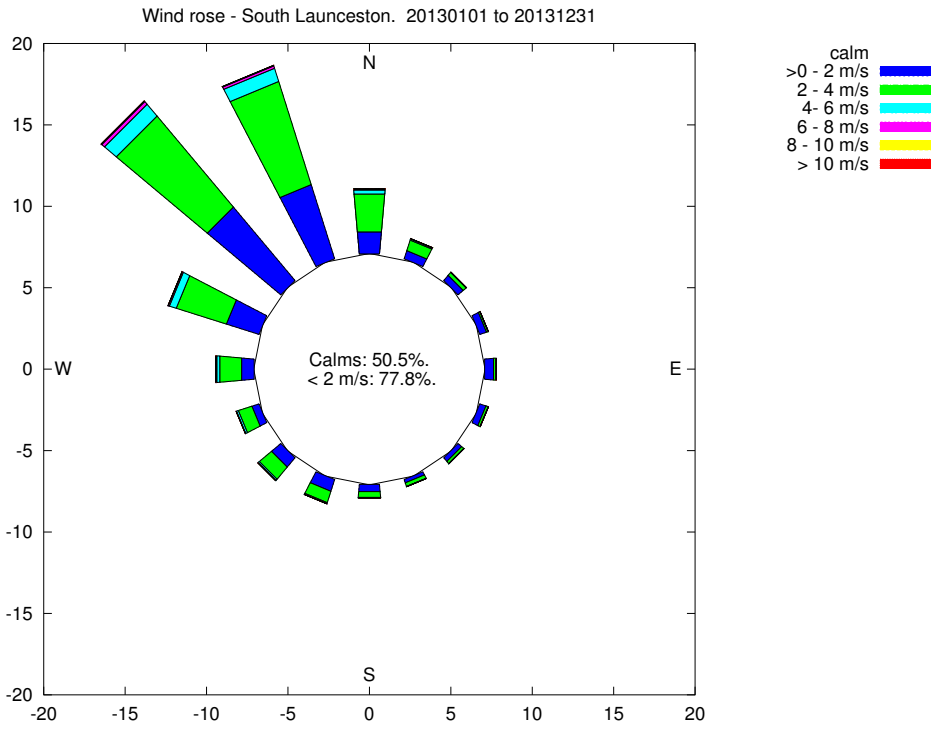


Figure 49: Wind rose for 2013 for South Launceston.

8.2.7 Wind roses in a spatial context

Figure 50 shows wind roses from the BLANkET stations of Smithton, Wynyard, Emu River, Sheffield, George Town and South Launceston arranged in a schematic view to represent their relative geographic locations. In this view, it is seen that the dominant wind directions vary from southwesterly at Smithton, to be frequently westerly at Wynyard and Emu River, to northwesterly at Sheffield and South Launceston. Winds at George Town are mostly northwesterly or southeasterly. The latter is likely to be a down–valley flow, with a katabatic component, in the lower Tamar River valley.

This apparent spatial pattern in prevailing winds over northern Tasmania potentially provides a context for interpreting some of the smoke behaviour measured in the BLANkET network and seen in the satellite images shown in Section 8.1. Smoke from a burn in the far northwest or upper west coast could be carried northeasterly or easterly across the Tasmanian coast into Bass Strait. If the smoke then encounters a northwesterly flow it could be brought back onshore. As noted, Section 8.1 documents several instances of this happening. There may be several distinct mechanisms for this behaviour – such as the formation on a lee ridge and accompanying low pressure system, or flows as a consequence of a high–pressure system to the east of Tasmania – as will be briefly discussed below. The prevalence of such wind systems will be explored in the following sections.

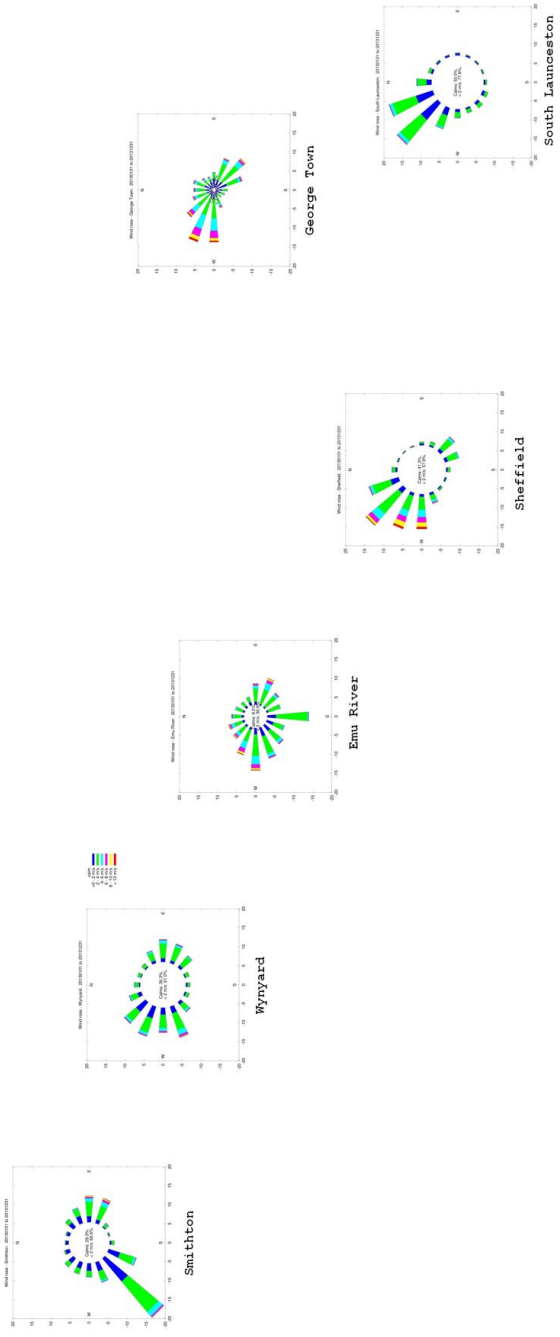


Figure 50: Wind roses for 2013 for Smithton, Wynyard, Emu River, Sheffield, George Town, and South Launceston stations schematically arranged to represent the relative locations of the stations.

8.3 Case–study I – Smithton and South Launceston

The wind roses presented in above are suggestive that prevailing winds shift from a southwesterly and westerly direction on Tasmania's upper west coast and far northwest to a more northwesterly flow in the central north. This section and the one that follows explores the nature of that suggestion in more detail by a comparison of winds at Smithton and South Launceston, and then at Wynyard and South Launceston, as measured by the BLANkET stations.

The schematic of wind roses in Figure 50, while interesting, provides no information on the temporal relationships between the prevailing winds at these stations. That is, while statistically it is clear that southwest wind often occur at Smithton, and northwest winds are common at South Launceston, the schematic does not answer the question of how frequently do southwest winds at Smithton at the same time as northwest winds occur at South Launceston.

To explore this question, Figure 51 shows a plot of wind direction at Smithton versus wind direction simultaneously measured at South Launceston, created using hour–averaged wind direction data for 2012 and 2013. The red rectangle defines the locus of points where wind direction at Smithton was between 200° to 270° ('southwest to westerly') and, simultaneously, the wind direction at South Launceston was between 300° and 350° ('northwesterly'). Just over 28% of the data points lie within the red rectangle. That is, for slightly more than one quarter of the time in the years 2012 and 2013, the wind was simultaneously southwesterly to westerly at Smithton, and northwesterly in the upper Tamar valley at South Launceston.

8.4 Case–study II – Wynyard and South Launceston

A similar analysis to the above was also performed for Wynyard and South Launceston. Figure 52 shows the plot of wind direction at Wynyard versus wind direction simultaneously measured at South Launceston, created using hour–averaged wind direction data for 2012 and 2013. The red rectangle in this figure defines the locus of points where wind direction at Wynyard was between 250° to 330° ('westerly to west–northwesterly') and, simultaneously, the wind direction at South Launceston was between 300° and 350° ('northwesterly'). Just over 32% of the data points lie within the red rectangle. Hence for approximately one third of the time in the years 2012 and 2013, the wind was simultaneously westerly to west–northwesterly at Wynyard and northwesterly at South Launceston.

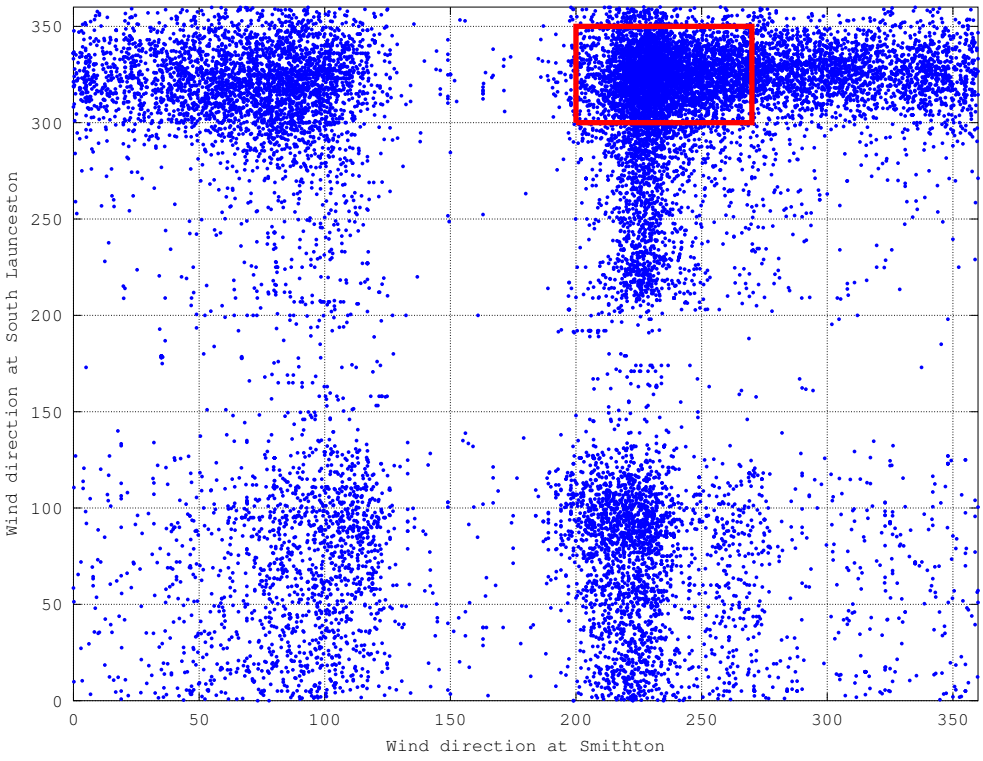


Figure 51: Wind direction at Smithton versus wind direction simultaneously measured at South Launceston. The data used are hourly-averaged wind direction data for 2012 and 2013. Just over 28% of the data points lie within the red rectangle.

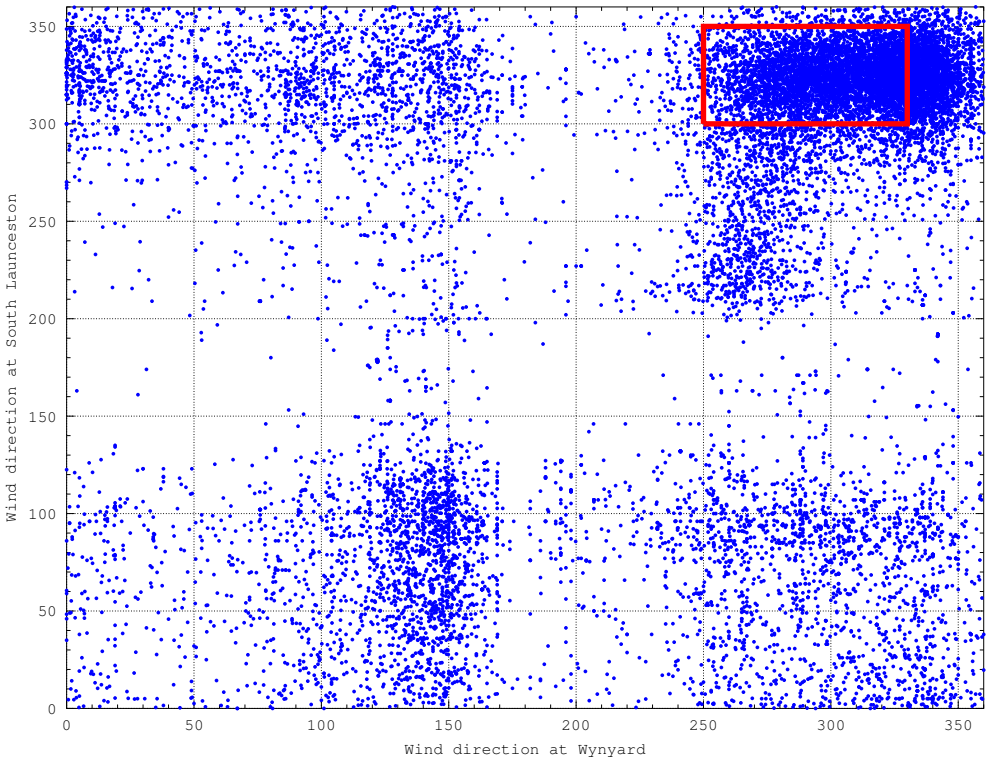


Figure 52: Wind direction at Wynyard versus wind direction simultaneously measured at South Launceston. The data used are hourly-averaged wind direction data for 2012 and 2013. Just over 32% of the data points lie within the red rectangle.

8.5 Discussion

Several instances outlined above illustrate that smoke from burns in the north–west of Tasmania can move eastward into Bass Strait then south–eastward into the Tamar region. The wind–direction case studies presented here suggest that this movement is consistent with certain wind patterns along the northern Tasmania coast and nearby hinterland, in that south–westerly winds at Smithton, westerly winds at Wynyard, and, simultaneously, north–westerly winds in Launceston occur about 25% of the time. These wind patterns, though similar in appearance, may arise from a number of different processes, as also noted above in the specific discussion of the smoke movement examples.

Hobart Bureau of Meteorology officer Dr. P. Fox–Hughes provided the following comments on this issue:

> "The winds over broad regions of the Tasmanian coast are often far from uniform. Low pressure systems can form in the lee of the island, given most wind directions. In a generally southwesterly flow, such as occurs when a high pressure system is located south of the Great Australian Bight, a lee low will often form off the northwest or central northern coast and direct a northwesterly wind onto Devonport or the mouth of the Tamar River, while winds over western parts of the north coast remain southwesterly. In other cases, after moving up the east coast, a cool change may propagate westward along the north coast before shedding a similar small-scale low pressure system that again directs the airflow onto parts of the north coast, even though the broadscale flow is quite different. Thus, the Australian Region Mean Sea Level Pressure chart is not always a good guide to whether the winds at a specific location are likely to be onshore or offshore".

The broad, open valley 'above' the Tamar proper, between the Western Tiers and the high ground further east (including the Mt Arthur, Mt Barrow, and Ben Lomond plateau), may also provide a local topographical influence for air moving off Bass Strait. A Google Earth view of this feature is given in Figure 53.

9 Conclusion

The analysis presented here identifies the 6100 ha planned burn at Temma, on the upper west coast of Tasmania, as the source of the smoke seen across the north–west coast and Tamar Valley regions on the afternoon and evening of the 15th of October 2014. The inferred smoke movement, generally eastward through the north–west coastal stations and into southern Bass Strait then up the Tamar Valley on a north–west wind, has been documented in several earlier cases. A study of the prevailing winds indicates this pattern occurs relatively often (perhaps one quarter of the time), and may arise due to several effectively independent mechanisms.

Figure 53: An oblique view with Google Earth up the Tamar river into the broad open valley (mostly grassland) between the Western Tiers at right and the high ground including Mt Arthur, Mt Barrow, and the Ben Lomond plateau at left. Tasmanian air stations are shown as red balloon icons. (Note: Deloraine station (DL) is not presently operational.)

10 Acknowledgments

The EPA Division thanks the many agencies that contribute support for the operation of the BLANkET network. BLANkET stations are sited at properties owned or operated by TasWater, Wynyard Waratah Council, Devonport TAFE, George Town Council, West Tamar Council, Tasherds, Northern Midlands Council, Dorset Council, Break O'Day Council, Aurora Energy, Inland Fisheries Service, Hobart City Council, Huon Valley Council, and the Tasmanian Department of Education.

We thank the PWS for providing information regarding the planned burn at Temma on the 14th and 15th of October 2014. We also thank the member of the public who submitted the digital images of the middle Tamar Valley under smoke on the afternoon of the 15th of October 2014. Senior severe–weather meteorologist Dr. Paul Fox–Hughes from the Hobart Bureau of Meteorology is thanked for discussions and valuable input regarding the wind field patterns in Tasmania.

Report compiled by J. Innis.

A Wind roses from the Bureau of Meteorology

The Bureau of Meteorology website[12] provides links to individual station data summaries, including wind rose data for 9 a.m. and 3 p.m. Wind roses for several selected northwestern Tasmanian stations are provided here for reference.

A.1 Cape Grim

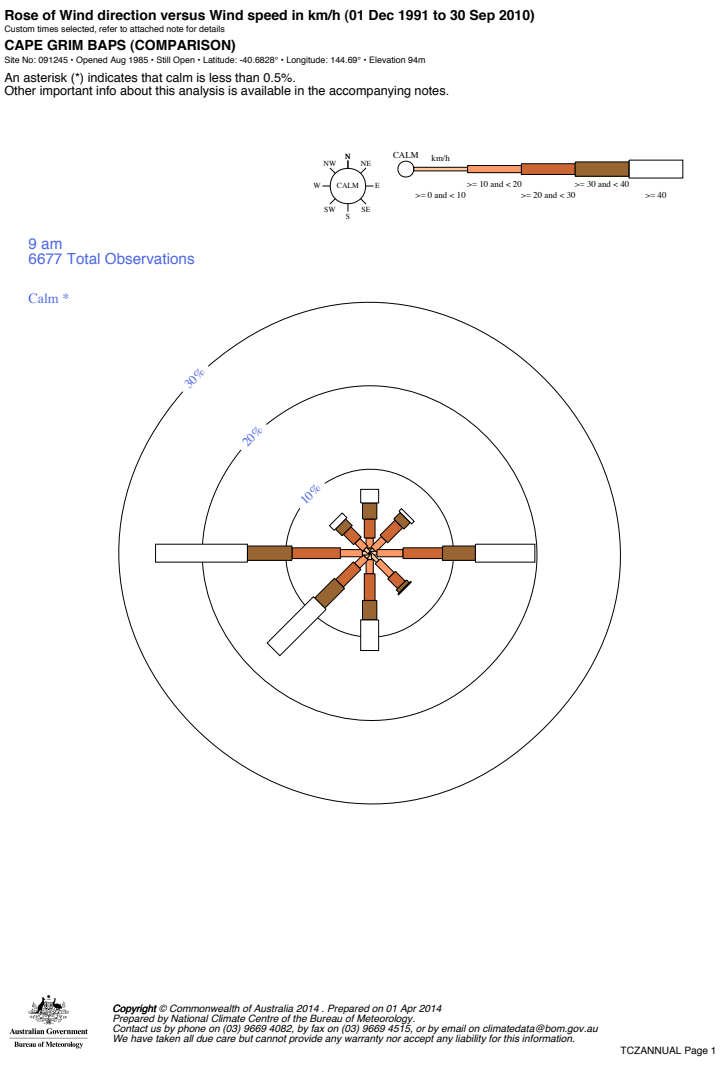


Figure 54: Bureau of Meteorology wind rose for 9 a.m. for Cape Grim.

[12] http://www.bom.gov.au/climate/data/index.shtml?bookmark=200

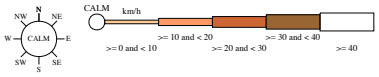
Rose of Wind direction versus Wind speed in km/h (01 Dec 1991 to 30 Sep 2010)

Custom times selected, refer to attached note for details

CAPE GRIM BAPS (COMPARISON)

Site No: 091245 • Opened Aug 1985 • Still Open • Latitude: -40.6828° • Longitude: 144.69° • Elevation 94m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
6674 Total Observations

Calm *

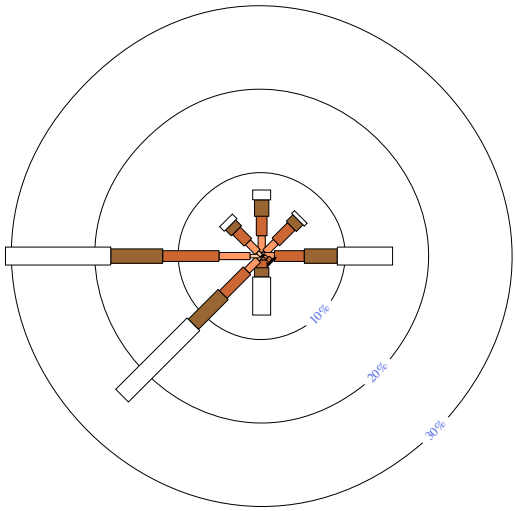


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Figure 55: Bureau of Meteorology wind rose for 3 p.m. for Cape Grim.

A.2 Redpa

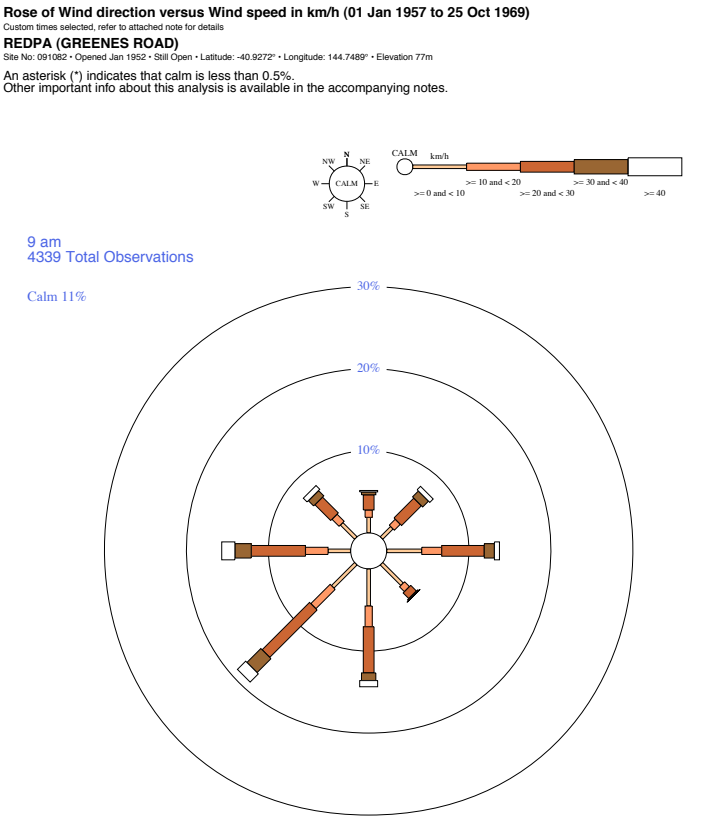


Figure 56: Bureau of Meteorology wind rose for 9 a.m. for Redpa.

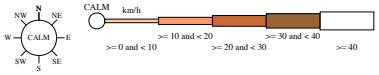
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 25 Oct 1969)

Custom times selected, refer to attached note for details

REDPA (GREENES ROAD)

Site No: 091082 • Opened Jan 1952 • Still Open • Latitude: -40.9272° • Longitude: 144.7489° • Elevation 77m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
4039 Total Observations

Calm 2%

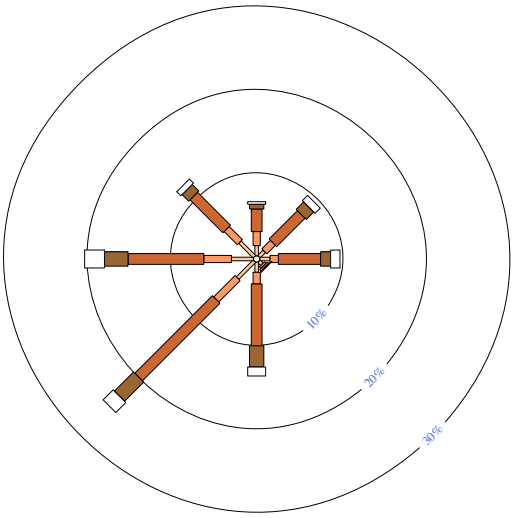


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Figure 57: Bureau of Meteorology wind rose for 3 p.m. for Redpa.

A.3 Smithton Aerodrome

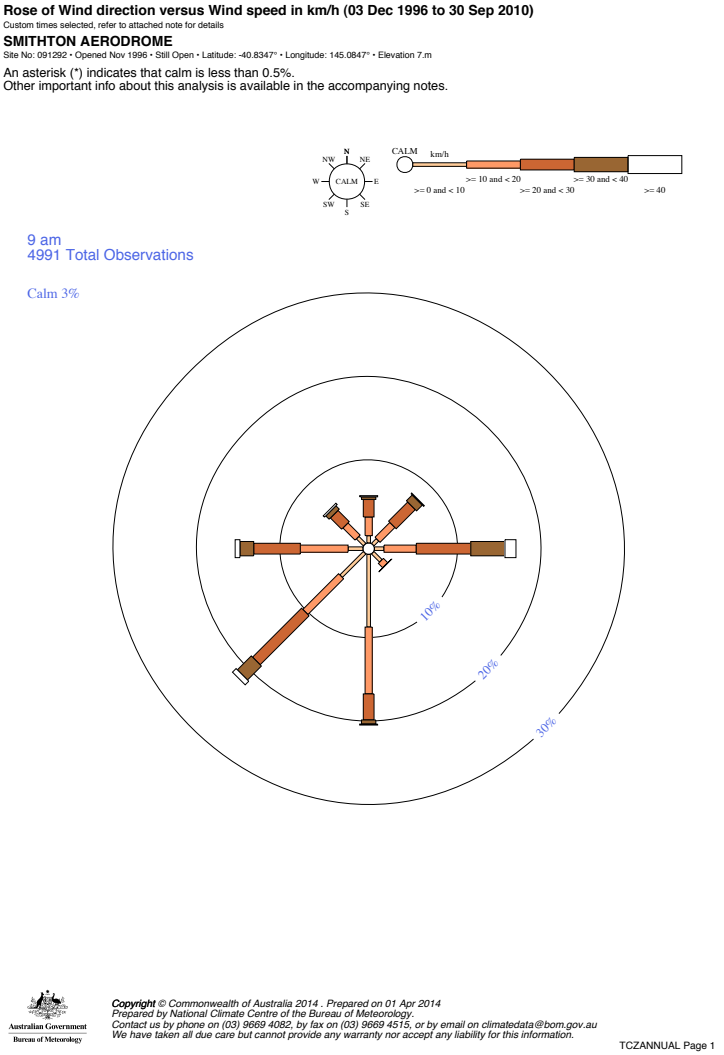


Figure 58: Bureau of Meteorology wind rose for 9 a.m. for Smithton Aerodrome.

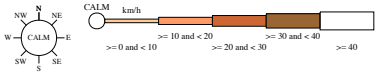
Rose of Wind direction versus Wind speed in km/h (03 Dec 1996 to 30 Sep 2010)

Custom times selected, refer to attached note for details

SMITHTON AERODROME

Site No: 091292 • Opened Nov 1996 • Still Open • Latitude: -40.8347° • Longitude: 145.0847° • Elevation 7.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
5004 Total Observations

Calm *

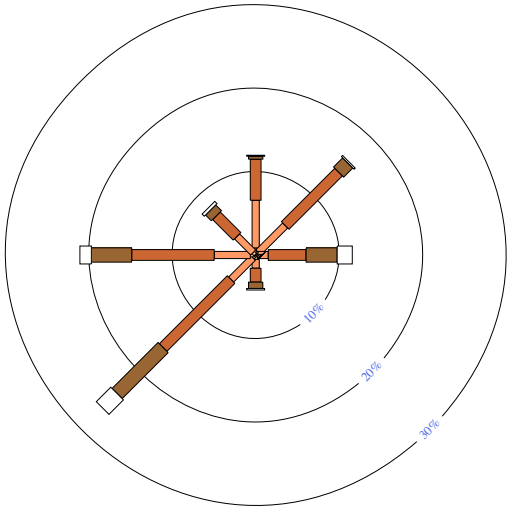


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Figure 59: Bureau of Meteorology wind rose for 3 p.m. for Smithton Aerodrome.

A.4 Smithton Grant Street

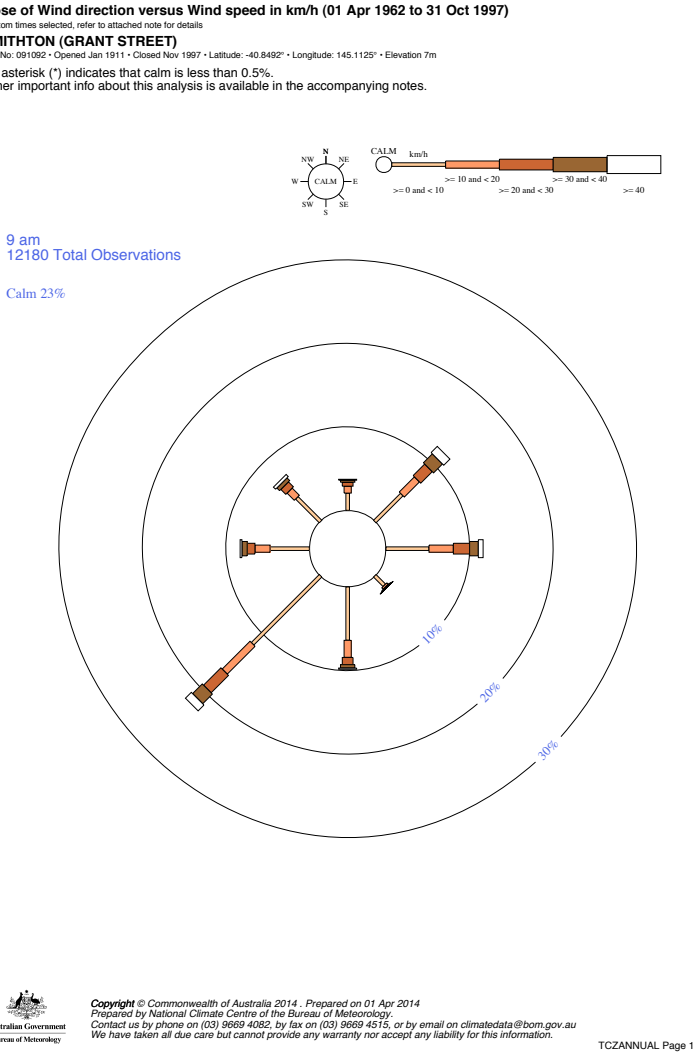


Figure 60: Bureau of Meteorology wind rose for 9 a.m. for Smithton Grant St.

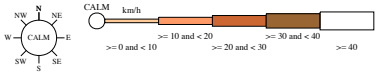
Rose of Wind direction versus Wind speed in km/h (01 Apr 1962 to 31 Oct 1997)

Custom times selected, refer to attached note for details

SMITHTON (GRANT STREET)

Site No: 091092 • Opened Jan 1911 • Closed Nov 1997 • Latitude: -40.8492° • Longitude: 145.1125° • Elevation 7m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
8237 Total Observations

Calm 3%

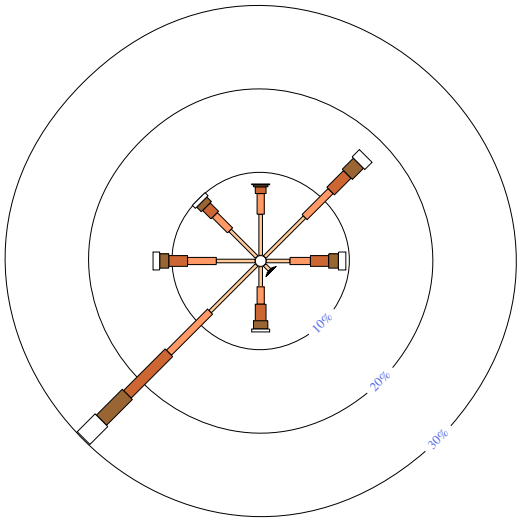


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Figure 61: Bureau of Meteorology wind rose for 3 p.m. for Smithton Grant St.

A.5 Stanley

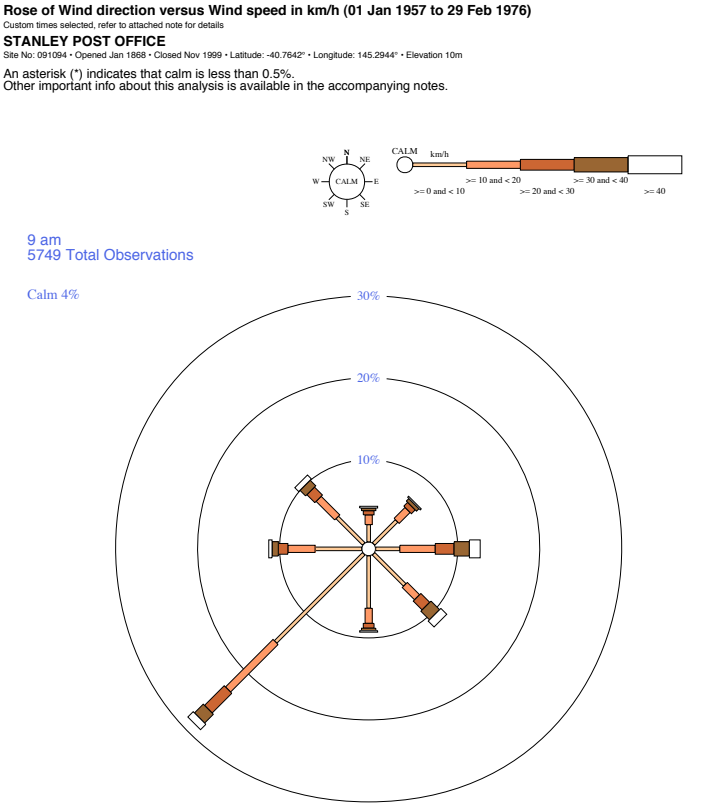


Figure 62: Bureau of Meteorology wind rose for 9 a.m. for Stanley.

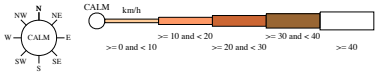
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 29 Feb 1976)

Custom times selected, refer to attached note for details

STANLEY POST OFFICE

Site No: 091094 • Opened Jan 1868 • Closed Nov 1999 • Latitude: -40.7642° • Longitude: 145.2944° • Elevation 10m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
5428 Total Observations

Calm 1%

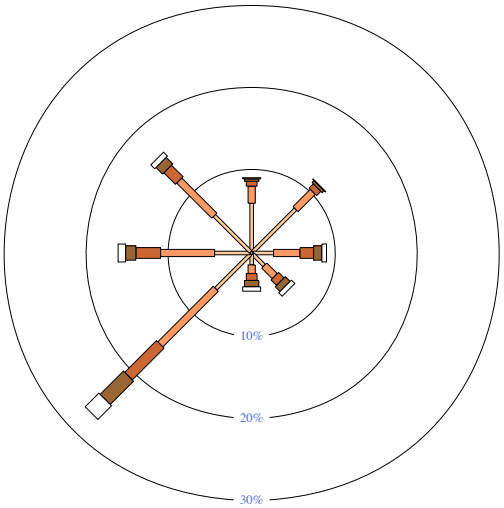


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Figure 63: Bureau of Meteorology wind rose for 3 p.m. for Stanley

A.6 Preolenna

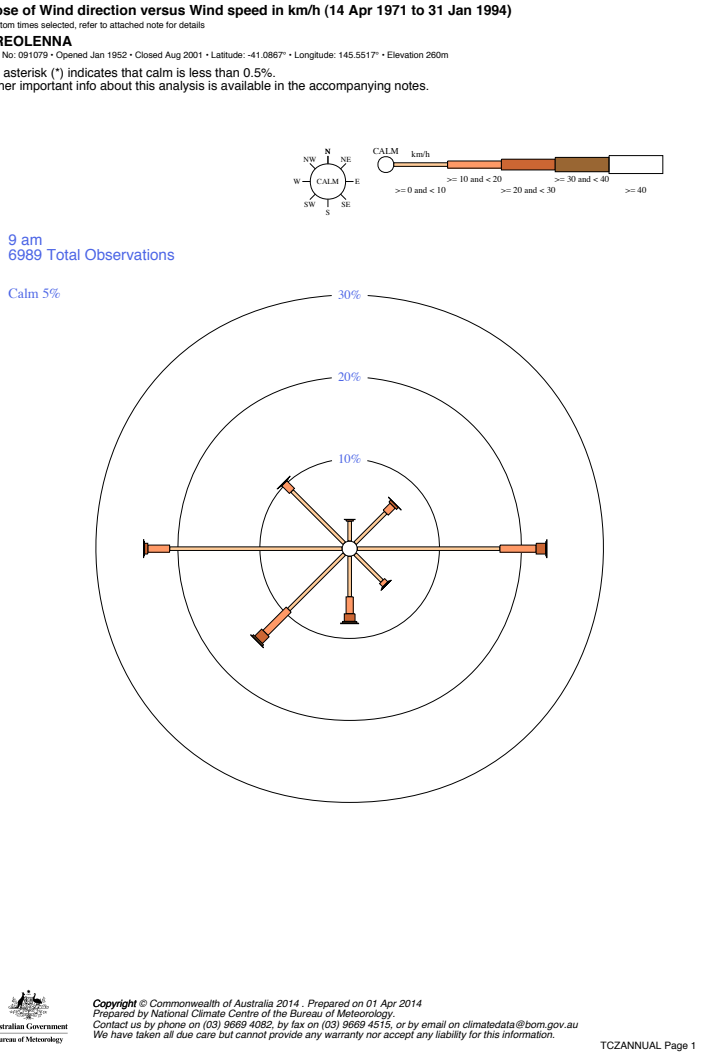


Figure 64: Bureau of Meteorology wind rose for 9 a.m. for Preolenna.

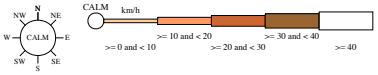
Rose of Wind direction versus Wind speed in km/h (14 Apr 1971 to 31 Jan 1994)

Custom times selected, refer to attached note for details

PREOLENNA

Site No: 091079 • Opened Jan 1952 • Closed Aug 2001 • Latitude: -41.0867° • Longitude: 145.5517° • Elevation 260m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
6859 Total Observations

Calm 2%

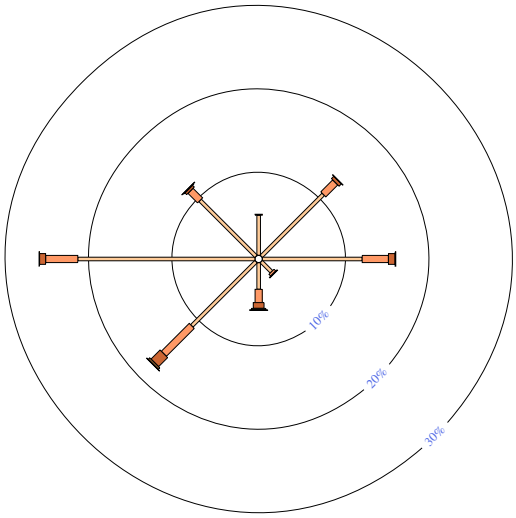


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Figure 65: Bureau of Meteorology wind rose for 3 p.m. for Preolenna

B Images from the middle Tamar, 15th October 2014

A member of the public submitted three images to the EPA of the middle Tamar valley under smoke on the late afternoon of the 15th of October 2014. One image was presented in Figure 1. Two other images obtained at that time are presented here.

Figure 66: Smoke in the middle Tamar Valley, taken on the late afternoon of the 15th of October 2014, looking generally up river from Bradys Lookout near Exeter. The photograph was submitted to the EPA by a member of the public.

Figure 67: Another view of smoke in the middle Tamar Valley, taken on the late afternoon of the 15th of October 2014. The photograph was submitted to the EPA by a member of the public.