THE WIND IN A BROAD VALLEY - THE LATROBE VALLEY OF VICTORIA

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Introduction

Data on wind direction and speed at chimney top are essential for wind loading design and for determination of the chimney height necessary to meet air quality objectives. In Victoria, the latter requirement is detailed in a recently released procedure (EPAV 1985). For strong winds, small chimneys and flat terrain there is little difficulty in determining a representative wind at a height of 10m above ground level and extrapolating these wind data to the heights of interest. However, for the Latrobe Valley and the tall stacks of the State Electricity Commission of Victoria extrapolation techniques often fail in all but strong winds.

The Latrobe Valley is situated near the southern extremity of the Great Divinding Range and runs east-west some 100 km. It is approximately 30 km wide with the floor at an elevation of 50 to 100m (Fig.1). The Range to the north rises to typically 1000m with a coastal range to the south rising to typically 500m. The Valley opens out to the sea to the east, and is only weakly delineated to the west, with the floor rising to 200m near Warragul.

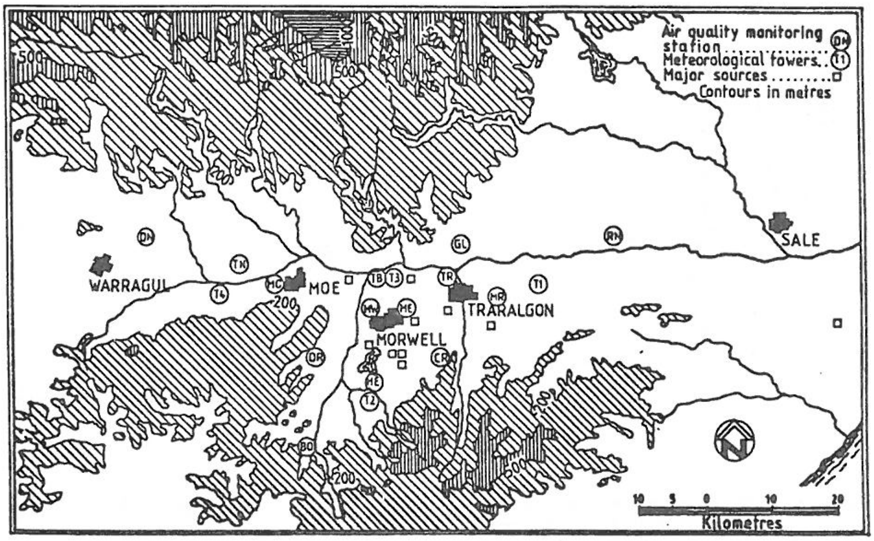

Figure 1. Latrobe Valley Air Monitoring Network.
Air Quality Stations: DN Darnum North; DR Driffield; BO Boolarra; HE Hazelwood Estate; CR Clarkes Road; GL Glengarry; TN Trafalgar North; MW Morwell West; TB Thoms Bridge; RN Rosedale North; MR Minniedale Road; MO Moe; TR Traralgon; ME Morwell East.
Meteorological Towers: T1 Flynn; T2 Yinnar; T3 Thoms Bridge; T4 Trafalgar.

To help meet Airshed Study objectives regarding air quality climatology and pollutant dispersion modelling, the Latrobe Valley Air Monitoring Network has been progressively installed over the period 1979 to 1983. It consists of 14 surface air quality stations and 4 110m meteorological towers which log data (Table 1) each minute under the control of a central computer. These data are processed and stored on magnetic tape. The primary data file consists of validated 1h average values, but 1 min values in raw form are also available. Each parameter at any station or tower can be interrogated at any time from one of four remote terminals. The air quality instruments are checked amd calibrated automatically at midnight, and all instruments are regularly serviced and undergo periodic reference calibrations by SEC and EPA staff (Laws-Herd 1984).

Other data include radiosonde ascents from Minniedale Road for the periods April 1975 to April 1977 and December 1983 to March 1986, and acoustic sounder data, both facsimile and Doppler, for various periods. Four 2-week

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intensive study periods comprising the Latrobe Valley Plume Tracking Experiment are presently underway (June 1984, March 1985, August 1985, February 1986) and these are giving additional upper air data, including direct measurements by aeroplane, of plume properties.

Table 1. LVAMN Measurements

(a) Air Quality Stations

Parameter	Height above Ground (m)	Stations
Nitrogen Oxide	3	All
Nitrogen Dioxide	3	All
Sulphur Dioxide	3	All
Ozone	3	Most
Carbon Monoxide	3	Towns only
Airborne Particulate Matter	3	All
Dry Bulb Temperature[1]	1	All
Wet Bulb Temperature[1]	1	All
Wind Speed	10.4[2]	All
Wind Direction	10.4[2]	All
Total Solar Radiation	2	Some
Ultra Violet Radiation	2	Some
Hi Vol Dust Sampler	2	All

(b) Meteorological Stations

Parameter	Height above Ground (m)[3]			
Air Temperature	10	25	50	110
Wind Speed	"	"	"	"
Wind Direction	"	"	"	"
Vertical Velocity	"	"	"	"
Dew Point Temperature	"			"
Rain Fall		Ground level		
Solar Radiation		"		
Net Radiation		"		
Soil Heat Flux		"		
Soil Temperature		"		

1. Stephenson's Screen. 2. Average, except Minniedale Road (13.1m), Moe (15.7m), Traralgon (15.8m).
3. Morwell West levels are 4,8,16,35m.

Winds Climatology

Consider, for example, the cumulative wind rose for all hours shown in Fig.2. The prevailing wind is westerly due, in part, to the phenomenon of channelling of the synoptic wind field. For strong winds extrapolation to around 1000m may be sufficiently accurate for some purposes, but upper level wind direction is crucial in determining air pollutant impact on particular localities and, as Fig.3 shows, this can be quite different on many occasions in the early morning.

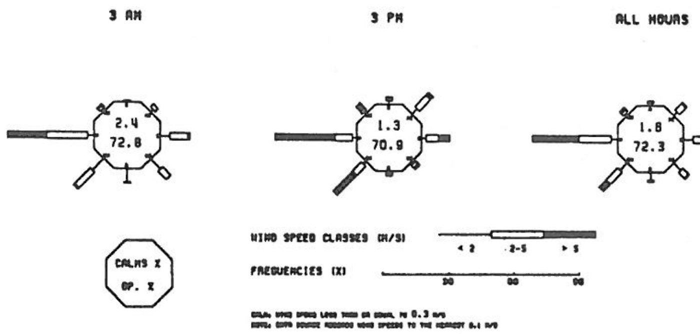

Figure 2. Cumulative wind rose for all hours obtained at Minniedale Road Air Quality Station for the period September 1979 to February 1985.

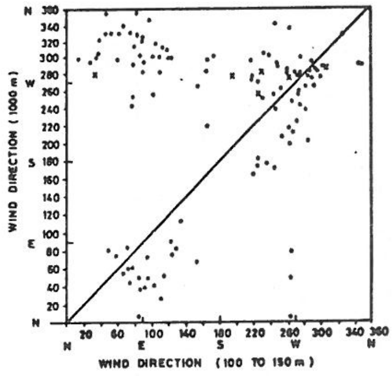

Figure 3. Relationship between wind direction in the layer 100 to 150m, and the wind direction at 1000m above the Minniedale Road Station at approximately 0800h over the period 1975-1977.

As discussed by Hoy (1985), the morning wind directions shown in Fig.3 at the levels of 1000m and 100m disagree by at least ±90° on 32% of occasions. The majority of these show typically upper-level north-westerly winds with lower-level easterly winds. Hoy concluded from his study that a three-level flow pattern is suggested on these occasions, with slope or drainage flows in the height range 10m to possibly 100m, an intermediate low-level easterly flow pattern above these from about 100m to possibly as much as 700m, and the large scale flow becoming predominant above this level. The low-level easterly flow is generally isolated from the overlying north-westerly wind by a temperature inversion and the strength of the flow is proportional to the synoptic pressure gradient.

There is no obvious single reason for the strong changes of wind direction with height shown in Fig.3. Hoy (1985) contends that it is usually associated with a lee trough - turning at lower levels due to Coriolis restoring force downwind of a long ridge, the Great Dividing Range. However, the dependence on pressure gradient indicates a role for mesoscale interaction with topography and surface roughness as well. Laboratory studies (Manins 1983) have indicated that a mesoscale eddy in the lee of the Range may also contribute on occasions when the ambient thermal stratification is signficant, much as it does for Melbourne during some easterly winds (Spillane 1978; EPAV 1985).

Thermal Influences

Consideration of upper air data from the first and second campaigns of the Plume Tracking Experiment (winter, June 1984; summer, March 1985 respectively) has shown that the degree of observed wind shear with height in the Latrobe Valley is strongly influenced by, but not determined completely by, the ambient thermal stability and this in turn depends on the strength of the upper-level winds and the time of day (Fitzgerald 1984).

At the risk of over-simplifying the picture, the conditions can be described in terms of a Froude Number, $F = U/NH$, where U is wind speed at about 1000m, N is the buoyancy frequency (a measure of the thermal stability, say between 100m and 1000m) and H is the height of the Range above Valley floor. F expresses the relative importance of wind mixing (U) to stabilization due to thermal stratification (NH). Thus if the conditions are characterised by large F the wind will be channelled by the topography, and wind-related problems are readily describable. If F is small, the airflow pattern is complex in the Valley and changes strongly with time of day when solar heating causes boundary layer growth. Air pollution problems will be difficult, with possibilities of fumigation of pollutants trapped aloft during the mornings and recirculation of pollutants in the Valley mesoscale flows during the day.

Conclusion

The Latrobe Valley Airshed Study has produced a long time-series of surface wind data at 19 stations and up to 3 km above the ground at a special-purpose radiosonde station. The winds observed are complex due to interaction of the flow with thermal stratification and the terrain. The data set and supporting documents are available for research use.

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