

# Meteorological perspectives on site selection for a rain-water composition study in the Latrobe Valley

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**Bureau of Meteorology data on rainfall in the Latrobe Valley, winds at Laverton, and winds at East Sale for calendar years 1983 to 1985 are used with wind data from four 110 m towers from the Latrobe Valley Air Monitoring Network to provide a basis for selecting sampling sites for a rain-water composition study in the Latrobe Valley. A strong preference for 900 hPa winds (24-hour average) from the 225° to 315° sector is found for rain days. This information, together with information on wind speed and aqueous-phase SO<sub>2</sub> oxidation rates, leads us to suggest that a network of five samplers would be desirable for study of rain-water composition in the Latrobe Valley, three located about 20 km to the east of the Loy Yang power station in an arc aimed at sampling wind directions from 225° to 315°, one located in the central valley region, and one to the west of the valley acting as an upwind control.**

## Introduction

The Latrobe Valley Airshed Study (LVASS) commenced in 1977 with the aims of providing data on air quality and on trends in air quality in the Latrobe Valley, and specifically on the impact of the Hazelwood and Jeeralang power stations. Over the ensuing twelve years of the Study, until its conclusion in mid-1988, a wealth of information was gathered on meteorology, photochemistry and aerosol properties in the valley. The history, brief, and achievements of the study have been summarised succinctly by Tucker (1988), with technical details covered by the remainder of the 33 papers presented at the End-of-Study Symposium (reprinted in a special issue of *Clean Air (Aust.)*, Vol. 22, No.4 (1988)).

The prime motivation underlying the LVASS was, given the location and strength of each of the major emission sources in the valley (coal-fired power stations, industrial and urban centres), to establish the meteorological, physical, chemical, biological and other factors which combine to produce high air concentrations of the pollutants SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, and APM (the latter being airborne particle matter, prescribed in terms of the defined variable Local Visual Distance (LVD)). These

pollutants, along with carbon monoxide and lead, are listed in the State Environmental Protection Policy (SEPP) as the primary indicators of air quality (Class 1 indicators), which have been given statutory values for 'acceptable' and 'detrimental' levels in the atmosphere. Consequently, the LVASS work concentrated heavily on conditions when build-up of primary emissions and secondary pollutants occurred. Typical of these conditions are autumn 'smog' periods characterised by light winds, a stable atmosphere with inversion-limited boundary layer, and clear skies which promote photochemical activity.

A notable omission from the LVASS, quite understandable given the absence of any related variable in the SEPP, was work on acidic deposition. However, given that emissions of NO<sub>x</sub> and SO<sub>2</sub> are in the range of some tens of hundred kilotonnes per annum in the valley, and might rise by a factor of 4 to 8 by the year 2005 (Marsiglio 1988), the question of acidic deposition merits some consideration (Manins 1988). To that end a small, joint study on rain-water composition in the valley has been initiated by the CSIRO and the State Electricity Commission of Victoria (SECV). The scope of this study is limited to investigation of rain-water composition at a small number of sites in the near field, within the immediate valley

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region. Long-range transport of emissions to regions outside the valley is not included at this stage.

It is important when planning such a study to ensure that the rain-water collection sites are carefully chosen. By its nature a study aimed at assessing the possibility of acidic deposition ought to seek out locations thought most likely to be impacted by such deposition. Thus a major input to choosing the site locations must come from a knowledge of relevant meteorological conditions, the aim being to place rain-water collection sites in locations most likely to be downwind of the major emission sources during rainy periods.

Despite the wealth of meteorological and related information recorded during the life of the LVASS, little is of relevance to the question of site selection for rain-water composition studies. The reason is simple: as noted above the LVASS focused quite intentionally on the 'smog' situations in which, almost by definition, clouds and rain are absent. Yet atmospheric transport and mixing processes cannot be assumed to be similar in 'smoggy' and rainy periods. Therefore it has been necessary to undertake the work described below in order to gain the necessary meteorological perspectives without which a rational selection of sites for rain-water sampling in the valley would be difficult. The point of this work is thus quite specific, and limited to the particular practical question of site selection. It is not intended to be a general and detailed meteorological analysis of rainy conditions in the Latrobe Valley.

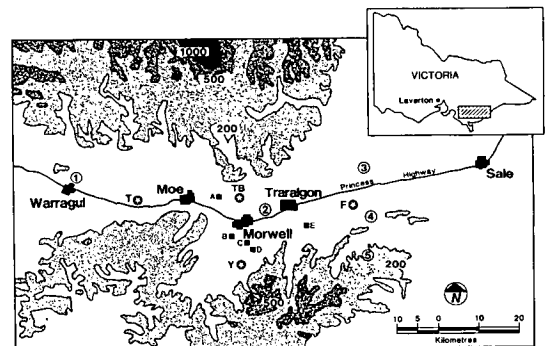
The chemical context within which this analysis is set is that the major emissions of acidic species from power stations occur as oxides of nitrogen and sulfur dioxide, which are not themselves strong acids but which are precursors of the strong mineral acids, nitric and sulfuric acids. Atmospheric oxidation of the precursor gases to nitric and sulfuric acids may occur homogeneously, in the gas phase (oxidation by OH radical), or heterogeneously, on the surface of aerosol particles or in cloud and rain drops. The homogeneous gas-phase pathways are usually slower (oxidation rates of order 1% per hour) than surface-catalysed or aqueous-phase oxidation pathways (oxidation

rates of order a few % per minute). Thus for a near-field situation such as the Latrobe Valley it is likely that rain-water acidity would be the result of either direct emissions of acids (which can occur in the case of hydrochloric acid emissions if the coal burnt contains significant levels of chloride), or from surface-catalysed or in-cloud oxidation of the acid precursors. Thus the transport of emissions to and at cloud-base level is of major interest here. Additional detail on the various acid-forming oxidation pathways is available from Calvert (1984).

## Scope of the analysis

Figure 1 comprises a map of the Latrobe Valley region with points of interest in this work identified. Table 1 contains some relevant information on the power stations which are the major point sources of SO<sub>2</sub> and NO<sub>x</sub> emissions in the valley.

**Fig. 1** Map of the Latrobe Valley showing location of power stations, and suggested locations (numbered circles) for rain-water samplers. A — Yallourn W power station; B — Hazelwood power station; C — Morwell power station; D — Jeeralang power station; E — Loy Yang power station. 110 m tower locations shown as stars: T — Trafalgar; TB — Thoms Bridge; Y — Yinnar; and F — Flynn. The 900 hPa data used came from the Bureau of Meteorology's observations at Laverton and East Sale.



**Table 1.** Data for Latrobe Valley power stations (W. Fitzgerald, private communication 1989).

Power station	Stack height (metres)	Installed capacity (megawatts)	Power produced 7/88-6/89 (GWh)
Loy Yang A	260 (2 stacks)	2000	14699
Yallourn W 1/2	168 (2 stacks)	700	3531
Yallourn W 3/4	165 (1 stack)	750	5215
Hazelwood	137 (8 stacks)	1600	8442
Morwell	92 (4 stacks)	100	837
Jeeralang (gas turbine)	32 (7 stacks)	400	548

Two specific questions form the focus of this investigation: in general is there a preferred direction in relation to the major sources in which rain-water collection sites should be located?, and at what distance downwind from the sources should the collection sites be located?

Answers to these questions are sought using historical meteorological data available from the National Climate Centre (NCC) of the Bureau of Meteorology, and the Latrobe Valley Air Monitoring Network (LVAMN). Specifically, wind information at a level near cloud base, wind information near the surface, and rainfall data from several sites in the valley are combined so as to yield the required meteorological perspectives.

## Data used

The three calendar years from 1983 to 1985 were selected for study as the required data were readily available for this period (data for later years were not available on PC-compatible computer disk). A record length of three years was chosen arbitrarily as providing a data file small enough to be easily manipulated, but large enough to avoid gross bias should an individual year be meteorologically very non-typical. Table 2 contains a summary of the data records used and their source. The broad aim was to use the wind data to

assess whether on rain days there is any preferred direction in which emissions would be transported horizontally during the period after emission prior to ingestion into cloud or rain. Additional transport in-cloud can be expected for emissions ingested into cloud elements that do not immediately produce rain.

The 900 hPa winds, with data available for Laverton and East Sale, were chosen as representing a level typical of cloud base and the lower levels of cloud, based on data (most unpublished) which we have obtained during airborne field work over the sea and the Victorian and Tasmanian coastal regions in 1981, 1983 and 1986 (some of the data were used by Mossop (1985); Gillett and Ayers (1988); and Berresheim et al. (1990)). This level corresponds to an altitude close to 1000 m above MSL. Near-surface wind information was obtained from the four LVAMN meteorological towers which are each 110 m in height above the valley floor, with the floor at 40-90 m above MSL. From the stack height data in Table 1, and acknowledging the buoyancy of the power station plumes ensures that effective emission height can be twice or more stack height (e.g. see Manins et al. 1988) it can be seen that prior to incorporation in clouds or rain the emissions from the major point sources should be confined mostly within the interval defined by these two wind levels.

The procedure adopted was to use the daily rainfall data from the six sites listed in Table 2 to

**Table 2. Sources of data. Data used cover calendar years 1983-1985.**  
(a) Rainfall data (from NCC)

<i>Site</i>	<i>Latitude</i>	<i>Longitude</i>	<i>Altitude (m)</i>
Hazelwood SEC	38°18'	146°23'	85
Morwell Post Office	38°14'	146°24'	82
Trafalgar	38°13'	146°09'	50
Warragul Post Office	38°10'	145°56'	116
Yallourn SEC	38°11'	146°22'	154
Yarragon	38°13'	146°05'	82

(b) 110 m winds (LVAMN towers)

<i>Site</i>	<i>Latitude</i>	<i>Longitude</i>	<i>Base alt. (m)</i>
Flynn	38°12'	146°40'	56
Thoms Bridge	38°11'	146°24'	40
Trafalgar	38°12'	146°09'	61
Yinnar	38°20'	146°23'	89

(c) 900 hPa winds (from NCC)

<i>Site</i>	<i>Latitude</i>	<i>Longitude</i>
Laverton	37°52'	144°45'
East Sale	38°06'	147°09'

define valley 'rain days' (a day with one or more of the six sites reporting non-zero daily rain) in the 1097 days covering the 1983–1985 period. For these rain days, daily averaged vector wind information was estimated from the 900 hPa Laverton and East Sale data, nominally available at six-hourly intervals (four per day), and from the four 110 m LVAMN tower records, nominally available as hourly averages (24 per day). Since the rainfall data are reported as totals to 0900 h, the wind data were averaged so that the end of each 24-hour period was 0900 also. This correspondence in time is not exact for the 900 hPa information, since it comes in a form most easily averaged to a 24-hour period ending at 0800. Additional uncertainty occurred on days when not all of the four daily 900 hPa wind observations were available, so that in many cases the daily average reflects only three, two, or even a single observation. For the 110 m tower winds, for which 24-hourly average values were nominally available, the daily average calculation was less affected by occasional missing data elements. However it will become apparent below that these uncertainties are unlikely to alter the outcome of the analysis. It should be added that the daily averaging is necessary because the Bureau's rainfall data are only available as daily totals. This is no constraint since it is quite consistent with the sampling strategy adopted for the rain-water composition study, which is to make daily (24-hour averaged) collections to 0900 h. Thus in what follows the term 'day' refers to the 24-hour period to 0900 h.

Data were not available for all 1097 days for a variety of reasons. In some instances 900 hPa readings were completely missing, as were some days of 110 m tower data. On some other days rainfall data were missing, or were reported as cumulative totals over two or more days. All such occasions were excluded from the analysis.

An example of the resultant partitioning of the data is shown in Table 3 for the 900 hPa data from East Sale. A rain day was defined as a day for which rain was reported from at least one of the six rainfall sites. A total of 725 out of the 1097 available days were flagged as rain days according to this criterion. As the Table shows, 73 of these days did not have valid 900 hPa data from East Sale, leaving a total of 652 days, or 90 per cent of rain days for which a daily wind direction and

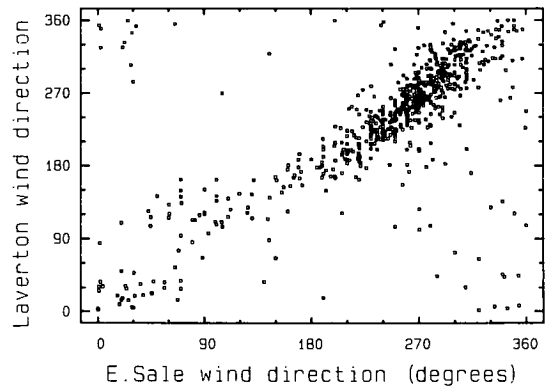
speed could be assigned. This daily wind direction was based on only a single valid wind reading in 373 cases, and between two and four valid readings in the remaining 279 cases. As noted above, the daily averages for the 110 m tower data were based on many more individual readings per day.

## Results

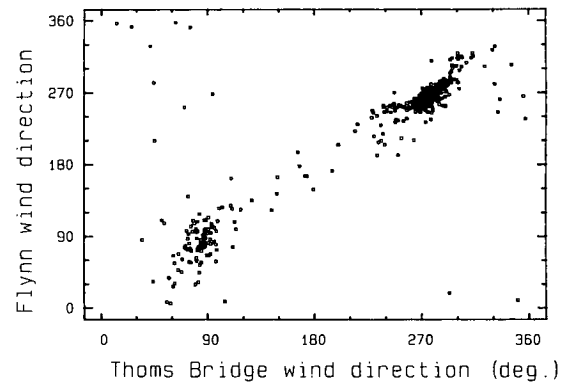
### Wind direction

Figure 2 displays a scatter plot of daily averaged 900 hPa wind direction from Laverton versus that from East Sale, for Latrobe Valley 'rain days'. Similar plots are shown in Figs 3 to 5 for the 110 m tower data, with the Thoms Bridge data as a common ordinate. Figure 6 displays a plot of the Thoms Bridge 110 m wind direction against the East Sale 900 hPa wind direction.

**Fig. 2** Daily averaged 900 hPa wind directions for Laverton plotted against those for East Sale. Data for Latrobe Valley rain days 1983–1985.



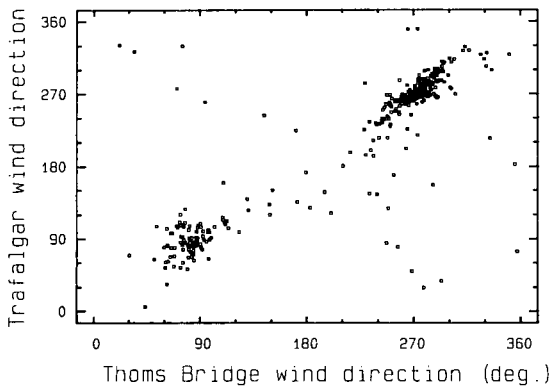
**Fig. 3** Daily averaged 110 m tower wind directions for Flynn plotted against those for the Thoms Bridge 100 m tower. Data for Latrobe Valley rain days 1983–1985.



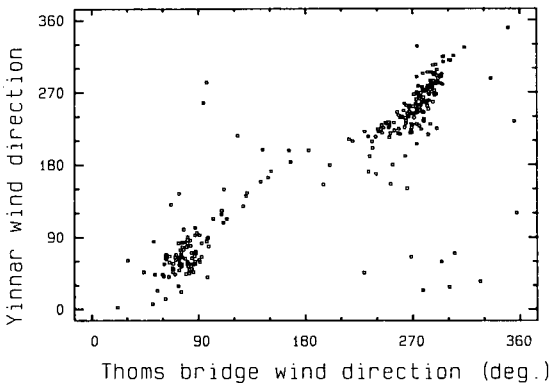
**Table 3.** Partitioning for 900 hPa East Sale wind direction data. All values shown are number of days per category. Total days with valid data = 877 out of the possible 1097 days.

	Rain at $\geq 1$ site	No rain
Valid wind data	652	137
No wind data	73	15

**Fig. 4** Daily averaged 110 m tower wind directions for Trafalgar plotted against those for the Thoms Bridge 100 m tower. Data for Latrobe Valley rain days 1983–1985.



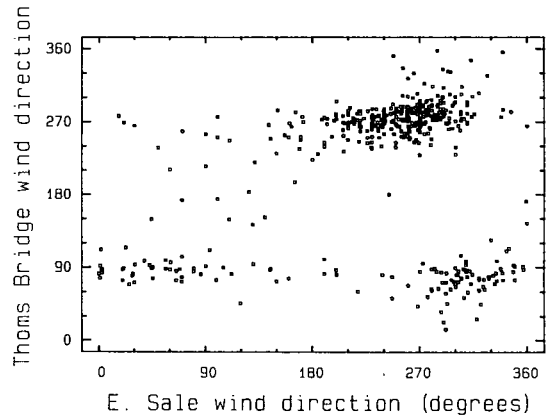
**Fig. 5** Daily averaged 110 m tower wind directions for Yinnar plotted against those for the Thoms Bridge 100 m tower. Data for Latrobe Valley rain days 1983–1985.



Figures 2 to 5 suggest that there is a mesoscale consistency in wind direction at each of the two levels: on average the 900 hPa wind direction at East Sale would serve as a reasonable estimator for that at Laverton, while the same can be said of the Thoms Bridge 110 m data in comparison with the data from the other 110 m sites. Thus the flow patterns appear to be quite consistent across the Latrobe Valley region at the two levels studied.

However Fig. 6 reveals that the east-west orientation of the valley induces a noticeable topographic steering of the 110 m wind in comparison with the 900 hPa winds. The 110 m wind direction tends to be either easterly or westerly irrespective of the 900 hPa wind direction, though with some preference for westerly 110 m wind when the 900 hPa wind is westerly. Of course there is probably

**Fig. 6** Daily averaged 100 m tower wind direction for Thoms Bridge plotted against daily averaged 900 hPa wind directions from East Sale. Data for Latrobe Valley rain days 1983–1985.



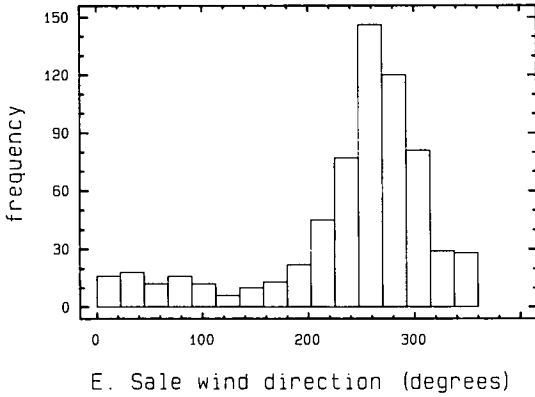
some topographic effect on the 900 hPa winds as well, for though only a small area of the ranges to the south extends above 600 m (going to 700 m at Mt Tassie) the Great Divide to the north has peaks exceeding 1000 m above MSL. However the absence of 900 hPa observations from a location within the valley makes it impossible to assess the topographic effects at 900 hPa, though it seems reasonable to presume that at this level, wind shear to the extent of easterly winds over the valley when winds at Laverton and East Sale are both westerly is unlikely.

Figures 7 and 8 display wind direction frequency distributions on rain days for the 900 hPa East Sale winds and 110 m Thoms Bridge winds. From Fig. 7 a very clear preference for winds from the westerly sector on rain days is evident. From Fig. 8 there is also a clear preference for westerly winds at 110 m, but the topographic steering discussed above produces an additional and quite significant second preferential direction centred on the easterly sector. These results accord well with the study by Hoy (1986) on the relationship between upper winds and mesoscale lower easterlies in the Latrobe Valley.

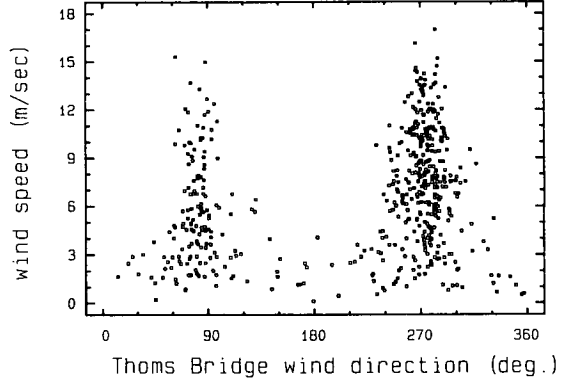
#### Wind speed and rainfall

Plots of wind speed versus direction on rain days are given for the 900 hPa East Sale data in Fig. 9 and the 110 m Thoms Bridge data in Fig. 10. The range of speeds is similar in the two plots, with most points distributed across the range from about 2 to 20 m s<sup>-1</sup>. There may be some association between higher wind speed and westerly wind direction at both levels, and for the range to extend to higher values at the 900 hPa level, but these features are not strong. Thus, broadly speak-

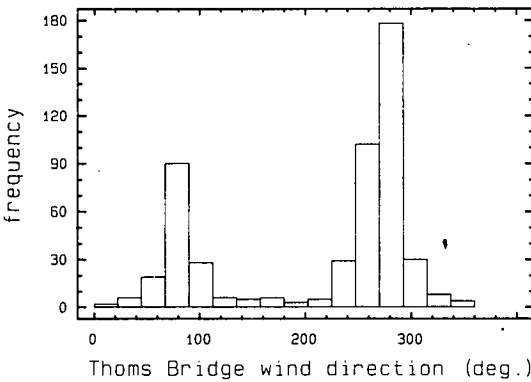
**Fig. 7** Wind direction frequency distribution, daily averaged East Sale 900 hPa winds, for Latrobe Valley rain days 1983–1985.



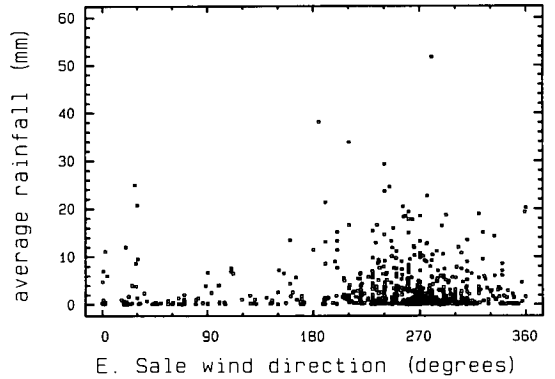
**Fig. 10** Wind speed versus wind direction, daily averaged Thoms Bridge 110 m tower winds, for Latrobe Valley rain days 1983–1985.



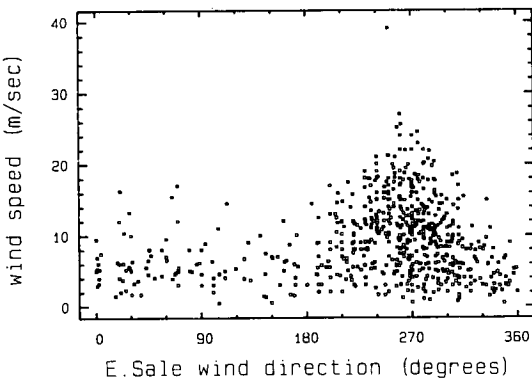
**Fig. 8** Wind direction frequency distribution, daily averaged Thoms Bridge 110 m tower winds, for Latrobe Valley rain days 1983–1985.



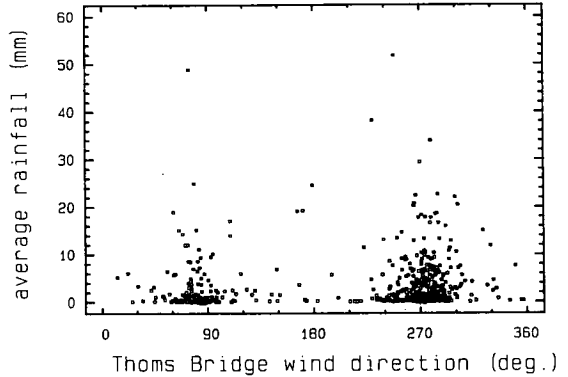
**Fig. 11** Daily rainfall versus daily averaged wind direction, East Sale 900 hPa winds, for Latrobe Valley rain days 1983–1985.



**Fig. 9** Wind speed versus wind direction, daily averaged East Sale 900 hPa winds, for Latrobe Valley rain days 1983–1985.



**Fig. 12** Daily rainfall versus daily averaged wind direction, Thoms Bridge 110 m tower winds, for Latrobe Valley rain days 1983–1985.



ing the wind speed distributions appear similar at the two levels except for the partitioning of the 110 m data into the two distinct, preferred wind directions, while most of the 900 hPa data fall within the westerly sector.

The most relevant feature of the plots of daily rainfall against wind direction shown in Figs 11 and 12 is that the higher rainfall events ( $> 10$  mm per day) occur predominantly for westerly 900 hPa winds, but once more this preference is split amongst the two separately preferred directions for the 110 m winds.

## Discussion

The first of the two questions listed at the outset as the prime foci for this work was: in general is there a preferred direction in relation to the major sources in which rain-water collection sites should be located? The plots above, especially Figs 7 and 8, indicate clearly that on rain days in the Latrobe Valley the preferred wind direction at both 110 m and 900 hPa (1000 m) is westerly, with most daily average wind directions falling within the range  $270^\circ \pm 45^\circ$ . Thus on the majority of occasions when winds tend westerly throughout the sub-cloud layer, the relative efficiencies of sub-cloud scavenging versus in-cloud scavenging of acidic emissions are immaterial. In either case wet deposition of scavenged emissions will occur predominantly to the east of the emission source.

However, as made clear by Fig. 8 (also Fig. 6), on a significant minority of days the lower winds (110 m tower, about 190 m above MSL) may be easterly even when the upper winds (900 hPa, or about 1000 m above MSL) are westerly. Under these conditions emissions from low levels may travel to the west initially, then on some occasions back to the east when mixed up to cloud base through what must be a significant layer of shear. In this scenario, emissions scavenged at low levels by precipitation could possibly be wet-deposited to the west of the emission source, while emissions that are transported initially to the west but subsequently are mixed up to cloud base may well return to the east where subsequent precipitation could occur. Finally there are indeed a small number of occasions (see Fig. 6) when easterly winds occur at both levels, so that deposition to the west is then assured.

For emissions from the taller stacks in the valley, for example Loy Yang power station which has both the tallest stacks and the largest point source strength, it is probably reasonable to assume that the effects of topography on wind direction are smaller than at lower levels. As mentioned earlier the effective emission heights for these stacks may be twice the physical height because of plume buoyancy, so these emissions should quickly achieve a height above the valley floor comparable with or greater than the mean

height of the ranges to the south of valley (300–400 m above the valley floor). Under these circumstances it seems reasonable to assume that the frequency of occurrence of easterlies would be lower than at 110 m, in other words for these taller stacks it is presumed that the relevant direction frequency distribution would be somewhere between those of Fig. 7 and Fig. 8. Some evidence in support of this conclusion comes from the analyses of Hoy (1986), who looked specifically at the relationship between upper (1000 m) and lower (100–150 m) winds on occasions when easterlies were underlying upper westerlies in the valley. From 26 cases investigated, Hoy (1986) concluded 'that most of the (easterly) flows were less than 400 m deep with the greatest number in the 200–299 m category', although infrequently the easterly layer could extend to 700 m.

Thus in answer to the first question posed at the outset, it is concluded that a majority of rain-water collection sites for the near-field study should be located to the east of the major points of emission so as to sample rain downwind of the major source regions in the prevailing westerly winds. However it would be prudent to have some measurements to the west of the emission sources in order to sample the minority of occasions when rain in the valley is accompanied by easterly winds up to 900 hPa. Since only a limited number of sites can be supported by the joint study there is no scope for considering other possibilities.

The second question posed at the outset was: at what distance downwind from the sources should the collection sites be located? Although acidic deposition is often a regional-scale phenomenon, which at northern mid-latitudes occurs typically over length scales up to several hundred to as much as a thousand kilometres from the source regions (Schwartz 1989), the initial study in the Latrobe Valley is focused on the near-field region of the valley itself. The question then becomes: how far downwind of a given power station should samplers be located to allow sufficient transport time for significant production of sulfuric acid from the  $\text{SO}_2$  emitted? Characteristic aqueous-phase oxidation rates for atmospheric  $\text{SO}_2$  via several plausible pathways (oxidation by hydrogen peroxide; metal-catalysed oxidation by dissolved  $\text{O}_2$ ; oxidation by dissolved ozone) can be of the order 1–10% per minute in moderately polluted conditions (Calvert 1984). Modelling studies involving microphysical-chemical cloud models predict significant in-cloud oxidation of  $\text{SO}_2$  over time-scales of 10–15 minutes via these pathways (Ayers and Larson 1990). Thus a subjective estimate might be that oxidation times of 15 minutes or more would be appropriate before sampling. Combining this time period with a median wind speed of order  $10 \text{ m s}^{-1}$  (Figs 9 and 10) leads to the conclusion that sampling sites in the Latrobe Valley should be located  $\geq 10$  km from each power station.

Finally, the question of sampler network density merits some comment. Ideally a survey of rain-water acidity in the valley would have a network of samplers spaced no further apart than the anticipated power station plume width at the given distance from any particular power station source. This would ensure that there would always be at least one rainfall sampler available to collect rain in the 'shadow' of the plume. Some perspective on the grid spacing required to achieve this in the Latrobe Valley can be obtained from the data on plume spread from the Loy Yang power station discussed by Carras and Williams (1988). Of course it must be acknowledged that this perspective can only be qualitative because the plume width measurements discussed by Carras and Williams (1988) were not made under the rainy conditions of interest here. Nevertheless, this qualitative perspective is better than none in the absence of measured data explicitly obtained during rainy periods. These authors give the following equations for horizontal plume spread for travel times of 100 to 10 000 seconds and horizontal wind speeds of 2 to 14 m s<sup>-1</sup>

$$W_y = 4.6 t^{0.87} \text{ (neutral boundary layer)} \quad \dots 1$$

and

$$W_y = 4.3 t^{0.85} \text{ (convective boundary layer)} \dots 2$$

where  $W_y$  is plume width in metres and  $t$  is travel time in seconds. Table 4 contains calculated plume widths for  $t$  ranging from  $0.5 \times 10^3$  to  $4 \times 10^3$  seconds, corresponding to sampler distances of 5 to 40 km downwind for a 10 m s<sup>-1</sup> wind speed.

**Table 4.** Plume widths calculated according to Eqns 1 and 2; plume width  $W_y$  in km, travel time in seconds.

	Travel time			
	$0.5 \times 10^3$	$1 \times 10^3$	$2 \times 10^3$	$4 \times 10^3$
$W_y$ (neutral)	1.0	1.8	3.4	6.1
$W_y$ (convective)	0.85	1.5	2.8	5.0

The table suggests that to ensure sampling of plume-affected rain by at least one site in the network at distances of order 10–20 km downwind of the source, spacing of rain-water samplers would need to be no more than about 5 km, preferably less. It is interesting to note that exactly this spacing (5 km at 15 km downwind) was chosen by Granat and Rodhe (1972) in a study of the near-field effects of the Stenungsund power station on precipitation acidity on the Swedish west coast.

However a density of one sampler per 5 km at 10–20 km distance from all the Latrobe Valley power stations would require many more sam-

plers than can be supported financially by the joint CSIRO-SECV rain-water composition project (again as an example we can cite the Swedish study of Granat and Rodhe (1972), which required the use of 78 samplers). Thus in the Latrobe Valley Rainwater Composition Study (LVRCS) the sampling objective cannot be to ensure sampling of rain-water which has had contact with the power station plumes no matter what the wind direction. Instead we suggest that the need to sample a representative number of occasions in which the power station plumes pass over a rain-water sampling site might best be achieved with five sampling sites (however financial constraints have actually limited the LVRCS field work to four sites).

This suggestion of five sites hinges on the data presented in Figs 7 and 8, which show the predominance of winds from  $270^\circ \pm 45^\circ$  at cloud level on rain days. The five locations suggested are shown in Fig. 1. The rationale behind this choice of locations is as follows: three of the five sites form an arc at the eastern end of the valley, about 20 km downwind of the Loy Yang power station and 35–40 km downwind of the other power stations, and about 15 km apart, so as to intercept emissions transported by the most common rain day wind directions of  $270^\circ \pm 45^\circ$ ; one site in a central valley location acts to distinguish any effects from the power stations to the west from those of Loy Yang to the east, which will not affect this site in the most common westerly winds (this situation is reversed for easterly wind occasions); the last site to the west of all power stations acts as an upwind control, revealing any advective input of rain-water acids not of power station origin, for example from the Melbourne airshed (again this station would take on the opposite character of a downwind station on the less frequent occasions of rain in easterly winds). The four-site compromise actually adopted in the LVRCS involved omission of site five.

It is pertinent to add that Carras and Williams (1988) also give an equation of the form

$$W_z = 25 t^{0.6} \text{ (neutral boundary layer)} \dots 3$$

as the best fit for the extent of vertical plume spread measured for Loy Yang power station in February 1986. This equation confirms that, in the conditions studied, for winds of order 10 m s<sup>-1</sup> the plume would indeed be mixed to a cloud base at 1000 m well before plume travel to a site located about 15 km downwind.

## Conclusions

Rain days in the Latrobe Valley for the years 1983–1985 have been characterised as having a strong tendency towards 24-hour averaged 900



hPa wind direction from the quadrant between southwest and northwest. This result, added to a consideration of the 900 hPa wind speeds and aqueous-phase oxidation times for atmospheric SO<sub>2</sub>, leads us to suggest that a network of five sampling sites would be desirable for assessment of the effects, if any, of power stations on rain-water composition in the Latrobe Valley. We suggest that three of these sites be located at the eastern end of the valley in an arc so as to sample the range of preferred wind directions between 225° to 315°, while one of the remaining two sites be located in the central valley area and the other be located to the west of the valley to serve as an upwind control. However, financial constraints have dictated that the LVRCS field work commence with only four sites.

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