Trends in the Victorian Wind Climate

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Introduction

The authors have investigated longer-term wind patterns throughout Victoria. Trends in wind climate could have wide-ranging effects on the design of buildings and infrastructure including natural ventilation characteristics of buildings, building structural loads and outputs from wind farms. This study has analysed wind records from a number of Victorian weather stations to determine whether there are discernable longer-term trends in the climate record. The study has attempted to minimise certain measurement variables, such as variations in the terrain surrounding a measurement location, which can have a significant effect on measured wind speeds.

Weather Station records from the Australian Bureau of Meteorology have been obtained. Weather stations with longer continuous records and relatively unchanging surrounds were selected to be analysed. The Cape Otway weather station is a good example of this, with a continuous record starting in 1861 to the present. The weather station is located on an exposed promentary in Bass Strait and the surrounding terrain is the cliffs and sea through approximately 240° and open country terrain through the remaining 120°. This exposure has been assumed to have remained relatively unchanged since the inception of the weather station.

Wind climate data from several weather stations were analysed to give values of annual hourly mean, median, standard deviation and maximum wind speeds. Annual average kinetic wind energy was also calculated

Source DATA

All data used in this study have been obtained from the Australian Bureau of Metorology [1].

Nine weather stations were chosen from 242 available records in Victoria. The stations were chosen on the basis of having continuous records over 40 years in length to the present and having been unlikely to have experienced a significant change in surrounding terrain (general vegetation and built environment within a radius of 20km).

The data selected for this study is hourly mean wind speed records. The "hourly" mean is nominal only, being, in fact, a 10 minute mean which, depending on the instrumentation, may be an estimated mean.

The data from these stations is considered to be of high quality, however, as stated in Bureau documentation [1], "...a reduction in the (apparent) wind speed can be caused by a number of factors including:

- Deterioration of the anemometer
- Change in the vegetation or buildings surounding the station
- A change in observer....."

Deterioration of the anemometer

No attempt to allow for the deterioration of the anemometer has been made in this study as the authors have no information regarding appropriate corrections for this effect.

Change in Surrounding Vegetation or Buildings

The study has attempted to negate possible changes in the vegetation or buildings surrounding the weather stations by selecting stations for which changes to the surrounds in the past 50 years appear unlikely to be significant. For example, data from the Melbourne Regional Office weather station (located at the northern edge of the Melbourne CBD) has not be included in this study as the surrounds have

clearly changed significantly in the past 50 years. The Nhill weather station data is an example of the type of exposure sought in this study. Although the township would have expanded over the past century it is entirely low rise. There is open country leading up to the anemometer through 270°. Some deforestation may well have occurred during the record period, however, records appear to suggest a decreasing exposure to wind (refer to Figure 2).

Changing Observers or Instrumentation

The study has attempted to reduce the effects of changing observers or instrumentation by selecting stations and/or periods during which the there was minimal changes to instrumentation. For example, the Nhill weather station (station number 78031) has a continuous record of nearly 100 years with no change in instrumentation (Dines Anemometer). However, the recording times at this station have changed as shown in the following table

Table 1 – Recording times at Nhill Weather Station

Record Period	Daily Recording Times	Record Period	Daily Recording Times
1910-1944	0900	1987-1995	0900 1200 1500 1800 2100
1944-1959	0900 1500	1995-2004	0900 1500 2100
1959-1985	0300 0600 0900 1200 1500 1800 2100	2004-2005	0900 1500
1985-1987	0600 0900 1200 1500 1800 2100		

The Beaufort Scale observer estimated values in early records are considered too subjective and too quantised to be of significant value and have not been included in the analyses presented in this study. This study has attempted to negate changes in observers and reduce the effects of instrumentation changes by looking, in most cases, at more recent data. In many cases, weather station records do not extend back before 1965, therefore, this study has concentrated on the last 40 years of wind data. Thus the changes in instrumenation for this study are from Dines anemometers to automatic weather stations with the changeover period being 1987-1997.

Selected DATA

On the basis of the preceeding discussion regarding changes to anemometer exposure, changing types of anemometer and length of continuous records, the following 9 weather station records have been selected for analysis in this study.

Table 2 – Selected Victorian Weather Station List

Weather Station name and number	Location Latitude, Longitude	Record Period used in this study	Weather Station name and number	Location Latitude, Longitude	Record Period used in this study
Ballarat Aero 89002	-37.5128, 143.7914	1965-2004	Mangalore Aero 88109	-36.8900, 145.1828	1965-2004
Cape Otway 90015	-38.8556, 143.5128	1965-2004	Mildura Aero 76031	,-34.2306, 142.0839	1965-2004
Gabo Island 84016	-37.5678, 149.9158	1965-2004	Nhill 78031	,-36.3347, 141.6367	1965-2004
Laverton RAAF 87031	-37.8565, 144.7566	1965-2004	Toolangi 86142	-37.5708, 145.5047	1965-2004
Longerenong79028	-36.6722, 142.2992	1965-2004			

Analysis

The available data from these 9 weather stations was analysed and annual mean, median, standard deviation and maximum hourly wind speeds were computed. The annual average wind kinetic energy was also computed and is expressed in $J.m^{-3}$, i.e. the annual average kinetic energy of a $1m^3$ volume of air. The results from all 9 weather stations have been averaged in an attempt to form Victorian regional averages. It is considered that, by averaging over a number of weather stations, anomilus results at individual stations will be eliminated and overall regional trends may be observed.

Results

The results of the analysis have been divided for this presentation into results for individual weather stations and results averaged over all 9 stations.

Results Averaged Over the 9 Selected Weather Stations

Results averaged over all 9 stations in the study (Figure 1 below) indicate relatively constant conditions over the 40 year period 1965-2004. Mean and median annual wind speeds increased marginally. Standard deviation of wind speed begins to drop around the period corresponding to the introduction of the Automatic Weather Stations (1987-1997). Maximum wind speeds appear to have increased somewhat with higher variability from year-to-year in the last decade of records. Annual average kinetic wind energy appears to have increased significantly during the first 20 years of the record set and experienced a significant decline in the last 20 years.

Results For Individual Weather Stations

In contrast to the results averaged over the 9 weather stations in this study, most individual weather station records showed significant variability during the record period. Records from the Nhill Weather Station (Figure 2) indicate a relatively constant exposure to annual maximum wind speeds (middle graph) with no discernable overall trend, however, annual mean wind speed and kinetic wind energy vary widely and appear to have a periodic nature.

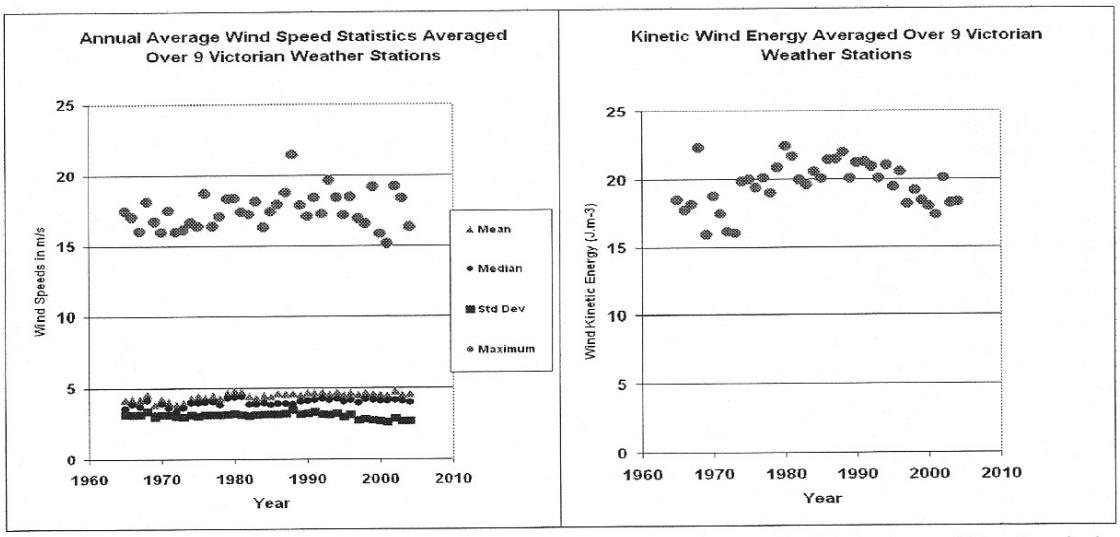

Figure 1 – Annual mean, median, standard deviation, maximum wind speeds and kinetic wind energy averaged over all 9 Victorian weather stations for the period 1965-2004.

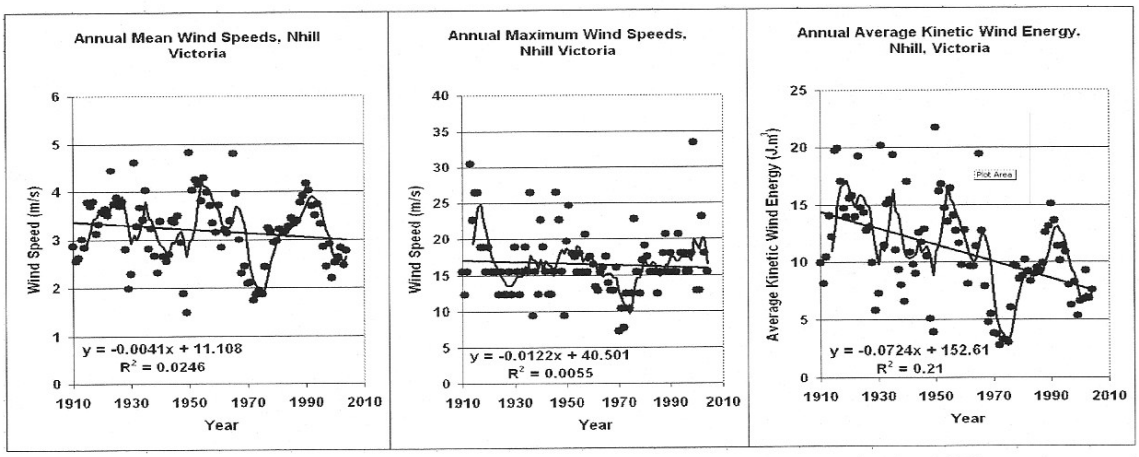

Figure 2 – Annual mean, maximum wind speeds and kinetic wind energy for the Nhill weather station for the period 1965-2004 with linear fit and 5-year moving average.

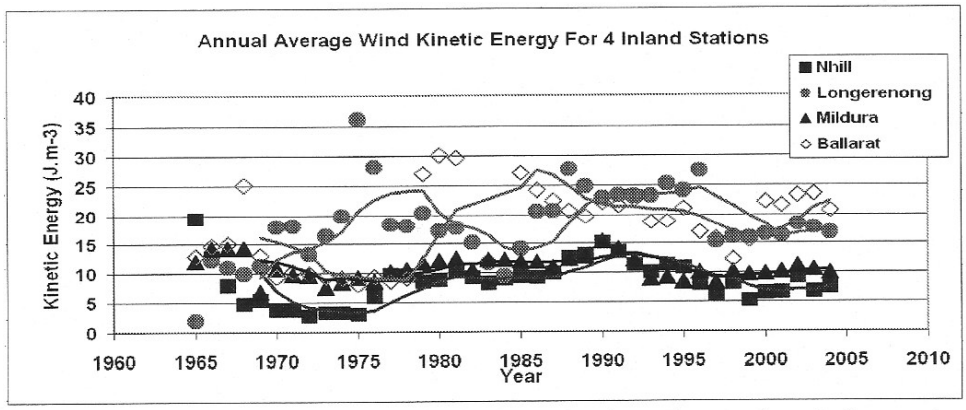

Figure 3 – Annual average wind kinetic energy for four inland weather stations in the western half of Victoria with 5-year moving average fit.

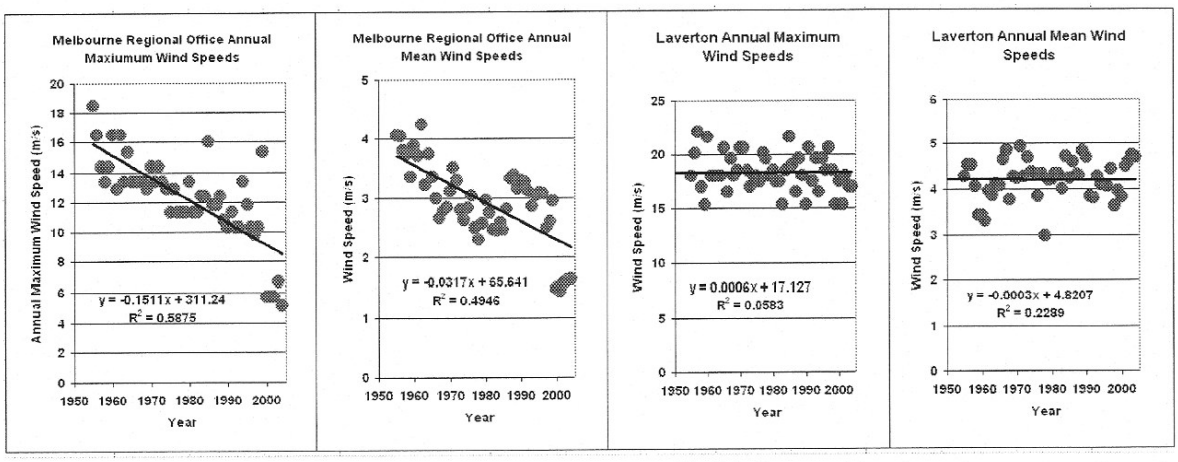

Figure 4 – Comparison of a weather station (Melbourne City) influenced by changing surrounds and a nearby weather station (Laverton RAAF) with relatively little change in surrounds during the record period. Note the Melbourne station was not included in this study for this reason.

Discussion

Whilst wind conditions averaged over all 9 weather stations in Victoria may suggest a relatively stable wind climate, winds in more localised areas appear to vary significantly from one year to the next and, in many cases, appear to have significant longer-term cyclic behaviour with periods of the order of 10 years.

It would seem that some caution is warranted when selecting wind speed records for wind climate analyses for application to building design and wind energy predictions. Whilst shorter wind speed records may be available, eg. from new weather stations with modern instrumentation, it seems reasonable to suggest that a record length of less than approximately 20 years could be quite misleading for any design purpose.

Figure 1 appears to indicate no statistically significant variation in maximum wind speeds over the past 5 decades for the Victorian region as a whole. The minor increase in maximum wind speeds presented may be explained by the much greater number of records taken by the more modern instrumentation. Figure 4 illustrates the importance of selecting a well exposed weather station for wind climate analyses.

The trends presented suggest to the authors that many measurement variables such as variations due to observer and the introduction of the Automatic Weather Stations have had a relatively small effect on the variability of wind climate records, with the major variable being the wind climate itself. This is supported to some extent by the results presented in Figure 3 which shows some significant correlation between different weather stations, particularly Nhill and Mildura.

Conclusion

Annual average wind speeds, maximum wind speeds and wind kinetic energies have been analysed for the past 40 years in several Victiorian locations. Annual averages at individual stations appear to vary significantly from year to year. Some long-period variations in wind speeds appear to be present in the records. It is assumed that such variations could be significant for developments such as wind farms. Accurate historical wind speed records appear too short to predict overall trends at this stage. This study has, to some extent, illustrated the variability of the Victorian wind climate.

References

1. Australian Government Bureau of Meteorology, 2005. Australian Hourly Wind Data, National Climate Centre, Melbourne Australia.