THE ANNUAL VARIABILITY OF AERMOD PREDICTIONS: SHOULD WE USE FIVE YEARS OF METEOROLOGICAL DATA?

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Abstract

The use of AERMOD, the new generation plume model, has grown dramatically in Australia and New Zealand over recent years. This is due in large to EPA (Environment Protection Authority) Victoria adopting AERMOD as its regulatory air dispersion model. The new requirements pose some challenges for air modellers transitioning from AUSPLUME, the most popular regulatory dispersion model in the region for decades.

Air modellers have previously used just a one year long input meteorological data file to assess air quality impacts using AUSPLUME. EPA Victoria has reinforced the use of five consecutive years of meteorological data when using AERMOD as a regulatory model. This guidance was included in their two draft guidelines published while adopting AERMOD as its regulatory air dispersion model.

The necessity of using five years of meteorological data for regulatory air modelling has been investigated in this study. All three types (Point, Area and Volume) of pollutant sources have been modelled with AERMOD using five years (2009 – 2013, 2008 – 2012) of meteorological data. The annual variability of model predictions was examined. The impact was assessed against maximum predicted values at discrete receptors.

The use of five years of meteorological data for air assessment using AERMOD has been justified in this study.

Keywords: AERMOD, AUSPLUME, Meteorology, Modelling

1. Introduction

AERMOD (US EPA, 2004) is currently treated as a new generation air dispersion model which enjoys regulatory status in many countries including Australia. It is also a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

AERMOD demands very detailed meteorology, reflecting the crucial importance of meteorology. It contains some parameters that have significant seasonal variability. There are other parameters such as the Bowen Ratio which depends on dryness or wetness of the year selected. The US EPA played a major role in developing AERMOD and was the first regulatory body to adopt AERMOD as their regulatory air dispersion model. The agency recommends using five years of meteorological data if useing AERMOD for regulatory purposes to address the aforementioned facts.

EPA Victoria, Australia (EPAV) adopted AERMOD as their regulatory air dispersion model from 1 st of January 2014. The use of AERMOD, the new generation plume model, has increased dramatically in Australia and New Zealand with this decision taken by EPAV.

AUSPLUME (similar to ISC3 in the US) was the regulatory air dispersion model in Australasia. It enjoyed regulatory status for decades. Modellers used single year meteorology for modelling.

EPAV rephrased the use of five years of meteorological data when using AERMOD for regulatory purposes in their draft guidelines published when adopting AERMOD as their regulatory model after discarding AUSPLUME. Australasian modellers who are very familiar with AUSPLUME have been somewhat reluctant to absorb this requirement and are questioning whether five years of meteorological data is necessary. In light of this argument, a scientific investigation to justify this requirement in this region is timely.

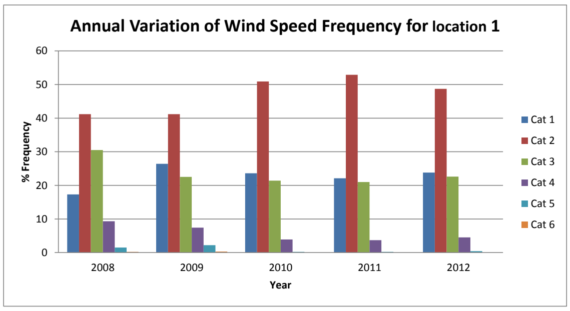
2. Methodology

AERMOD type meteorological data files (metfiles) were developed for two distinct locations in Victoria for five consecutive years (2008 – 2013). In order to avoid systematic errors, TAPM (The Air Pollution Model, developed by the CSIRO, Hurley, P.2008a), was used to simulate site-specific mandatory data (Winds and Temperature). Some supplementary data such as Net Radiation and Convective Mixing Height, were also simulated by TAPM, and used to develop metfiles following EPAV guidelines.

All three types of sources, Point, Area and Volume, were introduced with constant and monthly emission profiles. Arbitrarily selected discrete receptors (DRs) were introduced. AERMOD Version 12345 was used to run a simulation for five years for the two locations.

3. Results

3.1. Input Meteorology for Location 1



Wind Category	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Cat 6
Speed Range	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10+

Figure 1: Annual Variation of Wind Speed frequency for Location 1

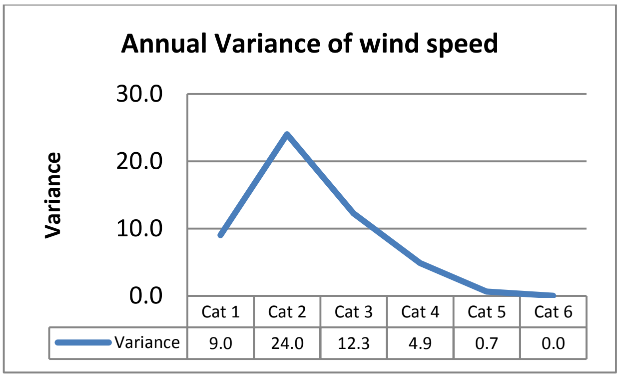


Figure 2: Variance of wind speed categories for Location 1

3.2. Input Meteorology for Location 2

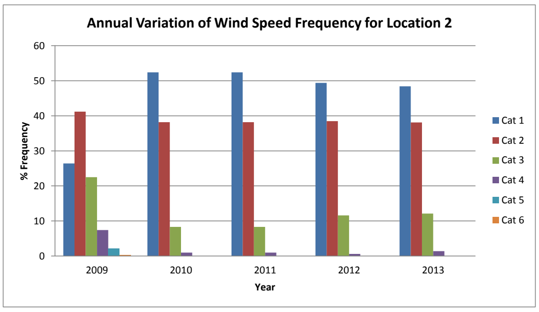


Figure 3: Annual Variation of Wind Speed frequency for Location 2

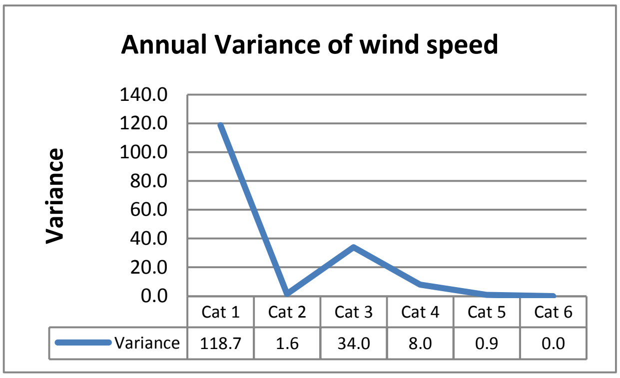


Figure 4: Variance of wind speed categories for Location 2

3.3. *Air Quality Predictions at Location 1*

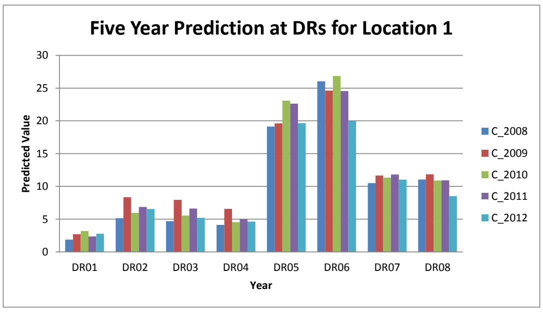


Figure 5: Five year prediction (99.9 percentile value) at selected discrete receptors (DRs) for Location 1

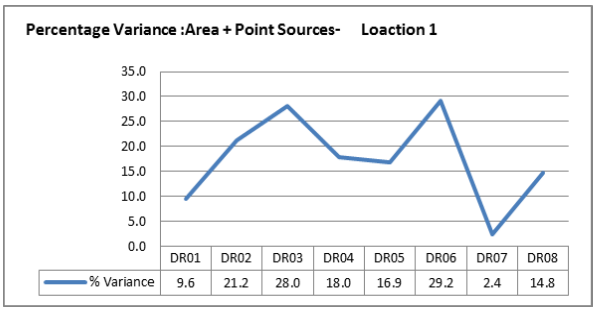


Figure 6: Percentage variance for Location 1 showing the highest variance at DR 6

3.4. *Air Quality Predictions at Location 2*

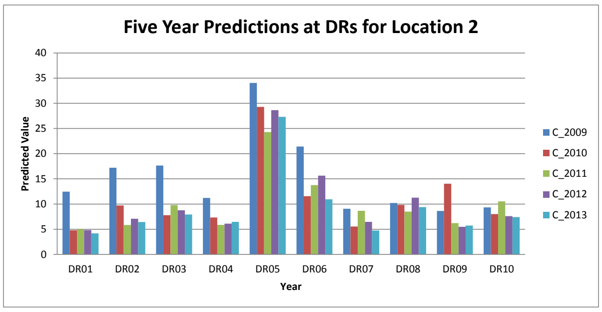


Figure 7: Five year prediction (99.9 percentile value) at selected discrete receptors (DRs) for Location 2

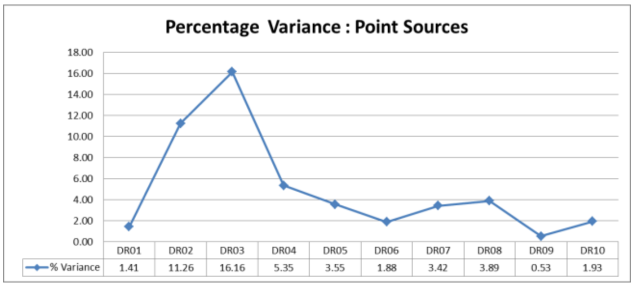


Figure 8: Percentage variance for Location 2 showing the highest variance at DR 2

4. Discussion

Scalar wind speed has been recognised as a crucial input which determines dispersion characteristics since many other scalar parameters such as U* (Friction Velocity) and L (Monin-Obukhov Length) that are used in AERMOD are dependent on scalar wind speed. Therefore, annual variations of wind speed frequencies were investigated to detect whether there are any annual variations.

This exercise clearly demonstrates that annual variations are evident even in the annual wind roses (graphical depiction of wind frequency) for both locations (Figures 1 and 2 in the Appendix). Further analysis revealed that the variances are dependent on the location. The highest variance for Location 1 is corresponding to wind category 2, while it corresponds to wind category 1 for Location 2 (Figures 2 and 4).

The air quality prediction (AERMOD V12345) results in Figures 5 and 7 clearly show year to year variations. The highest prediction (Location 1) was found to be in 2009 for receptors 2, 3 and 4, in 2010 for receptors 5 and 6, and in 2011 for receptor 7. For Location 2, the highest prediction was found to be in 2009 for most discrete receptors(DRs).

The predicted value for any single year could be 11 to 41 percent less than to the year which has the highest prediction for Location 1. This range is 30to 66 percent for Location 2.

This variation was further investigated by calculating percentage variance centring on a five year maximum. This exercise reveals that the variance is relatively high at some DRs (Figures 6 and 8).

5. Conclusions

The annual variations in scalar wind speed categories and the air quality predictions are evident. The predicted value for any single year, selected randomly could be as much as 66% less for a location. Therefore, decision making shouldn't be done based only on arbitrarily selected single year meteorology due to this fact. Instead, at least five years of meteorological data should be used to assess air quality.

References

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Appendix

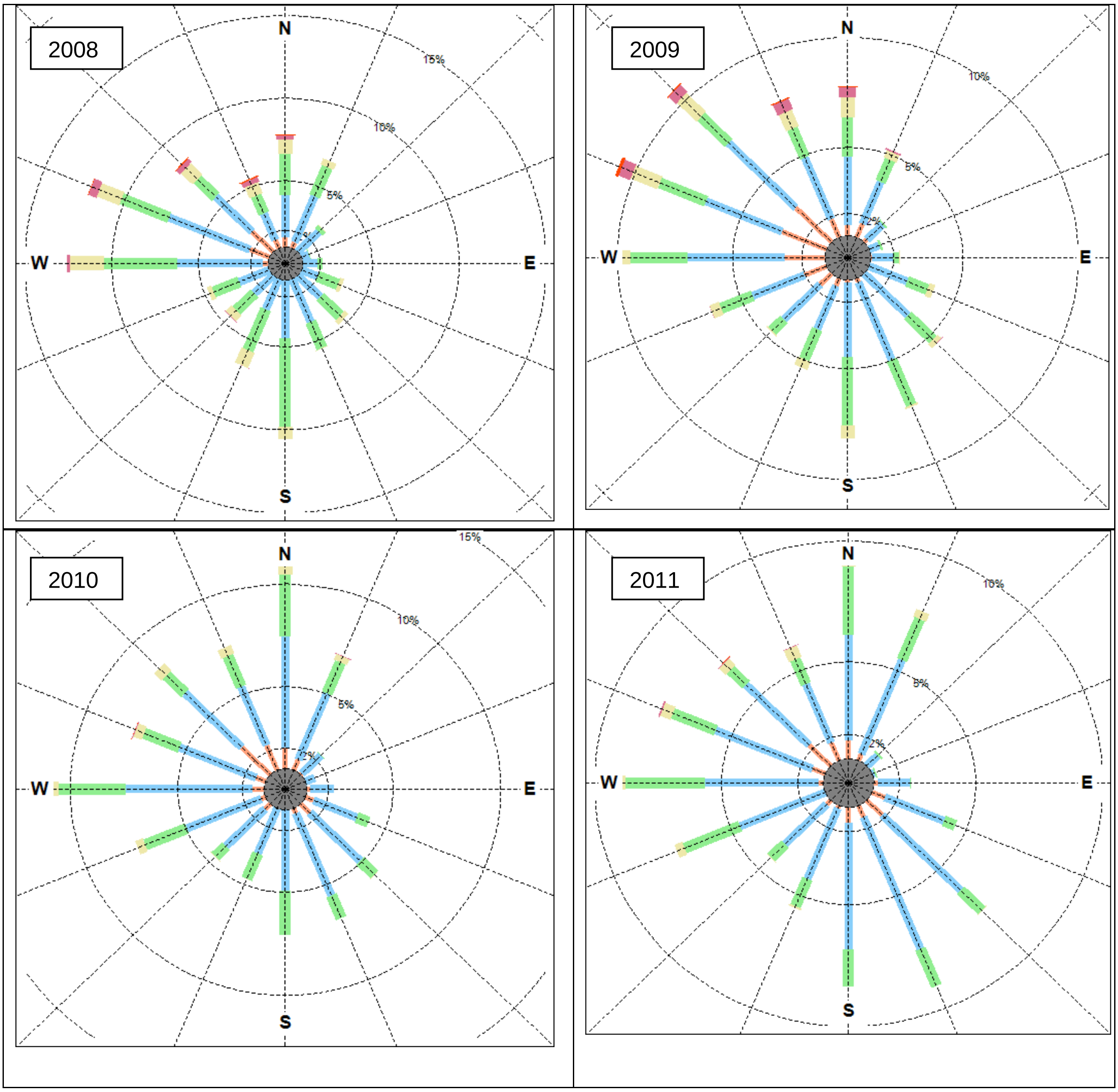

Figure 1: Annual Wind Roses for Location 1

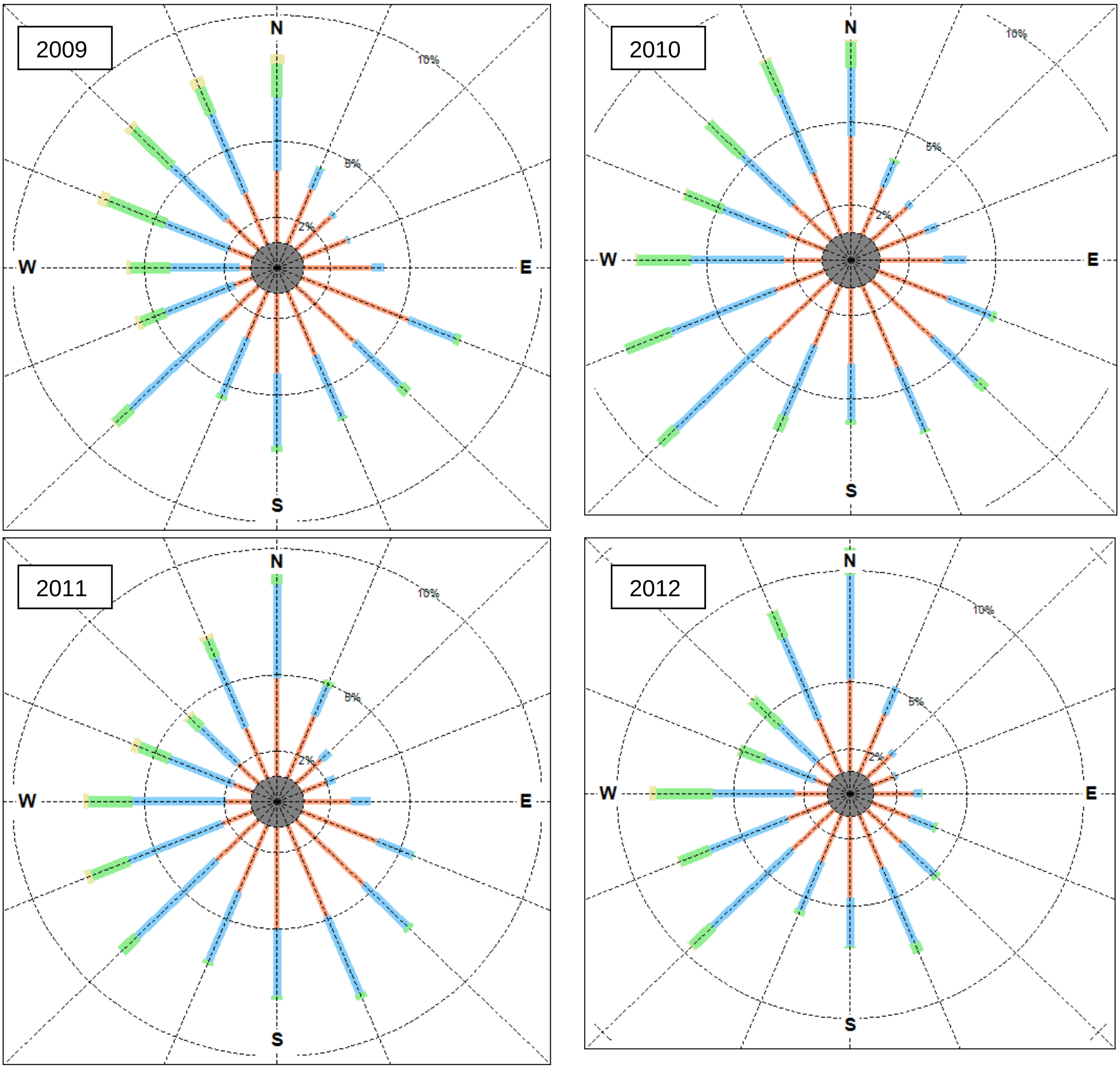

Figure 2: Annual Wind Roses for Location 2