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Investigating the sensitivity of ozone to changes in meteorology using hierarchical statistical modelling in Melbourne, Australia

J. Pearce (1), S. Walsh (2), P. Utiola (1), and J. Beringer (1)

(1) Department of Geography and Environmental Science, Monash University, Melbourne, Australia(john.pearce@arts.monash.edu.au), (2) Environmental Protection Authority, Melbourne, Australia

Introduction: The magnitude in which climate change will influence regional air quality will depend largely on the resulting impacts on local meteorological conditions. Additionally, changing patterns of atmospheric circulation at the hemispheric to global level are likely to be just as important as regional patterns for future local air quality. In order to assess these likely impacts air quality managers must first understand the current impacts of meteorological regimes on local air quality.

Methods: First, meteorological observations and air pollutant monitoring data from the Port Phillip Bay monitoring network were obtained for the period of 1997-2001from EPA Victoria and the Bureau of Meteorology. Second, a synoptic climatology of continental circulation patterns over Australia were classified into 'types' by applying a neural networking algorithm known as self-organizing maps (SOM) on ERA-40 reanalysis fields. Third, a hierarchical model was used to assess the influence of meteorological conditions on monitored air pollutant concentrations.

Results: General linear modelling with backward selection yielded temperature ($t=4.38$, $p<0.001$), relative humidity ($t=-3.03$, $p=0.003$), wind speed ($t=5.72$, $p<0.001$), and synoptic type as significant predictors for log O3, with a coefficient of determination of $R2 = 0.337$. Log O3 increases with increasing temperature and wind speed. Log O3 decreases with increasing relative humidity. Relationships with synoptic patterns show that log O3 increases when high pressure systems are to the east of Melbourne.

Discussion: Local variations seem to be influenced, to varying degrees, by synoptic-scale conditions, temperature, relative humidity, and wind-speed. Further analysis is necessary to incorporate the spatio-temporal components of the data.

Conclusion: Combining ERA-40, regional meteorological data and hierarchical statistical methods proved to be a complementary suite of tools for investigating the meteorological sensitivity of ozone in Melbourne, Australia. This analysis is crucial a step in preparing for the impacts of climate change on regional air quality.