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STATISTICAL METHODOLOGIES FOR EVALUATING AIR QUALITY CHARACTERISTICS OF AUSTRALIAN CITIES

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Summary

A broad range of tools is needed to assess and manage urban air. We have shown that detailed statistical analysis of the relatively substantial database of various Australian cities facilitates considerable insights into the spatial and temporal variability of urban air quality, beyond that determined by the usual numerical modelling. It was found that a focus on pollution-conducive synoptic types allows a much easier determination of air quality trends. Ozone (as well as fine particulate) levels are significantly increased if bushfire activity coincides with adverse meteorological conditions.

Keywords: Anthropogenic influences, urban air quality, air quality forecasts.

1. Introduction

Air quality management usually involves a synthesis of monitoring and modelling at various degrees of sophistication. Air quality guidelines often require an interpretation of extreme value statistics in the light of various expected community sensitivities. Pollution control schemes are evaluated from observed trends in information from spatially-limited monitoring networks and a variety of deterministic modelling techniques.

Urban air quality involves much greater variability in man-made emission rates, key meteorological factors and non-anthopogenic factors such as bushfires, lightning and biogenic emissions. Neither modelling nor monitoring alone are likely to be fertile avenues for testing out possible control strategies.

Relatively little attention has yet been paid to detailed statistical approaches. Available statistical toolkits include classification schemes (e.g. cluster analysis, principal components, pattern recognition techniques), predictive schemes (e.g. time series analysis, neural networks) and distribution theory (e.g. frequency distributions, extreme value statistics). Environmental parameters have a complex structure that depends on the time and spatial scales under consideration. Establishing causal links is difficult unless the allied issues of long-memory (non-stationarity) and fractality are addressed (Lunney 1995, Lovejoy and Schertzer 1990).

The major Australian conurbations are coastal cities where the local meteorology is dominated by thermal contrasts and moderately complex topography. Each city has expanded rapidly in the past 30 years and relies heavily on private rather than public transport. The city areas have become essentially islands of urbanisation within a semi-rural background, leading to an intimate air quality contact with nearby farming and forestry areas, especially for off-shore synoptic windflows. All Australian cities are strongly influenced by long-term cycles in rainfall, drought and dominant patterns of dispersion.

Future consolidation of growth may lead to large metropolitan sprawls that stretch at least 50-100 km along a coastal strip. Intra-airshed circulations are more likely to occur than the inter-airshed transport that dominates adverse European and North American situations. This relative separateness of major cities produces some fairly unusual characteristics and corresponding requirements for air quality management. In many situations, natural influences or activities normally not considered in conventional air quality emission inventories may be quite important.

Urban air quality management should identify:

- What can be controlled within an air-shed and whether alternative strategies are cost-effective. The relative roles of anthropogenic and natural emissions may differ between air-sheds and can determine the eventual success of control strategies.
- The magnitude and frequency of adverse conditions both for the overall population, and sensitive groups (e.g. elderly people in fringe coastal suburbs).
- The degree of fluctuations in emissions of all types and the consequences of meteorological variability within and between different years.
- Causal factors of the most common adverse air pollution episodes and any linkages with known emissions.

The likely trends in ambient air quality in Australian air-sheds can be estimated from:-

(a) Emission rates from regional emission inventories, assuming these will be reflected in ambient pollution levels.
(b) Numerical modelling of specific episodes employing detailed emission inventories and scenarios.
(c) Identification of statistically significant trends in air-shed characteristics from the monitoring data,