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WINDFIELD PREDICTION AND VERIFICATION FOR A VARIETY OF SITES ACROSS AUSTRALIA

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Summary

Accurate prediction of horizontal and vertical windfield structure is required for a variety of air quality and energy development assessments. Spatial and temporal interpolation of available measurements and/or numerical prognostic modelling offer practical approaches but may differ considerably when predicting near-surface conditions. This has implications for the validation of prognostic models and the dispersion treatment of normal anthropogenic pollution sources, especially in urban areas where microscale turbulence due to sub-grid scale roughness inhomogeneities may be considerable. A review of performance measures for windfield prediction suggests additional considerations beyond the normal indices, including the comprehensive treatment of synoptic weather types for a region and a weighting for information content. Extensive use of TAPM Versions 1 and 2 at a variety of inland and coastal sites suggests some initial rules to aid the non-specialist modeller.

Keywords: Meteorological model validation, performance measures, upscaling.

1. Introduction

Wind energy and air quality assessments both require the reliable prediction of near-surface meteorological parameters for locations where topographic features and land-use may be considerably different than those at the nearest monitoring locations. Both applications require the assessment of likely changes in windspeed due to perturbations in surface energy and roughness characteristics in the range from micro to macro scale. For locations well away from monitoring sites, spatial interpolation and other geostatistical techniques may be useful, dependent on the number and representativeness of monitoring stations. For remote locations in complex topographic settings, recourse is usually necessary to prognostic and/or diagnostic meteorological modelling techniques that may solve the primitive equations with a grid-based resolution of surface features. In reality, local surface conditions are unlikely to be represented by conditions at nearby monitoring sites or prescriptions used in the numerical models. This is especially important in transition areas (e.g. at the outskirts of an urban area where windflows may have either quasi-urban or quasi-rural characteristics, depending on wind direction) and in the interior of cities, forests or ranges of hills where the roughness elements give rise to a surface roughness layer (SRL) of considerable vertical extent (e.g. 30-300 m). Conventional instrumentation such as 10 m towers will then be within the SRL, and great care must be taken in the extrapolation of these measurements to higher levels in or above the SRL. On the other hand, numerical models that assume Monin-Obukov similarity or make traditional parameterisations of surface energy fluxes are unlikely to be relevant to conditions within the SRL (Rotach 1999, Belcher et al 2003).

The simplistic comparison of numerical modelling results and measurements in the lower part (10-50 m) of the boundary layer may sometimes be inappropriate. This may explain some of the recent flurry of disquiet about the varied performance of the CSIRO TAPM scheme in reproducing wind characteristics in many areas of Australasia. Other disciplines (e.g. rainfall forecasting) have emphasised that changing the scale of model output (point to area) or vice-versa may incur a "representativeness error" of up to 50% of the spatial average of the meteorological field. Recent approaches recommend multiscaling techniques (e.g. scale-recursive estimation) to downscale or upscale between point measurements and model predictions at various resolutions (Tustison et al 2003). For air quality applications, simpler techniques (e.g. hourly varying effective roughness and displacement lengths) may be adequate devices, although there is a general movement to use a combination of prognostic and geostatistical techniques.

The current paper summarises results from a large number of simulations for air quality and wind energy consultancy projects and seeks those conditions in which numerical models perform well or have quantifiable limitations. The overall aim has been to either seek correction factors for observations that will facilitate a more meaningful comparison of numerical modelling results or to change some of the input parameters to