Meteorological and Dispersion Modelling Using TAPM for Wagerup

Phase 1: Meteorology

Appendix A: Additional modelling details

Prepared for: Alcoa World Alumina Australia, P. O. Box 252, Applecross, Western Australia, 6153

Prepared by: CSIRO Atmospheric Research, Private Bag 1, Aspendale, Vic 3195; *Contact:* E-mail: ar_chief@csiro.au

Date: 14 February 2005

This is an appendix to the final CSIRO Report "Meteorological and Dispersion Modelling Using TAPM for Wagerup, Phase 1: Meteorology" (Report No. C/0986) submitted to Alcoa in November 2004. It contains additional modelling details prepared in response to questions submitted to CSIRO after the completion of the Phase 1 Report.

TAPM assumes a uniform deep soil volumetric moisture content for the whole area being modelled. Some RDA areas are treated as water bodies (see Section 3.2 of the Phase 1 Report), for which deep soil moisture content is irrelevant. Section 8 of the Phase 1 Report shows that varying the value of the deep soil moisture context within the accepted range does not change the predictions substantially and does not explain the differences between the modelled and observed meteorology.

In the meteorological modelling, the option of "rain processes" was on, and the "non-hydrostatic pressure" option was off. Scientifically, it is appropriate to invoke the rain processes, and it is now the default option in TAPM. The rainfall in the model affects the near-surface soil moisture content and evaporative fluxes, but does not influence the deep soil moisture content. The "non-hydrostatic pressure" option in TAPM is largely experimental at present, and is not as robust as the default hydrostatic option. The non-hydrostatic pressure option can cause numerical instability in some cases, and none of the previous TAPM verification studies has used this option.

TAPM is generally not capable of addressing/resolving any bolster or lee eddies, which are fine-scale processes. TAPM involves a good balance of the state-of-the-art science and the practicality of running a model (e.g. being able to carry out annual runs on a Personal Computer). Some CFD (Computational Fluid Dynamics) models may be able to resolve such eddies, but usually these models are only for neutral conditions, do not account for the diurnal cycle, are computationally more demanding and are unsuitable for annual air pollution modelling such as at Wagerup.

A.1 Topography in the model

TAPM uses two topographical datasets. For Australia-specific applications (such as Wagerup), terrain height data on a longitude/latitude grid at 9-second grid spacing (approximately 300 metres) available from Geoscience Australia (see http://www.auslig.gov.au) are used. For international applications, global terrain height data on a longitude/latitude grid at 30-second grid spacing (approximately 1 km) are used. These public domain global data are available from the U.S. Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC) (see http://edcdaac.usgs.gov/dataproducts.asp).

Topographical contours of height above mean sea level (in metres) determined based on the 300-m horizontal resolution Geoscience Australia terrain data are plotted in Figure A1 for the innermost meteorological grid domain for Wagerup. Selected key locations presented as reference on the map include the 100-m Multiflue stack of the Wagerup Refinery, the Residue Disposal Area (RDA), the Bancell Road meteorological station, and the Boundary Road ambient air monitoring station.

Figure A1 shows that the Refinery is opposite a promontory on the escarpment, with valleys cutting into the escarpment to the north and the south of the Refinery. These topographical details affect local wind speeds and wind directions.

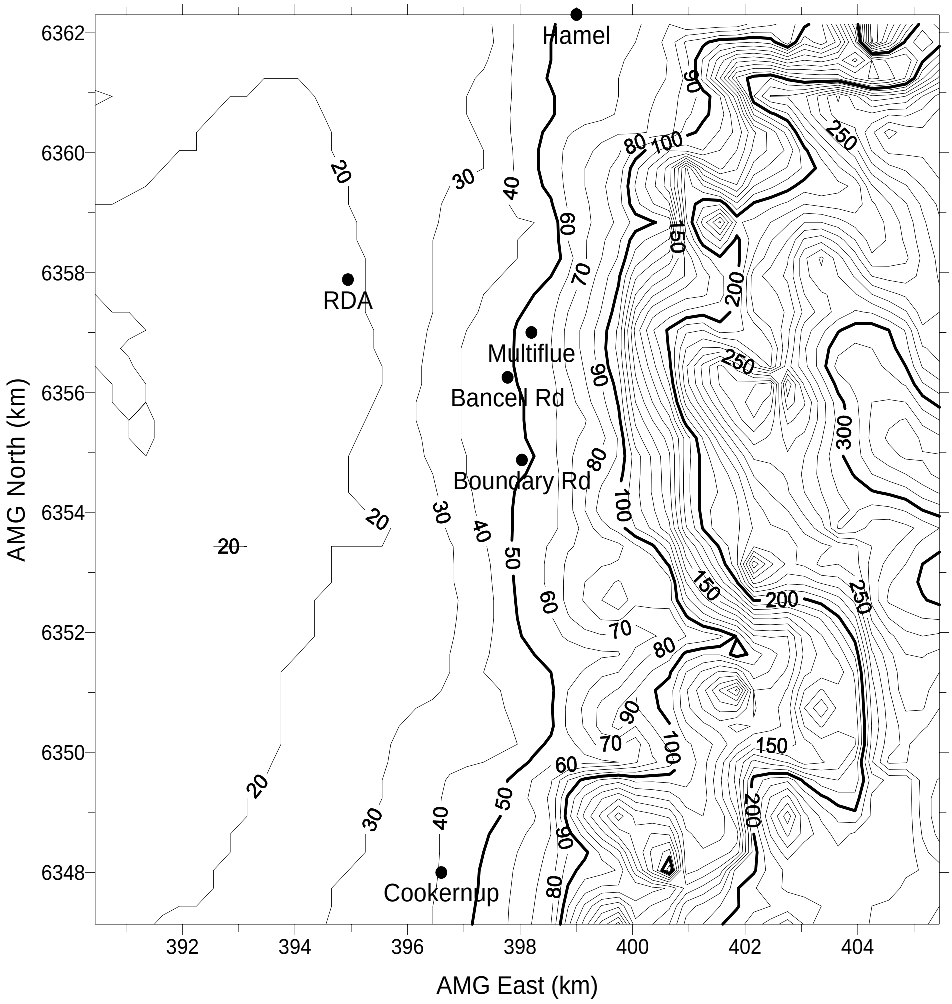

Figure A1: Topographical contours of height above mean sea level (in metres) determined using the 300-m resolution terrain data for the innermost meteorological grid domain for Wagerup. Selected key locations are presented for reference on the map.

For a coarser meteorological resolution in the model than the resolution of the topographical data, the model averages the topographical data over the meteorological grid. For Wagerup, TAPM was run with an innermost meteorological grid resolution of 500 m. Therefore, the model averaged the 300-m topographical data over the 500-m resolution. Topographical contours (in metres) calculated based on this 500-m resolution are plotted in Figure A2 for the innermost meteorological grid domain.

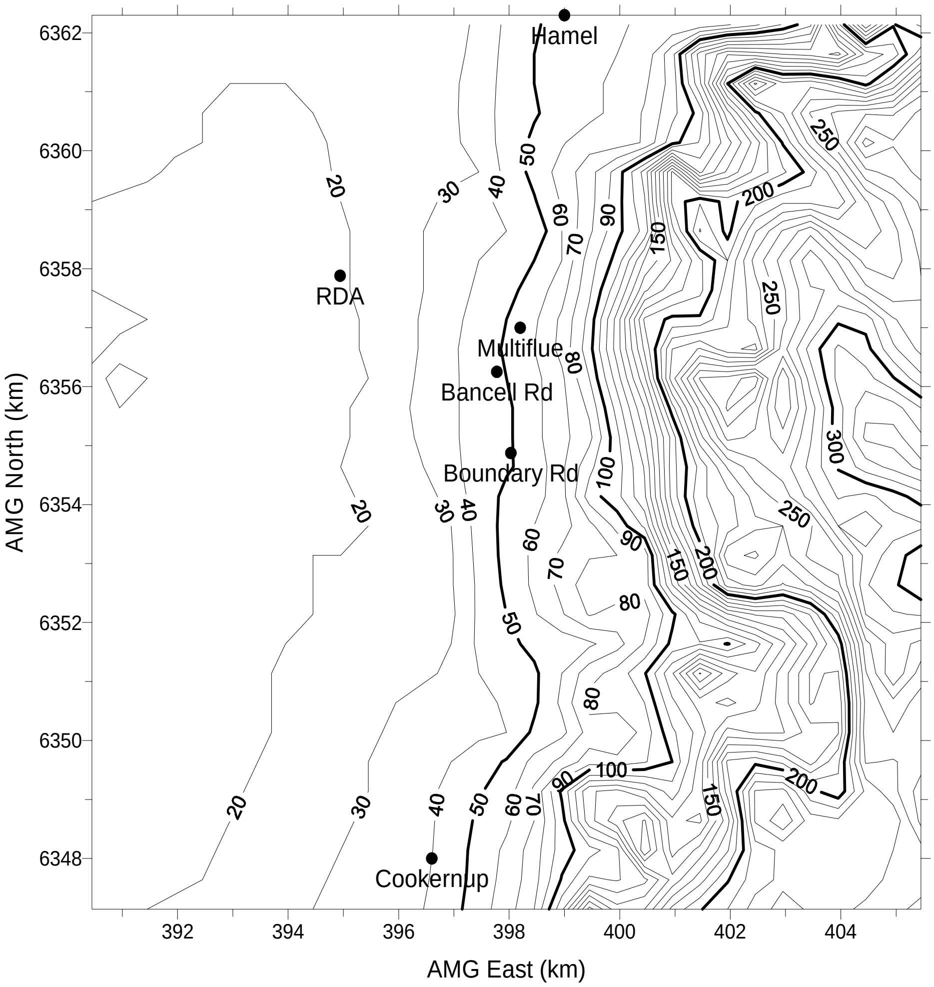

Figure A2: Topographical contours of height above mean sea level (in metres) determined using the 500-m resolution terrain data used by TAPM for the innermost meteorological grid domain for Wagerup. Selected key locations are presented for reference on the map.

A.2 Model year and inter-annual variability

The period April 2003–March 2004 was selected as the period for model simulation since it encompasses a complete, continuous winter season and a complete, continuous summer season, with the best meteorological data currently available. No previous continuous seasons were considered because new meteorological measurement systems were employed in the year 2003 (e.g. a 30-m tower, net radiation and radiosonde releases), providing extra meteorological data. However, it is instructive to examine the characteristics of the large-scale synoptic weather conditions during the model year with respect to those for other years, and to get an idea as to how large the interannular variability in synoptic meteorology is in the Wagerup region. In the Phase 3B report (CSIRO, 2005), such variability was investigated using the 6-hourly 10-m wind directions for the grid point closest to Wagerup in the Bureau of Meteorology's GASP (Global Analysis and Prediction) analyses (which are used as the synoptic input to TAPM) for the years 1997–2004. Figure A3 shows the wind direction probability distributions for these years together with that for the modelled year (April 2003–March 2004). The synoptic data were sorted into 22.5º bins centred on the directions labelled on the axis of Figure A3.

Figure 3A shows that the synoptic winds are in the southerly quadrants (i.e. south-east and south-west quadrants) about two-thirds of the time, and in the northerly quadrants (i.e. north-east and north-west quadrants) about one-third of the time. The annual variability in the frequency of each wind direction is represented by the shaded vertical bar; it is typically ±30% about the mean. The modelled year is seen to be a fairly average year, and lies within the range of variability. It is estimated that for the modelled year the frequencies of occurrence of winds from all sectors are within ±20% of the respective median values, except for the frequency of the southerly winds, which is 24% higher than the median value, and the frequency of the easterly winds, which is 33% lower than the median value.

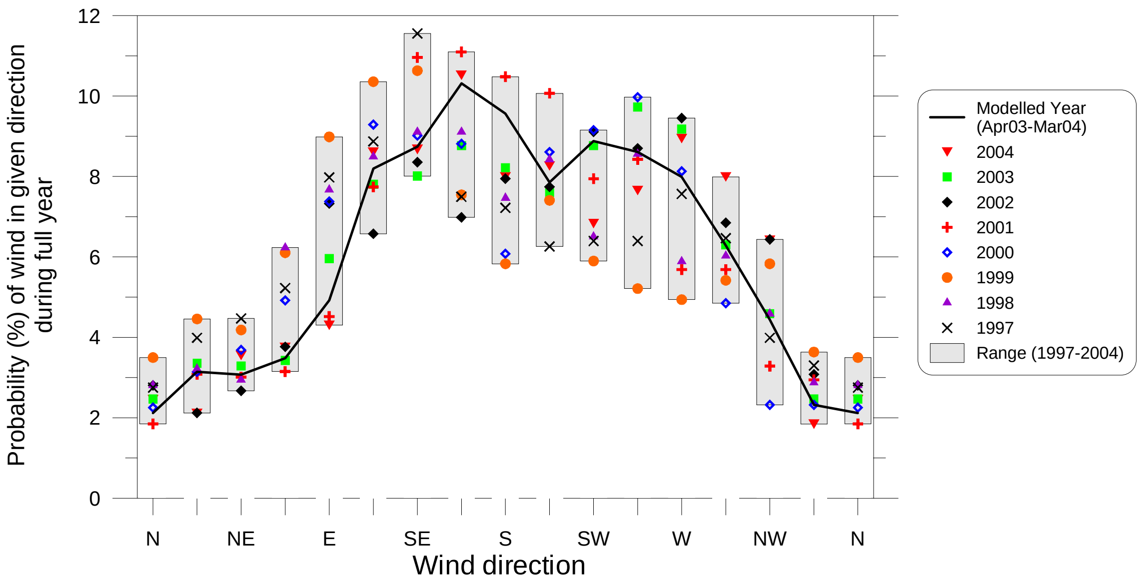

Figure A3: Probability distribution of 10-m wind directions at Wagerup for the years 1997–2004 compared with those for the modelled year (April 2003–March 2004). Data are from the 6-hourly GASP (Global Analysis and Prediction) analyses that are used as the synoptic input to TAPM.

References to Appendix A

CSIRO: 2005. Meteorological and Dispersion Modelling Using TAPM for Wagerup: Phase 3B: HRA (Health Risk Assessment) Concentration Modelling – Expanded Refinery Scenario. Draft report to Alcoa World Alumina Australia, February 2005, 133 pp.