PHOTOCHEMICAL POLUTION ASSESSMENT

TECHNICAL PAPER 5

PHOTOCHEMICAL POLLUTION ASSESSMENT OF A PROPOSED GAS-FIRED POWER STATION AT MUNMORAH

prepared for

Parsons Brinckerhoff Australia Pty. Ltd.

by

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FINAL REPORT

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Executive Summary

The impact of a proposed gas turbine addition to Munmorah Power Station on photochemical smog levels in the Sydney basin and surrounding areas has been investigated using a prognostic meteorological and chemical transport model TAPM-CTM. Four case-study days of moderate-high ozone levels were selected for modelling. These days had previously been identified as days on which emissions from power stations to the north of Sydney were transported to the Sydney basin.

The modelling results for the four events show that the maximum impact of emissions from the proposed gas turbine at Munmorah would be:

- An increase in the regional maximum hourly-averaged nitrogen dioxide (NO_2) concentration of 0.2 parts per billion (ppb), compared with existing levels of about 50 ppb.
- A decrease in the regional maximum hourly-averaged ozone (O_3) concentration of 1.5 ppb, compared with maximum levels of typically 120 ppb,
- and a decrease in the regional maximum 4-hourly-averaged O_3 concentration of 0.9 ppb, compared with maximum levels of typically 90 ppb.

In summary, emissions from the proposed gas turbine are predicted to result in no exceedences of air quality goals and standards for NO_2 and O3. Emissions from the gas turbine are predicted to have no adverse effect on concentrations of nitrogen dioxide and ozone in the Sydney basin region. In some areas outside the basin where levels of both NO_2 and O_3 are predicted to increase by up to 6 ppb, concentrations on days of photochemical activity are well below National Environment Protection Measure (NEPM) standards.

1 Introduction

CSIRO Marine and Atmospheric Research were sub-contracted by Parsons Brinckerhoff to undertake a study to investigate the impact on regional photochemical smog formation of emissions from a proposed gas turbine addition to the Munmorah power station on the Central Coast of New South Wales.

The term photochemical smog refers to a family of secondary gaseous and aerosol species which are generated through the process of photolysis and oxidation of photochemical smog precursors. The precursors to photochemical smog are oxides of nitrogen (NO_x), volatile organic compounds (VOCs) and carbon monoxide (CO). In NSW the principle component of photochemical smog is ozone. Other components of interest include nitrogen dioxide (NO_2), hydrogen peroxide, peroxyacetylnitrate, formaldehyde and aerosol nitrates.

Ozone is of particular concern in NSW because the NSW Environment Protection Authority (NSW–EPA) has observed breaches of the 1–hour and 4–hour National Environment Protection Measure (NEPM) standards of 100 ppb and 80 ppb for many years. Breaches of the 4–hour NEPM (80 ppb) in particular show little downward trend over recent years (NSW–EPA, 2003). The 1-hour NEPM standard for nitrogen dioxide is 120 ppb. Exceedances are rare, with maximum values usually no greater than 80 ppb.

This report presents results from the study, which examines potential changes to maximum ozone (O_3) and nitrogen dioxide (NO_2) levels in the Sydney metropolitan region and surrounding areas, as a result of the proposed Munmorah gas turbine. Emissions from the Metropolitan Air Quality Study (MAQS) inventory were included, as well as an industrial source inventory for major emitters outside the MAQS region (MAQSR).

Simulations were carried out for four meteorological 3-day events conducive to moderate-high photochemical smog. These 3-day events were identified during the IRTAPS study (Nelson et al., 2002) as days on which NO_x emissions from the Central Coast power stations were transported to the Sydney basin.

The impact assessment was undertaken using a prognostic meteorological and chemical transport model (TAPM-CTM) and two emission scenarios, one incorporating existing sources and the other using existing sources plus the proposed source.

2 Methodology

Our methodology and report have followed the guidelines issued by NSW Department of Environment and Conservation (DEC, 2005) in which the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in the state are listed. The modelling approach outlined below has received in-principle support from DEC's Air Technical Advisory Services Unit..

2.1 Modelling

A three dimensional modelling system (TAPM-CTM) has been used to assess the impact of NO_x emissions from the proposed Munmorah gas turbine on photochemical smog production in the MAQSR. The system has three major components.

- A numerical weather prediction system TAPM Version 3.0 (Hurley, 2005) which has been used for the prediction of meteorological fields including wind velocity, temperature, mixing ratio, radiation and turbulence.
- CSIRO's Chemical Transport Model CTM (Cope et al., 2004) for modelling photochemical transformation.
- The MAQS emissions inventory (Carnovale et al., 1996) with 2002 updates for the motor vehicle inventory (Charles Xu; NSW–EPA) and for the biogenic emissions methodology (CSIRO 2002).
- Industrial emissions inventory.

The air quality impact has been assessed by comparing modelled O_3 and NO_2 concentrations from a base-case emissions scenario (all existing sources plus a proposed power station at Newcastle) to those from a test-case scenario (all base-case sources plus the proposed gas turbine at Munmorah). This assessment has been undertaken for four 3-day photochemical smog episodes which have been observed in MAQSR over recent years.

TAPM-CTM was run in nested mode, with two 75 x 75 gridpoint modelling domains with grid spacings of 4 km and 2 km respectively for both meteorology and air quality. The domains are shown in Figure 2.1. The inner grid is centred on the Central Coast region and does not quite cover allof the Sydney region. Local wind observations from the MAQS surface monitoring network were assimilated into TAPM for each event.

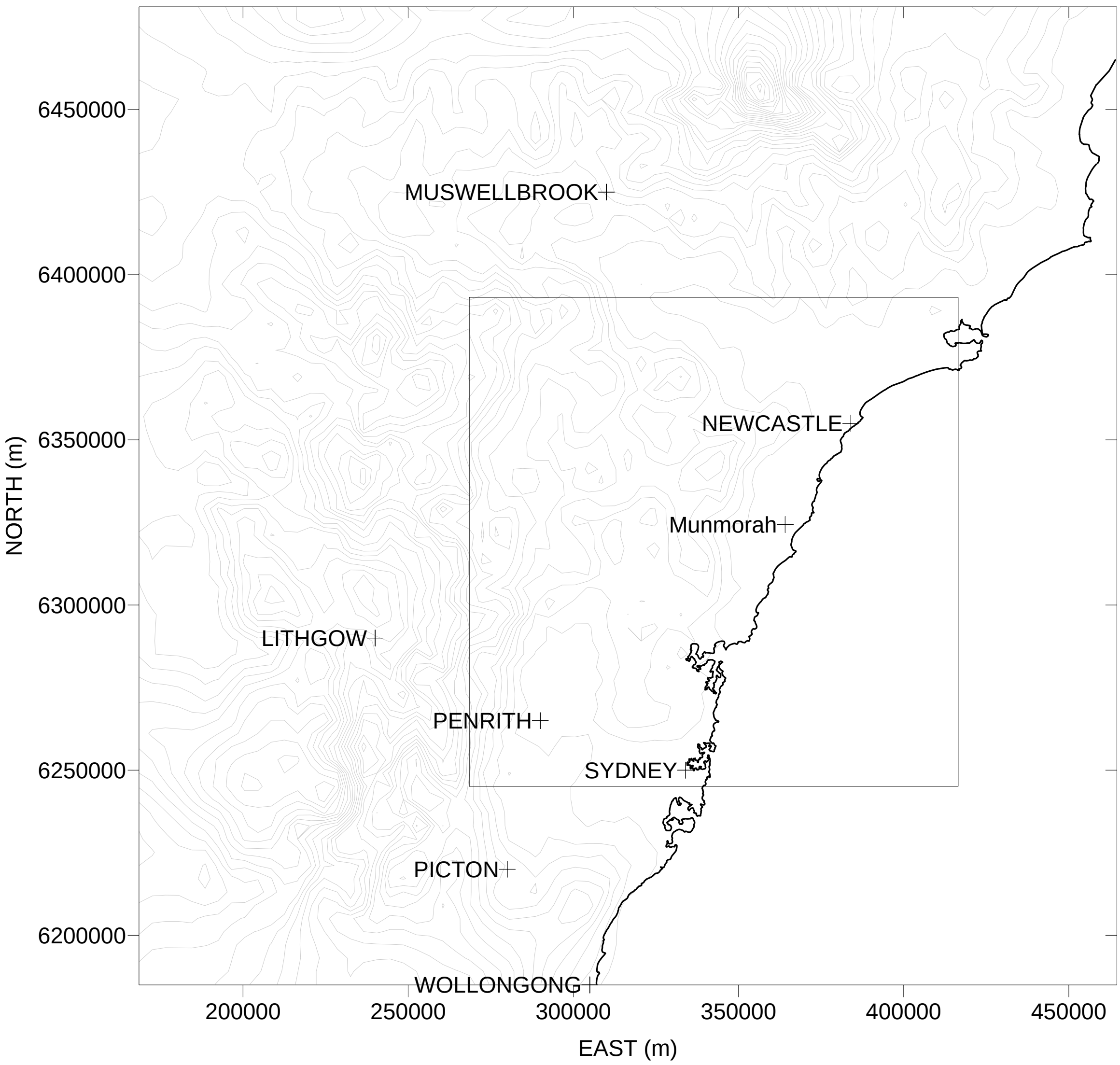

Figure 2.1 Modelling domains used in the study. The outer domain covers the Metropolitan Air Quality Study region.

2.2 Emissions

For this work, we have used the MAQS emissions inventory (Carnovale et al., 1996) with 2002 updates for the motor vehicle inventory (Charles Xu; NSW–EPA) and for the biogenic emissions methodology (CSIRO, 2002). The industrial emitters file used was created by M. Cope for the IRTAPS project (Nelson et al., 2002), and contains all the larger emitters, contributing about 90% of all industrial NO_x. It was also used in a study of the impact of a proposed power station at Newcastle (Cope et al., 2003). Permission to use an industrial emissions inventory which incorporates hourly-varying emissions of NO_x from the major power stations is also acknowledged (Eraring Energy and Delta Electricity). Hourly-varying emissions were used for the power stations in the simulations because sensitivity experiments in the IRTAPS project (Nelson et al., 2002) showed that larger ozone concentrations were obtained for a photochemical event with the hourly load emissions than when the power stations were run at a constant full load.

An additional source in the base-case simulation is the proposed Tomago power station at Newcastle. The Tomago scenario modelled here is that which gave highest ozone concentrations in the study of Cope et al. (2003). Under this scenario (denoted phase 3), the power station is liquid-fuelled with a combined-cycle operation and constant NO_x emissions of 99 g s^{-1}.

Background values of 20 ppb for O_3 and zero for NO_x were used.

Table 2.1 shows characteristics of the proposed Munmorah gas turbine source, consisting of four Alstom 13E2 turbines, with stacks spaced 20 m apart. It has been modelled as one source and the conservative assumption of no buoyancy enhancement between the four plumes has been assumed. It is estimated by Delta Electricity that each turbine may need to run on distillate instead of gas for 75 hours per year, and for a worst-case modelling scenario, the simulations assume that the turbine is fuelled by distillate during each event. NO_x emissions from distillate are shown in Table 2.1 and are double those emitted when the turbine is fuelled by gas. It has been assumed that 10% of the emitted NO_x is NO_2.

Table 2.1 Characteristics of the proposed Munmorah gas turbine source running on distillate.

Performance Parameter	*Unit*	*Value*
Output	MW	731.6
NO_x emissions (4 turbines)	g/s as NO_2	162.2
Stack height	m	35
Exit temperature	^oC	518
Volume flow (4 turbines)	$m^3 h^{-1}$ at 518^oC	17,918,036
Diameter	m	6
Exit velocity	m s^{-1}	44
Coordinates	AMG66	(364129.2, 6324355.3)

3 Selection of photochemical event days

Detailed airshed modelling was performed for specific event periods, identified in the IRTAPS project (Nelson et al., 2002). The episodes were selected on the basis of having high ozone concentrations and meteorological conditions that are suitable for inter-regional transport between the power stations and the Sydney region. These days were also used in the assessment study for a proposed power station at Newcastle (Cope et al., 2003). The periods selected for detailed study follow. The location of monitors in the NSW DEC air quality network can be found in Figure 3.1.

6–8 February 1997

The 8th February 1997 was a significant ozone event in Sydney with six monitoring sites measuring maximum ozone concentrations of at least 80 ppb. For three of these sites, maximum concentrations were greater than 100 ppb with a maximum of 125 ppb recorded at Bargo. In addition, 7 and 8 February had similar meteorology with alongshore flow in the early hours of the morning at the coast and north-east flow across the northern plateau.

11–13 March 1998

The 13th March 1998 was a significant ozone event in Sydney because moderate to high concentrations of ozone were measured throughout the region with two peaks of ozone concentrations being measured at many locations in the basin. Nine locations recorded maximum hourly concentrations of ozone of at least 80 ppb; three sites recorded maximum concentrations greater than 100 ppb and one site recorded a concentration greater than 120 ppb. Wind direction was generally from the north.

20–22 January 1997

The period 20th to 22nd January 1997 was selected for modelling on the basis that it was a significant ozone event in Sydney and there was evidence on all three days for inter-regional transport of ozone, oxides of nitrogen and sulfur dioxide from sources north of the Sydney Basin. Ozone concentrations up to 117 ppb (Oakdale) were recorded in the south and south western part of the Sydney Basin.

25–27 October 1997

The period 25 to 27 October contained a significant ozone event in the Sydney airshed (107 ppb Bargo, 27 October) and there was evidence on all three days for inter-regional transport of ozone, oxides of nitrogen and sulfur dioxide from sources north of the Sydney Basin.

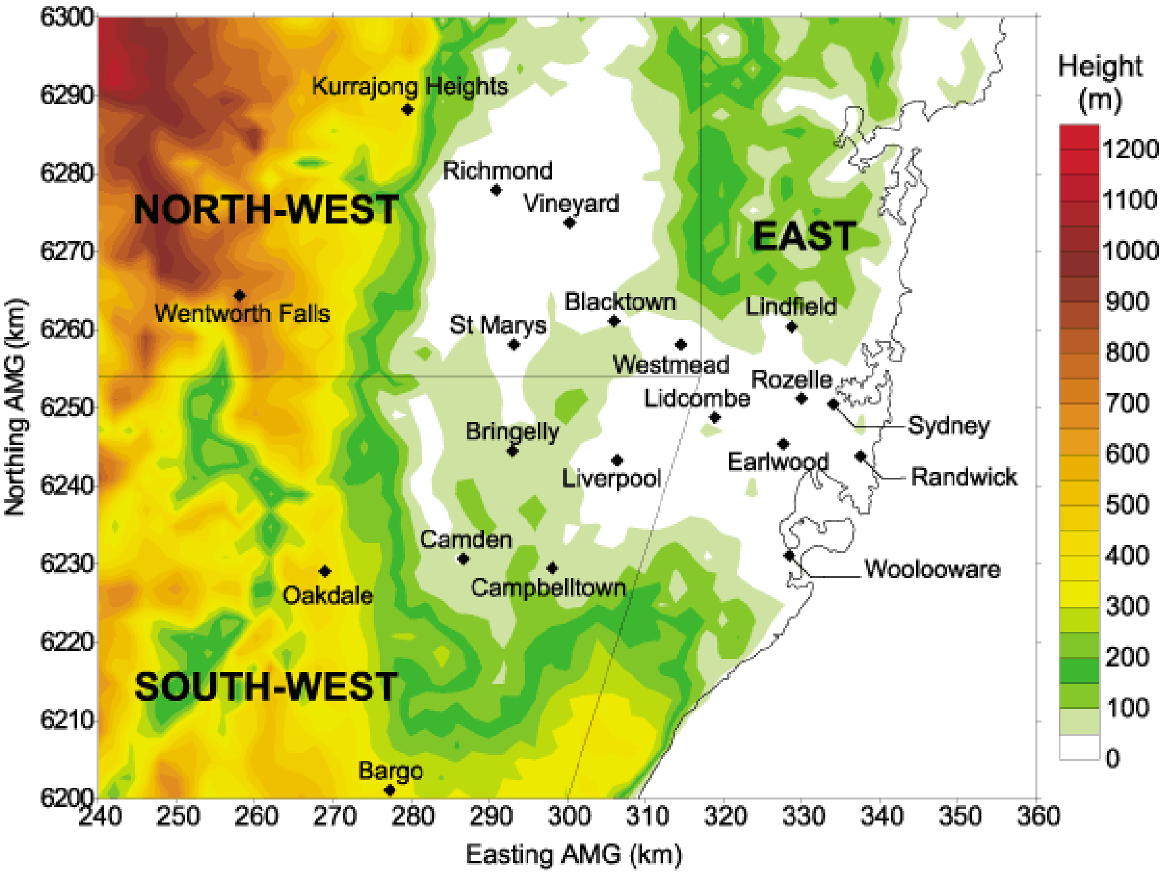

Figure 3.1 Monitor locations for the DEC air quality monitoring network for Sydney. From NSW Department of Environment and Conservation website http://www.environment.nsw.gov.au/air/sydney3.htm.

4 Results

The following sections examine results for regional NO_2 and O_3 maximum ground-level concentration (glc) for the base-case emission scenario, and for the difference in maximum glc between the test-case and the base-case. NO_2 results from the smaller grid (2-km spacing) are presented and discussed as it is likely that the larger NO_2 impacts of the proposed turbine would occur nearer the source than would the O_3 impacts. O_3 results are presented from the larger grid to allow a full interaction with the Sydney emissions to be evaluated.

In assessing the results in this section, it may be useful to recall that the NEPM standard for 1-hour NO_2 is 120 ppb, for 1-hour O_3 is 100 ppb and for 4-hour O_3 is 80 ppb. Maximum values observed in Sydney are no more than 80 ppb for NO_2, but exceedances of the ozone standards do occur on a few days per year, with the 1-hour values exceeding 130 ppb at times.

4.1 6-8 February 1997

Figure 4.1 shows contour plots of maximum hourly-averaged NO_2 and O_3 ground-level concentrations (glc) for the base-case and for the difference between the test-case and the base-case, for 6-8 February 1997. The results show that the modelled NO_2 peak of 54 ppb occurred in the western Sydney area, while the modelled O_3 peak of 129 ppb occurred about 50 km southwest of the Sydney CBD. Modelled versus observed concentrations for the 3-day period at monitors in these areas (Blacktown and Bargo) show that the model performed very well over this period (Figure 4.2). The maximum NO_2 occurred mid-evening on 8 February and the ozone peak was observed late afternoon on the same day.

Emissions from the proposed source had no effect on the highest regional concentration of NO_2, with Figure 4.1 showing that the highest increase in maximum glc at any point (1.5 ppb) occurs well away from the location of the regional maximum. The proposed source also had a minimal effect on hourly and 4-hourly-averaged O_3 with an increase in maximum glc at any point of less than 0.5 ppb. In the general area of the regional maximum glc, emissions from the proposed source actually brought about a small reduction in O_3 concentrations.

For each grid point, the difference between the test-case and the base-case versus the maximum base-case concentration is plotted in Figure 4.3 for hourly-averaged pollutants, and for 4-hourly averaged ozone. At most points, NO_2 concentrations increase, but the largest increases (up to 1.5 ppb) occur in areas where the base-case concentrations are low (less than 10 ppb). The main impact of the proposed source on O_3 is to decrease concentrations, by up to 1.2 ppb, at a distance of 150 km south west of Munmorah. Increases of up to 0.5 ppb occur about 70 km from the source.

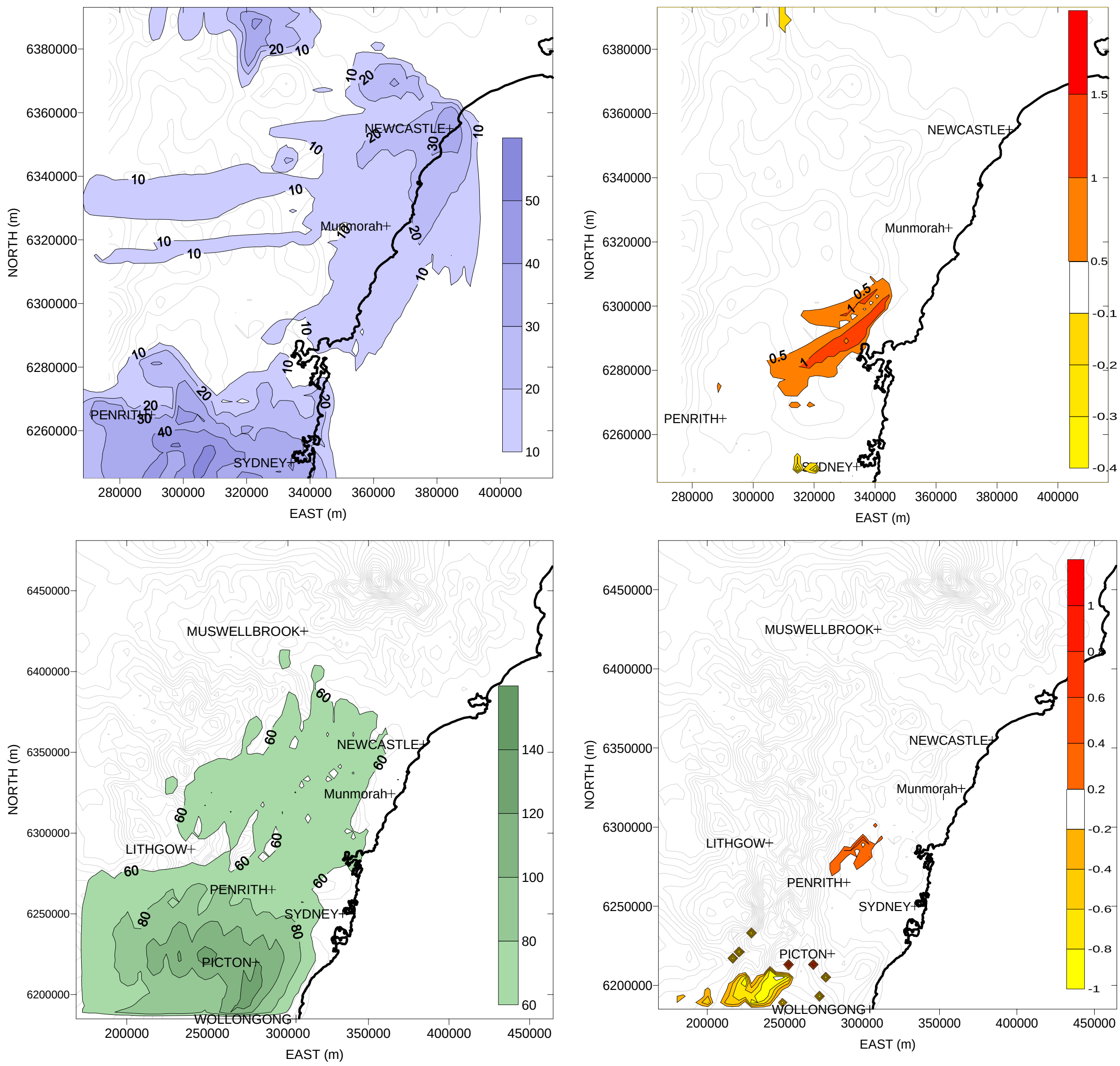

Figure 4.1 6-8 February 1997. Base-case maximum hourly-averaged glcs for NO_2 (top left) and O_3 (bottom left), and for the difference between test-case and base-case maximum glcs for NO_2 (top right) and O_3 (bottom right).

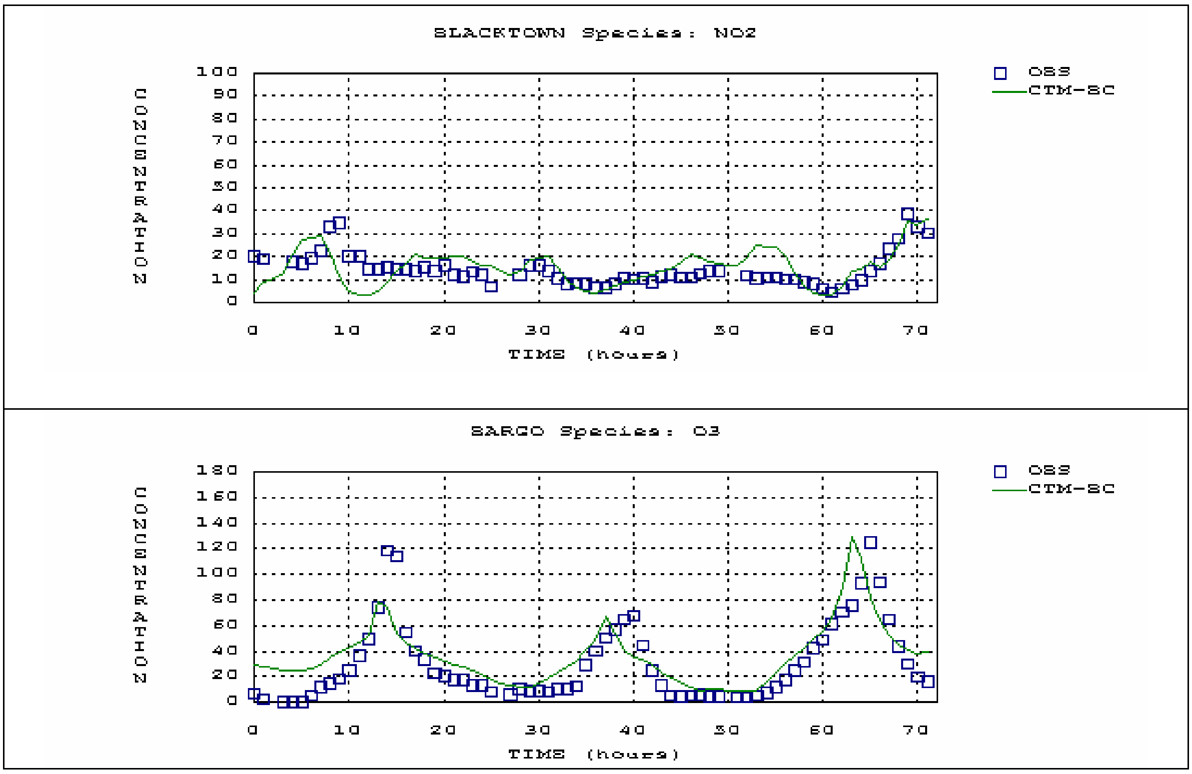

Figure 4.2 6-8 February 1997. Observed (OBS) and modelled (CTM_SC) hourly-averaged glcs for NO_2 (top) at Blacktown and O_3 (bottom) at Bargo.

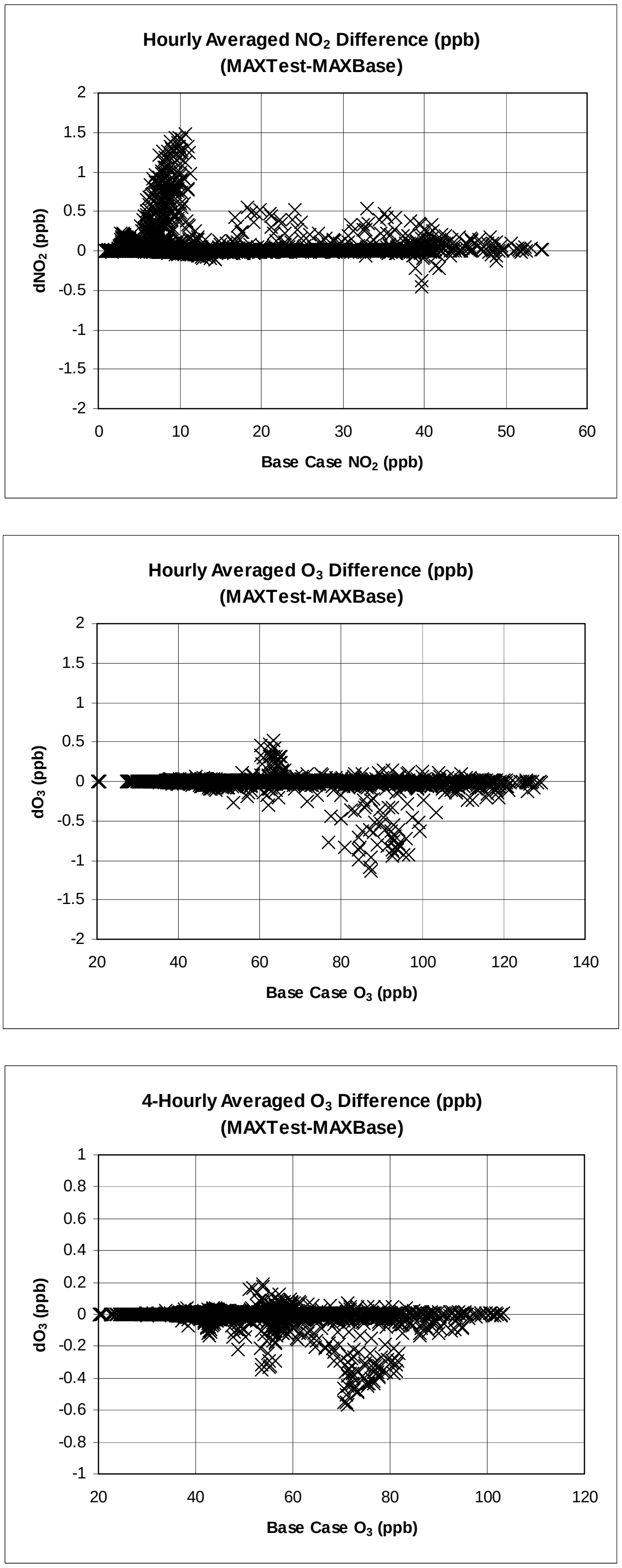

Figure 4.3 6-8 February 1997. The difference between test-case and base-case maximum glcs versus base-case maximum glcs at all gridpoints of the smaller domain for hourly-averaged NO_2 (top), and of the larger domain for hourly-averaged O_3 (middle) and 4-hourly averaged O_3 (bottom).

4.2 11-13 March 1998

Figure 4.4 shows contour plots of maximum hourly-averaged NO_2 and O_3 ground-level concentrations (glc) for the base-case and for the difference between the test-case and the base-case, for 11-13 March 1998. The results show that the modelled NO_2 peak of 78 ppb occurred in the western Sydney area, while the modelled O_3 peak of 109 ppb occurred well to the southwest of the Sydney CBD. Modelled versus observed concentrations for the 3-day period at monitors in these areas (Bringelly and Oakdale) show that the model underestimated peak concentrations by only a few ppb (Figure 4.5). The maximum NO_2 occurred early evening on 13 March and the ozone peak was observed mid-afternoon on the same day.

Emissions from the proposed source had no effect on the highest regional concentration of NO_2, with Figure 4.4 showing that the highest increase in maximum glc at any point (5.5 ppb) occurs to the north west of Munmorah, well away from the location of the regional maximum. The proposed source increased concentrations of hourly and 4-hourly-averaged O_3 by as much as 5.4 ppb to the west of Munmorah. In the general area of the regional maximum glc, emissions from the proposed source actually brought about a small reduction in O_3 concentrations.

For each grid point, the difference between the test-case and the base-case versus the maximum base-case concentration is plotted in Figure 4.6 for hourly-averaged pollutants, and for 4-hourly averaged ozone. At most points, NO_2 concentrations increase, but the largest increases (up to 5.5 ppb) occur in areas where the base-case concentrations are low (between 5 and 10 ppb). The main impact of the proposed source on O_3 is to increase concentrations, by up to 5.4 ppb, at a distance of 130 km west of Munmorah where base-case maximum concentrations are typically 50 ppb. In the same general area, increases of up to 1.3 ppb occur at base concentrations of 70 ppb. There is negligible impact on the Sydney basin.

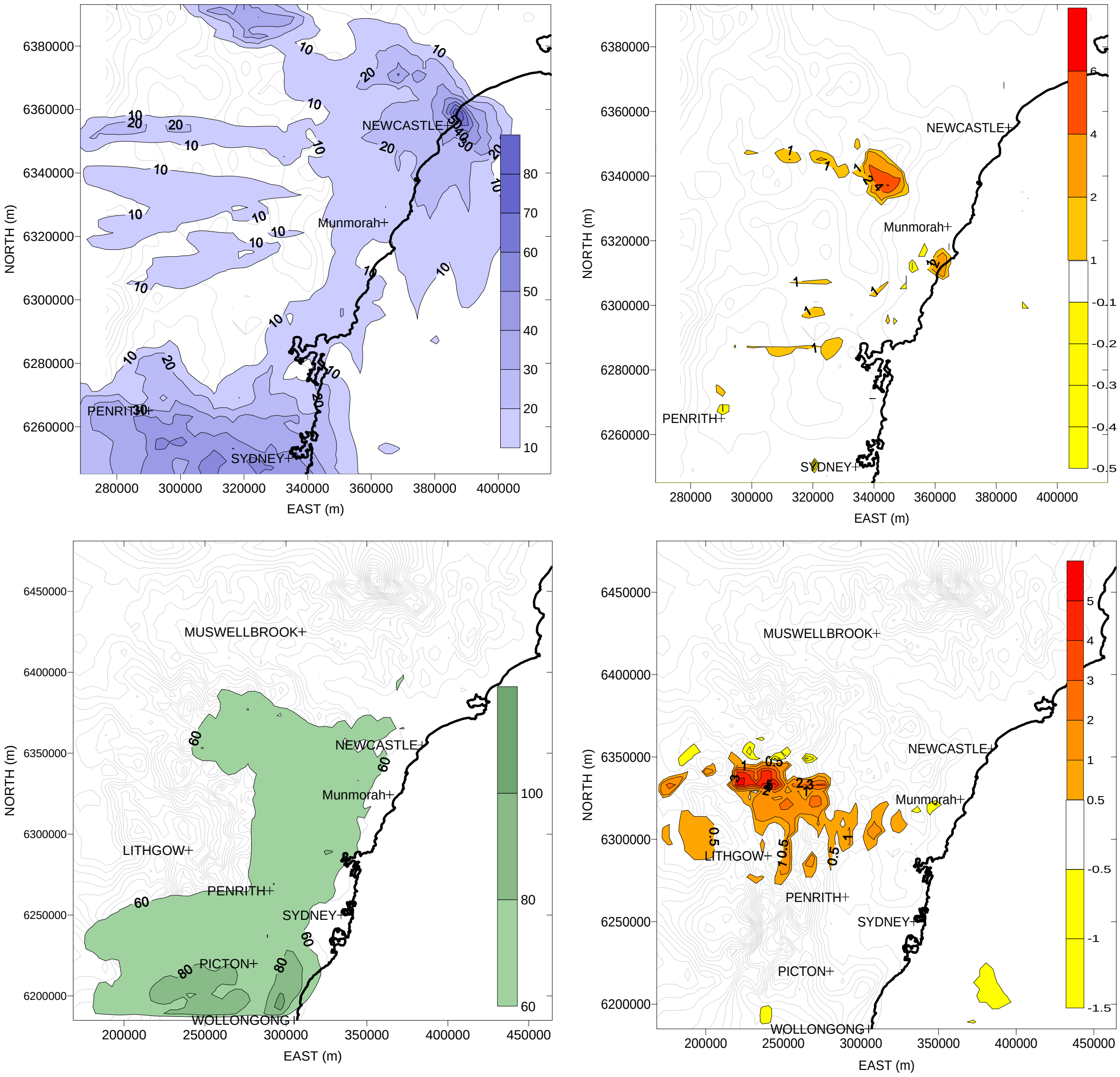

Figure 4.4 11-13 March 1998. Base-case maximum hourly-averaged glcs for NO_2 (top left) and O_3 (bottom left), and for the difference between test-case and base-case maximum glcs for NO_2 (top right) and O_3 (bottom right).

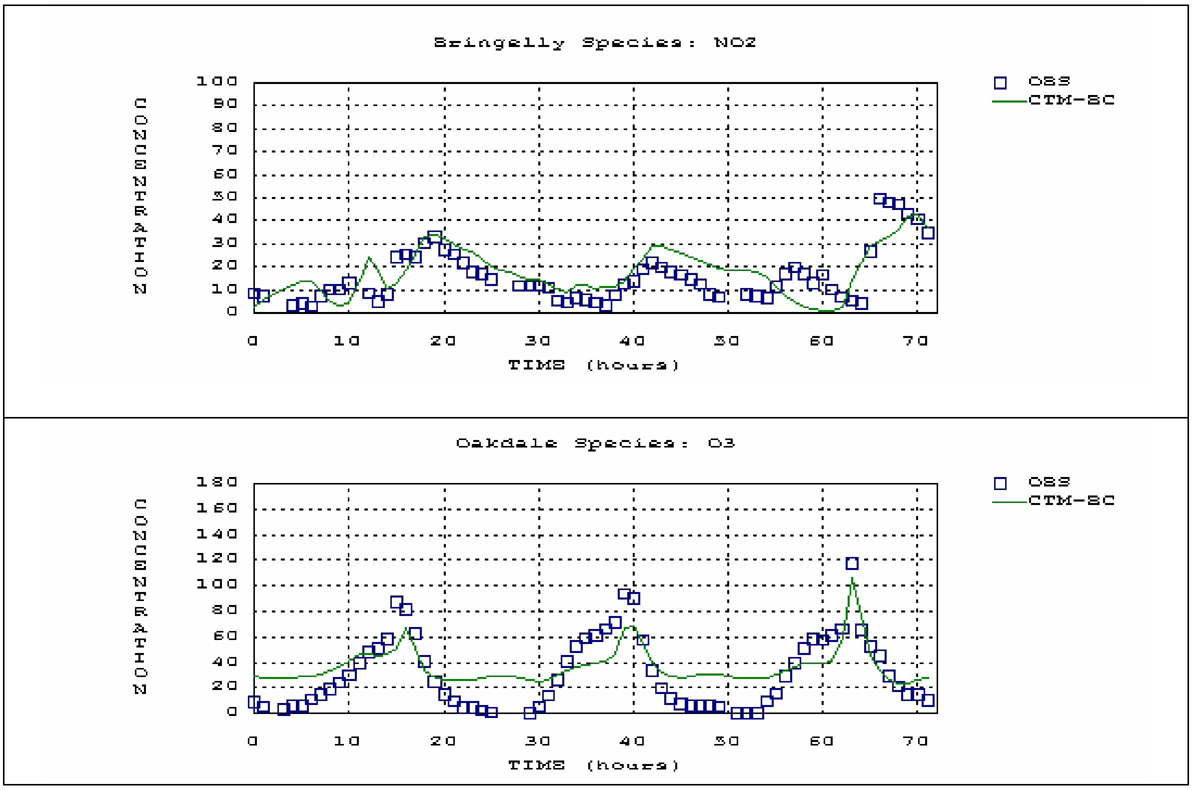

Figure 4.5 11-13 March 1998. Observed (OBS) and modelled (CTM_SC) hourly-averaged glcs for NO_2 (top) at Bringelly and O_3 (bottom) at Oakdale.

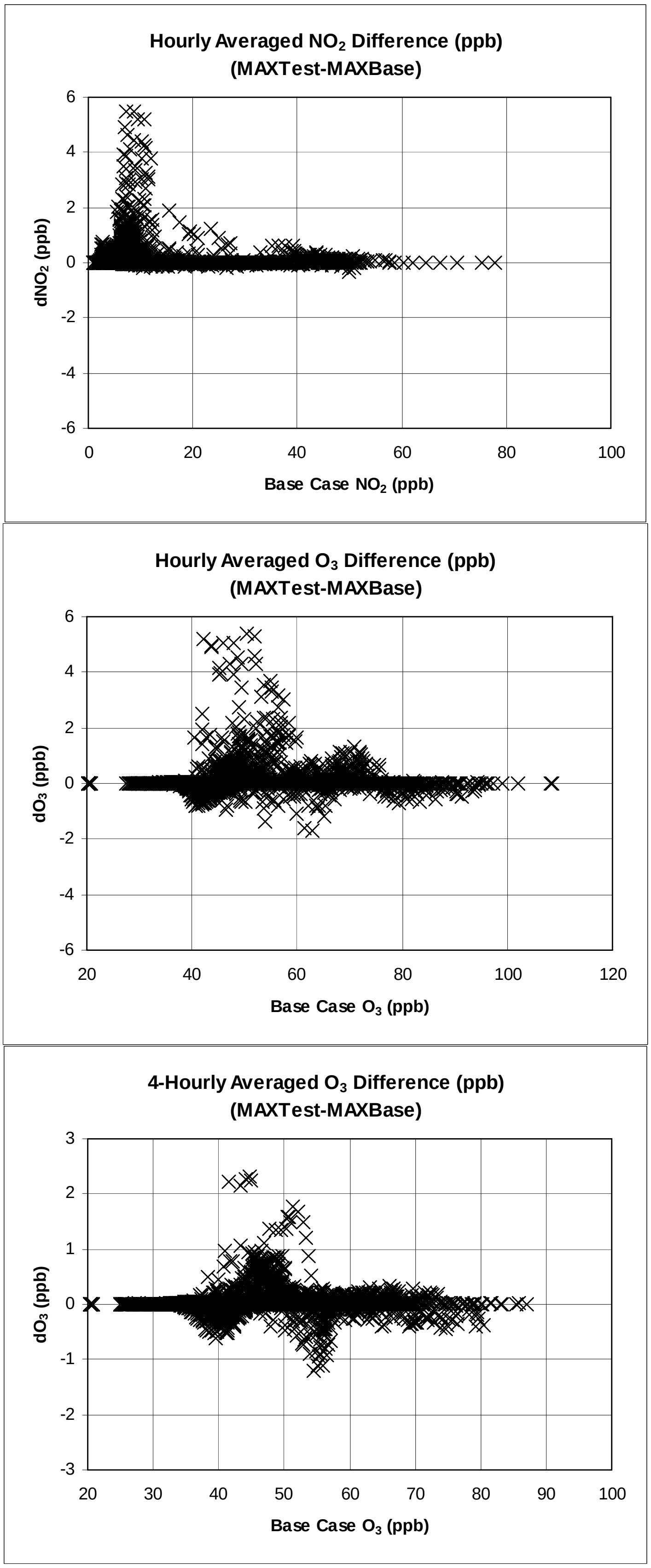

Figure 4.6 11-13 March 1998. The difference between test-case and base-case maximum glcs versus base-case maximum glcs at all gridpoints of the smaller domain for hourly-averaged NO_2 (top), and of the larger domain for hourly-averaged O_3 (middle) and 4-hourly averaged O_3 (bottom).

4.3 20-22 January 1997

Figure 4.7 shows contour plots of maximum hourly-averaged NO_2 and O_3 ground-level concentrations (glc) for the base-case and for the difference between the test-case and the base-case, for 20-22 January 1997. The results show that the modelled NO_2 peak of 39 ppb occurred in the central Sydney area, while the modelled O_3 peak of 118 ppb occurred about 60 km to the southwest of the Sydney CBD. Modelled versus observed concentrations for the 3-day period at monitors in these areas (Earlwood and Camden) show that the model did well for both pollutants, though estimating the NO_2 peak a couple of hours early, and underestimating the O_3 peak concentrations by a few ppb (Figure 4.8). The maximum NO_2 occurred late morning on 22 January and the ozone peak was observed mid-afternoon on the same day.

Emissions from the proposed source had no effect on the highest regional concentration of NO_2, with Figure 4.7 showing that the highest increase in maximum glc at any point (1.8 ppb) occurs over the sea, well away from the location of the regional maximum. The proposed source also had a minimal effect on hourly and 4-hourly-averaged O_3 with an increase in maximum glc at any point of less than 0.3 ppb.

For each grid point, the difference between the test-case and the base-case versus the maximum base-case concentration is plotted in Figure 4.9 for hourly-averaged pollutants, and for 4-hourly averaged ozone. At most points, NO_2 concentrations increase, but the largest increases (up to 1.8 ppb) occur in areas where the base-case concentrations are low (between 10 and 15 ppb). The proposed source increases O_3 concentrations by 0.3 ppb well west of Sydney, where base-case concentrations are typically 50 ppb. Concentrations are decreased by 0.4 ppb northwest of Sydney in an area where base-case concentrations are also about 50 ppb.

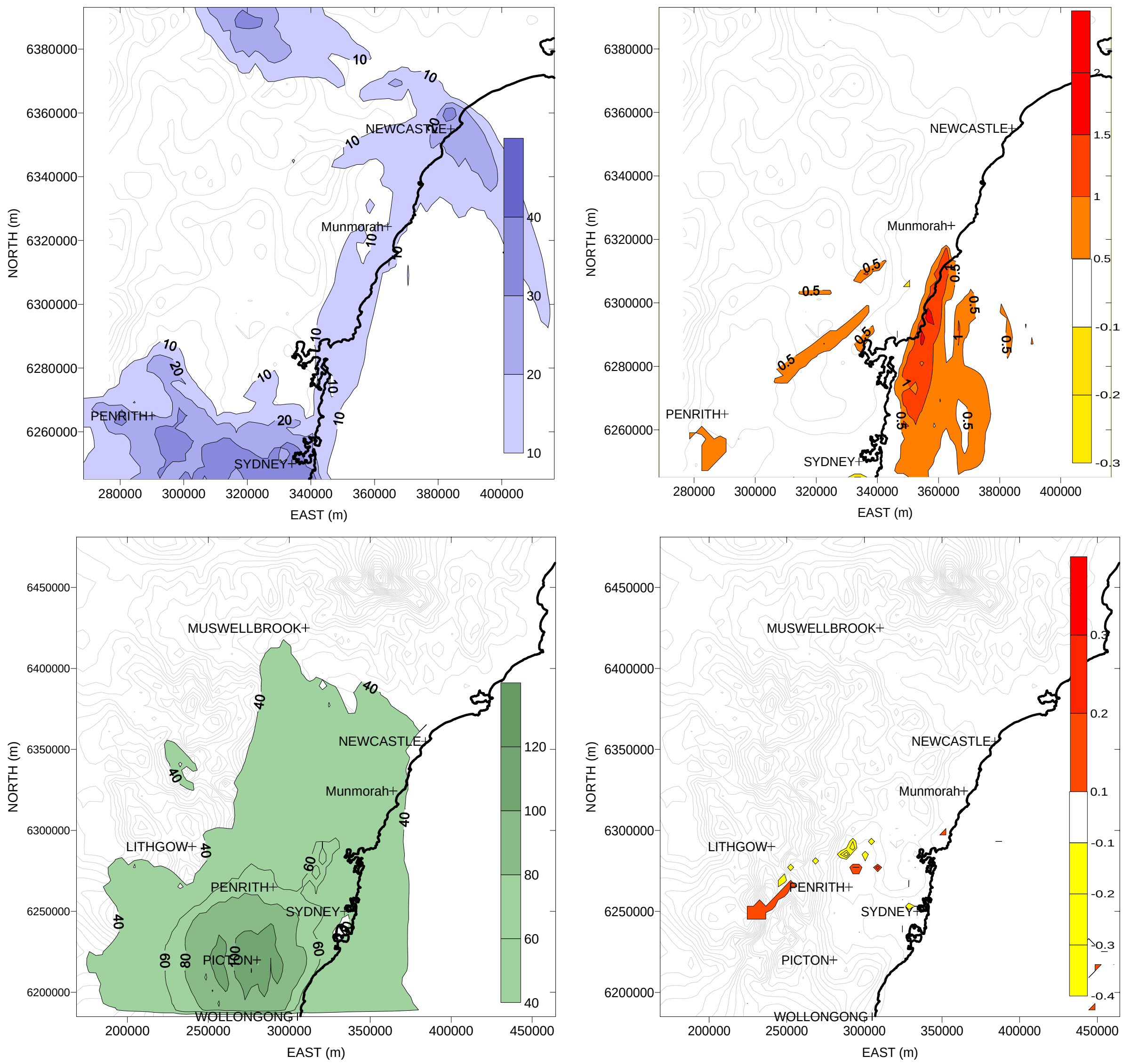

Figure 4.7 20-22 January 1997. Base-case maximum hourly-averaged glcs for NO_2 (top left) and O_3 (bottom left), and for the difference between test-case and base-case maximum glcs for NO_2 (top right) and O_3 (bottom right).

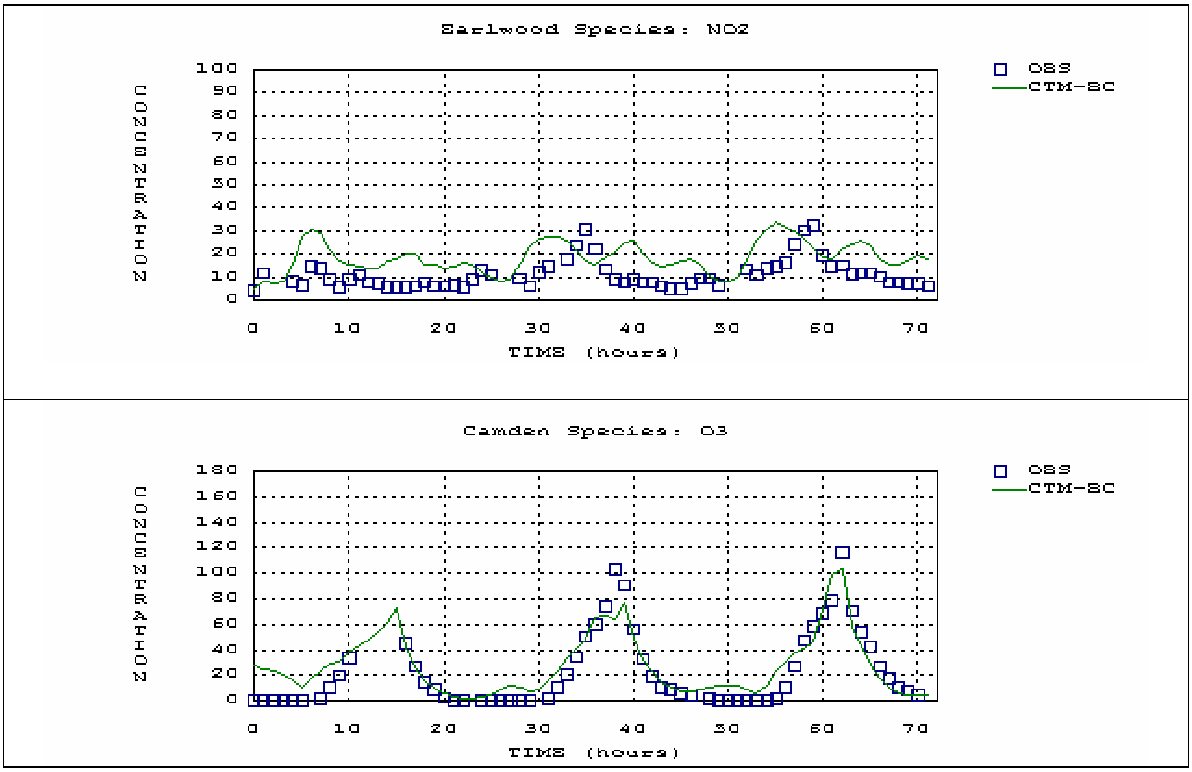

Figure 4.8 20-22 January 1997. Observed (OBS) and modelled (CTM_SC) hourly-averaged glcs for NO_2 (top) at Earlwood and O_3 (bottom) at Camden.

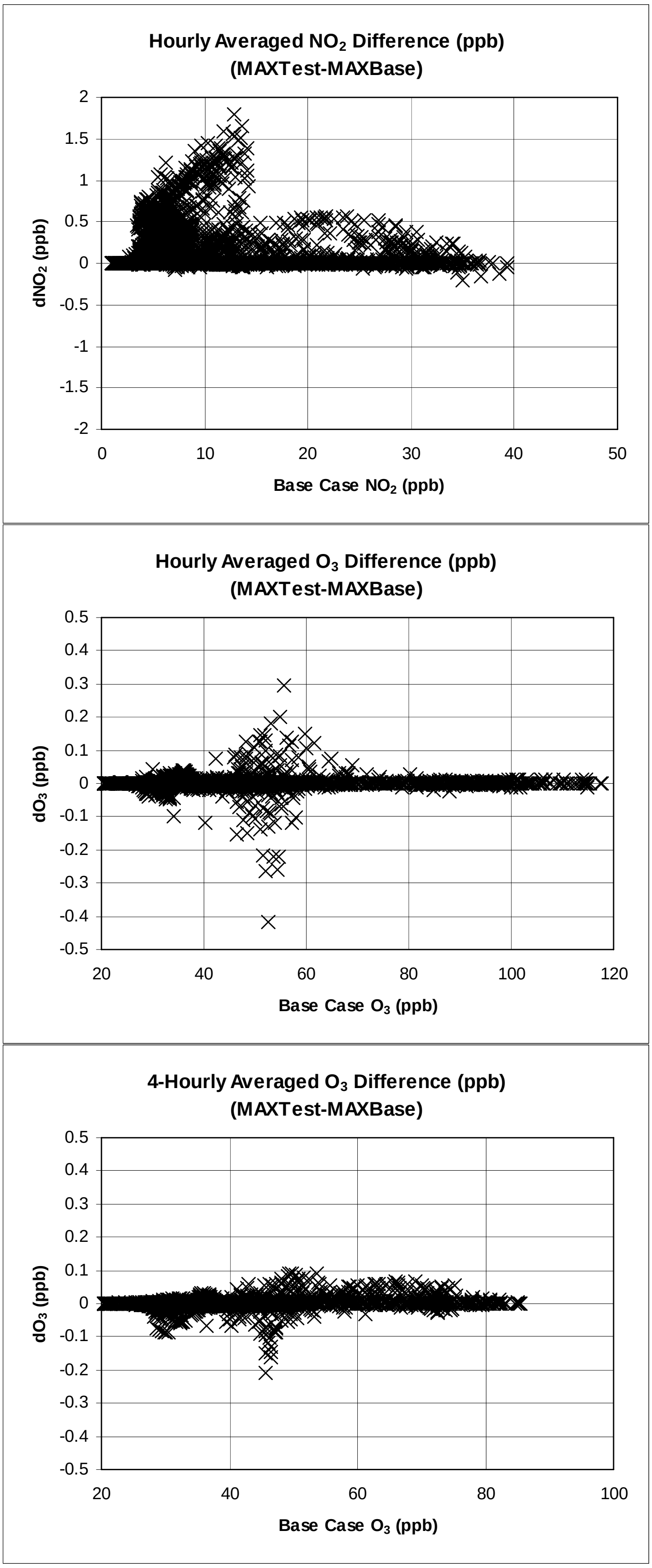

Figure 4.9 20-22 January 1997. The difference between test-case and base-case maximum glcs versus base-case maximum glcs at all gridpoints of the smaller domain for hourly-averaged NO_2 (top), and of the larger domain for hourly-averaged O_3 (middle) and 4-hourly averaged O_3 (bottom).

4.4 25-27 October 1997

Figure 4.10 shows contour plots of maximum hourly-averaged NO_2 and O_3 ground-level concentrations (glc) for the base-case and for the difference between the test-case and the base-case, for 25-27 October 1997. The results show that the modelled NO_2 peak of 76 ppb occurred in the central Sydney area, while the modelled O_3 peak of 85 ppb occurred about 100 km to the southwest of the Sydney CBD. Modelled versus observed concentrations for the 3-day period at monitors in these areas (St. Marys and Bargo) show that while the model performed satisfactorily for the first two days, it overestimated the NO_2 peak and underestimated the O_3 peak on 27 October (Figure 4.11). In general, not enough O_3 was produced by the model on this day (maximum of 85 ppb versus 107 ppb observed).

Emissions from the proposed source are estimated to decrease NO_2 concentrations slightly (by 0.3 ppb) in the area of highest regional concentrations in the Sydney basin (Figure 4.10). However, increases of NO_2 up to 3.4 ppb are predicted over the mountains to the southwest of Munmorah. In the same area, hourly-averaged O_3 concentrations are predicted to rise by up to 2.5 ppb, but larger decreases (up to 3.4 ppb) are predicted in the regional maximum area southwest of Sydney near Bargo. The proposed source also has similar effects on 4-hourly-averaged O_3 with an increase in maximum glc at any point of 1.4 ppb.

For each grid point, the difference between the test-case and the base-case versus the maximum base-case concentration is plotted in Figure 4.12 for hourly-averaged pollutants, and for 4-hourly averaged ozone. At most points, NO_2 concentrations increase, and it can be seen that where the largest increases (up to 3.4 ppb) occur (in the mountains), the base-case concentrations are low (between 2 and 6 ppb). Increases of hourly-averaged O_3 concentrations of 2.5 ppb occur in the same area at base-case concentrations of just over 60 ppb, while the increases (1.4 ppb) in 4-hourly-averaged concentration occur at base concentrations of 55 ppb. The dominant contribution to the relatively high base concentrations of O_3 in the mountain areas comes from biogenic sources. Figure 4.12 also shows that decreases in O_3 concentrations are predicted in those areas (south west of Sydney) where the base concentration is highest.

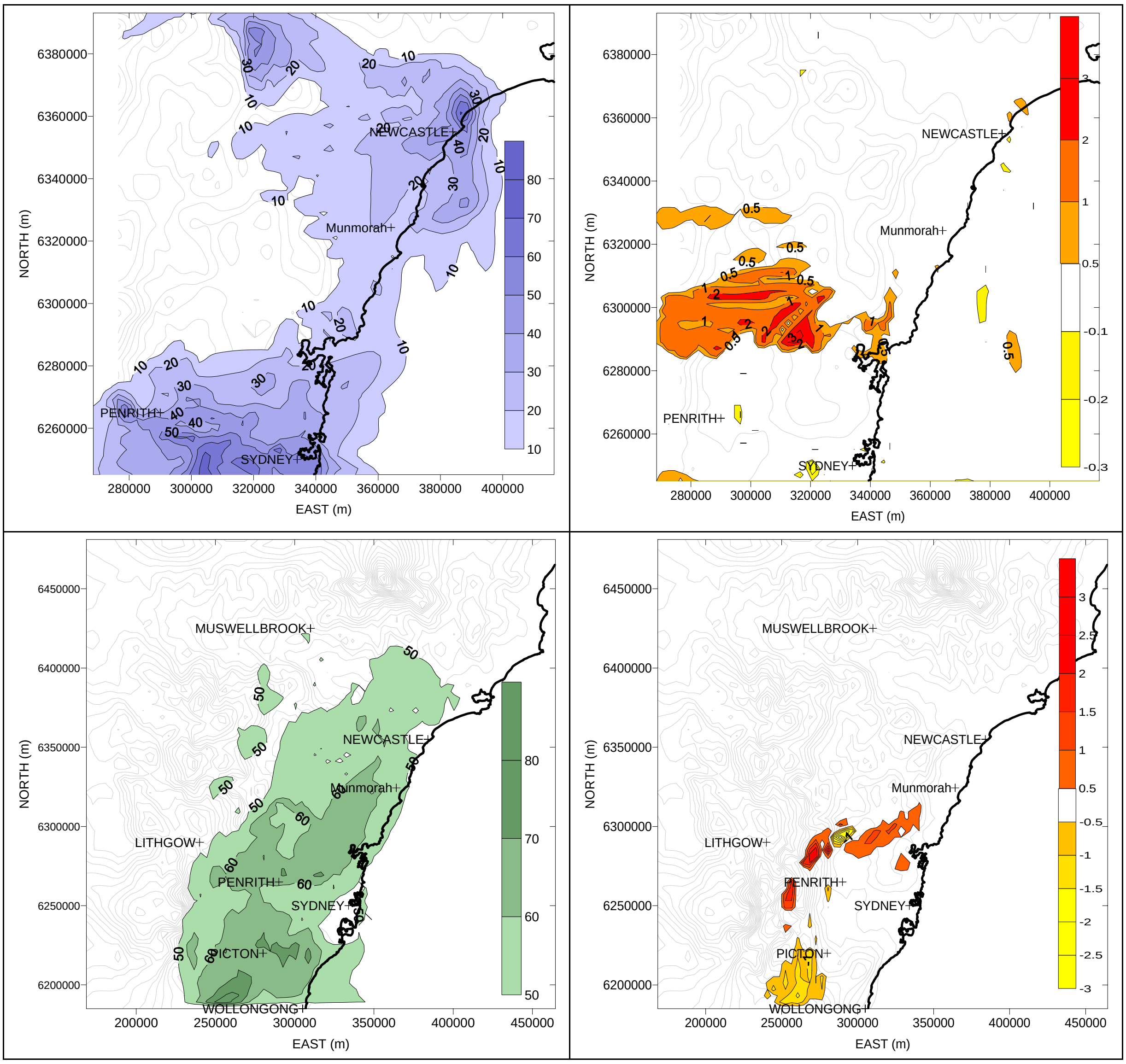

Figure 4.10 25-27 October 1997. Base-case maximum hourly-averaged glcs for NO_2 (top left) and O_3 (bottom left), and for the difference between test-case and base-case maximum glcs for NO_2 (top right) and O_3 (bottom right).

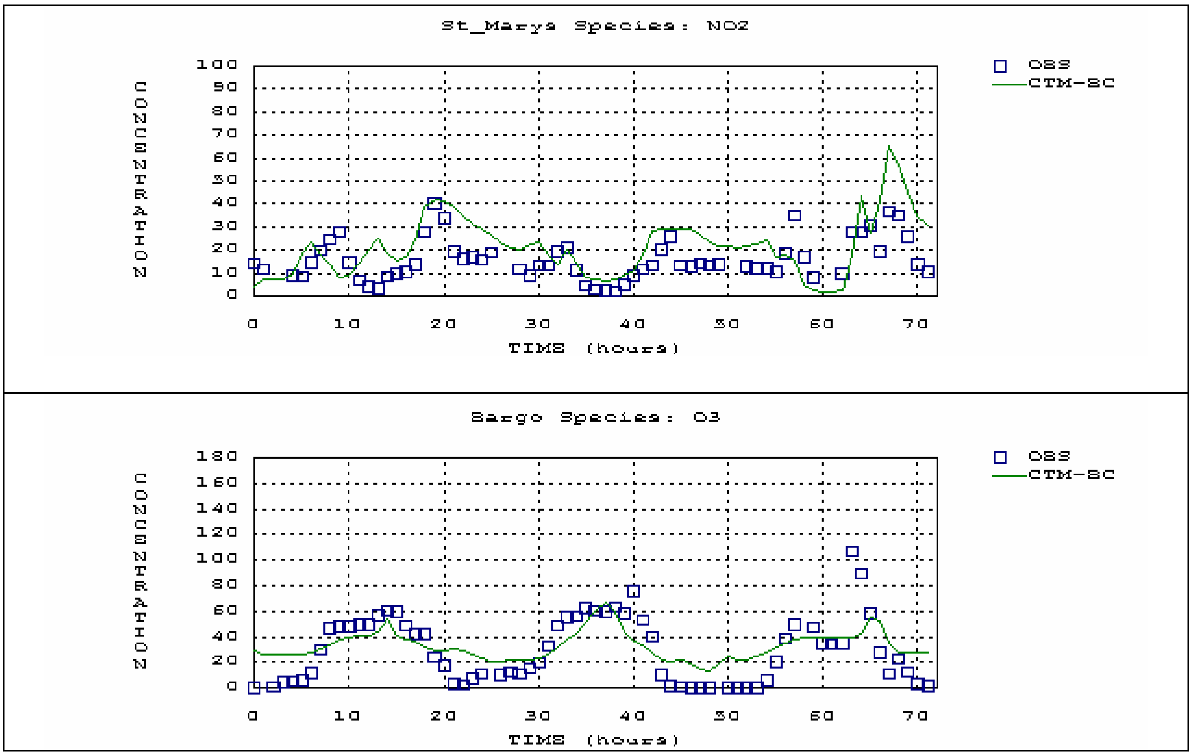

Figure 4.11 25-27 October 1997. Observed (OBS) and modelled (CTM_SC) hourly-averaged glcs for NO_2 (top) at St. Marys and O_3 (bottom) at Bargo.

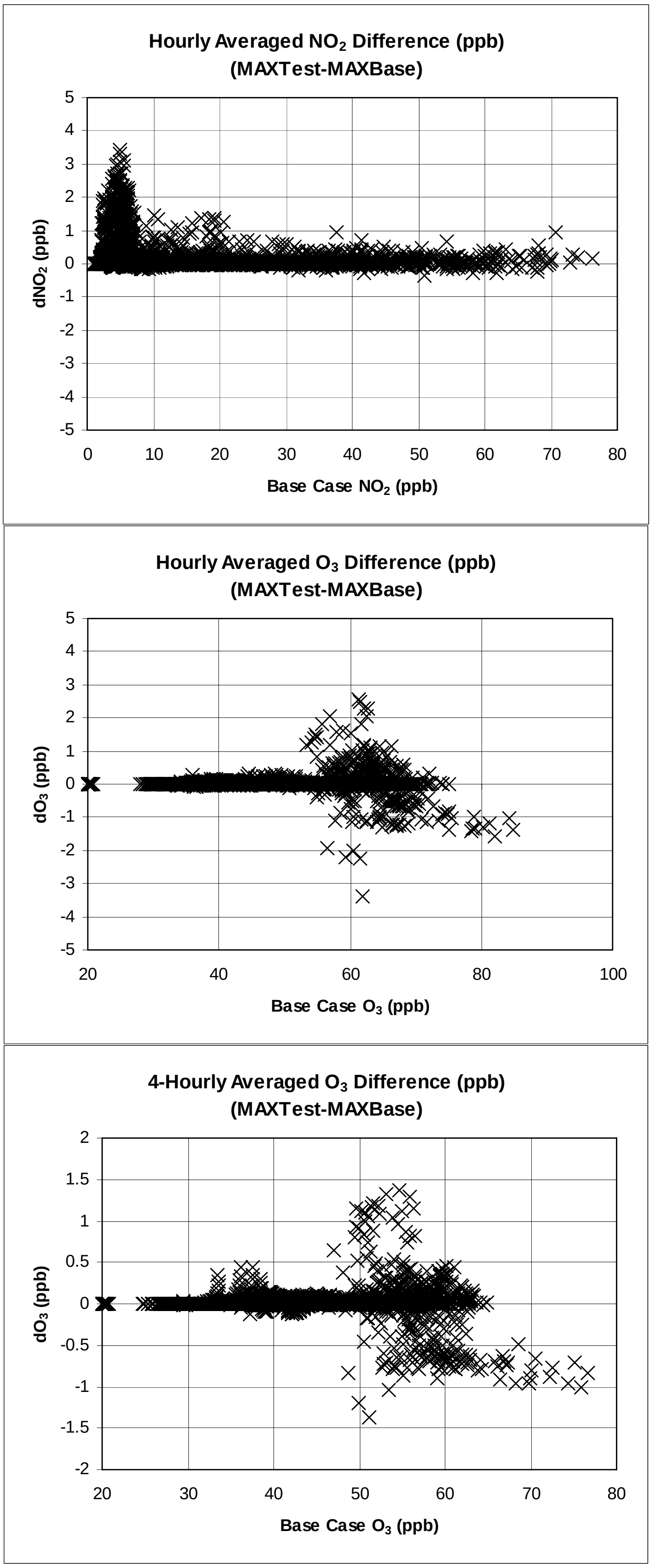

Figure 4.12 25-27 October 1997. The difference between test-case and base-case maximum glcs versus base-case maximum glcs at all gridpoints of the smaller domain for hourly-averaged NO_2 (top), and of the larger domain for hourly-averaged O_3 (middle) and 4-hourly averaged O_3 (bottom).

5 Discussion and Summary

The impact of a proposed gas turbine addition to Munmorah Power Station on photochemical smog levels in the Sydney basin and surrounding areas has been investigated using the prognostic meteorological and chemical transport model TAPM-CTM. Four case-study days of moderate-high ozone levels were selected for modelling. These days had previously been identified as days on which emissions from power stations to the north of Sydney were transported to the Sydney basin.

Table 5.1 shows the maximum concentration across the region for each event for the base-case (existing emissions plus the proposed Tomago power station at Newcastle) and test-case (base-case emissions plus proposed Munmorah emissions) simulations. Results are shown for both modelling domains and, apart from NO_2 for the 20-22 January event, confirm that the largest NO_2 concentrations are found on the inner (small) domain and that those for O_3 occur on the outer (large) domain. The modelling results for the four events show that the maximum impact of emissions from the proposed gas turbine at Munmorah would be:

- an increase in the regional maximum hourly-averaged NO_2 concentration of 0.2 ppb,
- a decrease in the regional maximum hourly-averaged O_3 concentration of 1.5 ppb,
- and a decrease in the regional maximum 4-hourly-averaged O_3 concentration of 0.9 ppb.

While the impact on the Sydney basin is estimated to be negligible, local NO_2 increases of between 1.5 ppb and 5.5 ppb were predicted. However, these were in sparsely-populated areas and occurred at base-case concentrations of less than 10 ppb. Local increases in hourly-averaged O_3 ranged from 0.5 ppb to 5.4 ppb and these too were in areas of little or no population, such as the mountains to the northwest and south west of Munmorah. Base-case O_3 concentrations in these areas at these times ranged between 50 ppb and 60 ppb. This is consistent with the finding of Nelson et al. (2002) that biogenic emissions in rural areas are available to generate moderate concentrations of photochemical smog, but are limited by the availability of NO_x.

Table 5.1. Regional maximum glc (ppb) for NO_2 and O_3 for the base-case and the test-case simulations.

Selected Event	**Domain**	**NO_2 1-hour**		**O_3 1-hour**		**O_3 4-hour**	
		Base	**Test**	**Base**	**Test**	**Base**	**Test**
6-8 February 1997	Small	54.5	54.5	95.9	95.9	81.3	81.3
	Large	56.9	56.8	129.3	129.3	103.2	103.2
11-13 March 1998	Small	77.8	77.8	85.2	85.2	78.0	78.0
	Large	77.0	77.0	108.6	108.6	87.0	87.0
20-22 January 1997	Small	39.3	39.3	95.9	95.9	85.0	85.0
	Large	63.9	63.8	117.7	117.7	85.5	85.5
25-27 October 1997	Small	76.3	76.5	74.3	74.5	66.4	66.4
	Large	75.4	75.5	84.8	83.3	76.6	75.7

In summary, emissions from the proposed gas turbine are predicted to result in no exceedences of air quality goals and standards for NO_2 and O3. Emissions from the gas turbine are predicted to have no adverse effect on concentrations of nitrogen dioxide and ozone in the Sydney basin region. In some areas outside the basin where levels of both NO_2 and O_3 are predicted to increase by up to 6 ppb, concentrations on days of photochemical activity are well below National Environment Protection Measure (NEPM) standards.

5.1 Uncertainties and Conservatism

Uncertainties will always exist in modelling studies because no model can ever reproduce atmospheric behaviour perfectly. However the evaluation in the IRTAPS study (Nelson et al., 2002) of TAPM's meteorological predictions and the performance of the airshed chemistry model CIT on photochemical inter-regional transport days was most encouraging. The CTM model replaced CIT in this study, but initial comparison of NO_2 and O_3 predictions with observations, some of which are reproduced in our report, indicates that CTM may be performing better than CIT.

The conservative assumptions used in the course of this study should be emphasised since they result in over-estimation and over-prediction of the impacts. Power station impacts are likely to be over-stated for the following reasons:

- Conservative assumptions are used in the biogenic emissions inventory.
- The necessary treatment of point source emissions as volume sources in an Eulerian grid model leads to more rapid onset of some stages in the photochemistry development. These stages are characterised by the generation of excess ozone.
- The modelling assumption that interruptions to the gas supply all occur on days of high photochemical activity is conservative. On such occasions, distillate is used as a fuel and its NO_x emissions are twice those emitted when natural gas is used. It is estimated by Delta Electricity that each turbine will use distillate for 75 hours per annum and gas for 500 hours.
- The assumption that there is no buoyancy enhancement of plumes from the four stacks means that the plume does not rise as high and more NO_x emissions remain in the boundary layer to be transported and react with emissions from other sources.
- Days modelled were known to be conducive to photochemical activity.

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