

***Interactive comment on “Process analysis and sensitivity study of regional ozone formation over the Pearl River Delta, China, during the PRIDE-PRD2004 campaign using the CMAQ model” by X. Wang et al.***

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Response to Reviewer #4

Thanks for your constructive comments. The followings are our responses.

General Comments:

(Q1) This paper presents a comprehensive modelling analysis on chemical and synoptic meteorological factors influencing ozone formation during one of the main ozone months (October) for the Pearl River Delta region of China. MM5-CMAQ model output

C11913

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Interactive Discussion

Discussion Paper



is compared with c.12 monitoring station data in the region during this month during the PRIDE-PRD campaign in 2004. Model investigations include integrated process rate analysis, ozone production efficiency analysis, and VOC vs. NO<sub>x</sub> precursor sensitivity analysis.

The manuscript has a good structure, is concise, and has clearly-presented written English. However, it is hard to defend that the overall conclusions of the authors present significant new insight into regional photochemical ozone in general. Thus the authors conclusion on page 26853 is that: “Through the transport process during nighttime and morning, O<sub>3</sub> precursors originating from different source regions are mixed and transported to downwind rural areas where they are then involved in the daytime O<sub>3</sub> photochemical production. . .these close interactions among precursor emissions, physical transport, and photochemical production ultimately resulted in regional O<sub>3</sub> pollution over the southern and western Pearl River Delta. . .” Such conclusions could have been written from our knowledge already of regional photochemical ozone, although I suppose it can be said that the authors have confirmed from the simulation work they present here that such processes are occurring in the PRD region. The above general comment about lack of significant new insight aside, the manuscript is suitable for publication in ACP, subject to response to other points raised.

(A1) Thanks. The general knowledge of interactions among emissions, transport, and photochemistry resulting in regional O<sub>3</sub> pollution is well known. However, the O<sub>3</sub> problem in PRD has its own local features, and is extremely complicated due to the unique emissions and meteorological conditions. Our simulation study here aims to investigate the influence from different processes (e.g emissions, transport, and photochemistry) that dominates the O<sub>3</sub> formation in a tempo-spatial manner in the region (such as described in the Section 3.3.2). Such discussions on O<sub>3</sub> pollution over inland PRD areas have not been addressed before.

To include more specific understandings on regional O<sub>3</sub> formation in PRD, we revised our conclusion on page 26835 line 20-26 as follows :

C11914

ACPD

9, C11913–C11918,  
2010

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Interactive  
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Discussion Paper



“Compared with previous studies, an in-depth understanding of the regional O<sub>3</sub> formation over inland PRD area is obtained by process analysis. Through the transport process during nighttime and morning, O<sub>3</sub> precursors originating from northern source areas (i.e. urban Guangzhou and Foshan) and from southern areas (i.e. Dongguan, Shenzhen and Hong Kong) are usually mixed and transported to western or southern rural areas, where they are then involved in the daytime O<sub>3</sub> photochemical production. Such close interactions among precursor emissions, physical transport, and gas phase chemistry resulted in significant O<sub>3</sub> chemical production on a large regional scale in the daytime. The sea-land circulations played an important role on the regional O<sub>3</sub> formation and distribution over PRD during the campaign.”

#### Specific Comments:

(Q2) Section 3.1 and Table 3: It is stated that simulated ozone values “compare well” against observed ozone but yet the correlation coefficient is only 0.60 so the explanatory coefficient of variance is only 36%. (Also the mean bias is -17.4%). The low CoV points to considerable residual lack of model skill at simulating variability in ozone. The authors state that the model evaluation statistical diagnostics are comparable to results of other CMAQ applications, but a statement of comparability with previous applications of this model doesn’t in itself equate to adequate demonstration of fitness for purpose. Furthermore, Table 3 indicates that the simulated-observed comparison was censored to include only pairs of data where observed ozone exceeded 40 ppb. No explanation is given for this censoring. Defend the justification for not using all data in the comparison - the suspicious might infer that inclusion of the additional data lowers the correlation (and increases the magnitudes of the bias statistics) between simulations and observations still further, otherwise why not retain all comparative data pairs?

(A2) Many factors affect the simulation performance of chemical transport models, such as the uncertainties in precursor emissions and meteorological inputs, as well as uncertainties associated with the kinetic parameters. The simulated concentration represents a volume average in a grid cell box with a resolution of several kilome-

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Discussion Paper



ters, whereas the observations are point measurement. This consistency has a negative influence on model performance. There are not absolute criteria or benchmarks which distinguish acceptable and unacceptable model performance, a reasonable and common-used way is to compare statistical measures of this simulation with other similar applications reported in the literature. The comparability of model evaluation statistics with previous CMAQ applications suggests an acceptable performance of similar application.

Because the normalized quantities can become large when the observations are small (Boylan et al., 2002), a prescribed threshold is recommended for calculations of O3 statistical performance measures with normalization, e.g. mean normalized bias (MNB, see the supplement for the definition) and mean normalized error (MNE, see the supplement for the definition) (US EPA, 1991; Russell and Dennis, 2000). A cut-off threshold of 40 ppb are usually applied for photochemical model evaluation in many studies (Boylan et al., 2002; O'Neill et al., 2006; Zhang et al., 2006; Hu et al., 2006; Lei et al., 2007).

For comparison with other applications, the cut-off of 40 ppb was applied in our O3 statistical evaluation. Since the normalized mean bias (NMB, see the supplement for the definition) and normalized mean error (NME, see the supplement for the definition) applied in our work are more robust than MNB and NME for cases with extremely low observed values, we remove the cut-off threshold for the statistical measures and obtain the following results: the correlation coefficient 0.73, NMB -5.4% and NME 37.1%. Considering the correlation coefficient and the number of data pairs, both with and without the cut-off threshold of 40 ppb, the simulated hourly O3 concentrations and the observations are significantly correlated with p-value less than 0.01, which suggests the simulations reasonably reproduce the variations of observed O3.

(Q3) For the sensitivity analysis, it is not stated how the NO<sub>x</sub> and VOC emissions reductions of 25% are applied. Is it linearly distributed across all spaces and even applied across time and space?

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(A3) The 25% reduction in the NO<sub>x</sub> and VOC emissions are only applied on the anthropogenic emission sources, no changes to biogenic emissions. And the reductions are linearly distributed across all NO<sub>x</sub> and VOC species and applied across time and space, all reduced with the same percentage, 25%.

Technical comments:

(Q4) A large number of the figures are too small usefully to discern the detail of their content (and of their axis labels also in some instances). Thus the 12 time series in Fig. 3 are too small to be of practical use in judging comparison between observed and simulated hourly ozone. Also Figs. 7, 8, 9, 11, 12, 14 and 15 are all hard to read.

(A4) The 12 time series in Fig. 3 are enlarged for a clearer presenting in two pages. The other Figs. are also revised for easily reading.

(Q5) P26843, line 16: delete one of “across” or “over”.

(A5) The word of “across” was deleted.

(Q6) P26851, line 10: define the acronym OBM.

(A6) The acronym “OBM” was replaced with the full name “observation-based model”.

Reference:

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Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/9/C11913/2010/acpd-9-C11913-2010-supplement.pdf>

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 9, 26833, 2009.

ACPD

9, C11913–C11918,  
2010

Interactive  
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