

## ***Interactive comment on “Spatial-temporal variations of surface ozone and ozone control strategy for Northern China” by G. Tang et al.***

**Anonymous Referee #1**

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This is the review of the paper ‘Spatial-temporal variations of surface ozone and ozone control strategy for Northern China’ by Tang et al.

The paper presents an interesting and comprehensive analysis of air pollution in Northern China based on data from a major field campaign in 2009–2010. The manuscript is well written and easy to understand and is an interesting contribution to the scientific literature. I recommend it for publication in ACP after the authors provided additional clarifications and addressed the major and minor comments given below. I hope the authors are able to address these comments, perform the requested changes and revise the manuscript within a couple of weeks.

Major comments:

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1)The analysis is based on data from a 1-year field campaign conducted in June 2009–September 2010. My main concern is how representative the meteorological conditions during this time period are in comparison to the long-term climatology. The authors state multiple times in the manuscript (e.g. P26080, L13) that meteorological conditions during summer are very similar from year to year. I think a quantitative proof for this argument would be valuable. Therefore, I suggest that the authors include a comparison of the meteorological conditions of the campaign period with the long-term climatology in the paper. Especially, as some confusion occurs as in the later sections the authors state that July and June had specific meteorological conditions in 2010.

2)The authors suggest possible control strategies for air pollution in Northern China based on the findings of their study. Following the points raised above, the proposed measures might just be effective if the meteorological conditions of 2009–10 are representative. In addition did the authors perform any sensitivity analysis on how changing emissions would affect the effectiveness of the proposed control strategies and/or performed or intend to perform any scenario analysis to which extent such measures would help to improve local/regional air quality? This might be an important issue considering the increasing trends reported in section 4.

3)How did the authors determine statistical skills on regional basis? Is it the mean over all  $n$  stations for each individual region or was any area weighted calculation performed? How did the authors deal with spatial dependence among the individual sites – or was this not considered in the analysis?

4)Although the minor and technical comments below include several suggestions to enhance readability, I would kindly ask the authors to check tense, grammar and spelling again for the revised version of the manuscript.

Minor and technical comments:

Title:

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I would suggest changing the title of the revised manuscript to 'Spatial-temporal variations in surface ozone in Northern China as observed during 2009-2010 and possible implications for future air quality control strategies'

Abstract:

P26058, L4: reword this sentence 'to provide a comprehensive record of ozone (O<sub>3</sub>), respirable particulate matter (PM<sub>10</sub>) . . . and contribute to an in-depth understanding air pollution in Northern China and its driving forces'.

P26058, L16: replace 'to decreasing cloudiness . . . ' with 'due to decreased cloud cover'

P26058, L23: replace 'meteorological results' with 'meteorological conditions'

P26060, L1: replace 'Our results are helpful' with 'The presented results are intended to provide guidance . . . '

1. Introduction:

P26059, L5-9: The authors provide a state-of-the-art introduction to the environmental and health concerns related to tropospheric ozone. Please provide an adequate number of references for this statement.

P26059, L13: typo: 'Bronnimann' should be 'Broennimann'

P26059, L25-27: please provide references for this statement

P26060, L1-3: Although it is well-known that the BTH region is one of the fastest developing regions I would appreciate if the authors could provide a reference to this statement. Same holds for L8-10 on this page.

P26060, L20 and following: remove 'For' at the beginning of the sentence; replace tighten with tightened; the authors list several policies and state that air quality standards have tightened. I would appreciate if the authors could provide along with the

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regulations the changes in air quality thresholds. Maybe this can be done in a Table in an Appendix to the manuscript. Further, the authors state that the regulations resulted in a decrease of pollutants from coal burning. Is there a study reporting on this? If so the authors should provide reference to the relevant literature.

P26060, L25: replace 'However, increasing automobiles and populations' with 'However, the increase in population and the number of motor vehicles'

P26061, L4: replace 'particulate matters' with 'particulate matter' or in short PM<sub>10</sub>

P26061, L5 and following: replace 'Beijing local government' with 'Beijing's local government'

P26061, L7: remove 'should'

P26061, L16: insert 'the' before Olympics and provide references to the relevant literature documenting the positive effect of governmental regulations on local-regional air quality during this period. I remember a study of Cermak and Knutti (2009), but the authors may want to include additional references.

P26061, L20: 'Previous investigations . . . ' remove this sentence it does not add value to the manuscript.

P26062, L2: replace 'clear picture' with 'comprehensive picture'

P26062, L2: replace 'illustrated' with 'illustrate'

P26062, L6: shouldn't it be August 2010?

P26062, L9: replace 'the factors that influence . . . ' with 'the main driving forces of summer O<sub>3</sub> concentrations . . . '

2. Methodology:

P26062, L16: for convenient reference provide full spelling of CAS-IAP-CERN and abbreviation in parentheses

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P26062, L20: replace '...., which each measures ...' with 'ambient concentrations of .... are measured in real-time at each station.' In addition I would appreciate if the authors would provide full station names, coordinates, altitude and if possible mean and maximum O3 concentrations on monthly basis along with the information already provided in Table 2.

P26062, L24: replace 'away' with 'remote'

P26063, L2: station abbreviations for the Beijing area are missing. Also it is a bit confusing for the reader to have two different listings of the stations. It is not clear why the one on P26062 differs from the one on P26063. Maybe one - well motivated - listing of stations is sufficient for the scope of the manuscript?

P26063, L7: replace 'Data from all sites were first screened by inspection the frequency of missing measurement' with 'Data quality was carefully evaluated and at all sites the frequency of missing values was checked prior to data analysis.'

P26063, L19: the information on 49 or 49C could also be included as additional information in Table 2.

P26064, L14: replace 'to investigate' with 'to analyze'.

P26064, L14 and following, as stated earlier the results of the statistical analysis would be valuable information in Table 2. In addition the authors may want to present a matrix of R, CV and COD for all stations. This would allow for quantitative comparison with the regional results provided in Table 3. It would be easy to evaluate if any station(s) can be considered as outlier(s) or the regions are 'fully' homogeneous.

P26064, L18: insert 'the' before shared variance.

P26065 and P26066: Please provide references for schemes used in the setup of the WRF model.

P26066, L16, the author's state that a half-day spin up was used in the simulations.

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This sounds rather short, did the authors investigate the influence of shorter, longer spin-up time on the results? Is there literature available that reports that this short spin-up time is sufficient for the analysis? If so please provide references.

P26066, L20: The authors state that meteorological simulations were compared with observations from 10 sites. I assume that meteorological information was not available at the other monitoring sites –right? If so please state this in the section.

P26068, L15: replace 'observation' with 'observations' and 'running' with 'operation'

P26068, L24: replace 'scenes' with 'observations' and 'that' with 'where'

P26069, L2: replace 'indicate' with 'indicating'

P26069, L3: replace 'ratio' with 'ratios' and 'a transient regime' with 'as transient regime'

3. Results:

P26069, L15: replace 'skill' with 'statistical skill'

P26069, L20&23: shouldn't MB be ME?

P26070, L17: replace 'North China Plain' with 'plain'

P26070, L20: remove 'the' before spring ... please check throughout the manuscript as this is often the case for different seasons

P26071, L3: The authors state that seasonal distribution patterns are similar to annual ones. This would be interesting to see, especially for summer as the authors discuss in particular this season. I would suggest to add seasonal panels either directly in Fig.5 or in a supplementary/additional Figure. Same is true for Fig. 6. Anyway as suggested below I would combine Figures 5 and 6.

P26071, L13-14: the sum of the individual contributions is 94.1%. Which source is the remaining fraction attributed to? Or is there a typo?

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P26071, L21: replace 'plains areas' with 'plains'. Same for L24 on this page.

P26072, L16: replace 'inconsistent' with 'different' – please change this throughout the manuscript.

P26074, L1: replace 'lowest' with 'particularly low'.

P26074, L7: replace 'emission' with 'emissions'.

P26075, L1: reword to "The results showed that a larger cloud fraction is directly correlated with more precipitation".

P26075, L11: ..... replace ' need to be deeply studied ...' with 'need further investigation and additional observational and modeling studies (although beyond the scope of the present analysis) are suggested for further work.'

P26075, L27: remove 'the' before ozone and replace 'peak' with 'peaks' and remove 'of ozone' after photochemical formation

P26076, L2: remove 'those' before in other seasons

#### 4. Discussions

Section 4.1: I suggest moving this section in the results section of the manuscript

P26077, L1: The authors provide information on how often Grade II is exceeded. How do the statistics for Grade I look like and how large is the threshold for this Grade?

P26077, L16: replace 'will be obtained' with 'can be suggested and evaluated'

Section 4.2: as section 4.1. I suggest moving this section in the results section of the manuscript

P26078, L6: replace 'The southern plains area presented modest exceedances ...' with 'Over the southern plains moderate exceedance of ...'

P26078, L28: 'while ...' replace by 'Meteorological conditions are found to be the

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main driving force for temporal variability. Yet, there is the unanswered question, what controls spatial variability in O<sub>3</sub>?

P26079, L4: replace: 'exhibit inconsistent' with 'show different meteorology'

P26079, L19: replace: 'clearly displayed' with 'shows a clear'

P26079, L26: reference for Zhang et al., 2009, should the reference not be included after automobiles?

P26080, L5: replace 'plains areas' with 'plains'

P26080, L6: replace 'In summary we arrived at two major conclusions' with 'From the results presented above two major conclusions can be drawn: ...'

P26080, L14: replace 'abatement' with 'reduction' and 'diminish' with 'decrease'

P26081, L2: I would suggest moving the last part of section 4.2 starting with 'Since 1997, with the strong ...' into the Discussion section and rename section 5 to 'Conclusions and Discussion of implications for future air quality control strategies in Northern China'

#### 5. Conclusions

P26082, L2: reword to 'The major field campaign conducted in 2009-10 allowed for the first time observation of the concentrations and spatial-temporal variations of ozone and nitrogen oxide over Northern China'

P26082, L16: remove 'an' before 'increasing ozone dry deposition'

P26082, L20: remove 'are' before 'the eastern ...'

P26082, L22: replace 'inconsistent' with 'different'

P26082, L24: insert 'frequency of' before 'exceedances' and 'of national air quality thresholds' before 'after 'exceedances'

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P26082, L30: replace 'are dominated' with 'are found to be mainly dominated'

Tables:

Table 1: provide explanation for ME, MBE, RMSE and R in Table caption

Table 2: see several comments provided above

Table 3: provide explanation for R, CV and COD in Table caption

Figures:

Figures 1, 5, 6, 12,13,15: For better readability the Figure legend should be centered over the Yellow Sea or in a box outside of the Figures.

Fig.3: Font size should be increased for better readability, also as black and red lines are the same in all 4 panels it would be sufficient to present the legend once. The Figure could be arranged in a (2,2) illustration to enlarge the individual panels. Also labeling ((a)-(d)) is missing.

Fig.4: Font size of axis labels and legend should be increased for better readability. Further as color scheme is similar for all 4 panels one large color bar right of panel b and d would be sufficient and increase readability.

Fig.5 and Fig.6 could be combined in one figure with panels (a) and (b).

Fig.7: see comment to Fig.4.

Fig.9: Vd for dry deposition is missing in the caption.

Fig.10 and Fig.11: Captions miss explanation on regional grouping.

Fig.12 and Fig.13 could be combined in one figure with panels (a) and (b).

References:

J. Cermak and R. Knutti (2009), Beijing Olympics as an aerosol field experiment, *Geophys. Res. Lett.*, 36, L10806, doi:10.1029/2009GL038572.

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Interactive comment on *Atmos. Chem. Phys. Discuss.*, 11, 26057, 2011.

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