Atmos. Chem. Phys. Discuss., 8, S4628–S4634, 2008
www.atmos-chem-phys-discuss.net/8/S4628/2008/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "An investigation into seasonal and regional aerosol characteristics in East Asia using model-predicted and remotely-sensed aerosol properties" *by* C. H. Song et al.

C. H. Song et al.

Received and published: 10 July 2008

First of all, thank you for your valuable comments and suggestions. In this revised manuscript we try to clarify what we intend to discuss in this manuscript by eliminating, modifying, and adding several parts from/into the original text (the added/modified parts are painted in a red color). Also, we improved many figures (Figs, 1, 2, 4, 7, 8, 9. 10, 12, 13) in this revised manuscript. Below are the point-to-point replies to your comments:

1. The conclusion that nitrates are important when determining AOD is one of the more significant features of the paper. Nitrates are often not included in large-scale models and the implications of this should be highlighted and discussed in more detail.

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Reply) Yes, it is a really important issue, particularly when NH3 and NOx emission fluxes are large. We further tried to highlight this issue in this revised manuscript. Please, check out p. 2:19-3:3, p.11:7-11, p.26:16-19, and p28:3-29:12.Also, we added Fig. 12 to clarify the contribution of nitrate to the AOD values (i.e., AOD budget study) in East Asia (refer to p.34:3-13).

2. In general the discussion is qualitative and although statistical values are given for comparison of the model, MODIS and AERONET AOD the cases showing poor agreement are not explored in much detail. If the model AOD differs significantly from that of AERONET and MODIS can this be explained by the emissions or by wet scavenging or by spatial sampling etc? Something should be learned from the comparison in order to justify the observations being shown.

Reply) We agree with you. Particularly, the comparison between tMODIS and tCMAQ provides us a good opportunity to investigate the accuracy of emission fluxes of particulate precursors. In order to investigate this, we re-drew (reanalyzed) Fig. 8 over four regions in our domain. Please check out the revised Fig. 8. Also, we added some more discussions into the text, regarding dust/sea-salt generations, biomass burning, and NH3 emissions in China. Please, refer to p. p28:3-p.29:12, p.30:6-22, and p.33:17-34:2.

3. The demonstration of a new AOD retrieval method from MODIS data is interesting but does not contribute much to the primary purpose of the paper - the M-BAER retrieval is shown to correlate almost as well with AERONET as the NASA C005 retrieval but how does this benefit the paper more than using just the NASA C005 retrieval? The paper is a study of seasonal and regional aerosol characteristics rather than a new retrieval mechanism. The authors should either highlight the significance of the two retrievals or use just one in the paper. Are there specific cases when the M-BAER retrieval out-performs the NASA retrieval and can be considered more reliable? There needs to be further justification for using the modified M-BAER algorithm as well as the NASA C005 algorithm.

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Reply) Although the primary purpose of this study was to investigate seasonally- and regionally-varying aerosol formation/transport characteristics in East Asia, we also aimed at testing two aerosol retrieval algorithms in East Asia. The reasons of using the two aerosol retrieval algorithms in this study are described at p.6:6-7:7. We also put more detailed discussions into the modified Sect 3.2 and newly-added Table 2 to contrast the M-BAER and NASA C005 algorithms.

4. How are the modes fixed within the model? In effective radius and size parameter? The number of modes should be specified. Also, as the AOD is based upon the mass concentrations has any evaluation of the species mass concentrations from the model been performed? If so, references to this should be included.

Reply) Other global-scale models (e.g., NASA GOCART and SPRINTARS) have fixed aerosol size parameters of particulate species for the sake of modeling simplicity, whereas the Models-3/CMAQ model employs modal approach. As described in Sect. 2.1, the aerosol dynamics module in the CMAQ model can consider a full spectrum of aerosol dynamics such as coagulation, condensation, and particle growth (Binkowski, 1999; Binkowski and Roselle, 2003). Therefore, the mode-fixing is not necessary.

5. This section details a qualitative comparison of MODIS AOD with the CMAQ model AOD. MODIS cloud screening is cited as a possible reason for discontinuities in the AOD due to the dust plume. If the model and MODIS AOD are to be compared then the comparison should not include model data where MODIS has been cloud-screened, otherwise, as the authors point out, this comparison is limited and potentially misleading given cloud-aerosol correlation. MODIS retrieval comparison: It should be made clear whether the M-BAER method produces better agreement with AERONET AOD than the C005 algorithm. If agreement is similar then this shows that the retrievals are reasonably robust however it does not necessarily justify the use of another retrieval than the NASA C005 algorithm. Can cases or regions be shown where one retrieval consistently shows better agreement with AERONET?

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Reply) There was a misunderstanding. Discontinuity in the AOD plume was not due to the cloud-filtering processes. In order to clarify this, we restructured Sect 4.1.1, and also added some more discussions. Please, check the revised Sect 4.1.1. In the improved Fig 4, 8, and 9 and Table 3, tCMAQ was averaged over the domain over-passing times of the Terra/MODIS platform, and also was excluded at the pixels where the AOD(MODIS) values were cloud-filtered. Please, refer to p.20:21-22:2. Again, some reasons (or justifications) of using the two aerosol retrieval algorithms in this study are described at p.6:6-7:7.

6. Can the poor agreement between AERONET and M-BAER AOD in the Fall really be attributed to lack of data when the NASA AOD shows a better correlation?

Reply) The reason is really unclear. What we would like to try to say here was that the paucity of tAERONET hampered further investigation into the cause of the poor agreement. We put some discussions into p.34:19-24.

7. Nitrates: The conclusion that nitrates are important when determining AOD is one of the more significant features of the paper. Nitrates are often not included in large-scale models and the implications of this should be highlighted. A figure showing the fraction of AOD attributed to nitrate for each of the seasons would be a powerful message.

Reply) Again, thank you for this point. Related to 1, we tried to highlight this. Please, check out p. 2:19-3:3, p.11:7-11, p.26:16-19, and p28:3-29:12. Also, we added Fig. 12 to clarify the contribution of nitrate to the AOD values in East Asia.

8. Secondary Organics: As the impact of SOA upon AOD is found to be significant I feel you should discuss the uncertainties in estimating SOA burden. It appears that the multiplication of the SOA concentration by a factor of four in equation 7 accounts for the substantial AOD of the SOA. I have had trouble locating a copy of Malm et al. (US EPA, 2000) from which the empirical relationship is taken. I think it is worth explaining the reasoning of Malm et al. for using this multiplication factor and quoting any available error estimates given.

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Reply) Obviously, specific extinction efficiency for SOAs is a function of the SOA composition. Probably, the SOA formation characteristics are different in Asia than those in USA. Therefore, several scientists are studying this issue for East Asia. But, the methodology is not yet fully developed and/or generalized sufficiently for the use of this kind study. So, we adopted Malm&'s methodology (the year 2000 version). More recent (but very similar to this study) estimation of the specific extinction efficiency can also be found in Malm and Hand (2007). Also, we believe that the dry mass extinction efficiency for dust particles is much more uncertain in East Asia. This is an important issue, since dust storms frequently occur and impact the East Asian air quality. We added some discussions regarding these points at p.18:1-9. Reference) Malm and Hand: Atmos. Environ., 41, 3407-3427, 2007.

9. Figures: Continental outlines not visible on Figure 4. Text is illegible in Figures 4 and 7.

Reply) We improved Figs. 4 and 7. Please, check those out.

10. p. 8662, line 16+: Remove "monitoring"; and & "measurements"; in brackets to improve the flow of the sentence.

Reply) Yes, we removed it (see p.4:17).

11. p. 8664, lines 26 & 27: "AERONETR" written in the subscript should be "AERONET".

Reply) Thank you for your correction. Those were removed in this revised manuscript.

12.p. 8665, line 16: "in the link with" should be "in conjunction with".

Reply) We corrected it (see p.6:4).

13. p. 8668, line 10: Reference for Four-D Data Assimilation (FDDA) techniques.

Reply) It is a well-built technique in the MET modeling. We put Stauffer and Seaman (1990, 1994) at p.10:7.

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14. p. 8669, line 1+: It is stated that some studies underestimate NOx emissions by 30% and Streets et al. estimate uncertainties of +/-37%, however it is also said that it is generally believed that the uncertainties in their emissions are relatively small. Please clarify this statement. are the numbers quoted considered small or is there evidence to suggest these are over-estimates?

Reply) It appears that there was a confusion. For clarification, we removed the "although....". Please, see p.10:524. In the East Asian air quality studies, SO2 and NOx emissions have been best established. In the NOx emissions, there are +/-16 and 30% uncertainties for SO2 and NOx emissions, respectively. But, for example, like other regional studies, NH3 emissions remain very uncertain, and are probably overestimated in East Asia by a fact of 2. The overestimation can be shown and discussed in modified Fig. 8 and corresponding discussions in the text (See, p.11:7-11; p28:3-p.29:12.

15. p. 8669, line 17+: Are there any references for the evaluation of the BC/OC emissions?

Reply) Together with NH3 emissions, BC/OC emissions are also very uncertain. There were some discussions about the accuracy of BC/OC emissions in Streets et al. (2003).

16. p. 8669, line 25: Equation 1 contains a delta-t term however the E(Dust) is said to be a mass flux which is per unit time by definition.

Reply) Thank you for this correction. The unit of E should be g/m2 sec. The Eq.(1) was the amount of dust generated during a time period given and over an area of interest, so that both delta term and area (A) should be removed in Eq. (1). (See p.11: bottom line)

17. p. 8672, line 7: "Look up tables" should be "look-up tables"

Reply) Yes, we corrected it (see p. 14:7).

18. p. 8672, line 28: good agreement - please define what is considered good agree-

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ment or quote a quantitative measurement used by Lee et al.

Reply) Quantitative values were quoted at p.16.1.

19. p. 8673, line 16: Delete "this will be".

Reply) We deleted the part (see p. 20:1)

20. p. 8677, line 4: "CAMQ" should be "CMAQ".

Reply) We corrected it (see p.20:20).

21. p. 8677, line 24+: Please provide a reference for "dust plumes are typically transported behind or below the cold frontal clouds"

Reply) Actually, this phenomenon is very common (and well-known) in East Asia during dust storms. We added two references into the text at p.21:16.

22. p. 8677, line 16: Delete "/can".

Reply) We deleted it (see p25:24).

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 8661, 2008.