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Geoscientific Model Development Discussions

Interactive comment on "Development of a numerical system to improve particulate matter forecasts in South Korea using geostationary satellite-retrieved aerosol optical data over Northeast Asia" *by* S. Lee et al.

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Response to Reviewer #2 First of all, we would like to thank you for your constructive comments and suggestions. Based on the comments from two reviewers and the executive editor, we have tried to address the issues raised by both reviewers in the revised manuscript. We would also like to respond to the comments point-by-point below. The added or modified parts in the revised manuscript are highlighted in a red color.

General comment

Comment) It is obvious that the model has the strict negative bias. The statistics analysis (Table C1630 4 and 5) shows large negative bias (MFB=-98.7-113.2% and NMB=-62.6-70.0%) in the noSTK case for AOD and PM10. Figure 7 shows that the model forecast PM10 concentrations less than half those of observations. The bias in the noSTK case is constant and so (negatively) large that this is not difficult that the STK cases obtain better scores (especially in short time forecast). In fact, negative biases are still found in the STK cases. I wonder if the application of the STK could show any modification in horizontal distribution (e.g., shape of PM10 plume) or timing of peak of PM10 and AOD.

Reply) We have tried to address the issue of whether the applications of the STK cases could also improve the performances of hindcast runs for less polluted conditions where the negative biases were relatively small compared with those in high polluted conditions. We have also tested whether there are any improvements in horizontal distributions and/or timing of peaks of PM10 and AOD. We found that there were positive effects not only on reducing negative biases but also on improving spatial distributions. Please see p. 8, lines 176-178; p. 17, lines 385-386; and pp. 24-25, lines 552-567. We also added Fig. 10 in the revised manuscript and one table in the supplement (refer to Table S1)

Comment) Other concern is the necessity of sophistication of model. The model bias rapidly negates the beneficial effect from modification of initial condition (i.e. the application of the STK), indicating that refinements of the model (e.g., emissions and parameterizations) might be much more effective to improve the PM10 forecast than the replacement of initial condition.

Reply) Yes, we completely agree with your opinion. The effects of the initial conditions cannot last long, which implies that both/either the CTM parameterizations and/or emissions is/are not currently perfect. We are working on these issues in separate frame-

works. We believe that improving the parameterizations and/or emissions are beyond the scope of this manuscript. Please, consider positive impacts on improving the performances of hindcast runs for 48 hours. Please, refer to pp. 24-25, lines 552-567 in the revised manuscript

Minor comments Comment) 1. (P5317, L13) The STK can use observed data more than what? Please specify.

Reply) We rephrased the sentence. Please, check out p. 2, lines 33-35 in the revised manuscript.

Comment) 2. (P5318, L21) What was low (< 60%)? Which score? Please specify.

Reply) We rephrased the sentence. Please, see pp. 3-4, lines 68-69.

Comment) 3. (P5322, L10) The system is planned to be used as operational system. Is 12-hour forecasting enough long for early warning of PM10?

Reply) We have been aware of this problem. In the revised manuscript, we showed the performances of hindcast runs for 48 hours. Please p. 8, lines 176-178; p. 17, lines 385-386; and pp. 24-25, lines 552-567. We also added Fig. 10 in the revised manuscript and one table in the supplement (refer to Table S1).

Comment) 4. (P5323, L20) Did you use SSA and FMF in this study?

Reply) We have not used SSA and FMF data from GOCI sensor due to their relatively large uncertainties. As soon as these data with high quality become available, we will try to include the SSA and FMF in our study.

Comment) 5. (P5325, L11) Please describe the mathematical linkage. In this study, the kriging is used for temporal and spatial interpolation (compensation). Data assimilation techniques are based on statistical estimation and used for integrate model and observation.

Reply) We corrected relevant sentences. Please, refer to p. 17, lines 393-394.

Comment) 6. (P5325, L25) Did you use the STK to smooth existing data points? Did you apply the STK only to fill missing points?

Reply) We constructed AOD fields at 12:00 LT, using the GOCI data at 09:30, 10:30, 11:30, and 13:30 LT over the model grid point where any data was not spatially coincided with GOCI observations. Therefore, all of ST-kriging AOD data were weighted averaged (or smoothed) by surrounding observation data.

Comment) 7. (P5326, L4) The STK method can use an AOD field at 12:00 derived from AOD fields observed at 9:30, 10:30, 11:30, 12:30 and 13:30. On the other hand, 3D-Var and OI are sequential technique. They can assimilate the AOD fields at observed times, sequentially. From this aspect, 3D-Var and OI can use more observation data points more than the STK method.

Reply) We rephrased the sentences. Please, check out p. 12, lines 267-271.

Comment) 8. (P5326, L1) 13:30 is better than 01:30.

Reply) We corrected it.

Comment) 9. (P5326, L10) “Uncertainties” is inadequate. “Biases” is proper.

Reply) We changed it. Thank you for your comment.

Comment) 10. (P5326, L15) The system is going to be used operationally. The light computational cost of the STK is one of advantages for operational forecasting. However, to calculate AOD field at 12:00 through the STK, we must wait for GOCI AOD data at 13:30. Is this OK for the schedule?

Reply) One of the objectives in this study is to find the best combination for the PM forecast over Northeast Asia. Therefore, we chose to include GOCI data at 13:30 for the enhancement of STK AOD quality. However, we completely agree that including GOCI data at 13:30 (or 12:30) should be considered carefully according to the available computational resources.

Comment) 11. (P5328, L20) How did you modify vertical profiles of concentrations from the GOCI AOD?

Reply) We rephrased relevant sentences to clarify the method for determining aerosol vertical profiles. Please, check out p. 16, lines 370-372.

Comment) 12. (Section 3.1) Can you show AOD fields before and after the application of the STK? Exhibiting how the STK compensates missing regions due to clouds and high reflectance will reinforce readers' understanding. Other concern is if there enough GOCI data to fill missing points. Sometimes, we found large missing fields in satellite-measured AOT maps due to clouds. Can the STK method with five GOCI AOT fields fill the missing field completely? If not, how do you replace the initial condition of the forecasting.

Reply) We added a figure showing the AOD fields before and after the application of the STK method. Please, check out Fig. A2 and p. 29, lines 654-656. We also added a sentence for clarifying how to fill out large missing fields. Please, see p. 18, lines 409-412.

Comment) 13. (P5330, L19-21) Do these sentences mean that when the model has a considerable negative bias, the STK is favorable comparing with other DA methods?

Reply) We changed the sentence in Sect. 3. 1. Please refer to p. 17, lines 393-394.

Comment) 14. (P5333, L11-16) This result means that excepting sea-salt and BC from CVs leaded to better results? In the other words, including sea salt and BC in CVs degraded results?

Reply) According to the background model simulations, the contributions of BC and sea-salt to AOD and PM10 were less than 5 % over the domain. Therefore, we assumed that the effect of selecting BC and sea-salt for CVs would be relatively small. In particular, for high pollution episodes, the contributions of both species to total mass in Seoul Metropolitan Area (SMA) are minimal. However, we agree that it is necessary to

consider those species as CVs in some episodes such as large biomass burning and in some areas nearby coastal regions.

Interactive comment on Geosci. Model Dev. Discuss., 8, 5315, 2015.