

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 #1: 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.

C2313

Main comments

Comment) One additional CMAQ simulation and analysis that I would like to see is a comparison between using initial conditions from GOCl but without using kriging (single frame on the time of initialization without filling any gap) vs using kriging. This would help show how valuable is to enhance the GOCl data with kriging, which is one of the main novelties of this study. You could add some of these results to Fig 6.

Reply) We agree with reviewer #1. We have carried out additional hindcast simulations, using initial conditions prepared by single frame of GOCl data. In these simulations, we did not fill any gap if there are not enough observations near model grids. Please, refer to p. 20, lines 454-460 and modified Fig. 6 in the revised manuscript.

Comment) The results are shown for specific air pollution episodes. However, since the system is planned to be used operationally, it would also be useful to see some performance statistics for the less polluted conditions. That way it can be stated if this is a tool for episodes only or for any condition.

Reply) We are happy to reply to this comment. We have also found that the STK method showed positive impacts on improving the performances of hindcast runs for less polluted conditions. We have tried to show the performances of the first and the second 24-h hindcast results, responding to a suggestion from reviewer #2. Please check out p. 8, lines 176-178; p. 17, lines 385-386; and pp. 24-25, lines 552-567 in the revised manuscript. Also, we added Fig. 10 into the revised manuscript.

Comment) Since MODIS AOD is also an operational product and shows slightly better performance than GOCl, it would be nice to see additional sensitivity experiment where MODIS AOD is included into the kriging stage along with GOCl. Since the MODIS bias is very low, this could help with the systematic bias you get in your CMAQ results.

Reply) We agree that the biases of GOCl data can be reduced with other observations such as MODIS data. However, unfortunately, the spatio-temporal kriging system used

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in this study can only treat the data on a regular spatial grid (e.g. the observation points are not changed with respect to time) collected by constant time interval. This is mainly due to the fact that the calculations of the semivariograms require some computational cost. For example, the MODIS case, where time and space of the observation are daily varied, needs additional time lags and fine spatial grids and/or some mathematical assumptions for the calculations of the semivariograms. In this context, we think that this technical issue would be a bit beyond the scope of our current work. We appreciate your comment. Please, refer to p. 26, lines 583-587 in the revised manuscript.

Comment) When comparing GOCl vs MODIS (Fig 3) you are comparing a 6km vs a 10km retrieval, so resolution might play a role in the differences seen in performance and spatial coverage. MODIS collection 6 provides 3km AOD, so it would be interesting to include this product as well to “bound” in some way the GOCl resolution.

Reply) We changed Fig. 3(a), using MODIS Collection-6 3km AOD products. We also modified Fig. 3(c) to show the hourly coverages from 1 March to 31 May, 2012. Please, see pp. 9-10, lines 209-218 and also check out modified Fig. 3.

Comment) In several places of the text the authors state that kriging is used instead of data assimilation (e.g., beginning of section 3.1 and section 2.3). However, the kriging is a data processing stage to enhance the GOCl data and is not related to data assimilation (i.e., combine model and observation). Actually, one could use the output from the kriging into a data assimilation system. What you are replacing by data assimilation is the way you change the model concentrations (e.g. assumption of a perfect observation, choice of observation operator and control variable). Please correct this throughout the text.

Reply) We removed the sentences p. 5325, line 11 in the original manuscript and modified the relevant sentences. Please, see p. 17, lines 393-394.

Other comments Comment) Page 5319, Line 11. SeaWIFS is no longer operational since 2010 so I wouldn't include as a product that can be used

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Reply) We removed SeaWIFS from the sentence.

Comments) Page 5322, Line 18. It is not clear what the numbers mean, hours? Configuration index? Please rephrase

Reply) We rephrased the sentence. Please, see p. 8, lines 170-172.

Comment) Section 2.2.1. Please clarify that the GOCl vs MODIS comparison is done before kriging

Reply) We modified the sentence in Sect. 2.2.1. Please, check out p. 9, lines 206-209.

Comment) Fig. 3. How is spatial coverage from GOCl computed? Do you use a single GOCl time for a similar time of the Terra overpass? Or you average several GOCl frames? Please explain this in the text to better understand where the differences in spatial coverage come from.

Reply) We changed the Fig. 3 to clarify how the spatial coverage from GOCl was computed, showing hourly-based spatial coverage. Please, check out the caption of Fig. 3.

Comment) Section 2.3. The kriging fill the gaps of the GOCl data. Is the kriging able to fill all of the gaps? If not, how do you determine if there is enough data to fill a gap. If you don't fill a gap, then this column in the CMAQ is not modified, right?

Reply) The ST-kriging methods can fill almost all of the gaps of GOCl data with some degree of uncertainties (e.g. the kriging variance explained in Sect. 3. 1). In this study, only the gaps having kriging variance (KV) less than 0.04 were used for preparing the initial conditions. Therefore, AOD columns having kriging variance greater than 0.04 were not used in the initial conditions. Please, refer to p. 18, lines 419-412. We also added a figure in Appendix A, reflecting a suggestion from reviewer #2. Please, check out p. 29, lines 654-656 and Fig. A2.

Comment) Page 5329, Lines 21-23. I'm having problems understanding this CV choice.

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You assume SO₄ and OA is the same only for the increment? Or you make SO₄ and OA be the same in the final model concentrations? You also mention something about the surface, so you don't do anything aloft? Please clarify

Reply) First, the ratios of surface SO₄ concentrations and surface OA concentrations were calculated at the selected model grid points where the ST-kriging AODs have the KVs less than 0.04. Then, OA concentrations through all model layers were multiplied by this ratio, and the surface OA concentrations were the same as the surface SO₄ concentration. Because OA concentrations (from the surface to the top layer) were changed, initial AOD fields were also changed by Eq (1) in p. 14. Then, the differences between the ST-kriging AODs and modified background AODs (observational increments) were used to update the initial SO₄ and OA concentrations corresponding to the contribution of SO₄ and OA AODs to the modified initial AOD fields. Please, note that to prepare concentrations of CVs above surface, background modeling-derived vertical profiles and size distributions of aerosol species were used for converting 2-D AOD to 3-D aerosol mass concentrations in all of the STK cases. We rephrased pp. 16-17, lines 366-372.

Comment) Page 5329, Lines 27. CV #4 balances SO₄, NO₃ and NH₄, but do you do anything with OA? Table 3 says you do change it.

Reply) CV #4 also made equal changes in the SO₄ and OA concentrations at the surface layer, which are the same as CV #3. Please, see p. 16, lines 370-372.

Comment) Page 5336, line 26-27. It can greatly influence composition but you show that for PM₁₀ and AOD differences between CVs are not large. Please rephrase this sentence.

Reply) We rephrased the sentence. Please, see p. 25, 576-578.

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