Response to Referee #2: We would like to thank the referee for the careful review and thoughtful suggestion, which helps us to improve the quality of the manuscript.

Our response follows (*the reviewer's comments are in italics and blue*)

General Comments:

Dust intensity and position errors are commonly found in model studies and difficult to be corrected especially the dust position error. In this study, the authors present a grid distorted data assimilation with the ensemble-based variational (4DEnVar) method to reduce the simulated dust position error for a dust storm event in May 2017 over East Asia. Their results demonstrate that the hybrid assimilation can correct both the dust position and intensity to provide the best initial condition for dust forecast. Generally speaking, the manuscript is scientifically sound and well-written. I recommend accepting it after addressing the following comments.

Major Comments:

According to the results, the improvements of the dust simulation and forecast are very limited with the dust emission inversion only. What is happened? Does your model successfully simulate the place and time of the dust emissions? Probably, this is due to you only show the comparisons on May 5. Can you also compare the results on start time of the dust event probably on May 2 or 3? And it is helpful to show the spatial and temporal differences of the dust emissions between the a priori and the emis inversion experiments.

Reply: An incorrect emission timing profile is indeed a potential origin of the position error. However, during the first two days after the dust emission started, the simulated dust plume was still in north China and showed a good match in position with the observation. This can be seen in the Himawari-8 AOD vs. model simulation on May 3 and 4 in our previous study (Jin et al., 2019b). The good phase match in general can also be seen from a snapshot of the ground PM_{10} observation vs. the simulated surface dust concentration at May 04 15:00 in Fig. 3 (also shown below). The good match in position between simulated and observed dust plume indicates that the emission timing profile is rather accurate too. When the dust plume is transported further southward, the simulated plume starts to deviate from the available surface measurements.

This has been described in ***Section 3.2 Uncertainty in emission timing profile*** on page 6, line 29-32, and page 8, line 1-7, by saying "***One potential origin of the position error is an incorrect emission time***

profile. That is, changes in the time period over which dust is released from the source regions could to some extent alter the position of the simulated plume.

Actually during the first 48 hours after dust emission started, the simulated dust plume was still in north China and showed in general the same pattern as visible in the observations. For example the aerosol optical depth (AOD) retrieved from the Himawari-8 geostationary satellite showed that the simulated plumes are correctly positioned in north China (Jin et al., 2019b). The good phase match in general can also be seen from a snapshot of the ground PM_{10} observation vs. the simulated surface dust concentration at May 04 15:00 (CST) in Fig. 3. There might already be position misfits in the dust simulation at these snapshots, but not easily detected. The magnitudes of the dust concentration showed discrepancies, but these could be corrected by emission inversion through assimilating those AOD observations or PM_{10} measurements. The good match in position between simulated and observed dust plume indicates that the emission timing profile is rather accurate too. When the dust plume is transported further southward, the simulated plume starts to deviate from the available surface measurements."

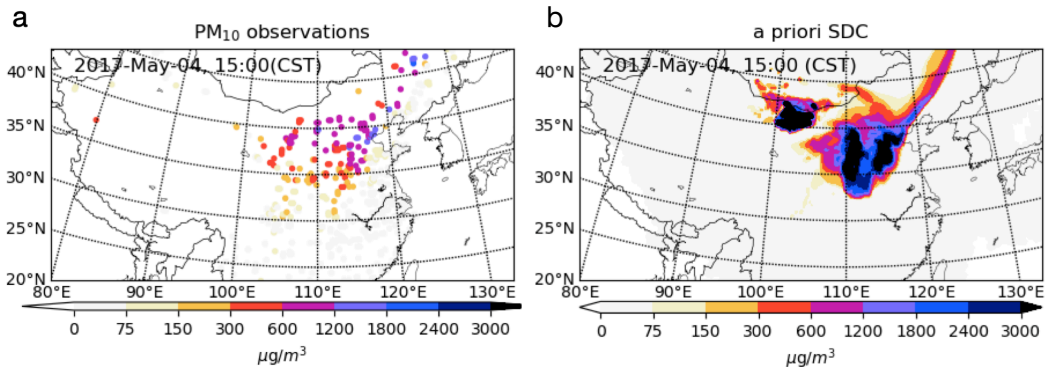

Figure 3. PM_{10} observations (a) and the a priori dust simulation (b) at 15:00 May 04. SDC: surface dust concentration.

A comparison between the *a priori* and emission inversion dust simulations during the early stage is added in the ***Supplementary*** (also shown below), and these show very similar values. A remark on this is added to page 15, line 4-6, ***"The emis inversion also has little effect on the dust simulation at earlier period of the dust event, which can be found through a comparison of the a priori and emission inversion only simulations at May 03, 13:00 in Fig. S1 in Supplementary. The a priori and emis inversion also present the relative similar performance in the early stage."***

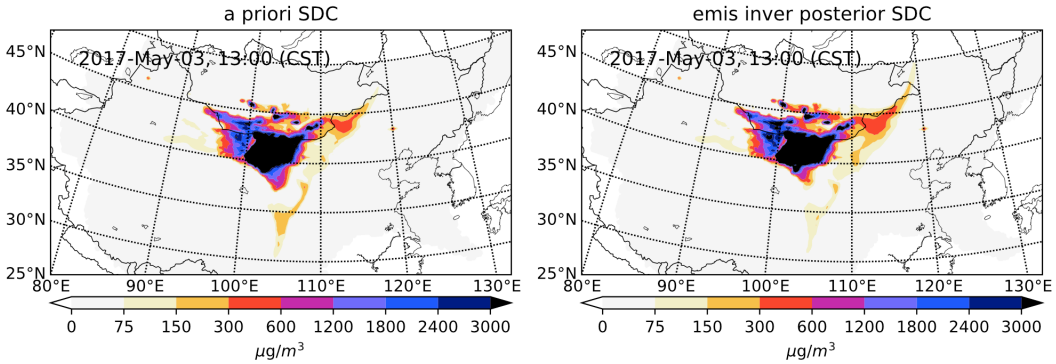

Figure S1. the a priori dust simulation (a) and posterior using the emission inversion at 15:00 May 03. SDC: surface dust concentration.

Specific comments:

Please add the color bar in Figure 1.

Reply: That was indeed missing. The modified Fig. 1 can be found on page 5.

Page 6 Line 6, Alex desert -> Alxa desert?

Reply: Corrected.

Page 13 Line 20 form from?

Reply: Corrected.