

Reply to Anonymous Referee #1

We thank the reviewer for the careful reading of the manuscript and helpful comments. We have revised the manuscript following the suggestion, as described below.

This manuscript addresses a topical and important issue in aerosol researches, i.e. how to improve the simulation and forecast of pollution levels in severe haze events. The influence of meteorological conditions in the regional WRF-CHEM model is explored by employing an ensemble simulation approach with perturbed initial and boundary atmospheric fields. The finding of the substantial sensitivity of the simulated PM_{2.5} concentrations to meteorological conditions on at the city scale highlights the importance of the ensemble approach in model assessment of air quality. Overall, the paper is well written, and I only have some minor comments for the authors to address.

1 Comment: The ensemble method needs to be clarified, as some technical details are not described clearly.

Response: We have clarified the ensemble method in Section 2 as suggested.

1.1 Comment: For example: What variables are perturbed in this method? A list of perturbed fields can be more informative. Are those variables equally important in the contribution to the uncertainty?

Response: We have clarified in Section 2: *“The perturbed variables include the horizontal wind components, potential temperature, perturbation pressure, and mixing ratio of water vapor. Other prognostic variables such as vertical velocity and mixing ratios of hydrometeors are not perturbed. In general, the perturbation in horizontal wind components constitute the most important uncertainty in those variables (Bei et al., 2008).”*

1.2 Comment: L101, the word “perturbations” comes from nowhere. Please clarify how to obtain them.

Response: We have changed “perturbations” to “members”.

1.3 Comment: L102-105, it seems that the boundary conditions are different in each ensemble member as well. However, the authors only mention “initial meteorological uncertainties” in the later discussions.

Response: We have removed “initial” in the later discussions because we have perturbed both the meteorological initial and boundary conditions, as the reviewer pointed out.

1.4 Comment: L111, what is the “average spread”, and what is the “mean of ensemble spreads” in Fig. 2? To my understanding, the spread is calculated as the standard deviation of the perturbations imposed on each ensemble member’s initial field.

Response: We agree to the reviewer’s comment and have clarified in Section 2: “*Figures 2a–d show the vertical distribution of the average initial ensemble spread which is calculated as the standard deviation of the perturbations imposed on each ensemble member’s initial field.*”

2 Comment: Readers may remain curious about how important the meteorological impacts on PM simulations are, compared to other uncertainties in the WRF-CHEM model, e.g. emission, or different chemistry/aerosol schemes. Is there a way to quantify the relative importance of each uncertainty source in the model?

Response: We have clarified in Section 4: “*It is worth noting that aside from meteorological fields, uncertainties in emissions or various chemistry/aerosol schemes, also considerably influence the WRF-CHEM model simulations. The extended response surface modeling (ERSM) technique can be used to quantify the relative importance of each uncertainty source in the WRF-CHEM model (Zhao et al, 2017).*”

3 Comment: The quality of figure can be further improved: - Figure 2, better to provide the percentage information as well. An ideal way to illustrate the ensemble experiment is to show the PDF of each quantity using color-coded contour plot. - Figure 3, too busy. Suggest having one panel for each city.

Response: Since the mean of ensemble meteorological fields might be close to zero, causing the very large percentage change, we have included the standard deviation of the initial ensemble spread and replotted Figure 2. For Figure 3, considering more than 10 cities, we have divided the cities in BTH into megacities and non-megacities and replotted it.

4 Comment: A grammar check is needed: - L354, “A climatological . . .”; remove “the” before “initial” - L356, “are generally in good agreement”, as ENSM here should refer to the means for each aerosol species. - L359, is it “primary aerosols”? - L372, “measurements” - L375, remove “the” before “ensemble”; replace “avoid” by “minimize”.

Response: We have corrected the grammatical errors and typos as suggested.