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Interactive comment on "Development of 3D Variational Assimilation System Based on GRAPES-CUACE Adjoint Model (GRAPES-CUACE-3D-Var V1.0) and Its Application in Emission Inversion" *by* Chao Wang et al.

Chao Wang et al.

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Anonymous Referee #1 Received and published: 23 February 2020

The authors developed the GRAPES-CUACE three dimensional variational assimilation system (GRAPES-CUACE-3D-Var) based on the GRAPES-CUACE aerosol ad-

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joint model by using the optimization algorithm and pollutants observations. It performed well in the inversion of BC emissions in Beijing-Tianjin-Hebei region. However, I still recommend this manuscript be revised before publication. Firstly, the inherent flaws in the transport model and emission inventory could produce the uncertainties in the results, please add some discussion. Secondly, the simulations were performed in wintertime, the stagnant conditions and temperature inversion are often difficult to reflect the reality. But almost all the pollutants reached a high level. How the author address the question? Some minor corrections are also needed listed in following. 1. “3D” in the title “Development of 3D Variational Assimilation System Based on GRAPESCUACE Adjoint Model (GRAPES-CUACE-3D-Var V1.0) and Its Application in Emission Inversion” is better replaced with the full name “three dimensional”. 2. Page2, line49,“Foreign scholars” is inappropriate. It is recommended to change it to "Many scholars ". 3. Page3, line64, “the accompanying model” should be “the adjoint model” ? 4. Page3, line83, “cuace” should be “CUACE” ? 5. Page3, line85, “Chen” should be “Chen et al.”? 6. Page5, line137, “ground state value” should be “basic-state value”? There are some other similar words. 7. Page5, line138, “variable s” should be “variables”? 8. Page5, line153, “priori source” should be “a priori source” ? “posterior source” should be “a posterior source”? There are some other similar words. 9. Page6, line185, “i.e.” should be “then” ? 10. Page7, line190, “is in the central” should be “is the central” ? 11. Page7, line195, “the start-up” should be “spin-up”? 12. Page7, line211, “the inverse evolution quantity” should be “inversion variables”? 13. Page11, line316, “(LIMITED-MEMORY BFGS QUASI-NEWTON METHOD)” is not necessary. Reply: We would like to thank the reviewer for his/her positive words and his/her helpful comments, which have allowed us to make improvements to our manuscript. Combined with the comments of Referee #2, we have upgraded the assimilation system, redesigned the emission inversion experiment, obtained more observations, and improved the readability of the text. The introduction and methods have been rewritten as suggested. Unfortunately, we spent a long time in upgrading and debugging the assimilation system, so that we did not obtain more satisfactory results of emission inver-

sion within the specified time. So in the revised manuscript, we are unable to present the results and conclusion, for which we are very sorry. The responses to the specific questions are shown below. Thanks again for the reviewer's valuable suggestions. As the reviewer understood, the inherent flaws in the transport model and emission inventory could produce the uncertainties in the results. The strongly constrained four-dimensional variational hypothesis the model is perfect, that is, model errors are not considered (Menard, 2010). So in our previous experiment, the uncertainties caused by the inherent flaws in the transport model were not considered. In the future, we will add the model evaluation with the priori and the optimized BC emission to determine the uncertainty of the model. We will also compare the optimized BC emission with other studies to quantify the uncertainty of the approach we used. The GRAPES-CUACE model used in this study is an online coupled meteorological-chemical model system. The interaction between meteorological conditions and pollutants has been included in the physical and chemical processes of the model. According to previous studies, the GRAPES-CUACE model can reasonably simulate the spatial distribution and temporal trend of PM2.5 concentrations in wintertime, and the correlation coefficient between the simulated concentration and the observed concentration of PM2.5 is about 0.5-0.9 (Wang et al., 2018a, 2018b). In the future, we will further evaluate the simulation effect and uncertainty of the GRAPES-CUACE model. 1. We have modified the title with "Development of Four Dimensional Variational Assimilation System Based on GRAPES-CUACE Adjoint Model (GRAPES-CUACE-4D-Var V1.0) and Its Application in Emission Inversion". 2. Yes, we have realized this is inappropriate and modified it in the revised manuscript. 3. Yes,"the accompanying model" should be "the adjoint model", and we have modified it. 4. Yes, "cuace" should be "CUACE", and we have modified it. 5. Yes,"Chen" should be "Chen et al.", and we have corrected it. 6. Yes,"ground state value" should be "basic-state value". We have modified it. 7. Yes,"variable s" should be "variables", and we have corrected it. 8. We used prior/posterior consistently throughout this time. 9. Done. 10. Done. 11. Yes, "the start-up" should be "spin-up", and we have modified it. 12. Done. 13. We have modi-

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fied the expression as “Limited-memory BFGS (L-BFGS)”.

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Fig. 1.

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