

Interactive comment on “Revealing the sulfur dioxide emission reductions in China by assimilating surface observations in WRF-Chem” by Tie Dai et al.

Anonymous Referee #1

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This manuscript developed a new emission inversion system based on 4D-LETKF and WRF-Chem to update the SO₂ emission by assimilating the ground-based hourly SO₂ observations. The inverted SO₂ emission over China in November 2016 is well in agreement with the “bottom-up” estimation, indicating that the newly developed emission inversion system can efficiently update the SO₂ emissions based on the routine surface SO₂ observations. Their investigation is interesting and valuable. The manuscript is well written and structured. I recommend publication after addressing the following concerns. Line 60: There are more recent research papers of ensemble-based assimilations to estimate the emission. Feng, S., Jiang, F*, Wang, H., Wang, H., Ju, W., Shen, Y., Zheng, Y., Wu, Z. & Ding, A

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(2020). NO_x Emission Changes over China during the COVID-19 Epidemic Inferred from Surface NO₂ Observations. *Geophysical Research Letters*, 47, e2020GL090080. <https://doi.org/10.1029/2020GL090080> Feng, S., Jiang, F*, Wu, Z., Wang, H., Ju, W., & Wang, H. (2020). CO Emissions Inferred From Surface CO Observations Over China in December 2013 and 2017. *Journal of Geophysical Research-Atmospheres*, 125(7). <https://doi.org/10.1029/2019JD031808> Chu, K., Z. Peng, Z. Liu, L. Lei, X. Kou, Y. Zhang, B. Xin and J. Tian: Evaluating the impact of emissions regulations on the emissions reduction during the 2015 China Victory Day Parade with an ensemble square root filter. *J. Geophys. Res.-Atmos*, 2018, doi:10.1002/2017JD027631 Line 76: Other two papers are also about the inverted SO₂ emissions Peng, Z., Lei, L., Liu, Z., Liu, H., Chu, K., & Kou, X. (2020). Impact of assimilating meteorological observations on source emissions estimate and chemical simulations. *Geophysical Research Letters*, 47, e2020GL089030. <https://doi.org/10.1029/2020GL089030> Peng, Z., Lei, L., Liu, Z., Sun, J., Ding, A., Ban, J., et al. (2018). The impact of multi-species surface chemical observation assimilation on air quality forecasts in China. *Atmospheric Chemistry and Physics*, 18(23), 17,387–17,404. <https://doi.org/10.5194/acp-18-17387-2018>

Line 142: How do you decide the locations of the super-observations? Line 143: How do you decide the assimilated and independent verification observation sites? Line 180: How does the emission model forecast the emissions $E_{(t_{(n+1)})}$ for 12 hours? How the temporal and spatial distribution of the ensemble spread of the emissions $E_{(t_{(n+1)})}$ ranged? Could you please show time series of hourly ensemble spread of the emissions $E_{(t_{(n+1)})}$ from 00:00 UTC 8 November to 00:00 UTC 18 November 2016 and their spatial distributions at typical time. Please discuss the forecast model first since the DA depends on the details of the forecast model. Line 181-183: Please write a bit more about the generation of the initial prior ensemble of SO₂ emissions. And also a bit more about the spatial distribution of the ensemble spread of the prior emissions $E_{(t_0)}$. Line 197-200: The SO₂ concentrations are updated “by recalculation of the WRF-Chem ensemble with the optimized emissions”: so the uncertainties of

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the forecast SO₂ concentrations could still be large. This will influence the assimilation results. Please discuss a bit more about them. Line 225-230: The spatial correlations among the grid points of the forecast emissions are not clear, so are the spatial correlations among the initial prior ensemble of SO₂ emissions. Figure 3: Which data are used to obtain the averaged SO₂ emissions? Could you please show the difference between the analysis and MEIC2016, or the ratio?

Line 250: Are the initial and lateral boundary chemical fields perturbed?

Line 272: Could you please show time series of hourly SO₂ emissions of the prior, the forecast and the analysis of the assimilation experiments from 00:00 UTC 8 November to 00:00 UTC 18 November 2016, not only the mean spatial distribution in Figure 3. These will make the reader to understand a priori value and the adjustment SO₂ emissions easily. Figure 6 and 7: I guess the SO₂ concentrations are obtained from the DA experiments. But I am not sure if they are the updated results by recalculation the WRF-Chem ensemble with the optimized emissions. Could you please show the difference between the updated concentrations and the original? L391: Could you please show the diurnal variations of the inverted SO₂ emissions of the DA experiments?

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1259>, 2020.