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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Exploring the relationship between surface $PM_{2.5}$ and meteorology in Northern India" *by* Jordan L. Schnell et al.

Anonymous Referee #1

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General comments

The authors applied the NOAA GFDL-AM4 model to simulate air quality over India for 20 years. They used a coarse horizontal resolution and two different emissions estimates (CMIP5 and CMIP6) in the model. They compared model predictions with observed PM25 in India for six winter months and performed detailed analysis. Model with CMIP5 substantially underestimated PM25 compared to observed data in Northern India. While the model with CMIP6 improved the predictions, it still underestimated PM25. Most monitoring stations in India are located in urban areas. The model with a coarse horizontal resolution is not suitable for examining PM25 in urban areas in India.

As such model under-prediction is expected. Finer scale resolution is needed. Several other issues need to be addressed.

Specific comments

Line 199-200 Reference is needed for the heterogeneous uptake coefficients used in the model.

Line 204-206 Several acronyms have already been defined before and are defined here and later. No need to define the acronyms multiple times.

Line 215-216 Dust1, dust2, ssalt1, ssalt2, ssalt3 are not defined in the article?

Line 261-266 and Figure 1 It is not clear if NO or NO2 emissions are shown in Figure 1. "NO" is used in one sentence but "NO2" is used in the other sentence. Need clarification. How NOx emissions are being speciated into NO and NO2 emissions?

Figure 2 Title of Figure 2 indicates "CMIP5-dry". However, legend shows "AM4-CMIP5 (wet)". Need clarification.

Figure 3 Observed data are taken from Kanpur site which is not clearly indicated in the Figure title.

Line 325-340 The model over-predicts aerosol nitrate substantially which may result from many factors including the use of high heterogeneous uptake coefficient for N2O5 (Table S1). Recent studies (Davis et al., 2008; Reimer et al., 2009; Brown et al., 2009; Phillips et al., 2016; Chang et al., 2016) suggest a much lower value for the heterogeneous uptake coefficient. A discussion of the impact of high heterogeneous uptake coefficient for N2O5 on model results is relevant.

Davis et al., 2008: Parameterization of N2O5 reaction probabilities on the surface of particles containing ammonium, sulfate, and nitrate, Atmos. Chem. Phys., 8, 5295–5311.

Riemer et al., 2009: The relative importance of organic coatings for the heterogeneous

hydrolysis of N2O5, JGR, 114.

Brown et al., 2009: Reactive uptake coefficients for N2O5 determined from aircraft measurements during the Second Texas Air Quality Study: Comparison to current model parameterizations, JGR, 114.

Phillips et al., 2016: Estimating N2O5 uptake coefficients using ambient measurements of NO3, N2O5, ClNO2 and particle-phase nitrate, ACP, 16, 13231-13249.

Chang et al., 2016: Evaluating N2O5 heterogeneous hydrolysis parameterizations for CalNex 2010, JGR: Atmosphere, 121, 5051–5070.

Line 443-444 The sentence suggests that annual cycle is shown in the Figure. However, it shows data for 6 months, not for the year.

Line 449-450 The sentence suggests model is biased high in RH. However, Figure 6b shows under-prediction of RH compared to observed data. Need clarification.

Line 492-497 Ram and Sarin (2011) analyzed measurement data and reported that nighttime aerosol nitrate level is five times greater than the day-time nitrate level. In contrast, this modeling study finds that aerosol nitrate peaks during mid-day. Despite the use of high uptake coefficient for N2O5, it finds that aerosol nitrate peaks during the day which reveals that HNO3 produced from the reaction of NO2 + OH likely dominates the production of aerosol nitrate. What caused the results to be completely opposite to that of Ram and Sarin (2011)?

Figure S7 Title is not clear. Figure d-f are missing.

Figure S8 Title refers to Figure 4 which should probably be Figure 5.

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