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 PM$_{25}$ in India for six winter months and performed detailed analysis. Model with CMIP5 substantially underestimated PM$_{25}$ compared to observed data in Northern India. While the model with CMIP6 improved the predictions, it still underestimated PM$_{25}$. Most monitoring stations in India are located in urban areas. The model with a coarse horizontal resolution is not suitable for examining PM$_{25}$ 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 Dust$_1$, dust$_2$, ssalt$_1$, ssalt$_2$, ssalt$_3$ are not defined in the article?

Line 261-266 and Figure 1 It is not clear if NO or NO$_2$ emissions are shown in Figure 1. “NO” is used in one sentence but “NO$_2$” is used in the other sentence. Need clarification. How NOx emissions are being speciated into NO and NO$_2$ 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 N$_2$O$_5$ (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 N$_2$O$_5$ on model results is relevant.

Davis et al., 2008: Parameterization of N$_2$O$_5$ reaction probabilities on the surface of particles containing ammonium, sulfate, and nitrate, Atmos. Chem. Phys., 8, 5295–5311.

Reimer et al., 2009: The relative importance of organic coatings for the heterogeneous
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, CINO2 and particle-phase nitrate, ACP, 16, 13231-13249.


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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