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Comment on acp-2022-513

Anonymous Referee #1

Referee comment on "Assessing the climate and air quality effects of future aerosol mitigation in India using a global climate model combined with statistical downscaling" by Tuuli Miinalainen et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-513-RC1>, 2022

This manuscript presents global model simulation results over India from ECHAM for air quality and radiative forcing under present and future emission scenarios (from GAINS) through 2030. For the region covering Delhi, the results were downscaled using random-forest corrections using multiple emission, met, and orography variables.

While the radiative forcing calculations from ECHAM is a known path, the use of the same to bias correct and estimate air quality for a city is new. The later methods have been used, but not for model resolutions at 1.9 degrees. Machine Learning (ML) approach is a new and emerging field and the benefits of using a global model for both air quality and climate applications cannot be overlooked. While the methodology is well explained for correcting the model results with biases from ML, the statistics also improved after the corrections, the gaps between the measured and model-corrected numbers is still significant.

The scenario analysis for air quality primarily hinges on the reproductive capacity of the model and the only question that is not clearly answered is why extract air quality data from such a coarse model (when the problem is known that coarser models have hard time replicating high-density urban areas with very distinct emission characteristics)? Especially, since FMI and IMD (author organizations) are known to conduct chemical transport modeling for air quality at much better resolutions globally and in India.

Why use a city like Delhi with so many stations with 0% data available in the ML testing phase? Why not use a city in Europe or the US with good availability rates and good representation of the sources, to show that the model is capable of replication after the bias corrections? The one drawback of the manuscript is the selection of the case study city (Delhi) -- which has strong seasonal trend, strong diurnal trend, and distinct sources (for SO₂, BC, and OC) over the months. A city(s) or region(s) with consistent emission loads would cut down some uncertainty in the model and corrections methods and then

apply to regions like India and China.

Line 237-242 and 290: It is not clear if the emissions and other variables extracted and used are still at the ECHAM resolution or further downscaled to support a region of 30km x 30km over Delhi? (L290) is an important observation - When making the bias corrections, besides the model grid variables, are there any variables that are segregating the Delhi area signatures for a better fit?

The results and conclusions of the study in terms of AQ and climate benefits of reducing emissions are as expected. However, since Delhi is the most polluted area/city in the world with not only a complex mix of emission sources, but also a complex mix of political and institutional setup to manage these emissions. While the manuscript presented % changes (benefits for air quality and RF), the discussion doesn't include any explanation on how these % emission reductions will be achieved in the Delhi area. It is understood that the emissions work comes from a different model (GAINS). Since the manuscript very specifically mentions and analyzes data for one city only, it would be appropriate to also discuss this space.

While there is merit to a new methodology to be able to model AQ data along with the climate data, the manuscript lacks punch and afraid that these correction results will be hard to replicate in another setting.