Reviewer 2

The manuscript describes numerical experiments of modelling of surface O3 and PM2.5 concentrations over India using EMEP's regional off-line chemical transport model. To facilitate comparisons between present levels of air pollutants and future concentrations -after assumed changes in air pollutant emissions and in climate - the EMEP model is fed with meteorological data from a regional climate model. To my knowledge is this the first study of its kind covering the Indian subcontinent and as such the work deserves to be published. The manuscript is well written, without any omissions and the results are, mostly, clearly presented. The manuscript could be published in its present form but it would definitely gain from tough editing. There is an overwhelming amount of figures included in the main text which distracts the reader from any clear take-home messages. My personal feeling is that the authors want to pack too much into the present paper – which already comes with a comprehensive Supplement. The ratio between text and figures is low; chapter 5.1, for example, discusses 3 figures (altogether 21 panels) in 14 lines of text.

The authors thank the reviewer 2 for the careful reading of the manuscript and for the thorough review. A detailed point by point reply (in blue) is provided hereafter. We are aware that this manuscript contains very many figures, but we believe that most are needed in order to reinforce the points made. However, we have moved 8, 10, and 15 to the supplement.

General comments:
Although the average seasonal cycle of O3 seems to be reasonably resolved by the EMEP model in the reference simulation (inferred by the similarity of the curves in Fig. 2a; it is not so meaningful to calculate the correlation of the 12 monthly averages of O3), is the mean bias of O3 substantial. The authors attribute this flaw to the fact that they compare the output from a regional model with observations from urban locations. I am perfectly aware of the paucity of data from regional background stations in India but the dissimilarity of station type raises concern about the validity of the model evaluation.
We agree. This was the reason we decided to show the comparison site by site in Fig. S2 and we plotted the values of bias and of the correlation coefficient on maps in fig. 2b & c., showing the spatial distribution of the stations.
Even if the number of rural stations is limited, we attempted to perform such comparison with Fig. 3. Unfortunately, to our knowledge no more background stations are available.

From Fig. 3c it is clear that O3 concentrations are also overestimated during large part of the year at the available rural stations. Can the general overestimation be attributed to imperfect boundary concentrations? PM2.5 is surprisingly well reproduced by the EMEP model.
Indeed, we have added this information (in bold):
"Several hypotheses could explain the overestimation in monthly averaged surface O_3. **These include general uncertainties in anthropogenic and biogenic emissions, an overestimation in the transported O_3 from the boundary conditions (including stratospheric-tropospheric exchange), inadequate accounting for the impacts of the large PM concentrations on gas-aerosol interactions, or systematic biases in the deposition estimates**. There is **also** very likely a misrepresentation of the NO_x-O_3 equilibrium."

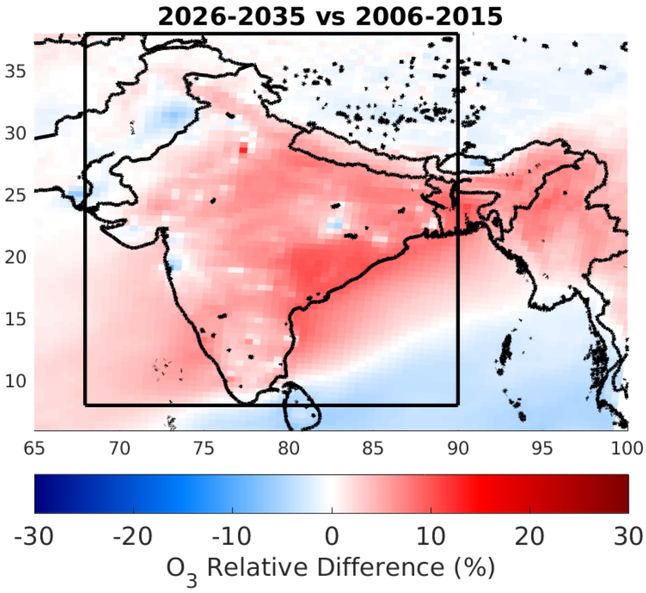
The introduction of small, rectangular, sub-regions in Fig. 9 and onwards is confusing. The selected areas don't cover all the grid-cells with the characteristics that the authors want to highlight (e.g. positive correlation between changes in O3 deposition velocity and near-surface concentration). Re-usage of the numbers 1, 2, 3 in Figs.9, Fig.12 and Fig.14 further adds to the confusion. If the different sub-regions should be retained in the presentation they should be given unique numbers.

Our choice was to select areas for each analysis since the purpose of these distinct regions was to describe and interpret:

- the change in O_3 due to the climate
- the change in $PM_{2.5}$ due to the climate
- the composition of $PM_{2.5}$ and the change in O_3 and $PM_{2.5}$ over a larger domain for the FCE scenarios. But we agree that using different regions with identical labels was confusing. We have decided to change their names to clarify our analysis in the revised manuscript.

In the discussion of the results of section 5.1 and 5.2 model results have been averaged over a rectangular subdomain (shown in Figs. 13a and 16a) covering vastly different countries, socio-economical and geographical regions. I find this choice arbitrary.

We understand the comment from the reviewer but as you can see with the following map, the selected region covers a large part of India, which also gathers the main locations of the available observations (e.g. Figs. 2, 4-6 in the ACPD manuscript):



For this map, we have used another matlab file describing the borders and not only the coastlines as presented in the manuscript. In comparison with the borders shown in this map, we decided to extend our selected region up to 38N since the region between ~35-38N corresponds to Kashmir which is a region often defined as an Indian region, even if we are aware that it is an area claimed by both India and Pakistan. For the same reason, we decided not to show the borderlines. Moreover this region (between ~35-38N) is included in the emissions inventory from Sharma and Kumar (2016)

We also did not extend up to 98E in order to limit the number of grid cells over China, Bangladesh and Myanmar on the O_3 and $PM_{2.5}$ averages calculated within the region delimited by the black box.

We agree that other areas can be defined but we still believe that the selected region is a good representation of India. Please also note that we do not define this box as “India”.

For your information, the domain used in our study is also a little bit smaller than the domain used for the air pollution forecast over India by the website IndiaAirQuality.info (see http://www.indiaairquality.info/iaqi-domain/).

To focus the presentation I would recommend the authors to consider excluding the 2026-2035 results as I don't think they add much to the general understanding of the evolution of O3 and PM2.5 from present times into the future.
The aim to present 2026-2035 was to highlight the fast impact of climate change and then the combined impact of climate and future emission scenarios on our O_3 and $PM_{2.5}$ distributions. We have decided to keep results for both periods.
However, the former Figs. 14 and S10 do not present the distributions for the FCE2030 scenario anymore.

Minor editorial/technical issues:

L 278: "-6%" in Fig. 5a it is +6%
Corrected.

L. 290-293: "It is worth nothing... for Hyderabad." Unclear what you want to say with these sentences here.
The sentences have been changed to clarify our explanation:
"A chemical speciation in the measurements will be helpful to interpret the biases found over these cities. Indeed, the EMEP model predicts a large contribution from primary particulate matter (PPM) to $PM_{2.5}$, reaching 50% in December and in January, mainly composed by primary organic matter (not shown), over the sites presented in Figs 6 and S4. The model also predicts a main natural contribution to $PM_{2.5}$ from May to September over these sites. For example, the site of Hyderabad reaches up to 70% in dust in July. An evaluation of the source attribution of the $PM_{2.5}$ simulated by the EMEP model will be an instructive information."

L 363: "Eastern" and "Western" are shifted
It has been corrected.

The appendix is never mentioned in the main text.
The following sentence has been added at the beginning of Section 3:
"The details of the statistical numbers are provided in the Appendix."

"Mean normalized Gross Error (MNGE)" is probably a valid term but I would perform the more descriptive term "Mean normalised absolute error".
It is correct that MNGE is a valid statistical term, which is used in numerous publications, see three examples chosen randomly:

- Kumar, R., Naja, M., Pfister, G. G., Barth, M. C., Wiedinmyer, C., and Brasseur, G. P.: Simulations over South Asia using the Weather Research and Forecasting model with Chemistry (WRF-Chem): chemistry evaluation and initial results, Geosci. Model Dev., 5, 619-648, https://doi.org/10.5194/gmd-5-619-2012, 2012
- Nguyen Thi, Kim Oanh: Integrated Air Quality Management: Asian Case Studies, March 29, 2017 by CRC Press, ISBN 9781138071841
- Qiao, X, Tang, Y,Hu, JL, Zhang, S,Li, JY,Kota, SH,Wu, L,Gao, HL,Zhang, HL,Ying, Q:Modeling dry and wet deposition of sulfate, nitrate, and ammonium ions in Jiuzhaigou National Nature Reserve, China using a source-oriented CMAQ model: Part I. Base case model results, Sc. of the total Env., 532, 831-839, DOI: 10.1016/j.scitotenv.2015.05.108, 2015.

However, we do not know and we did not find the term "Mean normalised absolute error".
We have found the normalized mean absolute error:

$$\text{NMAE} = \frac{1}{N}\frac{\sum_{i=1}^{N}|M_i - O_i|}{\max(Oi) - \min(Oi)} \times 100\%$$

See e.g.:
- Minh-Thang Do, Ted Soubdhan , Benoît Robyns: A study on the minimum duration of training data to provide a high accuracy forecast for PV generation between two different climatic zones, Renewable Energy, 85, 959-964, https://doi.org/10.1016/j.renene.2015.07.057, 2016.
- Dimitri Plemenos, Georgios Miaoulis: Intelligent Computer Graphics 2010, Springer, Berlin, Heidelberg, ISBN: 978-3-642-15689-2, DOI:https://doi.org/10.1007/978-3-642-15690-8.

Thus, we have calculated this parameter for the Figs. 2-6:
Fig2 NMAE=49.01%

Fig3a NMAE=60.85%
b NMAE=59.02%
c NMAE=25.83%

Fig.4 NMAE=12.78%

Fig5 NMAE=10.63%

Fig6
Delhi NMAE=29.78%
Chennai NMAE=31.64%
Kolkata NMAE=28.55%
Mumbai NMAE=25.83%
Hyderabad NMAE=37.71%

The formula for NMB is in error (1/N is missing).
The formula is correct:

$$NMB = \frac{(\sum_{i=1}^{N}(M_i - O_i))/N}{(\sum_{i=1}^{N} O_i)/N} \times 100\% = \frac{\sum_{i=1}^{N}(M_i - O_i)}{\sum_{i=1}^{N} O_i} \times 100\%$$

The factor 1/N is not missing.
See three examples chosen randomly providing this statistical metric:
- Qiao, X, Tang, Y,Hu, JL, Zhang, S,Li, JY,Kota, SH,Wu, L,Gao, HL,Zhang, HL,Ying, Q:Modeling dry and wet deposition of sulfate, nitrate, and ammonium ions in Jiuzhaigou National Nature Reserve, China using a source-oriented CMAQ model: Part I. Base case model results, Sc. of the total Env., 532, 831-839, DOI: 10.1016/j.scitotenv.2015.05.108, 2015.
- http://www.ecd.bnl.gov/steve/pres/metrics.pdf and
- Lucjan Pawlowski, Marzenna R. Dudzinska, Artur Pawlowski: Environmental Engineering III, March 23, 2010 by CRC Press, ISBN 9780415548823.

It is unnecessary to label the increasing and decreasing O3 with A and B in Fig. 7. These areas are quite visible any way
The labels have been deleted.