Atmos. Chem. Phys. Discuss., 15, C11349–C11354, 2016
www.atmos-chem-phys-discuss.net/15/C11349/2016/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mid-21st century air quality at the urban scale under the influence of changed climate and emissions: case studies for Paris and Stockholm" *by* K. Markakis et al.

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Received and published: 11 January 2016

We would like to thank the reviewer for the improvement brought upon in the manuscript from the insightful comments of this review.

General Comments

1. Why are different chains of models used for Paris and Stockholm for the climate and air quality simulations (Table 1)? More importantly, by utilizing different models for the two regions, how are cross-city comparisons affected. Have the authors performed any sensitivity runs with respect to different model configurations? Some discussion of

why different chains of models were employed in this analysis is needed somewhere in Section 2.1.

Reply: The sensitivity of modelled results to the use of different models is not the scope of this study (such intercomparison experiment is labour intensive and requires the re-design of many inputs in order to be implemented). In contrast, the current simulations were conducted in support of local scale health impact assessment in those regions (this information was added in the beginning of section 2.1) under the framework of the ACCEPTED project (Assessment of changing conditions, environmental policies, time-activities, exposure and disease) and the different models simply reflect the corresponding expertise of the two research teams in Paris and Stockholm. Of course it is well known that biases can be model-specific. Indeed, such discussion would be relevant in a cross-city comparison study which is not the case here. Results are presented separately for the two cities and at the final stage (section 5.5) the cities are used as illustrative examples (Stockholm is dominated by regional pollution while IdF exhibits less regional influence) to discuss possible policy misclassification issues. In that respect we find it appropriate not to overemphasize the use of different chain of models and the phrasing "a different chain of models was used for the two case studies" has been changed. Another possible misleading phrase ("therefore particularly interesting to compare") in page 27044, line 28 was also removed. We add "We should note that the range of uncertainty in the results presented here is probably underestimated due to the choice of a single model chain for each case study."

2. Why is the urban-scale modeling performed at 1 km resolution for Stockholm, but at 4 km resolution for Paris? If the emissions are available for Paris at 1 km resolution (Page 27049, Line 6), it seems odd not to model Paris at the same urban-scale resolution as for Stockholm. I would expect the higher resolution to be more important for Paris, since Stockholm has a stronger regional influence on air quality (Page 27058, Line 6). Some rationale is needed for why the horizontal resolutions are different between the two cities, and how this might affect modeling results.

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Reply: Paris region was modelled at 4km resolution based on findings of Markakis et al. (2105) (already referenced in the manuscript). There we show that modelled results in climate based simulations over IdF were not very sensitive to model resolution changes. Previous work (Valari and Menut, 2008) conducted in IdF showed that higher resolution also induces potential for error and model results were not improved by the increased model resolution. We have revised the first paragraph of section 2.2 accordingly: "In Markakis et al. (2015) we have conducted a sensitivity analysis on a decade simulation over IdF to test the response of modeled ozone and PM2.5 concentrations to the refinement of information related to model setup and inputs. On the basis of those findings, in the present study we implement a mesh-grid of 4km horizontal resolution (consisting of 39 grid cells in the west-east direction and 32 grid cells in the north-south direction), vertically resolved with 8 σ-p hybrid layers from the surface (999hPa) up to 5.5km (500hPa). The lowest layer is 25m thick."

Valari, M. and Menut, L.: Does an Increase in Air Quality Models' Resolution Bring Surface Ozone Concentrations Closer to Reality? J. Atmos. Oceanic Technol., 25, 1955–1968.

3. Section 2.1 (Page 27048, Line 7). Does the CHIMERE model include SOA chemistry like the MATCH model (Line 13)? If SOA chemistry is not included for Paris, how would this affect modeling PM under present and future climate scenarios?

Reply: Yes, CHIMERE includes SOA chemistry. A reference is added in section 2.1.

Specific Comments

4. Section 2.3 (Page 27051). A figure of sectoral emissions for Stockholm, similar to Paris (Figure 2), would be useful. To an unfamiliar reader, it is not clear how different the two cities are in their emission sources, and how this might affect future mitigation scenarios. For example, is it realistic for Stockholm to adopt the more aggressive local emissions mitigation strategy of Paris (Page 27051, Lines 16-19), beyond reducing traffic-related emissions only?

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Reply: Unfortunately, we cannot reach the high level of detail found on the IdF inventory as regards the Stockholm emissions due the difficulties related to the corresponding emission processing system. We have added some more information in the text.

5. Section 3 (Page 27052, Line 4). How is PM measured from the urban stations? I'm guessing by filter samples. If so, could there be sampling artifacts in the measurements that affect the model evaluation for PM (Page 27052, Lines 18-26)? For example, sampling artifacts for OC can be large and dependent on measurement techniques.

Chow, J.C., et al., Quantification of PM2.5 organic carbon sampling artifacts in US networks. Atmospheric Chemistry and Physics, 2010. 10: p. 5223-5239. DOI: 10.5194/acp-10-5223-2010.

Turpin, B.J., P. Saxena, and E. Andrews, Measuring and simulating particulate organics in the atmosphere: problems and prospects. Atmospheric Environment, 2000. 34: p. 2983-3013. DOI: 10.1016/S1352-2310(99)00501-4.

Reply: To our best of knowledge the measurements are conducted using TEOM instruments (which to our knowledge is not the method reported by the reviewer) that have been associated with artefacts due to unaccounted semi-volatile compounds like ammonium nitrate. To some degree the measurements underestimate the true atmospheric load but we do not have information on the magnitude. We have included a brief reference to this in the evaluation section: "We note that the measurements of particulate matter for the period in question was conducted using the Tapered-Element Oscillating Microbalance (TEOM) method that has been associated with negative sampling artefacts depending on the season, location and particle size (Allen et al., 1997)"

Allen, G., Sioutas, C., Koutrakis, P., Reiss, R., Lurmann, F.W. and Roberts, P.T.: Evaluation of the TEOM method for measurement of ambient particulate mass in urban areas, J. Air Waste Manag. Assoc., 47 (6), 682-689, 1997.

6. Section 3 (Page 27052, Line 29). Can the Norr Malma (rural) site be identified in

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Figure 1? Also, is the prevailing wind pattern such that this site is upwind or downwind of Stockholm?

Reply: Norr Malma is outside the model domain, and it is upwind from Stockholm. Thus it is slightly affected by the urban area. The description of the Stockholm measurement sites has been improved in the manuscript.

7. Section 5.6 (Page 27063, Lines 4-6). Not sure what is meant by this sentence. If Paris does not undergo a regime shift by 2050, shouldn't stronger NMVOC controls be emphasized?

Reply: Yes, this is correct but this is not what the local emission projection portrays. We revised this part: "Under VOC-sensitivity ozone benefit may be attained by either pushing NMVOCs mitigation over NOx or by enforcing enough mitigation on NOx emissions that will allow a shift of the photochemical regime towards NOx-limited conditions prior to 2050. In contrast the local emission projection enforces NOx over NMVOCs reductions while according to the long-term evolution of chemical regimes, studied with the use of chemical regime indicators, NOx mitigation is not strong enough for the aforementioned shift to take place by 2050."

8. Figure 3. To improve robustness of model evaluation, these plots would benefit from the addition of error bars that show the variability of the mean for the model and observations. Also, correlation coefficients of the model against observations should be reported somewhere.

Reply: Due to the nature of our simulations the evaluation process is based on decade average concentrations (for model and observations) rather than hourly or daily averages, typical in more short-term evaluations. This means that temporal correlation cannot be provided. Also, the evaluation of the variability of concentrations based on some intra-period temporal average (e.g., annual) is beyond the scope of this paper. Here we only interested in the ability of the model to simulate period average concentrations.

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9. Figures 4 and 5. Can a consistent color scale be applied between Figure 4 (Paris) and Figure 5 (Stockholm)? It is hard to interpret the color scales easily between the two cities otherwise.

Reply: This was done because the purpose of these figures is to visualize the responses within each city separately. Consistent colorbars across cities smooths even further some of the spatial gradients found within cities for example in the present-time and the ozone responses.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 27041, 2015.