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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A multi-model study of impacts of climate change on surface ozone in Europe" *by* J. Langner et al.

Anonymous Referee #2

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General comments

The current work presents simulations of 5 climate-chemistry models (4 off-line coupled and 1 online) over Europe aiming to investigate the impact of climate change on surface ozone. The control time slice of the study is selected to be 2000-2009 and the future time slice 2040-2049 (A1B scenario). Anthropogenic emissions are kept constant for the control and future simulation in order to isolate the impact of climate change on air quality. The paper addresses the scientific question of climate-air quality interactions, which is an interesting topic, well within the scope of the journal. However, there are some issues in the methodology followed, the presentation and the discussion of the material, requiring major revisions prior to publication. The most important issues raised are described below in detail.

Specific comments

The interesting part of this work is the presentation of results of five different models, which are harmonized to the most possible extent, in order to assess the variability in surface ozone predictions. The same i) meteorological forcing (ECHAM5/RCA3) ii) boundaries (DEHM/6 hourly) iii) anthropogenic emissions (RCP4.5) iv) domain set up (0.44) are applied in the EMEP, SILAM and MATCH models. Comparison of these 3 model results shows the sensitivity of simulated surface ozone on the internal model parameterizations.

The DEHM model is configured in a coarser resolution (150 Km) and is forced directly by the GCM ECHAM5. The differences in the meteorological forcing and the spatial resolution between DEHM and EMEP/SILAM/MATCH and their impact on surface ozone are discussed in the current manuscript.

EnvClimA is the only on-line model in this study, which is set up in a fine (50 km) and has the advantage of taking into account feedbacks of climate-chemistry interaction in each time-step. The major drawback in the application of EnvClimA model is the absence of biogenic emissions (BE), which is known to be an important ozone precursor. The absence of BE in the simulations, introduces an error in the calculation of present-time surface ozone and ignores the part of surface ozone future changes related to the climate-depended BE. I doubt that EnvClimA results represent valid surface ozone concentrations of the present decade, even if the summer bias appears to be below 10% (Table 3). Can the authors make an estimation of the impact of the BE-omission on background surface O3? How do they explain such a low O3 bias in summer? I am rather critical in including EnvClimA results in the calculation of the ensemble mean (Fig 5 and 6). In some studies (Meleux et al, 2007, Atmos Environ a.o.) isoprene was identified as the most important chemical factor in O3 sensitivity in view of climate change. Ito et al, 2009, JGR, provides a very detailed description of the impact of BVOCs on surface ozone with relation to temperature changes. The EnvClimA results could be discussed as a results of an experiment without considering the impact of BE.

2.2 Emission data

It is mentioned that all models use the same anthropogenic emissions (page 5, lines 4-10). However, in each model description there seems to be a different way of implementing anthropogenic emissions. It would be nice, if the authors could clarify if the emission annual average –or something else – is the same for all models and the temporal disaggregation differs. In DEHM anthropogenic emissions are distributed with height, including monthly-weekly-daily cycles (please clarify whether you mean daily or hourly). In DMI-EnvClimA it is mentioned that daily and diurnal variations are not prescribed in the emission inventory (page 9, line 1). In EMEP/MSC-W emissions seem to be available only as area ground level sources (page 9, line 19) without any elevation and no diurnal variability. In SILAM emissions are disaggregated on a monthly, daily and hourly basis and are distributed with height. In MATCH information on anthropogenic emissions is missing. Authors should definitely add some information. Table 1. It would be nice if you could compare your biogenic emission totals with others found in literature from previous studies, as well as their increase in the future decade.

2.3 Boundary conditions

Could you please specify whether the top chemical boundaries include transport of stratospheric ozone to the troposphere?

2.4 Model description

It is important that all models cite their previous validation work, so that the reader can be informed in detail about the performance of each modeling system, its strengths and weaknesses and its ability to serve as a useful tool for climate-air quality interactions. This ability is usually based on acceptable model performance.

2.4.1 DEHM

Please construct the existing model description material into distinct paragraphs Page 6, line 24 How do you calculate the annual background values? Could you provide

numbers for key-species?

2.4.2 DMI-EnvCLimA

Page 8, line 6 “The RegCM model, developed at the Abdus Salam. . .” You could move this sentence to page 7, line 29, where ICTP-RegCM is introduced. Page 8, line 15 Please provide the time-step of the coupling.

2.4.3 EMEP/MSC-W

Page 9, Line 30. Please refer to the spatial resolution of the current set up (it should be in accordance with Table 2) rather than to what is traditionally used.

2.4.4 SILAM

Page 10, line 12. Please provide the chemistry mechanism used in this study more in detail (e.g. if it is a standard like CB4) or cite relevant work.

2.4.5 MATCH

Please provide information on the implementation of anthropogenic emissions (temporal disaggregation, emission heights etc)

2.5 Model set up

Page 11, Line 15. “.. and the same ozone precursor emissions. . .” I don’t think this statement is correct, since biogenic emissions are O3 precursor emissions and are different in every modeling system as shown in Table 1.

Page 11, Line 18. “..the same anthropogenic emission data from RCP4.5” Please clarify that although annual averages (or else?) are identical for all models, the emission implementation is different for each model, since the temporal disaggregation and the emission heights are different, and this is expected to have an impact on the final surface ozone concentrations.

3.1 Comparison to observations

Page 11, Line 30 The observations should definitely be calculated for the same time-slice as model calculations i.e. 2000-2009. The EMEP data are available.

Page 12, Line 19-26 The discussion on the correlation is not sufficient. How should these numbers be interpreted? Explain why the spatial correlation is better in summer and better for the EnvClimA model.

All statistics are presented as averages over all EMEP stations and this does not give a very clear idea of what is happening. Most importantly, biases may cancel each other, providing a good average score which however, does not represent the truth. It is important that the scores are presented over each station (see e.g. Fig 4 and 5 of Zanis et al., 2011, Evaluation of near surface ozone in air quality simulations forced by a regional climate model over Europe for the period 1991-2000, Atmos Environ).

The discussion of the evaluation findings should be extended and thorough. It would be nice if, besides a measure of bias, a measure of the overall error, a measure of temporal correlation and a measure of the amplitude of variation (e.g. σm/σÎ£ the ratio of the standard deviation of model to the standard deviation of the observation) is also included. All results should be discussed in view of calculated metrics, avoiding qualitative expressions ("considerably", "slight positive bias").

Page 12, line 31. "All models show a clear seasonal variation in line with observation" I don't quite agree with this statement. The authors should calculate temporal correlations between each model and the observations (after extending the EMEP observations to 2000-2009). Which model performs better and why? The discrepancies should be discussed thoroughly. It would be nice if you could mention the countries which are taken into account when dividing into the 4 sub-domains (NW, NS, SW, SE).

Page 13, lines 11-19. The text is a mere description of the figure.

3.3 Climatically induced changes in ozone concentrations

It is important that each modeling team calculates the statistical significance of the

future surface ozone changes and discusses the results (similar work has been performed in Andersson and Engardt, 2010, JGR; Katragkou et al., 2011, JGR). Recent studies show that the changes in surface ozone, especially in the first half of the century, are not statistically significant for a great part of the European domain.

Since the surface ozone changes are investigated with respect to climate change it would be nice to see how key-meteorological parameters (temperature-solar radiation) change in the future decades. What is the temperature change according to the regional climate model? What is the pattern of changes in solar radiation? Are there any changes in the circulation patterns seen, affecting changes in ozone? What seems to be the driving factor of surface ozone change? What is the added value of the online model?

Conclusions

The conclusions reached are very generic and qualitative. Authors must provide evaluation statistics (suggestions on evaluation metrics described above) for each model and highlight current problems in model behavior as well as suggestions for improvement. They should provide concrete ranges of O3 sensitivity among different models and discuss their significance.

It is mentioned (page 3, line28) that "The inclusion of one CCM gives the possibility to analyze the importance of feedbacks of changes in ozone on meteorology". Could the authors summarize the importance of these feedbacks based on their analysis?

Technical corrections

Figure 1. It would be nice if you could specify whether the "boundary conditions" refer to meteorological or chemical. Page 5, Line 17 "Differences between models are.." Do you mean "Differences in biogenic emissions between models. . ."?

Page 13, line 4 Correct to "underestimates"

Page 32, figure 2 Which are the quadrants of the simulation domain?

Figures 3 and 4. Station dots could be colored according to the provided color-table giving information on surface ozone measurements.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 4901, 2012.