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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Modelling the impacts of climate change on tropospheric ozone over three centuries" *by* G. B. Hedegaard et al.

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Answers to anonymous Referee #2

We thank referee #2 for a thorough review of our paper. In the following we answer the issues raised by the reviewer:

Reviewer: This is an interesting study and contributes to the knowledge body of atmospheric chemistry and climate change. However, one of my major concerns remain about the paper is the presentation. The quality of figures definitely needs to be improved. For example, I don't understand why the white strips and quite some strange patters in the figures (almost in every figure) - these were not explained in the text and I don't know whether they are just some technical problems or any scientific reasons

for that – this makes it extremely hard to evaluate the results presented.

Answer: We thank the reviewer for the positive overall evaluation of the paper. We agree that the quality of figures is insufficient. New and clearer versions of the figures will be included in the revised version of the paper.

Reviewer: In addition, I am not convinced with the discussion on ozone trends in the free troposphere (the level at 5km altitude) (P6825, L16-29). I am very surprised with the authors" conclusion of "The ozone distribution in the free troposphere (last plate of Fig. 10) indicates that the effect from enhanced ozone precursors like isoprene exceeds the decrease in ozone concentration due to increased water vapour in and north of the subtropics and vice versa in the equatorial regions - and I don't see any evidence for this.

Answer: The reviewer raises a very interesting discussion about the processes involved in the climate change impacts on the future ozone concentrations. Keeping all anthropogenic emissions constant, as we do in the study, leaves us with a clearer signal concerning the natural processes. In the paper we give a detailed discussion about the main chemical processes with respect to the production and sink of ozone. We conclude that there are some dominating processes: 1) that the temperature increase is the dominating factor, 2) the temperature increases the biogenic VOC emissions as well as the contents of the water vapour in the atmosphere, 3) the increased isoprene results in increased ozone production, while the increased water vapour acts as a sink for ozone. There is, of cause, also other processes involved, but isoprene and water vapour is found to be the dominating parameters and therefore, the results indicate that in areas of increased ozone levels, the processes are dominated by the production from isoprene and in areas of decreased ozone levels the processes are dominated by the sink related to increased water vapour. The latter is supported by the results in Murazaki and Hess (J. Geophys. Res., 2006), where only the processes related to increased water vapour are included and where a general decrease in the ozone levels are simulated. The possible other explanation for the results in Fig 10 at higher altitudes

is a change in the atmospheric transport patterns due to climate change, however, a study of this is not within the scope of this paper but is planned as a future study.

Reviewer: I think some better description on model setup, in particular the treatment of boundary conditions (including both meteorology and chemistry) could help the readers better understand and interpret the results. The description in the text is not clearly enough: "Boundary conditions for the model domain depend on the direction of the wind, such that free boundary conditions are used for sections where wind flows out of the domain. Constant boundary conditions are used for sections of the boundary where wind is flowing into the domain; in this case, the boundary value is set to the annual average background concentration. For ozone these are taken from ozone soundings and are the same for all simulations in this study (Logan, 1999)." I guess I figured out what the authors meant by "Boundary conditions for the model domain depend on the direction of the wind" but this could really be confusing. Also what's the boundary conditions for tracers other than ozone? Were they obtained from a separate model?

Answer: We agree that the description of the chemical boundary conditions is rather technical. For meteorology, we do not consider boundary conditions important for interpretation of the results, since the climate model is a global model. We have changed the text to the following:

"When simulating climate change impacts on air pollution levels, the chemical boundary conditions are important for interpreting the results. Since the chemical species in this study has relatively short life times, and since the boundaries in the model are located far away from the areas of interest, constant boundary conditions can be used. In this study, the same and constant boundary conditions are used for all four decades so that the effects from the boundaries can eliminated from the interpretation of the results. The boundary conditions for ozone in DEHM are also constant over time, but vary in space, due to the large spatial variability of this particular specie. For ozone, the initial and boundary conditions are based on ozonesonde measurements, interpolated

to global monthly 3D values with a resolution of 4o x 5o (Logan, 1999)".

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 6805, 2011.