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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Attribution of projected changes in US ozone and $PM_{2.5}$ concentrations to global changes" *by* J. Avise et al.

J. Avise et al.

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We thank the anonymous reviewer for the insightful comments. We have considered the recommendations and made appropriate changes to the manuscript. Our responses to the specific comments are detailed below.

== Comment: The paper presents an analysis of the simulated impact of global changes in climate, land use, anthropogenic and (a selection of) biogenic emissions on US air quality indicated by changes in ozone and PM2.5. A companying paper by Chen et al. (2008) describes the applied modeling framework and the overall impact of global change on these parameters where Avise et al. focus on establishing the contribution by the various global change components. The paper is well written, addresses an interesting topic but going through the text there are issues of concern.

What does this study add to previously conducted analysis of future air quality in terms of the magnitude of the predicted changes in ozone and PM2.5? It would be good if the authors would indicate more specifically what this particular analysis adds to the assessment of future air quality as a function of global change.

== Reply: Beyond adding to the overall knowledge base of how global change may impact future air quality, our work also highlights two aspects of this research that has not been adequately addressed in previous studies: 1) the importance of incorporating projected land cover changes due to climate change and land management practices, and 2) systematically evaluating the relative impact of individual global changes on air quality through sensitivity simulations using downscaled global model output.

We have added a more specific discussion of what our analysis adds to the overall body of work assessing how global changes may influence future air quality.

== Comment: What about inconsistencies; I didn't find any discussion about the treatment/potential relevance of the feedback between atmospheric chemistry and climate. The global model simulations that have provided the boundary conditions might have considered to some extent the role of ozone in climate change but the regional meteorological model system reflects only the role of future land use in climate change and not as such how greenhouse gases and aerosols will alter future climate.

== Reply: The method of downscaling global climate model output used in our regional climate simulations is a commonly used approach for incorporating projected climate changes into regional air quality simulations (e.g., Hogrefe et al. 2004; Leung and Gustafson 2005; Tagaris et al. 2007). The outermost domain of our regional climate simulation was nudged towards the global climate model output, and as a result, the regional climate simulations inherit the simulated climate changes from the global climate model. Our regional climate simulations also incorporate projected changes in land use and the associated changes in surface-atmosphere energy exchanges, but do not incorporate feedbacks between atmospheric chemistry and meteorology. To incor-

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porate these feedbacks would require using a fully coupled regional climate/chemistry model such as WRF-Chem, rather than the decoupled MM5/CMAQ modeling system used in this work. Due to computational and time constraints, running a fully coupled regional climate/chemistry model was beyond the scope of this work.

== Comment: One particular issue of great concern of the presented analysis are the simulated changes in meteorology along the coasts. From Figure 3 it can be inferred that there are all along the coast predicted temperature increases up to 5K and increases in PBL height up to 400m compared to present day conditions. This is explained in the paper in terms of "a slight mismatch in the land-surface classifications for the present-day and future 2050 scenarios". It addresses the difficulty of such kind of analysis based on the use of a multi-model system with respect to the use of a consistent set of input parameters (emissions, land use) for the different model systems with different resolutions. The reason why I really have a difficulty with this is that, making an assessment of air quality in the US, the coastal regions with the large population density are actually very important. In addition one can expect that these simulated, potentially overestimated, impacts on meteorology will affect the simulated transport and chemistry for a larger domain than just the coastal zone. It would be interesting to see how land-sea breeze phenomena are represented in the future simulations. The resolution might still be too coarse but it is expected that the "misrepresentation"; of the coastal meteorology will result in enhanced transport due to the large gradients. This is relevant to assess since the analysis shows that actually the anticipated changes in long-range transport, e.g. the supply of pollution from Asia, is one key component in explaining future US air quality in the west. This is actually not discussed at all in the paper.

== Reply: The apparent change in temperature and PBL height along the coast in Figure 3 is an artifact due to a mismatch in the land-surface classifications between the present-day and future-2050 scenarios, and does not imply there is a misrepresentation of the coastal meteorology in the future-2050 scenario. The mismatch in

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land-surface classifications is roughly one grid cell, which means that in the future-2050 scenario, the coastal zone is shifted one grid cell away from land. Again, this does not mean that the coastal meteorology is misrepresented, but that the representation is shifted by one grid cell (i.e., the land-sea interface has been shifted by one grid cell). The gradients between a land cell and adjacent ocean cell are basically the same between the present-day and future-2050 scenarios (with any difference being associated with climate changes and not a misrepresentation of the meteorology), but the location of the gradient has been shifted one grid cell away from land. While this shift will have some impact on the grid cells directly adjacent to the land-sea interface, the shift has little impact on our overall results because inland grid cells do not care whether or not the coast line is one grid cell further away.

== Comment: What about other land-use related changes in emissions, in particular in biogenic N emissions due to changes in the application of fertilizers? From the discussion on the biogenic emissions it is inferred that only the impact of land use on BVOC emissions is considered where land use is actually expected to result in a decrease in BVOC emissions, partly explaining a decrease in the contribution of SOA to PM2.5. However, in many of the regions with an important contribution by biogenic emissions to the total emissions one can expect an important role of management practices. These could result in a complex change in the exchange of momentum, energy, moisture and mass (changes in deposition and emissions) which could all potentially affect aerosol production and fluxes. It would be useful to introduce some discussion on this.

== Reply: In our work, projected land use changes account for shifts in land cover types due to a changing climate and management practices in line with the IPCC A2 scenario. Projected management practices resulted in a large portion of the forested regions throughout the southeastern US being converted into croplands. This shift from forest to croplands has a large impact on biogenic emissions, as well as the land surface exchange of momentum, energy, moisture and deposition. Since our future MM5 simulations included the projected land use data, changes in land surface

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fluxes will be inherent in the simulations. Our projected changes in biogenic emissions, however, did not account for the associated changes in biogenic nitrogen emissions as a consequence of a projected increase in croplands. We have added a statement addressing this point in our manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 15131, 2008.