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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Drivers of the tropospheric ozone budget throughout the 21st century under the medium-high climate scenario RCP 6.0" *by* L. E. Revell et al.

Anonymous Referee #1

Received and published: 29 January 2015

This is a useful paper that presents the changes in tropospheric ozone and its precursors through the 21st century for one widely-used emissions/concentration scenario. It clearly demonstrates in a quantitative manner that changes in ozone precursor emissions dominate these changes, and that increased methane concentrations make a substantial contribution to this. It also highlights that climate changes under this scenario have little net impact on mid-tropospheric ozone, but that this masks increased ozone influx from the stratosphere and from lightning along with increased ozone destruction from humidity/temperature changes. These competing factors are not quantified, which is disappointing, and this constitutes one of my main concerns

the manuscript, as outlined below. However, the paper is worthy of publication once the points below have been addressed suitably.

General Comments:

The model used has a number of weaknesses, and the authors appear to avoid discussion of surface ozone or its changes wherever they can. On the positive side, the authors have justified their choices and have demonstrated that although there are some large biases in the mid troposphere compared with current observations, these are generally self-consistent and can be rationalized if not fully explained. However, the biases may be heavily influenced by what is happening at the surface, and so it would be very helpful for the reader if a few sentences were included in the evaluation section (3.1) on model performance at the surface.

The least satisfying part of the paper is the final paragraph before the conclusions, which highlights the potential impact on ozone of changes in lightning, but is unable to quantify this. While the paper demonstrates that this term together with the change in stratospheric influx (which is quantified) balance the increased destruction from humidity and temperature (which is not quantified), it is not clear if the two unknown terms are negligible (sub-ppb level) or substantial (4-5 ppb or more, but counteracting each other). Some attempt to establish this, or at least to speculate in a semi-quantitative manner, would add substantial value to the paper. A short model run with scaled lightning NOx emissions would be sufficient to estimate this, and hence quantify both terms. What have other studies found?

Specific Comments:

Abstract l.12: add "compared to 1960" somewhere in this sentence.

p.483, l.12: visibility doesn't just affect traffic.

p.484, l.2: the distribution and abundance of ozone may also be affected by changes in transport and convection.

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p.486, l.18: What are the implications of adding NMVOC as CO? This method captures some of the increase in O3 and decrease in OH that might be expected from NMVOC, but over much longer timescales and hence in different locations.

p.489, l.10: "constant removal value": a clear explanation is needed here. Is HNO3 given a simple first-order loss globally throughout the troposphere, or only where there are clouds or rainfall? What lifetime is assumed?

p.489, l.16: how might inclusion of anthropogenic NMVOC affect these biases? Nitrate formation and RO2 could increase NOx removal and ozone formation may be localized where lifetimes are much shorter, reducing O3?

p.490, l.22: emissions are a source of uncertainty, but are the same as those used in other model studies, e.g., ACCMIP. How do the NO2 biases compare with those from other models?

p.493, l.25: the mid-tropospheric signal is clearly not representative of the surface, but it is broadly consistent with it. How does the surface ozone compare with that seen in recent model studies, e.g., ACCMIP?

p.497, l.14: "on atmosphere": word missing here.

p.497, l.26: "... up to 6 ppb almost everywhere" is unclear; 6 ppb is a maximum, and not everywhere. Either present this as a range (2-6 ppb?) or drop "almost everywhere".

Figure 3: Panels c and d showing the ratio would be clearer with a dichromatic color scale centered at 1 (perhaps red/blue like Fig 6). Is this figure (and Fig 4) a multi-annual average?

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 481, 2015.