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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Lightning NO_x, a key chemistry–climate interaction: impacts of future climate change and consequences for tropospheric oxidising capacity" *by* A. Banerjee et al.

Anonymous Referee #1

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Review of 'Lightning NOx, a key chemistry-climate interaction: impacts of future climate change and consequences for tropospheric oxidising capacity', by Banerjee et al.

General comments:

The paper investigates the impact of a future climate on changes in lightning NOx, ozone and OH by means of climate-chemistry model simulations. The paper is well written and certainly suited for publication after revisions.

My main concerns are:

1. The lightning changes are not investigated at all. However they are a crucial part of the lightning NOx simulation. I suggest to inlcude some more information why LNOx is increased. Is more convection occuring or is altitude of the convection increasing and hence the parameterisation is increasing the LNOx (5th power)? Note that a different lightning parameterisation is giving a decrease in lightning, because the number in convective events decreased and the increased intensity did not compensate (Grewe, 2009). This result is in agreement with Brinkop (2002) and DelGinio et al. (2007). This should be discussed since it affects significantly the conclusion on the compensation of a reduction of precursor emissions by increased lightning NOx-emissions.
2. The paper suggests at several text pasages and Figures a linear relationship between lightning NO_x, the production of ozone, and the ozone burden. Actually the figures (Fig. 2) and the table 1 clearly shows the saturation of the chemical regime. Only changes in LNOx and changes in P(Ox) are linearly correlated. $\rightarrow$ dLNOx $\sim$ dP(Ox). The ozone production (LNOx $\not\sim$ P(Ox)) is not linear. And even the changes in the ozone burden react in a non-linear way. A 40% saturation is found. This part should be revised properly. (See also comments below).
3. The conclusions are to some extend exaggerated. I do not think that ozone from lightning is one of the key parameters for climate simulations. Ocean, sea-ice, carbon-cycle, feedbacks are key parameters. The tropospheric ozone is only a part in climate simulations.

Specific comments:

8754 l9-10 Changes in convection were not investigated!

8754 Might sound picky, but I think it is important. P(Ox) increases linearly with increases in LNOx. Not: with total LNOx. dP(O3)=a*dLNOx is ok but certainly not other versions like: P(O3) = a *LNOx or dP(O3)=a*LNOx.

8754 l24 Projections of future climate might be too general. Ozone changes are only contributing by a small part to climate change and LNOx is then a part of that. Still it is important. The conclusion should focus more on future ozone projections. And it is not consistent with the argument given on page 8760 l 20 'Our goal ...'

8756 l1-4 I think all the mentioned papers parameterise the flash frequency depending on the cloud top heights. It often has been argued that this is a statistical rather than a physical relationship. Other studies using convective mass flow or updraft estimates based on the convective mass flow predict a decrease in lighting NOx production (Grewe, 2009 and Dahlmann et al. 2011). There are studies suggesting that convective activity might decrease in the future in terms of number of events, but the individual events might be stronger. If that is true, what will happen with the lightning NOx? What is the more important parameter, - the decrease in total number of convective events or the increase in intensity of each individual event? It seems that Price and Rind, since the intensity is parameterised with the fifth order is more important and that an updraft parameterisation is less sensitive to the intensity and hence the number of events dominates. This would lead to a decrease in LNOx! See also e.g. Brinkop, 2002 and DelGenio et al., 2007.

8761 / Section 3.1 Changes in lightning is a key to this investigation. However, the causes for the changes are not investigated. Figure one suggests that the tropopause altitude increases in a future climate. Is this true for the convective heights? Or is the stratification of the troposphere getting more stable and hence the convective events are getting more intense (higher), but rare? I suggest to include some more analysis on the reasons for the lightning changes in a future climate.

Section 3.2 / Fig. 2 Two notes on the linearity of the system:

1. It could be worth mentioning the non-linearity of the system. E.g. doubling the LNOx from 6 to 12 TgN is not doubling the P(Ox), since it increases from ~4700 Tg/y to ~5700 Tg/y, only. Only the changes are linear.
2. The ozone burden change seems to react pretty non-linear on the LNOx increase. Fg. 2b: blue line base->CC4.5 gives an increase of 30 TgO3 per 2.04 TgN changes. This rate of change would (linearly) give 70 TgO3 for the run CC8.5, but only 43 TgO3 increase is found, which is already a deviation from lienarity by 40%. A remarkable saturation effect! And this is true for all sets of simulation. I propose not to fit the data in Fig. 2b but to draw lines betwen the individual data points and further discuss this non-linearity in the section.

8766 "A positive and linear relationship between LNOx and P(Ox) is found" No that is not true, see above. Linear would imply doubling of LNOx doubles P(Ox) that's not true. Only the perturbation is linear.

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