**Atmospheric
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Interactive comment on "Lightning NO$_x$ emissions over the USA investigated using TES, NLDN, LRLDN, IONS data and the GEOS-Chem model" *by* L. Jourdain et al.

Anonymous Referee #1

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The study "Lightning NOx emissions over the USA investigated using TES, NLDN, LRLDN, IONS data and the GEOS-CHEM model" by L. Jourdain et al. uses TES measurements of O3 and GEOS-CHEM model runs for different lightning parametrizations to constrain the production of NOx by lightning.

The paper is well written. The authors use different datasets/model settings to comprehensively study the impact of LNOx on O3, which is a highly important issue of atmospheric chemistry research. The study is definitely suited for publication in ACP.

However, there is one important drawback in this study, which severely affects the conclusions. This requires larger revisions of the paper.

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1. The impact of the treatment of the stratosphere

In section 2.3, the authors describe different model setups. In 2.4, they present comparisons of the model runs to ozonesondes measurements. As impressively illustrated by Fig. 3, Sbase as well as Slighx2 are significantly underestimating O3, while Sstrat shows a considerable improvement.

So my conclusion is that it is really important to treat the stratosphere as in Sstrat, not as in Sbase etc. However, the authors continue discussing the impact of different LNOx settings, keeping the "wrong" stratospheric implementation.

This is in fact challenging the conclusions (that Slighx2 fits better): also Fig. 7 illustrates that Sstrat (i.e. the corrected stratosphere and LNOx as in NLDN (260 moles/flash)) gives much better results than Slighx2 (i.e. wrong stratosphere and doubled LNOx)!

So the stratosphere is by far the dominating factor in this study! Thus, after having found a way to improve its implementation in the Sstrat run, all further studies on the impact of different LNOx parameterizations must use this stratospheric setting! Otherwise the found improvement for upscaled LNOx is probably just an artefact due to the wrong implementation of the stratosphere; it could be that a run "Slighx10" would give even "better" results, while probably no one would believe such high LNOx production.

For this reason, I recommend to perform the different lightning runs again using the improved stratospheric implementation. From the current model runs using the wrong stratosphere, it is not possible to judge how far the conclusions are justified.

2. Vertical profiles of LNOx

A further aspect concerning the approach of this study: The authors present measurements and model results for O3, but draw conclusions on LNOx production. However, there are more factors determining O3 production from LNOx than just the total production per flash. In particular, the vertical distribution plays an important role. Thus, if there is a discrepancy between modelled and measured O3, this could be due to

a wrong amount of LNOx production per flash in the model, but as well the model might place the LNOx at the wrong altitude. This aspect could also be investigated by additional model runs with alternative vertical profiles.

3. Some minor comments:

- Abstract lines 12-17: Try to split this into two sentences.

- 1125,3-5: Even if O3 production would be linear with NOx, knowledge of this source would be needed...

- 1129, 6: LNOx instead of NOx

- 1130, 10: Note that Boccippio et al. found strong regional differences for the IC/CG ratio!

- 1130, 14: LNOx instead of NOx

- 1129-1130: I am a little bit confused:

Sbase has 0.1 Tg N and 260 mol/flash.

SNLDN has 0.14 Tg N

Slighx2 has 520 mol/flash.

So SNLDN has 260 mol/flash like Sbase? That would imply that SNLDN locates a higher percentage of global flashes to the US?

Fig. 2: Bottom left: If flashes are scaled to OTD/LIS, why are the resulting spatial distributions and absolute levels that different? GEOS-CHEM seems to be systematically lower, and is in particular not capable to reproduce the Congo maximum observed by OTD/LIS.

Fig. 2: Bottom right: How can you define flash rates from NLDN outside North America?

Fig. 3: According to the caption, Sstrat should be green.

Fig. 4: Red triangles should be explained in the caption.

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