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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Possible catalytic effects of ice particles on the production of NO_x by lightning discharges" *by* H. S. Peterson and W. H. Beasley

Anonymous Referee #1

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Possible catalytic effects of ice particles on the production of NOx by lightning discharges

General Comments:

Authors hypothesize that catalytic processes on ice particles enhance the production of NOx by lightning charges. Such processes seem plausible to this non-expert. Subject is of great interest to the ACP community.

Article needs substantial revisions before it is ready for publication. Specifically, a more careful selection of plots/tables, a few additional equations, and more consideration of the bottom line is needed.

Specific Comments:

12652: L2-4: Greatest amount of adsorption per unit ... dendrite crystal habit Which habit is likely to have the greatest total adsorption? Is a different crystal habit more common than the dendrite habit? Which habit is most likely in regions of lightning-NO production?

12652: "precedent for consideration of these types of ..." You reference one study. Additional examples would strengthen your hypothesis.

Fig. 1 shows the decrease in temperature with time following a return stroke. While interesting it is someone else's plot and doesn't add to this paper. I would prefer a plot that shows an estimate of the amount of time it takes for the temperature to decrease from $\sim$5000K to $\sim$1000K. This temperature range is important because your calculations are done at 2000, 3000, and 4000 K. This plot could also be used as a guide for a back-of-the-envelope estimation of the total production of NO from catalytic and non-catalytic processes.

Fig. 2 is also a curious choice. Based on the text, I expected to see a plot comparing specific surface areas for different ice crystal habits and/or a plot showing how common each type of habit is in regions where lightning is occurring. Replace figure with another showing the above or delete.

12653 L16: "Since it cannot be assumed that ice crystals within the hot core ... survive ..." Is this meant to logically follow from the previous paragraph's discussion? i.e., Are you saying that ice crystals are unlikely to survive in and near the lightning channel and that an alternative hypothesis (i.e., that ice crystals survive in the corona sheath instead) is needed? Please clarify.

Section 3. Stability of ice crystals at high temperatures Please clarify the bottom line? Will enough ice crystals survive to allow for substantial catalytic NO formation?

12653: 1-15: You give sizes below which ice crystals will not survive. Can you put this

in context? i.e., Will only the very largest survive? Will many survive What is a typical size distribution within a cloud, etc.

12656 L1: "between 10 and 10^5 crystals per cubic meter." What a wide range! Can it be narrowed down? i.e., Is there a PDF somewhere showing the expected distribution?

12660: 2-4: "If experiments were to confirm ..." In a discussion section or here, please outline the experiments needed to confirm or refute the importance of these catalytic reactions.

12661: L26-27: "However, it appears that the difference in total production is not enough to account for the differences in CG and IC lightning NOx production" How did you come up with this conclusion? Is it a back of the envelope calculation? Within a discussion section show how you came up with this conclusion.

Table 2: I would expand Table 2 including columns for ice crystal density (or mass) and for hydrogen vs. chemical bonds. It would also be useful if estimates of how long the temperature is within each range were included.

4 Calculations Several of the factors controlling the NO production rate seem to vary by orders of magnitude within the cloud. For example, crystal mass [10-8,10-4], capacitance [0.01,10], crystal density [10,10^5]. With uncertainties this large, it would be nice to see a "best guess" range of estimates in Table 2.

Additional Plot? A summary plot highlighting the results shown in the expanded Table 2 is needed. Something a reader and cut and paste into a presentation!

In the abstract, you state that this process may be relevant to the question of the relative importance of CG vs IC flashes for lightning production. Within a discussion section, please indicate how this process increases the production of IC flashes more than CG flashes.

Technical Corrections:

12650 L 21 Also include a reference to the first paper concluding that NO is an important precursor to O3.

12651: L5 Cook –> Cook et al.

12651: L31: ice oarticles –> ice particles

12653: L6: A 293 page book by Rogers and Yau is referenced on several different occasions. To aid the reader please give page numbers within each reference.

12653: L23: Discussion in this section would be easier to follow if the Eyring equation is added. Please add it.

12655 L7 "... no more than 12% of nitrogen ..." Where do you get this number from? Is there a simple equation that can be added to make this more clear?

12656: "crystal mass of 10-8 g. Where did Rogers & Yau get this value from? Is it reasonable. You use 10-4 g later (as a sensitivity study)

12656 L 11: "picture in Figure 13" What Figure 13? I don't see one here or in Rogers & Yau.

12659: L17-19. "Thus temperatures that favor ..." Perhaps this line should be added to abstract and/or summary.

12659: Can Equation 3 be derived from equations R1-R6? If no, please add reference.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 12649, 2011.