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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of a new lightning-produced NO_x parameterization for cloud resolving models and its associated uncertainties" *by* C. Barthe and M. C. Barth

Anonymous Referee #2

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Major comments

This paper describes a novel parameterization for lightning-produced NOx (LNOx) developed for cloud resolving models (CRM), a topic appropriate for publication in ACP. In addition, sensitivity studies are carried out in large detail to select the most important parameters and to point out which parameter values fit the observations best. Such comprehensive sensitivity studies concerning LNOx parameterization are lacking in the literature and therefore this paper adds valuable knowledge to the LNOx community. The authors give proper credit to related work, however some minor improvements are necessary (see specific comments). Some improvements are also recommended

for one section of the sensitivity studies (see specific comments). The paper is well structured, easy to follow, conclusive and well written. The presented figures are well chosen. The English language is good.

Specific comments

The LNOx parameterization presented is based on three "unique characteristics"; including a vertical velocity threshold to select lightning-producing cells, a flash rate estimate from the product of non-precipitation and precipitation ice mass fluxes, and a filamentary LNOx source location. The described relationships have already been found and published by other authors and not been developed by the authors of this paper (as you get the impression from the abstract and partly introduction). However, here for the first time these "unique characteristics" are combined in a meaningful way to improve the parameterization of lightning-produced NOx. This should be pointed out more clearly. It is mentioned that Ott et al. (2007) first applied a filamentary LNOx source location in their CRM. How does the LNOx parameterization in the Ott et al. CRM differs from the one described here? How are lightning-producing cells selected and the flash rate determined in their model (same or different methods)?

In the introduction you present the different parameters that you investigate in your simulations as total flash rate, spatial flash distribution, LNOx production per flash and so on with references. Here some information about flash length, that you give in Sect. 5.4, should also be added.

In Section 5.4 the flash length is discussed (Page 6625). Line 23-25: "The value of 21 km corresponds to the mean flash length simulated when a lognormal distribution for the flash length is used and when short duration flashes are taken into account. The aim of these sensitivity test is to investigate the impact of using a constant or a varying flash length." It is not surprising that both simulations give about the same result since on average both is the same. Instead, it would be important to vary the flash length and to consider the number of flashes with a certain flash length. Is the LNOx contribution

ACPD

8, S2746–S2752, 2008

from many short flashes (˜1 km) more or less important than the contribution from a few long flashes (e.g. >30 km)? This would be a very important question to answer.

Is it necessary to describe a lot of model chemistry (page 6612, upper half) when you write in line 22-23: "LNOx is transported only and does not undergo any chemical reactions."

Many of the technical corrections are references to specific figures and tables. Please check throughout the paper that the reader more easily can follow which figure or table you are discussing.

Numbers for the LNOx production rate for flashes are given at several places. Please add what kind of flashes you mean (IC or CG)?

Technical corrections

Page 6604, line 6-7: "Third, the source location is filamentary instead of volumetric, as in previous parameterizations". Change to "as in most previous parameterizations".

Line 10: "the simulated flash rate and NO mixing ratio". Add "(control experiment)".

Line 11: "An individual flash produces". IC or CG?

Line 13: Add that the selected storm is dominated by IC flash activity.

Line 18: Add that the simulations show almost no impact from the different cloud-to-ground (CG) ratios and the LNOx production rates per CG flash used as input to the model.

Page 6606, line 6: "The vertical distribution of the NO molecules is either uniform". Change to "The vertical distribution of the NO molecules in the models is either uniform"

Line 7: Explain more in detail what a "bimodal and Gaussian distribution for IC and CG flashes" is?

Line 9-10: "distributed below the -15°C isotherm. NO is deposited above the". Change

ACPD

8, S2746–S2752, 2008

to "distributed below the -15°C isotherm and above the -15°C isotherm when produced by".

Line 26: "111 moles NO per CG". Change to "IC".

Line 27: "Wang and Prinn (2000) tested". What were the results?

Page 6607, line 23: "eight models". Change to "eight different models".

Line 23 and line 25: "Two of the models" "The four other models". In line 23 you wrote eight models (what about the other two models?).

Line 28: Are the values given for IC or CG flashes? Check throughout the paper.

Page 6608, line 2: "in a small volume along the simulated lightning flash". Add "(filamentary)".

Page 6609, line 6: "must exceed 15 m s-1". Who found that (references)? For the U.S.?

Line 7-8: Can U.S. updraft velocities be compared to Australia?

Line 23: "(kg m s-1)" "(kg s-1)". Check if different units are ok?

Page 6610, line 8: "(radius 4 km". Reference or how determined?

Line 13: "bimodal distribution". Needs some explanation as mentioned above.

Line 20-22: "The flash length — constant or to have a lognormal distribution". Give some range and values as mentioned above.

Line 23-24: Add that this was a laboratory study.

Page 6613, line 1: Values given for IC or CG?

Page 6614, line 12: "moved at 1.5 m s-1". Change to "with".

Line 14: "21:30 to 03:00". Add "UTC" and check the times throughout the paper.

ACPD

8, S2746–S2752, 2008

Page 6615, line 1-2: "1 to 400 km". Give reference.

Line 8-9: "Wang et al.". Add "from laboratory studies".

Line 18: "23:40-02:15". Add UTC.

Page 6616, line 7: "cross sections of the NO mixing ratio". Change to "cross sections of the simulated NO mixing ratio".

Line 9: "At 3600". Add "(Fig. 4a)".

Line 12: Cut "(Fig. 4a)".

Line 18: "At 5400 s". Add "during the transition stage".

Line 22: "flash rate". Add "(Table 3)".

Page 6617, line 3: "(Fig. 5)". Change to "(Fig. 5a)" and label the figures 5a-5t. Or change to "(Fig. 5 "Observations")".

Line 5: "Several regions of NO mixing ratio". Change to "Several regions of simulated NO mixing ratio".

Line 7: "(Fig. 5)". Change to "(Fig. 5b)" or "(Fig. 5 "REF")".

Line 8: "multicell and transition stage". Why not supercell stage?

Line 9: "After 1 h of simulation". Add "left panels".

Line 11: "The simulated transect". Add "REF".

Line 15: "After 1 h 30 min of simulation". Add "right panels".

Line 29: "efficiently transported in the mid- and upper troposphere". Any quantification of the BL-NOx transport to the upper troposphere?

Page 6618, line 1-2: Why reduced?

Line 17-19: Give section numbers in brackets.

ACPD

8, S2746–S2752, 2008

Page 6621, line 1-18: Try to shorten this part.

Line 19-20: Add "(Table 2)".

Page 6622, line 3-5: Mention that the findings from Boccippio et al. are not applied to this study.

Page 6627, line 7: Compare this value for NO_SDF to the value for REF (121.3 moles).

Line 10: I do not agree for Fig. 7.

Page 6628, line 25: Fig. 7 (right middle panel): Why are the simulated values at the beginning much higher than the observations?

Page 6630, line 7: Add "(Fig. 8)".

Line 20: Change to "360 moles of NO for both IC and CG flash".

Page 6631, line 1: "PROD_CG_2 and PROD_CG_10". Continue with line 5-8 to explain the abbreviations.

Line 3-4: Are the values correct and from where are the values?

Line 10: "by 2 or 10". Change to "by a factor 2 or 10".

Page 6632, line 10: Add some interruption ",".

Page 6633, line 5-8: I do not agree that the LNOx parameterization is not very sensitive to the lightning flash length. Here you would have to add that you investigated the influence of different distributions of the lightning flash length (constant or lognormal).

Page 6642, Table 2, column 3: What does the three numbers in brackets mean?

Page 6644, Fig. 1: Add "m s-1" to the color bar.

Page 6646, Fig. 3 legend: Switch "red" and "green" since in the figures green is shown (b) before red (c).

ACPD

8, S2746–S2752, 2008

Page 6647, Fig. 4: Write the stages "multicell", "transition", and "supercell" to the right of the figures and add the times 3600, 5400, and 7200 s. Then this figure is better comparable to Fig. 6.

Page 6648, Fig. 5: Add "pmol mol-1" to the color bar.

Page 6649, Fig. 6-8: The two blue colors used are hard to distinguish. Use cyan blue of pink instead.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 6603, 2008.