Atmos. Chem. Phys. Discuss., 8, S2859–S2862, 2008
www.atmos-chem-phys-discuss.net/8/S2859/2008/

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 #1

Received and published: 20 May 2008

General comments

The manuscript presents results from the inclusion of a complex lightning NOx parameterization in a cloud-resolving model. The parameterization estimates both flash rate and the amount of NO produced. Observed flash rates are reproduced remarkably well, and the temporal evolution of flash rate is better reproduced by the new parameterization than by Price and Rind (1992) who estimated flash rate based on peak updraft velocity. Simulated NO mixing ratios also compare favorably with aircraft observations. This new approach represents a valuable contribution to studies of atmospheric chemistry, both in cloud-scale and larger-scale models. In addition to the

results of the reference simulation, results from a number of sensitivity studies are presented. The impact of flash rate, flash length, the number of CG flashes, NO production by short-duration flashes, vertical and horizontal distribution of LNOx, and NO production per flash are considered. While many studies have considered one or two of these quantities, there has been no similar study which tests the sensitivity to so many parameters within a single framework. These results will be a useful reference for future studies of LNOx production and are suitable for publication for ACP.

My main concern is that the sensitivity to flash length is not adequately addressed because the two simulations testing this have the same mean length (21 km). Because great uncertainty surrounds flash length estimates and they are the basis for NO production in this study, I think another simulation assuming a significantly different flash length would be very useful. I also think the discussions of CG ratio and CG production might be better addressed by combining section 5.2 with the second half of section 5.7 (CG NO production).

Specific Comments

p. 6609, line 6 - I am curious to know if any sensitivity tests were done to evaluate the impact of the choice of the 15 m/s threshold for lightning activity in a convective cell. If such tests were done in the development of the parameterization, it would be nice to include some discussion of them.

p. 6610, paragraph 1 - Were any sensitivity tests of the size of the lightning triggering region and the flash propagation area done? This may also be useful.

p. 6618, line 1 - Is this decrease in NOx in the boundary layer due only to transport? It is very large. I wonder if chemical conversion may also be playing a role here?

p. 6621, lines 17-18 - The authors state that the simulations producing more NOx in the convective core region (transect 1) have more NOx transported into the anvil (transect 2). It looks to me from Figure 6 that the FR_PR92_CELL simulation produces much

ACPD

8, S2859–S2862, 2008

higher spikes of NO in transect 1, but in transect 2, the peak values of FR_PR92_CELL are slightly less than FR_OBS. I assume this is due to the timing differences between the observed and PR92 flash rates, but I think the sentence may need to be modified to discuss this.

p. 6622, Section 5.2 - Is NO production per flash estimated in the same way for CG and IC flashes? Are flash lengths calculated using the same distribution for both IC and CG flashes? This needs to be clarified. If NO production from CG flashes is treated the same as IC flashes except for the vertical distribution, then it is not surprising that the factor of 10 larger CG ratio predicted by PR93 has little impact on NOx mixing ratios.

p. 6625-6626 - I don't think the impact of flash length on LNOx production is adequately addressed. The simulations presented are the reference simulation which assumes a lognormal distribution of flash length with a mean of 21 km, and a simulation which assumes this mean of 21 km for all flashes. Essentially this is testing the impact of flash length variations, but not not flash length itself since the means are the same (21 km). I think a simulation assuming the Defer et al. (2001) value of 34 km (mean with no short duration flashes) would be interesting here, especially because flash length is such an uncertain quantity but is the basis of NO production in this approach.

p. 6630, paragraph 1 - The sensitivity tests for the CG NOx production were done using the NLDN observations which showed a very small number of CG flashes (˜2%). I think this test would be more useful if combined with the CG ratio test presented earlier, specifically the ˜20% CG ratio derived from the Price and Rind (1993) relationship. While this ratio is not realistic for this storm, it is closer to the climatological CG ratio derived from satellite and ground-based observations (e.g. Boccippio et al., 2001) and I think would give a sensitivity to the CG NOx production that is more broadly applicable.

Technical Comments

Abstract - I think the authors should be a bit more careful about specifying either grid cells or convective cells. For example, "First, the convective cells that can produce

ACPD

8, S2859–S2862, 2008

Interactive Comment

lightning..."

p. 6605, line 17 - Change "For each step..." to "For each component..."

p. 6605, line 29 - The authors may want to add that observations of total lightning for a particular storm are difficult to obtain because ground-based networks (like the NLDN in the U.S. and BLIDS in Europe) typically record CG flashes primarily.

p. 6606, lines 27-29 - It is mentioned that Wang and Prinn (2000) tested two estimates of NOx production per flash but the authors do not include whether this study concluded that either estimate was realistic.

p. 6607, line 29 - The authors may want to add the range of production values for IC flashes as well since that is mainly what is examined in this paper.

Fig. 3 caption - I think the caption for (b) should be "... ice mass flux product (green curve)" and for (c) should be "... in each individual cell (red curve)."

p. 6616, line 2 - Add more specifics on how much earlier supercell stage in simulation begins as well as how much stronger simulated mass flux was.

Fig. 4 - Need to add (a)-(f) labels since these are referenced in text.

p. 6625, lines 2-3 - Change to, "...is more readily transported to higher altitudes..."

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

ACPD

8, S2859–S2862, 2008

Interactive Comment