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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of satellite observations for freshly produced lightning NO_x" *by* S. Beirle et al.

S. Beirle et al.

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We thank the reviewer for the positive feedback and suggestions. We reply to the raised issues point by point:

1) page 18120, line 5: the cloud resolving model was run with the assumption that an IC flash produces only 50to the likelihood that IC and CG flashes produce roughly equal amounts of NO per flash. How might the "visibility" and "sensitivity" respond if the assumption of production equality had been made in the cloud model (likely increasing the amount of LNO_x in the upper portion of the cloud). I would guess that the estimates of these characteristics would increase. Perhaps some comments could be made to address this issue in the section of the paper on uncertainties.

Reply: We have further stressed the uncertainties concerning IC and CG flashes in the

manuscript.

In the CSRMC model setup used in this study, the partitioning between IC and CG flash rates was 10.43, while the ratio of LNO_x production efficiencies (i.e. LNO_x per flash) was 5e25/10e25=0.5. In total, for this CSRMC run, the amount of produced IC LNO_x is thus 5 times higher than the amount of CG LNO_x.

The review of Schumann and Huntrieser, 2007 (SH07 hereafter), summing up recent studies on LNO_x production, indicates that both numbers are probably off, but the updated numbers seem to compensate each other: As pointed out by the reviewer, there are several studies reporting on IC LNO_x production being as efficient as CG (see table 19 in SH07), which would mean that our study underestimates IC LNO_x production. On the other hand, the ratio of flash rates of about 10 is probably too high (see table 9 in SH07) and could be as low as 3 instead. Hence, this effect might compensate (or even overcompensate) the underestimation of IC LNO_x production efficiency.

We extended the discussion in section 4.1.1. However, despite the remaining high uncertainties in IC/CG flash frequencies and LNO_x production efficiencies, we consider the potential impact on our study to be moderate, since a) the CG LNO_x is lofted to the UT very efficiently (reducing the importance of distinguishing between IC and CG LNO_x) in the CSRMC (see Salzmann et al., 2008), and b) the effect of shifting the modelled NO_x profiles up or down on the resulting sensitivity is quite small (see first paragraph on p. 18130).

2) page 18129, line 20: But Dye et al. (2000) found that the flash rate maximum was downwind of the updraft core in a multicell storm that evolved into a storm with supercell characteristics. This reference should be included and some discussion added on what the influence of this storm structure would be on the sensitivity.

Reply: We added a reference to Dye et al., 2000, and extended the corresponding discussion.

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CG flashes are horizontally placed at the location of the maximum vertical velocity. This choice is consistent with Ray et al. (1987), who found, based on dual Doppler radar and very high frequency lightning observations, that in a multi-cell storm, lightning tended to coincide with the reflectivity and updraft core. It could, nevertheless, potentially lead to a small over-estimate of the upward transport of lightning NO_x if lightning occurs downwind of the updraft core, instead, as discussed on page 18129.

However, for the event decribed in Dye et al., 2000 (e.g. plate 2b and discussion on page 10,034), most flashes "are located in the moderate updrafts and downdrafts", so the LNO_x profile will be close to the initial release of LNO. As IC flashes are the dominant source of lightning for this particular thunderstorm, the LNO_x profile would peak within the cloud, i.e. where visibility is high.

However, Dye et al. discuss a single continental thunderstorm over about 5 hours and conclude section 3.3. ("Lightning location in the Storm") with "... there are relatively few publications relating the location of lightning to vertical air motion structure. ... More work is needed to better understanding these relationships".

3) page 18134 line 13: Here and in the abstract the mean value of sensitivity is given as 0.46. However, on page 18126 it is given as 0.41. Please clarify.

Reply: On page 18126, the mean sensitivity, defined as mean of all individual sensitivities matching the criteria given on page 18122, lines 23-26, is given (0.41). In contrast, the number 0.46 results from averaging the total sensitivities (see eq. 15) over all OTSs (see page 18127, lines 5-21).

In practice, spatially integrated flash counts will be set in relation to spatial means of NO_2 columns. For this approach, the definition of E_{total} (eq. 15) is appropriate, and hence the number of 0.46 is considered as the relevant sensitivity, given in abstract and conclusions.

To clarify the manuscript in this respect, we introduced subsections in section 3.

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