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Interactive Comment

Interactive comment on "Estimating the NO_x produced by lightning from GOME and NLDN data: a case study in the Gulf of Mexico" *by* S. Beirle et al.

S. Beirle et al.

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We want to thank the referee for his constructive comments and helpful suggestions. In the following, we refer to them point by point.

Reviewer comment 1) Sections 1-3 are very well written. Sections 4 and 5 are more difficult to follow. It would be helpful to include a table that summarizes the factors involved in the calculation of NOx / flash. The table could also contain the uncertainties in each component. The calculation of the total uncertainty from the individual sources was unclear.

Reply: Section 4 is soundly revised and re-ordered. Some paragraphs and several equations are added to illustrate the calculation procedure of our LNOx estimate.

Reviewer comment 2) The calculation of the AMF in section 4.1 includes a convolution of box AMFs from Hild et al. with an expected vertical profile of lightning emissions from Pickering et al. This is a reasonable approach, however it appears to neglect vertical variation in the NO / NO2 ratio. The box AMFs were calculated for NO2 while the vertical profile of lightning emissions is for NOx. A suggestion to correct this issue is to multiply the profile of NOx emissions by the vertically resolved NO2 / NOx ratio (i.e. Bradshaw et al., GRL, 1999, 471-474) before convolution with the box AMFs.

Reply: In our estimation, we implicitly used a constant NO2/NOx ratio what is indeed a simplification. The reason for this simplification was the fact that the NO2/NOx ratio measured by Ridley et al. (1996) for the thunderstorms in New Mexico is almost constant over a range of almost 4km in the upper core and anvil region. Nevertheless, we revised our calculation with a height resolved NO2/NOx as the reviewer suggests. For this purpose, we use the numbers given in tables 2 and 4 of Ridley et al. (1996) for the upper 4 km. Below, no NO/NO2 information is given in Ridley et al. (1996). But in Ridley et al. (1994), average height profiles of NO and NOx from 12 measurement flights are presented that are taken in July/August over New Mexico. Most flights are performed under cumulonimbus cloud conditions. Vertically NO2/NOx ratios are calculated from these profiles and used to convert the Pickering et al. (1998) and Fehr et al. (2004) NOx profiles to NO2 profiles.

Reviewer comment 3) The NO2/NOx ratio used in section 4.4 is based on measurements in the thunderstorm anvil. However as noted by the authors, GOME has some sensitivity to NO2 below the anvil due to multiple scattering. It would be more complete to use an "effective NO2/NOx ratio" that represents the observed ratio over the column. A possible approach would be to convolve a vertically resolved NO2/NOx ratio with the vertically resolved GOME sensitivity weighted by the profile of lightning NOx emissions.

Reply: We derive an "effective NO2/NOx" ratio by accounting for height dependent GOME sensitivity and NOx partitioning and the NOx profile.

The consideration of vertically varying NO2/NOx ratios leads to a lower effective AMF, since the NO2 in the lower and middle troposphere (with low visibility) is weighted stronger due to the higher NO2/NOx ratios there. However, at the same time the "effective NO2/NOx ratio" increased. Both effects partly cancel out. Thus the actual number of the estimated LNOx production changes only slightly.

Reviewer comment 4) A longitudinally invariant stratospheric AMF was effectively used in this analysis. Enhanced sensitivity to stratospheric NO2 above cloud top could contribute to a minor enhancement in the NO2 slant columns and introduce a small bias in the vertical columns. A potential approach to quantify the bias from this issue would be to compare NO2 slant columns at a similar latitude and month as found here over the remote ocean for two different cases: 1) no cloud and 2) a high cloud without lightning.

Reply: The sensitivity to NO2 above the cloud is indeed enhanced, but the effect is negligible. According to Hild et al. (2002), figure 3, the box-AMFs above the cloud top (13 km) fast approach the cloud-free stratospheric AMF with increasing height. For the peak of stratospheric NO2 at ˜30 km, the cloud has almost no effect on the AMF.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 11295, 2005.