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# Estimating the production of lightning NOx from satellite observations of NO2

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The amount of nitrogen oxides (NOx=NO+NO2) produced by lightning is a key uncertainty for the assessment of tropospheric ozone production. In this study, we discuss the potential and limitations of satellite observations of NO2 to estimate lightning NOx (LNOx).
Despite the mean NO2 enhancements due to lightning being rather small (compared to strong anthropogenic sources), LNOx has been identified clearly in satellite observations which show (a) average column enhancements over lightning active regions as well as (b) a direct enhancement for measurements coinciding with thunderstorms in space and time. The task is to transfer these qualitative findings to quantitative estimates that actually improve our knowledge of LNOx production.
In a model study, we assess the sensitivity of NO2 satellite observations for LNOx under cumulonimbus cloud conditions: a cloud resolving model, providing profile information on NOx, NO2, and clouds, was used to derive synthetic “satellite measurements”, i.e. slant column densities of NO2 for cloudy sky, involving the Monte-Carlo Radiative Transfer Model McArtim. From this study we find on average a “sensitivity” of 0.46 (0.37-0.55), i.e. the observed slant column of NO2 is expected to be 46% of the vertical LNOx column. Hence, a strong thunderstorm should result in a clear column enhancement for direct satellite overpass.
Several such satellite measurements coinciding with lightning have been found over tropical oceans. Continental thunderstorms, however, are missed due to the fact that current UV/vis instruments operate in the morning (GOME, SCIAMACHY, GOME-2) or shortly after noon (OMI), whereas continental lightning activity peaks in late afternoon. To study LNOx over continents, one has to relate the observed NO2 columns to LNOx produced the previous day(s). In addition, one has to keep in mind that in particular over continents, convection of anthropogenic NOx might interfere with LNOx.
We present estimates of LNOx production for both, freshly produced LNOx as well as aged LNOx, from the relation of observed NO2 column enhancements to flash rates from LIS, NLDN, and WWLLN. From the studies performed so far, we find LNOx per flash productions that correspond to a global release of about 1-2 Tg [N]/yr. This is significantly lower than the often used estimate of 5 Tg [N]/yr.
Ongoing studies have to deal with the rather high variability of the NO2 columns. In addition, systematic regional (and possibly seasonal) differences of the LNOx production, which have been discussed recently, are analyzed. In particular for this, the time series with global coverage available from satellite shows its high potential.