Direct satellite observation of lightning-produced NOx

http://www.firstlight.cn 2010-11-24

Lightning is an important source of NOx in the free troposphere, especially in the tropics, with strong impact on ozone production. However, estimates of lightning NOx (LNOx) production efficiency (LNOx per flash) are still quite uncertain.

In this study we present a systematic analysis of NO2 column densities from SCIAMACHY measurements over active thunderstorms, as detected by the World-Wide Lightning Location Network (WWLLN), where the WWLLN detection efficiency was estimated using the flash climatology of the satellite lightning sensors LIS/OTD. Only events with high lightning activity are considered, where corrected WWLLN flash rate densities inside the satellite pixel within the last hour are above 1 /km2/h. For typical SCIAMACHY ground pixels of 30 × 60 km2, this threshold corresponds to 1800 flashes over the last hour, which, for literature estimates of lightning NOx production, should result in clearly enhanced NO2 column densities.

From 2004–2008, we find 287 coincidences of SCIAMACHY measurements and high WWLLN flash rate densities. For some of these events, a clear enhancement of column densities of NO2 could be observed, indeed. But overall, the measured column densities are below the expected values by more than one order of magnitude, and in most of the cases, no enhanced NO2 could be found at all.

Our results are in contradiction to the currently accepted range of LNOx production per flash of 15 (2–40)×1025 molec/flash. This probably partly results from the specific conditions for the events under investigation, i.e. events of high lightning activity in the morning (local time) and mostly (for 162 out of 287 events) over ocean.

Within the detected coincidences, the highest NO2 column densities were observed around the US Eastcoast. This might be partly due to interference with ground sources of NOx being uplifted by the convective systems. However, it could also indicate that flashes in this region are particularly productive.

We conclude that current estimates of LNOx production might be biased high for two reasons. First, we observe a high variability of NO2 for coincident lightning events. This high variability can easily cause a publication bias, since studies reporting on high NOx production have likely been published, while studies finding no or low amounts of NOx might have been rejected as erroneous or not significant. Second, many estimates of LNOx production in literature have been performed over the US, which is probably not representative for global lightning.

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