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Lightning-produced NO_x in tropical, subtropical and midlatitude thunderstorms: New insights from airborne and lightning observations

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Lightning-produced NO_x (LNOx) is one of the most uncertain NO_x sources in the upper troposphere. A source strength between 1 and 20 TgN yr^{-1} is frequently given in the literature. In this study recent airborne and lightning measurements from the second TROCCINOX field campaign (Brazil, February 2005) are combined to estimate the annual mean global LNOx strength. Measurements of NO, NO_y, CO, O_3 and J(NO_2) were carried out with the Falcon aircraft in the outflow of thunderstorms and a local VLF lightning detection network (LINET) was set up to monitor the lightning stroke distribution.

A new method was developed to estimate the vertical LNOx flux in the thunderstorms, based on NO and vertical velocity measurements from the Falcon aircraft. The amount of NO_x produced per lightning stroke was determined for a tropical and a subtropical thunderstorm. A rough mean value of 500$\pm$300 gN per LINET stroke was estimated. Furthermore, based on Falcon, LINET and laboratory measurements, LNOx as a function of LINET peak current was calculated. The results indicate that the LNOx production per subtropical stroke may be almost twice as large as the production per tropical stroke on average.

Thunderstorms over Germany (midlatitudes) were also studied to strengthen this finding. The LINET peak current distributions on two “golden days” were compared:

29 July 2005 over southern Germany and 4 February 2005 over Brazil. The results indicate that LNOx per LINET stroke was 1.6 times larger in the midlatitude thunderstorms in comparison to the tropical thunderstorms. The main reason for the difference is probably that the number of strokes with low peak currents (0-5 kA) is higher in tropical thunderstorms in comparison to subtropical/midlatitude thunderstorms. In the latter thunderstorms the frequency of strokes $>$5 kA (mainly 10-20 kA) is higher than in tropical thunderstorms (LNOx increases with peak current). Furthermore, the ratio of cloud-to-ground strokes to the total number of strokes (intra-cloud plus cloud-to ground) is on average twice as high in the midlatitude/subtropical thunderstorms in comparison to the tropical thunderstorms. All these findings are used to estimate the annual mean global LNOx strength. Lightning stroke data from LINET is combined with lightning data from the LIS (Lightning Imaging Sensor) instrument aboard the TRMM satellite to scale up LNOx observations from TROCCINOX to the global scale.