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Estimates of lightning NO_x production from GOME satellite observations

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Abstract. Tropospheric NO_2 column retrievals from the Global Ozone Monitoring Experiment (GOME) satellite spectrometer are used to quantify the source strength and 3-D distribution of lightning produced nitrogen oxides (NO_x=NO+NO_2). A sharp increase of NO_2 is observed at convective cloud tops with increasing cloud top height, consistent with a power-law behaviour with power 5±2. Convective production of clouds with the same cloud height are found to produce NO_2 with a ratio 1.6/1 for continents compared to oceans. This relation between cloud properties and NO_2 is used to construct a 10:30 local time global lightning NO_2 production map for 1997. An extensive statistical comparison is conducted to investigate the capability of the TM3 chemistry transport model to reproduce observed patterns of lightning NO_2 in time and space. This comparison uses the averaging kernel to relate modelled profiles of NO_2 to observed NO_2 columns. It exploits a masking scheme to minimise the interference of other NO_x sources on the observed total columns. Simulations are performed with two lightning parameterizations, one relating convective preciptation (CP scheme) to lightning flash distributions, and the other relating the fifth power of the cloud top height (H5 scheme) to lightning distributions. The satellite-retrieved NO_2 fields show significant correlations with the simulated lightning contribution to the NO_2 concentrations for both parameterizations. Over tropical continents modelled lightning NO_2 shows remarkable quantitative agreement with observations. Over the oceans however, the two model lightning parameterizations overestimate the retrieved NO_2 attributed to lightning. Possible explanations for these overestimations are discussed. The ratio between satellite-retrieved NO_2 and modelled lightning NO_2 is used to rescale the original modelled lightning NO_x production. Eight estimates of the lightning NO_x production in 1997 are obtained from spatial and temporal correlation methods, from cloud-free and cloud-covered observations, and from two different lightning parameterizations. Accounting for a wide variety of random and possible systematic errors, we estimate the global NO_x production from lightning to be in the range 1.1–6.4 Tg N in 1997.

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