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Sensitivity of satellite observations for freshly produced lightning NO_x

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Abstract. In this study, we analyse the sensitivity of nadir viewing satellite observations in the visible range to freshly produced lightning NO_x. This is a particular challenge due to the complex and highly variable conditions of meteorology, (photo-) chemistry, and radiative transfer in and around cumulonimbus clouds. For the first time, such a study is performed accounting for photo-chemistry, dynamics, and radiative transfer in a consistent way: A one week episode in the TOGA COARE/CEPEX region (Pacific) in December 1992 is simulated with a 3-D cloud resolving chemistry model. The simulated hydrometeor mixing ratios are fed into a Monte Carlo radiative transfer model to calculate box-Air Mass Factors (box-AMFs) for NO_2. From these box-AMFs, together with model NO_x profiles, slant columns of NO_2 (S^{NO_2}), i.e. synthetic satellite measurements, are calculated and set in relation to the actual model NO_x vertical column (V^{NO_x}), yielding the "sensitivity" S^{NO_2}/V^{NO_x}.

From this study, we find a mean sensitivity of 0.46. NO_x below the cloud bottom is mostly present as NO_2, but shielded from the satellites' view, whereas NO_x at the cloud top or above is shifted to NO due to high photolysis and low temperature, and hence not detectable from space. However, a significant fraction of the lightning produced NO_x in the middle part of the cloud is present as NO_2 and has a good visibility from space. Due to the resulting total sensitivity being quite high, nadir viewing satellites provide a valuable additional platform to quantify NO_x production by lightning; strong lightning events over "clean" regions should be clearly detectable in satellite observations. Since the observed enhancement of NO_2 column densities over mesoscale convective systems are lower than expected for current estimates of NO_x production per flash, satellite measurements can in particular constrain the upper bound of lightning NO_x production estimates.

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