Estimating Lightning \(\text{NO}_x\) Production Using \(\text{NO}_2\) Columns from the TROPOMI Instrument and Flashes from the Geostationary Lightning Mappers

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Nitric oxide (NO) is produced in lightning channels and quickly comes into equilibrium with nitrogen dioxide (\(\text{NO}_2\)) in the atmosphere. The production of \(\text{NO}_x\) (NO + \(\text{NO}_2\)) leads to subsequent increases in the concentrations of ozone (\(\text{O}_3\)) and the hydroxyl radical (OH) and decreases in the concentration of methane (CH\(_4\)), thus impacting the climate system. Global production of \(\text{NO}_x\) from lightning is uncertain by a factor of four. \(\text{NO}_x\) production by lightning will be examined using \(\text{NO}_2\) columns from the TROPOspheric Monitoring Instrument (TROPOMI) on board the Copernicus Sentinel-5 Precursor Satellite with an overpass time of approximately 1330 LT and flash rates from the Geostationary Lightning Mapper (GLM) on board the NOAA GOES-16 (75.2° W) and GOES-17 (137.2° W) satellites. Where there is overlap in coverage of the two GLM instruments, the greater of the two flash counts is used. Two approaches have been undertaken for this analysis: a series of case studies of storm systems over the United States, and a gridded analysis over the entire contiguous United States, Central America, northern South America, and surrounding oceans. A modified Copernicus Sentinel 5P TROPOMI \(\text{NO}_2\) data set is used here for the case-study analysis to improve data coverage over deep convective clouds. In both approaches, only TROPOMI pixels with cloud fraction > 0.95 and cloud pressure < 500 hPa are used. The stratospheric column is removed from the total slant column, and the result is divided by air mass factors appropriate for deep convective clouds containing lightning \(\text{NO}_x\) (L\(\text{NO}_x\)). Case studies have been selected from deep convective systems over and near the United States during the warm seasons of 2018 and 2019. For each of these systems, \(\text{NO}_x\) production per flash is determined by multiplying a TROPOMI-based estimate of the mean tropospheric column of L\(\text{NO}_x\) over each system by the storm area and then dividing by a GLM-based estimate of the flashes that contribute to the column. In the large temporal and spatial scale analysis, the TROPOMI data are aggregated on a 0.5 x 0.5 degree grid and converted to moles L\(\text{NO}_x\)*. GLM flash counts during the one-hour period before TROPOMI overpass are similarly binned. A tropospheric background of L\(\text{NO}_x\)* is estimated from grid cells without lightning and subtracted from L\(\text{NO}_x\)* in cells with
lightning to yield an estimate of freshly produced lightning NO\textsubscript{x} designated LNO\textsubscript{x}. Results of the two approaches are compared and discussed with respect to previous LNO\textsubscript{x} per flash estimates.