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Weekly cycle of NO_x emissions as laboratory of atmospheric chemistry

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Satellite observations provide unique information on the amount and spatial distribution of tropospheric NO2. Several studies use such datasets for deriving NOx emissions. However, due to nonlinearities in the NOx chemistry (i.e., the dependency of the OH concentration and thus the NO2 lifetime on the NO2 concentration), the observed column densities of NO2 are not directly proportional to the underlying NOx emissions. Consequently, a certain reduction in NOx emissions could result in disproportionate reduction of the corresponding NO2 columns, which could be stronger or weaker depending on the chemical state (O3, NOx and VOC levels) and conditions like temperature, humidity and acitinic flux. This effect complicates the quantification of NOx emissions from satellite measurements of NO2, and e.g. biases the emission reduction as derived from the reduction of NO2 column densities observed during recent lockdowns.

Here we quantify the nonlinearity of the NOx system for different cities as well as power plants by investigating the effect of reduced NOx emissions on days of rest, i.e. Fridays/Sundays in Muslim/Christian culture, respectively. The reduction of NOx emissions is thereby quantified based on the continuity equation by calculating the divergence of the mean NO2 flux. This method has been proven to be sensitive for localized sources, where the uncertainties due to NO2 lifetime are small (Beirle et al., Sci. Adv., 2019). This reduction in emissions is then set in relation to the corresponding reduction of NO2 columns integrated around the source, which strongly depend on the NO2 lifetime.