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Estimation of NO_x emissions from NO_2 hotspots in polluted background using satellite observations

Fei Liu (1), Steffen Beirle (2), Qiang Zhang (1), and Thomas Wagner (2)

(1) School of environment, Tsinghua University, Beijing, China, (2) MPI Chemie Mainz, Satellite remote sensing, Mainz, Germany (steffen.beirle@mpic.de)

Satellite observations have been widely used to study NO_x emissions from power plants and cities, which are major NO_x sources with large impacts on human health and climate. The quantification of NO_x emissions from measured column densities of NO_2 requires information on the NO_x lifetime, which is typically gained from atmospheric chemistry models. But some recent studies determined the NO_x lifetime from the satellite observations as well by analyzing the downwind plume evolution; however, this approach was so far only applied for strong isolated "point sources" located in clean background, like Riyadh in Saudi Arabia.

Here we present a modified method for the quantification of NO_x emissions and corresponding atmospheric lifetimes based on OMI observations of NO_2, together with ECMWF wind fields, but without further model input, for hot spots located in polluted background. We use the observed NO_2 patterns under calm wind conditions as proxy for the spatial patterns of NO_x emissions; by this approach, even complex source distributions can be treated realistically. From the change of the spatial patterns of NO_2 at larger wind speeds (separately for different wind directions), the effective atmospheric lifetime is fitted. Emissions are derived from integrated NO_2 columns above background by division by the corresponding lifetime.

NO_x lifetimes and emissions are estimated for 19 power plants and 50 cities across China and the US. The derived lifetimes are 3.3 ± 1.2 hours on average with extreme values of 0.9 to 7.7 hours. The resulting very short lifetimes for mountainous sites have been found to be uncertain due to the potentially inaccurate ECMWF wind data in mountainous regions. The derived NO_x emissions show overall good agreement with bottom-up inventories.