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NO_X emissions of European cities derived from modelled and spaceborne tropospheric NO_2 columns

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Worldwide, air pollution causes millions of premature deaths. Surface nitrogen oxides (NO_X = NO + NO_2) is an important air polluter and plays a key role in tropospheric chemistry. NO_2 is an important tropospheric ozone (O_3) precursor affecting the production of the hydroxyl radical and as such the chemical lifetime of key atmospheric pollutants and reactive greenhouse gases. High NO_X emissions may result from combustion processes in industrial, traffic and household activities located in large and densely populated urban areas.
For human health reasons mapping NO_X emissions is essential but attempts are not always very accurate since reported emissions factors may differ from real-time emissions in order of magnitude. Modelled NO_2 levels and lifetimes may also have large associated uncertainties which can mask missing NO_X chemistry in current chemistry transport models (CTM's). That is why the estimations of both the NO_2 lifetime as well as the NO_2 emissions by applying exponential and Gaussian models on tropospheric NO_2 columns lines densities have the potential to improve the surface NO_X emission maps.
Here we evaluate if this methodology applied on the tropospheric NO_2 columns simulated by the LOTOS-EUROS (Long Term Ozone Simulation-European Ozone Simulation) CTM can reproduce the NO_X emissions used as model input. The methodology is also applied on tropospheric NO_2 column observations from OMI for comparison.
First we process the modelled tropospheric NO_2 columns for the period April-September 2013 for 25 selected European urban areas under windy conditions (averaged vertical wind speeds between surface and 500 m from ECMWF > 5 m s^{-1}) as well as the accompanying OMI (Ozone Monitoring Instrument) data providing us with real-time observation-based estimates of midday NO_2 columns. From the windy conditions we then derive the NO_2 lifetime for each city by determining the exponential decay of NO_2 down-wind the city in combination with the averaged wind speed profile. Since most cities in Europe cannot be considered as one large single source or point source for NO_X, we assess the NO_2 patterns of the city under calm wind conditions.
Preliminary results show that the mean lifetime for cities such as Amsterdam, London, Antwerp, Brussels and Paris from OMI observations (3.9±1.0 h) is comparable to the mean lifetime derived from model simulations (3.3±0.4 h). In general, for the 18 cities out of 25 where the NO_2 lifetime could be computed the mean LE lifetime is 4.1±1.0 h and the mean LE top-down estimate is 7.9±8.1, while the mean MACC3 emission is 8.2±6.4 mg m^{-2} d^{-1}. The OMI derived mean lifetime is 4.3±1.3 h and the mean OMI top-down emission estimate of 5.5±3.4 mg m^{-2} d^{-1} is slightly lower than the LE values. These preliminary results suggest that the top-down derived surface NO_X emissions from both the modelled as well as the spaceborne tropospheric NO_2 columns of 2013 are comparable with the 2011 MACC3 emission inventory used in the LE CTM as input to simulate the NO_2 columns.