Geophysical Research Abstracts
Vol. 16, EGU2014-2148, 2014
EGU General Assembly 2014

Measurement of NO_x fluxes by eddy covariance from the BT tower, London during the ClearfLo project

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The vast majority of air pollutants are emitted directly into the atmosphere from activities occurring at the Earth's surface. One of the key anthropogenic pollutants is NO_x (defined as the sum of NO and NO_2), which is emitted as a result of most anthropogenic combustion processes. Whilst the chemical reactions and atmospheric processing of NO_x are reasonably well understood, and can be modelled with some skill, large uncertainties arise in models due to uncertainty associated with the rate of emissions. In recent years it has become clear that measured trends in certain pollutants, for example NO_2, have not followed trends predicted by inventories. Continued exceedances of certain air pollution targets are of significant concern to governments, who have identified reducing this uncertainty associated with emissions as key evidence need.

As part of the UK Natural Environment Research Council (NERC) Clean Air for London (ClearfLo) project, concentrations and fluxes of NO_x were measured from the top of the BT tower, which is a 188m high telecommunications tower, situated in central London (51^{o}31'17.4"N; 0^{o}8'20.04W). The tower is surrounded by a mixture of commercial and residential buildings with an average height of 15 m. The typical daytime flux footprint of the tower is dominated by commercial/residential buildings and roads (82%) but also includes urban parkland (13%) and impervious ground (5%). High time resolution (10 Hz) chemiluminescence measurements of NO and NO_2 (photolytic conversion to NO followed by chemiluminescence) were combined with fast turbulence measurements from a sonic anemometer to calculate fluxes using the eddy covariance technique. In brief, NO_x fluxes per notional half-hourly averaging period were obtained by maximising the covariance between instantaneous (i.e. mean for the averaging period subtracted from each 10 Hz data point) fluctuations of NO_x mixing ratio and vertical wind velocity. 24 hour NO_x flux measurements were made on 36 days during June, July and August 2012 and 28 days in March and April 2013.

The data showed a clear diurnal cycle, with NO_x flux broadly following measured traffic flow in the surrounding streets, with a typical maximum daytime flux of 4μg m^{-2} s^{-1}. Mixing ratios of NO_x can be seen to be a function of the NO_x flux and the boundary layer height evolution during the day. A clear weekday / weekend dependence is seen on the NO_x flux measurements, again following the traffic flow data. The measured fluxes were averaged over 24 hours and scaled up to give a 'top down' estimate of the annual emission rate of 79.6 T km^{-2} yr^{-1}. This compares well to estimates from the UK National Atmospheric Emissions Inventory, however some differences are seen when the data is separated into different wind sectors. Conversely, a 'bottom up' dispersion model (ADMS-Urban) was run using measured meteorological data and the detailed London Atmospheric Emissions Inventory as input. ADMS-Urban has previously been validated using near-surface measurements, but the current work demonstrates that the model gives good agreement with the flux measurements, both in terms of magnitude and diurnal cycle.