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Monitoring CO_2 and CH4 concentrations in London, UK using a rooftop atmospheric measurement network and an atmospheric chemistry-transport model

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A rapidly developing research field is the development of monitoring networks and data assimilation systems to provide an optimal estimate of urban greenhouse gases based on both observations and the output of a chemistry-transport model driven by current emissions inventories. A key first step in development of this methodology is to evaluate the ability of the chemistry-transport model to simulate observations at the chosen measurement sites.
In this study, funded by Astrium Services SAS, a network comprising four state-of-the-art atmospheric sensors was placed on rooftop sites in and around London during the summer of 2012. Two sites were located in the inner city and two 'background' sites (one suburban and one rural) were positioned to enable examination of the urban increment of GHG concentrations. The chemistry-transport model, CHIMERE, was run at 2 km resolution using temporally and spatially derived emissions inventories from the National Atmospheric Emissions Inventory (NAEI), driven by European Centre for Medium-Range Weather Forecasts (ECMWF) meteorology. Here, we focus on the analysis of the urban increments of total CO_2, total CH4 and fossil fuel CO_2 during the afternoon hours 12:00 to 17:00, aiming to identify the key sources of misfits between the model and the observations.
Results showed there was improved agreement between the observed and modelled urban increments compared with total modelled and observed values for individual sites. This suggests that some of the misfits arose from the selection of appropriate boundary conditions for the model. However, there remained underestimation of the observed values and an inability of the model to simulate observed variability.
The observations at the two inner city sites showed evidence of different contributions from local (<2 km-scale) sources, despite their proximity. A simple CO-based method was used to attribute fossil fuel CO_2 from observations and showed that there were localised traffic based fossil-fuel sources at one inner city site in particular. CHIMERE was unable to simulate these differences. In addition, the inner city site identified to be most suitable for use for a CO_2 inversion was least suitable for CH4, highlighting the difficulty in selecting sites for multi-species greenhouse gas analysis.
This research concludes that low level urban measurement sites are problematic for use in GHG monitoring, due to sizeable local variability that is difficult to account for with even high resolution models. However, placement of a higher platform instrument may provide a benchmark for filtering rooftop data and therefore increase the value of the rooftop sites. Higher resolution inventories and increased representation of the urban area within the model in terms of the urban winds and variation in NEE may also improve the ability of the model to represent surface stations.