Detectability and Quantification of Atmospheric Boundary Layer Greenhouse Gas Dry Mole Fraction Enhancements from Urban Emissions: Results from INFLUX

N. Miles[1], S. Richardson[1], K.J. Davis[1], T. Lauvaux[1], A.J. Deng[1], C. Sweeney[2,3], A. Karion[2,3], J. Turnbull[4], K.R. Gurney[5] and R. Patarasuk[5]

[1]The Pennsylvania State University, University Park, PA 16802; 814-880-8087, E-mail: nmiles@met.psu.edu
[2]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309
[3]NOAA Earth System Research Laboratory, Global Monitoring Division, Boulder, CO 80305
[4]GNS Science, National Isotope Centre, Lower Hutt, New Zealand
[5]Arizona State University, Tempe, AZ 85287

We assess the detectability of city emissions via a tower-based greenhouse gas (GHG) network, and quantify the spatial and temporal patterns in atmospheric GHG dry mole fractions. Towards that end, we present afternoon-averaged results from a network of carbon dioxide (CO_2), methane (CH_4), and carbon monoxide (CO) mole fraction measurements in Indianapolis, Indiana, for 2011–2013, as part of the Indianapolis Flux (INFLUX) study. The platform for these measurements is twelve communications towers, ranging in height from 39 to 136 m above ground level, which are instrumented with cavity ring-down spectrometers. A background site on the predominantly upwind side of the city is utilized. The temporal variability of the daily afternoon-averaged GHG mole fractions for the INFLUX sites is large: at the site on the downwind edge of the city, two-sigma of the daily values are within a 44 ppm CO_2 range. Averaging over several months during the dormant season, the urban enhancement ranges from 0.5 ppm CO_2 at the site 24 km downwind of the edge of the city to 3.2 ppm at the downtown site. Comparison of the observations to modeled (using the Lagrangian Particle Dispersion Model, WRF-Chem, and Hestia 2012 emissions) atmospheric mixing ratios shows consistent spatial gradients across the network (shown in the figure below). In addition, the suitability of various sites as a background is characterized and the variability of measured urban enhancement as a function of wind direction is described. These observations show that a dense network of urban GHG measurements yield a detectable urban signal, with spatial information that appears to be compatible with atmospheric inversion of urban-scale spatially- and temporally-varying emissions.

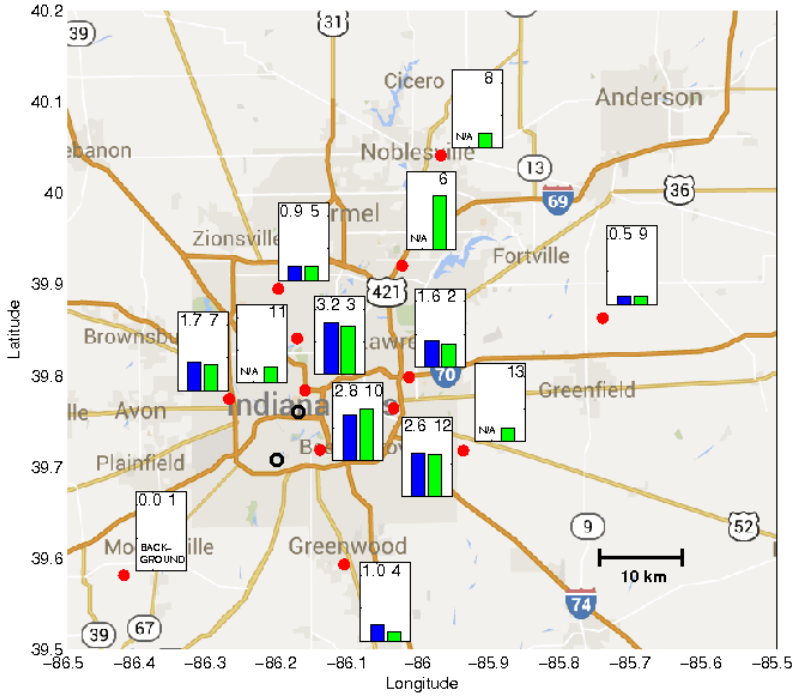

Figure 1. Observed (blue) time-averaged afternoon CO_2 mole fraction above background (Site 01) for INFLUX tower sites (1 January – 30 April 2013) at each of the INFLUX towers (represented by red dots). Corresponding model results (prior to inversion) using Hestia 2012 fluxes are shown in green. Note that not all the sites have CO_2 mole fraction data available during this period; these sites are indicated by 'N/A'. The Harding Street Power Plant is indicated by the black circle south of the downtown area; the South Side Landfill is 2 km to the northwest. The smaller C.C. Perry Power Plant is indicated by the black circle near downtown.