# Measuring $CO_2$ and $CH_4$ Emissions from Indianapolis: Preliminary Results from an Urban Atmospheric Inversion System

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Efforts to reduce greenhouse gas emissions, whether voluntary or in response to regulation, require independent assessment. The Indianapolis Flux study (INFLUX) is testing methods of measuring the emissions of $CO_2$ and $CH_4$ from an urban environment. The primary emphasis of the experiment is determining and improving the precision and accuracy of the measurement methods. The study includes both atmospheric inversions and inventory approaches, methods that are complementary and largely independent. The study aims to quantify the strengths and limitations of both approaches. The current INFLUX observation network includes twelve in-situ tower-based, continuous measurements of a combination of $CO_2$, CO, and $CH_4$, weekly flask samples including $^{14}CO_2$ measurements, four eddy covariance flux towers, a Doppler lidar, and periodic mobile measurements using automobiles and aircraft. A Total Carbon Column Observation Network Fourier transform spectrometer was deployed for approximately four months. The tower-based measurements reveal the enhancement of atmospheric mole fractions as air passes over the city (Figure 1), with the median enhancements at midday reaching 5 ppm $CO_2$, 20 ppb CO, and 10 ppb $CH_4$ depending on the wind direction, with the maxima occurring when the wind crosses over the city. Flux measurements illustrate the seasonal evolution of the urban surface energy balance, a key driver of urban boundary layer mixing. The numerical modeling system includes the Weather Research and Forecast model (WRF) and Lagrangian Particle Dispersion Model (LPDM), combined with a Bayesian matrix inversion. Forward modeling shows the typical along-wind and cross-wind $CO_2$ mole fractions as a function of season, wind speed and boundary layer depth. Preliminary experiments with the inversion system illustrate the expected reduction of error in flux estimates with the regional network of tower measurements. Indianapolis is intended to serve as a test bed; the results will inform efforts at measuring emissions from urban centers worldwide, including megacities.

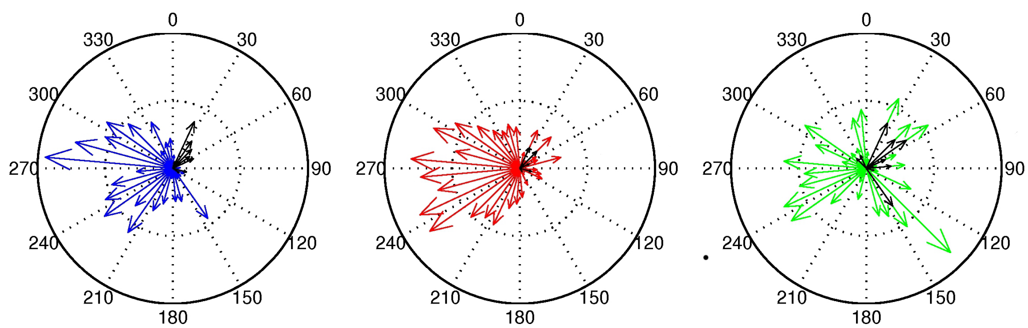


**Figure 1.** The median $CO_2$ (left), CO (middle), and $CH_4$ (right) urban enhancement between an urban and a background tower, as a function of wind direction, for daytime Apr – Nov 2011. Colored arrows point to sources when the urban site measures larger values. The radial direction shows the magnitude of the mole fraction enhancement where the outer ring represents 5 ppm, 20 ppb and 10 ppb, respectively.