Investigation of methane emission sources from Indianapolis using an aircraft-based platform

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INTRODUCTION
Quantification of the magnitude and uncertainties of greenhouse gas emissions is important for establishing scientifically sound policies for mitigating fossil fuel emissions in urban environments. Recent studies have shown that urban city centers are significant sources of anthropogenic methane (e.g. Wunch et al., 2009). However, urban CH4 fluxes do not correlate with emissions from combustion sources (Mays et al., 2009). While the emission inventory for carbon dioxide is relatively well understood, the methane source function is less defined because of the diverse range of sources and relatively limited observational studies of this potent greenhouse gas.

In the spring and fall of 2008, carbon dioxide and methane were measured in the air shed of Indianapolis using an aircraft-based platform (Purdue University’s Airborne Laboratory for Atmospheric Research, see Figure 1), equipped with a cavity ring-down CO2/CH4 spectrometer, a flash sampling system, and a Baseline Turbulence probe for high-resolution wind measurements. Because Indianapolis is significantly removed from other metropolitan areas, greenhouse gas signals from this urban center can be detected with relative ease, making it an ideal location for developing methods for fossil fuel emission measurements. The aircraft-based measurements in 2008 enabled the estimation of the area-wide CO2 and CH4 emissions from the Indianapolis urban environment (Mays et al., 2009).

In this work, we revisit the 2008 aircraft-based experiment conducted in the spring and fall of 2008.

Lagrangian Particle Dispersion Model
The aircraft observation footprint was calculated using the meteorological variables from the mesoscale atmospheric model WRF at 2-km resolution (20m resolution for the first vertical level), coupled to the Lagrangian Particle Dispersion Model (Lspar, 1994). Particles are released at the exact locations of the observations during the flight, every few seconds. The integration of the particles at the surface show the area of influence corresponding to elevated CH4 measurements (r=1890ppb).

RESULTS AND DISCUSSION
Figures 6 (a) and (b) show the CO2 and CH4 concentrations as a function of altitude and horizontal distance (data from April 14 flight experiment). CH4 hotspots were observed at distinct points on the horizontal trajectory where no CO2 hotspots were detected, and vice versa. This result suggests that there are sources that are unique to these two gases.

Back trajectories (figure 8) associated with the observed methane hot spots were calculated using the HYSPLIT particle dispersion model. Also shown in figure 8 are the locations of potential CH4 hotspots that are emitted from areas surrounding the Indianapolis urban area as well as from neighboring city centers. The back trajectories that traverse the Indianapolis urban area will serve as guides for future modeling efforts in investigating emissions sources.

CONCLUSIONS
The Indiana very important greenhouse gas that is 25 times more potent than CO2. Because of its high global warming potential and relatively short life, reductions in its abundance may have a significant near-term effect. Urban emissions of CH4 were observed to be much higher than currently reported in emission inventories, clearly indicating that there are uncharacterized sources of CH4 in urban environments. While we present here initial results of our efforts to investigate the areas of influence associated with observed elevated CH4 concentrations in the Indianapolis area, the combination of aircraft measurements and inverse modeling provides a unique opportunity to further investigate unknown CH4 sources from this urban environment.

REFERENCES

SCHOLARSHIP
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Fig. 1: The Purdue University Airborne Laboratory for Atmospheric Research (ALAR) flying over an instrumented tower.

Fig. 2: Installation of the Picarro CRDS and NOAA flask sampling system in a recent flight experiment on Nov 22, 2010.

Fig. 3: Wind carrying background concentrations of CO2 and CH4 blows over the city, where it intercepts and picks up strong greenhouse gas emissions from anthropogenic sources such as cars, power plants, landfills, etc.

Fig. 6 (a) CO2 and (b) CH4 concentrations as a function of altitude and horizontal distance across the curtain flight transect. Data from April 14, 2008. CH4 hotspots were observed at distinct points where no CO2 hot spots were observed, and vice versa.

Fig. 7: Footprint corresponding to a wide plume of CH4 observed on April 14, 2008.

Fig. 8: HYSPLIT – derived back trajectories corresponding to elevated methane concentrations.