Quantification of anthropogenic emissions from an urban region: First results of time-integrated flask samples from the Indianapolis Flux Project (INFLUX)

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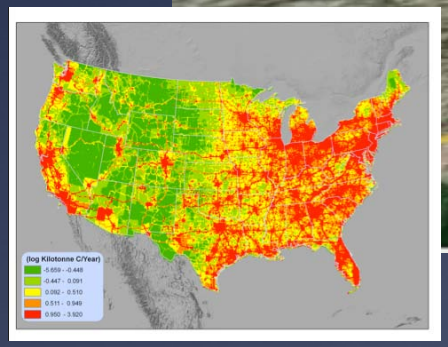
INFLUX: Indianapolis Flux Project

Develop and test techniques/approaches for measurement of urban-scale greenhouse gas emission fluxes – top-down and bottom-up

Aircraft-based measurements
~biweekly flights
In situ and flasks

Driving tours
~monthly
In situ and flasks



Bottom-up inventories
Vulcan 0.1° for US
Hestia block level for Indianapolis

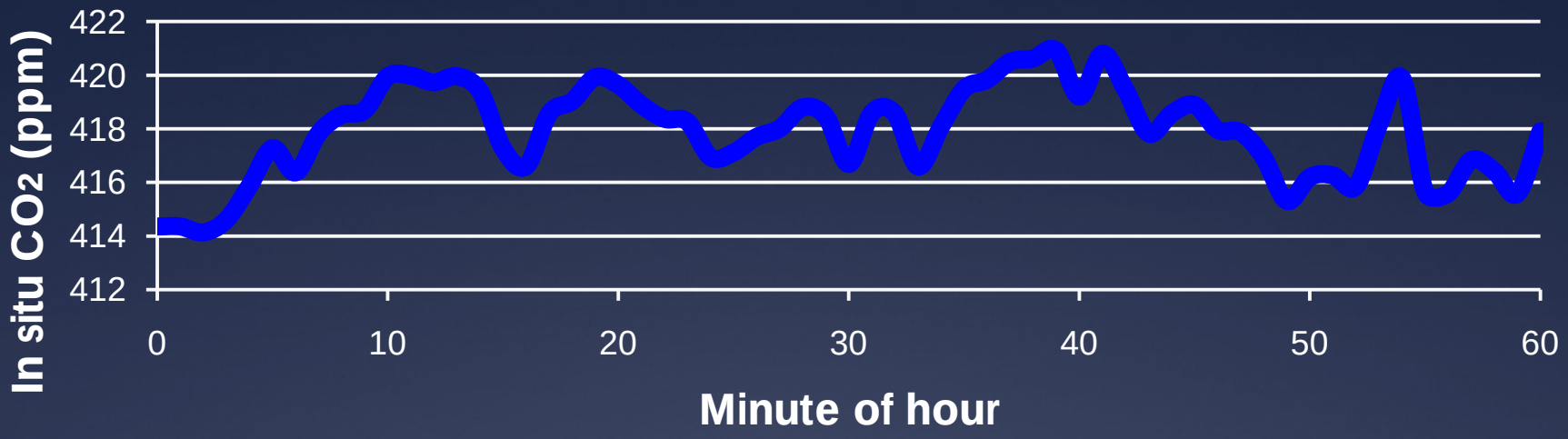
Tower-based measurements – 12 towers
In situ - CO_2/CO/CH_4
Flasks – 52 species and isotopes

Data analysis and modeling
Mass balance approach
WRF-CHEM inversions

INFLUX
tower flask sampling

- New integrated flask sampling system
- First flask measurements

Why use time-integrated flask samples?



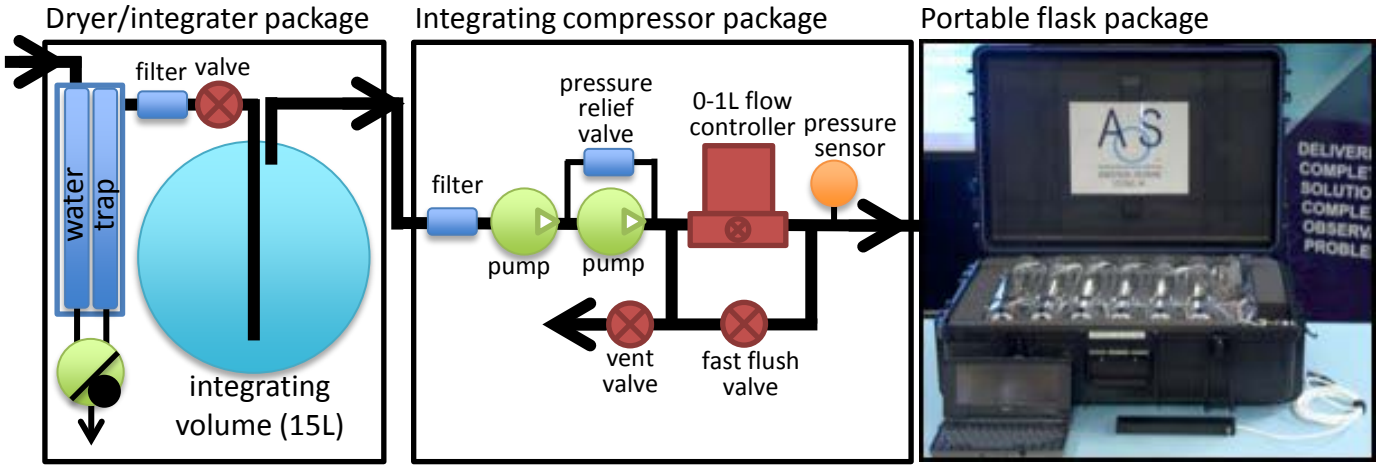
INFLUX tower 1, 2011-04-09 20:00-21:00 UTC

In urban regions, can have substantial variability in mixing ratios – integrated samples reduce some of this noise

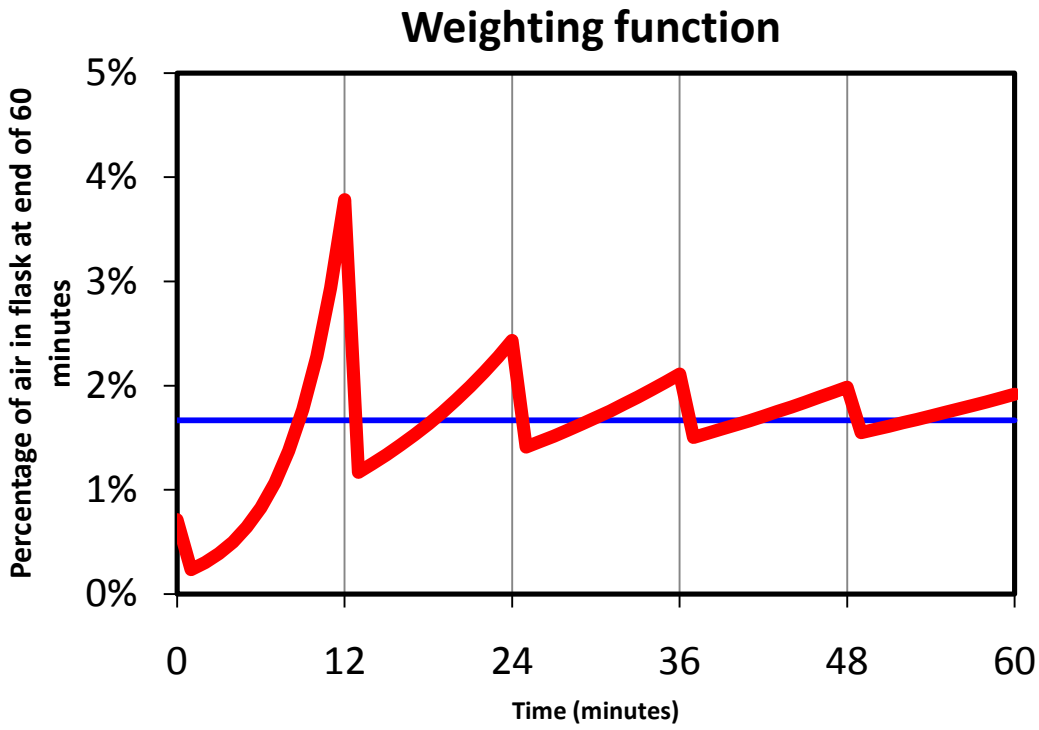
Match atmospheric sampling with the ~1 hour time step of regional models and meteorological data

Keep integrating time short enough that meteorology is consistent

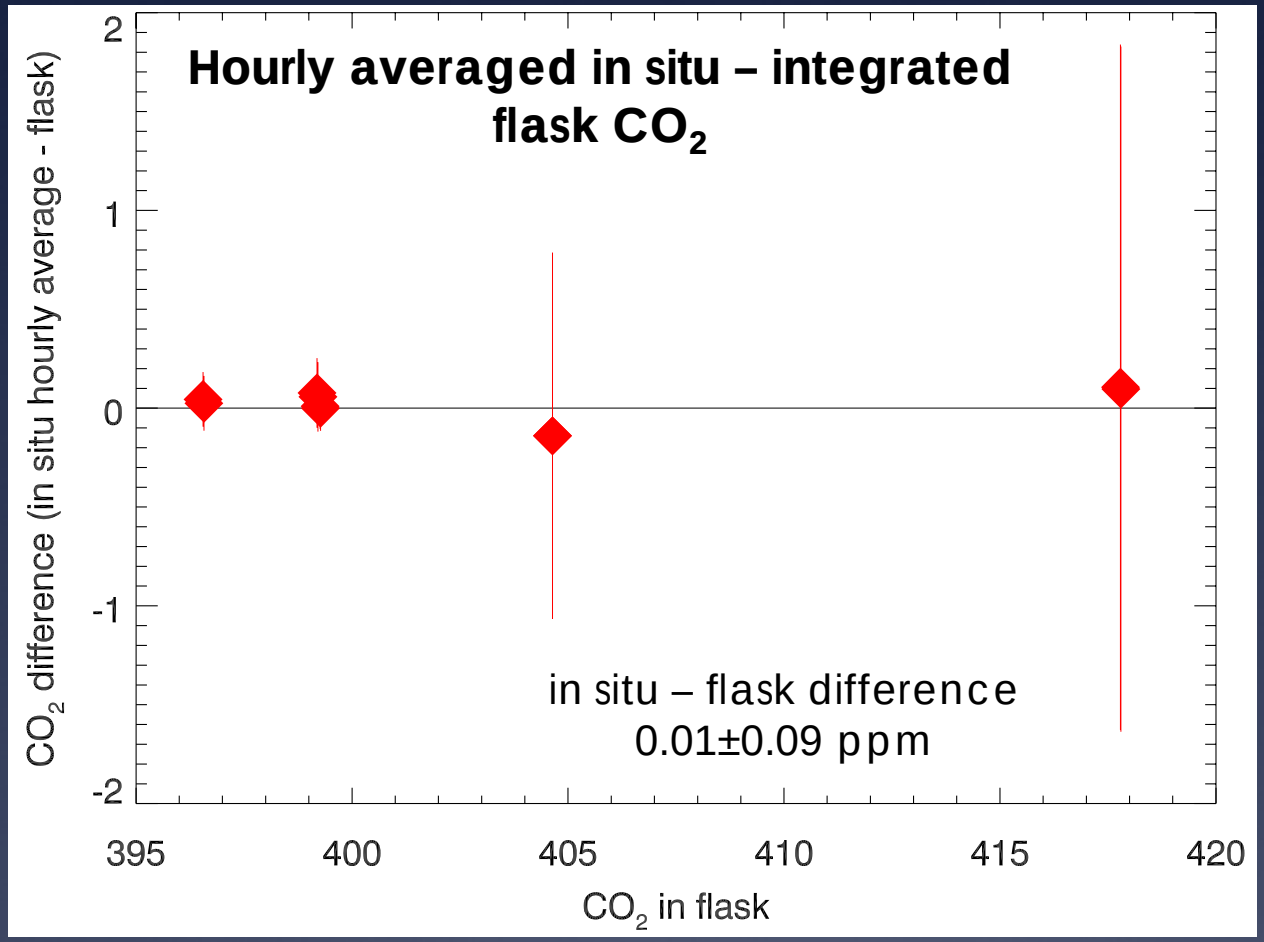
Integrated flask sampling



- Sample collected over 1 hour
- Mix 1 hour of air by flowing through a large mixing volume
- Vary flow rate during filling to obtain close to linear mixture
- Collect air into 2 PFP flasks for measurement

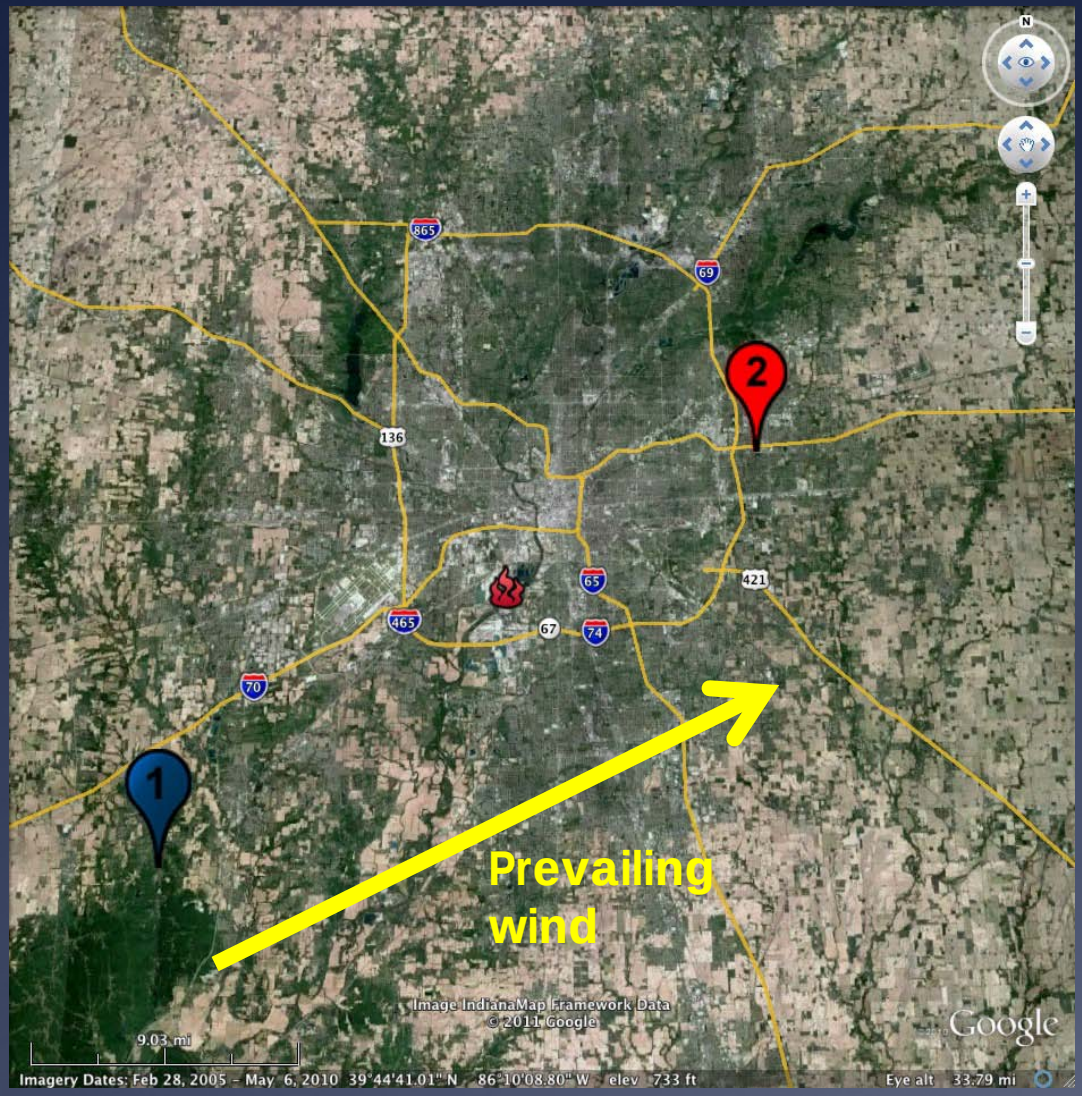


Integrated flask sampling validation



For comparison: LEF 396 m in situ vs grab flask samples (2006-2011)
in situ – flask difference 0.03±0.38 ppm

INFLUX: Tower flask results

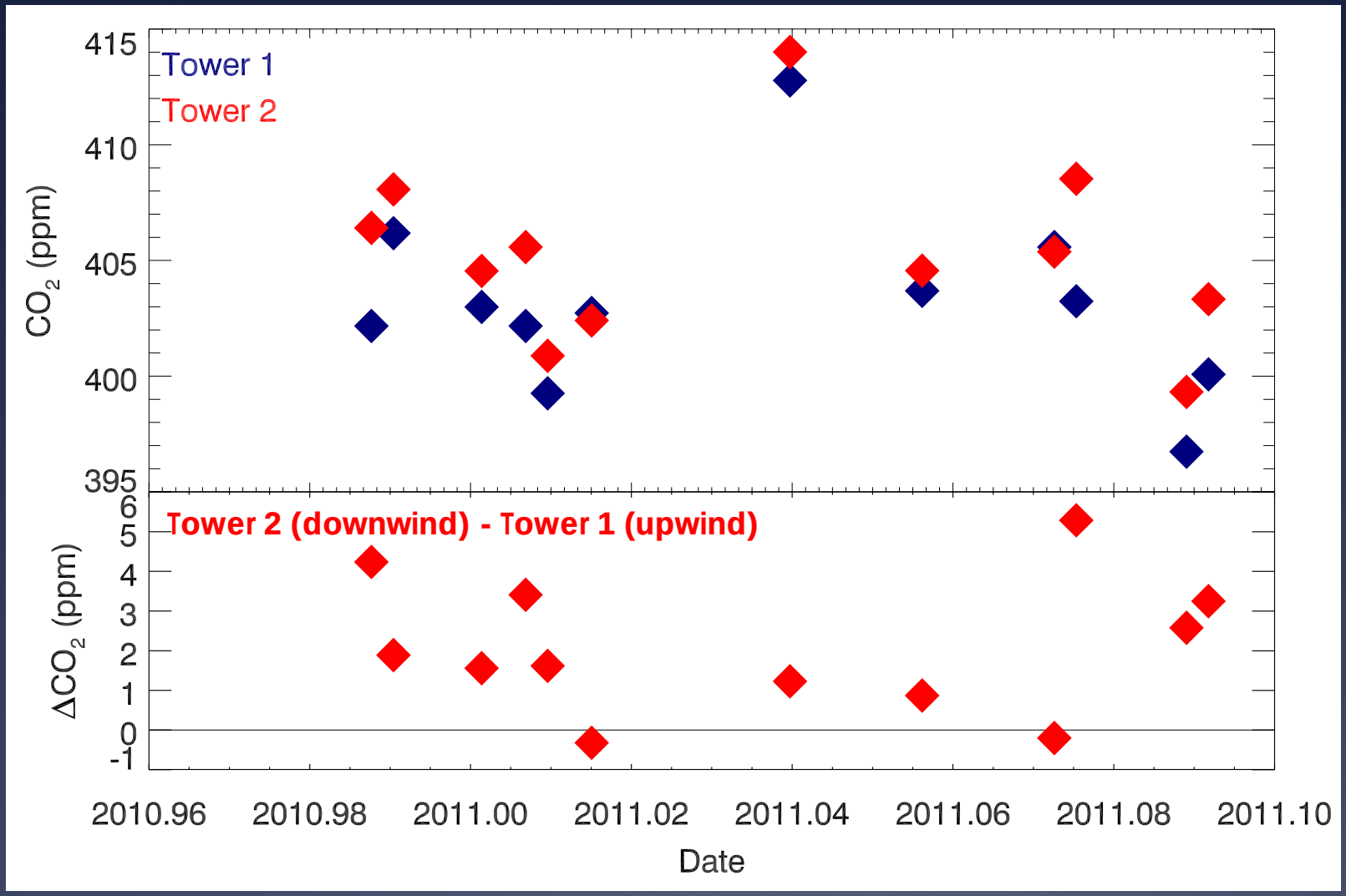


Flask samples collected only when Tower 2 is downwind

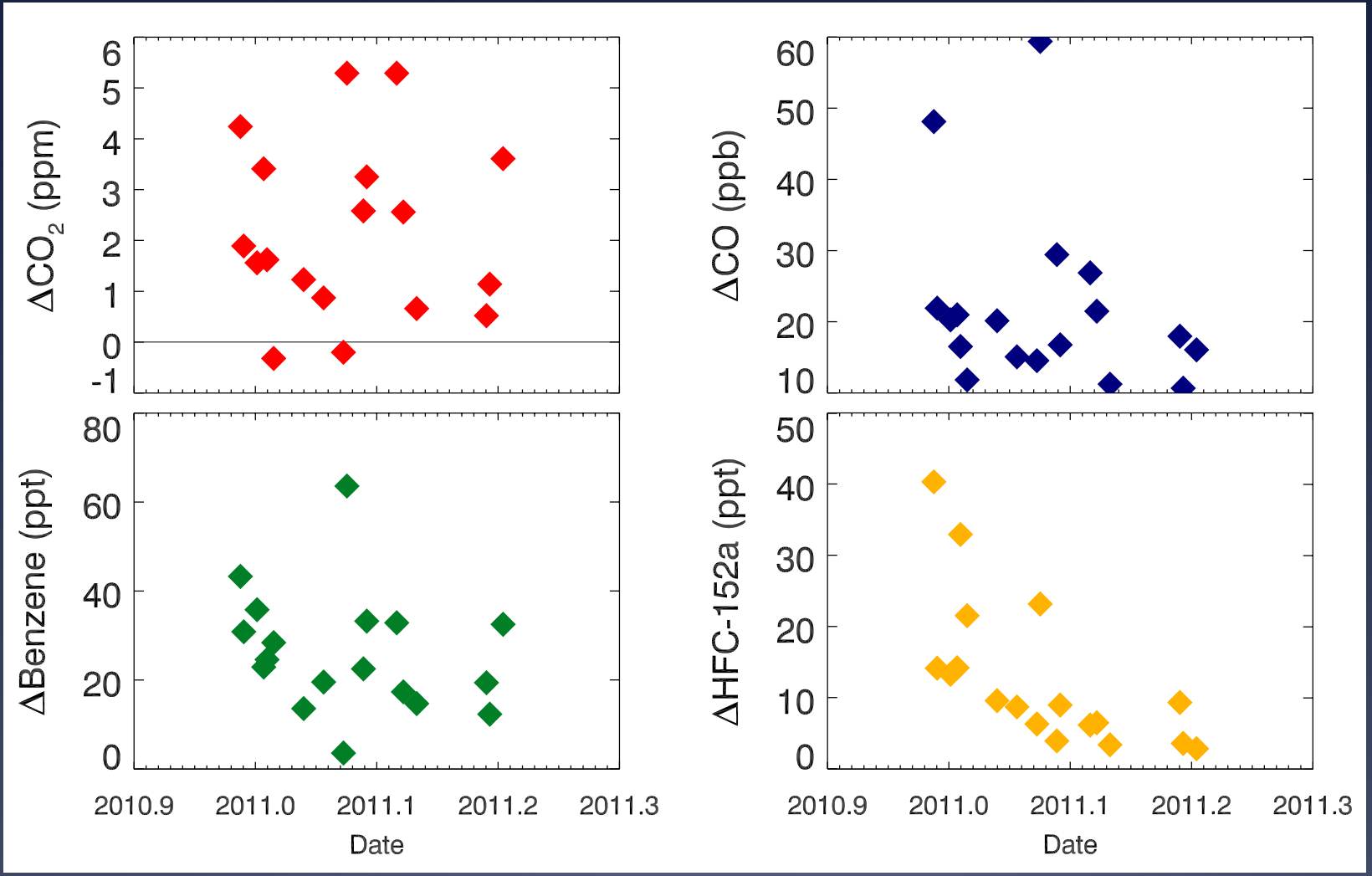
Tower 1 is always upwind, background station

(Criteria met 25% of days)

CO_2 enhancements across Indianapolis



Enhancements across Indianapolis

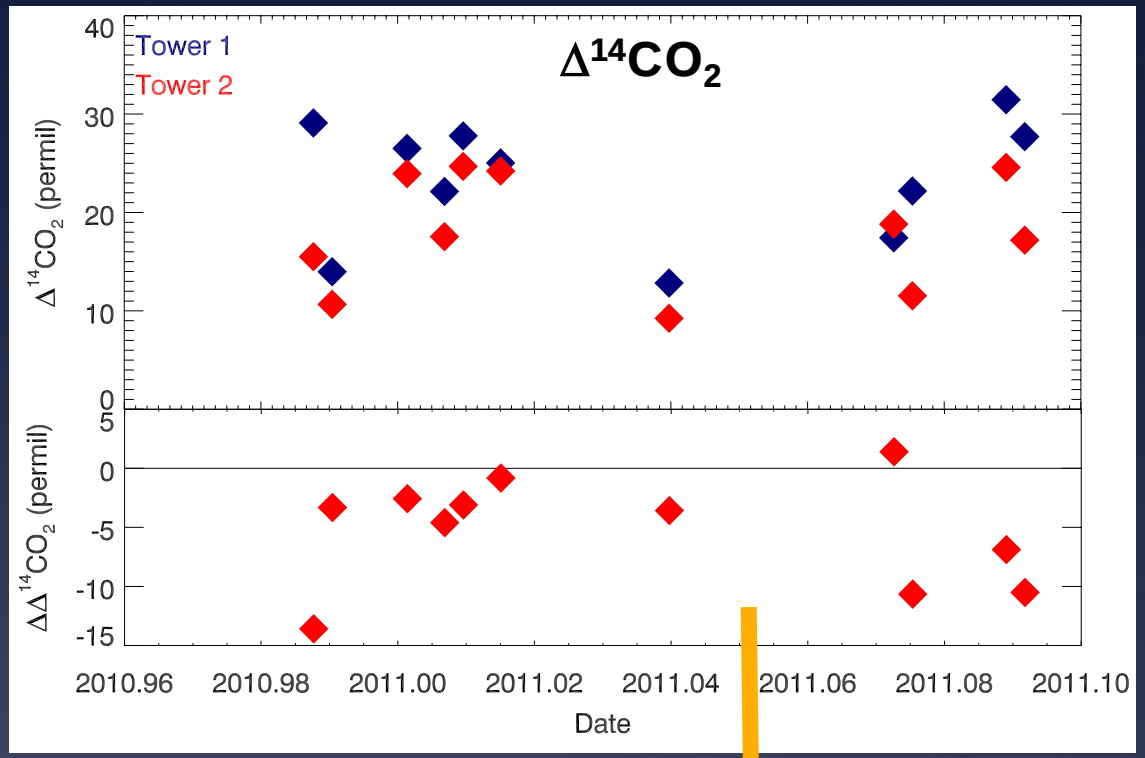


Strong enhancements in most anthropogenic species

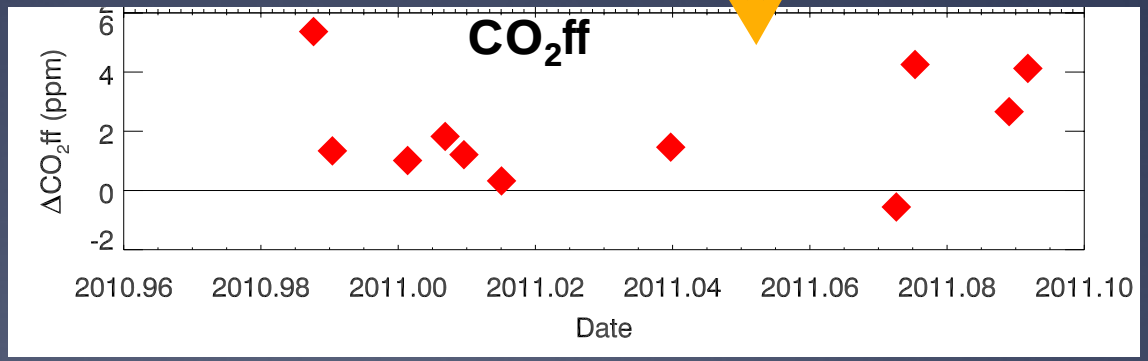
$\Delta^{14}CO_2$ and fossil fuel CO_2

$\Delta^{14}CO_2$ is lower at Tower 2 – ^{14}C-free CO_2ff decreases $\Delta^{14}CO_2$

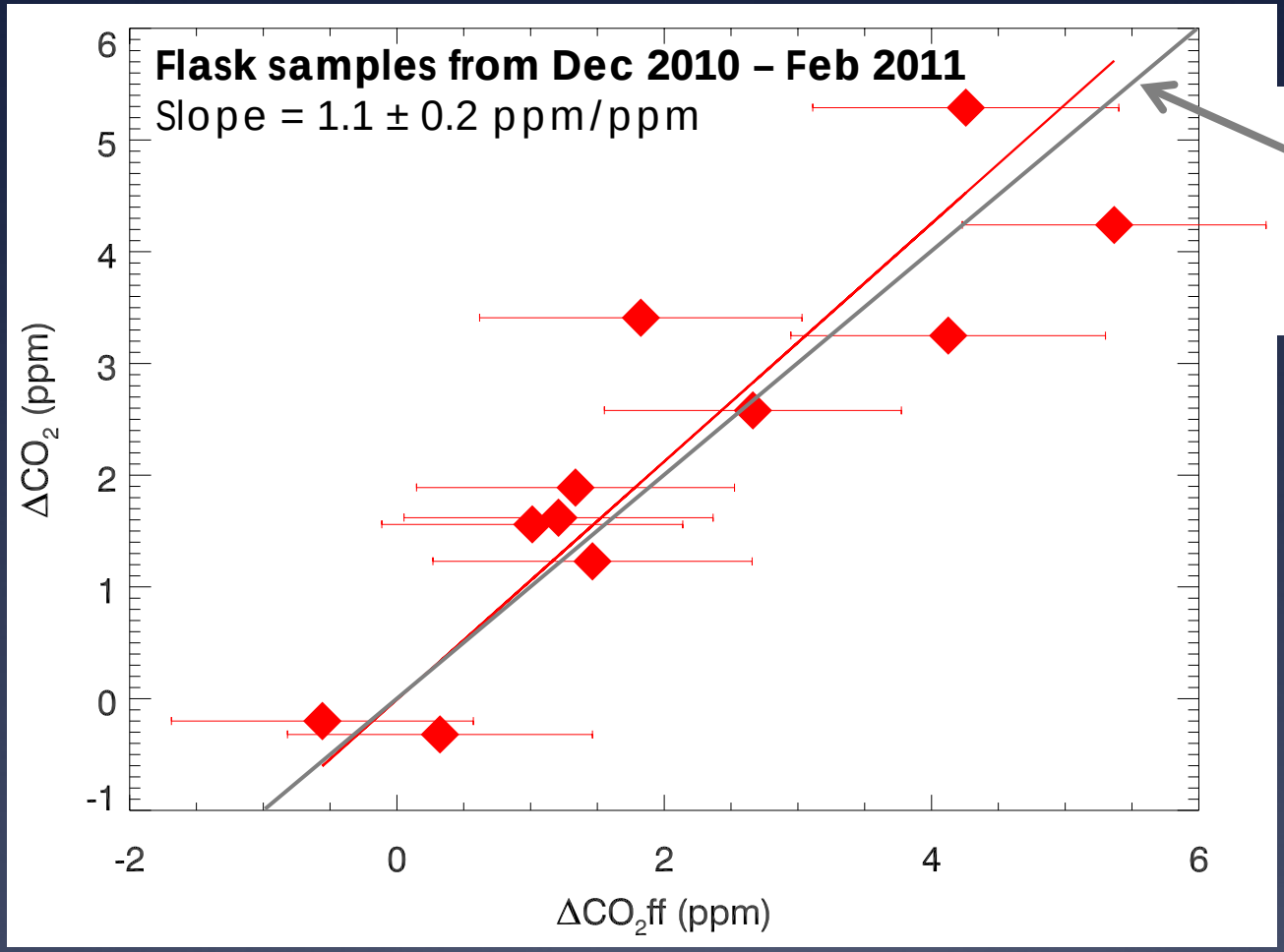
CO_2ff enhanced at Tower 2



$$CO_2ff = \frac{CO_{2obs}(\Delta_{obs} - \Delta_{bg})}{\Delta_{ff} - \Delta_{bg}} - \frac{CO_{2r}(\Delta_r - \Delta_{bg})}{\Delta_{ff} - \Delta_{bg}}$$



Contributions to CO_2 enhancement

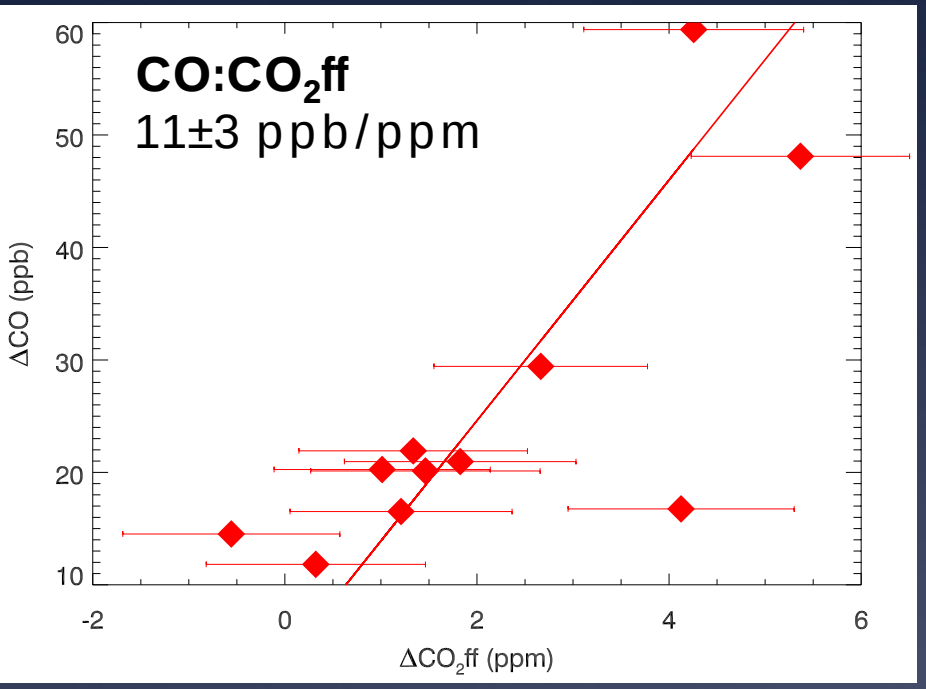


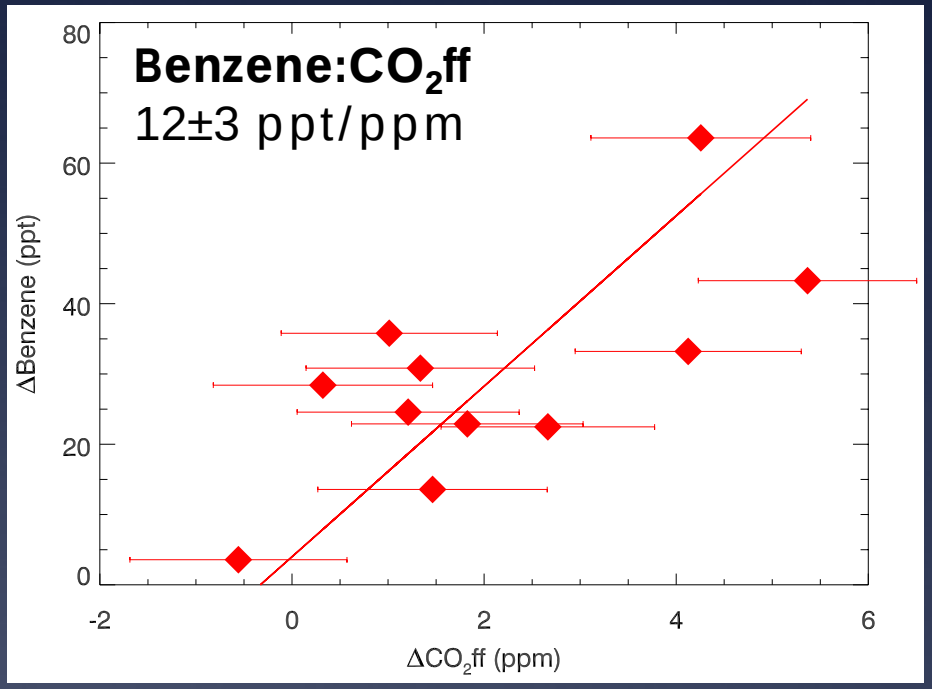
Indiana has 10% bio-ethanol in gasoline – expect ΔCO_2 7-10% higher than ΔCO_2ff

CO_2ff and bio-ethanol explain all of ΔCO_2 in winter

No significant respiration/photosynthesis contribution

Correlation with CO and benzene





Emission ratios are slighter lower than observed in other US cities

Large power plant contributes 30% of Indy CO_2ff = lower emission ratios?

Summary

- INFLUX towers use a new time-integrated flask sampling system to collect samples averaged over a 1 hour period
- Tower sampling is designed to capture both upwind (background) and downwind signals
- Strong enhancements in anthropogenic species across the urban region
- In winter in Indianapolis, the CO_2 enhancement appears to be entirely due to CO_2ff and bio-ethanol (there is no apparent photosynthesis/respiration signal)
- Reasonable correlations of CO_2ff with combustion tracers such as CO and benzene, with emission ratios slightly lower than Western US cities, likely due to influence of power plant
- Correlations with other species (e.g. halocarbons) also seen

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Opportunities for Collaboration

We welcome collaborators to enhance and expand the INFLUX effort. Possibilities include:

Enhanced atmospheric sampling

- ✓ $^{14}CO_2$ /flask measurements
- ✓ In situ CO measurements
- ✓ Measurement from vehicles
- ✓ Other species and isotopes

Atmospheric transport will be a primary source of uncertainty in our final results:

- ✓ wind profiler (4Km)
- ✓ Airborne doppler profiler
- ✓ Radiosonde measurements

Remote Sensing

- ✓ GOSAT (CO_2, CH_4), MOPITT (CO)
- ✓ MODIS, LANDSAT (Biosphere),AVIRIS (IR emissions), FTIR

New Methods

- ✓ Inverse Modeling
- ✓ Multiple bottom-up data streams
- ✓ New measurement techniques and species