Can We Detect the Conversion of the Harding Street Power Plant in Indianapolis from Coal to Natural Gas Using Tower-based CO_2 Mole Fraction Data Alone?

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INTRODUCTION

- Over the past few years a number of local groups and organizations urged the Harding Street Power Plant in downtown Indianapolis, Indiana to retire due to its excessive pollution (**Fig. 1**)
- In 2014 the decision was reached to convert the power plant from coal to natural gas, similarly to many other power plants across the country (**Fig. 2**)
- The conversion process was completed in March 2016

Figure 1. Photo of the Harding Street Power Plant.

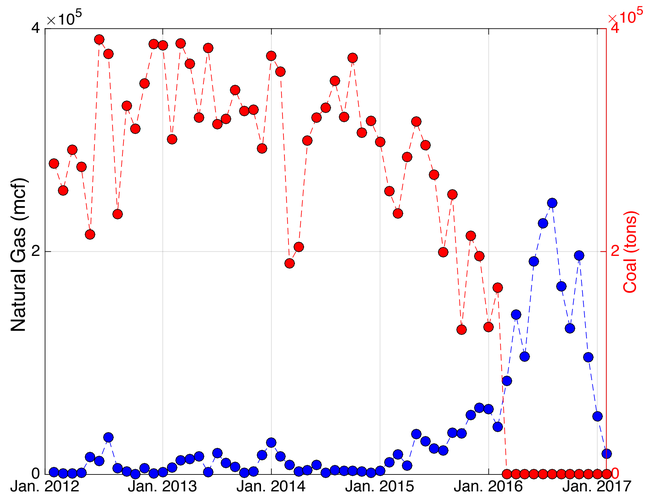

Figure 2. Monthly use of coal (red) and natural gas (blue) by the Harding Street Power Plant (data from the U.S. Energy Information Administration).

RESEARCH GOAL

- Indianapolis, Indiana contains the densest network of highly-calibrated greenhouse gases (GHGs) sensors ever deployed over an urban area as a part of the Indianapolis Flux (INFLUX) experiment
- The goal of this work is to detect a change in the CO_2 measurements that is directly attributable to the power plant conversion from coal to natural gas
- To achieve this goal, the INFLUX tower network is utilized

METHODOLOGY

- Identify an INFLUX site that would accurately capture power plant plumes (**Fig. 3**)
- We use sector-by-sector atmospheric CO_2 mole fractions, in percentage contribution for each site (**Fig. 4**)
- CO_2 measurements at site 10 should capture any changes that occurred overtime at the power plant
- Sites 5 and 1 are used as references; they are not influenced by significant sources from the west (**Fig. 5**)

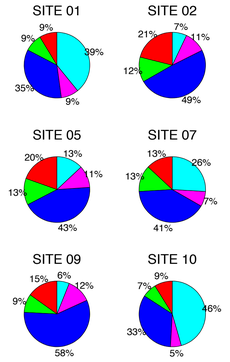

Figure 4. Emissions combined with footprint analysis.

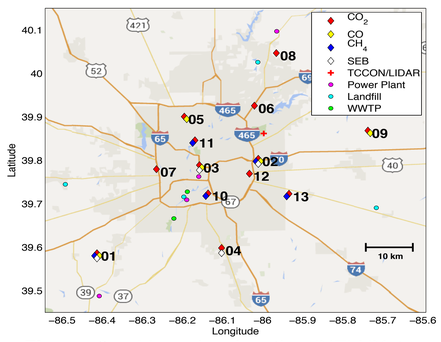

Figure 3. Map showing the INFLUX tower network.

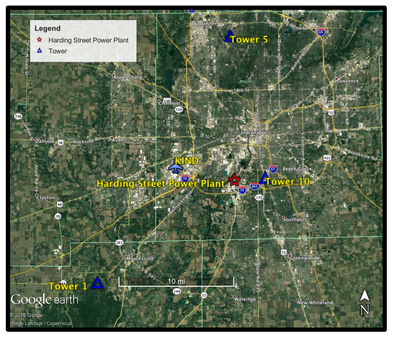

Figure 5. Map of the Harding Street Power Plant, airport, and relevant towers.

DECLINING CO_2 PLUME

- To analyze the power plant plumes, we look at the CO_2 enhancements at the site 10, which are calculated by subtracting CO_2 values of sites 1 and 5 from the site 10 values
- For our analysis we use polar bivariate plots
- Wind data are from the airport (**Fig. 5**)
- Hourly CO_2 data from 16-21 UTC are binned by wind speed and wind direction (**Fig. 6**)
- Hours with wind speeds less than 3 m/s are eliminated
- Adjacent hours with wind direction differences over 20° are also eliminated
- **Figure 7** indicates a yearly decline of the CO_2 plume that presumably originates from the power plant

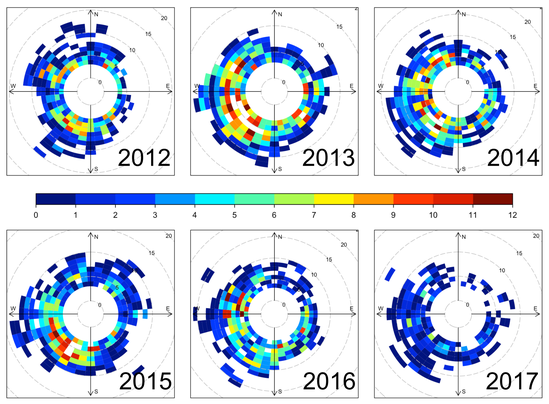

Figure 6. Hourly data frequency at site 10 as a function of wind speed and wind direction (color bar indicates a number of hours available at each bin).

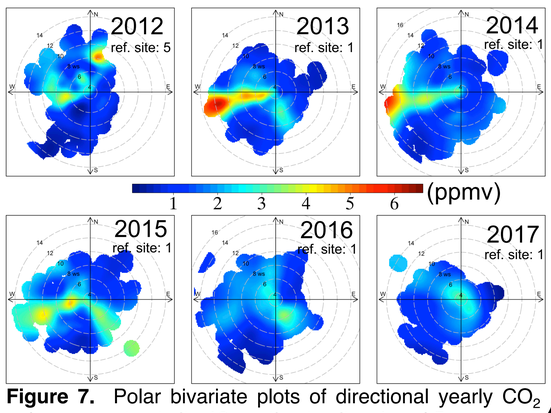

Figure 7. Polar bivariate plots of directional yearly CO_2 enhancements at site 10 relative to sites 1 and 5.

ADDITIONAL EVIDENCE

- Analysis of the hourly CO_2 standard deviations at site 10 reveals significant decrease in the hourly CO_2 variability when the winds are from the west (**Fig. 8**)
- This result implies that we are able to clearly observe the power plant switch using the data from site 10

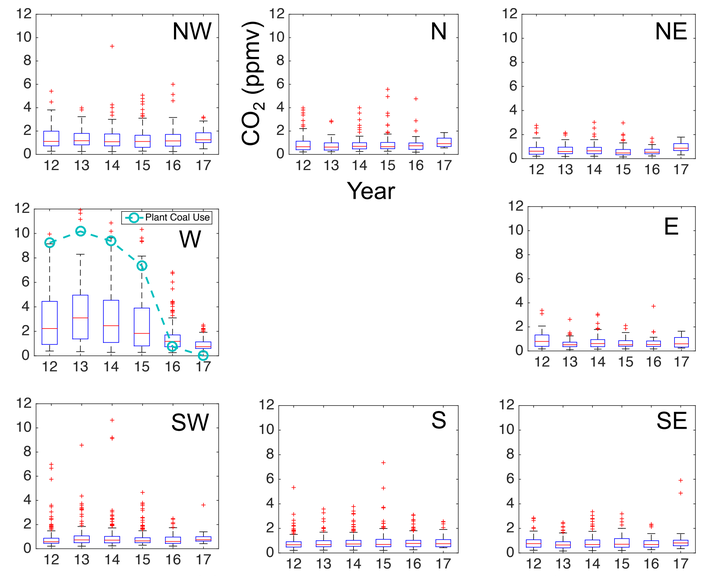

Figure 8. Hourly CO_2 standard deviations over 16-21 UTC for 2012-2017 at site 10 separated into the eight different wind directions.

CONCLUSIONS

- The Harding Street Power Plant gradually switched from coal to natural gas over the 2014-2016 time period
- CO_2 data from the INFLUX tower network were used to detect a change in the measurements due to the power plant conversion process
- Multiple types of analyses indicate that site 10 is highly sensitive to the power plant CO_2 emissions
- At site 10, CO_2 concentrations decreased steadily for time periods with westerly winds along with the decline in the use of coal at the power plant
- Future work will try to determine the effect power plant conversion process had on the CO_2 emissions of the whole city of Indianapolis using the inversion system

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