# Estimating CO2 Emissions Using Real and Simulated Total Column Observations

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**Abstract**

Total column measurements of CO2 (XCO2) have been proposed as a possible way to estimate emissions from large urban regions. Using calculations from the Weather Research and Forecasting (WRF) model with a 1km emissions field, we investigate the viability of both real and proposed observing systems consisting of surface and/or column measurements for constraining emission sources of various types and sizes in the San Francisco Bay Area. We find that column observations are best suited for assessing enhancements downwind of very large emissions sources. For smaller sources (such as highways), in situ surface monitors are required to provide sufficient sensitivity. We explore methods for estimating emissions from the real and simulated observations.

# ESTIMATING $CO_2$ EMISSIONS USING REAL AND SIMULATED TOTAL COLUMN $XCO_2$ OBSERVATIONS

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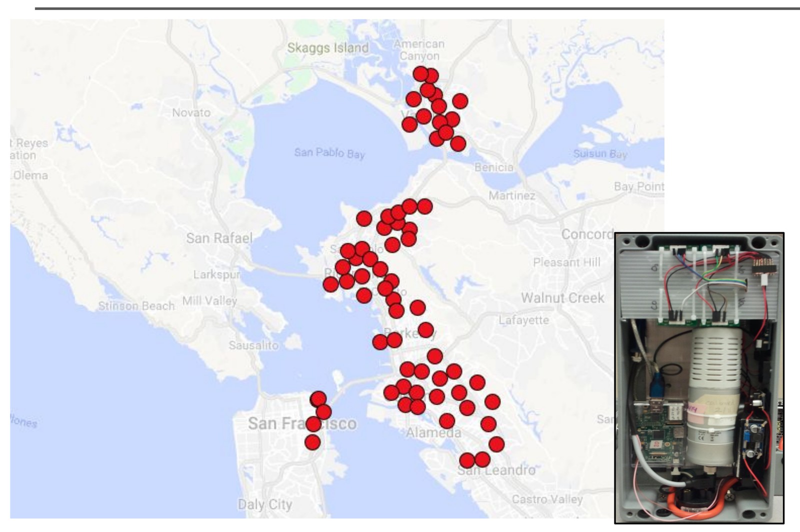
## BACKGROUND AND MOTIVATION

Rising atmospheric $CO_2$ concentrations necessitate deeper understanding of urban sources and sinks. Various sensor technologies and data assimilation strategies can be used to determine short- and long-term atmospheric trends. We seek to find the optimal synthesis of various measurement types in order to characterizing different types of sources in an urban environment.

### SURFACE MEASUREMENTS

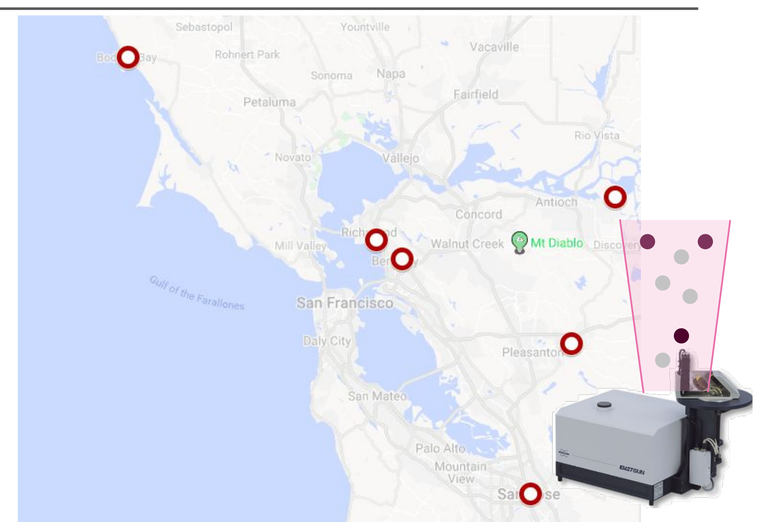


BEACO2N Sensor Network
$CO_2$, CO, PM, $O_3$, $NO_2$, NO

Hypothesized to be sensitive to:
- Boundary Layer Height
- Shallow circulations
- Local traffic emissions

75+ sites **Extensive** — $6,000/node **Operationally Simple**

### COLUMN MEASUREMENTS



Berkeley-Harvard 2016 Field Campaign
EM27/SUN FTIR Spectrometers - $CO_2$

Hypothesized to be sensitive to:
- Regional-scale meteorology
- Mean wind speeds
- Emissions integrated through large area

4 instruments **Sparse** — $27,000/node **Operationally Complex**

## METHODS

1. Select 3 study areas to assess surface, column measurements for understanding point emissions sources in a city, using WRF-CHEM modeled data from June 2013 at 1 km resolution.

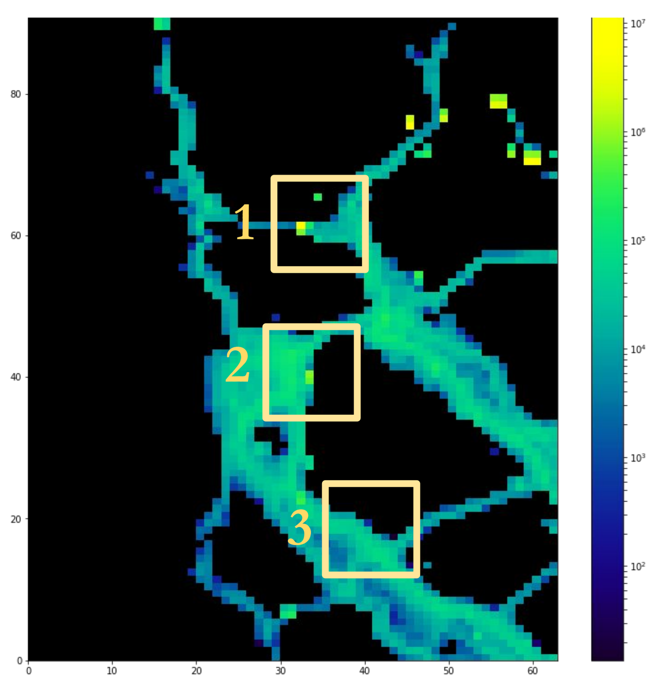



*Figure 1. Total Daily Emissions over SF Bay Area (Log Scale)*

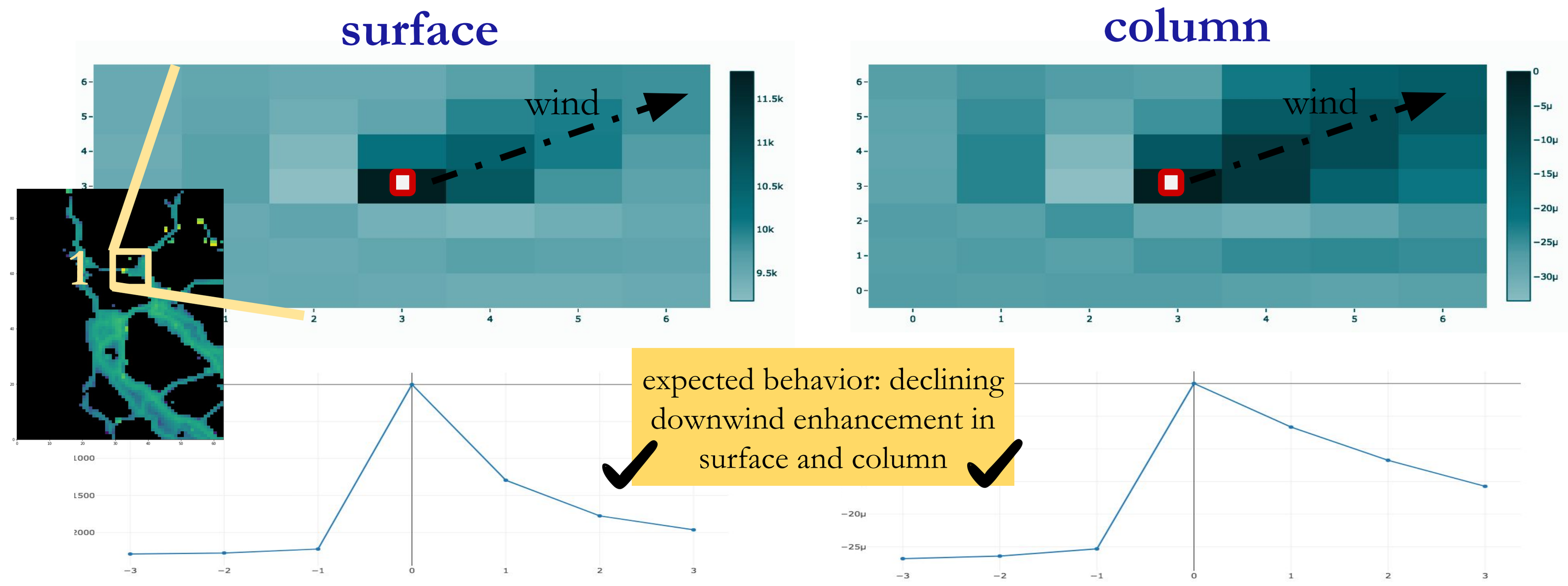
[1] Refineries, Richmond, CA
**46x** larger than surroundings
[2] Power Plant, Upper SF Peninsula
**9x** larger than surroundings
[3] Power Plant, Lower SF Peninsula
**2x** larger than surroundings

## POINT SOURCES

2. Integrate the difference of each model box diurnal cycle from the diurnal cycle of the source model box and evaluate downwind patterns.

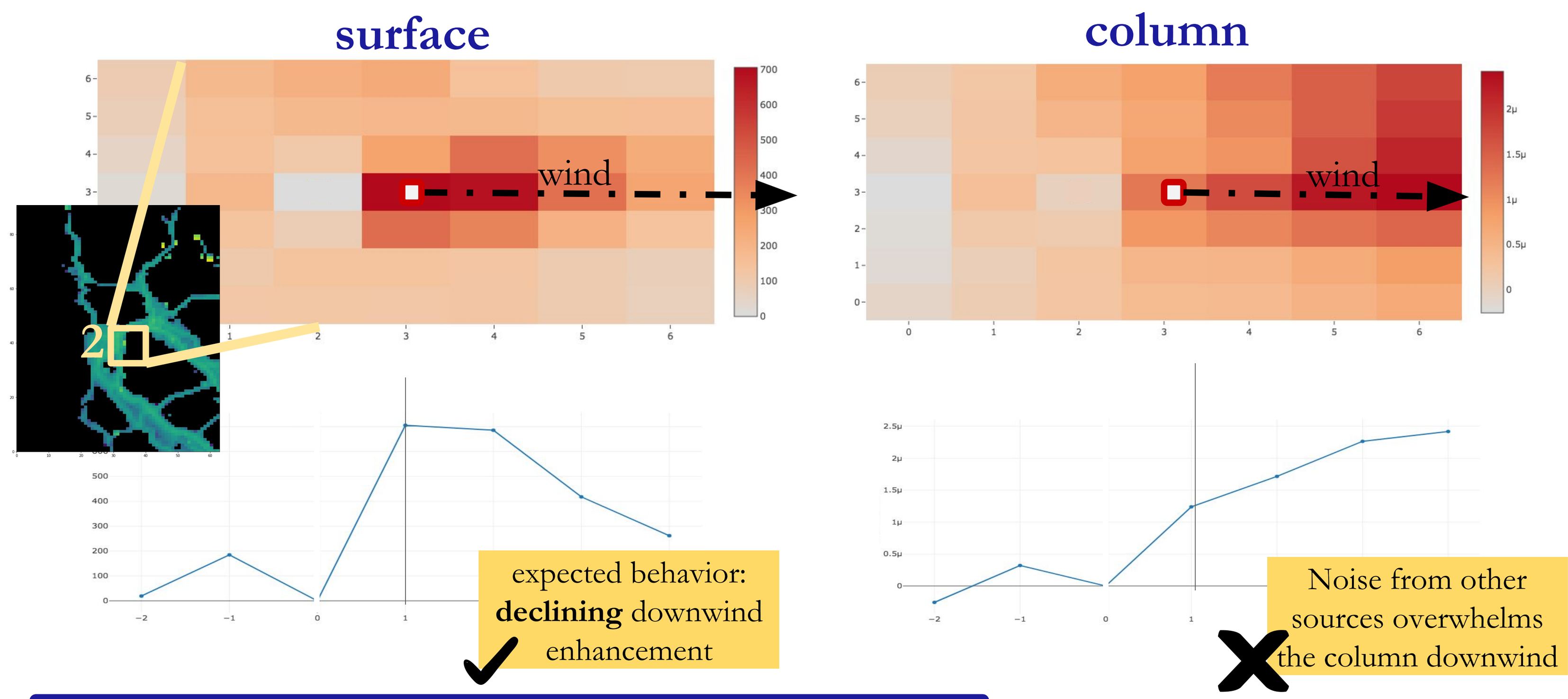
### Source 1: Large Refinery

**46x** larger than surrounding emissions



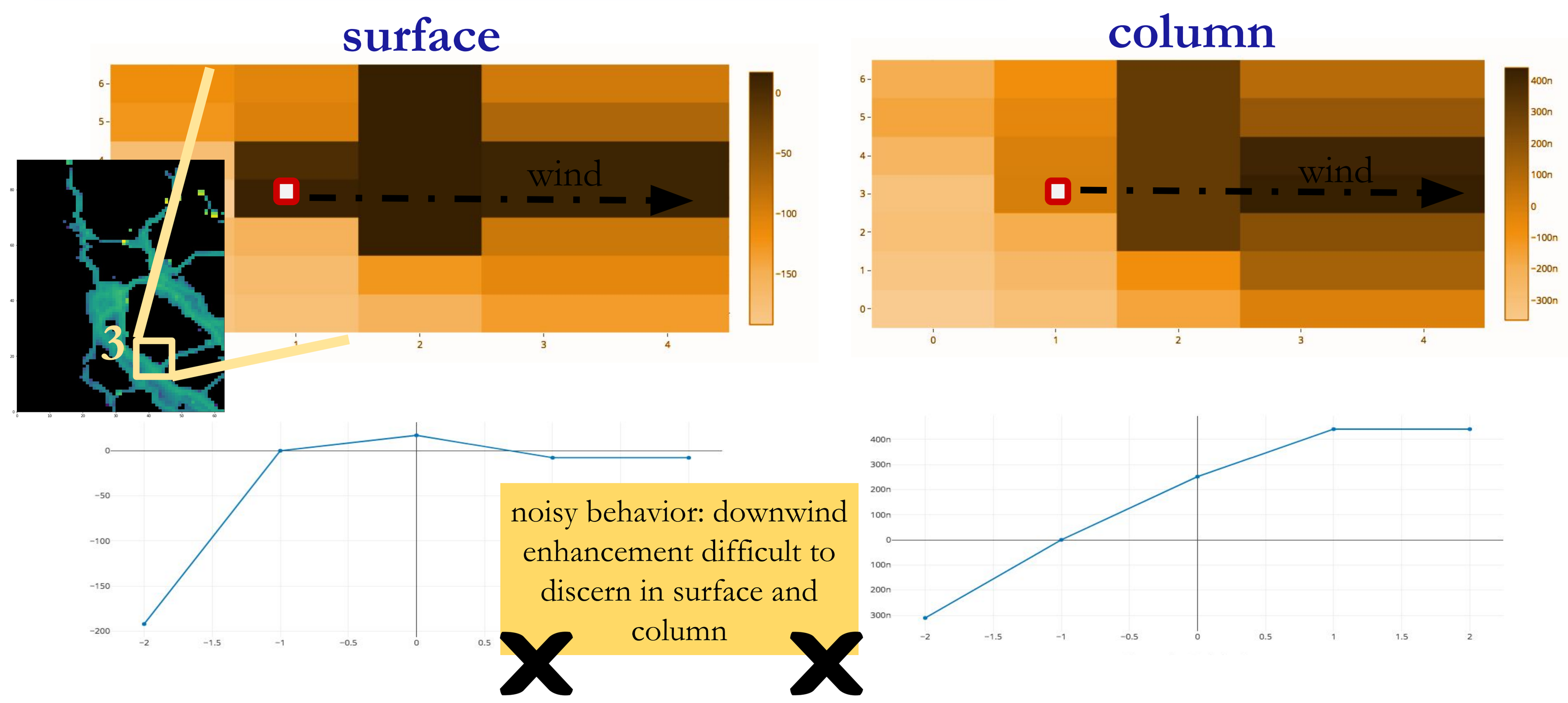

### Source 2: Large Power Plant

**9x** larger than surrounding emissions



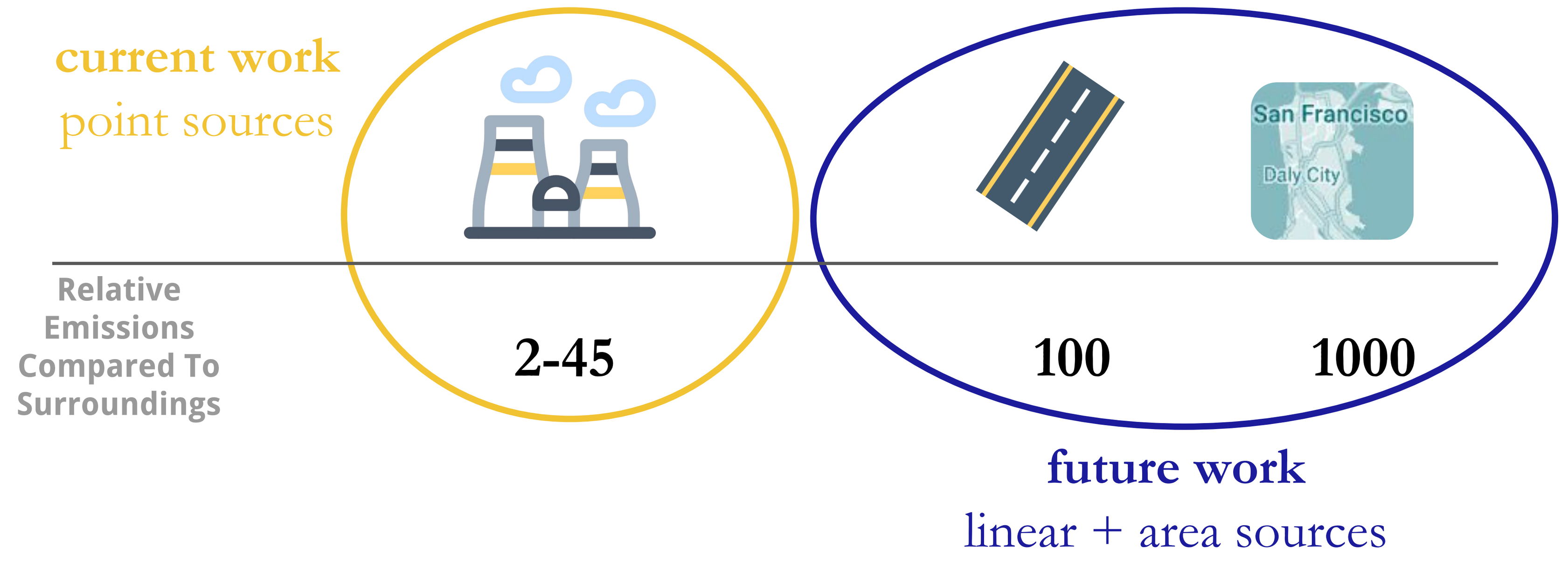

### Source 3: Small Power Plant

**2x** larger than surrounding emissions




## CONCLUSIONS AND FUTURE WORK

- Larger sources show clear declining enhancement pattern downwind of emissions and can be detected with both approaches
- Smaller magnitude sources are overwhelemed by other emissions, with column measurements failing at intermediate levels and both methods failing at the lowest emissions tested




## APPLICATIONS

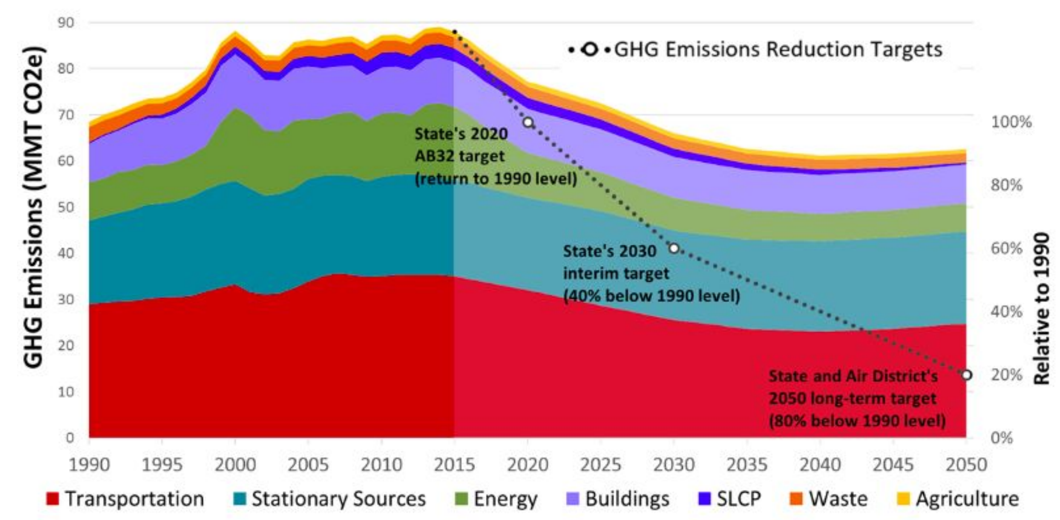



*Figure 2. AB32 California Climate Action Plan: Greenhouse Gas Emissions and Reduction Targets for 2050*

- AB32 California Climate Action Plan Goal: reduce emissions to 1990 levels by Year 2020 & further reductions by 2030 and 2050
- Assessment of greenhouse gas emissions reductions will need atmospherically measured validation
- Surface and $XCO_2$ measurements need to be synthesized to find the optimum method for assessing total reductions and sector-wise reductions in emissions