Insights into urban CO_2 emissions from BEACO$_2$N

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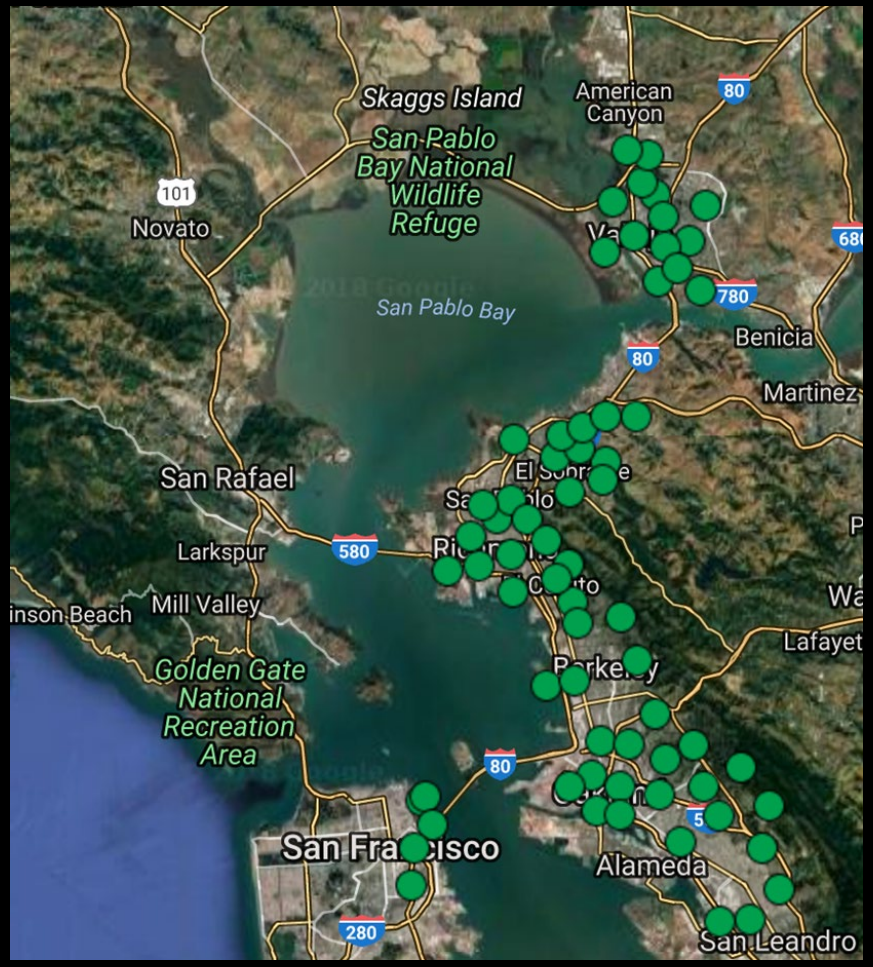
What observations would support cities' evaluation of their successes in various kinds of emissions reductions?

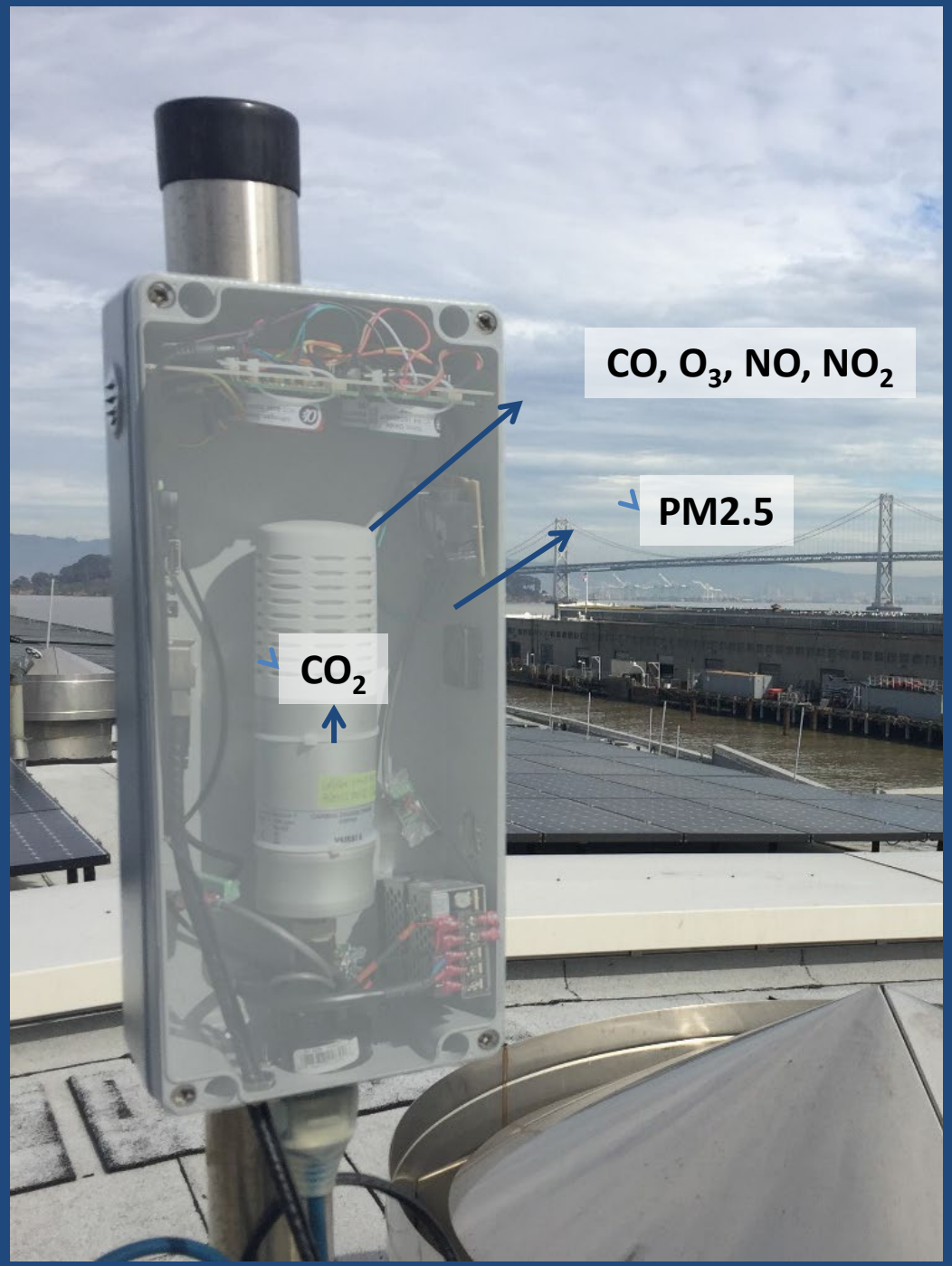
How can observations point to win-win-wins for climate, air quality and equity of exposure.

Dense Observing systems—a new approach to understanding urban emissions

Berkeley
Environmental
Air Quality and
CO_2
Observation
Network



http://beacon.berkeley.edu



NO_2, NO, O_3, CO, CO_2, particles

$8500 + shipping; Monthly fee for share of technical support and data management

Maintenance ~10% or less/yr

Note: Hardware costs are small compared t o ongoing interpretation.

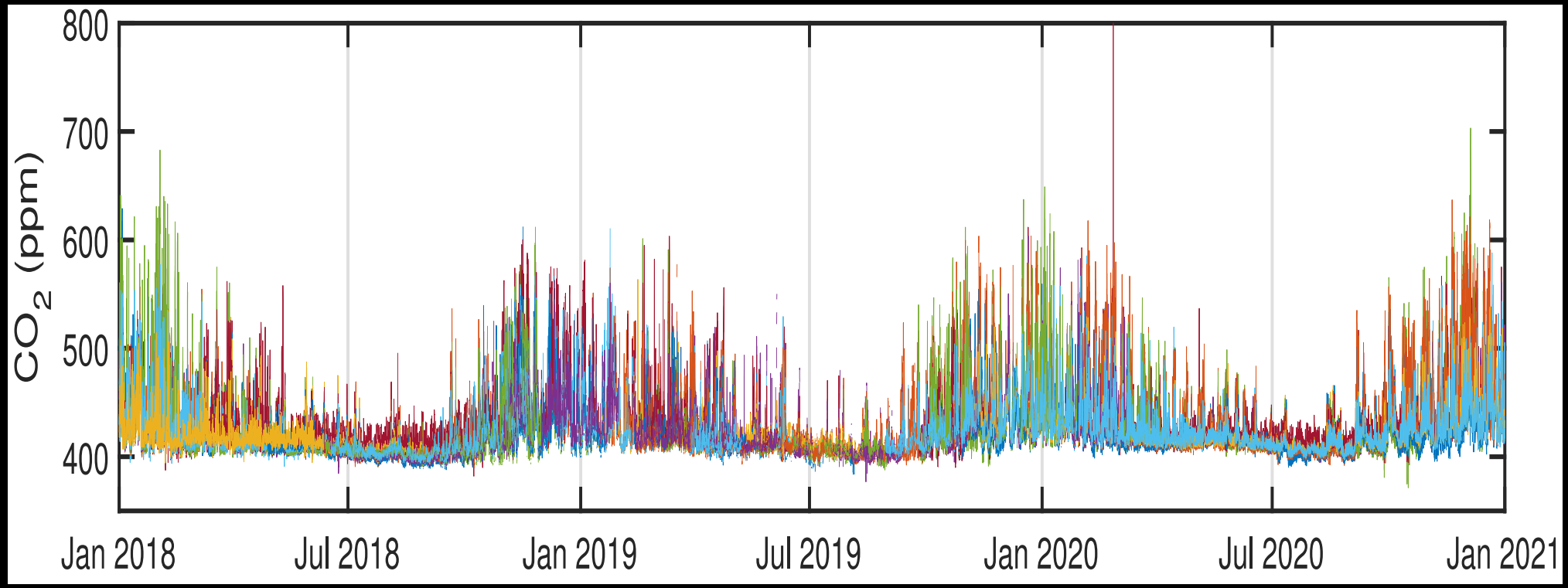
~20nodes = 1 person year

A. Shusterman, et al., ACP. 2016

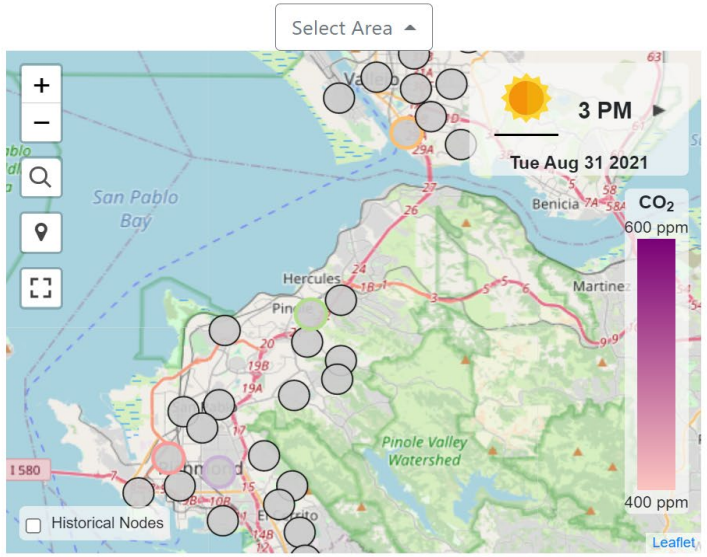
J. Kim, et al. AMT, 2018

E.R. Delaria et al. ACP. 2021

What makes BEACO$_2$N unique is the combination of CO$_2$ and AQ. This brings together siloed research (AQ, GHGs, Climate, EJ) and policy communities (NGOs, cities, regions, national government) that should be working more closely together.



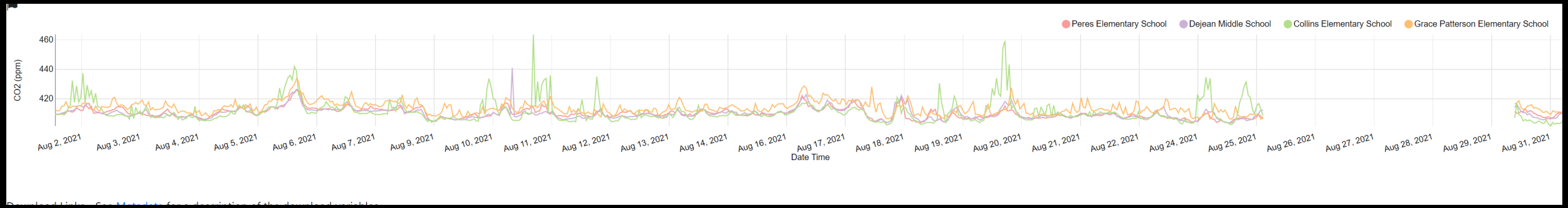
climate change, and reports back to this site where the collected data is publicly available for viewing and download. The nodes also collect data on nitrogen oxides, ozone, carbon monoxide, and particulate matter which are indicators for the overall air quality of an area, and may be useful for tracing the origins of CO_2 emissions. CO_2, CO, and aerosol data are available for download via this site. Data for other species is not yet ready for public viewing, but will be added to the site soon.



× Peres Elementary School
× Dejean Middle School
× Collins Elementary School
× Grace Patterson Elementary School

Date Range: 2021-08-01 15:00:00 to 2021-08-31 15:00:00 CO2

Real-time



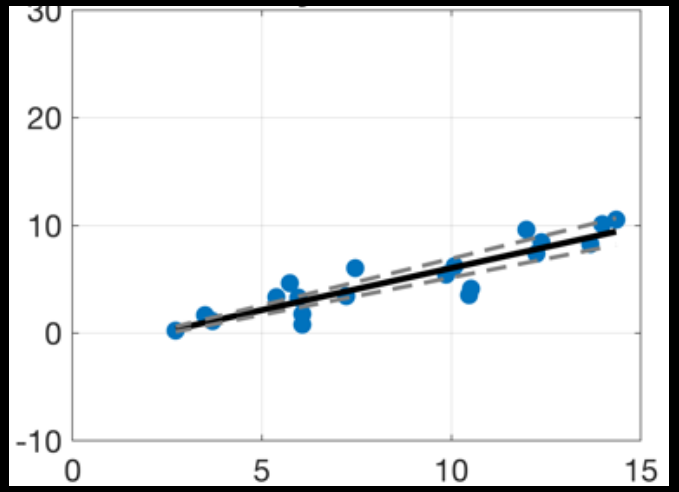
Data is posted and available to the public as it comes in.

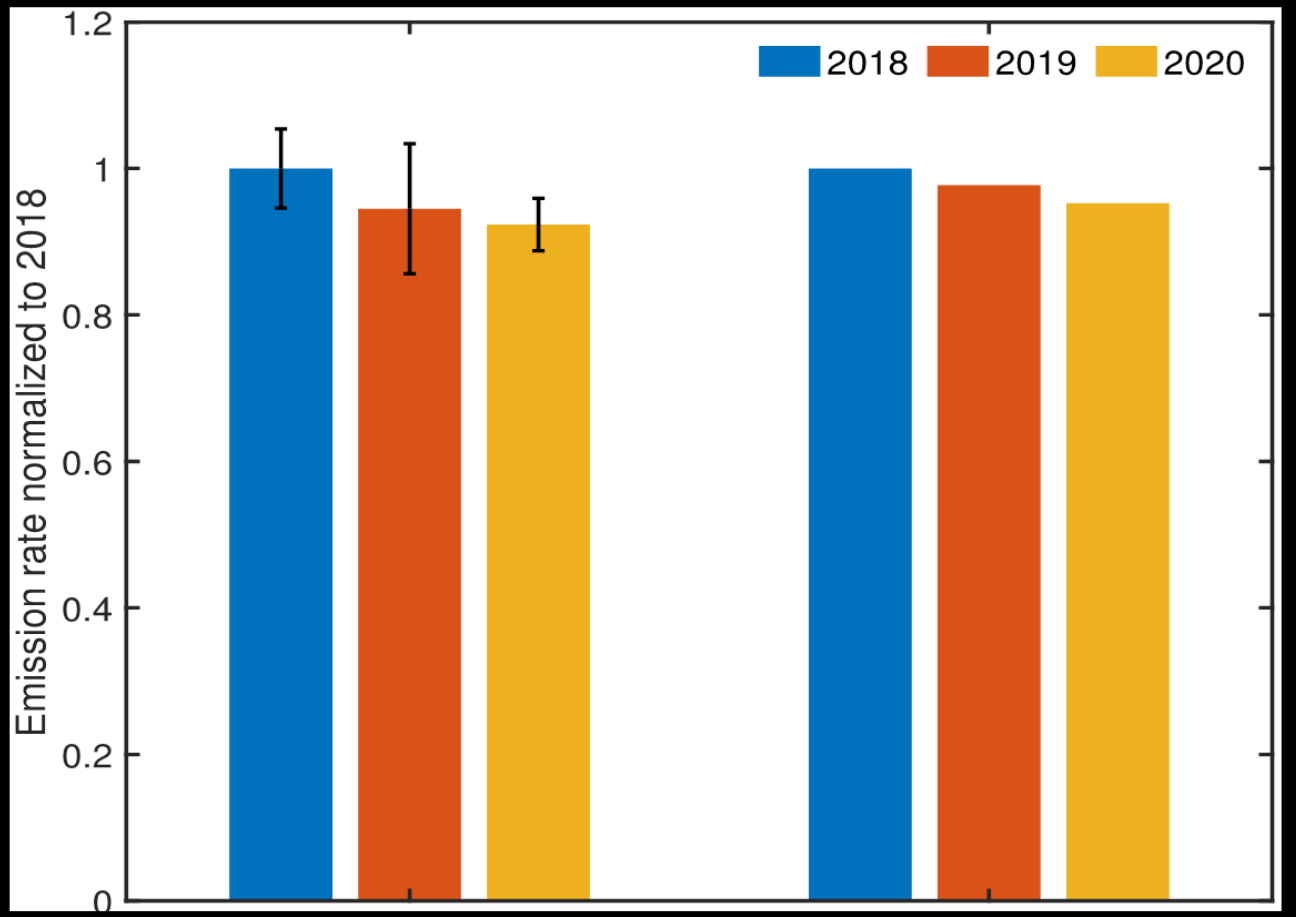
Open data, calibration and interpretation.

http://beacon.berkeley.edu

1. Trends in annual emissions per vehicle

Combining data from 50 locations



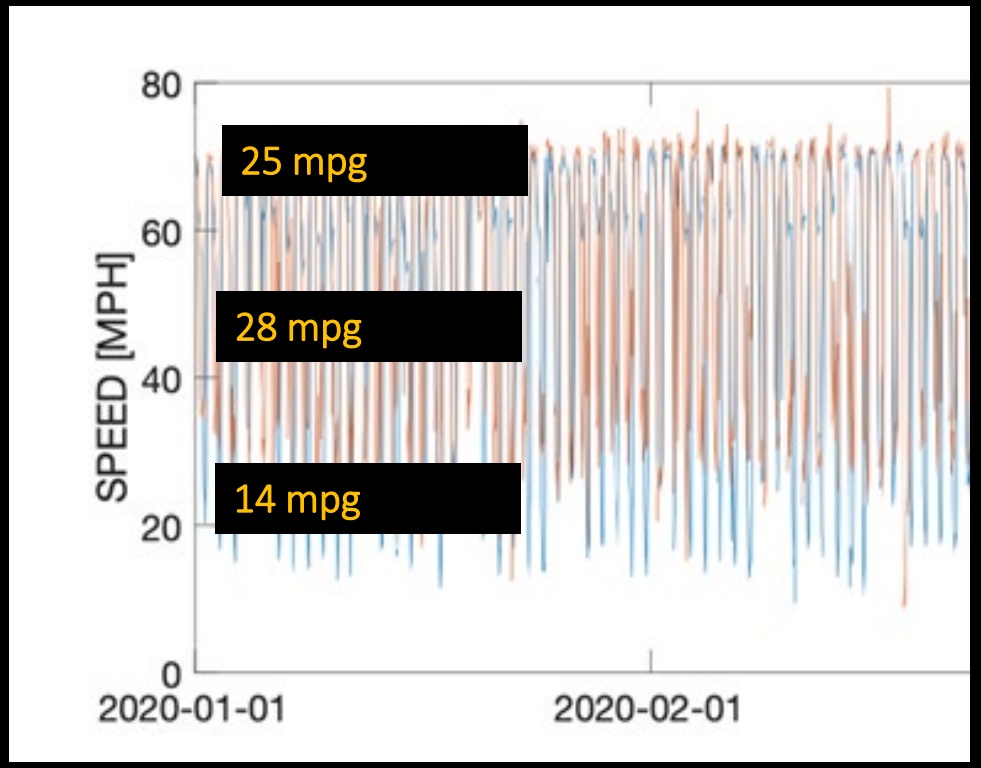


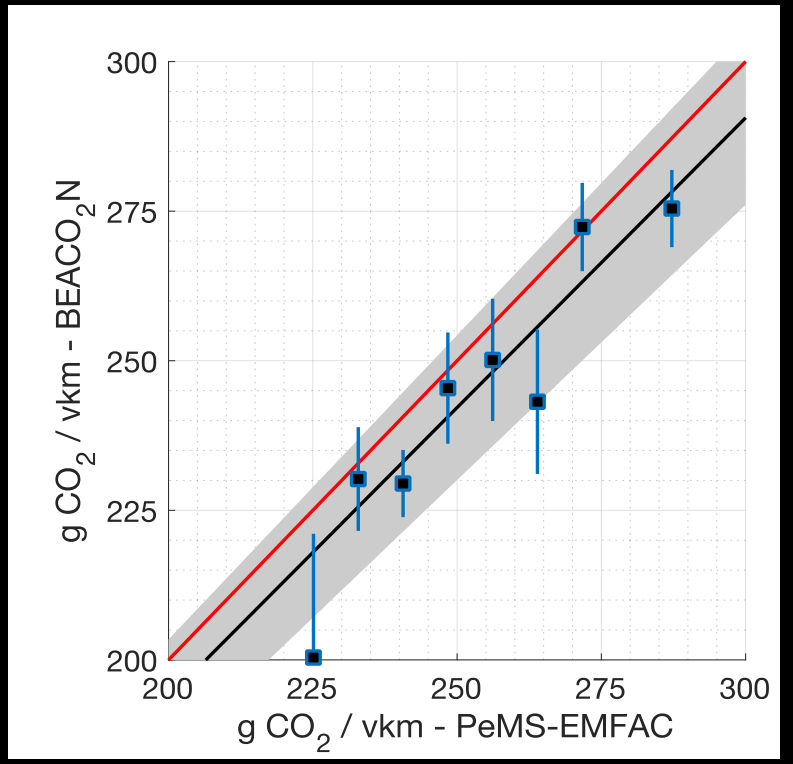
Kim et al. ES&T 2022

Observed 3.8%/yr

Modeled 2.3%/yr

2. Current fleet fuel efficiency vs. speed





Slow speeds, less efficient

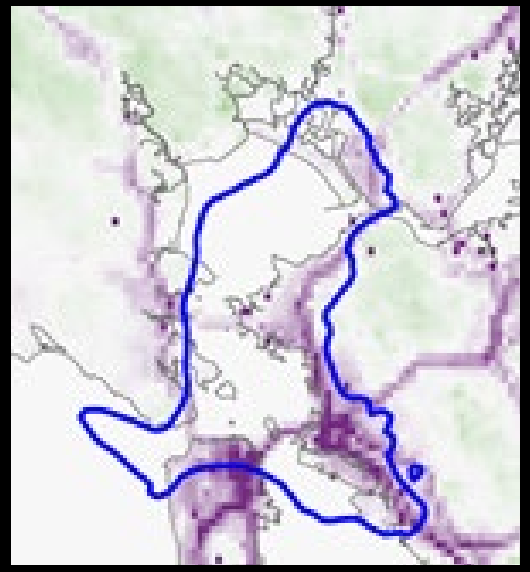
Optimal speeds, more efficient

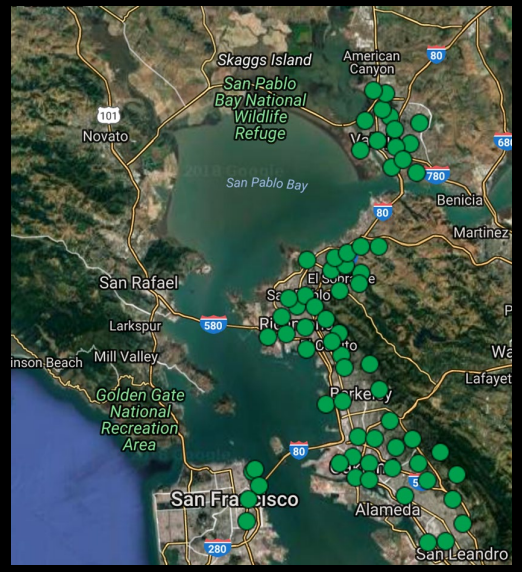
$BEACO_2N$ suggests entire vehicle fleet slightly more fuel efficient than predicted at all speeds. Confirms predicted speed dependence is accurate.

Fitzmaurice et al. ACP 2022

3. How much did CO_2 emissions drop in the early phase of the COVID-19 shelter-in-place and why?

3 steps in a cycle of observation driven understanding of emissions





$$\hat{\mathbf{x}} = \mathbf{x_a} + (\mathbf{HB})^T \left(\mathbf{HBH}^T + \mathbf{R}\right)^{-1} (\mathbf{y} - \mathbf{Hx_a})$$

Predictions/ hypotheses

economic, social, and weather

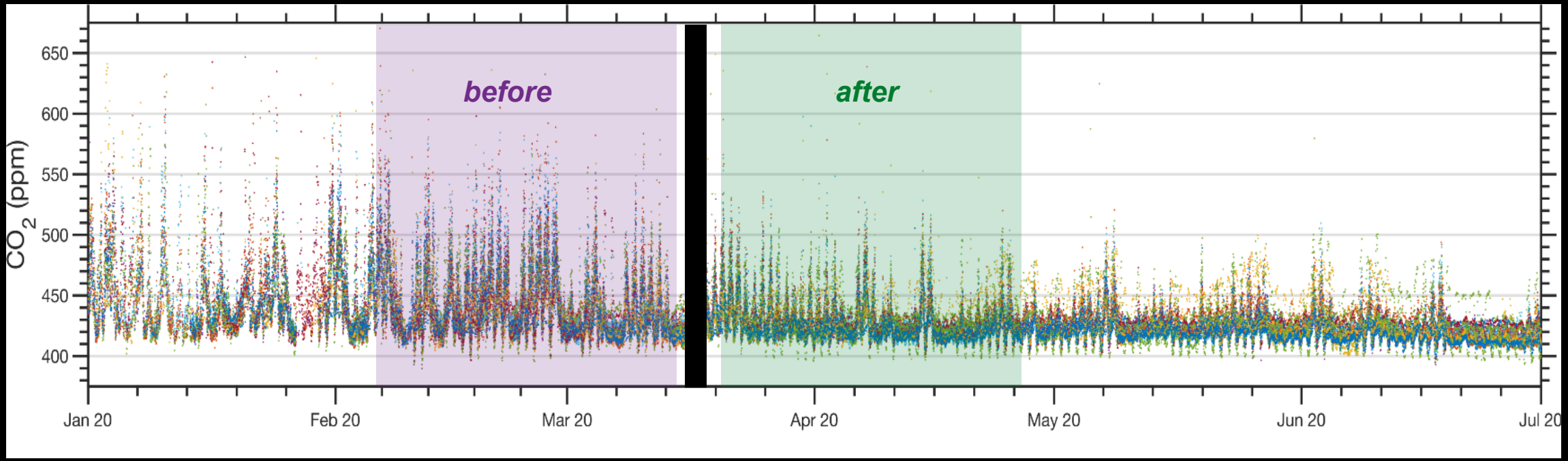
Observations

BEACO$_2$N

Synthesis/iterative improvement

inverse model

BEACO$_2$N CO$_2$ observations SF Bay Area January – July 2020



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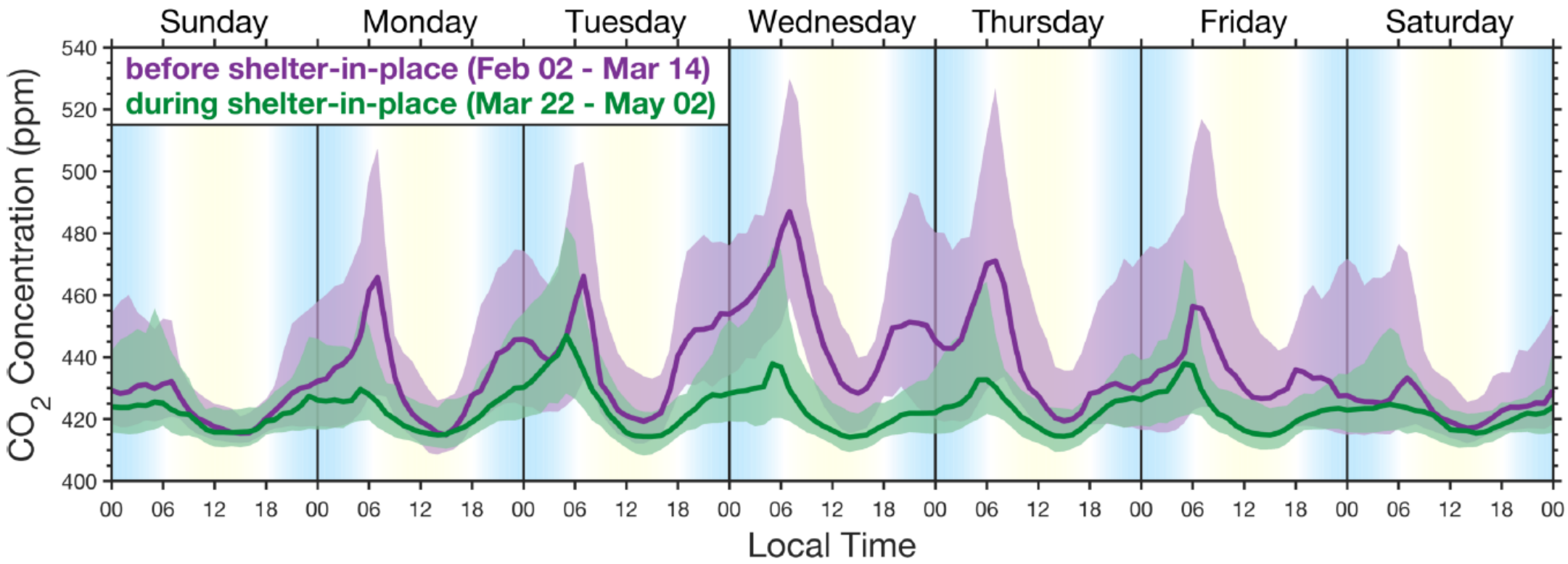
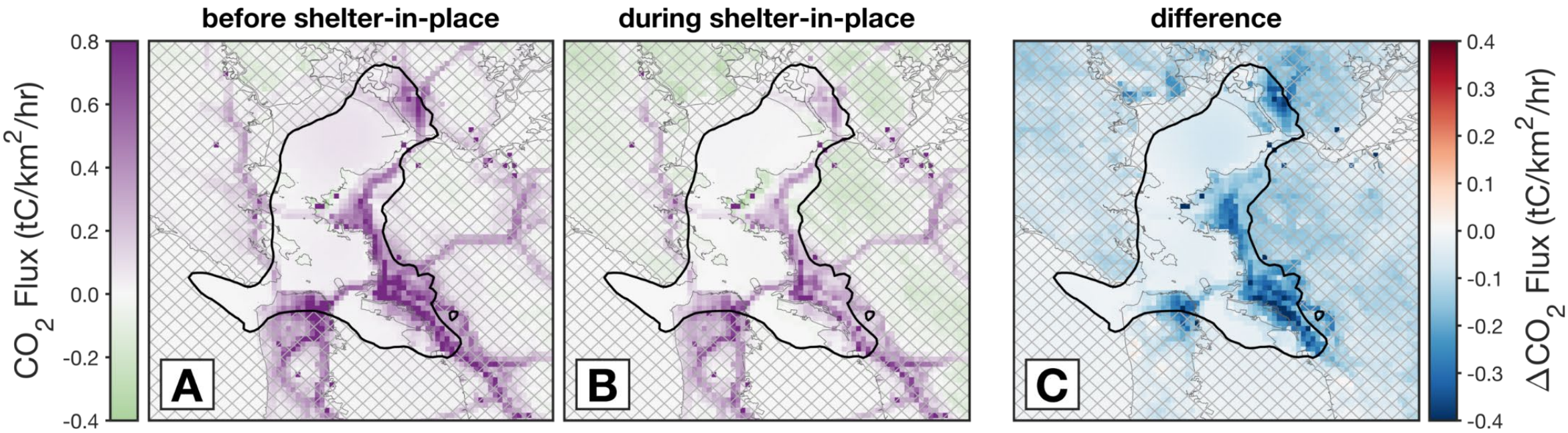


Turner, et al., Geophys. Res. Lett. doi.org/10.1029/2020GL09003, 2020

Inverse model leverages synthesizes prior knowledge with observations

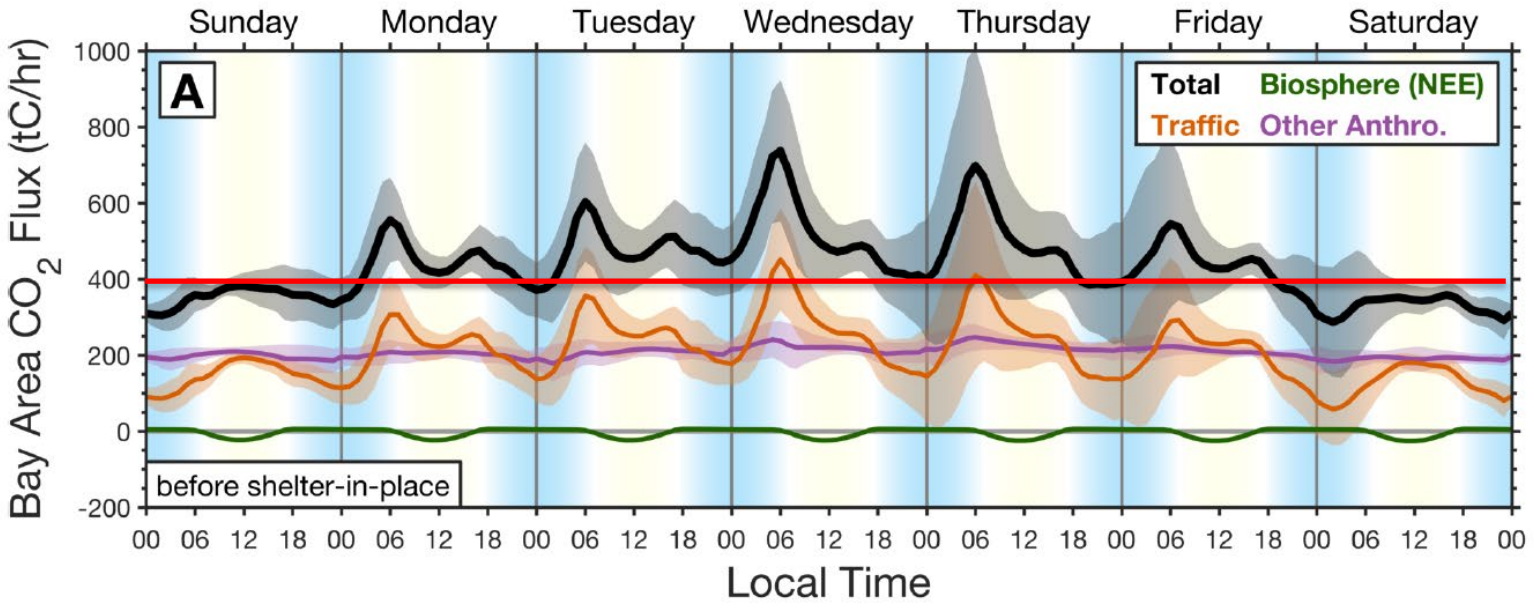
$$\hat{\mathbf{x}} = \mathbf{x_a} + (\mathbf{HB})^T \left(\mathbf{HBH}^T + \mathbf{R} \right)^{-1} (\mathbf{y} - \mathbf{Hx_a})$$

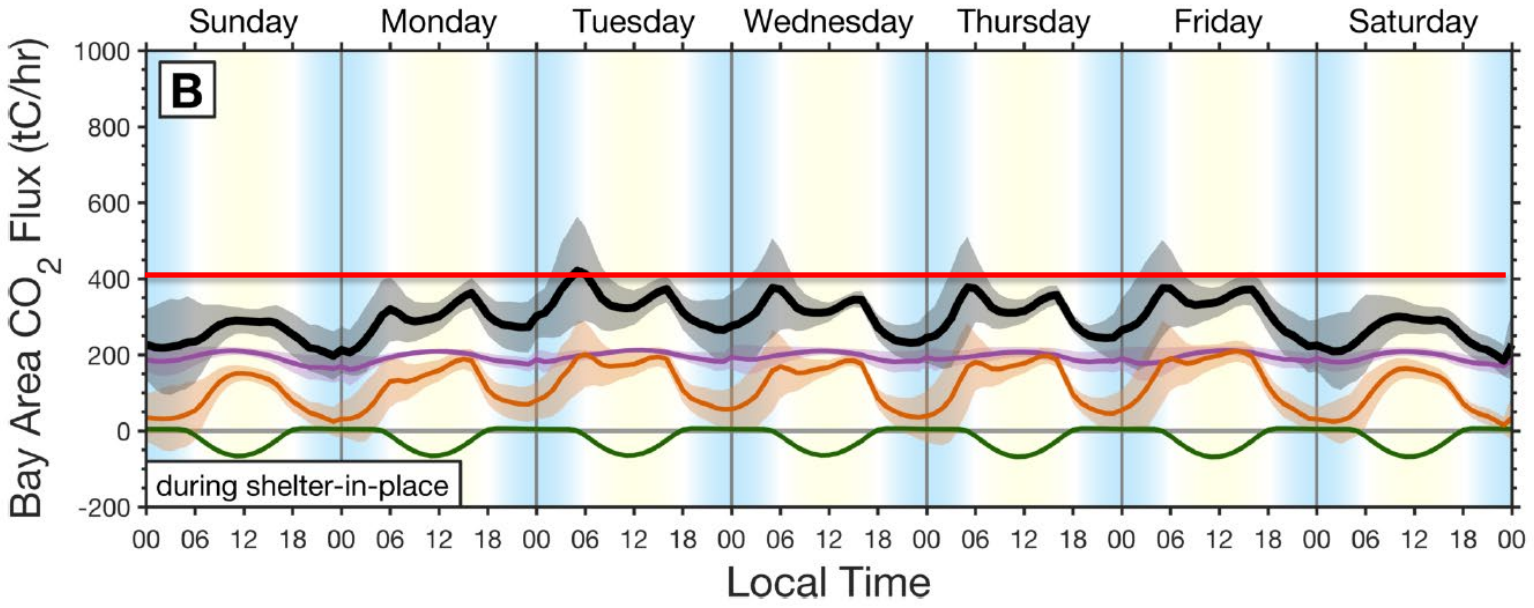
Results on a Map



- The emissions are best constrained inside the black line
- Largest changes on freeways; implied emissions on city streets changed

GHG (CO_2) Emissions from the observations





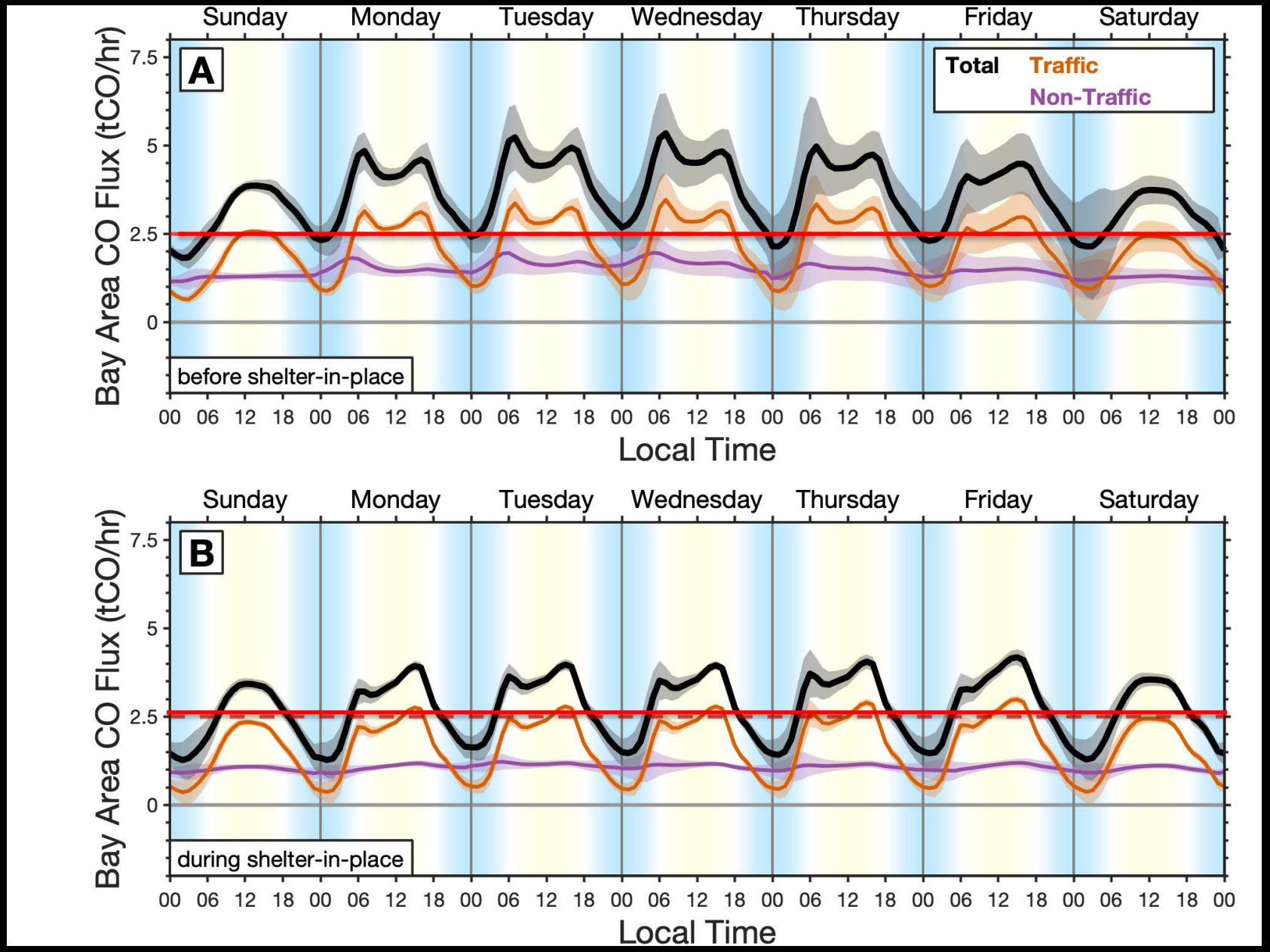
2020

CO_2 emissions before and after COVID shelter-in-place

25% overall reduction

45% vehicle reduction

Air Quality (Carbon Monoxide) Emissions from the observations



2020

CO fluxes before and after COVID shelter-in-place

New locations with BEACO$_2$N hardware

Glasgow, Scotland — 12, soon 25 nodes
UC Berkeley and Univ. Strathclyde

Los Angeles — 12 nodes
USC, Will Berelson

Leicester, UK — delivered 10 nodes
Univ. Leicester, Hartmut Boesch

Providence — 25 nodes
Brown Univ., Meredith Hastings

In discussions with several other cities, please join us

Conclusions

Demonstrated rapid (within months) reporting of CO_2 emissions and changes, attribution of emissions by sector, testing of processes within emission models (e.g. speed), annual changes in vehicle emissions.

Our tools are ready to support these and other key elements of urban GHG reduction plans.

AQ results emerging; tests of cold start models. Connection to CO_2.

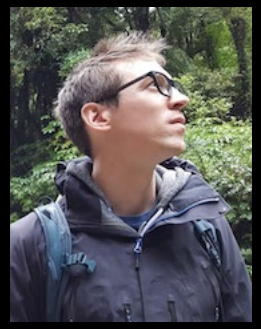
Thank you!

Catherine Newman

Alexis Shusterman

Jinsol Kim

Kevin Worthington



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