BEACO$_2$N: Berkeley Atmospheric CO$_2$ Observation Network

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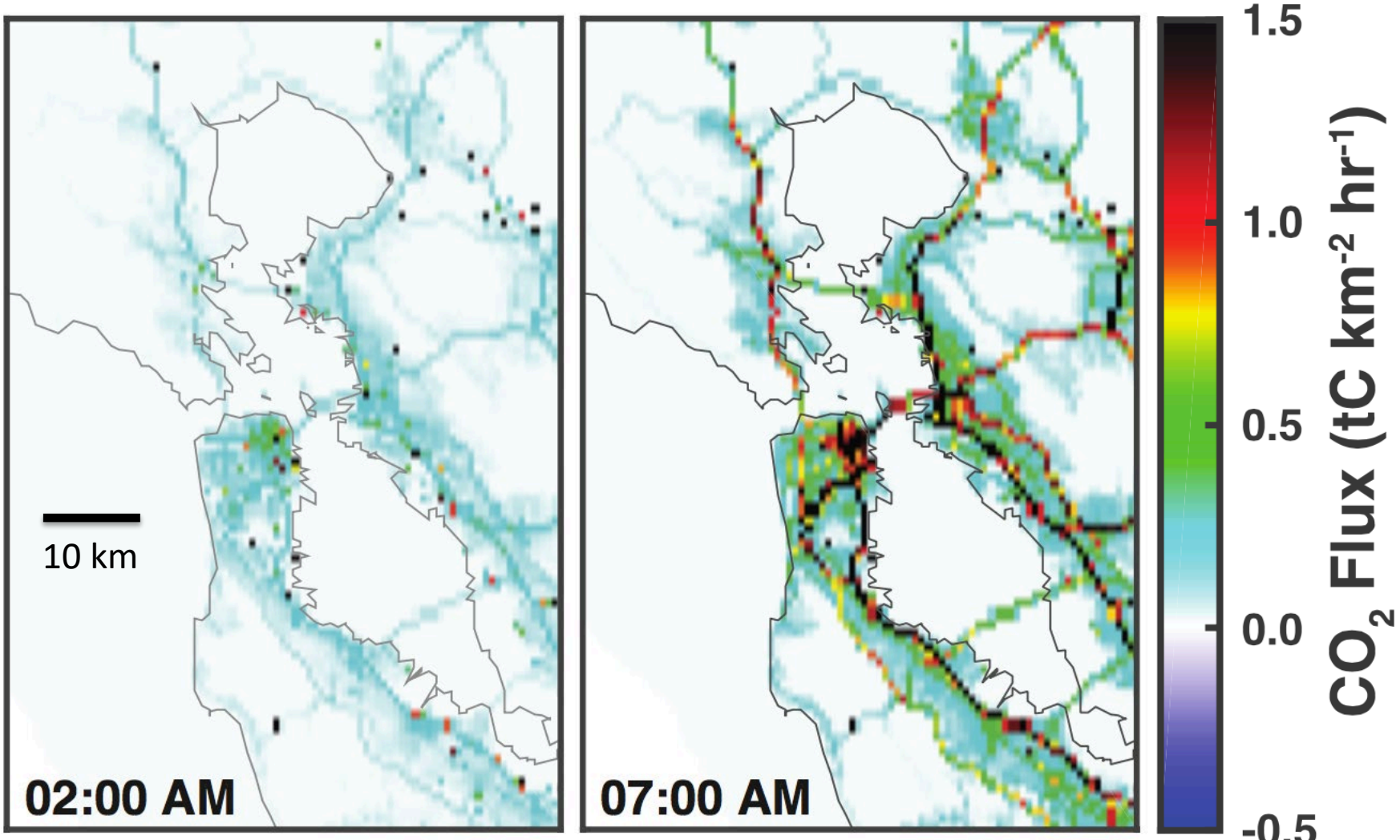
$ UC Berkeley, Koret Foundation, NASA

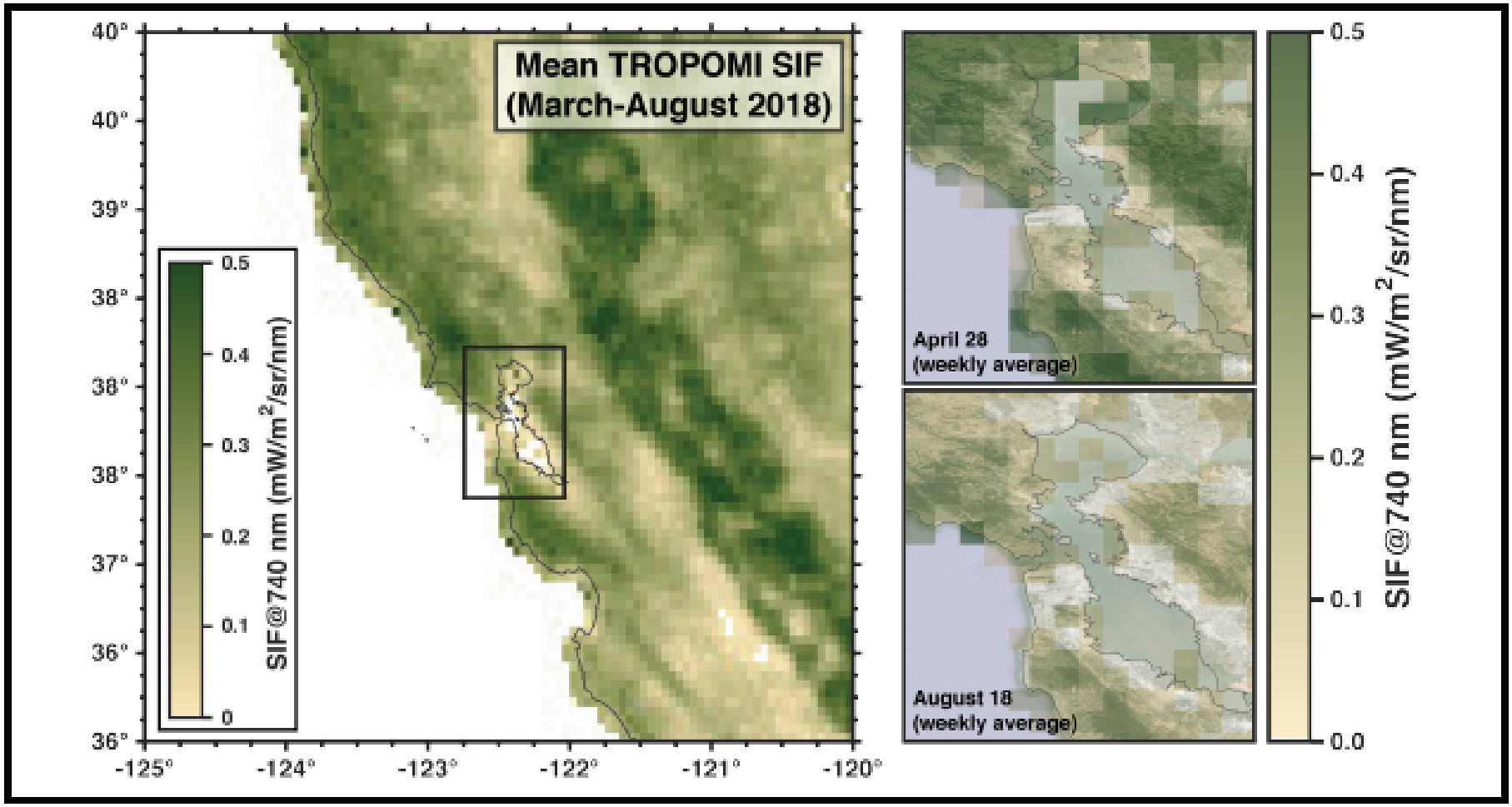
Processes responsible for, and spatial patterns of emissions/deposition within cities are essentially untested by observation.

Anthropogenic CO_2 Emission Inventory



(Turner et al., 2016)

Biogenic emissions/uptake



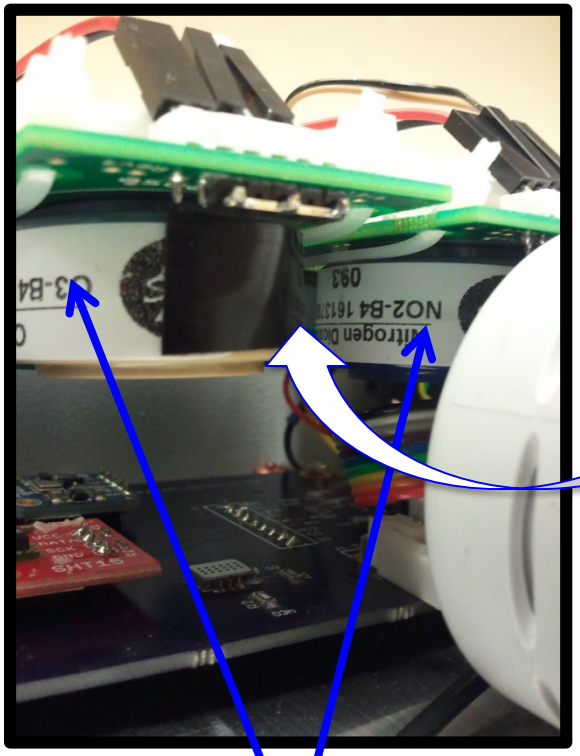
We are interested in neighborhood scale allocation and interannual trends in specific processes.

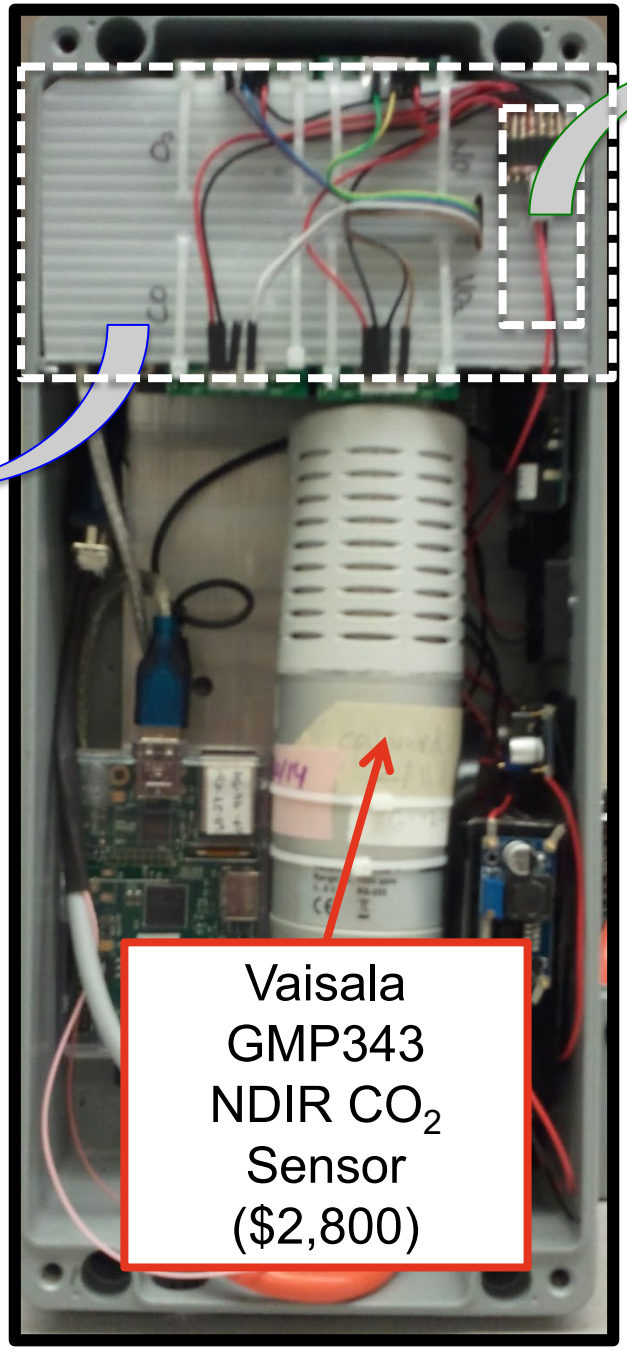
Patterns of CO_2 emissions/uptake: vehicles, homes, industry, biosphere.

Is cold start the dominant source of NO_x; if so what changes in spatial pattern have occurred are occurring?

Are emissions of household organics (e.g. solvents for paint) competitive with emissions from vehicles as source of urban reactive carbon? (and therefore urban aerosol?) (Mcdonald et al. Science 2018)

BEACO$_2$N: 2.5m – 130m AGL



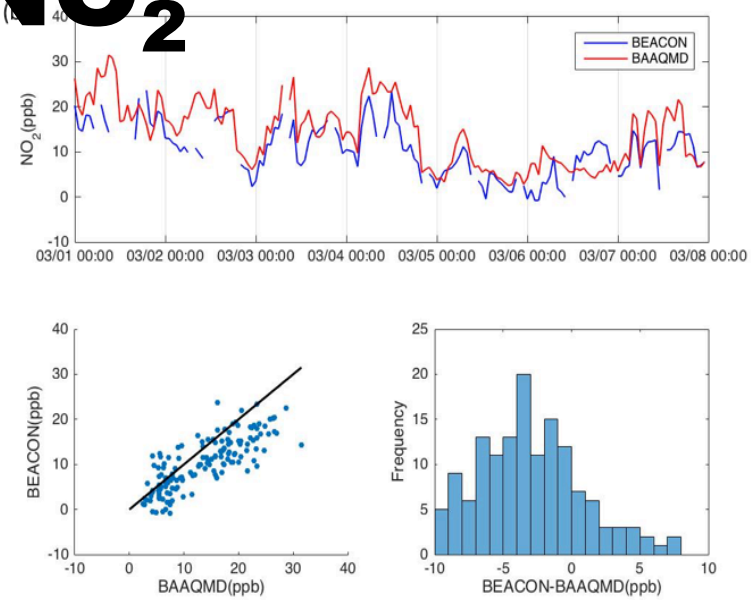


Alphasense B4 Electrochemical O_3, CO, NO & NO_2 Sensors ($216 ea.)

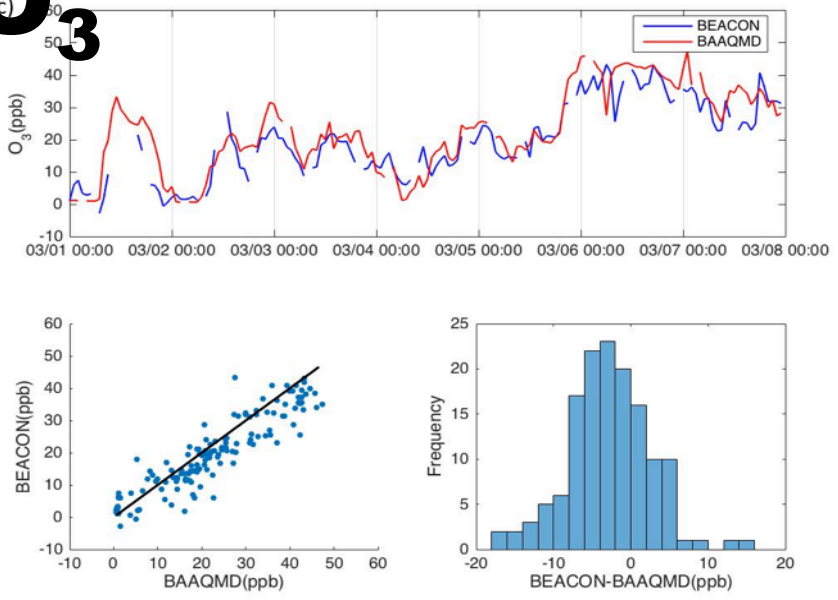
Vaisala GMP343 NDIR CO_2 Sensor ($2,800)

Shinyei PPD42NS nephelometric particulate matter sensor ($16)

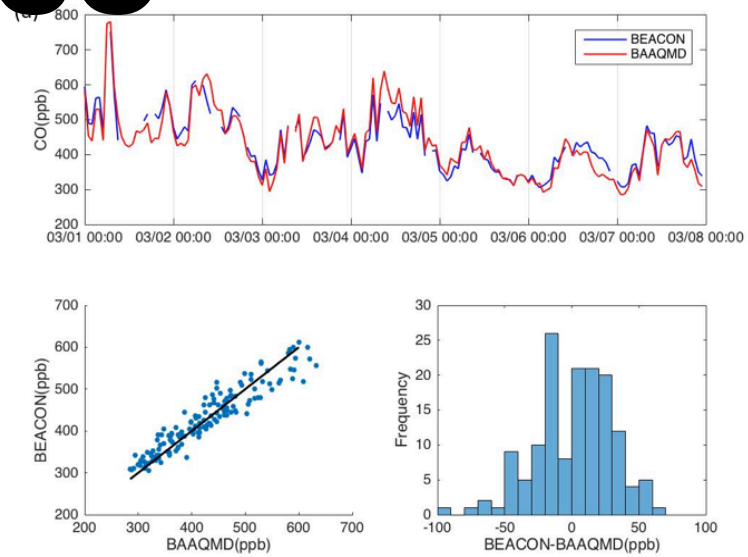
NO_2



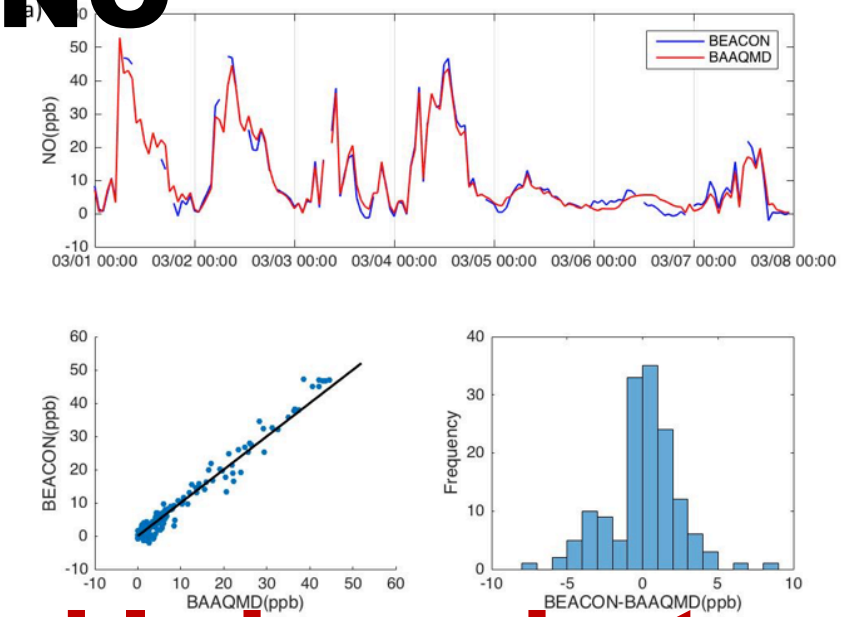
O_3



CO

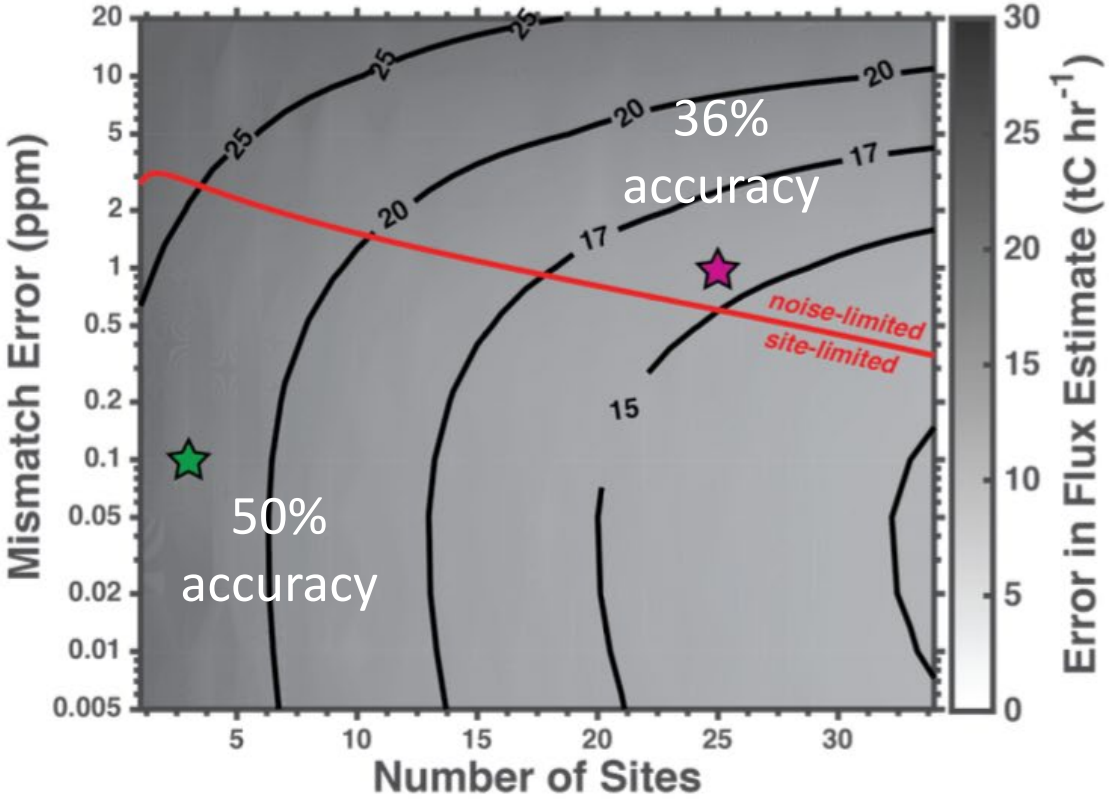


NO



Blue $BEACO_2N$ Red Independent

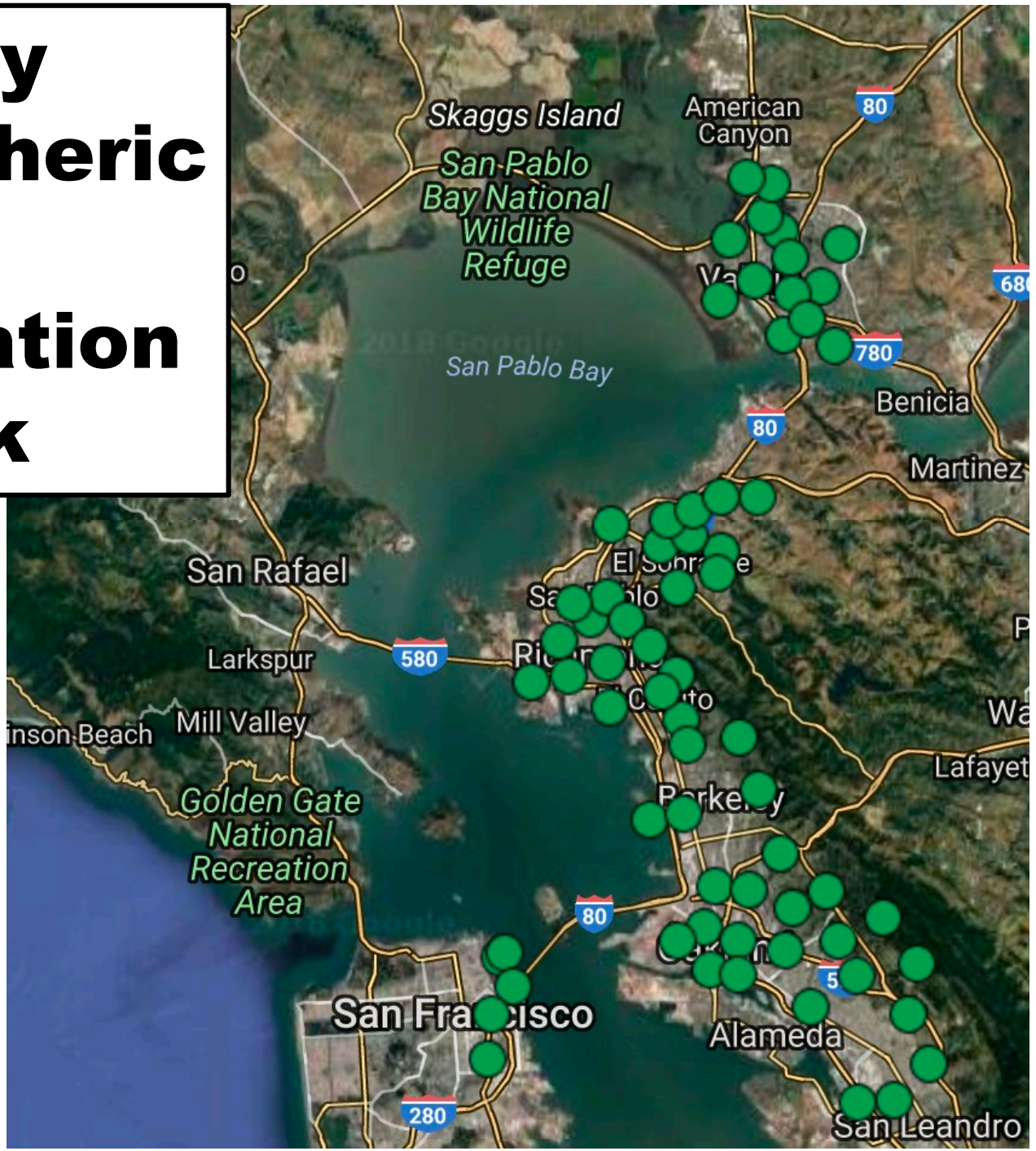
Networks are better



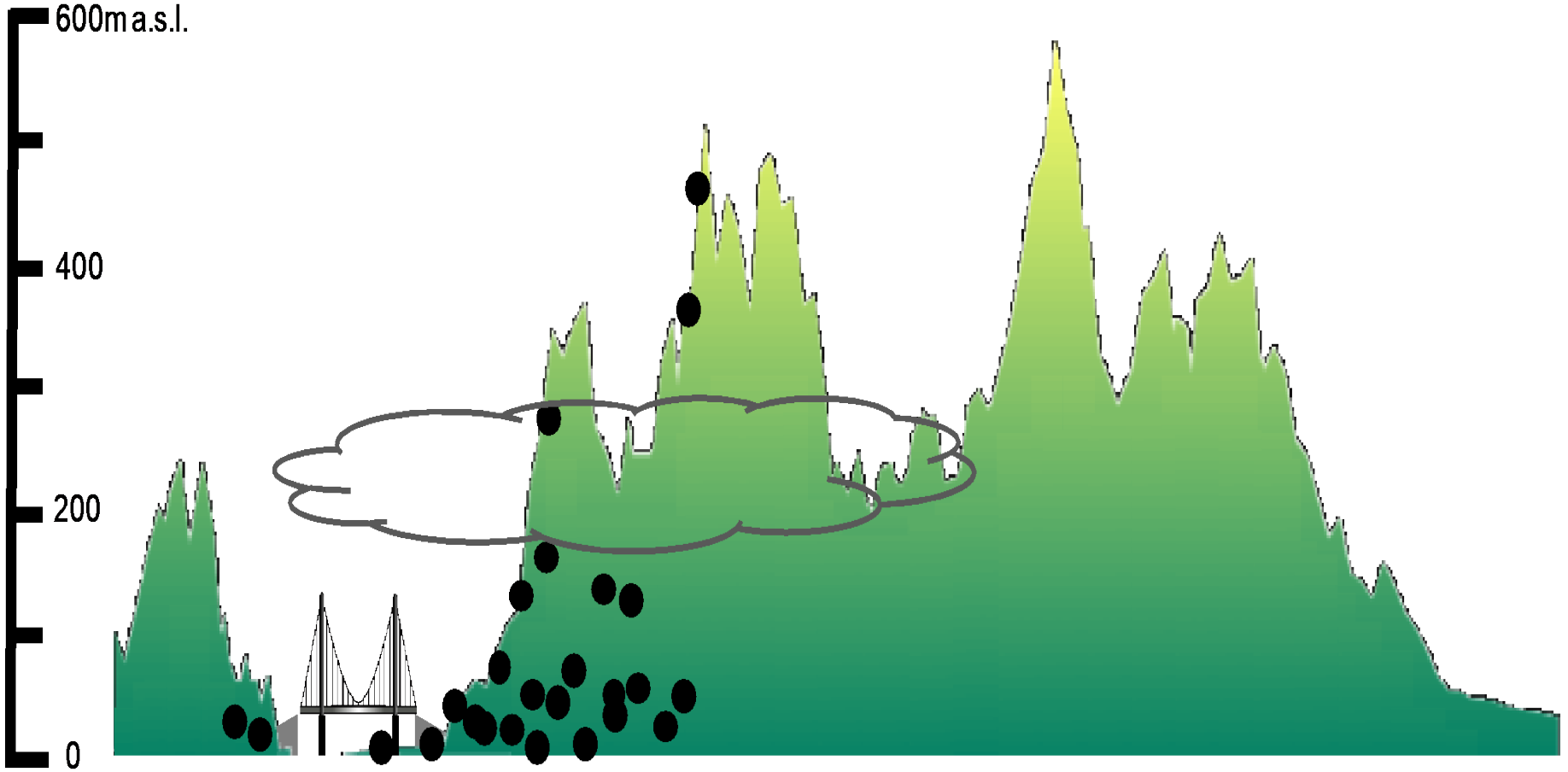
Large numbers of low cost instruments (★) will out perform a few state-of-the-art high cost ones (★) for quantifying emissions within a city.

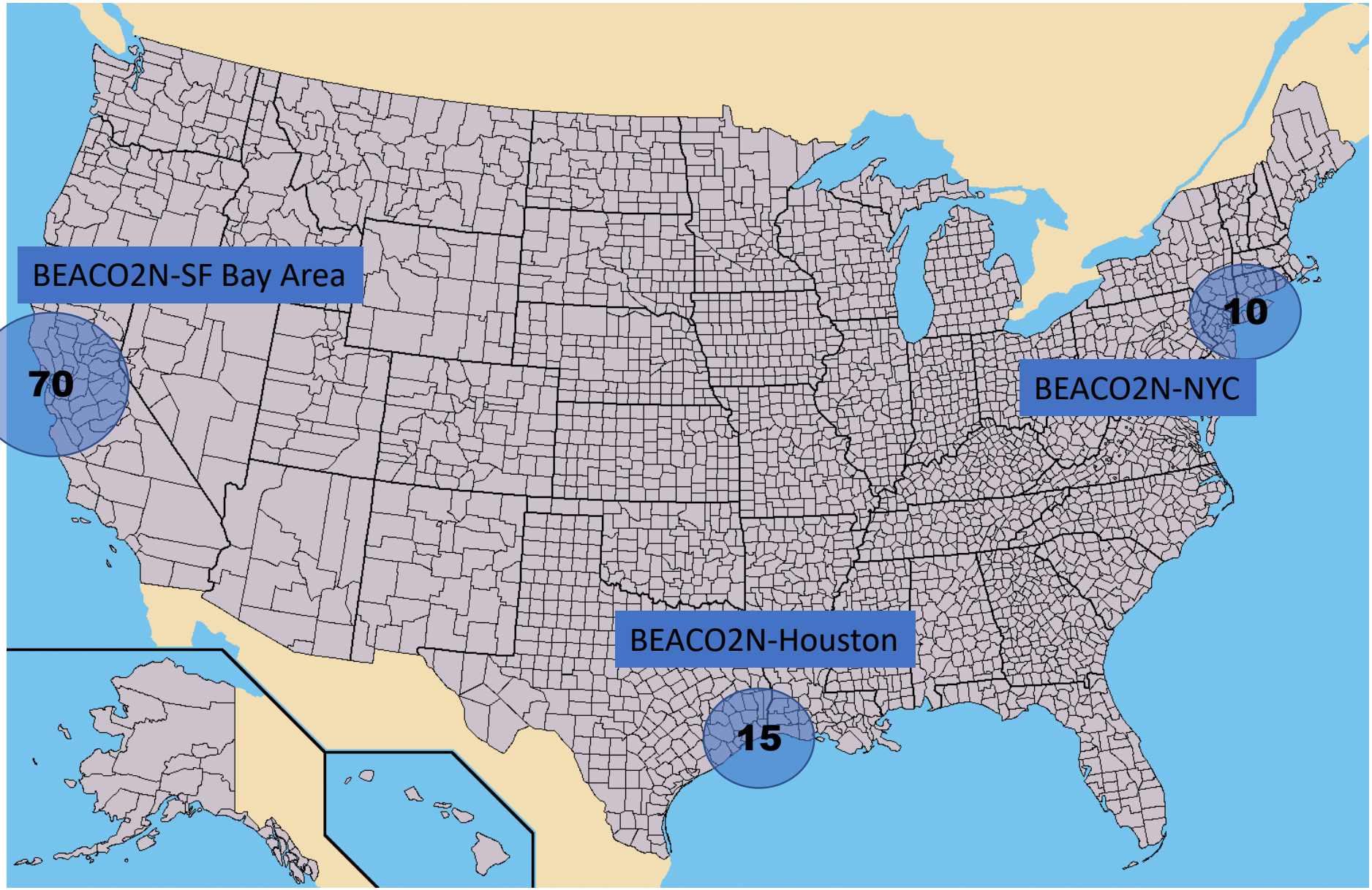
***Turner et al. ACP 2016*.**

BErkeley Atmospheric CO_2 Observation Network

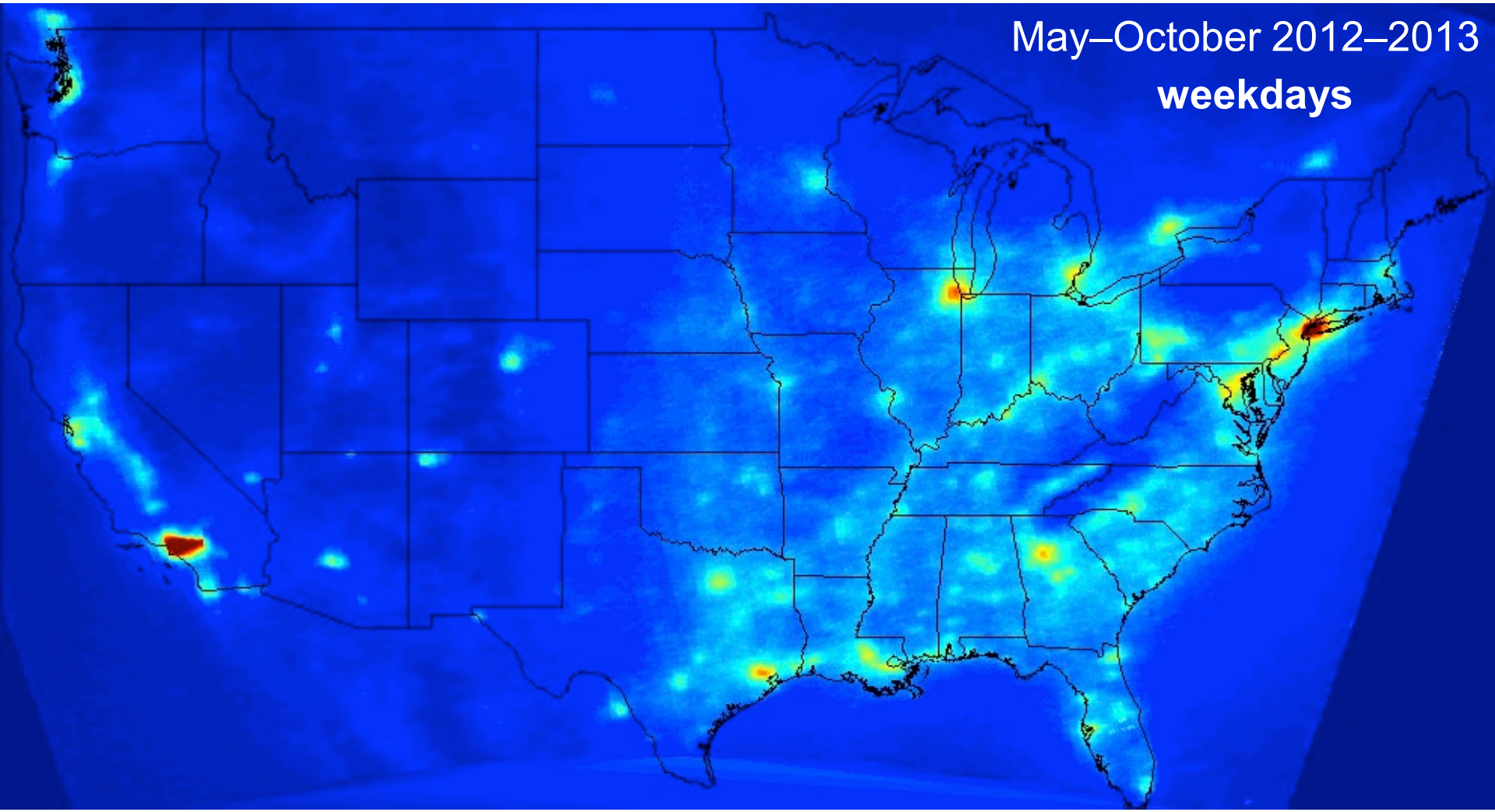


BEACO$_2$N

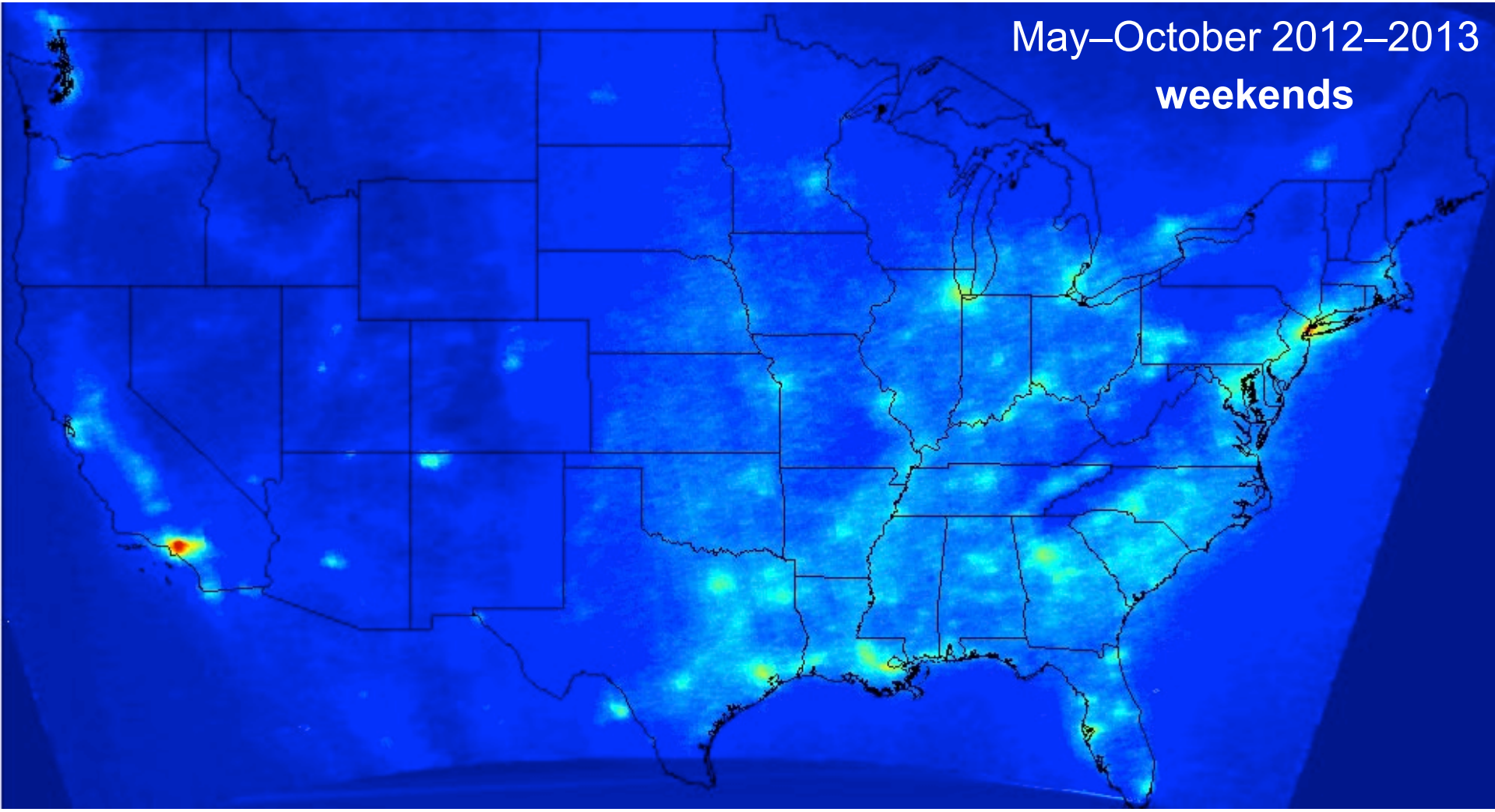


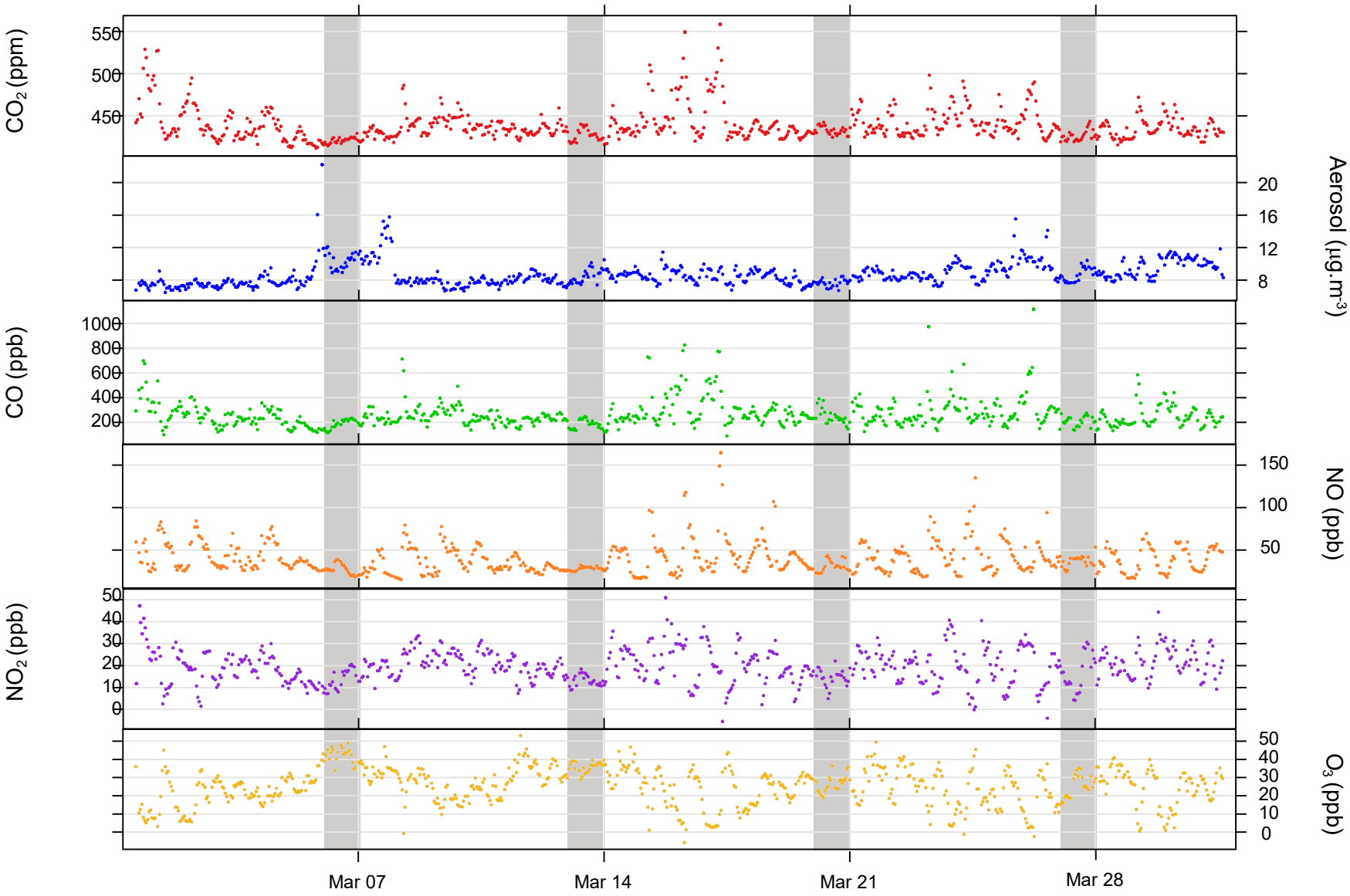

BEACO2N-SF Bay Area
70
10
BEACO2N-NYC
BEACO2N-Houston
15

Weekdays


May–October 2012–2013
weekdays
0 1 2 3 4 5 6 7 8 9 10x10^15
NO2 (molecules cm−2)
OMI Berkeley High-resolution Retrieval (BEHR)

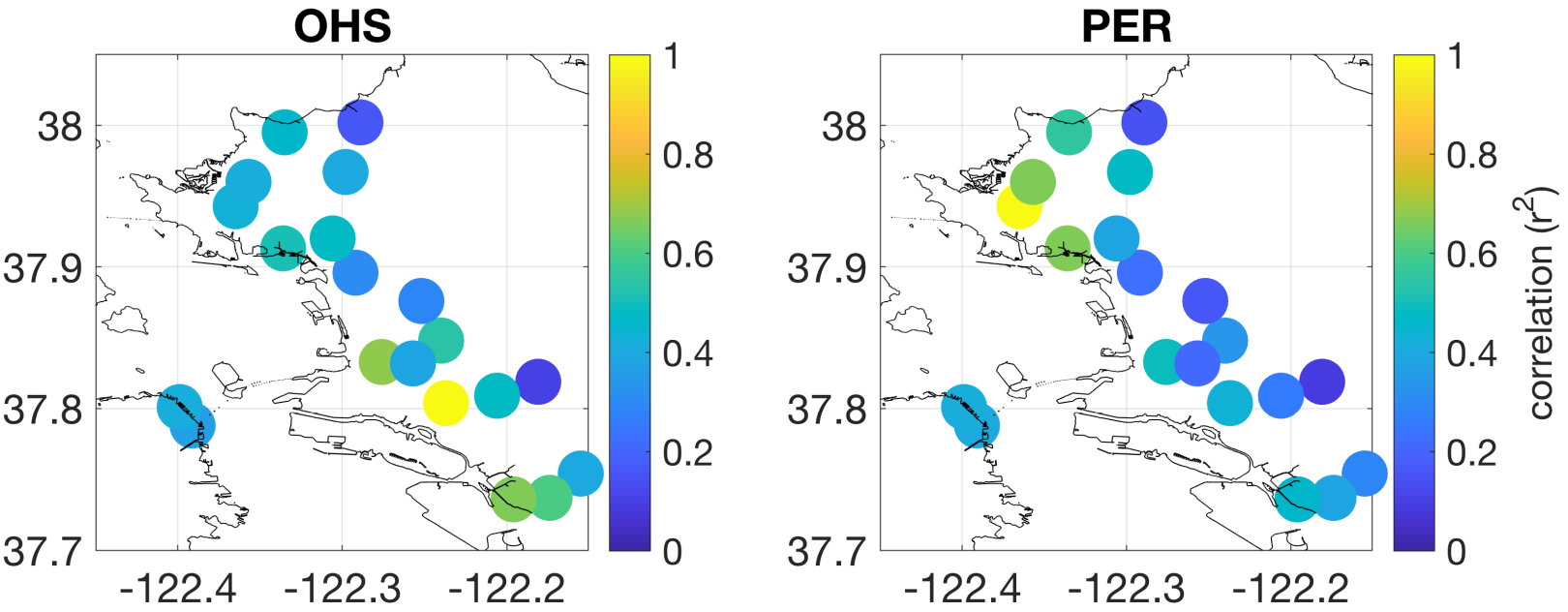
Weekends


May–October 2012–2013
weekends
0 1 2 3 4 5 6 7 8 9 10x10^{15}
NO_2 (molecules cm^{-2})
OMI Berkeley High-resolution Retrieval (BEHR)

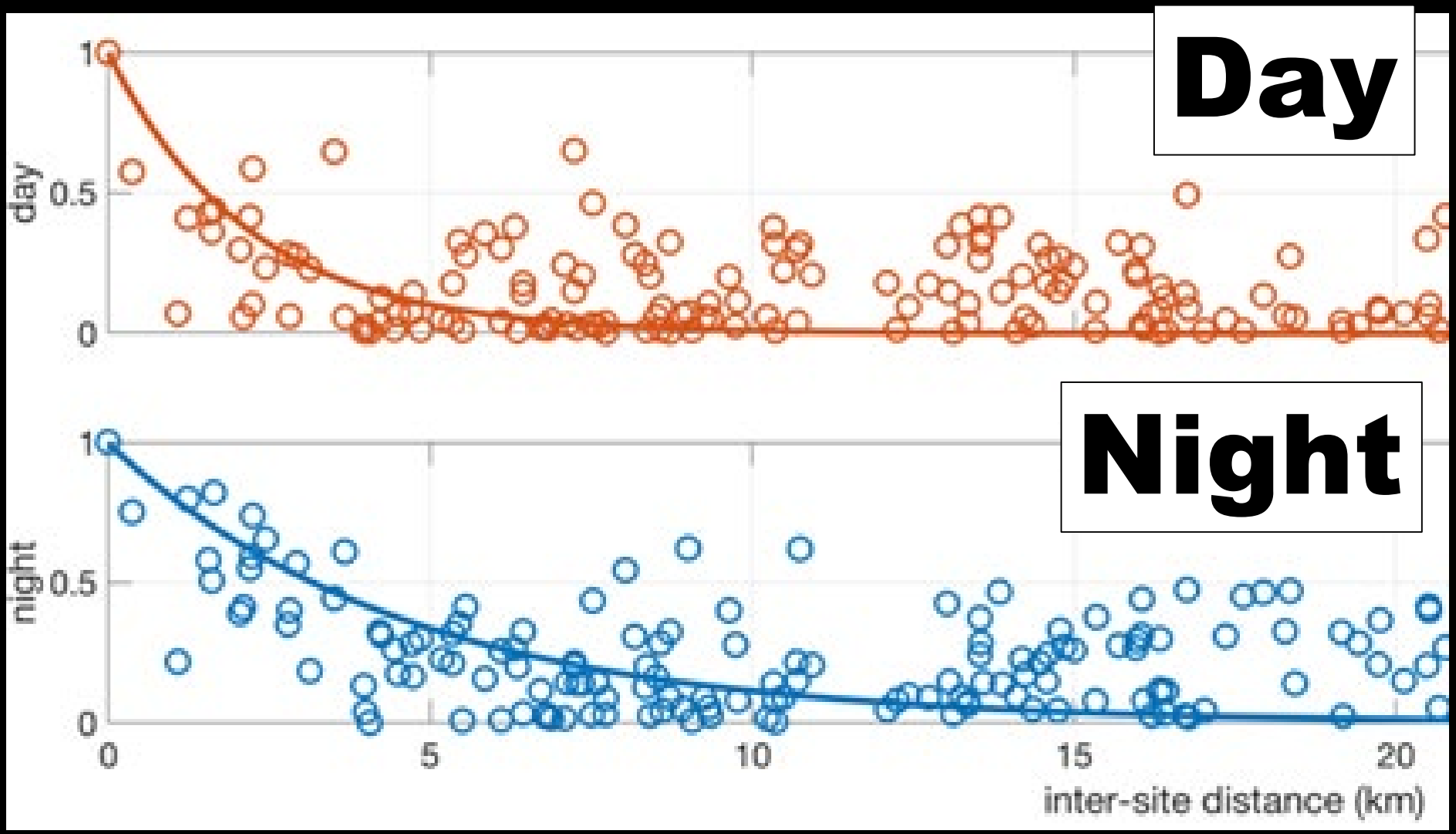

Laney - March 2016
CO2 (ppm)
550
500
450
Aerosol (µg.m-3)
20
16
12
8
CO (ppb)
1000
800
600
400
200
NO (ppb)
150
100
50
NO2 (ppb)
50
40
30
20
10
0
O3 (ppb)
50
40
30
20
10
0
Mar 07
Mar 14
Mar 21
Mar 28

Network scale relationships

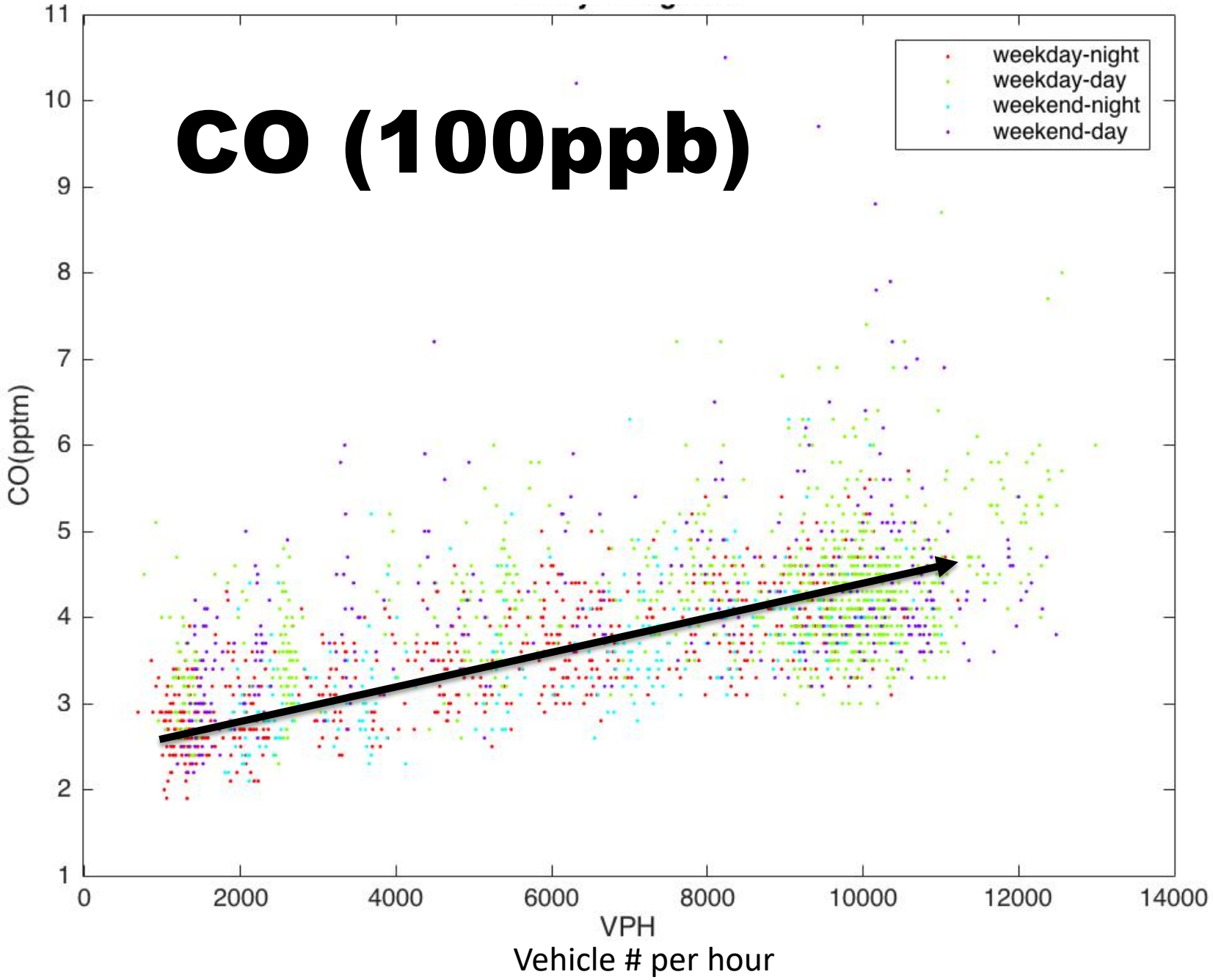
CO_2 correlation length scale

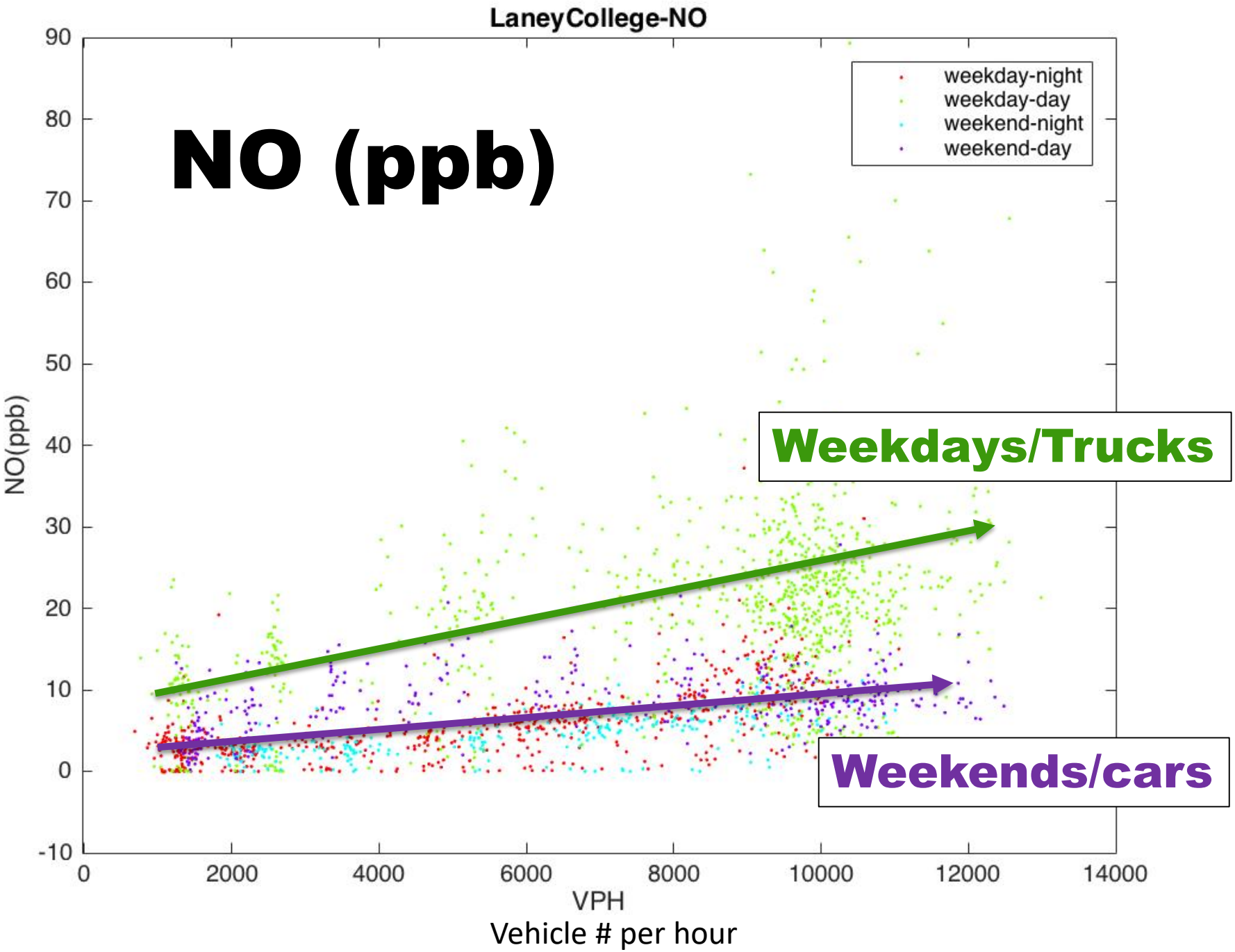


CO_2 correlation length scale



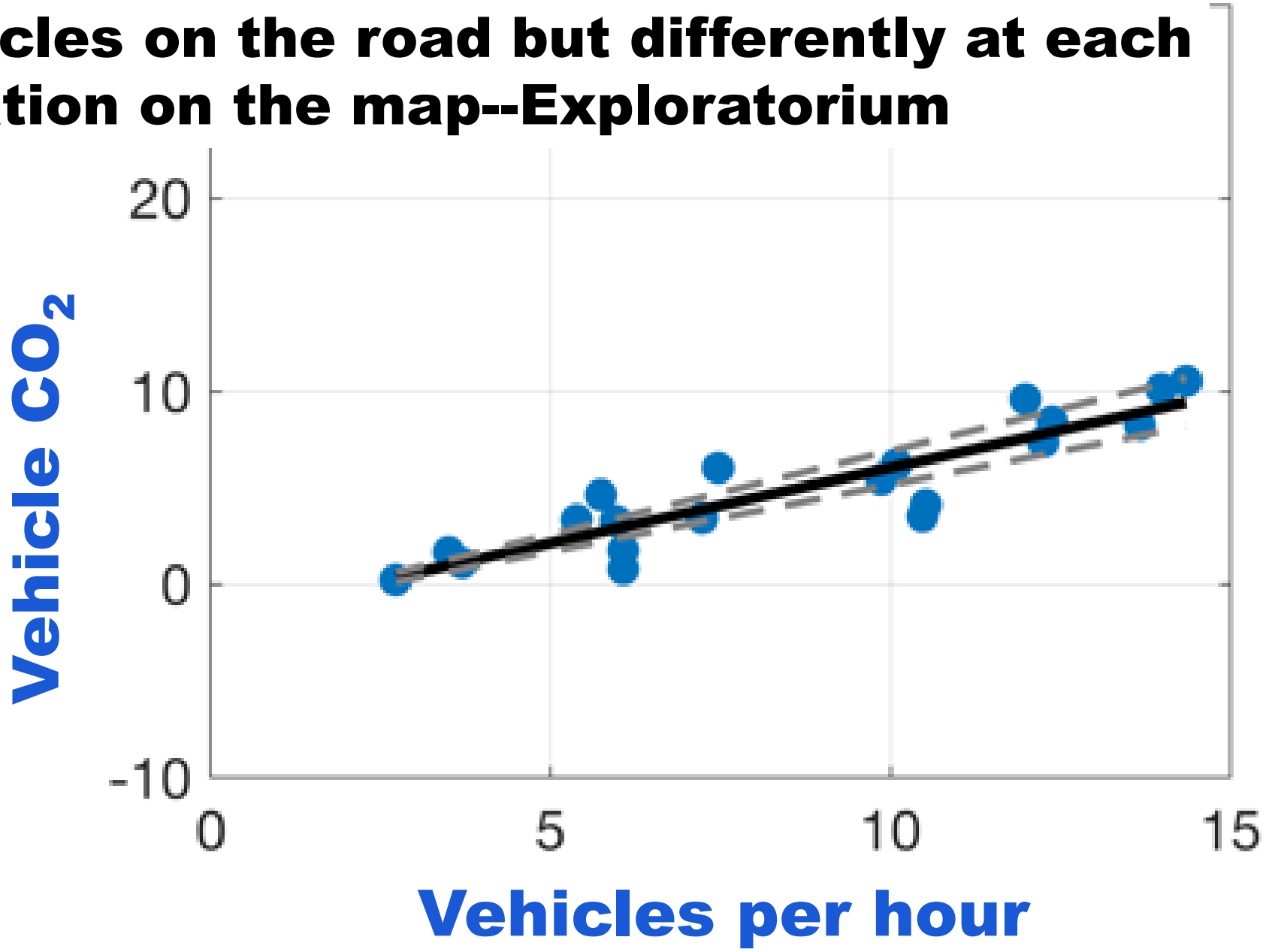
Emissions per vehicle


CO (100ppb)
weekday-night
weekday-day
weekend-night
weekend-day
CO(pptm)
VPH
Vehicle # per hour
0
2000
4000
6000
8000
10000
12000
14000
1
2
3
4
5
6
7
8
9
10
11



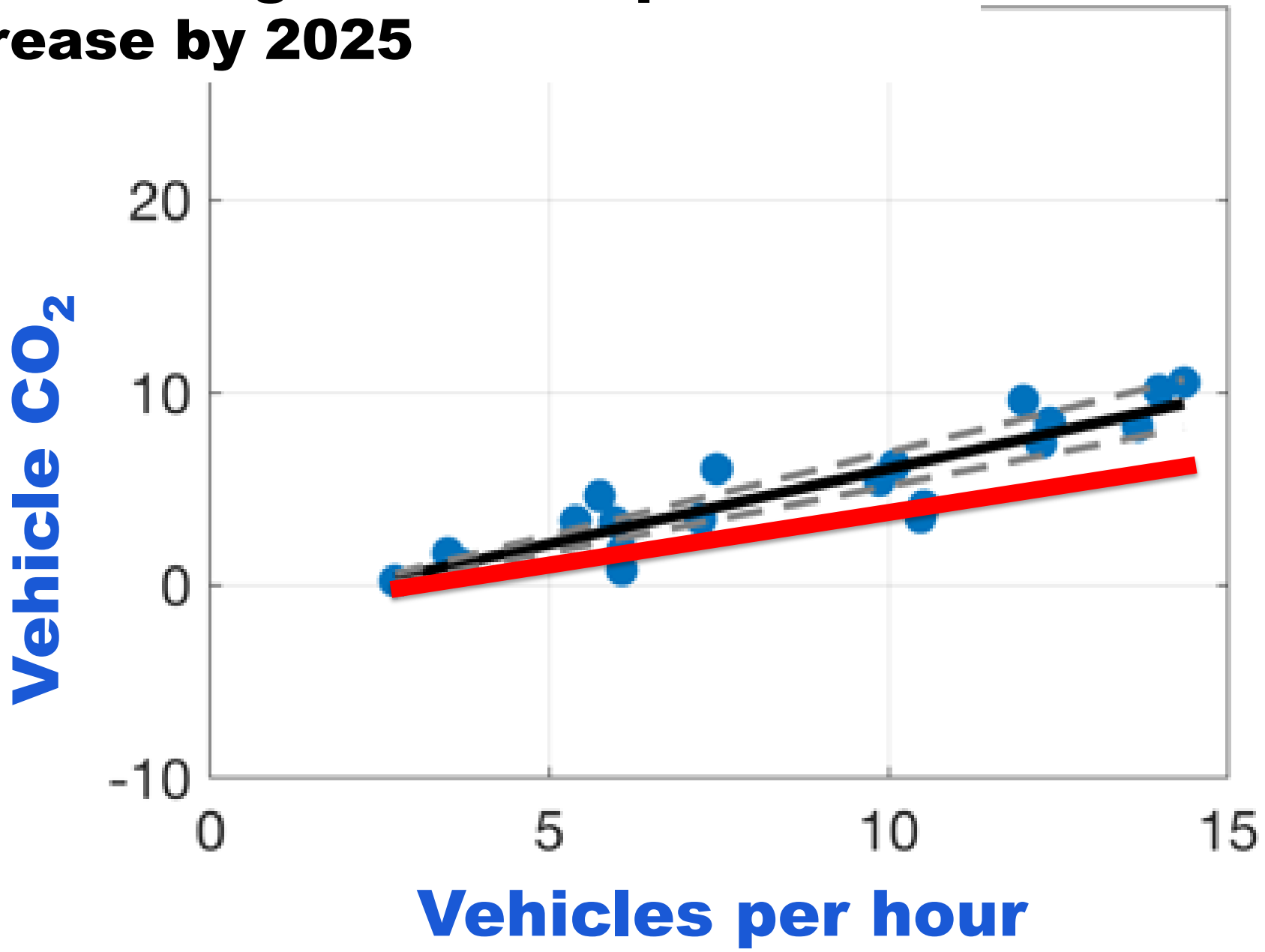
Vehicle # per hour

CO_2 in the network follows the number of vehicles on the road but differently at each location on the map--Exploratorium



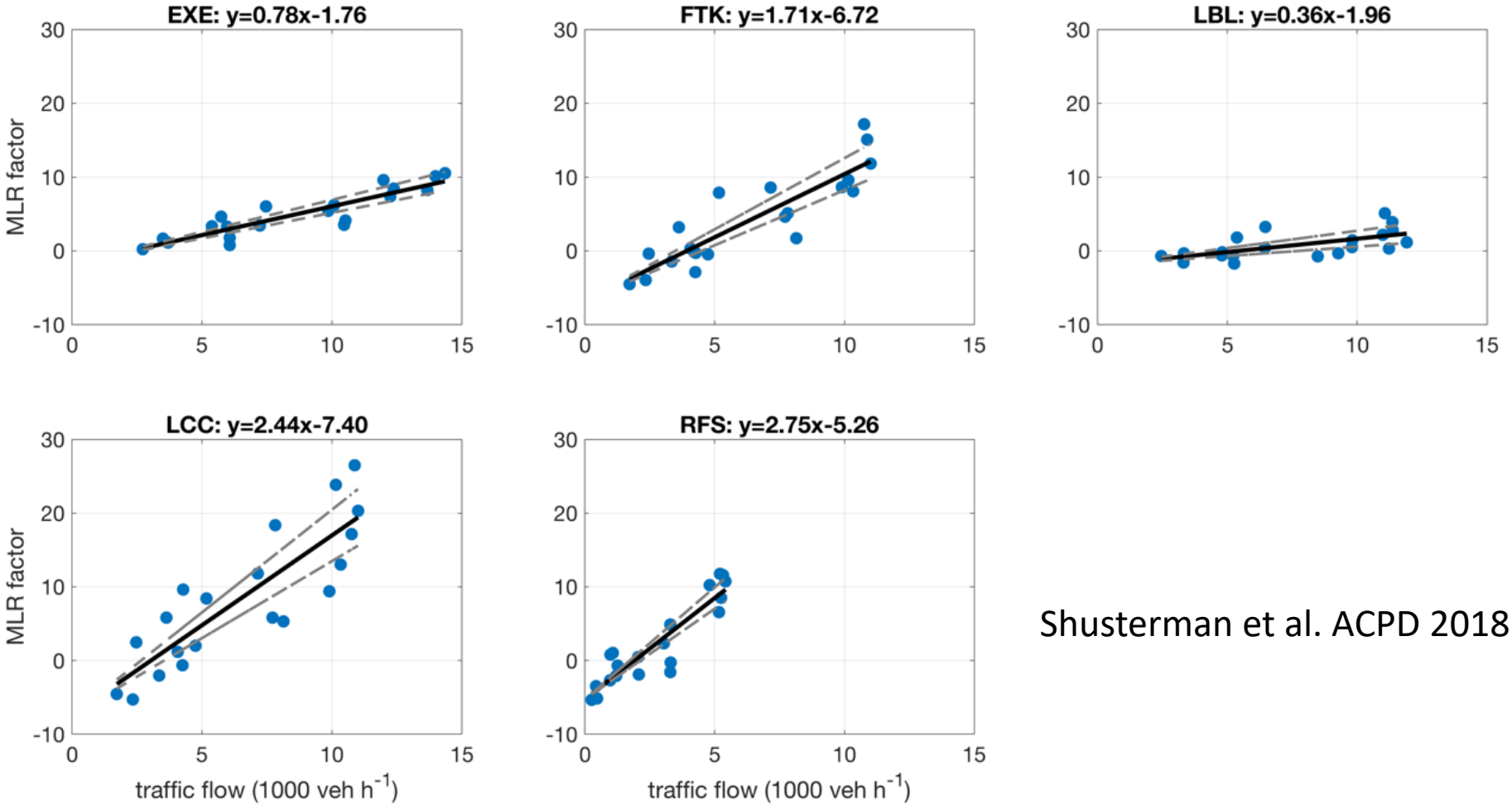
Shusterman et al. ACPD 2018

California regulations require 35% decrease by 2025



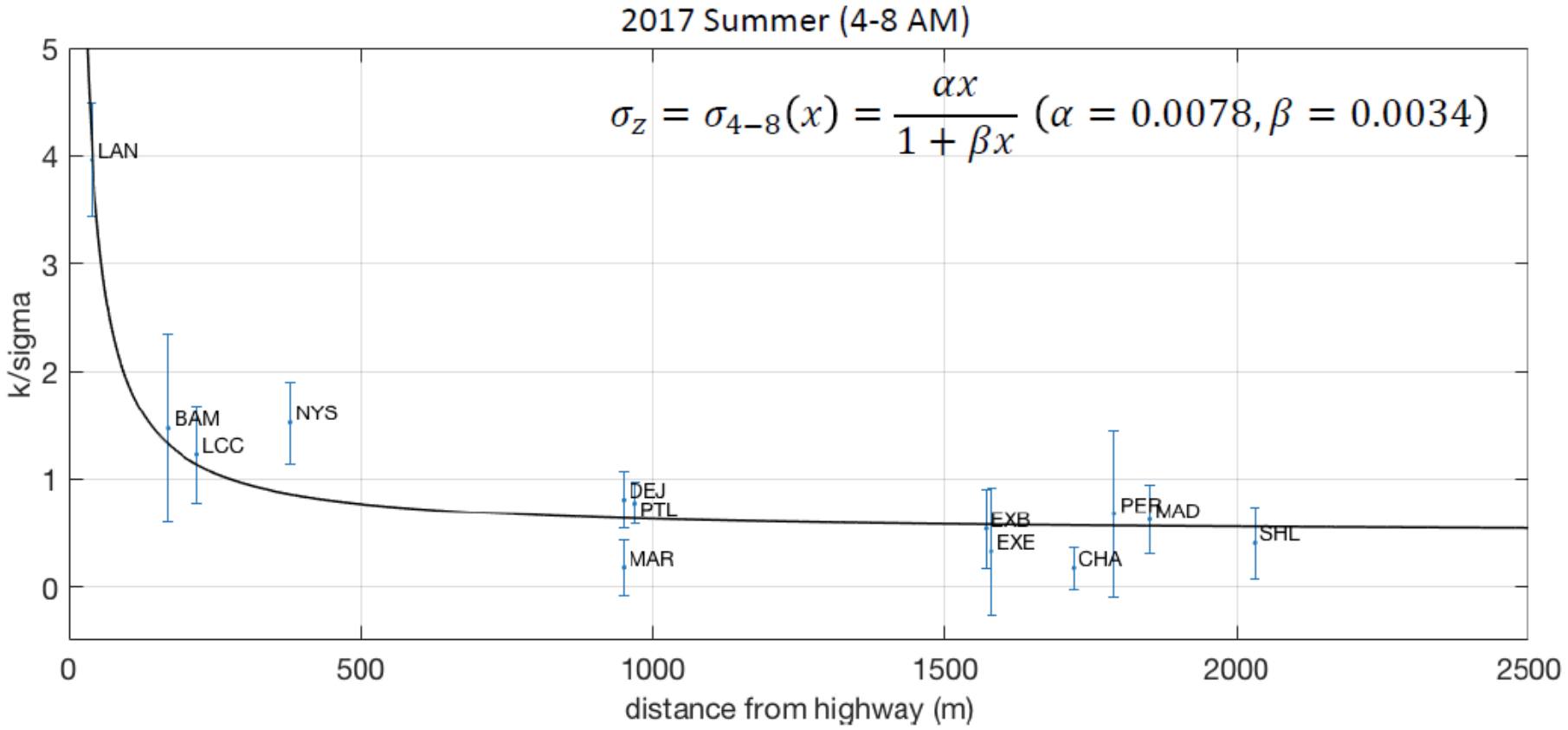
Shusterman et al. ACPD 2018

CO_2 throughout the network is correlated with the number of vehicles on the road

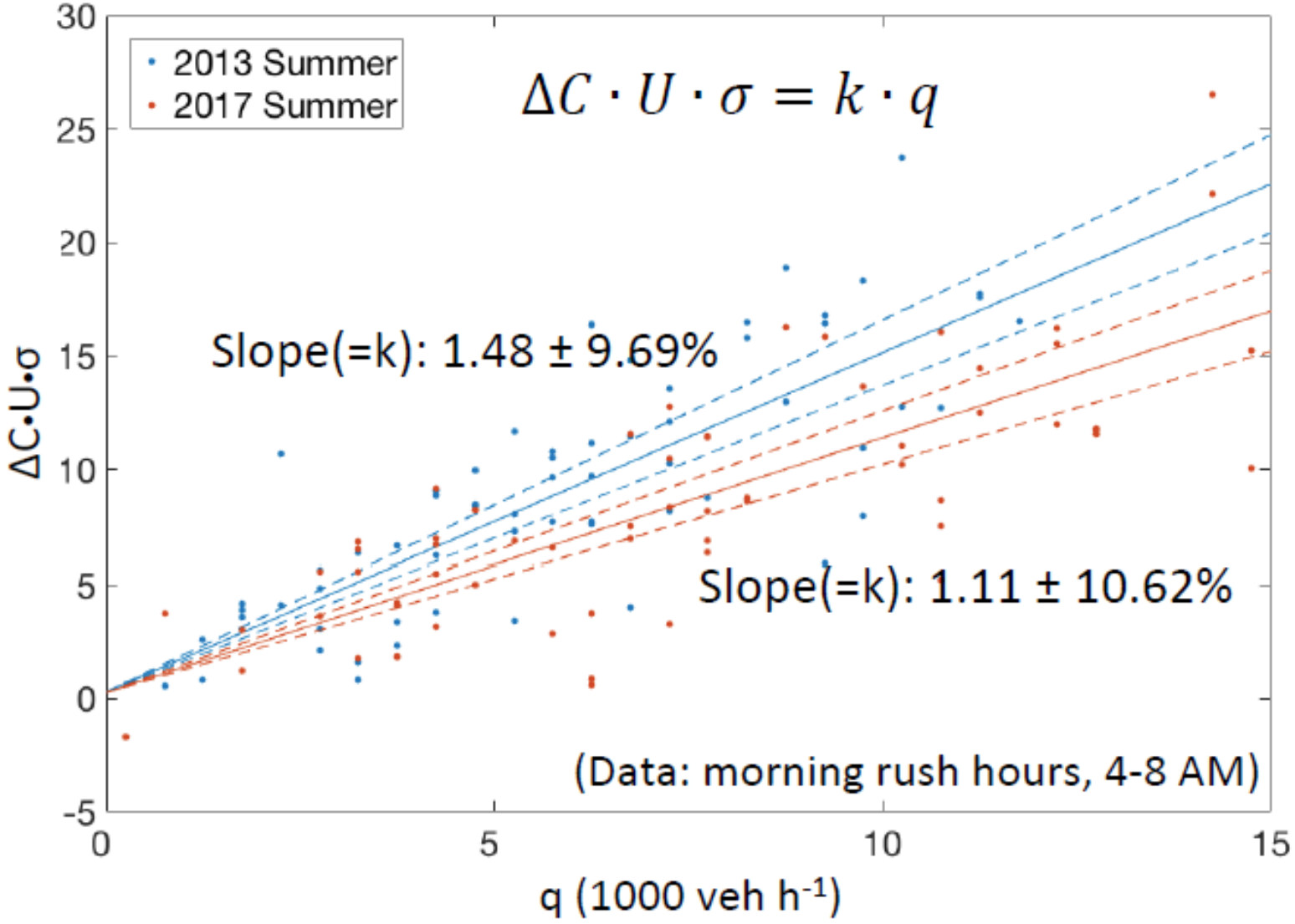


Shusterman et al. ACPD 2018

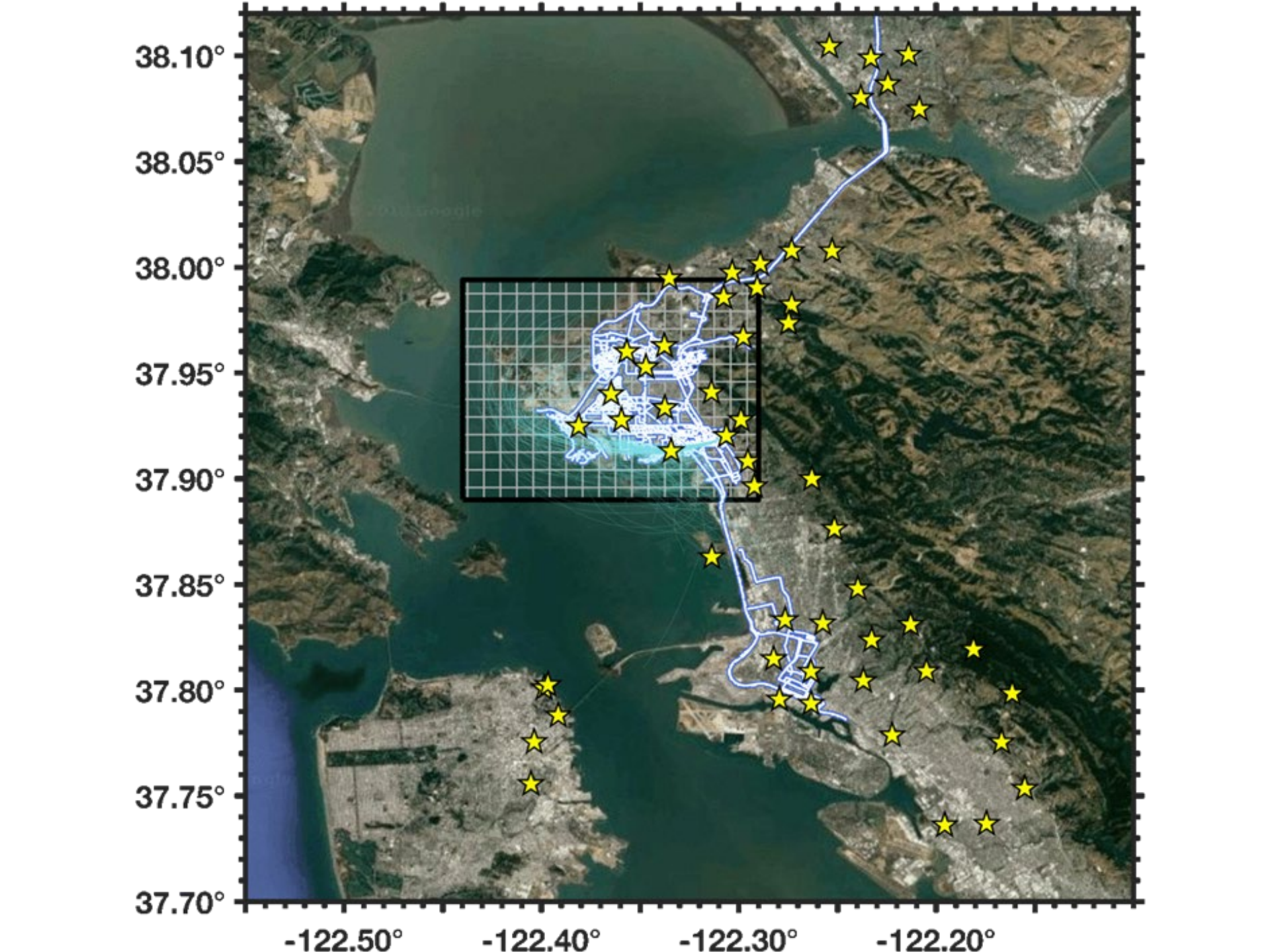
Organize correlation with vehicle number by distance from the highway



From 2013-2017 we find a ~25% decrease in emissions/vehicle.
Tabulated data suggests a ~10% decrease.



Toward more formal inversions


38.10°
38.05°
38.00°
37.95°
37.90°
37.85°
37.80°
37.75°
37.70°
-122.50°
-122.40°
-122.30°
-122.20°

Conclusions and Outlook

High space and time resolution observations using networks with multiple chemicals and aerosol offer a new window into mechanisms affecting emissions and chemistry in cities.

We are:

- **learning to interpret dense networks as more than the sum of individual instruments.**
- **learning to think about daily variability in ways that teach us about processes.**

BEACO$_2$N: A high spatial resolution observing system for GHGs (CO_2) and air quality (CO, O_3, NO, NO_2, particles)

CO_2

A.A. Shusterman, V. Teige, A.J. Turner, C. Newman, J. Kim, and R.C. Cohen: T*he BErkeley Atmospheric CO_2 Observation Network: initial evaluation*, Atmos. Chem. Phys., 2016.

A.J. Turner, A.A. Shusterman, B.C. McDonald, V. Teige, R.A. Harley and R.C. Cohen, *Network design for quantifying urban CO_2 emissions: Assessing tradeoffs between precision and network density* Atmos. Chem. Phys., 2016.

A.A. Shusterman, J. Kim, K.J. Lieschke, C. Newman, P.J. Wooldridge, R.C. Cohen, *Observing local CO_2 sources using low-cost, near-surface urban monitors*, Atmos. Chem. Phys. 2018.

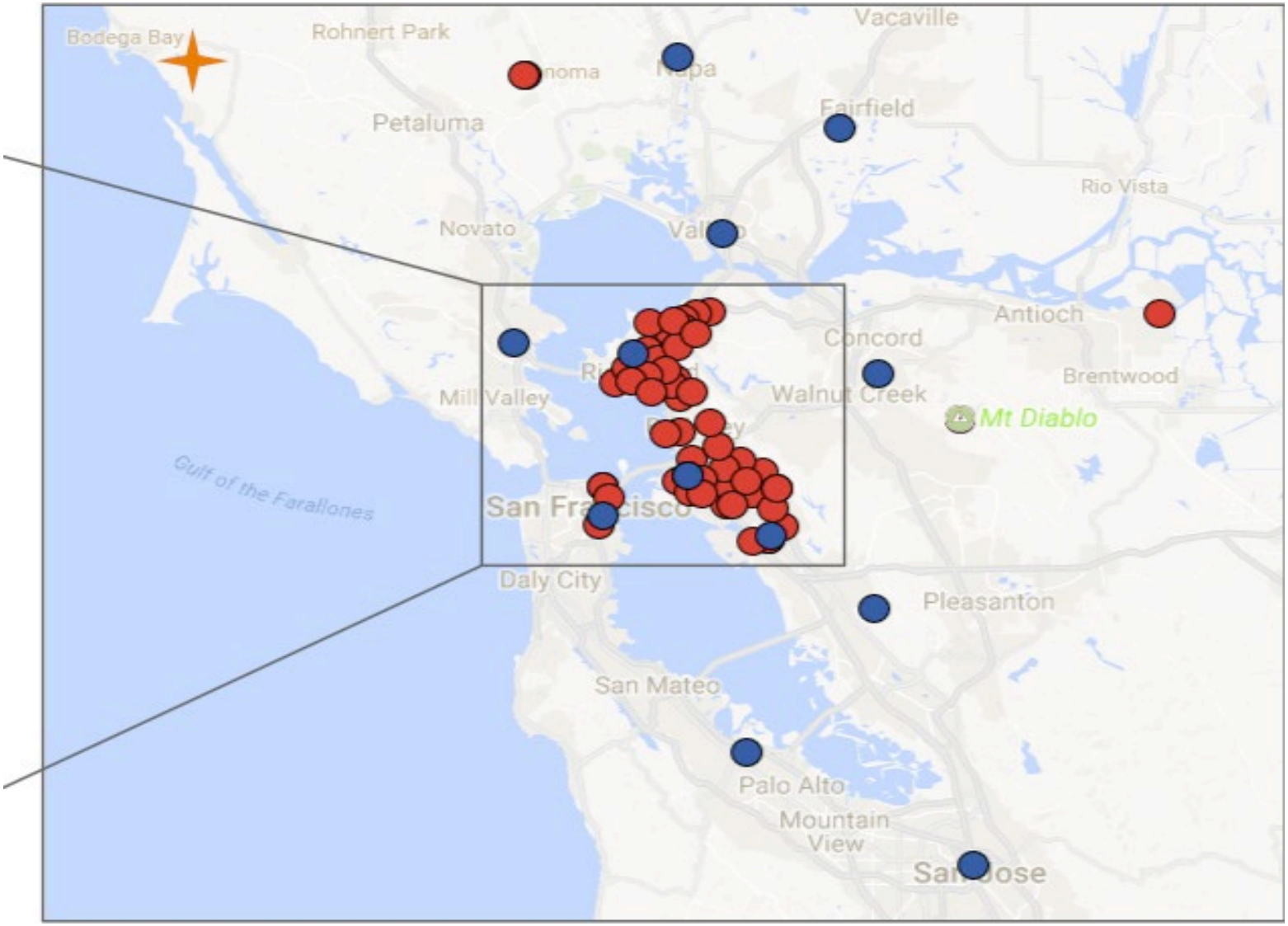
AQ gases

J. Kim, A.A. Shusterman, K.J. Lieschke, C. Newman, and R.C. Cohen, The BErkeley Atmospheric CO_2 Observation Network: field calibration and evaluation of low-cost air quality sensors, Atmos. Meas. Tech., 2018.

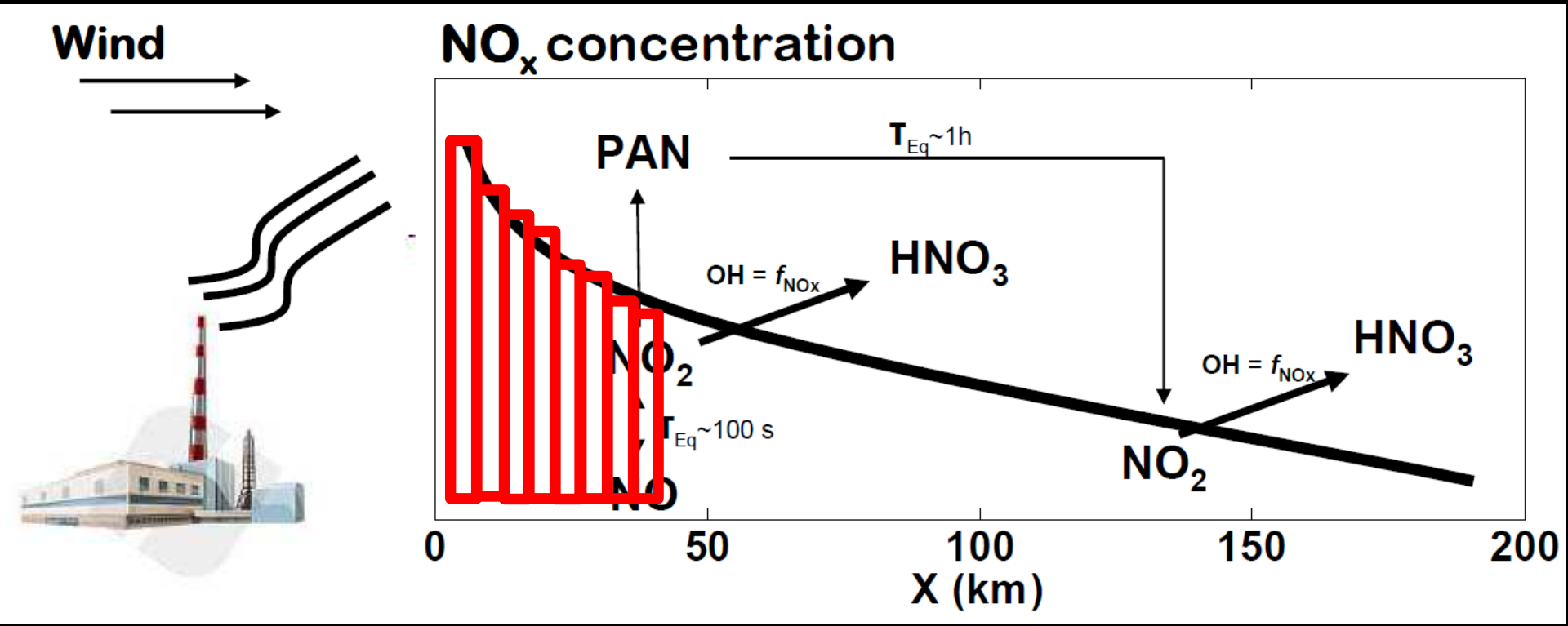
Aerosol

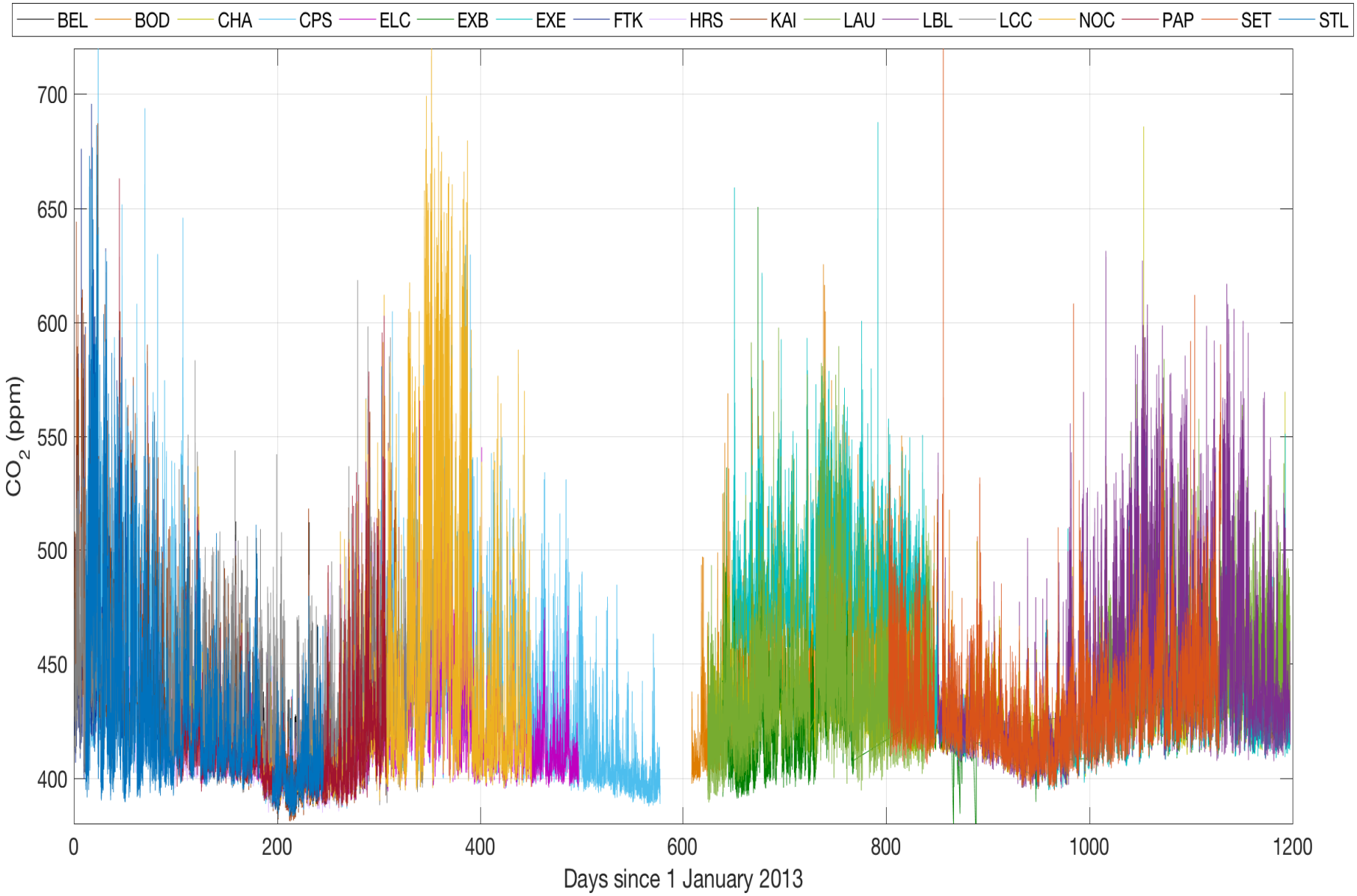
Thank you!

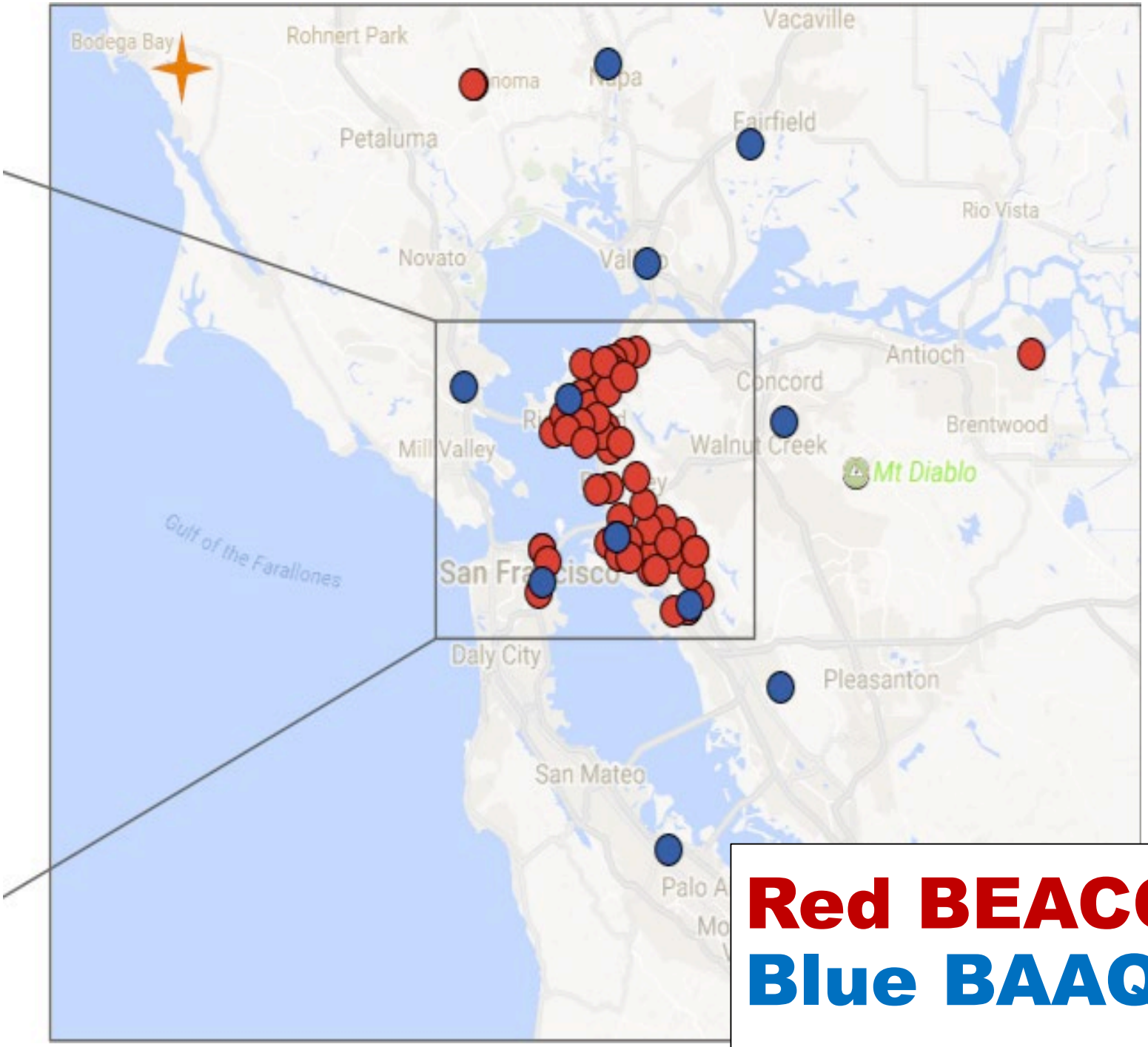
Red—high resolution map BEACO$_2$N.
Blue—Standard mapping, BAAQMD



TEMPO – UV/Vis instrument in GEO actual is twice resolution shown; hourly in sunlight




BEL
BOD
CHA
CPS
ELC
EXB
EXE
FTK
HRS
KAI
LAU
LBL
LCC
NOC
PAP
SET
STL
700
650
600
550
500
450
400
CO_2 (ppm)
0
200
400
600
800
1000
1200
Days since 1 January 2013


Bodega Bay
Rohnert Park
Vacaville
Petaluma
Fairfield
Rio Vista
Novato
Antioch
Concord
Brentwood
Walnut Creek
Mill Valley
Mt Diablo
Gulf of the Farallones
San Francisco
Daly City
Pleasanton
San Mateo
Red BEACO2N
Blue BAAQMD