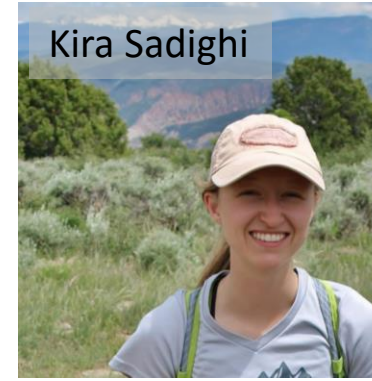


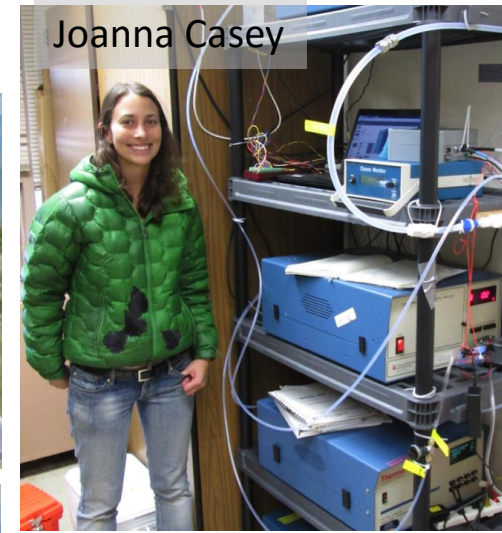
# Case studies of O<sub>3</sub> and methane small sensor networks in LA and Colo Front Range

Mike Hannigan

Nick Masson, Ana Ilie, Jake Thorson, Lauren Deanes, Mike Russell, Drew Meyers, Rebecca Bullard, Rachel Moore, Rob Dick, Li Shang, Qin Lv, Daven Henze, Bill Griswold, Max Menarini, Jill Johnston, Bhavna Shamasunder, Niki Wong, Esperanza Community Housing, Brandon Feenstra, Andrea Polidori, Hannah Halliday, Boulder County Public Health, Colorado Dept of Public Health and the Environment, SCAQMD



Kira Sadighi



Joanna Casey



Katya Hafich



Evan Coffey



Pods



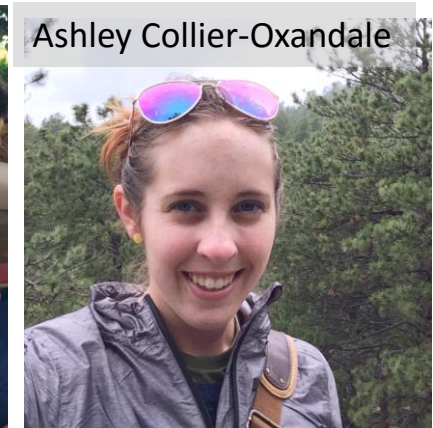
Pods



Lucy Cheadle



Ricardo Piedrahita



Ashley Collier-Oxandale



# AQ-IQ (Air Quality InQuiry)

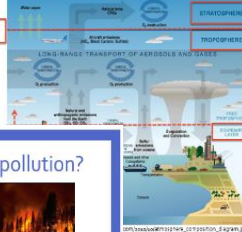
## Education & Outreach Program

### 1. Project-based Learning Curriculum

An Introduction to Air Quality

AirWaterGas

Our atmosphere differs on the surface of the earth



What are the primary causes of air pollution?

- Combustion
- Chemicals
- Some compounds volatilize (enter the gas phase)
- Mechanically generated (e.g., dust)



Meteorology in Carbon Dioxide

Date and Time	CO2 (ppm)	Temperature (deg. C)	Relative Humidity (%)	Wind Speed (m/s)	Wind Direction	CO2 (ppm)	Temperature (deg. C)	Relative Humidity (%)	Wind Speed (m/s)	Wind Direction
1	415.2	15.2	22.1	1.2	135	415.2	15.2	22.1	1.2	135
2	415.1	15.1	21.5	1.1	135	415.1	15.1	21.5	1.1	135
3	415.0	15.0	21.0	1.0	135	415.0	15.0	21.0	1.0	135
4	414.9	14.9	20.5	0.9	135	414.9	14.9	20.5	0.9	135
5	414.8	14.8	20.0	0.8	135	414.8	14.8	20.0	0.8	135
6	414.7	14.7	19.5	0.7	135	414.7	14.7	19.5	0.7	135
7	414.6	14.6	19.0	0.6	135	414.6	14.6	19.0	0.6	135
8	414.5	14.5	18.5	0.5	135	414.5	14.5	18.5	0.5	135
9	414.4	14.4	18.0	0.4	135	414.4	14.4	18.0	0.4	135
10	414.3	14.3	17.5	0.3	135	414.3	14.3	17.5	0.3	135
11	414.2	14.2	17.0	0.2	135	414.2	14.2	17.0	0.2	135
12	414.1	14.1	16.5	0.1	135	414.1	14.1	16.5	0.1	135
13	414.0	14.0	16.0	0.0	135	414.0	14.0	16.0	0.0	135
14	413.9	13.9	15.5	0.0	135	413.9	13.9	15.5	0.0	135
15	413.8	13.8	15.0	0.0	135	413.8	13.8	15.0	0.0	135
16	413.7	13.7	14.5	0.0	135	413.7	13.7	14.5	0.0	135
17	413.6	13.6	14.0	0.0	135	413.6	13.6	14.0	0.0	135
18	413.5	13.5	13.5	0.0	135	413.5	13.5	13.5	0.0	135
19	413.4	13.4	13.0	0.0	135	413.4	13.4	13.0	0.0	135
20	413.3	13.3	12.5	0.0	135	413.3	13.3	12.5	0.0	135
21	413.2	13.2	12.0	0.0	135	413.2	13.2	12.0	0.0	135
22	413.1	13.1	11.5	0.0	135	413.1	13.1	11.5	0.0	135
23	413.0	13.0	11.0	0.0	135	413.0	13.0	11.0	0.0	135
24	412.9	12.9	10.5	0.0	135	412.9	12.9	10.5	0.0	135
25	412.8	12.8	10.0	0.0	135	412.8	12.8	10.0	0.0	135
26	412.7	12.7	9.5	0.0	135	412.7	12.7	9.5	0.0	135
27	412.6	12.6	9.0	0.0	135	412.6	12.6	9.0	0.0	135
28	412.5	12.5	8.5	0.0	135	412.5	12.5	8.5	0.0	135
29	412.4	12.4	8.0	0.0	135	412.4	12.4	8.0	0.0	135
30	412.3	12.3	7.5	0.0	135	412.3	12.3	7.5	0.0	135

### 3. University Mentors



### 2. Technology Check-out Program

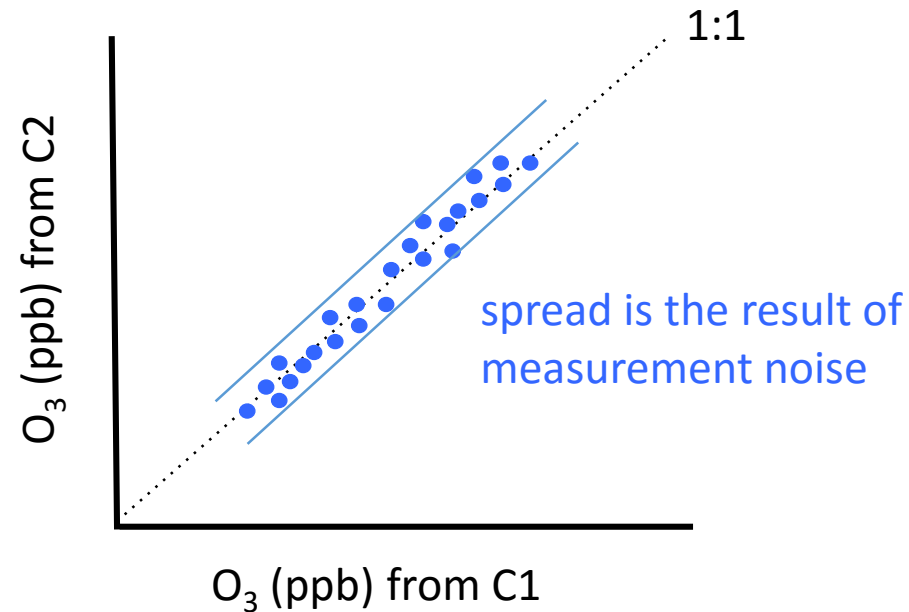
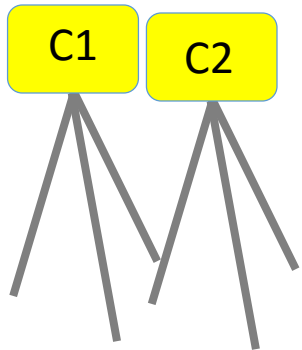
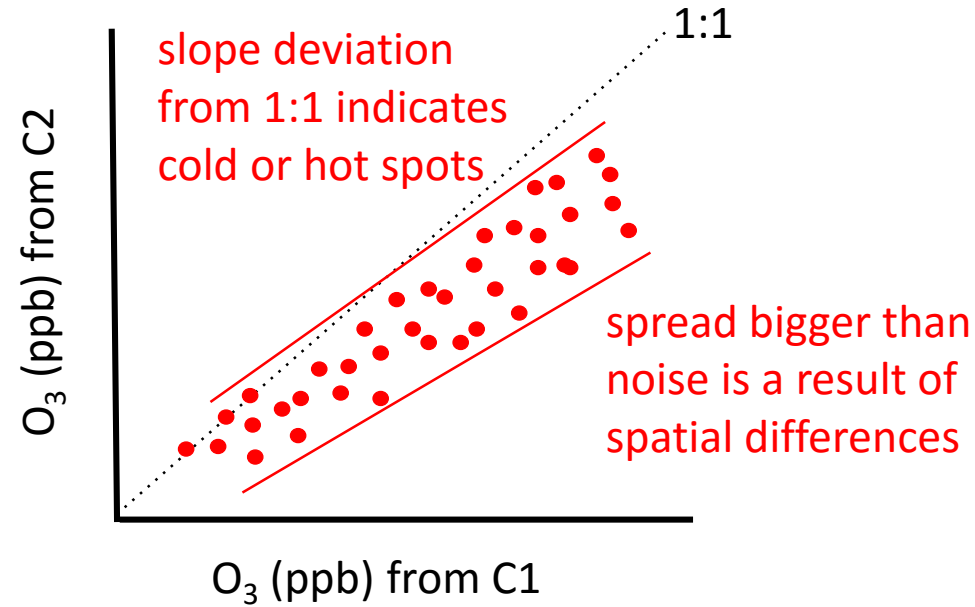
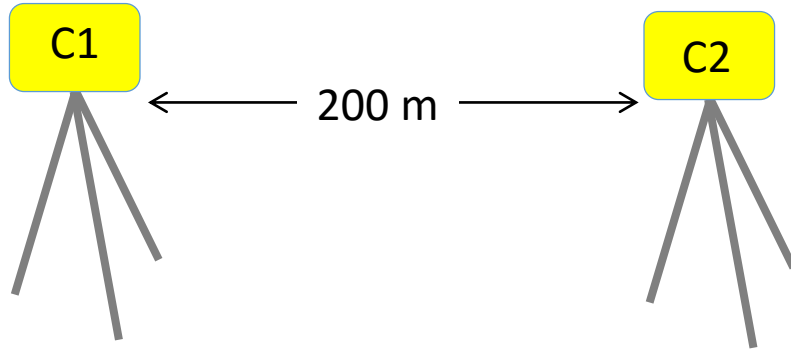


# Can $O_3$ sensors be used to help site regulatory ozone monitors?

- Can sensors find hot (or cold) spots for ambient  $O_3$  between regulatory monitoring stations?
- What spatial (and temporal) scale do we observe  $O_3$  concentration differences?
- Do trees impact  $O_3$  concentration?
- How much traffic does it take on a roadway to impact  $O_3$  concentration?
- Does local industry impact  $O_3$  concentration?

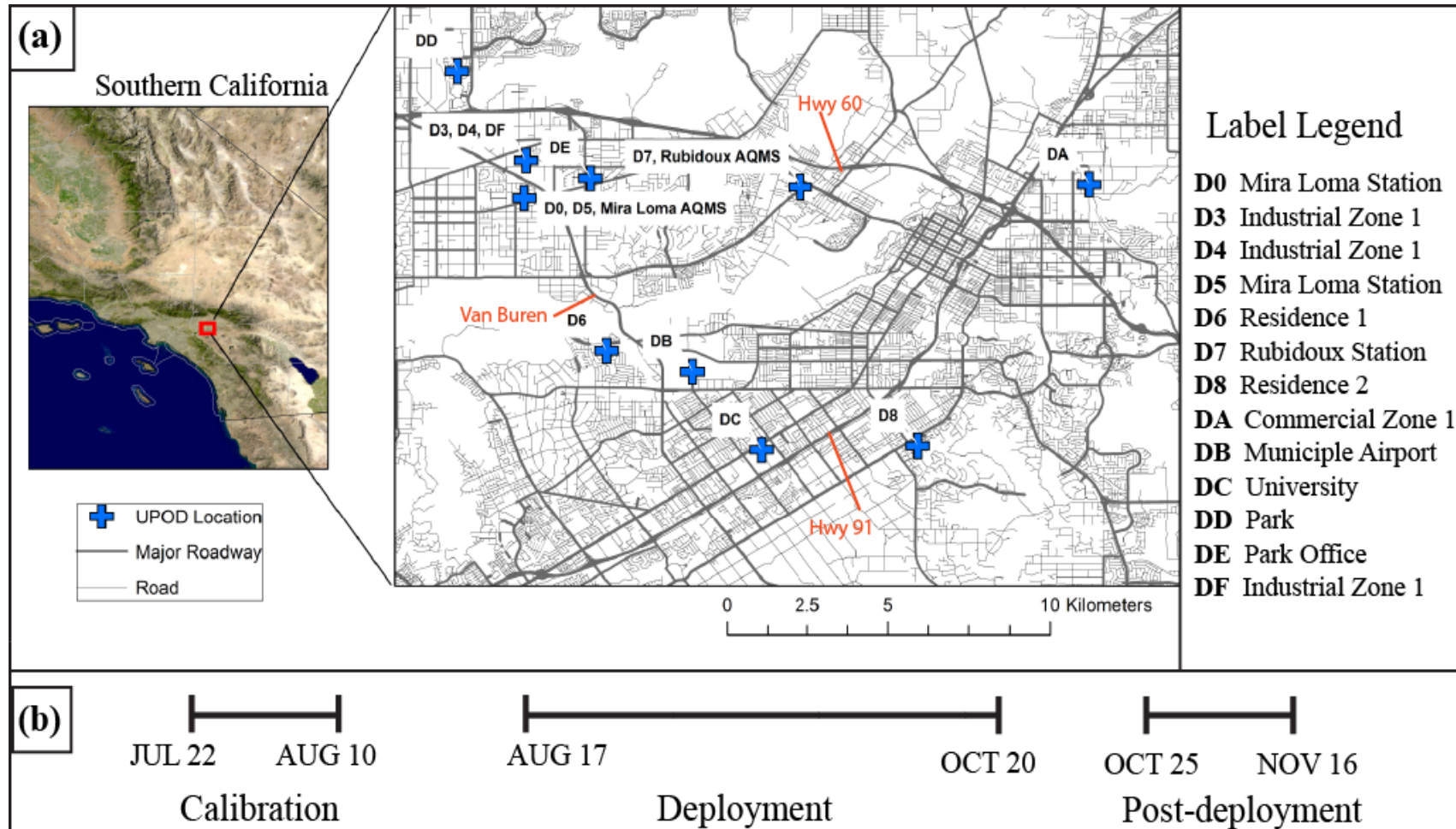


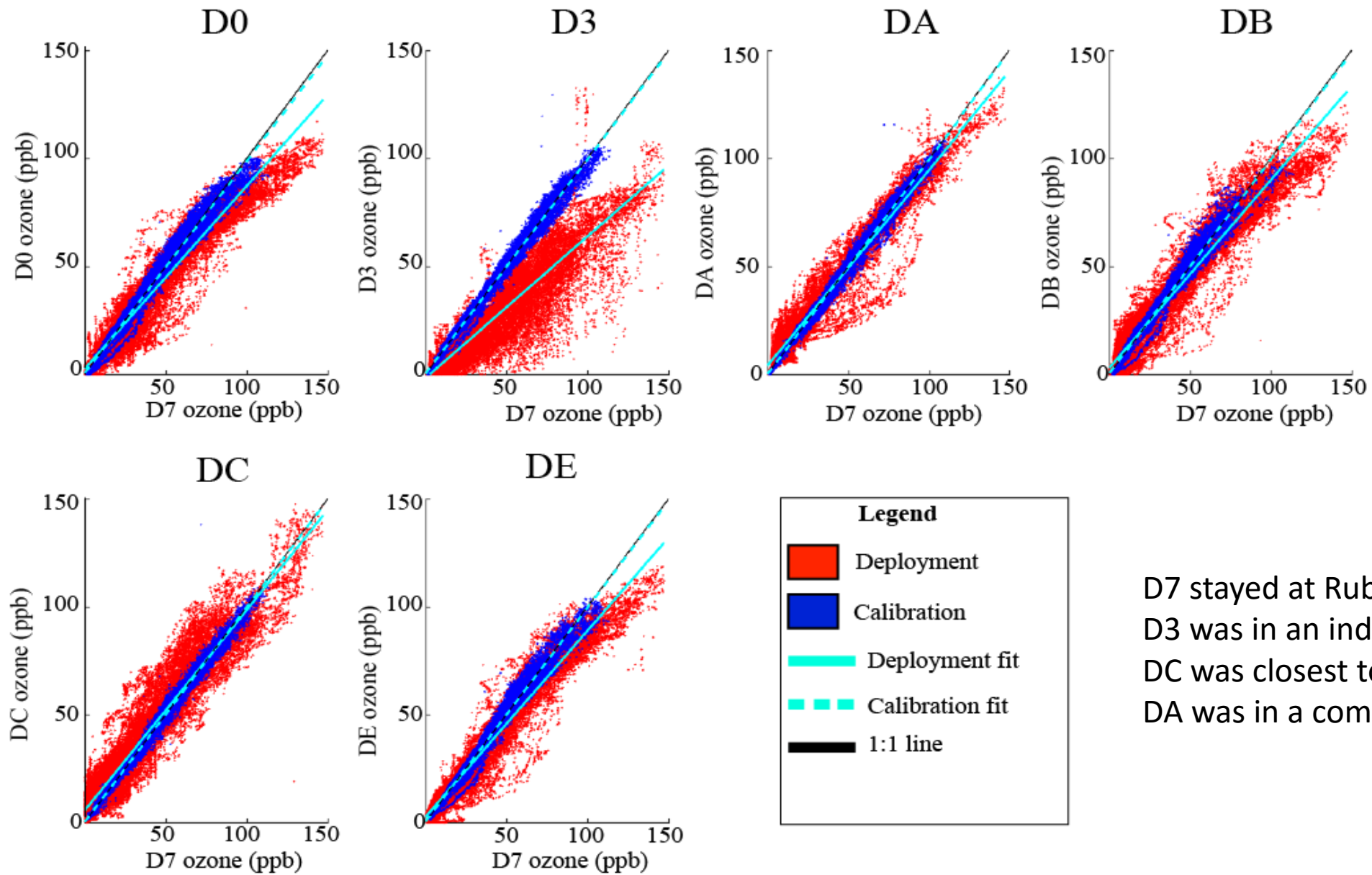
# How do you design this experiment?





# O<sub>3</sub> in Riverside during the summer 2015

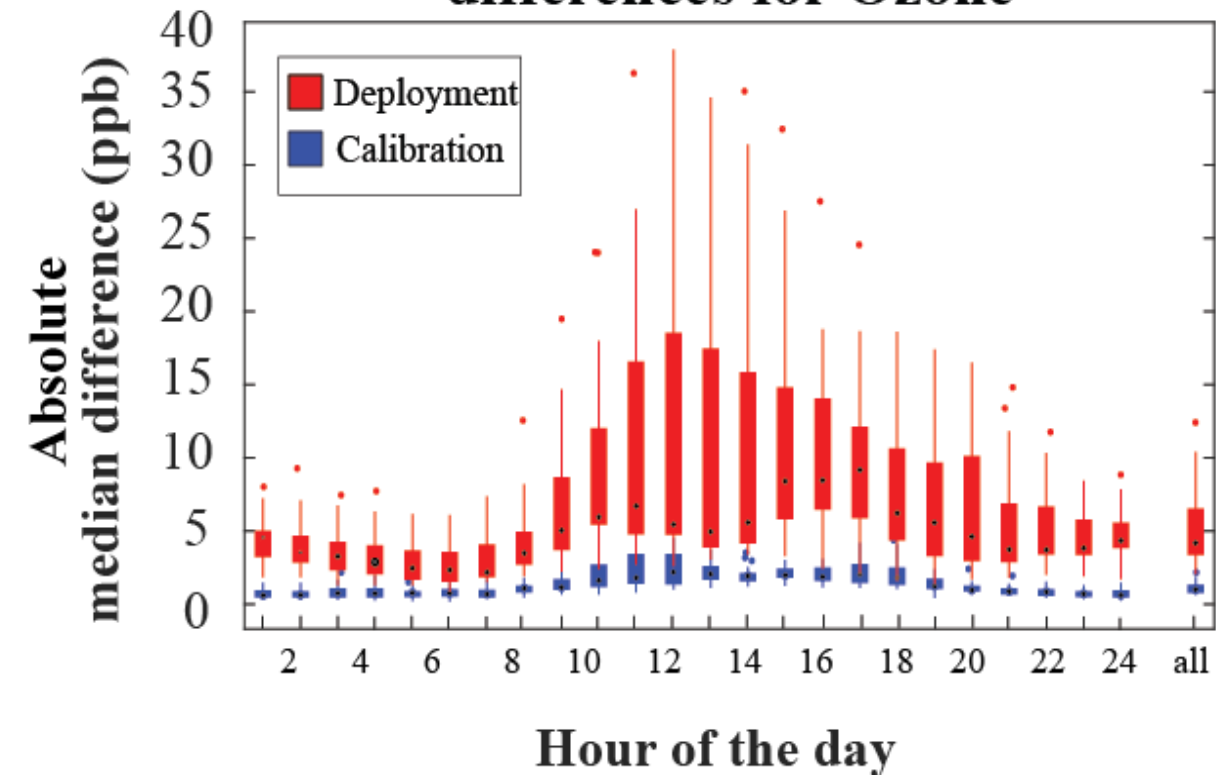




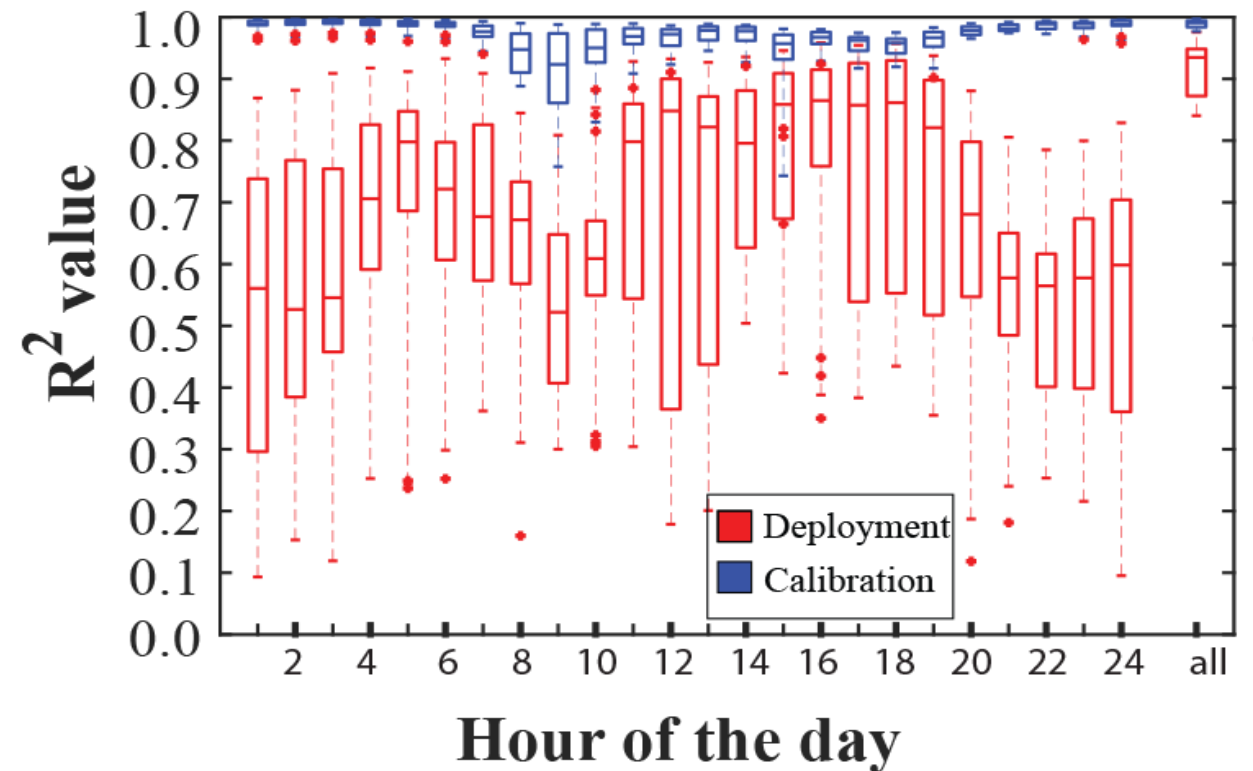
D7 stayed at Rubidoux SCAQMD site  
D3 was in an industrial park  
DC was closest to Highway 91  
DA was in a commercial zone

Since O<sub>3</sub> has a nice daily cycle, we should look at the data that way ...

**Deployment and calibration differences for Ozone**

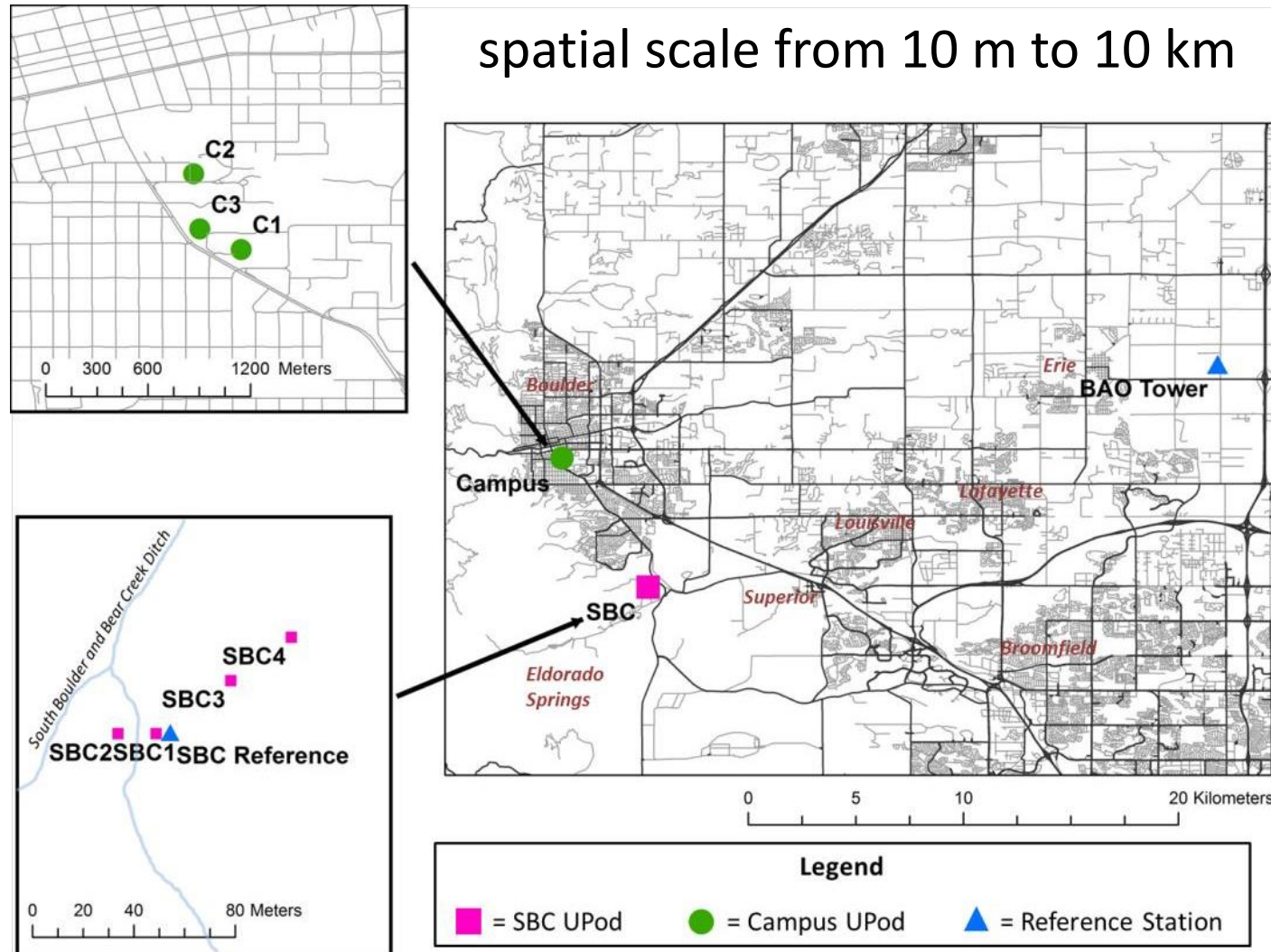


**R<sup>2</sup> values for ozone by time period**





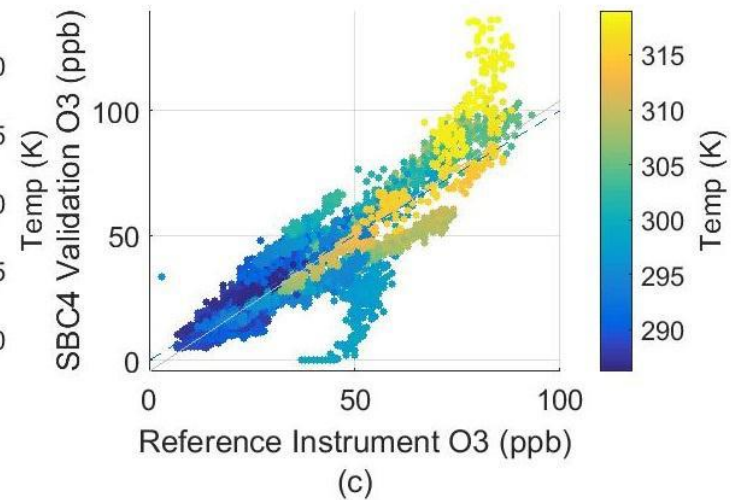
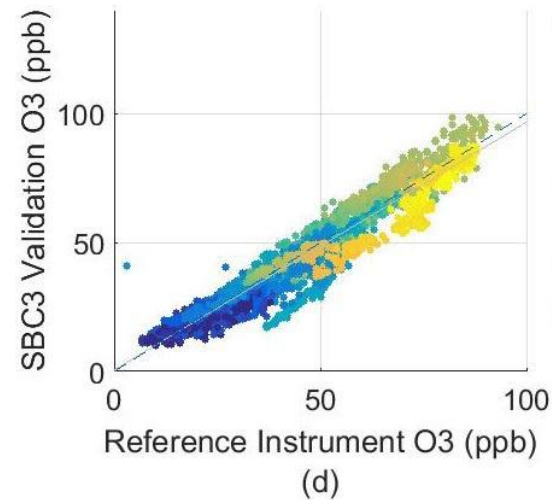
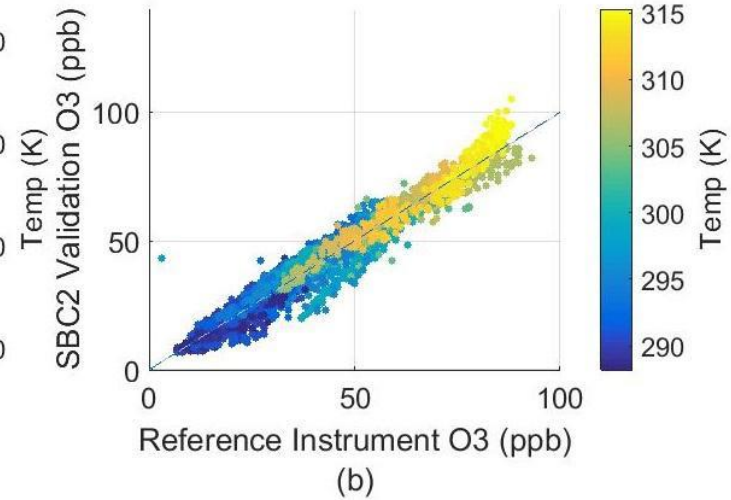
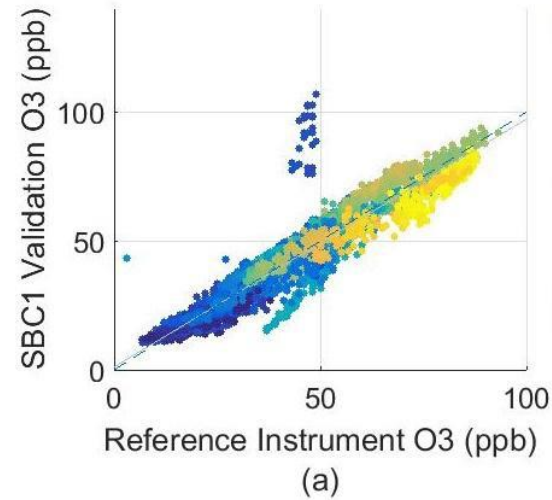
# O<sub>3</sub> in and around Boulder during summer 2015



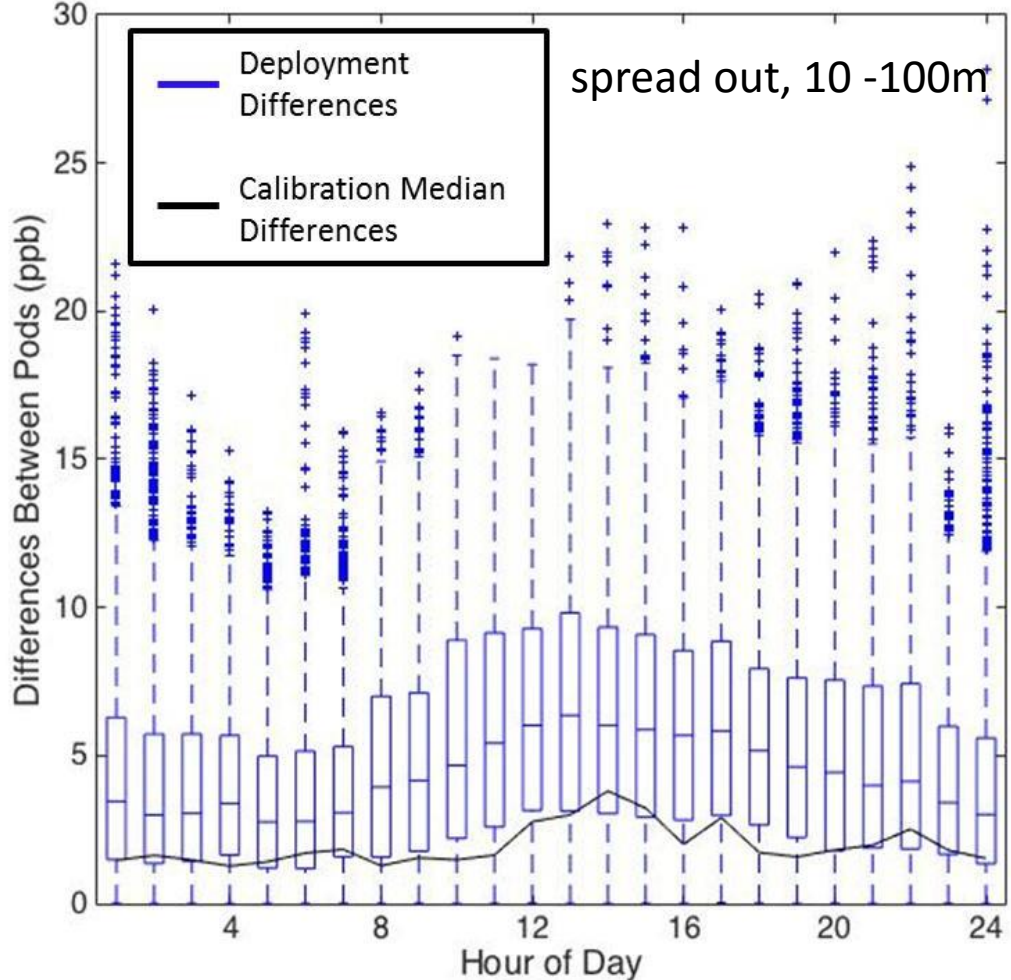
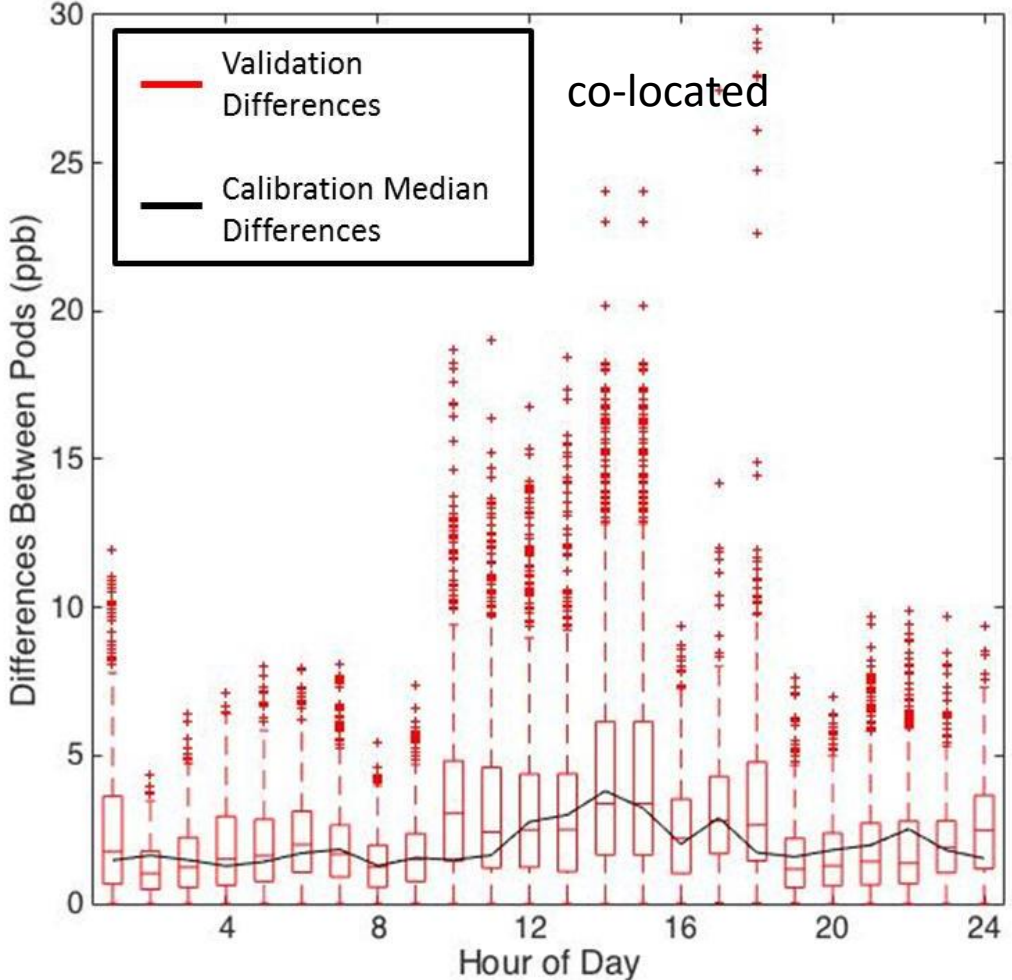
South Boulder Creek & CU campus



# How is the calibration/normalization working?



# Diurnal differences at South Boulder Creek



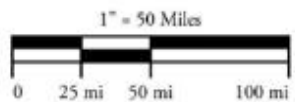
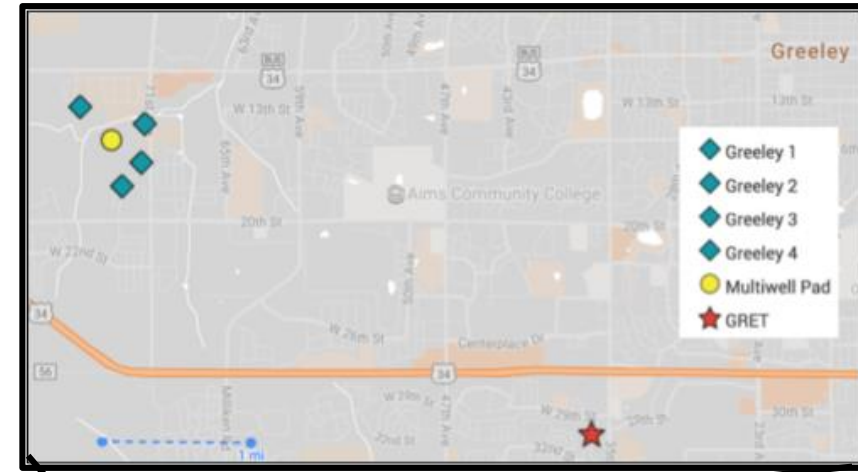
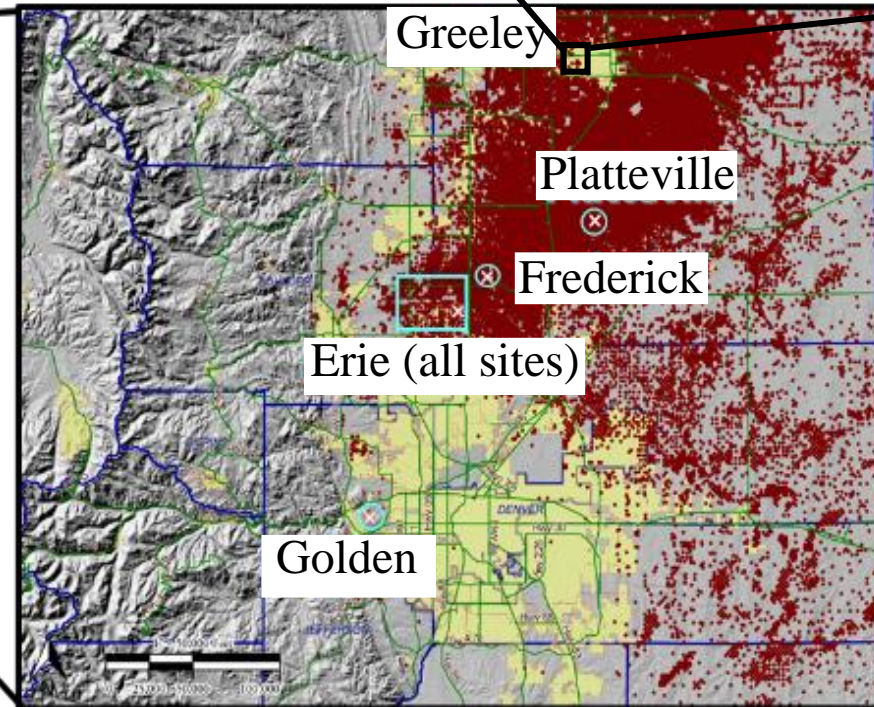
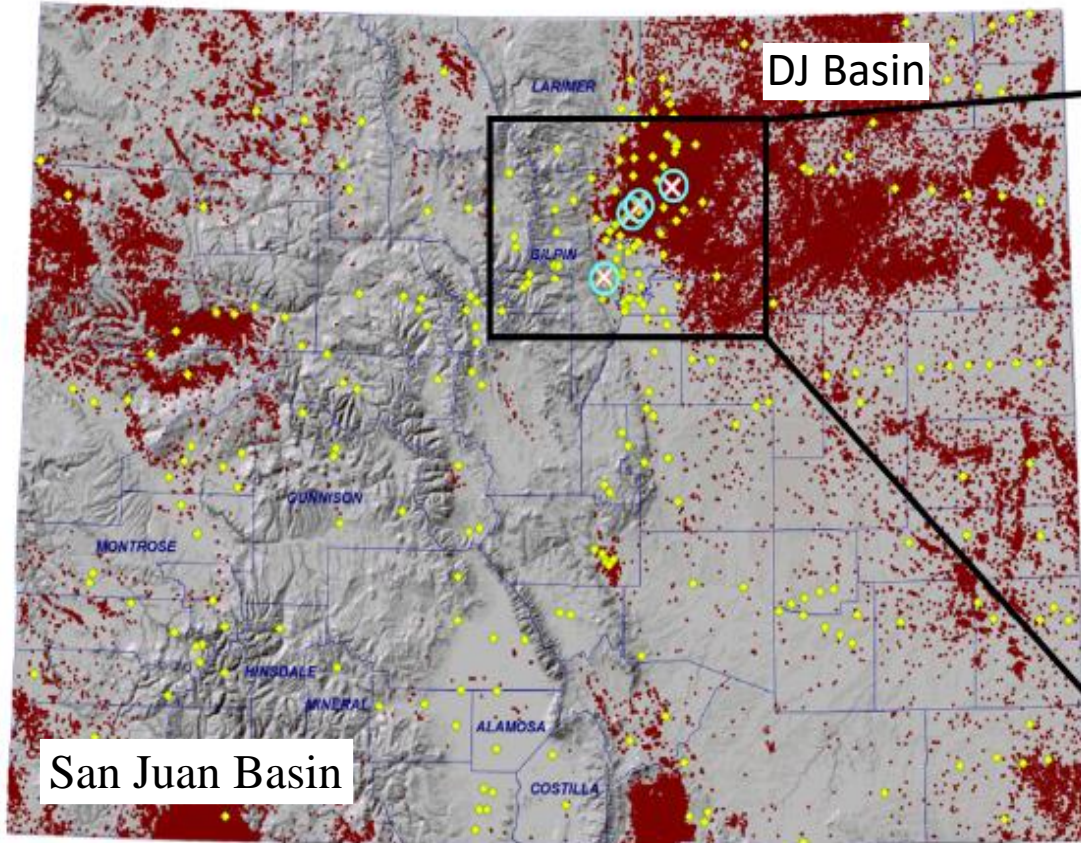


# Can a sensor system be used for community scale methane monitoring?

- What is the range of ambient methane concentrations in communities in oil and gas development basins?
- Can a sensor system “see” that range or is the spatial variability less than the instrument noise?
- If we can observe spatial differences, then what activities and/or processes are causes those differences?



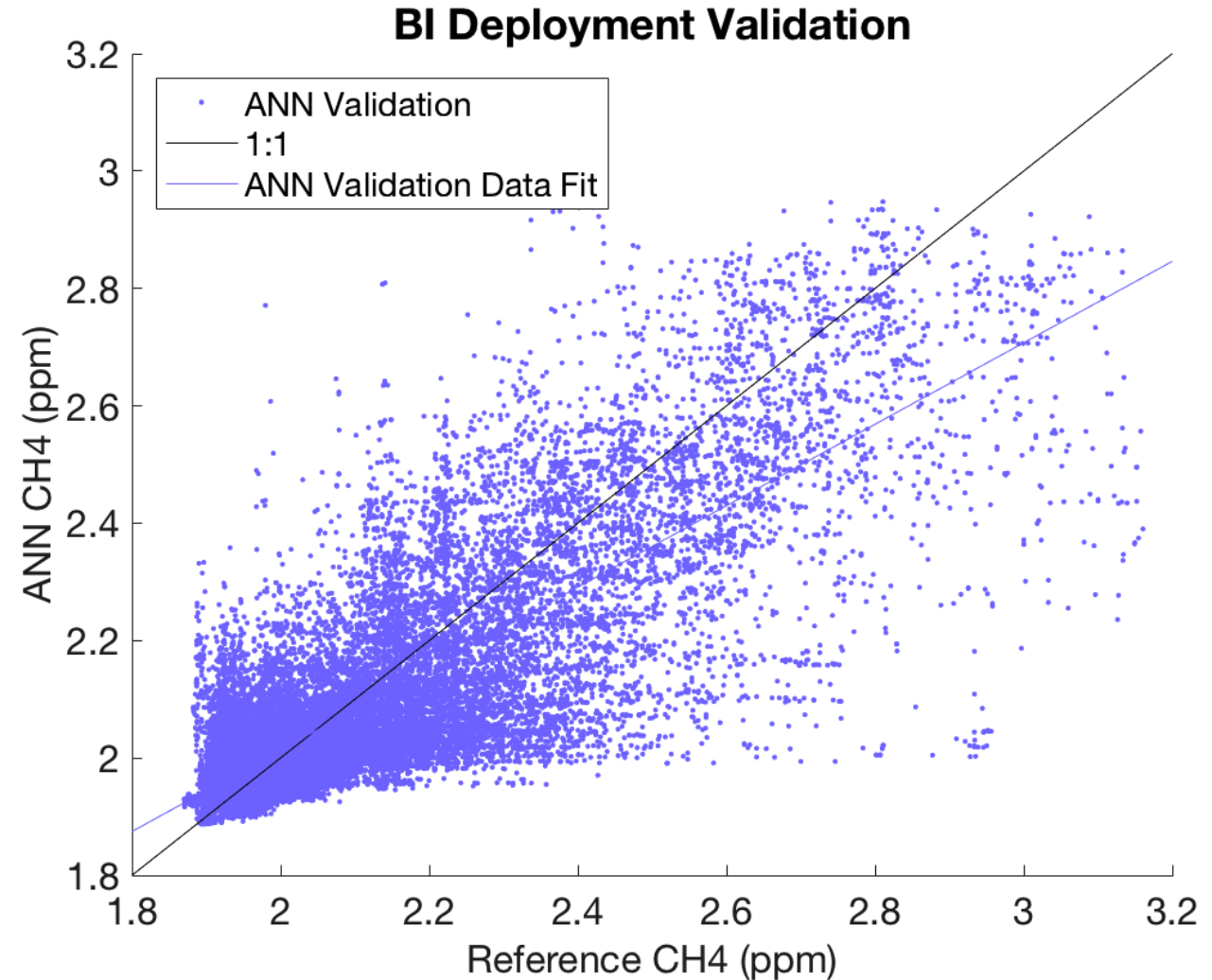
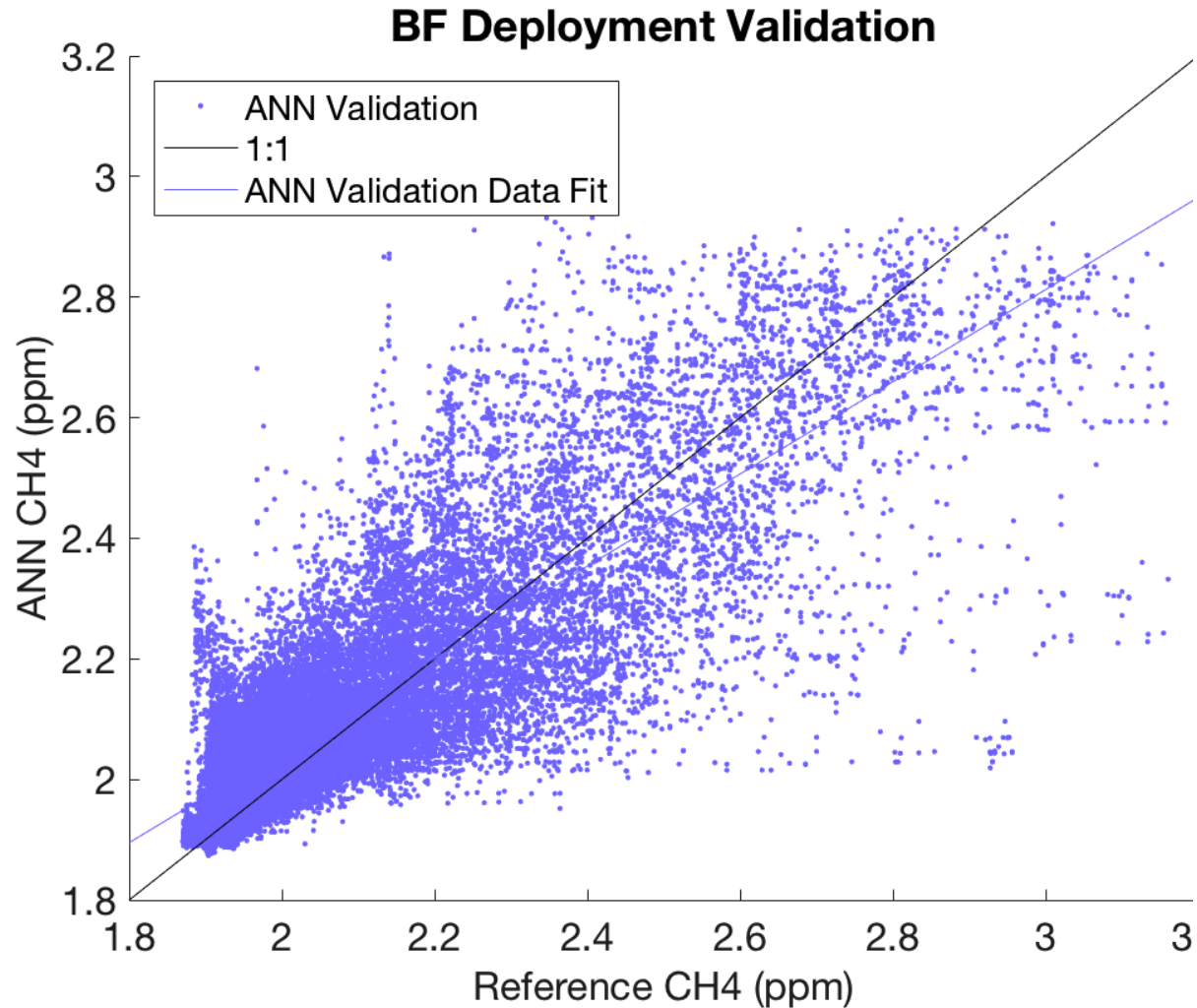
# Colorado sampling ...



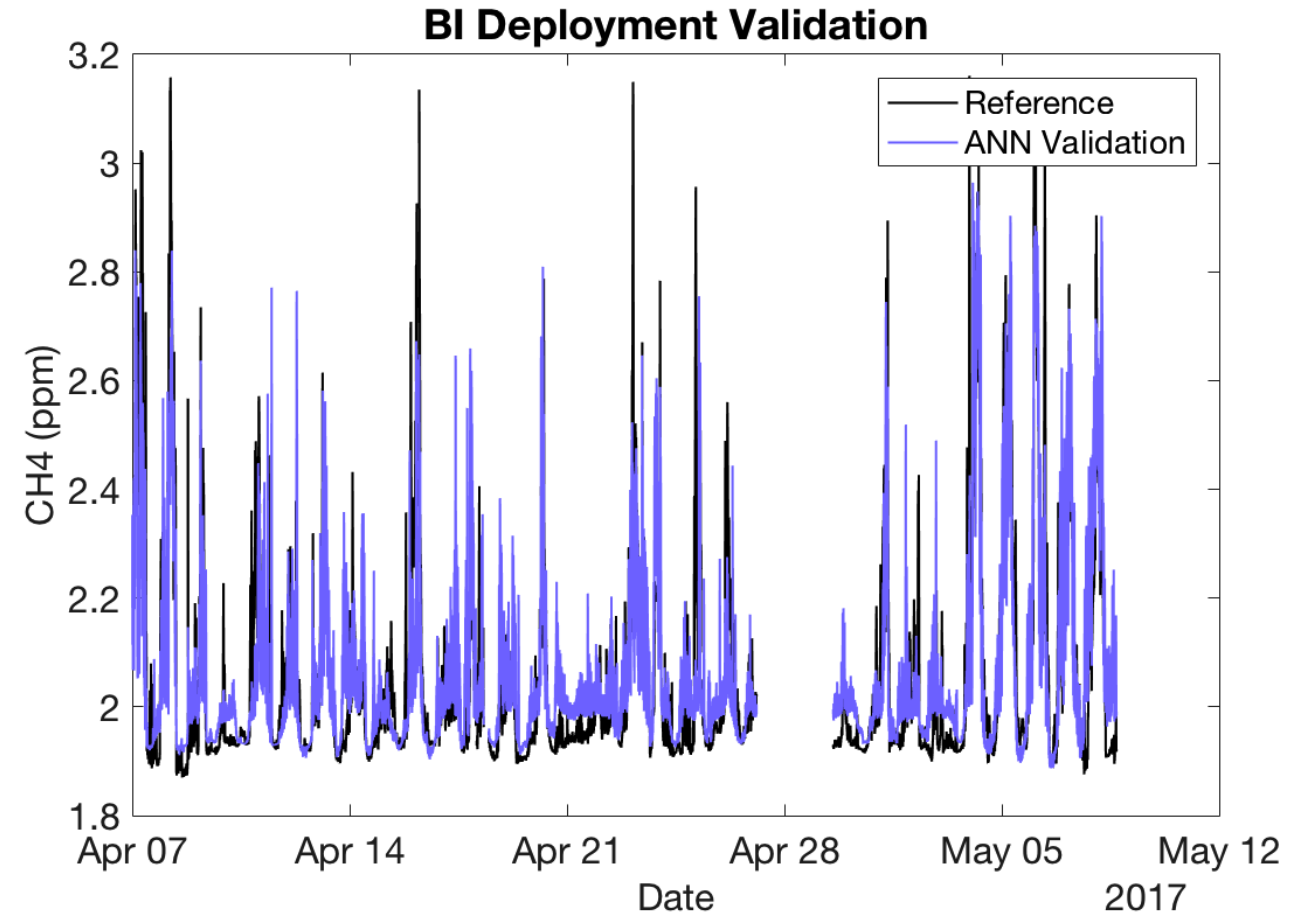
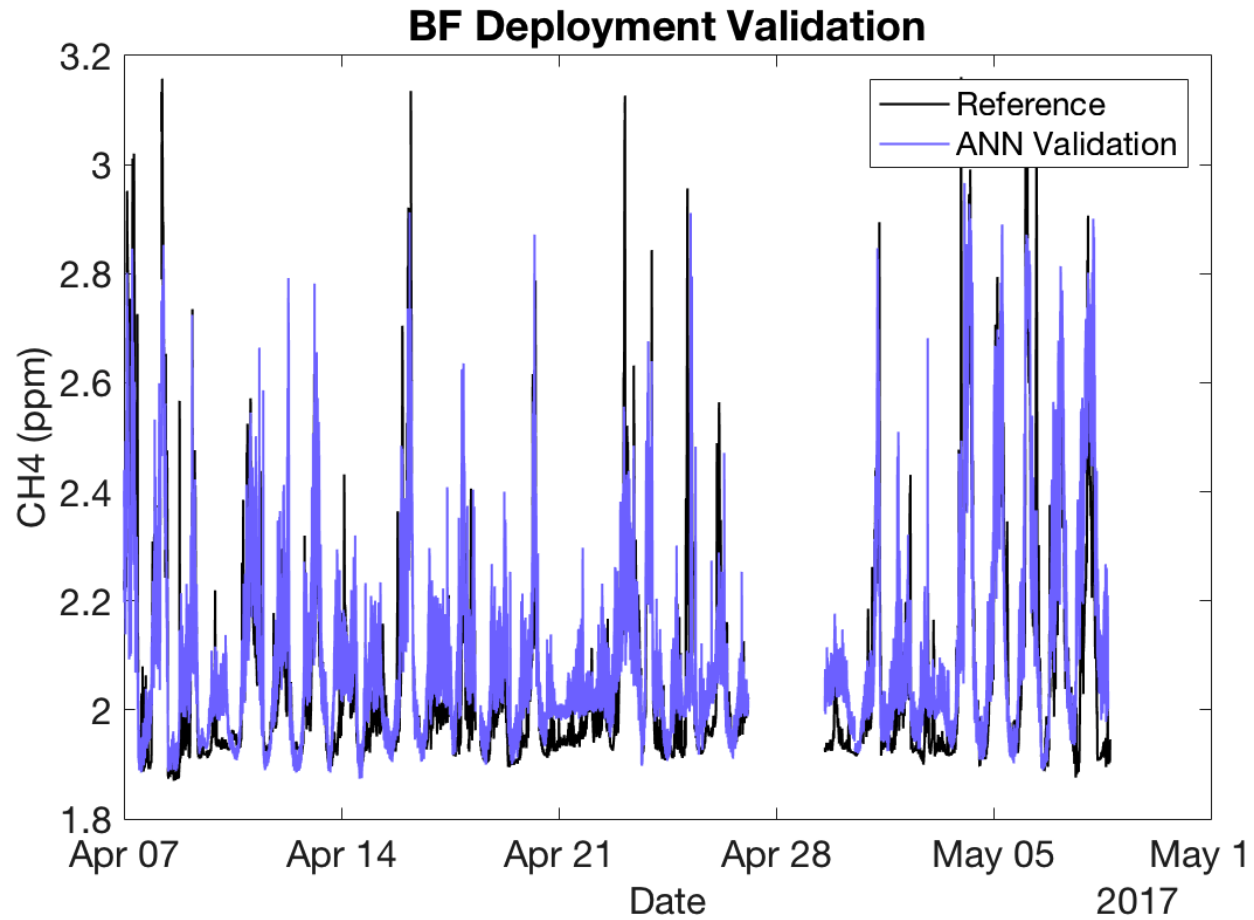
● Main Sites  
● Wells



Lots of work trying to “see” methane at relevant concentration range ...

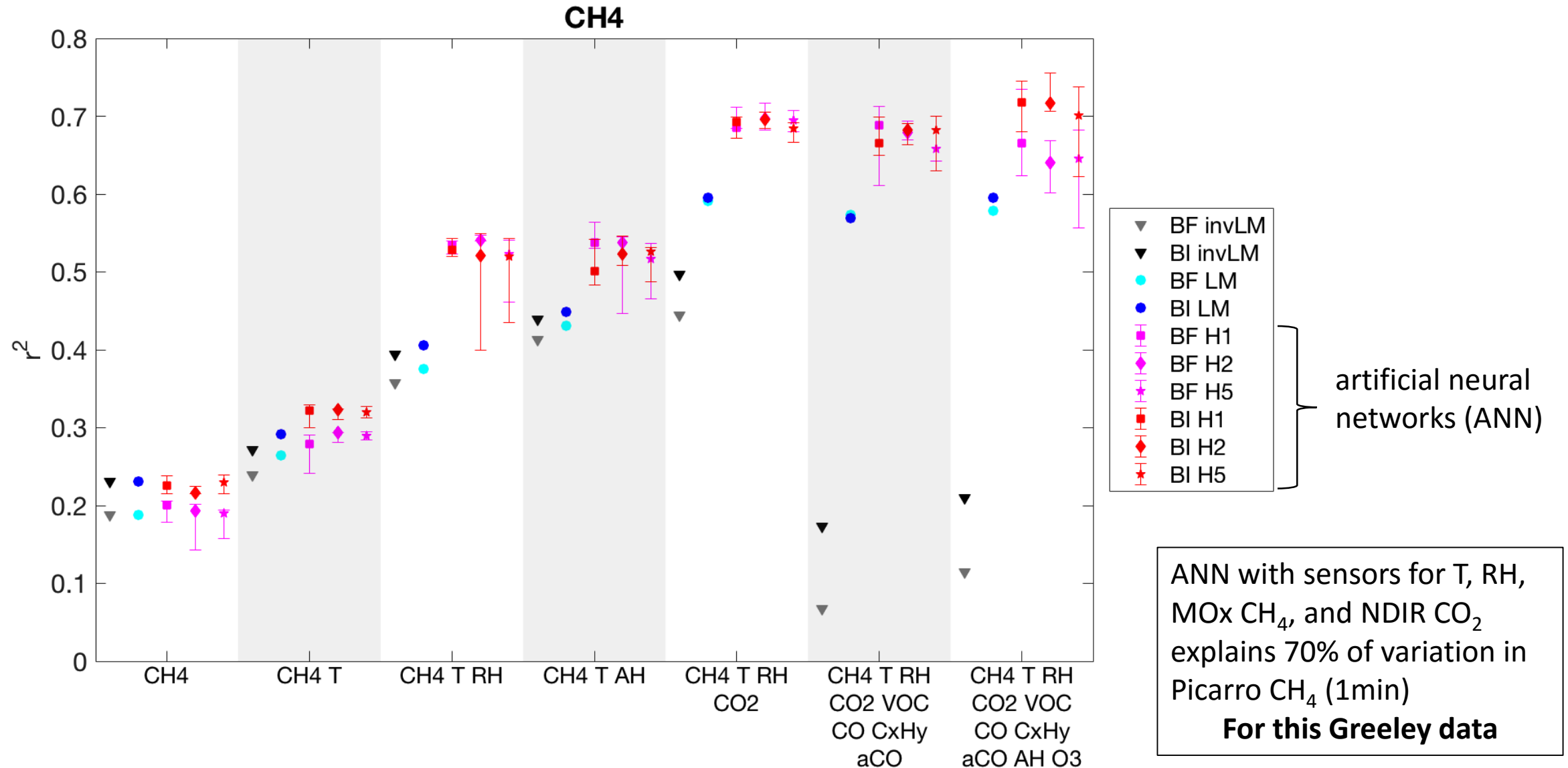


# How does that look in a time series ...

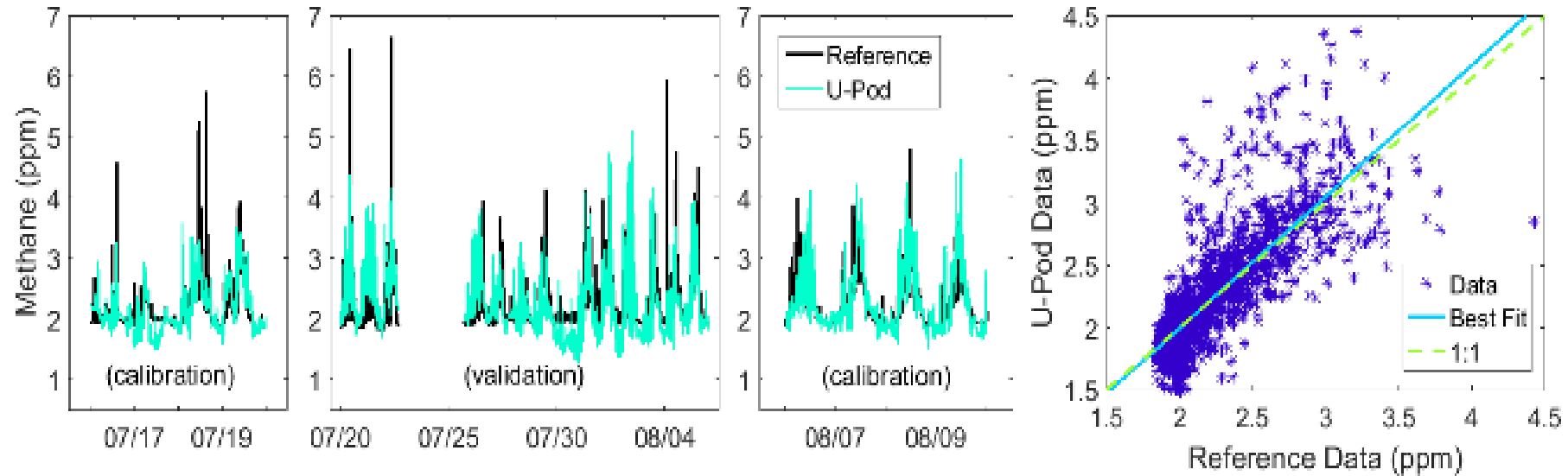




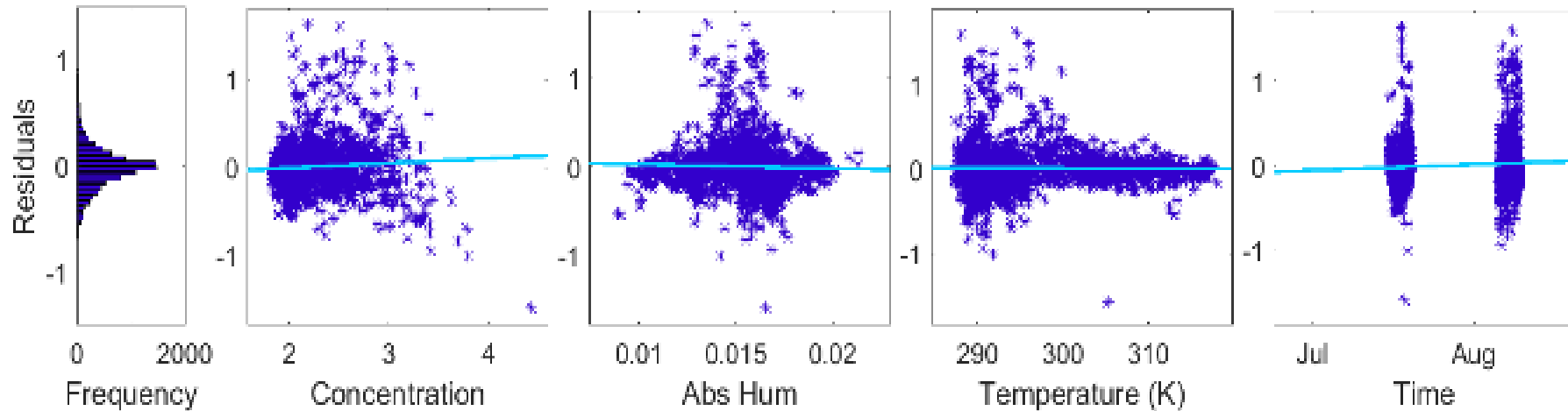
# Pushing calibration to improve our ability to observe differences ...



If we are within a km of a well pad, linear is OK

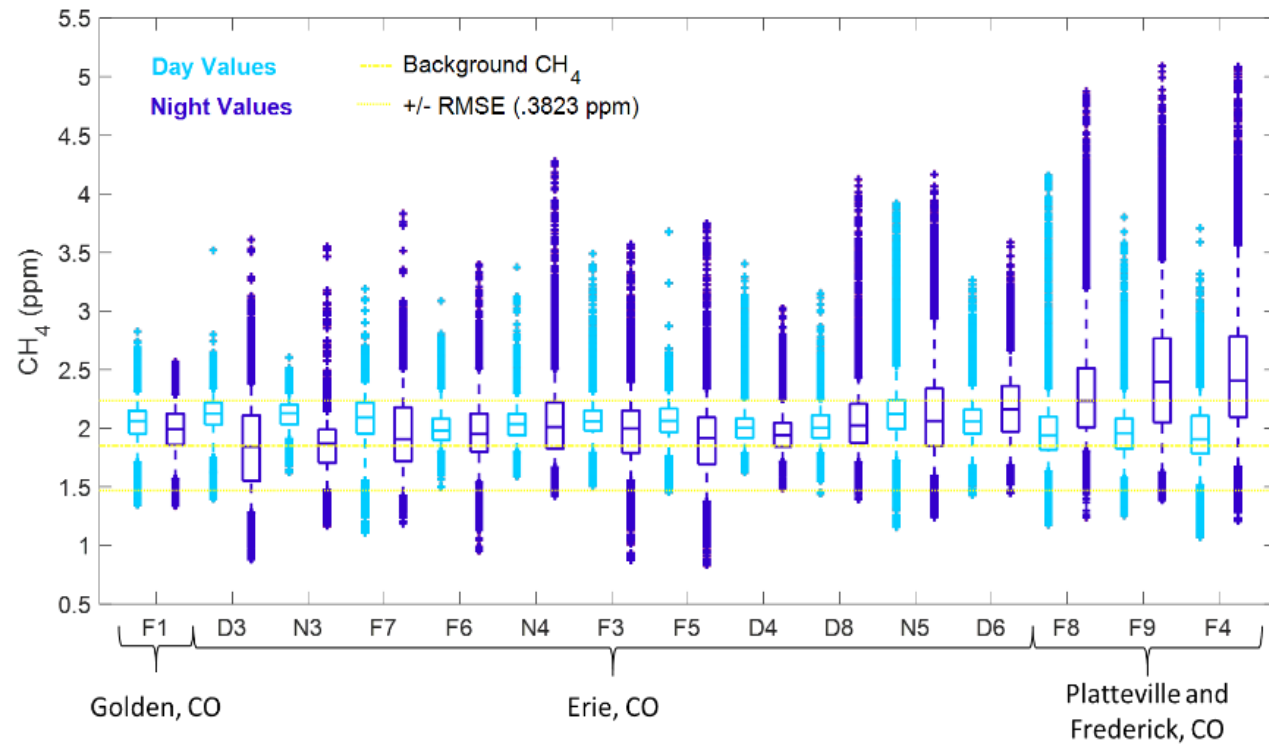
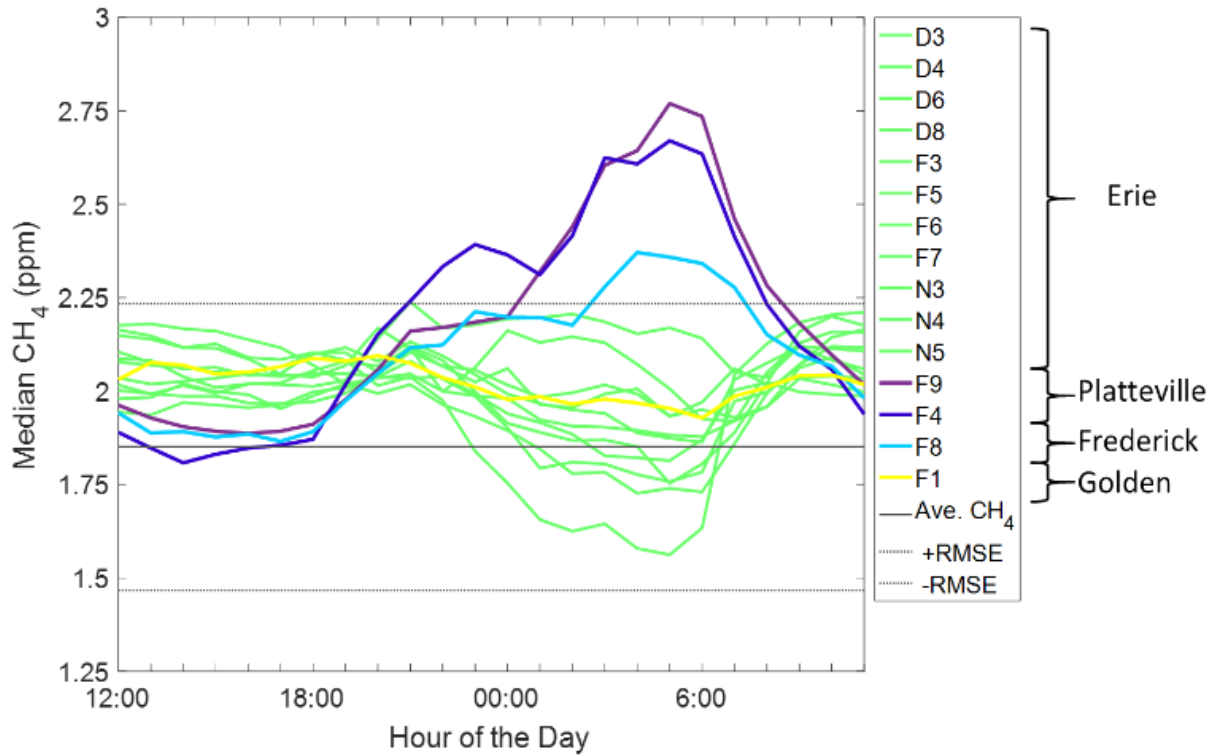


Platteville

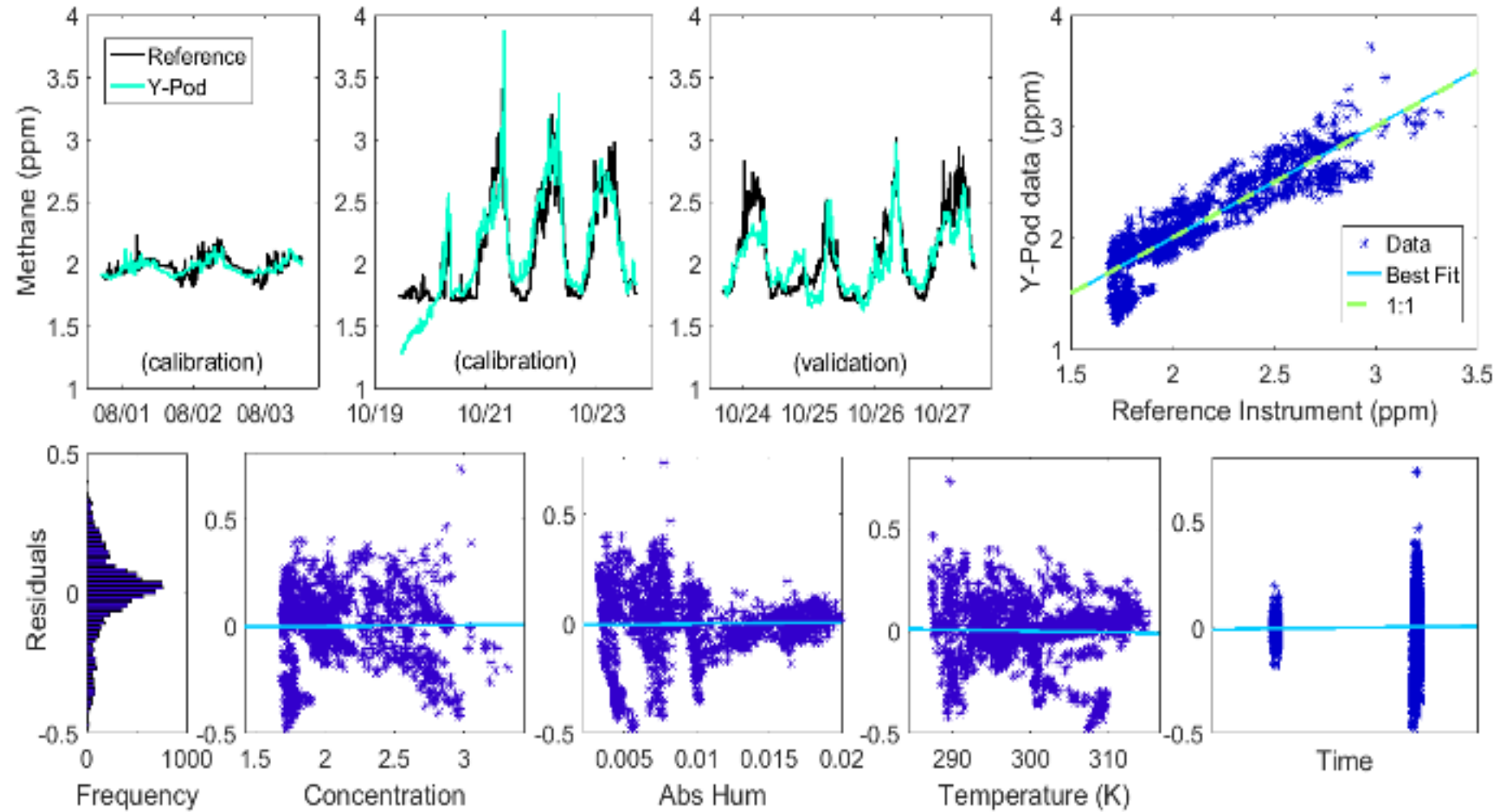




# So, can we see spatial differences ...



In LA, methane range is also “better” ...





How do oil development processes compare to major freeways in terms of their impact on south LA community-scale VOC and O<sub>3</sub> concentrations?

