Linking the 24-year Trinidad Head, CA, ozonesonde record to surface ozone pollution

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2020 MARAMA Workshop, 10 December 1:50 pm

Talk Roadmap

1) Introduction and Motivation

2) Trinidad Head, CA, Ozonesondes (~weekly profiles, 1997-2019)
   - Clustering O_3 profile data with self-organizing maps (SOM)
   - Ancillary data analysis of geopotential heights, satellite CO
   - Correspondence among O_3 profile clusters and surface O_3

3) Separate 2020 Analysis (COVID-19 Impacts)
   - Record low tropospheric O_3 at Trinidad Head
   - How does surface O_3 respond?

Introduction and Motivation

- Relative contributions of transported vs. locally-produced O_3 is a topic of constant evaluation by environmental regulators
  1. Intercontinental/Long-range transport of pollution
  2. Stratosphere-Troposphere Exchange (STE)
  3. Local/Regional production from anthropogenic emissions

- New 70 ppbv NAAQS for O_3 in 2015 placed new emphasis on long-range transport, especially in the Western US

- We examine a >20-year record of ozonesonde profiles in CA to link tropospheric O_3 to meteorology, chemistry, and surface O_3 pollution

Trinidad Head, CA (THD) Ozonesondes

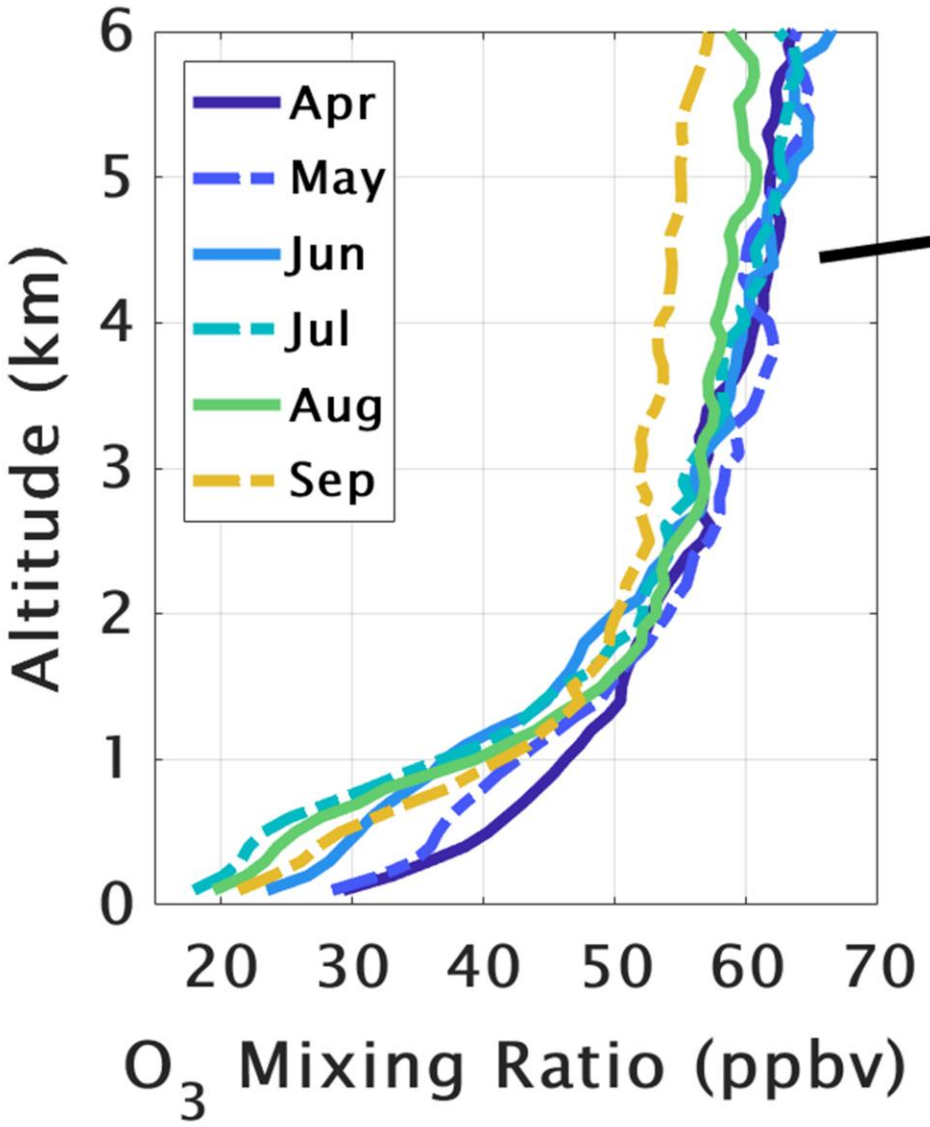
~Weekly ozonesonde profiles initiated in Aug 1997 by NOAA

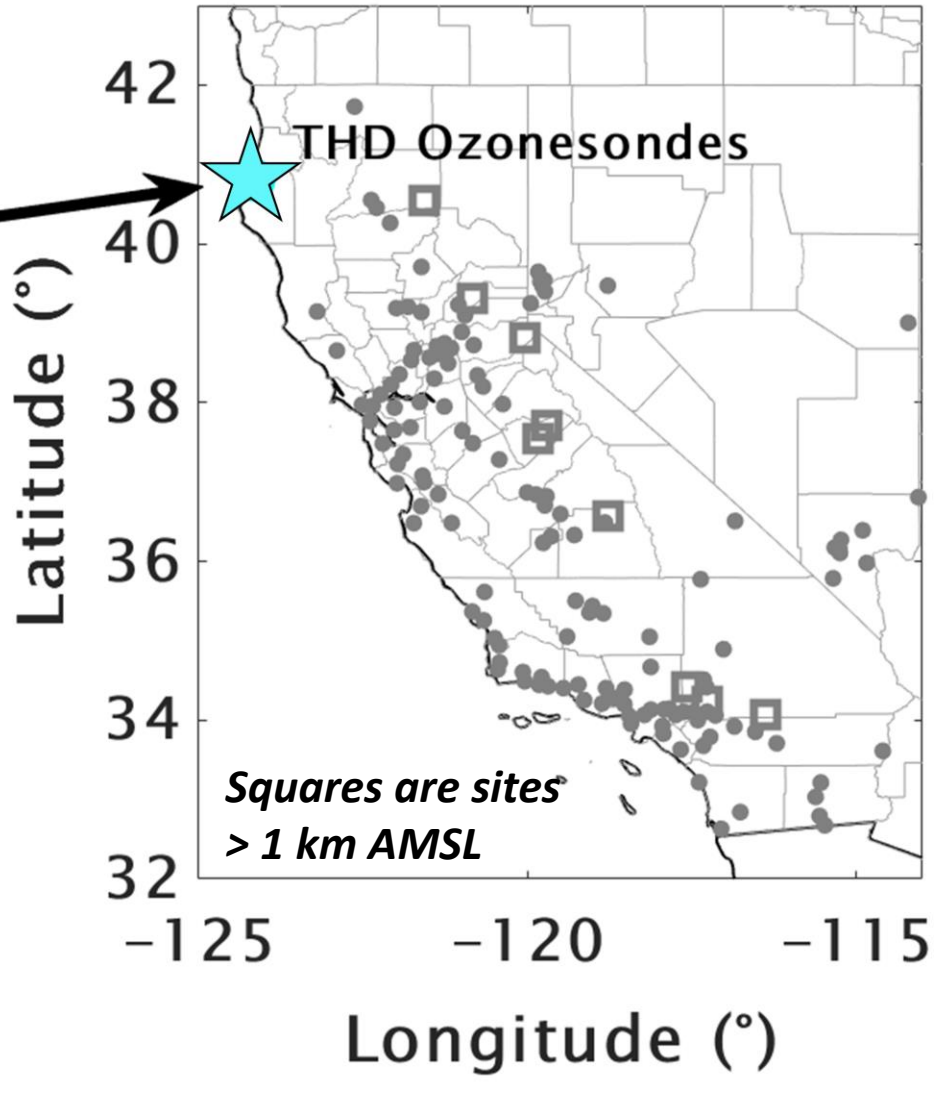
Note: ~weekly ozonesondes at Wallops Island, VA since 1970!

We will focus on Apr-Sep, 1997-2019 data to link the O_3 profiles to surface O_3 pollution

Left: Monthly-averaged THD O_3 profiles show little variability

Right: Surface O_3 sites considered



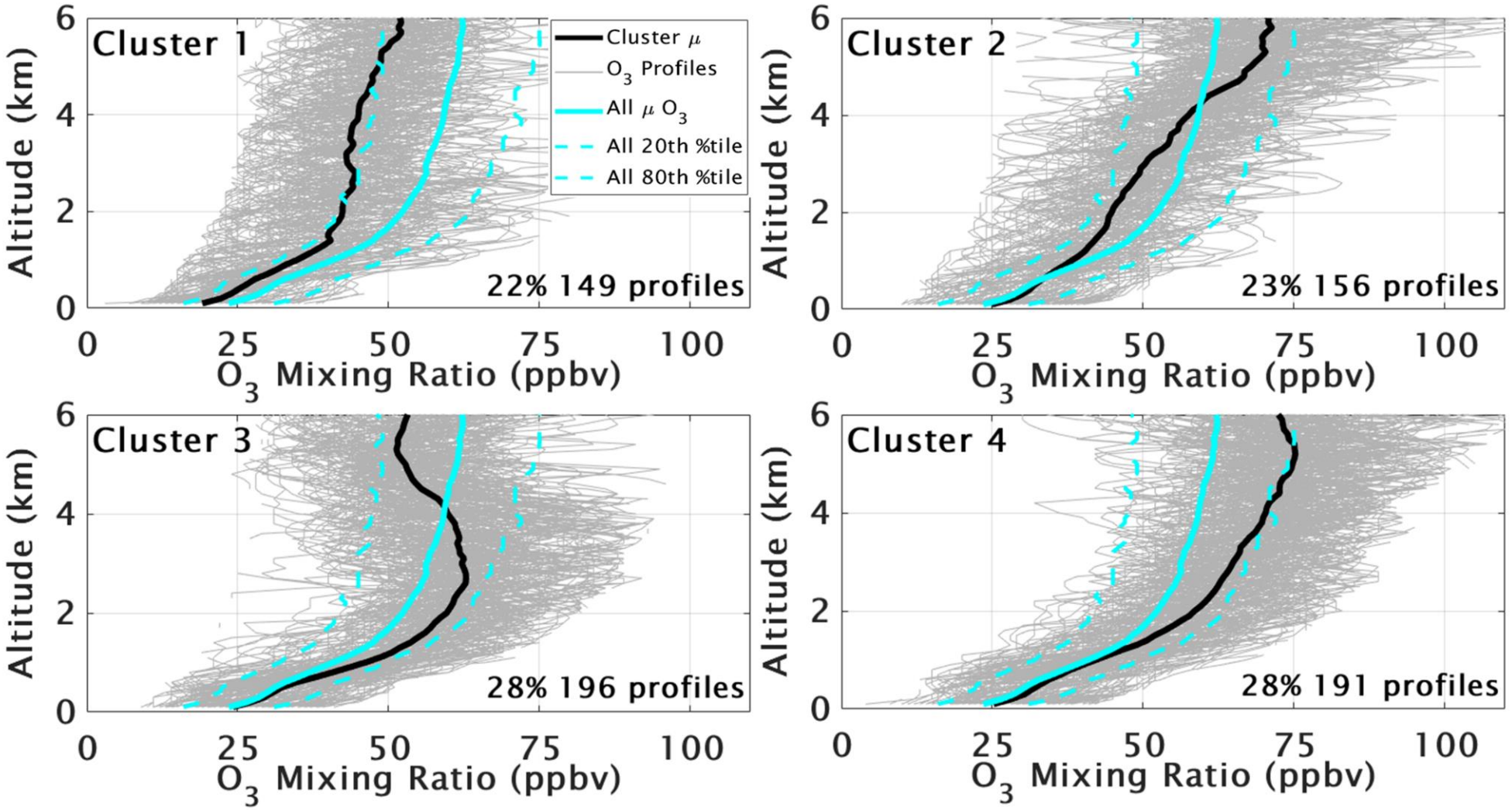


Self-Organizing Map (SOM) Clustering

Monthly averaged O_3 profiles are not particularly helpful – we cluster the profiles so similar "shapes" are grouped

Clusters are numbered from lowest (1) to highest (4) O_3 amounts

Compare cluster means to overall 20th, 80th percentiles and mean

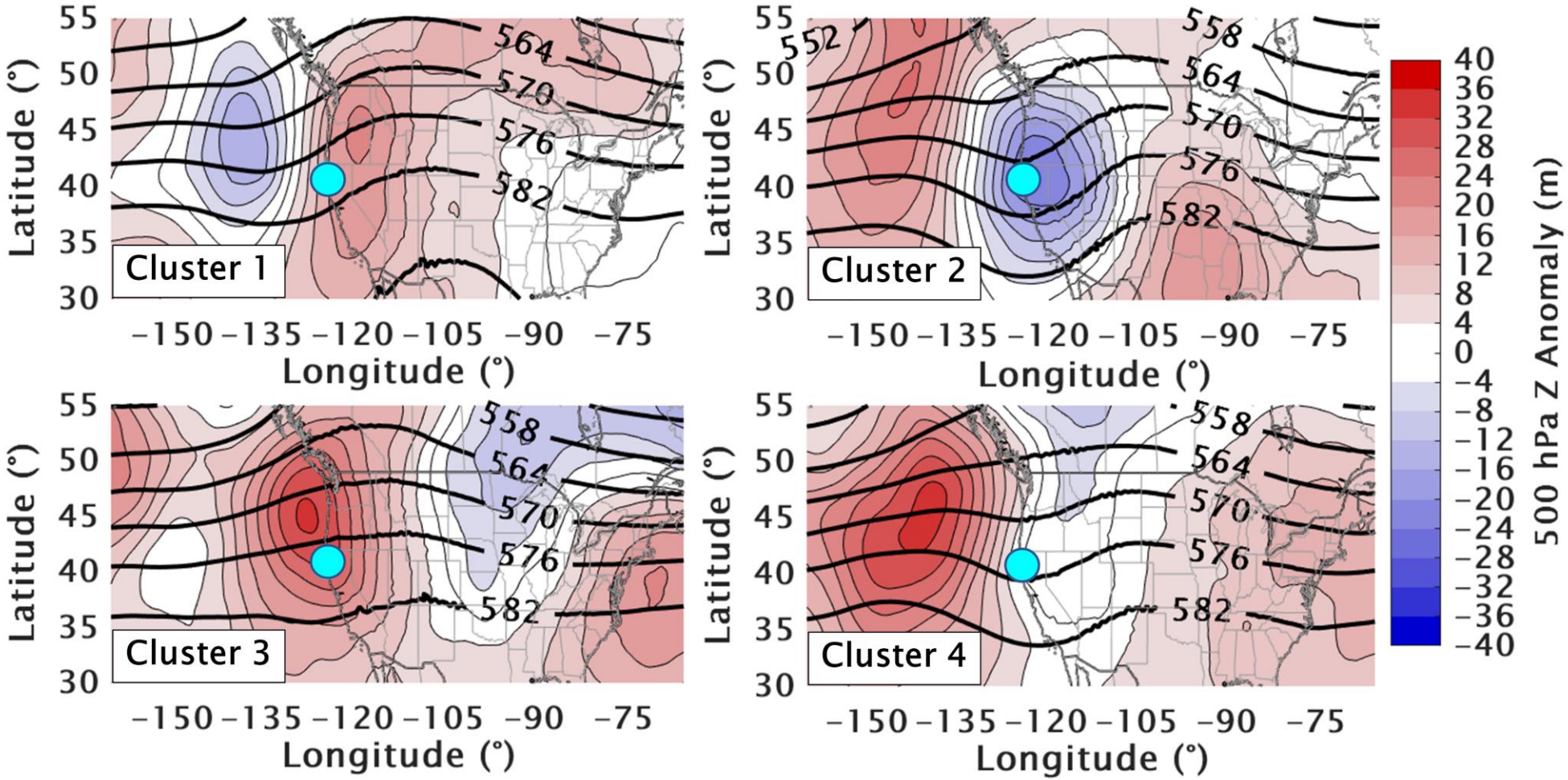


Meteorological Analysis (500 hPa heights)

Composite maps of corresponding MERRA-2 500 hPa geopotential height anomalies for each cluster

Immediately we can see the trough associated with Cluster 2: *Unsettled weather*

Clusters 1, 3, and 4 show subtle differences in the positioning of a 500 hPa ridge

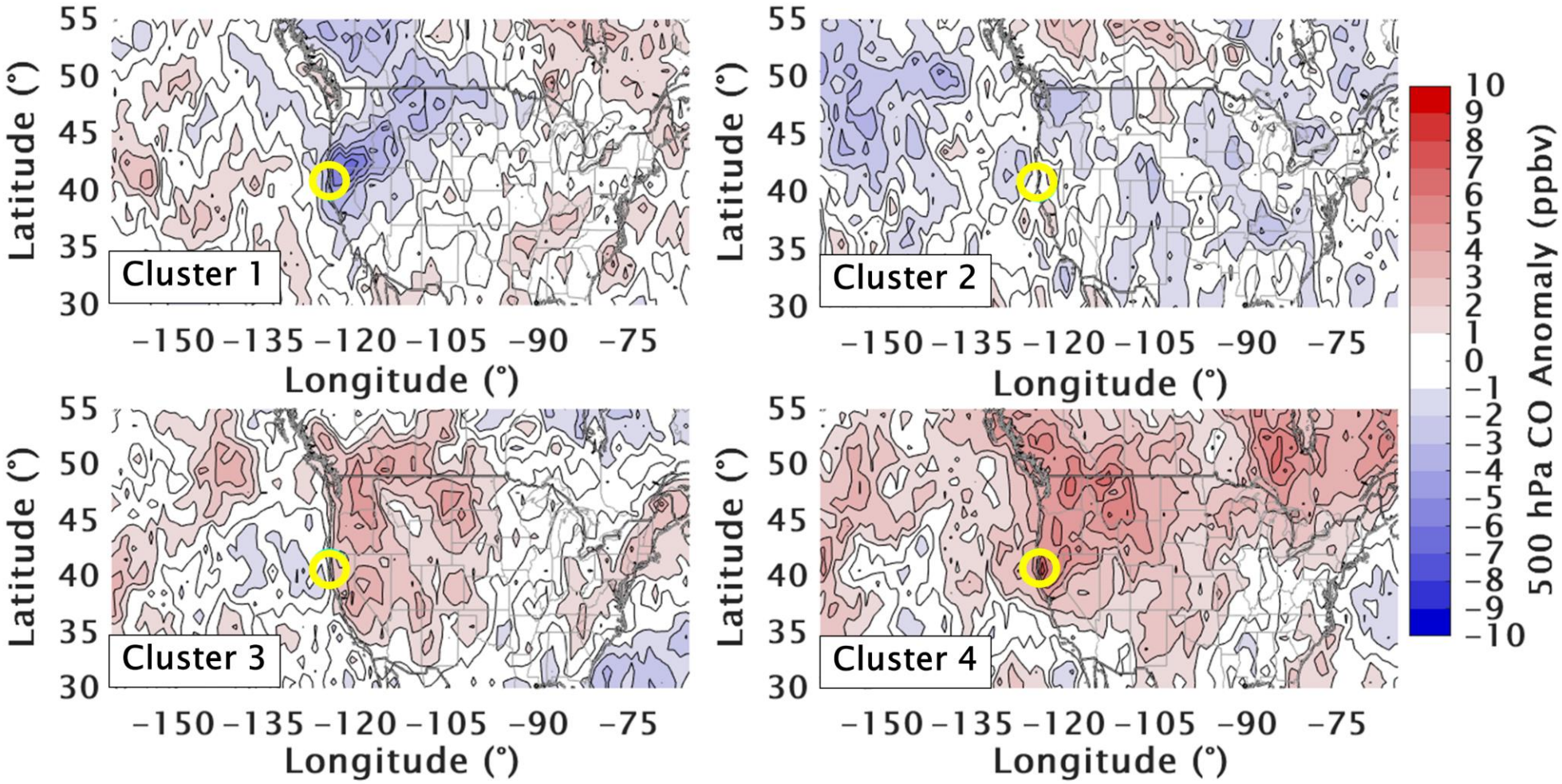


Satellite CO from AIRS (Pollution Tracer)

Composite maps of corresponding AIRS 500 hPa CO anomalies for each cluster

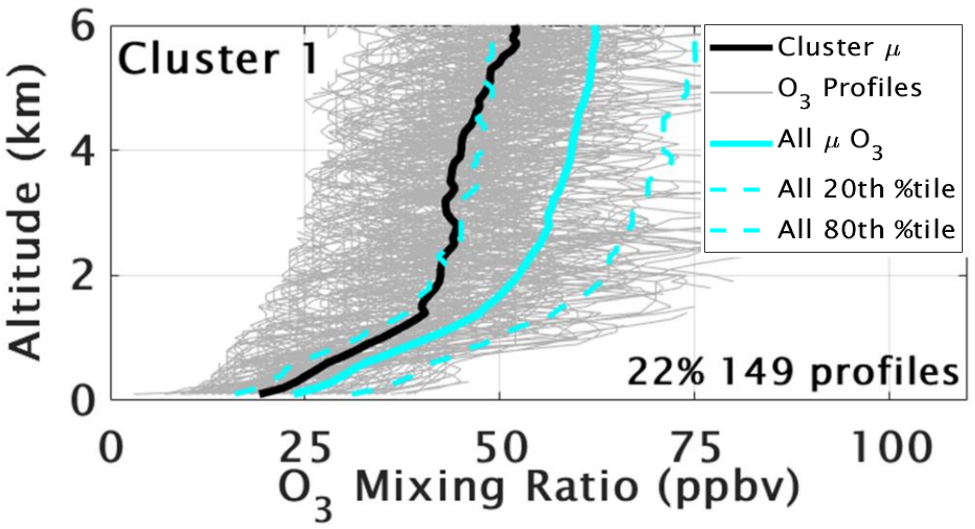
Cluster 1 clearly corresponds to low CO. Given the low O_3 low CO, we declare this to be the "baseline" O_3 cluster

Cluster 4 is particularly polluted in the troposphere

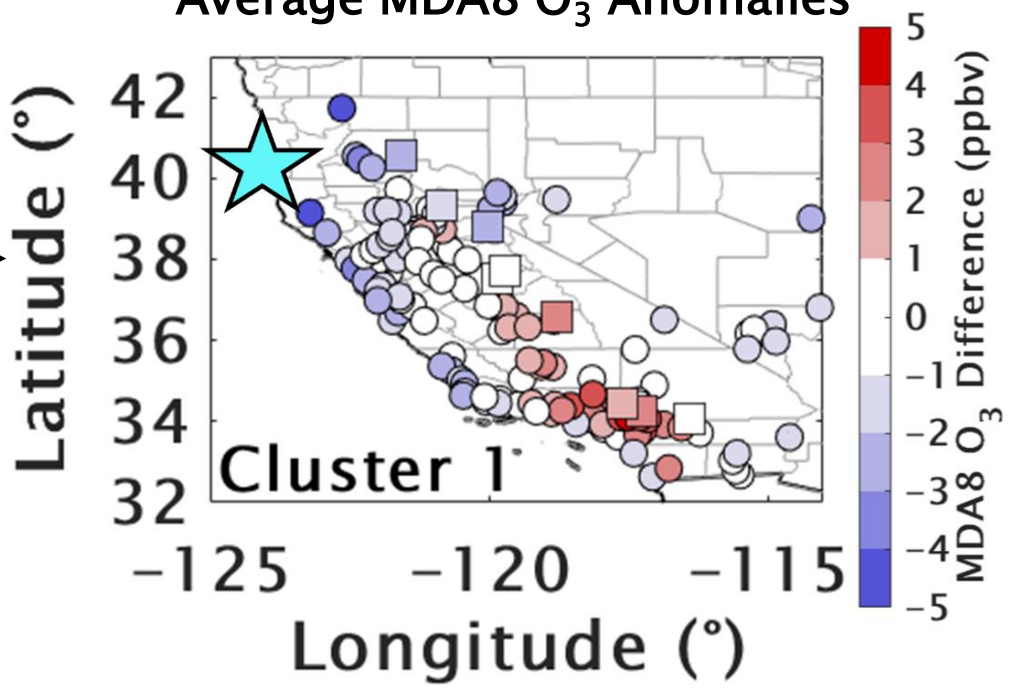


Correspondence to Surface Ozone, Cluster 1

O_3 Profile Cluster



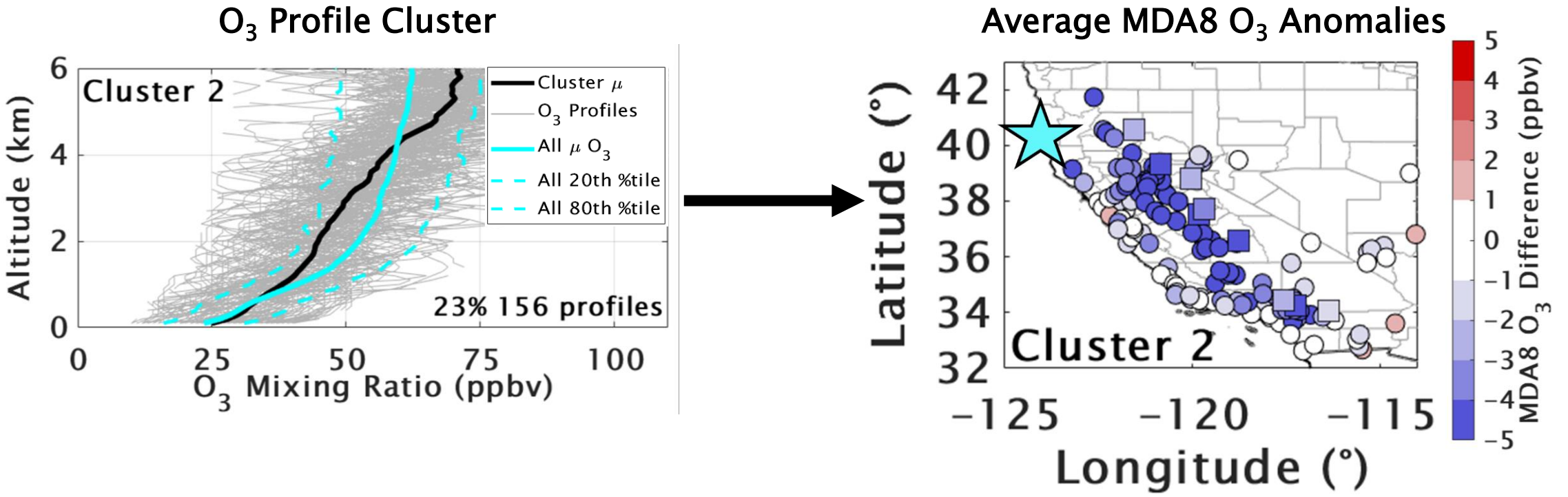
Average MDA8 O_3 Anomalies



Cluster 1: "Baseline" very low O_3 with low corresponding CO, upper-level ridge

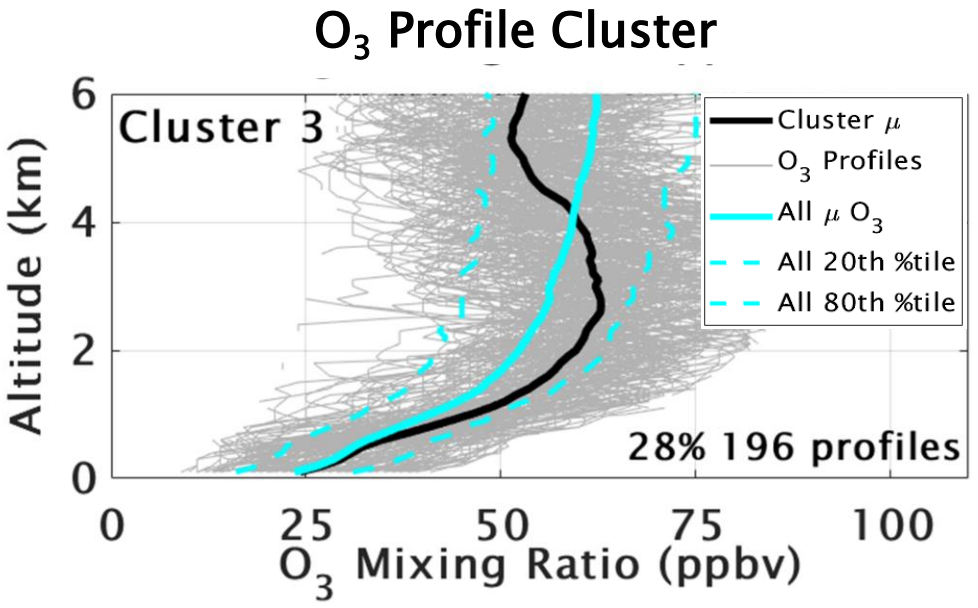
Surface O_3: Lower O_3 North, but higher O_3 South near and downwind of LA

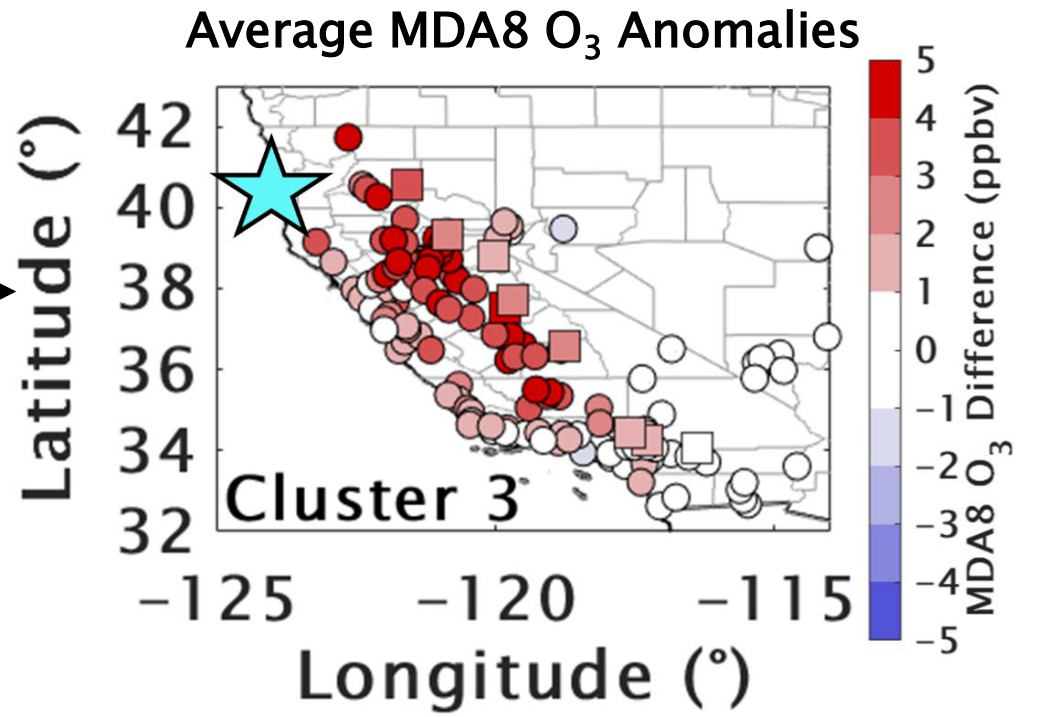
Correspondence to Surface Ozone, Cluster 2



Cluster 2: Strat-trop exchange (STE) with high O_3 above 5 km (upper-level trough)
Surface O_3: Low O_3 throughout the West, only 6 of 144 sites have above average MDA8

Correspondence to Surface Ozone, Cluster 3

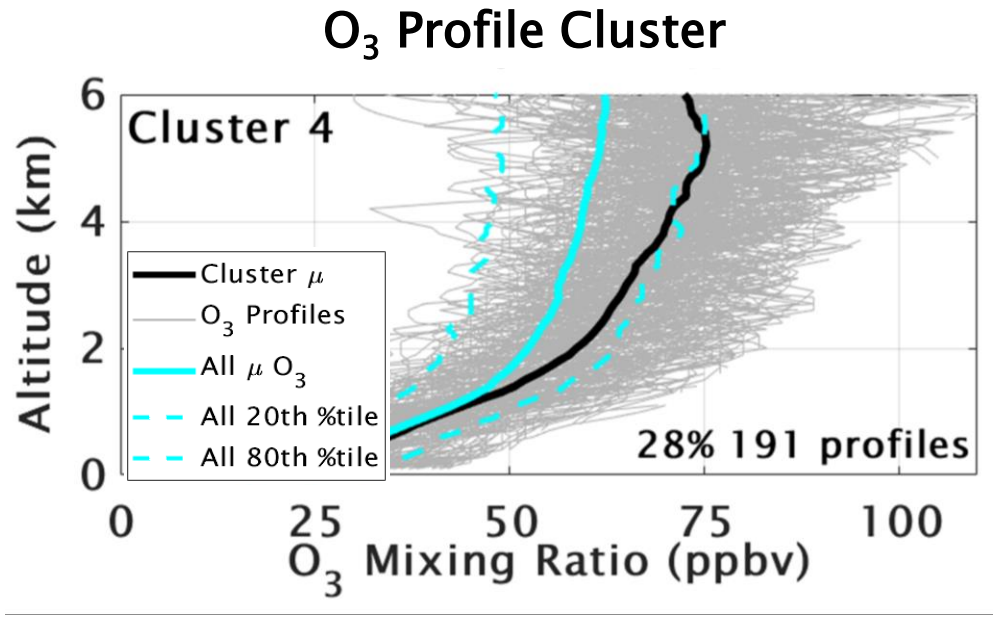


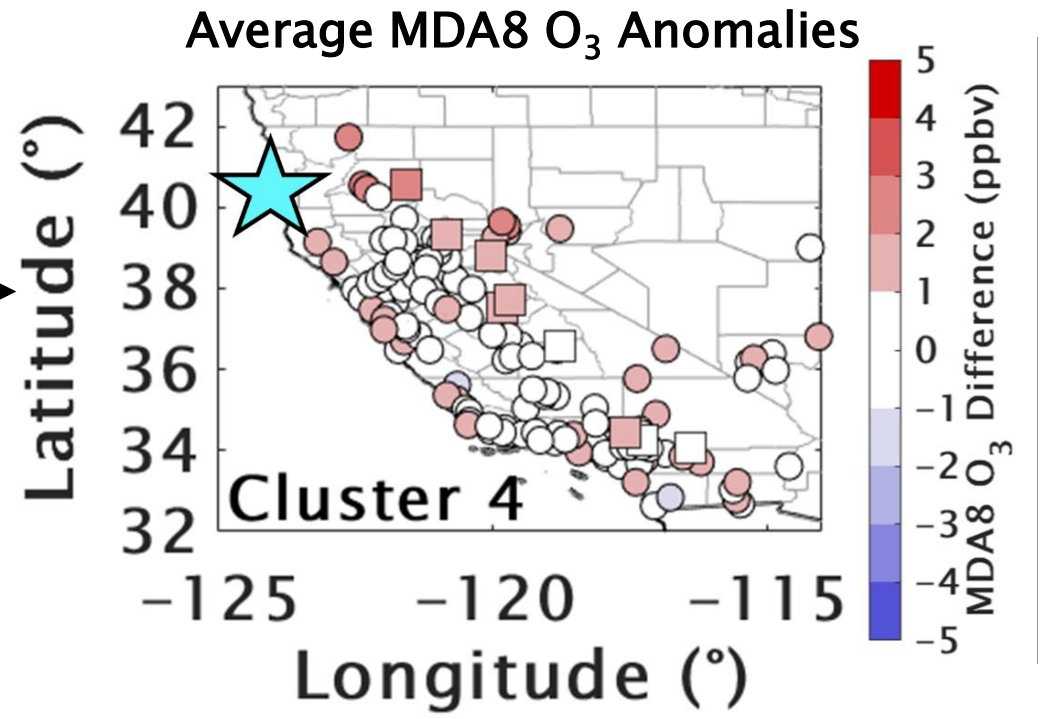


Cluster 3: Layers of high O_3 near surface, downstream of upper-level ridge

Surface O_3: High O_3 throughout the West, only 15 of 144 sites have below average MDA8

Correspondence to Surface Ozone, Cluster 4





Cluster 4: Highest tropospheric O_3, high corresponding CO
Surface O_3: Mixed bag, no clear high/low surface O_3 patterns

<u>Takeaway</u>: Highest and lowest tropospheric O_3 *do not* correspond to highest and lowest surface O_3. The O_3 profile shape and meteorology matter!

Conclusions from 1997-2019 Study

- Monthly-averaged O_3 over Trinidad Head shows little variability
- Clusters of O_3 profiles reveal prototypical baseline, STE, and polluted conditions, identified in patterns of 500 hPa geopotential heights and satellite CO data
- Tropospheric O_3 averages below 6 km do a poor job of explaining surface O_3 pollution, something to consider for upcoming geostationary measurements (i.e. TEMPO)
- O_3 amounts measured at Trinidad Head are actually anti-correlated with surface O_3 in Southern CA

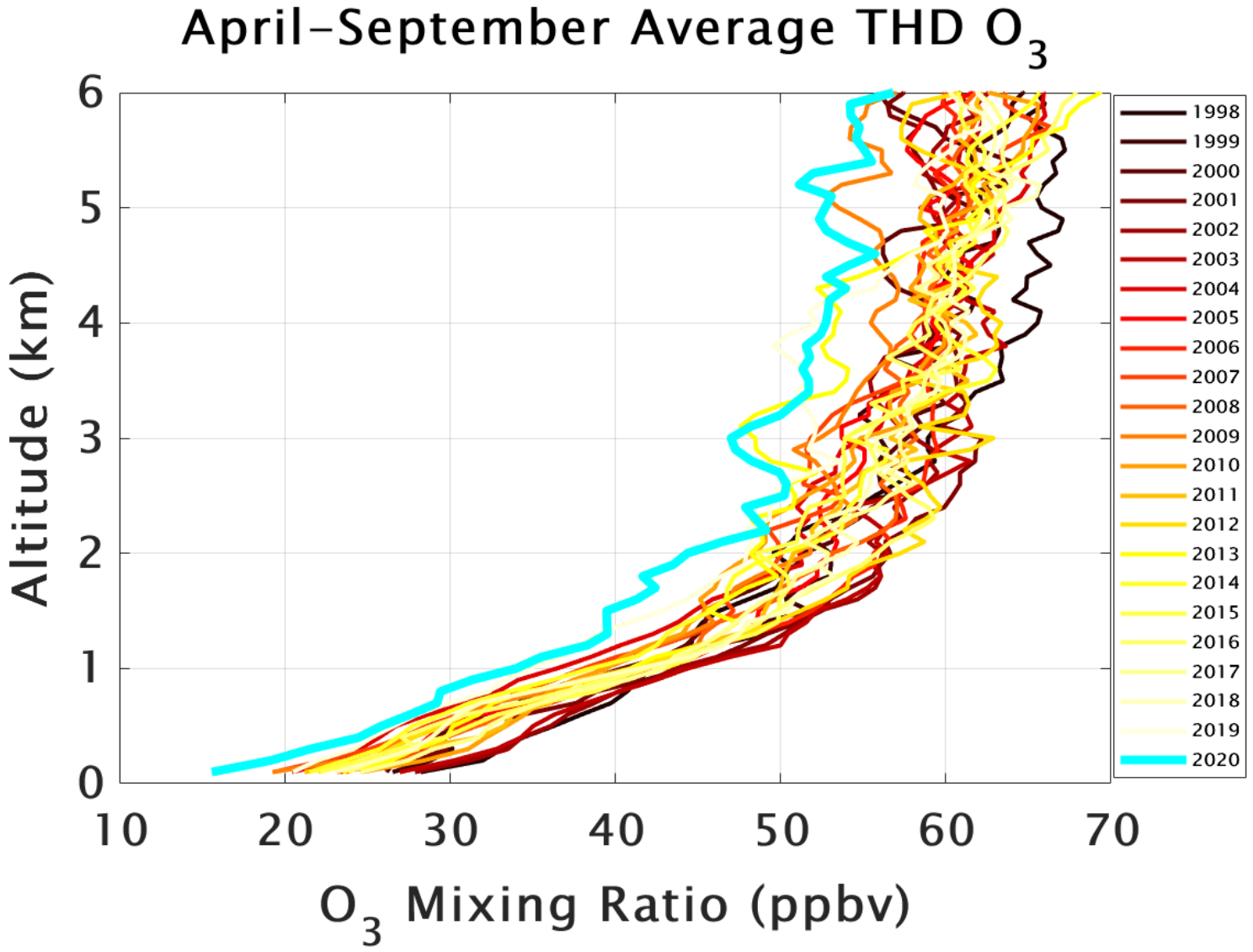
What about 2020 and COVID Impacts?

2020 Record Low O_3 at Trinidad Head

Average O_3 from surface to 6 km altitude was 3 ppbv lower than any other year on record. *Note: Excluding 1998 here because the record began in August 1997*

This phenomenon is observed throughout the Northern Hemisphere (Steinbrecht et al., 2020, submitted to GRL), and is related to COVID-19 emissions reductions

How does surface O_3 in the Western US respond?

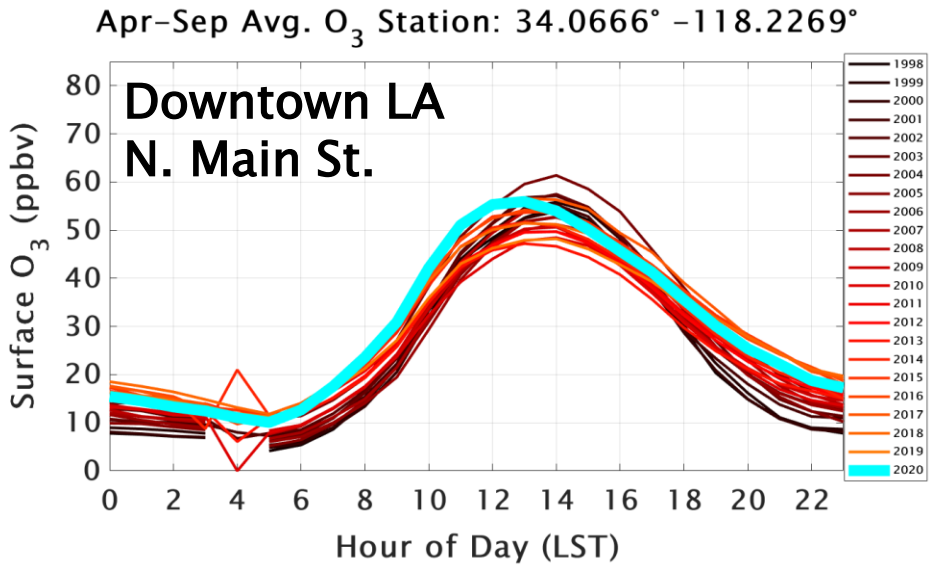


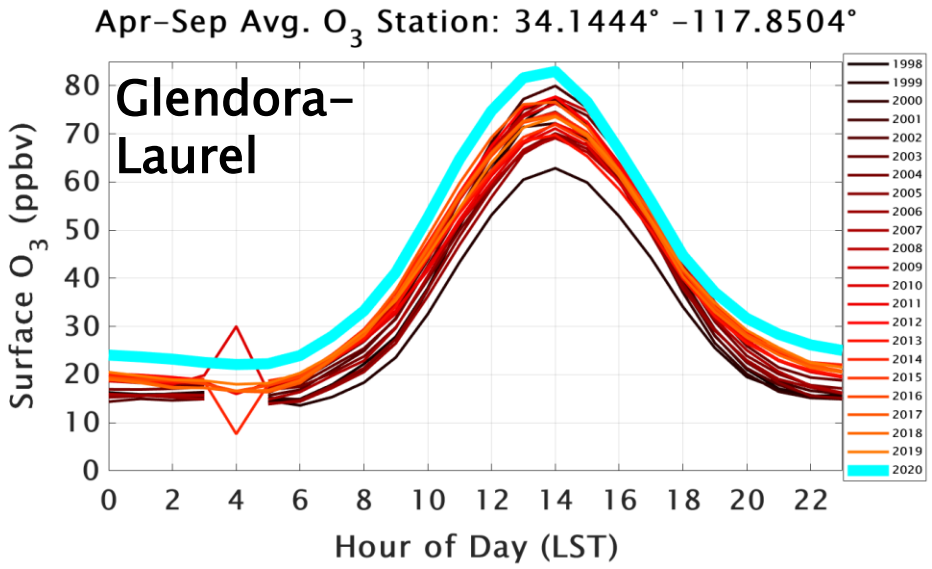
Example Site Diurnal Surface O_3 1998-2020

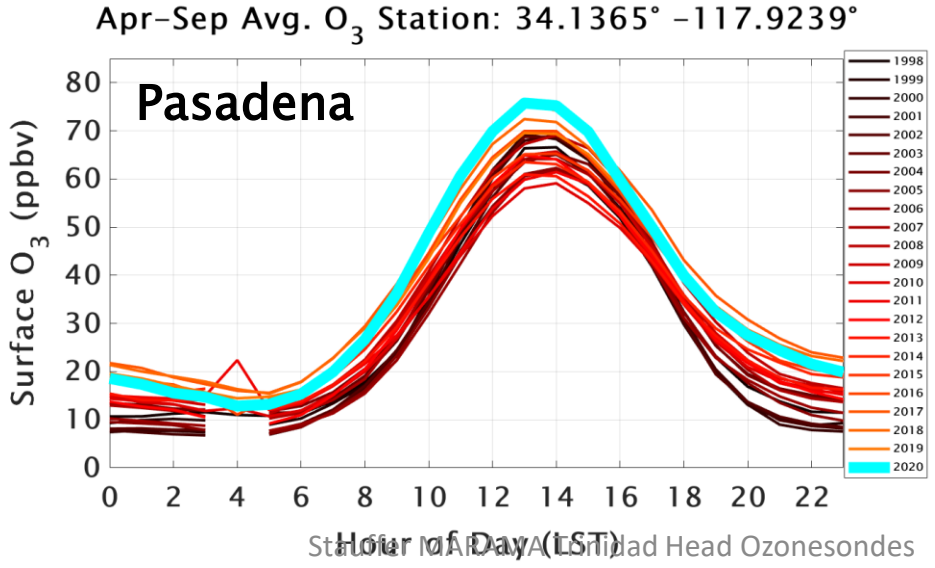
Four typical polluted O_3 monitors from LA County show that 2020 contained the highest, or close to highest O_3 since 1998

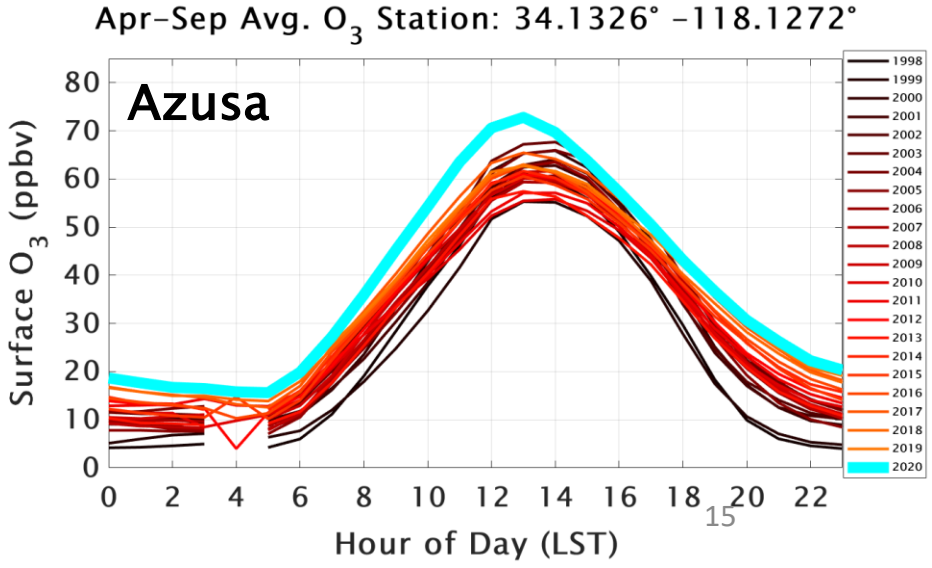
Clearly there is large disconnect between tropospheric O_3 and surface O_3 pollution near LA in 2020

Is this higher 2020 O_3 typical throughout CA?







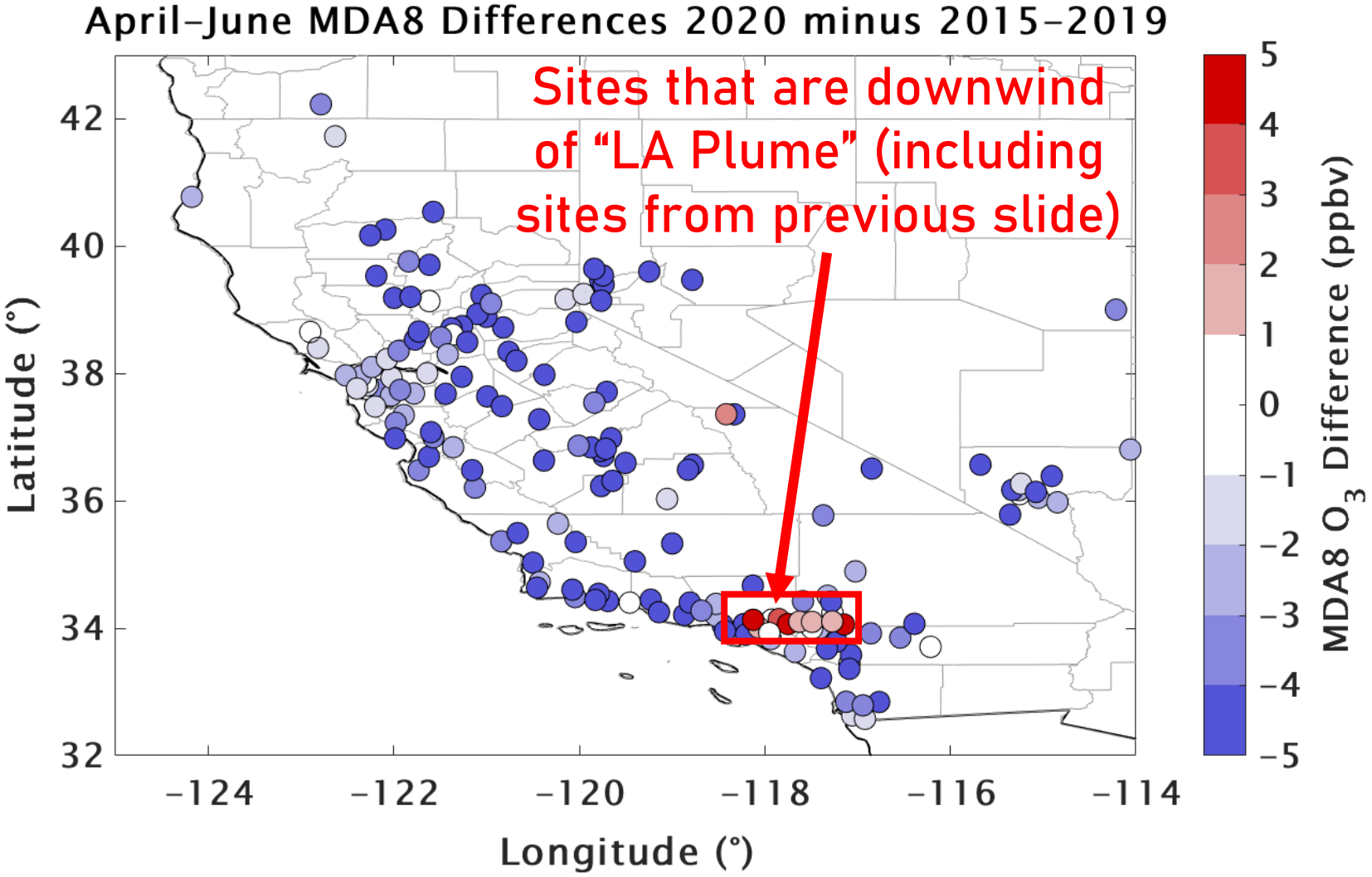


2020 MDA8 Compared to 2015-2019 (Apr-Jun)

No! It is not typical. This behavior only occurs at stations near LA, downwind of significant NO_x emissions

Note: Only April-June shown here. Data from many sites have not been updated through September in EPA AQS database

We can learn a lot about NO_x/VOC-limited O_3 production from COVID-19 emissions reductions (Parker et al., 2020; GRL; D. Goldberg, next talk)



Conclusions from Preliminary 2020 Analysis

- Average O_3 over Trinidad Head, CA, was the lowest on record (since 1998) in 2020. This is common throughout Northern Hemisphere ozonesonde stations

- April-June 2020 surface O_3 at monitors in the LA area observed some of the highest O_3 in over two decades (2020 MDA8 as much as +8.5 ppbv compared to 2015-2019)

- The rest of CA, and other parts of the Western US observed below average MDA8 O_3 (average of 182 monitors = -3.9 ppbv)

- Working on model O_3 comparisons, quantifying stratospheric O_3 input, surface NO_x, etc.

Thanks!

AGU: See Morteza Amini's poster for more Trinidad Head ozonesonde/COVID-19 work (A067-0012, presented yesterday but still available online if registered)

Relevant References:

- **Stauffer, R. M., A. M. Thompson, B. J. Johnson, D. E. Kollonige, A. J. Carlson, J. S. Partida, S. Amini, and T. Kuwayama (2020). Linking the 23-year Trinidad Head, CA, ozonesonde profile record to surface O_3 pollution, *Environ. Manager*, November 2020. (https://www.awma.org/empastissues)**

- **Stauffer, R. M., A. M. Thompson, S. J. Oltmans, and B. J. Johnson (2017), Tropospheric ozonesonde profiles at long-term U.S. monitoring sites: 2. Links between Trinidad Head, CA, profile clusters and inland surface ozone measurements, *J. Geophys. Res. Atmos.*, 121, 1261–1280. doi:10.1002/2016JD025254**

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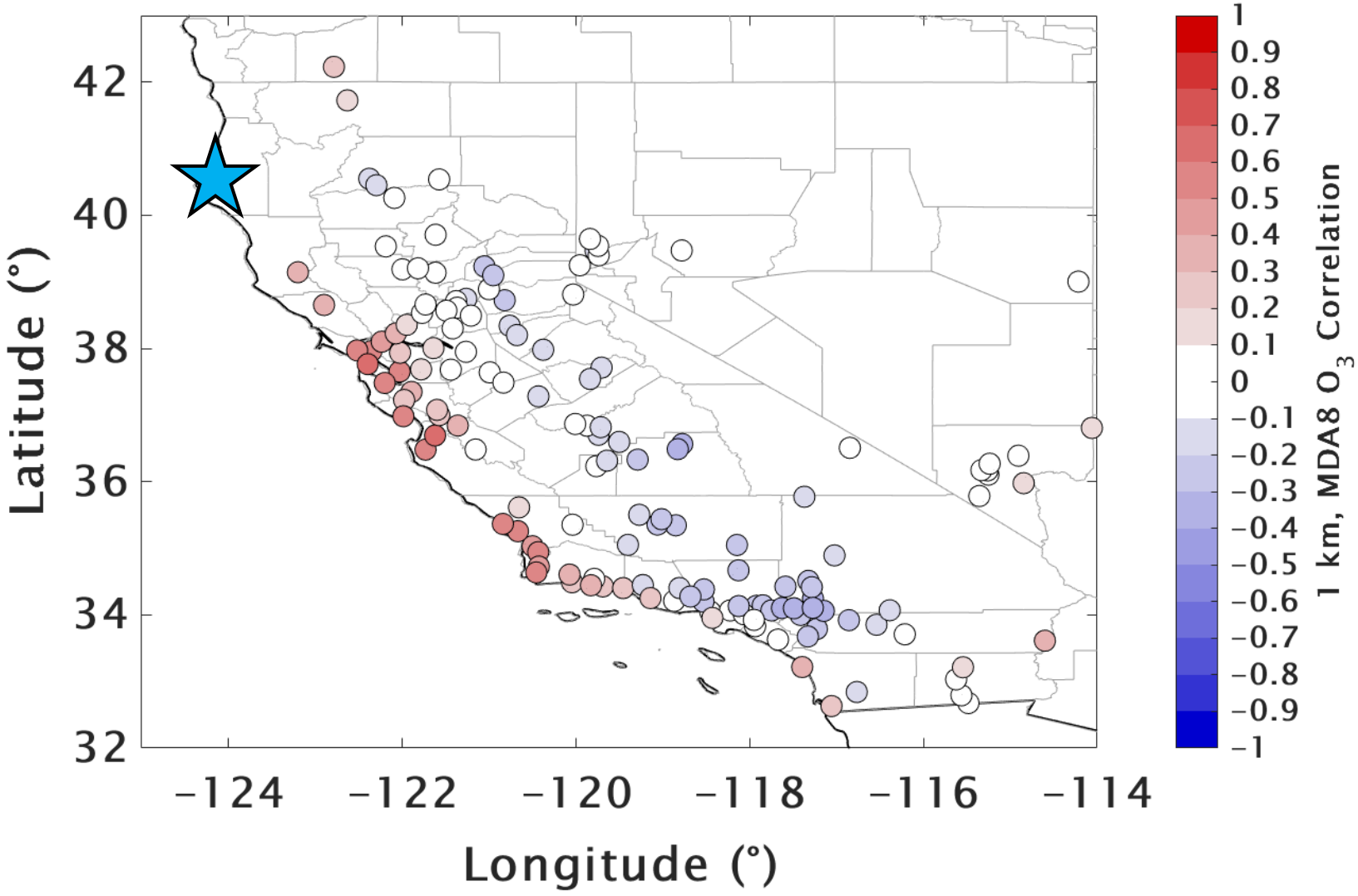
Extras

How Does THD O_3 Correlate to Surface O_3?



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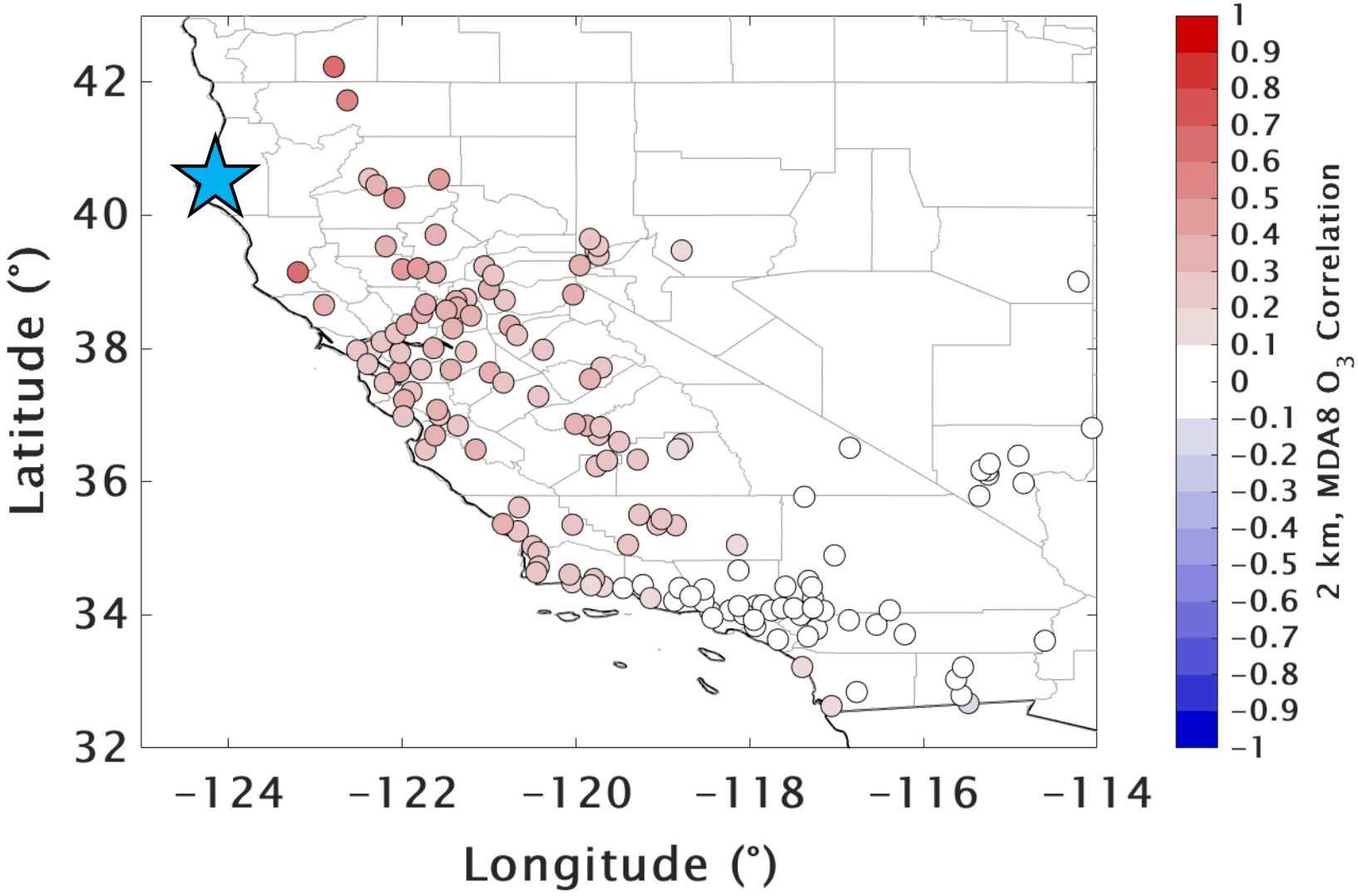
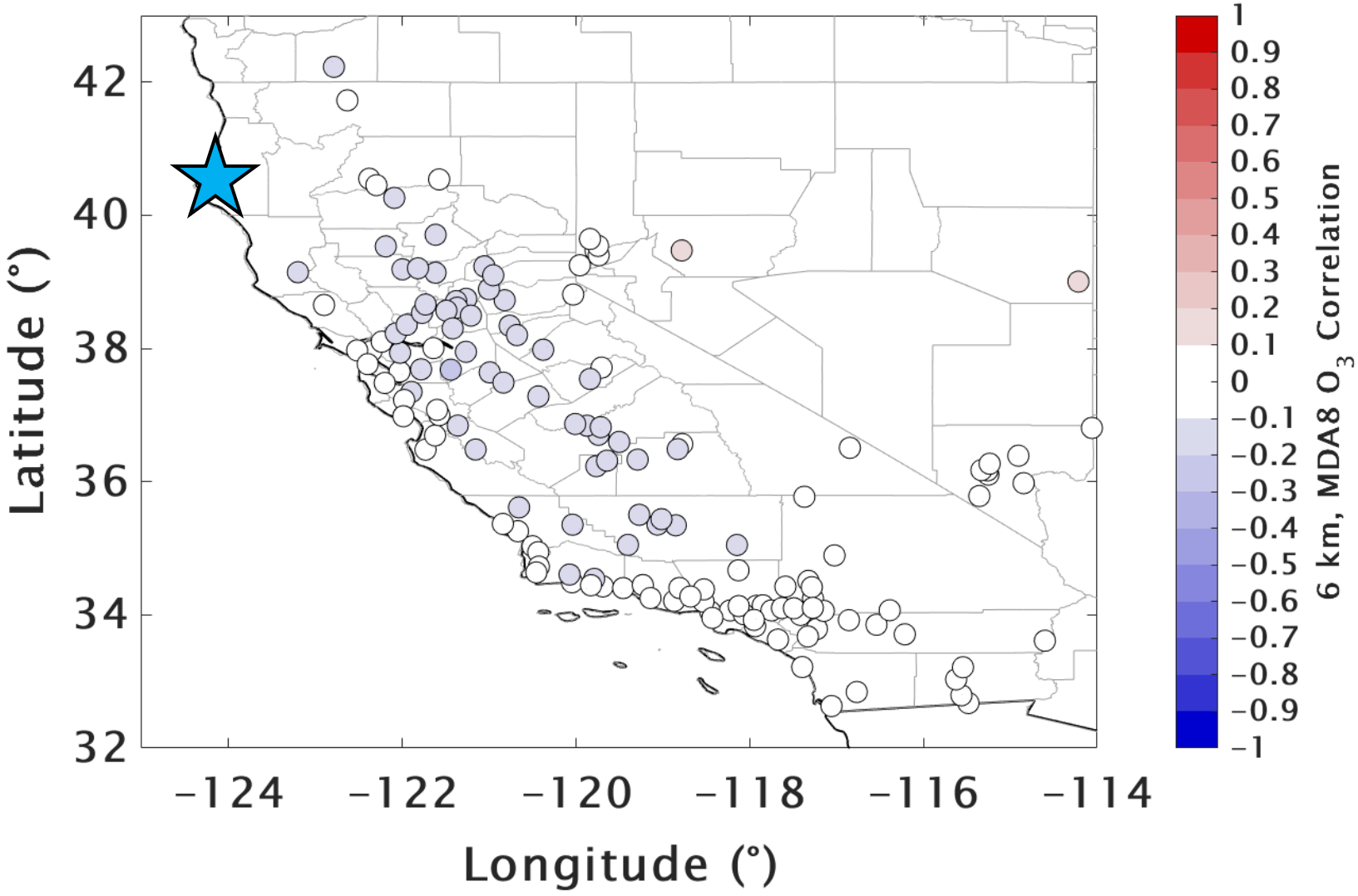
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