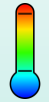
# Strong Dependence of Atmospheric Formaldehyde Concentration on Air Temperature 

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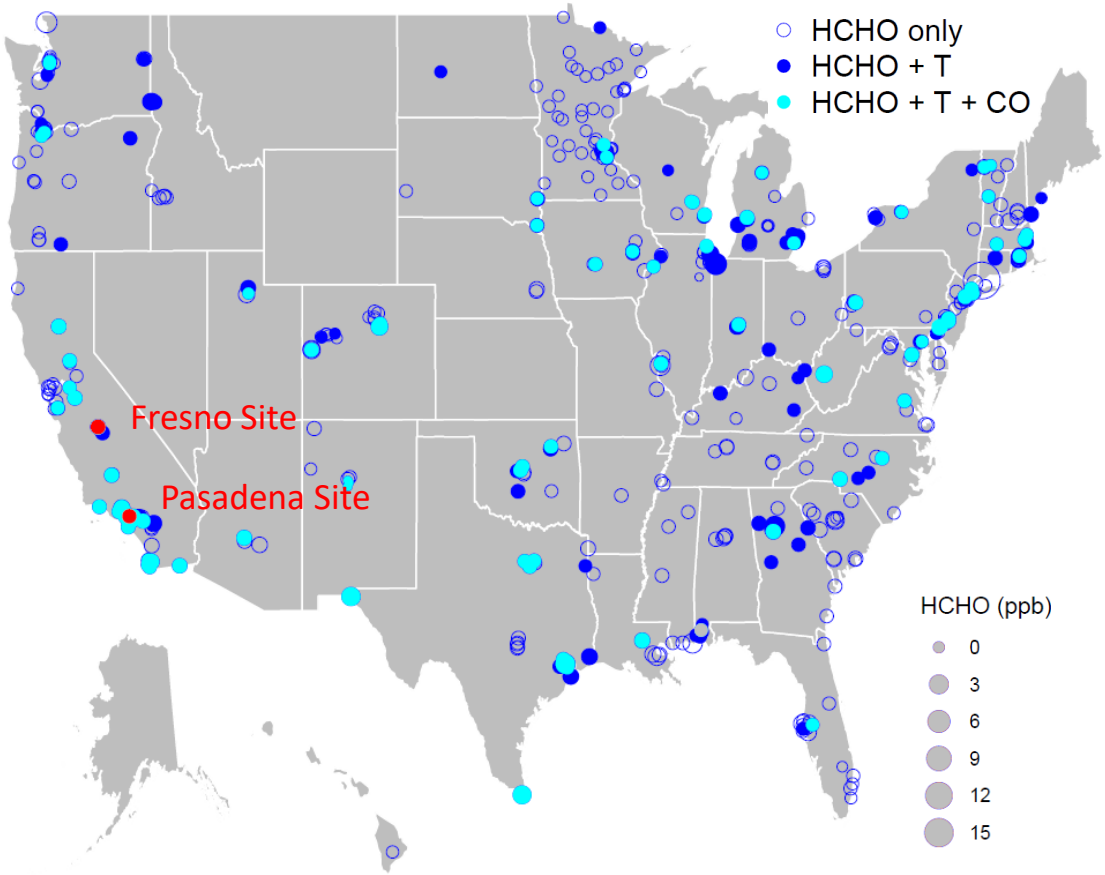
# Background

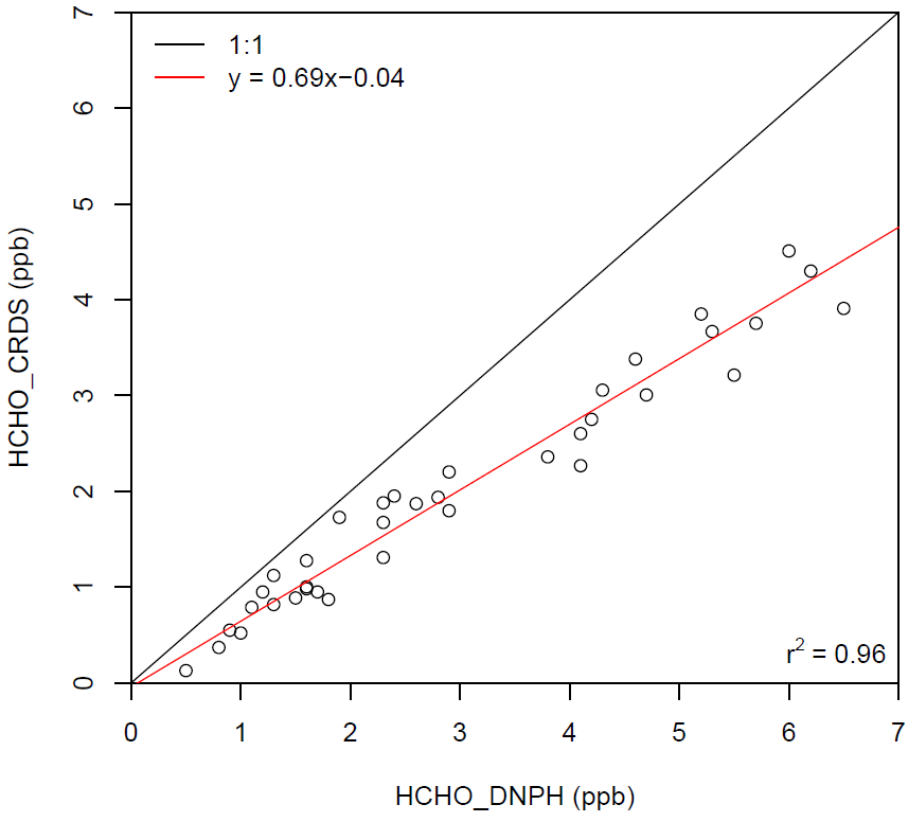
- Ubiquitous Presence: Found both indoors and outdoors.
- Diverse Sources: Biogenic emissions, biomass burning, fossil fuel combustion, industrial emissions, off-gassing from building materials, photochemical production.
- Health Implications: Irritates eyes, nose, throat, lungs, triggers asthma attack; prolonged exposure can cause cancer.
- Photochemical Significance:
  - Oxidation product of many VOCs.
  - Photolysis of HCHO is important source of $HO_x$ radicals.
  - High ozone formation potential in the SJV and SoCAB of California (Liu et al. 2022 ACP).
- Monitoring Challenges: Not easy to measure, lack of high time resolution measurements.

# Data Used in This Study



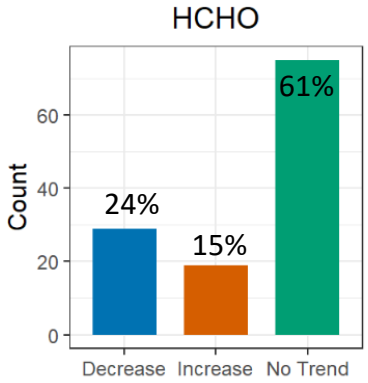

- AQ monitoring sites (535 total)
  - HCHO only: 357 sites
  - HCHO + T: 178 sites
  - HCHO + T + CO: 101 sites
  - Daily data every ~6-12 days 1987–2022 (35 years)
  - DNPH method
- Fresno Site
  - March 2019–July 2021 (2+ years)
  - 2-s data
  - CRDS (Picarro G2307)
- Pasadena (RECAP-CA Campaign)
  - August–September 2021 (1 month)
  - 2-s data
  - CRDS (Picarro G2307)

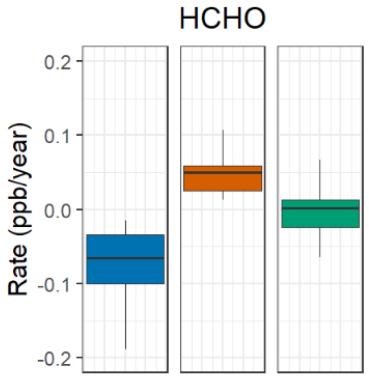
# CRDS vs DNPH

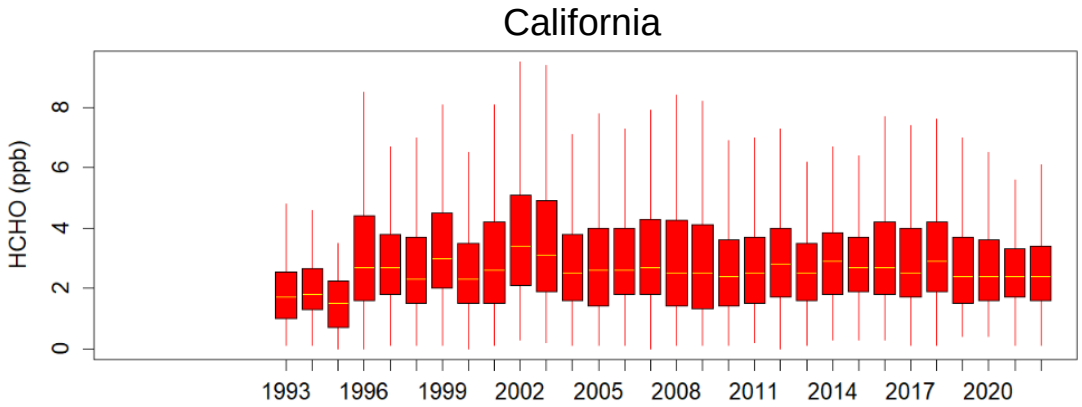



- HCHO from DNPH method is 30% higher. Similar findings from New York measurement.
- Possible explanation:
  - $NO_2$ reacts with DNPH and form a product that exhibits similar retention time compared to the HCHO derivatives (Vogel et al. 2000, Szulejko et al. 2015).
  - Matrix interference: compounds that have similar retention time to HCHO derivative.
  - Sample contamination during storage or shipment by diffusion of VOCs through the sample bottle seal.
  - Drifts in CRDS measurements

# HCHO Trends from AQ Monitoring Sites

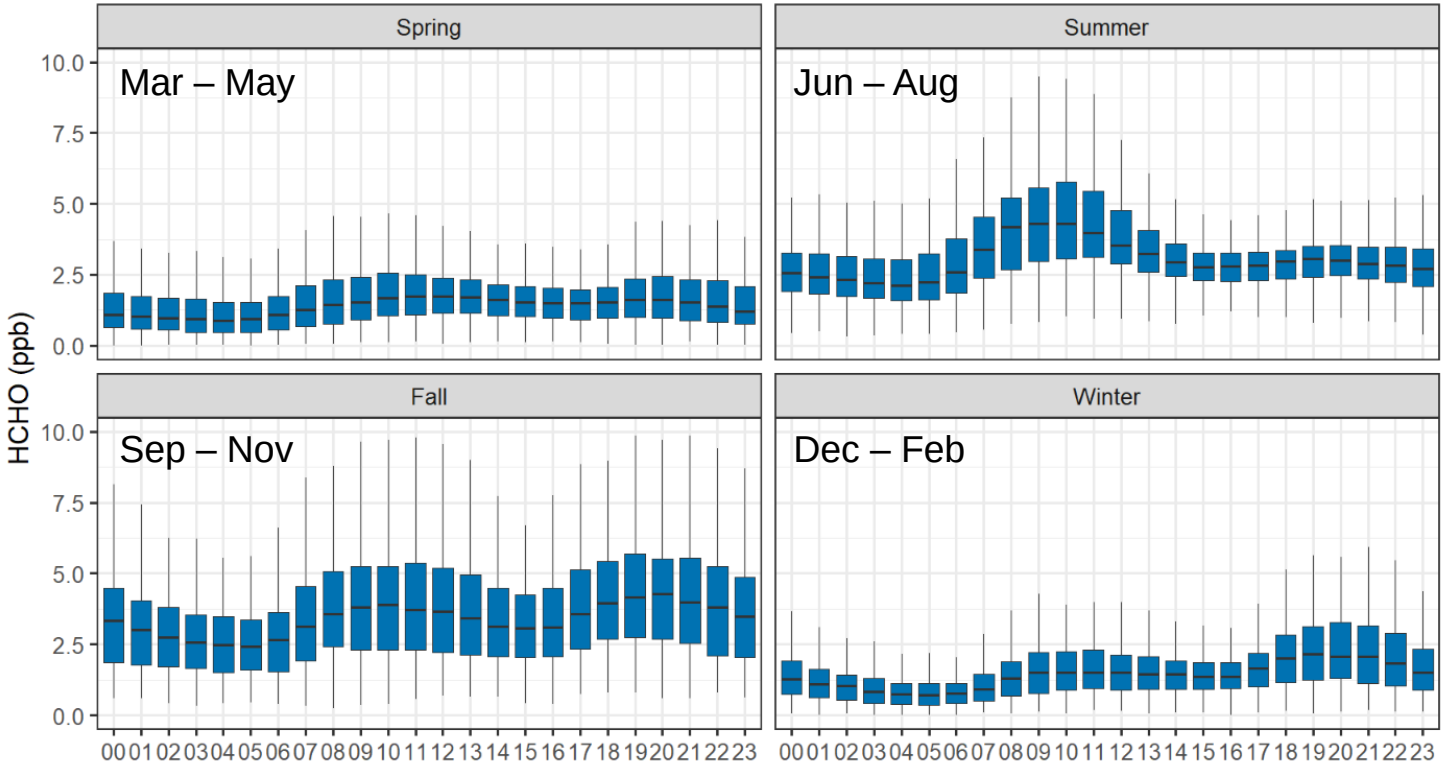


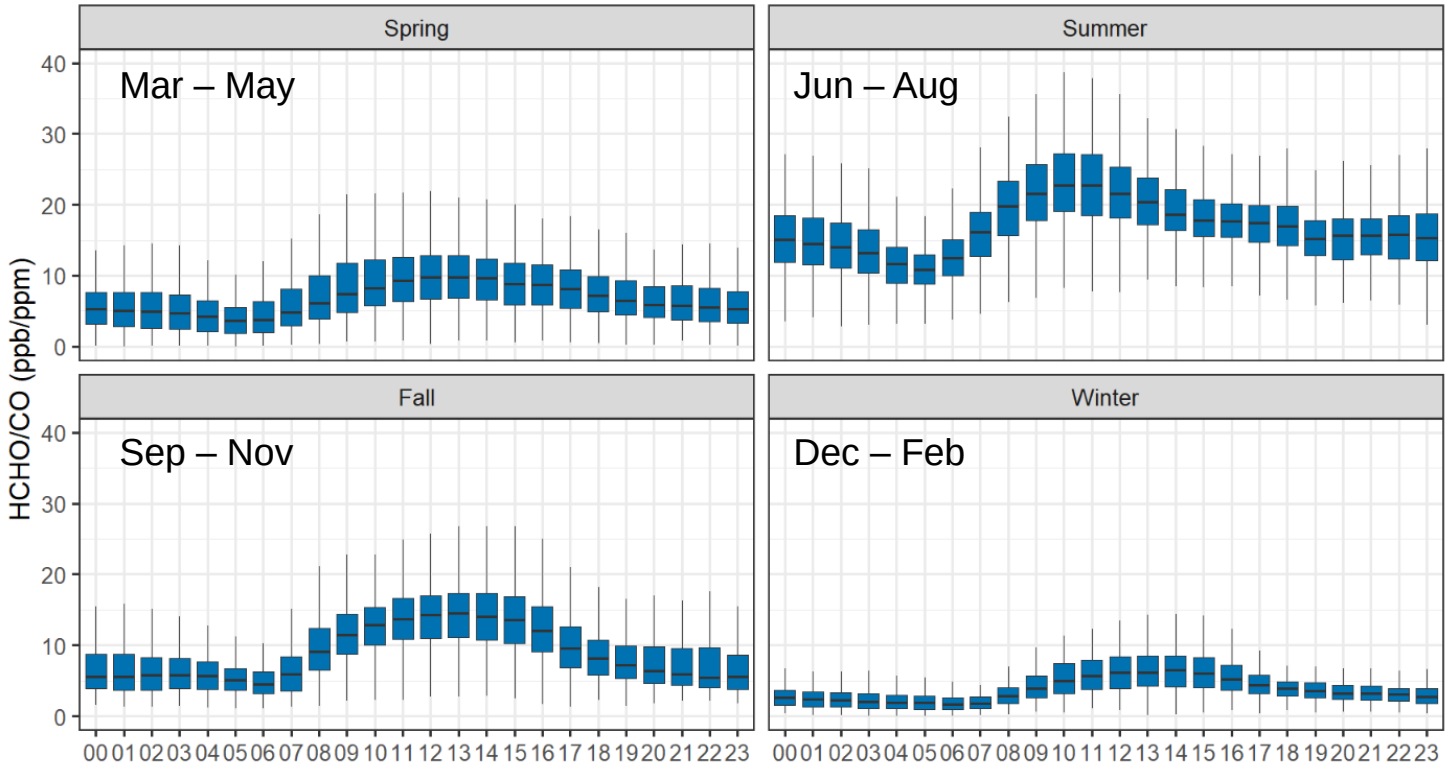

- Lack of trend suggests HCHO is mostly secondary from natural precursors.

# Seasonal and Diurnal Variation of HCHO in Fresno



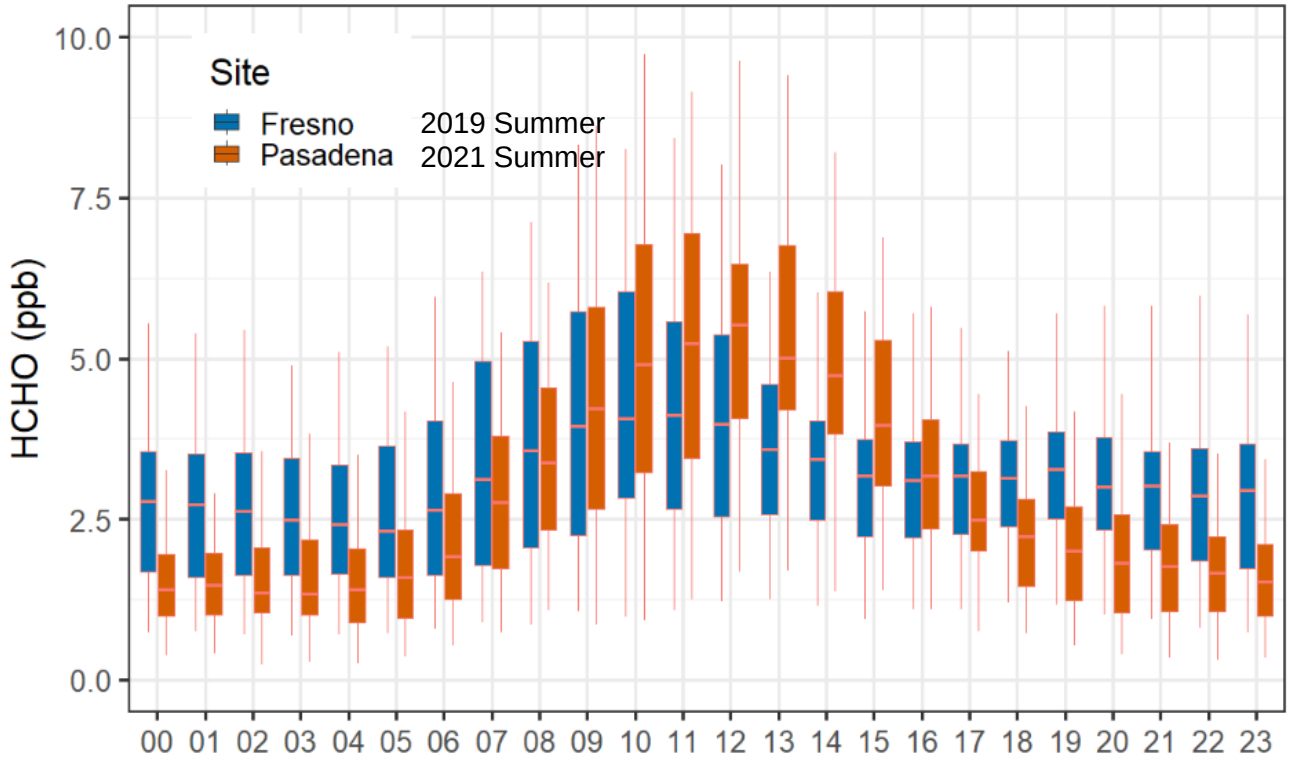

- Highest conc. in summer and fall.
- Two peaks in fall and winter.

# Seasonal and Diurnal Variation of HCHO/CO in Fresno



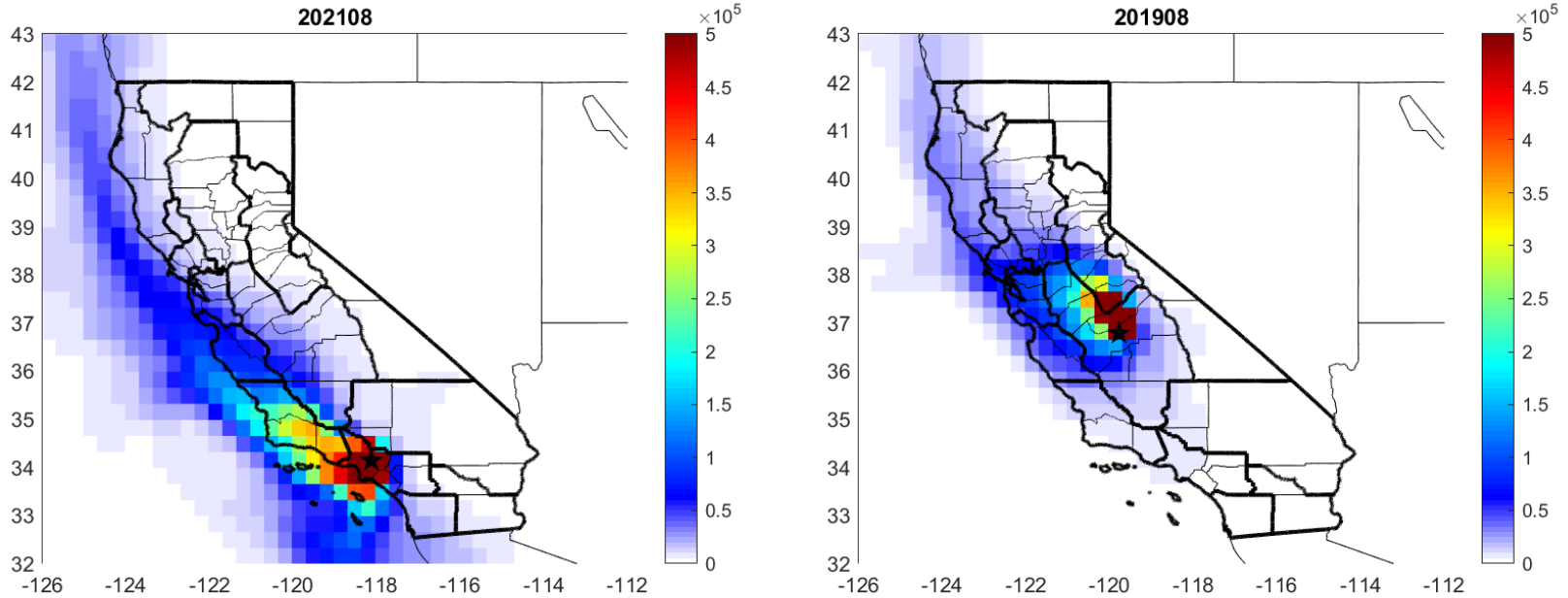

- CO-normalized profiles show one peak.

# Diurnal Cycle of HCHO: Pasadena vs Fresno



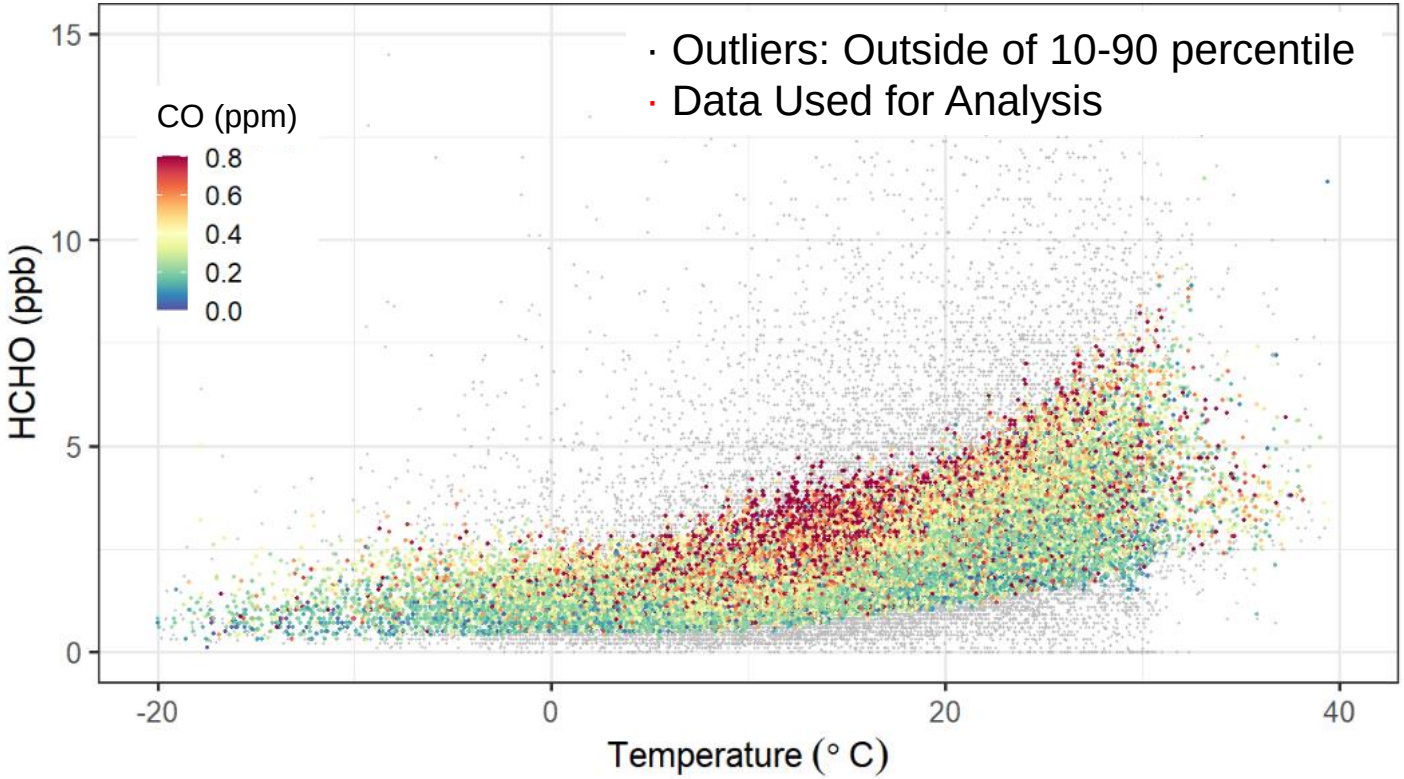

- The HCHO peak lags 2-3 hours in Pasadena.

# Air Mass Back-Trajectories: Pasadena vs Fresno



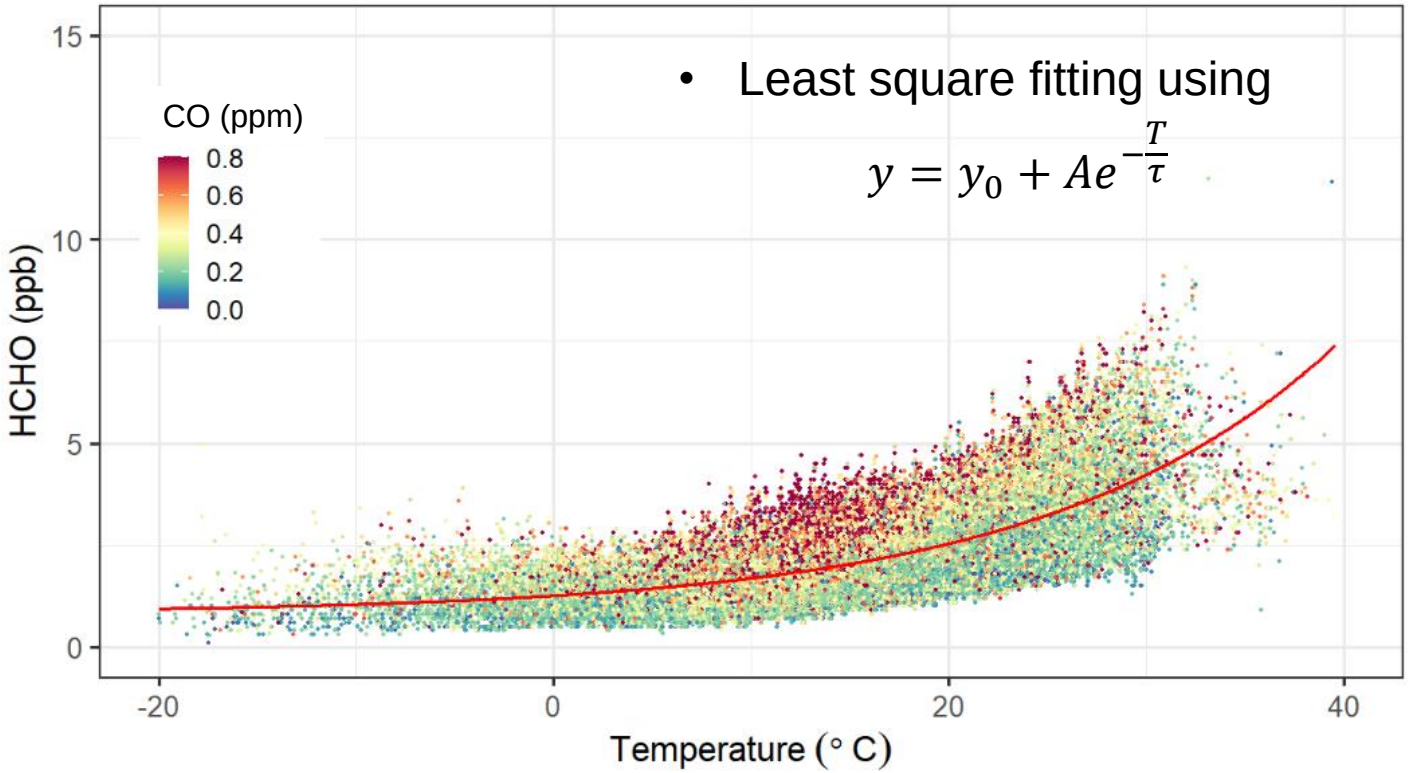

- Simulated using FLEXPART model with ERA5 hourly data (30 km).
- Pasadena is impacted by a larger region compared to Fresno.

# HCHO Strongly Depends on Temperature




- HCHO has strong correlation with temperature, scatters relate to CO.

# HCHO Parameterization Using of Temperature



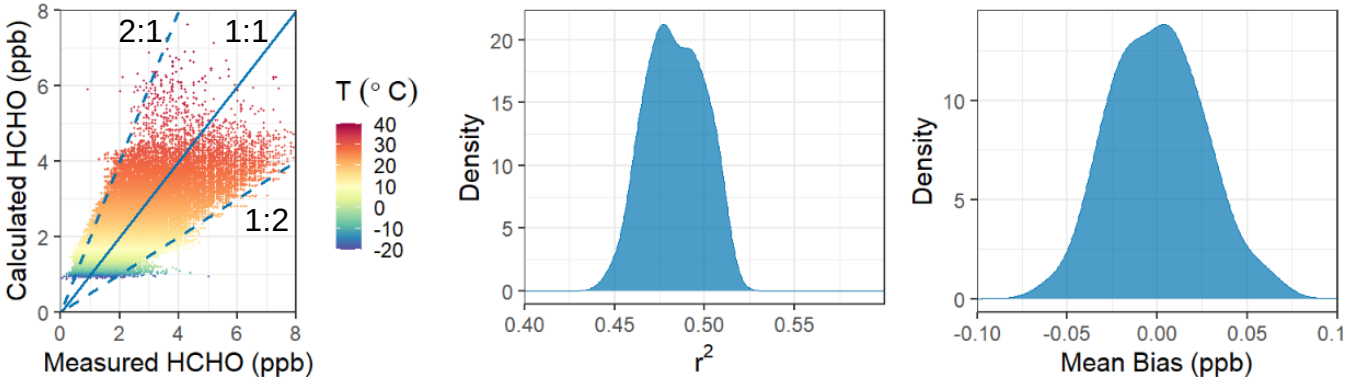

- Least square fitting using

$$y = y_0 + Ae^{-\frac{T}{\tau}}$$

- HCHO has strong correlation with temperature, scatters relate to CO.

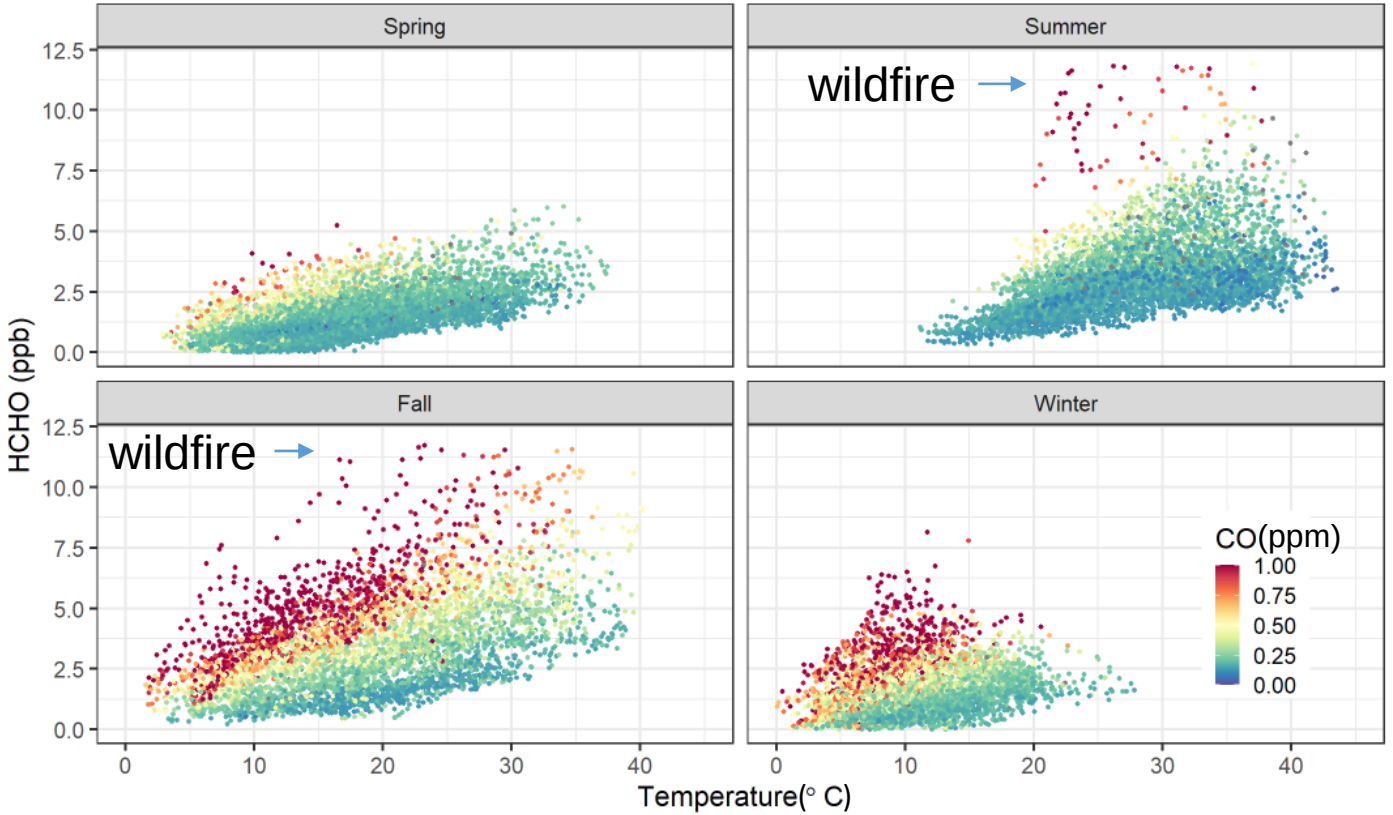
# Parameterization Evaluation Using Cross-Validation

$$y = y_0 + Ae^{-\frac{T}{\tau}}$$



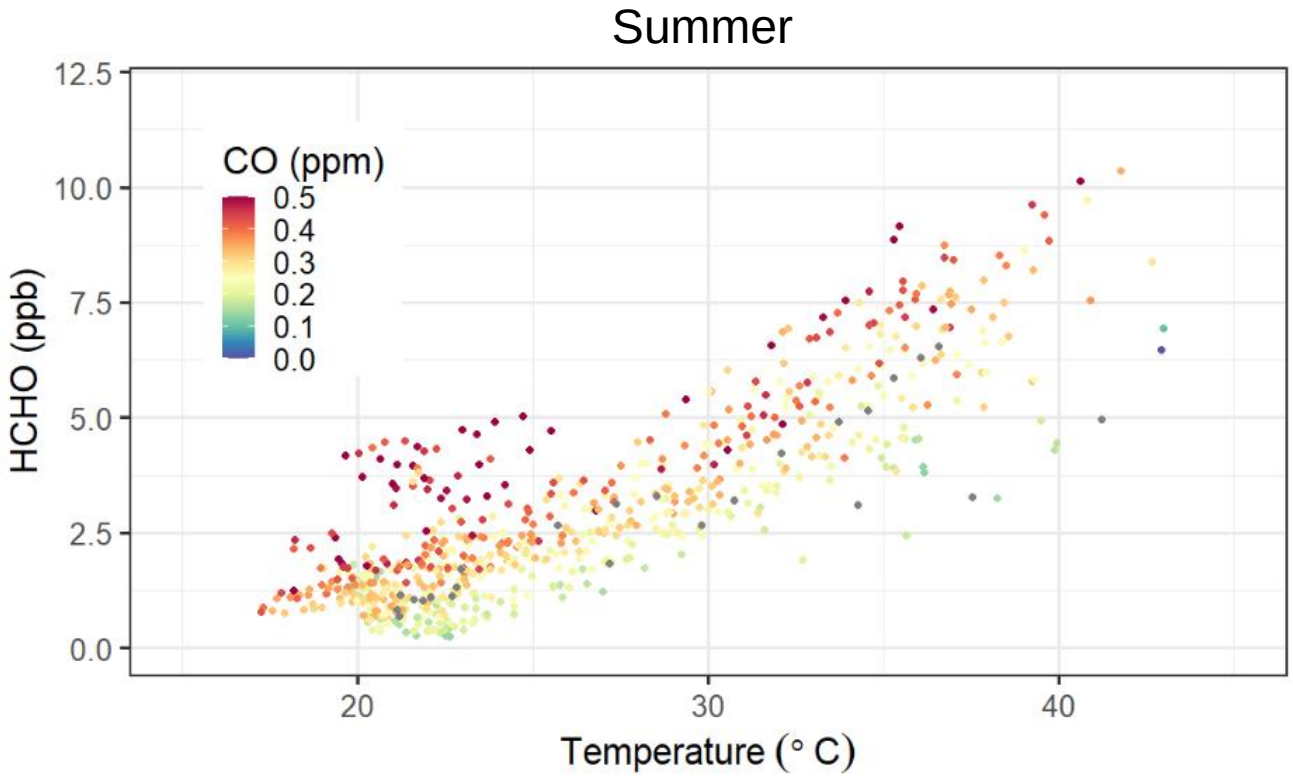

- Temperature alone explains ~50% of the HCHO variability.

# HCHO vs Temperature in Fresno



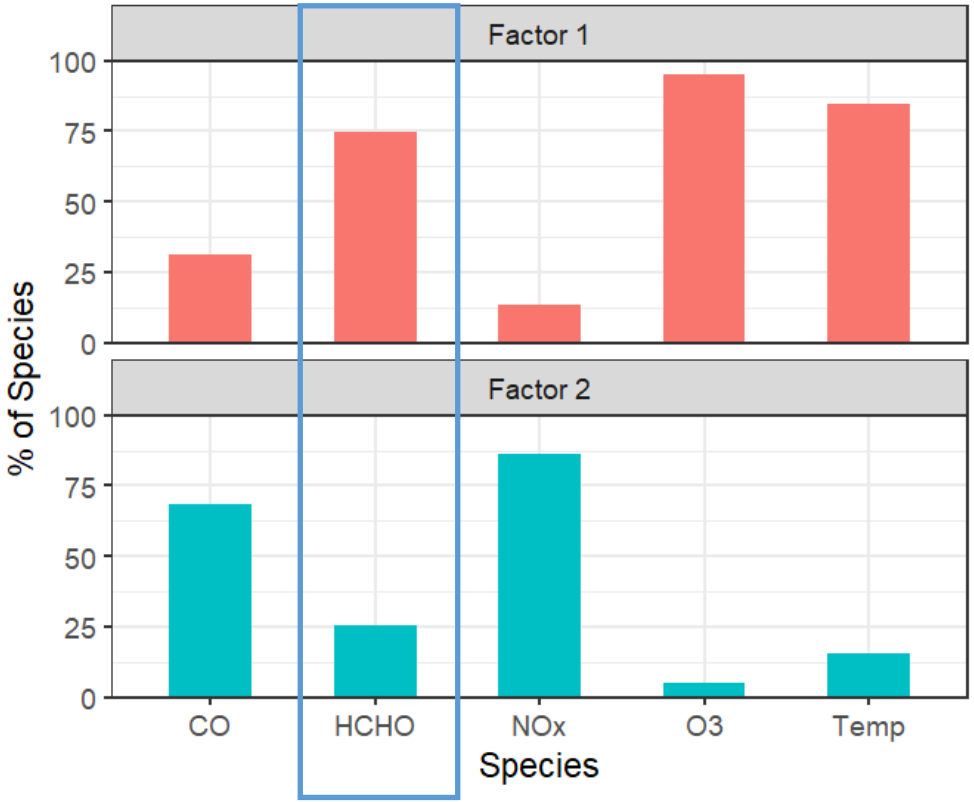

- HCHO has strong correlation with temperature, scatters relate to CO.

# HCHO vs Temperature in Pasadena




- HCHO has strong correlation with temperature, scatters relate to CO.

# Sources Apportionment of HCHO in Fresno




PMF Factors:

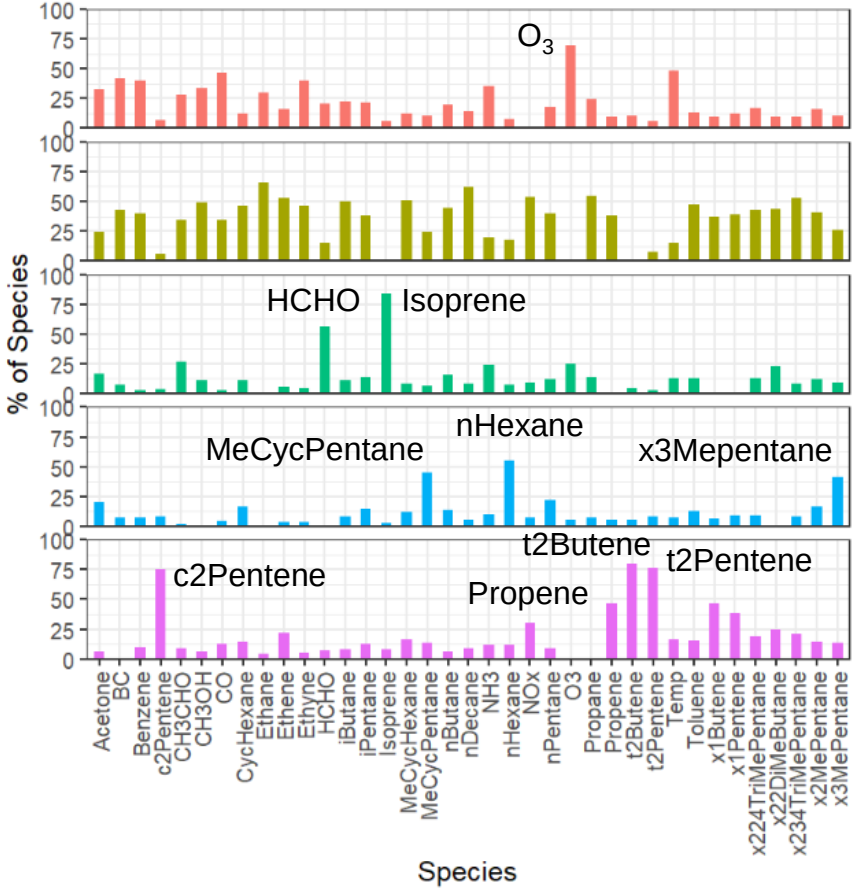
- Factor 1: T-dependent source
- Factor 2: Primary combustion

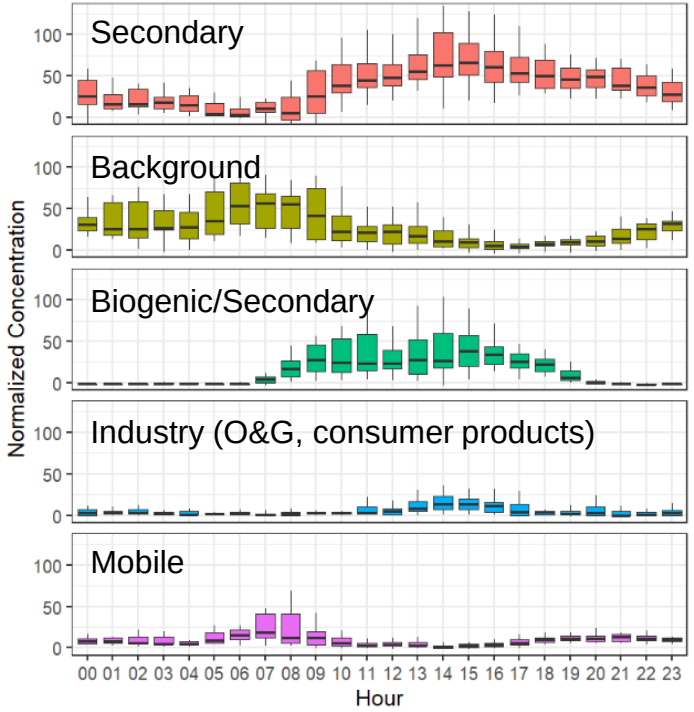
Notes:

- Daily data
- 5 species
- 2-factor solution

About 75% of HCHO is from T-dependent source.

# Sources Apportionment of HCHO in Pasadena

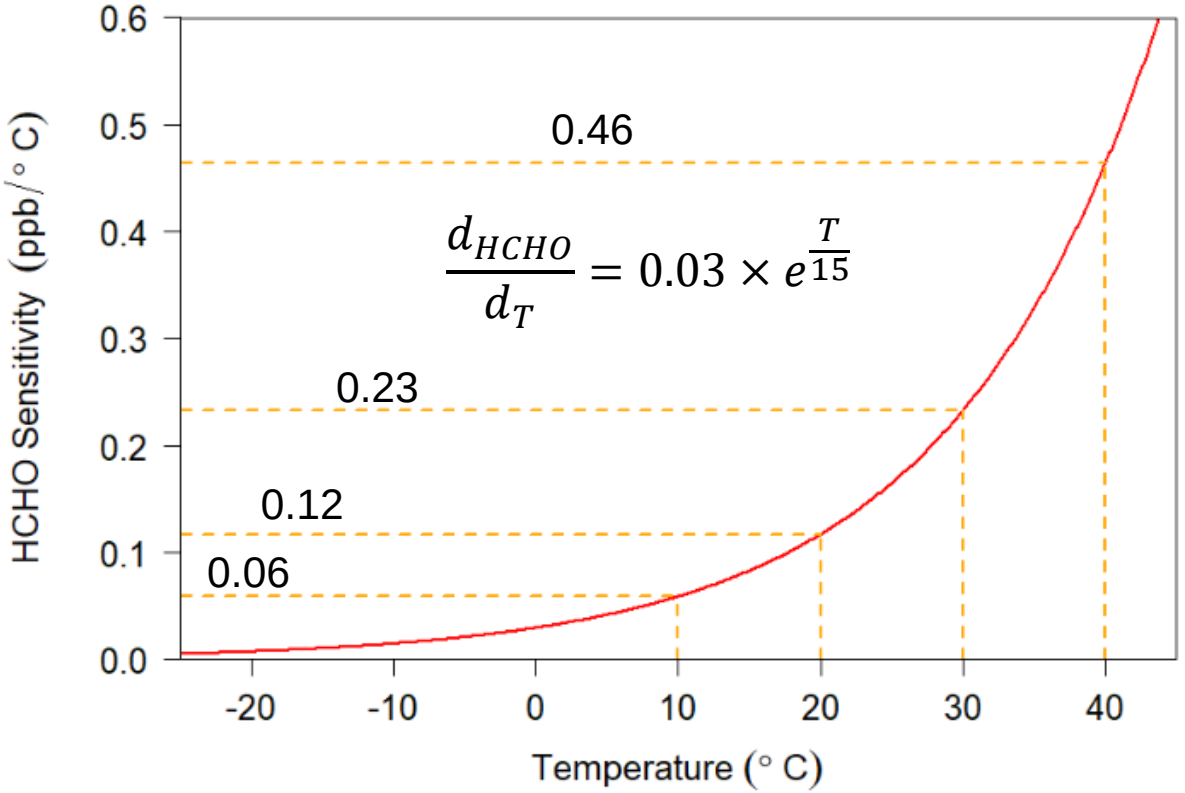



| HCHO% |
|---|
| 20% |
| 15% |
| 56% |
| 1% |
| 7% |

About 75% of HCHO is from T-dependent sources.

# Sensitivity of HCHO to Temperature




- HCHO becomes sensitive to temperature as temperature increases.

# Conclusions and Future Work

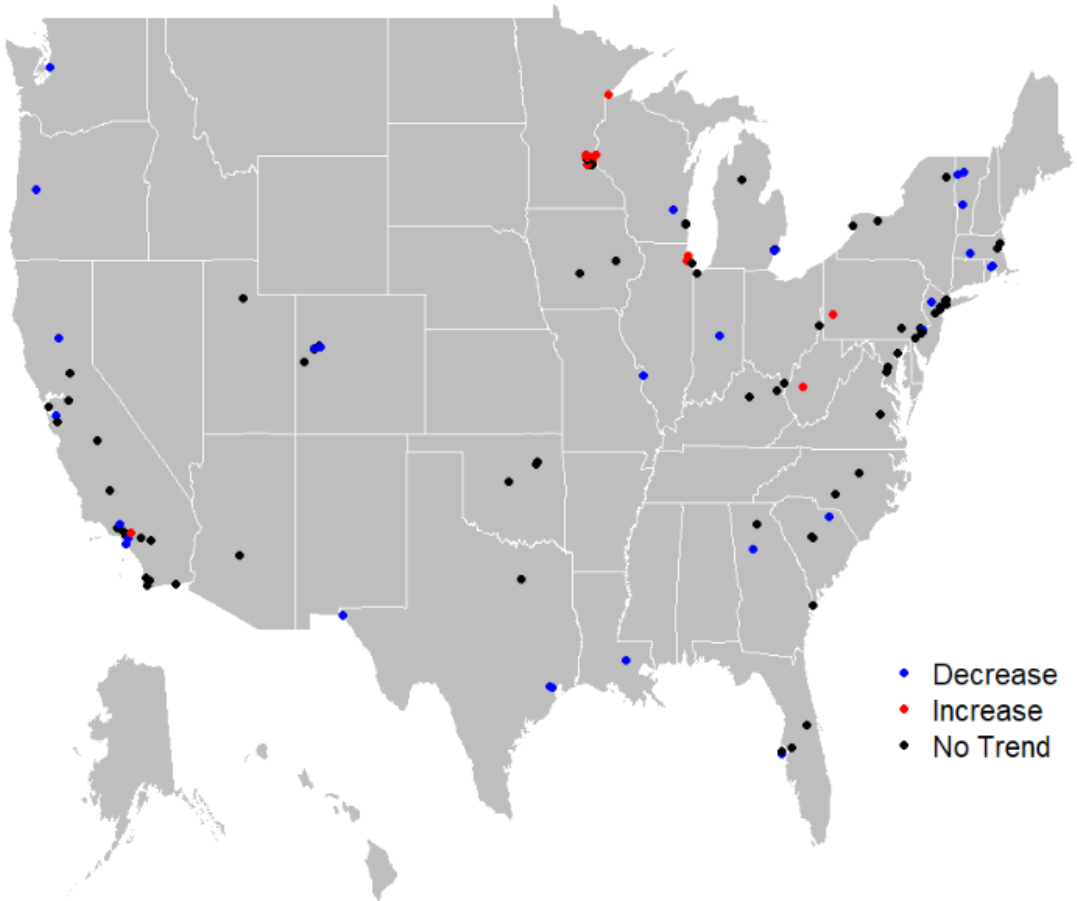
**Conclusions**

- HCHO measurements in the SJV, SoCAB, and the US consistently show exponential increase with temperature.
- Temperature alone can explain 50% of the HCHO variability.
- HCHO concentration is also affected by combustion sources, especially in fall and winter.
- Source apportionment suggest that 75% of HCHO is from temperature-dependence sources and 25% is from anthropogenic sources in CA.

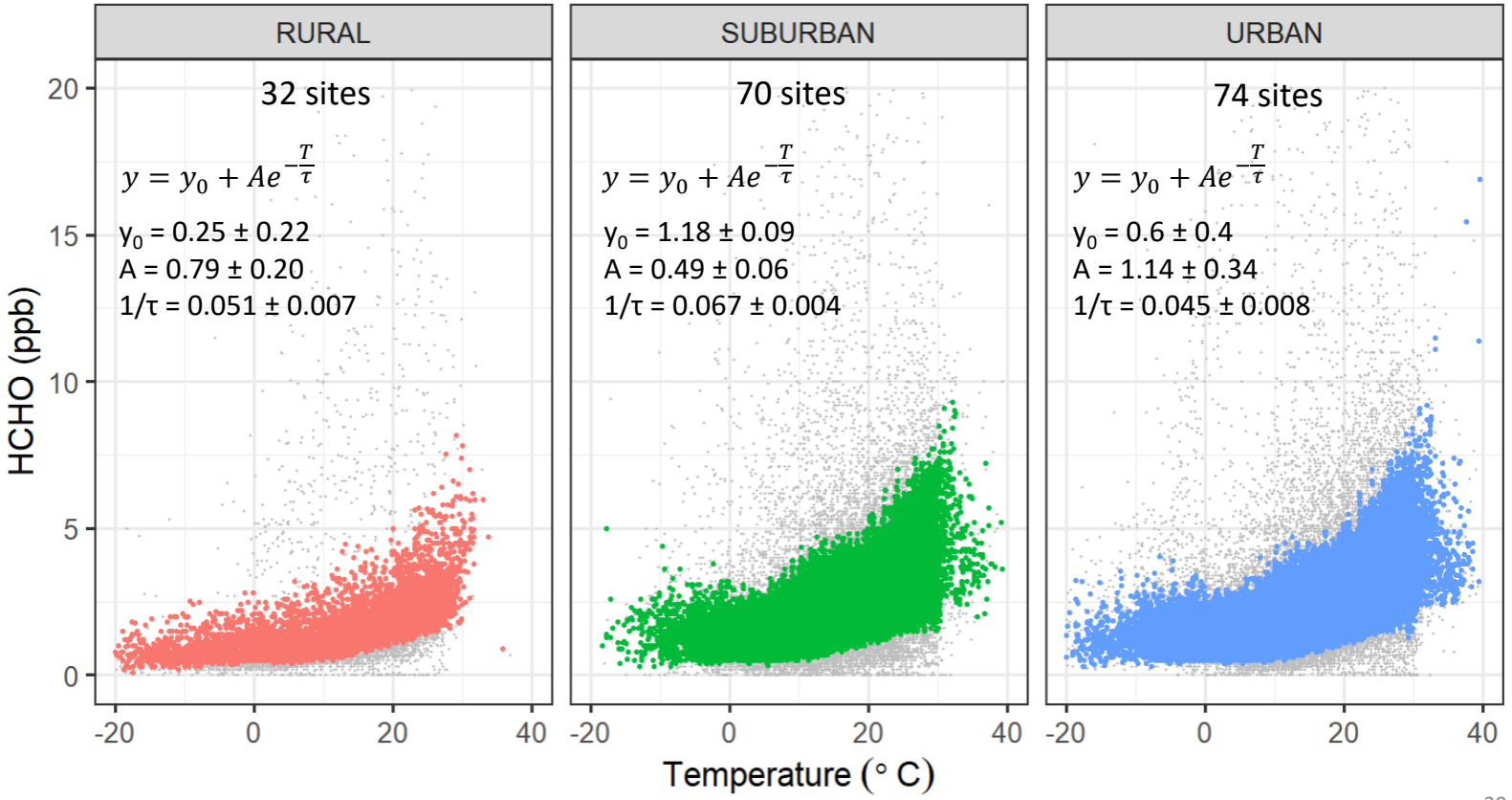
**Future Work**

- Contributions of emissions vs chemistry to the T-dependence.
- Refine source apportionment analysis.

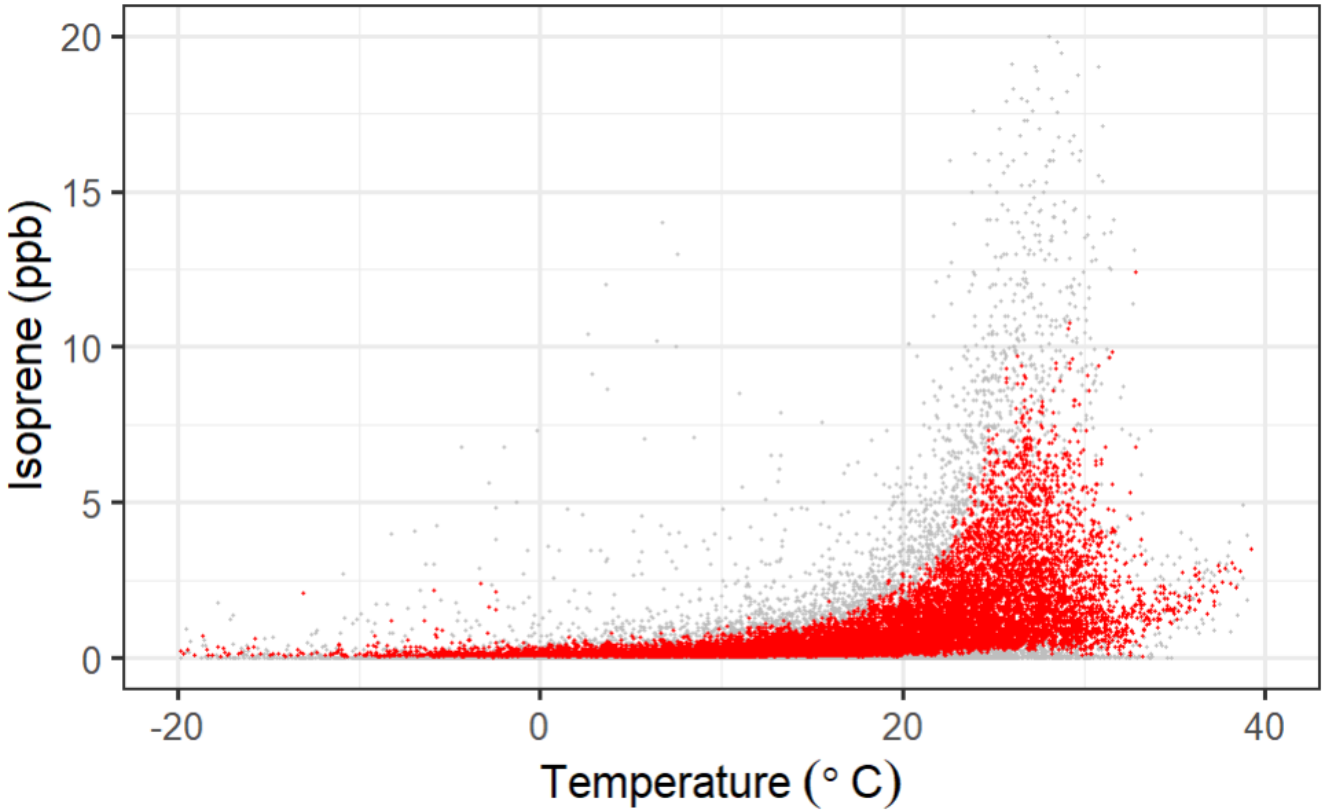
# HCHO Trend Map



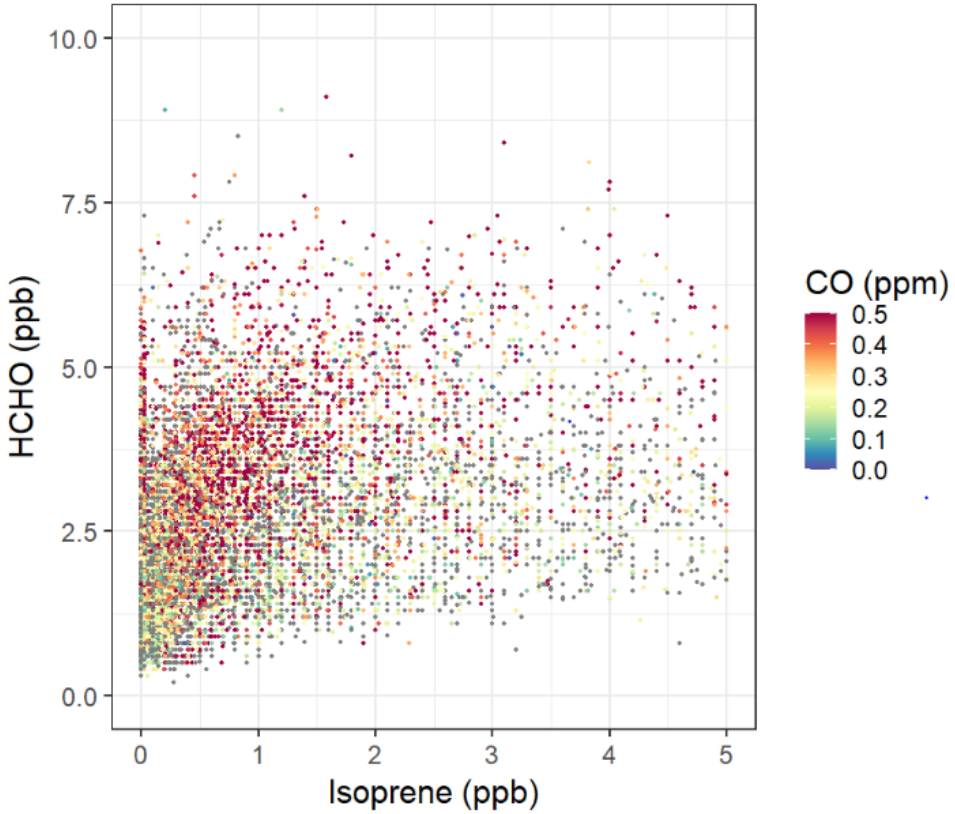
# HCHO vs T by Location Setting



# Isoprene vs Temperature

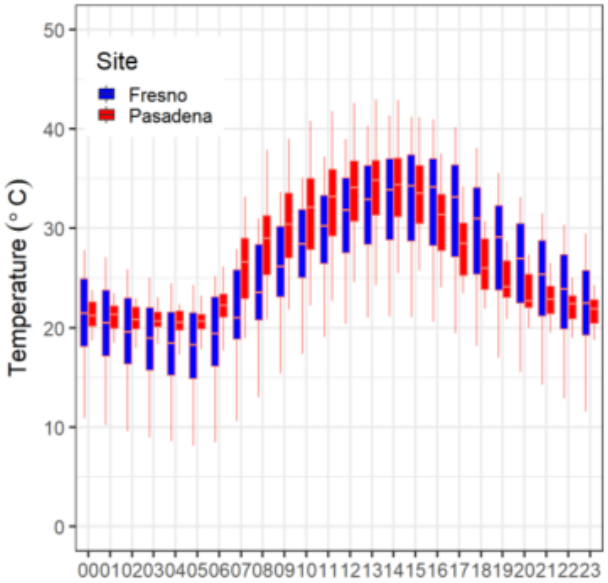


# HCHO vs Isoprene

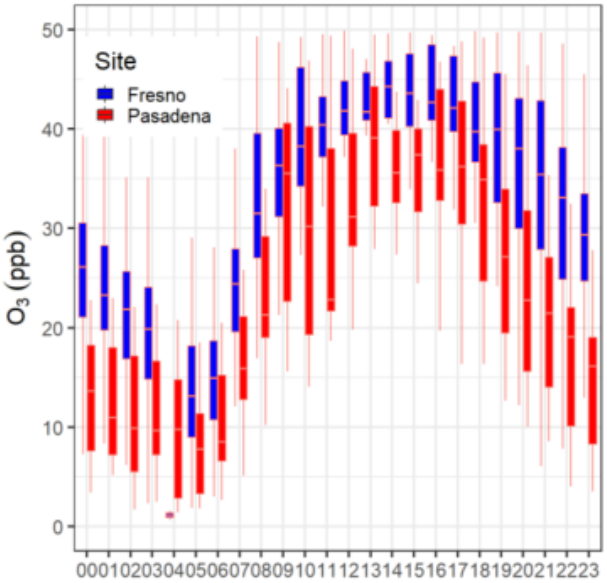


# Diurnal Cycle of T/$O_3$/NOx in Pasadena vs Fresno

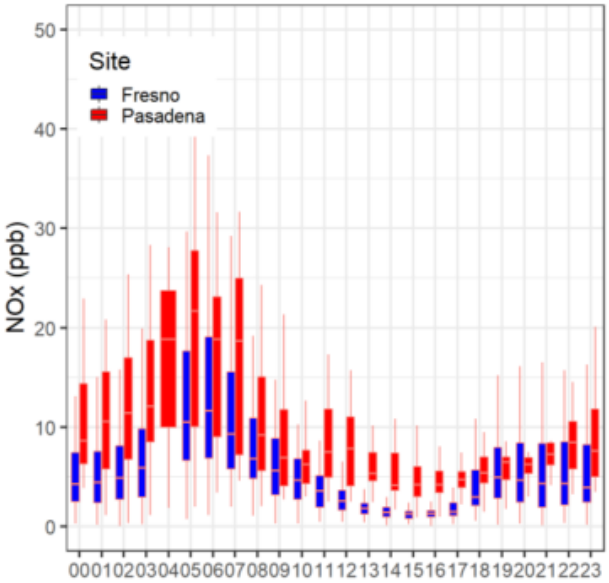
Temperature




$O_3$

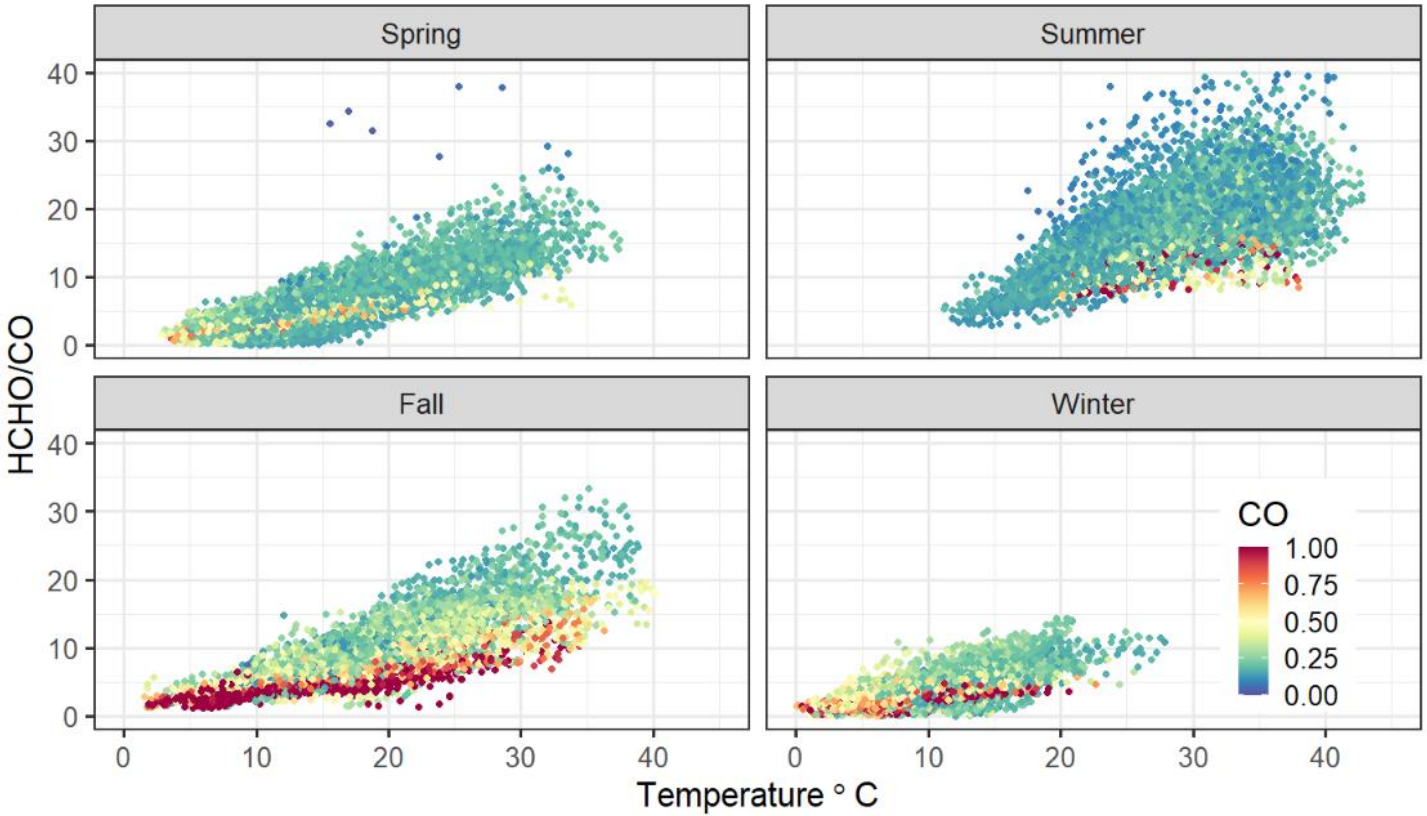



NOx

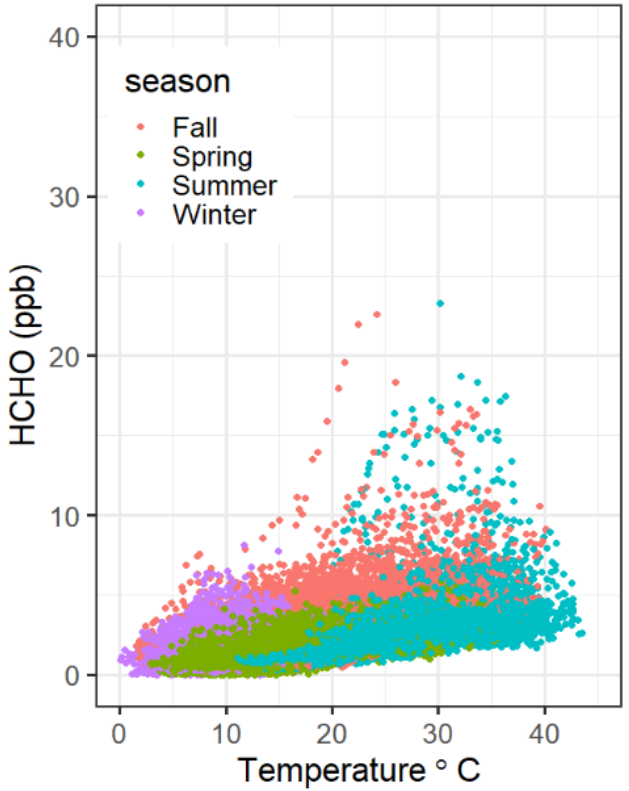


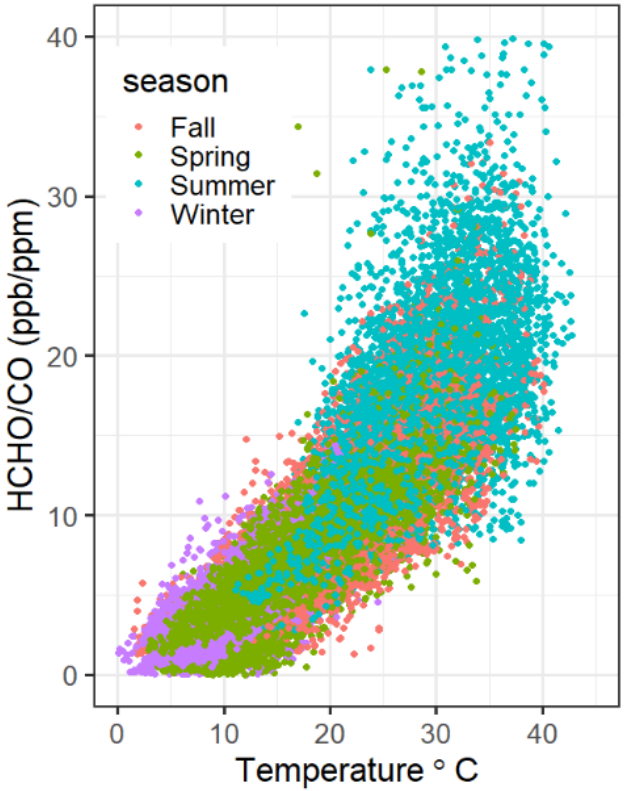

- Diurnal cycles of T, $O_3$, and NOx are similar between Pasadena and Fresno.

# HCHO/CO vs Temperature in Fresno

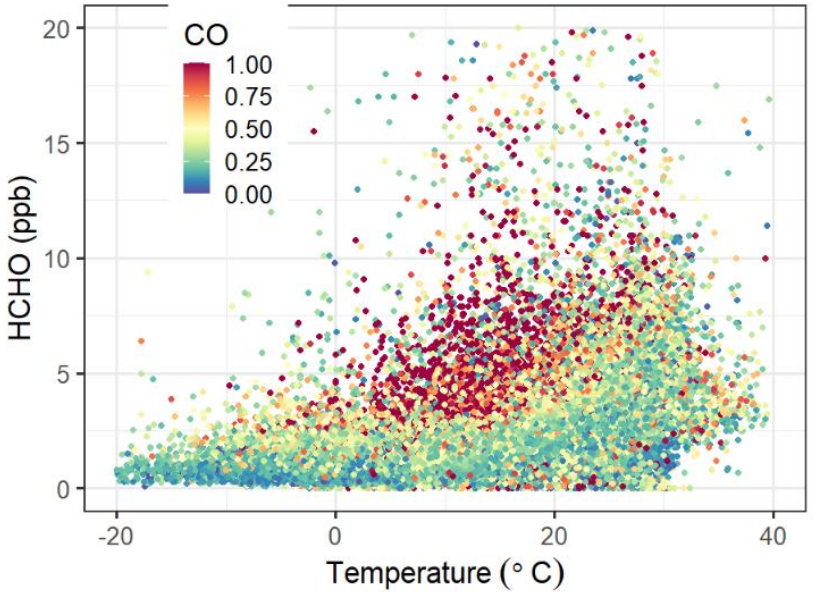


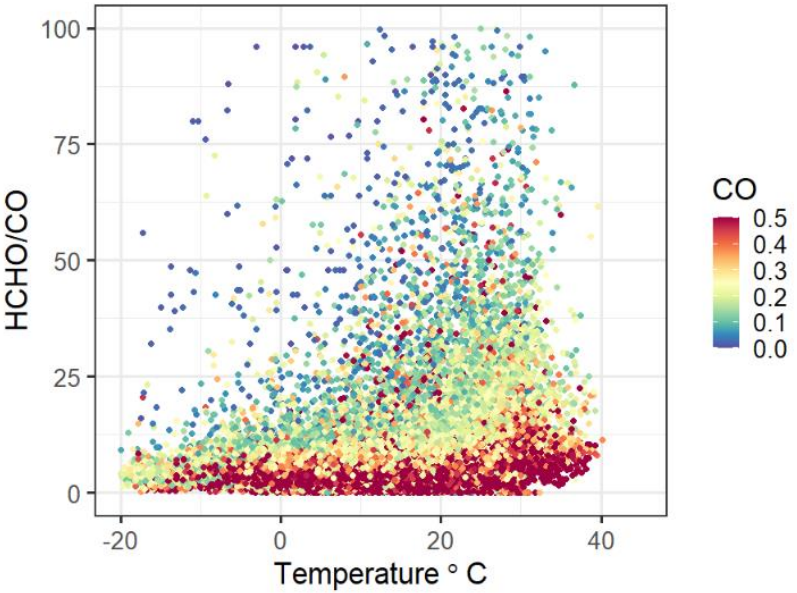
# HCHO vs T and HCHO/CO vs T in Fresno



# HCHO and HCHO/CO vs Temperature in the US




- HCHO has strong correlation with temperature, scatters relate to CO.