CALIFORNIA
AIR RESOURCES BOARD

Modeling Air Quality in California's South Coast and San Joaquin Valley in 2021

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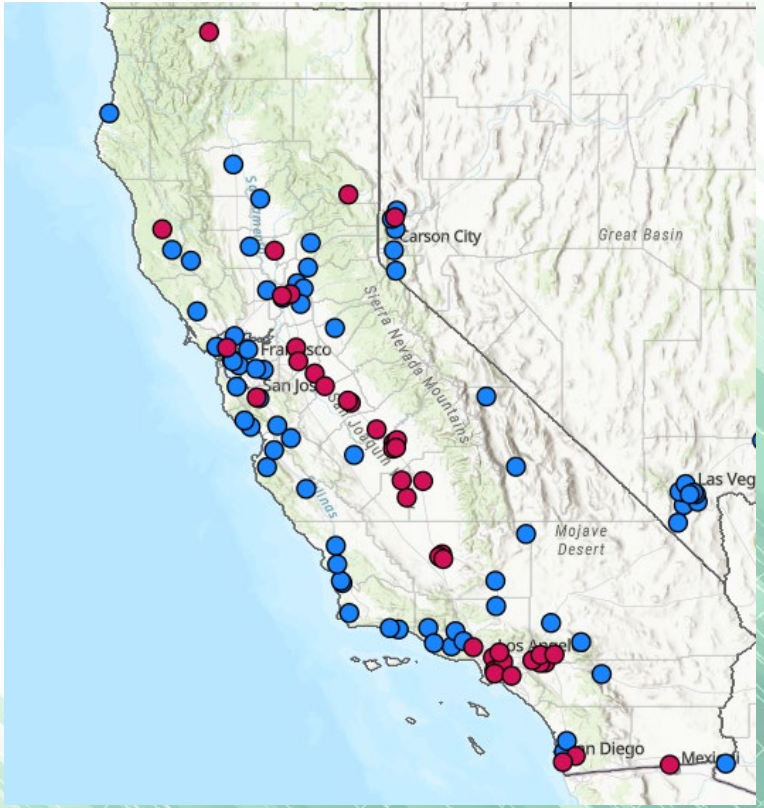
PM2.5 Annual DVs (2021-2023)

Areas violating 9 µg/m^3 PM2.5 NAAQS in CA (red on the right plot):

Siskiyou*, Mendocino, Plumas, Sutter, Sacramento, Contra Costa, Santa Clara, San Diego, Imperial counties and South Coast, SJV basins

*Anticipated attainment after 2021 and 2022 Exceptional Event removal (2021-2023 DV of 8.4 µg/m^3)



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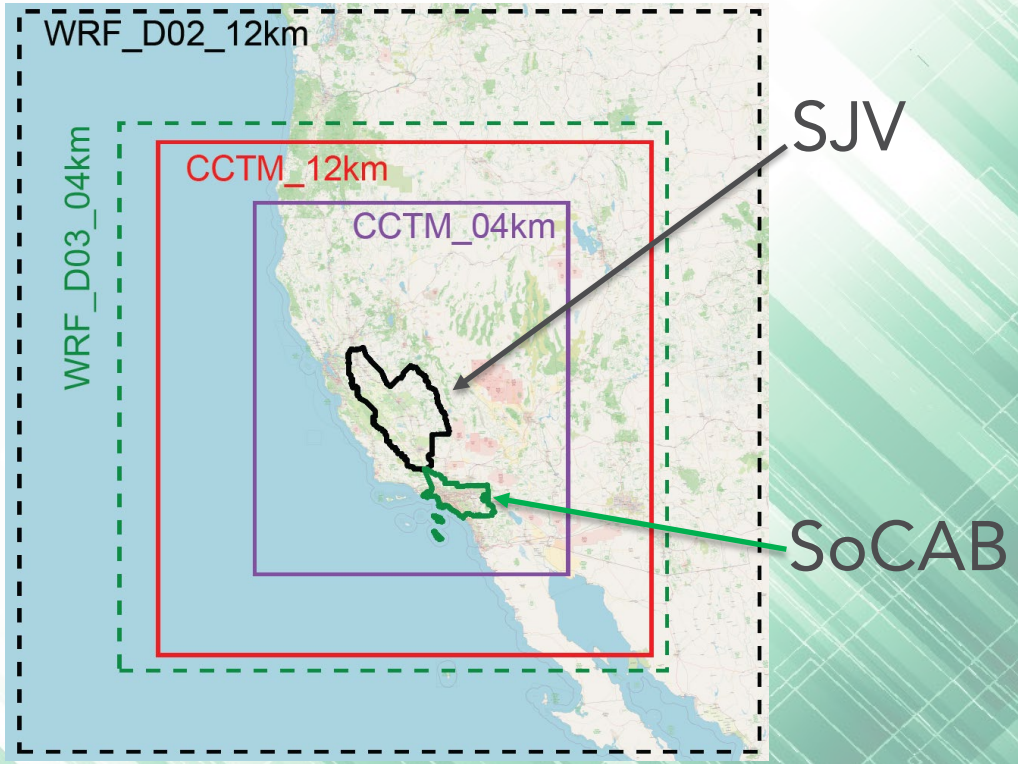
Objectives

- Use as a testbed for the new annual PM2.5 NAAQS SIP model demonstrations
- Explore and optimize met model/WRF physics for California
- Identify potential gaps in emissions for improvements
- Improve boundary conditions from the global atmospheric chemistry model GEOS-Chem

Current Model Setup

- Meteorological model: WRFv4.4.2
- Air quality model: CMAQv5.4.0.4 with SAPRC07tic, aero7i module and a fix to accommodate chemical boundary conditions from GEOS-chem
- Anthropogenic emissions: CARB 2021 inventory
- Biogenic emissions: MEGANv3.0 +DNDC soil NO
- Chemical boundary conditions for CCTM_12km domain: GEOS-Chem outputs



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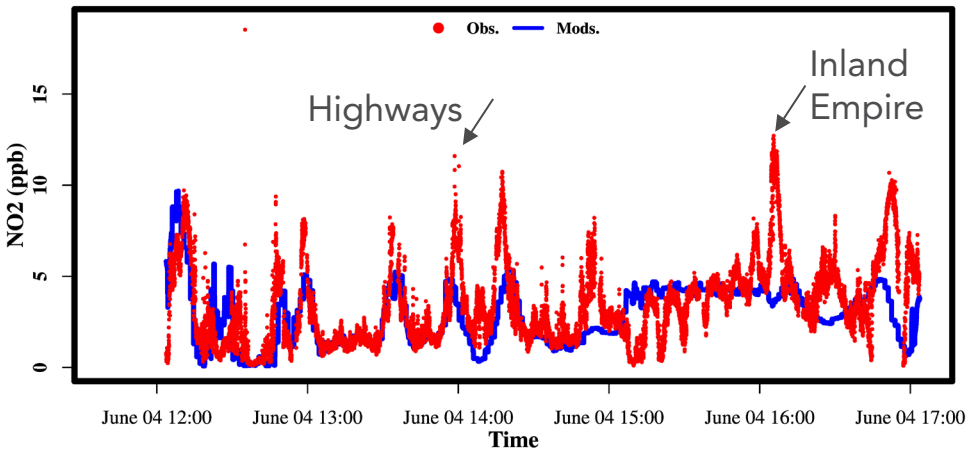
Measurement data

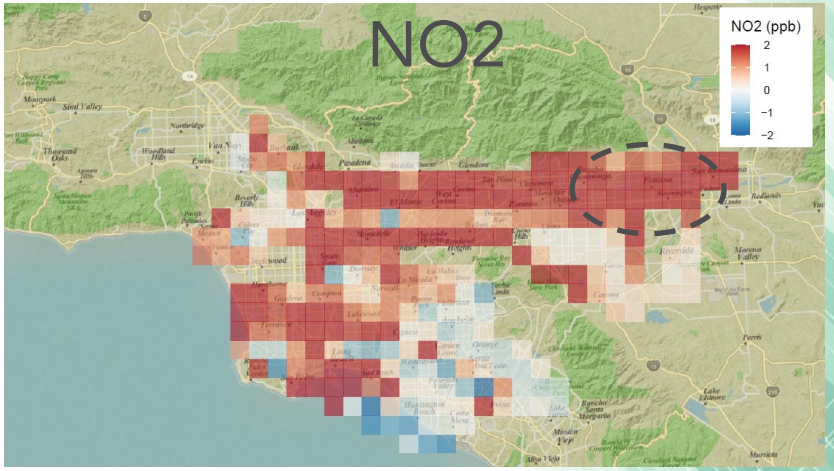
- Routine ground air quality data such as PM2.5, PM2.5 speciation, O3, NOx downloaded from the EPA Air Quality System (AQS)
- Photochemical Assessment Monitoring Stations (PAMS) data
- RECAP-CA Airborne NOx and VOCs measurements in June 2021 from UC Berkeley
- RECAP-CA VOCs measurements at the Pasadena ground site from August 2 to September 7 from NOAA
- Satellite observations: TROPOMI NO2 and ISAI NH3 column data

SoCAB NO2 (RECAP-CA Airborne)

20210604 flight



Obs-Mod, all flights aggregated



- Model over-estimates NO2 in some grid cells near coast and under-estimate NO2 inland
- Model underestimates NO2 in areas where warehouses (circled, Inland Empire) and highways are located

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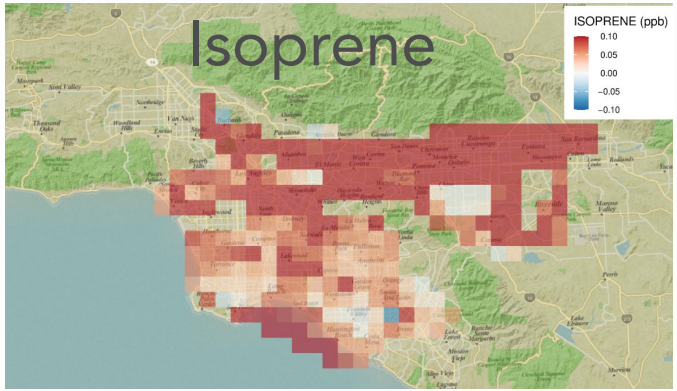
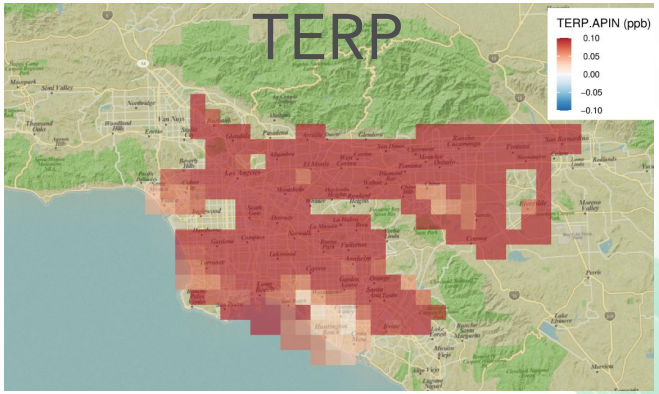
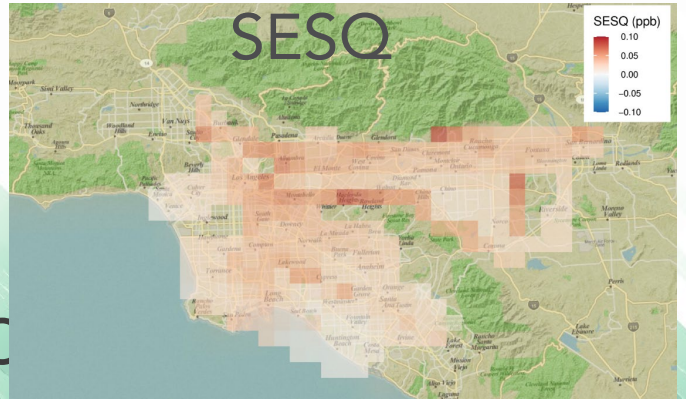
SoCAB Terpenoids (RECAP-CA Airborne)

Obs-Mod, all flights aggregated

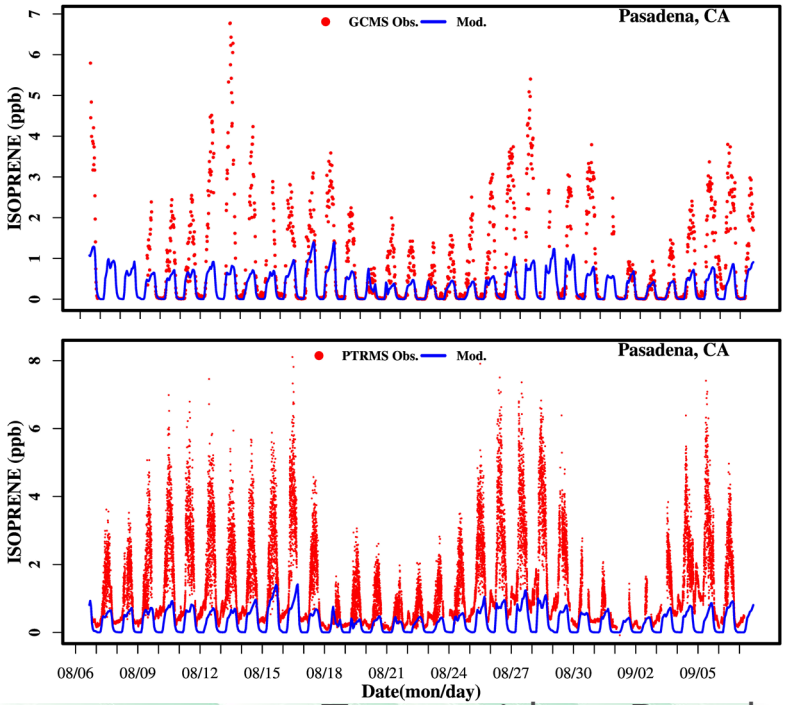


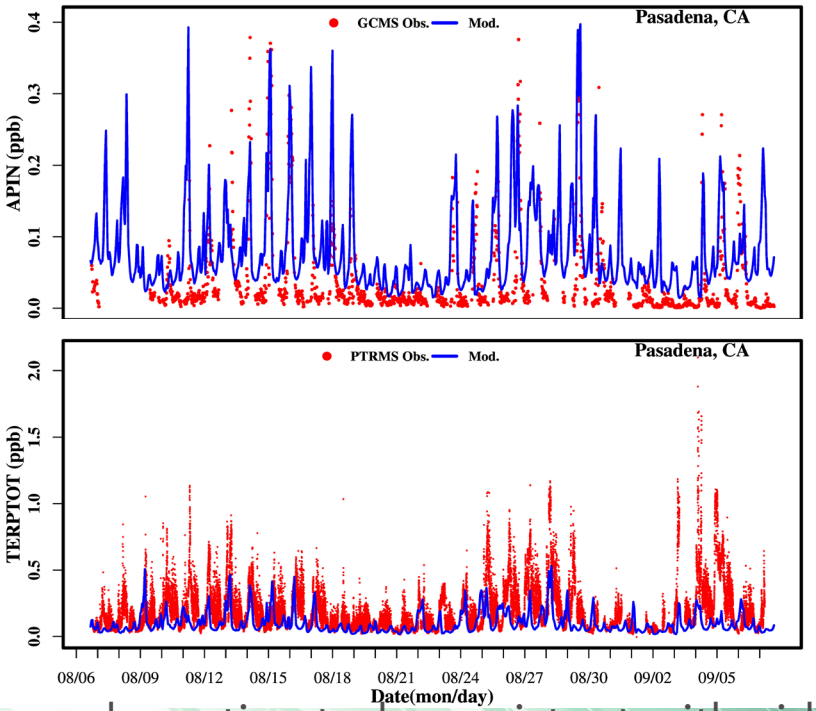




Model under-estimates terpenoids in general comparing to airborne observations

Terpenoids at Pasadena Ground Site





Terpenoids at Pasadena are under-estimated, consistent with airborne observations, but modeled alpha-pinene has a good agreement with the observations.

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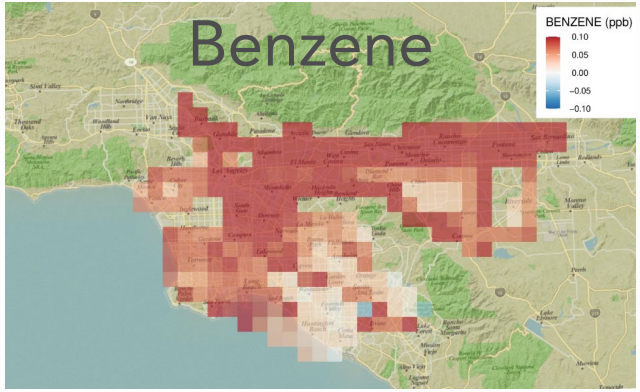
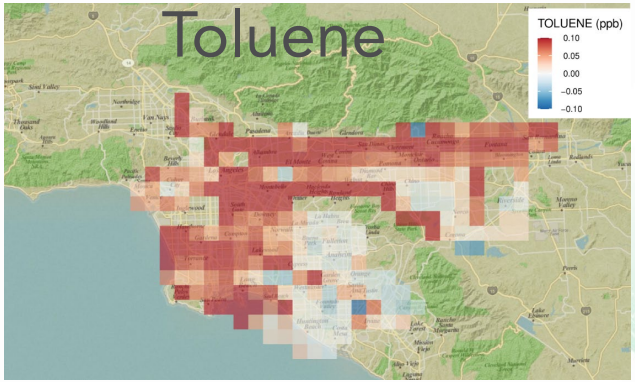
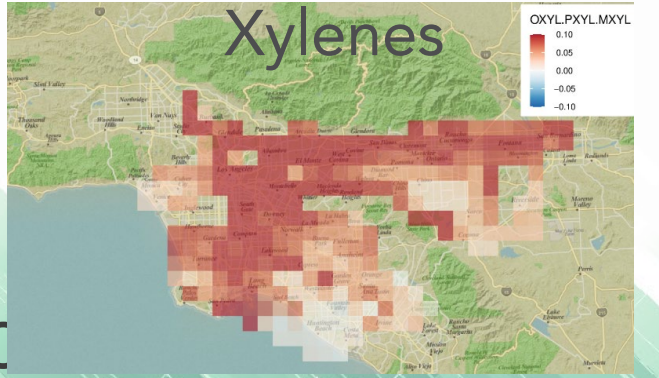
SoCAB Benzene, Toluene and Xylenes (RECAP-CA Airborne)

Obs-Mod, all flights aggregated

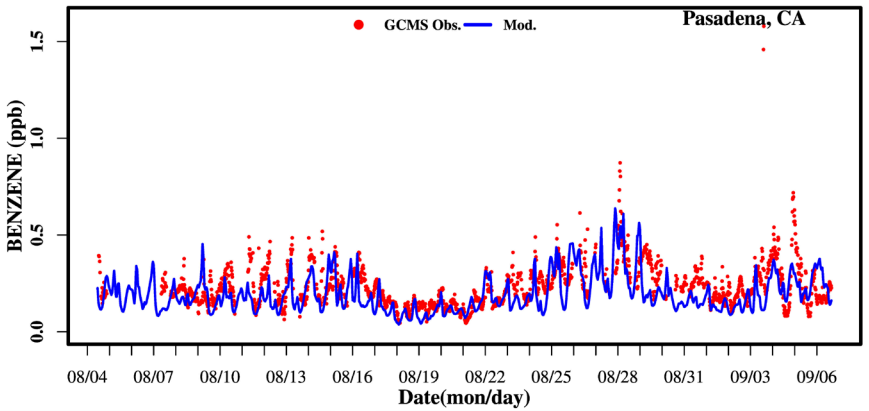


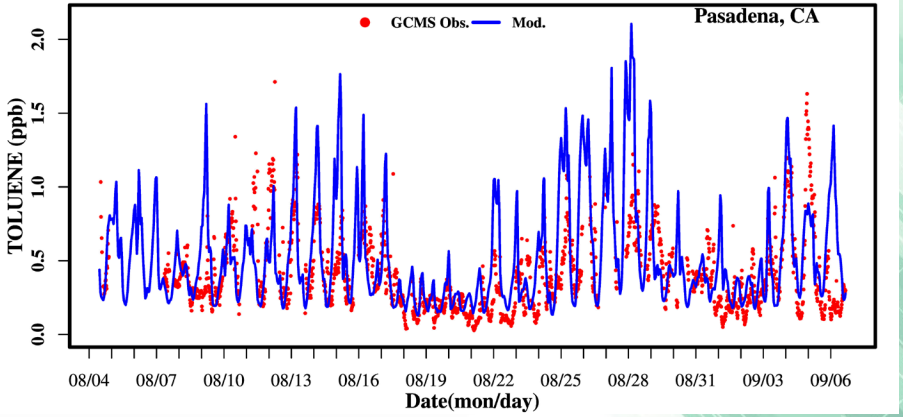




Benzene, Toluene and Xylenes, which are mainly associated with fuel combustion/transportation, are under-estimated except in Anaheim and Santa Ana comparing to airborne measurements

Benzene and Toluene at Pasadena





Modeled Benzene and Toluene compare much better to observations at the ground site than corresponding airborne data comparisons

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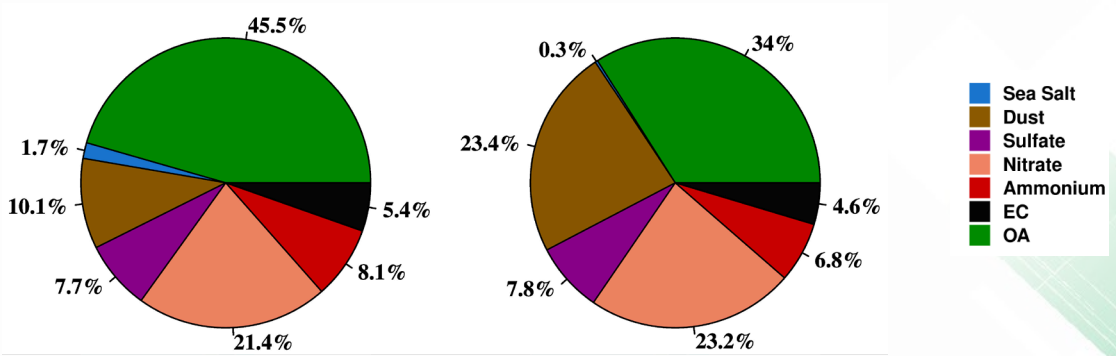
SoCAB Annual PM2.5 (Fontana)

Obs, 14.5μg/m^3 **Mod,** 11.3μg/m^3



- Model under-estimates annual organic mass at Fontana, San Bernardino County
- EC and inorganic compositions are close to observations.
- Modeled PM2.5 dust is too high
- Modeled PM2.5 sea salt is too low, but sea salt is the smallest component

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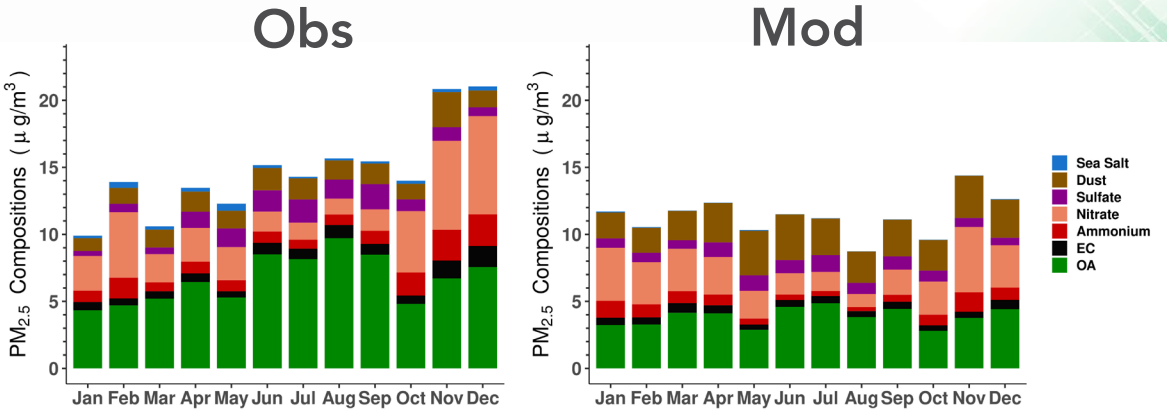
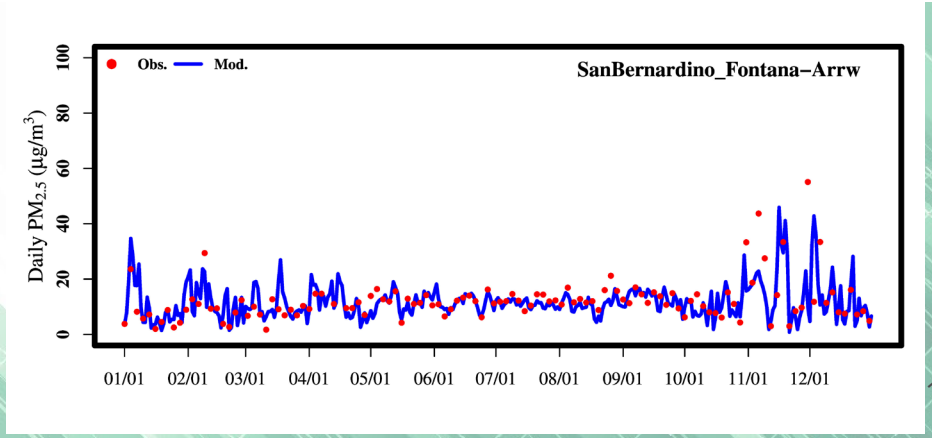
Monthly and Daily PM2.5 at Fontana

The model under-estimates monthly averages for most of the months at Fontana. The monthly organic mass compositions are lower than the observations and the model also under-estimates nitrate mass in Oct, Nov, and Dec



The modeled daily PM2.5 mass compares well with the observations



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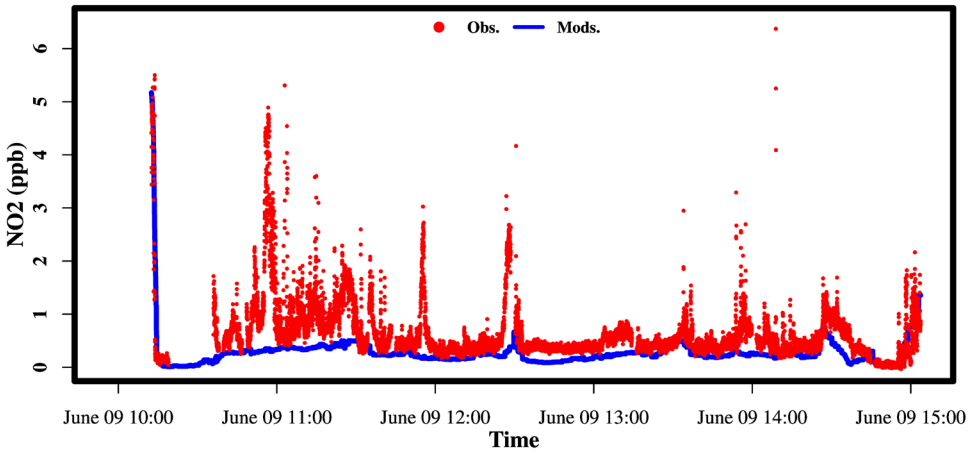
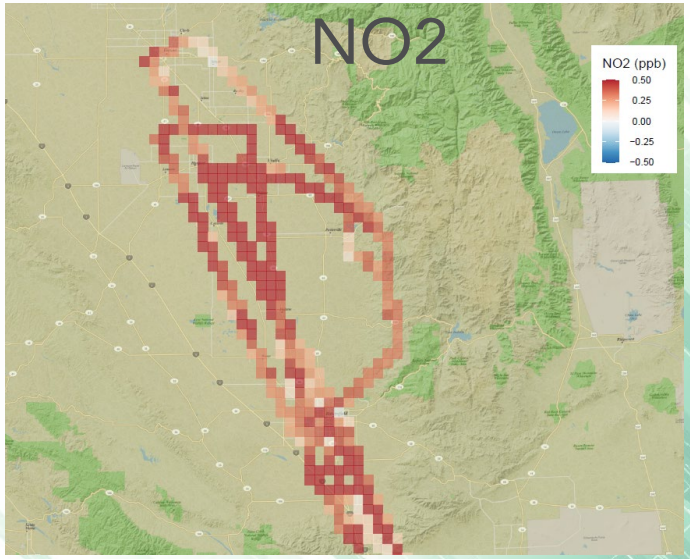
SJV NO2 (RECAP-CA Airborne)

20210609 flight



Obs-Mod, all flights aggregated



Model underestimates NO2, comparing to the airborne observations

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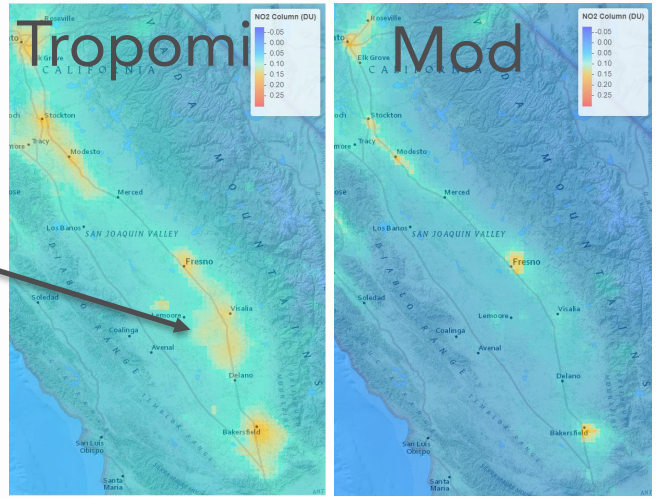
Average SJV NO2 and NH3 Column in 2021

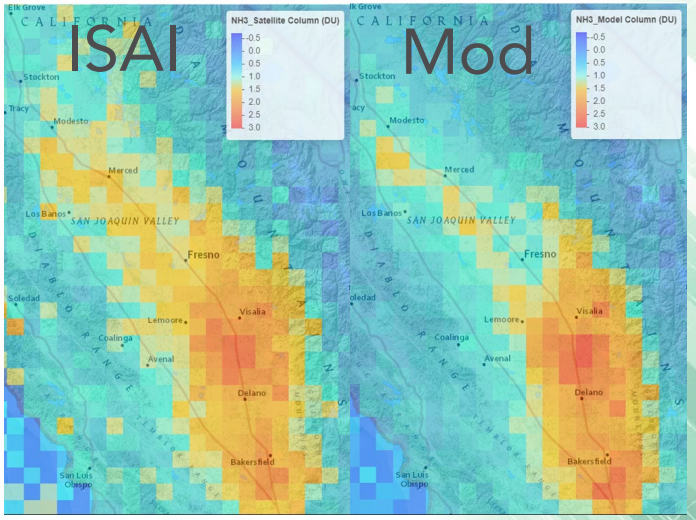
NO2 column



Kings and Tulare

Model underestimates NO2 hotspots in SJV, especially in Kings and Tulare counties

NH3 column



Model can reasonably reproduce NH3 distribution in the valley

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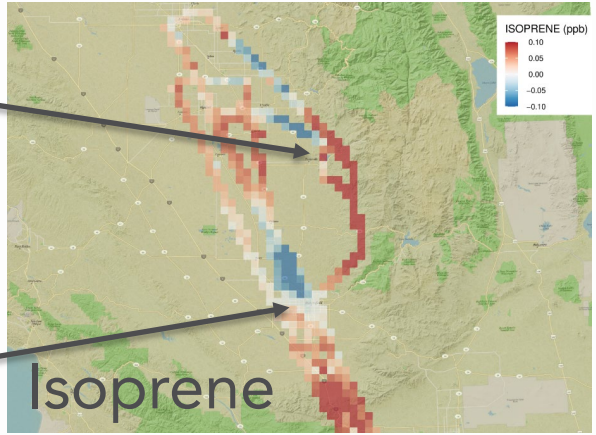
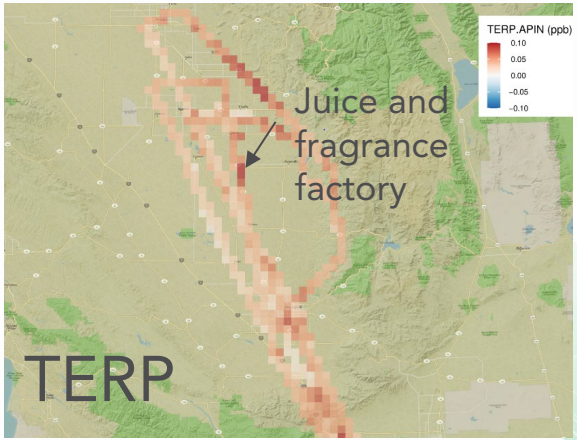
SJV Terpenoids (RECAP-CA Airborne)

Obs-Mod, all flights aggregated

Porterville

Bakersfield





Isoprene is over-estimated in areas north of Porterville and north of Bakersfield.

Monoterpenes are under-estimated in SJV. In addition to biogenic sources, juice and fragrance factory can contribute to the underestimation.

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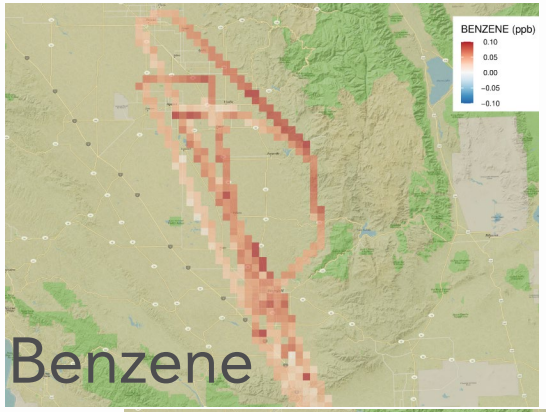
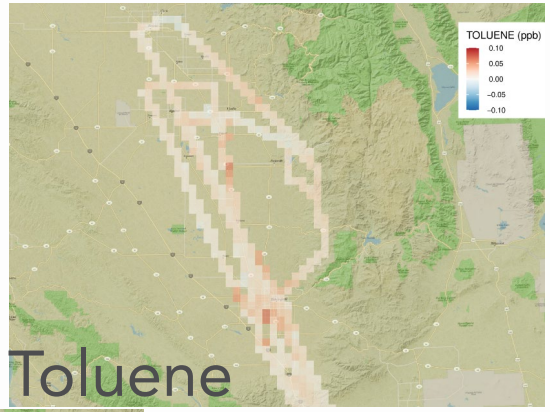
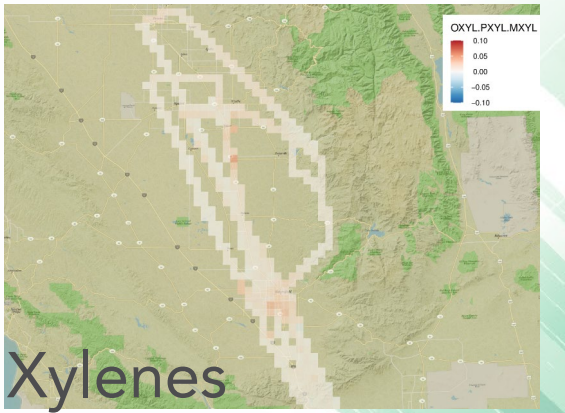
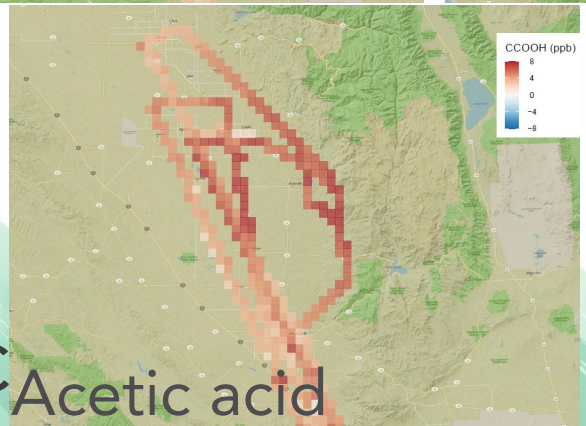
SJV Other VOCs (RECAP-CA Airborne)

Obs-Mod, all flights aggregated



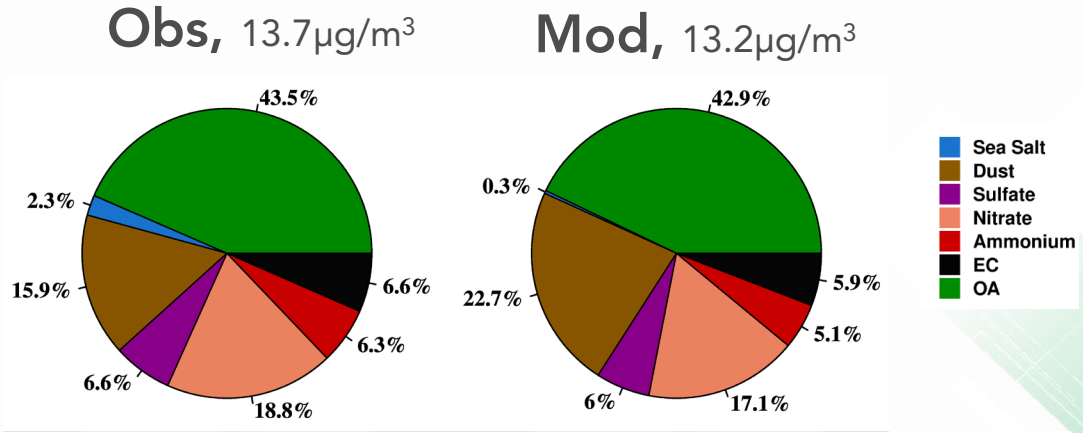






Benzene, toluene, xylene and acetic acid are all under-estimated by the model

SJV Annual PM2.5 (Fresno)



- Modeled annual organic mass, EC, nitrate, ammonium, sulfate compositions compare well with the observations at Fresno-Garland
- Modeled PM2.5 dust is too high
- Modeled PM2.5 sea salt is too low comparing to the observations, although a small portion of the PM2.5 concentrations

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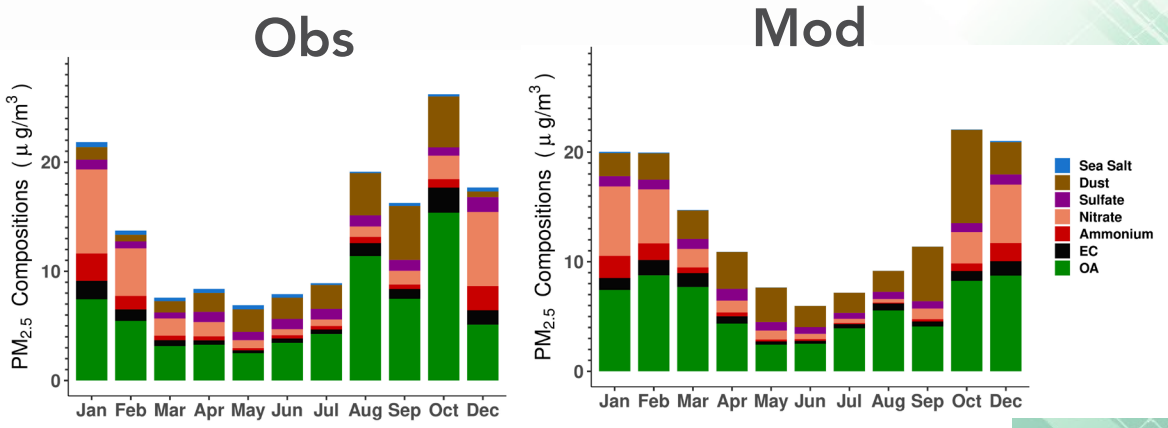
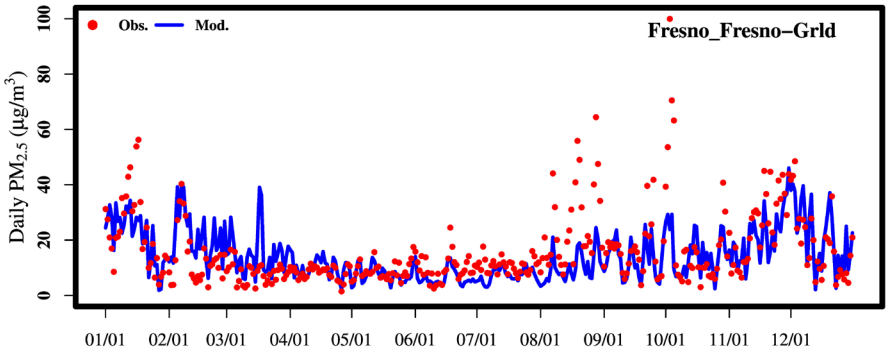
Monthly and Daily PM2.5 at Fresno

At Fresno in SJV, aside from significant under-estimation due to wildfires in August and September, there are days when model under-estimates PM2.5 considerably in Jan, although monthly average compared well with the observations. We will investigate these days more later.





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Summary

- In the SoCAB, the modeled NO_2 concentrations are higher than the observations in some coastal areas and lower than the observations inland. In contrast, in the SJV, the modeled NO_2 concentrations are generally underestimated
- Terpenoids are mostly underestimated by the model in the SoCAB and the SJV, except for isoprene concentrations, which are overestimated in some areas of the SJV
- The modeled concentrations of VOCs associated with mobile sources such as benzene agree better with ground measurements than airborne observations
- For the PM2.5 composition, modeled organic aerosol fraction is lower than the observation at Fontana (SoCAB), while the modeled fraction agree reasonably well with the observation at Fresno (SJV)
- The modeled generally overestimated dust components of $PM_{2.5}$ and underestimated sea salt

Next Steps

- Working with UCD on developing WRF-irrigation model to improve meteorology
- GEOS-chem runs with improved emissions and wildfire plume rise scheme
- NU-WRF (NASA-Unified Weather Research and Forecasting Model) runs with observational data assimilation at the satellite resolvable scale
- Emissions updates…