



South Coast
AQMD

Evaluation of AQM Air Quality Forecasts in South Coast AQMD Jurisdiction

Air Quality Forecaster Focus Group Workshop

College Park, MD

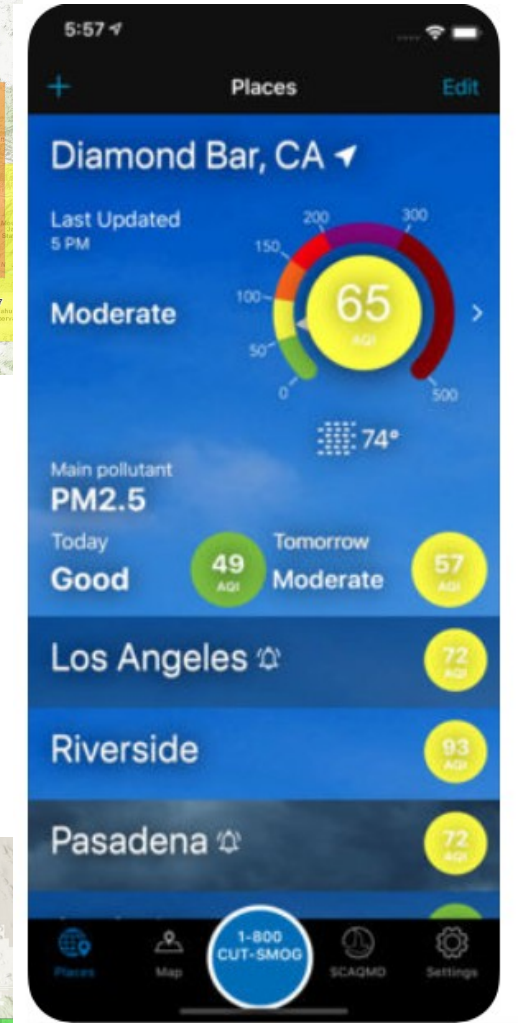
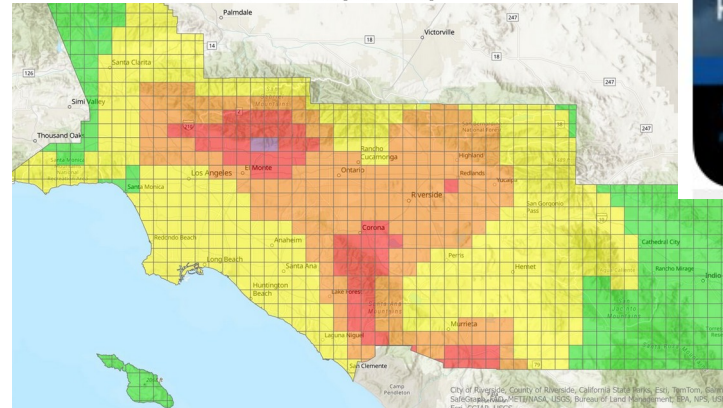
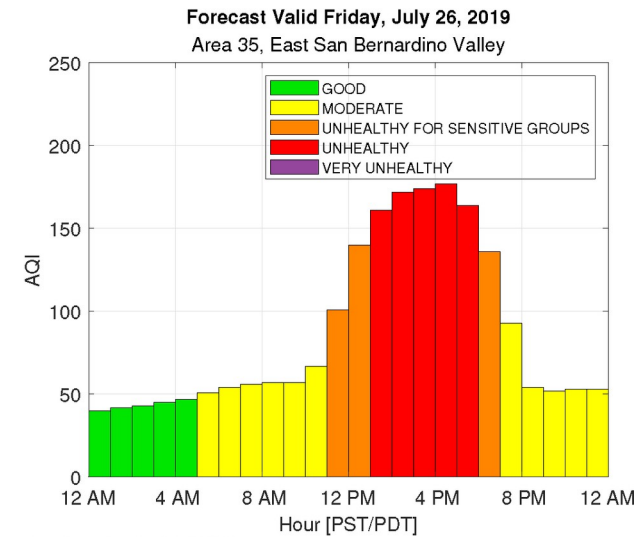
October 9-10, 2024

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Scott A. Epstein, Ph.D.

South Coast Air Quality Management District

- Forecast Products at South Coast AQMD
- Process
- Performance during recent high-impact Wildfires
- Evaluation
 - Model residual trends

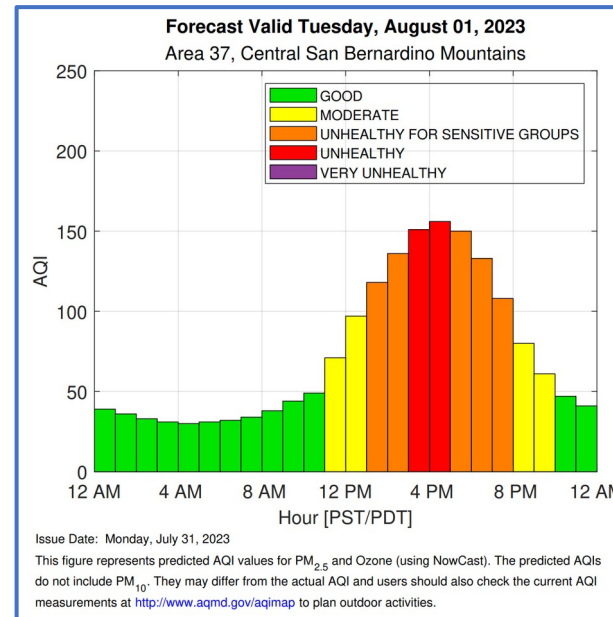


Forecast Products

Daily Forecast With Cleanest Time Of Day

16	North Orange County	43	GOOD	Ozone	Similar all day
17	Central Orange County	38	GOOD	Ozone	Similar all day
18	North Coastal Orange County	34	GOOD	Ozone	Similar all day
19	Saddleback Valley	46	GOOD	PM2.5	Similar all day
20	Central Coastal Orange County	38	GOOD	PM2.5	Similar all day
21	Capistrano Valley	42	GOOD	PM2.5	Similar all day
22	Corona/Norco Area	100	MODERATE	Ozone	Similar all day
23	Metropolitan Riverside County	105	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 1 PM
24	Perris Valley	101	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 12 PM
25	Lake Elsinore Area	77	MODERATE	Ozone	Similar all day
26	Temecula Valley	49	GOOD	Ozone	Similar all day
27	Anza Area	58	MODERATE	Ozone	Similar all day
28	Hemet/San Jacinto Valley	71	MODERATE	Ozone	Similar all day
29	Banning/San Geronio Pass	97	MODERATE	Ozone	Cleanest from 6 AM to 1 PM
30	Coachella Valley	77	MODERATE	Ozone	Similar all day
31	East Riverside County	41	GOOD	Ozone	Similar all day
32	Northwest San Bernardino Valley	101	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 12 PM
33	Southwest San Bernardino Valley	100	MODERATE	Ozone	Similar all day
34	Central San Bernardino Valley	147	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 12 PM
35	East San Bernardino Valley	147	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 12 PM
36	West San Bernardino Mountains	108	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 12 PM
37	Central San Bernardino Mountains	154	UNHEALTHY	Ozone	Cleanest from 6 AM to 12 PM
38	East San Bernardino Mountains	112	UNHEALTHY FOR SENSITIVE GROUPS	Ozone	Cleanest from 6 AM to 11 AM
39	Phelan	84	MODERATE	Ozone	Similar all day
40	Hesperia	90	MODERATE	Ozone	Cleanest from 6 AM to 11 AM

Hourly Forecast



Advisories

Select Language

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SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Wildfire Smoke Advisory

www.aqmd.gov @SouthCoastAQMD

Valid Wednesday 9:00 AM until Thursday 4:00 PM

WILDFIRE SMOKE ADVISORY
Wed., Sep. 27, 2023 - Thu., Sep. 28, 2023

South Coast AQMD Jurisdiction
Approximate Fire Location
Areas of Potential Direct Smoke Impact

Current Conditions

- As of 9:00 AM on Tuesday the Bobcat Fire is burning in the San Gabriel Mountains and producing smoke
- The fire has burned 100,000 acres
- As of Monday morning, monitors in Los Angeles reached the **Unhealthy** category
- For more information, see the [Cal Fire website](#)

Conditions may change quickly due to fire activity and weather. Download the [South Coast AQMD app](#) or visit www.aqmd.gov/AQImap to view current air quality in your neighborhood.

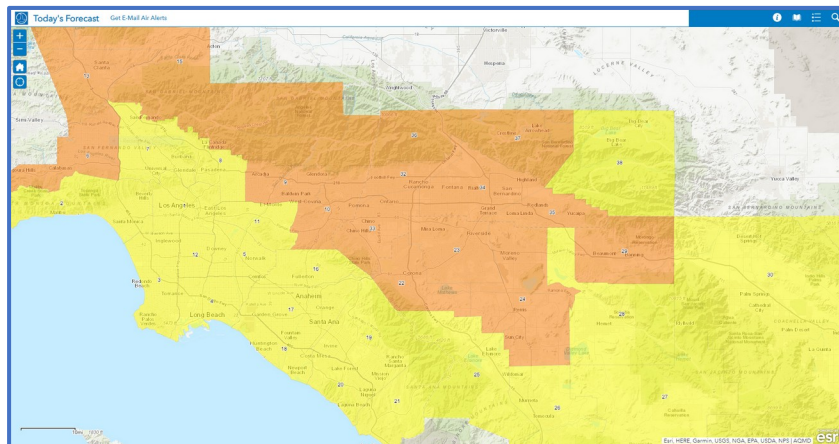
► Show recent air quality trends (up to Friday, 1:00 AM)

Forecasted Smoke and Air Quality Impacts

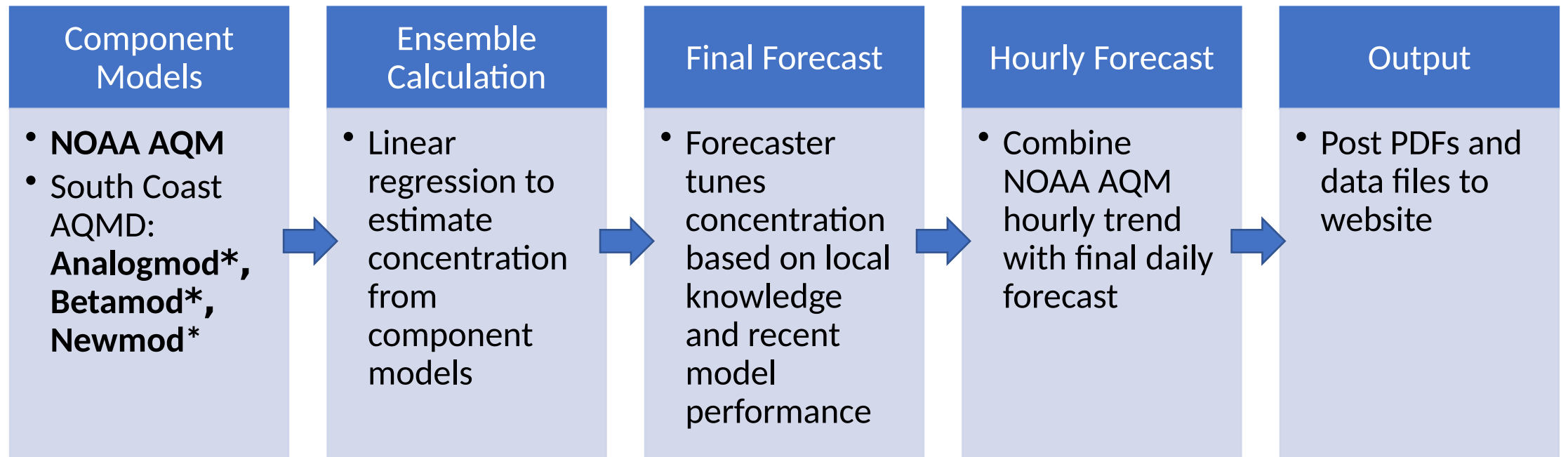
- On Tuesday afternoon, Air Quality Index (AQI) levels may reach the **Unhealthy** category in the Los Angeles Metropolitan area

Forecast-Based Rules

- Fugitive Dust Control in Coachella Valley
- Open Burning, No-Burn Days



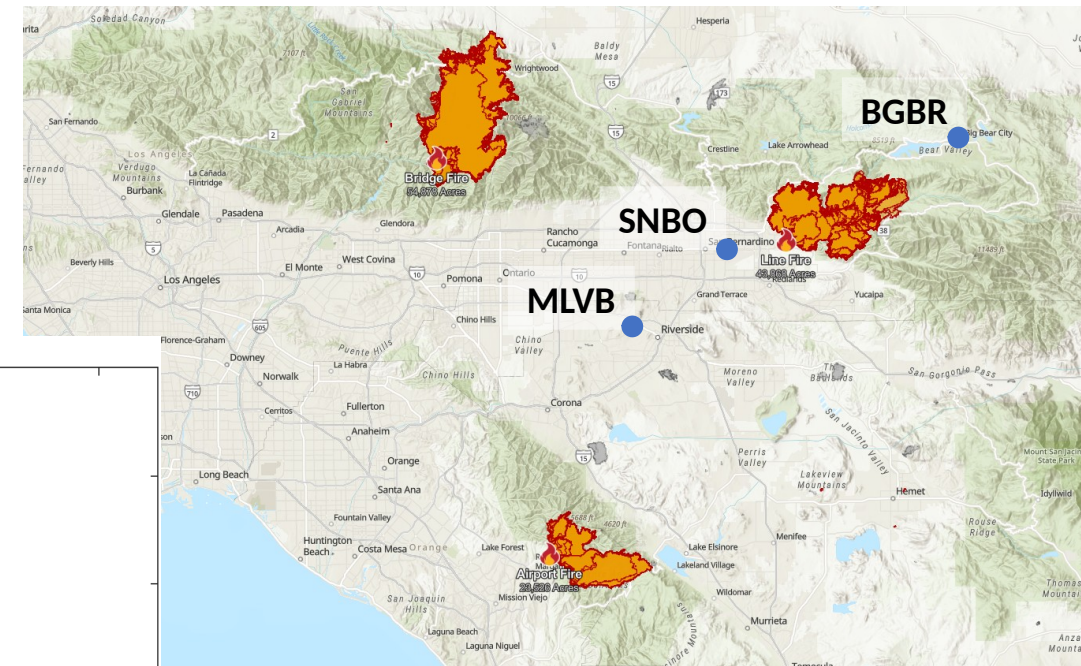
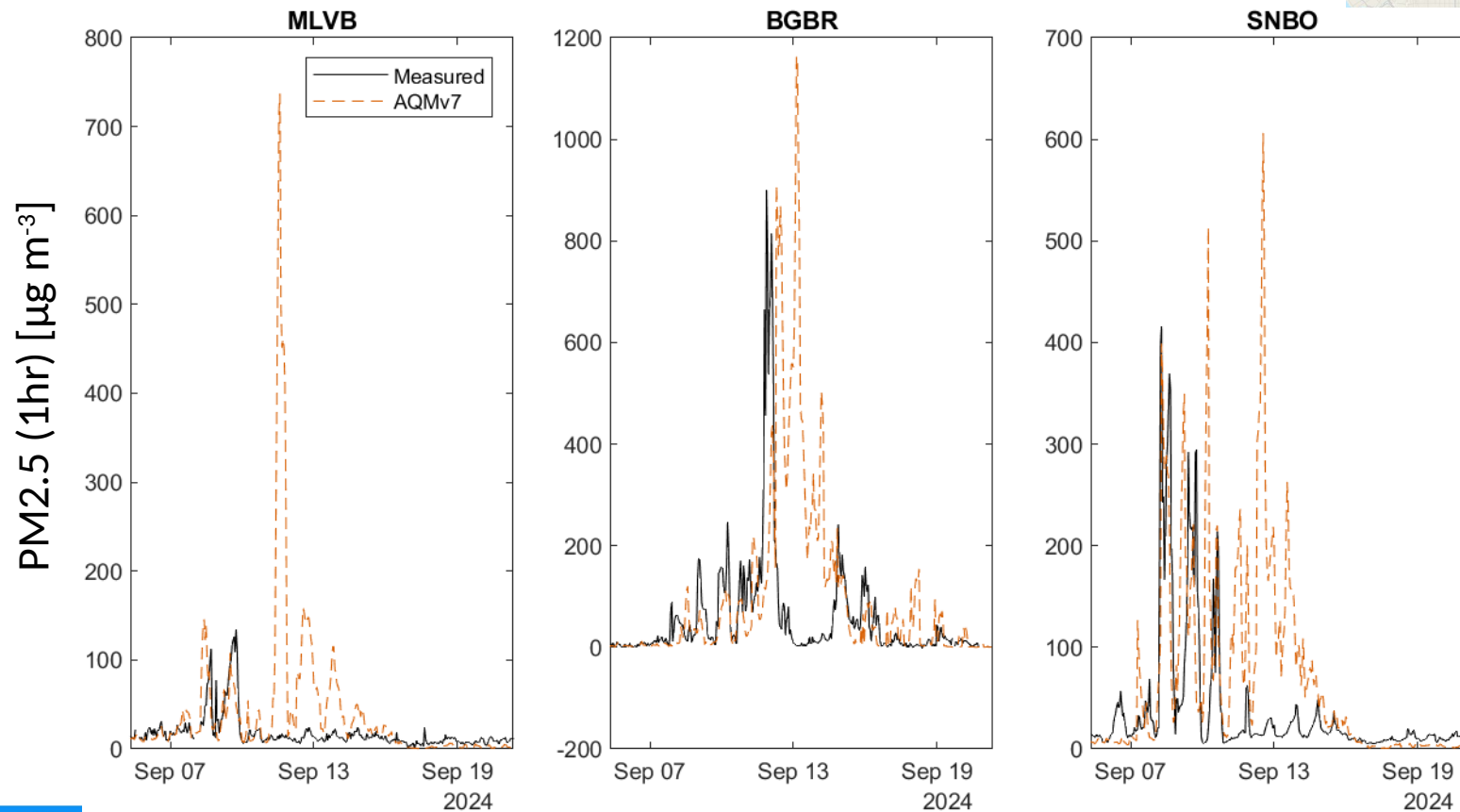
Forecast Process



*In-House statistical models

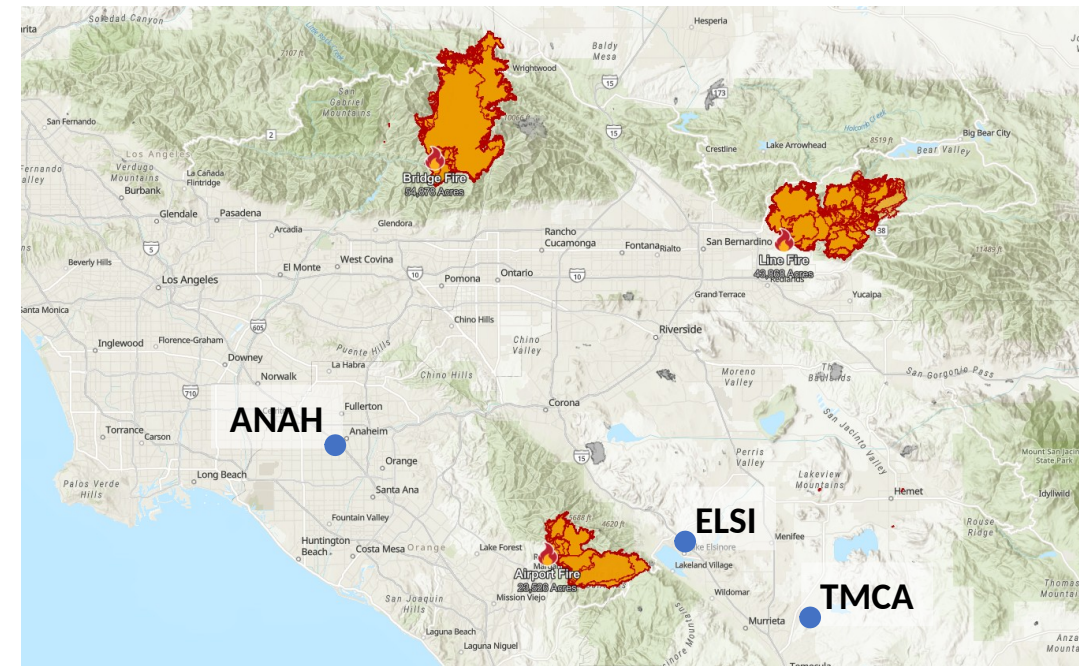
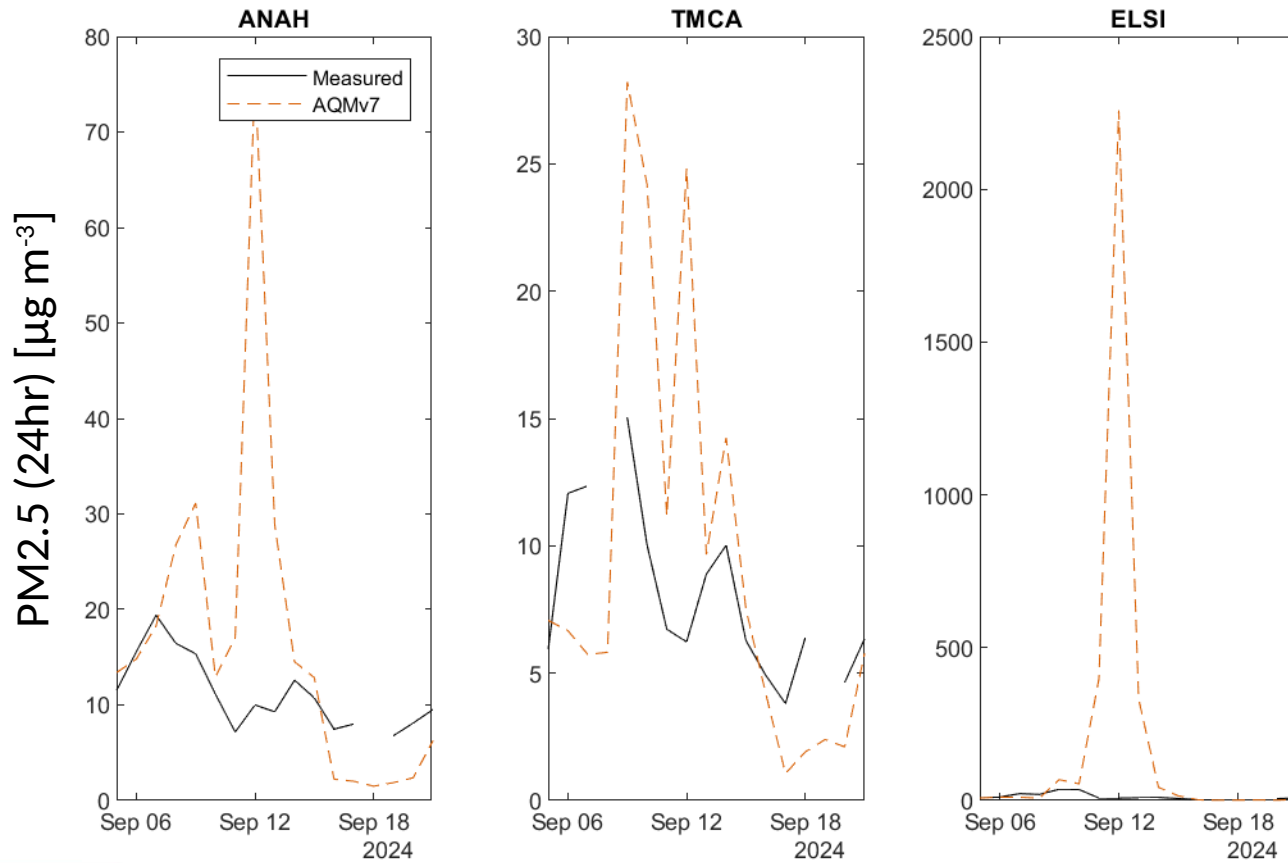
AQM During Recent High-Impact Wildfires

Line, Bridge, and Airport Fires (Sep 5, 2024) – PM2.5



- AQMv7 captured initial PM2.5 spike from Line Fire well at BGBR and SNBO
- Starting Sep 11, AQMv7 overpredicted PM2.5 at SNBO and MLVB
- AQMv7 overpredicted PM2.5 spike at BGBR from Sep 12 - 14

Line, Bridge, and Airport Fires (Sep 5, 2024) – PM2.5

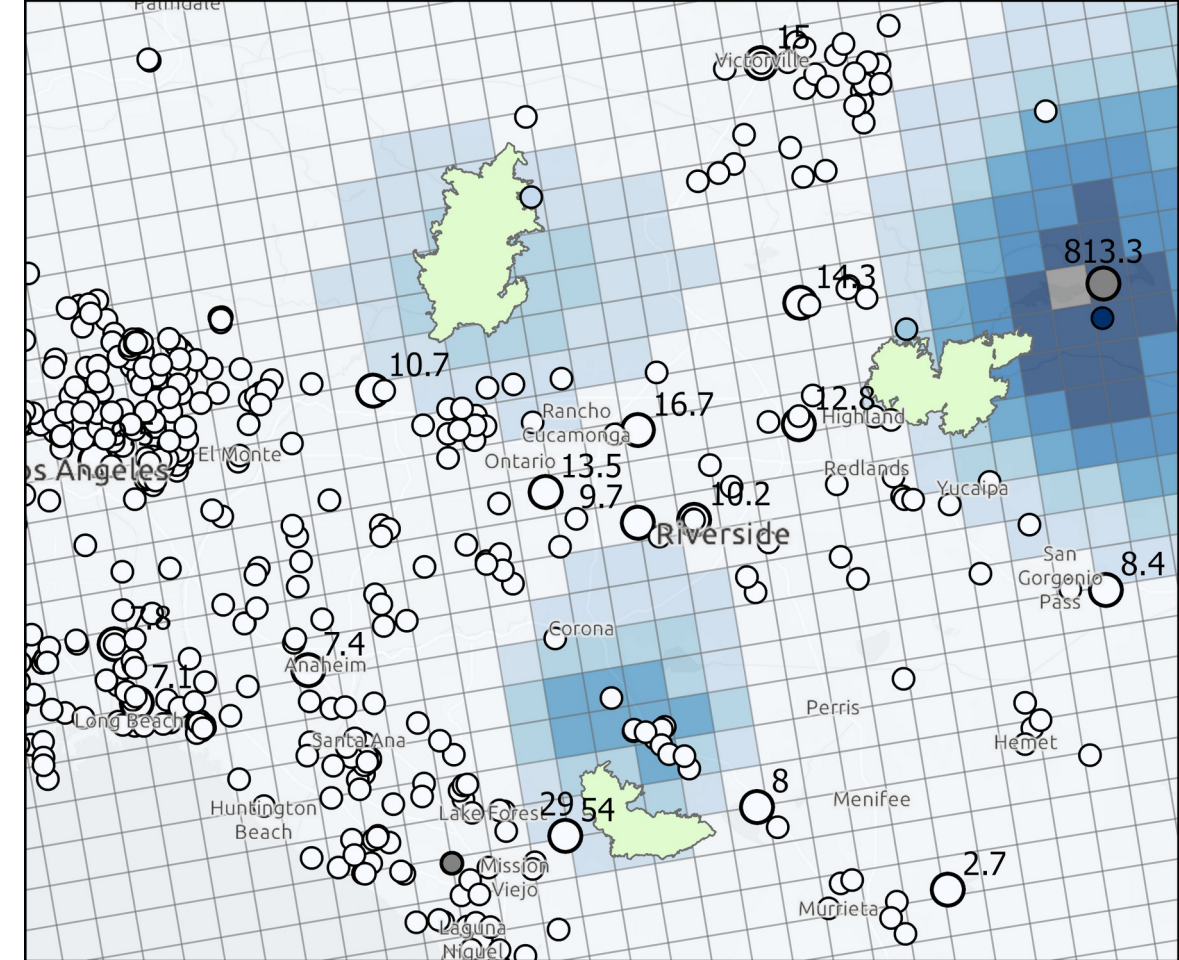
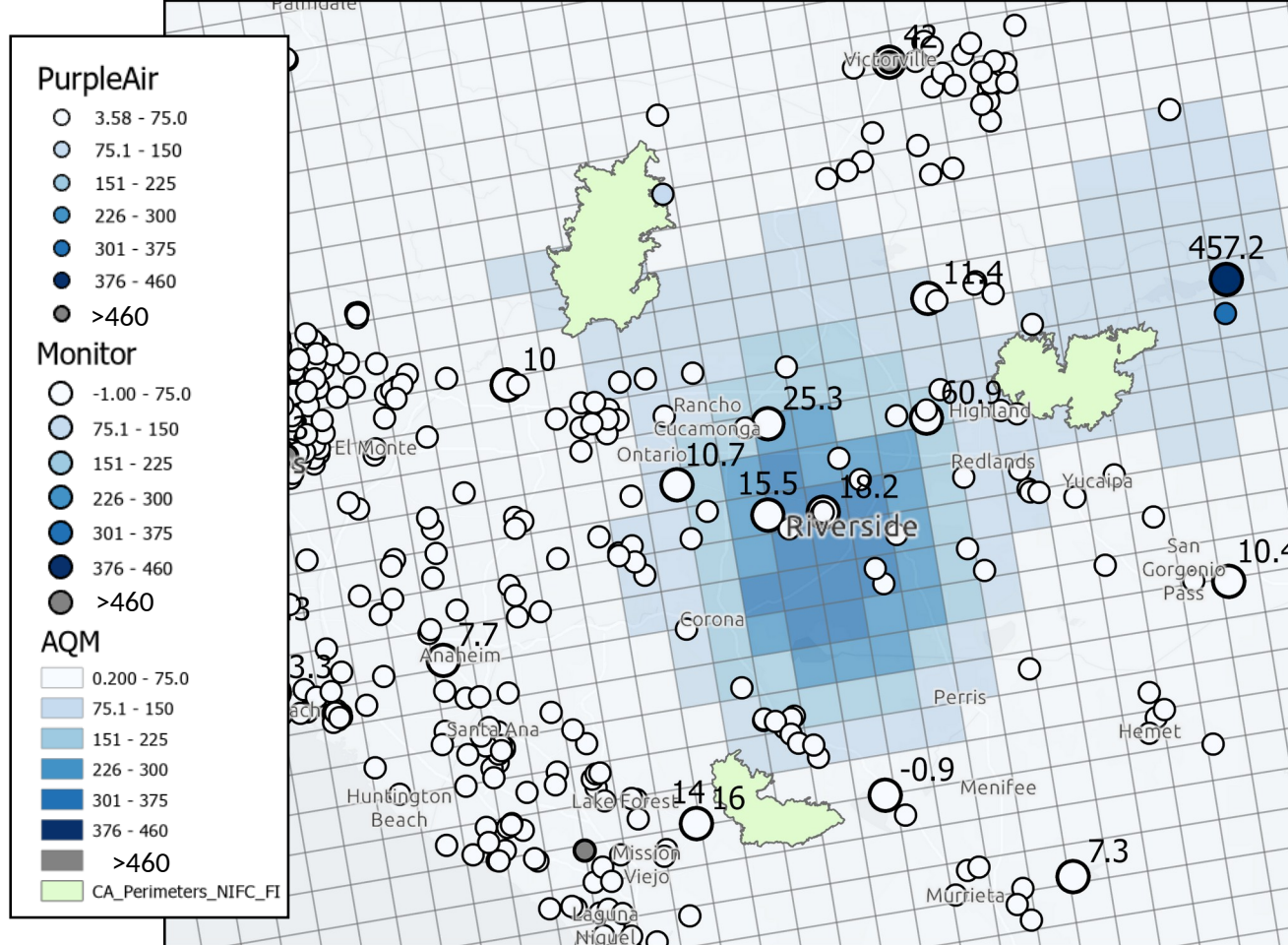


- AQMv7 overpredicted smoke impacts at ANAH, TMCA, and ELSI

Line, Bridge, and Airport Fires (PM2.5 Map)

Current Time: 9/11/2024 12:00 PM to 9/11/2024 1:00 PM

Current Time: 9/11/2024 6:00 PM to 9/11/2024 7:00 PM



County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

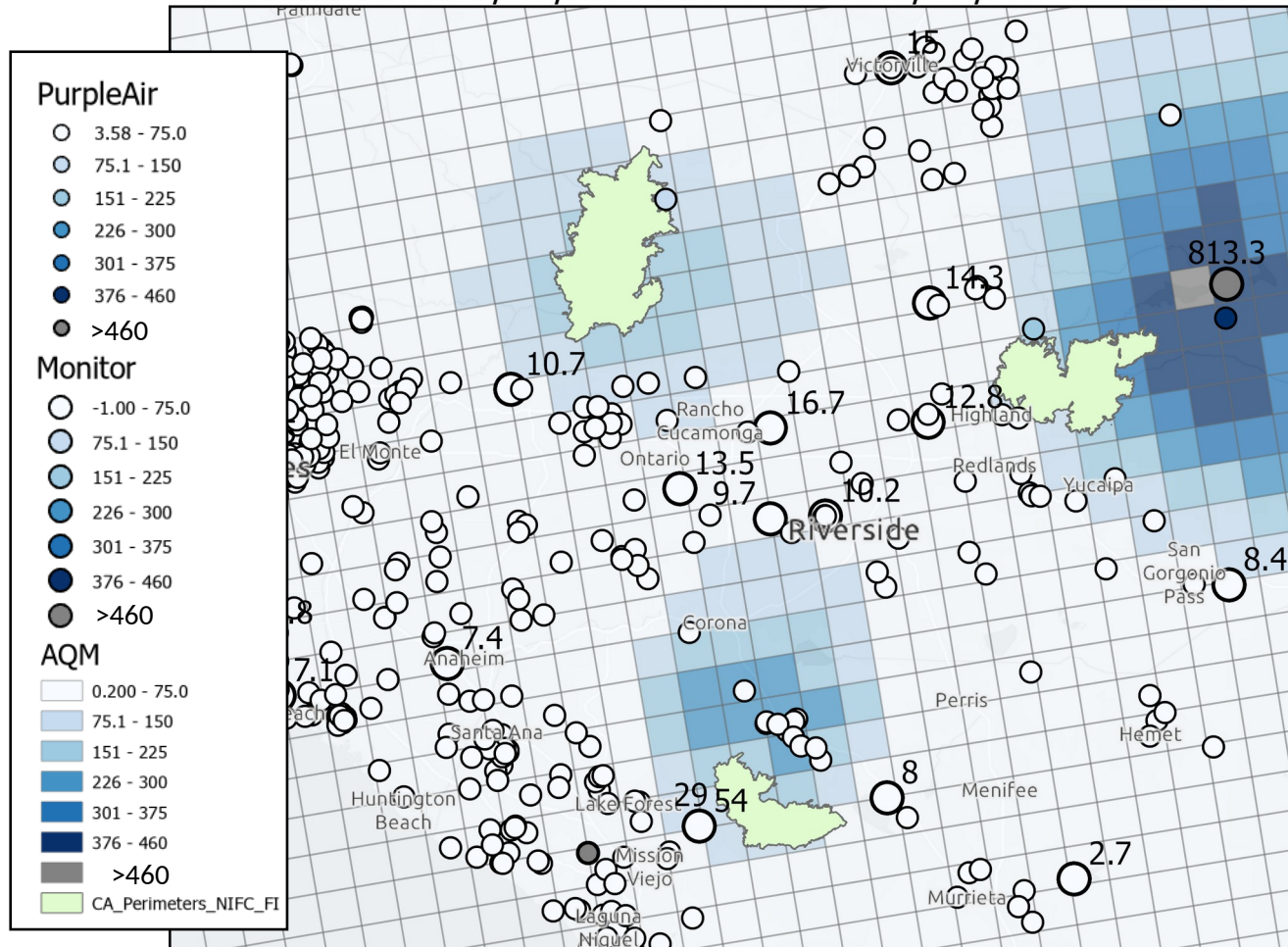
County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

Times are in PST (UTC-8)
Using NOAA 9/11/2024 6z forecast

- AQM predicted PM2.5 spikes in Riverside/Corona but measured PM2.5 is low (< 18.2 ug/m3)
- AQM correctly predicted PM2.5 spikes near the Big Bear Monitor

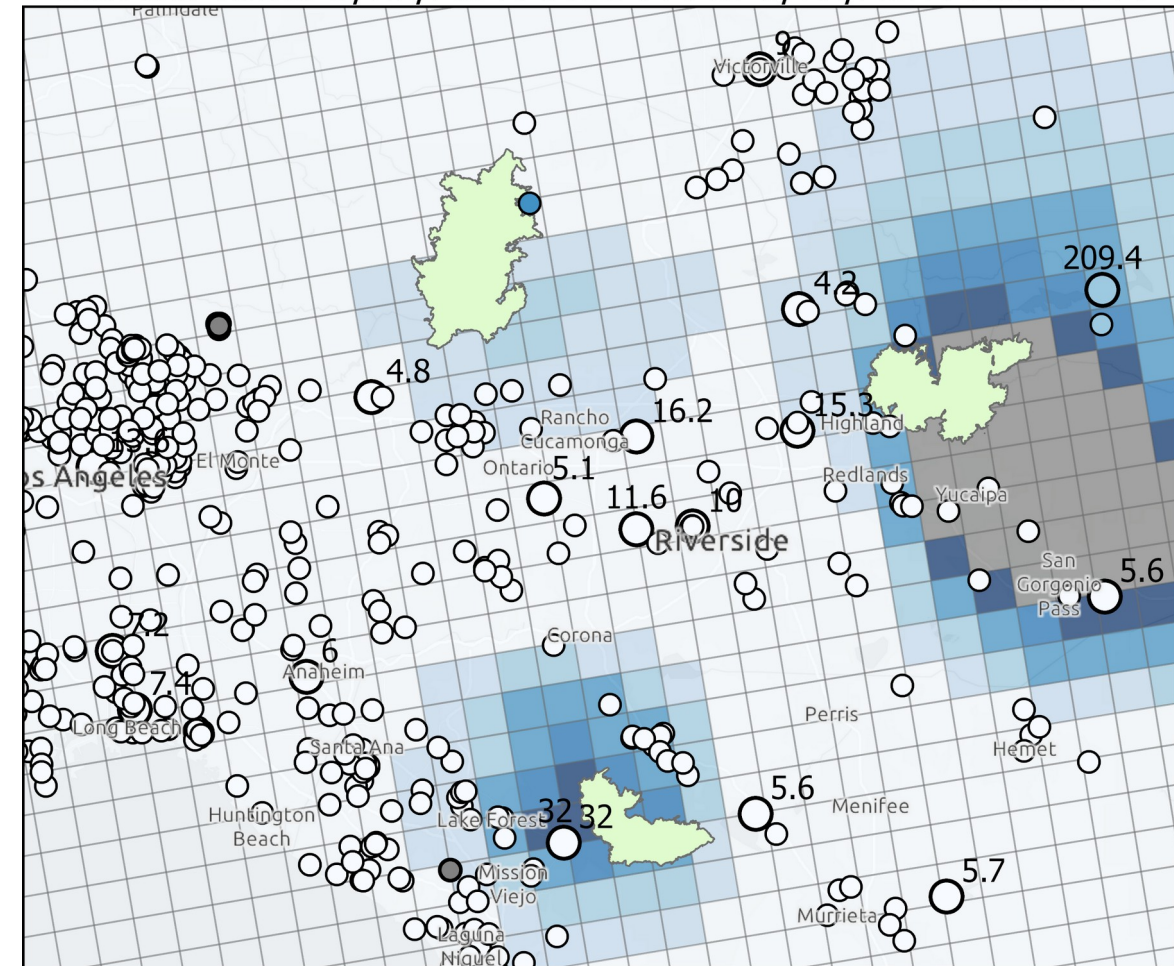
Line, Bridge, and Airport Fires (PM2.5 Map)

Current Time: 9/11/2024 6:00 PM to 9/11/2024 7:00 PM



County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

Current Time: 9/11/2024 9:00 PM to 9/11/2024 10:00 PM



County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

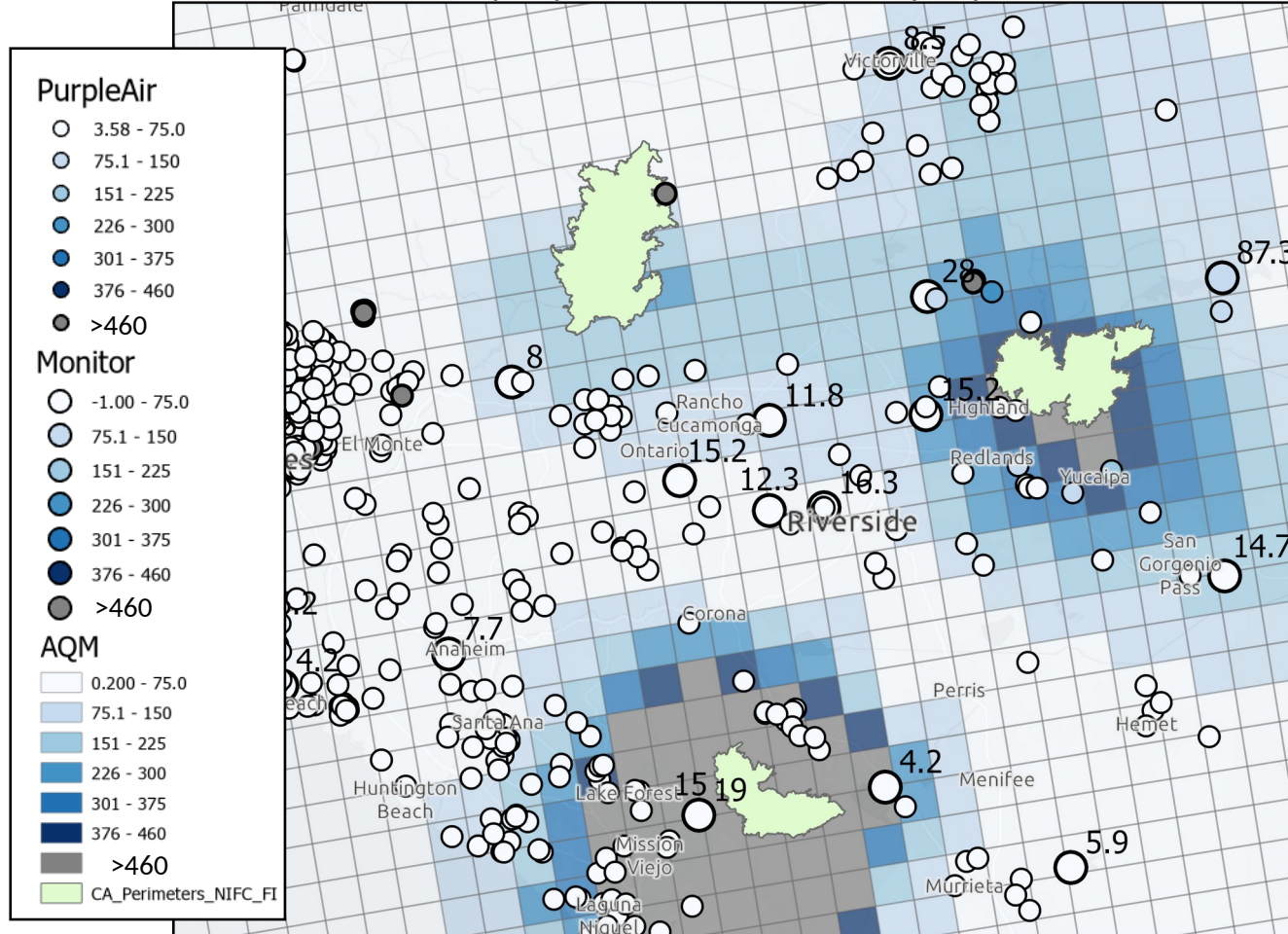


Times are in PST (UTC-8)
Using 9/11/2024 6z run

- AQM overpredicted PM2.5 in Redlands, Yucaipa, San Geronio Pass
- AQM overpredicted PM2.5 near Lake Forest and in Corona/northeast of Santa Ana mountains

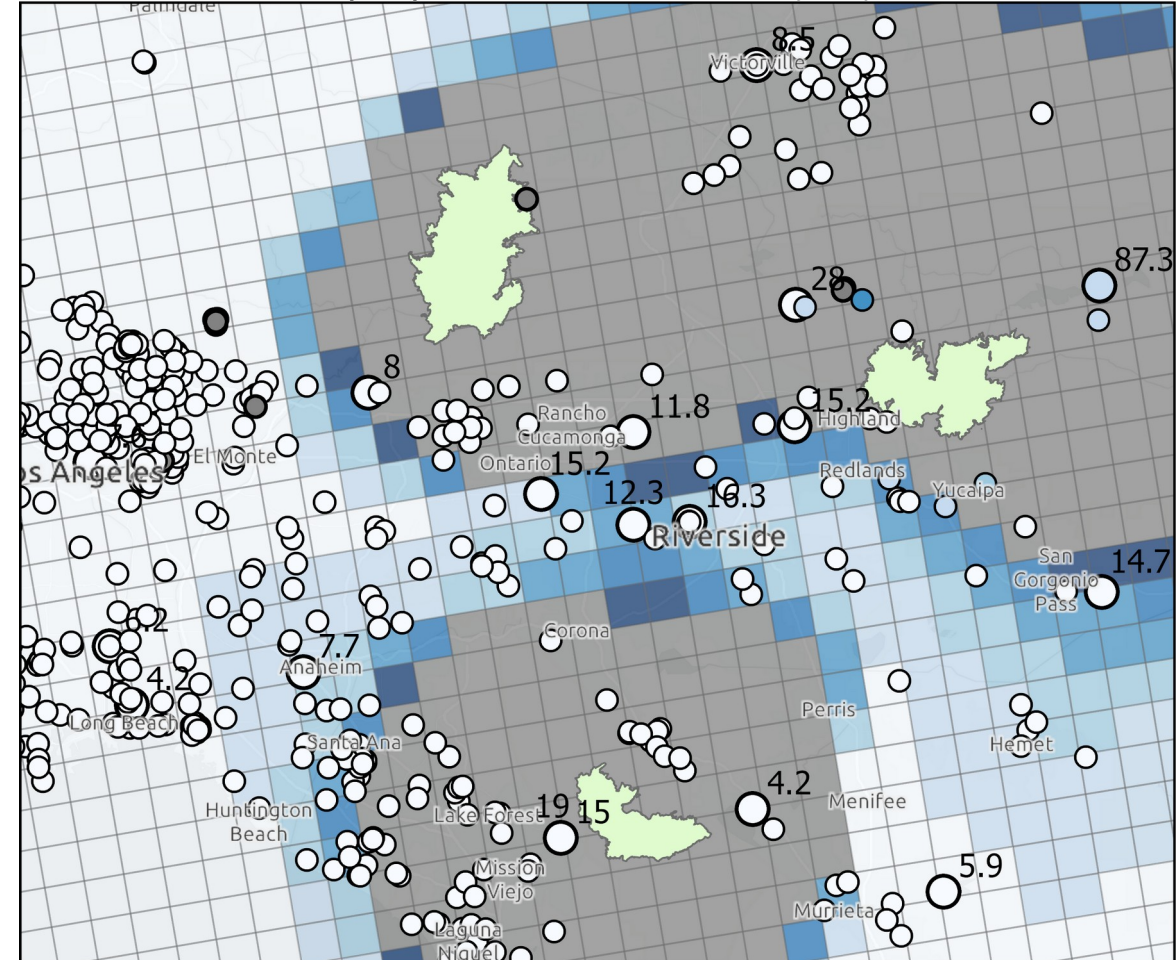
Line, Bridge, and Airport Fires (PM2.5 Map)

Current Time: 9/12/2024 6:00 AM 9/11/2024 6z run



County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

Current Time: 9/12/2024 6:00 AM 9/12/2024 12z run

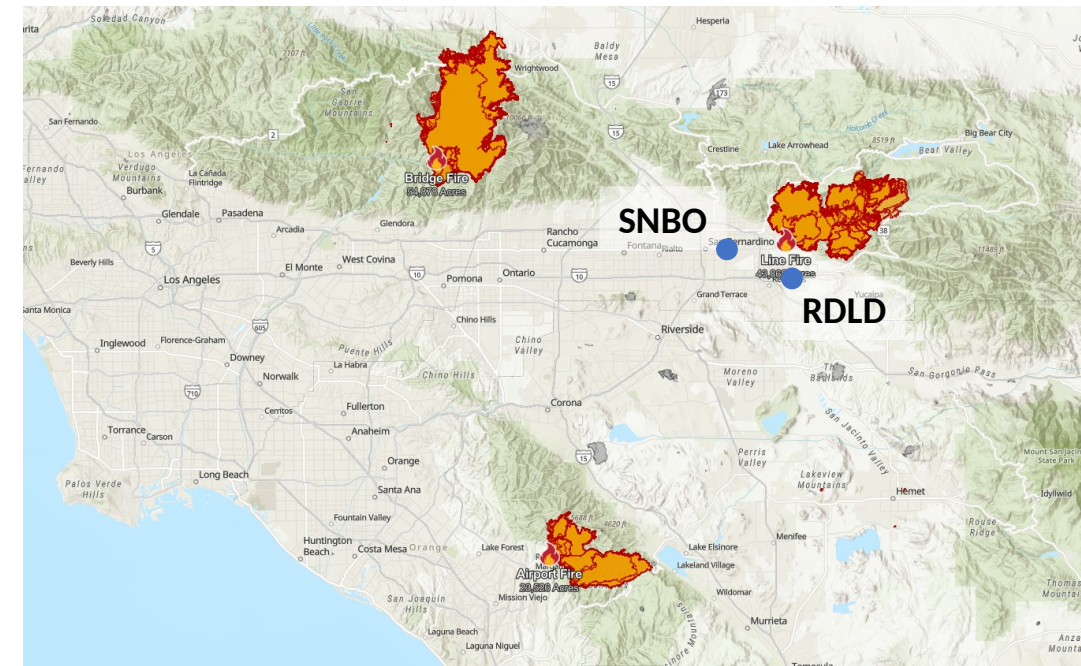
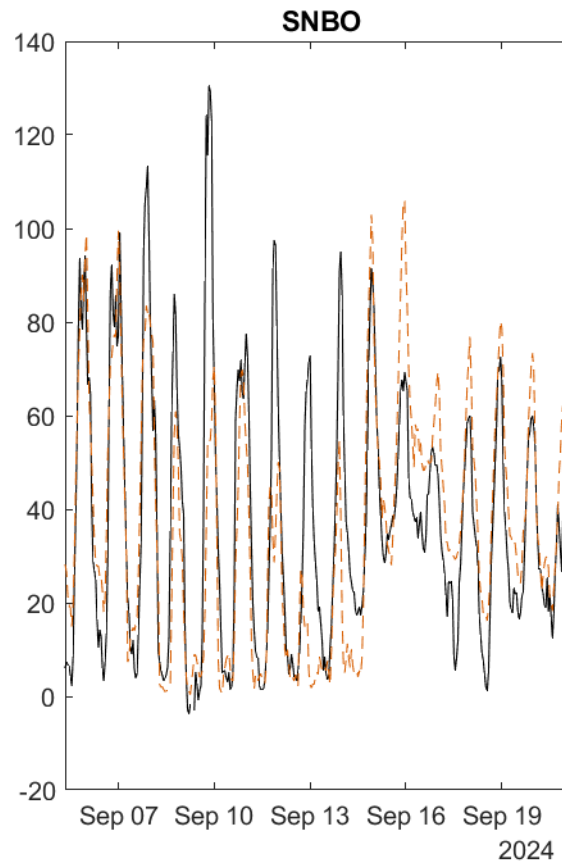
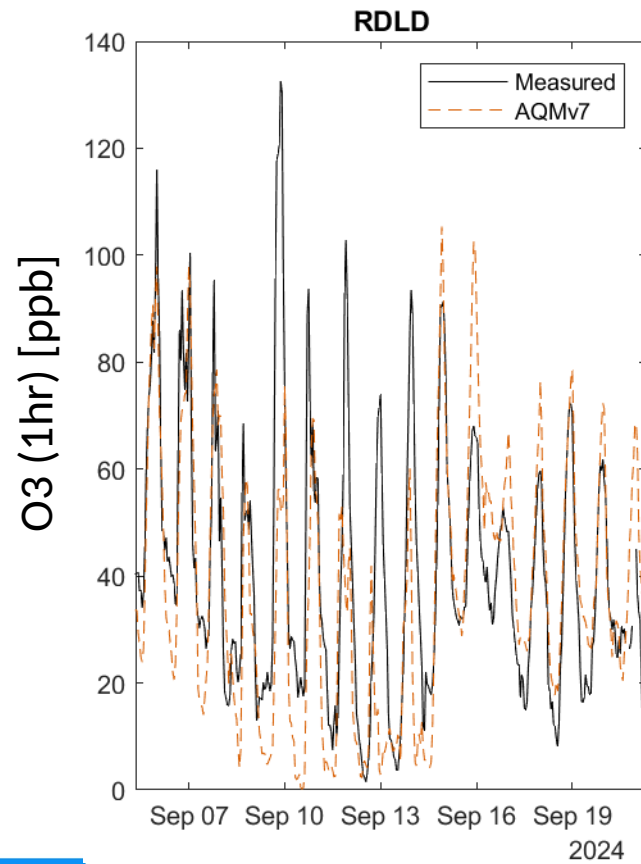


County of Riverside, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

Times are in PST (UTC-8)

- Big Bear Lake: 6z 9/11 run compares well with measurements but 12z 9/12 run significantly overpredicts
- Both runs significantly overpredict near Lake Elsinore and in Orange County

Line, Bridge, and Airport Fires (Sep 5, 2024) - Ozone



- AQMv7 underpredicted ozone peaks on Sep 10 - Sep 14 at RDLD and SNBO

What caused PM2.5 overprediction at times during the fires?

- Did AQMv7 overpredict wildfire emissions?
- Did AQMv7 overpredict vertical mixing of the plume down to the surface? (see photo of airport fire showing large plume rise)
- AQMv7 is used to interpolate real-time monitor and sensor measurements for our real-time AQI map

Sep 11, 2024 view of Airport Fire



From OC Fire Authority PIO

AQM Evaluation

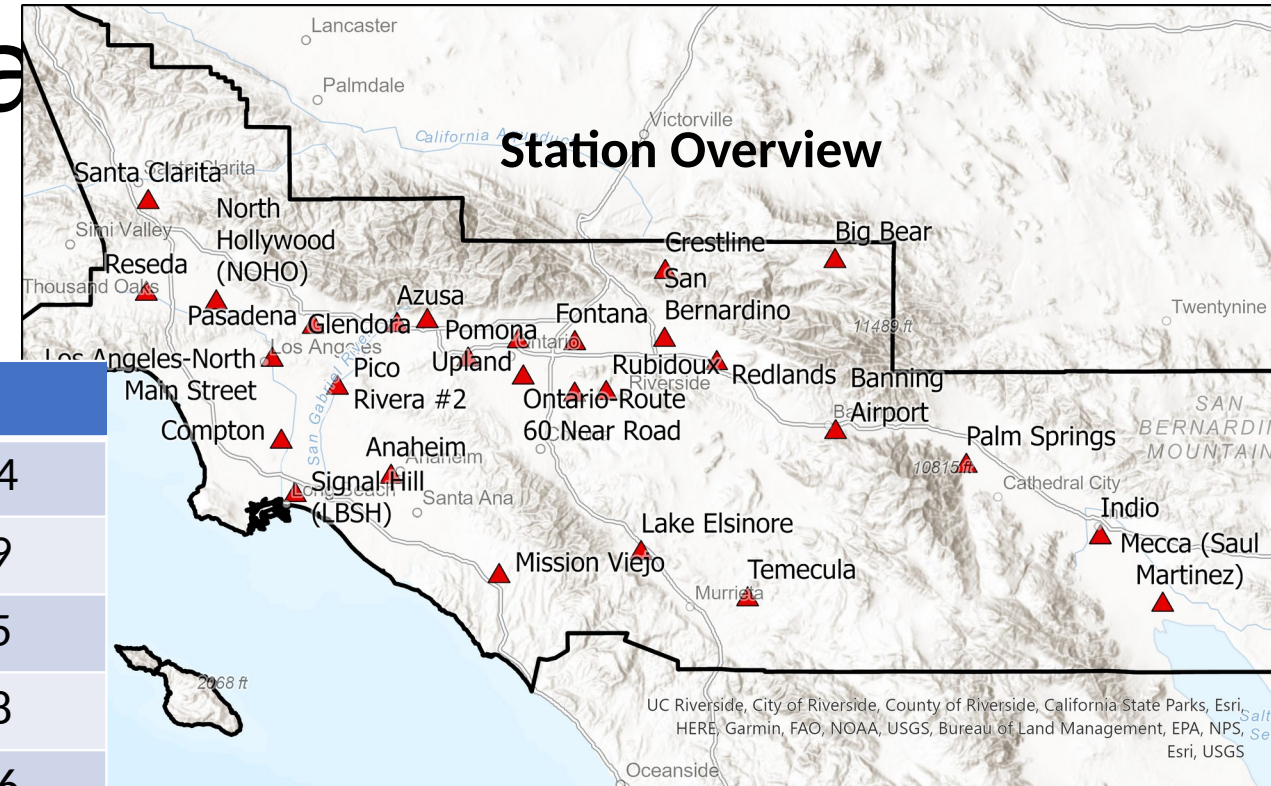
Evaluation Metrics

Metric	Formula
Root Mean Square Errors (RMSE)	
Mean Bias (MB)	
Heidke Skill Score (HSS)	
For binary true/false forecast	is percent correct for a persistence forecast

Evaluation Summary

Average RMSE and MB for all stations

	Model	O38hr Max [ppb]		PM2.5 [$\mu\text{g m}^{-3}$]	
		2023	2024	2023	2024
RMSE	AQMv7	7.98	8.13	4.61	6.39
	Analogmod	8.55	8.96	4.86	5.15
	Persistence	12.87	15.31	5.93	6.58
MB	AQMv7	0.07	1.02	0.33	-0.06
	Analogmod	-1.95	1.24	-1.50	-1.26
	Persistence	-0.13	0.70	0.02	0.41



2023 data:

- 2022-7-1 through 2022-8-31
- 2022-12-1 through 2023-1-31
- 2023-4-1 through 2023-9-27

2024 data:

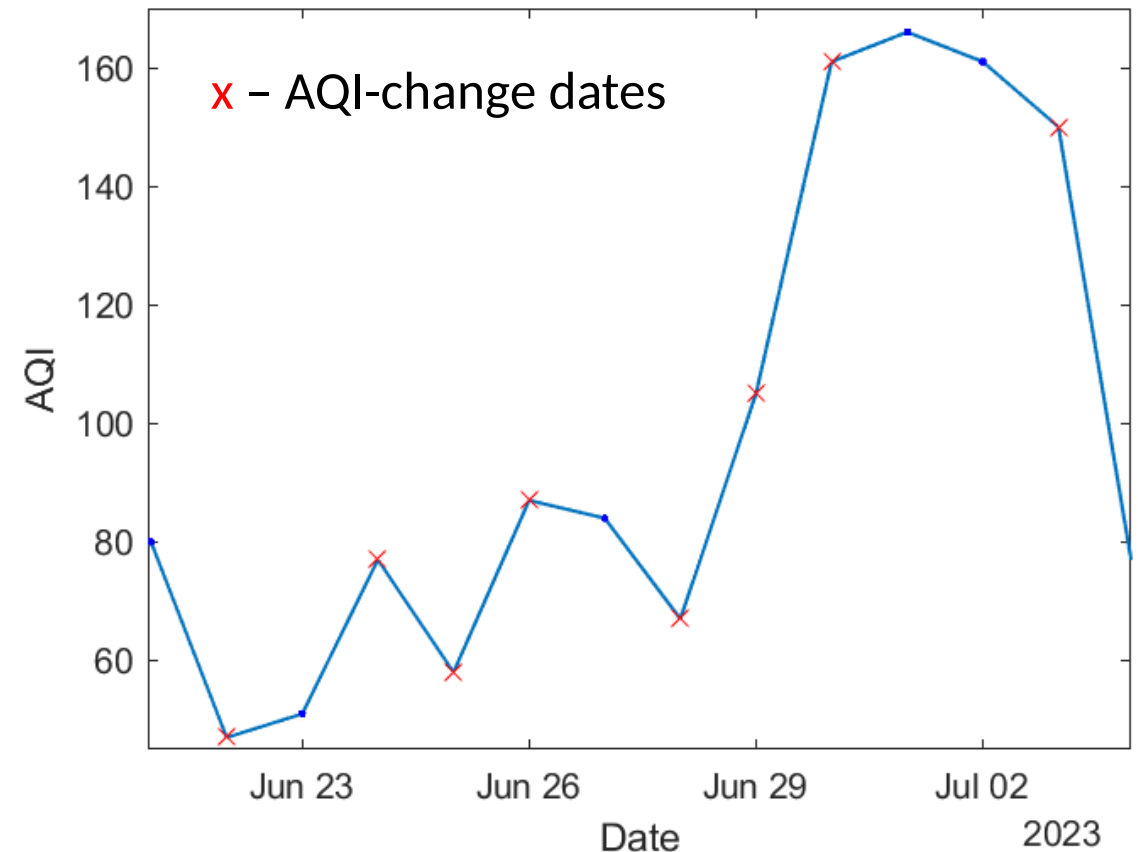
- 2023-10-1 through 2024-9-30

AQMv7 Ozone RMSE is best among the models
 Analogmod PM2.5 RMSE is best among the models
 Mean Bias is small for all models

AQI-Change Dates Evaluation Method

- Calculate RMSE and MB only on AQI-change dates
- AQI-change dates:
 - Measured AQI changed by at least 10
 - This removes “persistent” time periods from evaluation data
 - Forecast is most useful when AQI is changing
- CTOD calculated using full data set

Example of AQI-Change

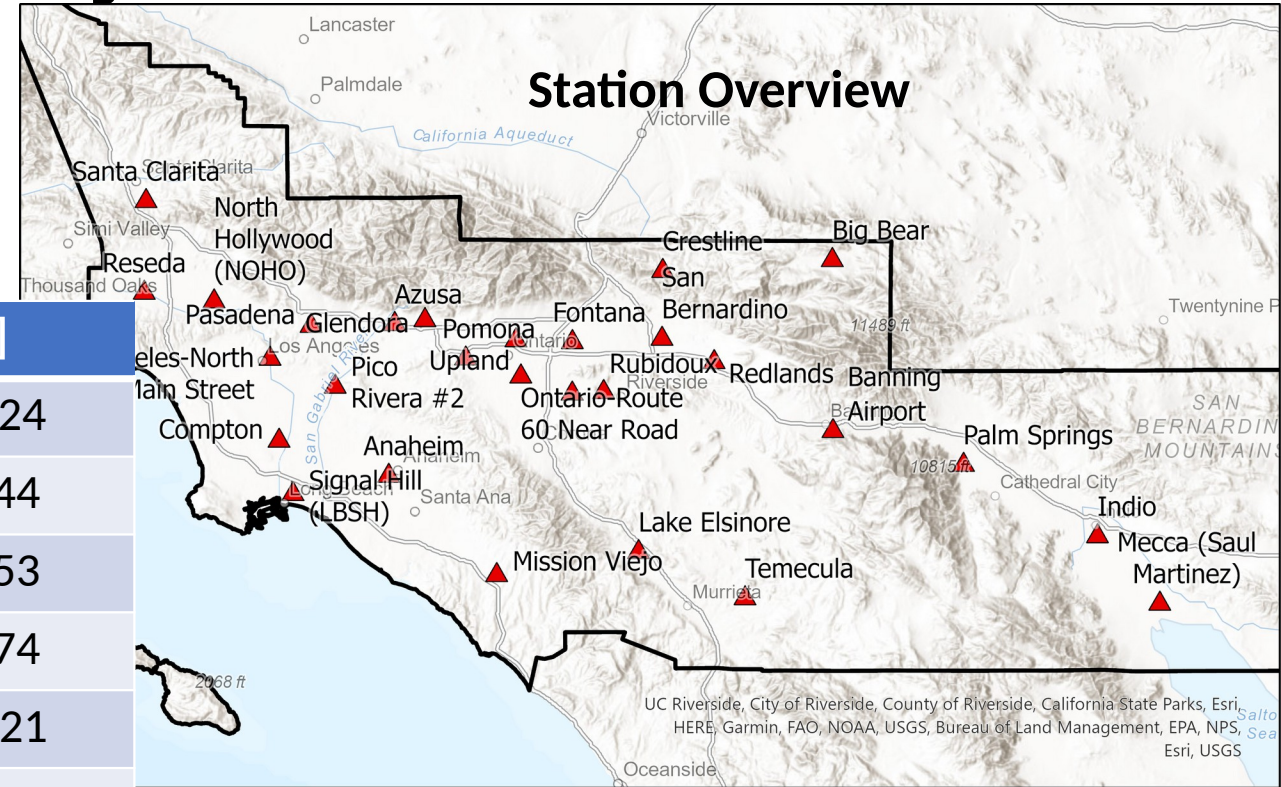


Evaluation Summary

Average RMSE and MB for all stations

* Using AQI-Change dates

	Model	O38hr Max [ppb]		PM2.5 [$\mu\text{g m}^{-3}$]	
		2023	2024	2023	2024
RMSE	AQMv7	9.15	6.81	5.54	5.44
	Analogmod	9.65	7.64	5.35	4.53
	Persistence	16.0	11.64	7.07	5.74
MB	AQMv7	0.92	0.46	0.74	-0.21
	Analogmod	-1.13	0.80	-1.05	-1.54
	Persistence	0.66	0.23	0.38	-0.01



2023 data:

- 2022-7-1 through 2022-8-31
- 2022-12-1 through 2023-1-31
- 2023-4-1 through 2023-9-27

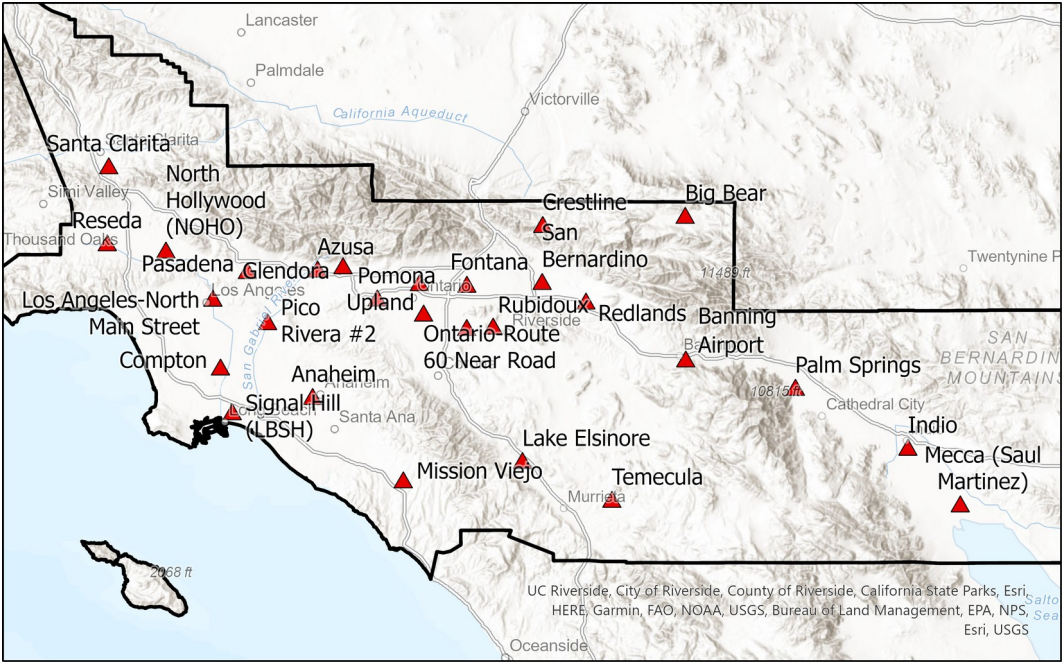
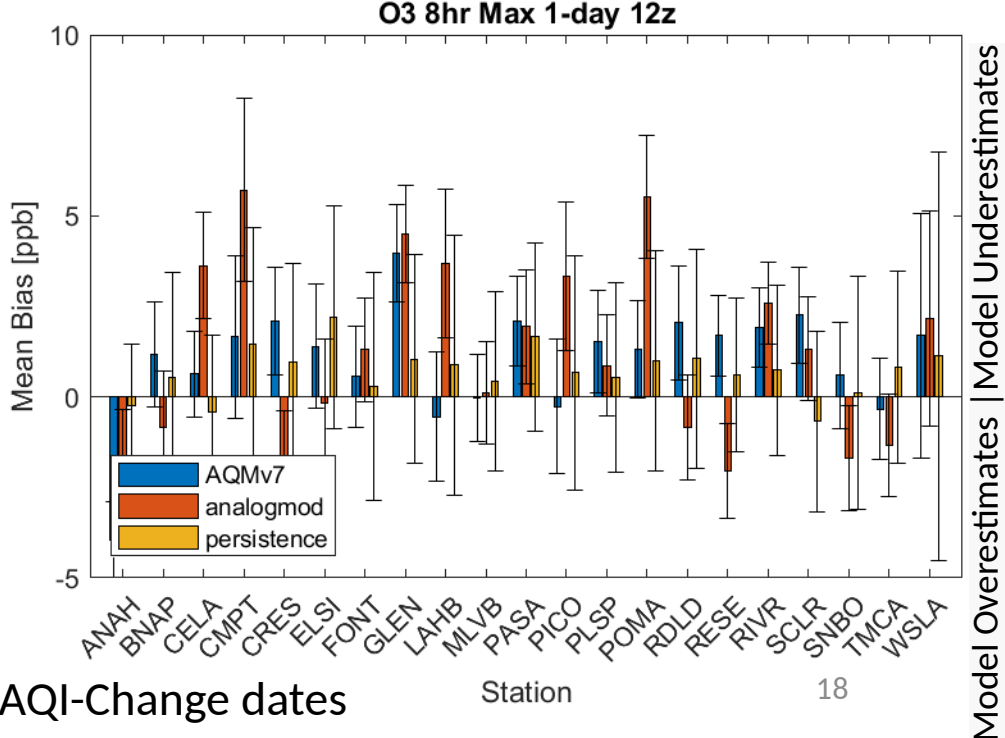
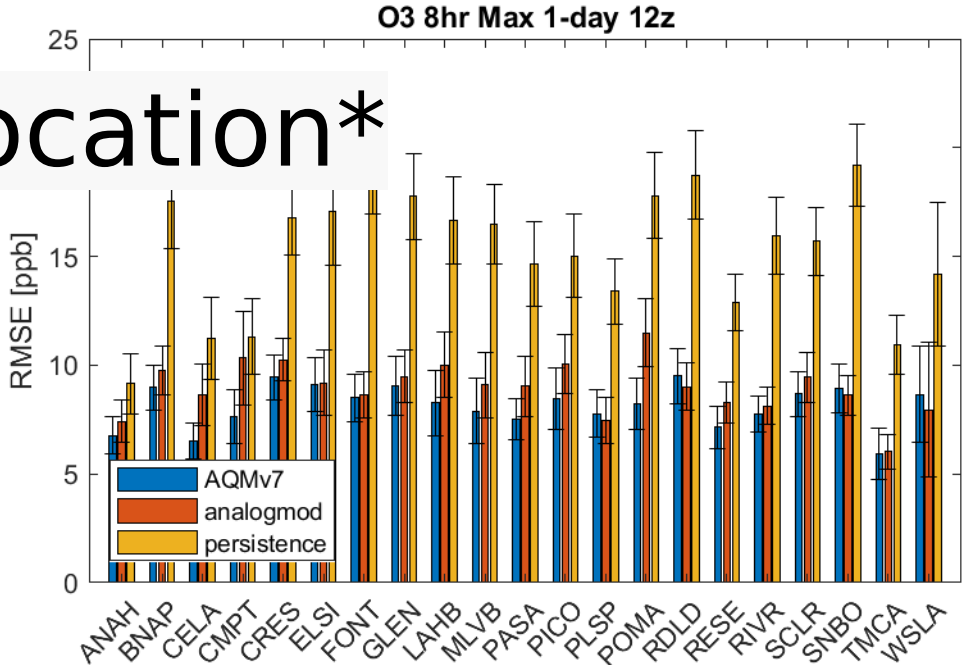
2024 data:

- 2023-10-1 through 2024-9-30

AQMv7 Ozone RMSE is best among the models
 Analogmod PM2.5 RMSE is best among the models
 Mean Bias is small for all models

Ozone 8hr Average Max by Location*

- AQMv7 and analogmod have similar RMSE and perform much better than persistence
- AQMv7 generally has low (< 2 ppb) mean bias
- Analogmod has higher bias in some cases



* Using AQI-Change dates

Station

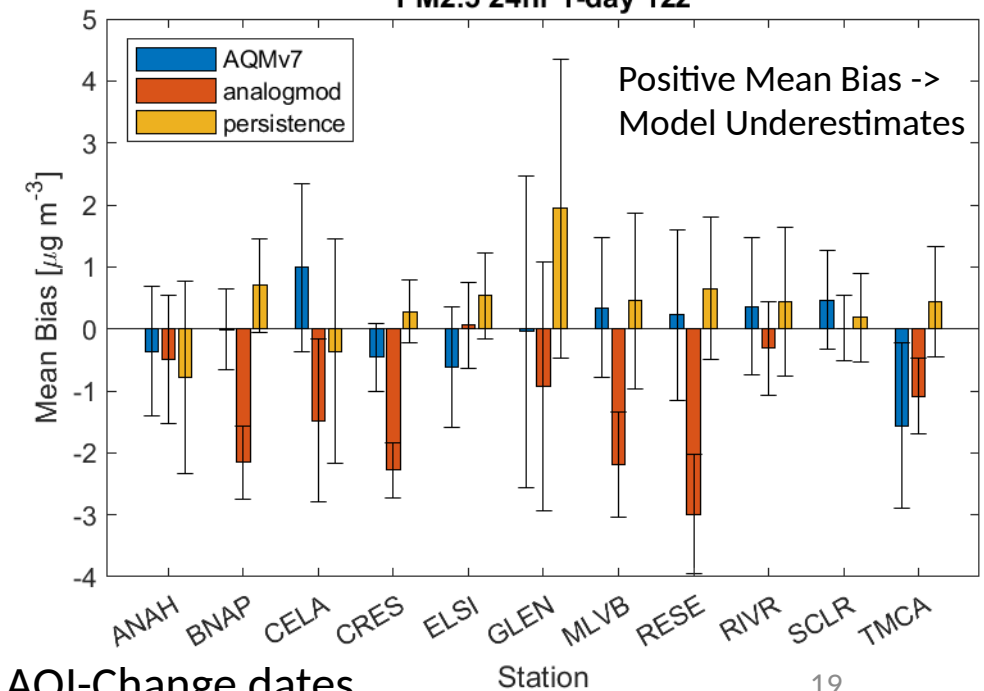
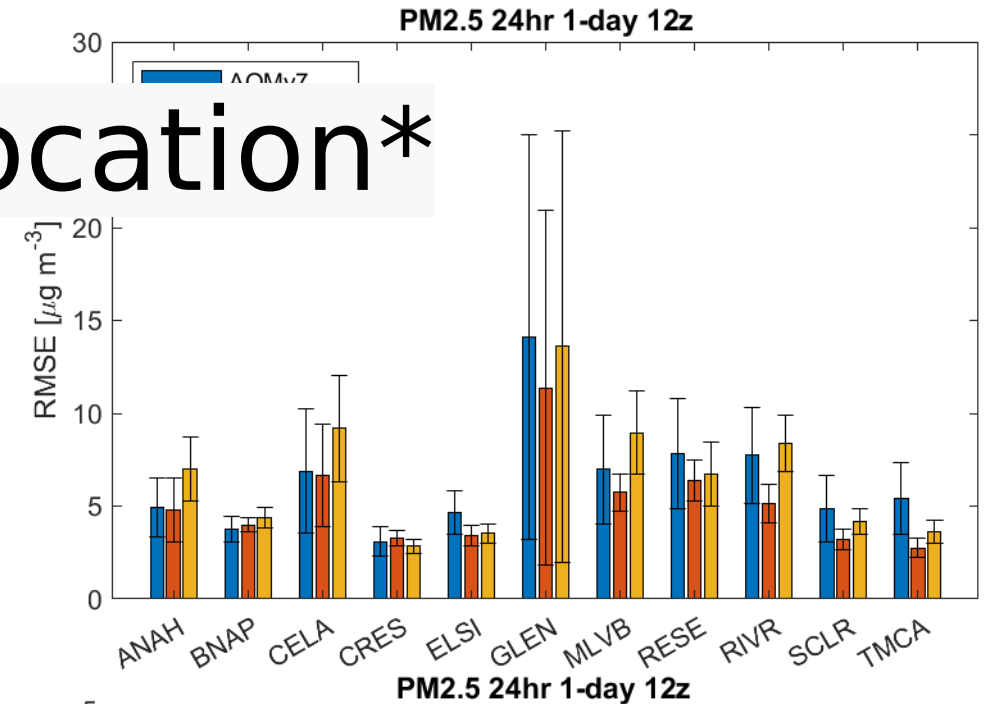
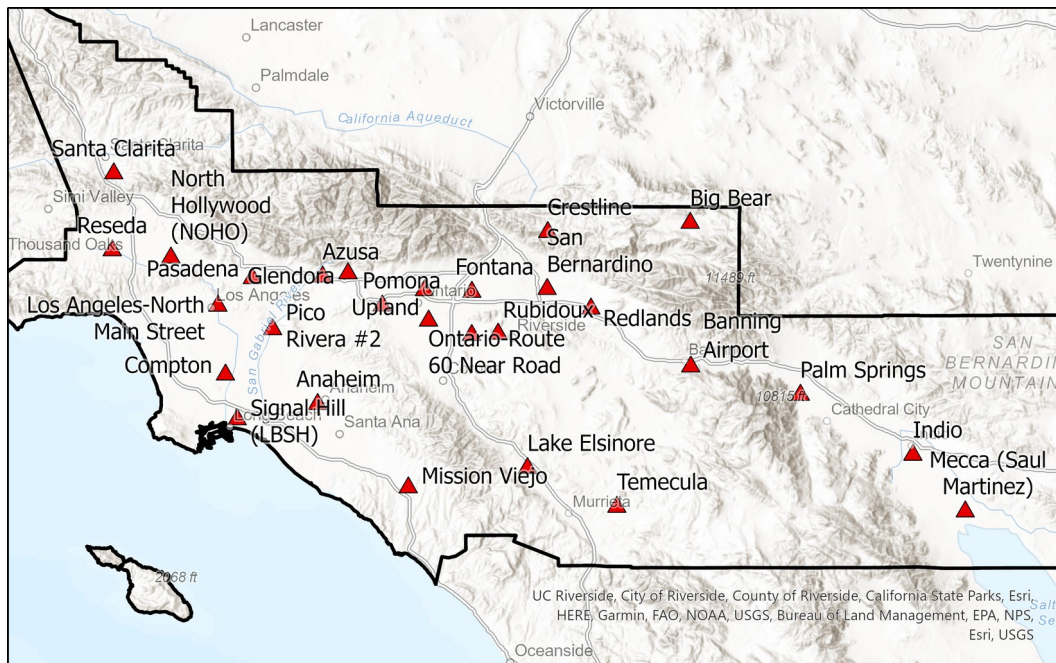
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Model Overestimates | Model Underestimates



PM2.5 Daily Average by Location*

- AQMv7 and analogmod have similar mean bias and similar performance to persistence
- AQMv7 has small MB
- Analogmod MB usually negative (overprediction). May need to be retrained using most recent measurement data to reduce bias.



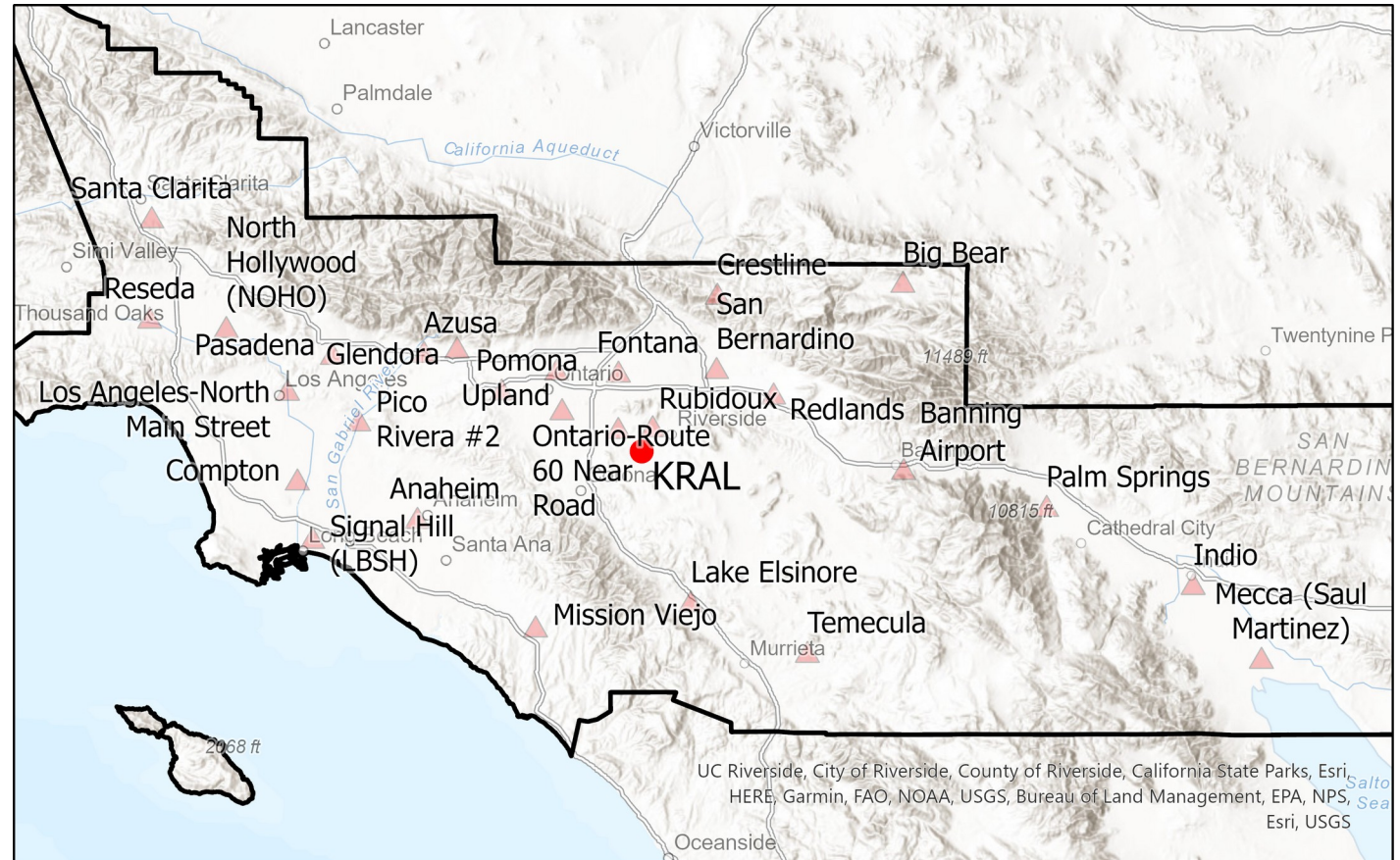
* Using AQI-Change dates

Model Overestimates | Model Underestimates

Model Residual Trends

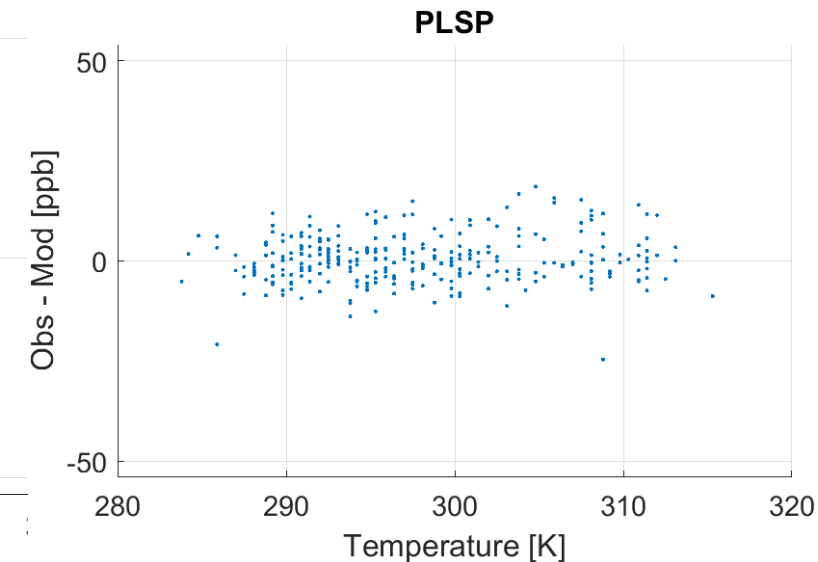
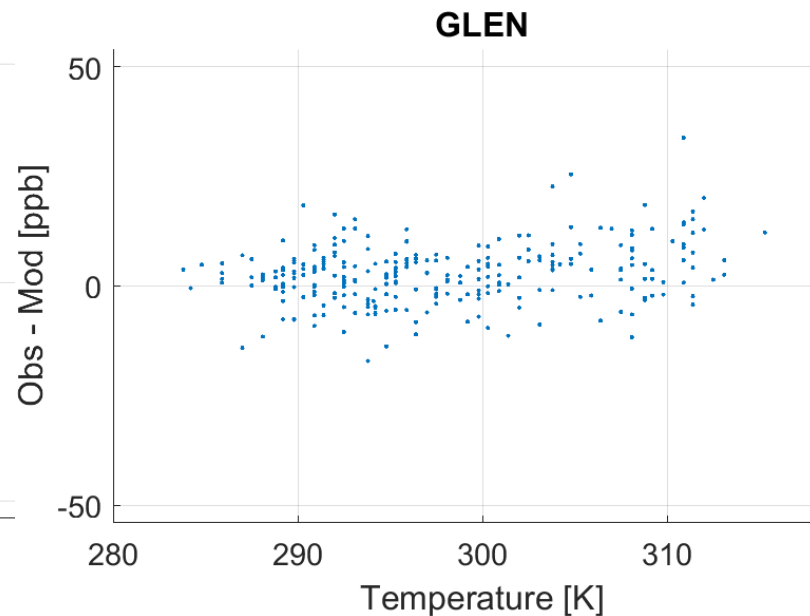
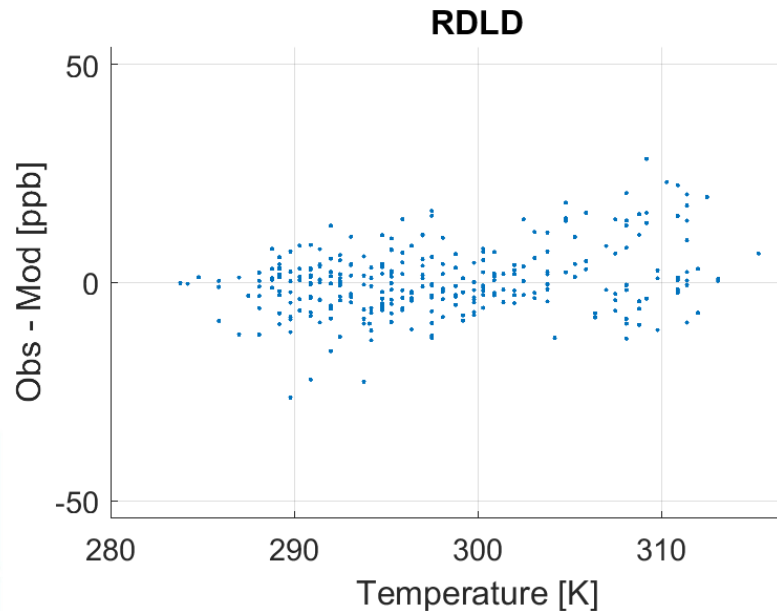
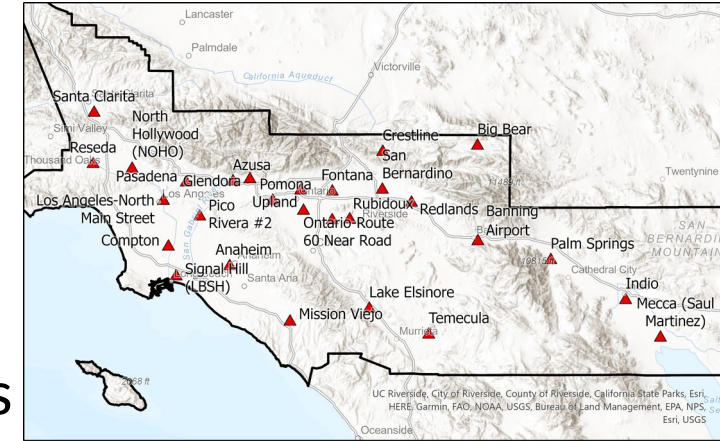
Residual Trends Analysis

- Analyzed Residual vs Met Data
- Met Data: Riverside Municipal Airport (KRAL) Automated Surface Observing System
 - Processed using AERMET to derive mixing height and surface friction velocity



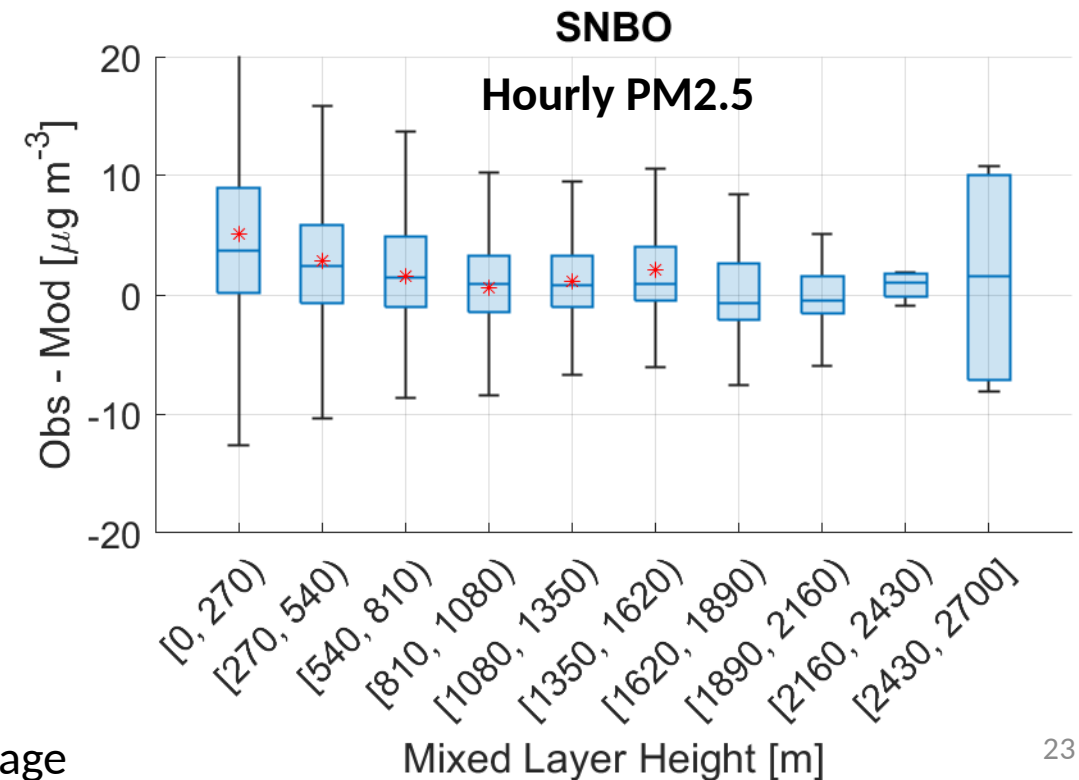
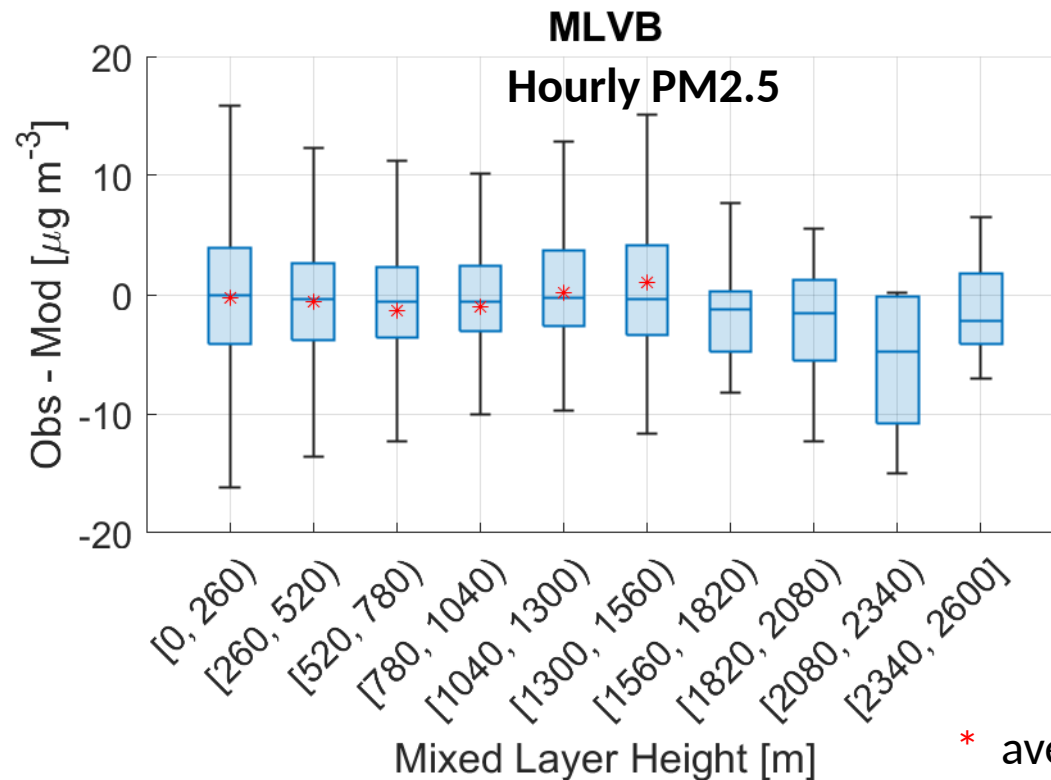
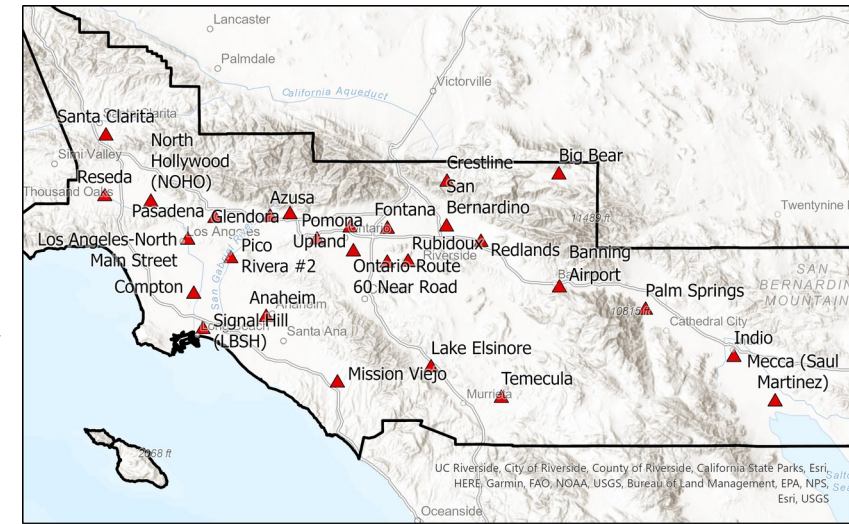
O3 8hr Max Residual vs Maximum Temperature

- Plotted residual of daily maximum 8-hr average ozone vs daily max 10 m temperature at Riverside Airport (KRAL)
- Model tends to underestimate Ozone at Glendora at high temperature ($\sim > 310$ K)
- Less evidence of underestimation at Palm Springs and Redlands



Mixed Layer Height

- Underestimation of PM_{2.5} at SNBO when mixing height is low at Riverside Airport (KRAL)
- Most other stations have low/no trend with mixing height



Conclusions

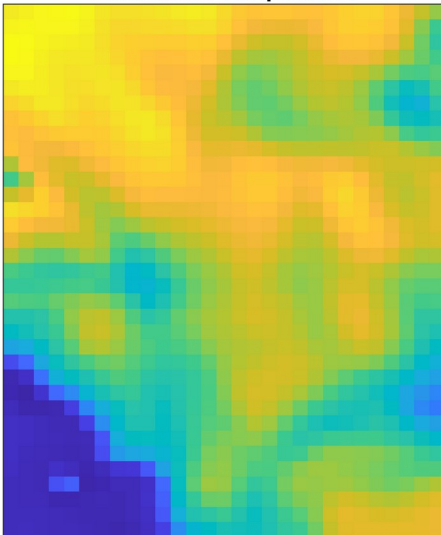
- AQMv7 has good ozone performance (among the best models in our jurisdiction)
 - Although during Line/Bridge/Airport fire the model underestimate Ozone spikes and underestimated/overestimated PM2.5 spikes in some cases
- About the same PM2.5 performance at most stations
 - Nearly as good as the best PM2.5 model for our jurisdiction
- AQMv7 tends to underestimated PM2.5 at SNBO when mixing height is low
- Overall AQMv7 is one of the best-performing forecast models we use

Backup Slides

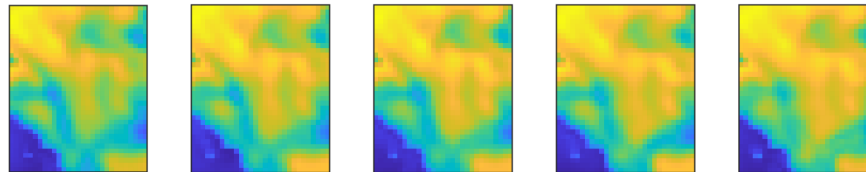
Air Quality Forecasting Models (South Coast AQMD Analog Forecast Model)

- Model developed by AQ Assessment Group compares meteorological fields on forecasted day with historical meteorological fields
- Identifies analogous days and uses them to make predictions
- Daily predictions of O₃, PM_{2.5}, PM₁₀, NO₂, and CO at every measurement station

Forecasted Temperature

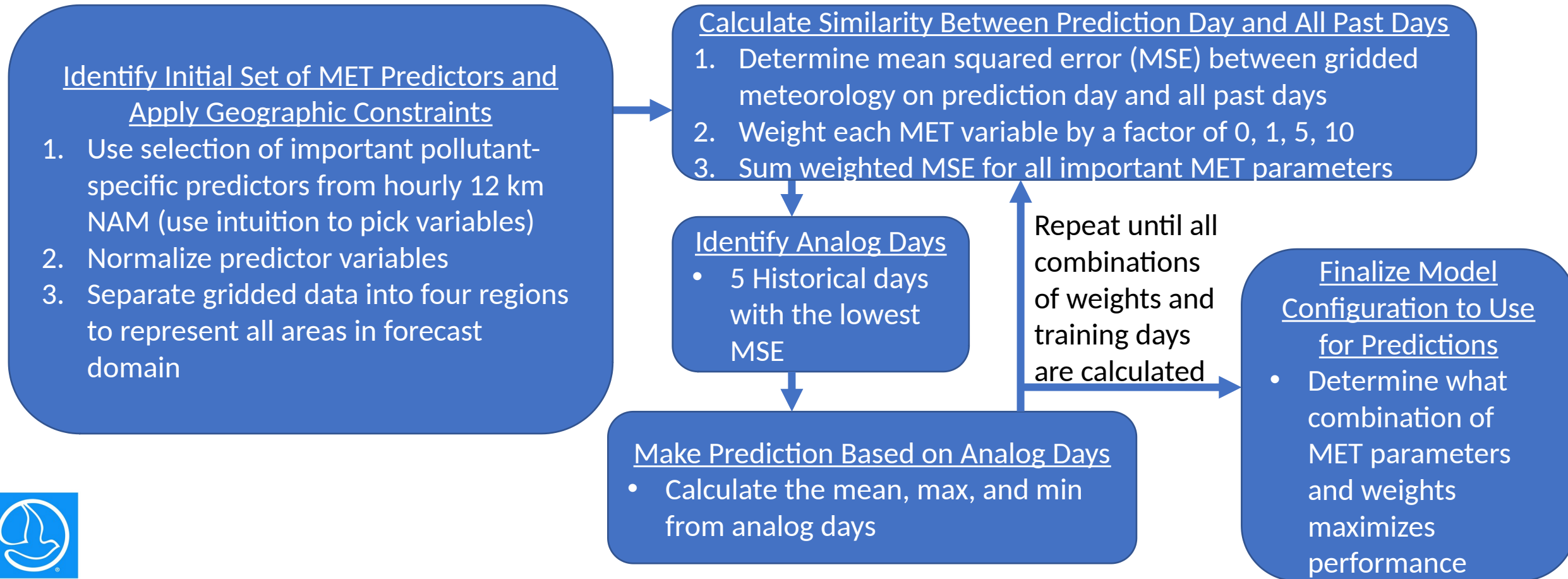


Temperature on Historical Days

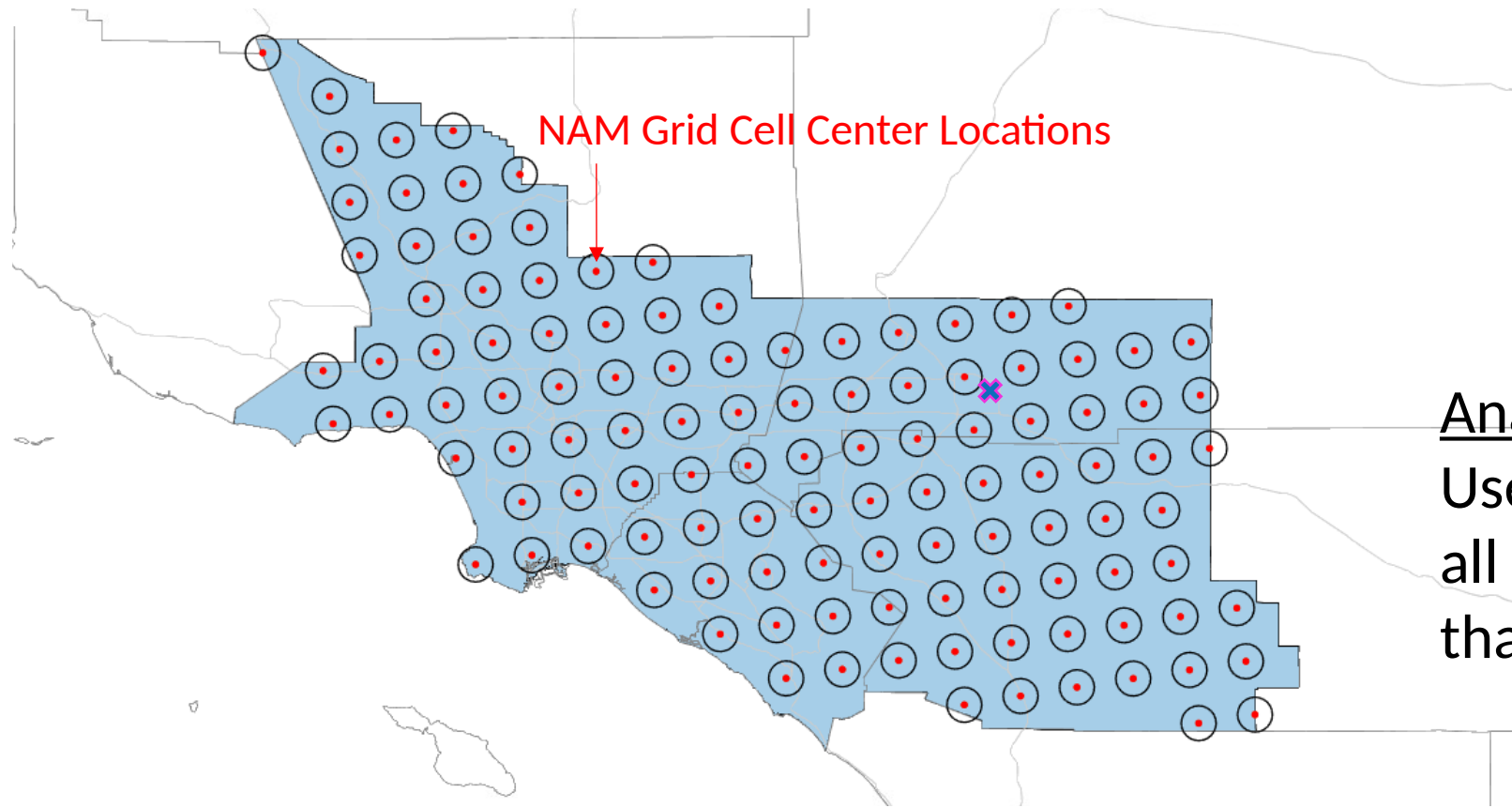


Analog Model Training Methodology

- For all pollutants at every monitoring station:



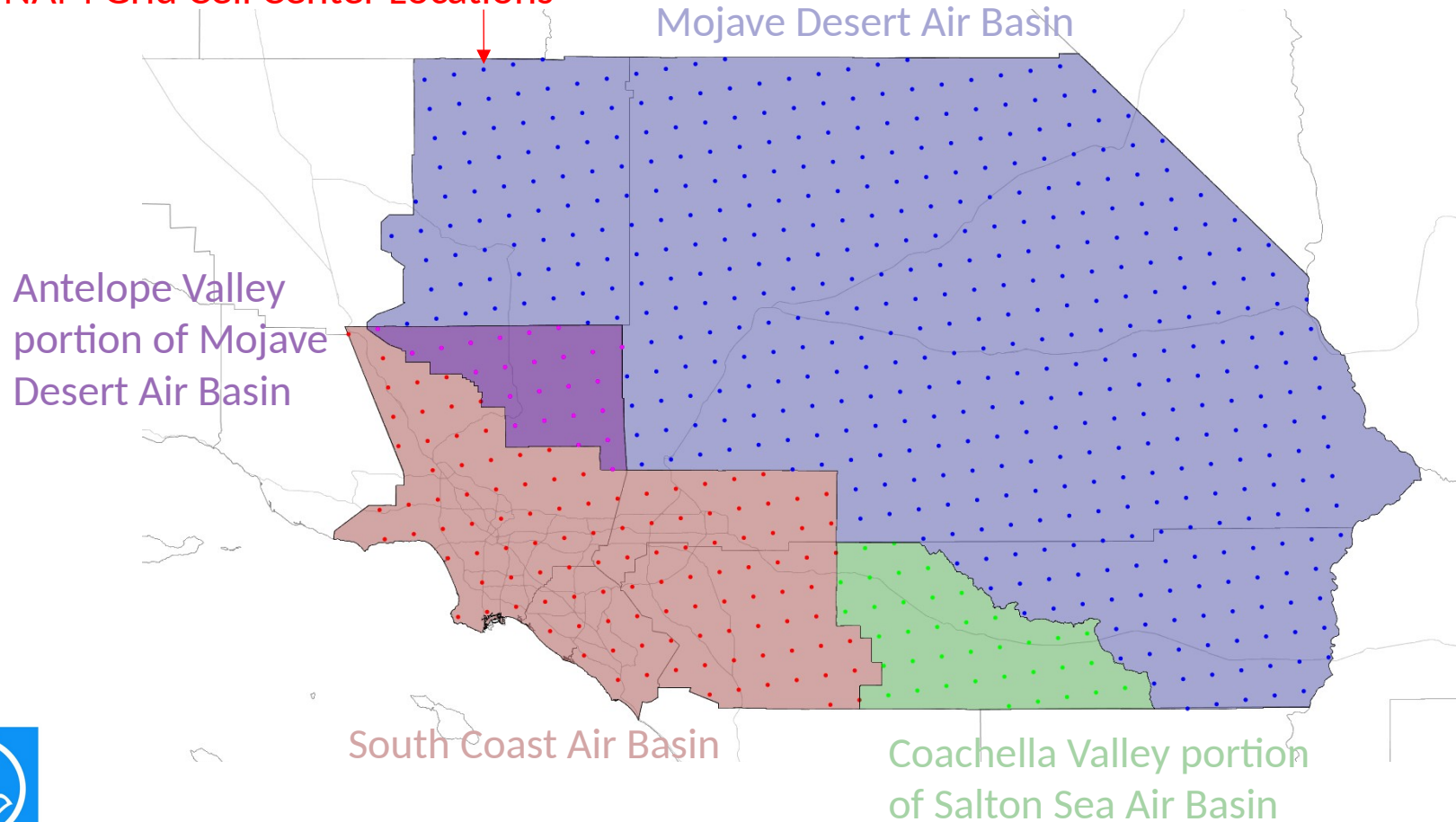
Analog Day Selection Methodology



Analog Day Identification
Uses the meteorology for
all grid cells in the region
that the station resides

Analog Day Selection Methodology

NAM Grid Cell Center Locations



Forecasting domain
split into 4 regions

Analog Prediction Methodology

- For all pollutants at every monitoring station:

Calculate Similarity Between Tomorrow and All Past Days

1. Determine mean squared error (MSE) between tomorrow's gridded meteorology and all past days
2. Apply weights to MSE calculated with training
3. Sum weighted MSE for all important MET parameters

Identify Analog Days

- 5 Historical days with the lowest MSE

Make Prediction Based on Analog Days

- Calculate the mean, max, and min from analog days

Cleanest Time Of Day

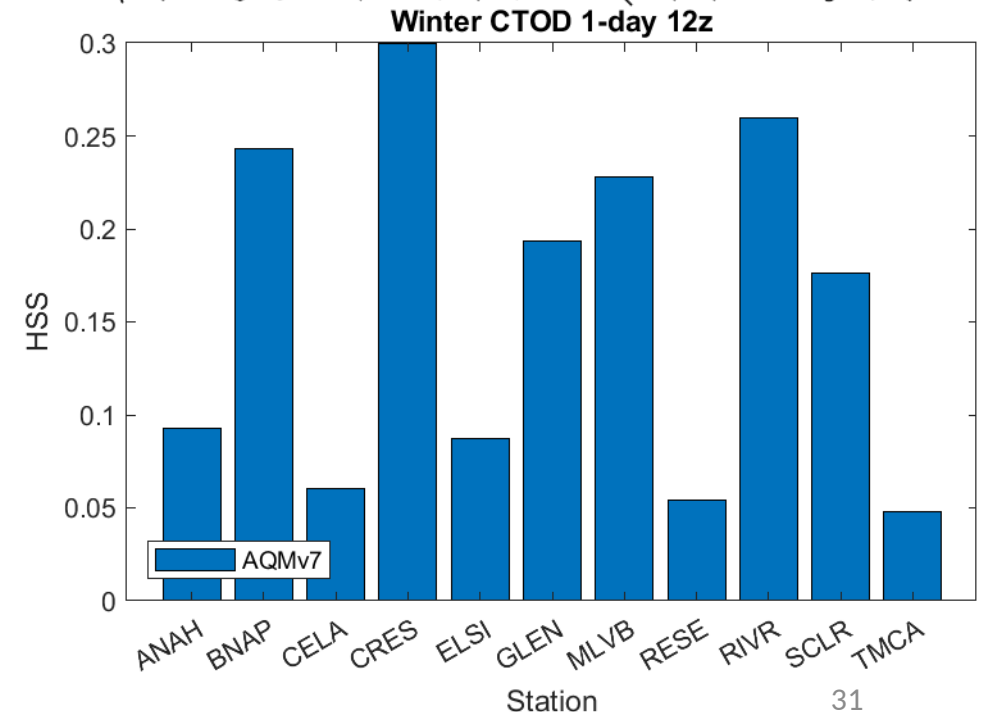
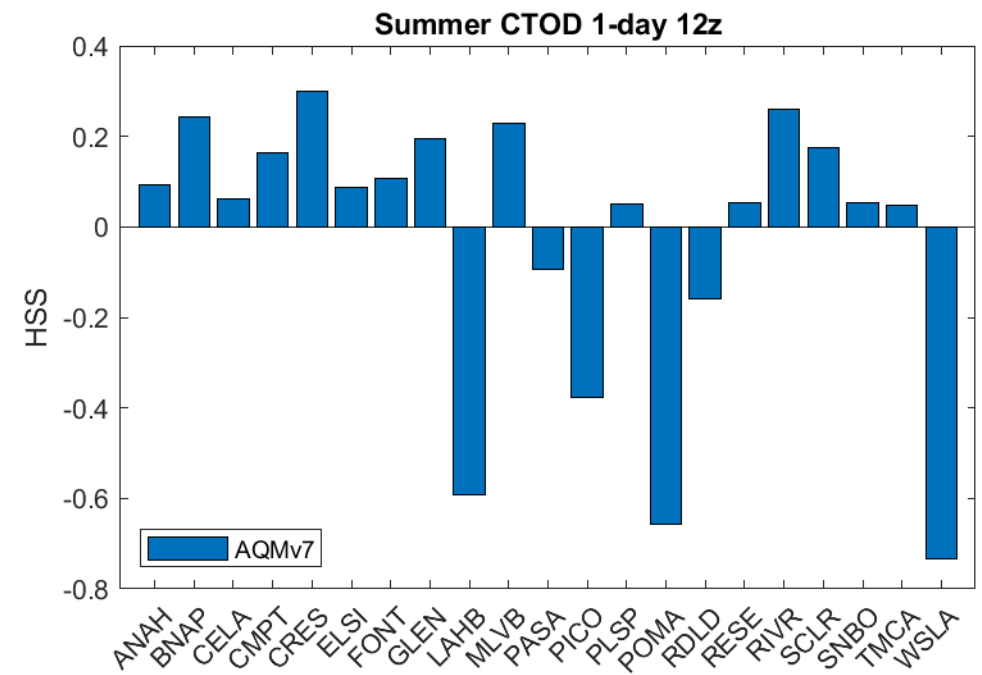
- **Cleanest Time of the Day:**

- Predicted AQI is at least 10 AQI points less than the day's average AQI*
- Binary true/false forecast for each hour
- Used to present hourly forecast

- **HSS:** Percent correct relative to a persistence forecast

- At most stations HSS is moderate but positive

- Indicates model has some skill in predicting hourly Ozone and PM2.5 trends



* AQI based on O3 and PM2.5