Scientific, Technical & Modeling Peer Review Advisory Group (STMPR) Meeting

August 3, 2023

Item 2

Emission Inventory Updates for the PM Plan

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STMPR Meeting on August 3, 2023
South Coast Air Quality Management District

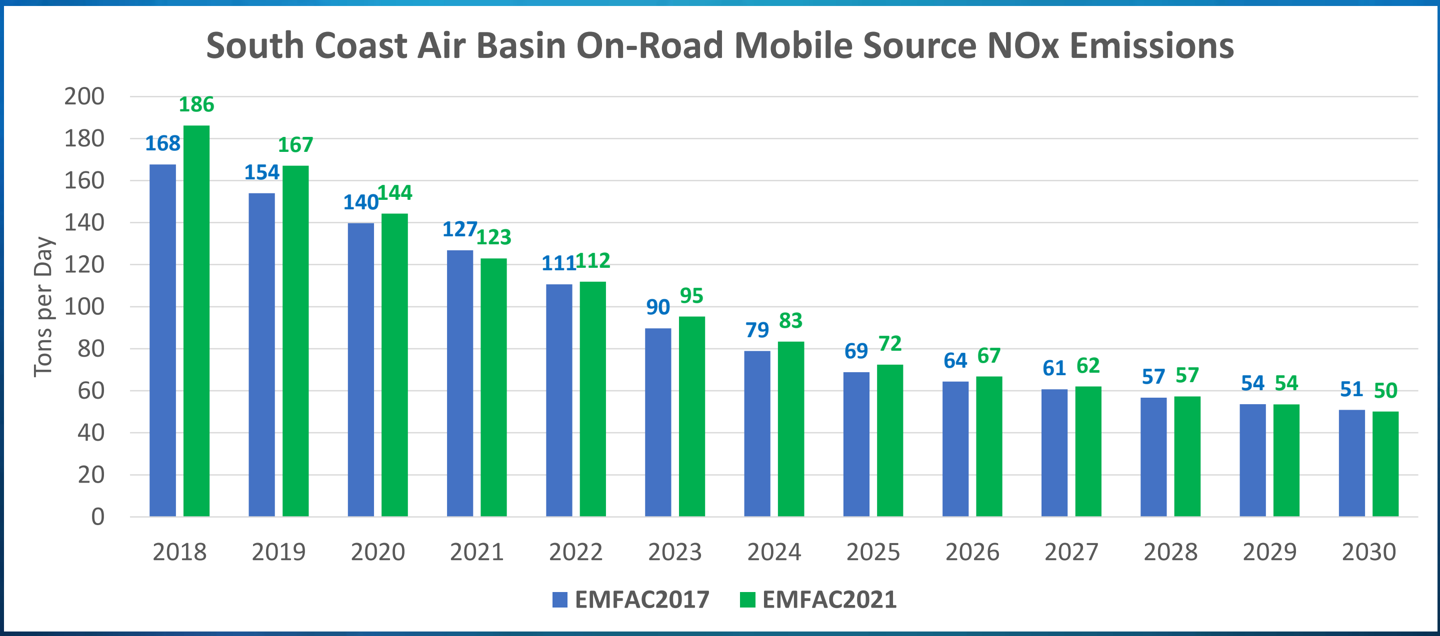
Introduction

- South Coast Air Basin is in “serious” nonattainment of the 2012 annual PM2.5 National Ambient Air Quality Standard (NAAQS) of 12 $\mu g/m^3$
- An attainment plan was submitted to U.S. EPA in 2017, however, U.S. EPA has not acted on the plan
- Since the submittal of the plan, near road (NR) monitors have accumulated sufficient data to use in attainment demonstration
- Currently CA-60 Ontario NR has the highest level of annual PM2.5 in the South Coast Air Basin
- South Coast AQMD is developing a new attainment plan including NR stations with a new attainment date, 2030
- Base year is 2018, of which emissions were used to project future years’ emissions. Base year’s meteorology and air quality measurements were used for modeling performance evaluation as well
- All emissions in this presentation are draft estimates

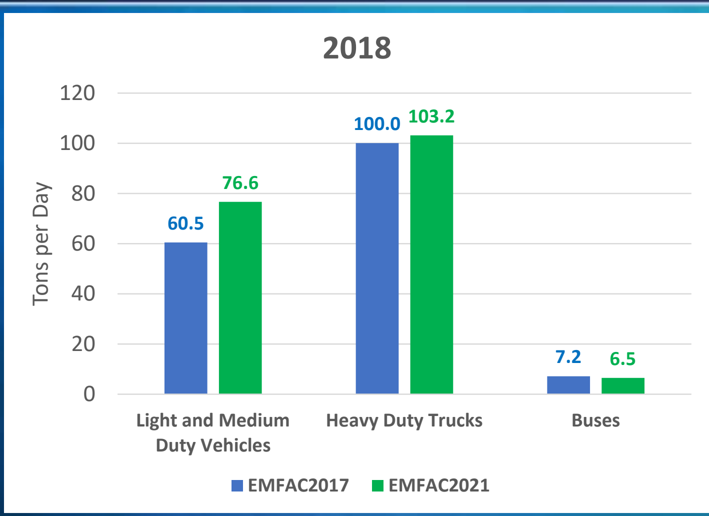
Emissions Inventory Update

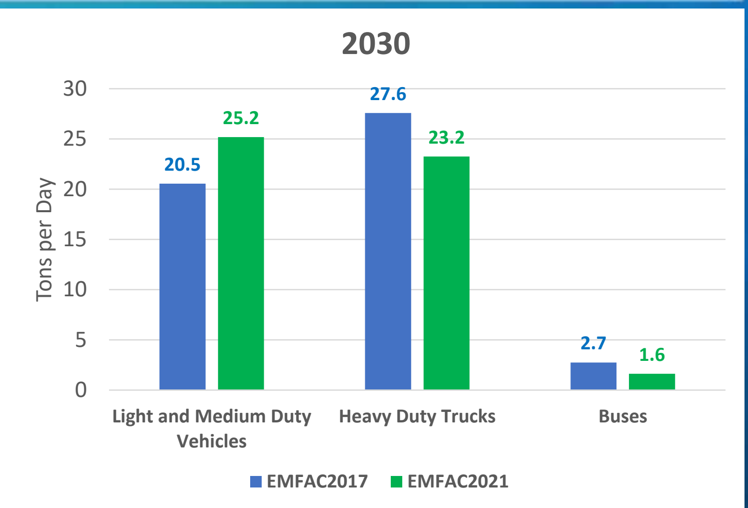
Point	Area	On-road Mobile	Off-road Mobile
• 2018 Annual Emission Reporting (AER) database	• 2022 AQMP	• 2020 SCAG RTP Travel Activity Data (2022 AQMP) • EMFAC2021 Emission Rate	• 2022 AQMP • Minor Correction in Offroad Equipment

EMFAC 2017 vs 2021: NOx Emission



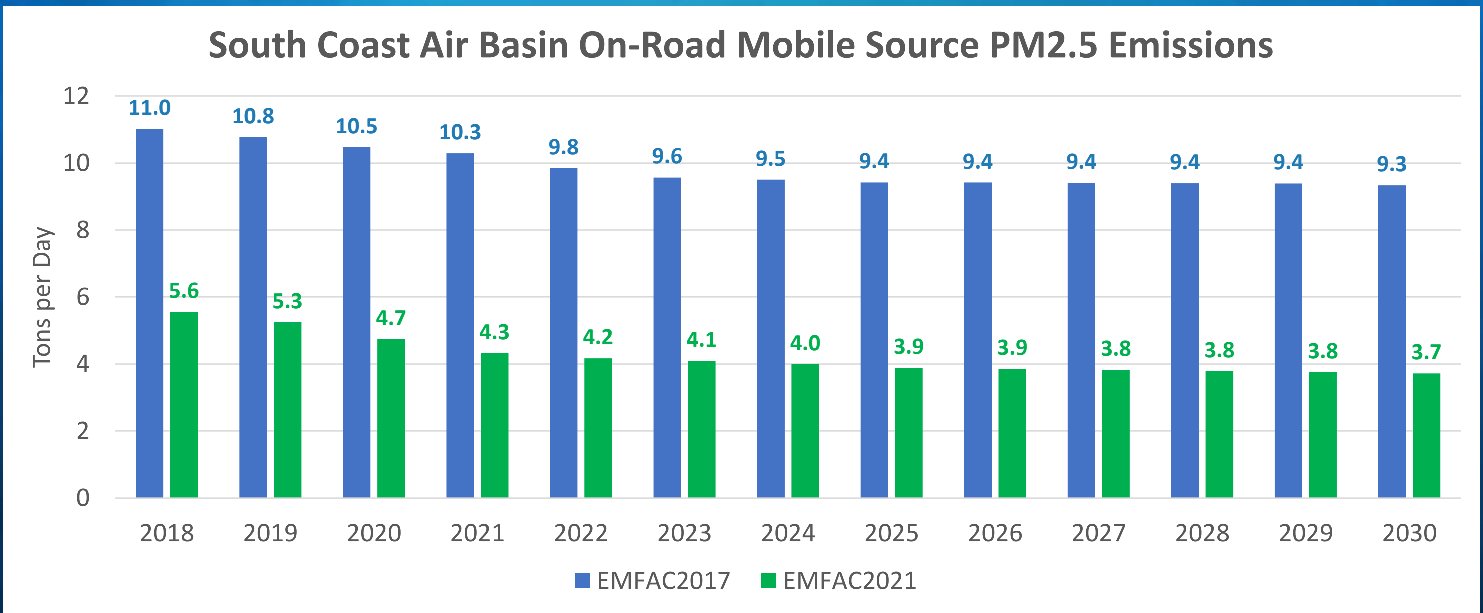
On-Road NOx Emissions by Vehicle Type



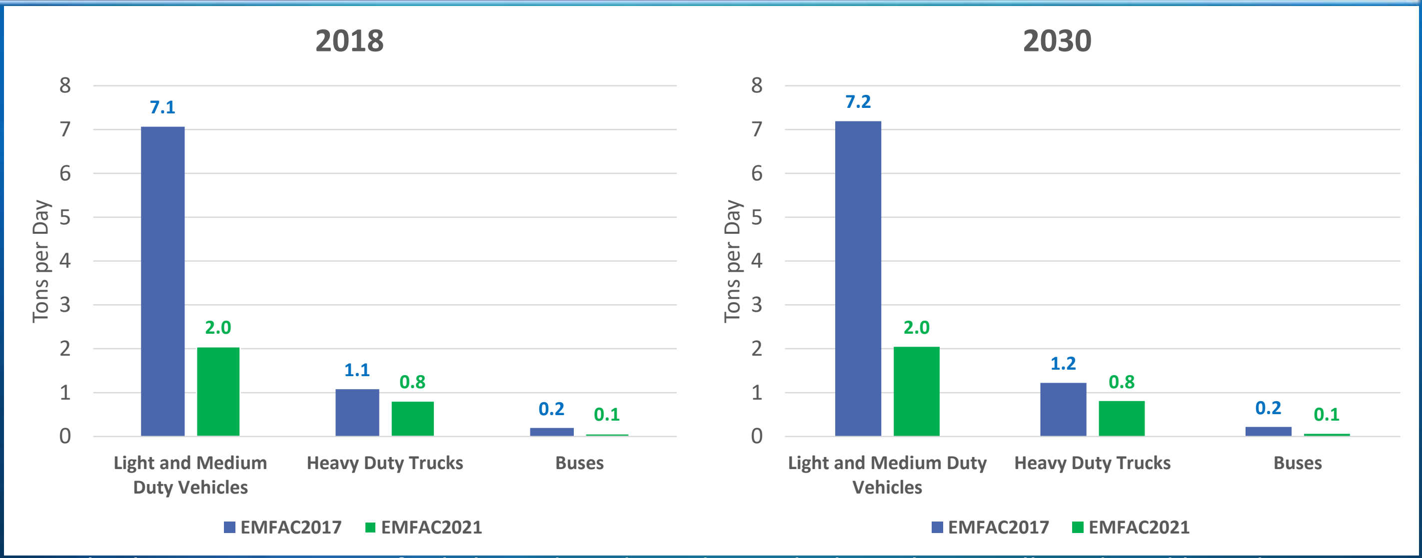


- Light-duty vehicles have higher exhaust emissions, based on new vehicle test data
- Medium heavy-duty trucks are older than what was assumed in EMFAC2017, based on DMV data

EMFAC 2017 vs 2021: PM2.5 Emission

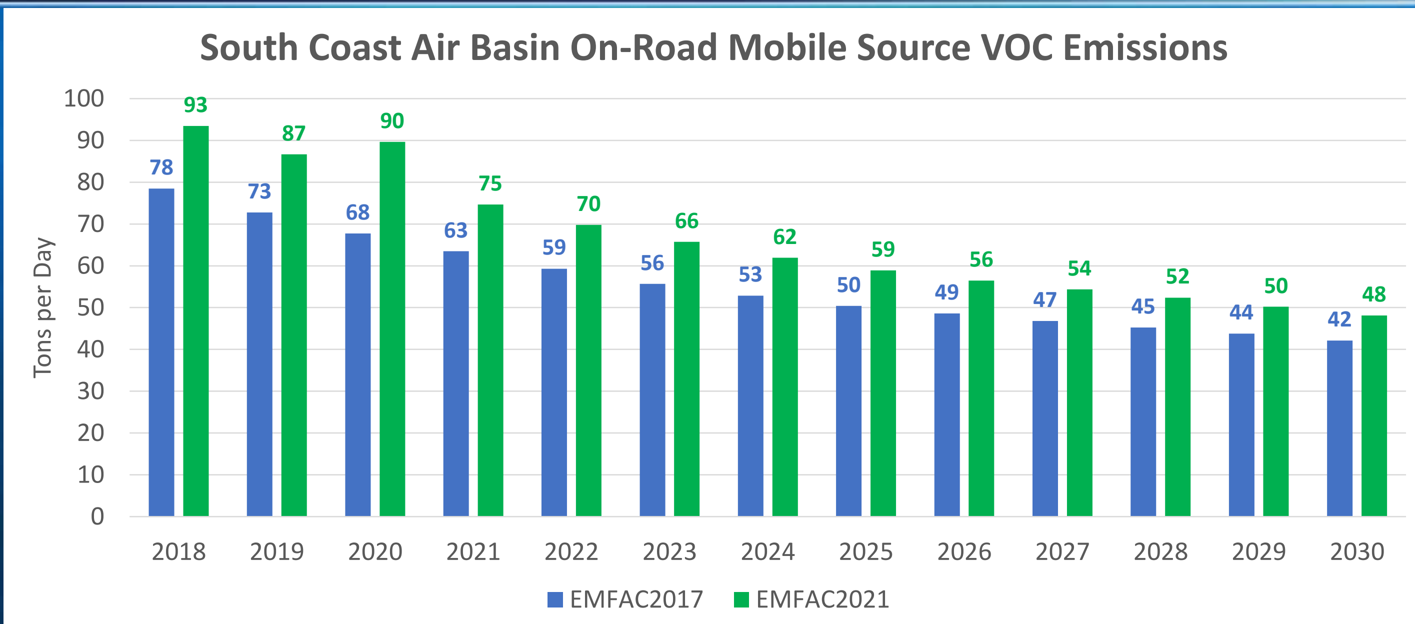


Tire and Brake Wear PM2.5 Emissions

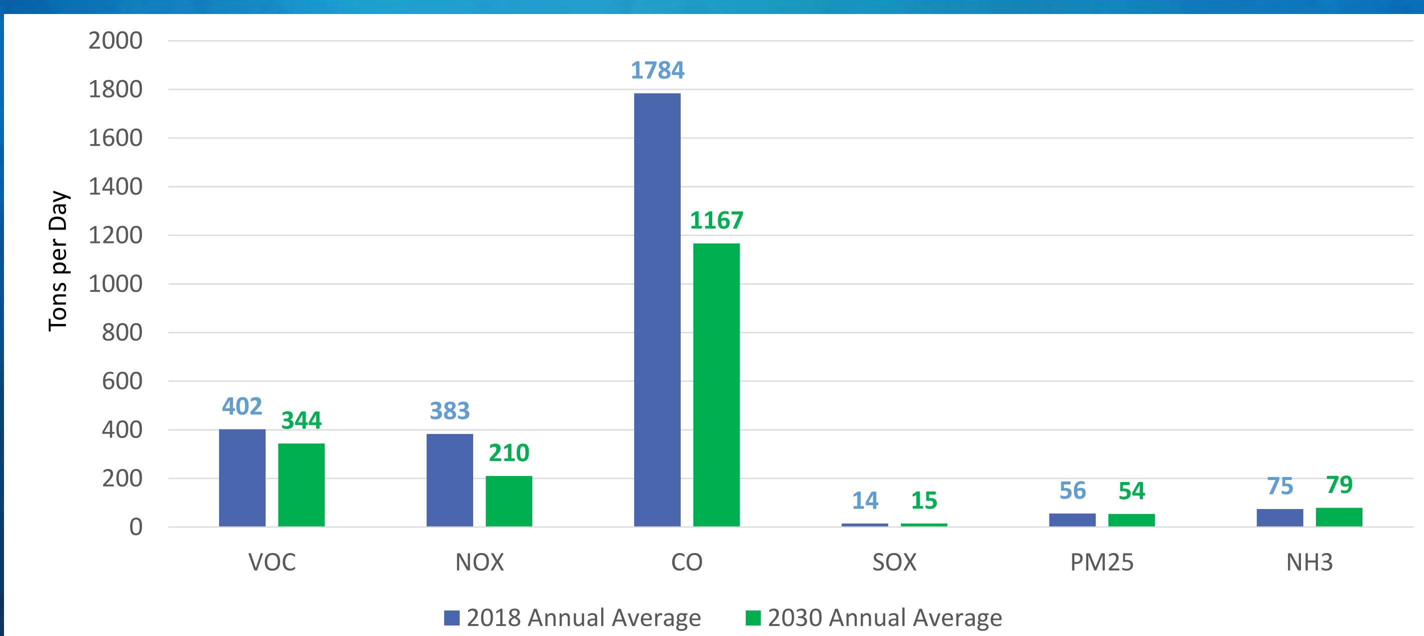


- PM brake-wear emissions for light and medium duty vehicles substantially reduced based on new updated data and speed correction factors
- Tire and brake wear emissions for 2030 are projected to be similar to the base year's emissions

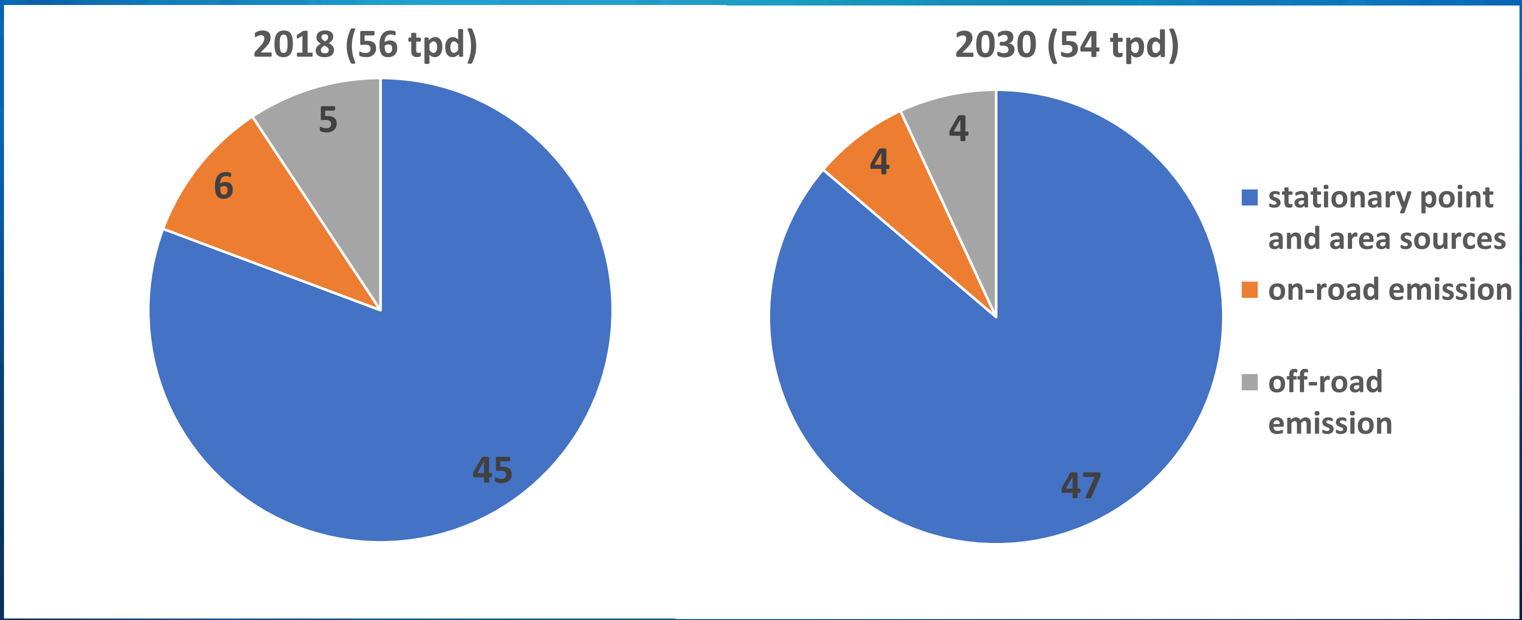
EMFAC 2017 vs 2021: VOC Emissions



South Coast Air Basin Total Emissions



Basin Total PM2.5 Emissions



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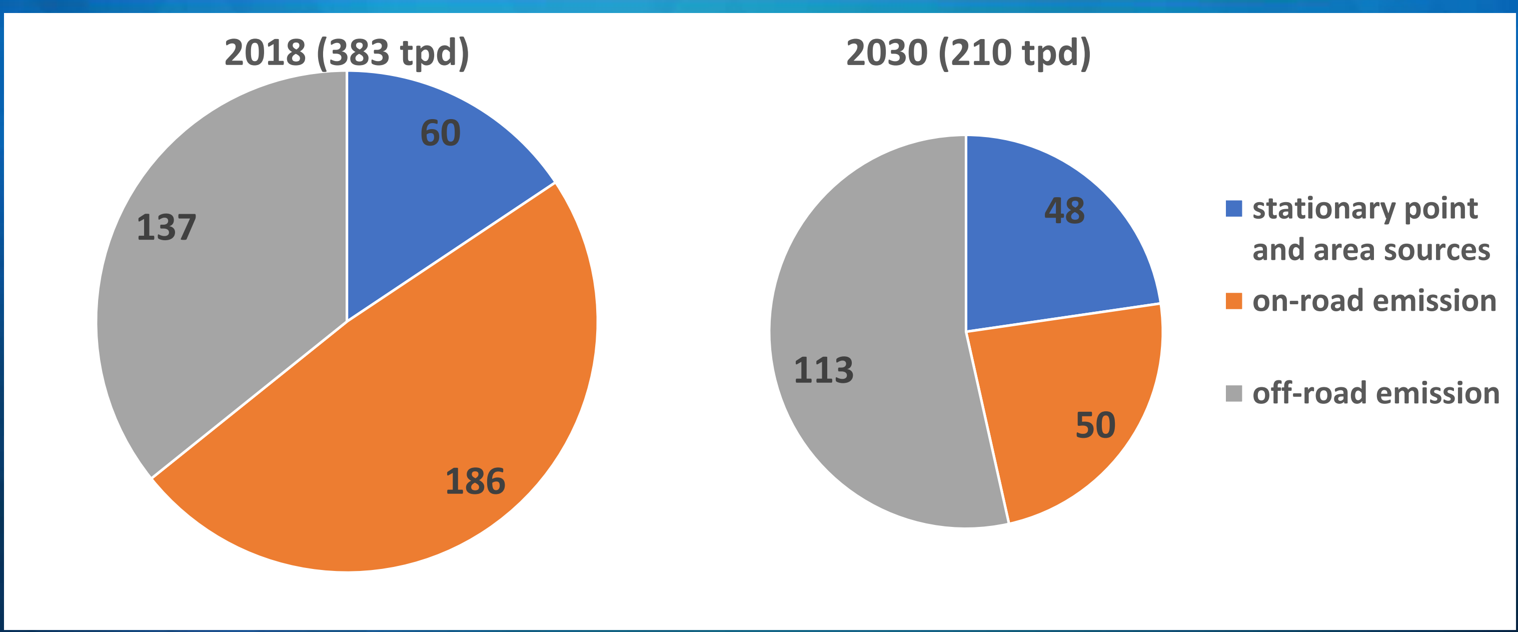
Basin Total NOx Emissions



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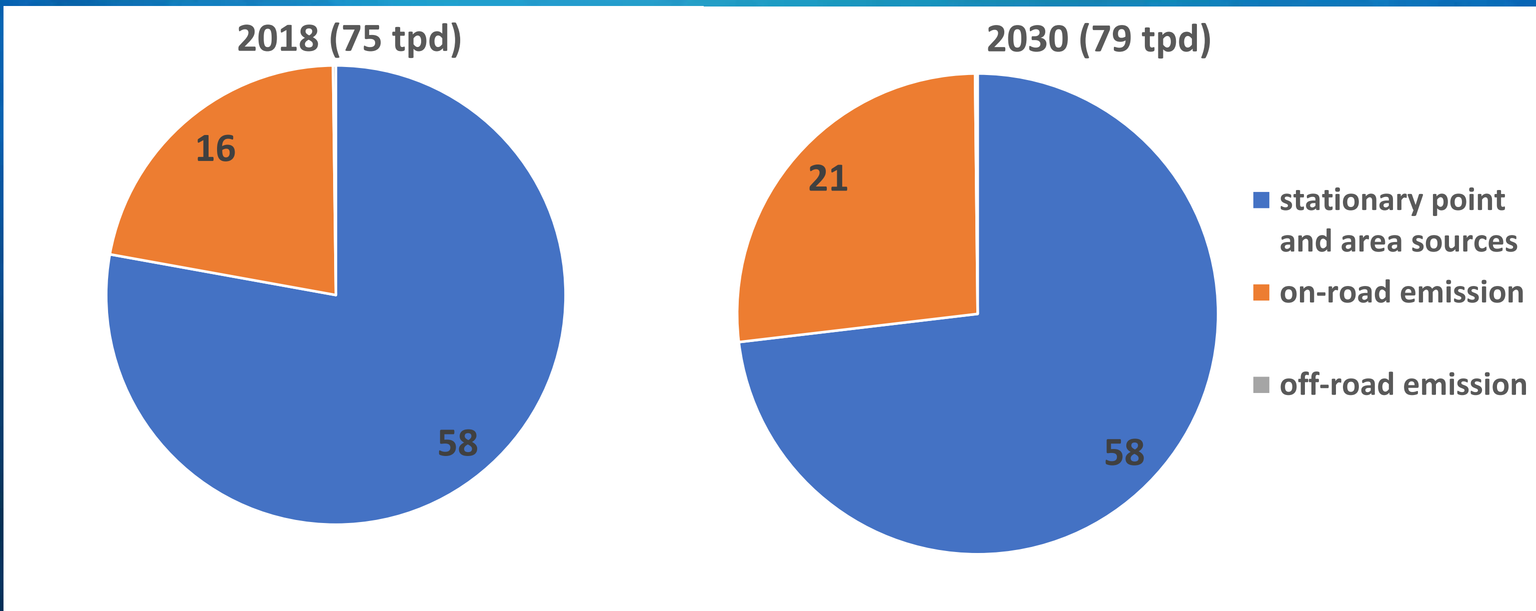
Basin Total NH3 Emissions



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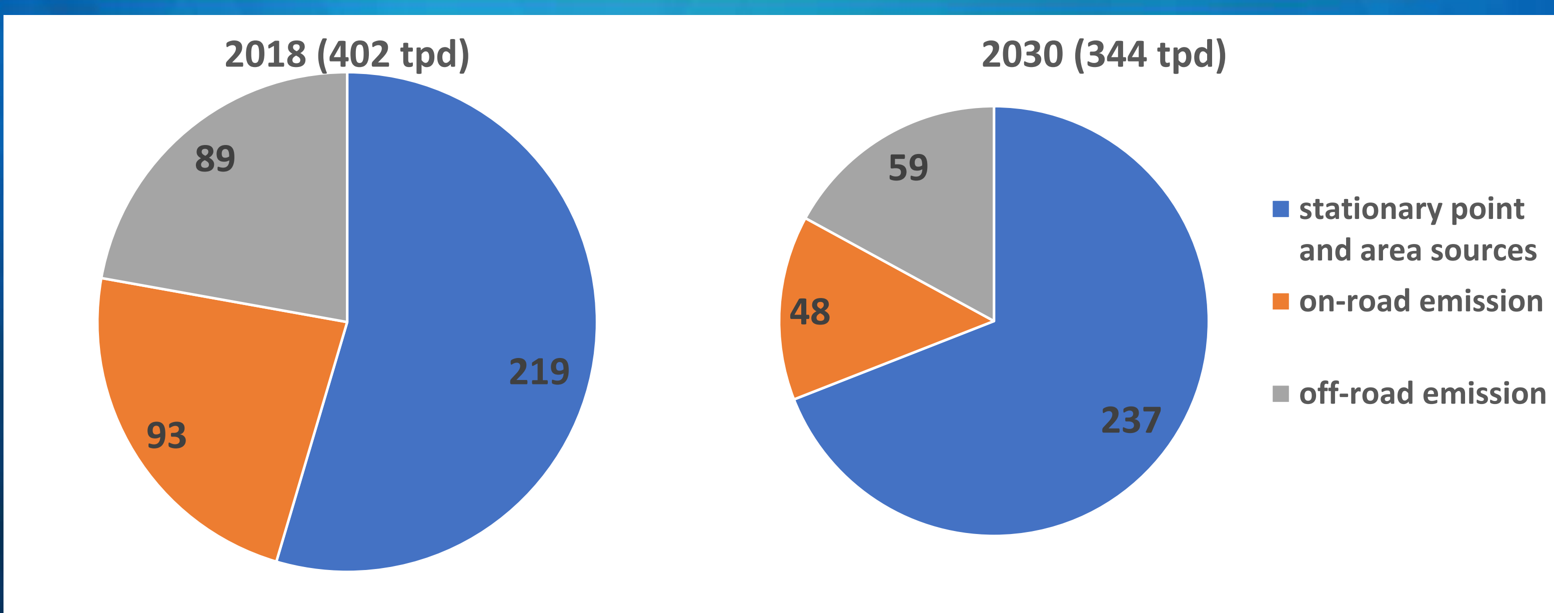
Basin Total VOC Emissions



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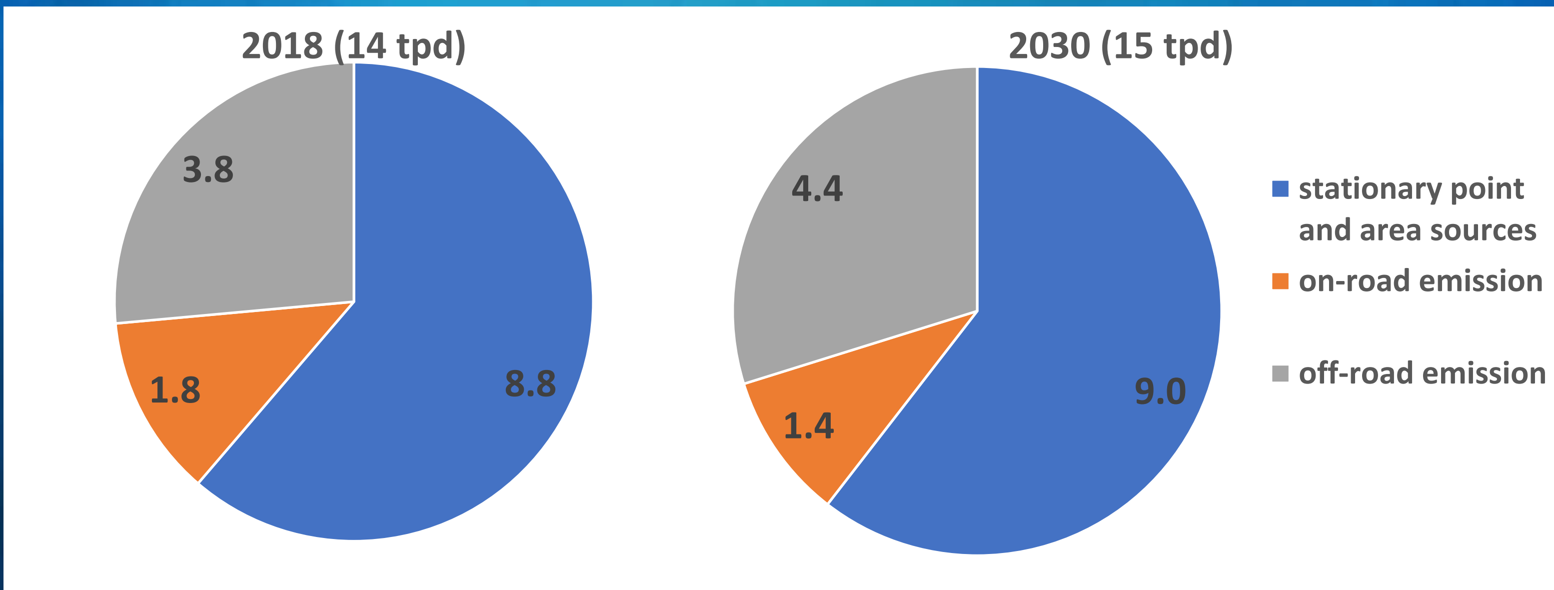
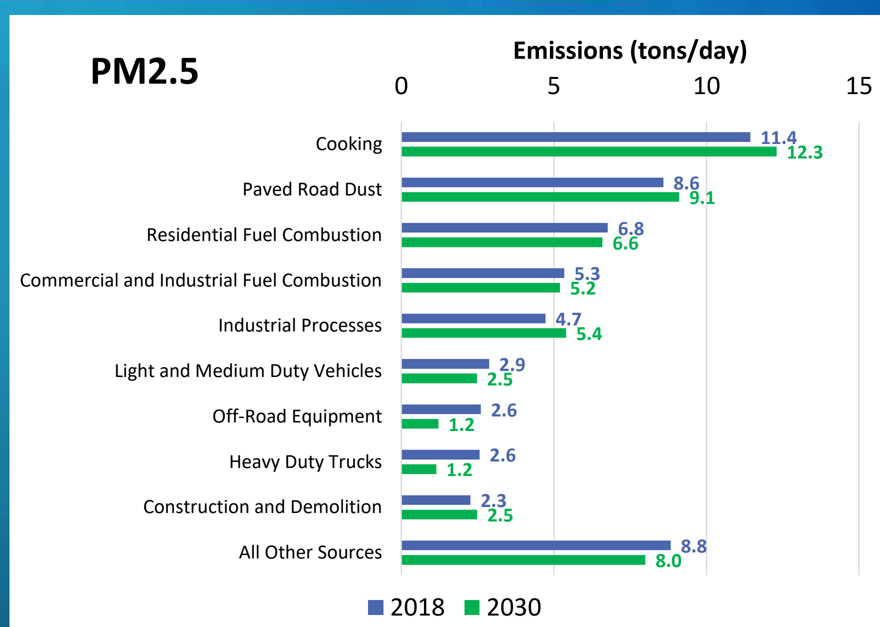
Basin Total SOx Emissions



(number may not add up due to rounding)

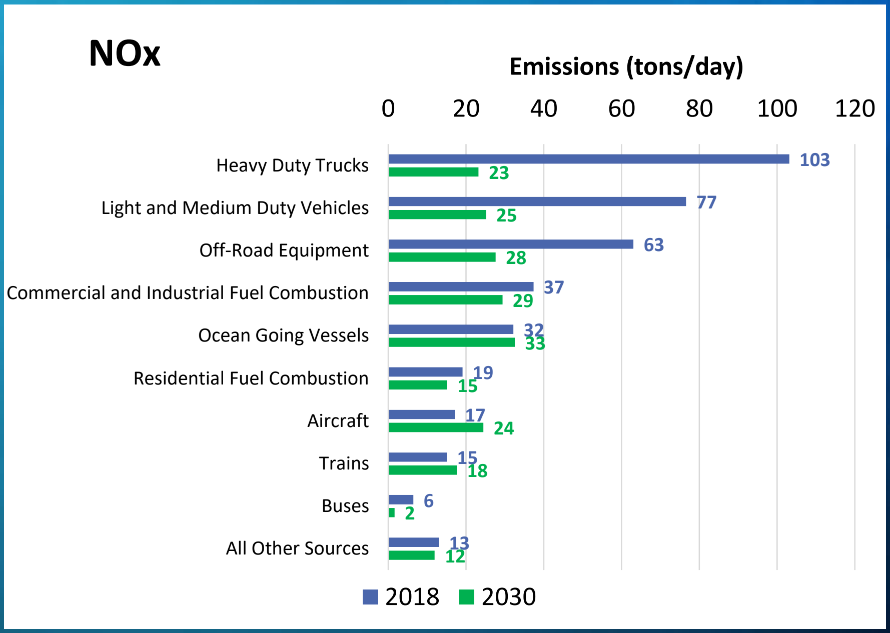
Top Sources of PM2.5 Emissions

- Large portion of direct PM2.5 are emitted from area sources
- Emissions from top two sources (cooking and paved road dust) are expected to increase proportionally to population and VMT growth
  - Most other sources will reduce emissions, even with increased future activity



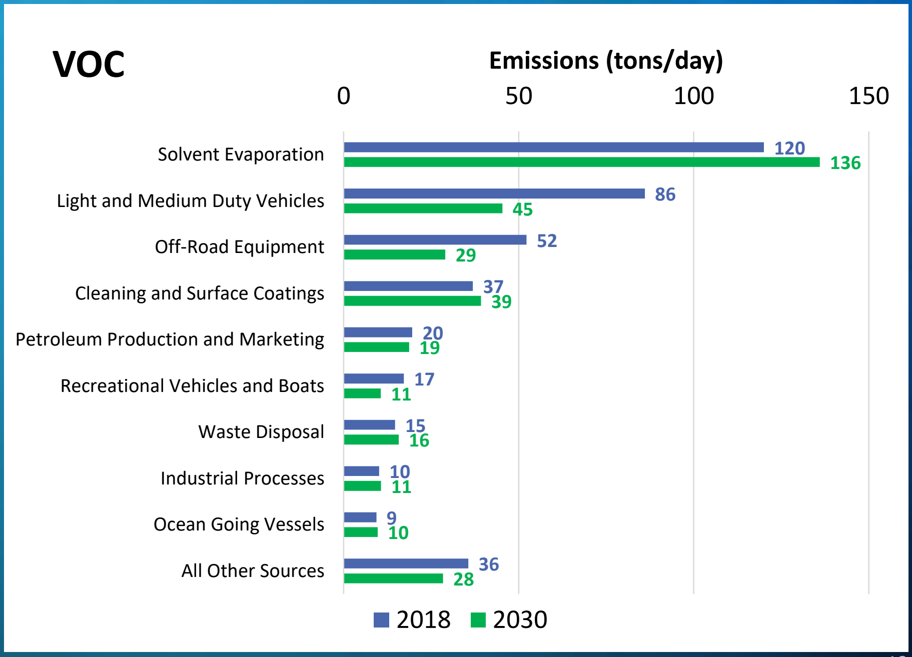
Top Sources of NOx Emissions

- NOx emissions are dominated by mobile sources
- NOx emissions projected to decrease significantly due to ongoing implementation of adopted regulations and programs



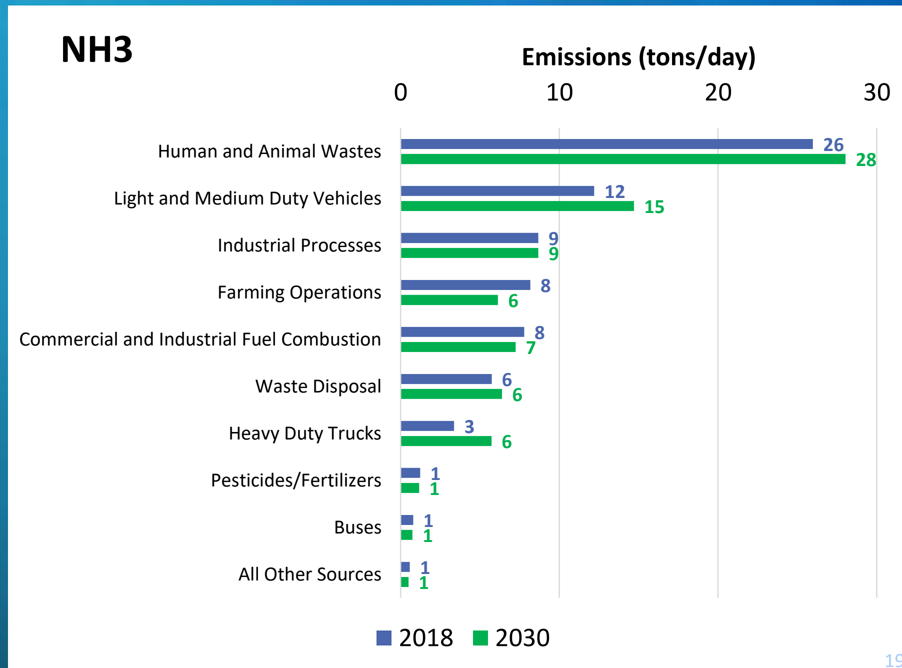
Top Sources of VOC Emissions

- Emissions from solvent evaporation projected to increase due to population growth
  - Majority of the solvent evaporation emissions come from consumer products



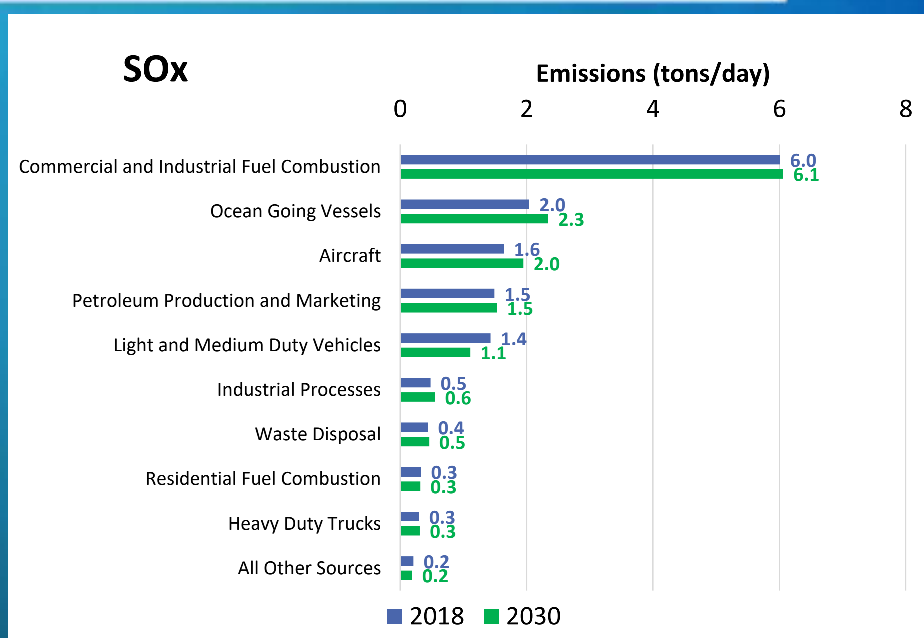
Top Sources of NH3 Emissions

- Emissions from human and animal waste and on-road mobile sources are the main sources of NH_3 emissions and projected to increase due to population growth



Top Sources of SOx Emissions

- SOx emissions are expected to increase in ocean going vessels and aircraft categories due to increased activity



Summary of Emission Inventory Update

- Emissions inventory for this PM plan was built from the 2022 AQMP inventory
- Major update introduced to on-road mobile source category by switching to EMFAC2021
- EMFAC2021 includes higher NOx and VOC emissions than previous version, but PM2.5 emissions are lower
  - More pronounced in base year than attainment year
- Top sources of direct PM2.5 are commercial cooking, paved road dust, and residential fuel combustion
- Top sources of NH3 are human and animal waste, and on-road vehicles

Item 3

Design Values for Modeling Attainment Demonstration

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STMPR Meeting on August 3, 2023

South Coast Air Quality Management District

PM2.5 3-Year Design Values

- Design values are used to designate and classify nonattainment areas, as well as to assess progress towards meeting the NAAQS
  - ➢ The design value is the annual arithmetic mean concentration, averaged over 3 years

Annual Standard

Year 1				Year 2				Year 3			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Annual average				Annual average				Annual average			
Average = Design value											

Attainment: Design value must be less than or equal to **12 µg/m³** standard

U.S. EPA has proposed a new standard between 9-10 µg/m³

Design Value for Modeling Attainment Demonstration

- EPA Modelling Guidance recommends using a 5-year weighted DV, i.e. average of three 3-year DVs, for an attainment demonstration
- 5-year weighted average exhibits less year to year variability than a single design value
- Base year 2018 and 5-year weighted DVs covering the period of 2016-2020 were chosen for this Plan

2018 Base Design Value (DVB)

DV 2018	DV 2019	DV 2020
2016-2018	2017-2019	2018-2020

Average = DVB =

$$\frac{(DV\ 2018) + (DV\ 2019) + (DV\ 2020)}{3}$$

Modified Design Value (DVB 2018)

- Because of the exceptionality of 2020, we propose the use of a modified weighting that excludes 2020
- This is consistent with the approach used in the recent San Joaquin Valley ozone SIP
- Proposed Base Design Value (DVB) uses 3-year DVs for 2018 and 2019, and a modified DV for 2020, which excludes 2020

2018 Base Design Value (DVB)

DV 2018	DV 2019	DV Modified
2016-2018	2017-2019	2018-2019

Average = DVB =

$$\frac{(\boldsymbol{DV}\ \mathbf{2018}) + (\boldsymbol{DV}\ \mathbf{2019}) + \left(\frac{\boldsymbol{Avg}\mathbf{2018} + \boldsymbol{Avg}\mathbf{2019}}{\mathbf{2}}\right)}{\mathbf{3}}$$

Atypical 2020: COVID-19 Pandemic

Atypical 2020: Record-Setting Wildfires

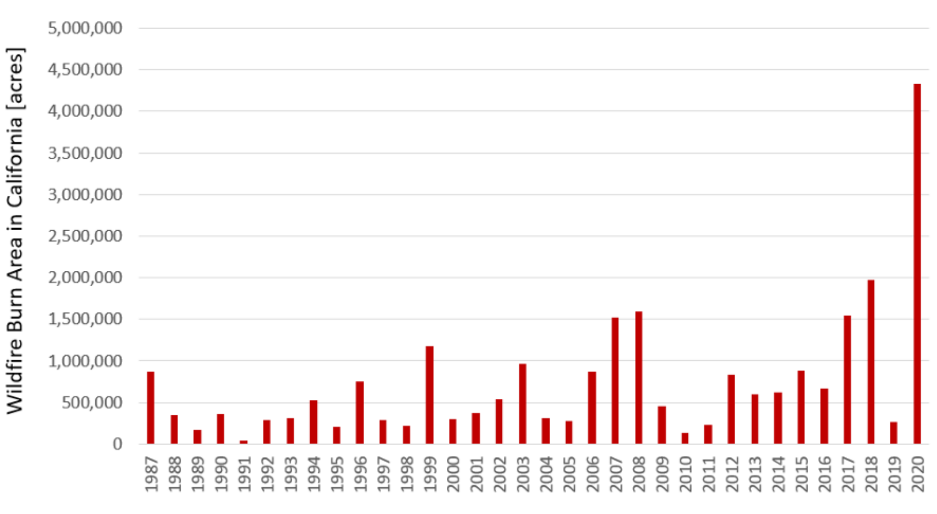
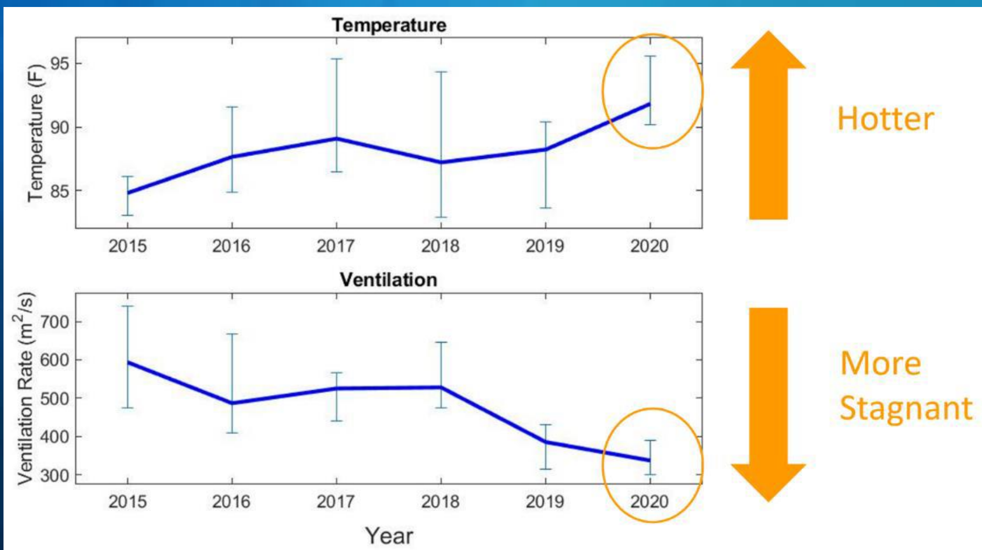


FIGURE 2-19
WILDFIRE BURN AREA IN CALIFORNIA SINCE 1987. SOURCE CALFIRE.

- Over 4 million acres burned in 2020, more than double the previous modern record set in 2018
- Both fires within the South Coast Air Basin (e.g., the Bobcat, El Dorado, Silverado, Blue Ridge, Ranch2, Apple and Snow fires) and fires in Northern and Central California affected air quality in 2020

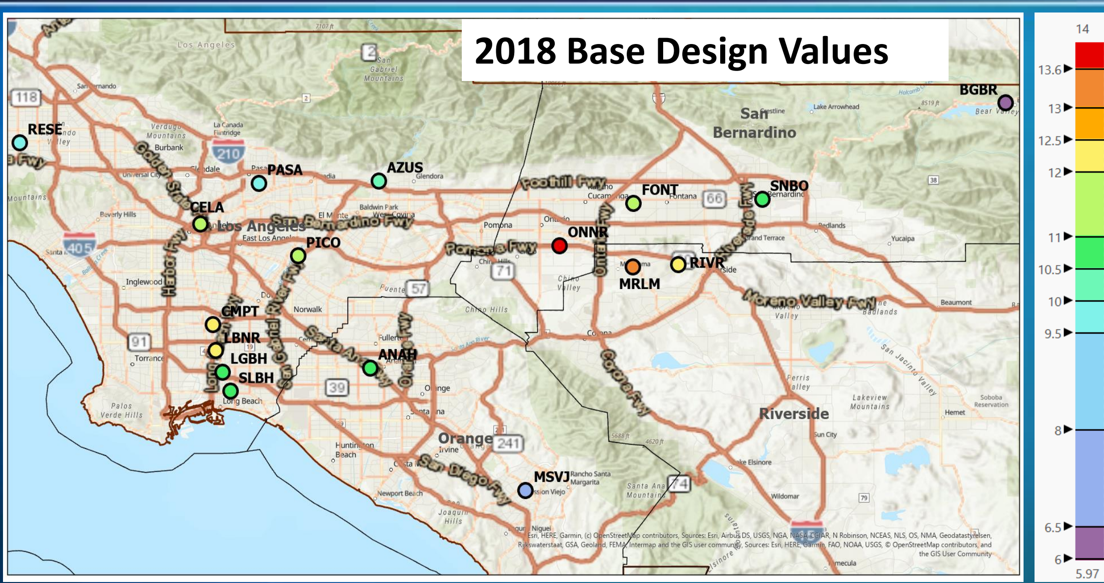
Hot and Stagnant Meteorology in 2020

MODELED TEMPERATURE AND BASIN VENTILATION ON THE HIGHEST OZONE DAYS EACH YEAR IN LOS ANGELES



- 2020 had hot and stagnant conditions which are conducive to poor air quality
- The summer of 2020 was the third hottest summer on record in the Basin and the hottest summer statewide

PM2.5 5-year weighted Design Values for 2018



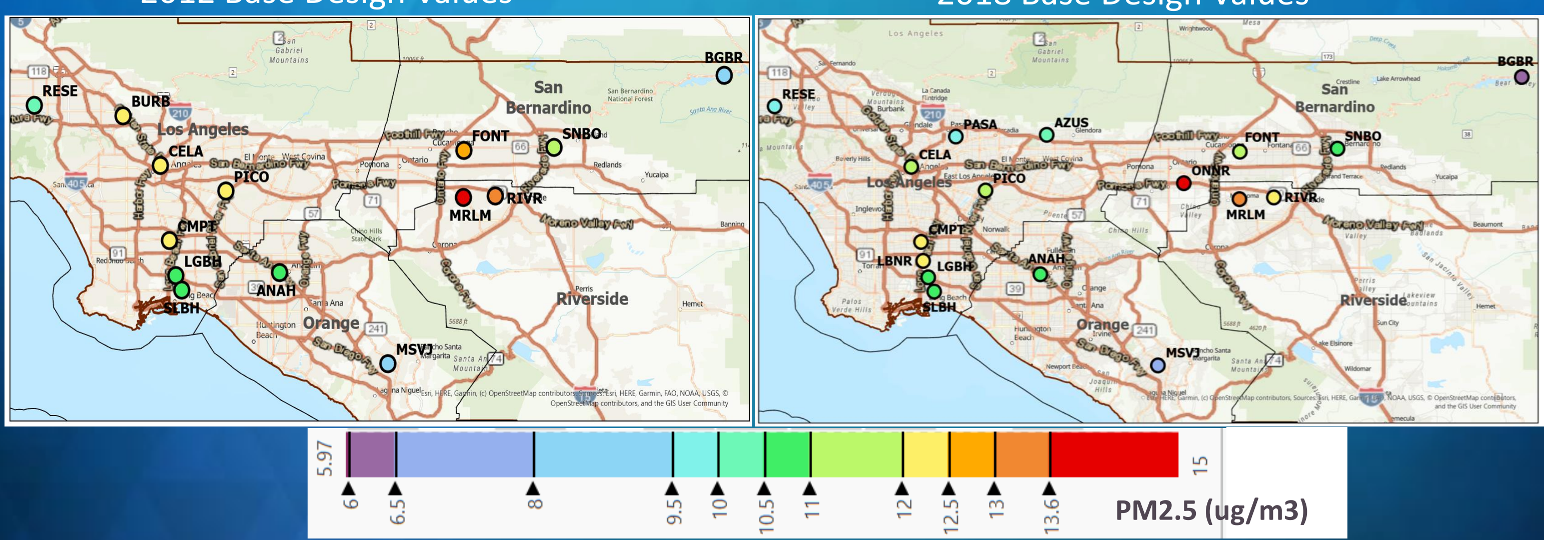
Code	Station
ANAH	Anaheim
AZUS	Azusa
BGBR	Big Bear
CELA	Los Angeles-North Main Street
CMPT	Compton
FONT	Fontana
LBNR	Long Beach I-710 Near Road
LGBH	North Long Beach
MRLM	Mira Loma (Van Buren)
MSVJ	Mission Viejo
ONNR	Ontario CA-60 Near Road
PASA	Pasadena
PCHG	Pechanga
PICO	Pico Rivera #2
RESE	Reseda
RIVR	Rubidoux
SLBH	South Long Beach
SNBO	San Bernardino

- July 4th and 5th are removed as exceptional events due to fireworks
- Ontario NR DVBs are 14.11 ug/m3 and 13.98 ug/m3, respectively, with and without July 4 and 5
- Mira Loma DVBs are 13.60 ug/m3 and 13.53 ug/m3, respectively, with and without July 4 and 5

PM2.5 5-year weighted DVs for 2012 vs 2018

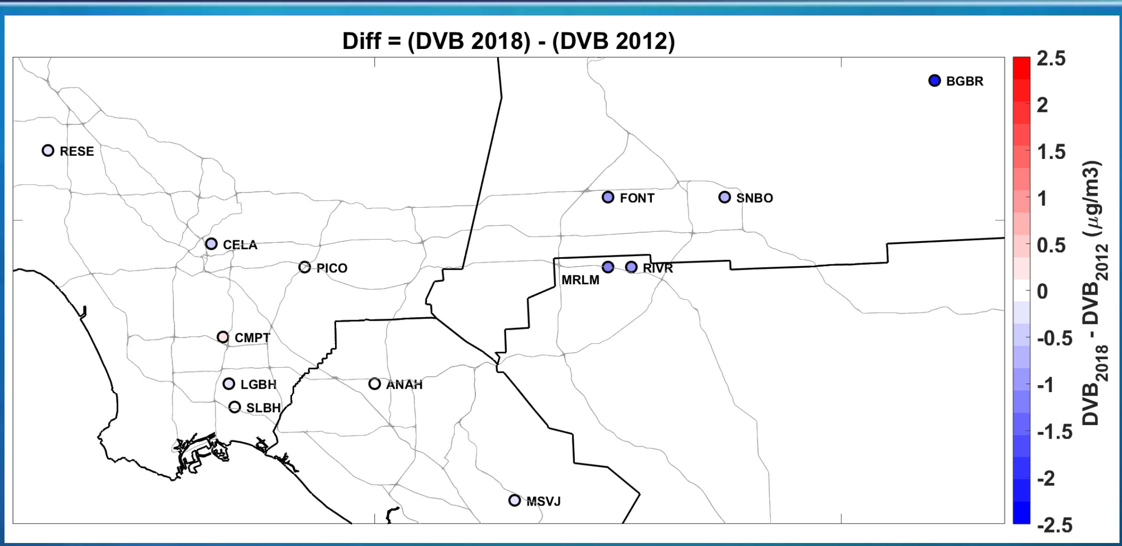
2012 Base Design Values

2018 Base Design Values



- Mira Loma DVBs are 14.87 ug/m3 in 2012 and 13.53 for 2018
- Ontario Near Road monitor did not exist in 2012
- 2012 DVBs include all days and 2018 DVBs exclude EE days

Changes Between 2012 and 2018



- DVBs 2018 have decreased compared to DVBs 2012 except in Compton (0.14 ug/m3) and Anaheim (0.07 ug/m3) stations
- Maximum decrease is 2.05 ug/m3 in Big Bear followed by Mira Loma (1.27 ug/m3)

Summary

- 5-year period of 2016-2020 was used to estimate DVB for the modeling attainment demonstration
  - Modified DVB is proposed to exclude 2020 primarily due to abnormal pandemic-era emissions, as well as meteorology and wildfires
- PM2.5 DVs have decreased at most sites between 2012 and 2018
- Design site has changed from Mira Loma (14.87 ug/m3) in 2012 DVB to Ontario near-road (13.98 ug/m3) in 2018 DVB

Item 4

Modeling Framework and Performance Evaluation

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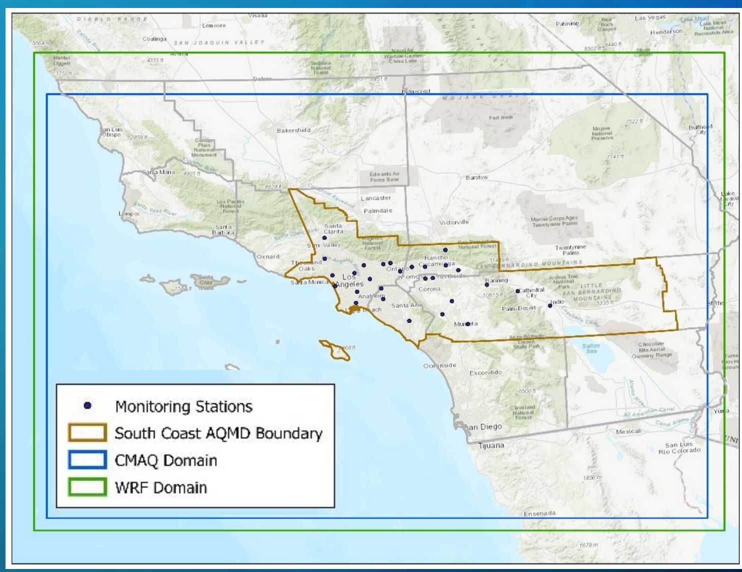
STMPR Meeting on August 3, 2023
South Coast Air Quality Management District

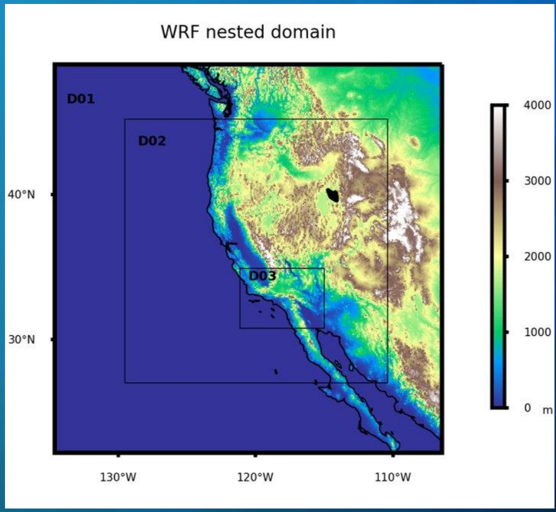
Air Quality Modeling Framework

- Base and Future attainment years are 2018 and 2030
- Modeling domain size and spatial resolution are the same as the 2022 AQMP modeling framework
- Updated to a newer version of models
  - WRF version 4.4.2 with Pleim-Xiu land-surface model
  - CMAQ version 5.3.3
- Biogenic emissions were adjusted to the updated meteorology with new WRF version



WRF Modeling: Setup and Physical/Met Schemes

- Weather Research and Forecast (WRF) v4.4.2
- North American Region Re-analysis (NARR) with The Group for High Resolution Sea Surface Temperature (GHRSST) updates
- Yonsei University (YSU) boundary layer and Pleim-Xiu Land Surface Model schemes
- Nested modeling with three domains:
  - ➢ 36km-12km-4km grid spacing
- Annual simulation from 1/1/2018 to 12/31/2018



WRF Modeling Performance Evaluation

2022 AQMP vs PM Plan Comparison:

1) Water Vapor Mixing Ratio and Temperature:

Cold (Jan 2018) vs hot (July 2018) months

Coast vs Inland Locations

2) Boundary Layer Height: Coast vs Inland Locations

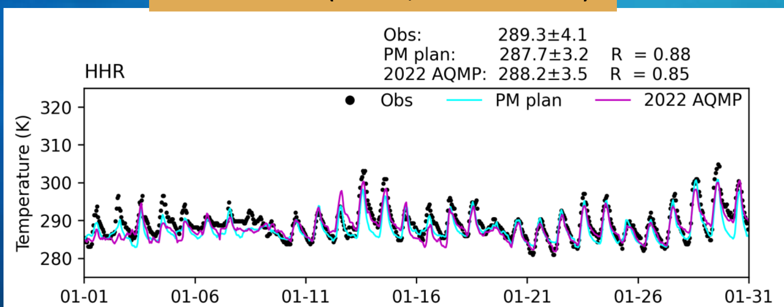
3) Wind Roses at Fullerton Municipal Airport (FUL) in 2018

WRF Modeling: Version Release History

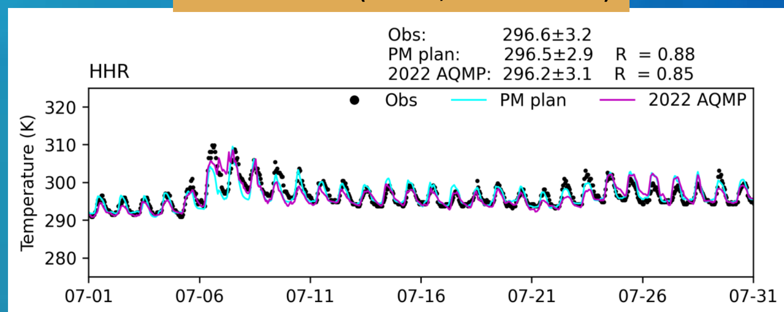
- WRF 4.5 release in 2023 April
- **WRF 4.4.2 release in 2022 December – to be used for this PM plan**
- WRF 4.0.3 release in 2018 December - AQMP
- Many updates/bug fix from WRF 4.0.3 to WRF 4.4.2 related to:
    land surface; temperature inversion layers; convection; buoyancy; cloud/rain; observation nudging; temperature; moisture; wind; boundary etc.

WRF Predicted Temperature at Coast vs Inland Locations During Cold vs Hot Months

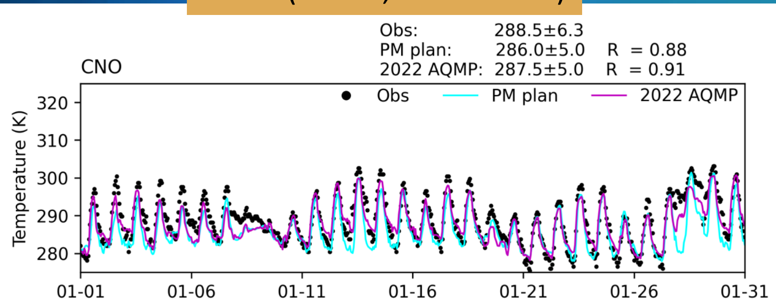
Hawthorne (coast, cold month)



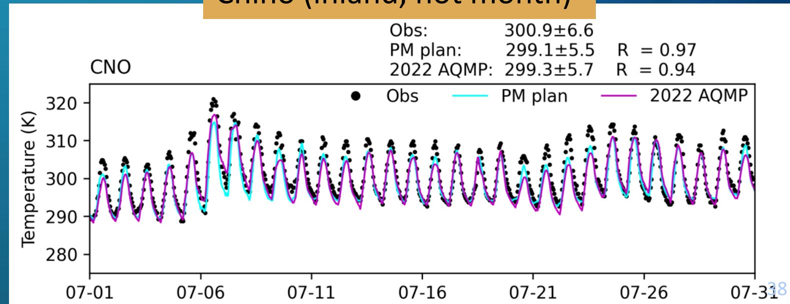
Hawthorne (coast, hot month)



Chino (inland, cold month)

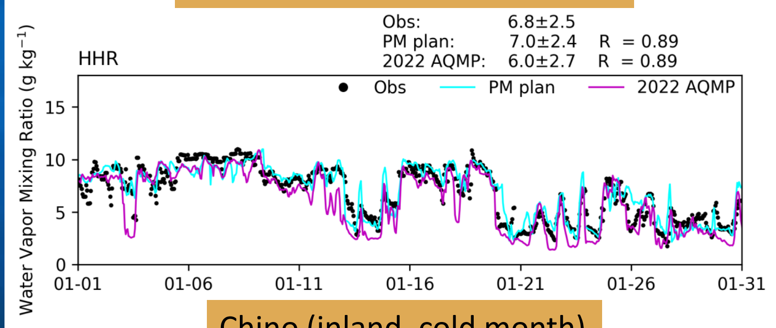


Chino (inland, hot month)

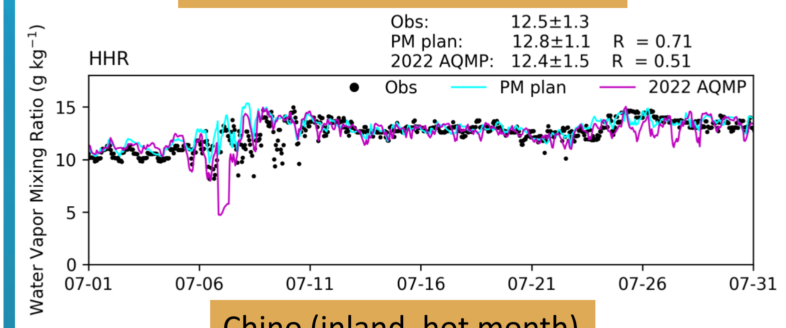


WRF Predicted Water Vapor Mixing Ratio at Coast vs Inland Locations During Cold vs Hot Months

Hawthorne (coast, cold month)



Hawthorne (coast, hot month)



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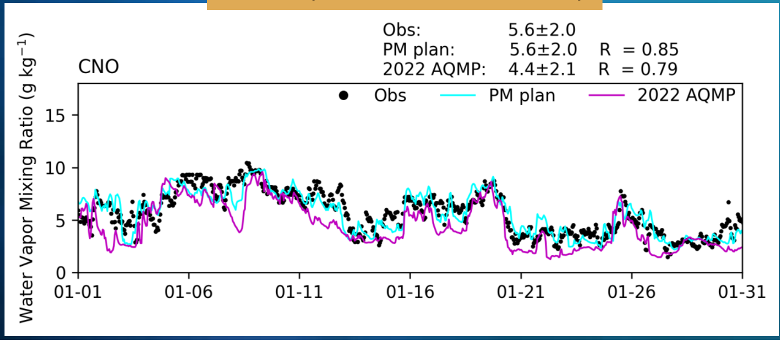

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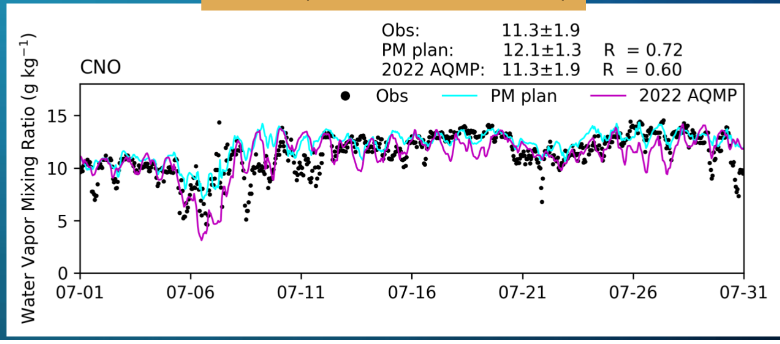
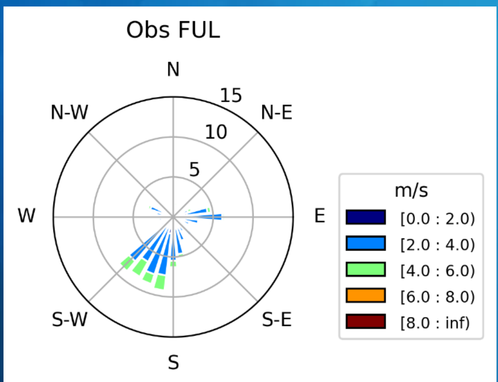
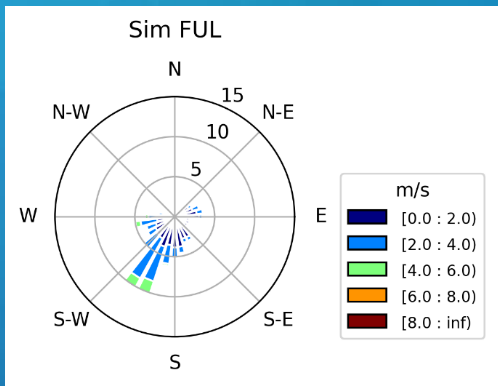


WRF Predicted vs Observed Wind Rose at Fullerton Municipal Airport

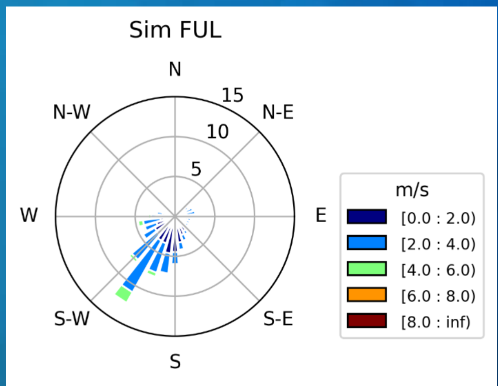
Observed



Simulations for this PM plan



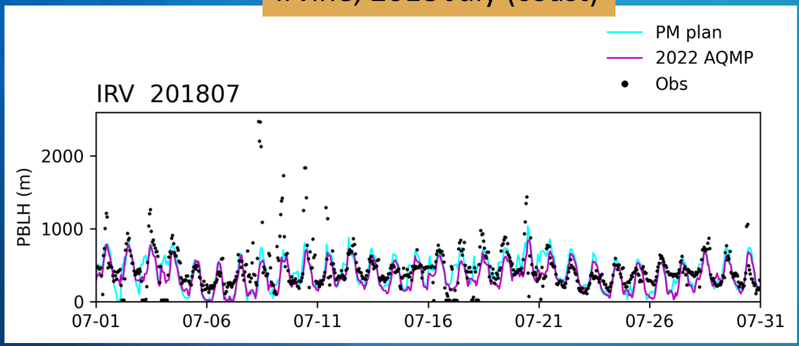
2022 AQMP



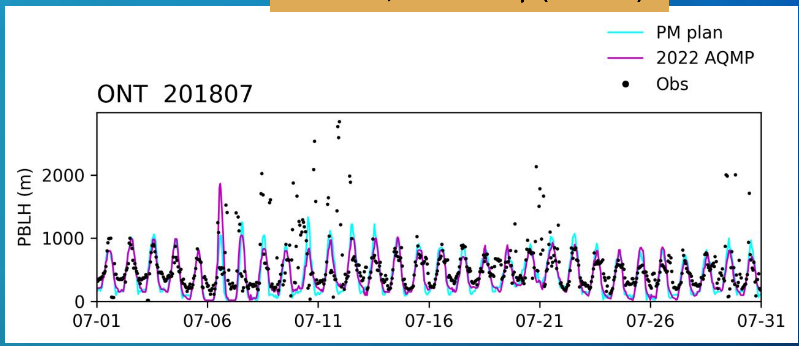
- Both simulations show good performance for wind directions; PM plan simulation improved wind speed predictions; upper range of wind speed is between 4-6 m/s consistent with observations

WRF Predicted vs Observed Boundary Layer Height

Irvine, 2018 July (coast)



Ontario, 2018 July (inland)



- Observations are retrievals from Ceilometers
- Both simulations captured diurnal variation of boundary layer height (PBLH), the PM plan simulation shows marginal improvement

WRF Predicted Temperature, Water Vapor Mixing Ratio and Wind Speed at 15 Stations

		Winter (Dec.,Jan.,Feb.)			Summer (Jun.,Jul.,Aug.)		
		Obs.	PM plan	2022 AQMP	Obs.	PM plan	2022 AQMP
T (K)	Mean (K)	287.7	286.7	288.0	297.2	296.9	297.4
	Bias (K)		-1	0.3		-0.3	0.2
	RMSE (K)		2.7	2.7		1.9	2.1
Q (kg/kg)	Mean (kg/kg)	5.5	5.8	4.6	10.7	11.7	10.9
	Bias (kg/kg)		0.4	-0.9		1.1	0.2
	RMSE (kg/kg)		1.6	1.9		2.5	2.4
WS (m/s)	Mean (m/s)	1.9	2	2.2	2.7	2.6	2.7
	Bias (m/s)		0.1	0.3		-0.2	2.5
	RMSE (m/s)		1.9	1.9		1.4	1.2

- WRF simulations for this PM plan showed similar performance as those in the 2022 AQMP
- PM plan shows improved predictions for water vapor mixing ratio and wind speed during winter

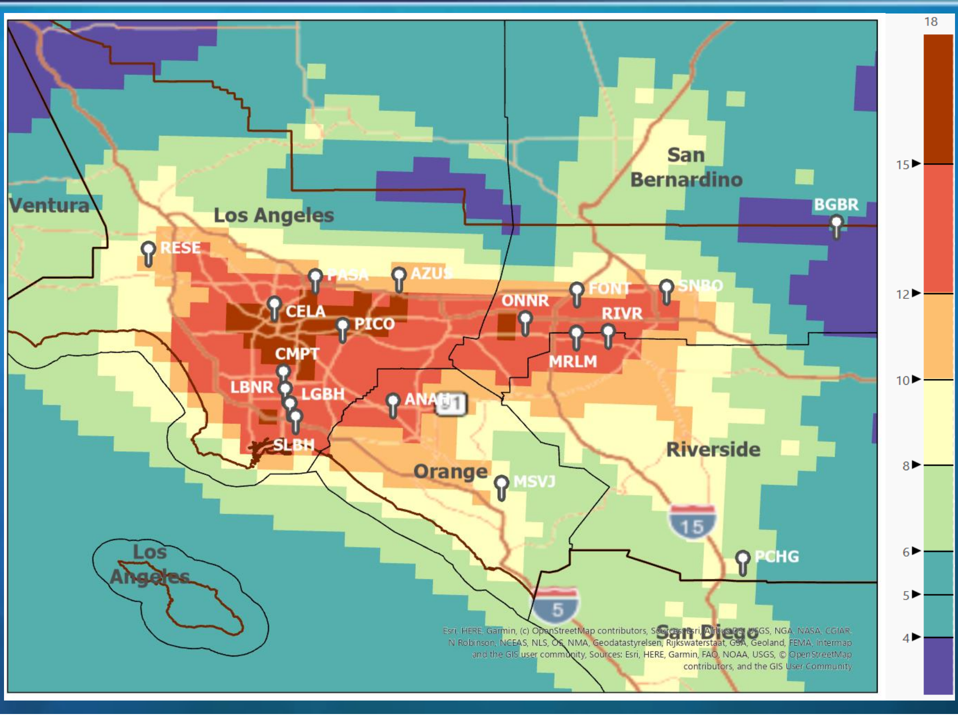
Emission Modeling: Tools and Setup

Gridded Stationary and Off-Road Emissions	• Sparse-Matrix Operational Kernel Emissions (SMOKE) v4.8 • CARB's latest 1km resolution Spatial Surrogates for emissions spatial allocation • CARB's CEDARIS temporal profiles
Gridded On-Road Emissions	• ESTA model for gridded on-road emission • Vehicle activity temporally adjusted using hourly California Department of Transportation Performance Measurement System (PeMS) sensor data
Gridded Ocean-going Vessels Emissions	• Temporal/spatial allocation of OGV emissions using Automated Identification System (AIS)
Gridded Aircraft Emissions	• Aviation Environmental Design Tool (AEDT); Aircraft Communication Addressing and Reporting System (ACARS) data for major airports aircraft emission • CARB's Gridded Aircraft Trajectory Emissions (GATE) for rest airports aircraft emission
Gridded Biogenic Emissions	• Model of Emissions of Gases and Aerosols from Nature version 3.0 (MEGAN3.0) with CARB's Leaf Area Index from 1km MODIS data

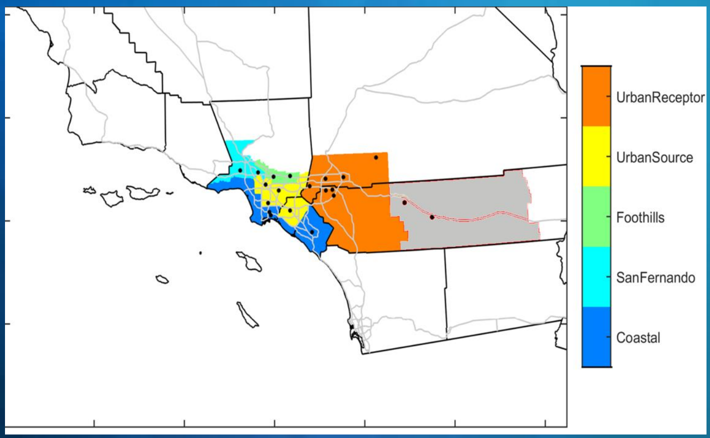
Community Multiscale Air Quality (CMAQ) Configuration

Version	CMAQ V5.3.3
Chemical Mechanism	SAPRC07 with version "c" toluene updates
Aerosol Mechanism	aero6
Point Source Emissions	Inline calculation of plume rise
Domain Setup	Two nested domains 12 km and 4 km, 30 vertical layers
Simulation Time Period	365 days annual simulation: Jan 1 – Dec 31, 2018
Boundary Condition	Nested modeling with 12km statewide CMAQ The Outer CMAQ domain used boundaries from the global model of Community Atmosphere Model with Chemistry (CAM-chem)

Simulated 2018 Annual Average PM2.5 Concentrations

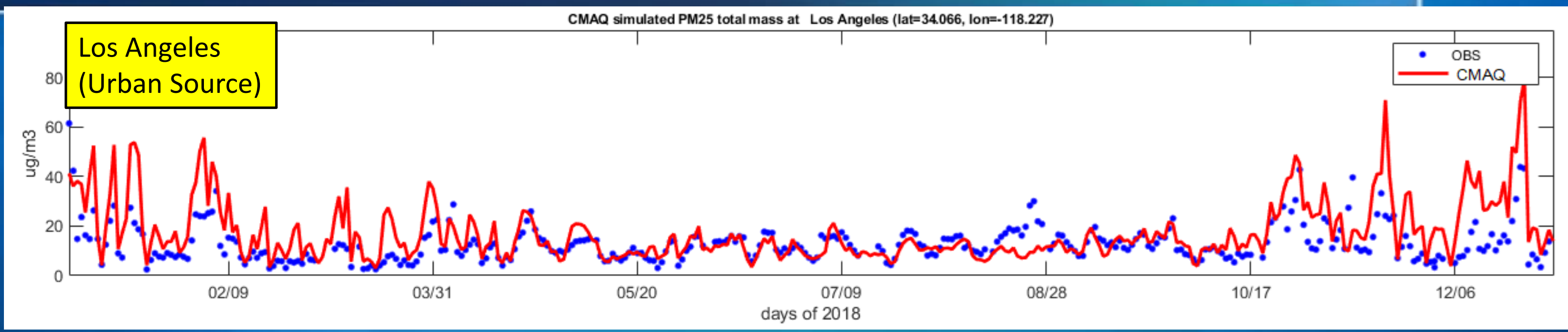


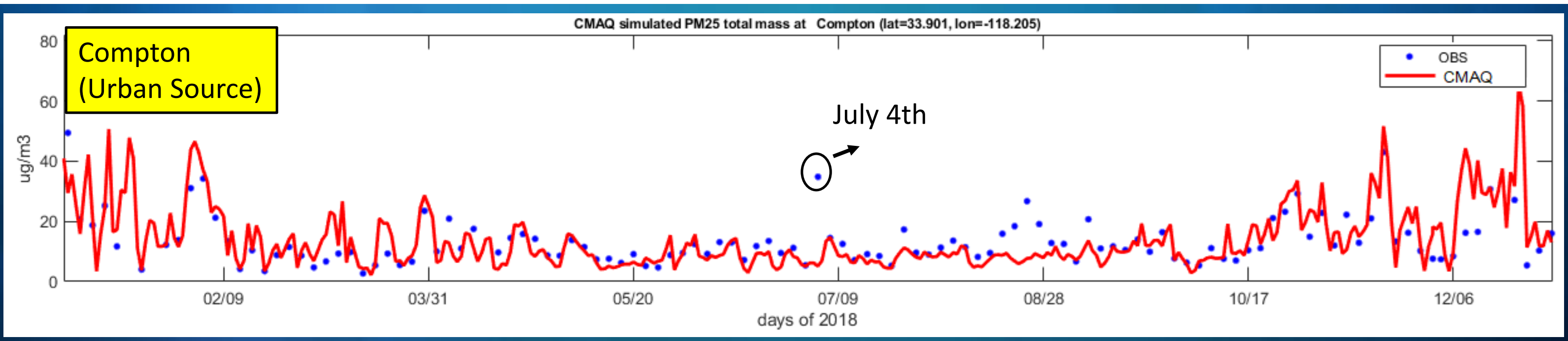
Model Performance Evaluation Zones



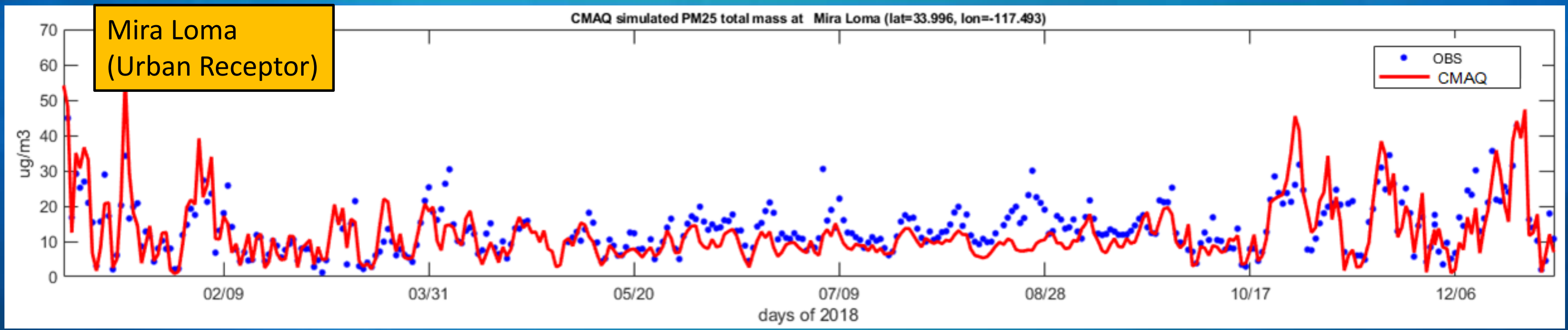
Station Location	Station Abbreviation	Performance Evaluation Zone
Long Beach	LGBH	Coastal
Mission Viejo	MSVJ	Coastal
South Long Beach	SLBH	Coastal
Azusa	AZUS	Foothills
Pasadena	PASA	Foothills
Burbank	BURK	San Fernando
Reseda	RESE	San Fernando
Fontana	FONT	Urban Receptor
Mira Loma	MRLM	Urban Receptor
Ontario Near Road	ONNR	Urban Receptor
Riverside	RIVR	Urban Receptor
San Bernardino	SNBO	Urban Receptor
Anaheim	ANAH	Urban Source
Compton	CMPT	Urban Source
Los Angeles	CELA	Urban Source
Pico Rivera	PICO	Urban Source

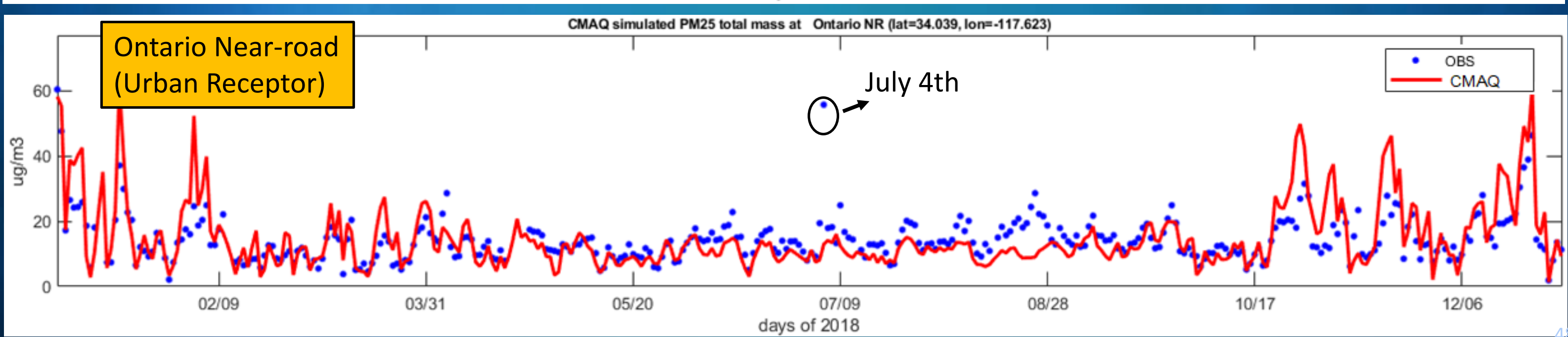
Simulated Daily PM2.5 Concentrations





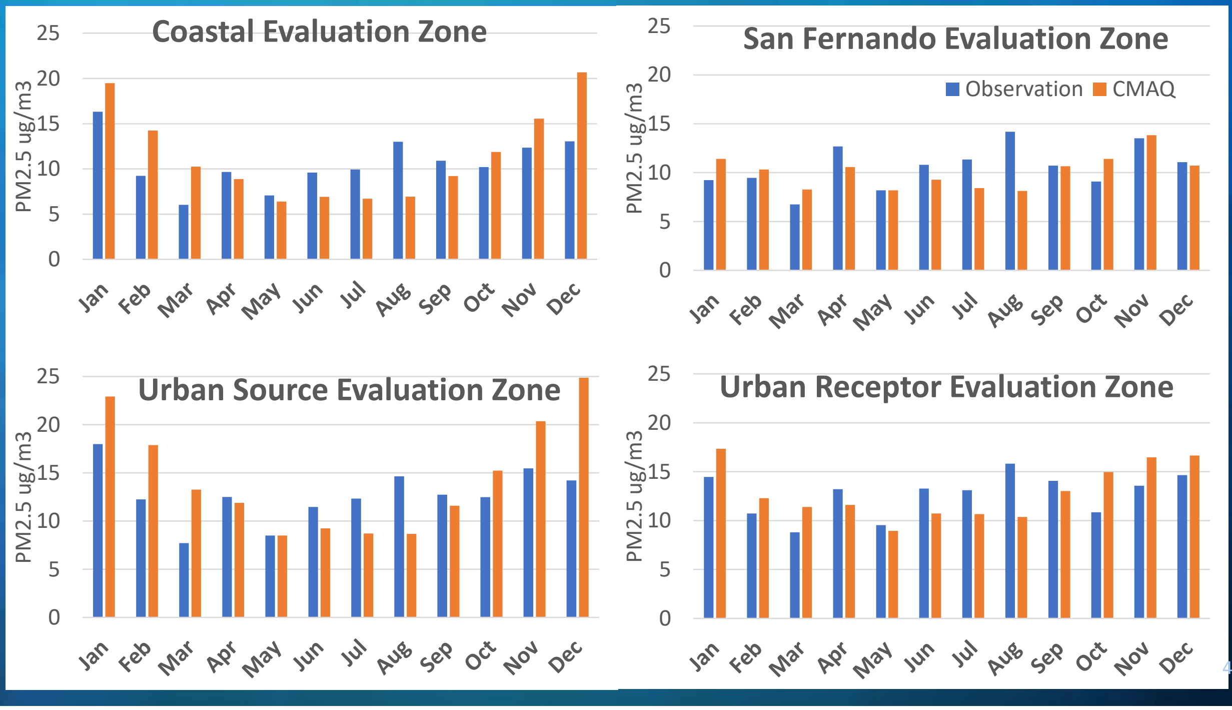
Simulated Daily PM2.5 Concentrations





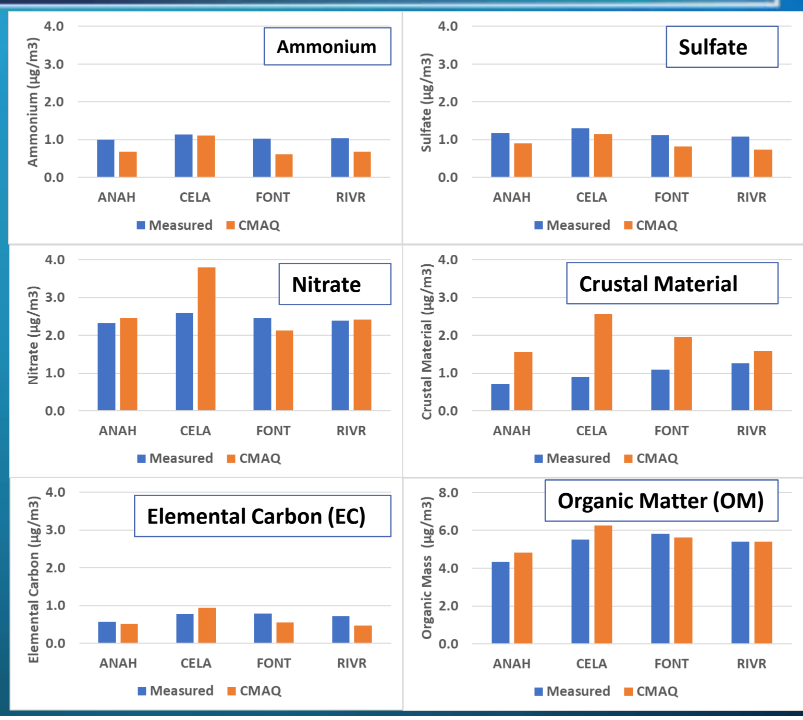
Model Performance for PM2.5 Seasonality in 2018

- CMAQ captures the PM2.5 mass seasonality reasonably well
- CMAQ tends to underestimate during summer season and overestimate during winter season



Model Performance for PM Species in 2018

- Measurements are not SANDWICH*-adjusted; OC and Crustal Material are calculated**
- Model predicts EC, sulfate, nitrate, OM, and ammonium ion reasonably well with negative bias in inland stations

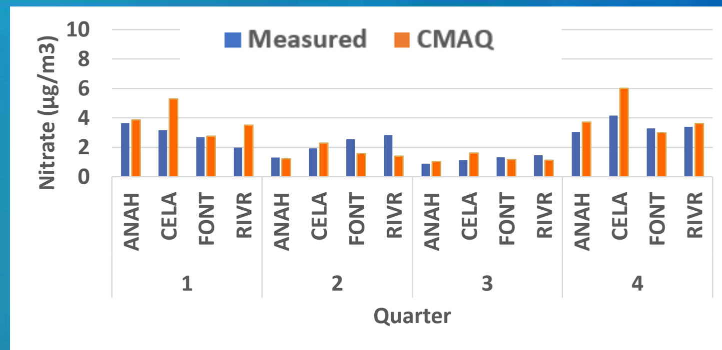


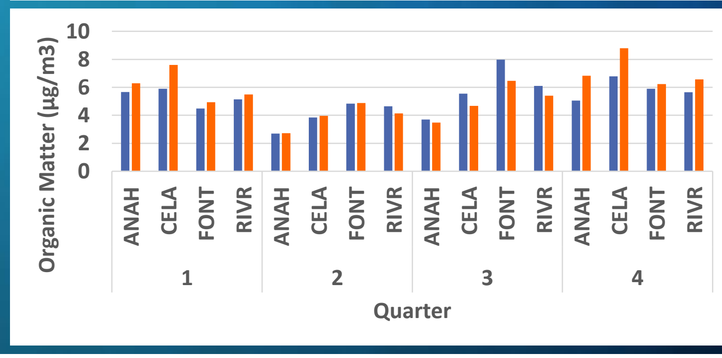
** Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous material balance approacH (SANDWICH). Frank, 2006. J. Air Waste Manage. Assoc., 56, 500-511*

*** Organic Matter = 1.4 × Organic Carbon*
Crustal Material = 2.2 × Aluminum + 2.49 × Silicon + 1.63 × Calcium + 2.42 × Iron + 1.94 × Titanium

Seasonal Variation of Nitrate and Organic Matter in 2018

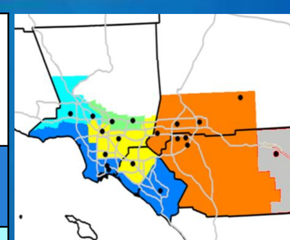
- Model captured the seasonality of OM and nitrate levels well; higher nitrate and OM during cold months and lower levels in warm months
  - In fall and winter, cool temperatures, high humidity and frequent nocturnal inversions favors the formation of ammonium nitrate
  - In summertime higher vaporization
- Model generally captured the spatial distribution; urban areas (Anaheim and Central LA) have higher levels of nitrate and OM than inland stations





Model Performance for daily PM2.5 for 2018

	Observation (ug/m3)	Simulation (ug/m3)	Correlation R2	Normalized Mean Bias (%)	Normalized Mean Error (%)
Coastal	10.5	11.4	0.66	7.8	43.0
San Fernando	10.5	10.1	0.53	-3.5	33.1
Foothills	10.6	15.1	0.49	38.5	56.8
Urban Source	12.7	14.4	0.68	12.4	41.4
Urban Receptor	12.7	12.9	0.68	0.6	33.8



- CMAQ underestimates PM2.5 mass in San Fernando region and overestimates in Foothills and Urban Source region
- The Urban Receptor region including the Basin's design site has the best model performance

Summary and Conclusion

- State-of-the-art SIP modeling platform is used to demonstrate attainment of 2012 annual PM2.5 standard
- Thorough evaluations of modeling performance for meteorology and PM2.5 concentrations were conducted
  - WRF captures synoptic patterns as well as key meteorological factors such as surface temperature, relative humidity and PBL height generally well
  - Real-world sensor data are incorporated into the on-road mobile, OGV and aircraft emission processing to better spatially and temporally allocate emission in modeling grids
  - CMAQ predicts daily PM2.5 mass and seasonal variation of PM species reasonably well with overestimation in winter months and underestimation in summer months
  - CMAQ performed better in “Urban Receptor” area where elevated PM2.5 levels occur in the Basin

Item 5 Prediction of Future PM2.5 Levels

Sang-Mi Lee, Ph.D.

Planning and Rules Manager

STMPR Meeting on August 3, 2023

South Coast Air Quality Management District

Future Design Value Calculation Methodology

1) Total PM2.5 FRM Mass:
Collect total PM from FRM data and calculate 5-year weighted quarterly data

2) Determine speciation:
1. **Collect speciation data for NO3, NH4, SO4, others**
2. **Calculate base year Particle Bound Water (PBW) based on measured NO3, NH4, SO4**
3. **Calculate OC based on the SANDWICH method**
4. **Normalize components to determine species fractions**

3) Apply species fractions from (2) to PM values in (1)

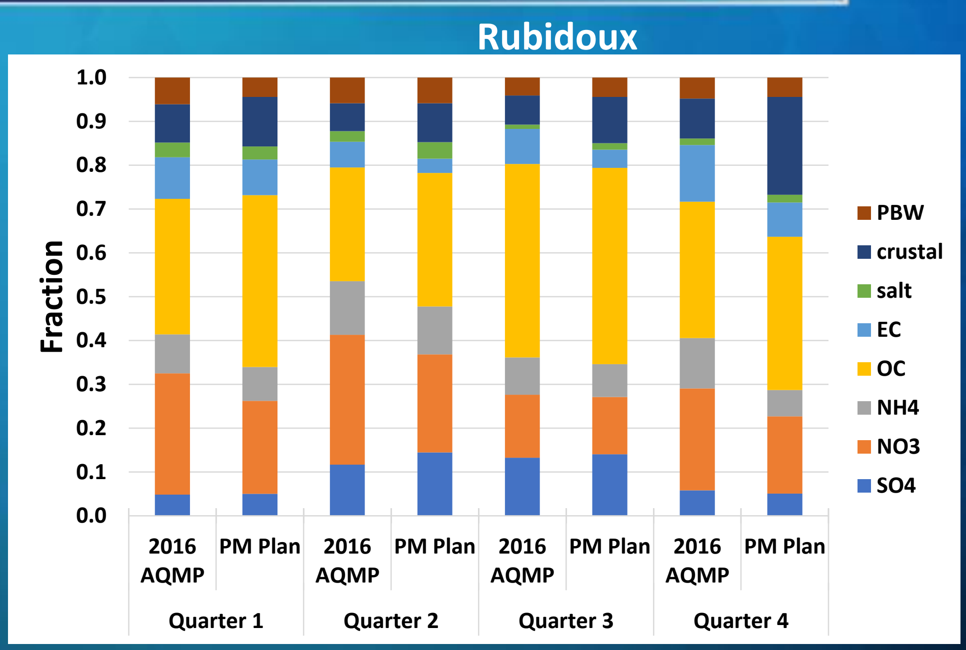
4) Apply RRF to all species based on modeling to calculate future concentrations

5) Recalculate PBW with future NO3, NH4, SO4

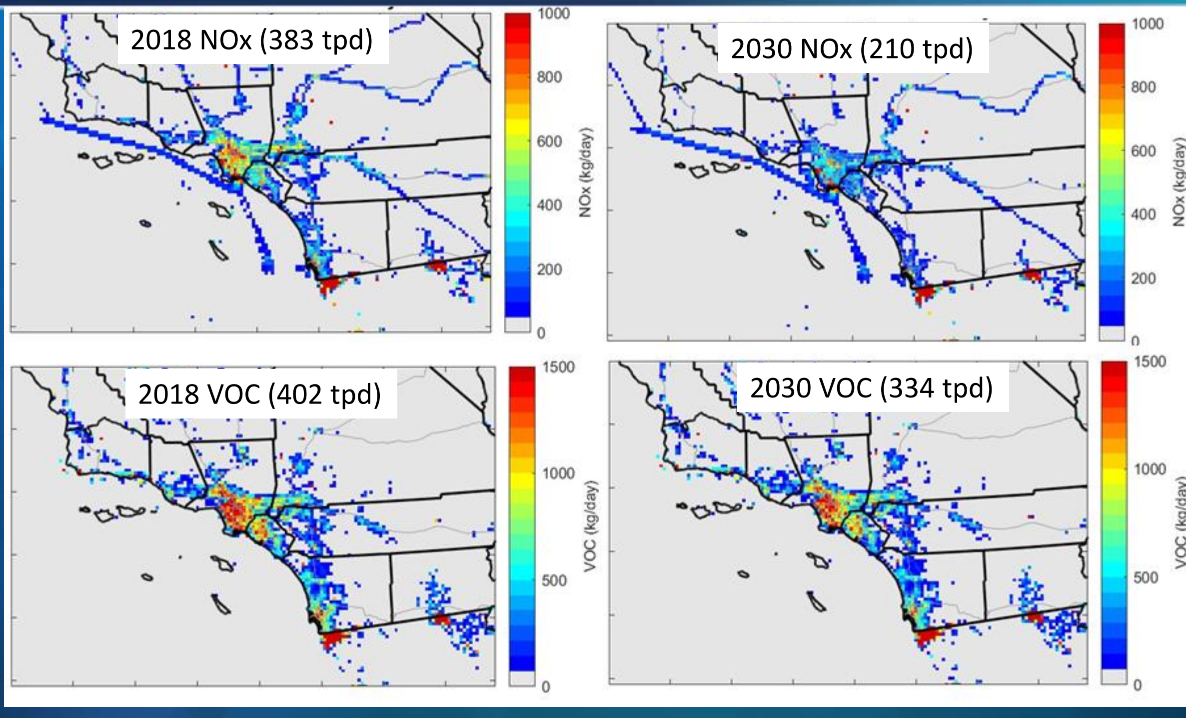
6) Add all individual species to determine total future PM

SANDWICH Adjusted Speciation Data

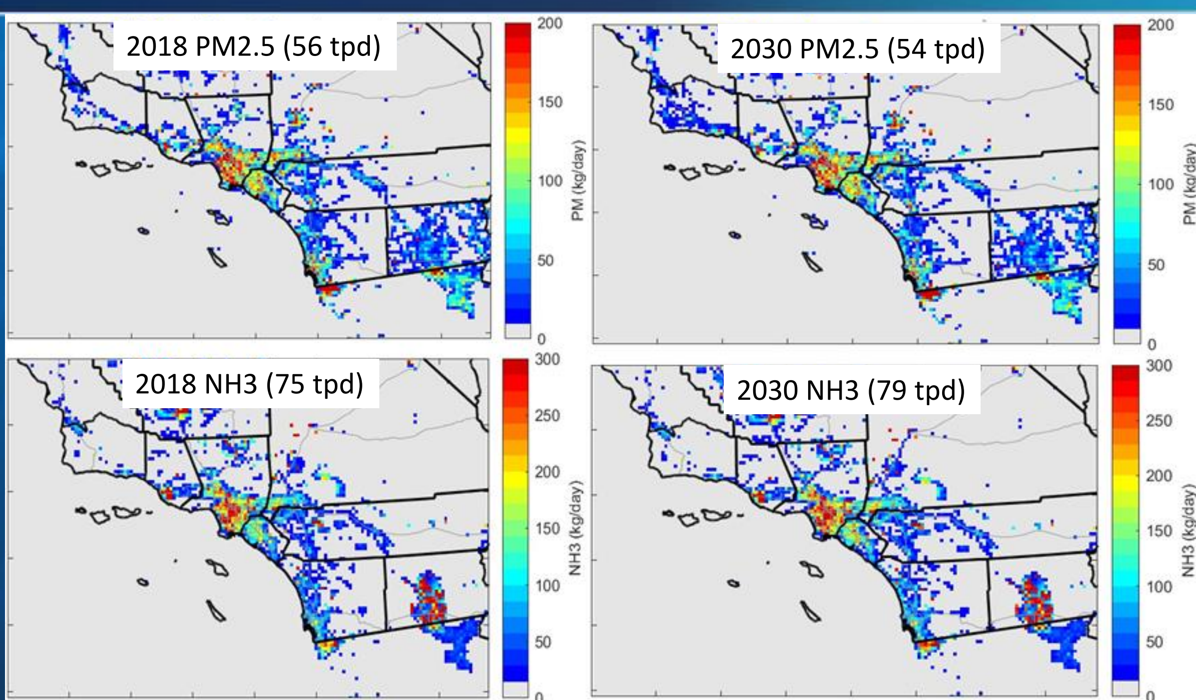
- Speciation data from 2017-2019 were used for this plan
- In general, the fraction of ammonium (NH4) and nitrate (NO3) decreased with respect to 2016 AQMP
  - Lower NO3 fraction makes DV less responsive to NOx reductions



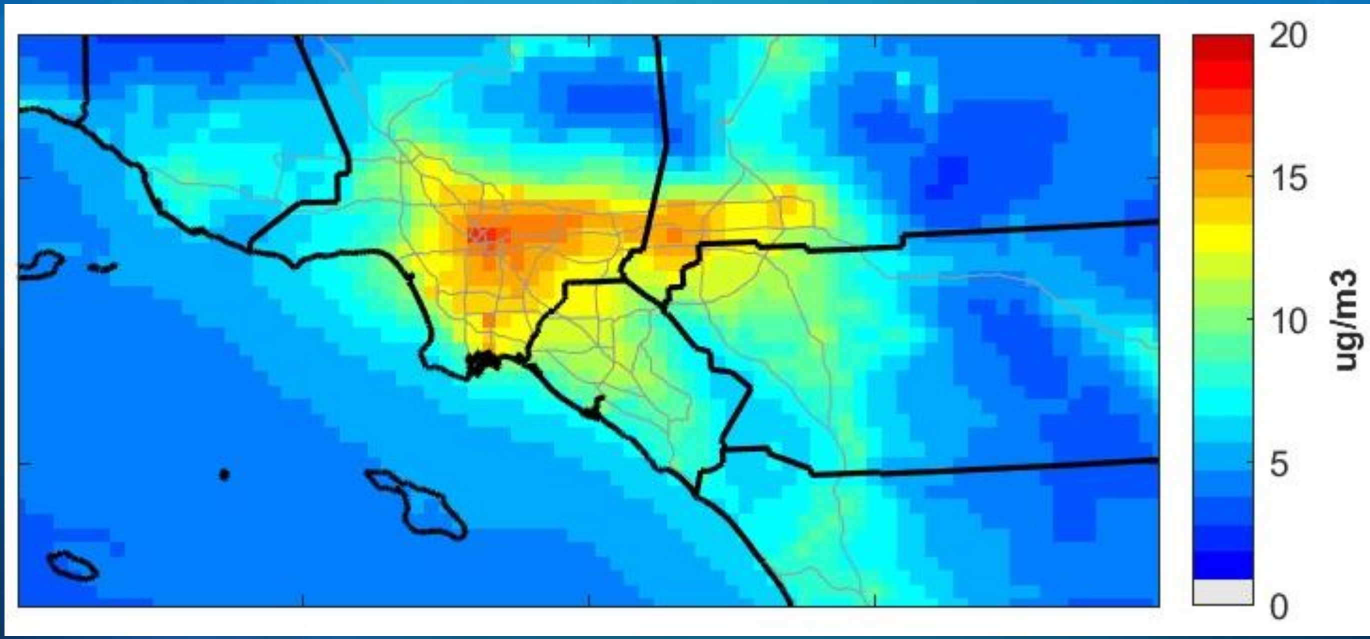
NOx and VOC Emissions in 2018 vs 2030



PM2.5 and NH3 Emissions in 2018 vs 2030

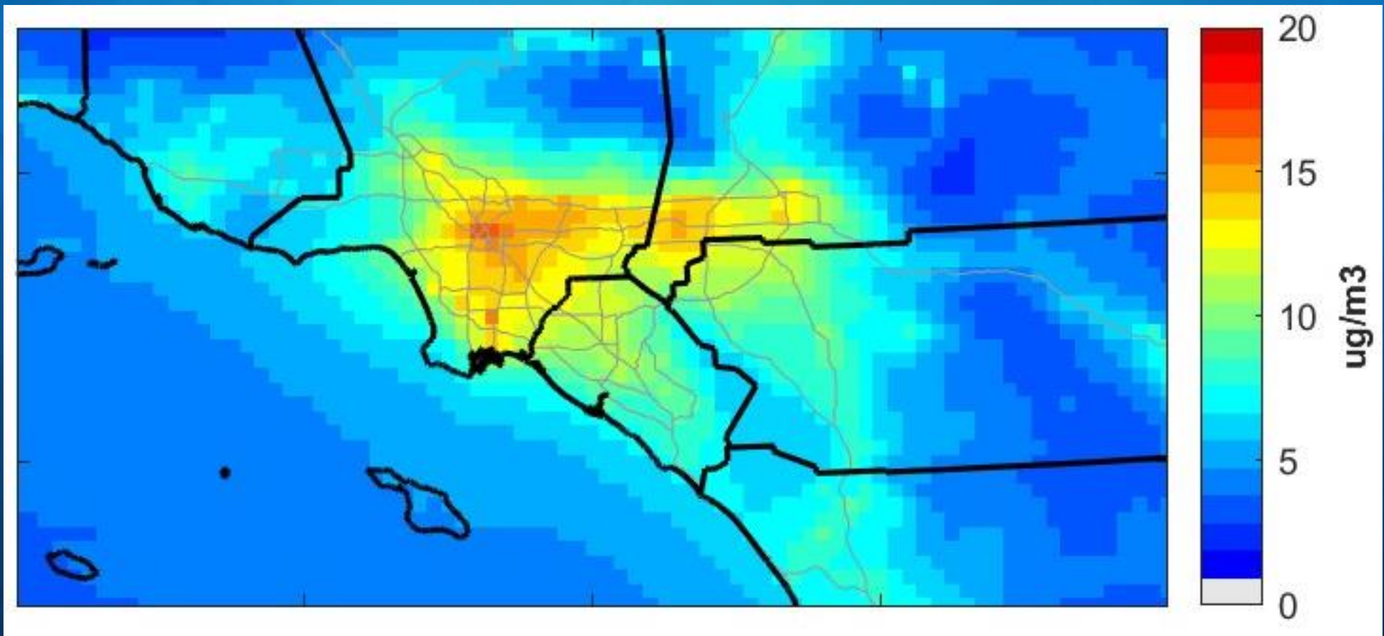


CMAQ Predicted PM2.5 Levels for 2018



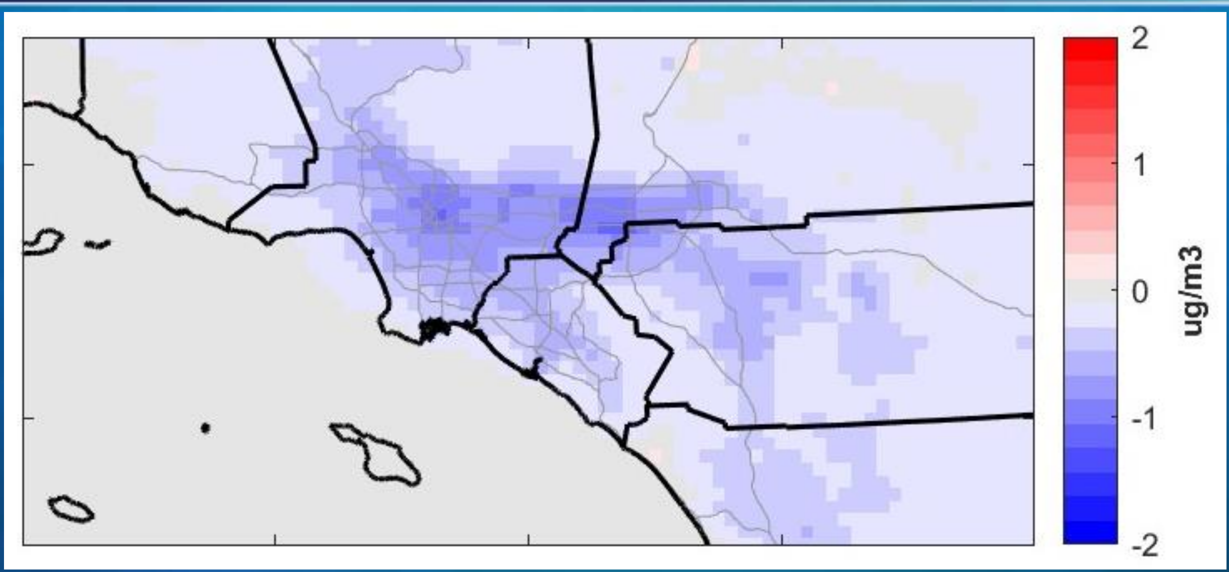
(Not RRF adjusted)

CMAQ Predicted PM2.5 Levels for 2030 Baseline



(Not RRF adjusted)

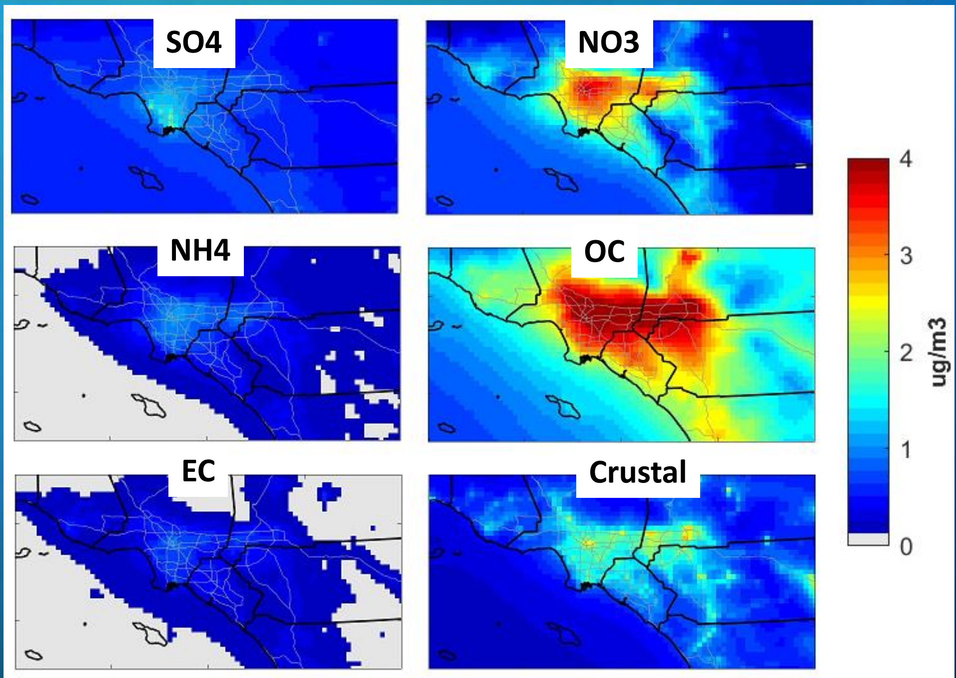
Changes in PM2.5 Levels



- CMAQ simulated overall decrease in PM2.5 throughout the Basin

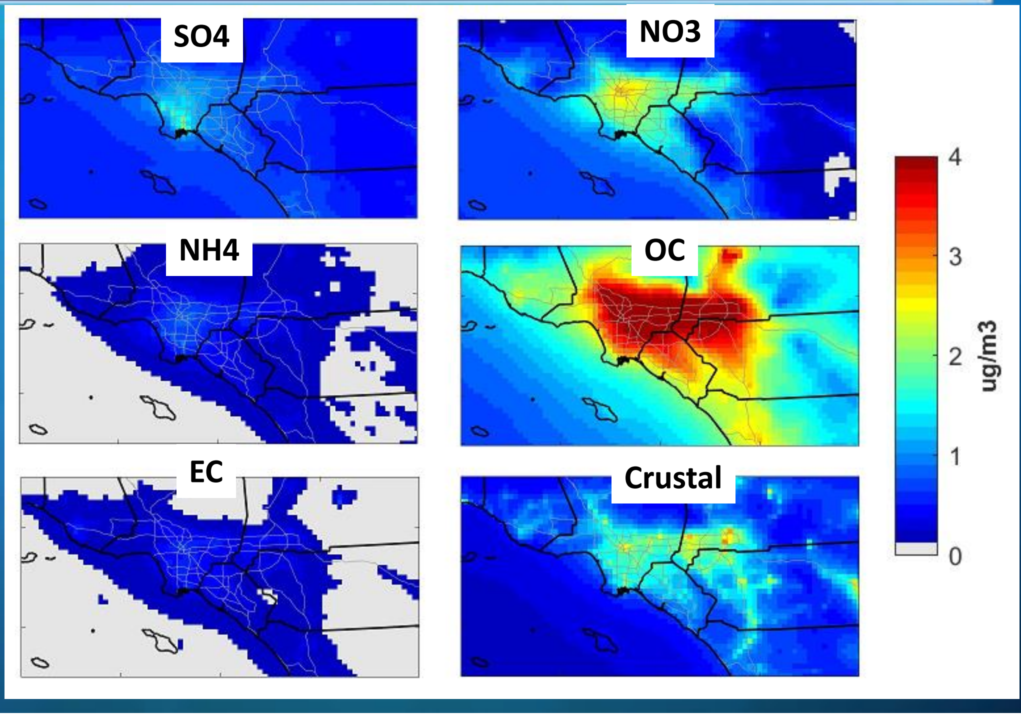
Predicted PM2.5 Chemical Species for 2018

- PM2.5 chemical species follow the spatial pattern of its precursor emissions
- Nitrate and organic carbon are the dominant components of PM2.5 mass



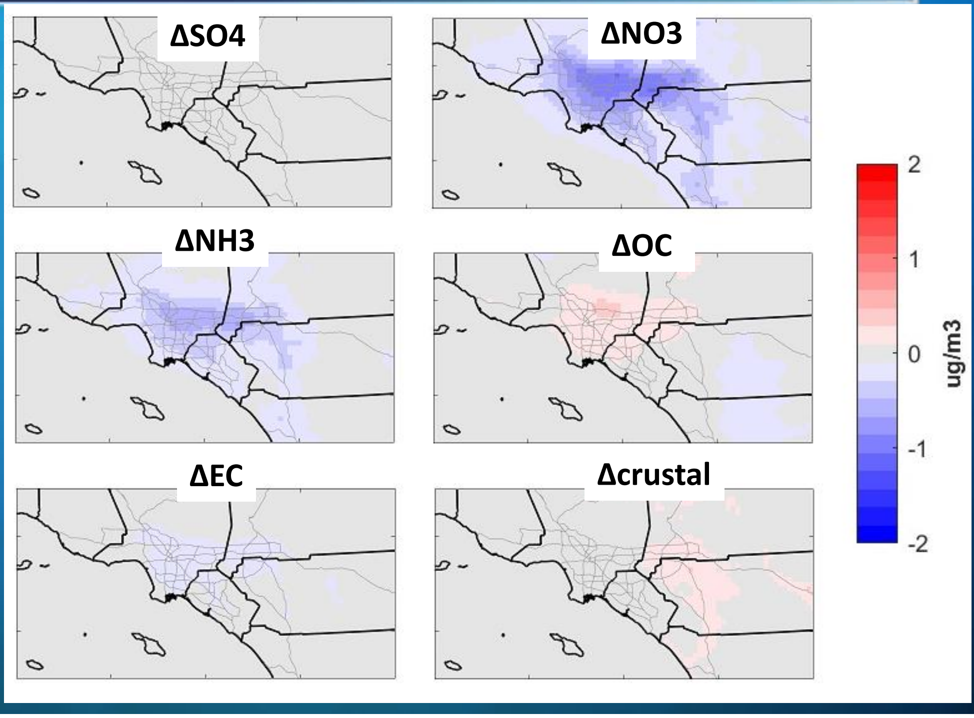
Predicted PM2.5 Chemical Species for 2030 Baseline

- Marginal reductions in most species throughout the Basin, while NO3 and OC remained as dominant species

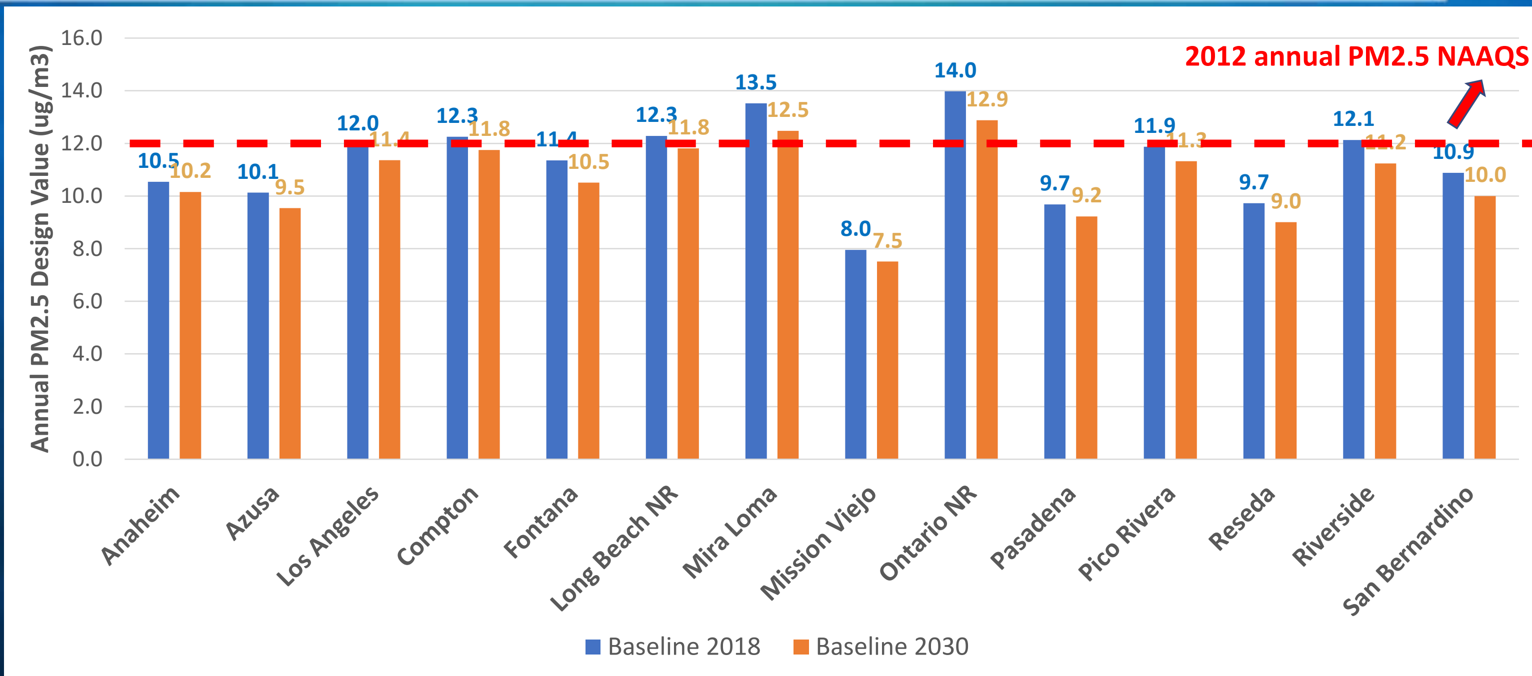


Changes between 2018 and 2030 baseline

- PM2.5 nitrate and EC concentration decrease following the emissions trend
- Decrease of total PM2.5 mass is driven by nitrate decrease
- PM2.5 OC and crustal components increase in future year

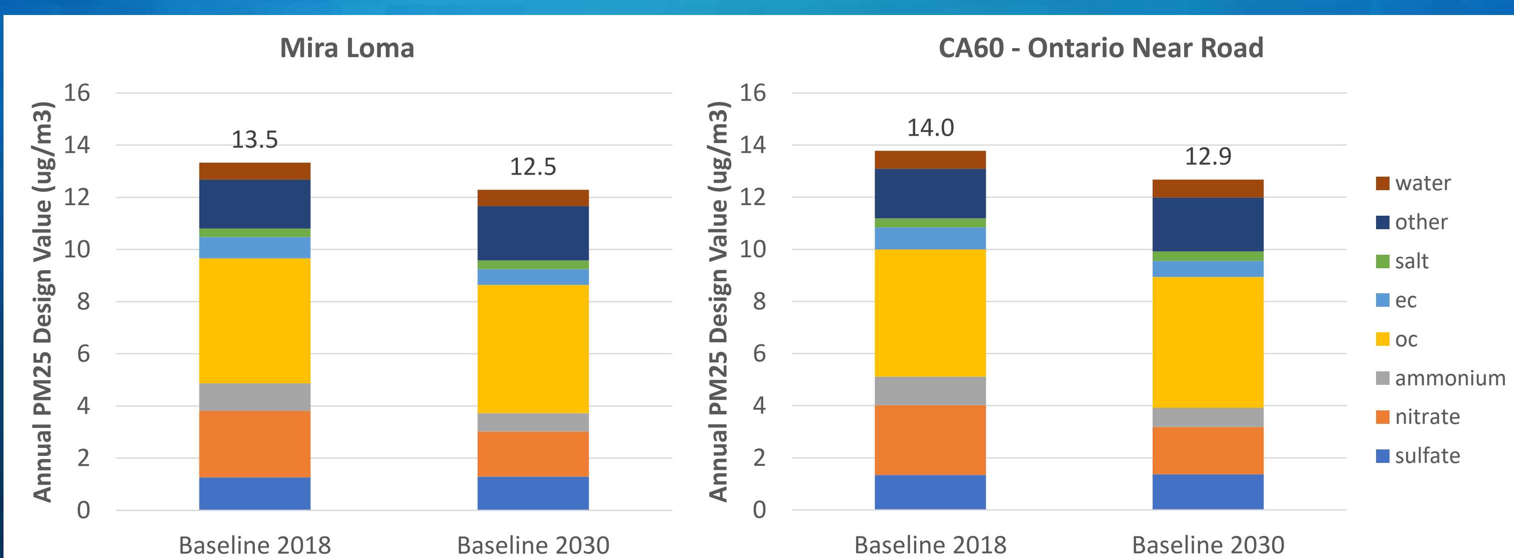


Projected RRF-Calculated PM2.5 DV for 2030 Baseline



(RRF – Relative Response Factor)

Projected Future Annual PM2.5 Design Values



Summary

- U.S. EPA guidance method was used to calculate PM2.5 chemical species and future PM2.5 design values
- CMAQ simulations were performed for base (2018) and future attainment target (2030) year
- Preliminary modeling of 2030 baseline emissions (business as usual condition) yielded 12.9 ug/m3 at CA60 and 12.5 ug/m3 at Mira Loma, indicating further emission reductions are needed for attainment
- 2030 simulation captures the decreases in NOx emissions well