NMED CAMx 2022v2 12/4 km

Development of 2032 Emissions and 2022 and 2032 Ozone Source Apportionment Modeling

June 30, 2026

RAMBOLL

Bright ideas.
Sustainable change.

Content

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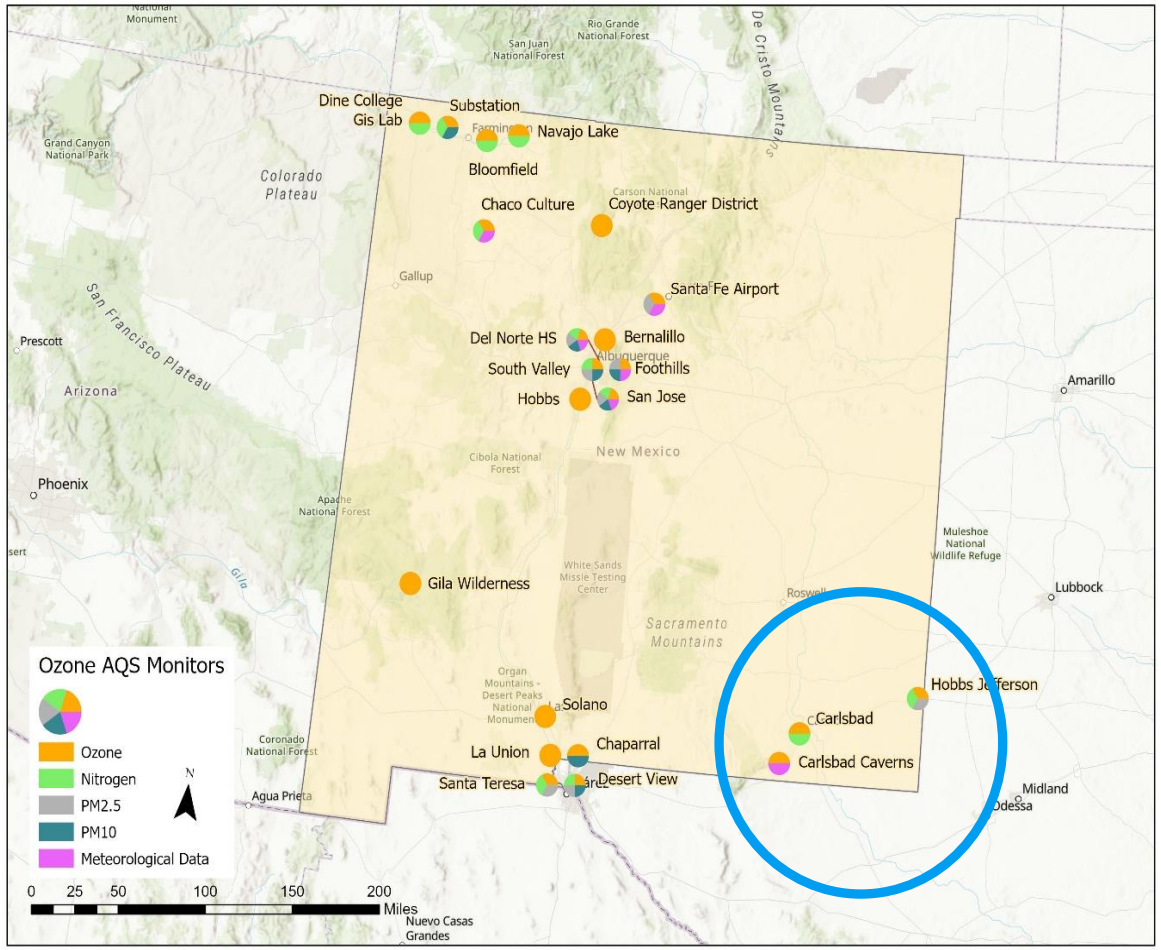
- 2032 State Specific Ozone Source Apportionment Modeling
- Potential Next Steps FY2027

Highlights of CAMx 2022v2 12/4 km Base Case Model Evaluation

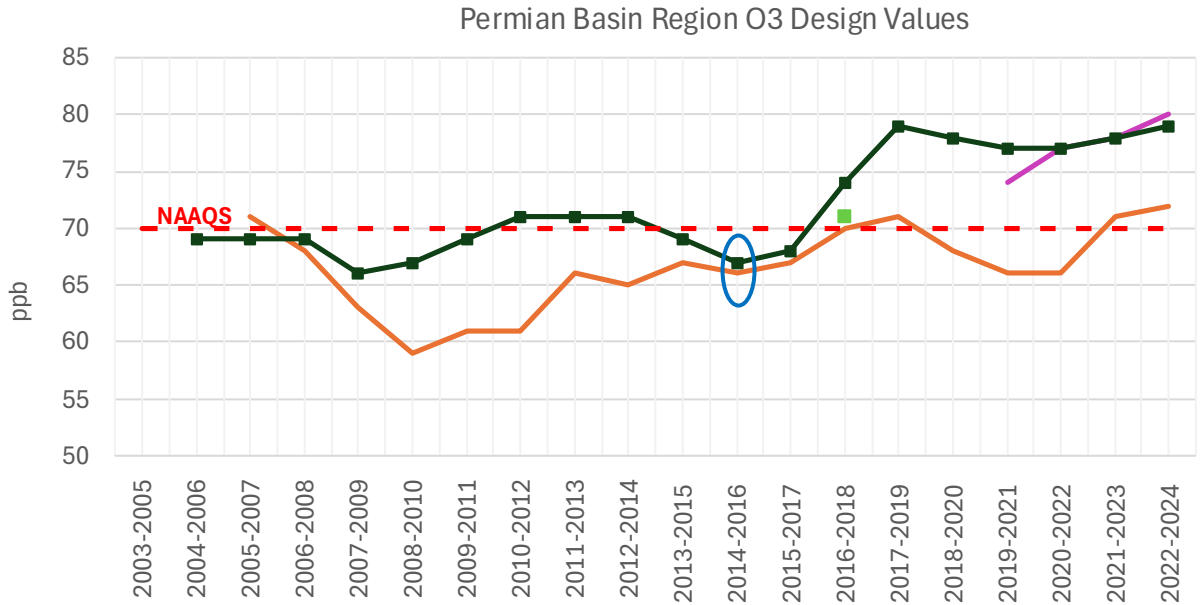
Phase I (2022v1 4 km Flexinest) vs. Phase II (2022v2 4 km)

Phase II: May – September 2022 (5 months)

Focus MPE on Ozone, NOx and VOC in NM Permian Basin



Site ID	County	Location
350150010	Eddy	Carlsbad Caverns
350151005	Eddy	Carlsbad (City)
350250008	Lea	Hobbs Jefferson



Hobbs Jefferson

Carlsbad Caverns NP site Active

Carlsbad Caverns NP site

Carlsbad City

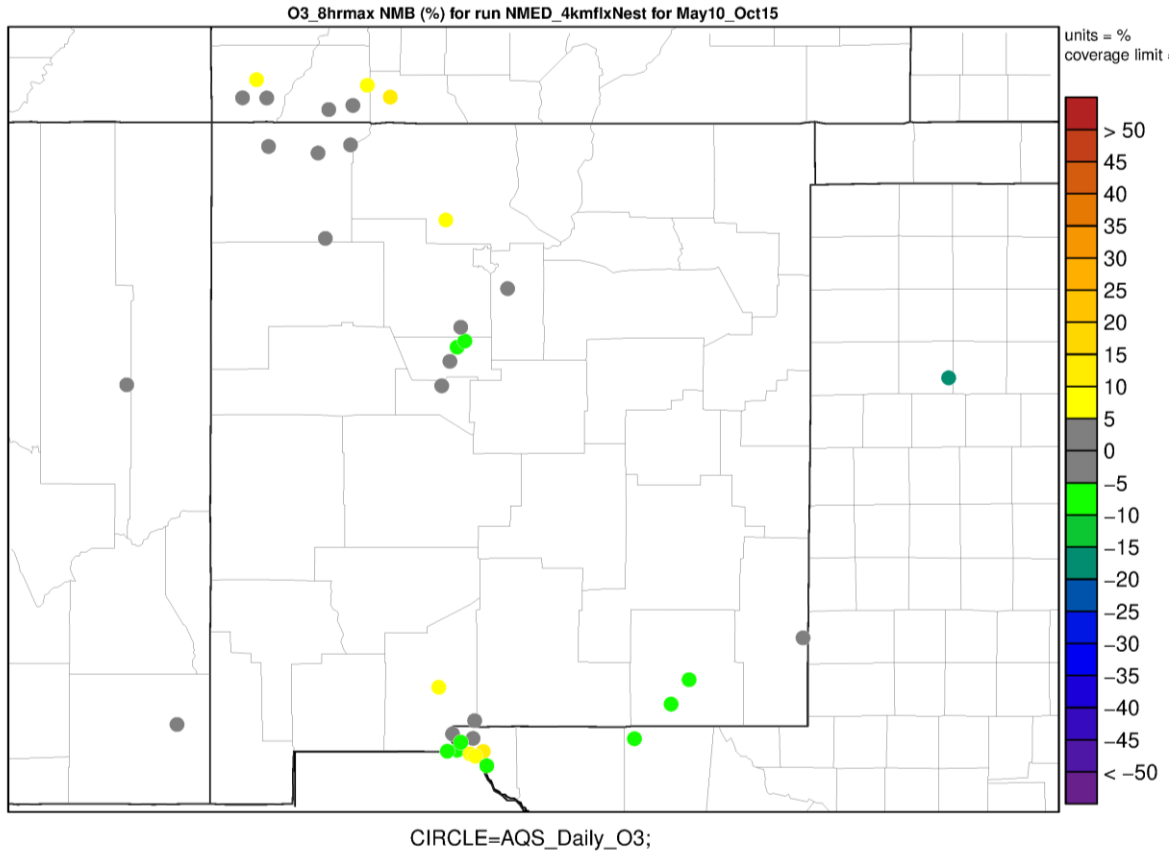
- Ozone nonattainment area designations based on 2014-2026 Design Values that were below 70 ppb 2015 ozone NAAQS
- Since 2018, ozone Design Values in Permian Basin have been exceeding the 2015 NAAQS

MDA8 O3 Normalized Mean Bias (NMB)

Goal: NMB≤±5%
Criterion: NMB≤±15%

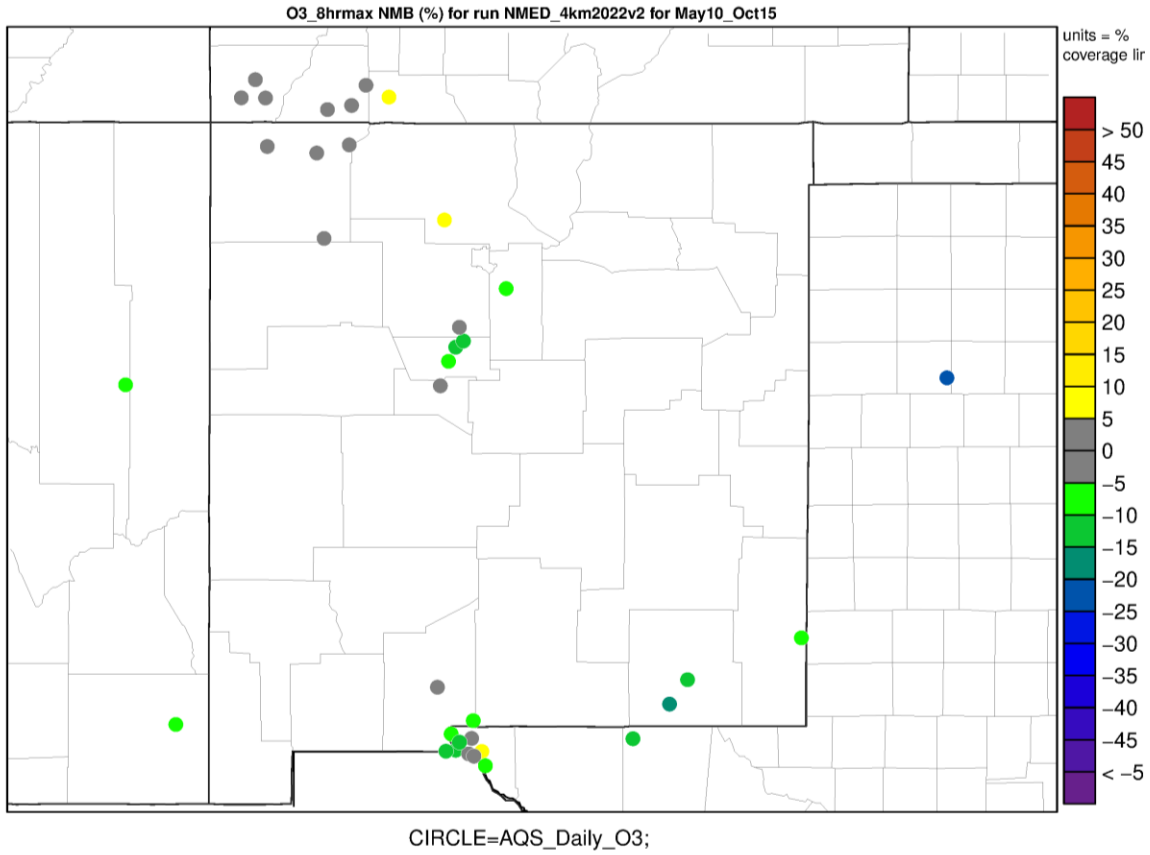
Phase I 4kmflexinest 2022v1
4 km Met / 12 km Emissions

4kmflxnest: 12km Interpolated to 4 km (flexinest)



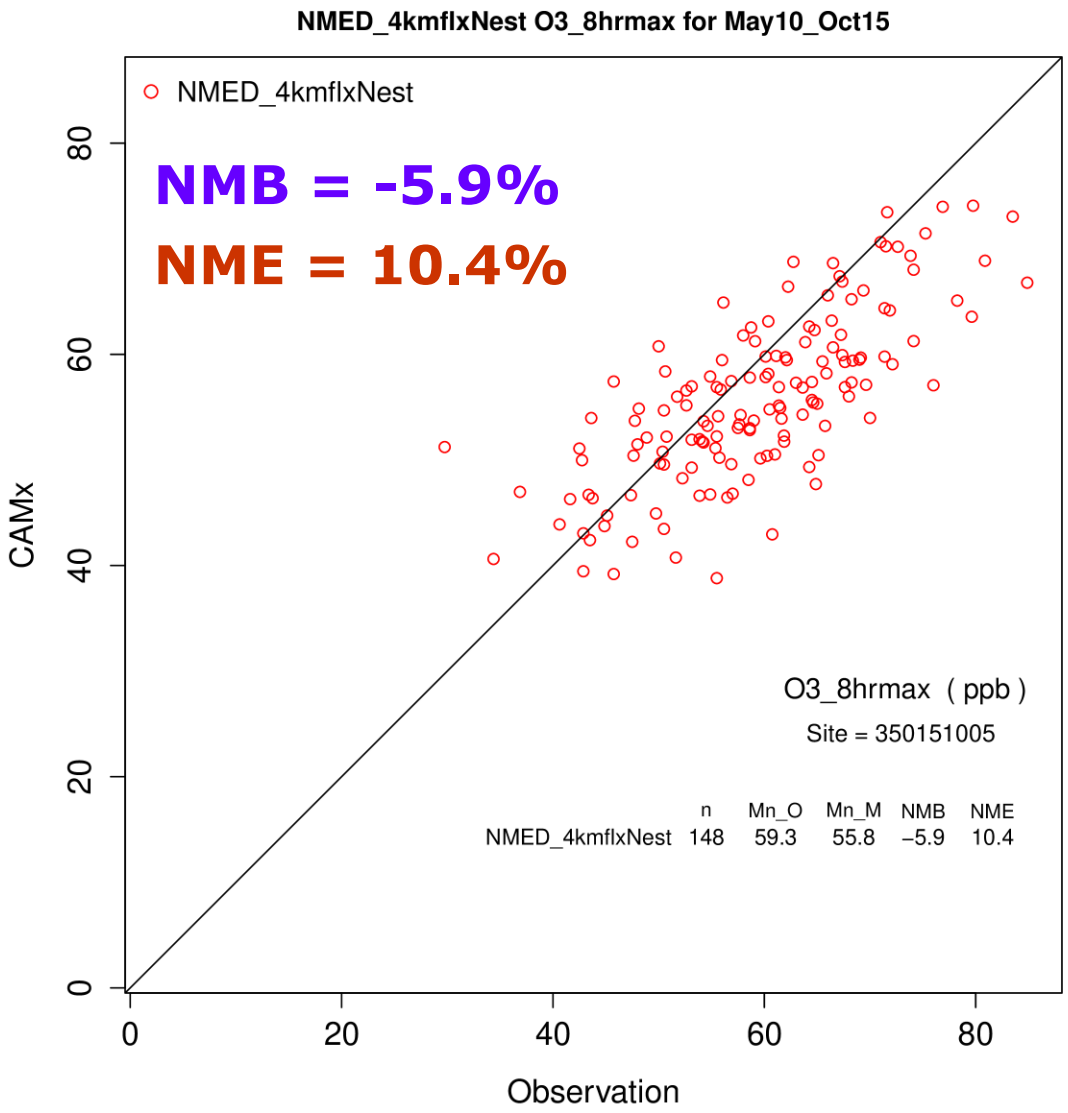
Phase II 4km2022v2
4 km Met & Emissions

4km2022v2: Native 4 km

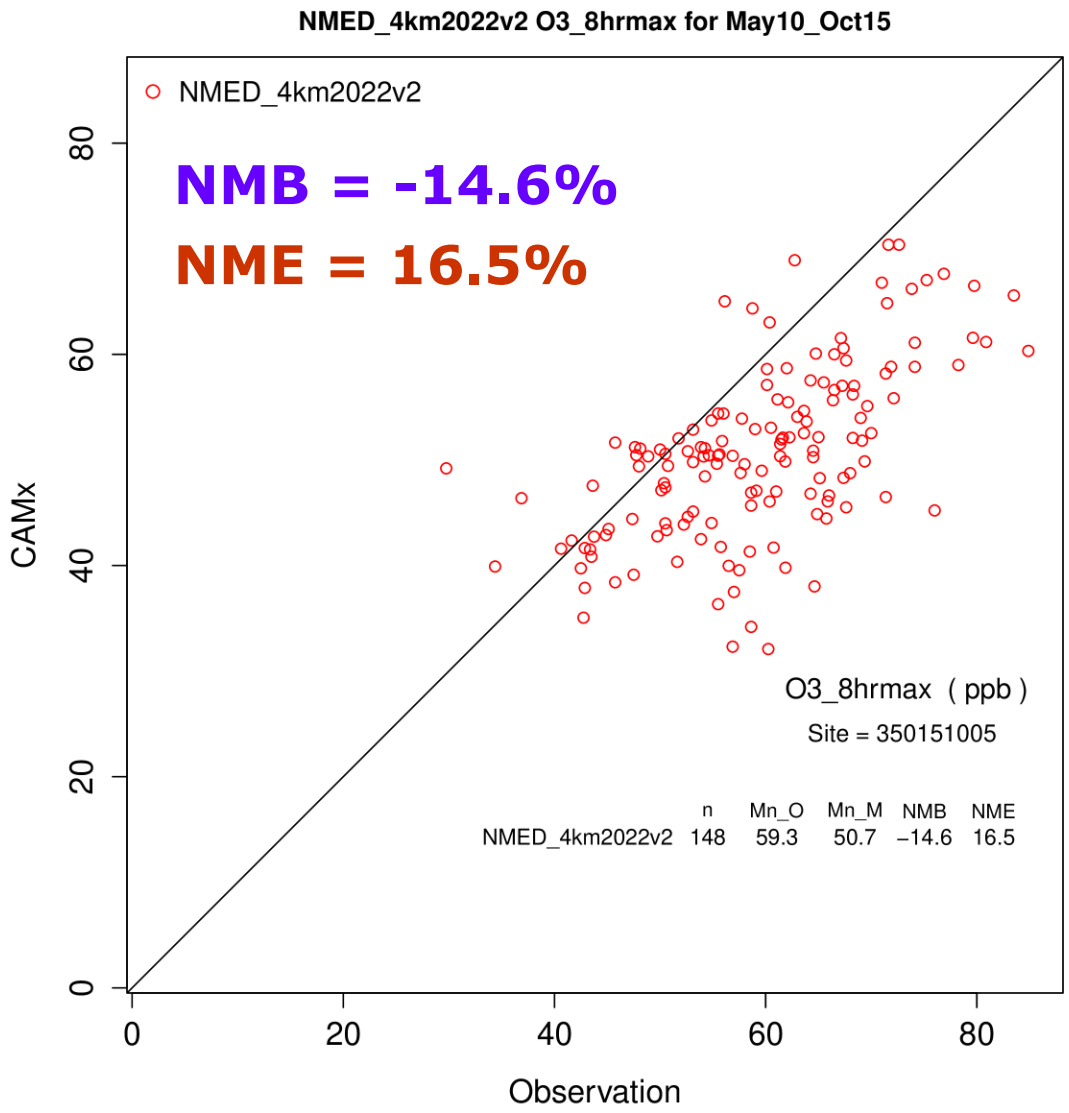


MDA8 O3 NMB May-Oct 2022: Carlsbad City

Phase I: 4kmflxnest2022v1

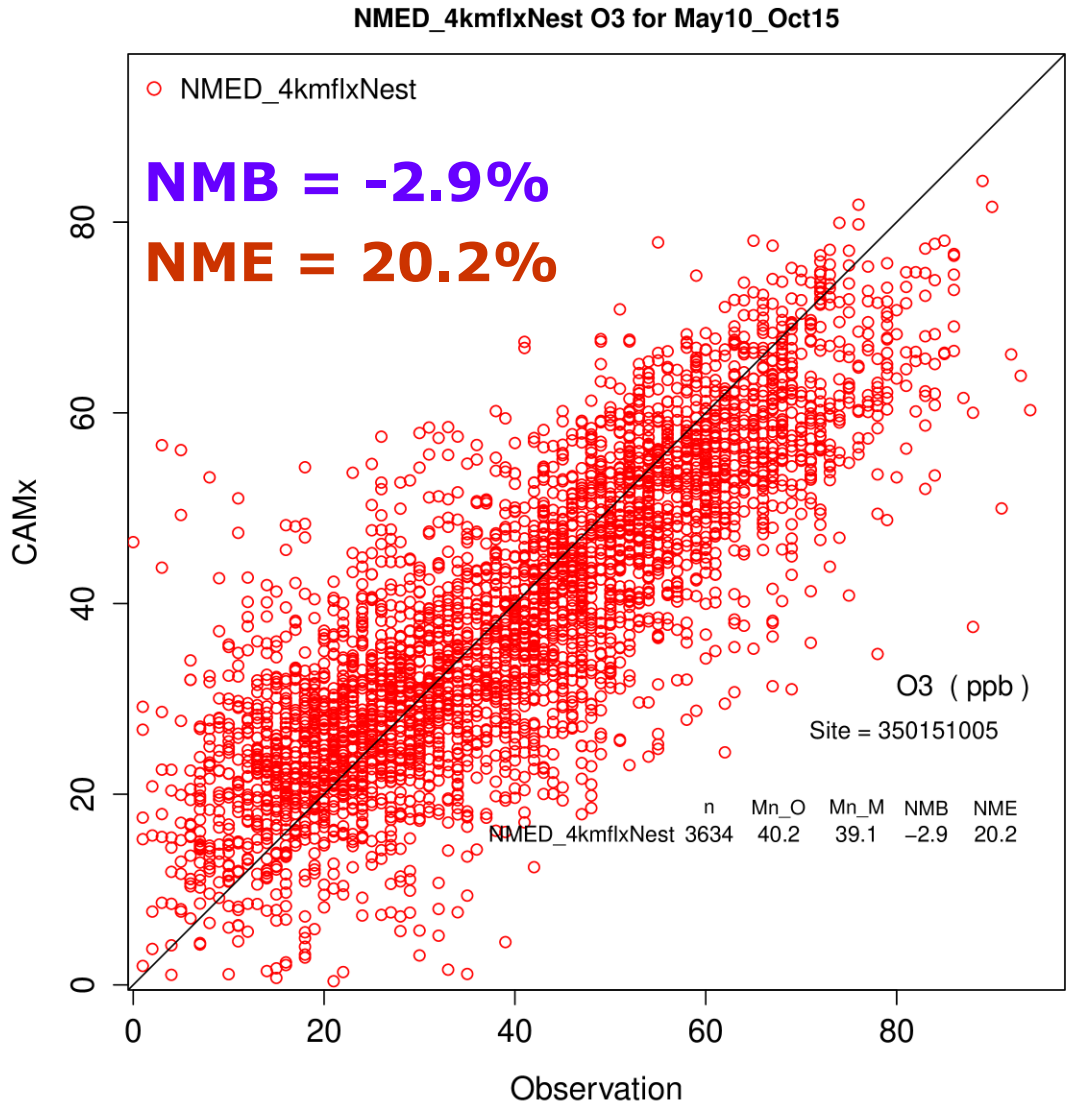


Phase II 4km2022v2

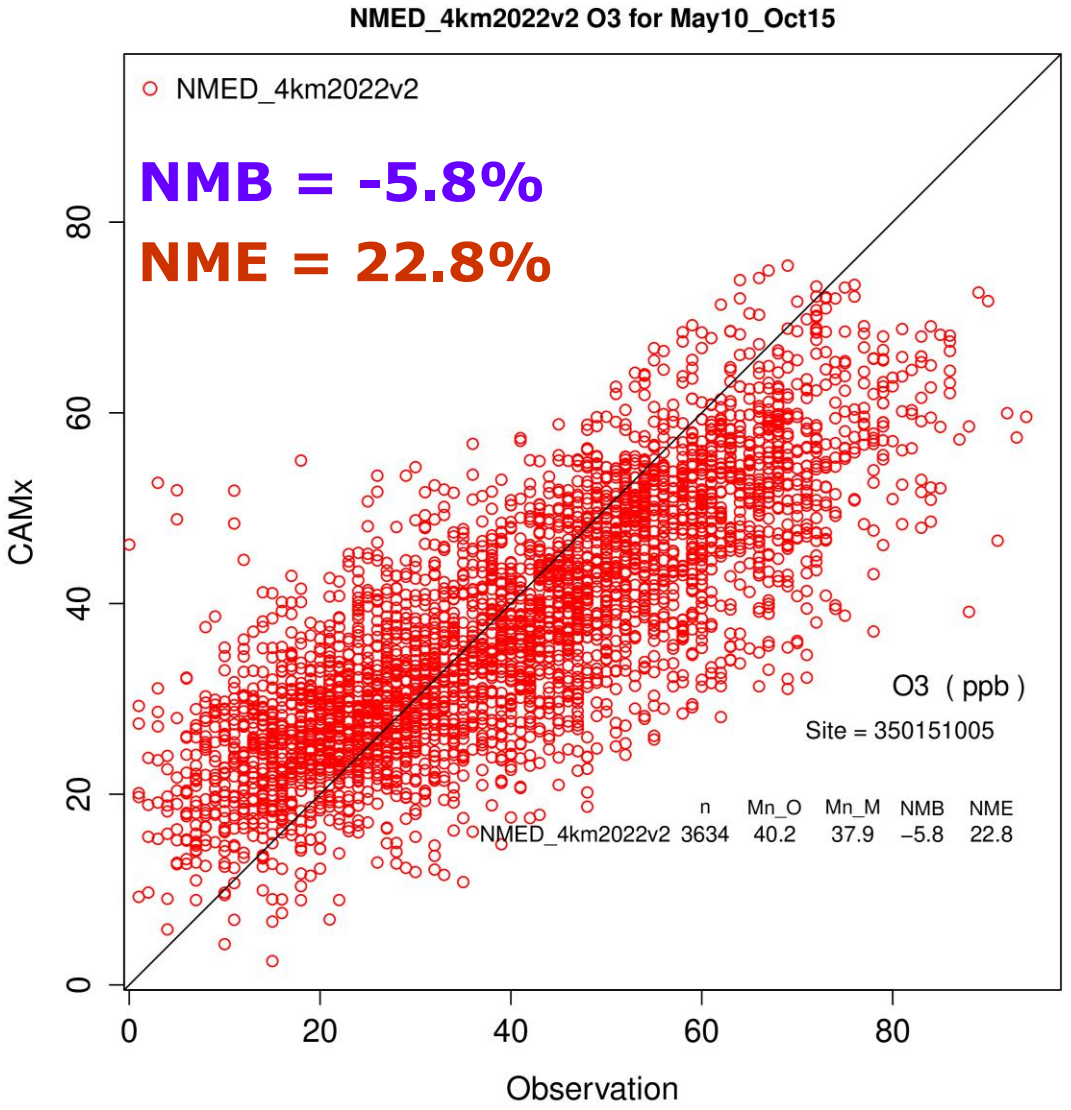


Hourly O3 May-Oct 2022: Carlsbad City

4kmflxnest 2022v1

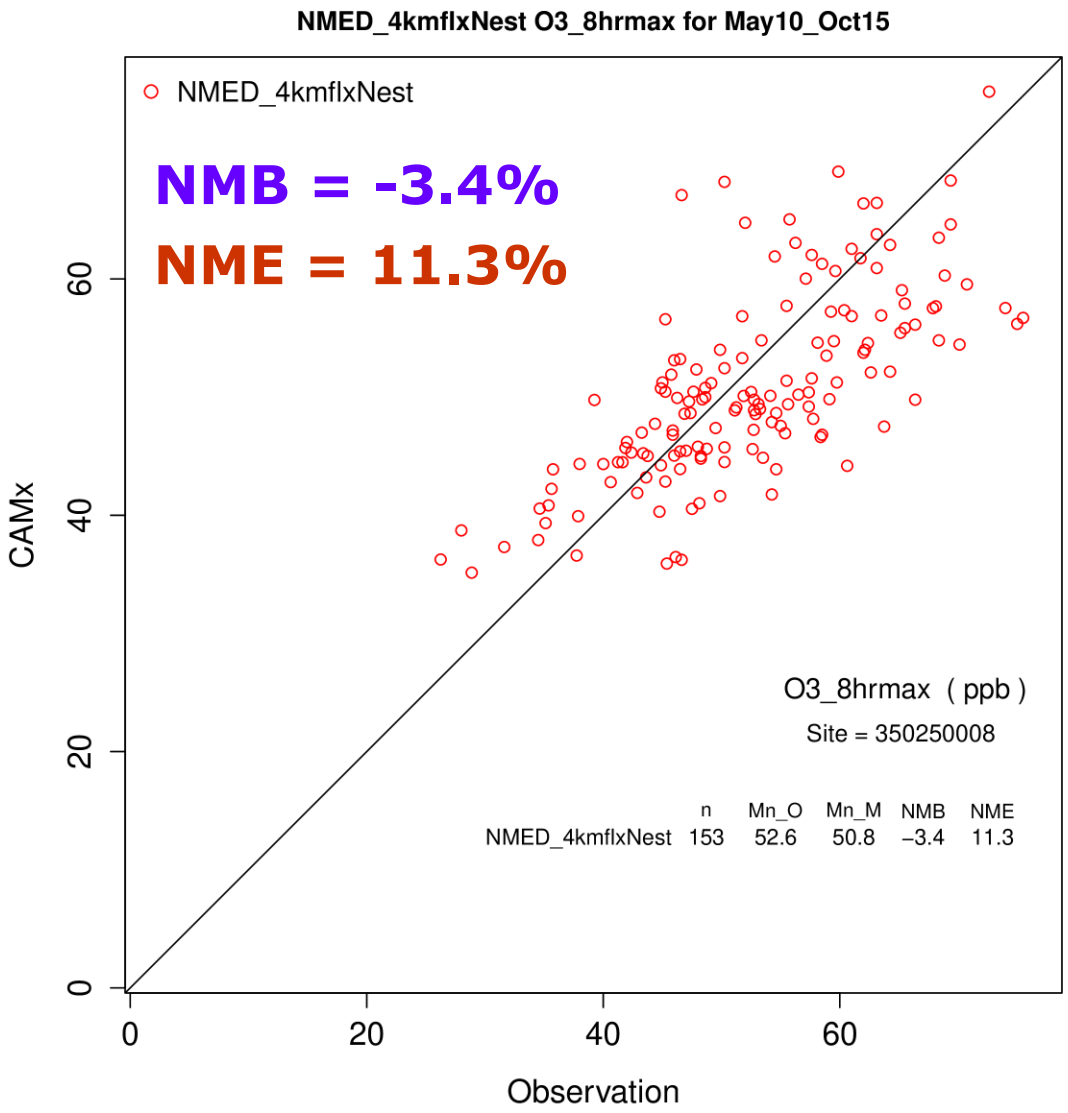


4km2022v2

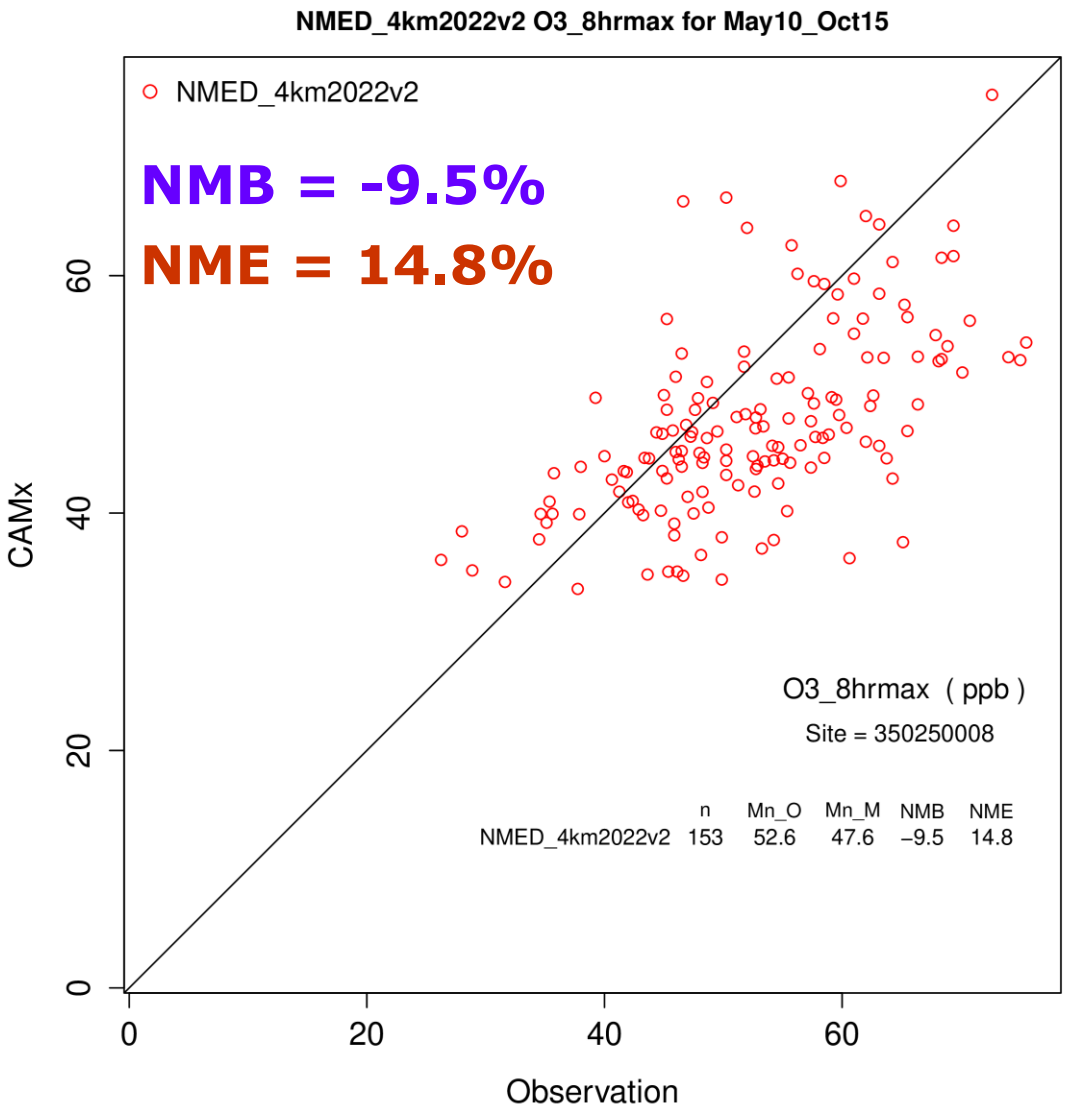


MDA8 O3 NMB May-Oct 2022: Hobbs

4kmflxnest 2022v1

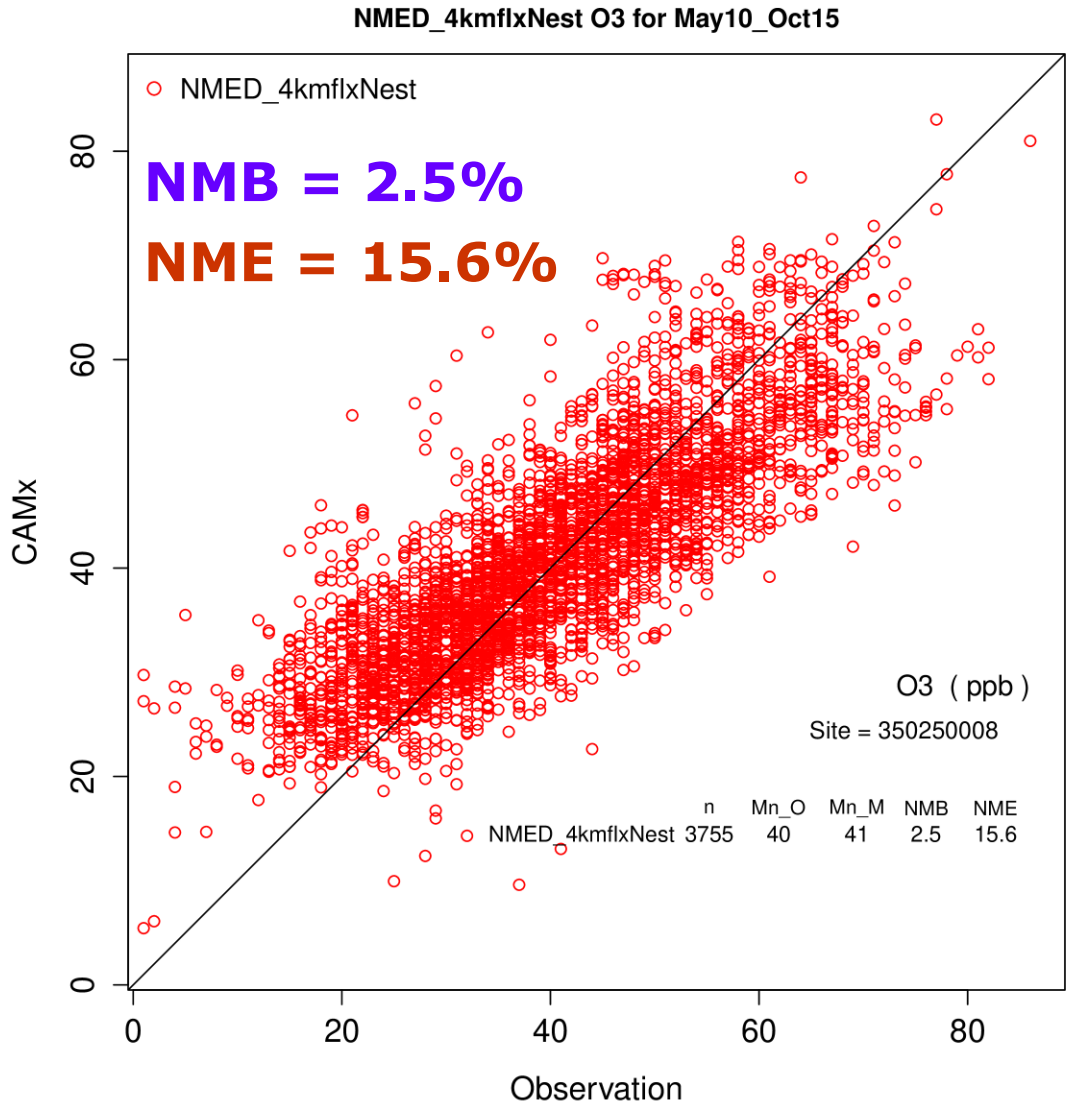


4km2022v2

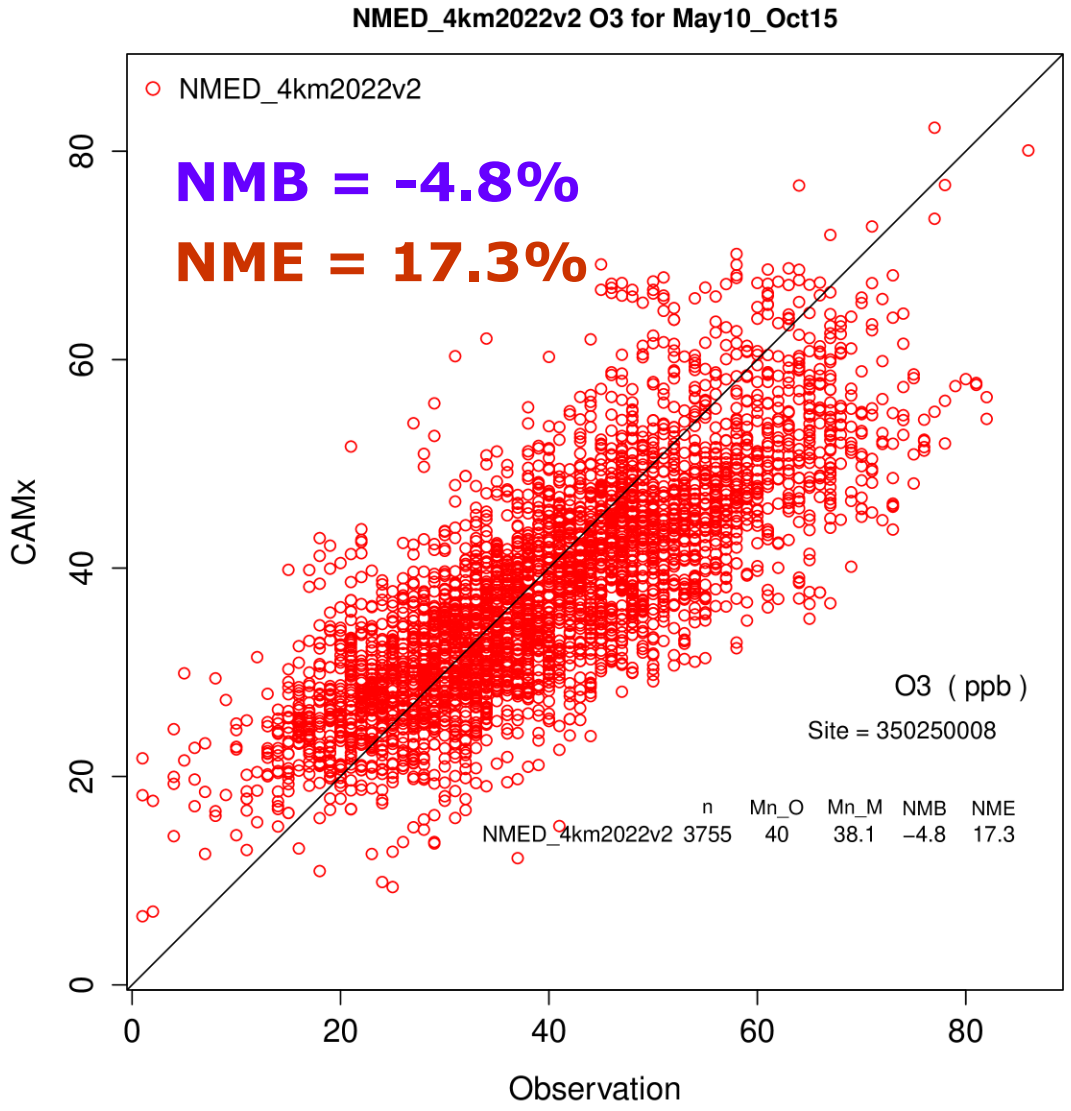


Hourly O3 May-Oct 2022: Hobbs

4kmflxnest 2022v1



4km2022v2

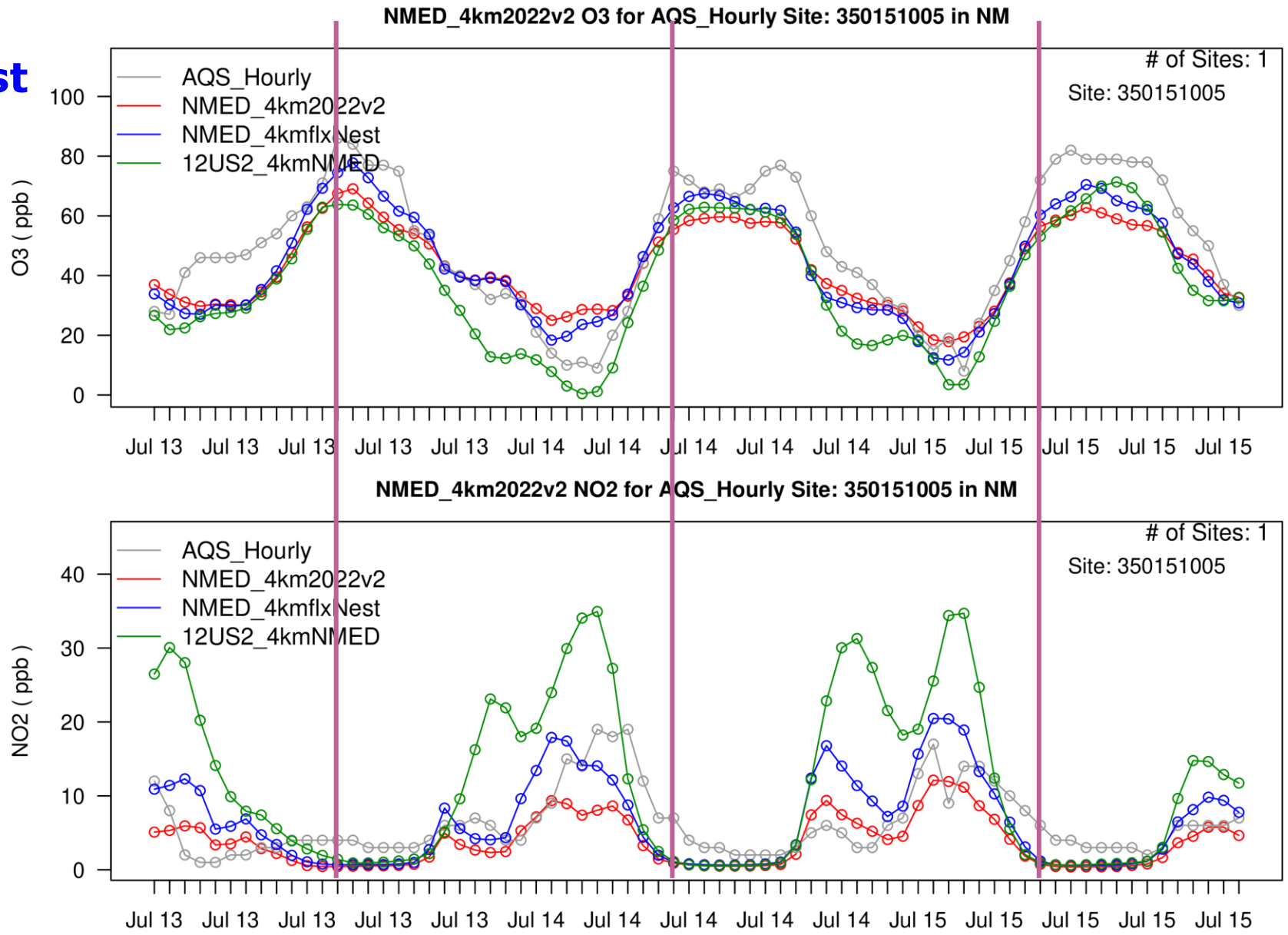


July 13-15, 2022: Carlsbad City: Ozone (top) and NO_2 (bottom)

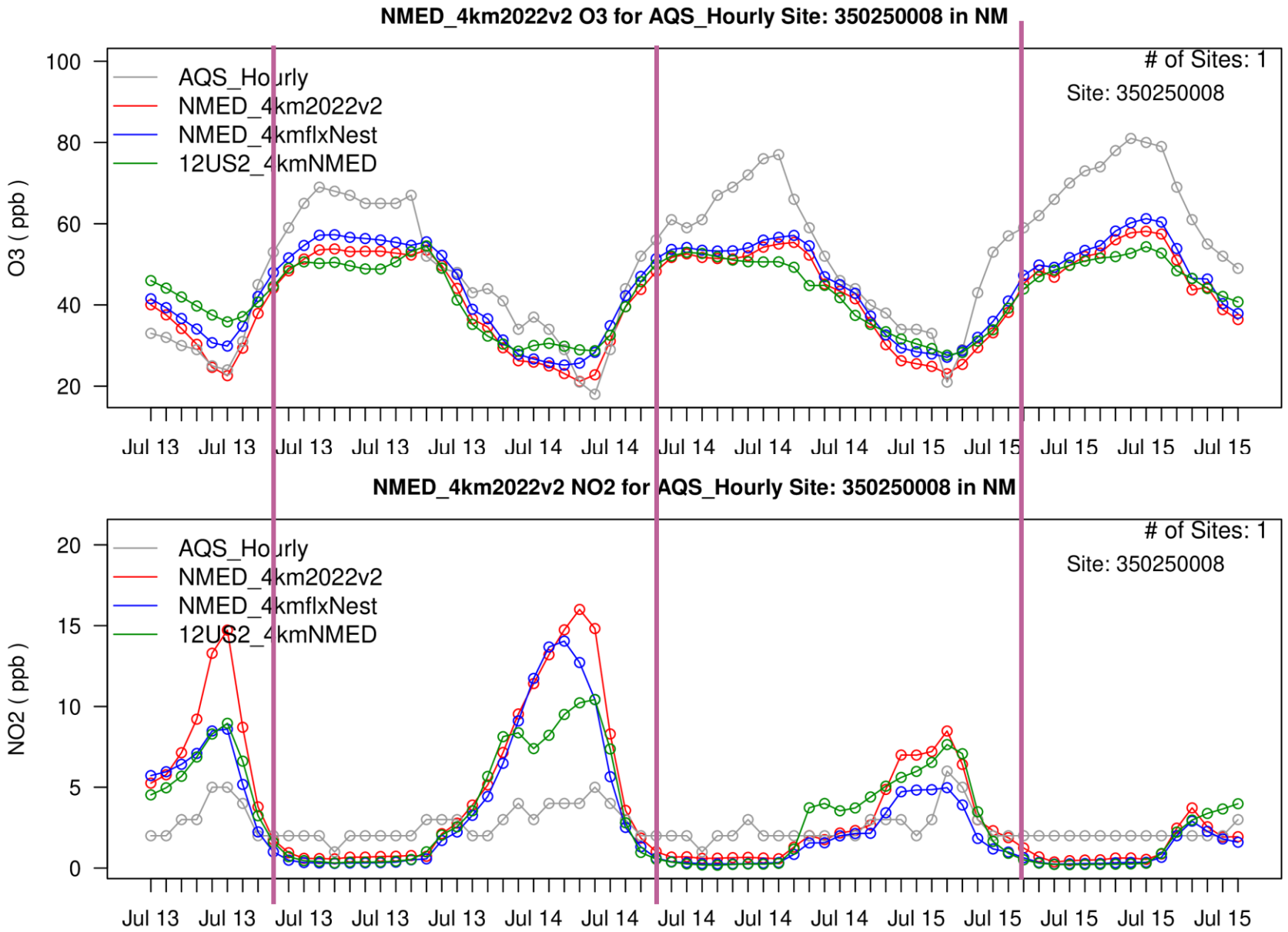
4km2022v2
4km2022v1_flexinest
12km2022v1

Modeled **O_3** stalls in early afternoon while observed O_3 keeps rising.

Modeled **NO_2** is nearly depleted in early afternoon limiting photochemistry while observed NO_2 stays higher.



July 13-15, 2022: Hobbs – Ozone (top) and NO_2 (bottom)?



Preliminary Ozone and NOx MPE of Initial Phase 2 CAMx 12/4 km Simulation

- **Why did Phase I CAMx 2022v1 4 km flexinest obtain better ozone model performance than Phase II CAMx 4 km 2022v2?** 2022v2 4 km emissions degrade ozone model performance relative to the 2022v1 flexinest platform, particularly in the Permian Basin.
  - Carlsbad City MDA8 ozone NMB underprediction degrades from -6% to -15%

- 2022v2 New Mexico O&G non-point NO_x emissions are 40% lower than 2022v1, excerpt from the 2022v2 EITSD, which may explain the weaker ozone performance

> **2.2.4 Nonpoint Oil and Gas Sector (np_oilgas)**
>
> ***2022v2 updates relative to earlier 2022 emissions modeling platforms***
>
> The 2022v2 emissions changes for the non-point oil and gas sector included the following:
>
> - Nonroad emissions factor correction which significantly reduced NOX emissions (about 74%) from drill rigs and hydraulic fracturing engines

- This implies a 74% reduction in drilling and fracing engine NO_X emissions reduced Non-Point O&G NO_X emissions by 40%, which seems reasonable. The higher O&G NO_X emissions in 2022v1 explains the better ozone performance than obtained using the 2022v2 emission inventory

Preliminary Ozone and NOx MPE of Initial Phase 2 CAMx 12/4 km Simulation

What we learned from hourly timeseries: Observed O_3 continues rising into the afternoon, while modeled O_3 stalls. During these hours, observed NO_2 remains elevated, but modeled NO_2 drops to near zero, shutting down NO_2 photolysis and halting ozone production.

Outstanding Questions:

- Are Permian Basin O&G NO_X and/or VOC emissions understated?
- Could observed NO_2 be higher than modeled simply due to the minimum detection level for NO_2 monitors, especially at Hobbs?
- Can there be NO_2 measurement interference with other species (e.g., PAN, PNA, HNO3) resulting in higher measured "NO_2"?

Next Steps: While developing 2032 emissions, investigate CAMx ozone model performance using additional performance approaches and conduct sensitivity tests for a selected episode in May-October 2022:

- Vertical mixing sensitivity tests: to check for NO_2 over-dilution
- Emissions sensitivity tests: because Permian Basin O&G emissions might be understated

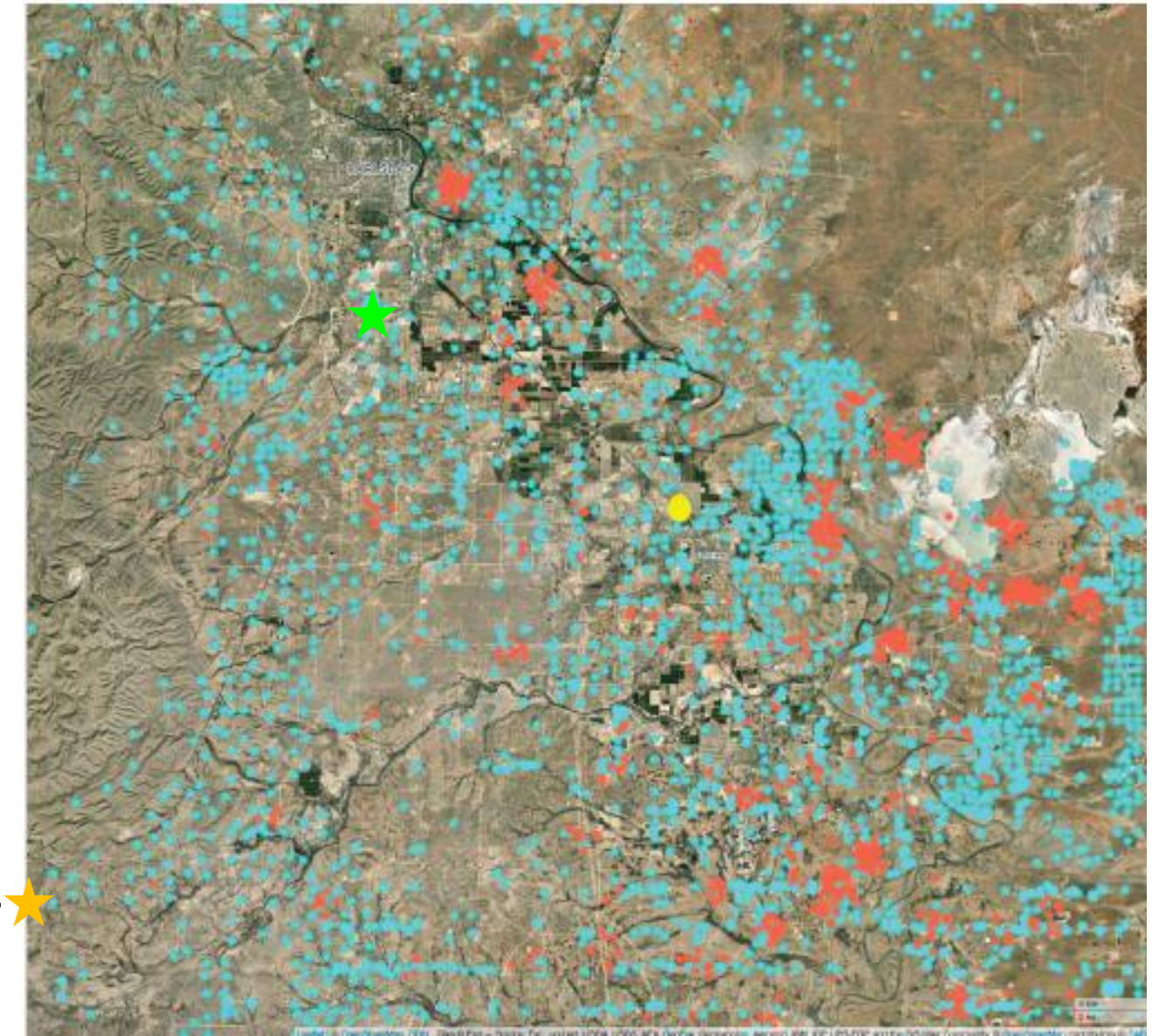
Evaluation for VOCs: 2021 CarCavAQS 2-2023 HEI Loving, NM

2022 modeling VS. 2021 & 2023 Measured VOC and NOx

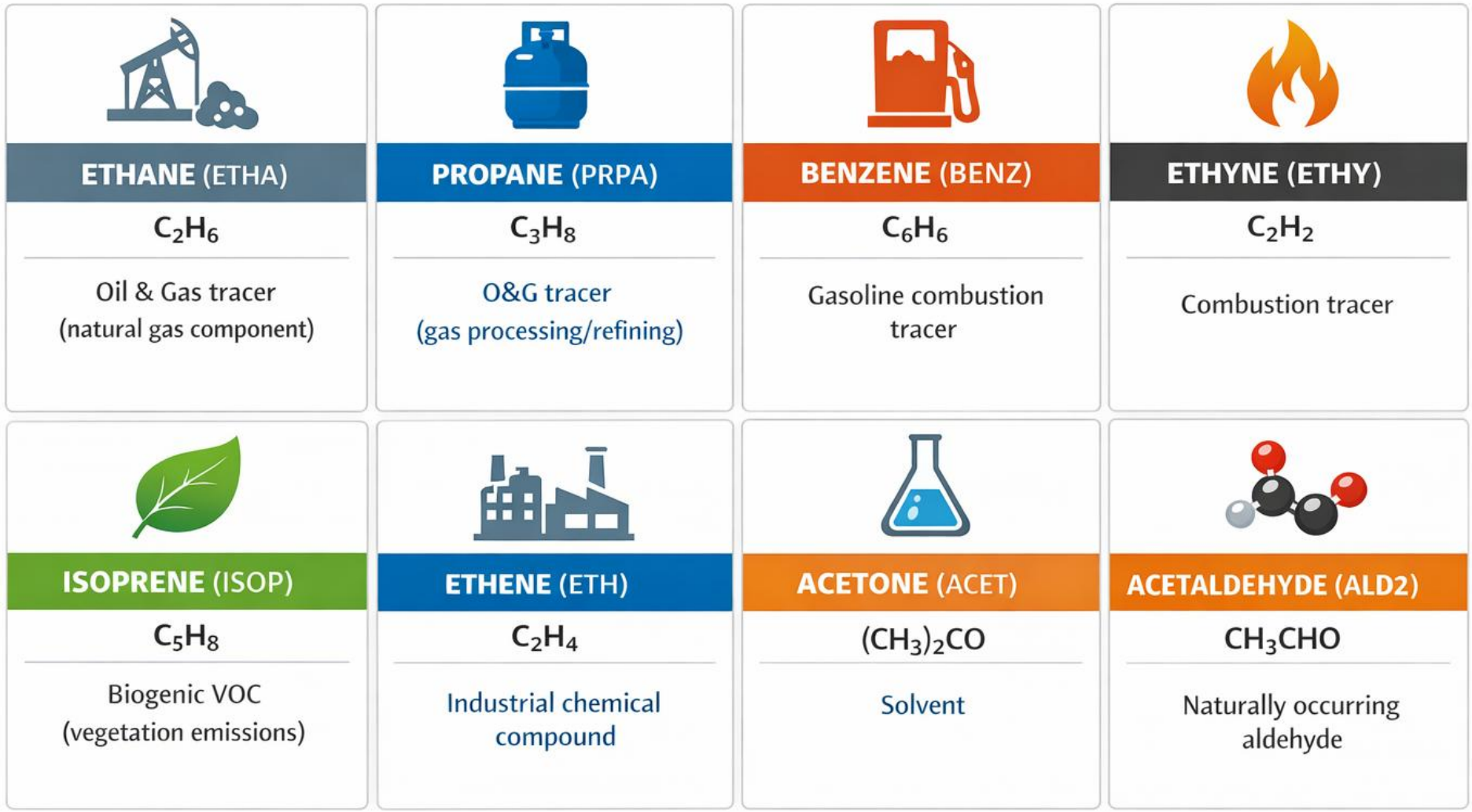
VOC: 2021 CarCavAQS and 2023 HEI Loving, NM (LNM)

- CarCavAQS: July 17 – August 19, 2021
- LNM: May 2023 – June 2024*
- Challenges in VOC Evaluation:
  - VOC measurements not concurrent with 2022 modeling period
    - ➢ Compare frequency distributions of modeled & observed hourly VOC – box & whisker plots
  - CAMx CB7 condensed chemical mechanism uses lumped species
    - ➢ Evaluate for explicit VOC species in CB7

- Yellow Circle = Loving, NM site
- Green Star = Carlsbad City Site
- Orange Star = CarCavAQS Site (further west)
- Cyan Dots = Active Wells
- Red Dots = Satellite Flare Detection



Evaluation for 8 Explicit VOC Species in CB6r5

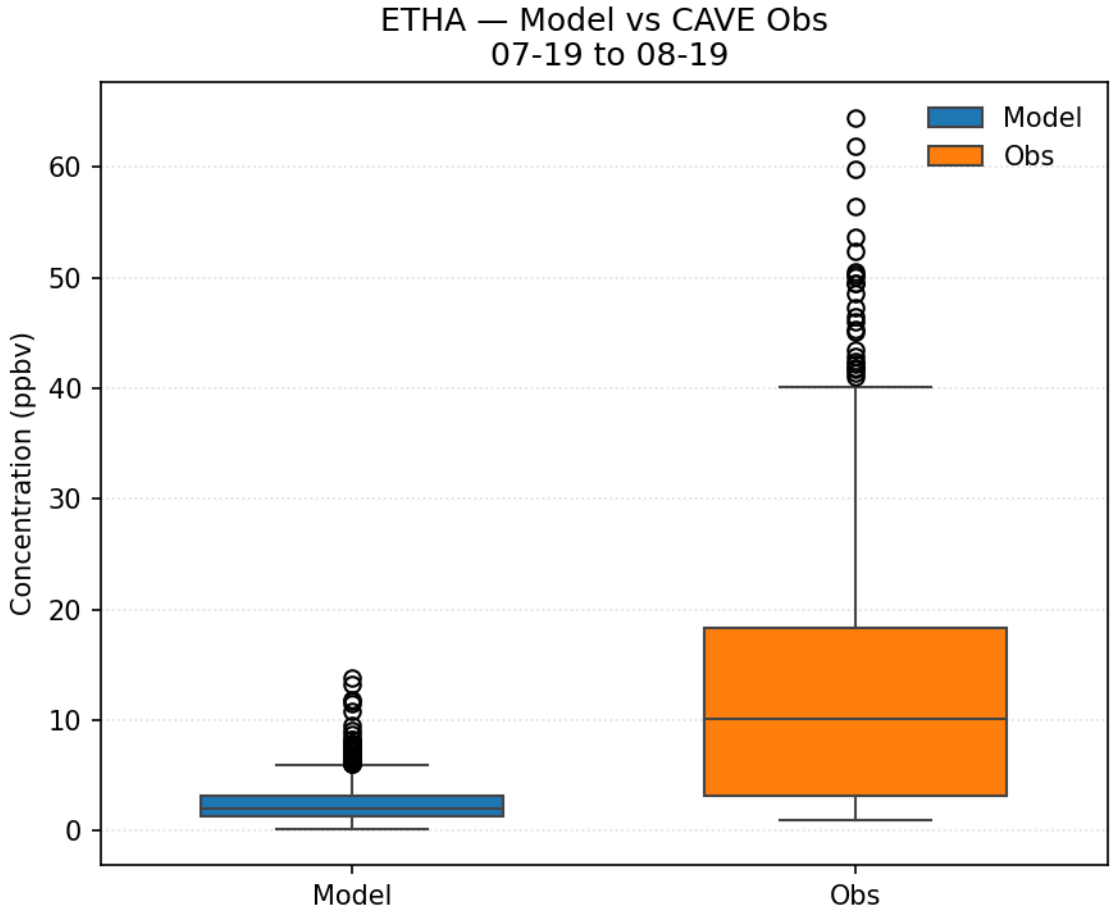


CarCavAQS Ethane (ETHA) & Propane (PRPA) – O&G

Results suggests 2022 oil and gas VOC emissions inventory may be understated in the Permian Basin

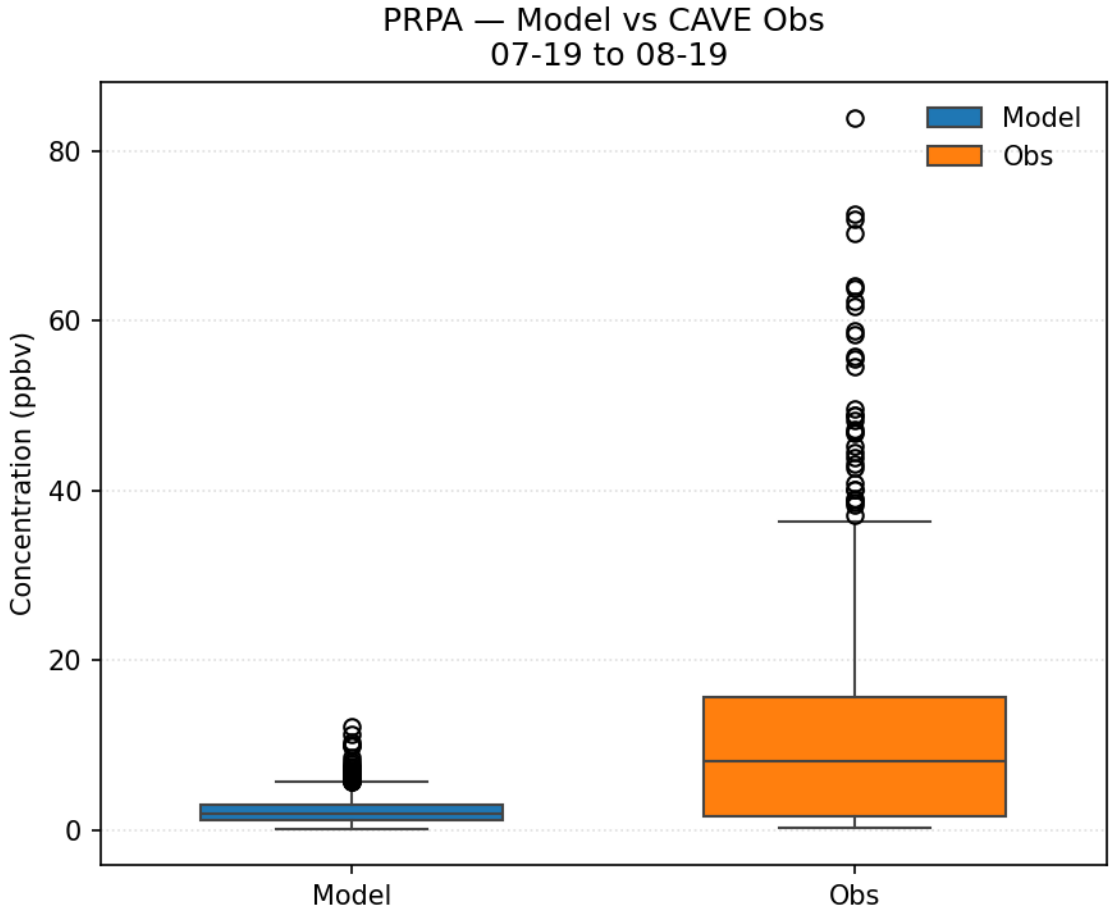
Ethane

- Median Underprediction: **5.3** times (10 vs 2 ppb)
- Mean Underprediction: **5.2** times (13 vs 3 ppb)



Propane

- Median Underprediction: **4.4** times (8 vs 2 ppb)
- Mean Underprediction: **5.2** times (12 vs 2 ppb)



LNM Ethane and Propane -- Oil and Gas Tracers

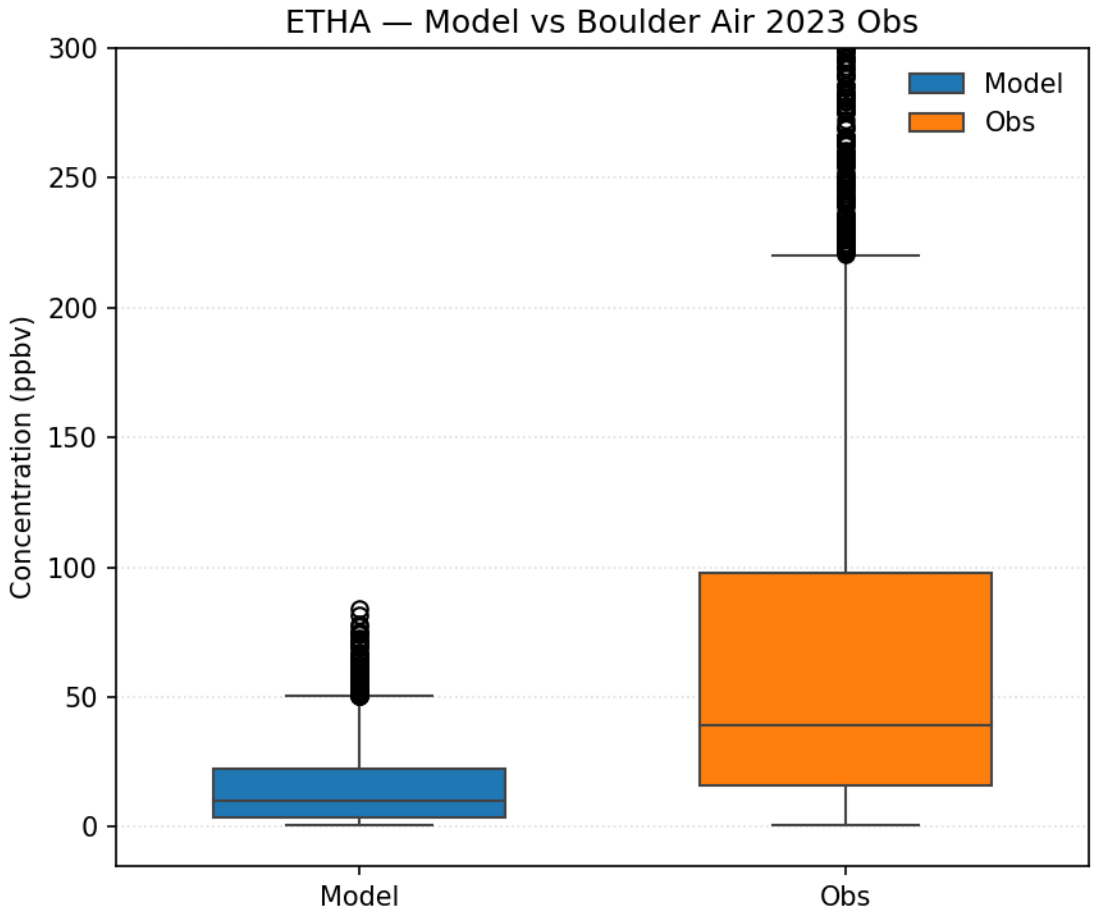
Results suggests 2022 oil and gas VOC emissions inventory may be understated in the Permian Basin

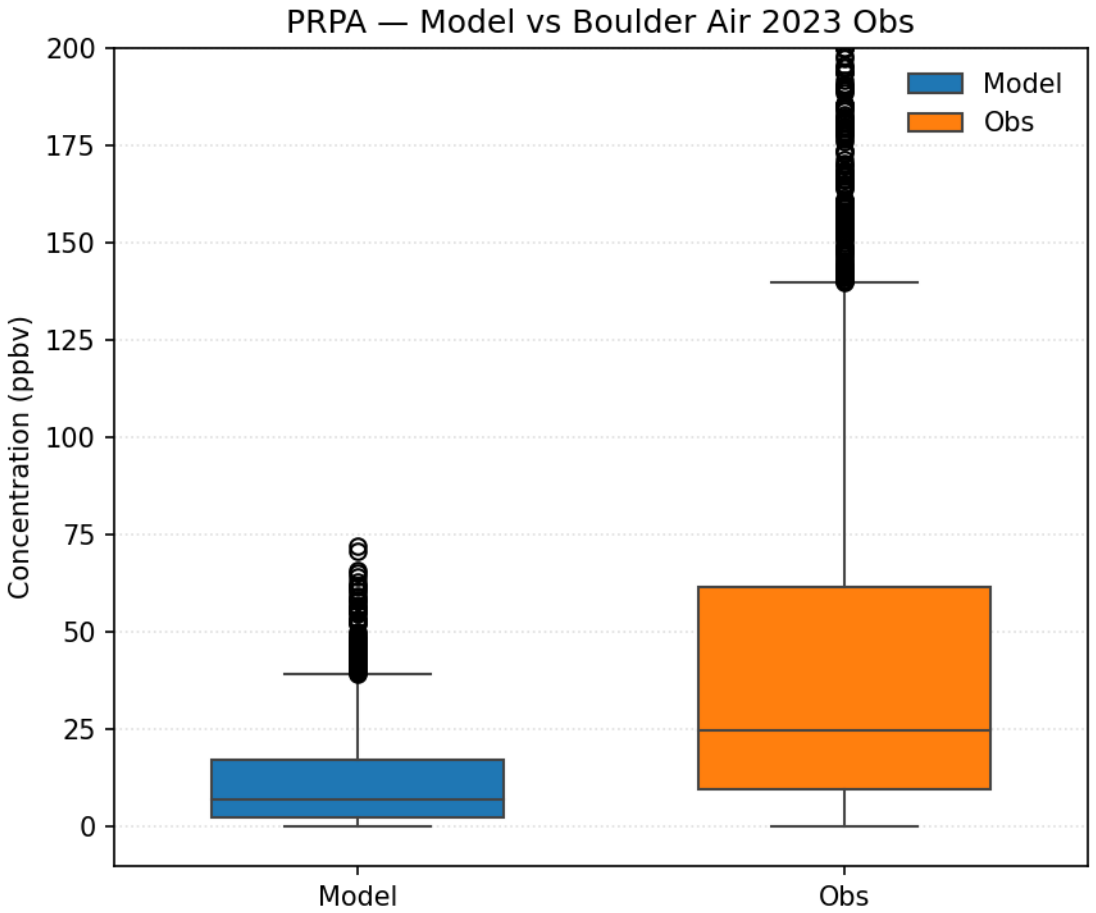
Ethane

- Median Underprediction: **4.0** times (39 vs 10 ppb)
- Mean Underprediction: **5.4** times (79 vs 15 ppb)

Propane

- Median Underprediction: **4.4** times (8 vs 2 ppb)
- Mean Underprediction: **5.2** times (12 vs 2 ppb)

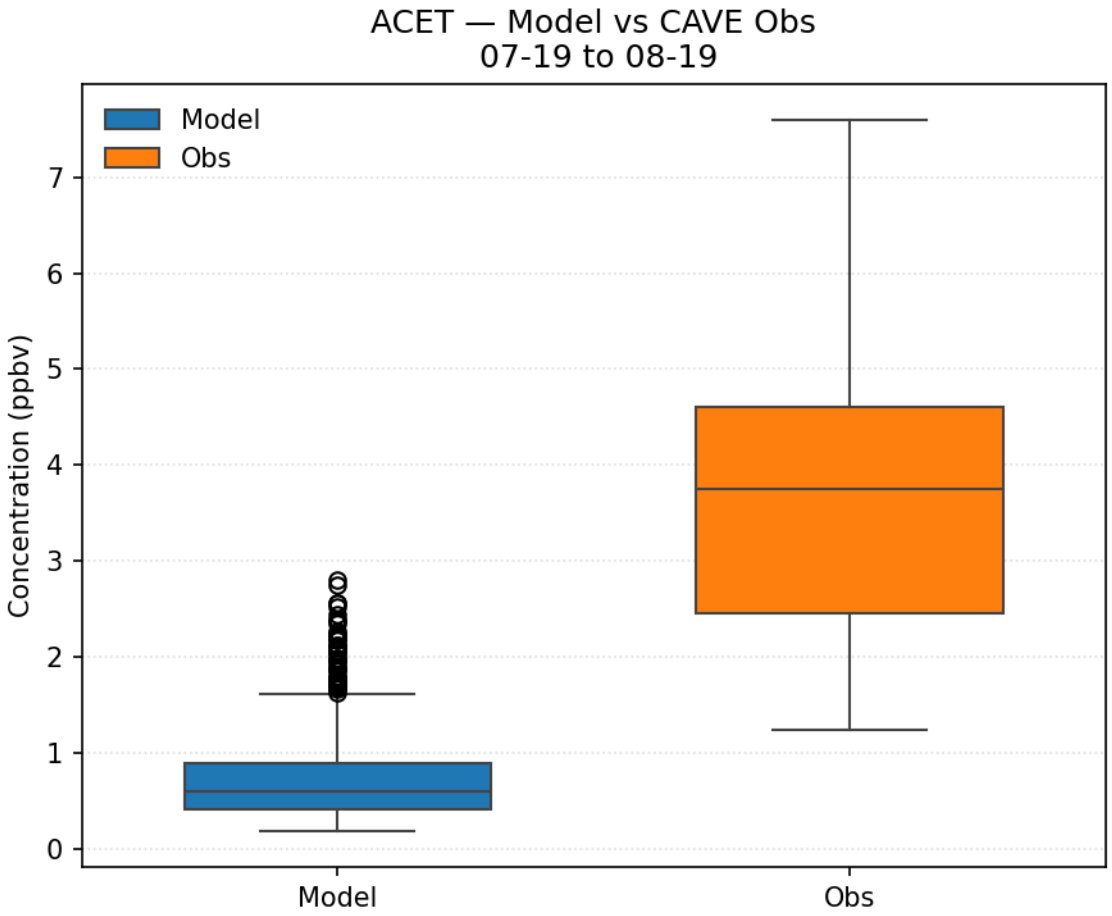


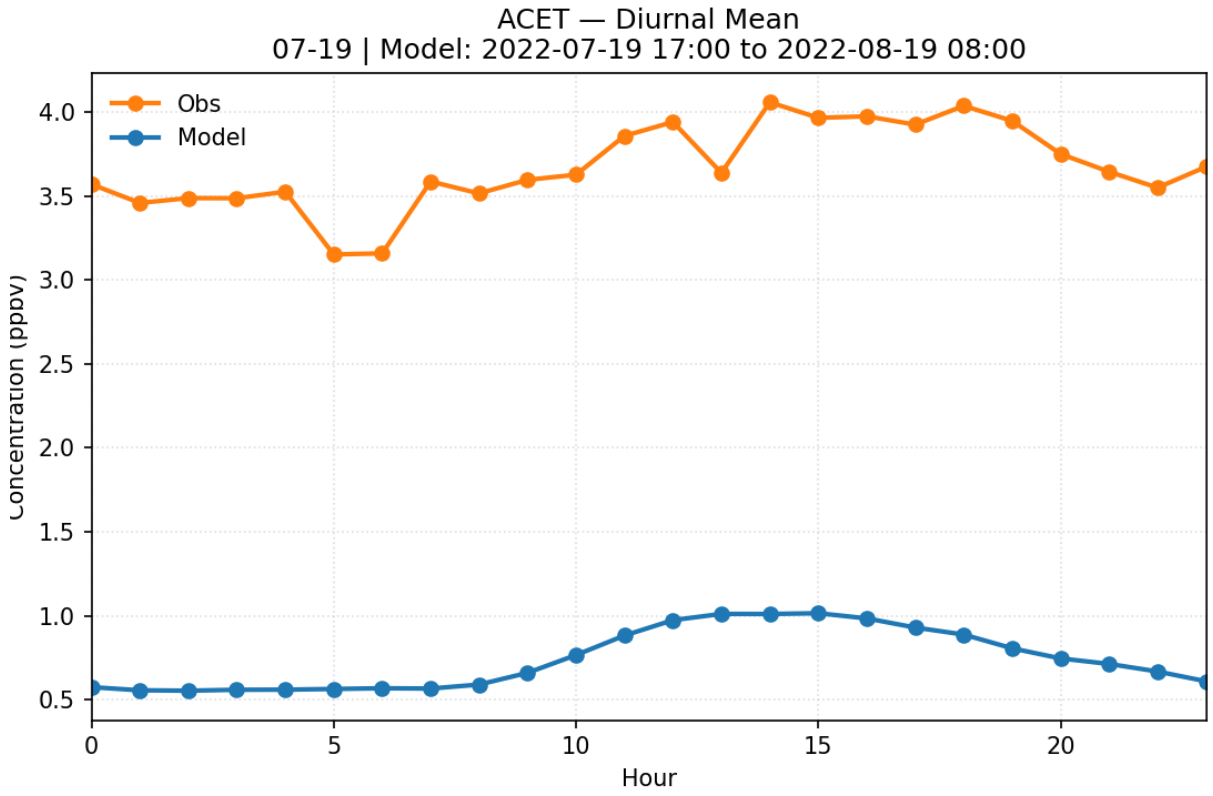


Ramb

CarCavAQS Acetone – Solvent used in O&G

- Acetone is greatly underestimated by the model by factor of **5-6** on average (3.7 vs. 0.7 ppb) with the 75th percentile modeled value below the 25th percentile observed value

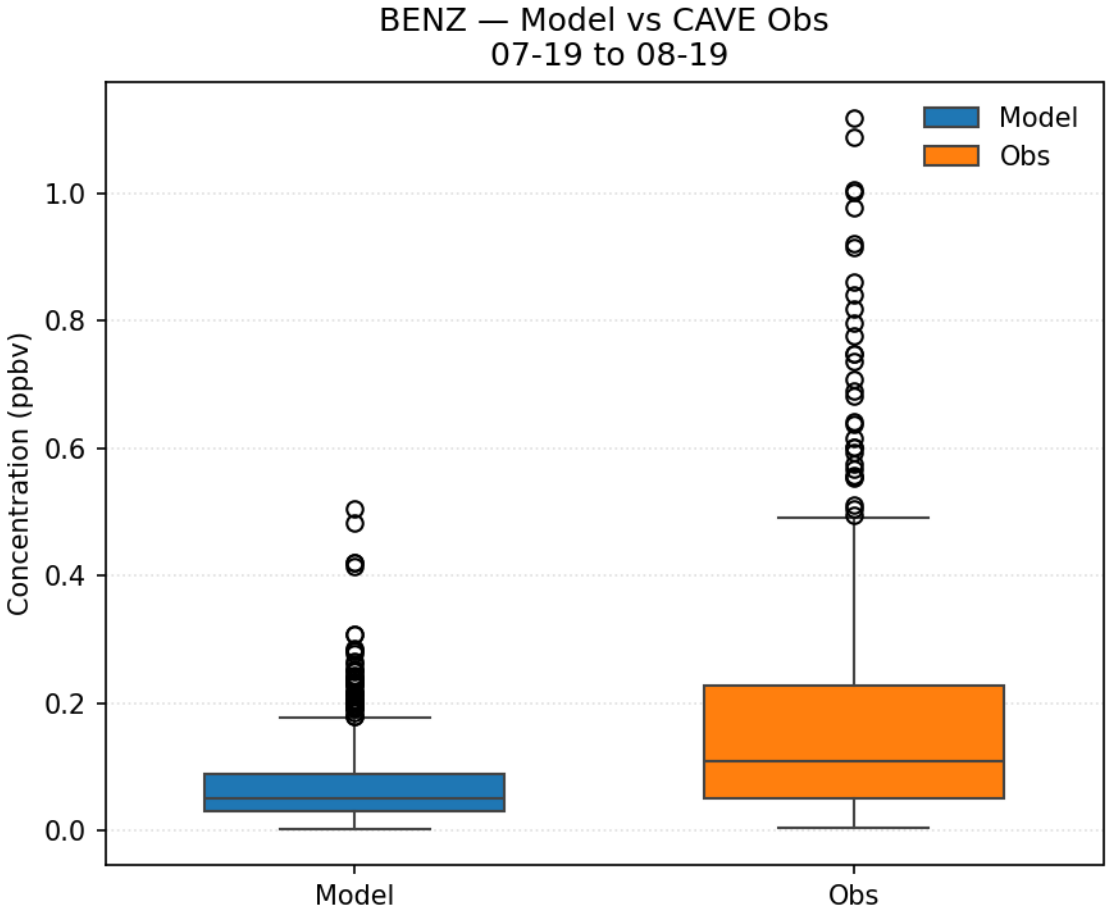




Benzene (Gasoline Combustion)

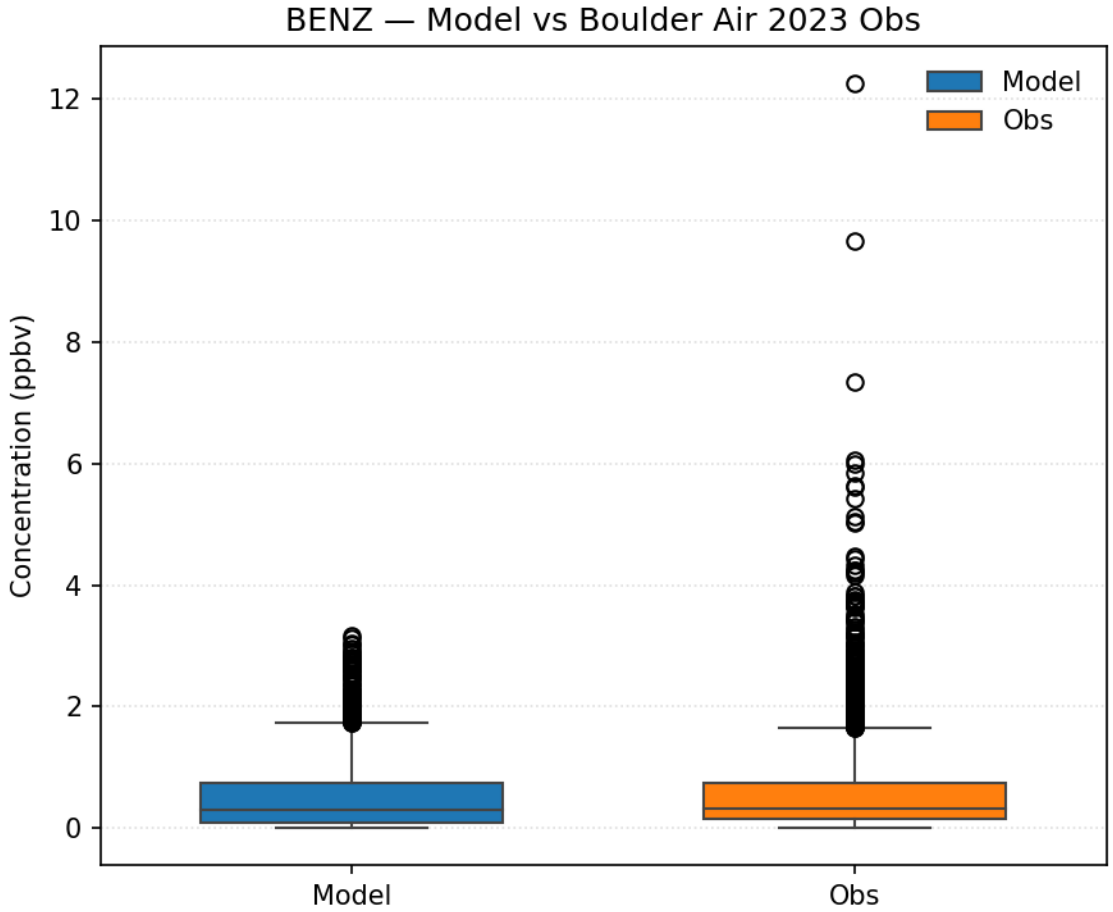
CarCavAQS

- Median Underprediction: **2.2** times
- Mean Underprediction: **2.4** times



LNM

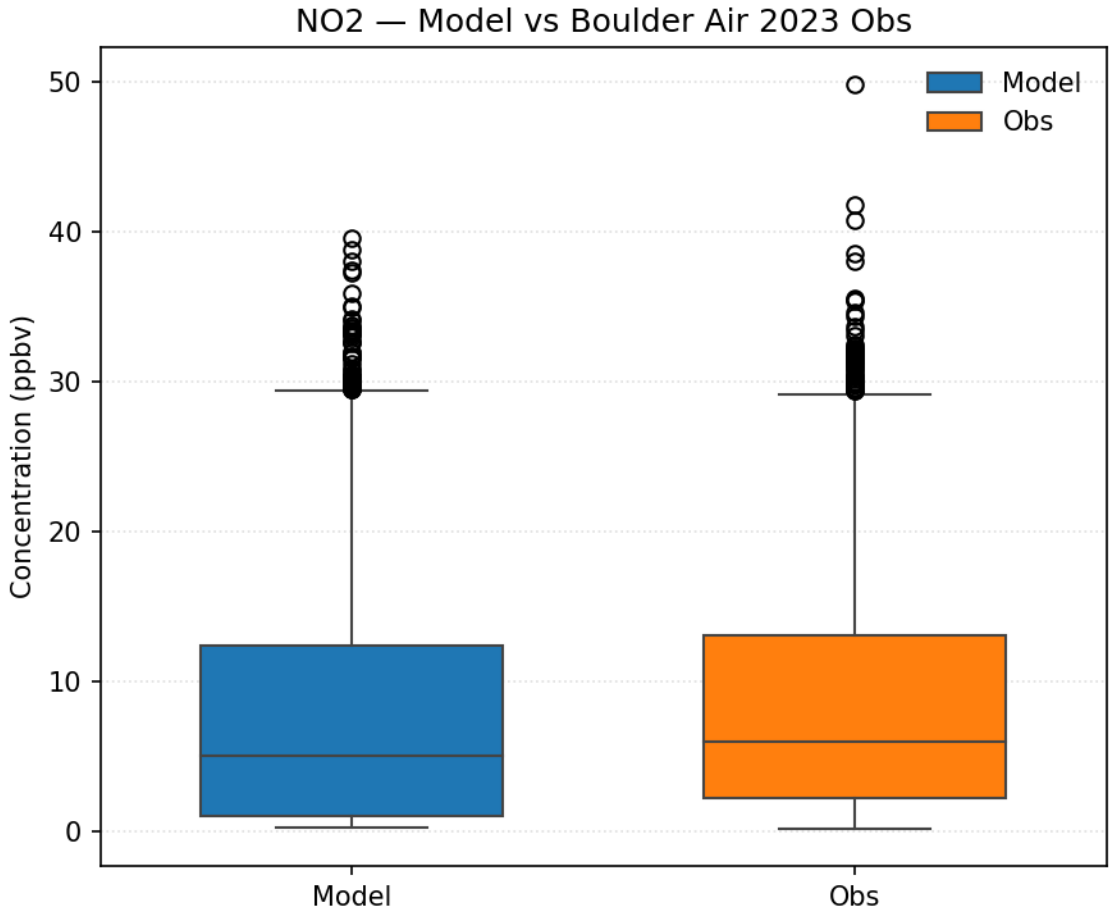
- Median Within 10% (**1.1** times)
- Mean Within 20% (**1.2** times)



LNM and CarCavAQS NO_2

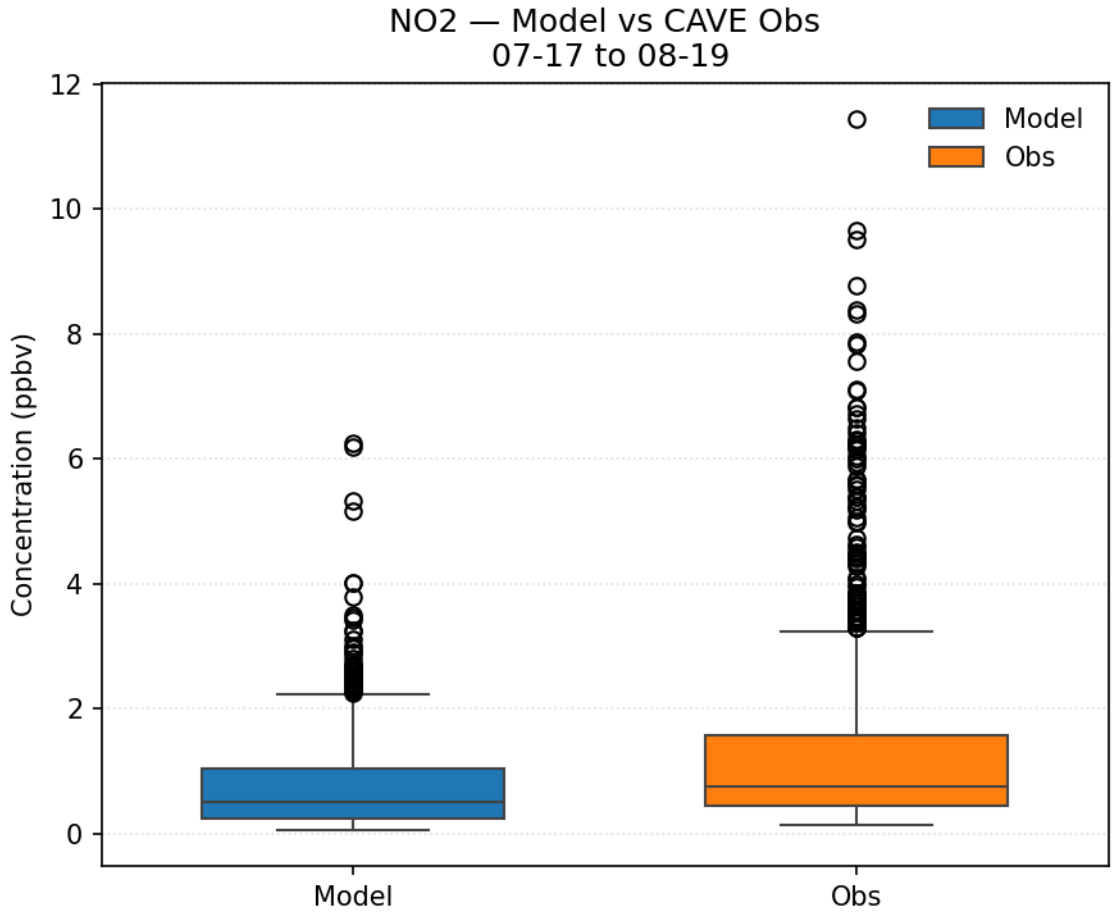
LNM

- Median Underprediction: **1.2** times (6.0 vs 5.1 ppb)
- Mean Underprediction: **1.1** times (8.5 vs 7.6 ppb)



CarCavAQS

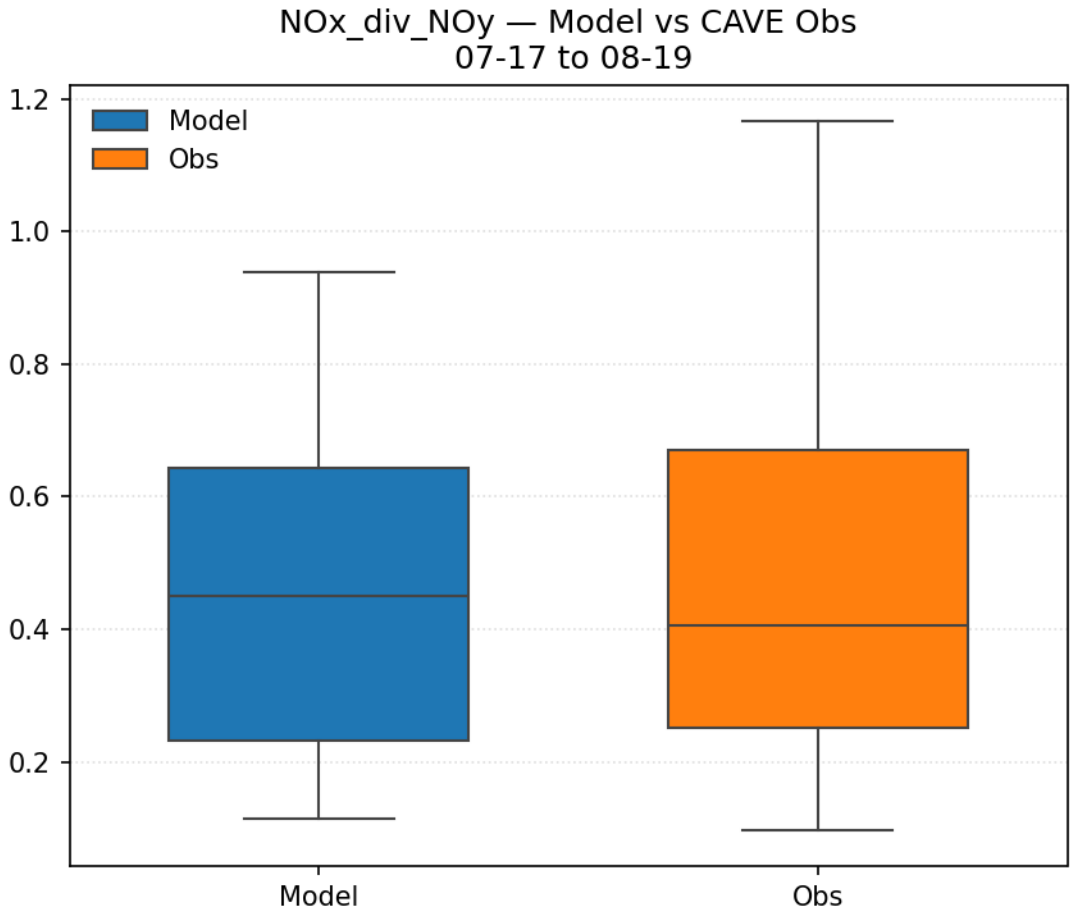
- NO_2 is underestimated by ~**1.5×** (median) and ~**1.8×** (mean).



Conclusions CarCavAQS LNM VOC/NO_X Evaluation

- O&G VOC tracers (Ethane and Propane) are underestimated by a factor of ~5 at both sites
  - Suggests 2022v2 O&G VOC emissions are understated
- Combustion tracers underestimated by factor of ~2 (Benzene) to good agreement on average (Ethyne) – could be related to 4 km grid cell averaging in model
- Isoprene (Biogenic) concentrations are very low and model has good agreement with observations
- Acetone has large underestimation (5x) – solvent used in O&G production
- NO_2, NO_X and NO_Y show underestimation - May be due to grid cell dilution

CarCavAQS NO_X/NO_Y Ratios – measure of aging of NO_X emissions with good agreement (within 10% on average between observations and model ~0.4)



Conclusions: CarCavAQS vs. LNM VOC/NO_X Evaluation

Key Takeaway: Both special field study monitoring datasets indicate that Permian Basin O&G VOC emissions in the 2022v2 platform are understated, O&G NO_X emissions may also be understated

LNM much closer to O&G activities than CarCavAQS so measures higher concentrations

Species/O&G Tracer	Observed LNM vs CarCavAQS	Model LNM vs CarCavAQS	Model Bias (against Obs)
Ethane	4–6× higher	5–6× higher	~4-5× too low
Propane	3-4× higher	4-5× higher	~4-5× too low
Benzene	3x Higher	6-7x Higher	2× low @ CarCavAQS
NOx	8x Higher	10x Higher	~1.5-2× too low

Sensitivity Test Modeling

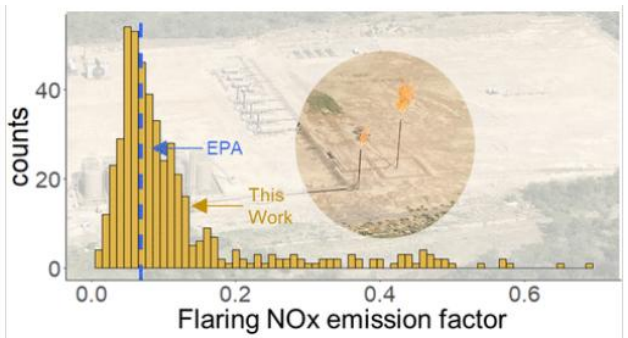
June 28 – July 17, 2022: 20 days

Permian Basin Emissions are Likely Underestimated in 2022 Platform

ENERGY AND CLIMATE | January 8, 2024

In Situ Sampling of NOx Emissions from United States Natural Gas Flares Reveals Heavy-Tail Emission Characteristic

Genevieve Plant*, Eric A. Kort*, Alan M. Gorchov Negron, Yuanlei Chen, Graham Fordice, and Colin Harkins



ELSEVIER

Remote Sensing of Environment

Volume 334, 1 March 2026, 115229

Space-based assessment of NO_x emissions from global oil and gas fields: Bridging the gap in current emission inventories

Piyushkumar N. Patel [a 1], Ritesh Gautam [a b], Mark Omara [a b]

- Top-down satellite-based analysis reveals current bottom-up inventories underestimate NOx emissions from Oil & Gas basins by 61-92%.

Numerous reported excess emissions leading to potential fines that represent a fraction of the actual excess emissions

Recent Major Penalties and Settlements (2023–2025):

- **Targa Northern Delaware, LLC (Dec 2024):** $47.8 million penalty for excessive emissions in Lea County, NM.
- **Ameredev II LLC (April 2024):** $24.5 million settlement for state air regulation violations.
- **Apache Corporation (Feb 2024):** $4 million in penalties with $5.5 million for compliance, totaling $9.5M.
- **Mewbourne Oil Company (Aug 2023):** $5.5 million penalty and $4.6 million in compliance costs.
- **Callon Permian LLC (July 2023):** $1.285 million penalty for violations involving tank pressure and emissions.
- **Permian Resources (March 2023):** $610,000 penalty for air pollution violations.
- **Matador Production Company (March 2023):** $1.15 million penalty. U.S. Environmental Protection Agency (.... +4

Satellite-based Quantification of NOx Emissions from Global Oil and Gas Fields

ATMOSPHERIC SCIENCES | CLIMATOLOGY (GLOBAL CHANGE) | EMISSIONS | ENVIRONMENTAL SCIENCES | NOX | OIL AND GAS | REMOTE SENSING | SATELLITE DATA

Piyushkumar Patel, Ritesh Gautam, Mark Omara

December 26, 2024 – ESS Open Archive

Delaware Basin NO_x emissions underestimated by 91-95% based on TROPOMI

Emission Sensitivity Tests

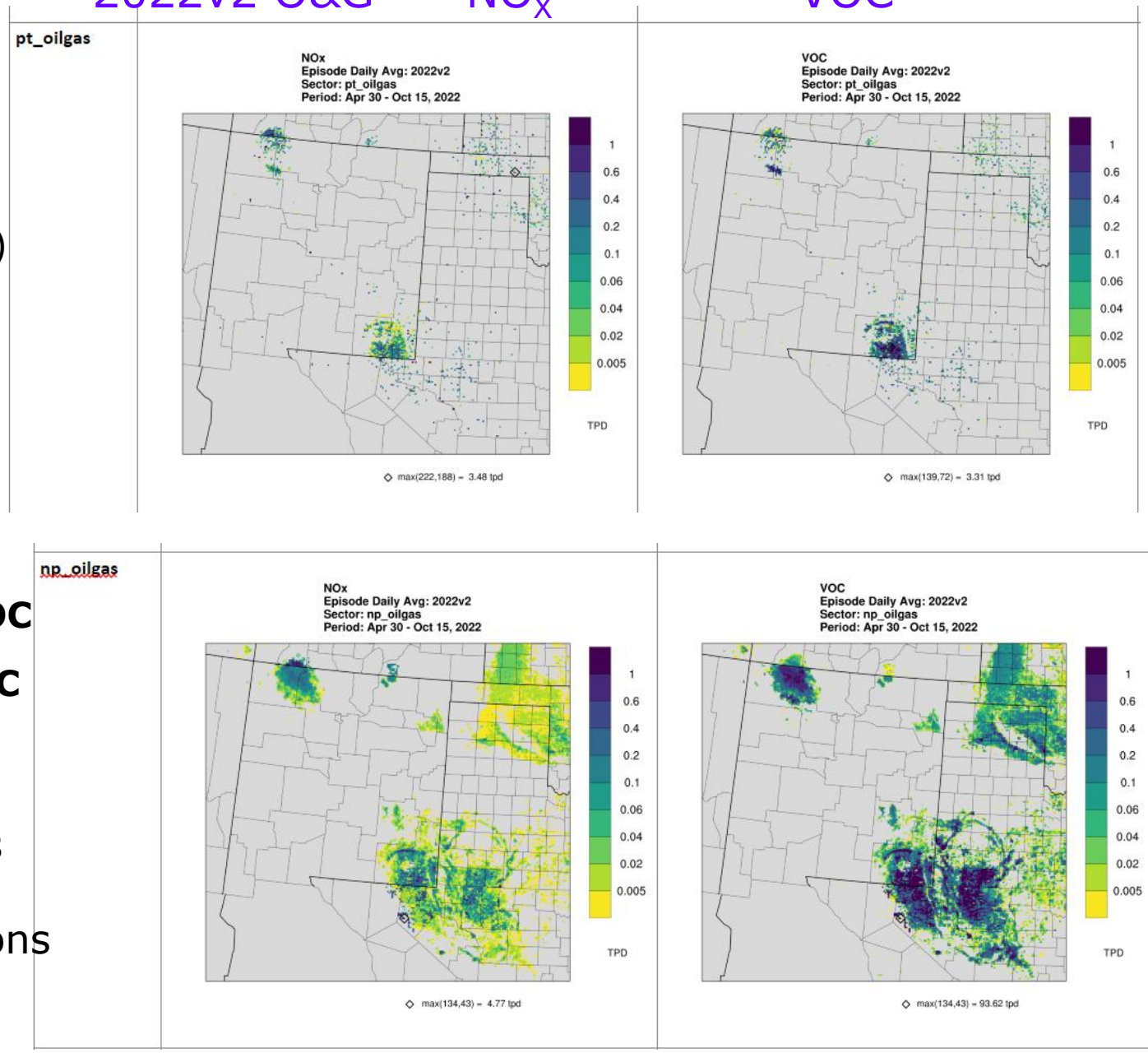
Permian Basin (PB) O&G Emissions Sensitivity Tests

Increase New Mexico (NM) or Texas (TX) portions of Permian Basin (PB) O&G emissions by a factor of 3

- 4km2022v2 = Base Case 2022v2 PB O&G
- Sens3 = 3 x 2022v2 **NM** PB O&G **NO_X**
- Sens4 = 3 x 2022v2 **NM** PB O&G **VOC**
- Sens5 = 3 x 2022v2 **NM** PB O&G **NO_X & VOC**
- Sens7 = 3 x 2022v2 **TX** PB O&G **NO_X & VOC**

- The factor of 3 is arbitrary and the locations of the missing O&G emissions likely don't align with the spatial distribution of the 2022v2 O&G emissions

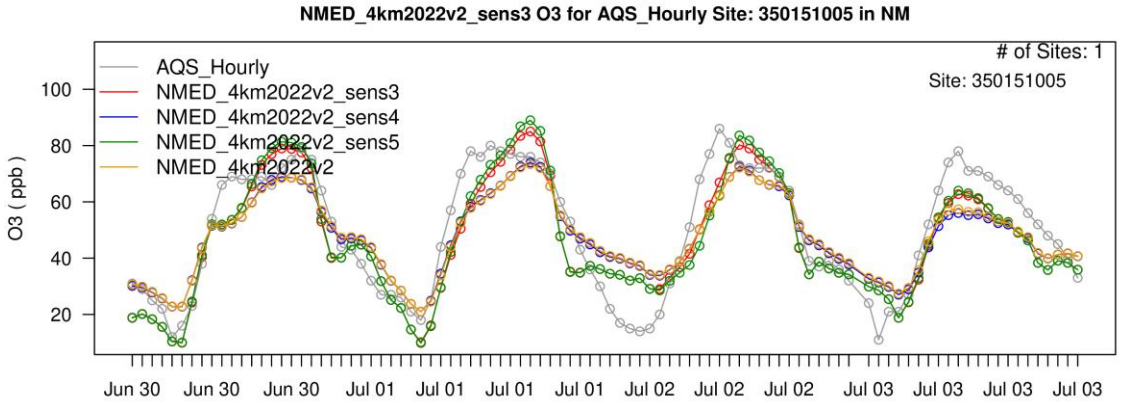
2022v2 O&G NO_X VOC

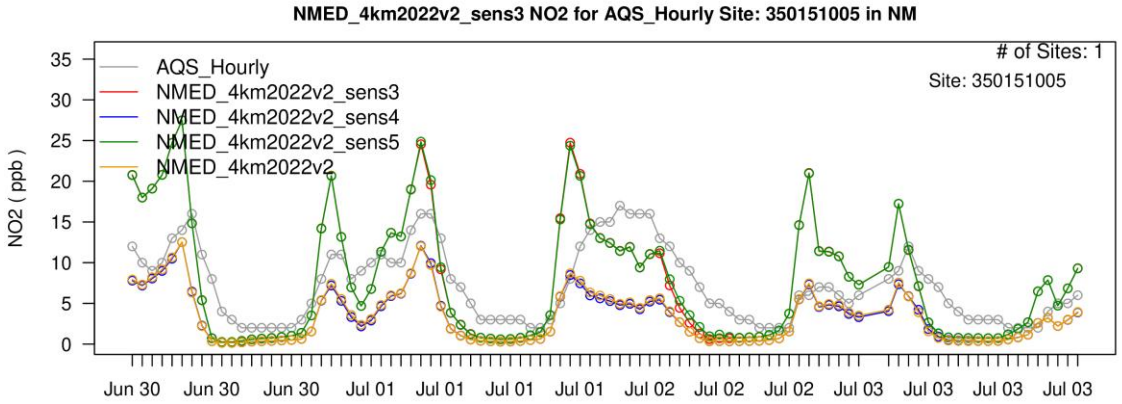


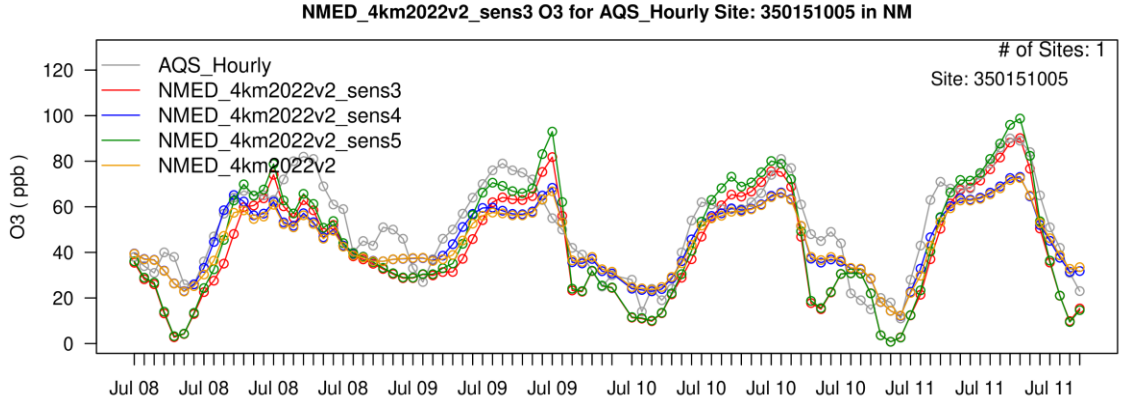
Carlsbad City NM PB O&G Sensitivities O_3 and NO_2

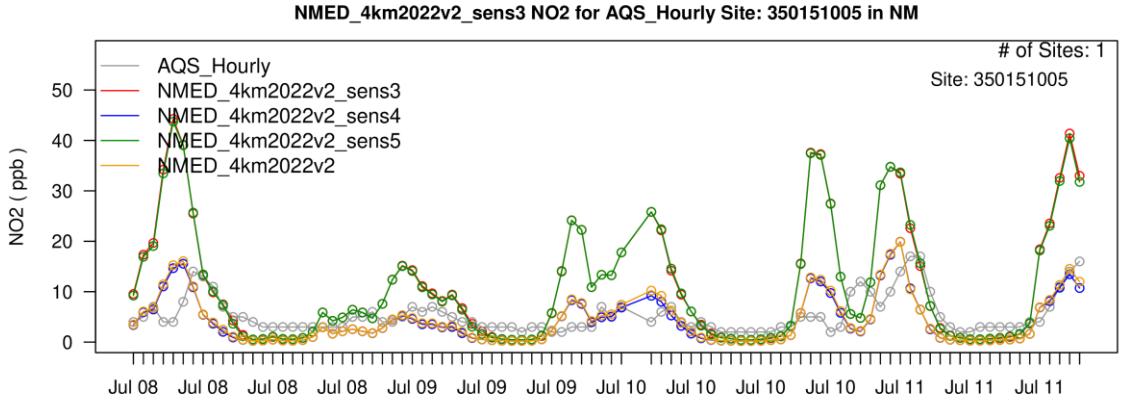
2022v2 Base Case; Sens3 3 x NO_X; Sens4 3 x VOC; Sens5 3 x NO_X & VOC

- Better ozone performance with 3 x NO_X O&G (**Sens3** and **Sens5**), but some NO_2 overestimation (3x to high?)
- **Sens5** produces lower nighttime ozone than the other tests. Ozone performance improves across the full concentration range, not just at the high end. Modeled afternoon NO_2 still lower than observed.
- 3 x VOC O&G (**Sens4**) has small effect on ozone (will show later that model understates VOC-sensitivity)



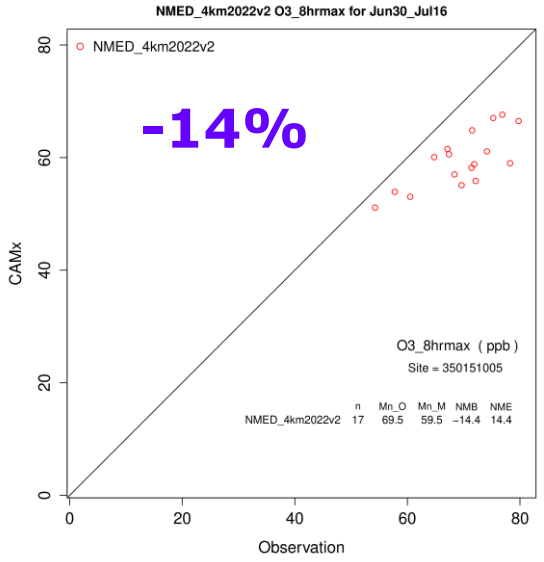


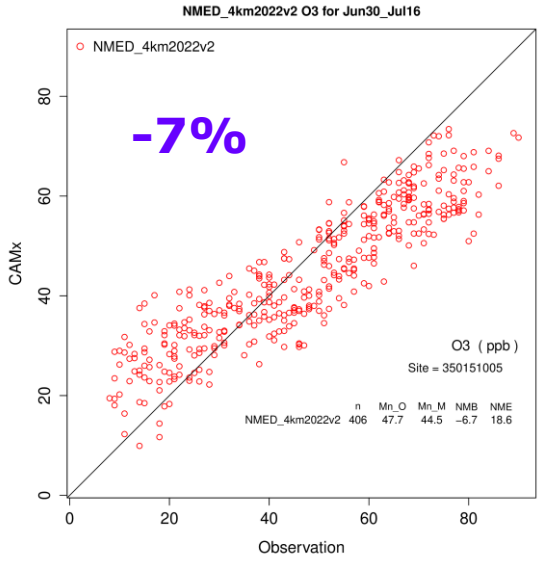




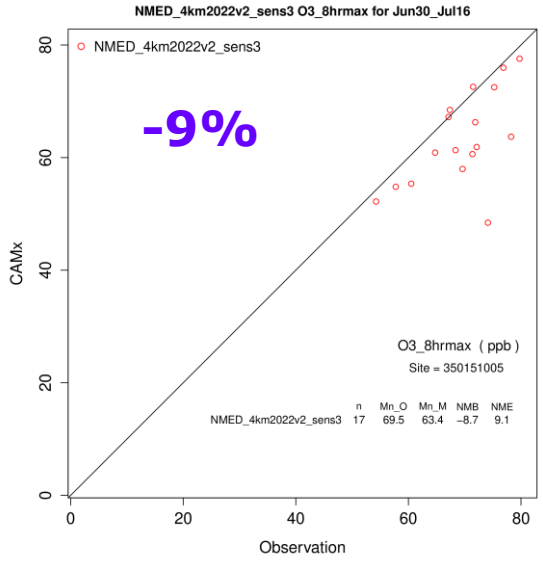
NM PB O&G: Carlsbad City MDA8 (Top) & Hourly (Bottom) O_3

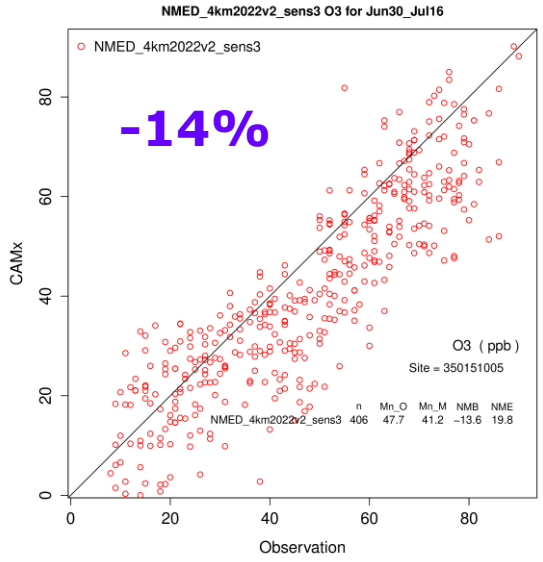
4km2022v2



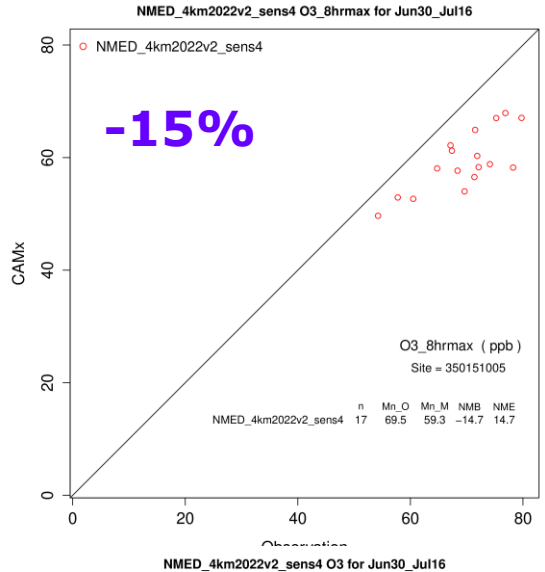


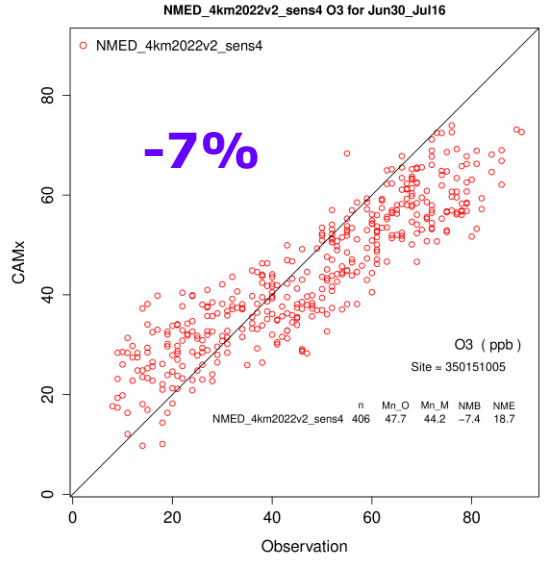
3 x NO_x O&G



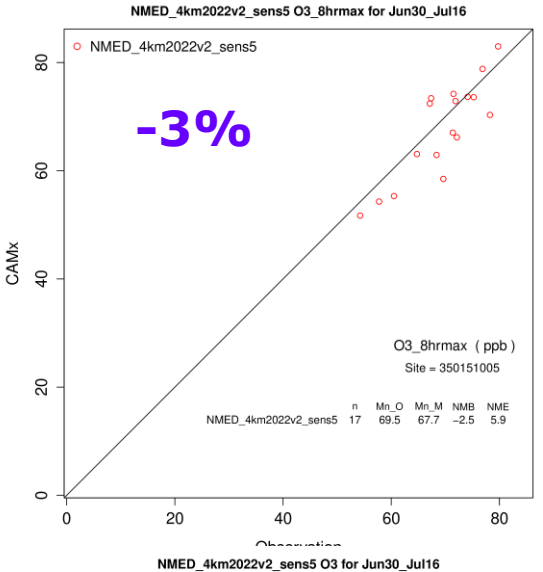


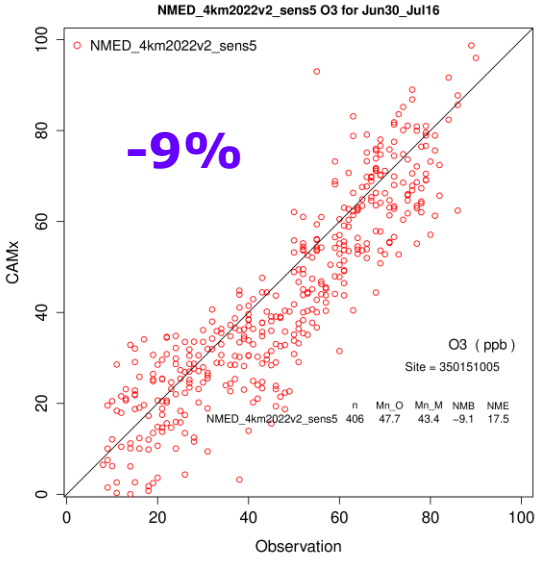
3 x VOC O&G





3 x NO_x & VOC O&G





LNM Oil and Gas Tracers – 2022v2 Base & Sens5 vs. Obs

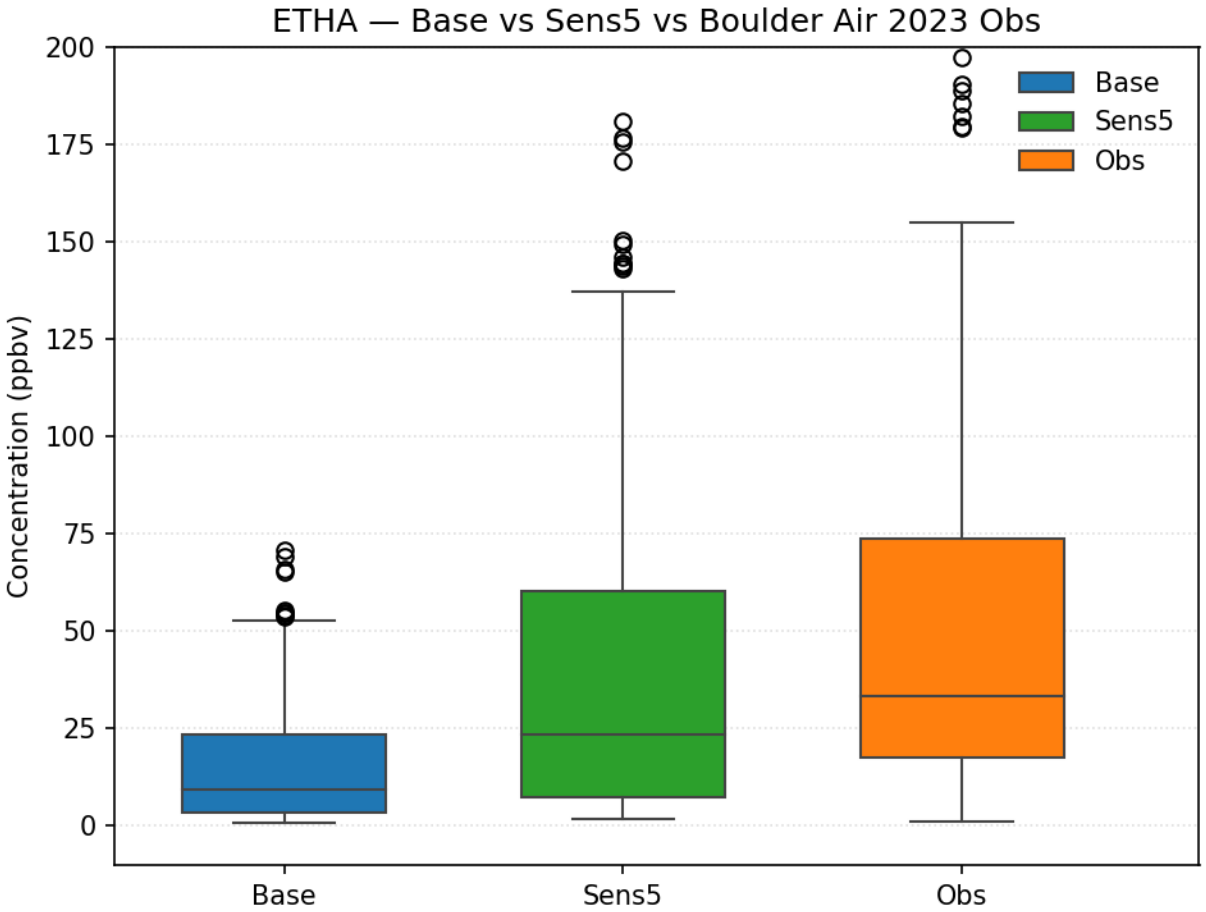
Even with 3 x NM Permian Basin O&G VOC emissions, model still underestimates ethane and propane

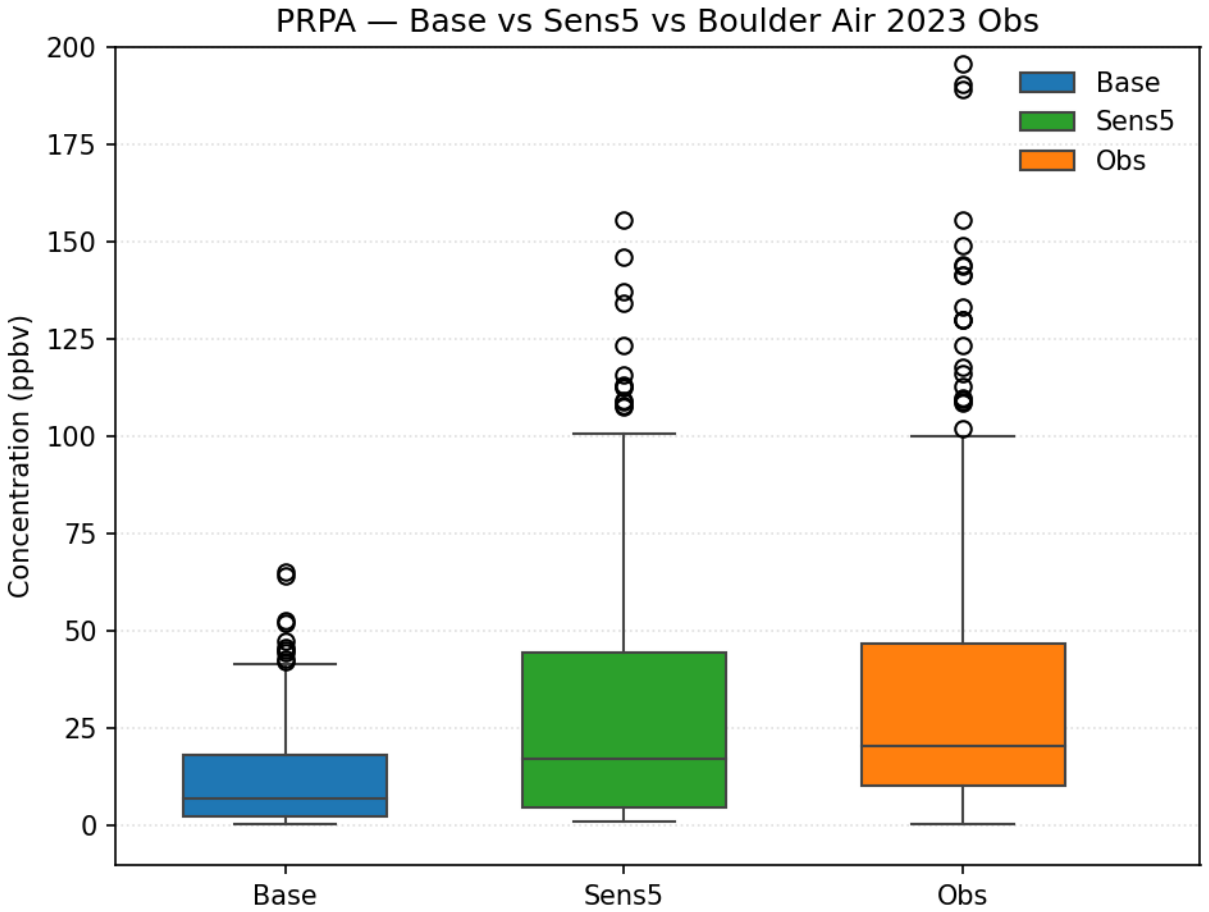
Ethane

- Median Underprediction: **1.4** times (33 vs 24 ppb)
- Mean Underprediction: **1.5** times (58 vs 39 ppb)

Propane

- Median Underprediction: **1.2** times (20 vs 17 ppb)
- Mean Underprediction: **1.2** times (36 vs 29 ppb)



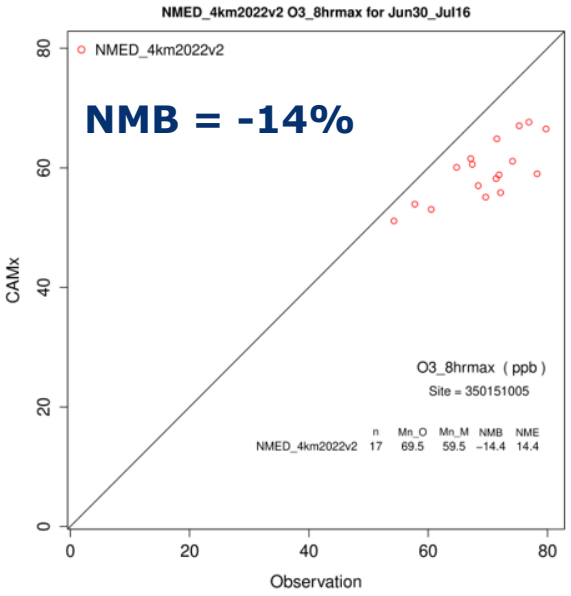


Sens7: 3 x Texas Permian Basin O&G NO_X and VOC

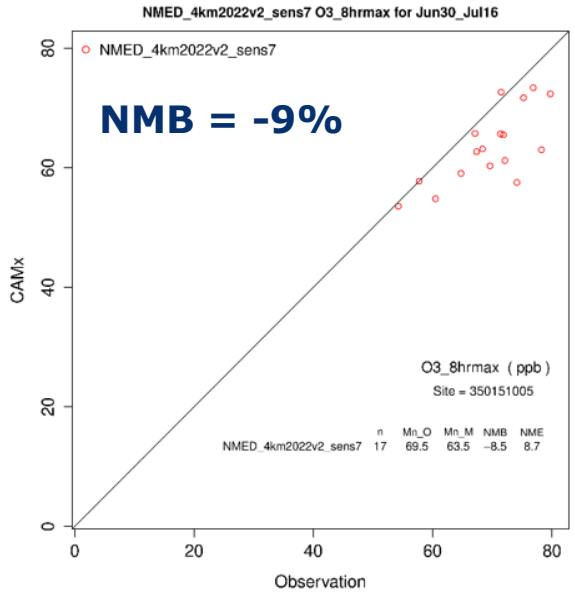
- Increase O&G NO_X and VOC in Texas Permian Basin improves ozone model performance
- Carlsbad City NMB from -14% to -9%; Hobbs NMB from -14% to -7%
- Missing O&G emissions from TX PB in 2022v2 platform may be part of the CAMx 2022v2 ozone underestimation issue

Carlsbad City, NM

2022v2 12/4 Base Case

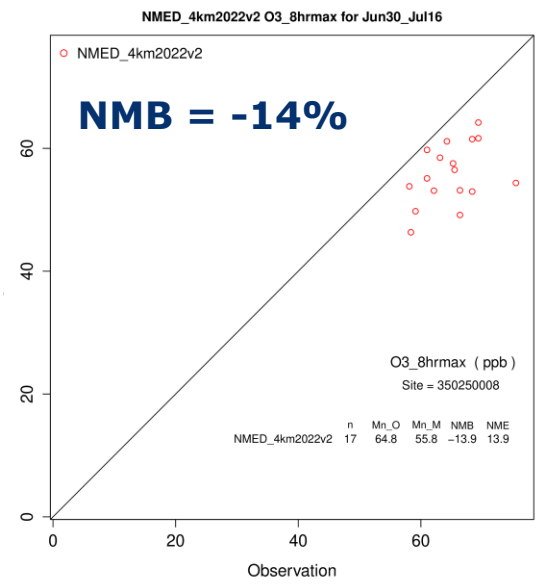


Sens7: 3 x TX PB O&G NO_X/VOC

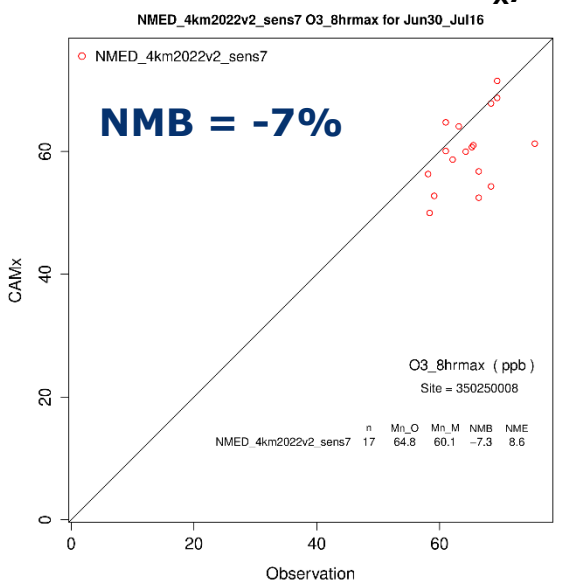


Hobbs, NM

2022v2 12/4 Base Case



Sens7: 3 x TX PB O&G NO_X/VOC



Assessment of NM and TX 3 x PB O&G NO_X and VOC

- Sens5 with 3 x NM PB O&G NO_X and VOC Emissions:
  - Much improved ozone performance
  - Reduced Ethane and Propane underestimation bias
    - Still have underestimation
  - Results in Benzene overestimation
  - Results in NO_X overestimation
- O&G sources of ethane and propane (and methane) different than primary sources of benzene and NO_X
  - HEI study conducted Receptor Modeling of Boulder AIR VOC measurements from Loving, New Mexico:
    - Ethane and Propane mainly from Venting
    - A majority of Benzene from Produced Water, Combustion and Traffic
    - NO_X from Combustion and Traffic
- Sens7 3 x TX PB O&G NO_X and VOC Emissions:
  - Improves Ozone, Ethane and Propane Performance

- VOC Receptor Modeling (NMF) Source Apportionment Modeling at Loving, New Mexico (Source: Franklin, et al., 2025; HEI Report No., 231, December 2025)

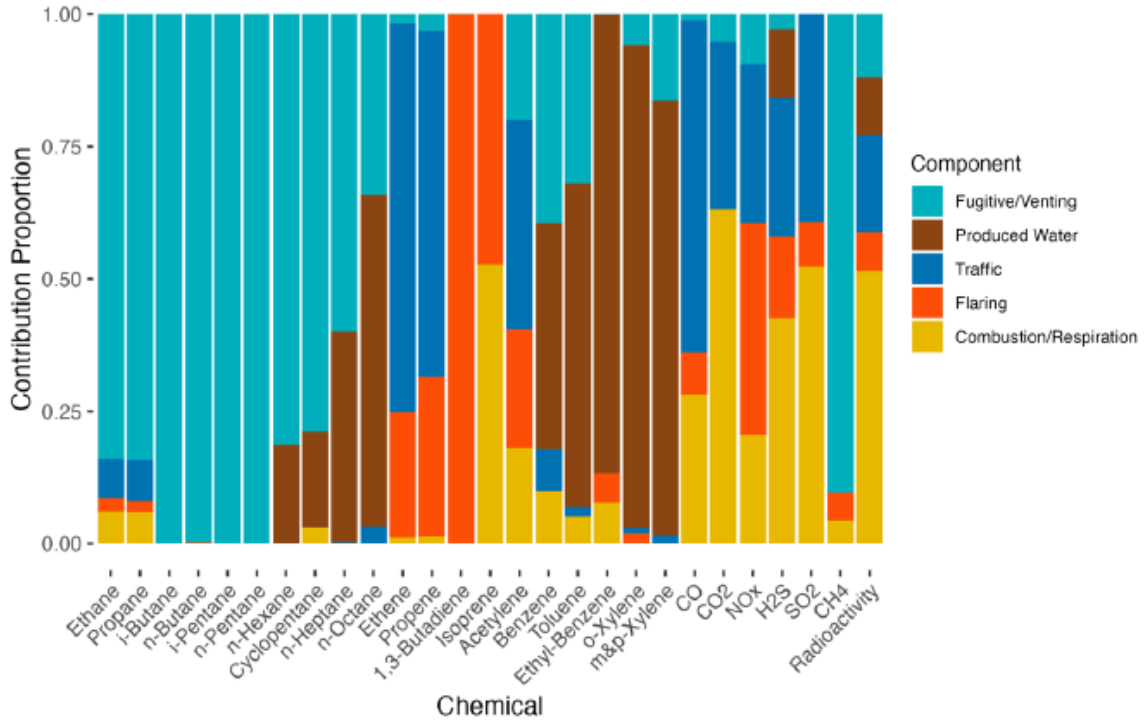


Figure 32. Contribution proportions of each compound to the five NMF-derived source factors at LNM.

Permian Basin O&G NO_X/VOC Sensitivity Tests

What we know about the emissions

Permian Basin O&G emissions in the 2022v2 are understated

- Reported and not reported excess emissions are not included in the 2022v2 emissions inventory
- This is a bigger issue for VOC than NO_X emissions

What sensitivity tests show

- The 3 x NM PB Basin O&G NO_X emissions produced better ozone model performance at the New Mexico Permian Basin ozone monitoring sites whether alone (Sens3) or with 3 x VOC (Sens5)
- 3 x NM PB O&G NO_X produced some NO_2 overestimation, but 3 x TX PB O&G NO_X does not
- 3 x NM PB O&G VOC much better performance for O&G tracers (ETHA and PRPA)
- 3 x NM or TX O&G NOX and VOC produce better ozone and ethane/propane model performance

Implications for future modeling

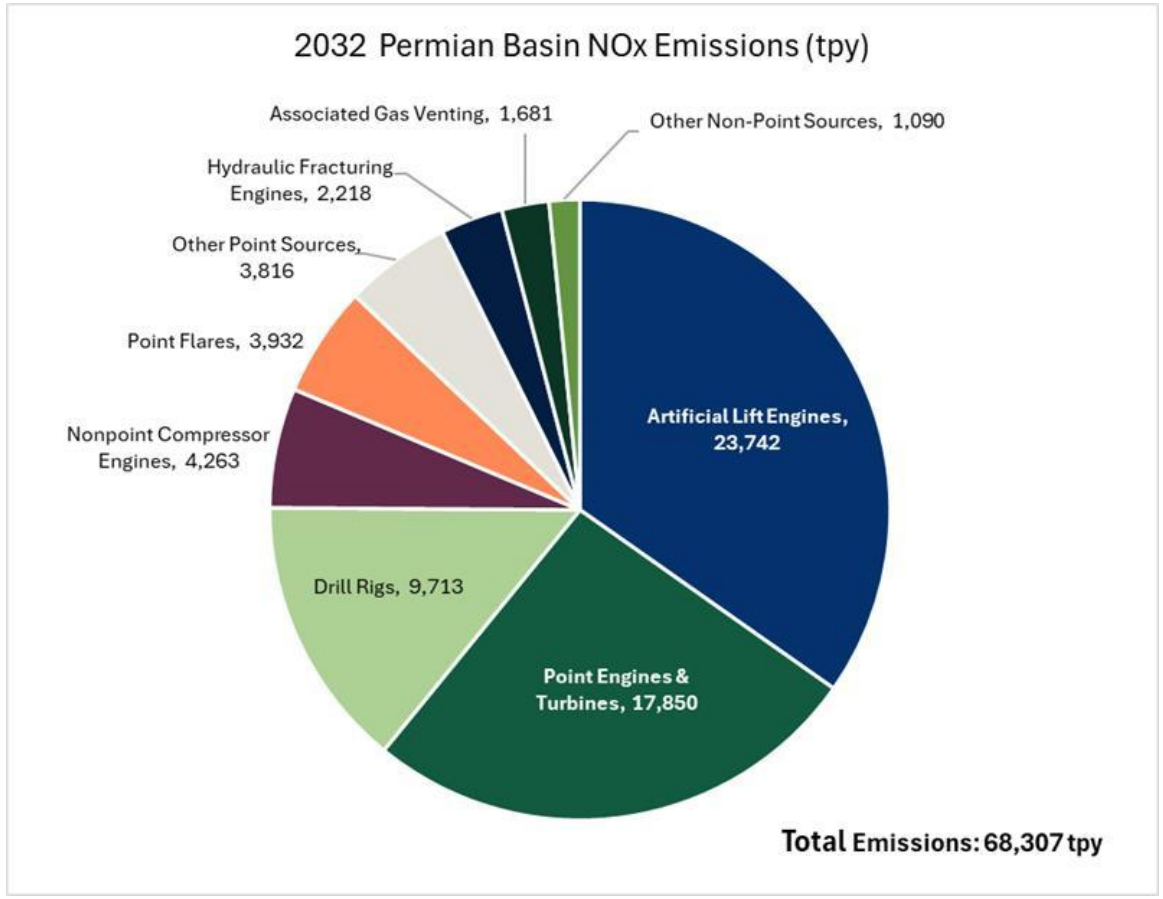
- Unclear how to use this information to improve the Permian Basin O&G emissions inventory
  - Could try and include the reported excess emissions in the emissions inventory; but that would be resource intensive, just a snapshot, and only represents part of the missing excess emissions
  - When interpreting the CAMx 2022v2 12/4 km modeling results, need to recognize that the Permian Basin O&G emission are understated

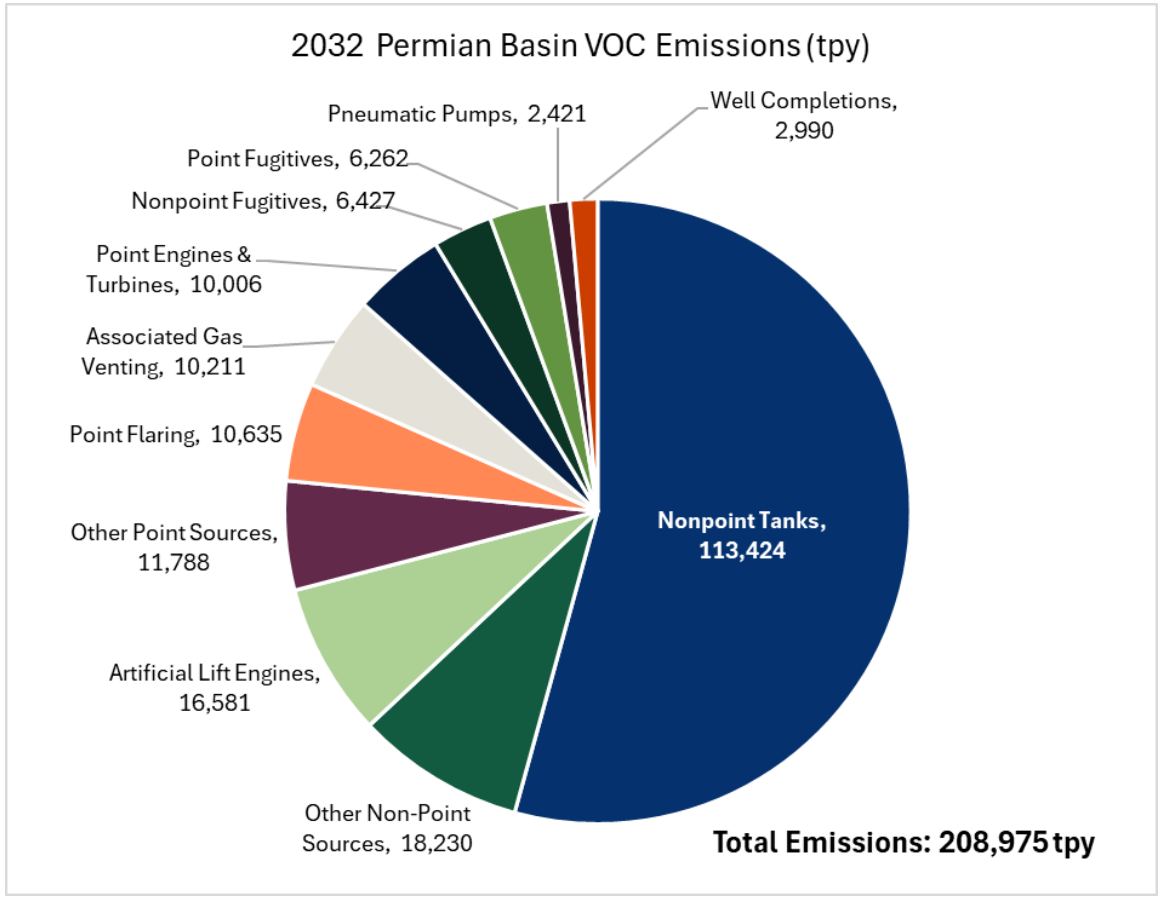
2032 Emissions Development

Development of 2032 O&G Emissions NM 4 km Domain

- 2032 Oil and Gas (O&G) emissions were developed for the New Mexico 4 km domain by projecting the 2022v2 EMP 2022 O&G emissions to 2032
  - NM and TX Permian Basin; South (NM) and North (CO) San Juan Basin
  - O&G Activity Changes (Growth and Decline):
    - Actual historical changes in O&G activity from 2022 to 2025
    - Forecasted O&G activity from 2025 to 2032 based on EIA 2025 Annual Energy Outlook (AEO2025)
  - Assume On-the-Book (OTB) control measures from 2022v1 2026 projections
    - Currently treating OOOOb/c O&G controls as OTB even though current Administration trying to rescind them

New Mexico Permian Basin 2032 O&G NO_X and VOC





Comparison of New Mexico 2022 and 2032 Emissions

	New Mexico					
Tons per Day (TPD)	**2022v2**	**2022v2**	**2032**	**2032**	**%Diff**	**%Diff**
Source Sector	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
EGU point	19.1	0.6	14.5	0.7	-23.9%	17.0%
Non-EGU point	7.1	5.5	6.7	5.5	-5.1%	-0.2%
O&G	265.9	963.7	287.1	713.4	8.0%	-26.0%
Rail	44.2	1.8	43.7	1.8	-1.2%	-1.7%
Non-Point	11.5	110.2	10.9	113.3	-5.6%	2.8%
Non-Road Mobile	11.9	13.9	8.1	13.3	-31.9%	-4.6%
On-Road Mobile	78.7	35.4	25.7	19.7	-67.3%	-44.3%
Airports	1.7	1.0	1.8	1.1	3.3%	5.7%
Anthro Total	***440.1***	***1132.0***	***398.5***	***868.7***	***-9.4%***	***-23.3%***
Fires	64.3	1872.6	64.3	1872.6	0.0%	0.0%
Biogenic	58.8	1567.6	58.8	1567.6	0.0%	0.0%
Natural Total	***123.1***	***3440.2***	***123.1***	***3440.2***	***0.0%***	***0.0%***

- 2022 to 2032 Change in Total New Mexico Emissions:
  - -9% in NO_X
  - -23% in VOC
- 2022 to 2032 Change in NM O&G:
  - +8% in NO_X
  - -26% in VOC
- Percent Total (Ant+Nat) is Natural:
  - 2022 NO_X = 22%
  - 2032 NO_X = 24%
  - 2022 VOC = 74%
  - 2032 VOC = 80%

Comparison of Texas Permian Basin 2022/2032 Emissions

Texas Permian Basin						
Tons per Day	**2022v2**	**2022v2**	**2032**	**2032**	**Difference (%)**	
Source Sector	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
EGU point	20.2	0.8	22.5	2.1	11.7%	166.2%
Non-EGU point	6.9	4.9	6.7	5.0	-3.1%	0.6%
O&G	302.9	2339.3	271.2	1109.3	-10.5%	-52.6%
Rail	13.3	0.6	13.2	0.5	-0.8%	-0.7%
Nonpoint	4.9	88.1	4.7	91.0	-4.8%	3.3%
Non-Road	13.9	9.3	9.4	8.7	-32.3%	-6.6%
On-Road	59.4	16.4	23.0	10.2	-61.3%	-37.8%
Airports	1.5	0.9	1.5	0.9	2.3%	2.7%
Anthro Total	***423.0***	***2460.3***	***352.3***	***1227.7***	***-16.7%***	***-50.1%***
Fires	3.6	28.8	3.6	28.8	0.0%	0.0%
Biogenic	112.6	1019.3	112.6	1019.3	0.0%	0.0%
Natural Total	***116.2***	***1048.1***	***116.2***	***1048.1***	***0.0%***	***0.0%***

- 2022 to 2032 Change in Total Texas PB Emissions:
  - -17% in NO_X
  - -50% in VOC
- 2022 to 2032 Change in TX PB O&G:
  - -11% in NO_X
  - -53% in VOC
- Percent Total (Ant+Nat) is Natural:
  - 2022 NO_X = 23%
  - 2032 NO_X = 25%
  - 2022 VOC = 30%
  - 2032 VOC = 46%

2032 Ozone Design Value Projections

2032 Ozone Design Value Projections

- Software for the Modeled Attainment Test (SMAT-CE) follows EPA guidance (EPA, 2018) to make ozone Design Value projections
  - Use CAMx 2022 and 2032 ozone modeling results in a relative fashion to scale (RRF) the observed 2020-2024 base year ozone Design Value ($DVB_{2020\text{-}2024}$) to project 2032 future year ozone DVF_{2032}

$$\mathbf{RRF = \Sigma\ Model\text{-}Ozone_{2032}\ /\ \Sigma\ Model\text{-}Ozone_{2022}}$$

$$\mathbf{DVB_{2020\text{-}2024} = (DV_{2020\text{-}2022} + DV_{2021\text{-}2023} + DV_{2022\text{-}2024})\ /\ 3}$$

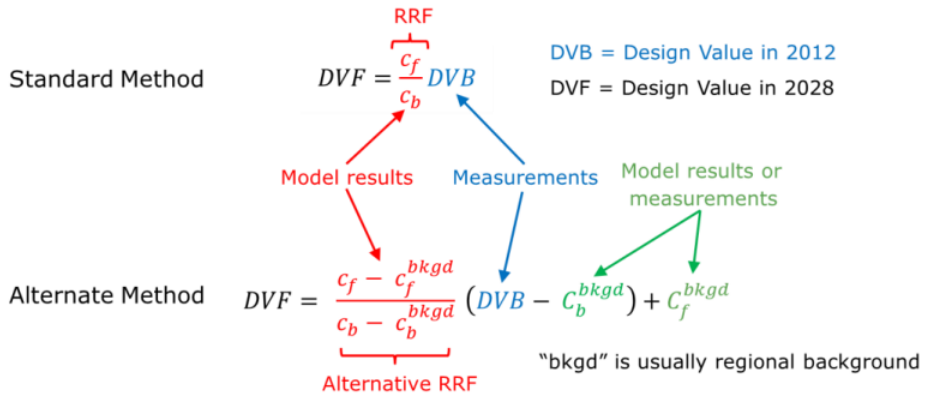
$$\mathbf{DVF_{2032} = RRF\ x\ DVB_{2020\text{-}2024}}$$

  - SMAT-CE includes an Unmonitored Area Analysis (UAA) that spatially interpolates the observed 2020-2024 ozone DVB and makes 2032 ozone DVF projections across the domain

  - SMAT-CE used to make 2032 ozone DVF projections using CAMx modeling results two ways: (1) May through September 2022; and (2) June 10 through August 15, 2022

Alternative 2032 Ozone Design Value Projections

- Adapt approach developed in CRC Project A-122 that uses anthropogenic ozone DVB increments (without ozone background) to project future year ozone DVFs:



- Account for understated ozone due to missing Permian Basin O&G emissions by decomposing observed 2020-2024 ozone DVB into a Local (i.e., Permian Basin O&G) and Non-Local components and use CAMx 2022 and 2032 Local Source ozone source apportionment results to project 2032 ozone DVF:

2020-2024 DVB = DVB_{Local} + $DVB_{Non\text{-}Local}$

2032 DVF = RRF_{Local} x DVB_{Local} + $RRF_{Non\text{-}Local}$ x $DVB_{Non\text{-}Local}$

Ozone $DVB_{2020\text{-}2024}$ and Projected DVF_{2032} using Jun-Aug

- 7 NM sites have ozone $DVB_{2020\text{-}2024}$ above the 70 ppb 2015 NAAQS
- 4 NM sites have ozone $DVB_{2020\text{-}2024}$ above the 75 ppb 2008 NAAQS
- 4 NM sites have projected 2032 ozone DVF_{2032} above 2015 NAAQS:
  - 75.1 ppb Carlsbad Caverns, Eddy County
  - 74.3 ppb Carlsbad City, Eddy County
  - 72.7 ppb Desert View, Dona Ana County
  - 71.4 ppb La Union, Dona Ana County

Jun-Aug		2020-24	2032					
Name	Site ID	DVB	DVF	RRF	Low	#Day	State	County
Carlsbad Caverns	350150010	78.3	75.1	0.9595	60	10	New Mexico	Eddy
Carlsbad City	350151005	78.0	74.3	0.9532	61	10	New Mexico	Eddy
Hobbs	350250008	69.7	65.9	0.9469	60	5	New Mexico	Lea
La Union	350130008	76.0	71.4	0.9397	62	10	New Mexico	Doña Ana
Chaparral	350130020	70.3	65.6	0.9341	60	7	New Mexico	Doña Ana
Desert View	350130021	77.3	72.7	0.9417	62	10	New Mexico	Doña Ana
Santa Teresa	350130022	73.5	68.5	0.9326	61	10	New Mexico	Doña Ana
Solano	350130023	67.3	64.2	0.9549	60	5	New Mexico	Doña Ana
Ivanhoe	481410029	64.3	61.7	0.9608	61	10	Texas	El Paso
El Paso Chamizal	481410044	69.0	65.7	0.9532	60	10	Texas	El Paso
Ascarate Park SE	481410055	70.0	66.9	0.9559	61	10	Texas	El Paso
Socorro Hueco	481410057	71.7	68.4	0.9546	61	10	Texas	El Paso
Skyline Park	481410058	70.3	65.8	0.9368	61	10	Texas	El Paso
Del Norte	350010023	69.7	66.4	0.9527	60	10	New Mexico	Bernalillo
South Valley	350010029	66.0	63.2	0.958	60	6	New Mexico	Bernalillo
Foot Hills	350011012	72.3	68.6	0.9495	61	10	New Mexico	Bernalillo
Bernalillo	350431001	68.3	65.3	0.957	61	10	New Mexico	Sandoval
Bloomfield	350450009	65.3	62.8	0.9629	61	10	New Mexico	San Juan
Navajo Lake	350450018	69.3	66.0	0.9533	60	10	New Mexico	San Juan
Sub Station	350451005	67.0	65.3	0.9754	60	8	New Mexico	San Juan
Shamrock	80671004	64.0	60.9	0.952	60	9	Colorado	La Plata
Ignacio	80677001	66.3	61.6	0.9305	61	10	Colorado	La Plata
Bondad	80677003	66.0	61.3	0.9298	62	10	Colorado	La Plata
Cortez	80830006	62.3	61.1	0.9813	60	6	Colorado	Montezuma

Projected 2032 Ozone using Alternative Approach

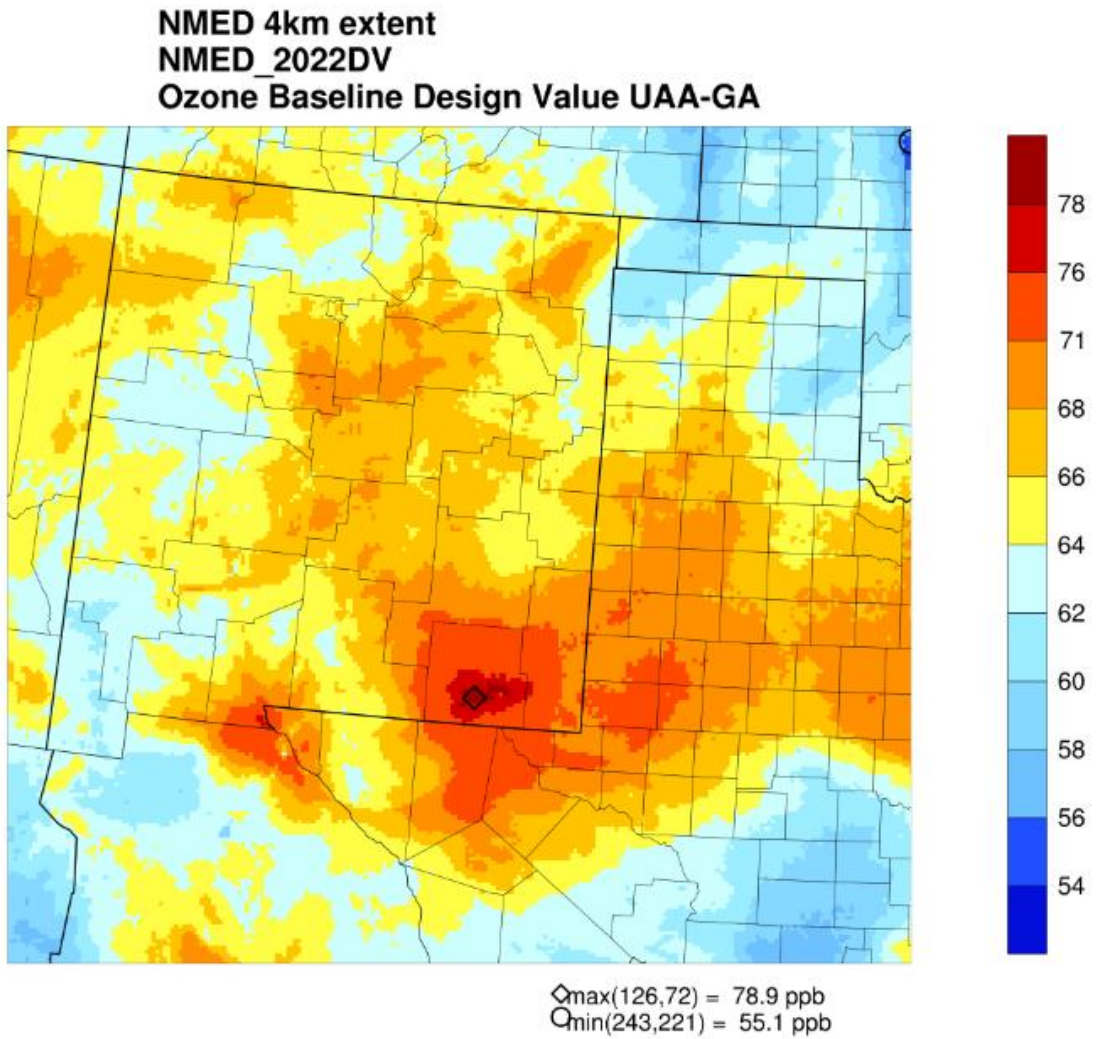
- Use CAMx 2022 Local Source ozone source apportionment to adjust New Mexico plus Texas Permian Basin O&G ozone contributions two ways was to eliminate CAMx underestimation bias at New Mexico Permian Basin sites:
  - ➢ Alternative #1 = Increase NM&TX PB O&G ozone contributions so that Total 2022 MDA8 Ozone averaged across the 10 SMAT days match the observed 2020-2024 ozone DVB
  - ➢ Alternative#2 = Increase NM&TX PB O&G 2022 ozone contributions to eliminate the underestimation bias between the 2022 MDA8 ozone observed and 2022 MDA8 ozone modeled averaged across top 10 days

Monitoring Site	Observed 2020-2024 Ozone DVB	SMAT-CE Full Model Period	SMAT-CE June 10 - August 15	Alternative#1 10 SMAT Days $DVB_{Non-Local}$	Alternatuve#2 Adjust Ozone MPE DVB_{Local}
Carlsbad City	78.0	77.0	75.1	74.1	74.0
Carlsbad Caverns	78.3	76.4	74.3	75.3	75.3
Hobbs	69.7	68.3	65.9	65.9	65.9

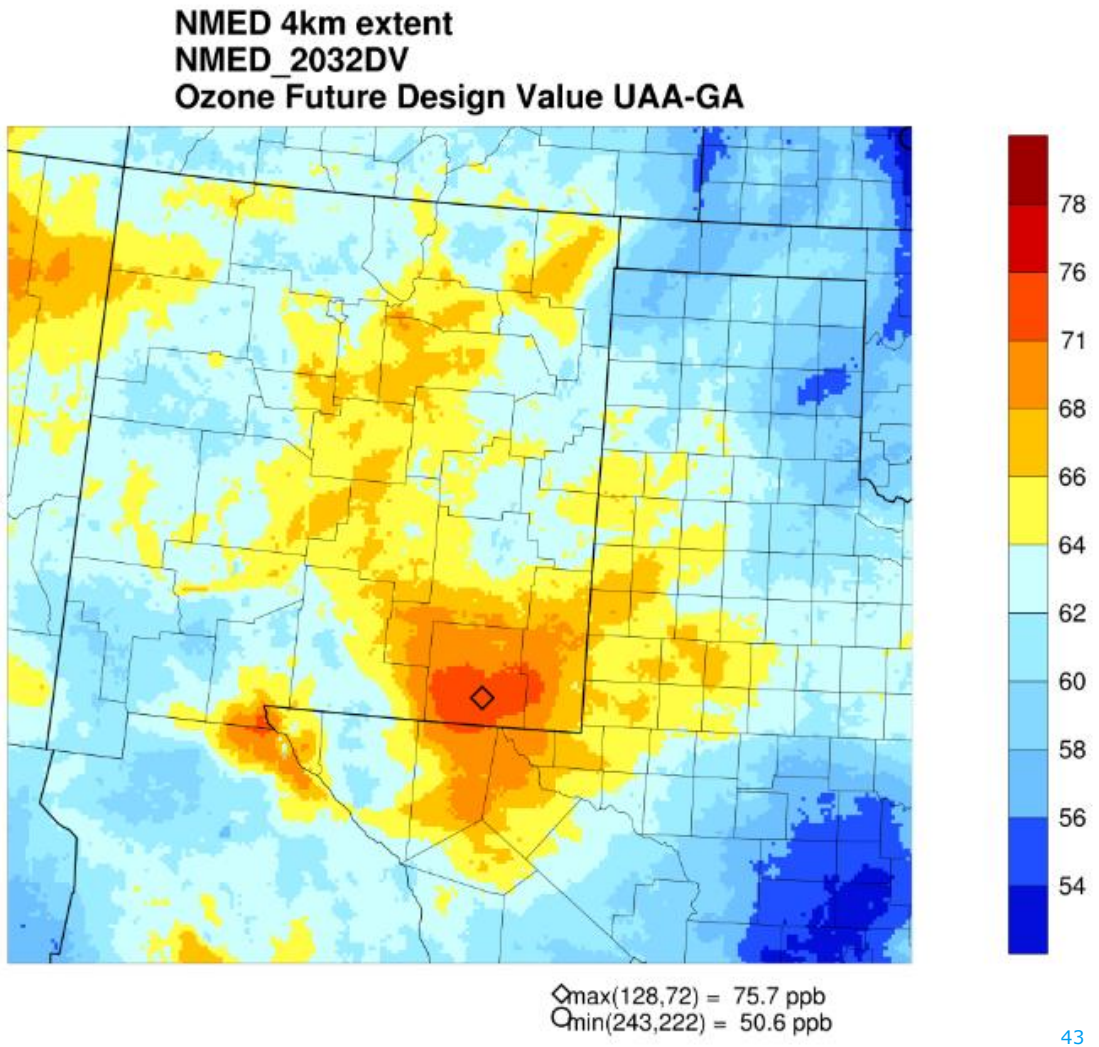
- Using the full (May-Oct) episode with SMAT-CE to projected 2032 ozone DVFs very stiff with small ozone reductions due to MDA8 ozone on May-June days dominated by BCs
- The three methods (SMAT-CE and Two Alternative) to make 2032 DVF projections using the June 10 – August 15, 2022 modeling results produce 2032 DVFs within 1 ppb of each other

SMAT UAA 2020-2024 DVF and 2032 DVF (Jun-Aug)

2020-2024 Ozone DVB



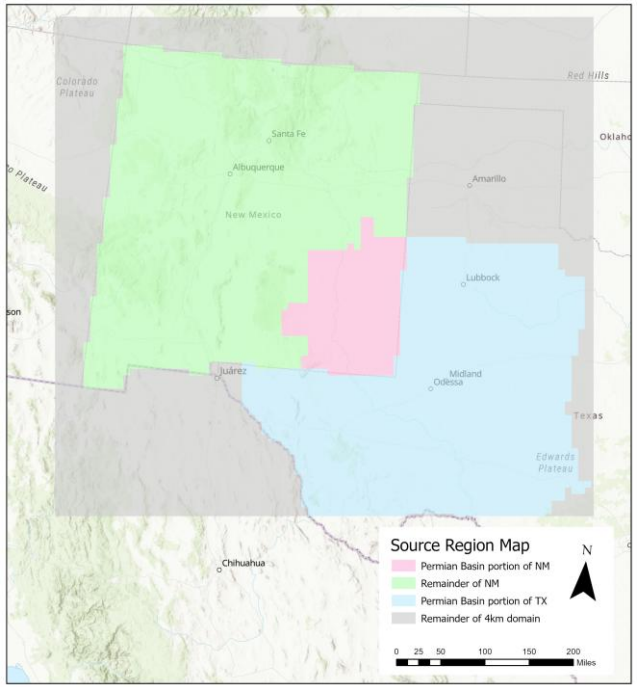
2032 Ozone DVF

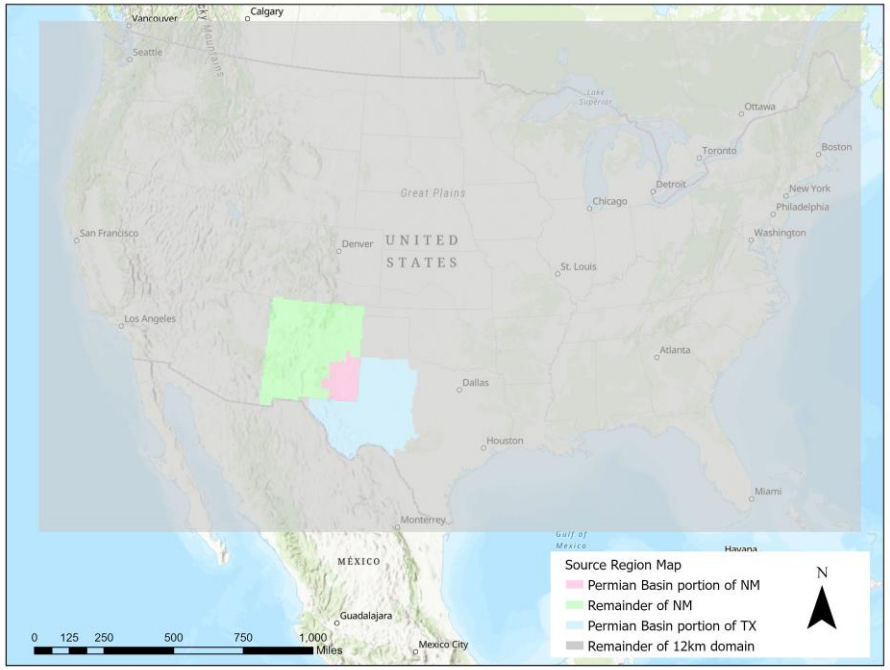


2022 and 2032 Local Source Ozone Source Apportionment Modeling

Local Source Ozone Source Apportionment Modeling

- **June 1 – August 15, 2022** Modeling Period and **2022 and 2032** Emission Years (2 Runs)
  - Although some high ozone in May 2022, Phase I CAMx 2026v1 12 km ozone source apportionment modeling showed it was mainly due to international emissions (i.e., BCs)
- **Four Source Regions** focusing on Permian Basin and New Mexico: (1) New Mexico Permian Basin; (2) Remainder New Mexico; (3) Texas Permian Basin; and (4) Remainder 12/4 km domain
- **Ten Source Categories**:
  1. Natural (Biogenic + LNOx)
  2. Fires
  3. O&G Pre-Production
  4. O&G Production
  5. O&G Midstream
  6. EGU Point
  7. Non-EGU Point
  8. On-Road Mobile
  9. Non-Road Mobile
  10. Remainder Anthropogenic

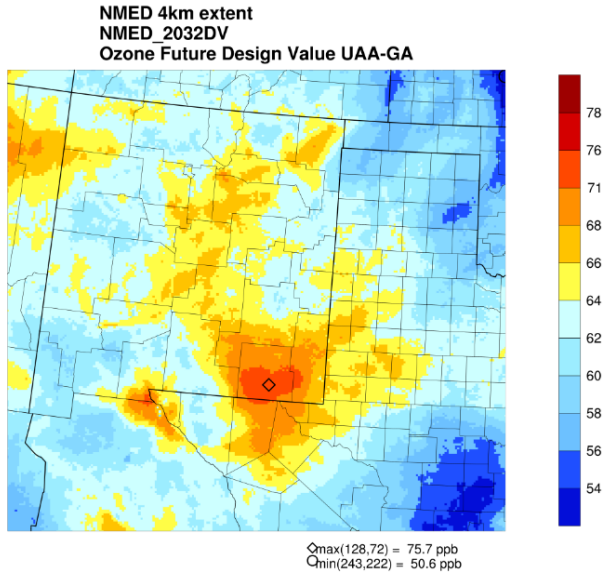




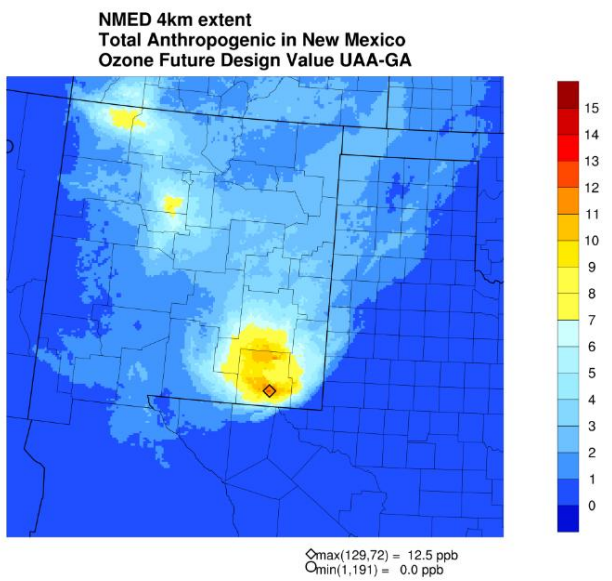
- Results in separate ozone contributions from 42 Source Groups (= 4 x 10 + 2) (simulation takes ~2 weeks elapsed time)

Local Source: Source Sector Contributions to 2032 DVF

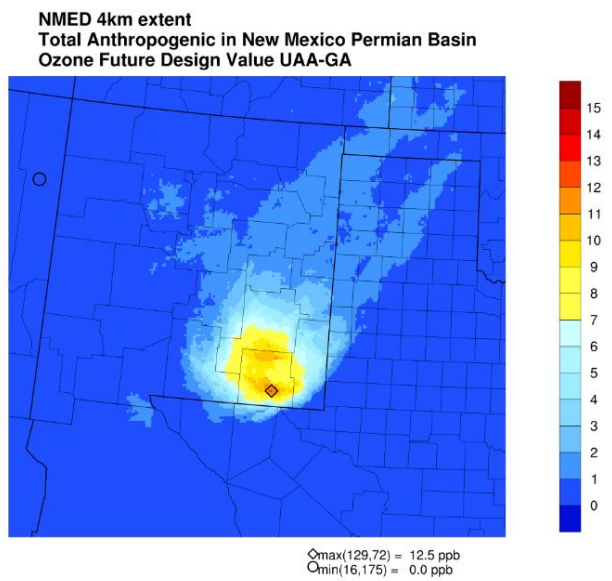
2032 DVF - 75.7 ppb



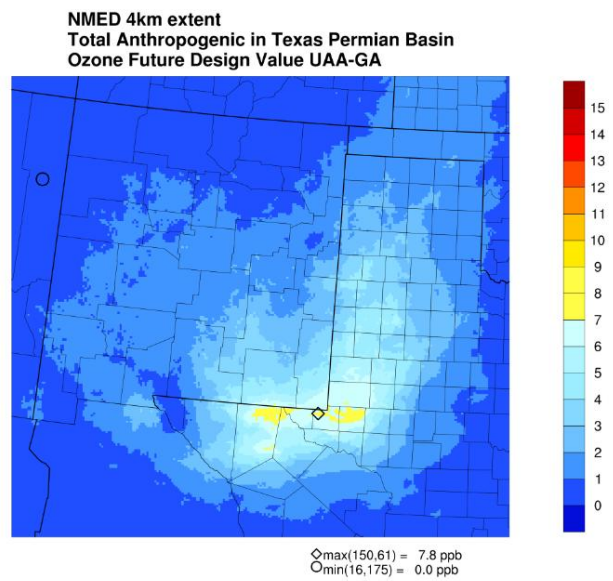
NM Anthro - 12.5 ppb



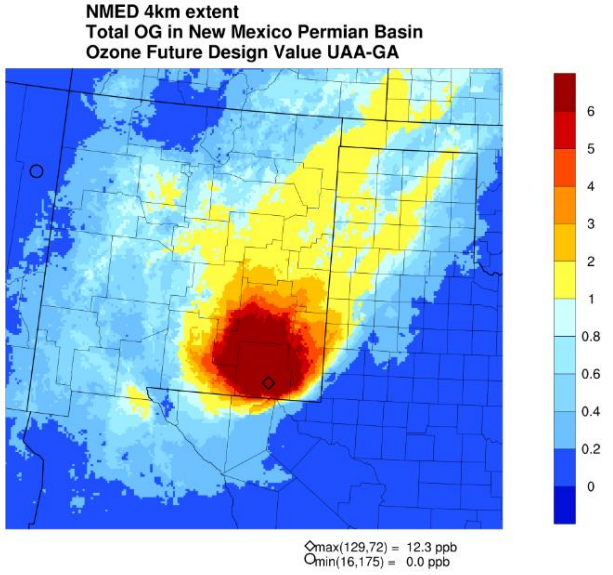
NM PB Anthro – 12.5 ppb



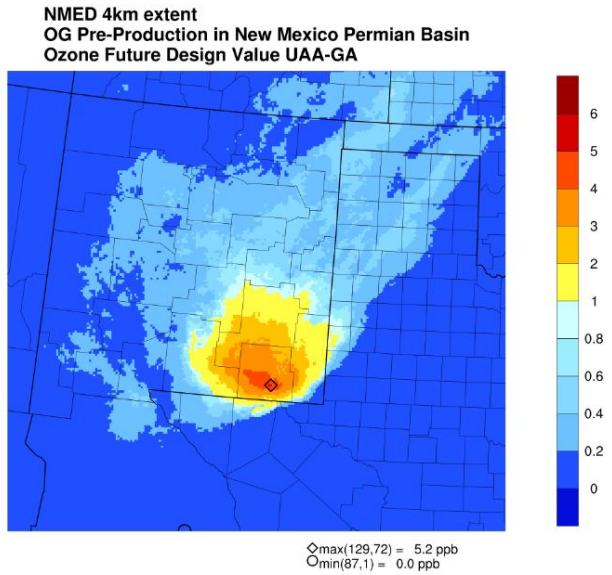
TX PB Anthro – 7.8 ppb



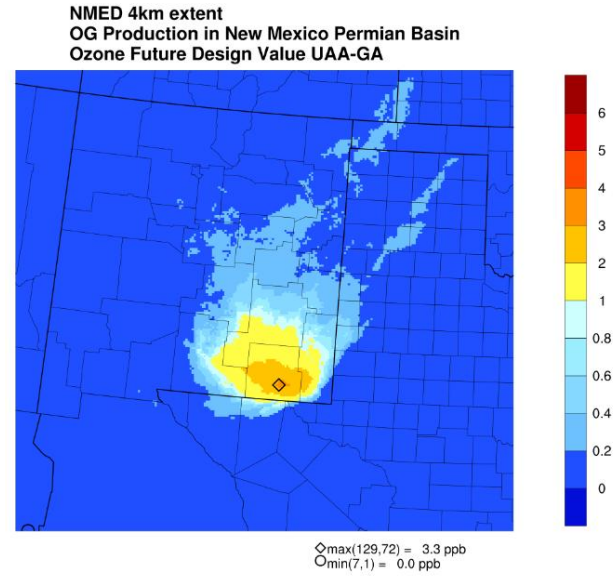
NM PB O&G – 12.3 ppb



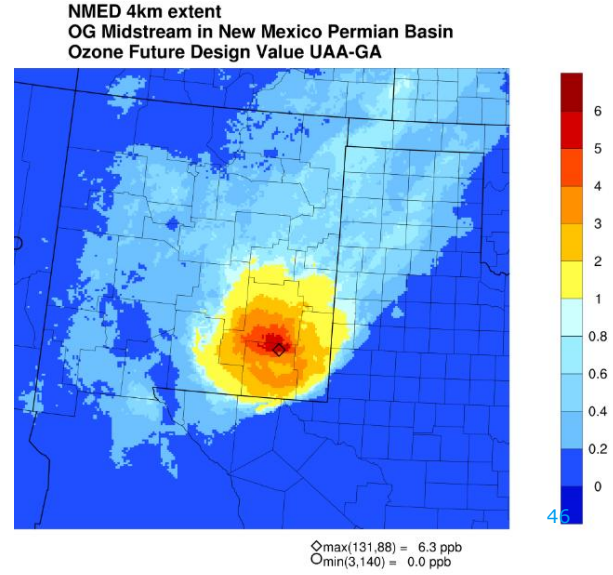
Pre-Production – 5.2 ppb



Production – 3.3 ppb

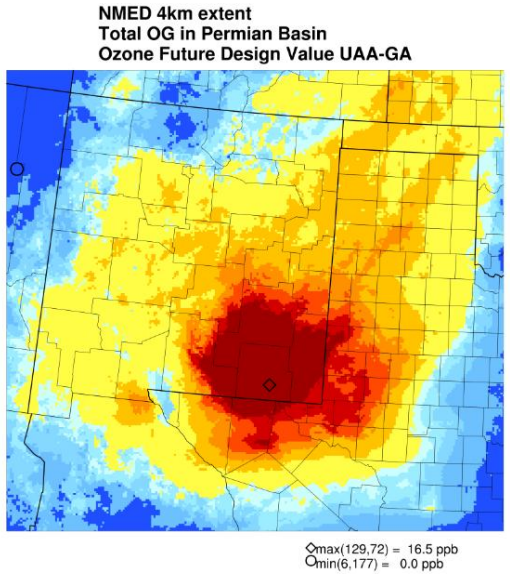


Midstream – 6.3 ppb

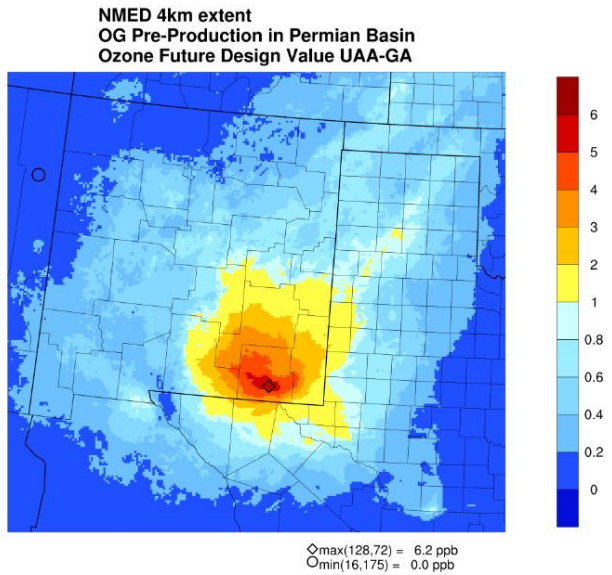


Local Source: Source Sector Contributions to 2032 DVF

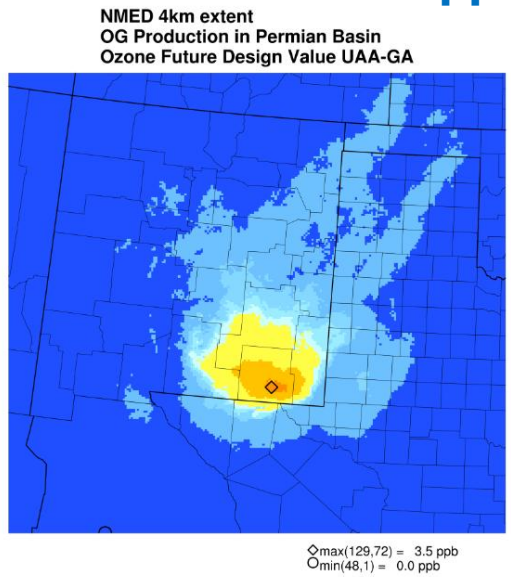
NM&TX PB O&G – 16.5 ppb



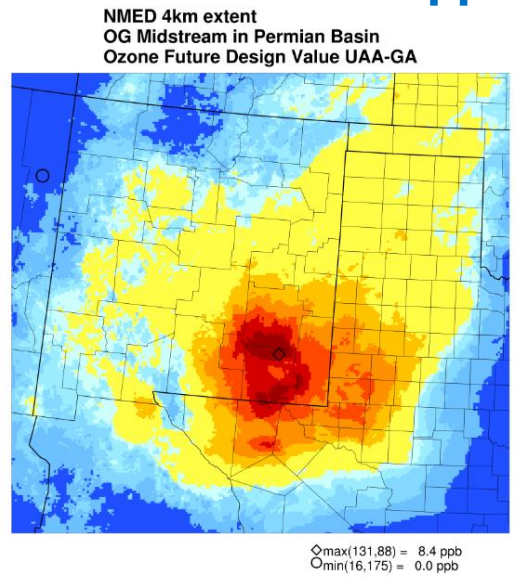
Pre-Production – 5.2 ppb



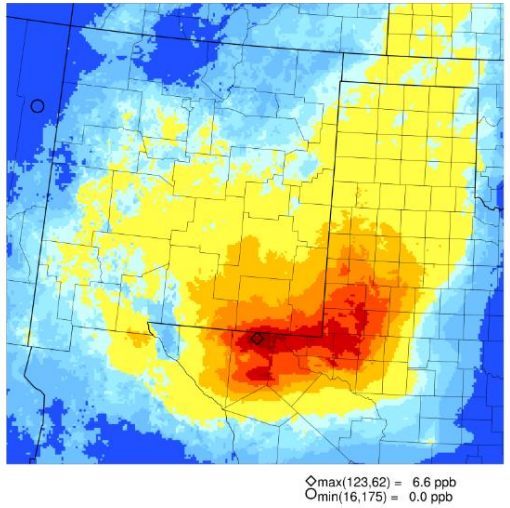
Production – 3.5 ppb



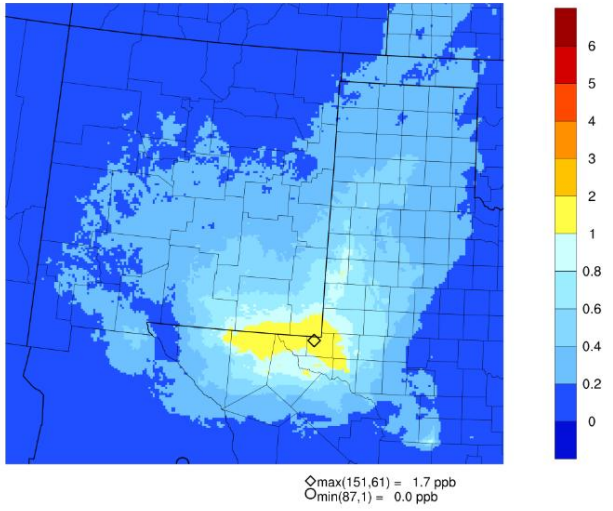
Midstream – 8.4 ppb



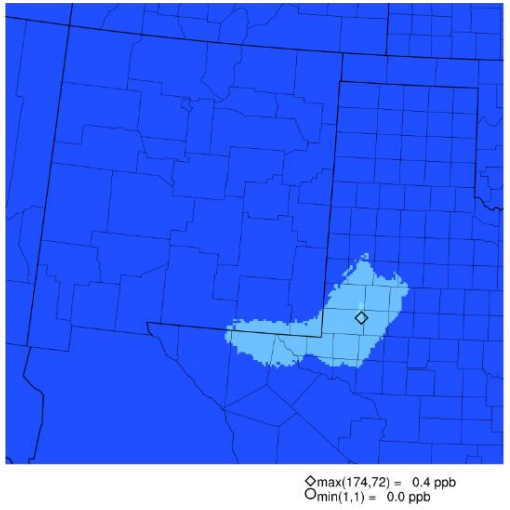
TX PB O&G – 6.6 ppb



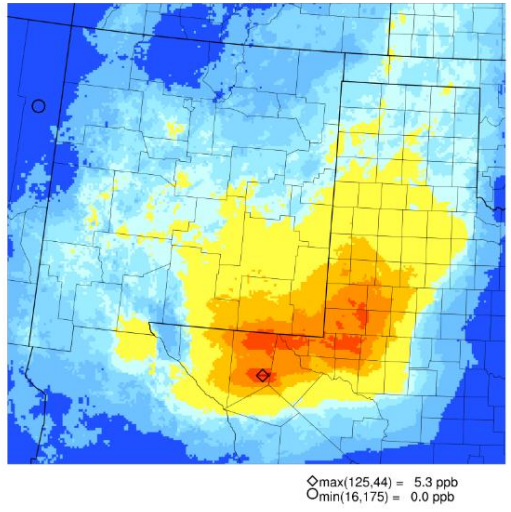
Pre-Production – 1.7 ppb



Production – 0.4 ppb



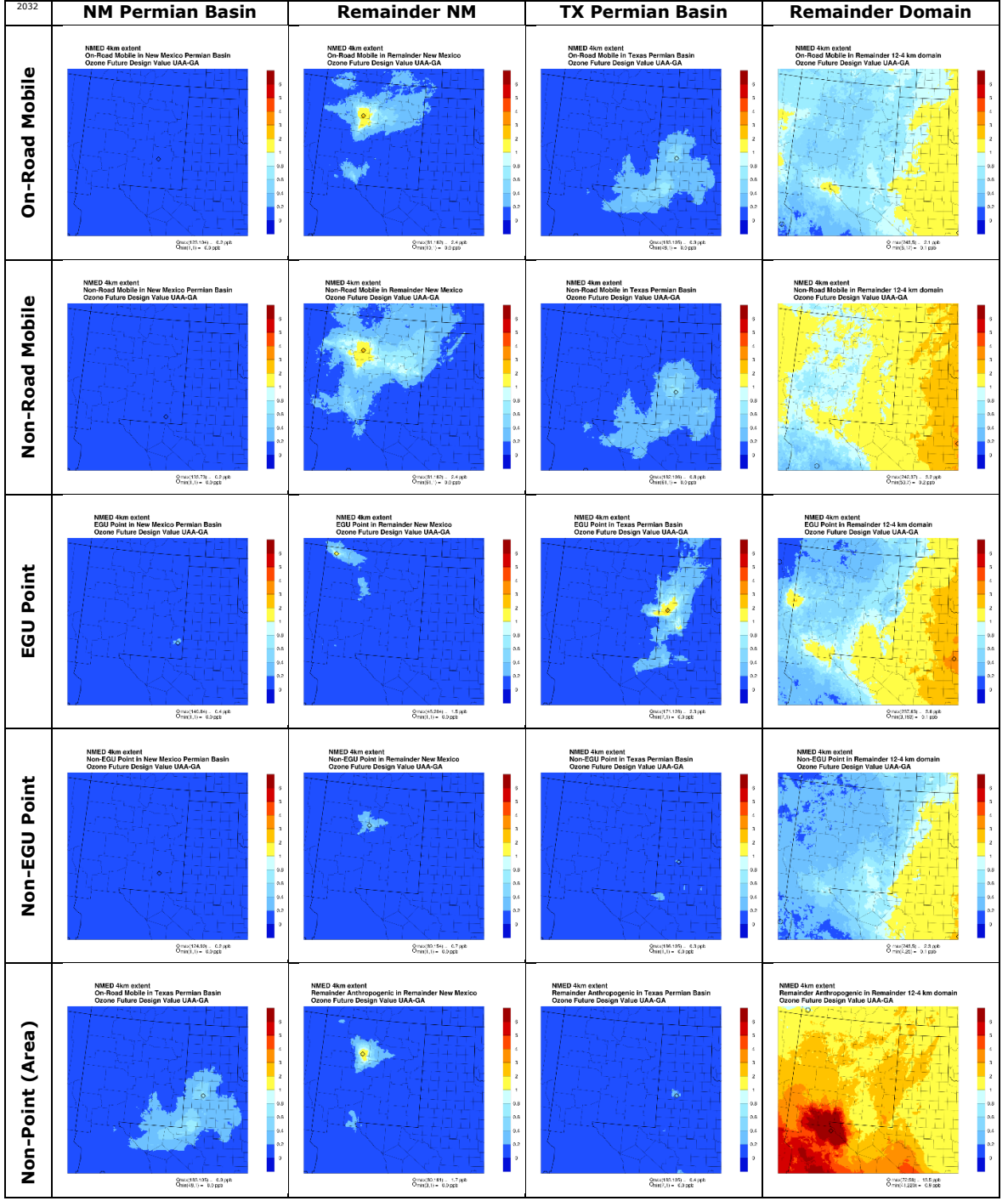
Midstream – 5.3 ppb



Local Source: Source Sector Contributions to 2032 DVF

- Maximum contribution to 2020-2024 ozone DVB and 2032 ozone DVF

Source	NM Permian Basin		Remainder NM		TX Permian Basin	
Sector Sector	2020-4 DVB	2032 DVF	2020-4 DVB	2032 DVF	2020-4 DVB	2032 DVF
Oil & Gas	12.4	12.3	7.5	7.4	7.7	6.6
On-Road	0.8	0.2	4.8	2.4	2.4	0.9
Non-Road	0.3	0.2	2.4	2.4	1.1	0.8
EGU Point	0.8	0.4	2.2	1.5	2.9	2.3
Non-EGU Pt	0.2	0.2	0.7	0.7	0.5	0.3
Non-Point	0.2	0.1	1.6	1.7	0.4	0.4



Local Source: Contributions to MDA8 Ozone at Monitors

- CAMx 2022 and 2032 Local Source ozone source apportionment MDA8 ozone contributions were extracted at the monitoring sites and loaded into Excel Dashboards where the user can drill down and displays stack bard charts and pit charts of Source Region and Source Category contributions to 2022 or 2032 MDA8 ozone concentrations at the user-selected monitoring site and days.
- The Source Region and Source Category naming convention used in the Dashboards are as follows:

Source Regions

A. **BCD**: Boundary Conditions
B. **NMPB**: New Mexico portion of the Permian Basin
C. **NMRE**: Remainder New Mexico
D. **REMD**: Remainder 12/4 km Domains
E. **TXPB**: Texas portion of the Permian Basin

Source Categories

1. **BCD**: Boundary Conditions
2. **EGU**: Eletrical Generating Units
3. **FIR**: Fires
4. **NAT**: Natural (Biogenic + LNOx)
5. **NEG**: Non-EGU Point
6. **NON**: Nonroad Mobile
7. **OGD**: Pre-Production O&G
8. **OGM**: Midstream O&G
9. **OGP**: Production O&G
10. **ONR**: On-Road Mobile
11. **REA**: Remainder Anthropogenic

- There are three Dashboards: one for 2022 and one for 2032 for all New Mexico monitoring sites and one for the three New Mexico Permian Basin monitoring sites where the Permian Basin (NM&TX) O&G ozone contributions have been adjusted upward to account for understated ozone contributions.

Example Local Source 2022 Dashboard for Carlsbad City

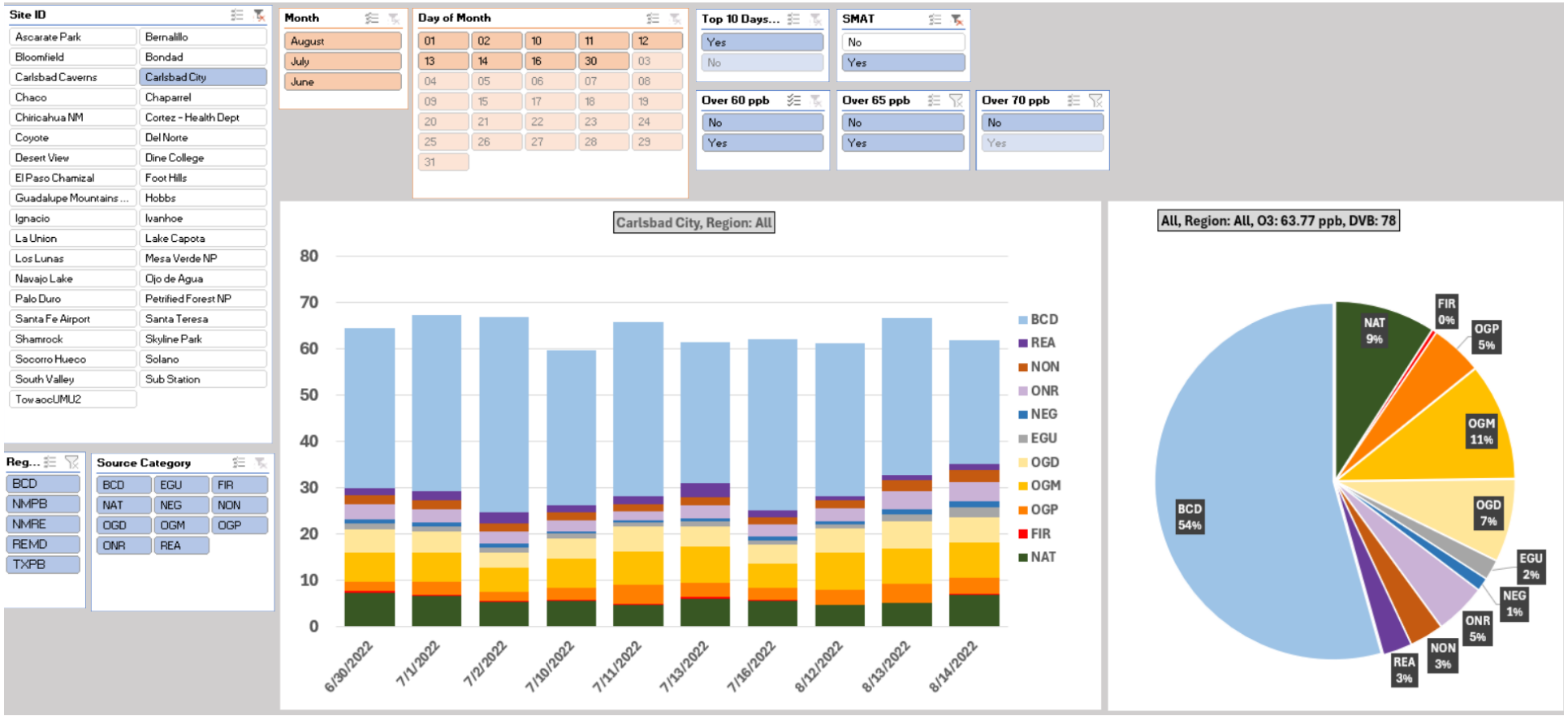
- Left Selection Panels: Monitoring Site; Source Regions; and Source Categories
- Top Selection Panels: Used to select days. Top 10 Days; Over 60, 65 and 70 ppb. User defined.

Days

Sites

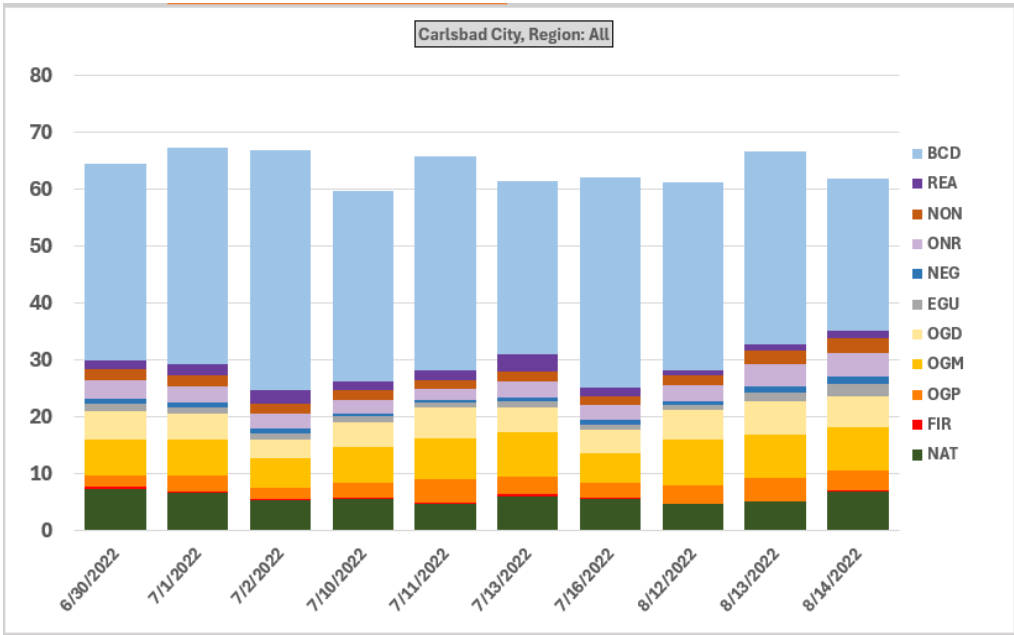
Regions

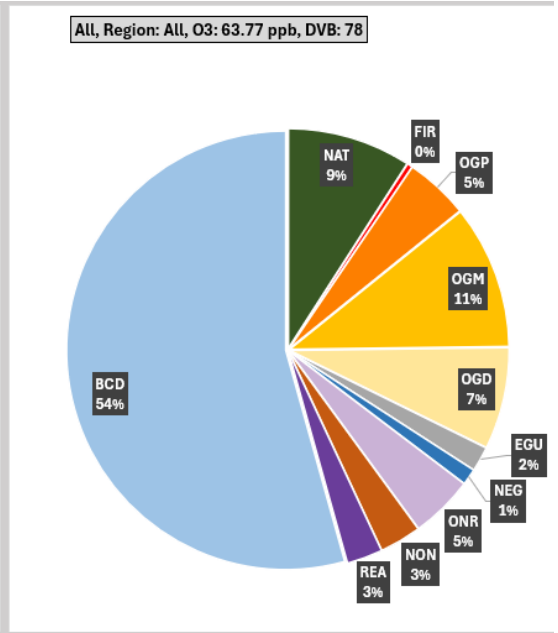
Categories

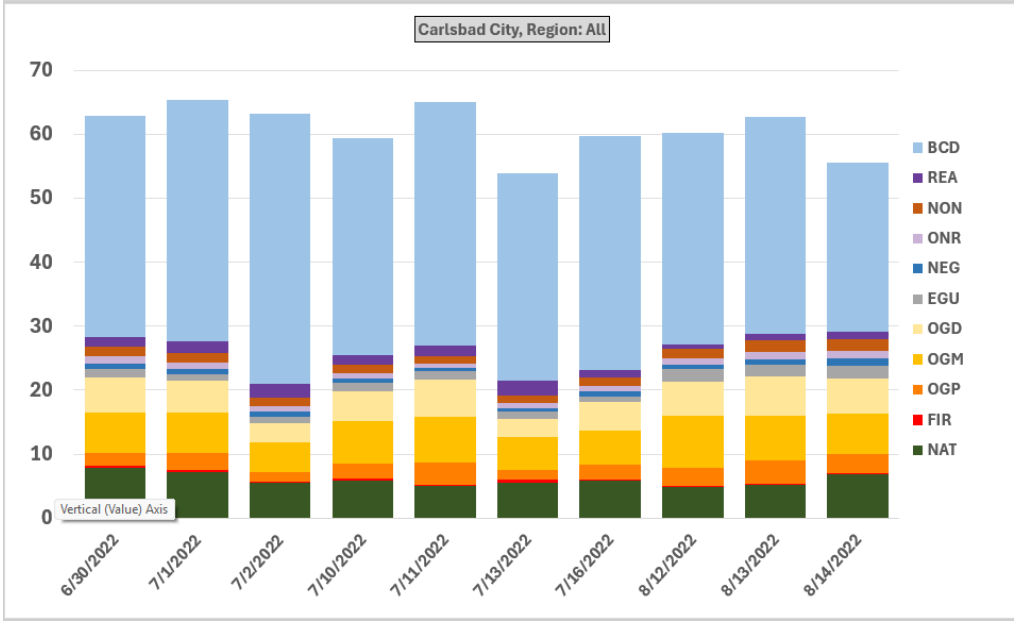


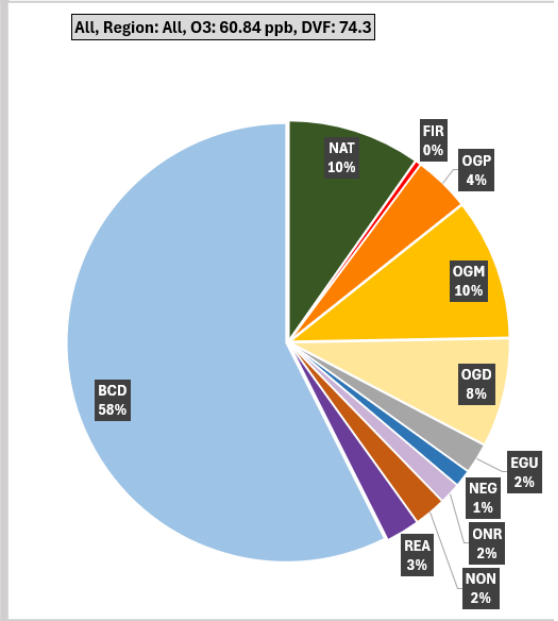
2022 & 2032 Dashboard

- Carlsbad City
- All Source Regions and Source Categories
- Top 10 MDA8 Ozone Days
- Results:
  - Average of top 10 2022 MDA8 days (63.8 ppb) much lower than 2020-2024 ozone DVB (78.0 ppb)
  - Over half of the ozone on average is from BCs around the 12 km CONUS domain (54-58%)
  - O&G is the largest Source Category Contributor (22-23%)



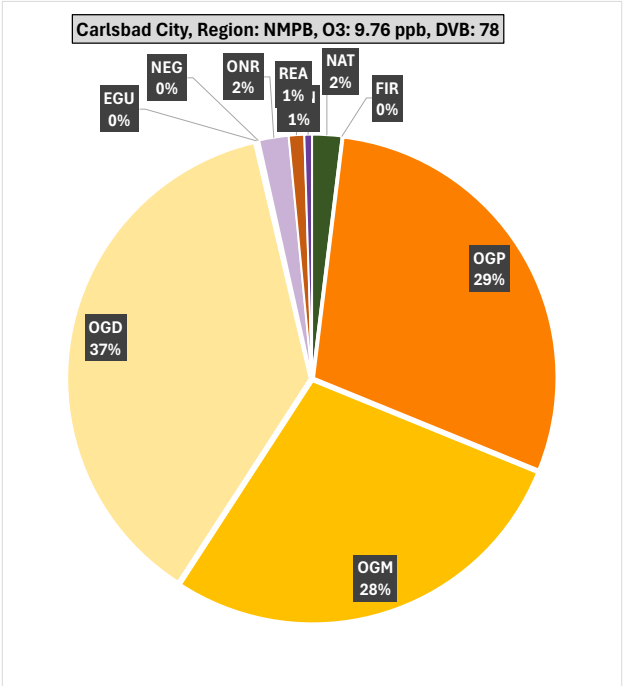


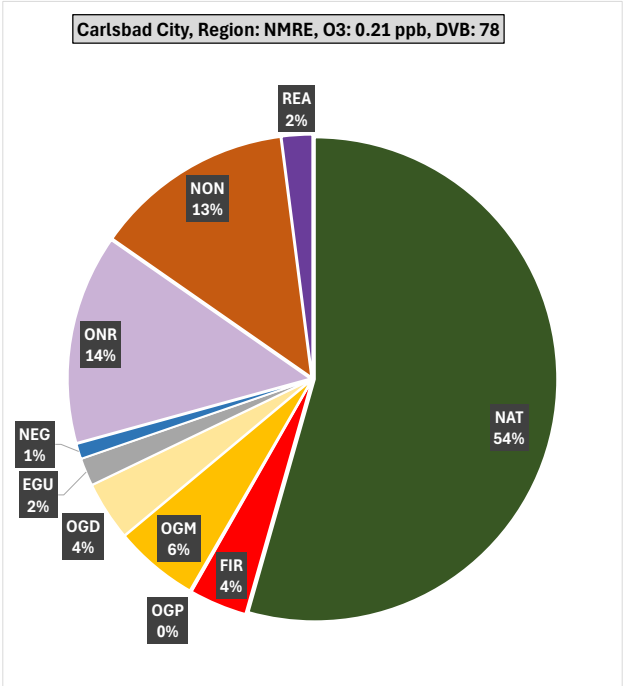


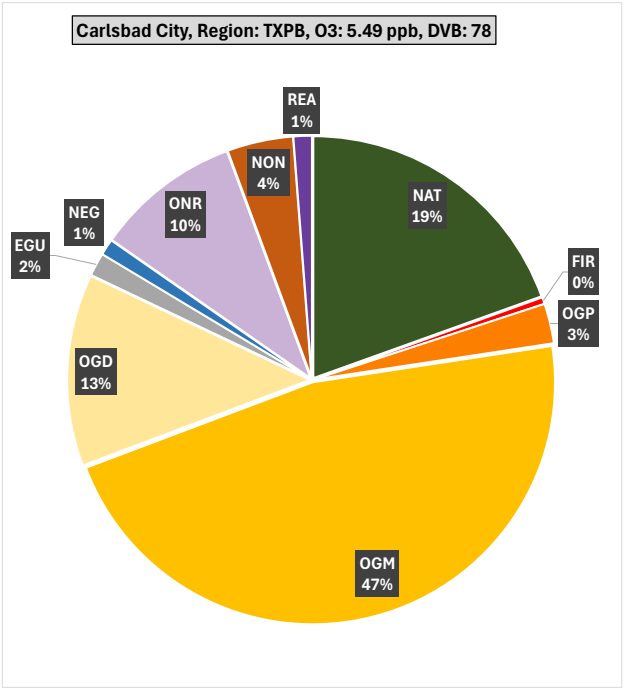


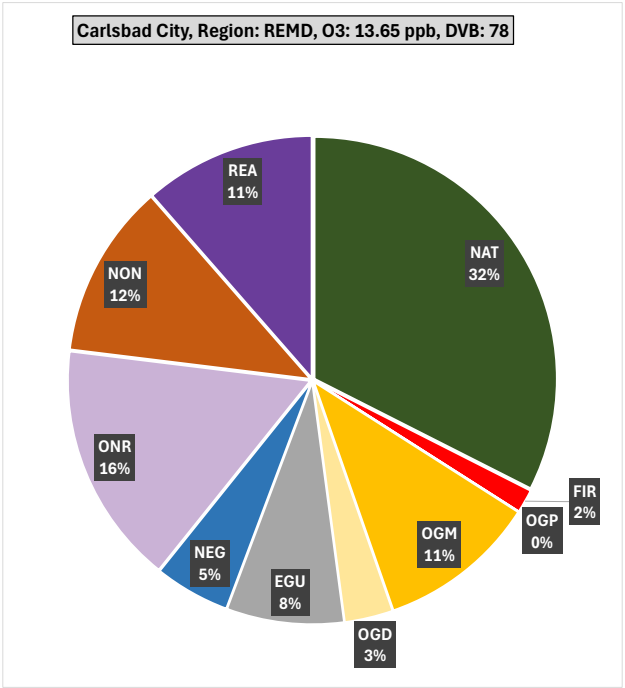
Carlsbad Caverns 2022 by Source Regions

- **NM Permian Basin** (9.8 ppb)
  - 94% from NM PB O&G
    - ➢37% Pre-Production
    - ➢29% Production
    - ➢28% Midstream
- **Remainder New Mexico** (0.2 ppb)
  - 54% Natural
- **TX Permian Basin** (5.5 ppb)
  - 63% from TX PM O&G
    - ➢13% Pre-Production
    - ➢3% Production
    - ➢47% Midstream
  - 19% Natural
- **Remainder Domain** (13.7 ppb)



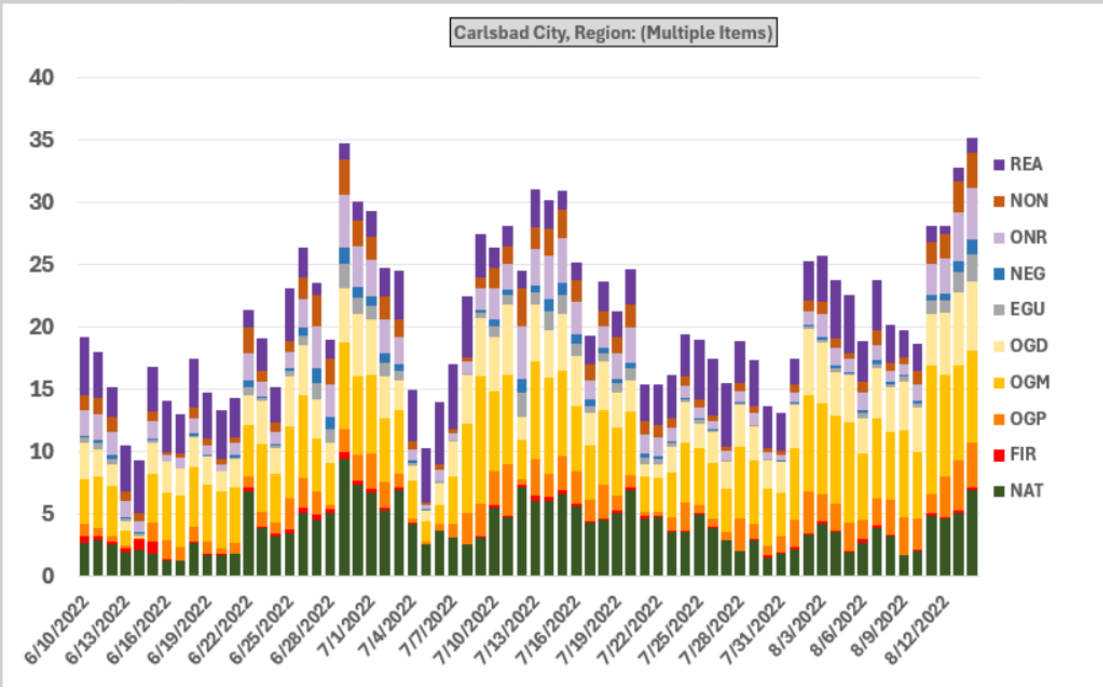


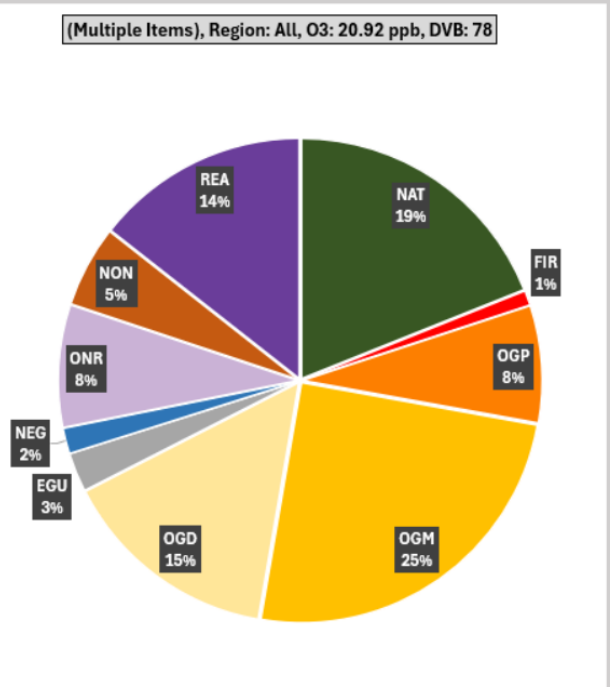


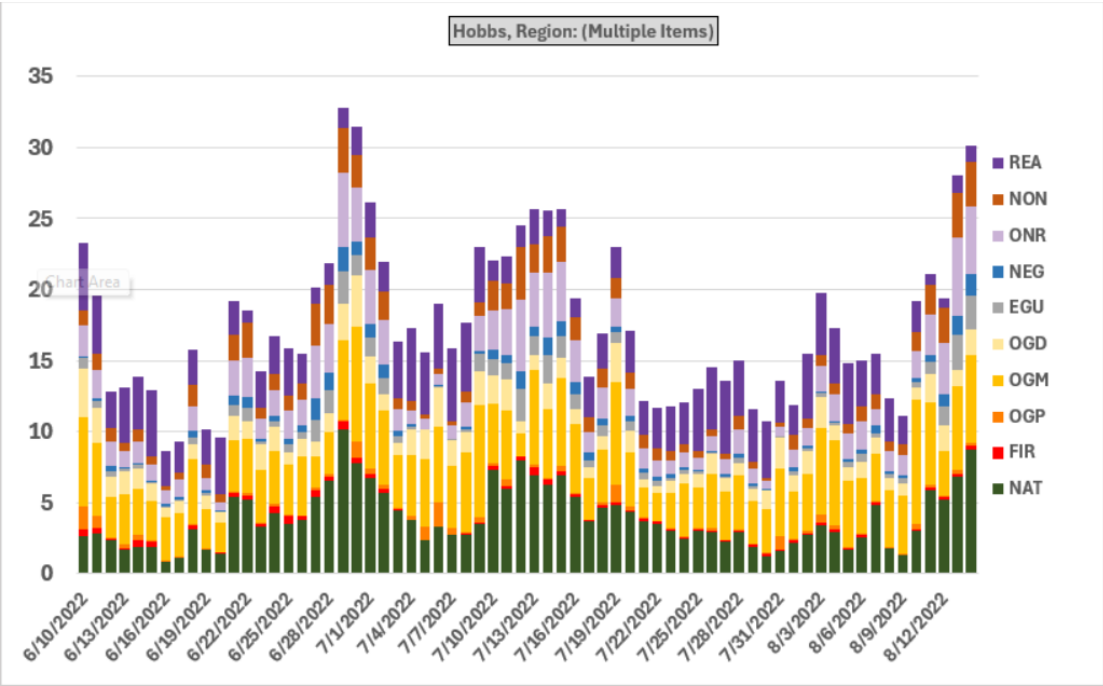


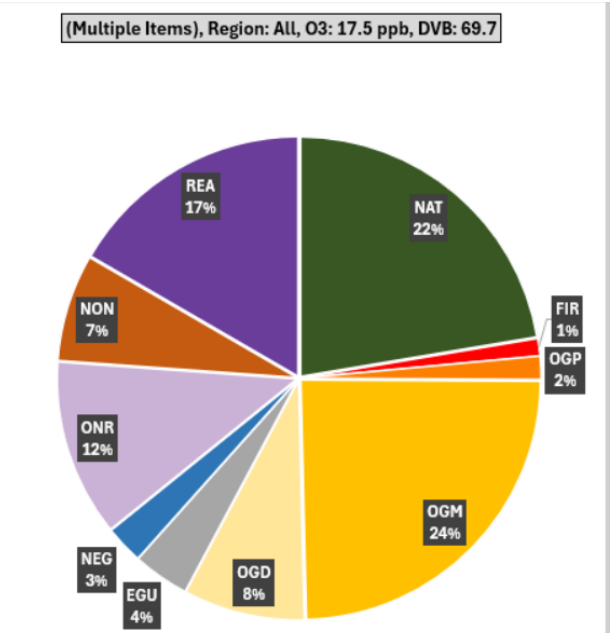
2022 All Days, Regions/Categories but no BC

- **Carlsbad City** (20.9 ppb)
  - 48% O&G
  - 19% Natural
  - 14% Remainder Anthro (includes Mex Mobile
  - 8% On-Road
  - 5% Non-Road
- **Hobbs** (17.5 ppb)
  - 34% O&G
  - 22% Natural
  - 17% Remainder Anthro
  - 12% On-Road
  - 7% Non-Road



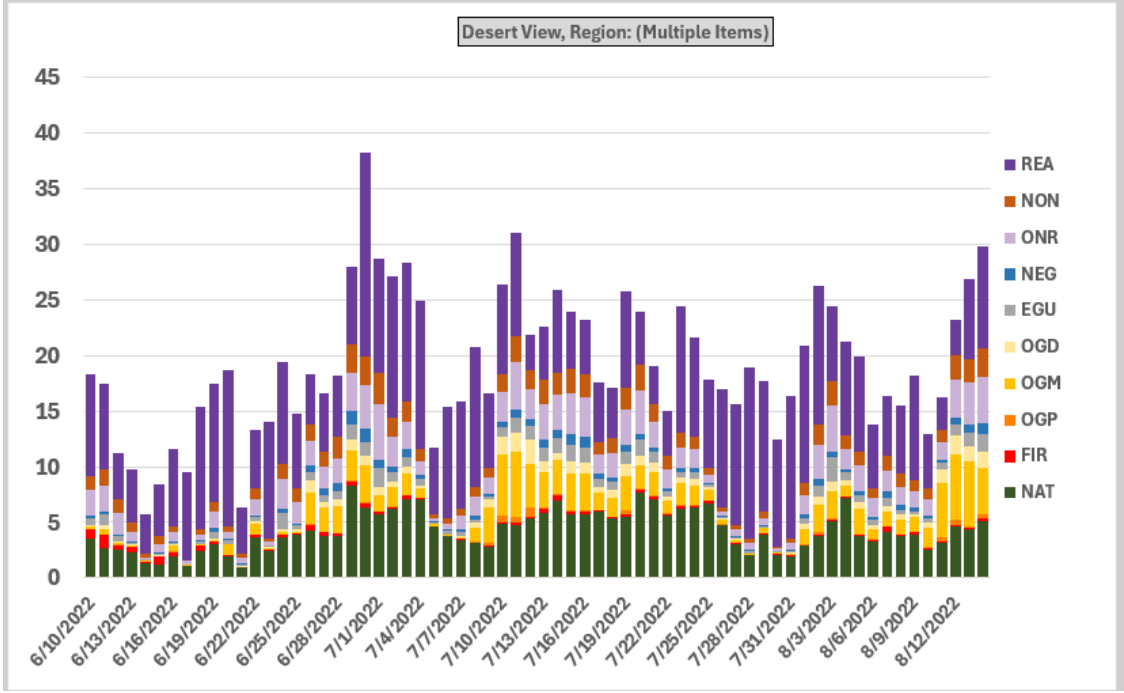


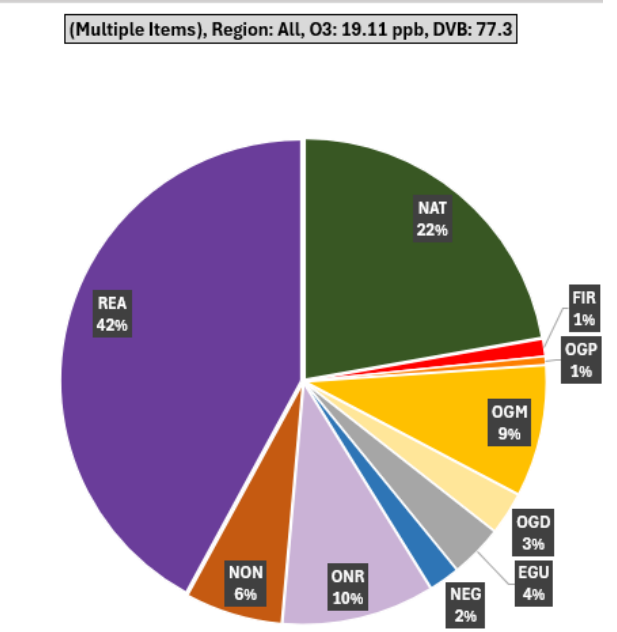


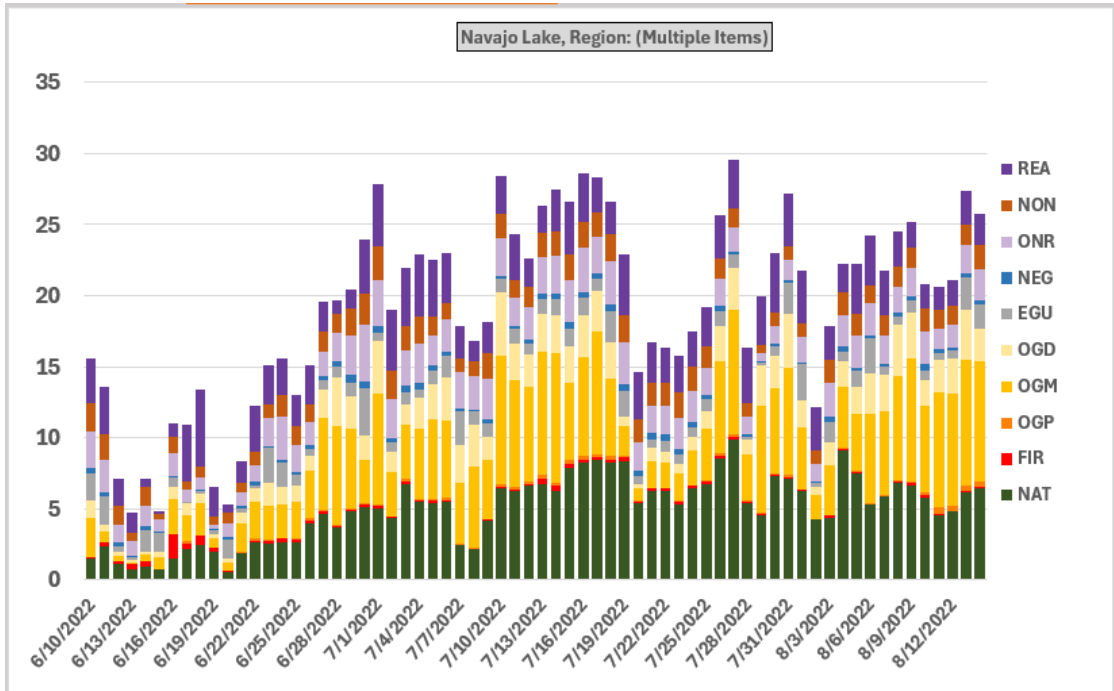


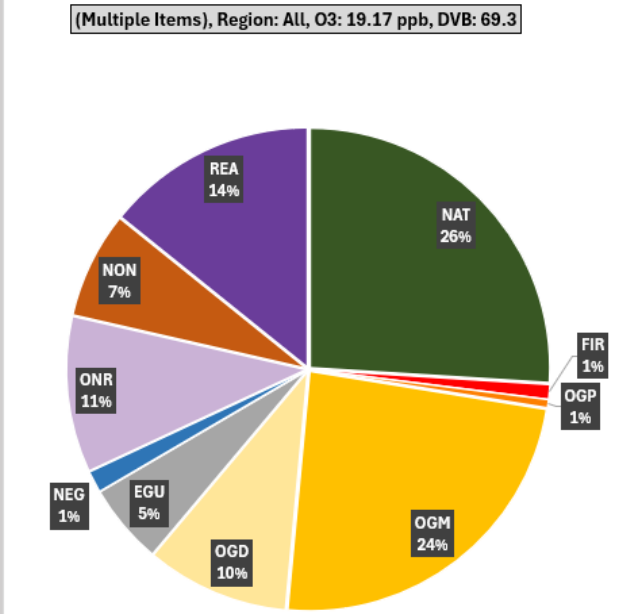
2022 All Days, Regions/Categories but no BC

- **Desert View** (19.1 ppb)
  - 42% Remainder Anthropogenic (includes Mexico Mobile)
  - 22% Natural
  - 13% O&G
  - 10% On-Road
  - 6% Non-Road
- **Navajo Lake** (19.2 ppb)
  - 35% O&G
  - 26% Natural
  - 14% Remainder Anthro
  - 11% On-Road
  - 7% Non-Road



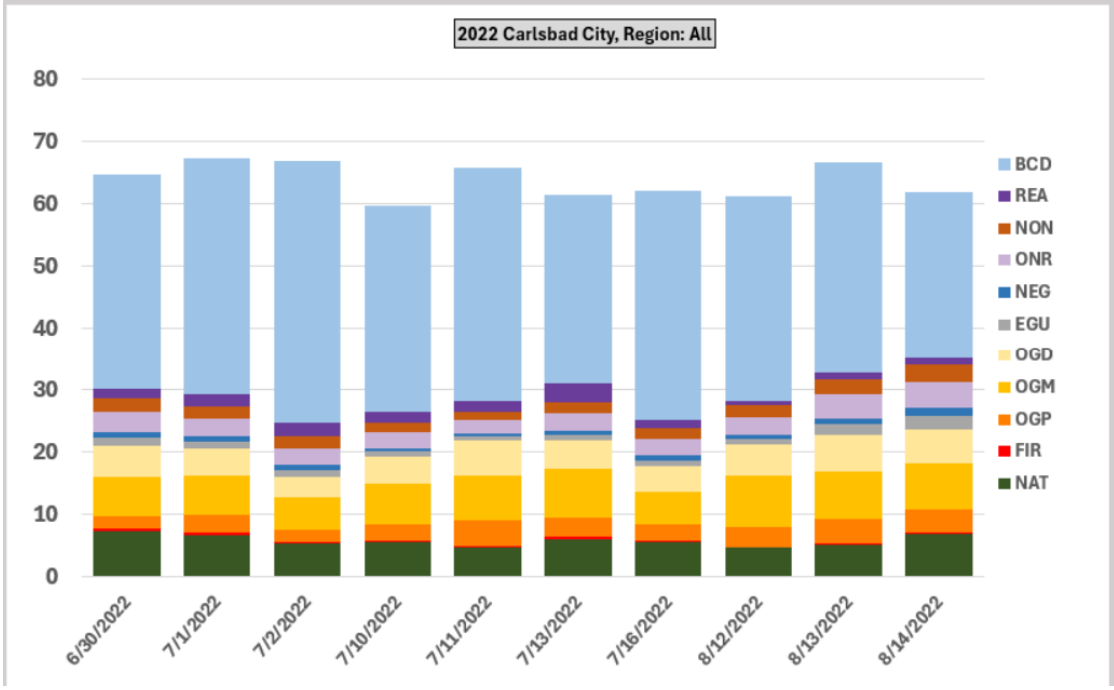


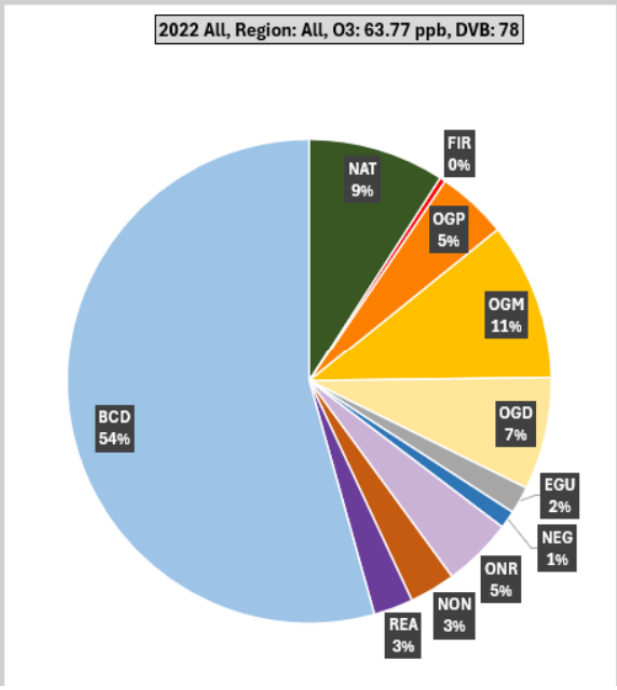


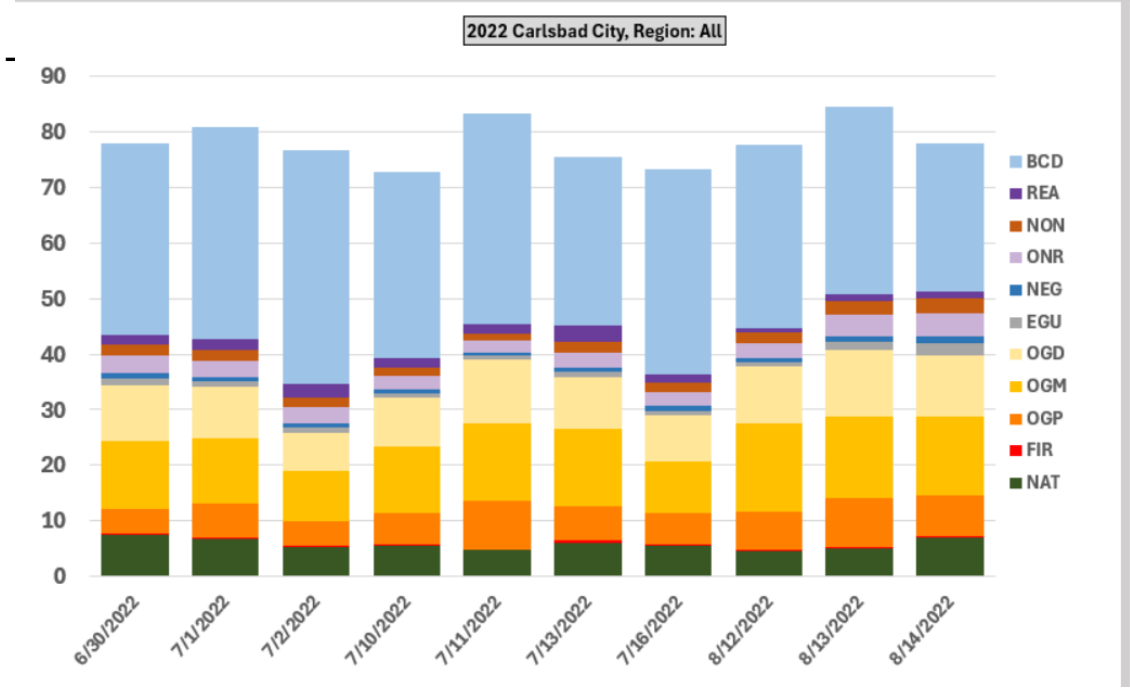


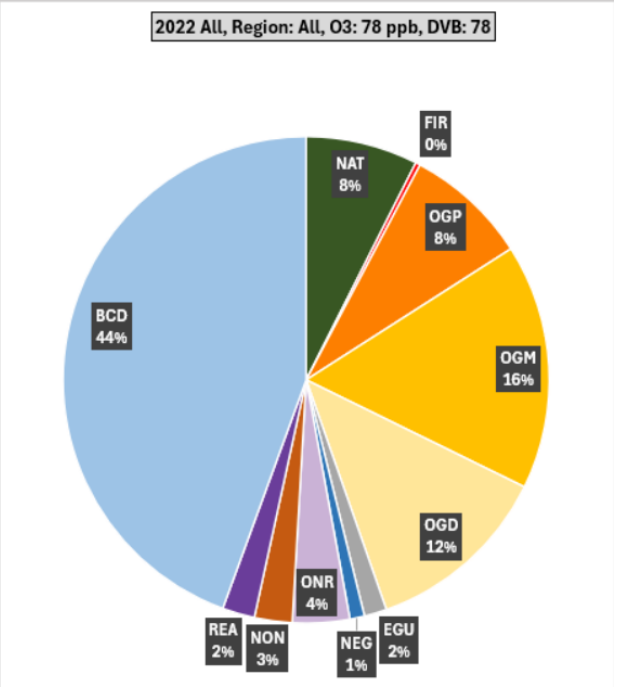
2022 Contributions with Permian Basin O&G O_3 Adjustments

- PB O&G ozone contribution is adjusted to eliminate the ozone underestimation bias at NM PB monitoring sites
- Results for 10 SMAT Days
- Unadjusted (top)
  - Avg Model = 63.4 ppb vs. 2020-2024 DVB = 78 ppb
  - BC = 54%
  - O&G = 23%
- Adjusted (bottom)
  - Avg Model = 78 ppb vs. 2020-2024 DVB = 78 ppb
  - BC = 44%
  - O&G = 36%









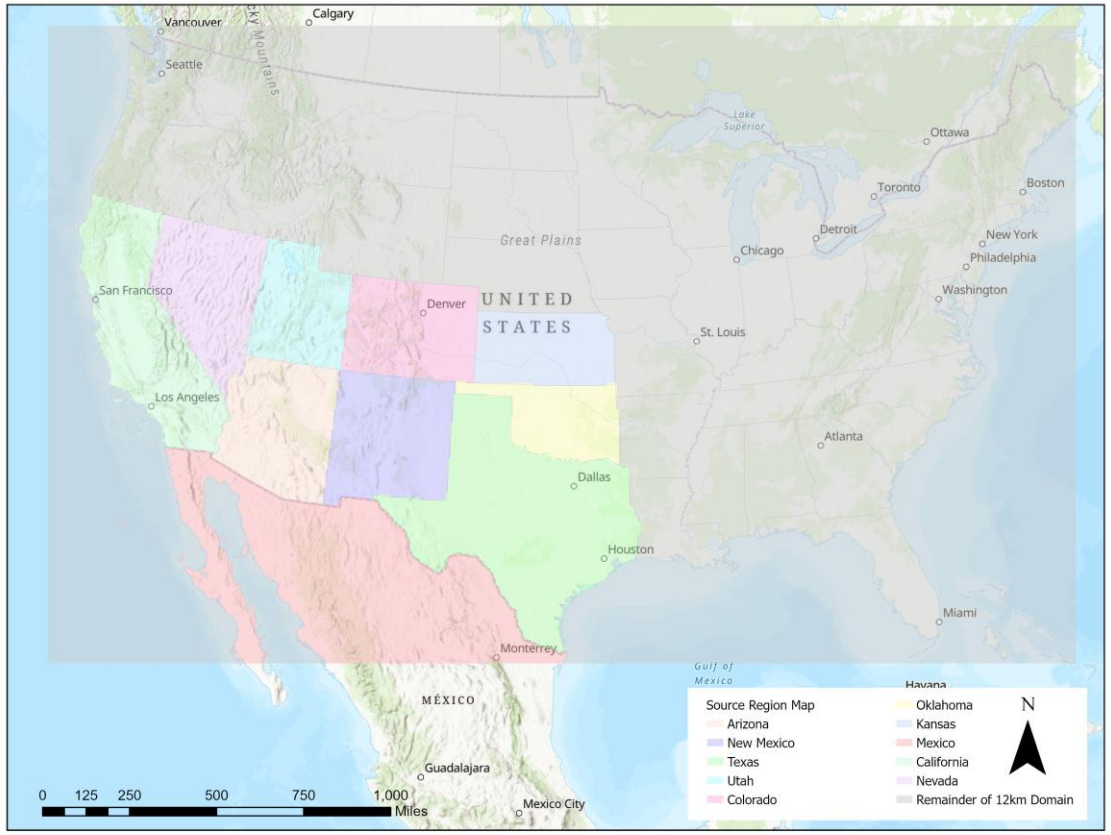
2022/2032 Local Source Ozone SA Conclusions

- Boundary Conditions (BCs; i.e., the incoming concentrations defined around the lateral boundaries of the 12 km CONUS domain) contribute over half of the ozone at all sites in New Mexico
- The highest ozone concentrations in New Mexico occur in the Permian Basin in southern Eddy County with NM and TX Permian Basin O&G emissions contributing approximately a third and a sixth, respectively, to the non-BC ozone contribution
  - At Carlsbad City, almost all of the New Mexico Permian Basin contribution is due to O&G emissions with Pre-Production O&G having the highest contribution (37%) and Production and Midstream O&G having a similar contributions (28-29%)
  - However, the Carlsbad City ozone contribution from O&G in the Texas portion of the Permian Basin mostly comes from Midstream O&G (47%) with Pre-Production (13%) and Production (3%) O&G contributions being much lower
- When increasing the NM and TX Permian Basin O&G ozone contribution to eliminate the CAMx ozone underestimation bias as an approach for accounting for missing O&G emission, the O&G ozone contribution increases from 23% to 36% so that it is more comparable to the BC contribution (44%)
- BCs have a higher contribution to ozone in the southern Doña Ana County sites than the Permian Basin with the remainder anthropogenic emission, which includes Mexico area and mobile sources, being the largest source category contributor

2032 State Specific Ozone Source Apportionment Modeling

State Specific Ozone Source Apportionment Modeling

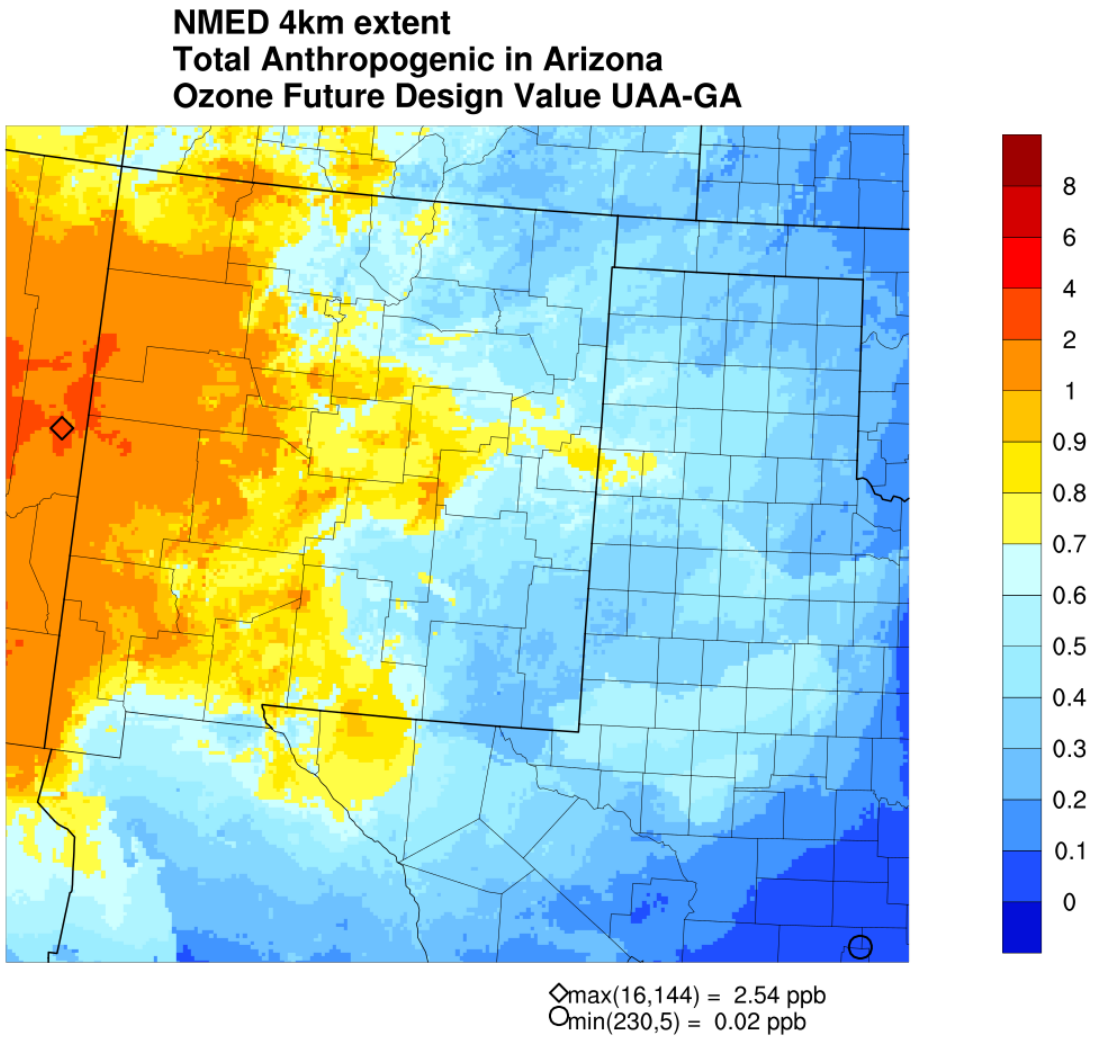
- Run CAMx in a similar fashion as EPA's Good Neighbor Plan modeling
- Emissions Year: **2032**
- **May 1 – August 15, 2022** Modeling Period
- **3 Source Categories**: (1) Biogenic; (3) Fires+LNOx; (3) Anthropogenic
- **10 Source Regions**: 9 Western States, Mexico and Remainder 12 km Domain
- 35 Source Groups (3 x 10 + 2)
- EPA has used 1% of the NAAQS (0.70 ppb) as a significant threshold (1.0 ppb also suggested)



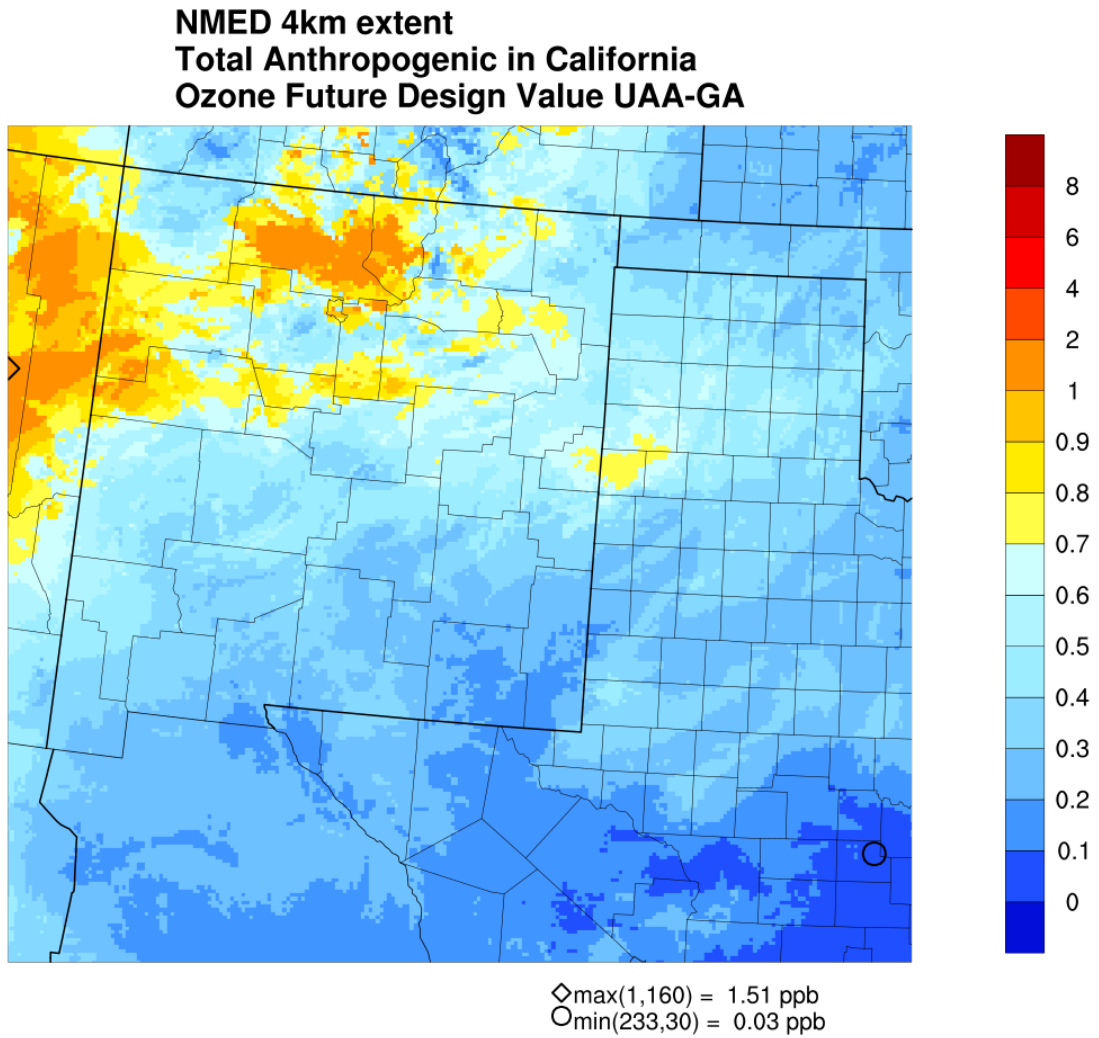
EPA has run 2022 HCMAQ with no international anthropogenic emissions (for Intl Anthro in BCs) but it is being reviewed by EPA upper management and was not released in time for NMED Phase II

Contributions to Projected 2032 Ozone DVF (ppb)

Arizona Anthropogenic

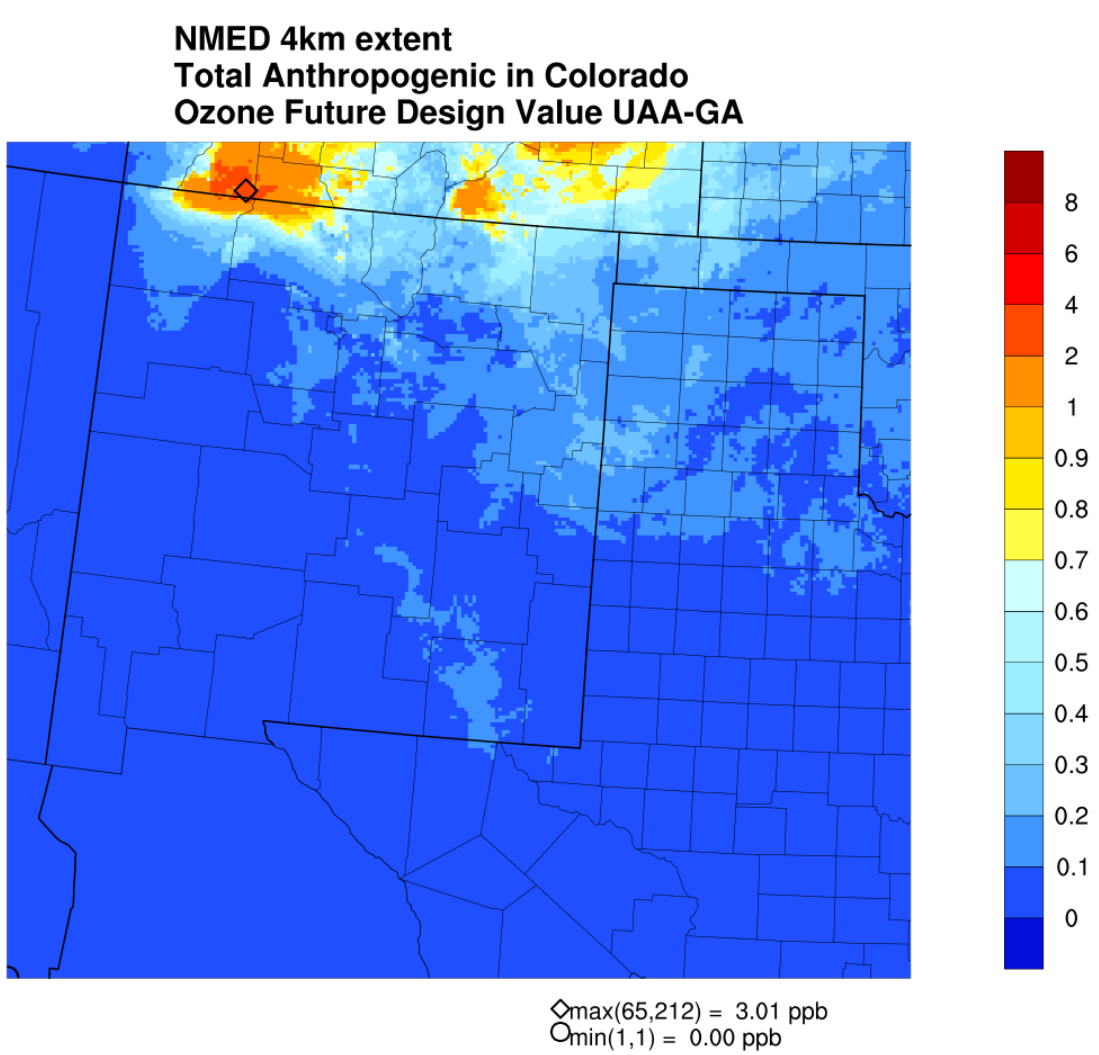


California Anthropogenic

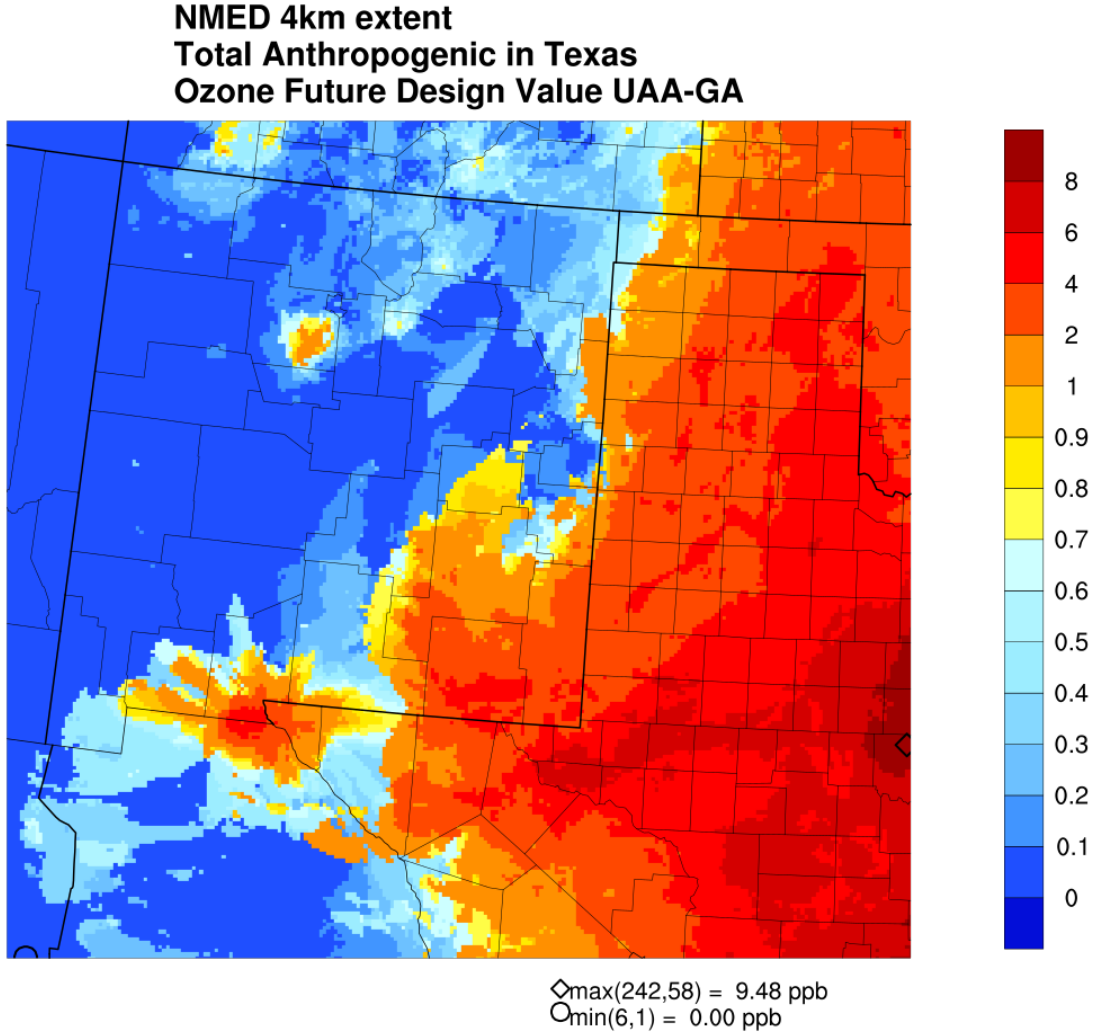


Contributions to Projected 2032 Ozone DVF (ppb)

Colorado Anthropogenic

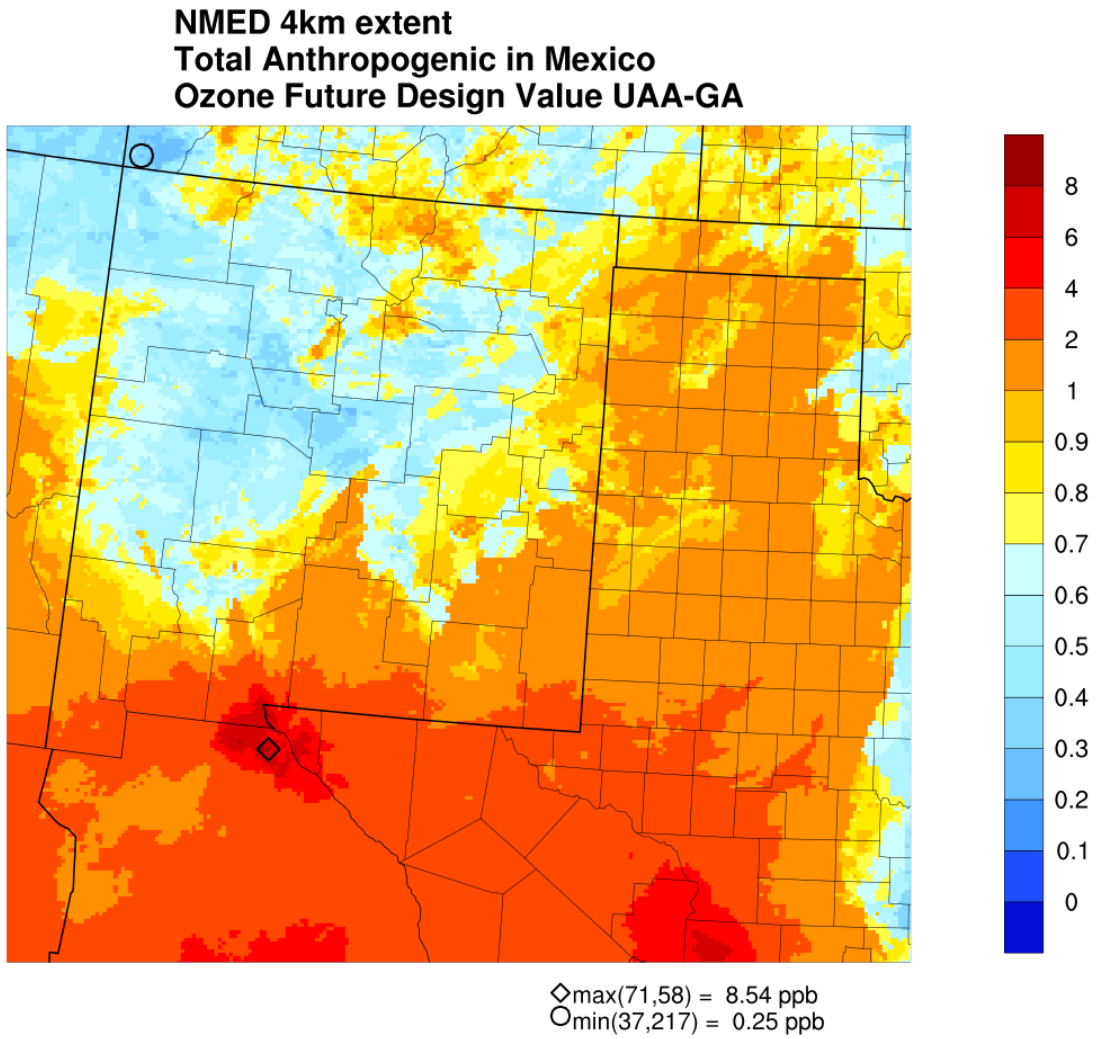


Texas Anthropogenic

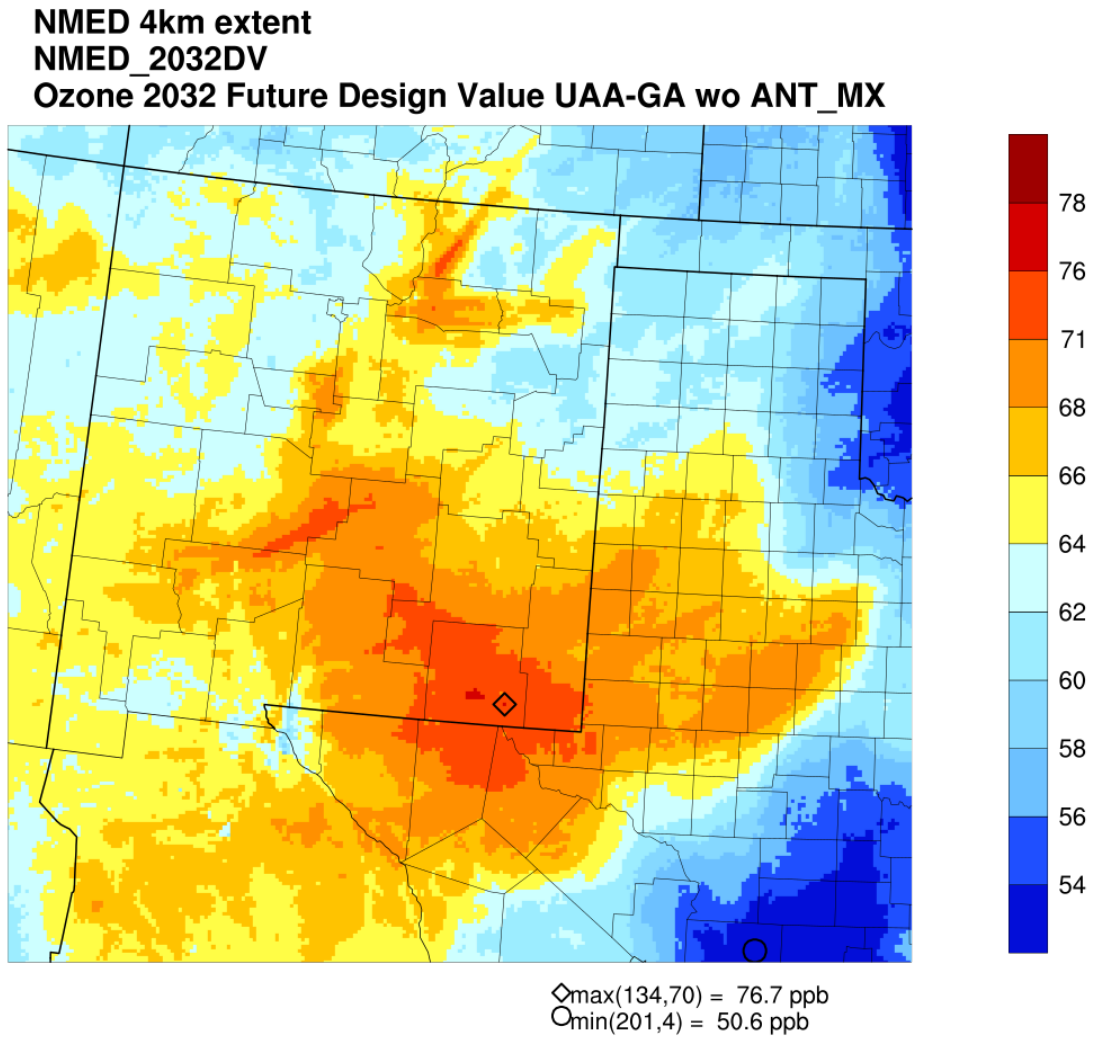


In-Domain Mexico Contributions & 2032 DVF w/o Mexico

Mexico Anthropogenic



2032 Ozone DVF w/o Mexico Anthro



State Specific O_3 Source Apportionment Conclusions

- Anthropogenic emission from Arizona, Colorado, Texas, California and Mexico all contribute over 1 ppb to the projected 2032 ozone Design Values (DVs) in New Mexico
  - Arizona, Texas and Mexico have contributions over 1 ppb to 2032 ozone DVs in southern New Mexico where the projected ozone 2032 DVs exceed the 2015 ozone NAAQS
- Kansas, Nevada, Oklahoma and Utah contributions to 2032 ozone DVs in New Mexico are always less than 0.7 ppb
- Mexico anthropogenic emissions within the 12 km CONUS domain contribute over 4 ppb to the 2032 ozone DV in southern Dona Ana County and ~2 ppb to southern Eddy County in the Permian Basin
  - Even with the elimination of Mexico anthropogenic emissions in the 12 km CONUS domain, the maximum projected 2032 DV in southern Eddy County (76.7 ppb) is above the ozone NAAQS
  - The study could not include the elimination of international anthropogenic emissions that are embedded in the Boundary Conditions as such data were not available, so no findings are available on the contributions of international anthropogenic emission to ozone in New Mexico.

Potential Next Steps FY2027

Possible Next Steps FY2027

A. Additional 2022 and/or 2032 Sensitivity Modeling using CAMx 2022v2 12/4 km Modeling Platform
   i. Modeling Ozone/PM Impacts of Proposed New Sources
   ii. Other Sensitivity Tests (e.g., alternative Permian Basin O&G Inventories)
B. Develop Improved O&G Inventories for the Permian Basin
   i. Analyze Known Excess Emissions
   ii. Review and update O&G EI development and modeling (e.g., speciation) data
   iii. Top-Down Adjustments
C. CAMx 2024 12/4 km Modeling Platform
   i. Issues with 2022 ozone performance across intermountain west; 2022 severe wildfires in NM
   ii. 2024 has concurrent VOC measurements (LNM) and TEMPO satellite data
   iii. Preliminary CAMx 2024 12 km CONUS modeling indicate improved ozone performance
   iv. Revised CAMx 2024 12/4 km ozone source apportionment with improved O&G emissions
   v. Evaluation of New Mexico NO_X emissions inventory using TEMPO