NEW MEXICO OZONE ATTAINMENT INITIATIVE

Revised 2014v2 Base Case, 2028 Base Case Modeling and 2028 NM O&G Control Strategy

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NM OAI Study Webinar

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RAMBOLL Bright ideas. Sustainable change.

REVISED 2014V2 BASE CASE AND 2028 BASE CASE MODELING

01 Revised 2014v2 Base Case Modeling

02 2028 Base Case Modeling and Ozone DV Projections

03 2028 New Mexico O&G Control Scenario

04 Design of 2028 State/Category APCA Source Apportionment

05 Design of 2028 VOC- & NOx-limited OSAT Source Apportionment

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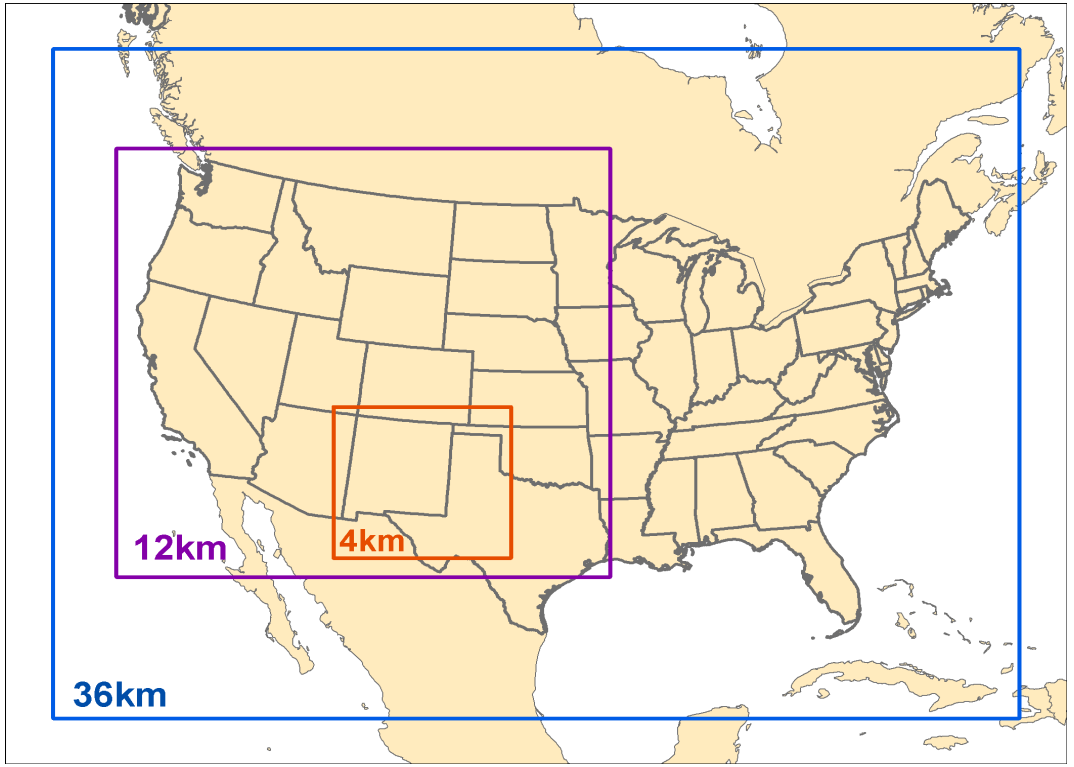
CAMX 2014 NM OAI STUDY MODEL CONFIGURATION

- Episode: May-August 2014
  - 16-day spin-up before first high ozone day in NM
    - 68 ppb on May 17
- 36/12/4-km Modeling Domains
  - 36/12-km domains same as WRAP Regional Haze
  - New 4-km New Mexico domain
- Boundary Conditions (BC) WRAP 2014 GEOS-Chem
- Four Meteorological Diagnostic Sensitivity tests
  - Selected WRF/NAM with Kv=CMAQ
- WRAP 2014v2 base year emissions
  - EPA NEI2014v2 w/ western state updates



- WRAP 2028OTBa2 for future year w/ 2014 actual fires and new 2028 NM O&G

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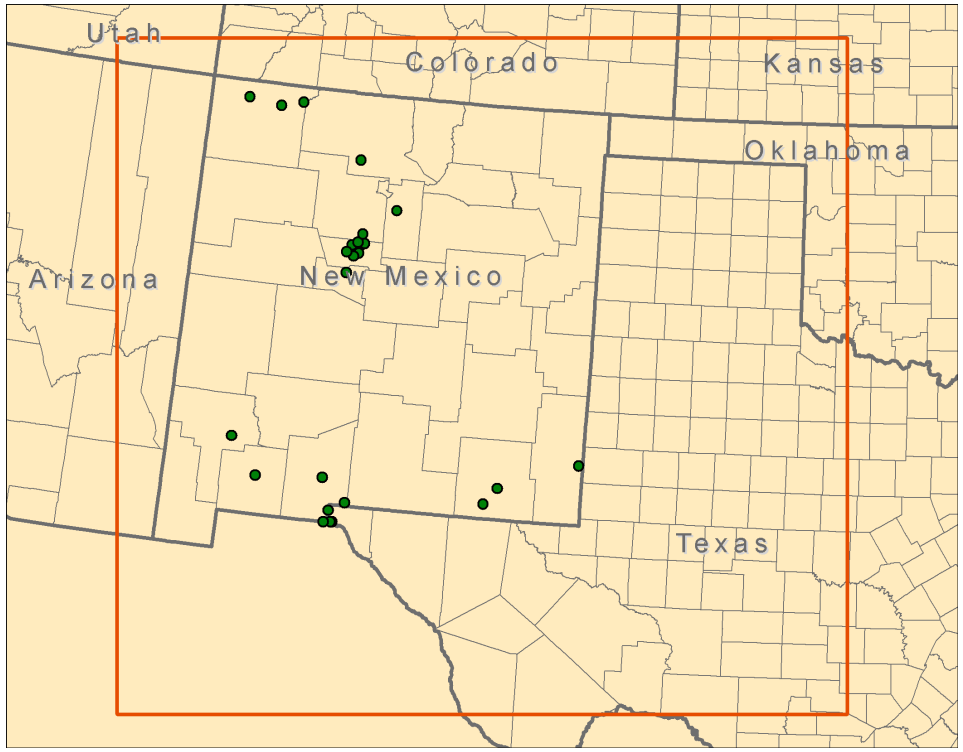
ORIGINAL CAMX CONFIGURATION

- Similar to WRAP CAMx 36/12-km Regional Haze set-up w/ 4-km NM domain added
- Two changes in revised 2014v2 Base Case:
  - Use CAMx v7.1
  - Use BEIS biogenic emissions



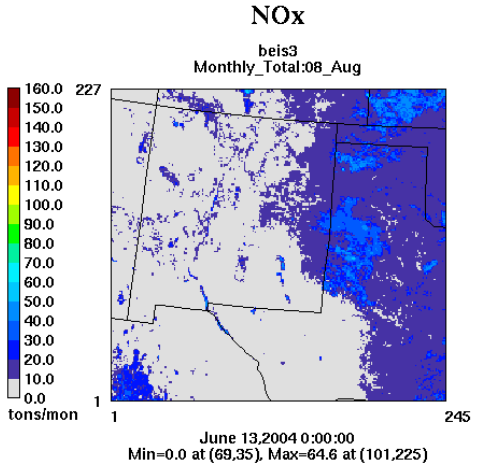
Science Options	CAMx	Comment
Model Codes	CAMx v7.0	Latest version of CAMx made publicly available May 2020 (www.camx.com)
Horizontal Grid Mesh	36/12/4-km	
36-km grid	148 x 112 cells	36US domain
12-km grid	227 x 215 cells	12WUS2 domain. Includes buffer cells
4-km grid	245 x 227 cells	New Mexico 4-km domain. Includes buffer cells
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 ~20 m. Model top at 50 mb (~19 km). Layer collapsing from 35 vertical layers in WRF
Grid Interaction	36/12/4 km two-way nesting	
Initial Conditions	Start on May 1, 2014	First high ozone day is May 17, 2014
Boundary Conditions	WRAP 2014 GEOS-Chem	For 36US domain lateral boundaries
Emissions		
Emissions Processing	SMOKE, SMOKE-MOVES2014, MEGAN	WRAP/WAQS 2014v2 emissions and EPA 2023fh for future year
Sub-grid-scale	Plume-in-Grid (PiG)	NOx > threshold
Chemistry		
Gas Phase	CB6r4	(Yarwood et al., 2010)
Meteorological Processor	WRFCAMx	Compatible with CAMx v7.0
Horizontal Diffusion	Spatially varying	K-theory with Kh dependence
Vertical Diffusion	CMAQ-like Kv	Evaluated YSU Kv scheme
Diffusivity Min	Kv-min = 0.1 to 1.0 m^2/s in lowest 100 m	Urban land use fraction
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme	(Zhang et. al, 2001; 2003)

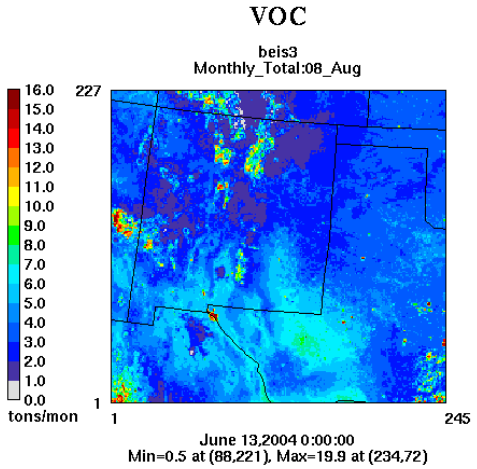
REVISED CAMx 2014v2 BASE CASE SIMULATION

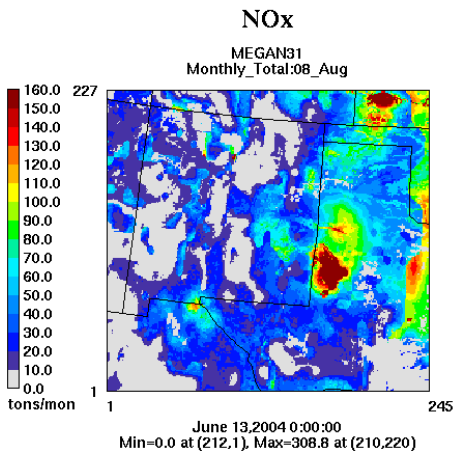
REVISED CAMX 2014V2 36/12/4-KM BASE CASE AND MPE

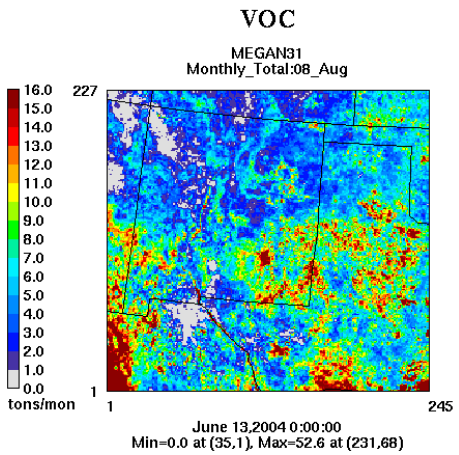
- Two changes between original CAMx 36/12/4-km 2014 and revised 2014v2 base cases
  - Use CAMx v7.1 instead of CAMx v7.0
    - Bugs in source apportionment tools in CAMx v7.0 necessitated change
    - Little change expected in ozone results due to model version
  - Switched from MEGAN v3.1 to BEIS biogenic emissions in 4-km domain
    - MEGAN v3.1 very new and turned out to be not ready to run out of the box
    - MEGAN v3.1 missing LAI in urban areas so has zero biogenic emissions unless extra work is performed to do data filling
    - MEGAN v3.1 has much higher (~3x) biogenic NOx than BEIS, and previous versions of MEGAN
    - WRAP 2014/RepBase/2028 regional haze modeling is using BEIS
    - Denver 2020 Serious ozone SIP used MEGAN but for follow-on 2023 and 2026 modeling switched to BEIS because of zero urban biogenic emissions and biogenic NOx that seemed high

BEIS V3.7 VS. MEGAN V3.1 BIOGENIC EMISSIONS - AUGUST









BEIS

Tons/month		MEGAN	BEIS3	Abs Diff (BEIS3-MEGAN)	Ratio (BEIS3/MEGAN)
May	NOX	35,050	10,602	-24,448	0.30
	VOC	128,323	159,809	31,486	1.25
Jun	NOX	42,445	13,134	-29,311	0.31
	VOC	267,055	256,379	-10,676	0.96
Jul	NOX	51,639	12,838	-38,801	0.25
	VOC	317,697	251,562	-66,135	0.79
Aug	NOX	41,002	11,923	-29,079	0.29
	VOC	354,570	216,032	-138,538	0.61

MEGAN

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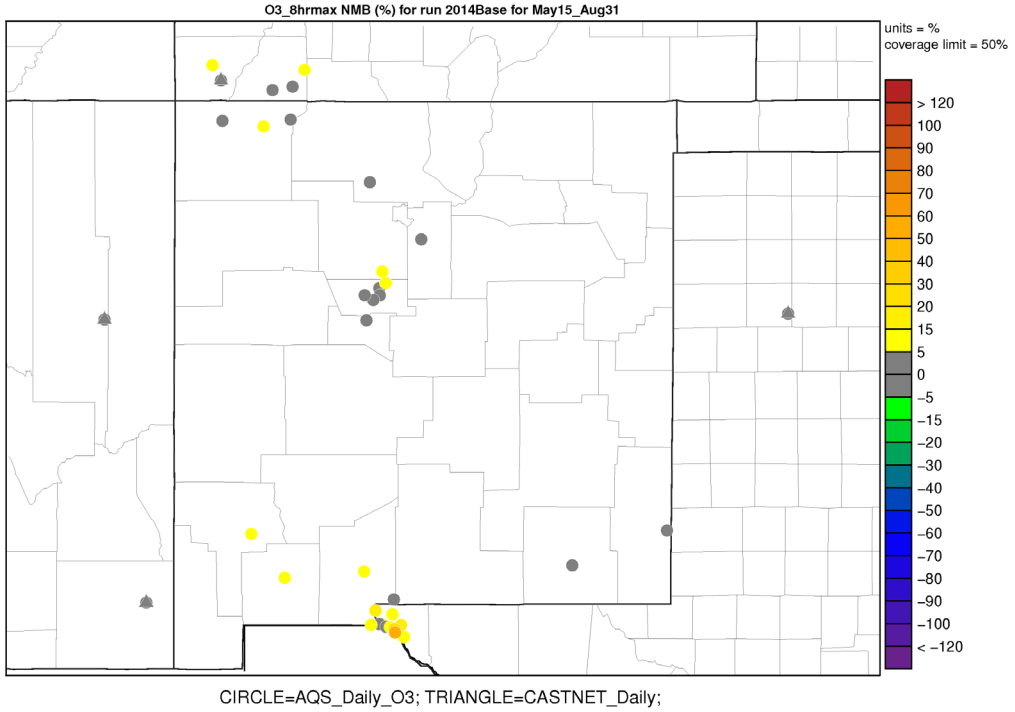
2014 (MEGAN) AND 2014V2 (BEIS) BASE CASE MPE

- Used EPA's AMETv1.4 MPE tool
- Model evaluated against EPA AQS and CASTNet Surface Air Quality Data for 2014
- Model performance compared with standard PGM goals and criteria values (Emery et al., 2016)
- "Goals" - statistical value that the best model can be expected to achieve
- "Criteria" - statistical value that majority of models have achieved

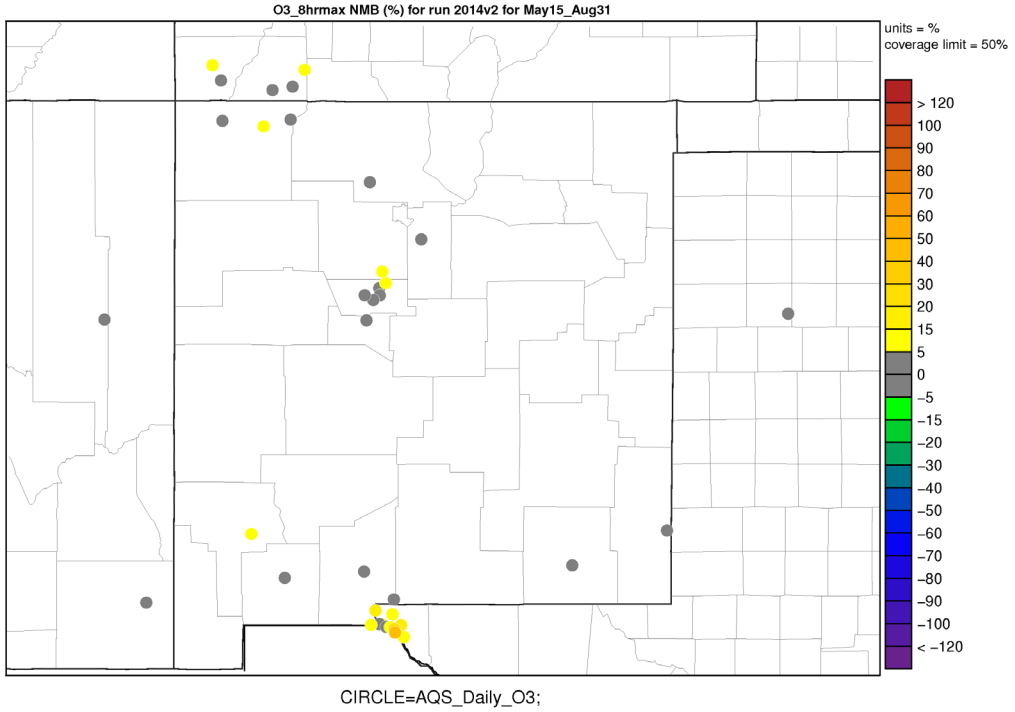
Species	NMB		NME	
	Goal	Criteria	Goal	Criteria
1-hr & MDA8 Ozone	<±5%	<±15%	<15%	<25%

NMB (BIAS) WITHOUT 60 PPB CUTOFF

2014Base (MEGAN)



2014v2 (BEIS)

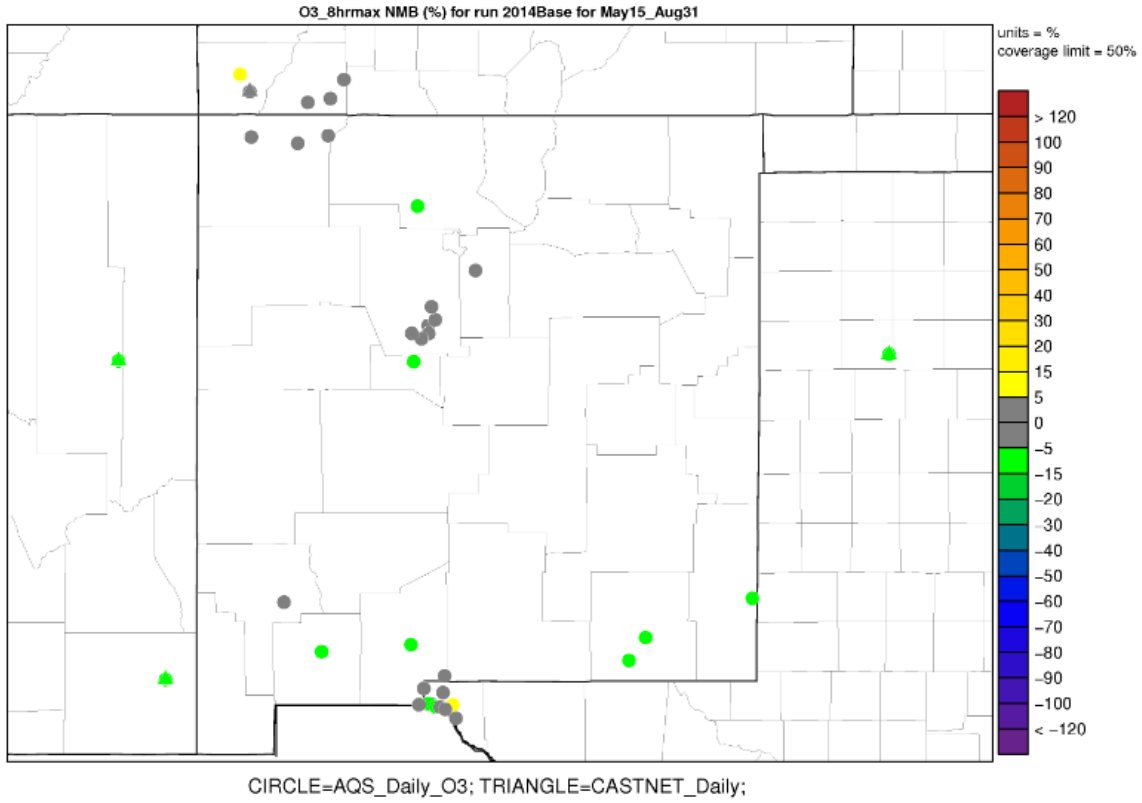


Both 2014 Base and 2014v2 meet ozone Performance Criteria at all sites but one in El Paso

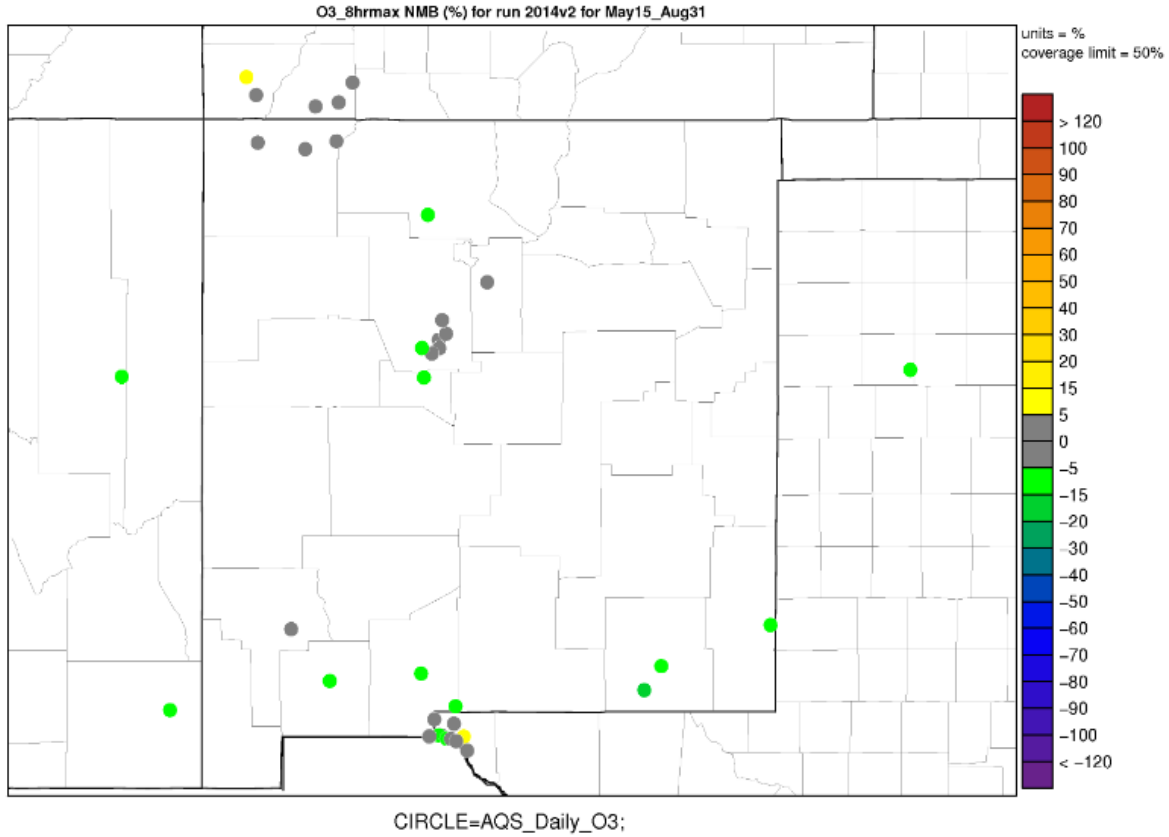
2014v2 has more sites achieving Performance Goals (grey)

NMB (BIAS) WITH 60 PPB CUTOFF

2014Base (MEGAN)



2014v2 (BEIS)



2014v2 larger underestimation at a few sites with 60ppb cutoff compared to 2014Base but still achieves Performance Criteria

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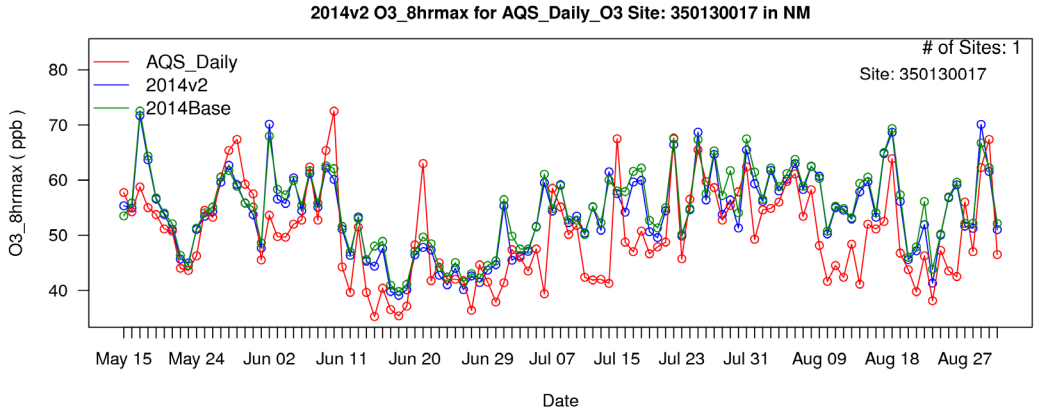
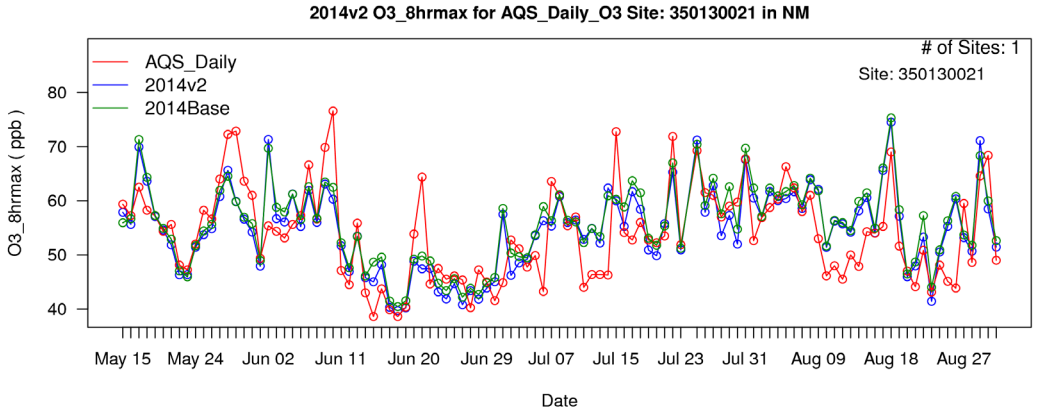
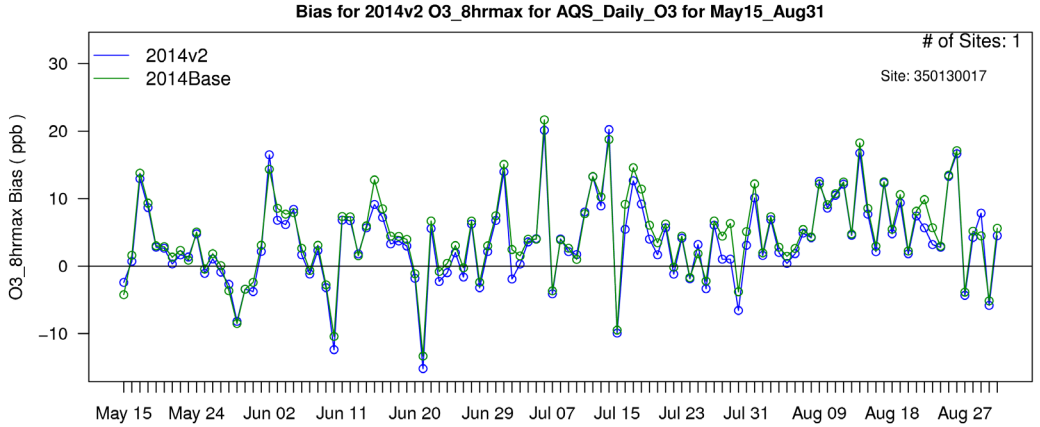
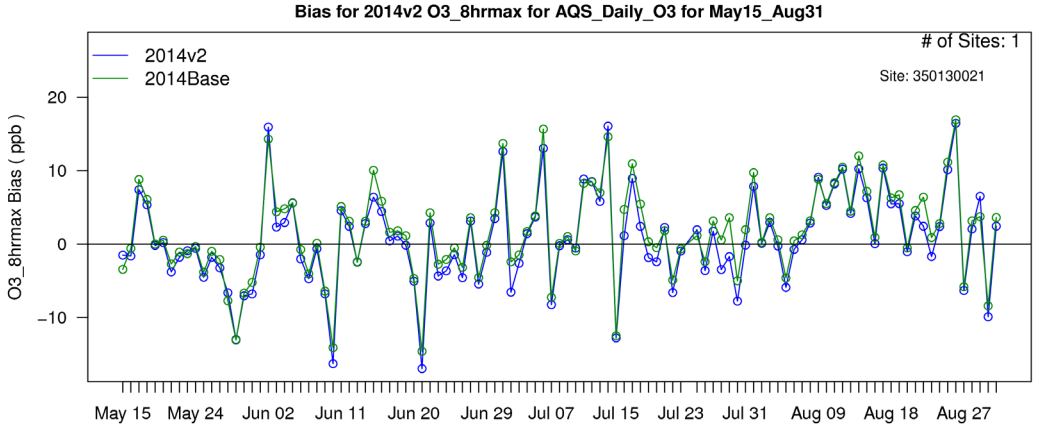
SUNLAND PARK AND DESERT VIEW (DONA ANA COUNTY)









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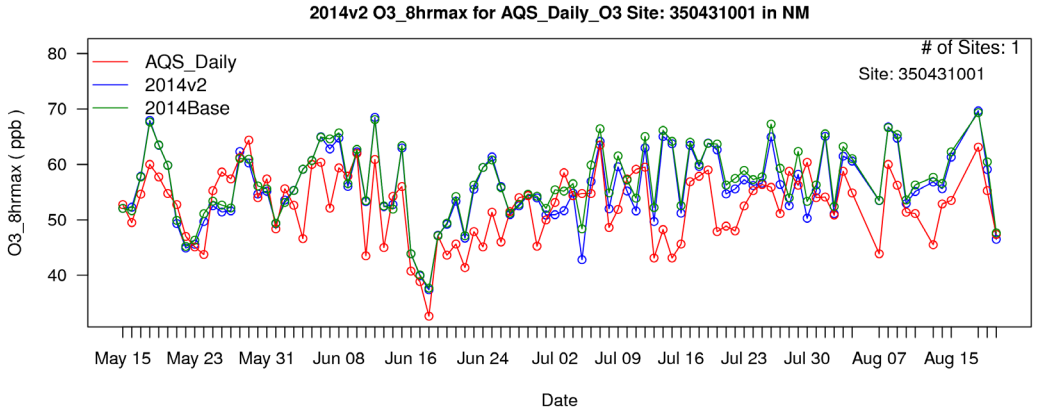
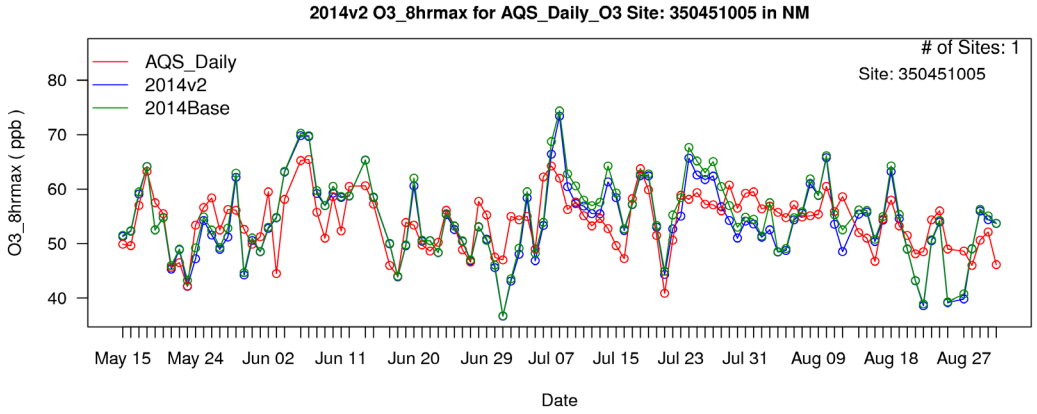
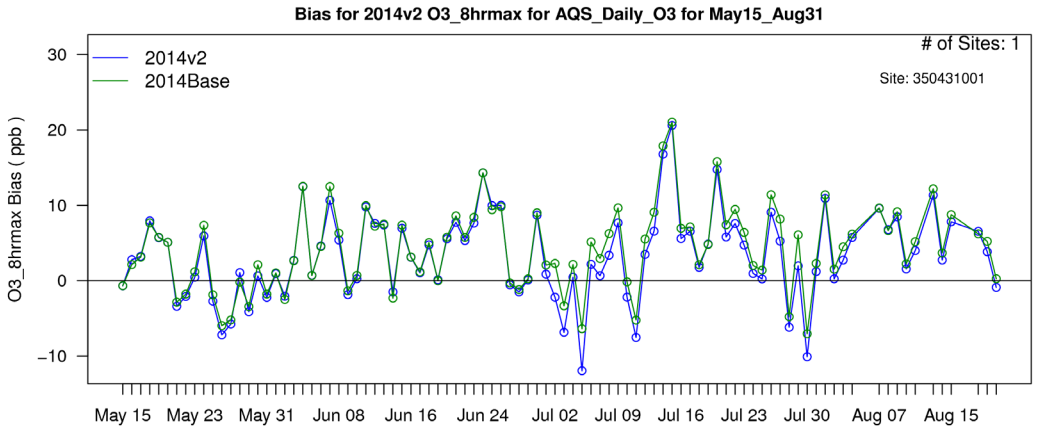
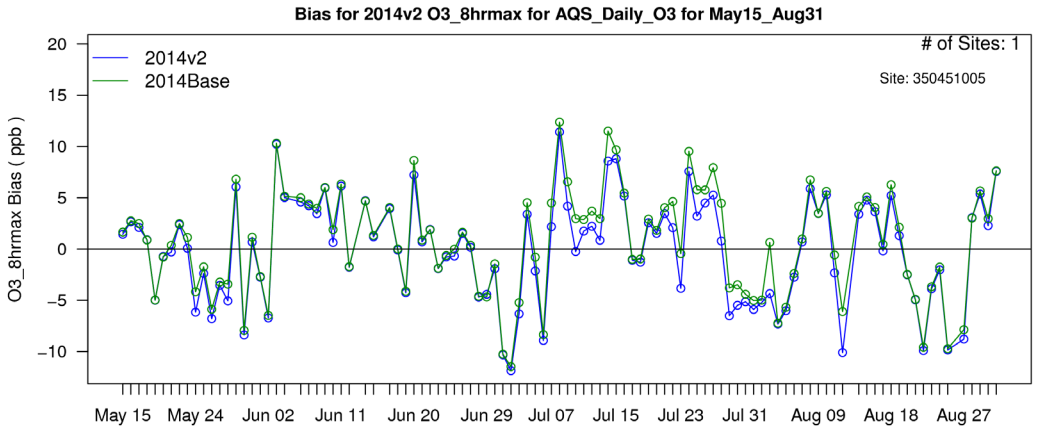
BERNALILLO (SANDOVAL CTY) & SUB STATION (SAN JUAN CTY)









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OZONE MPE BY NEW MEXICO SUBREGIONS

- Original 2014 Base Case

	Nocutoff		Withcutoff	
Region	**NMB(%)**	**NME(%)**	**NMB(%)**	**NME(%)**
North NM	4.3	9.1	0	6.4
Bernalillo	4.3	9.4	-2.8	7.1
South NM	5.8	10.5	-6.1	8.5

- Revised 2014v2 Base Case

	Nocutoff		Withcutoff	
Region	**NMB(%)**	**NME(%)**	**NMB(%)**	**NME(%)**
North NM	2.6	8.6	-1.0	6.6
Bernalillo	2.6	9.6	-4.3	8.5
South NM	3.5	10.2	-7.8	9.9

- Consistent with MEGAN v3.1 having higher NOx emissions than BEIS v3.7, CAMx revised 2014v2 base has slight lower ozone than original 2014 base
  - Also consistent with time series plots
- Results in slight improvement in ozone performance statistics when no cutoff is used
- Results in a slight degradation in ozone performance statistics when 60 ppb observed ozone cutoff is used
- Very similar ozone model performance

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OZONE MPE BY NEW MEXICO MONITORING SITE

2014Base (with MEGAN)			
SiteID	SiteNames	NMB No Cutoff	NMB 60 ppb Cutoff
350010023	Del Norte	1.7	-3.9
350010024	South East Heights	3.1	-2.4
350010029	South Valley	3.1	-2.8
350010032	Westside	1.1	-3.4
350011012	Foot Hills	13.6	2.0
350130008	La Union	17.4	-1.6
350130017	Sunland Park Yard	9.0	-3.6
350130020	Chaparral	4.8	-4.7
350130021	Desert View	3.2	-5.1
350130022	Santa Teresa	8.2	0.1
350130023	Solano	6.1	-6.5
350151005	Carlsbad	-1.1	-12.3
350171003	Chino Copper	9.1	-1.0
350250008	Hobbs Jefferson	2.1	-9.9
350290003	Deming Airport	6.2	-5.0
350390026	Coyote Ranger	3.3	-5.4
350431001	Bernalillo	8.1	3.8
350450009	Bloomfield	7.2	2.5
350450018	Navajo Lake	2.2	-0.6
350451005	Sub Station	1.4	3.3
350490021	Santa Fe Airport	3.8	-1.7
350610008	Los Lunas	0.8	-6.5

2014v2 (with BEIS)			
SiteID	SiteNames	NMB No Cutoff	NMB 60 ppb Cutoff
350010023	Del Norte	0.5	-4.9
350010024	South East Heights	1.3	-3.6
350010029	South Valley	0.9	-4.4
350010032	Westside	-1.0	-5.4
350011012	Foot Hills	11.9	0.8
350130008	La Union	15.0	-3.0
350130017	Sunland Park Yard	7.4	-4.1
350130020	Chaparral	2.8	-5.8
350130021	Desert View	1.4	-6.3
350130022	Santa Teresa	5.8	-1.8
350130023	Solano	3.9	-8.2
350151005	Carlsbad	-4.3	-14.5
350171003	Chino Copper	7.0	-1.8
350250008	Hobbs Jefferson	-1.2	-12.6
350290003	Deming Airport	3.8	-8.6
350390026	Coyote Ranger	1.2	-5.6
350431001	Bernalillo	6.4	3.3
350450009	Bloomfield	6.0	1.7
350450018	Navajo Lake	0.5	-3.6
350451005	Sub Station	-0.1	2.2
350490021	Santa Fe Airport	1.5	-2.5
350610008	Los Lunas	-1.7	-9.0

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CONCLUSIONS: REVISED CAMX 2014V2 BASE CASE

- With lower biogenic emissions, the CAMx revised 2014v2 base case (BEIS) produces slightly lower ozone concentrations that the original CAMx 2014 base case (MEGAN)
  - Slightly improves ozone performance when overestimated (e.g., when not using ozone cutoff)
  - Slightly degrades ozone performance when underestimated (e.g., when using 60 ppb ozone cutoff)
  - Overall ozone model performance is comparable and basic MPE features nearly identical
- How to document in the NMED OAI Study?
  - 2014 database development and model evaluation report for original CAMx 2014 base case posted to NMED OAI website
    - https://www.wrapair2.org/pdf/NM_OAI_2014_BaseCase_MPE_v3.pdf
  - Ozone performance not appreciably changed

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CAMX 2028 BASE CASE RESULTS

SMAT CONFIGURATION

- SMAT run with "default" options except where highlighted:
  - Request spatial field output
    - Ozone DV spatial interpolation performed with and without using concentration gradients
  - Updated SMAT ozone observations file
  - Base year design values calculated centered on 2014 (i.e., 2012-2016)

Option	Main category	Setting	Default	This Study
Desired Output	Project Name			NMED_OAI
	Point Estimates Forecast	Forecast Ozone DV at monitors	Yes	Yes
	Quarterly model data	output used model data file	Yes	Yes
	Spatial Field	Interpolate monitor data to spatial field	No	Yes
	Neighbor File	Spatial Field	No	No
	Actions on run completion	Extract all selected output files	Yes	Yes
	Design Value Periods	output all DV periods	No	No
	Base an Future DV	Output Max DV	No	No
Data Input	Monitor Data	Ozone Data	SMAT_OZONE_MAX4DV_STD70_2002_2015.CSV	SMAT_OZONE_MAX4DV_STD70_2002_2018.CSV
	Model Data	Baseline File	EPA_test	2014v2.csv
		Forecast File	EPA_test	2028.csv
	Using Model Data	Temporal adjustment at monitor	3x3	3x3
			Max-paired in space	Max-paired in space
Filtering/ Interpolation	Choose Ozone DV	Start Year	2009-2011	2012-2014
		End Year	2011-2013	2014-2016
	Valid ozone monitors	Minimum number of DV	1	1
		Required DV	None selected	None selected
	Default interpolation method	Inverse Distance Weights	Yes	Yes
		check to set max interpolation distance	not checked	not checked
RRF/ Spatial Gradient	RRF setup	Top x modeled ozone days	10	10
		Initial threshold value (ppb)	not checked	not checked
		Minimum number days in baseline above threshold	NA	NA
		Minimum allowable threshold value (ppb)	60	60
		Min number of days above min allowable threshold	5	5
		Enable backstop minimum threshold for spatial fields	not checked	not checked
		subrange first day ozone used in RRF	-	-
		subrange last day ozone used in RRF	-	-
		paired days based on high concentration instead of date	not checked	not checked
	Spatial Gradient Setup	Start Value	1	1
		End Value	5	5

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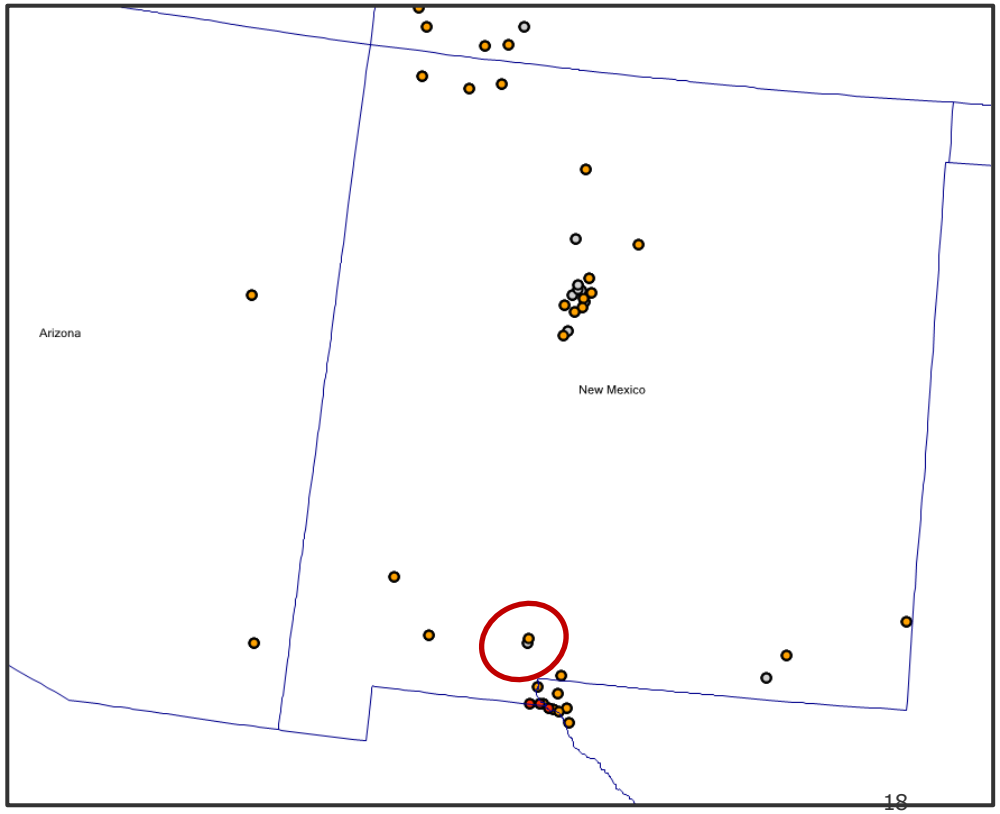
SMAT DESIGN VALUES NEW MEXICO

AQS ID	DVC: 2014 (ppb)	DVF: 2028 (ppb)	DVF – DVC (ppb)	County
350010023	66.3	60.9	-5.4	Bernalillo
350010024	68.0	62.3	-5.7	Bernalillo
350010029	66.0	61.0	-5.0	Bernalillo
350010032	67.0	62.6	-4.4	Bernalillo
350011012	65.0	59.1	-5.9	Bernalillo
350130008	66.3	60.0	-6.3	Dona Ana
350130017	67.0	61.9	-5.1	Dona Ana
350130020	67.0	62.3	-4.7	Dona Ana
350130021	72.0	67.0	-5.0	Dona Ana
350130022	71.3	66.1	-5.2	Dona Ana
350130023	65.0	60.3	-4.7	Dona Ana
350151005	69.0	66.7	-2.3	Eddy
350171003	62.0	59.0	-3.0	Grant
350290003	66.0	62.7	-3.3	Luna
350390026	64.0	60.8	-3.2	Rio Arriba
350431001	64.0	58.4	-5.6	Sandoval
350450009	64.3	61.0	-3.3	San Juan
350450018	67.0	64.8	-2.2	San Juan
350451005	63.7	60.8	-2.9	San Juan
350490021	64.3	60.6	-3.7	Santa Fe
350610008	66.3	62.2	-4.1	Valencia

- Only two sites in NM have DV over 71 in the base case period (2012-2016)
  - Desert View and Santa Teresa



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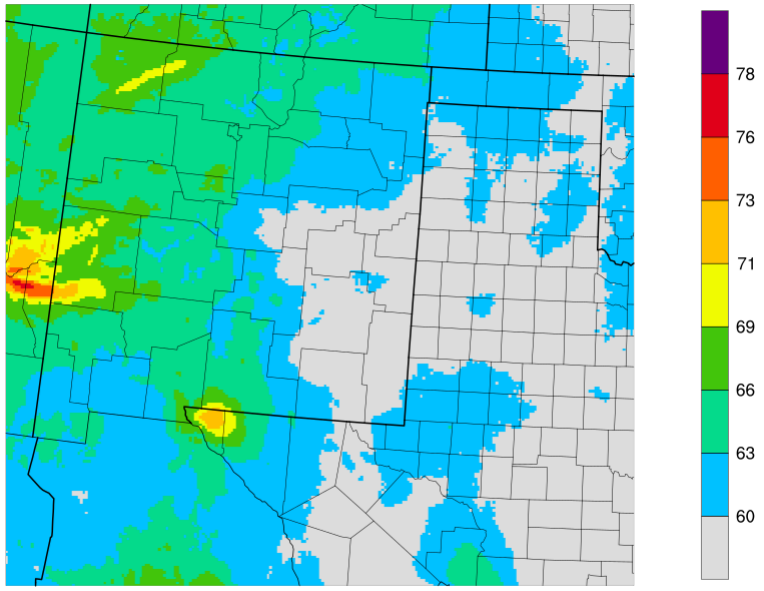
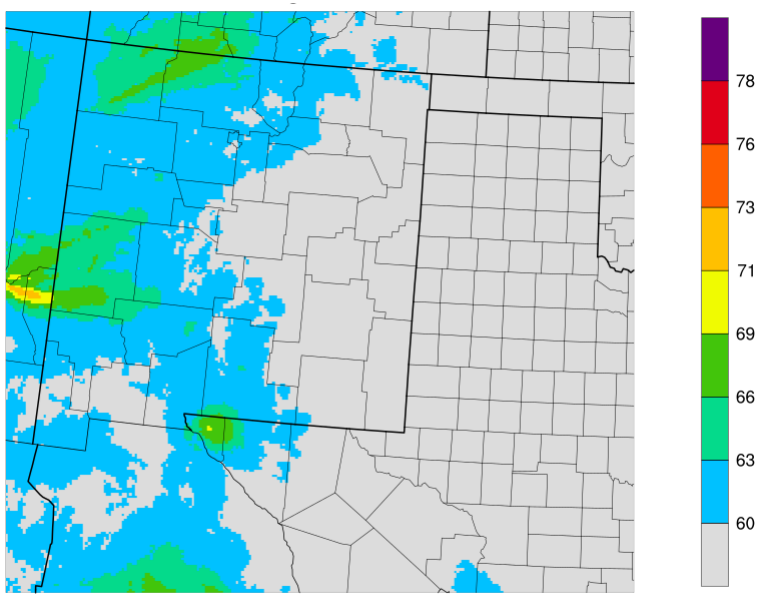
UNMONITORED AREA ANALYSIS USING MODELED GRADIENTS IN 2012-2014 OZONE DV SPATIAL INTERPOLATION

DVC: 2014



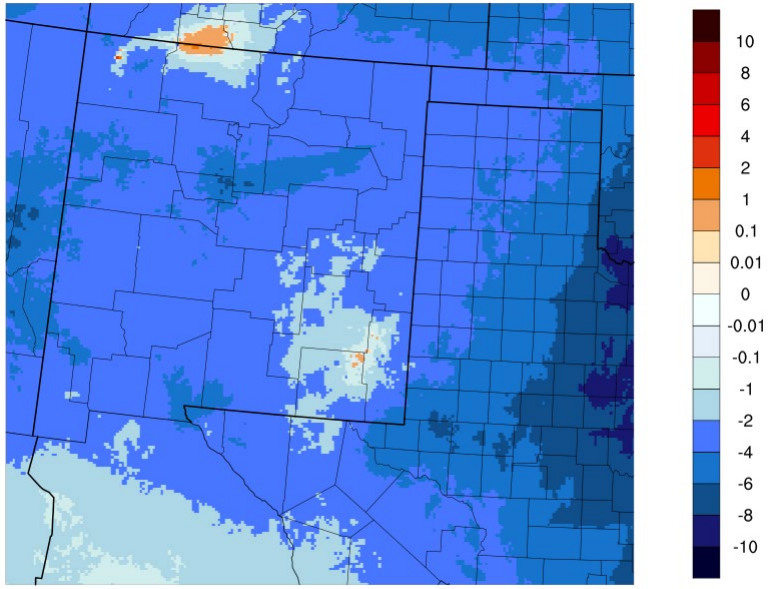
max(7,117) = 77.4 ppb
min(238,27) = 55.2 ppb

DVF: 2018



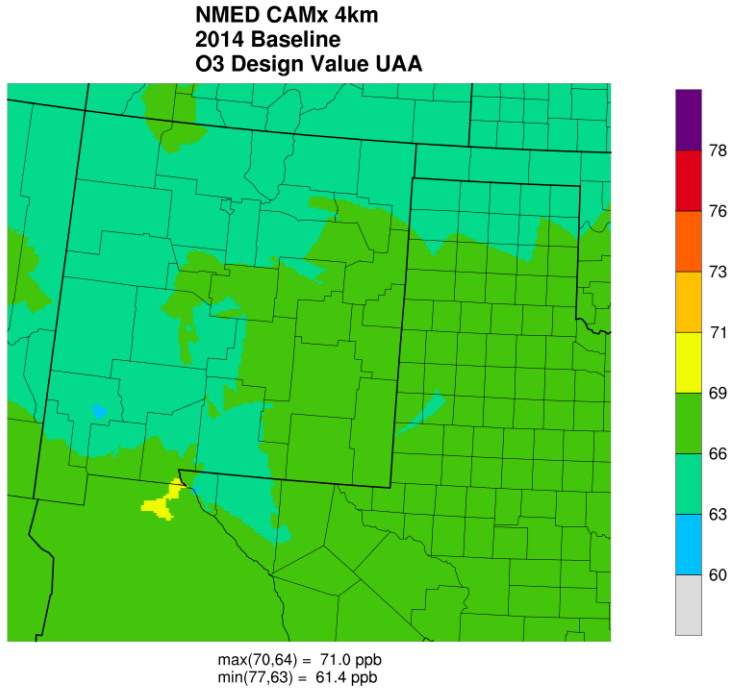
max(7,117) = 72.6 ppb
min(241,28) = 47.7 ppb

DVF - DVC

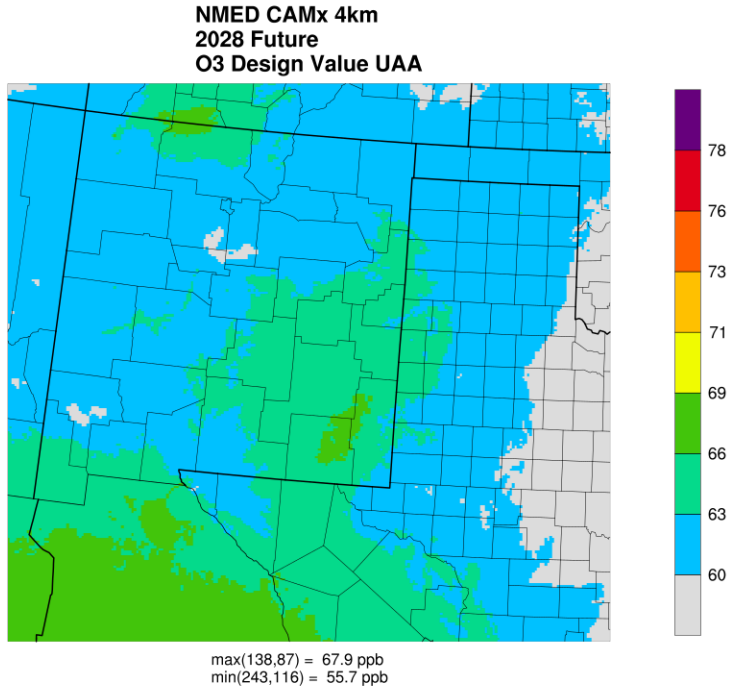


UNMONITORED AREA ANALYSIS NOT USING MODELED GRADIENTS IN 2012-2014 OZONE DV SPATIAL INTERPOLATION

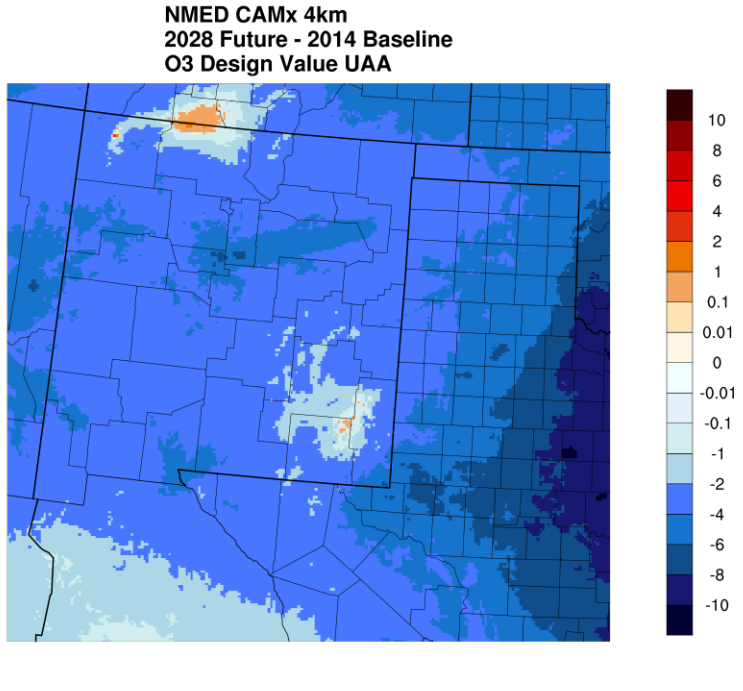
DVC: 2014



DVF: 2018



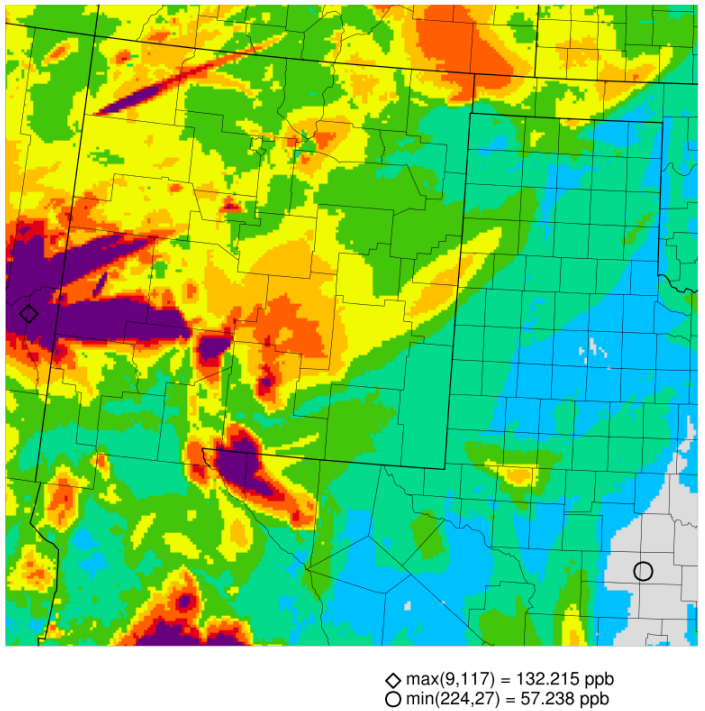
DVF - DVC

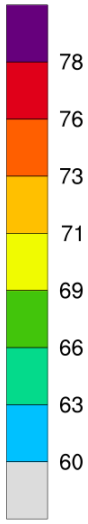


MODEL MDA8 RESULTS

EPISODE MAXIMUM MDA8 AND DIFFERENCE

Max(2014)





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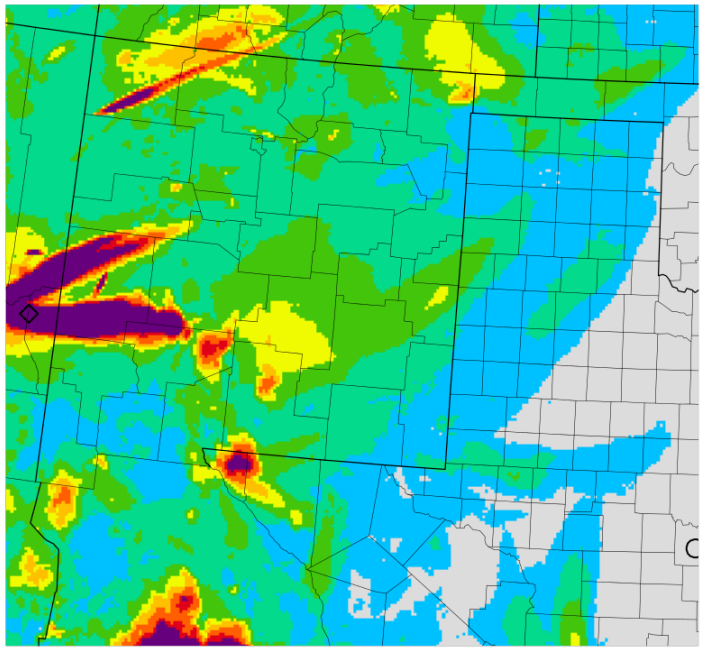
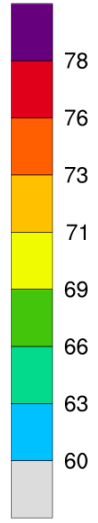
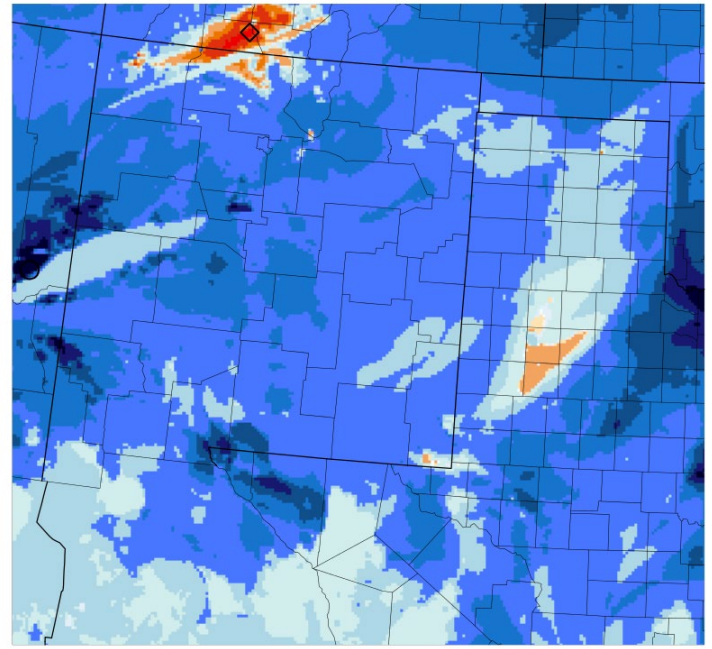
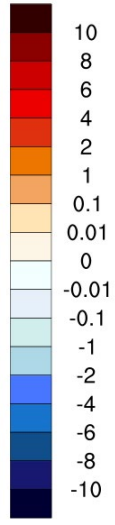




Max(2028) – Max(2014)



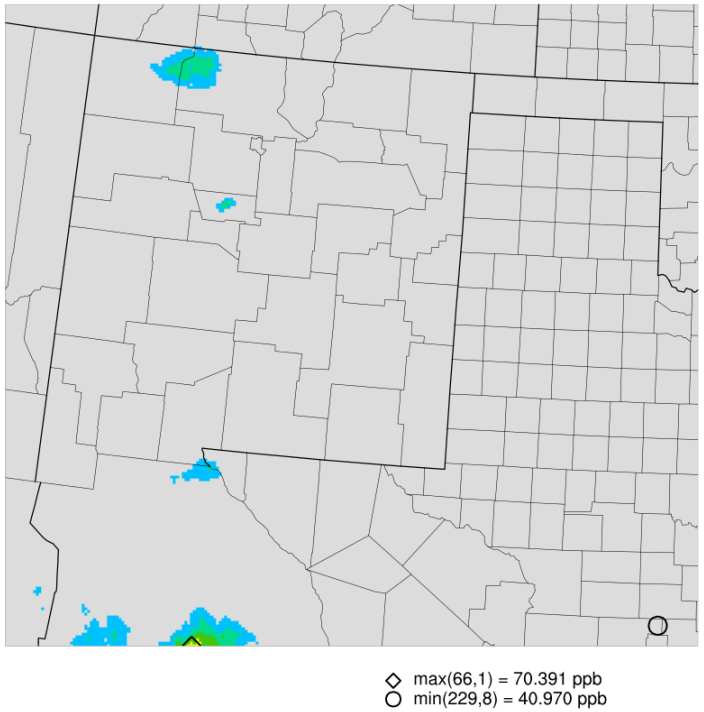


- Maximum values and differences are unpaired in time.
- High concentrations tend to occur on western part of the domain where there are no monitors

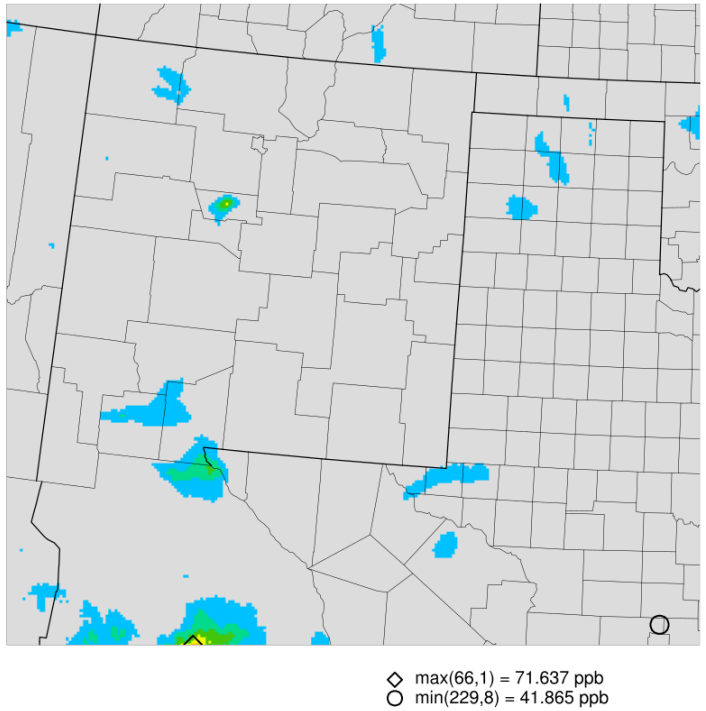
RAMBOLL

MAXIMUM ONE DAY DIFFERENCE: AUG 17

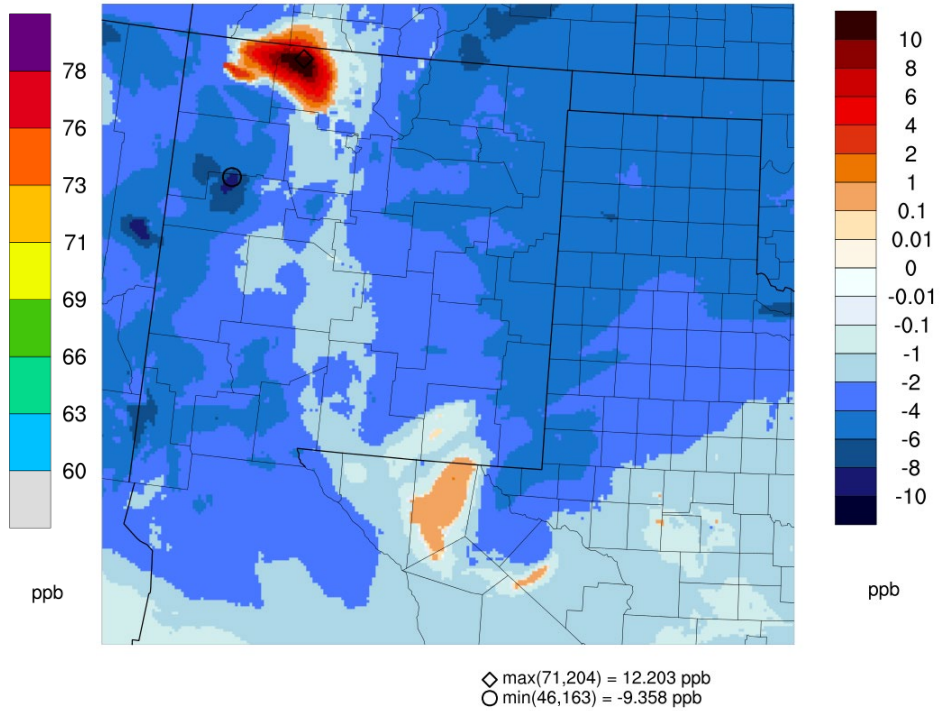
2028



2014



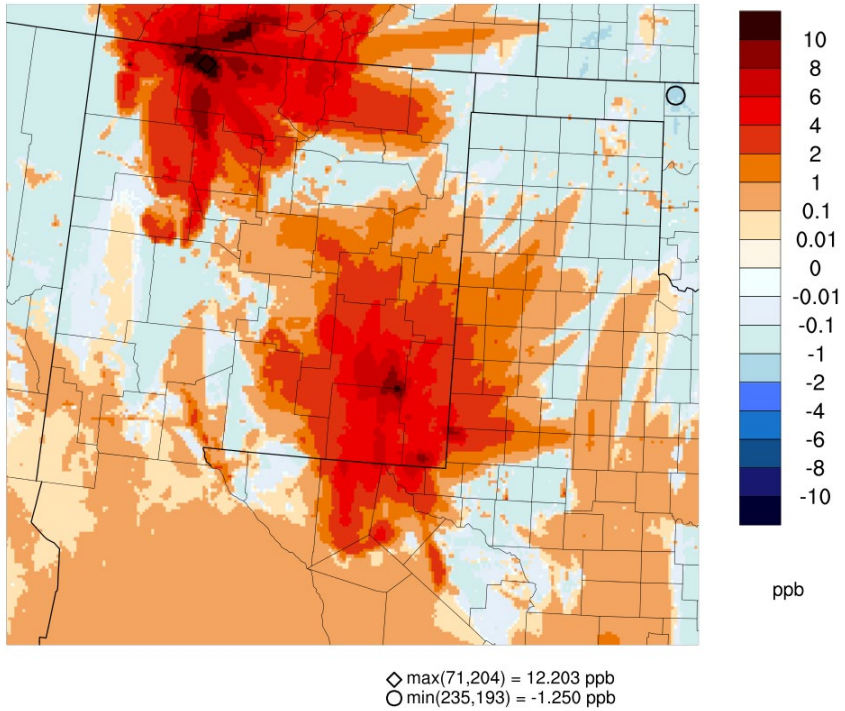
2028 - 2014



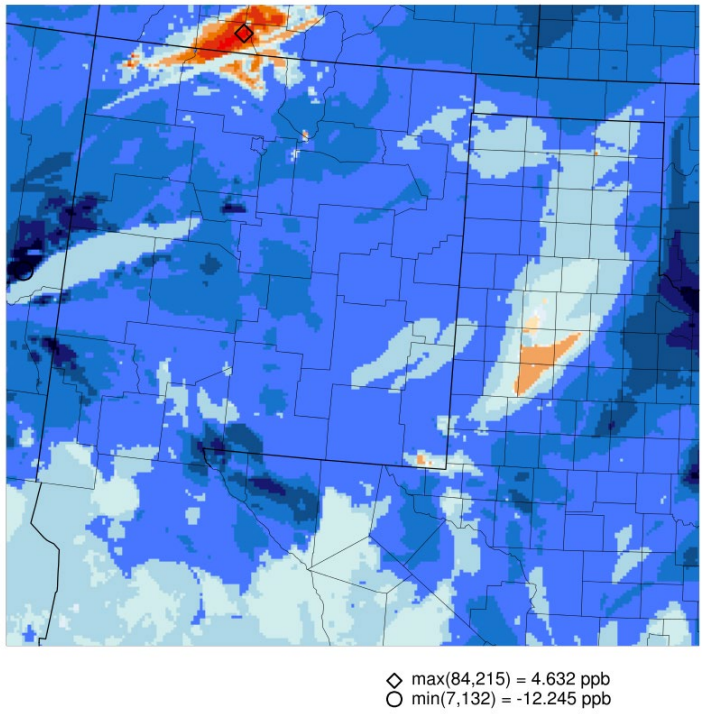
- Maximum difference (12.2 ppb) occurs in NW part of the domain in a day with low ozone concentrations

COMPARISON AMONG DIFFERENCES

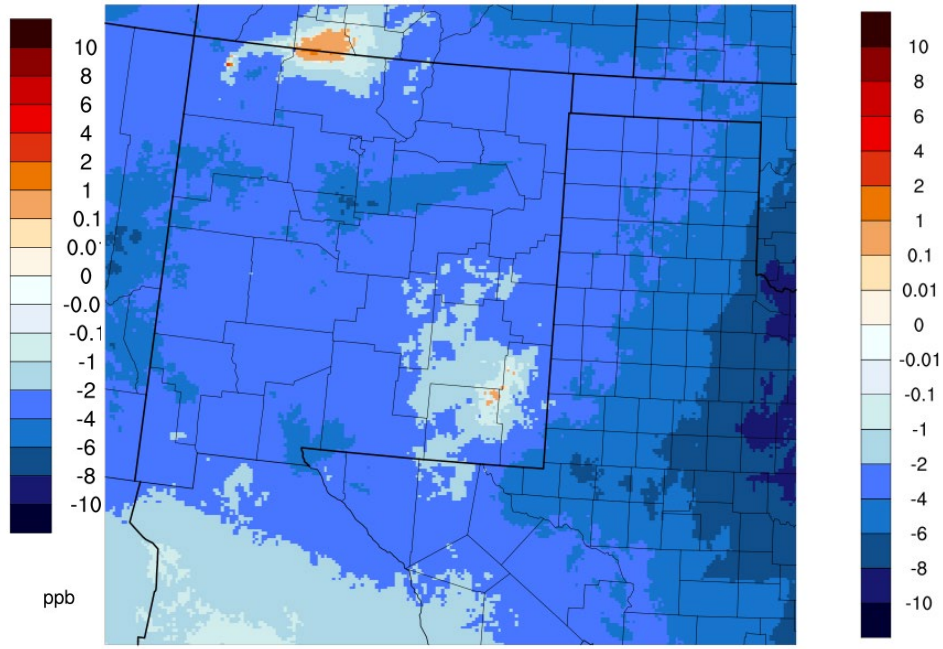
MAX (DIFF)



DIFF (MAX)



UAA DIFF

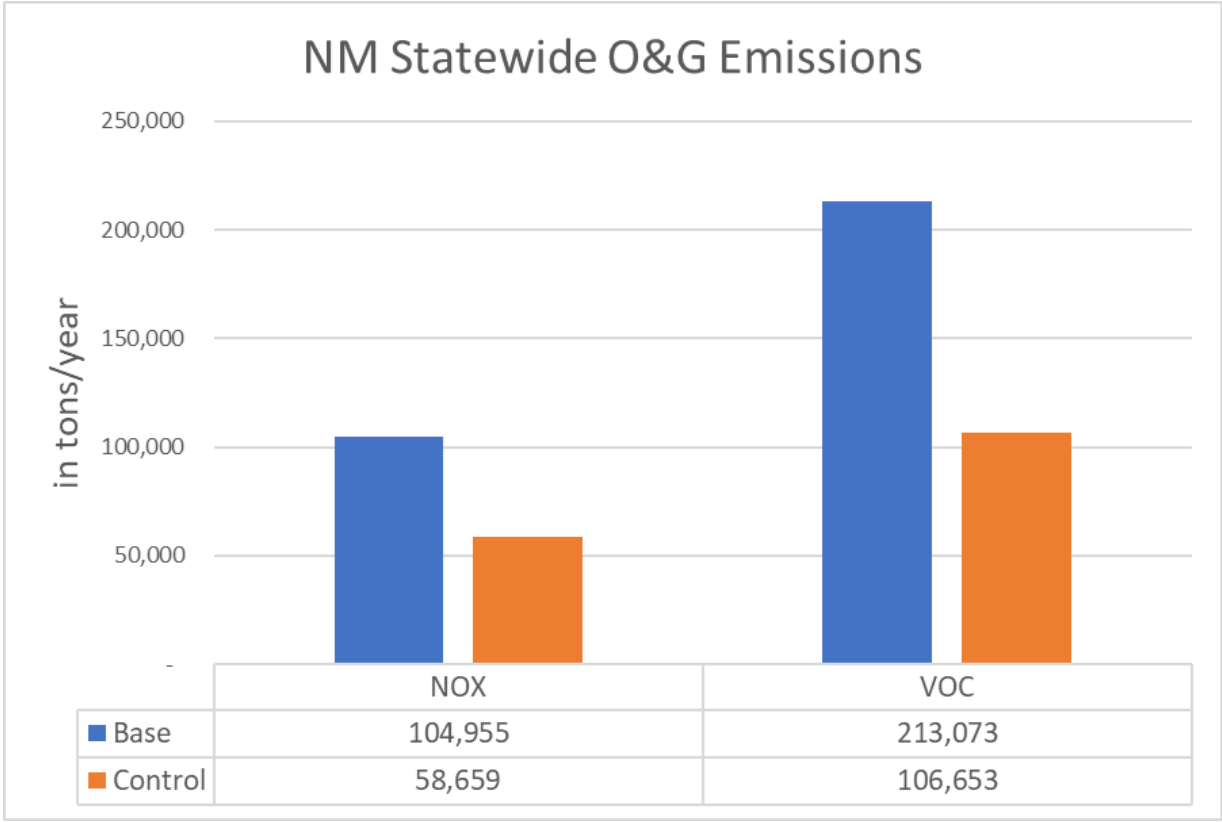


- Feature with increased ozone in 2028 over northern NM appears in all figures

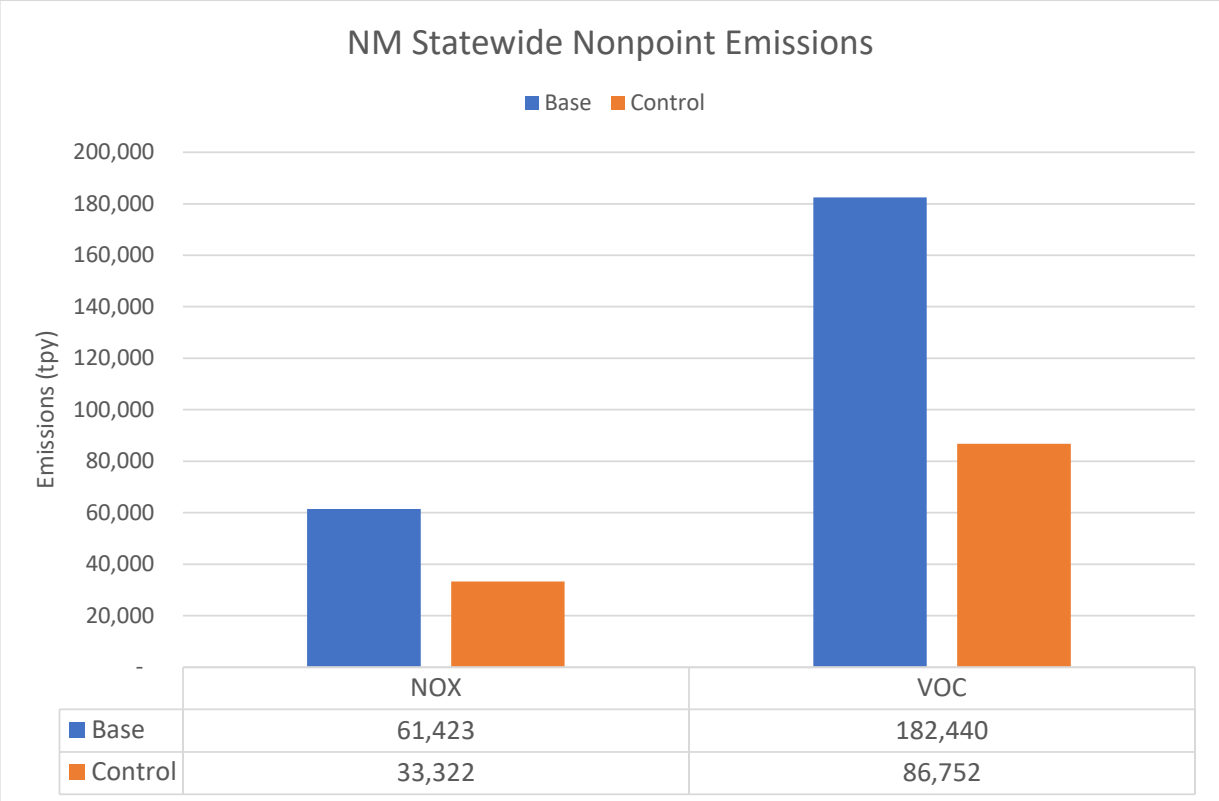
STATUS OF 2028 NEW MEXICO OIL AND GAS (O&G) CONTROL STRATEGY (CS) MODELING

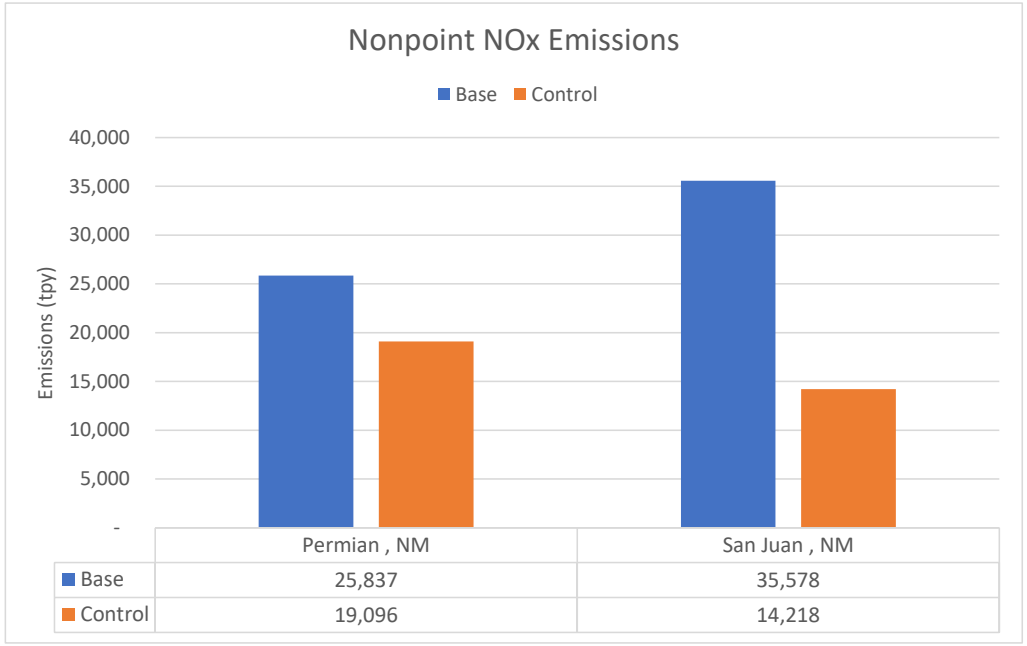
2028 O&G CONTROL SCENARIO EMISSIONS

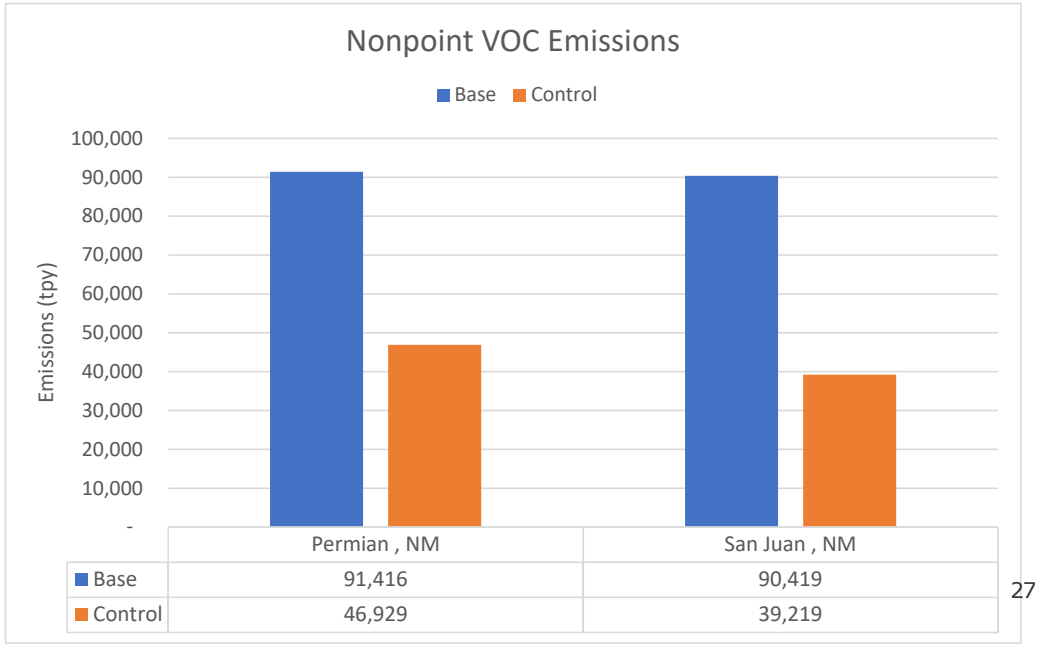
- ERG provided revised point and nonpoint NM emissions for affected counties/SCCs/pollutants.
- 7 NM counties included in ERG's inventory
  - San Juan Basin (4 counties)
  - Permian Basin (3 counties)
- Bar chart display to show comparisons between 2028 Base and Control Scenario O&G emissions for NM
- 44% NOx and 50% VOC reductions in total O&G emissions



NEW MEXICO NONPOINT O&G







- 46% NOx reduction in nonpoint O&G
- 52% VOC reduction in nonpoint O&G

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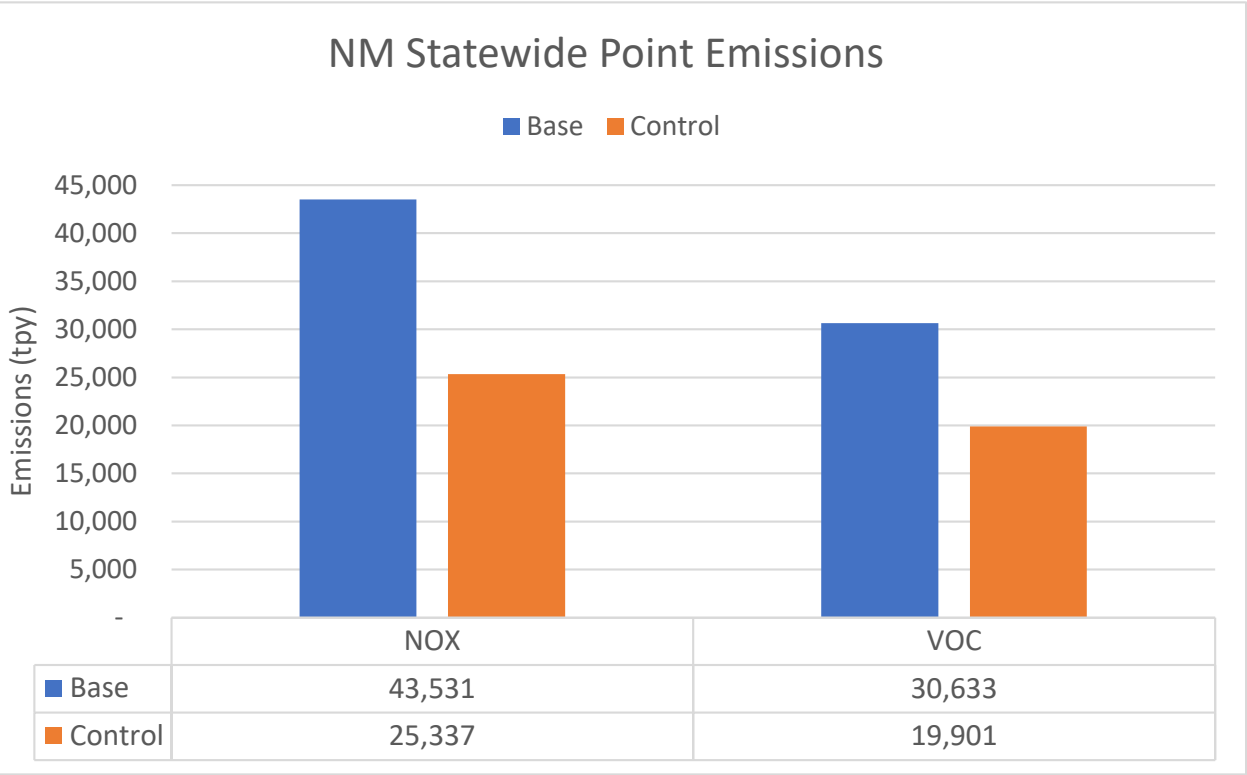
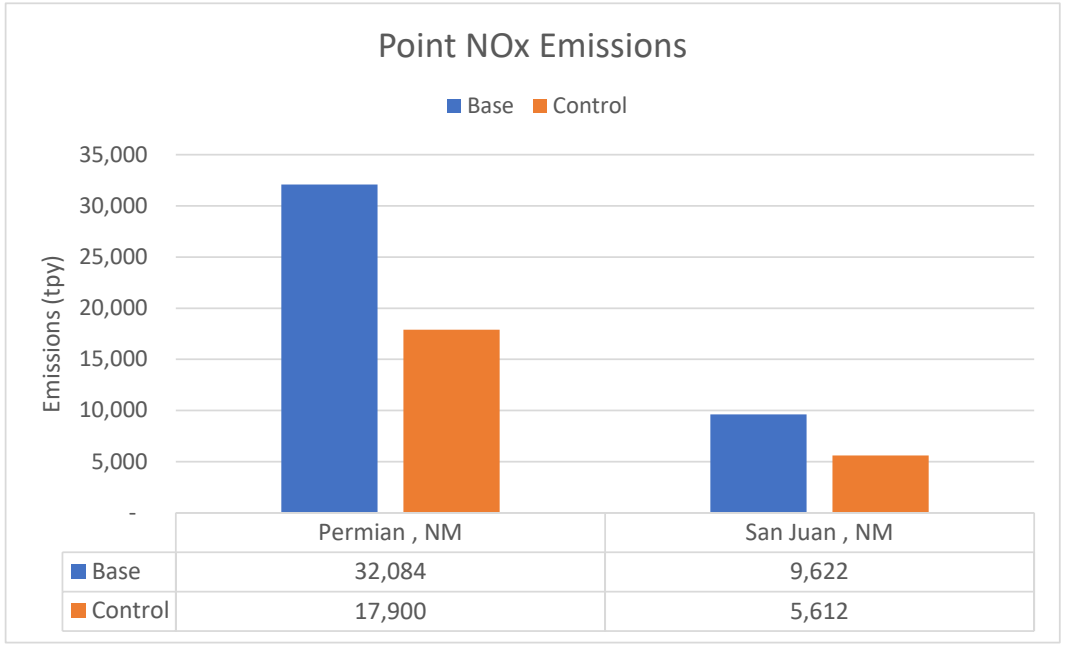
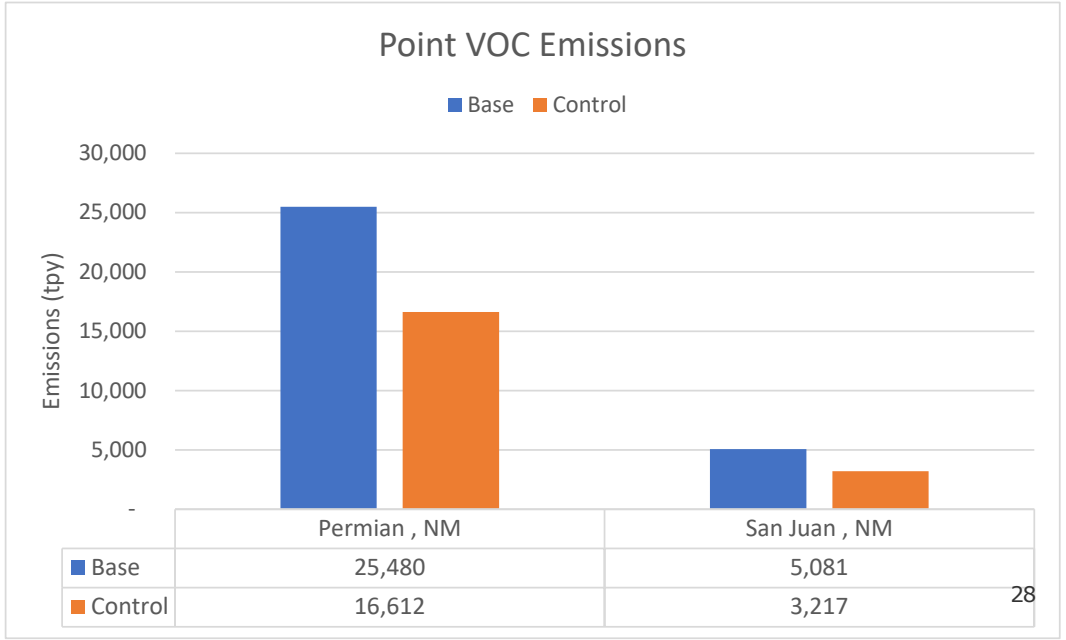
NEW MEXICO POINT O&G



	NOX	VOC
Base	43,531	30,633
Control	25,337	19,901



	Permian , NM	San Juan , NM
Base	32,084	9,622
Control	17,900	5,612



	Permian , NM	San Juan , NM
Base	25,480	5,081
Control	16,612	3,217

- 42% NOx reduction in point O&G
- 35% VOC reduction in point O&G

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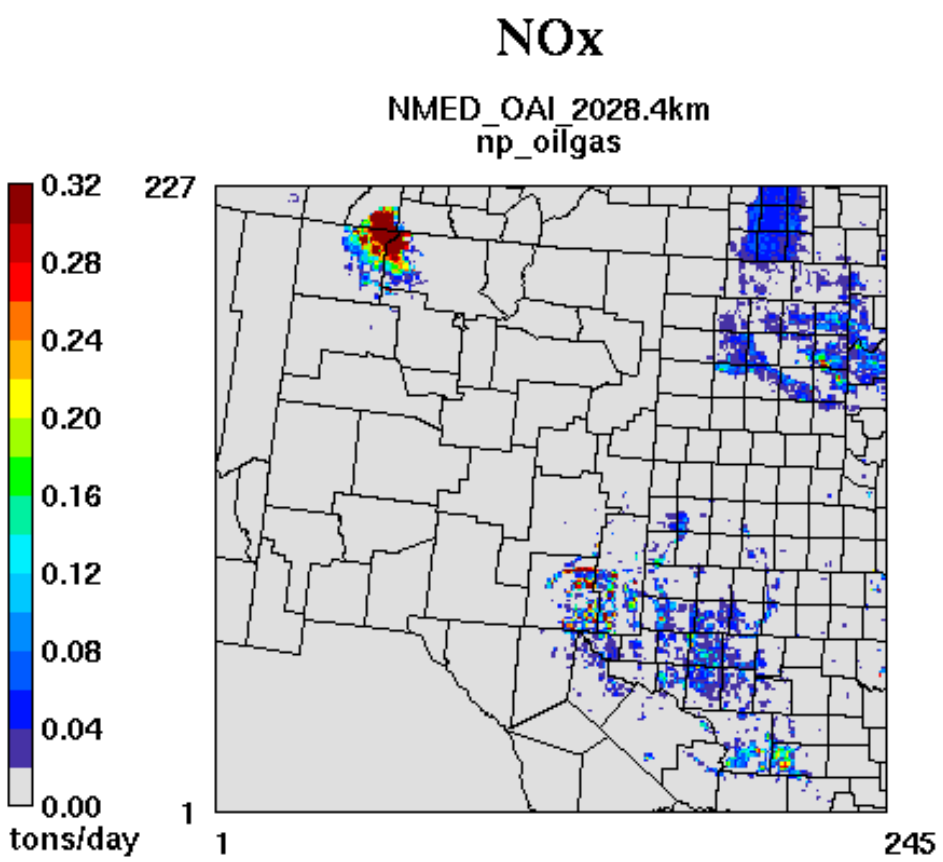
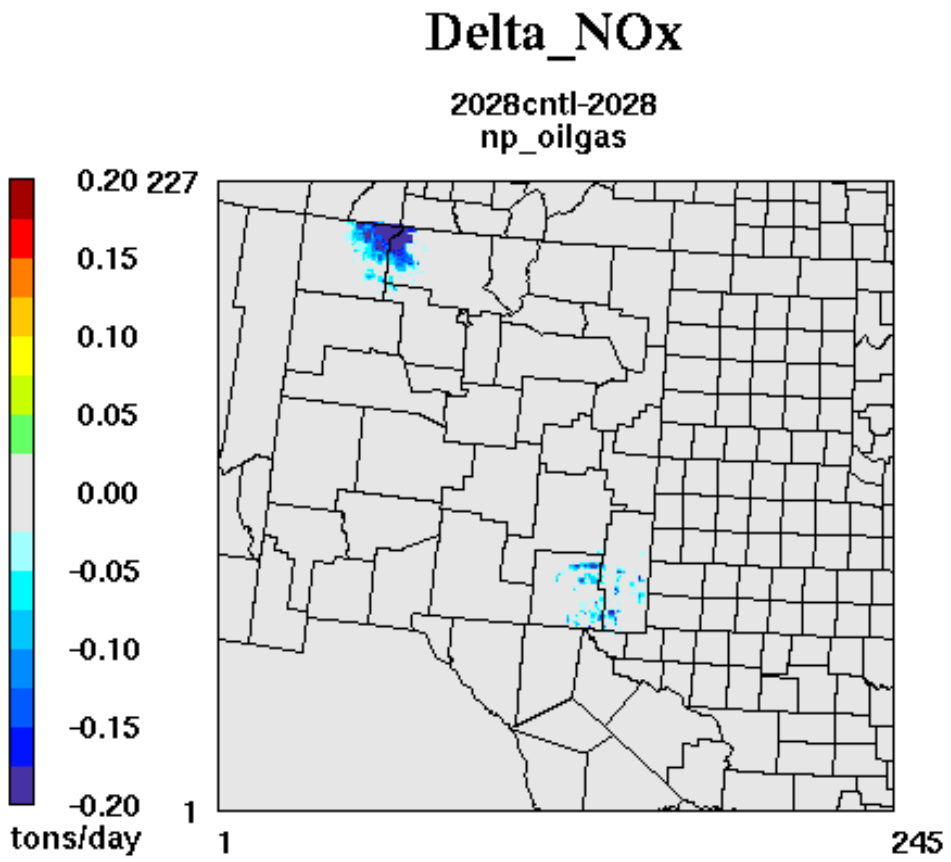
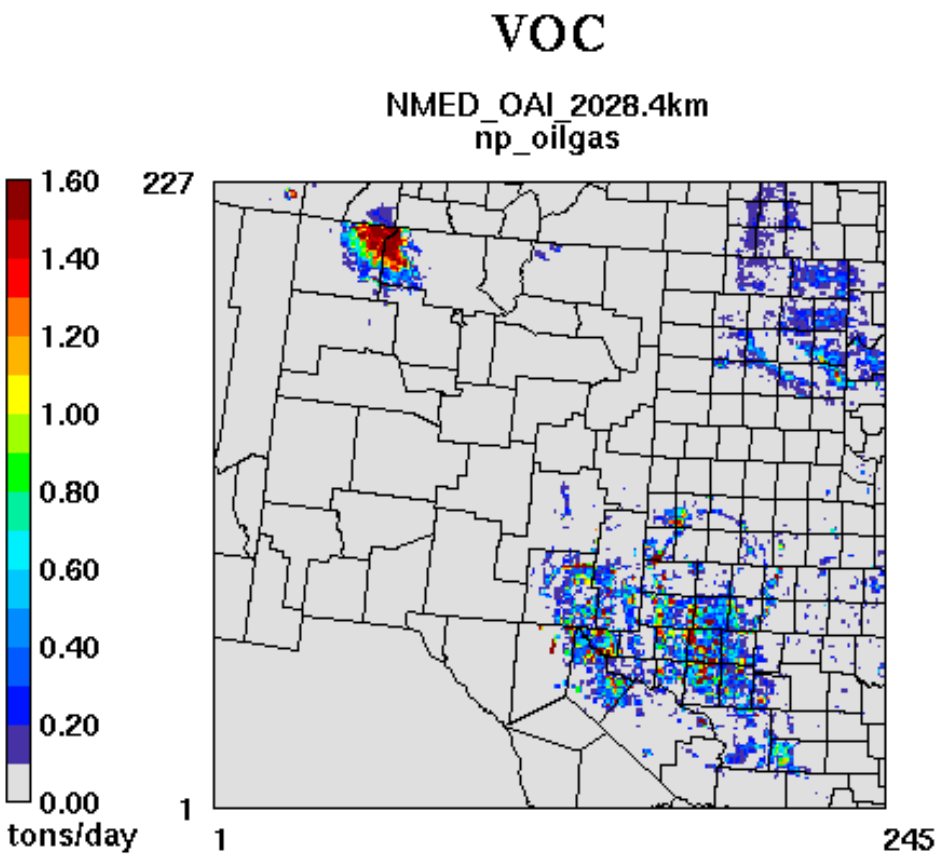
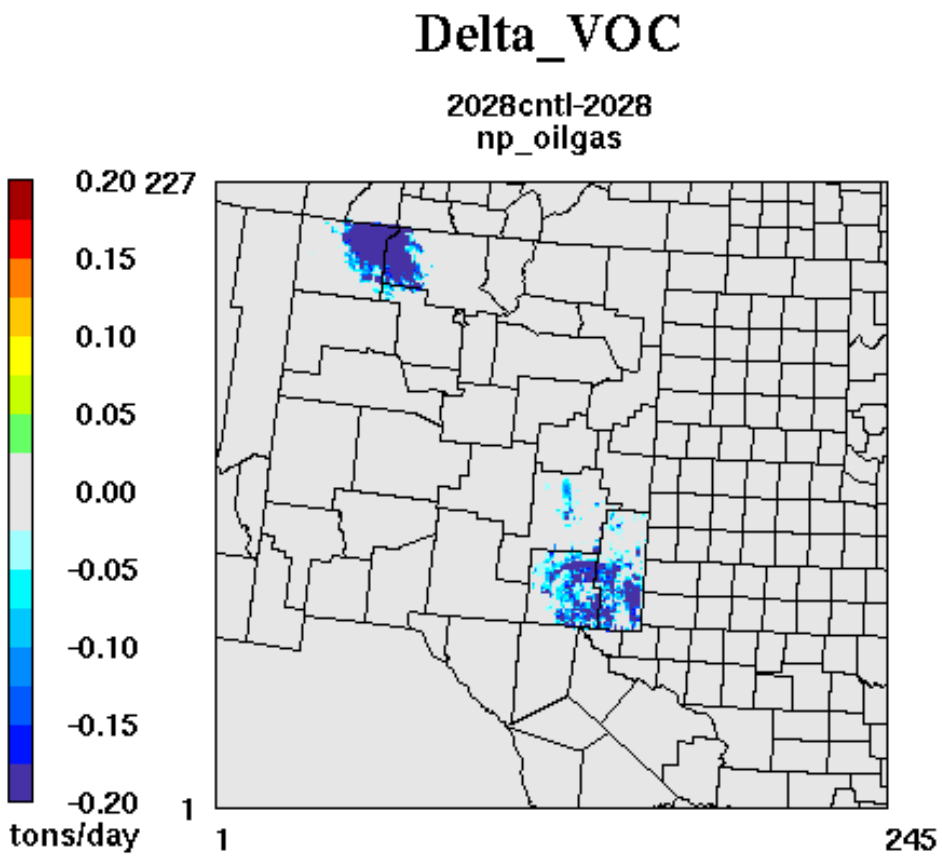
NONPOINT O&G COMPARISON: NOX



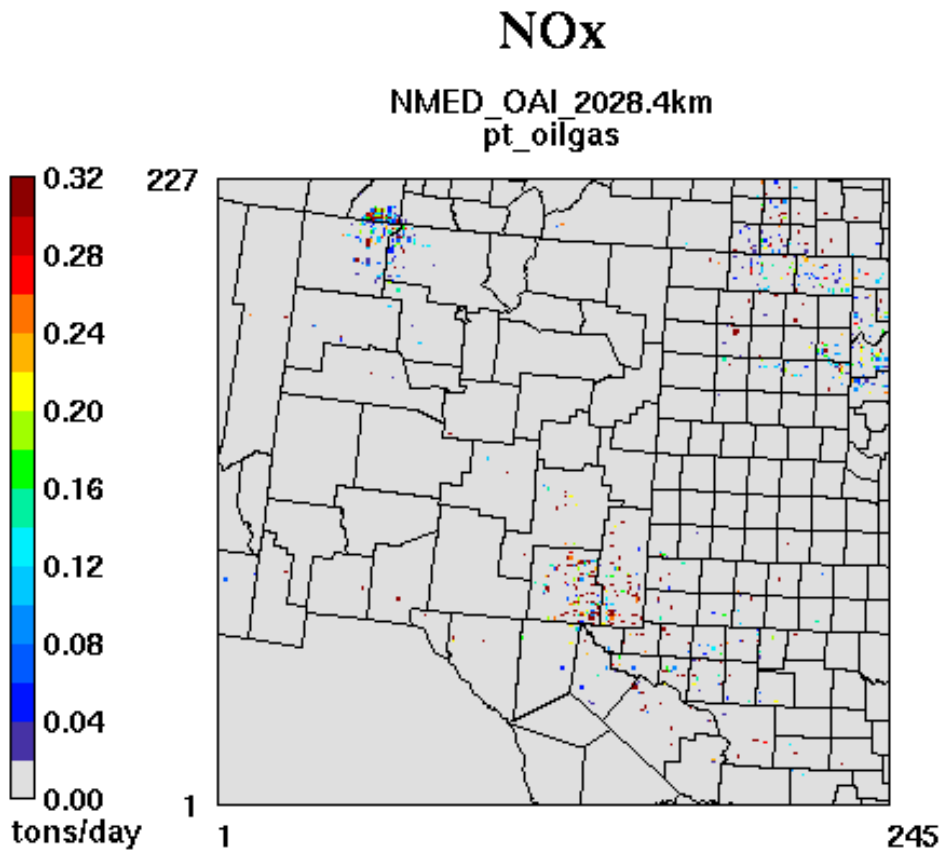


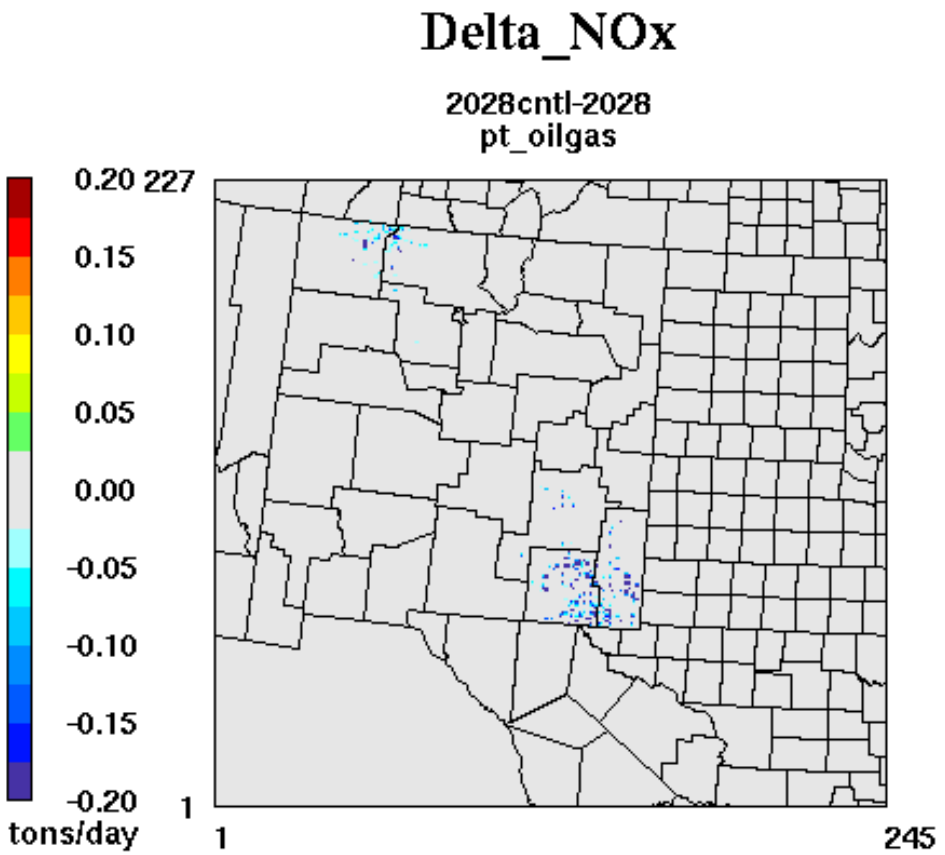
NONPOINT O&G COMPARISON: VOC



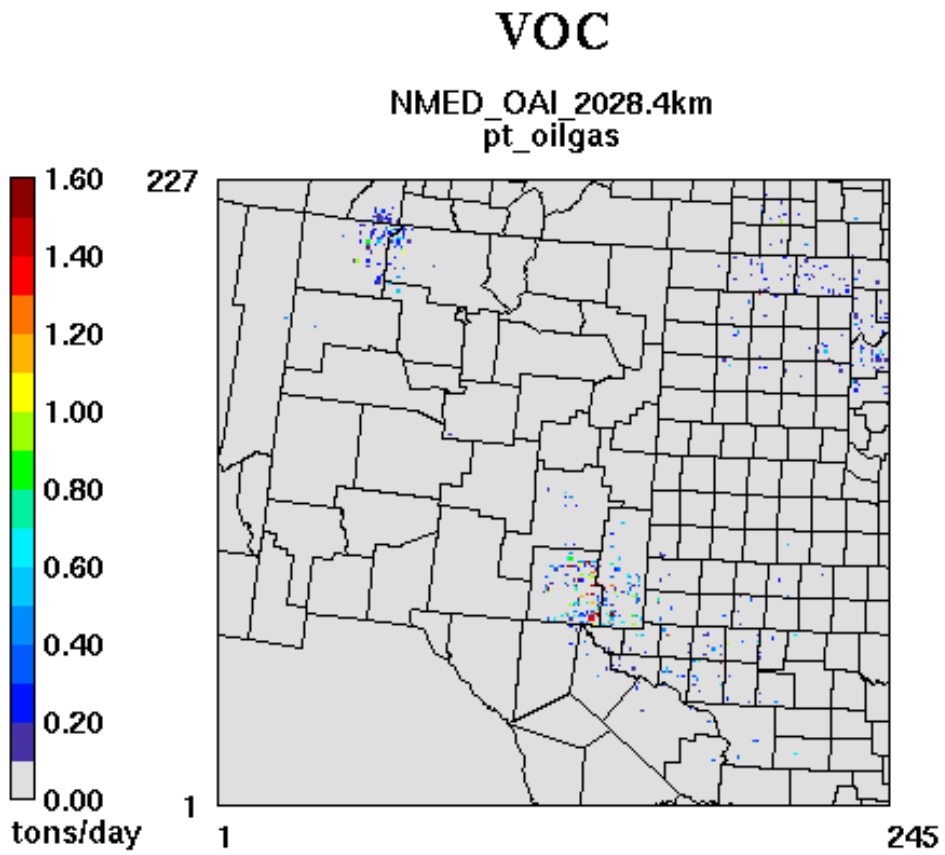


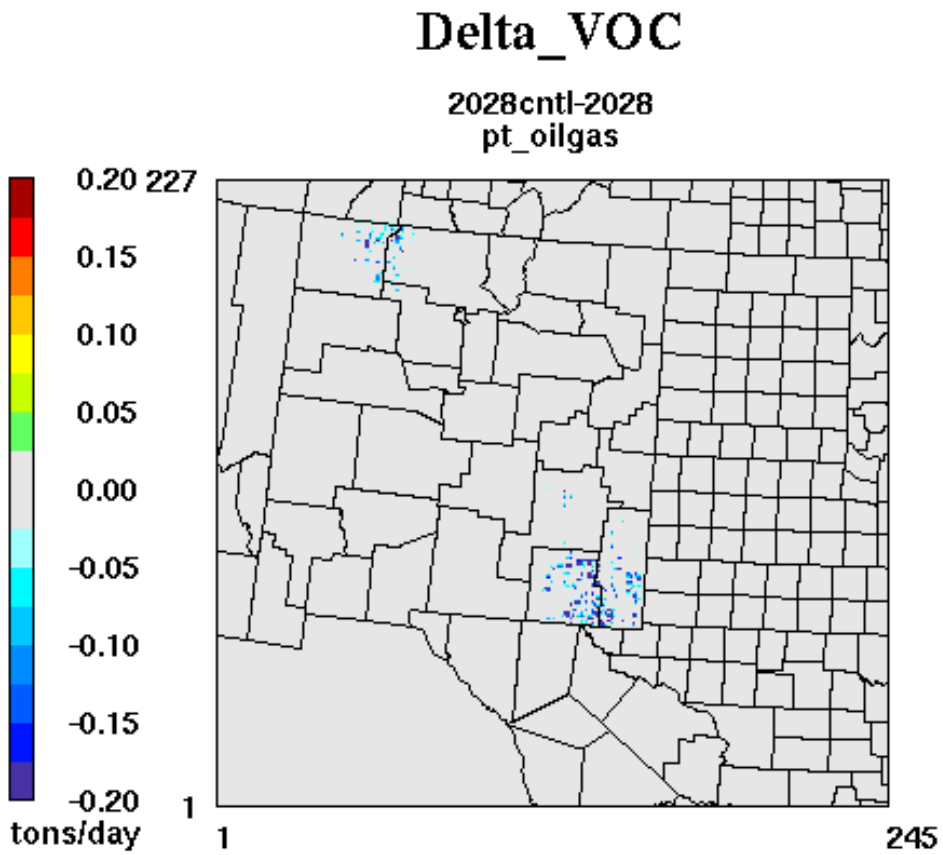
POINT O&G COMPARISON: NOX





POINT O&G COMPARISON: VOC





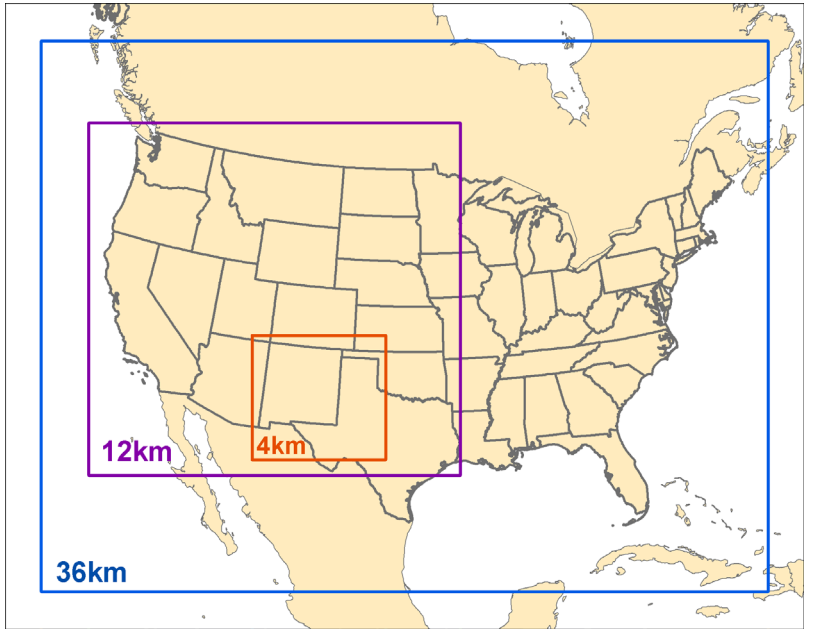
CURRENT STATUS AND NEXT STEPS

- Completed processing of 2028 O&G emissions for New Mexico O&G Control Scenario
- Started 2028 CAMx runs for O&G Control Scenario last Friday (2/5)
- Analyze CAMx outputs and provide ozone results to NMED

DESIGN OF 2028 NM O&G CS SOURCE REGION AND CATEGORY APCA OZONE SOURCE APPORTIONMENT

CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

- Purpose: To determine contributions of 9 Source Categories within New Mexico and rest of U.S. as well as international anthropogenic emissions to ozone concentrations in New Mexico under the 2028 NM O&G CS emissions scenario.
- Approach:
  - Model: CAMX version 7.1 (released December 2020)
  - Domains: NMED OAI Study 36/12/4-km
  - Period: May – August 2014
  - Boundary Conditions: WRAP 2014 GEOS-Chem
  - Emissions Scenario: WRAP 2028OTBa2 except:
    - Actual 2014 Fire Emissions (U.S. WF, Rx and Ag)
    - 2028 New Mexico Oil and Gas Control Strategy (2028 NM O&G CS)
  - Source Apportionment: Anthropogenic Precursor Culpability Assessment (APCA) version of CAMx ozone source apportionment tool.



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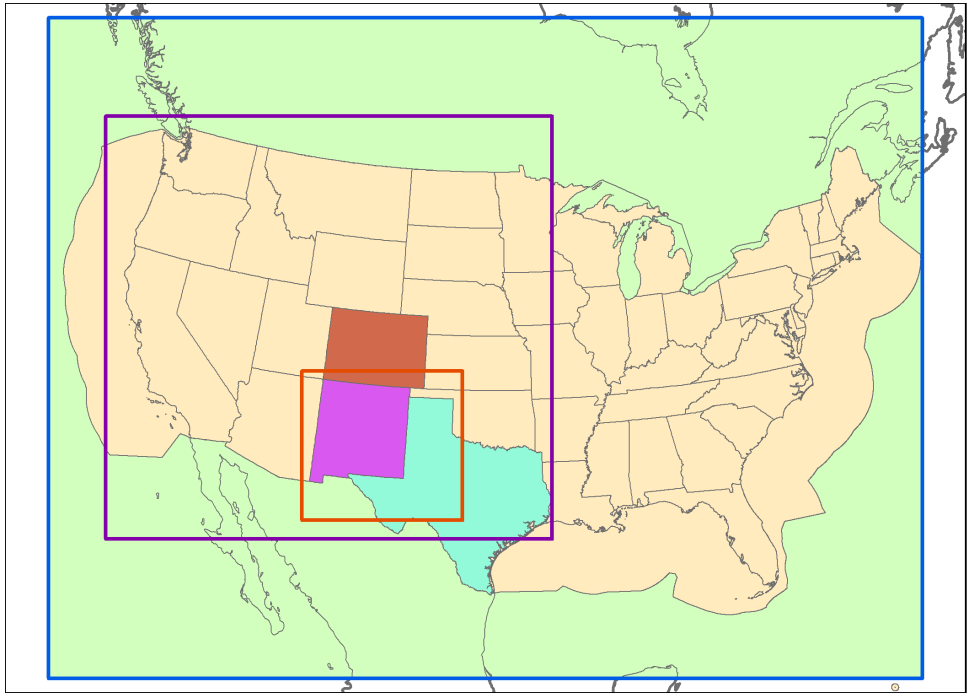
CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

- CAMx Ozone Source Apportionment Technology (OSAT) ozone source apportionment tool:
  - Ozone contributions are obtained for user-defined Source Groups:
    - A Source Group typically consists of a Source Category emitting from a geographic Source Region
    - For example, on-road mobile source emissions from New Mexico
  - OSAT uses reactive tracers for ozone (O3V and O3N) and precursors (e.g., VOC and NOx) and intermediate species (e.g., NO3 and PAN) that run in parallel to the host model
  - When ozone is formed in the host model, OSAT determines whether ozone formation is more VOC-limited or NOx-limited and assigns the ozone formed to Source Groups O3V or O3N based on the relative contribution of the Source Groups' limiting precursor to the total precursor concentration
- CAMx Anthropogenic Precursor Culpability Assessment (APCA) ozone source apportionment tool:
  - APCA differs from OSAT in that it recognizes that natural emissions are not controllable so only allocates ozone to natural emissions Source Groups when it is due to natural NOx interacting with natural VOC
  - When ozone is formed due to natural VOC and anthropogenic NOx under VOC-limited conditions, a case OSAT would assign to the natural Source Group, APCA redirects the ozone formed to the anthropogenic Source Group
  - APCA provides more control-strategy relevant information

RAMBOLL

CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

- **Definition of Source Groups**
  - Boundary Conditions (BCs) from 2014 GEOS-Chem runs:
    - BC_{Intl} - International anthropogenic emissions
    - BC_{USA} – U.S. anthropogenic emissions
    - $BC_{Natural}$ – Natural sources
    - BC_{Top} – BC above the top of domain
  - Source Categories (9):
    1. Natural (biogenic, lightning NOx, etc.);
    2. Fires (WF, Rx, Ag, other);
    3. Oil and gas point sources (surrogate for midstream);
    4. Oil and gas non-point sources (surrogate for upstream;
    5. EGU point;
    6. Non-EGU point;
    7. On-road mobile;
    8. Non-road mobile; and
    9. Remainder anthropogenic.
  - Source Regions (5):
    - New Mexico
    - Texas
    - Colorado
    - Remainder U.S.
    - International (Mex, Can, CMV > 200 nmi)
  - 50 Source Groups (50 = 5 x 9 + 5)



RAMBOLL

CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

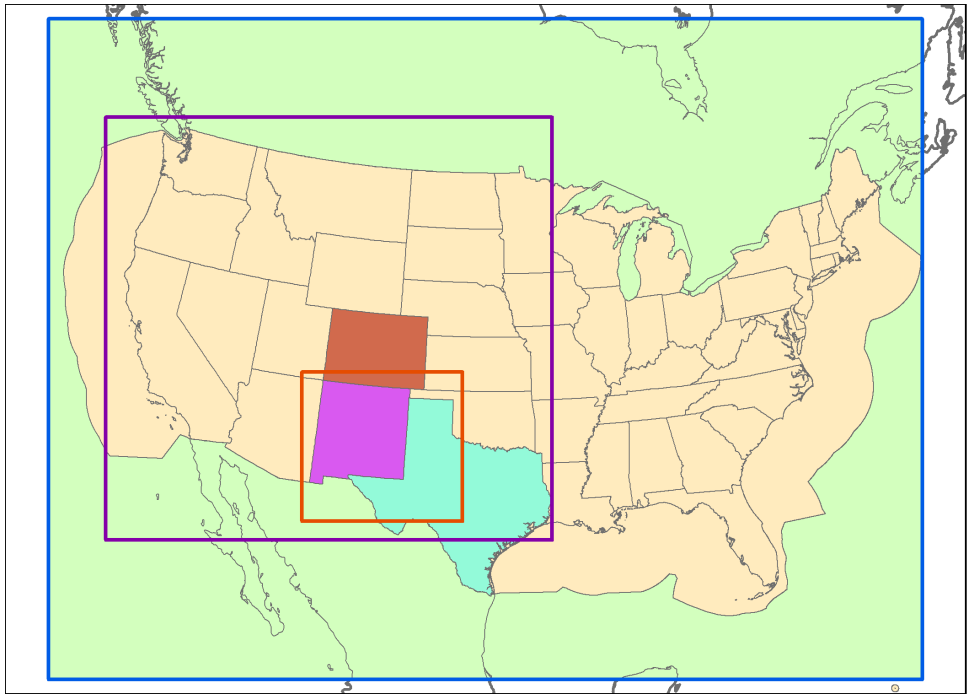
- Post-Processing of CAMx 2028 NM O&G CS APCA Source Apportionment Results
  - MDA8 Ozone Concentrations at the Monitoring Sites
    - Generate stacked Bar Charts and Pie Charts of source contributions using an Excel Dashboard
    - User select monitoring sites and group of 10 days to display, and stacked bar charts are generated for the 10 days and pie chart for the average of the 10 days (e.g., 10 days used in SMAT for 2028 ozone projections)
  - Spatial maps of MDA8 ozone for Source Categories within New Mexico across 4-km domain
    - Provides a footprint of New Mexico Source Category contributions
    - Other spatial maps of MDA8 ozone (e.g., Source Categories and State across Western U.S.)
  - International Anthropogenic Emission Contributions
    - Run SMAT removing contributions from International anthropogenic emissions (i.e., Mex/Can/CMV + BC_{Intl}) to obtain 2028 ozone DVs w/o International emissions and compare with 2028 NM O&G CS ozone DV projections

RAMBOLL

DESIGN OF 2028 NM O&G CS OSAT VOC-VS. NOX-LIMITED OZONE SOURCE APPORTIONMENT

CAMX 2028 NM O&G CS OSAT OZONE SOURCE APPORTIONMENT

- Purpose: To estimate relative amount of VOC-Sensitive vs. NOx-sensitive ozone formation within 2028 New Mexico.
- Use the OSAT version of CAMx ozone source apportionment tool
- Definition of Source Groups
  - Source Regions (5):
    - Use same 5 Source Regions as APCA SA run
  - Source Categories (2):
    - Anthropogenic Emissions
    - Natural and Fire Emissions
  - 12 Source Groups (5 x 2 + 2 [IC,BC])
    - Will run faster than CAMx APCA SA Run (50 Source Groups)



RAMBOLL

CAMX 2028 NM O&G CS OSAT OZONE SOURCE APPORTIONMENT

- Post-processing of CAMx 2028 NM O&G CS OSAT ozone source apportionment results
  - Monitoring site displays
    - Extract Hourly and MDA8 ozone at the monitoring sites and load in Excel Dashboard to display stacked Bar Charts and Pie Charts of IC/BC and VOC-sensitive vs. NOx-sensitive ozone formation contributions
  - Spatial maps across 4-km NM domain depicting fraction of MDA8 ozone formed under VOC-sensitive vs. NOx-sensitive formation conditions:
    - Total MDA8 ozone; BC ozone; O3V ozone; and O3N ozone
    - Ratio of O3V/O3N: When > 1 → more VOC-sensitive and when < 1 → more NOx sensitive
    - Percent NOx-sensitive ozone formation to total ozone without BC (i.e., 100 x ∑O3N /(∑O3N +∑O3V)