NEW MEXICO OZONE ATTAINMENT INITIATIVE

2028 New Mexico Oil and Gas Control Strategy Modeling

Marco Rodriguez, Pradeepa Vennam, Jung Chien, John Grant, Tejas Shah and Ralph Morris, Ramboll

Tom Moore and Mary Uhl, WESTAR

NM OAI Study Webinar

February 24, 2021 (Revised February 25, 2021)

RAMBOLL Bright ideas. Sustainable change.

2028 NEW MEXICO OIL & GAS CONTROL STRATEGY MODELING

01 Overview of Revised 2014v2 Base Case and 2028 Base Case Modeling

02 Summary of 2028 New Mexico O&G Control Scenario

03 2028 New Mexico O&G Control Scenario CAMx Modeling Results

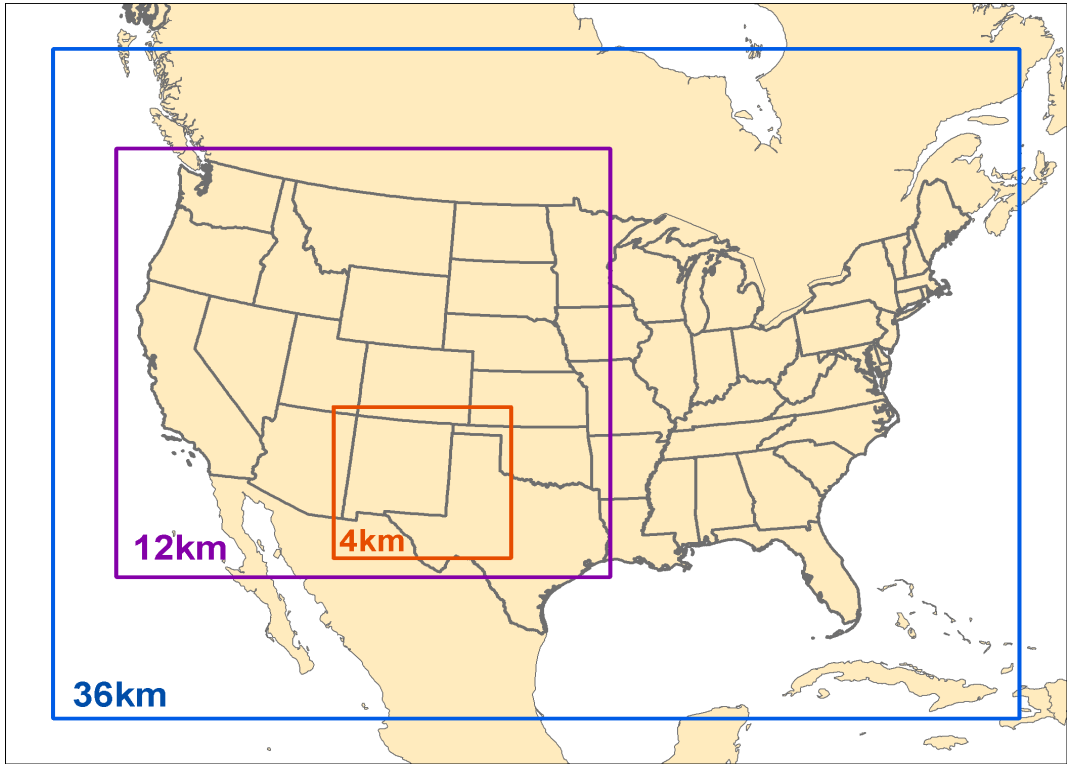
04 Overview of 2028 State & International Source Category APCA and OSAT 2028 VOC/NOx-limited Ozone Source Apportionment Modeling

RAMBOLL

REVISED 2014V2 BASE CASE AND 2028 BASE CASE MODELING

CAMX 2014 NM OAI STUDY MODEL CONFIGURATION

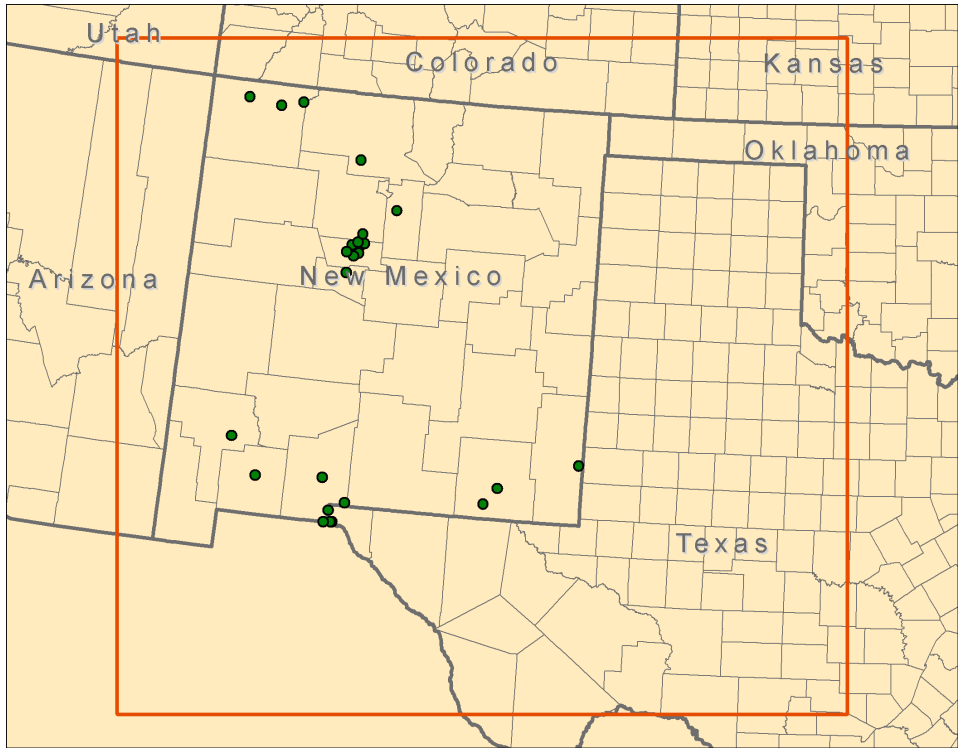
- Episode: May-August 2014
  - 16-day spin-up before first high ozone day in NM
    - 68 ppb on May 17
- 36/12/4-km Modeling Domains
  - 36/12-km domains same as WRAP Regional Haze
  - New 4-km New Mexico domain
- Boundary Conditions (BC) WRAP 2014 GEOS-Chem
- Four Meteorological Diagnostic Sensitivity 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



RAMBOLL

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 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, missing LAI in urban areas so has zero biogenic emissions
  - MEGAN v3.1 has 20% less (May) to similar (June) to ~30-60% more (Jul&Aug) VOC than BEIS v3.7
  - MEGAN v3.1 has 3x more biogenic NOx
  - CAMx v7.1 w/ BEIS ozone MPE very similar; bias 1-2 percentage point lower
    - 2014v2 MPE Addendum Report

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

RAMBOLL

FUTURE YEAR OZONE DESIGN PROJECTION APPROACH

- EPA's Ozone Modeling Guidance (2018) recommends making future year ozone Design Value (DVF) projections using the relative change in modeling results between the base (2014) and future (2028) years to scale the current year ozone design value (DVC)
  - The model derived scaling factors are called Relative Response Factors (RRFs) and are the ratio of the future to current year CAMx modeling results averaged across the 10 highest modeled MDA8 ozone days > 60 ppb in the current (2014) year base case near the monitor:

$$RRF = \sum MDA8\ Ozone_{2028} / \sum MDA8\ Ozone_{2014}$$

$$DVF = RRF \times DVC$$

  - By "near the monitor" the maximum 2014 modeled MDA8 ozone within a 3x3 array of 4-km grid cells centered on the monitor from the 2014 is used and the value in the same grid cell is used from the 2028 modeling
  - If there are not 10 modeled MDA8 ozone days in the 2014 base case > 60 ppb for the RRFs, then you can use less than 10 days, but EPA guidance recommends there be at least 5 days
  - EPA recommends that the observed current year design value (DVC) be based on the average of 3 years of ozone DVs over 5-years centered on the base modeling year to modulate the year-to-year variability in ozone concentrations:

$$DVC = 1/3 \times (DV_{2012\text{-}2014} + DV_{2013\text{-}2015} + DV_{2014\text{-}2016})$$

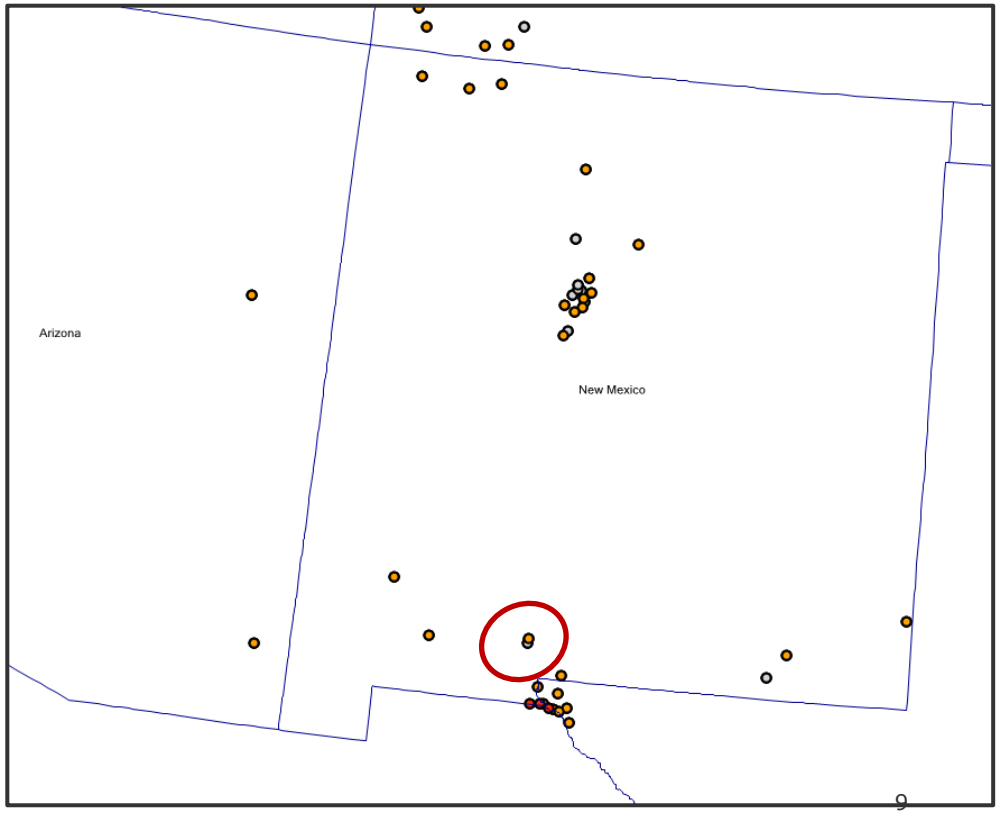
FUTURE YEAR OZONE DESIGN PROJECTION APPROACH

- EPA has codified their recommended future year ozone DV projection technique in the Software for Modeled Attainment Test (SMAT)
- SMAT was initially applied using default settings and the 2014v2 and 2028 base case CAMx modeling results to obtain projected 2028 ozone DVF projections for:
- 2028 future year ozone DVF projections were not obtained using SMAT default settings for the Hobbs monitoring site in Lea County because there were not at least 5 days with CAMx 2014v2 MDA8 ozone > 60 ppb
    - SMAT was applied a second time with a 4-day minimum of MDA8 ozone > 60 ppb for the RRFs and 2028 ozone DVF projections were obtained for two additional monitoring sites: Hobbs in Lea County New Mexico and a site in Roberts County, Texas
    - SMAT 2028 ozone DVF projections for the other sites remained unchanged using the 4-day minimum criteria for the RRFs

2028 BASE CASE PROJECTED OZONE DESIGN VALUES -- NM

AQS_ID	2012-16 DVC (ppb)	2028 Base DVF Base (ppb)	2028 Base DVF DVF - DVC	Site Name	State	County
Northern New Mexico						
350390026	64.0	60.8	-3.2	Coyote Ranger District	NM	Rio Arriba
350431001	64.0	58.4	-5.6	Bernalillo (E Avenida)	NM	Sandoval
350450009	64.3	61.0	-3.3	Bloomfield	NM	San Juan
350450018	67.0	64.8	-2.2	Navajo Lake	NM	San Juan
350451005	63.7	60.8	-2.9	Substation	NM	San Juan
350490021	64.3	60.6	-3.7	Santa Fe Airport	NM	Santa Fe
Bernalillo County						
350010023	66.3	60.9	-5.4	Del Norte HS	NM	Bernalillo
350010024	68.0	62.3	-5.7	South East Heights	NM	Bernalillo
350010029	66.0	61.0	-5.0	South Valley	NM	Bernalillo
350010032	67.0	62.6	-4.4	Westside	NM	Bernalillo
350011012	65.0	59.1	-5.9	Foothills	NM	Bernalillo
Southern New Mexico						
350130008	66.3	60.0	-6.3	La Union	NM	Dona Ana
350130017	67.0	61.9	-5.1	Sunland Park City Yard	NM	Dona Ana
350130020	67.0	62.3	-4.7	Chaparral	NM	Dona Ana
350130021	72.0	67.0	-5.0	Desert View	NM	Dona Ana
350130022	71.3	66.1	-5.2	Santa Teresa	NM	Dona Ana
350130023	65.0	60.3	-4.7	Solano	NM	Dona Ana
350151005	69.0	66.7	-2.3	Carlsbad	NM	Eddy
350171003	62.0	59.0	-3.0	Chino Copper Smelter	NM	Grant
350250008	66.0	64.0	-2.0	Hobbs Jefferson	NM	Lea
350290003	66.0	62.7	-3.3	Deming Airport	NM	Luna
350610008	66.3	62.2	-4.1	Los Lunas (Los Lentes)	NM	Valencia

- Only two sites in NM have 2012-2016 DVC over 71
  - Desert View and Santa Teresa



2028 BASE CASE PROJECTED OZONE DESIGN VALUES

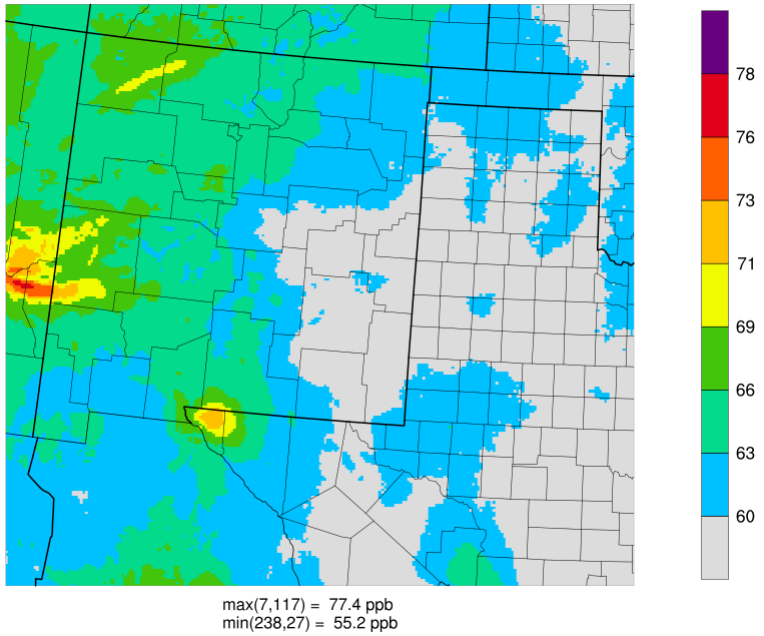
- Within 4-km domain but outside of NM similar level of 2028 ozone DV reduction (-1.6 to -5.2 ppb) is seen as occurs in NM (-2.0 to -6.3 ppb)

AQS_ID	2012-16 DVC (ppb)	2028 Base DVF Base (ppb)	2028 Base DVF DVF - DVC	Site Name	State	County
Arizona, Colorado and Texas						
40038001	68.0	64.0	-4.0	Chiricahua NM	AZ	Cochise
40170119	66.7	61.9	-4.8	Petrified Forest	AZ	Navajo
80677001	67.7	66.1	-1.6	UTE 1	CO	La Plata
80677003	66.7	64.4	-2.3	UTE 3	CO	La Plata
80830006	63.0	59.7	-3.3	Cortez - Health Dept	CO	Montezuma
80830101	66.0	62.4	-3.6	Mesa Verde NP	CO	Montezuma
481410029	61.0	58.0	-3.0	Ivanhoe	TX	El Paso
481410037	71.0	66.2	-4.8	El Paso UTEP	TX	El Paso
481410044	67.7	62.5	-5.2	El Paso Chamizal	TX	El Paso
481410055	62.7	59.2	-3.5	Ascarate Park SE	TX	El Paso
481410057	66.5	63.3	-3.2	Socorro Hueco	TX	El Paso
481410058	68.0	63.4	-4.6	Skyline Park	TX	El Paso
483819991	66.7	62.4	-4.3	Palo Duro	TX	Randall

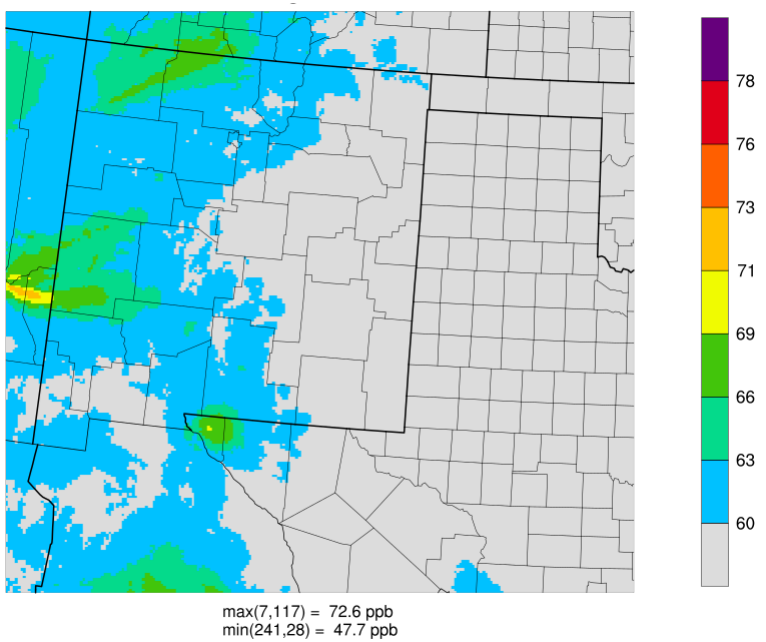
RAMBOLL

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

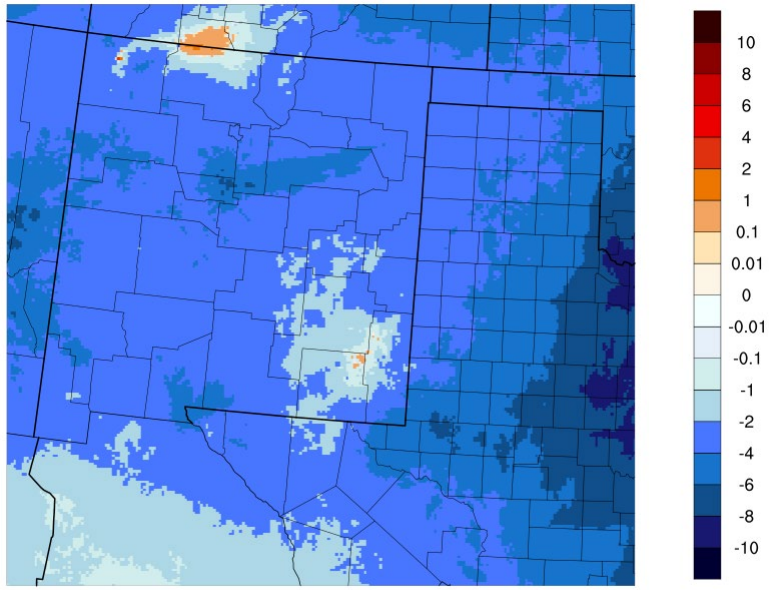
DVC: 2014



DVF: 2028



DVF - DVC

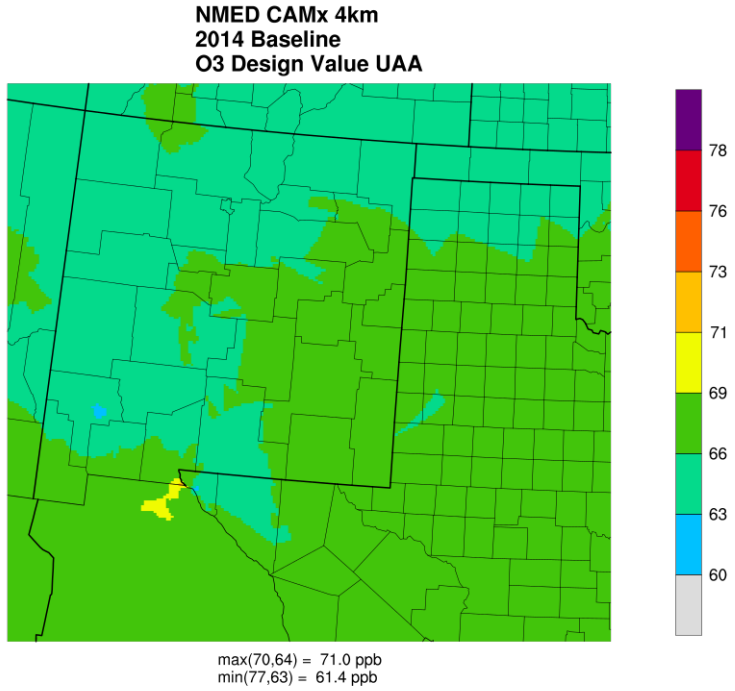


Influence of fires in eastern Arizona and Four Corners region affects SMAT interpolated UAA 2012-2016 ozone DVCs

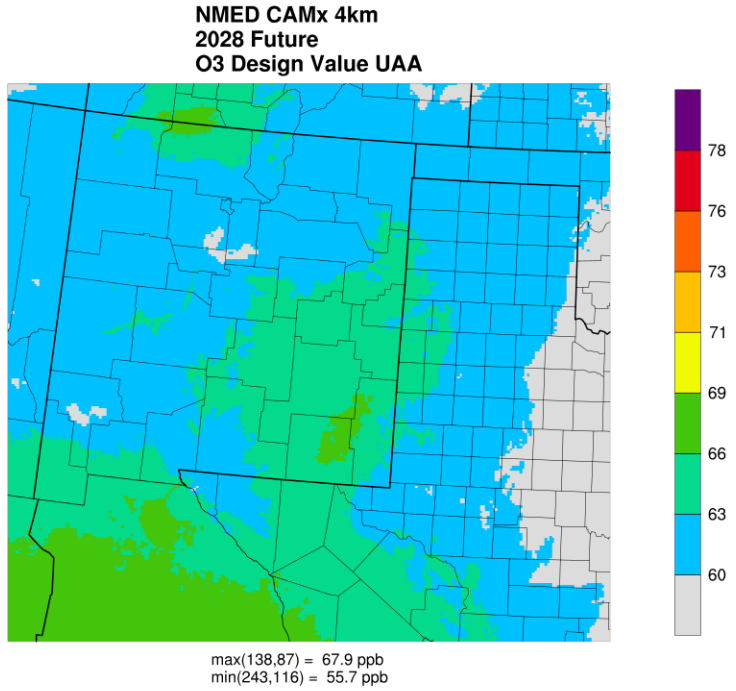
RAMBOLL

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

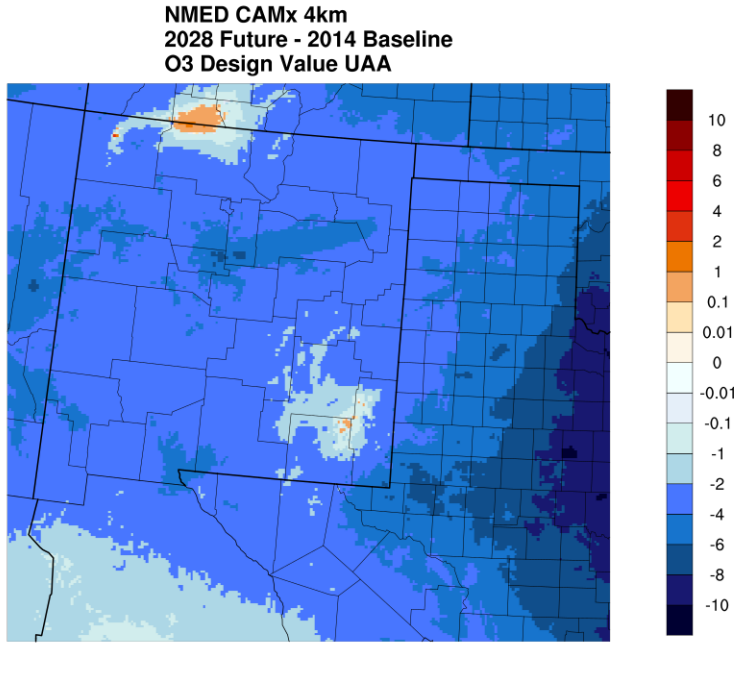
DVC: 2014



DVF: 2028



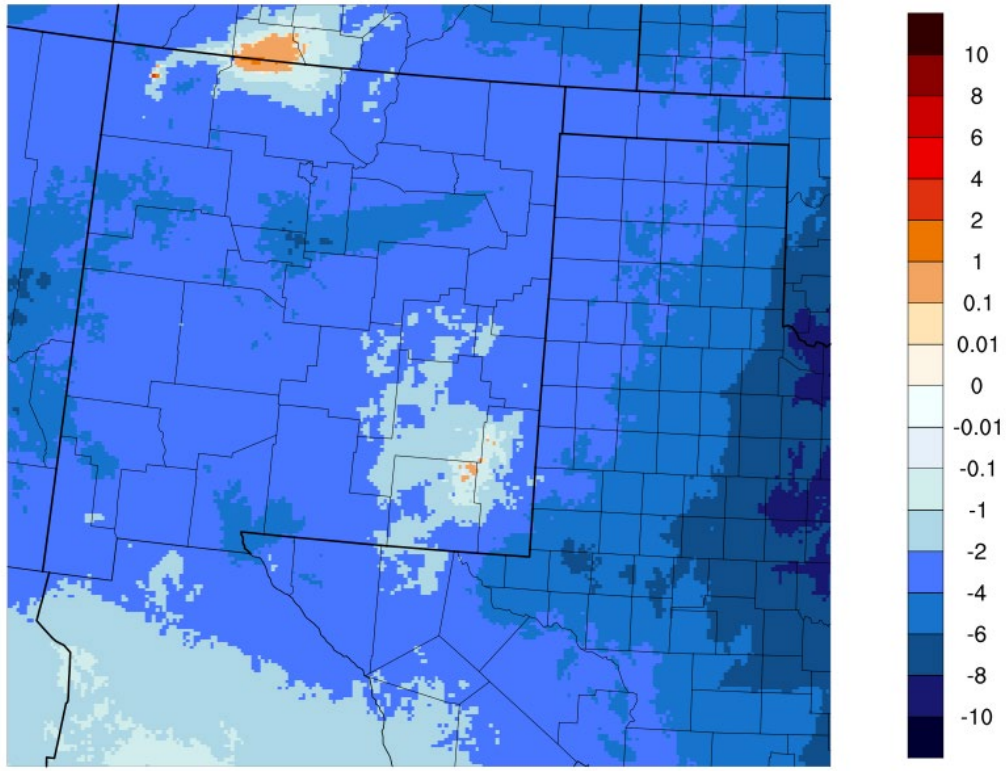
DVF - DVC



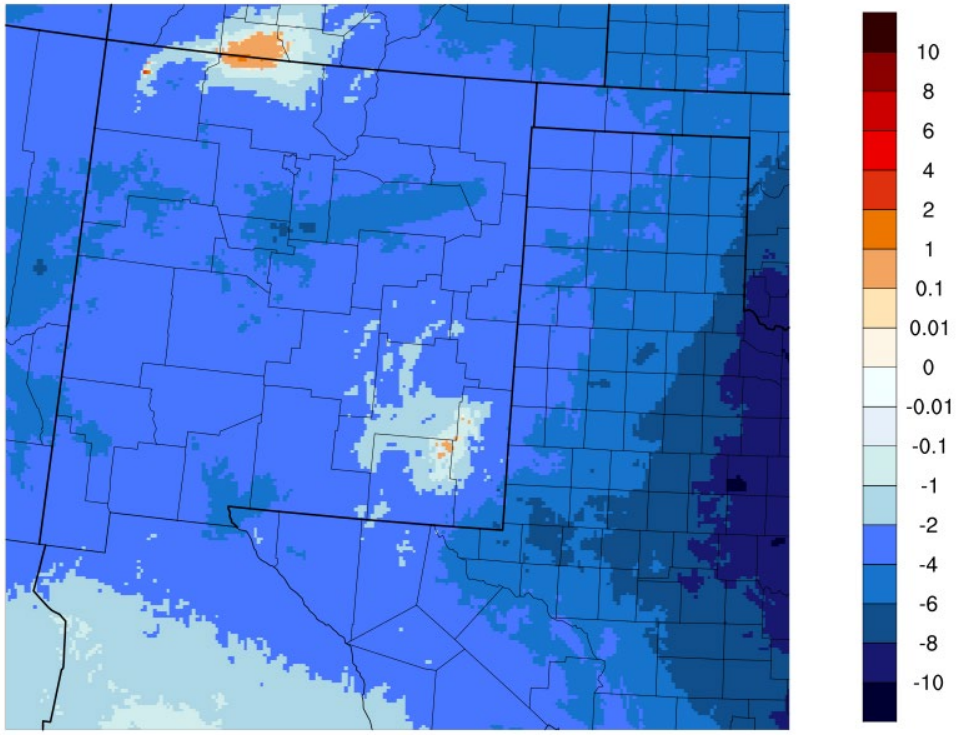
SMAT UAA 2028 BASE – 2024V2 BASE OZONE DV DIFFERENCES

- Although use of modeled spatial gradients in SMAT UAA 2012-2016 ozone DV spatial interpolation affects absolute ozone DV concentrations, it has small effect on differences in ozone DVs between scenarios (so present without gradients)

With Gradients



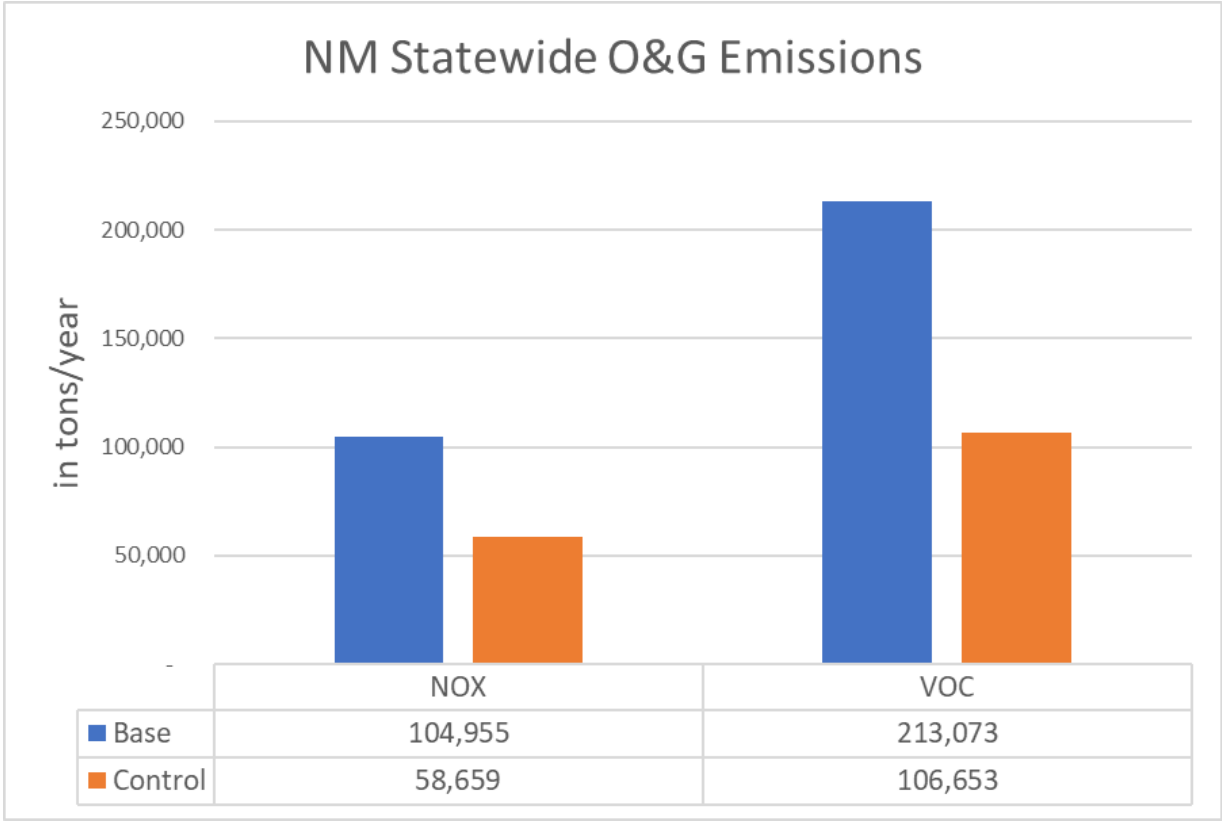
Without Gradients



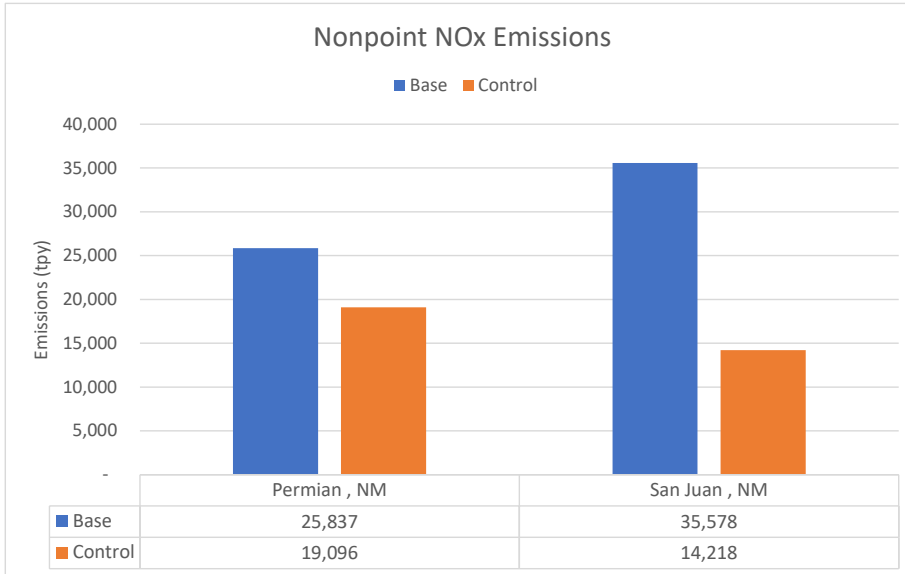
SUMMARY OF 2028 NEW MEXICO OIL AND GAS CONTROL STRATEGY EMISSIONS

2028 O&G CONTROL SCENARIO EMISSIONS

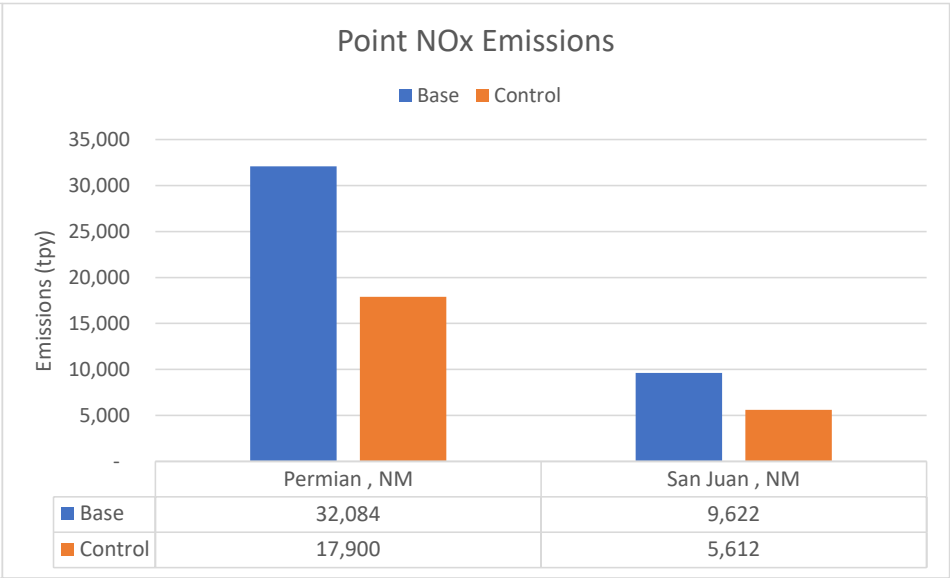
- ERG provided revised point and nonpoint NM emissions for affected counties/SCCs/pollutants.
- 7 NM counties included in ERG's inventory
  - San Juan Basin (4 counties)
  - Permian Basin (3 counties)
- Bar chart display to show comparisons between 2028 Base and Control Scenario O&G emissions for NM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



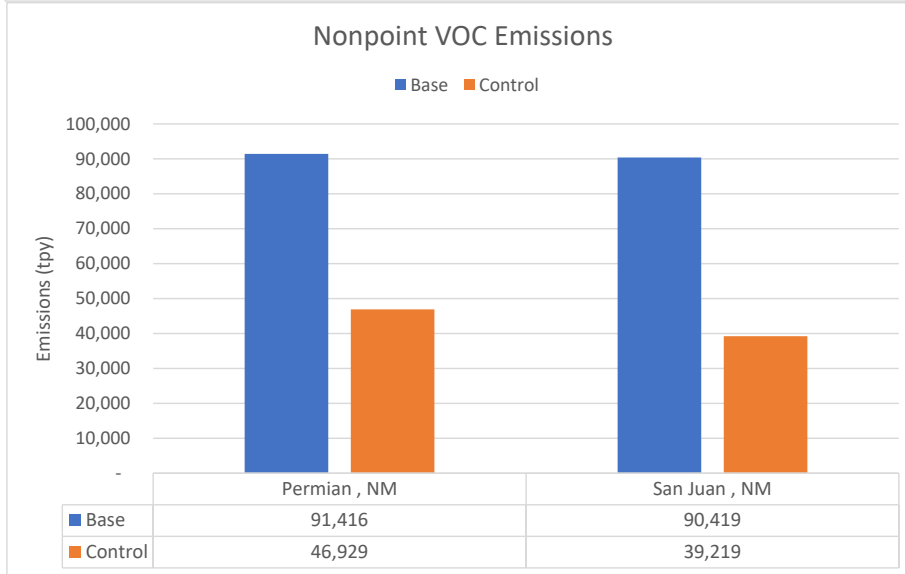
NEW MEXICO NONPOINT O&G



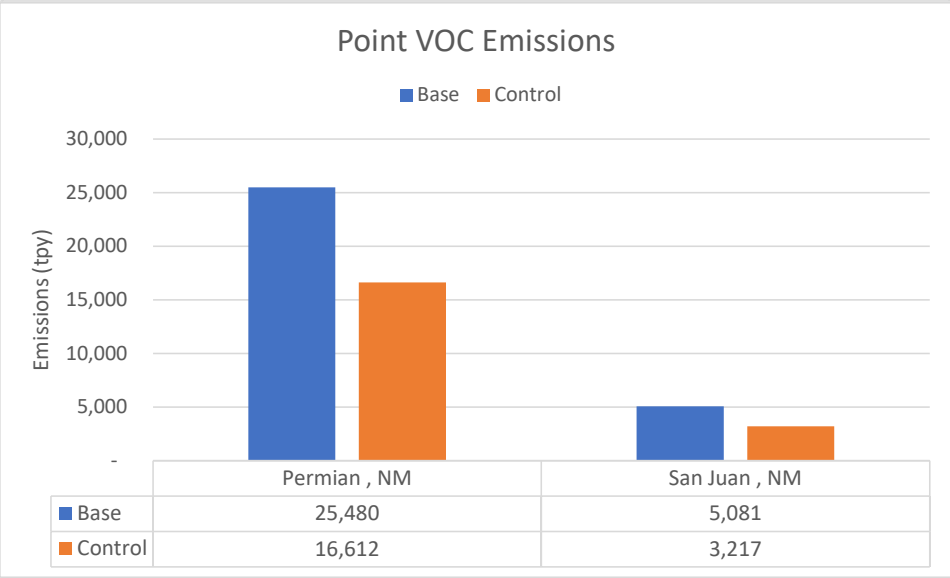
	Permian , NM	San Juan , NM
Base	25,837	35,578
Control	19,096	14,218



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



	Permian , NM	San Juan , NM
Base	91,416	90,419
Control	46,929	39,219

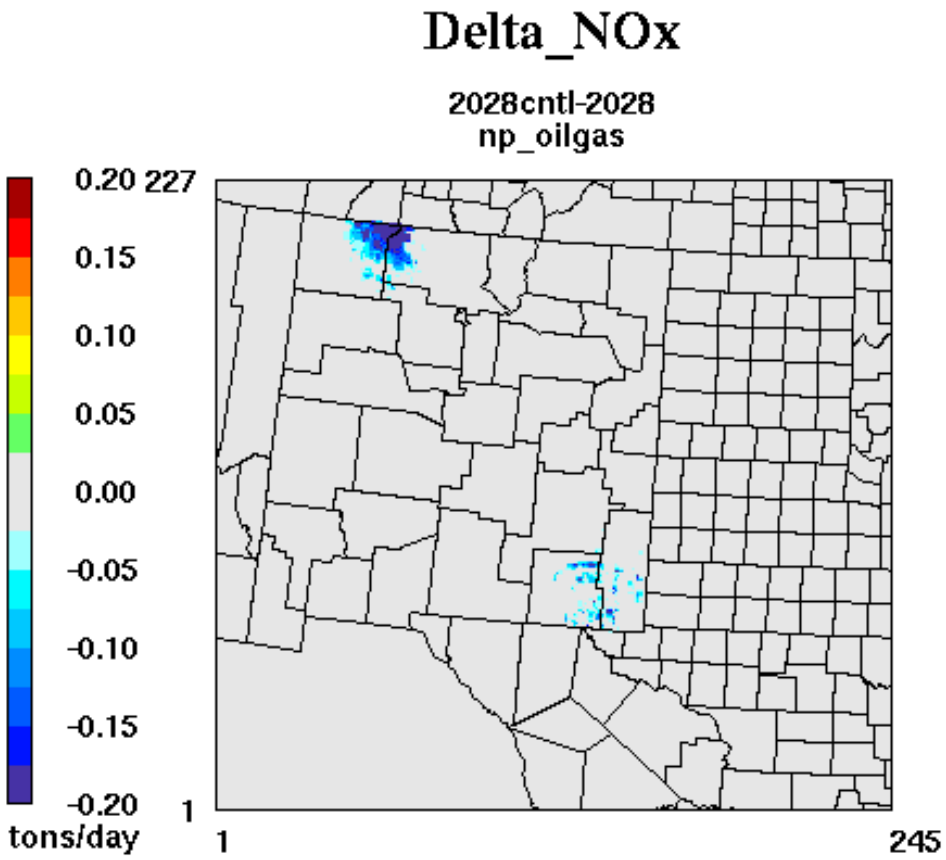


	Permian , NM	San Juan , NM
Base	25,480	5,081
Control	16,612	3,217

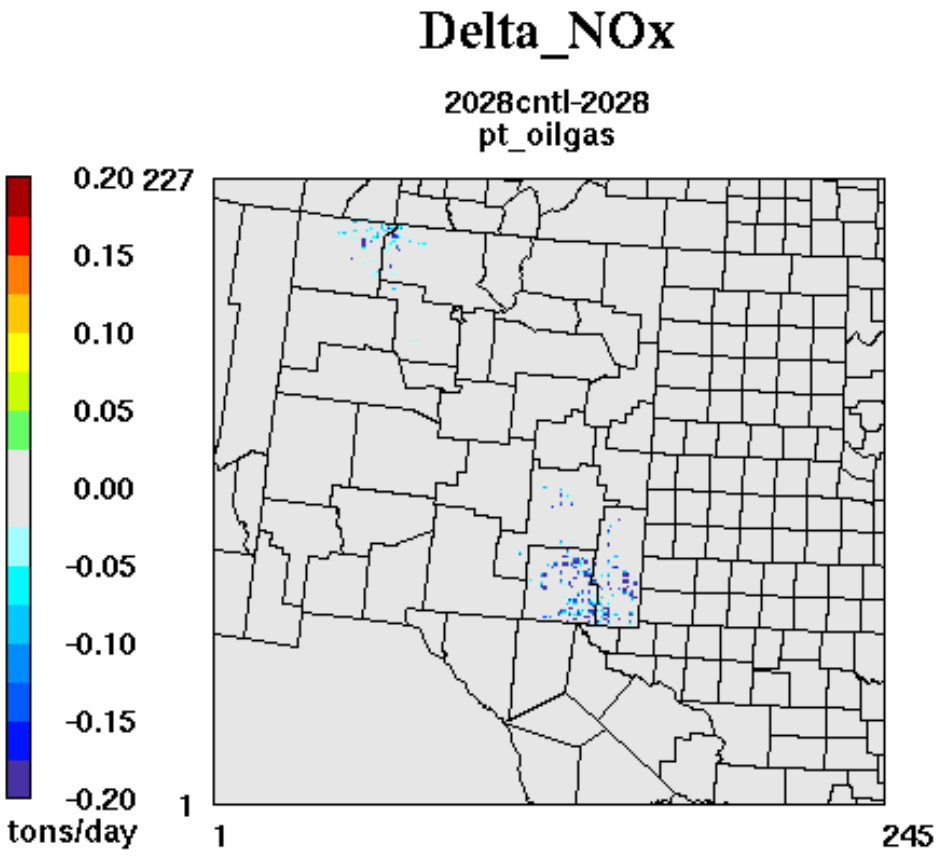
- NM State-Wide
  - 46% NOx reduction in nonpoint O&G
  - 52% VOC reduction in nonpoint O&G
  - 42% NOx reduction in point O&G
  - 35% VOC reduction in point O&G

2028 BASE – 2028 NM O&G CS DIFFERENCES -- NOX

Non-Point O&G

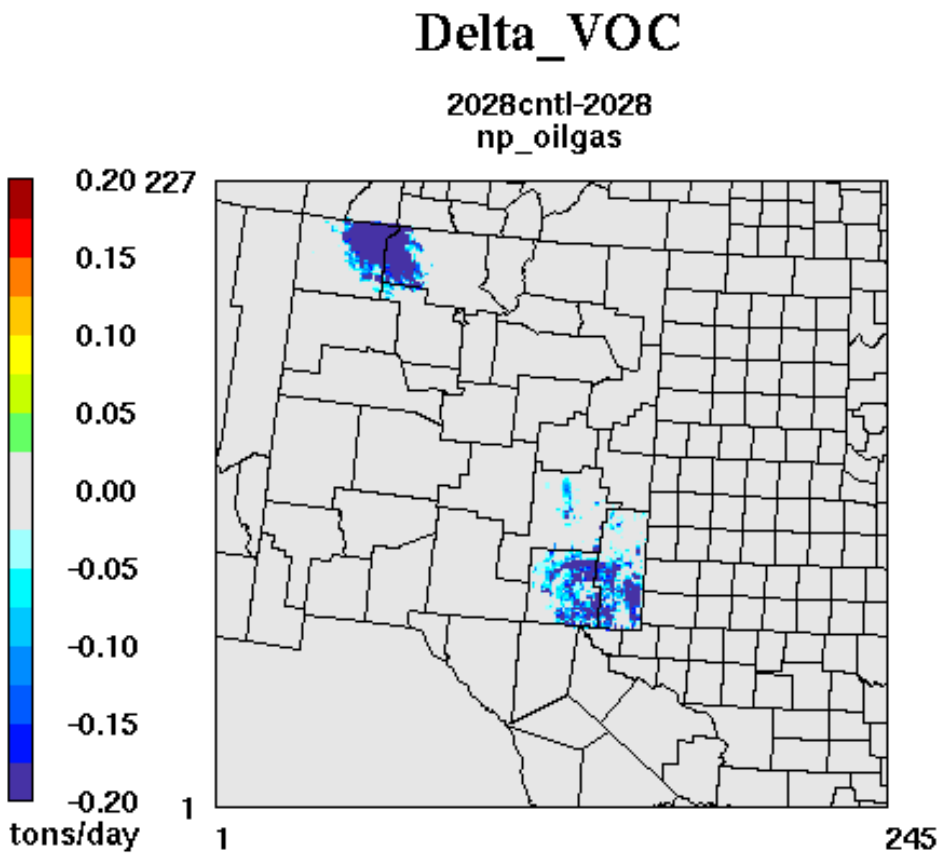


Point O&G

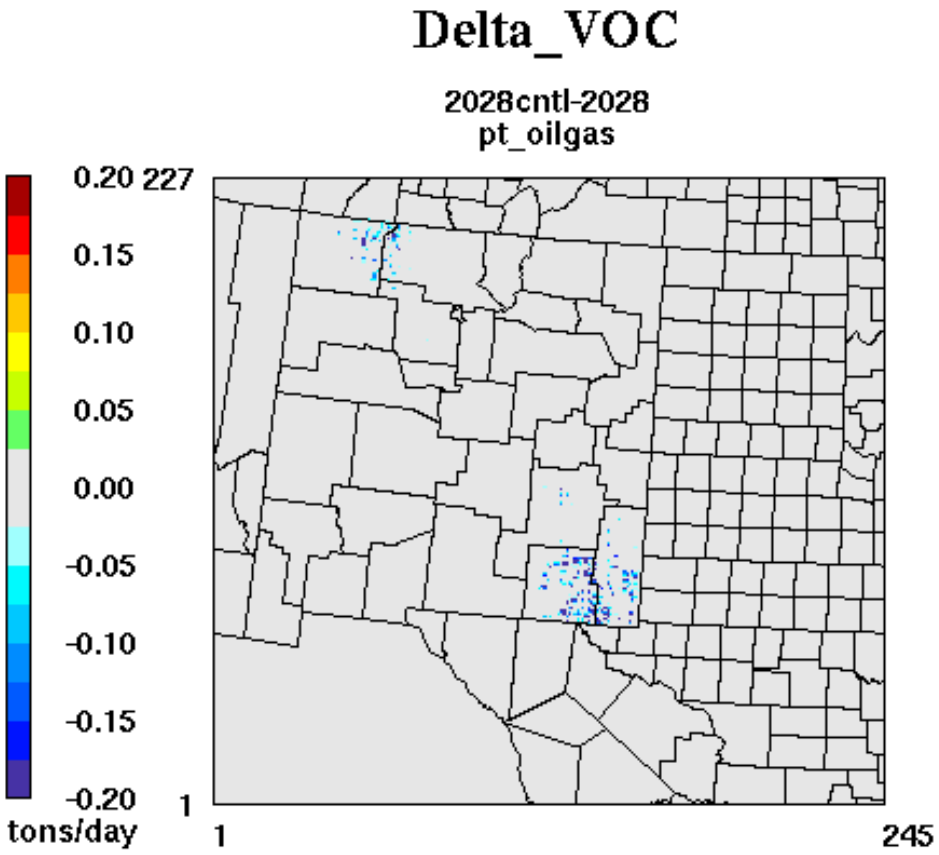


2028 BASE – 2028 NM O&G CS DIFFERENCES -- VOC

Non-Point O&G



Point O&G



2028 NEW MEXICO O&G CONTROL STRATEGY OZONE RESULTS

FUTURE YEAR OZONE DESIGN PROJECTION APPROACH

- EPA's Ozone Modeling Guidance (2018) recommends making future year ozone Design Value (DVF) projections using the relative change in modeling results between the base (2014) and future (2028) years to scale the current year ozone design value (DVC)
  - The model derived scaling factors are called Relative Response Factors (RRFs) and are the ratio of the future to current year CAMx modeling results averaged across the 10 highest modeled MDA8 ozone days > 60 ppb in the current (2014) year base case near the monitor:

$$RRF = \sum MDA8\ Ozone_{2028} / \sum MDA8\ Ozone_{2014}$$

$$DVF = RRF \times DVC$$

  - By "near the monitor" the maximum 2014 modeled MDA8 ozone within a 3x3 array of 4-km grid cells centered on the monitor from the 2014 is used and the value in the same grid cell is used from the 2028 modeling
  - If there are not 10 modeled MDA8 ozone days in the 2014 base case > 60 ppb for the RRFs, then you can use less than 10 days, but EPA guidance recommends there be at least 5 days
  - EPA recommends that the observed current year design value (DVC) be based on the average of 3 years of ozone DVs over 5-years centered on the base modeling year to modulate the year-to-year variability in ozone concentrations:

$$DVC = 1/3 \times (DV_{2012\text{-}2014} + DV_{2013\text{-}2015} + DV_{2014\text{-}2016})$$

RAMBOLL

FUTURE YEAR OZONE DESIGN PROJECTION APPROACH

- EPA has codified their recommended future year ozone DV projection technique in the Software for Modeled Attainment Test (SMAT)
- SMAT was initially applied using default settings and the 2014v2 and 2028 base case CAMx modeling results to obtain projected 2028 ozone DVF projections for:
- 2028 future year ozone DVF projections were not obtained using SMAT default settings for the Hobbs monitoring site in Lea County because there were not at least 5 days with CAMx 2014v2 MDA8 ozone > 60 ppb
    - SMAT was applied a second time with a 4-day minimum of MDA8 ozone > 60 ppb for the RRFs and 2028 ozone DVF projections were obtained for two additional monitoring sites: Hobbs in Lea County New Mexico and a site in Roberts County, Texas
    - SMAT 2028 ozone DVF projections for the other sites remained unchanged using the 4-day minimum criteria for the RRFs

2028 PROJECTED OZONE DVF

- Effects of 2028 NM O&G Control Strategy on Projected 2028 ozone DVFs
  - Northern New Mexico: -0.2 to -1.5 ppb reduction. Largest reductions at Navajo Lake (-1.5 ppb) and Substation (-1.2 ppb) in San Juan County
  - Bernalillo County: -0.2 to -0.5 ppb reduction
  - Southern New Mexico: -0.1 to -0.3 ppb Reduction. Largest reduction at Carlsbad (-0.3 ppb).

AQS_ID	2012-16 DVC (ppb)	Projected 2028 DVF Base (ppb)	Cntl (ppb)	Cntl - Base	Site Name	State	County
Northern New Mexico							
350390026	64.0	60.8	60.0	-0.8	Coyote Ranger District	NM	Rio Arriba
350431001	64.0	58.4	58.1	-0.3	Bernalillo (E Avenida)	NM	Sandoval
350450009	64.3	61.0	60.2	-0.8	Bloomfield	NM	San Juan
350450018	67.0	64.8	63.3	-1.5	Navajo Lake	NM	San Juan
350451005	63.7	60.8	59.6	-1.2	Substation	NM	San Juan
350490021	64.3	60.6	60.4	-0.2	Santa Fe Airport	NM	Santa Fe
Bernalillo County							
350010023	66.3	60.9	60.7	-0.2	Del Norte HS	NM	Bernalillo
350010024	68.0	62.3	62.0	-0.3	South East Heights	NM	Bernalillo
350010029	66.0	61.0	60.5	-0.5	South Valley	NM	Bernalillo
350010032	67.0	62.6	62.1	-0.5	Westside	NM	Bernalillo
350011012	65.0	59.1	58.8	-0.3	Foothills	NM	Bernalillo
Southern New Mexico							
350130008	66.3	60.0	59.8	-0.2	La Union	NM	Dona Ana
350130017	67.0	61.9	61.8	-0.1	Sunland Park City Yard	NM	Dona Ana
350130020	67.0	62.3	62.2	-0.1	Chaparral	NM	Dona Ana
350130021	72.0	67.0	66.8	-0.2	Desert View	NM	Dona Ana
350130022	71.3	66.1	66.0	-0.1	Santa Teresa	NM	Dona Ana
350130023	65.0	60.3	60.2	-0.1	Solano	NM	Dona Ana
350151005	69.0	66.7	66.4	-0.3	Carlsbad	NM	Eddy
350171003	62.0	59.0	58.9	-0.1	Chino Copper Smelter	NM	Grant
350250008	66.0	64.0	63.3	-0.7	Hobbs Jefferson	NM	Lea
350290003	66.0	62.7	62.5	-0.2	Deming Airport	NM	Luna
350610008	66.3	62.2	62.0	-0.2	Los Lunas (Los Lentes)	NM	Valencia

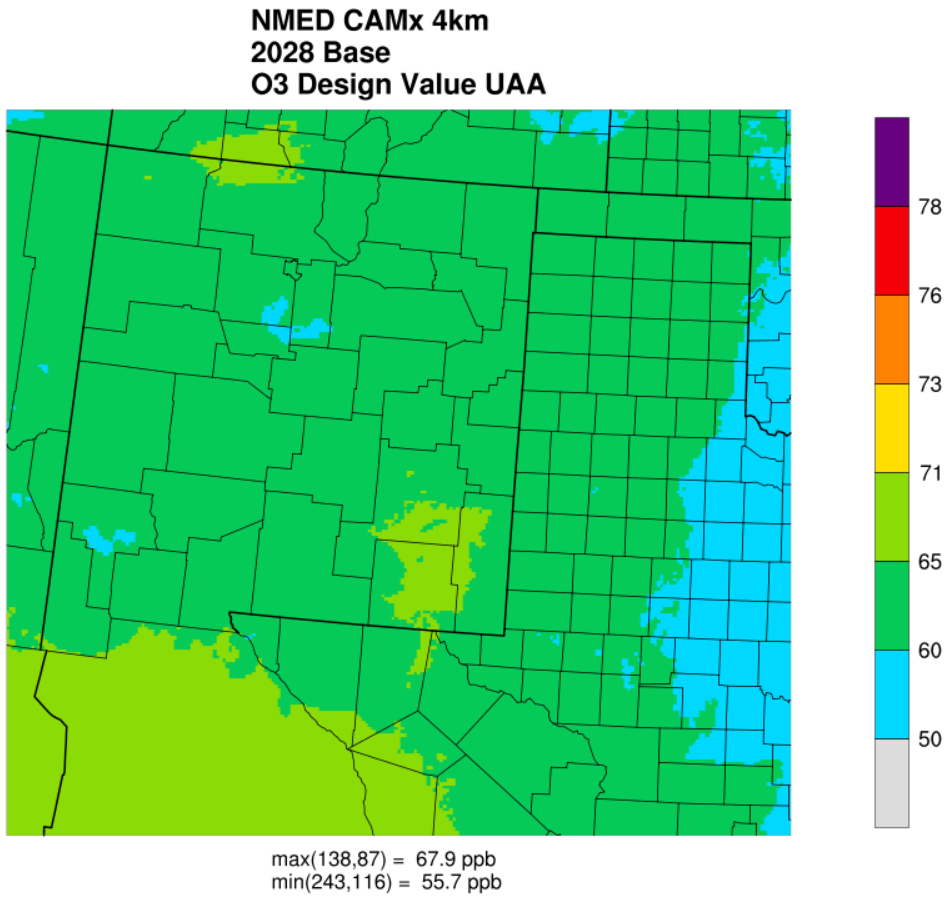
RAMBOLL

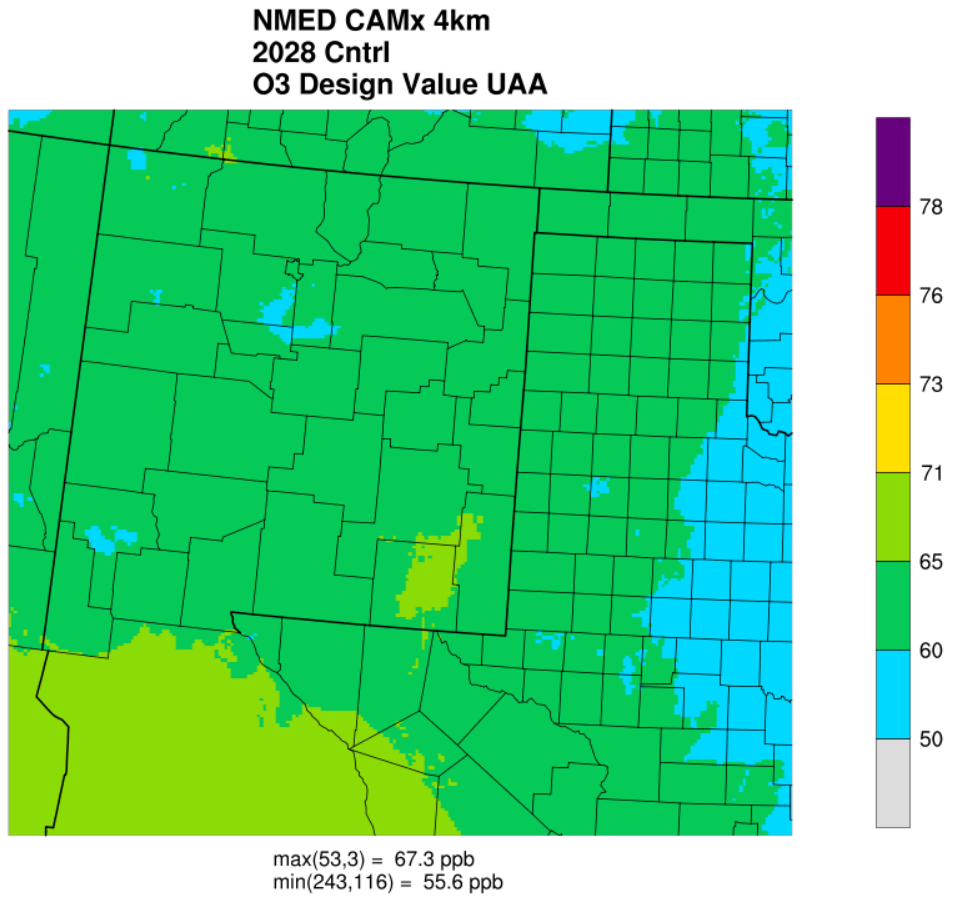
2028 PROJECTED OZONE DVF

- Also benefits in other States
  - Little impact at Arizona sites
  - Colorado as much as -0.9 ppb reduction in ozone DFV in La Plata County
  - Texas -0.1 ppb reduction in ozone DVF in El Paso. -0.2 in Palo Duro.

AQS_ID	2012-16 DVC (ppb)	Projected 2028 DVF Base (ppb)	Cntl (ppb)	Cntl - Base	Site Name	State	County
Arizona, Colorado and Texas							
40038001	68.0	64.0	63.9	-0.1	Chiricahua NM	AZ	Cochise
40170119	66.7	61.9	61.9	0.0	Petrified Forest	AZ	Navajo
80677001	67.7	66.1	65.2	-0.9	UTE 1	CO	La Plata
80677003	66.7	64.4	63.7	-0.7	UTE 3	CO	La Plata
80830006	63.0	59.7	59.2	-0.5	Cortez - Health Dept	CO	Montezuma
80830101	66.0	62.4	61.9	-0.5	Mesa Verde NP	CO	Montezuma
481410029	61.0	58.0	57.9	-0.1	Ivanhoe	TX	El Paso
481410037	71.0	66.2	66.1	-0.1	El Paso UTEP	TX	El Paso
481410044	67.7	62.5	62.4	-0.1	El Paso Chamizal	TX	El Paso
481410055	62.7	59.2	59.1	-0.1	Ascarate Park SE	TX	El Paso
481410057	66.5	63.3	63.2	-0.1	Socorro Hueco	TX	El Paso
481410058	68.0	63.4	63.4	0.0	Skyline Park	TX	El Paso
483819991	66.7	62.4	62.2	-0.2	Palo Duro	TX	Randall

2028 BASE & NM-O&G-CS SMAT UAA OZONE DV (NO GRADIENTS)





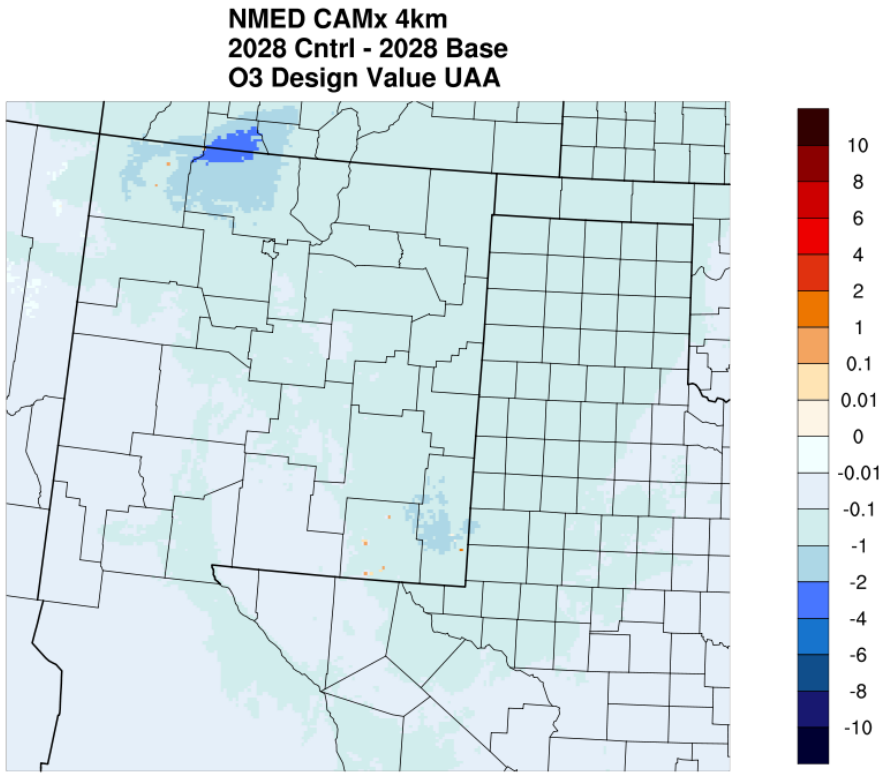
SMAT UAA OZONE DV DIFFERENCES: 2028 BASE – 2028 CONTROL

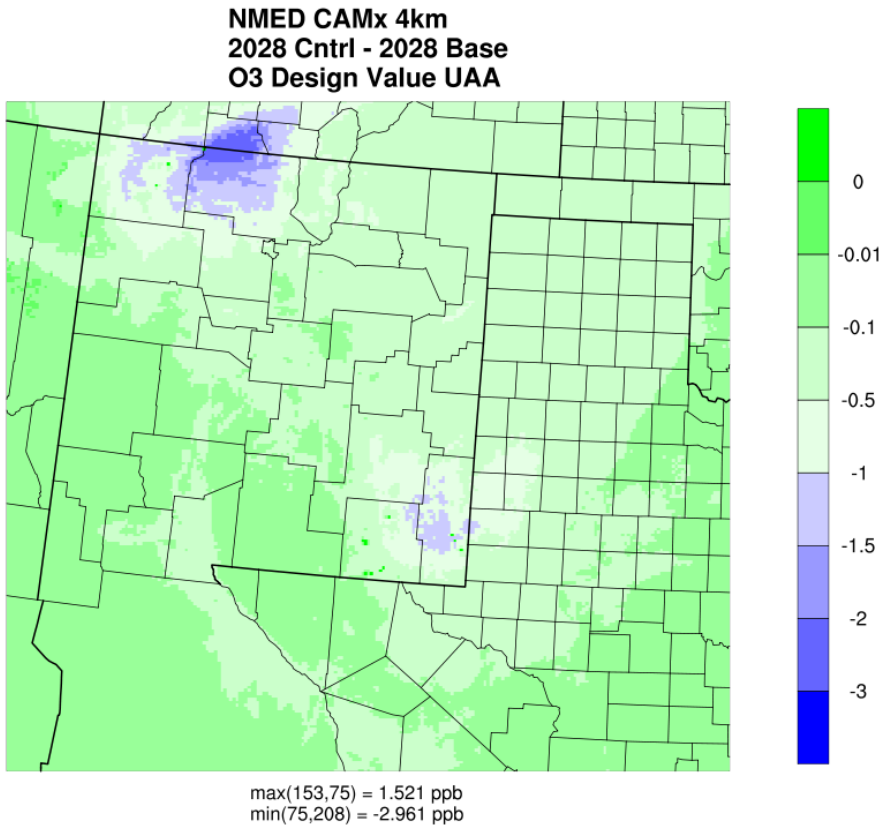
Differences in SMAT UAA ozone DVs without concentration Gradients

Same difference plot using two different scales

Max = +1.52 ppb (highly localized at point source NOx controls)

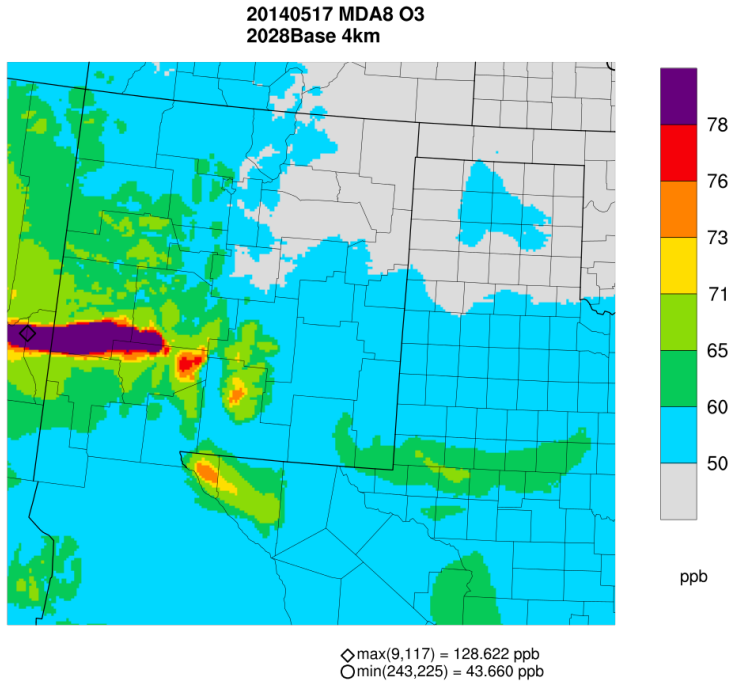
Min = -2.96 ppb (-1.0 ppb in San Juan and Permian Basins)

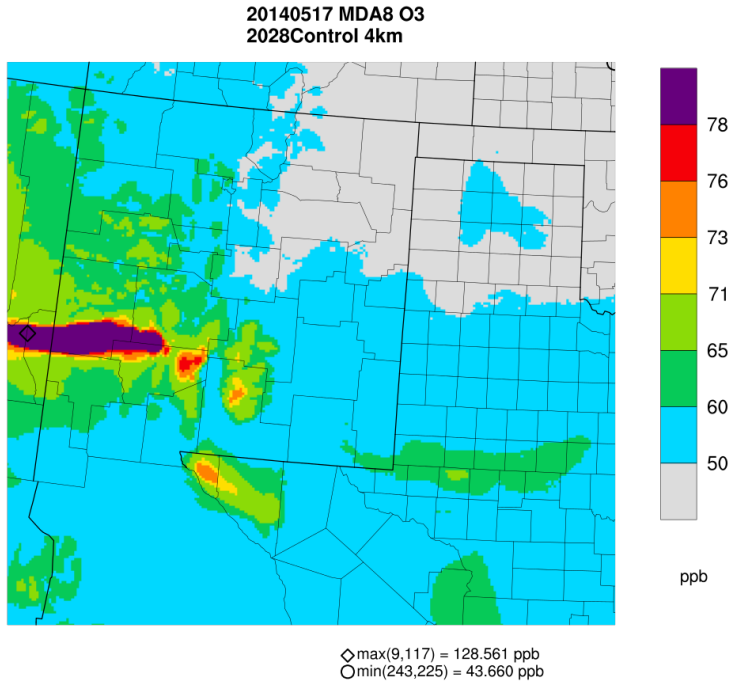


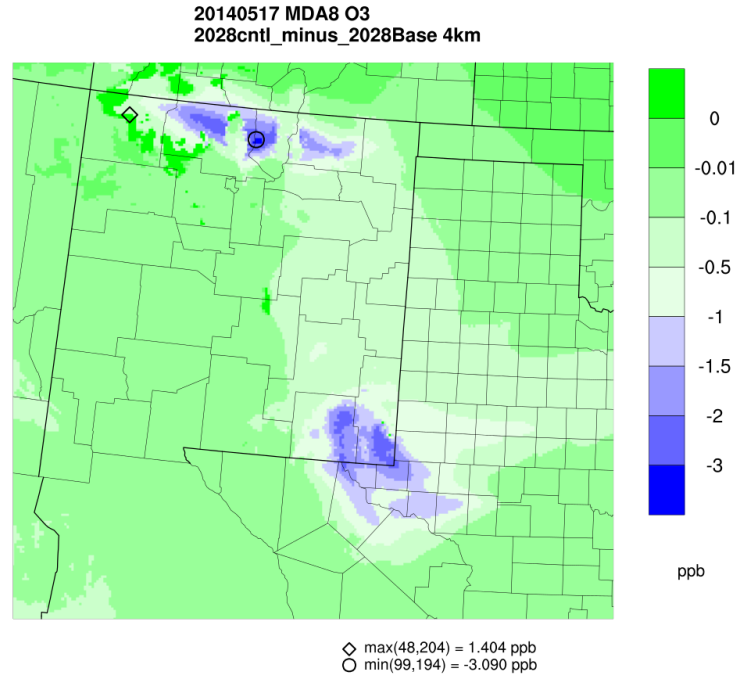


2028 MDA8 OZONE: MAY 17, 2014

Day with fire influences
Max Increase from NM-O&G-CS = +1.4 ppb
Max Decrease from NM-O&G-CS = -3.1 ppb

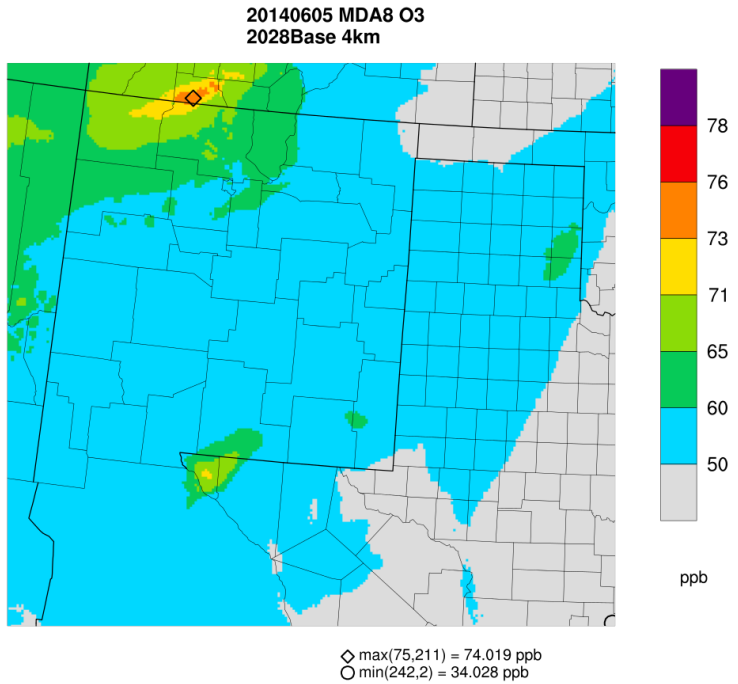


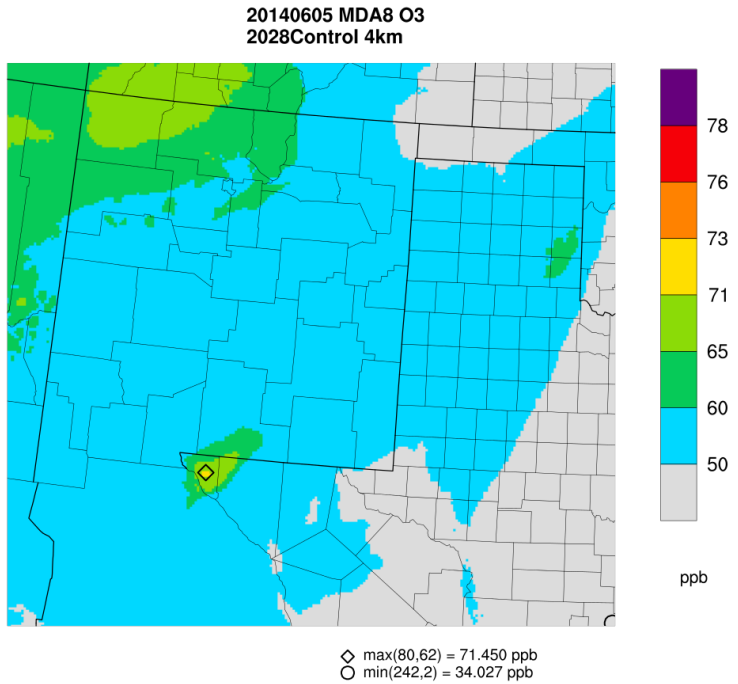


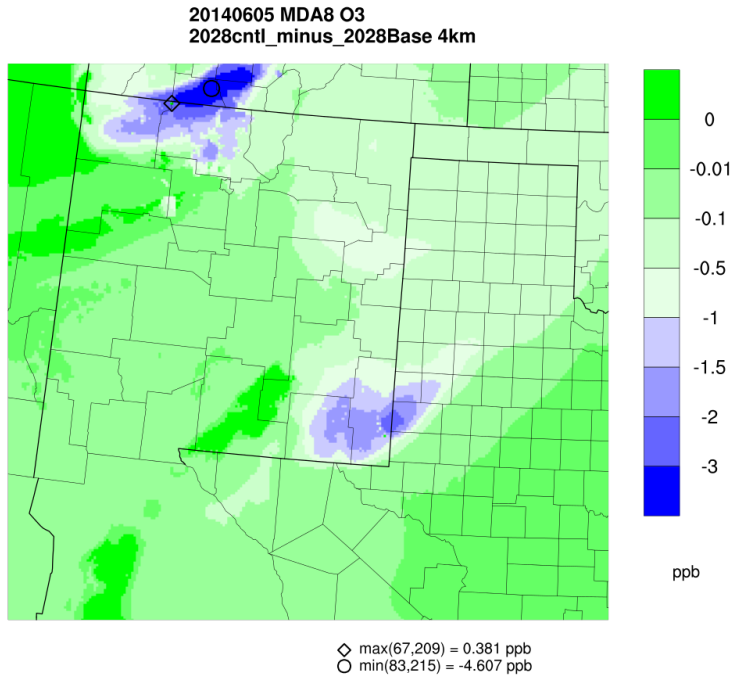


2028 MDA8 OZONE: JUNE 5, 2014

2028 Base Peak MDA8 Ozone of 74.0 ppb in San Juan Basin (> 71 ppb in NM)
2028 NM O&G CS reduces MDA8 Ozone in SJ Basin to below 71 ppb
Max Decrease in MDA8 Ozone in SJ Basin of -4.61 ppb

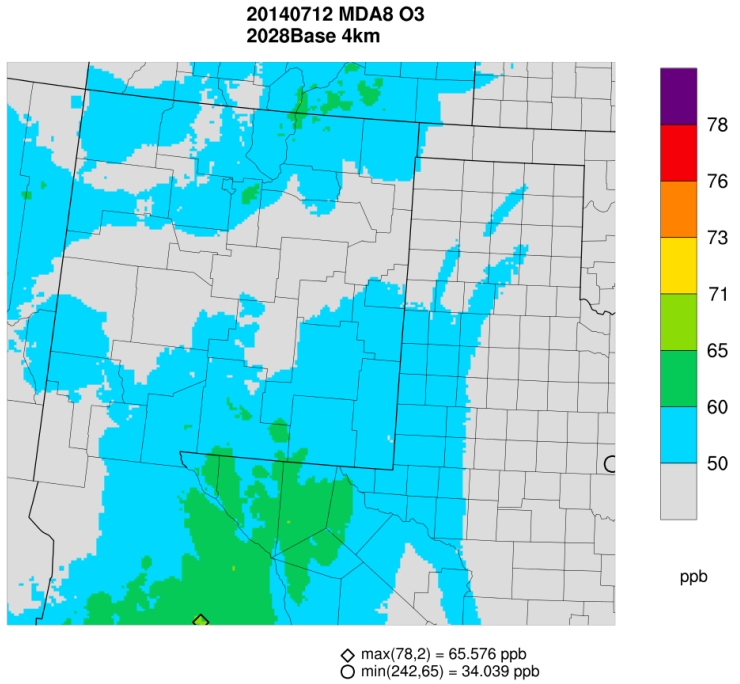


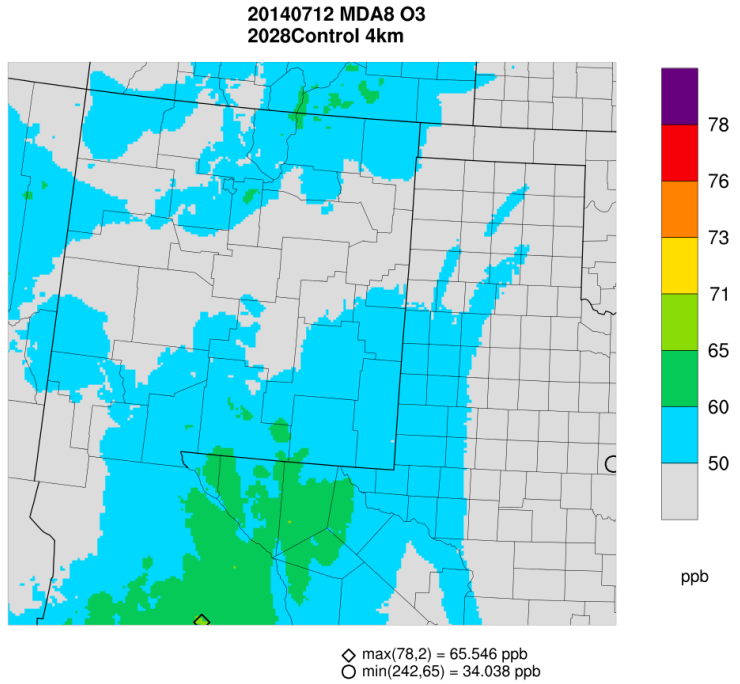


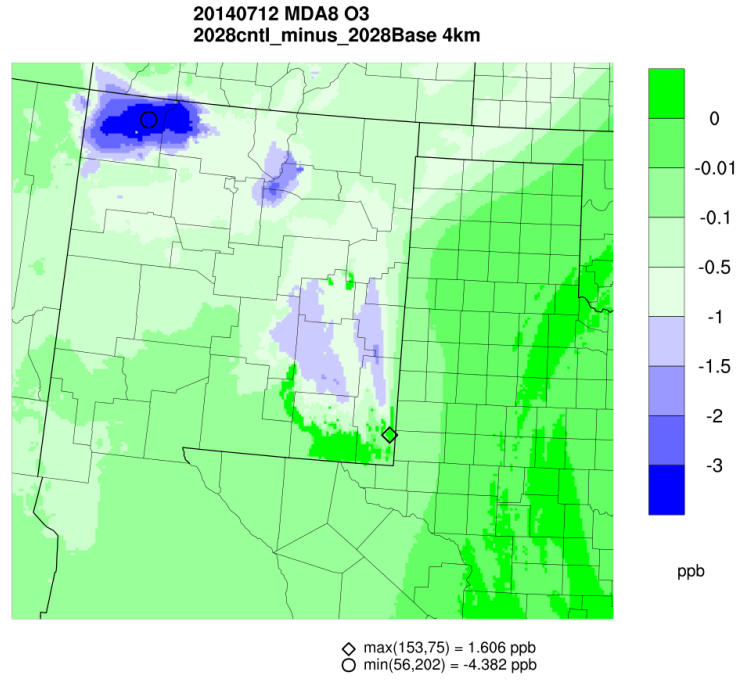


2028 MDA8 OZONE: JULY 12, 2014

Fairly Typical Day: MDA8 ozone 40-55 ppb in New Mexico
Ozone reductions of -1 to -1.5 ppb in Permian Basin
Ozone Reductions of -1 to -4 ppb in San Juan Basin

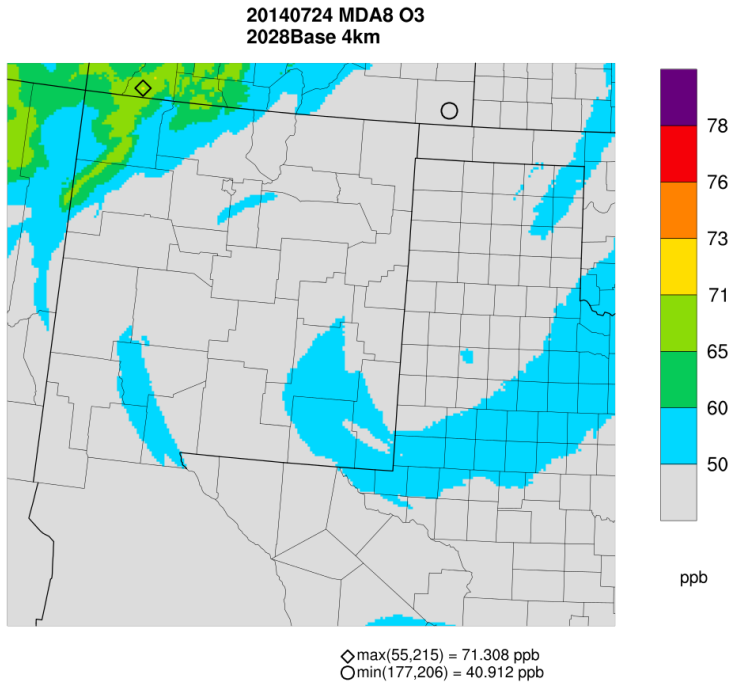


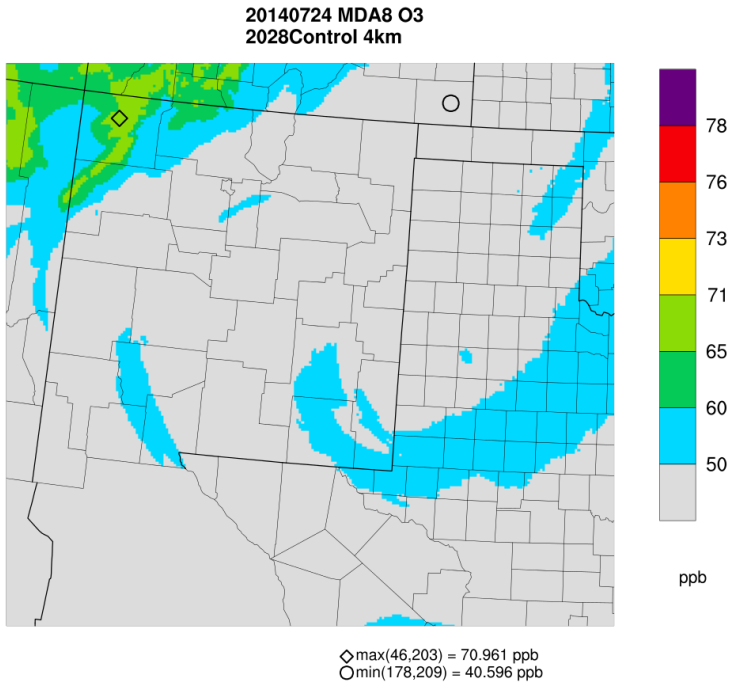


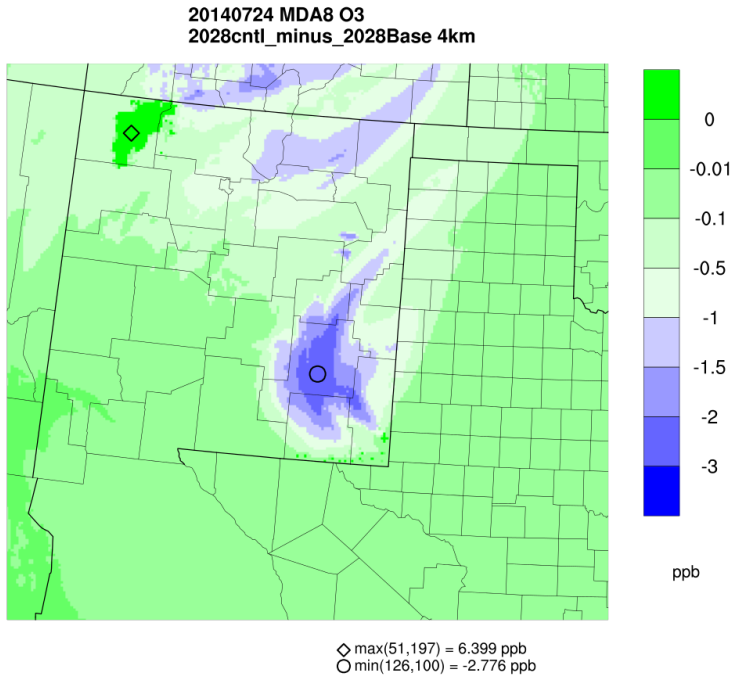


2028 MDA8 OZONE: JULY 24, 2014

Day with largest ozone increase due to NM O&G CS (+6.4 ppb in SJ Basin)
Peak MDA8 of 71.3 ppb reduced to 71.0 ppb in 2028 NM O&G CS case



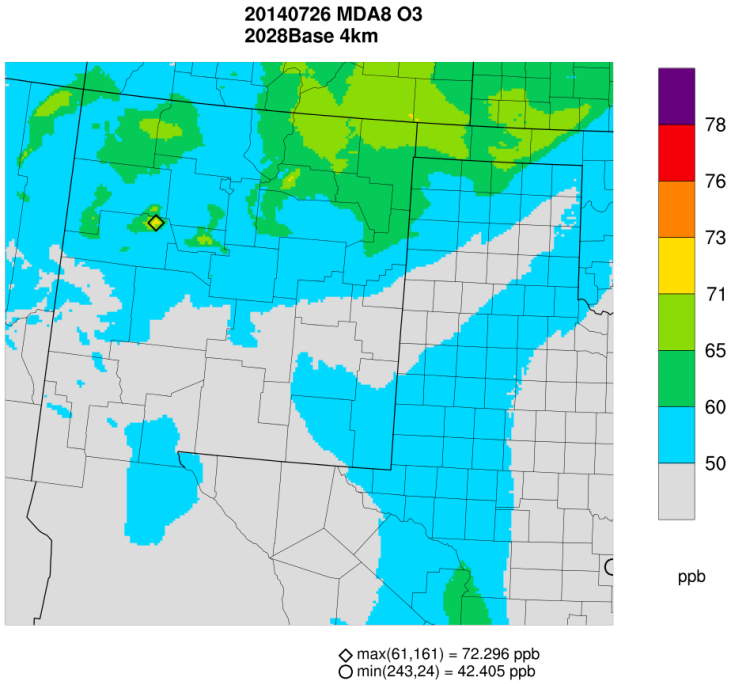


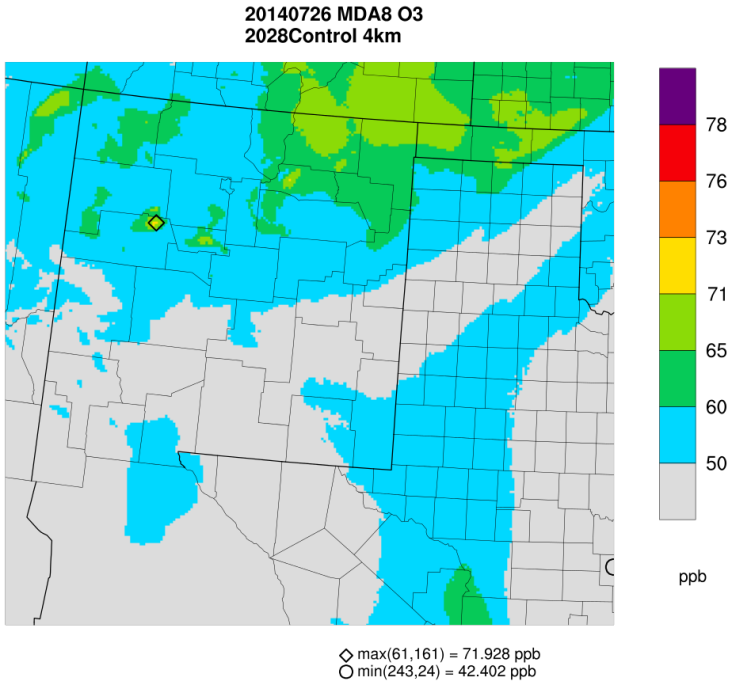


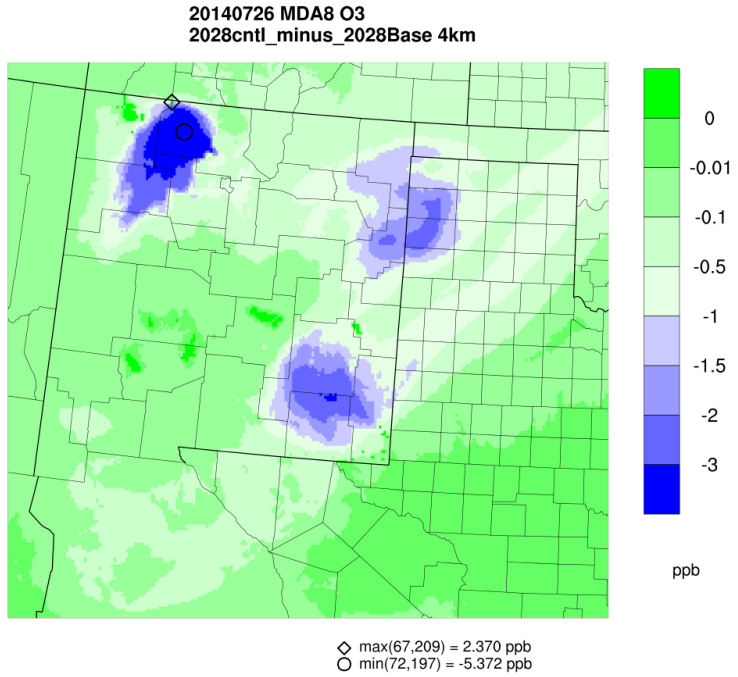
2028 MDA8 OZONE: JULY 26, 2014

MDA8 ozone peak in Cibola County reduced from 72.3 ppb to 71.9 ppb

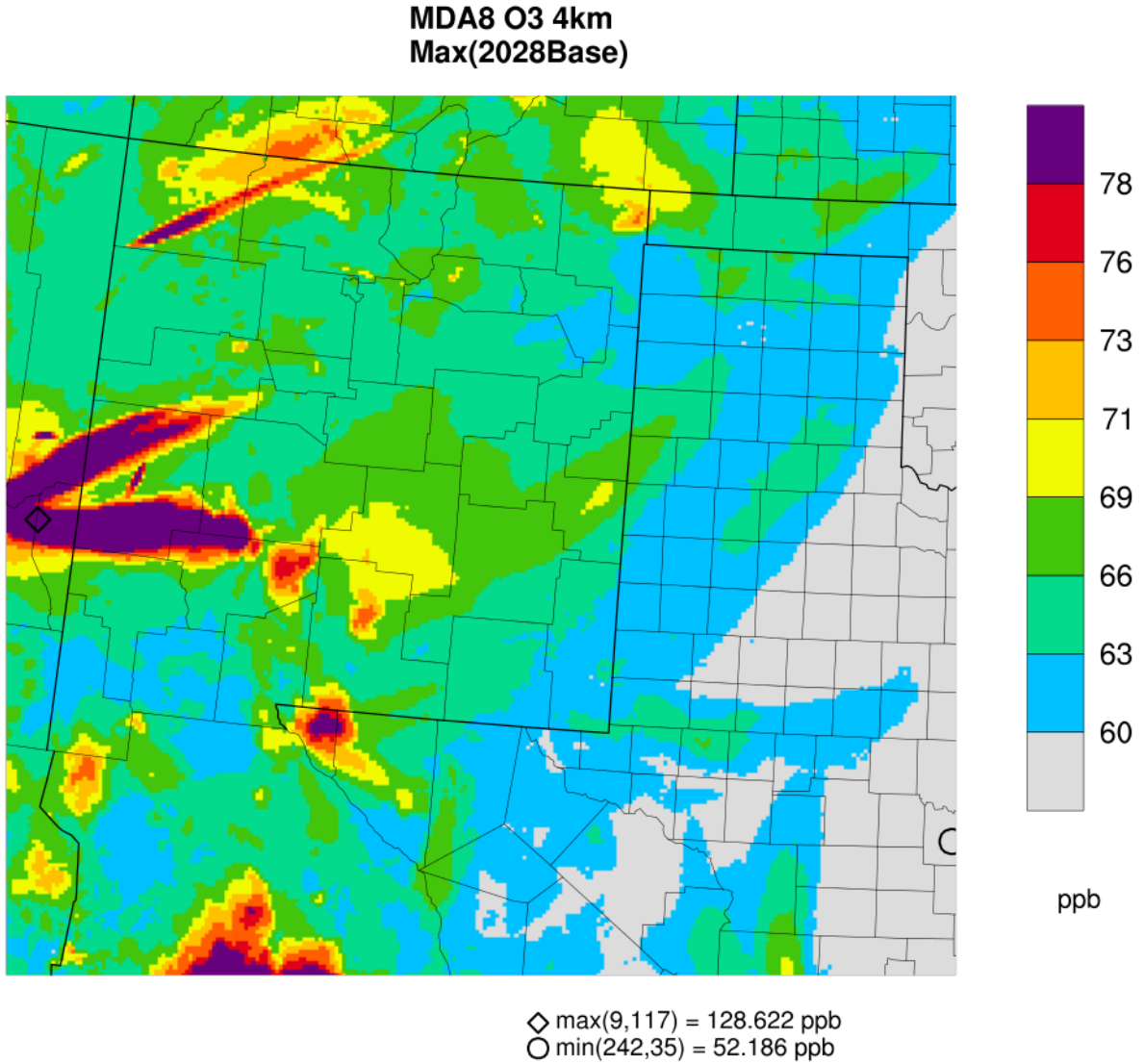
MDA8 ozone reduced as much as -5 ppb in San Juan Basin and -3 ppb in Permian Basin

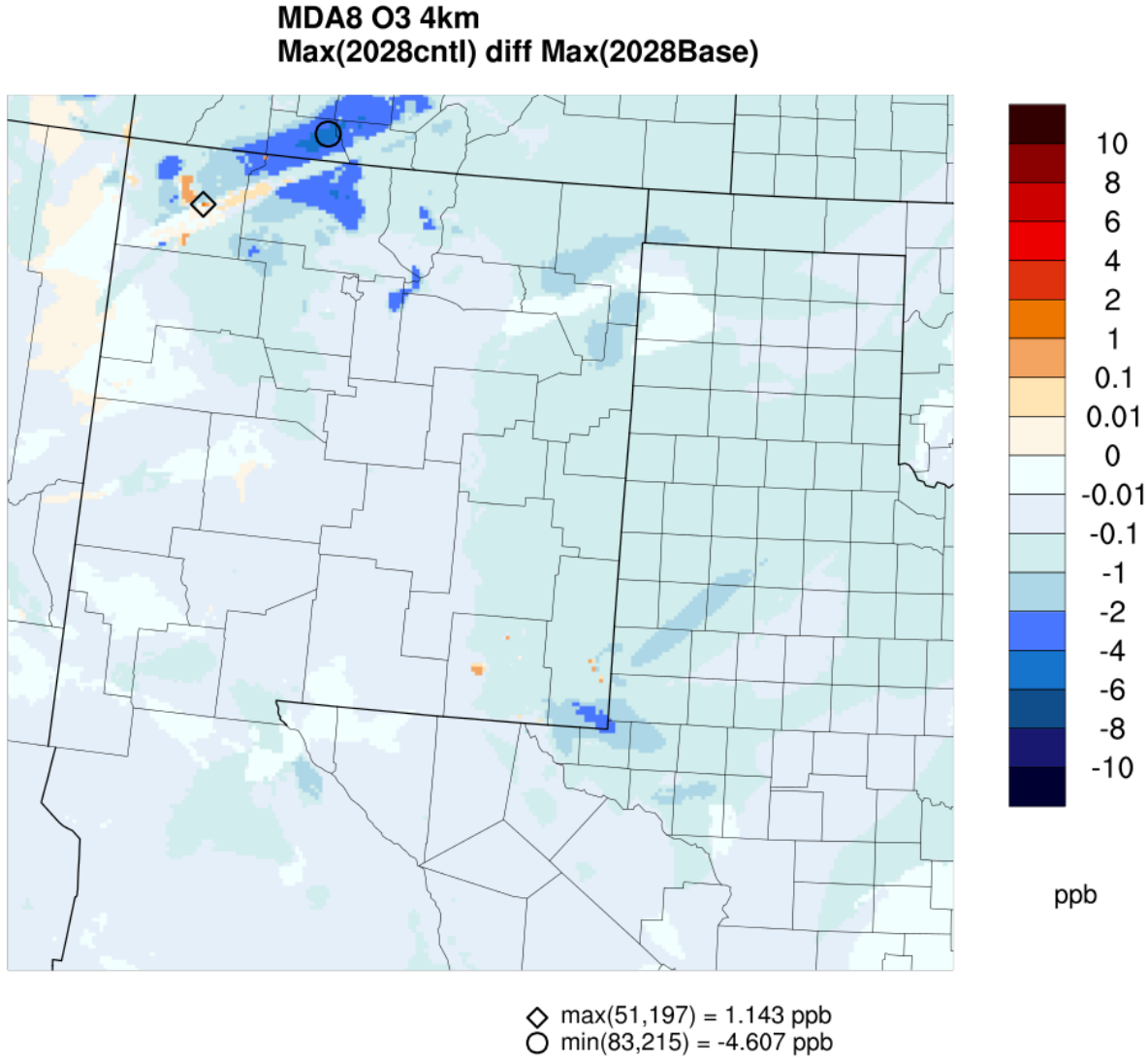






2028 EPISODE MAXIMUM MDA8 OZONE AND DIFFERENCES

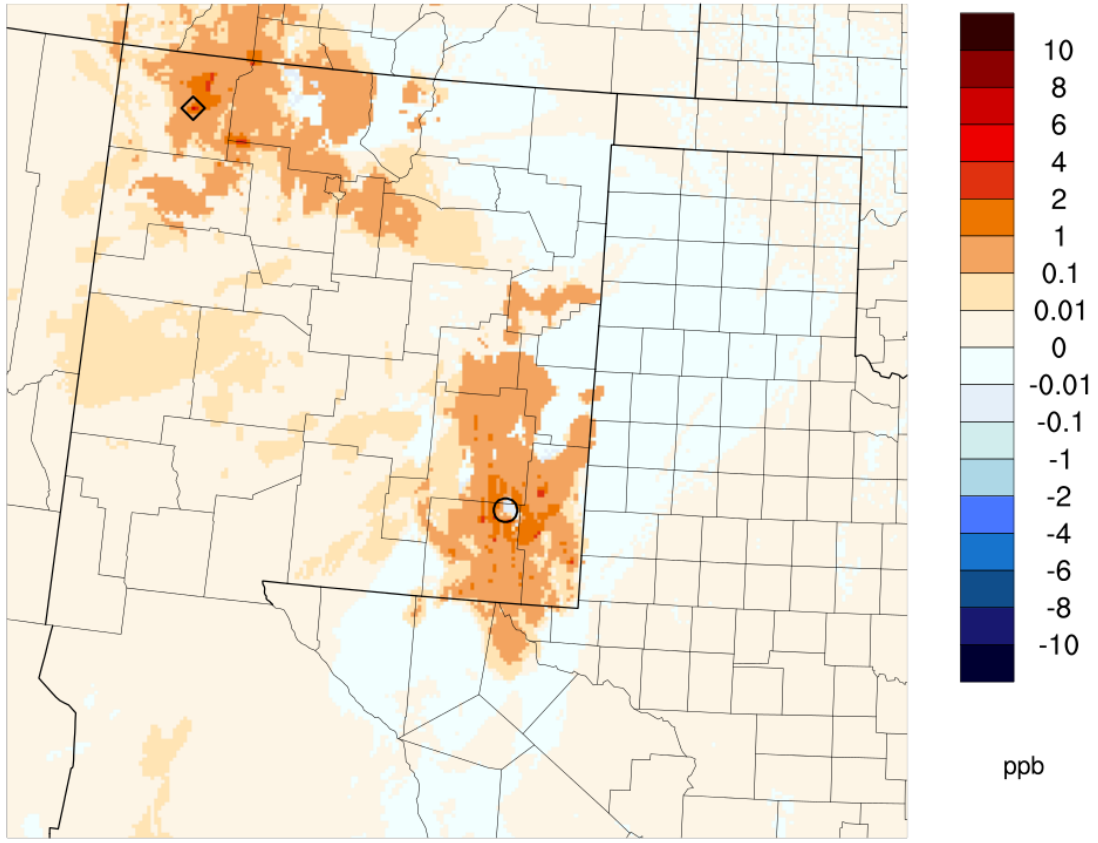




MAXIMUM INCREASES AND DECREASES IN MDA8 OZONE

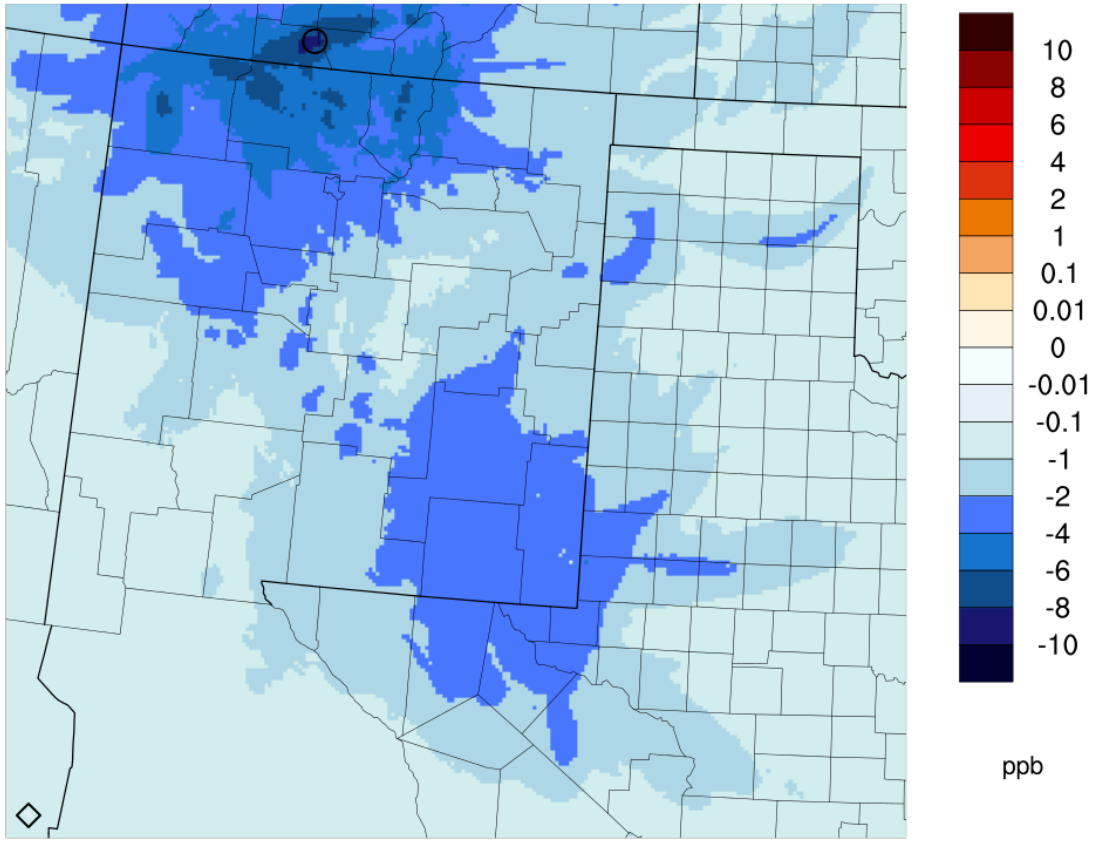
In San Juan Basin maximum decreases in MDA8 ozone range from -2 to -8 ppb
In Permian Basin maximum decreases in MDA8 ozone range from -2 to -4 ppb
In both Basins maximum increases are generally < 1-2 ppb except at isolated grid cells

MDA8 O3
Maximum (2028cntl diff 2028Base) 4km



◇ max(51,197) = 6.399 ppb
○ min(135,89) = -0.067 ppb

MDA8 O3
Minimum (2028cntl diff 2028Base) 4km



◇ max(7,7) = -0.095 ppb
○ min(84,215) = -8.399 ppb

CONCLUSIONS: 2028 NM O&G CONTROL STRATEGY

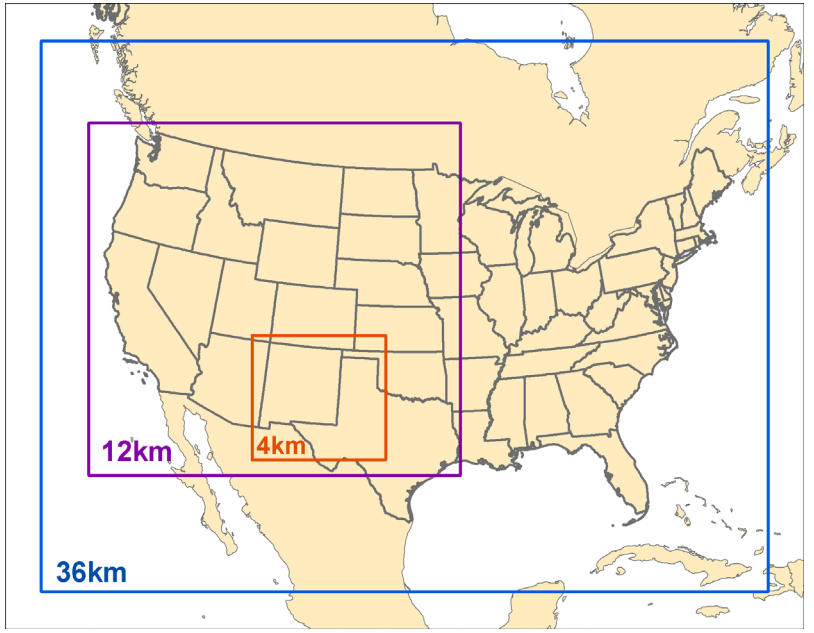
- New Mexico Oil & Gas Control Strategy reduces the projected 2028 ozone Design Values (DVs) across New Mexico:
  - -0.1 to -1.5 ppb reduction in ozone DVs at northern New Mexico monitoring sites with largest reductions at Navajo Lake (-1.5 ppb) and Substation (-1.2 ppb) in San Juan County
  - -0.2 to -0.5 ppb reduction in ozone DVs in Bernalillo County
  - -0.1 to -0.3 ppb reduction at southern New Mexico monitoring sites with largest reduction at Carlsbad City (-0.3 ppb)
- 2028 MDA8 ozone is reduced every day due to NM O&G control strategy
  - In San Juan Basin maximum ozone reductions range from -2 to -8 ppb
  - In Permian Basin maximum ozone reductions range from -2 to -4 ppb
  - Isolated grid cells with ozone increases due to NOx point source reductions
    - Likely due to less local titration of ozone due to fresh NO emissions ($NO + O_3 \rightarrow NO_2 + O_2$)

RAMBOLL

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

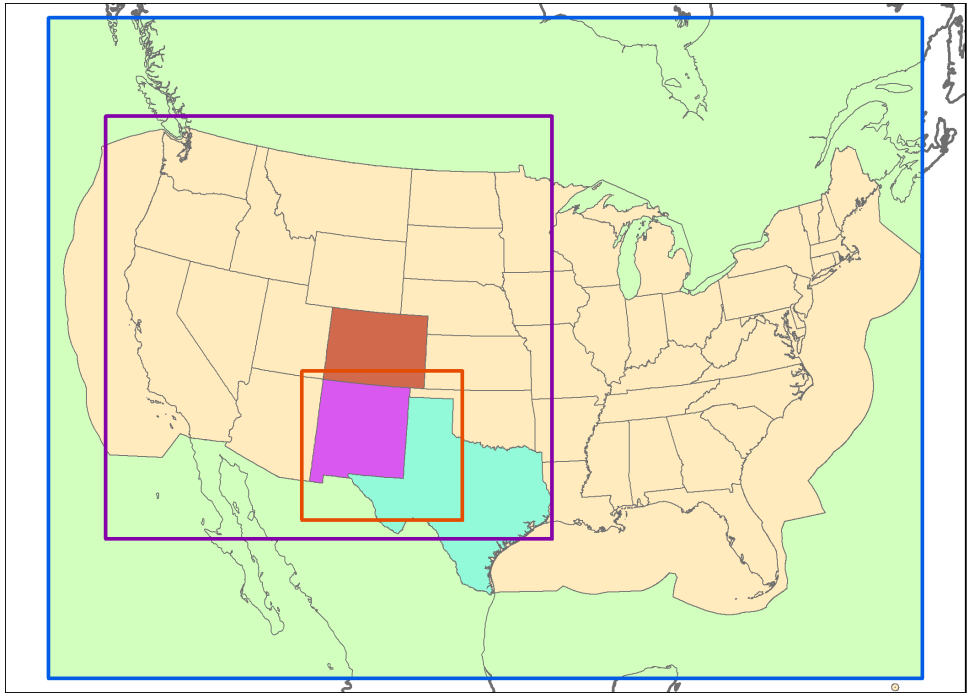
CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

- 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.



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

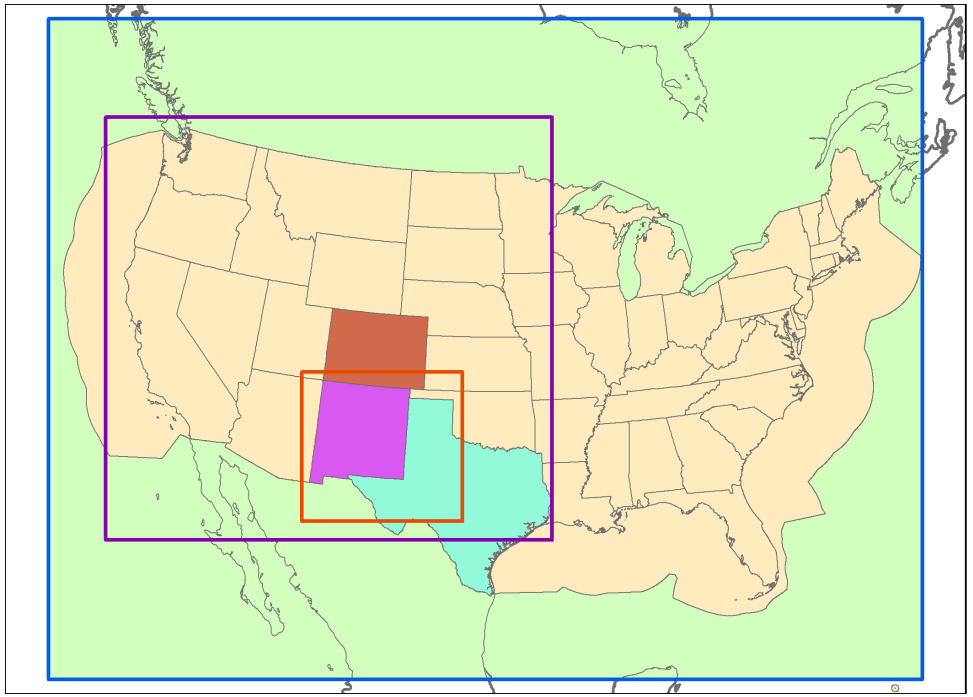
CAMX 2028 NM O&G CS APCA OZONE SOURCE APPORTIONMENT

- 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

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)