NEW MEXICO OZONE ATTAINMENT INITIATIVE

2014 and 2023 Emissions, CAMx WRF Sensitivity Tests and Selection of Final Model Configuration

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Tom Moore and Mary Uhl, WESTAR

NM OAI Study Webinar#3

July 27, 2020

RAMBOLL Bright ideas. Sustainable change.

AGENDA – NMED OAI STUDY WEBINAR#3 – JULY 27, 2020

- Welcome and agenda review – Tom and all
- 2014 and 2023 emissions QA, updates and processing – Ramboll
  - 2014 and 2023 Emissions QA and identification of duplicate sources
  - 2014 SMOKE emissions processing and results
  - 2014 natural emissions
- CAMx meteorological sensitivity tests and CAMx final 2014 base case configuration – Ramboll
  - WRF NAM and ERA simulations
  - Ozone evaluation of CAMx four meteorological input sensitivity tests
  - Final CAMx 2014 36/12/4-km base case configuration
- Upcoming schedule, milestones when NMED needs support for EIB process - all

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2014 AND 2023 EMISSIONS

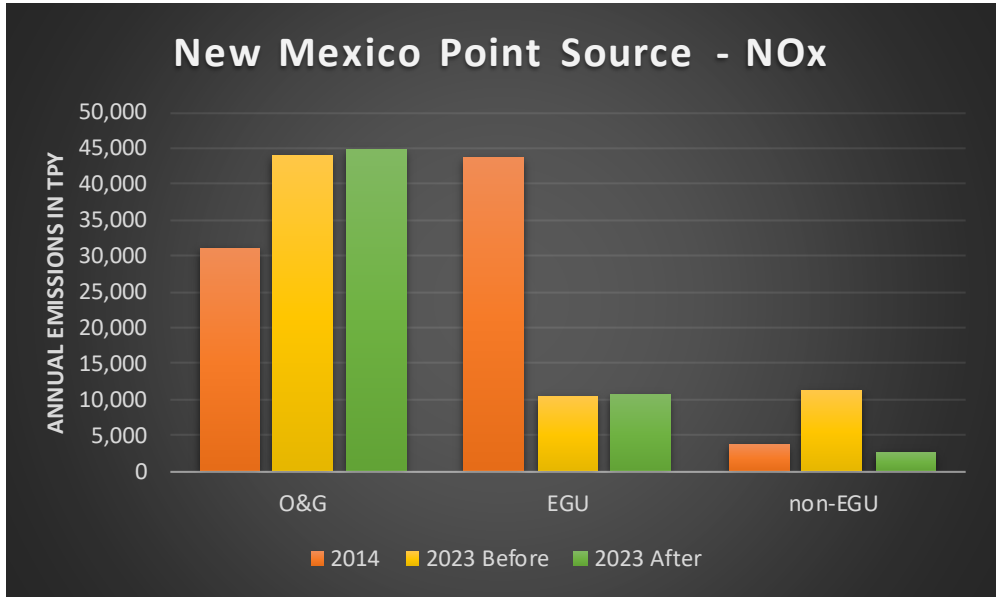
NEW MEXICO EMISSIONS DATA

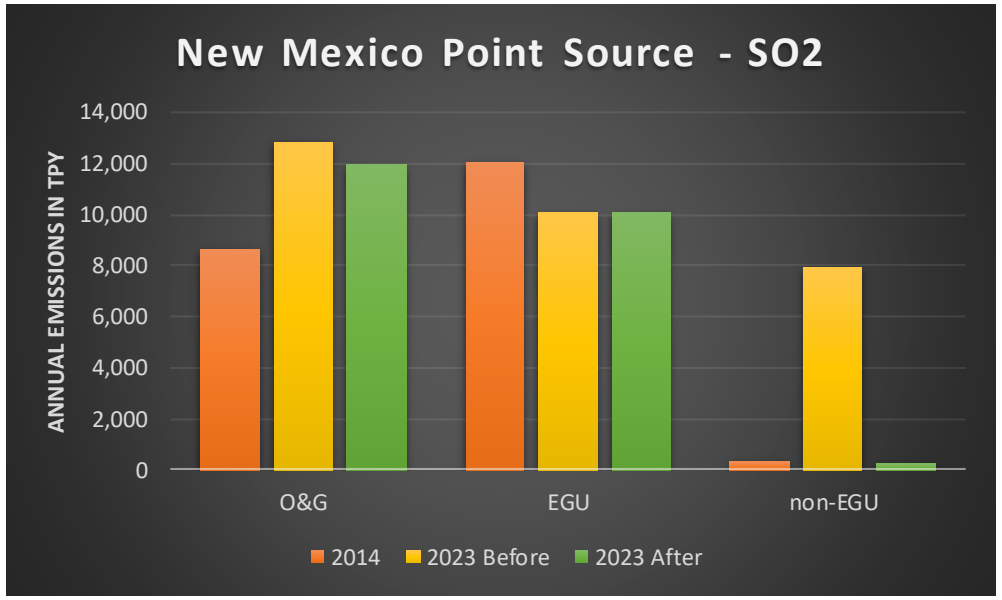
- 2014 anthropogenic emissions are based on the WAQS 2014v2
  - NMED found a generator engine missing in 2014v2 inventory (94 tpy NOx)
  - No double counting of sources in 2014v2 inventory
  - Consistent emissions data between the Regional Haze and OAI studies

- 2023 anthropogenic emissions are based on the EPA 2016v1 platform
  - NMED found some point sources exist in both 2023 point O&G and non-EGU sectors
  - Found double counting of sources in WRAP O&G inventory: Title V and minor point sources
  - Found Lordsburg Generating Station is missing
  - Add two O&G sources: Chaco Gas Plant (NOx 2,053 tpy) and Mountainair CS (NOx 645 tpy)

DUPLICATE POINT SOURCES IN 2023

- NMED identified 21 facilities double counted in 2023 non-EGU and WRAP point O&G inventory
  - Double counted emissions: NOx 8,669 TPY and SO2 7,662 TPY
  - Represents approximately 9% (NOx) and 24% (SO2) of the New Mexico 2023 O&G emissions
- Duplicates in the WRAP O&G inventory: Some sources were present in Title V and minor point O&G sources datasets in the OGWG inventory.
  - Double counted emissions NOx: 1,927 TPY and SO2: 942 TPY





O&G SOURCES IDENTIFIED IN NON-EGU INVENTORY BASED ON NAICS CODES

O&G NAICS found in ptnonipm but not duplicate

Duplicates found by EPA/NMED in pt_oilgas and ptnonipm sectors

Duplicates found based on NAICS

Sum of ann_value					poll						
region_cd	state	facility_name	facility_id	naics	CO	NH3	NOX	PM10	PM25	SO2	VOC
8123	CO	OVERLAND PASS - FT LUPTON METER NORTH	14794011	486990							1
8123	CO	OVERLAND PASS - FT LUPTON METER SOUTH	14919211	486990							3
8123	CO	OVERLAND PASS - FT LUPTON/DJ JUNCTION	14794111	486990							5
8123	CO	OVERLAND PASS - GROVER STATION	14794411	486990							10
8123	CO	OVERLAND PASS - LILLI METER	16286411	486990							3
8123	CO	OVERLAND PASS - LUCERNE METER	14793811	486990							4
8123	CO	OVERLAND PASS - LUCERNE/DJ JUNCTION	14919311	486990							7
8123	CO	OVERLAND PASS - MEWBOURN METER	14919411	486990							5
8123	CO	OVERLAND PASS - MEWBOURN/FT LUPTON	14919511	486990							8
8123	CO	OVERLAND PASS - OPPL/DJ JUNCTION &DJ PL	14793911	486990	0		0	1	1	1	9
8123	CO	OVERLAND PASS - PAWNEE CREEK	16203211	486990							2
35001	NM	Albuquerque Refined Products Terminal	12817711	48691	3		1				22
35005	NM	NuStar Logistics Operation LP - Hope Pump St	7565111	48691	4		101	0	0	0	0
35015	NM	Artesia Gas Plant	7411811	21112	380		351	11	11	19	73
35015	NM	Chaparral Gas Plant	17128911	21112	72		110	3	3	4	133
35015	NM	DCP Midstream - Pecos Diamond Gas Plant	7761811	21112	46		59	4	4	0	165
35015	NM	Empire Abo Gas Plant/Compressor Station	7584511	21112	12		84	0	0	162	42
35015	NM	Oxy - Indian Basin Gas Plant	7905211	21112	29		161	4	4	51	40
35025	NM	DCP Midstream - Eunice Gas Plant	5228911	21112	224		606	11	11	1,437	70
35025	NM	Denton Gas Plant	8091311	21112	32		26	2	2	952	28
35025	NM	Eunice Gas Processing Plant	8092311	21112	357		2,046	22	21	23	72
35025	NM	Jal No3 Gas Plant	5226911	21112	382		381	16	16	1,968	266
35025	NM	Linam Ranch Gas Plant	8241211	21112	449		692	28	28	109	103
35025	NM	Maljamar Gas Plant	5226611	21112	50		87	7	7	213	57
35025	NM	Saunders Gas Plant	8241411	21112	116		821	10	10	416	66
35025	NM	Targa - Monument Gas Plant	8241311	21112	195		361	17	5	1,953	89
35043	NM	San Luis Pump Station	6723811	48699	2		3	0	0		1
35043	NM	San Ysidro Pump Station GCP1-1145	6724211	48699	2		9	1	1	1	20
35045	NM	Harvest Pipeline - San Juan Gas Plant	7231911	21112	63		527	17	17	1	47
35045	NM	Huerfano Pump Station	6735511	48699	10		25	1	1	0	23
35045	NM	Kutz Canyon Processing Plant	7230311	21112	603		767	14	14	3	510
35045	NM	San Juan River Gas Plant	8091911	21112	92		137	4	4	143	78
35045	NM	Val Verde Treatment Plant	7992811	21112	107		139	25	25	43	156
38093	ND	Jamestown East Products Terminal	8012911	486910							39
46005	SD	NuStar PipeLine Operating Partnership	15648111	486910							41
46013	SD	NuStar Pipeline Operating Partnership LP	15646411	486910							73
46029	SD	Magellan Pipeline Company	15646511	486910							83
46035	SD	NuStar Pipeline Operatng Partnership	15646711	486910	0		0	0	0	0	14
46099	SD	Magellan Pipeline Company	15646311	486910	14		9	0	0	0	165
46099	SD	NuStar Pipeline Operating Partnership LP	2911811	486910	0		2	0	0	0	17
46135	SD	NuStar PipeLine Operating Partnership	15646611	486910							102
56025	WY	Casper Gas Plant	17924811	211130	41	0	32	2	2	0	10
56037	WY	Rock Springs Terminal	6939911	486910	0		0	0	0		33
Grand Total					3,284	0	7,537	199	186	7,500	2,698

INTRODUCTION TO EMISSION PROCESSING

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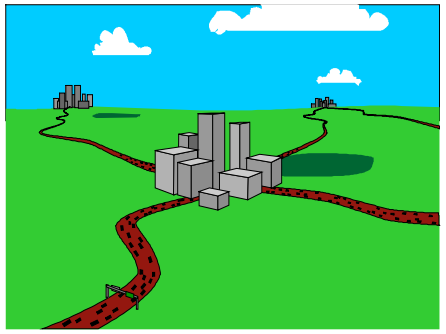
Start With

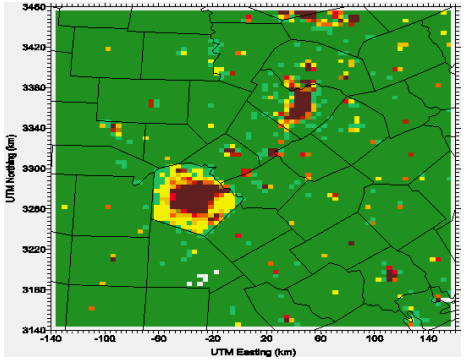


Annual Estimates (tons/year)

County Totals

Criteria Pollutants (NOx, CO, VOC)

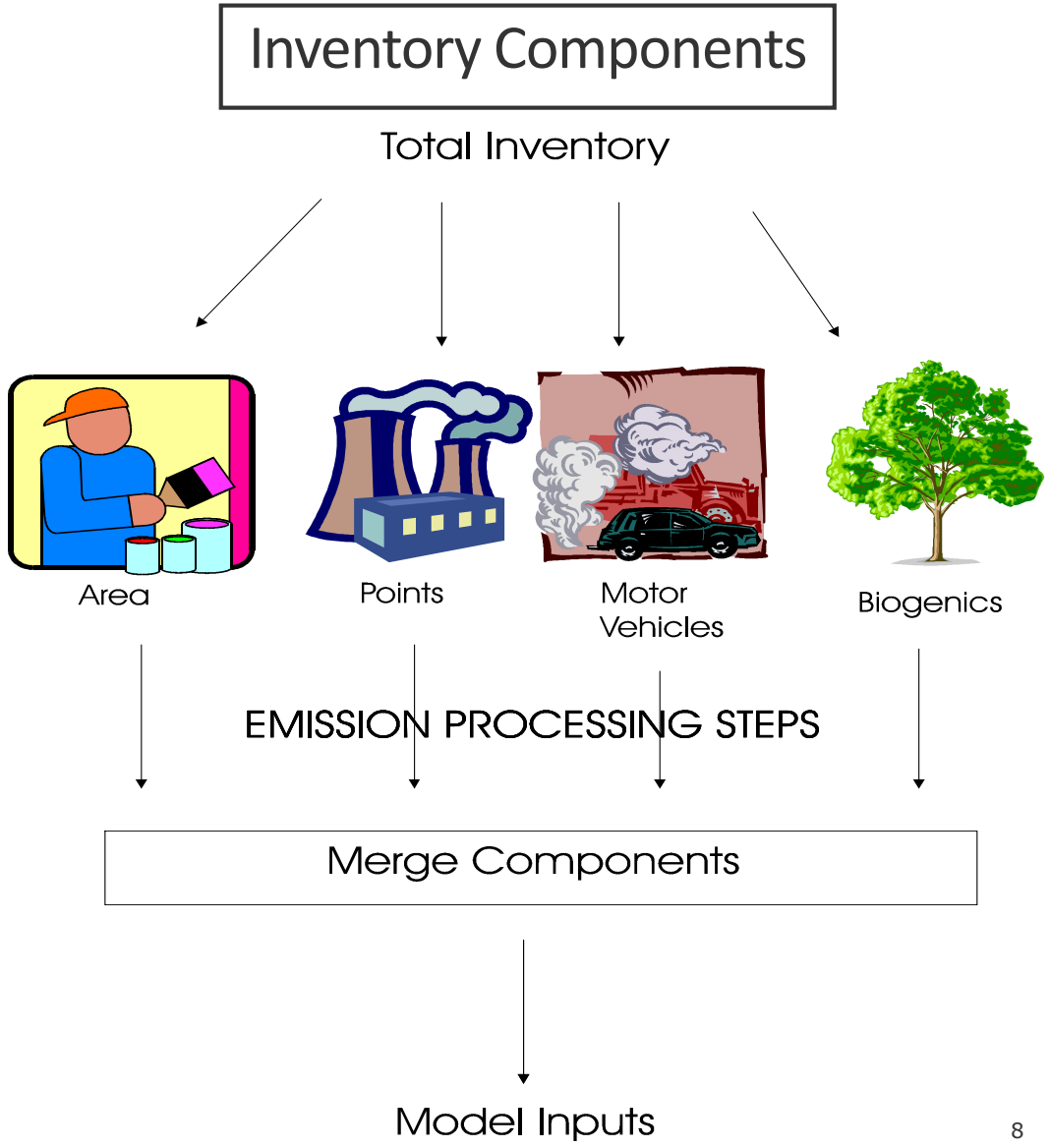
Model Ready



Hourly

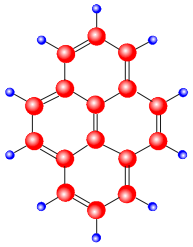
Gridded

Speciated



INTRODUCTION TO EMISSION PROCESSING

Area source emission processing



Temporal Allocation

↓

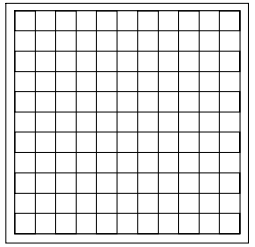
Speciation

↓

Growth/Controls

↓

Gridding



Point source emission processing

Temporal Allocation

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Speciation

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Growth/Controls

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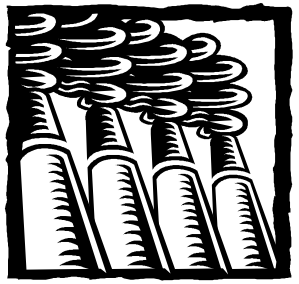
Vertical Resolution



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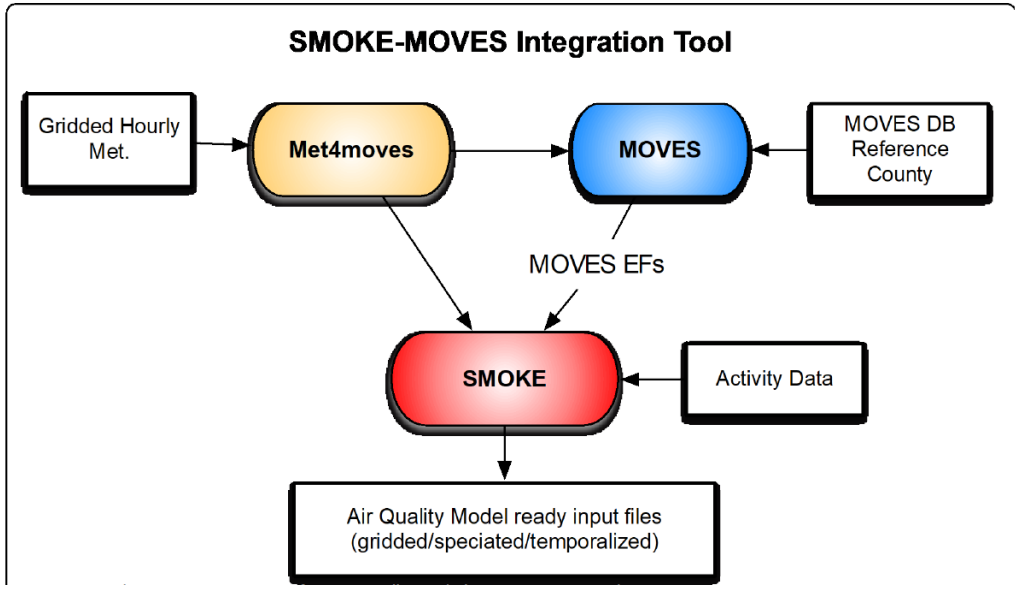
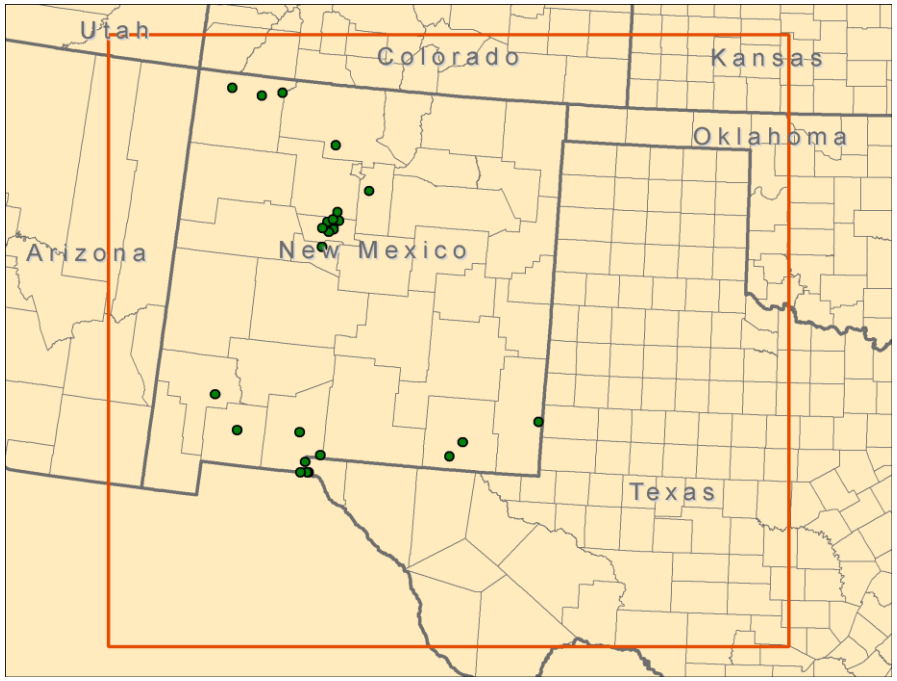
OVERVIEW OF SMOKE-MOVES PROCESSING

- Requires emission rate "lookup" tables generated by MOVES
- Uses gridded, hourly, day-specific temperatures
- SMOKE processing applies the emission factors to the activity data to compute grid-cell emissions



SMOKE PROCESSING OF 2014 EMISSIONS

- SMOKE version 4.7
- Process emissions for 4-km domain
- Spatial surrogates**:** O&G spatial surrogates are based on 2014 O&G activity data and other 4-km surrogates obtained from EPA's Emission Modeling Platform (EMP).
- Speciation for CB6r4 chemical mechanism in CAMx



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SMOKE PROCESSING SECTORS

2014 4-km emissions in average tons/day

Sector	CO	NOx	VOC
ag	0.0	0.0	43.4
nonpt	141.3	28.5	213.2
nonroad	570.3	133.4	73.2
np_oilgas	286.8	311.7	1,642.5
np_oilgas_wrap_only	237.7	157.8	567.3
onroad	1,476.2	444.5	150.6
onroad_mex	356.3	98.4	34.4
othar	19.9	42.2	103.3
othpt	28.4	20.2	8.3
ptegu	89.2	210.6	5.0
pt_oilgas	113.8	205.2	48.4
pt_oilgas_wrap_only	89.9	114.7	56.1
ptnonipm	74.4	47.5	24.4
rail	22.9	122.7	6.2
rwc	7.0	0.1	1.2
TOTAL	**3,513.9**	**1,937.6**	**2,977.3**

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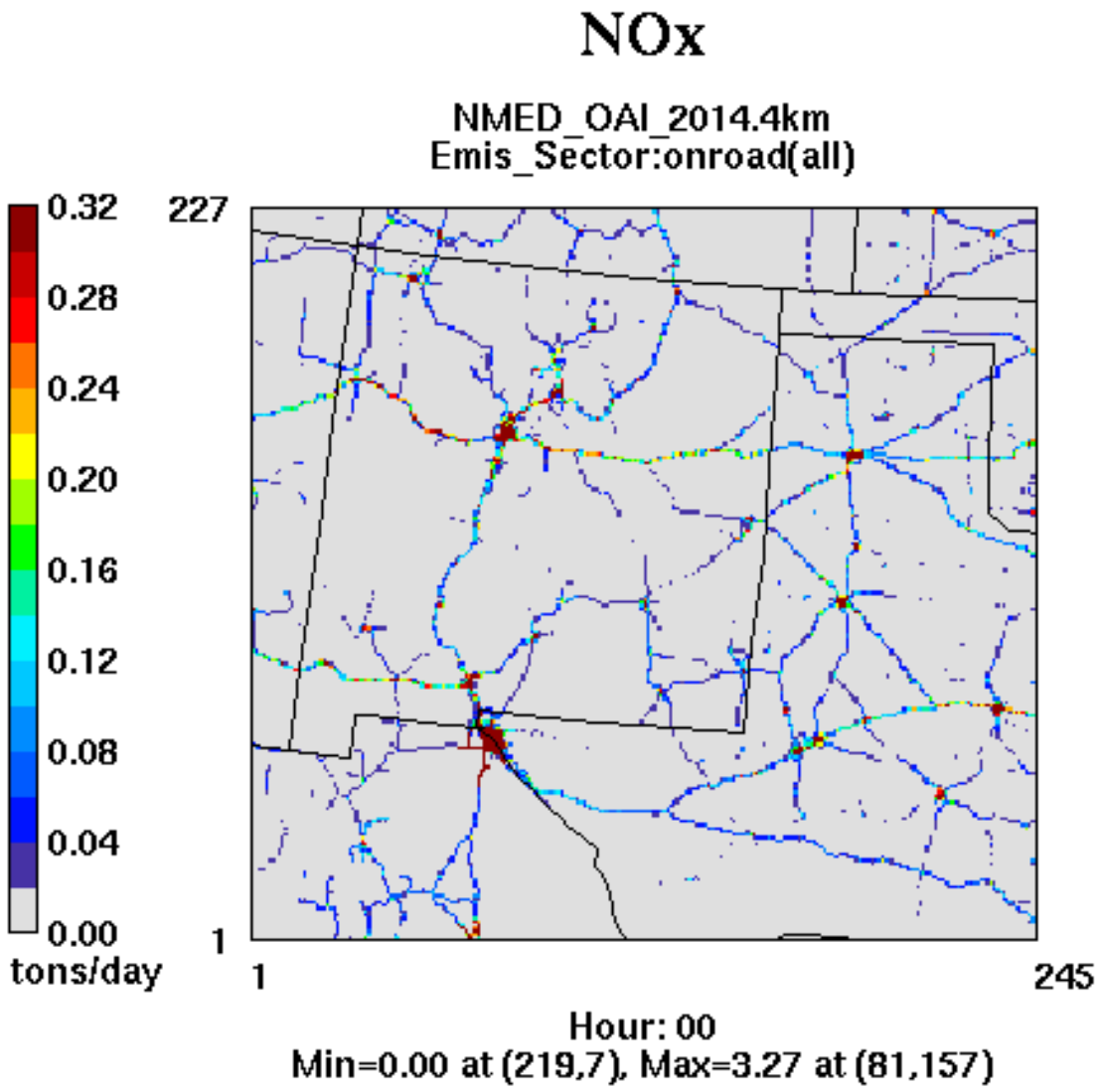
Sector	Description
afdust_adj	- Area fugitive dust
ag	- Agricultural ammonia sources
nonpt	- Other nonpoint sources
np_oilgas_wrap	- Non-point Oil and Gas for 7 WRAP states (CO, MT, NM, ND, SD, UT, WY)
np_oilgas	- Non-point Oil and Gas
nonroad	- Non-road mobile
rail	- Locomotive
onroad	- On-road mobile
ptegu	- EGU point sources
ptnonipm	- Non-EGU point sources
pt_oilgas_wrap	- Point Oil and Gas for 7 WRAP states (CO, MT, NM, ND, SD, UT, WY)
pt_oilgas	- Point Oil and Gas
rwc	- Residential Wood Combustion
onroad_mex	- Mexico onroad mobile
othar	- Mexico area
othpt	- Mexico point sources
MEGAN/BEIS	- Biogenic
LtNOx	- Lightning Nox
AG fire	- Ag Fire
RX fire	- Prescribed Fire
WF fire	- Wild Fire
Ptfire_othna	- Mexico fire
WBD	- Windblown Dust

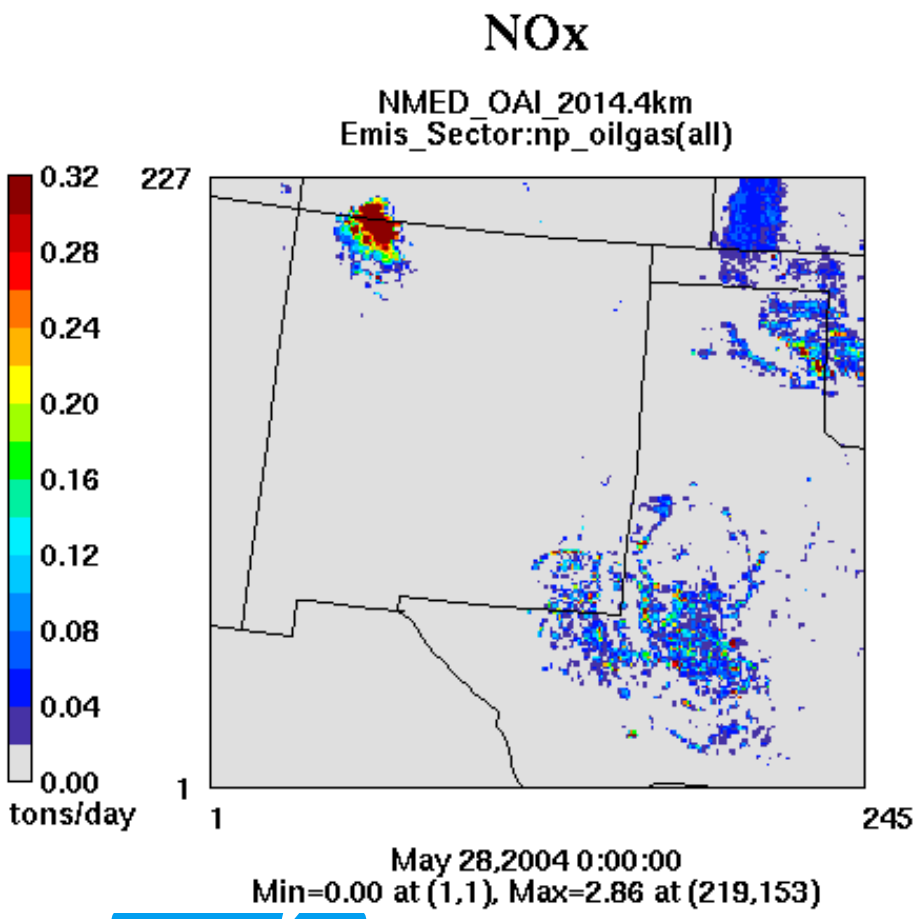
ONROAD EMISSIONS

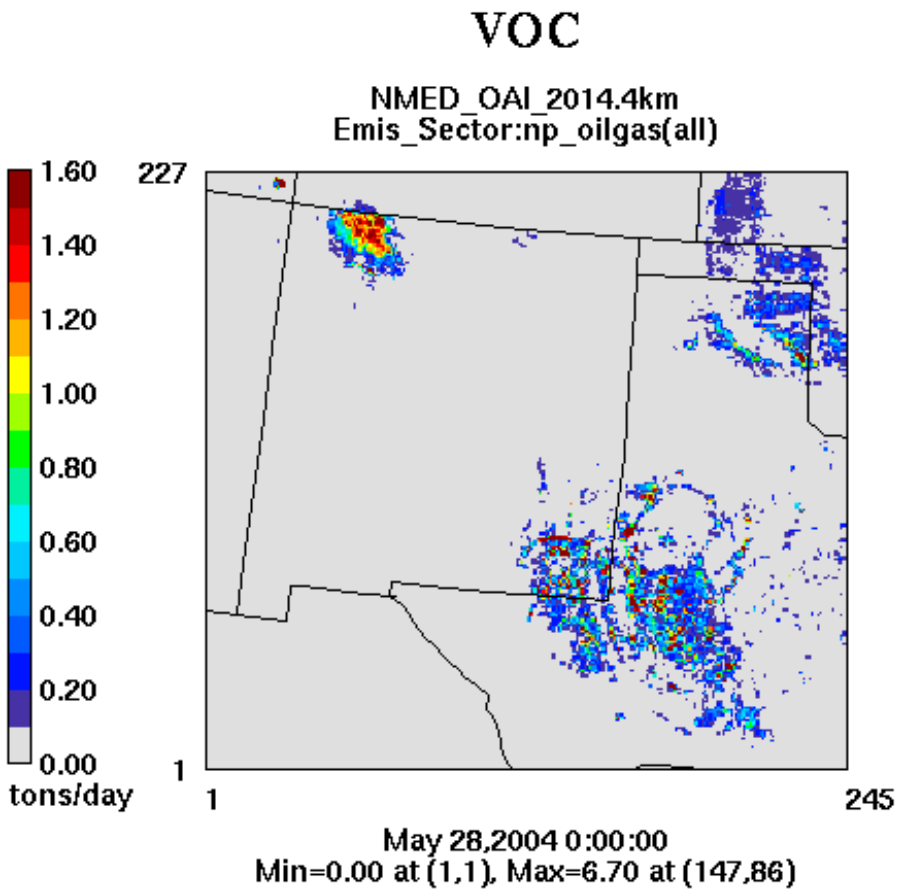
- On-road emissions developed using SMOKE-MOVES processing with 2014/2023 activity data and day-specific hourly gridded 2014 WRF meteorology
  - 2014 MOVES lookup tables and 4-km MCIP data
- SMOKE-MOVES processing:
  - rate-per-distance (RPD) (30 mins per day)
  - rate-per-vehicle (RPV) (10 mins per day)
  - rate-per-profile (RPP)
  - rate-per-hour (RPH)



NON-POINT O&G EMISSIONS

Basin-specific speciation profiles





Surrogate	Surrogate Description
688	Gas production at oil wells
689	Gas production at all wells
690	Oil production at all wells
691	Well count - CBM wells
692	Spud count
693	Well count - all wells
694	Oil production at Oil wells
695	Well count - oil wells
696	Gas production at gas wells
697	Oil production at gas wells
698	Well count - gas wells
699	Gas production at CBM wells

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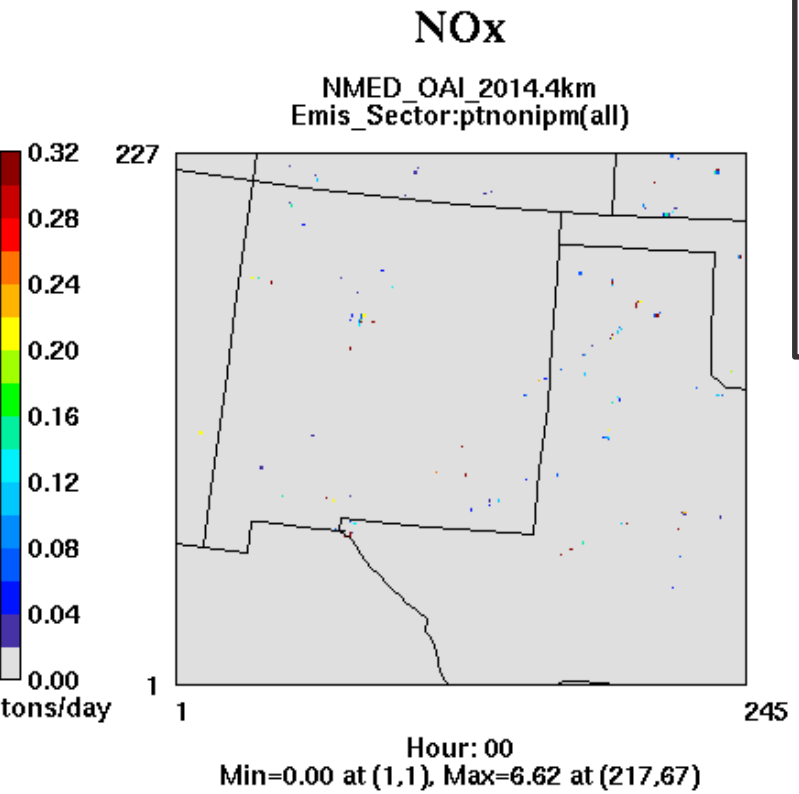
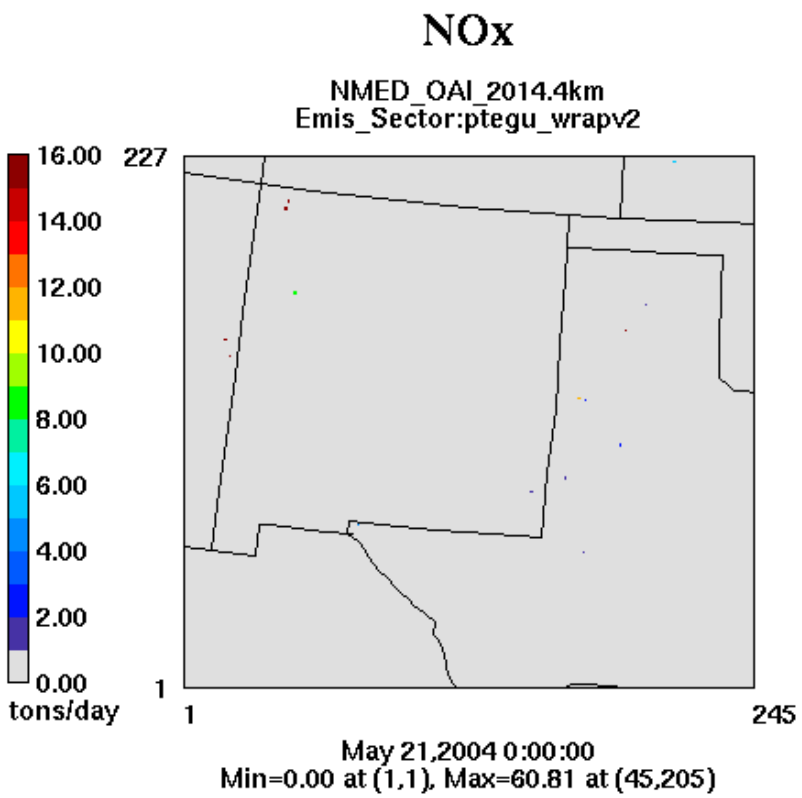
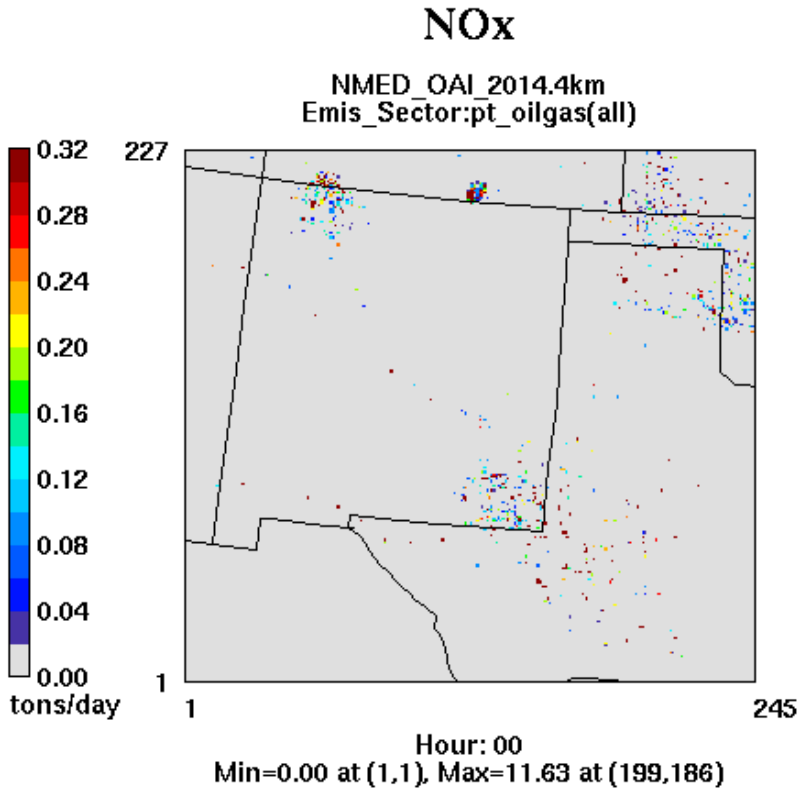
POINT SOURCE EMISSIONS

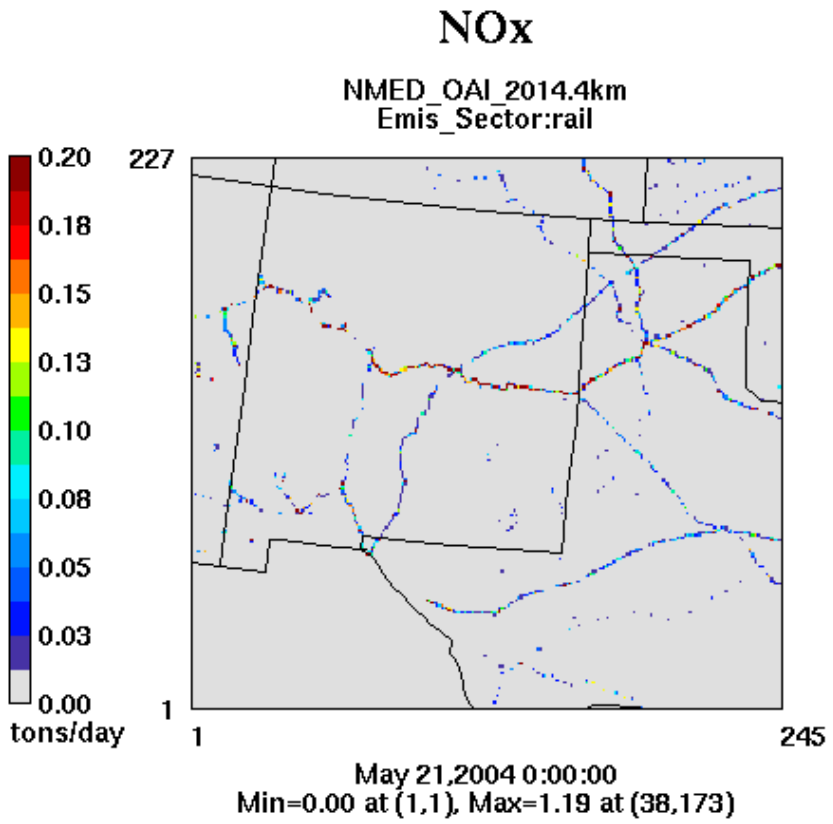
Point source processing generates elevated and low-level gridded files. Elevated files contain x/y coordinates for each point source so they are not domain dependent.

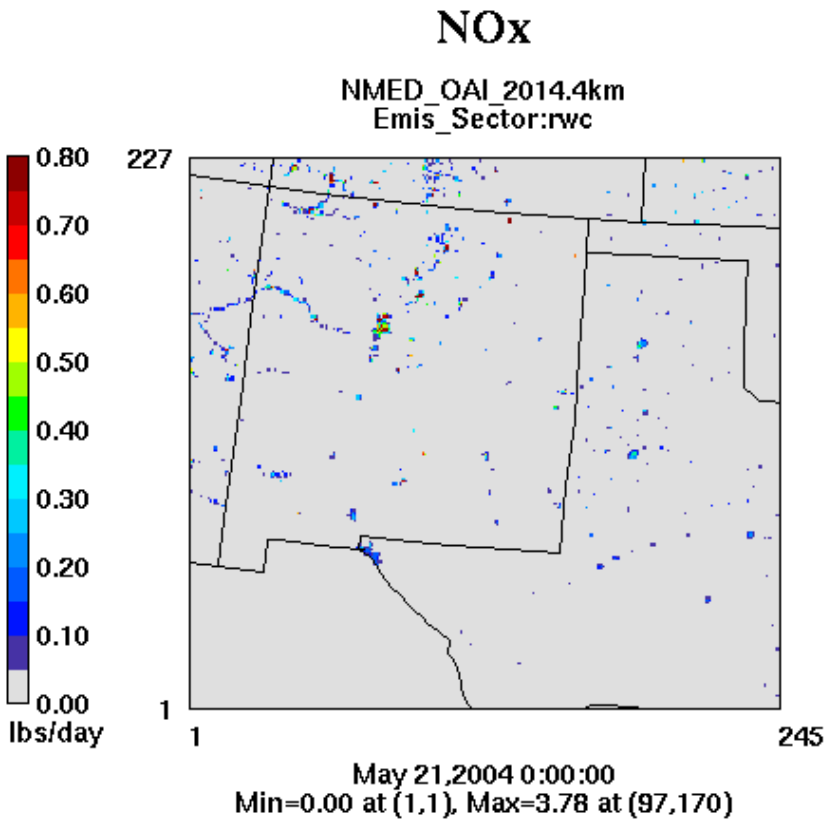




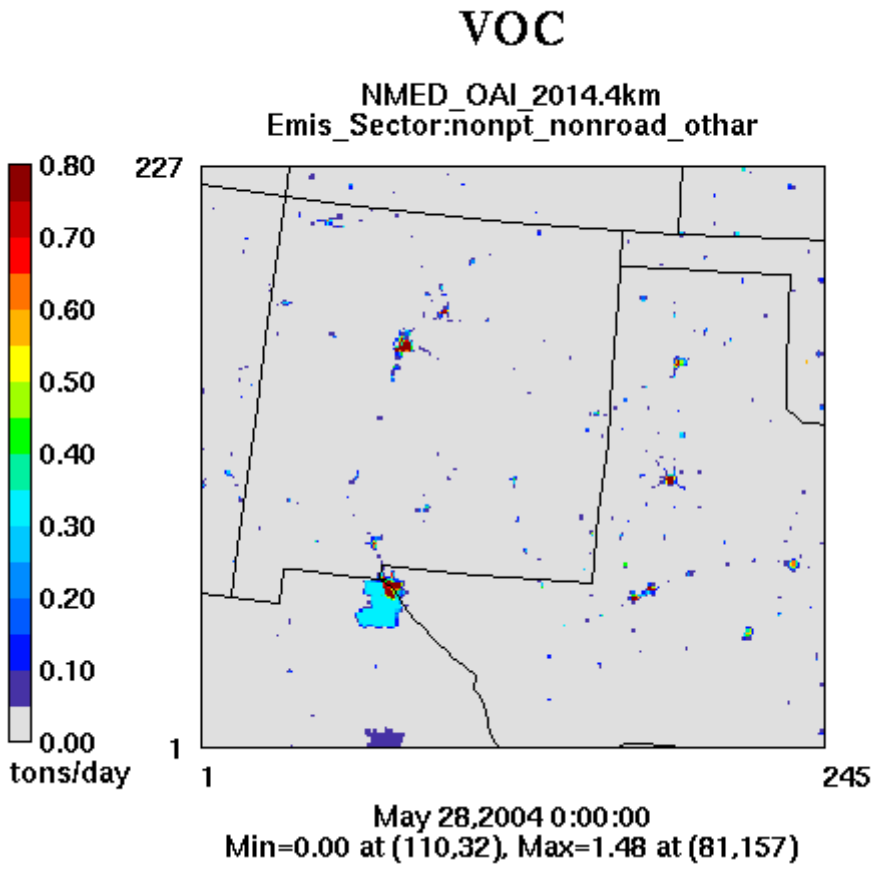


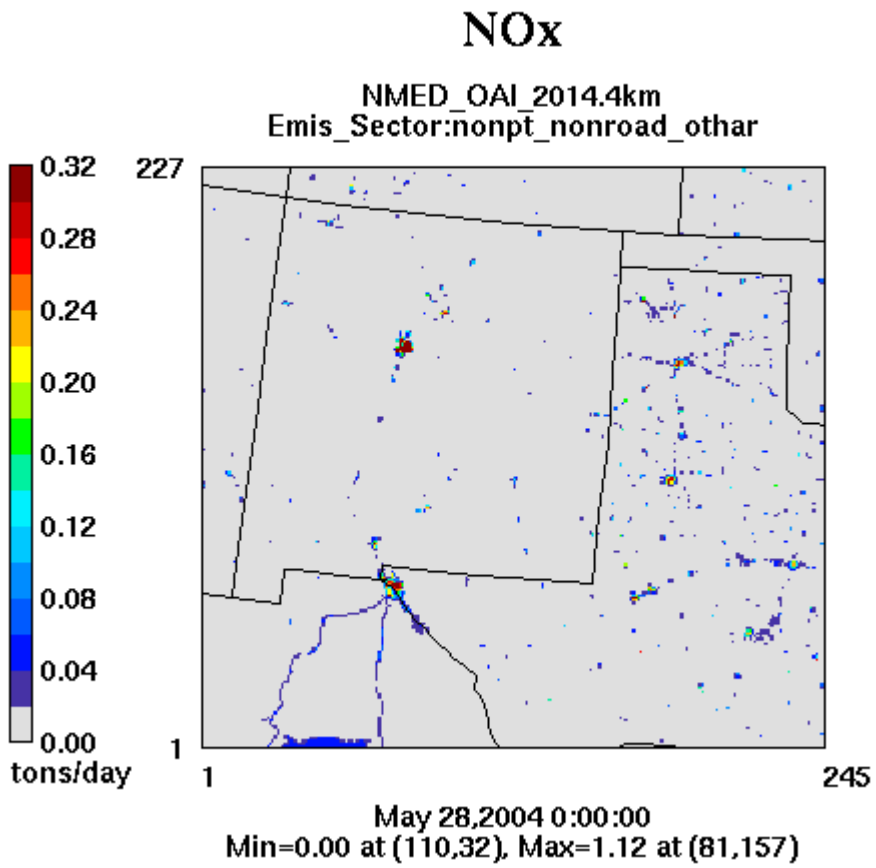
RAIL AND RWC EMISSIONS





NONPOINT AND NONROAD EMISSIONS





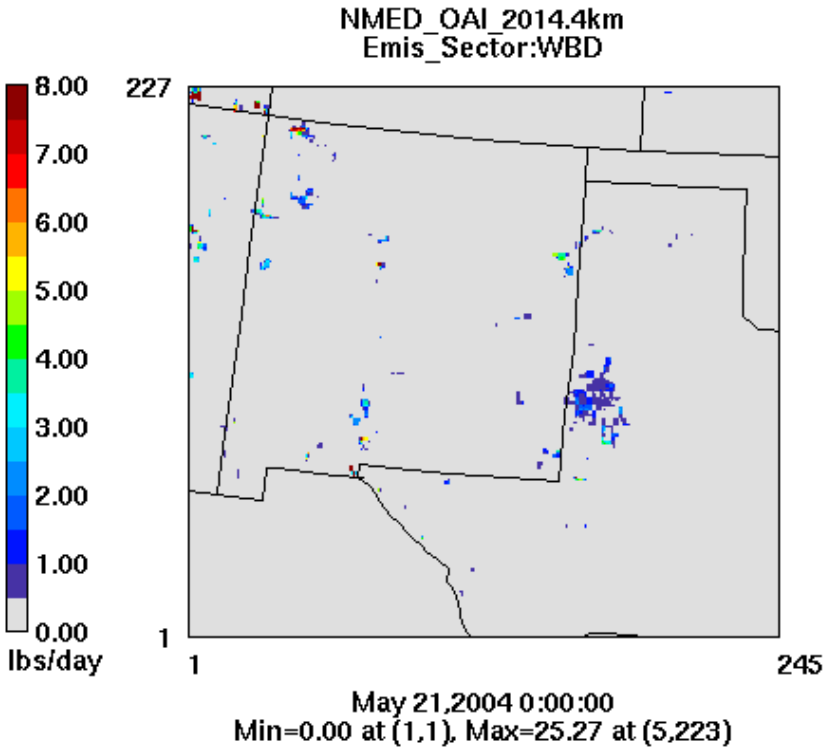
NATURAL EMISSIONS

- Lightening NOx: Lightning NOx (LNOx) emissions processor with 2014 WRF meteorological data to generate CAMx-ready emissions
- Oceanic Emissions: OCEANIC emissions processor was used to generate sea salt and dimethyl sulfide (DMS) emissions
- Fire Emissions: Agricultural, prescribed burn and wildfire emissions from WRAP 2014v2 modeling developed by WRAP Smoke and Fire Workgroup
- Windblown dust: CAMx windblown dust (WBD) processor
- Biogenic Emissions: MEGAN or BEIS biogenic emissions model

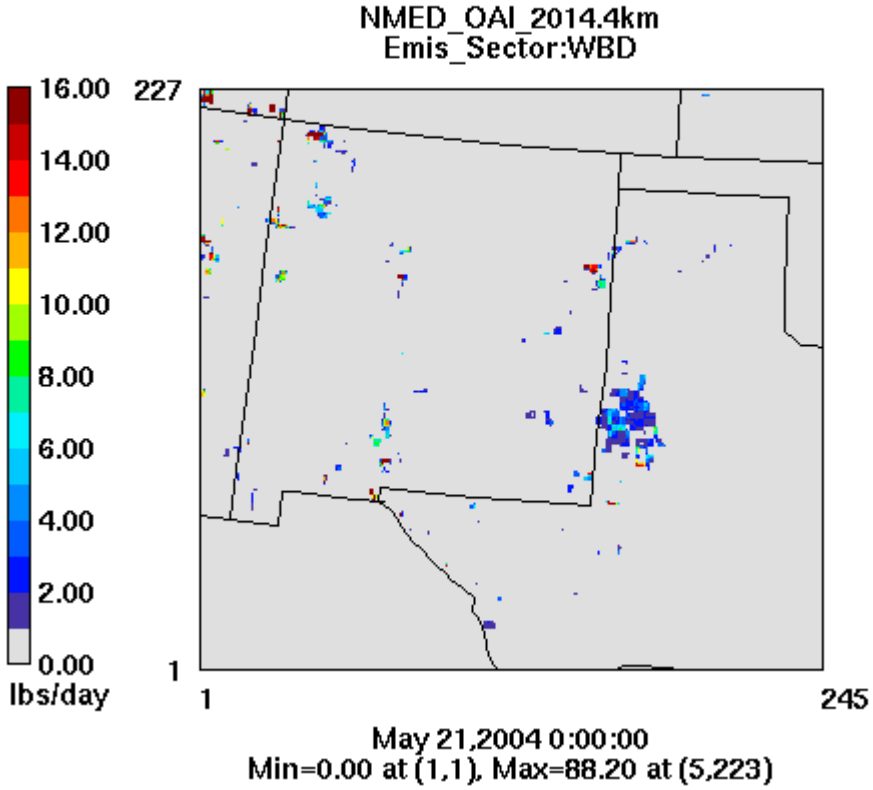
WINDBLOWN DUST EMISSIONS

	Emissions (tons/day)	
Year	PM2_5	CPRM
2014	20.9	80.2

PM25

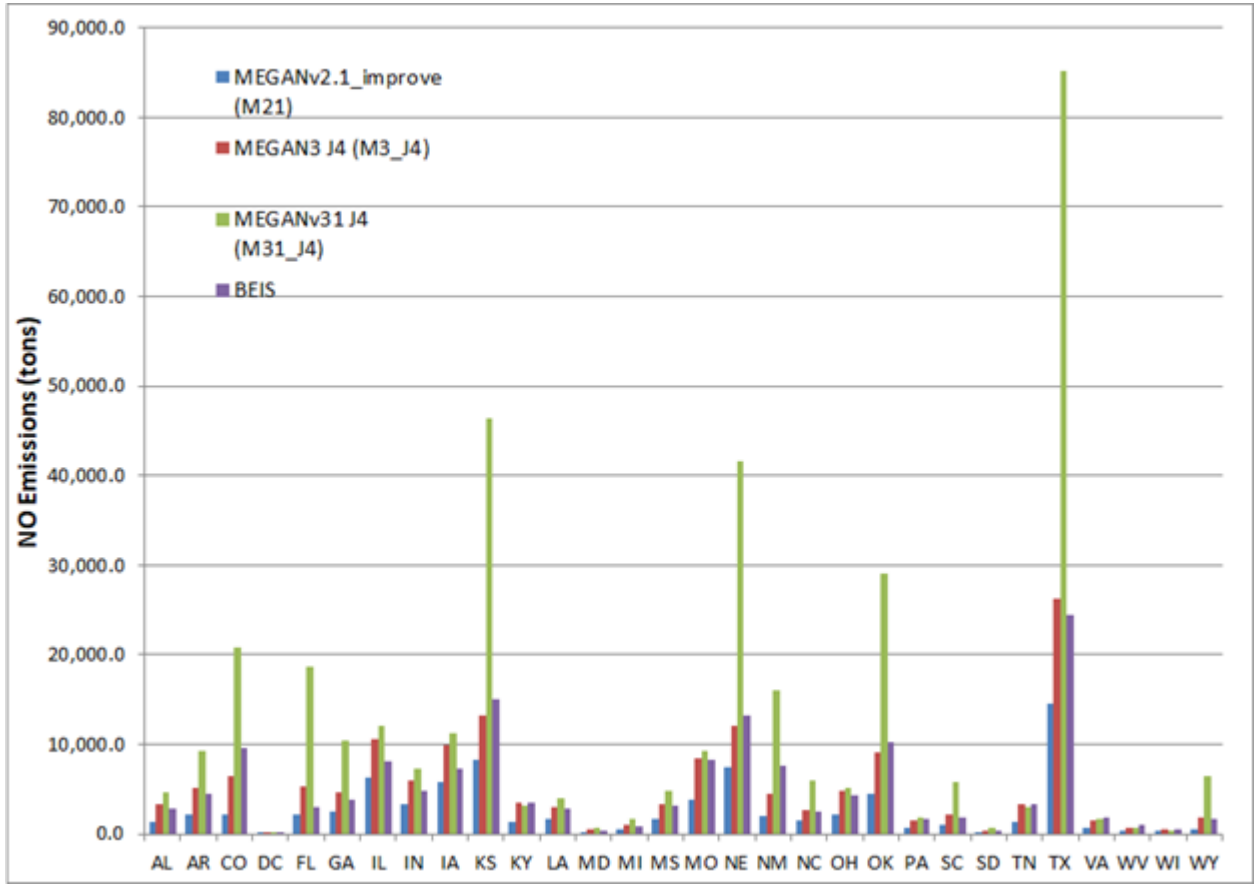


PMC



BIOGENIC EMISSIONS

- MEGAN3.1 improvement: Replaced soil NO code (Yienger and Levy approach) used by MEGAN3.0 (and BEIS) with state-of-the-art BDSNP approach. This model was already available to the community in GEOS-chem and WRF-CMAQ but required on-line AQ model.
- Summer soil NOx (June 1-July 15, 2013 period) for New Mexico estimated using different biogenic models.
- Agricultural regions with high fertilizer application rates have large NO emissions
- Will use MEGAN v3.1 emissions as latest data



Reference: Guenther, A. et al (2018). Final Report For Project 18-005: Next steps for improving Texas biogenic VOC and NO emission estimates. Prepared for Air Quality Research Program (AQRP).

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CAMX METEOROLOGICAL SENSITIVITY TESTS AND FINAL CONFIGURATION

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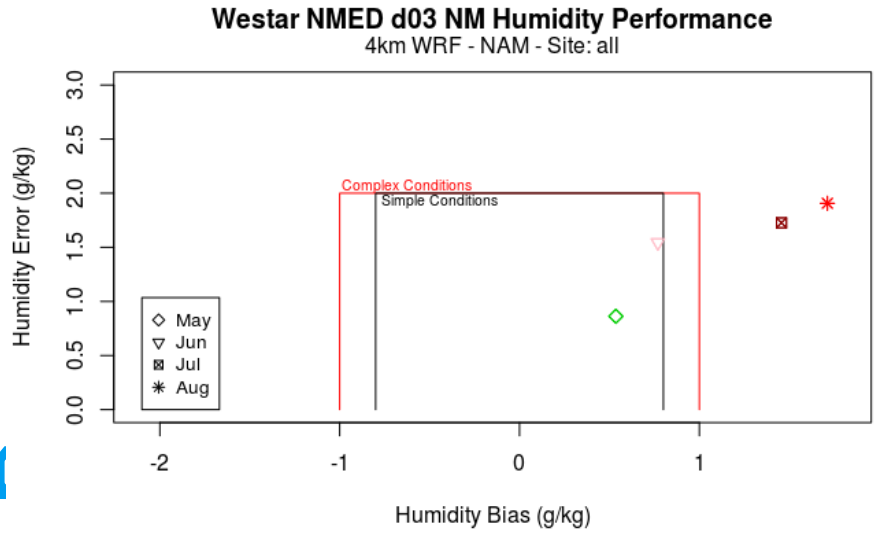
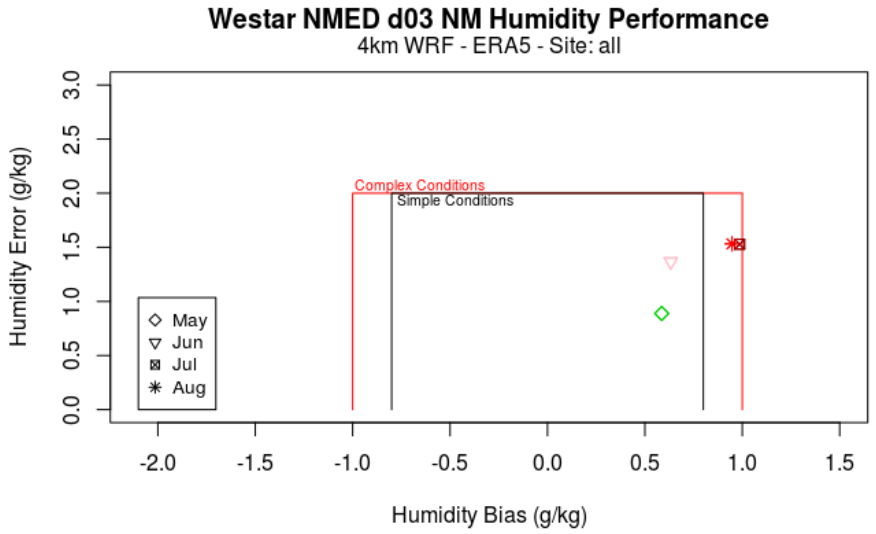
OVERVIEW

- Explore CAMx model performance using various WRF simulations presented on June 26, 2020 webinar (WRF sensitivities)
- CAMx model configurations used for WRF sensitivities
- Determine the WRF input and model configuration that best performs on selected period to use for 2014 CAMx base case

2014 WRF PERFORMANCE SUMMARY (JUNE 26 WEBINAR)

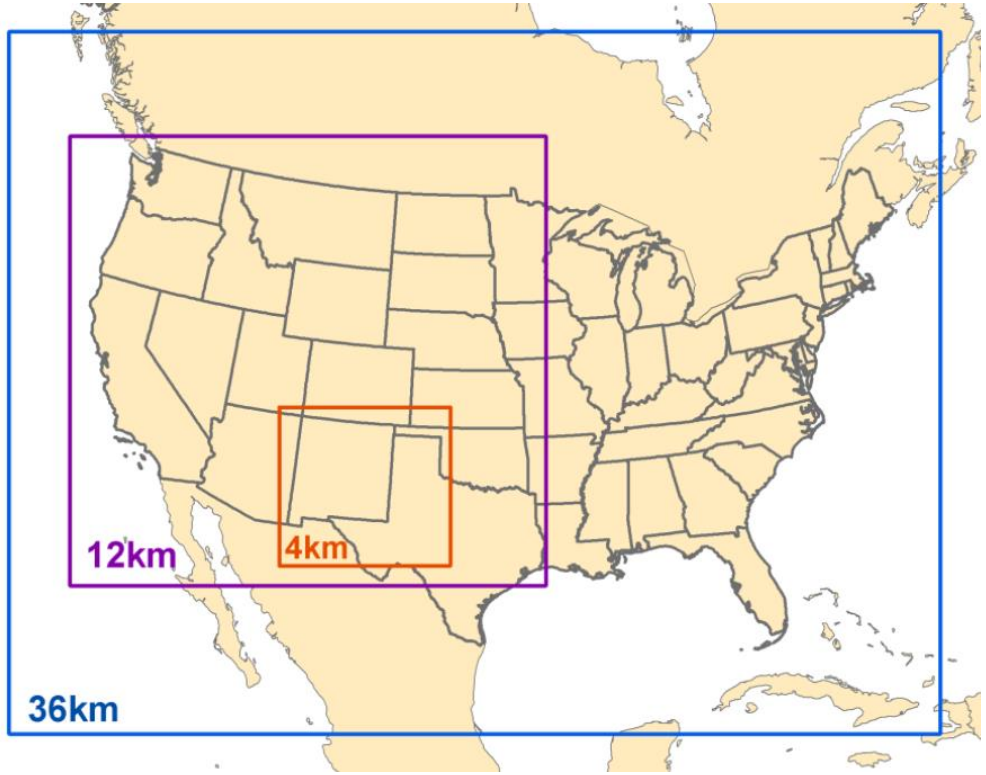
- WRF summer 2014 simulations using NAM and ERA5 analysis fields
  - Analysis fields used for initialization and boundary conditions (BCs) and for 36/12-km four-dimensional data assimilation (FDDA/nudging)
- WRF model performance reasonable for both NAM and ERA5 simulations
  - Surface meteorology (WS, WD, T, Q) and precipitation (PRISM)
- Differences between NAM and ERA5 are smaller in comparison to EPA/WAQS
- NAM wet bias in Jun-Aug may be partly associated with overactive summer convection
  - ERA5 has smaller wet bias





MODELING DOMAIN AND CONFIGURATION

- Performed CAMx simulations using 36/12/4-km nested domains with available WRF met (NAM and ERA5) for selected period: May 15 to Jun 5
- Emissions and other inputs identical on all sensitivities.
- CAMx flexi-nesting used for 4 km domain emissions
- Tested two types of vertical diffusivities (Kv): CMAQ and YSU
- Total of four CAMx sensitivities:
  1. **NAM CMAQ**
  2. **NAM YSU**
  3. **ERA5 CMAQ**
  4. **ERA5 YSU**



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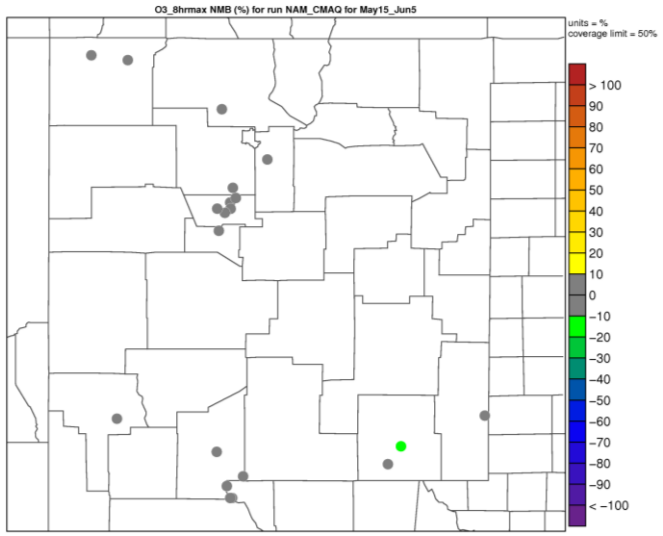
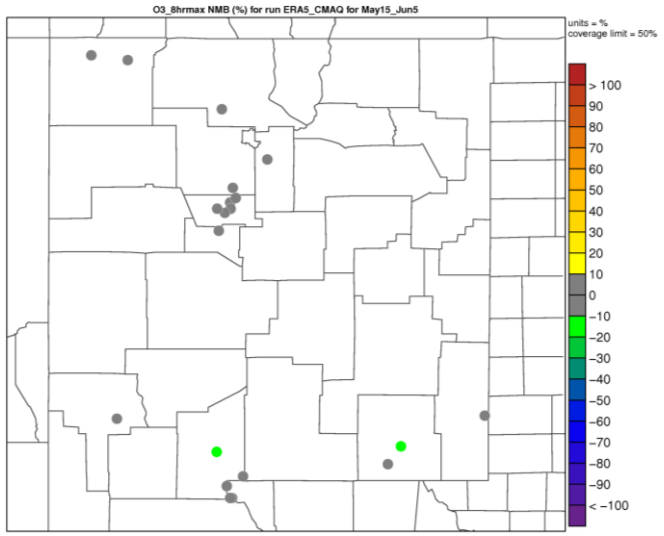
OZONE BIAS COMPARISON: NMB WITH 60 PPB CUT-OFF

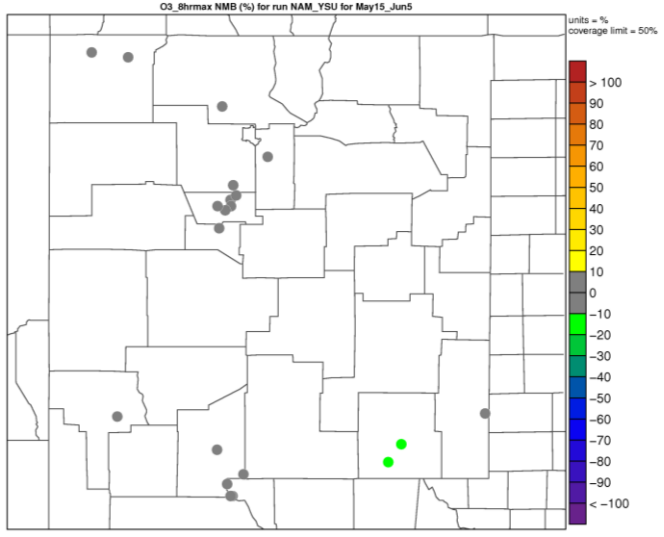
NAM CMAQ



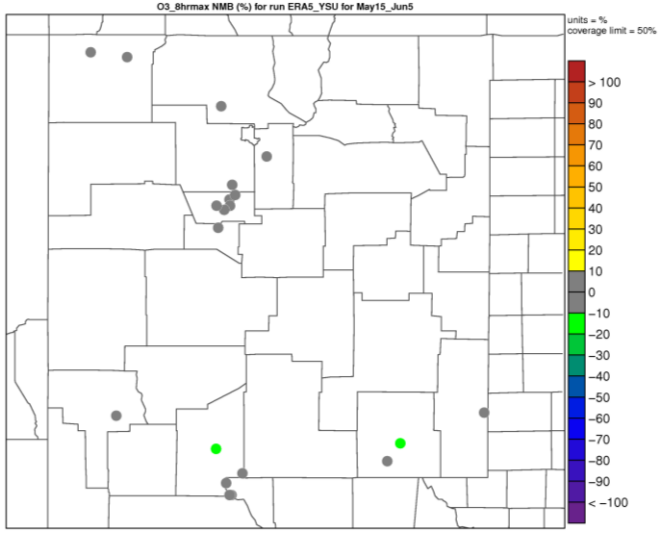
ERA5 CMAQ



NAM YSU



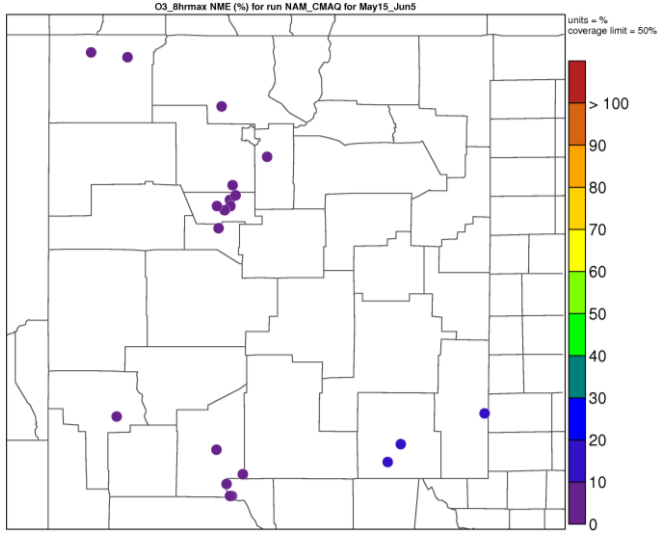
ERA5 YSU



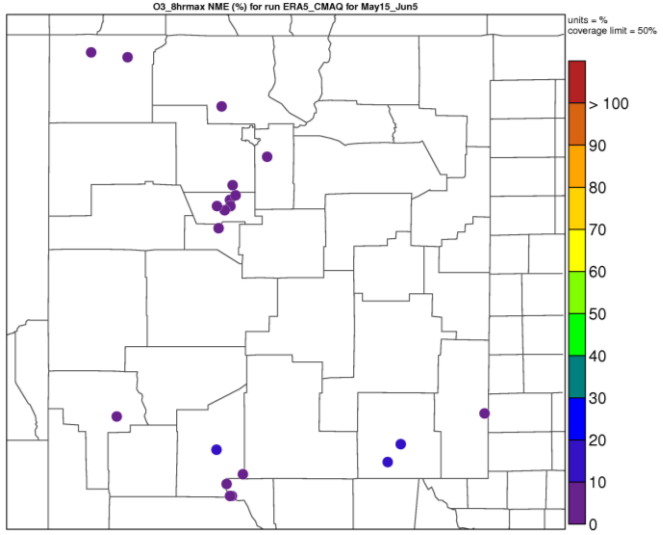
- NMB for all sensitivities generally within Performance Goal
  - Goal: NMB < ±5%
  - Criteria: NMB < ±15%
- Worst performance occurs in Southern portion of NM
- Based on NMB, NAM CMAQ is the configuration with best performance

OZONE ERROR COMPARISON: NME WITH 60 PPB CUT-OFF

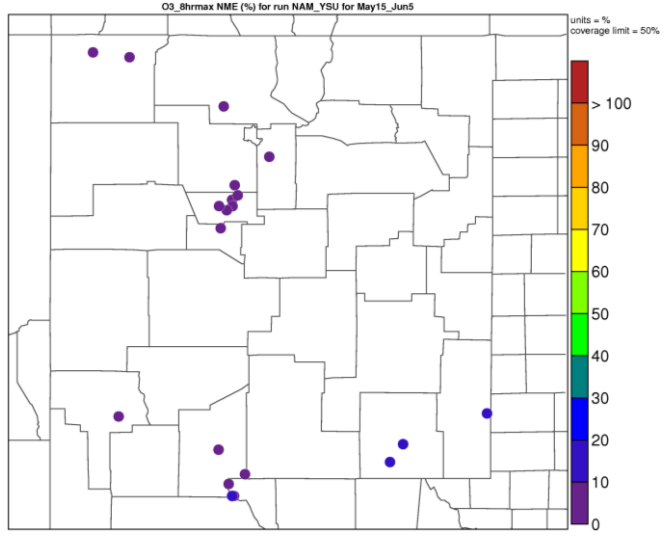
NAM CMAQ



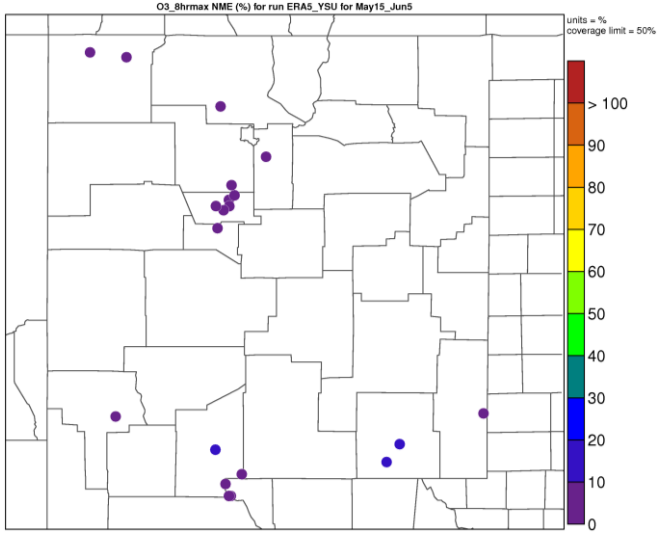
ERA5 CMAQ



NAM YSU

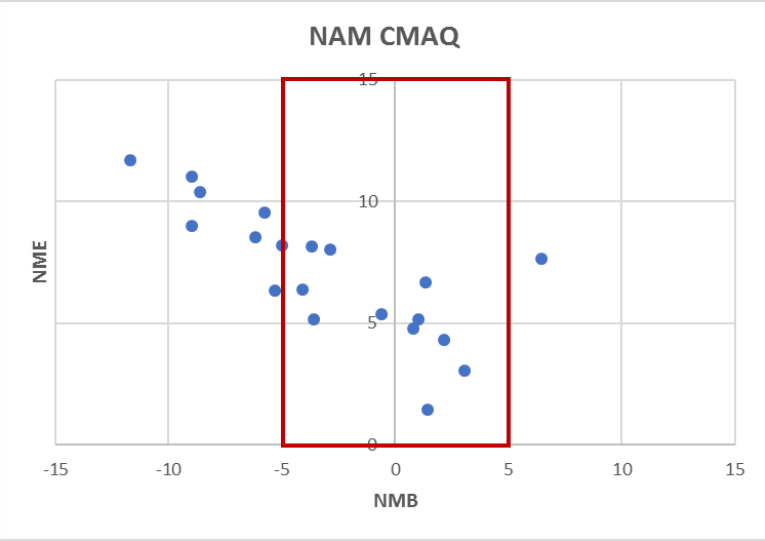


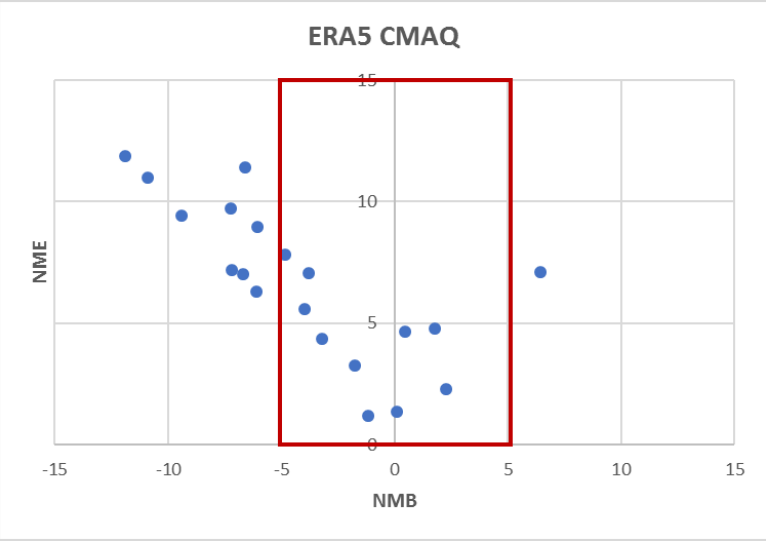
ERA5 YSU

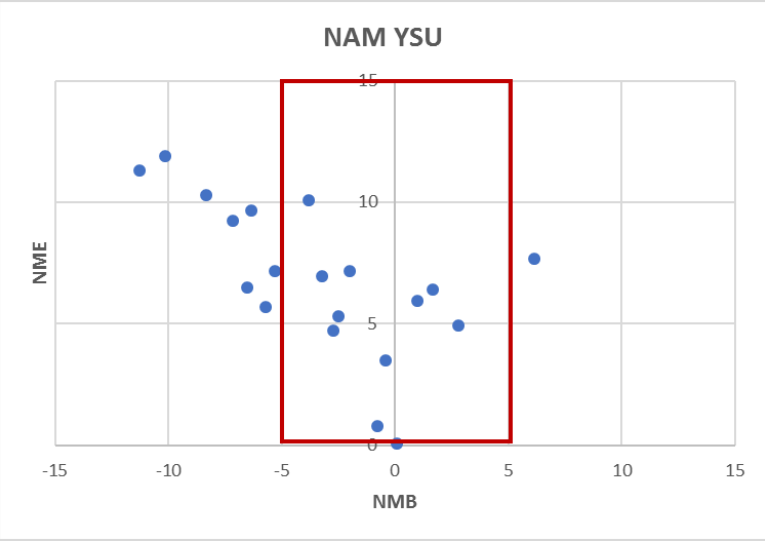


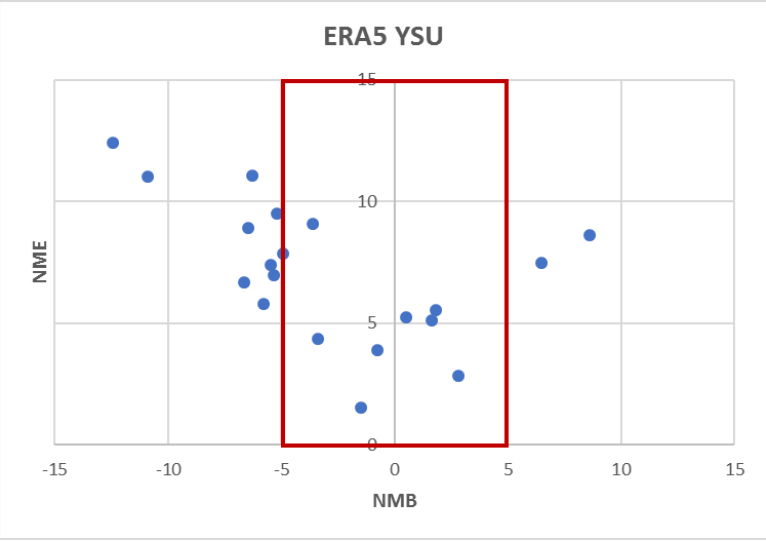
- NME for all sensitivities generally within Performance Goal
  - Goal: NME < 15%
  - Criteria: NMB < 25%
- Worst performance occurs in Southern portion of NM
- Based on NME, NAM meteorology is the best performing

SITE-SPECIFIC COMPARISON: SOCCER PLOTS 60 PPB CUT-OFF





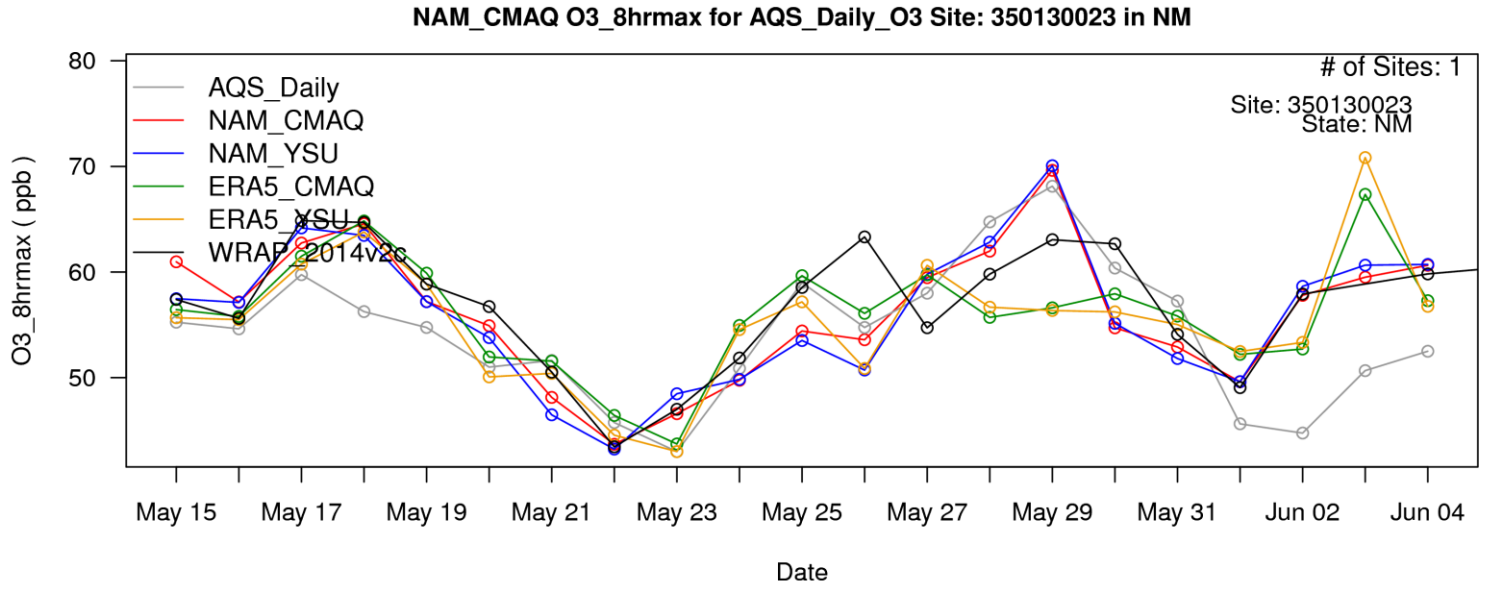


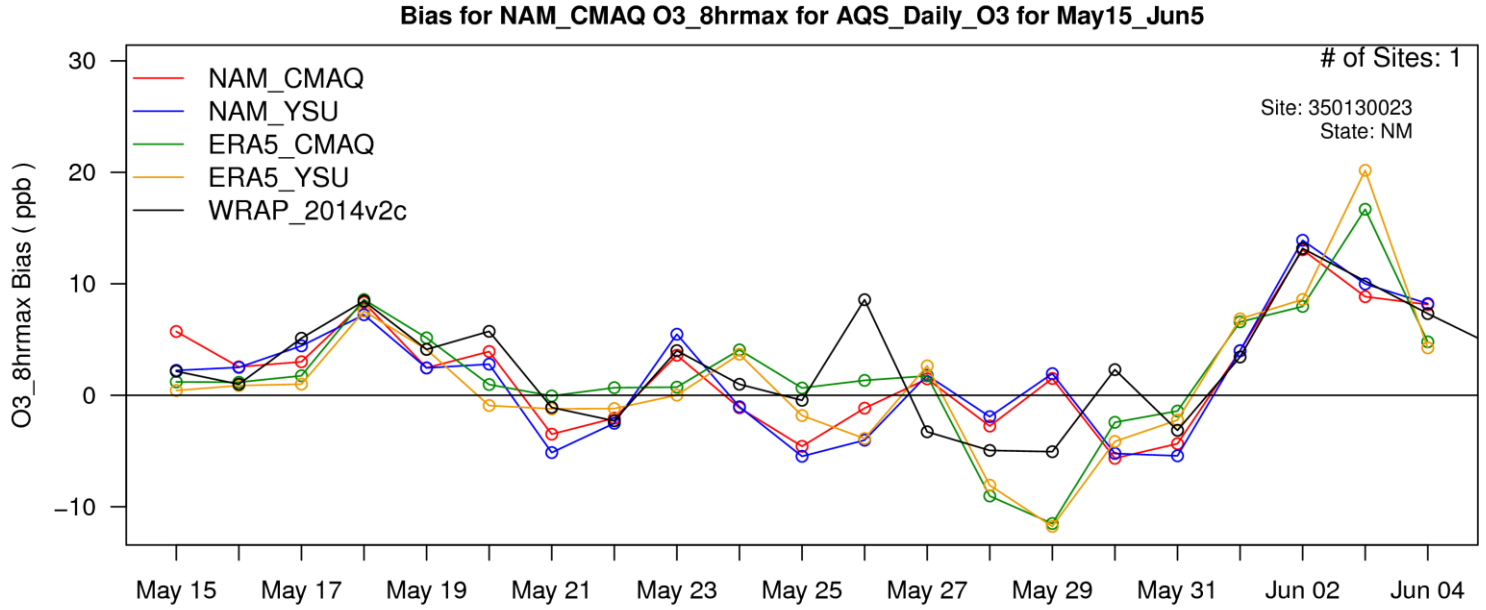


- With a 60 ppb cut-off all sensitivities show CAMx tends to underpredict ozone peaks
- Still all sensitivities within Performance Criteria
- NAM shows slightly better performance than ERA5
  - More sites achieve Performance Goals
- NAM CMAQ shows sites with smaller NME compared to NAM YSU

RAMBOLL

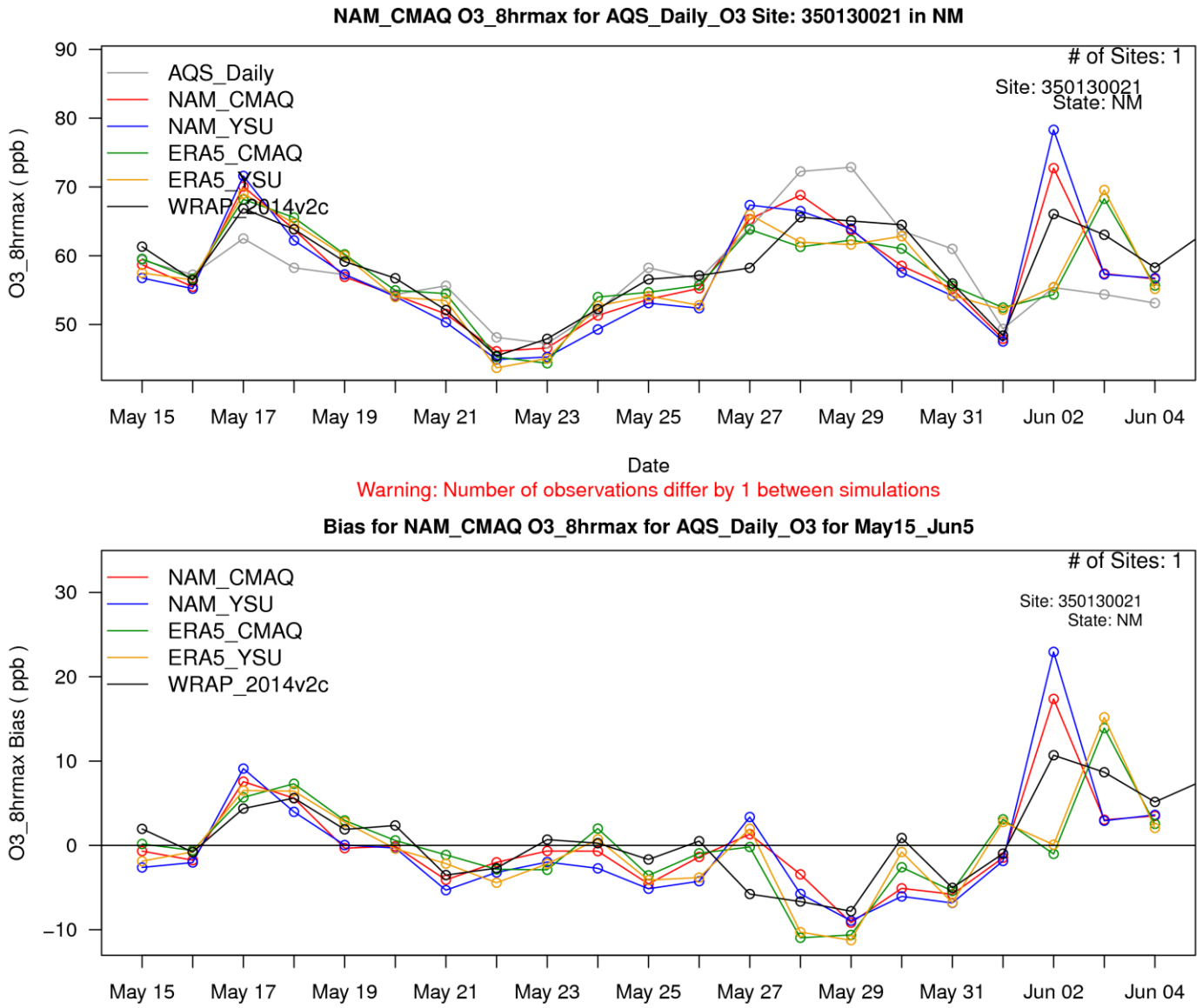
SELECTED SITES TIMESERIES: SOLANO RD (DONA ANA COUNTY)





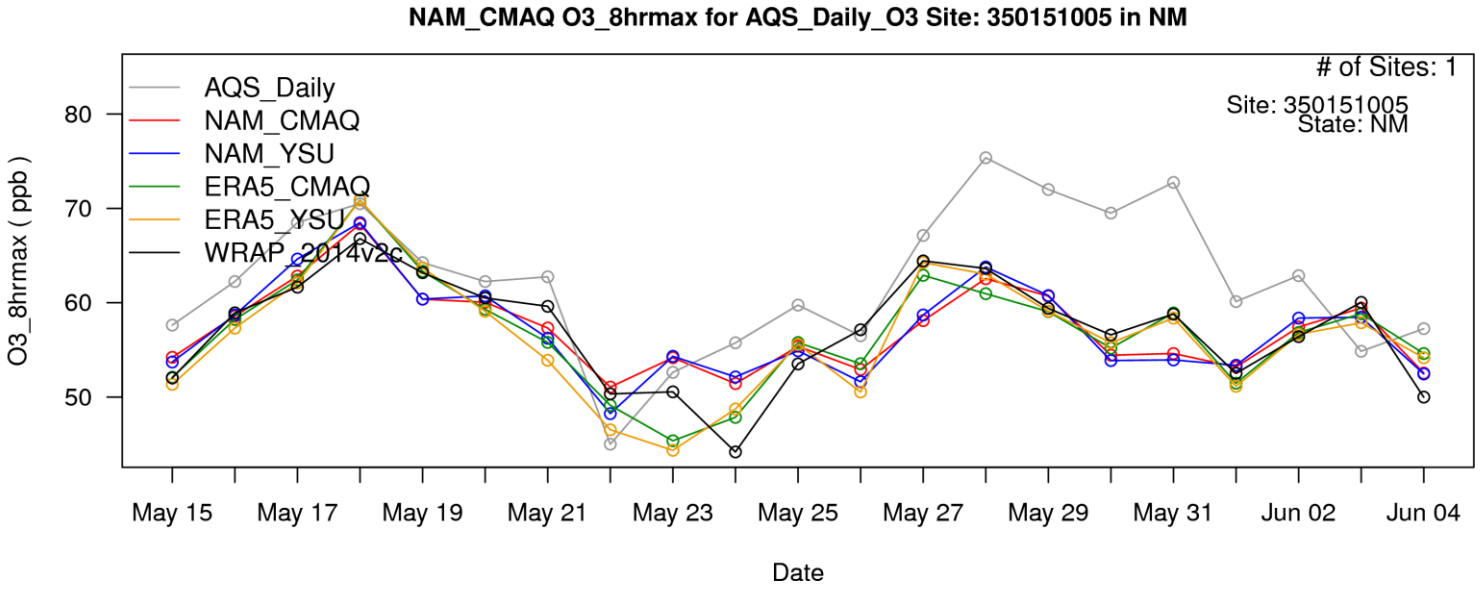
- NAM sensitivities better capture peak on May 29

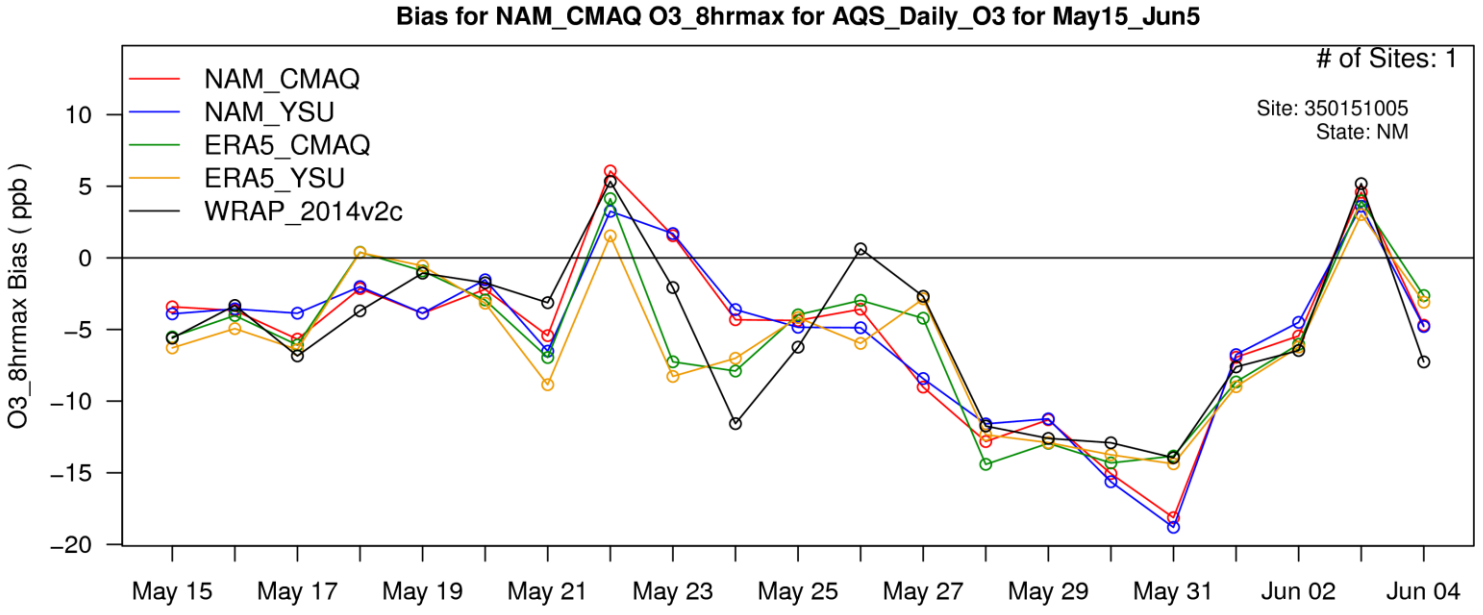
SELECTED SITES TIMESERIES: DESERT VIEW (DONA ANA COUNTY)



- Underestimate observed peaks May 28-29
- WRF/NAM better than other WRF

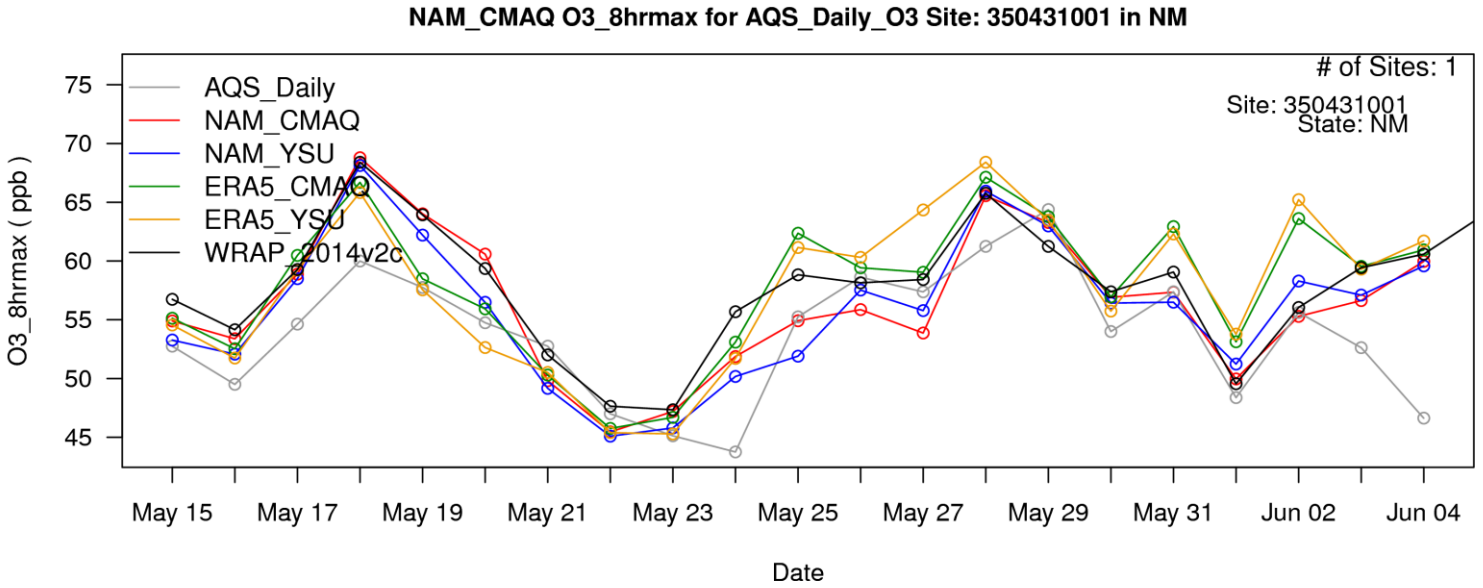
SELECTED SITES TIMESERIES: CARLSBAD (EDDY COUNTY)

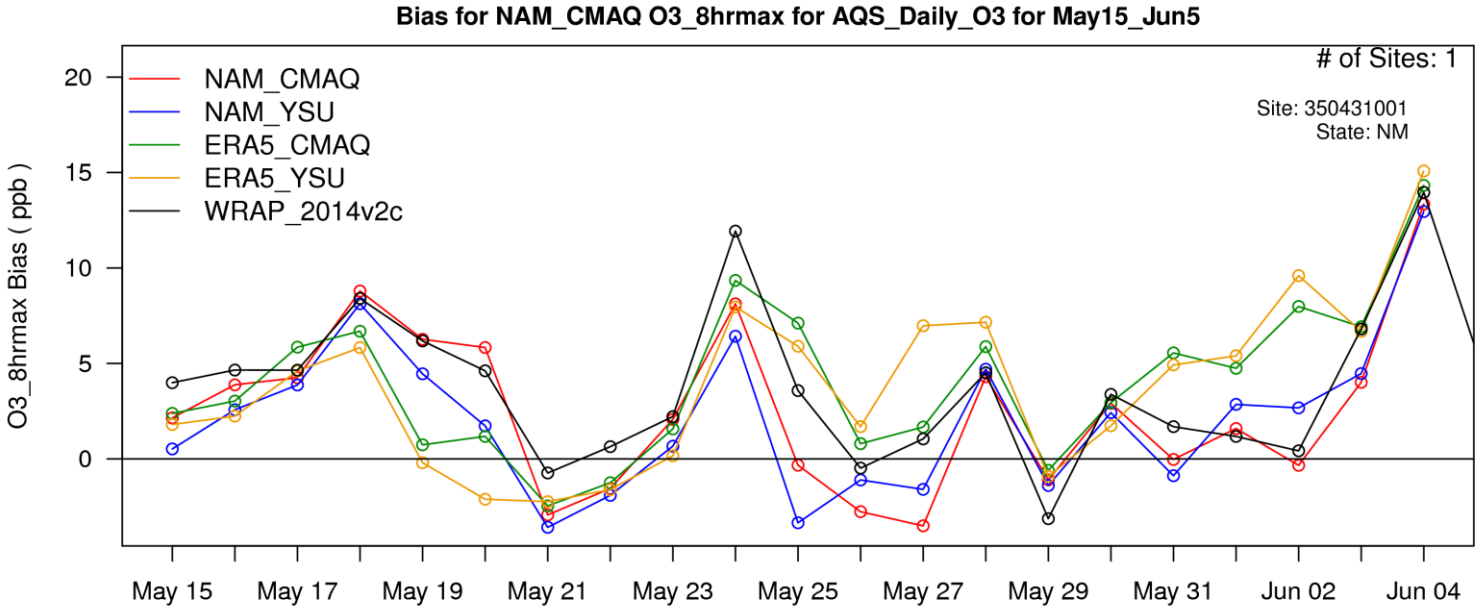




- All sensitivities miss high ozone on May 27 to May 31

SELECTED SITES TIMESERIES: SANDOVAL COUNTY





- All sensitivities get high ozone on May 29. NAM CMAQ has lower bias

CAMX SENSITIVITIES SUMMARY

- All sensitivities have NMB and NME values that are within Performance Criteria, most sites within Performance Goals
- Differences between all sensitivities are relatively small among each other
- NAM meteorology captures peak ozone concentrations better than ERA5
- Caveats:
  - WRF sensitivities run for May-Jun so they may not reflect the observed precipitations biases in WRF for Jun-Aug
  - WRF performance showed that precipitation biases could occur over NE NM where there are no ozone monitors, so performance is unknown there
- NAM with CMAQ Kv treatment selected to simulate 2014 base case based on slightly better performance on NMB

FINAL CAMX 2014 BASE CASE CONFIGURATION

- CAMx summer 2014 36/12/4-km meteorological inputs based on WRF simulation using NAM analysis fields processed with WRFCAMx with CMAQ Kv option
  - Same WRF/NAM configuration as used by WRAP-WAQS CAMx 2014 base case

Science Options	CAMx	Co
Model Codes	CAMx v7.0 (May 2020)	Latest version of C WRAP/WAQS 2014 Haze modeling
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. I
4-km grid	245 x 227 cells	New Mexico 4-km buffer cells
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 thickness 50 mb (~19 km)
Grid Interaction	36/12/4 km two-way nesting	
Initial Conditions	Start on May 1, 2014	First high ozone da
Boundary Conditions	WRAP 2014 GEOS-Chem	For 36US domain
Emissions		
Baseline Emissions Processing	SMOKE, SMOKE-MOVES2014, MEGAN	WRAP/WAQS 201 EPA 2023fh for fut
Sub-grid-scale Plumes	Plume-in-Grid for major NO_X sources in New Mexico	Keep same PiG sou 2023 emission yea
Chemistry		
Gas Phase Chemistry	CB6r4	Latest chemical rea rates with halogen et al., 2010)
Meteorological Processor	WRFCAMx	Compatible with CA
Horizontal Diffusion	Spatially varying	K-theory with Kh g
Vertical Diffusion	CMAQ-like Kv	Evaluate YSU Kv s
Diffusivity Lower Limit	Kv-min = 0.1 to 1.0 m^2/s in lowest 100 m	Depends on urban
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme	(Zhang et. al, 200
Wet Deposition	CAMx -specific formulation	rain/snow/graupel
Numerics		

CURRENT STATUS AND NEXT STEPS

CURRENT STATUS/NEXT STEPS

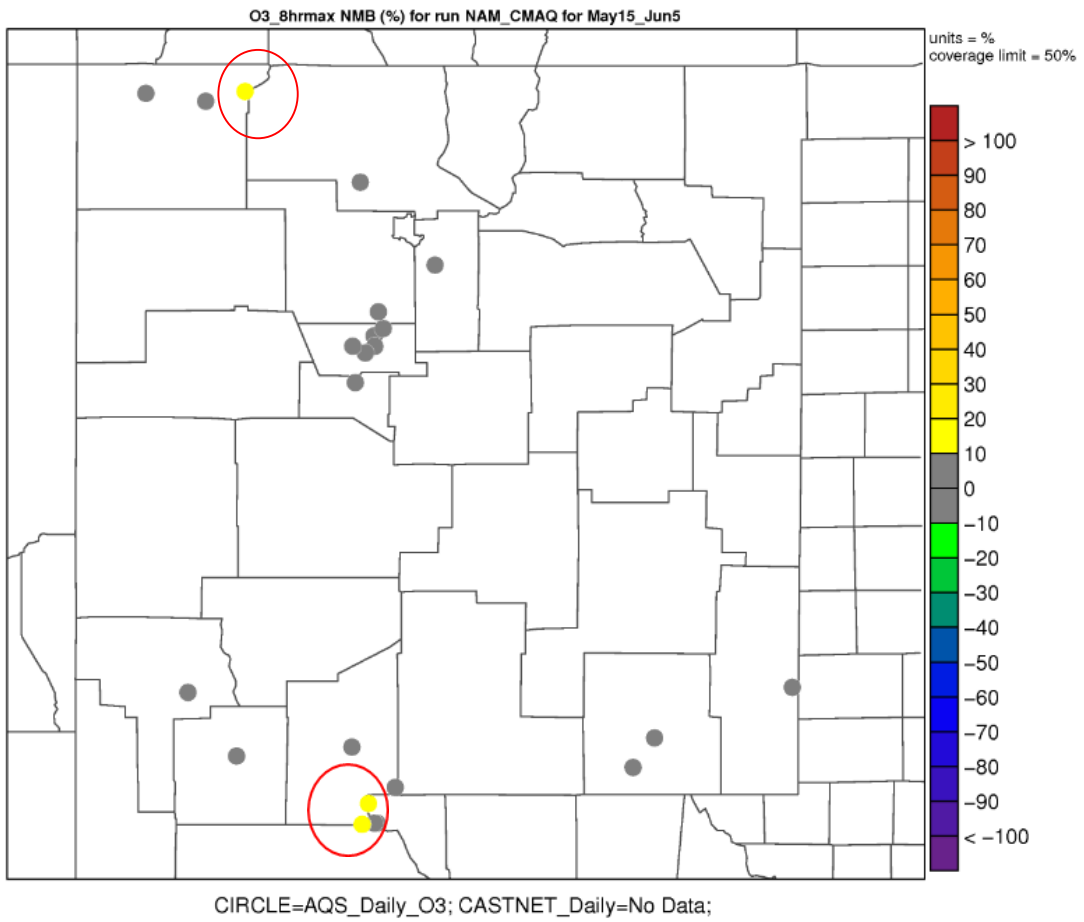
- CAMx Summer 2014 36/12/4-km base case simulation in August 2020
  - Model Performance Evaluation
  - Task 5 2014 Base Case and MPE Report
- 2023 SMOKE Emissions Processing in August

Webinar Number	Webinar Topics by Task	Date	Status
1.	1. Modeling Protocol and Work Plan 2.1 Evaluate Existing Met 4.1 Recommend 2014 and 2023 Emissions 4.2.1 Recommend 2014 & 2023 Mobile Source Emissions	May 2020	• Done • Done • Done • Done
2.	2.2 Additional Met Modeling 3.1 Evaluate BC Data 4.1 Summary of 2014 and 2023 Emissions	Jun 2020	• Done • Done • Done
3.	4.2.1 Summary of 2014 and 2023 Mobile Source Emissions 4.3 2014 Natural Emissions Results (e.g., Biogenic & LNOx)	Jul 2020	• Done • In Progress
4.	4.2.3 2014 & 2023 SMOKE-MOVES Results 4-km NM Domain 4.4 2014 & 2023 SMOKE Emissions Modeling Results	Aug 2020	• Partly Done • Partly Done
5.	4.5 FY Emissions Strategy Results 5. 2014 CAMx Base Case Modeling and MPE	Sep 2020	
6.	6.1 2023 CAMx Modeling Results 6.2 2023 Ozone Design Value Projections	Oct 2020	
7.	6.3 2023 Control Strategy Results 6.4 2023 Source Apportionment Modeling Results	Nov 2020	

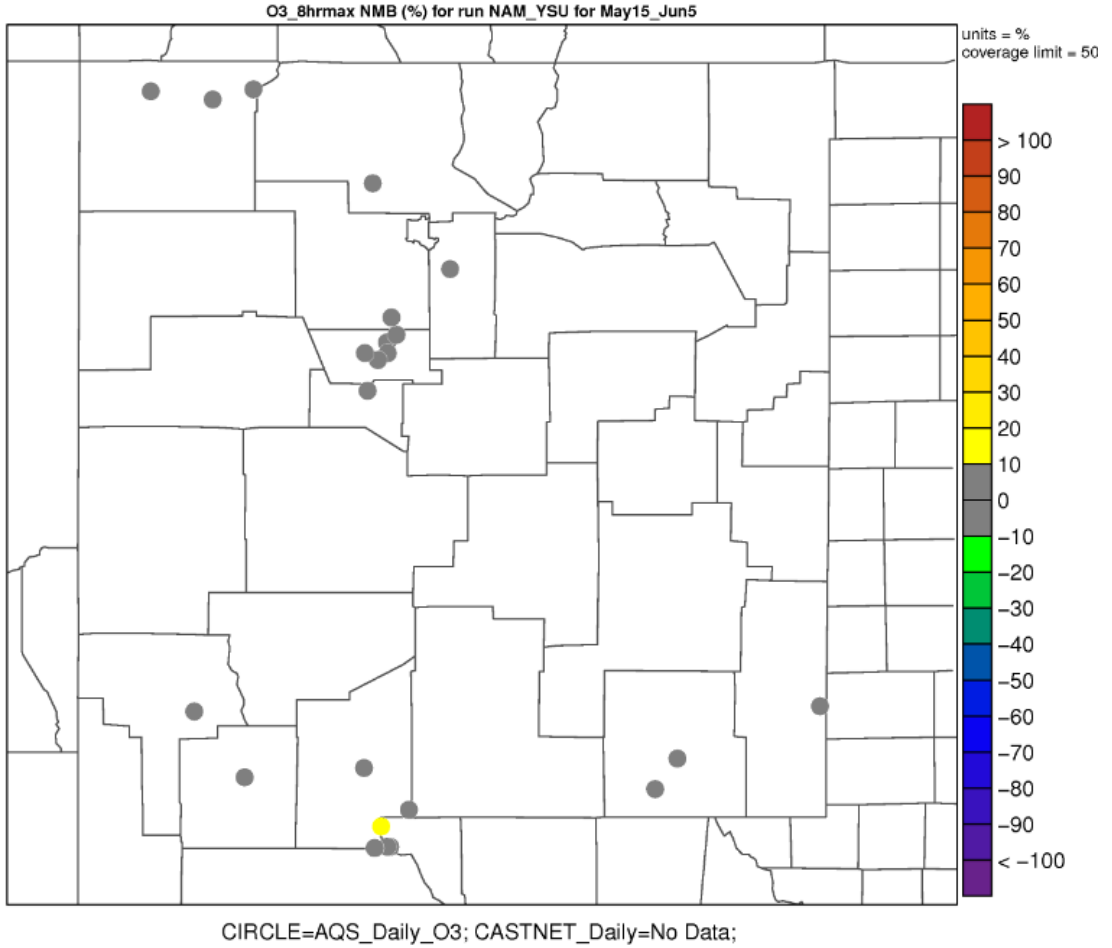
RAMBOLL

ADDITIONAL SLIDES

NAM_CMAQ with no 60ppb cut-off

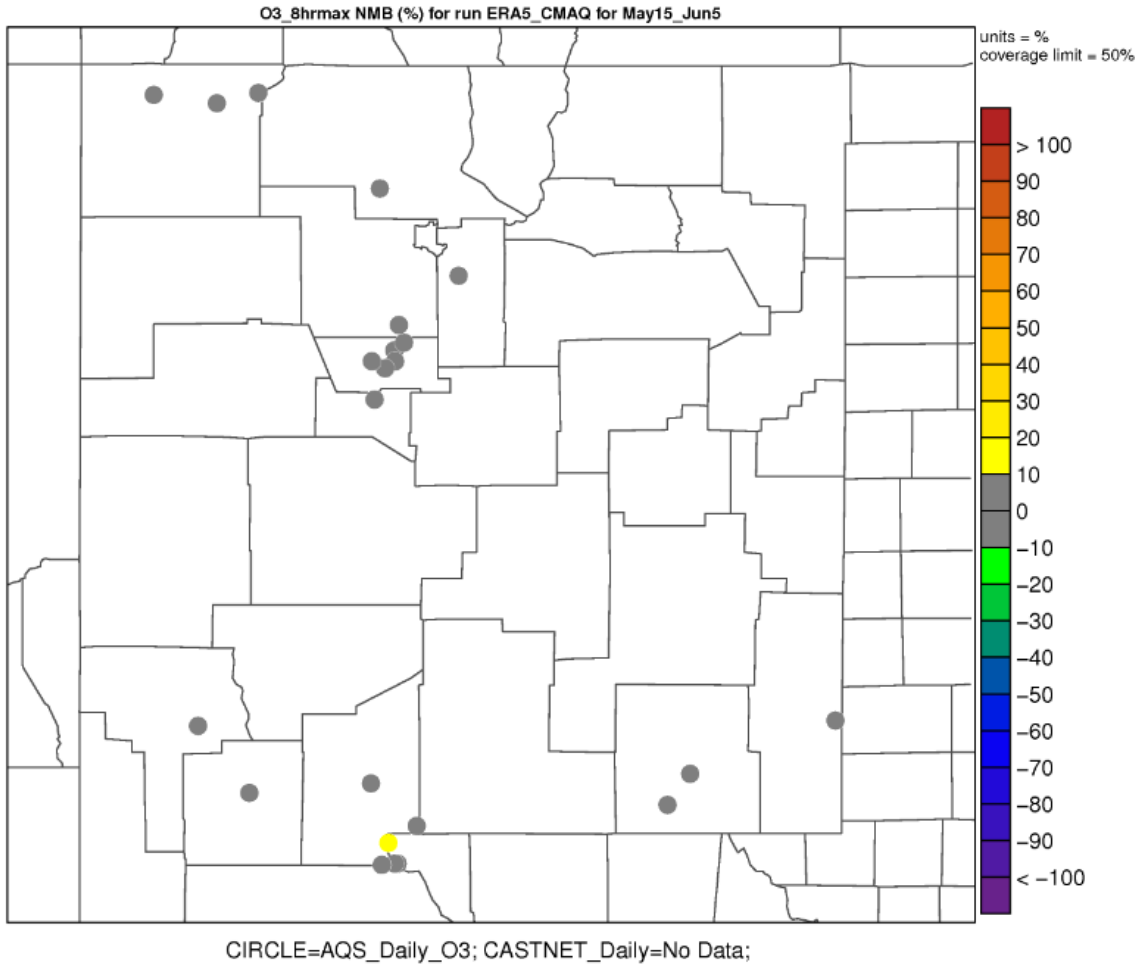


NAM_YSU with no 60ppb cut-off

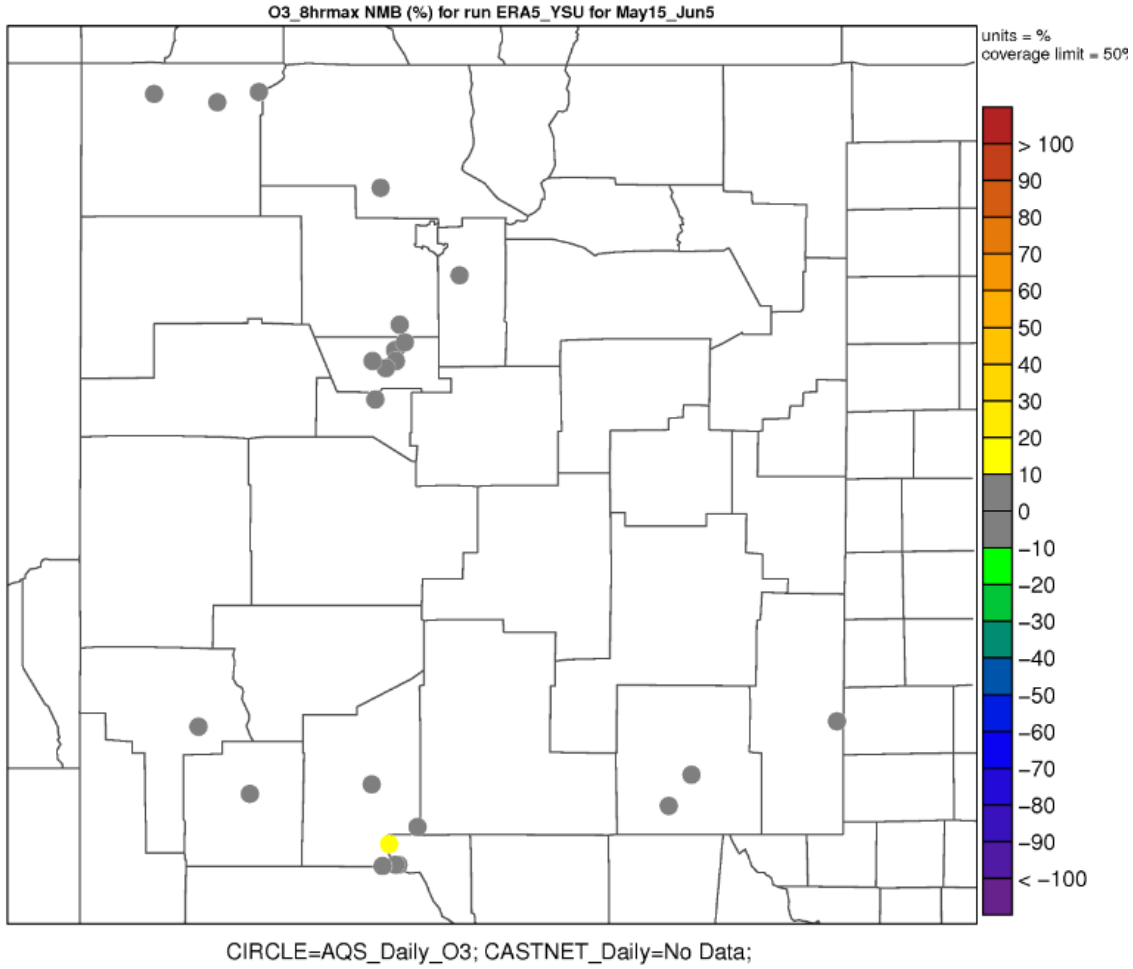


RAMBOLL

ERA5_CMAQ with no 60ppb cut-off



ERA5_YSU with no 60ppb cut-off



RAMBOLL