New Mexico OAI Study Photochemical Modeling – 1st Monthly Webinar May 2020

WESTAR and Ramboll

May 28, 2020

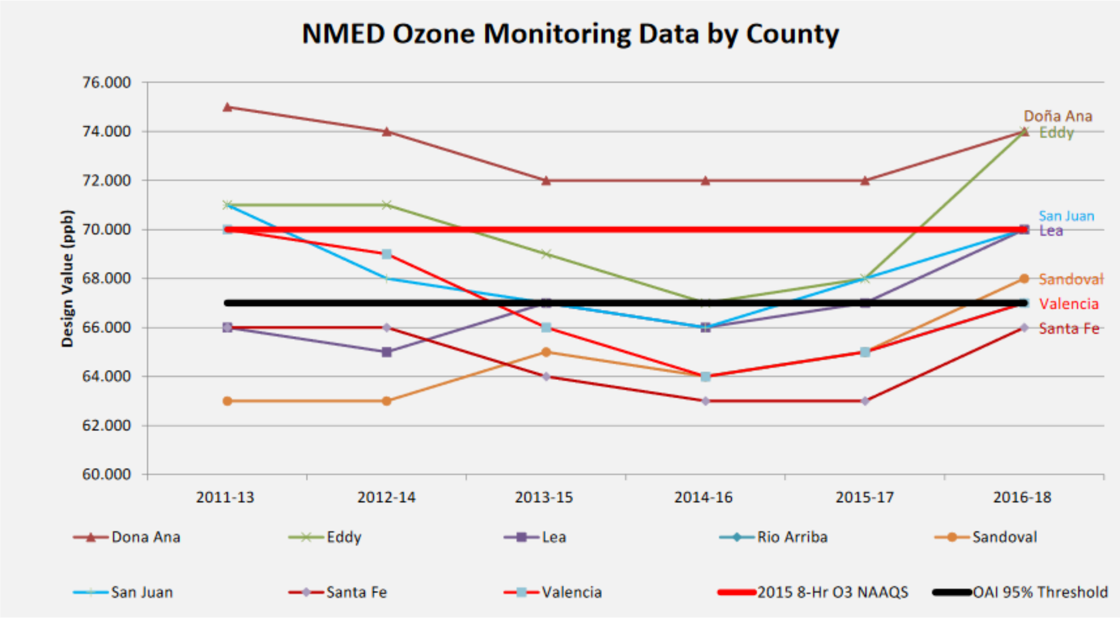
RAMBOLL Bright ideas. Sustainable change.

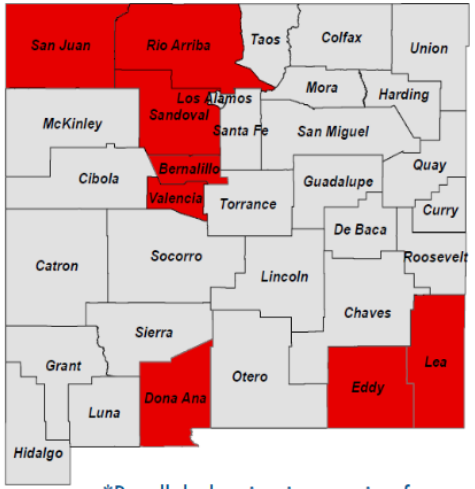
Content

- Introduction
- Work Plan
- Evaluation of Existing 2014 WRF and Proposed NM OAI Study WRF Configuration
- Evaluation of 2014 Boundary Conditions (BCs) from WRAP 2014 GEOS-Chem
- Modeling Protocol Overview
- 2014 and 2023 Emissions for New Mexico
- 2014 and 2023 Mobile Source Assumptions and Activity Data for New Mexico
- Next Steps

Introduction

- New Mexico Air Quality Control Act (NMAQCA) requires the NMED to develop a plan to address elevated ozone levels when air quality is within 95% of the ozone NAAQS (74-3-5.3, NMSA 1978)
- There are 8 counties in New Mexico with measured ozone concentrations within 95% of the 70 ppb 2015 ozone NAAQS
- NMED contracted with WESTAR/Ramboll to conduct 2014 and 2023 photochemical modeling to assess the contributions of sources to and effects of control measures on ozone concentrations





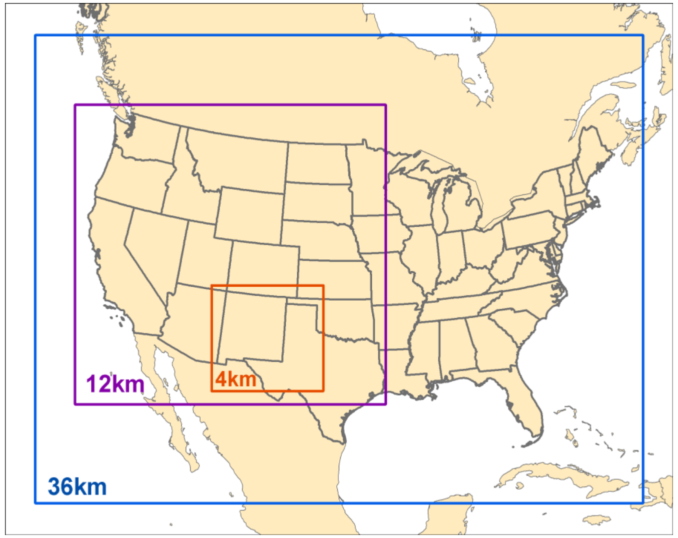
*Parallel planning is occurring for Bernalillo County through the Albuquerque/Bernalillo County Department of Environmental Health

- Counties within 95% of the standard:
  - San Juan (Navajo Lake, 70 ppb)
  - Doña Ana (several monitors, 74 ppb)
  - Eddy (Carlsbad, 74 ppb)
  - Lea (Hobbs, 70 ppb)
  - Rio Arriba (Coyote, 67 ppb)
  - Sandoval (Bernalillo, 68 ppb)
  - Valencia (Los Lunas, 67 ppb)

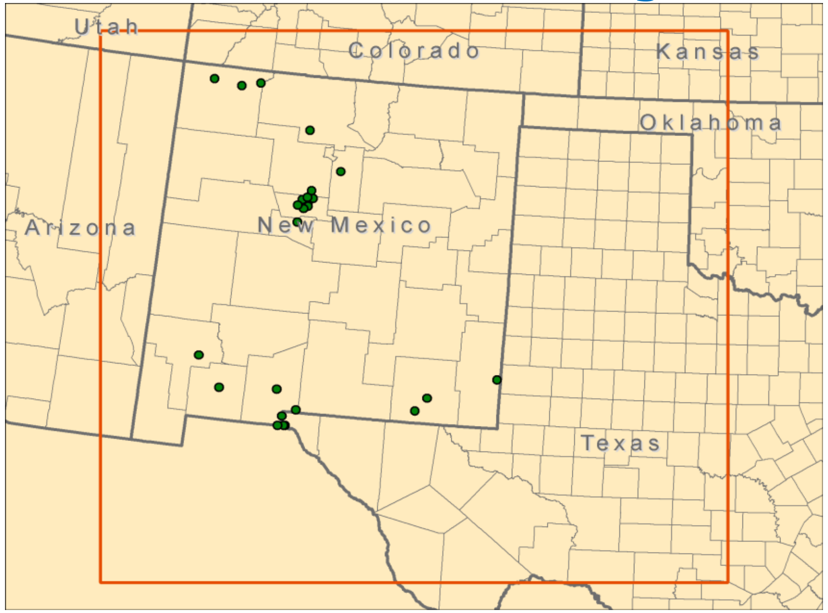
Work Plan (1 of 2)

- Task 1: Development Modeling Protocol/QAPP and Work Plan
  - Modeling Plan provides a roadmap on how the study will be carried, including episode, domain and model selection and current and future year modeling approaches

36/12/4-km Domain Structure



New Mexico 4-km Modeling Domain



- Task 2: WRF Meteorological Modeling
  - Develop CAMx meteorological inputs for May-Aug 2014 and 36/12/4-km domains
- Task 3: Evaluate Boundary Condition Inputs
  - Based on WRAP 2014 GEOS-Chem global chemistry model

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Work Plan (2 of 2)

- Task 4: 2014 and 2023 Emissions Development
  - Sources of 2014 and 2023 Emissions
  - Mobile Source Emissions
  - Natural Emissions
  - SMOKE Emissions Modeling
  - 2023 Emission Control Measures
- Task 5: CAMx 2014 Base Case Modeling
  - Model Performance Evaluation
  - Formal 2016 Base Case Modeling and MPE Report on Tasks 2-5
- Task 6: 2023 Future Year CAMx Modeling
  - 2023 Base Case and Future Year Ozone Design Value Projections
  - 2023 Ozone Source Apportionment Modeling
  - 2023 Control Measure Evaluation
- Task 7: Air Quality Technical Support Document (AQTSD)
  - Prepare formal AQTSD documenting the study
  - Transfer Modeling Databases and Results to Intermountain West Data Warehouse (IWDW)
  - Maintain NM OAI Study Webpage on WRAP website throughout the study

Current Schedule

Task	Deliverable	Date
1. Formal Modeling Protocol/QAPP and Work Plan		
	Kick-Off Conference Call	Apr 2020
	Draft Modeling Protocol/QAPP and Work Plan	May 2020
	PPT on final approach and project plan	May 2020
	Final Modeling Protocol/QAPP and Work Plan	May2020
	Response-to-Comments (RTC) Document	May 2020
2. Base Year Meteorological Modeling (Met)		
2.1 Evaluate Met Model	*PPT on 2014 WAQS and EPA WRF*	May 2020
2.2 Additional Met Model	*PPT on New WRF 4-km MPE in New Mexico*	Jun 2020
2.3 Process Met Data	PGM summer 2014 36/12/4-km met inputs	Jun 2020
3. Boundary Conditions (BC)		
3.1 Evaluate BC Data	*PPT on WRAP 2014 GEOS-Chem BCs*	Jun 2020
4. Base Year (2014) and Future Year (2023) Emissions		
4.1 2014 and 2023 Emissions for 4-km New Mexico Domain	*PPT on sources of 2014 and 2023 New Mexico EI*	May 2020
	PPT and tile plots/excel spreadsheets for 2014 and 2023 emissions in the 4-km NM domain	Jun 2020
4.2 Mobile Sources		
4.2.1 Evaluate Mobile EI	*PPT on options for 2014/2023 mobile sources*	Jun 2020
	PPT on final 2014/2023 mobile source EI	Jun 2020
4.2.3 Prepare Mobile Source Emission Inputs	*PPT on 2014/2023 SMOKE-MOVES*	Aug 2020
	Model-ready 2014/2023 mobile source inputs	Aug 2020
4.3 Biogenic/Natural Emissions	*PPT on biogenic and natural emission modeling*	Jul 2020
	Model-ready 2014 natural emissions inputs	Jul 2020
4.4 SMOKE Modeling	*PPT on 2014/2023 SMOKE modeling*	Aug 2020
	Model-ready 2014/2023 anthropogenic EI inputs	Aug 2020
4.5 FY Emissions Strategies	*PPT on FY 2023 SMOKE control/strategies*	Aug 2020
	Summary tables/plots for 2023 scenarios	Aug 2020

5. 2014 Base Year (2014) Air Quality Modeling		
	Webinar PPT on final 2014 base case and MPE	Sep 2020
	Draft report on Tasks 2-5, 2014 Base and MPE	Sep 2020
	Final report on Tasks 2-5, 2014 Base and MPE	Oct 2020
	RtC on 2014 base case and MPE report	Oct 2020
6. Future Year (2023) Air Quality Modeling		
6.1 FY PGM Modeling	*PPT on 2023 PGM Modeling*	Oct 2020
	Difference plots of FY-BY Ozone Concentrations	Oct 2020
6.2 Attainment Test	*PPT on 2023 ozone DV projections*	Oct 2020
	PPT on FY Source Apportionment Modeling	Nov 2020

Current Webinar Schedule and Content

Webinar No.	Webinar Topics by Task	Date
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
2.	2.2 Additional Met Modeling 3.1 Evaluate BC Data 4.1 Summary of 2014 and 2023 Emissions	Jun 2020
3.	4.2.1 Summary of 2014 and 2023 Mobile Source Emissions 4.3 2014 Natural Emissions Results (e.g., Biogenic, LNOx)	Jul 2020
4.	4.2.3 2014/2023 SMOKE-MOVES for 4-km NM Domain 4.4 2014 & 2023 SMOKE Emissions Modeling Results	Aug 2020
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

Subtask 2.1: Evaluate Existing 2014 Meteorology and Define NM OAI Study WRF 2014 36/12/4-km Model Configuration

NM OAI vs WAQS vs EPA WRF Configurations

WRF Option	Proposed NM OAI	2014 WAQS	2014/2015 EPA
Vertical Coordinate	hybrid	eta	eta
Domains run	36/12/4-km	36/12/4-km	12-km
Microphysics	Thompson	Thompson	Morrison 2
LW Radiation	RRTMG	RRTMG	RRTMG
SW Radiation	RRTMG	RRTMG	RRTMG
LSM	Noah	Noah	Pleim-Xiu
PBL scheme	YSU	YSU	ACM2
Sfc Layer Physics	MM5 similarity	MM5 similarity	MM5 similarity
Cumulus	36/12/4-km Multi-scale Kain Fritsch	36/12-km Multi-scale Kain Fritsch	Kain-Fritsch
BC, IC Analysis Nudging Source	12-km NAM/ERA5	12-km NAM	12-km NAM
Analysis Nudging Grids	36/12-km	36/12-km	12-km
Obs Nudging	None	4-km	None
Sea Sfc Temp	FNMOC	FNMOC	FNMOC

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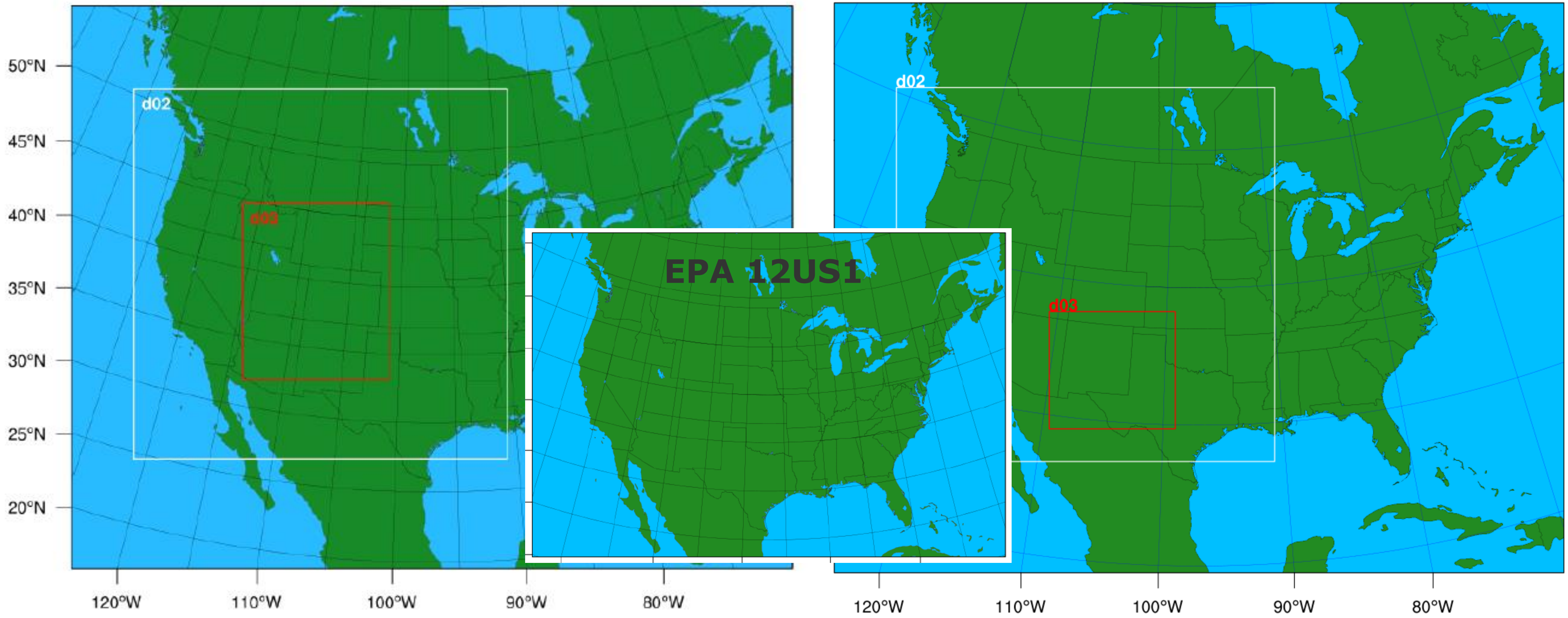
NM OAI vs WAQS vs EPA WRF Domains

WAQS 36/12/4 km

NM OAI 36/12/4 km



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EPA vs WAQS WRF MPE Approach

- Evaluate EPA 12US1 and WAQS 12WUS2 for April-August 2014
  - For both EPA and WAQS, include observation sites within New Mexico only
- Quantitative Evaluation
  - METSTAT – model/obs pairing, bias/error statistics against NCAR ds3505 observations
    - Soccer plots – monthly stats
    - Time series – hourly and daily
    - Plots for all sites in NM, and each individual site within NM
- Qualitative Evaluation
  - PRISM precipitation spatial maps
    - Monthly and daily

WRF Statistical Benchmarks

Meteorological Variable	Simple Conditions		Complex Conditions	
	Bias	Error	Bias	Error
Temperature	< ±0.5 °C	< 2.0 °C	< ±2.0 °C	< 2.5 °C
Wind Speed	< ±0.5 m/s	< 2.0 m/s (RMSE)	< ±1.5 m/s	< 2.5 m/s (RMSE)
Wind Direction	< ±10 degrees	< 30 degrees	< ±10 degrees	< 50 degrees
Humidity	< ±0.8 g/kg	< 2.0 g/kg	< ±1.0 g/kg	< 2.0 g/kg

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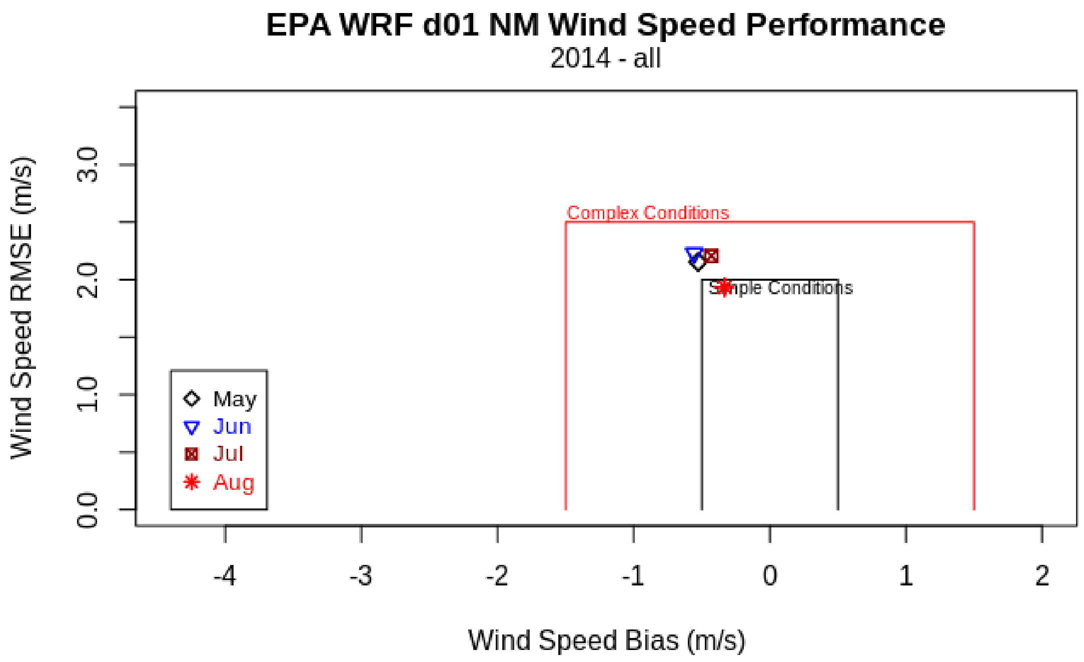
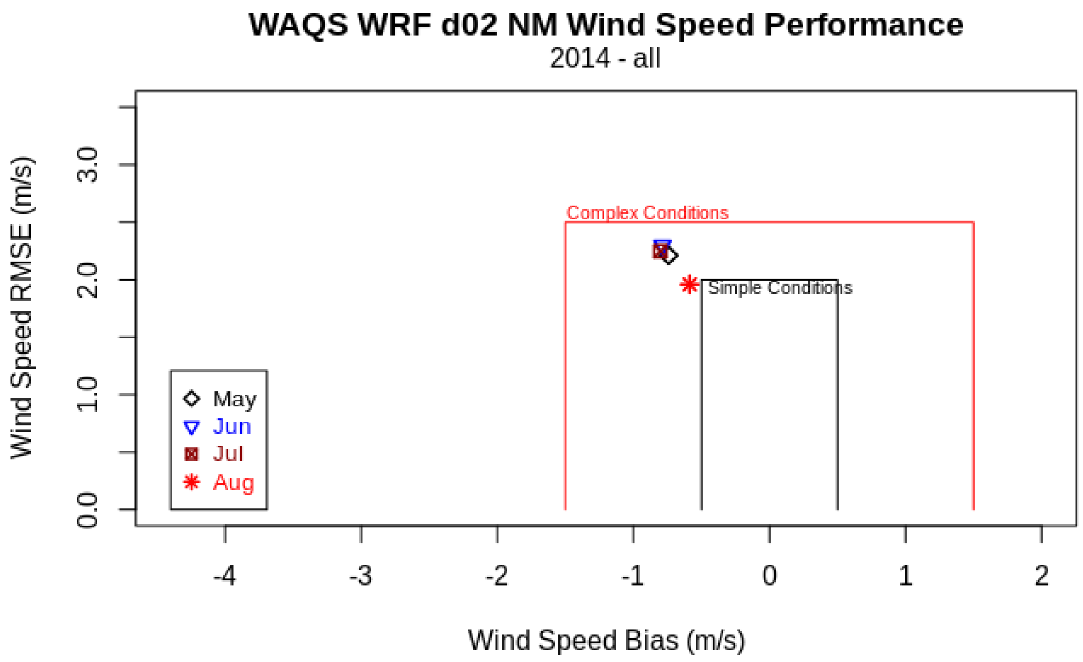
Soccer Plots – Wind Speed for all NM sites

EPA 12 km



WAQS 12 km



All months within complex conditions goal for both runs

Both runs have underprediction bias for all months; EPA slightly better

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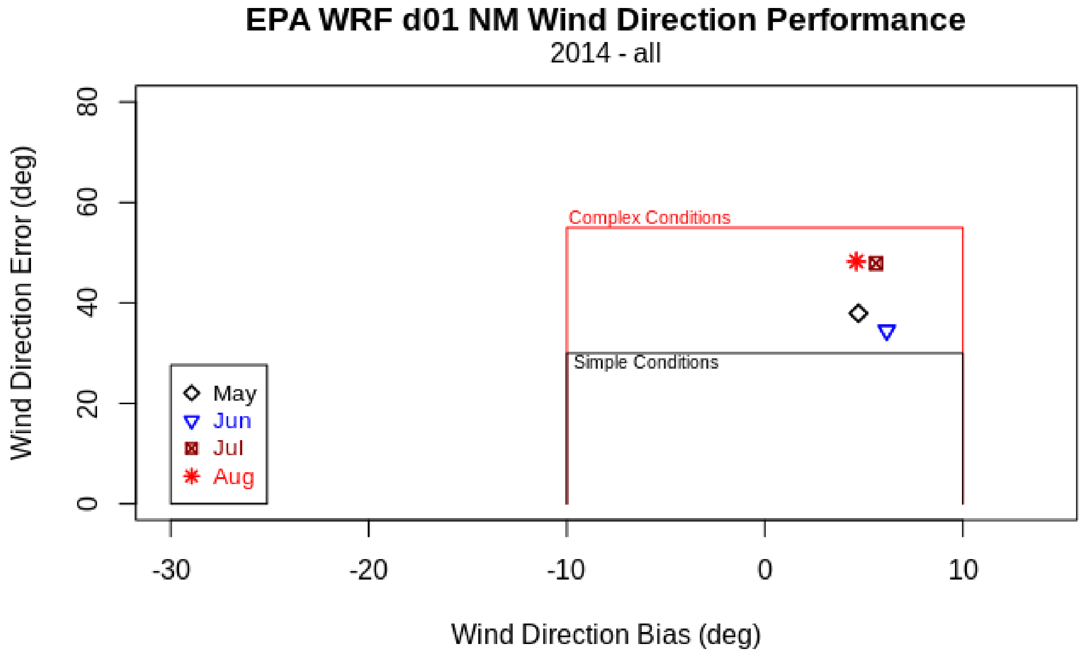
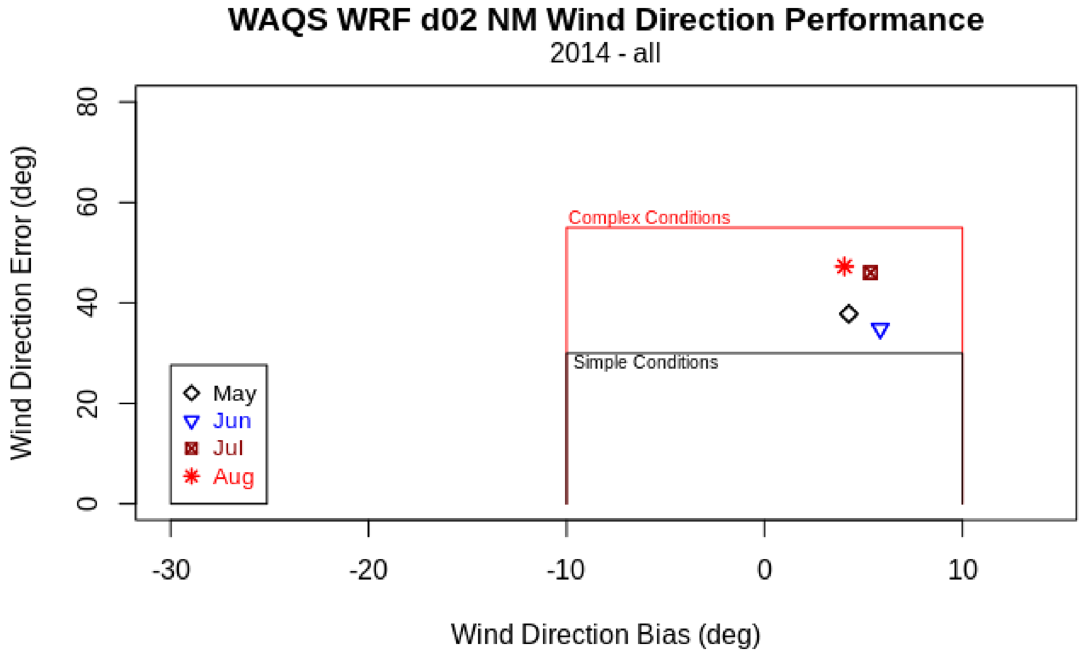
Soccer Plots – Wind Direction for all NM sites

EPA 12 km



WAQS 12 km



WAQS and EPA performance nearly identical

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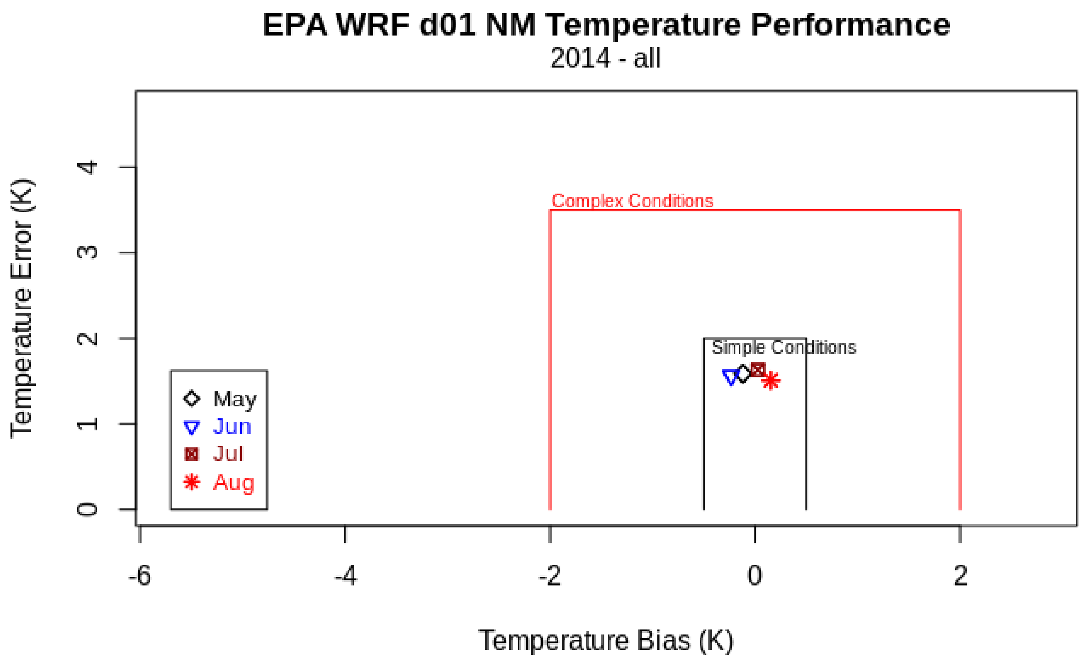
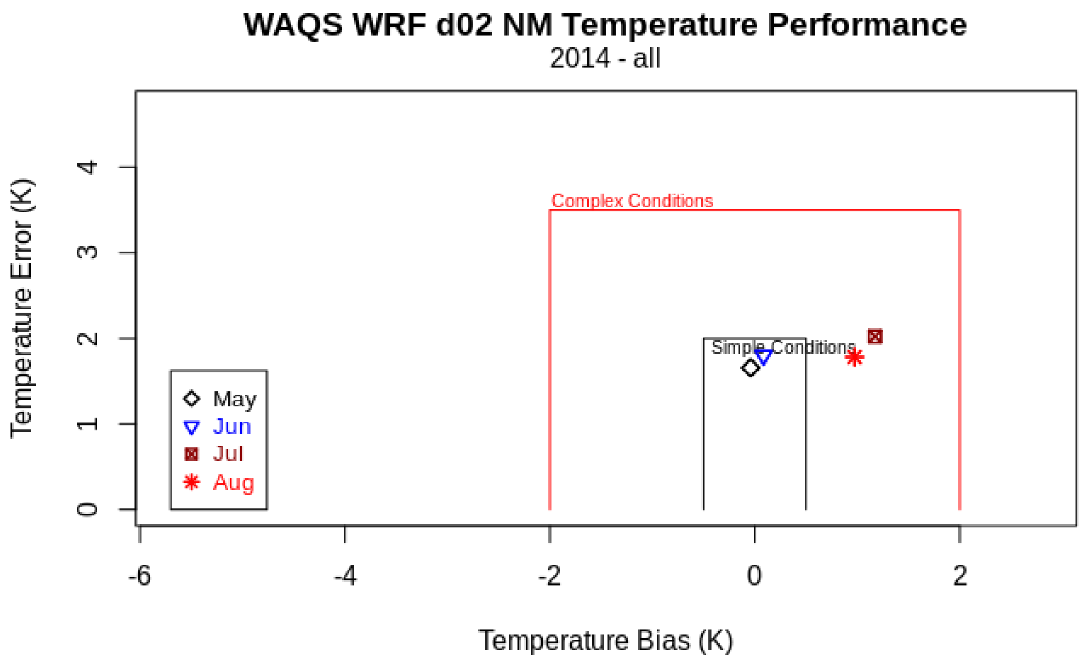
Soccer Plots – Temperature for all NM sites

EPA 12 km



WAQS 12 km

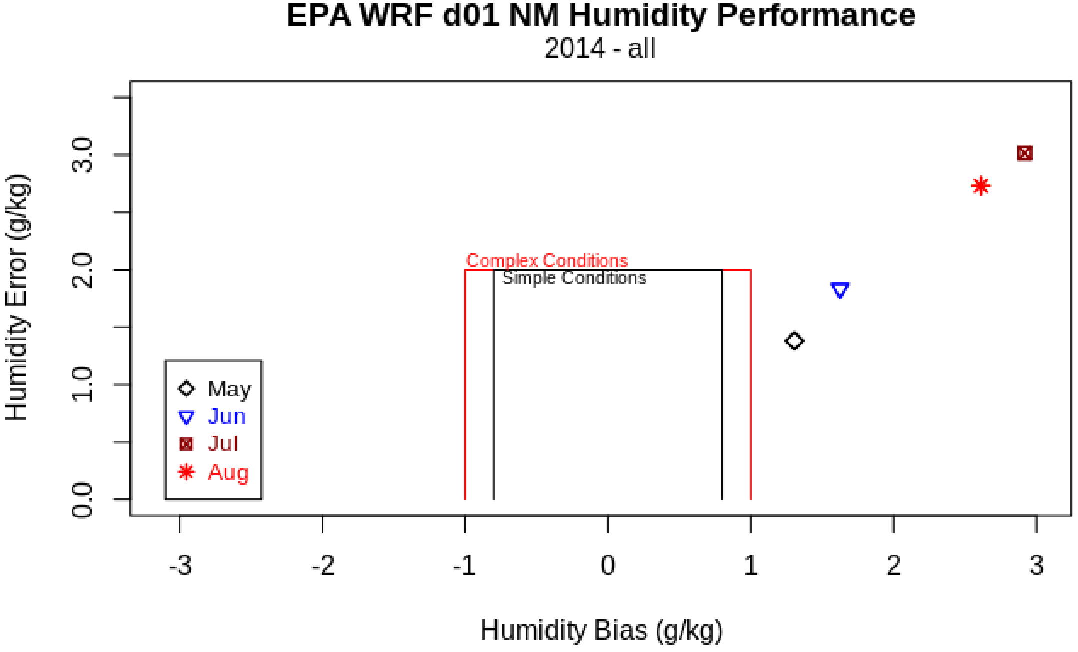


EPA run outperforms WAQS

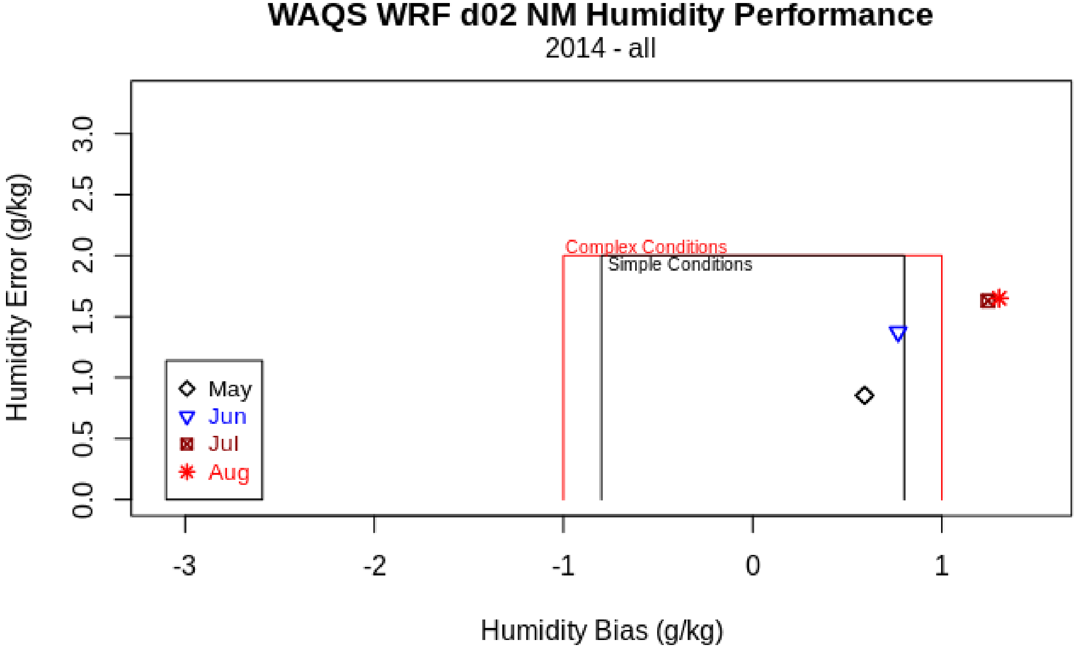
WAQS temperature poorest for Jul-Aug with warm bias

Soccer Plots – Humidity for all NM sites

EPA 12 km



WAQS 12 km

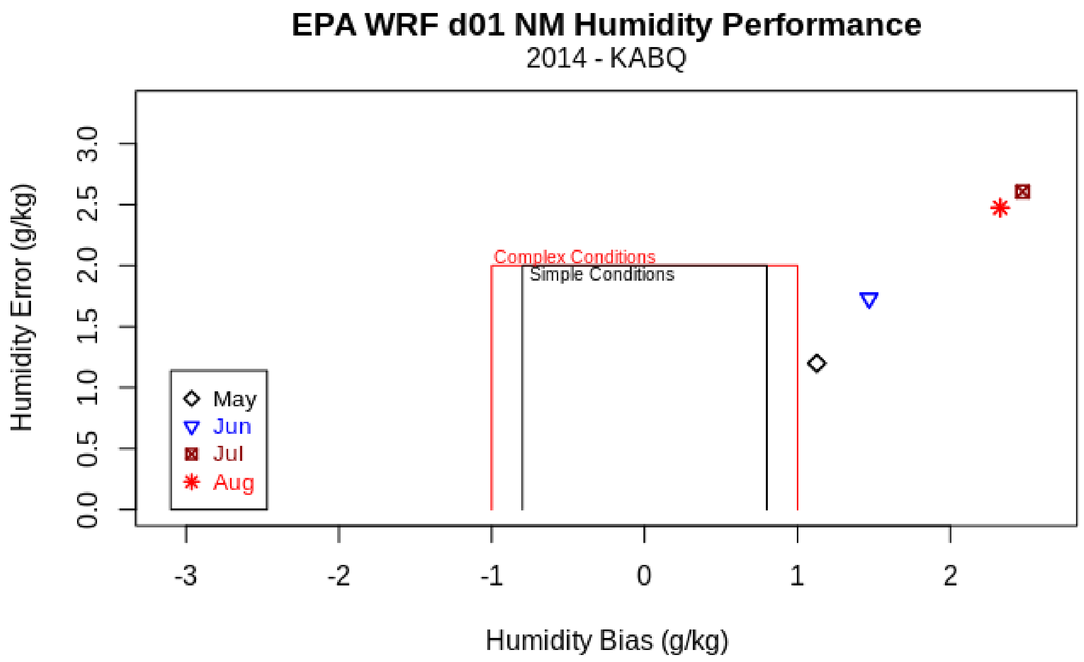


WAQS run outperforms EPA; both runs have positive (wet) bias for all months

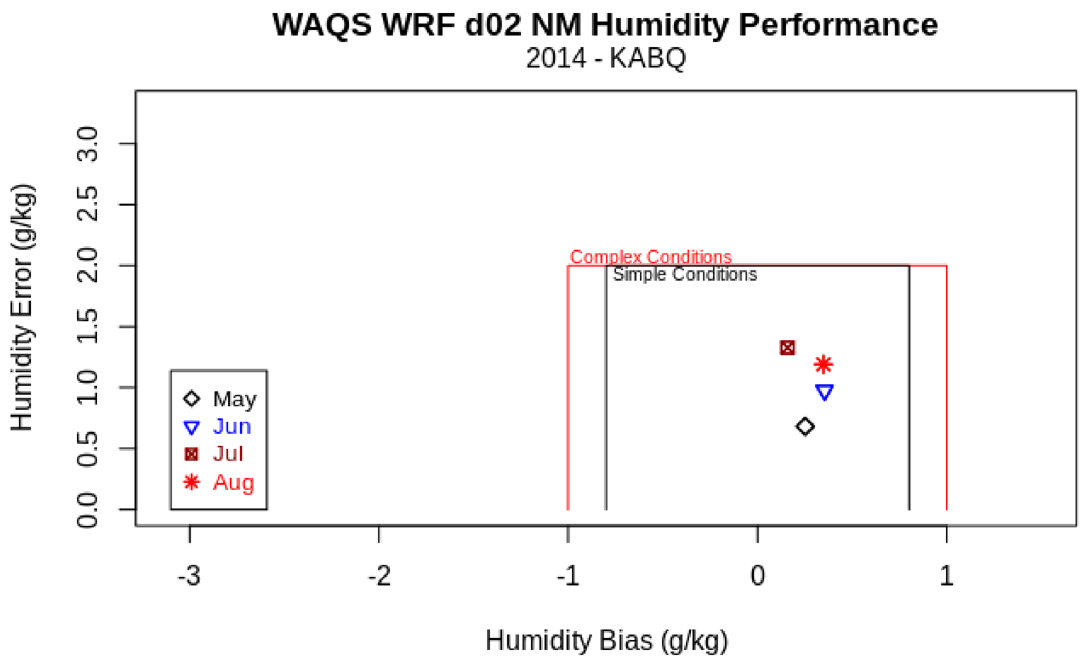
EPA performance poorest for Jul-Aug: overactive convection?

Soccer Plots – Humidity for KABQ

EPA 12 km

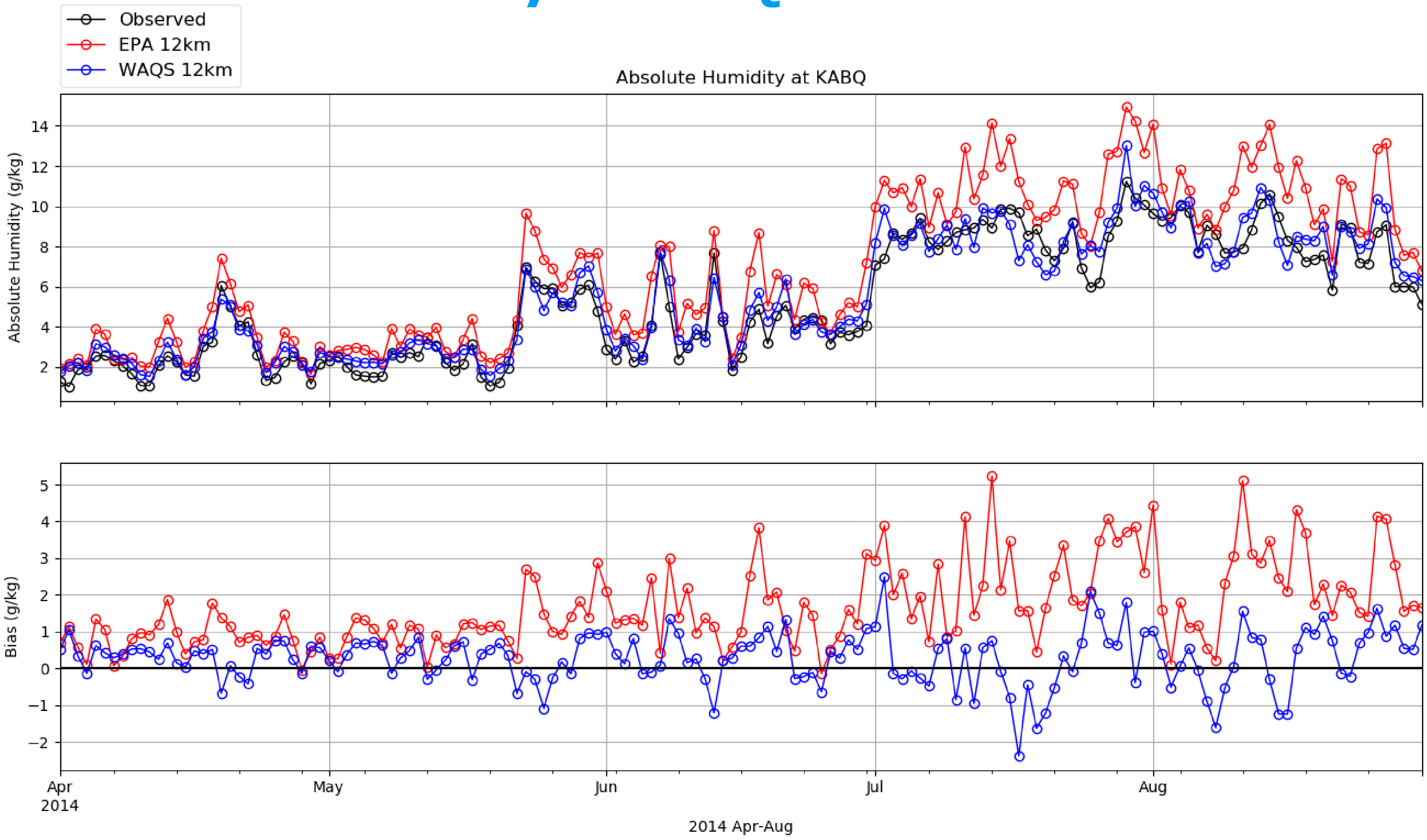


WAQS 12 km



WAQS run outperforms EPA; much smaller wet bias for all months

Time Series – Humidity at KABQ



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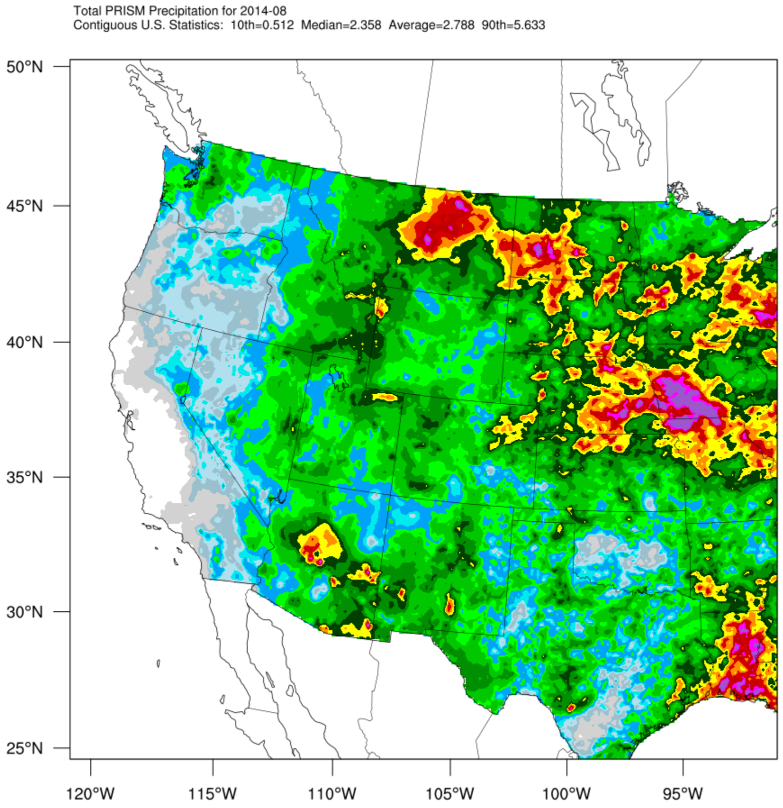
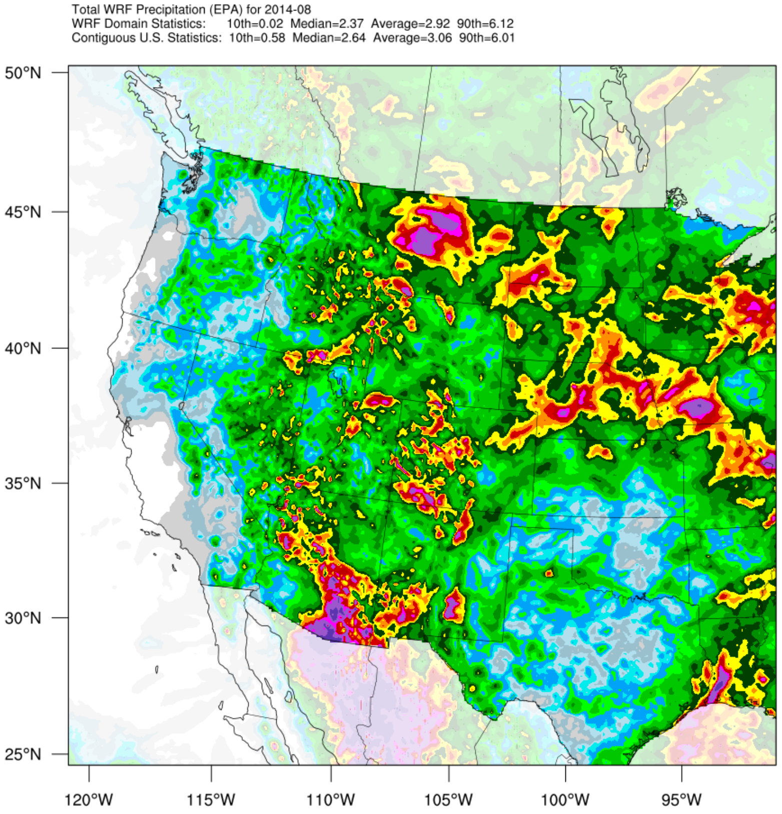
Monthly Precipitation Plots – Aug 2014

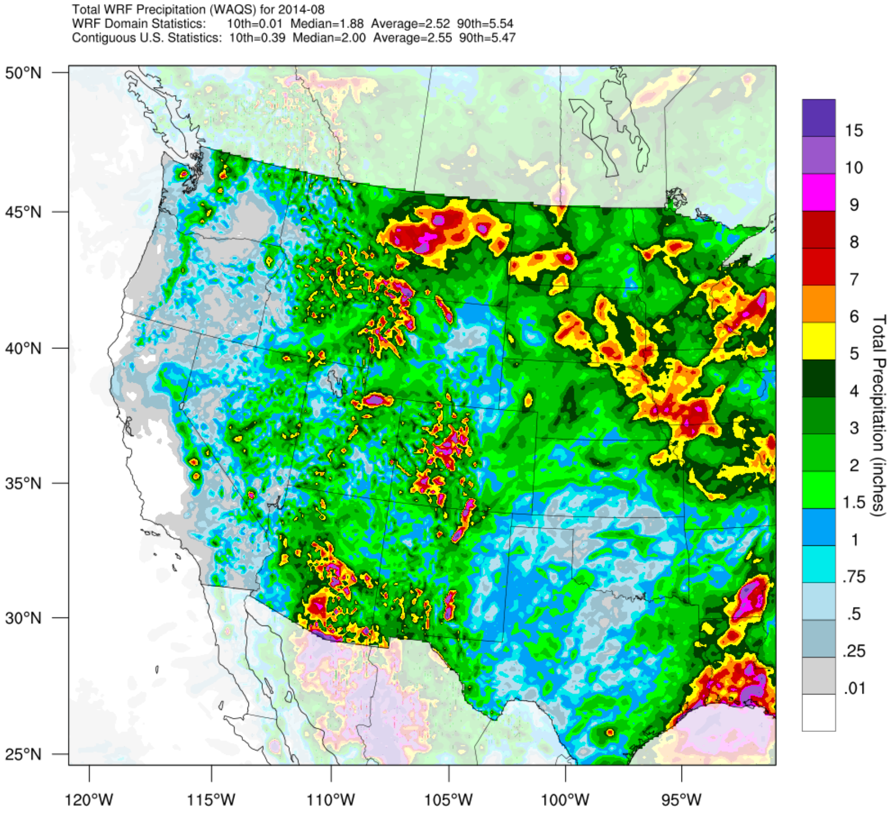
PRISM Obs



EPA 12 km



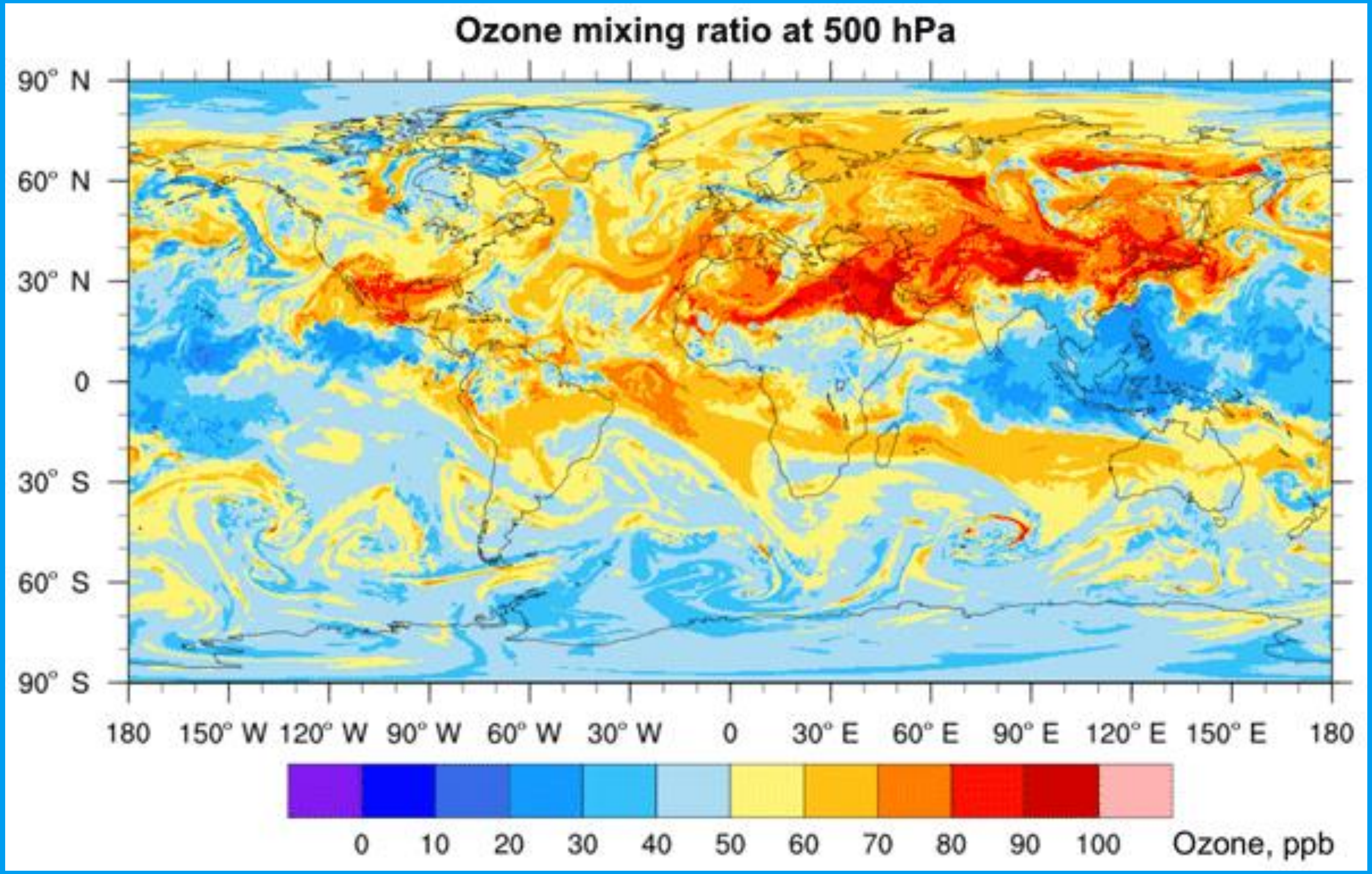
WAQS 12 km



Existing 2014 WRF MPE Summary and Conclusions

- WRF performance reasonable for both simulations outside of humidity/precipitation
- EPA wet bias in summer months associated with overactive summer convection
- WAQS smaller wet bias
- NM OAI proposed WRF configuration aligns closely with WAQS to avoid overactive summer convection in New Mexico, with these differences
    - Reposition 4 km domain to encompass all of New Mexico
    - Use hybrid vertical coordinate to improve representation of upper troposphere/lower stratosphere
    - Add second simulation driven by ERA5 analysis
    - No observation nudging
- Two NM OAI WRF simulations (WRF/NAM12 and WRF/ERA5) currently running
- Present evaluation of these two simulations in June webinar

Task 3: Evaluate 2014 Boundary Conditions Based on WRAP 2014 GEOS-Chem



Overview of 2014 BC Evaluation

- Overview of WAQS-WRAP 2014 GEOS-Chem modeling
- Overview of WAQS 2014 Representative Base case Scenario
- Analysis of WAQS 2014 modeling results and BC contributions

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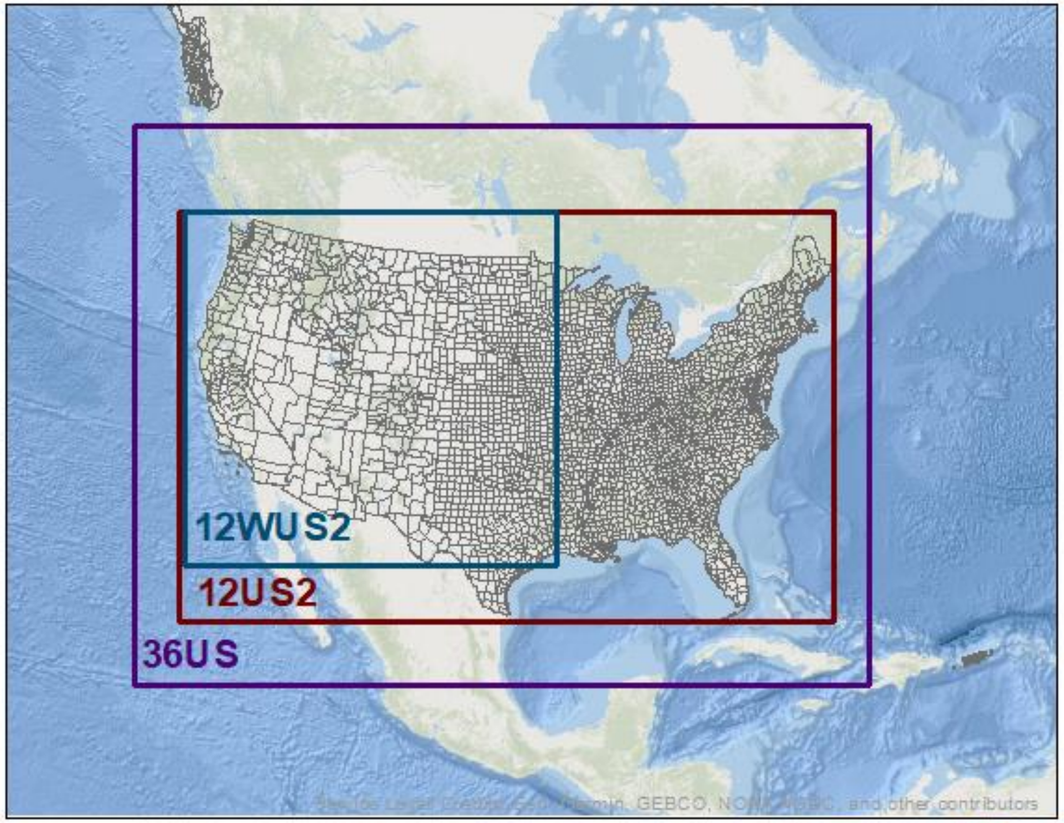
Background

- Phase I and II of WRAP 2014 Shake-Out study developed a 2014v1 PGM modeling platform:
  - 36-km 36US and 12-km 12WUS2 domains
  - CMAQ and CAMx PGMs
  - **<u>EPA 2014 GEOS-Chem BCs</u>**
  - 2014v1 Emissions
    - 2014NEIv2 with western state updates
  - BEIS Biogenic Emissions



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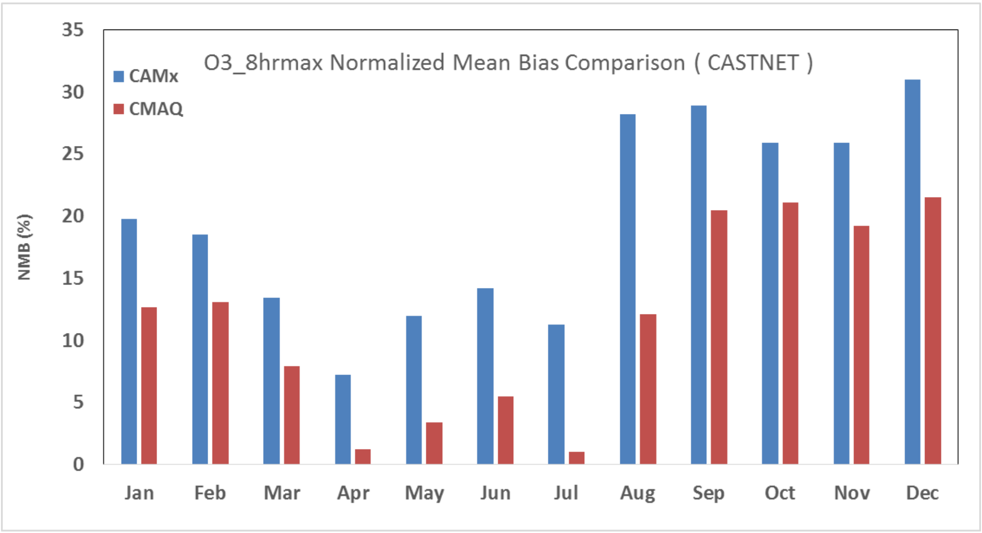
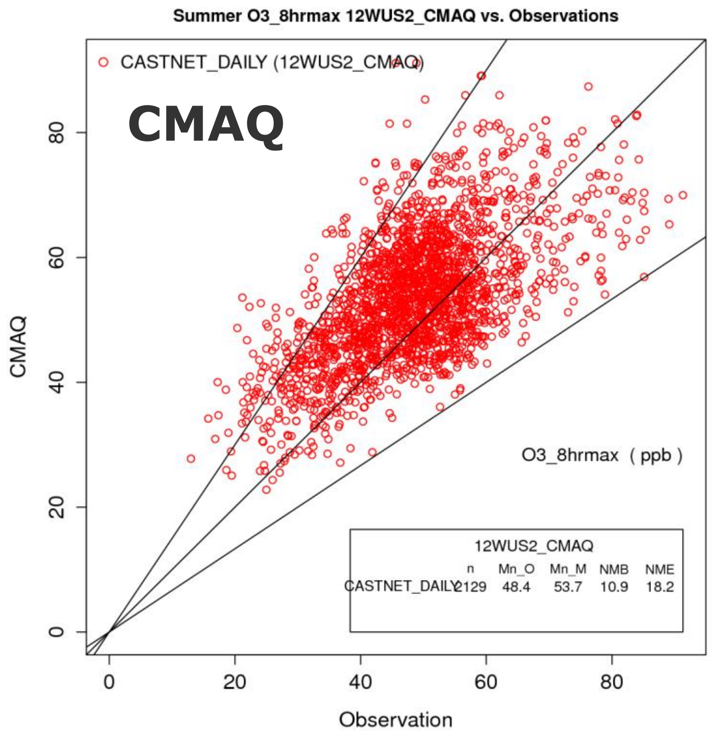
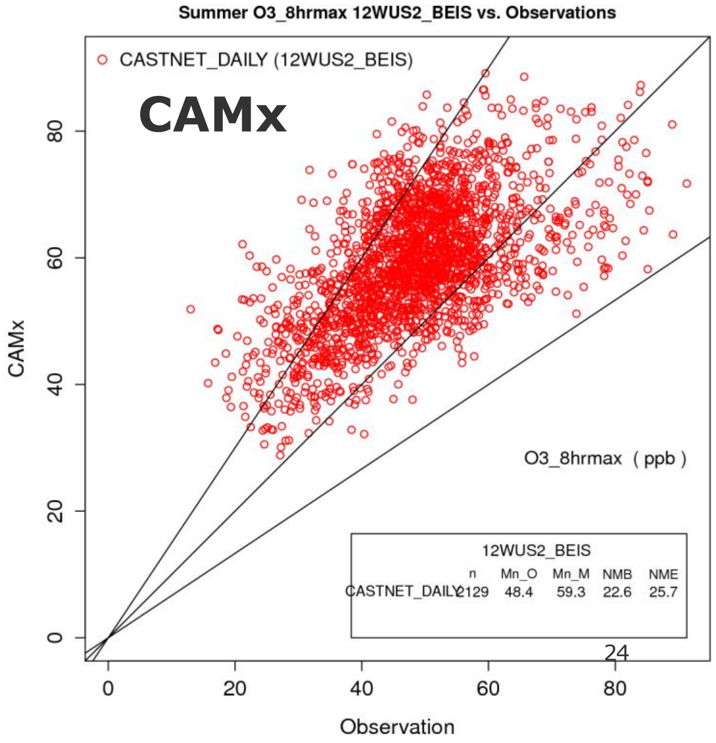
BCs Based on EPA 2014 GEOS-Chem had issues

- Year-round ozone overestimation bias
  - In both CMAQ and CAMx, but more pronounced in CAMx
- Maybe some SO4 overestimation, even after eliminating volcano eruptions and DMS emissions







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Revised 2014 GEOS-Chem simulation

- WRAP elected to conduct a revised 2014 GEOS-Chem simulation
  - Use updated emissions, newer GEOS-Chem version and other updates as used by EPA and Ramboll in their 2016 GEOS-Chem runs that produced BCs without the large ozone overestimation bias in the CMAQ and CAMx simulations.

Science Options	WRAP 2014 Basecase	EPA 2014 Basecase	EPRI 2016 Basecase
Version	Version 12.2.0 (2019-02-19)	Version 11-01 (2017-02-01)	Version 11-02r (2018-06-22)
Vertical Grid Mesh	72 Layers	47 Layers	72 Layers
Chemistry mechanism	standard chemistry with complex SOA option	tropospheric chemistry with complex SOA option	standard chemistry with complex SOA option
Horizontal Grids	2x2.5 degree (Nx, Ny = 144, 91)	4x5 degree (Nx, Ny = 72, 46)	2x2.5 degree (Nx, Ny = 144, 91)
Initial Conditions	6-month spin-up	1-year spin-up	6-month spin-up
Meteorology	2014 GEOS-FP meteorology	2014 GEOS-5 meteorology	2016 GEOS-FP meteorology
Photolysis	Default (FAST-J)	Default (FAST-J)	Default (FAST-J)
Advection Scheme	Default (TPCORE)	Default (TPCORE)	Default (TPCORE)
Cloud Convection	On/Relaxed Arakawa-Schubert	On/Relaxed Arakawa-Schubert	On/Relaxed Arakawa-Schubert
PBL	Lin and McElroy	Lin and McElroy	Lin and McElroy
Dry Deposition	Default (Wesely)	Default (Wesely)	Default (Wesely)
Chemistry Solver	Default (FLEXCHEM)	Default (FLEXCHEM)	Default (FLEXCHEM)
Parallelization	Open Multi-Processing (OMP)	Open Multi-Processing (OMP)	Open Multi-Processing (OMP)

Representative Base Case Simulation Description

- WRAP 2014 GEOS-Chem used to derive Boundary conditions for 2014v2 and Representative Baseline (RepBase)
- Two additional GEOS-Chem simulations were performed to separate the Natural, Anthropogenic International and US contributions in the boundary conditions themselves:
  - Natural (NAT) and Zero-Rest-Of-the-World (ZROW)
- RepBase was instrumented in CAMx with source apportionment technology to track the ozone and PM contributions from the following 14 categories including boundary conditions:

Source Group Number	Brief Description
1	Natural Emissions
2	U.S. Wildfires (WF)
3	U.S. Prescribed Burns (Rx)
4	U.S. Agricultural Burning (Ag)
5	U.S. Anthropogenic Emissions (USAnthro)
6	Mexico Anthropogenic Emissions
7	Canada Anthropogenic Emissions
8	Off-Shore Commercial Marine Vessel (CMV) C3 Ocean Going Vessels (OGV) within 200 nautical miles of the coast (i.e., within the Emissions Control Area, ECA)
9	Remainder off-shore anthropogenic emissions that includes CMV C3 OGV outside of the ECA and non-U.S. O&G
10	Boundary Conditions: International contributions (BC_Intl)
11	Boundary Conditions: Natural contributions (BC_Nat)
12	Boundary Conditions: US contributions (BC_US)
13	Initial Conditions contributions
14	Top Boundary Concentrations contributions (top of the model)

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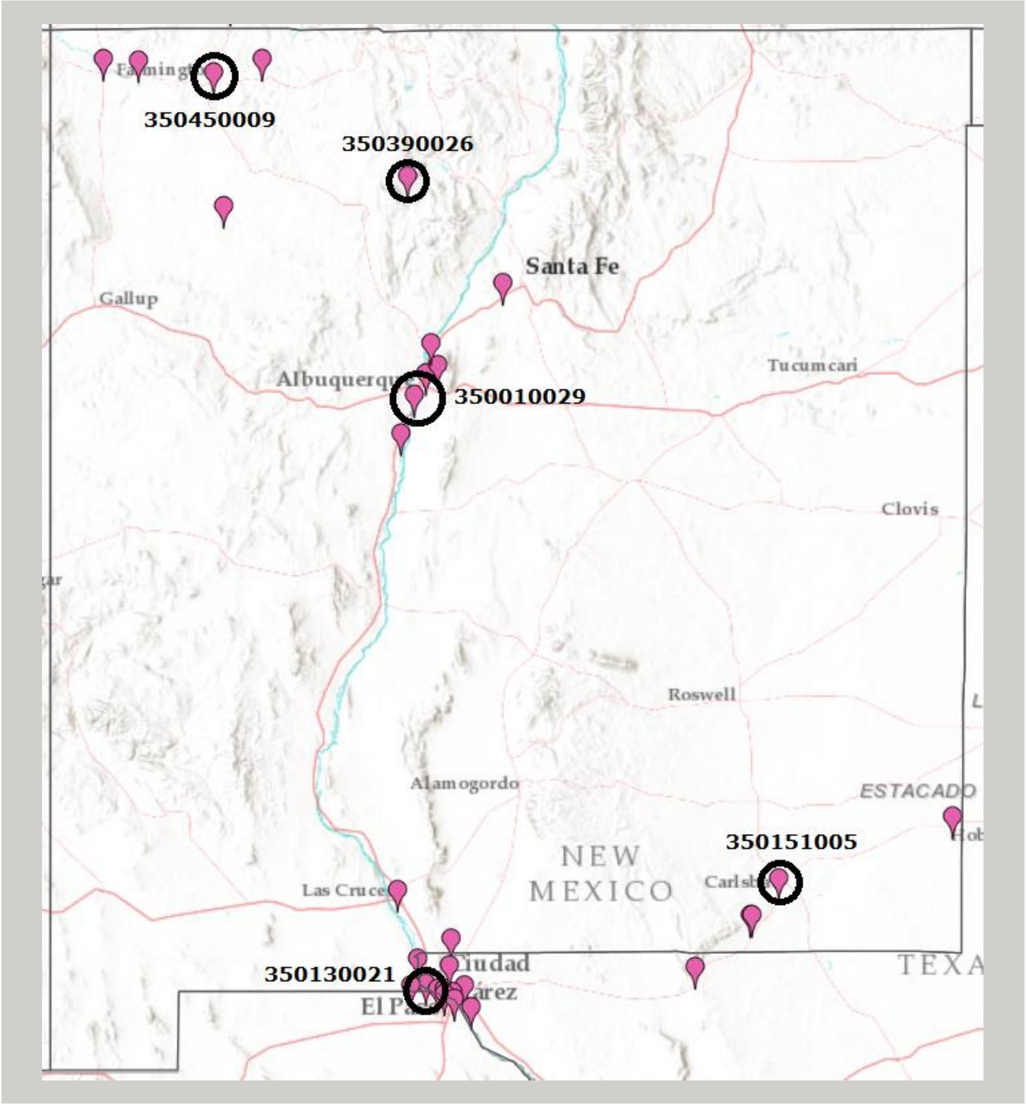
Boundary Conditions Analysis Sites



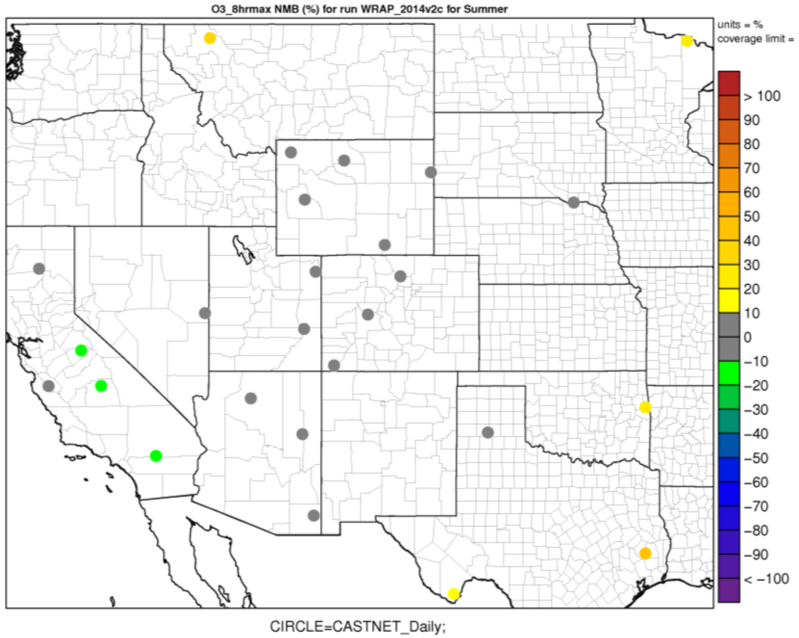
- Compared MDA8 ozone from WRAP Representative Base scenario (RepBase) source apportionment with a few selected and representative AQS sites in NM

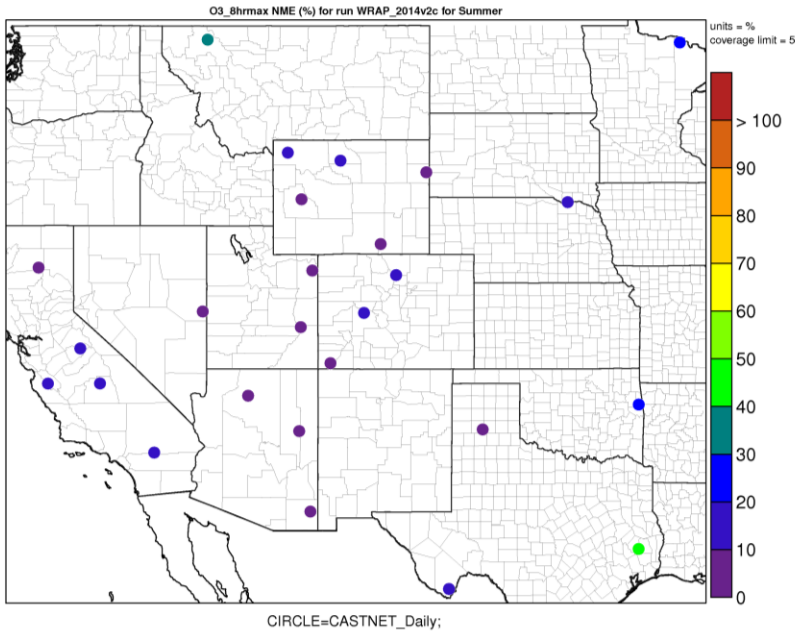
Site ID	County	Latitude	Longitude
350450009	San_Juan	36.74	-107.98
350390026	Rio_Arriba	36.19	-106.70
350010029	Bernalillo	35.02	-106.66
350130021	Dona_Ana	31.80	-106.58
350151005	Eddy	32.38	-104.26

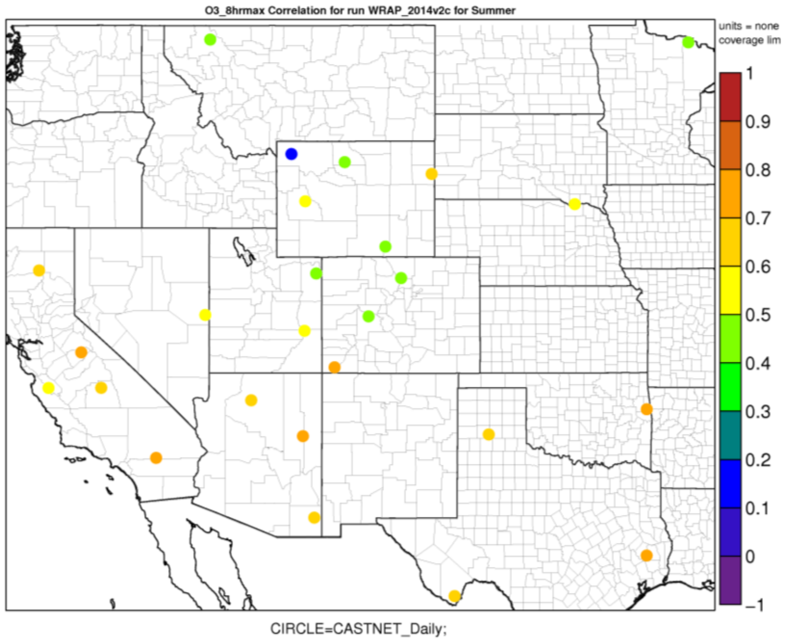
Selected Sites Ozone Model Performance

- RepBase does not have year specific emissions and is not meant to represent 2014. Fires contributions have been removed from this analysis
- RepBase statistics indicate performance for scenario in these sites are almost all within the goals for NMB and NME, within criteria for r
- Consistent with 2014v2 AZ, UT, CO ozone **NMB**, **NME** and **r** in the Summer (no CASTNET sites in NM)

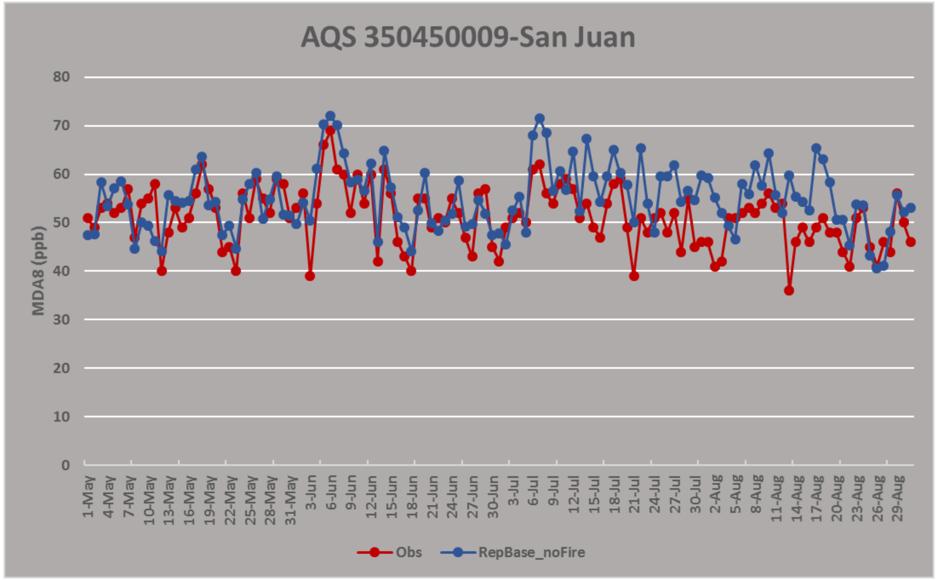
Site ID	County	NMB (%)	NME (%)	r
350450009	San_Juan	7.36	10.36	0.63
350390026	Rio_Arriba	3.24	8.62	0.57
350010029	Bernalillo	1.34	8.10	0.66
350130021	Dona_Ana	0.26	8.03	0.72
350151005	Eddy	-4.33	9.45	0.72

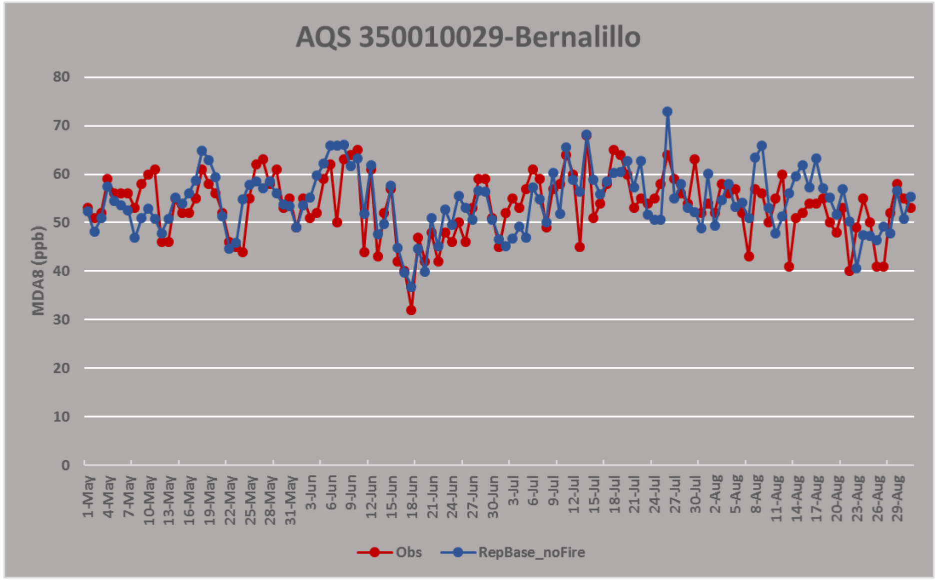


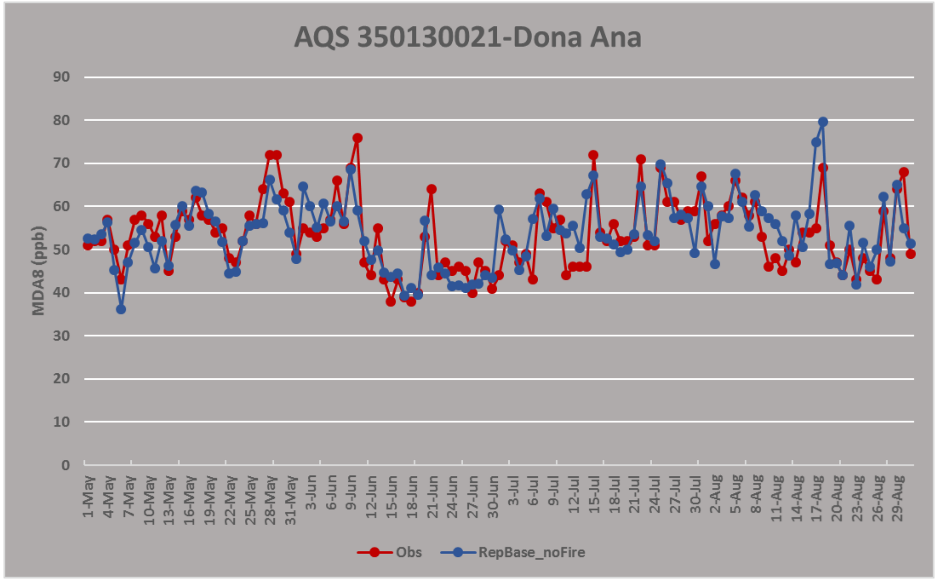


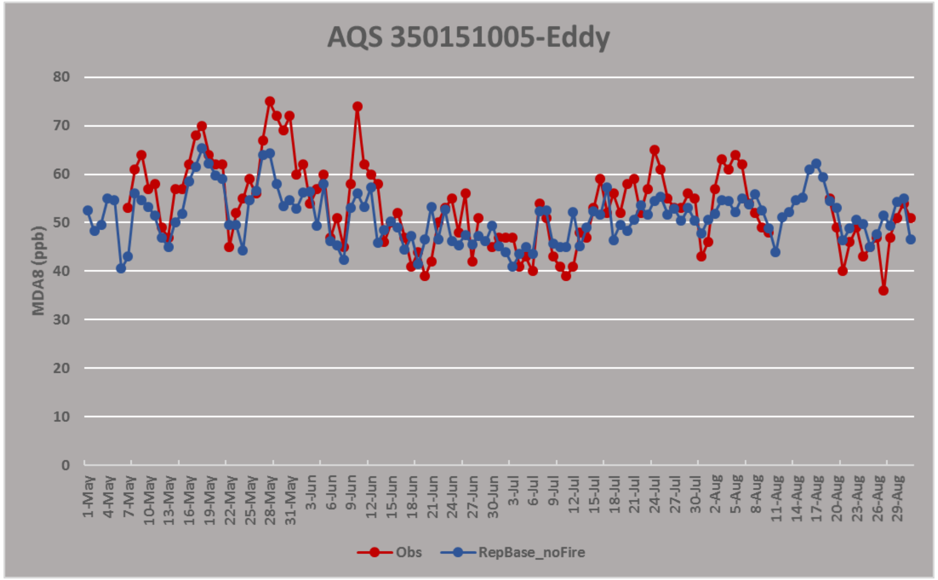


Selected Sites Time Series



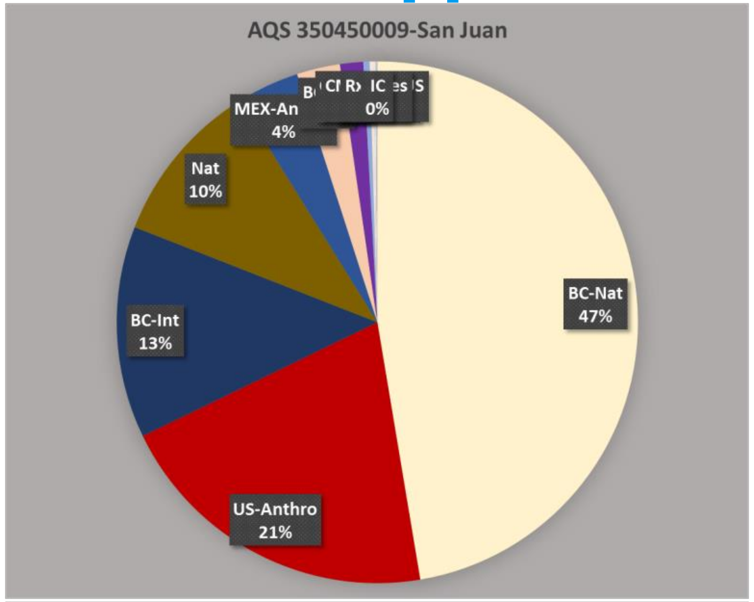


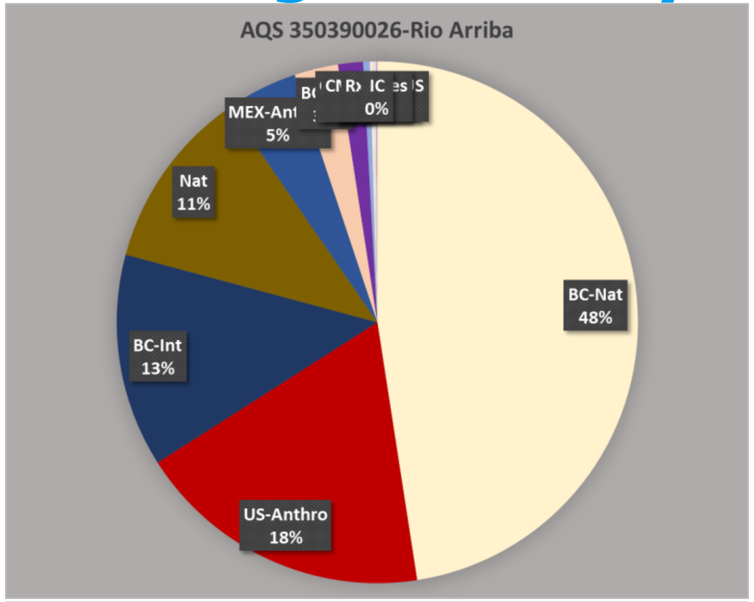


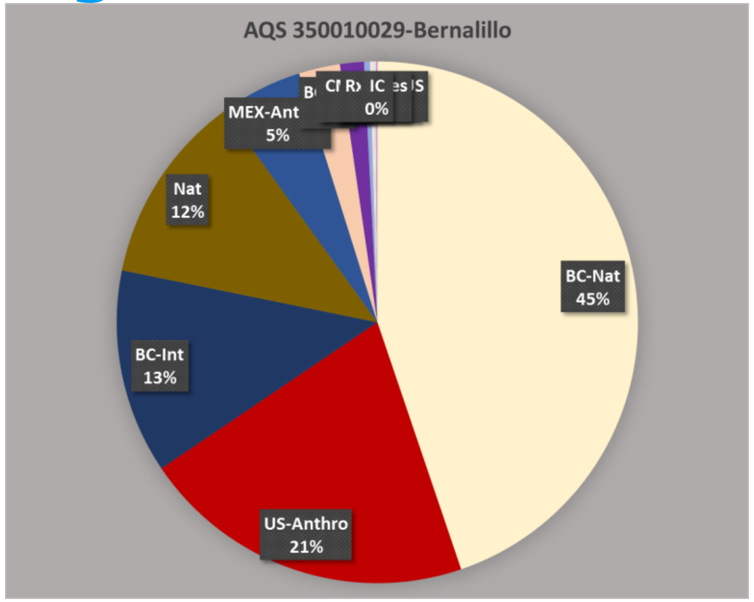


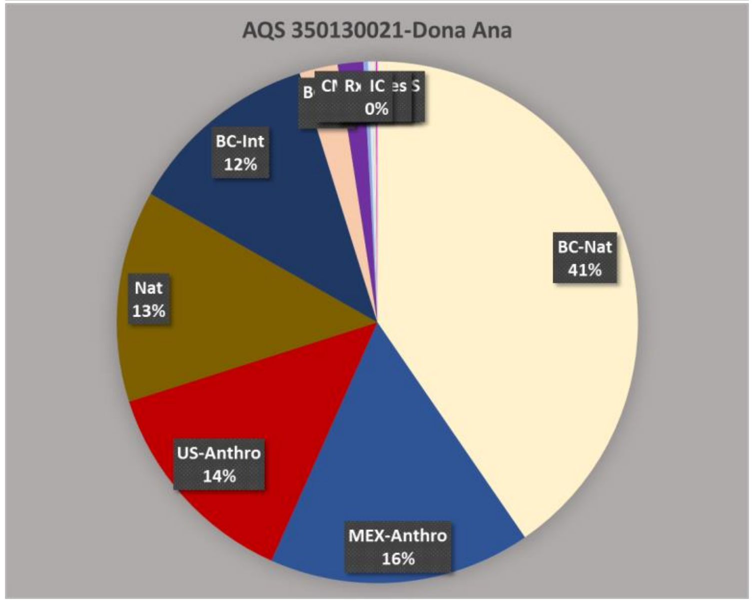
- RepBase statistics and time series suggest that is reasonable to use Source Apportionment results to understand sources of ozone at these sites

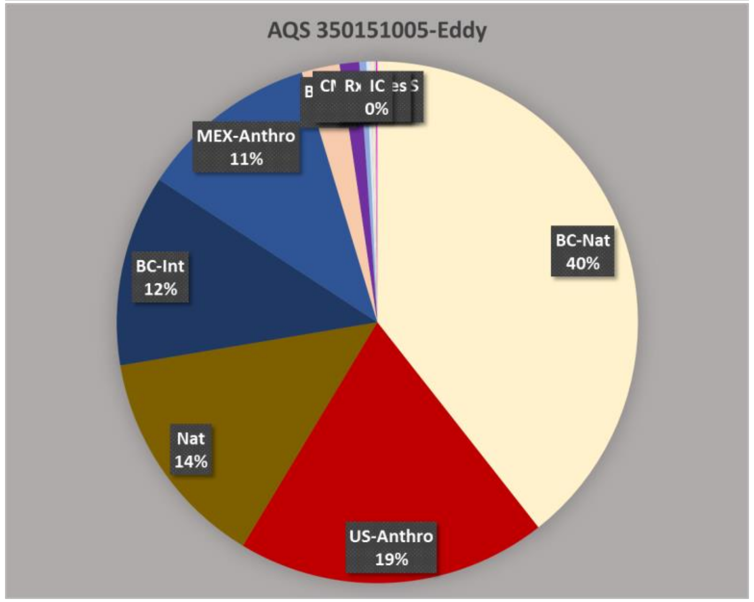
Source Apportionment Average over May to August











- Natural contribution from the GEOS-Chem Boundary Conditions ~ 40% to 48% of the ozone
- US Anthro ~ 14% to 21%
- International BC ~13%
- Mexican Anthro ~5%. Largest at Dona Ana county at 16%

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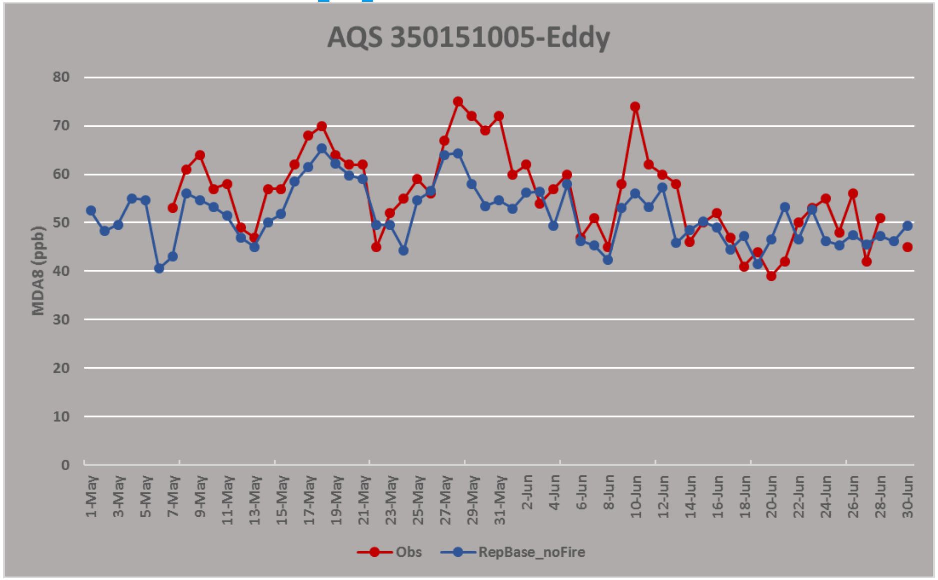
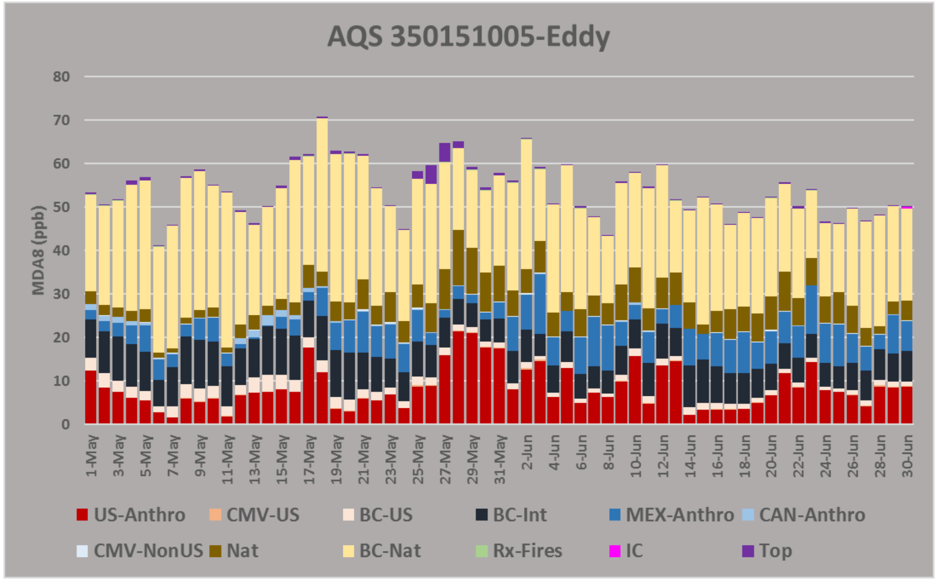
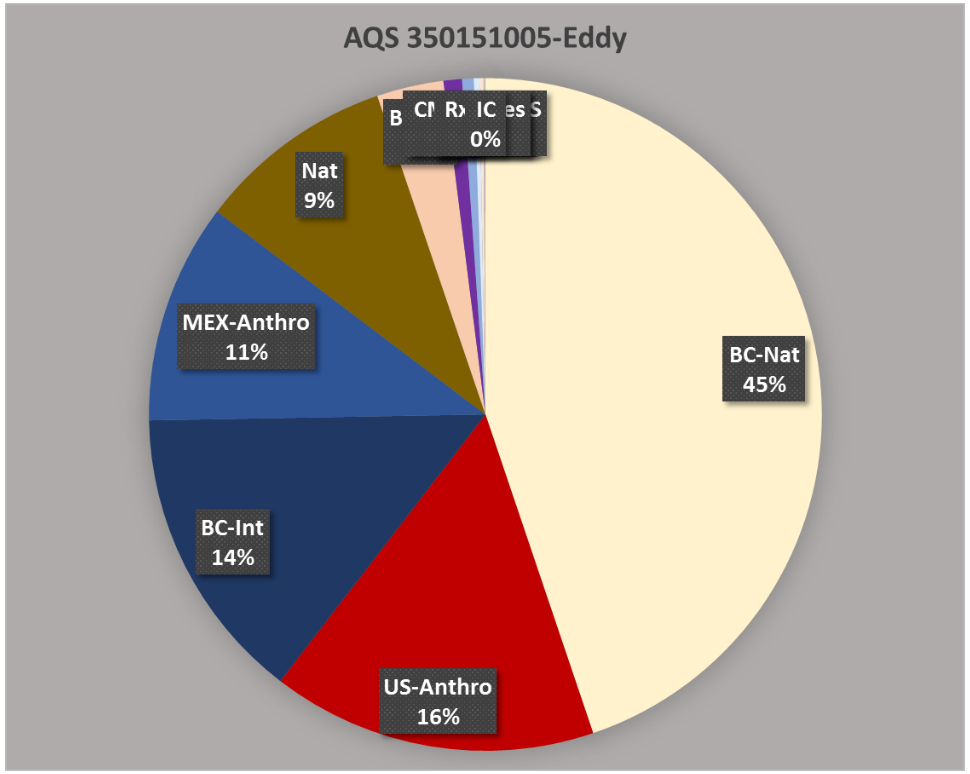
Source Apportionment: Eddy County

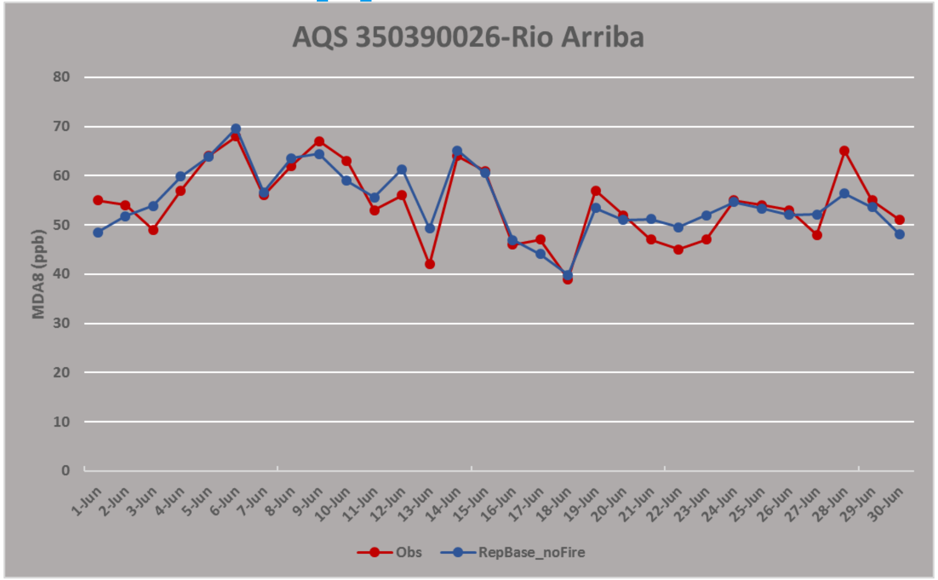


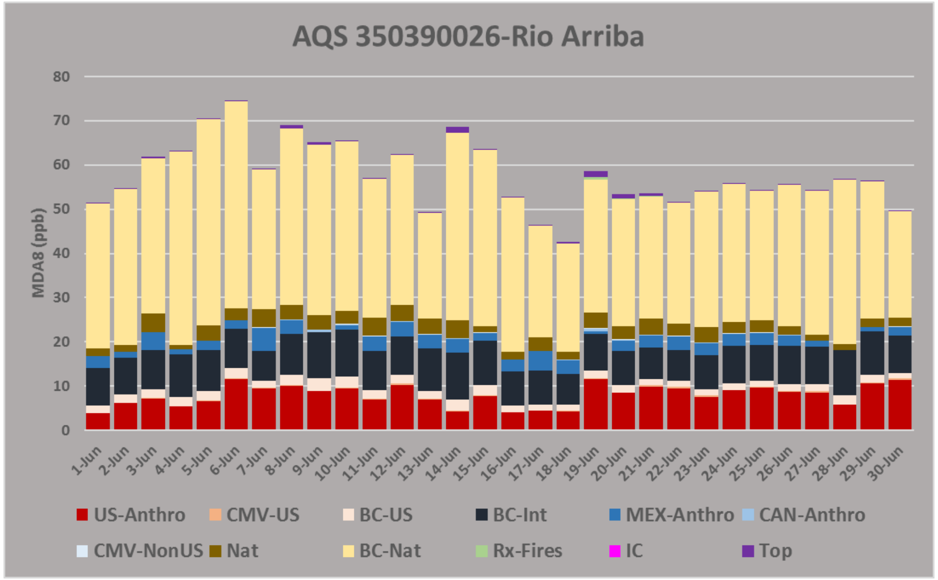


- Obs in Eddy County Site in May-Jun show multiple days with MDA8>70 ppb
- US Anthro and International BC contributions show equivalent contributions (16 and 14%)
- Peak on May 25 to 27 has some influence from the top of the model

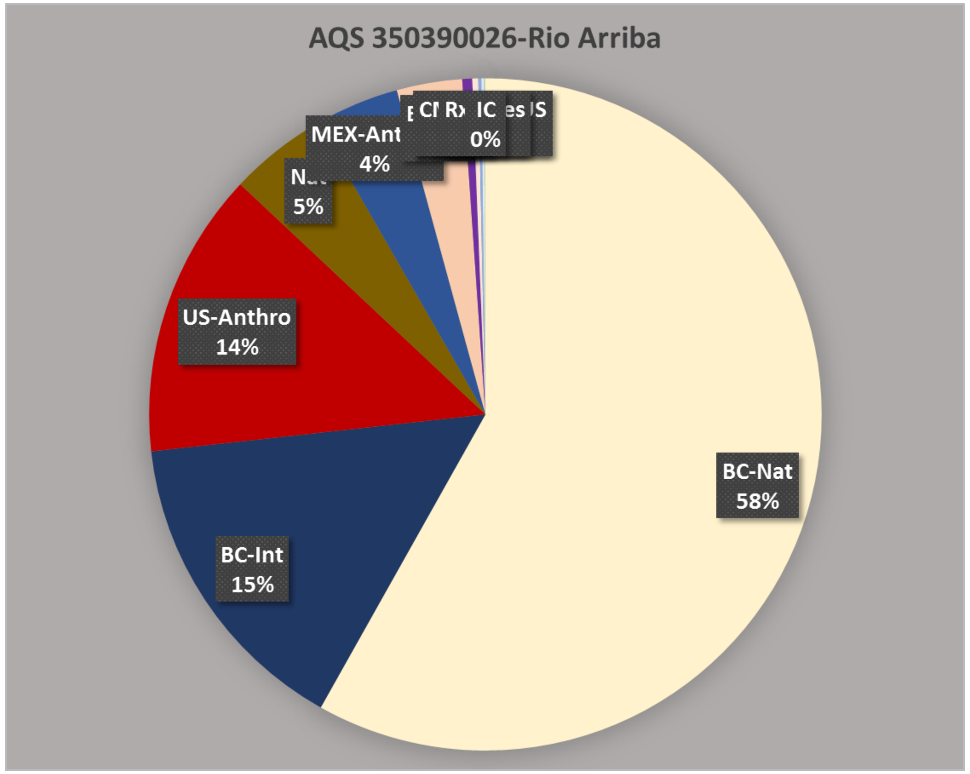


Source Apportionment: Rio Arriba county





- International BC and US Anthro contributions show equivalent contributions (15 and 14%)
- Peak on June 6 dominated by Natural contributions from the Boundary



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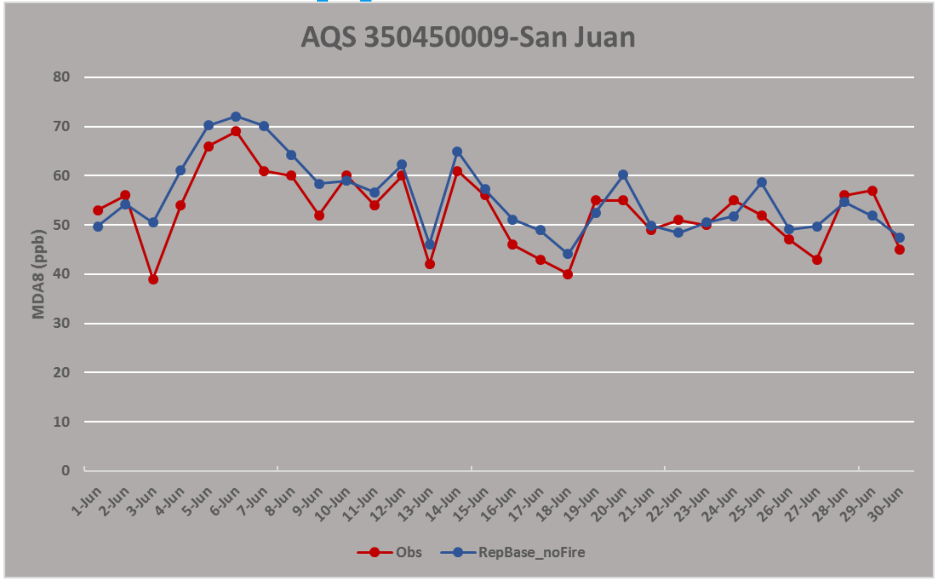
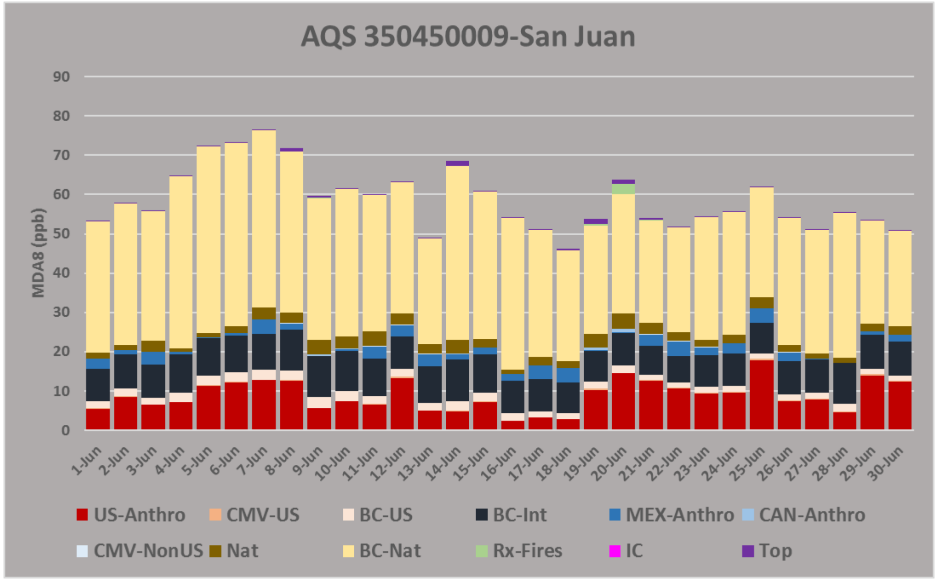
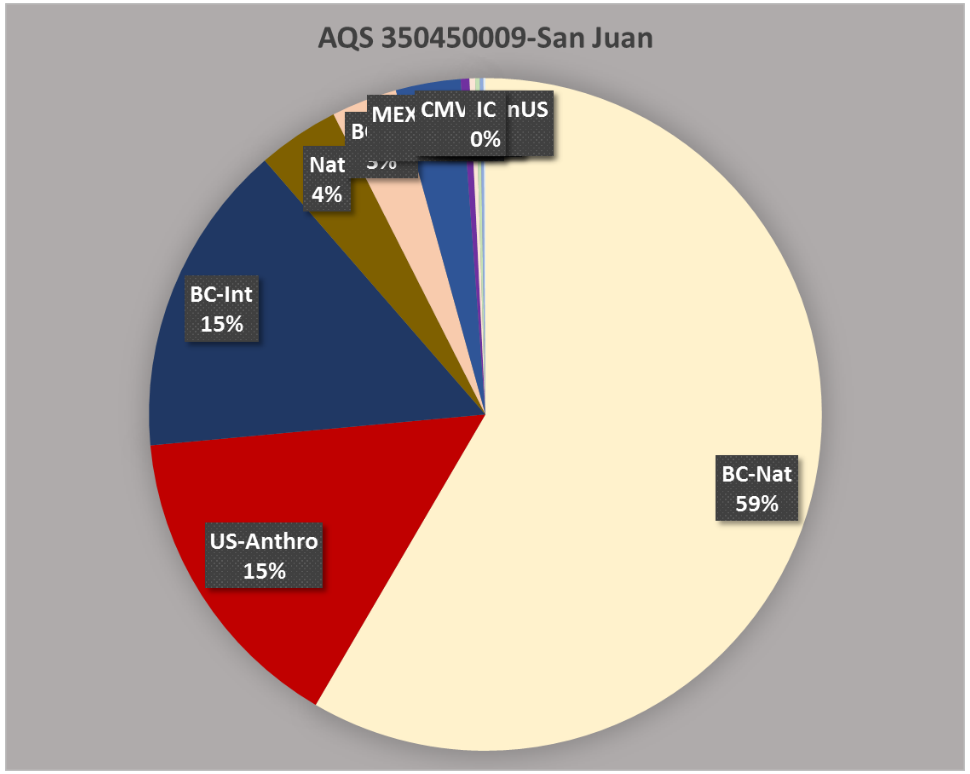
Source Apportionment: San Juan county





- International BC and US Anthro contributions show equivalent contributions (15%)
- Peak on June 7 dominated by Natural contributions from the Boundary



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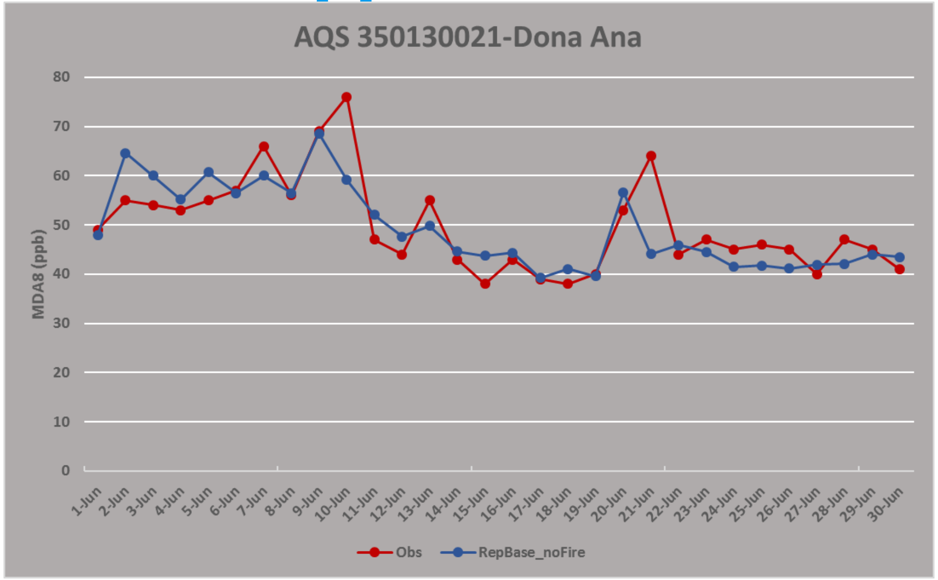
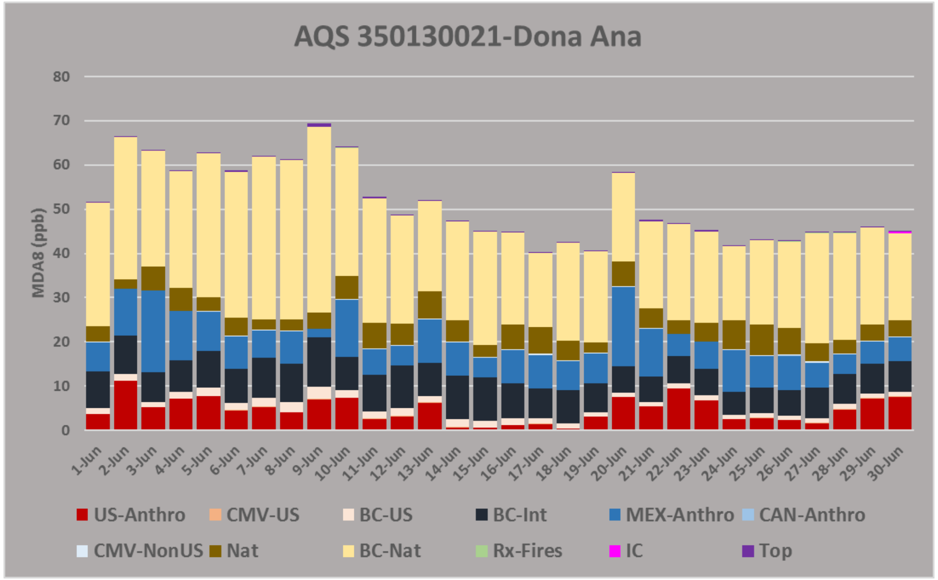
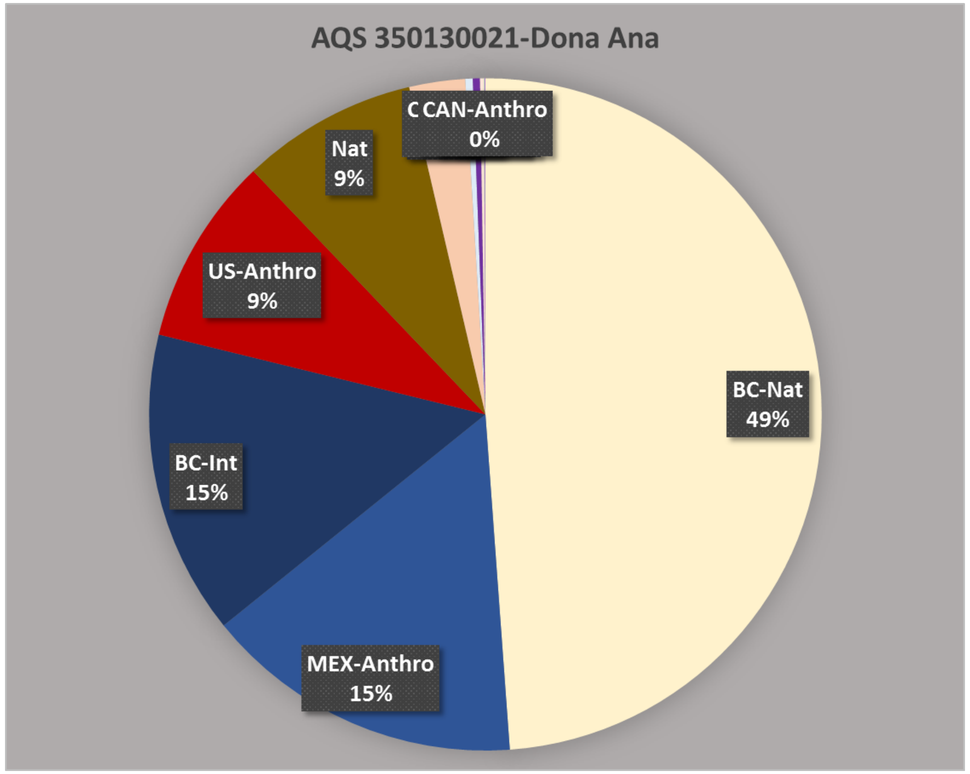
Source Apportionment: Dona Ana county

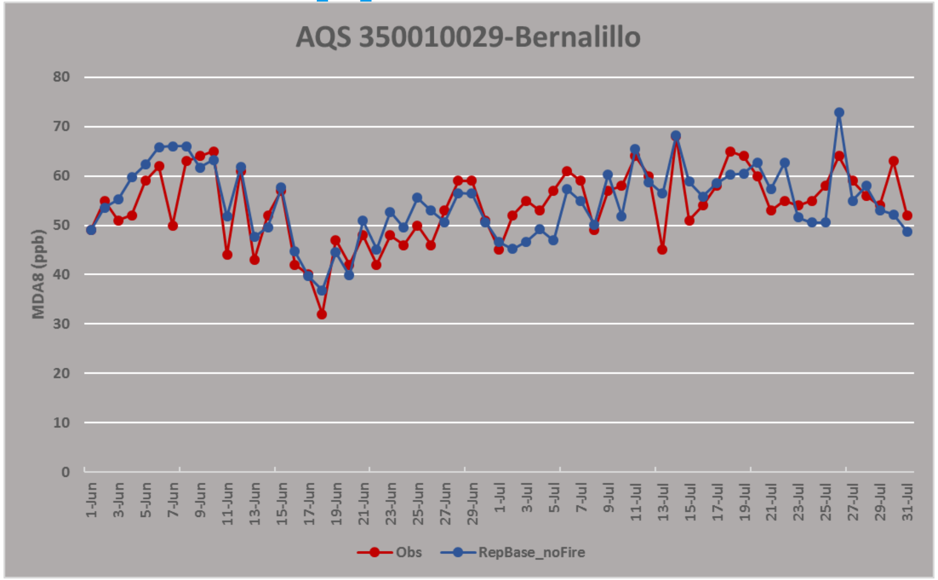


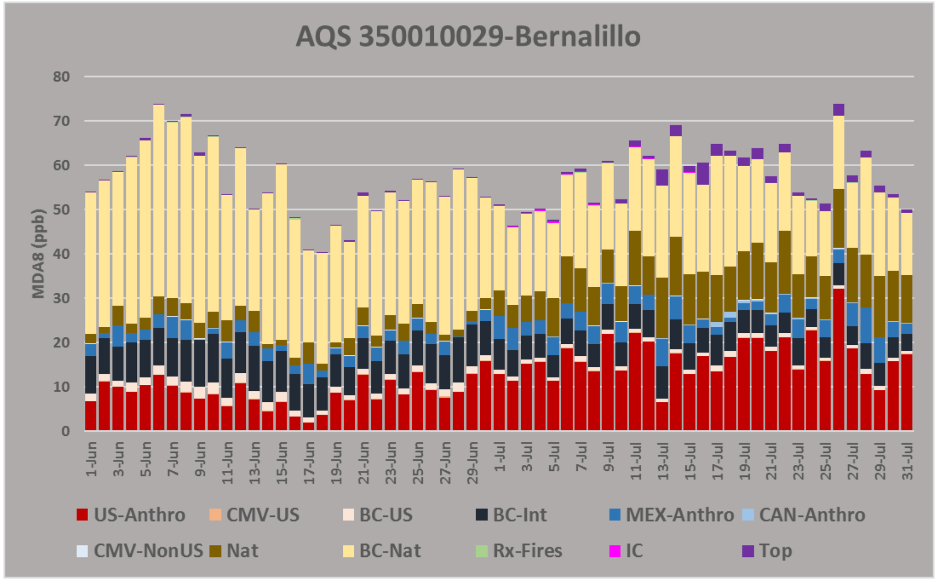


- International BC and Mexican Anthro contributions show equivalent contributions (15%)
- Peak on June 9 dominated by Natural contributions from the Boundary

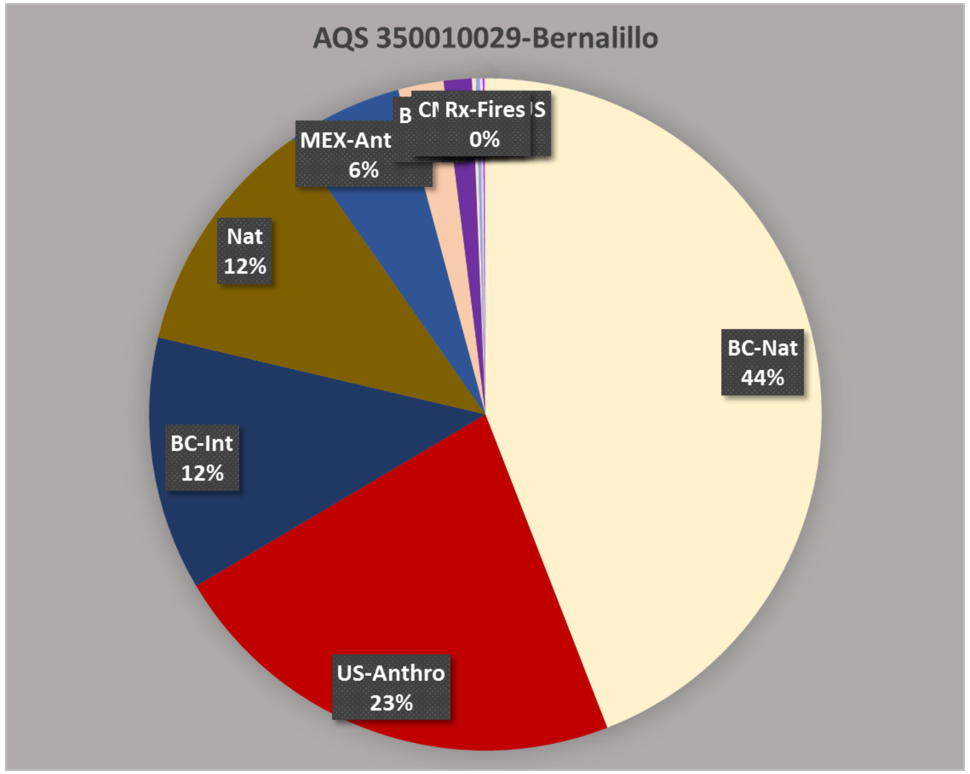


Source Apportionment: Bernalillo county





- US Anthro is almost twice as large as International BC contributions
- First peak in June has large US and International contributions, second peak in July more dominated by US natural sources



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GEOS-Chem Summary of Recent Updates

- WRAP 2014 Base Case used GEOS-Chem version 12.2.0 released 2019-02-19
- Current GC stable version is 12.8.2 released 2020-05-27
- Cumulative updates relevant for ozone :

Feature	Type	Version
Grid independent lighting NOx, biogenic and soil NOx emissions	Science	12.4.0
Updated offline biogenic emissions generated with GC 12.3.0	Science	12.5.0
Small alkyl nitrate chemistry	Science	12.7.0
Ozone deposition to the ocean	Science	12.8.0

http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-Chem_12#12.8.1

Conclusions: BCs from WRAP 2014 GEOS-Chem

- Initial WRAP 2014v1 CAMx and CMAQ simulations using EPA 2014 GEOS-Chem BCs exhibited large ozone overestimation bias year-round
  - Made it difficult to evaluate other model options (e.g., biogenic emissions)
- WRAP elected to conduct their own 2014 GEOS-Chem using new versions of the model and emission inventories in CAMx 2014v2 and RepBase simulation
  - Much better ozone model performance across the western states
- We more closely examined WRAP CAMx 2014v2 ozone model performance in New Mexico
  - CAMx 2014v2 ozone performance in New Mexico good mostly achieving ozone performance goals
- We examined WRAP CAMx RepBase ozone source apportionment at sites in New Mexico
  - Found approximately 60%-75% of ozone was due to BCs, BCs from natural sources higher (40-50%)
  - Higher BC ozone contribution in northwest than southeast Counties in New Mexico
- Few recent updates to GEOS-Chem could affect ozone but would likely not significantly affect ozone BCs and would affect costs and schedule

Task 1: Overview of Modeling Protocol

Modeling Protocol – 1. Introduction

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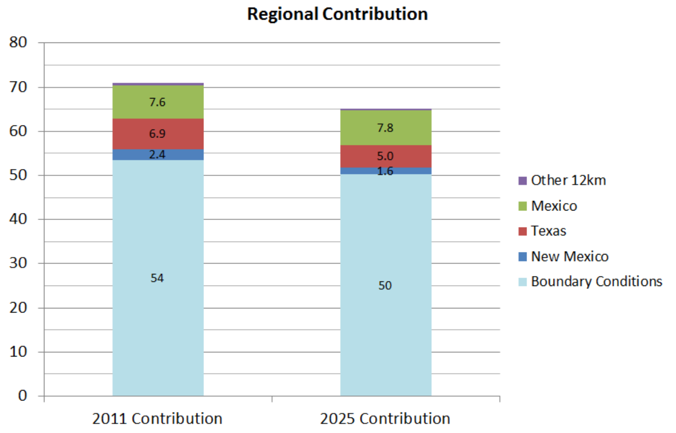
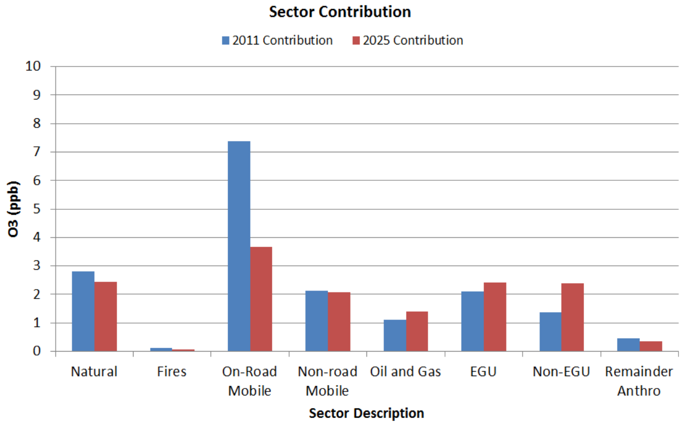
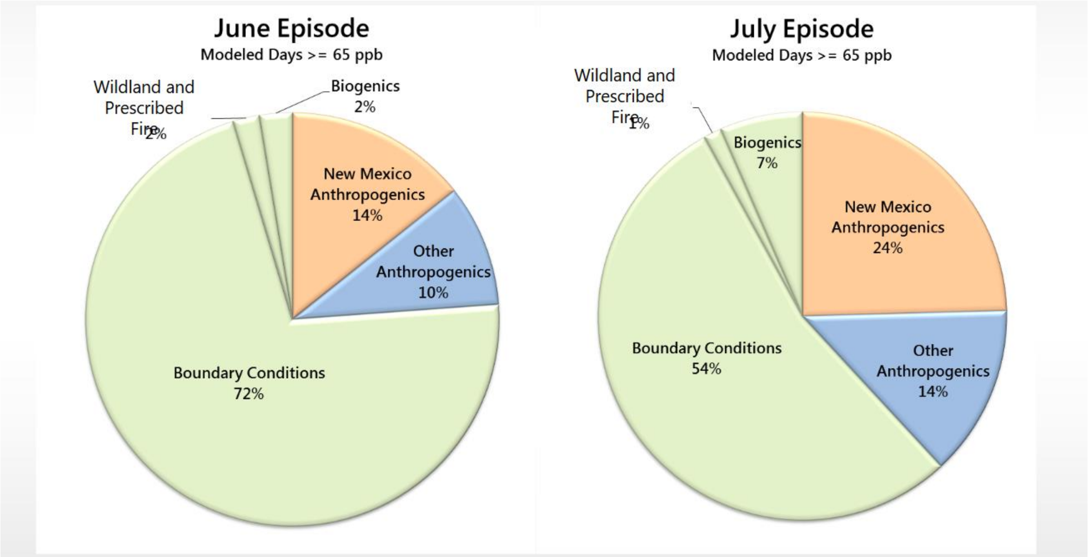
Modeling Protocol – 1. Introduction – 1.3 Related Studies

- Southern New Mexico Ozone Study (SNMOS)
  - Contributions to 2011 and 2025 Ozone Design Values at Desert View (2-3% due to NM)





- City of Albuquerque Ozone Study – Contributions to Ozone in Albuquerque



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Modeling Protocol – Model and Episode Selection

2. Model Selection

- Mainly Consistent with WRAP/WAQS 2014v2 and EPA 2016v1 modeling platforms
- CAMx – Photochemical
  - Used in WRAP, SNMOS, EPA, Denver SIP, etc.
- WRF – Meteorological
  - Current state-of-science
- SMOKE – Emissions Processor
  - Most widely used Emissions Model
- MEGAN – Biogenic Emissions
  - Selected over BEIS used in WRAP 2014v2
- GEOS-Chem – Global
  - For 36-km domain Boundary Conditions (BCs)

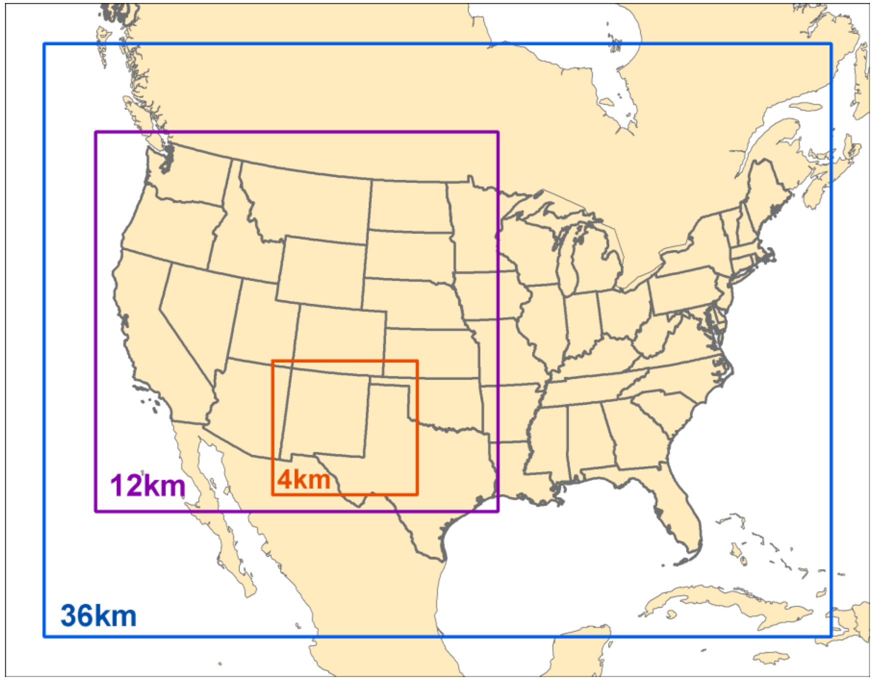
3. Episode Selection – May-Aug 2014

- Need to leverage existing photochemical modeling database so choose between 2014 or 2016
- Select 2014 because:
  - Coincides with an NEI Year
  - Higher quality emissions with updates from western states (WRAP 2014v2)
  - Observed ozone close to ozone DVs
  - 2014 has more ozone exceedance days (8) than 2016 (3)

Modeling Protocol – Domain Selection and WRF Modeling

4. Domain Selection

- 36/12/4-km domains
- 4-km domain include New Mexico and O&G production areas in San Juan and Permian Basin



5. WRF Modeling

WRF Option	NM OAI Study	2014 WAQS	2014/2015 EPA
Vertical Coordinate	Hybrid	eta	eta
Domains run	36/12/4-km	36/12/4-km	12-km
Microphysics	Thompson	Thompson	Morrison 2
LW Radiation	RRTMG	RRTMG	RRTMG
SW Radiation	RRTMG	RRTMG	RRTMG
LSM	Noah	Noah	Pleim-Xiu
PBL scheme	YSU	YSU	ACM2
Sfc Layer Physics	MM5 similarity	MM5 similarity	MM5 similarity
Cumulus	36/12/4-km Multi-scale Kain Fritsch	36/12-km Multi-scale Kain Fritsch	Kain-Fritsch
BC, IC Analysis Nudging Source	12-km NAM/ERA5	12-km NAM	12-km NAM
Analysis Nudging Grids	36/12-km	36/12-km	12-km
Obs Nudging	None	4-km	None
Sea Sfc Temp	FNMOC	FNMOC	FNMOC

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Modeling Protocol – 2014 Base Case & Model Performance Evaluation

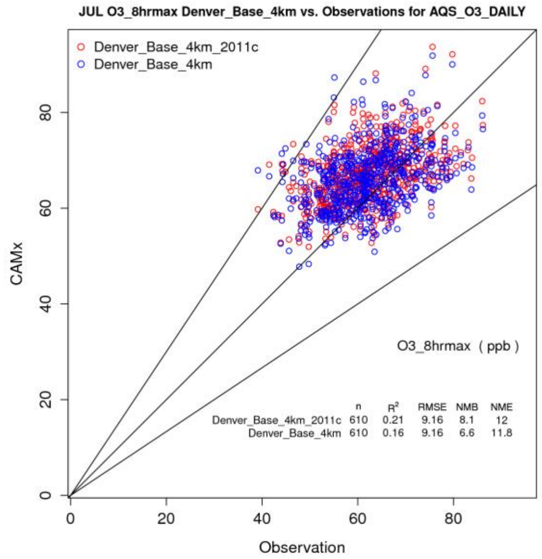
6. CAMx 2014 Inputs Preparation

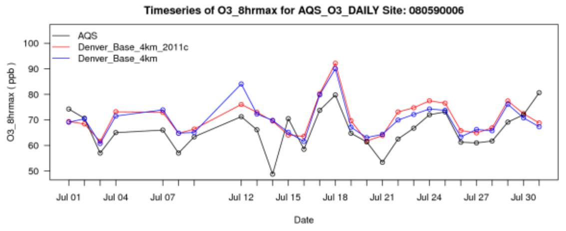
- CAMx Configuration and Options

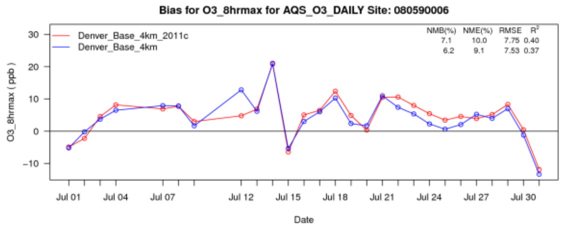
Science Options	CAMx	Comment
Model Codes	CAMx v7.0	Latest version of CAMx used in WRAP/WAQS 2014v2 and EPA Regional Haze modeling
Horizontal Grid Mesh	36/12/4-km	
36-km grid	148 x 112 cells	36US domain
12-km grid	227 x 215 cells	12WUS2 domain. Includes buffer cells
4-km grid	245 x 227 cells	New Mexico 4-km domain. Includes buffer cells
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 thickness ~20 m. Model top at 50 mb (~19 km)
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
Emissions		
Baseline Emissions Processing	SMOKE, SMOKE-MOVES2014, MEGAN	WRAP/WAQS 2014v2 emissions and EPA 2023fh for future year
Sub-grid-scale Plumes	Plume-in-Grid for major NO_x sources in New Mexico	Keep same PiG sources in 2014 and 2023 emission years
Chemistry		
Gas Phase Chemistry	CB6r4	Latest chemical reactions and kinetic rates with halogen chemistry (Yarwood et al., 2010)
Meteorological Processor	WRFCAMx	Compatible with CAMx v7.0
Horizontal Diffusion	Spatially varying	K-theory with Kh grid size dependence
Vertical Diffusion	CMAQ-like Kv	Evaluate YSU Kv scheme
Diffusivity Lower Limit	Kv-min = 0.1 to 1.0 m^2/s in lowest 100 m	Depends on urban land use fraction
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme	(Zhang et. al, 2001; 2003)
Wet Deposition	CAMx -specific formulation	rain/snow/graupel
Numerics		
Gas Phase Chemistry Solver	Euler Backward Iterative(EBI)	EBI fast and accurate solver
Vertical Advection Scheme	Implicit scheme w/ vertical velocity update	Emery et al., (2009a,b; 2011)
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	Colella and Woodward (1984)
Integration Time Step	Wind speed dependent	~0.5-1 min (4-km), 1-5 min (12-km), 5-15 min (36-km)

7. 2014 Base/Model Performance Evaluation

- Focus on ozone performance in NM 4-km Domain
- Ozone Performance Goals and Criteria
  - NMB < 5% & NMB < 15%
- AMET evaluation tool
- Diagnostic Sensitivity Tests:
  - WRF/NAM vs. WRF/ERA5
  - YSU vs. CMAQ-like Kv
- MPE Graphical Displays







Modeling Protocol – Future Year Modeling

8. 2023 CAMx Modeling

- EPA 2023fh Emission Projections
- Natural Emissions at 2016 Levels
- 2023 Control Measure Sensitivity Modeling
  - Control assumptions to be provided by NMED
- 2023 Ozone Source Apportionment
  - Design Document to be reviewed by NMED
  - Geographic Regions
    - NM, TX, OK, CO, AZ, CA, Mex, Can
  - Source Sectors
    - Upstream Oil and Gas, Midstream Oil and Gas, EGU Point, Non-EGU Point, On-Road Mobile, Non-Road Mobile, Other Anthropogenic, Fires (WF, Rx and Ag), Natural, BC from International Anthropogenic Emissions, BC from US Anthropogenic Emissions, BC from Natural Sources, Initial Concentrations

9. Ozone Design Value (DV) Projections

- EPA recommended ozone DV projection approach uses the model in a relative sense to scale the observed ozone DVB

$$DVF_{2023} = DVB_{2014} \times RRF$$

$$RRF = \sum MDA8\ Ozone_{2023} / \sum MDA8\ Ozone_{2014}$$

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

10. Quality Assurance Project Plan (QAPP)

- Elements of QAPP built into sections of Modeling Protocol
- QA/QC critical component of all aspects of PGM modeling

11. References

New Mexico 2014 and 2023 Emissions

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New Mexico Emissions Data

- 2014 base year anthropogenic emissions inventory for New Mexico will be based on the WAQS 2014v2 emissions
  - NMED will review the WAQS 2014v2 emissions and provide updates as needed
- 2023 anthropogenic emissions will be based on the EPA 2016v1 platform
- Onroad emissions based on SMOKE-MOVES processing with 2014 activity data and day-specific hourly gridded 2014 WRF meteorology
- O&G emissions based on state-of-the-science O&G emissions estimates from the IWDW-WAQS platform

Emission Modeling Sector Description

Sector	Description
afdust_adj	Area fugitive dust
ag	Agricultural ammonia sources
cmv_c1c2	Category 1 & 2 Marine Vessels
cmv_c3	Category 3 Marine Vessels
nonpt	Other nonpoint sources
np_oilgas	Non-point Oil and Gas
nonroad	Non-road mobile
onroad	On-road mobile
ptegu	EGU point sources
ptnonipm	Non-EGU point sources
pt_oilgas	Point Oil and Gas
rail	Locomotive
rwc	Residential Wood Combustion

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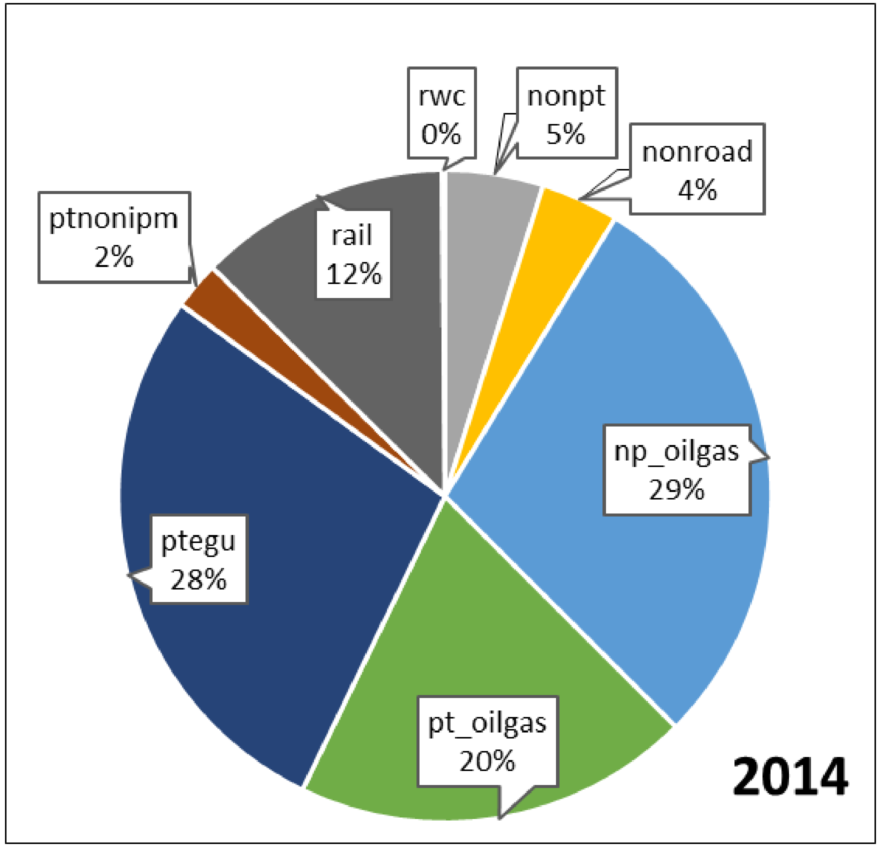
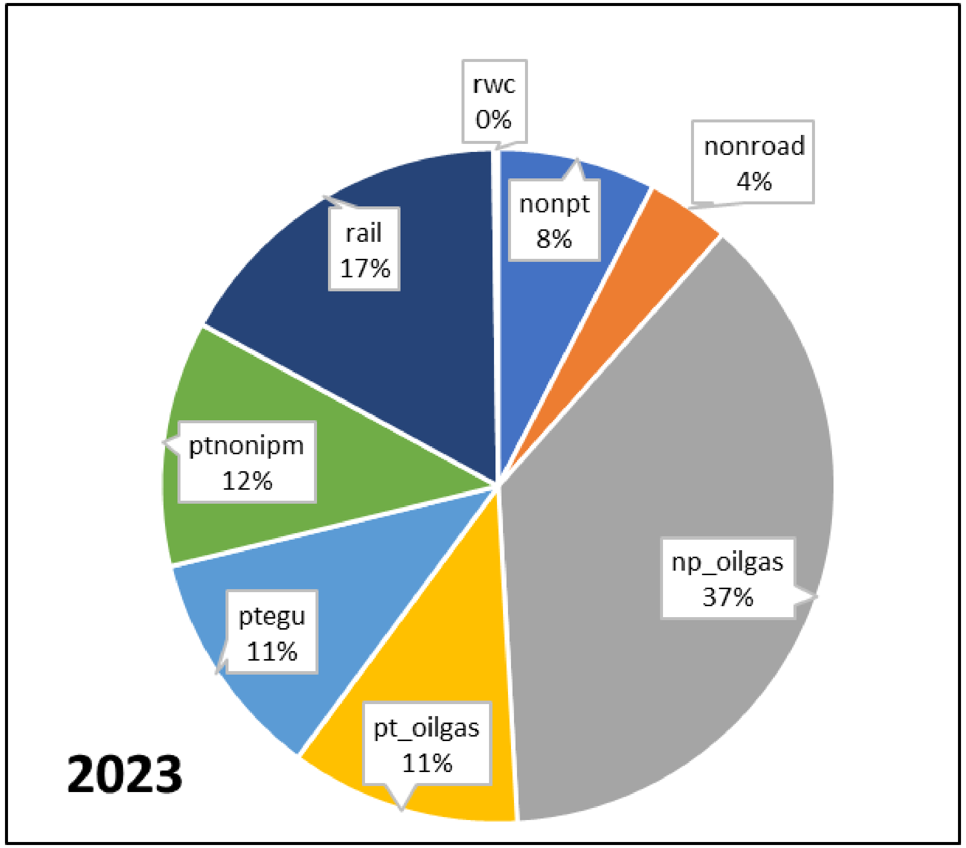
New Mexico Emissions: 2023 vs. 2014 NOx

All anthro source categories except onroad



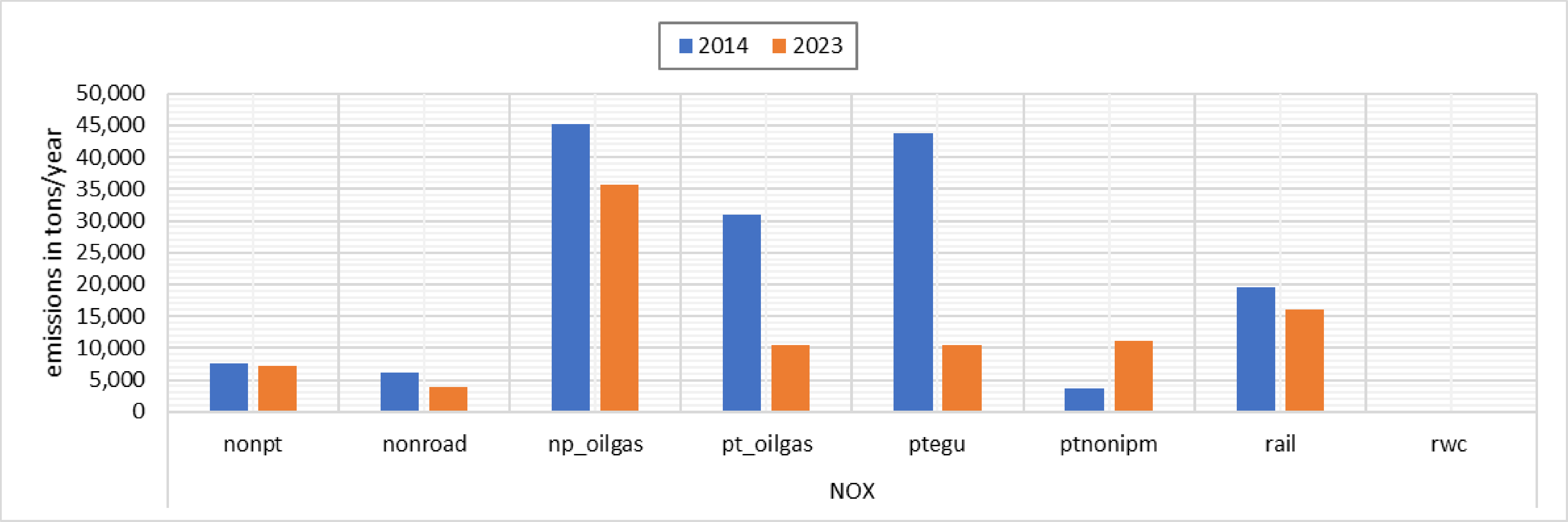


157,415 TPY

95,157 TPY

-62,258 TPY (40%) Reduction

New Mexico Emissions: 2023 vs. 2014 NOx by Source Category



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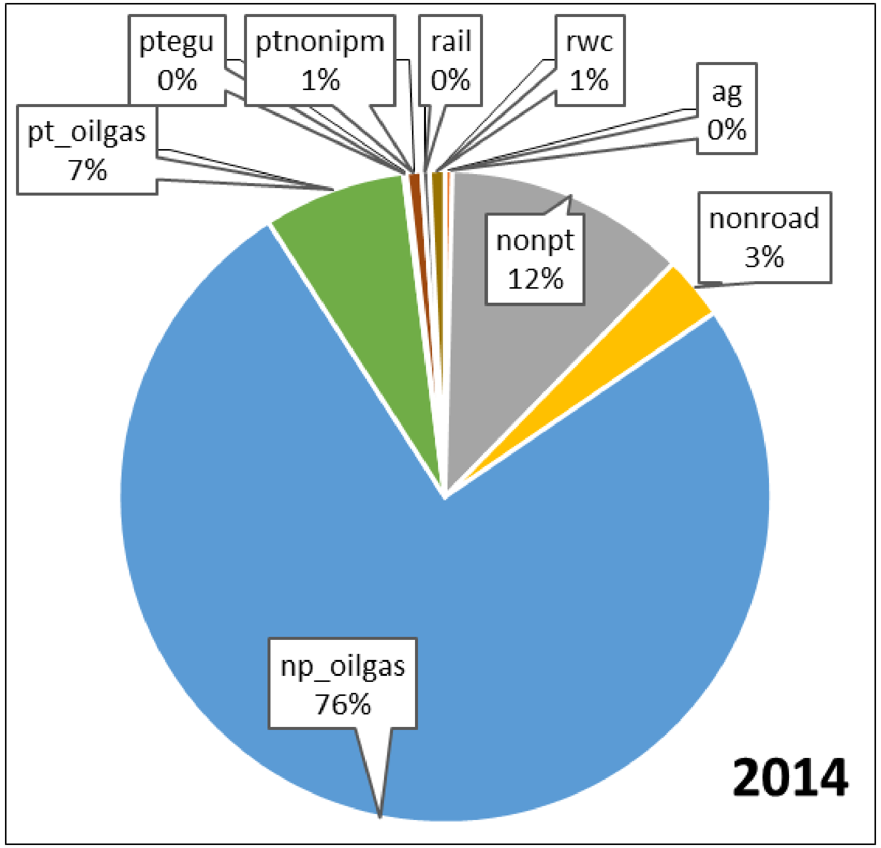
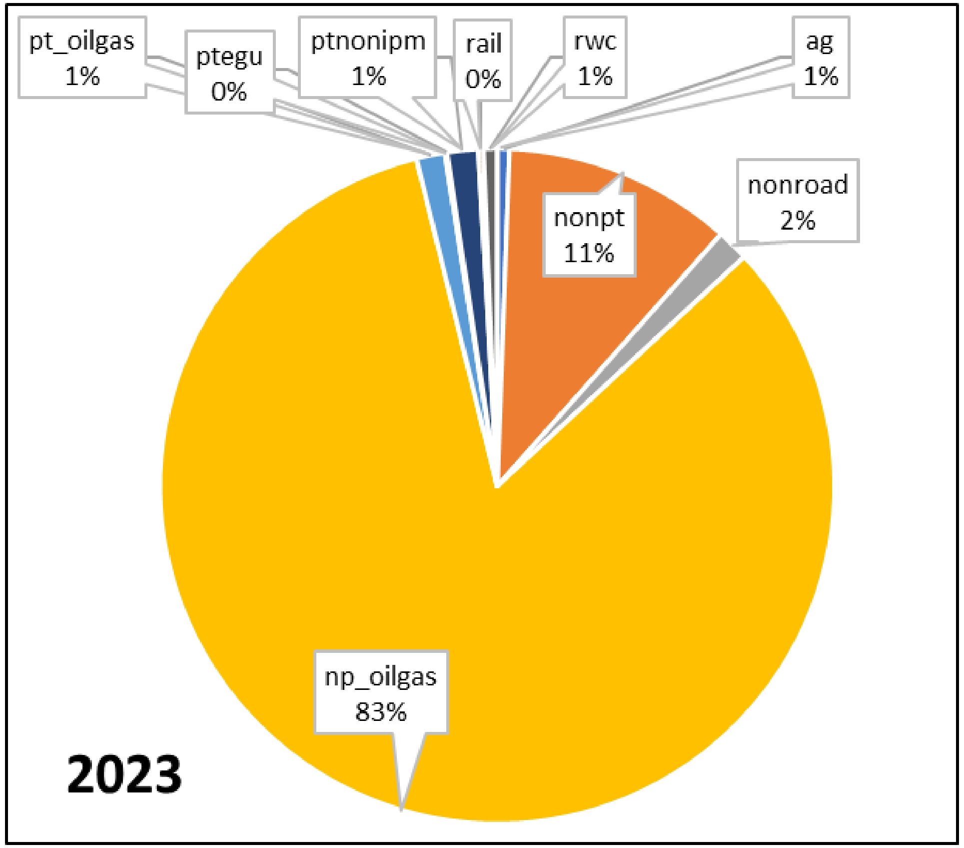
New Mexico Emissions: 2023 vs. 2014 VOC

All anthro source categories except onroad



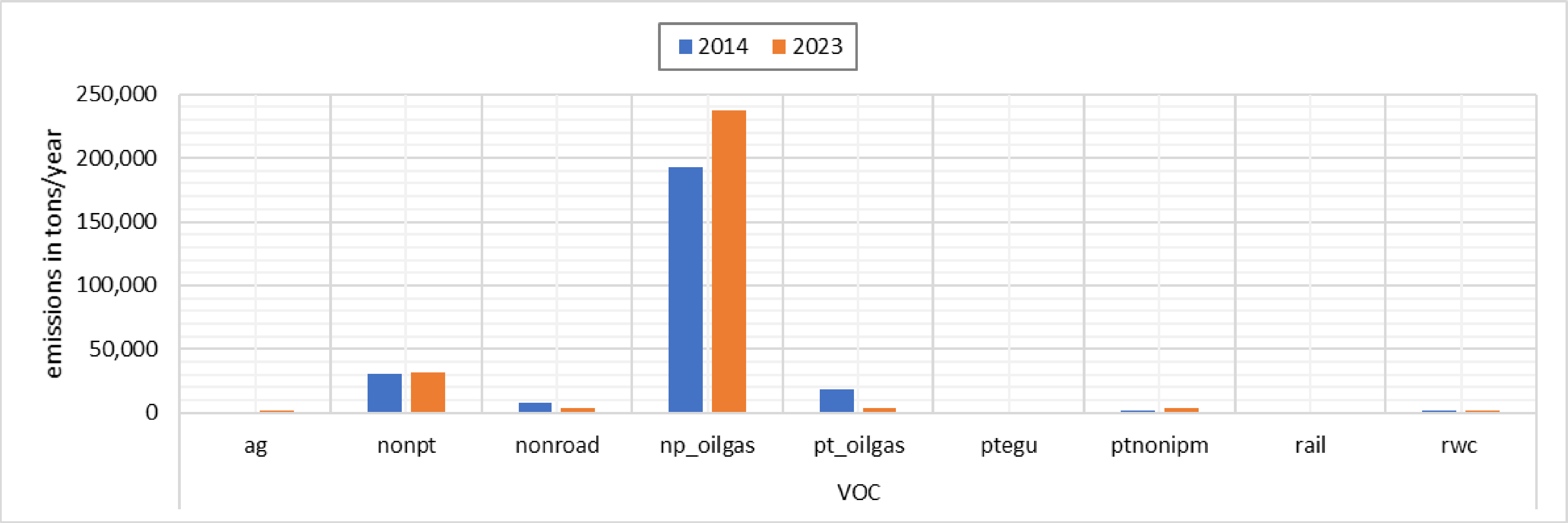
255,765 TPY



285,240 TPY

+29,475 TPY (12%) Increase

New Mexico Emissions: 2023 vs. 2014 VOC by Source Category



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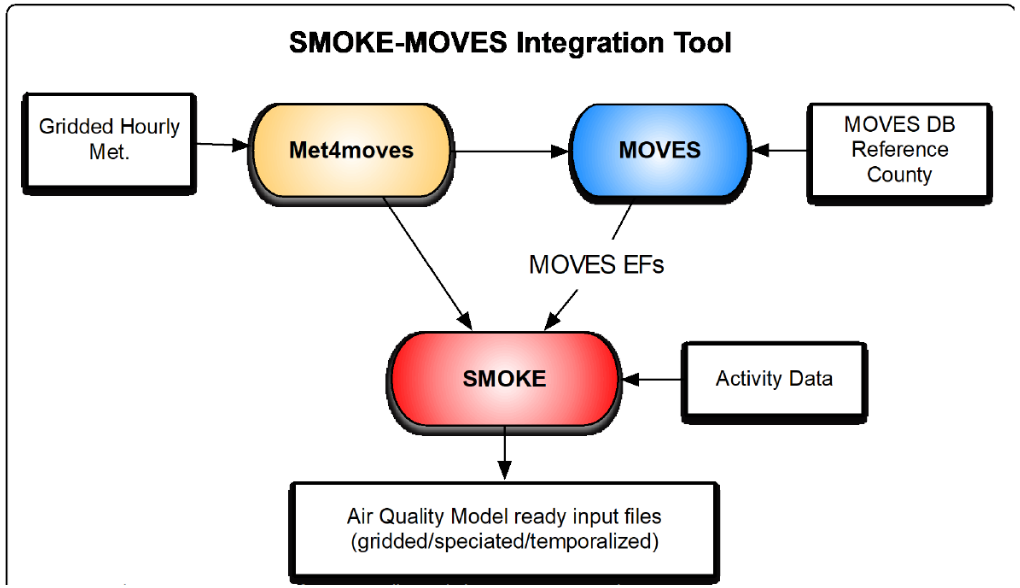
Overview of SMOKE-MOVES Processing

- Requires emission rate “lookup” tables generated by MOVES
  - EPA generated 2014 and 2023 MOVES “lookup” tables for modeling platform
- Uses gridded, hourly, day-specific temperatures
- Emission factors by temperature bin and speed for a series of “representative counties”, to which every other county is mapped



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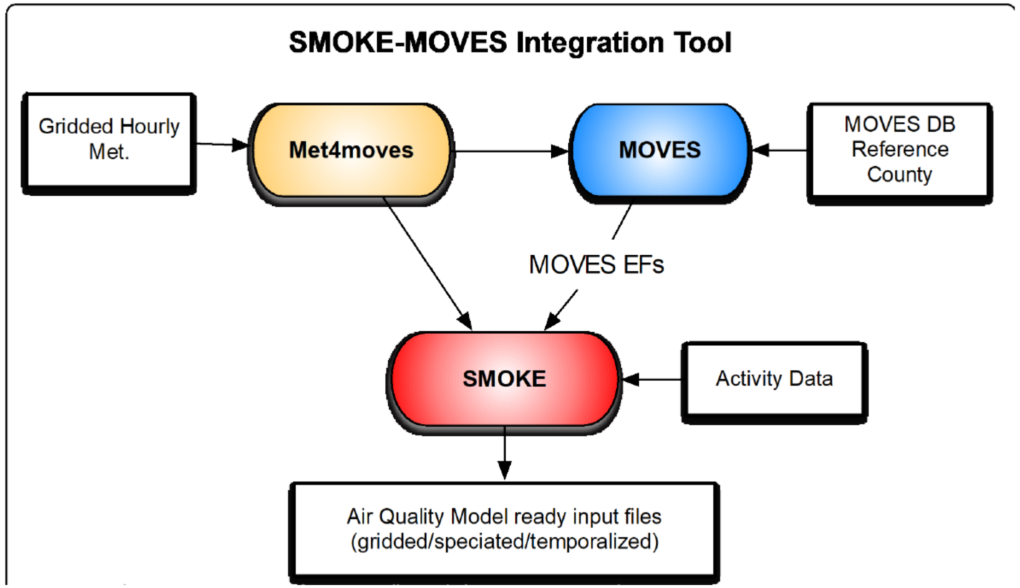
Creating Onroad Emissions using SMOKE-MOVES

- Met4MOVES: Meteorological data preprocessor
- SMOKE processing applies the emission factors to the activity data to compute grid-cell emissions
- Activity Data
  - Vehicle Miles Travelled (VMT)
  - Vehicle Population
  - Extended Idling Hours



Review of On-Road Mobile Source Activity Data

- Activity data from EPA emission modeling platform
- Developed a spreadsheet tool to assist NMED to review activity data for 13 WRAP states
    - Show 2014 and 2023 population and activity of on-road vehicles
- The tab "Dashboard" shows comparisons of vehicle population and VMT by state, vehicle type, fuel type and road type.
- The tab "Scaling_factor" provides ratio of future year/base year activities by state, vehicle type and fuel type.

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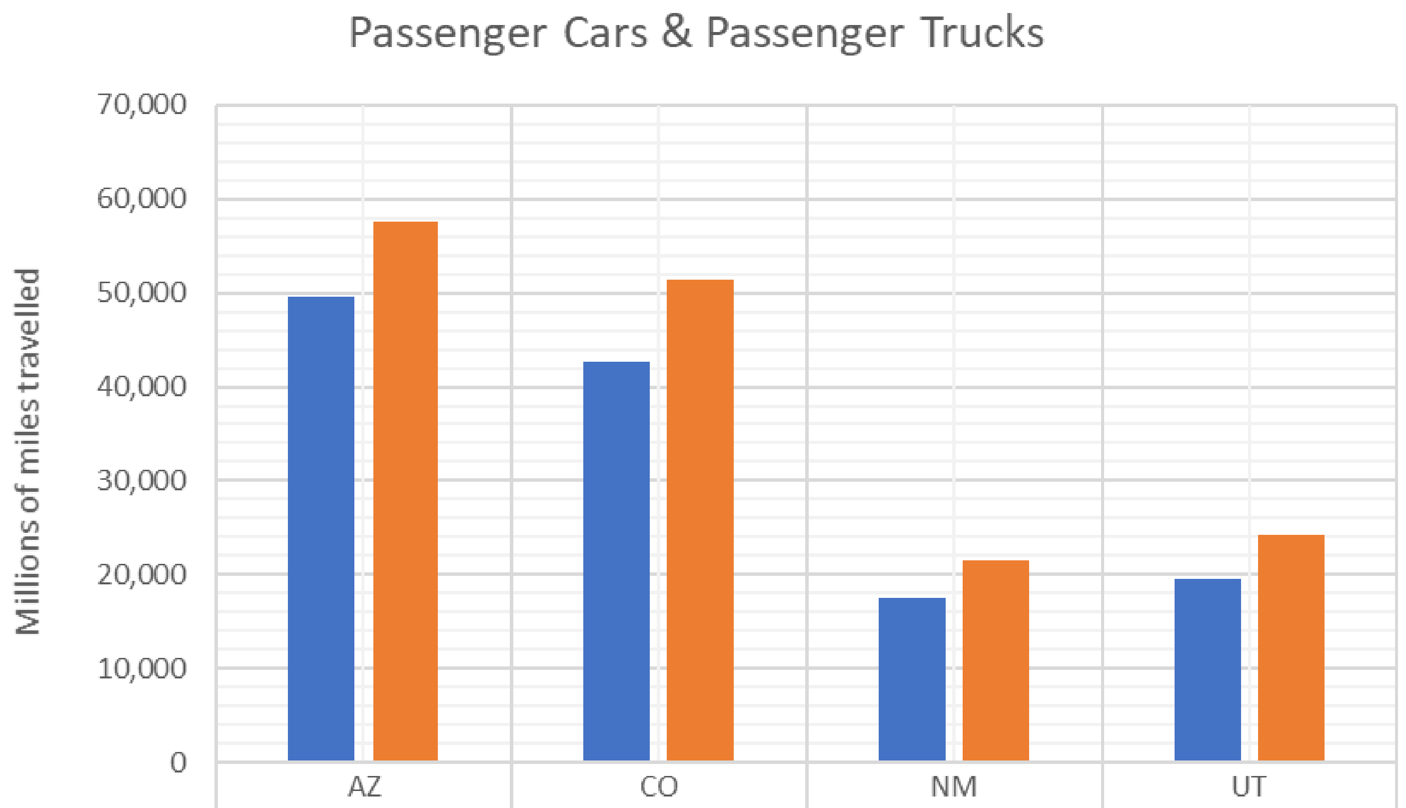
Gasoline Vehicles VMT for NM and Neighboring States

- Gasoline passenger vehicles
- Overall EPA projected 21% VMT increase in 2023 from 2014 for New Mexico



	AZ	CO	NM	UT
VMT - 2014	49,611,302,812	42,612,933,488	17,580,133,527	19,472,109,923
VMT - 2023	57,618,555,325	51,344,327,905	21,417,137,380	24,159,496,567

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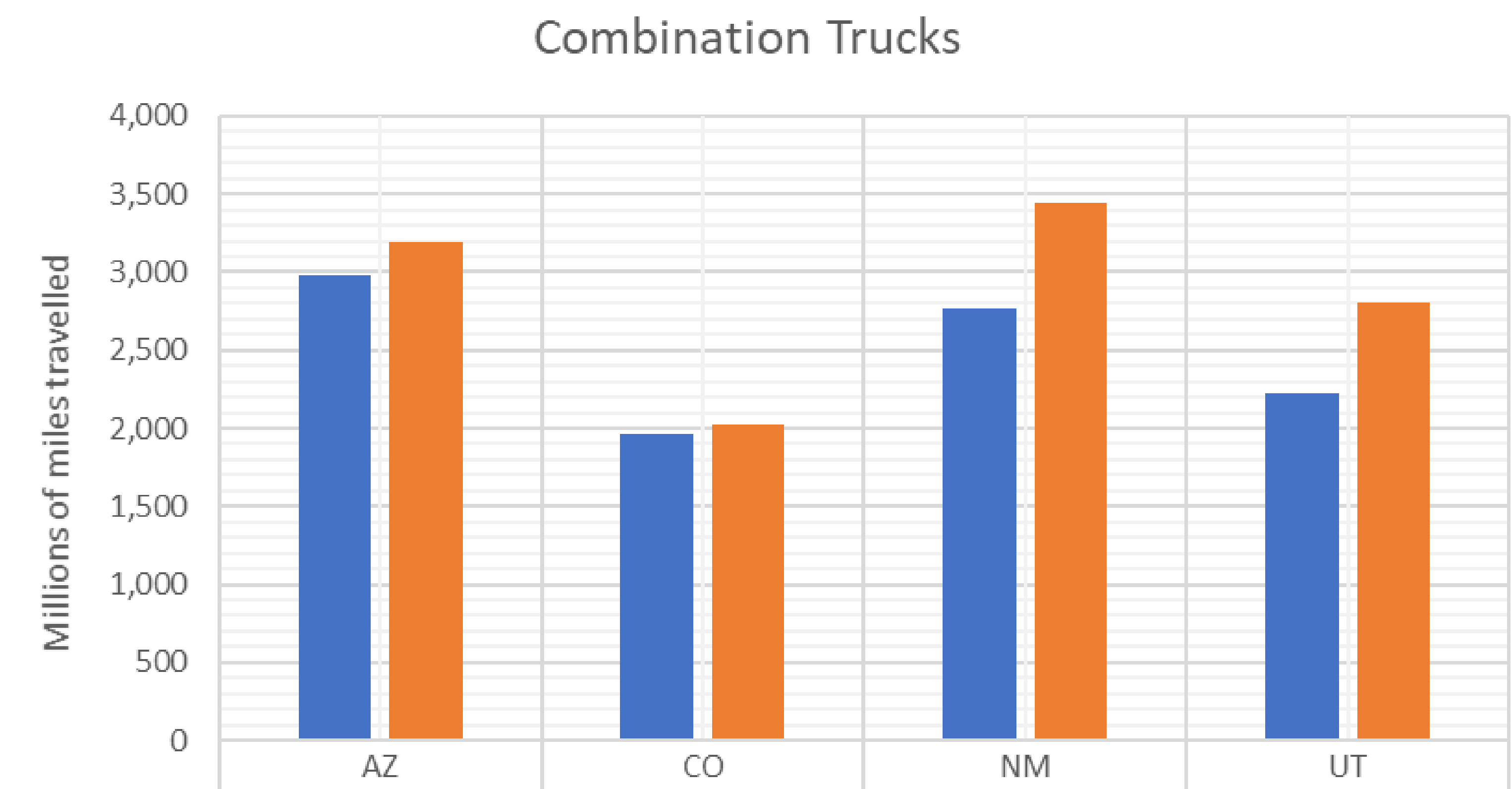
Heavy-Duty Diesel Trucks VMT for NM and Neighboring States

- Heavy-duty diesel truck VMT
- Overall EPA estimated 24% VMT increase in 2023 from 2014



	AZ	CO	NM	UT
VMT - 2014	2,975,833,524	1,962,675,410	2,774,084,652	2,224,748,322
VMT - 2023	3,191,373,208	2,026,076,660	3,445,853,700	2,801,196,117

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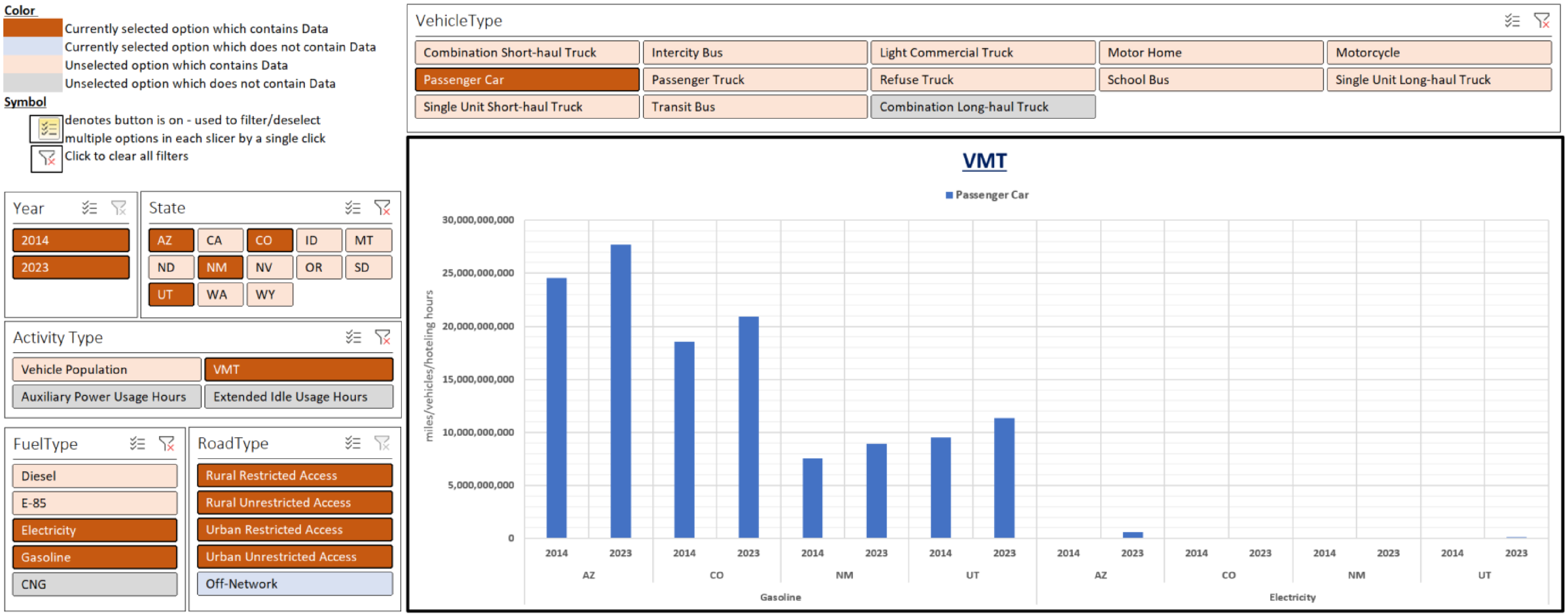
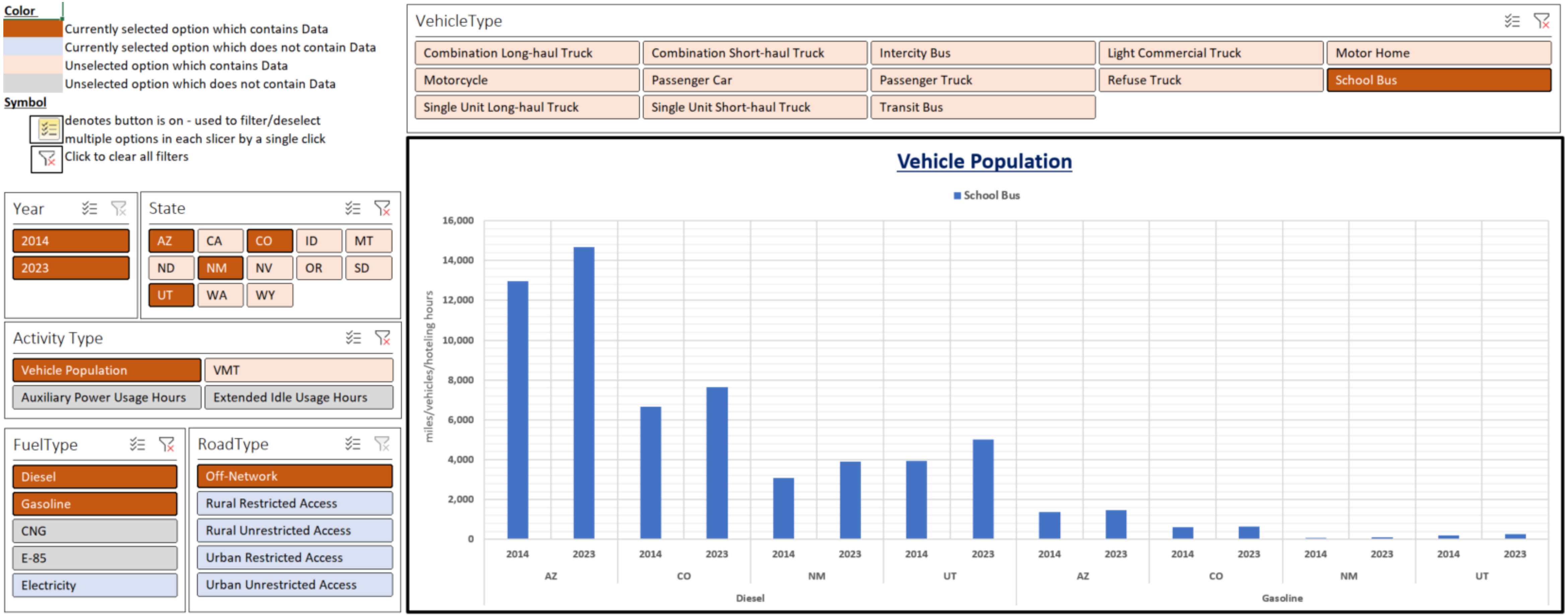
Example Plots that can be Created with the Tool



**Vehicle population data do not vary by road type. To show vehicle population, select Off-Network under road type.

- Gasoline and Electric Passenger car VMT comparison for 2014 and 2023



**Vehicle population data do not vary by road type. To show vehicle population, select Off-Network under road type.

- School bus population comparison for NM, AZ, UT and CO by fuel type

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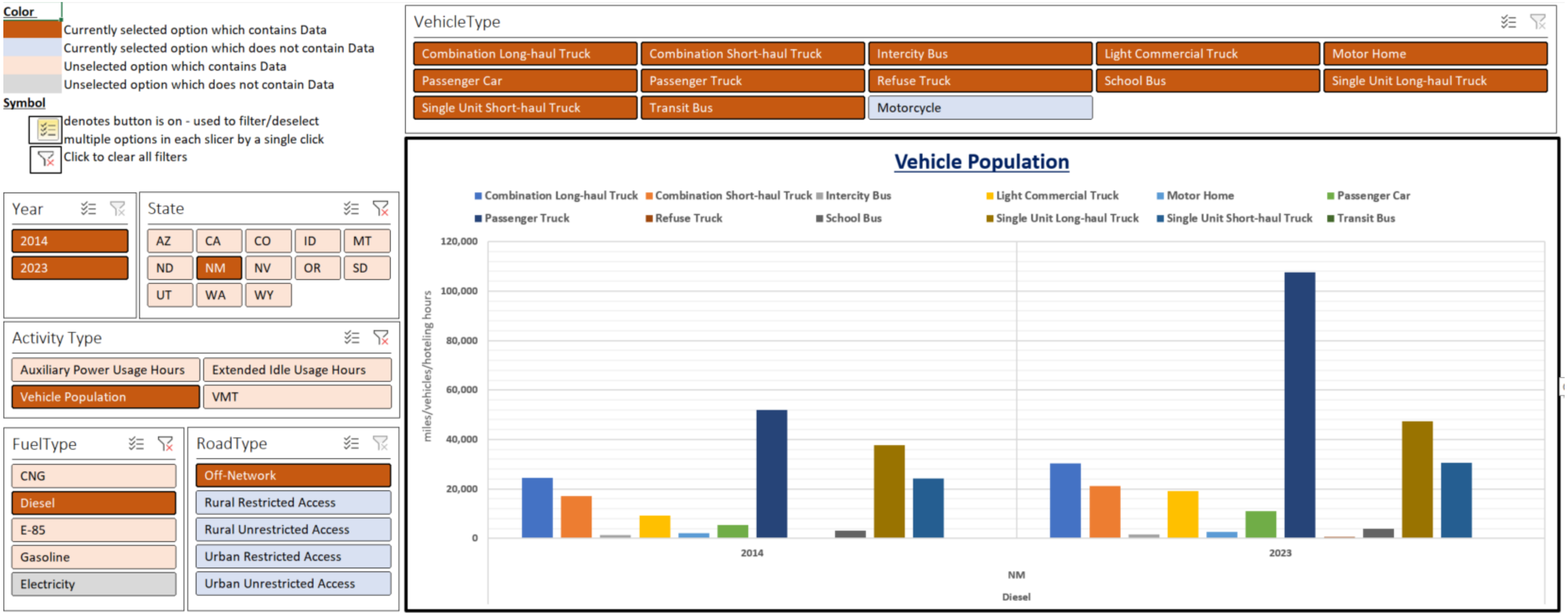

**Vehicle population data do not vary by road type. To show vehicle population, select Off-Network under road type.

- NM diesel vehicle population by vehicle type

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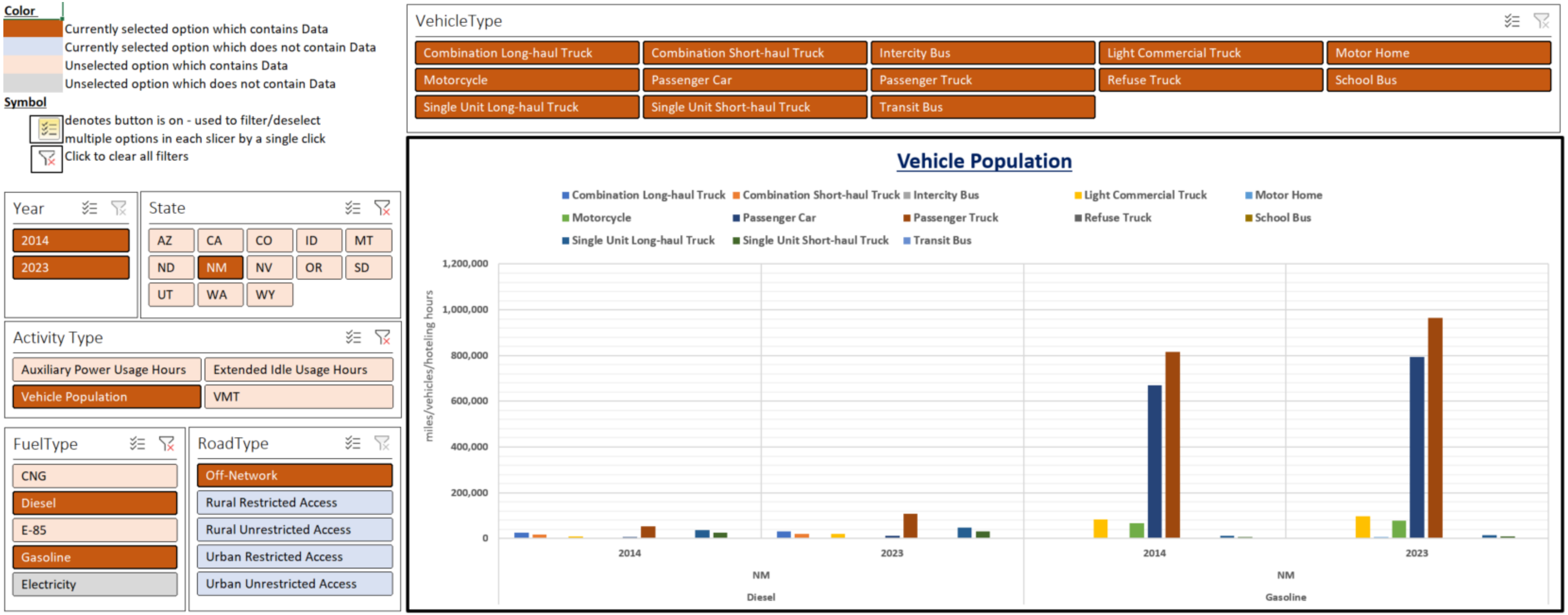
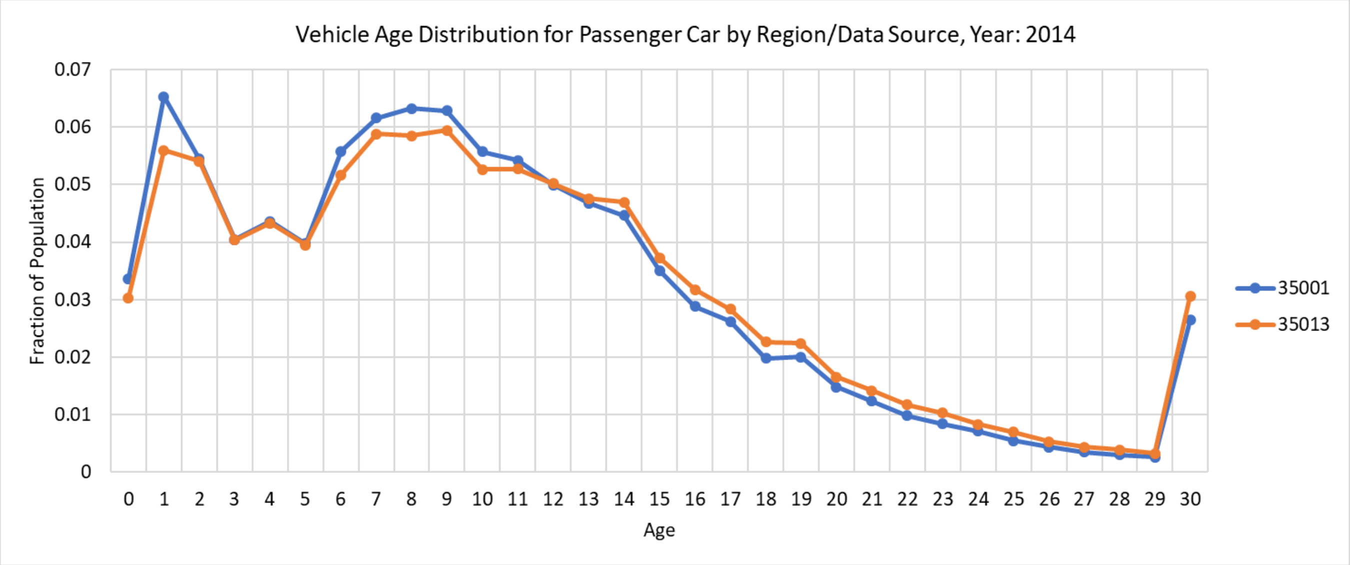


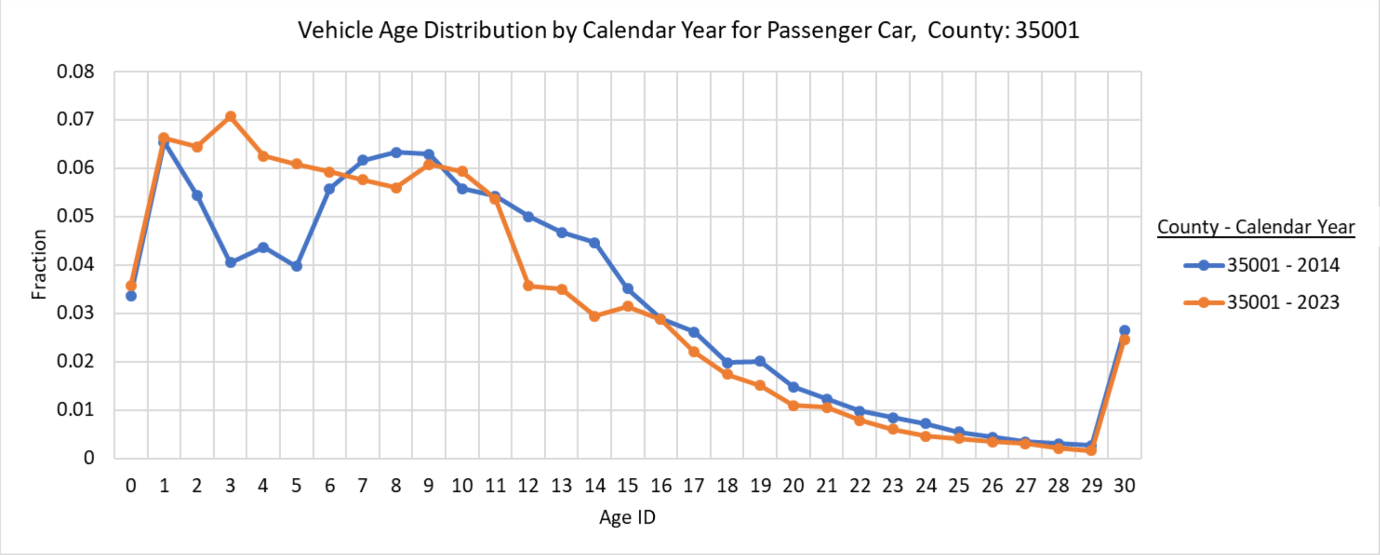
**Vehicle population data do not vary by road type. To show vehicle population, select Off-Network under road type.

- NM diesel and gasoline vehicle population by vehicle type

MOVES Inputs: Vehicle Age Distribution

- Vehicle age distribution for passenger cars
- The last bin of age distribution represents vehicles 30 year and older





RAMBOLL

MOVES Inputs: I&M Coverage

Inspection and Maintenance Coverage (imcoverage table)

Source: MOVES2014b defaults

Rep county affected	Calendar Year	Program Test	Range of ModelYears affected	Pollutant_Emissions Process Affected	Compliance Factor (%)* Passenger Car_Gasoline	Light Commercial Truck_Gasoline	Passenger Truck_Gasoline	Light Commercial Truck_Ethanol	Passenger Car_Ethanol	Passenger Truck_Ethanol	Single Unit Short-haul Truck_Gasoline	Single Unit Short-haul Truck_Ethanol
35001	2014	**Exhaust OBD** Check**	1996_2012	CO_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				CO_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				NOx_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				NOx_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
		Evaporative Gas Cap Check	1975_2006	THC_Evap Fuel Vapor Venting							93.1	93.1
			1975_1995	THC_Evap Fuel Vapor Venting	93.1	93.1	93.1	93.1	93.1	93.1		
		Two-mode, 2500 RPM/Idle Test	1975_1995	CO_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				CO_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
		Evaporative System OBD Check	1996_2012	THC_Evap Fuel Vapor Venting	93.1	93.1	93.1	93.1	93.1	93.1		
			2007_2012	THC_Evap Fuel Vapor Venting							93.1	93.1
	2023	**Exhaust OBD Check**	1996_2021	CO_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				CO_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				NOx_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				NOx_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
		Evaporative Gas Cap Check	1975_2006	THC_Evap Fuel Vapor Venting							93.1	93.1
			1975_1995	THC_Evap Fuel Vapor Venting	93.1	93.1	93.1	93.1	93.1	93.1		
		Two-mode, 2500 RPM/Idle Test	1975_1995	CO_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				CO_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Running Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
				THC_Start Exhaust	93.1	93.1	93.1	93.1	93.1	93.1	93.1	93.1
		Evaporative System OBD Check	1996_2021	THC_Evap Fuel Vapor Venting	93.1	93.1	93.1	93.1	93.1	93.1		
			2007_2021	THC_Evap Fuel Vapor Venting							93.1	93.1

Note: CDBs from 2016v1 and 2014v7.1 platforms did not include local/state IM coverage information. Platforms used MOVES defaults data where available.
MOVES2014b default database includes I/M coverage information only for Rep County 35001, other counties would be assumed to not have I/M program.
*The compliance factor represents the percentage of vehicles within a source type that actually receive the benefits of the program
**On-Board Diagnostics (OBD)

NM OAI Study Next Steps

Next Up in June 2020

- A little ahead of schedule (Task 3 completed month early)
- Need comments from NMED on Modeling Protocol and Work Plan
- Need approval from NMED to proceed with WRAP 2014v2 and EPA 2023 New Mexico emissions and mobile source assumptions
- Task 2.2 WRF modeling simulation will be finished in early June.
    - Conduct MPE and CAMx sensitivity test modeling
- Task 3 Evaluate BC data completed a month ahead of schedule (May instead of Jun)
- Task 4 -- Would like to start 2014 SMOKE and SMOKE-MOVES emissions modeling in June