Western Regional Air Partnership (WRAP) briefing on the WestJumpAQMS for CenSARA and EPA Region 6

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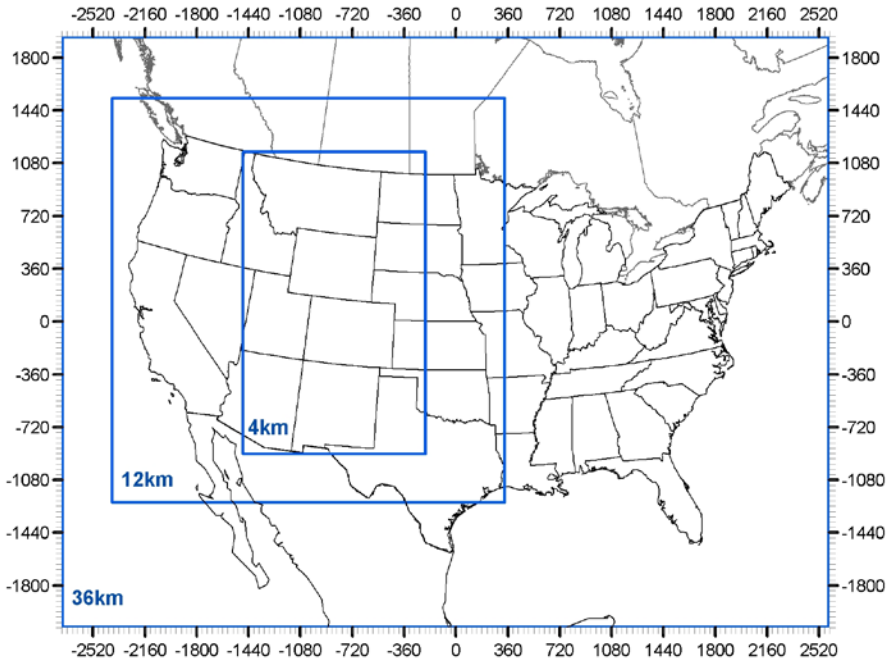
Introduction

- West-wide Jump-start Air Quality Modeling Study (WestJumpAQMS) was initiated to:
  - Develop the next generation of regional air quality modeling databases for ozone, $PM_{2.5}$, visibility and deposition planning in the western U.S.
  - Provide information on the role of interstate and international transport to ozone and $PM_{2.5}$ under current and potential future NAAQS
  - Assess contributions of major source categories (e.g., Points, O&G, mobile etc.) to air quality in the west
  - Provide detailed information to the community

Overview of Approach

- 2008 Modeling Database
  - 36 km CONUS; 12 km WESTUS; 4 km IMWD
- WRF meteorological; CAMx photochemical; SMOKE emissions models
- 2008 WRAP Phase III O&G emissions
- 2008 NEI emissions
- Model Evaluation
- Sensitivity Tests



Modeling Domain

- State-Specific and Source Category-Specific Ozone and $PM_{2.5}$ Source Apportionment Modeling

WestJumpAQMS Products

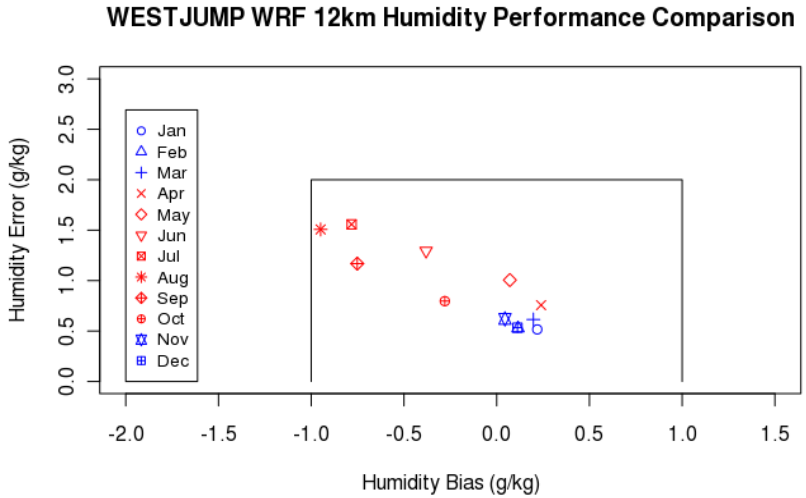
Information on WestJumpAQMS website:

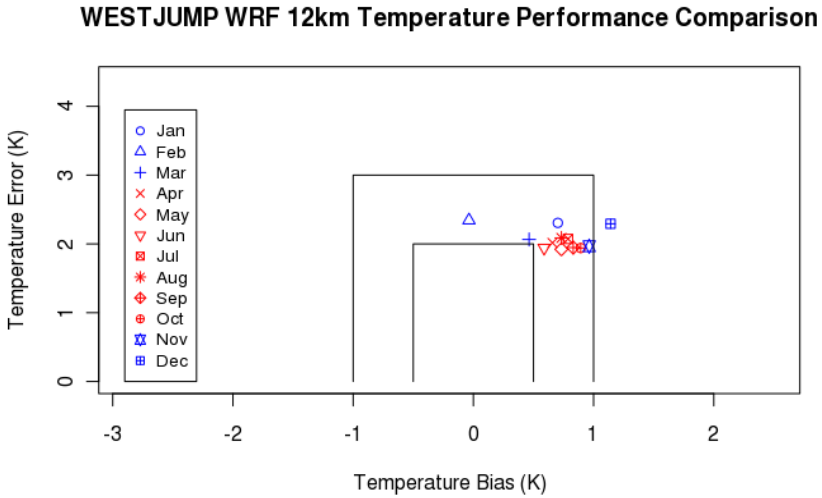
- Final Report
  - 15 Electronic Appendices
  - Response-to-Comments (in preparation)
- Ammonia Emissions Recommendations Memo
- Modeling Protocol
  - Response-to-Comments
- WRF Application/Evaluation Report
  - Evaluation down to individual monitoring site
  - Response-to-Comments
- 16 Technical Memorandums on Emissions
  1. Point Sources
  2. Area + Non-Road
  3. On-Road Mobile
  4. Oil and Gas (5 sections)
  5. Fire (WF, Rx & Ag)
  6. Fugitive Dust
  7. Off-Shore Shipping
  8. Ammonia
  9. Biogenic
  11 Mexico/Canada
  12. Sea Salt and Lighting
  13. Emissions Modeling Parameters

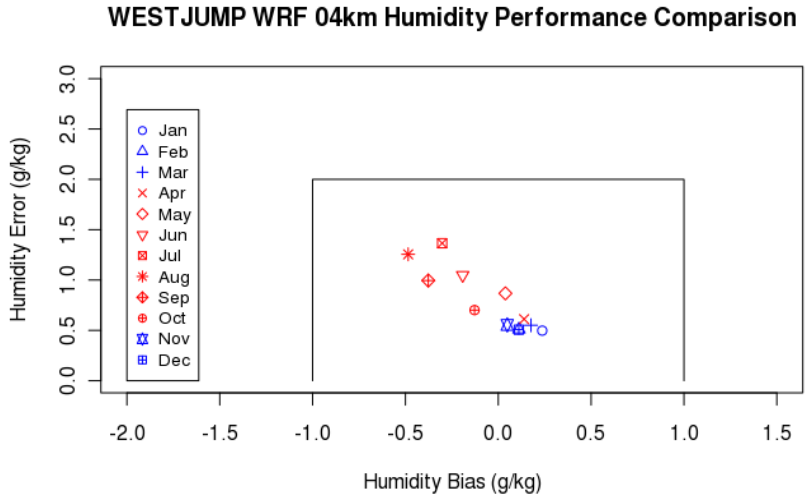
WRF Meteorological Modeling

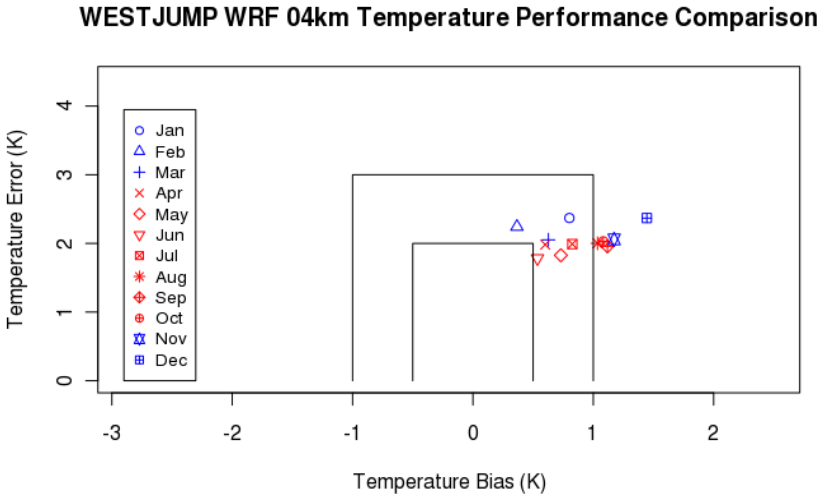
- 2008 36/12/4 km Application/Evaluation
- Sensitivity tests to improve model performance
- WRF Model Performance Evaluation
  - Quantitative evaluation against surface wind speed and direction, temperature and mixing ratio
    - 36 CONUS, 12 WESTUS and 4 IMWD km domains
    - By State and individual site in 4 km IMWD
    - Comparison against Meteorological Model Performance Goals: Simple and Complex
  - Qualitative evaluation comparing monthly precipitation totals against CPC analysis fields based on observations

WRF Humidity and Temperature 12/4 km

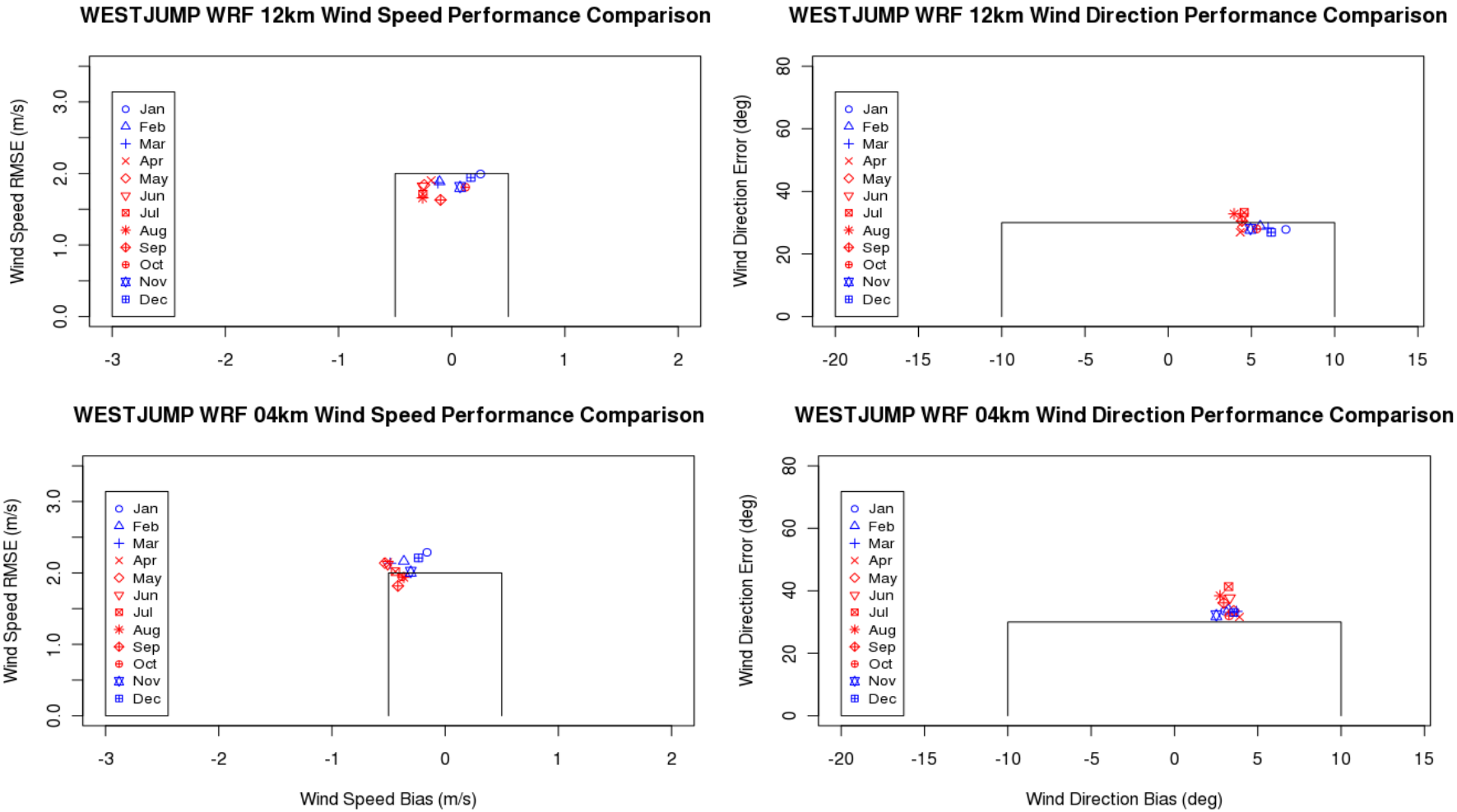






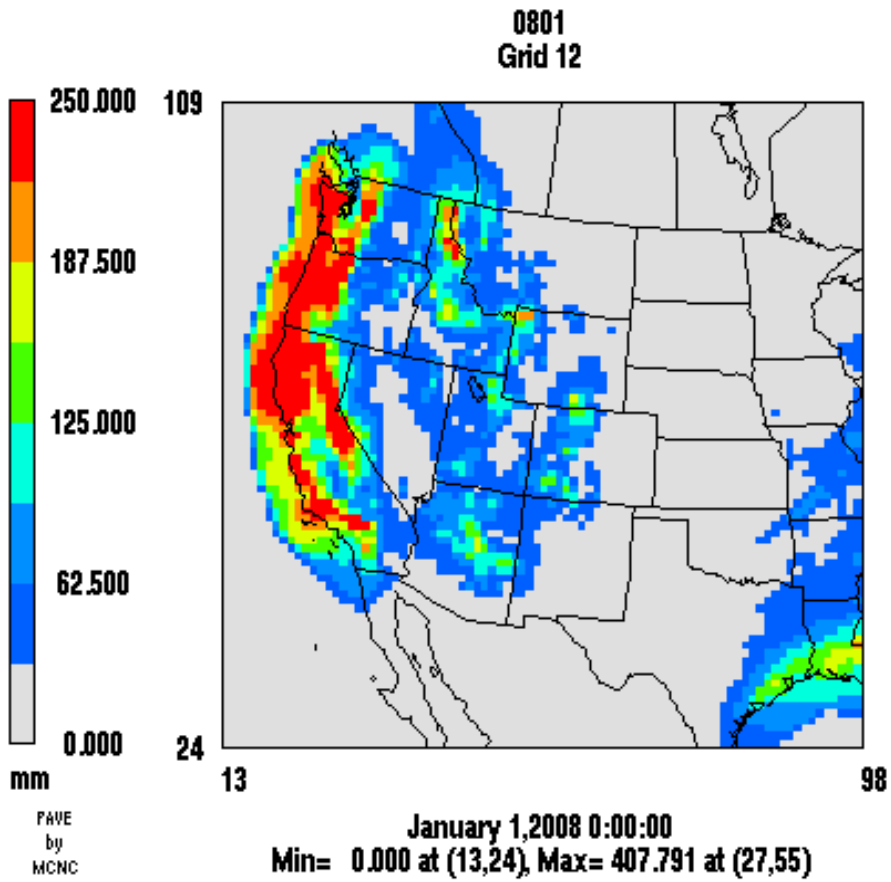


WRF Wind Speed and Direction 12/4 km

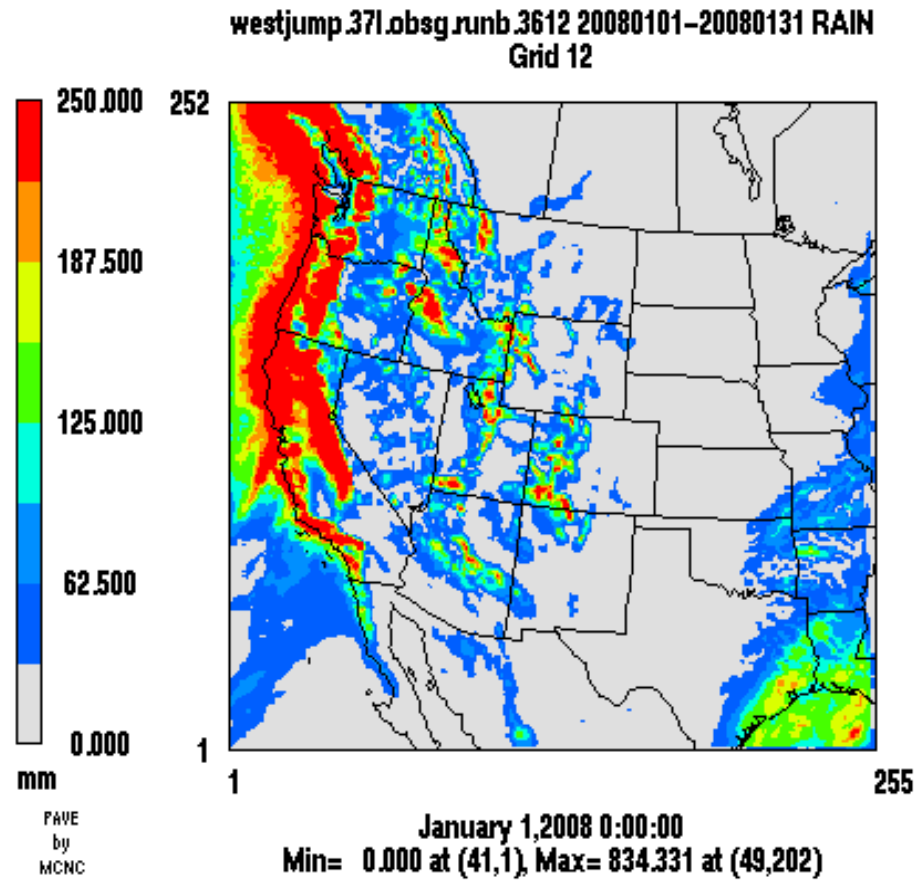


WRF January Precipitation 12 km

CPC Precip



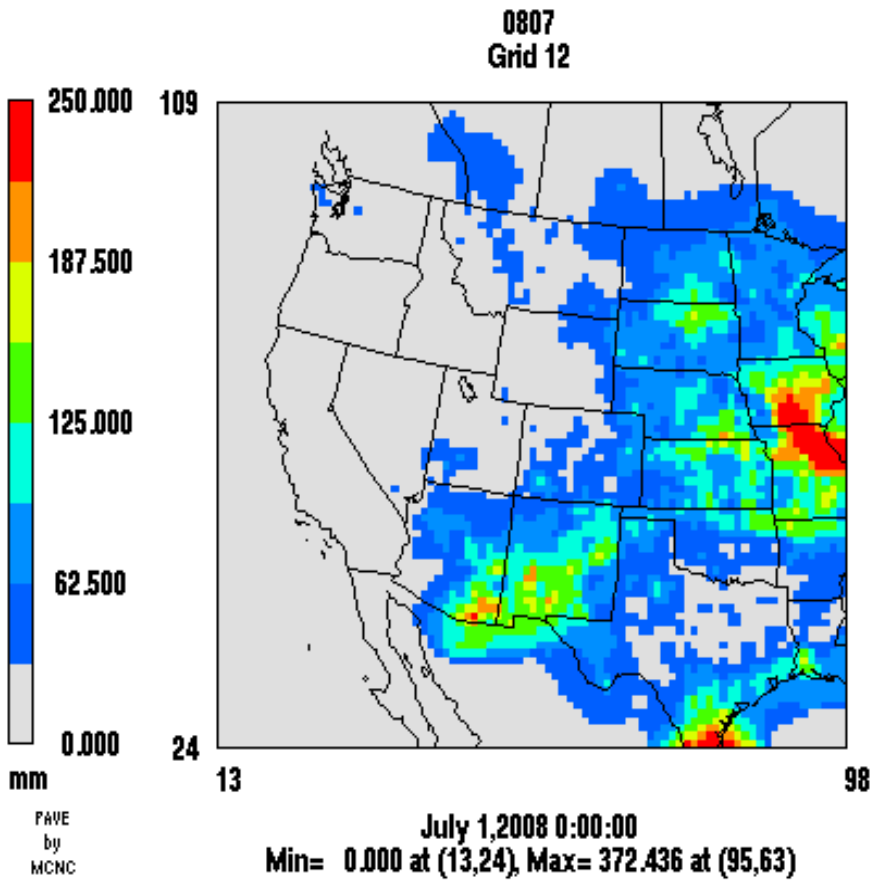
WRF Precip



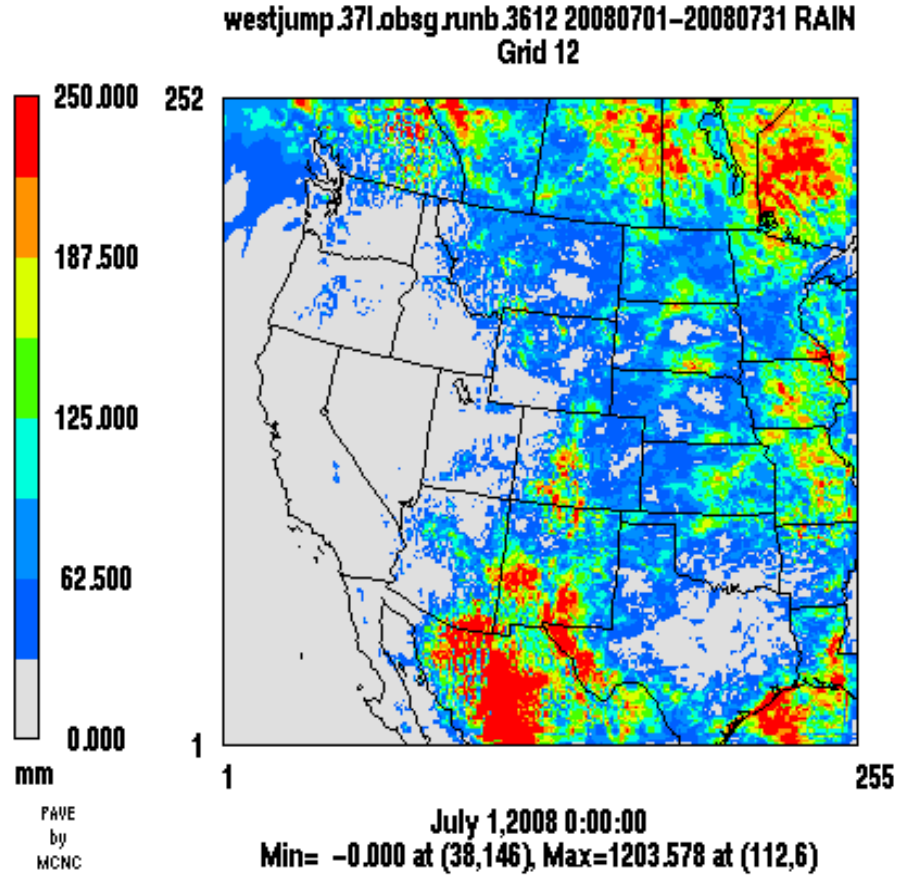
Note: CPC does not include precipitation over non-USA

WRF July Precipitation 12 km

CPC Precip



WRF Precip



Note: CPC does not include precipitation over non-USA

WRF Model Performance Conclusions

- WRF 2008 performance in Rocky Mountains better than exhibited by MM5 in past
- Humidity achieves simple performance goals with a dry bias in summer
- Temperature bias falls between Simple/Complex goal with 0.5-1.0 K warm bias
- Wind speed and direction achieves Simple goal for bias and mostly Simple goal for error
  - Slight slow wind speed bias in 4 km domain
- Precipitation patterns match CPC analysis fields well
  - Winter performance better than summer

2008 Emissions Modeling

- WRAP Phase III O&G for Basins in CO,NM, UT & WY
- New Permian Basin O&G using Phase III Methodology
- On-Road Mobile based on MOVES2010a (EMFAC2011)
- Day-specific hourly emissions for large point sources with CEMS data
  - Screened for data filling
- Remainder Anthropogenic based on 2008 NEI
  - Non-Road, Point, Area, O&G outside of WRAP Phase III
- MEGAN Biogenic
  - Recent WRAP updates
- Windblown Dust
  - WRAP WB Model
- Sea Salt and Lightning
- DEASCO$_3$ Fires
  - FINN Base08a
- SMOKE V3.1 emissions model
- New Spatial Surrogates based on 2010 Census
- Chemical speciation using CB05 & CB6 chemical mechanism
- QA/QC

CAMx Model Performance Evaluation

- Ozone model performance
  - Comparison of predicted and observed daily maximum 8-hour ozone concentrations (DMAX8)
    - WRAP State scatterplots and performance statistics
    - Comparison against goals for Bias (≤±15%) and Error (≤35%)
- PM model performance
  - $PM_{2.5}$ mass and speciated $PM_{2.5}$ (SO4, NO3, NH4, EC, OA & OPM2.5)
  - 36 km and 12 km domain and by state

Fractional Bias (FB)	Fractional Error (FE)	Comment
≤±15%	≤35%	Ozone Model Performance Goal
≤±30%	≤50%	PM Model Performance Goal
≤±15%	≤35%	PM Model PerformanceCriteria.

- Performance across 4 km CARMMS (CO) modeling domain
  - Ozone, $PM_{2.5}$, precursor and other species

CAMx 2008 36/12 km Base08c Ozone MPE

- Ozone Model Performance Goals
  - Bias ≤ ±15% and Error ≤ 35%
  - Original EPA (1991) guidance used Mean Normalized Bias (MNB) and Gross Error (MNGE)

$$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i - O_i)}{O_i}$$

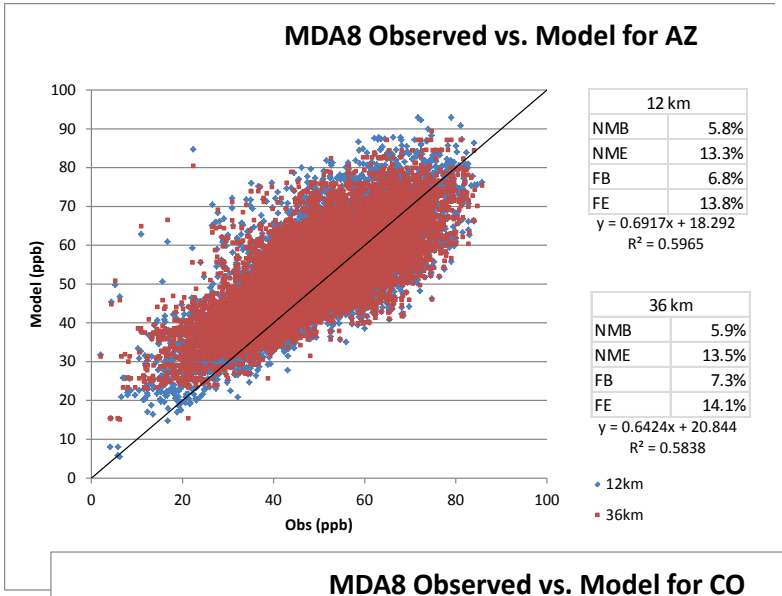
  - Simon, Baker and Philips (2012):
    - Don't recommend MNB as not balanced and can blow up at low observed concentrations so recommend:
  - Fractional Bias (FB):

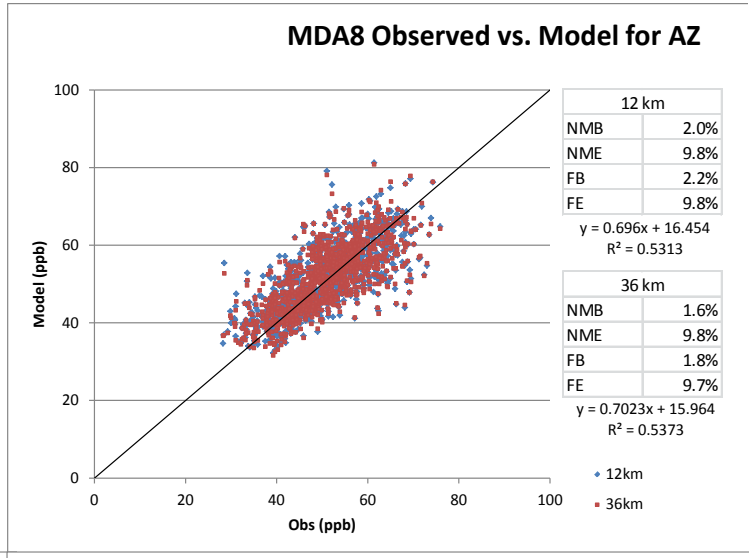
$$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i - O_i}{P_i + O_i}\right)$$

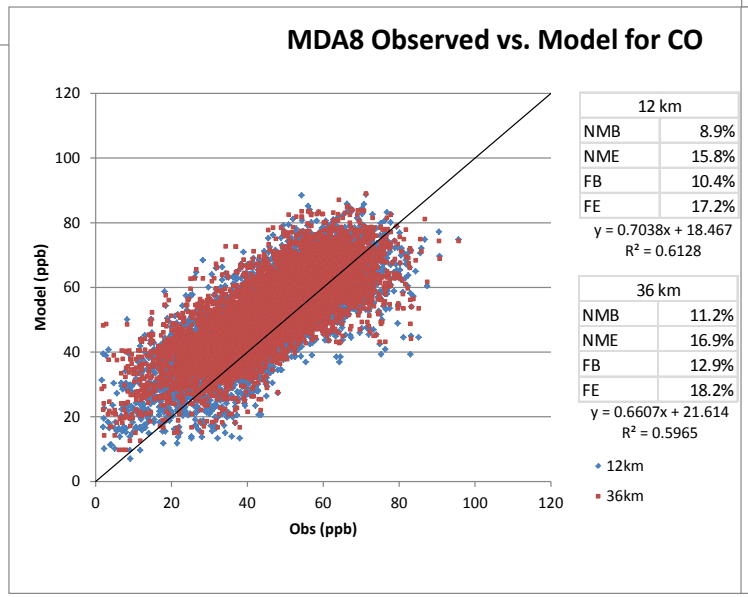
    - Bounded (≤±200%)
  - Normalized Mean Bias (NMB):

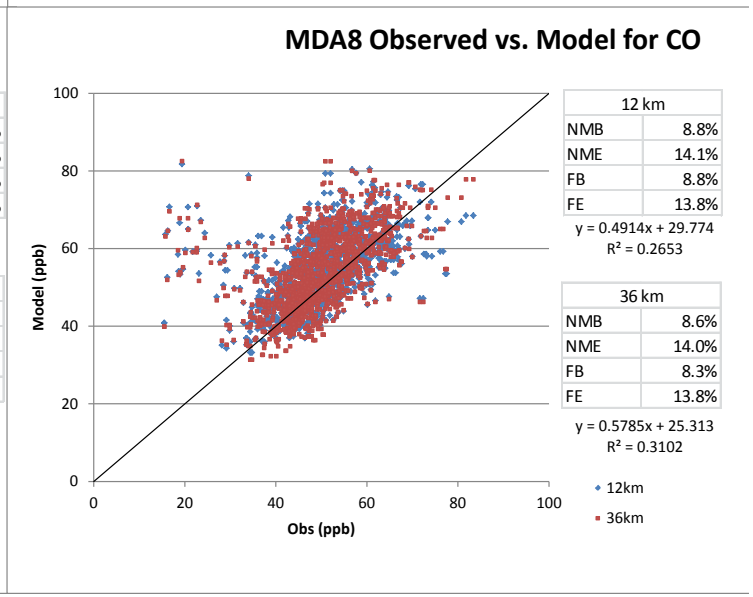
$$\frac{\sum_{i=1}^{N}(P_i - O_i)}{\sum_{i=1}^{N}O_i}$$

CAMx 36/12 km DMAX8 AZ & CO









AZ

Bias

6-7% AQS

2% CNet

Error

13-14% AQS

10% CNet

CO

Bias

9-13% AQS

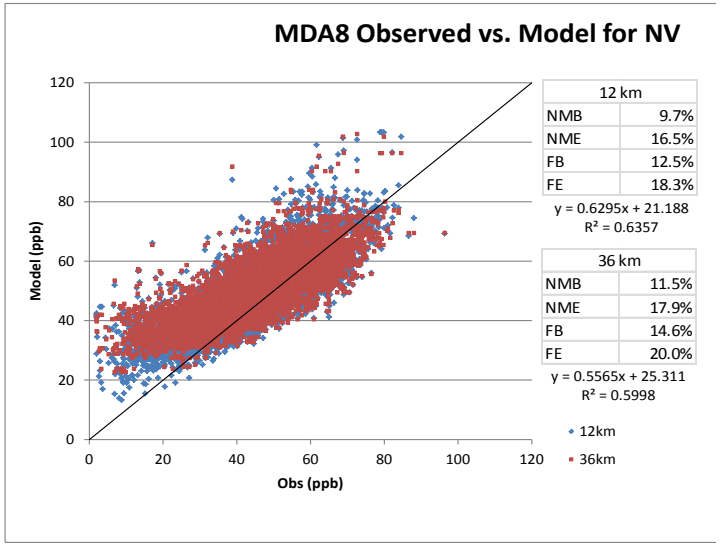
8-9% CNet

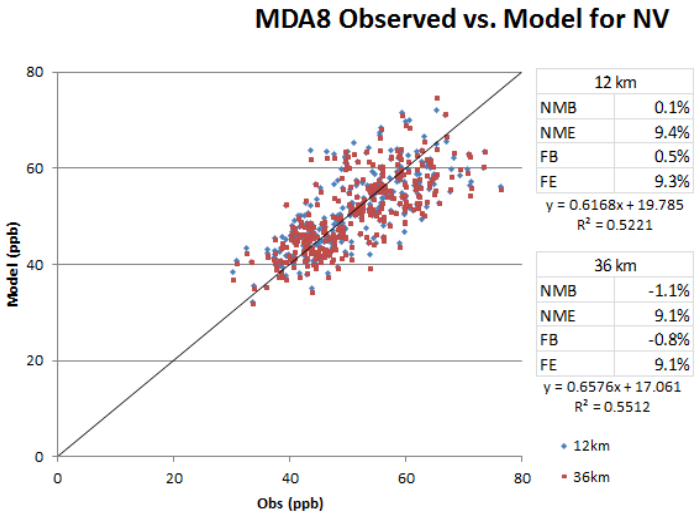
Error

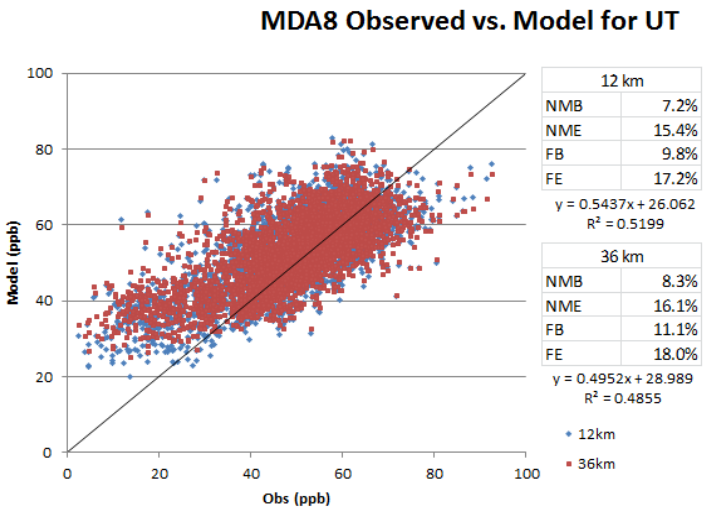
16-18% AQS

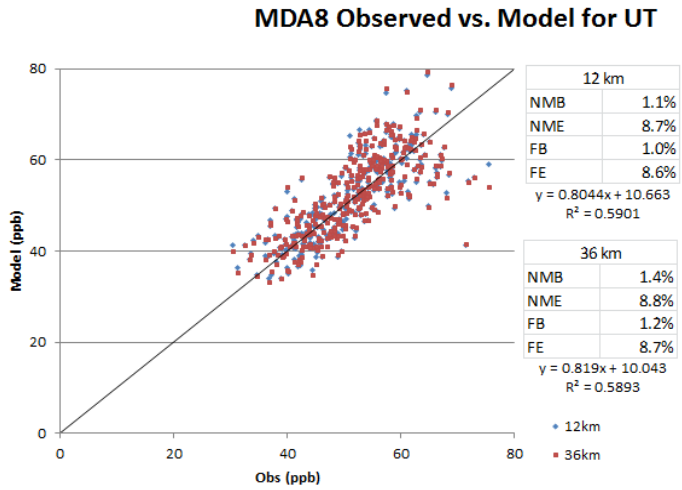
14% CNet

CAMx 36/12 km DMAX8 NV & UT









NV

Bias

10-15% AQS

-1-1% CNet

Error

17-20% AQS

9% CNet

UT

Bias

7-11% AQS

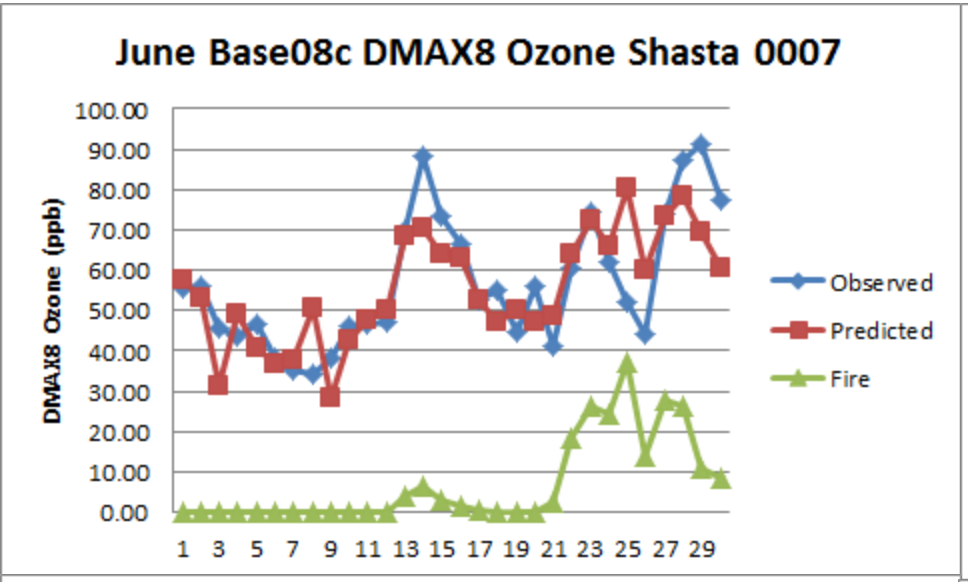
1% CNet

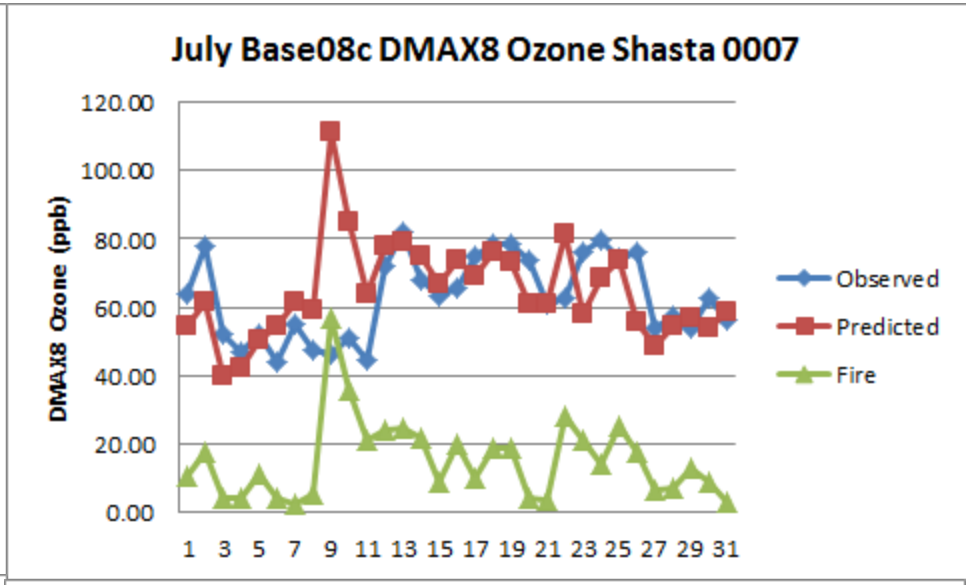
Error

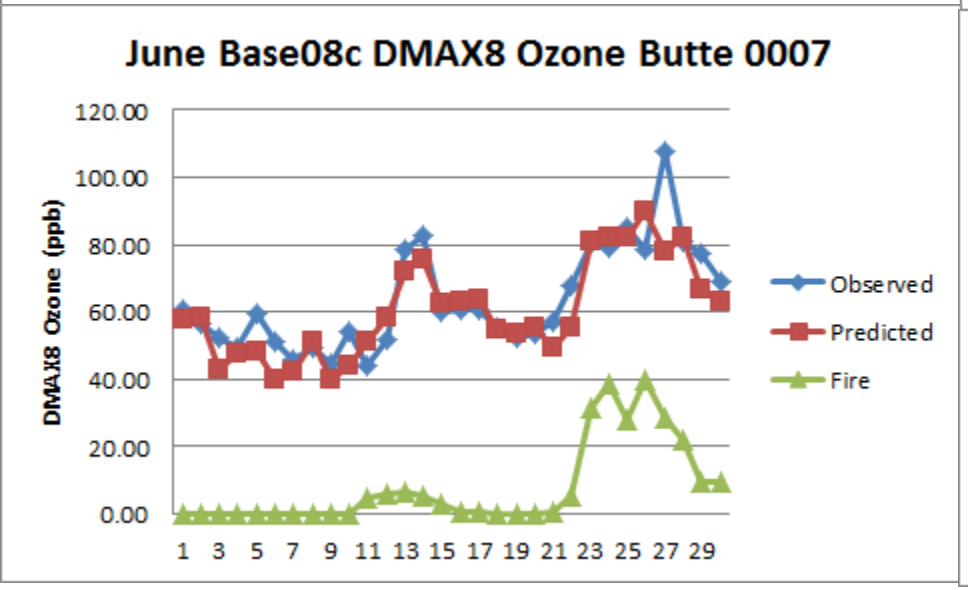
15-18% AQS

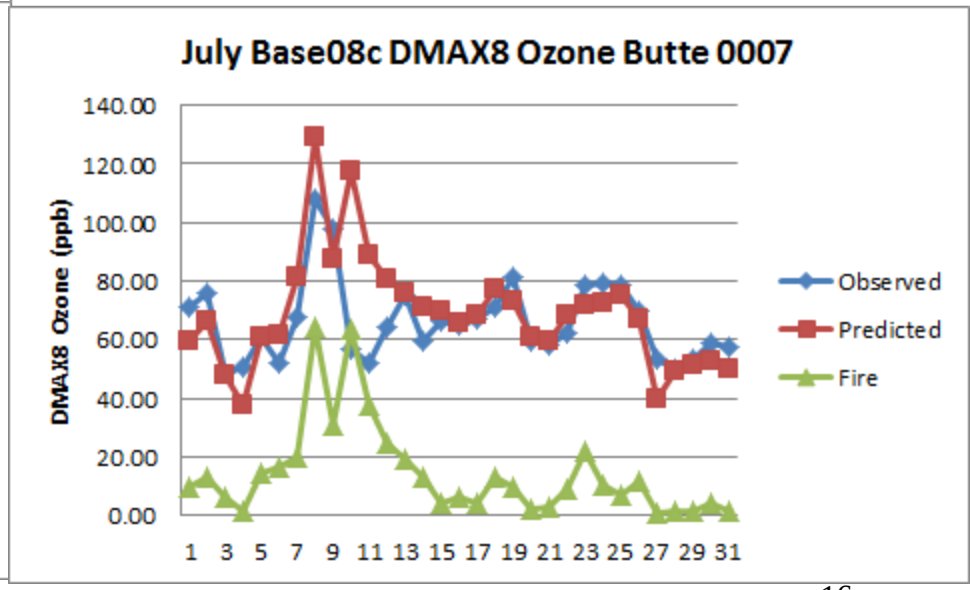
9% CNet

Northern California Wildfires Jun-Jul 2008





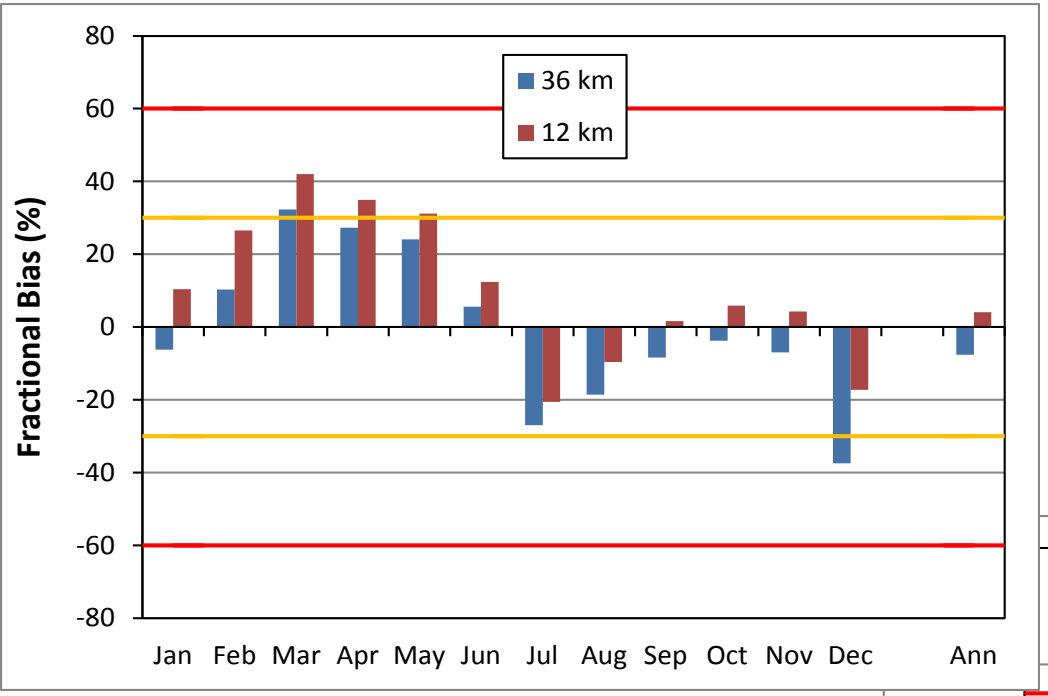




CAMx 2008 36/12 km Ozone Model Performance

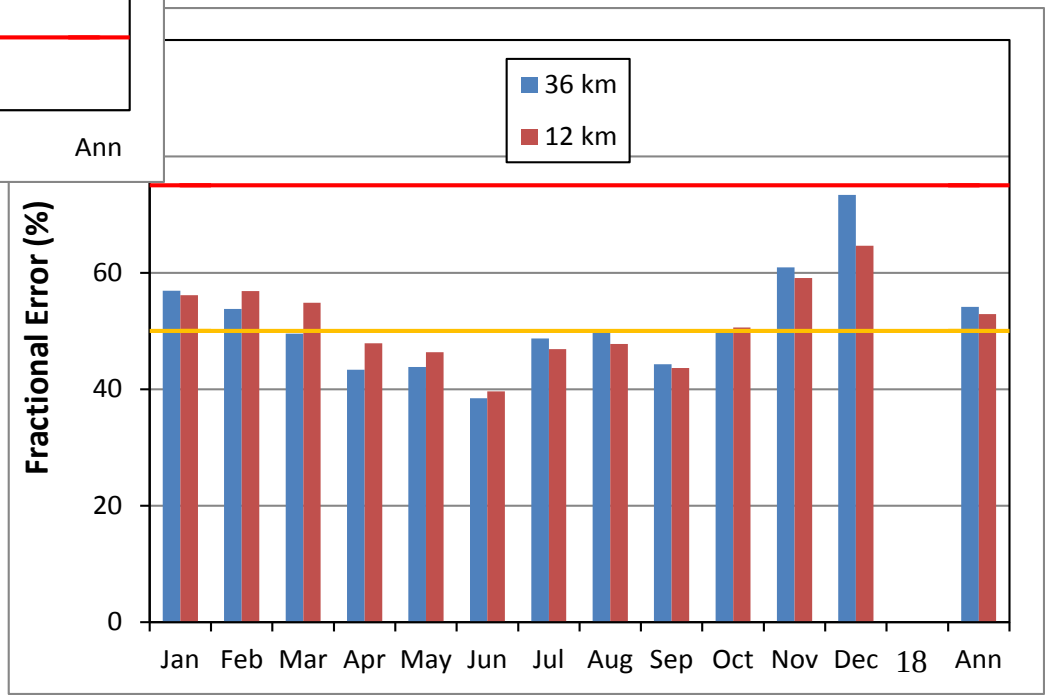
- CAMx Base Case DMAX8 ozone mostly achieved performance goals across western states
  - Exception in California where 36/12 km grid insufficient to simulate sea breeze environment
  - Some questionable observations in MT and CO
    - Glacier MT CASTNet ozone goes to zero at night even though no local NOx sources
    - Gothic CO CASTNet site pegged at ~20-30 ppb for extended periods in summer
  - Some overestimate bias (e.g., NM, OR and WA)
- Ozone model performance as good or better than past regional modeling studies

CAMx FRM $PM_{2.5}$ Mass Model Performance



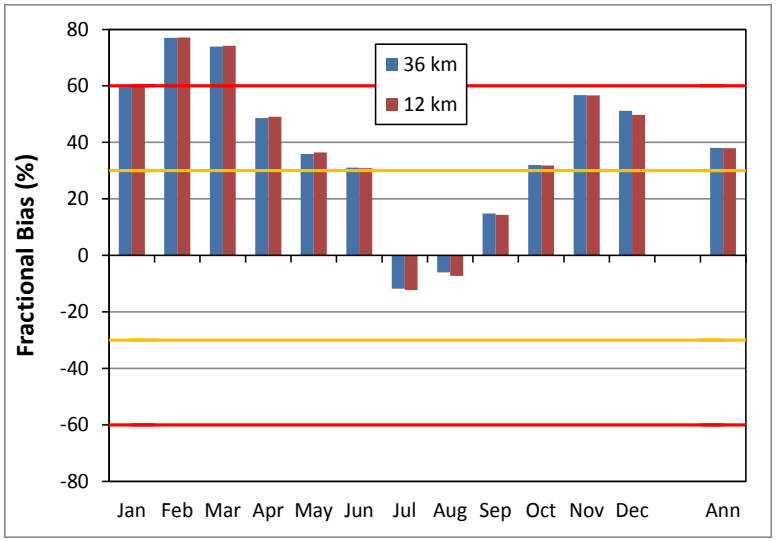
- ← Bias WESTUS Domain
- Annual
  - 36 km = -8%
  - 12 km = +4%
  - PM Goal ≤±30%

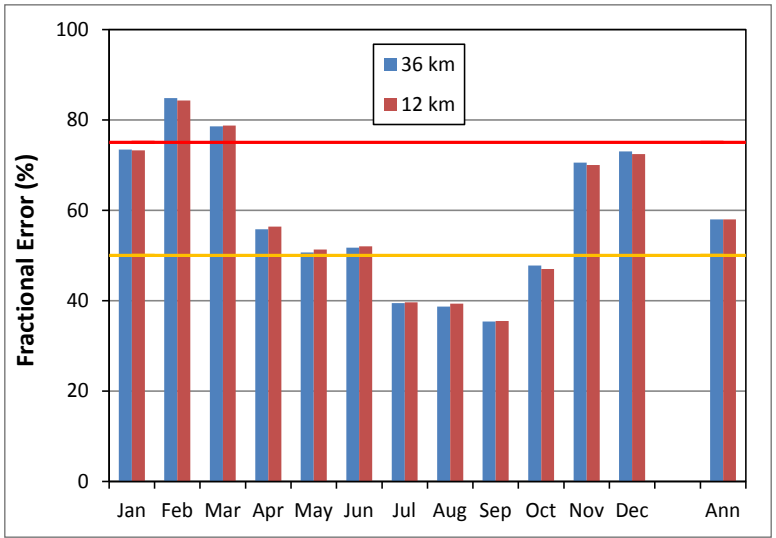
- Error WESTUS Domain →
- Annual
  - 36 km = 54%
  - 12 km = 52%
  - PM Goal ≤ 50%
  - PM Criteria ≤ 75%



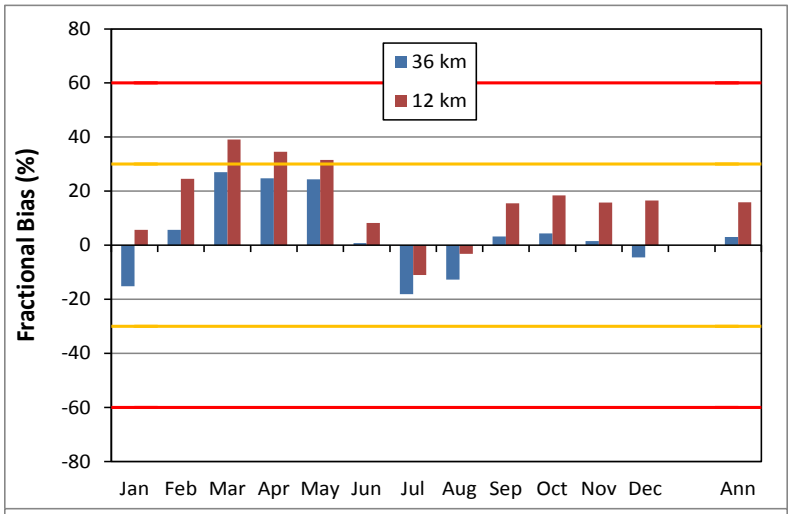
CAMx $PM_{2.5}$ Mass Model Performance WESTUS

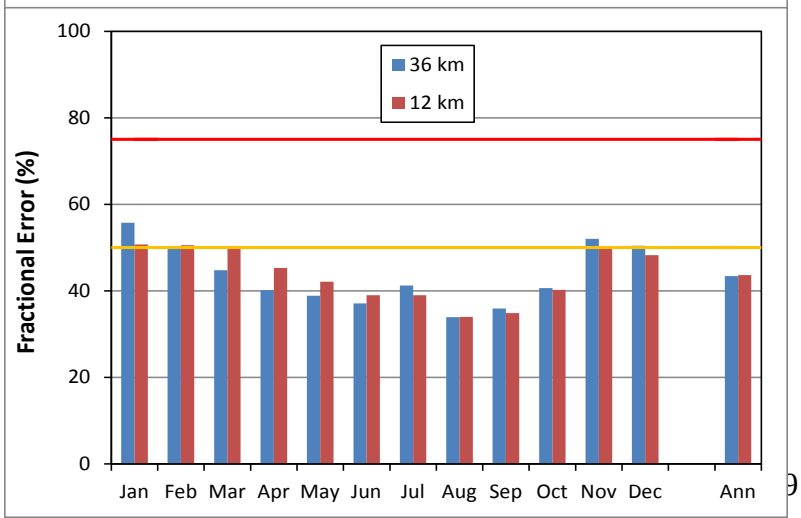
- IMPROVE





- CSN

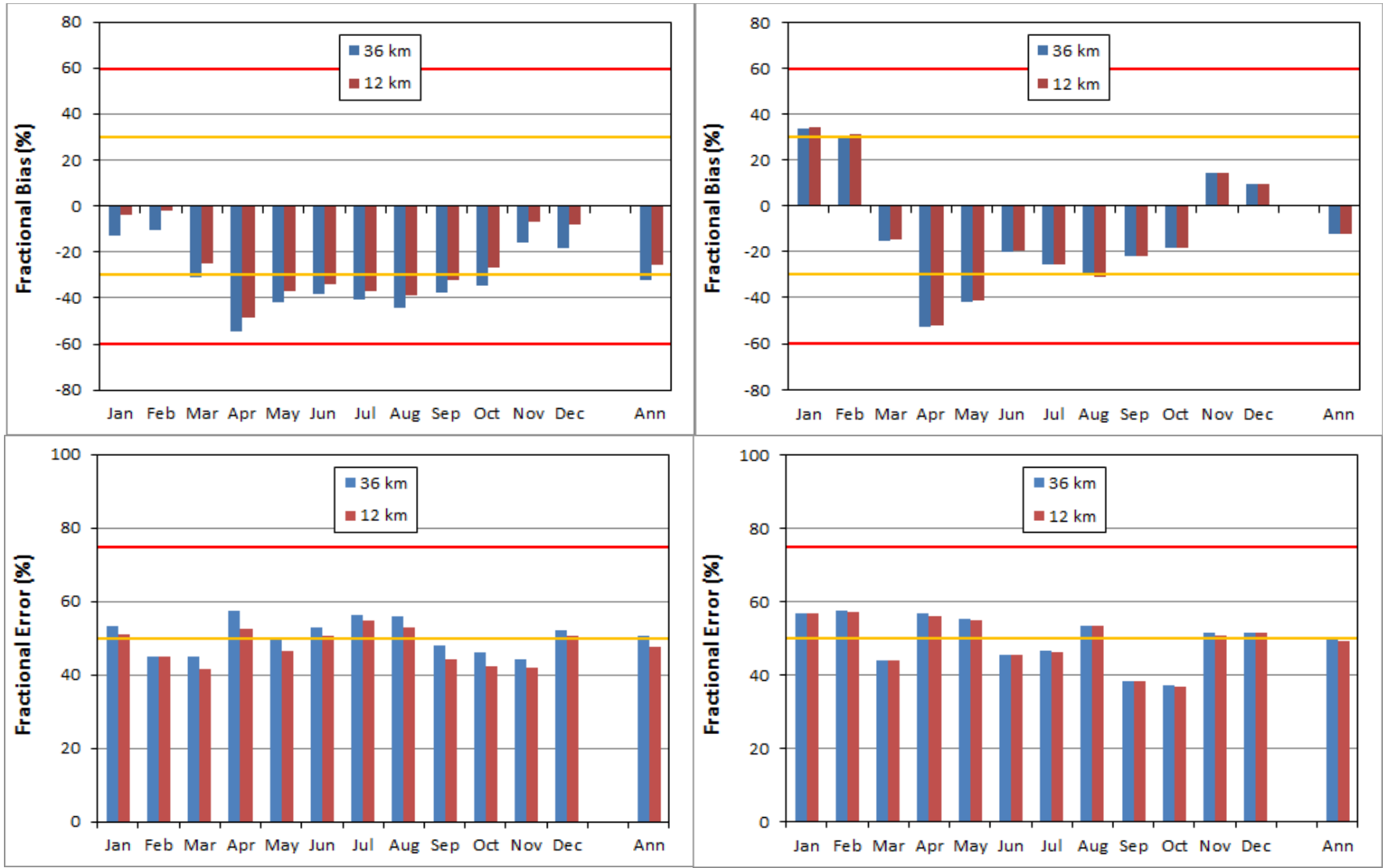




Sulfate (SO4) 12 km WESTUS

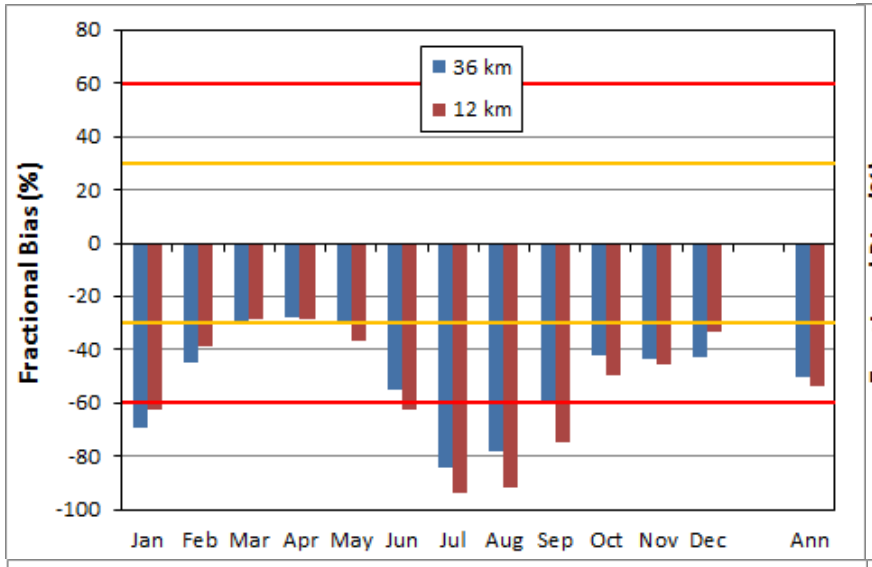
CSN

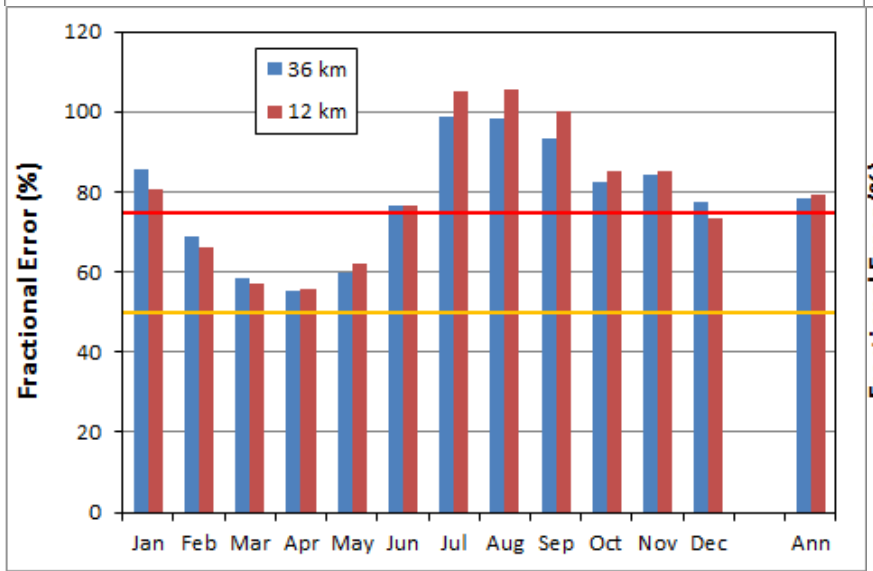
IMPROVE



Nitrate (NO3) 12 km WESTUS

CSN





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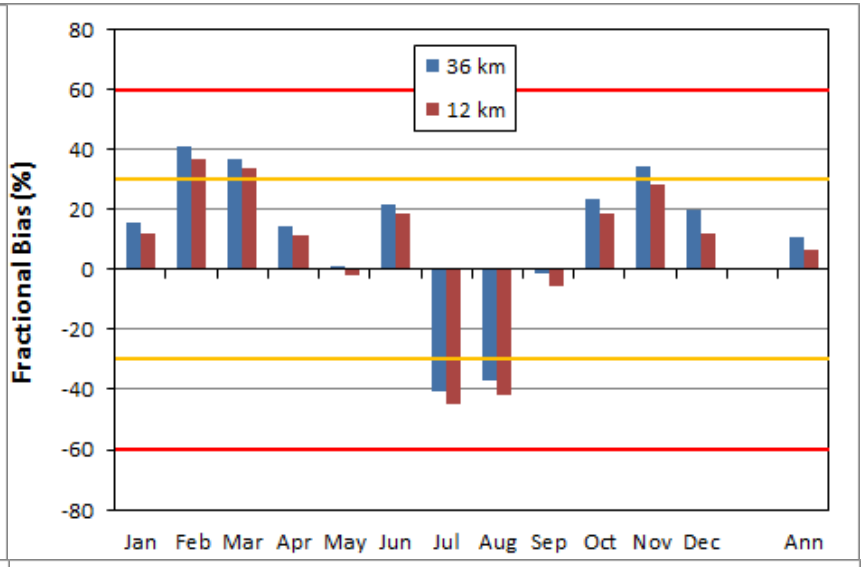
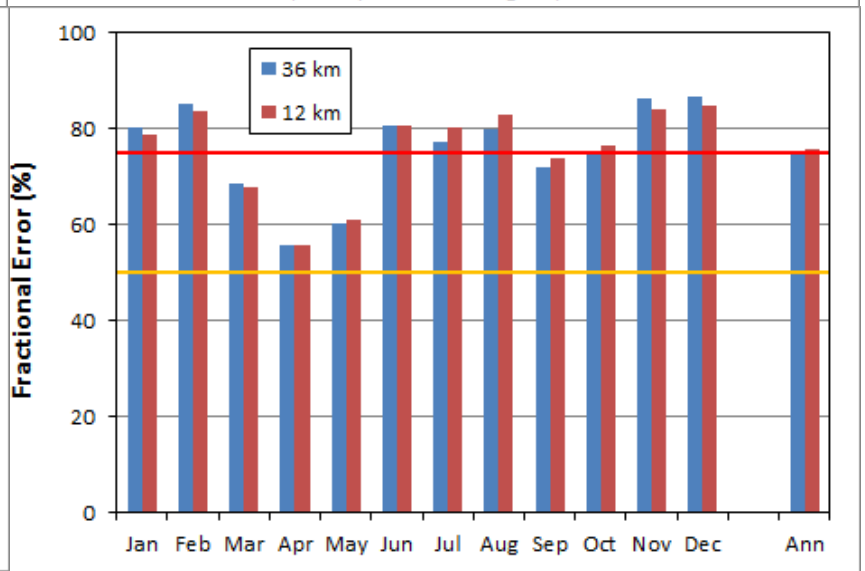
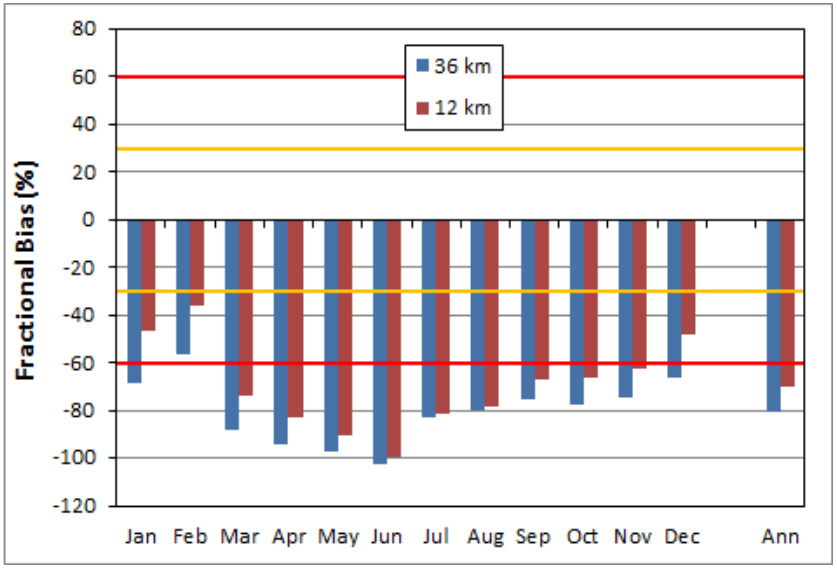




Organic Aerosol (OA) and Other $PM_{2.5}$ (OPM2.5)

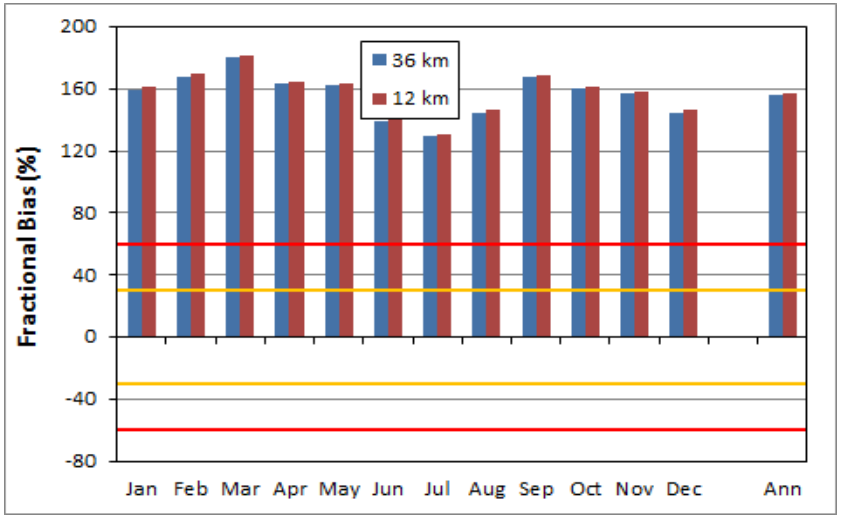
FBias across CSN in 12 km WESTUS Domain

- OA = 1.4 x OC



- 2008 CSN Carbon measurements unreliable

- OPM2.5 = PM2.5 – (SO4 + NO3 + NH4 + EC + OA)



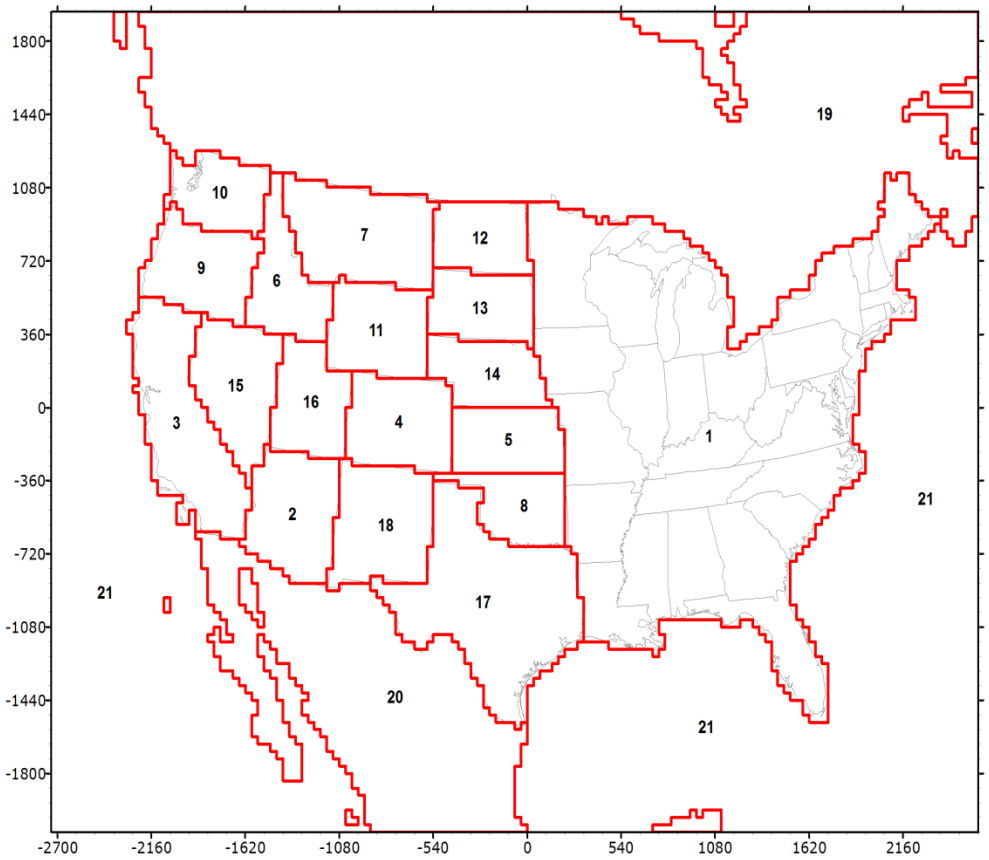
- Includes measurement artifacts
- If OPM2.5 < 0 set to 0

Summary CAMx 2008 PM Model Performance

- Differences in PM species definitions in monitoring vs. modeling (OA, OPM2.5, NH4d)
- In general $PM_{2.5}$ mass, SO4, NH4 and EC performance is reasonably good
- NO3 underestimation in summer w/ low concentrations
- OA is underestimated and OPM2.5 is overestimated
  - Likely connected via measurement artifacts
  - Missing SVOC emissions and processes

State-Specific Ozone Source Apportionment

- 2008 36/12 km Base
- 17 Western States
  - Plus EUSA, Can, Mex & Off-Shore
  - Includes TX, OK, KS NB (CenSARA)
- 5 Source Categories
  - Natural (Bio+Lx+WBD+SS)
  - WF, Rx and Ag Fires
  - Anthropogenic
- 107 Source Groups (21 x 5 + 2)
  - 4 Extra Species for each Group
    - NOX, VOC, O3V & O3N
    - = 428 additional species
    - Standard Model = 70 species
    - Computationally Demanding

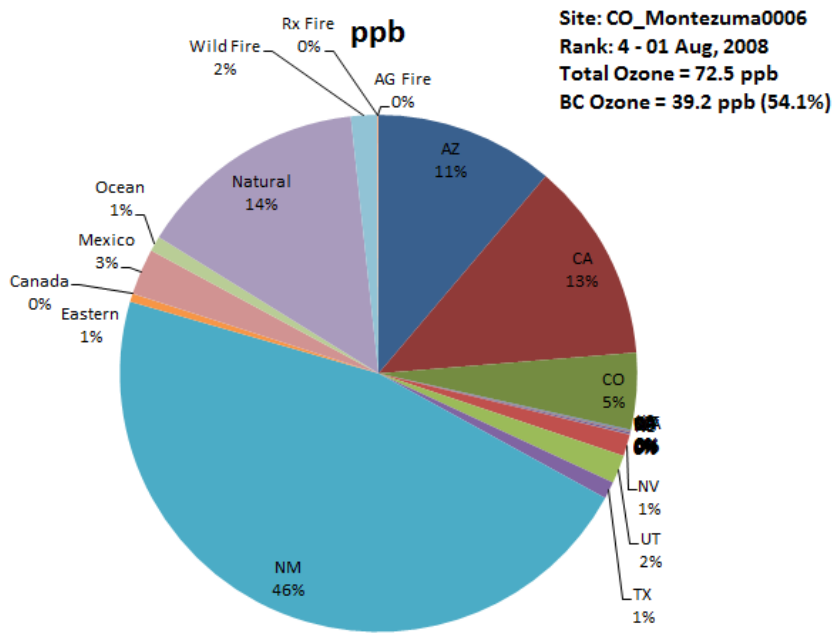


State-Specific Ozone Source Apportionment

- Purpose: To provide information on the role of ozone transport to exceedances of the current and potential future ozone NAAQS in the western U.S.
- Approach: Analyze ozone apportionment several ways:
  - Upwind state contribution to downwind state nonattainment using Cross State Air Pollution Rule (CSAPR-type) approach
    - Use EPA method for projecting ozone Design Values (RRFs)
  - State contributions to modeled high ozone DMAX8 ozone at monitors in 12 km WESTUS domain
  - Spatial extent of modeled state contributions to 1stmax and 4thmax DMAX8 ozone greater than current and potential future NAAQS
  - Source category analysis (Natural, Fires & Anthropogenic)

Ozone/PM Source Apportionment Displayed 2 Ways

- **Absolute modeling results**
  - Process raw source apportionment results
  - For example, pie charts of state contributions on 10 highest modeled DMAX8 ozone days



Mesa Verde, CO

- **Relative Modeling Results**
  - Use EPA's Modeled Attainment Test Software (MATS) to get obtain upwind state contribution to downwind state DMAX8 ozone Design Values (DVs)
  - MATS normally used with current year and future year modeling results to project current year DVs (DVC) to future year DVs (DVF)

$$DVF = DVC \times RRF$$

  - Relative Response Factors (RRFs) use the relative change in modeling results from current to future year

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CSAPR-Type Analysis using MATS

- Current Year Modeling Results = CAMx 2008 Base Case
  - Observed Current Year Design Value (DVC)
- "Future" Year Modeling Results = CAMx Base Case with ozone due to a state's anthropogenic emissions removed
  - DVF = DVC x RRF
- State ozone contribution to downwind DVs = DVC - DVF
- The sum of all Source Group (SG) ozone contributions does not equal the total DVC (and contributions can even be negative)
  - Difference in DVC and sum of SG MATS DVC contributions = "Unexplained"
  - For ozone DVCs, "Unexplained" is usually small
    - Due to MATS selecting maximum DMAX8 ozone in array around monitor
  - For $PM_{2.5}$ DVCs, "Unexplained" can be large
    - Missing species (e.g., SOA, Sea Salt, Blank Correction, etc.)
    - For 24-Hour $PM_{2.5}$ 98th percentile for DVF re-orders days

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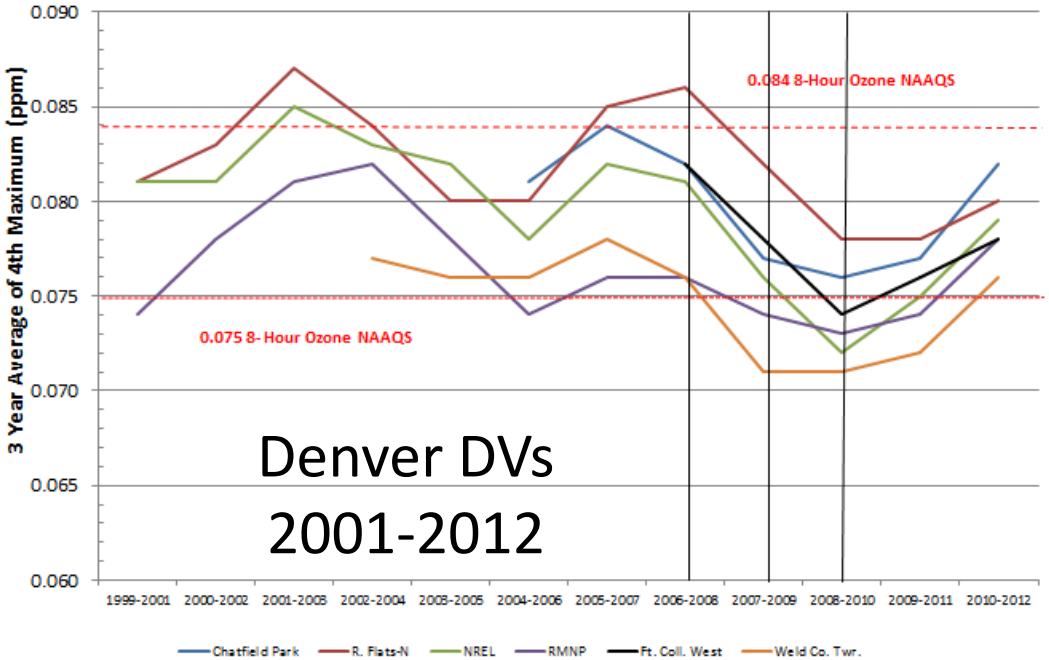
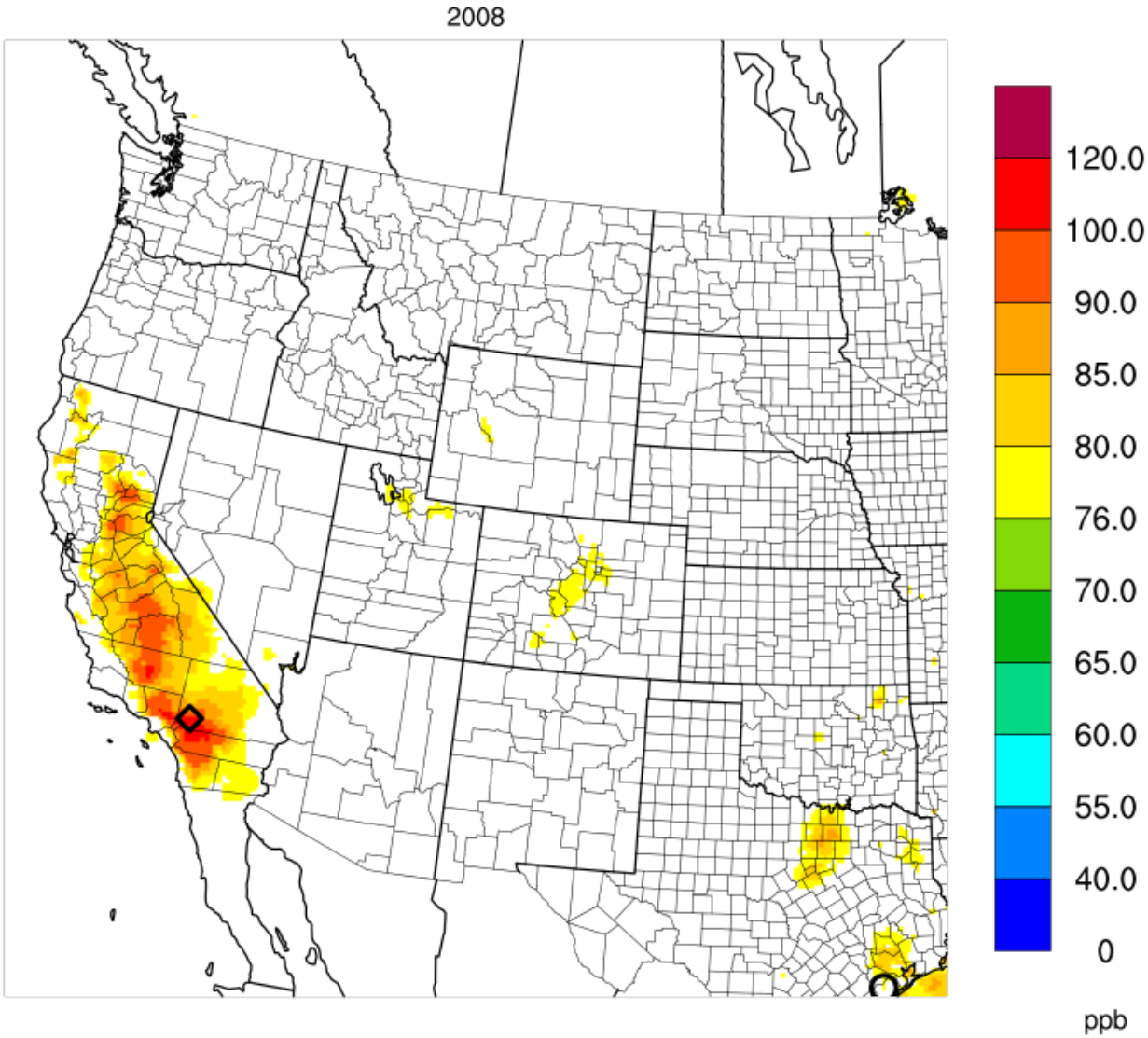
MATS Unmonitored Area Analysis (UAA)

- Default MATS calculates current year Design Value (DVC) using an average of three Design Values
  - Design Value (DV) is defined as the three year average of the fourth highest daily maximum 8-hour ozone (DMAX8)
  - MATS DVC defined as avg of 2006-8, 2007-9 & 2008-10 DVs

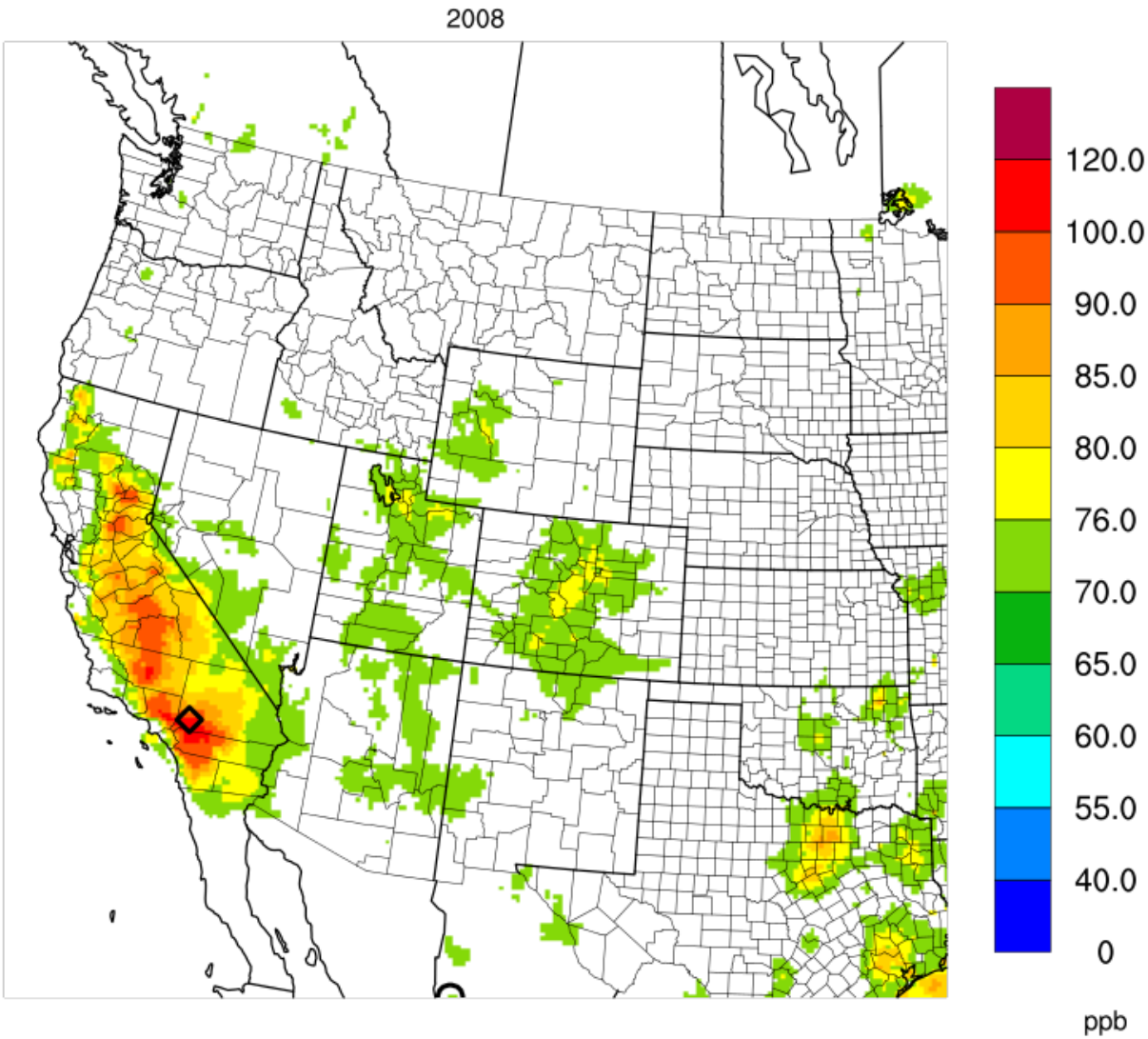
- MATS UAA interpolates DVCs across domain using observed DVCs at monitor and modeled concentration gradients
- Since low ozone in 2009, ozone has been increasing in west



MATS UAA with DVC (2006-2010) ≥ 76 ppb

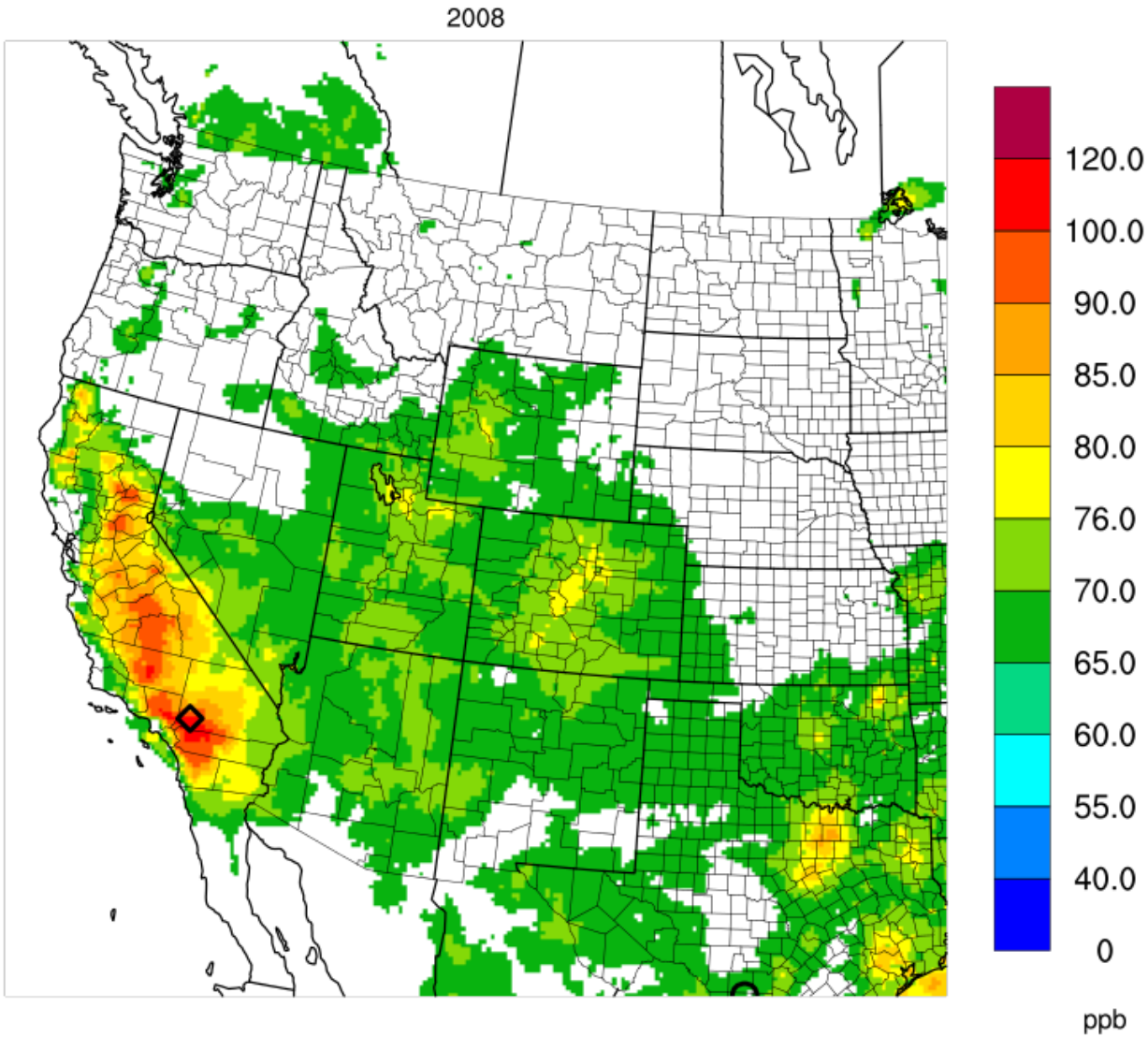


MATS UAA with DVC (2006-2010) ≥ 70 ppb

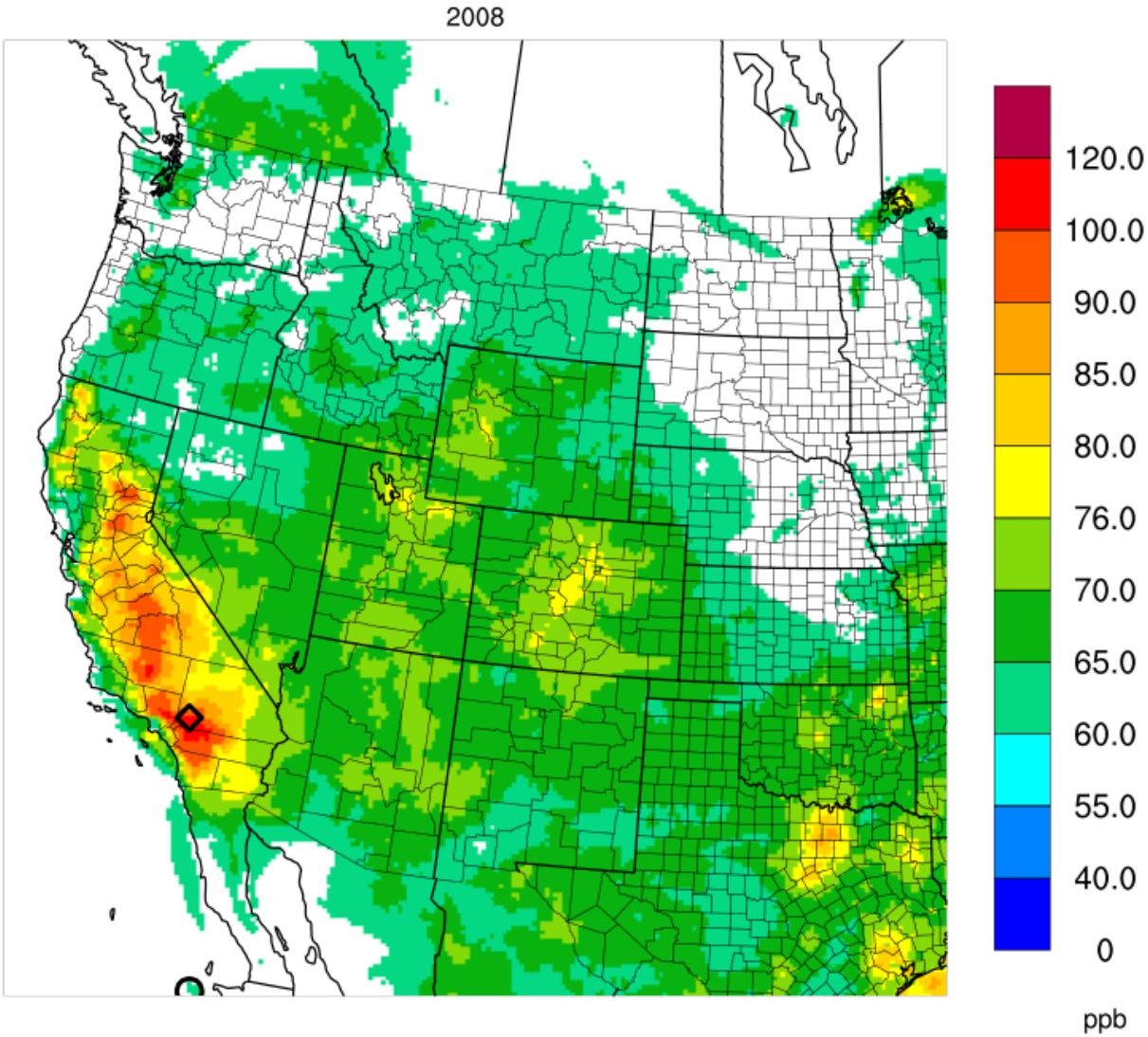


○ Min(107,1) = 70.00, ◇ Max(45,67) = 113.30

MATS UAA with DVC (2006-2010) ≥ 65 ppb



MATS UAA with DVC (2006-2010) ≥ 60 ppb



○ Min(45,2) = 60.00, ◇ Max(45,67) = 113.30

CSAPR-Type Analysis for Current (76 ppb) NAAQS

- CSAPR looked at contributions to:
  - AvgDV = Average of DVs from 2006-2010 (like in MATS)
  - MaxDV = Max DVs from 2006-2010
- 136 ozone monitors in 12 km WESTUS domain with AvgDVC exceeding NAAQS
  - 86 sites (63%) in California
- For 17 upwind western states examine 2008 contribution to DMAX8 ozone DVC in downwind states
  - CSAPR used a 1% NAAQS significance threshold (≥0.76 ppb)
- **This analysis is for 2008 and is not a regulatory analysis that would have to examine a future year**

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CSAPR-Type Analysis for Current NAAQS (76 ppb)

Upwind State	# Monitors ≥ 0.76 ppb	Maximum Contribution (ppb)	State with Maximum	AvgDV at Site
Arizona	23	1.15	NV	76.00
California	15	16.89	NV	76.00
Colorado	0	0.51	TX	80.00
Idaho	3	1.02	WY	78.67
Kansas	3	8.95	MO	76.00
Montana	0	0.39	WY	78.67
North Dakota	0	0.12	TX	77.67
Nebraska	0	0.28	MO	76.33
New Mexico	1	0.82	AZ	77.33
Nevada	20	1.28	CA	101.00
Oklahoma	18	6.52	MO	76.00
Oregon	26	1.13	CA	92.67
South Dakota	0	0.13	MO	76.33
Texas	4	11.55	OK	76.00
Utah	5	2.53	CO	82.0
Washington	1	1.03	WY	78.67
Wyoming	5	1.53	CO	78.00

State-Specific CSAPR-Type Ozone Analysis

- Interactive Excel spread sheet to display Upwind State contributions to DMAX8 ozone Design Values at maximum monitor in up to five downwind states (Appendix A in Final Report)
  - User selects **"Upwind State"** and **"NAAQS"** level
  - Appendix A will display AvgDV and MaxDV at maximum monitor in up to 5 downwind States and **"Upwind State"** ozone contribution to the DV when:
    - MaxDV ≥ **"NAAQS"**
    - "State" contribution ≥ 0.01 x **"NAAQS"** (1% of the NAAQS)

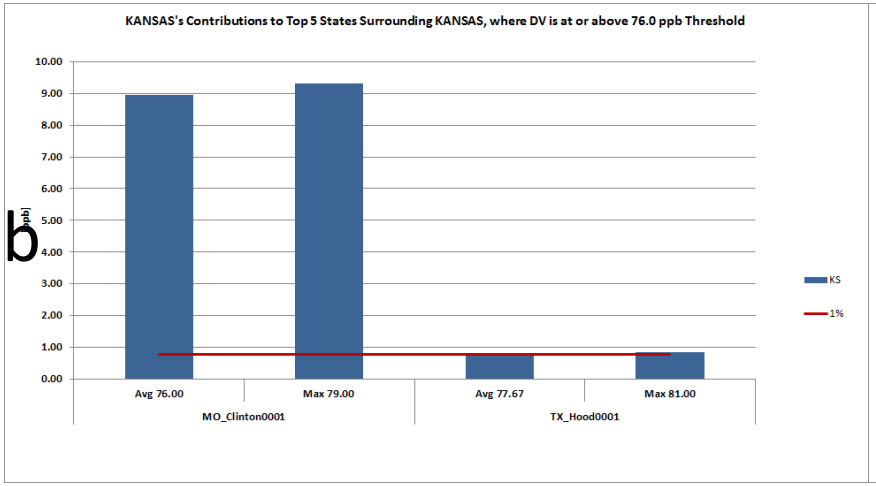
35

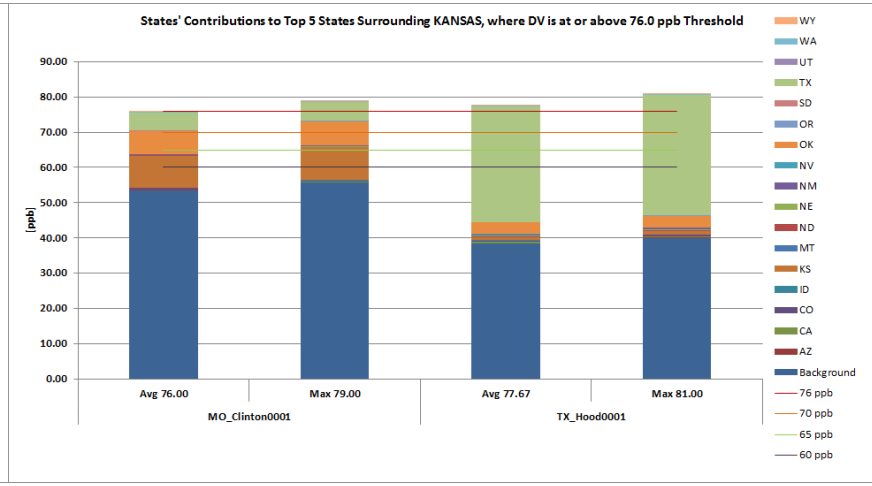
KS CSAPR-Type Ozone Analysis for 76 & 65 ppb NAAQS

(From Appendix A)

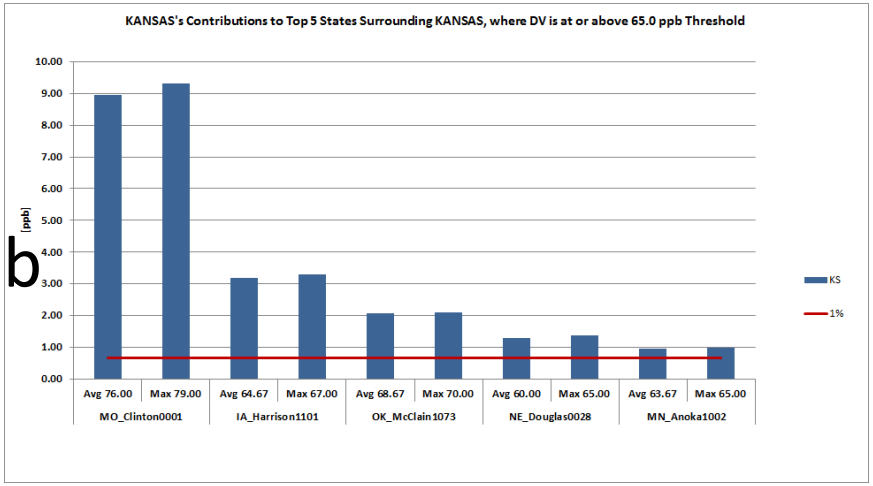
Kansas Ozone Contributions Downwind State DVCs

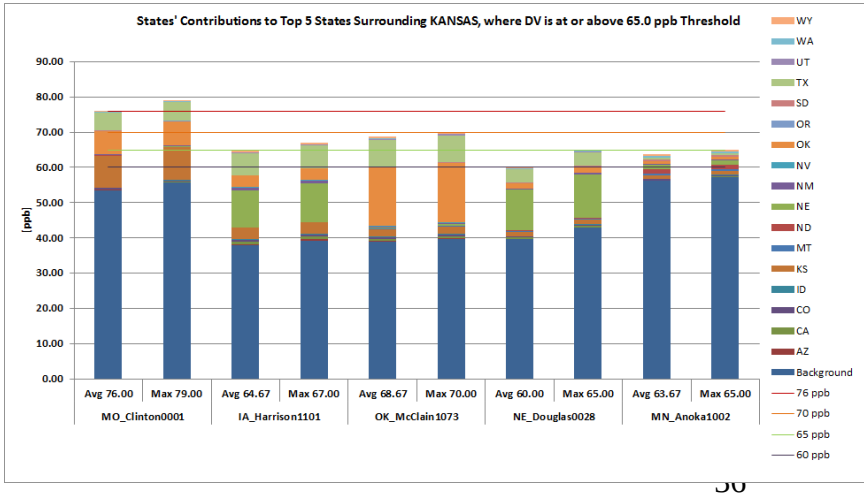
76 ppb





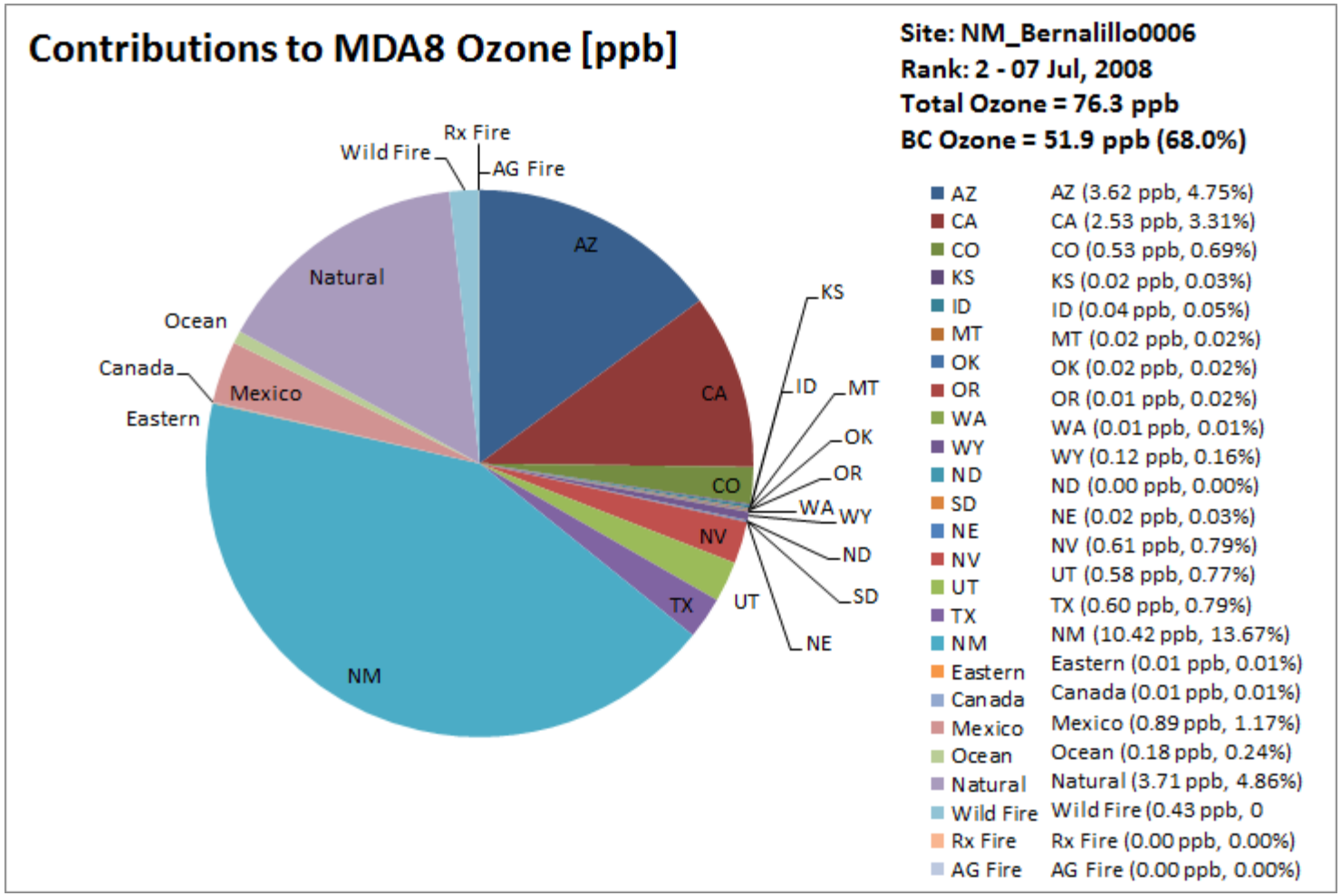
65 ppb





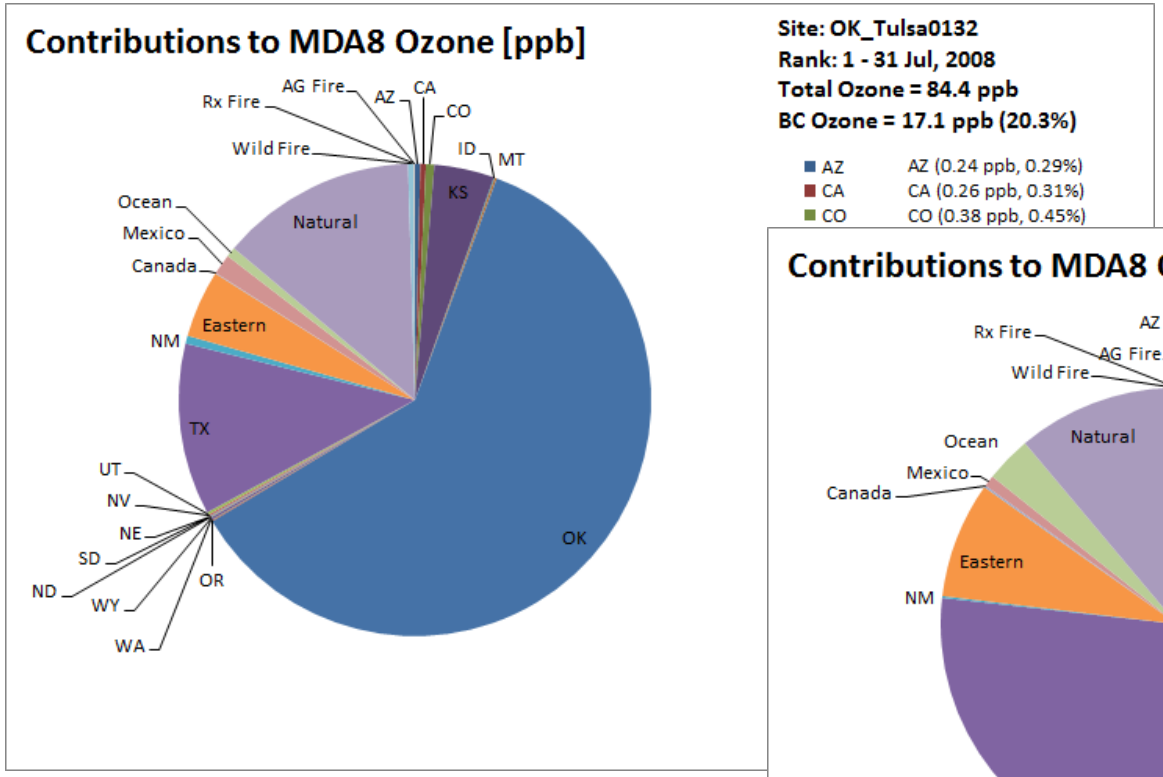
Appendix B: State Contributions to Modeled 10 Highest DMAX8 Ozone Days

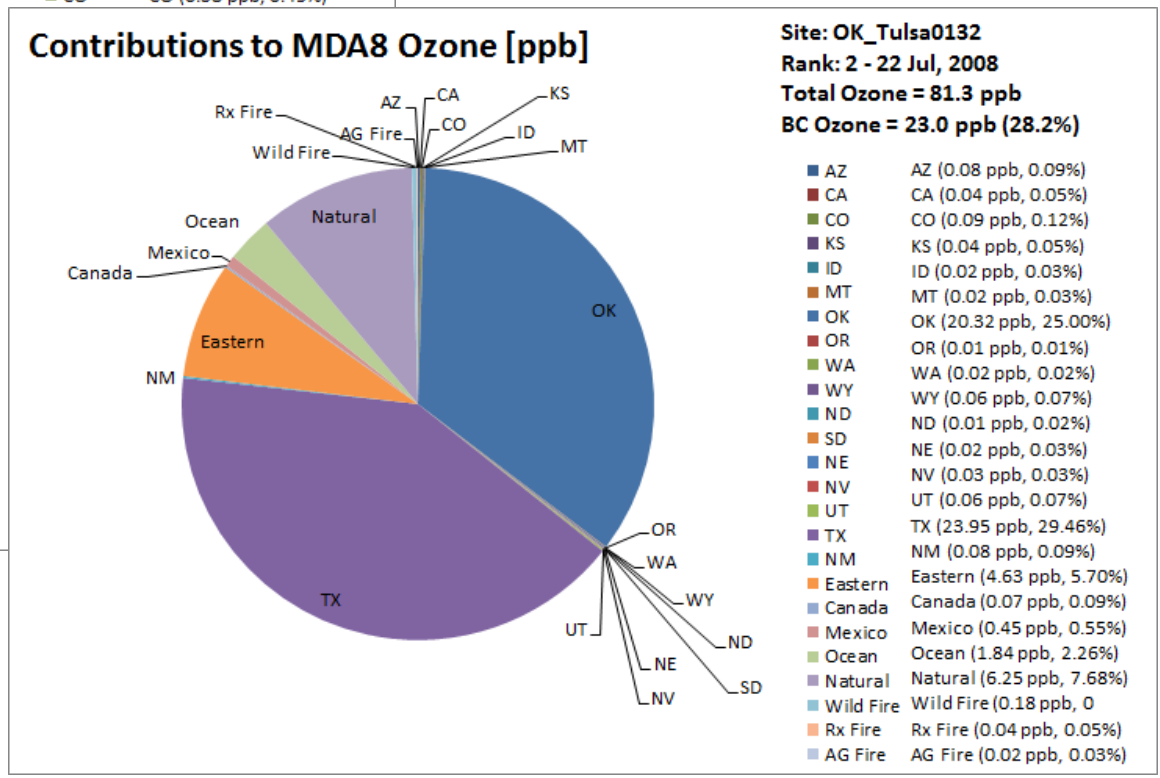
2nd Highest Modeled DMAX8 Day @ Albuquerque, NM



Appendix B: 10 Highest DMAX8 Ozone Days

1st and 2nd highest Ozone Days at Tulsa, OK





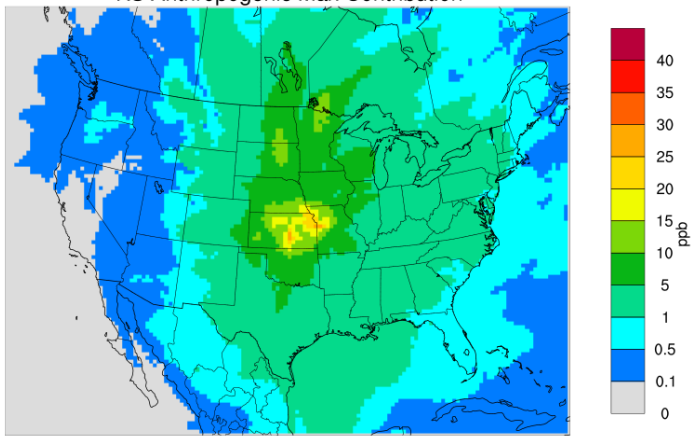
Appendix C: State Ozone Contributions Footprints

- Spatial distribution of state's ozone contribution to DMAX8 ozone concentrations greater than or equal to:
  - 76 ppb (current NAAQS)
  - 70 ppb; 65 ppb and 60 ppb (potential future NAAQS)
  - 0 ppb (highest contribution in year)
- Two types of metrics:
  1. Maximum modeled contribution to Highest and 4th Highest DMAX8 ozone (Appendix C)
  2. MATS UAA projection contribution to 8-hour ozone DVC
- Example follows for:
  - KS, NE, OK & TX Maximum contribution to highest DMAX8 ever
  - NM Maximum contribution to 4th high DMAX8 > 76 and 65 ppb

2008 KS, NE, OK & TX Highest O_3 Contribution

Contrib. to CAMx Daily Max 8-Hour Ozone >= 0 ppb

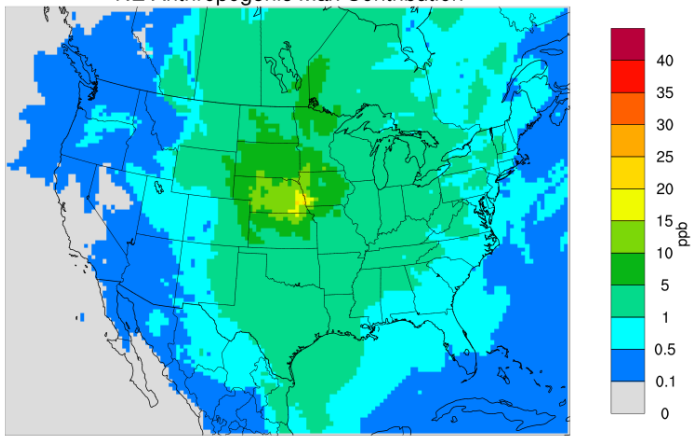
KS Anthropogenic Max Contribution



Max(75,52) = 28.20

Contrib. to CAMx Daily Max 8-Hour Ozone >= 0 ppb

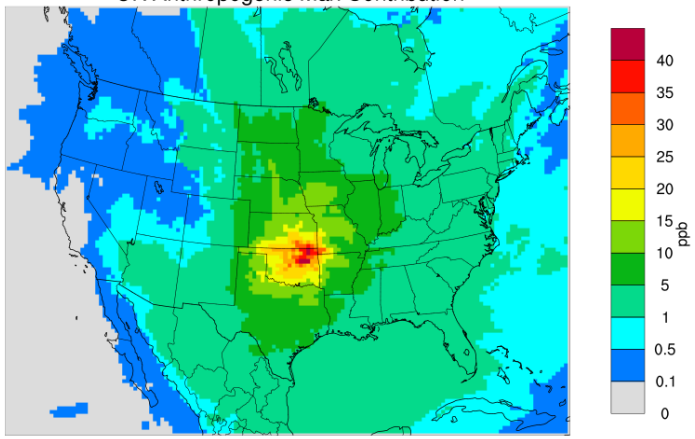
NE Anthropogenic Max Contribution



Max(79,63) = 22.01

Contrib. to CAMx Daily Max 8-Hour Ozone >= 0 ppb

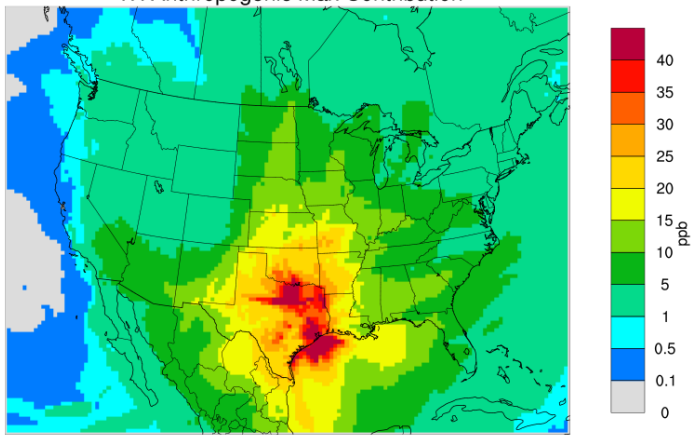
OK Anthropogenic Max Contribution



Max(80,48) = 46.23

Contrib. to CAMx Daily Max 8-Hour Ozone >= 0 ppb

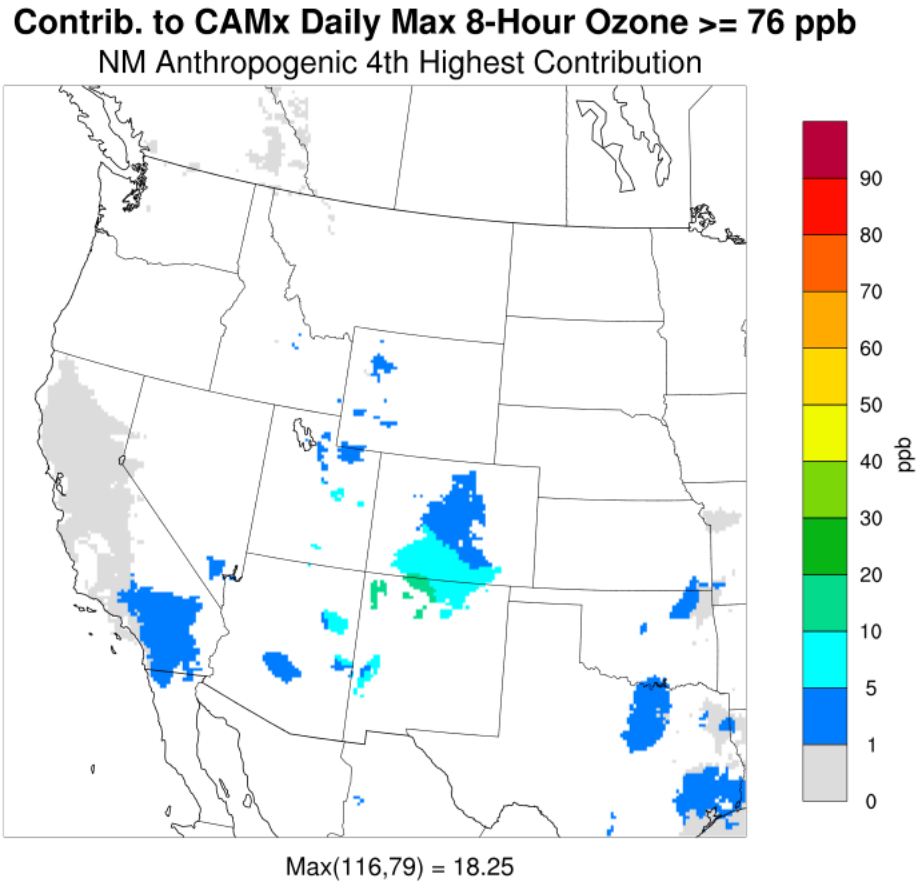
TX Anthropogenic Max Contribution



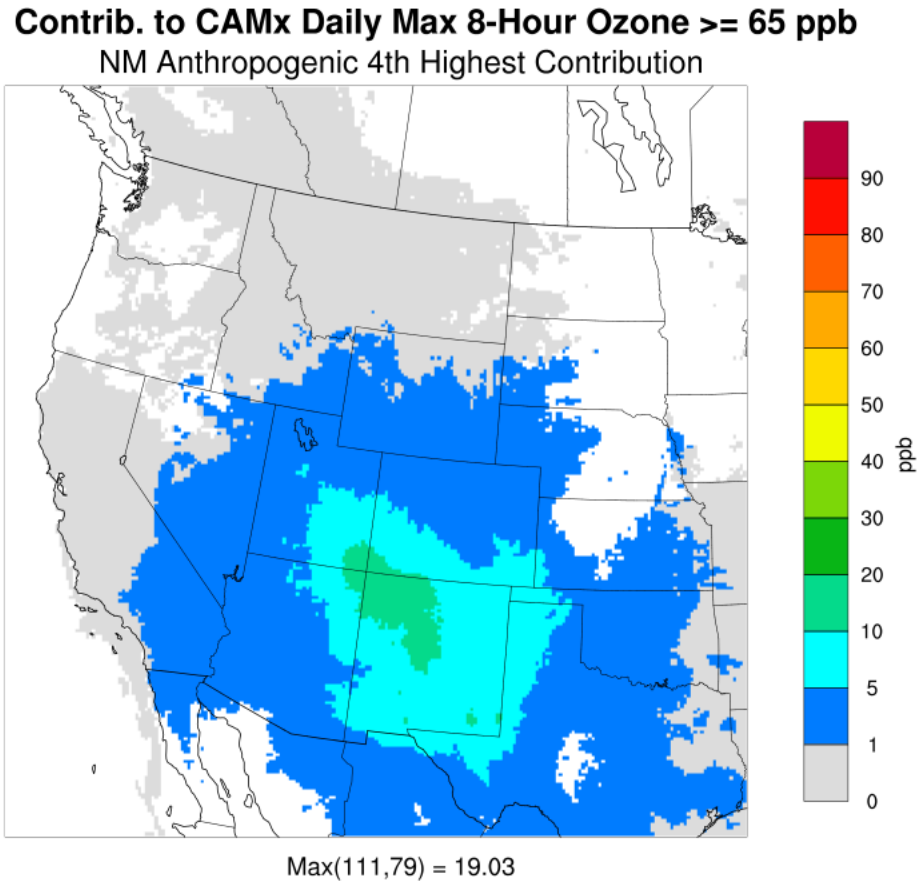
Max(80,27) = 60.45

New Mexico Max Contrib. to 4th High DMAX8

DMAX8 Ozone ≥ 76 ppb

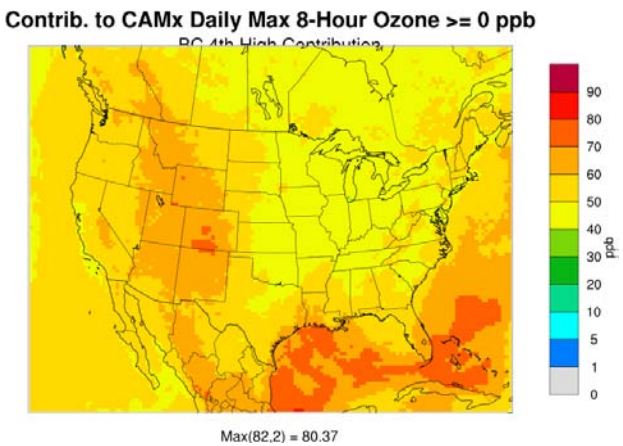


DMAX8 Ozone ≥ 65 ppb

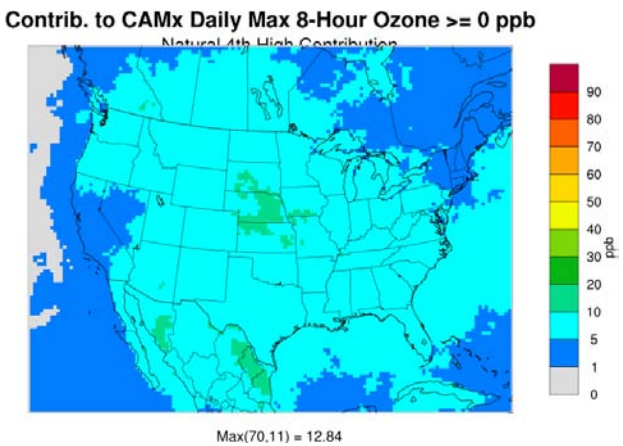


Source Category Max Contrib. 4th High DMAX8

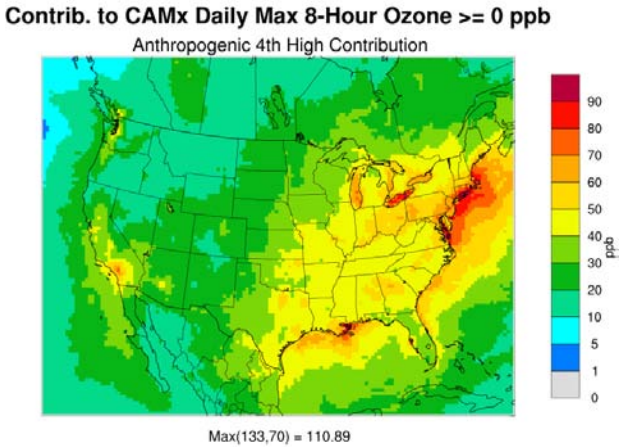
BC

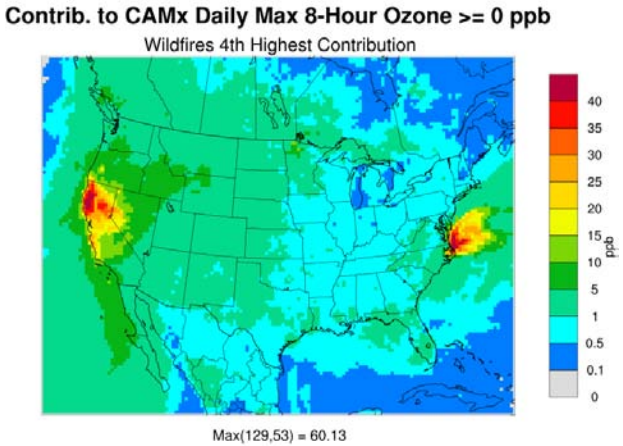


Natural

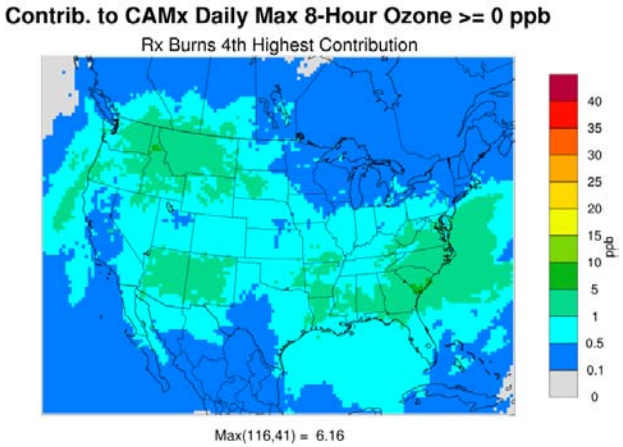


Anthropogenic

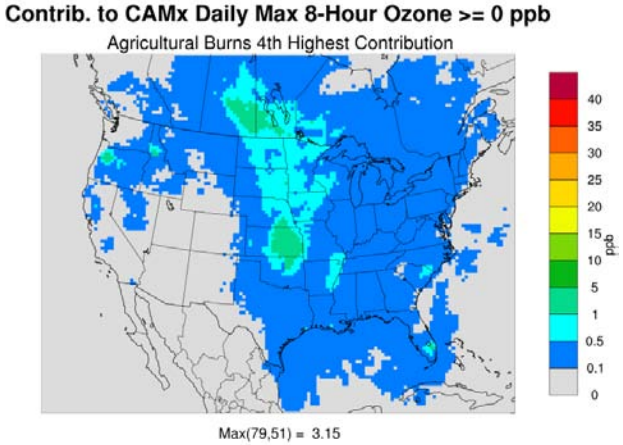




WF



Rx



Ag

CSAPR-Type Annual $PM_{2.5}$ Analysis Current NAAQS

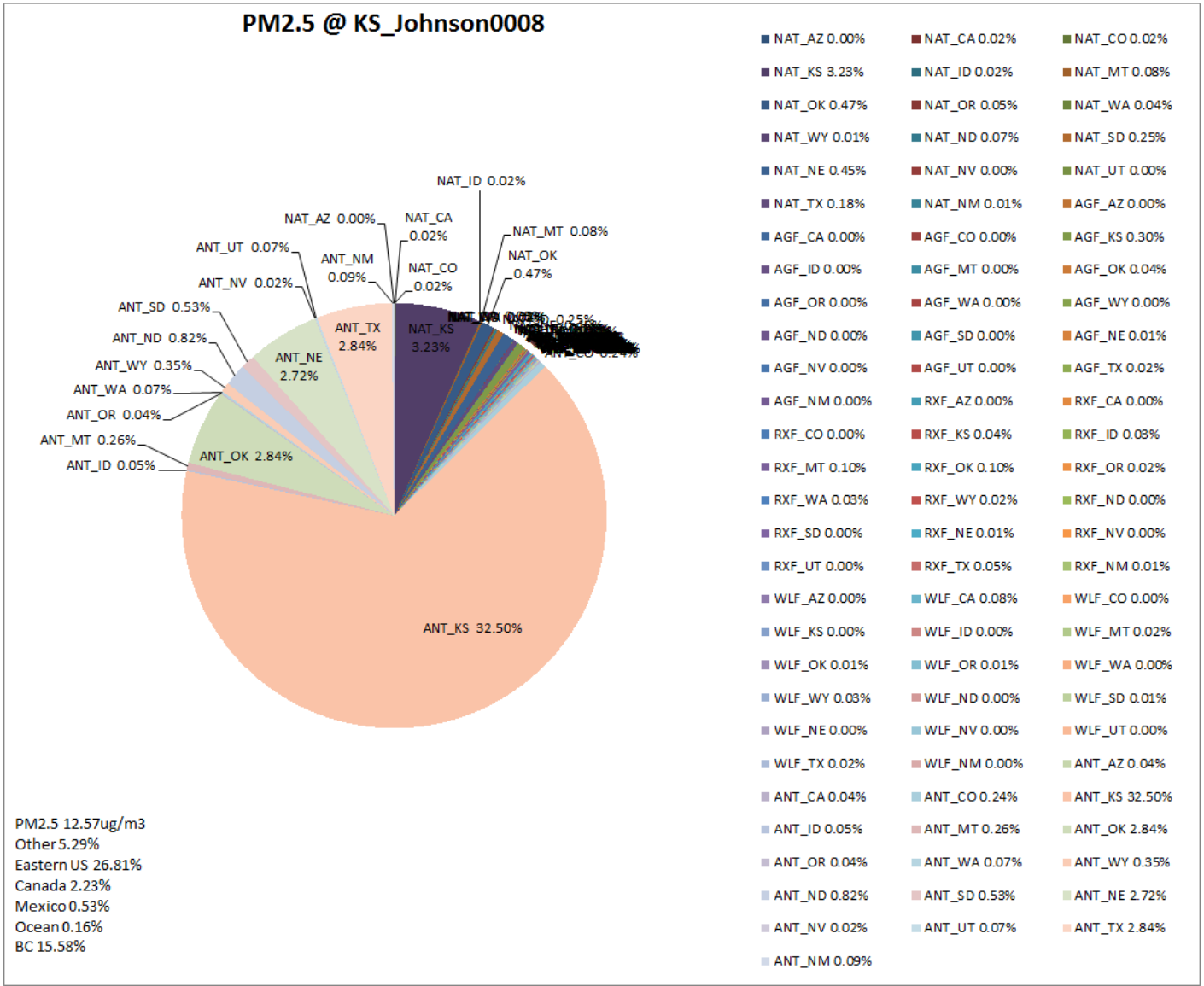
Upwind State	#Sites ≥ 0.12 µg/m³	Maximum Contribution (µg/m³)	State with Maximum	AvgDV at Site
Arizona	0	0.08	CA	15.05
California	1	0.24	AZ	12.88
Colorado	0	0.02	AZ	12.88
Idaho	1	2.56	MT	12.52
Kansas	17	0.18	IA	12.98
Montana	0	0.05	IA	12.98
N. Dakota	1	0.12	IA	12.98
Nebraska	2	0.15	IA	12.98
New Mexico	1	0.12	AZ	12.88
Nevada	0	0.09	CA	12.43
Oklahoma	2	0.19	AR	12.21
Oregon	1	0.38	MT	12.52
S. Dakota	0	0.04	IA	12.98
Texas	58	0.52	AR	12.21
Utah	0	0.03	AZ	12.88
Washington	1	1.65	MT	12.52
Wyoming	0	0.04	MO	12.27

CSAPR-Type 24-Hour $PM_{2.5}$ Analysis Current NAAQS

Upwind State	# Monitors ≥ 0.35 µg/m³	Maximum Contribution (µg/m³)	State with Maximum	AvgDV at Site
Arizona	7	2.00	CA	36.1
California	11	3.00	OR	46.0
Colorado	0	0.10	WI	36.3
Idaho	12	3.80	UT	39.5
Kansas	2	1.20	IA	36.4
Montana	0	0.20	IA	36.4
N. Dakota	0	0.20	IA	36.4
Nebraska	2	0.80	IA	36.4
New Mexico	1	0.70	CA	36.1
Nevada	5	0.60	CA	41.6
Oklahoma	1	0.40	IA	36.4
Oregon	5	2.30	WA	42.5
S. Dakota	0	0.10	WA	37.2
Texas	1	0.40	IA	36.4
Utah	1	31.6	ID	45.6
Washington	0	0.3	UT	40.4
Wyoming	5	1.50	ID	45.6

State Contributions to Annual $PM_{2.5}$ at Johnson Cty KS

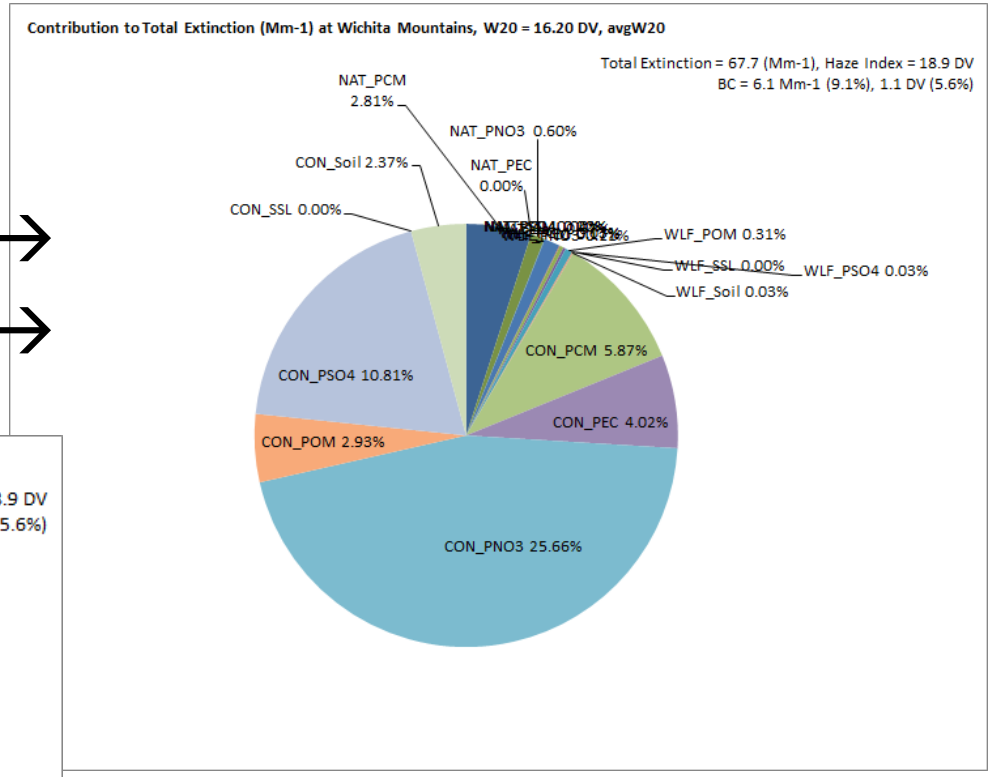
Appendix E

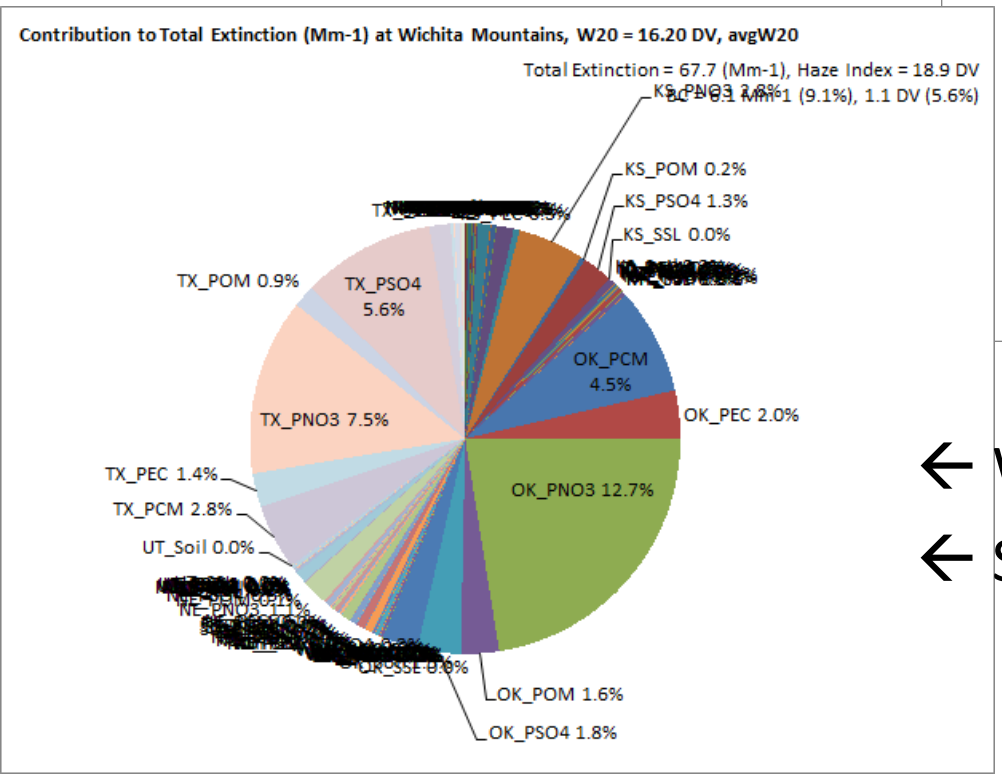


State Contrib to Visibility Impairment (App O)

Wichita Falls, OK AvgW20% Days →

Source Category x Species →





← Wichita Falls AvgW20% Days

← State x Species

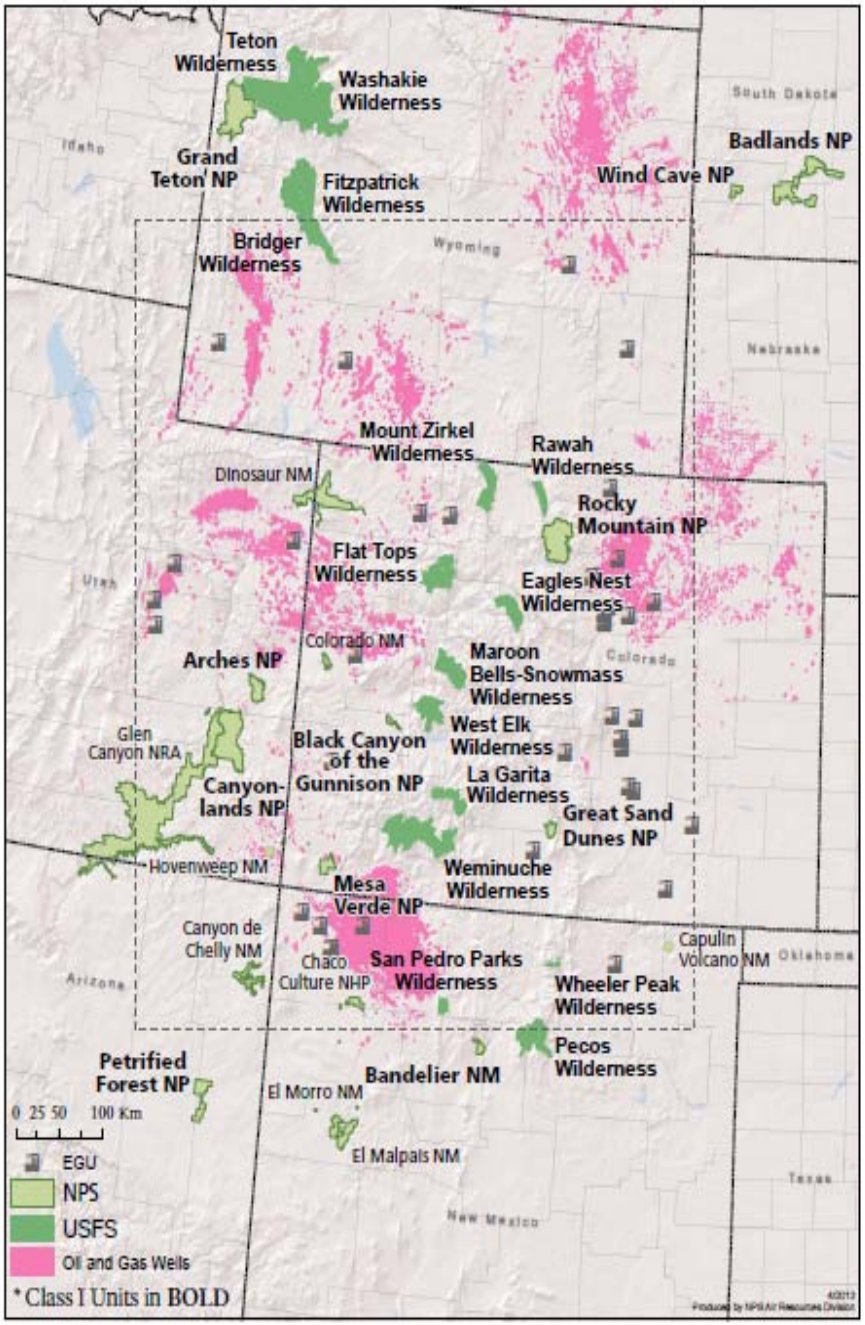
Source Category-Specific Source Apportionment

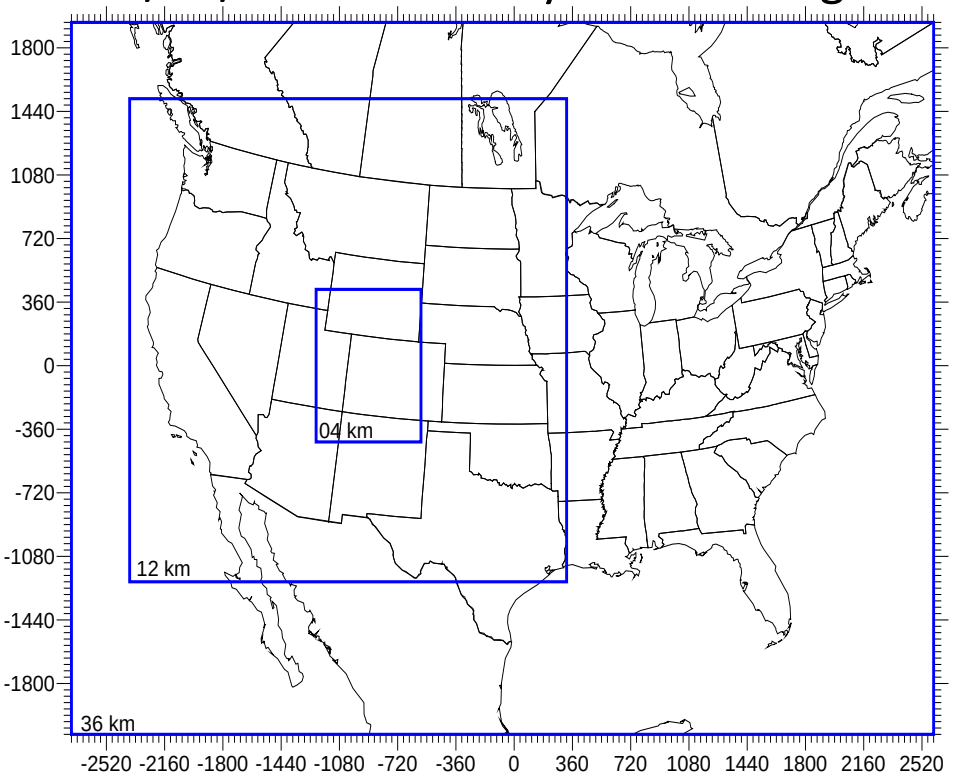
- Six Source Categories:
  - Natural (Biogenic, Lightning, Sea Salt & WBD)
  - Fires (WF, Rx, & Ag)
  - Upstream Oil and Gas (O&G)
  - Point Sources (EGU & Non-EGU)
  - Mobile Sources (on-road, non-road & CMV)
  - Remainder (Area/Non-Point)
- Ozone Apportionment
  - May-Aug 2008
  - 36/12/4 km Domains
  - 4 States (CO, NM, UT & WY)
- PM Apportionment
  - 2008 Annual
  - 36/12 km Domains
  - One Source Region
- PSAT Families:
  - SO4, NO3/NH4 and Primary PM; -- No SOA

Ozone Source Category-Specific Source Apportionment

← 4 km Detailed SA Domain (DSAD)

36/12/4 km Two-Way Grid Nesting



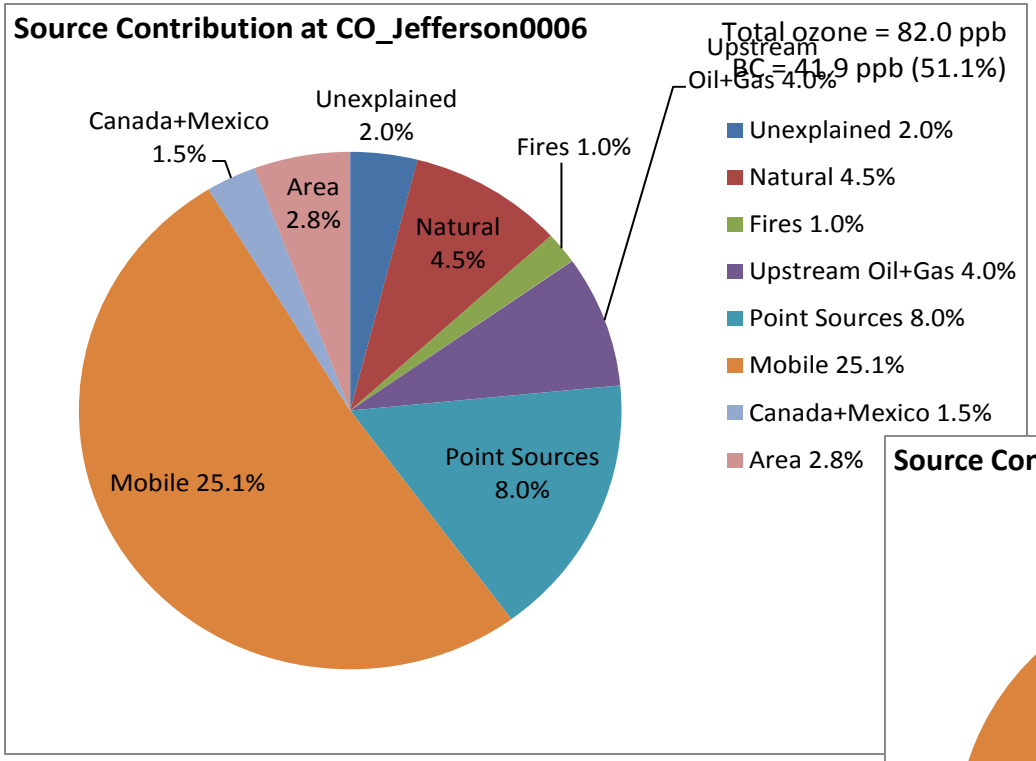


CAMx Modeling Domain

36 km : 148 x 112 (-2736, -2088) to (2592, 1944)
12 km*: 227 x 230 (-2388, -1236) to (336, 1524)
04 km*: 164 x 218 (-1228, -436) to (-572, 436)

* includes buffer cells

Source Category Contribution to Ozone DVCs



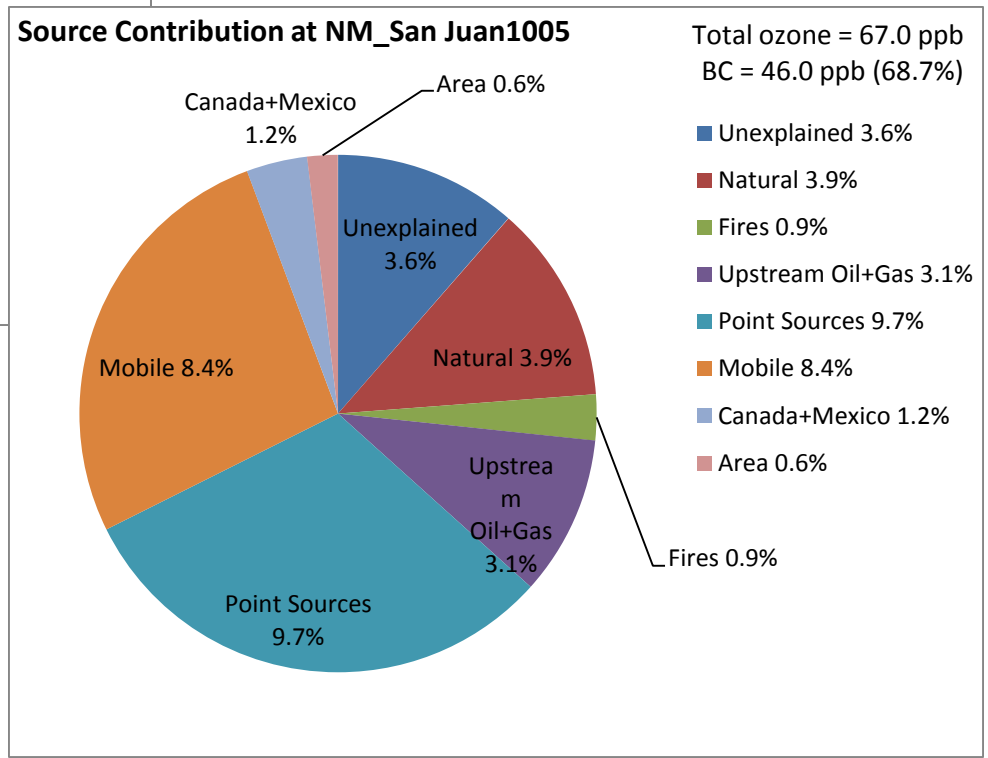
(Appendix H)

← Rocky Flats North, CO

DVC = 82 ppb

BC = 42 ppb (51%)

"Unexplained" = 1.6 ppb (2.0%)



San Juan County, NM →

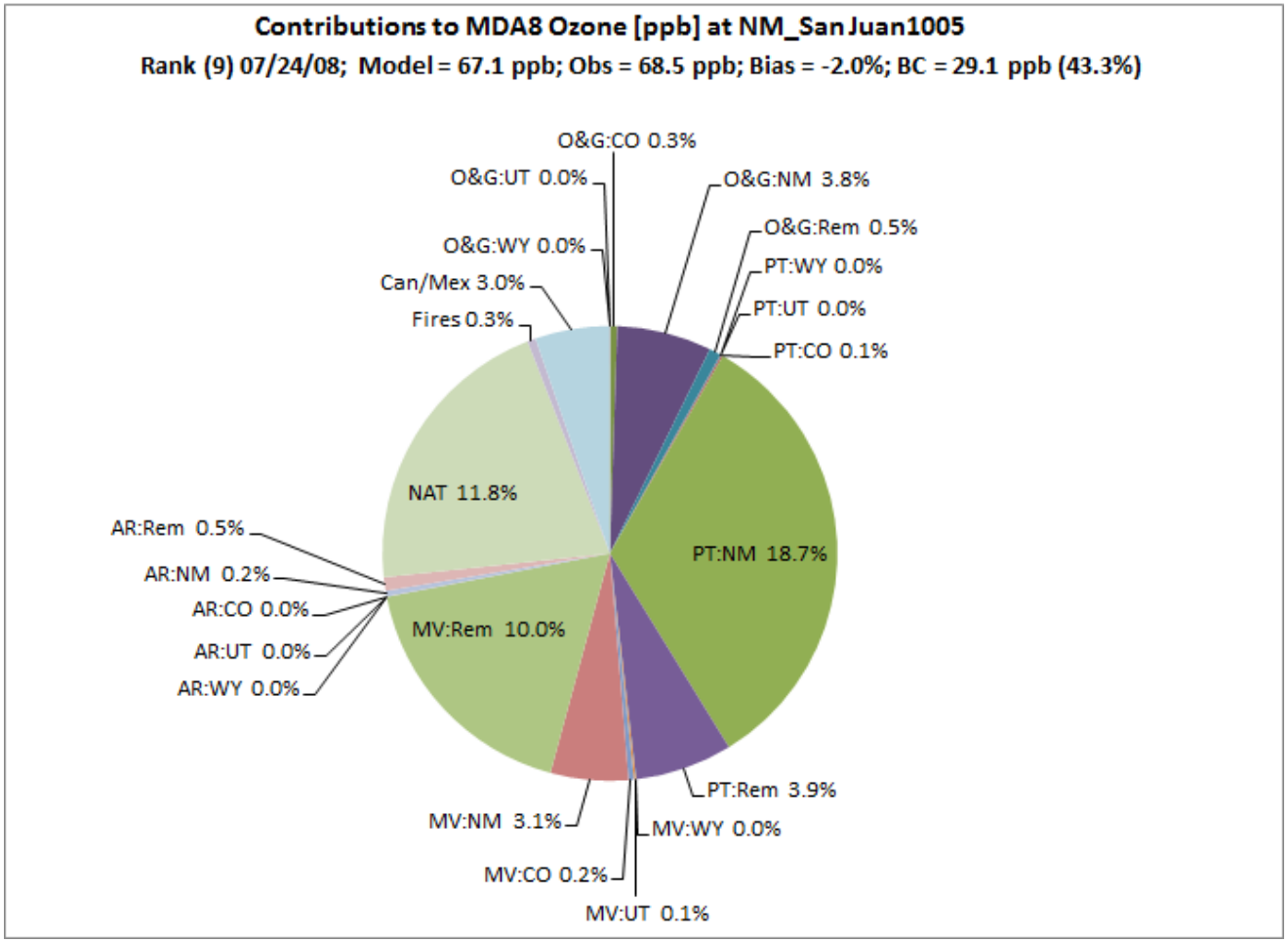
DVC =67 ppb

BC = 46 ppb (69%)

"Unexplained" = 1.5 ppb (3.6%)

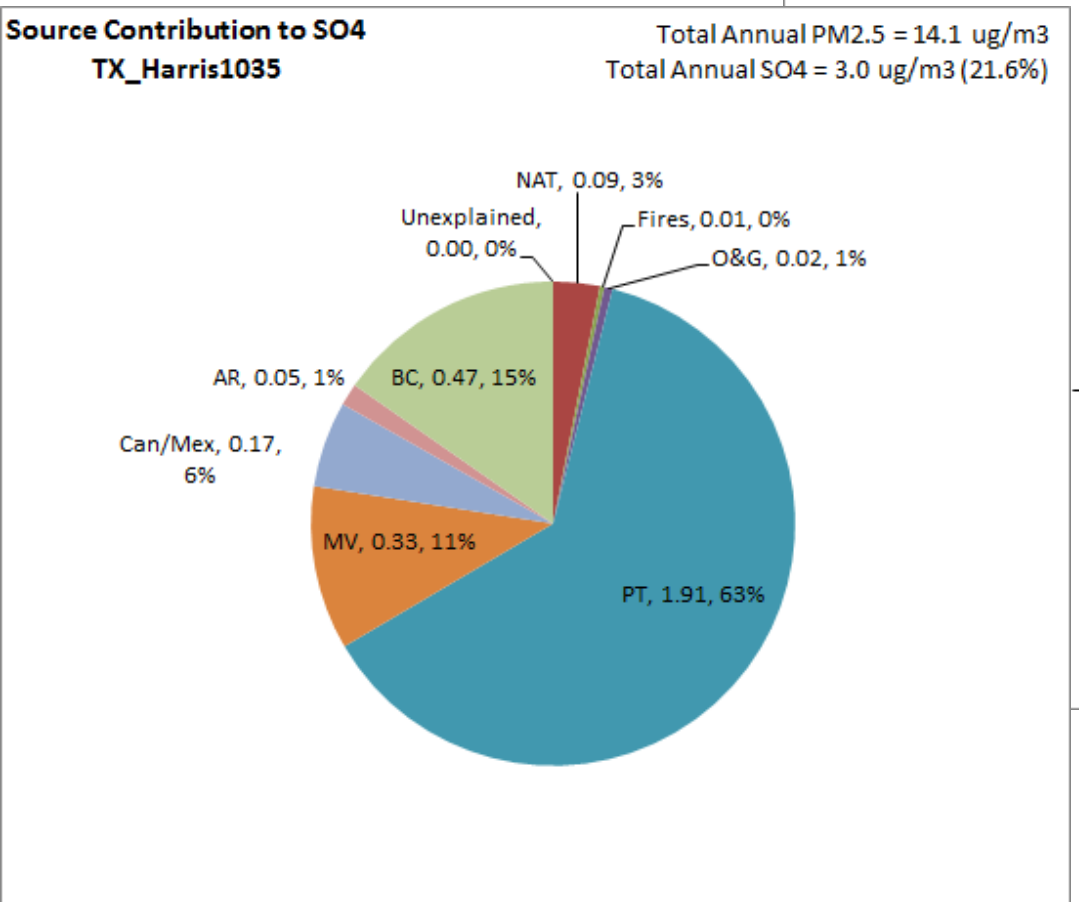
Source Category Contribution to 10 Highest Modeled DMAX8 O_3 Days (Appendix I)

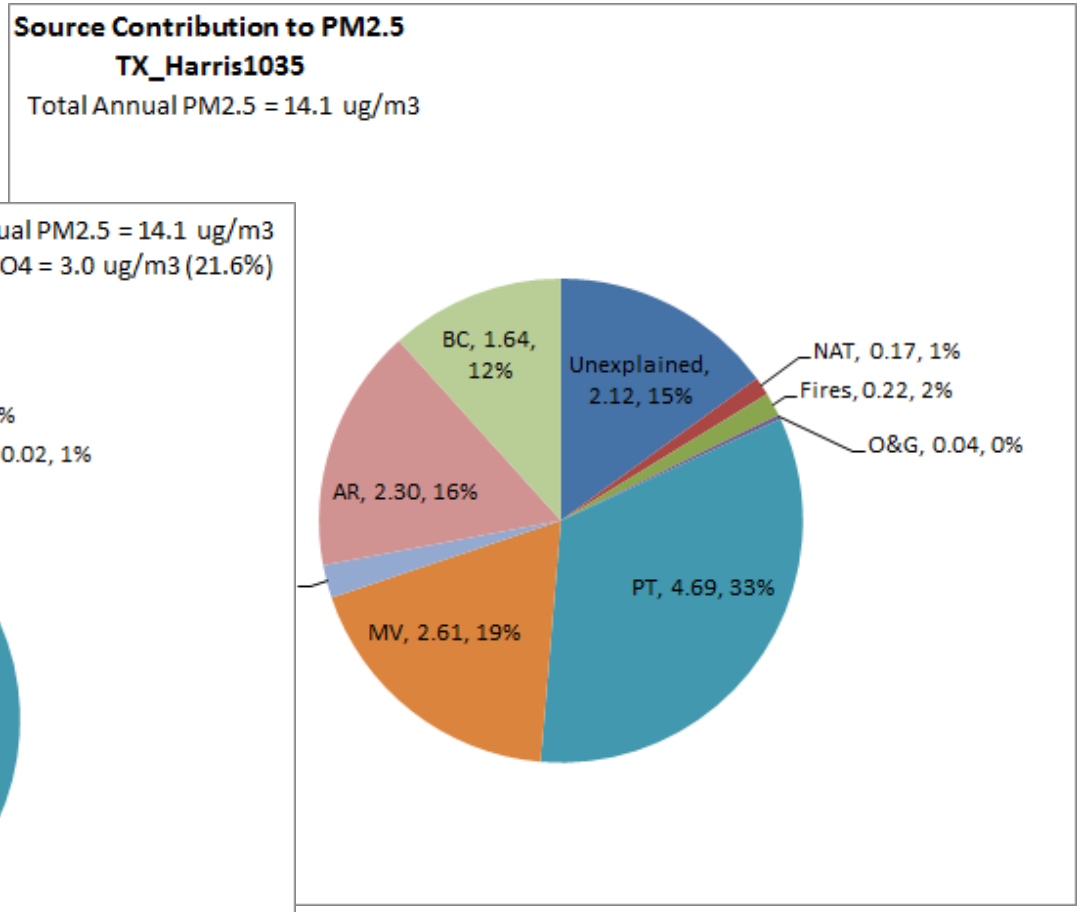
Example: 9th Highest DMAX8 Days at San Juan County, NM



Source Category Contribution to Annual $PM_{2.5}$ Design Values (Appendix J)

Harris County, TX





Category Contributions to Annual Modeled $PM_{2.5}$

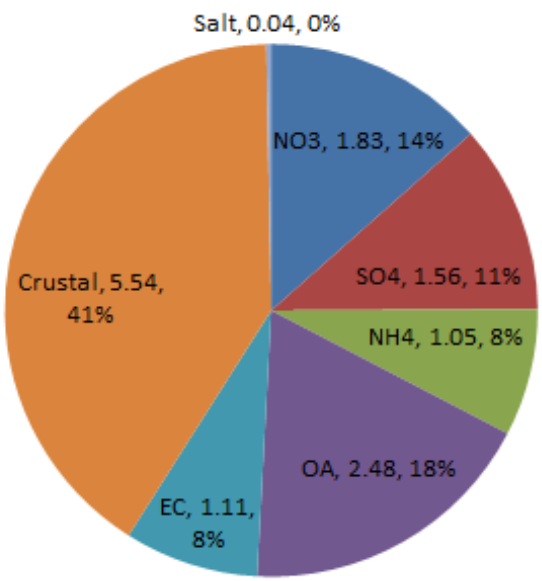
(Appendix K)

Douglas County, NE

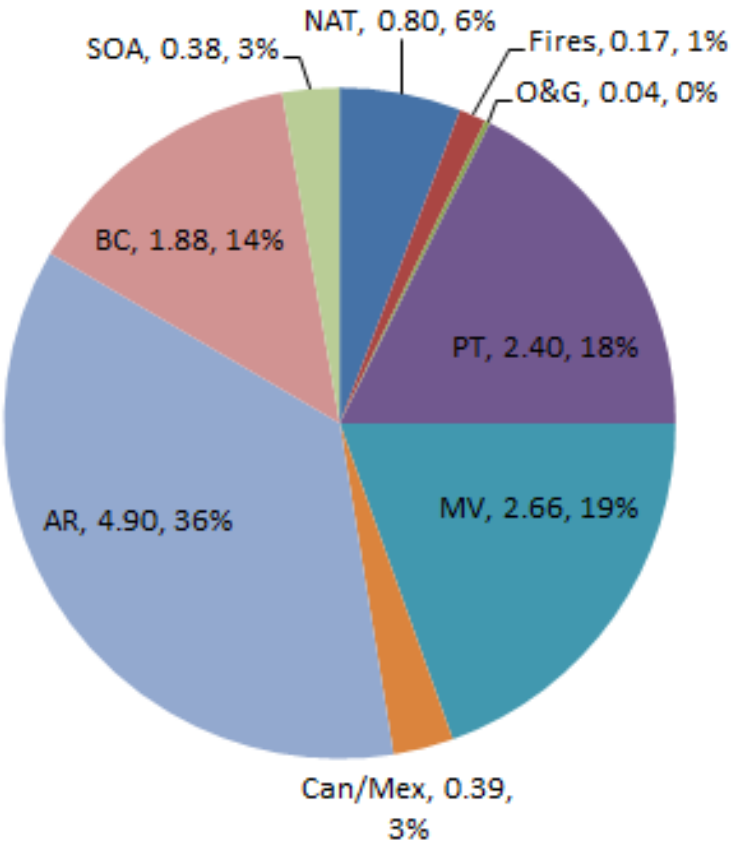
Source Categories →

Species ˅

Composition of Annual Average PM2.5 in ug/m3
NE_Douglas0019
PM2.5 = 13.61 ug/m3

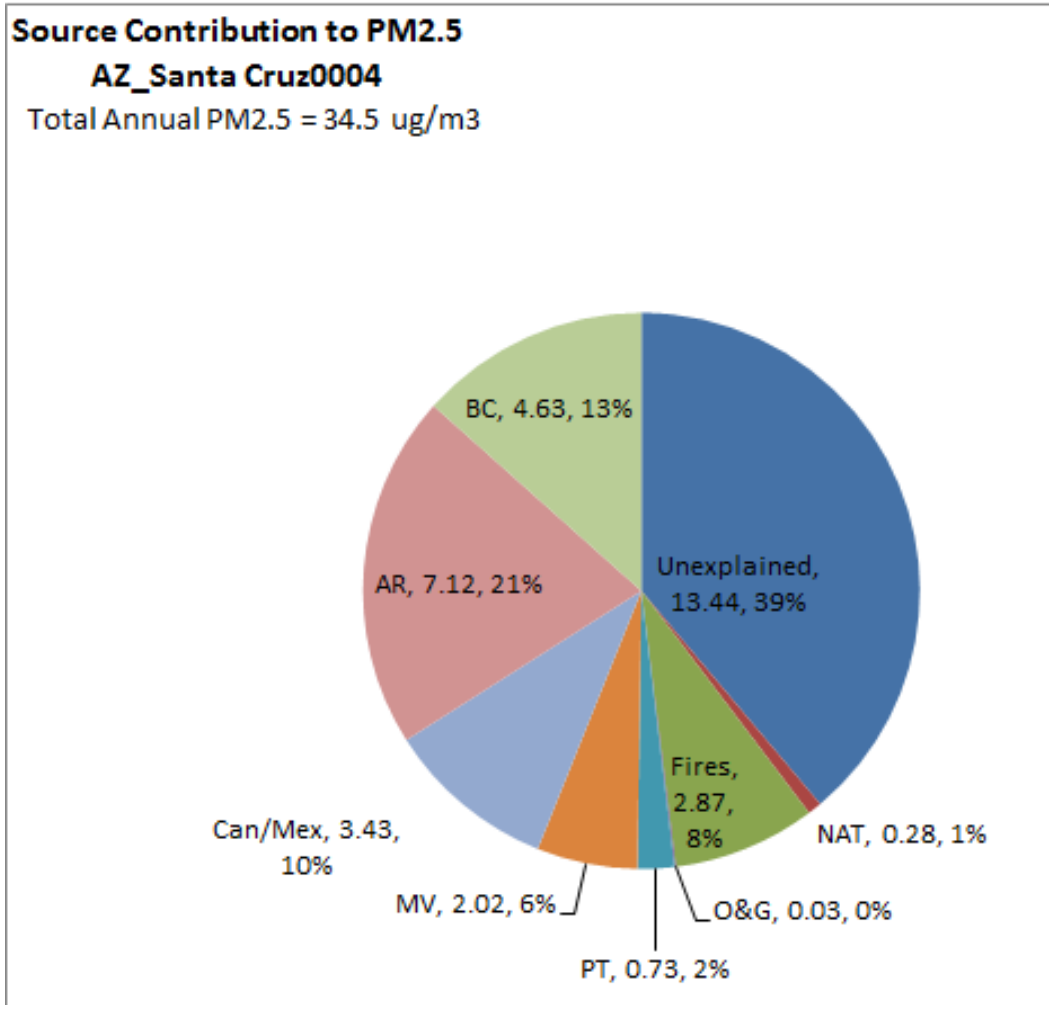


Source Contribution to Annual Average PM2.5 in ug/m3
NE_Douglas0019
PM2.5 = 13.61 ug/m3; PM2.5 = 13.61 ug/m3 (100.0%)



Src Cat Contributions to 24-Hour $PM_{2.5}$ DVCs

- Appendix L
- Very large "Unexplained" portion
  - Like Annual $PM_{2.5}$ missing SOA, SS, PBW and Blank Correction
  - MATS re-ordering of days in DVF to obtain 98th percentile adds to this
  - In future don't use MATS for this type of analysis
  - e.g., look at contributions to top 2% of days in DVC
- **Results not Meaningful**



Appendix M: Src Cat Contribution to 10 Highest Modeled 24-Hour $PM_{2.5}$ Days

Tulsa 4th highest 24-hour $PM_{2.5}$ Day

Src Cat X Species

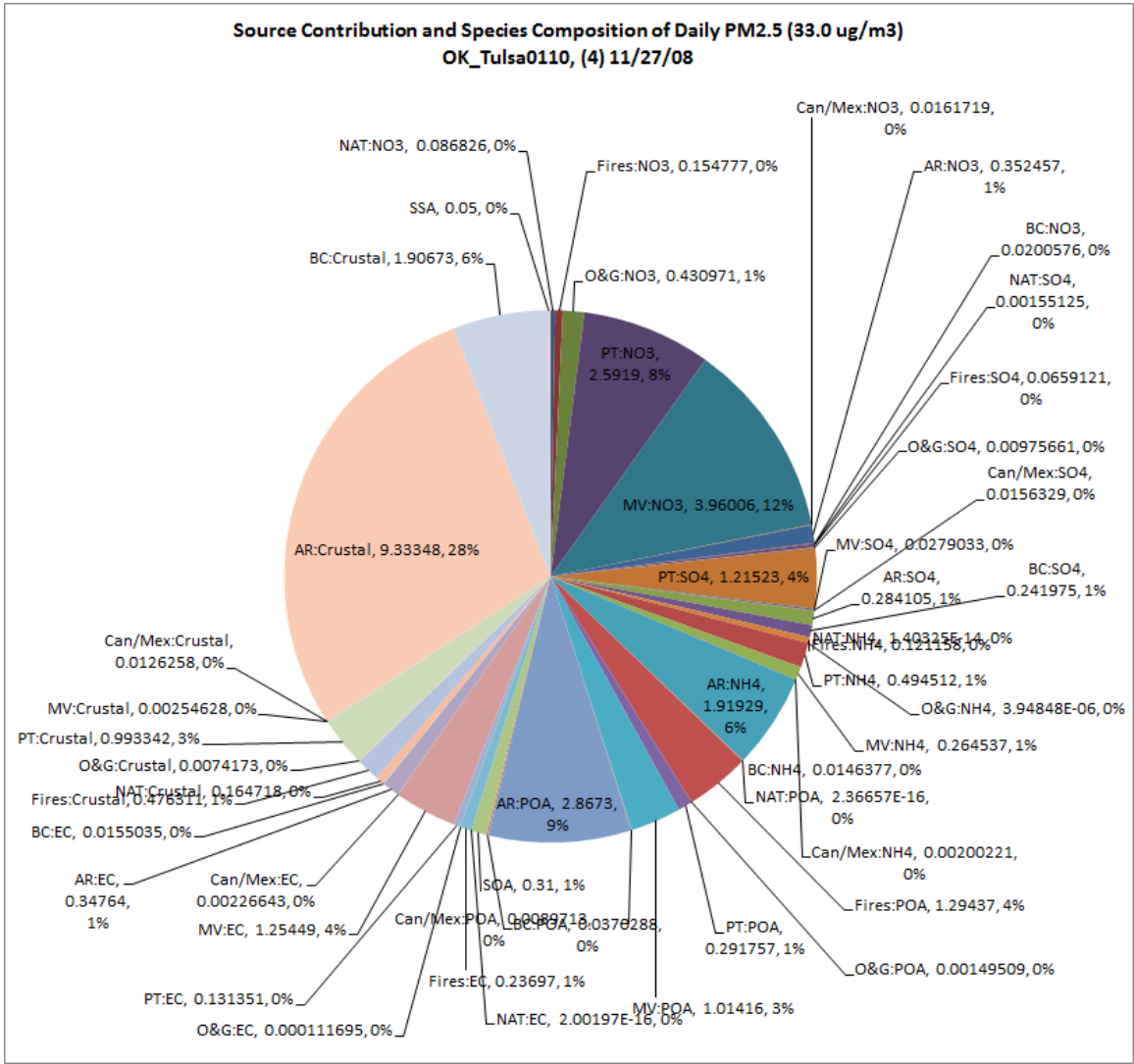
Can Break Down:

Select = Src Cat

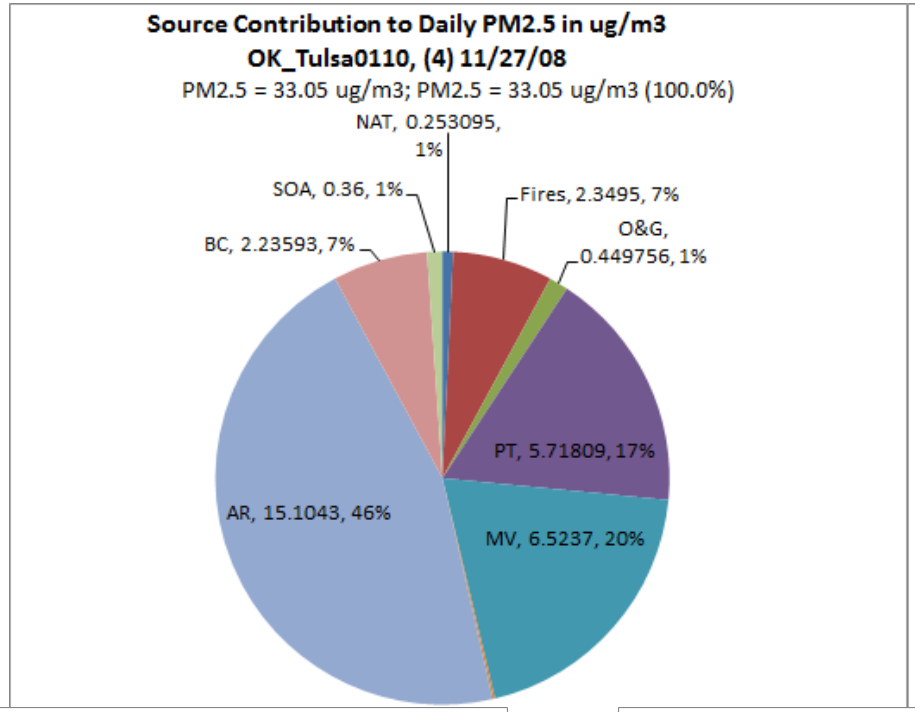
Get By Species

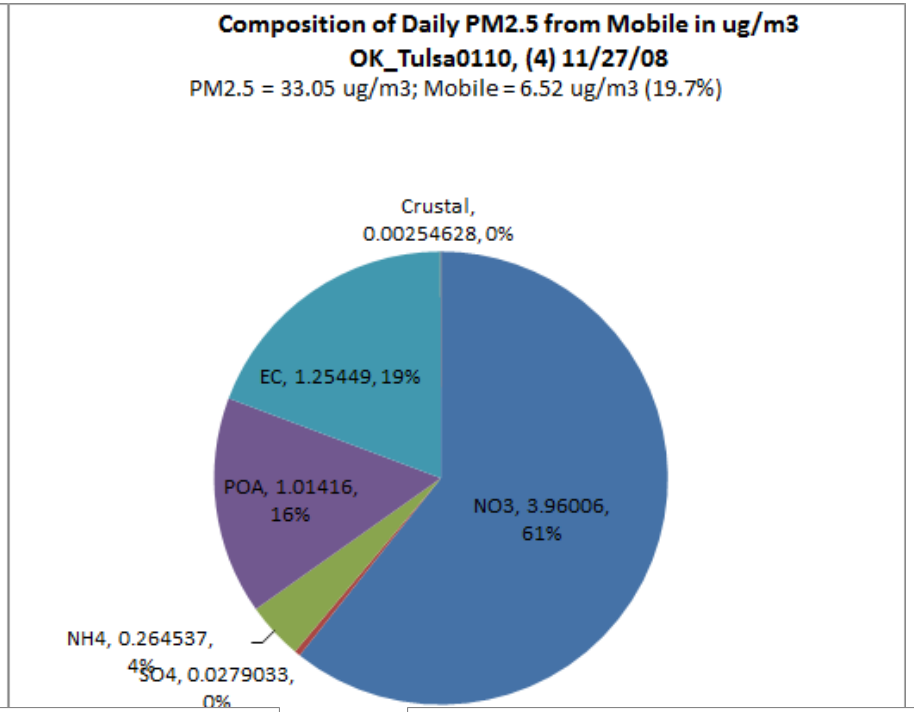
Select = Species

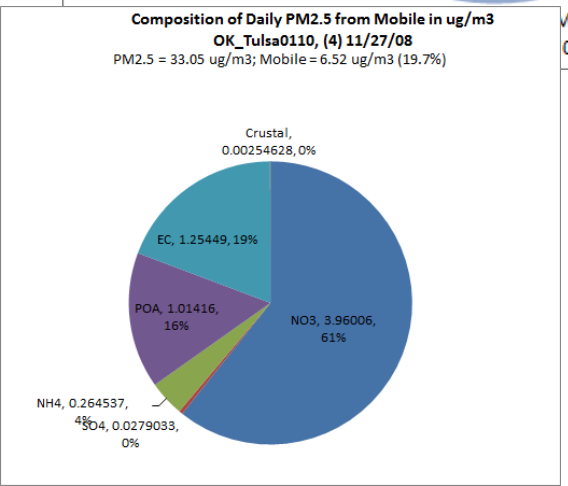
Get by Species

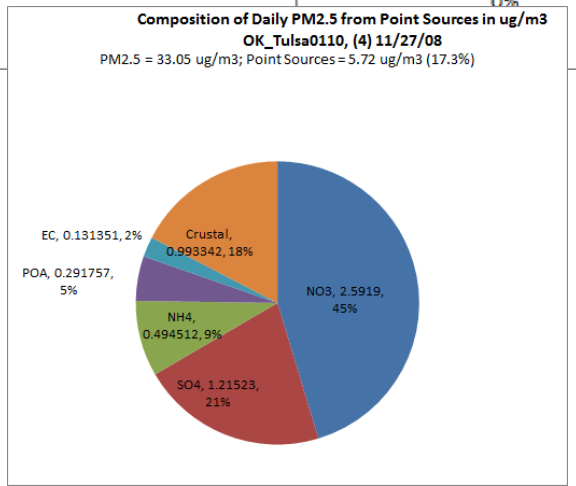


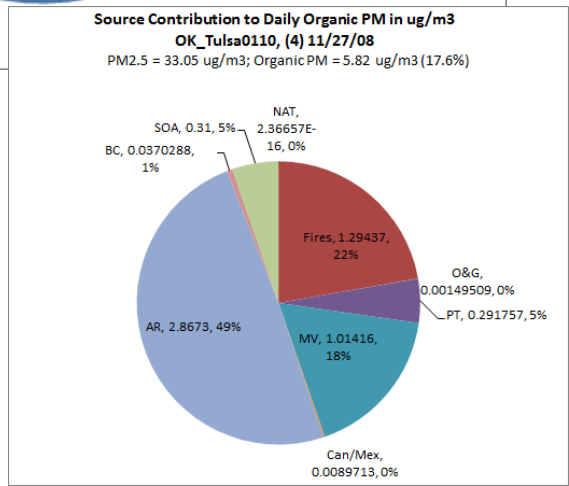
Break Down Tulsa 4th High. 10 Max 24-Hr $PM_{2.5}$



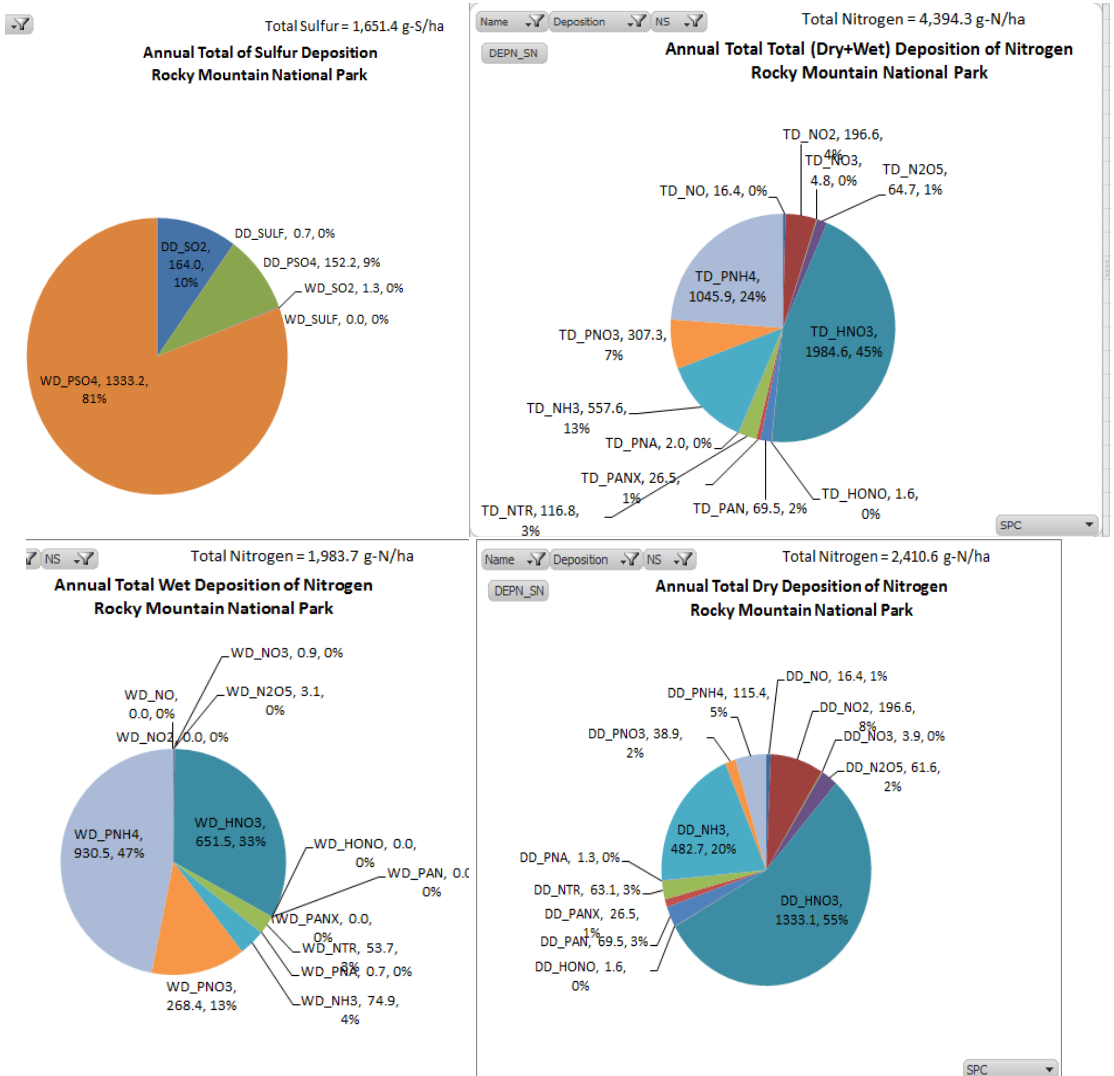








S and N Species Contributions to Wet and Dry Deposition at IMPROVE Sites (Appendix N)



Ex: Rocky Mtn NP

Sulfur Deposition

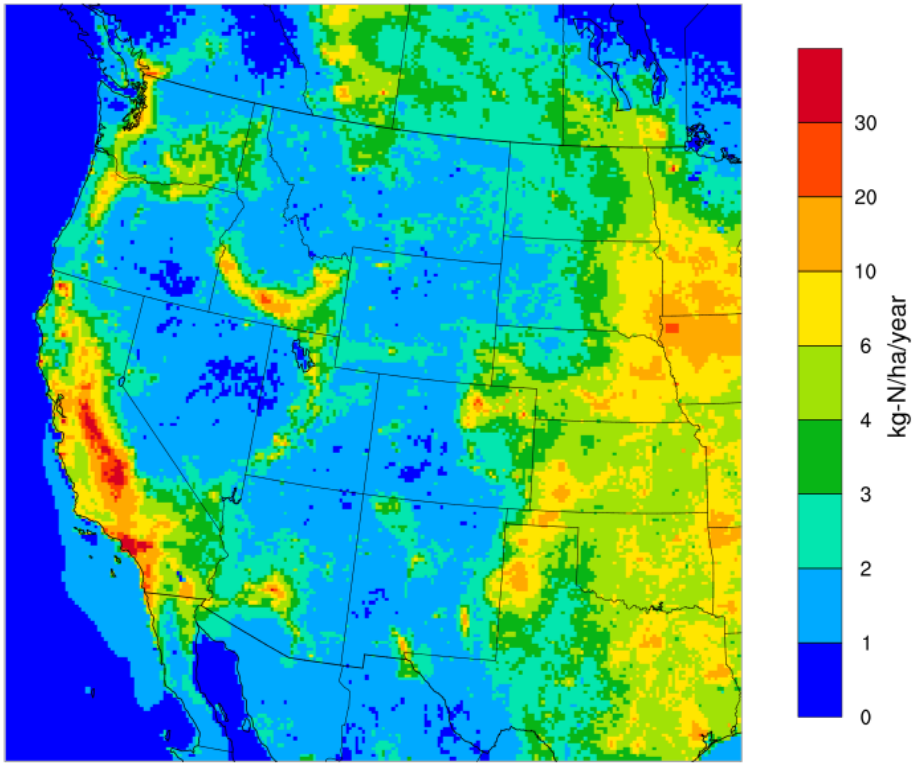
Essentially 2 species
Mainly Wet SO4 (~80%)
Dry SO2 & SO4 (~10% ea.)

Nitrogen Deposition

Many Species
Mainly HNO3 (45%)
(30% Dry & 15% Wet)
NH4 Next (24%)
(21% Wet & 3% Dry)
Dry NH3 (11%)
Wet NO3 (8%)

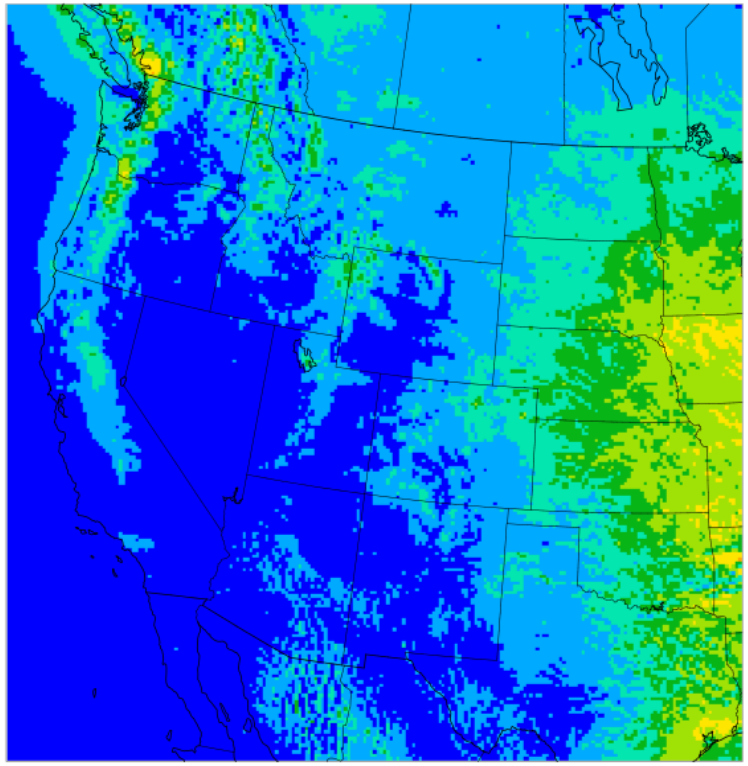
Spatial Maps of Deposition: Example for N

Dry N Deposition



Min(2,229) = 0.14, Max(38,67) = 56.70

Wet N Deposition



Min(56,4) = 0.01, Max(46,209) = 11.29

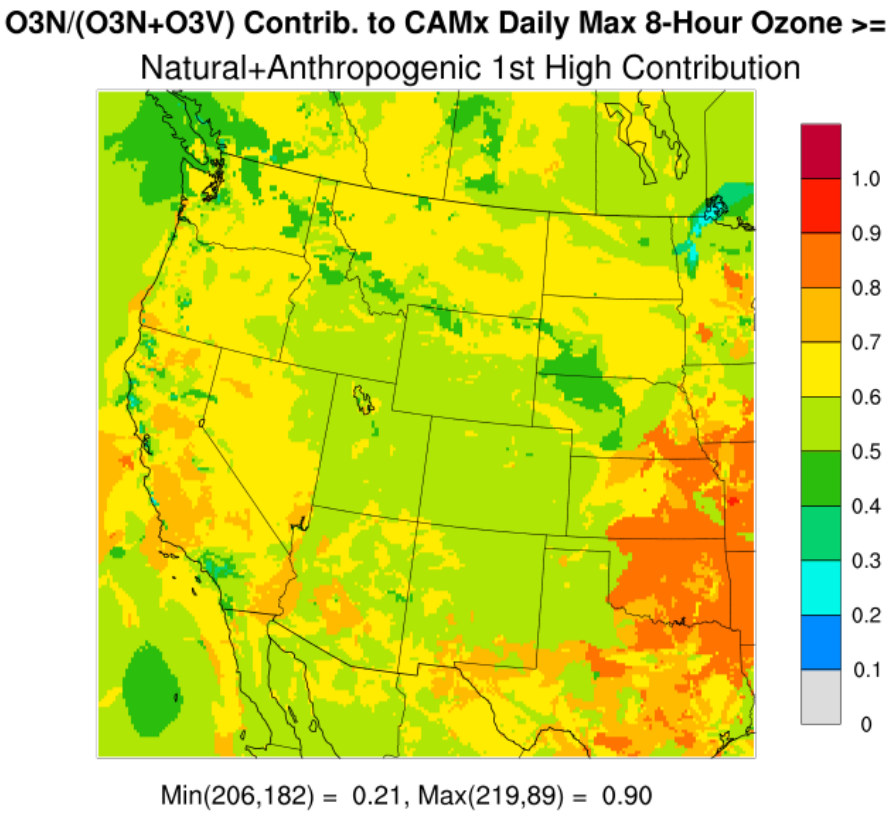
WestJumpAQMS Sensitivity Simulations

- Fires: Fire Inventory from NCAR (FINN) vs. DEASCO3
  - FINN = ~2 x DEASCO3 Emissions
- Boundary Conditions (CONUS): MOZART vs. GEOS-Chem Global Chemistry Models
  - GEOS-Chem slightly lower ozone, no change in MPE conclusions
- Chemistry: CB6 vs. CB05
  - CB6 exacerbates ozone overestimation, esp. in EUSA
  - CB6 undergoing revisions (CB6 R2D2 released soon)
- OSAT Source Apportionment: (instead of APCA)
  - O3V and O3N tracers provide indication of whether ozone formation is more NO_X-limited or VOC-limited

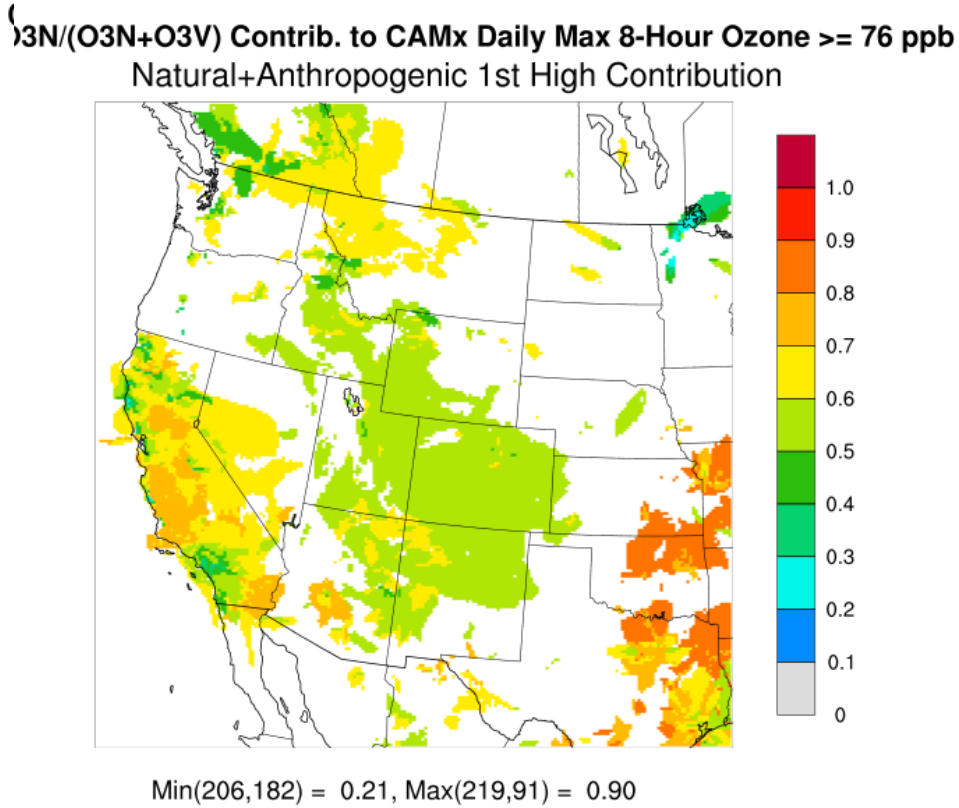
OSAT Sensitivity: NO_X-Limited vs. VOC-Limited

- Total Ozone (Anthropogenic + Biogenic)
  - O3N/(O3N+O3V) = Fraction ozone formed under NO_X limited Conditions

DMAX8 Ozone > 0 ppb



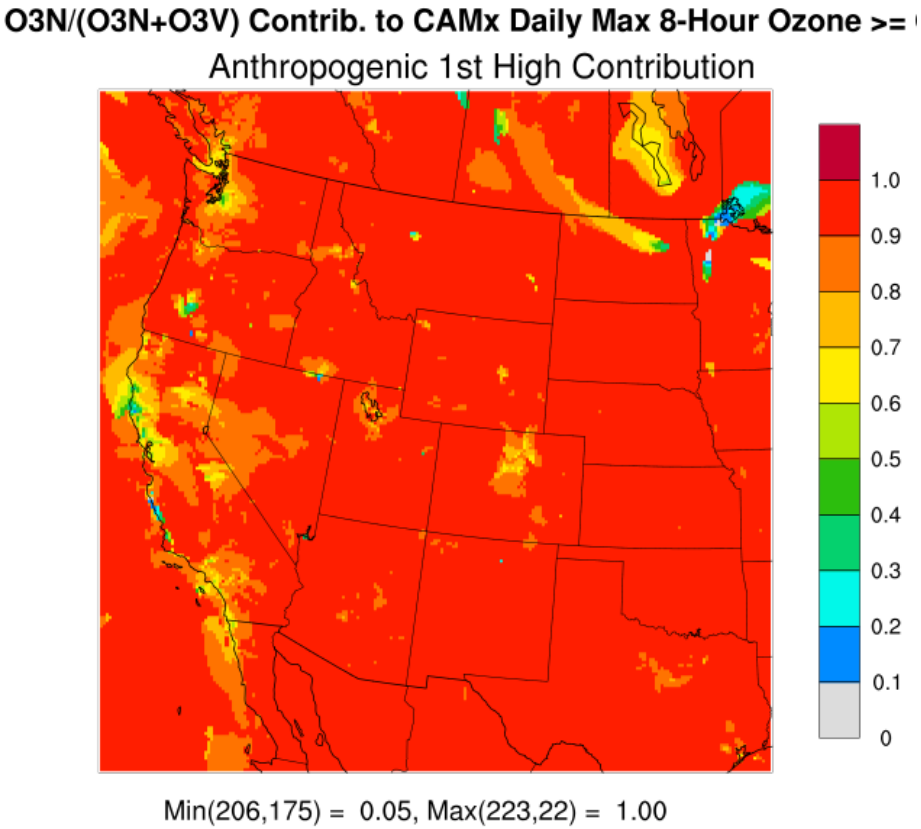
DMAX8 Ozone > 76 ppb



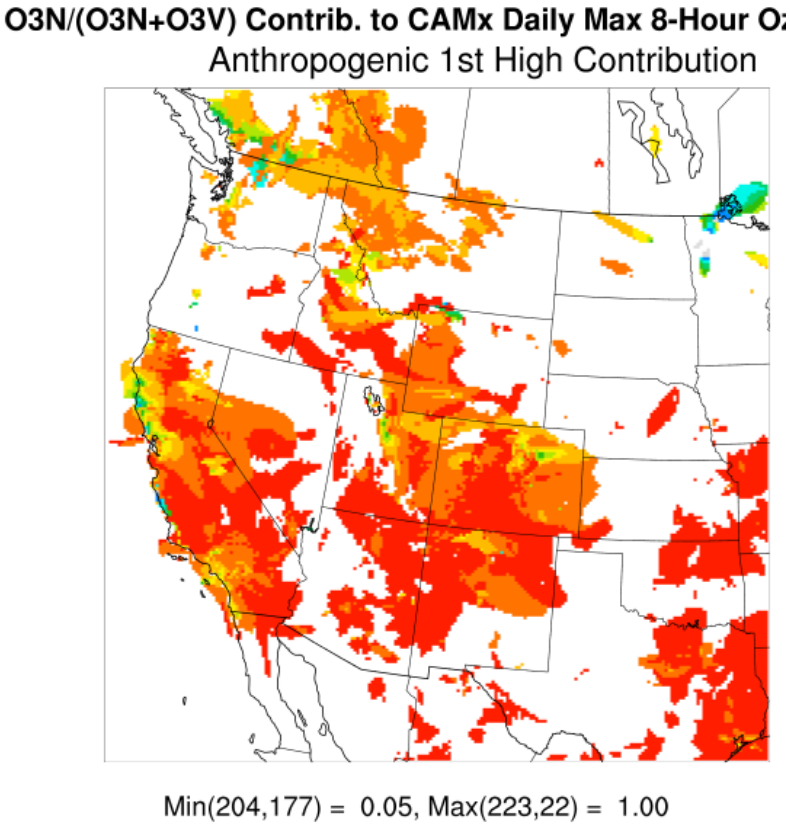
OSAT Sensitivity: NO_X-Limited vs. VOC-Limited

- **Anthropogenic Ozone Only [O3N/(O3N+O3V)]**

DMAX8 Ozone > 0 ppb



DMAX8 Ozone > 76 ppb



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WestJumpAQMS Benefited From

- WRAP Regional Modeling Center (2002 Platform)
- Four Corners Air Quality Task Force (2005 Platform)
- Continental Divide-Creston EIS (2005/2006 Platform)
  - NEPA O&G EIS using PGM for far-field AQ/AQRV
- Denver Ozone SIP Modeling and Follow-On
- 2008 National Emissions Inventory (2008 NEIv2.0)
  - Cornerstone to 2008 emissions
- WRAP Phase III O&G Emissions Study
  - Projected to 2008 plus add Permian Basin
- WRAP MEGAN Biogenic Emissions Enhancement Study
- DEASCO3 2008 Fire Emissions

Studies that Benefited from WestJumpAQMS

- Colorado Air Resource Management Study (CARMMS)
  - 2008 4 km Modeling Platform
- Deterministic & Empirical Assessment of Smoke's Contribution to Ozone (DEASCO3)
  - 2008 36/12 km Modeling Platform
- PMDETAIL -- Smoke contributions to PM
- Three-State Data Warehouse (3SDW) and Three-State Air Quality Study (3SAQS)
  - 2008 36/12/4 km Modeling Platform; Test database for 3SDW
- Additional Follow-On Studies
  - NPS, BLM, etc.

Life After WestJumpAQMS

- Three State Data Warehouse (3SDW) and Air Quality Study (3SAQS):
  - CO, UT, WY, EPA, NPS, USFS, FWS, BLM
  - Grant funding through NPS to:
    - Tom Moore, 3SDW Technical Coordinator
    - CSU/CIRA develop 3SDW website
    - UNC/IE perform 3SAQS modeling and analysis using WestJumpAQMS 2008 platform and develop 2011 modeling platform
- 3SDW to archive WestJumpAQMS 2008 modeling databases and results
  - Repository for emissions, AQ observations and modeling
  - Tested data retrieval using WestJumpAQMS database
  - Plan to implement on-line SA tools like interactive Appendices