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

ENVIRON International Corporation
Alpine Geophysics, LLC
University of North Carolina At Chapel Hill

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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**
- **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
  10. Mexico/Canada
  11. Sea Salt and Lighting
  12. 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

WESTJUMP WRF 12km Humidity Performance Comparison

WESTJUMP WRF 12km Temperature Performance Comparison

WESTJUMP WRF 04km Humidity Performance Comparison

WESTJUMP WRF 04km Temperature Performance Comparison
WRF Wind Speed and Direction 12/4 km

WESTJUMP WRF 12km Wind Speed Performance Comparison

WESTJUMP WRF 12km Wind Direction Performance Comparison

WESTJUMP WRF 04km Wind Speed Performance Comparison

WESTJUMP WRF 04km Wind Direction Performance Comparison
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

July 1, 2008 0:00:00
Min = 0.000 at (13, 24), Max = 372.436 at (95, 63)

WRF Precip

westjump.371.obs.g.unsb.3612 20080701-20080731 RAIN
Grid 12

July 1, 2008 0:00:00
Min = -0.000 at (38, 146), Max = 1203.578 at (112, 6)

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

<table>
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<tr>
<th>Fractional Bias (FB)</th>
<th>Fractional Error (FE)</th>
<th>Comment</th>
</tr>
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<tr>
<td>≤±15%</td>
<td>≤35%</td>
<td>Ozone Model Performance Goal</td>
</tr>
<tr>
<td>≤±30%</td>
<td>≤50%</td>
<td>PM Model Performance Goal</td>
</tr>
<tr>
<td>≤±15%</td>
<td>≤35%</td>
<td>PM Model Performance Criteria.</td>
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</table>

• 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)
    ▪ 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
- Error: 2% CNet
- 13-14% AQS
- 10% CNet

**CO**
- Bias: 9-13% AQS
- Error: 8-9% CNet
- 16-18% AQS
- 14% CNet

MDA8 Observed vs. Model for AZ

<table>
<thead>
<tr>
<th>Distance</th>
<th>NMB</th>
<th>NME</th>
<th>FB</th>
<th>FE</th>
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<td>12 km</td>
<td>5.8%</td>
<td>13.3%</td>
<td>6.8%</td>
<td>13.8%</td>
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<tr>
<td>36 km</td>
<td>5.9%</td>
<td>13.5%</td>
<td>7.3%</td>
<td>14.1%</td>
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MDA8 Observed vs. Model for CO

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<thead>
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<th>NME</th>
<th>FB</th>
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<tbody>
<tr>
<td>12 km</td>
<td>8.9%</td>
<td>15.8%</td>
<td>10.4%</td>
<td>17.2%</td>
</tr>
<tr>
<td>36 km</td>
<td>11.2%</td>
<td>16.9%</td>
<td>12.9%</td>
<td>18.2%</td>
</tr>
</tbody>
</table>

Linear Regression Curves:
- y = 0.6917x + 18.292
- R² = 0.5965
- y = 0.6424x + 20.844
- R² = 0.5838
CAMx 36/12 km DMAX8 NV & UT

**NV**
- Bias: 10-15% AQS
- Error: -1-1% CNet
- Error: 17-20% AQS
- Error: 9% CNet

**UT**
- Bias: 7-11% AQS
- Error: 1% CNet
- Error: 15-18% AQS
- Error: 9% CNet
Northern California Wildfires Jun-Jul 2008

**June Base08c DMAX8 Ozone Shasta 0007**

- Observed
- Predicted
- Fire

**July Base08c DMAX8 Ozone Shasta 0007**

- Observed
- Predicted
- Fire

**June Base08c DMAX8 Ozone Butte 0007**

- Observed
- Predicted
- Fire

**July Base08c DMAX8 Ozone Butte 0007**

- Observed
- Predicted
- Fire
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 $\leq \pm 30\%$

- **Error WESTUS Domain** $\rightarrow$
- **Annual**
  - 36 km = 54%
  - 12 km = 52%
  - PM Goal $\leq 50\%$
  - PM Criteria $\leq 75\%$
CAMx PM$_{2.5}$ Mass Model Performance WESTUS

- IMPROVE

- CSN
Sulfate (SO4) 12 km WESTUS

CSN

IMPROVE

Graphs showing fractional bias and fractional error for 36 km and 12 km models.
Nitrate (NO₃) 12 km WESTUS

CSN

IMPROVE

[Graphs showing fractional bias and fractional error for CSN and IMPROVE at 36 km and 12 km resolution.

Bar charts compare fractional bias and fractional error across different months.]
Organic Aerosol (OA) and Other PM\textsubscript{2.5} (OPM2.5) FBias across CSN in 12 km WESTUS Domain

- OA = 1.4 x OC
- OPM2.5 = PM2.5 – (SO\textsubscript{4} + NO\textsubscript{3} + NH\textsubscript{4} + EC + OA)

- 2008 CSN Carbon measurements unreliable
- 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

- **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

Mesa Verde, CO
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
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 monitors 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
MATS UAA with DVC (2006-2010) ≥ 65 ppb

Min(177,1) = 65.00, Max(45,67) = 113.30
MATS UAA with DVC (2006-2010) ≥ 60 ppb
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
# CSAPR-Type Analysis for Current NAAQS (76 ppb)

<table>
<thead>
<tr>
<th>Upwind State</th>
<th># Monitors ≥ 0.76 ppb</th>
<th>Maximum Contribution (ppb)</th>
<th>State with Maximum</th>
<th>AvgDV at Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>23</td>
<td>1.15</td>
<td>NV</td>
<td>76.00</td>
</tr>
<tr>
<td>California</td>
<td>15</td>
<td>16.89</td>
<td>NV</td>
<td>76.00</td>
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<tr>
<td>Colorado</td>
<td>0</td>
<td>0.51</td>
<td>TX</td>
<td>80.00</td>
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<td>Idaho</td>
<td>3</td>
<td>1.02</td>
<td>WY</td>
<td>78.67</td>
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<td>Kansas</td>
<td>3</td>
<td>8.95</td>
<td>MO</td>
<td>76.00</td>
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<td>Montana</td>
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<td>0.39</td>
<td>WY</td>
<td>78.67</td>
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<td>North Dakota</td>
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<td>TX</td>
<td>77.67</td>
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<td>CO</td>
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<td>1.03</td>
<td>WY</td>
<td>78.67</td>
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<tr>
<td>Wyoming</td>
<td>5</td>
<td>1.53</td>
<td>CO</td>
<td>78.00</td>
</tr>
</tbody>
</table>
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)
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

2\textsuperscript{nd} Highest Modeled DMAX8 Day @ Albuquerque, NM
Appendix B: 10 Highest DMAX8 Ozone Days

1\textsuperscript{st} and 2\textsuperscript{nd} highest Ozone Days at Tulsa, OK

Contributions to MDA8 Ozone [ppb]
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 O₃ Contribution

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

Max(75, 60) = 28.00

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
NE Anthropogenic Max Contribution

Max(79, 63) = 22.01

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

Contrib. to CAMx Daily Max 8-Hour Ozone >= 76 ppb
NM Anthropogenic 4th Highest Contribution

Max(116,79) = 18.25

DMAX8 Ozone ≥ 65 ppb

Contrib. to CAMx Daily Max 8-Hour Ozone >= 65 ppb
NM Anthropogenic 4th Highest Contribution

Max(111,79) = 19.03
Source Category Max Contrib. 4th High DMAX8

**BC**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
BC 4th High Contribution

Max(82.21) = 80.37

**Natural**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
Natural 4th High Contribution

Max(70.11) = 12.84

**Anthropogenic**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
Anthropogenic 4th High Contribution

Max(133.70) = 110.89

**WF**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
Wildfires 4th Highest Contribution

Max(129.53) = 60.13

**Rx**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
Rx Burns 4th Highest Contribution

Max(116.41) = 6.16

**Ag**

Contribution to CAMx Daily Max 8-Hour Ozone >= 0 ppb
Agricultural Burns 4th Highest Contribution

Max(76.51) = 3.15
## CSAPR-Type Annual PM$_{2.5}$ Analysis Current NAAQS

<table>
<thead>
<tr>
<th>Upwind State</th>
<th>#Sites $\geq 0.12$ µg/m$^3$</th>
<th>Maximum Contribution (µg/m$^3$)</th>
<th>State with Maximum</th>
<th>AvgDV at Site</th>
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<td>0.04</td>
<td>MO</td>
<td>12.27</td>
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<tr>
<td>Upwind State</td>
<td># Monitors ≥ 0.35 µg/m³</td>
<td>Maximum Contribution (µg/m³)</td>
<td>State with Maximum</td>
<td>AvgDV at Site</td>
</tr>
<tr>
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State Contributions to Annual PM$_{2.5}$ at Johnson Cty KS

Appendix E

PM$_{2.5}$ 12.57µg/m³
Other 5.29%
Eastern US 26.81%
Canada 2.23%
Mexico 0.53%
Ocean 0.16%
BC 15.58%
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

**Source Contribution at CO_Jefferson0006**
- **Unexplained**: 2.0%
- **Natural**: 4.5%
- **Fires**: 1.0%
- **Upstream Oil+Gas**: 4.0%
- **Point Sources**: 8.0%
- **Mobile**: 25.1%
- **Canada+Mexico**: 1.5%
- **Area**: 2.8%

**Total ozone = 82.0 ppb**
- **BC = 41.9 ppb (51.1%)**

“Unexplained” = 1.6 ppb (2.0%)

**Source Contribution at NM_San Juan1005**
- **Unexplained**: 3.6%
- **Natural**: 3.9%
- **Fires**: 0.9%
- **Upstream Oil+Gas**: 3.1%
- **Point Sources**: 9.7%
- **Mobile**: 8.4%
- **Canada+Mexico**: 1.2%
- **Area**: 0.6%

**Total ozone = 67.0 ppb**
- **BC = 46.0 ppb (68.7%)**

“Unexplained” = 1.5 ppb (3.6%)

San Juan County, NM ➔
- **DVC = 67 ppb**
- **BC = 46 ppb (69%)**
- “Unexplained” = 1.5 ppb (3.6%)

(Appendix H)

← Rocky Flats North, CO
- **DVC = 82 ppb**
- **BC = 42 ppb (51%)**
- “Unexplained” = 1.6 ppb (2.0%)
Source Category Contribution to 10 Highest Modeled DMAX8 O₃ 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 \(^\vee\)

Composition of Annual Average PM2.5 in ug/m$^3$
NE_Douglas0019
PM2.5 = 13.61 ug/m$^3$

- Crustal, 5.54, 41%
- EC, 1.11, 8%
- OA, 2.48, 18%
- NH$_4$, 1.05, 8%
- SO$_4$, 1.56, 11%
- NO$_3$, 1.83, 14%
- Salt, 0.04, 0%

Source Contribution to Annual Average PM2.5 in ug/m$^3$
NE_Douglas0019
PM2.5 = 13.61 ug/m$^3$; PM2.5 = 13.61 ug/m$^3$ (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 98$^{th}$ 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 4$^{th}$ 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 SO$_4$ (~80%)
- Dry SO$_2$ & SO$_4$ (~10% ea.)

**Nitrogen Deposition**
- Many Species
- Mainly HNO$_3$ (45%)
- (30% Dry & 15% Wet)
- NH$_4$ Next (24%)
- (21% Wet & 3% Dry)
- Dry NH$_3$ (11%)
- Wet NO$_3$ (8%)
Spatial Maps of Deposition: Example for N

Dry N Deposition

Min(2,292) = 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 NOX-limited or VOC-limited
OSAT Sensitivity: NO$_x$-Limited vs. VOC-Limited

- Total Ozone (Anthropogenic + Biogenic)
  - $O_3N/(O_3N+O_3V)$ = Fraction ozone formed under NO$_x$ limited Conditions

DMAX8 Ozone $> 0$ ppb  
DMAX8 Ozone $> 76$ ppb

$O_3N/(O_3N+O_3V)$ Contrib. to CAMx Daily Max 8-Hour Ozone $>= 1$
Natural+Anthropogenic 1st High Contribution

Min(206,182) = 0.21, Max(219,89) = 0.90

Min(206,182) = 0.21, Max(219,91) = 0.90
OSAT Sensitivity: $\text{NO}_x$-Limited vs. VOC-Limited

- Anthropogenic Ozone Only $[\text{O}_3\text{N}/(\text{O}_3\text{N}+\text{O}_3\text{V})]$
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