West-wide Jumpstart Air Quality Modeling Study

Final Project Report and Modeling Results

November 15, 2013

Tom Moore
WRAP Air Quality Program Manager

Technical Project Team
ENVIRON, Alpine Geophysics, Univ. of North Carolina

Funding from State of NM and National BLM Air Program

Oversight by western states, local air agencies, federal land managers, EPA regional and national offices
Introduction

• West-wide Jump-start Air Quality Modeling Study (WestJumpAQMS) was initiated in late 2010 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., point, O&G, mobile, et cetera) 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

- Final Report
  - 15 Electronic Appendices
  - Response-to-Comments
- 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
4a-e. Oil and Gas (5 geographic areas)
5. Fire (WF, Rx & Ag)
6. Fugitive Dust
7. Off-Shore Shipping
8. Ammonia
9. Biogenic
11 Mexico/Canada
12. Sea Salt and Lightning
13. Emissions Modeling Parameters

All information on WestJumpAQMS website
WestJumpAQMS Progress Webinars

• June 20, 2013: 2008 Database Development
• July 26, 2013: State-Specific Source Apportionment
• August 29, 2013: Source Category-Specific Source Apportionment
• Interactive agenda from WestJumpAQMS Final Project Report meeting, Denver, CO – September 25, 2013
• Presentations and all project materials at: http://www.wrapair2.org/WestJumpAQMS.aspx
Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 76 ppb

Min(210,3) = 76.00, Max(45,67) = 113.30
Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 70 ppb

Min(107,1) = 70.00, Max(45,67) = 113.30
Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 65 ppb

Min(177,1) = 65.00, Max(45,67) = 113.30
Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 60 ppb

Min(45,2) = 60.00, Max(45,67) = 113.30
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:
  1. 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)
  2. 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)
  3. Detailed Source Category-Specific Source Apportionment
     ▪ 6 key source categories across 4 states in intermountain West
     ▪ 2-way nesting between model domains
State-Specific Ozone Source Apportionment

- 2008 36/12 km Base
- 17 Western States
  - Plus EasternUS, Can, Mex & Off-Shore
- 5 Source Categories
  - Natural
    (Biogenics+Lightning+WBDust+SeaSalt)
  - WF, Rx and Ag Fires
  - Anthropogenic
- 107 Source Groups (21 x 5 + 2)
  - 4 Extra Species for each Group
    - 428 additional species
    - Standard Model = 70 species
    - Computationally Demanding
CSAPR-Type Analysis for Current (76 ppb) NAAQS

• CSAPR looked at contributions to:
  – Average Design Value = Average of DVs from 2006-2010
  – Max Design Values = Max DVs from 2006-2010

• 136 ozone monitors in 12 km WESTUS domain with Average Design Value exceeding NAAQS
  – 86 sites (63%) in California

• For 17 upwind western states examine 2008 contribution to DMAX8 ozone Design Value 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
UT CSAPR-Type Ozone Analysis for 76 & 65 ppb NAAQS (from WestJumpAQMS Appendix A)

Utah Ozone Contributions

Downwind State Design Values

76 ppb

States’ Contributions to Top 5 States Surrounding UTAH, where DV is at or above 76.0 ppb Threshold

<table>
<thead>
<tr>
<th>State</th>
<th>Avg</th>
<th>Max</th>
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<tr>
<td>UT</td>
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<td>CA</td>
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<tr>
<td>CO</td>
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</table>

65 ppb

States’ Contributions to Top 5 States Surrounding UTAH, where DV is at or above 65.0 ppb Threshold

<table>
<thead>
<tr>
<th>State</th>
<th>Avg</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>UT</td>
<td>82</td>
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<td>CA</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

Background

- 76 ppb
- 70 ppb
- 65 ppb
- 60 ppb
State Contributions to Modeled 10 Highest DMAX8 Ozone Days (from WestJumpAQMS Appendix B)

2nd Highest Modeled DMAX8 Day @ RFNO, CO

Contributions to MDA8 Ozone [ppb]

Site: CO_Jefferson0006
Rank: 2 - 15 Jul, 2008
Total Ozone = 80.1 ppb
BC Ozone = 40.7 ppb (50.8%)
Spatial Distribution of State Ozone Contributions

• 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 4\textsuperscript{th} Highest DMAX8 ozone (from WestJumpAQMS Appendix C)
  2. Attainment Test Unmonitored Areas projection contribution to 8-hour ozone design value

• Examples for Colorado next:
  – Maximum contribution to highest DMAX8 ever and design value
  – Maximum contribution to 4\textsuperscript{th} high DMAX8 for 76 and 65 ppb
2008 Colorado 8-Hour Ozone Contribution

Highest Modeled Contribution

Attainment Test Design Value Contribution

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

CO Anthropogenic Max Contribution

Max(144,110) = 29.18

Min(3,1) = 0.00, ◇ Max(142,107) = 17.60
Colorado Max Contribution to 4th High DMAX8 Ozone

DMAX8 Ozone ≥ 76 ppb

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

Max(142,109) = 24.25

DMAX8 Ozone ≥ 65 ppb

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

Max(142,109) = 24.25
“Other Sources” Max Contrib. 4th High DMAX8 Ozone

Boundary Conditions

Natural

Anthropogenic

Wildfire

Prescribed Fire

Agricultural Fire
Northern California Wildfires June-July 2008
Denver Ozone Monitors July 2008

- Jul DMAX8 Ozone Rocky Flats No
- Jul Base08c DMAX8 Ozone Chatfield
- Jul Base08c DMAX8 Fort Collins West
- Jul Base08c DMAX8 Greeley
Detailed 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)
Ozone Source Category-Specific Source Apportionment

← 4 km Detailed Source Apportionment Domain

36/12/4 km Two-Way Grid Nesting

(Results in Appendix I on WestJumpAQMS webpage)
Summary of WestJumpAQMS 2008 Modeling Results for Northern Colorado

- Average Upwind Ozone Contribution to Denver Metro Area/Northern Front Range Monitors on Top 10 Modeled Days (from Appendix B)

- Colorado’s Ozone Contribution to Downwind States (from Appendix A)

- Spatial distribution of total modeled daily 8-hour maximum ozone contribution and Colorado’s contribution at 65 ppb NAAQS level (from Appendix C)

- Detailed Average Ozone Contribution to Denver Metro Area/Northern Front Range Monitors by Source/Location on Top 10 Modeled Days (from Appendix I)
### Average 8-Hour Ozone Concentration of Top 10 Modeled Values at Each Monitor & Source Contribution
(from WestJump AQMS Appendix B)

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Fort Collins-West</th>
<th>Rocky Flats North</th>
<th>Chatfield SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of Top 10 Modeled Values</td>
<td>75.7</td>
<td>78.0</td>
<td>78.7</td>
</tr>
<tr>
<td>Western Boundary Conditions (CA coast / 36 KM domain)</td>
<td>46.8</td>
<td>46.7</td>
<td>51.8</td>
</tr>
<tr>
<td>Natural (Biogenic &amp; Lightning)</td>
<td>3.5</td>
<td>3.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Canada, Mexico, Eastern &amp; Ocean</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Fires (AG, Rx &amp; Wild)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Colorado</td>
<td>16.4</td>
<td>16.6</td>
<td>14.5</td>
</tr>
<tr>
<td>Wyoming</td>
<td>1.7</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Utah</td>
<td>1.6</td>
<td>2.5</td>
<td>2.5</td>
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<tr>
<td>California</td>
<td>0.9</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Nevada</td>
<td>0.4</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Remainder of Western States</td>
<td>3.1</td>
<td>3.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Anthropogenic emissions total from western states</td>
<td>7.7</td>
<td>10.0</td>
<td>7.9</td>
</tr>
</tbody>
</table>
Average Contribution to 2008 Top 10 Modeled Values
Fort Collins-West Larimer0011 (75.7 ppb)

Transported Anthropogenic Emissions from western states totals 7.7 ppb
Average Contribution to 2008 Top 10 Modeled Values
Rocky Flats North Jefferson0006 (78.0 ppb)

Transported Anthropogenic Emissions from western states totals 10.0 ppb
Source Apportionment of the 10 Highest Modeled at NREL (36/12 Grid) (from WestJumpAQMS Appendix B)

### Top 10 MDA8 Ozone and Its Contributions at CO_Jefferson0011

<table>
<thead>
<tr>
<th>Date</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-Jun</td>
<td>79.09 ppb</td>
</tr>
<tr>
<td>08-Jul</td>
<td>78.32 ppb</td>
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<tr>
<td>15-Jul</td>
<td>77.19 ppb</td>
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<tr>
<td>16-Jul</td>
<td>76.47 ppb</td>
</tr>
<tr>
<td>18-Jul</td>
<td>75.19 ppb</td>
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<td>07-May</td>
<td>74.95 ppb</td>
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<td>31-Jul</td>
<td>74.14 ppb</td>
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<td>09-Jul</td>
<td>73.98 ppb</td>
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<tr>
<td>14-May</td>
<td>73.74 ppb</td>
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<tr>
<td>24-May</td>
<td>73.33 ppb</td>
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</table>
Average Contribution to 2008 Top 10 Modeled Values
Chatfield SP Douglas004 (78.7 ppb)

Transported Anthropogenic Emissions from western states totals 7.9 ppb
Colorado’s Ozone Contribution to Downwind States
(from WestJumpAQMS Appendix A)

• A significant contribution for this analysis is 1% of the standard or contributions > 0.76 ppb, addressing the current Ozone NAAQS

• At the current Ozone NAAQS level of 75 ppb Colorado, including the DMA/NFR, does not significantly contribute to downwind nonattainment in surrounding States

• If the Ozone NAAQS were lowered below 70 ppb then Colorado would start to be a significant contributor to downwind exceedances especially in San Juan County NM and in Oklahoma

• This analysis is for 2008 and is not a regulatory analysis that would have to examine a future year. A future year analysis, as is done for CSPAR, would be required in a Transport SIP.
States' Contributions to Top 5 States Surrounding Colorado, where DV is at or above 70.0 ppb Threshold

<table>
<thead>
<tr>
<th></th>
<th>WY</th>
<th>WA</th>
<th>UT</th>
<th>TX</th>
<th>SD</th>
<th>OR</th>
<th>OK</th>
<th>NV</th>
<th>NM</th>
<th>NE</th>
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<th>CO</th>
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<tbody>
<tr>
<td>Avg 67.00</td>
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<td>70 ppb</td>
</tr>
<tr>
<td>Avg 67.67</td>
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<td>60 ppb</td>
</tr>
</tbody>
</table>
Colorado's Contributions to Top 5 States Surrounding COLORADO, where DV is at or above 70.0 ppb Threshold

Avg 67.00
Max 71.00
Avg 67.67
Max 70.00
Colorado’s Ozone Contribution to Downwind States, cont.
(from WestJumpAQMS Appendix A)

• If the Ozone NAAQS were lowered to below 65 ppb then Colorado would start to be a significant contributor (> 0.65 ppb) to downwind exceedances especially in San Juan County NM, Oklahoma, Texas, and in Kansas

• If the Ozone NAAQS were lowered to below 60 ppb then Colorado would continue to be a significant contributor (> 0.60 ppb) to downwind exceedances in San Juan County NM, Oklahoma, Texas, and in Kansas, but not expand to be a significant contributor to additional states

• This analysis is for 2008 and is not a regulatory analysis that would have to examine a future year. A future year analysis, as is done for CSPAR, would be required in a Transport SIP.
States' Contributions to Top 5 States Surrounding Colorado, where DV is at or above 65.0 ppb Threshold

<table>
<thead>
<tr>
<th>State</th>
<th>Avg 67.00</th>
<th>Max 71.00</th>
<th>Avg 67.67</th>
<th>Max 70.00</th>
<th>Avg 70.67</th>
<th>Max 74.00</th>
<th>Avg 67.67</th>
<th>Max 71.00</th>
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</table>
Colorado's Contributions to Top 5 States Surrounding COLORADO, where DV is at or above 65.0 ppb Threshold

<table>
<thead>
<tr>
<th>State</th>
<th>Avg</th>
<th>Max</th>
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<tr>
<td>NM_San Juan</td>
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<td>71.00</td>
</tr>
<tr>
<td>OK_Dewey</td>
<td>67.67</td>
<td>70.00</td>
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<td>TX_Travis</td>
<td>70.67</td>
<td>74.00</td>
</tr>
<tr>
<td>KS_Sedgwick</td>
<td>67.67</td>
<td>71.00</td>
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</table>

[ppb]
States' Contributions to Top 5 States Surrounding Colorado, where DV is at or above 60.0 ppb Threshold

<table>
<thead>
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<th>State</th>
<th>Avg</th>
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<tr>
<td>NM_San Juan1005</td>
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</tr>
<tr>
<td>KS_Sedgwick0010</td>
<td>67.67</td>
<td>71.00</td>
</tr>
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</table>

Background levels:
- 76 ppb
- 70 ppb
- 65 ppb
- 60 ppb
Colorado's Contributions to Top 5 States Surrounding COLORADO, where DV is at or above 60.0 ppb Threshold

<table>
<thead>
<tr>
<th>State</th>
<th>Avg</th>
<th>Max</th>
<th>Avg</th>
<th>Max</th>
<th>Avg</th>
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<tbody>
<tr>
<td>NM_San Juan</td>
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<tr>
<td>TX_Travis</td>
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</tbody>
</table>

[ppb]

Colorado's Contributions to Top 5 States Surrounding COLORADO, where DV is at or above 60.0 ppb Threshold
Spatial Distribution of the Maximum Modeled 2008 Anthropogenic contribution at a 65 ppb level for the Ozone NAAQS
(from WestJumpAQMS Appendix C)

- If the Ozone NAAQS is lowered to 65 ppb then Colorado and portions of a number of other western states would be modeled as nonattainment areas.
Spatial Distribution of the Maximum Modeled 2008 Colorado Anthropogenic contribution at a 65 ppb level for the Ozone NAAQS (from WestJumpAQMS Appendix C)

- From previous slides Colorado would have a significant contribution (> 0.65 ppb) to non-attainment at the San Juan County monitor in northwestern New Mexico, as well as monitors in Oklahoma, Texas, and Kansas.
Detailed 2008 Modeled Contribution 4th Maximum at Fort Collins West (from WestJumpAQMS Appendix I)

Contributions to MDA8 Ozone [ppb] at CO_Larimer0011
Rank (4) 05/07/08; Model = 71.7 ppb; Obs = 61.6 ppb; Bias = +16.4%; BC = 43.0 ppb (60.0%)
Detailed 2008 Source Contribution – Average of 10 Highest Modeled Values at Fort Collins West
(from WestJumpAQMS Appendix I – additional processing, combining sources within WY, UT, and NM)

Fort Collins West Top 10 Average Conc.=70.14 PPB
Detailed 2008 Modeled Contribution 4th Maximum at Rocky Flats North
(from WestJumpAQMS Appendix I)

Contributions to MDA8 Ozone [ppb] at CO_Jefferson0006
Rank (4) 07/15/08; Model = 75.0 ppb; Obs = 77.8 ppb; Bias = -3.5%; BC = 40.4 ppb (53.9%)
Detailed 2008 Source Contribution – Average of 10 Highest Modeled Values at Rocky Flats
(from WestJumpAQMS Appendix I – additional processing, combining sources within WY, UT, and NM)

Rocky Flats North Top 10 Modeled Concentration Average = 74.73 PPB

- BC, 41.08, 55%
- Colorado, 18.10, 25%
- Mob:CO, 11.68, 16%
- PT:CO, 2.93, 4%
- Area:CO, 1.37, 2%
- OG:CO, 2.12, 3%
- Can/Mex, 1.08, 1%
- Natural, 3.58, 5%
- Fire, 0.76, 1%
- Rem, 5.89, 8%
- Ut, 1.66, 2%
- NM, 0.66, 1%
- Wy, 1.91, 2%
Detailed 2008 Modeled Contribution 4th Maximum at Chatfield S.P.
(from WestJumpAQMS Appendix I)

Contributions to MDA8 Ozone [ppb] at CO_Douglas0004
Rank (4) 05/14/08; Model = 77.7 ppb; Obs = 63.3 ppb; Bias = +22.8%; BC = 59.8 ppb (77.0%)
Detailed 2008 Source Contribution – Average of 10 Highest Modeled Values at Chatfield S.P.

(from WestJumpAQMS Appendix I – additional processing, combining sources within WY, UT, and NM)
Detailed 2008 Modeled Contribution 4th Maximum at Greeley Tower (from WestJumpAQMS Appendix I)
Detailed 2008 Source Contribution – Average of 10 Highest Modeled Values at Greeley Tower
(from WestJumpAQMS Appendix I – additional processing, combining sources within WY, UT, and NM)

Greeley Tower Top 10 Average Modeled Concentration = 69.91 PPB
WestJumpAQMS Benefited From

- WRAP Regional Modeling Center (2002 Platform)
- Four Corners Air Quality Task Force (2005 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
- WESTAR-funded MEGAN Biogenic Emissions Enhancement Study
- DEASCO$_3$ 2008 Fire Emissions
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.
Thanks –

Tom Moore, WRAP Air Quality Program Manager
Western States Air Resources Council (WESTAR)

e: tmoore@westar.org | o: 970.491.8837

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