Development of REMSAD emissions tagging scheme in support of MANE-VU contribution assessment

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NESCAUM/ MANE-VU

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What’s REMSAD model?

- 3-D Eulerian grid model developed by Systems Applications International, Inc. (SAI)
- Nested-grid capabilities and user defined vertical layers
- Simulate both inert and chemically reactive pollutants (micro-CB-IV chemical mechanism)
- Parameterized aerosol chemistry and dynamics for fine and coarse particles
- Tagging scheme for sulfur, nitrogen, cadmium and mercury
Role of REMSAD modeling

• MANE-VU is building a weight of evidence approach looking at monitoring data, emissions inventory data, regional air-quality modeling and key data analysis findings

• All these techniques have been synthesized and interpreted in an interim “contribution assessment” or pollution apportionment report

• REMSAD is the 2nd most comprehensive model (to CMAQ) with source tagging capability
REMSAD modeling in Weight of Evidence Approach

<table>
<thead>
<tr>
<th>Analytical technique</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions/distance</td>
<td>Empirical</td>
</tr>
<tr>
<td>Incremental Probability</td>
<td>“Receptor”-based trajectory technique</td>
</tr>
<tr>
<td>Cluster-weighted Probability</td>
<td>“Receptor”-based trajectory technique</td>
</tr>
<tr>
<td>Emissions x upwind probability</td>
<td>Empirical/trajecotry hybrid</td>
</tr>
<tr>
<td>Source Apportionment Approaches</td>
<td>Receptor model/trajecotry hybrid</td>
</tr>
<tr>
<td>REMSAD tagged species</td>
<td>“Source”-based grid model</td>
</tr>
<tr>
<td>CALPUFF with MM5-based meteorology</td>
<td>“Source”-based dispersion model</td>
</tr>
<tr>
<td>CALPUFF with observation based meteorology</td>
<td>“Source”-based dispersion model</td>
</tr>
</tbody>
</table>
Previous REMSAD modeling

• Sulfur tagging: Elevated point sources from 32 eastern states only
• USEPA Clear Skies [2003] 2001 “proxy” inventory
• USEPA 1996 MM5 meteorology
• National domain with 36km grid
“New” REMSAD modeling platform

- Sulfur source tagging:
  - Elevated & Low level sources from 31 eastern states and Canada (Run 1, 2, 3)
- Boundary Conditions are tagged
- RPO 2002 EI (MANE-VU/VISTAS/MRPO/CENRAP) and 2000/2002 Canadian Inventory
- UMD 2002 MM5 meteorology
- Eastern US domain with 12km grid
• 12km Eastern US domain
• 36km National Domain CMAQ run served as BC
Emissions Inventory Used

• MANE-VU: Ver. 2
• Other RPOs: VISTAS/MRPO/CENRAP (EI utilized for the VISTAS revised Phase II modeling)
• CANADA: Y2000 EC emissions, 2002 NPRI (from NYSDEC)
• Biogenic: BEIS3.12 through SMOKE
REMSAD Emission Tags (Run 1, 2, 3)

Black : Run 1
Red : Run 2
Blue : Run 3
REMSAD Emissions Tagging

Updated speciation profile

Tag-Ready SMOKE

Tagged SMOKE-ready EI

SMOKE-ready EI

Tagged REMSAD-ready Emissions

REMSAD

In-house tagging software
Tagged Emissions
REMSAD performance

IMPROVE/STN measurement vs. REMSAD (SO4)
REMSAD tagged concentration

Ann Avg of CT's TSO4_1n

Ann Avg of DE's TSO4_2o

Ann Avg of ME's TSO4_3p

Ann Avg of MD's TSO4_4q

Ann Avg of MA's TSO4_5r

Ann Avg of NH's TSO4_6s

Minimum: 0.000 at (2.171), Maximum: 3.444 at (124.84)
Minimum: 0.000 at (2.171), Maximum: 1.541 at (154.122)
Minimum: 0.000 at (2.171), Maximum: 0.920 at (142.131)
REMSAD tagged concentration

Ann Avg of NJ's TSO4_7t

Ann Avg of NY's TSO4_8u

Ann Avg of PA's TSO4_9v

Ann Avg of Non-MANE-VU St

(TSO4_0m/TSO4l)*100 [ST1b]

m=xysum.TSO4_0.ann.2002.out (non-MANE-VU states)
l=xysum.TSO4.ann.2002.out (TSO4 sum of Tags)

 ug/m³

0.000 1 1
1.250 1.625 1
2.500 3.125 1
3.750 4.375 1
5.000 1.172 1

% 1

January 1,2002 5:00:00

Min= 0.641 at (2.171), Max= 14.490 at (45.9)

January 1,2002 5:00:00

Min= 34.5 at (138,102), Max= 100.0 at (4,166)
Location of four class-I areas (receptor site)

- Lye Brook
- Acadia
- Brigantine
- Shenandoah
Contribution analysis
(Annual average sulfate concentration)

Percent Contributions of Various Methods

<table>
<thead>
<tr>
<th>Location</th>
<th>REMSAD</th>
<th>CALPUFF(VT)</th>
<th>CALPUFF(MD)</th>
<th>Percent</th>
<th>Upwind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acadia</td>
<td>0.68</td>
<td>0.79</td>
<td>1.22</td>
<td>0.98</td>
<td></td>
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<tr>
<td>Brigantine</td>
<td>0.58</td>
<td>0.50</td>
<td>0.72</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Lye Brook</td>
<td>0.41</td>
<td>0.38</td>
<td>0.56</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Shenendoah</td>
<td>0.49</td>
<td>0.39</td>
<td>0.53</td>
<td>0.48</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- MANEU
- MIDWEST
- VISTAS
- CENRAP
- CANADA
- OUTSIDE DOMAIN
Contribution to PM sulfate in a receptor site

Ann Avg of MA's TSO4_5r

XYSUM
r=xysum.TSO4_5.ann.2002.out (ST1b)

January 1, 2002 5:00:00
Min= 0.000 at (2,171), Max= 1.541 at (154,122)

Acadia NP

MA 10.1%
CANADA 8.7%
OTHER 33.7%

NJ 1.4%
NH 2.2%
MD 2.2%
IN 2.1%
MI 2.0%
VA 1.5%
NC 1.5%
VA 1.5%
DC 0.0%
MS 0.0%
VT 0.1%
RI 0.3%
TN 0.6%
GA 0.7%
CT 0.8%
DE 1.0%
IL 1.4%
KY 1.2%
CENRAP 0.9%

Contribution from provinces/territories:
MA: 10.1%
Canada: 8.7%
Other: 33.7%
New Jersey: 1.4%
New Hampshire: 2.2%
Maryland: 2.2%
Indiana: 2.1%
Michigan: 2.0%
Virginia: 1.5%
North Carolina: 1.5%
District of Columbia: 0.0%
Maryland: 1.4%
Kentucky: 1.2%
CENRAP: 0.9%
Contribution to PM sulfate in a receptor site

Ann Avg of PA's TSO4_9v

Lye Brook, VT
Contribution to PM sulfate in a receptor site

Ann Avg of PA's TSO4_9v

XYSUM
v=xysum.TSO4_9.ann.2002.out (ST1b)

January 1, 2002 5:00:00
Min = 0.000 at (2,171). Max = 3.556 at (98,89)

Brigantine, NJ
Contribution to PM sulfate in a receptor site

Shenandoah, VA
Comparison of Sulfate Extinctions on 20% Worst days

![Comparison of Sulfate Extinctions on 20% Worst days](image.png)
Conclusion and On-going Work

- Emissions tagging can reveal forward source contributions without having many zero-out runs.
- Will do the same emissions processing and air quality modeling for the year 2018 control case (BOTW).
- NESCAUM has been using REMSAD model for mercury tagging as well but will move on to tagging version of CMAQ as it will be available in the near future.
- More detailed information can be found in our contribution assessment report.
Thank You!