Visualization of 1999 NEI as a Prelude to 2002 NEI Inventory for Mid-Atlantic and Northeastern States

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ABSTRACT

A recent emissions inventory improvement project for a Mid-Atlantic and Northeastern states ozone modeling exercise included a detailed emissions inventory mapping for QA/QC and visualization purposes. Following this example, analysis of county level emissions for criteria pollutants, PM$_{2.5}$, and NH$_3$ has been undertaken for the 1999 NEI inventory for the Mid-Atlantic and Northeastern states. This will identify the most important source categories in the region, and gaps and abnormalities in the data to help prioritize 2002 emissions inventory needs. The 2002 inventory is expected to be the basis for upcoming ozone, PM$_{2.5}$, and regional haze modeling.

Specifically, this paper i) summarizes 1999 point, area, highway, and non-road CO, NH$_3$, NO$_x$, SO$_2$, PM$_{10}$, PM$_{2.5}$, and VOC emissions for the Mid-Atlantic and Northeastern states, ii) includes county level emission density maps for the four major source groups (point, area, onroad, and nonroad), iii) compares 1999 NEI emission levels with previous inventories, and iv) identifies (SCC based) source categories comprising at least 90% of the emissions in the region for each pollutant. Special attention should be given to these categories when preparing the 2002 inventory to eliminate gaps and data abnormalities, create consistency in emissions calculation methods, and establish transparency.

INTRODUCTION

The 1999 National Emissions Inventory (NEI) version 2, officially announced on December 2, 2002, has been used for this study. A draft version 3 of the 1999 NEI was announced on March 11, 2003, and further state revisions are expected. A few states in the Mid-Atlantic and Northeast region (i.e. New Jersey, New York, and probably some others) will have improved data in version 3, especially for point sources. Therefore, emissions presented in this study do not necessarily reflect the most up to date NEI data corrected by some of the states. However, QA/QC and visualization of the NEI take time, and one must initiate this process in parallel with preparation of new versions of inventories.

The purpose of this study is not to prepare a better or improved 1999 regional inventory for (which has no modeling significance) but to learn from 1999 inventory as a prelude to prepare a better 2002 inventory. The purpose is to help understand the most important source categories for the precursors of ozone, PM$_{2.5}$, and haze in the Mid-Atlantic and Northeast Visibility Union.
(MANE-VU), and identify data gaps and abnormalities in the 1999 NEI. Lessons learned will be used to improve the 2002 base year modeling inventory and focus inventory work on those source categories where improvements are necessary. No inventory is ever complete or perfect. Usually very limited time is available between the release of a national inventory and required modeling studies for SIP or other demonstration purposes. It is anticipated that this will be especially the case for 2002 visibility modeling work. Therefore pro-active work targeted towards preparing a better 2002 inventory will be beneficial.

Tables and plots presented in this paper give a brief overview of the 1999 inventory for the Mid-Atlantic and Northeastern states. A much larger suite of summary tables and plots, and county based emissions density maps for those SCC categories comprising a large portion of the inventory for each pollutant of concern (CO, NH$_3$, NO$_x$, SO$_2$, PM$_{2.5}$, PM$_{10}$, and VOC) are available online at www.marama.org/visibility. Comments are invited.


Mid-Atlantic Regional Air Management Association (MARAMA) states are Delaware, the District of Columbia, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia.

Northeast States for Coordinated Air Use Management (NESCAUM) states are Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

**SUMMARY of EMISSIONS in the MID-ATLANTIC and the NORTHEAST**

Figure 1.a. and 1.b. show the total annual and ozone season daily (OSD) emissions by state in the Mid-Atlantic and the Northeast for NH$_3$, NO$_x$, SO$_2$, PM$_{2.5}$, PM$_{10}$, and VOC. These figures give an overall comparison of emissions levels between the states for each pollutant.

Table 1 tabulates emissions on a more specific level, by four major source types (point, area, onroad, and nonroad) for annual and OSD levels in the MANE-VU region. Tables showing emissions for each pollutant by four major source types by state can be found online at www.marama.org/visibility.

**IMPORTANT SOURCE CATEGORIES in the MANE-VU REGION**

This discussion focuses on those source categories that represent the major contributions to primary fine particulate emissions and the gaseous precursors of secondary particulates in the MANE-VU region.

Emission summaries developed in this study will assist MANE-VU in deciding where to focus emissions inventory improvement activities. Emissions are presented for aggregate source categories summed for all states in the MANE-VU region for each pollutant for annual and OSD
levels. Emissions totals for at least 90% of the emissions for each pollutant in the region can be found online at [www.marama.org/visibility](http://www.marama.org/visibility). In this paper, an example summary for NH$_3$ is presented in Table 2.

**Carbon Monoxide**

Gasoline Highway Vehicles (about 63%) and Gasoline Off Highway Vehicles (about 17%) comprise an overwhelming 79% of the CO emissions annually in the MANE-VU region.

**Ammonia**

On the annual basis, Agricultural Production (Livestock—Cattle: 36% and Poultry: 12%) comprises over 48% of the regional NH$_3$ emissions followed by Highway Vehicles with over 16%. Miscellaneous Area Sources and Wastewater Treatment activities each contribute about 10% to the total NH$_3$ emissions in the region (Table 2). An emissions density map for annual area source NH$_3$ emissions is presented in Figure 2.a.

**Oxides of Nitrogen**

External Combustion Boilers (Electric Generation) makes up about 22% of the regional NO$_x$ emissions. Highway Vehicle emissions (Gasoline: 21% and Diesel: 20%) comprise about 40% of the regional total. Residential Stationary Source Fuel Combustion, Diesel Nonroad Vehicles, and Industrial External Combustion Boilers are the other major NO$_x$ contributors. An emissions density map for annual onroad NO$_x$ emissions is shown in Figure 2.b.

**Particulate Matter**

Emissions from Roads (Paved: 24% and Unpaved: 22%) contribute about 46% of the PM$_{10}$ emissions. Industrial Construction, Agricultural Crop Production, and Residential Wood Combustion are the following major contributors.

**Fine Particulate Matter**

Similarly, Roads (Paved: 15% and Unpaved: 8%) contribute about 23% to the total PM$_{2.5}$ emissions. Residential Wood Combustion and Open Burning comprise about 14% and 10% respectively. Industrial External Boilers and Industrial Construction are other major PM$_{2.5}$ sources in the region. An emissions density map for annual area source PM$_{2.5}$ emissions is shown in Figure 2.c. (Note that a paper by A. Bauman, S. Roe, and K. Thesing and +++ on Open Burning Emissions presented at this conference shows a need to revise the NEI for Open Burning.)

**Sulfur Dioxide**

External Combustion Boilers (Electric Generation) are responsible for about 70% of the regional SO$_2$ emissions. Industrial External Combustion Boilers, and Industrial Stationary Source Fuel Combustion are the following major source categories. An annual point source SO$_2$ emission level map is shown in Figure 2.d.

**VOC**

Gasoline Highway Vehicles make up about 29% of the regional VOC emissions. Residential Stationary Source Fuel Combustion, Consumer Solvents, Industrial Surface Coating, and Pleasure Craft are other major contributors.
The distribution of emissions among different source categories for each pollutant in summer only slightly differs from annual emissions. See Table 2 for NH$_3$ and the web site for other pollutants. However, the amount of emissions may differ substantially by season, and this is not reflected. Both PM2.5 and regional haze modeling will require reasonsal analyses, since atmospheric processes differ and monitored data show different source contribution by season. Having the ability to compare annual and summer emissions is a step in the right direction. However, the NEI lacks the data needed to identify seasonal emissions variations. Currently, seasonal and other temporal allocation of emissions is done through emissions modeling processes prior to air quality modeling. Therefore, it is crucial for the emissions inventory and modeling community to scrutinize the seasonal profiles, as well as monthly and daily profiles, used in those models.

Emissions summaries for each pollutant (presented for NH$_3$ in Table 2) identify the source category groupings that may be the most significant contributors to pollution problems. A series of county based emissions density maps for the region for all source types (point, area, onroad, and nonroad) and for important source category grouping is available on-line at www.marama.org/visibility. These maps are being reviewed to judge data accuracy and, more importantly, to detect possible emissions calculation inconsistencies between states. This effort will help establish transparency as well as initiate a move towards consistency in emissions calculations.

**COMPARISON of the 1999 NEI with the PREVIOUS INVENTORIES**

Figures 3.a. through 3.e. display the comparisons between the 1996 and 1999 NEI annual emissions for NH$_3$, NO$_x$, PM$_{10}$ (primary), PM$_{2.5}$ (primary), and SO$_2$. NH$_3$, NO$_x$, and PM$_{2.5}$ emissions show a moderate increase in 1999 compared to 1996 in most states, and, on the other hand, a decrease in PM$_{10}$ and SO$_2$ emissions. When comparing 1996 and 1999 emission levels it should be kept in mind that most of the 1996 and 1999 PM$_{2.5}$ and NH$_3$ estimates were prepared by EPA with a top down approach, whereas for other pollutants state submitted data generally prevailed.

A somewhat more detailed comparison has been made between the 1995 OTAG, 1997 MARAMA and 1999 NEI inventories for OSD emissions from area and point sources for CO, NO$_x$, and VOC. The 1997 MARAMA inventory was the result of a regional effort to improve 1996 NEI with state supplied data. The comparisons are available on-line at www.marama.org/visibility.

**CONCLUSIONS**

QA/QC of emissions inventories is a non-trivial and ambiguous task. Emissions modeling tools, such as SMOKE and EMS have visualization capabilities, however, only for the processed (spatially gridded, chemically speciated, temporally allocated) emissions. In most cases, visualization of raw data, i.e. NEI data, is beneficial to detect errors, data gaps, abnormalities, and inconsistencies between neighboring states or regions due to differences in emissions calculation methods. In an attempt to help detect those problems and to prevent them in the upcoming 2002 inventory, MARAMA prepared a series of summary tables, comparison plots, and county-based
emission density maps of 1999 NEI data for the Mid-Atlantic and Northeastern states. This is a step in the right direction, however, it is time consuming.

The U.S. EPA’s online emissions database AIRDATA is very useful, however, it is not possible to create regional maps other than for EPA regions, or for a region covering more than 10 states. MANE-VU includes 11 states and the District of Columbia. In addition, the AIRDATA tool only allows mapping of prescribed large SCC groupings. AIRDATA only allows the visualization of 1996 and 1999 NEI. In summary, the AIRDATA tool does not allow the users to make an analysis similar to the one presented in this paper.

MARAMA will be investigating options to automate a procedure to answer our regional needs. In this context an enhancement of the existing AIRDATA tool could be a resource-effective option. The AIRDATA tool has capabilities of browsing and summarizing the data, and generating on-the-fly plots and maps. Modifying the tool to accommodate i) more flexible geographic coverage options, ii) a more detailed SCC selection options, and iii) the creation of emissions density maps in addition to emissions distribution maps will be of great value.

Much work remains in order to produce timely, high quality 2002 emissions inventories for ozone, PM2.5, and regional haze policy evaluations. This work is intended to help set priorities for emissions inventory improvements.

ACKNOWLEDGEMENTS

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KEYWORDS

Emission Inventory
Regional Haze
1999 NEI
MANE-VU
MARAMA
NESCAUM
Point Source
Area Source
Onroad Sources
Nonroad Sources
AIRDATA.
### Table 1. 1999 NEI total annual emissions in the Mid-Atlantic and Northeast

<table>
<thead>
<tr>
<th>Emissions</th>
<th>CO</th>
<th>NH$_3$</th>
<th>NO$_x$</th>
<th>PM$_{10}$ (Filt.)</th>
<th>PM$_{10}$ (Pri)</th>
<th>PM$_{2.5}$ (Filt.)</th>
<th>PM$_{2.5}$ (Pri)</th>
<th>PM (Cond)</th>
<th>SO$_2$</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point - Annual (t/y)</td>
<td>898,941</td>
<td>17,152</td>
<td>2,848,813</td>
<td>323,481</td>
<td>429,243</td>
<td>200,478</td>
<td>303,868</td>
<td>7,003,132</td>
<td>102,615</td>
<td>468,404</td>
</tr>
<tr>
<td>Point - OSD (t/d)</td>
<td>3,125</td>
<td>52</td>
<td>8,879</td>
<td>1,007</td>
<td>1,294</td>
<td>598</td>
<td>903</td>
<td>20,724</td>
<td>295</td>
<td>1,496</td>
</tr>
<tr>
<td>Area - Annual (t/y)</td>
<td>2,767,008</td>
<td>479,163</td>
<td>537,752</td>
<td>2,235,597</td>
<td>2,430,273</td>
<td>590,033</td>
<td>784,709</td>
<td>589,994</td>
<td>2,063,255</td>
<td></td>
</tr>
<tr>
<td>Area - OSD (t/d)</td>
<td>5,787</td>
<td>1,301</td>
<td>800</td>
<td>6,503</td>
<td>6,288</td>
<td>1,660</td>
<td>1,793</td>
<td>1,390</td>
<td>7,139</td>
<td></td>
</tr>
<tr>
<td>Nonroad - Annual (t/y)</td>
<td>6,008,532</td>
<td>7,962</td>
<td>736,662</td>
<td>62,904</td>
<td>57,671</td>
<td>202</td>
<td>77,343</td>
<td>640,157</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonroad - OSD (t/d)</td>
<td>23,285</td>
<td>23</td>
<td>2,656</td>
<td>223</td>
<td>202</td>
<td>274</td>
<td>2,052</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onroad - Annual (t/y)</td>
<td>17,009,641</td>
<td>65,358</td>
<td>2,069,963</td>
<td>59,464</td>
<td>45,525</td>
<td>78,670</td>
<td>1,331,459</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onroad - OSD (t/d)</td>
<td>39,364</td>
<td>192</td>
<td>5,674</td>
<td>157</td>
<td>118</td>
<td>224</td>
<td>3,768</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total - Annual (t/y)</strong></td>
<td><strong>26,684,123</strong></td>
<td><strong>569,634</strong></td>
<td><strong>6,193,190</strong></td>
<td><strong>2,559,078</strong></td>
<td><strong>2,981,883</strong></td>
<td><strong>790,511</strong></td>
<td><strong>1,191,772</strong></td>
<td><strong>155,570</strong></td>
<td><strong>7,749,140</strong></td>
<td><strong>2,063,255</strong></td>
</tr>
<tr>
<td><strong>Total - OSD (t/d)</strong></td>
<td><strong>71,561</strong></td>
<td><strong>1,569</strong></td>
<td><strong>18,008</strong></td>
<td><strong>7,510</strong></td>
<td><strong>7,962</strong></td>
<td><strong>2,258</strong></td>
<td><strong>3,016</strong></td>
<td><strong>22,612</strong></td>
<td><strong>14,456</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. 1999 NEI summary by source category for NH$_3$ in the Mid-Atlantic and Northeast

<table>
<thead>
<tr>
<th>Source Category</th>
<th>Source Type</th>
<th>ANNUAL</th>
<th>OSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Production – Livestock – Cattle</td>
<td>Area</td>
<td>177,916</td>
<td>483</td>
</tr>
<tr>
<td>Agricultural Production – Livestock – Hogs</td>
<td>Area</td>
<td>134,336</td>
<td>365</td>
</tr>
<tr>
<td>Agricultural Production – Livestock – Poultry</td>
<td>Area</td>
<td>77,677</td>
<td>211</td>
</tr>
<tr>
<td>Highway Vehicles – Gasoline</td>
<td>Onroad</td>
<td>63,855</td>
<td>189</td>
</tr>
<tr>
<td>Misc. Area Source – Agricultural Production – Crops</td>
<td>Area</td>
<td>47,280</td>
<td>130</td>
</tr>
<tr>
<td>Wastewater Treatment</td>
<td>Area</td>
<td>30,453</td>
<td>84</td>
</tr>
<tr>
<td>Industrial - Chemical Manufacturing</td>
<td>Point</td>
<td>4,976</td>
<td>14</td>
</tr>
<tr>
<td>Agricultural Production – Livestock – Other</td>
<td>Area</td>
<td>6,452</td>
<td>18</td>
</tr>
<tr>
<td>Stationary Source Fuel Combustion – Residential</td>
<td>Area</td>
<td>2,665</td>
<td>2</td>
</tr>
<tr>
<td>Petroleum Industry</td>
<td>Point</td>
<td>2,065</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total NH$_3$ Emissions</strong></td>
<td></td>
<td>547,676</td>
<td>1,503</td>
</tr>
</tbody>
</table>

Other Point Sources:<br>Point: 10,111 1.8 32 2.1<br>Other Nonroad Sources: Nonroad: 7,962 1.4 23 1.5<br>Other Onroad Sources: Onroad: 1,503 0.3 3 0.2<br>Other Area Sources: Area: 2,383 0.4 8 0.5

Total NH$_3$ Emissions: 569,635 100.0 1,569 100.0
Figure 3.a. Comparison of 1996 and 1999 NEI total annual NH₃ emissions

Figure 3.b. Comparison of 1996 and 1999 NEI total annual NOₓ emissions
Figure 3.c. Comparison of 1996 and 1999 NEI total annual PM$_{10}$ (primary) emissions

Figure 3.d. Comparison of 1996 and 1999 NEI total annual PM$_{2.5}$ (primary) emissions
Figure 3.e. Comparison of 1996 and 1999 NEI total annual SO$_2$ emissions