

January 23, 2012

WestJumpAQMS EMISSIONS TECHNICAL MEMORANDUM No. 7

To: Tom Moore, Western Regional Air Partnership (WRAP)

From: Cyndi Loomis, Alpine Geophysics, LLC
Ralph Morris and Amnon Bar-Ilan, ENVIRON International Corporation
Zac Adelman, University of North Carolina/Institute for the Environment

Subject: Off-Shore Shipping Emissions

INTRODUCTION

ENVIRON International Corporation (ENVIRON), Alpine Geophysics, LLC (Alpine) and the University of North Carolina (UNC) at Chapel Hill Institute for Environment are performing the West-wide Jump Start Air Quality Modeling Study (WestJumpAQMS) managed by the Western Governors' Association (WGA). WestJumpAQMS is setting up the CAMx and CMAQ photochemical grid models for the 2008 calendar year (plus spin up days for the end of December 2007) on a 36 km CONUS, 12 km WESTUS and several 4 km Inter-Mountain West domains. The WestJumpAQMS Team are currently compiling emissions to be used for the 2008 base case modeling, with the 2008 National Emissions Inventory (NEI) being a major data source. Thirteen (13) Technical Memorandums discussing the sources of the 2008 emissions by major source sector are being prepared as part of the WestJumpAQMS:

1. Point Sources including Electrical Generating Units (EGUs) and Non-EGUs;
2. Area plus Non-Road Mobile Sources;
3. On-Road Mobile Sources that will be based on MOVES;
4. Oil and Gas Sources;
5. Fires Emissions including wildfire, prescribed burns and agricultural burning;
6. Fugitive Dust Sources;
7. Off-Shore Shipping Sources;
8. Ammonia Emissions;
9. Biogenic Emissions;
10. Eastern USA Emissions;

11. Mexico/Canada;
12. Sea Salt and Lightning Emissions; and
13. Emissions Modeling Parameters including spatial surrogates, temporal adjustment parameters and chemical (VOC and PM) speciation profiles.

This document is Technical Memorandum Number 7 that discusses the approach to be used for developing 2008 emissions for the Off-Shore Shipping Commercial Marine Vessel source sector.

OFF SHORE SHIPPING SOURCES

Large ships, such as container ships, tankers, bulk carriers and cruise ships, are significant contributors to air pollution in many of our nation's cities and ports. There are two types of diesel engines used on large ships: main propulsion and auxiliary engines. The main propulsion engines on most large ships are "Category 3" marine diesel engines, which can stand over three stories tall and run the length of two school buses. Auxiliary engines on large ships typically range in size from small portable generators to locomotive-size engines.

To account for these emissions, a separate set of SMOKE input files was developed for the 2005 NEIv4.1. Based on earlier 1996 and 2002 inventories, the current 2005 was developed by ICF International (ICF, 2007¹) combining updated port and maneuvering estimation methods. These estimates are combined with detailed spatial information regarding port locations and shipping lanes.

The 2008 inventory has been developed for Class 3 Commercial Marine Vessels by interpolating the 2005 and 2016 files from the 2005 NEI v4.1.² These emissions are developed and carried as point sources, rather than the area-level files generally used for off-road mobile sources, including marine emissions sources. Using the point source format allows for: (1) detailed location information for the emissions, rather than use of generalized spatial allocation profiles; and (2) processing of the emissions as elevated sources, rather than distributing all of Class 3 marine emissions into the lowest level of the model. Emissions from large marine vessels are buoyant and emitted out of tall stacks several stories high so would not be injected in the lowest layer of the model, which is approximately 20 m thick for the WestJumpAQMS modeling. Thus, it is important to treat them as point sources.

Details on the Off-Shore Shipping emissions are provided in a report "Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory – Methodology" prepared by Eastern Research Group (ERG, 2010³) dated March 30, 2010.

It should be noted that the Off Shore Shipping emissions category discussed in this Technical Memorandum only includes the Class 3 Commercial Marine source. Smaller vessels (Class 1

1 ftp://ftp.epa.gov/EmisInventory/2005_nei/mobile/commercial_marine_vessels_2002_and_2005.pdf

2 ftp.epa.gov/EmisInventory/2005v4.1/2005emis/2005v4_1caphap_orl_alm.zip and ftp.epa.gov/EmisInventory/2005v4.1/2016emis/2016cr_05b_orl_alm.zip April 2011 download)

3 http://www.epa.gov/ttn/chief/net/nei08_alm_popup.htm |

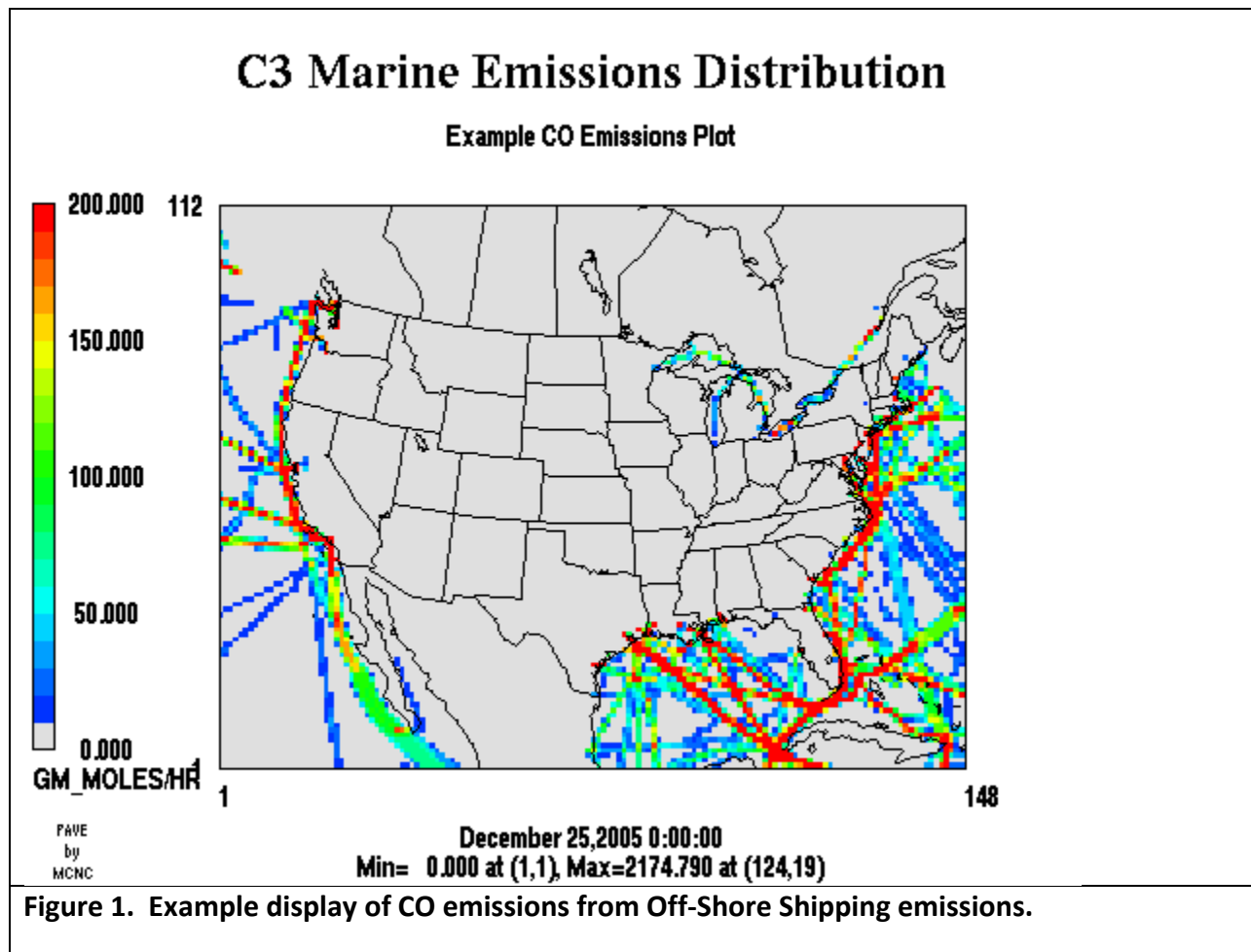
and 2) are included with the Non-Road Mobile Source category and will be discussed in Technical Memorandum Number 2.

EMISSIONS PROCESSING

The commercial marine emissions are processed as point sources using SMOKE Version 3.0. The emissions estimates include location information (latitude/longitude) and elevated emissions source data (stack parameters and emission rates).

Spatial Allocation

The emissions will be allocated to the 36/12/4 km modeling grids, using the location information in the SMOKE-ready One Record per Line (ORL) emission input files available in the NEI. Figure 1 is an example display of the Category 3 Off-Shore Shipping emissions inventory that displays the main shipping lanes for the vessels.



Temporal Allocation

The Off-Shore Shipping emissions are provided as average day emissions. The associated SCC code (2280003000) has a temporal profile (19531) developed specifically for use with these files. The hourly and weekly assigned profile allocates the emissions evenly over the day and week. The monthly profile is fairly flat but does show increased emissions during the summer months as shown in Figure 2.

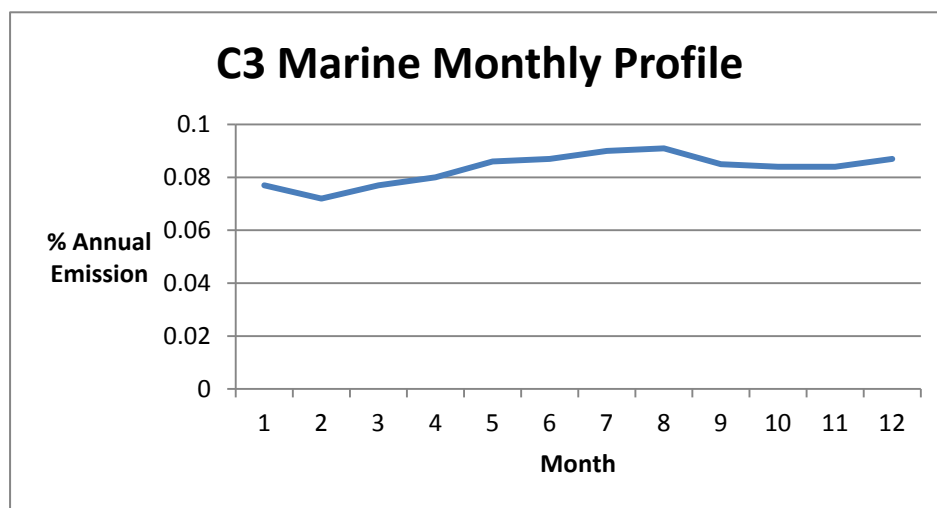


Figure 2. Monthly spatial allocation profile for Off-Shore Shipp source category (SCC = 2280003000).

Quality Assurance

Quality assurance (QA) will be performed following the emissions quality assurance protocol developed during WRAP (Adelman, 2004⁴). These procedures include systematic procedures for:

- Modeling QA – accuracy assurance and problem identification.
- System QA – software and data tracking.
- Documentation – tracking QA issues, recording the QA process and report writing.

An emissions QA checklist is developed that delineates each step of the QA process and allows a systematic approach to the QA process to assure critical steps are not overlooked. The completed QA checklists and templates include:

- Model configuration settings.
- Inventory file log.

⁴ http://www.epa.gov/ttnchie1/conference/ei13/gaqc/adelman_pres.pdf

- Ancillary input file log.
- Model execution log.

A series of QA products are produced that are compared to other studies and the expected outcomes:

- Spatial plots of emissions by source category.
- Annual time series plots of emissions for subregions.
- Diurnal time series plots.
- Daily vertical profile plots.

The emissions QA officer is required to generate, review and distribute the QA products to the modeling team and buy off on the results prior to execution of the air quality model.

Input Emissions Summaries

Detailed spatial plots and summary tables of the Off-Shore Shipping emissions will be prepared and distributed when they are processed by the SMOKE emissions model as part of the WestJumpAQMS. Table 1 displays a summary of 2008 Off-Shore Shipping emissions by state. Most of the shipping emissions are off-shore and not associated with any state. For example, 57% of the NO_x emissions are off-shore and not assigned to a state. Florida has the largest amount of the shipping emissions with 6.8% of the NO_x emissions followed closely by California (6.6%), Louisiana (5.2%) and Alaska (4.9%).

Table 1. Summary of 2008 Off-Shore Shipping emissions by state (tons per day) [Average Daily Emissions by State; Class 3 Commercial Marine; SCC2280003000; Average TPD]

State	CO	NO _x	VOC	SO ₂	PM ₁₀	PM _{2.5}	PMC
Alabama	1.29	5.93	0.22	2.72	0.38	0.35	0.03
Alaska	20.85	257.08	8.84	142.18	19.32	17.76	1.55
California	31.03	343.40	12.60	139.53	19.72	18.11	1.61
Connecticut	0.33	3.78	0.14	1.72	0.23	0.21	0.02
Delaware	1.45	16.03	0.61	20.41	0.97	0.89	0.08
Florida	30.87	354.27	12.95	158.83	21.96	20.18	1.78
Georgia	1.92	21.55	0.82	11.28	1.29	1.19	0.10
Hawaii	6.95	79.81	2.94	32.68	4.65	4.27	0.38
Illinois	0.02	0.29	0.01	0.13	0.02	0.02	0.00
Indiana	0.01	0.12	0.00	0.06	0.01	0.01	0.00
Louisiana	24.36	271.99	10.03	120.36	16.94	15.54	1.40
Maine	1.17	13.36	0.49	5.79	0.80	0.74	0.06
Maryland	4.79	54.57	2.03	22.91	3.25	2.99	0.26
Massachusetts	9.03	103.05	3.82	44.18	6.13	5.64	0.49
Michigan	2.49	30.14	1.06	12.95	1.82	1.67	0.15
Minnesota	0.07	0.85	0.03	0.40	0.05	0.05	0.00
Mississippi	0.30	3.37	0.12	1.68	0.22	0.20	0.02
New Hampshire	0.01	0.08	0.00	0.03	0.00	0.00	0.00
New Jersey	6.17	68.72	2.63	36.42	4.18	3.85	0.33
New York	3.35	39.00	1.44	16.63	2.36	2.17	0.19
North Carolina	15.16	173.16	6.43	73.05	10.22	9.41	0.81
Ohio	0.58	6.96	0.25	3.03	0.42	0.39	0.03
Oregon	4.30	47.76	1.90	19.23	2.82	2.59	0.23
Pennsylvania	0.77	8.93	0.31	5.56	0.56	0.51	0.04
Rhode Island	0.78	8.94	0.33	4.32	0.53	0.49	0.04
South Carolina	5.86	66.22	2.49	33.62	3.95	3.64	0.31
Texas	10.33	108.06	4.09	55.22	7.74	7.10	0.64
Virginia	4.31	49.21	1.83	21.39	2.92	2.69	0.23
Washington	8.72	98.08	3.91	42.33	6.27	5.69	0.58
West Virginia	0.01	0.07	0.00	0.03	0.00	0.00	0.00
Wisconsin	0.18	2.15	0.08	0.94	0.13	0.12	0.01
Other (Off Shore)	255.53	3001.50	108.39	1896.30	255.80	235.24	20.45
Total	452.99	5238.43	190.79	2925.91	395.66	363.71	31.82