CAMx Model Sensitivity Analysis of Emissions Temporal Profiles: Impacts on 2011 Modeled NOx/NOy Concentrations

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Background

Studies have attempted to evaluate emissions inventories by examining measured vs. modeled precursor concentrations and ratios. Some of these studies have shown that modeled NOx and/or NOy concentrations are over-predicted and hypothesized that mobile source inventories may be an important part of those over-predictions.

In addition to the absolute number of annual tons of emissions, an important aspect of modeling is the temporalization of annual, seasonal, and or monthly inventory information down to the hourly input level which is needed by chemical transport models (CTMs).

CAMx Sensitivity Studies

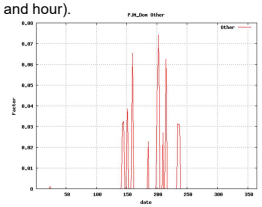
This study examined the impact of changing day-of-year, day-of-week, and hour-of-day temporal profiles for some EGU emissions, on-road emissions, and non-road emissions.

CAMx Model Run	Scenario Name	Description
CAMx 2011 base case	Base case	-2011 emissions and meteorology -12km resolution -Contiguous U.S. model domain
Sensitivity #1	EGU non-CEMS temporal profile sensitivity	Flat day-of-year temporal profile for non-CEMS EGUs burning "other fuel" (mostly municipal waste incinerators)
Sensitivity #2	On-road mobile temporal profile sensitivity	Replace state diurnal profiles with EPA national profiles derived from "VTRIS" data
Sensitivity #3	Non-road mobile temporal profile and emissions sensitivity	-Update diurnal profiles for construction, lawn and garden, and agricultural equipment -Adjust growth in equipment population by reducing non-road emissions by ~7%

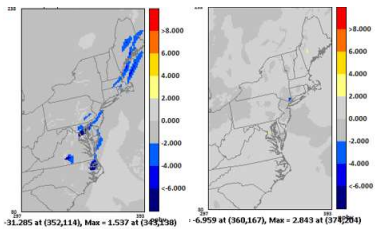
After examining emissions patterns, NOx, and ozone concentrations in the 2011 CAMx base case, several sensitivity runs were performed to explore the impacts on modeled concentrations. Sensitivity runs 1 and 2 only adjusted temporal profiles, with *no adjustments to annual emissions*. Sensitivity 3 combines non-road hour-of-day temporal adjustments with a NOx emissions reduction of ~7%.

EGU Temporal Profiles (non-CEMS sources)

There are a number of point sources that generate electricity that do not have CEMS data. The hourly emissions for these sources were temporalized using regional average profiles from CEMS sources (by fuel type). Some average regional profiles had a large percentage of emissions concentrated on a few days and hours (see example below). It was determined that these profiles were not appropriate for sources such as municipal waste combustors and co-generation units, which do not operate in a "peaking" mode. For sensitivity run #1, the temporal profile for these sources was changed to a flat profile (same emissions for every day and hour).



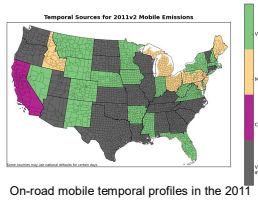
Example day-of-year temporal profile for EGU sources (fuel="other") in Eastern Virginia. Up to 7% of the annual emissions are emitted on a single day.



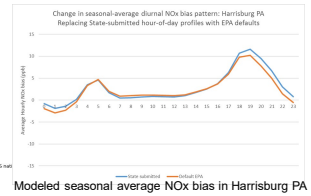
Modeled hourly average ozone change (in ppb) from sensitivity #1 on July 21st at 19 UTC (left) and July 2nd at 21 UTC (right).

On-road Mobile Temporal Profiles

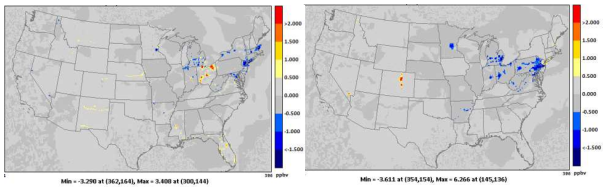
The 2011 base case used several different data sources to derive hour-of-day temporal profiles for on-road mobile sources. The map below shows where EPA default data (derived from VTRIS) was used (grey) vs. state submitted data (green and yellow). Sensitivity run #2 replaced all state submitted temporal profile data with EPA VTRIS derived profiles (except California).



On-road mobile temporal profiles in the 2011 base case.



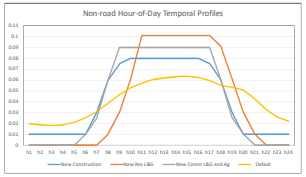
Modeled seasonal average NOx bias in Harrisburg PA for 2011 base case (blue) and sensitivity #2 (orange) .



Modeled hourly average NOy change due to sensitivity #2 on July 22nd at 12 UTC (left) and July 23rd at 4 UTC (right).

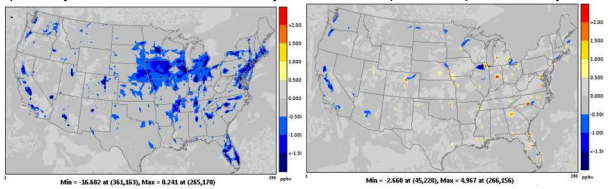
Non-road Mobile Temporal Profiles

Several alternative temporal profiles were proposed for non-road equipment categories with high overall emissions. In the 2011 base case, the same default profile was used for construction, lawn and garden (residential and commercial), and agricultural equipment. The default profile (yellow line in the plot below) has a gradual peak in the afternoon, with a significant fraction of emissions overnight.



While some construction emissions can be expected in the overnight hours, we would expect minimal overnight emissions from the lawn and garden and agricultural sectors. For sensitivity run #3, the temporal profiles for these sources were replaced with profiles with fewer overnight emissions and higher daytime peaks.

In addition to the non-road temporal profiles changes, sensitivity run #3 also includes a ~7% reduction in non-road NOx emissions based on preliminary testing of revised equipment population growth rates in the NONROAD model. The growth rates currently used in NONROAD are thought to overestimate equipment populations in most equipment categories beyond the 1996-2000 population base years. While the revised growth rates are not publically available at this time, sensitivity run #3 tests the potential impact of this adjustment.



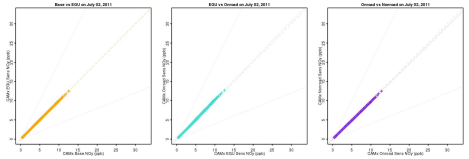
Modeled hourly average NOy change due to sensitivity #3 on July 23rd at 4 UTC (left) and July 22nd at 14 UTC (right).

Discover-AQ NOy Aircraft Data

Discover-AQ aircraft NOy data for the Baltimore-Washington area for July 2011 was compared to the modeled CAMx base case and sensitivity cases. The aircraft data is available for 14 days in July. Below is the NOy mean bias (MB) and normalized mean bias (NMB) by flight day and model run.

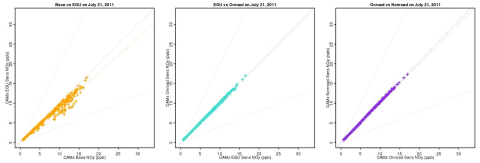
Day in July	Base		EGU Sensitivity		Onroad Sensitivity		Nonroad Sensitivity	
	MB (ppb)	NMB (%)	MB (ppb)	NMB (%)	MB (ppb)	NMB (%)	MB (ppb)	NMB (%)
1	-0.60	-17.38	-0.60	-17.41	-0.54	-15.82	-0.50	-14.71
2	0.39	9.75	0.39	9.84	0.45	11.32	0.36	9.14
5	1.97	69.19	1.83	64.34	1.85	65.09	1.77	62.33
10	3.03	204.70	3.06	206.45	3.16	213.84	3.00	202.78
11	3.45	268.42	3.48	270.25	3.51	272.77	3.58	278.57
14	0.49	35.88	0.49	35.77	0.52	37.95	0.57	41.56
16	0.84	33.25	0.86	34.12	0.92	36.24	0.84	33.20
20	3.91	112.29	3.78	108.81	3.88	111.60	4.01	115.43
21	2.85	104.66	2.37	86.90	2.41	88.43	2.54	93.33
22	2.69	129.54	2.50	120.73	2.55	123.07	2.64	127.02
26	0.36	16.37	0.35	15.85	0.38	17.29	0.42	18.69
27	0.97	56.44	0.94	55.04	0.98	57.09	1.02	59.25
28	3.78	122.14	3.76	121.50	3.79	122.56	3.93	126.92
29	3.51	203.77	3.44	199.51	3.45	200.60	3.50	203.37

July 2nd



Aircraft NOy comparison of modeled 2011 Base case (x-axis) vs. sensitivity cases (y-axis) [sensitivity #1= yellow, sensitivity #2= blue, and sensitivity #3= purple] July 2nd above and July 21st below

July 21st



Conclusions and Follow-up

Conclusions

- The change in ozone, NOx, and NOy due to the three CAMx sensitivity runs was relatively small and does not eliminate the overall NOx/NOy bias.
- Modeled concentration changes due to the (non-CEMS) EGU sensitivity run (#1) were small on most days, but ozone and NOx reductions were large on several days in July, in areas close to municipal waste combustors, most notably on July 21st and 22nd.
- Modeled concentration changes due to the on-road temporal profile sensitivity (#2) were small, even in states where the profiles changed.
- NOx and NOy concentration changes due to the non-road temporal profile and emissions adjustments were relatively small and varied by time of day and location.
  - NOx changes were larger at night due to the emissions adjustments and the change in nighttime allocations of non-road emissions.

Follow-up

- Even though most of the sensitivity runs led to relatively small changes in ozone and NOx concentrations, many of the temporal profile changes should be permanently implemented in future model runs because they are improvements.
- Additional analysis of the non-road equipment population and growth rates is needed to better quantify the current and future year non-road emissions.
  - State and/or county specific equipment populations and/or growth rate adjustments are needed to most accurately model local conditions.