Source Apportionment of Atmospheric Nitrogen Deposition in the Chesapeake Watershed and Tidal Bay Using an Airshed Model Tracer Analysis

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Purpose and Objectives

Recent advances in the Chesapeake Bay Airshed Model allow updated and improved estimates of the transport and fate of atmospheric emissions of oxidized nitrogen (NOx) and ammonium (NH_4^+). The analysis centers on the question, "For a nitrogen emission from a source type within a source region, what is the fraction that is deposited to regions, States, or to a point of the Chesapeake Bay Program?" The results will be used for two primary purposes:

1. Estimate the change in deposition resulting from a change in an emission source type such as a BMP, to a point, County, or State in the Chesapeake watershed or to the tidal Chesapeake.
2. Estimate the total deposition to the Chesapeake watershed or tidal Bay of an emission source type.

Previous estimates of the relative contribution of atmospheric deposition were available for a single emission type which was all combined oxdized emission sources.

Emission Source Types

The fate and transport of all species of nitrogen will be tracked from eight emission source types. They are: 1) electric generating units (EGUs), 2) mobile sources, 3) off-road sources, 4) poultry manures, 5) other animal manures, 6) fertilizer, 7) marine sources, and 8) other emission sources[1]. Emission source types 1-7 generally have some prospect of being managed, or have been managed, in the past. It is necessary to limit emission sources, otherwise run times of the tracer analysis will become untenable.

Emission Source Regions

The model will track all emission source types for each defined geographic source region. The result is that the coefficients relating emission to deposition will be constant for a given source type, e.g., all EGUs, within an emission source region no matter how spatially distanced the separate EGUs are within the source region. Source regions represent regions of relatively homogenous transport and are reasonably compact so that coefficients derived from the analysis can accurately represent the deposition change in the Chesapeake watershed resulting from a change in any emission source type within an emission source region. The emission source regions include the entire area of the Chesapeake watershed jurisdictions so that the total contribution of a Bay Program partner jurisdiction can be reasonably estimated. As with source

[1] The "other" emission source represents concentrations for a particular species attributed to untracked emission sources, untracked secondary precursors of the main compound(s) of interest, and other model processes that may produce a particular compound(s) independent from the emission sources based on the model setup. The non-tracked emissions include agricultural and wild/prescribed fires, oil and natural gas operations, residential wood combustion, other transportation sources like rail and airports, biogenic contributions, lightning, and other non-US sources, e.g., on-road mobile sources for Canada and Mexico.

types, the number of source regions are limited by run time. For simplicity of model execution and application of the results, each county within watershed jurisdictions is assigned to a single source region.

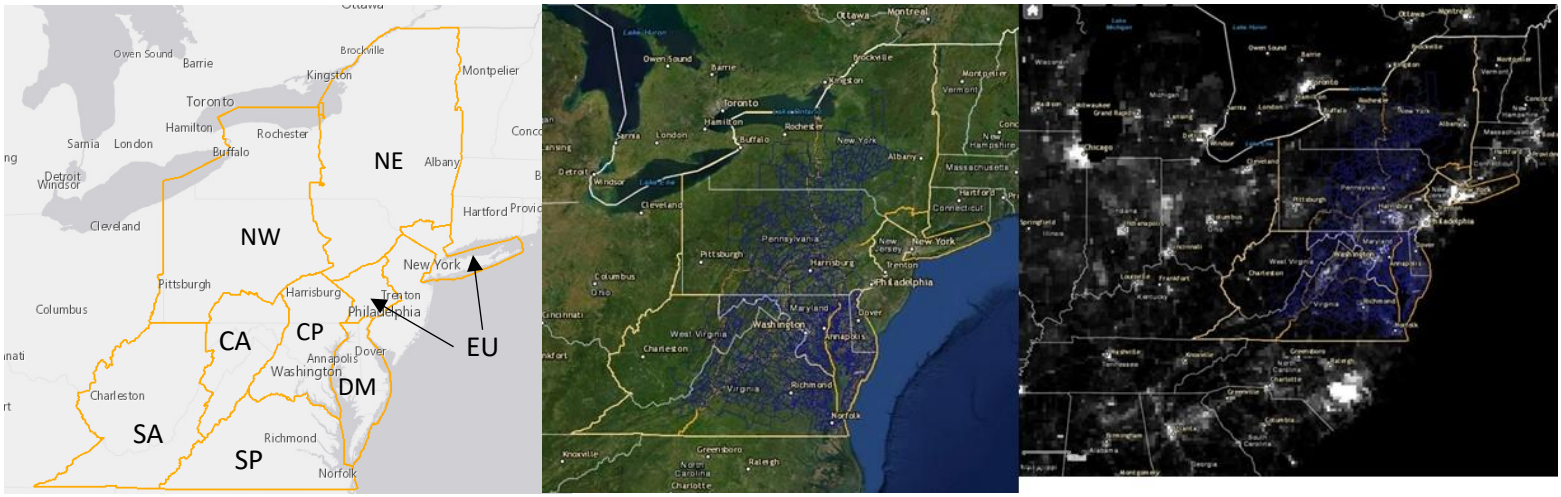

Figure 1. Emission source regions. The left panel shows the source regions with labels and the center panel indicates the source regions, state boundaries, and watershed model segments. The right panel shows the emission density for total nitrogen. The map may be manipulated dynamically through a web interface: https://gis.chesapeakebay.net/modeling/

Figure 1 shows the emission source regions chosen for the study. There are eight source regions which completely encompass the watershed jurisdictions, plus an unpictured source region of the CONUS-scale model domain outside of the watershed jurisdictions for a total of nine source regions. Sources outside the Airshed Model domain are handled as boundary conditions.

Year

The year 2016 is used because it has recent emissions, has a representative hydrology throughout the CB watershed, is a National Emission Inventory (NEI) development year with good emission estimates, and is a year that can be better assessed and constrained through remote sensed satellite observations of NO_2 and NH_4^+.

Products

The CMAQ-ISAM will output a time series of deposition on a CMAQ grid scale of 12 km by 12 km. A separate time series will be produced for each nitrogen species, source region, and source type. For transmission to the CBP, these will be processed to monthly output and aggregated to deposition types of wet oxidized, wet reduced, dry oxidized, and dry reduced N, expressed as fraction of emitted. Table 1 gives sample output.

Table 1: source-receptor transfer coefficients

Receptor Cell	Source Region	Source Type	Month	Wet Oxy	Wet Red	Dry Oxy	Dry Red
1	Delmarva	EGU	1	0.000436	0.00048	0.000528	0.000581
1	Delmarva	Fertilizer	1	0.000393	0.000432	0.000475	0.000523

1	Lower Piedmont	EGU	1	0.000353	0.000389	0.000428	0.00047
1	Lower Piedmont	Fertilizer	1	0.000318	0.00035	0.000385	0.000423
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The above example table will be sufficient to allow for calculation of the effects of individual BMPs as well as state policies such as the implementation of the VW Settlement and also allow for a CAST model run that can determine the fraction of emitted load by source region and source type that reaches the tidal Bay waters as shown in Table 2. In addition direct deposition to the tidal Bay can be calculated by emission type and source region.

Table 2: fraction of emission reaching tidal waters

source region	EGU	fertilizer	poultry manure	mobile
Delmarva	0.0200	0.0220	0.0242	0.0266
Upper Piedmont	0.0180	0.0198	0.0218	0.0240
Lower Piedmont	0.0162	0.0178	0.0196	0.0216
Upper Mountain	0.0146	0.0160	0.0176	0.0194

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