Emission processing in North_Eastern North America using the SMOKE model

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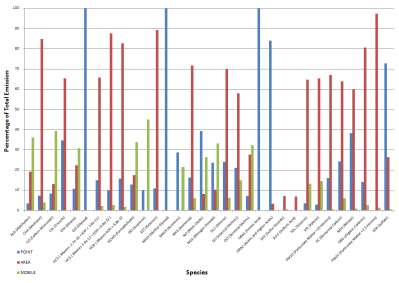
Introduction:

A critical and challenging step in atmospheric chemistry and Air Quality Models (AQMs) is preparing the emission inputs. It is generally believed that emissions are one of the, if not the most, uncertain inputs into AQMs (Pierson et al., 1990; Geron et al., 1994; Simspon et al., 1995). Emission inventories typically have an annual-total emissions value for each emissions source, or perhaps an average-day emissions value. The AQMs, however, typically require emissions data on an hourly basis, for each model grid cell (and perhaps model layer), and for each model species. Consequently, to achieve the input requirements of the AQM, emissions processing must (at a minimum) transform inventory data by temporal allocation, chemical speciation, spatial allocation, and perhaps layer assignment.

The main purpose of our study is the investigation of the effects of change in aerosols on clouds and precipitation patterns in North America. We are mainly going to asses the effects on meteorology (especially clouds and precipitation) of changes in aerosols that may occur due to future changes in population and emissions regulations. The first task is the creation of a series of emission scenarios reflecting the expected changes in these parameters. The scenario studies require the accurate emission rate for aerosol particles and gaseous species. We used the Sparse Matrix Operator Kernel Emissions (SMOKE v2.7) to process emissions. SMOKE is primarily an emissions processing system designed to create gridded, speciated, hourly emissions for input into a variety of air quality models such as CMAQ, REMSAD, CAMX and UAM. It supports area, biogenic, mobile (both on-road and non-road), and point source emissions processing for criteria, particulate, and toxic pollutants. We calculated the hourly anthropogenic and biogenic emission input data for WRF-Chem model in a domain covering North Eastern part of North America with 12-km horizontal grid spacing.

contribution of point, area and mobile sources in total emission in whole domain



1. Importing raw inventory data:

We used the annual, state or county-wide total emission inventories for Area, Point and Mobile sources. The Canadian emission inventories for year 2006 provided by Environment Canada and the corresponding U.S. inventories for year 2008 are available from the EPA (www.epa.gov/ttn/chief/net/2008inventory.html) website.

2. Temporal Allocation:

In order to convert the inventory data to hourly temporal resolution needed by WRF-Chem, we applied the temporal factors based on the source characteristics to the emission data from SMOKE inventory file. These factors include monthly, weekly-weekend and diurnal profiles.

3. Spatial Allocation:

In spatial processing or gridding allocation we combined the grid specification for the WRF-Chem domain with source locations from the SMOKE inventory file. The resulting gridding matrix is a sparse matrix that describes in which grid cells the emissions for each source occur within the modeling domain. The gridding matrix is applied to the inventory emissions to transform source-based inventory emissions to gridded emissions. For area and mobile sources, the county-total emissions are spread among the cells intersecting the county through the use of gridding surrogates. The Surrogate files were generated by processing a set of GIS shape files using the Surrogate Generator Tool. We generates 62 surrogate files for U.S. and 35 for Canada. These files contains the information of population, construction, agriculture and so on.

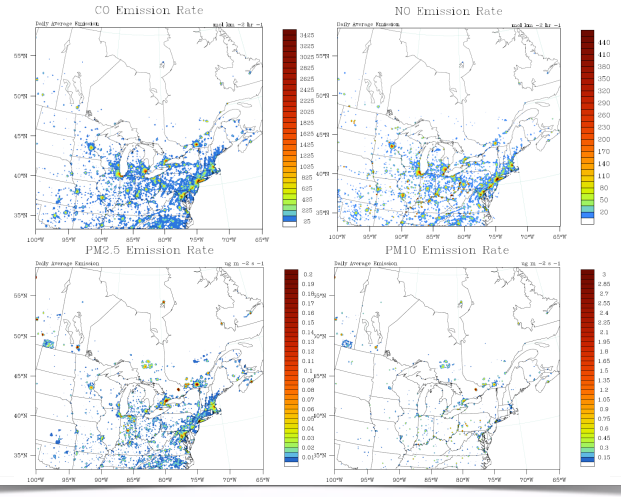
4. Chemical Speciation:

Emission inventories report CO, NOX, VOCs, SO2, PM10 and PM2.5. However, the chemical mechanism used by the WRF-Chem model contain a simplified set of equations that use “model species” to represent atmospheric chemistry. We used the chemical speciation profiles to convert the inventory pollutants to model species used in RADM2 chemical mechanism.

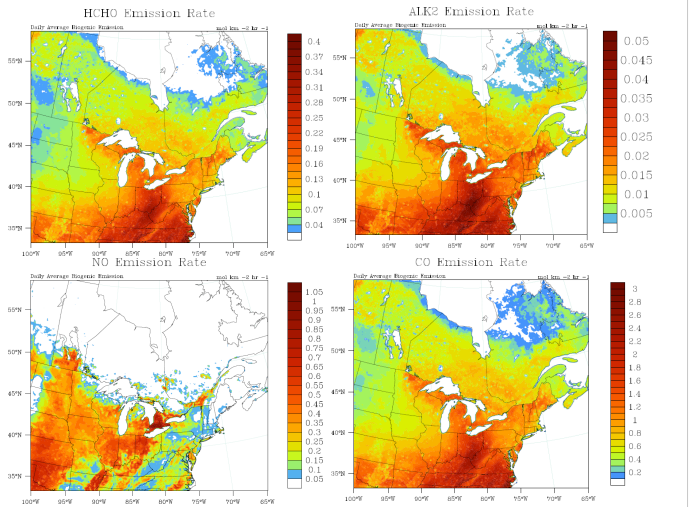
Biogenic emissions

We used the 1-km land-use data obtained from the Biogenic Emission Land Use data version 3 (BELD3). The surrogate tool is then used to allocate the BELD3 land use data onto the 12-km model grid cells. Finally, the SMOKE-BEIS3.12 (Biogenic Emission Inventory System) ran using the WRF meteorological adjustment and gridded land use data to calculate the model-ready emissions.

Emission rate of CO, NO, PM2.5 and PM10 from Area, Mobile and Point sources (daily mean, April 1st, 2009)



Emission rate of HCHO, ALK, NO and CO from Biogenic emission sources (daily mean, April 1st, 2009)



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