An Evaluation of NOx and VOC Emissions in the National Emission Inventory by Source Apportionment Technology

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Abstract

Source apportionment is a useful methodology for examining and quantifying air quality impacts resulting from geographically and temporally diverse emissions. In this study, photochemical modeling is conducted on a regional scale for a 2011 summer episode using Ozone Source Apportionment Technology (OSAT) adopted in the Comprehensive Air Quality Model with Extension (CAMx) and Integrated Source Apportionment Method (ISAM) implemented in the Community Multi-scale Air Quality Model (CMAQ). Ozone contributions from NOx and VOCs of various emission sectors (on-road, non-road, EGUs and non-point) at the state level are analyzed in terms of their relative importance in National Emission Inventory (NEI). Policy implications along with future improvement in emission inventory development for use in regional air quality modeling are discussed.

Source Apportionment

- **Ozone Source Apportionment Technology (OSAT)**
- **Integrated Source Apportionment Method (ISAM)**
- **Model runs are being conducted for three summer months (June, July, August) for the base and future years**

Category	OSAT	ISAM
Baseline Model	CAMx6.30	CMAQ5.0.2
Domain Size	Eastern states (172*172)	Eastern states (172*172)
Emission version	EPA2011el	MARAMA beta
Meteorology	WRFCAMx (v4.4)	WRF-MCIP (v4.3)
Speciation	CB6r2	CB05
Boundary Condition	GEOS-CHEM provides boundary at eastern domain	GEOS-CHEM provides boundary at eastern domain
Initial Condition	15-ramp up days from May 15	May 31 output by NYSDEC
Emission Grouping	32 states x 21 sectors	32 states x 3 major sectors
Others	Kv patch, PT override fix	3D point sources (not inline)

- Emission grouping (or tags) for ISAM include onroad, non-road, and EGUs;
- Emission grouping for OSAT include all 21 sectors in EPA2011el platform (next page);
- CAMx-OSAT can handle only three tagged sectors (plus "left-over" tag) at a time;
- With three tags per run, ISAM takes 10 times longer to complete than OSAT

Emission Sectors

X: "tagged" sectors for CAMx-OSAT in this study

No.	SectorID	Category	Group One Sector Tags	Group Two Sector Tags	Notes
(1)	onroad	onroad	x		4 sub-sectors
(2)	onroad_catx_adj	onroad		x	4 sub-sectors
(3)	othon	non-point		x	Canada/Mexico onroad
(4)	othpt	point		x	Canada/Mexico point, offshore oil and cmv
(5)	othar	non-point		x	Canada/Mexico non-point
(6)	cmv	non-point	x		commercial marine vessel
(7)	ptfire_mxca3D	point		x	Canada/Mexico
(8)	ptegu	point	x		EGUs
(9)	ptnonipm	point	x		non-ipm point
(10)	pt_oilgas	point	x		point oil and gas
(11)	ptfire3D	point		x	wild/prescribed fire
(12)	nonroad	non-point	x		non-road equipment
(13)	nonpt	non-point	x		remaining non-point
(14)	np_oilgas	non-point	x		non-point oil and gas
(15)	rwc	non-point	x		residential wood combustion
(16)	rail	non-point	x		rail locomotives
(17)	ag	non-point	x		livestock/fertilizer
(18)	agfire	non-point	x		agricultural fire
(19)	afdust	non-point		x	fugitive dust
(20)	othafdust	non-point		x	Canada's fugitive dust
(21)	beis	biogenic		x	Canada/Mexico incl'd

- All 21 emission sectors in EPA2011el platform have been tagged for CAMx-OSAT;
- O3 contributions from group one will be identified/quantified by both state and sector;
- O3 contributions from group two will be identified by sector as a whole (no state);
- Three "other" sectors listed in group two (**othon, othpt, and othar**) can be tagged as group one;
- Sub-sectors (such as RPD/RPV/RPP/RPH in onroad) can be tagged as well (in progress);
- More tags = more model runs

Differences from EPA Transport Modeling

Category	EPA	This Study
Domain Size	CONUS (396 x 246)	OTC12 (172 x 172)
Baseline Model	CAMx6.32 (EPA-revised version)	CAMx6.30 (publicly released version)
Tagging	By state	By state and by sector
Model Years	FY only	BY and FY
Plume Behavior	No	Graphical Display
O3 Contributions	Averaging	Hourly
Comparison with Observations?	O3 contributions only	O3 contributions + observations

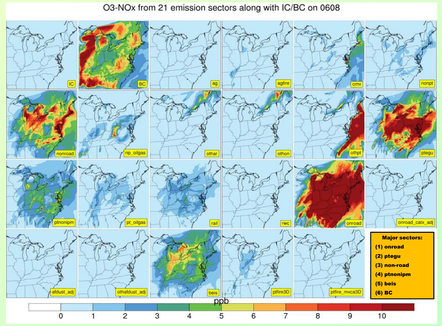
- The study used the same 2011el emission platform as EPA transport modeling;
- EPA modeling can be revised and improved to be compatible with more elaborated and sophisticated modeling done in this study

Emissions Processing

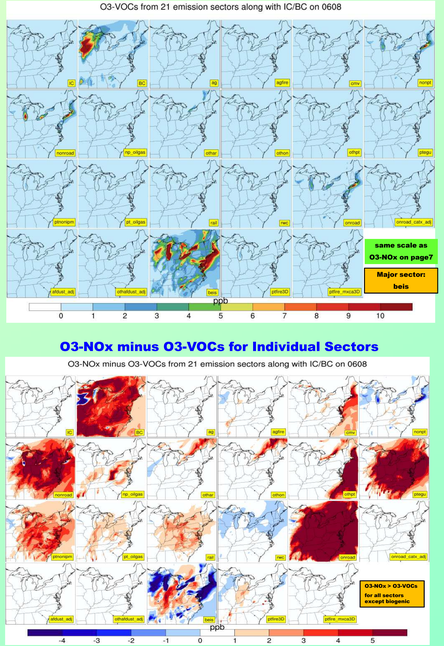
- **SMOKE-EMF with EPA 2011el platform**
- **Process 21 emission sectors with modifications of (1) a revised domain of eastern half of US (OTC12), and (2) inline source apportionment**
- **Follow EPA's practice of converting all (area and point) emissions to point sources with k cell override tags for accurately apportioning contributions**
- **Supply tagged emissions as separate sectors**
  - CAMx requires "point-only" tagged sectors to have similar and consistent file format as the primary "point-only" emission files where emissions of non-tagged sectors are zeroed out
- **Develop scripts for zeroing out inline (group one tags) and non-inline files (group two tags)**
- **Merge tagged sector with non-tagged (zero-out) sectors**
- **Prepare source region map with "matching" k cell tags**

Emission processing would be a lot easier provided that
(1) Regular" emissions (i.e., not inline) are supplied;
(2) Graphical display of plume spread is omitted

O3-NOx Sector-Wide Contributions from Individual Sectors



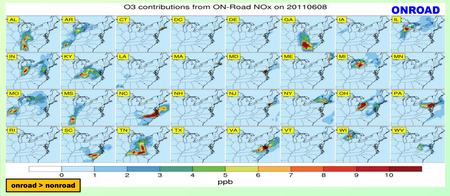
O3-VOCs Sector-Wide Contributions from Individual Sectors

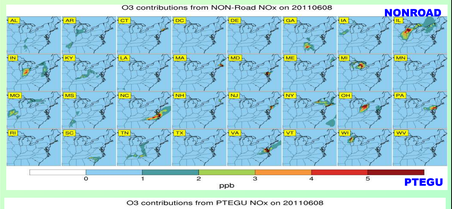


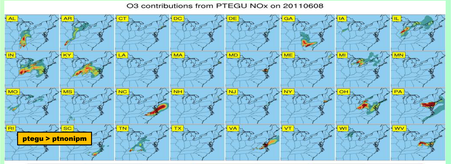
O3-NOx minus O3-VOCs for Individual Sectors

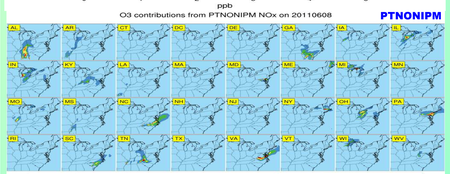
Graphical Display of O3-NOx or O3-VOCs Plume by Sector and/or by State

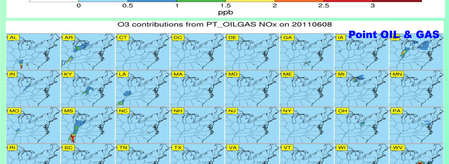
- **Time shown is at 4pm EST on date indicated on the charts;**
- **Concentration scale varies by sector**
- **2011 O3 episode in the northeast:**
  - **June 8 – June 9, 2011**
  - **July 20 – July 21, 2011**

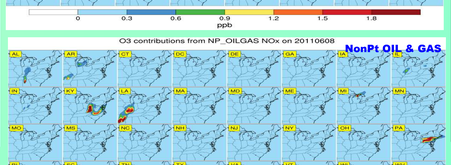


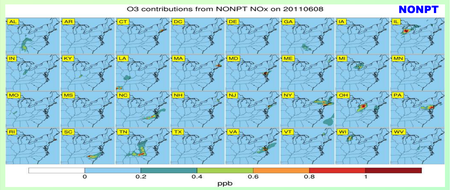


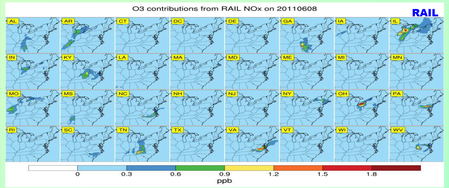


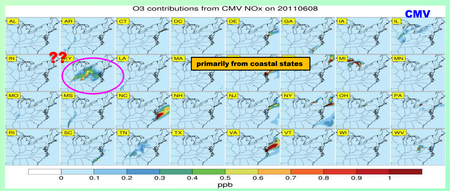


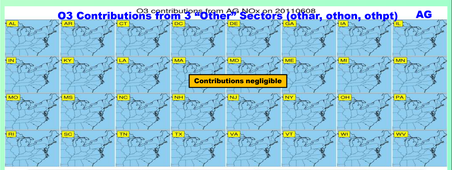


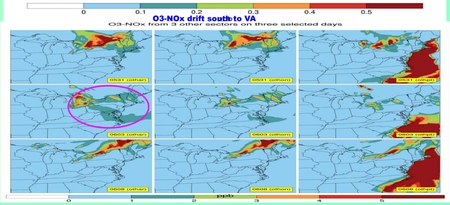


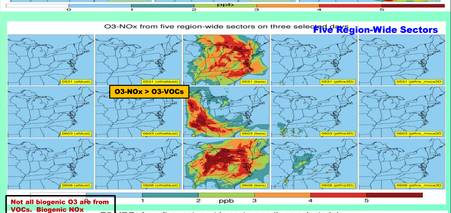


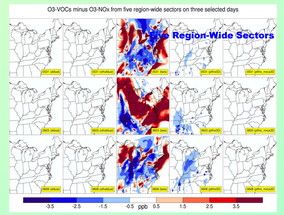




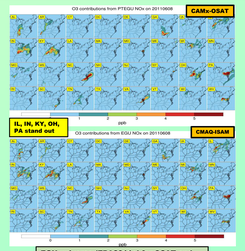








If APCA is turned on (instead of OSAT), O3-NOx from biogenic sources will be allocated to anthropogenic NOx at the expense of O3-VOCs from biogenic sources (see June 22, 2017 presentation by VADEQ)

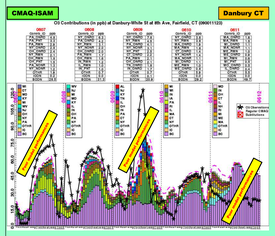


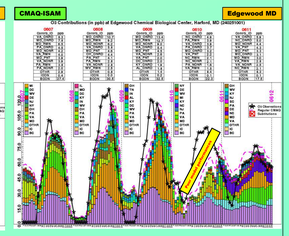
EGU universe (EPA2011el for OSAT and MARAMA beta for ISAM) are different

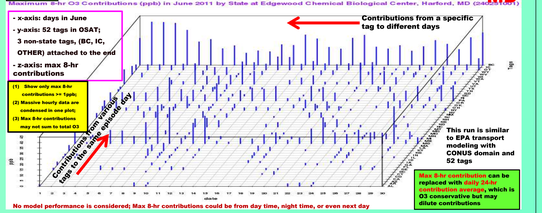
O3 Contributions to Monitors

Sector Abbreviation for CMAQ-ISAM

Notation	Note
ONRD	Contribution from state's on-road
NONR	Contribution from state's non-road
PNT	Contribution from state's EGUs
RMN	Contribution from state's "remaining" emissions
OTHR	Contribution from "left-over" (non-tagged) emissions
ICON	Contribution from initial condition
BCON	Contribution from boundary condition







Overall Summary

- **EPA's SMOKE-EMF platform has been tested and established to facilitate ongoing and future emission modeling**
- **O3 contributions from 21 emission sectors in EPA2011el have been quantified, either by state or by sector as a whole**
- **Apart from boundary conditions, the majority of ozone are from five major emission sectors: onroad, nonroad, ptegu, ptnonipm, and biogenics**
- **Contributions from ptfire (wildfire and prescribed fire) are localized; Contributions from ag, agfire, afdust, othafdust, and rwc are negligible**
- **Contributions from Canada (othon and othar) could drift south, affecting northeastern states and as far south as Virginia**
- **O3 contributions from NOx are greater than O3 contributions from VOCs for all sectors except biogenics**
- **EGU sector is the most reliable in terms of emission estimates (thanks to CEM/CAMD measurements), but is rarely the primary O3 contributor other than to its home-state monitors**
- **Emissions from on-road are poorly developed (per MOVES studies by VADEQ), but the sector is almost always the top contributor**
- **Emissions of major contributing sectors should be scrutinized carefully**

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