COMMONWEALTH OF VIRGINIA
STATE AIR POLLUTION CONTROL BOARD

OZONE ADVANCE ACTION PLAN
FREDERICKSBURG, VIRGINIA

Appendix B: Modeling Support Information

OTC 2007 Level 3 Modeling

NY, NJ, VA

and

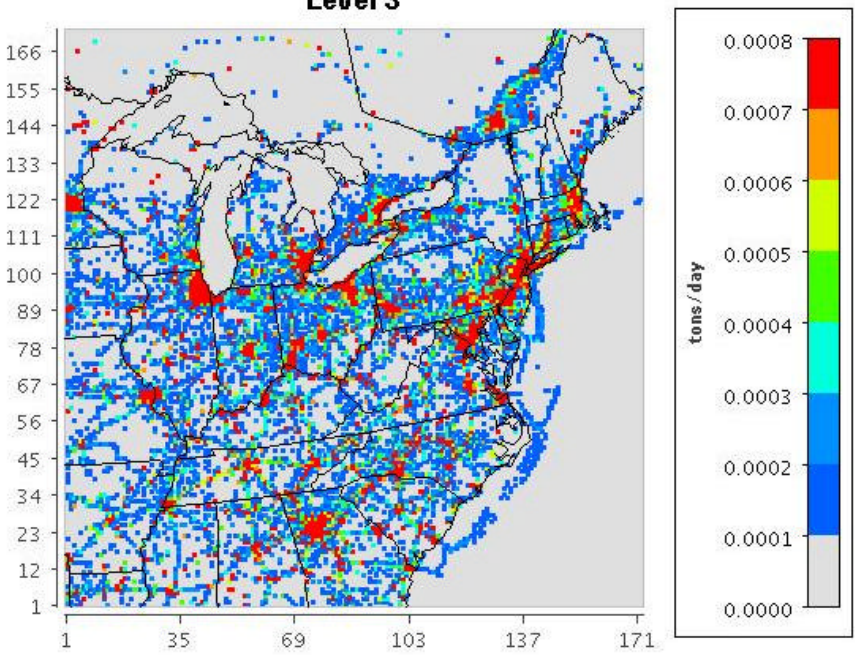
MARAMA

EMISSIONS

NOx and VOC for August 3, 2007 from each sector

Anthropogenic NOX Emissions

Level 3

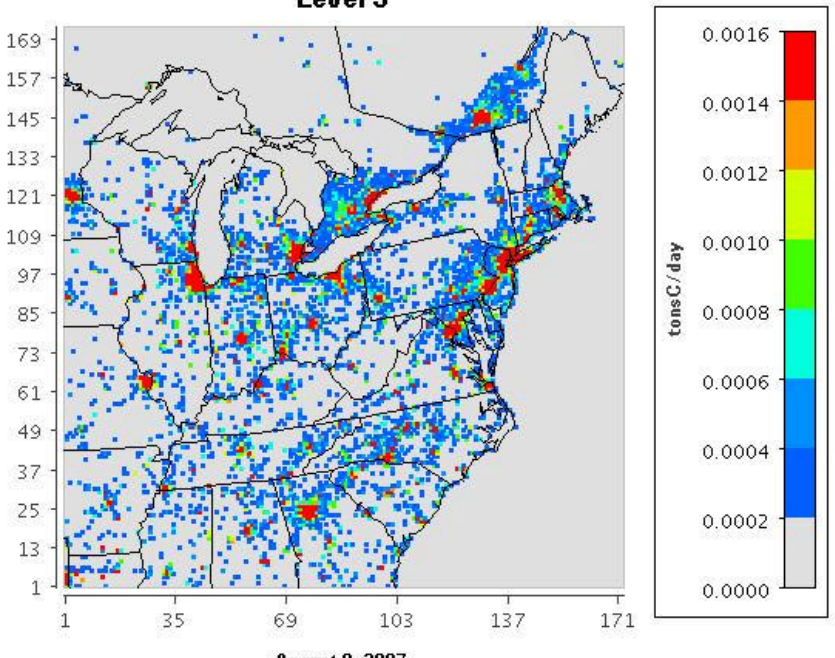


August 3, 2007

Min (105, 1) = 0.0000, Max (138, 102) = 0.0314

Anthropogenic VOC Emissions

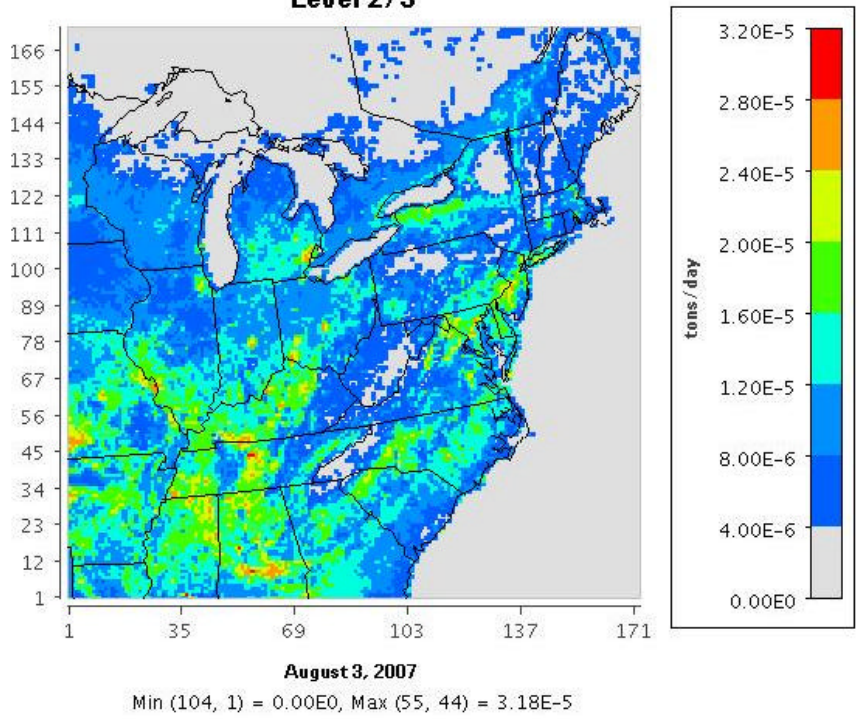
Level 3



August 3, 2007

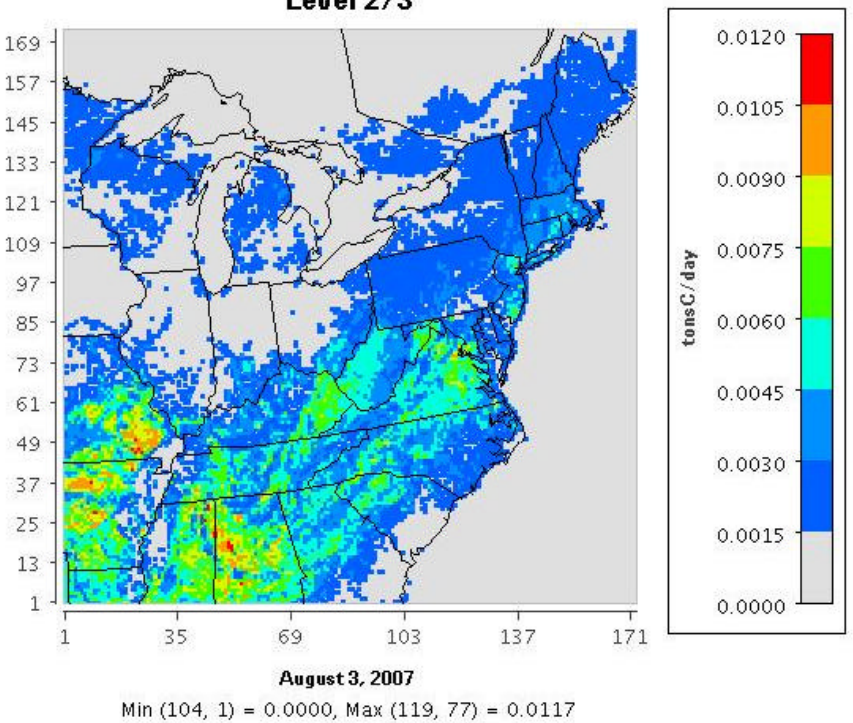
Min (105, 1) = 0.0000, Max (138, 102) = 0.0182

Biogenic NO Emissions

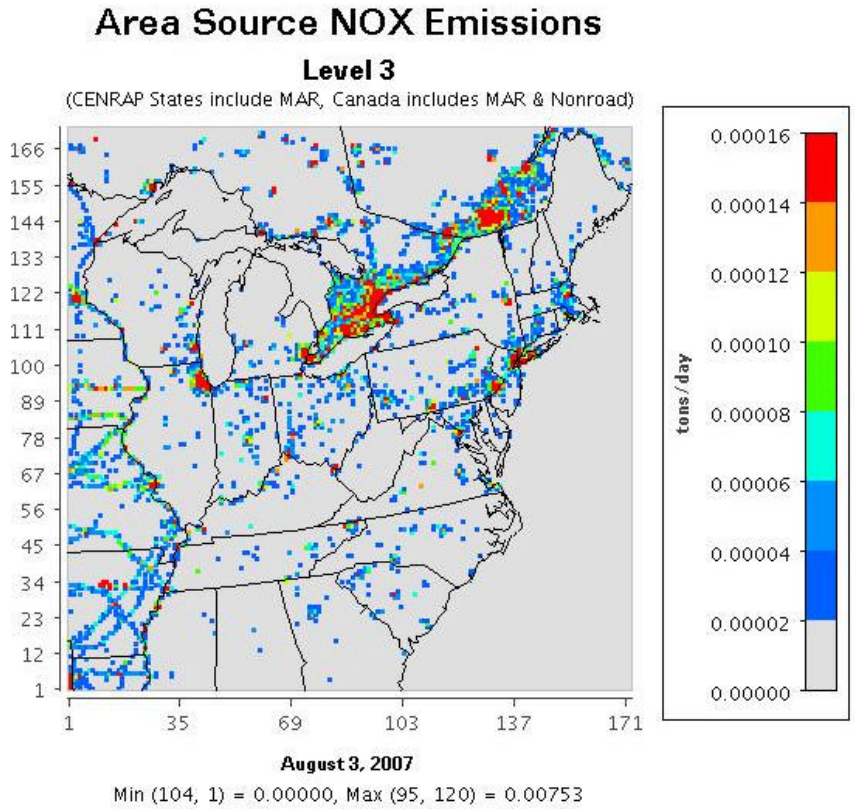


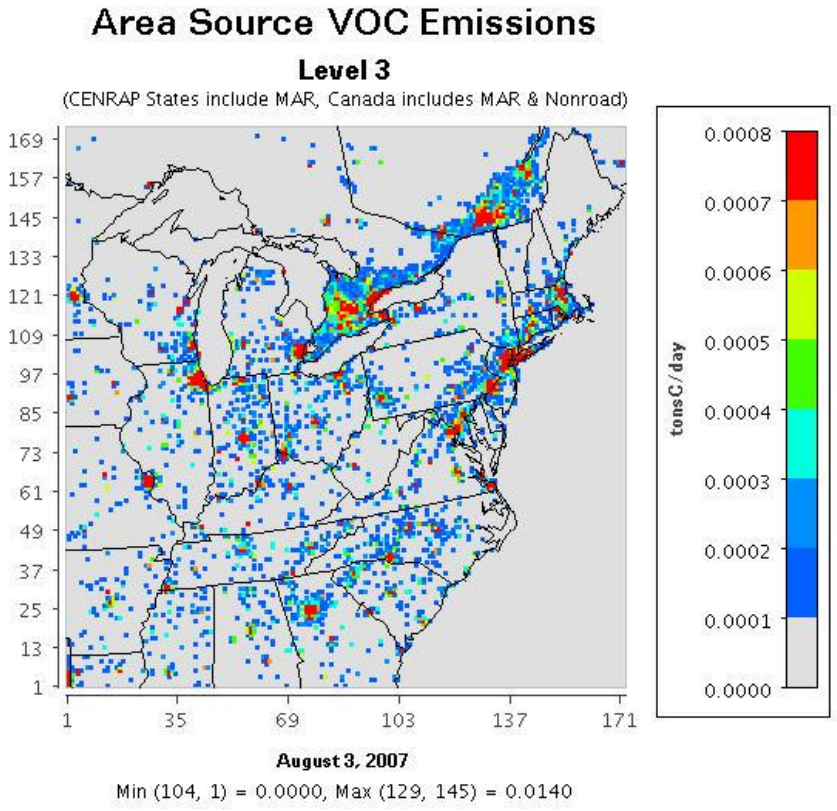
Min (104, 1) = 0.00E0, Max (55, 44) = 3.18E-5

Biogenic VOC Emissions



Min (104, 1) = 0.0000, Max (119, 77) = 0.0117

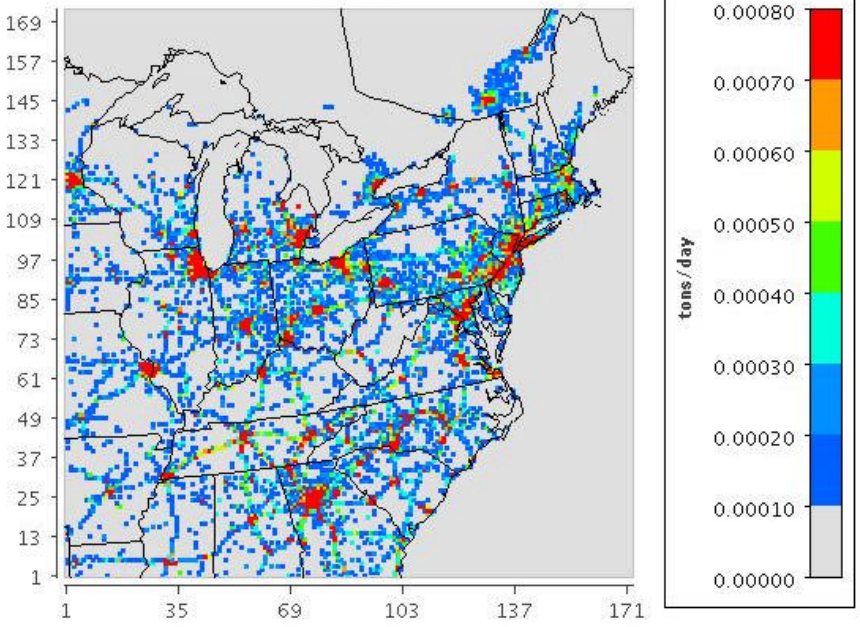




CENRAP States include MAR, Canada includes MAR and Non-road.

Mobile Source NOX Emissions

Level 3

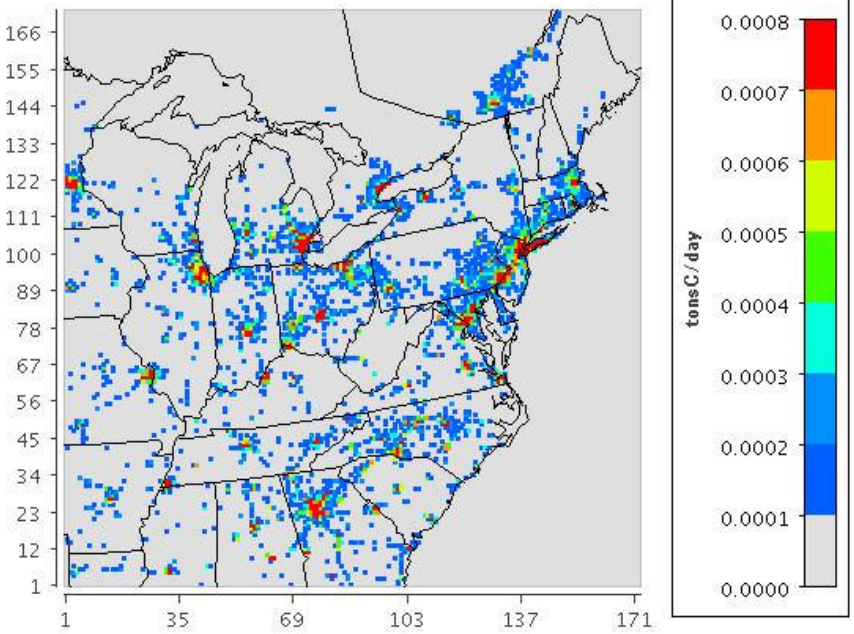


August 3, 2007

Min (104, 1) = 0.00000, Max (138, 102) = 0.00806

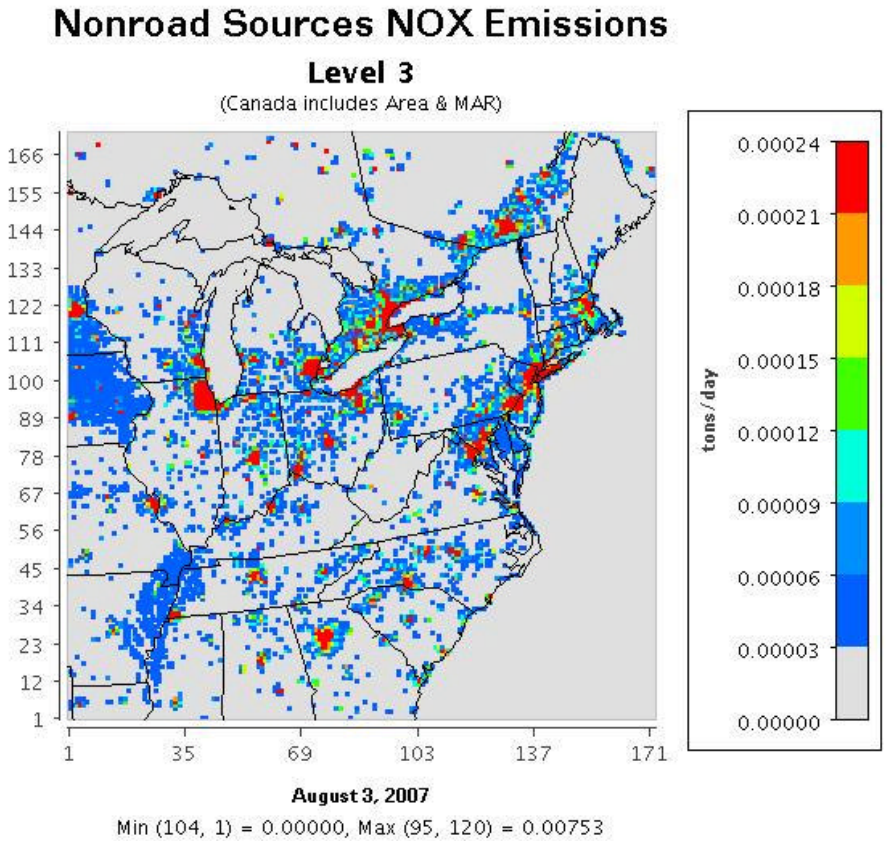
Mobile Source VOC Emissions

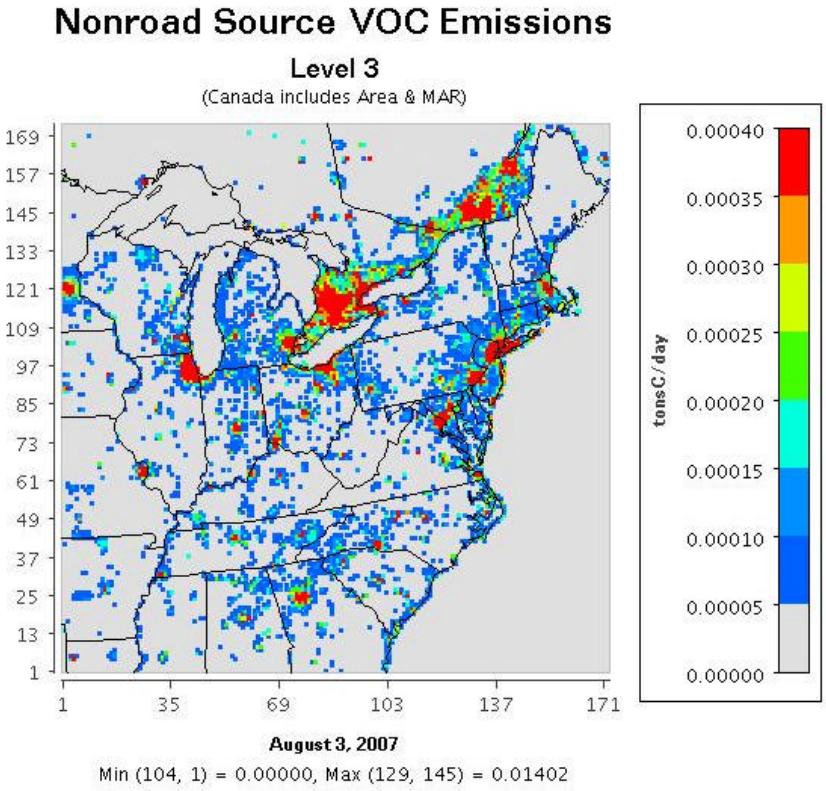
Level 3



August 3, 2007

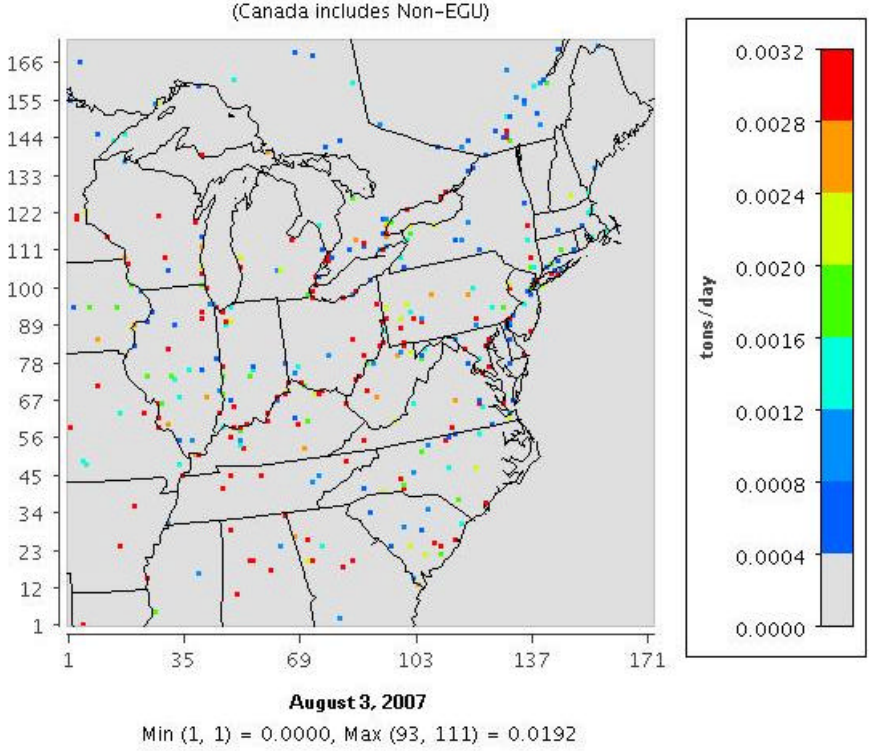
Min (104, 1) = 0.0000, Max (138, 102) = 0.0038





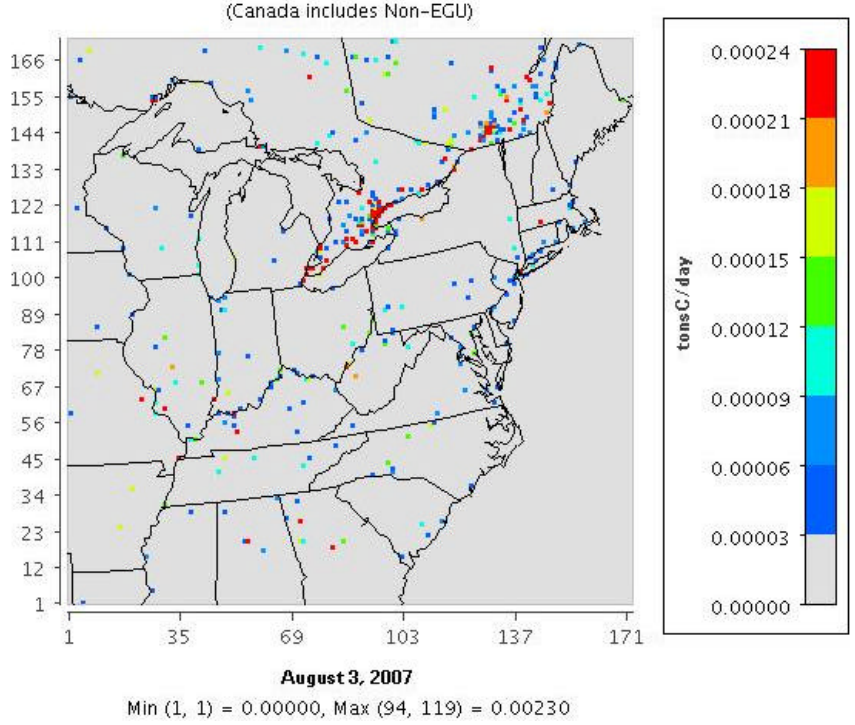
Canada includes Area and MAR.

EGU Point Source NOX Emissions



Min (1, 1) = 0.0000, Max (93, 111) = 0.0192

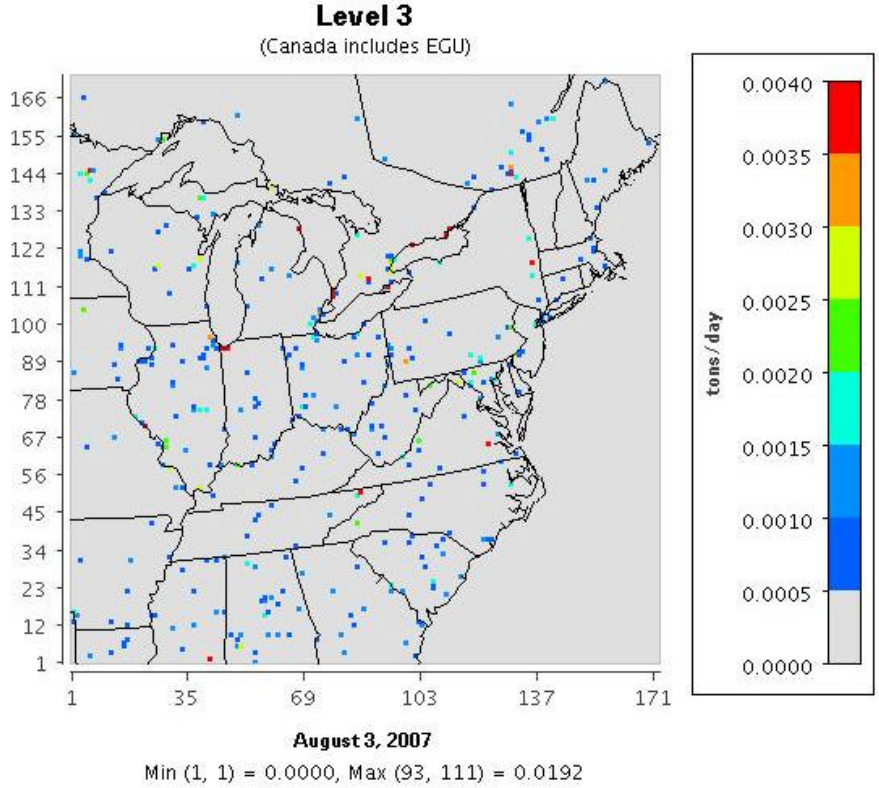
EGU Point Source VOC Emissions



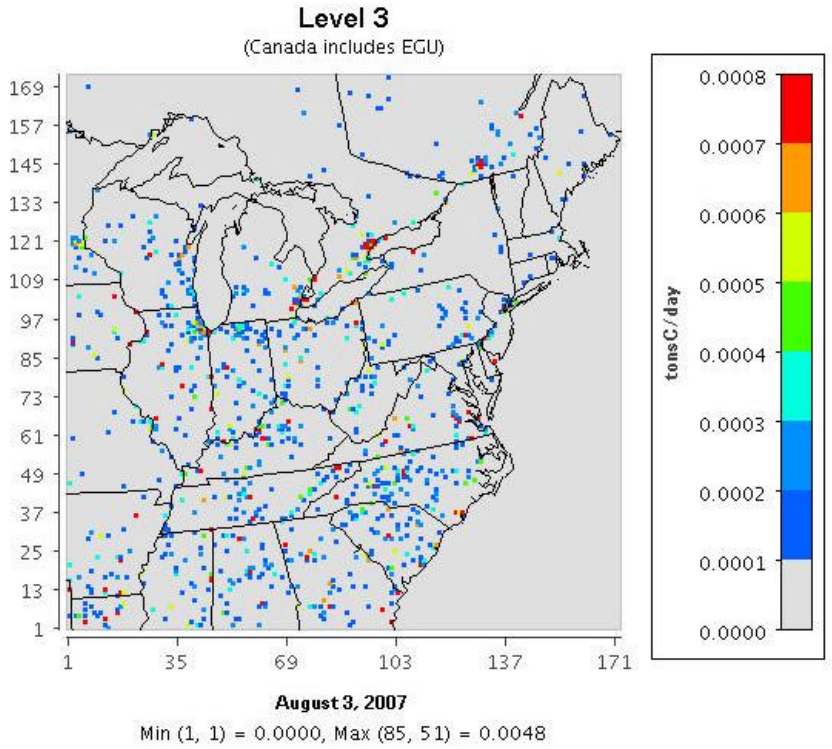
Min (1, 1) = 0.00000, Max (94, 119) = 0.00230

Canada includes Non-EGU

Non-EGU Point Source NOX Emissions

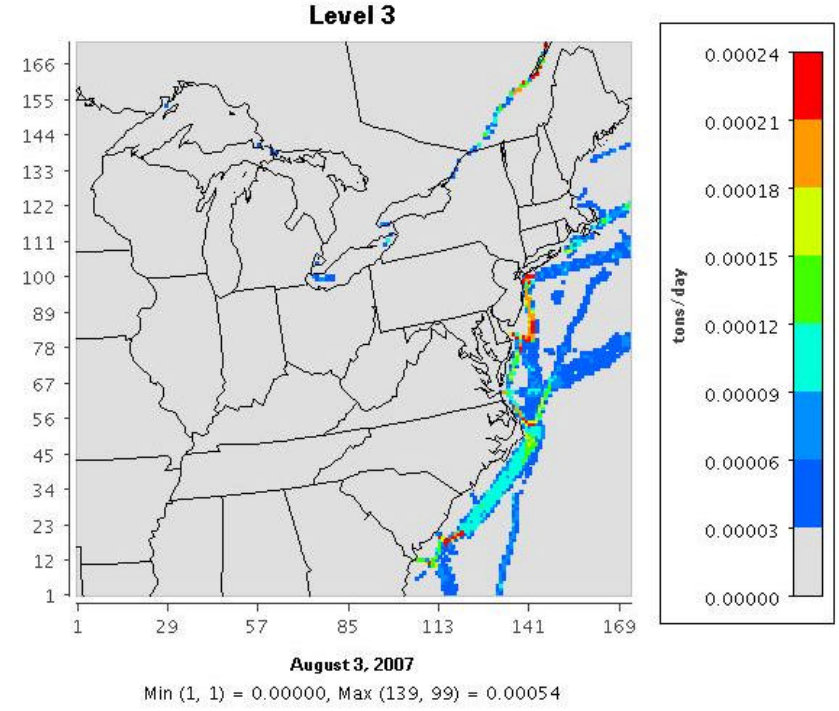


Non-EGU Point Source VOC Emissions



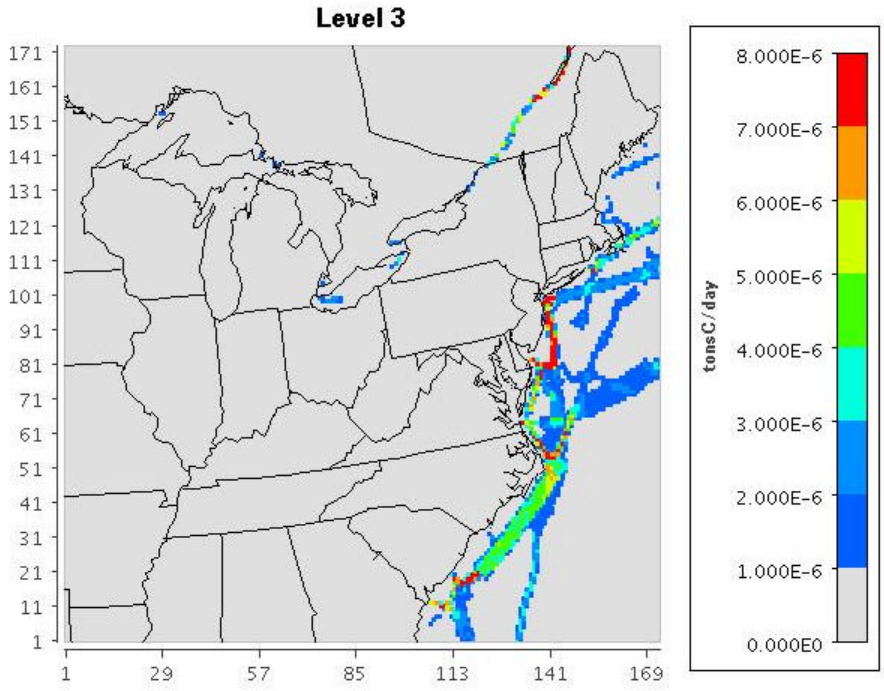
Canada includes EGU

Category 3 Marine Vessel NOX Emissions

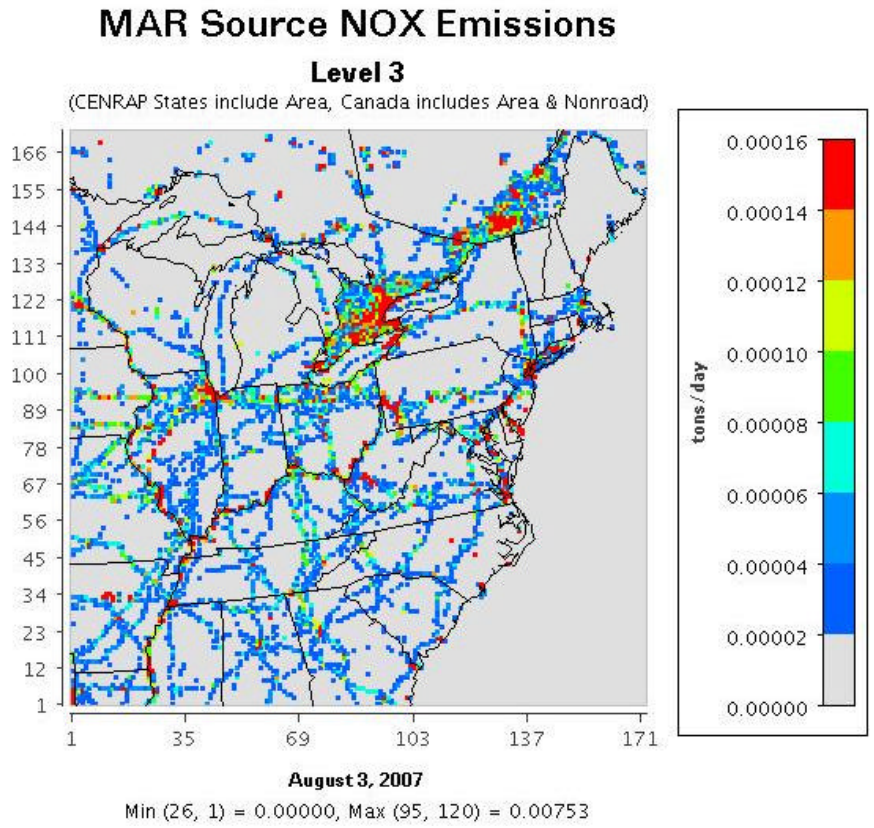


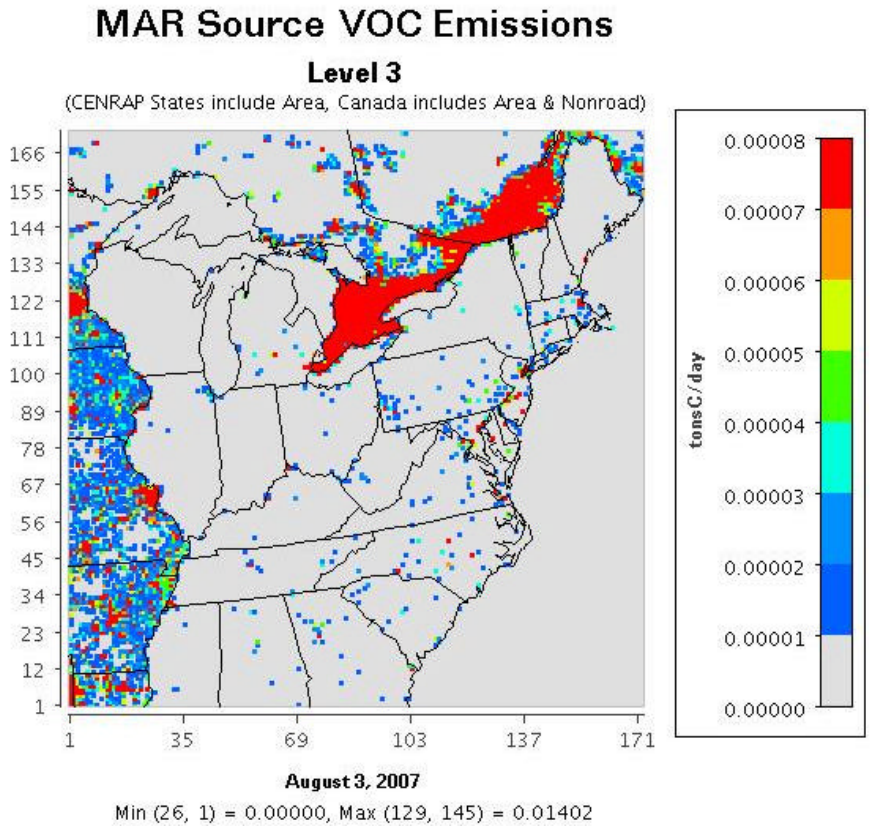
Min (1, 1) = 0.00000, Max (139, 99) = 0.00054

Category 3 Marine Vessel VOC Emissions



Min (1, 1) = 0.000E0, Max (139, 99) = 2.505E-5





CENRAP States include Area, Canada includes Area and Non-road

OTC Level 3 Modeling

- CMAQ4.71 with CB05 chemistry aero5 aerosol module.
- MARAMA/OTC Level 3 emission inventories.
- Annual simulations for 36 km U.S. Continental domain and 12 km Eastern U.S. domain
- Time-variant boundary conditions of 12 km domain using 36 km simulations.

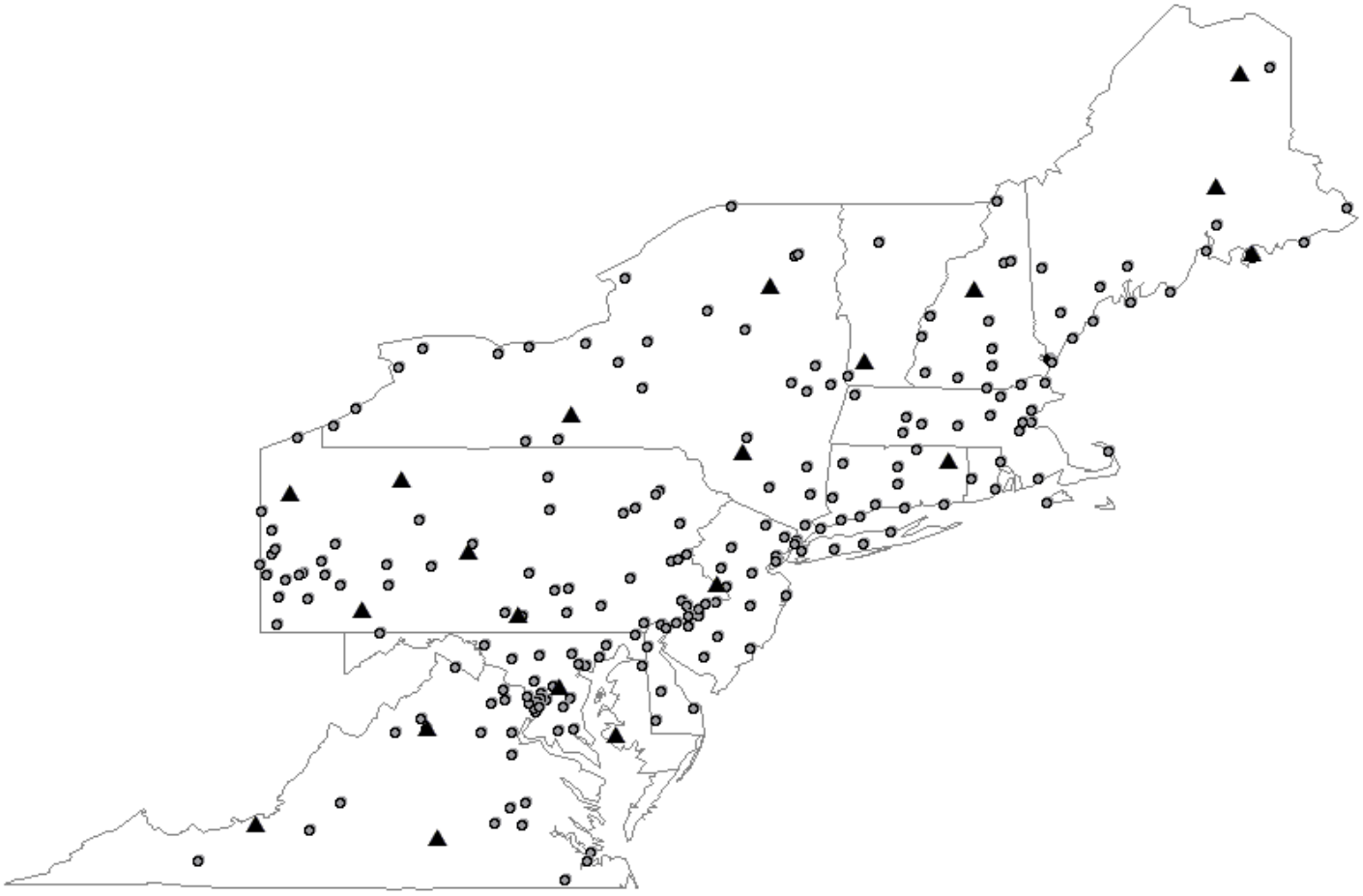
Performance evaluation of the 2007 CMAQ L3 12-km base case

Ozone

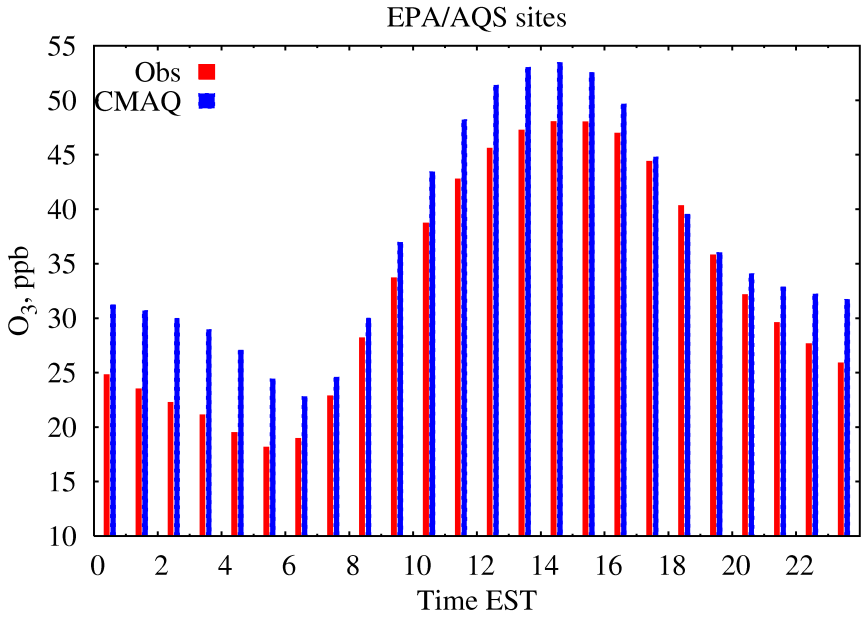
O_3 evaluation

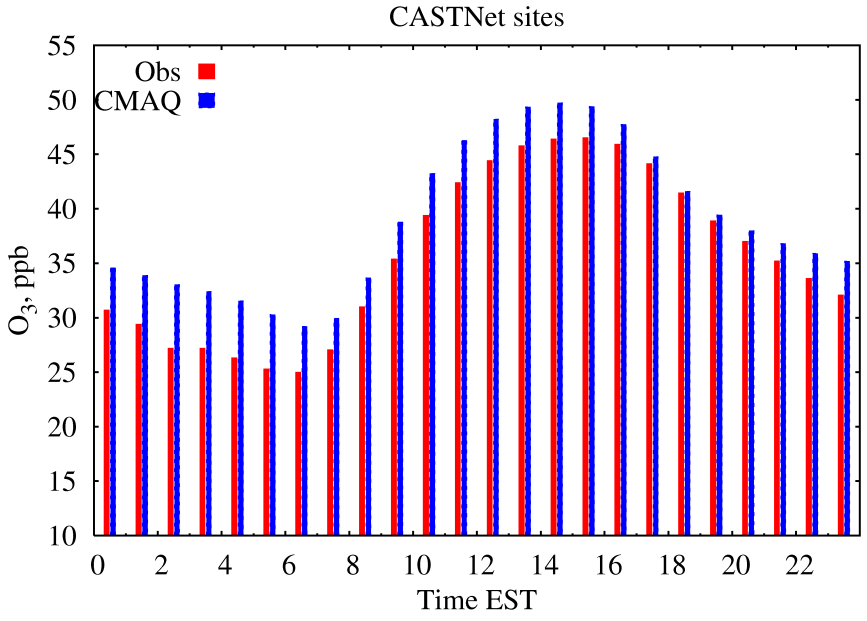
- OTR region plus all of VA
  - EPA/AQS (S/L/T), 210 sites
  - CASTNet, 20 sites
- Focus on O_3 season (April-October)
- 1-hour O_3 – diurnal variations
- Daily-maximum 8-hour O_3 – model bias and error, in space and time

Locations of potential EPA/AQS sites (circles) and CASTNet sites (triangles) across the OTR+VA region, 2007



Diurnal variations

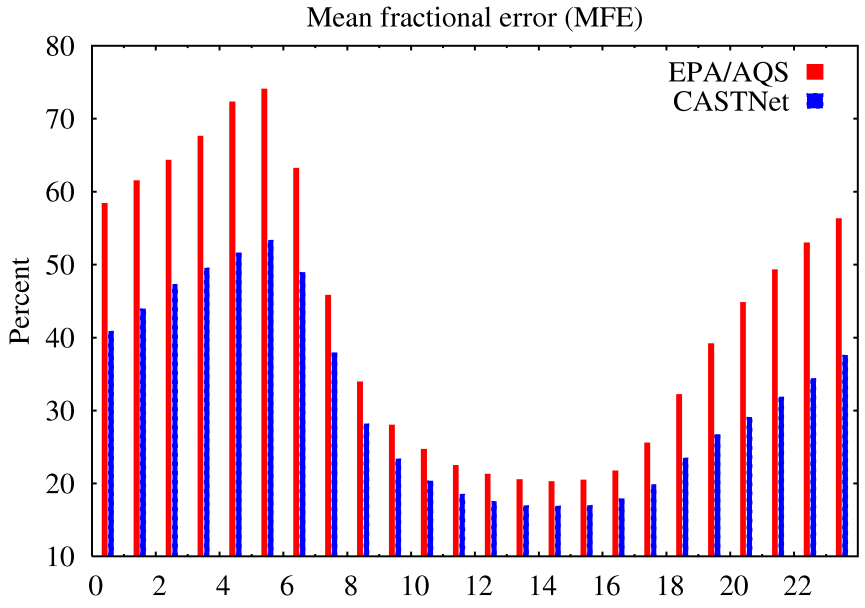


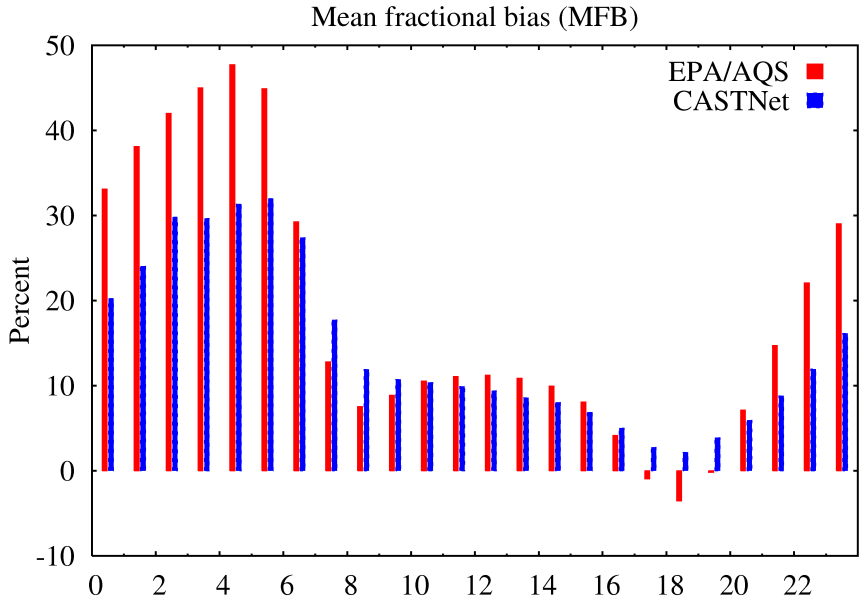


Average diurnal variation of O_3 aggregated across EPA/AQS (top panel) and CASTNet (bottom panel) sites across the OTR+VA

Good qualitative agreement between observed and predicted O_3; largest overprediction during nighttime/early morning hours, better agreement during late morning through afternoon hours

For most hours of the day, CMAQ overpredictions are ~1-2 ppb larger at EPA/AQS sites compared to CASTNet sites



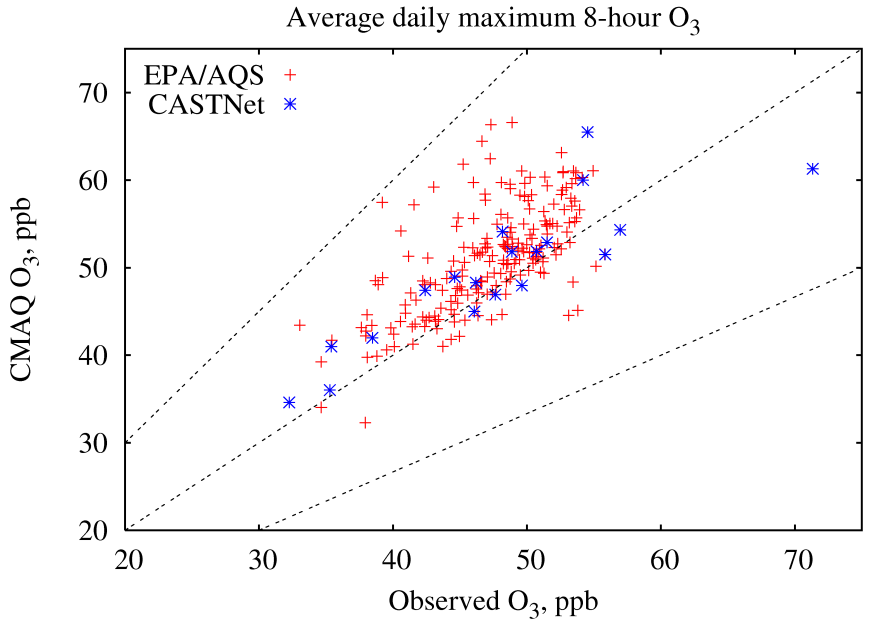


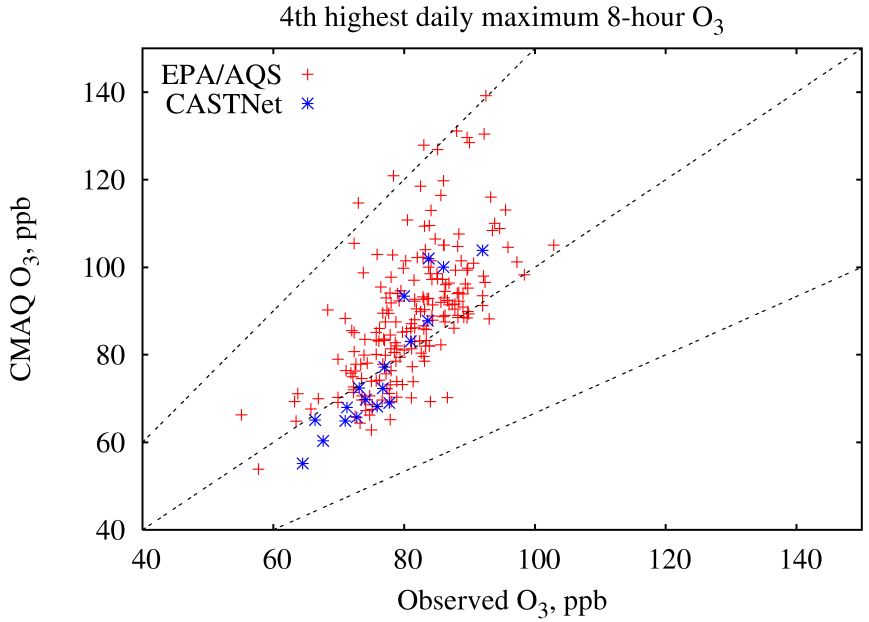
Mean fractional error (top panel) and mean fractional bias (bottom panel) aggregated across the OTR+VA

As noted in the previous slide, the largest MFE and MFB tend to occur during the nighttime and early morning hours, and MFE and MFB tend to be larger at the EPA/AQS sites compared to CASTNet

Overall, MFE<25% and MFB<10% during the late morning through afternoon hours

Daily maximum 8-hour O_3

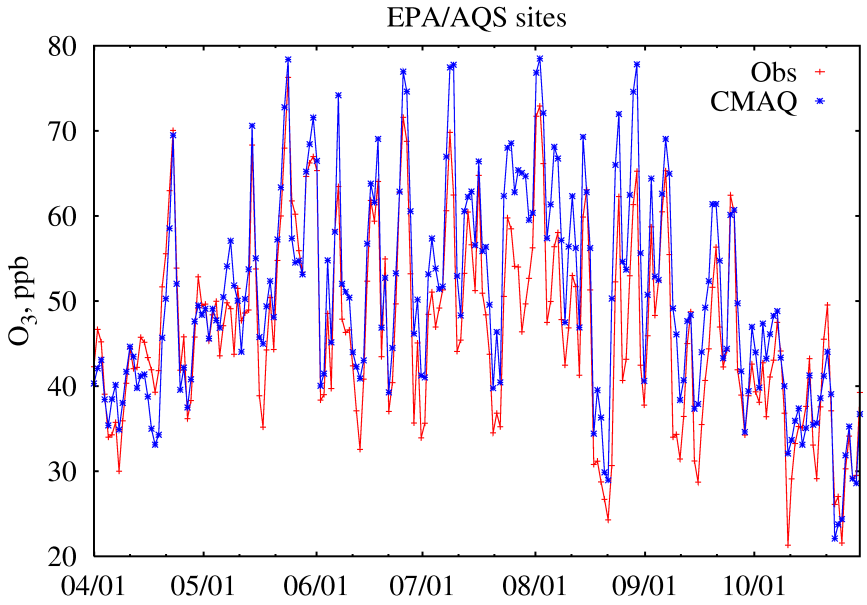


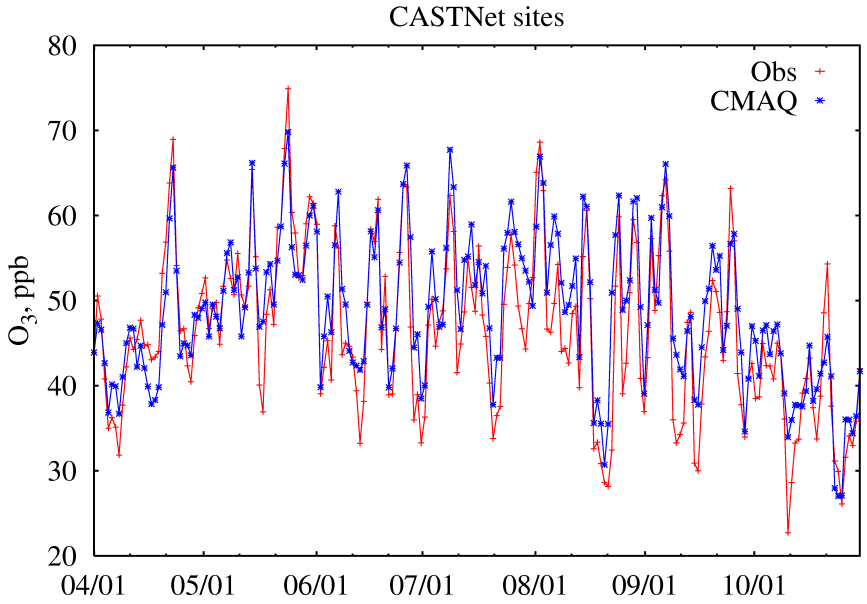


Comparison of observed and predicted average daily maximum 8-hour O_3 (top panel) and 4th highest daily maximum 8-hour O_3 at EPA/AQS and CASTNet sites across the OTR+VA, April-October 2007

Dashed lines denote 1:1, 1:1.5, and 1.5:1

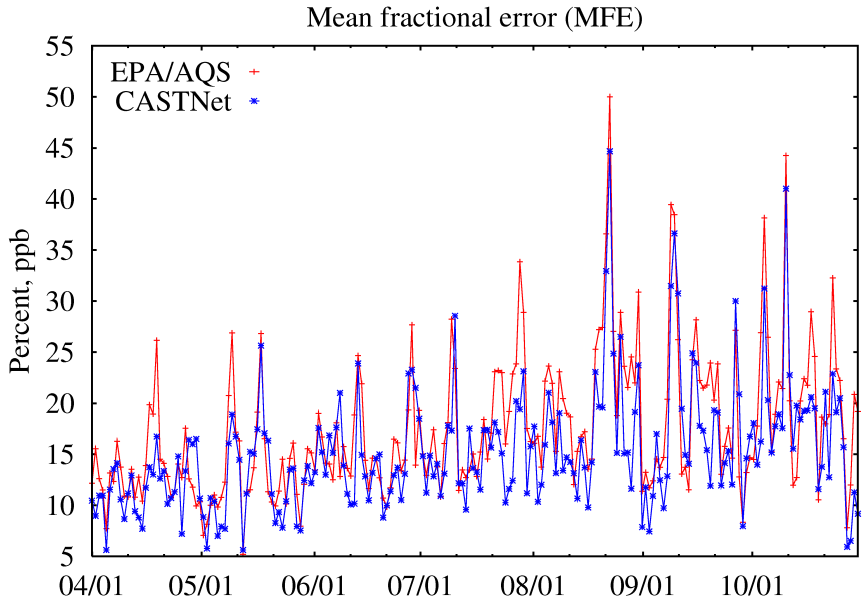
CMAQ tends to overestimate daily maximum O_3, but for <u>average</u> daily maximum O_3 all sites fall within the 1:1.5 and 1.5:1 lines

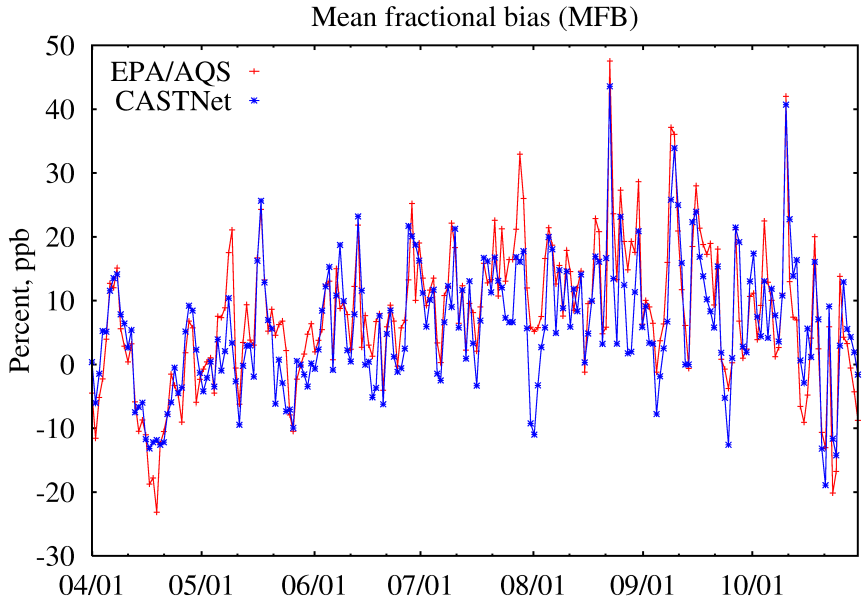




Daily maximum 8-hour O_3 at EPA/AQS (top panel) and CASTNet (bottom panel) sites aggregated across the OTR+VA

CMAQ generally captures the seasonality in daily maximum O_3 levels, although there is a tendency to overpredict O_3 especially at EPA/AQS sites from about mid-May to mid-September

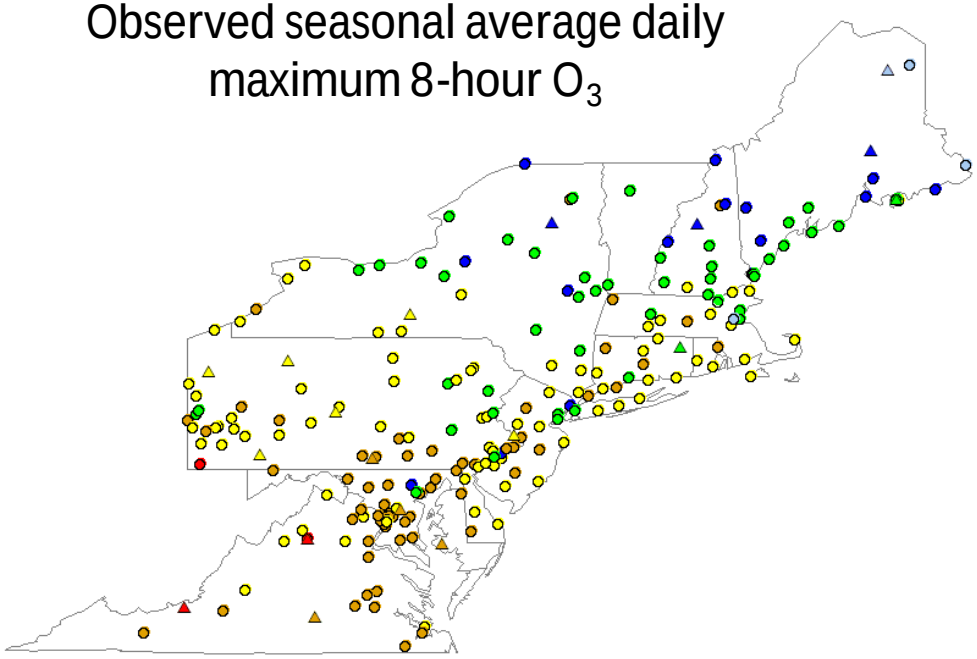




Mean fractional error (top panel) and mean fractional bias (bottom panel) in daily maximum 8-hour O_3 aggregated across the OTR+VA

MFE and MFB tend to be higher at EPA/AQS sites compare to CASTNet

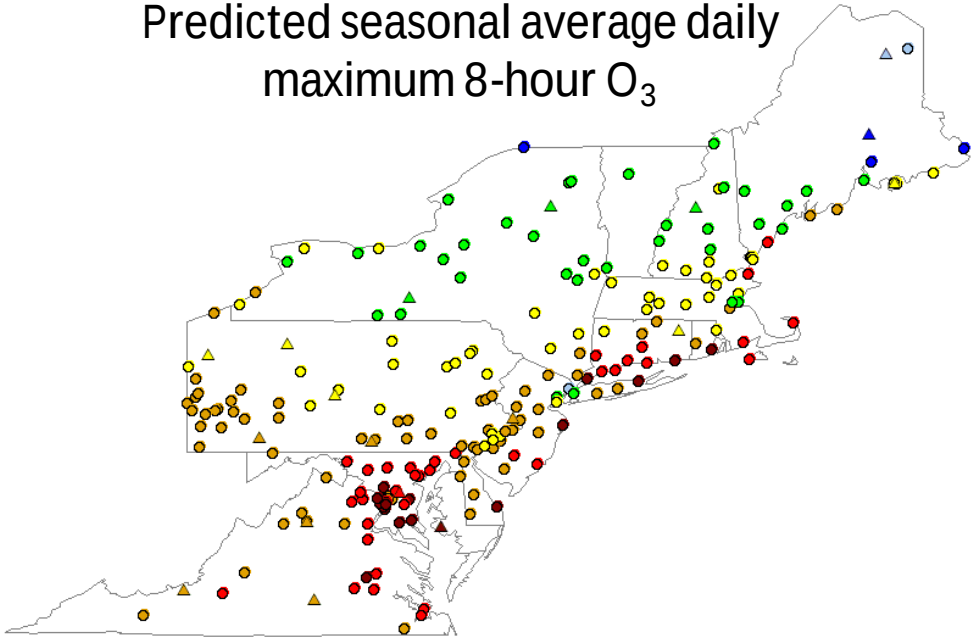
Observed seasonal average daily maximum 8-hour O_3



EPA/AQS – circles
CASTNet – triangles

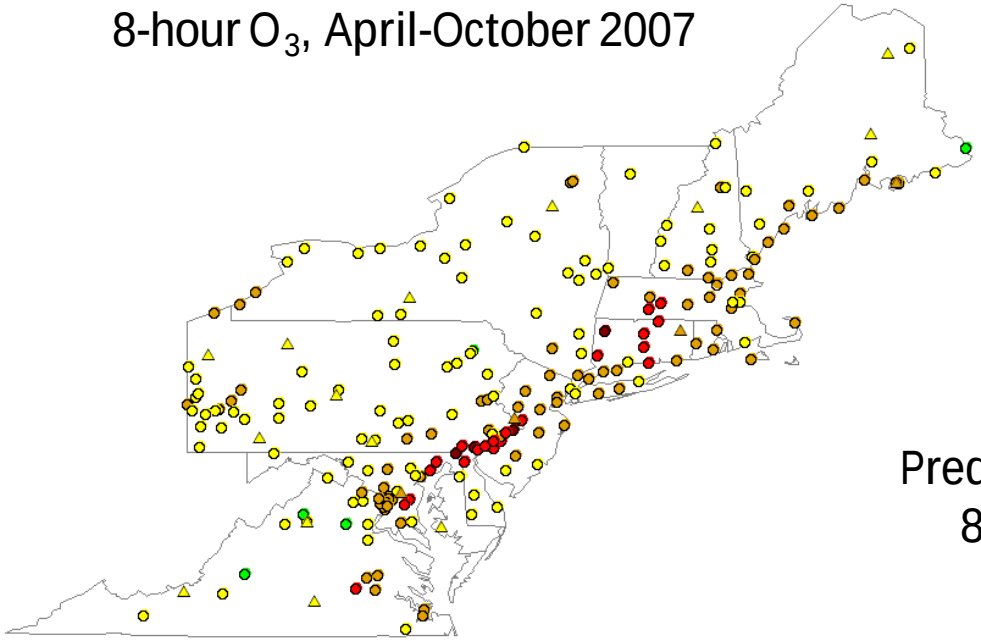
Largest overpredictions tend to occur along the coast/urban corridor

Predicted seasonal average daily maximum 8-hour O_3

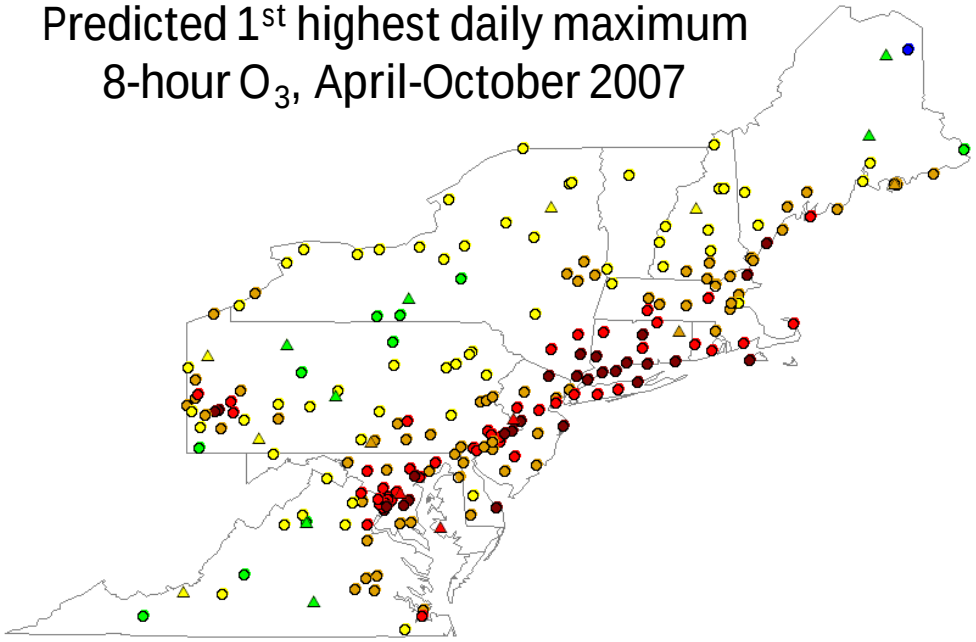


? < 35 ppb
? 35-40 ppb
? 40-45 ppb
? 45-50 ppb
? 50-55 ppb
? 55-60 ppb
? > 60 ppb

Observed 1st highest daily maximum 8-hour O_3, April-October 2007

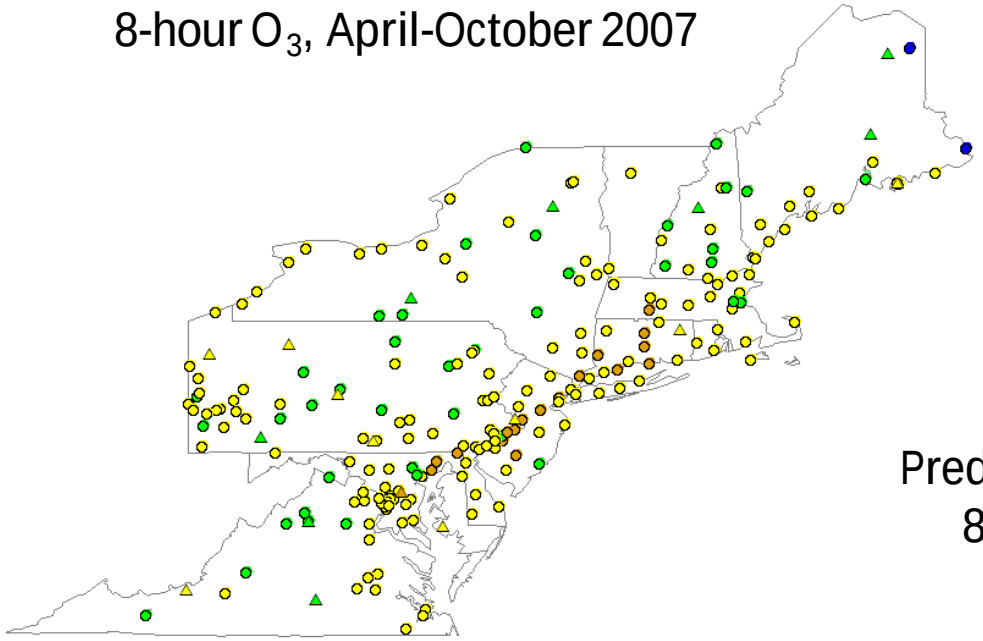


Predicted 1st highest daily maximum 8-hour O_3, April-October 2007



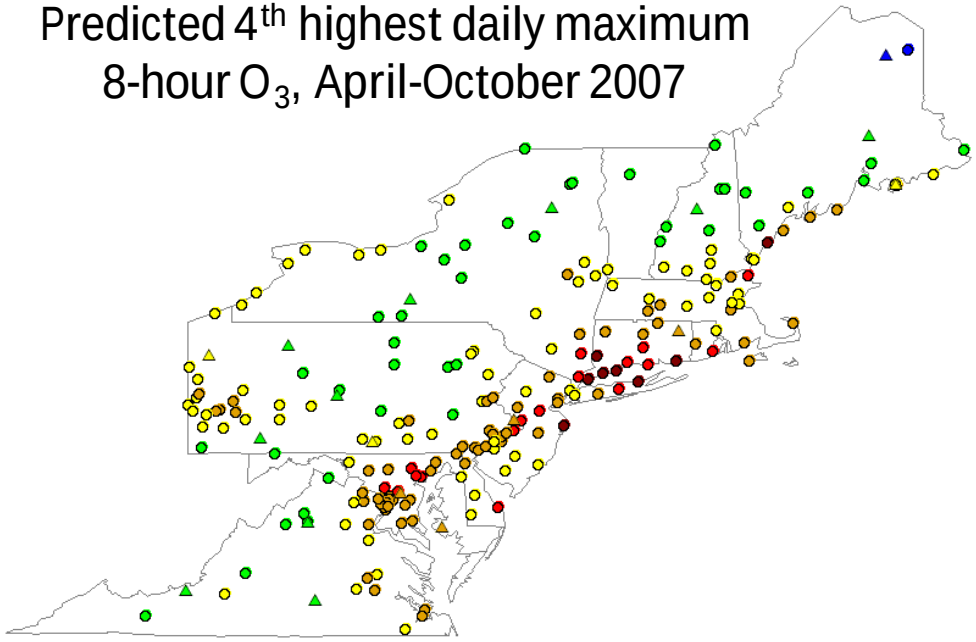
? < 60 ppb
? 60-75 ppb
? 75-90 ppb
? 90-105 ppb
? 105-120 ppb
? > 120 ppb

Observed 4th highest daily maximum 8-hour O_3, April-October 2007

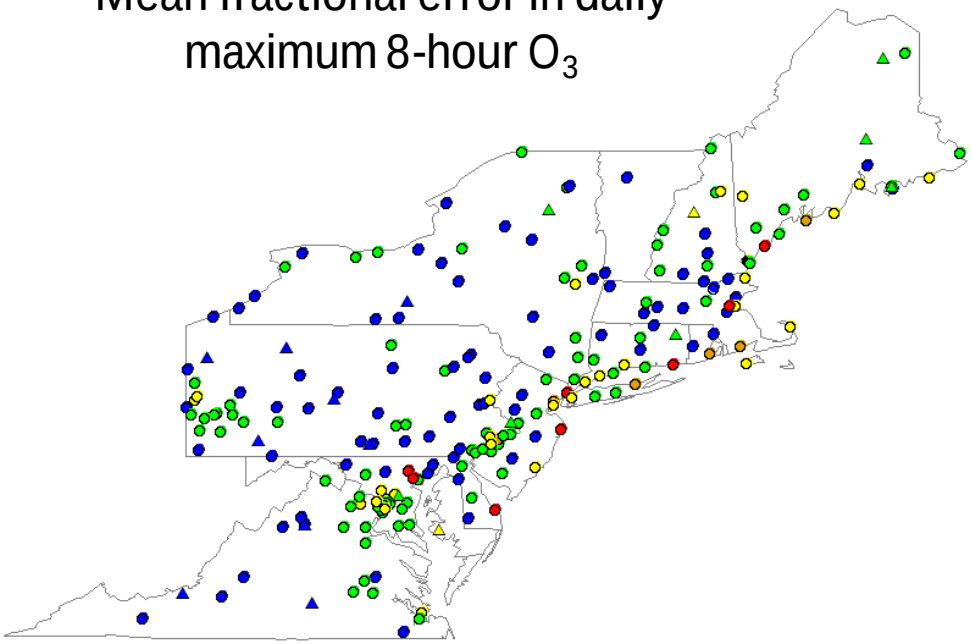


? < 60 ppb
? 60-75 ppb
? 75-90 ppb
? 90-105 ppb
? 105-120 ppb
? > 120 ppb

Predicted 4th highest daily maximum 8-hour O_3, April-October 2007



Mean fractional error in daily maximum 8-hour O_3

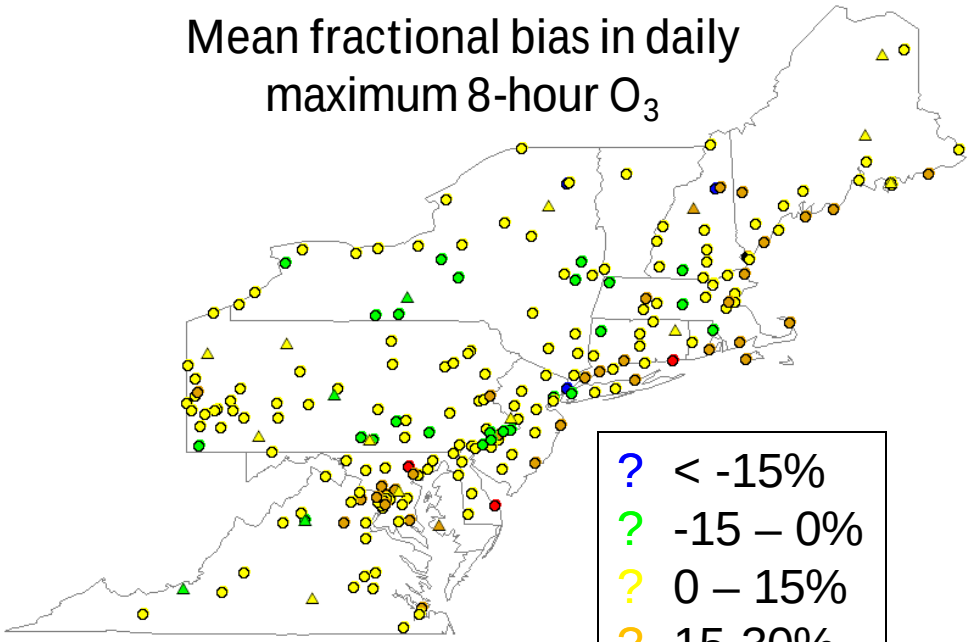


? < 15%
? 15-20%
? 20-25%
? 25-30%
? >30%

Largest errors tend to occur along the coast and downwind of some urban areas (e.g. DC/Baltimore)

Most sites have MFE<20% and MFB between ?15%

Mean fractional bias in daily maximum 8-hour O_3



? < -15%
? -15 – 0%
? 0 – 15%
? 15-30%
? > 30%

Summary

- CMAQ performed well in capturing the observed diurnal and temporal pattern
- Less error in daytime than nighttime that may due to excessive vertical mixing in the night time
- CMAQ performed better with rural monitors (CASTNet) than urban monitors (AQS)

Level 3 Modeling											
	2007					2020 Base Adjustments for NOX and VOC					
	OTR incl VA	LADCO	SEMAP excl VA	CENRAP	CANADA	OTR incl VA		Non-OTR excl VA		CANADA	
	All Pollutants	All Pollutants	All Pollutants	All Pollutants	All Pollutants	NOX	VOC	NOX	VOC	NOX	VOC
Mobile	MOVES 2007 Ver. 2	NY&VA Converted LADCO 07 /08 default inputs MOVES inventory run. Gasoline PM	SEMAP 2007	EPA 2007 national MOVES inventory run, Gasoline PM emissions temperature-adjusted	OME 2005 (Canadian MOBILE6 Activity and Input Data)	MARAMA 2020 Ver. 2 (Draft)		Proxy from 2007**		Proxy from OME 2005 **	
								64%	60%	64%	60%
EGU	MARAMA 2007 Ver. 3	LADCO 2007 (converted)	SEMAP 2007	NEI 2008 v2	OME 2005	Proxy from 2007		Proxy from 2007		Proxy from OME 2005	
						State by state *	Incr. 24%	35%	Incr. 24%	35%	Incr. 24%
Other Point	MARAMA 2007 Ver. 3	LADCO 2007 (converted)	SEMAP 2007	NEI 2008 v2	OME 2005	MARAMA 2020 Ver. 3		Proxy from 2007		Proxy from OME 2005	
								1%	Incr. 2%	1%	Incr. 2%
Cat 3 Marine - Offshore	EPA CHIEF 2008 platform	EPA CHIEF 2008 platform	EPA CHIEF 2008 platform	NA	EPA CHIEF 2008 platform	EPA CHIEF 2020		EPA CHIEF 2020		EPA CHIEF 2020	
MAR	MARAMA 2007 Ver. 3	LADCO 2007	SEMAP 2007	NEI 2008 v2	OME 2005	MARAMA 2020 Ver. 3		Proxy from 2007		Proxy from OME 2005	
								33%	12%	33%	12%
Nonroad	MARAMA 2007 Ver. 3	LADCO 2007	SEMAP 2007	NEI 2008 v2	OME 2005	MARAMA 2020 Ver. 3		Proxy from 2007		Proxy from OME 2005	
								49%	46%	49%	46%
Area	MARAMA 2007 Ver. 3	LADCO 2007	SEMAP 2007	NEI 2008 v2	OME 2005	MARAMA 2020 Ver. 3		Proxy from 2007		Proxy from OME 2005	
								7%	10%	7%	10%
Oil & gas	Not necessary	Not Necessary	Not Necessary	Not Necessary	Not necessary	Not included		Not included		Not included	
Anthropogenic Chlorine	EPA CHIEF 2008 platform	EPA CHIEF 2008 platform	EPA CHIEF 2008 platform	EPA CHIEF 2008	N/A	EPA CHIEF 2008		EPA CHIEF 2008		Not included	
Oceanic Chlorine	EPA CHIEF 2005	EPA CHIEF 2005	EPA CHIEF 2005	EPA CHIEF 2005	EPA CHIEF 2005	EPA CHIEF 2005		EPA CHIEF 2005		EPA CHIEF 2005	
Biogenic	MEGAN	MEGAN	MEGAN	MEGAN	MEGAN	MEGAN		MEGAN		MEGAN	

* EGU emission reductions for NOX and SO2 calculated by Andy Bodnarik. Based on CSAPR.

EGU emissions for VOC and PM2.5 based on percent change in OTR as follows:

VOC: Increases 24 %

PM2.5: Increases 5 %

** Based on Mike Ku calculations (email of 8/9/12 @ 1:49 PM), the mobile reductions achieved within the OTR between 2007 and 2020 will be applied to the 2007 emissions for other USA regions and Canadian mobile emissions as follows:

NOX: 64% (as indicated in the table above)

VOC: 60% (as indicated in the table above)

PM2.5: 51%

SO2: 30%