Summertime State-Level Source-Receptor Relationships between Nitrogen Oxides Emissions and Surface Ozone Concentrations over the Continental United States



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Research paper:

Tong, D.Q. and

Mauzerall, D.L., Summertime State-Level Source-Receptor Relationships between NO_x Emissions and Downwind Surface Ozone Concentrations over the Continental United States, *Environmental Science & Technology*, in press, 2008.

Key Questions

- What is influence of NO_x emissions from each state on O_3 concentrations in other states?
- How much surface O₃ in each state results from NO_x emissions from sources within its borders and from other states?

Objectives

- Establish source-receptor relationships between NO_x emissions and O₃ concentrations for all continental US states.
- Determine where the O₃ a states NO_x emissions create goes.
- Determine from which states NO_x the surface O_3 over a state comes from.
- Evaluate the efficacy of the Clean Air Interstate Rule (CAIR) for O₃.

Model Description

Model: Community Multiscale Air Quality (CMAQ) v.4.2 Meteorology: MM5

Domain: Continental United States

Resolution: 36x36 km², surface-15km, 12 vertical layers

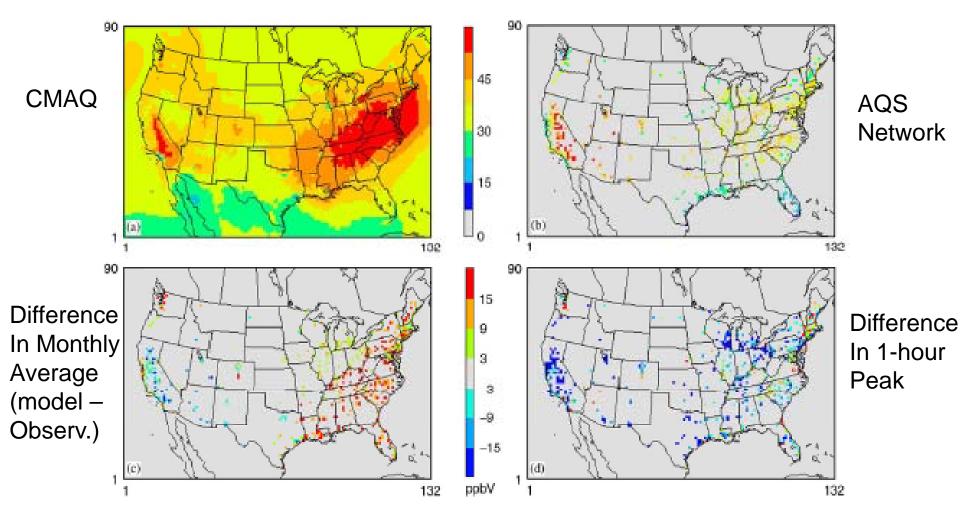
- Emissions: 1996 county level US EPA National Emissions Inventory (NEI)
- Boundary conditions for chemical constituents from global model MOZART-2 (*Horowitz et al.*, 2003)

Evaluated: Simulation results with over 1000 surface sites from AIRS and CASTNet and vertical O₃ sonde data (*Tong and Mauzerall*, 2006)

Simulation Design

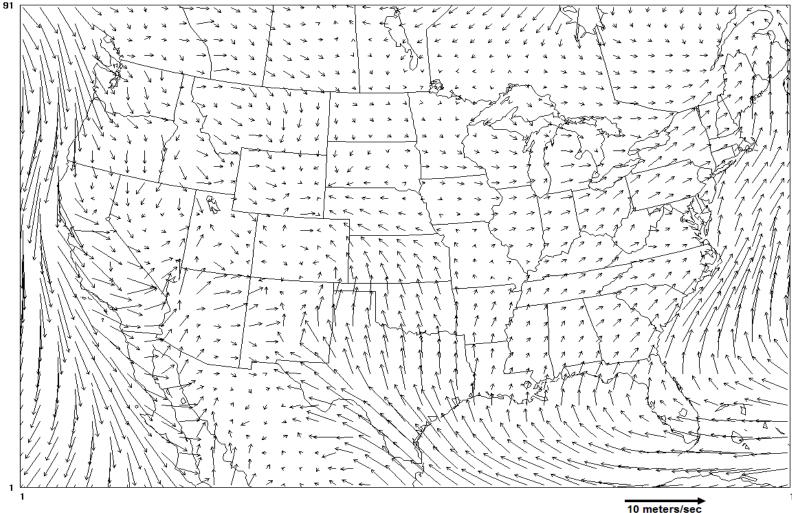
- Simulations conducted for July 1-31, 1996
- One base simulation and 48 perturbation simulations in which individual state NO_x emissions are removed.
- Difference between base and perturbation simulations used to quantify the change in surface O_3 across the domain resulting from a state's NO_x emissions.
- GIS used to establish changes within each state.
- State-level source-receptor matrices constructed.

Model Evaluation — Comparison of Simulated and Observed Monthly Average Surface Ozone Concentrations



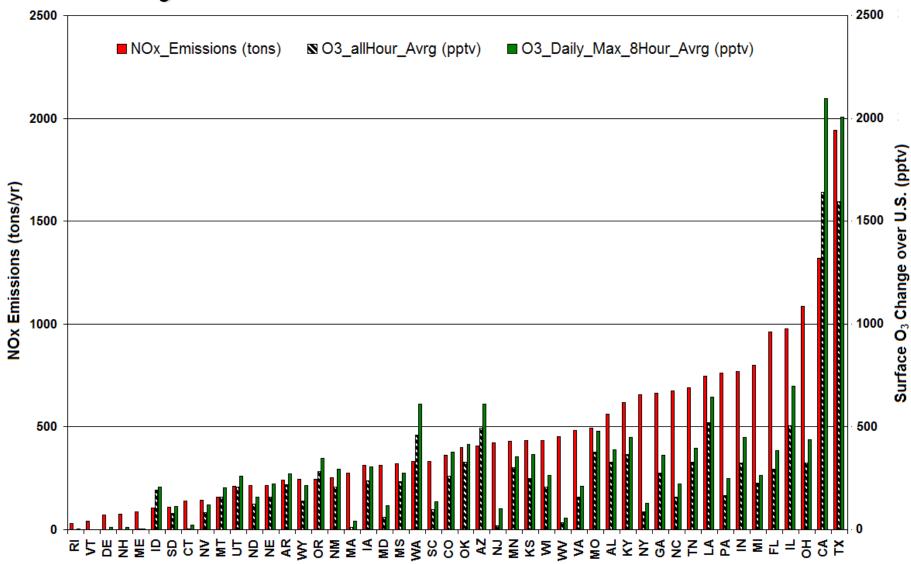
(Tong and Mauzerall, 2006)

Monthly mean surface winds in July 1996 (from MM5)

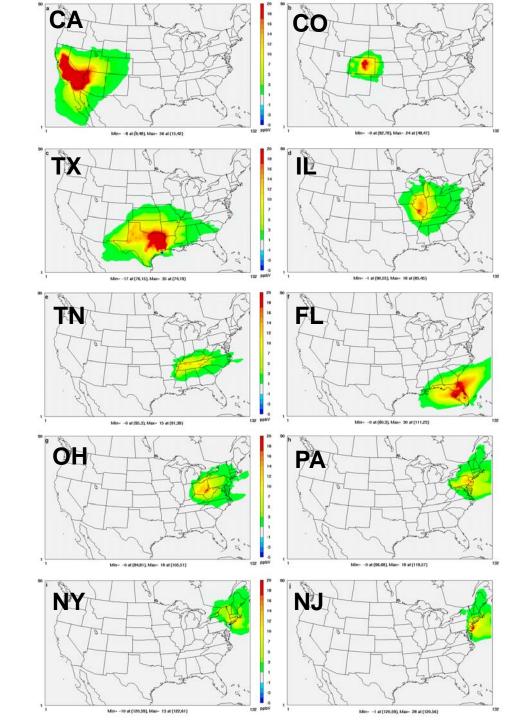


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Annual state-level NO_x emissions and resulting changes in monthly mean all-hour and peak 8-hour O_3 concentrations over the United States



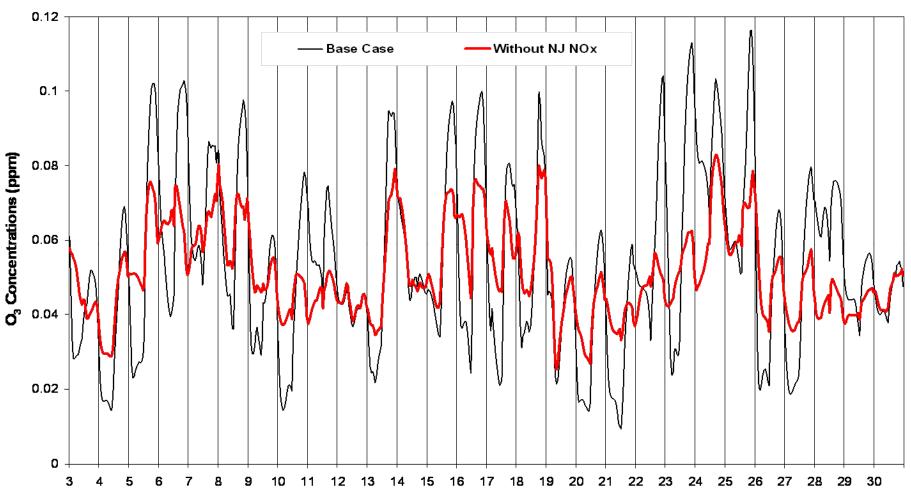
States



Changes in monthly mean maximum 8-hour average O_3 concentrations in July resulting from state NO_x emissions

Time series of surface O₃ concentrations at Trenton, NJ during the July 1996 simulations

Trenton, NJ



Days in July, 1996

Summer Source-Receptor Relationships between NO_x emissions from source states and changes in monthly mean maximum 8-hour average surface O_3 (ppbv) concentrations in receptor states

SRC AL AZ AR CA CO CT DE FL GA ID IL IN IA KS	KY LA ME MD MA MI MN MS MO MT NE NV NH NJ NM	I NY NC ND OH OK OR PA RI SC SD TN TX UT VT VA WA WV	WI WY
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Effect of California

NO_x emissions on downwind state's monthly mean maximum 8-hour average surface O_3 (ppbv) concentrations

S\F	AZ	CA	CO 🙀	ID IL IN IA KS K	Y LA ME MD MA	MI MN MS MO M1	NV 📊 NM		R PA RI SC SD TN	TX UT VT VA WA	WY
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PA RI	0.0 0.0 0.0		In private limit, the second se	The second s	A NUMBER OF AN OWNER AND ADDRESS OF A DESCRIPTION OF A DE		And start in the number of the second s	and the second			0.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
SC	0.0 0.0 0.0		Conception and Property and Pro	and the second		0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0	and the second se	and the second statement of the se	CONTRACTOR DESCRIPTION OF TAXABLE PROPERTY AND ADDRESS OF TAXABLE PROPERTY.	0.0 0.0 0.0
SD TN	0.0 0.0 0.0 1.4 0.0 0.8		.0 0.0 0.0 0.0 .0 0.0 0.0 1.1		the second s		0.9 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0		and the second se		0.0 0.0 0.0 1.1 0.0 0.0
TX	1.9 0.0 8.6 0.0 0.6 0.0		.0 0.0 0.1 1.1 .0 0.0 0.0 0.0				0.4 0.0 0.0 0.0 2.7 0.0 0.0 0.0 0.0 0.0 0.5 0.0		The second s	11.8 0.0 0.0 0.0 0.0 0.0 5.3 0.0 0.0 0.0	0.1 0.0 0.0
VT	0.0 0.0 0.0	0.0 0.0 0.	.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.	0 0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.1 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.4 0.0 0.0	the second se
VA	0.0 0.0 0.0		the second se	0.0 0.0 0.0 0.0 0.0 0. 2.6 0.0 0.0 0.0 0.0 0.			0.0 0.0 0.0 2.2 0.0 0.1 0.0 0.6 0.0 0.0 0.0 0.0			a second second second second bits and second se	1.3 0.0 0.0 0.0 0.0 0.6
WV	0.0 0.0 0.0	0.0 0.0 0.	.0 0.2 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.	0 0.0 0.0 1.4 0.0 0	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.1 0.0 0.1 0.0 0	0.4 0.0 0.0 0.0 0.0	0.0 0.0 0.0 1.2 0.0	3.3 0.0 0.0
WI	0.0 0.0 0.0	tion of the local division of the local divi	Name and the state of the second state of the	the state of the second s	the intervention interview or an interview of the stream of the	and the statement of the	0.0 0.0 0.0 0.0 0.0 0.7 0.9 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.1 0.6 0.0 0 0.0 0.0 0.0 0.0 0	the second sufficient and an end second s	interaction and providences and extended a start of the same	0.0 5.2 0.0 0.0 0.0 3.8

Effect of *Texas*

NO_x emissions on downwind state's monthly mean maximum 8-hour average surface O_3 (ppbv) concentrations

S\R	AL	AR	GA	KS K	(Y LA	MS MO	NM OK	SC TN		wv wi wy
AL AZ AR CA CO	9.4 0.0 0. 0.0 10.4 0. 0.5 0.0 5. 0.0 8.5 0. 0.0 0.0 0.	0 0.1 0.5 2 0.0 0.0 0 22.0 2.1 0 0.0 7.4	0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.3 0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0	.0 0.0 0.0 0.0 0.1 0. .0 0.5 0.2 0.0 0.1 1. .3 0.0 0.0 0.0 0.0 0. .0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0 0 0.7 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0	.0 0.0 0.0 0.0 0.3 7.3 0.0 0.0 1.4 .0 0.0 0.0 0.0 1.2 0.0 0.0 0.0 0.6	0.0 0.0 0.0 0.1 0 0.0 0.1 0.0 0.0 0.4 0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.2 0	0 0.0 0.0 0.2 0.0 2.8 1 0.0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 1.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5.9 0.0 0.0 0.0 0.0 0.1 0.1 0.0 0.0 0.0 0.0	and the second se
CT DE FL GA			0.0 4.0 0.0 0.0 0 0.0 0.0 0.0 13.1 4.0 0	.0 0.0 0.0 0.0 0.0 0 .	0 0.0 0.0 0.4 0.0 0 0 0.3 0.0 0.0 0.0 0	0 0.0 0.0 0.0 0.0 0.0 1.1 0.0 0.0 0 0.0	0.0 0.0 0.0 0.0 0.0 0 0.0 0.2 0.0 0.0 0.0 0 0.0 2.7 0.0 0.0 0.0 0	0 0.0 4.2 0.0 0.0 0.0 0 0.1 0.0 0.0 0.0 0.0 0 0.0 0.0 1.7 0.0 0.0 0 0.0 0.0 7.2 0.0 1.4 4 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
IL IN IA KS KY		0 0.0 0.0 2 0.0 0.0 4 0.0 0.4	0.0 0.1 0.0 0.2 0 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0 0	.0 2.1 9.7 0.0 0.0 4. .0 2.3 1.0 5.5 0.3 0.	1 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0	3 0.3 0.7 3.1 0.0 0.0 0.0 0.1 0.0 5 0.0 0.1 0.3 0.0 0.0 0.0 0.1 0.3 0.0 1 1.0 0.0 1.7 0.0 0.6 0.0 0.1 0.3 0.0 0 0.1 0.2 0.0 0.6 0.0 0.1 0.0	0.9 0.8 0.0 4.4 0.0 0 0.0 0.0 0.0 0.4 0.0 0 0.0 0.0 0.0 0.4 0.0 0	0 1.2 0.0 0.0 0.0 2.4 0 1.5 0.0 0.3 0.0 1.5 0 0.0 0.0 0.0 0.4 1.5 0 0.0 0.0 0.0 0.4 0.1 0 0.0 0.0 0.0 0.4 0.1 0 0.0 0.0 0.0 0.4 0.1 0 1.5 0.0 0.8 0.0 3.1	0.0 0.0 0.5 1.7 0.0	2.0 1.8 0.0 2.6 0.0 0.0 0.0. 1.6 0.0 0.0 0.0 0.0 4.8 0.0 0.0
LA ME MD MA	0.0 0.0 0.	0 0.0 0.0 0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 1.3 9.9 0.0 0.0 0 1.1 0.0 0.0 0.0 0	.0 0.0	0 0.0 0.4 0.0 0.0 0 0 0.0 0.0 10.0 1.1 0 0 0.0 2.4 0.0 1.8 0	.0 0.0	0.0 0.0 0.0 0.0 0.0 0 0.2 0.3 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0.0 0 0	0 0.0 0.0 1.1 0.0 1.3 0 0.0 0.0 0.0 0.0 0.0 0 1.8 1.5 0.0 0.0 0.0 0.0 0 0.0 1.4 0.0 0.0 0.0 0.0 0 0.0 1.4 0.0 0.0 0.0 0.0 0 1.5 0.1 0.0 0.0 0.1 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1 1.5 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.4 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1 0.0 0.0 0.0 1 1.1 1.0 0.0
MN MS MO MT	0.0 0.0 0. 3.0 0.0 0. 0.5 0.0 2. 0.0 0.0 0. 0.0 0.0 0.	5 0.0 0.0 2 0.0 0.0 0 0.0 0.0	0.0 0.0 0.3 1.4 0 0.0 0.0 0.0 0.0 0	0 0.0	4 2.0 0.0 0.0 0.0 0	.0 0.1 0.9 7.0 0.0 0.5 0.0 0.0 0.0 0.0	0.0 0.2 0.0 0.0 0.0 0 0.0 0.1 0.0 0.7 0.4 0 0.0 0.0 0.2 0.0 0.0 0	0 0.0 0.0 0.7 0.0 0 0.0 0.0 0.9 0.0 1.8 0 0.1 0.0 0.0 0.0 1.8 0 0.1 0.0 0.0 0.0 1.8 0 0.0 0.0 0.0 0.0 1.8 0 0.0 0.0 0.0 0.0 1.8 0 0.0 0.0 0.0 0.0 1.3	0.0 0.0 0.0 0.1 0.0	0.0 3.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.1 0.0 0.0 0.0 0.1
NV NH NJ NM	and the second s	0 0.0 0.0 0 0.0 0.0	0.0 0.0 0.0 0.0 0 4.8 3.9 0.0 0.0 0	0 0.0	0 0.0 0.7 0.0 0.0 0 0 0.0 1.5 0.5 3.0 0 0 0.0 0.0 0.0 0.0 0	0 0.0 0.0 0.0 0.0 2.1 0.0 0.0 0.0 0 0.0	0.0 0.0 0.0 0.0 0.0 0 1.3 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0.0 0.0 0 0	0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0 0 0.4 4.4 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.1 0.0 0.0 0.0 0.0 1.7 0.0 0.0 0.4 0.1 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
NC ND OH OK	0.0 0.0 0. 0.1 0.0 1.	0 0.0 0.0 0 0.0 0.0 8 0.0 0.2	0.0 0.0 0.0 0.0 0.0 0 1.6 1.9 0.0 0.0 0 2 0.0 0.0 0.0 0	0 0.0 0.0 0.3 0.0 0. .0 0.0 0.8 0.0 0.0 2. .0 0.0 0.0 0.1 3.5 0.	0 0.0 0.0 0.0 0.0 0 0 0.0 0.3 3.0 1.3 0 1 0.0 0.0 0.0 0.0 0	0 0.0 0.0 0.0 0.0 0.0 0.0 0.4 0.0 0 0.7 0.0 0.0 0.1 0.5 0.0	0.0 0.0 3.1 0.0 0.0 0 2.0 1.2 0.0 8.8 0.0 0 0.0 0.0 0.0 0.0 7.7 0	0 0.0 0.0 0.0 1.7 0.0 0 5.0 1.1 0.5 0.0 0.2 0 0.0 0.0 0.0 0.0 0.2	0.0 0.0 1.2 3.0 0.0 0.4 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 7.8 0.0 0.0 0.0 0.0 0.0
PA Ri SC	0.0 0.0 0. 0.0 0.0 0. 0.0 0.0 0.	0 0.0 0.0	0.1 0.0 0.0 0.0 0	.0 0.0 0.0 0.0 0.0 0.	0 0.0 0.2 0.0 0.5 0 0 0.0 0.0 0.0 0.0 0 .0 0	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.0 0.0 0.0 0.0 0.0		0.0 0.0 0.0 0.1 0.0	0.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1 0.0 0.0 0.1 0.0 0.0 1 0.0 0.0
	1.9 8	B.6 0 0.0 0.0 0 0.0 0.0 0 0.7 0.0	0.0 0.0 0.0 0.0 0.0 0 1.2 5.1 0.0 0.0 0	.0 0.0 0.0 0.0 0.0 0.0 .0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0 0.0 0.0 0.0 0.0 0 0 0.0 0.0 0.0 0	0 0.0 4 0 0.0 2.7 0 0.0 2.7 0 0.0 0.0 0.0 0.0 0.0 0.0 2.7 0 0.0 0.0 0.0 0.0 0.0 0.0 2.7 0 0.0 <th>0.0 0.0 0.0 0.0 0.0 0</th> <th></th> <th>0.0 0.0</th> <th>0.1 0.0 0.0 0.0 0.0 0.6 0.0 0.0 0.0 1.3 0.0 0.0 0.0 0.0 0.0</th>	0.0 0.0 0.0 0.0 0.0 0		0.0 0.0	0.1 0.0 0.0 0.0 0.0 0.6 0.0 0.0 0.0 1.3 0.0 0.0 0.0 0.0 0.0
WV WI	0.0 0.0 0. 0.0 0.0 0. 0.0 0.0 0. 0.0 0.0 0.	0 0.0 0.0 0 0.0 0.0	0.0 0.2 0.0 0.0 0 0.0 0.0 0.0 0.0 0	.0 0.0	0 0.0 0.0 1.4 0.0 0	0 0.0	0.0 0.1 0.0 0.1 0.0 0 0.7 0.0 0.1 0.6 0.0 0	0 0.4 0.0 0.0 0.0 0.0 0 0.2 0.0 0.0 0.1 0.0 0 0.0 0.0 0.0 0.4 0.0	0.0 0.0 0.0 1.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.3 0.0 0.0 0.0 5.2 0.0 0.0 0.0 3.8

Effect of Upwind State's NO_x emissions on monthly mean maximum 8-hour average surface O_3 concentrations (ppbv) in New Jersey

S/R		
	AR CA CQ CT DE FL GA ID IL IN IA KS KY LA ME MD MA MI MN MS MO MT NE NV 0.0	NY NC ND OH OK OR PA RI SC SD TN TX UT VA WA WV WI WY 0.0 1.5 0.0 0.0 0.0 0.0 2.9 0.0 2.3 0.0 0.0 0.2 0.0
	5.2 0.0 0.0 0.0 0.0 0.0 0.3 0.0 0.5 0.2 0.0 1.1 0.0 0.0 0.0 0.0 1.5 0.0 <th>0.0 0.1 0.0 0.4 0.0 0.0 0.2 0.0 2.9 0.0</th>	0.0 0.1 0.0 0.4 0.0 0.0 0.2 0.0 2.9 0.0
DE	0.0 0.0 7.4 0.0 0.0 0.0 0.0 0.0 0.0 1.2 0.0 0	0.0 0.0
	0.5 0.0 0.0 0.0 0.0 0.2 0.0 11.0 5.9 1.9 0.0 3.6 0.0 0.4 0.0 2.3 0.3 0.7 3.1 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.0 0.2 0.0 11.0 5.9 1.9 0.0 3.6 0.0 0.4 0.0 2.3 0.3 0.7 3.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.2 0.0 2.1 9.7 0.0 0.0 0.4 0.0 0.1 1.0 0.0	0.8 0.3 0.0 2.5 0.0 0.0 1.2 0.0 0.0 0.2 4 0.0 0.0 1.1 0.0 2.0 1.8 0.0 0.9 0.8 0.0 4.4 0.0 0.0 1.5 0.0 0.3 0.0 1.5 0.0 0.0 1.5 0.0 0.0 1.5 0.0 0.0 0.1 0.5 1.7 0.0 2.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.0
MD	2.8 0.0 0.0 0.0 0.9 2.1 0.0 0.2 0.0 0.0 0.1 16.4 0.0	0.0 0.1 0.0 0.0 0.0 0.0 1.1 0.0 1.2 0.4 0.0
	1 0.0 0.0 0.0 0.0 0.0 1.2 0.8 2.7 0.1 0.0 0.0 0.0 1.3 4.8 0.0 0.3 0.0 0.2 0.0 0.5 0.0 0.0 0.0 0.3 1.4 0.0 0.0 0.0 0.0 0.0 0.0 1.3 4.8 0.0 0.3 0.0 0.2 0.0 0.5 0.0 0.0 0.0 0.0 1.4 0.0	0.0 0.0 0.8 0.2 0.0 0.0 0.0 0.0 0.7 0.0
NJ	0.0 0.1 0.0 0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0
NY	0.0 0.0 0.1 1.1 0.0 0.3 0.0 0	0.0 8.7 0.0 0.0 0.0 0.0 0.4 2.1 0.0 0.4 0.0 0.0 0.0 3.1 0.0 0.1 0.0 0.0 0.0 0.3 1 0.0 0.0 0.0 0.0 0.0 1.7 0.0 0.0 0.0 3.1 0.0 0.1 0.0 0.0 0.0 0.0 3.1 0.0 0.0 0.0 0.0 1.7 0.0
OH	1 0.0 0.0 3.5 6.4 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.4 4.6 2.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.4 4.6 2.8 0.0	2.6 0.2 0.0 2.0 0.0 6.0 3.2 0.0 0.0 0.0 0.0 0.0 0.0 1.3 0.0 0.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.3 0.0 0.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.4 0.0
PA	0.8 0.0 0.0 0.0 0.0 0.1 1.0 0.3 0.5 0.0 0.2 0.1 0.0 0.3 0.5 0.0 0.0 0.4 0 0.0 0.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.0 0.3 0.5 0.0 0.0 0.1 0.0	0.0 2.6 0.0 0.4 0.0 0.0 0.0 1.7 0.0 8.7 0.0 0.0 0.0 0.1 1.0.0 0.0 0.0 0.2 0.0 0.4 0.0 0.0 0.0 1.7 0.0 8.7 0.0 0.0 0.0 0.0 1.1 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.1 1.0 0.2 1.1 0.0 0.1 0.0
VA		0.0 0.0 0.0 0.0 5.9 0.0
WY 0.0 0	1.0 0.0 0.0 1.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

Maximum contribution of a source state's NO_x to monthly mean peak 8-hour O_3 concentrations within a single grid cell over each receptor state (ppbv)

								9																															· .	
SRC/RCP	AL	AZ A	AR CA	со	ст	DE	FL GA	ID	IL	IN	IA	KS	KΥ	LA	ME		IA	мі і	NN I	MS I	ио мт	NE	NV	NH	NJ	NM N	Y N	ND	оно	< OF	PA	RI S	cs	DT	тх и	UT	VT VA	WA	wv	NI WY
AL	27.4	0.0	0.0 0.0	0.0	0.0	0.0	11.4 14.3	8 0.0	0.0	0.0	0.0	0.0	2.1	2.9	0.0	0.0	.0	0.0	0.0 1	1.3	0.0 0.0	0.0	0.0	0.0	0.0	0.0 <mark>0</mark> .	.0 5.	1 0.0	0.0 0.	0.0	0.0	0.0 3	.9 0.	.0 8.6	0.0	0.0	0.0 1.9	0.0	0.0	0.0 0.0
AZ	0.0	42.1	0.0 10.	5 3.4	0.0	0.0	0.0 0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0 0.0	0.0	10.5	0.0	0.0 1	5.2 0 .	. 0 0.	0.0	0.0 1.	6 0.0	0.0	0.0 0	.0 0.	.0 0.0	3.2	12.4	0.0 0.0	0.0	0.0	0.0 0.0
AR	3.0	0.0 1	2.7 0.0	0.0	0.0	0.0	0.0 1.8	0.0	3.9	1.6	0.0	1.2	4.9	6.8	0.0	0.0	.0	0.0	0.0 1	1.8	9.8 0.0	0.0	0.0	0.0	0.0	0.0 <mark>0</mark> .	.0 1.	0.0	0.0 5.	5 0.0	0.0	0.0 1	.2 0.	.0 12.	7 3.9	0.0	0.0 1.0	0.0	0.0	0.0 0.0
			0.0 54.	2 4.1	0.0	0.0	0.0 0.0			-							_			_					_								.0 0.				0.0 0.0	0.0	0.0	0.0 2.6
		2.2 (24.3	0.0				0.0			8.8				0.0					0.0 0.0								0.0 4.				.0 1.			3.6	0.0 0.0	0.0		0.0 10.7
			0.0 0.0				0.0 0.0		0.0	_											0.0 0.0			-					0.0 0.				_			-	1.7 0.0			0.0 0.0
DE	0.0		0.0 0.0				0.0 0.0		0.0				0.0								0.0 0.0				13.7 (0.0	0.0 0.				_		0.0		0.0 1.0			0.0 0.0
							30.2 15.6	_		-	-							_				_		-					0.0 0.	_			_				0.0 0.0		0.0	0.0 0.0
GA ID		0.0	0.0 0.0		0.0		5.7 25.5 0.0 0.0		0.0	_		0.0		0.0		_	_	_		_	0.0 0.0	_			0.0				0.0 0.			0.0 17 0.0 0			6 0.0		0.0 1.9 0.0 0.0		0.0	0.0 0.0
			4.0 0.0	_			0.0 1.9														8.4 0.0																0.0 2.4		2.5 9	3.5 0.0
IN			+.0 0.0 0.8 0.0				0.0 1.6														2.0 0.0															-	1.0 3.9			2.9 0.0
							0.0 0.0														6.5 0.0															-	0.0 0.0			
KS							0.0 0.0														2.0 0.0															-	0.0 0.0			
KY		0.0					0.0 2.5	_			0.0						_	_			8.0 0.0	_								_		0.0 2	_	.0 8.3		0.0	0.0 8.3			0.0 0.0
LA	9.7	0.0 1	6.5 0.0	0.0	0.0	0.0	6.0 3.3	0.0	1.3	0.9	0.0										1.8 0.0								0.0 1.			0.0 1	.7 0.	.0 3.8	20.9	0.0	0.0 0.0	0.0	0.0 (0.0 0.0
ME	0.0	0.0	0.0 0.0	0.0	0.0	0.0	0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	.0	0.0	0.0	0.0	0.0 0.0	0.0	0.0	1.0	0.0 (0.0 0 .	. 0 0.	0.0	0.0 0.	0.0	0.0	0.0 0	.0 0.	.0 0.0	0.0	0.0	0.0 0.0	0.0	0.0	0.0 0.0
MD	0.0	0.0	0.0 0.0	0.0	1.8	14.9	0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	34.1 1	.8	0.0	0.0	0.0	0.0 0.0	0.0	0.0	1.3	14.9 (0.0 <mark>2</mark> .	.4 4.	1 0.0	0.0 0.	0.0	13.6	1.8 0	.0 0.	.0 0 .0	0.0	0.0	0.9 12.9	0.0	7.8 (0.0 0.0
MA	0.0	0.0	0.0 0.0	0.0	3.1	0.0	0.0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	.9	0.0	0.0	0.0	0.0 0.0	0.0	0.0	4.3	0.0	0.0 1.	.2 0.	0.0	0.0 0.	0.0	0.0	2.7 0	.0 0.	.0 0.0	0.0	0.0	3.0 0.0	0.0	0.0	0.0 0.0
MI		0.0	0.0 0.0	0.0	1.6	1.0	0.0 0.0		2.4			0.0									0.0 0.0												.0 0.		0.0		2.0 1.5	0.0	2.3 6	6.2 0.0
																																	_				0.0 0.0			1.6 0.0
			6.3 0.0				4.7 2.2		1.2		-	0.0		11.5							2.2 0.0				0.0			5 0.0				0.0 1	_		0.0		0.0 0.0			0.0 0.0
MO			7.3 0.0				0.0 1.2														3.3 0.0				0.0				1.7 7.				_			-	0.0 1.3		1.2 1	1.2 0.0
MT	0.0	0.0 () 4.9		0.0		_	0.0			0.0								_	0.0 10.2 7.6 0.0											0.0 0		.8 0.0		0.0	0.0 0.0	0.0	0.0	0.0 0.6
NE NV	0.0	9.5 (0.0																															0.0 0.0	0.0		
NH							0.0 0.0														0.0 0.0																1.3 0.0			0.0 0.0
NJ																																					3.1 2.0			
NM			0.0 0.0				0.0 0.0														0.0 0.0																0.0 0.0			
NY						_										_	_			_					_								_				6.7 0.0			
NC			0.0 0.0				0.0 2.4														0.0 0.0								0.0 0.								0.0 14.4			0.0 0.0
ND	0.0	0.0	0.0 0.0	0.0	0.0	0.0	0.0 0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	.0	0.0	4.2	0.0	0.0 2.3	1.5	0.0	0.0	0.0 (0.0 0 .	. 0 0.	0 7.1	0.0 0.	0.0	0.0	0.0 0	.0 4.	.5 0.0	0.0	0.0	0.0 0.0	0.0	0.0	0.0 0.0
OH	0.0	0.0	0.0 0.0	0.0	2.2	2.5	0.0 0.0	0.0	0.0	7.2	0.0	0.0	11.1	0.0	1.1	9.0 2	2.0	6.3 (0.0	0.0	0.0 0.0	0.0	0.0	1.6	3.0 (0.0 <mark>6</mark> .	.1 2.	6 0.0	17.5 0.	0.0	14.4	1.6 1	.2 0.	.0 2.2	2 0.0	0.0	1.7 7.3	0.0	17.5 (0.0 0.0
OK	1.1						0.0 0.0			_						_	_	_		_	9.2 0.0	_			_			_		_			_				0.0 0.0	0.0	0.0	0.0 0.0
							0.0 0.0														0.0 1.6																0.0 0.0	12.9	0.0	0.0 0.8
PA							0.0 0.0														0.0 0.0								2.6 0.							-	3.3 5.8			0.0 0.0
RI							0.0 0.0		0.0	-											0.0 0.0								0.0 0.			5.0 0	_				0.0 0.0			0.0 0.0
SC			0.0 0.0				0.0 8.2			_							_			_	0.0 0.0	_							0.0 0.				_			-	0.0 1.3			0.0 0.0
SD	0.0	0.0 (2.1 0.0			0.0			0.0	-							_			_	0.0 1.3								0.0 0.							0.0		0.0		0.0 1.6
TN TX	3.1	13 2	16 0.0	0.0			0.0 11.1 1.6 1.9																									0.0 3					0.0 9.3	0.0		
							0.0 0.0														0.0 0.0																0.0 0.0			
VT			_				0.0 0.0															_											_			0.0				0.0 0.0
VA			0.0 0.0			_	0.0 0.0		0.0	-											0.0 0.0								0.0 0.						_	0.0				0.0 0.0
WA			0.0 4.1				0.0 0.0									_	_	_	_	_	0.0 4.3	_			_					_			_				0.0 0.0			0.0 1.3
WV			0.0 0.0				0.0 0.0		0.0			0.0									0.0 0.0								3.6 0.							0.0		0.0		0.0 0.0
																																					0.0 0.0			0.9 0.0
WY	0.0	0.0	0.0 0.0	9.6	0.0	0.0	0.0 0.0	1.2	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 4.1	9.6	0.0	0.0	0.0	0.0 <mark>0</mark> .	.0 0.) 1.1	0.0 0.	0.0	0.0	0.0 0	.0 4.	.2 0.0	0.0	4.4	0.0 0.0	0.0	0.0	0.0 12.3
										_				_					_	_		_	_							_				_		_				_

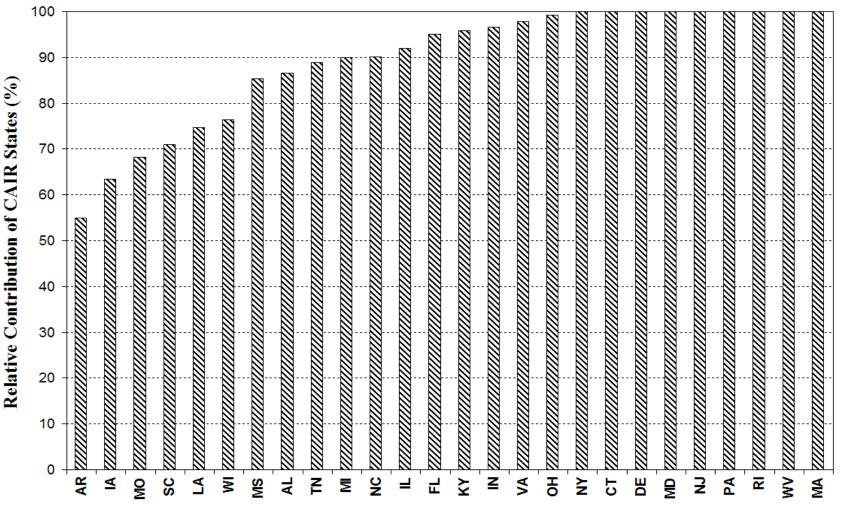
Maximum contribution of New Jersey's NO_x to monthly mean peak 8-hour O_3 concentrations within a single grid cell over each receptor state (ppbv)

	1		- 1			- 1			$\mathbf{\nabla}$		1	1	1		-		- ,										_		•		•	1	1					ור								1	
SRC/RCF	AL	AZ	AR	CA	С С	11	DE	;A	ID	IL	IN	IA	KS	KY			= 1	VIL		VI A		vis	мо	ИТ	NE	NV	N	N,	J	N	r NO		0	H OK	OF	P	AI	۲I	SD	TN	ТΧ	UT	VT	VA	WA	NV	WI WY
AL	-	-	_				_	-																																					_		0.0 0.0
AZ		42.1					_	0.0																								_	_	0 1.6											0.0		0.0 0.0
AR	-	0.0 1			.0 0.	-	_	0 1.8		3.9	-				-	_	_	_	_		_	_		_				-	0.0	_	0 1.0	_	_	0 5.5	-				0.0				0.0		0.0		0.0 0.0
CA CO		37.3	0.0		.1 0.0		0 0.	0.0	2.0	0.0	0.0	0.0	0.8	0.0	0.0	_	_	0.0			_	_	0.0	_					_	_	0.0		0.	0 1.0	2.2	0.0		0.0	0.9	0.0	0.9	18.7	0.0	0.0	0.0		0.0 2.6
CT			0.0	0.0 2	4.3 U.	1 0.0	0 0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				_	0 0			0.0	_					0.0	_	4 0.0	0.0	0	0 0.0	0.0			0.0	0.0	0.0	2.4	0.0	17	0.0	0.0		0.0 0.0
DE	-		0.0		.0 0.	_	7 0.		_		0.0	_			0.0	_	_	0.0	_	0 0		_	0.0	_				-	0.0	_	0.0	_	_				0.0		0.0			0.0	0.0	1.0	0.0		0.0 0.0
FL					.0 0.	_	_	2 15.6		0.0	-	-	-	0.0		_	-	0.0	_				0.0										_	0 0.0										0.0	0.0		0.0 0.0
GA	11.5	i 0.0	0.0	0.0	. 0 0.	0.0	0 5.	7 25.5	5 0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0) 0.	00	.0 (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	D 7.'	1 0.0) 0.	0.0	0.0	0.0	0.0	17.4	0.0	10.6	0.0	0.0	0.0	1.9	0.0	0.0	0.0 0.0
ID		0.0	0.0	0.0 1	.3 0.		0 0.	0.0		8 0.0													0.0	_							0.0) 0.			0.0		0.0	0.0		0.0	6.0	0.0	0.0	6.8		0.0 3.2
<u>IL</u>			4.0		.0 0.	_	_			18.4	-	-			2 0.0	_		0.0					8.4	_			0.0	-	-	_	0 1.9	_	_	6 0.0		2.2			0.0			0.0			0.0		B.5 0.0
IN IA	-	-		0.0	.0 0.		_	0 1.6 0 0.0		13.0 8.2		5 0.0 9.0	-	12.4				0.0					2.0 6.5				0.9	-		_	0 3.0	_	_	.3 0.0		2.6		1.5				0.0	1.0		_		2.9 0.0 6.2 0.0
KS	-	0.0	2.0		.3 0.		_	0.0	_	0.2 1.1	-	-		0.0														-		_	0.0	_	_	0 1.0			-	0.0				0.0			_		0.0 0.0
KY	2.0	0.0	2.8	0.0 0	.0 0.	0 1.0	0 0.	0 2.5	0.0	10.0	12.8	3 0.0	-		-		_	-	_		_	_		_					-				_	.4 0.0		-				8.3	0.0	0.0	0.0	8.3			0.0 0.0
LA	9.7	0.0 1	6.5	0.0	.0 0.	0.0	0 6.	0 3.3	0.0	1.3	0.9	0.0			27.				_				1.8	_					0.0	_				0 1.6					0.0	3.5	20.9	0.0	0.0	0.0	0.0	0.0	0.0 0.0
ME	0.0	0.0	0.0	0.0	. 0 0.	0.0	0 0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0) 3.2	0.0	0.0) 0.	00	.0 (0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0) 0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0
MD	_	0.0	_		.0 1.3	_	_		_			0.0		_	0.0	_	-	_	_			_	0.0						0.0	_	4 4.1	_	_	0.0		13.6			0.0					12.9	0.0		0.0 0.0
MA	0.0	0.0	0.0	0.0	.0 3.1	1 0.0	0 0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0				_	_	0.0	_					0.0	1.2	2 0.0	0.0) 0.	0 0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0		0.0 0.0
MI	0.0	0.0	0.0	0.0 0	.0 1.		0 0.	0.0	0.0	2.4	5.1	0.0 7.8	0.0	1.3	0.0	0 1.3		2.0									1.9			6.8	5 0.9 0 0.0		9.	5 0.0	0.0	6.5	1.1	0.0	0.0 5.2	1.0	0.0	0.0	2.0	1.5	0.0		6.2 0.0 1.6 0.0
MS			6.3		0 0.				_	2.7 1.2	-			_		0.0	-	_	_	.8 11 .0 0	_	_					0.0	_	0.0		0.0		_	0 0.0 0 0.0		0.0	0.0		0.0	0.0 8.6		0.0		0.0	0.0		0.0 0.0
MO	-				.0 0.			0 1.2		13.3	-	-	-	7 10.4		_	_	0.0			_	2.5 1					0.0	-	0.0		0 1.0	_	_	7 7.4		1.0			1.1		0.9	0.0		1.3	0.0		1.2 0.0
MT	0.0	-	0.0	0.0	.0 0.		_		_	0.0		-	0.0	_	0.0	_	0.0	0.0		0 0		0.0		0.2	1.6	0.0		-		_	0.0	_	_			0.0			2.8	0.0	0.0	0.0	0.0	0.0	0.0		0.0 6.6
NE	0.0	0.0	0.8	0.0 4	.9 0.	0.0	0 0.	0.0	0.0	0.0	0.0	8.2	6.5	0.0	0.0	0.0	0.	0.0) 0.	.0 2	.1 (0.0	7.6	0.0	9.4	0.0	0.0	0.0	0.0	0.0	0.0) 1.2	2 0.	0 0.9	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 2.7
NV	-	-			_	0.0	0 0.	0 0.0	0.0			-	-	0.0	0.0	0.0	0.0	0.0) 0.	00		0.0		_			0.0	0.0	0.0		0.0		_	0.0		0.0	0.0	0.0	0.0		0.0				0.0		0.0 0.0
	_		0.0			-			.0			0.0								-	_	0.0			0.0					-	0.0	_	_	0 0.0			_								0.0		0.0 0.0
NJ		0.0 8.6		0.0 1	9	./	15	5.3	.0	0.0	0.0			0.0	-	2.8	34	.5	6	.0			0.0		0.0		2	28.	1	12.	6 1.0	0.0		0 0.0		16	.7	6.7	-	0.0	0.0 7.5	0.0 6.6			_		0.0 0.0
NY		0.0			0 12	5 0 0		0 0.0	0.0		_		_	0.0	0.0	37				0 0		_		_			47	54		12	9 0.0		_	0 0.0		40	97		0.0	0.0				0.0	_		0.0 0.0
NC		0.0	0.0	0.0	.0 1.:							0.0			0.0								0.0						0.0		5 18.) 0.			_		11.5					0.0				0.0 0.0
ND	0.0	0.0	0.0	0.0	.0 0.	0.0	0 0.	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	_	_	_		_		0.0						0.0		0.0	7.1	0.	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 0.0
OH	0.0	0.0	0.0	0.0	.0 2.:	2 2.5	5 0.	0.0	0.0	0.0	7.2	0.0	0.0	11.1	0.0) 1.1	9.0	2.0) 6.	.3 0	.0 (0.0	0.0	0.0	0.0	0.0	1.6	3.0	0.0	6.1	1 2.0	6 0.0) 17	.5 0.0		14.4			0.0	2.2	0.0	0.0	1.7	7.3	0.0 1	7.5	0.0 0.0
OK			9.2	0.0 4	.3 0.	0.0	0 0.	0.0	0.0			0.9	11.9	9 1.1	0.9		-	0.0				_	9.2	_				0.0	1.4	0.0	0.0	0.0) 0.	0 18.	0.0	0.0	0.0	0.0	0.0	1.1	6.6	0.0	0.0	0.0	0.0		0.0 0.0
OR		0.0	0.0	12.4 0	.0 0.	0.0	0 0.	0.0	7.5	0.0		0.0	0.0	0.0	0.0		0.0								0.0			0.0	0.0	0.0	0 0.0	0.0	0.	0 0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	12.9		0.0 0.8
PA RI					.0 5. .0 5.	_	_	0.0 0.0		0.0	-	_	-	0.0	0.0	_	_	7 4.1		0 0		_	0.0				_	_	5 0.0 0.0	_	7 2.8 0 0.0	_	_	6 0.0 0 0.0		18.5 0.0	4.1 5.0		0.0				3.3 0.0	5.8 0.0	0.0		0.0 0.0
SC	-	-			.0 0.		_	0 8.2		0.0	-	-	-	0.0	_	_	_	0.0	_		_		0.0					-	-	-	0 15.	_	_	0 0.0	_				0.0				0.0		0.0		0.0 0.0
SD		0.0	0.0	0.0	.0 0.	_	_		-	0.0	-	-	-		0.0	_	-	_		0 4		_	0.0	_			0.0	-		_	0.0	_	_						4.6		0.0	0.0		0.0	0.0		0.0 1.6
TN	7.0	0.0 1	3.1	0.0	.0 0.			0 11.1		5.7		_				3 0.0		0.0	_		_	_	9.5	_			_	_		_		3 0.0						3.4	0.0				0.0		0.0		0.0 0.0
ТХ	-	1.3 2	_		.7 0.		_			2.9					_	1 0.0	_						6.7									_	_	0 23.					0.0		34.1						0.0 0.0
UT	-	11.7			.3 0.	_				0.0				_	0.0	_	-	_				_	0.0						2.8		0.0) 0.			0.0	<u> </u>		0.0		0.0						0.0 5.2
	-				0 0.		_	0.0		0.0	-	-	-			_	-	_				_	0.0					-	-	-		-	_	0 0.0	_				0.0			0.0		0.0			0.0 0.0
VA WA		0.0	0.0		.0 2.	1 7.1		0.0	11.0	0.0	0.0	0.0	0.0									_	0.0	_								3 0.0 0 0.0	_	0.0	21.3	4.8	0.0		0.0		0.0	0.0		22.2	_		0.0 0.0 0.0 1.3
WV		0.0			.0 0.	0.0	9 0	0.0	0.0	0.0	0.0	0.0											0.0						0.0	_				6 0.0	_			0.0			0.0	0.0	0.0		0.0		0.0 0.0
WI	-	0.0					_	0.0		9.5	-	-	-	_		_	_	_			_	_						-		_		-	_	4 0.0	-		-		0.9		0.0	0.0			0.0		0.9 0.0
WY	0.0	0.0	0.0	0.0	.6 0.	0.0	0 0.	0.0	_	0.0	-	-	_	_		_	_	_	_		_	_		_				-				_	_	0.0							0.0	4.4	0.0	0.0	0.0	0.0	0.0 12.3
																							_														_			_							_

Maximum contribution of source state's NO_x to monthly mean peak 8-hour O_3 concentrations within a single grid cell over *New Jersey* (ppbv)

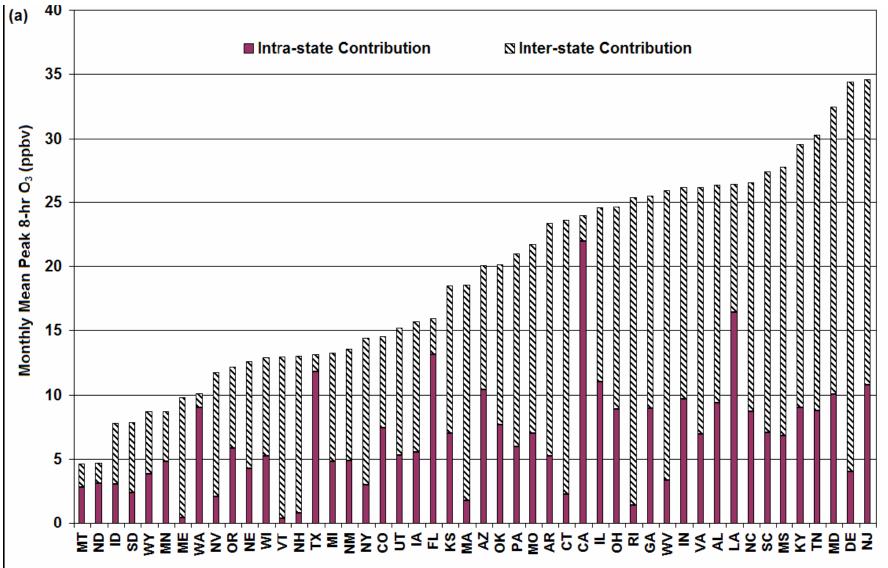
												_	-		_																						_								
SRC/RCP	AL	AZ AF	R CA	со	ст	DE	FL	GA	ID	IL	IN	IA	ĸs	KY	LA	ME	ME	MA	м	М	N	ns N	ю м.		EN	IV I	N	NJ	IN		: NI	D O	н ок	OR	PA	RI	sc	SD	TN	rx u	т и	T VA	WA N	NV V	vi wy
AL	27 4	0.0 0.	0 0.0	0.0	0.0	0.0	11 4	14.3	0.0	0.0	0.0	0.0	0.0	21	29	0.0	0.0	0.0					.0 0.0).0		UNI		.0 5.1					0.0	0.0	3.9	0.0	8.5 (.0 0.	0 0	0 1.9	0.0		.0 0.0
AZ		42.1 0.				0.0						-					-	0.0				_						0.0 1			_	_			0.0					_	_	0 0.0			.0 0.0
AR		0.0 12	_			0.0				3.9	-	-	1.2			-	-	0.0	_			_	.8 0.0	_		_		0.0 0			_	_		-	0.0		1.2		12.7 3	_	_		0.0		.0 0.0
CA	0.0	37.3 0.	0 54.2	2 4.1	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.	0 0.	.0 0	0 0.0	.0 0.	B 1.	7 3	7.3	0.0	0.0 3	.7 0	. 0 0.0) 0.	0 0.	0 1.0	2.2	0.0	0.0	0.0	0.9	0.0	.9 18	.7 0.0	0.0	0.0	0.0 0	.0 2.6
CO		2.2 0.	0 0.0	24.3	0.0	0.0	0.0	0.0	0.0		0.0							0.0	_	0 0.		0.0			_		0.0	0.0 5		.0 0.0						0.0	0.0	1.1		.4 3.	.6 0.0		0.0		.0 10.7
ОТ		0.0 0.	_			0.0					-		-			_	-	4.9	_			_	.0 0.	_	_	-		~ -		.4 0.0					0.0			0.0		_	_	7 0.0	0.0		.0 0.0
CI		0.0 0.	_			13.7				0.0	0.0	-	-			0.0	-	_	_		_	_	.0 0.	_		_	1	3.7	1	.0 0.0	_	_			3.7					.0 0.		0 1.0	0.0		.0 0.0
CA		0.0 0.	_	-		0.0		15.6		0.0			-			-	-	0.0			_	0.2 0	.0 0.			_	0.0	0.0 0		.0 2.1	_	_	-		0.0										.0 0.0 .0 0.0
GA	_	0.0 0.		1.3				0.0								0.0		_								_		0.0 0	_		_	_					_	_	10.6 0 0.0 0	_	-	0 1.9 0 0.0	0.0 6.8		.0 0.0
IL		0.0 4.				0.0				18.4													3.4 0.0					0.9 0	_						2.2				6.2 (0 2.4	0.0		.5 0.0
IN		0.0 0.	_				0.0			13.0																		1.0 0			_	_	-							_	_	_			.9 0.0
IA	0.0	0.0 1.	1 0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	1.8	9.0	3.2	1.0	0.0	0.0	0.0	0.0	1.	3 4.	.2 0	.8 6	.5 0.0	D 8.	2 0).0 (0.0	0.0 0	.0 0	.0 0.0) 1.	0 1.	0 1.0	0.0	0.8	0.0	0.0	4.9	1.0 (.0 0.	0 0.0	0.0	0.0	0.0 6	.2 0.0
KS		0.0 2.				0.0	0.0	0.0		1.1							_	0.0					2.0 0.0		_	_		0.0 0	_		_	_		_	0.0			1.5	0.0 1	.8 0.	0 0.0	0.0	0.0	0.0 0	.0 0.0
KY		0.0 2.	-					2.5												-				-	-			0.9 0				-													.0 0.0
IΔ	-+	0.0 16	_							1.3	-	-	-			-	-	_	_		_		_				0.0	0.0 0		.0 1.2	_	_	_				_				_				.0 0.0
MC		0.0 0.		-	_		0.0			0.0	-				-	-	-	0.0					.0 0.	0 0.	0 0 0 0		1	4.9		.0 0.0		0 0.	_		0.0 13.6				0.0 0	_	_	_	_		.0 0.0 .0 0.0
		0.0 0.	_				0.0			0.0			-				-	_	_		_		.0 0.0	_	0 0	_				.4 4.		_		_	0.0						_				.0 0.0
MI		0.0 0.	_	0.0	1.6	1.0												2.0	_		_	_	.0 0.	0 0.	0 0	0.0	-	1.0		.5 0.9	0.	0 9.	5 0.0				_		1.0 0		0 2.				.2 0.0
IVIIN	v. v	0.0 0.	0 0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	1.6												.0 0.0	0 2.	4 0).0			0	.0 0.0) 5.	5 1.	0 0.0	0.0	0.0	0.0	0.0	5.2	0.0	.0 0.	0 0.0	0.0			
MS	12.1	0.0 6.	3 0.0	0.0	0.0	0.0	4.7	2.2	0.0	1.2	0.0	0.0	0.0	1.6	11.5	5 0.0	0.0	0.0	0.	0 0.	.0 14	4.2 2	.2 0.0	D O .	0 0	_		0.0 0		.0 1.5	5 0.	0 0.	0.0	0.0	0.0	0.0	1.4	0.0	8.6	.0 0.	0 0.0	0.0	0.0	0.0 0	.0 0.0
MO	1.6	0.0 7.	3 0.0	0.0	0.0	0.0	0.0	1.2	0.0	13.3	5.0	-	-				-	_	1.	0 1.	.3 2	2.5 13	3.3 0.0	D <u>5</u> .	6 0			0.0 0		. 0 1.0	_	_	7 7.4	0.0	1.0	0.0	0.8	1.1	10.4	.9 0.	0 0.0	0 1.3	0.0	1.2 1	.2 0.0
	_	0.0 0.		-	_	0.0		0.0		0.0						0.0	-				.0 0		.0 10.	2 1.	-	_		0.0 0		.0 0.0	_	_					_			_	0 0.0				.0 6.6
NE	_	0.0 0. 9.5 0.				0.0				0.0								0.0				0.0 7 0.0 0		0 9.	4 0 0 11	-	0.0	0.0 0		.0 0.0					0.0	_			0.0 0						.0 2.7 .0 0.0
NJ	-+	0.0 0.	_					0.0		0.0		0.0					-	_		0 0.		0.0 0					2	8.1		.0 0.0		0 0.		_	0.0				0.0 0			_			.0 0.0
_		0.0 0.					0.0			0.0		-	-	-		-	-	_	_	-	.0 0		.0 0.0		0 0				_	2.6 1.0				_	16.7				_			1 2.0			.0 0.0
I NY	-+	8.6 0.	_				0.0			0.0			-		_	-	-	_				0 0.0			8 0		-5	.4		.0 0.0	_	_	0 4.6		0.0						_	_			.0 0.0
		0.0 0.			12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	7.4	0.	0 0.	.0 0	0.0	.0 0.	0 0.	0 0).0	_	_	12	2.9 0.0) 0.	0 0.	0.0	0.0	4.0	9.7	0.0	0.0	0.0 (.0 0.	0 6.	7 0.0	0.0	0.0 0	.0 0.0
NC	-+	0.0 0.	_	_		_		2.4					-	-	_	-	-	_	_				.0 0.0		0 0	-	1	.8		.5 18.	_	_	0.0	_						_	_	-			.0 0.0
OH	L 1	0.0 0.	_		_		_	0.0			-	-	-			_	-	_	_		_		.0 2.3		5 0		2	Δ		.0 0.0	_	_								_		_			.0 0.0
		0.0 0.	_	-				0.0			-	-	-	-		-	-	_	_		_	_	.0 0.		0 0		J	.0		.1 2.6		_		_							_				.0 0.0
PA		0.0 9.	_		_			0.0															.2 0.	5 <u>2</u> . 6 0		1.0	1	8.5	0	.0 0.0) 0.	0 0.		16.3	0.0				0.0 0						.0 0.0 .0 0.8
	J.J	0.0 0.	-					0.0															.0 0.0	0 0.	0 0	0.0	•	5.0		3.7 2.8	3 0.	0 2.	-												.0 0.0
RI		0.0 0.					-			0.0	-	-	-	-		-	-	_	_		_	_	.0 0.0	_	0 0	-				.0 0.0	_	_	_	-	0.0		_			_	_	0.0			
SC	0.0	0.0 0.	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.	0 0.	.0 0	0.0	.0 0.	D O .	00).0	v.v	0.0 0	0	. <mark>0</mark> 15.	0 0.	0 0.	0.0	0.0	0.0	0.0	15.0	0.0	0.0	.0 0.	0 0.0	0 1.3	0.0	0.0	.0 0.0
SD		0.0 0.			_		0.0			0.0						_					_	0.0			-			0.0 0	_	. 0 0.0	_	_			0.0			_	0.0	_	_				.0 1.6
TN		0.0 13.						11.1																0 0.				0.0 0		.0 11.								_				-			0.0
TX UT		1.3 21. 11.7 0.0	_							2.9 0.0	-		-			_	-	0.0	_			_	.7 0.			_		0.0 1		0 1.4	_	_	-		0.0	0.0			6.0 3 0.0 (_			.0 0.0 .0 5.2
		0.0 0.					<u> </u>					-	-				-	0.0	_		_	0.0 0			_	0.0	_ `	0.0 2	-	.0 0.0	_	_			0.0				0.0 0		_	_	0.0		.0 0.0
	- +	0.0 0.	_	-		7.1	0.0			0.0	-	-	-			-	-	B 2.2		0 0.		_	.0 0.0		_).0	1	5.2	-	.4 13.	_	0 0.	-		4.8						0 0.0		0.0		.0 0.0
VA	-	0.0 0.		-	_	0.0				0.0						-	_	_					.0 4.			2.4	0	-		.0 0.0	_	_			0.0			_	_	.0 1.			23.4		.0 1.3
W۱	, 1	0.0 0.	0 0.0	0.0	0.0	0.9	0.0											5 0.0				0.0	.0 0.	D O .	0 0).0 (0	0.9	0	.0 1.1	0.	03.	6 0.0	0.0	4.8	0.0	0.0	0.0	0.0	.0 0.	0 0.0	0 4.9	0.0	5.7 0	.0 0.0
V V V	- 4	0.0 0.	_			0.0				9.5											.8 0	_	.1 0.0	_	_).0				. 5 0.0	_	_	_	_	1.3								0.0		0.0
VV T	U.U	0.0 0.	0 0.0	9.6	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.	0 0.	.0 0	0 0.0	.0 4.1	1 <mark>9</mark> .	6 0	0.0	0.0	0.0 0	.0 <mark>0</mark>	.0 0.0) 1.	1 0.	0.0	0.0	0.0	0.0	0.0	4.2	0.0	.0 4.	4 0.0	0.0	0.0	0.0 0	.0 12.3

Relative contributions of NO_x emissions from CAIR-regulated states to changes in monthly mean maximum 8-hour O₃ concentrations



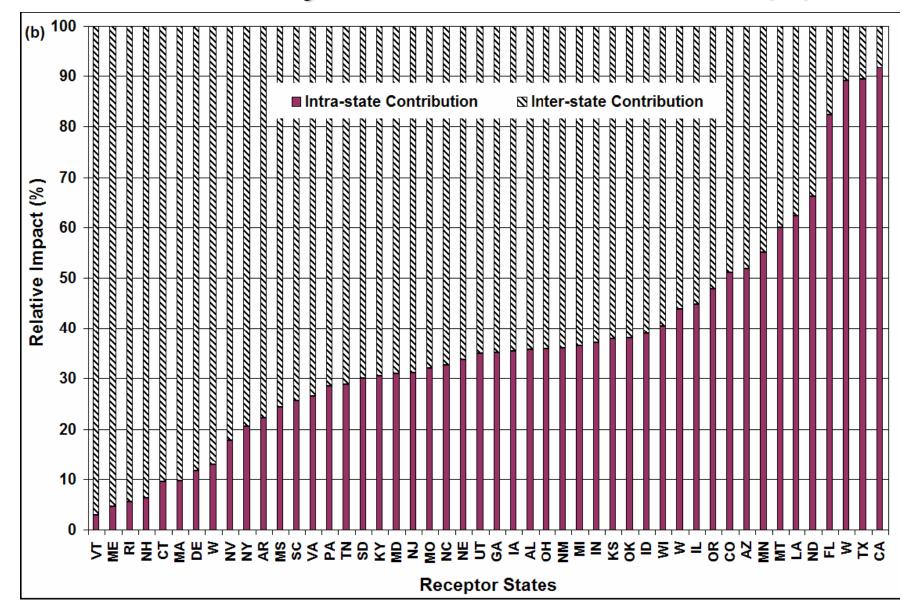
States Participating in the CAIR O₃ Program

Contributions from intra- and inter-state NO_x Emissions to Monthly Mean Peak 8-hr surface O_3 concentrations (ppbv)



Receptor States

Contributions from intra- and inter-state NO_x emissions to surface O_3 concentrations in each state (%).



Conclusions

- In the eastern US, influence of out-of-state NO_x emissions is often greater than in-state NO_x emissions on in-state O₃.
- Regional NO_x control is necessary for many states to attain O_3 NAAQS.
- The Clean Air Interstate Rule (CAIR) facilitates regional O₃ control but could be significantly improved by including Texas in the NO_x cap-and-trade program.
- Unrestricted trading under the CAIR NO_x emissions cap could reduce reductions of O₃ concentrations over the continental United States.

Papers are available at:

http://www.princeton.edu/~mauzeral/dlm_publications.htm

Specific relevant papers:

- Tong, D.Q. and Mauzerall, D.L., Summertime State-Level Source-Receptor Relationships between NOx Emissions and Downwind Surface Ozone Concentrations over the Continental United States, *Environmental Science & Technology*, submitted 2007. [full text]
- Tong, D. Q., Mauzerall, D. L., "Spatial variability of summertime tropospheric ozone over the continental United States: Implications of an evaluation of the CMAQ model," *Atmospheric Environment*, 40, 3041-3056, 2006. [full text (pdf)]
- Mauzerall, D. L., Sultan, B., Kim, J, Bradford, D., "NOx Emissions: Variability in Ozone Production, Resulting Health Damages and Economic Costs," *Atmospheric Environment*, Volume 39: No. 16, pp. 2851-2866, May 2005. [full text (pdf)]

Thank you! 🙂