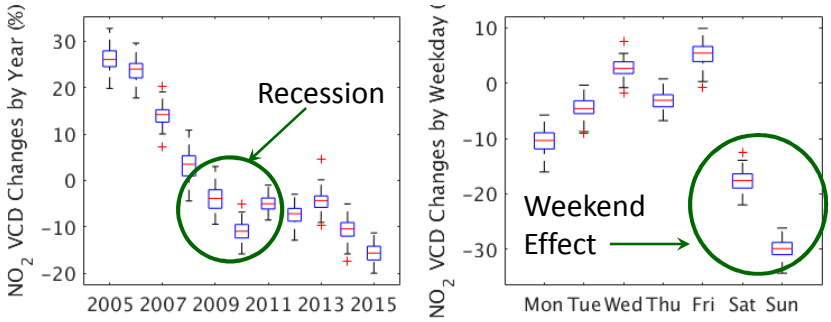
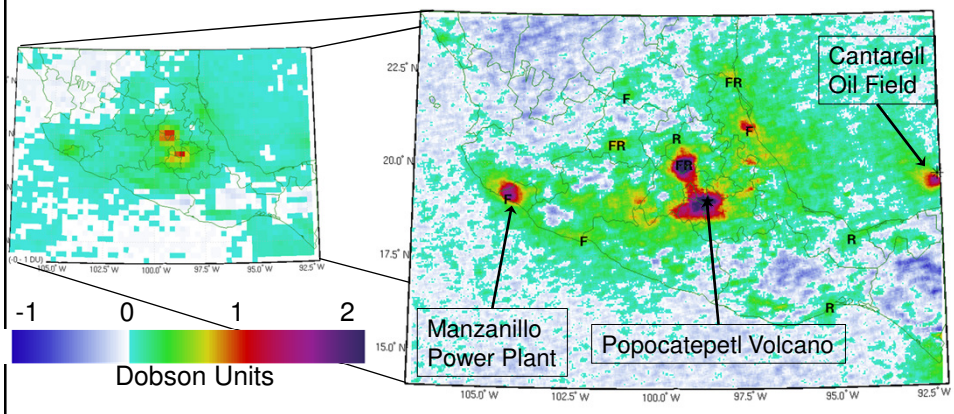
OMI NO_2 Columns for Emission Inventories Development

Benjamin de Foy
Saint Louis University
St. Louis Monitoring Meeting, 17 May 2016



Long-term trends, reductions at the time of the recession and weekend effects over St. Louis

OMI SO_2 Oversampling



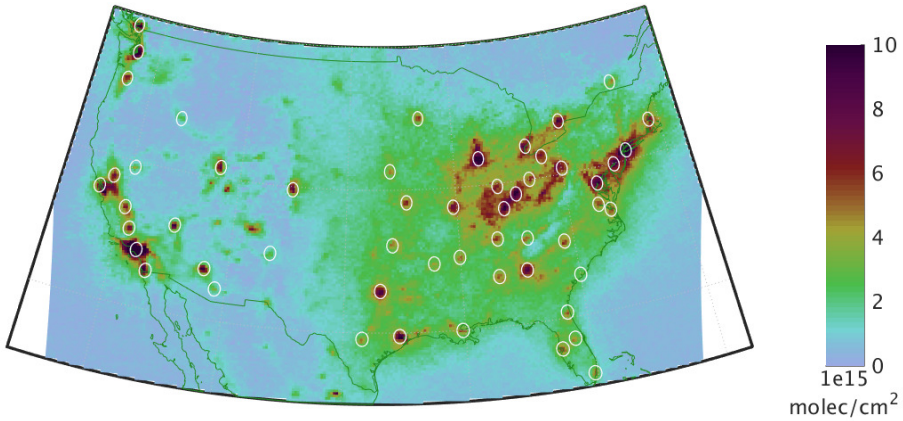
Averaging to 0.125° shows the main plumes but smooths out details (OMI SO_2 PBL column over Mexico, 2004-2007 average)

Oversampling to 3km grid reveals sources and plume transport:

F: Fuel Oil Power Plant
R: Refinery

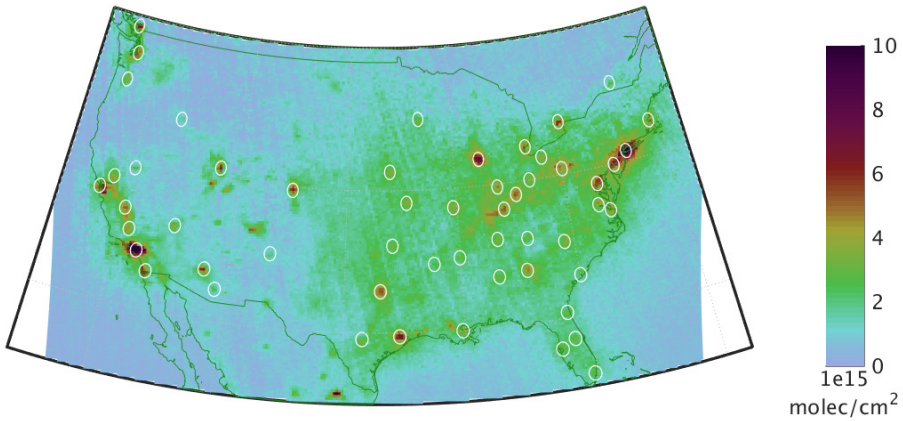
de Foy et al., "Hit From Both Sides," Atmospheric Chemistry and Physics, 2009

OMI NO_2 over the USA - 2005



Benjamin de Foy, Zifeng Lu, David G. Streets:
Impacts of control strategies, the Great Recession and weekday variations on NO2 columns above North American cities, Atmospheric Environment, 2016

OMI NO_2 over the USA - 2014



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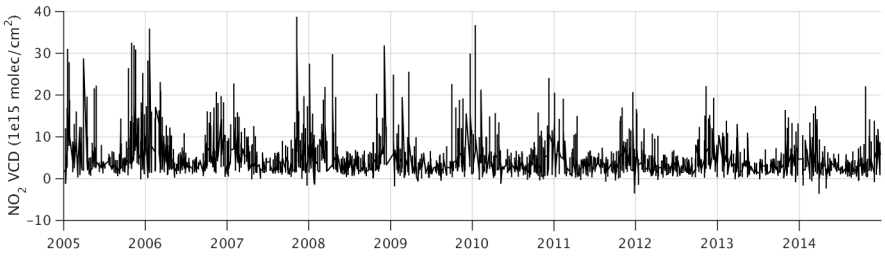
Atlanta: 8,500 OMI Pixels over 10 years
Clear trend, but lots of variability



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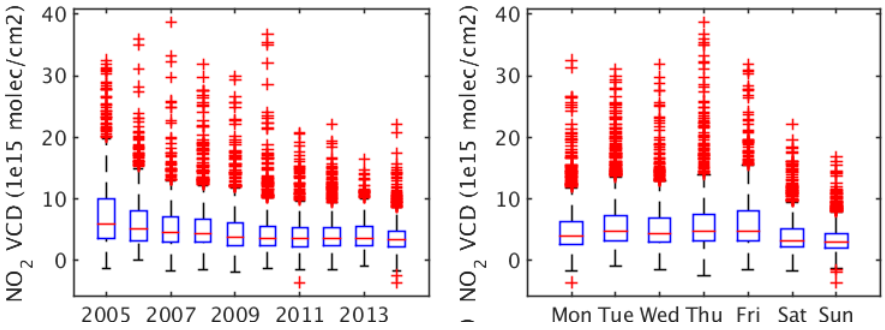
Boxplots by Different Time Windows over Atlanta:
Clear long term trend and weekend effect, but considerable data variability masks detailed changes



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Factors Contributing to Variation in OMI NO_2 Columns

Annual	Seasonal	Weekday	Meteorology	Pixel Resolution
Linear Trend	Sin 1 year	Monday	Wind Speed	Pixel Size
and/or	Cos 1 year	Tuesday	Wind Direction	Pixel Distance from Urban Center
Annual Factors	Sin 6 months	Wednesday	Temperature	
	Cos 6 months	Thursday		
		Friday		
		Saturday		
		Sunday & Holidays		

Multiple Linear Regression to Estimate Combined Contribution from Different Factors

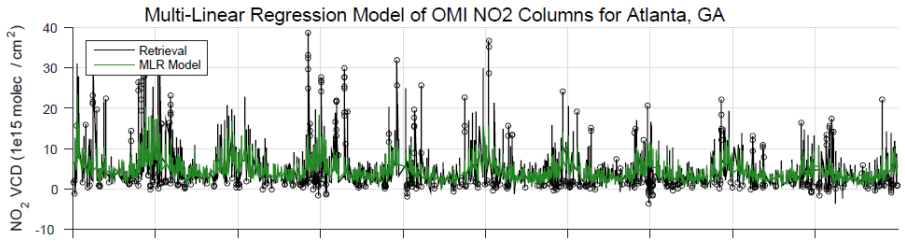
$$\log(C) = c_{lin}t_{lin} + \sum_{yr=2008}^{2011} c_{yr}t_{yr} + \sum_{wd=Mon}^{Sun} c_{wd}t_{wd} + f(\text{other}) + \epsilon$$

$$f(\text{other})$$

$$f(\text{seasons}) = \sum_{j=1}^{2} c_{sj}\sin\left(\frac{2\pi jt}{365.25}\right) + c_{cj}\cos\left(\frac{2\pi jt}{365.25}\right)$$

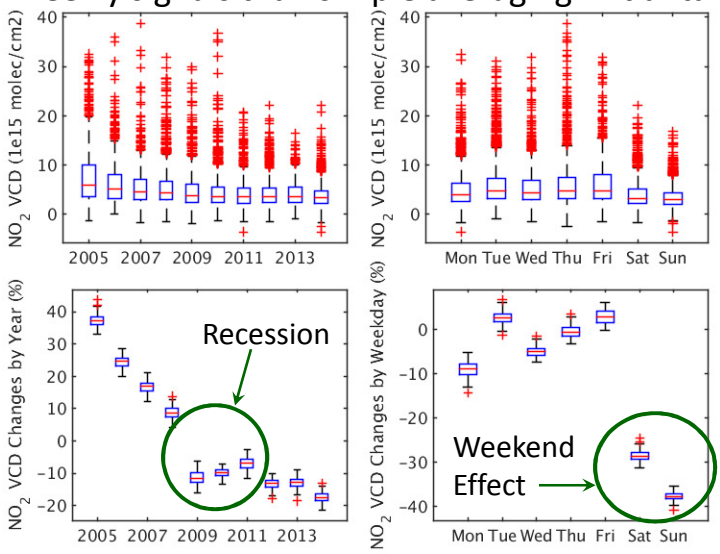
$$f(\text{meteorology}) = c_{ws}\left(\log(WS+3)\right)' + c_{t2}T_2' + c_{u10}U_{10}' + c_{v10}V_{10}'$$

$$f(\text{resolution}) = c_{dmin}D_{min}' + c_{dmax}D_{max}'$$



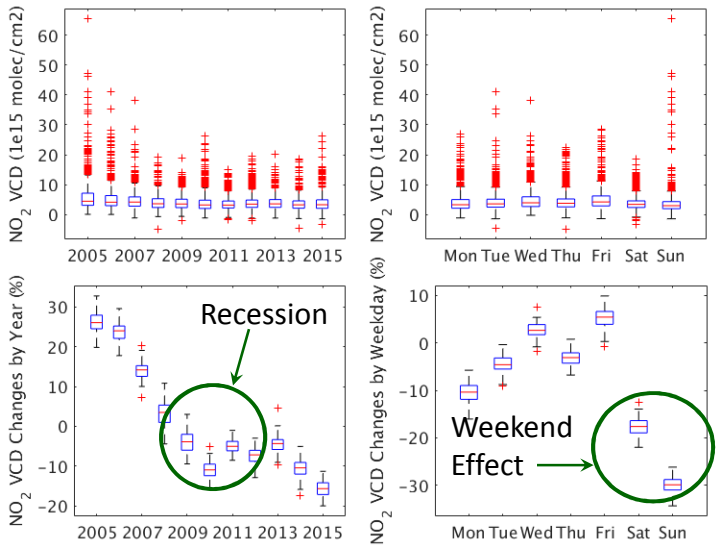
Stats		Annual	%	Weekday	%	Met/Pixel	
Nobs	8525	Trend	-5.5	Mon	-9.0	WS10	-0.18
Noutliers	462	2008	-3.6	Tue	2.6	T2	-0.07
r	0.74	2009	-16.4	Wed	-5.1	U10	-0.00
Mean VCD	5.3	2010	-10.8	Thu	-0.5	V10	-0.02
		2011	-2.6	Fri	3.2	Dmin	-0.10
				Sat	-28.7	Dmax	-0.07
				Sun	-37.7		

Multiple Linear Regression yields cleaner annual and weekly signals than simple averaging - Atlanta



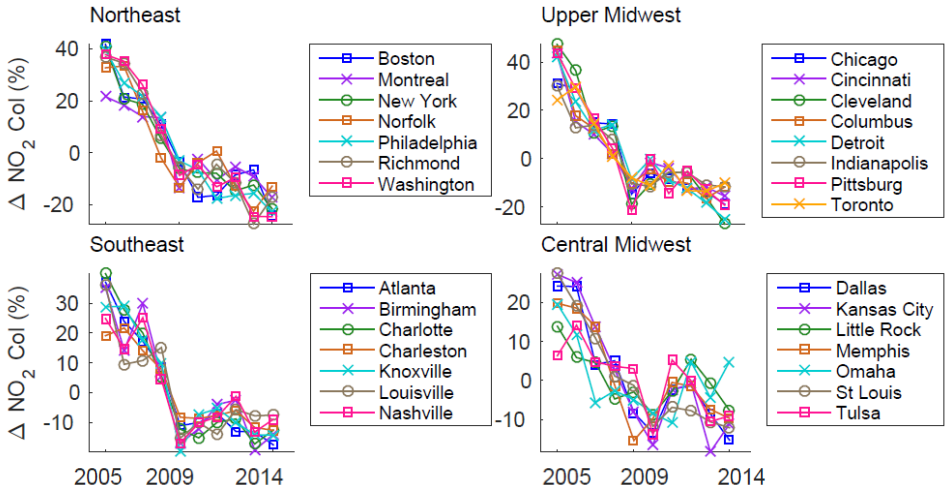
Uncertainty Analysis of Regression Model using Bootstrapping Algorithm

Multiple Linear Regression yields cleaner annual and weekly signals than simple averaging – St. Louis

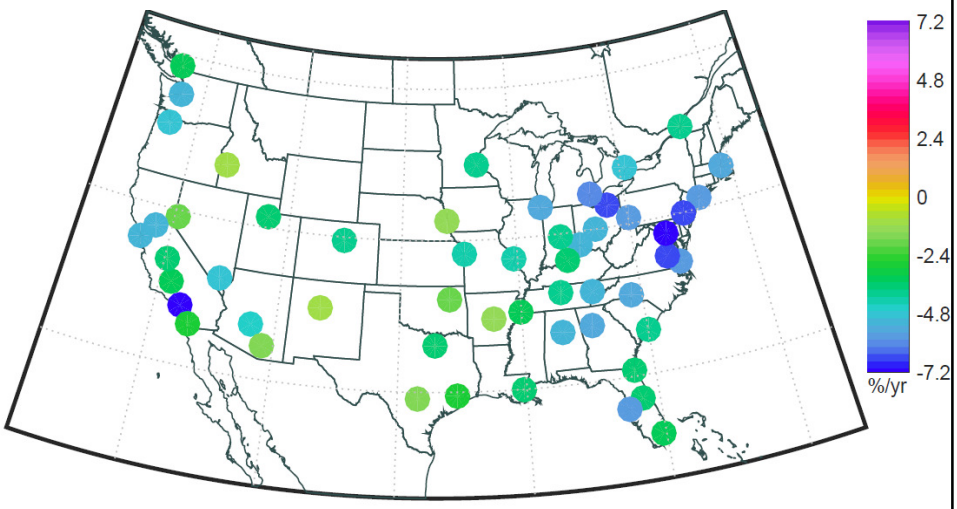


Uncertainty Analysis of Regression Model using Bootstrapping Algorithm

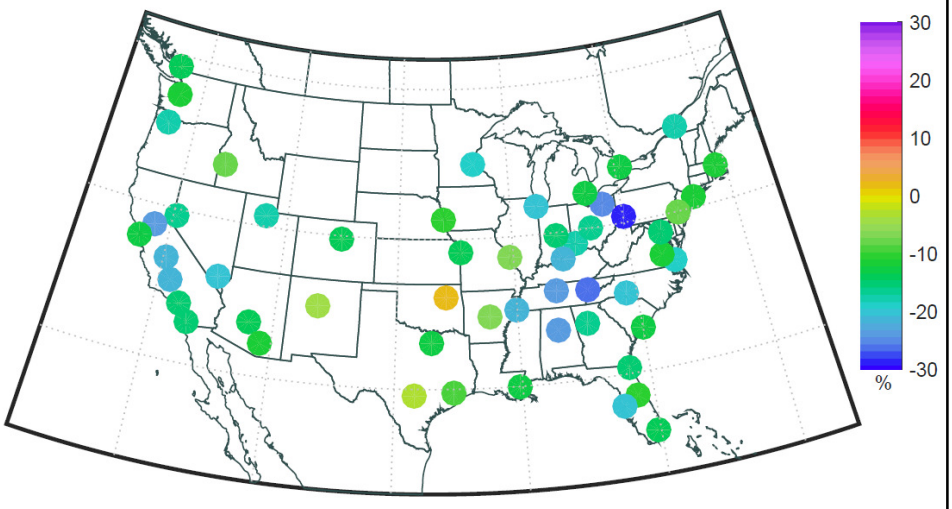
North American Metropolitan Areas: Strong long-term reductions, temporary recession impacts



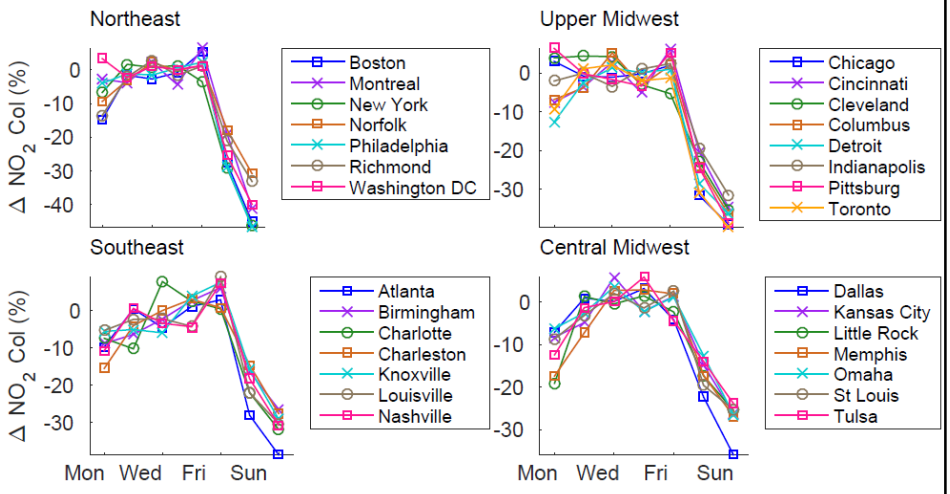
Map of 10-year Trends: Reductions of up to 7% per year



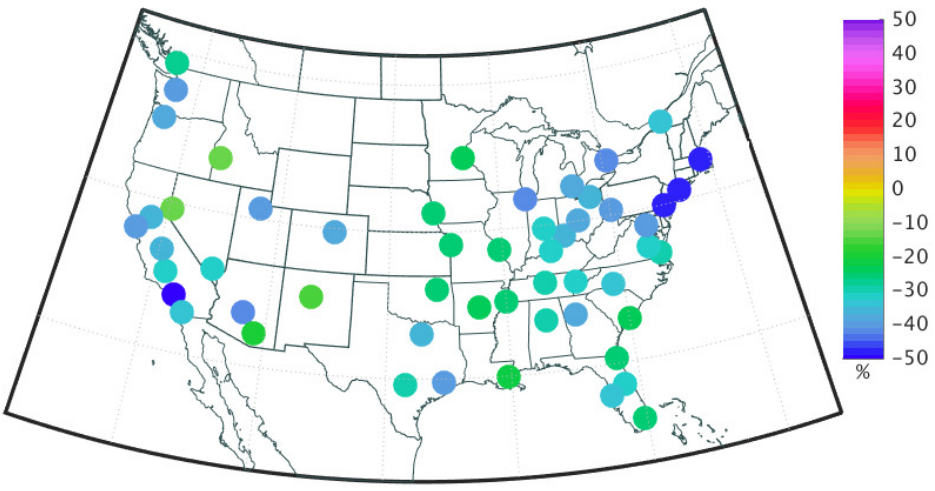
Reductions in 2009: Some urban areas had NO_2 columns 30% lower than the linear trend would have predicted



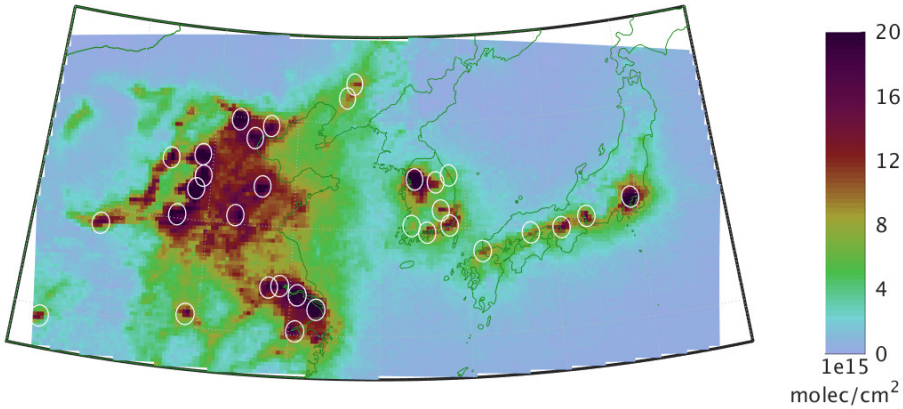
North American Metropolitan Areas: Weekend Effects: Strong, but Variable



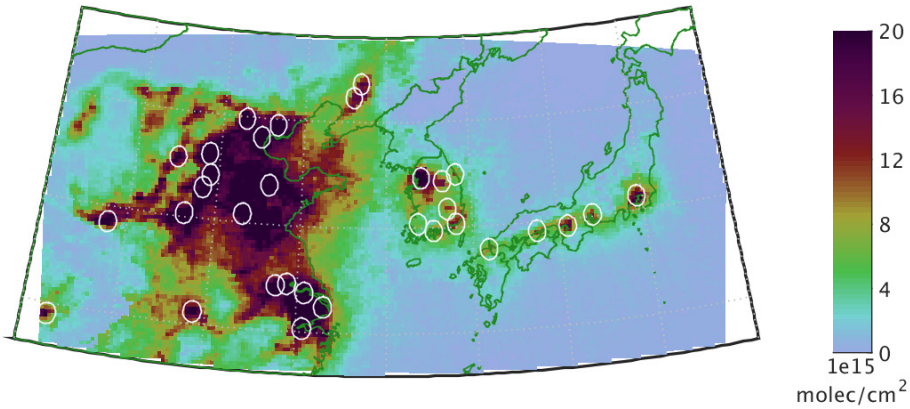
Sunday reductions in OMI NO_2 columns by urban region (%)



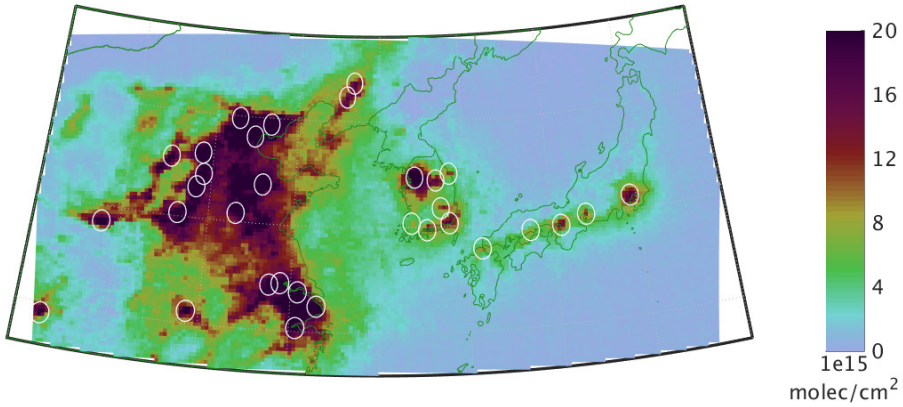
OMI NO_2 over NE Asia - 2005



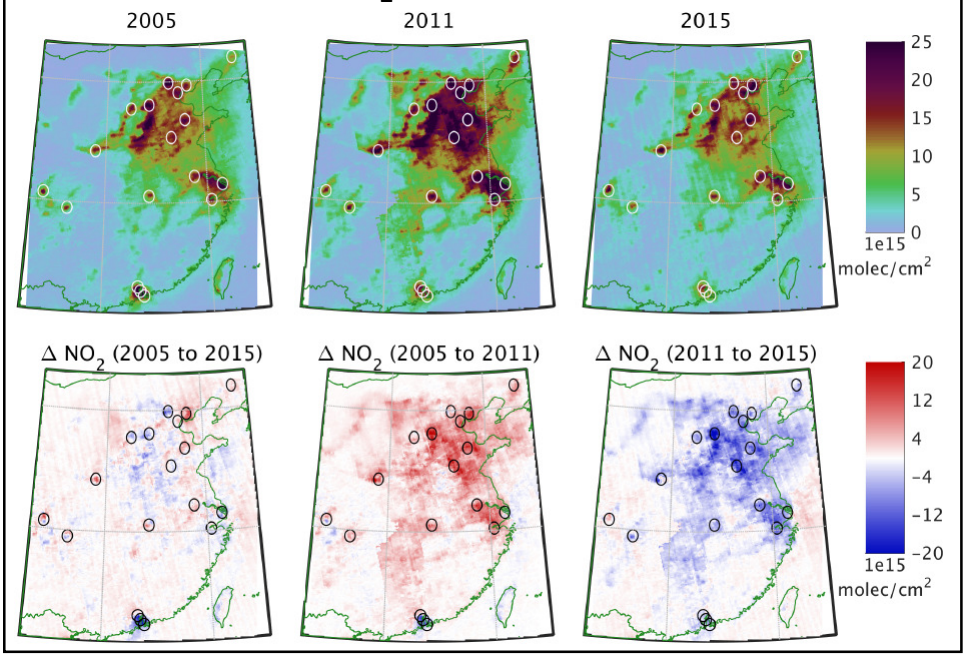
OMI NO_2 over NE Asia - 2011



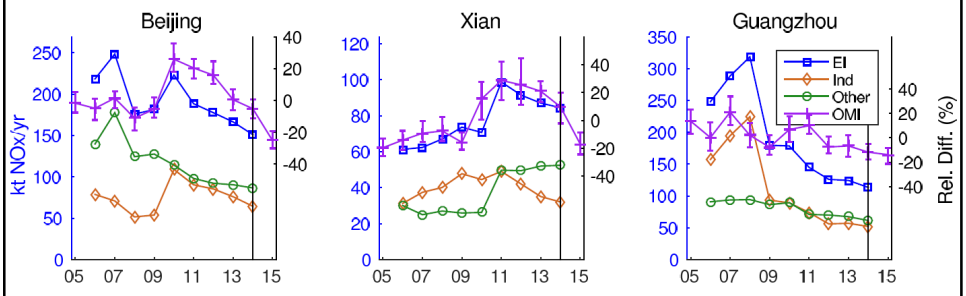
OMI NO_2 over NE Asia - 2014



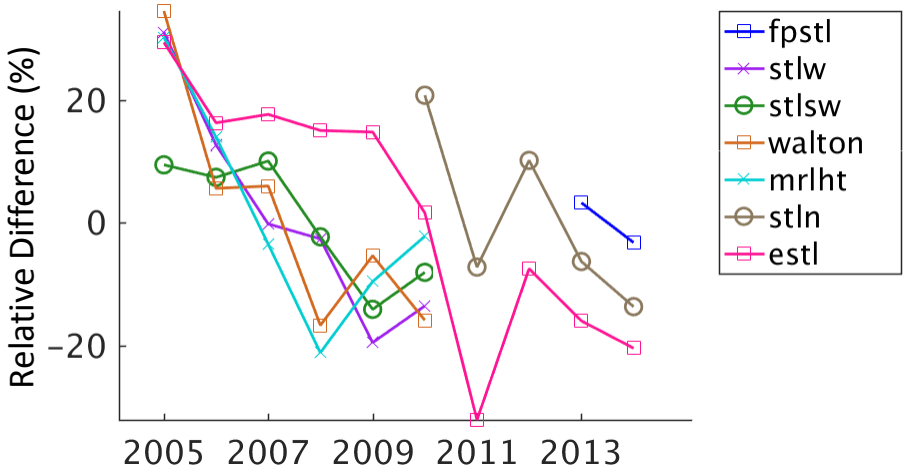
OMI NO_2 over Eastern China



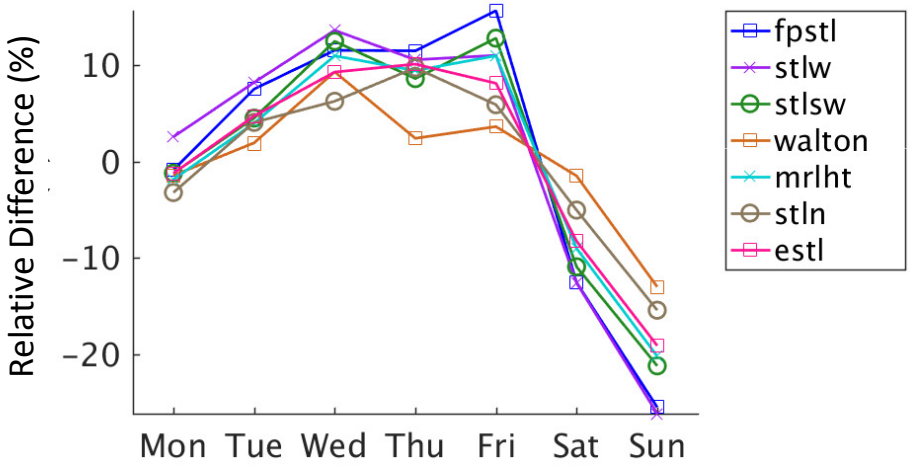
OMI NO_2 over Eastern China



Analysis of St. Louis Monitoring Data
Annual Trends for NOx Concentrations



Analysis of St. Louis Monitoring Data: Weekday Patterns of NOx Concentrations



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OMI NO_2 Columns for Emission Inventories Development

Benjamin de Foy, Saint Louis University

AQAST NASA AIR QUALITY APPLIED SCIENCES TEAM

- Policies for reducing NO_2 have had large impacts in both North America and Northeast Asia
- Reductions at the time of the Recession vary in intensity
- Weekend effect is strong in the USA but weak in China, and can differ from city to city
- Multiple Linear Regression Analysis accounts for variations from multiple factors and hence gives clearer estimates of temporal signals in the data