Impact of the 2008 economic recession on urban emissions in US megacities

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The Great Recession

- Starting Ending time: December 2007 October 2009;
- Cause: Bursting of the housing bubble in 2007, followed by a subprime mortgage crisis in 2008;
- Impacts:
 - > Unemployment rate: 4.7% in Nov 2007 \rightarrow 10.1% in Oct 2009.
 - Income level: dropped to 1996 level after inflation adjustment;
 - > Poverty rate: $12\% \rightarrow 16\%$ (50 millions);
 - GDP: contract by 5.1%;
- Worst economic recession since the Great Depression

Question: What does it mean to Air Quality (and Emissions)?



Emission Indicator – Urban NOx in Summer

- > Short lifetime \rightarrow proximity to emission sources
- > Urban NO2 dominated by local sources;
- > High emission density \rightarrow low noise/signal ratio;

NOx Data sources

- > Satellite remote sensing (OMI-Aura NO2).
- Ground monitoring (EPA AQS NOx);
- Emission data (NOAA National Air Quality Forecast Capability operational emissions);

Methodology

- ✤ Deriving the trend: (Y2-Y1)/Y1×100%
- Selection of urban areas



NO_x Regulatory Actions Since 2005

• 2003 – 2008: NO_x Budget Trading Program (SIP Call)

- Summer time power plant emission reductions in 20 states
- Point sources can pay for reductions at other facilities (trading)
- 2500 large combustion units affected.
- 2005: Clean Air Interstate Rule (CAIR)
 - NO_x reductions of 53% by 2009 (2003 baseline). Affects 28 states
 - Thrown out by courts in 2008.
- State-specific rules beyond Federal CAIR have led to further NO_x reductions in some states.
- 2011: Cross-State Air Pollution Rule (CSAPR)
 - Replacement of CAIR
 - Add five additional mid-West states to reduce NOx during ozone season.
- Tier II Tailpipe NO_x Emission Standards 5% reduction in fleet emissions per year over 2002 to 2010.

Ozone Monitoring Instrument (OMI)





One of four sensors on the EOS-Aura platform (OMI, MLS, TES, HIRDLS) *Courtesy of OMAR Torres* Launched on 07-15-04

Instrument Characteristics

-Nadir solar backscatter spectrometer

-Spectral range 270-500 nm (resolution~0.6 nm)

-Spatial resolution: 13X24 km footprint

-Swath width: 2600 km (global daily coverage)

-13:45 (+/- 15 min) Local equator crossing time (ascending node)

Data Quality Control

- VCD quality flag;
- Cloud fraction;
- Row Anomaly;
- Outliners (5% at each end)

AQS: EPA Ambient NO2 Monitoring

- * Method: Chemiluminescence
 - > Interferences with PAN, O3 and alkyl nitrates
 - > Uncertainty higher at lower end
- Select early morning rush hours (6-9AM): higher values and less photochemistry



NAQFC Emission Updates in 2012

* Base Emission Inventories

- US EPA National Emission
 Inventory 2005 (NEI2005) for U.S.
- Environment Canada 2000 El for Canada;
- Mexico 1999 inventories for six board states;

Emission Updates

- Point Sources: Annual updates with Continuous Emission Monitoring (CEM) data and DOE Annual Energy Outlook projections.
- > 2006 Canadian emissions
- 2012 updates: Nonroad and mobile sources using from the Cross-State Air Pollution Rule (CSAPR) dataset.







local time (hour)



11/21/2014

OMI Observed NOx Change (July)

Tropospheric NO2 [10¹⁵ molec cm⁻²]



0.1 0.9 1.8 2.7 3.6 4.5 5.4 6.3



Contributed by Lok Lamsal

Inter-Comparison of OMI, AQS and NAQFC



Inter-Comparison of OMI, AQS and NAQFC (Continued)



Morning Rush Hours vs Early Afternoon



Seven-year NOx Changes

City	Atlanta .	Boston	Dallas .	Houston	Los	New	Philadel-	Washing-	¢	Maan
					Angeles	York	phia.	ton, DC.		Iviean»
OMI _e	-42%	-37%.	-34%~	-24%+	-40%~	-32%~	-26%	-47%	¢	-35%~
AQS	-45%.	-33%	-33‰	-25%*	-37‰	-45‰	-37%.	-48%~	¢	-38‰
NAQFC	-31‰	-28%	-24%	- 28% @	-15%	-22%	-25%»	- 28% @	ę	-25%

- Both observations (OMI and AQS) revealed -5%/yr reduction rate;
- NAQFC adopted change corresponds to -3.5%/yr;

NOx Changes Prior to, during and after the Recession

Store	Sources	Atlanta	Boston	Dallas	Houston	Los	New	Philadel-	Washing-	Mean
Jage						Angeles	York	phia	ton, DC	
Before	OMI SP	-11.7	-9.4	-7.5	-5.7	-3.3	-7.5	-0.6	-12.3	-7.3
	AQS	-9.9	-2.1	-5.2	0.7	-2.0	-5.5	-5.5	-18.7	-6.0
During	OMI SP	-5.5	-7.5	-8.9	-7.9	-13.1	-6.2	-11.7	-13.0	-9.2
	AQS	-17.5	-7.0	-13.0	-14.0	-10.3	-13.6	-7.0	-3.7	-10.8
After	OMI SP	- 6. 0	-3.3	-2.1	0.4	-5.0	-3.2	-1.2	-2.3	-2.8
	AQS	1.4	-6.1	0.1	0.2	-6.4	-5.4	-6.1	-5.3	-3.4

Distinct regional difference;

1

- Average NOx changes are consistent for OMI and AQS data;
- -6%/yr -7%/yr prior to Recession;
- -9%/yr -11%/yr during Recession;
- ✤ -3%/yr after Recession (Recovery?).

Summary

- Derived long-term urban NOx trends from satellite (OMI) and ground observations (AQS);
- Revealed consistent NOx responses to the 2008 Economic Recession by OMI and AQS (-6%, -10%, and -3% reduction per year before, during and after the Recession);
- The 2012 NAQFC updates adjusted NOx emission in the right direction, but further emission reduction is needed;
- Demonstrated how to use space and ground observations to evaluate emission updates.