Challenges in Air Quality Services

Daniel Tong
George Mason University, Fairfax, VA

Gregory Carmichael, Pius Lee, Daven Henze, Lok Lamsal, Robert Levy

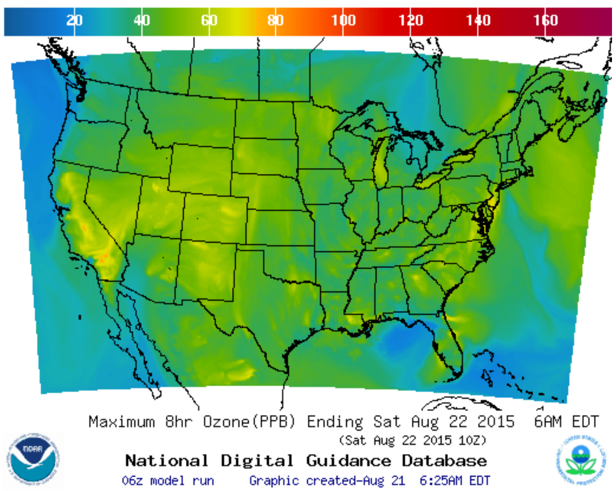
- **Forecasting and Early Warning;**
- **Public Health;**
- **Land management;**
- **Agricultural and food security;**
- **State Implementation Plan (SIP);**

Forecasting and Early Warning

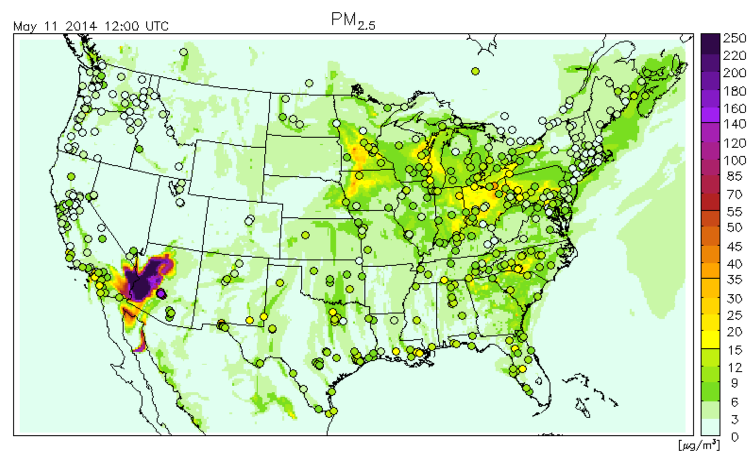
(Stakeholders: Ivanka Stajner and Pius Lee, NOAA)

- **NOAA National Air Quality Forecast Capability (NAQFC) generates four real-time products: Ozone, $PM_{2.5}$, Fire/Smoke, and Dust.**

O_3 Forecasting



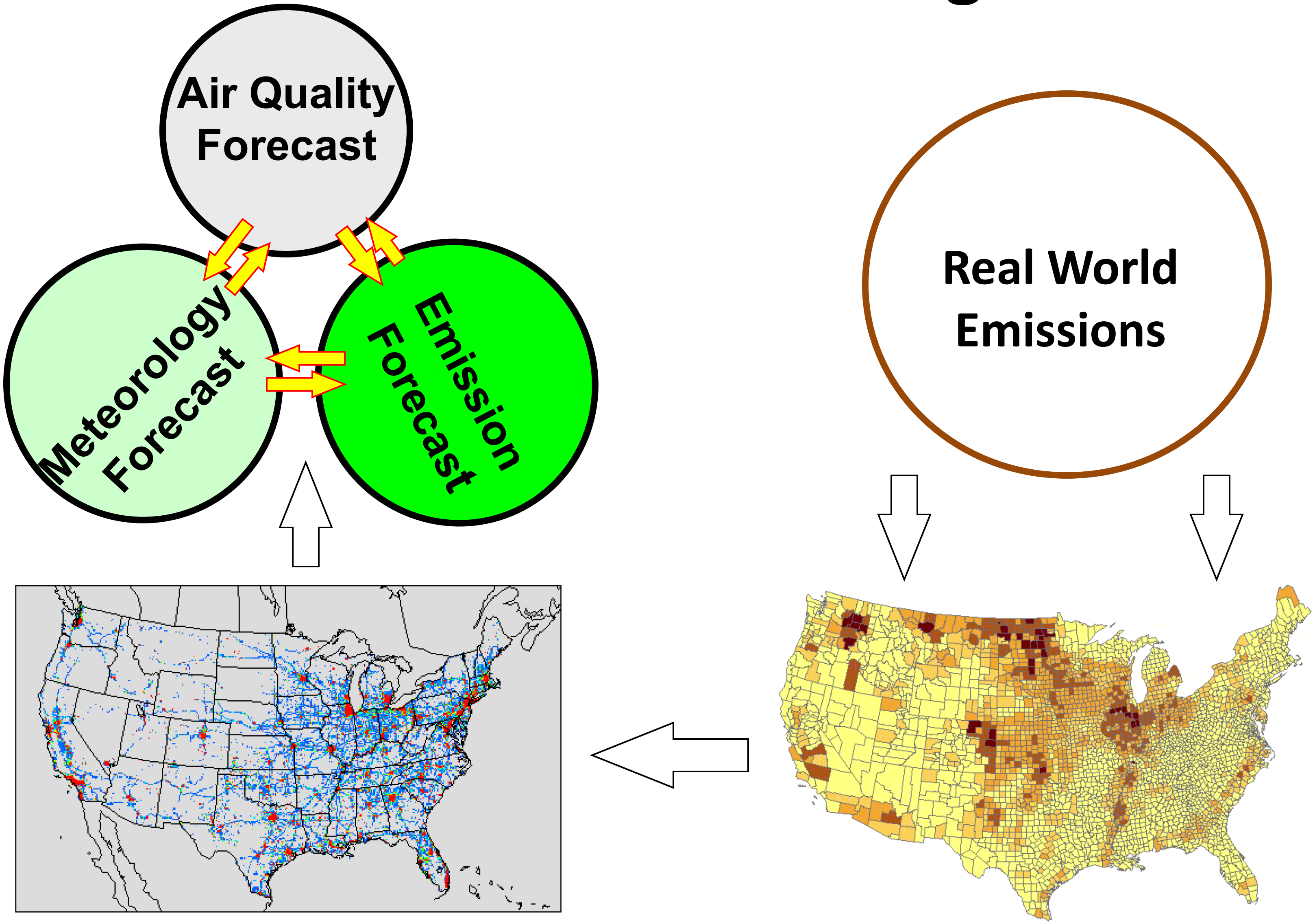
$PM_{2.5}$ Forecasting



http://airquality.weather.gov/

[A major gateway to disseminate satellite observations and model prediction of air quality products to the public.]

Emission Modeling



Model-ready Emission

Emission Inventories

Need of rapidly updated Emissions

- **Time lag is a major obstacle for AQF.**

  Forecasters want: *emissions for tomorrow;*
  Data availability: *emission data 4+ years old*.

  How to overcome this problem?

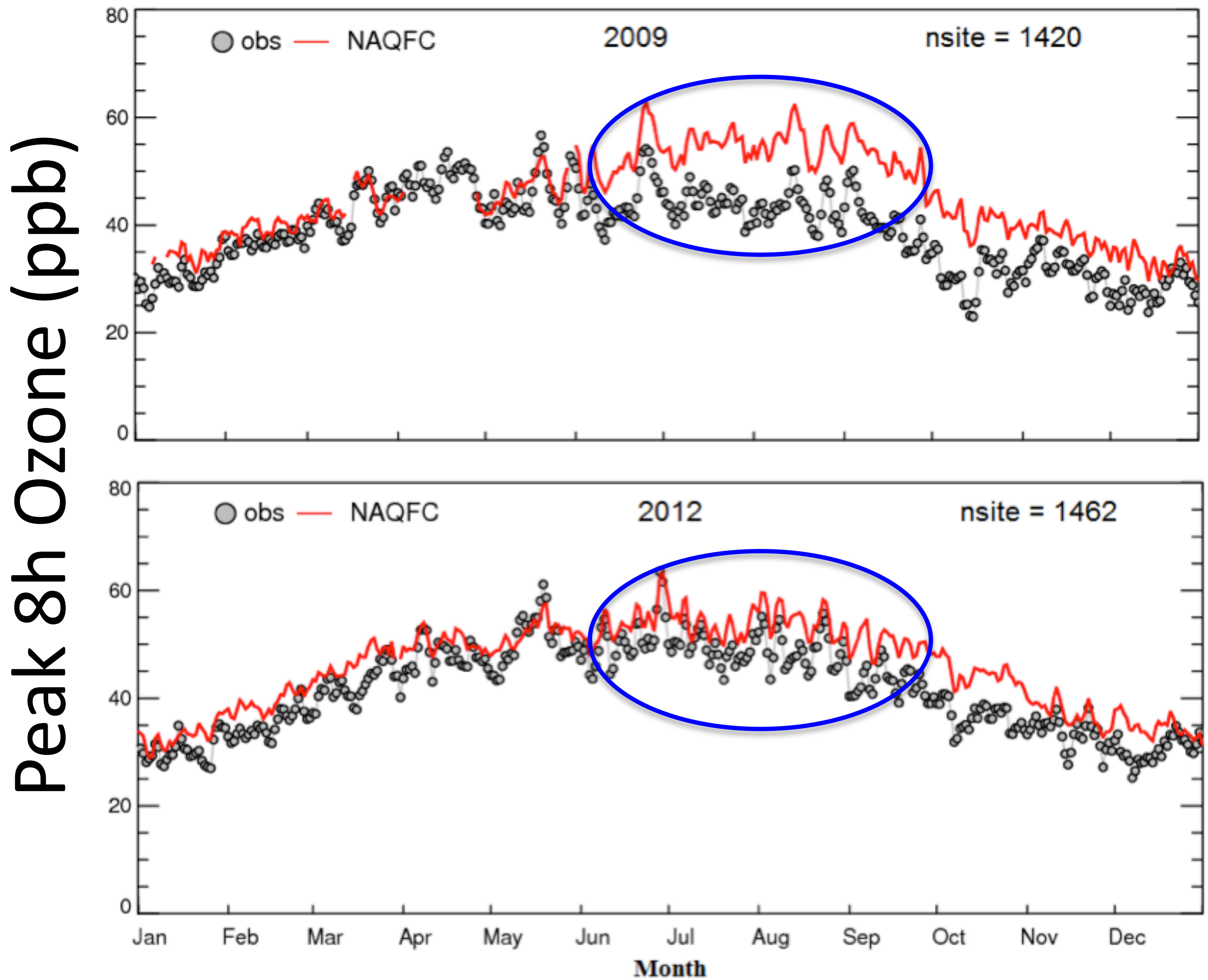
- **Common Practices:**

  Option 1, no update;

  Option 2, use emission projection;

  Option 3, update with satellite observations.

NOAA NAQFC Ozone Forecast



2009:
NEI Only

(NEI: National Emission Inventory)

2012:
NEI with Projection

(Tong et al., 2015)

The 2008 Global Economic Recession

- Cause: Housing bubble in 2007 followed by a subprime mortgage crisis in 2008;

- Impacts:

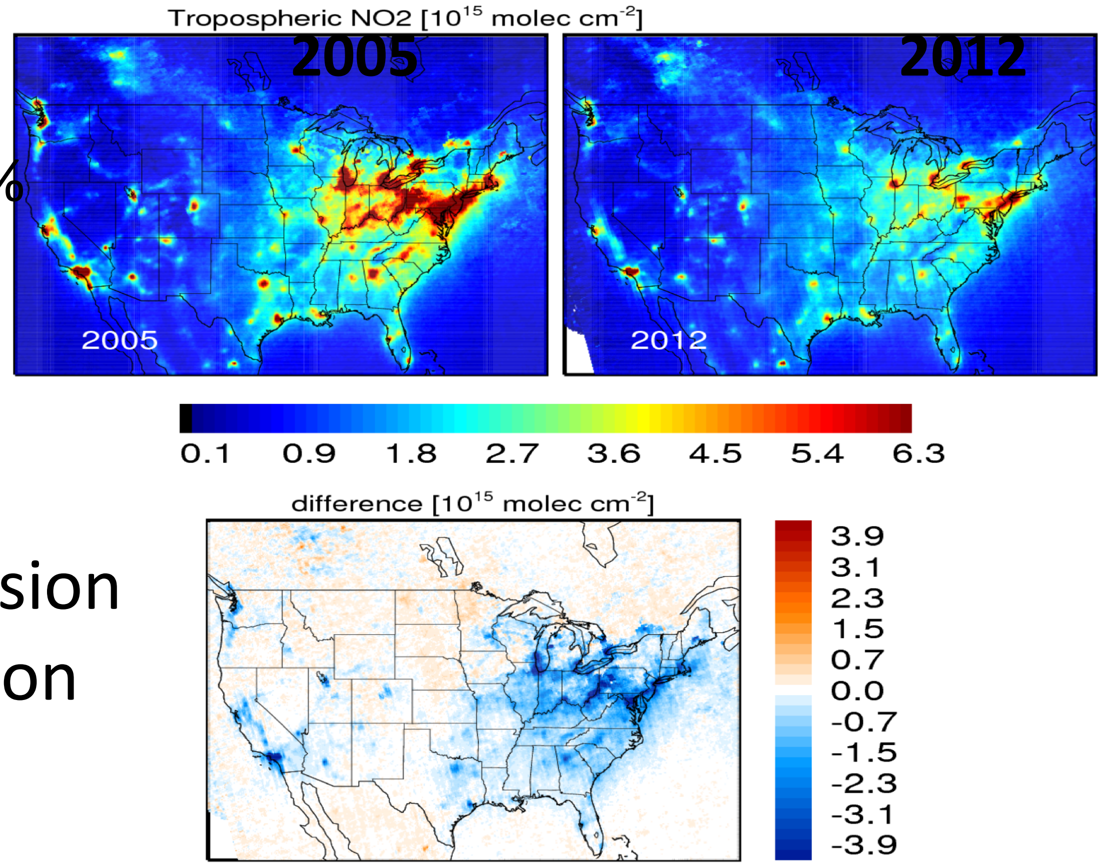
 - Unemployment rate: 10.1% in 2009.

 - Poverty rate: 16%;

 - GDP: contract by 5.1%;

- Worst economic recession since the Great Depression

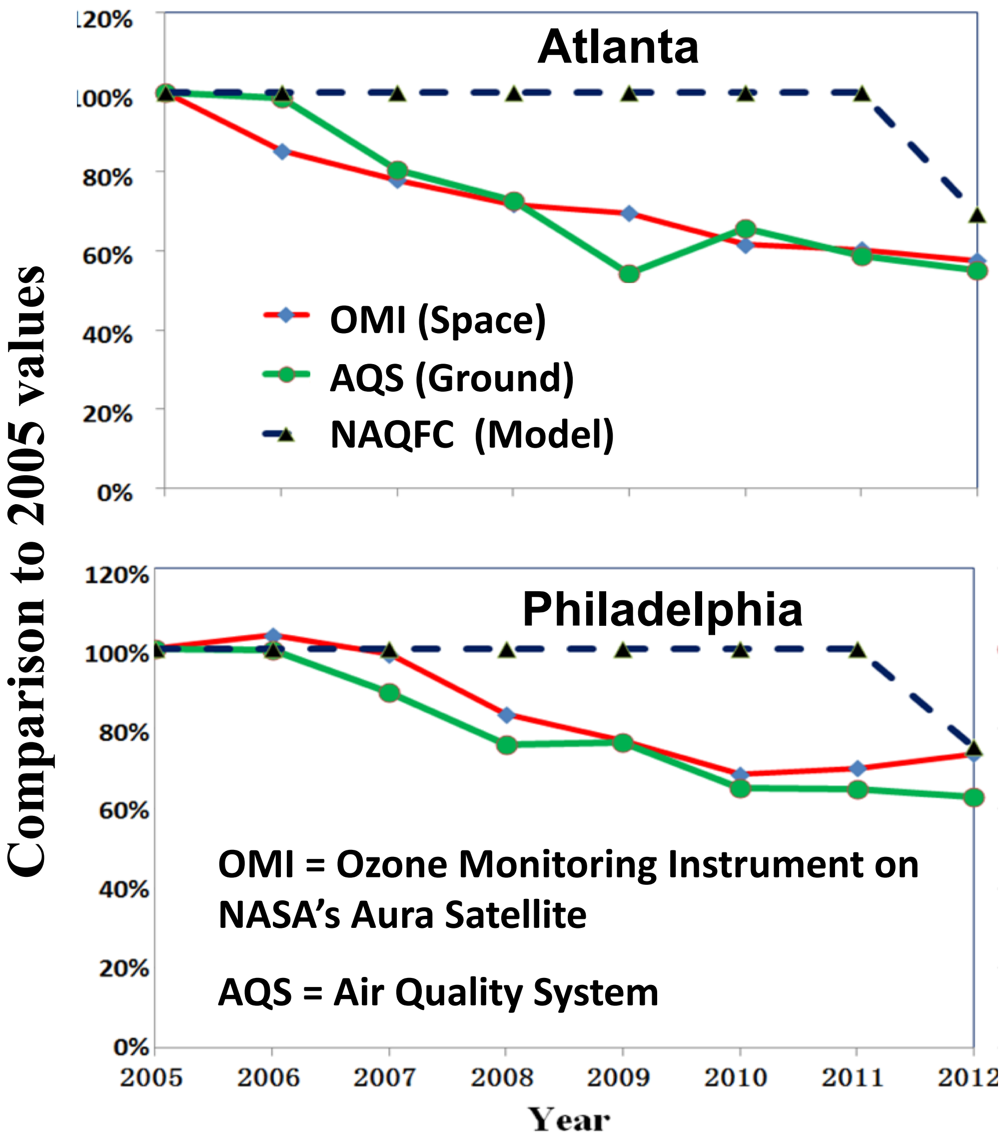
NO_2 Changes from OMI



Difference

Question: Was the change reflected in NAQFC emissions?

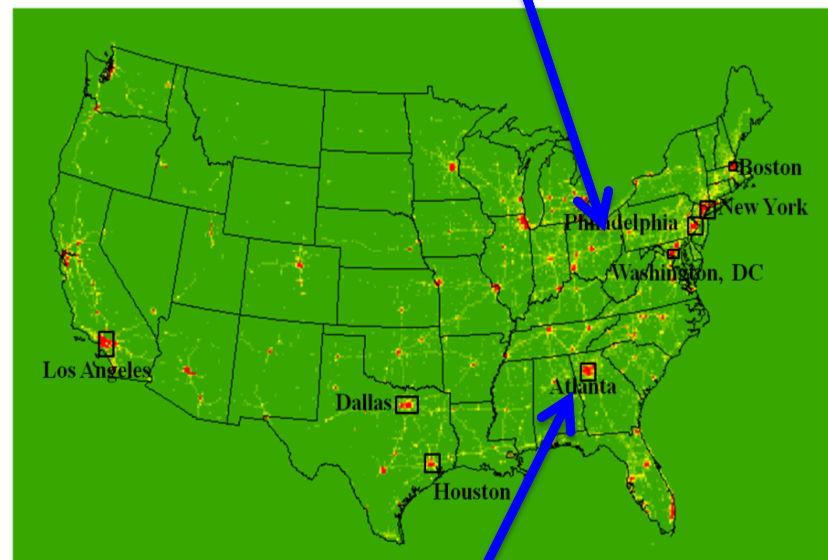
NO_x Trends from OMI, AQS and NAQFC



OMI = Ozone Monitoring Instrument on NASA's Aura Satellite

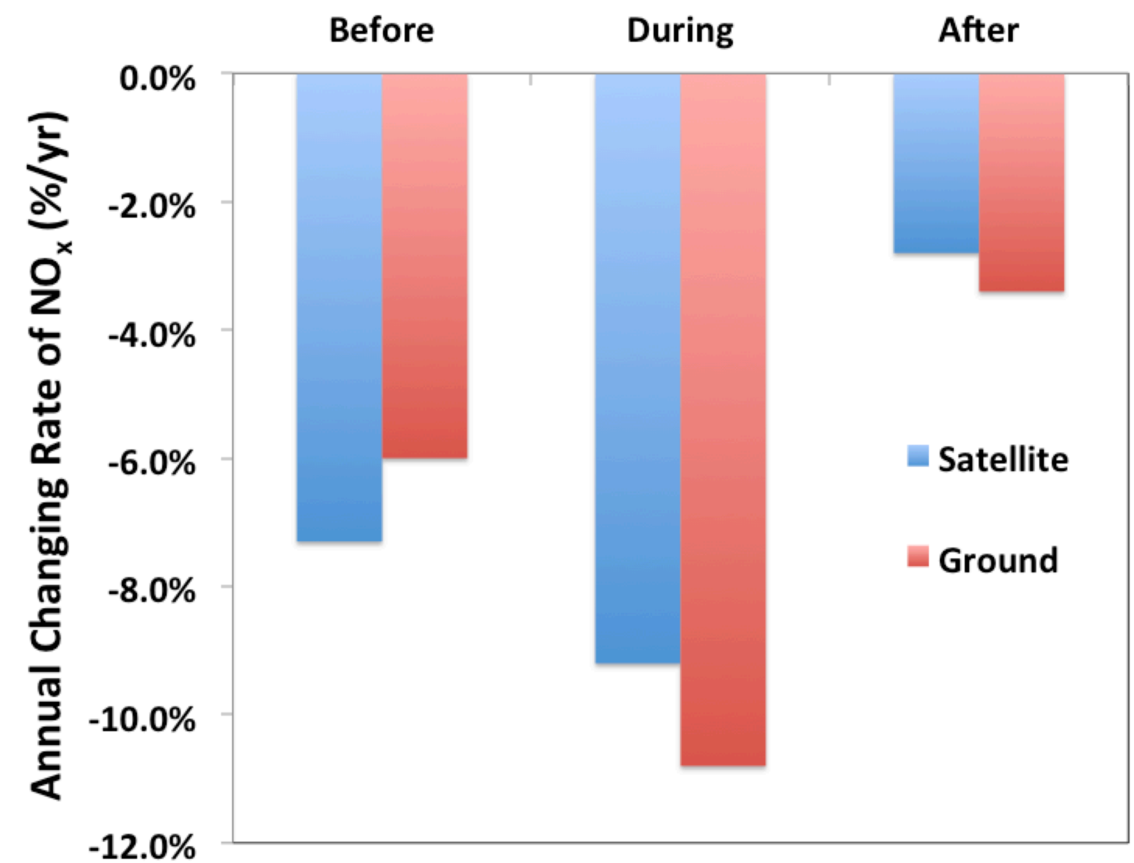
AQS = Air Quality System

Philadelphia



Atlanta

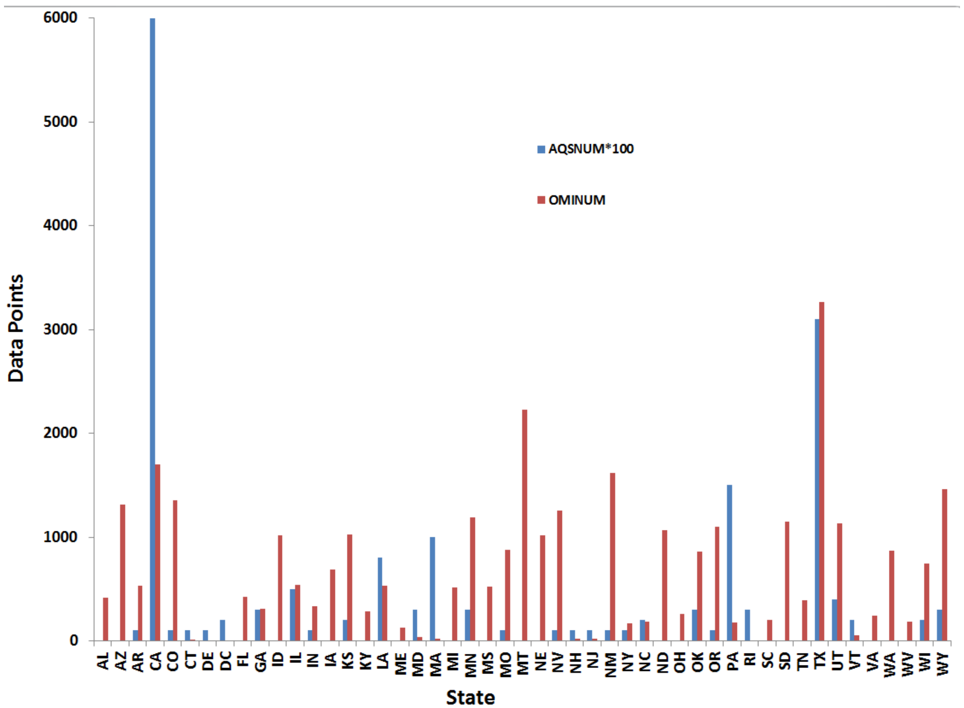
NO_x Trends during the Great Recession



- Consistent trends from OMI and AQS;
- Faster NOx reduction during the Recession and slower after that.

"Recession" Emissions

Use fused satellite (OMI) and ground (AQS) data to obtain realistic emission changes



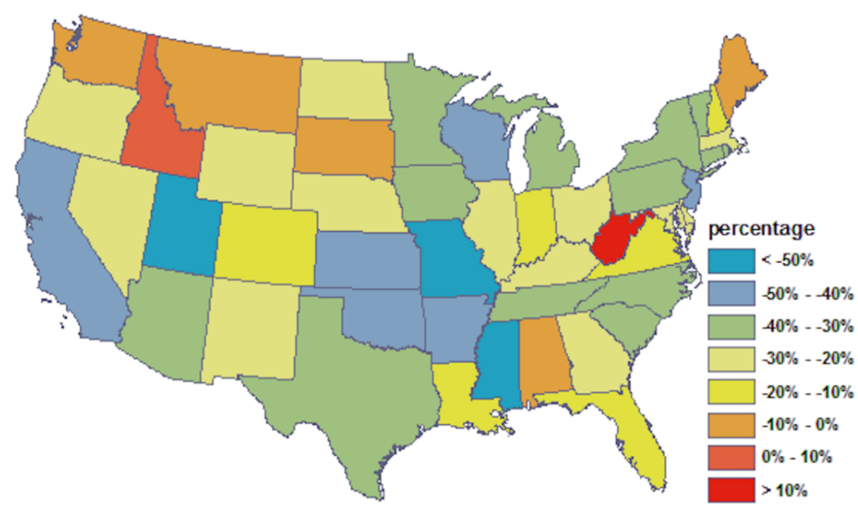
Comparison of OMI and AQS (x100) Samples

(Source: Tong et al., 2016)

Fusing AQS & OMI

$$AF = \frac{\Delta S \times N_S \times f_S + \Delta G \times N_G \times f_G}{N_S \times f_S + N_G \times f_G}$$

State-level Changing Factors

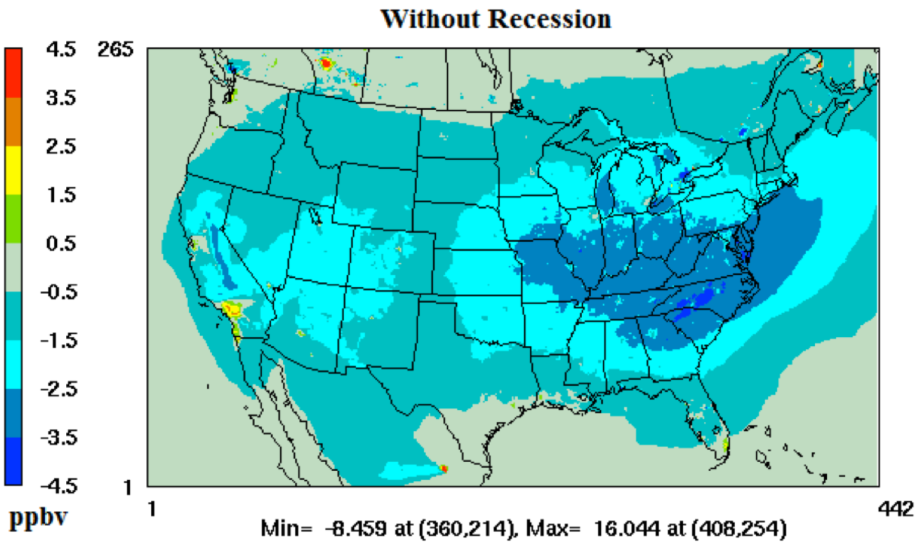


(2005 to 2011)

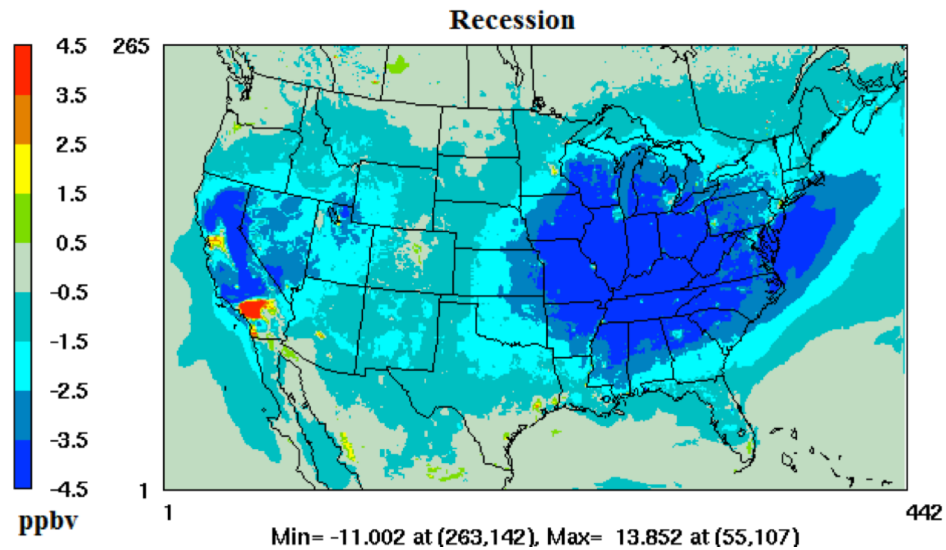
O_3 Changes with/without Recession

(2005 – 2011)

Without Recession

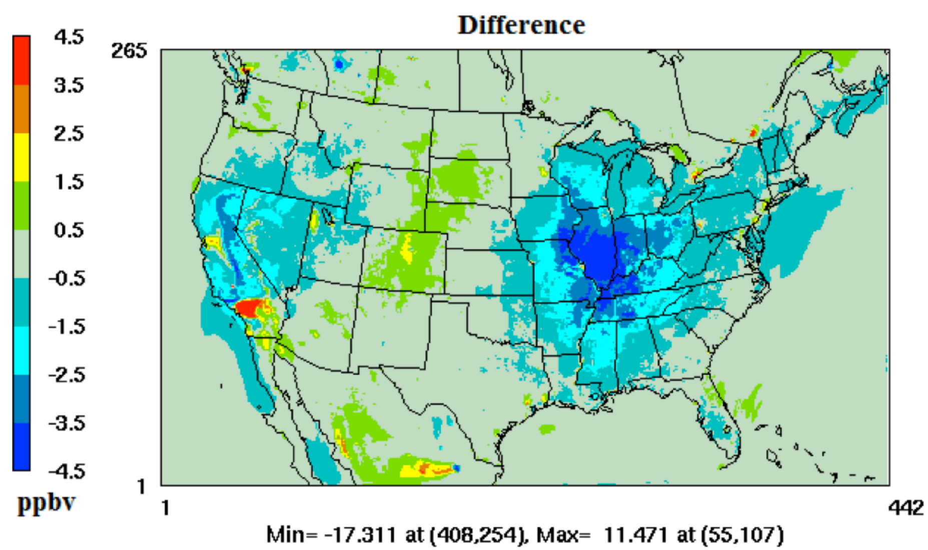


Recession



Scenario	Emission
Base Case	2005 NEIs
Business-as-Usual	NEI 2005 adjusted by EPA Cross-State Air Pollution Rule (CSAPR) Projection
Recession	NEI 2005 adjusted by fused OMI and AQS observations

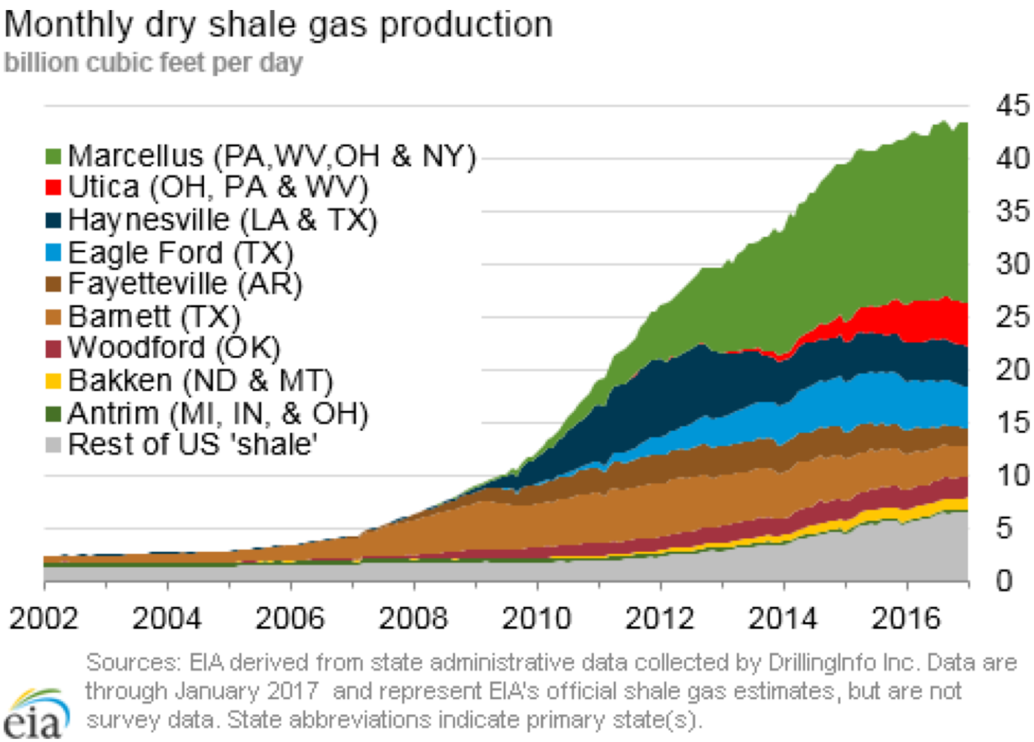
(Tong et al., 2016)



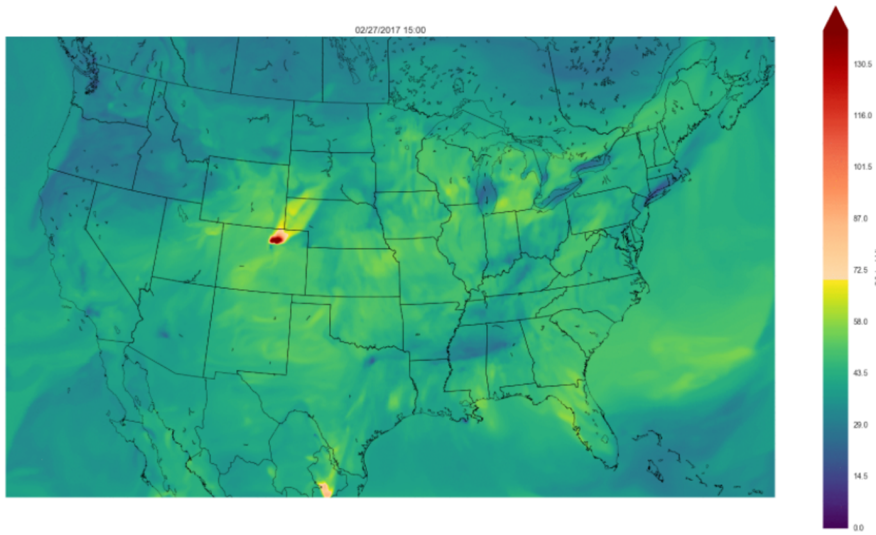
Oil and Gas Emissions

(Stakeholder: Ivanka Stajner, NOAA/NWS)

Shale Gas Production



Ozone Impact



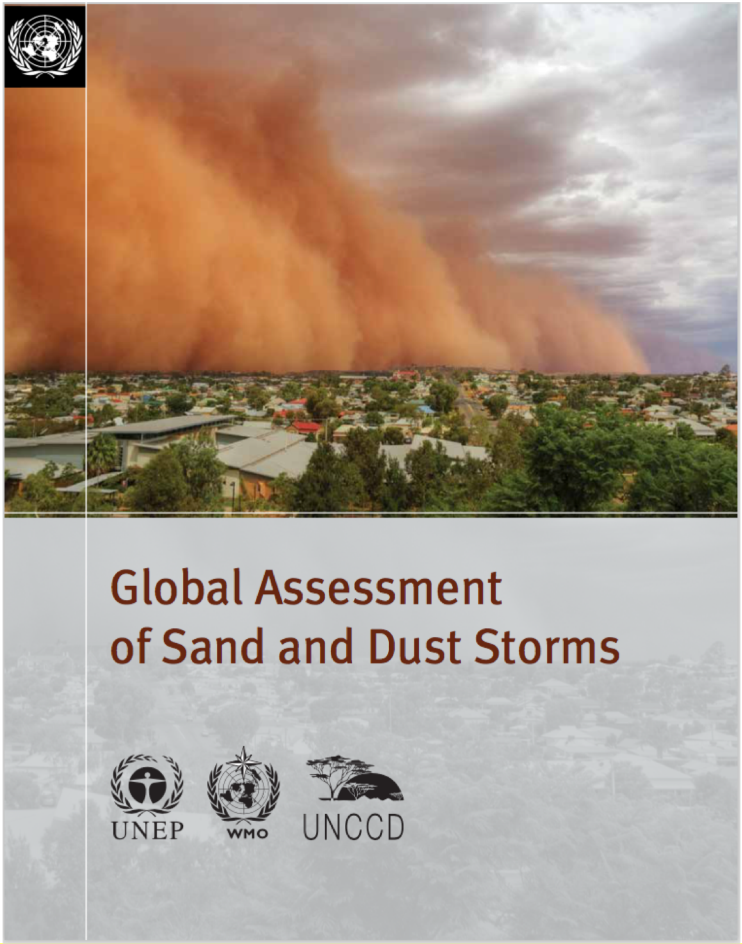
- Rapid increase in shale gas production (NO_x and VOCs);
- Shift of fuel use in power plants;

Challenges:

Unknown impact on emissions and air quality.

Dust Storms and Valley Fever

- Rapid increase in Valley fever infection (CDC, 2013);
- Increased Ca^{2+} deposition in rainfall (Brahney et al., 2013);
- Increased dust deposition in snowfall (Clow et al., 2016);
- Earlier onset of spring dust season (Hand et al., 2016);



Challenges:

1. **Need consistent and robust long-term dust trends;**
2. **Understand health impacts of increased dust activity.**

State Implementation Plan (SIP) Modeling

- **Modeling datasets (emission, meteorology, initial concentration, lateral boundary conditions, etc.);**
- **Natural event identification (wildfire, dust storms, stratospheric intrusion);**
- **Trans-boundary transport;**
- **Air quality of emission sectors;**
- **End of Season Emission Surge;**

Summary

Challenges	Outstanding Issues
1. Emission and air quality forecasting	Emission time lag; fire (time lag, intensity, injection height; gas species); dust; oil and gas; NH_3;
2. Major Socio-economic Events (Recession, Fracking)	Timely capture of emission changes; credible assessment of their impact on air quality (and human health);
3. SIP Modeling	Benchmark dataset; Reliable base case; boundary conditions; natural events (fire, etc).
4. Agriculture	Wind erosion over rangeland; Ozone over cropland; Seasonal outlook/forecasting;
5. Exposure	Long-term nose-level data records; PM2.5 chemical composition; real-time information for emergency response;