Creating Building Blocks for a More Dynamic Air Quality Management Framework

EPA STAR “Dynamic Air Quality Management” Kick-Off
Research Triangle Park, NC

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Research Team

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Research Plan/Objectives

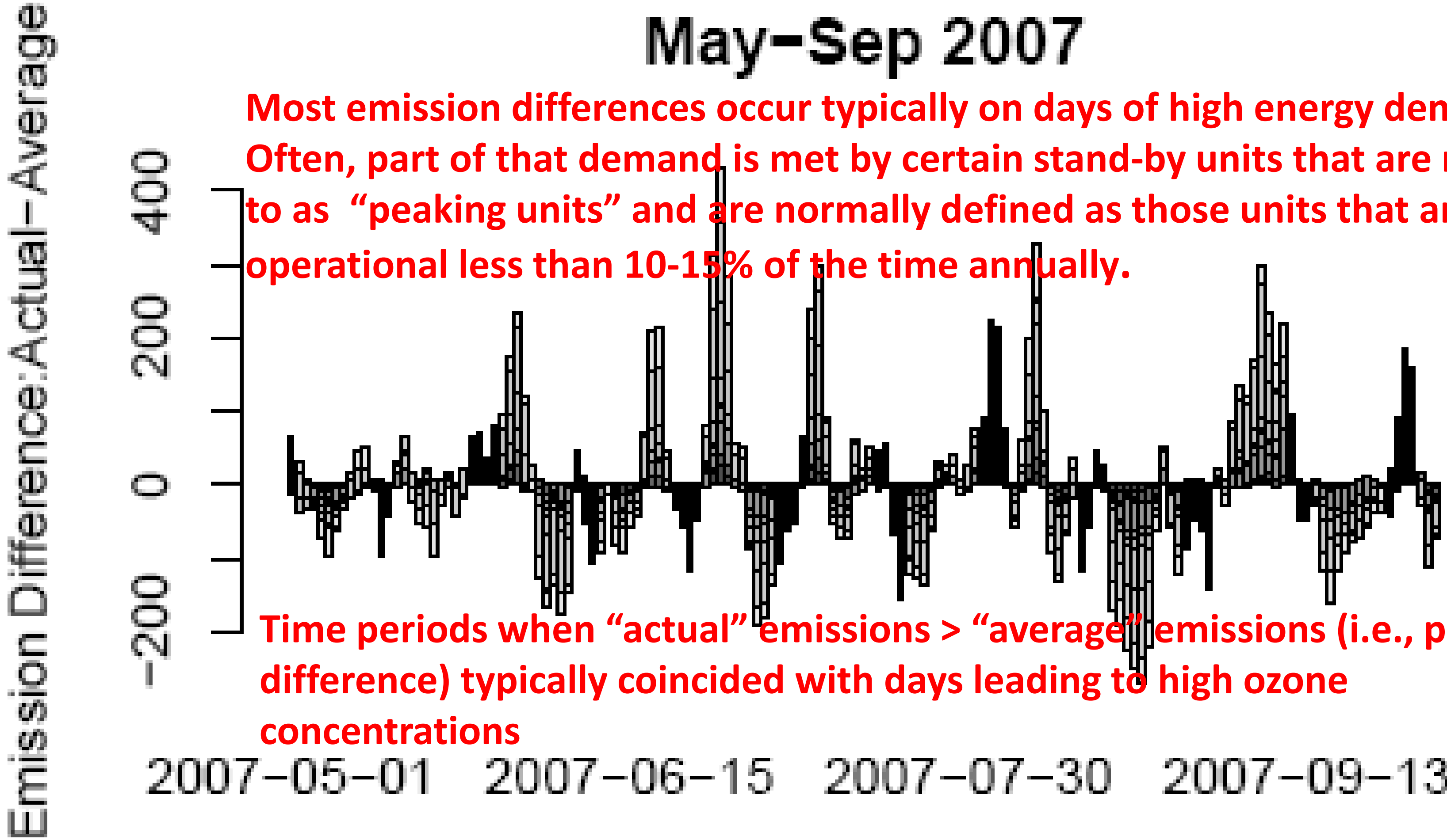
- Develop a prototype system to provide real-time information on the contribution of short-term emission sources to air quality
- Perform a comprehensive multi-pollutant air quality assessment that examines trends in pollutant concentrations versus emission controls and co-pollutant effects
- Develop possible indicators that aid in improved tracking of the effect of emissions controls.

Develop Real-Time Emission Estimates for Enhanced Air Quality Forecasting

- Analyze historic relationships (2001-2010) between meteorology and power plant emissions (CEM data) utilizing archived energy load forecasts and meteorological surface observations.
- Develop approaches for incorporating the relationship between predicted meteorology and emissions (power plant and mobile sources) into SMOKE.
- Incorporate emissions from "peaking units" by analyzing CEM data, assigning emission sources to one of three operating classes (>50%, 15-50% and <15%); peaking units fall within the <15% category.

NCEF-WRF/CMAQ Modeling Domain

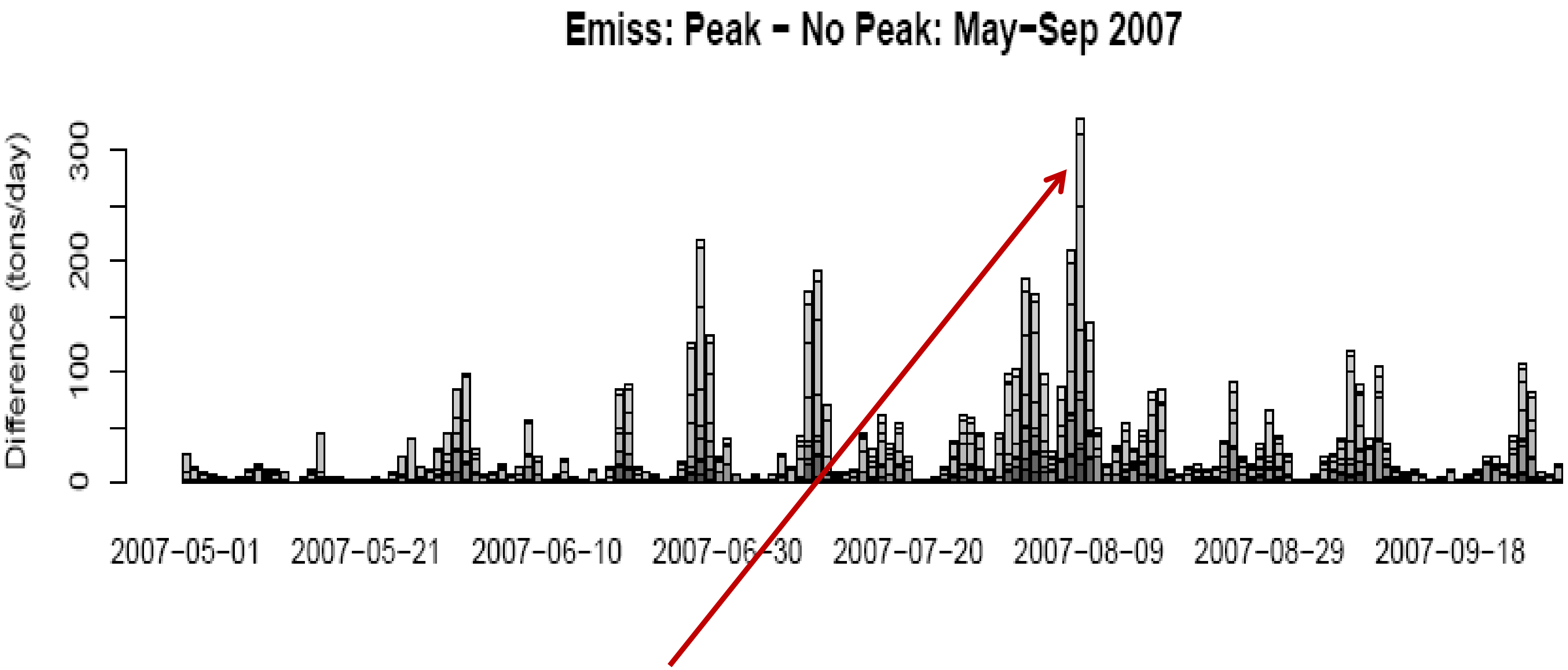
Differences in Daily EGU NO_x Emissions Across the MANE-VU Region: "Actual" versus "Average" Emissions



Most emission differences occur typically on days of high energy demand. Often, part of that demand is met by certain stand-by units that are referred to as "peaking units" and are normally defined as those units that are operational less than 10-15% of the time annually.

Time periods when "actual" emissions > "average" emissions (i.e., positive difference) typically coincided with days leading to high ozone concentrations

NO_x Emissions from "Peaking Units" in the MANE-VU Region: May to September 2007



Peaking unit emissions can be significant. For example, on 8/8/2007, the peaking units emitted nearly 350 tons/day of NO_x (~25% of total point source NO_x emissions within the MANE-VU region).

Quantifying the Effects of Episodic Control Measures Using AQFMS

- Enhance the current AQFM system (WRF/CMAQ) by integrating the Direct Decoupled Method (DDM) to estimate the effect of perturbations of selected emission sources on simulated air quality
- WRF/CMAQ DDM simulations will be configured to track individual and cross-sensitivities of pollutant concentrations to 1) all anthropogenic emissions; 2) mobile source emissions; 3) combined area and nonroad; 4) power plant peaking units; 5) all power plant emissions; 6) other point source emissions; and 7) biogenic emissions
- Sensitivity fields will be calculated separately for emissions from the greater NYC area, other areas in the MANE-VU region, and the rest of the modeling domain to isolate sensitivities towards local vs. regional emissions

- The WRF/CMAQ DDM sensitivity fields will be analyzed to quantify their temporal and spatial variations
- For days and locations with predicted O_3 or $PM_{2.5}$ exceedances, we will apply a reduced form model to estimate the O_3 and $PM_{2.5}$ concentrations resulting from a range of perturbed emission scenarios for every hour and grid cell covered by the CMAQ-DDM simulation. Of particular interest are the impacts of hypothetical episodic controls from peaking unit EGUs and traffic control measures aimed at reducing mobile source emissions.
- The planned analyses will provide information that may be relevant in building a more dynamic AQM framework in which some control measures are targeted towards predicted exceedance events.

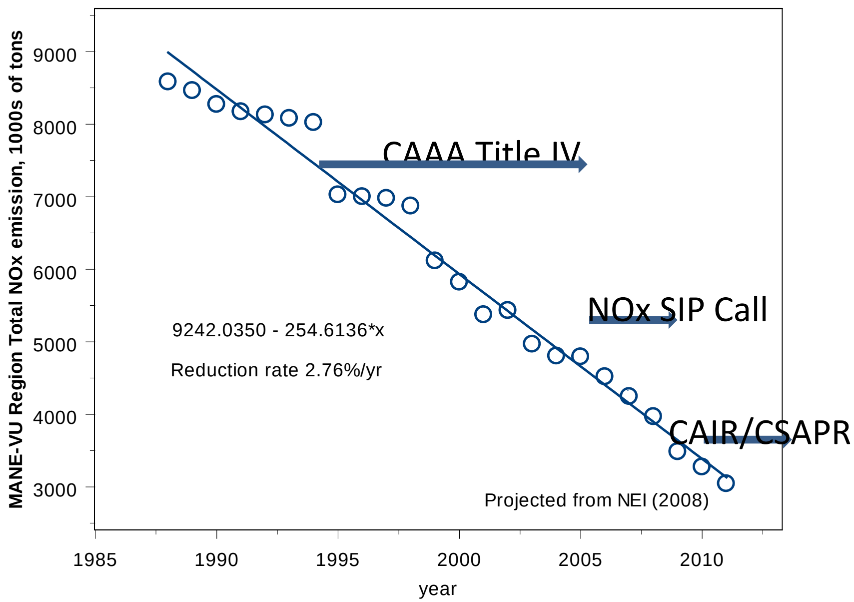
Comprehensive Multi-Pollutant Air Quality Assessment

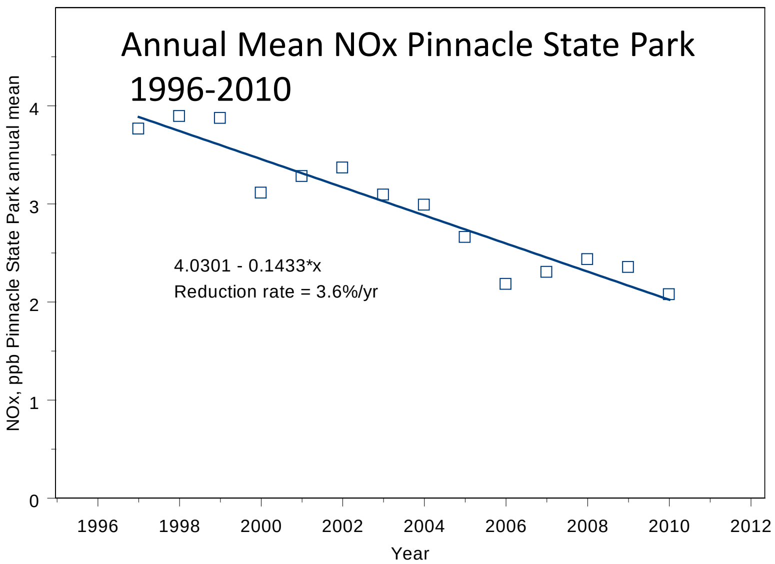
- Review and Analysis of Emission Trends
- Multi-Tracer Relationships as Indicators of Emission Controls
- Tracking Ozone Air Quality in Response to NOx-CO-VOC precursor Trends
- Integrating Results into a Dynamic AQ Management Plan

Measurement Sites

Urban: Queens College, Bronx, NY; Suburban: Rochester, NY ; Rural: Whiteface Mountain and Pinnacle State Park, NY, Thompson Farm, NH

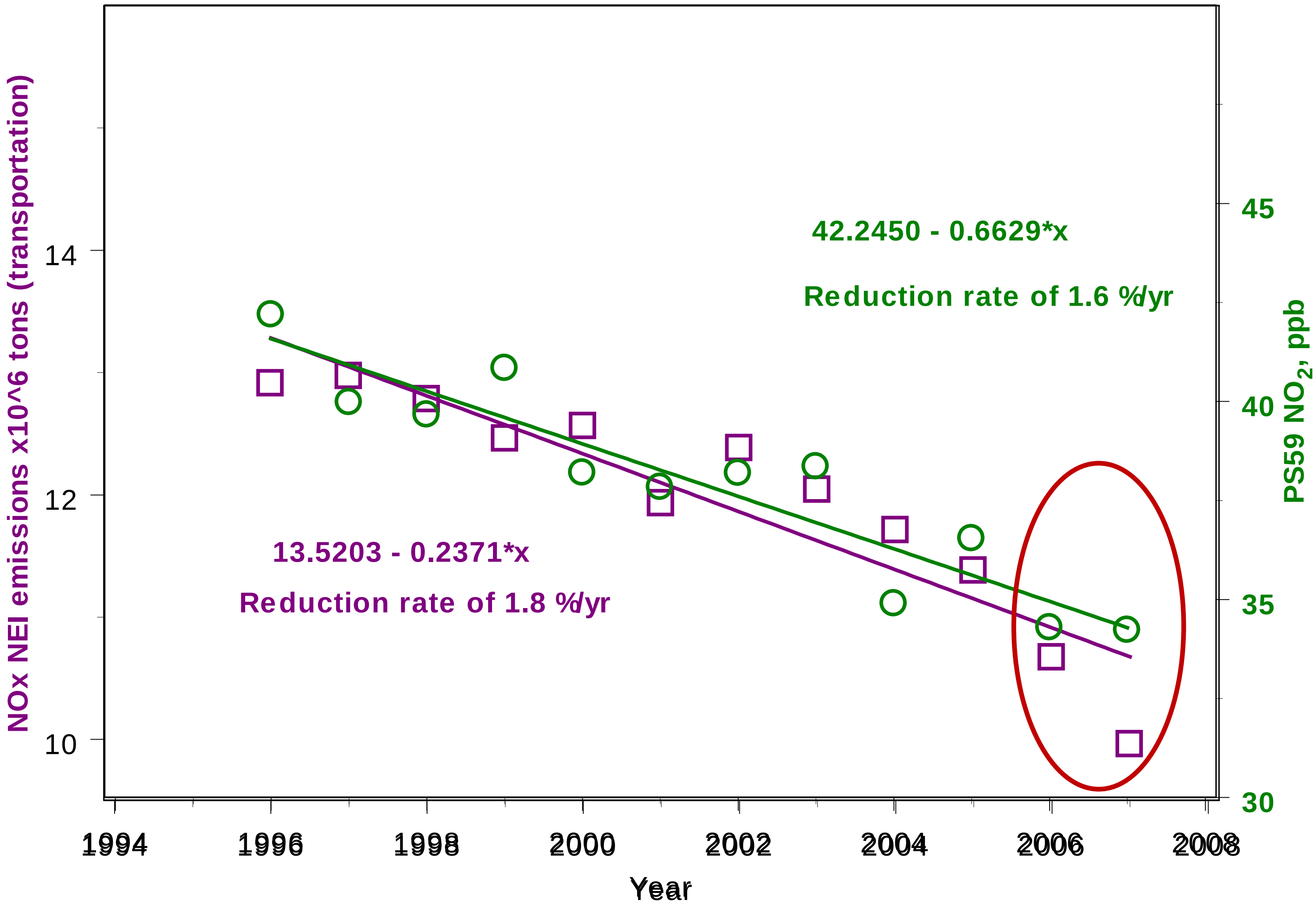
Review and Analysis of Emission Trends



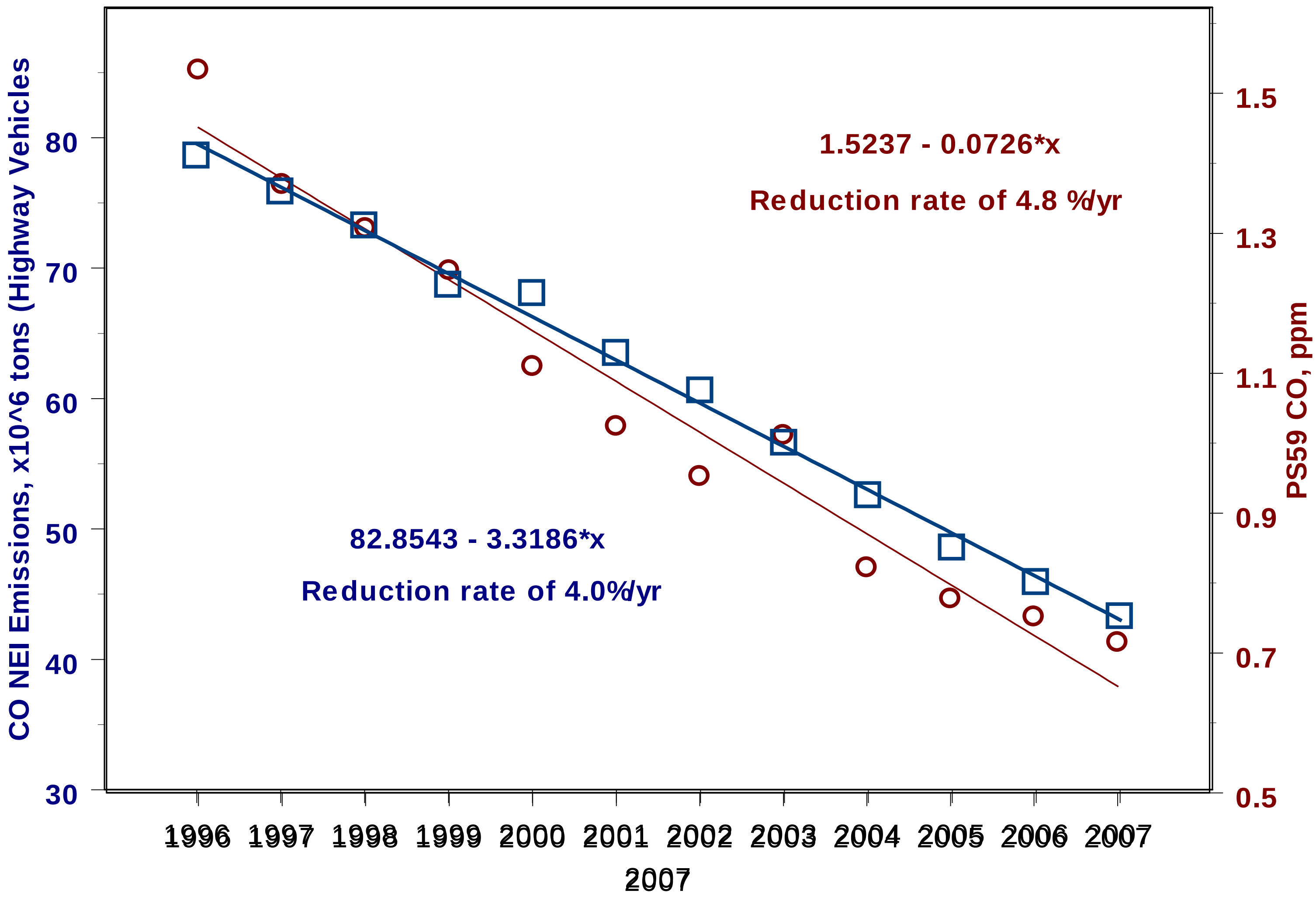


Trends in estimated NOx emission reductions in the N.E. are significant and consistent with reductions observed in NOx/NO2 ambient concentrations.

NEI Annual NOx Transportation Emission vs. NO_2 Trend PS59 (1996-2007)



NEI Annual CO Highway Emission vs. Concentration Trend (1996-2007)



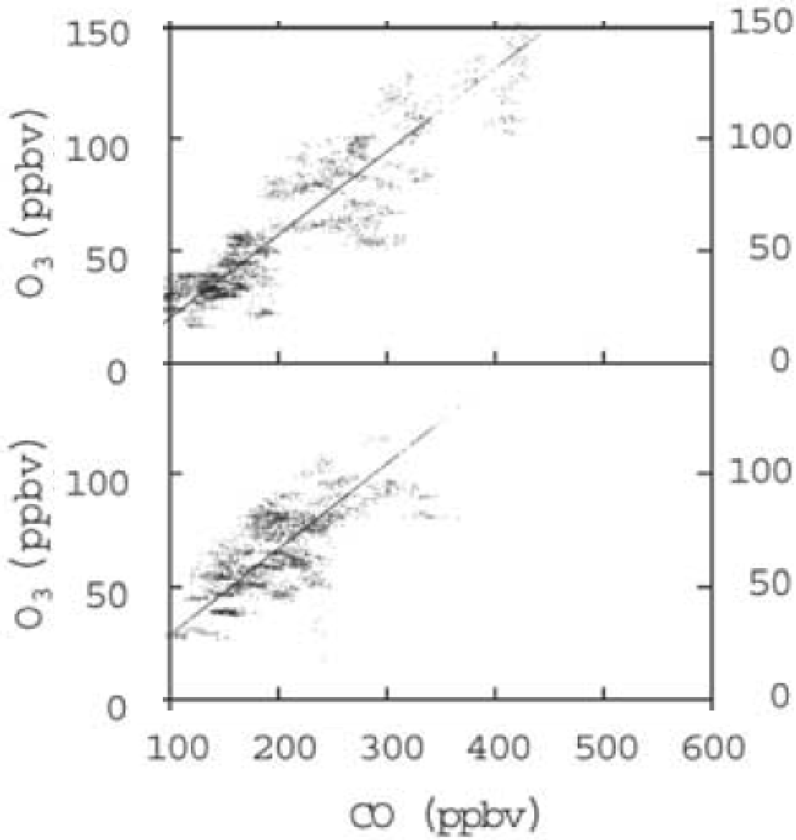
Multi-Tracer Relationships as Indicators of Emission Controls

- Identify trends in CO-O_3 correlation and NOy-O_3 correlation at these sites and investigate their implications on ozone production considering trends in CO and NOx emissions in the northeastern U.S.
- The slope value of summertime CO-O_3 and NOz-O_3 positive correlation can be used to estimate the influence of exported anthropogenic pollutants and the efficiency of photochemical O_3 production (Parrish et al., 1993, 1998; Mao and Talbot, 2004).

Local afternoon in summer 2002, Thompson Farm, NH

Easterly to Southerly Quadrant

Southerly to westerly Quadrant



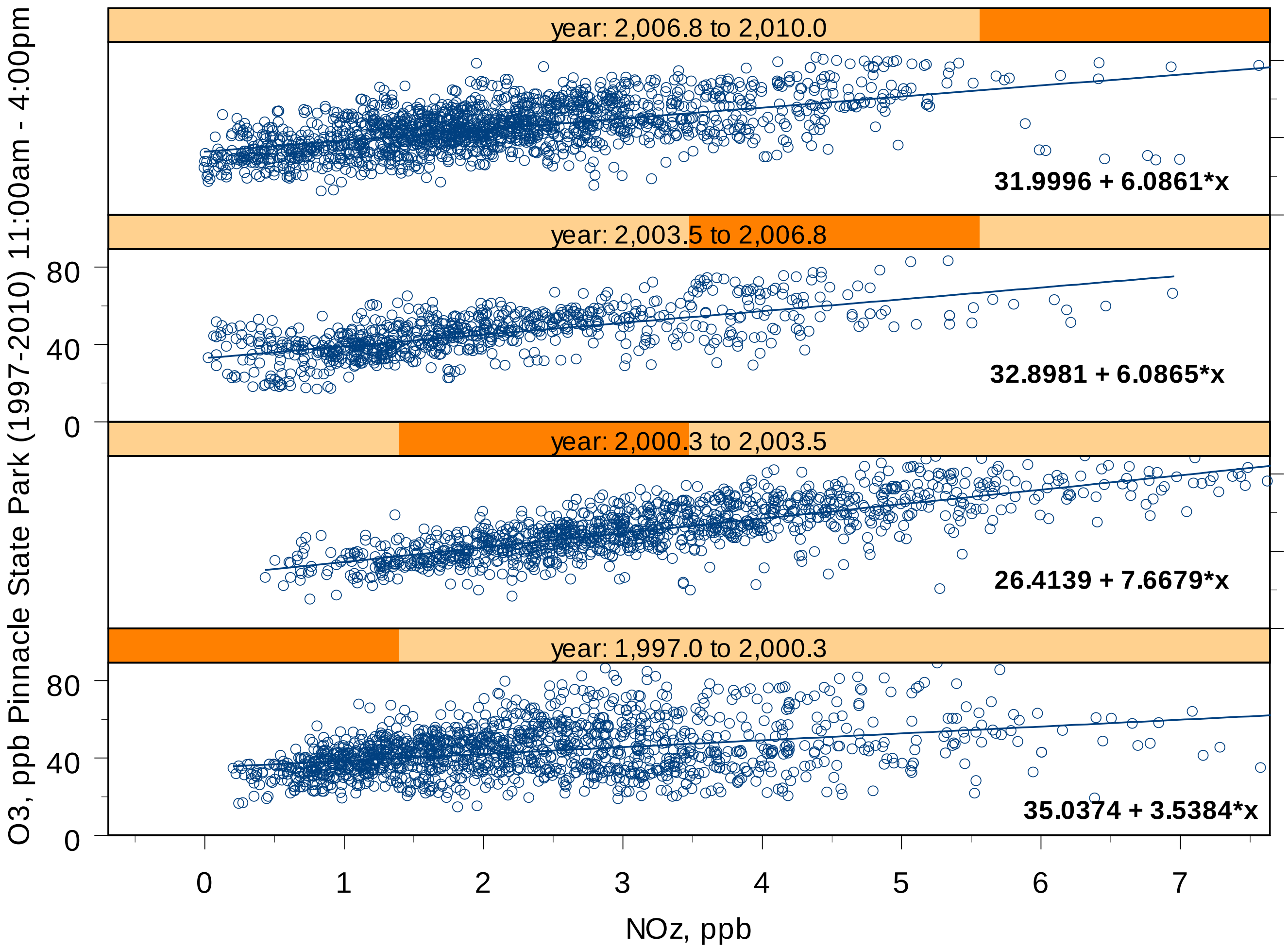
- ➢ Linear correlation between O_3 and CO in air masses, transported via easterly to westerly flows from the NE corridor and possibly Mid-Atlantic States, that had undergone photochemical evolution.

- ➢ Slope values ~ 0.30.

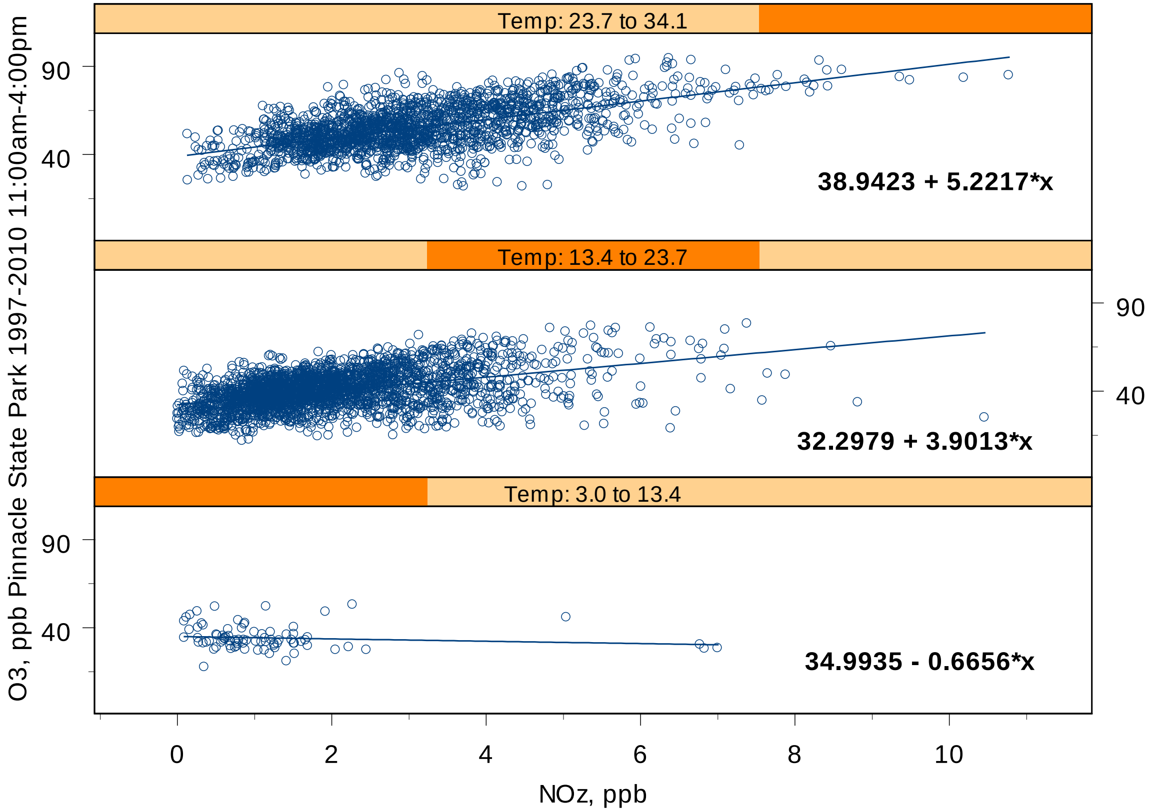
Mao and Talbot (2004, JGR)

❖ **Has this slope value changed over the summers of 2001 – 2010 considering the decline trends in CO and hydrocarbon emissions in NE US?**

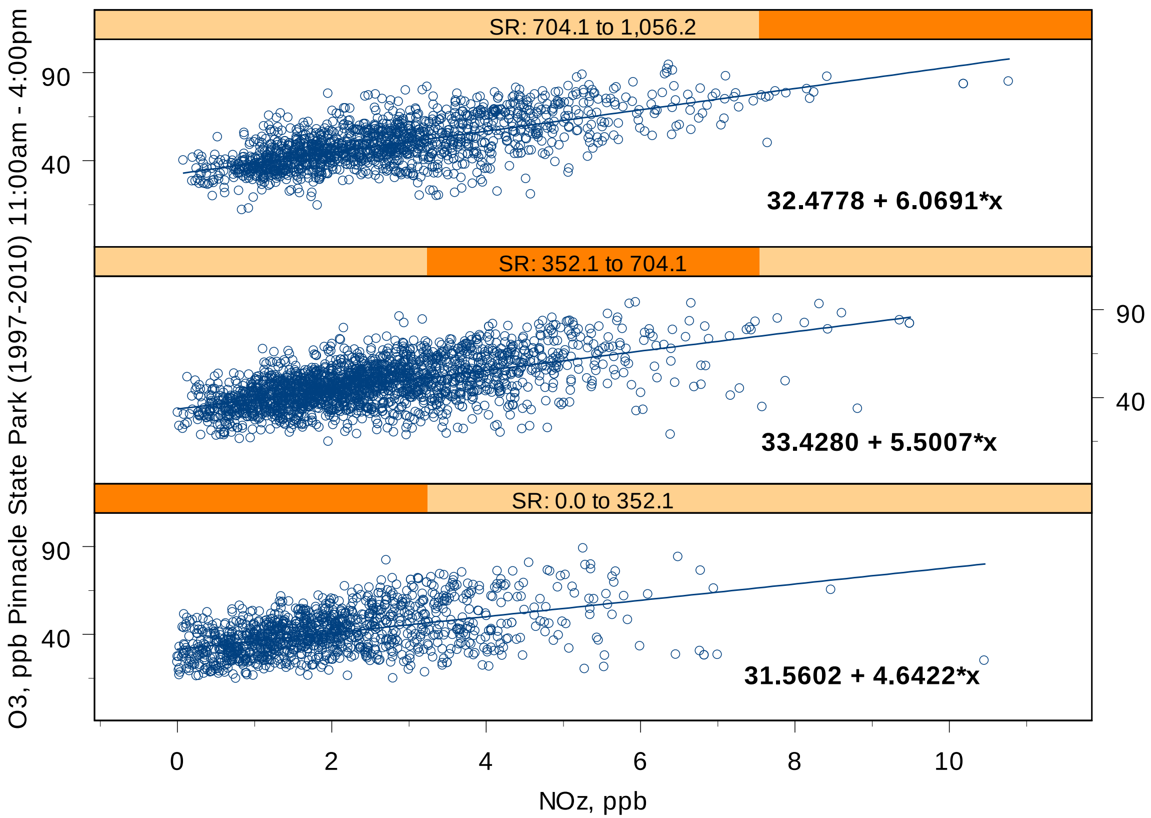
Ozone Production Efficiency 1997-2010
PSP June - August, hrs: 11am–4pm



Ozone Production Efficiency PSP June - August, hrs: 11am–4pm (1997-2010) vs T



Ozone Production Efficiency PSP June - August, hrs: 11am–4pm (1997-2010) vs. SR



- Quantify and separate the contributions from trends in emissions and inter-annual variability in trace gases directly emitted from anthropogenic sources.

Season of interest: Winter

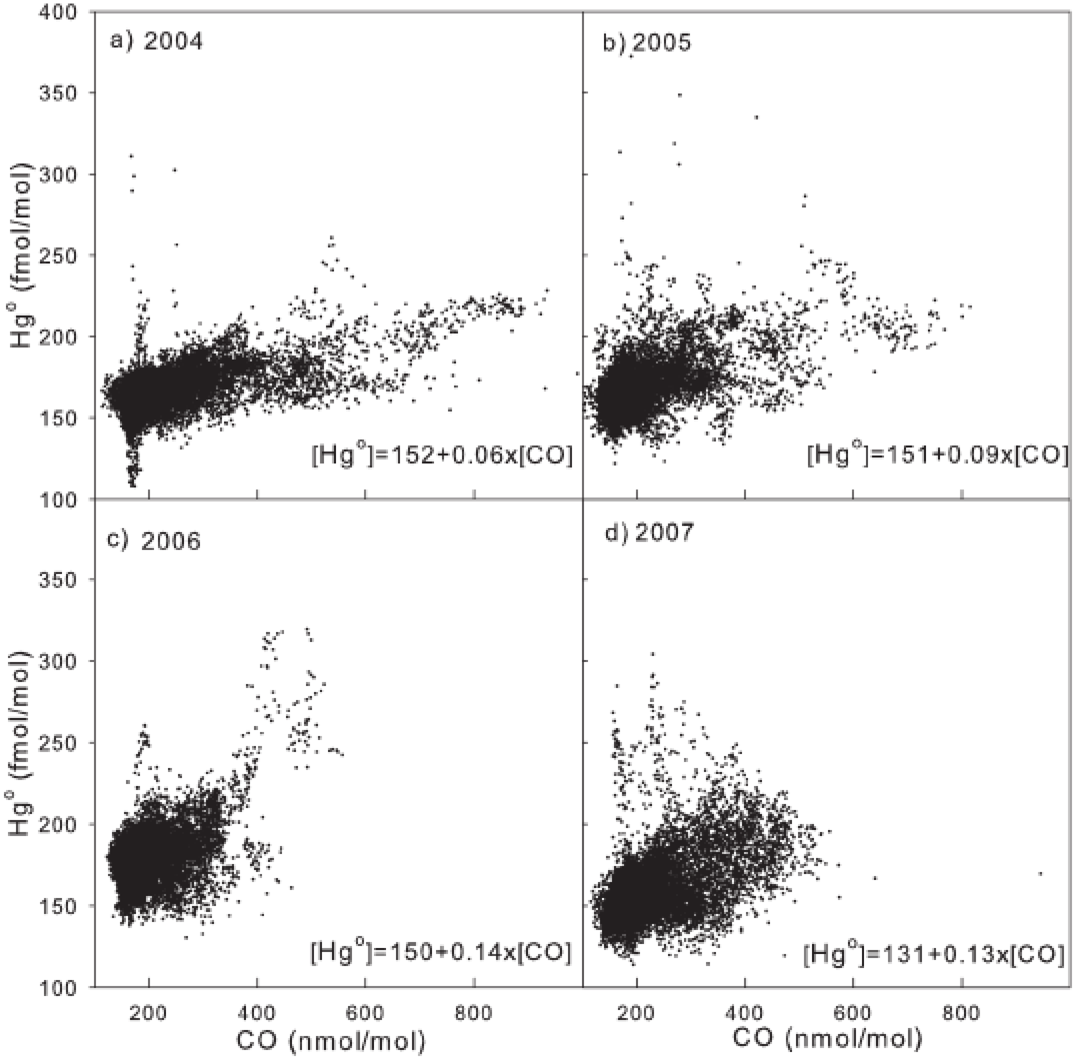
-- To minimize confounding issues with natural sources

1) Hg^0-CO

2) CO-CO_2

3) CO – selected VOCs

Hg° vs. CO mixing ratios at Thompson Farm, NH during winters 2004 **(a)**, 2005 **(b)**, 2006 **(c)**, and 2007 **(d)**.



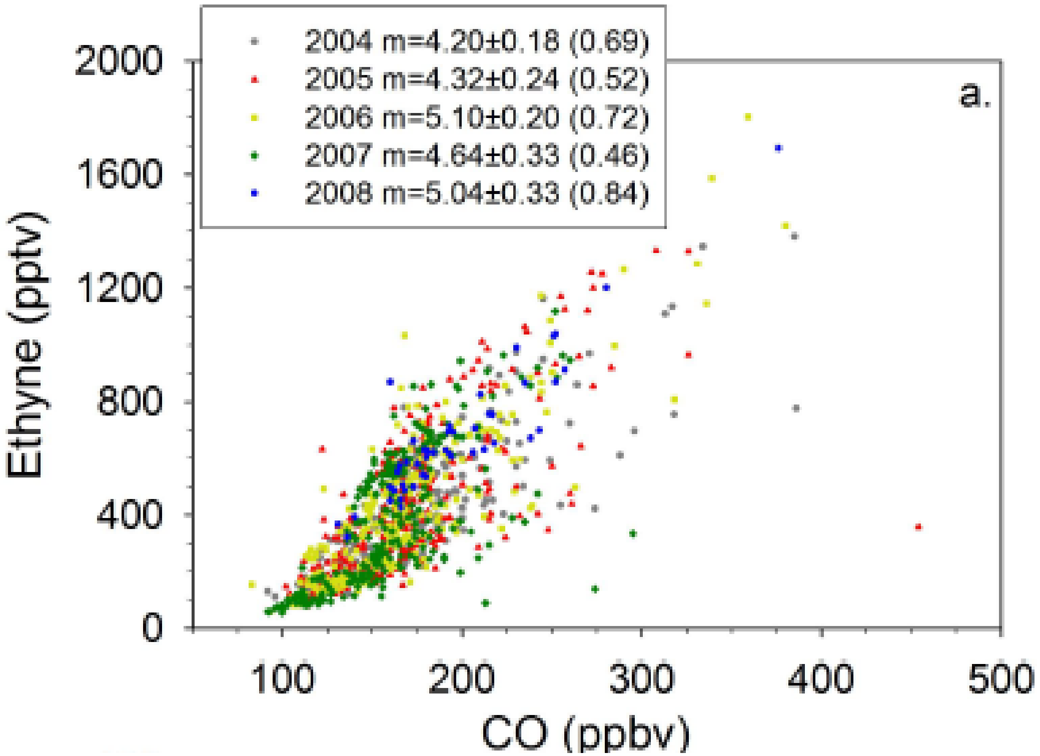
Slope values:

0.06 → 0.14

Climate, and/or trends in CO emissions?

Mao at el. (2008, ACP)

CO vs. C_2H_2 at Thompson Farm, NH During 2004 - 2008



Russo et al. (2010, ACP)

- Slope values : 4.2 pptv/ppbv in 2004 → 5.0 pptv/ppbv in 2008

Project Schedule

	Project Quarter											
Obtain and Assemble Data Sets for Track 1												
Develop Real-Time Emission Estimation Methods												
Quantify the Effects of Episodic Control Measures												
Obtain and Assemble Data Sets for Track 2												
Emission Analysis												
Multi-Tracer Analysis												
Analysis of Changes in O_3 and its Precursors												
Incorporating Results Into the AQM Framework												
Annual and Final Reporting												

Oct2012

Thanks For Your Attention