RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

Transport and formation of secondary pollutants in New Jersey

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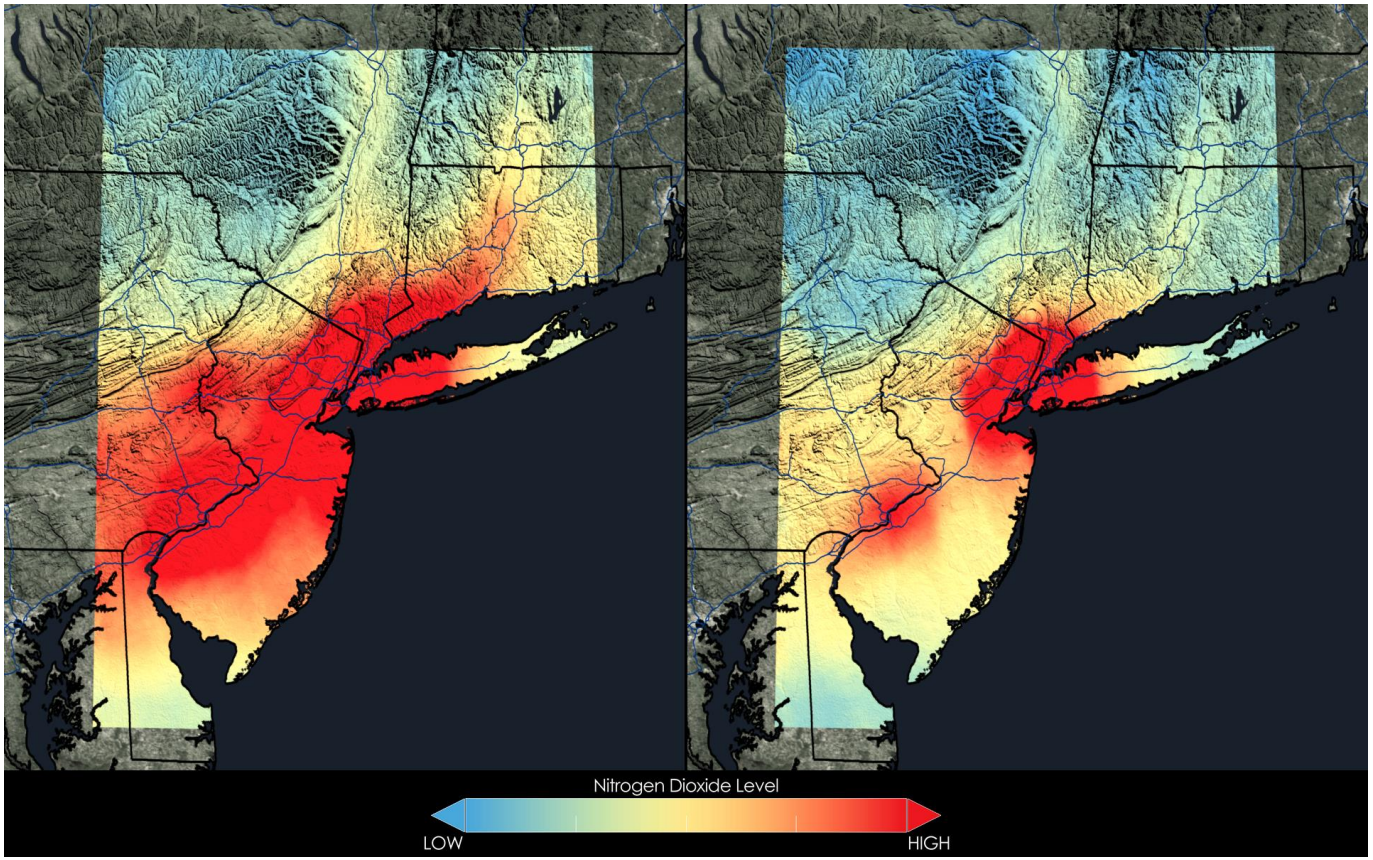
Clean Air :: Historical Perspective

Chester Higgins Jr., 1973

John O'Connell, 2008

AQ improvement seen from space

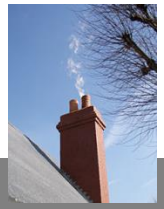
2005-2007 **2009-2011**

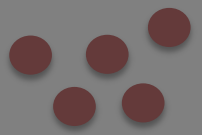


Encouraging but NJ **NOT** doing as well as the country overall

http://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/

Secondary Formation



VOC + Oxidant (O_3, OH, NO_3,…) → Products → O_3 + 

KOknockout920 at English Wikipedia

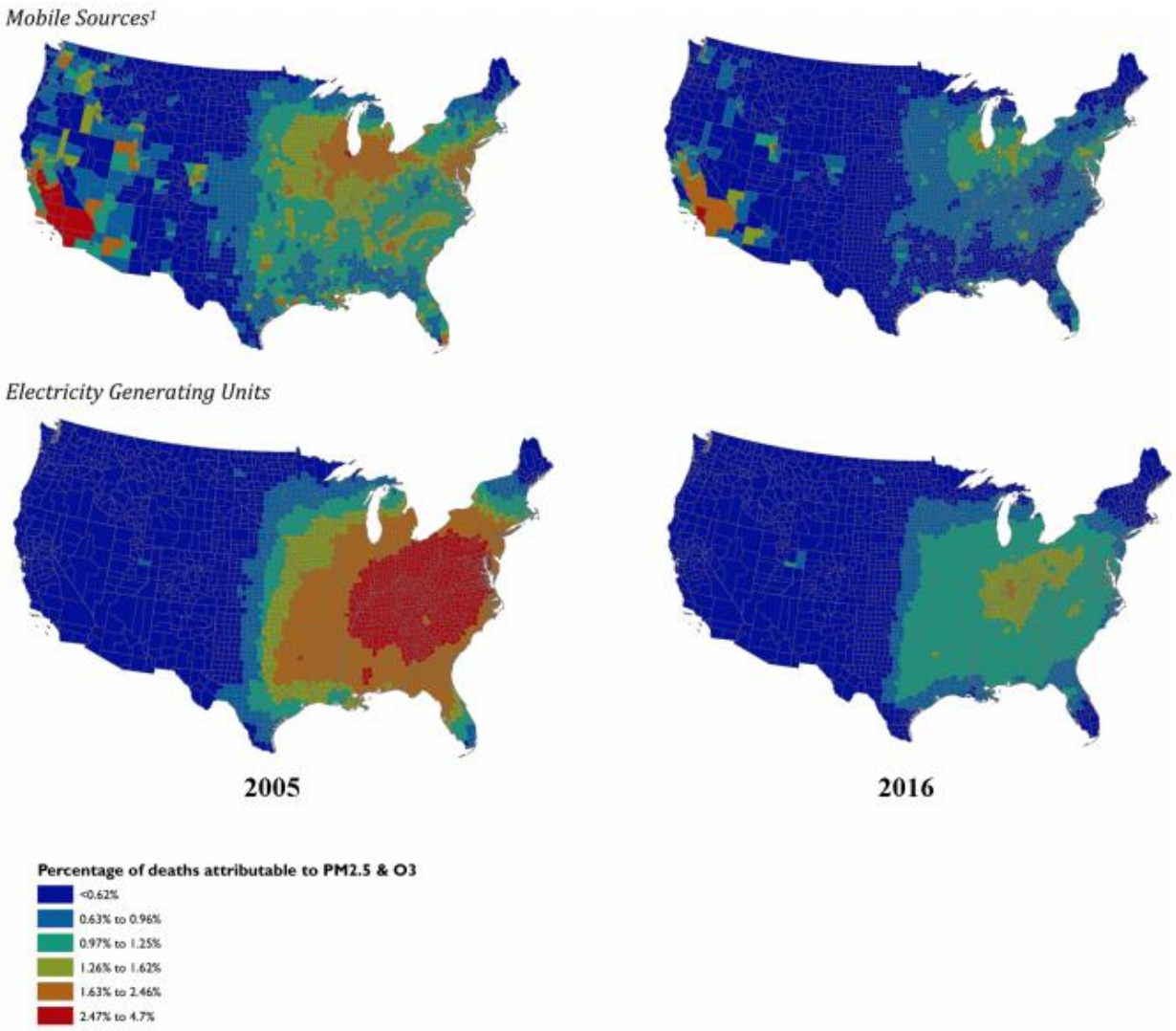
Ozone and fine particulate matter ($PM_{2.5}$)

Human health: premature death, variety of illness, increased autism risk (Brook et al, 2004; WHO, 2014; Raz et al., 2014)

Food and security: air pollution reduces crop yields (Avnery et al, 2011, 2013; Klingberg et al., 2011; Tai et al., 2014; Pentagon 2014)

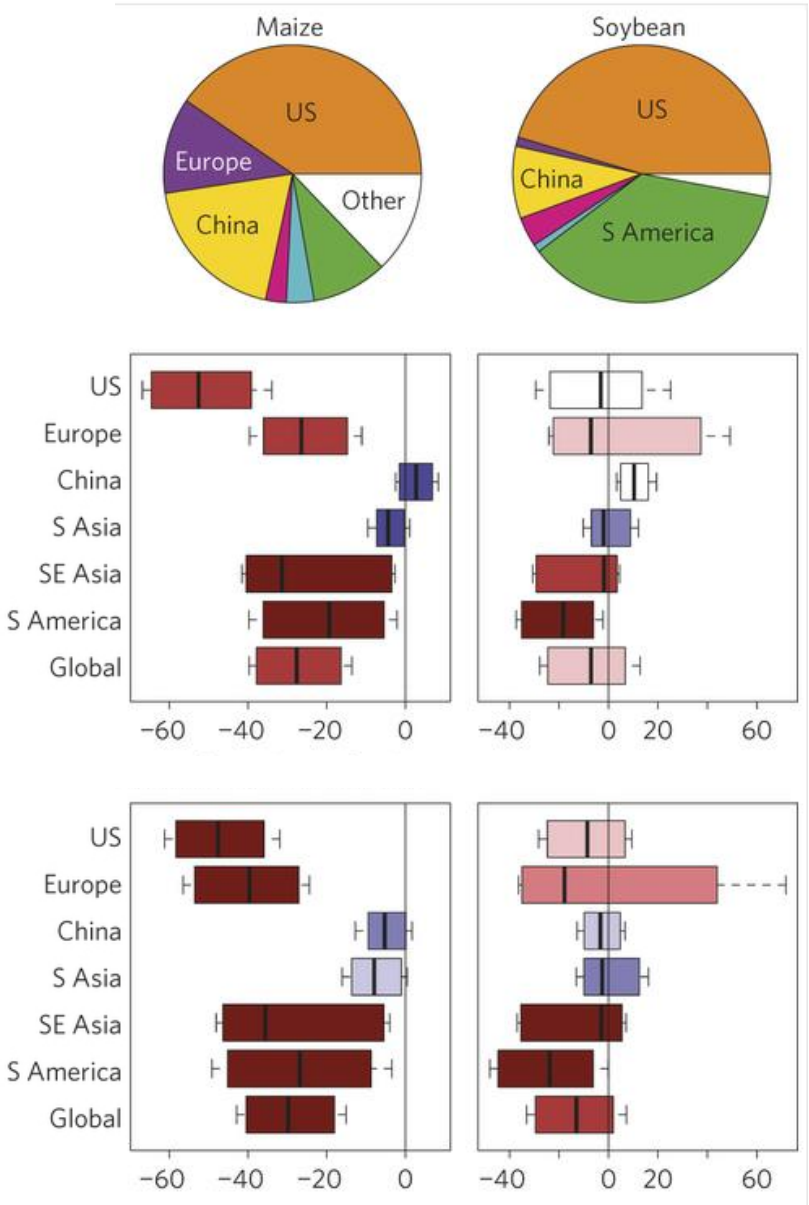
A variety of negative economic impacts from non-priced externalities arise from emission choices

Percentage of annual all-cause deaths from $PM_{2.5}$ & O_3: EGUs and motor vehicles



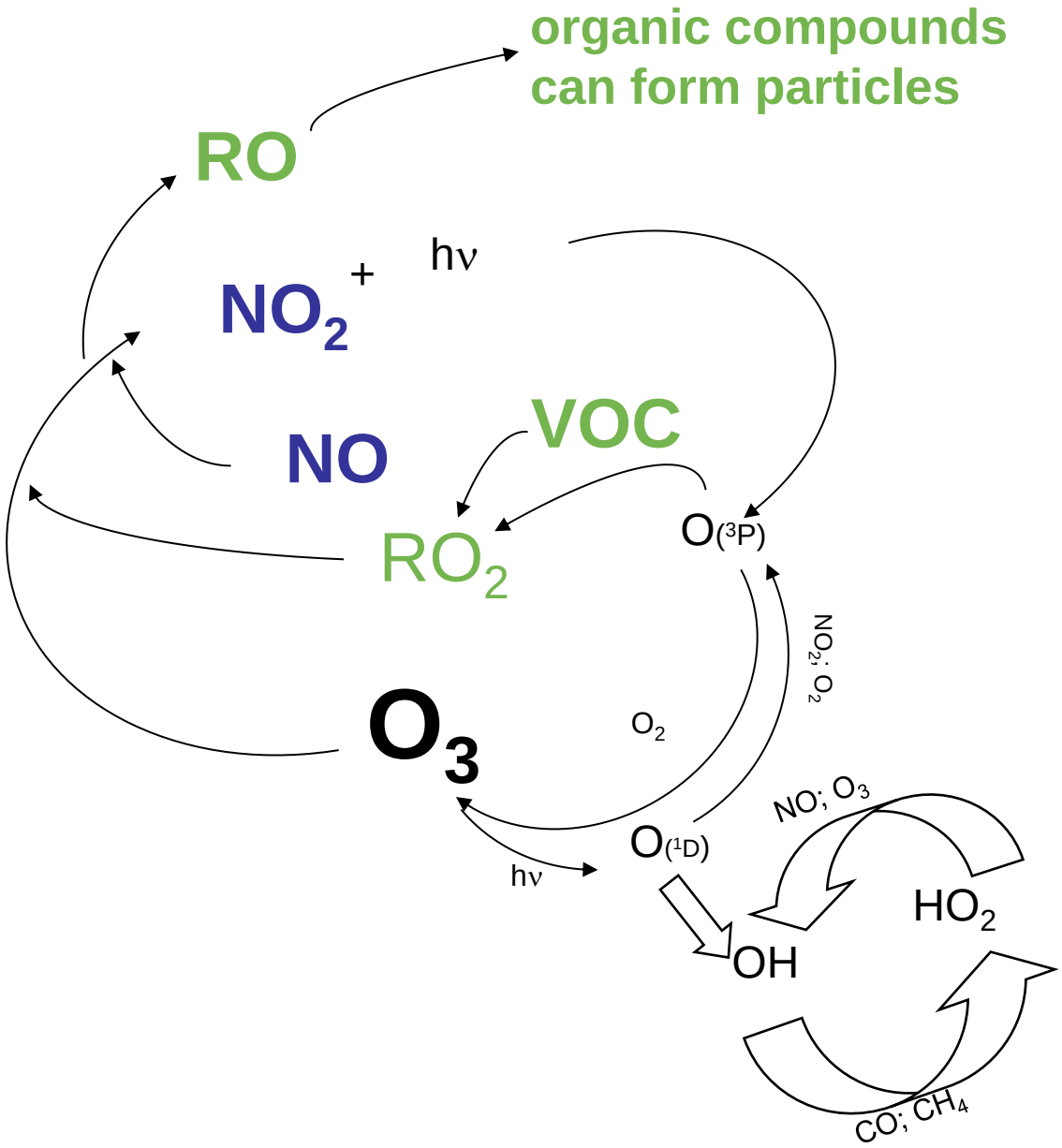
Fann et al., “Recent and future health burden of air pollution apportioned across U.S. Sectors”, *Environmental Science & Technology*, 2013.

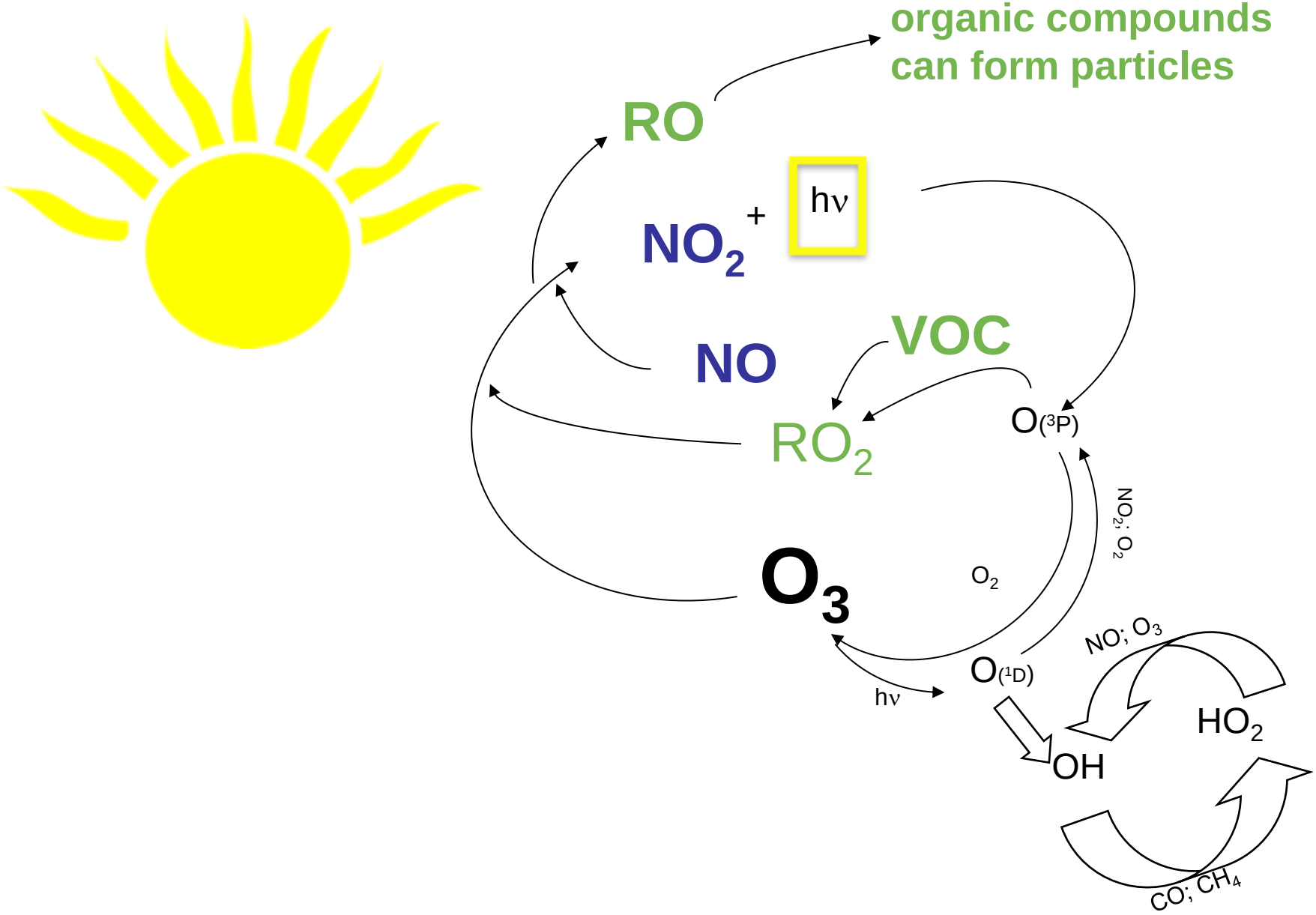
Tai et al., “Threat to future global food security from cliamte change and ozone air pollution”, *Nature Climate Change*, 2014



Projected (2000-2050) % change in production

Simplified mechanism




organic compounds
can form particles
RO
hν
NO2 +
NO
VOC
RO2
O(3P)
O3
O2
NO2; O2
O(1D)
hν
NO; O3
HO2
OH
CO; CH4

organic compounds
can form particles

RO

NO_2 + hν

NO

VOC

RO_2

$O_{(^3P)}$

O_3

O_2

NO_2; O_2

$O_{(^1D)}$

hν

NO; O_3

HO_2

OH

CO; CH_4

Traditional understanding of controls on O_3

Urban areas **VOC-limited** for **O_3 Production** → limit VOC emissions

Los Angeles, San Francisco, Phoenix and New York City

(Milford et al., 1989,1994; Kleinman et al., 2000; Harley et al., 1993; Kleinman et al., 2005; Steiner et al., 2006)

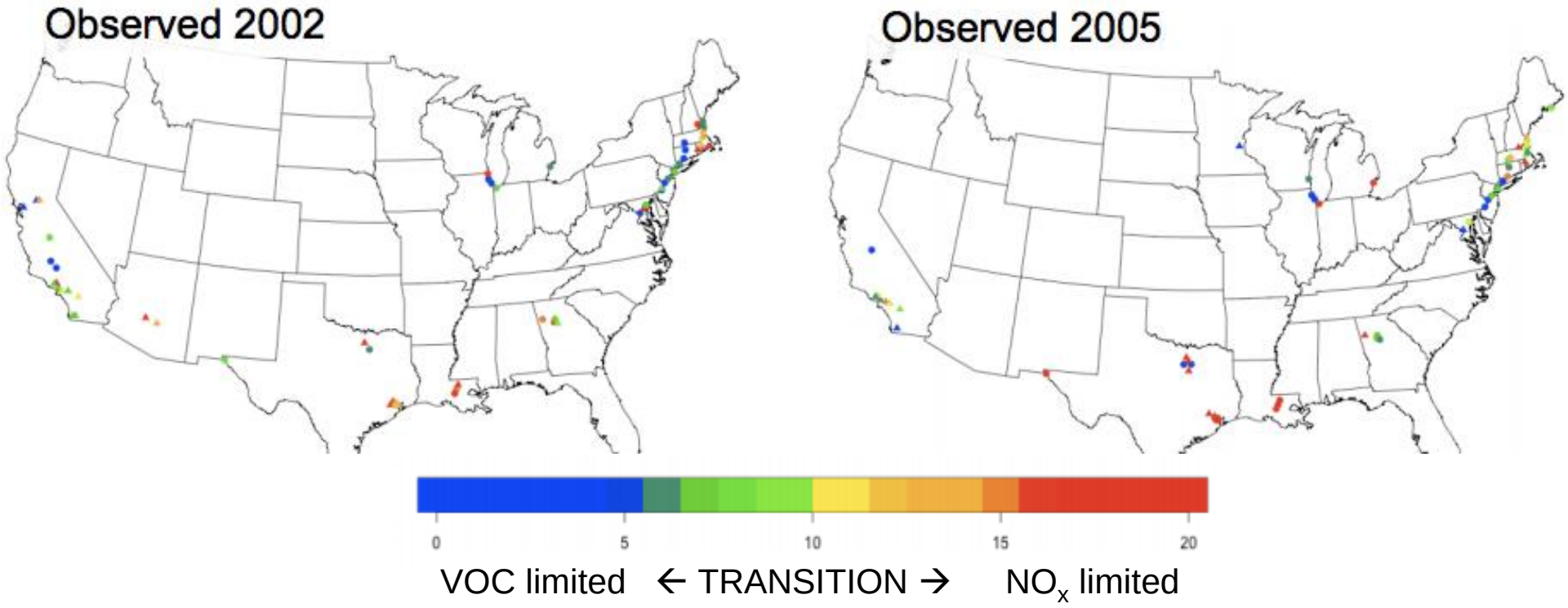
Rural/suburban NOx-limited for O_3 Production → limit No_x

Rural/suburban areas and urban centers in close proximity to an intact biosphere, e.g., Atlanta and Nahsville (Milford et al., 1989; 1994; Sillman 1995; Daum et al., 1996; Kleinman et al., 2005)

NOx- and VOC-limited → combination of approaches

Houston and Philadelphia (Daum et al., 2004; Kleinman et al., 2005)

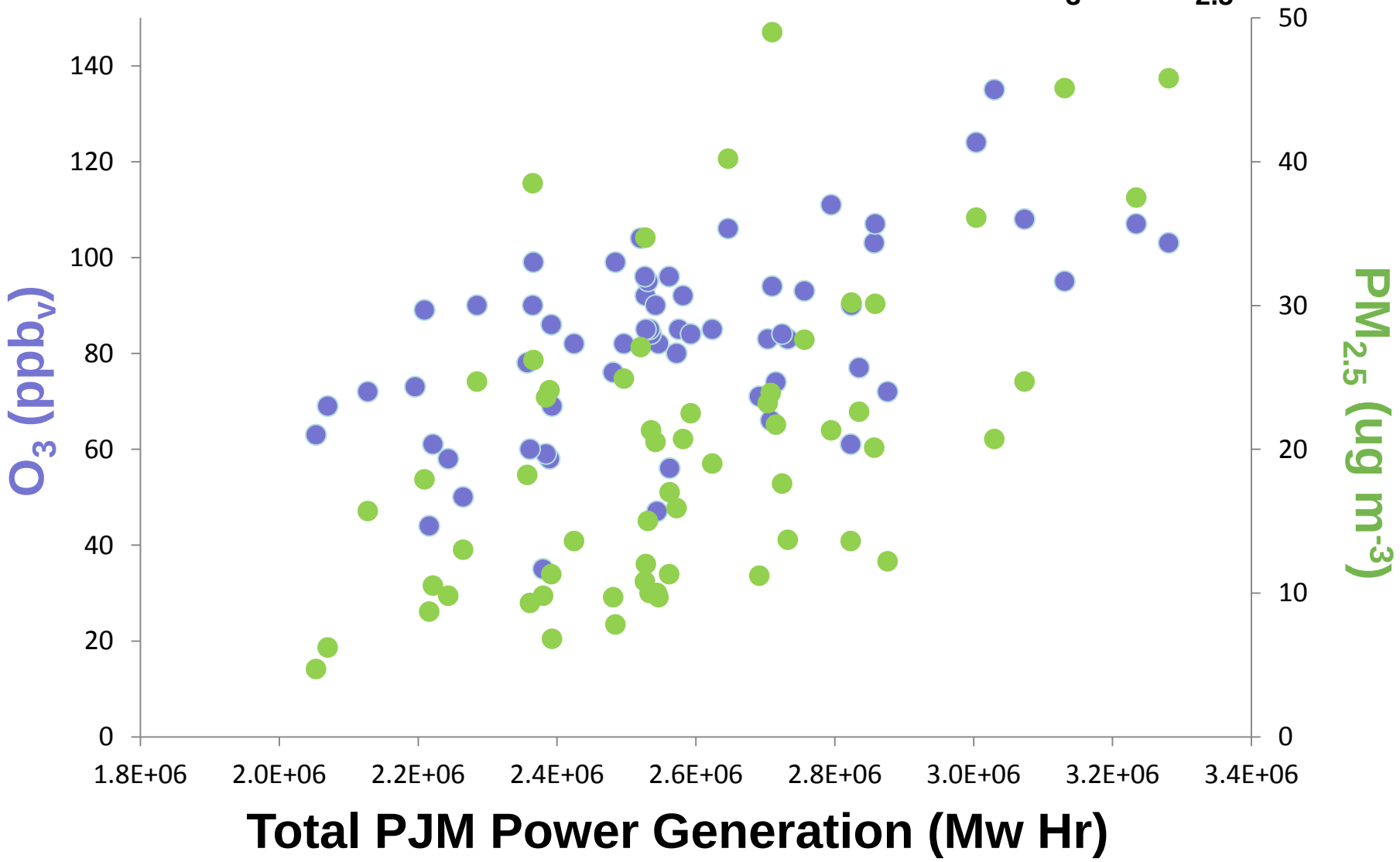
VOC:NO_2 when $[O_3]$> 70ppm



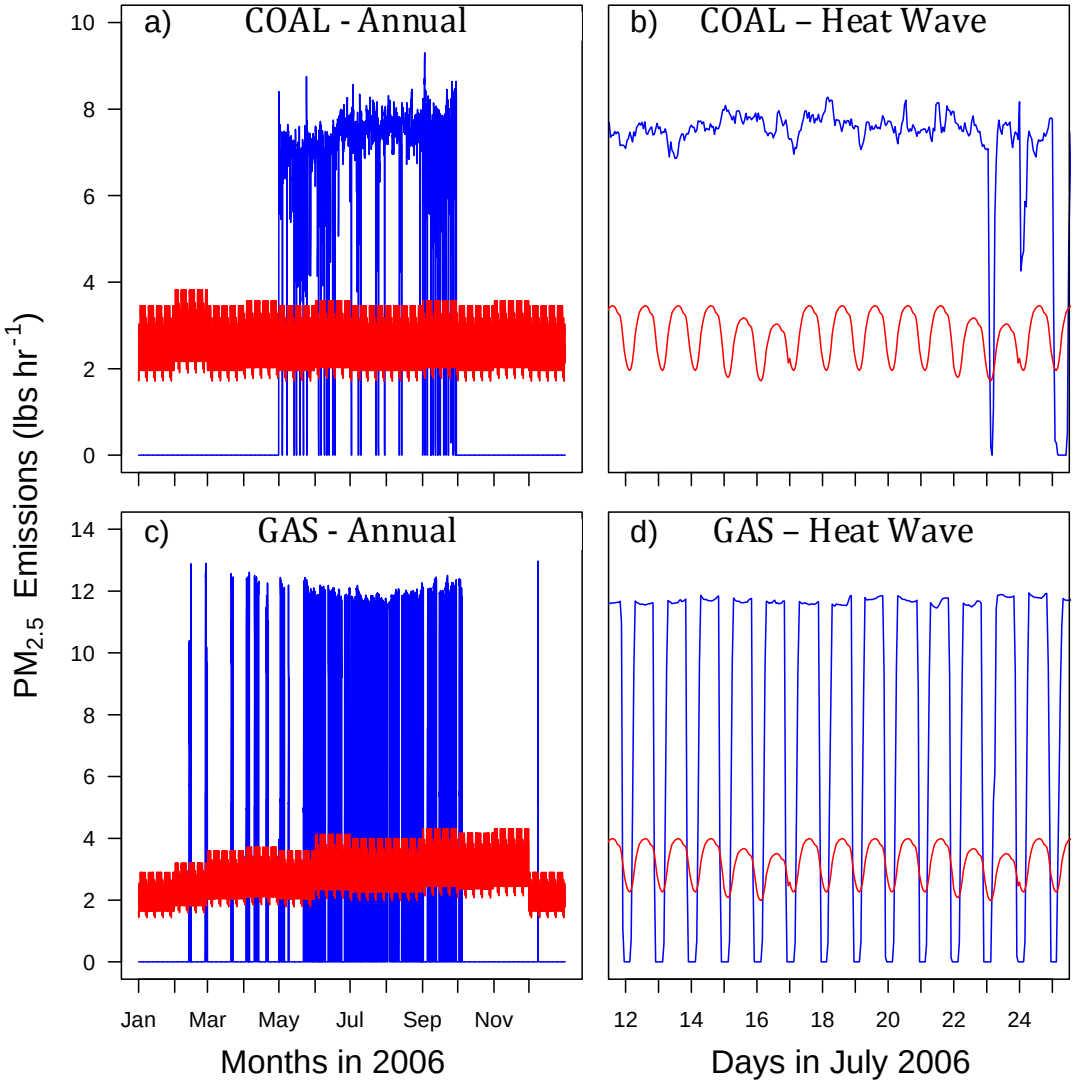
Nominal photochemical regime at **peak** $[O_3]$ different than '**average**' conditions: time of day, day of week

Baker and Carlton, 2010

Total PJM Power Generation Correlates with Measured O_3 & $PM_{2.5}$ in NJ



Farkas et al., *Environ. Sci. Technol.*, 2010

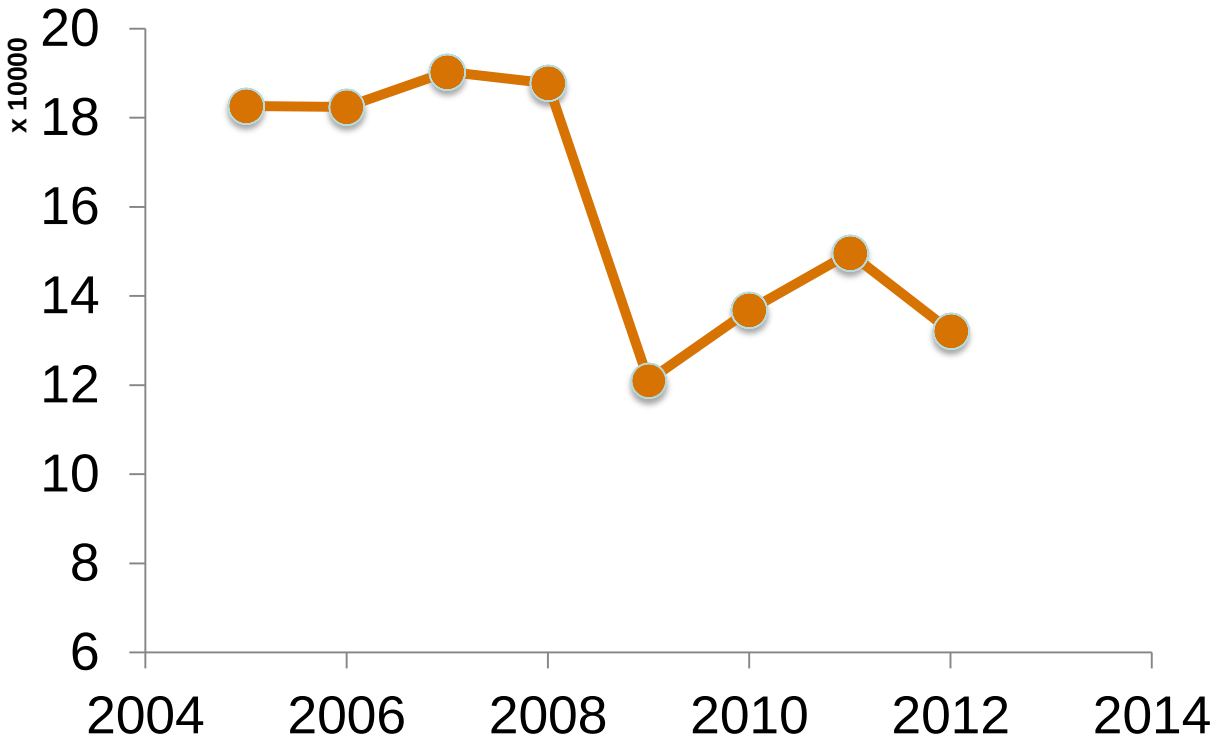


Current AQ evaluation and modeling techniques not aimed at the peak conditions that drive NAAQS non-attainment and negative impacts.

Default profile in EPA's SMOKE model vs. Carlton group application of CEM data

Farkas et al., *Environ. Sci. Technol.*, 2010

Annual Total
PA NO_x
emissions
(tons yr^{-1})



Annual Total
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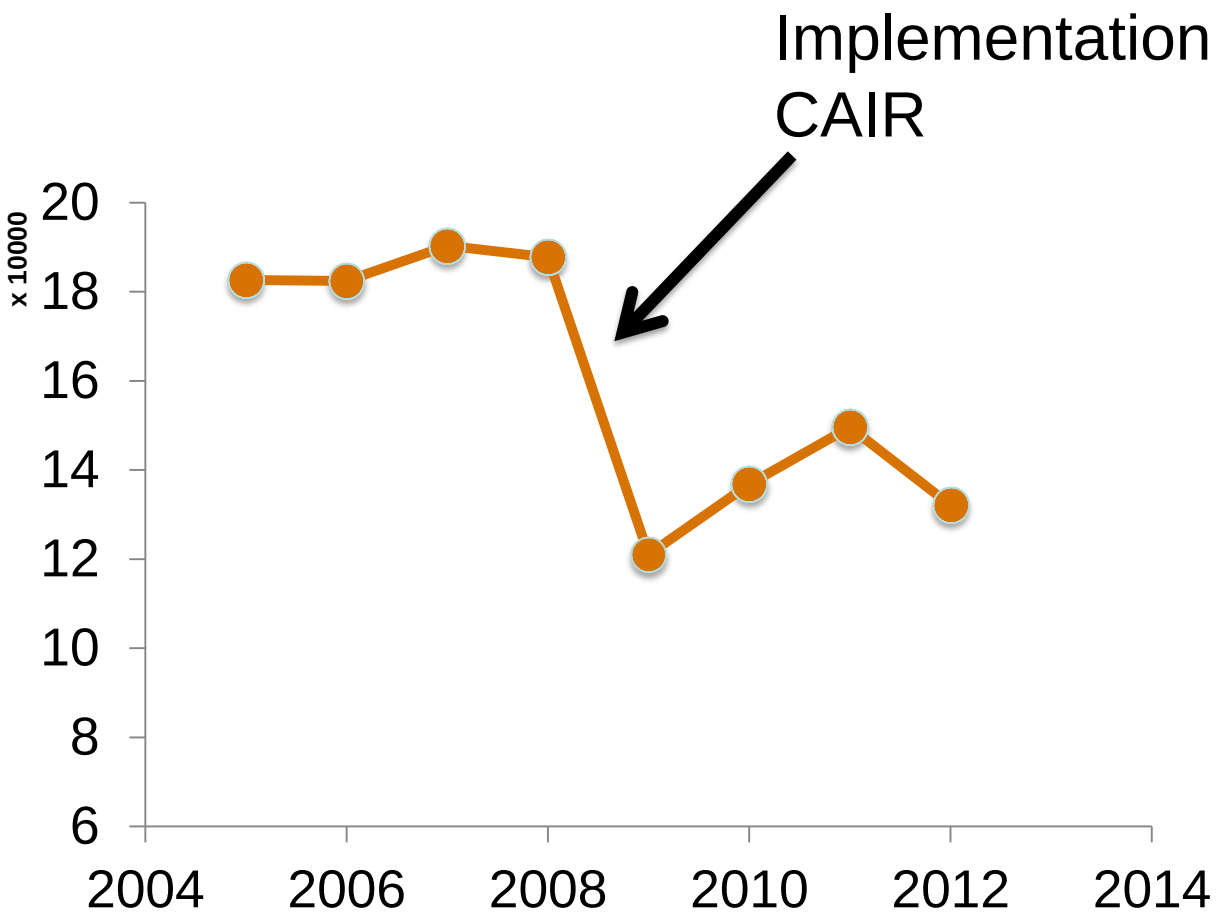
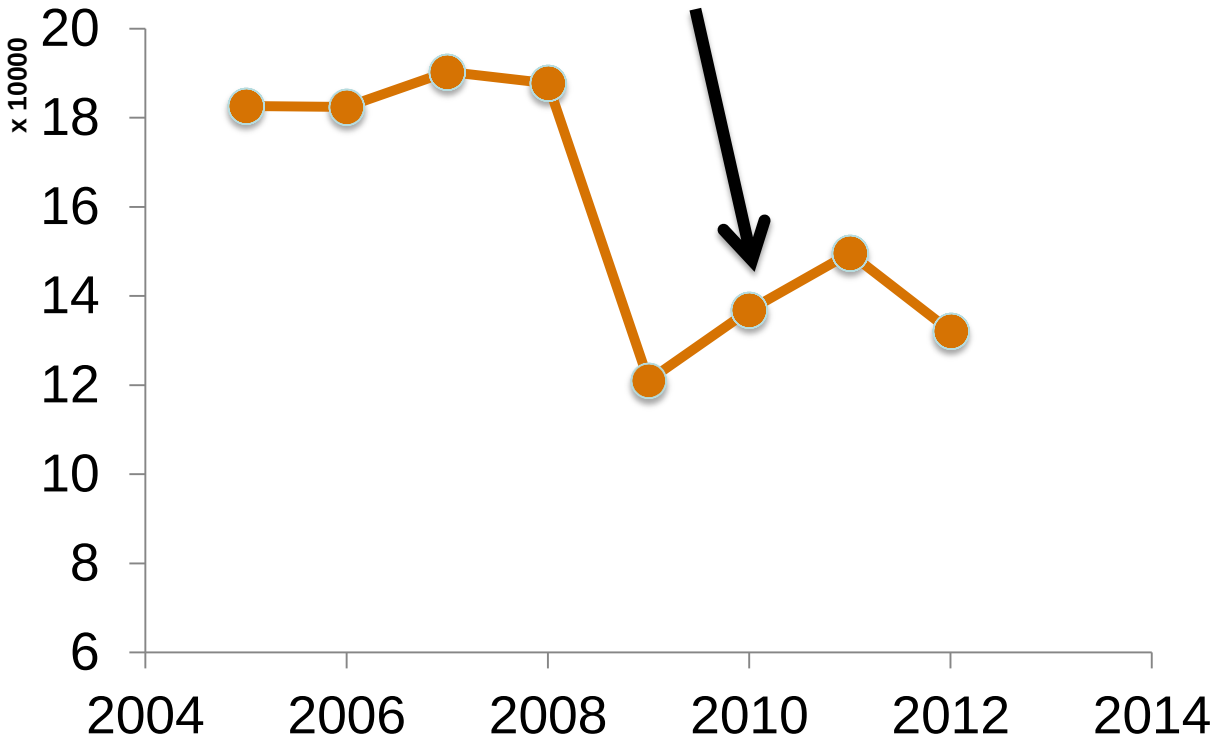
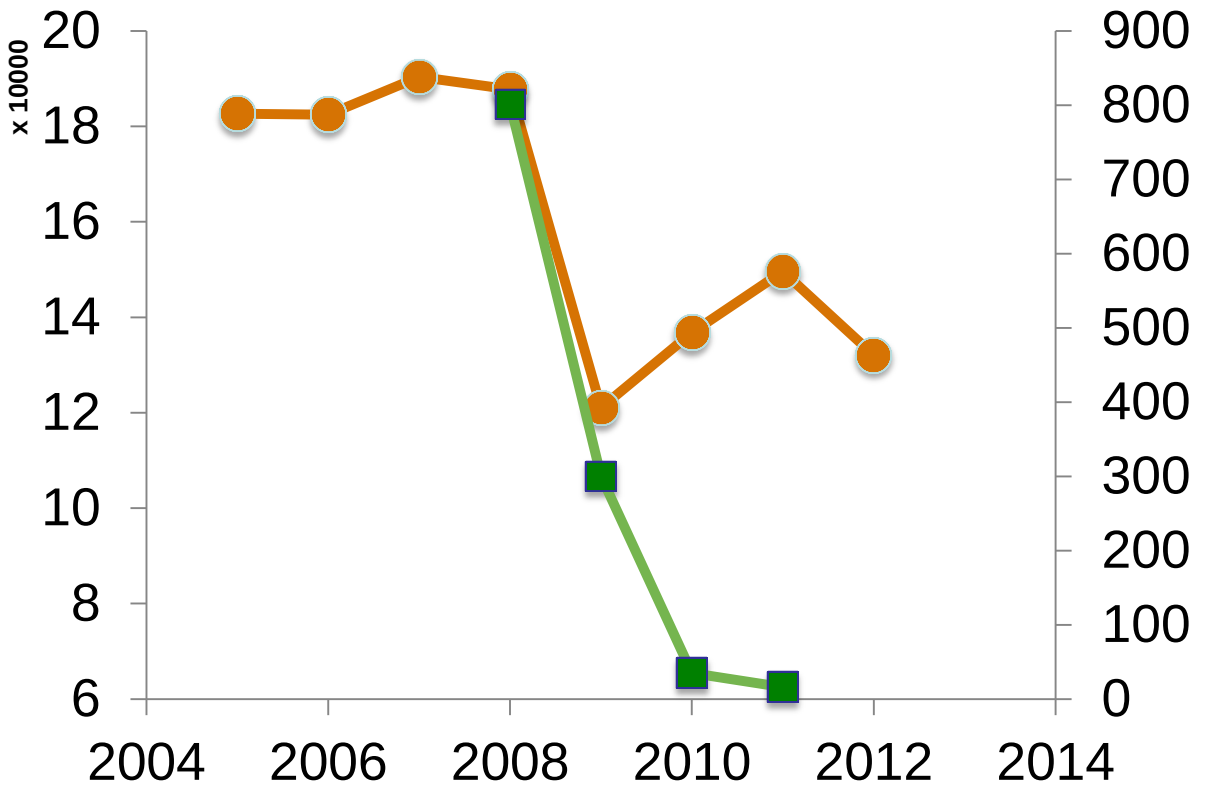


Annual Total PA NO_x emissions (tons yr^{-1})

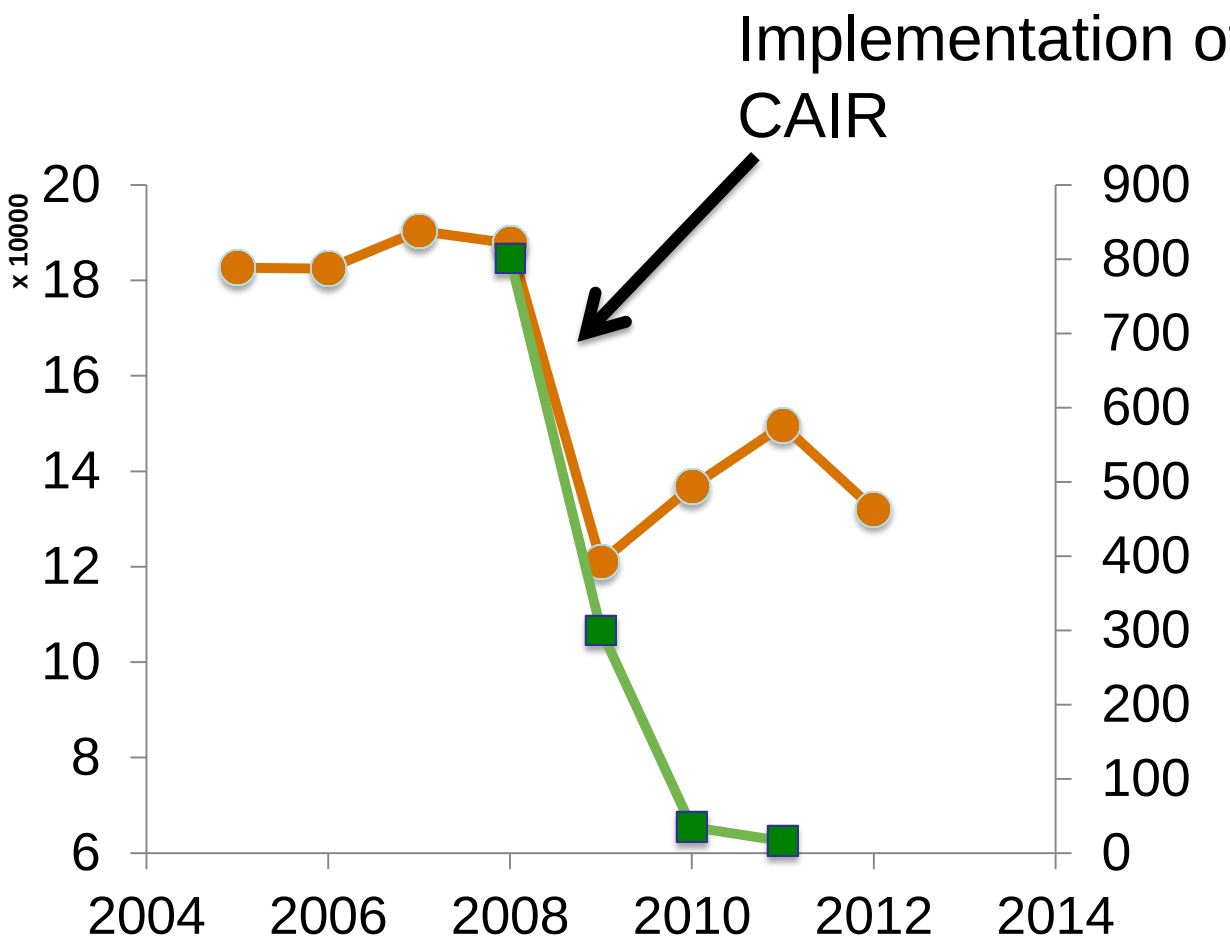


PA NO_x emissions (tons yr^{-1})



NO_x trading price ($)

PA NO_x emissions (tons yr^{-1})

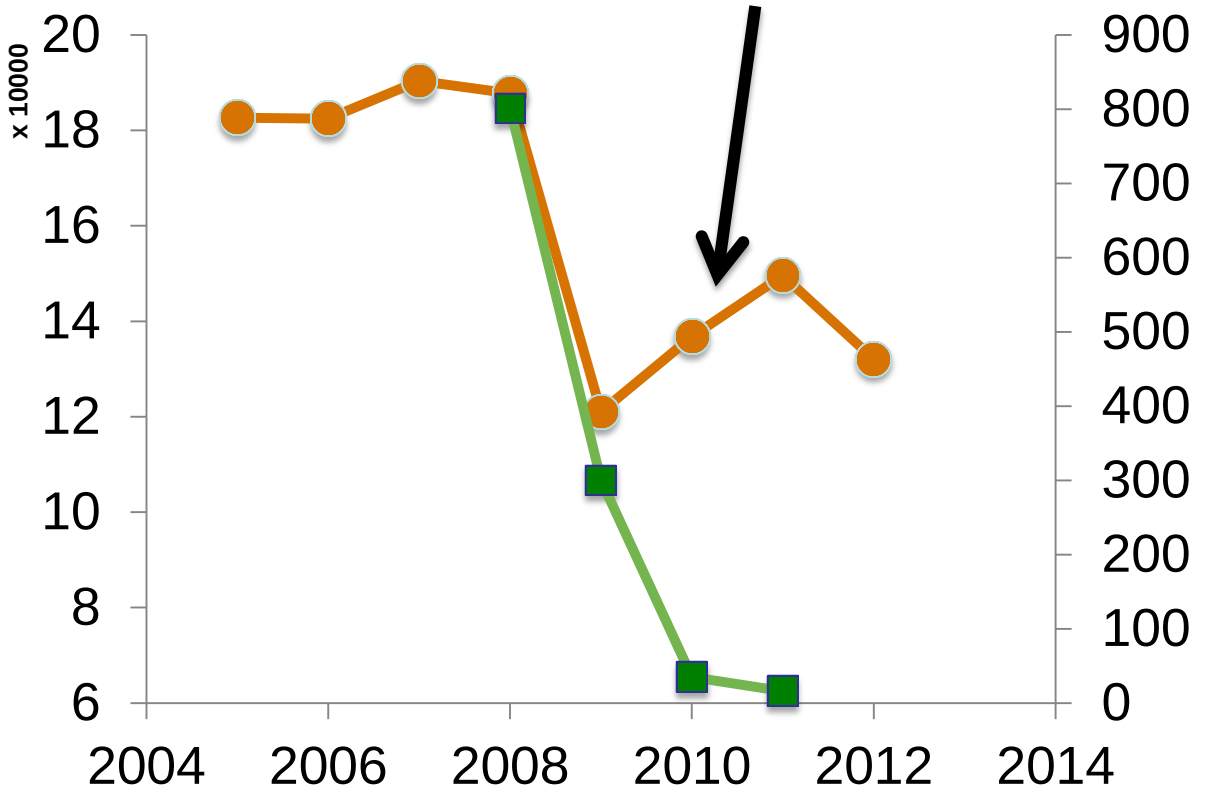


NO_x trading price ($)

CAIR: cap on annual total emissions
command and control regulation is effective

Crash in NO_x trading price
limitations on CAIR implementation

PA NO_x emissions (tons yr^{-1})



NO_x trading price ($)

Decline in NO_x trading price & emissions anti-correlated
>80% of variability after 2008

Science :: Policy

- Combination of approaches necessary for the next generation of air quality benefits
- Annualized approaches are not ideal to mitigate peak concentrations that drive non-attainment and the worst health and ecosystem impacts
- To be consistent, economic considerations must include monetization of non-priced externalities associated with poor air quality