Air Quality at Centreville, AL in June-July
A Historical Perspective for SOAS at CTR

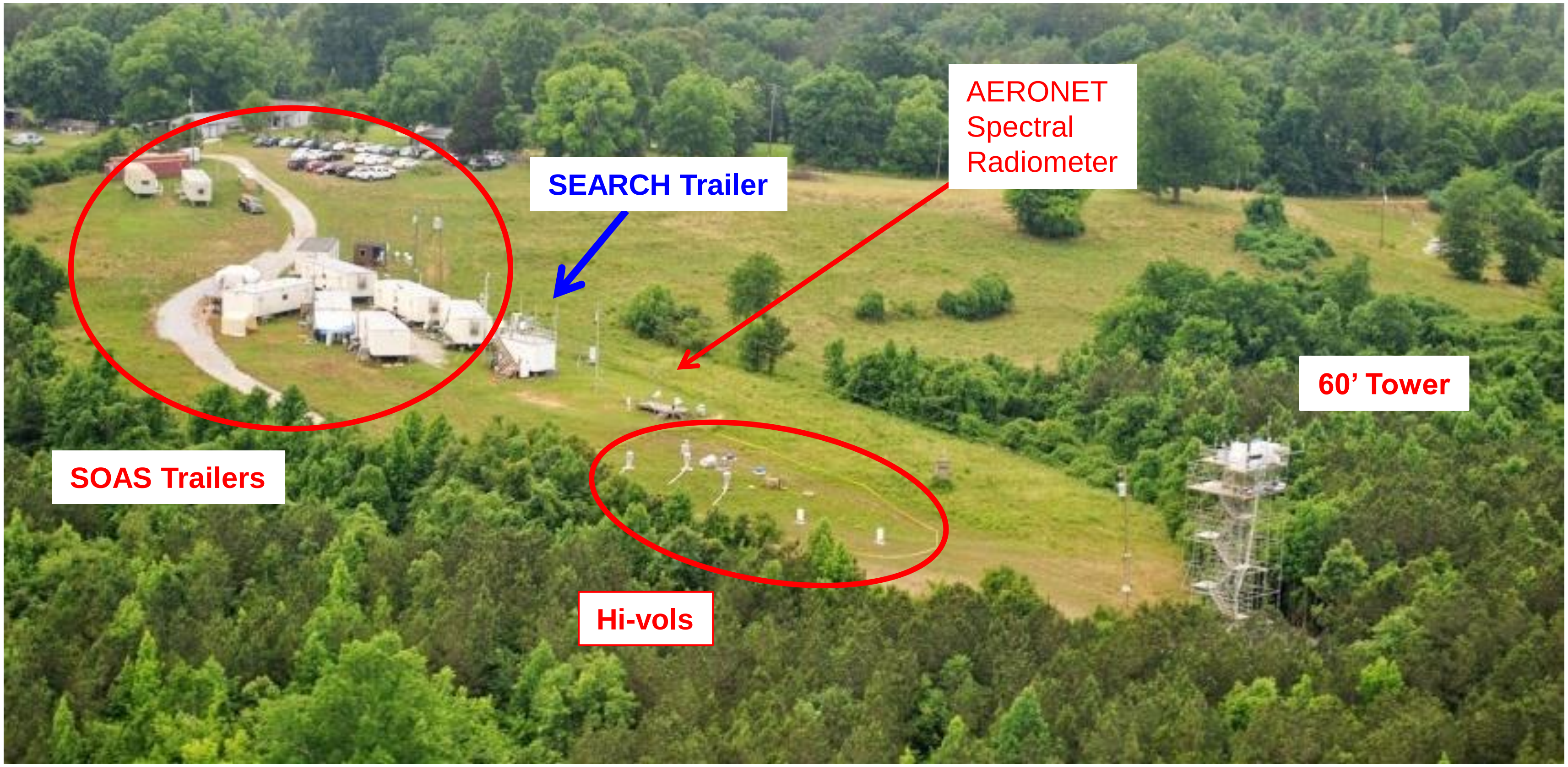
SAS Data Analysis Workshop

March 31 – April 2, 2014

Karsten Baumann, Eric Edgerton, Charles Blanchard, George Hidy, Stephanie Shaw

Question

How do the air quality conditions encountered
at CTR during SOAS period 6/1-7/15 2013
fit into the long-term trend observed by SEARCH?

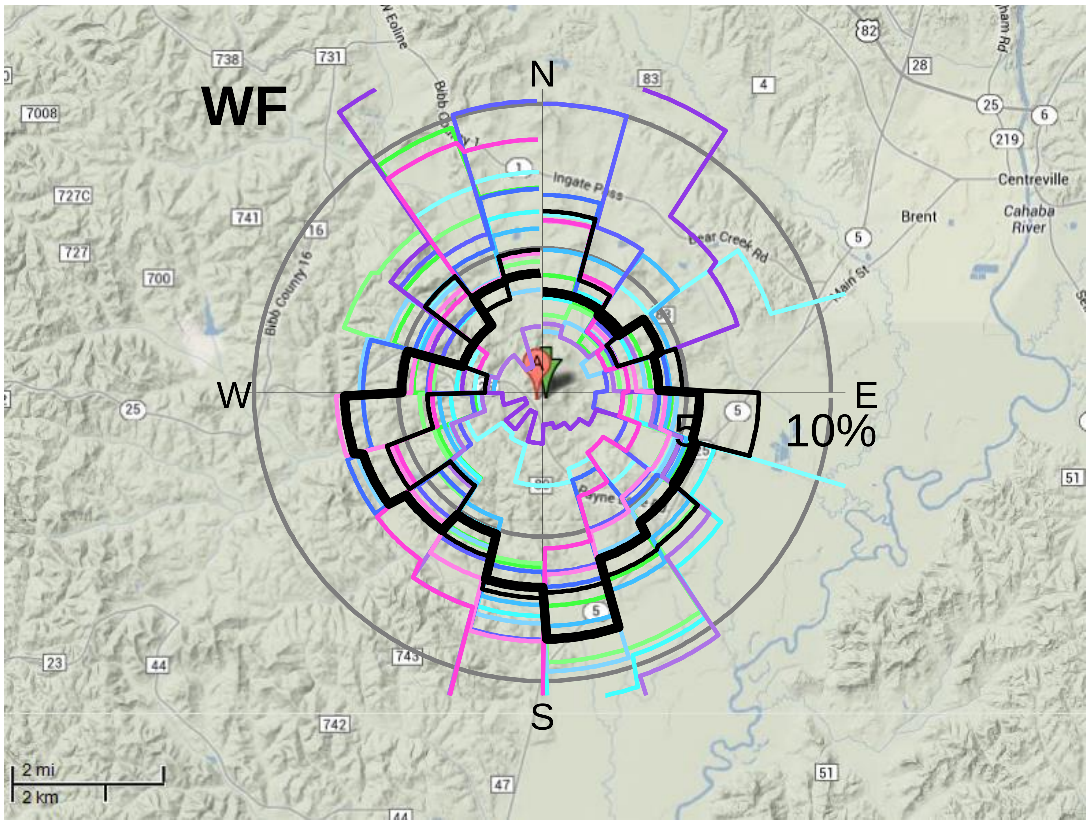


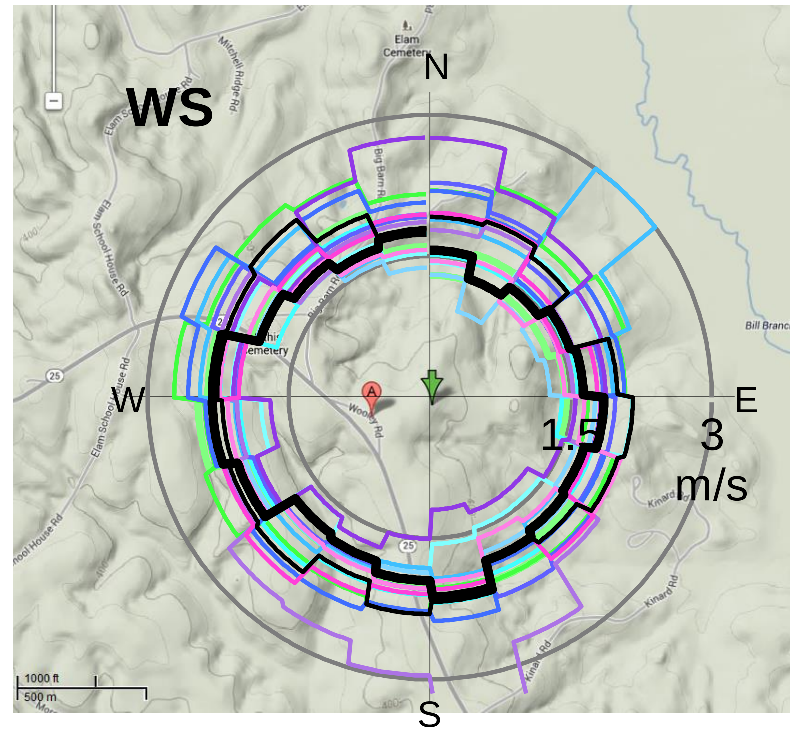
Atmospheric Research & Analysis

Air Mass Transport 2000-2013

CTR-ARA 45-Day Period June 1 - July 15

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

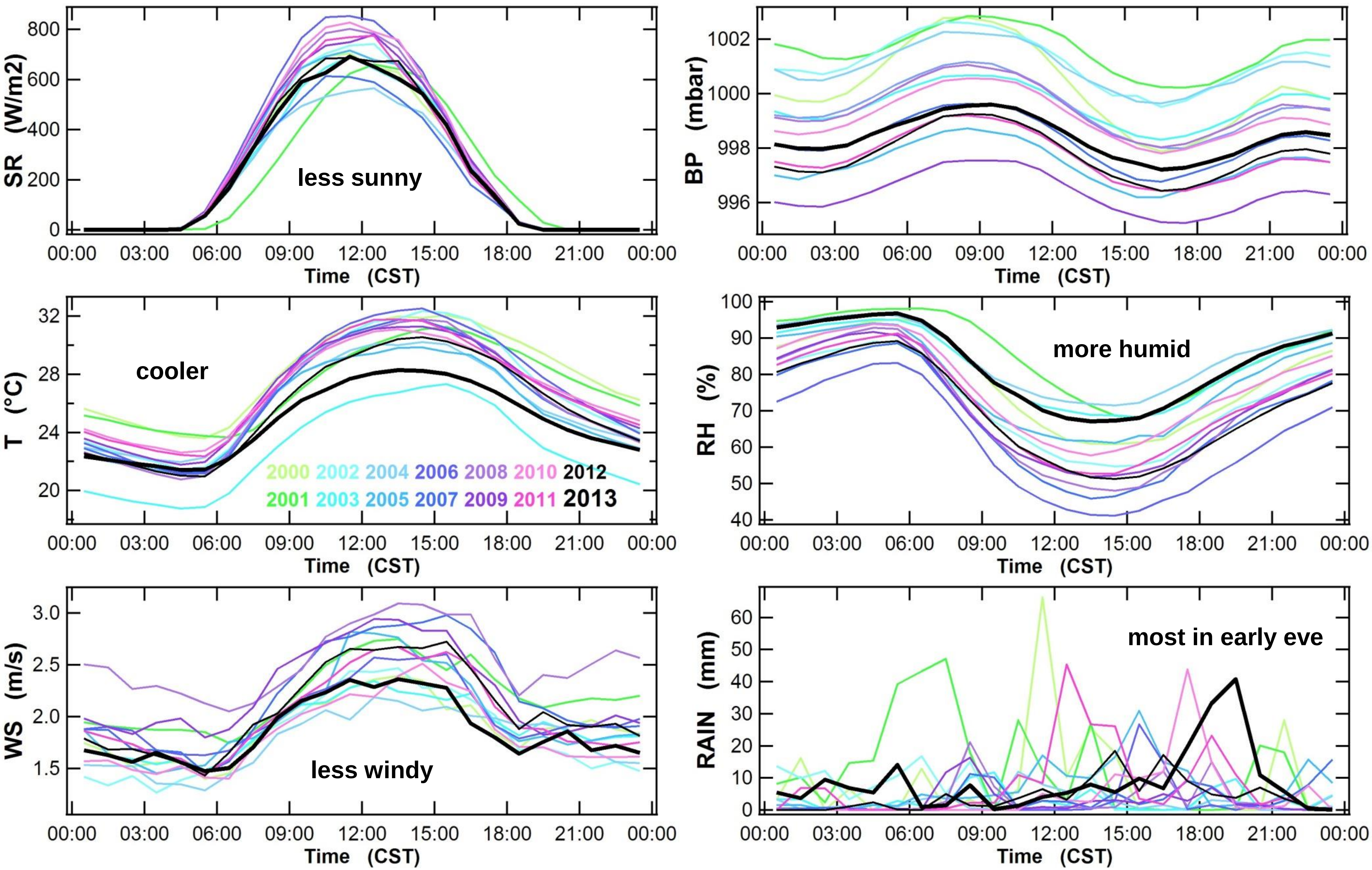




Less northerly and more westerly component flow than in previous years!

Westerly winds are consistently strongest (excl. 2008**), indicating influence by synoptic p-gradient.**

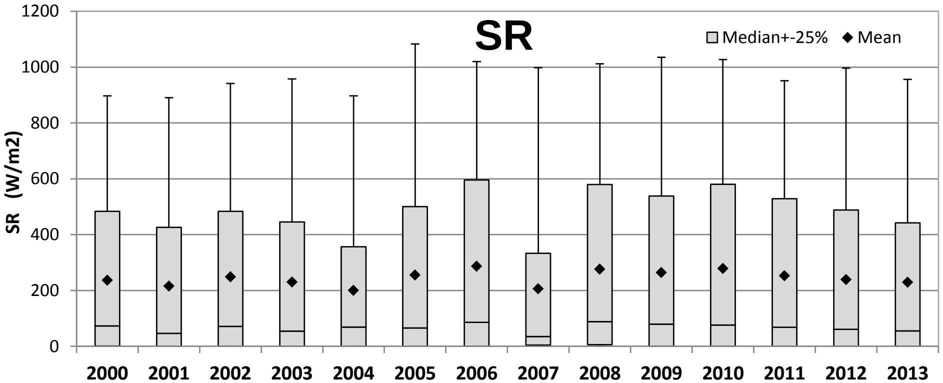
Diurnal Met Parameters 2000-2013

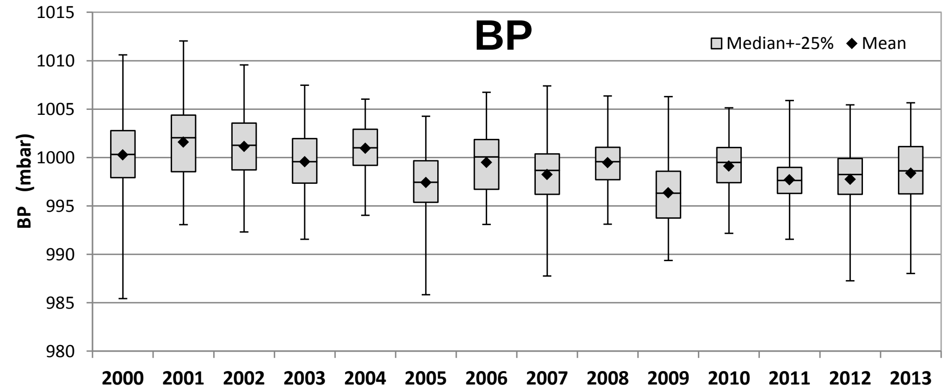


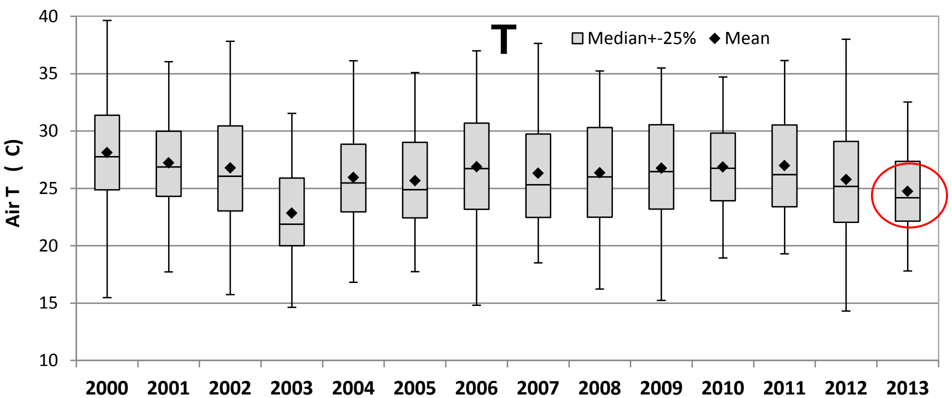
RAIN (mm) shows sum for each hour in 6/1-7/15 period

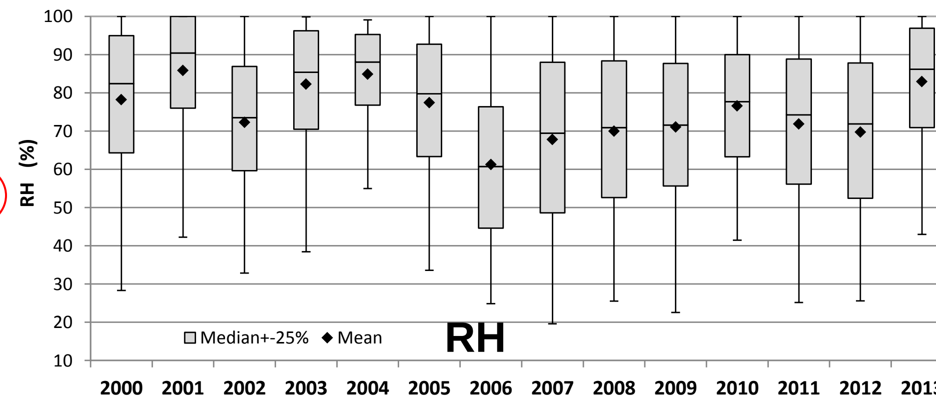
Atmospheric Research & Analysis

Met Statistics 2000-2013

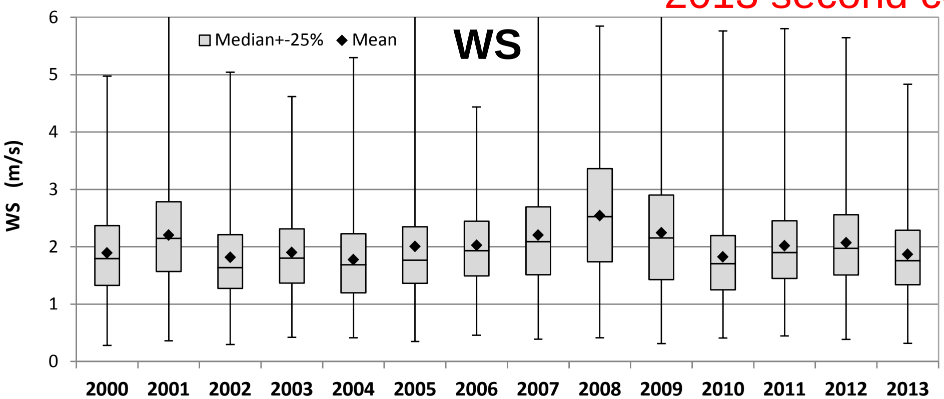


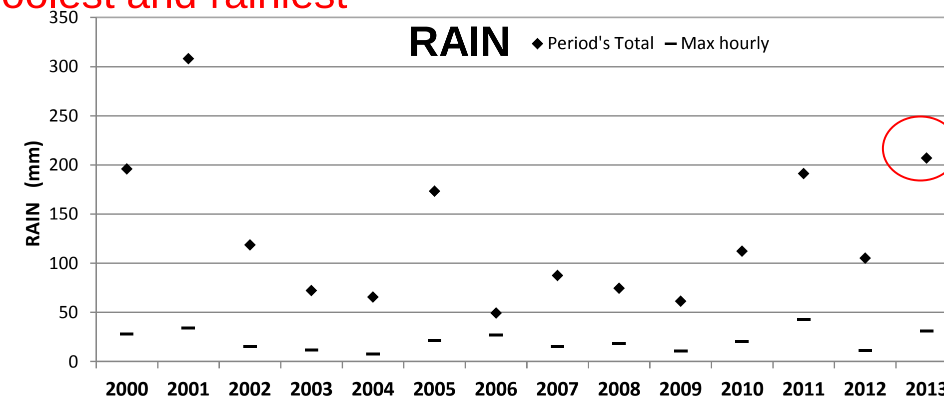






2013 second coolest and rainiest

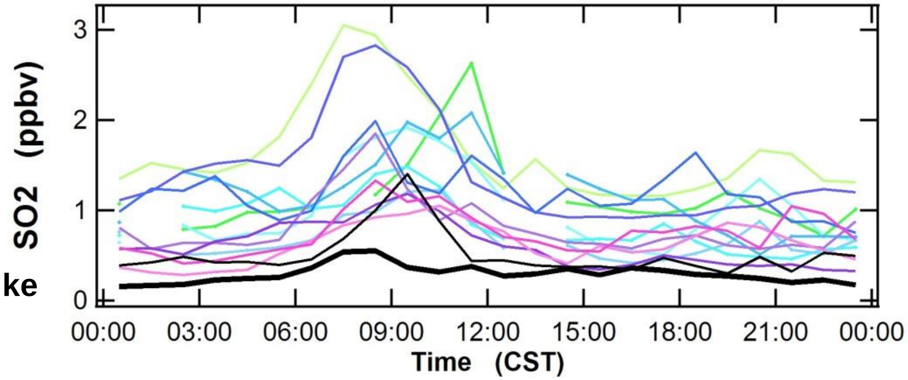




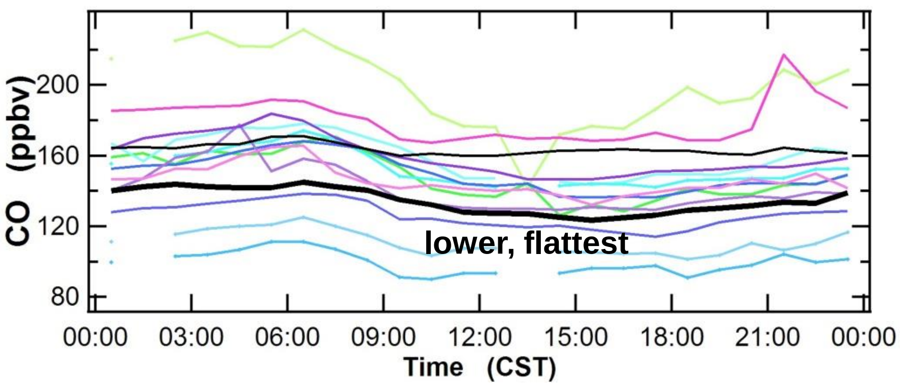
Atmospheric Research & Analysis

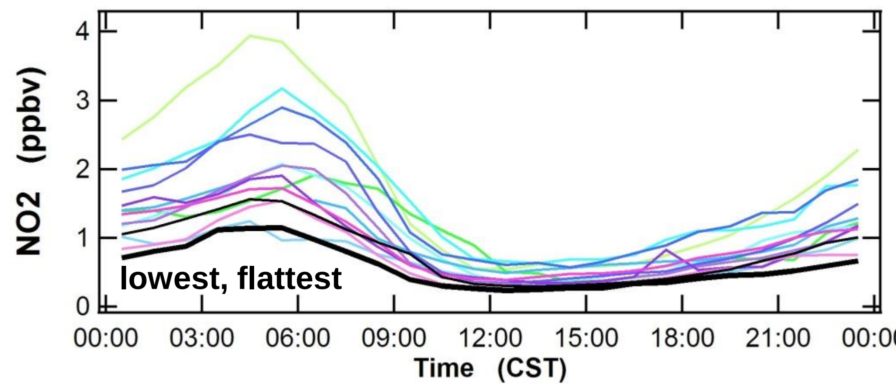
Diurnal Primary Gases 2000-2013

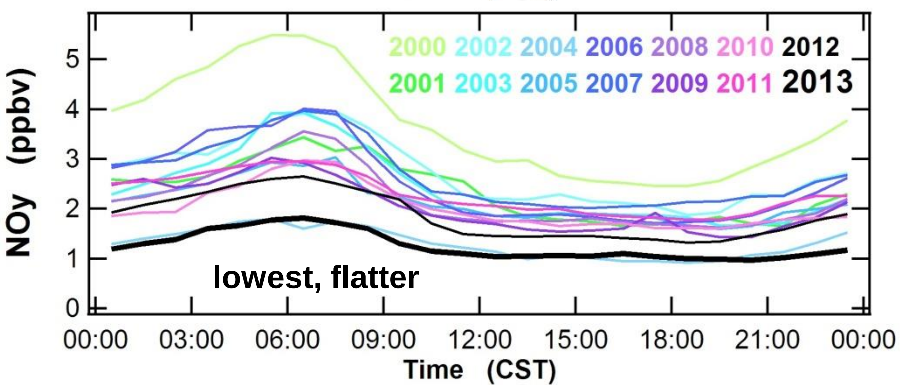
lowest, minimal spike

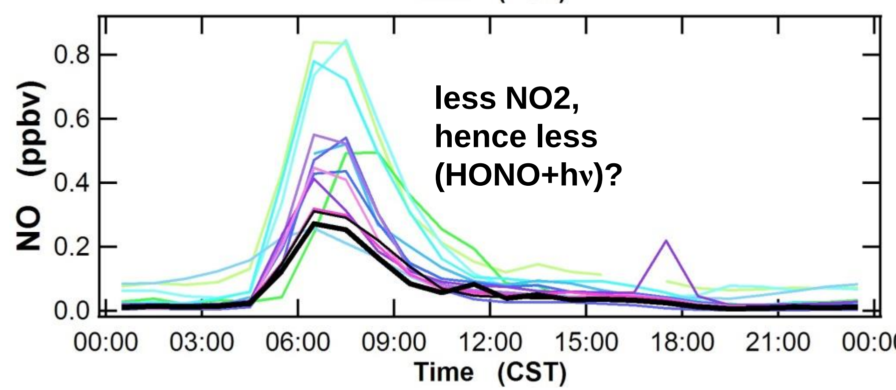


Spikes in morning SO2 due to down-mixing of occasional SO2 plume aloft with breakup of nocturnal inversion and development of CBL





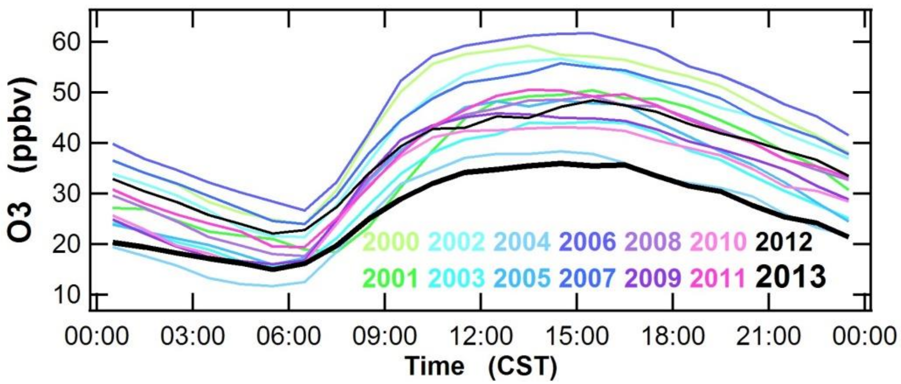


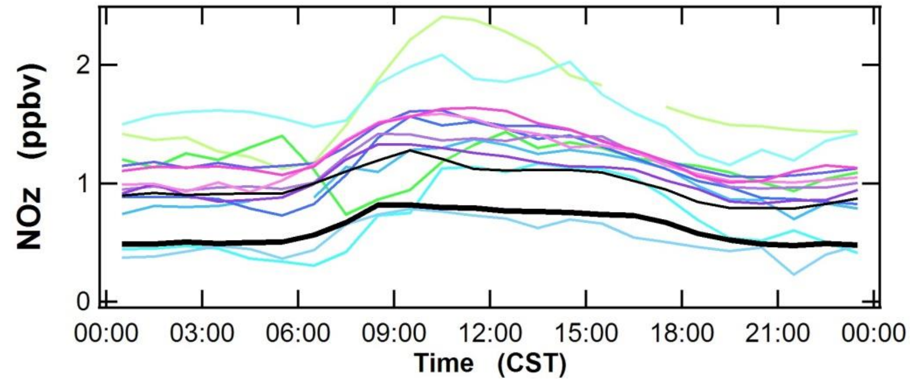


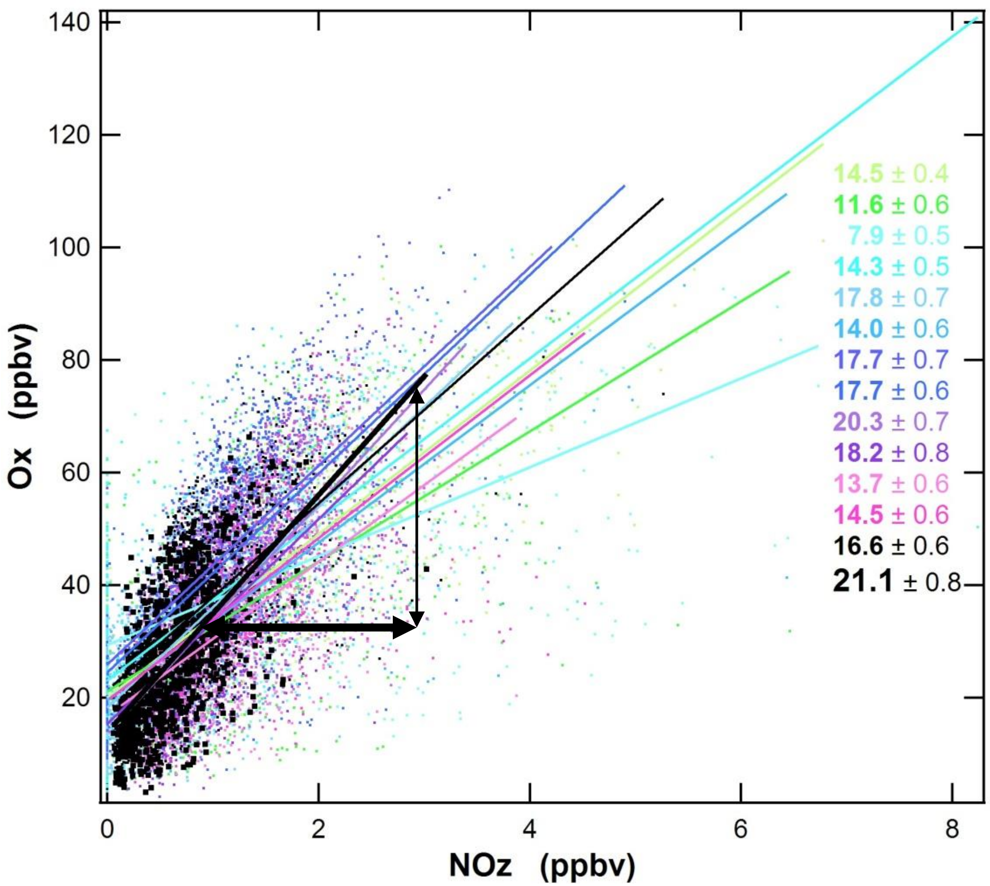
Spike at 1700 in 2009 NOx and NOy due to singular event

Atmospheric Research & Analysis

Diurnal Secondary Gases 2000-2013



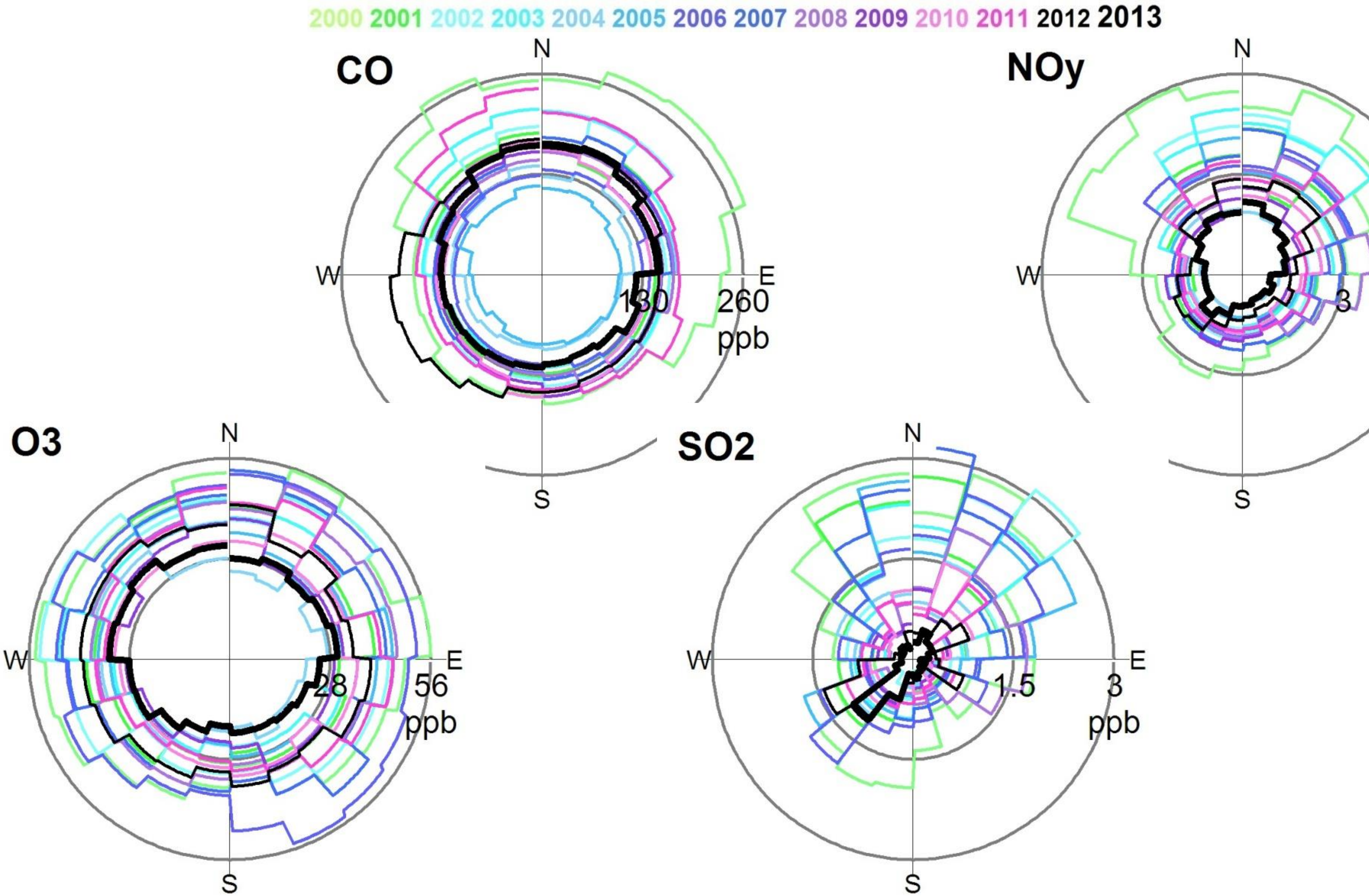




In 2013:
More O3 produced per NOx oxidized.
or:
Less NOx removed for same ΔO3 produced.
Did NOx recycle more often or more efficiently in 2013?

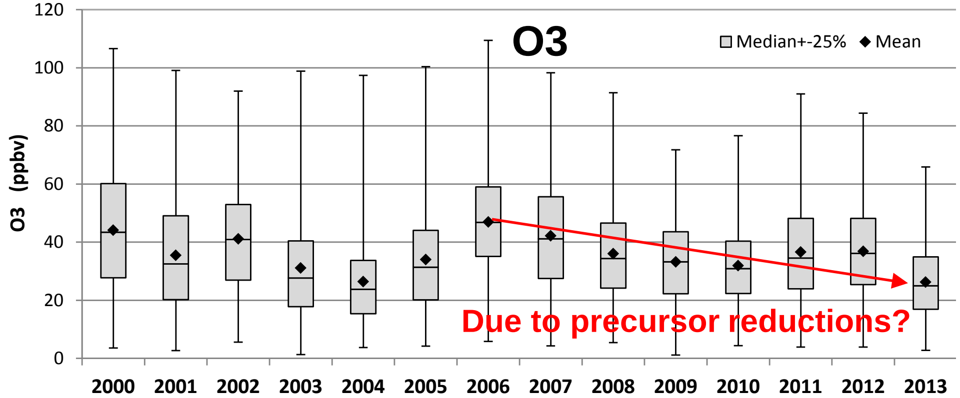
Atmospheric Research & Analysis

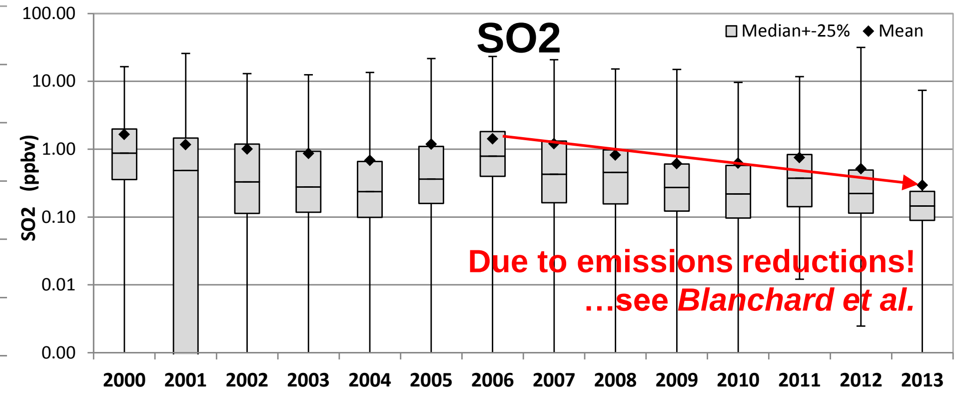
Gaseous AP Transport 2000-2013

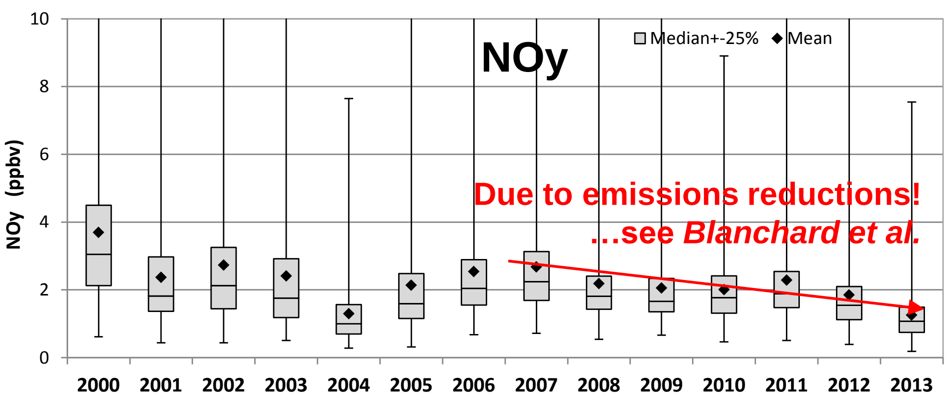


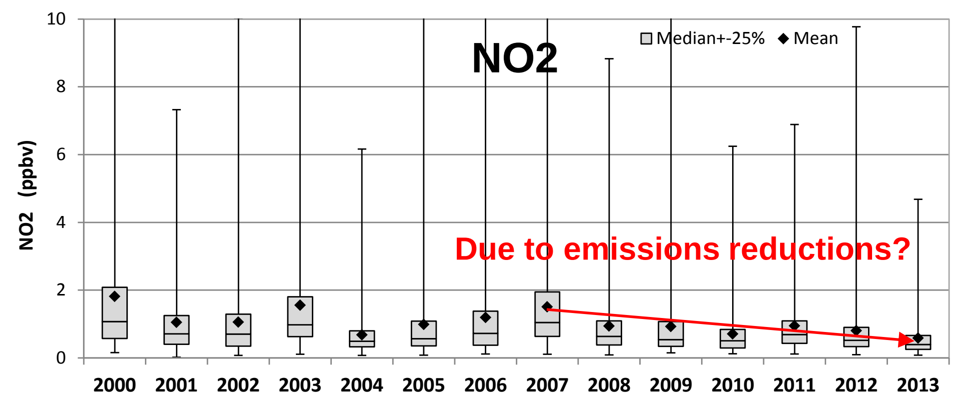
- **In general, O3 and CO appear more regional than NOy and esp. SO2!**
- **Northerly flow generally transports more APs to the site than southerly flow.**
- **In 2013, northern SO2 influence is gone, and SW influence largely reduced.**

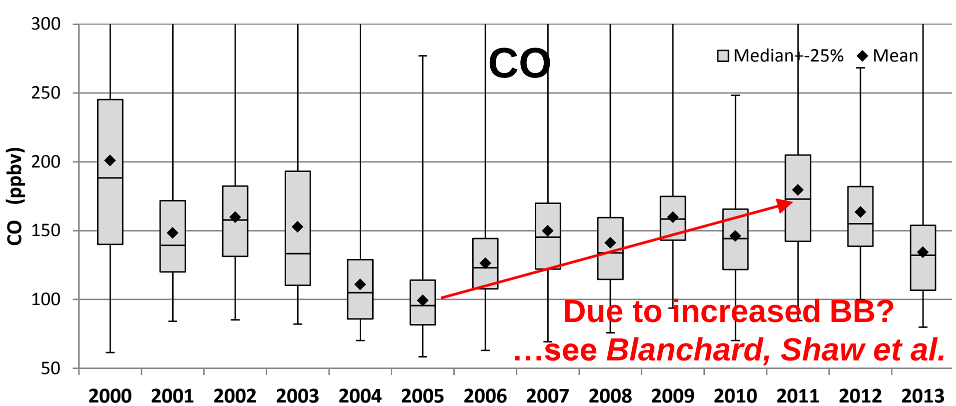
Gaseous AP Statistics 2000-2013

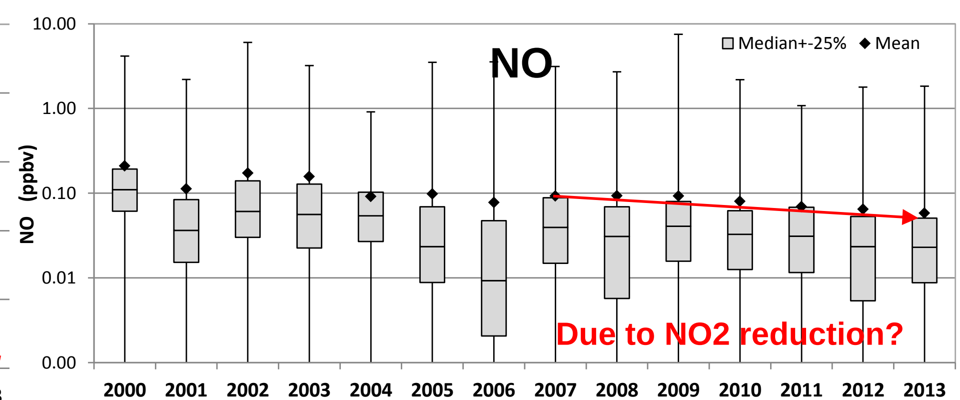










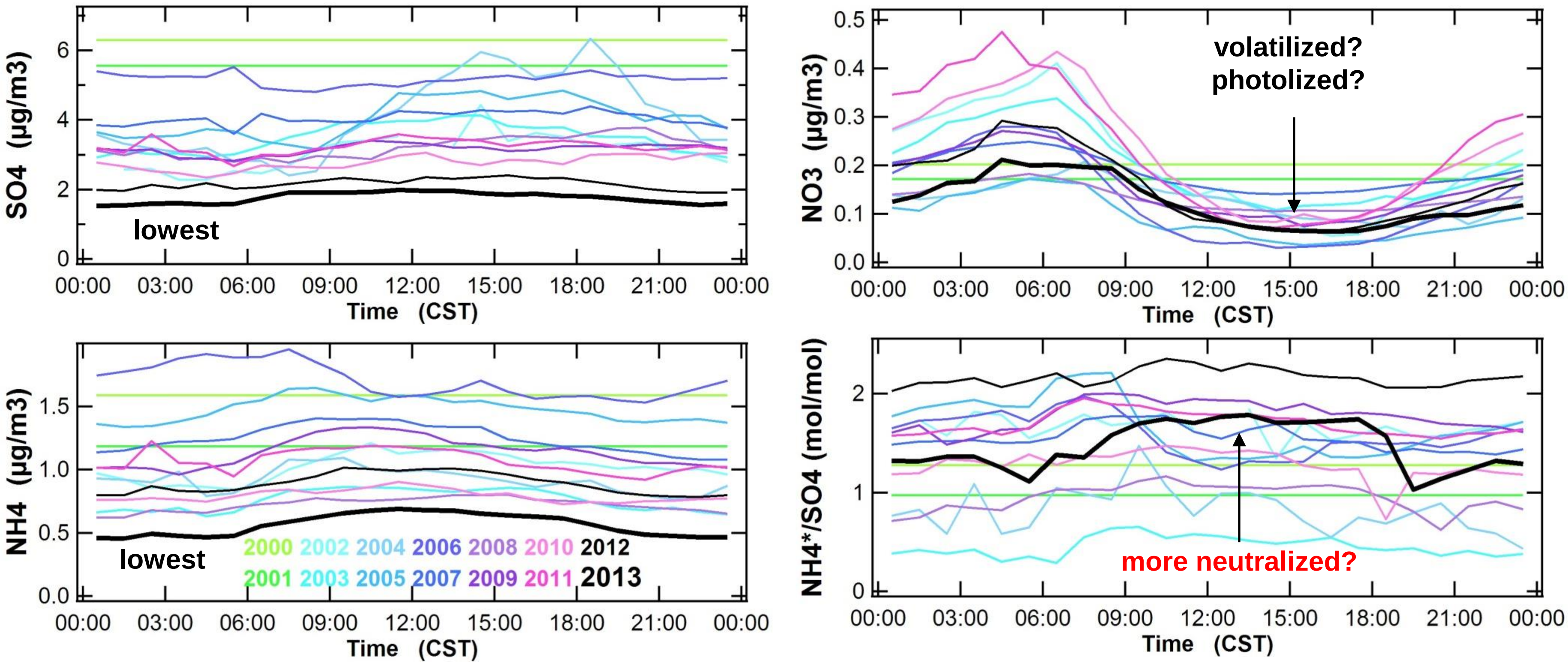


NO, SO2 highly skewed, hence log-scale

Atmospheric Research & Analysis

Diurnal Ionic $PM_{2.5}$ 2000-2013

2000+01 SO4, NO3, NH4 are from 24h FRM filters

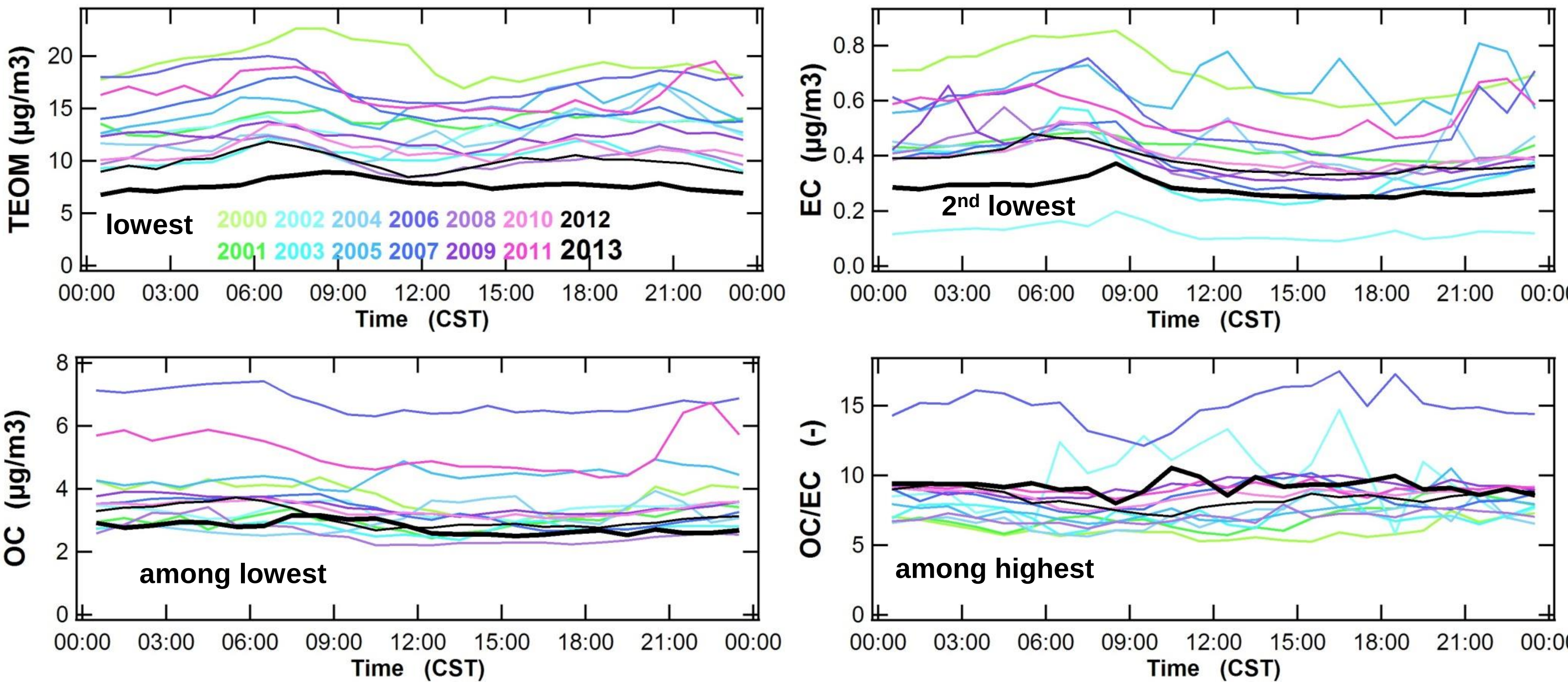


NH4* = available post-NH4NO3

- **Clear year-to-year downward trend in SO4 and NH4.**
- **SO4 daytime highs become shallower over time.**
- **NO3 loss (volatilization) during midday, while NH4 more retained.**
- **SO4-neutralization has barely changed region wide; see Hidy et al. poster**

Atmospheric Research & Analysis

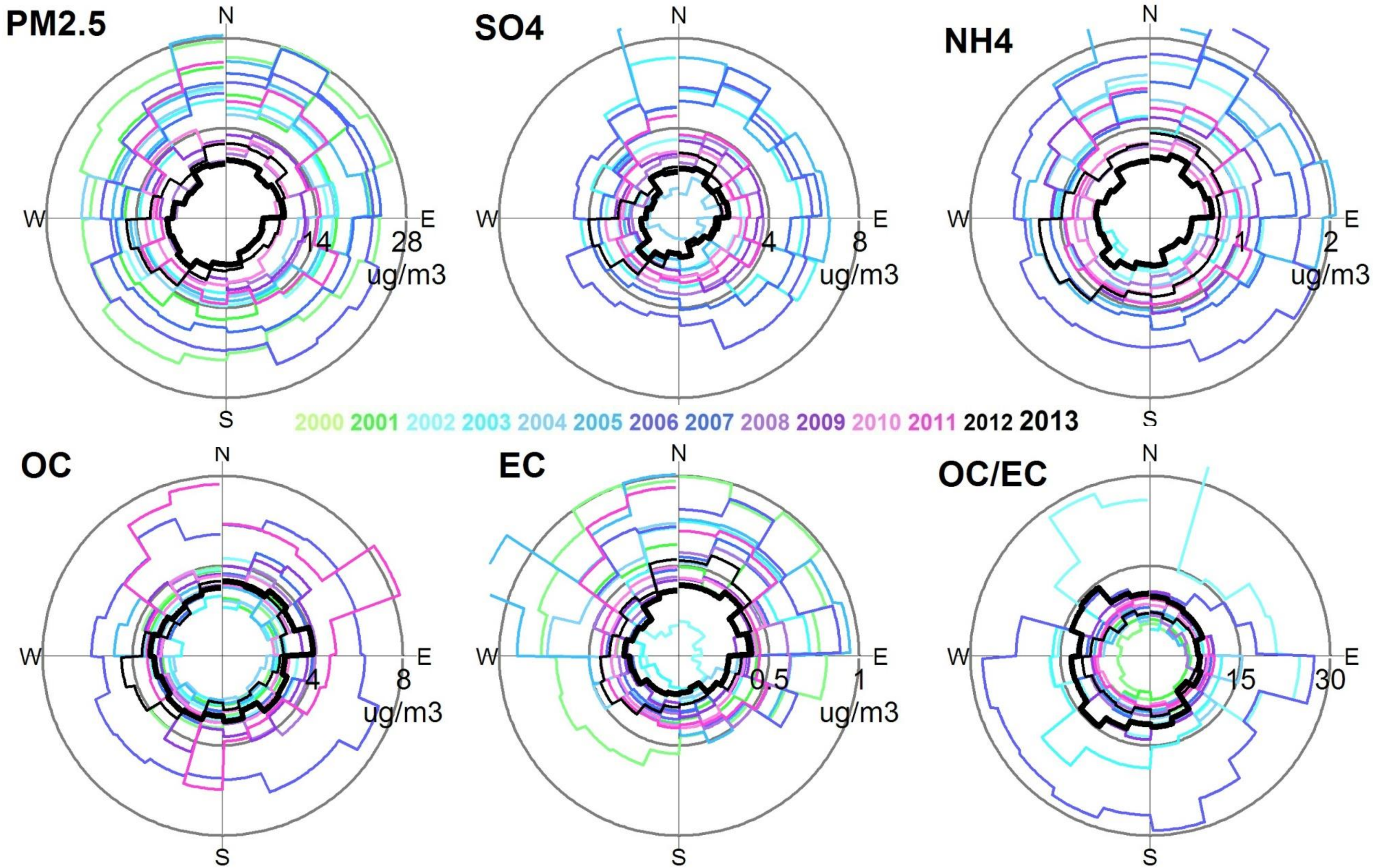
Diurnal $PM_{2.5}$ Mass + Carbon 2000-2013



- PM2.5 mass clearly lowest in 2013; OC and EC less clear.
- Diurnal profile flatter in 2013 for PM2.5 mass, OC and EC.
- OC/EC ratio in 2013 among highest.
- Random spikes in OC/EC point to sporadic <u>nearby</u> BB influence.

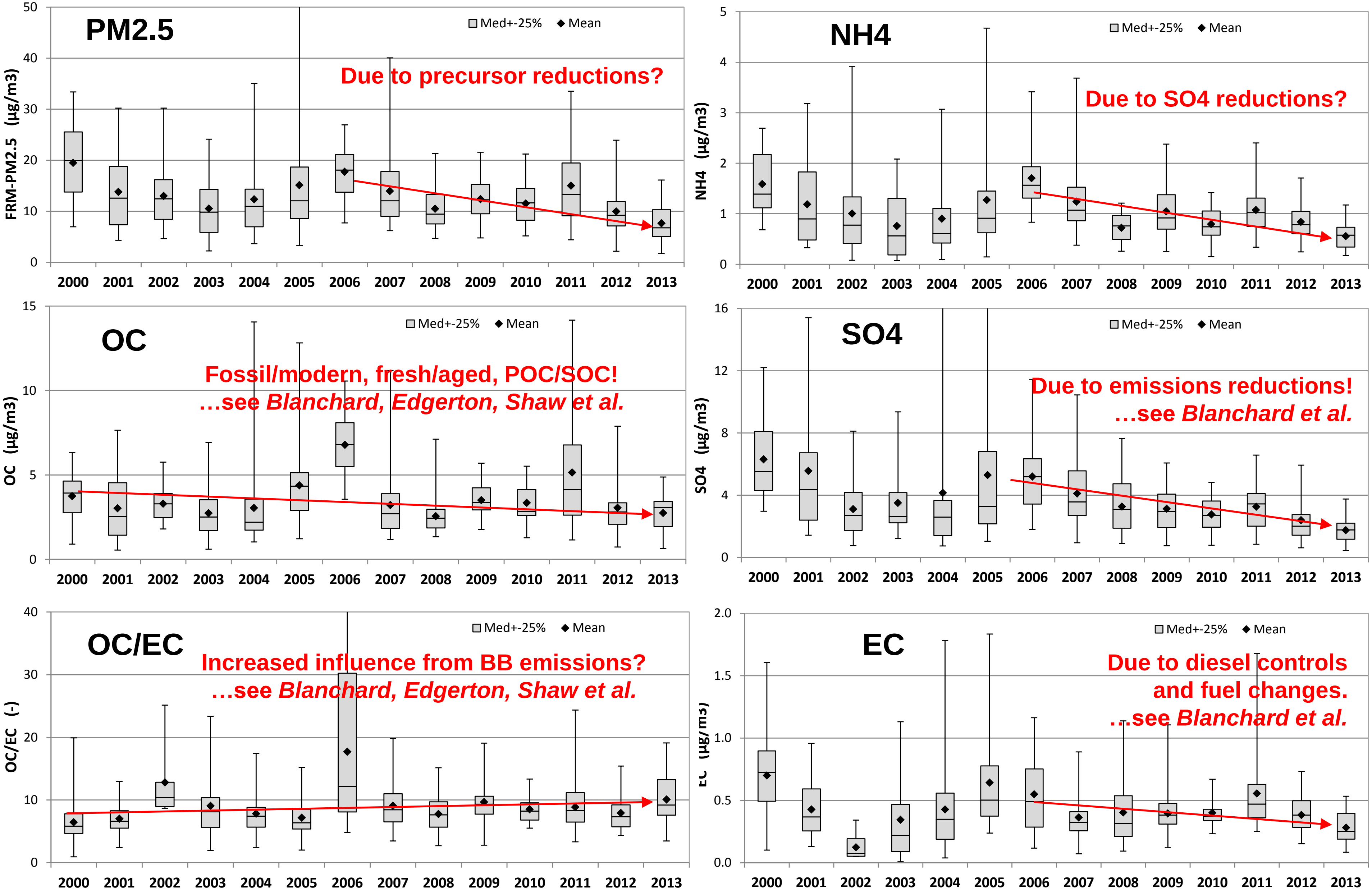
ATMOSPHERIC RESEARCH & ANALYSIS

Fine PM Transport 2000-2013



- **PM2.5 mass and components in 2013 appear more regional (concentric).**
- **OC/EC in 2013 point to <u>nearby</u> BB influence from NW and SW (**more so in 2002 and 2006**).**

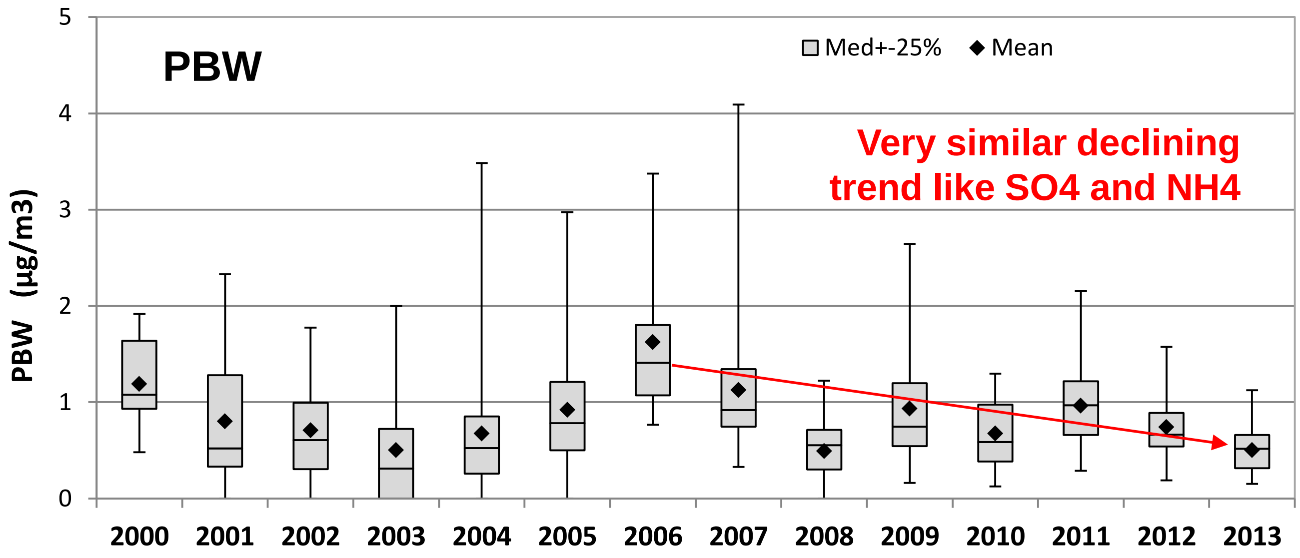
Fine PM Statistics 2000-2013



Atmospheric Research & Analysis

PBW Associated with Ionic PM2.5 at CTR

- **Particle bound water estimated using SMAT* approach based on AIM model (Clegg, 1998)**
  - Inputs are NH4, SO4, NO3 adjusted to FRM
  - Assumed 35% RH and 21° C (FRM weighing conditions)
- **Derived empirical equation to describe relationship**
  - **PBW** = -0.002618 + 0.980314*nh4 - 0.260011*no3 - 0.000784*so4 - 0.159452*nh4**2 - 0.356957*no3*nh4 + 0.153894*no3**2 + 0.212891*so4*nh4 + 0.0444366*so4*no3 - 0.048352*so4**2

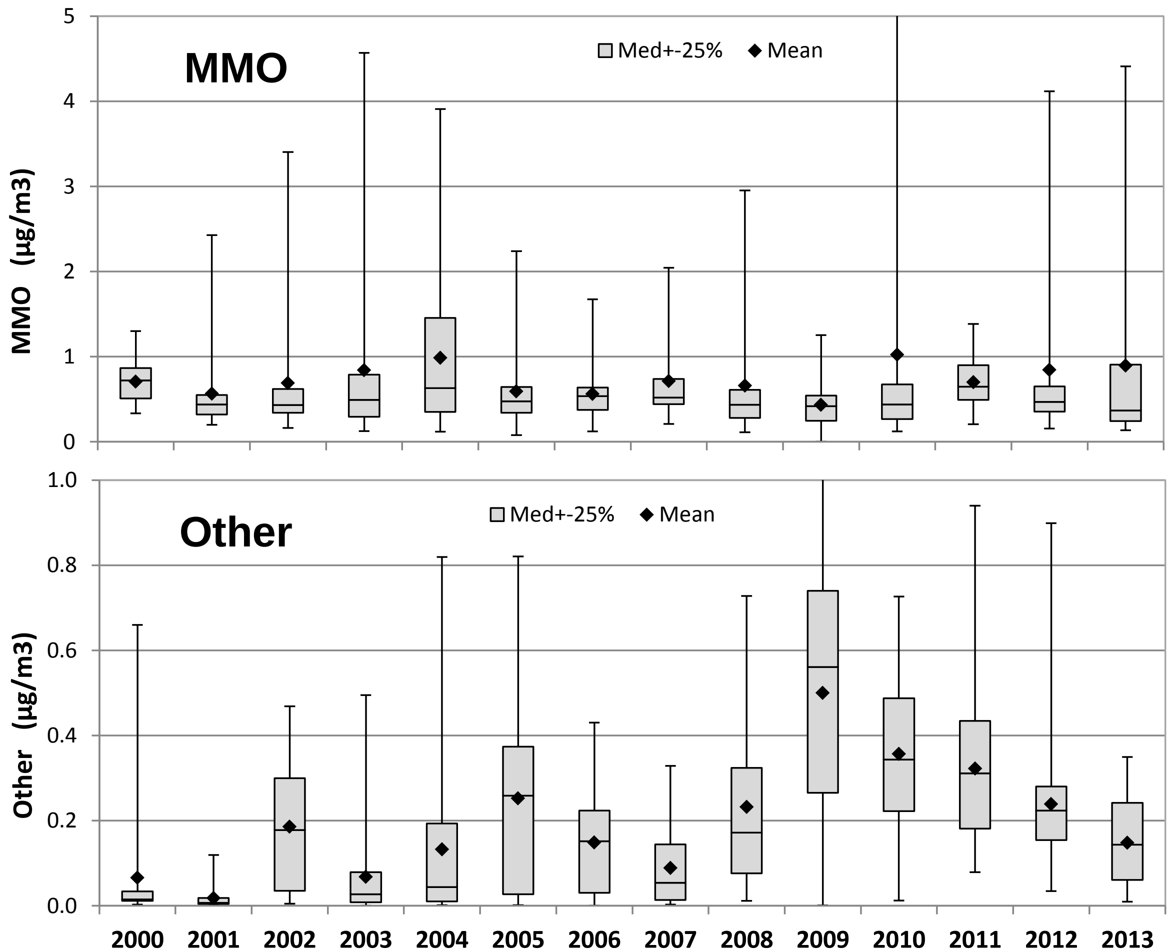


GA Tech will double-check these numbers via ISORROPIA !

*) Speciated Model Attainment Test team, B. Timin, B. Cox, N. Frank, T. Rao, B. Hubbell, EPA/OAQPS, VISTAS Joint Workgroup Meeting, September 23, 2005.

MMO and Other Elements in PM2.5 at CTR

- Major Metal Oxides based on ED-XRF of FRM filters
  - **MMO** = Al2O3 + SiO2 + K2O + CaO + TiO2 + Fe2O3
  - **Other** = Na + Mn + Zn + nonSO4-S (i.e. XRF-S - SO4/3)



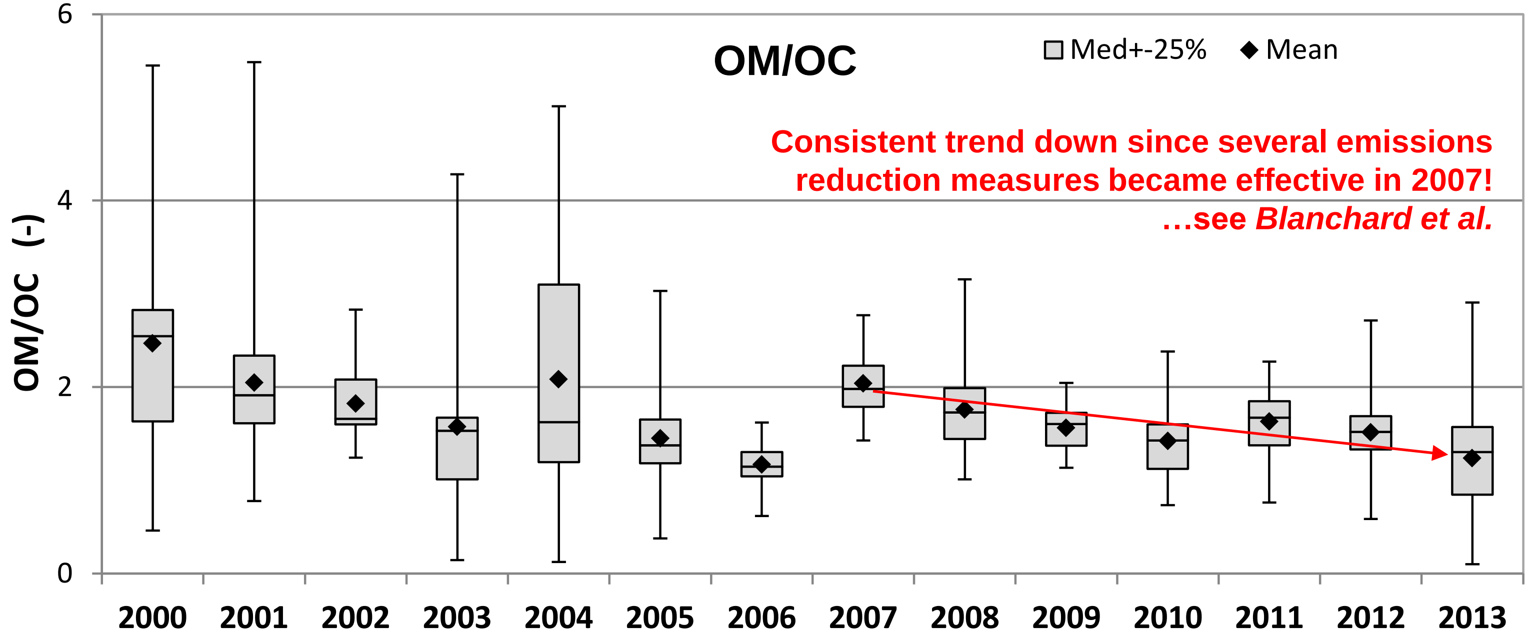
Sporadic high MMO due to mineral dust from local or distant sources. 2013 saw two events suggesting long-range transport from N-Africa.

- **PM2.5 contributions from both MMO and Other are not negligible.**
- **Other elements consistently decline since 2009.**

Atmospheric Research & Analysis

OM from PM2.5 mass Balance at CTR

- Organic Mass upper limit estimated from PM2.5 mass balance:
  - **OM** = $PM2.5_{FRM}$ - EC - SO4 - NH4 - NO3 - PBW_{ions} - MMO - Other



- **What are the implications or causes of this downward trend?**
- **How much water is associated with OM?**
- **Has aerosol hygroscopicity declined?**
- **Has the oxidative capacity of the atmosphere decreased and with it SOA formation?**
- **What role does biomass burning play in this trend?**

How do the air quality conditions encountered during SOAS fit into the long-term trend?

"Answer"

- **Fewer northerly winds, calmer, cooler, and moister.**
- **Less O3 and less NOx removed per O3 produced.**
- **Less NOy, SO2, SO4, and EC in line with reduced emissions trend (Blanchard et al.).**
- **SO4-neutralization has barely changed (also region wide; see Hidy et al. poster).**
- **PBW_{ions} in line with declining SO4 and NH4 (ISORROPIA check pending).**
- **Less OC but higher than what mobile source OC reductions would suggest.**
- **OC/EC in 2013 point to nearby BB influence from NW and SW.**
- **BB seems to play an increasingly important role in SOA formation.**

Open Questions

- **Has aerosol hygroscopicity declined?**
- **Has the oxidative capacity of the atmosphere decreased and with it SOA formation?**
- **What role does biomass burning play in this?**