Historical Context of the SOAS 2013 Centreville Field Study: Impacts of Emissions on $PM_{2.5}$ EC and OC in the SEARCH Network, 1999 - 2013

SAS Data Analysis Workshop

March 31 – April 2, 2014

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SEARCH EPRI ELECTRIC POWER RESEARCH INSTITUTE SOUTHERN COMPANY Energy to Serve Your World℠ ATMOSPHERIC RESEARCH & ANALYSIS ENVAIR

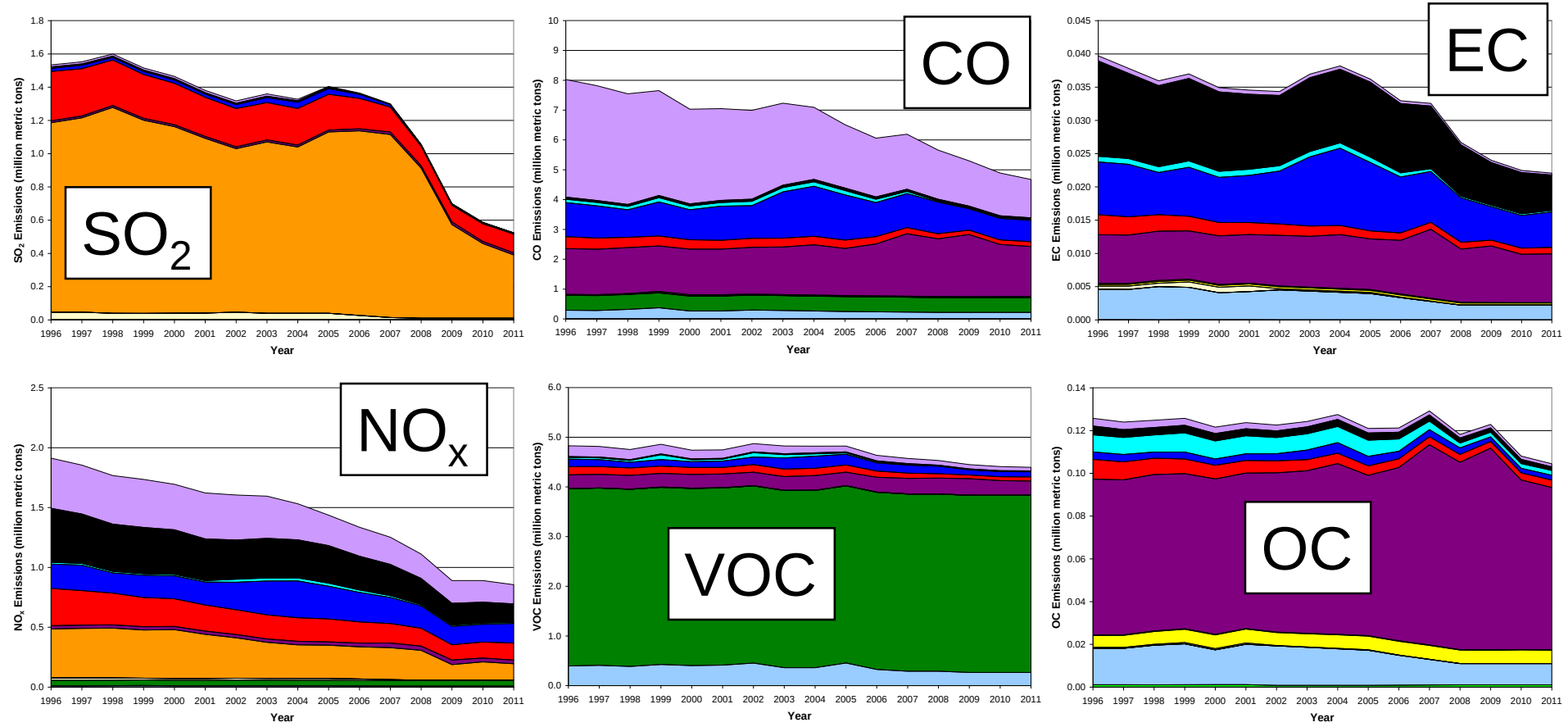
Question

Were urban & rural SEARCH sites substantially impacted by mobile-source emissions and biomass burning between 1999 and 2013?



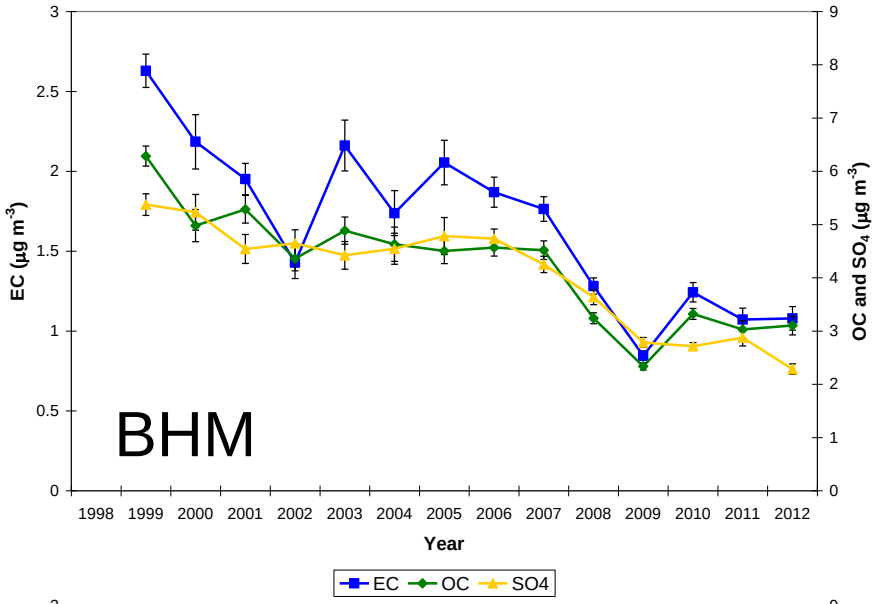

What are the magnitudes of the impacts?

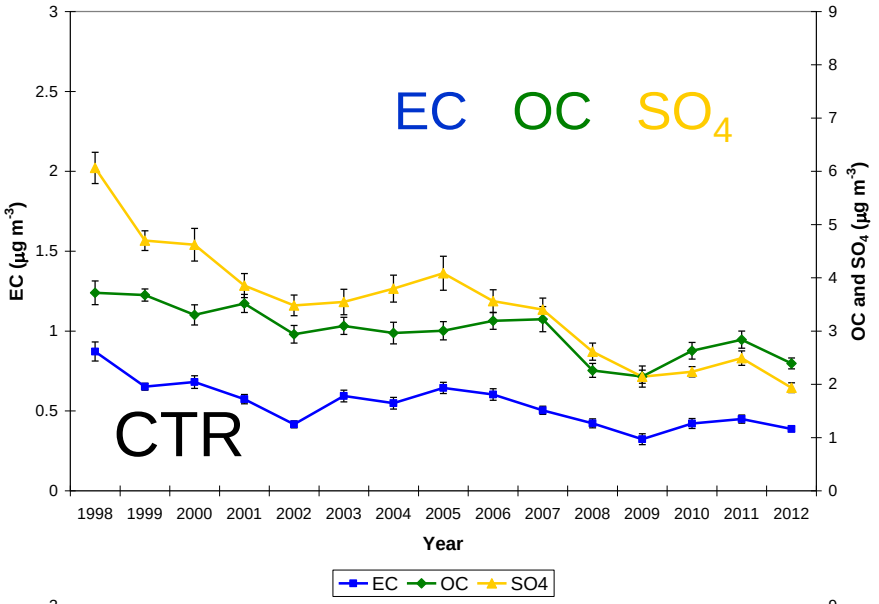
Decreasing Anthropogenic Emissions in AL, GA, MS, NW FL (SE), 1996 - 2011

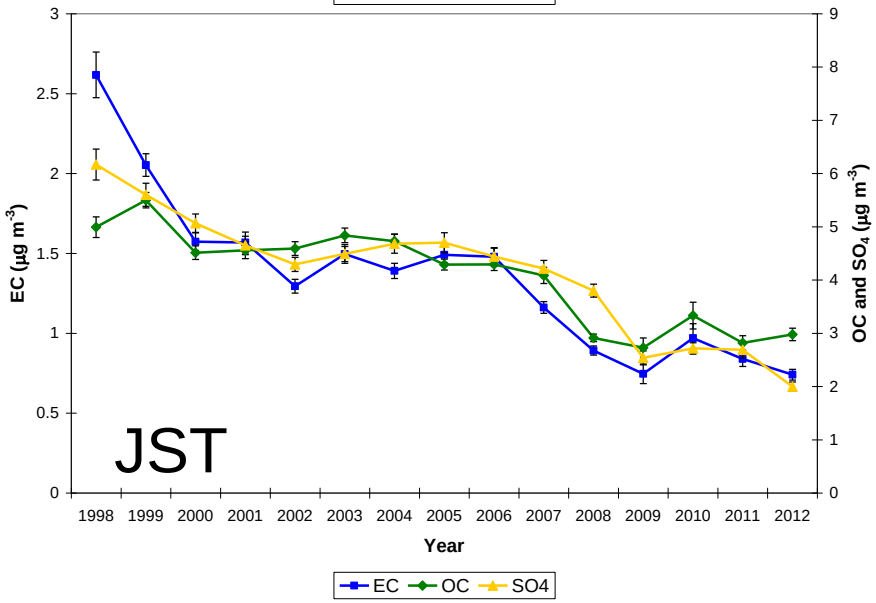


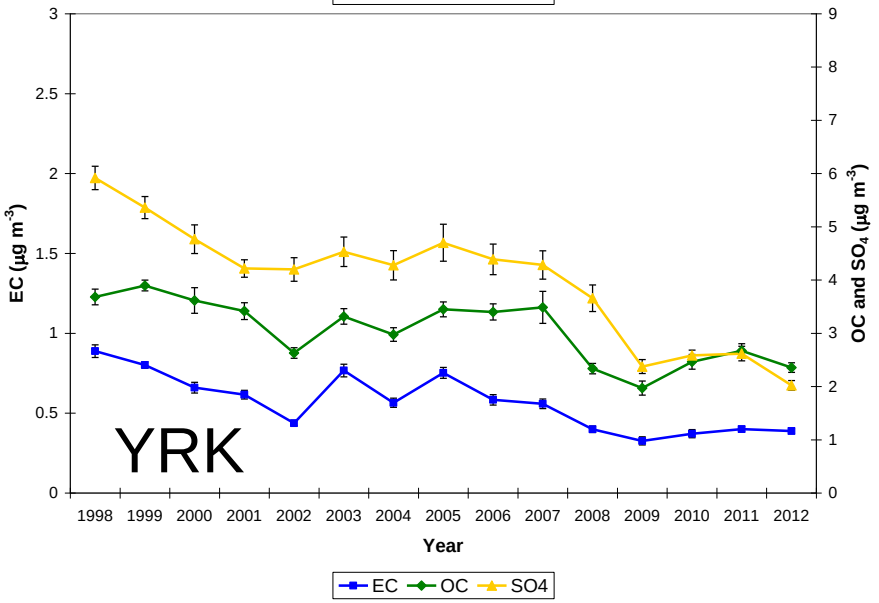
Blanchard et al. 2013. *ES&T.* (NEI, CEMs, MOVES, NONROAD, SPECIATE, WF & Rx)

All SEARCH Sites Exhibit Declining Annual $PM_{2.5}$ SO_4, EC, and OC – Why?

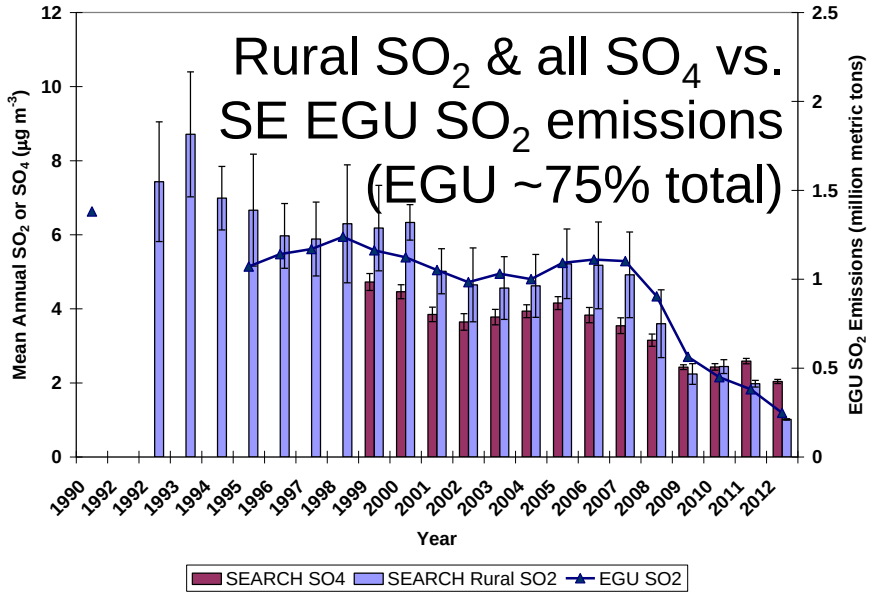


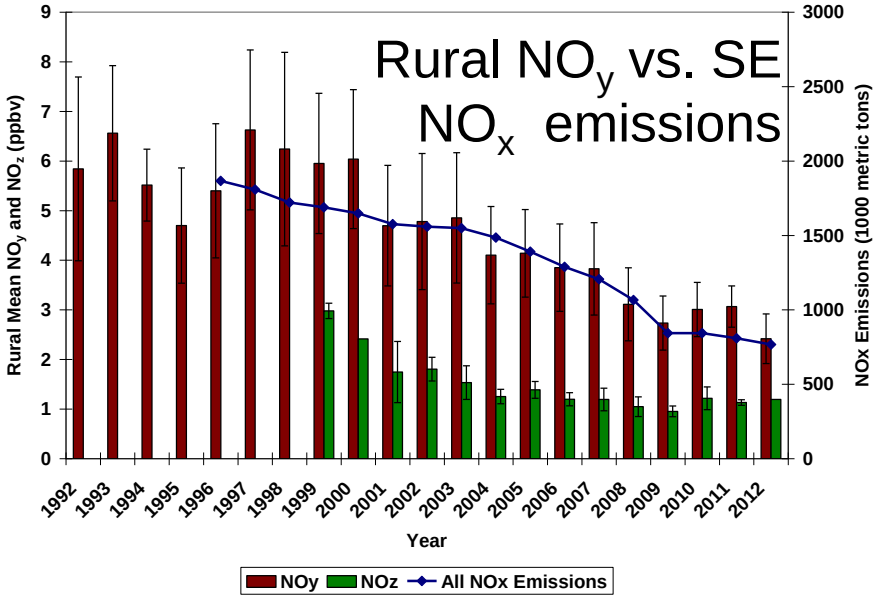


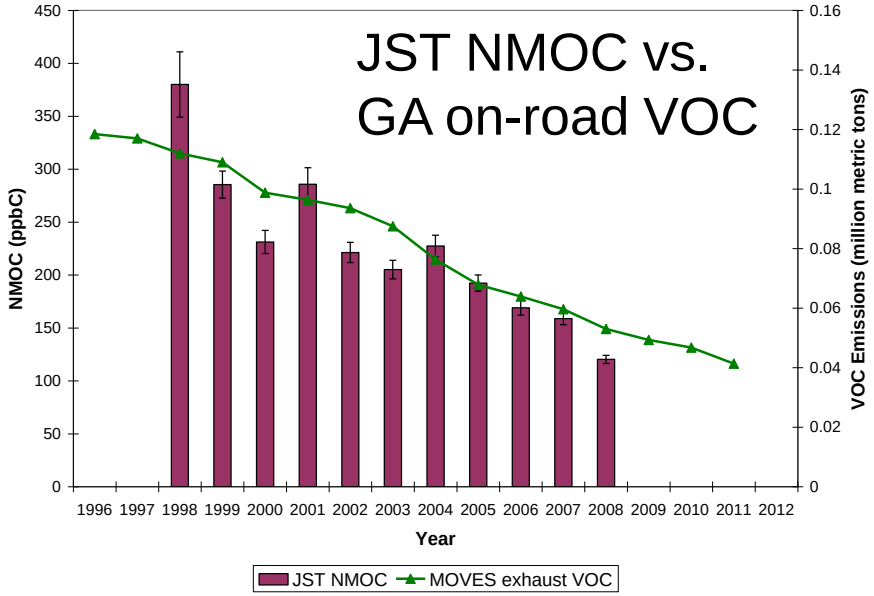


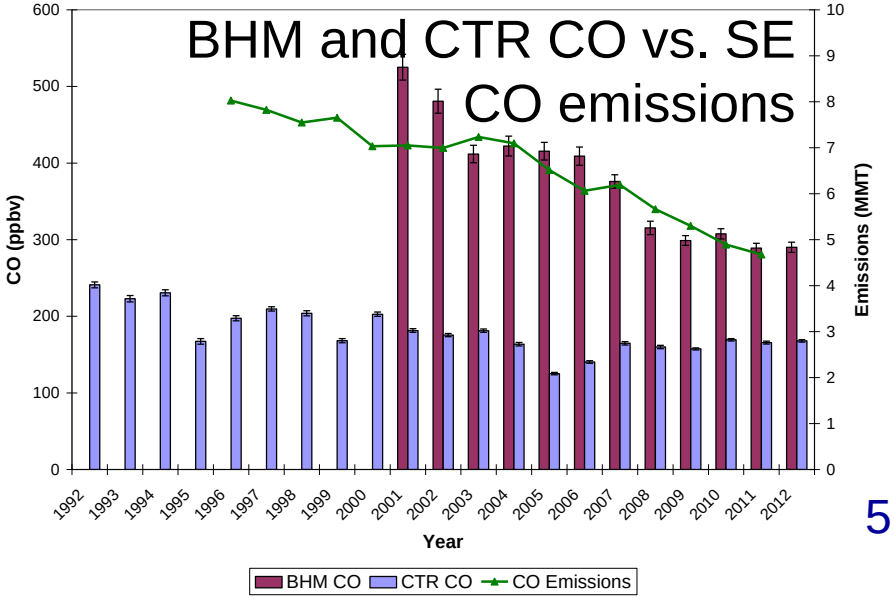


Gases (SO_2, NO_y, NO_z, NMOC, CO) and $PM_{2.5}$ SO_4 Track Emissions

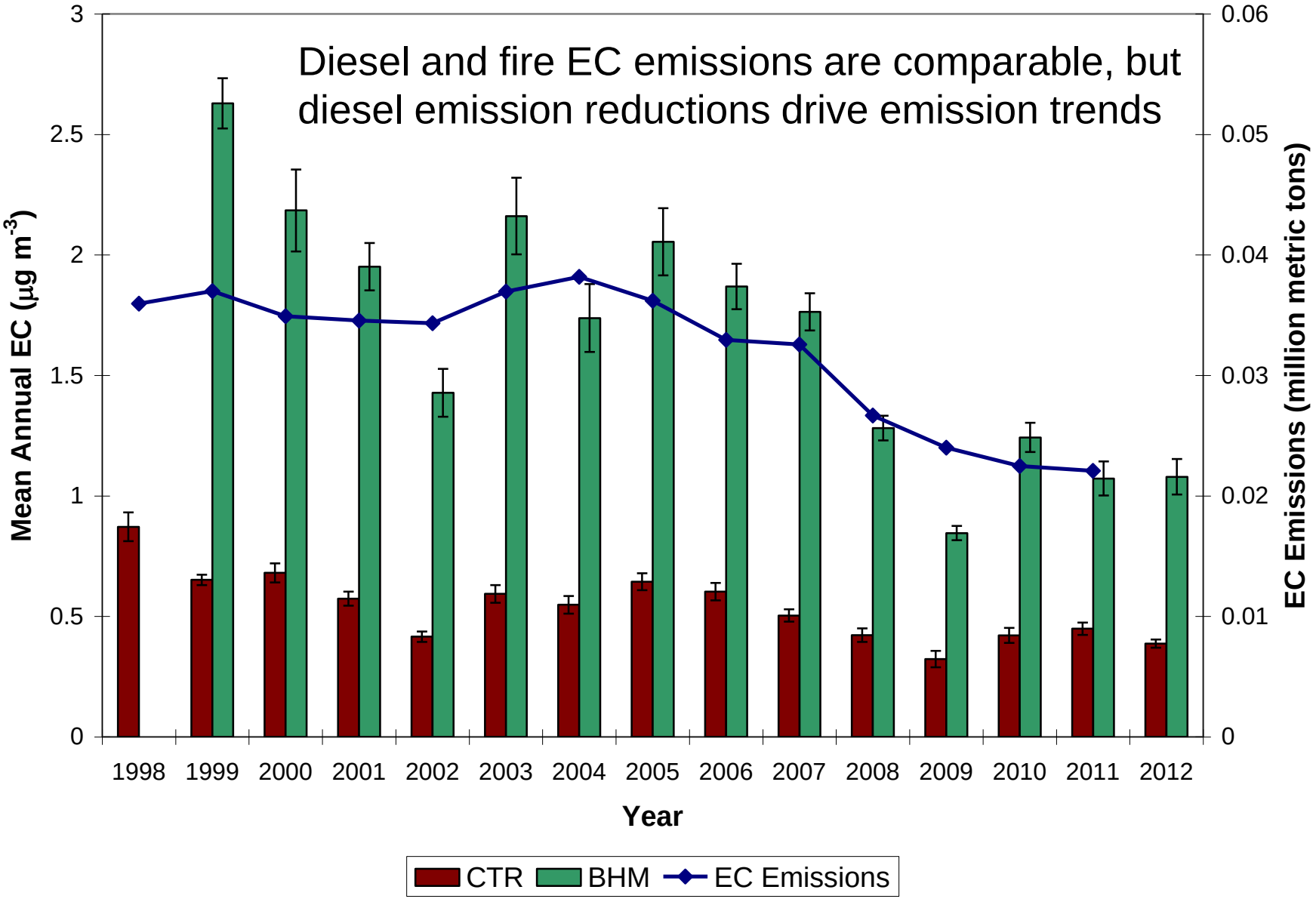




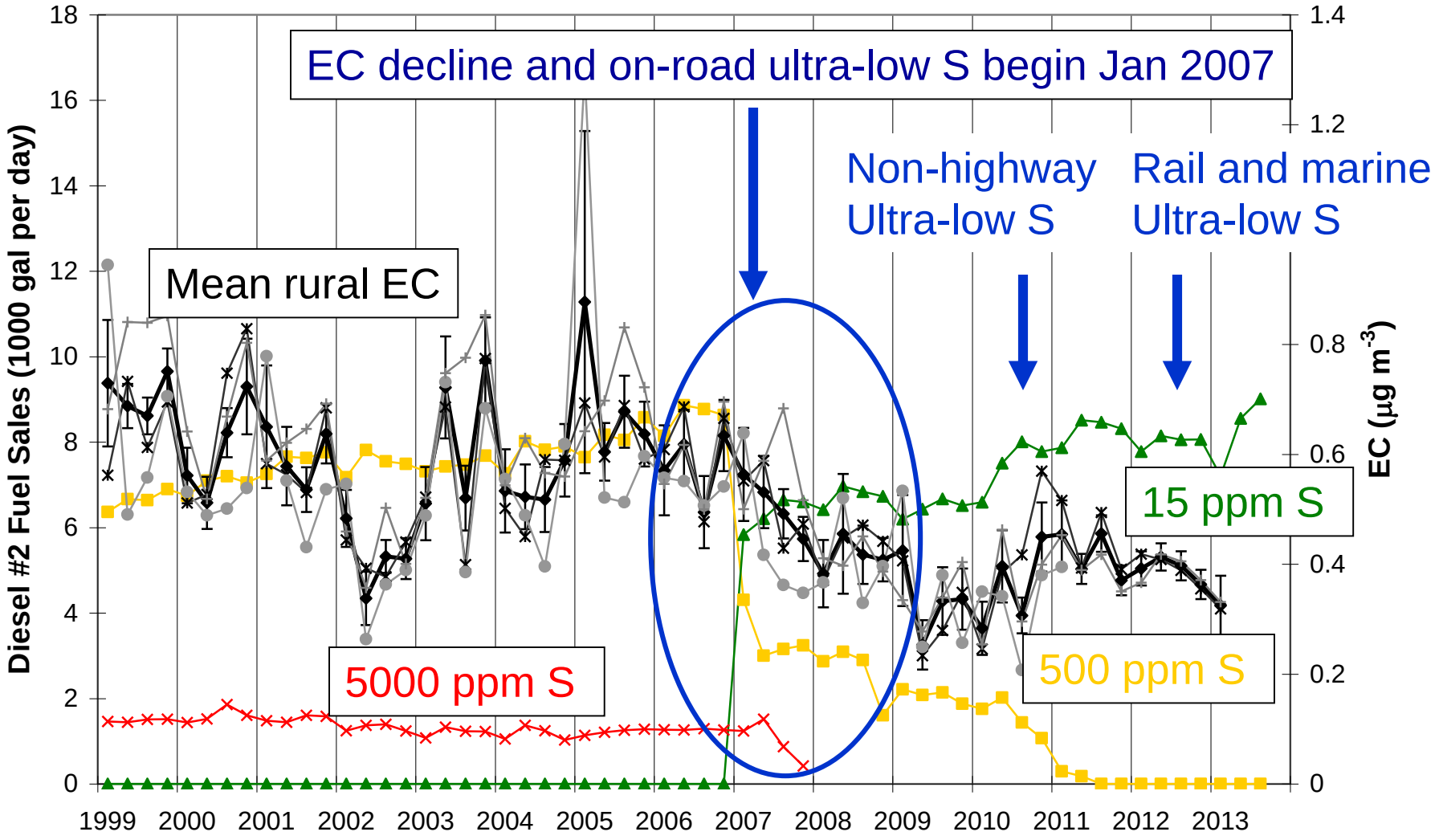




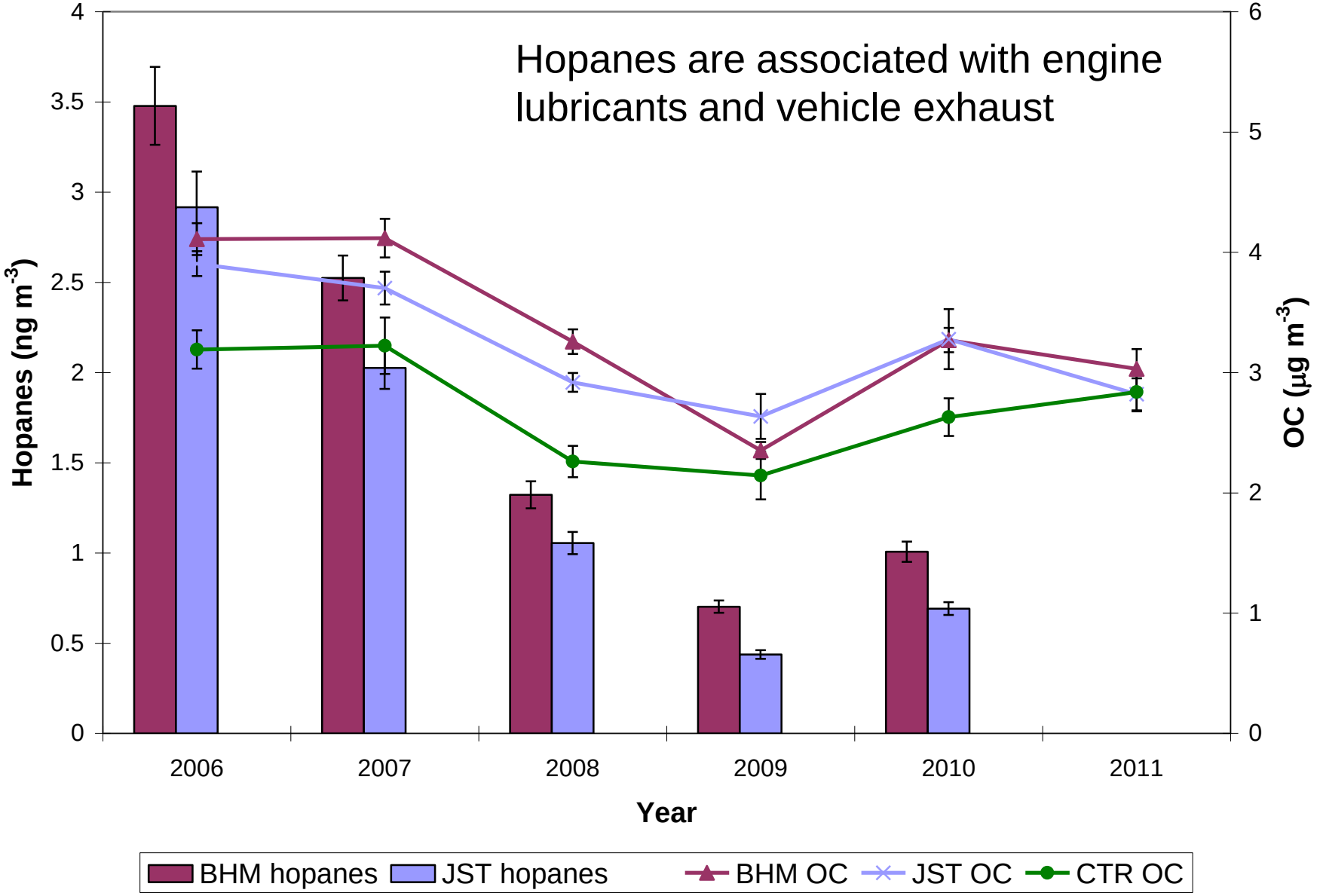
Are SEARCH EC Trends Consistent With EC Emissions? – Yes!



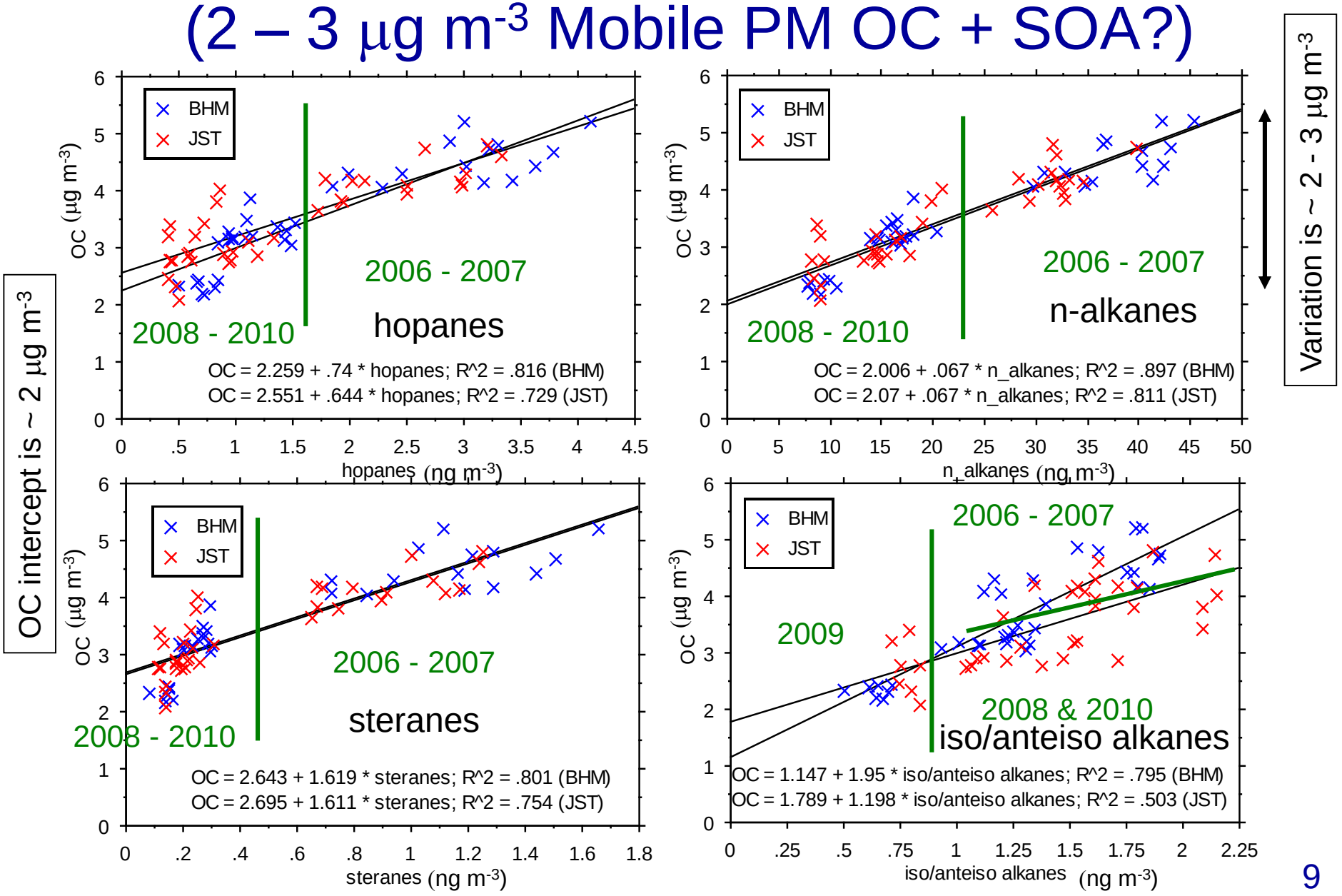
SEARCH Rural EC Decline Coincides With Introduction of Ultra-Low S Diesel Fuel



OC Trends Correlate With Decline in Non-polar OC Species (hopanes, etc)



Urban OC Varies with Non-polar Species (2 – 3 μg m^{-3} Mobile PM OC + SOA?)



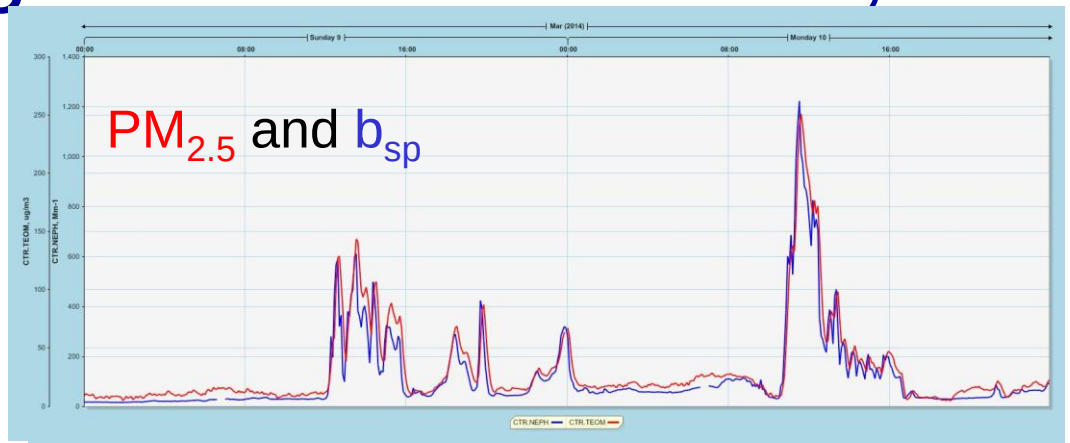
Data are 2006 – 2010 annual day-of-week means

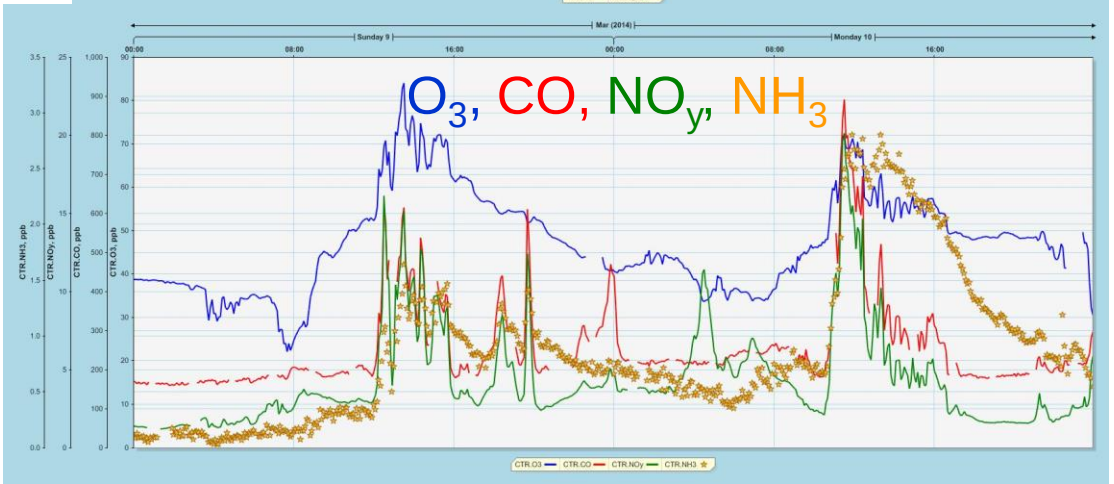
Biomass Burning Event March 9 –10, 2014

Location
- ~10 km N of CTR
- ~ 1000 acres
- WDR ~ 300° (250 – 20)

EC and TC
- OC/EC 15:1 – 20:1 at peaks

Gases
- 8-hour O_3
  - -62 & 56 ppbv
  - -52 & 45 ppbv at BHM
- CO 300–900 ppbv





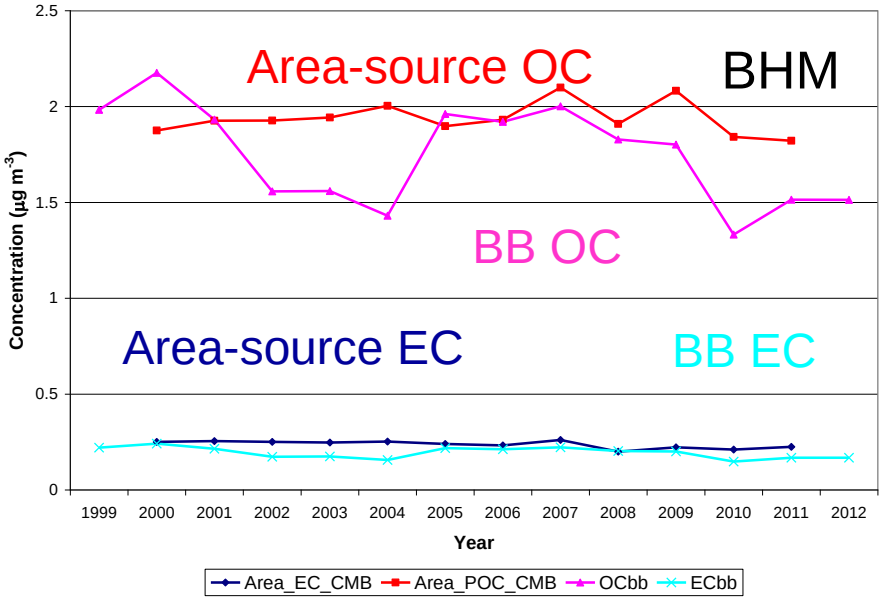
Application of Potassium Tracer Method to Estimate Biomass Burning OC

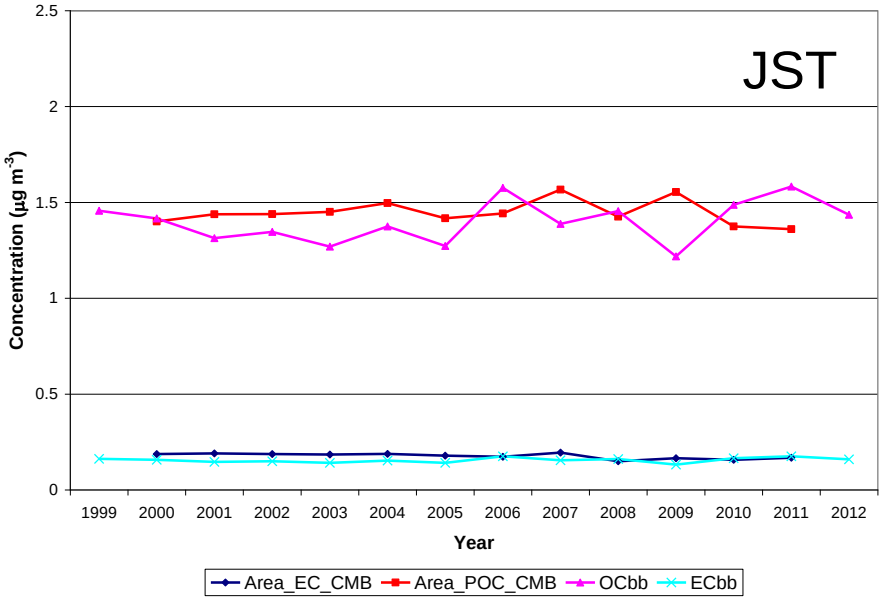
- Use K tracer approach*:
  - regress K against X**: $K = \alpha + \beta * X$
  - compute $Kb = K - \beta * X$
  - PM_{coarse}: tight $\Delta K / \Delta Si$ (0.10 – 0.13; $r^2 \sim 0.8$)
- Kb > 0.4 $\mu g\ m^{-3}$ are on 4th of July and Jan 1!
- Scale from Kb to BB TC, OC, and EC
  - TC/Kb varies widely among fire types (wild << Rx)
  - Inventory annual average BB TC/Kb 28:1 – 36:1
  - 2004-05 data: modern $\Delta TC / \Delta Kb \sim 22:1 – 82:1$

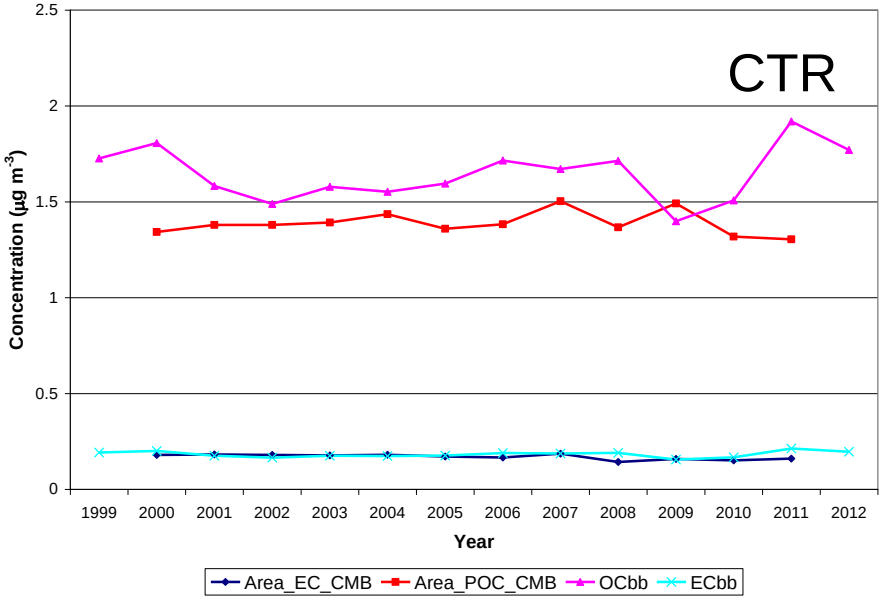
* Recently described by Pachon et al. 2013. *Atmos. Poll. Res.*

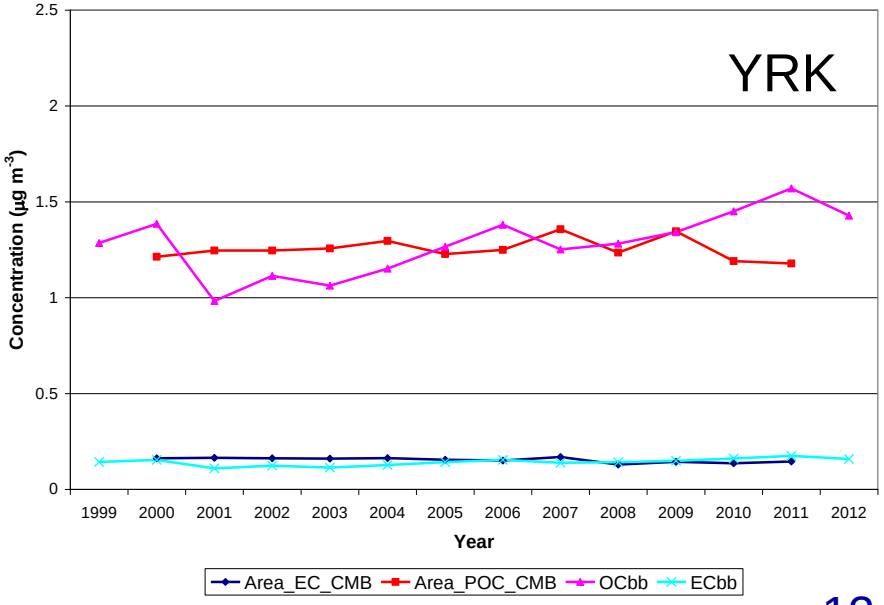
** X is an element that derives primarily from crustal material

K-Tracer BB Trend Consistent with CMB*



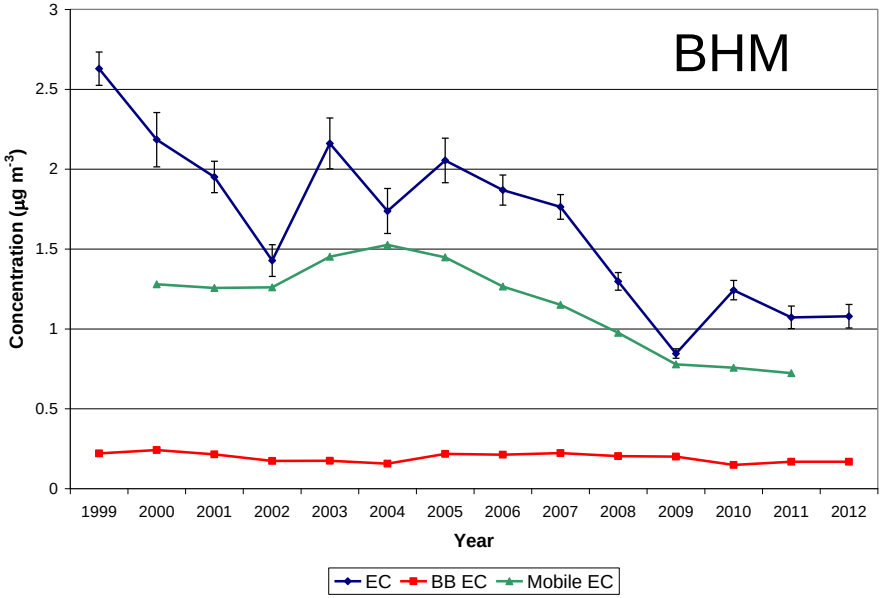


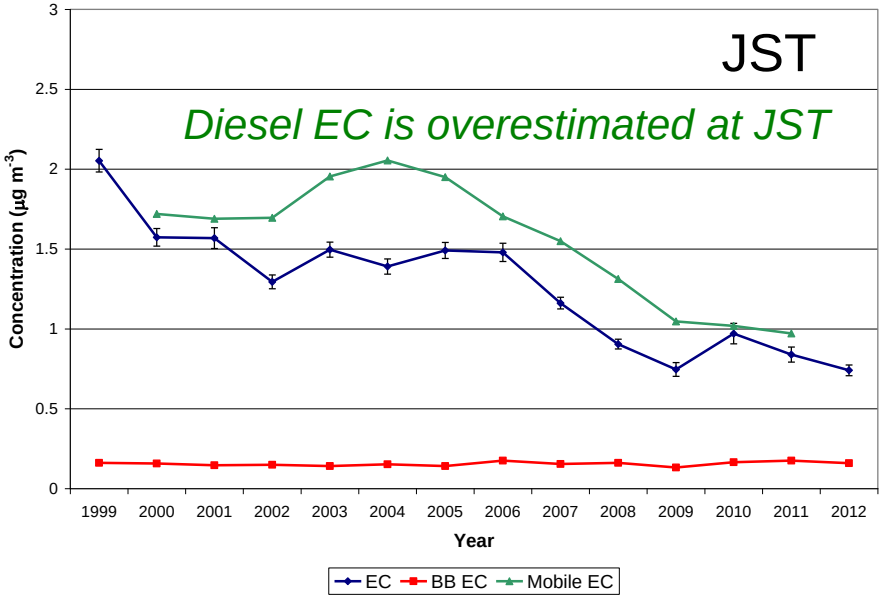


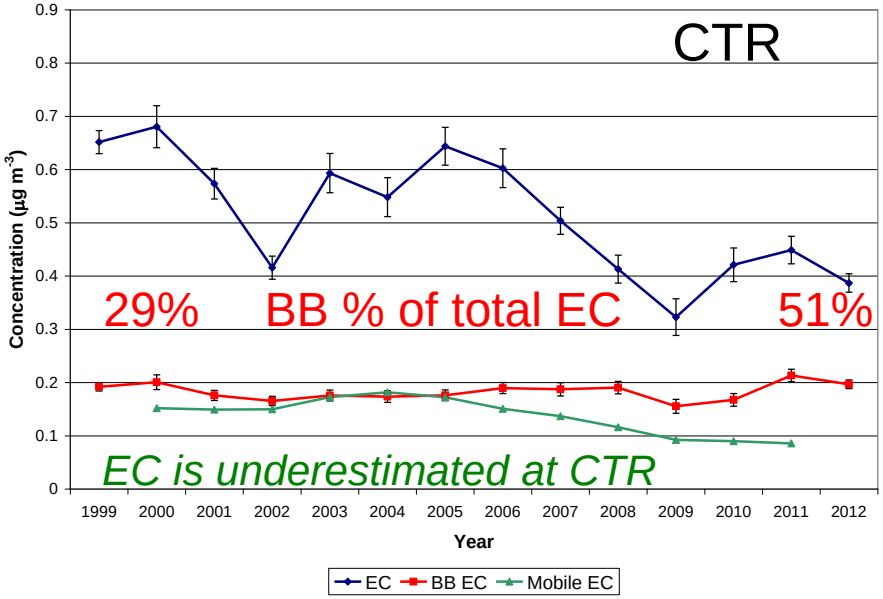


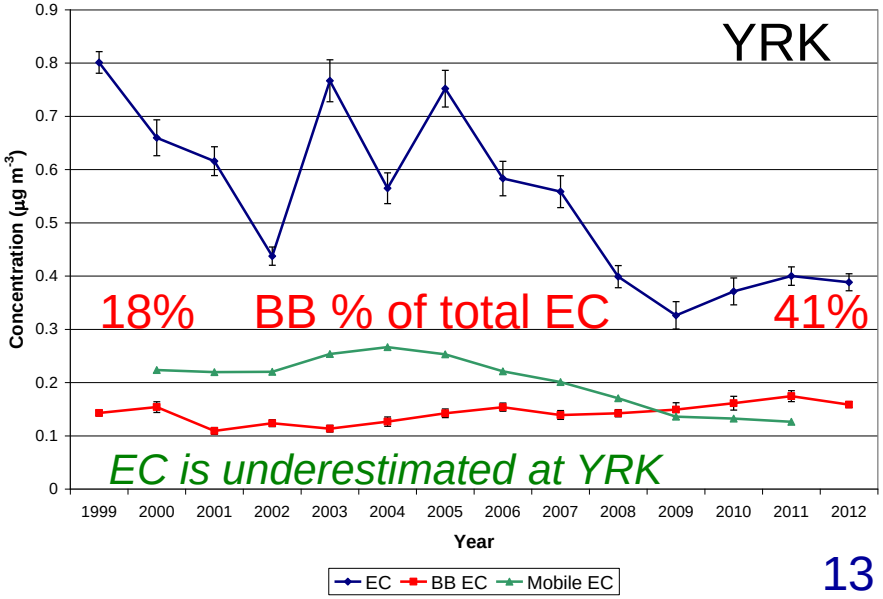
* Blanchard et al. 2013. *ES&T.* (Area source is predominantly fires)

BB EC ~ Constant but Increasing Fraction



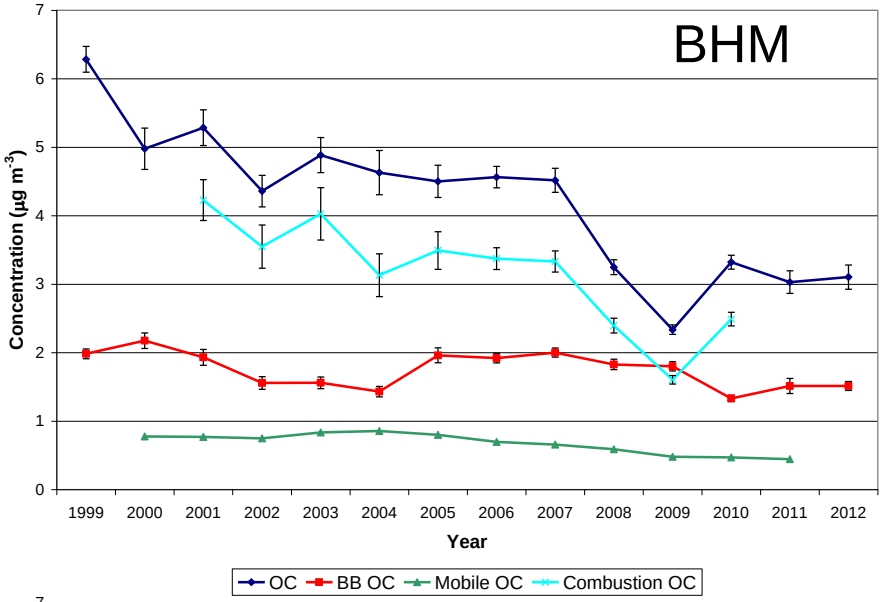


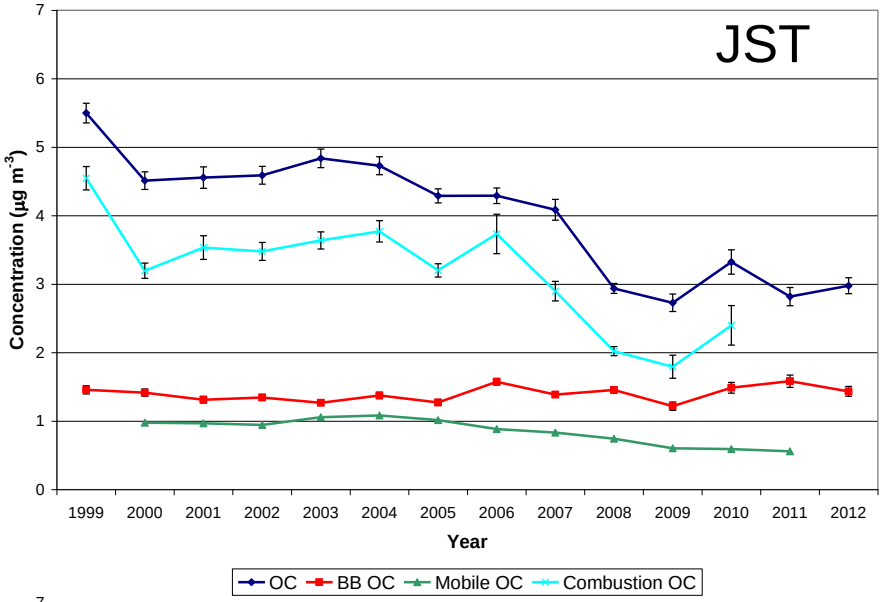


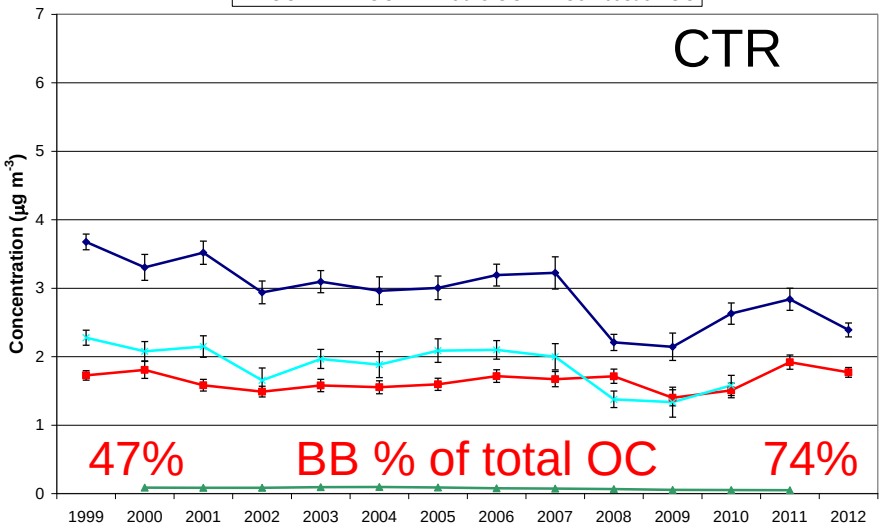


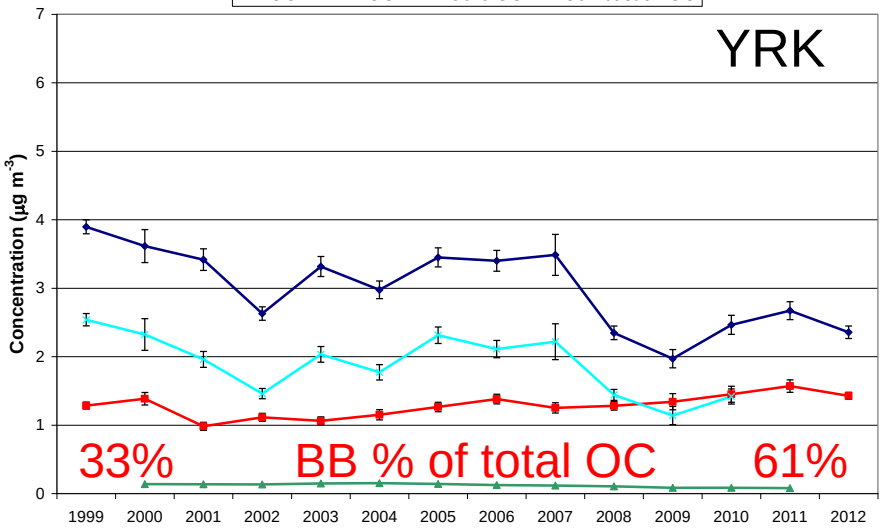
Mobile EC (diesel + gasoline PM EC) from Blanchard et al. 2013. *ES&T.*

BB OC ~ Constant but Increasing Fraction









Mobile OC (diesel + gasoline PM OC) from Blanchard et al. 2013. *ES&T.*

Combustion OC is calculated from tracers EC, CO, non-soil K (Blanchard et al., 2008)

Summary: Anthropogenic Influences on EC and OC

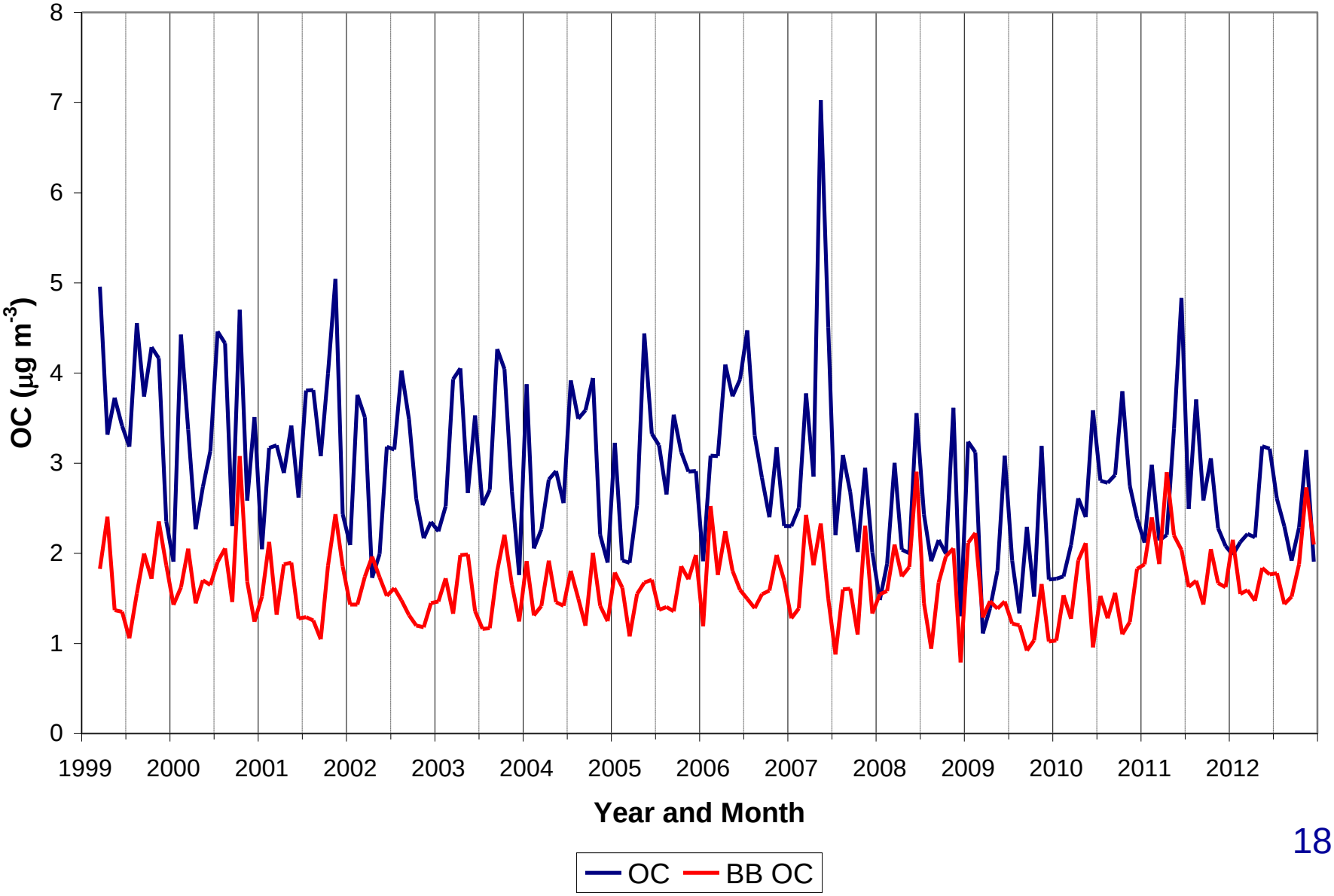
- Large reductions of anthropogenic emissions of SO_2, NO_x, CO, VOC, EC, OC in SE US
- SEARCH ambient trends in SO_2, NO_y, CO, NMOC, EC, OC, SO_4, NO_3 track emission trends between 1999 (1992) and 2012
- SEARCH hourly and daily 1999 - 2012 measurements indicate that emissions from mobile sources and biomass combustion together are major contributors (~50 – 75%) to mean concentrations of EC and OC at CTR and at all SEARCH sites

SEARCH Presentations

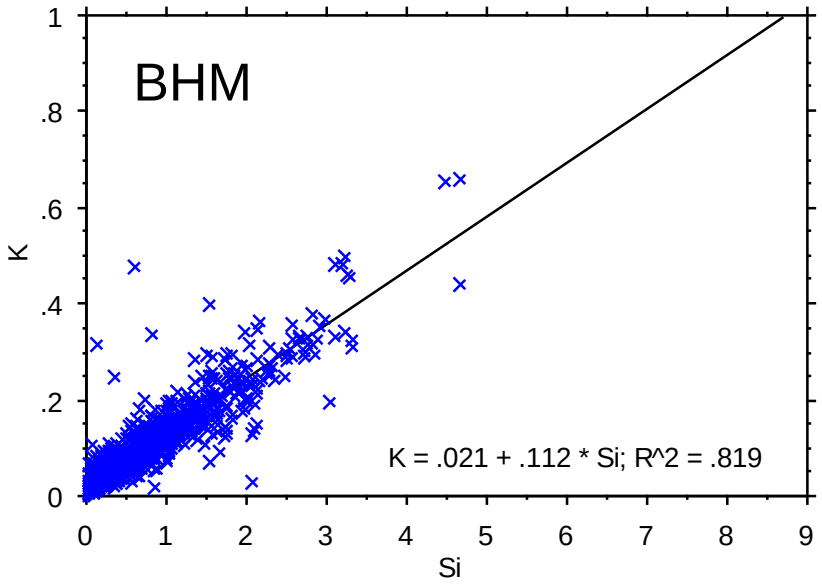
- Tuesday morning, Session 5
  - K. Baumann et al.: *An Historical Perspective on Air Quality at CTR in Jun-Jul*
  - S. Shaw: *Outstanding Questions on Organic Aerosols*
- Poster Session 2
  - E. Edgerton et al.: *First Look at ^{14}C Data During the Centreville, AL SOAS Campaign*
  - G. Hidy et al.: *Chemical Climatology of the Southeastern U.S., 1999 - 2013*

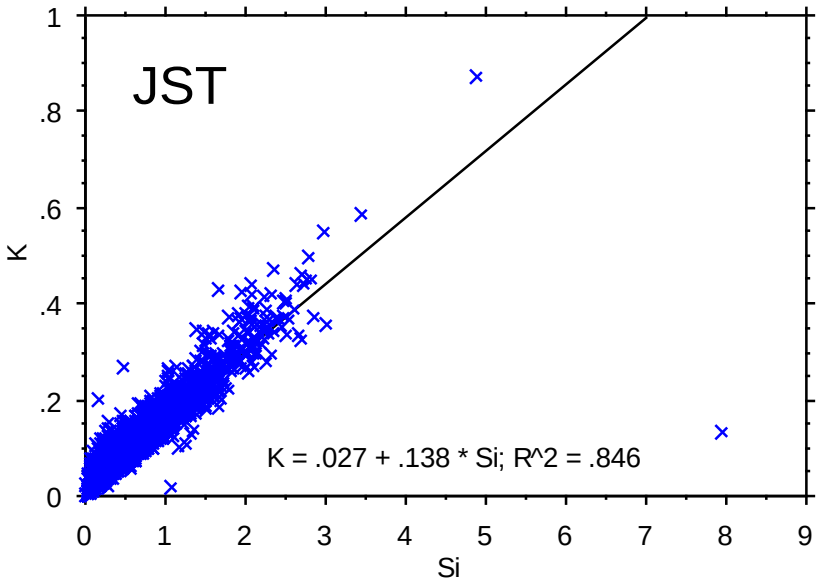
Extras

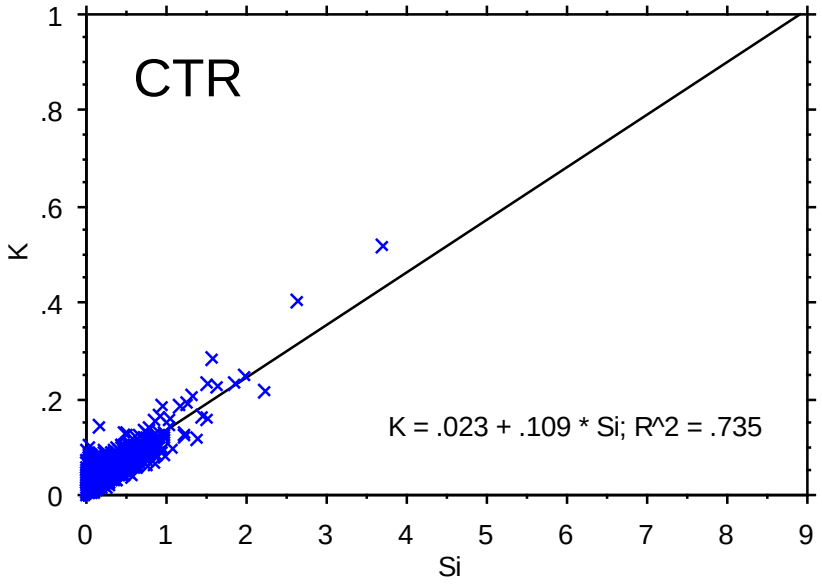
CTR Monthly Average OC and BB OC

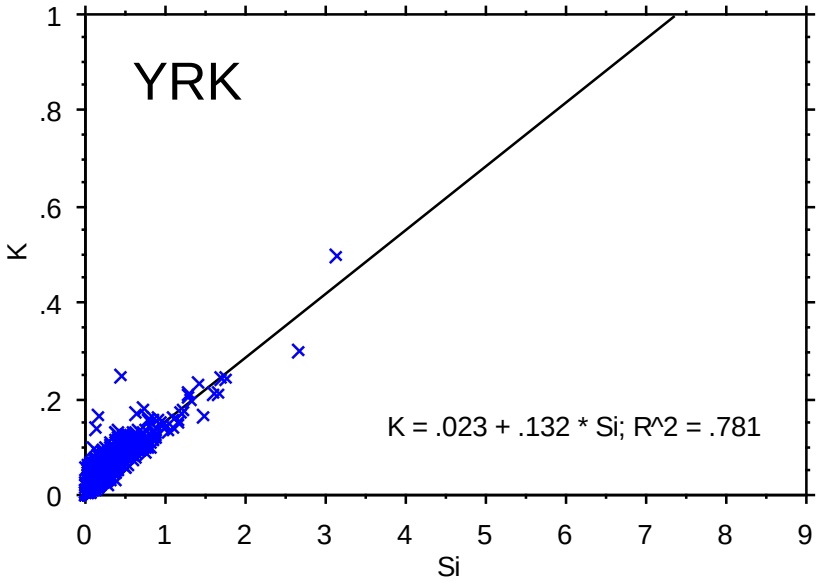


Correlation between K and Si in PM_{coarse}

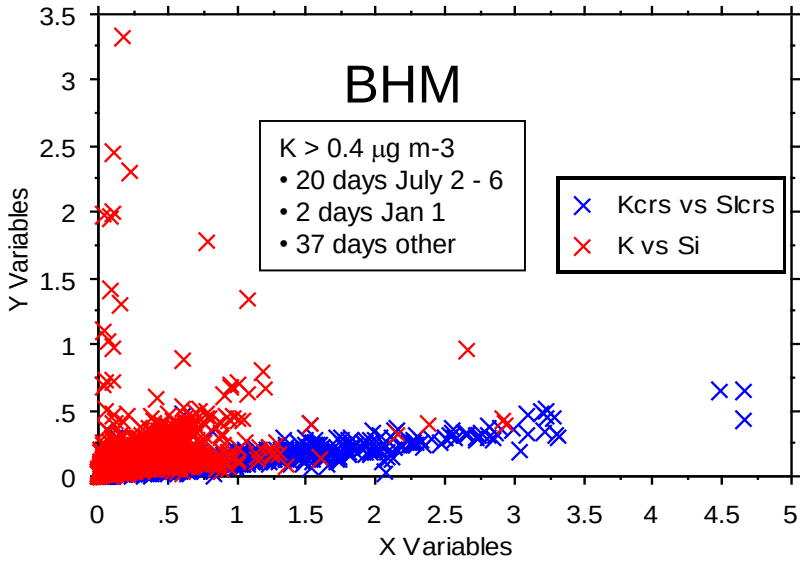


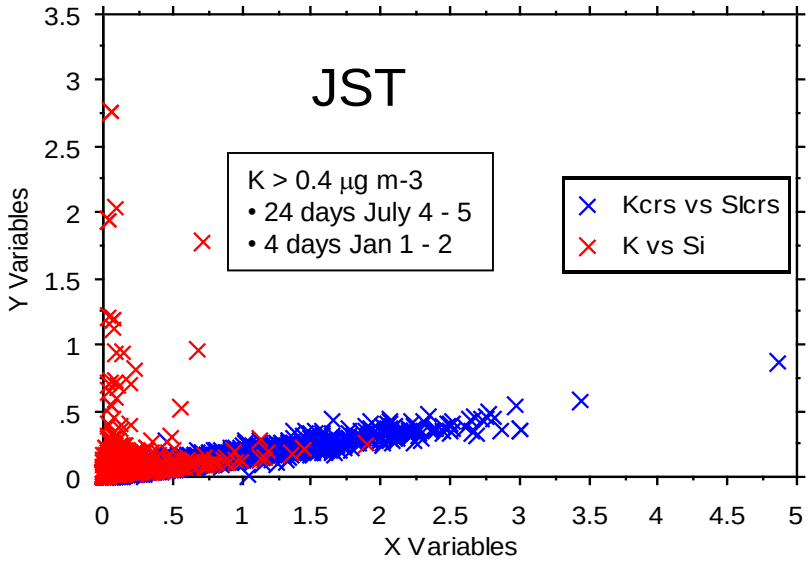


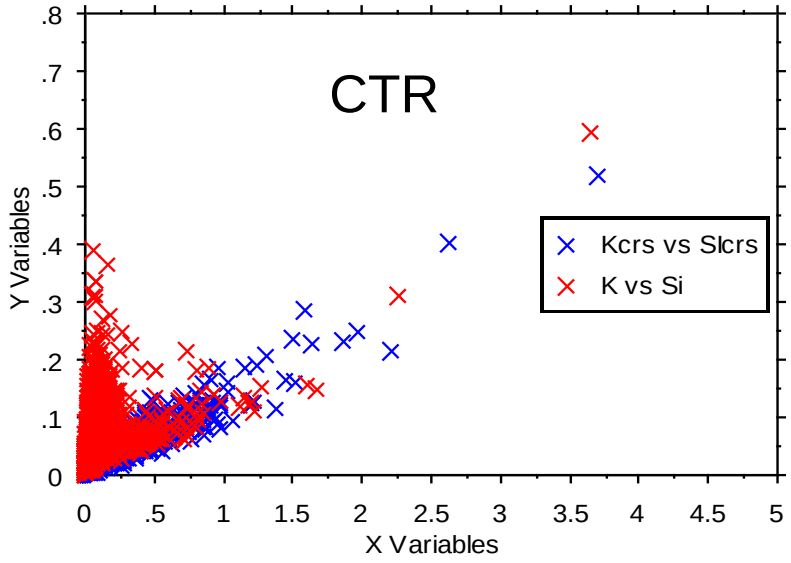


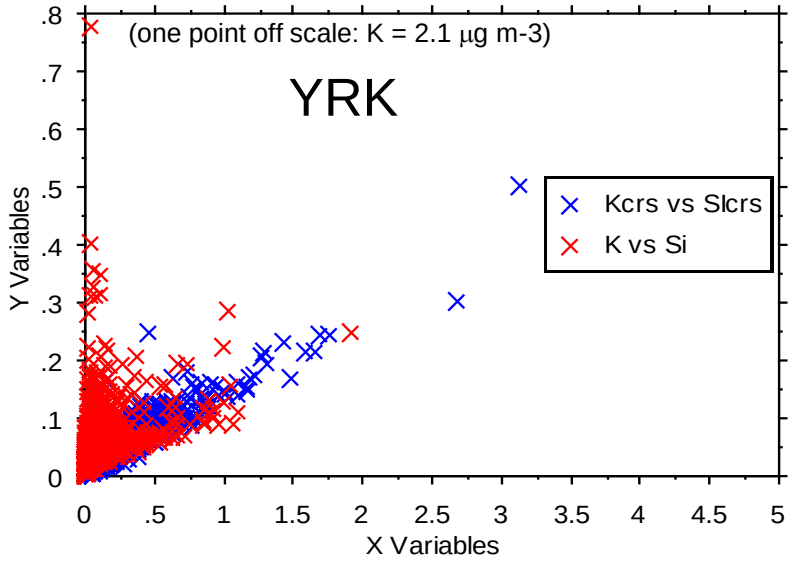


Non-soil K Sources in $PM_{2.5}$

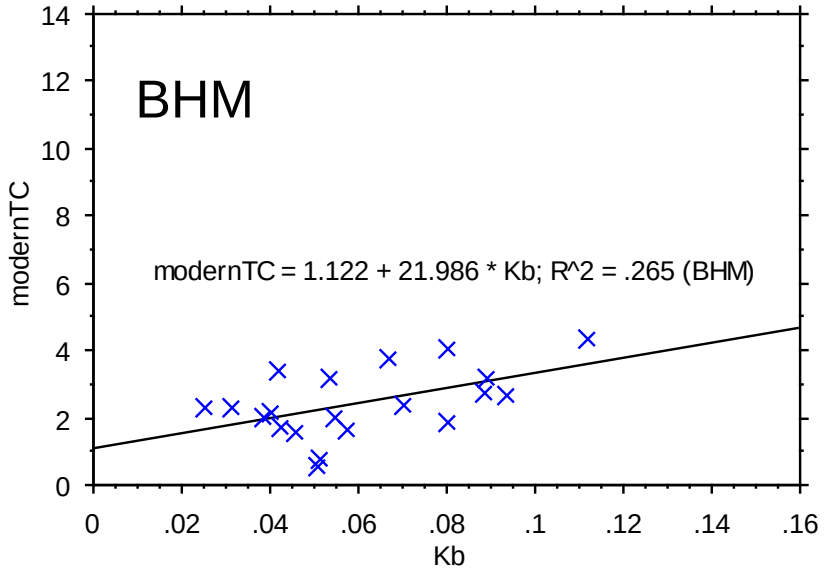


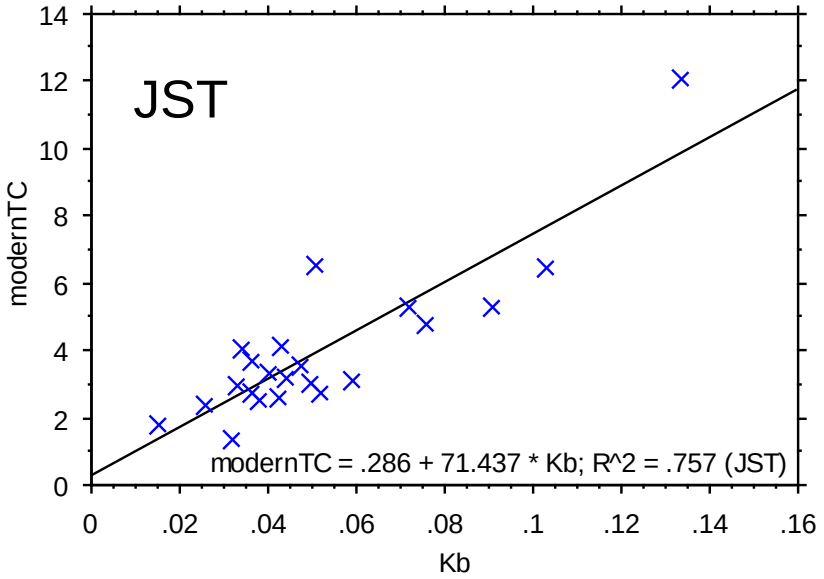


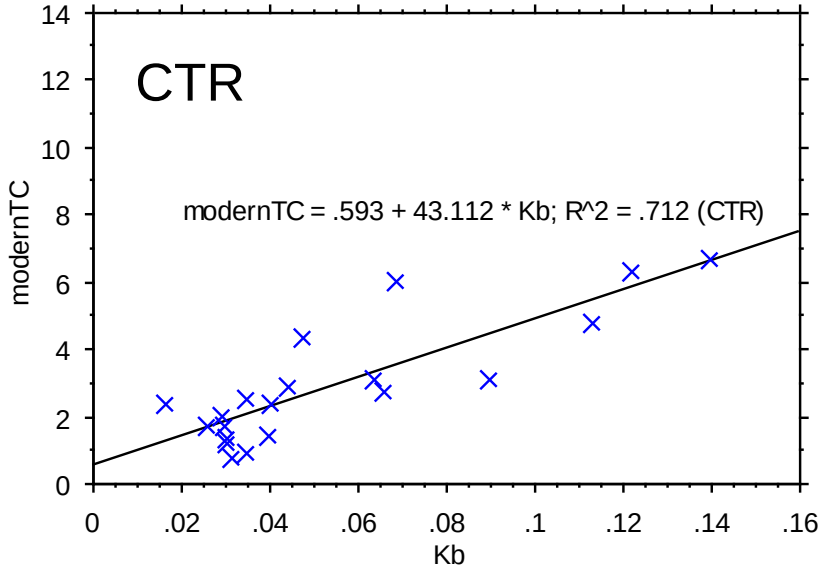


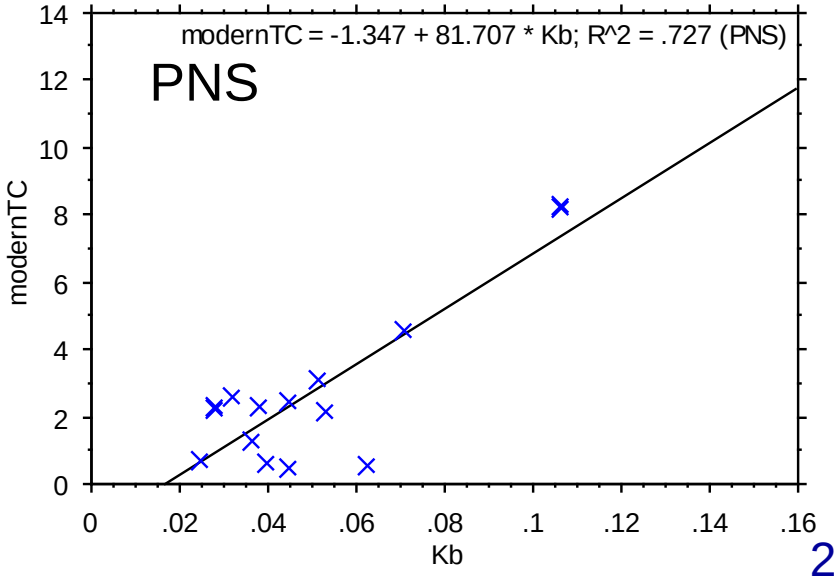


Kb vs. ModernTC by Site (Oct – Apr)

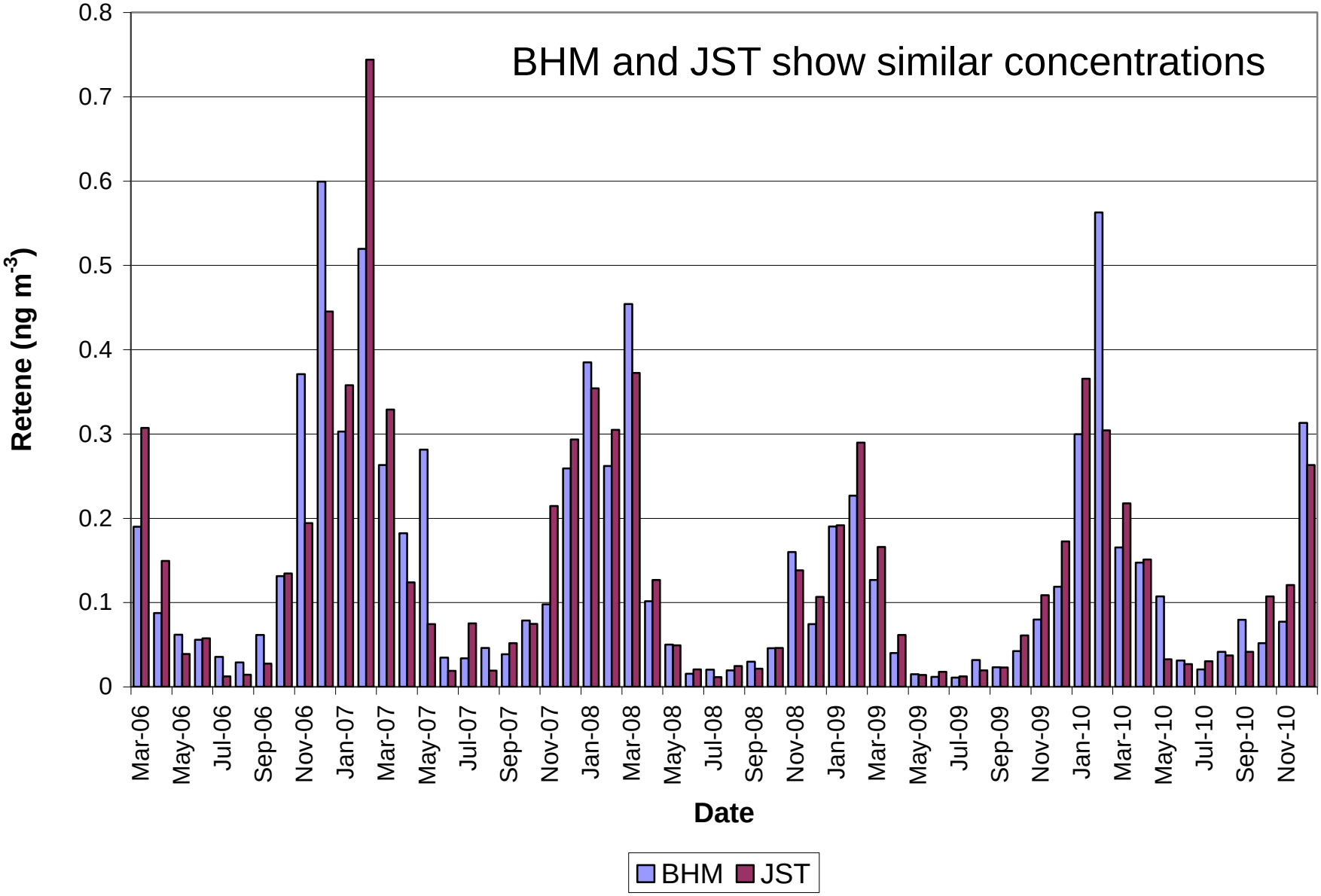




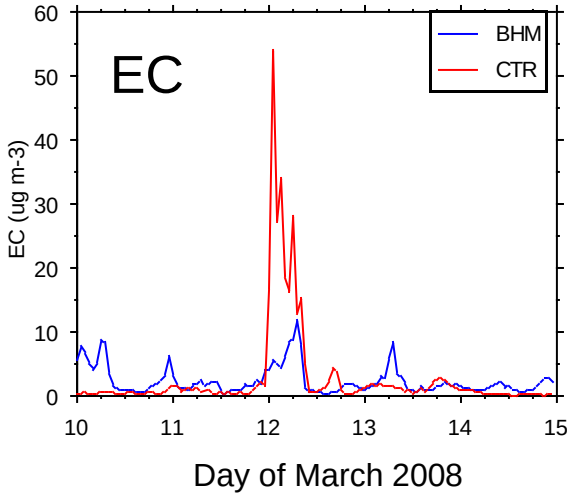


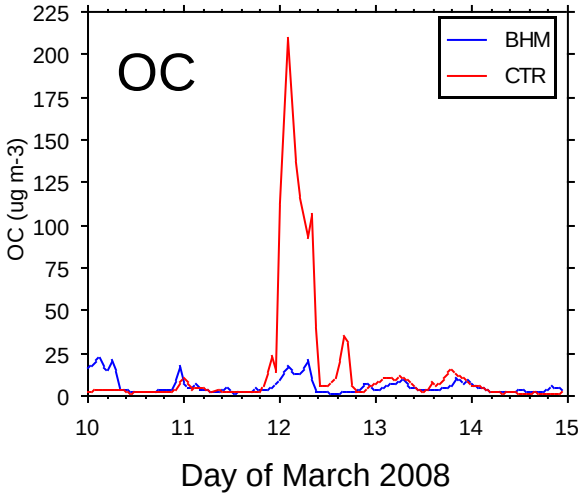


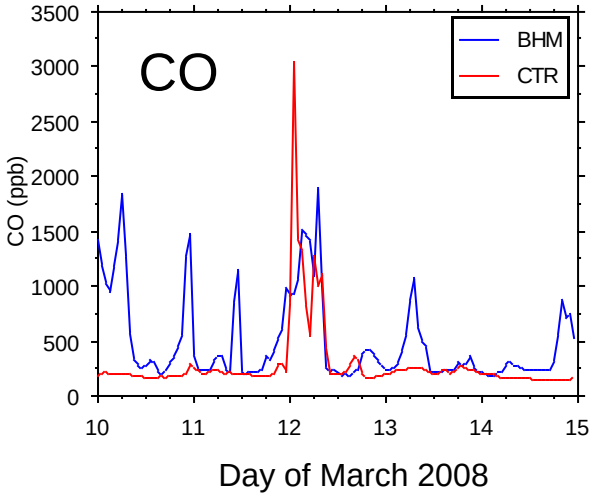
Tracers of Biomass Burning are Seasonal but Always Present

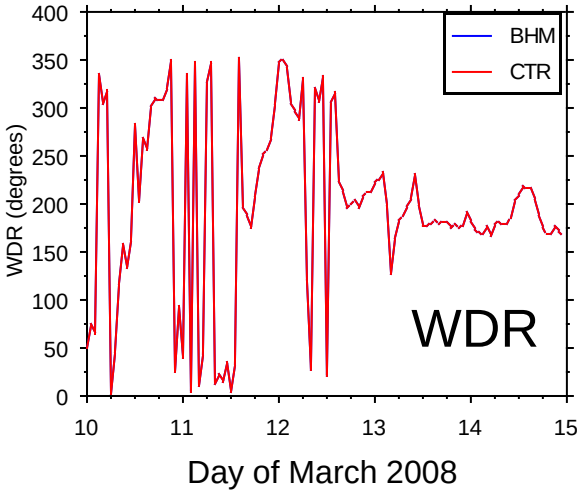


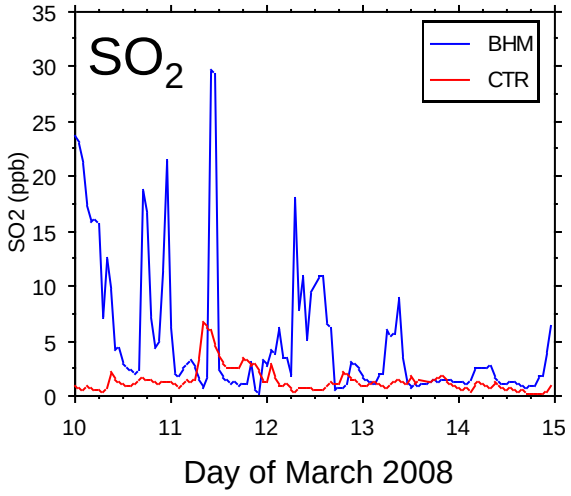
Example Biomass Burning Event March 11 – 12, 2008

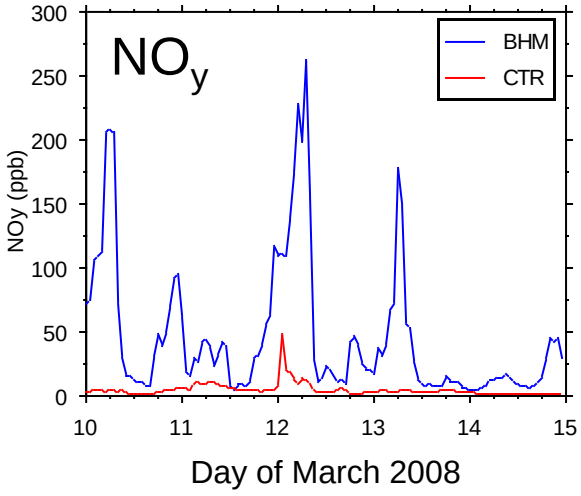






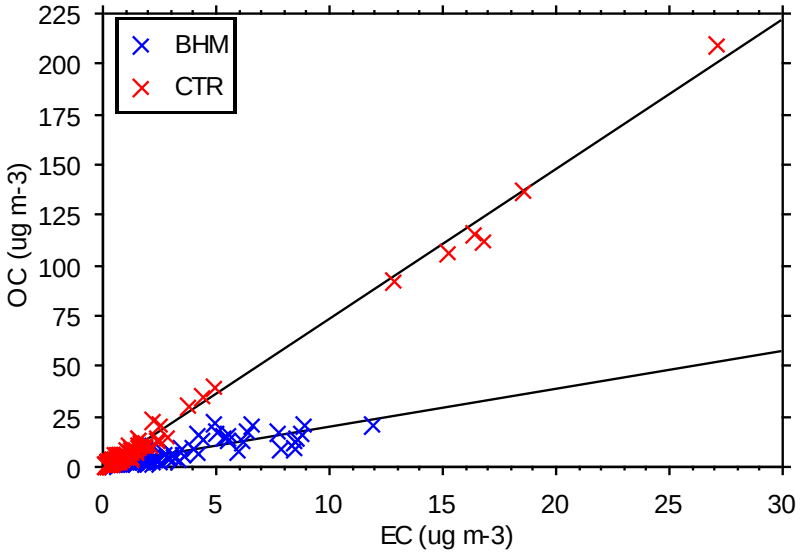




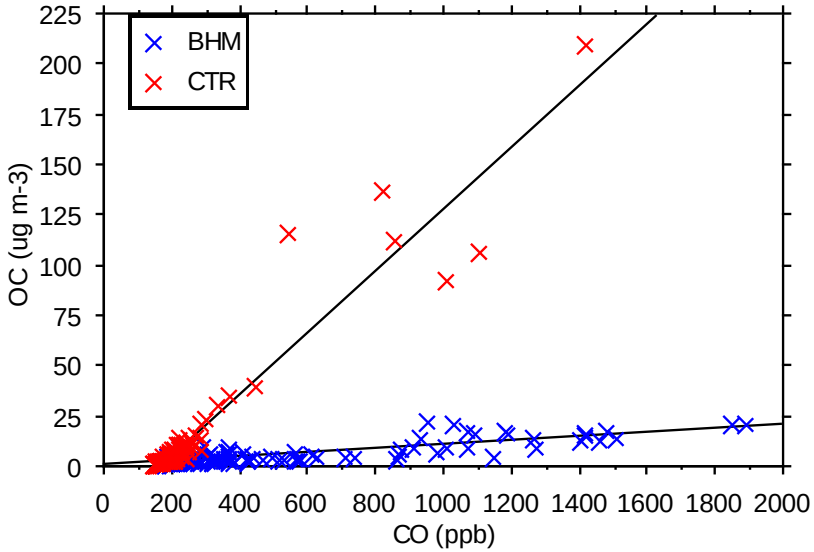


EC, OC, CO enhanced at CTR – some excess NO_y – no excess SO_2

Characteristics of the 3/12/2008 Event



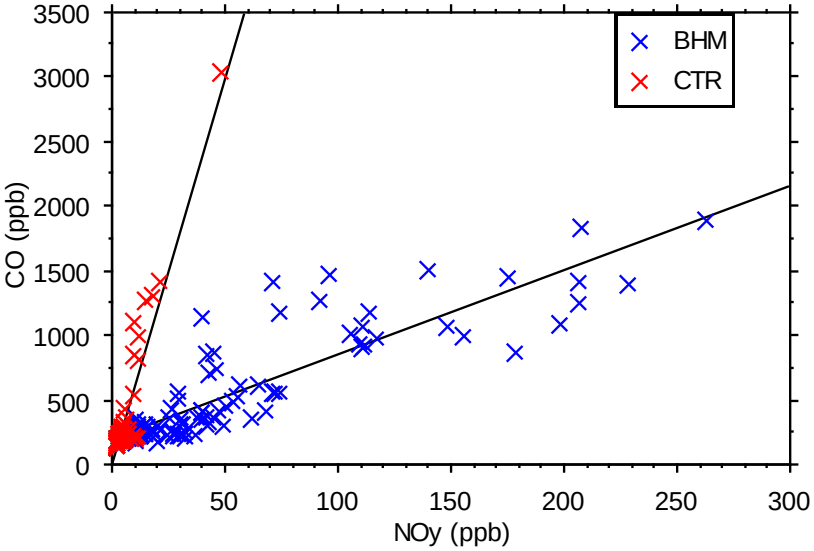
OC (ug m-3) = 1.361 + 1.881 * EC (ug m-3); R^2 = .72 (BHM)
OC (ug m-3) = -.862 + 7.395 * EC (ug m-3); R^2 = .994 (CTR)



OC (ug m-3) = .769 + .01 * CO (ppb); R^2 = .692 (BHM)
OC (ug m-3) = -25.261 + .153 * CO (ppb); R^2 = .912 (CTR)

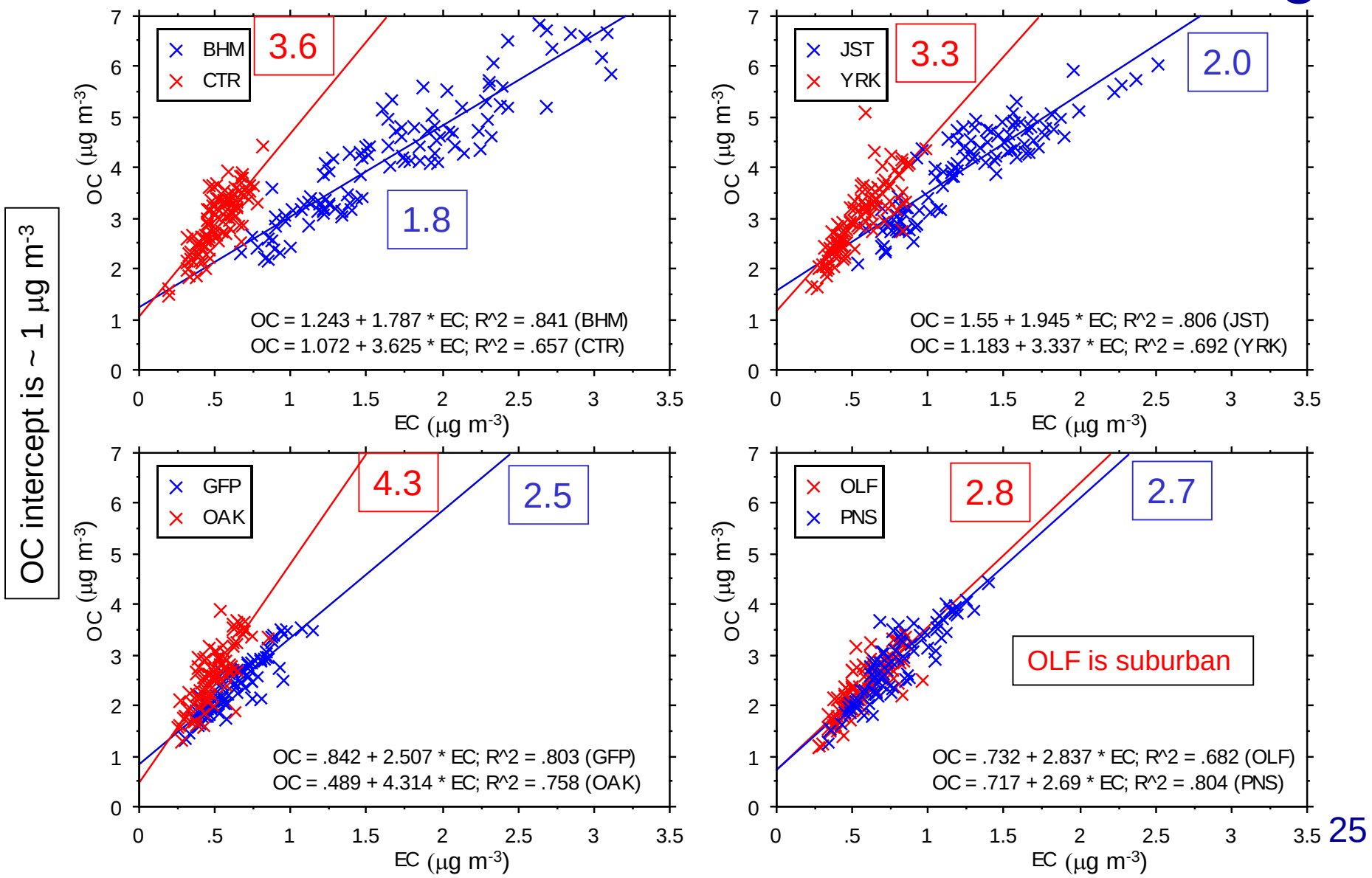
- CTR ΔOC/ΔEC = 7.4
- BHM ΔOC/ΔEC = 1.9

- CTR ΔCO/ΔNOy = 60.0
- BHM ΔCO/ΔNOy = 6.5



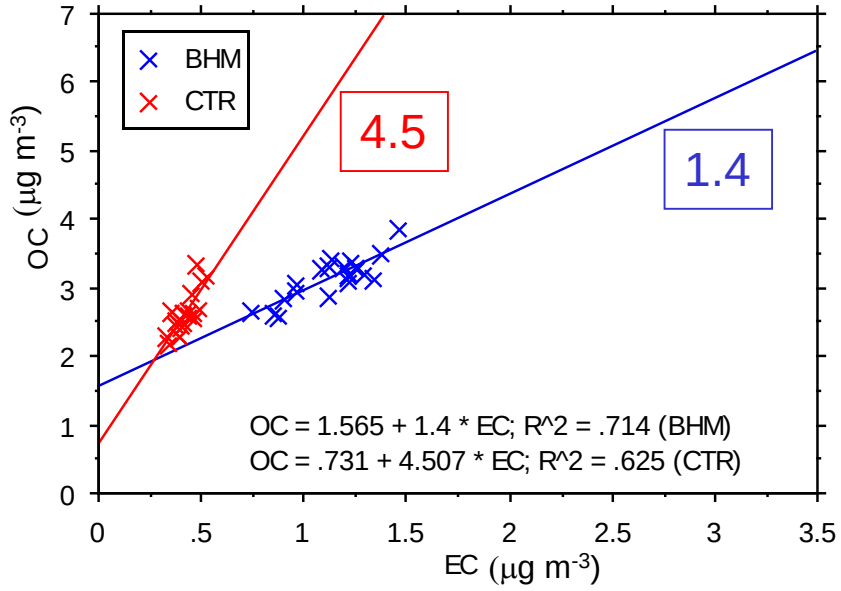
CO (ppb) = 195.171 + 6.493 * NOy (ppb); R^2 = .791 (BHM)
CO (ppb) = -10.438 + 59.954 * NOy (ppb); R^2 = .827 (CTR)

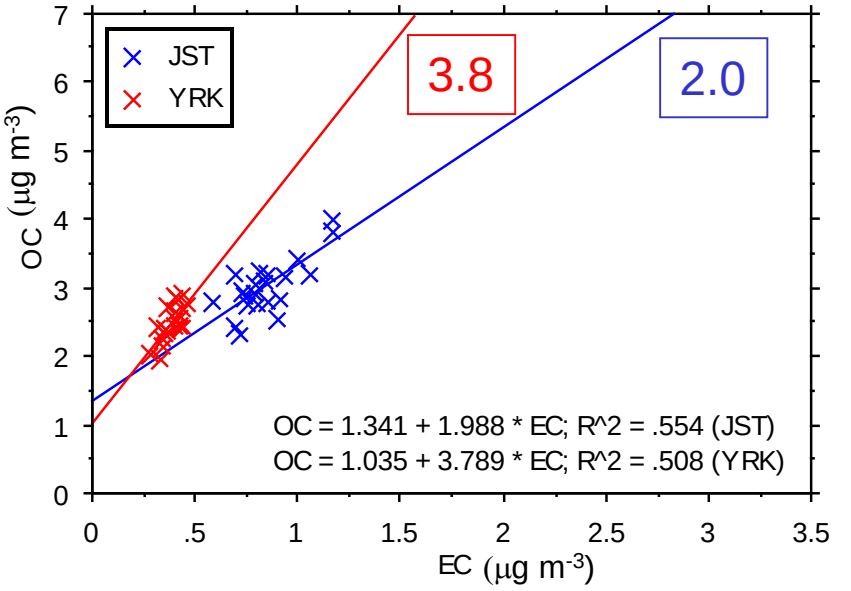
1999 – 2012 ΔOC/ΔEC Signatures: Urban Mobile & Rural Biomass Burning

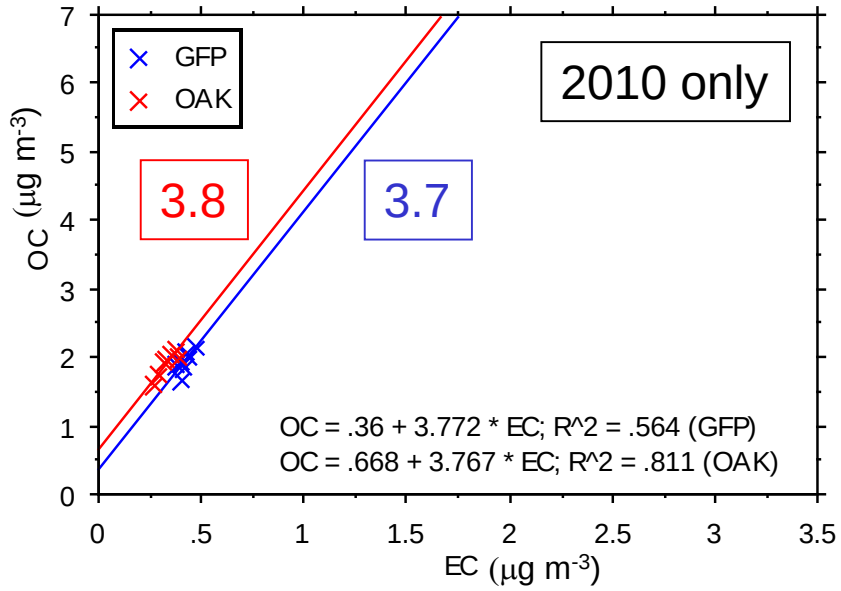


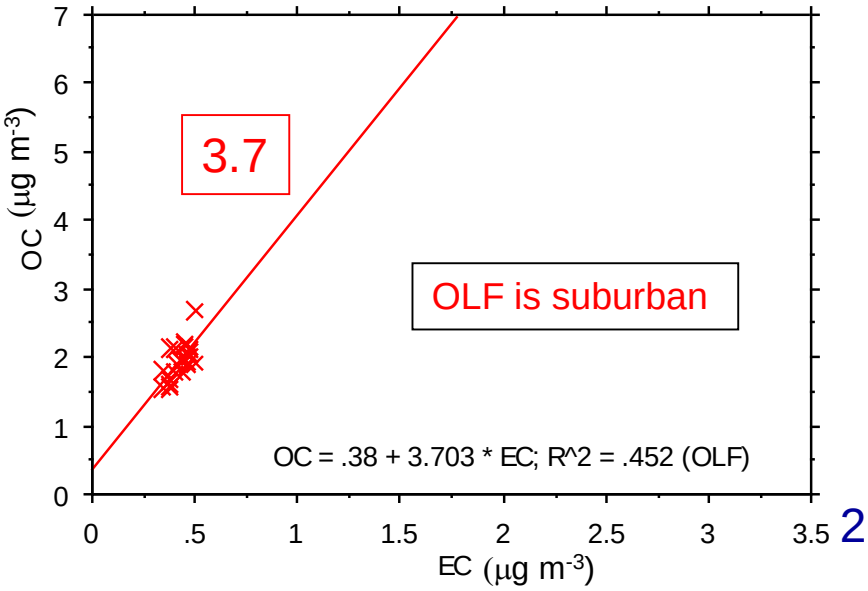
2010 – 2012: Reduced EC and OC with More Similar Urban & Rural OC Range

OC intercept is ~ 1 µg m^{-3}



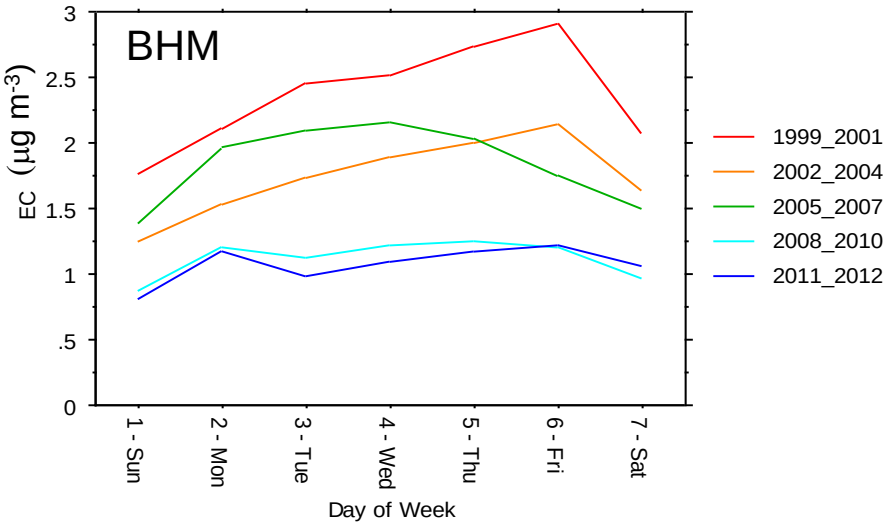


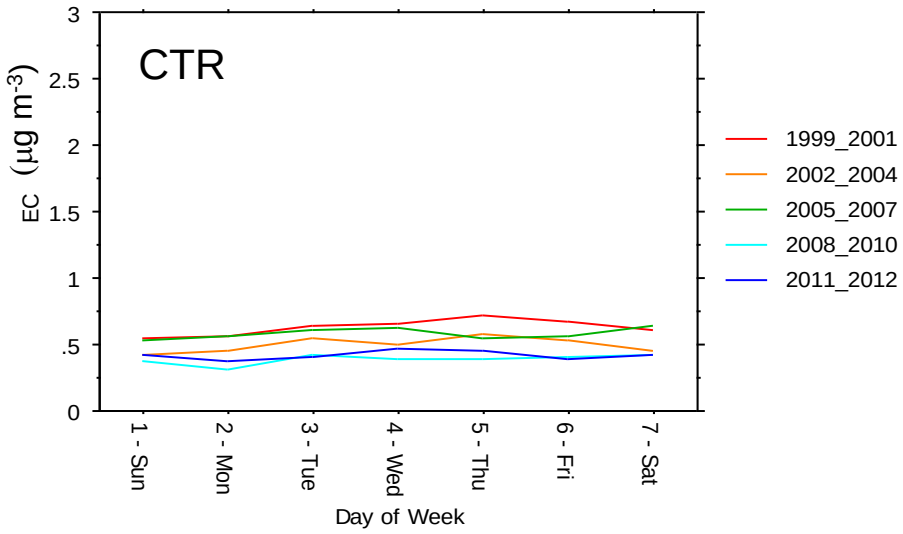


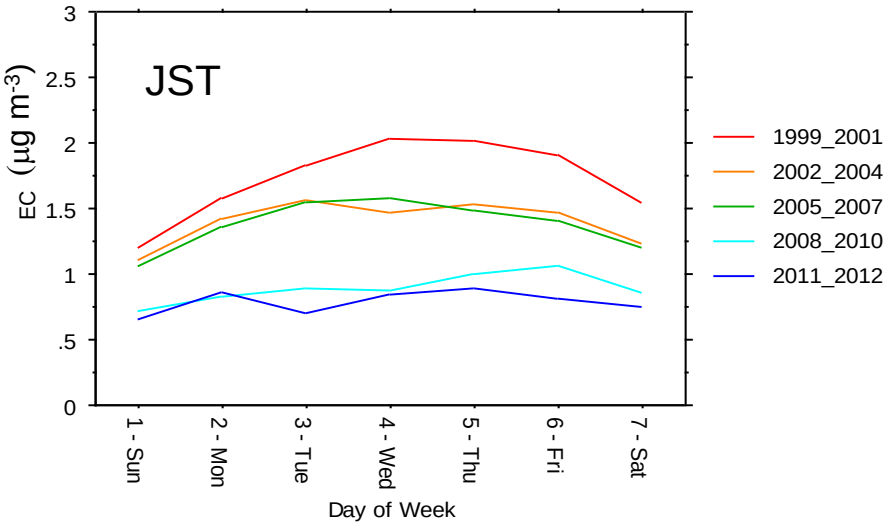


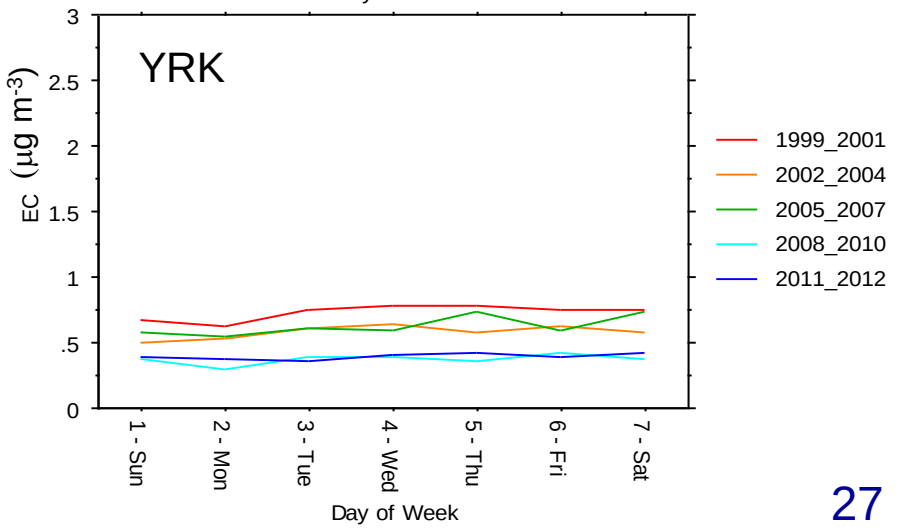
Urban Excess EC and Day-of-Week Variations Declined from 1999 to 2012*

Lower EC post-2007 reflects diesel PM emission reductions





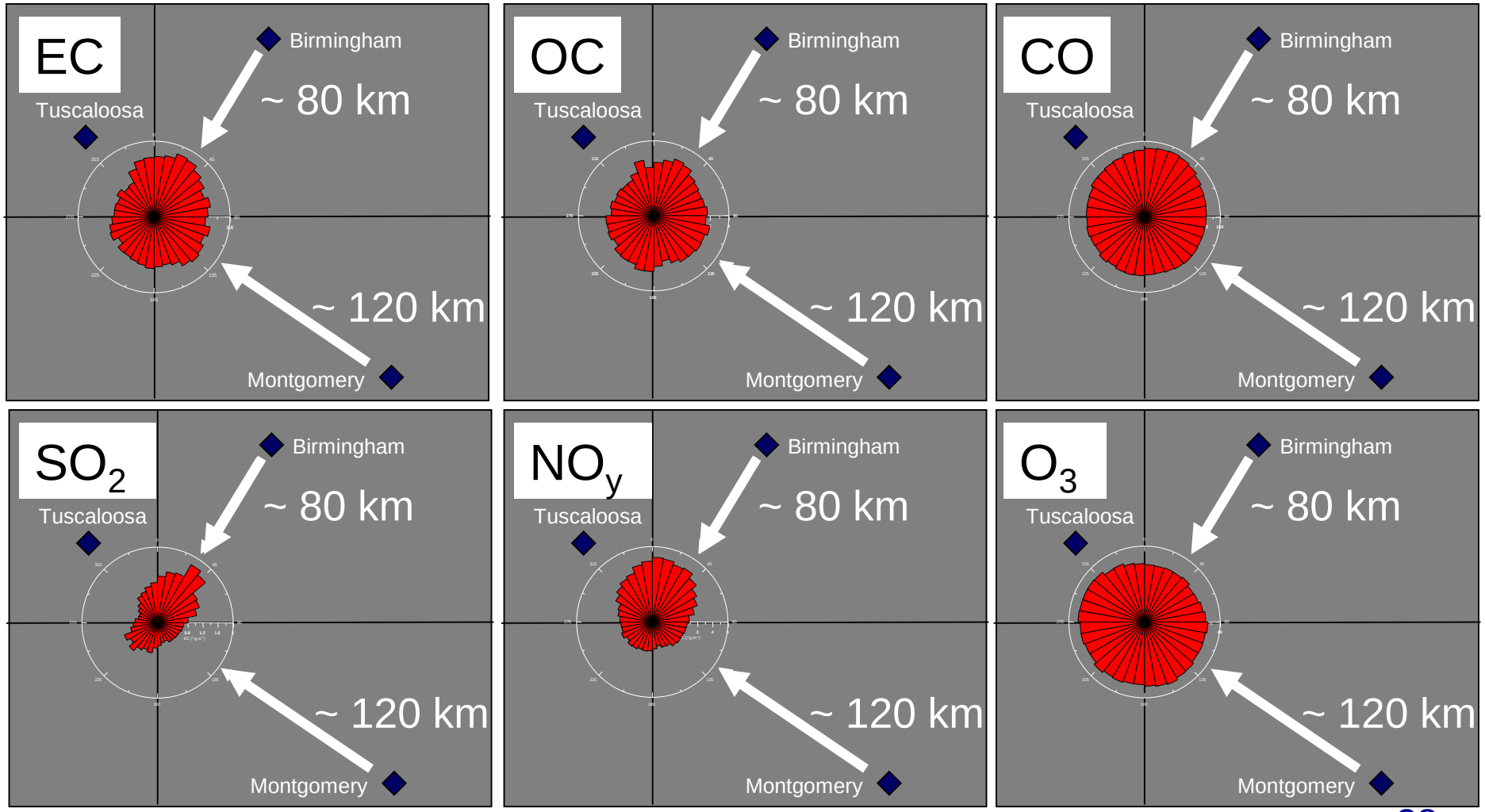




*DoW EC Variations are Linked to HD Diesel Traffic Patterns

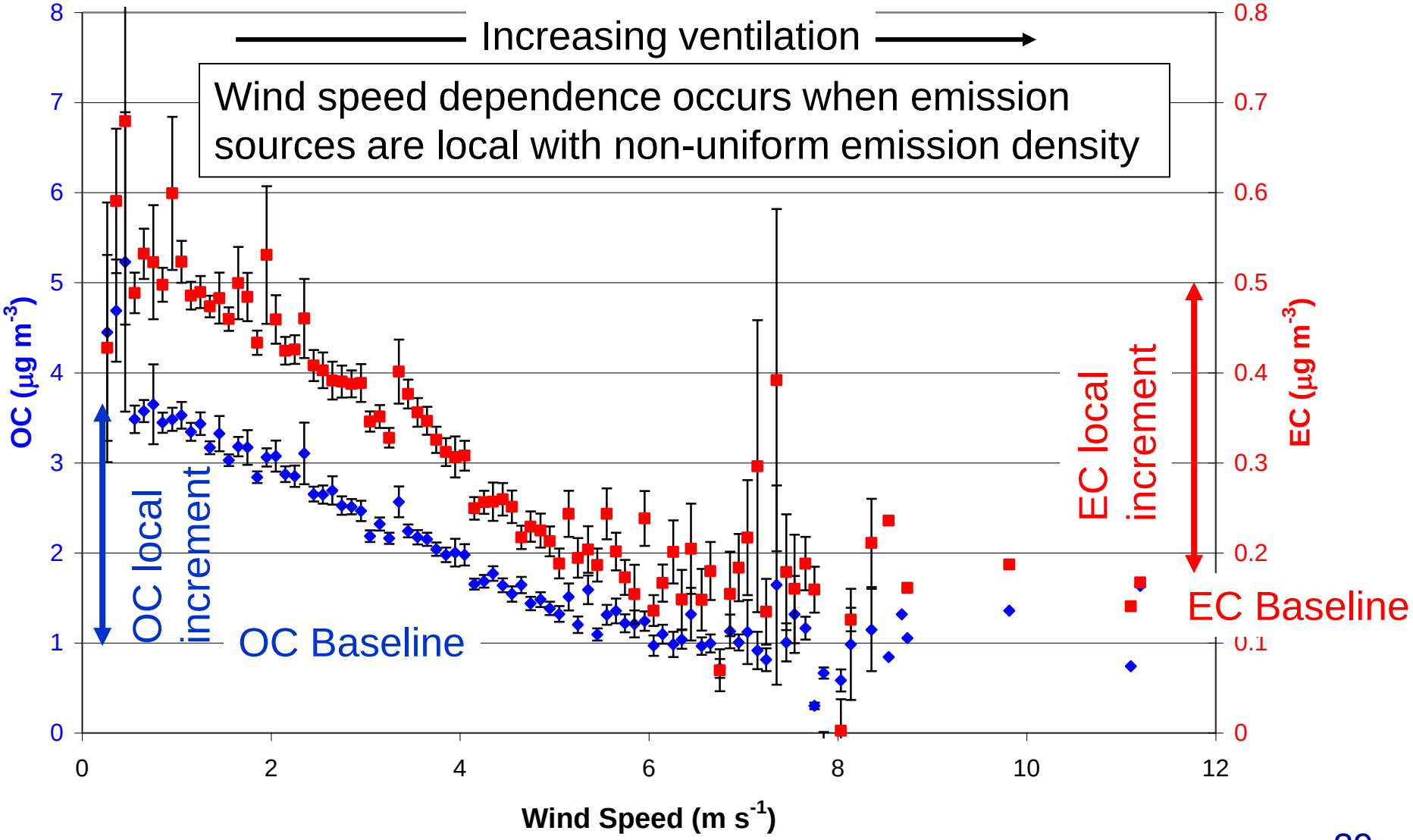
CTR EC, OC, CO, SO_2, NO_y Higher With Winds From Birmingham & Montgomery*

Directionality implies local source contributions



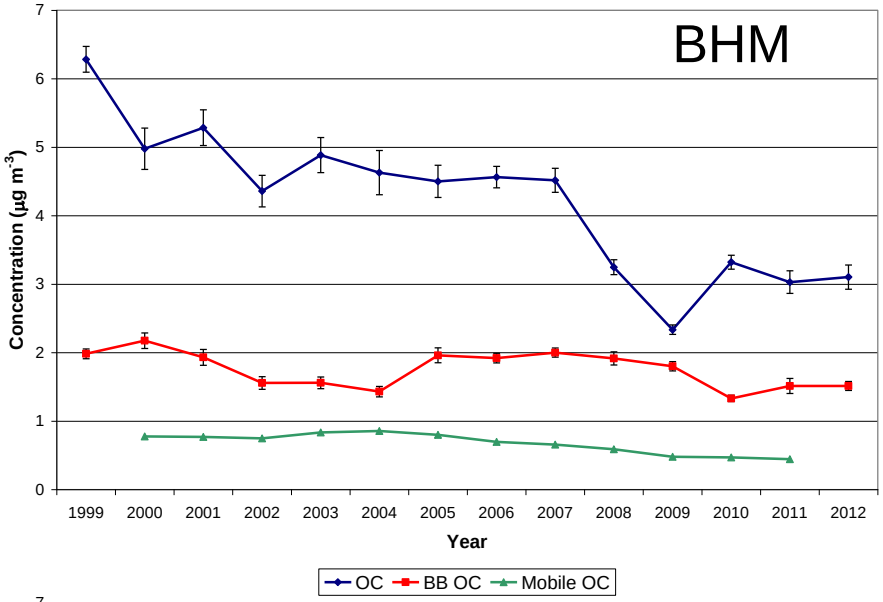
* All hourly data, 2008 - 2010

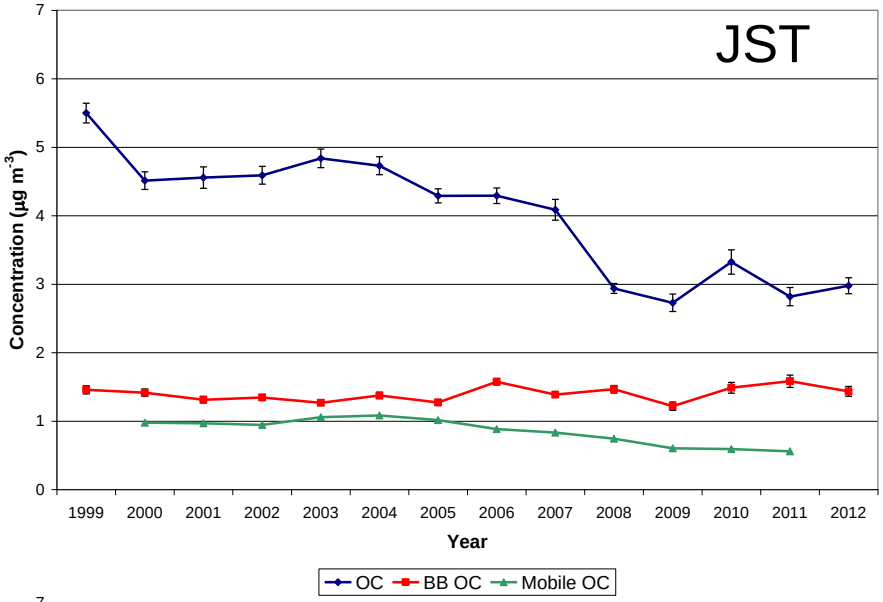
Mean CTR Hourly EC & OC Decline with WS to Baseline Levels

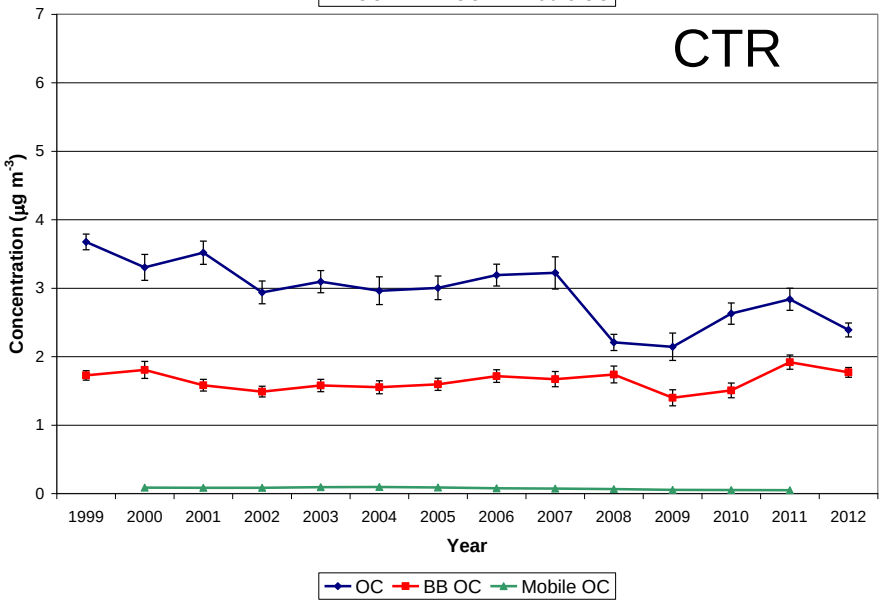


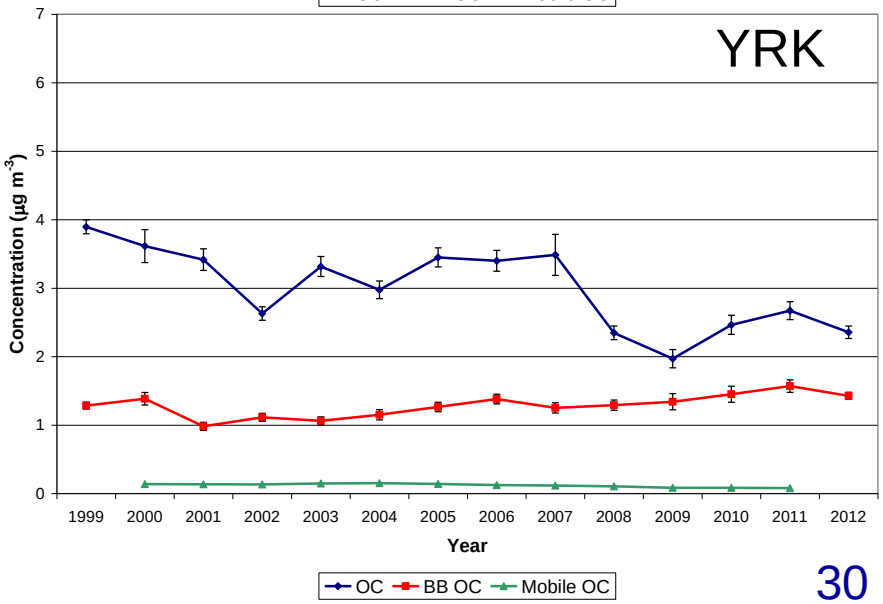
2008 – 10 data in 0.1 m s^{-1} bins

BB OC ~ Constant but Increasing Fraction



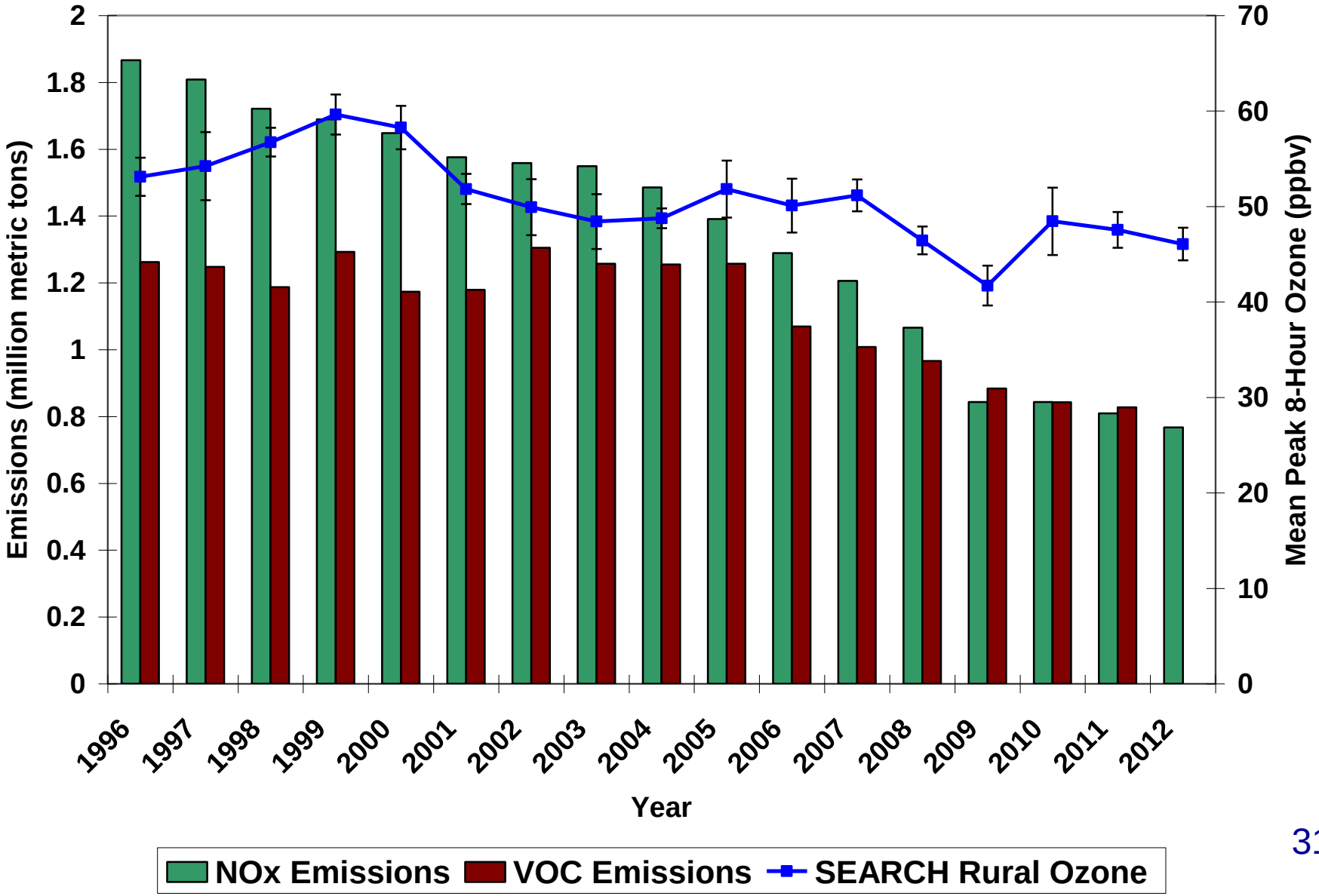






Mobile OC from Blanchard et al. 2013. *ES&T.* (diesel + gasoline PM)

What Hasn't Changed (Much)? – O_3!



Mean Concentrations n-alkanes