A photograph of the St. Louis skyline featuring the Gateway Arch in the center. The arch is a large, white, catenary-shaped structure. In the background, several skyscrapers are visible, including the Chase Tower. The foreground shows a road, a fence, and some trees. The sky is overcast.

Characterizing Ambient Fine Particulate Matter Mass in St. Louis

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National Air Monitoring Conference
Las Vegas, NV
November 6-9, 2006

St. Louis – Midwest Supersite

- Four year campaign, core monitoring site in East St. Louis, IL
 - Two years of intensive measurements (5/2001 – 5/2003)
 - Two years of measurements with a subset of the initial monitoring platform (6/2003 – 3/2005)
- Data collection and analysis to support:
 - Development and evaluation of monitoring methods
 - Exposure and health effects studies
 - **Source apportionment and SIP planning**



*St. Louis - Midwest Supersite
East St. Louis (IL)*

SIP Planning Support Grant to WUSTL

1. Coordination
2. Organic Carbon Source Apportionment
3. Data Harmonization & Episodes Analysis
4. **Urban / Rural Contrast** & Intraurban Variability
5. Transport Regimes Analysis
6. **Refinements to PM_{2.5} Mass Apportionment**
7. Soil / Road Dust Characterization

Many of these analyses designed to support (model validation) or complement (weight-of-evidence) chemical transport modeling

Subcontractors:

- University of Wisconsin (Schauer group)
- Sonoma Technology, Inc.

STL Fine PM Mass Apportionment Studies

Site	Period	Method	Source
10 sites in STL area (RAPS)	5/75-4/77	PMF2	Kim & Hopke (2005)
10 sites in STL area (RAPS)	7/76-8/76	CMB	Dzubay et al. (1980)
Carondelet (Six-Cities Study)	1979-1988	APCA	Laden et al. (2000)
Blair Street (STN)	4/01-4/02	CMB	Kenski & Koerber (2002)
Blair Street (STN)	4/01-4/02	PMF*	Coutant & Swinton (2002)
Blair Street (STN)	8/00-7/01	PMF*	Battelle (2003)
Blair Street (STN)	[insert]	EPA PMF	MDNR (internal) (2005)
Blair Street (STN)	1/00-1/04	PMF2	Lee & Hopke (2006)
Arnold (STN)	1/01-1/04	PMF2	Lee & Hopke (2006)
East St. Louis (STL-SS)	6/01-5/03	PMF2	Lee et al. (2006)
East St. Louis (STL-SS)**	6/01-5/03	EPA PMF	Garlock (2006)

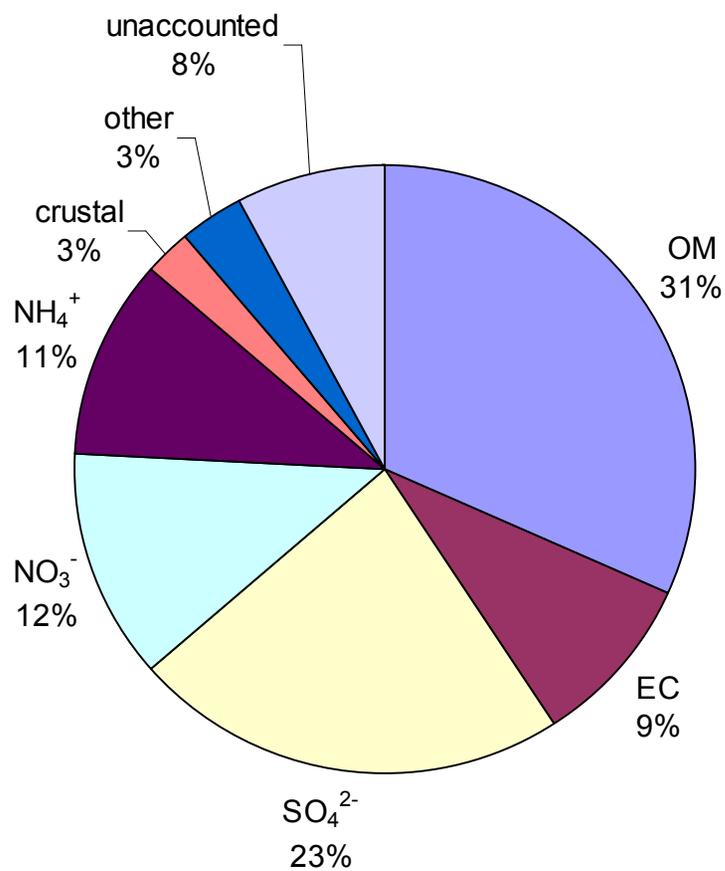
* Version of PMF to be determined

** Sensitivity studies and refinements to the apportionment of Lee, Hopke and Turner (2006)

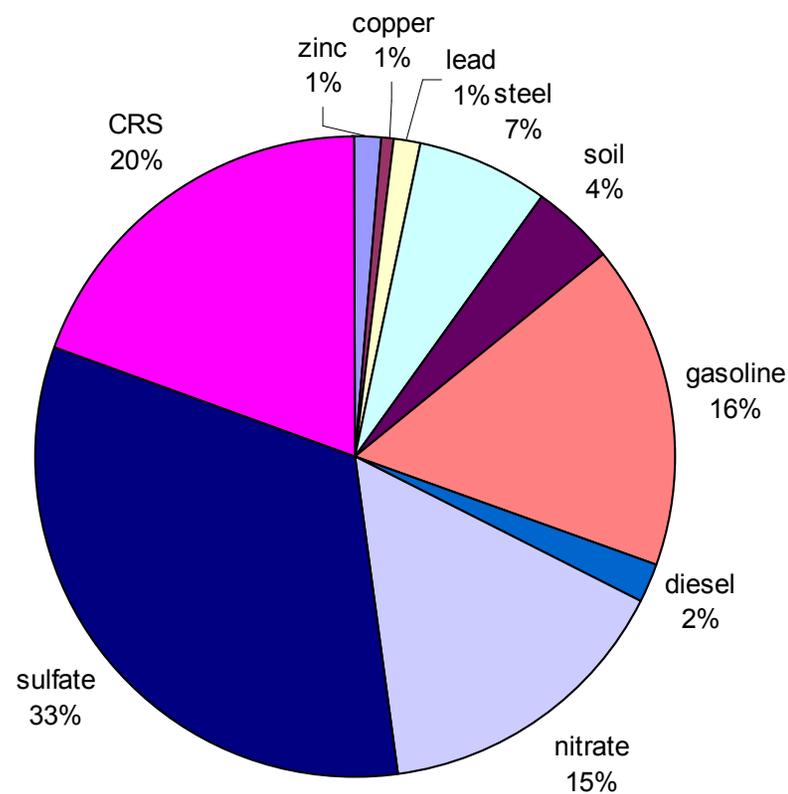
Acknowledgement: Mike Davis (EPA Region VII) for draft synthesis of the contemporary STL PM_{2.5} mass apportionment studies

East St. Louis Fine PM Mass Apportionment by Positive Matrix Factorization (PMF) (Lee et al. 2006)

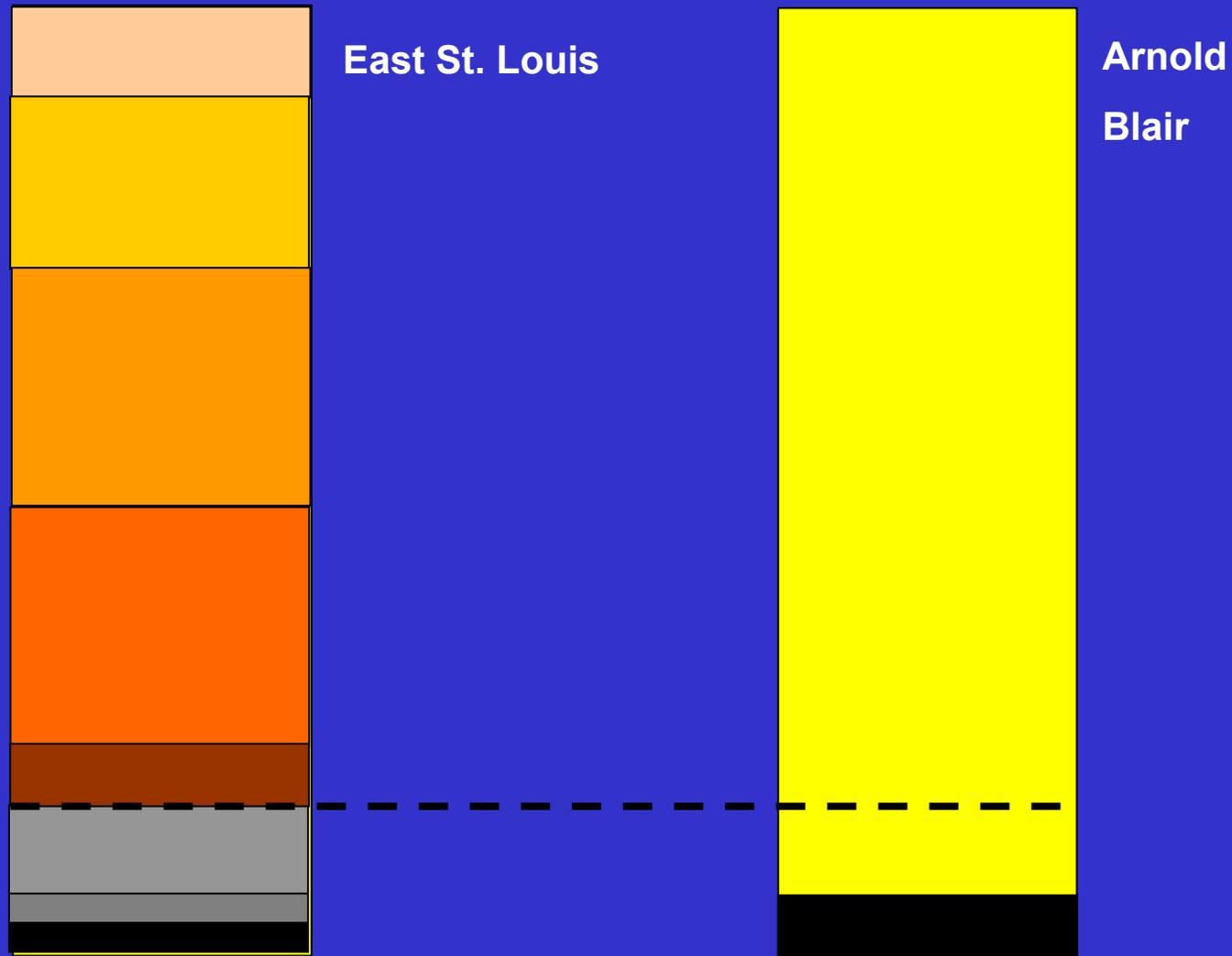
Measured Species Contributions to PM_{2.5}



Factor Contributions to PM_{2.5}



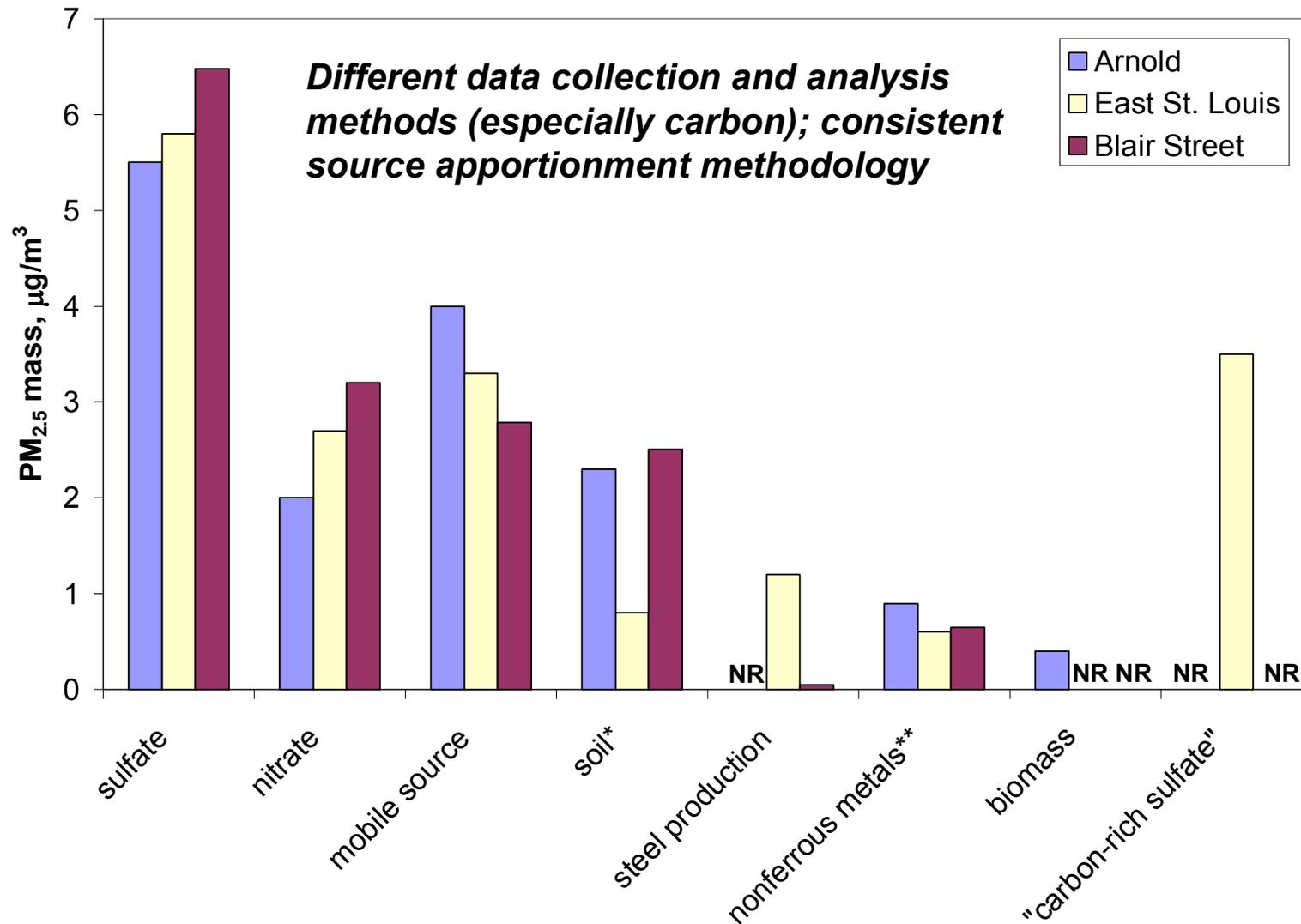
Carbon in the Hopke Group Apportionments



IMPROVE carbon fractions

NIOSH OC/EC

Reconciling the Hopke Group (Clarkson) Apportionments

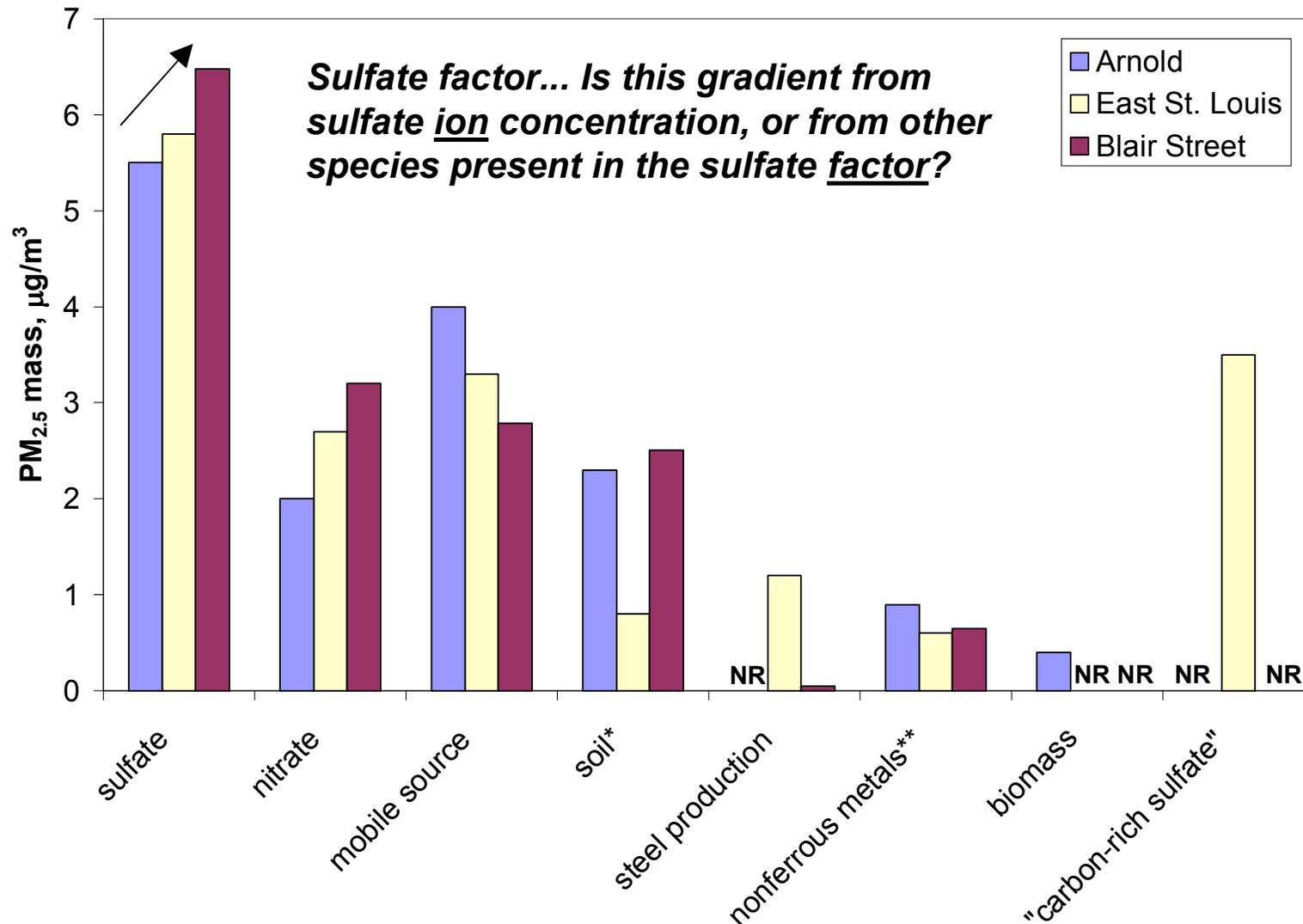


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

NR = factor not resolved

Sulfate Factor

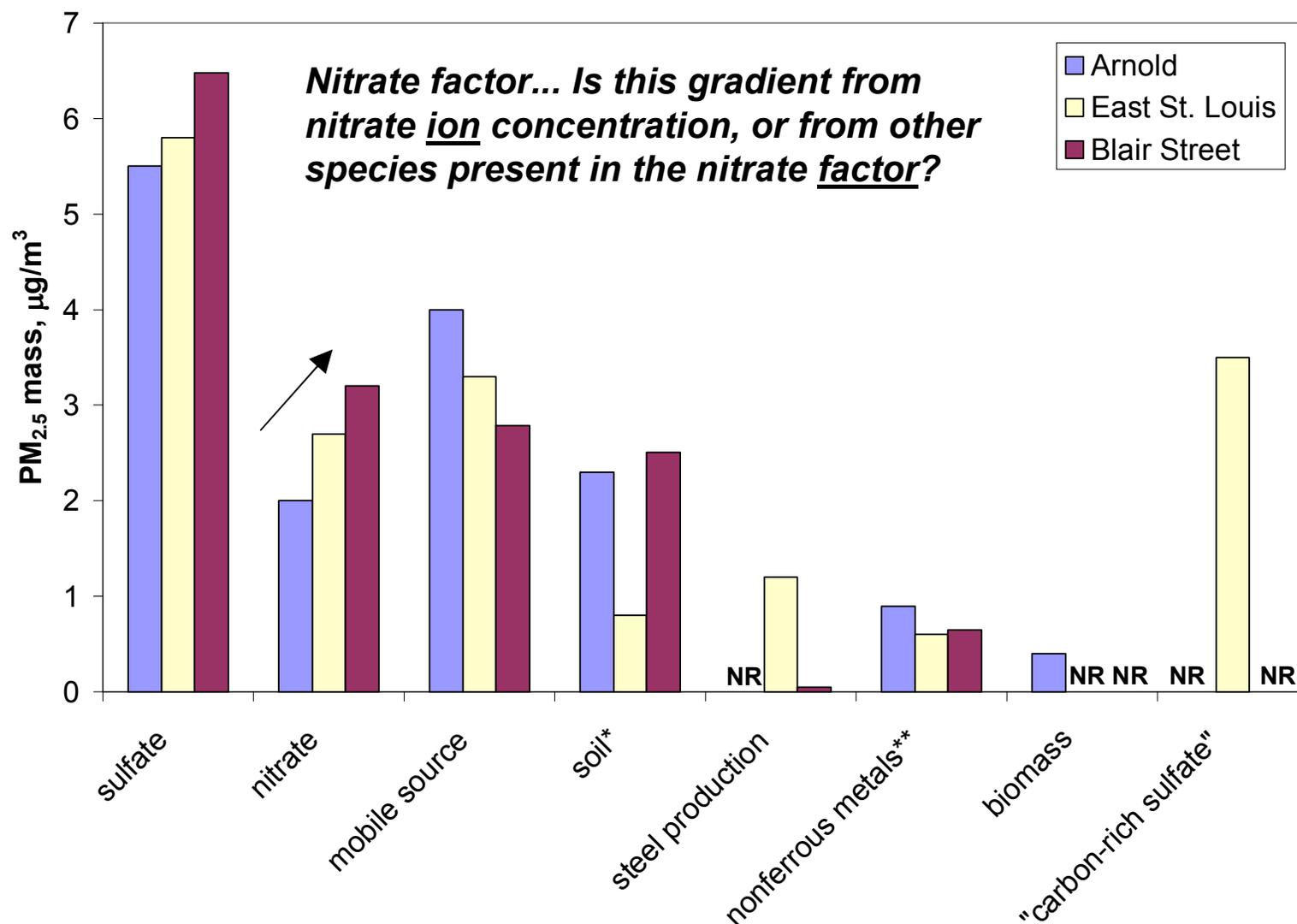


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

NR = factor not resolved

Nitrate Factor

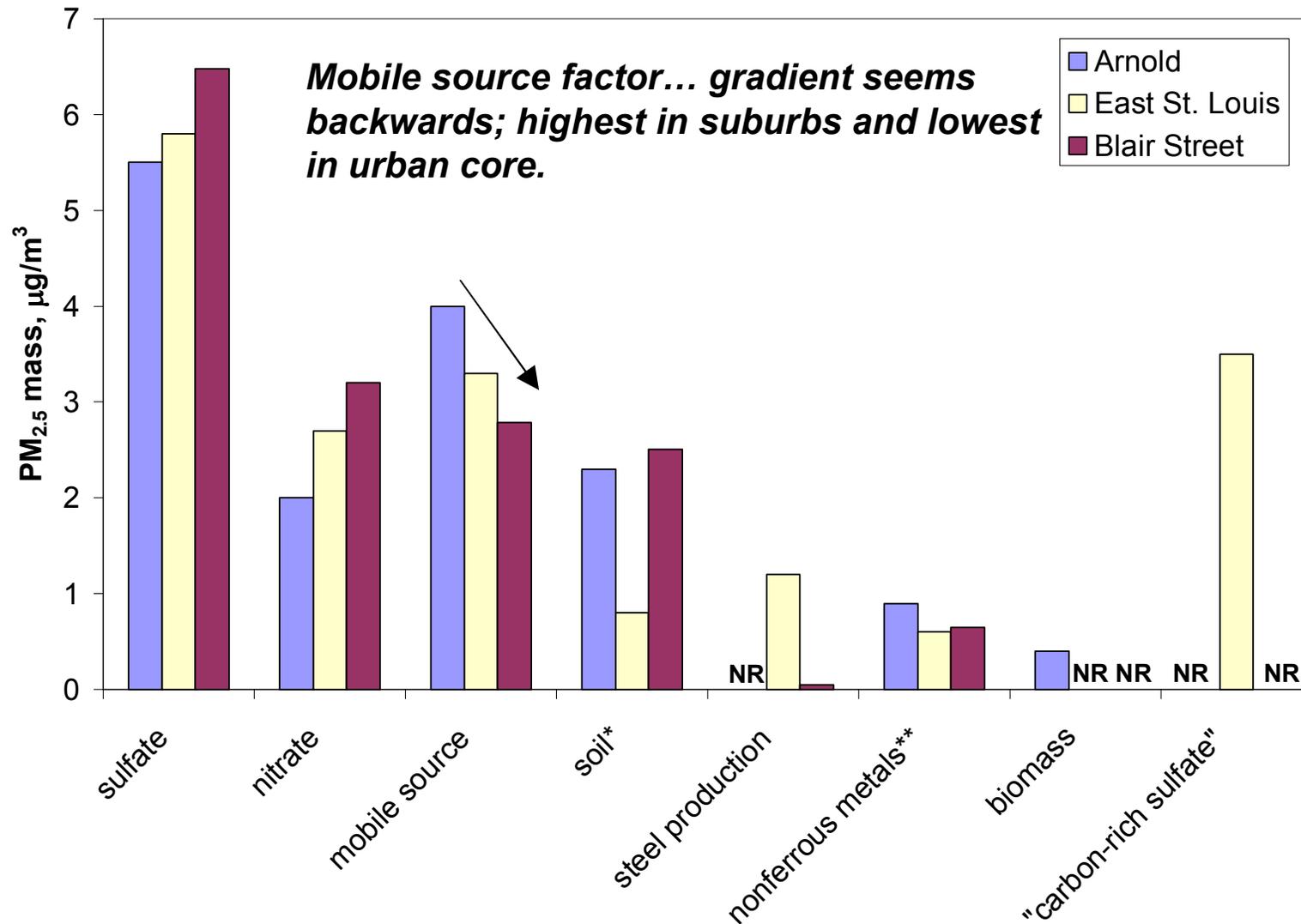


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

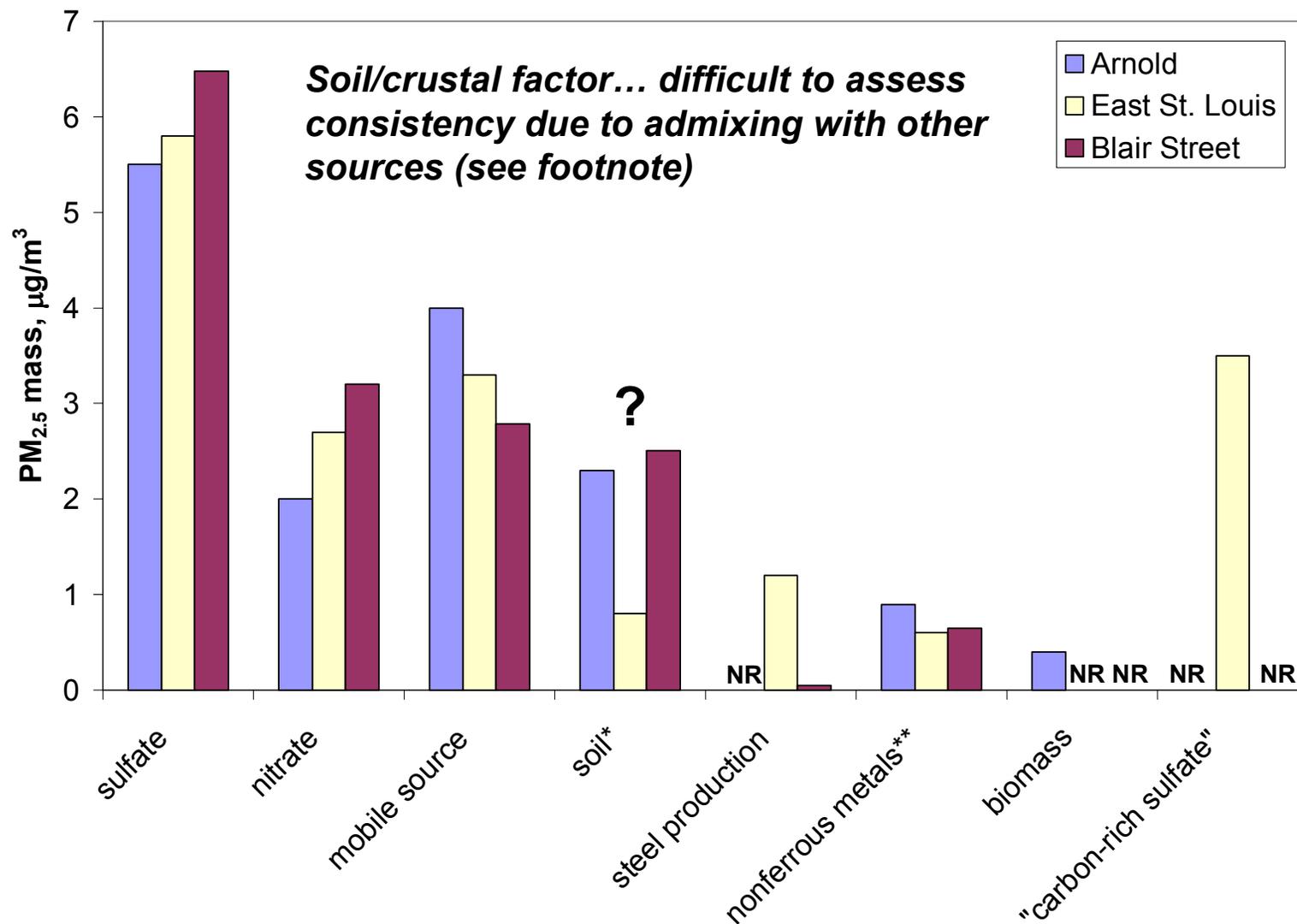
NR = factor not resolved

Mobile Source Factor



(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial
 (**) Nonferrous Metals: Arnold includes steel processing
 NR = factor not resolved

Soil / Crustal Material Factor

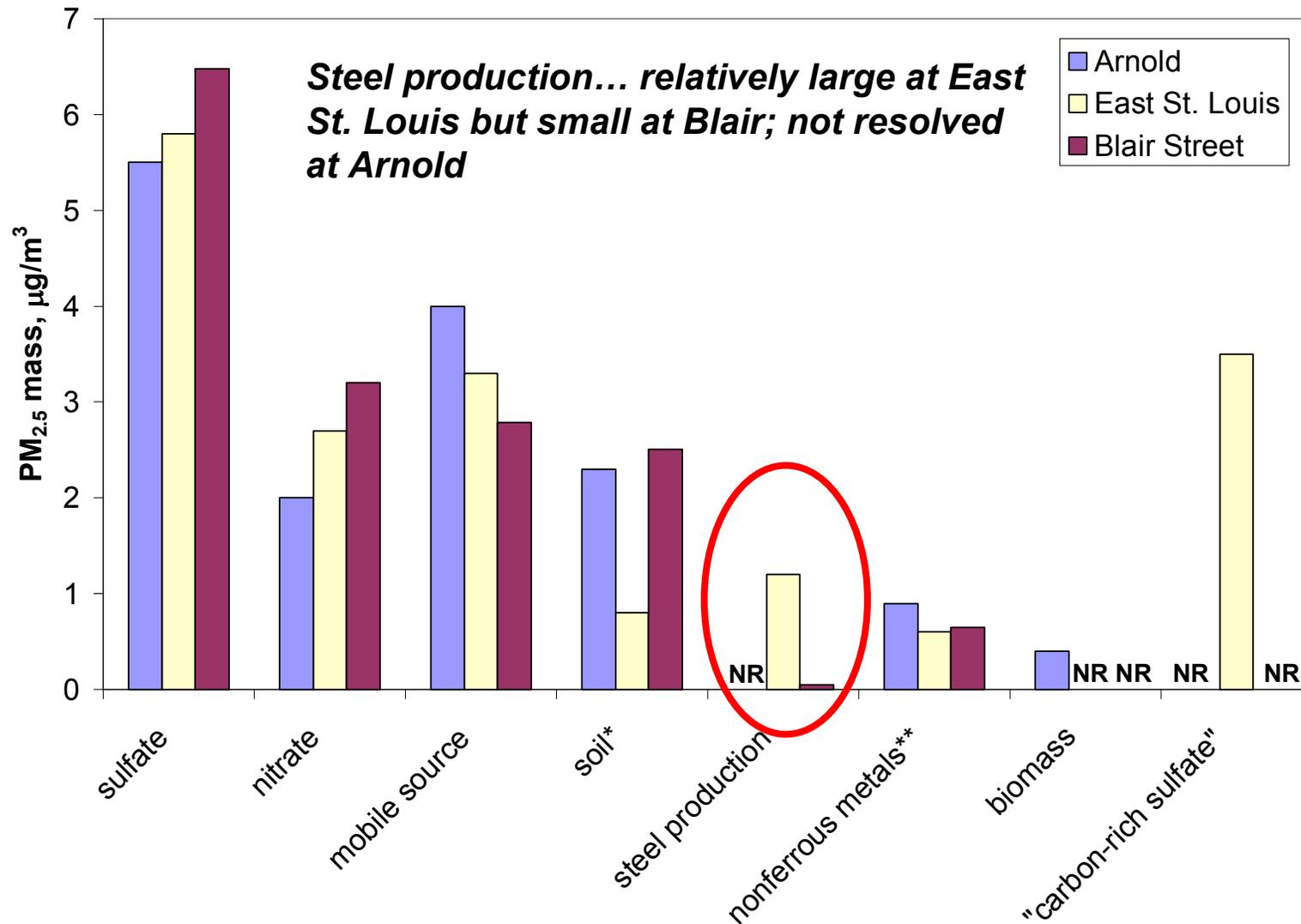


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

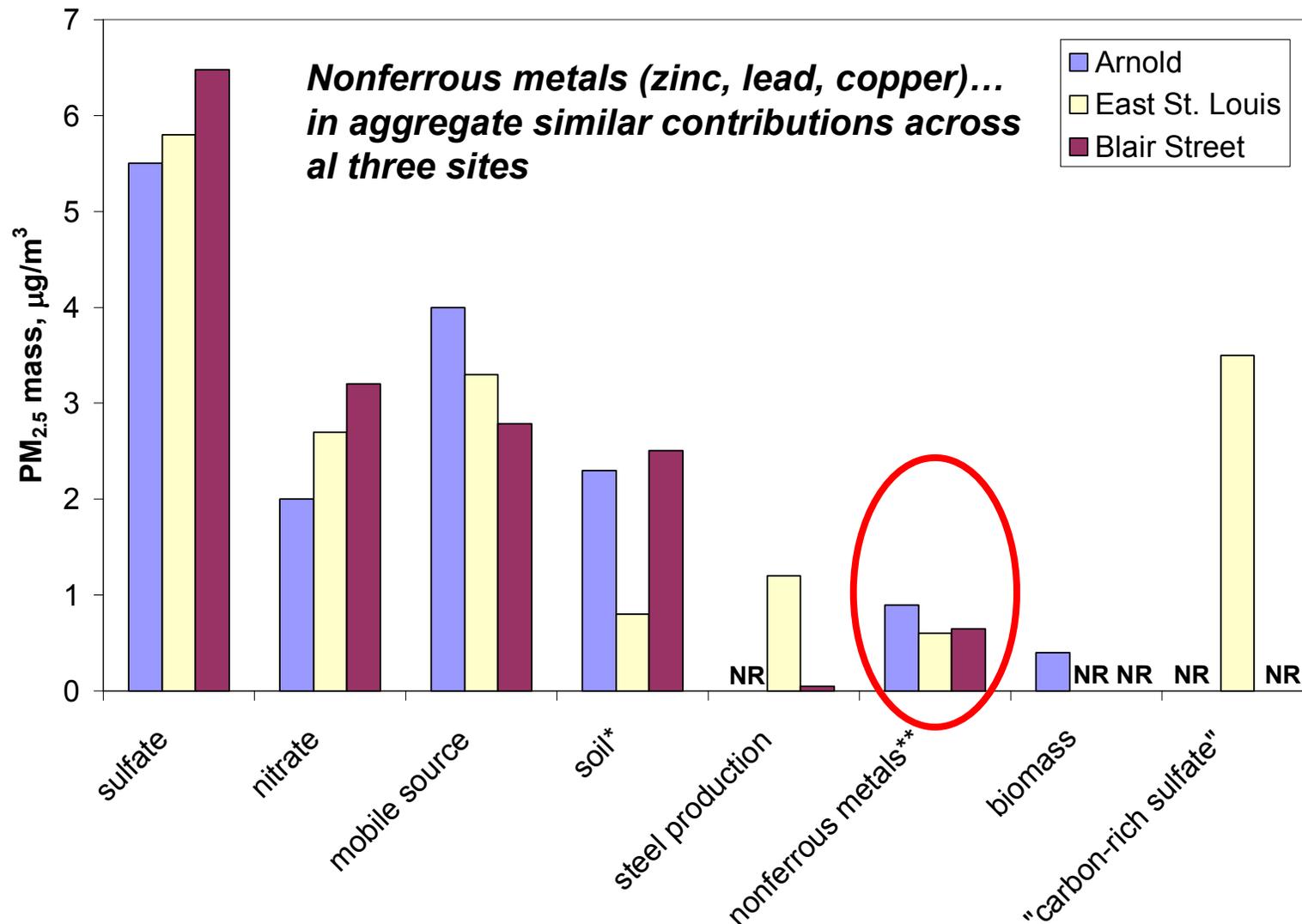
NR = factor not resolved

Steelmaking Factor



(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial
 (**) Nonferrous Metals: Arnold includes steel processing
 NR = factor not resolved

Nonferrous Metals Processing Factor

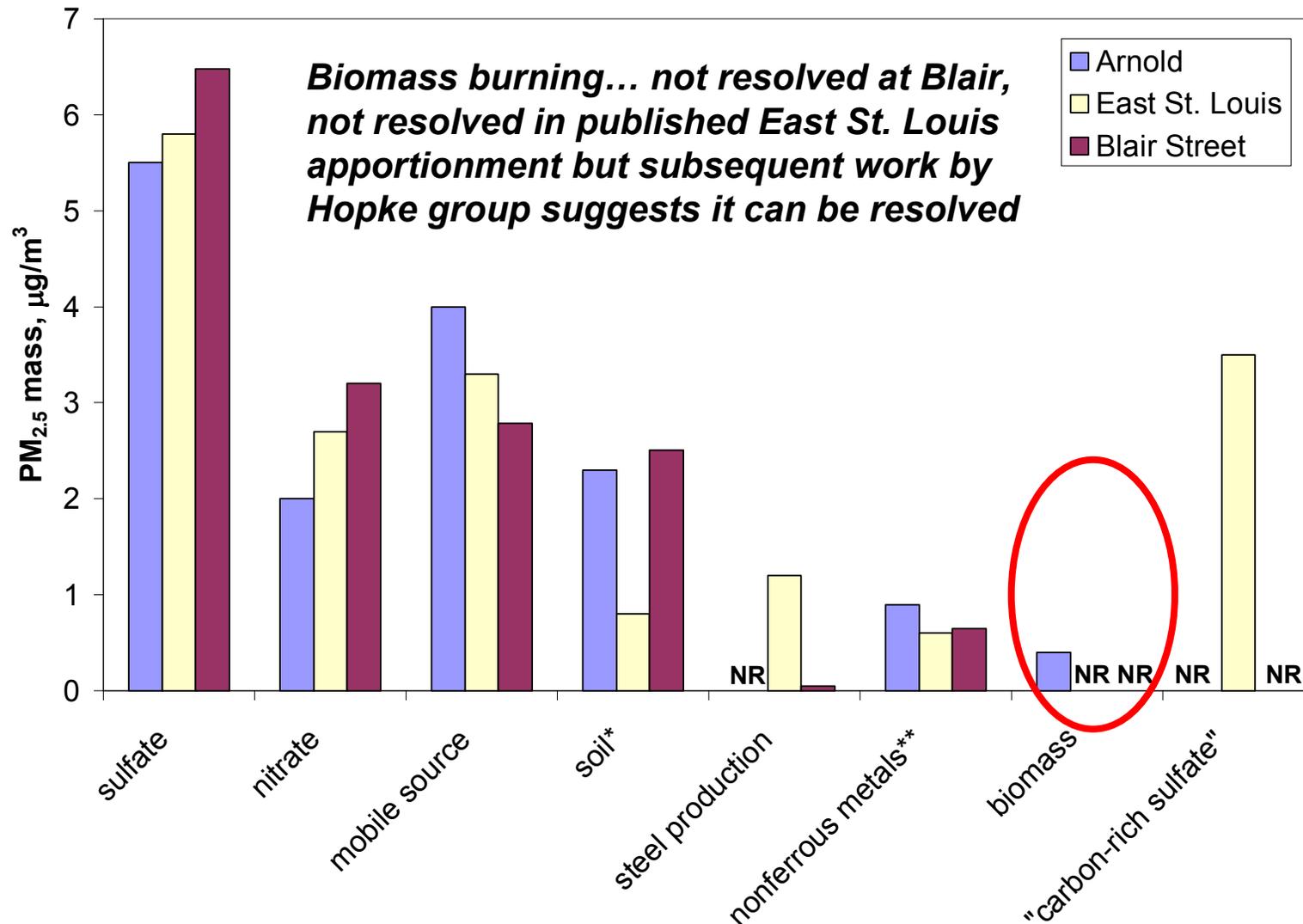


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

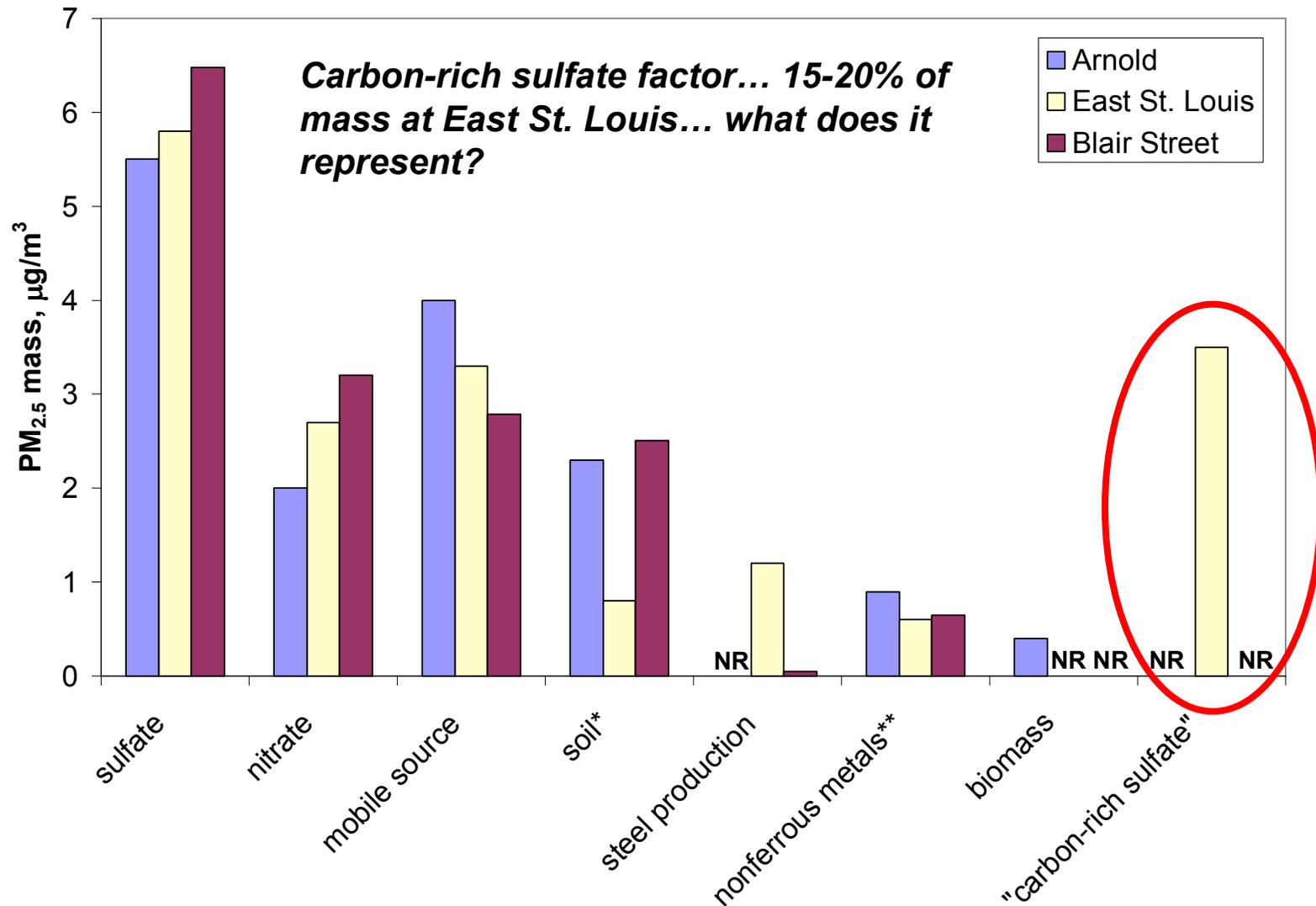
NR = factor not resolved

Biomass Burning Factor



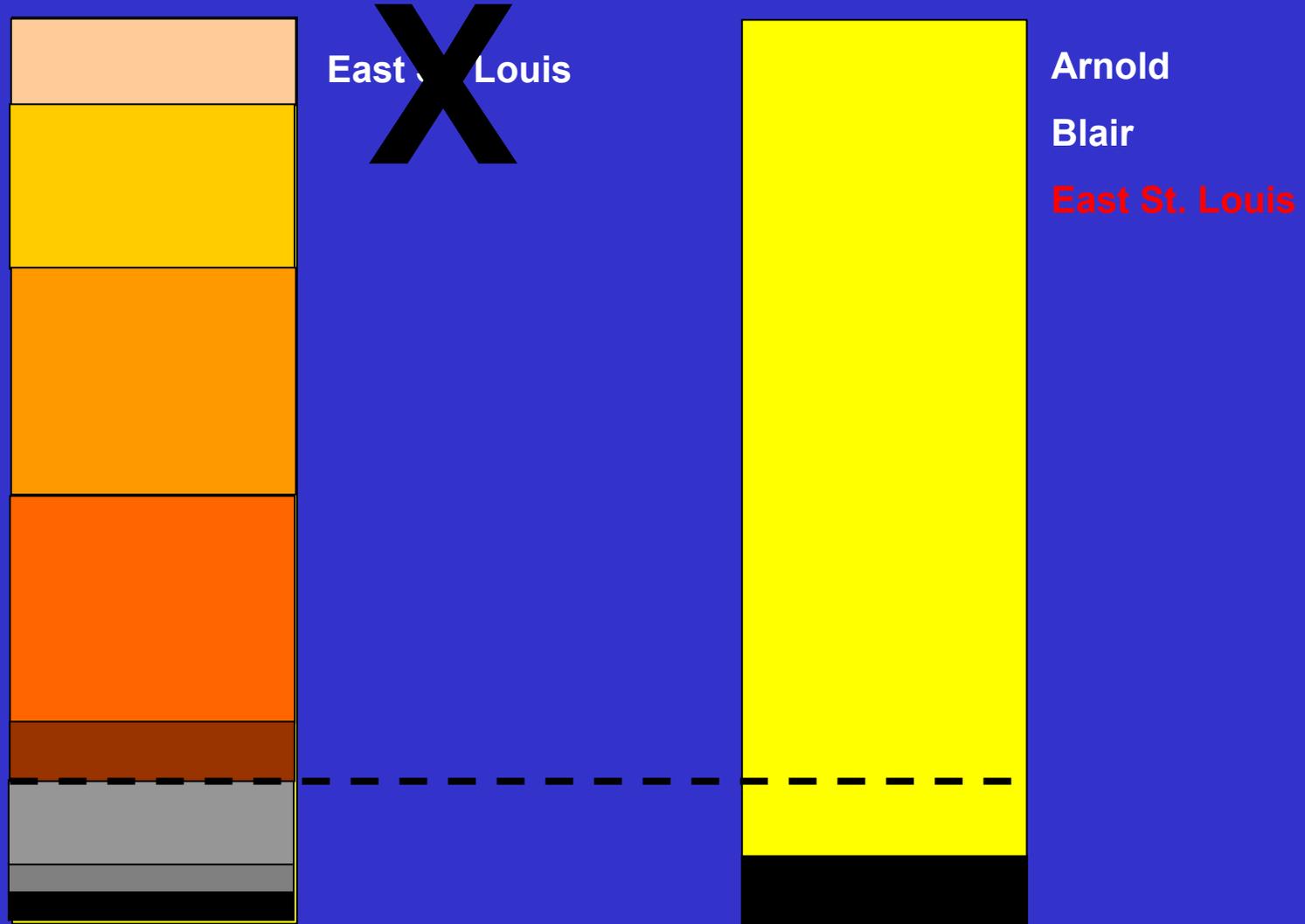
(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial
 (**) Nonferrous Metals: Arnold includes steel processing
 NR = factor not resolved

“Carbon-Rich Sulfate” Factor



(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial
 (**) Nonferrous Metals: Arnold includes steel processing
 NR = factor not resolved

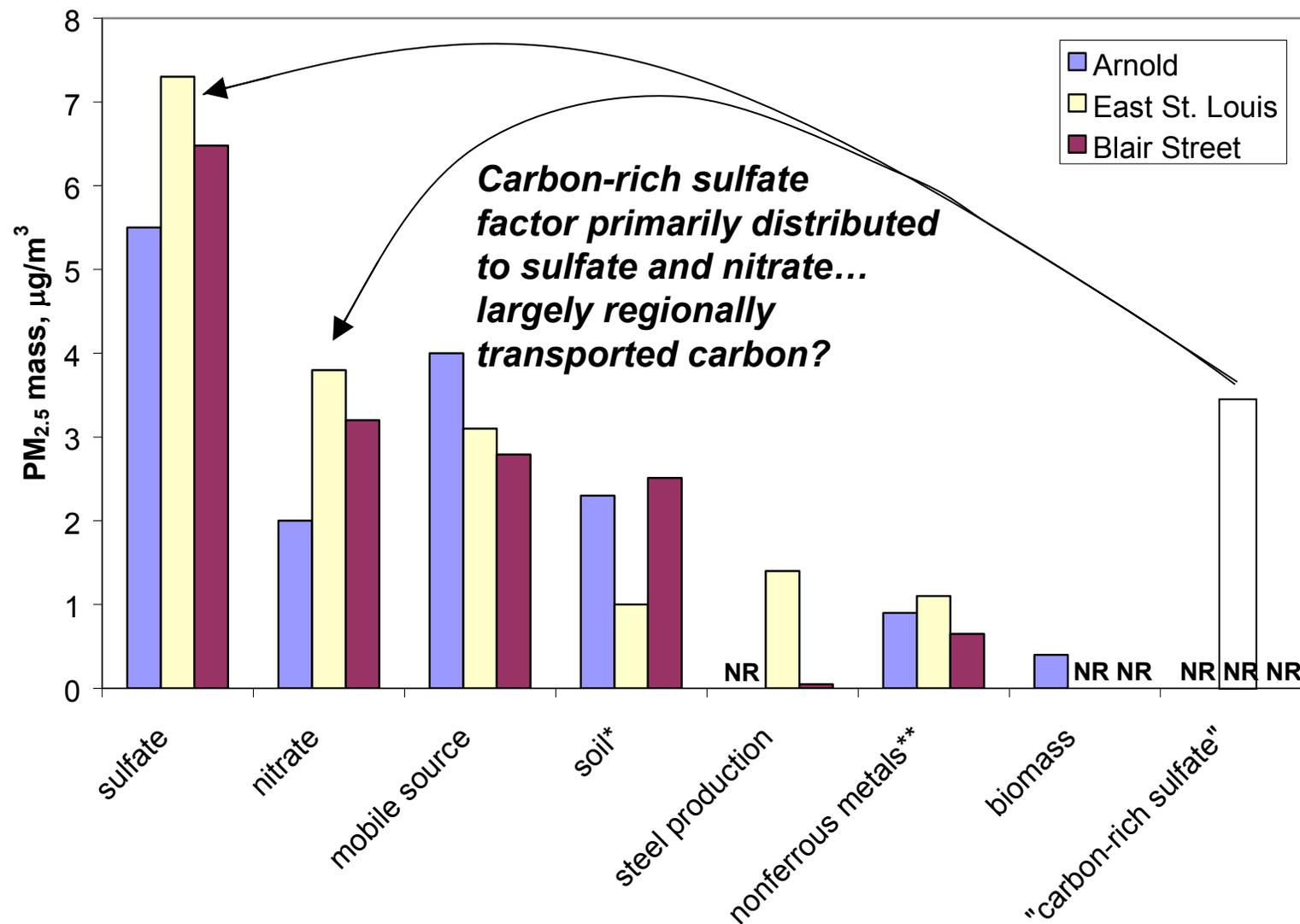
PMF with Consistent Carbon Representation



IMPROVE carbon fractions

NIOSH OC/EC

Apportionments with NIOSH OC/EC at all Sites

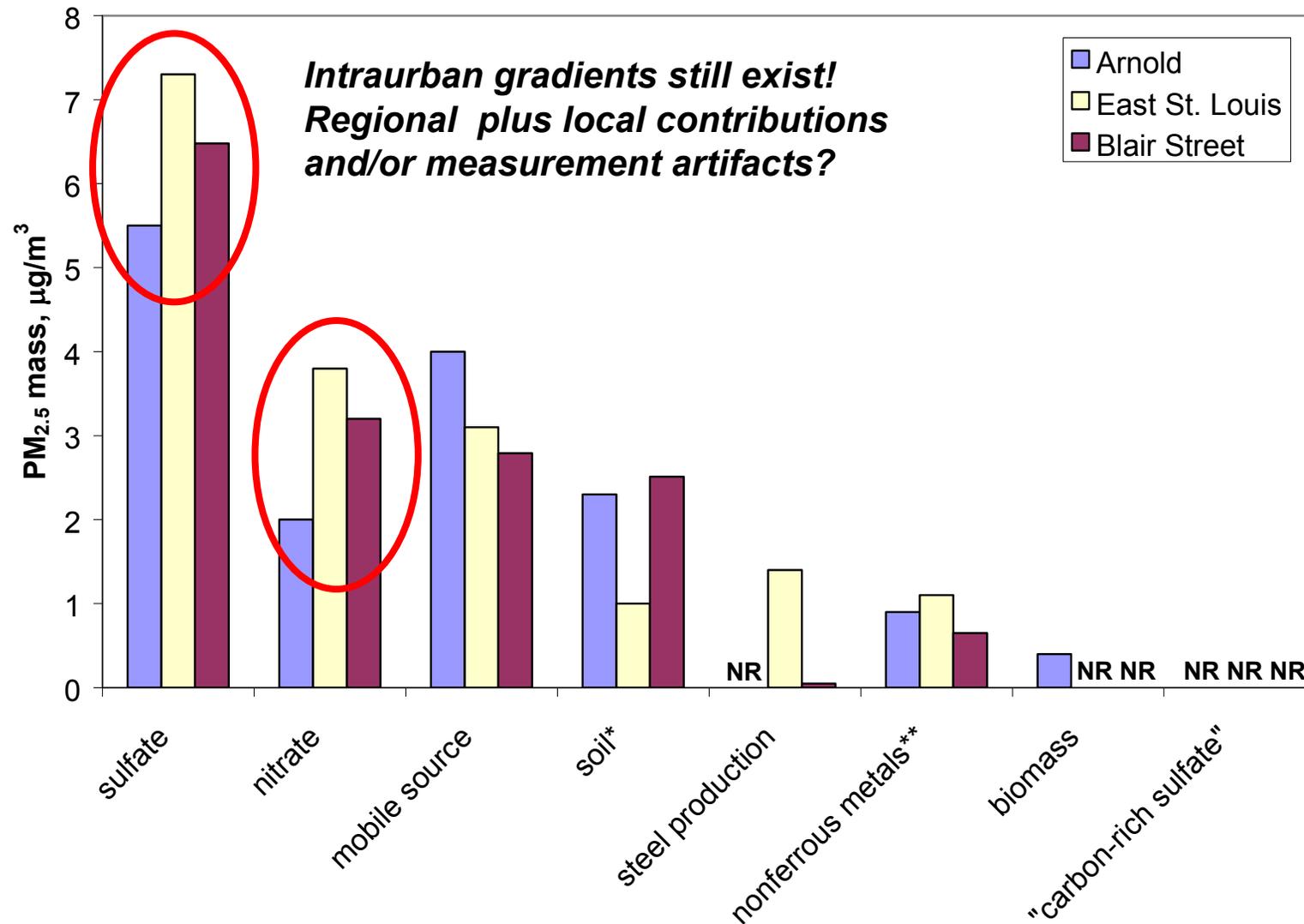


(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

NR = factor not resolved

Apportionments with NIOSH OC/EC at all Sites



(*) Soil: Arnold includes separate Ca-rich factor; Blair = soil + non-soil industrial

(**) Nonferrous Metals: Arnold includes steel processing

NR = factor not resolved

Interpretation of Carbon-Rich Sulfate Factor

- Factor profile predominantly carbon, some sulfate
 - Relatively high EC/OC ratio suggests unaged carbon and thus likely local sources
 - However, modeled apportionments using different representations for carbon suggests the factor represents regional sources
- Reconcile East St. Louis TC apportionment with urban/rural contrast, August-November 2001 measurements (Park Hills)

Monitoring Locations: 8/17/01 – 11/20/01



St. Louis Supersite
core site,
East St. Louis, IL

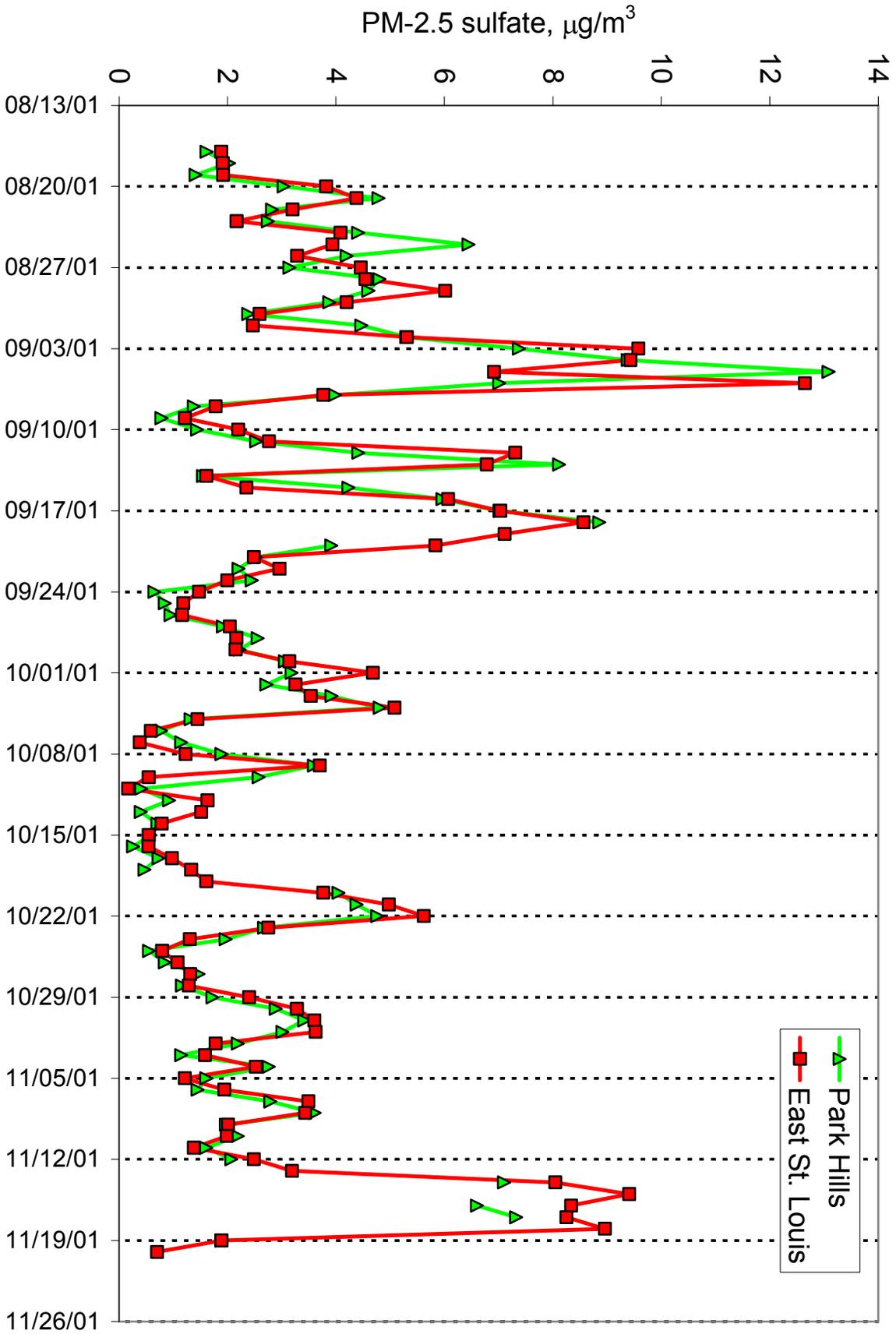
URBAN

St. Louis Supersite
satellite site,
Park Hills, MO

RURAL

East St. Louis (IL) is approximately 3 km east of the City of St. Louis (MO) central business district. Park Hills (MO) is a predominantly rural site ~100 km south/southwest of the St. Louis urban core.

Sulfate at the Urban and Rural Sites



Urban/Rural Analysis Objective

- Examining the Total Carbon Attribution -

**Measured Regional
TC (Park Hills)**

Urban/Rural Analysis Objective

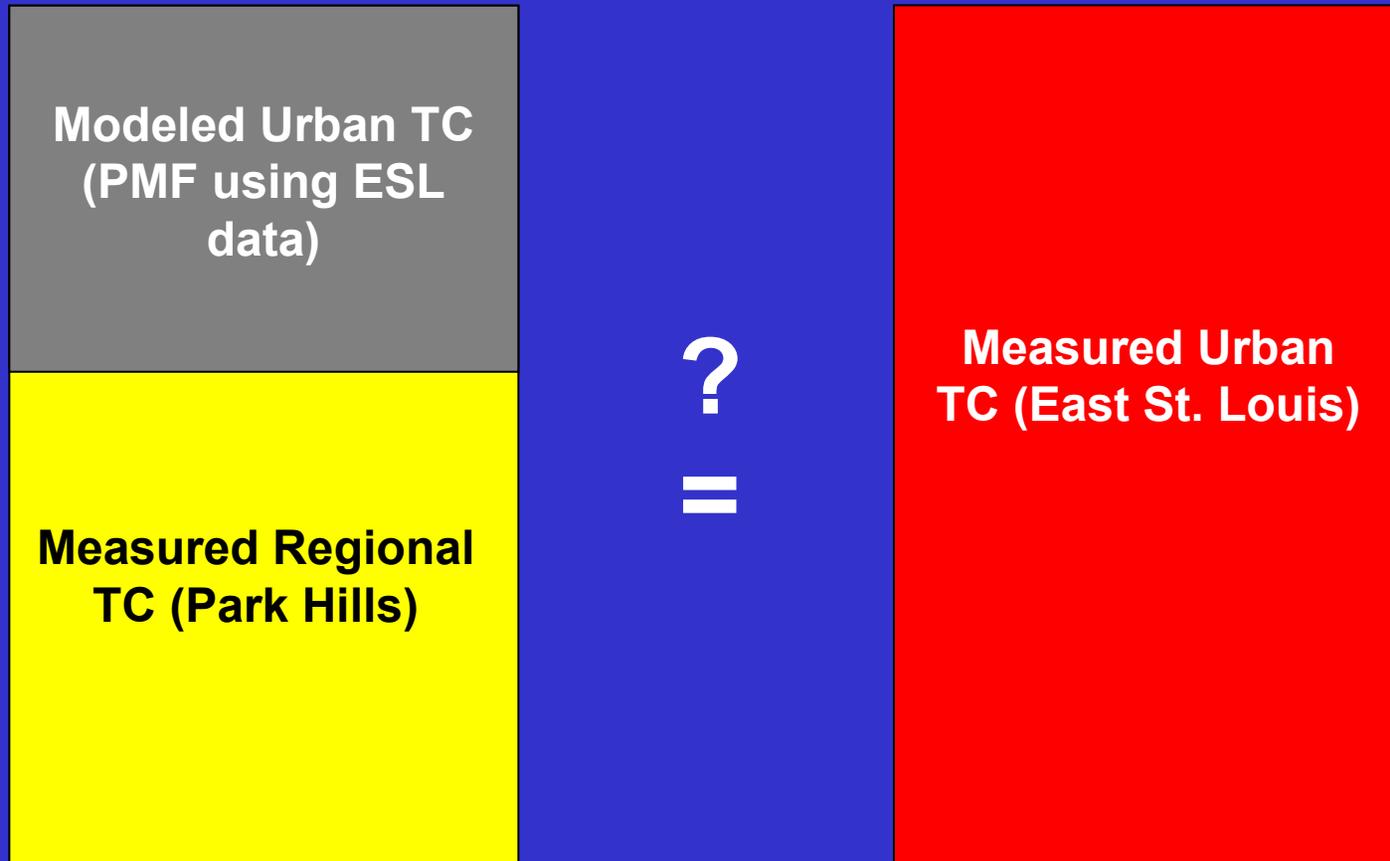
- Examining the Total Carbon Attribution -

**Modeled Urban TC
(PMF using ESL
data)**

**Measured Regional
TC (Park Hills)**

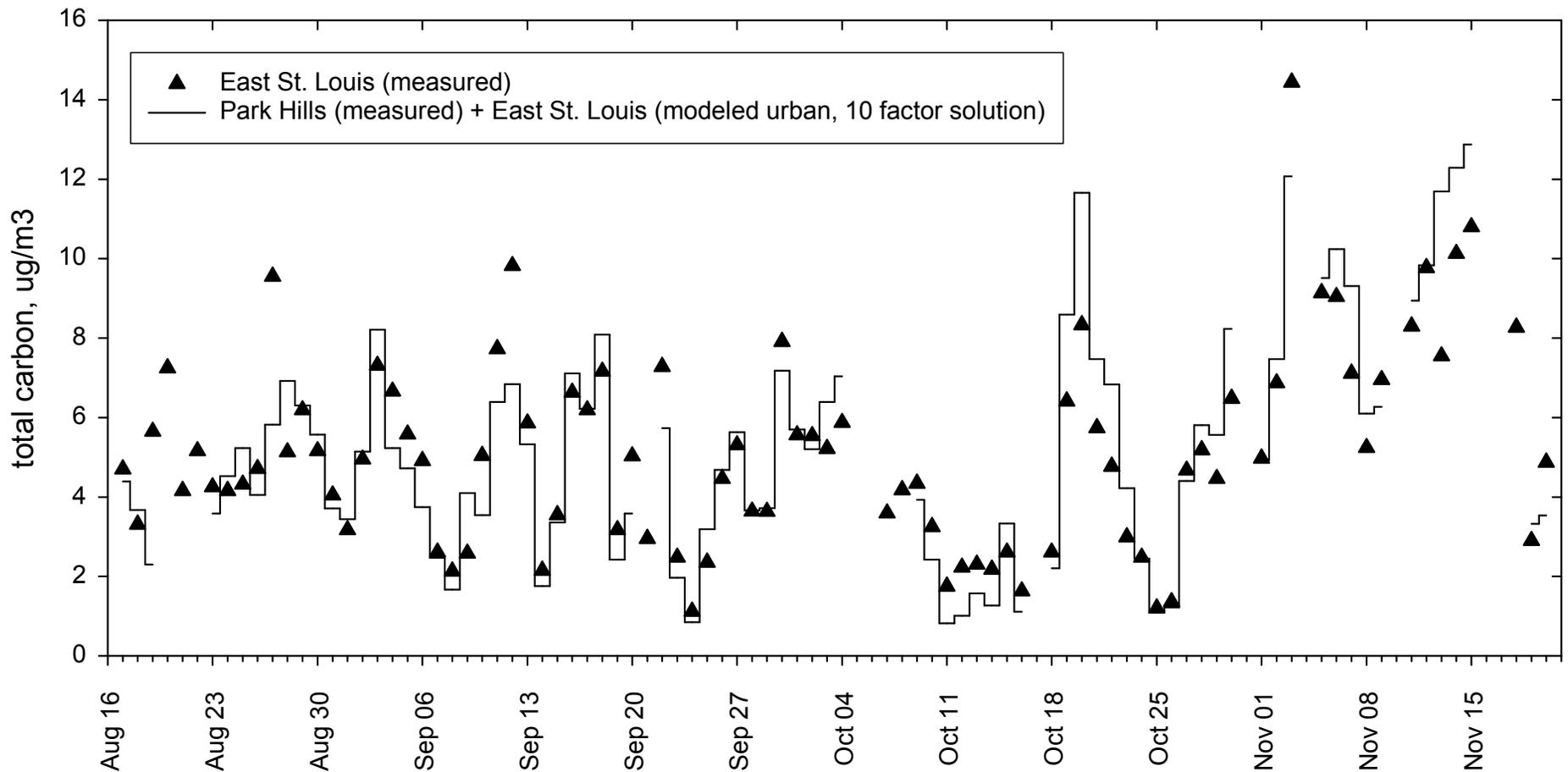
Urban/Rural Analysis Objective

- Examining the Total Carbon Attribution -



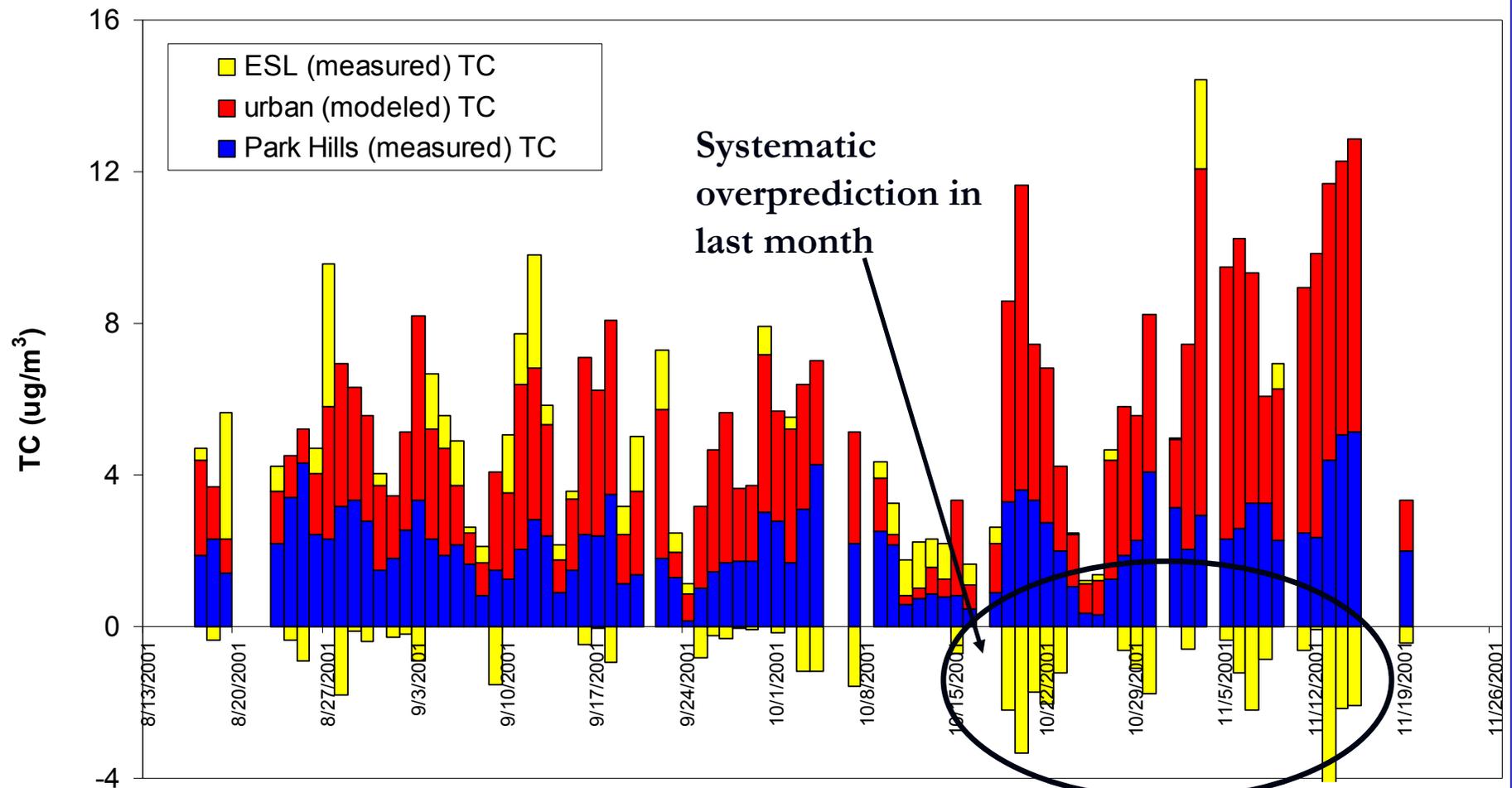
PMF-Modeled Urban Excess for Carbon

- PMF model does indeed capture the STL “urban excess” for carbon

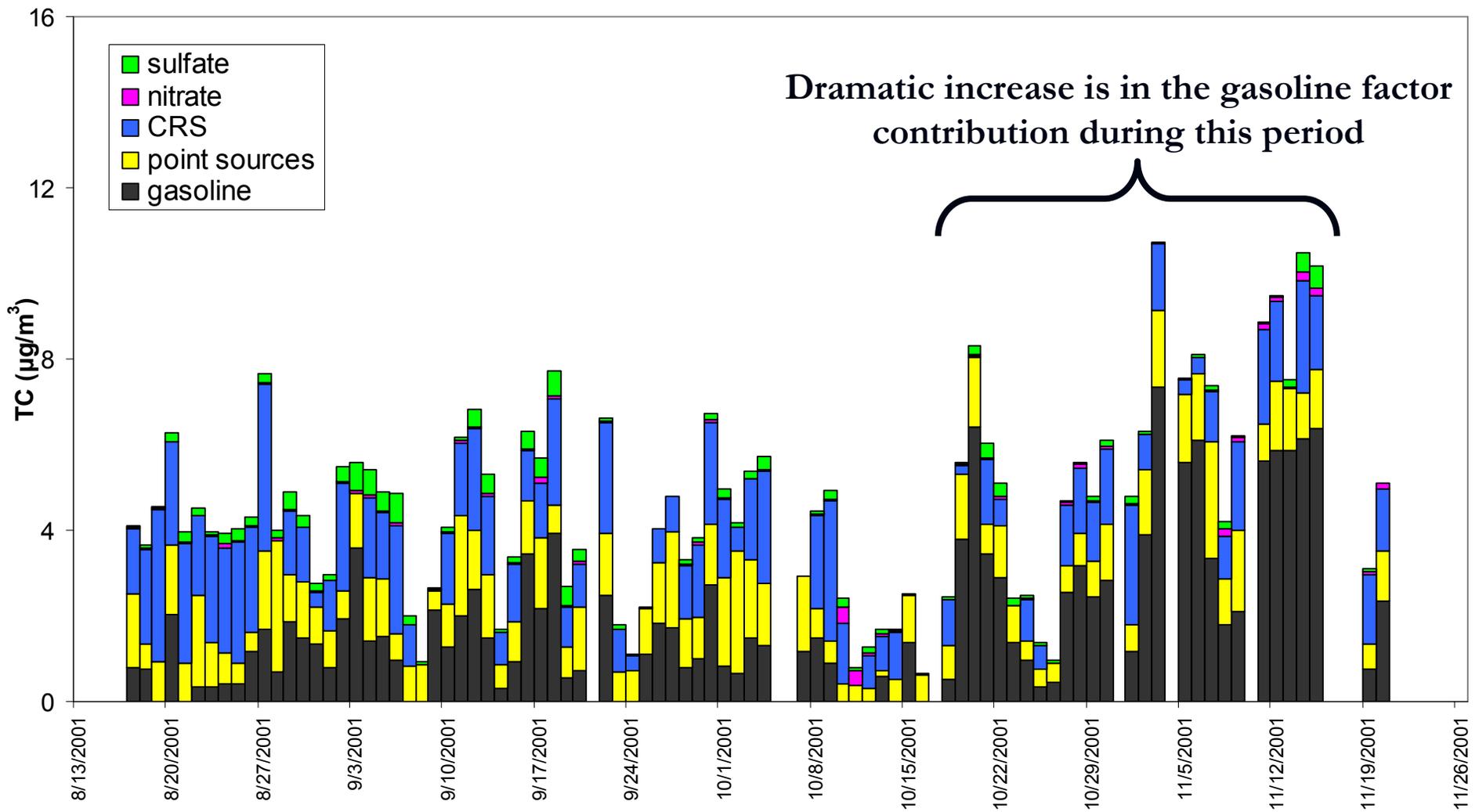


Daily Total Carbon Reconstruction

- Negative ESL concentrations indicate that Park Hills + modeled urban TC overestimated the measured ESL TC

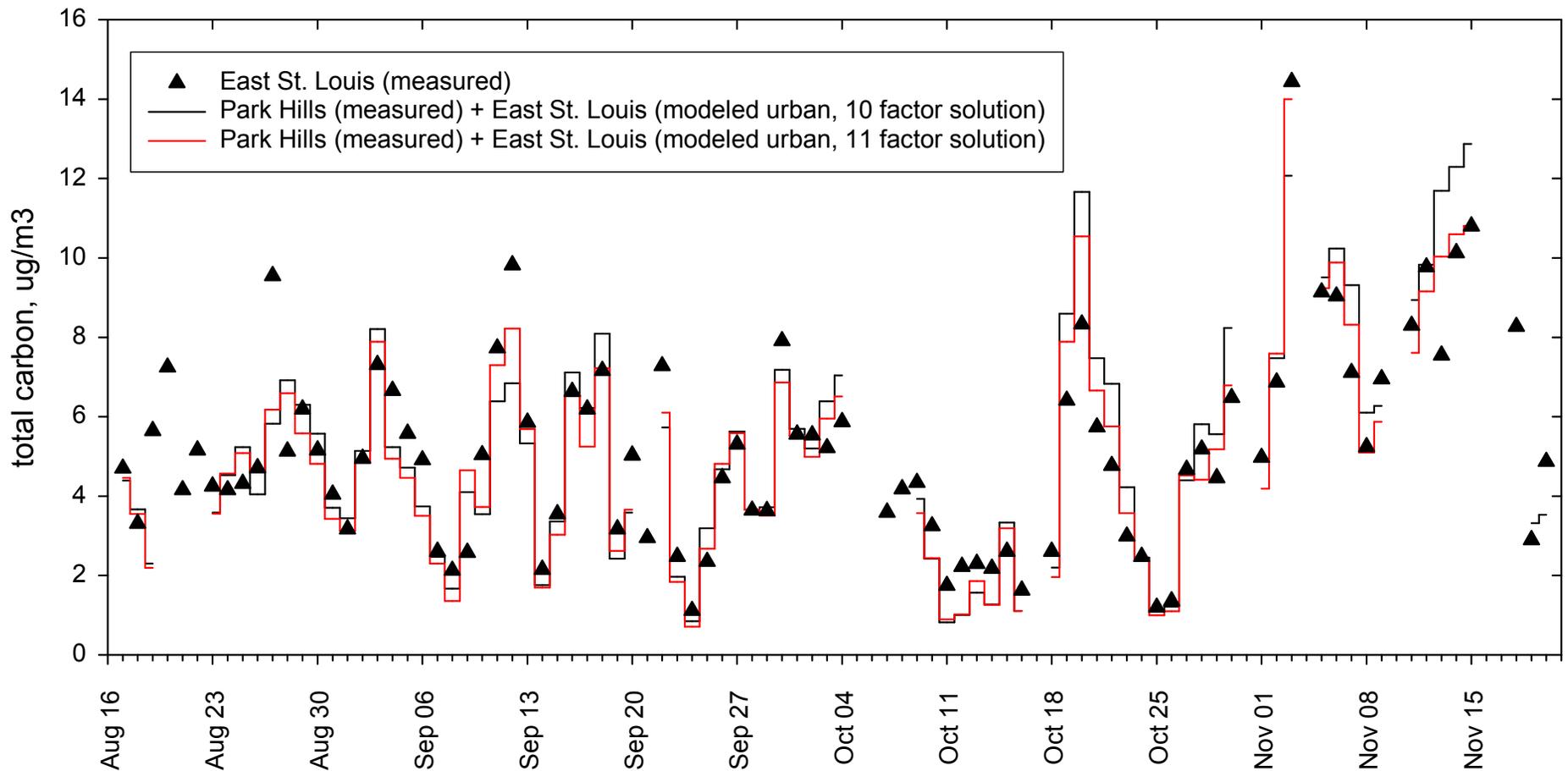


Daily Source Contributions to Total Carbon



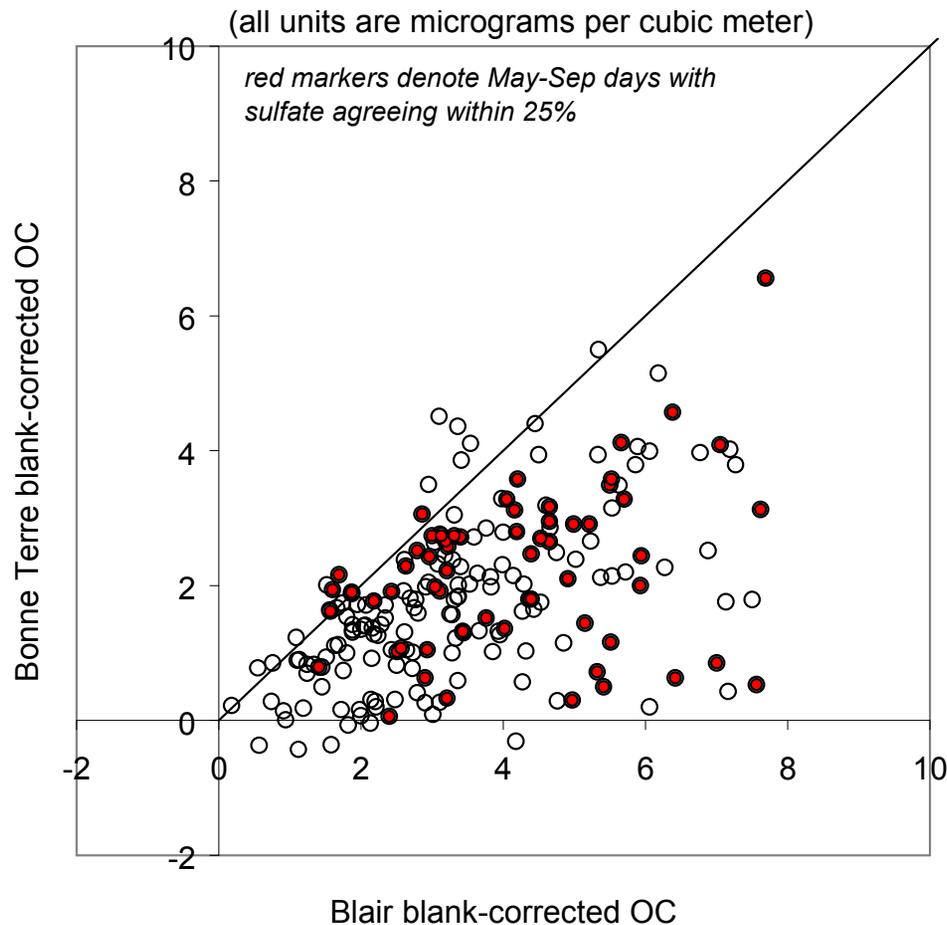
PMF-Modeled Urban Excess for Carbon

- Agreement is better for the 11-factor solution (wood smoke factor)



Urban/Rural Contrast – STN Organic Carbon

- Comparing Blair (City of St. Louis – urban) to Bonne Terre (rural), there is an OC urban excess at Blair on virtually every sampling day



May - September only, 2003 & 2004

$$\frac{\overline{OC(Blair)}}{\overline{OC(Bonne\ Terre)}} = 1.9$$
$$\frac{\overline{TCM(Blair)}}{\overline{TCM(Bonne\ Terre)}} = 2.0$$

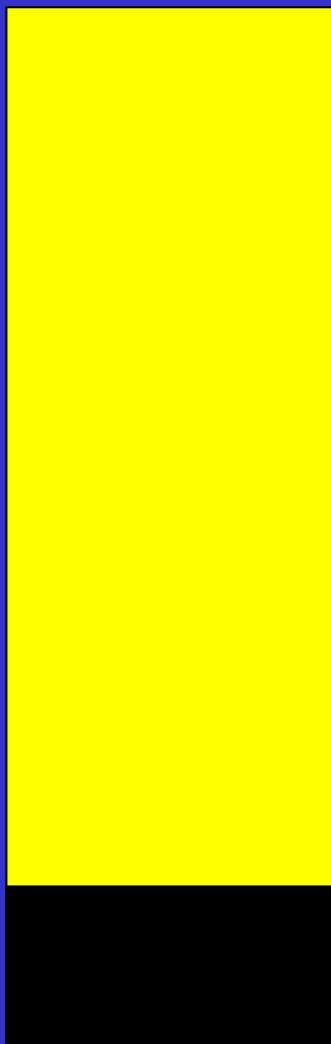
Assuming urban plumes do not impact the rural site, then nearly 100% urban excess for the summer months!

Fine Particulate Matter Carbon in St. Louis

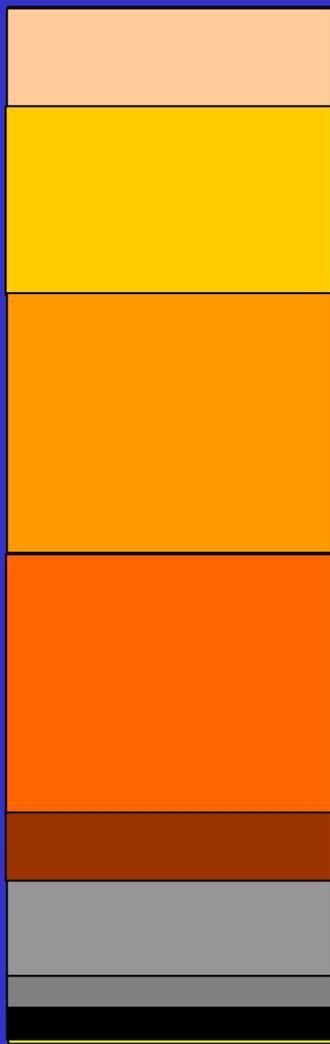
- From the carbon attribution in the PMF mass apportionment modeling (East St. Louis)...
- From the average of daily differences between observed urban and rural carbon burdens (Arnold, Blair)
 - Annual average, at East St. Louis and Arnold*:
 - Regionally transported carbon: ~50%
 - Locally emitted/generated carbon: ~50%
 - Summertime average, at Blair Street*:
 - Regionally transported carbon: ~50%
 - Locally emitted/generated carbon: ~50%

(currently working on annual average)
 - *Results for Arnold and Blair Street sensitive to how the data is conditioned (urban excess could be as low as 35-40%)
- What are the sources of the locally emitted/generated carbon?
 - Fine PM mass apportionment not designed to answer this question
 - Need more-sophisticated approaches...

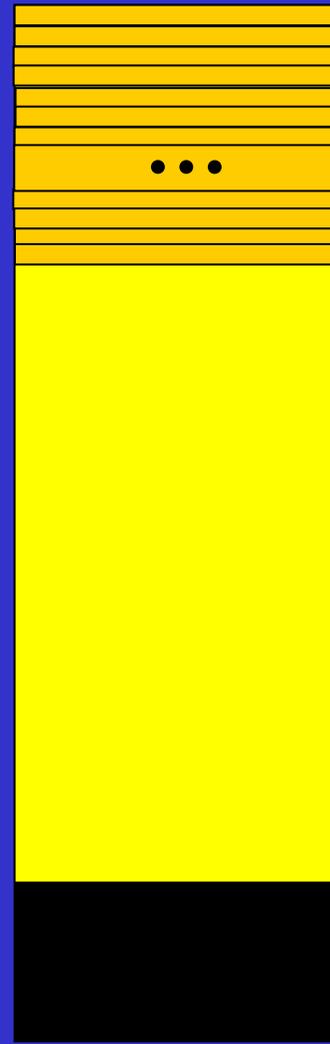
Towards more specificity in representing carbon



OC/EC



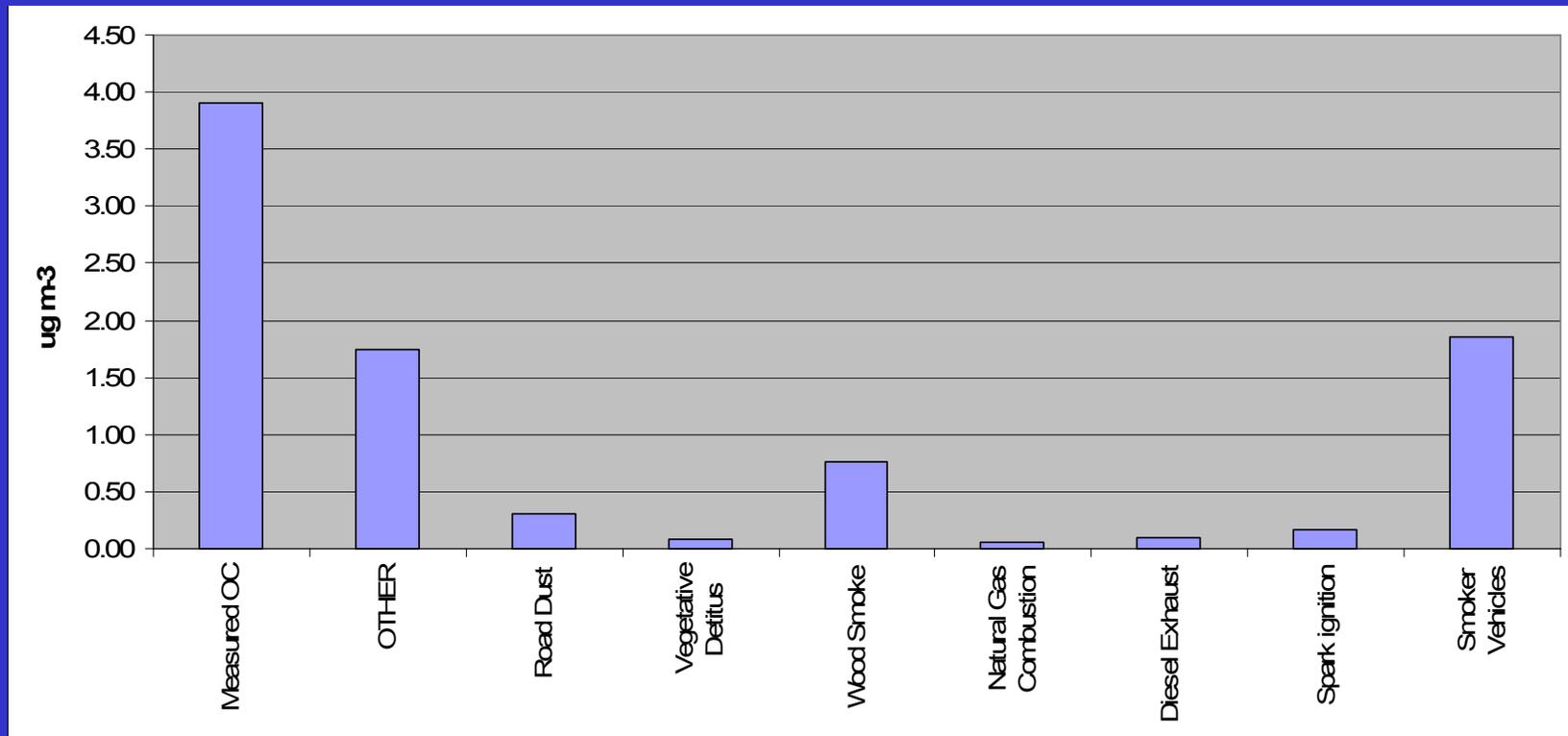
thermal carbon fractions



speciated organics

Primary OC Apportionment by CMB (Schauer Group, U. Wisconsin)

- East St. Louis, 1-in-6 day data with organic speciation by extraction-GCMS, June 2001 – May 2003
- CMB apportionment assumes we know all of the primary OC sources and have representative source profiles!



- PMF resolved eight factors including one mobile source factor, also two point source factors and secondary organic aerosol (SOA) not in CMB

Summary

- St. Louis – Midwest Supersite program has collected a wealth of data for fine particle physical and chemical properties
- Together with the state/local routine monitoring data, there is substantial information to support in PM_{2.5} SIP planning for the St. Louis area
- Ultimate goal is a defensible control strategy
 - Currently analyzing the observational data to provide technical support towards that effort
- East St. Louis Fine PM Mass Apportionment
 - Use of allied data (in this case, paired urban/rural data) provided significant insights into the original apportionment