IDENTIFYING SOURCES OF PM$_{2.5}$ IN PITTSBURGH USING PMF AND PSCF

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INTRODUCTION

Project Objective: Use PMF-modeled factors that represent sources of PM$_{2.5}$ with the potential source contribution function (PSCF) and conditional probability function (CPF) to determine most probable locations of the sources.

– During the Pittsburgh Air Quality Study, PM$_{2.5}$ samples were collected and analyzed for sulfate, nitrate, organic carbon, elemental carbon, trace elements, and several organic carbon species

– Ambient concentration data were used with Positive Matrix Factorization (PMF) to determine 11 factors that represent major source compositions and contributions

– Using PSCF and CPF with several of the factors, results are compared and sources are evaluated as regional or local

– Most probable locations are compared with known locations of sources obtained from the US EPA Toxic Release Inventory (TRI) facility reports

PMF 11-FACTOR MODEL FOR PAQS DATA

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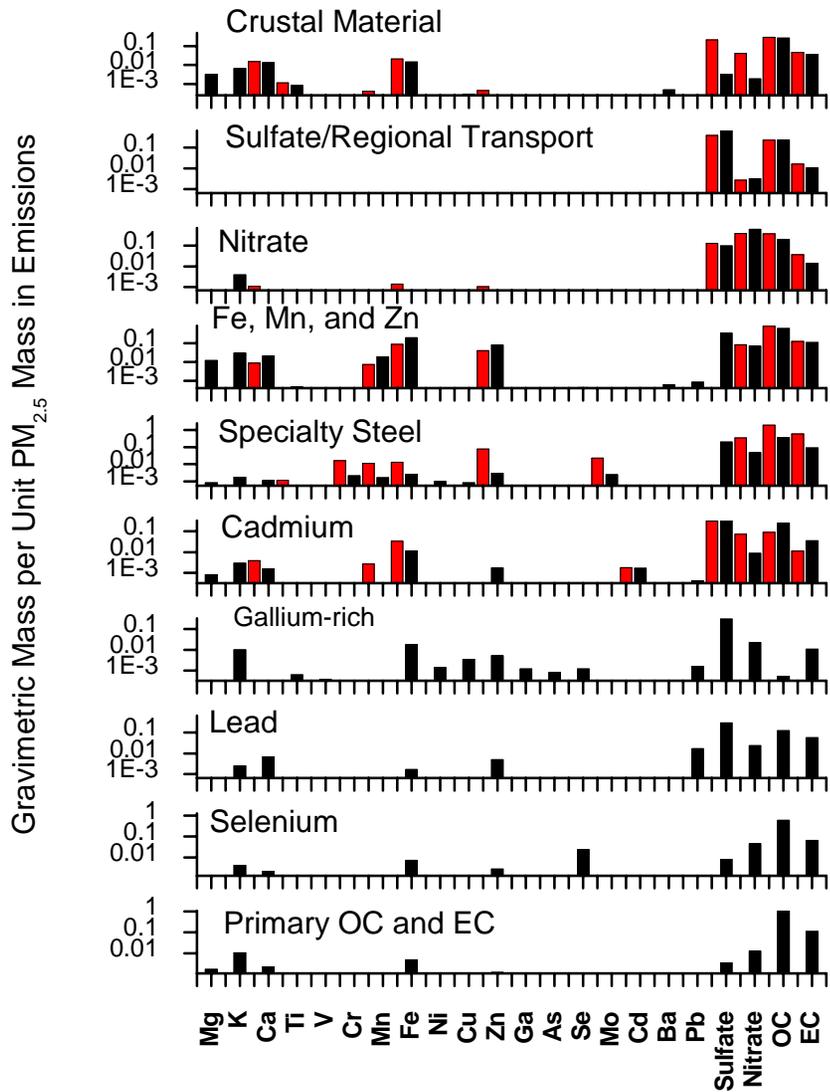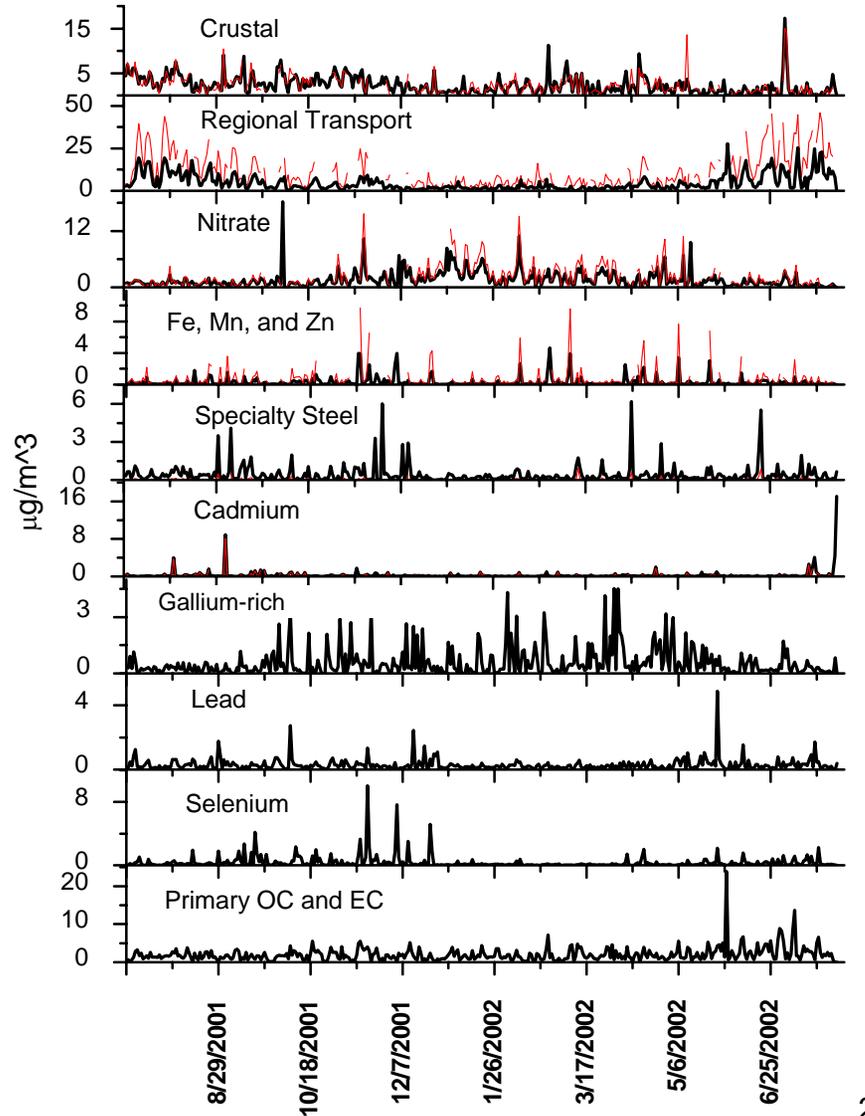
CONDITIONAL PROBABILITY FUNCTION (CPF)

$$CPF = \frac{m_{\Delta\Theta}}{n_{\Delta\Theta}}$$

- $n_{\Delta\Theta}$ = number of times wind direction was from sector $\Delta\Theta$
- $m_{\Delta\Theta}$ = number of times source contribution peaked while wind direction was from sector $\Delta\Theta$
- CPF close to 1.0 for a given sector $\Delta\Theta$ therefore indicates a high probability that a source is located in that direction
- 10° wind direction sectors used
- All 15-minute wind direction averages applied to the corresponding 24-hour source contributions
- Time periods with wind speeds < 1m/s not used due to inaccuracy of measurement at low wind speeds

# POTENTIAL SOURCE CONTRIBUTION FUNCTION (PSCF)

$$PSCF = \frac{m_{ij}}{n_{ij}}$$

– PSCF uses HYSPLIT back trajectories rather than wind direction so most probable location as well as direction of sources can be determined

– n_{ij} = number of times trajectory passed through cell (i,j) where i is latitude and j is longitude

– m_{ij} = number of times source contribution peaked while trajectory passed through cell (i,j)

  • Top 75th or 90th percentile source contributions used for m_{ij}

– All 6-hour back trajectories, for every 6 hours, applied to the corresponding 24-hour source contributions

– Cells sized 0.1°×0.1°

SULFATE FACTOR PSCF AND CPF
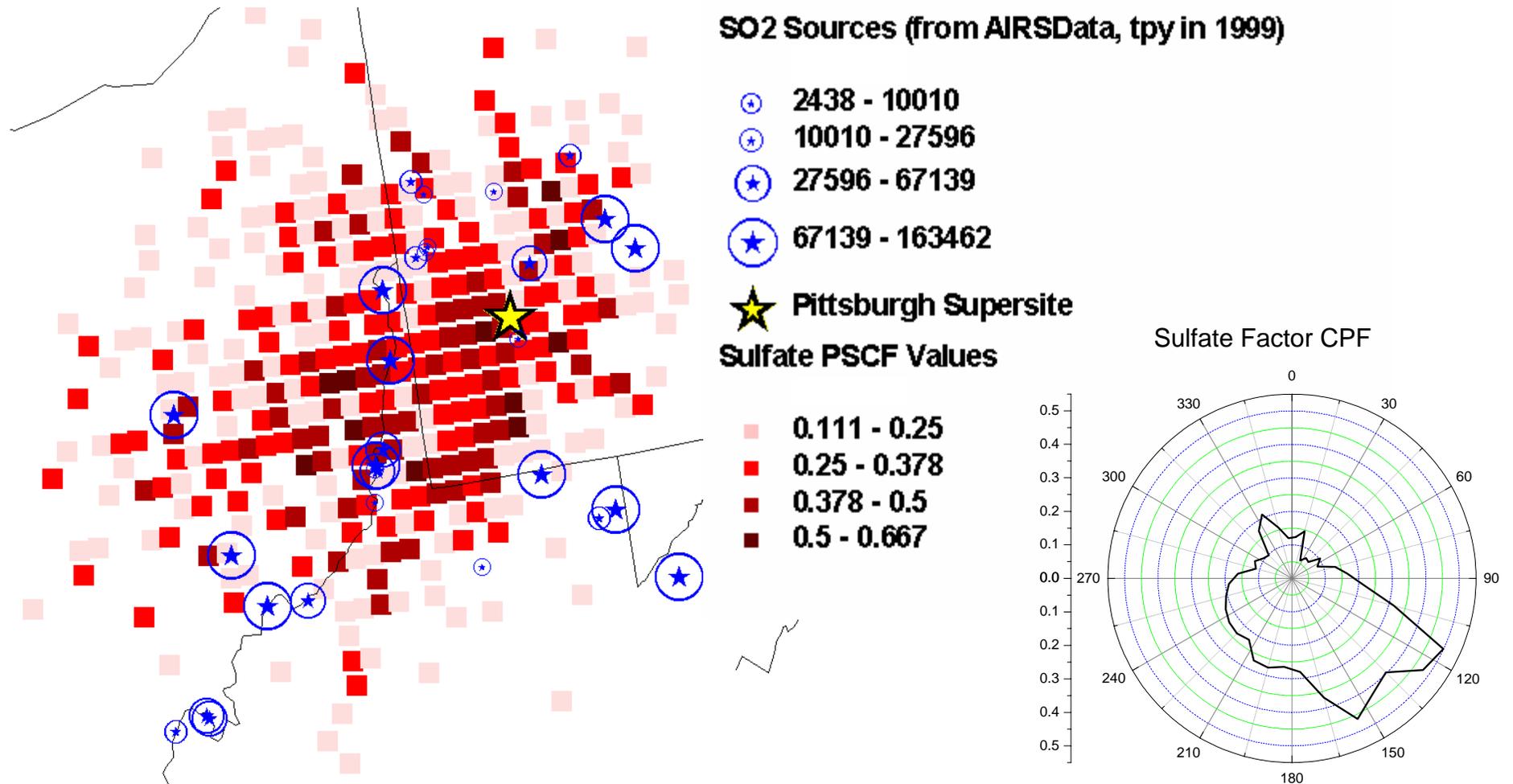
PSCF shows most probable location of the sulfate sources SW of the Supersite in the Ohio River Valley, the location of many coal-fired power plants (SO_2 sources reported to the US EPA AIRSDatabase). CPF, however, shows a most probable direction more to the SE rather than SW.
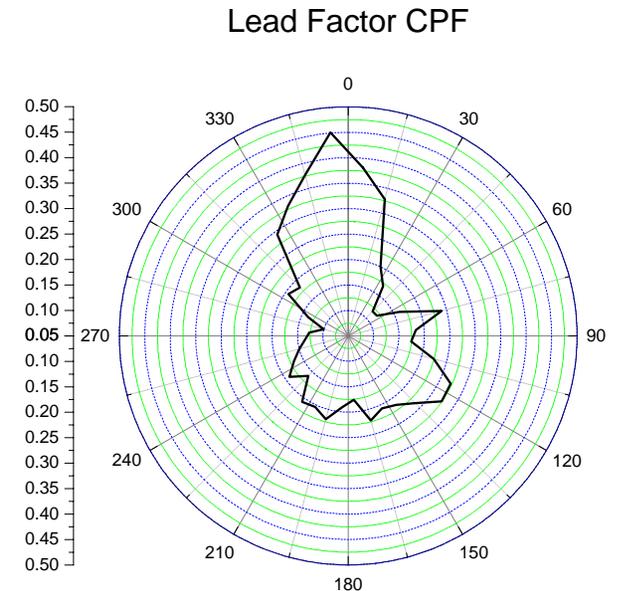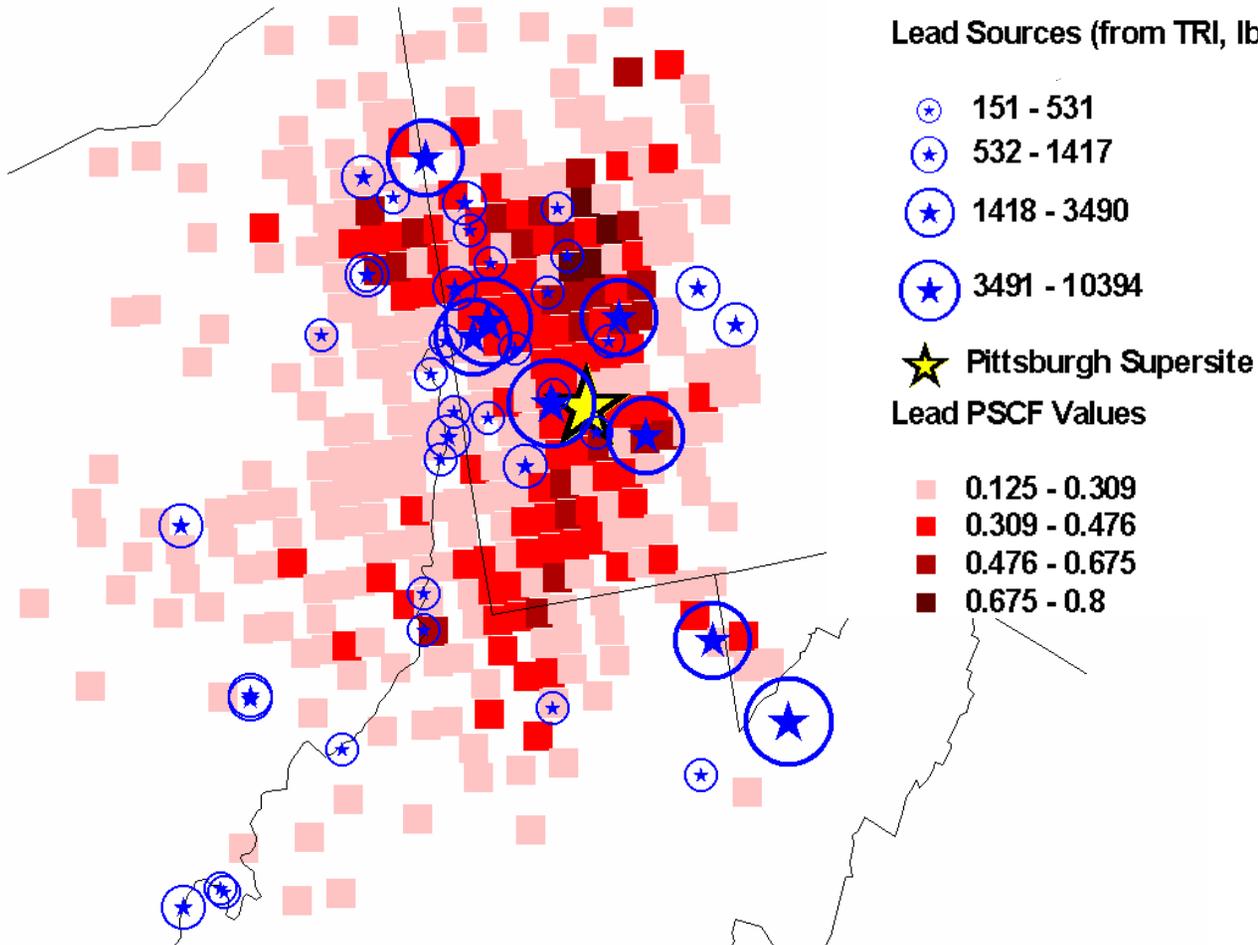
SELENIUM FACTOR PSCF AND CPF
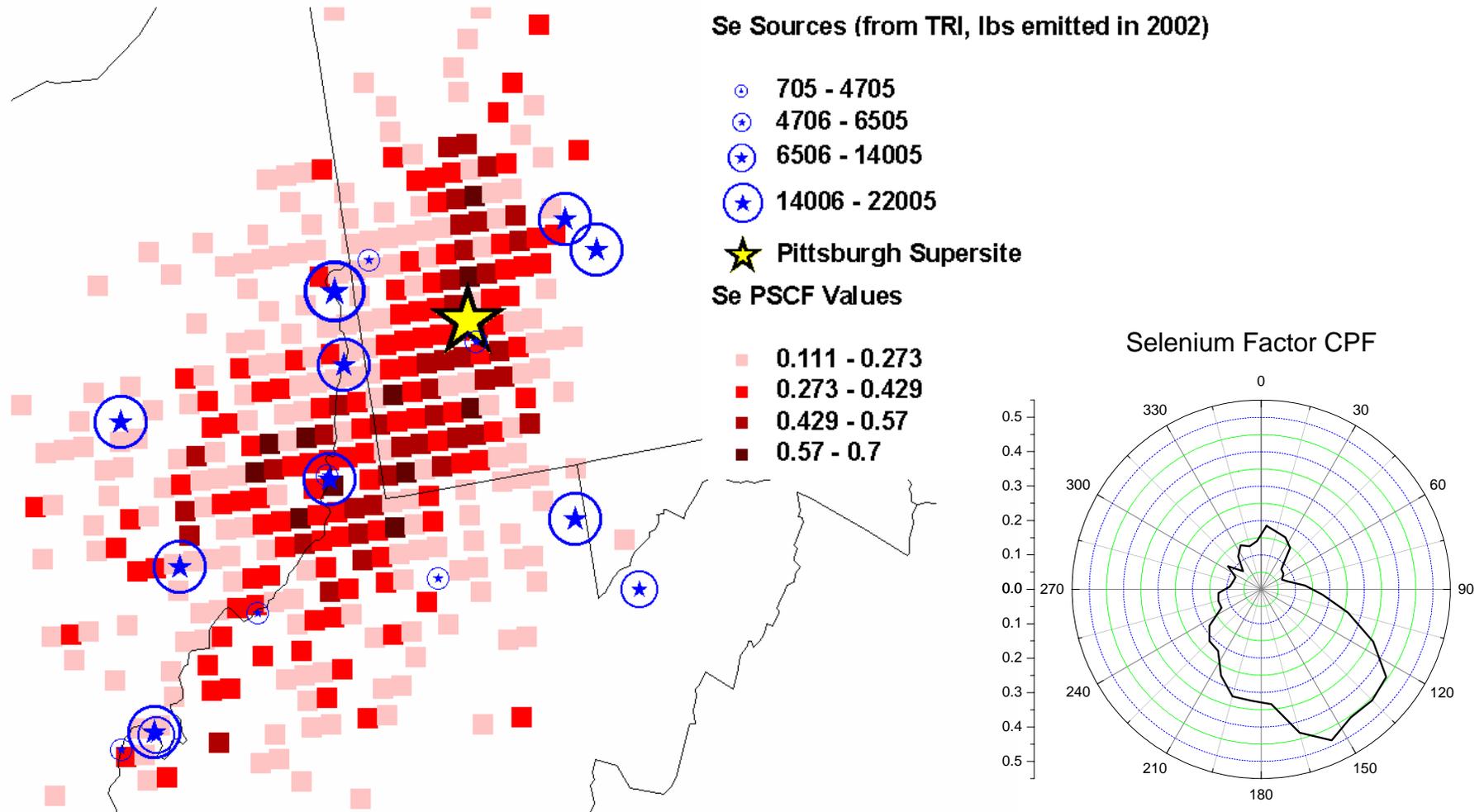
PSCF shows most probable location of the selenium sources SW of the Supersite, in agreement with the locations of Se sources reported to the TRI (all coal-fired power plants). As with the sulfate factor, CPF shows a most probable direction more to the SE rather than SW.

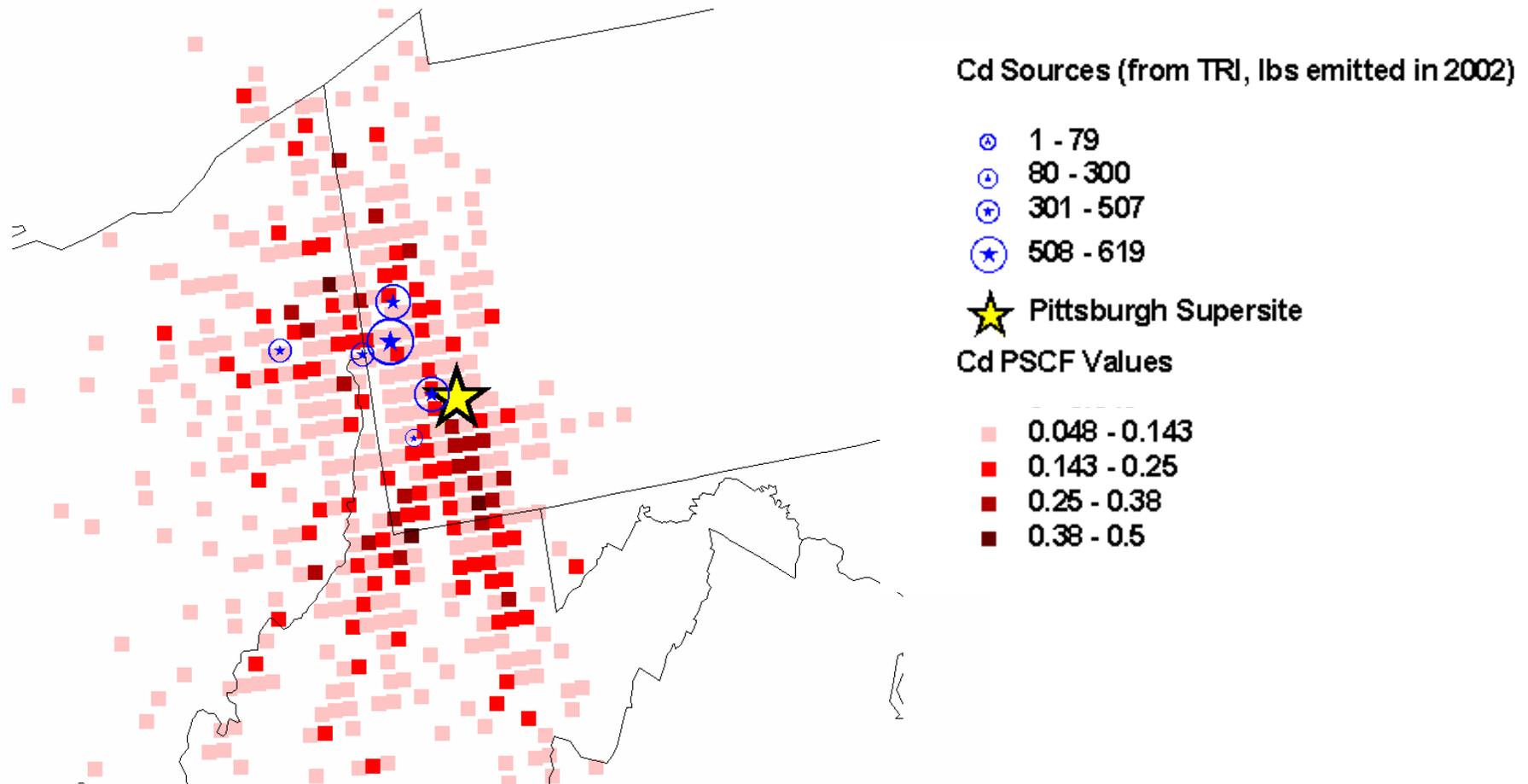# SPECIALTY STEEL FACTOR PSCF AND CPF
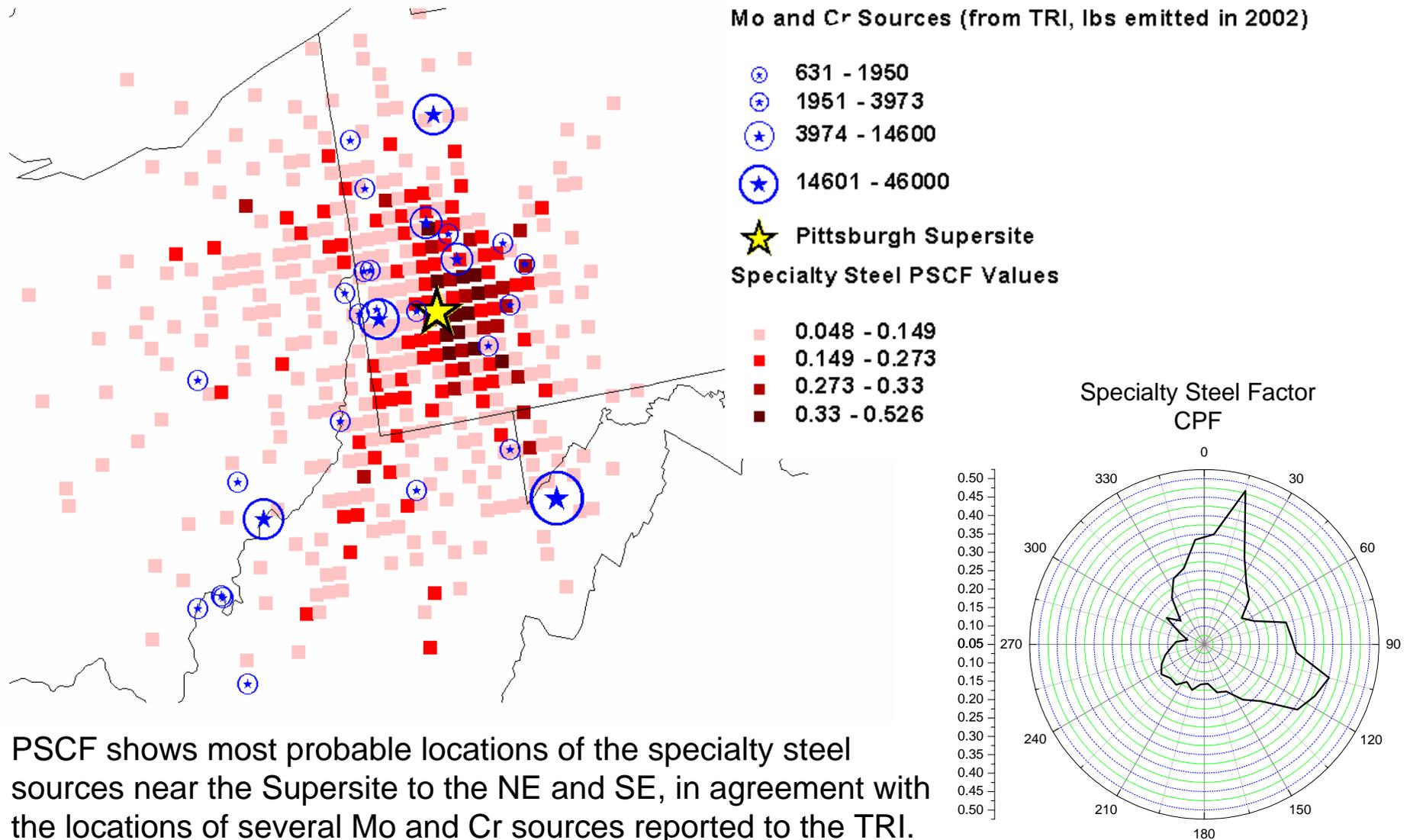
PSCF shows most probable locations of the specialty steel sources near the Supersite to the NE and SE, in agreement with the locations of several Mo and Cr sources reported to the TRI. CPF results also show NE and SE most probable directions.

LEAD FACTOR PSCF AND CPF

Lead Sources (from TRI, lbs emitted in 2002)

⊛ 151 - 531
⊛ 532 - 1417
⊛ 1418 - 3490
⊛ 3491 - 10394

★ Pittsburgh Supersite

Lead PSCF Values

■ 0.125 - 0.309
■ 0.309 - 0.476
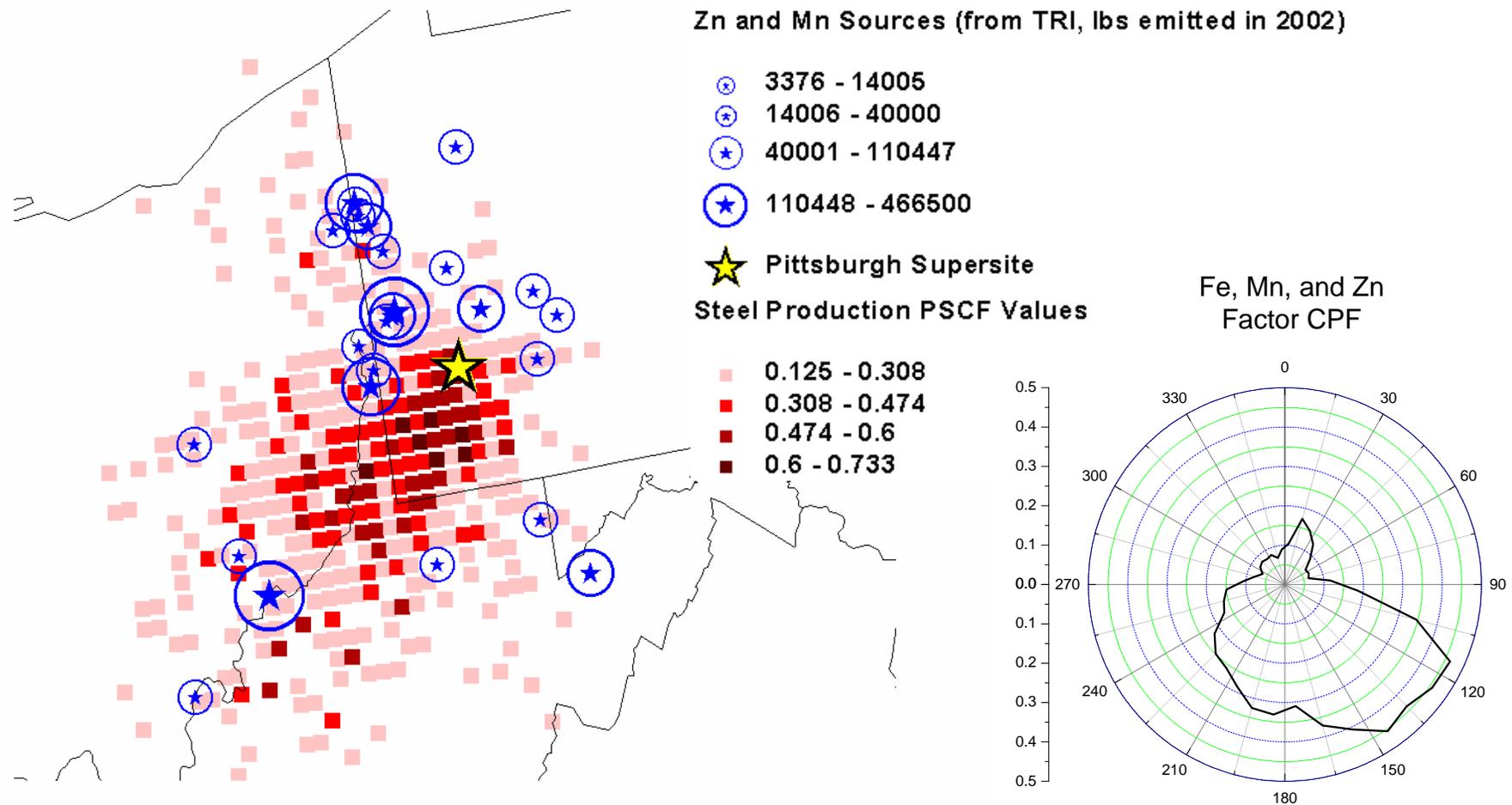■ 0.476 - 0.675
■ 0.675 - 0.8

Lead Factor CPF

PSCF shows most probable locations of the lead sources near the Supersite to the N and also S, in agreement with the locations of several Pb sources reported to the TRI. CPF results also show a N most probable direction.

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CADMIUM FACTOR PSCF

Cd Sources (from TRI, lbs emitted in 2002)

- ⊙ 1 - 79
- ⊙ 80 - 300
- ⊛ 301 - 507
- ⊛ 508 - 619

⭐ Pittsburgh Supersite

Cd PSCF Values

- ▪ 0.048 - 0.143
- ▪ 0.143 - 0.25
- ▪ 0.25 - 0.38
- ▪ 0.38 - 0.5

PSCF shows most probable locations of the cadmium sources N of the Supersite, in agreement with the few Cd sources in the area as reported to the TRI. The high probability of Cd sources to the S may be due to facilities that did not report emissions of Cd to the TRI. CPF results had less than 25% probability in all wind directions and were therefore inconclusive.

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Fe, Mn, AND Zn FACTOR PSCF AND CPF

Zn and Mn Sources (from TRI, lbs emitted in 2002)

- ⊛ 3376 - 14005
- ⊛ 14006 - 40000
- ⍟ 40001 - 110447
- ⍟ 110448 - 466500

★ Pittsburgh Supersite

Steel Production PSCF Values

- ▪ 0.125 - 0.308
- ▪ 0.308 - 0.474
- ▪ 0.474 - 0.6
- ▪ 0.6 - 0.733

Fe, Mn, and Zn Factor CPF

PSCF shows most probable locations of the Fe, Mn, and Zn sources, likely related to the steel production industry, SW of the Supersite in the Ohio River Valley. Fe emissions are not reported to the TRI; however, the Mn and Zn sources are not in good agreement with the PSCF results. CPF results show SE as the most probable direction.

GALLIUM-RICH FACTOR PSCF AND CPF
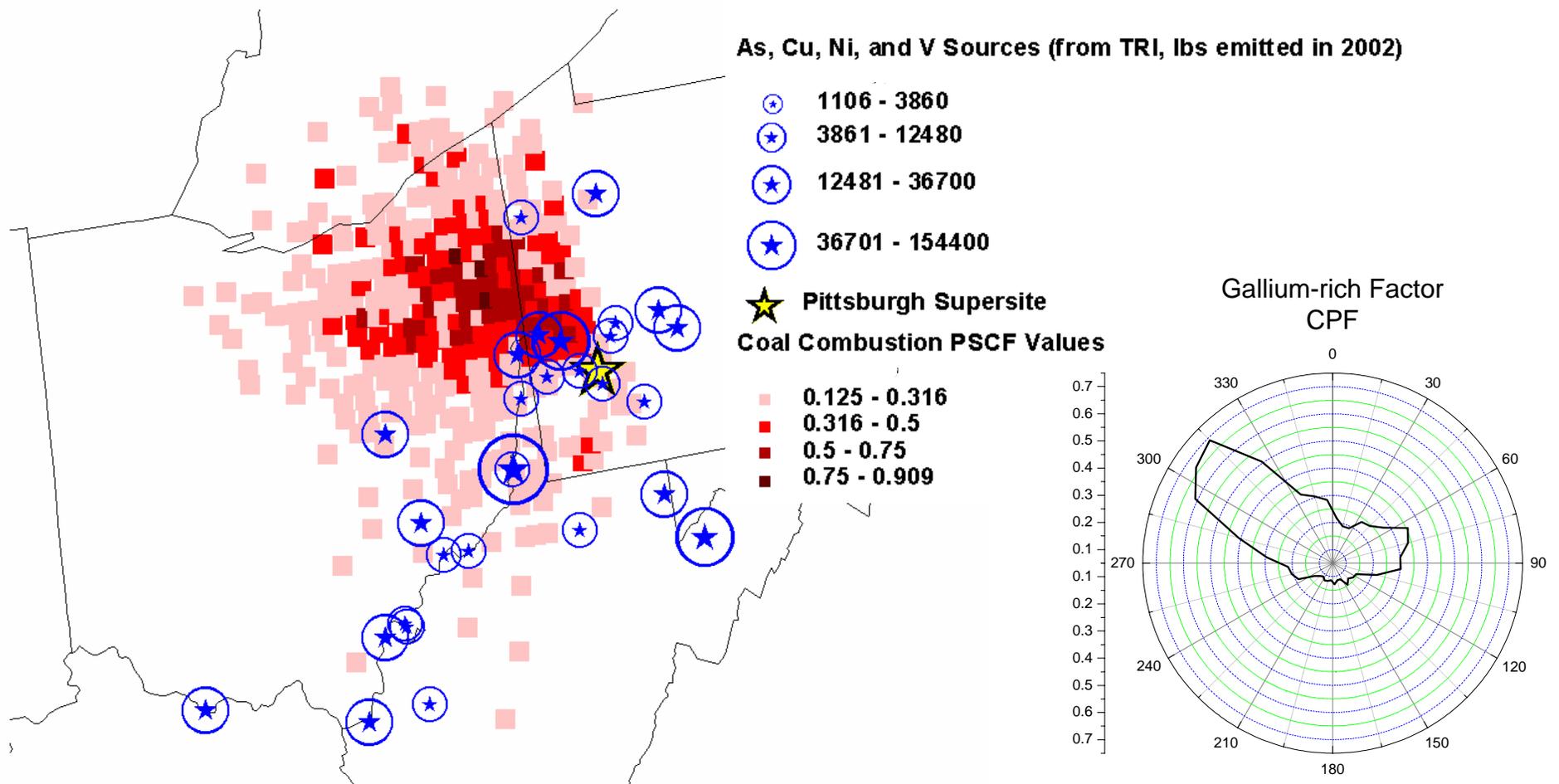
PSCF and CPF agree that the probability of a gallium-rich source(s) to the NW of the Supersite is very high. Ga emissions are not reported to the TRI; however, As, Cu, Ni, and V, significant in this factor, have sources to the NW as well as other directions. Ga could be associated with coal combustion, but influence from coal-fired power plants in the Ohio River Valley is not seen in the PSCF or CPF results as would be expected.

CONCLUSIONS

- PSCF and CPF results for the PMF-modeled factors presented can be grouped into three different categories:
  - Regional sources: Sulfate and selenium from coal-fired power plants in the Ohio River Valley
  - Local sources: Specialty steel, lead, and cadmium factors represent sources mostly within Allegheny County
  - Potentially regional or local: Fe, Mn, and Zn (from steel production industry), gallium-rich (unknown source)
- PSCF and CPF results agree for the lead factor, the gallium-rich factor, and the specialty steel factor
- PSCF shows the Ohio River Valley to the SW as the source location for the sulfate, selenium, and Fe, Mn, and Zn factors while CPF shows a more SE most probable direction
- Despite limitations in using 24-hour averaged ambient data, probable locations are determined for several of the modeled sources of $PM_{2.5}$ by using PSCF and CPF

Acknowledgements