Appendix B

PM2.5 Source Apportionment at Georgia STN Sites using Positive Matrix Factorization

(presentation by A. Marmur, Georgia EPD, February 2006

$PM_{2.5}$ source apportionment at Georgia STN sites using Positive Matrix Factorization

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Overview (Slide 1 of 3)

- Positive Matrix Factorization (PMF) was used to apportion $PM_{2.5}$ concentrations at eight STN sites:
  - Macon (June 02 – May 05; 162 samples)
  - Savannah (July 02 – December 04; 119 samples)
  - Athens (March 02 – May 05; 157 samples)
  - Douglas (July 02 – May 05; 128 samples)
  - Atlanta (March 01 – May 05; 468 samples)
  - Rome (May 02 – May 05; 167 samples)
  - Columbus (May 02 – May 05; 151 samples)
  - Augusta (May 02 – May 05; 155 samples)

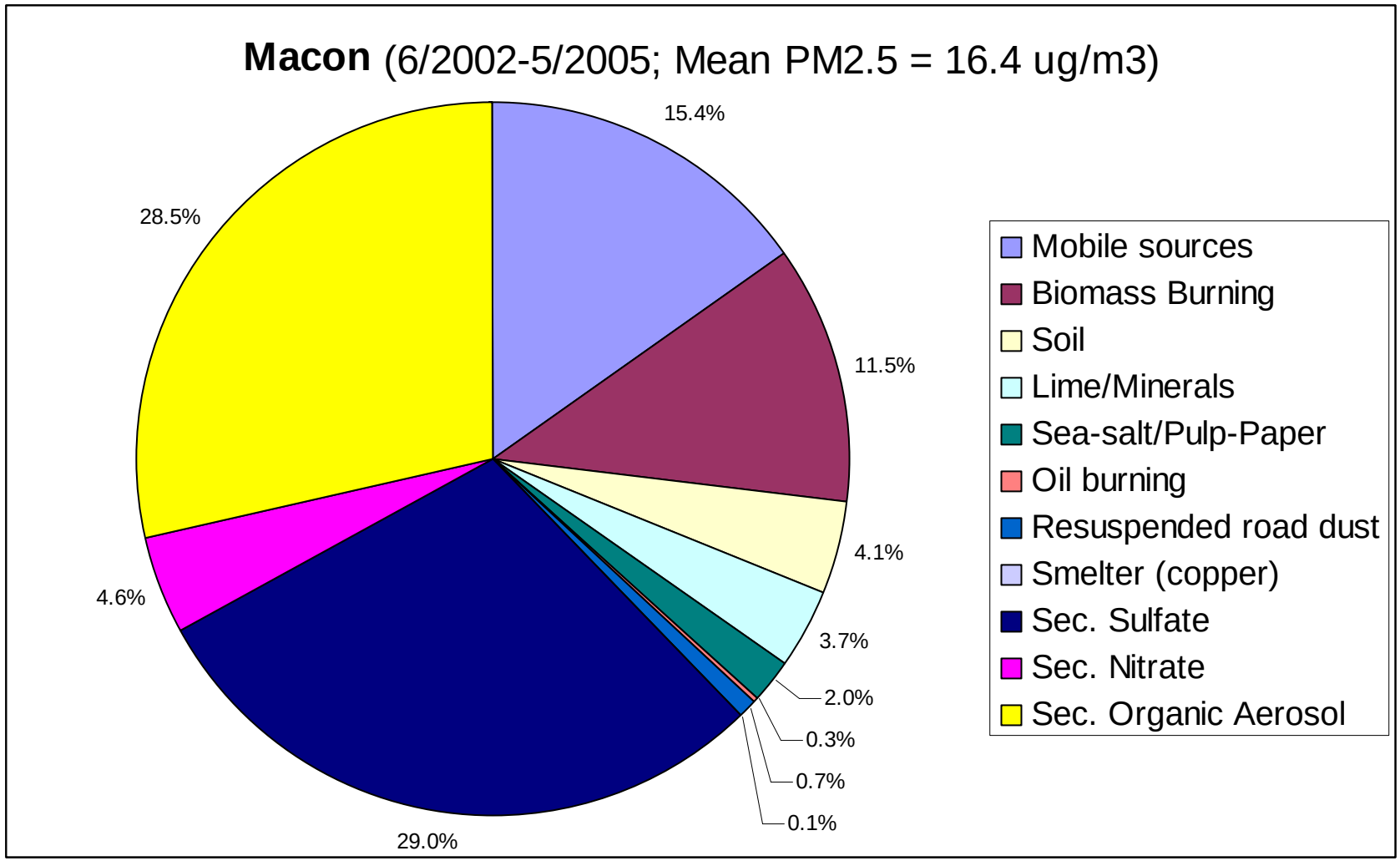
Overview (Slide 2 of 3)

- The analysis was carried out twice for each site:
  - A stand-alone analysis for each site ("site-specific")
  - A analysis based on the combined dataset of all measurements from all sites ("combined-dataset")
- The two sets of results per site were compared to assess uncertainties in source classifications and contributions
- The analysis based on the combined dataset allowed for an "apples-to-apples" spatial comparison across sites (similar factors and compositions)

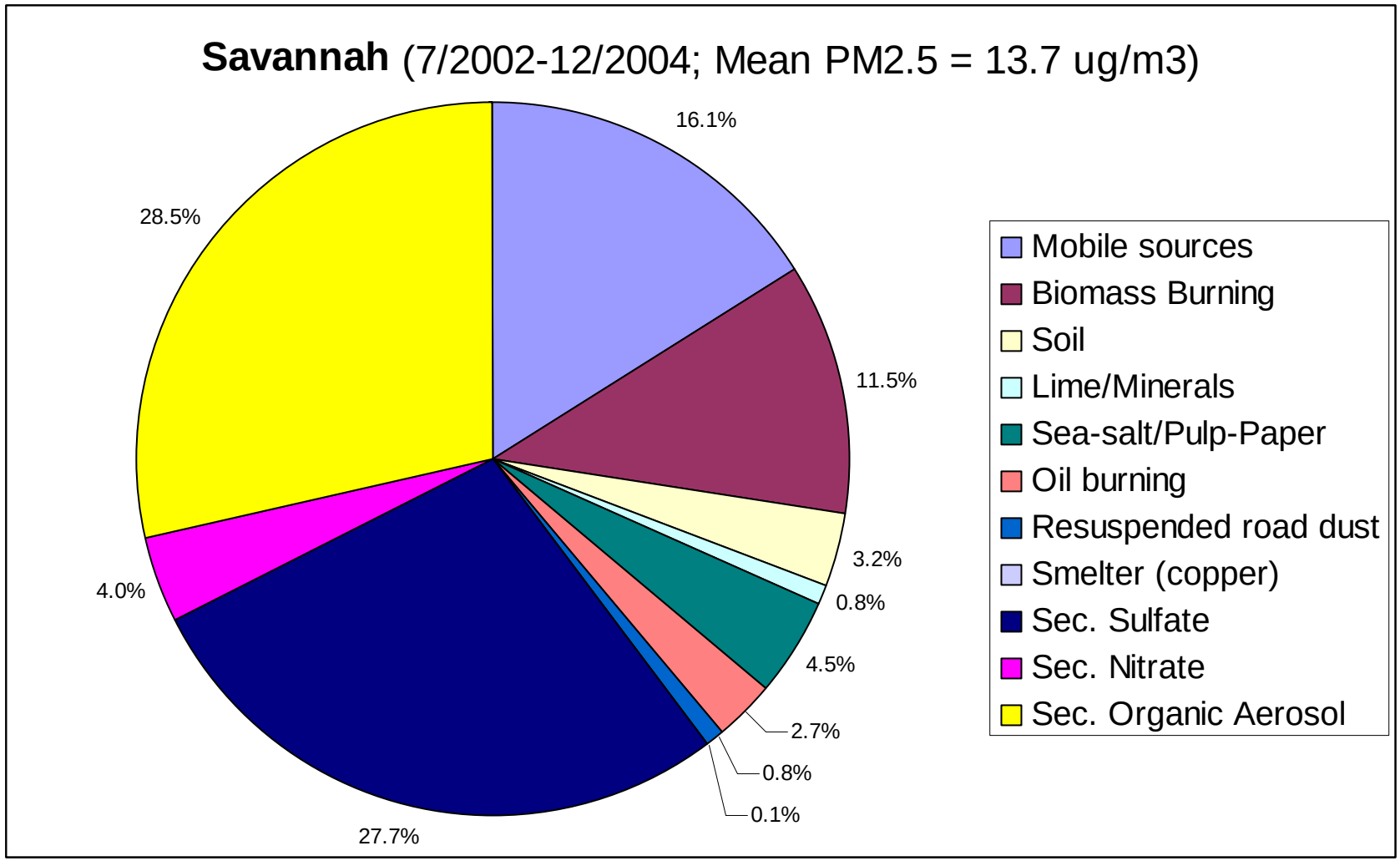
Overview (Slide 3 of 3)

- Temporal analyses were carried out to identify weekly, seasonal and annual patterns
- Specific analyses were carried out on days of high $PM_{2.5}$ concentrations, to identify the impacting sources and provide useful information to start addressing the new daily $PM_{2.5}$ standard
- **Note: all results in this presentation are based on the "combined-dataset" analysis, except for slides comparing "site-specific" results to "combined-dataset" results**

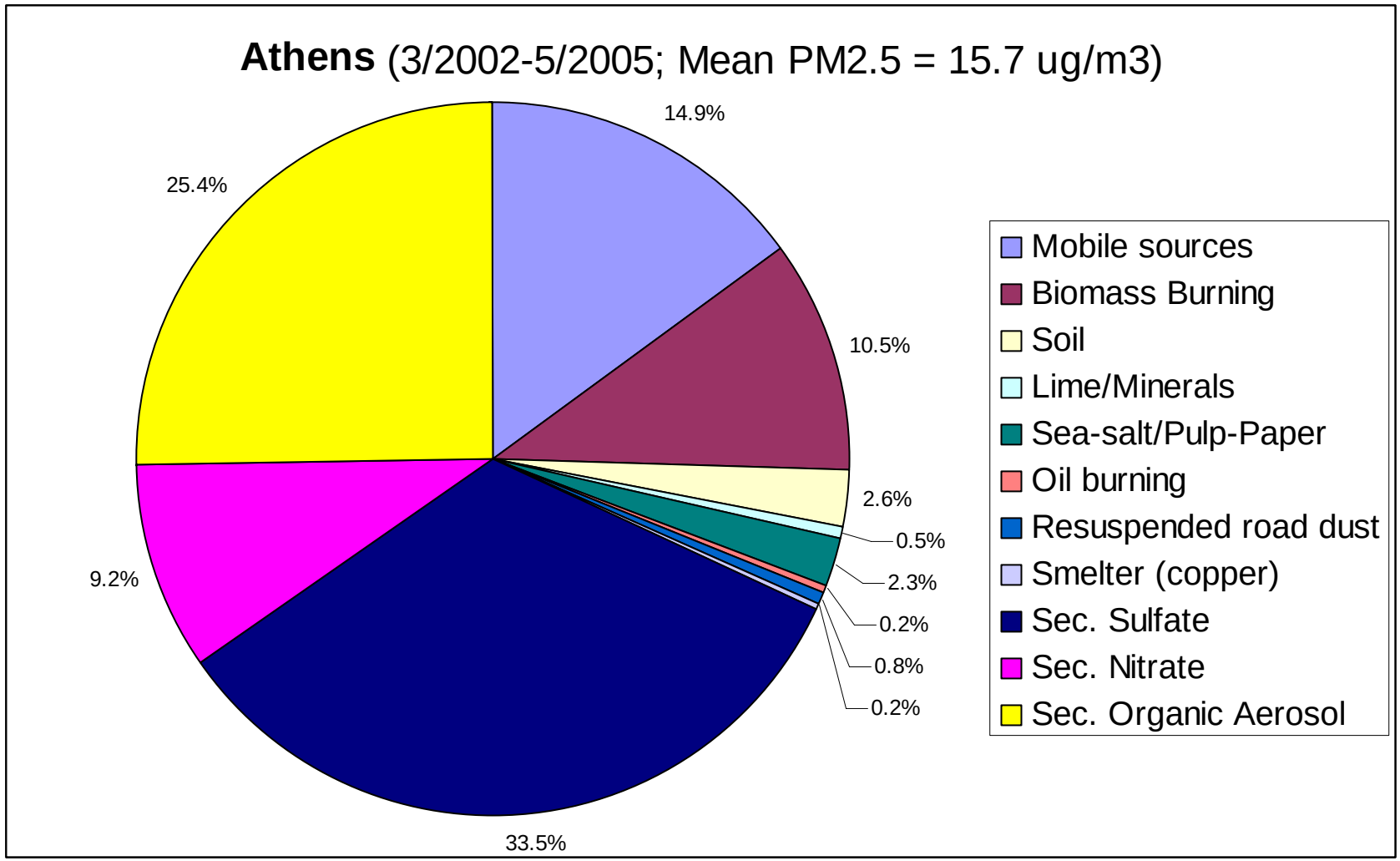
Average source-contributions: Macon



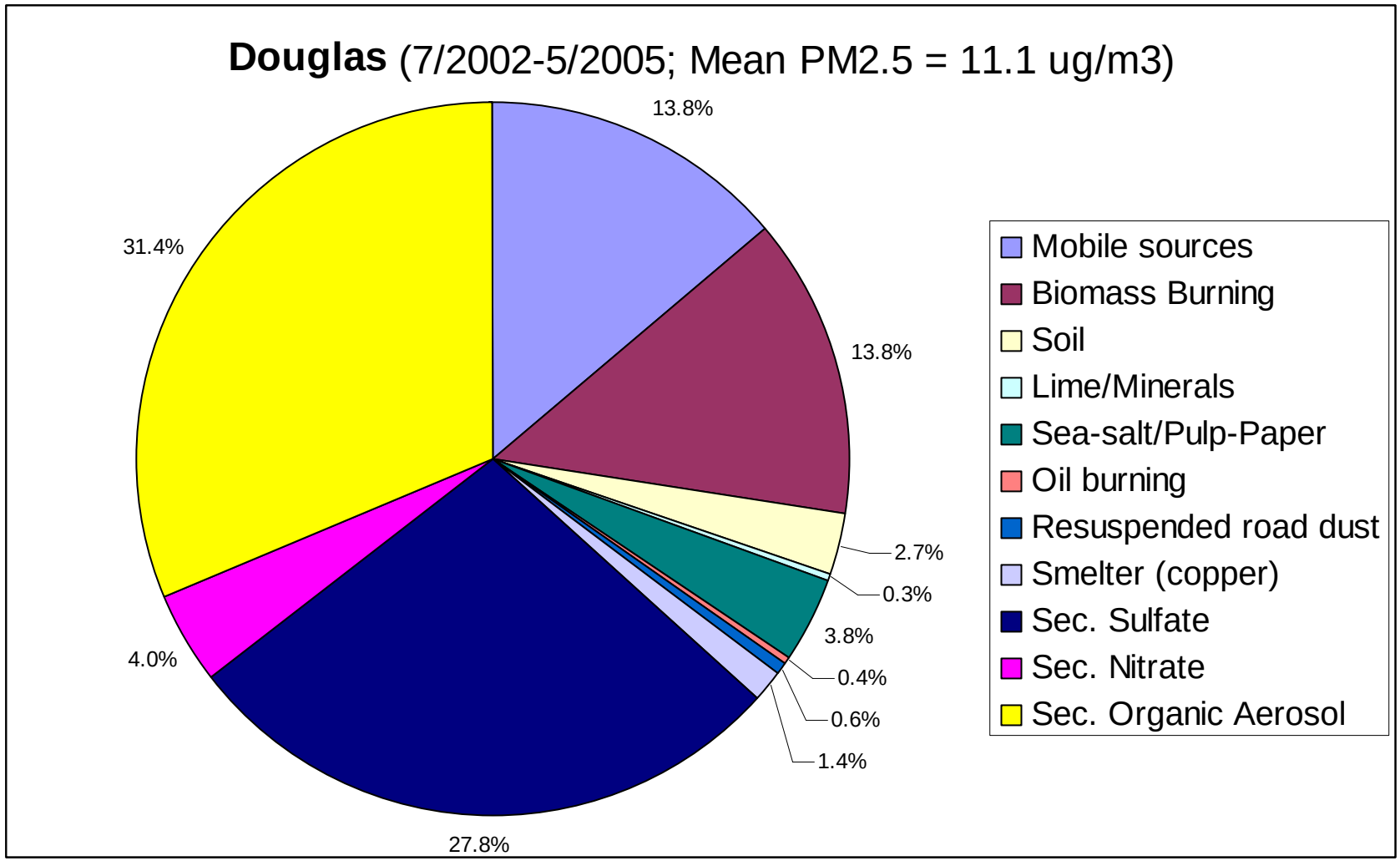
Average source-contributions: Savannah



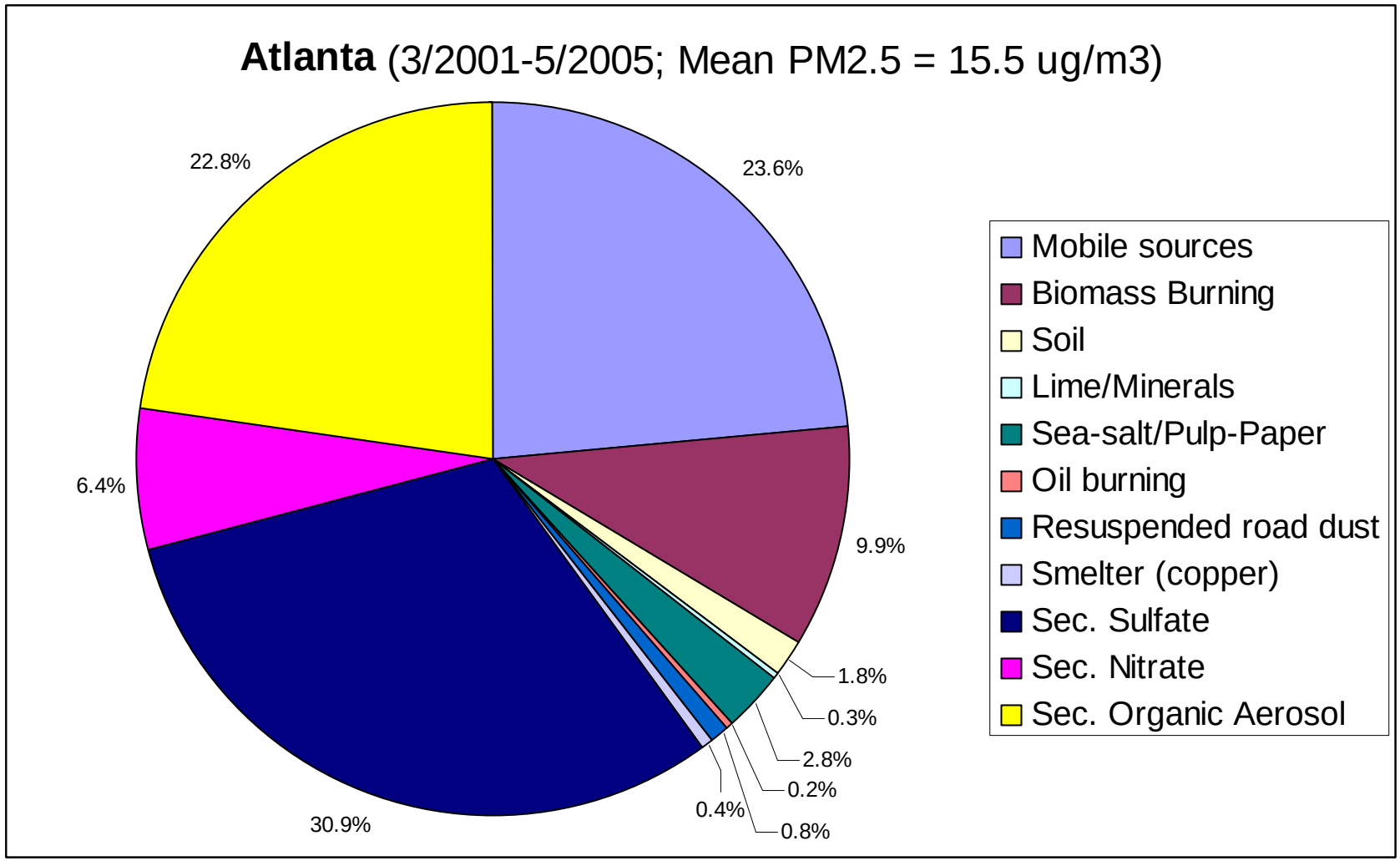
Average source-contributions: Athens



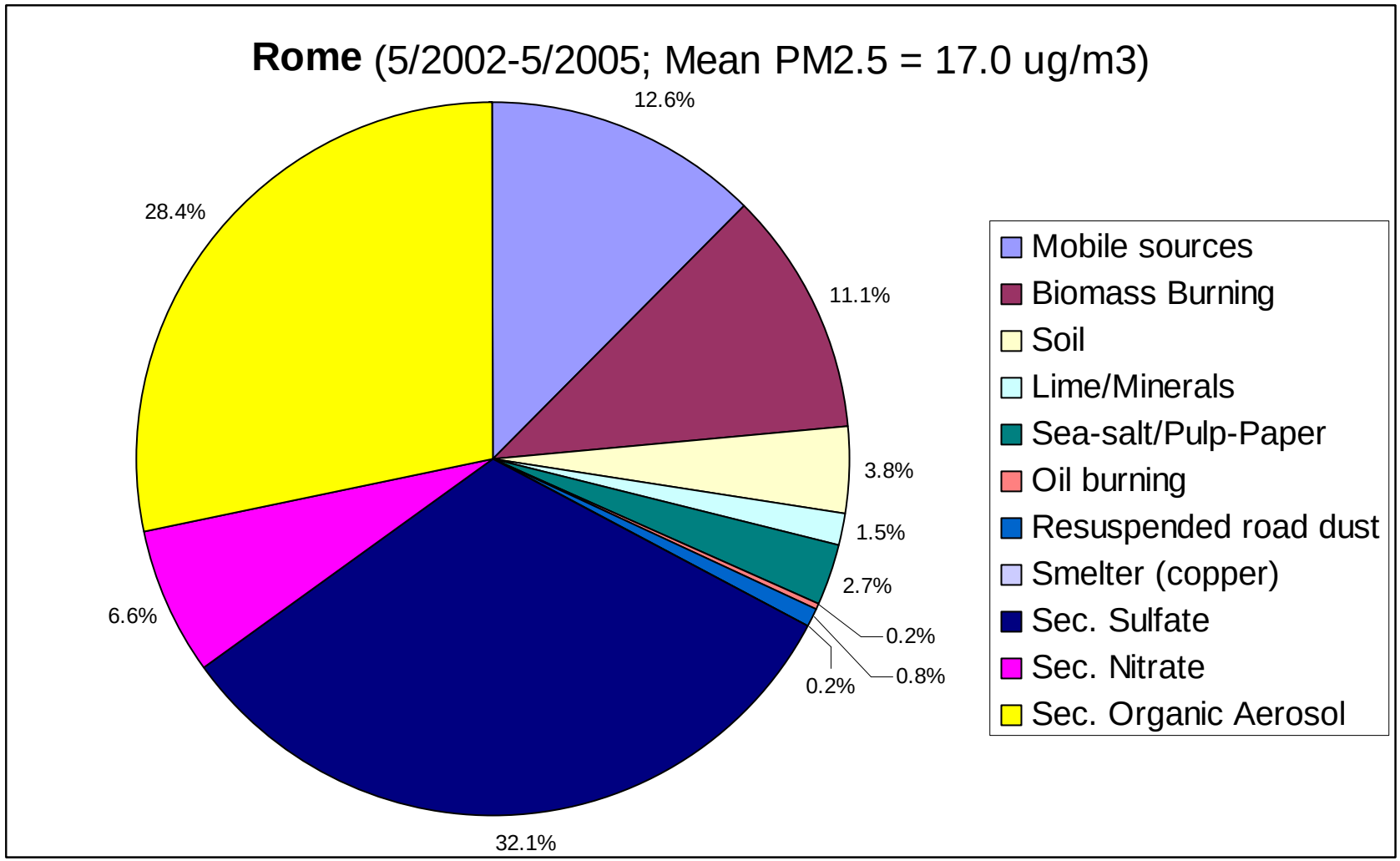
Average source-contributions: Douglas



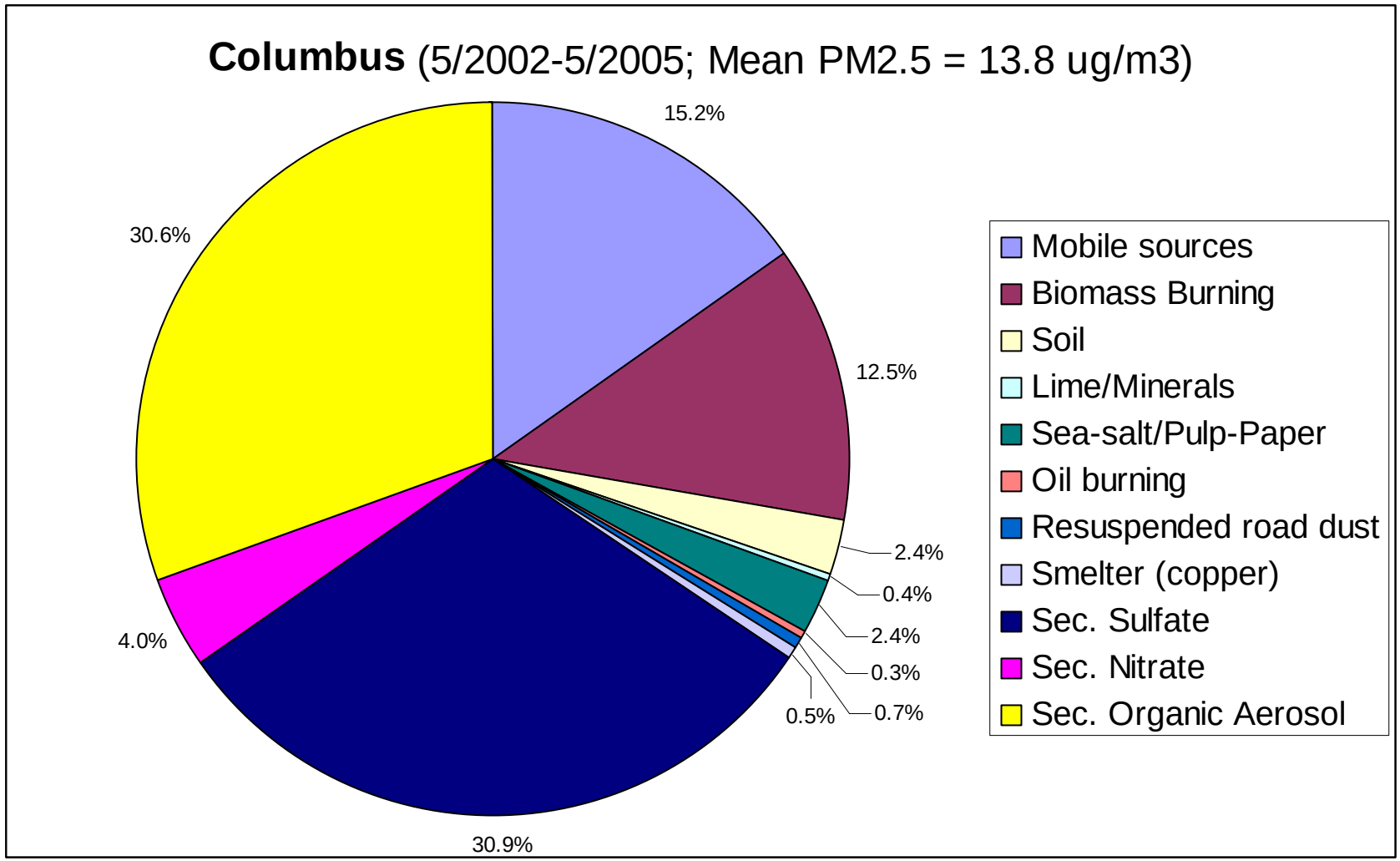
Average source-contributions: Atlanta



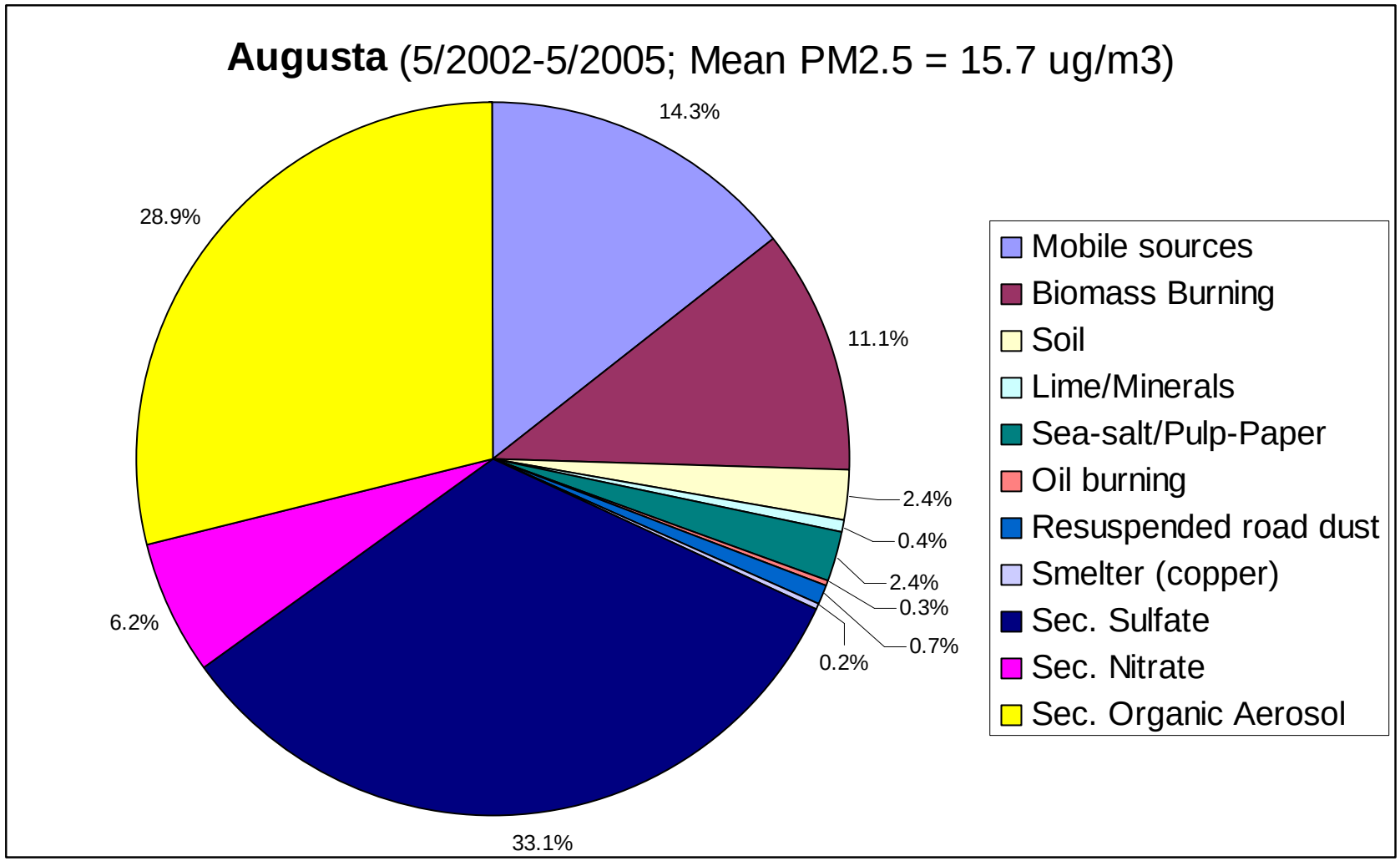
Average source-contributions: Rome



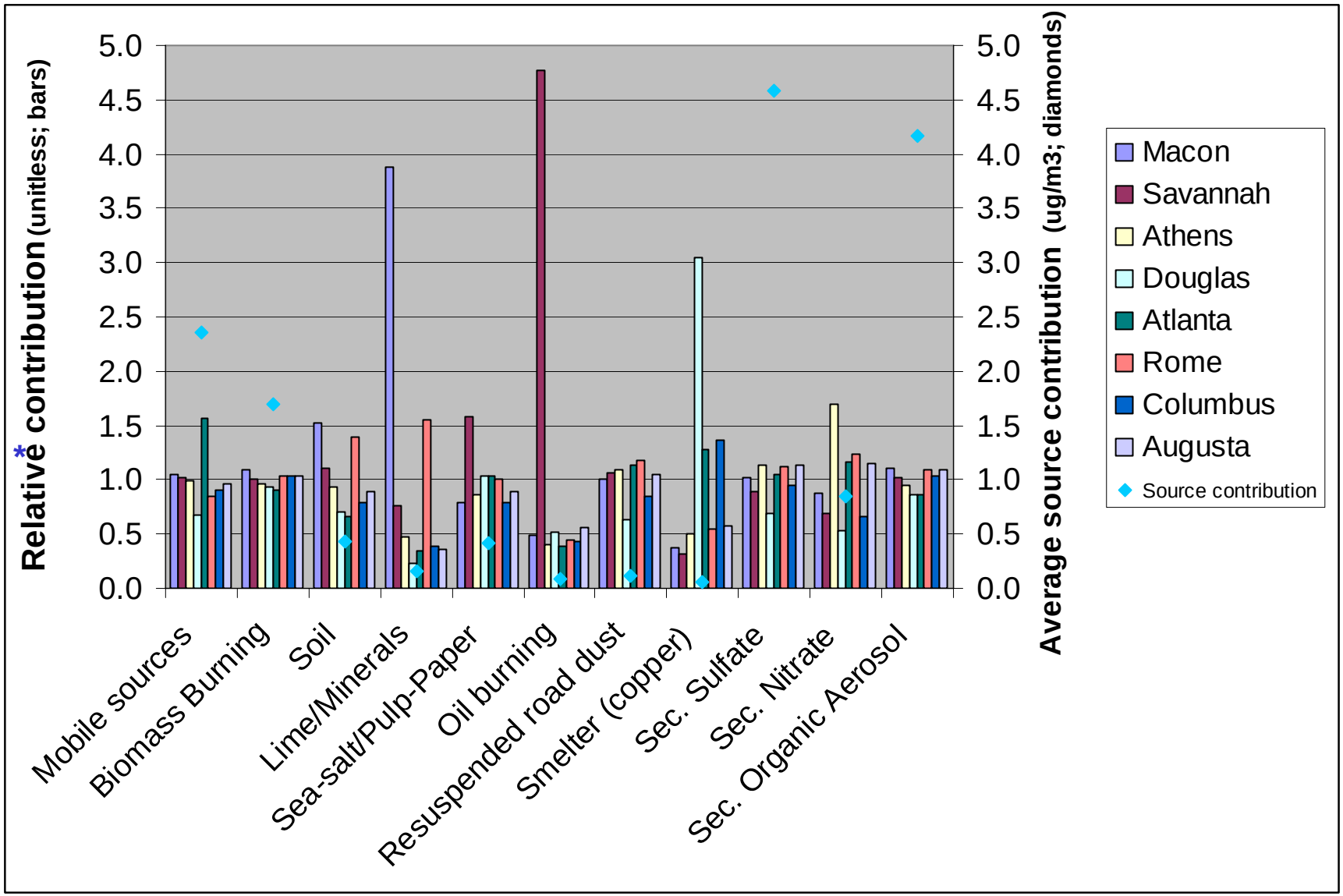
Average source-contributions: Columbus



Average source-contributions: Augusta



Spatial patterns in source contributions

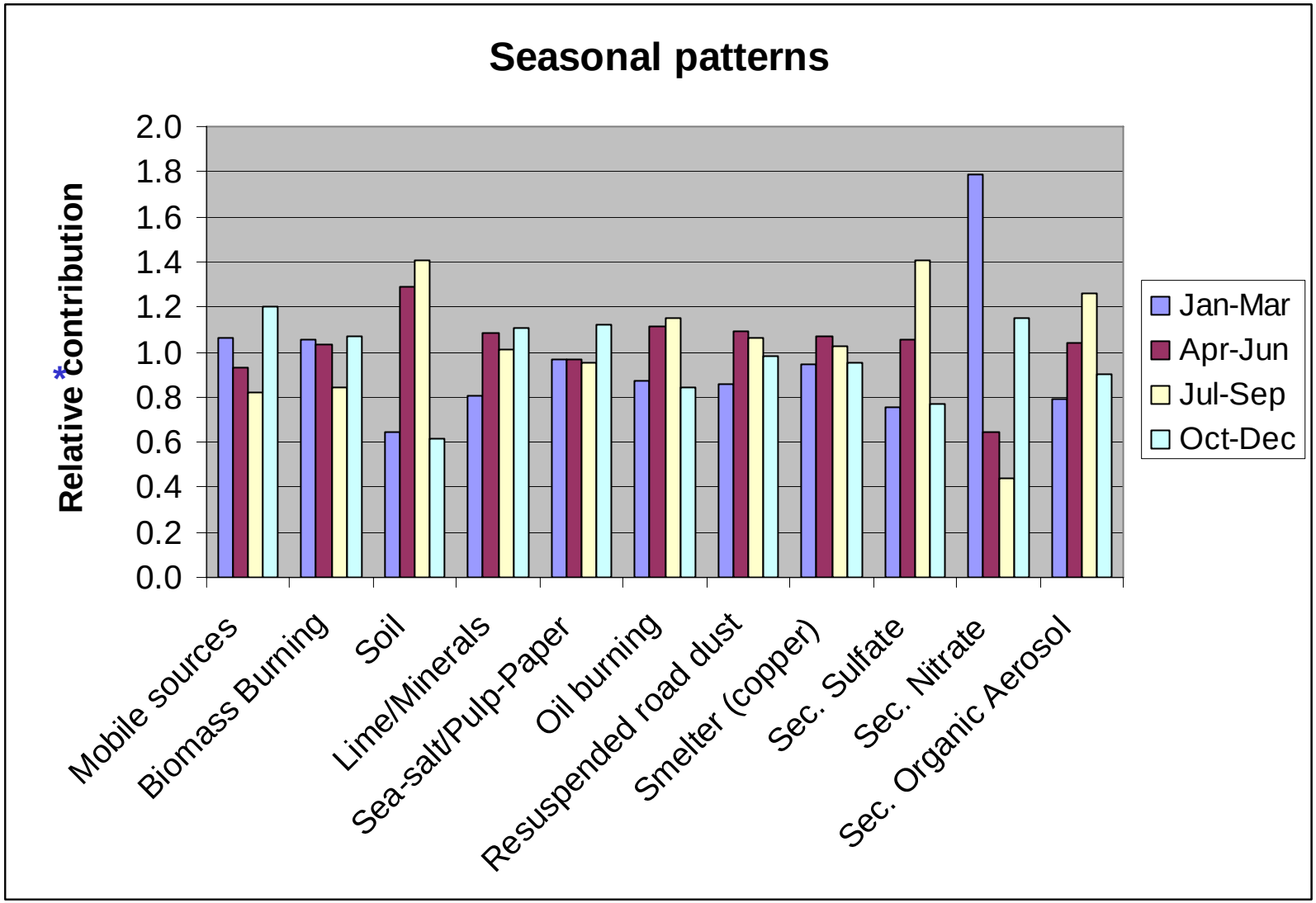


* - Ratio of average contribution at each site to average contribution in all statewide samples

Major findings from spatial analysis

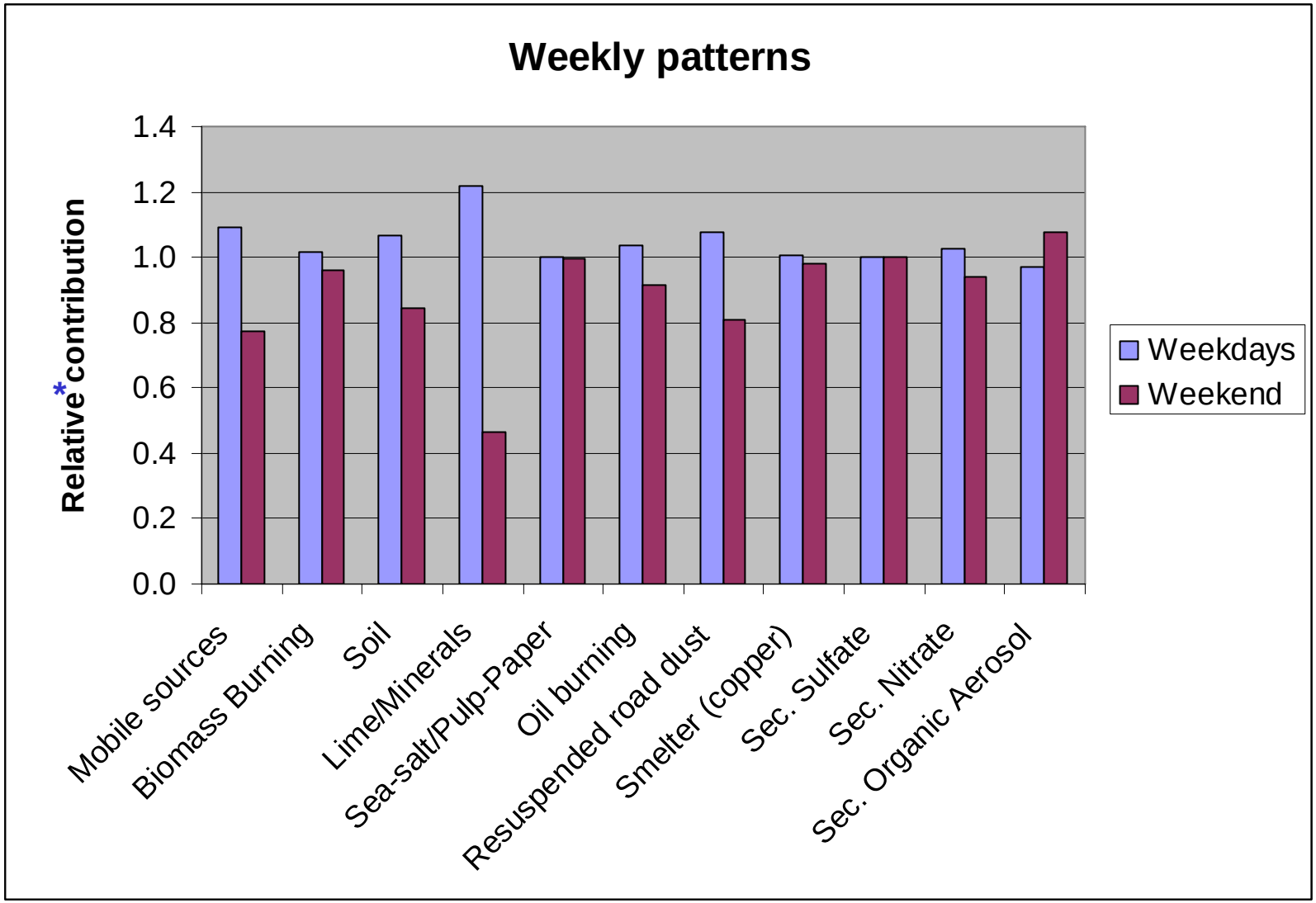
- Major source-categories across all sites are: secondary organics, sulfate, nitrate; mobile-sources; biomass-burning
- Atlanta shows the highest contribution from mobile-sources
- Savannah shows elevated levels of sea-salt aerosol and oil-combustion particles (likely from ships)
- Macon site seems to be impacted by a lime/minerals facility
- Douglas (Coffee county) site seems to be impacted by a copper smelter
- Athens site shows elevated nitrate levels (due to local availability of ammonia?)
- In contrast to previous analyses, biomass-burning impact at Columbus is similar to other sites
  - Likely due to more accurate apportionment of organic carbon between the “biomass-burning” and “secondary organic aerosol” categories using the combined dataset

Seasonal patterns in source-contributions (average across all sites)



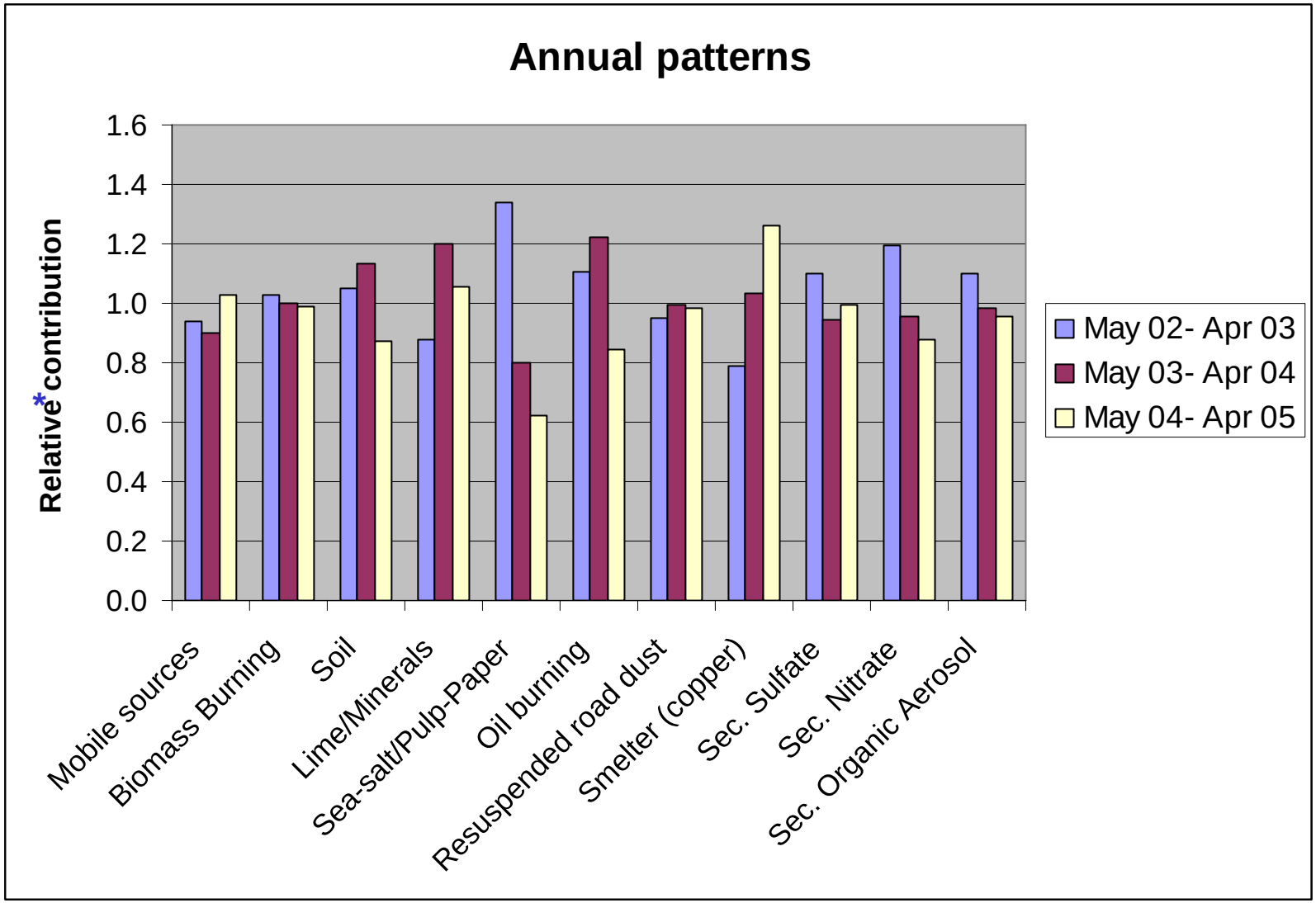
* - Ratio of average quarterly contribution to average contribution in all samples

Weekly patterns in source-contributions (average across all sites)



* - Ratio of average weekday or weekend contributions to average contribution in all samples

Annual patterns in source-contributions (average across all sites)

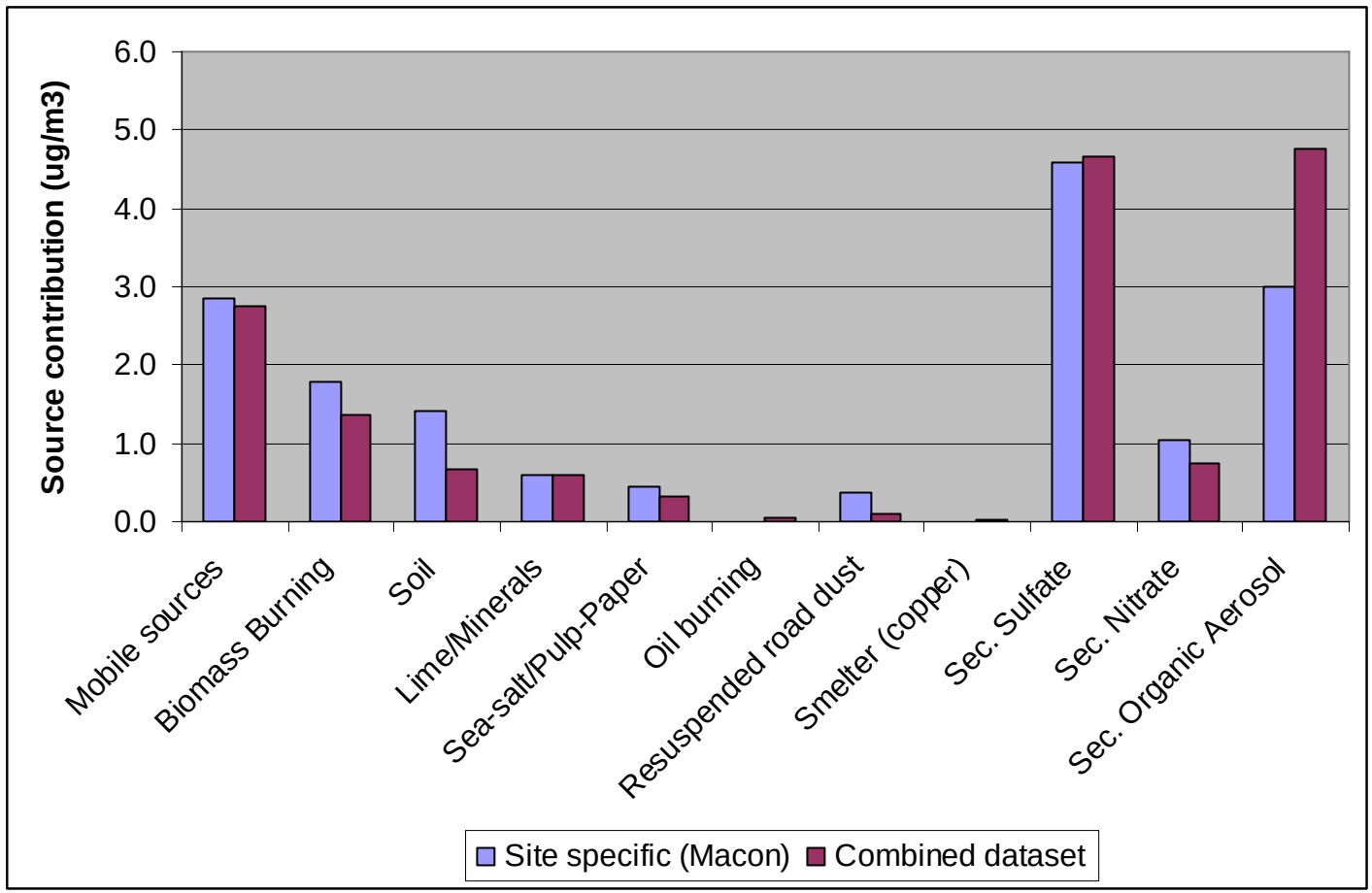


* - Ratio of average yearly contributions to average contribution in all samples

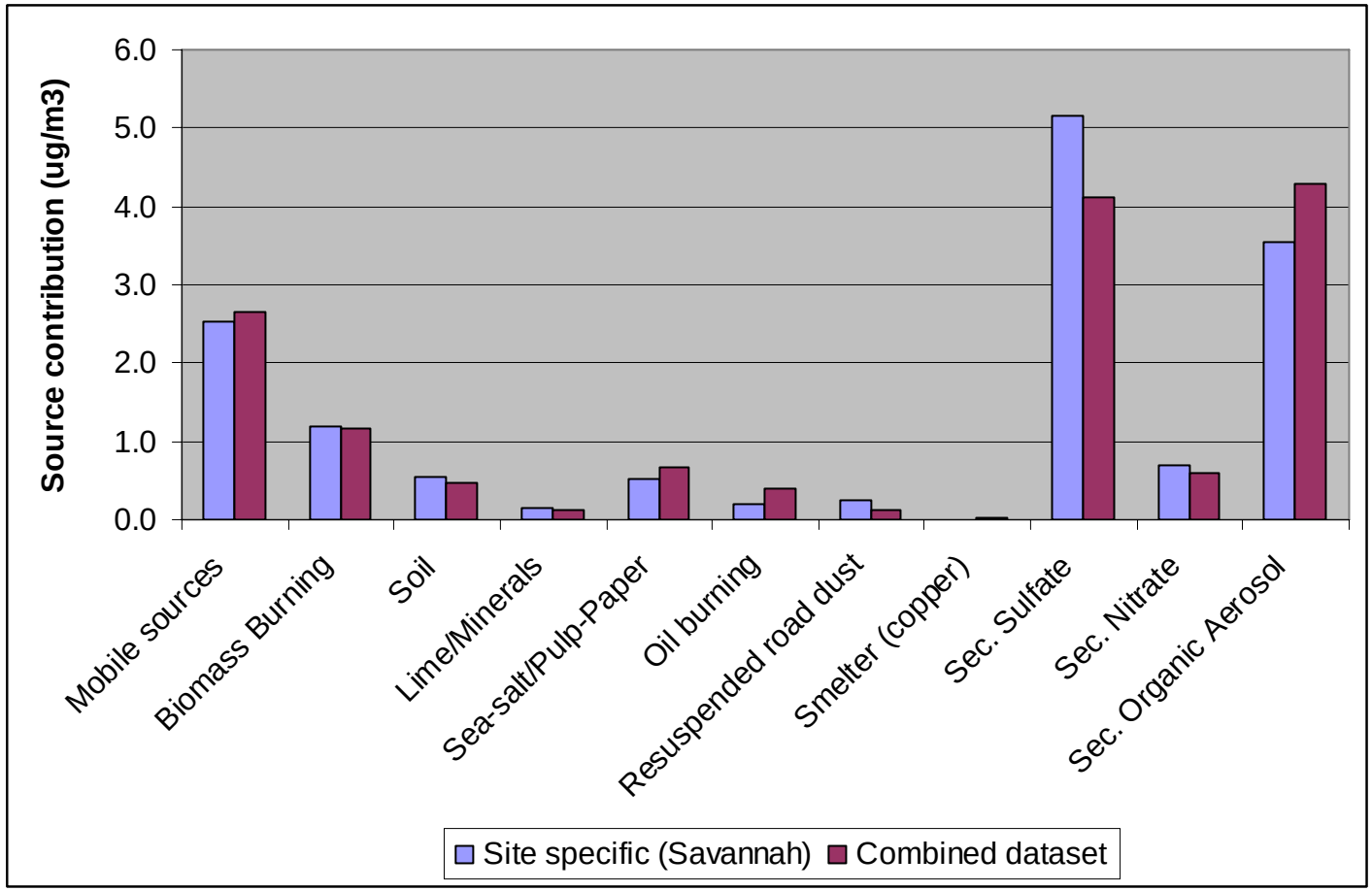
Major findings from temporal analysis

- Expected seasonal patterns were observed:
  - Higher secondary organics, sulfate in summer
  - Higher secondary nitrate in winter
  - Higher mobile-source impact in winter (less mixing; roughly similar VMTs year-round)
  - Lower biomass burning in summer (burning ban)
  - More soil, road dust in spring,summer (less rain)
- Strong weekday/weekend pattern for mobile-source, soil, road dust and lime/minerals
- Difficult to draw conclusions based on annual trends for three years only (some sites have even less data)
  - More data needed
  - Measurement effects? (sharp decrease in Na^+ [sea-salt/pulp-paper] in all sites throughout the state?)

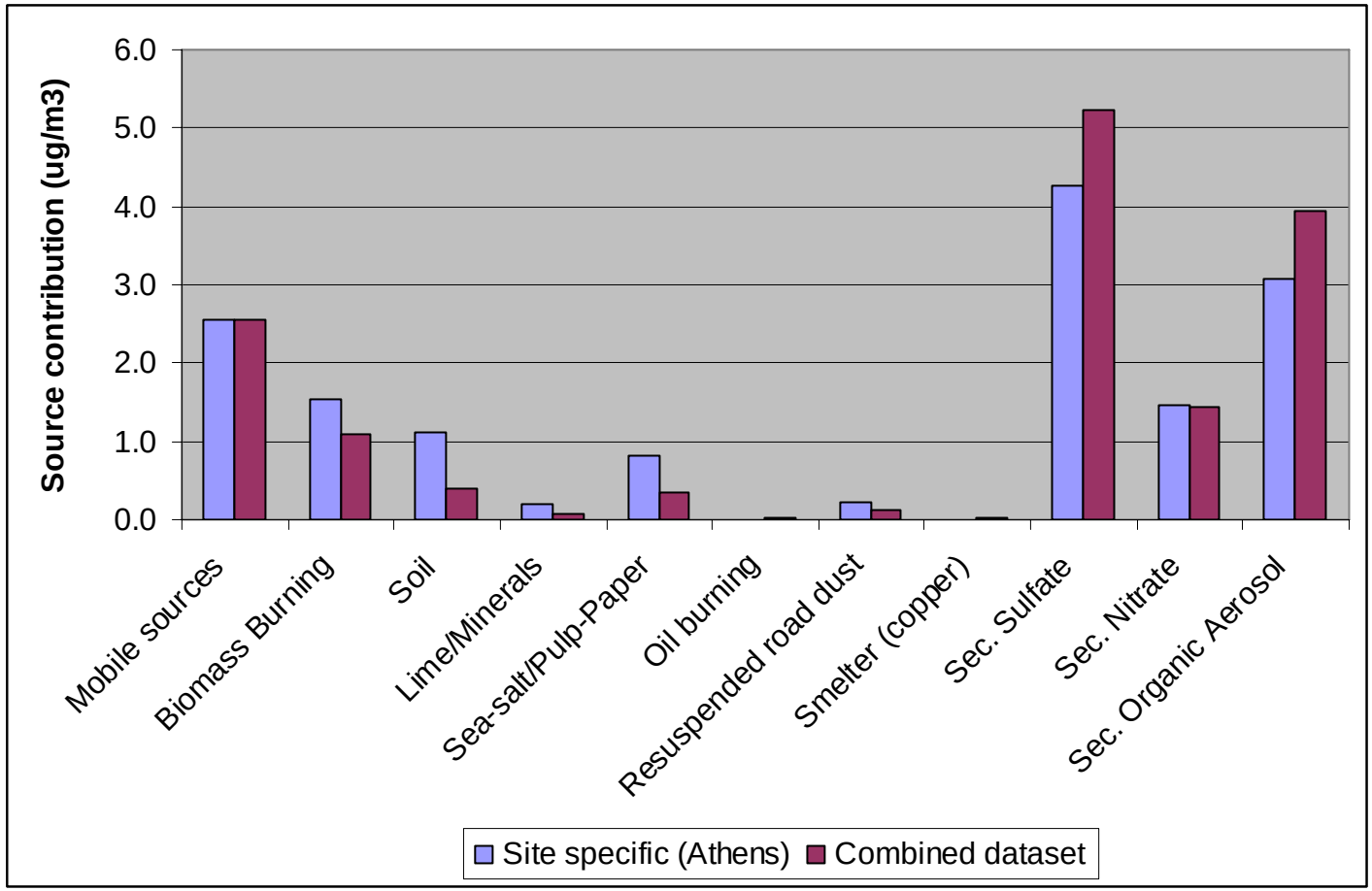
Site-specific vs. combined dataset: Macon



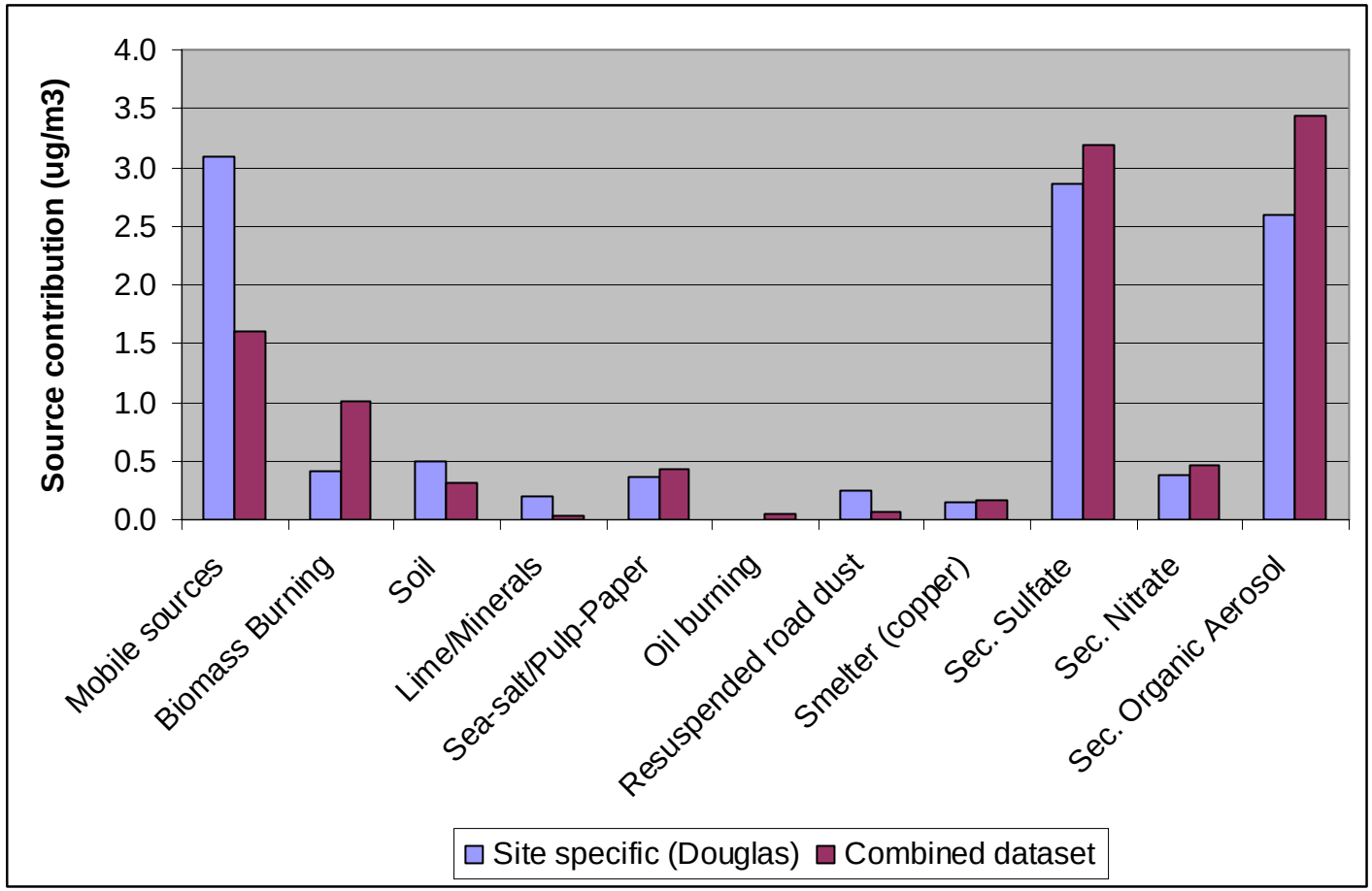
Site-specific vs. combined dataset: Savannah



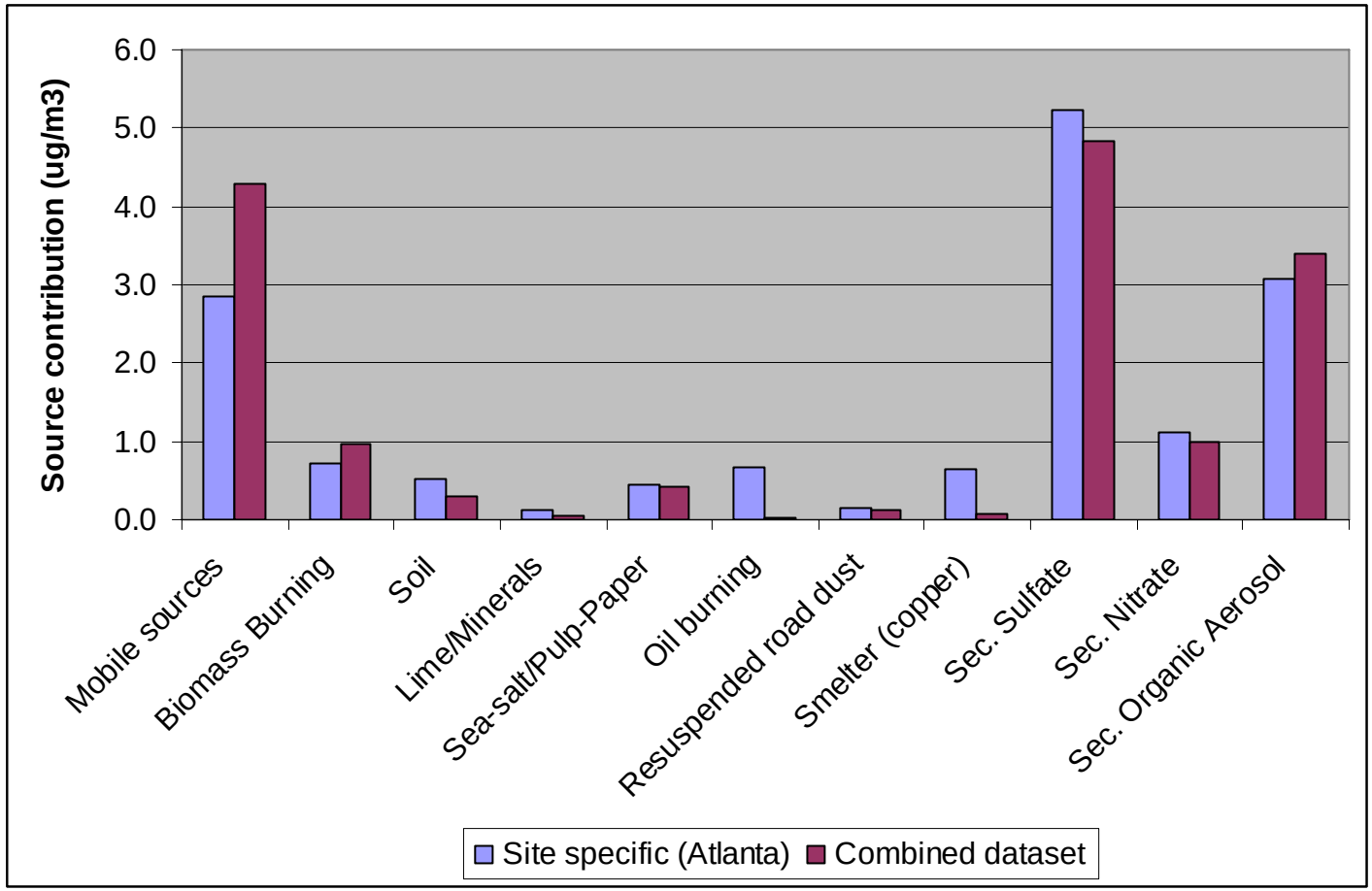
Site-specific vs. combined dataset: Athens



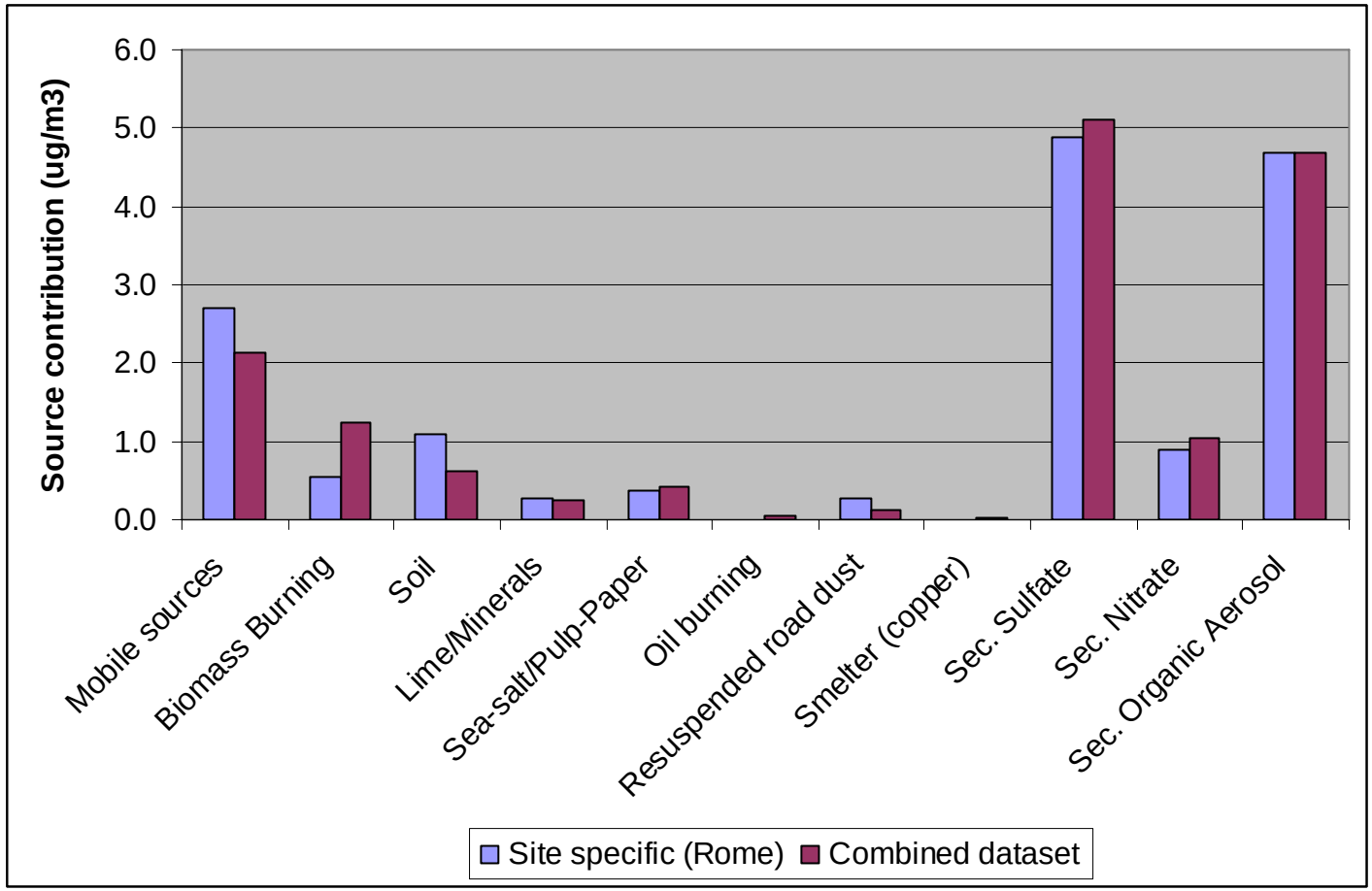
Site-specific vs. combined dataset: Douglas



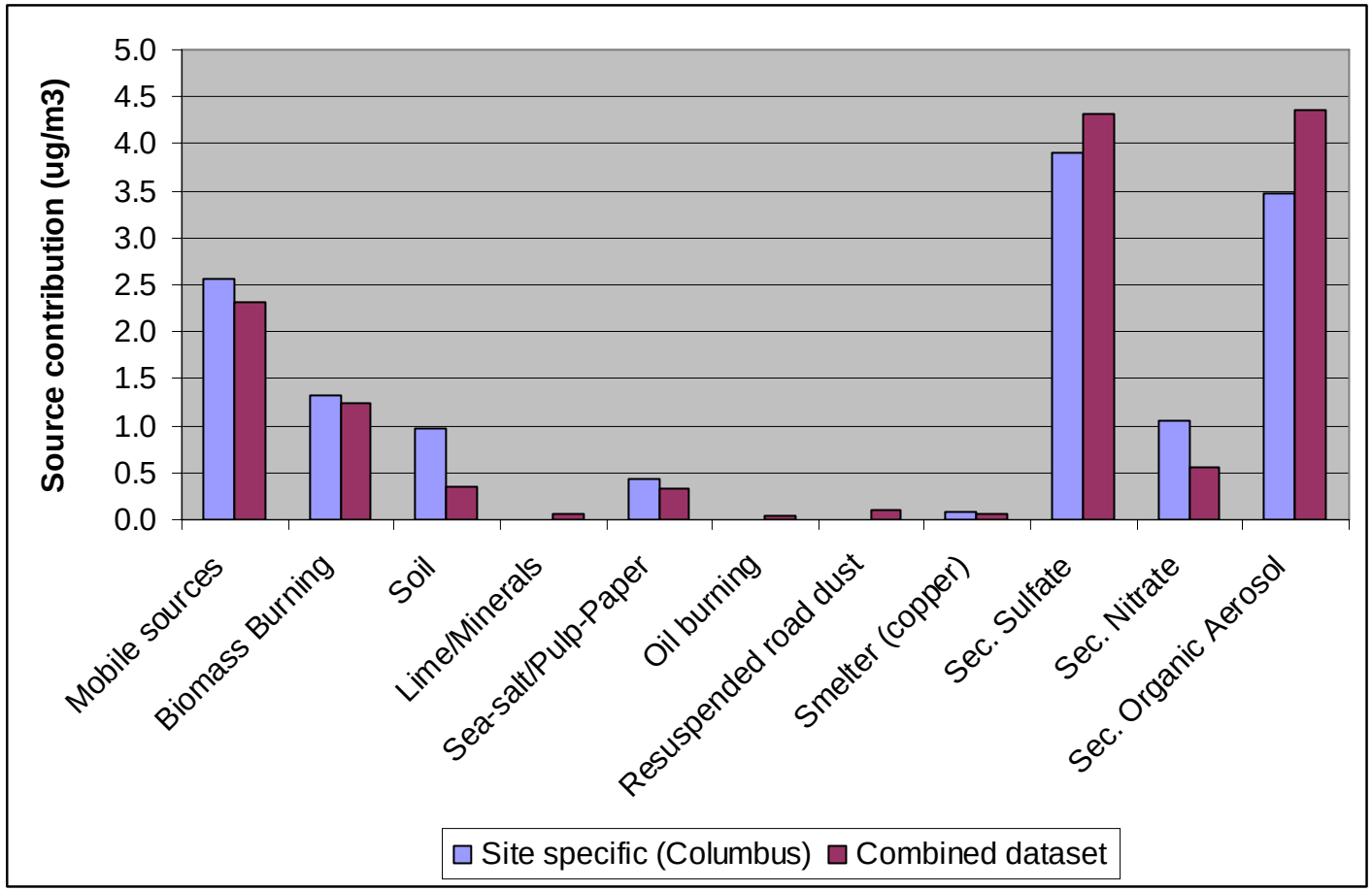
Site-specific vs. combined dataset: Atlanta



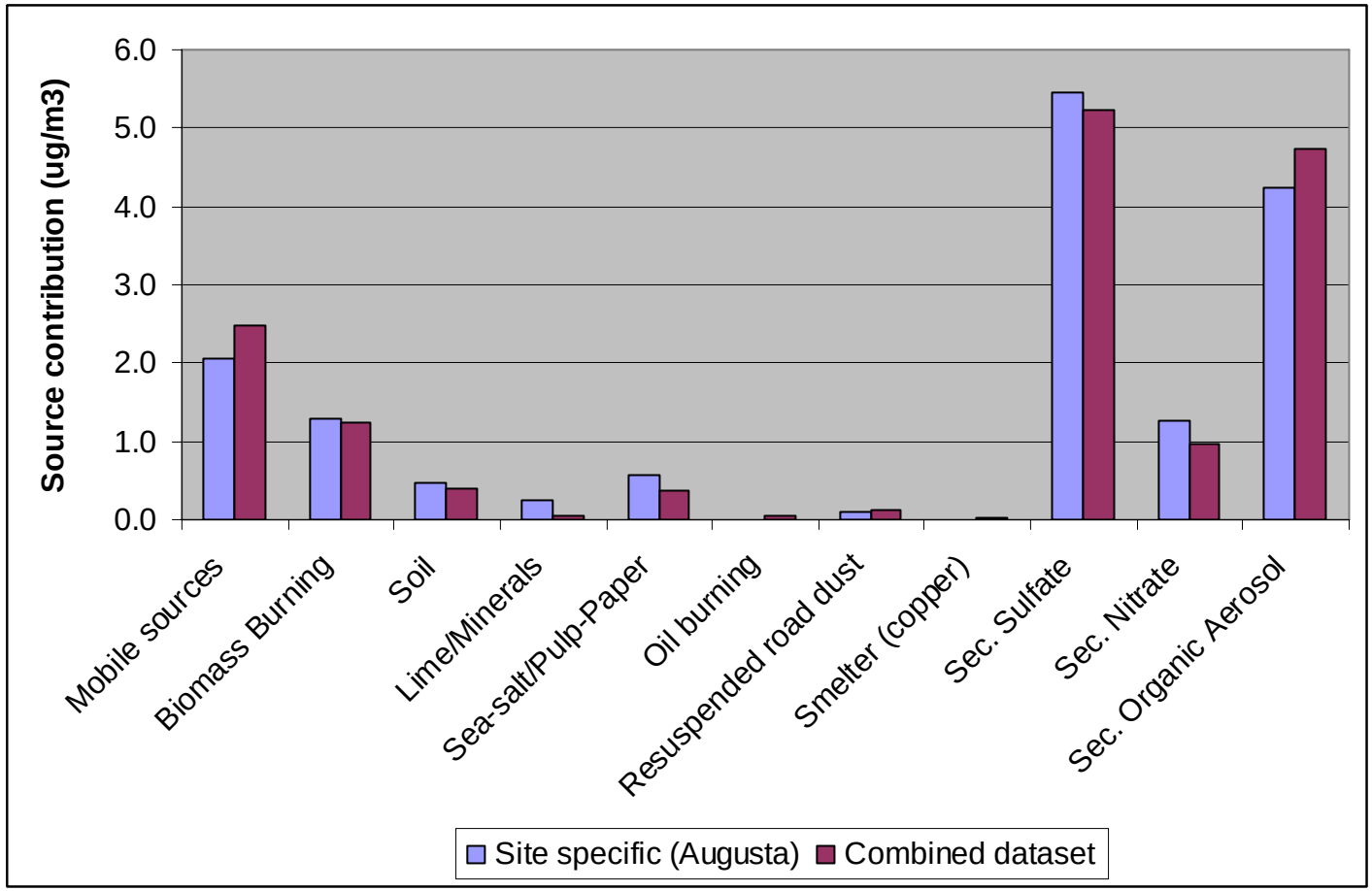
Site-specific vs. combined dataset: Rome



Site-specific vs. combined dataset: Columbus



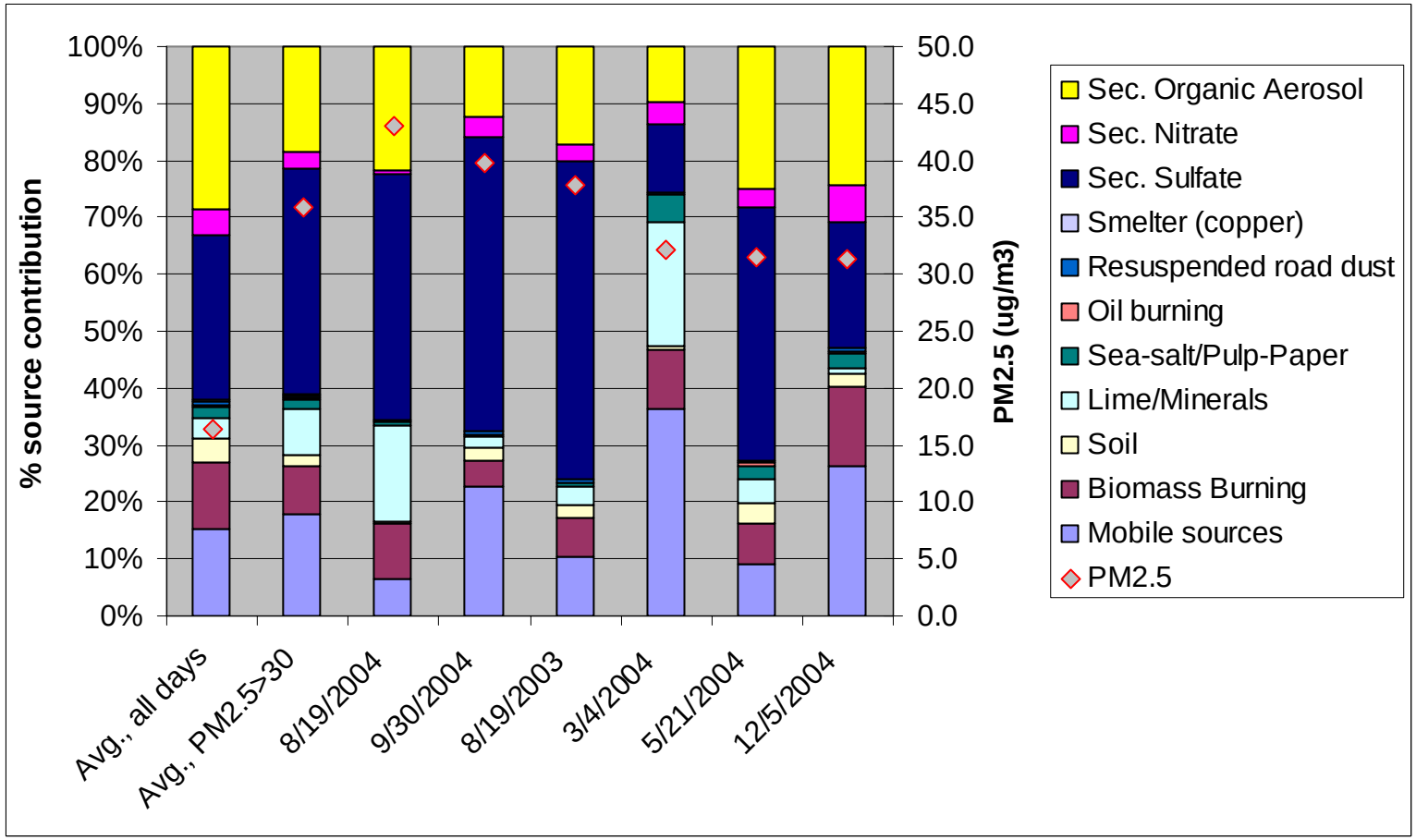
Site-specific vs. combined dataset: Augusta



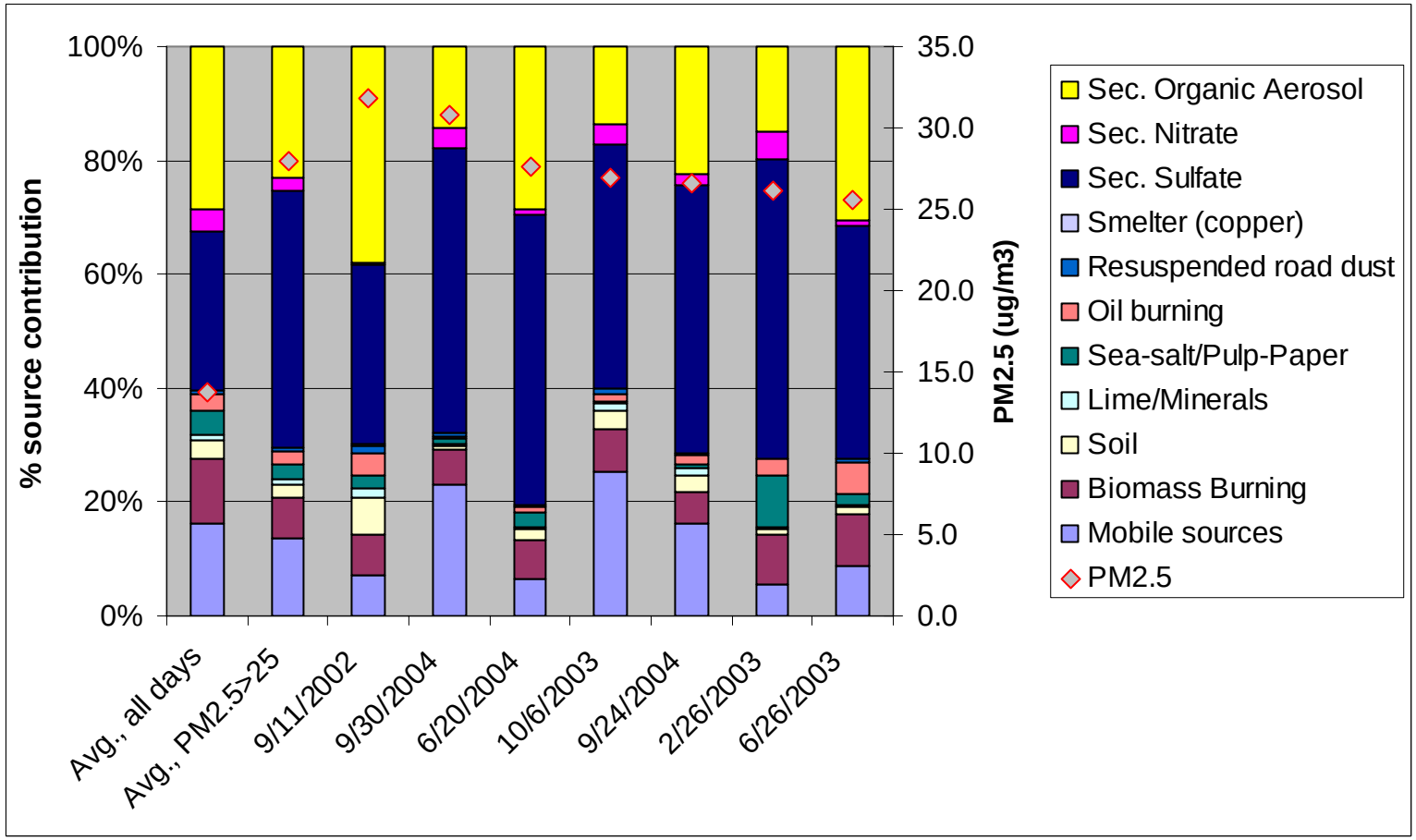
Major findings from comparison of "site-specific" vs. "combined-dataset" results

- Good agreement between the two sets of results, providing certainty in findings
  - **Comment: to allow for the comparison between the two sets of results, a uniform ratio of OM/OC=1.4 was used. However, pie-charts of combined-dataset results were based on OM/OC ratios of 1.4, 1.2, and 2.1 for secondary organics, mobile-sources and biomass-burning, respectively, as these best reconstructed ambient $PM_{2.5}$**
- Some discrepancies arising from the apportionment of OC and sulfate:
  - In site-specific analyses, more OC/sulfate is apportioned to sources of primary $PM_{2.5}$ compared to the combined dataset analysis
    - As a result, secondary organics and sulfate are somewhat lower in site-specific analyses compared to combined analysis, while sources such as soil and road dust are usually higher in the site-specific analyses
- Analysis of temporal patterns in source impacts (correlations, not shown here) showed good agreement between the two sets of results
  - Lowest correlations for secondary organics (again, indicating to this category being the least certain)

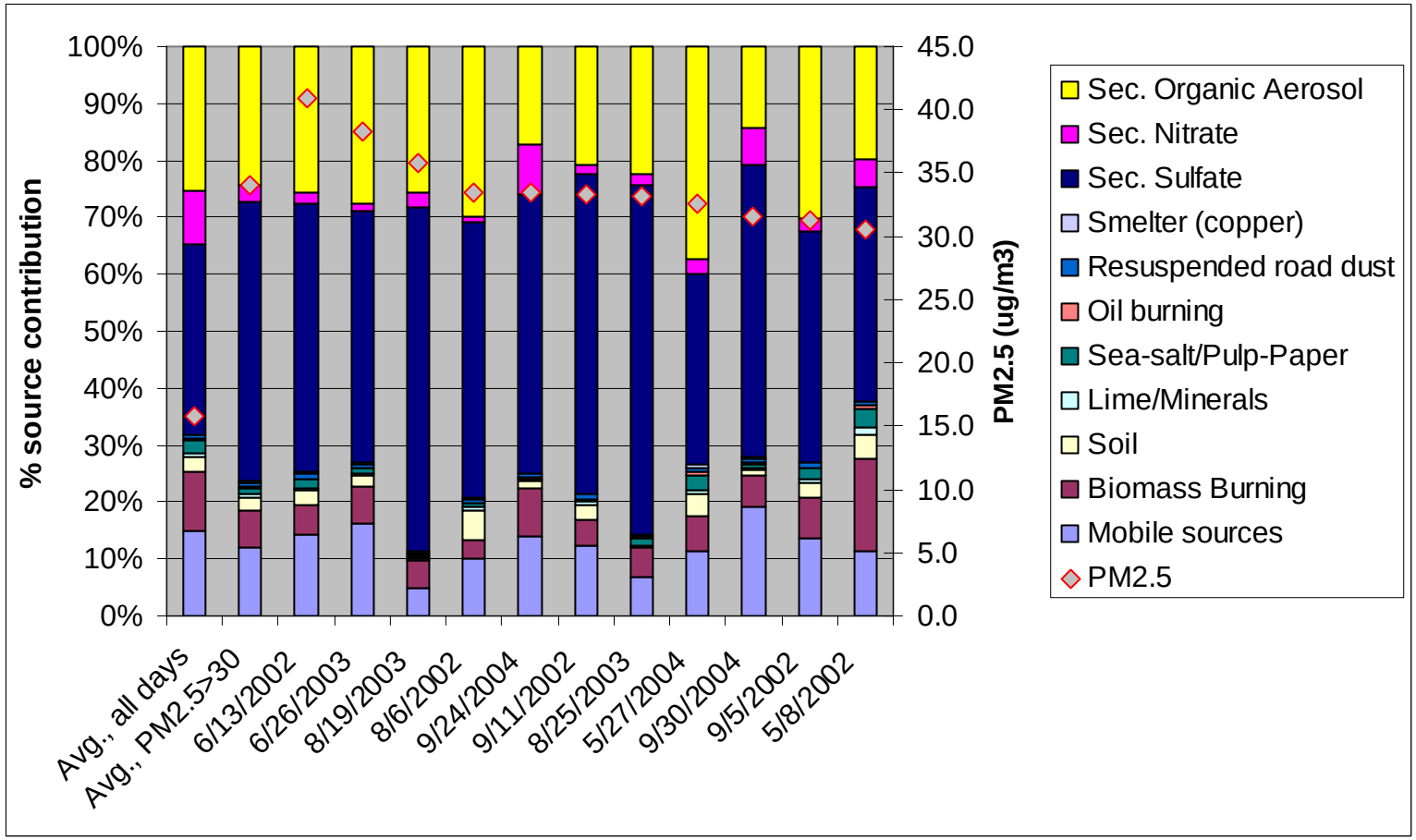
Source-contributions on high $PM_{2.5}$ days: Macon



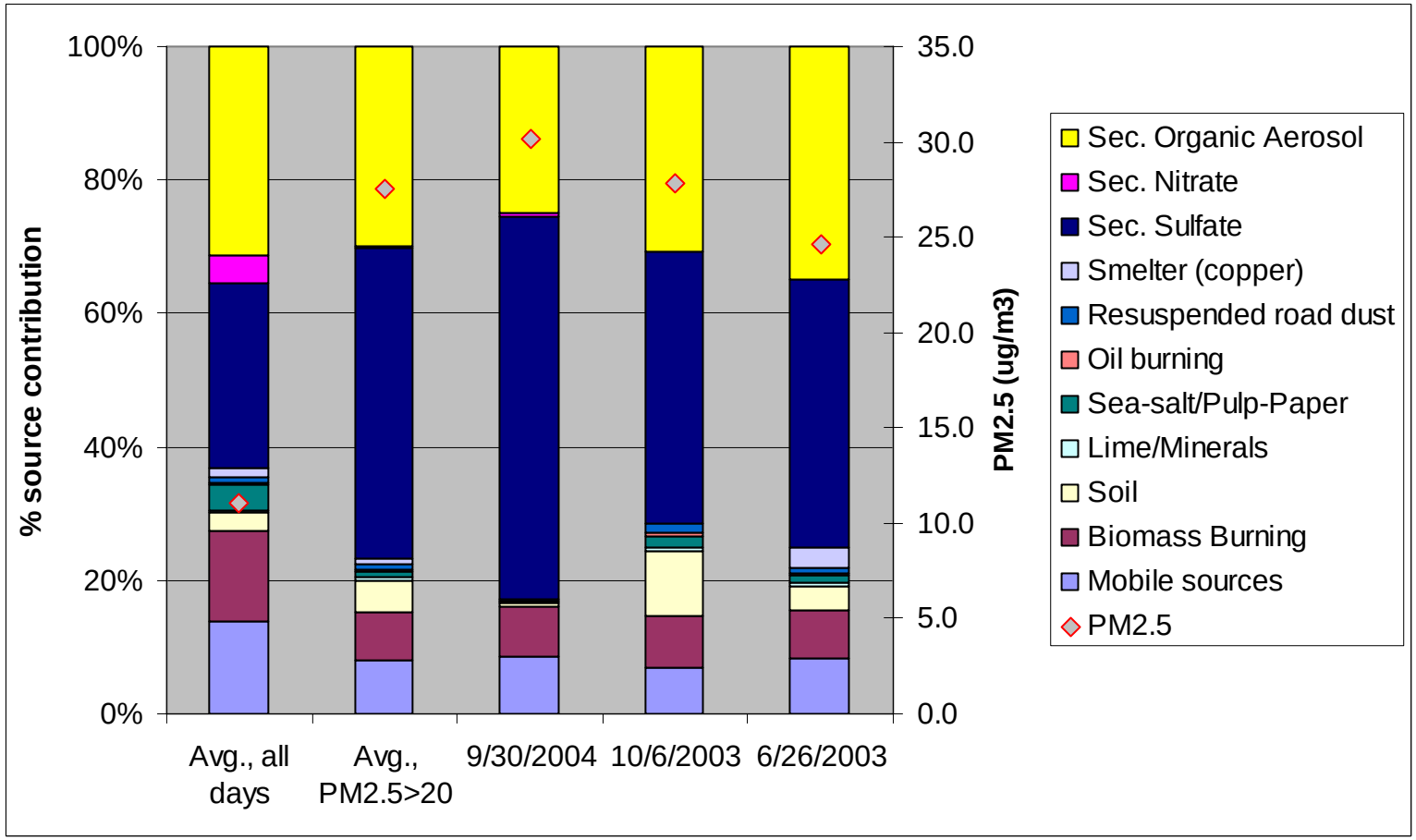
Source-contributions on high $PM_{2.5}$ days: Savannah



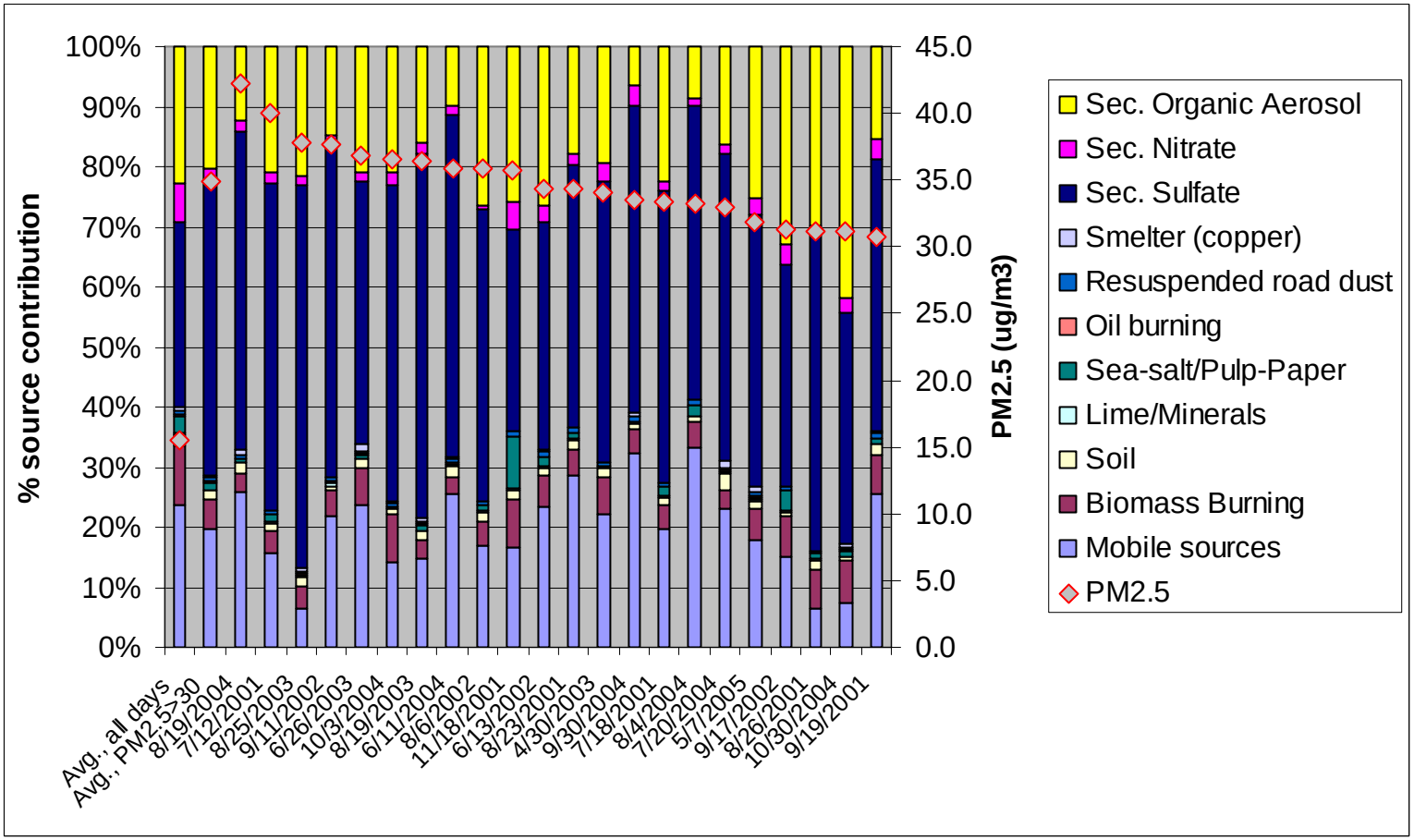
Source-contributions on high $PM_{2.5}$ days: Athens



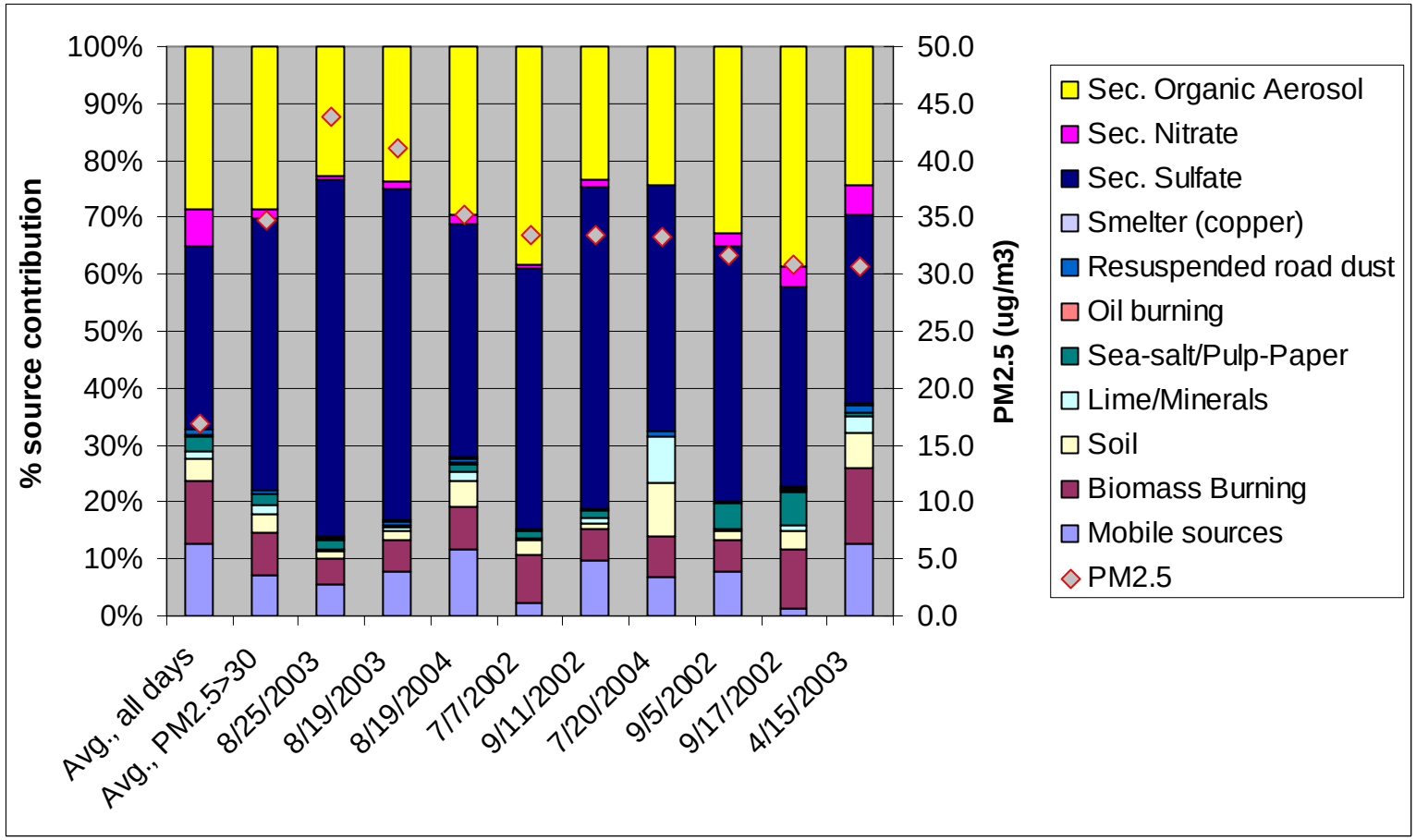
Source-contributions on high $PM_{2.5}$ days: Douglas



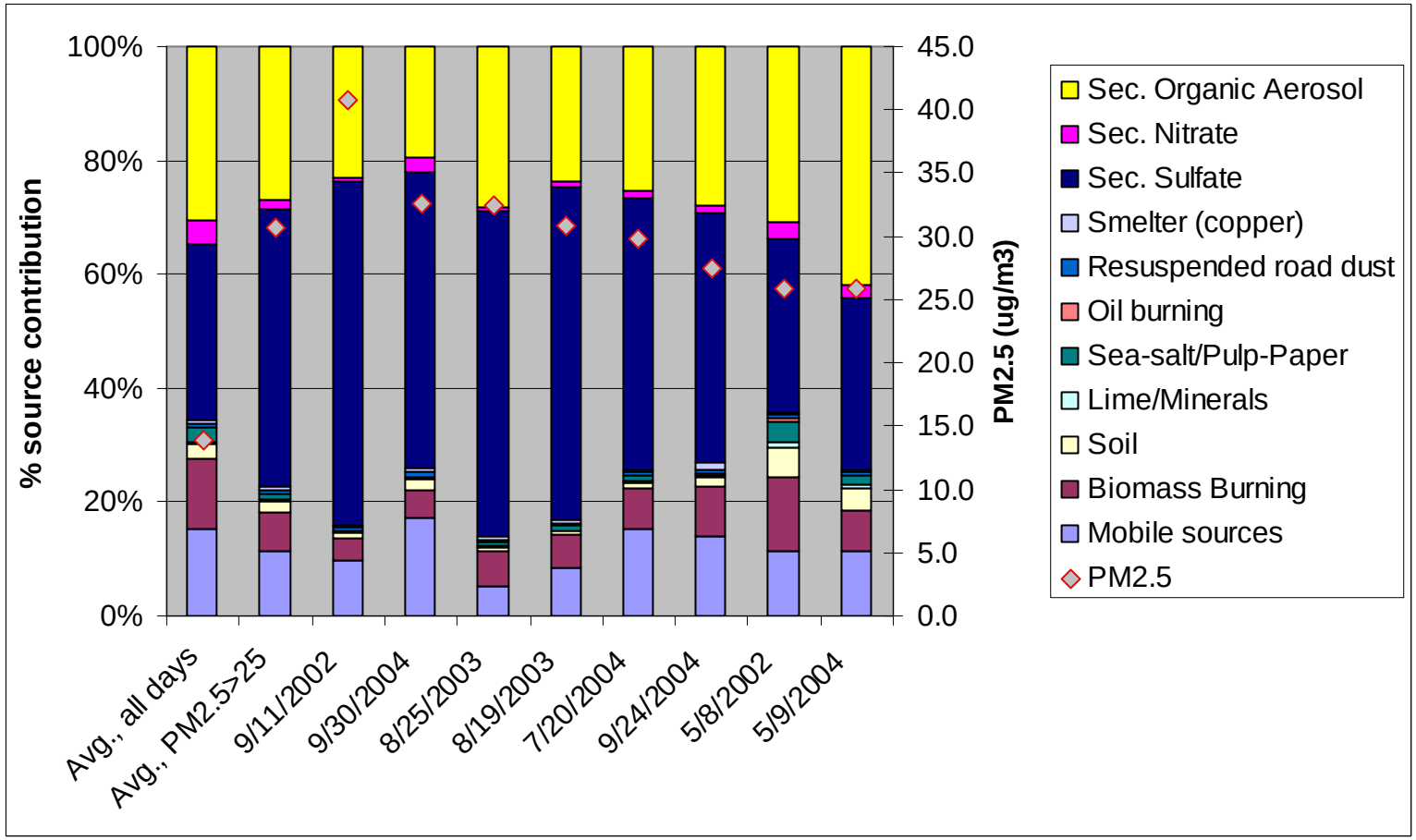
Source-contributions on high $PM_{2.5}$ days: Atlanta



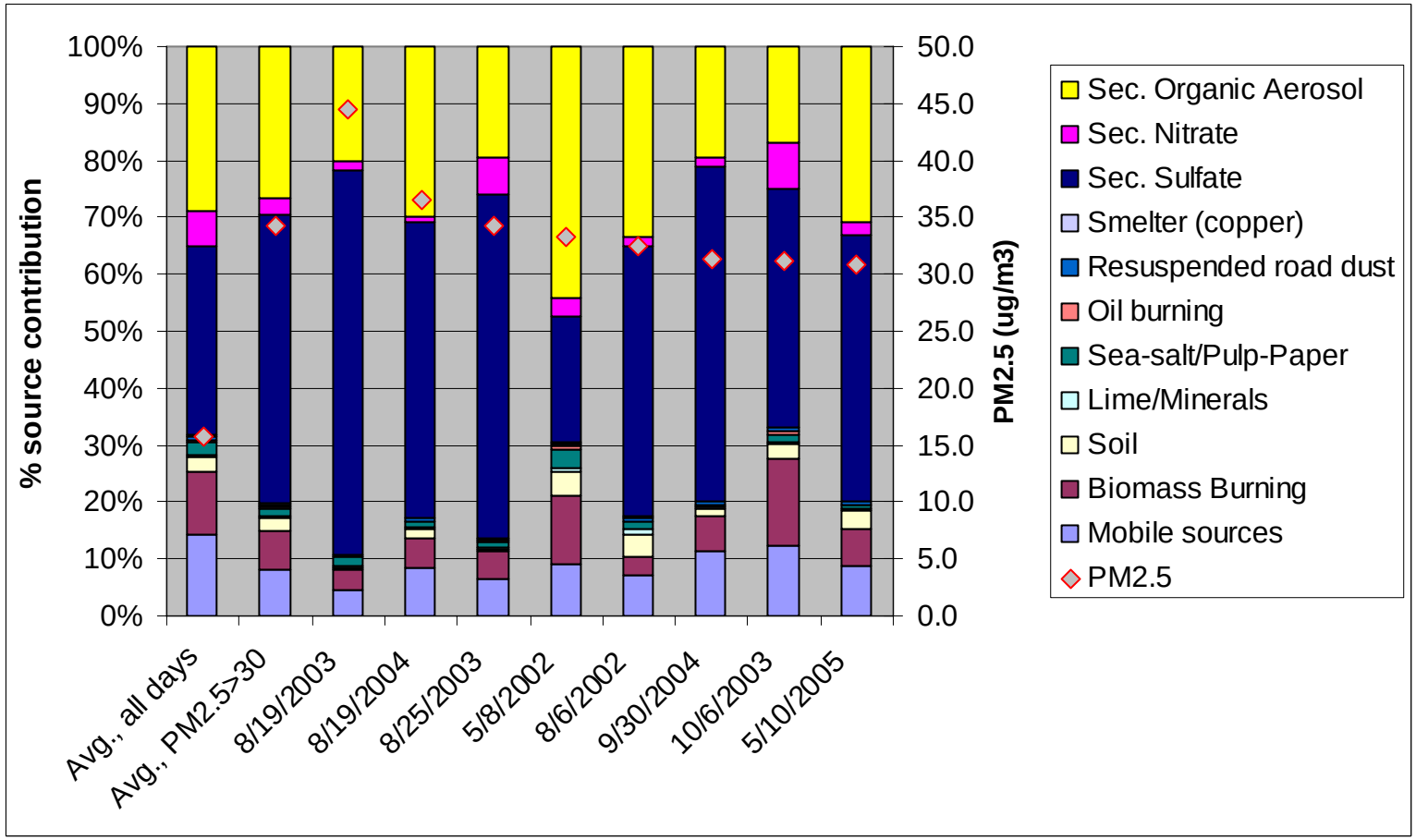
Source-contributions on high $PM_{2.5}$ days: Rome



Source-contributions on high $PM_{2.5}$ days: Columbus



Source-contributions on high $PM_{2.5}$ days: Augusta



Major findings analysis of source-contributions on high $PM_{2.5}$ days

- The vast majority of high $PM_{2.5}$ days are dominated by elevated sulfate levels
  - Sulfate controls would be more efficient on high $PM_{2.5}$ days compared to controls on other days and other sources
- The percent source contribution from mobile sources, biomass burning, and SOA are smaller on the high $PM_{2.5}$ days
  - However, the absolute contributions are still higher compared to the average and should be considered for additional controls

Future work

- This analysis was based on speciation data up to May 2005. Speciation data beyond that period is now available, and the analysis will be expanded to include these data. This will:
  - Help to explain the increasing trend in $PM_{2.5}$ levels in the 2004-2006 period
  - Help address the issue of higher PM2.5 levels in the Phenix City, AL site compared to the Columbus, GA site
    - Preliminary analysis for Phenix City (based on 14 months of data, 67 samples only) indicated that biomass burning and mobile sources contributions explain most of the difference in $PM_{2.5}$ concentrations between the two sites (see separate summary)
    - Additional data collected at the two sites since the last analysis (4 months ago) will be useful for further examining this issue