Source Apportionment of Particulate Matter in Georgia: What We Think We Know

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Context

- Much of Georgia has PM (and ozone) levels near or above the standard
  - Tomorrow may enlarge the fraction…
- Developing effective control strategies requires knowing how specific sources impact air quality
  - Source apportionment
- Variety of approaches exist to estimate source impacts
  - Models have their strengths and weaknesses
- ➢ What do we think we know about what sources are impacting air quality across Georgia?
  - Do we really know this?

- Caputring non-linearities
  - Ozone and PM

Before going on…

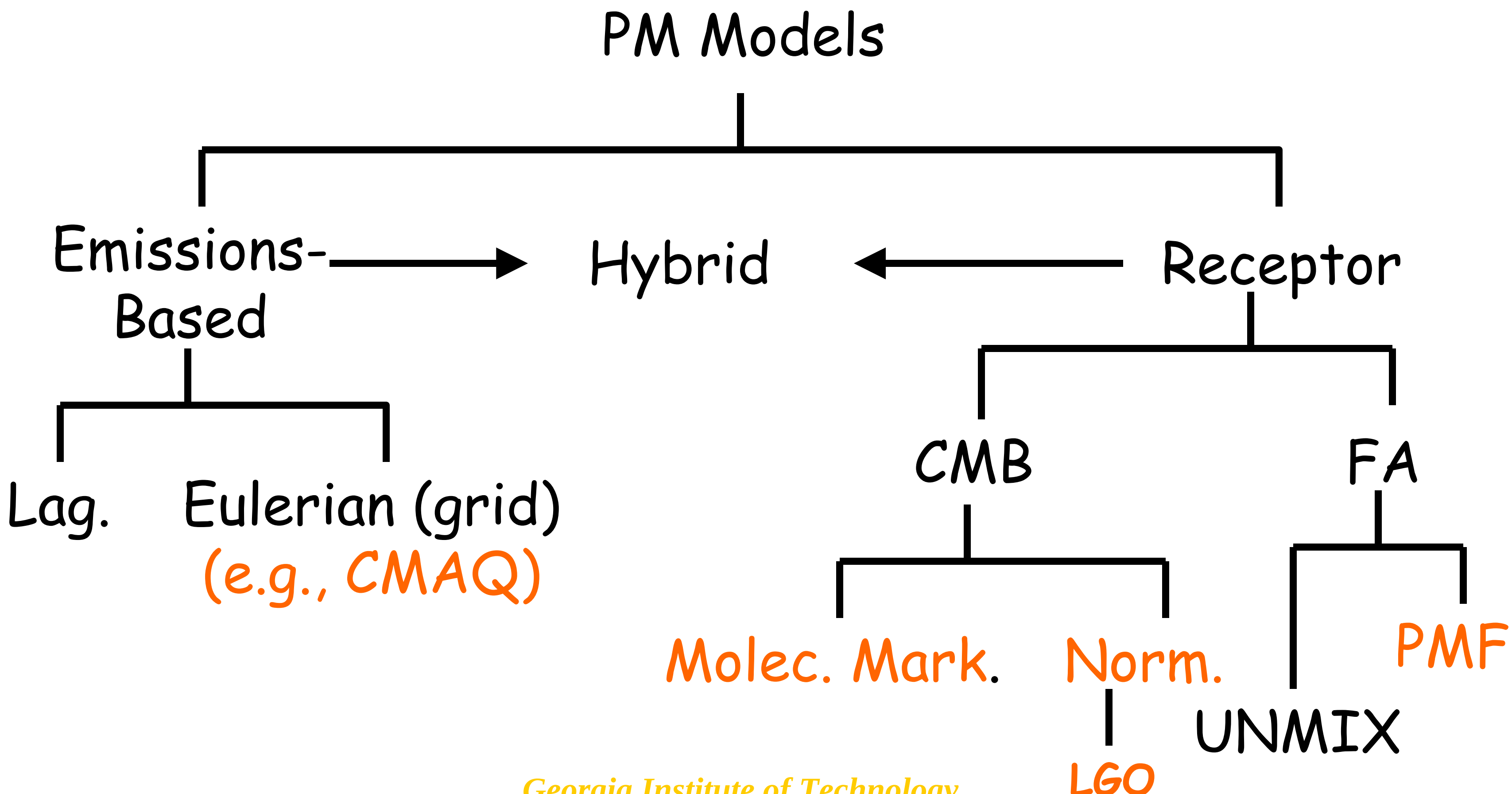
- Many of the results that follow are a results of one of three studies
  - Fall Line Air Quality Study (Ga DNR):
    - Study of ozone formation and control in the fall line cities of Georgia and the region
  - Continuing assessment of the composition of PM in the Atlanta area (Georgia Power)
    - PM measurements using a variety of techniques to help identify sources in GA and assist in air quality analyses
  - Development and testing of advanced source apportionment techniques, and emissions inventory improvement (US EPA)
    - Combination of additional measurements, and various models, to assess source impacts and emissions

Before we begin, remember…

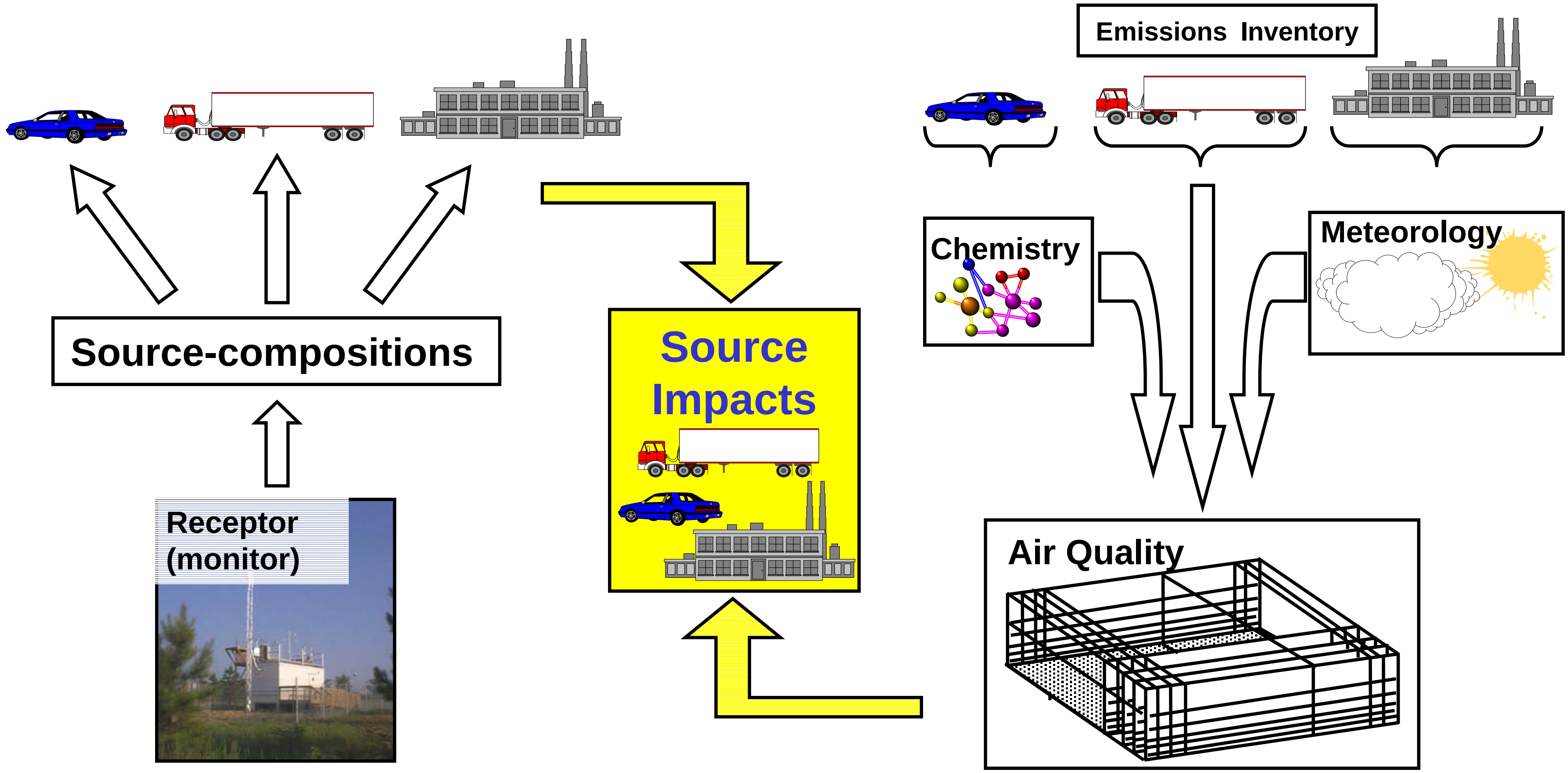
All models are wrong,
but some are useful

PM (Source Apportionment) Models

(those capable of providing some type of information as to how specific sources impact air quality)



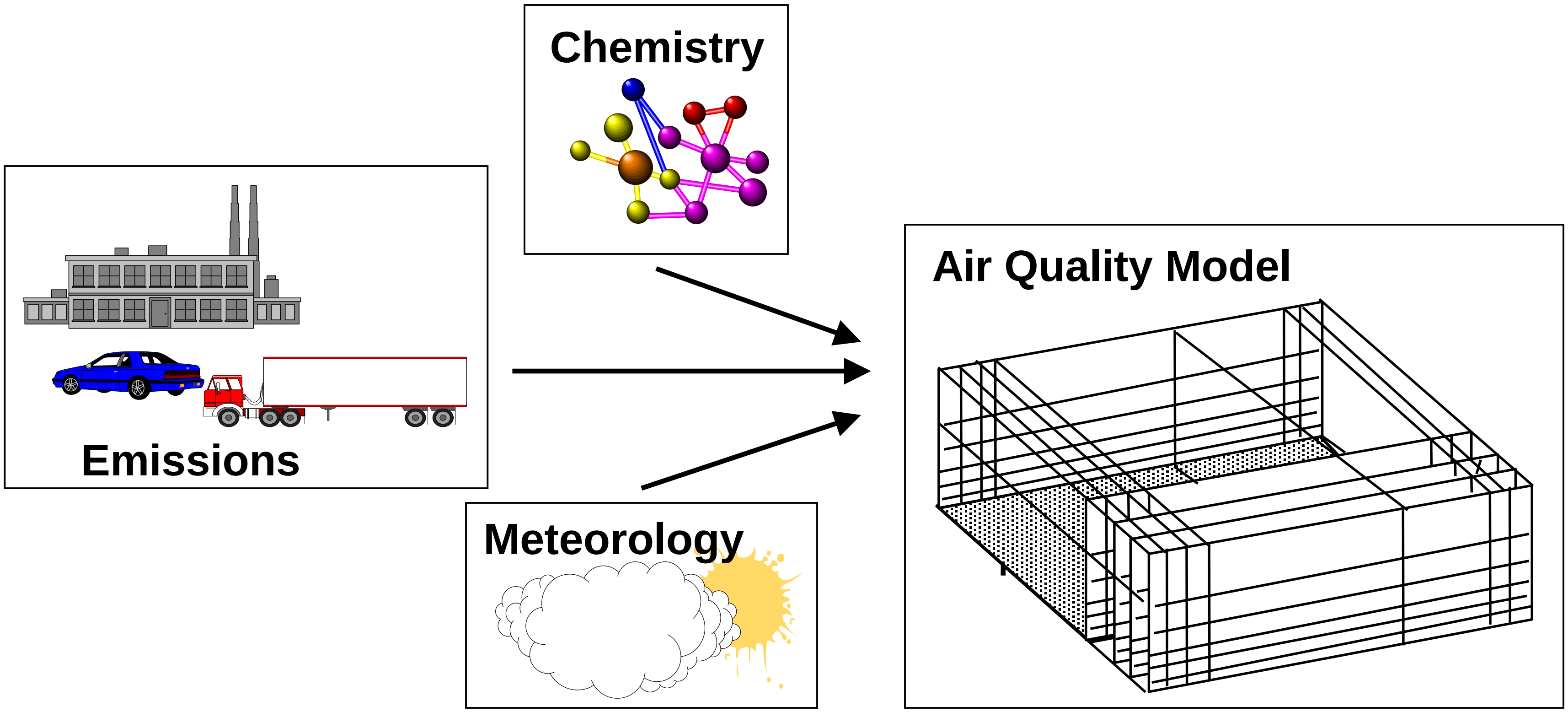
Receptor vs. Emissions-Based Models



Receptor Model

Emissions-based Model
(3D Air-quality Model)

Source-based Models



$$\frac{\partial c_i}{\partial t} = -\nabla(\mathrm{u}c_i) + \nabla(\mathrm{K}\nabla c_i) + R_i + S_i$$

Source-based Models (e.g. CMAQ)

- Strengths
  - Direct link between sources and air quality
  - Provides spatial, temporal and chemical coverage
  - Can track non-linear formation and destruction (ozone)
  - Foundation for assessing how future controls will impact air quality
- Weaknesses
  - Result accuracy limited by input data accuracy (meteorology, emissions…)
    - In case I forget: On a day-to-day basis, meteorological uncertainties lead to bigger errors than emissions
  - Resource intensive

Receptor Models

Mass Balance

Observed Air Quality $C_i(t)$ → $$C_i = \sum_{j=1}^{n} f_{i,j} S_j$$ → Source Impacts $S_j(t)$

C_i - ambient concentration of species i (μg/m^3)

$f_{i,j}$ - fraction of species i in emissions from source j (μg/μg)

(Known when using CMB, found when using PMF)

S_j - contribution (source-strength) of source j (μg/m^3)

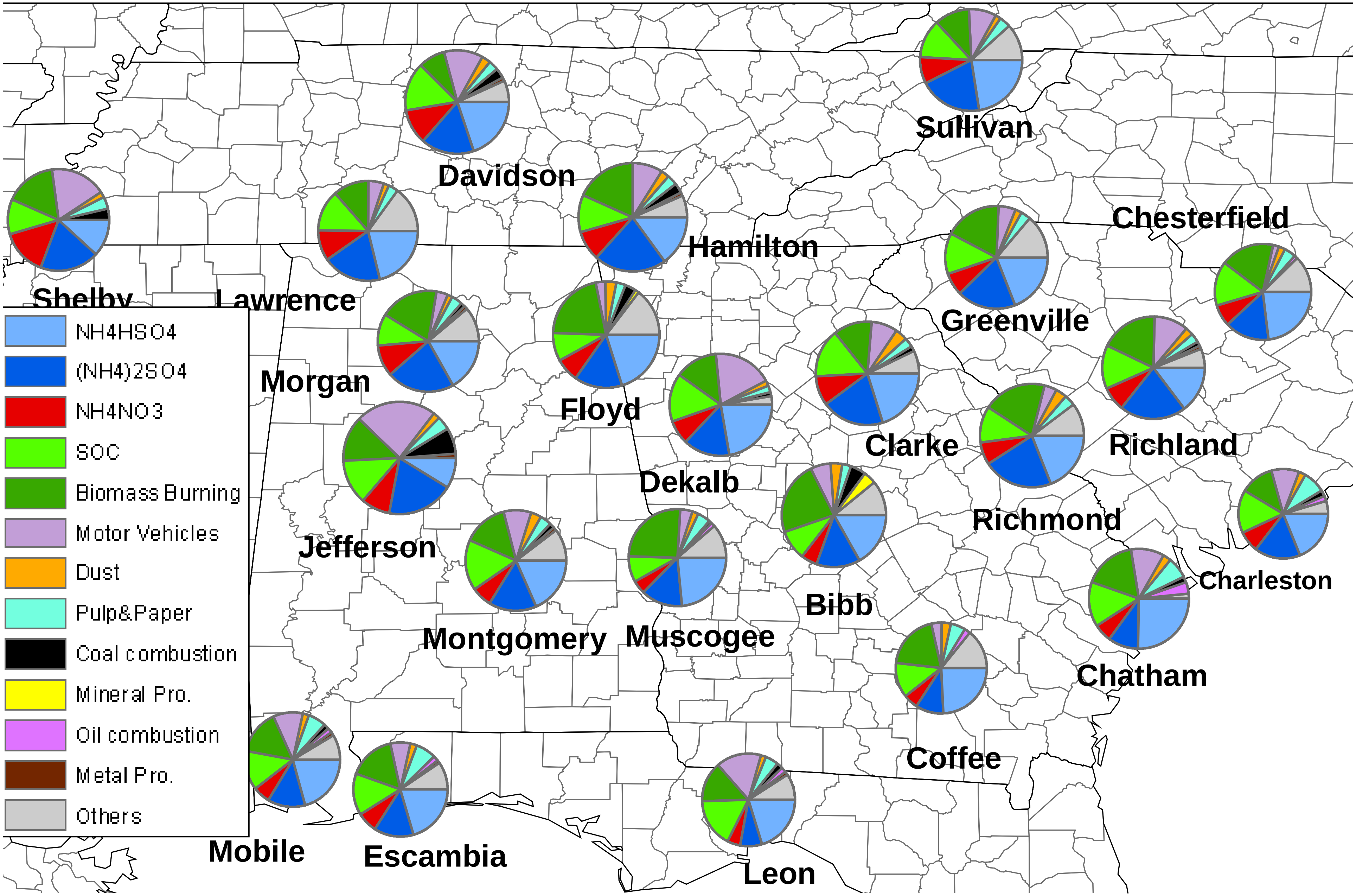
Receptor Models (e.g. CMB, PMF)

- Strengths
  - Directly linked to observed air quality
  - Fast, if data is available
  - Can capture source impacts with the same temporal resolution as the data
- Weaknesses
  - Significant data needs
    - Speciated composition of observations and emissions (CMB), or
    - Lots of speciated observational data (PMF)
  - Does not capture nonlinear formation (e.g., ozone, nitrate, …)
  - Results are dependent on data quality
  - Results can be user dependent

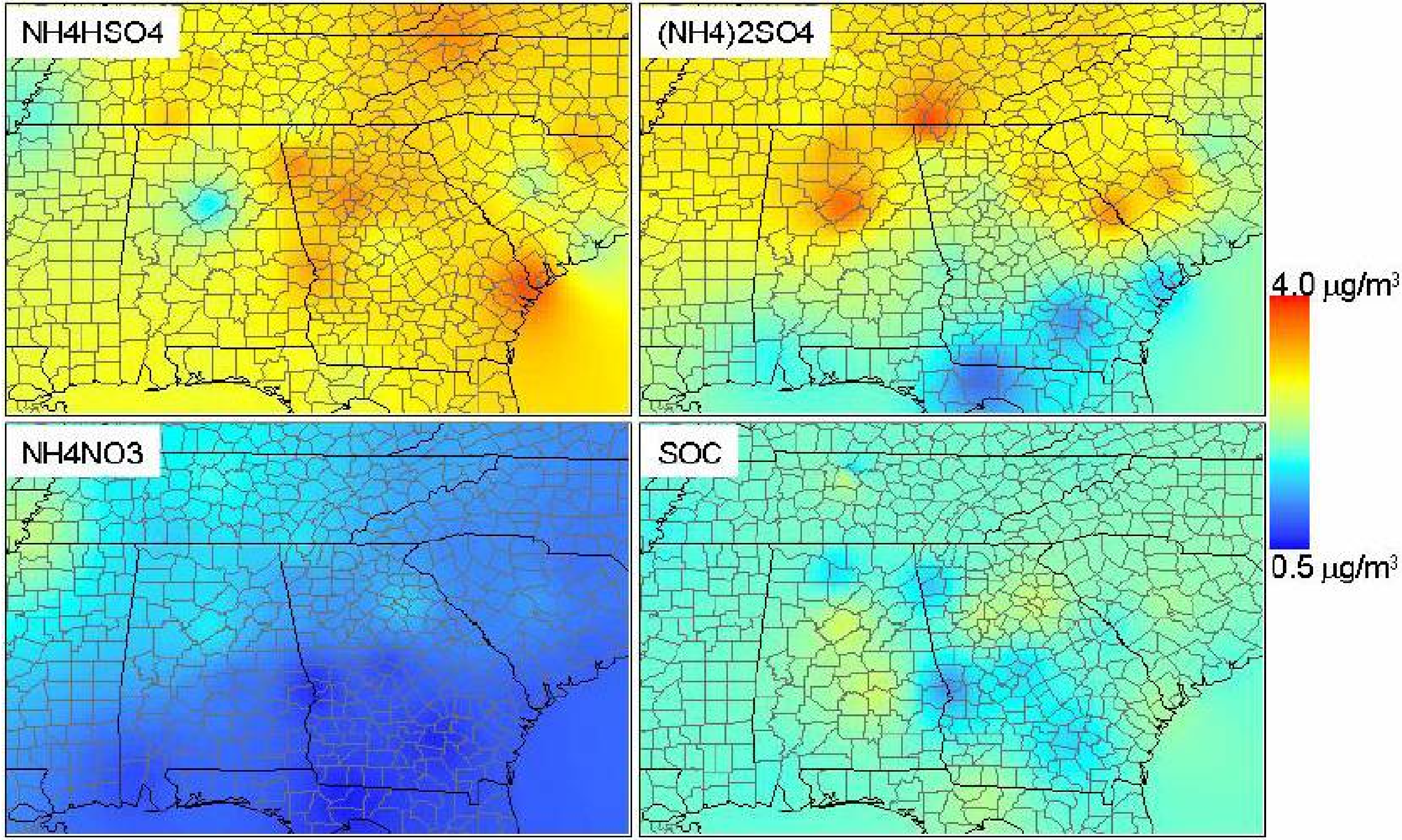
Pause for a second…

- What have we seen so far:
  - Ozone and PM composition in Georgia (Boylan, Marmur, Edgerton)
    - Initial identification of sources using CMB
    - Application of CMAQ
  - CMB-MM source apportionment (Zheng)
    - Found additional detail provided from knowing organics
  - Secondary organic formation can be important
    - Science is still evolving
  - Traffic and fires major contributors to PM (Naeher, Guensler, Weber, Goodwin)
  - Most results applied to Atlanta
- So lets take a few minutes to see what we think we might know about PM and ozone sources throughout Georgia
  - CMB applied to STN
  - CMAQ with source apportionment tool for ozone and PM

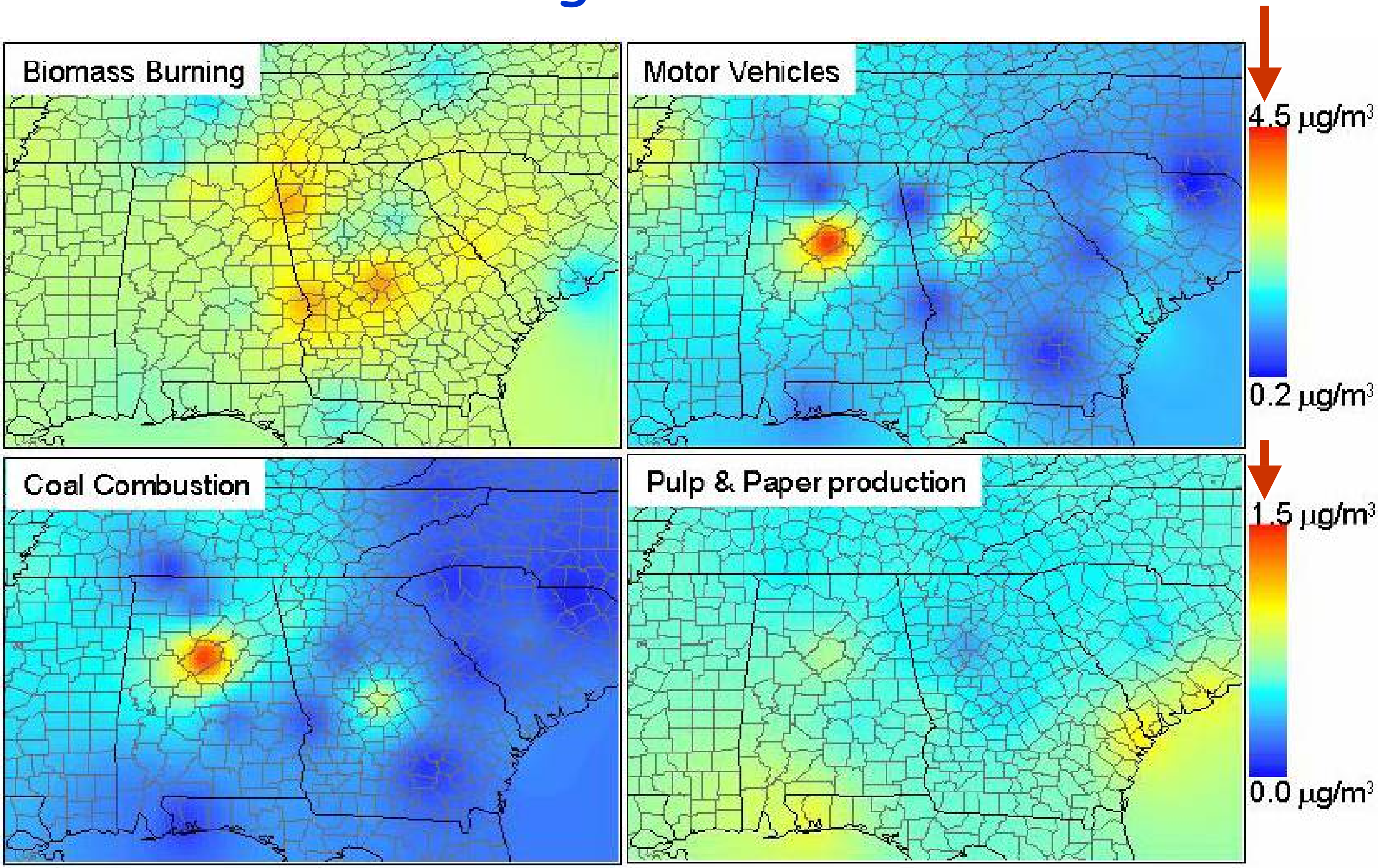
PM Source Apportionment using CMB: 2002



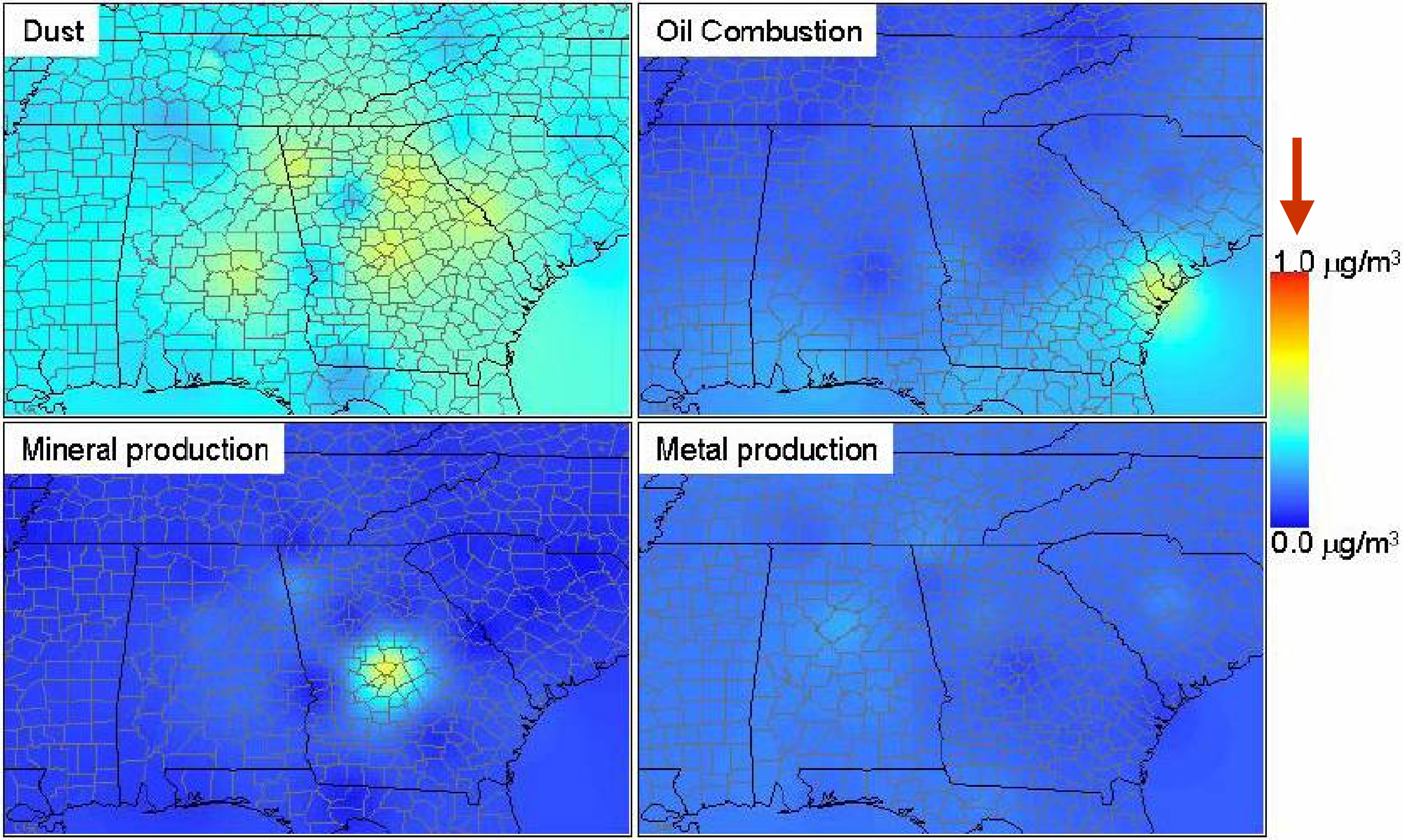
Regional PM



Regional PM


Biomass Burning
Motor Vehicles
Coal Combustion
Pulp & Paper production
4.5 µg/m3
0.2 µg/m3
1.5 µg/m3
0.0 µg/m3

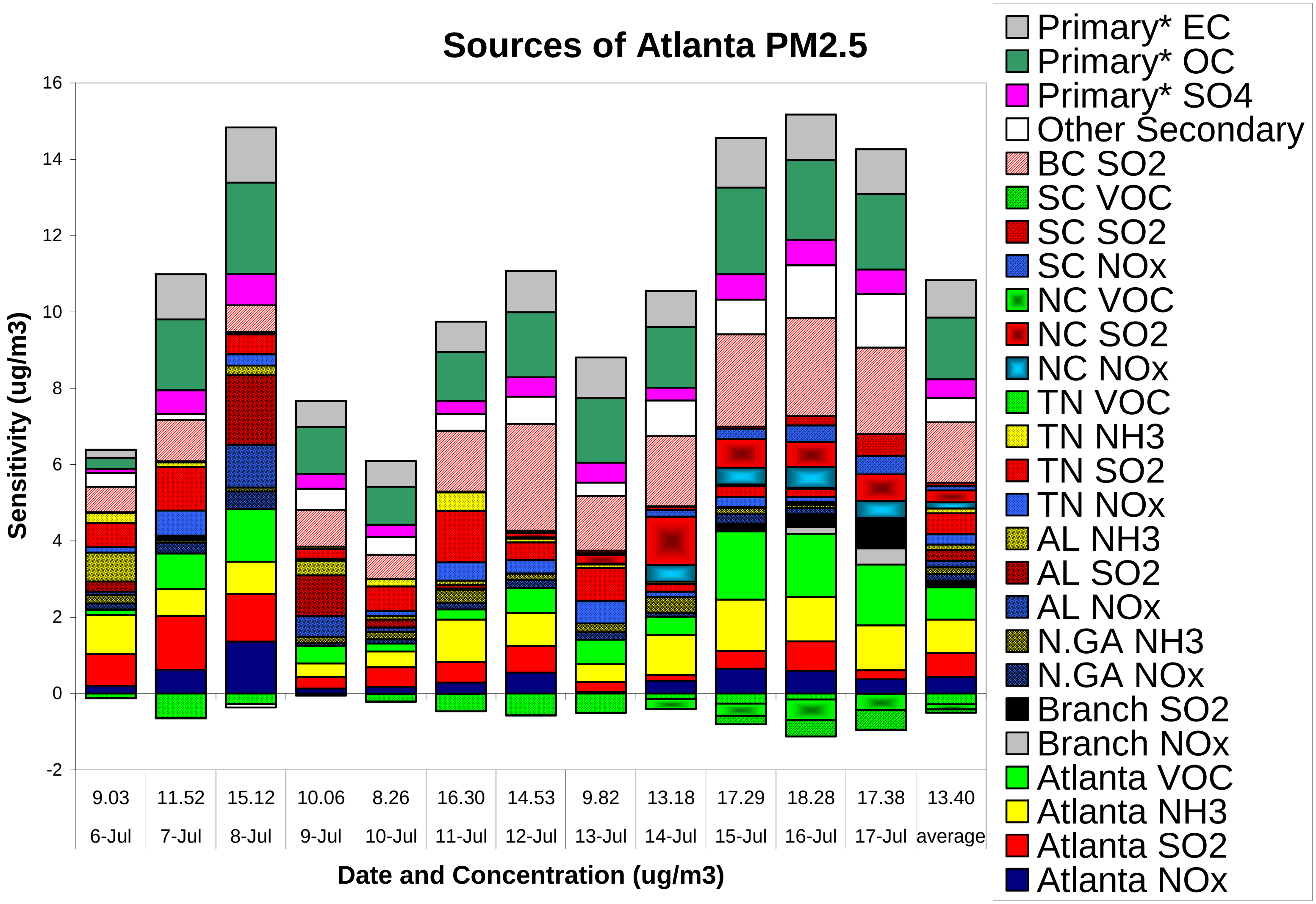
Regional PM


Dust
Oil Combustion
Mineral production
Metal production
1.0 µg/m3
0.0 µg/m3

CMAQ Source Apportionment

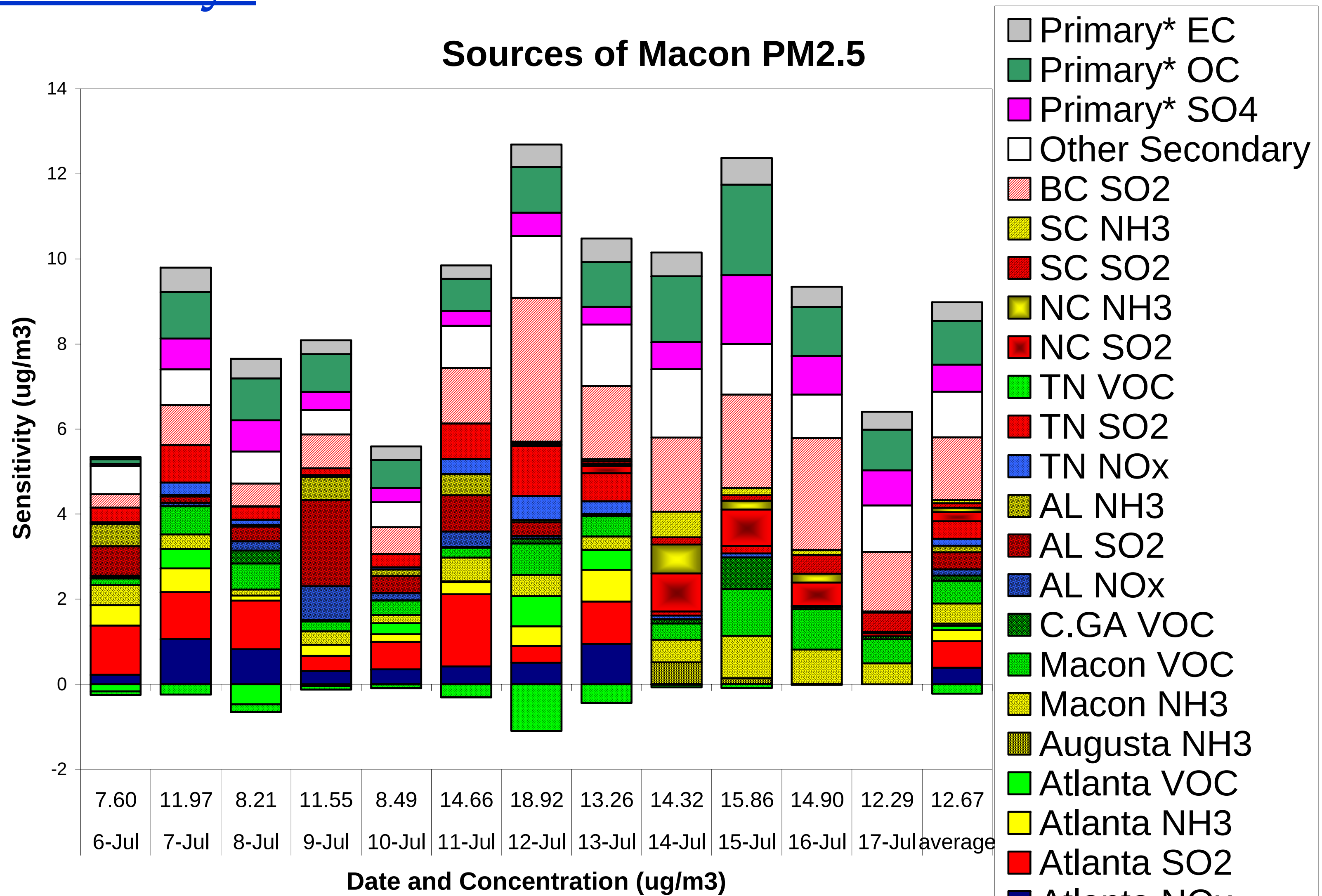
- Short term using DDM source apportionment tool (Napelenok)
  - Application to Fall-line Cities and Atlanta
- Directly calculate source impacts directly from estimated emissions

Secondary PM Source Contributions in Atlanta



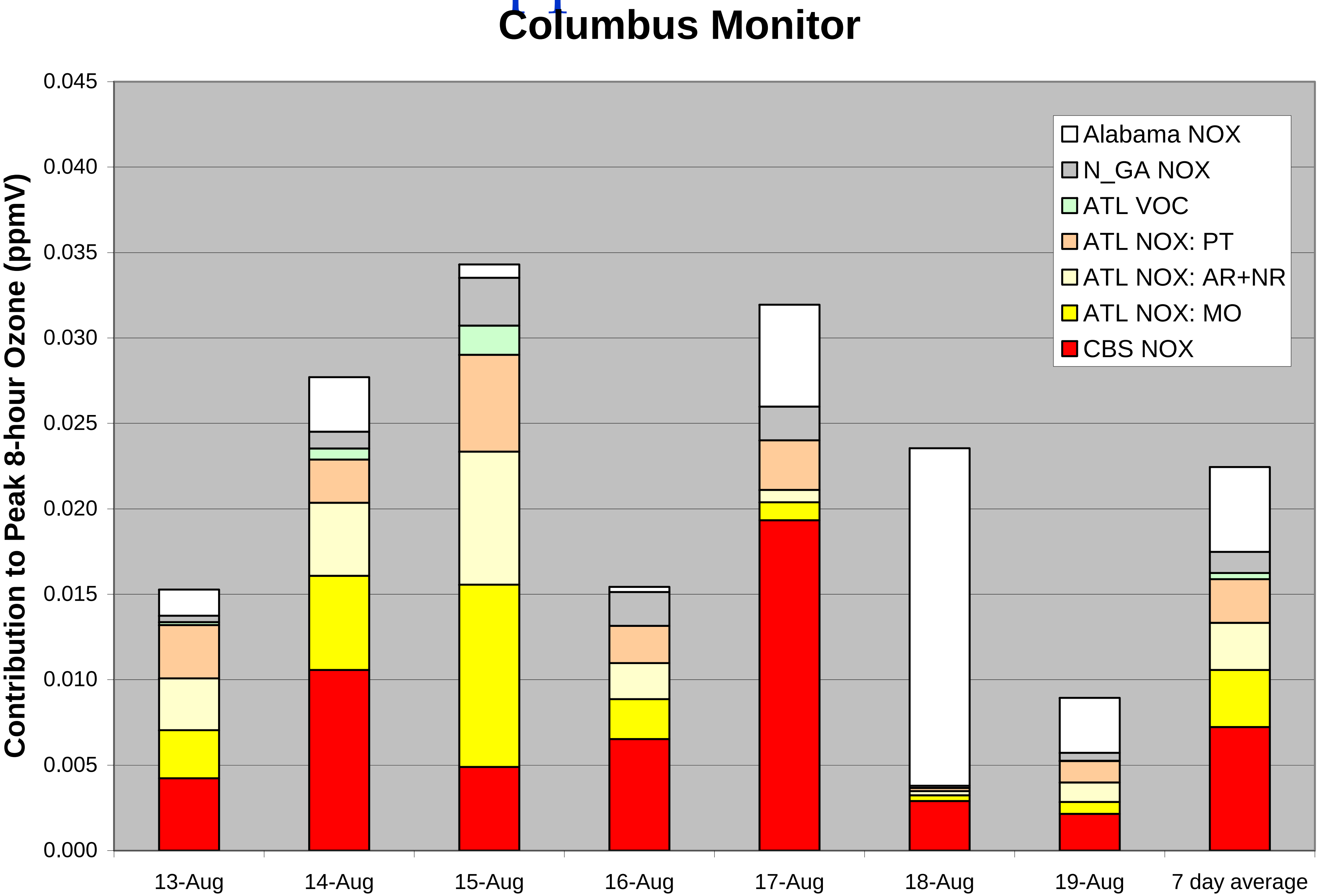
Did not consider biogenic SOA

Secondary PM Source Contributions in Macon



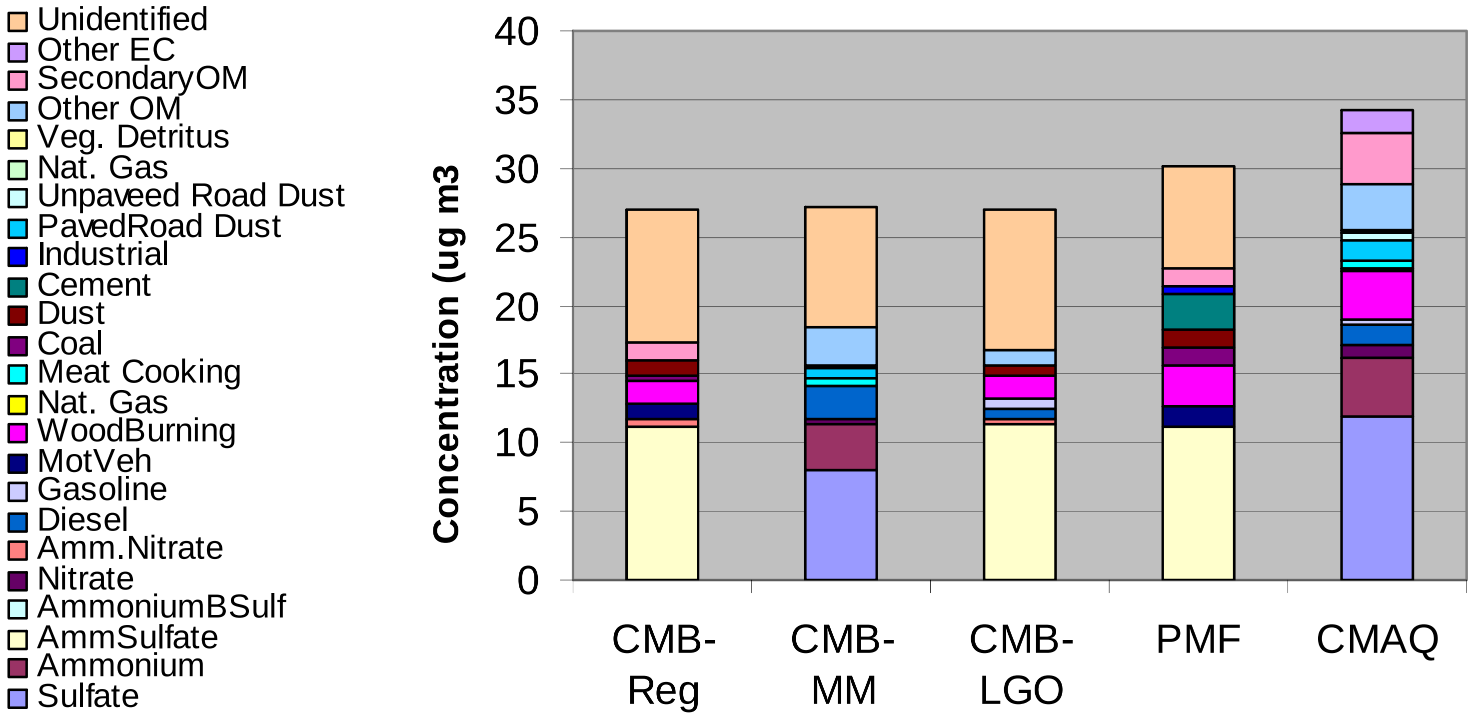
Did not consider biogenic SOA

Ozone Source Apportionment in Columbus



Another Pause… How Sure Are We?
If we apply different methods, do we get similar answers?

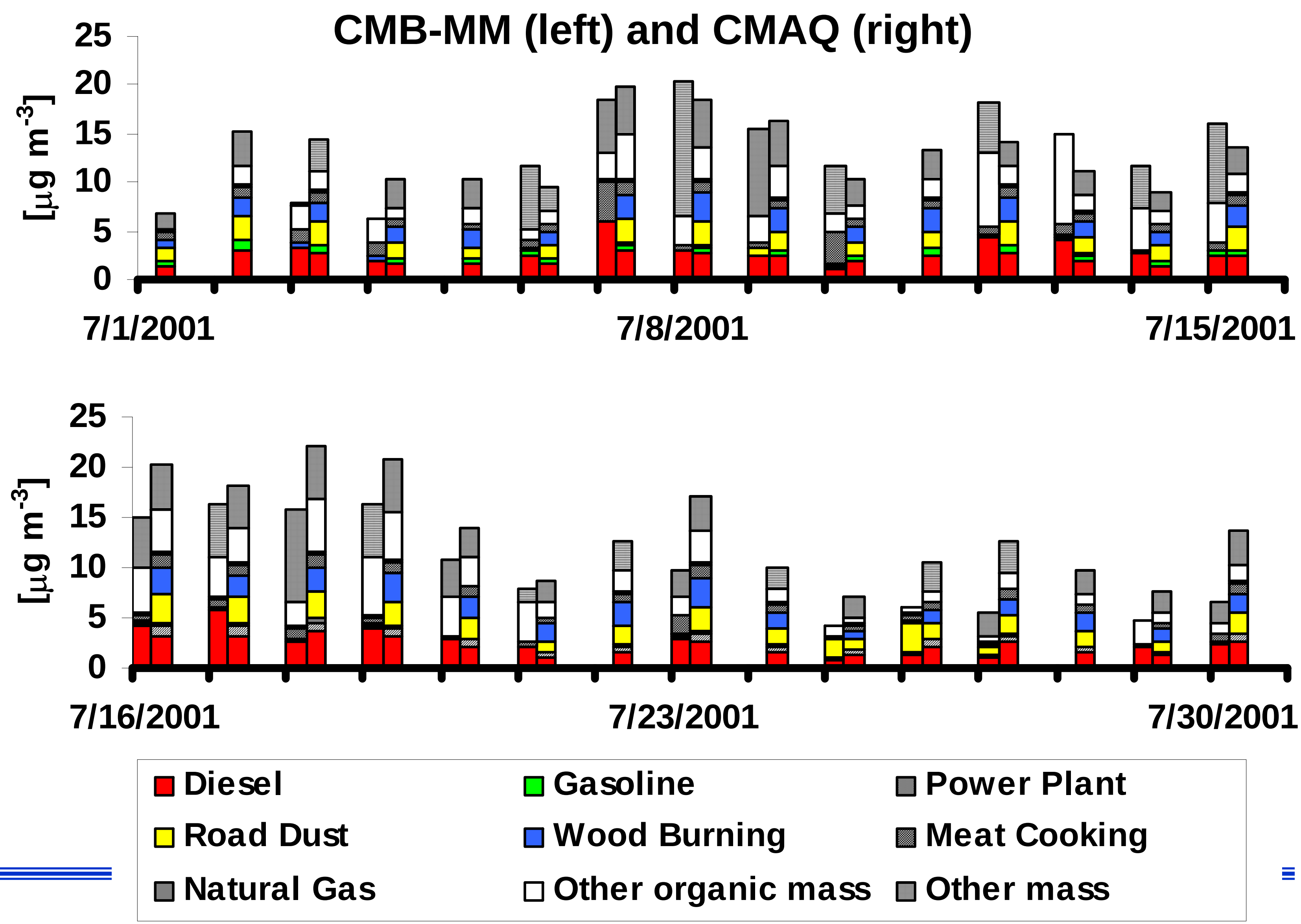
Many Methods, Many Answers



July 17, 2001

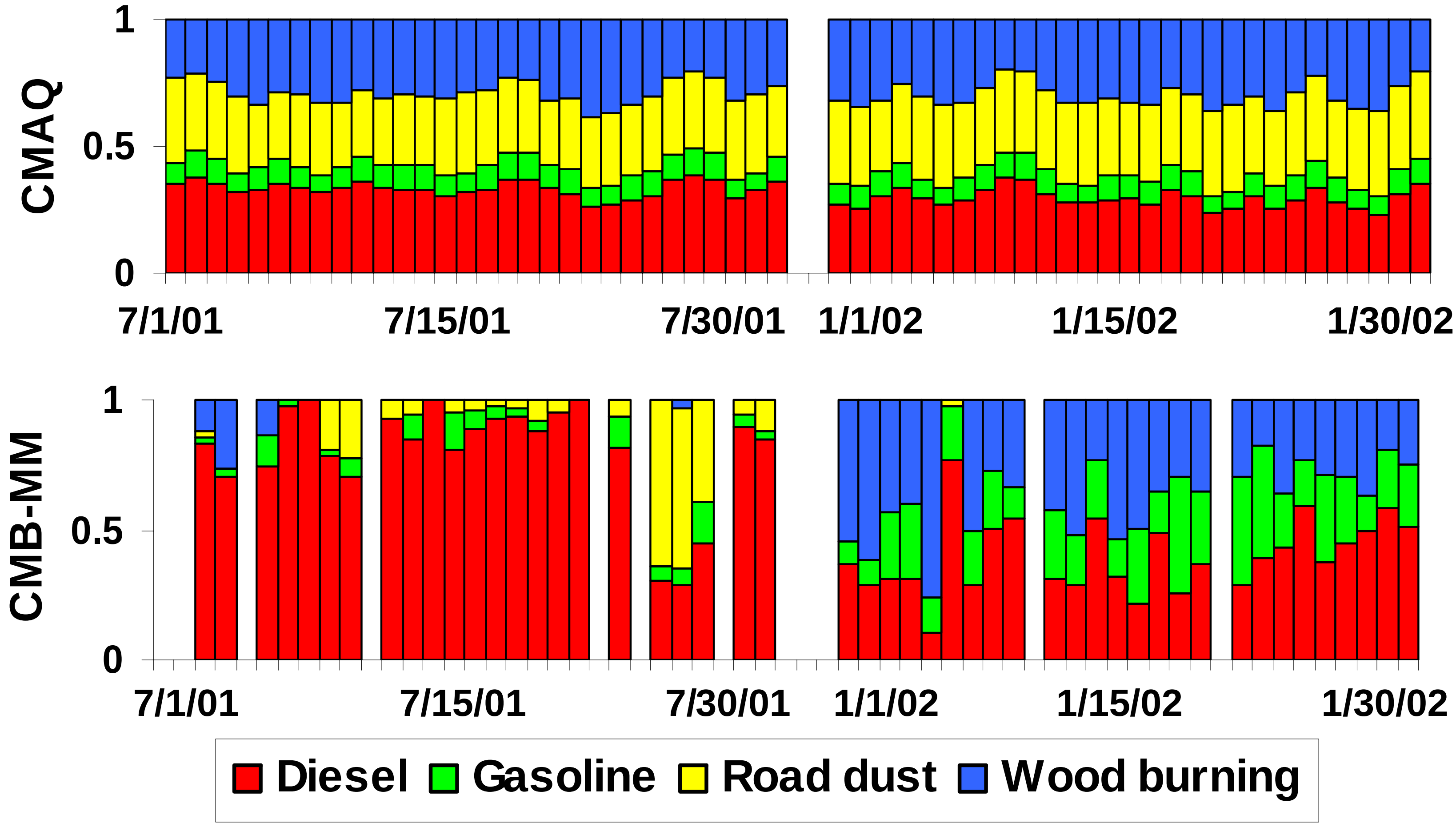
Immediate observation: Receptor models can not identify all of the sources impacting a site.

Daily average mass contributions to PM2.5 in Atlanta July 2001



One issue:

Daily variation of fraction of major $PM_{2.5}$ sources at JST



Summary

- Major sources of PM in Georgia
  - Sulfate (and associated ammonia) from power plants
    - Much of this from outside the state
  - Biomass burning
    - Highly seasonal
  - Mobile sources in large cities
  - Secondary biogenic
- Model results agree reasonably well when averaged over relatively long periods, but not day-to-day
  - CMAQ misses finer scale temporal variations, but captures non-linear formation/response (secondary PM, ozone)
    - Good for planning, need to think about its use for health studies
  - Receptor models also disagree day-to-day
    - Possible collinearity and other data problems
- Using models to evaluate emissions inventories
  - Longer story…