Mass Balance Closure and the Federal Reference Method for $PM_{2.5}$ in Pittsburgh

Allen L. Robinson, Sarah L. Rees, Andrey Khlystov, Charles O. Stanier, Spyros N. Pandis

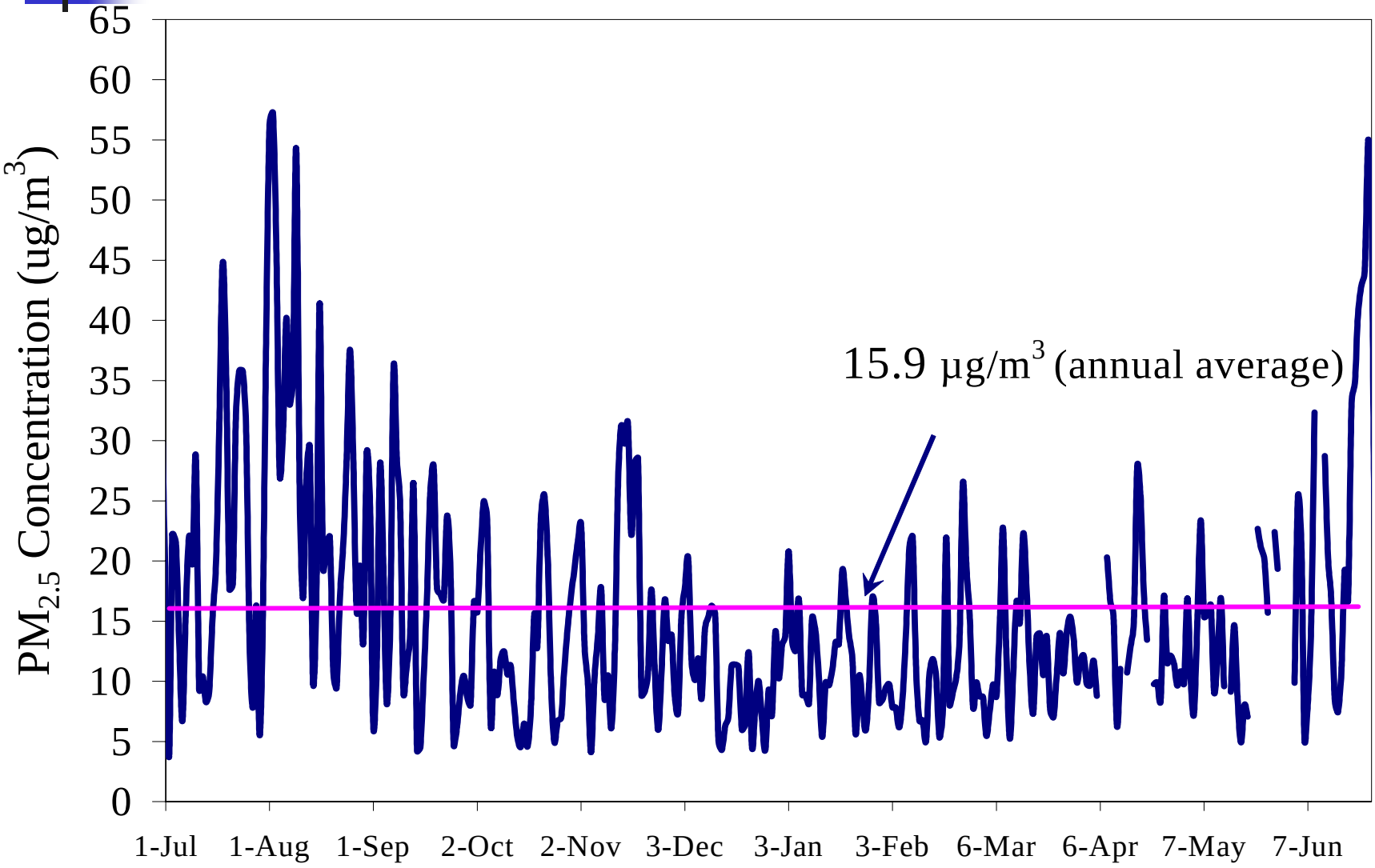
Carnegie Mellon University

Presented at *AAAR Specialty Conference: Particulate Matter, Supersites Program & Related Studies February 7-11, 2005, Atlanta GA.*

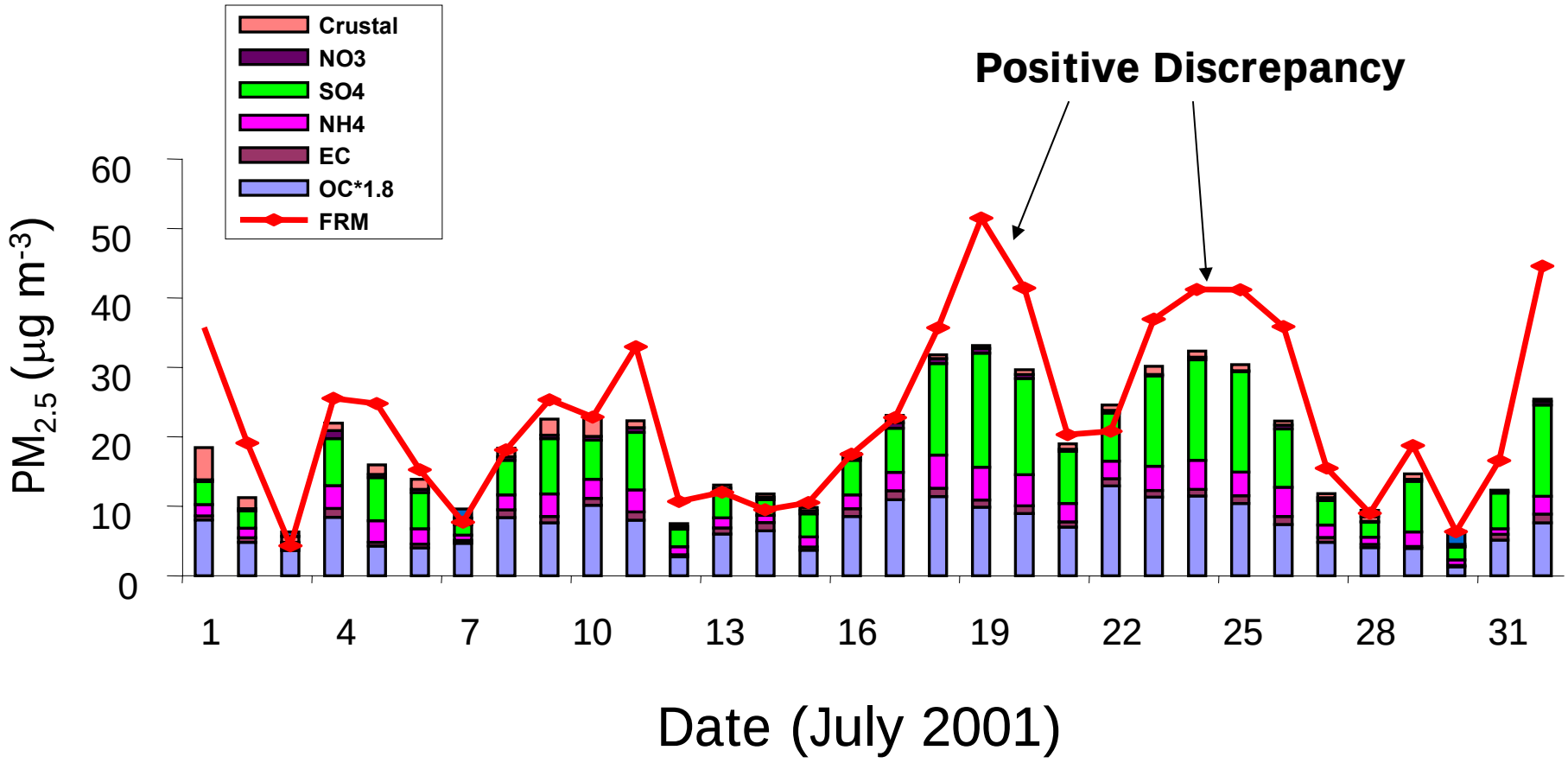
Overview

- Compare FRM $PM_{2.5}$ mass to the sum of aerosol chemical components
- Mass balance discrepancy
  - Positive: FRM > Σ chemical components
  - Negative: FRM < Σ chemical components
- Water
- Volatilization of Organics and Nitrate

FRM Mass July 2001 – June 2002

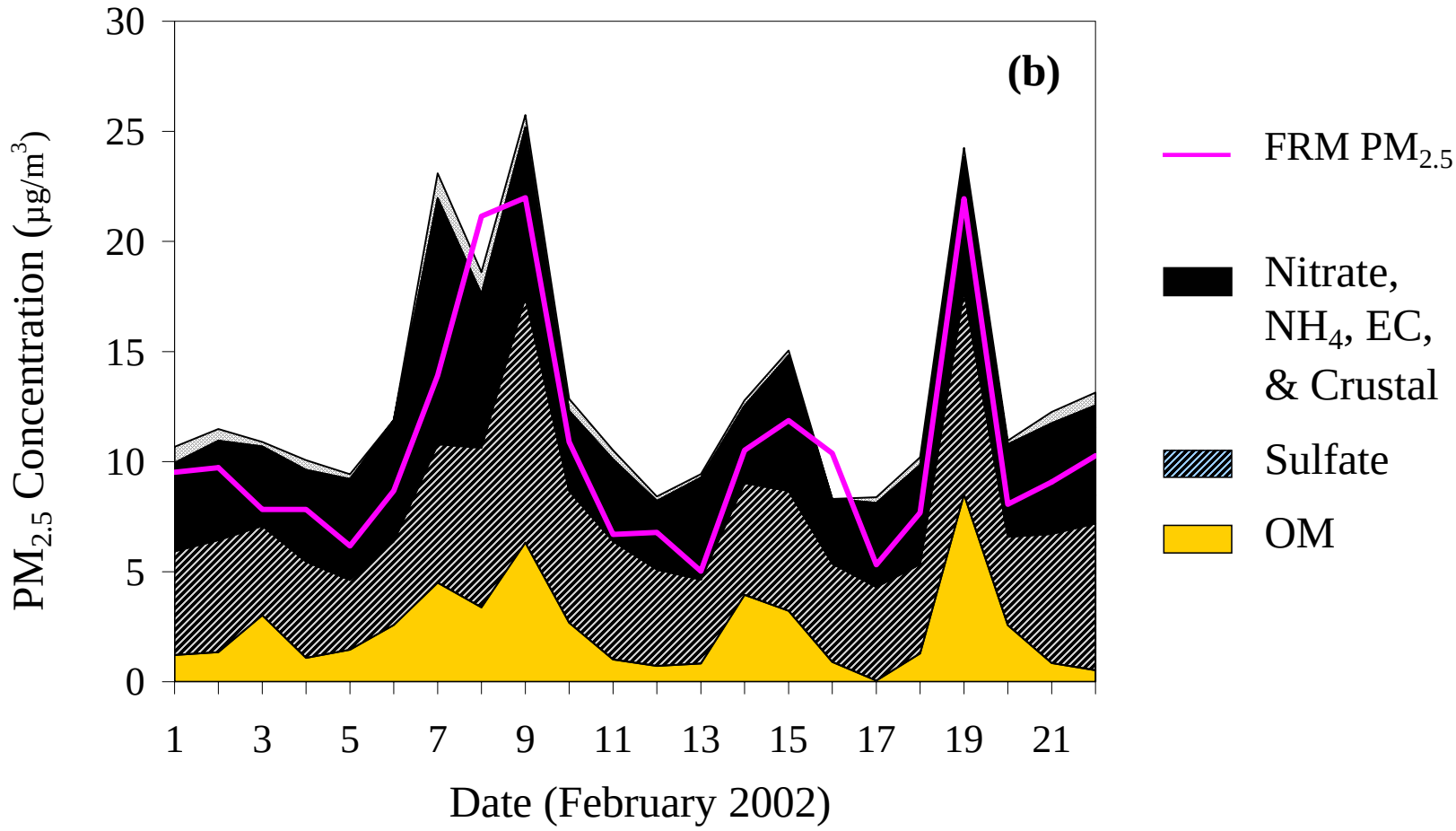


Mass Balance – July 2001

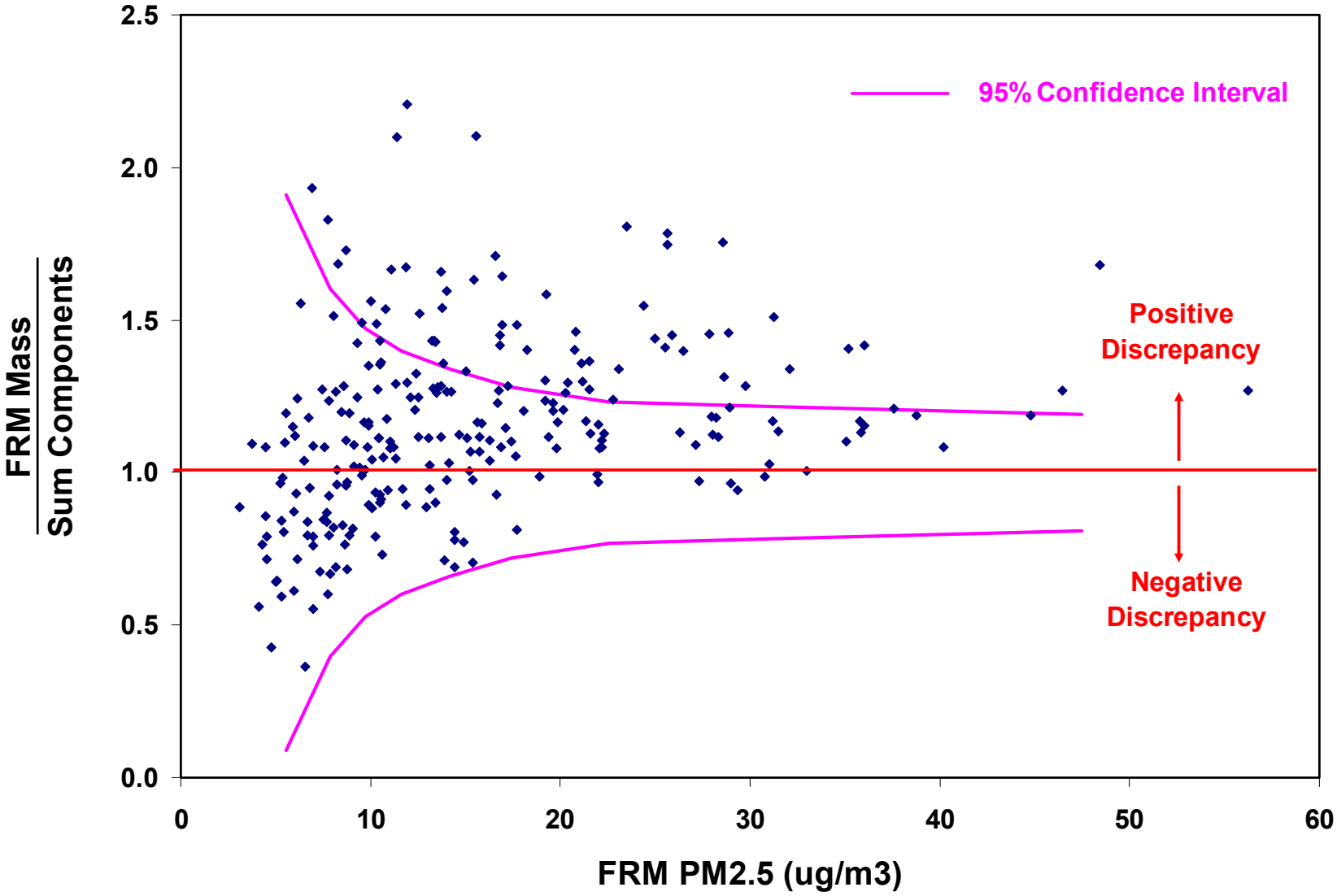


OM = OC x 1.8

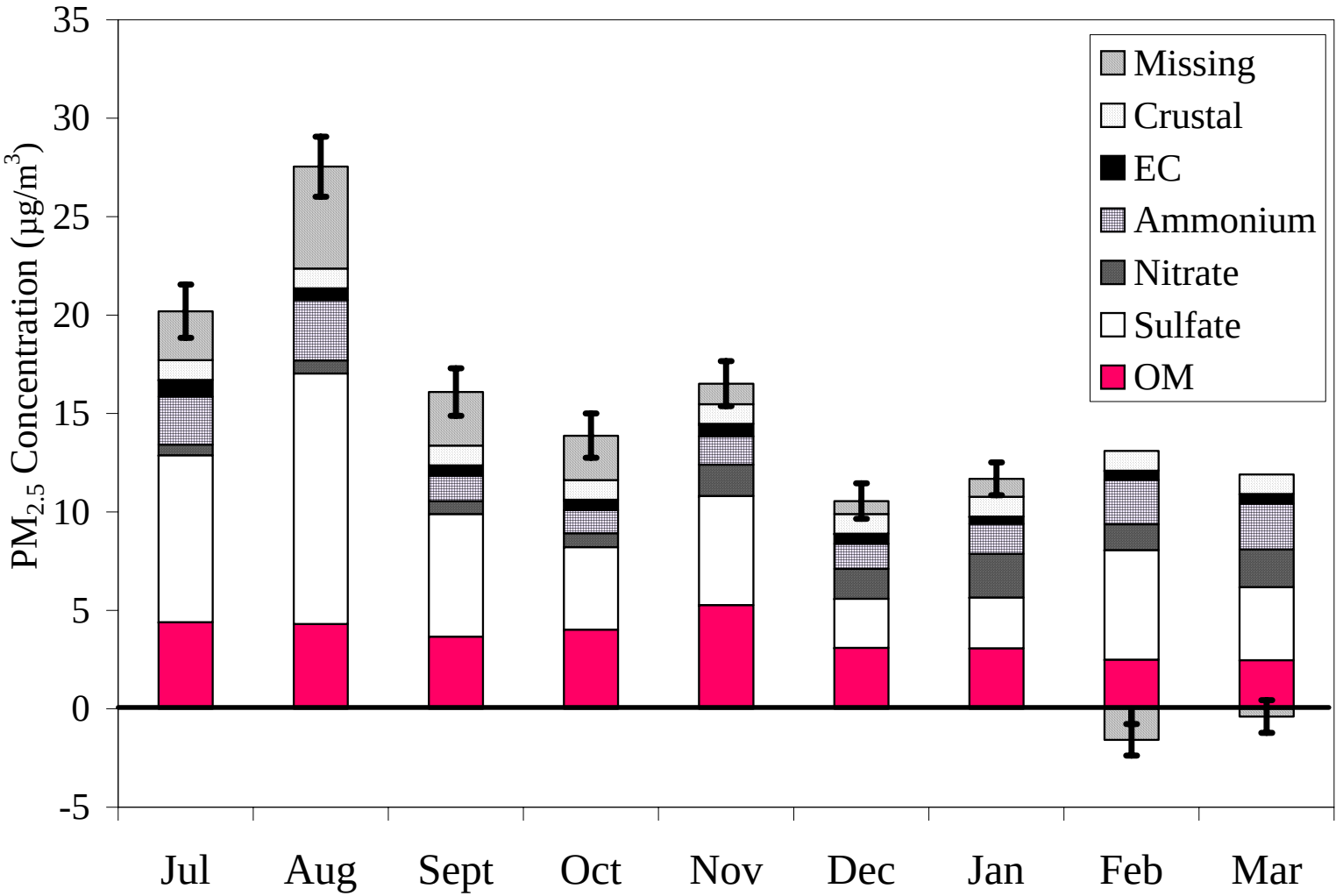
Mass Balance - February 2002



Daily Mass Balance Discrepancy



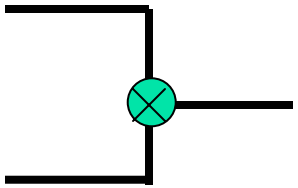
Monthly Mass Balance



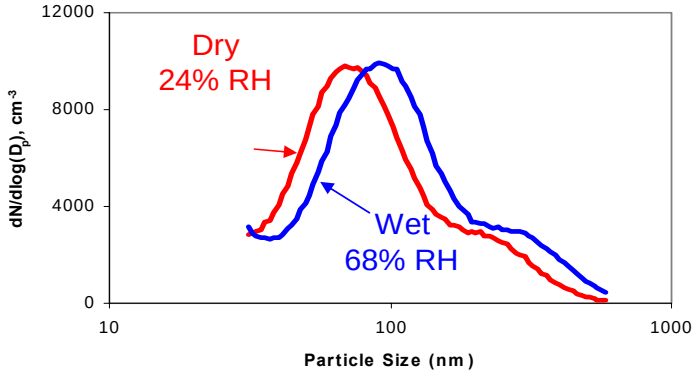
Hypotheses to Explain Mass Discrepancy

- Water: Positive mass discrepancy (FRM > components)
- Volatilization: Negative mass discrepancy (FRM< sum of components)
  - Organic volatilization
  - Nitrate volatilization

Measurements of aerosol water content



Particle Sizers
Nano-SMPS
SMPS
APS



DAASS: Dry/Ambient Aerosol Size Spectrometer
12PD-14

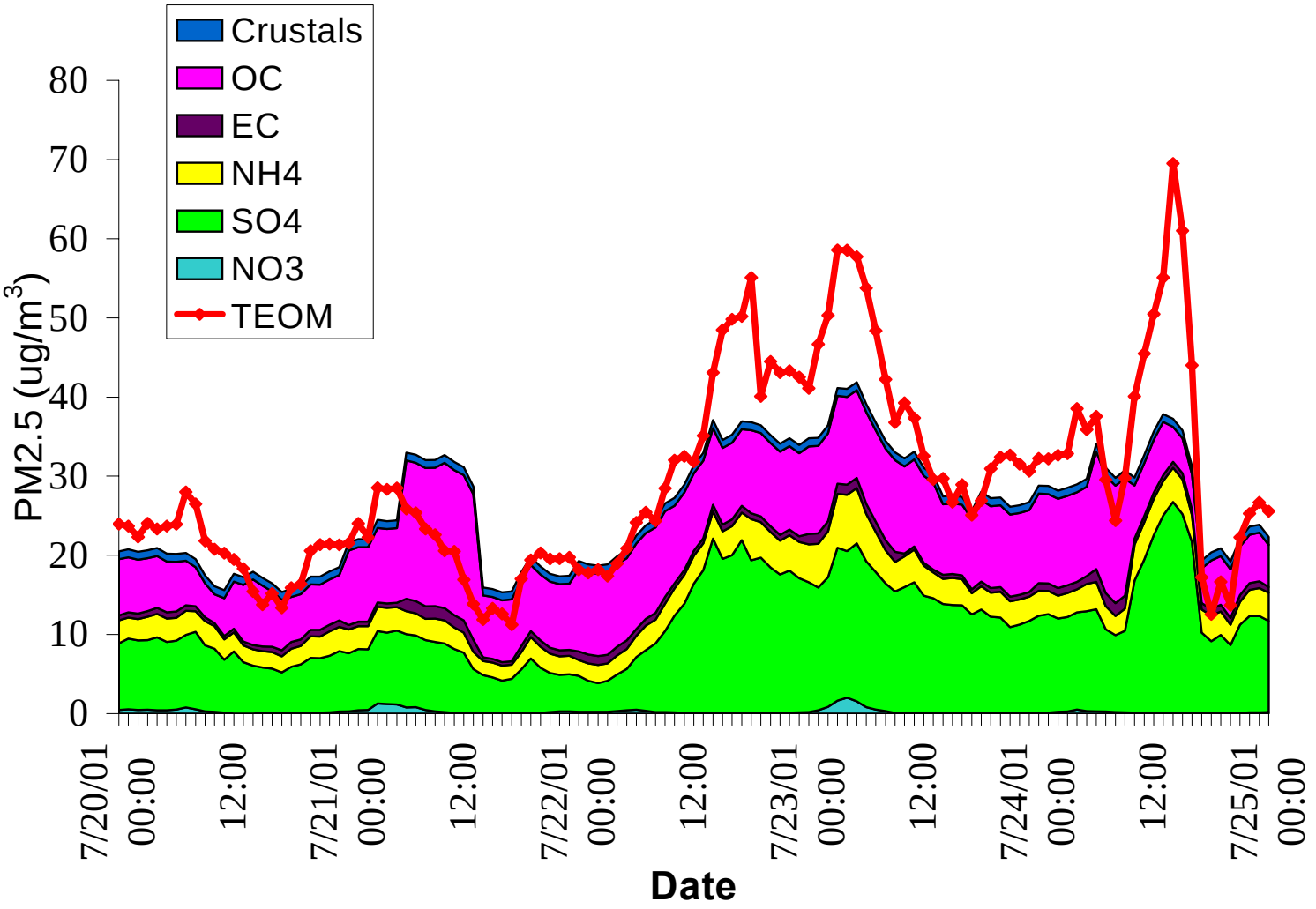
Estimating Aerosol Water at 35% RH

$$M_{H2O} = \left(V_{wet} - \frac{M_{dry}}{\rho_{dry}} \right) \rho_{H2O}$$

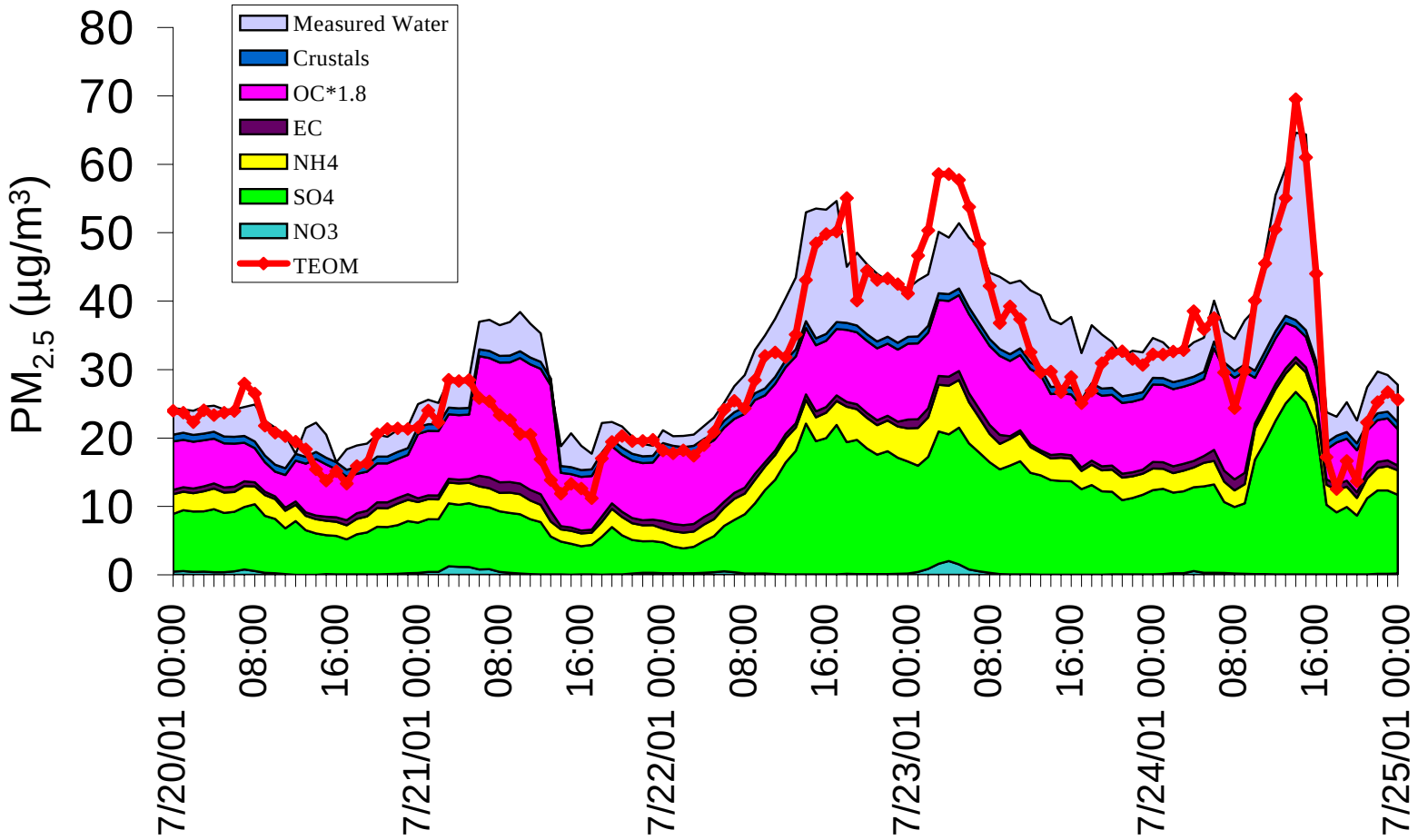
$$\frac{1}{RH} = 1 + B \frac{M_{dry}}{M_{water}}$$

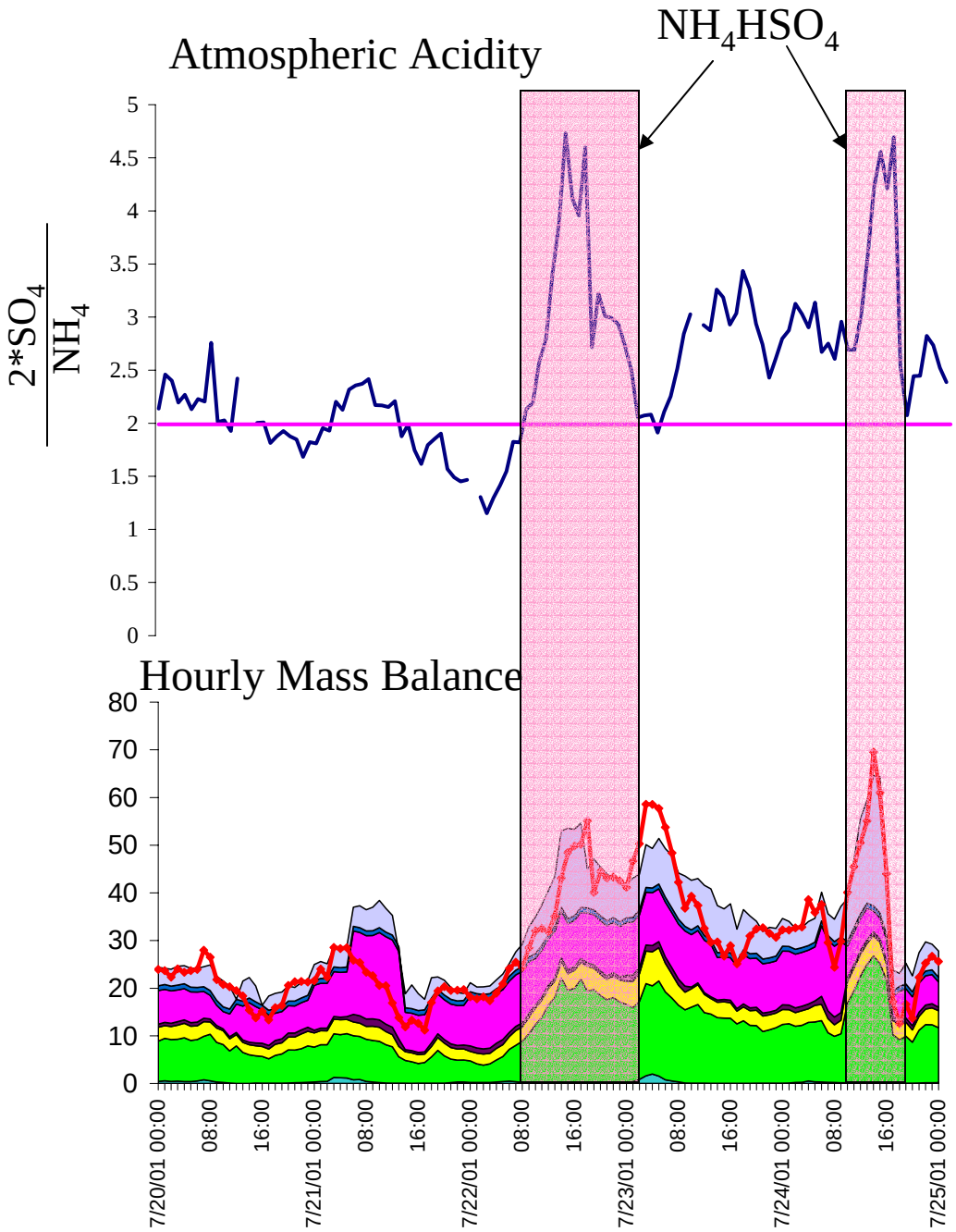
Where V_{wet} is $PM_{2.5}$ volume, M_{dry} is dry mass – sum of components, ρ_{dry} is dry density, and **B** is f(RH, composition).

Hourly Mass Balance



Hourly Mass Balance With Water

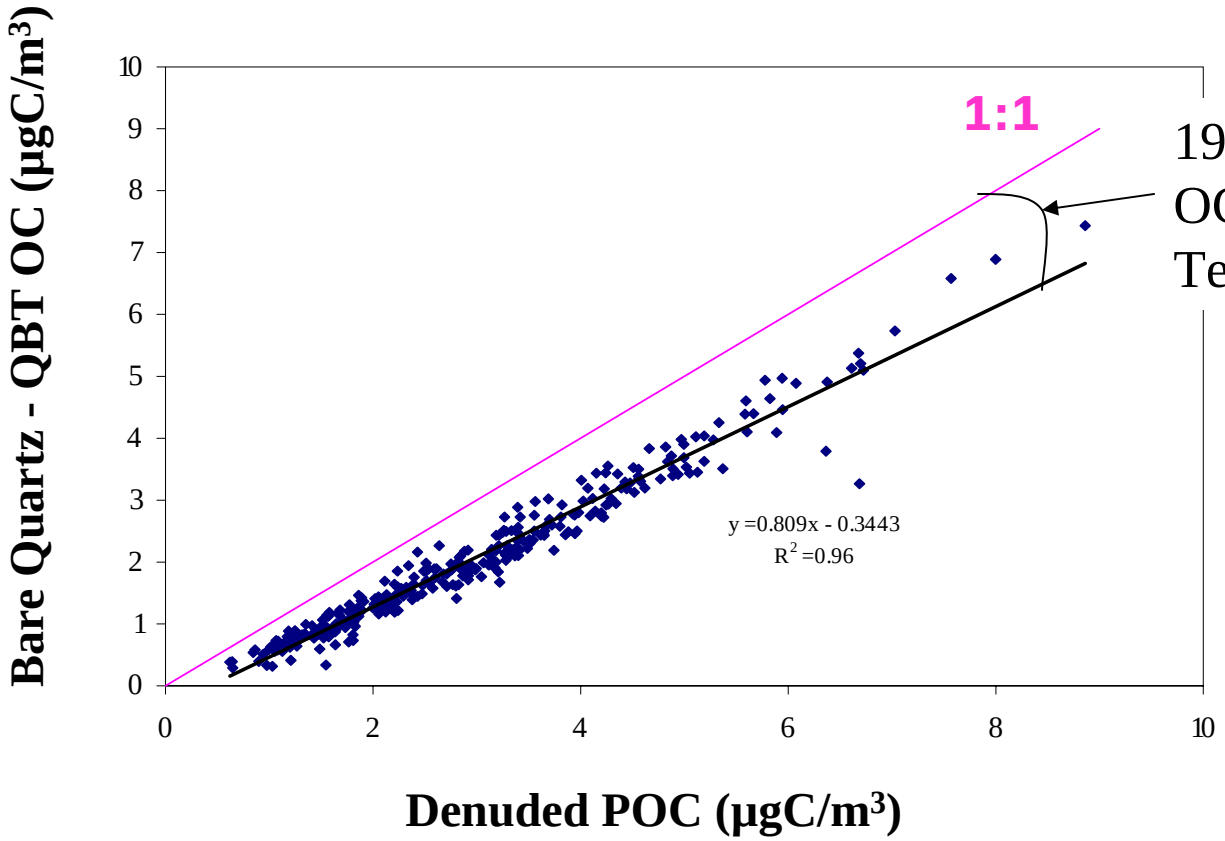




Water content seems impacted by acidity; the more acidic the atmosphere, the greater the aerosol water

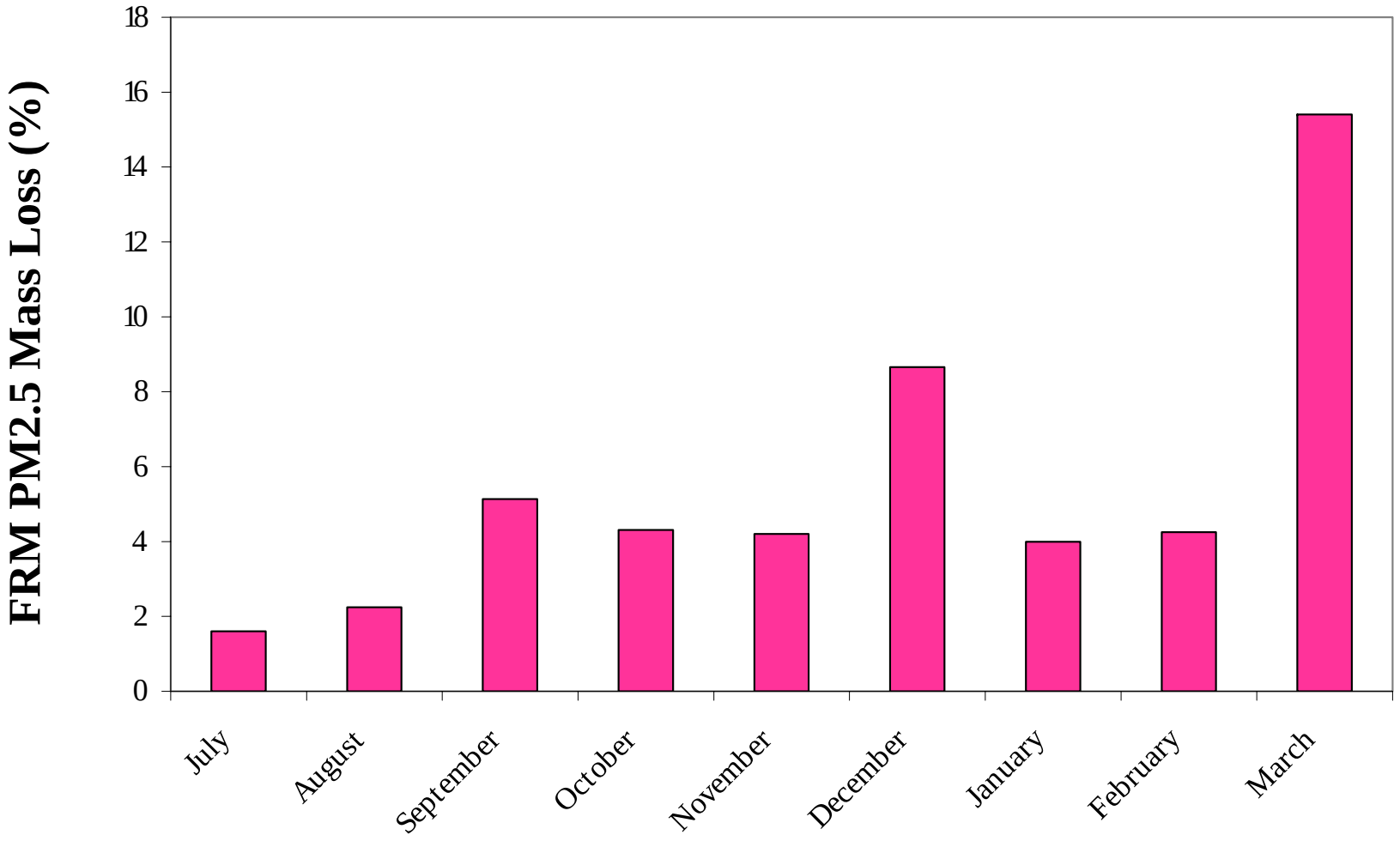
Corresponds to presence of NH_4HSO_4, a species with hygroscopic properties.

Volatilization of Organics

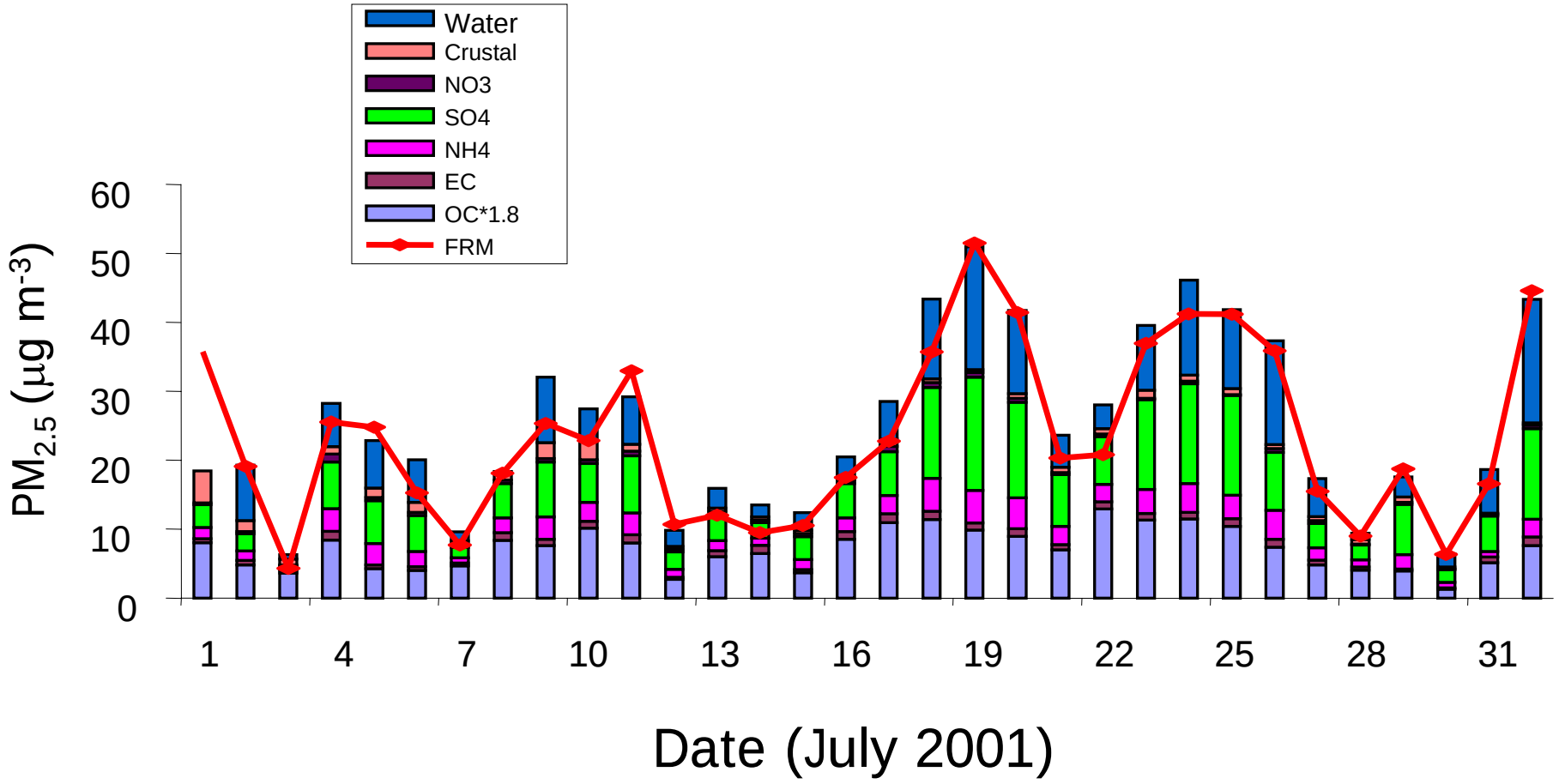


19% volatilization
OC mass loss from
Teflon filter

Mass loss from volatilization of Nitrates

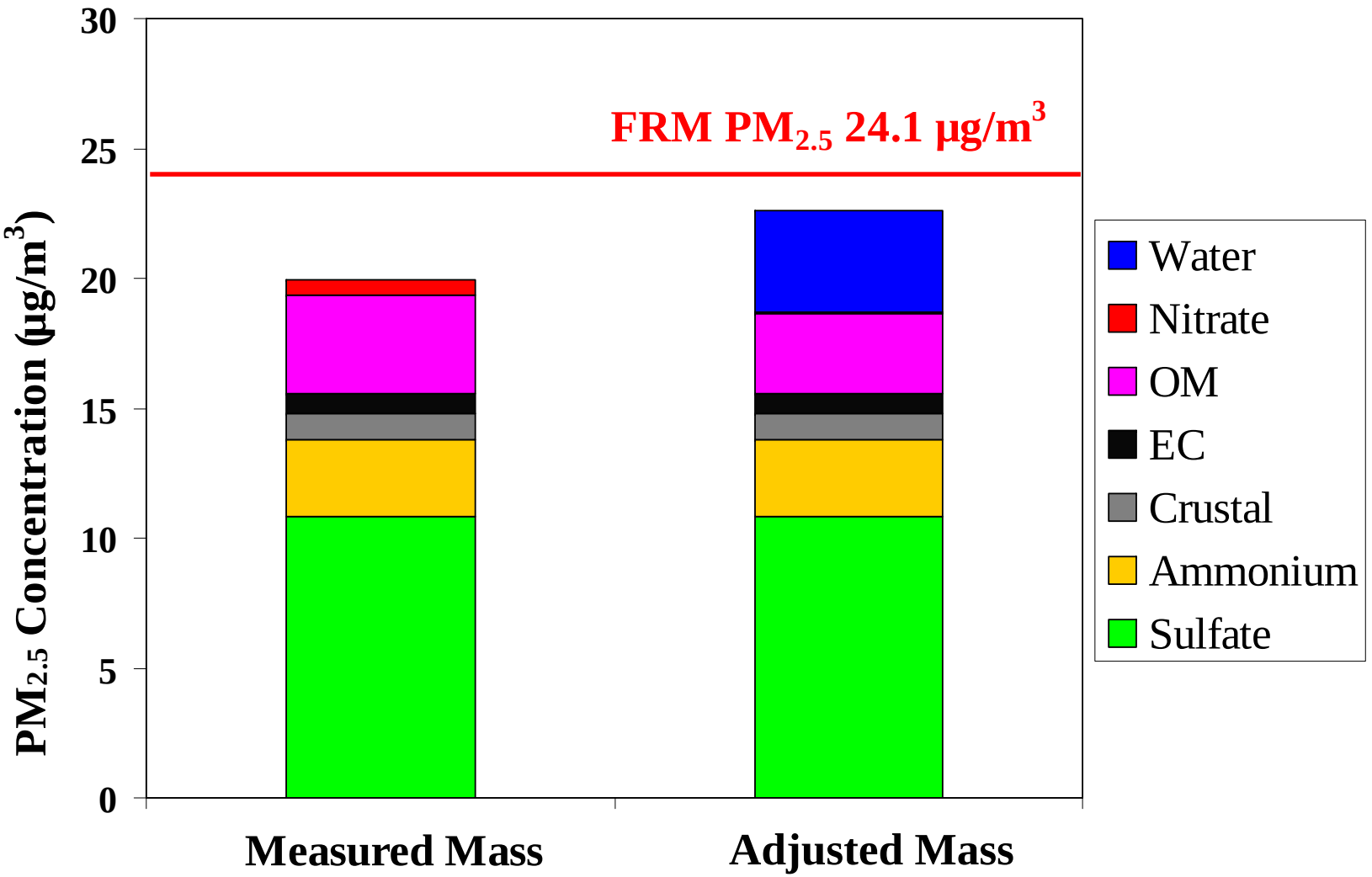


Mass Balance Closure – July 2001

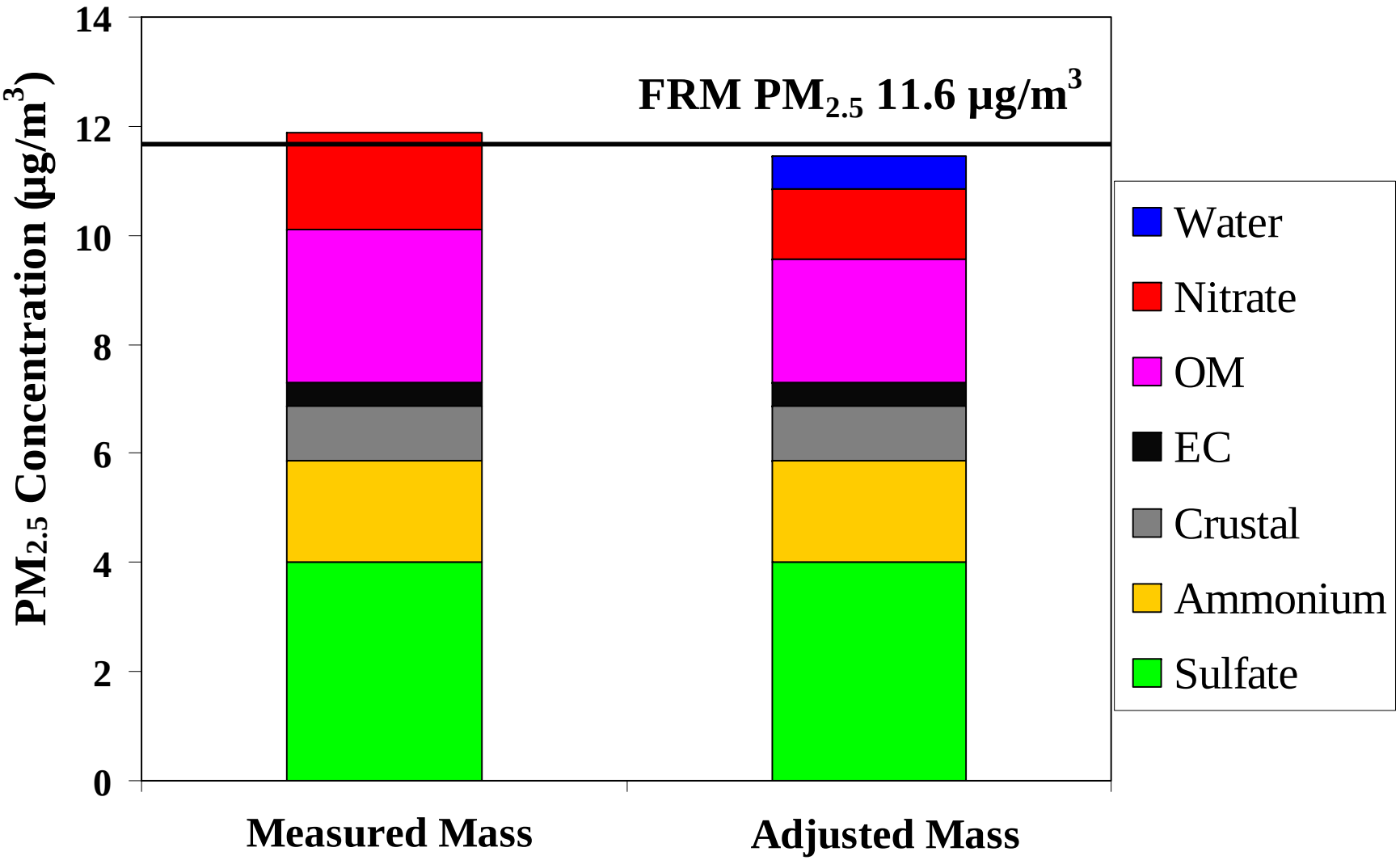


Good mass balance was achieved for the winter months

Mass Balance Closure Summer 2001



Mass Balance Closure Winter 2002



Conclusions

- Accounting for water and volatilization we can account for FRM mass in Pittsburgh
  - Water retention significant on acidic high PM days
  - Volatilization losses in winter corresponding to higher nitrate

S.L. Rees, A.L. Robinson, A.Y. Khlystov, C.O. Stanier, and S.N. Pandis, “Mass Balance Closure and the Federal Reference Method for PM2.5 in Pittsburgh, Pennsylvania,” Atmospheric Environment, 38: 3305-3318, 2004.

Acknowledgements

- This research was conducted as part of the Pittsburgh Air Quality Study, which was supported by US Environmental Protection Agency under contract R82806101 and the US Department of Energy National Energy Technology Laboratory under contract DE-FC26-01NT41017. This talk has not been subject to EPA's peer and policy review, and therefore does not necessarily reflect the views of the Agency. No official endorsement should be inferred.
- The many, many undergraduate students, graduate students, post-docs and collaborators who made PAQS possible