10 Years (2011-2020) of the NCore Network: $PM_{2.5}$ FEMs vs FRMs

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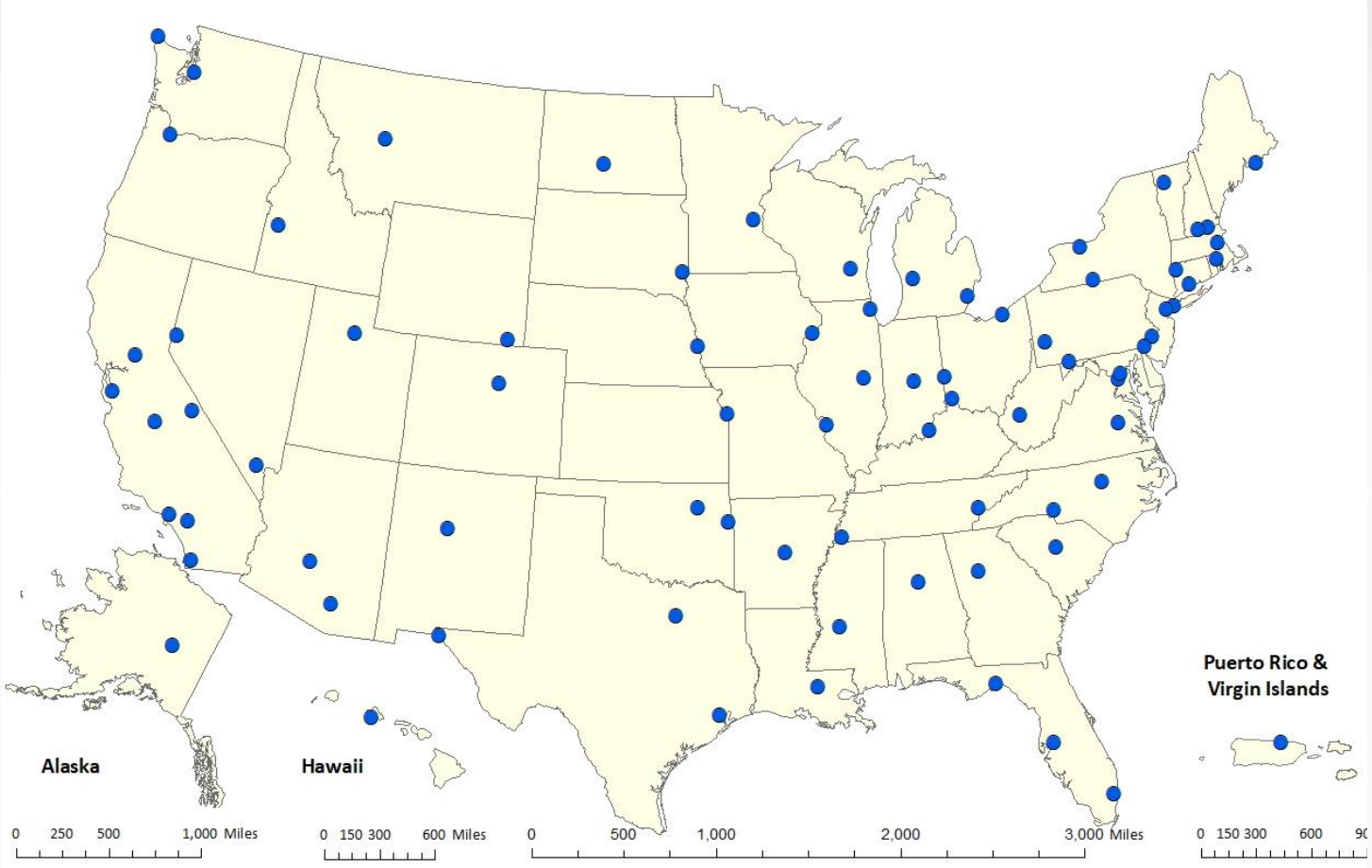
Hypothesis: NCore measurements can help us understand $PM_{2.5}$ FRM-FEM differences

Map of NCore sites

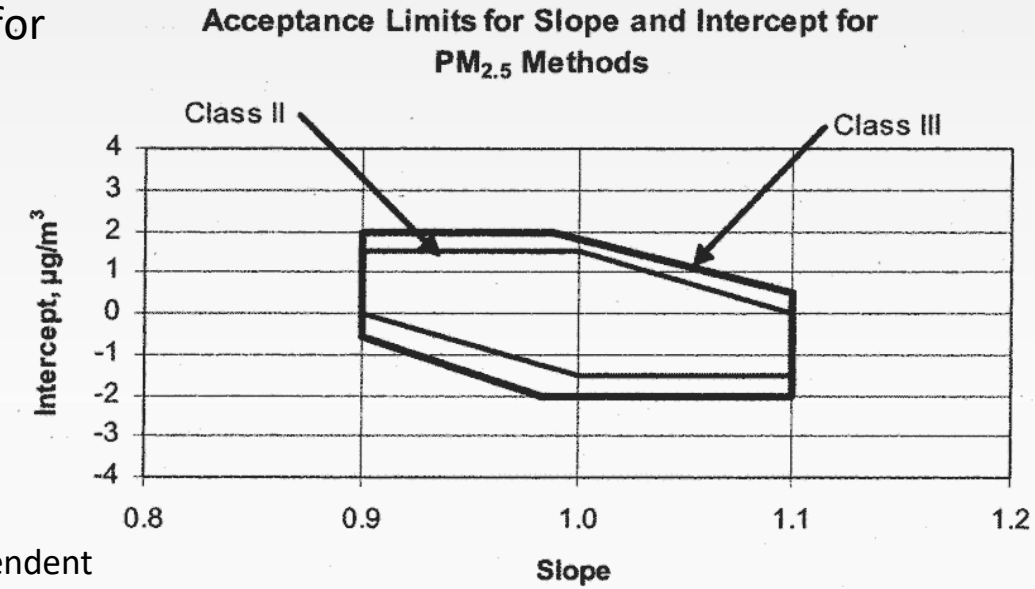


Measurements required at NCore sites

Parameter	Comments
PM2.5 speciation	Organic and elemental carbon, major ions and trace metals (24 hour average; every 3rd day); IMPROVE or CSN
PM2.5 FRM mass	24 hour average at least every 3rd day
continuous PM2.5 mass	1 hour reporting interval; FEM or pre-FEM monitors
PM(10-2.5) mass	Filter-based or continuous
ozone (O3)	all gases through continuous monitors
carbon monoxide (CO)	capable of trace levels (low ppm and below) where needed
sulfur dioxide (SO2)	capable of trace levels (low ppb and below) where needed
nitrogen oxide (NO)	capable of trace levels (low ppb and below) where needed
total reactive nitrogen (NOy)	capable of trace levels (low ppb and below) where needed
surface meteorology	wind speed and direction (reported as "Resultant"), temperature, RH

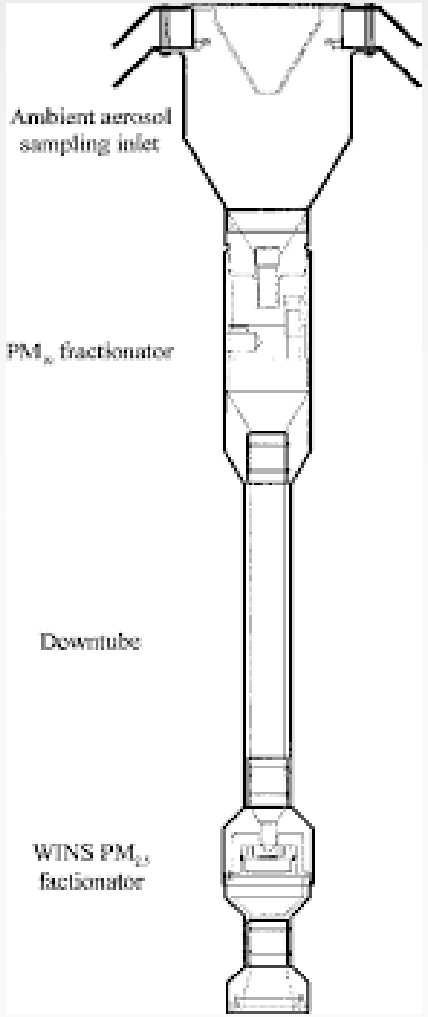
$PM_{2.5}$ FRM and FEMs (Noble et al. 2001)

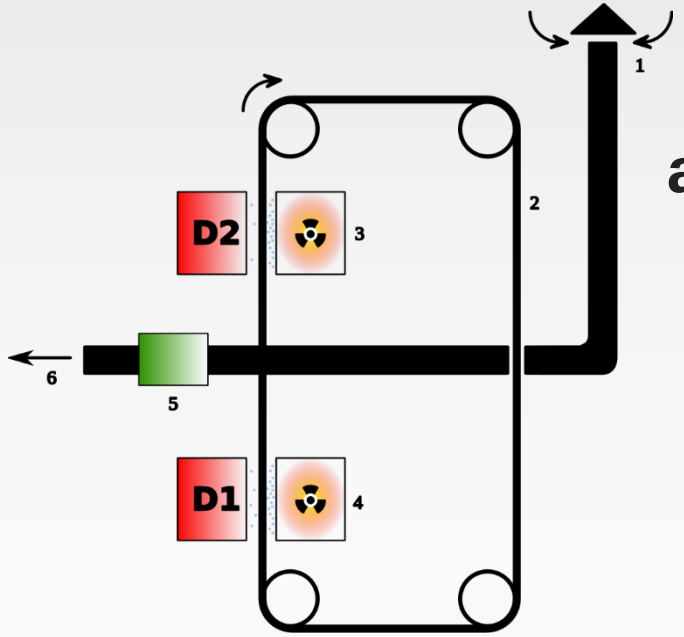
- $PM_{2.5}$ Federal Reference Method (FRM)
  - An integrated, gravimetric method intended to provide a measurement of the particle mass concentration over a 24 h sampling interval for the purpose of evaluating community-oriented fine PM concentration for compliance with the NAAQS
- $PM_{2.5}$ Federal Equivalent Method (FEM)
  - Comparability criteria:
    - Slope of 1 ± 0.1
    - Y-intercept between $15.05 - (17.32 \times \text{slope})$, but not less than -2.0; and $15.05 - (13.20 \times \text{slope})$, but not more than + 2.0
    - Regression coefficient (R^2) of ≥ 0.93
  - Three main types of Class III FEMS:
    - **Beta-attenuation**: attenuation of beta radiation (electrons) is exponentially dependent on the mass of particulate matter
    - Tapered Element Oscillating Microbalance with Filter Dynamics Measurement System (**TEOM-FDMS**). A conditioned sample stream provides measurement of volatile and nonvolatile PM fractions. Aerosol is measured by oscillation frequency of a small vibrating glass tube that is dependent on the mass of particulate matter
    - **Light scattering**: scattered light spectrum can determine the sampled particle size according to Lorenz-Mie Theory and used to estimate the mass of particulate matter



$PM_{2.5}$ FRM and FEMs types

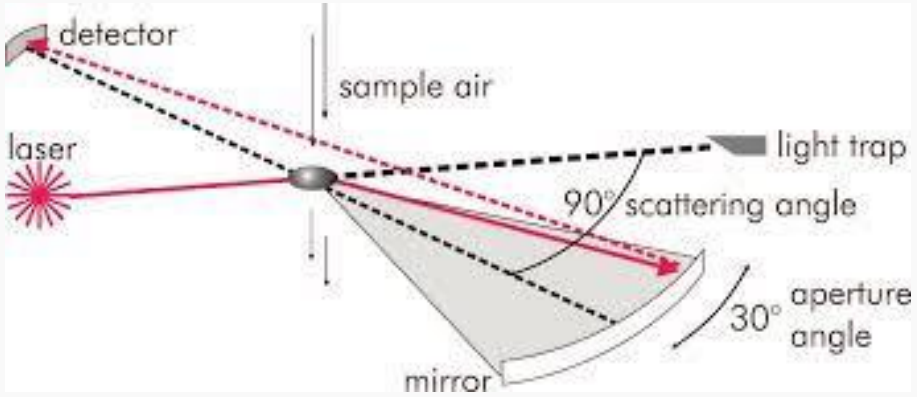
FRM



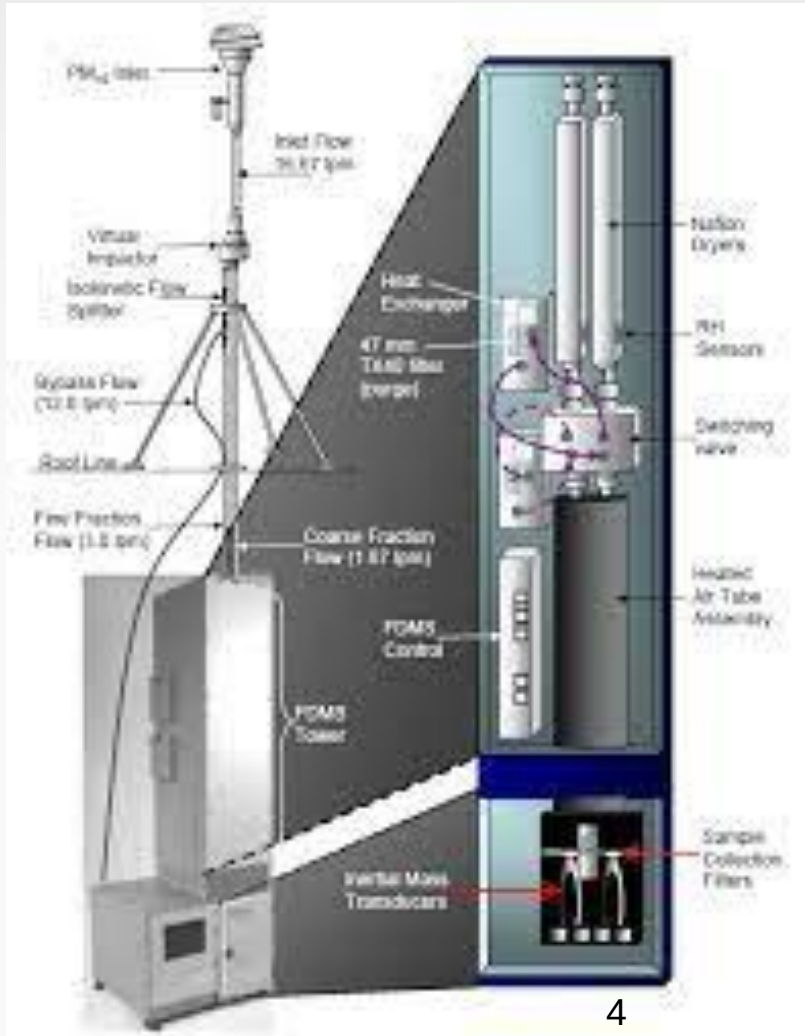


Beta-attenuation

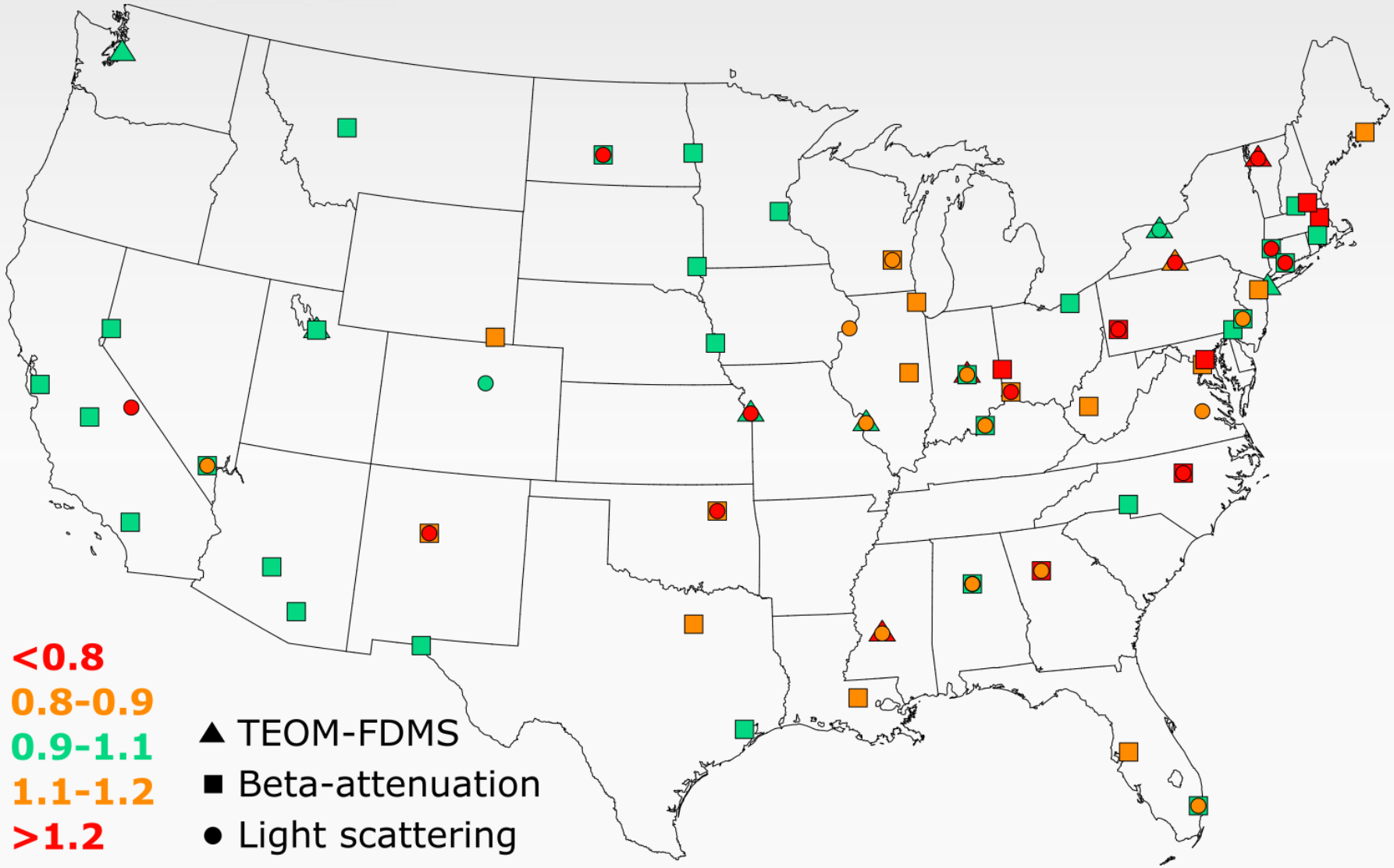
Light Scattering



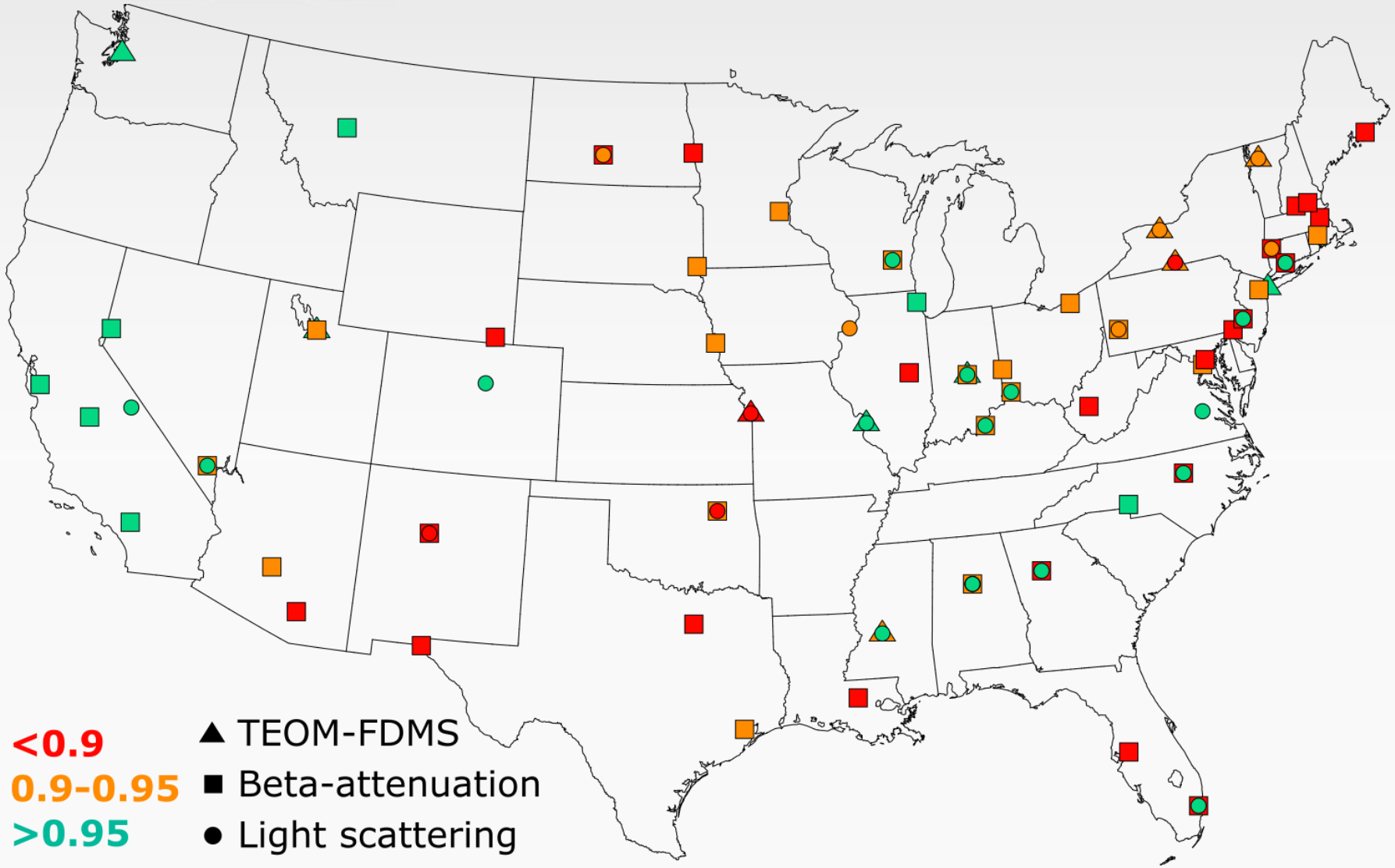
Tapered Element Oscillating Microbalance (TEOM-FDMS)



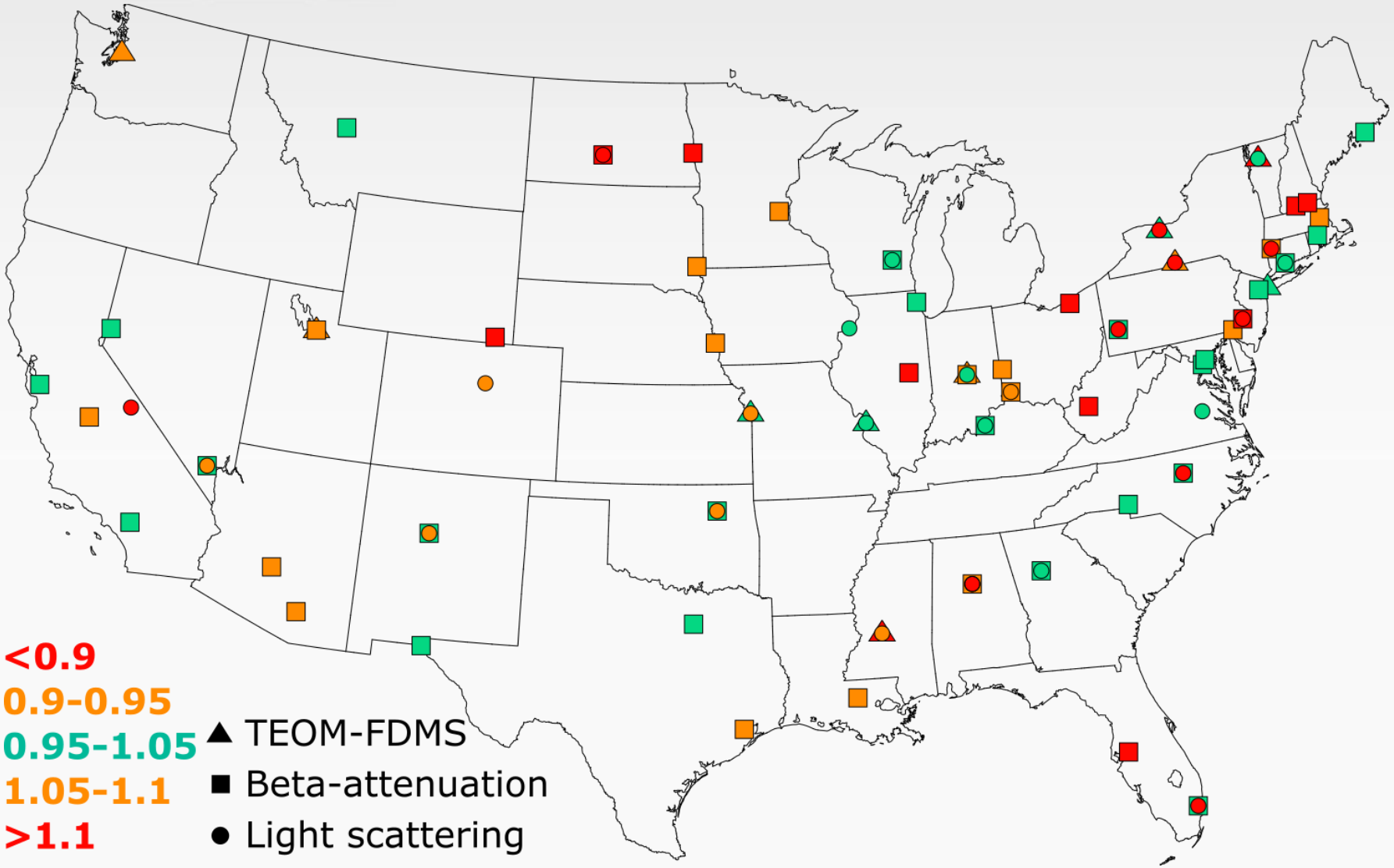
Overall $PM_{2.5}$ FEM/FRM ratio (2011-2020)



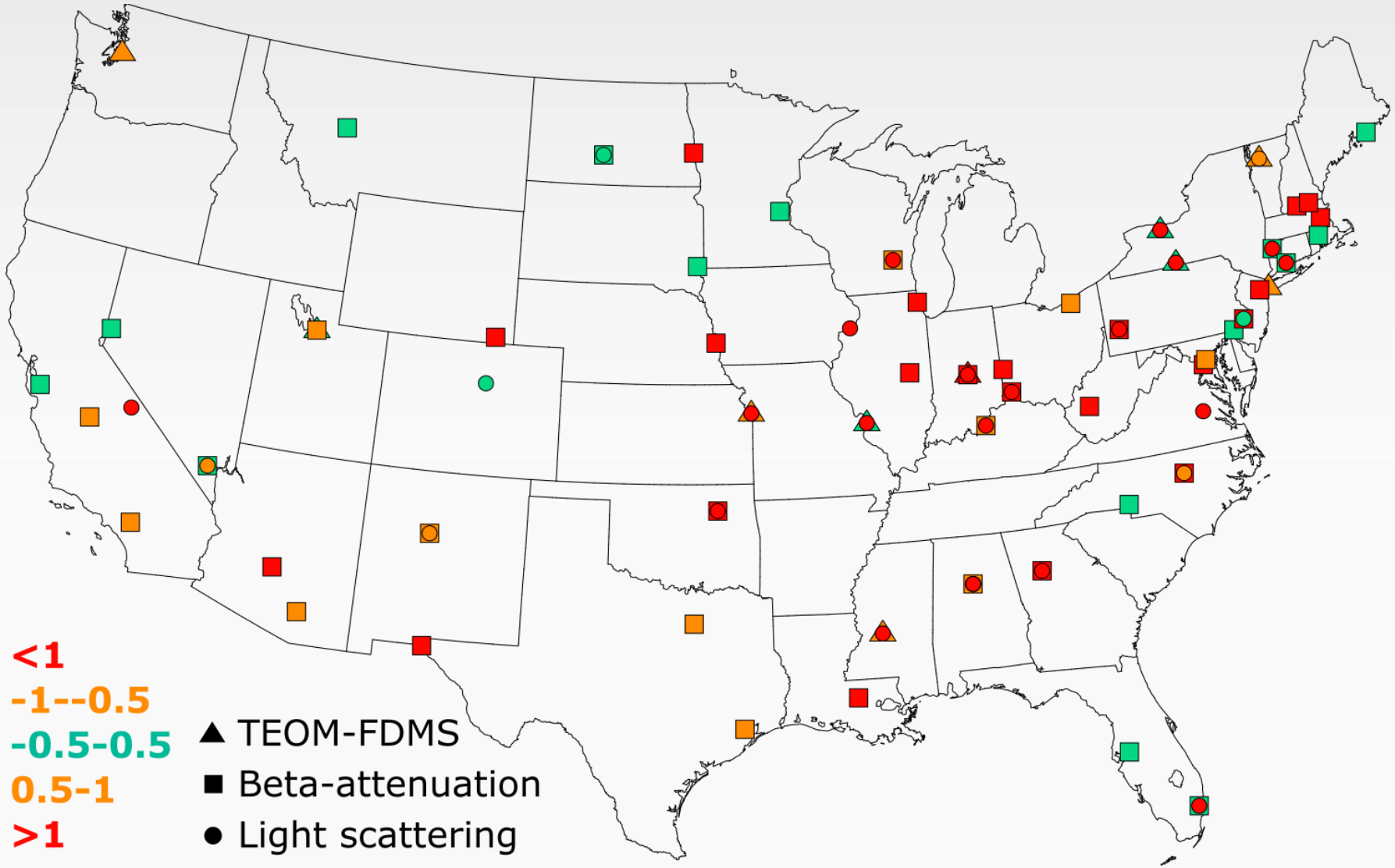
Overall $PM_{2.5}$ FEM-FRM correlation (2011-2020)



Overall $PM_{2.5}$ FEM-FRM slope (2011-2020)

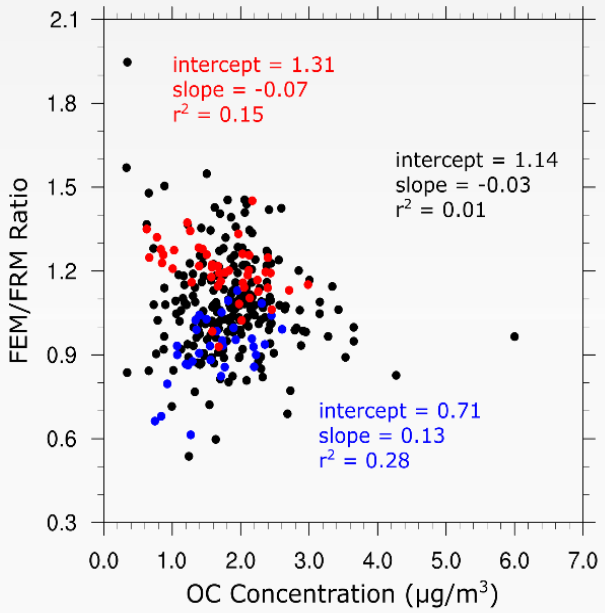


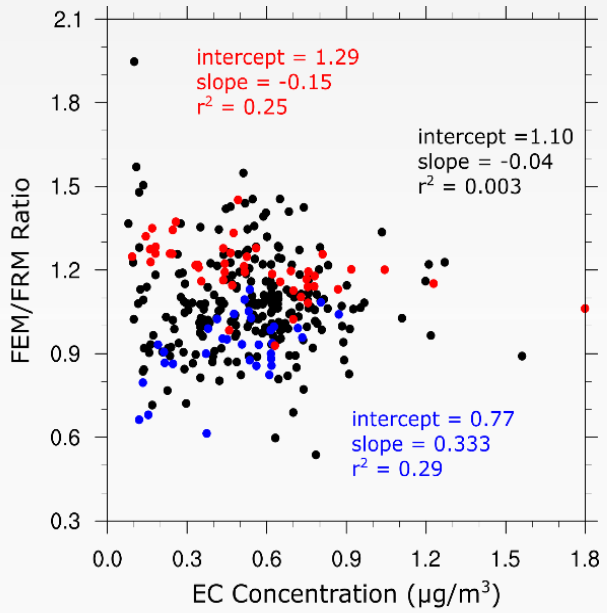
Overall $PM_{2.5}$ FEM-FRM y-intercept (2011-2020)

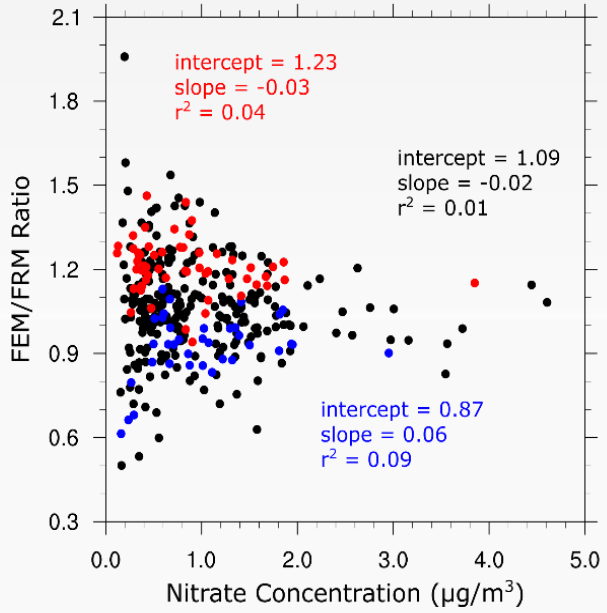


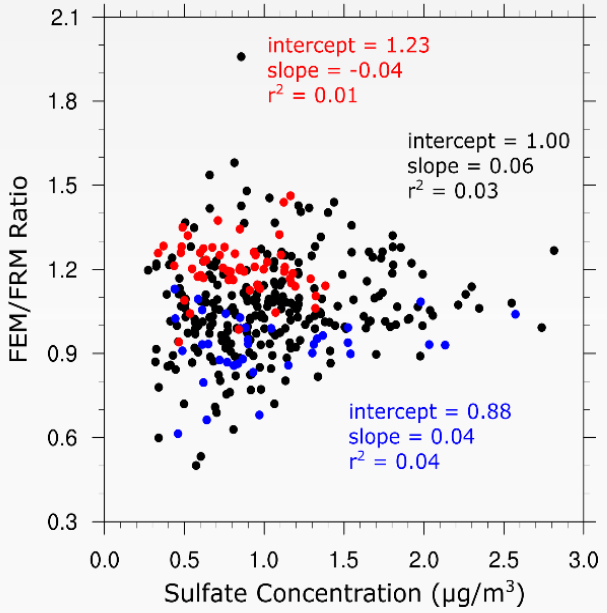
Annual average $PM_{2.5}$ FEM/FRM vs speciation scatterplots

TEOM-FDMS
Beta-attenuation
Light scattering

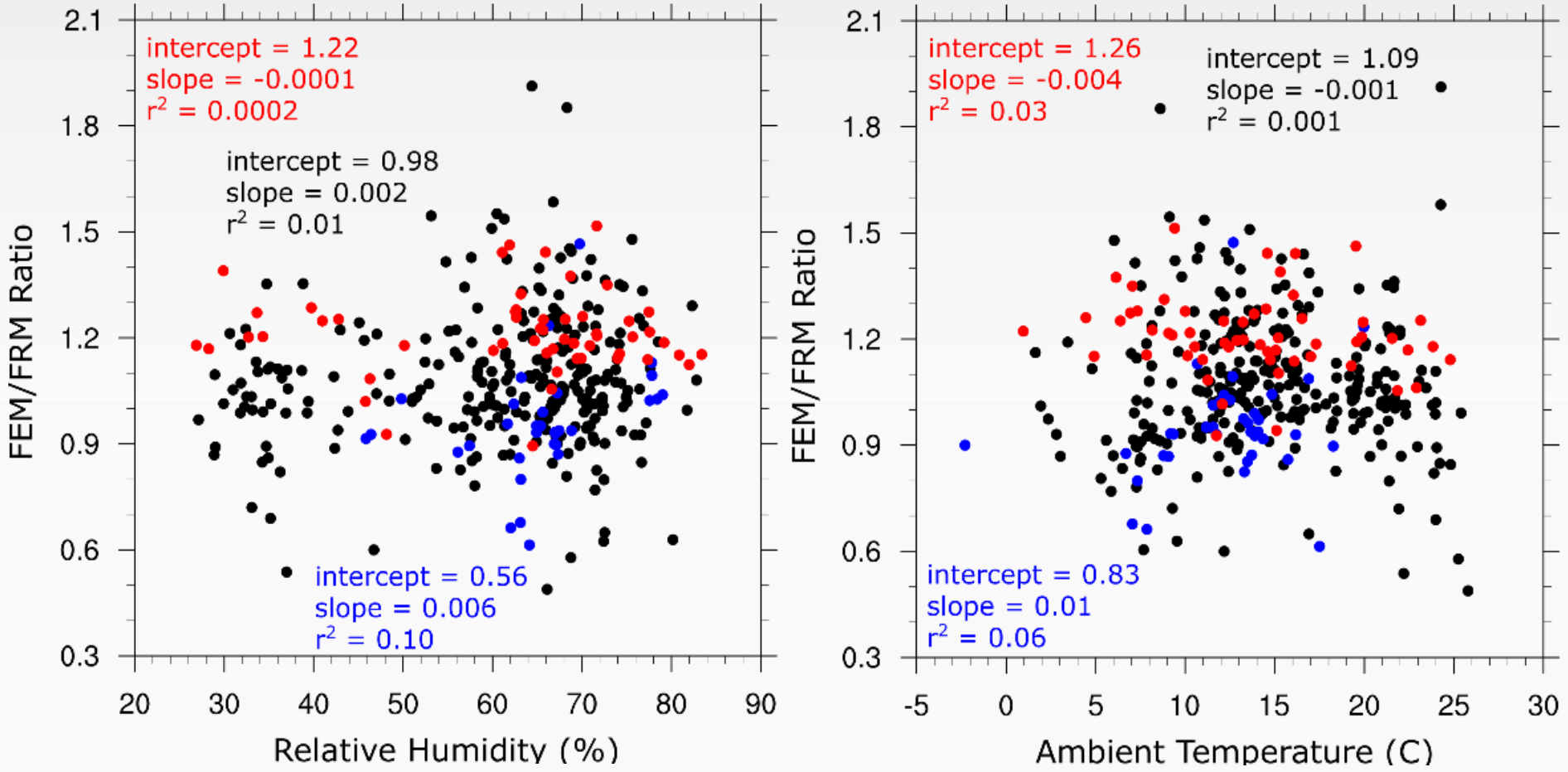






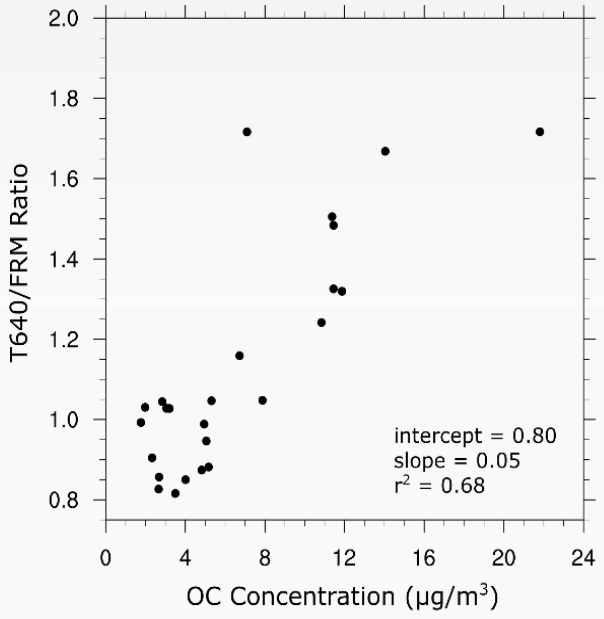


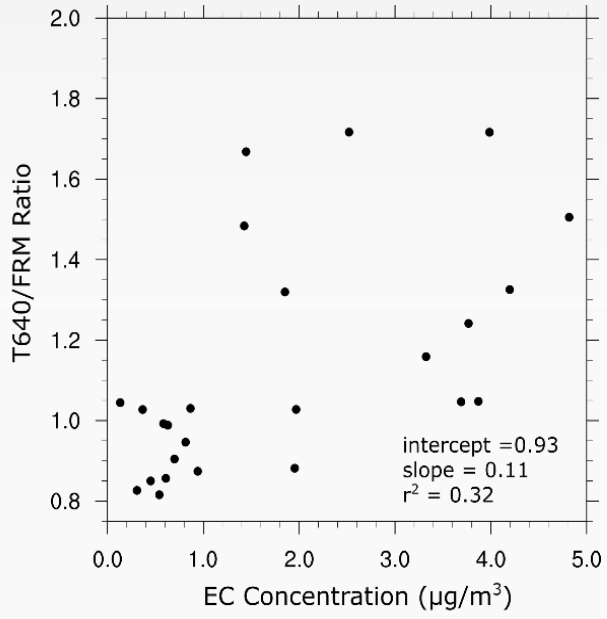
Annual average $PM_{2.5}$ FEM/FRM vs meteorology scatterplots

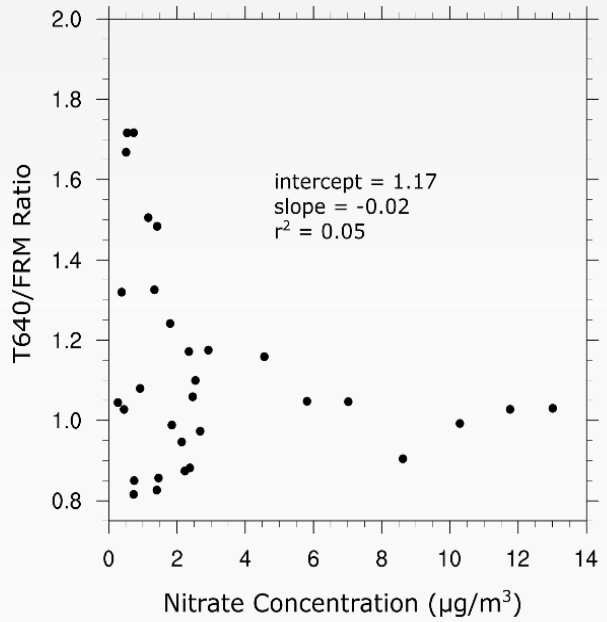


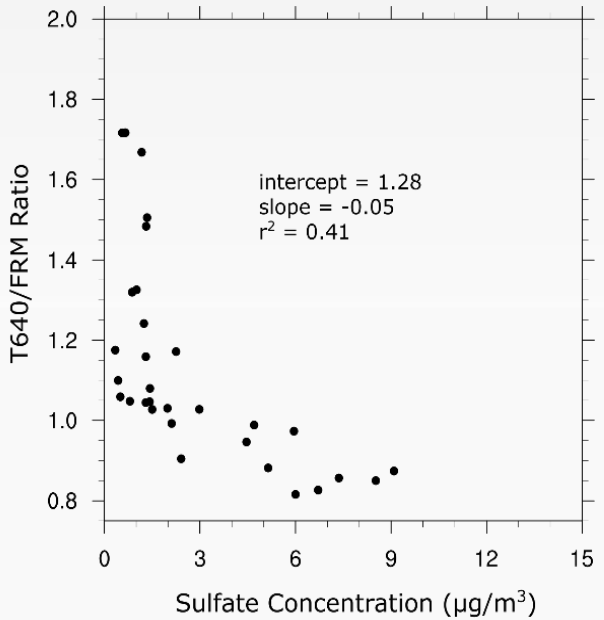
TEOM-FDMS
Beta-attenuation
Light scattering

Daily average T640/FRM vs speciation scatterplots on high (>25 µg/m³) $PM_{2.5}$ days

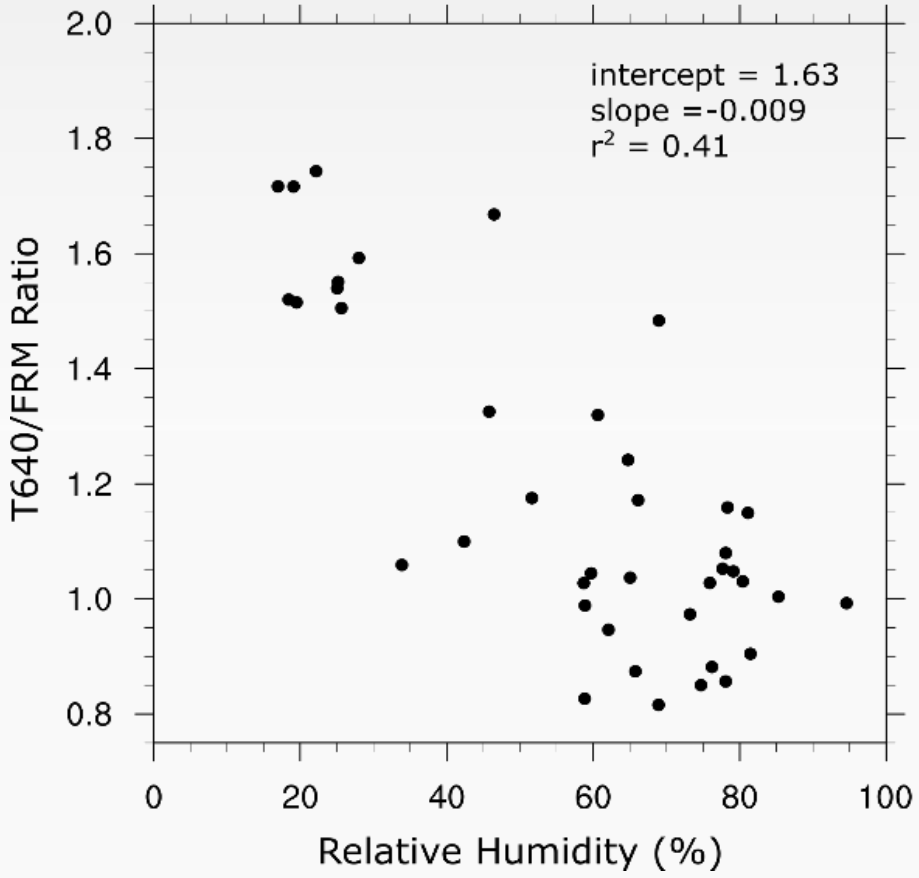


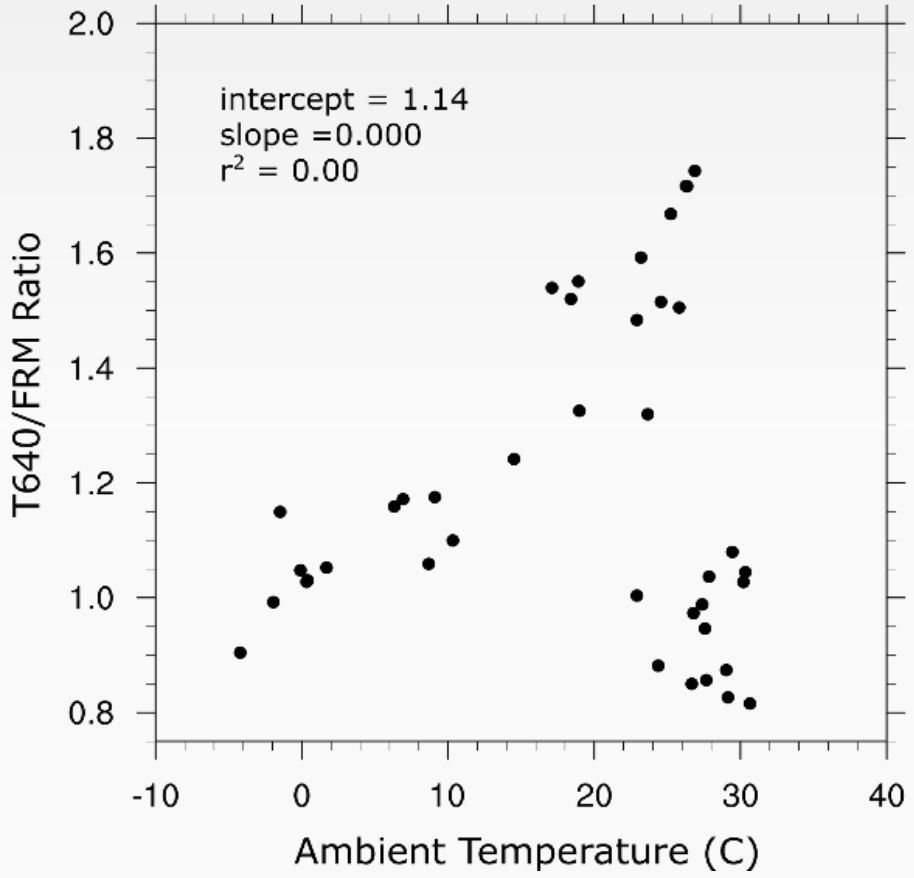




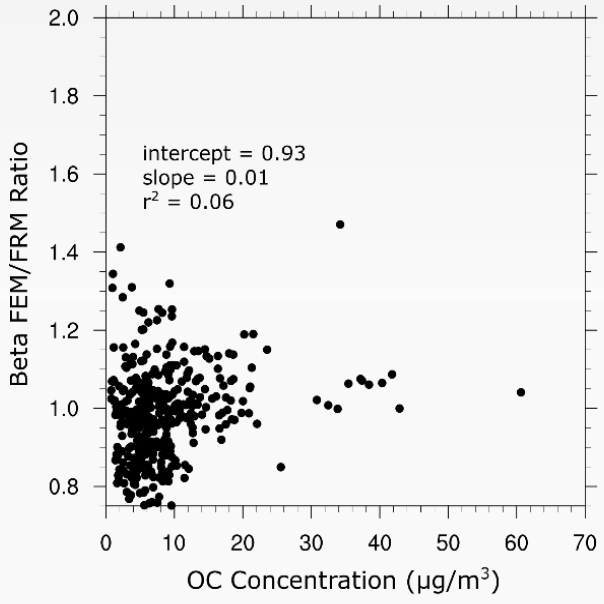


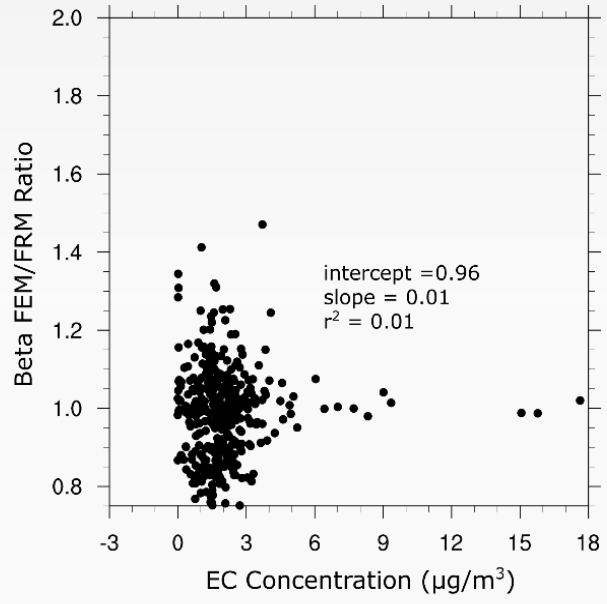
Daily average T640/FRM vs meteorology scatterplots on high (>25 µg/m³) $PM_{2.5}$ days

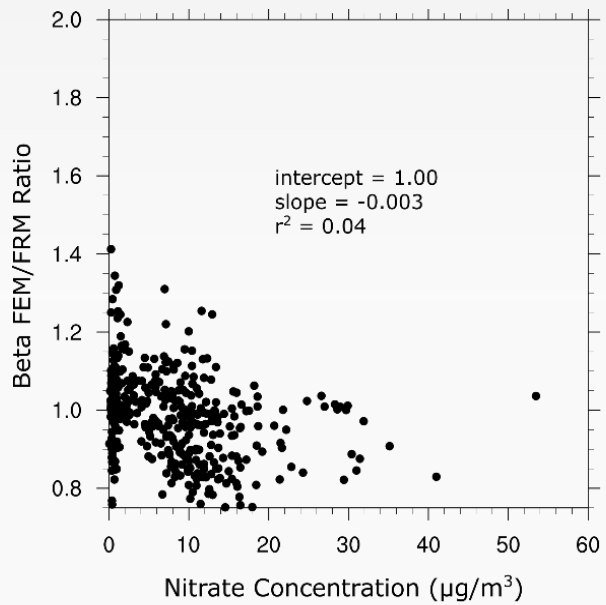


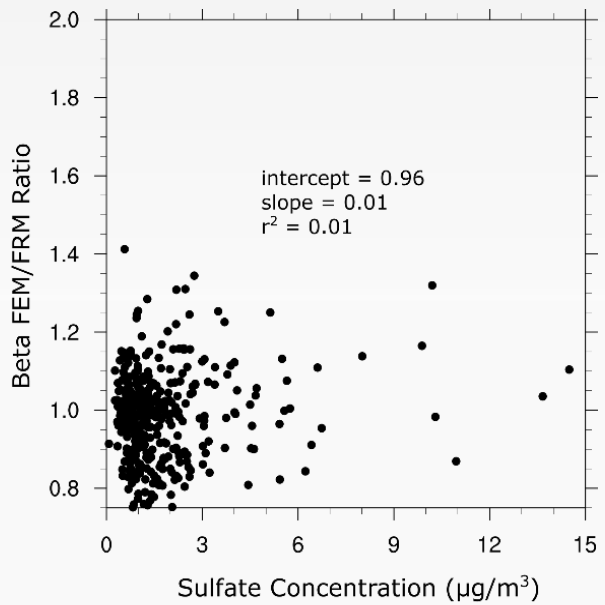


Daily average beta/FRM vs composition scatterplots on high (>25 µg/m³) $PM_{2.5}$ Days

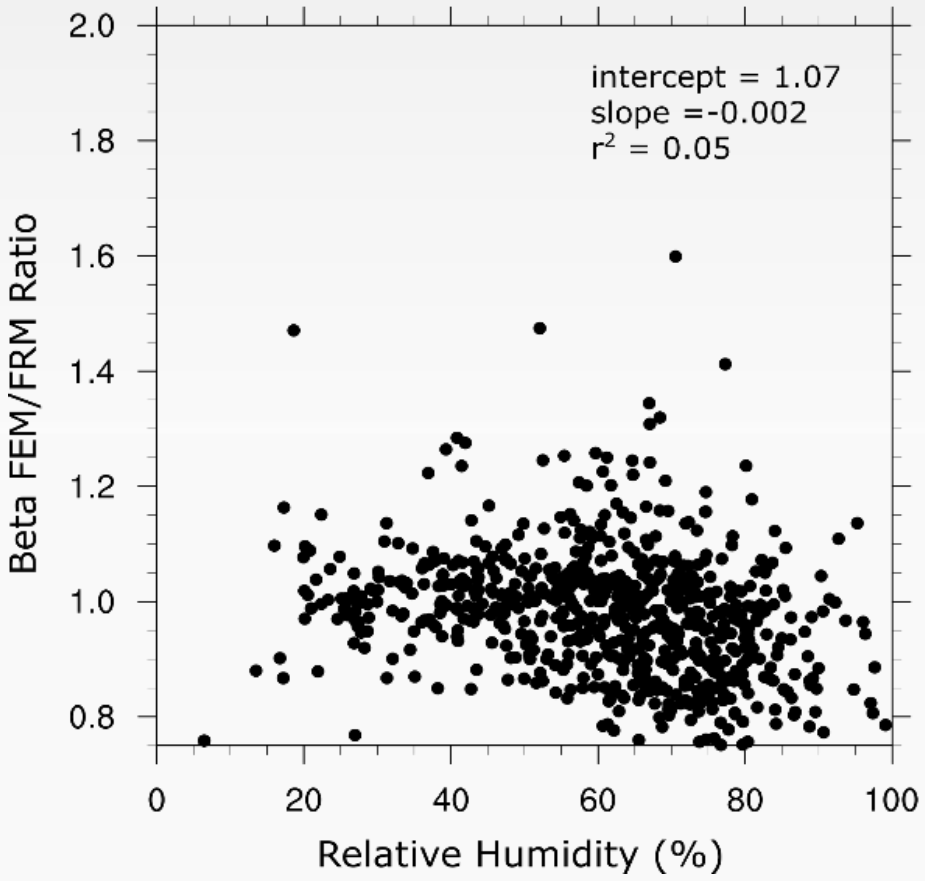


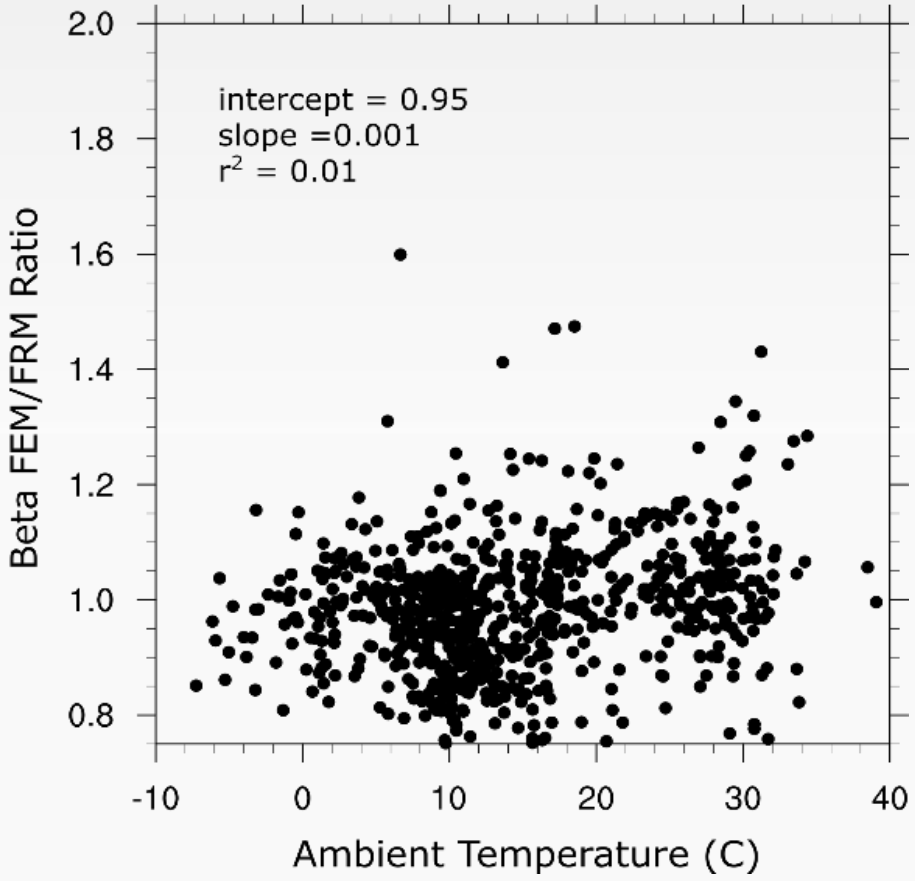






Daily average beta/FRM vs meteorology scatterplots on high (>25 µg/m^3) $PM_{2.5}$ Days





Summary

- 10 years (2011-2020) of NCore has provided opportunities to analyze long term trends, optimize data quality, and evaluate instrumentation using multipollutant measurements
- The $PM_{2.5}$ FEM-FRM comparability throughout the NCore network depends on FEM type
  - TEOM-FDMS FEMs generally underpredicted FRM mass
  - Beta-attenuation FEMs generally had low bias
  - Light scattering FEMs generally overpredicted FRM mass
- Linear regression of light scattering FEMs indicted high correlations, slopes mostly near 1, and y-intercepts largely > 1
  - Suggests that a correction factor might be able to improve much of the overprediction
- The high biases of light scattering FEM were not geographically clustered nor were well correlated with $PM_{2.5}$ speciation or meteorological parameters
- Daily comparison of T640/FRM on high $PM_{2.5}$ days indicated increasingly large overpredictions during periods of high OC and EC concentrations and low RH that are indicative of wildfire smoke