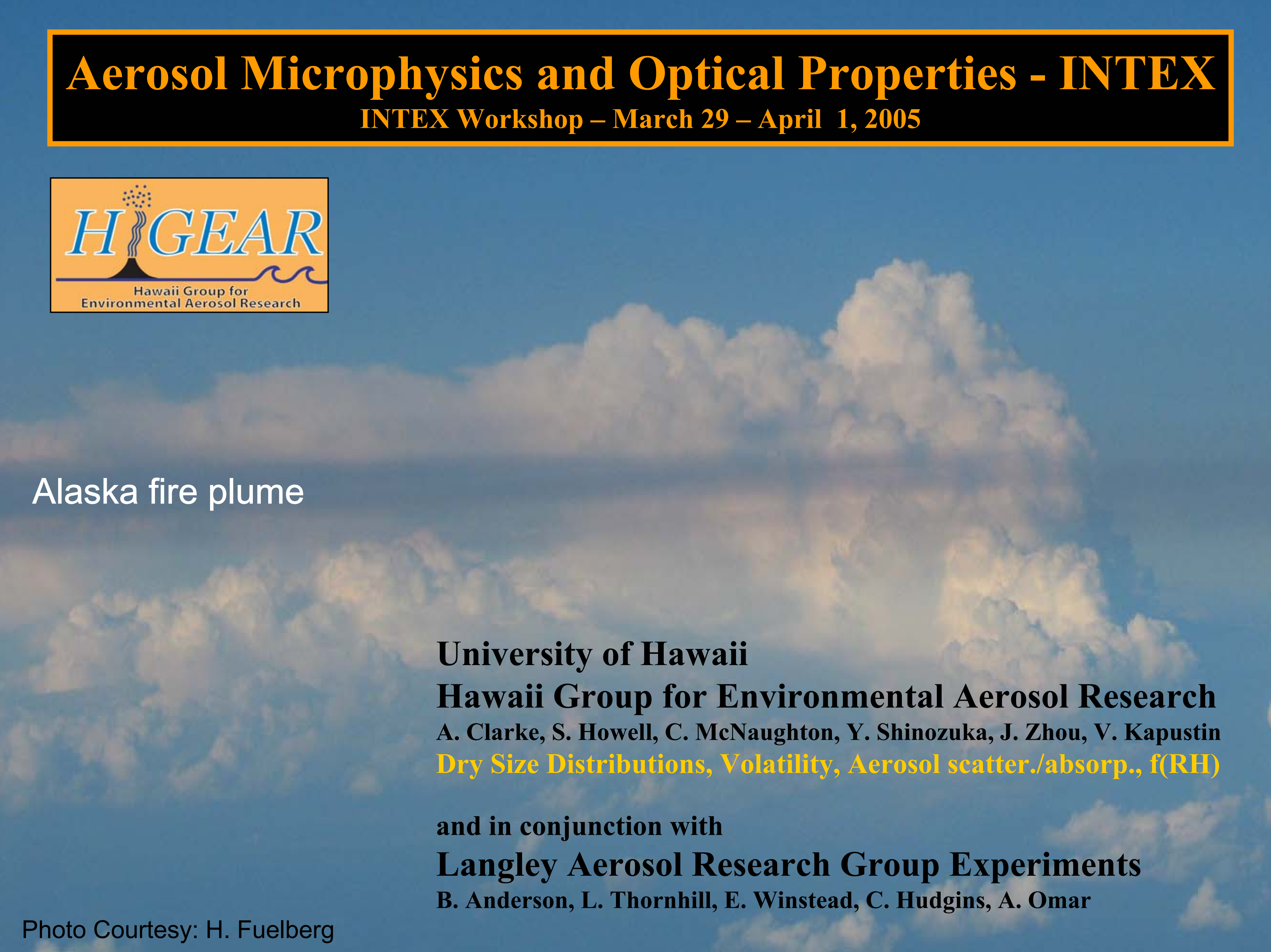
Aerosol Microphysics and Optical Properties - INTEX

INTEX Workshop – March 29 – April 1, 2005



Alaska fire plume

University of Hawaii

Hawaii Group for Environmental Aerosol Research

A. Clarke, S. Howell, C. McNaughton, Y. Shinozuka, J. Zhou, V. Kapustin

Dry Size Distributions, Volatility, Aerosol scatter./absorp., f(RH)

and in conjunction with

Langley Aerosol Research Group Experiments

B. Anderson, L. Thornhill, E. Winstead, C. Hudgins, A. Omar

Photo Courtesy: H. Fuelberg

Measurements

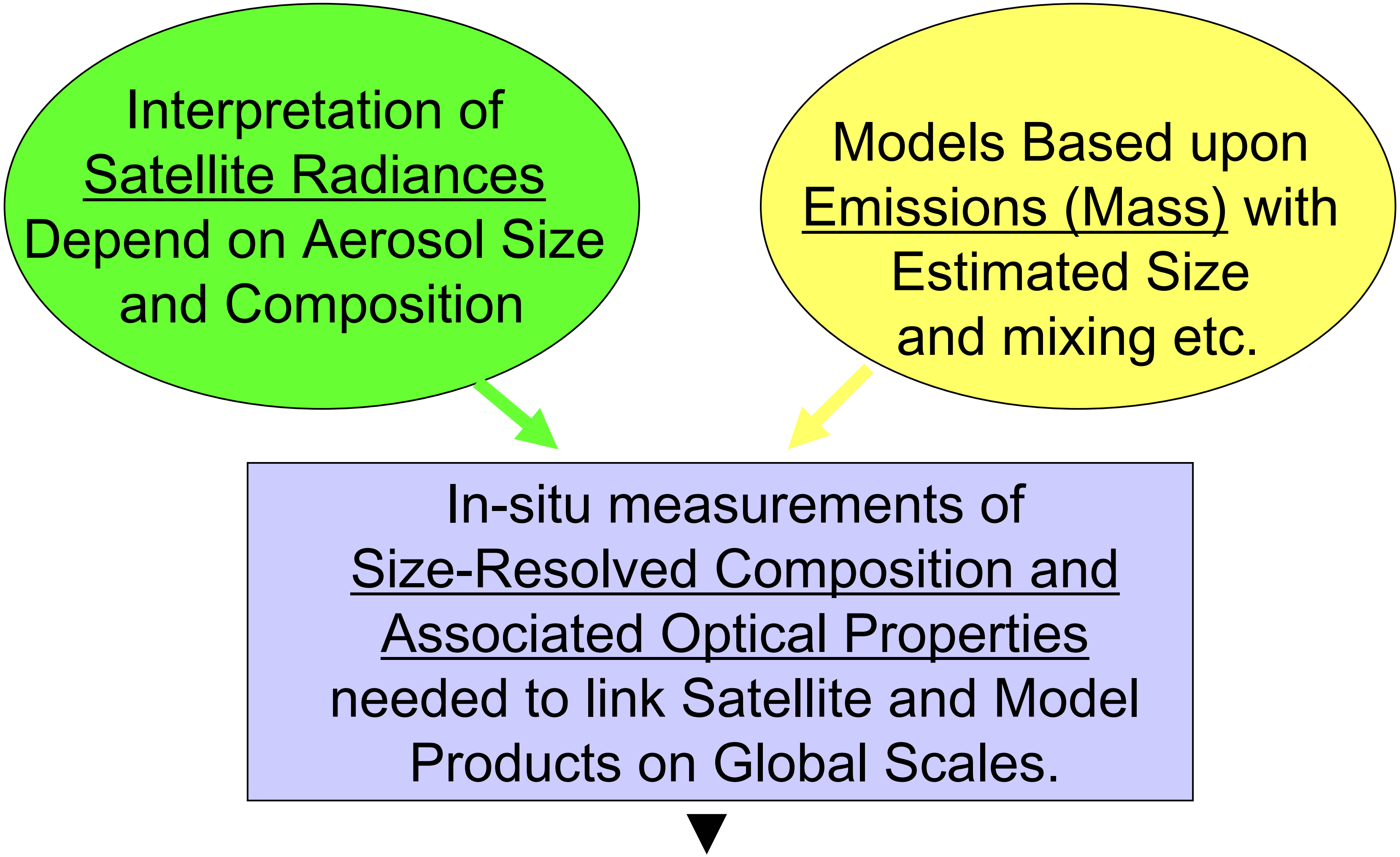
- Size distributions - DMA**(0.01-.15um); OPC** (0.15-1.5um); APS>1um
- Condensation Nuclei (total, refractory, volatile at 300C) (Dp > 0.10um)
- Ultrafine Condensation Nuclei (total) (Dp>0.003um)
- Light scattering & backscattering (Total and Submicron at 450, 550, 700nm)
- Light absorption (est. Black Carbon at 450, 550, 700nm)
- f(RH) or Gamma (humidity dependence of light scattering)

** OPC (processing correction)
DMA (size correction at small sizes)
Ultrafine (about 9% flow correction)
These will have revisions complete by next week ready for next merge
– replace with corrected data when merge available.

Some Interests and Objectives

- Size Distributions and Volatility as a measure of size-resolved composition and black carbon estimates
- Relation to aerosol humidity dependent growth and optics
- Spectral dependence of optical properties linked to sources
- Coupling of measured and model aerosol properties
- Atmospheric radiation and satellite products (MISR – MODIS)
- In-situ assessment of satellite estimates of CCN

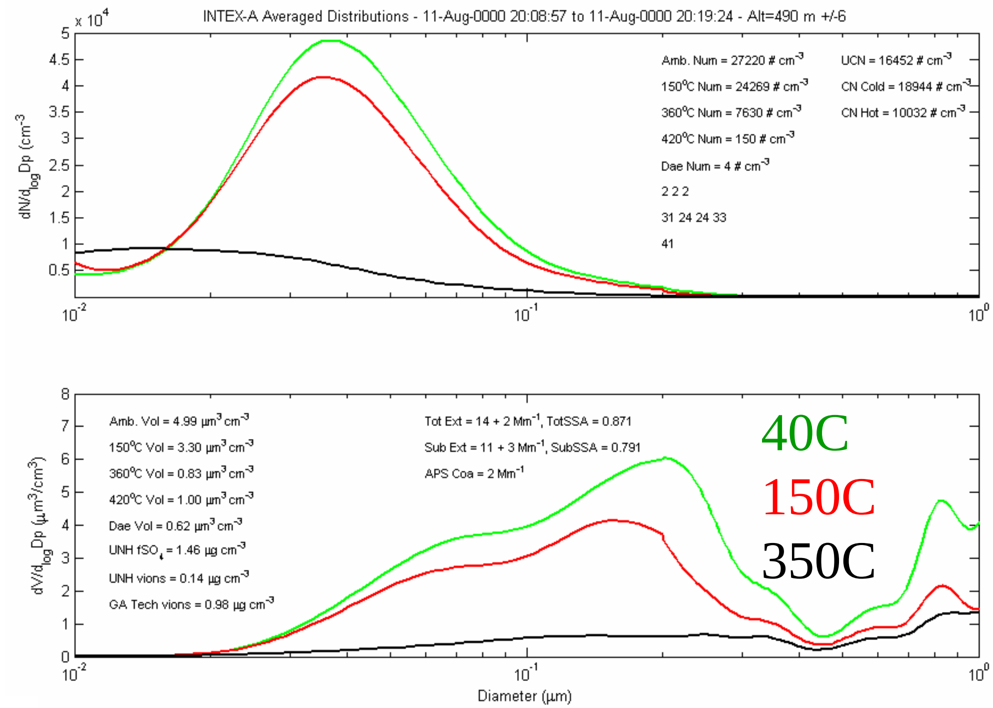
In-situ Aerosol Physiochemical Data Needed to Link Optically Derived Satellite Products to Emission (mass) Based Global Models

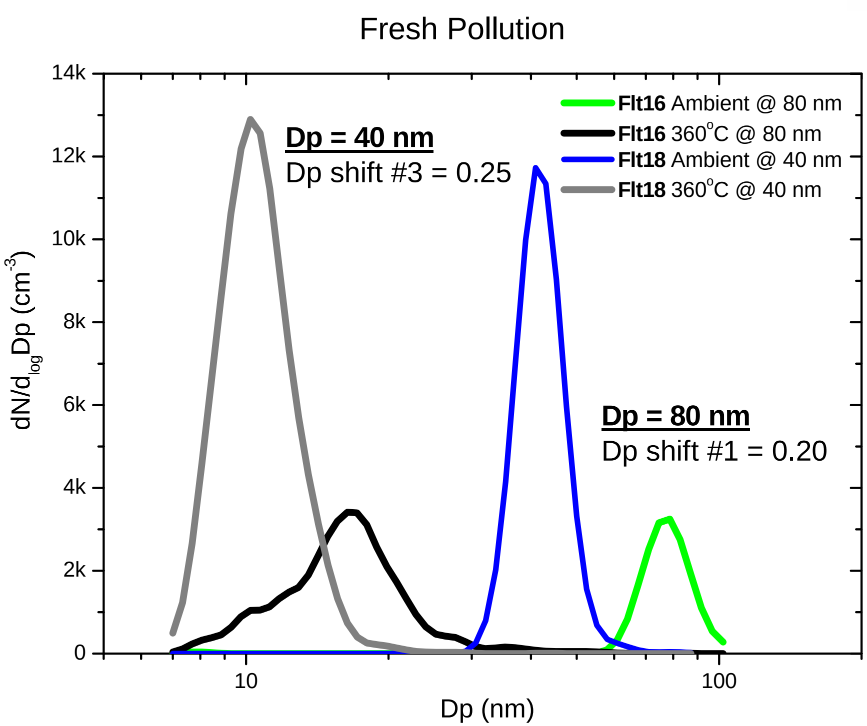


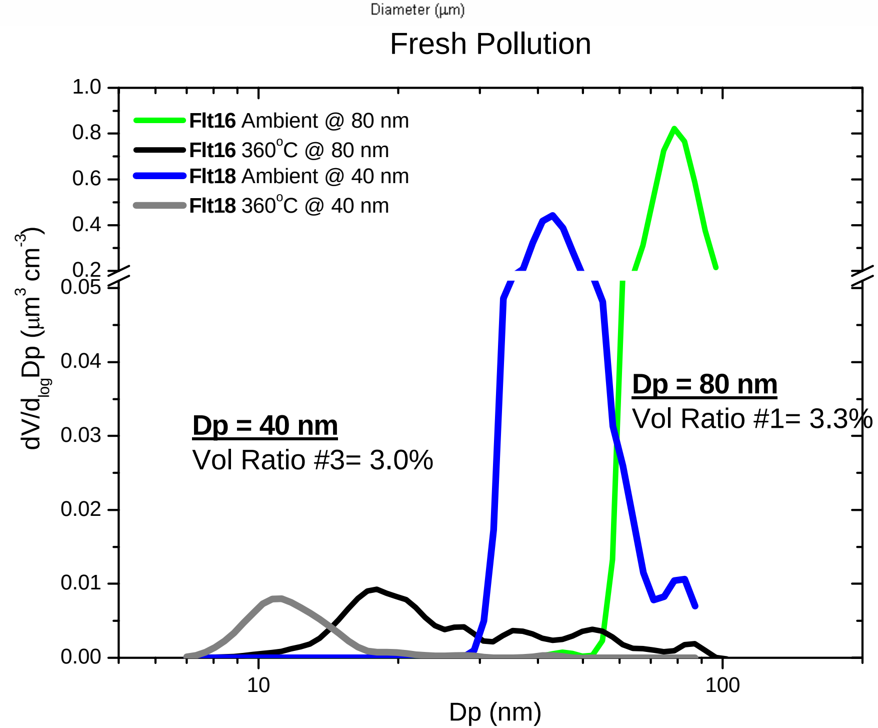
Global Satellite and Model Products Depend on Realistic Aerosol Physiochemistry and Optics for Regional Aerosol Types.

Thermally Resolved Composition

Flight 18 – Fresh Pollution On Approach to Mid-America, IL

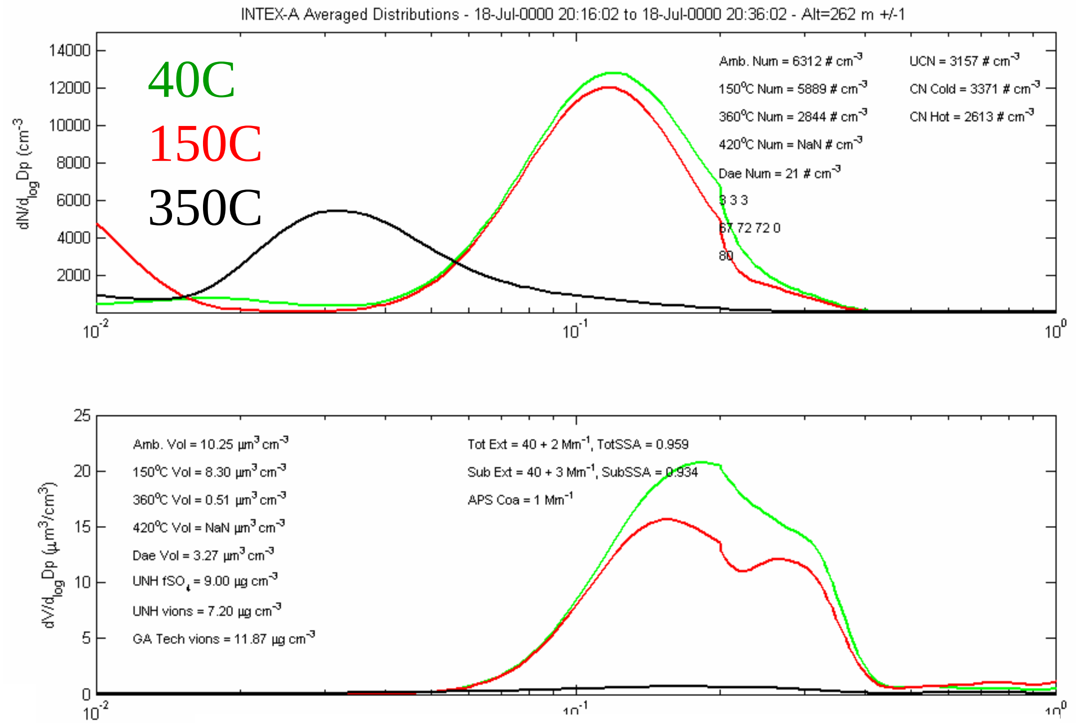


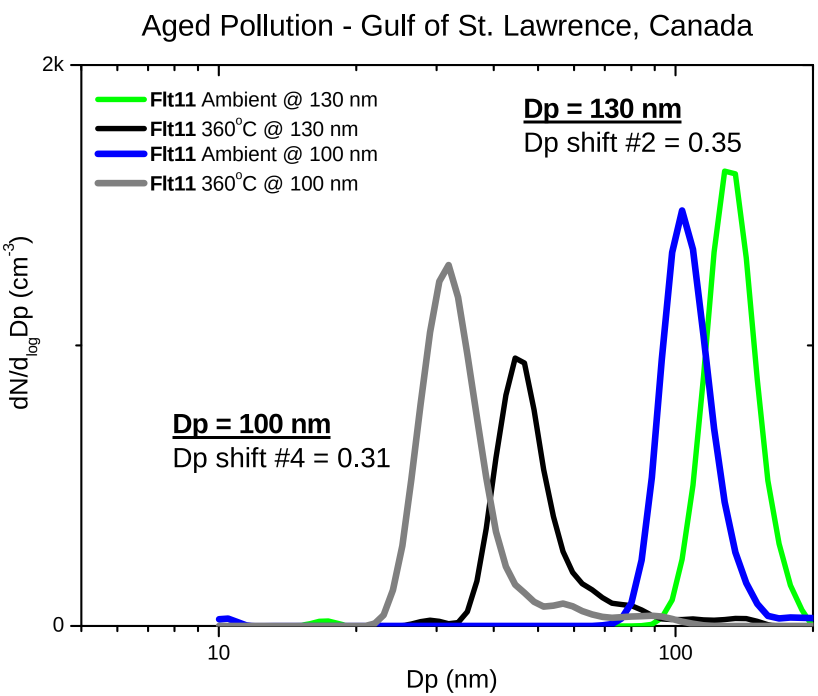


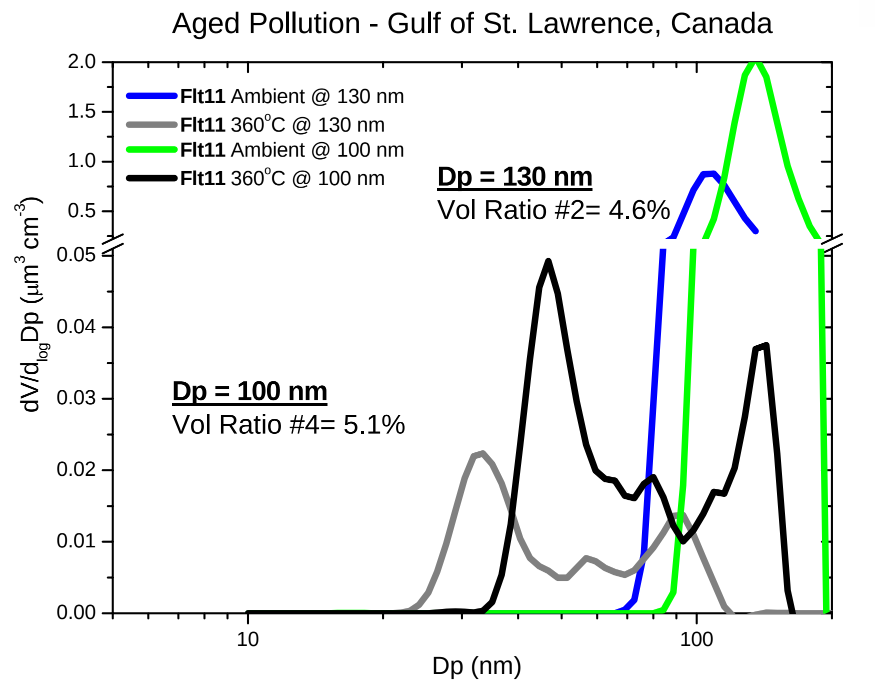


Thermally Resolved Composition

Flight 09 – Aged Pollution Southern Coast of Newfoundland, Canada

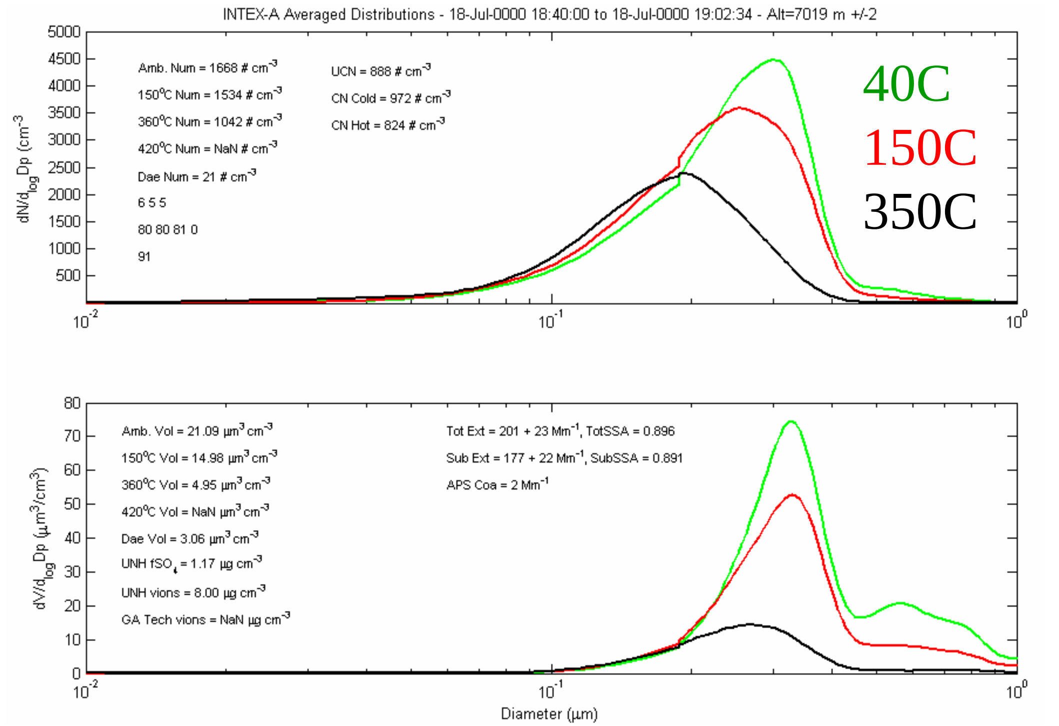


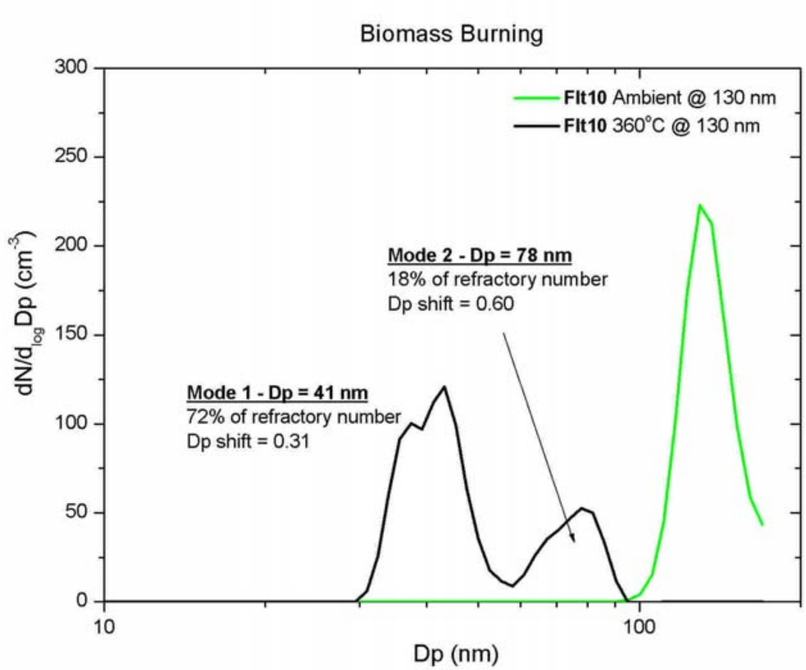


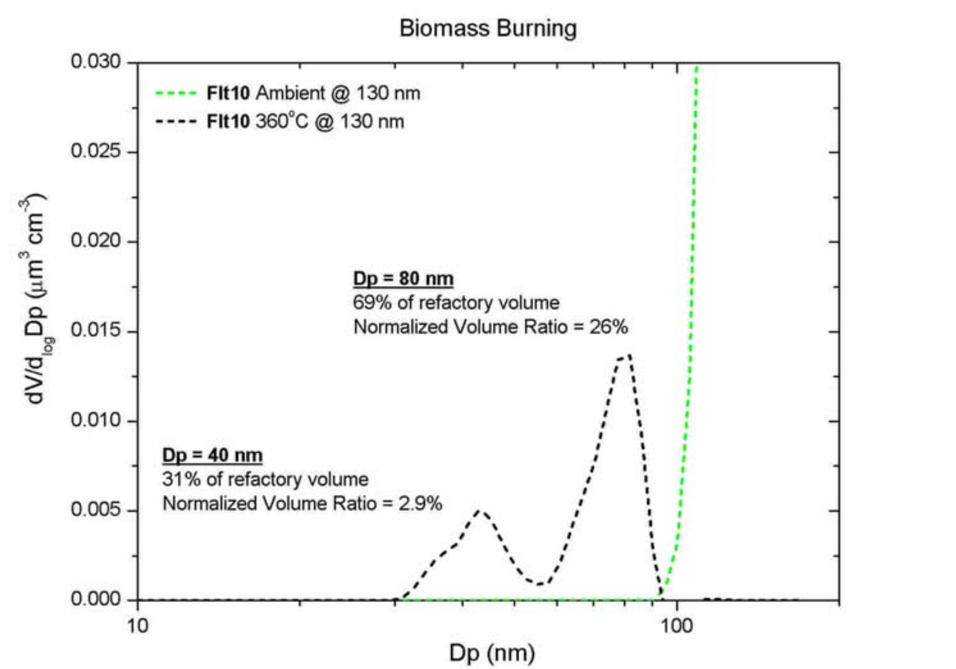


Thermally Resolved Composition

Biomass Burning Aloft over Huntsville at 3600m

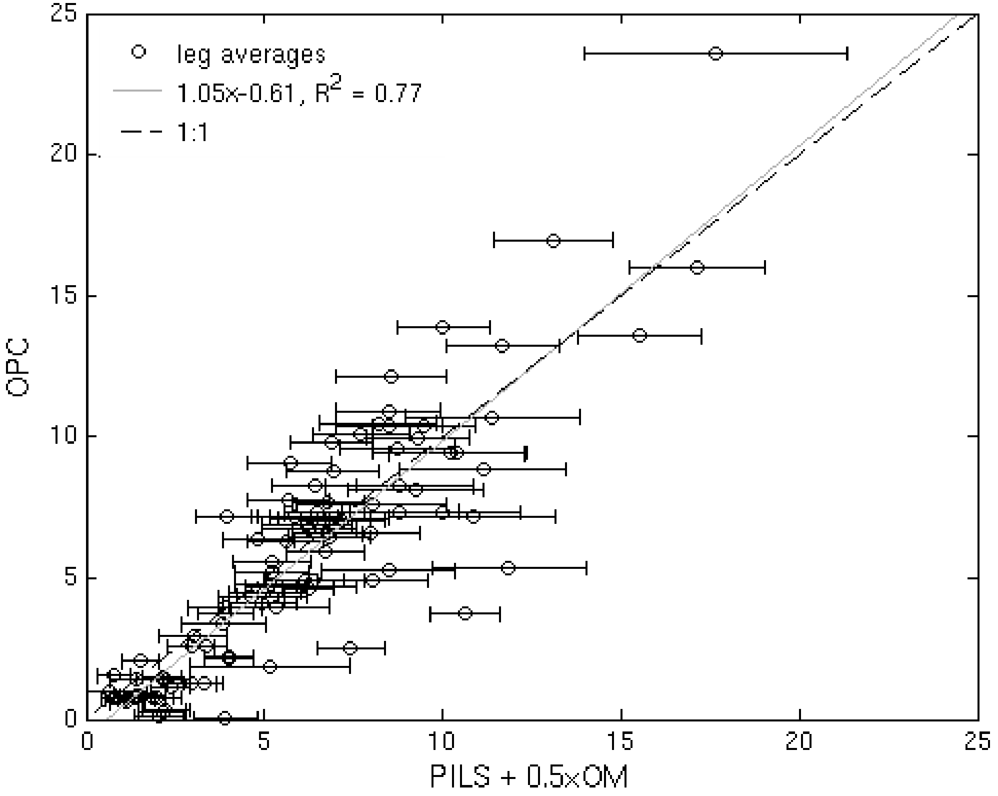






Link between aerosol volatile volume and sum of PILS soluble species and 1/2Organic Matter (OM) (soluble est.)

ACE-Asia: OM about 2 x SO4 mass



INTEX?

OM ?>SO4

OC vs. WSOC?

Significant Observations

Aerosol Optical properties are strongly influenced by water uptake by soluble species

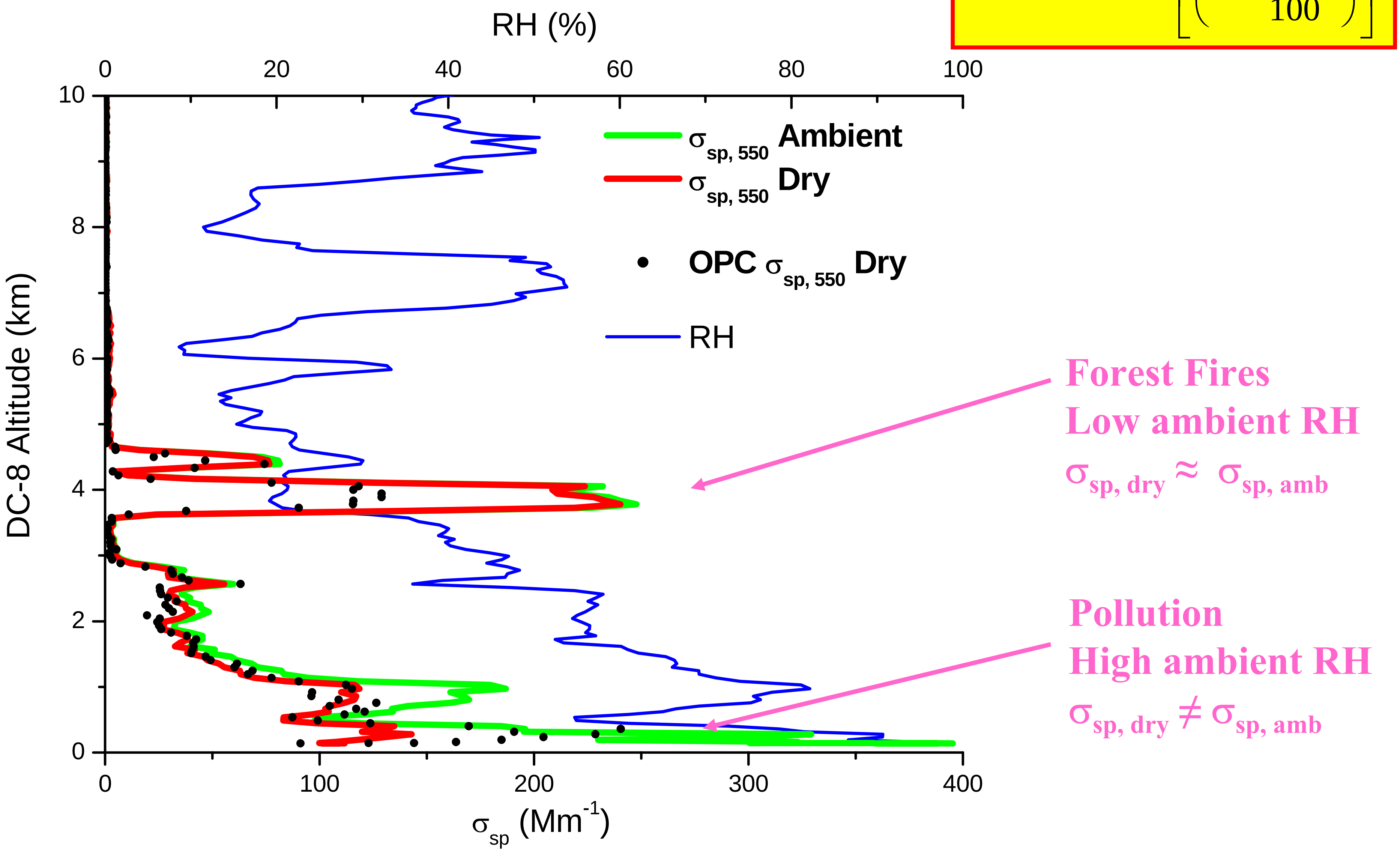
But

A significant fraction of INTEX aerosol can be Organic Matter (ICARRT data) and largely insoluble

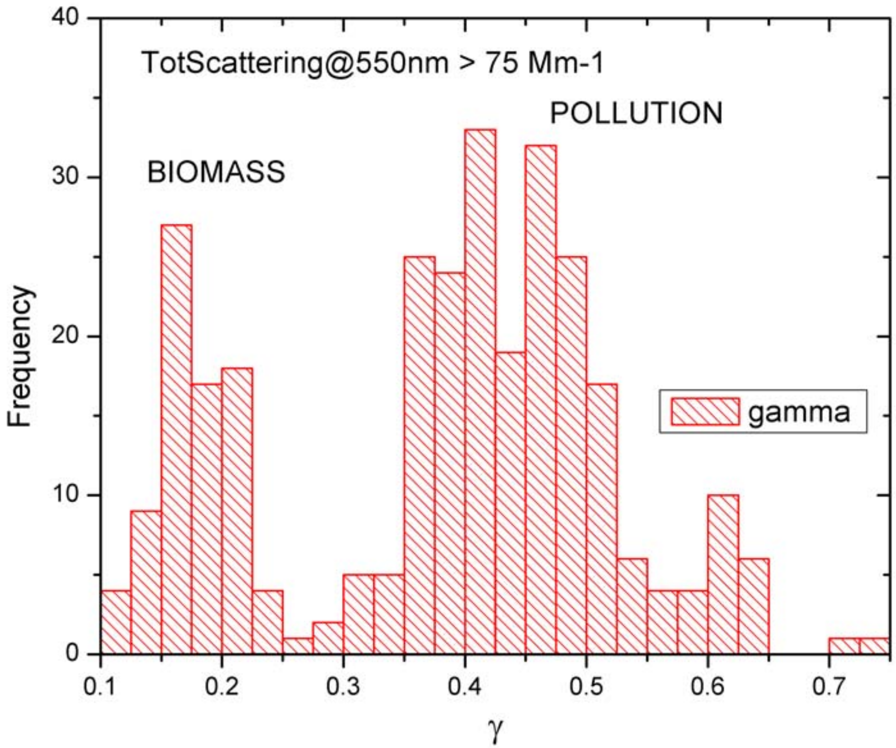
This changes our prior estimates of the response of regional light scattering to humidity described by f(RH) or gamma

Ambient light scattering is calculated from dry scattering using γ. Gamma is empirically derived from our *in-situ* measurements of f(RH) and ambient humidity.

$$\sigma_{sp,amb} = \sigma_{sp,dry} \cdot \left[\frac{\left(1 - \frac{RH_{dry}}{100}\right)}{\left(1 - \frac{RH_{wet}}{100}\right)} \right]^{\gamma}$$

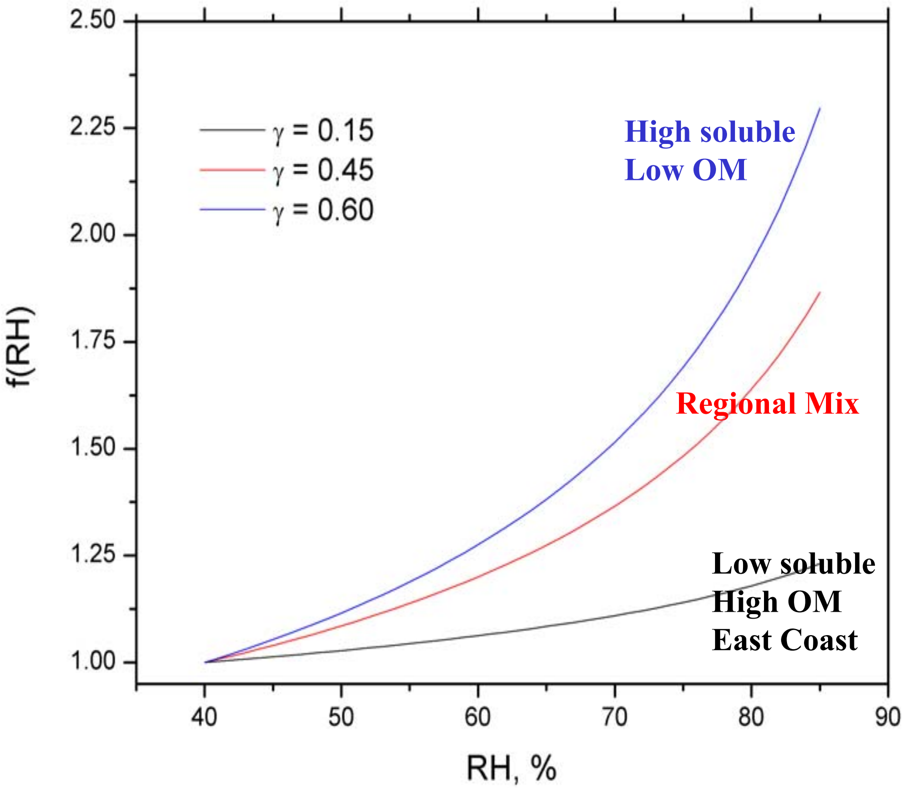


Frequency of γ for three common aerosol types evident during INTEX



$$\sigma_{sp,amb} = \sigma_{sp,dry} \cdot \left[\frac{\left(1 - \frac{RH_{dry}}{100}\right)}{\left(1 - \frac{RH_{wet}}{100}\right)} \right]^{\gamma}$$

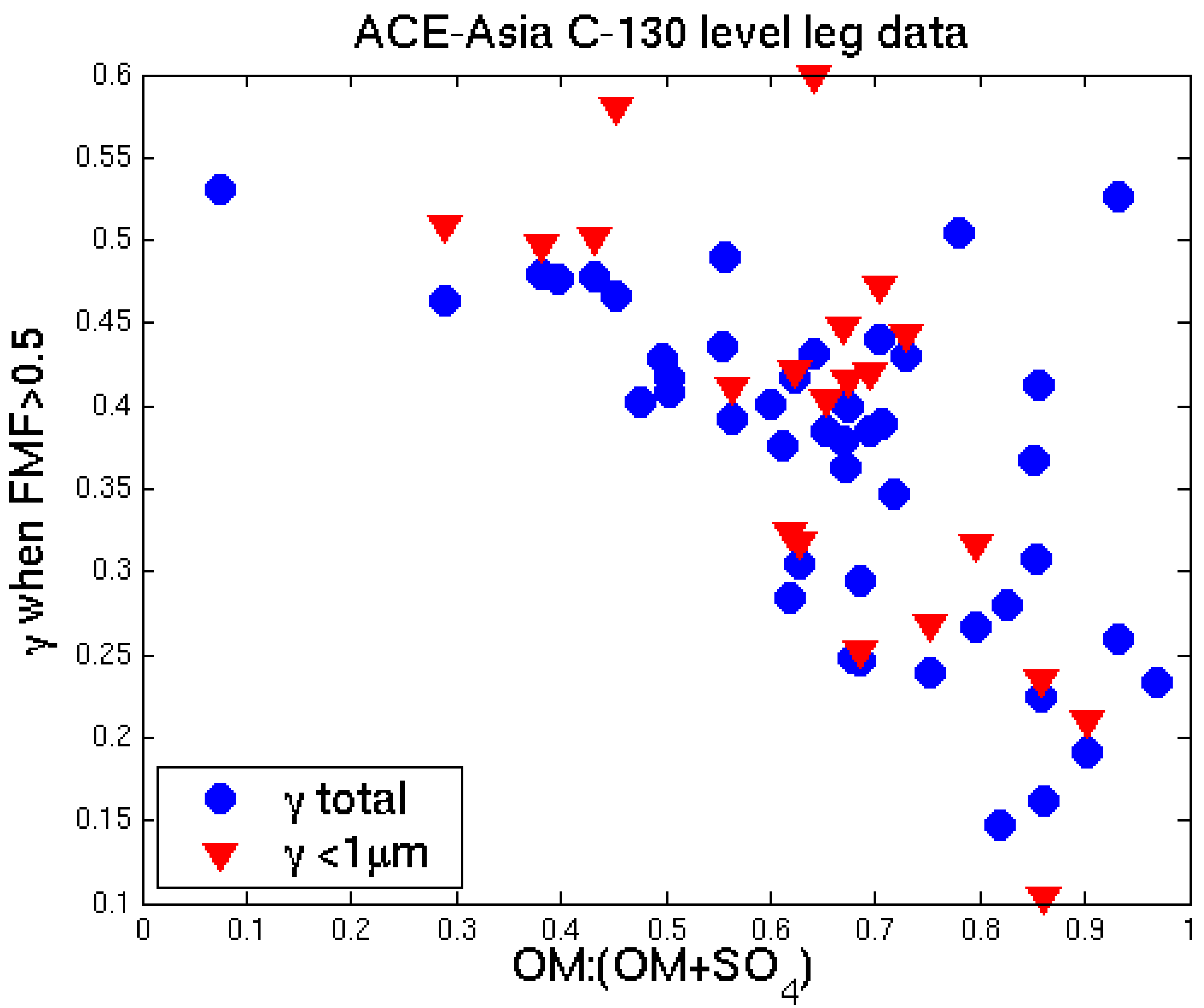
f(RH) dependence on gamma



HiGEAR
Hawaii Group for Environmental Aerosol Research

The decrease in f(RH) or γ due to the presence of increasing fine mode organic aerosol fraction – ACE-Asia

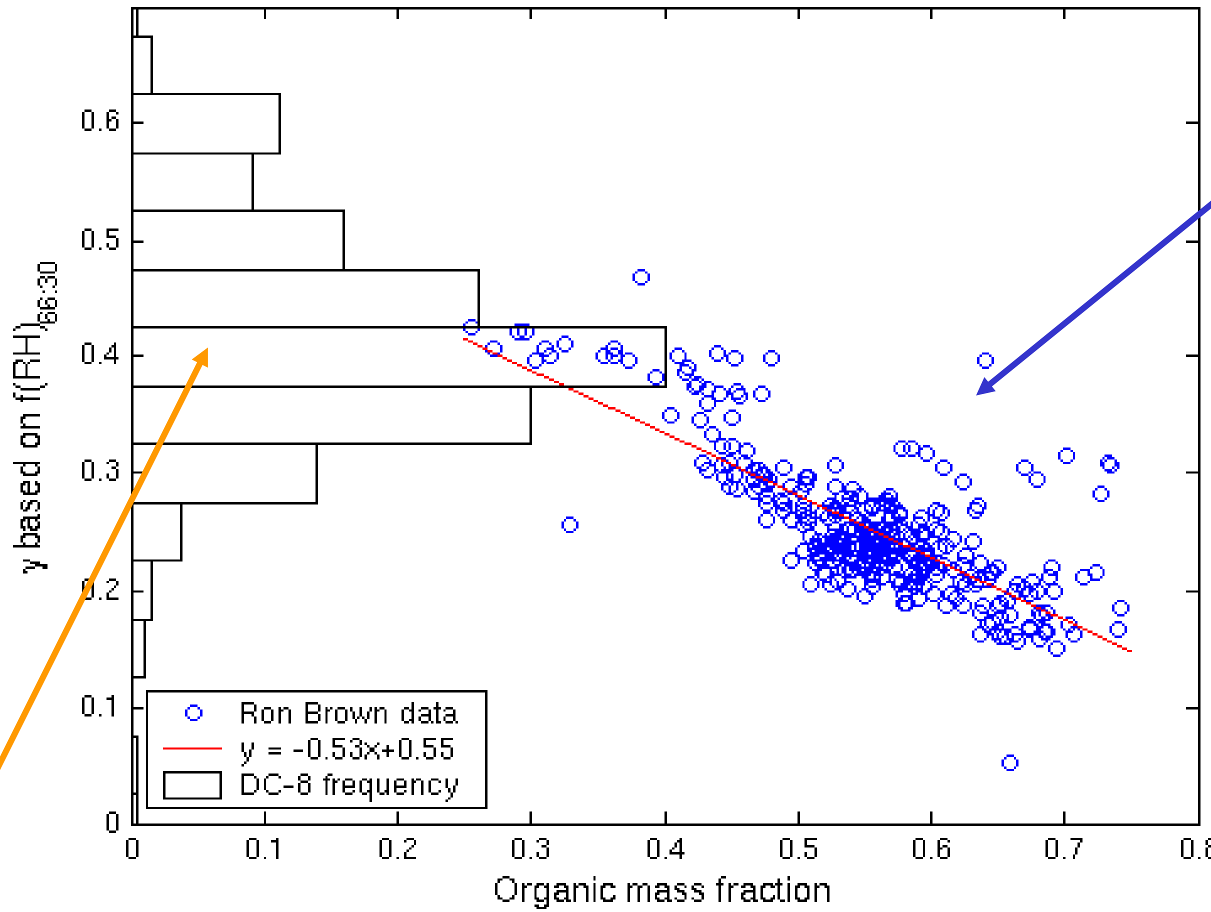
S. Howell, A. Clarke, B. Huebert, R. Weber –for CCSP Assessment 2005



Increasing Organic Mass Faction >>>>>

The decrease in f(RH) or gamma due to the presence of increasing fine mode organic aerosol fraction – ICARRT/INTEX

P. Quinn, T. Bates, T. Baynard, S. Howell, A. Clarke –for CCSP Assessment 2005

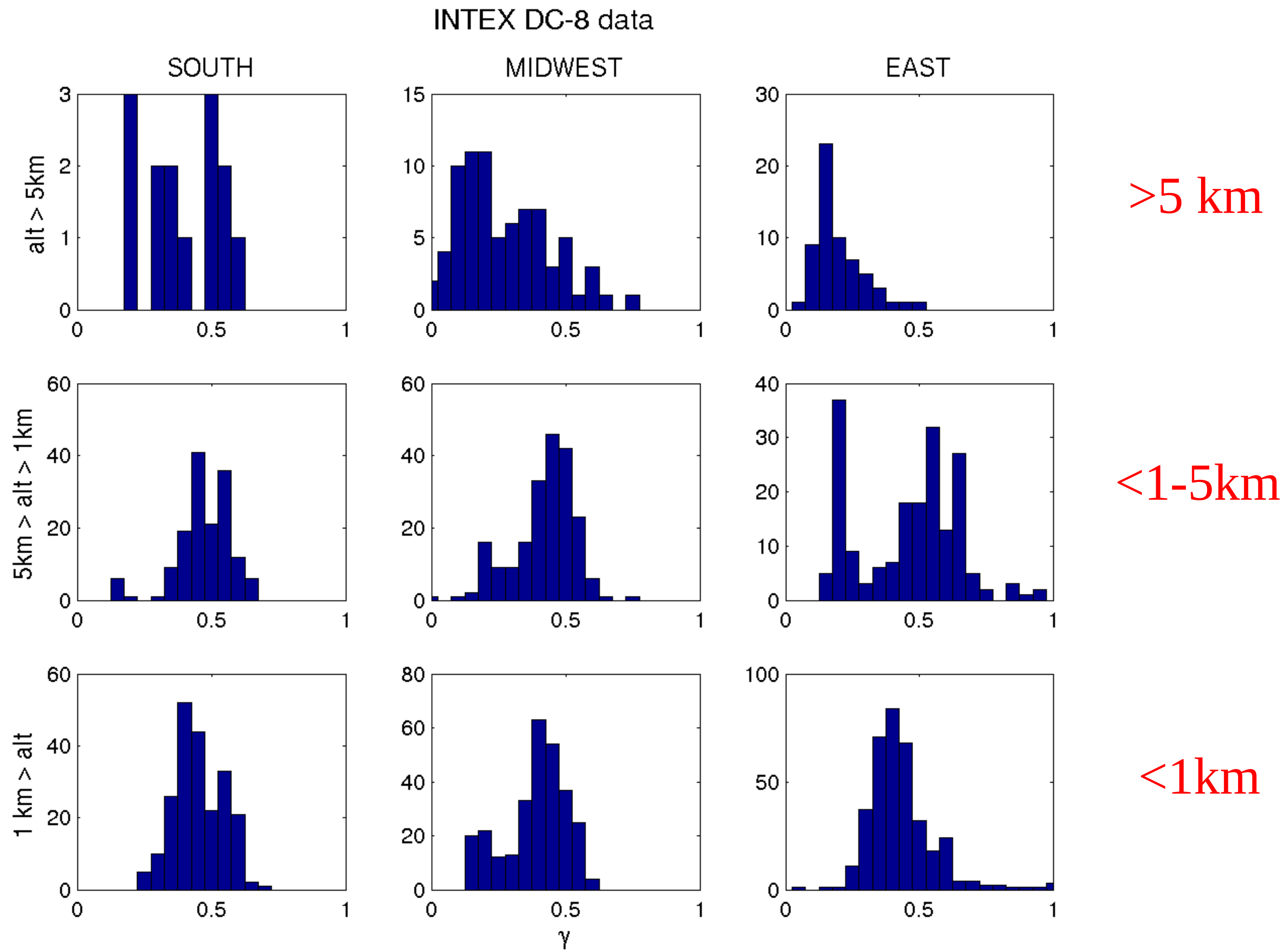


Ron Brown data for low level outflow off continent over Gulf of Main, ICARRT.

Increasing Organic Mass Fraction >>>>>

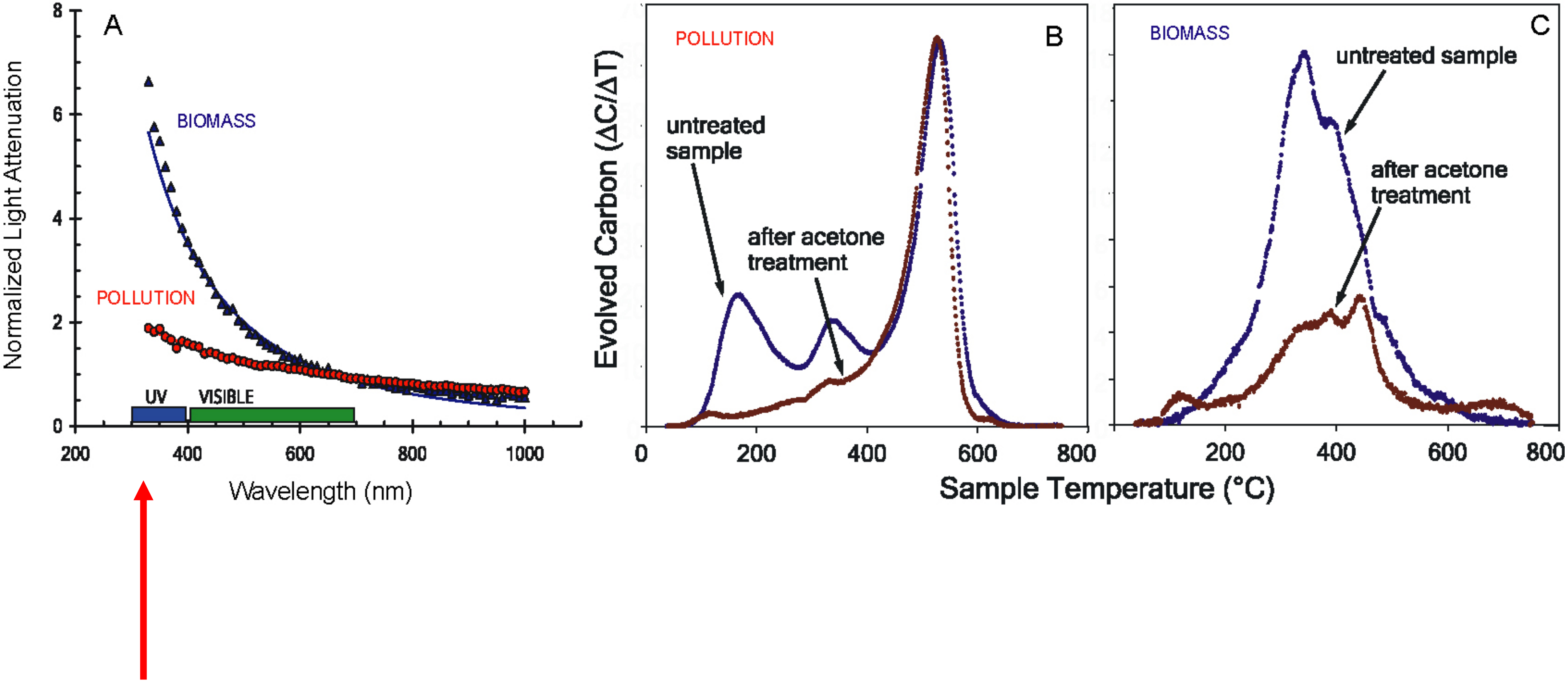
Histogram for all DC-8 data below 2km and east of 75W, INTEX

Some Altitude and Regional variations in Gamma (f(RH) Tendency for Mid-level increases in f(RH) relative to surface except for biomass influence but generally lower values aloft –> different chemistry



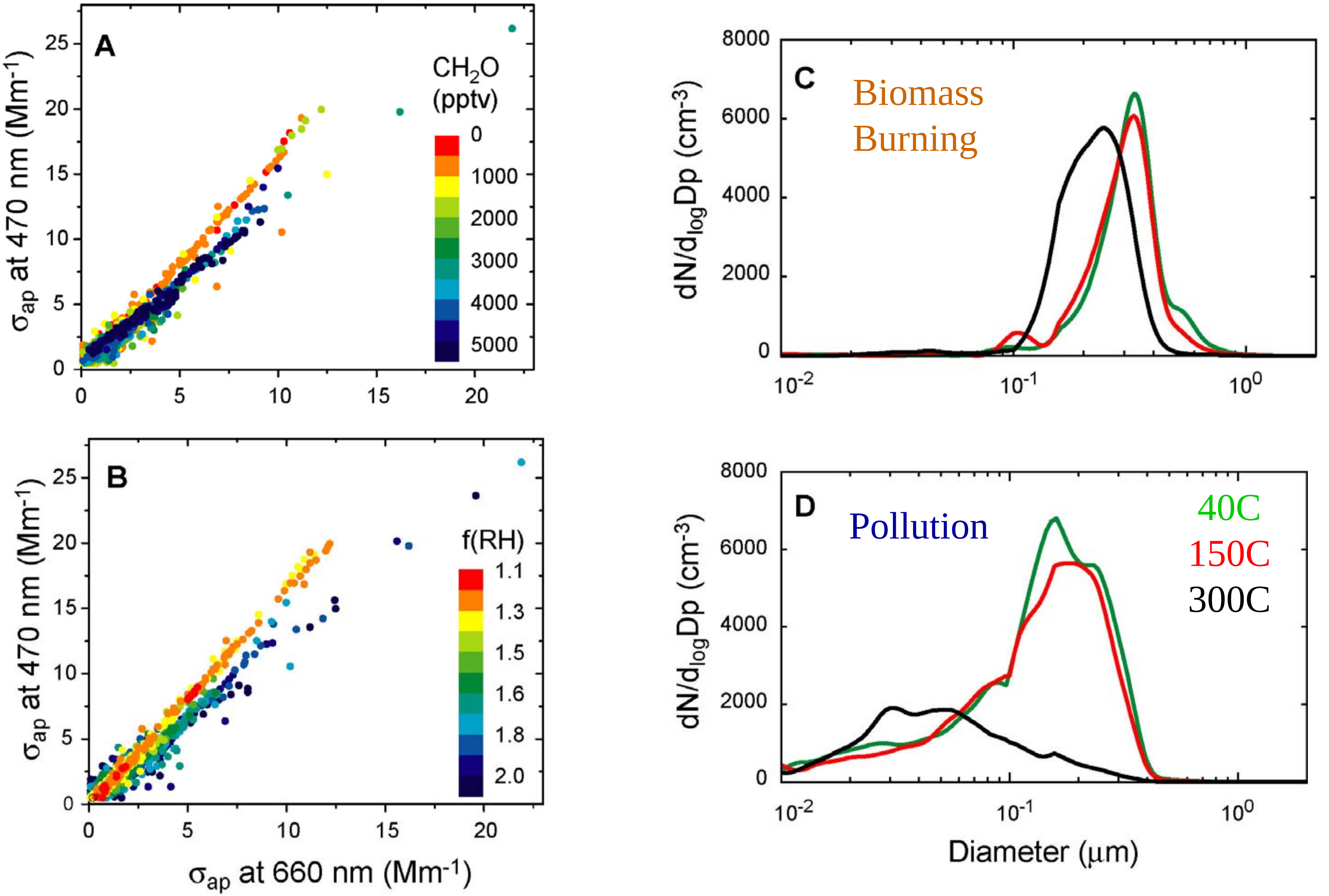
Spectral dependence of absorption recently related in part to Organic Matter and its differences in Pollution and Biomass Aerosols As evidenced in their thermal evolution before and after acetone treatment.

Kirchstetter et al., JGR, D21208,2004 :Spectral light absorption by aerosols

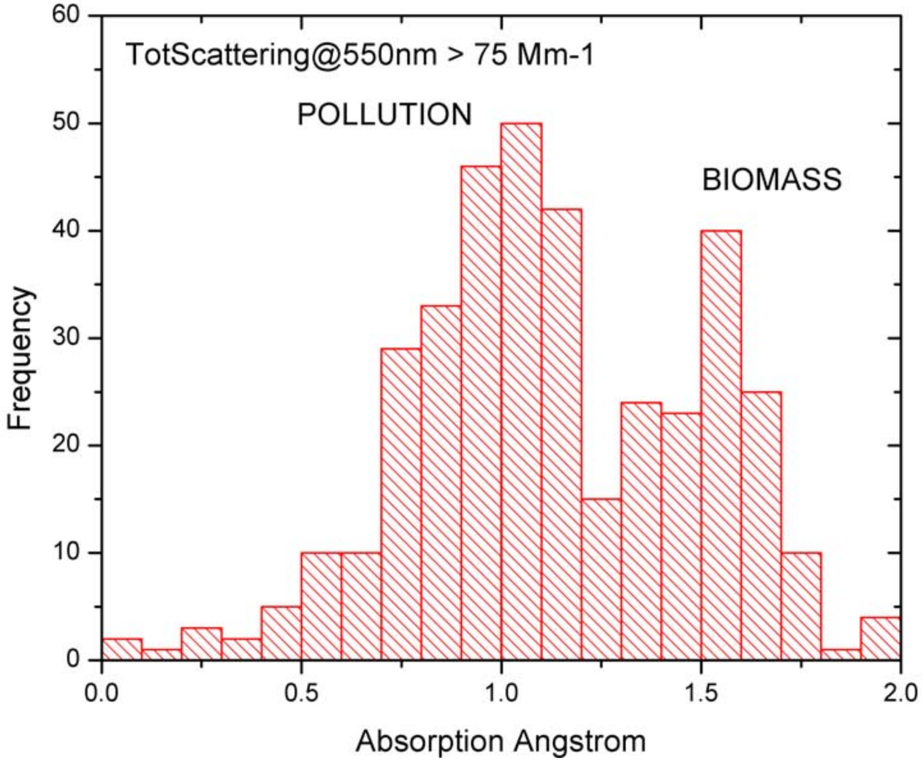


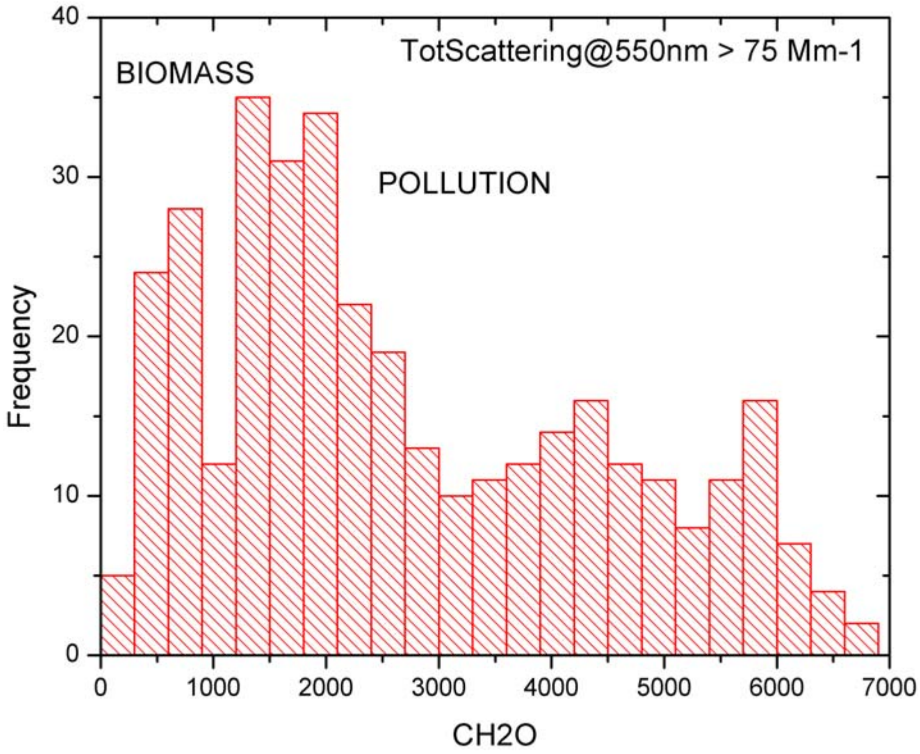
Biomass absorbs toward UV due to high temperature refractory organics

Spectral dependence of scattering and absorption also related to Differences in Size-Distributions of scattering and absorbing components

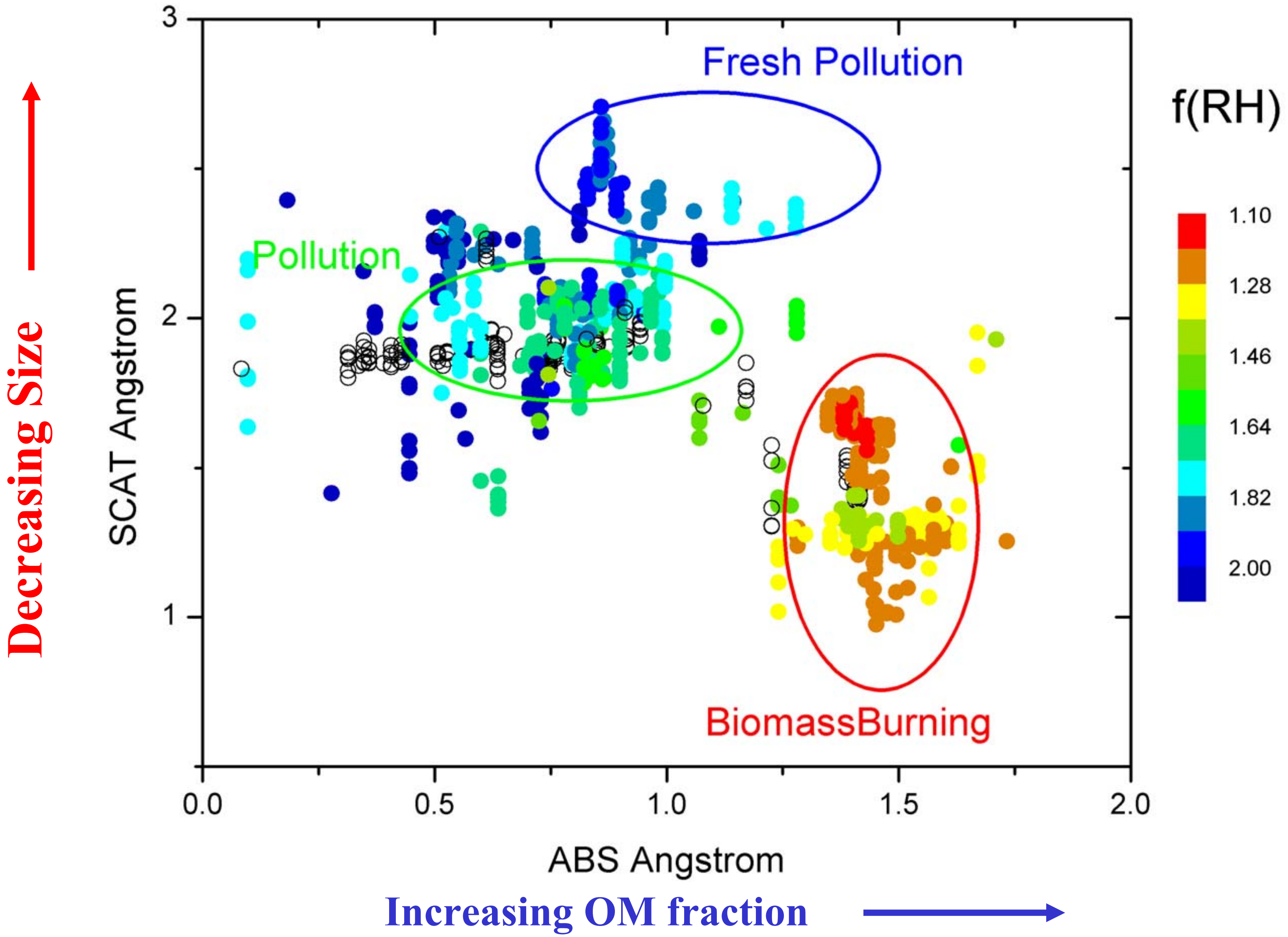


Histograms of distributions for Absorption Angstrom and Formaldehyde Pollution and Biomass Highlighted

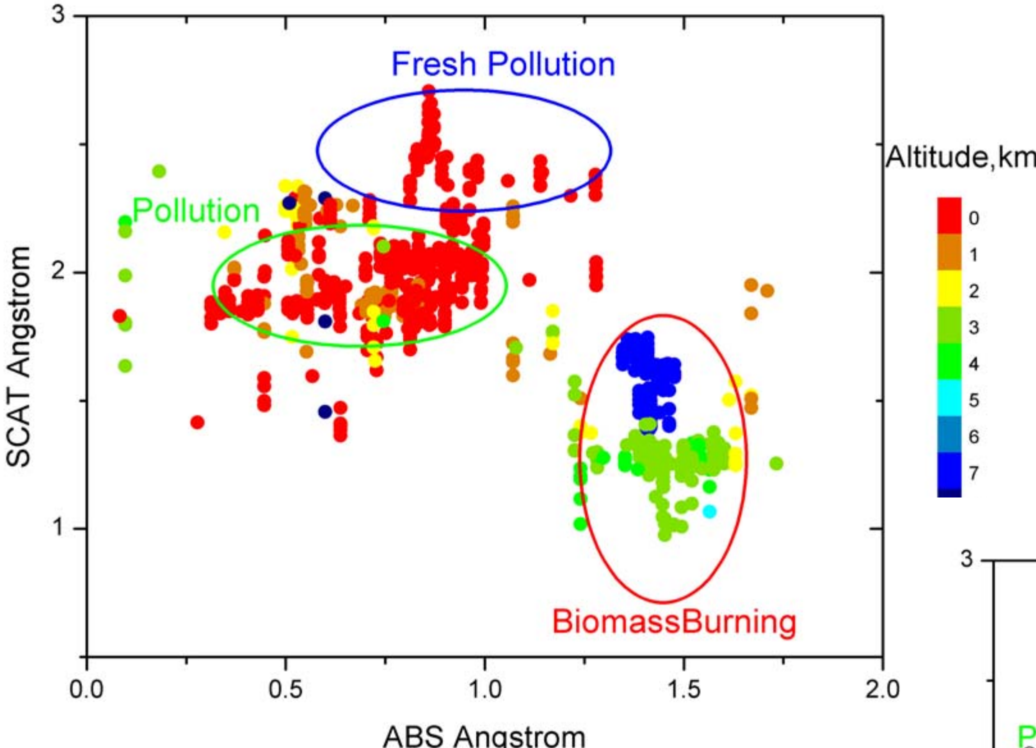


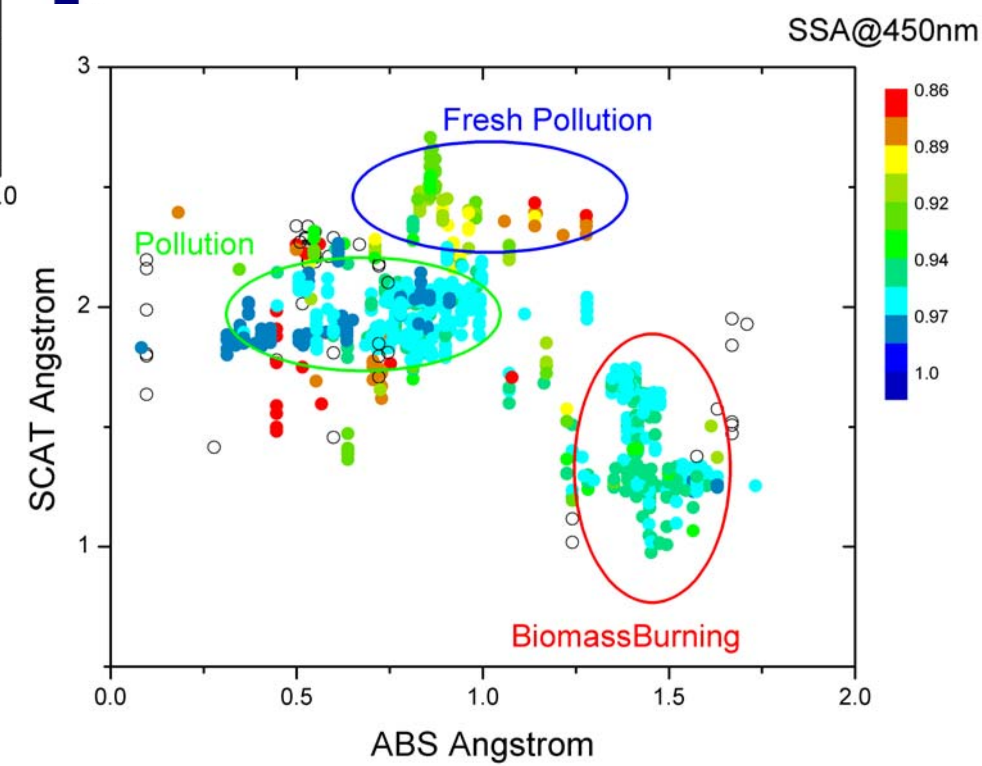


Source types resolved by spectral dependence of scattering and absorption
Color coded with f(RH)

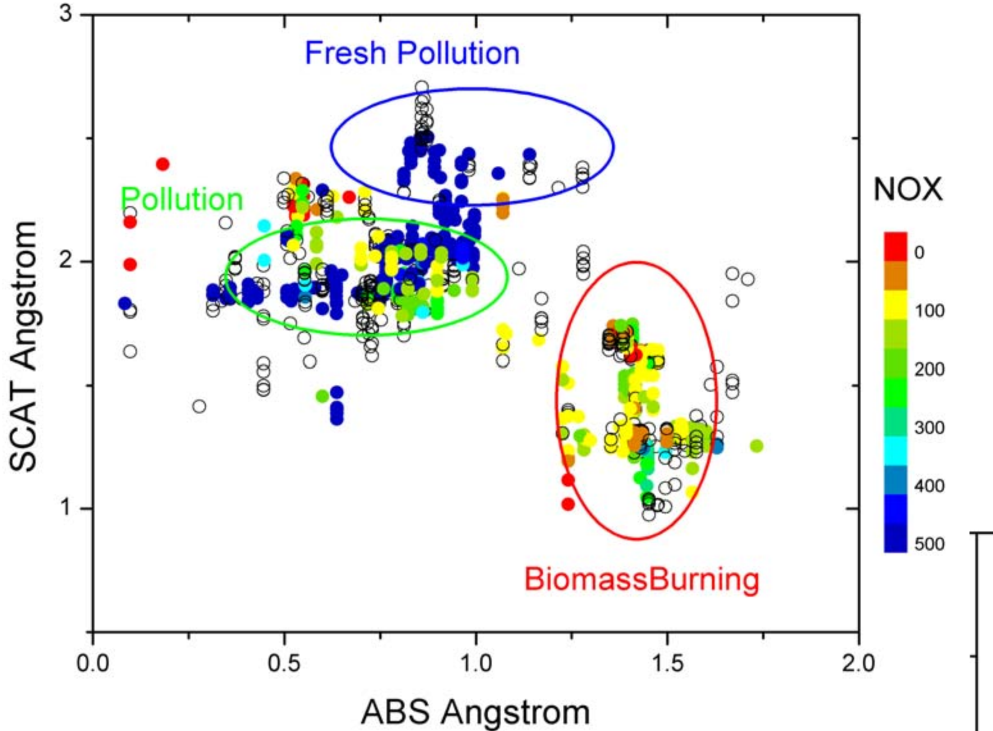


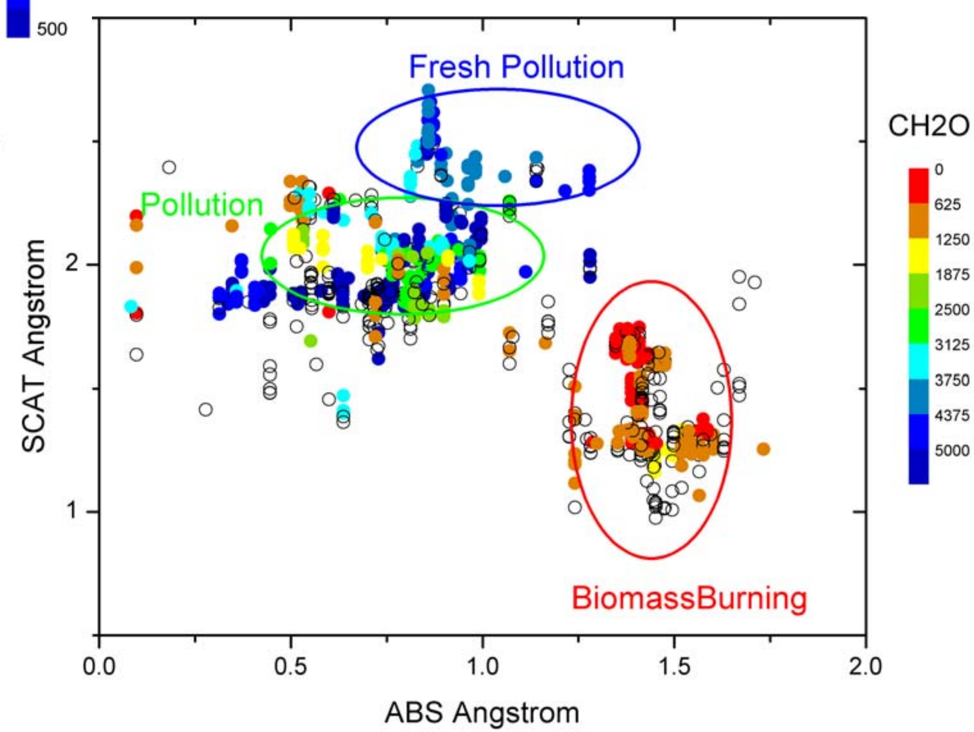
Source types resolved by spectral dependence of scattering and absorption
Altitude dependence and Relation to Single Scatter Albedo





Source types resolved by spectral dependence of scattering and absorption
Relation to gas phase indicators





CONCLUSIONS

- Regional physio-chemical-optical characteristics may help stratify the roles of Black carbon and condensed species for model refinements.
- f(RH) - Humidity growth is strongly modulated by OM fraction and must be recognized in optical properties reflected in models and satellite retrievals.
- Optical closure with satellites coupled to regional aerosol characterization shows promise in refining satellite retrievals and links to source emissions.
- Size, composition, optics and growth measurements provide a means to estimate the potential for satellite retrieval of CCN.

Potential INTEX Papers

- **Pollution and biomass burning aerosol over North America: Black carbon, f(RH), microphysics and optics** – A. Clarke, V. Kapustin, S. Howell, Y. Shinozuka, C. McNaughton, R. Weber et al.

- **In situ aerosol optical closure experiments under MISR** – C. McNaughton, R. Kahn, P. Russell, Y. Shinozuka, A. Clarke et al.

- **An evaluation of multimodal aerosol retrievals for MODIS and MISR as a tool to obtain a CCN proxy** - Y. Shinozuka, V. Kapustin, A. Clarke, et al.

- **An assessment of measured & modeled aerosol size resolved concentrations and optical parameters during INTEX** – C. McNaughton, G. Carmichael, A. Clarke, Y. Tang, et al.)