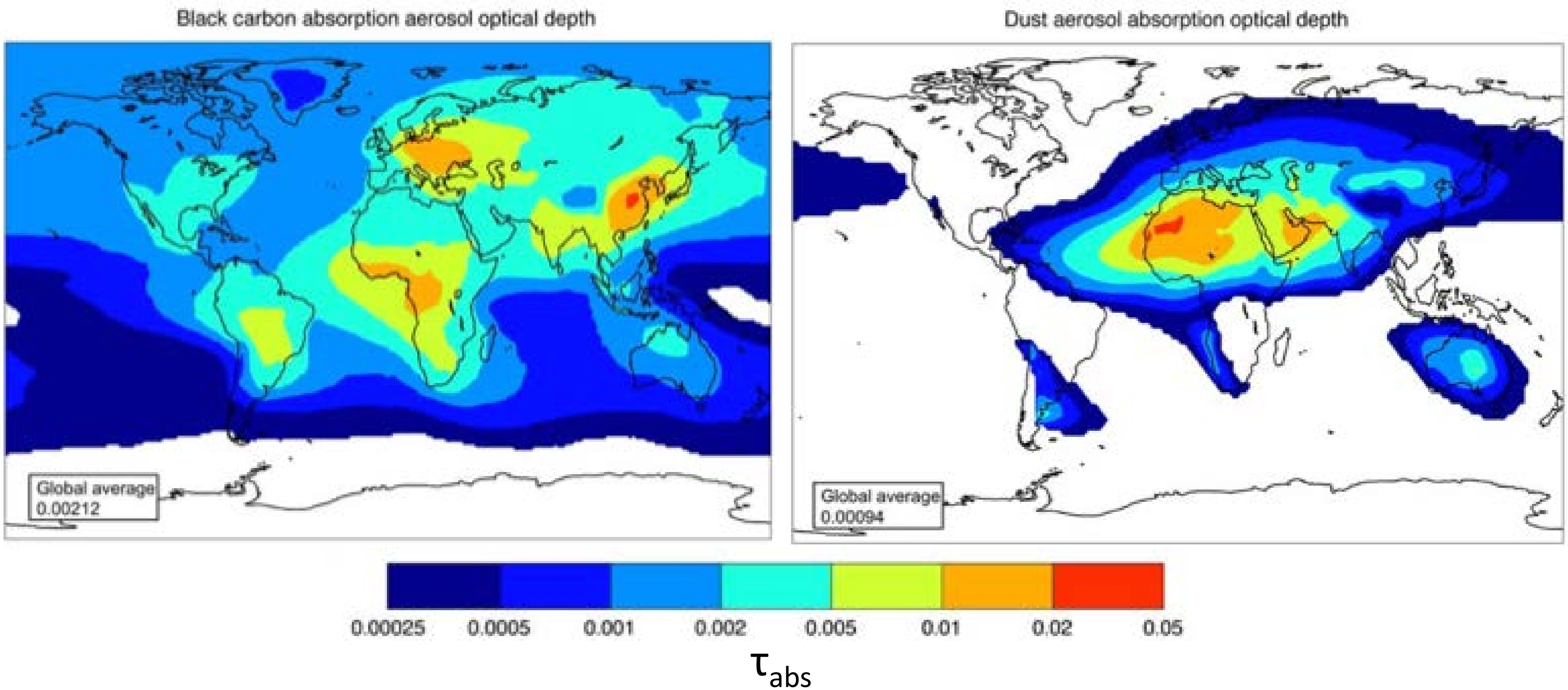
ALWG: Absorbing Aerosol Breakout

Direct Radiative Forcing by Aerosol

$$F = \tau \times AFE$$

$$AFE = f(\omega, g)$$

Attribution of radiative forcing to different atmospheric constituents is important for informing policy and model evaluation



50% of the uncertainty in BC radiative forcing has been attributed to separating the contributions of dust and BC to absorbing aerosol optical depth

Bond et al. 2013

Direct Radiative Forcing by Black Carbon

$$F = \underbrace{\overbrace{E \times L}^{B} \times MAC}_{\tau_{aBC}} \times AFE$$

where

F = global mean anthropogenic BC direct radiative forcing

E = global mean anthropogenic BC emissions

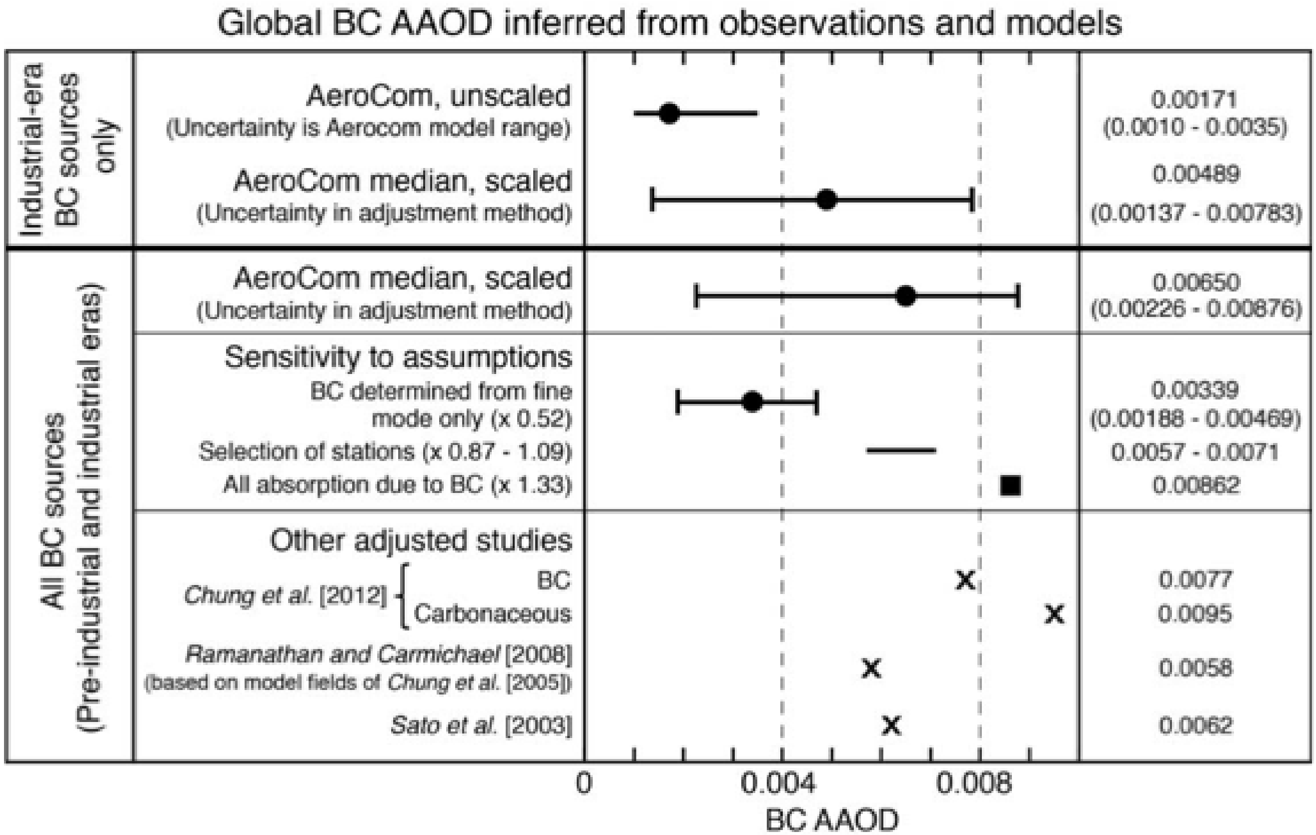
L = global mean lifetime = global mean anthropogenic BC burden B / E

MAC = global mean BC mass absorption cross section

= global mean anthropogenic BC absorption optical depth τ_{aBC} / B

AFE = anthropogenic BC absorption forcing efficiency = F / τ_{aBC} (from models)

So $$F = \tau_{a_{BC}} \times AFE$$



Bond et al. 2013

Speciating Absorbing Aerosol from AOS Observations

Rao Kotamarthi, Yan Feng, Maria Cadeddu and Narendra Ojha

Spectral differencing for speciation of absorption

For submicron (<1 micron) particles and assuming dust is negligible

$$Absp_i = Absp_{BC,i} + Absp_{BrC,i}$$

(i=467,530 and 660 nm)

$$Absp_{BC,i} = Absp_{BC,ref}\left(\frac{wavl_i}{wavl_{ref}}\right)^{-(\lambda_{BC,i,ref})}$$

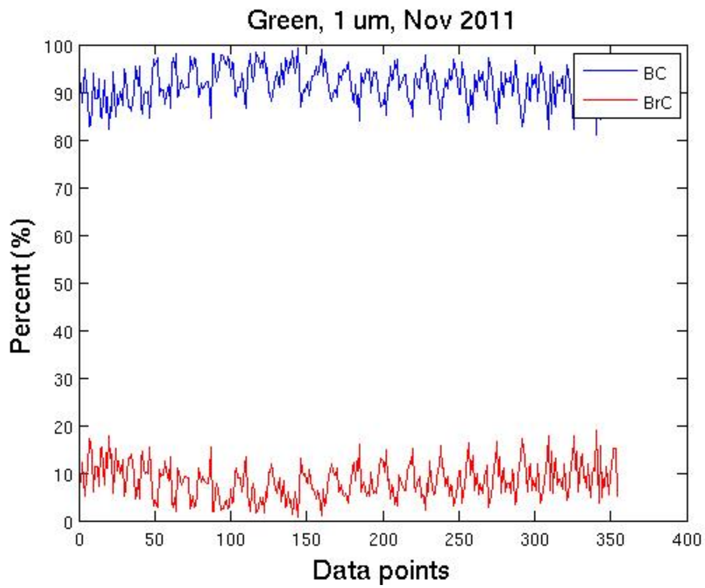
$$Absp_{BrC,i} = Absp_{BrC,ref}\left(\frac{wavl_i}{wavl_{ref}}\right)^{-(\lambda_{BrC,i,ref})}$$

$Absp_i = absorption\ coefficient$

$Absp_{BC,i} = absorption\ angstrom\ \ exponent\ \ BC(0.8-1)$

$\lambda_{BrC,i} = absorption\ angstrom\ exponent\ of\ BrC(\sim 4.4)$

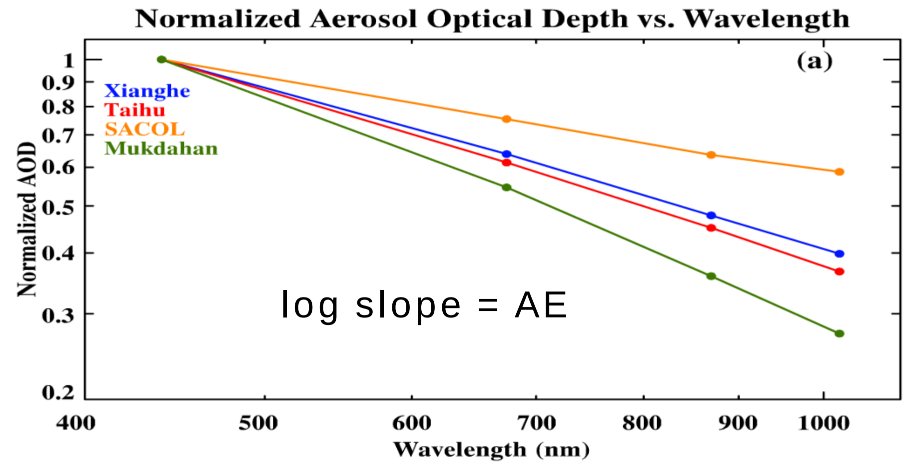
$wavl_i = wavelength\ measured$

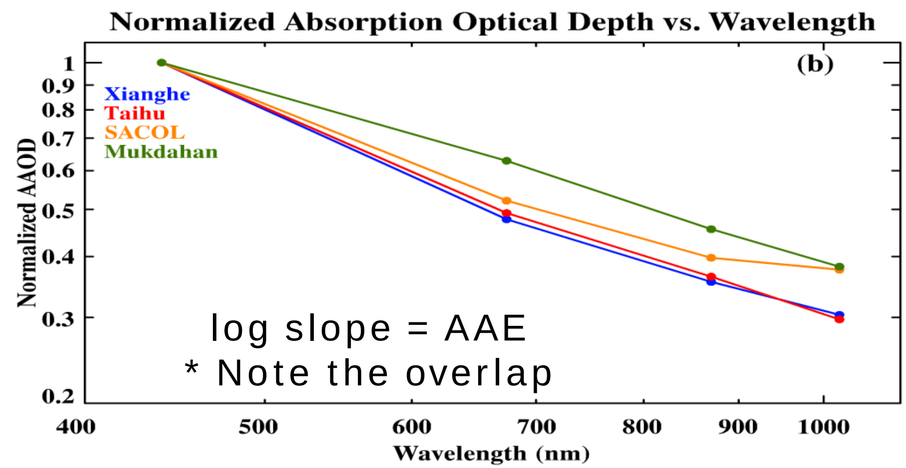


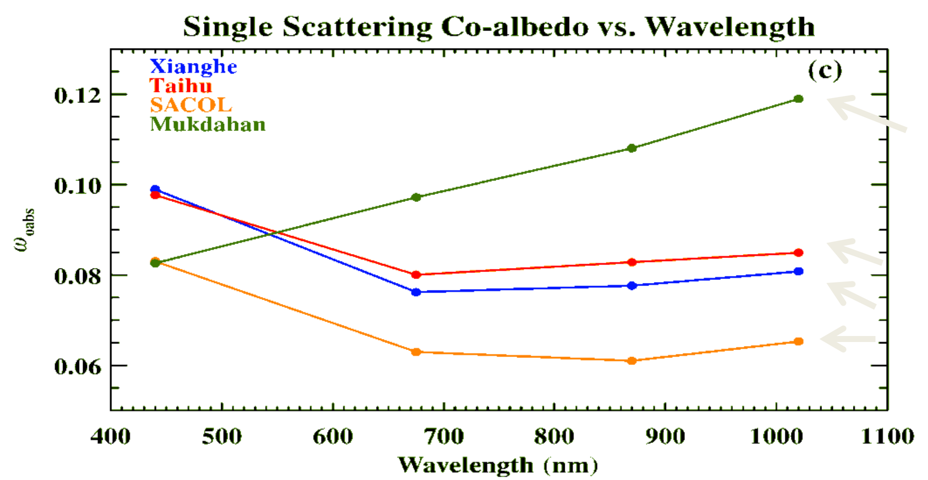
Monthly mean BC and BrC fractions (<1um)

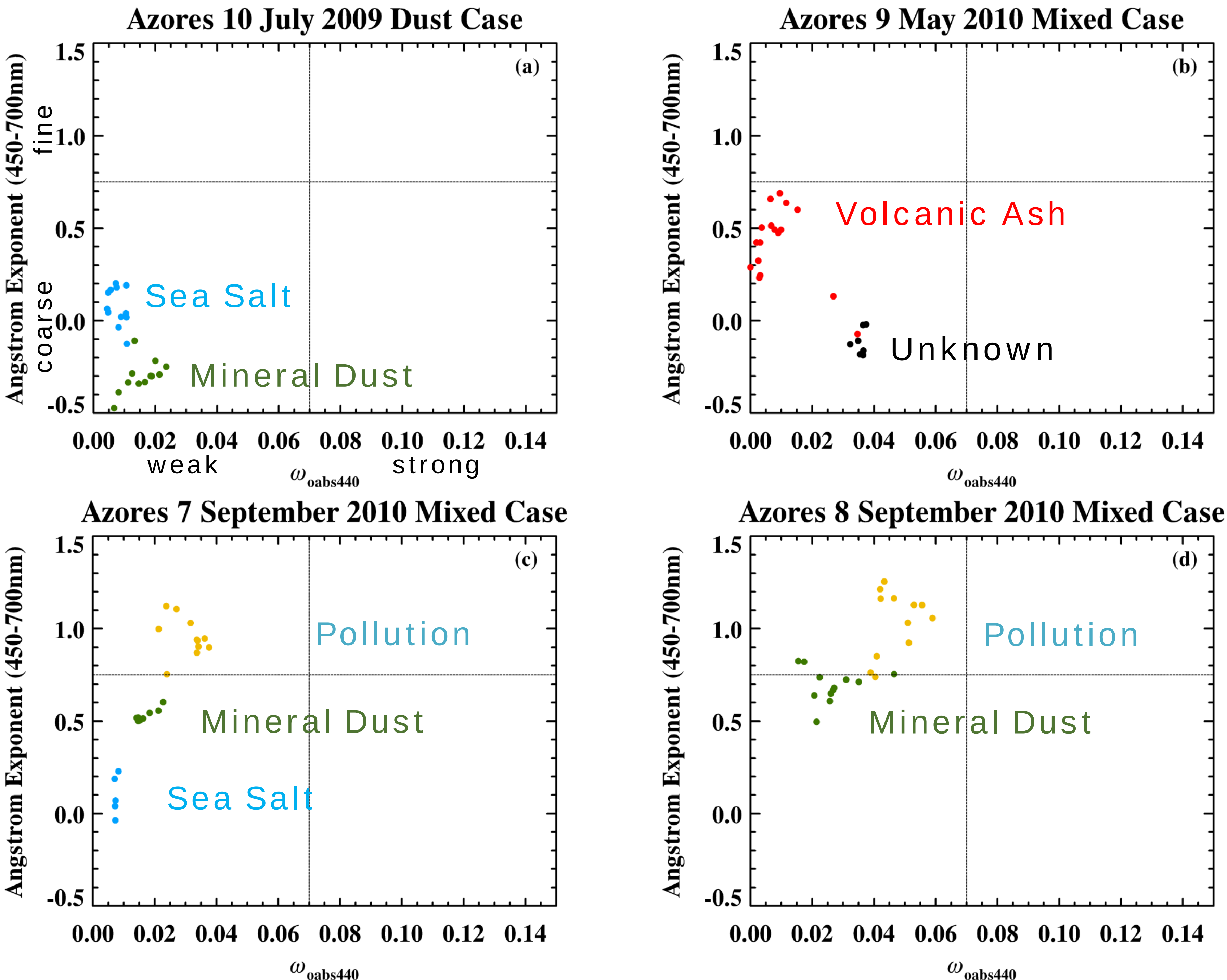
Absorption (%)	Blue (470nm)	Green (530nm)	Red (660nm)	n
BC	89	91.5	96.5	360
BrC	**11**	**8.5**	**3.5**	360

- (a) AOD spectral dependence (AE)
  - SACOL – weakest (coarse mode dominant)
  - Mukdahan – strongest (fine mode dominant)
  - Taihu and Xianghe – intermediate (mixture of fine and coarse modes)
- (b) AAOD spectral dependence (AAE)
  - Mukdahan – nearly linear (BC and weak absorbing OC)
  - Xianghe/Taihu – strongest (BC and strong absorbing OC + mineral dust)
  - SACOL – strong in visible, weak in near IR (mineral dust)
- (c) Ratio of absorptive to extinctive AOD or ω_{oabs}
  - Can better separate aerosol type at the four sites
  - Increasing absorption with wavelength (biomass)
  - Decreasing absorption in near IR with wavelength (mineral dust)
  - Strong absorption in visible, weak in near IR (pollution)








Azores 10 July 2009 Dust Case
(a)
Angstrom Exponent (450-700nm)
fine
coarse
Sea Salt
Mineral Dust
weak
strong
$\omega_{oabs440}$
Azores 9 May 2010 Mixed Case
(b)
Volcanic Ash
Unknown
Azores 7 September 2010 Mixed Case
(c)
Pollution
Mineral Dust
Sea Salt
Azores 8 September 2010 Mixed Case
(d)
Pollution
Mineral Dust
1.5
1.0
0.5
0.0
-0.5
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14

Aerosol Absorption Measurements Inter-Comparison

IOP planning discussion

Objective

Promote better understanding of the advantages and limitations, specifically with respect to measurement uncertainty, of different approaches to in situ aerosol light absorption measurements.

Outcome

Report accuracy and precision for instruments used to measure aerosol optical properties.

Provide a basis of determination for investment in and deployment of particular instruments for continuous, long-term operation at ARM-like fixed sites.

Goals for this discussion

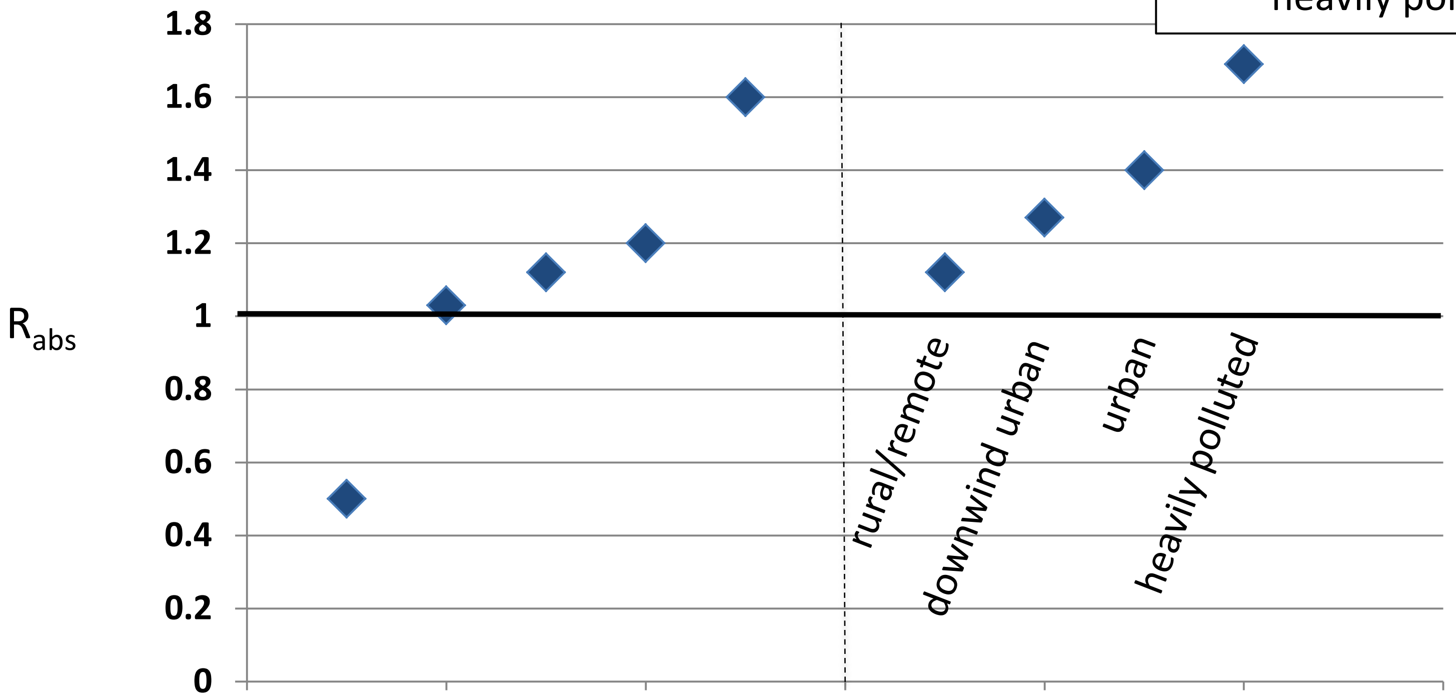
- Why?
- What?
- Where?

Aerosol Absorption Measurements Inter-Comparison

Consistency in measurement approaches is lacking

OA mass (µg m^{-3})
rural/remote = 0-2.5
downwind urban = 2.5-5.0
urban = 5.0-12.5
heavily polluted = >12.5

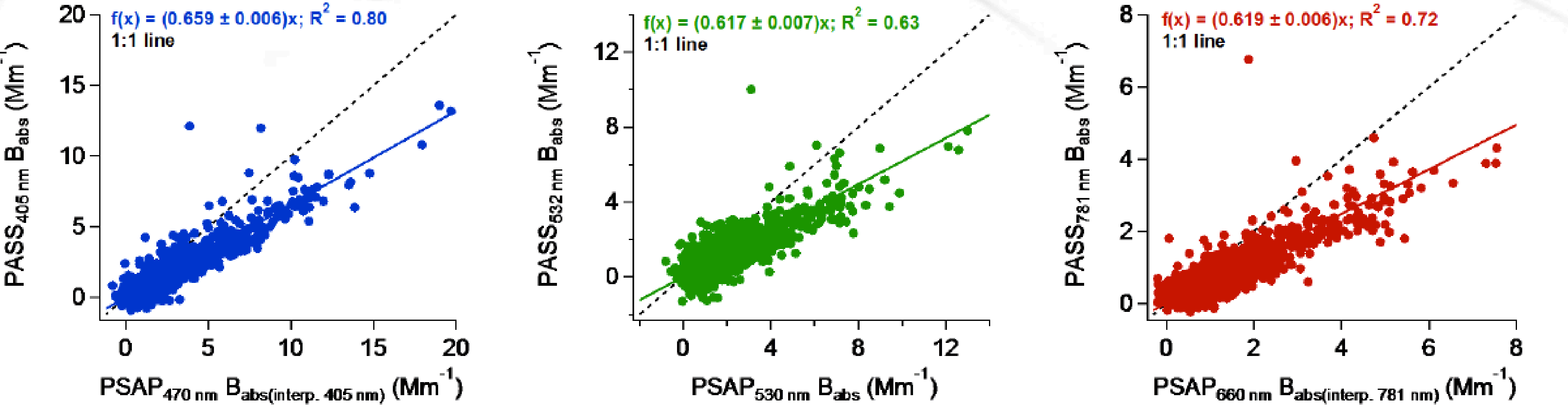
$R_{abs} = \sigma_{abs}$ filter/σ_{abs} ref



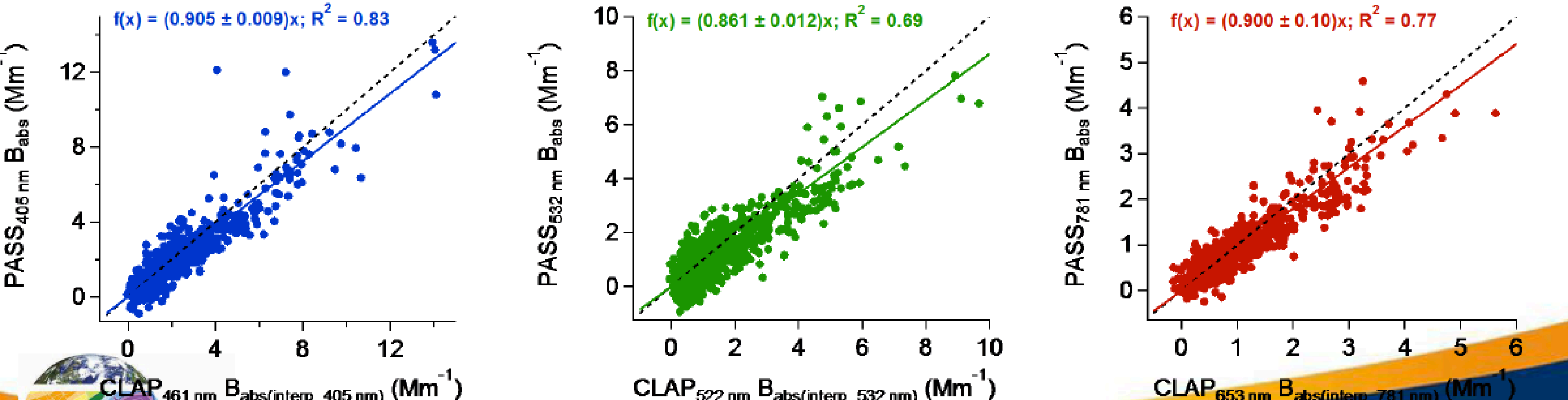
Lack et al. 2008

Absorption: PASS vs PSAP and CLAP

- PSAP



- **CLAP (shorter time period)**



Aerosol Absorption Measurements Inter-Comparison

Defining (Refining) Why

- Under what conditions do in situ filter-based, difference, and direct measurements of aerosol absorption disagree?
- Is the accuracy in these measurements sufficient to address aerosol climate-forcing problems?
- Can calibration or correction factors be developed/improved for filter-based aerosol absorption measurements?
- Do these measurement approaches allow for defining relationships between aerosol absorption optical properties, aerosol chemical composition, and column radiative fluxes?

Aerosol Absorption Measurements Inter-Comparison

Deciding What

- What geophysical parameters are most important to evaluate?
  - light absorption coefficient
    - range of wavelengths
    - absorption angstrom exponent
- With what accuracy do we need to measure these parameters?
  - sensitivity studies
  - do we actually understand the reported uncertainty of these instruments? (can we explain accuracy, precision, resolution?)
- At what temporal resolution do we need to sample these parameters?
- What ancillary information or set of measurements is required to answer the established science questions?
  - passive remote sensing
  - active remote sensing
  - airborne measurements

Aerosol Absorption Measurements Inter-Comparison

Determining Where

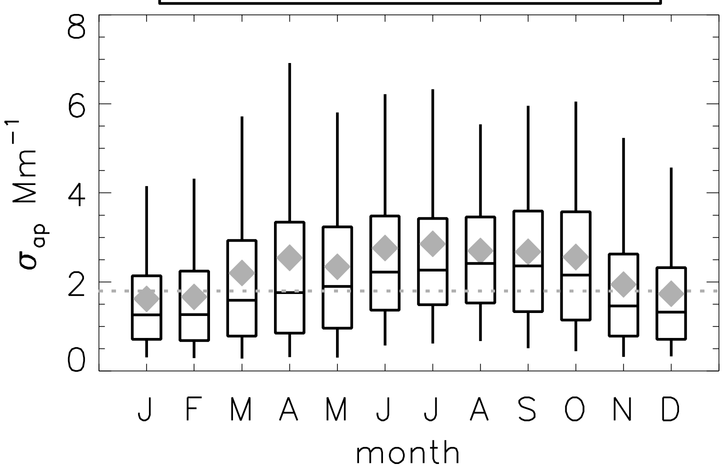
- What conditions are required to answer the established science questions?
  - range in aerosol loading
  - range in aerosol composition
  - range in relative humidity
- Can this work be accomplished at an existing ARM fixed-site? (requiring far fewer resources)

Aerosol Absorption Measurements Inter-Comparison

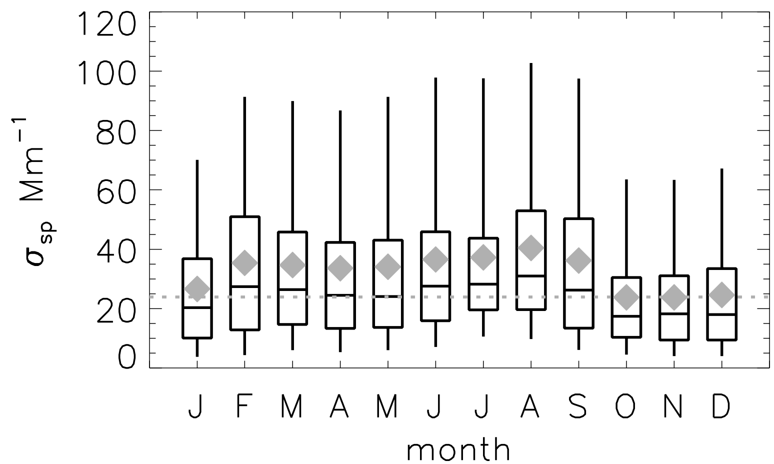
Defining (Refining) Where

SGP: 1996-2012

PSAP Absorption



Neph Scattering



Aerosol Absorption Measurements Inter-Comparison

Defining (Refining) Where

SGP: 1998-2006