Remote Sensing of Aerosol Composition

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- Water Uptake
- Black Carbon
- Dry Aerosol

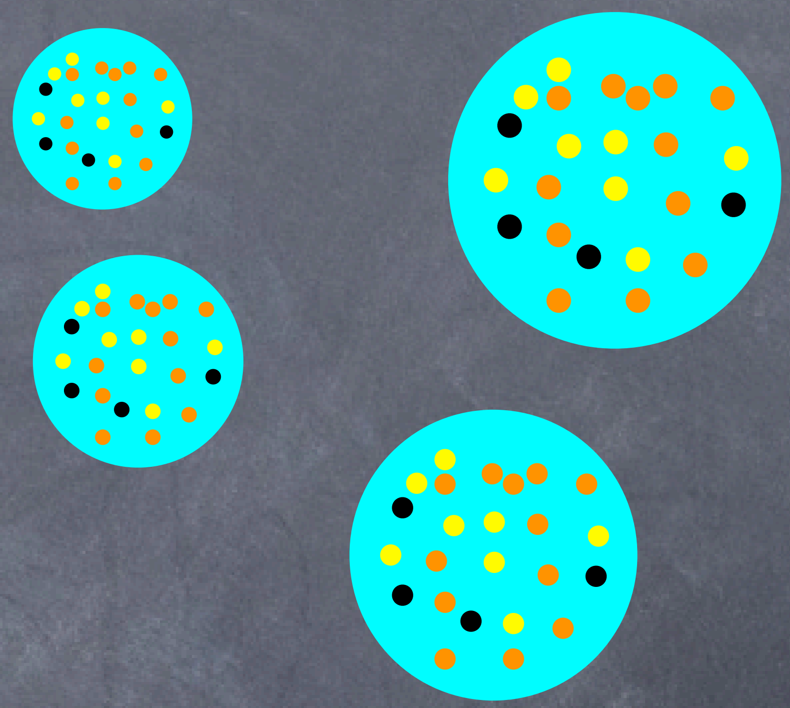
- Results have been applied to the AERONET database of surface instruments.
- Technique is readily adaptable to other instruments that are capable of retrieving complex refractive index.

3-Component Aerosol Retrieval Scheme

Infers composition from the aerosol complex refractive index

- Assume an internal mixture of four aerosol species
  1. Black carbon
  2. Water
  3. Dry Aerosols
     a) Ammonium Nitrate (surrogate for solubles)
     b) Dust (insoluble component)
- Iterate black carbon concentration until imaginary refractive index of the mixture "matches" retrieved values at 670, 870, and 1020 nm for AERONET.
- Iterate the soluble/insoluble concentration until the real refractive index "matches" the retrieved values (at all wavelengths).
- Use an empirical constraint for soluble fraction:

$$\frac{inslbl}{slbl} \propto \left(\frac{inslbl}{slbl}\right)_{clmt} (m_r - 1.33)^3$$

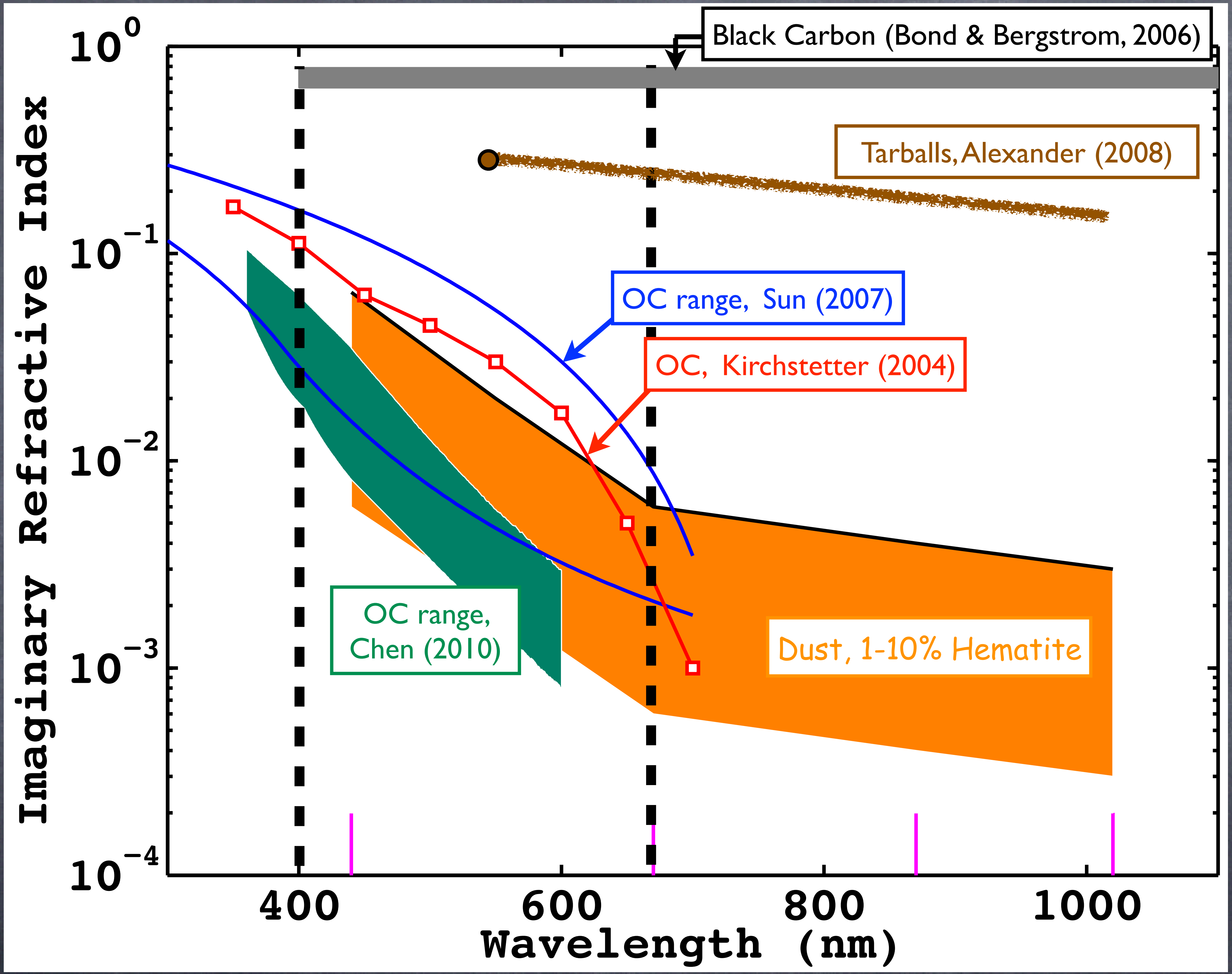


Maxwell-Garnett effective medium approx and Lacis code

Schuster et al, GRL (2009)

Sensitivity studies (Schuster et al, JGR, 2005; Schuster et al, GRL, 2009):
- Black carbon: +/- 50%
- Water: +/- 0.3

Black Carbon is much more absorbing than anything else

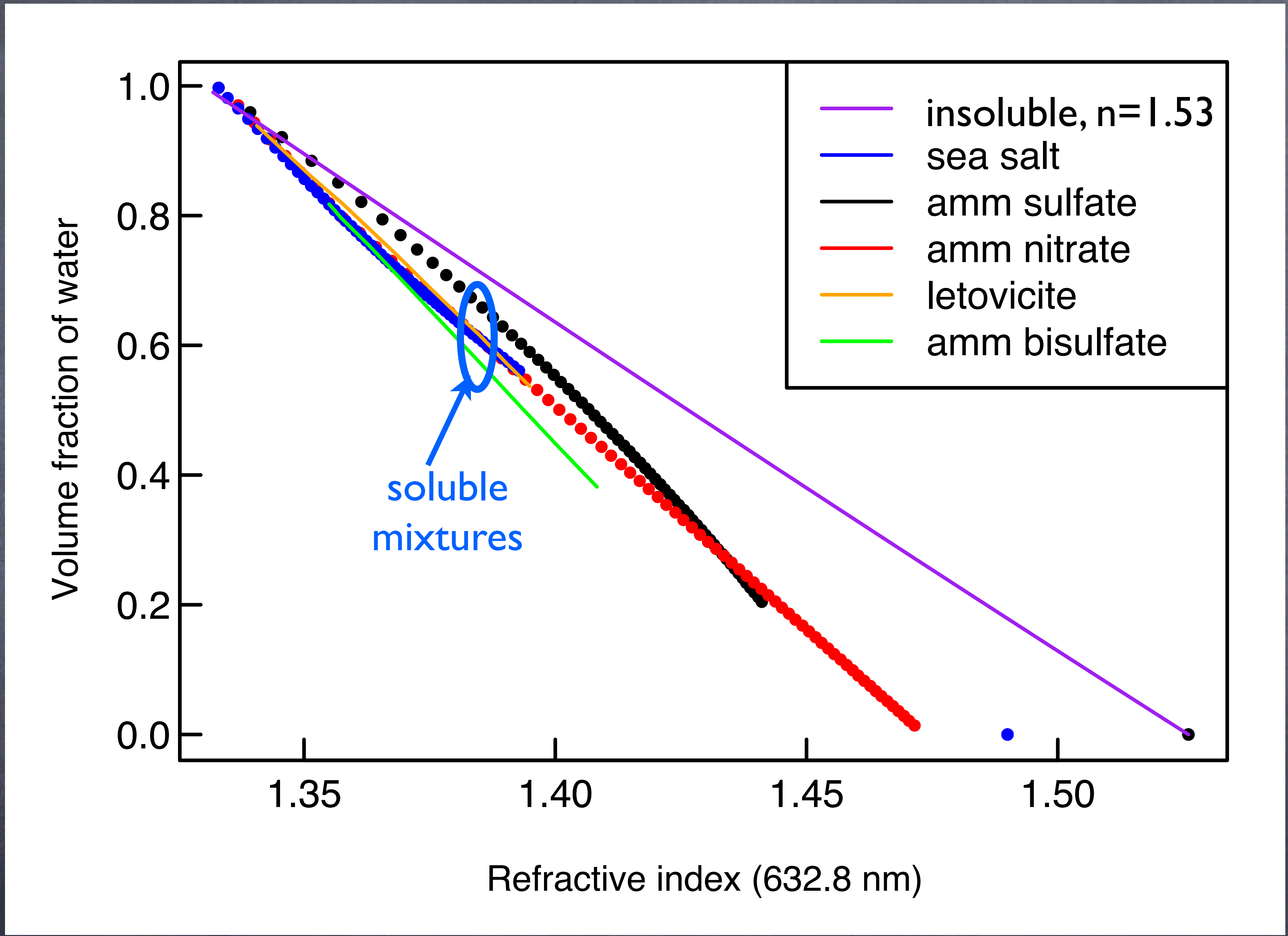


See

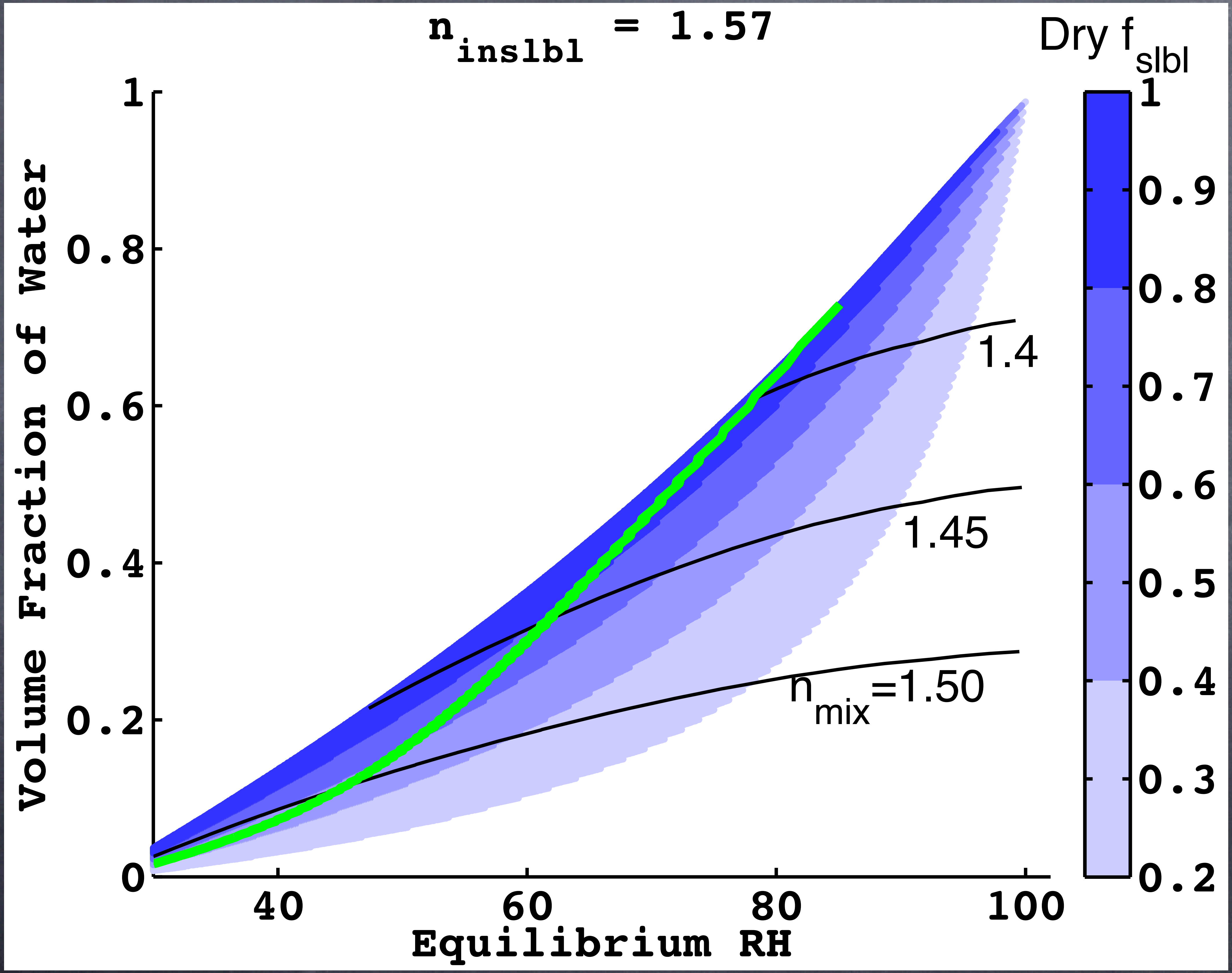
Arola, A., G. Schuster, G. Myhre, S. Kazadzis, S. Dey, and S. N. Tripathi (2011), Inferring absorbing organic carbon content from AERONET data, Atmospheric Chemistry and Physics, 11(1), 215-225.

Koven and Fung (2006), Inferring dust composition from wavelength- dependent absorption in Aerosol Robotic Network AERONET data, J. Geophys. Res., 111, D14205, doi:10.1029/2005JD006678.

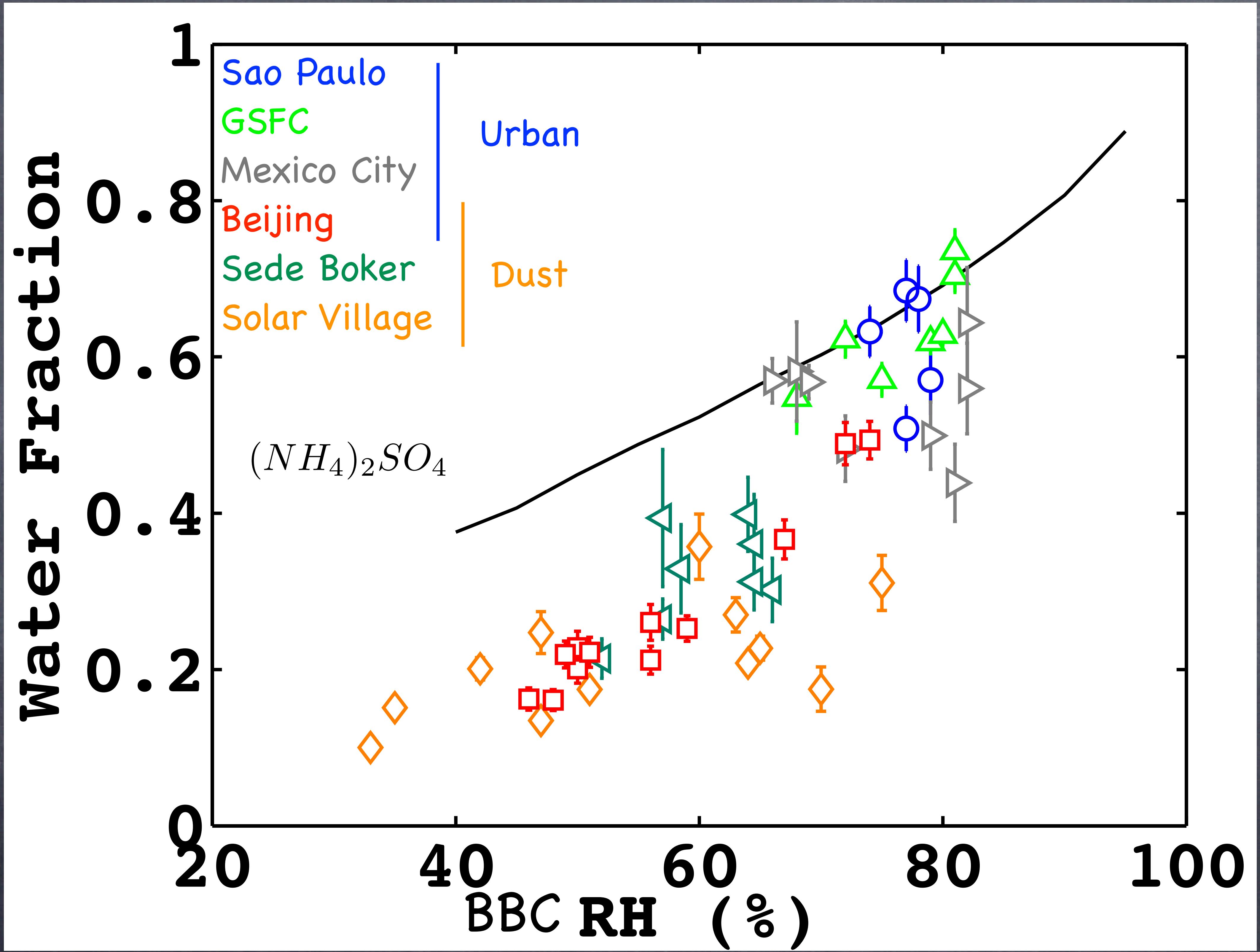
Soluble aerosol mixtures have similar water fractions for a given refractive index



Modeled Water Fraction



Monthly averaged water uptake



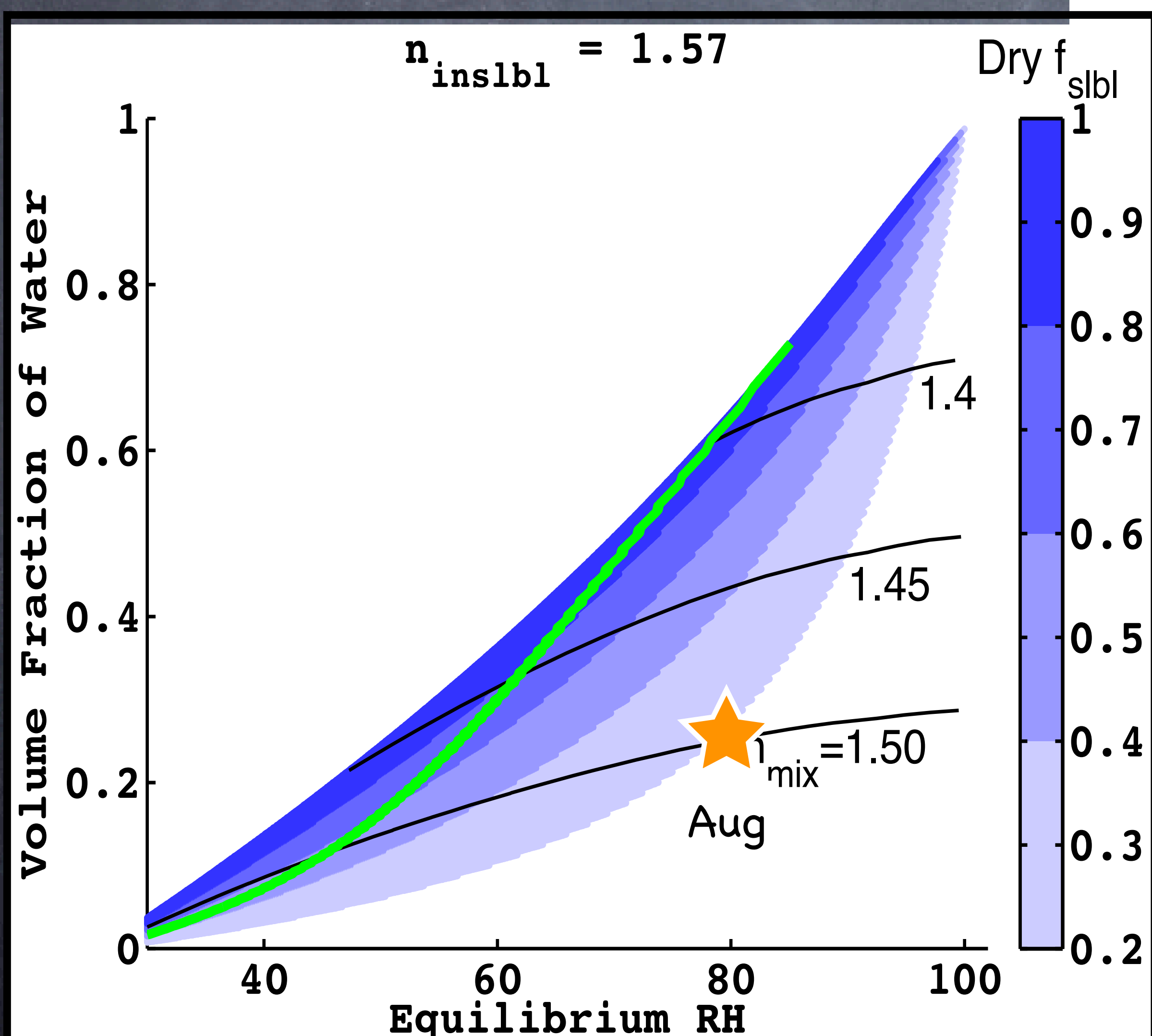
AERONET Level 2.0, so AOD(440) > 0.4

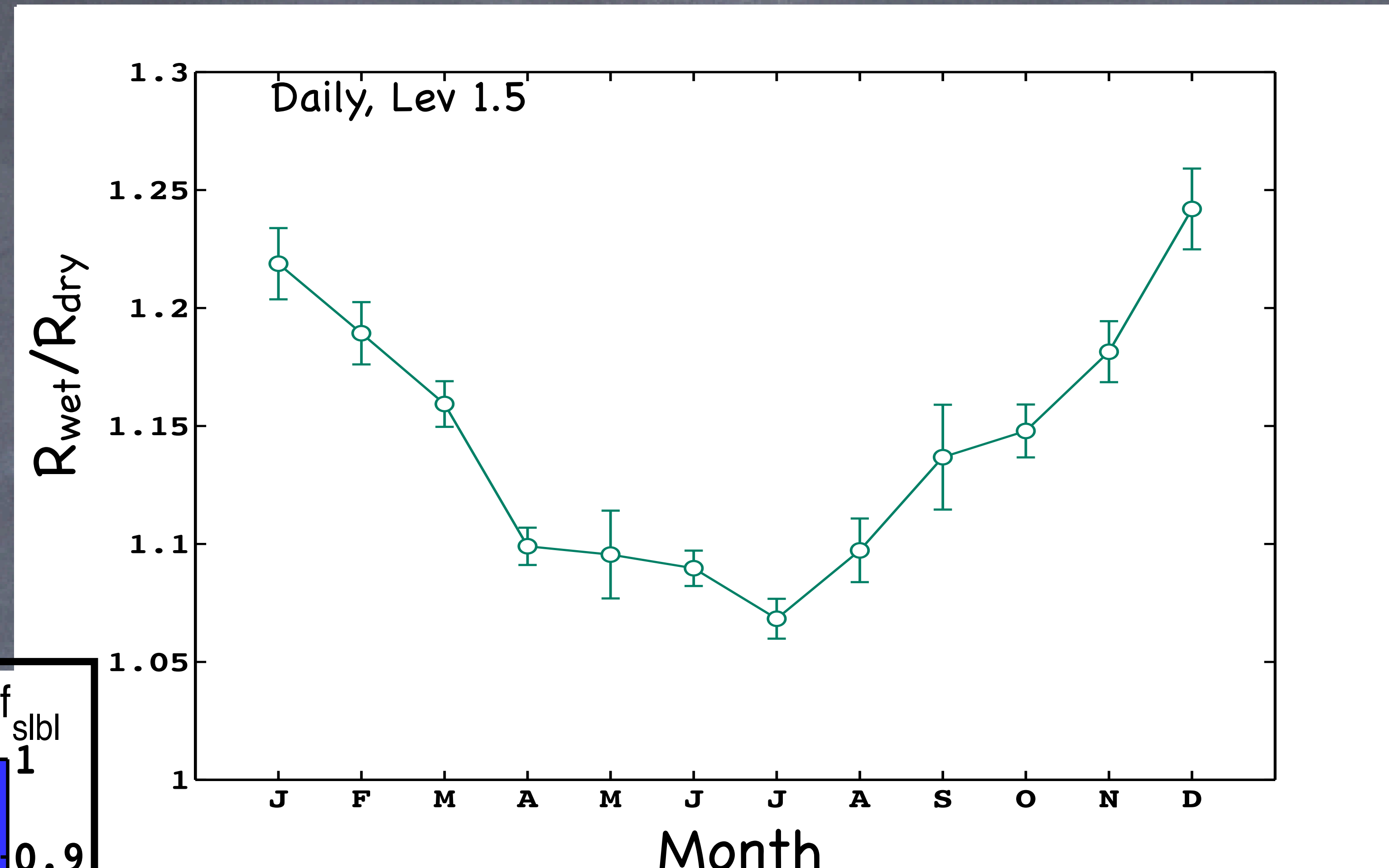
Hygroscopic Growth at Ouagadougou (West Africa)

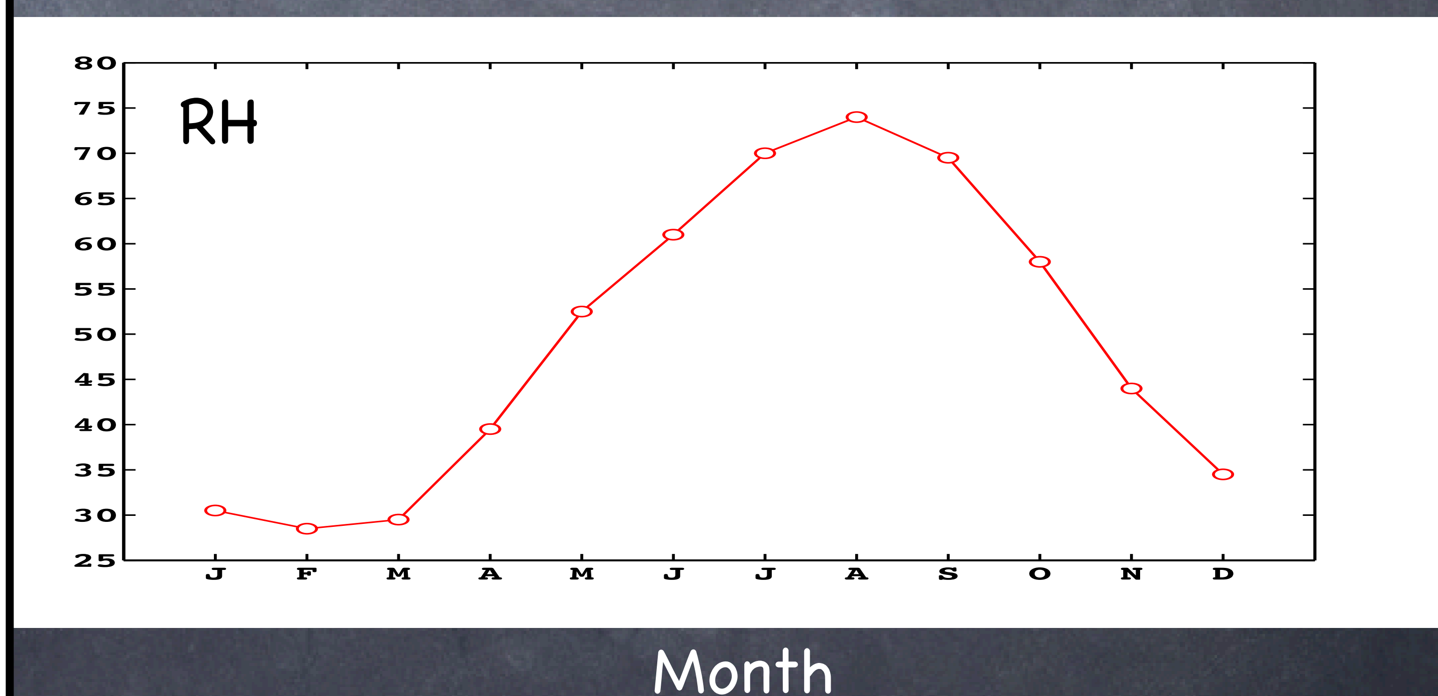
Soluble fraction constrained by empirical equation

$$\frac{inslbl}{slbl} \propto \left(\frac{inslbl}{slbl}\right)_{clmt} (m_r - 1.33)^3$$

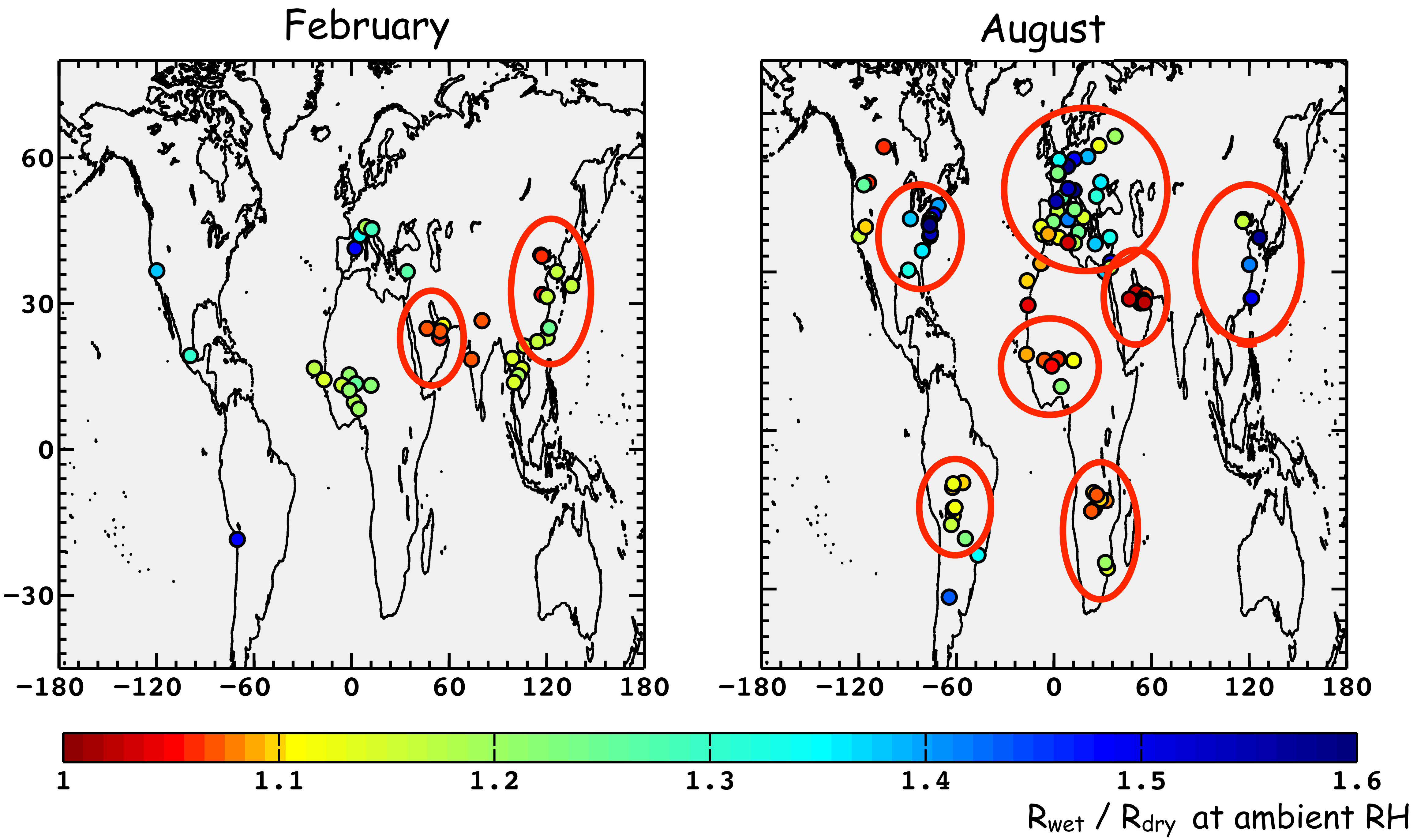
Monthly climatological RH determines soluble fraction







Regional hygroscopic growth is consistent with climate

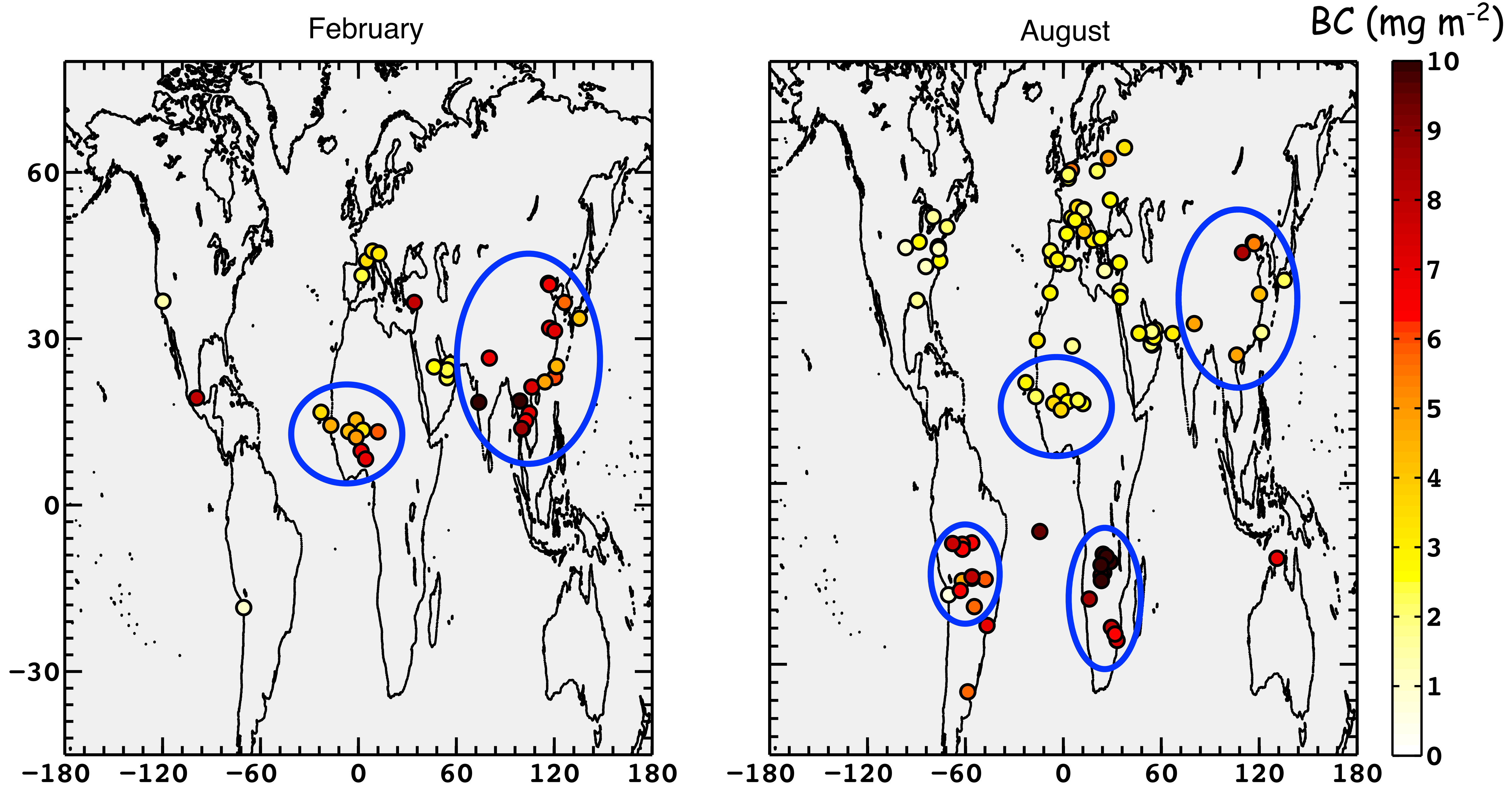


Classifications at 90% RH (Swietlicki et al., 2008):

R_{wet} / R_{dry} $= 1.0 - 1.11 \rightarrow$ nearly hydrophobic
$= 1.11 - 1.33 \rightarrow$ less hygroscopic
$> 1.33 \rightarrow$ more hygroscopic

AERONET all-points, level 2.0 dataset, minimum of 20 retrievals

Black Carbon retrieval is consistent with regional and seasonal patterns



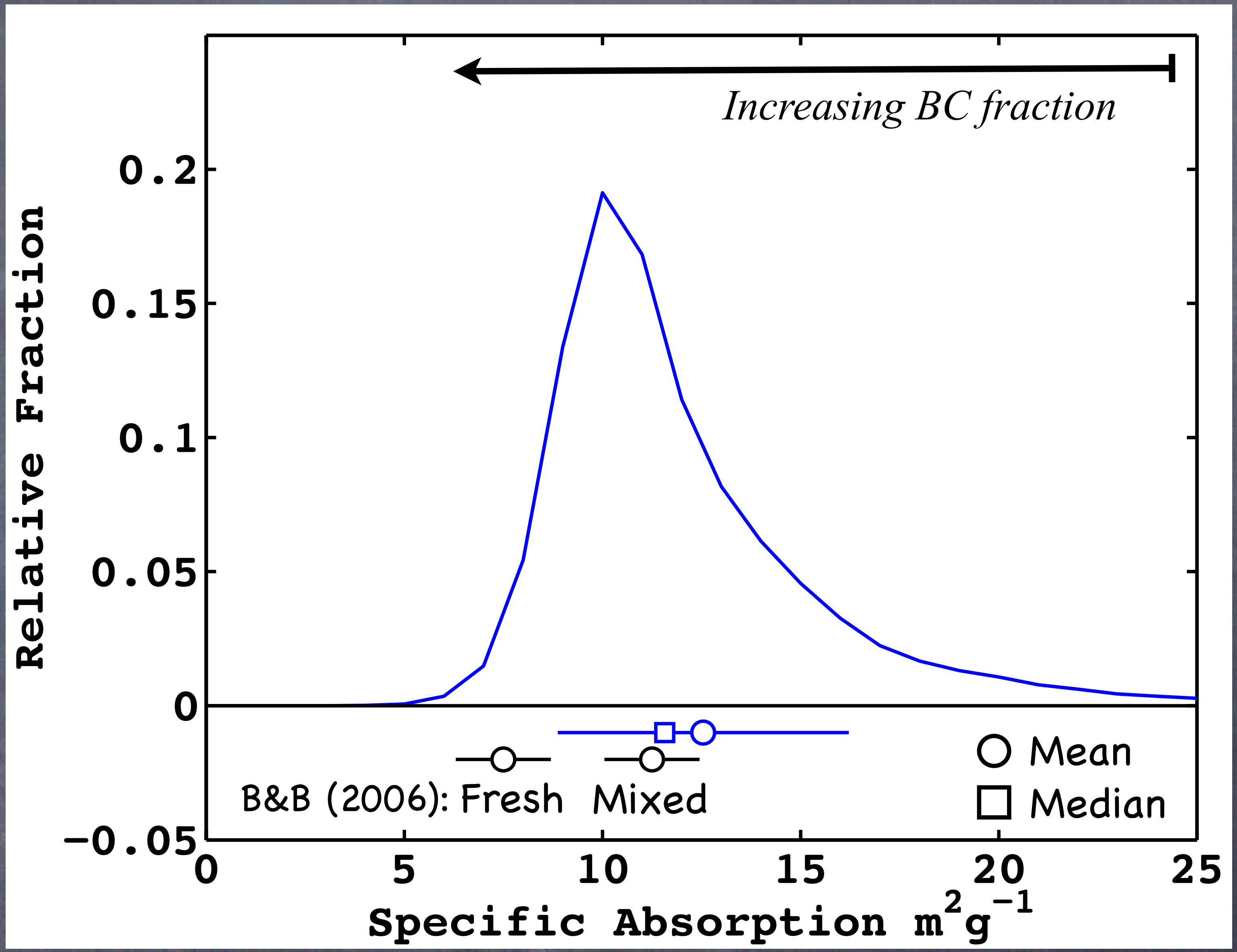
AERONET all points level 2.0 dataset, minimum of 20 retrievals

Retrieval Produces Reasonable Values for the BC Mass Absorption Efficiency

Specific Absorption, or MAE:

$$\frac{AAOD(550)}{[BC]}$$

- Bond and Bergstrom, AST (2006) recommend 7.5 +/- 1.2 m^2g^{-1} for freshly generated LAC, with an enhancement factor of 50% for coated LAC (or 11.25 m^2g^{-1}).
- Median for 76,281 retrievals at 417 AERONET sites (since 1993) is 11.6 m^2g^{-1}.



Conclusions

- ✓ Real refractive index provides information about the aerosol water content.
- ✓ Black carbon can be uniquely determined from the aerosol imaginary index because it is so much more absorbing than any other aerosol at wavelengths greater than 650 nm.
- ✓ 3CAR provides reasonable results for all regions and seasons, except aerosol water content over West Africa.
- ✓ Including RH as an input parameter improves the retrieval over West Africa.

Data: http://asd-www.larc.nasa.gov/~gregs/

Acknowledgments:

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