

Bias in filter based aerosol light absorption measurements due to organic aerosol loading: Evidence from field and laboratory measurements*

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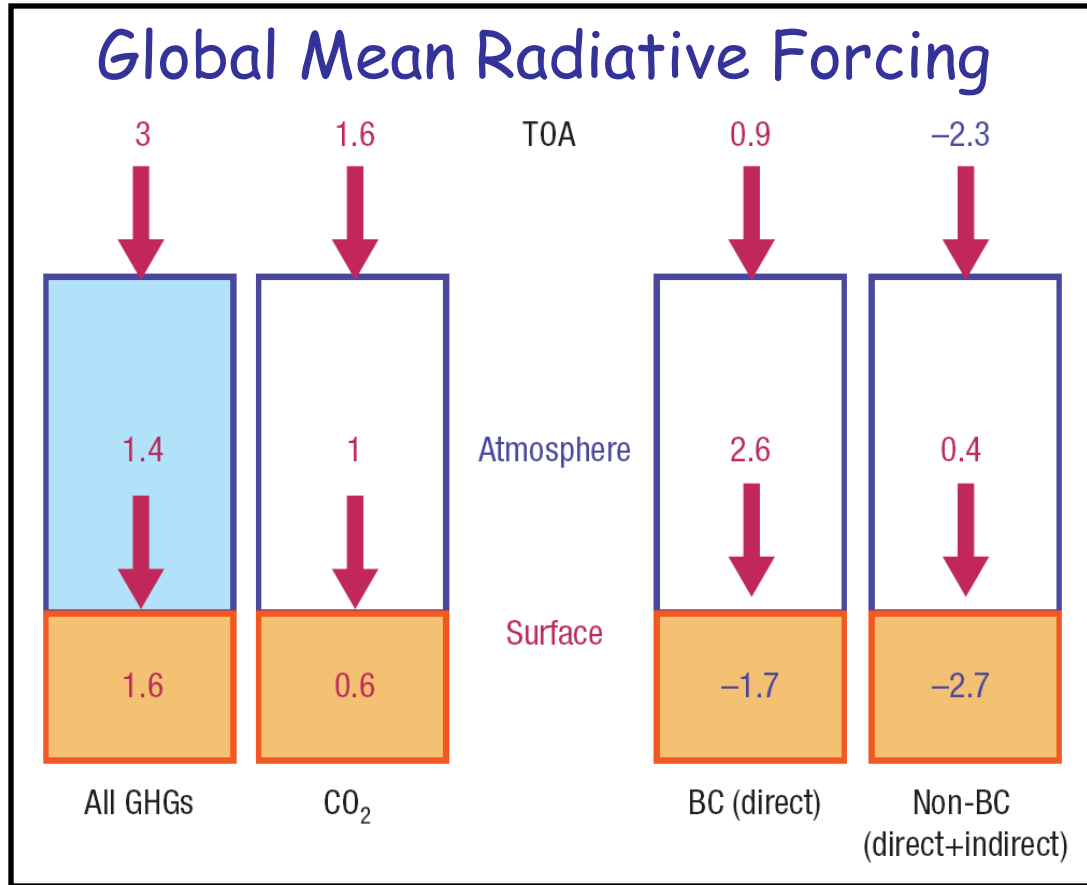
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*Now in press at AS&T

Light Absorption by Aerosols



Ramanathan and Carmichael (2008)

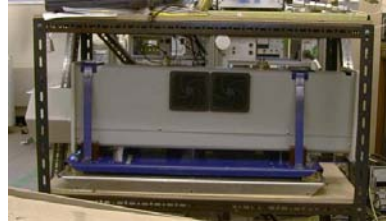
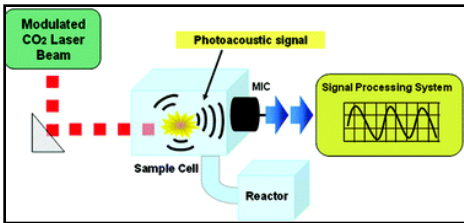
Significant contribution
to lower-atmosphere
solar heating

Surface Dimming

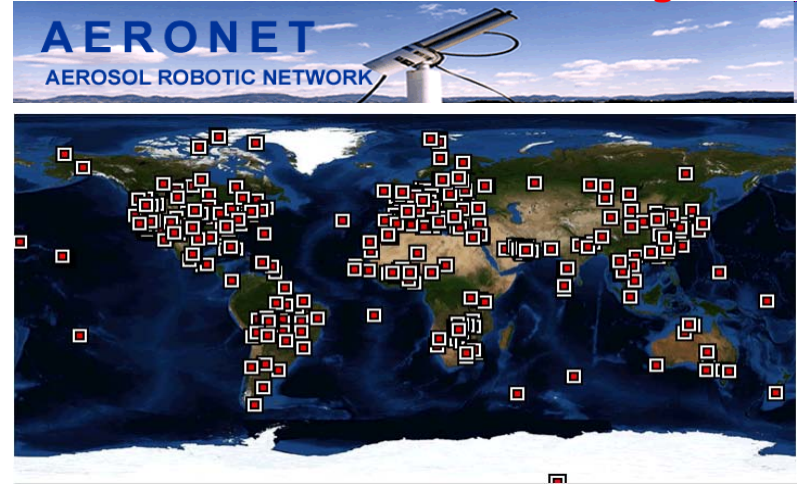
Increases TOA
radiative forcing

How do we measure light absorption by aerosols?

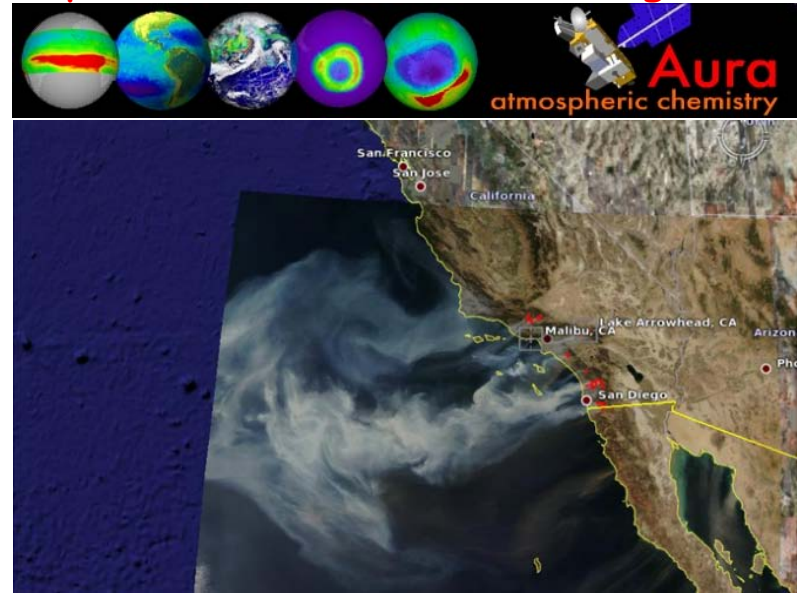
In-Situ Measurements



Ground-based remote sensing



Space-based remote sensing



Light Absorption Measurement: Filter vs. non-Filter Techniques

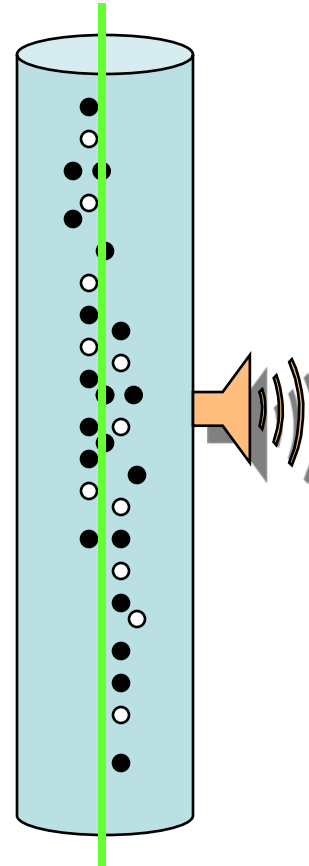
Filter-based Techniques

Collect particles on a filter and measure light transmission through the filter.

Need to correct for scattering by non-absorbing particles

non-Filter Techniques

Photoacoustic

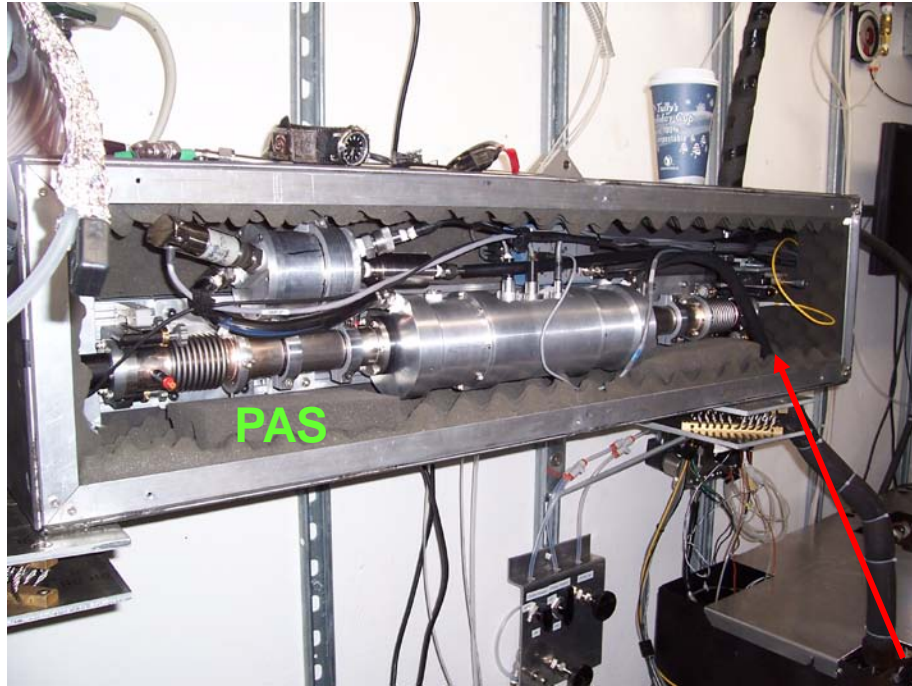


Particles are kept in suspension

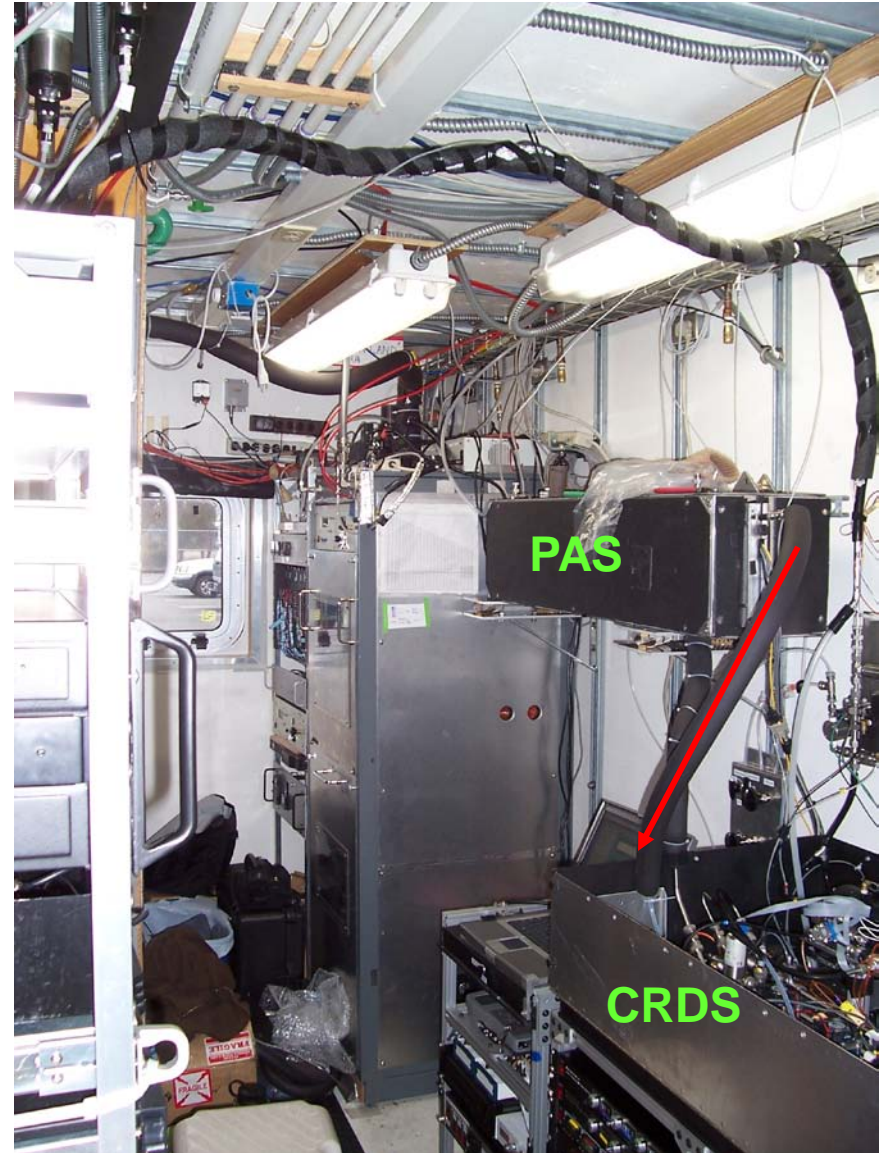
Can be directly calibrated

Need to account for gas-phase absorbers

The NOAA PAS



Sensitivity $\sim 0.4 \text{ Mm}^{-1}$ (2σ) in 2 sec
Accurate to $<5\%$



1. Field Observations

- TexAQS/GoMACCS 2006 study
- 37 days of measurements in the Gulf of Mexico and inland waters near Houston

Instrumentation included:

PAS, PSAP, CRDS, Nephelometer, SMPS, AMS



2. Lab Experiments

- Comparison between PAS and PSAP measurements using soot, nigrosin dye, secondary organic aerosol and ammonium sulfate aerosol and combinations thereof
- Included CRDS extinction measurement



R/V Ronald H. Brown

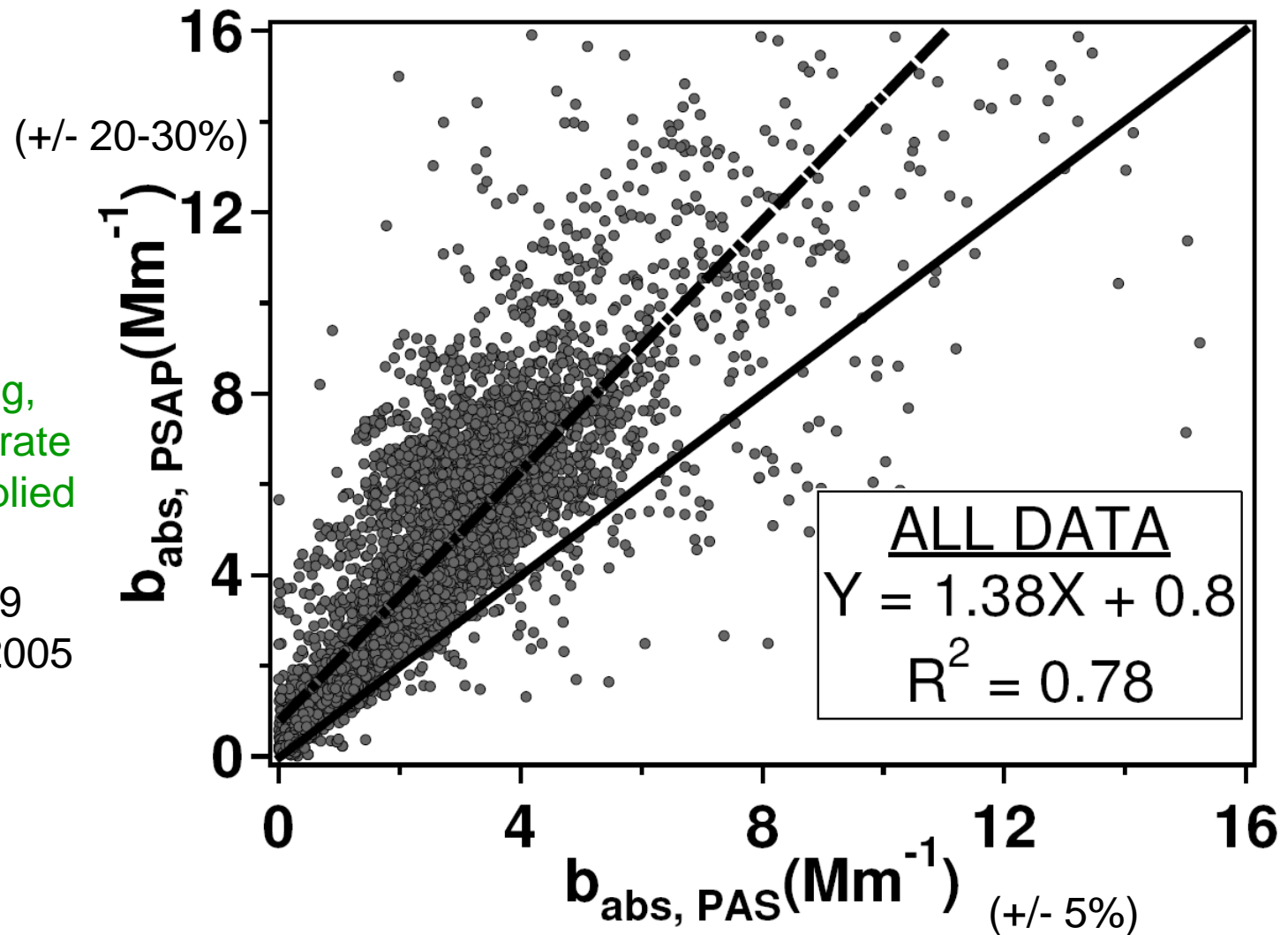
TexAQs/GoMACCS Observations

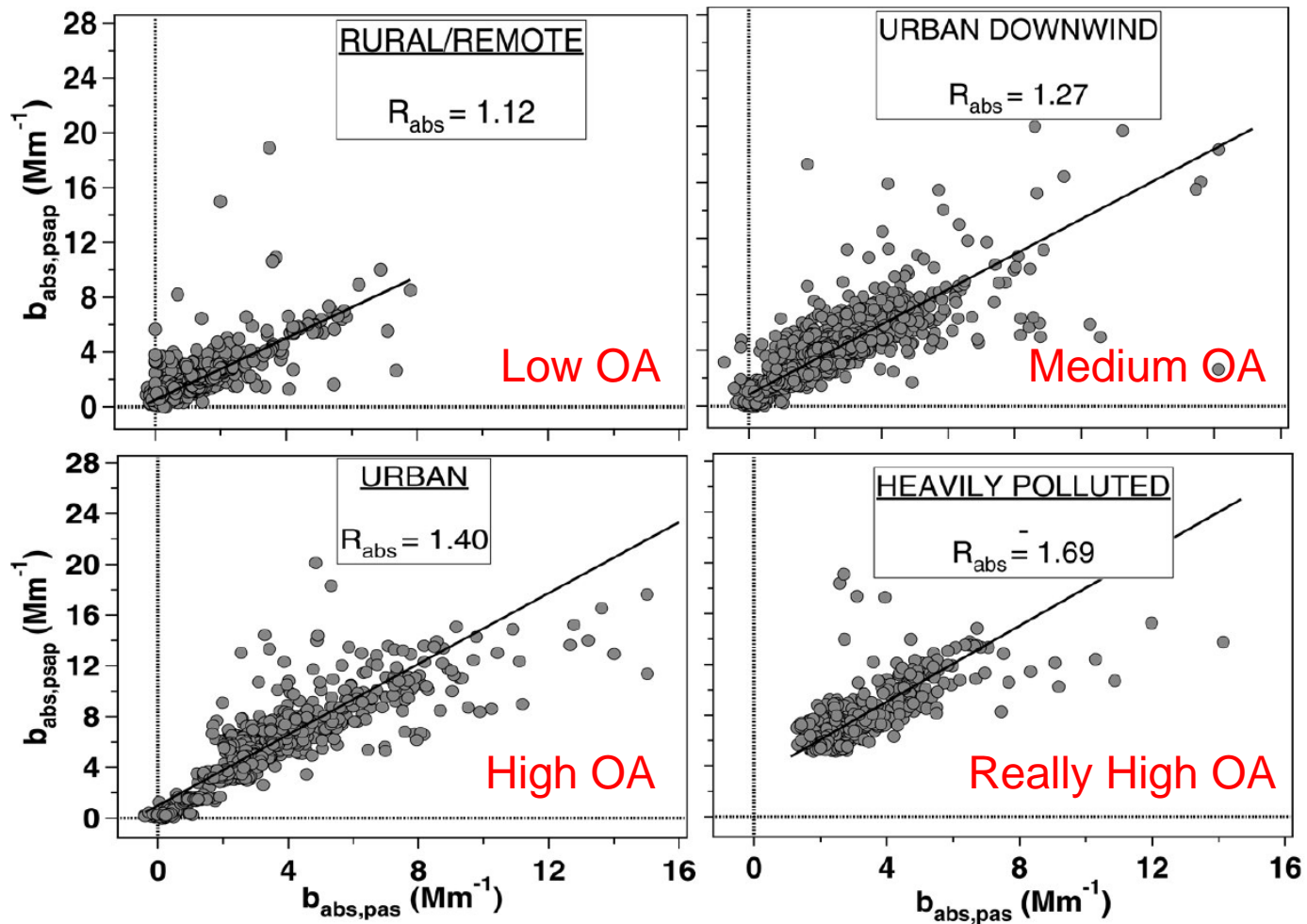
$\lambda \sim 530 \text{ nm}$

Filter, scattering,
spot size, flow rate
corrections applied
to PSAP

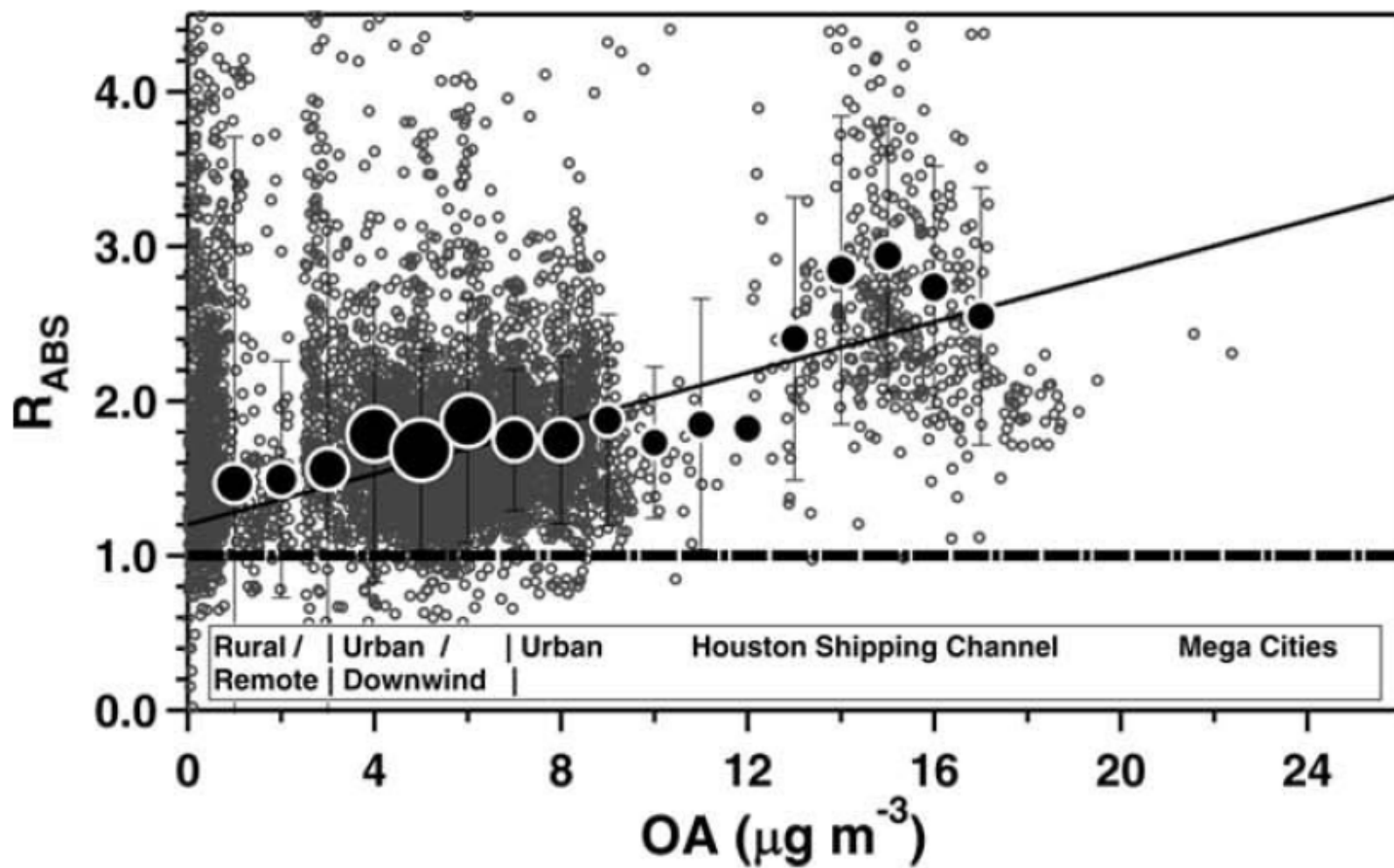
Bond et al., 1999

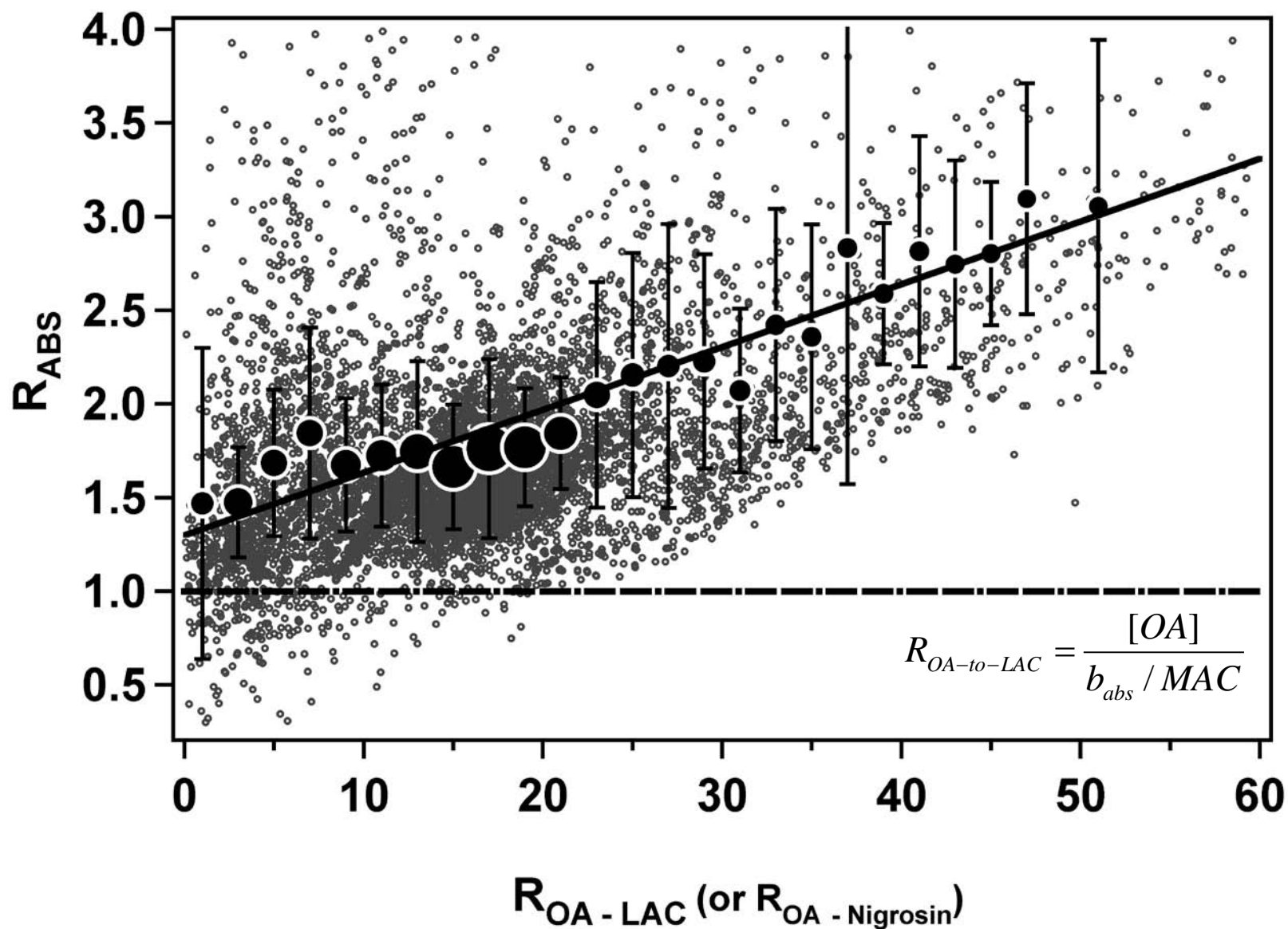
Virkkula et al., 2005





Classification	Rural/Remote	Urban Downwind	Urban	Heavily Polluted
AMS OA Mass ($\mu g\ m^{-3}$)	0 – 2.5	2.5 – 5.0	5.0 – 12.5	> 12.5
Slope	1.12	1.27	1.40	1.69
Intercept (Mm^{-1})	0.5	0.8	0.9	2.0
R^2	0.75	0.82	0.80	0.80





Lab Experiments

Single component and external mixtures considered

SOA from α -pinene + O_3 (essentially non-absorbing at 532 nm)

Soot from inverted flame (presumably low OC)

Ammonium sulfate and nigrosin dye from atomization (dried to <5% RH)

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- ❶ Does the standard transmission correction work for SOA? (No)
 - ❷ Does (non-absorbing) SOA influence absorption measurements? (Yes)

① Does the standard transmission correction work for SOA?

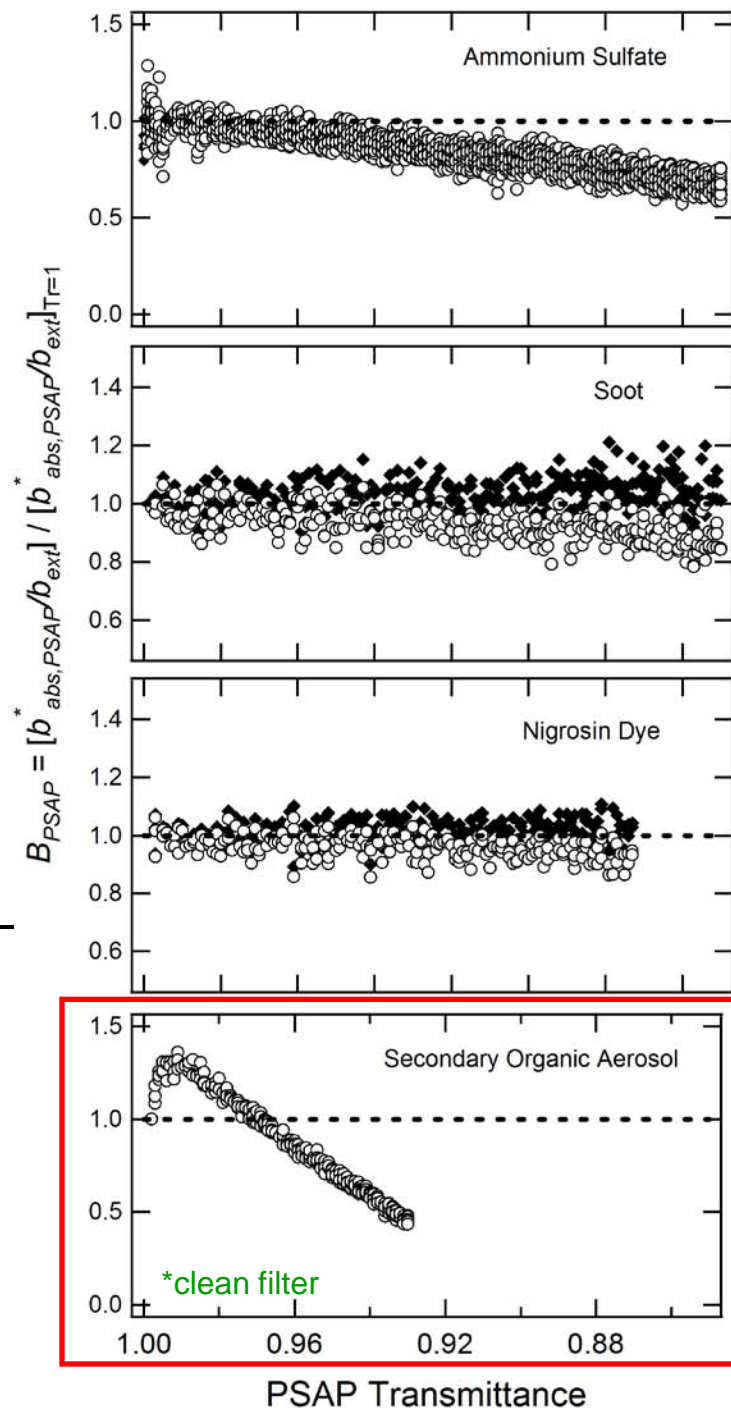
Transmission Correction

Measured
“absorption” $b^* = \frac{A}{V} \ln \left(\frac{I_{t-1}}{I_t} \right)$

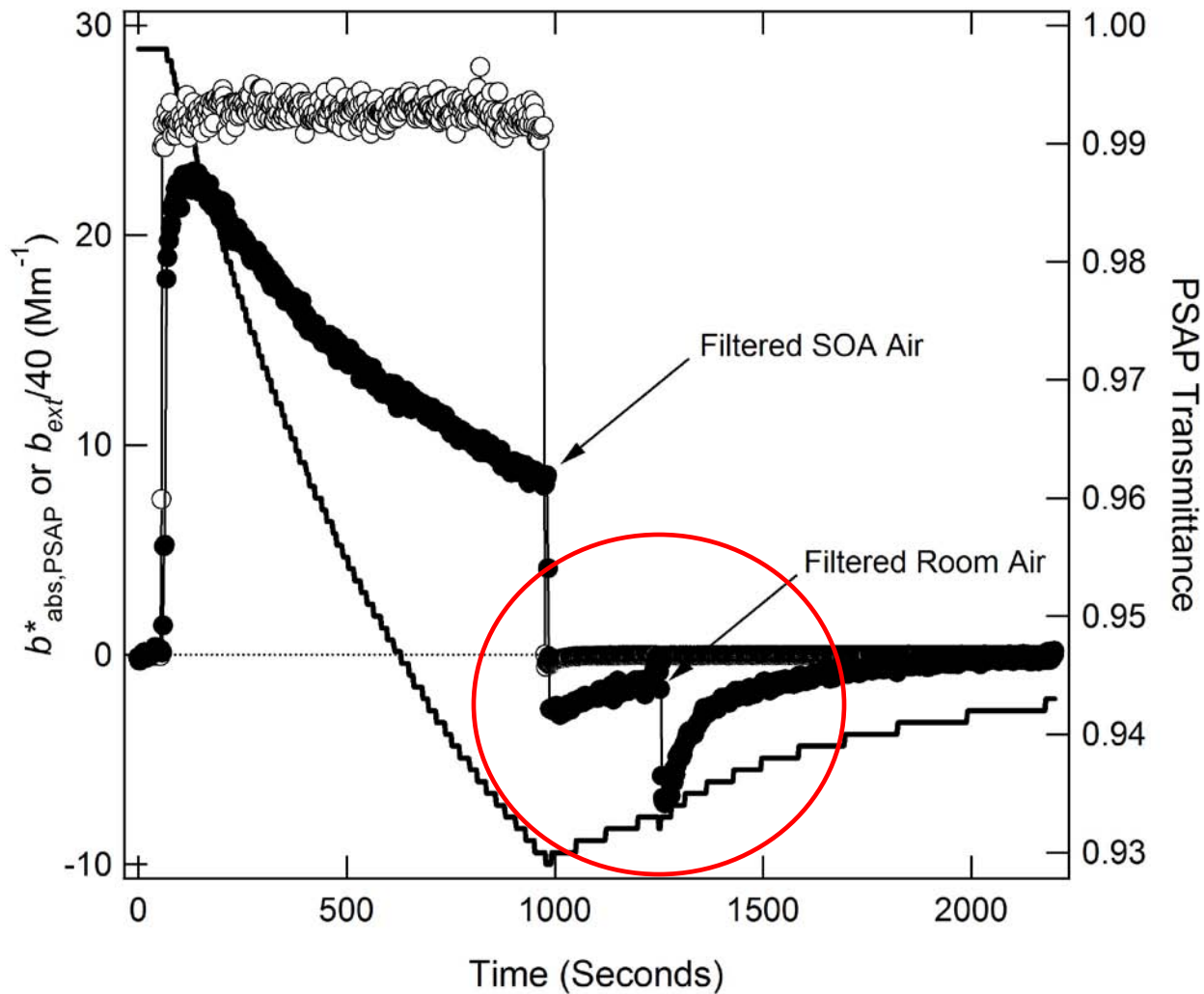
$$b_{abs,PSAP}^* = 0.873 \left[\frac{b^*}{1.0796 \cdot Tr + 0.71} \right] \times \frac{1}{1.22}$$

Bond et al., 1999; Virkkula et al., 2005

$$B_{PSAP} = \frac{\left[b_{abs,PSAP}^* / b_{ext} \right]_{Tr}}{\left[b_{abs,PSAP}^* / b_{ext} \right]_{Tr=1}}$$

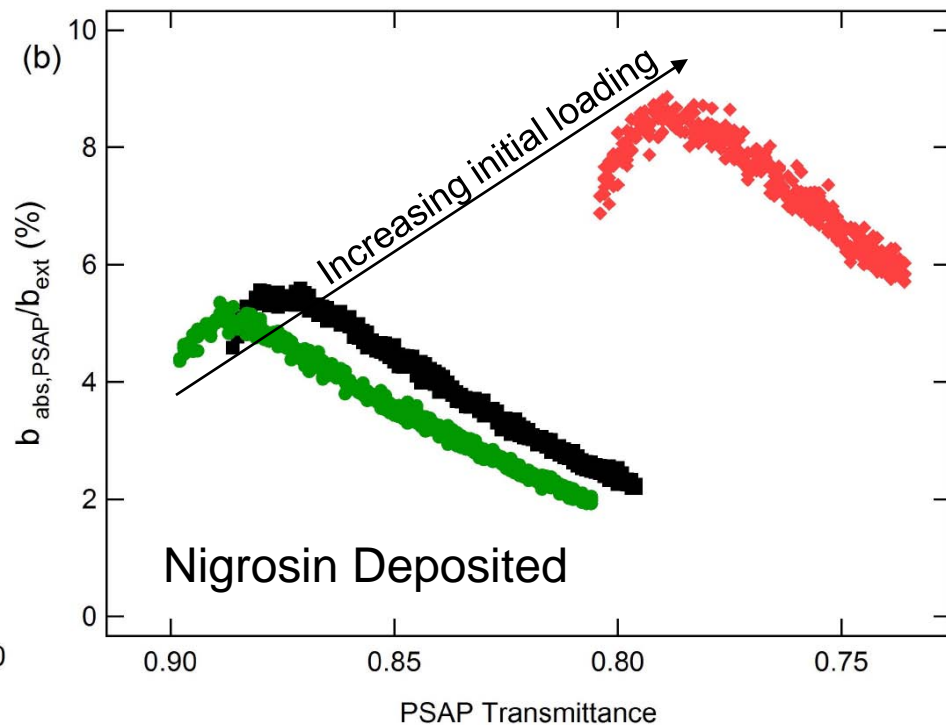
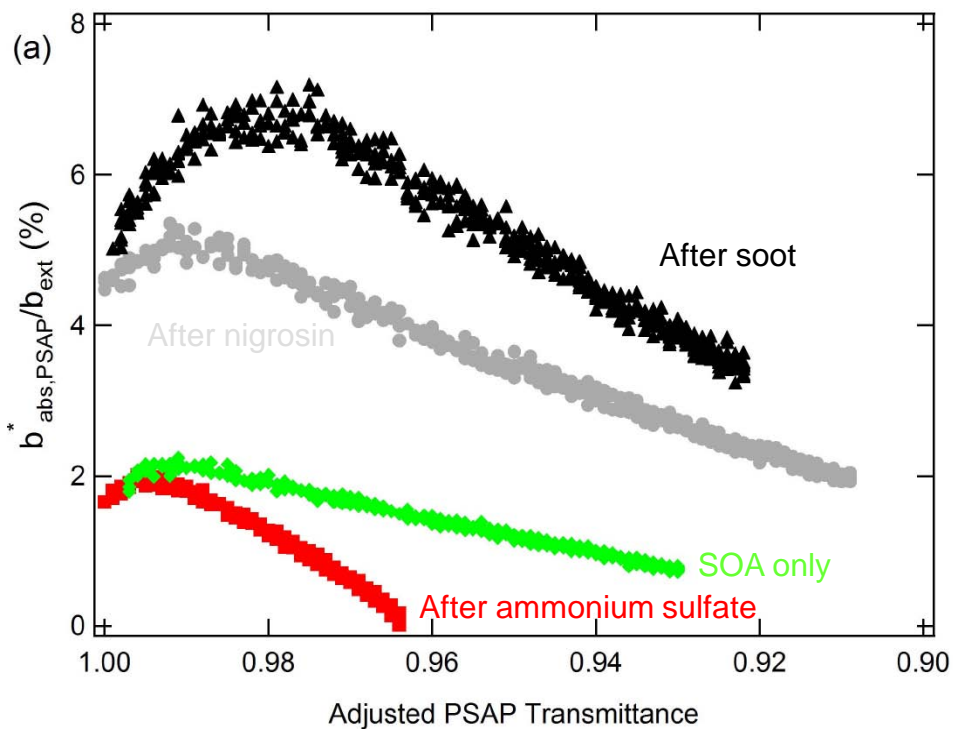


❶ Does the standard transmission correction work for SOA?



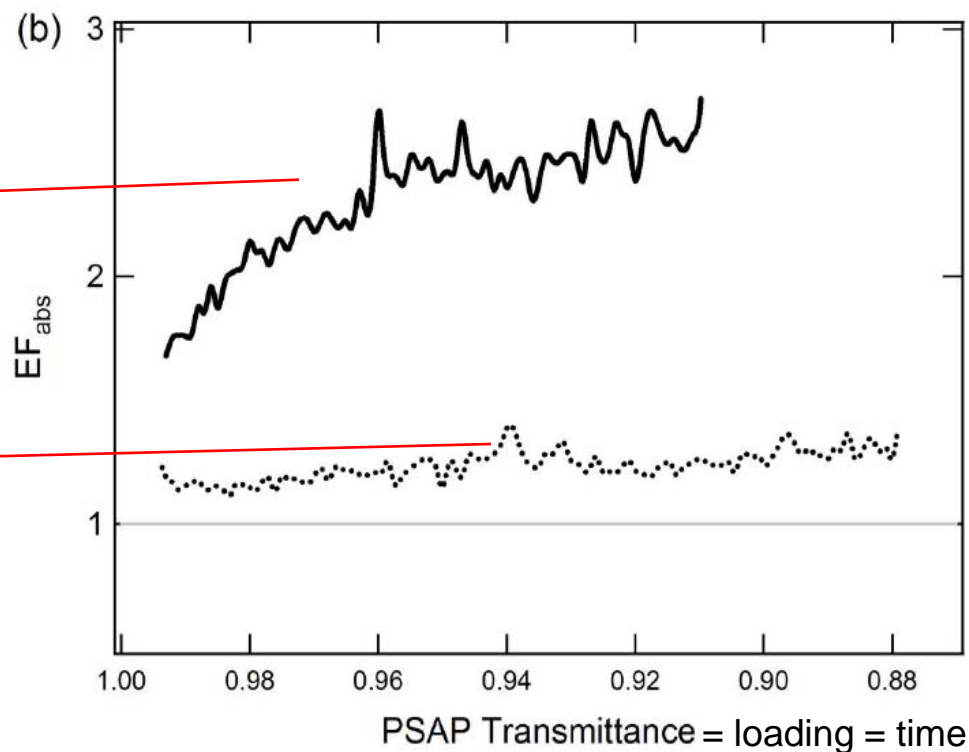
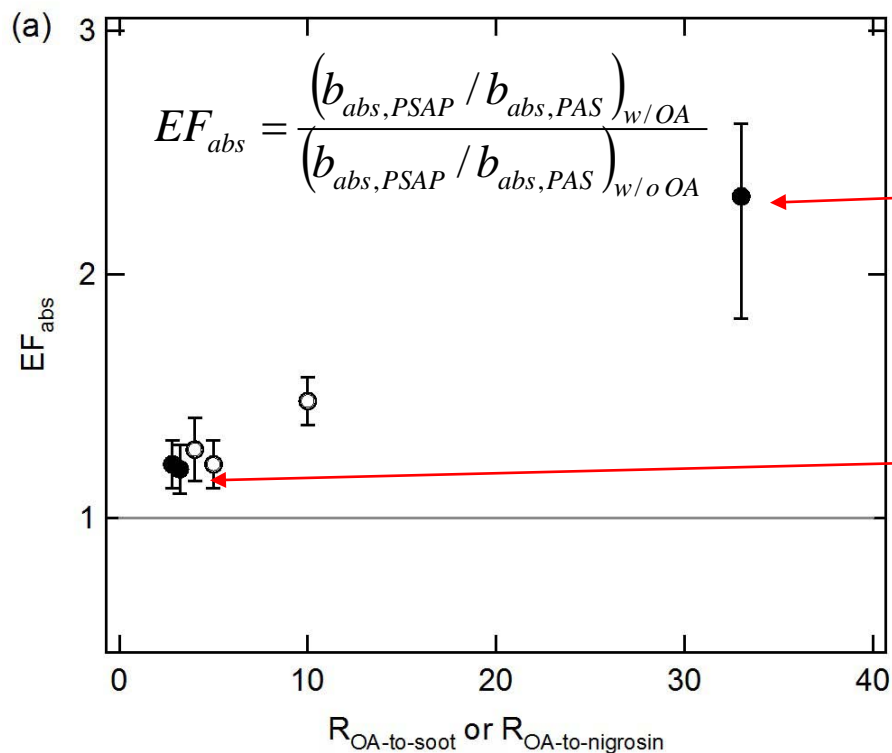
② Does (non-absorbing) SOA influence absorption measurements?

Add SOA to “dirty” filter

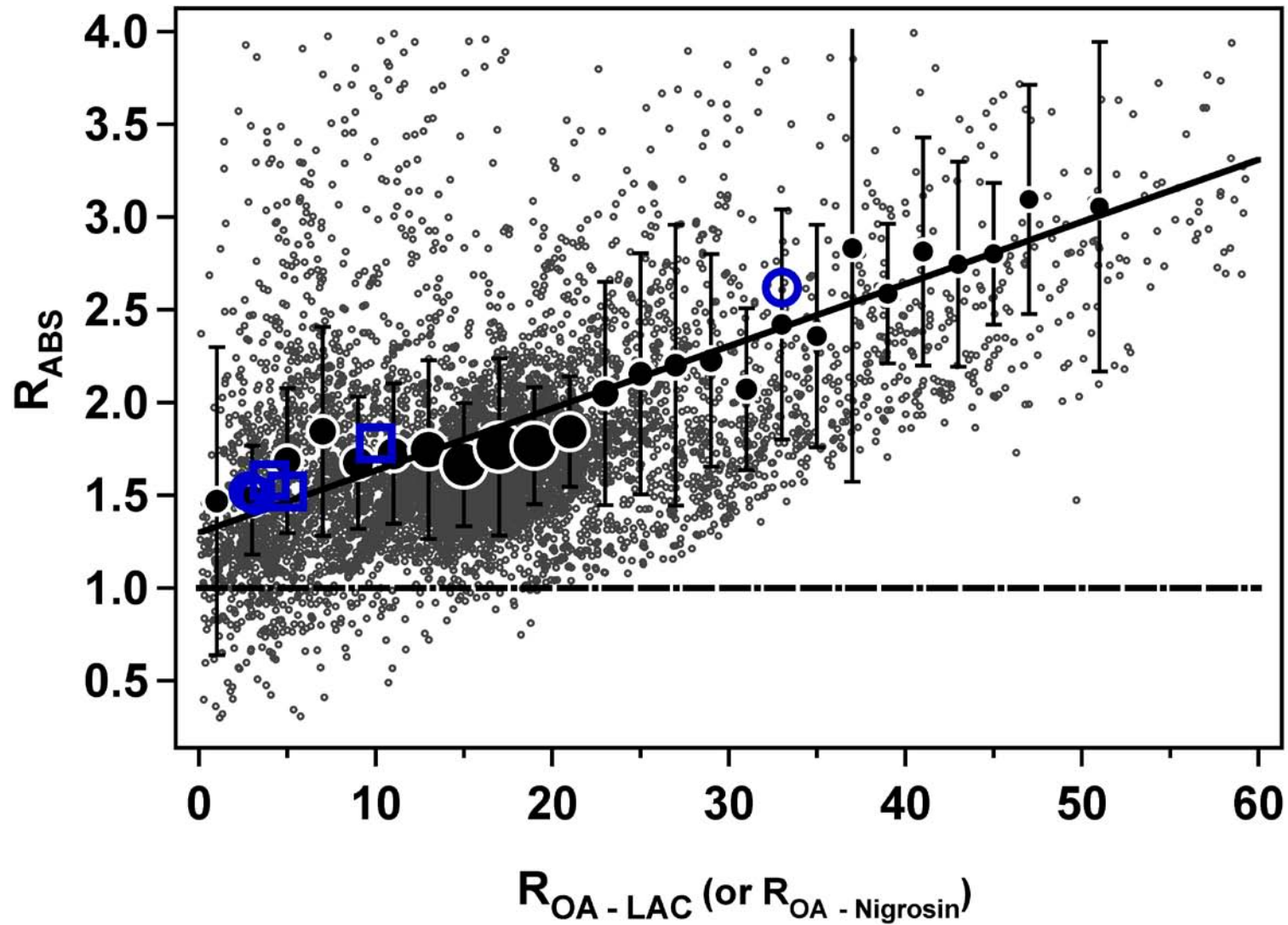


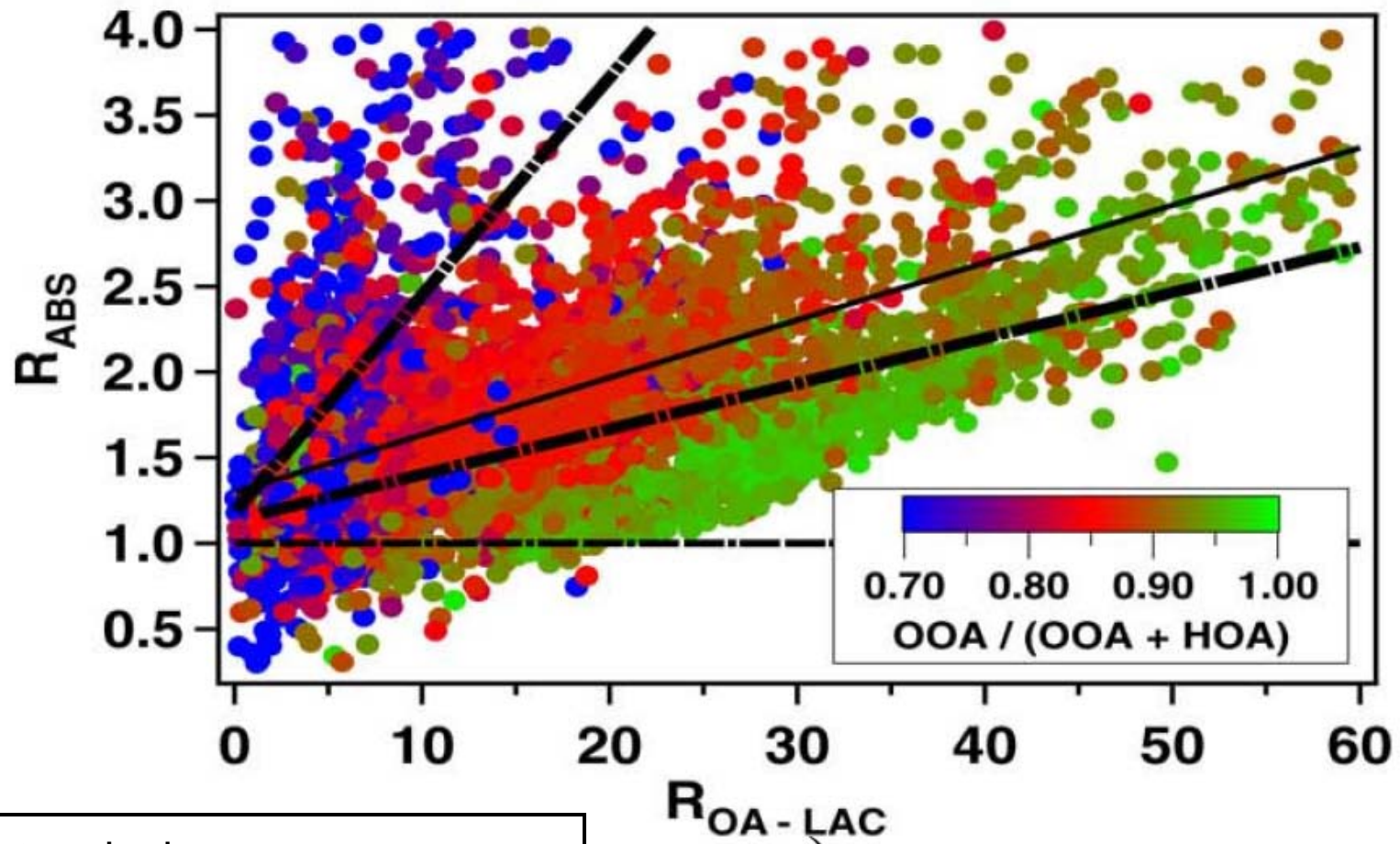
② Does (non-absorbing) SOA influence absorption measurements?

External mixtures of SOA with soot () or nigrosin ()



Lab vs. Field?





AMS terminology

OOA ~ highly oxidized aerosol

HOA ~ “hydrocarbon-like” aerosol

Other Measurements?

Observed PSAP/PAS relationship can be highly variable.

Mazzoleni/Dubey (personal communication): PSAP/PAS depends on OA and SO_4^{2-}

Arnott and co-workers: SGP-IOP \rightarrow PSAP/PAS = 1.6 (*Arnott et al., 2003*)
Reno \rightarrow no bias or uncorrelated (*Virkkula et al., 2005*)

Schmid et al. (2006): Amazon \rightarrow excellent agreement***
*** after “correcting” PSAP data for RH and T-dependence determined from comparison with PAS

Conclusions and Implications

$b_{abs,PSAP} / b_{abs,PAS}$ explicitly depends on [OA]: evidence from both field observations and lab experiments

Increasing PSAP bias with particle age (i.e. increasing [OA]/[BC])?

Seasonal cycles of b_{abs} : larger bias in summer vs. winter?

Long-term measurements of b_{abs} : are these influenced by concurrent changes in OA? If OA is constant and BC ↓ will the trend in b_{abs} be too small?

Will this bias be present in other filter-based measurements, such as the Aethelometer? What about the MAAP?

Does the (relatively inexpensive) PSAP require that it be run next to (significantly more expensive) instruments (nephelometer, AMS, SP2?) to provide accurate measurements?