Vertical Profiles of Light-Absorbing Aerosol: In-situ and AERONET Observations during NASA DISCOVER-AQ

LUKE D. ZIEMBA[1], Andreas Beyersdorf[1], Gao Chen[1], Chelsea Corr[1,2], Suzanne Crumeyrolle[3], David Giles[4], Brent Holben[4], Charles Hudgins[1,5], Robert Martin[1], Richard Moore[1,2], Michael Shook[1,5], K. Lee Thornhill[1,5], Edward L. Winstead[1,5], and Bruce E. Anderson[1]

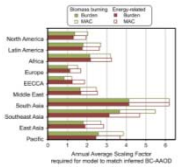
Contact: *luke.ziemba@nasa.gov*
315.244.0980

[1]Science Directorate, NASA Langley Research Center, Hampton, VA 23681
[2] Oak Ridge Associated Universities, TN 3831
[3] Laboratoire d'Optique Atmospherique, CNRS-Universite de Lille 1, Villeneuve d'Ascq, Fran
[4]NASA Goddard Flight Center, Greenbelt, MD 20771
[5] Science, Systems, and Applications Inc., Hampton, VA 23666

Introduction

Understanding the vertical profile of aerosols plays a vital role in utilizing spaceborne, column-integrated satellite observations. The properties and distribution of light-absorbing aerosols are particularly uncertain despite significant air quality and climate ramifications. The NASA DISCOVER-AQ project motivated a statistical assessment of spatial, temporal, and source-related variability for light-absorbing aerosol properties in these distinct regions.

In-situ sampling in conjunction with a dense network of AERONET sensors allowed evaluation of the sensitivity and limitations of remote-sensing data products over a wide range of conditions. AERONET retrievals of absorption aerosol optical depth (AAOD) have been extensively utilized as an observational constraint for global models, requiring significant scaling factors to achieve consistency (*right*). Here, we compare AERONET AAOD retrievals and AAOD determined from airborne (P-3B) observations.



(*Bond et al., JGR, 2013*)

Objectives and Impacts

1. Assess AERONET AAOD retrievals using in-situ observations to evaluate the use of model scaling factors
2. Evaluate the AAOD-SSA relationship and dependence on other atmospheric variables

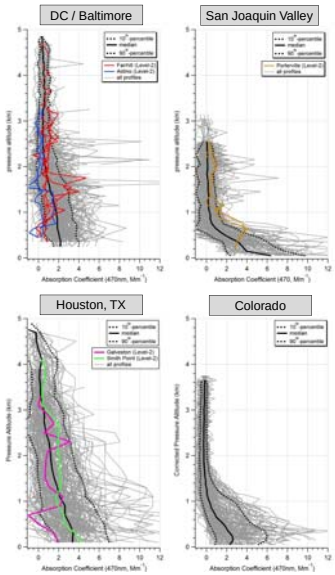
Conclusions and Future Work

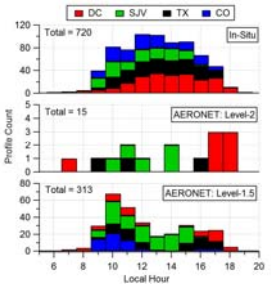
	AAOD difference (AERONET – Insitu)		AAOD ratio (AERONET/Insitu)	
	Level 1.5	*Level 2.0*	*Level 1.5*	*Level 2.0*
DC/Baltimore	0.007	0.013	2.1	5.2
San Joaquin Valley	0.007	0.018	2.9	5.2
Houston, TX	0.005	0.011	1.7	2.6
Colorado	0.011	NA	4.1	NA

- AERONET AAOD is significantly greater than in-situ
- Low AOD and AAOD values make retrievals uncertain, but minimize absolute differences
- SSA generally agreed to ±0.02

1. Vertical Profiles

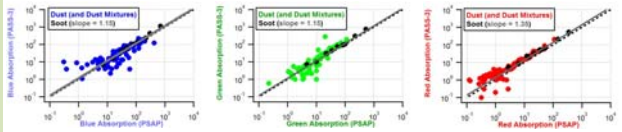
- Absorption coefficient was measured by a particle soot absorption photometer (PSAP) at 470, 532, and 660 nm wavelengths, corrected by *Virkkula et al. 2010.*
- Profiles were observed during P-3B spirals over 6-8 ground sites 3 times daily, in each region (below).





- AERONET measurements are available at each spiral location and many additional sites throughout each region.
- Profiles at many locations extend to ~20m above the surface (left).
- In-situ profiles covered a significant portion of the day; 09:00 to 17:00 (local).
- AERONET retrieval of AAOD rely on almucantar scans that occurred at ~ 10:00 and 16:00 (local), except at SJV (above).
- Profiles suggest very different dynamics at each site, especially SJV and CO where a shallow BL limited the aerosol vertical extent.

2. Laboratory Absorption Measurement Validation



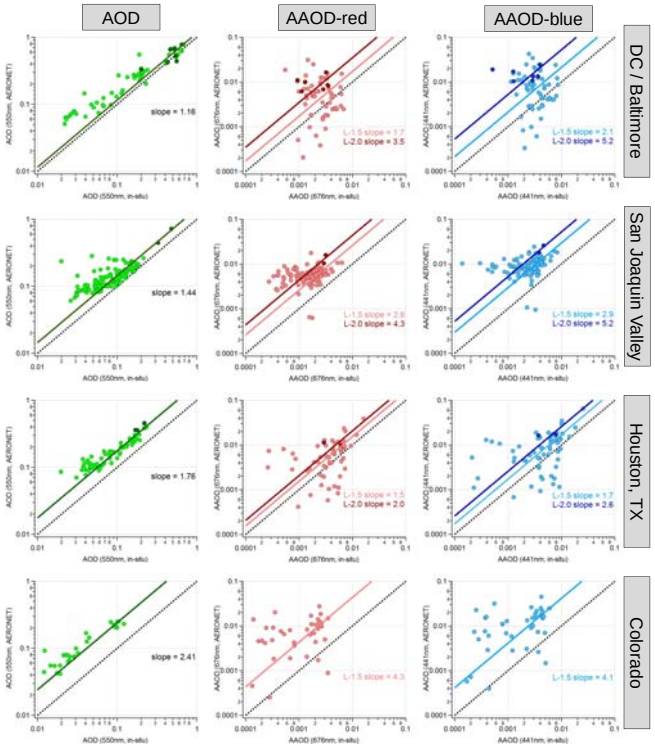
- PSAP measurements suffer from uncertainties and filter artifacts
- Laboratory observations using a DMT PASS-3 (photo-acoustic) showed excellent agreement for soot and dust aerosol

** STEER (Statistical Evaluation of Aerosol Retrievals) – PI: Greg Schuster

3. AERONET Comparison

Light-coloring → Level-1.5 data
Dark-coloring → Level-2.0 data

- Linear extrapolation extended aircraft observations to ground-level if necessary



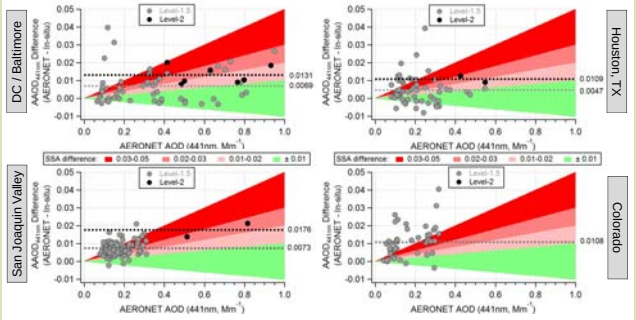
- Good AOD AERONET/in-situ correlation observed at AOD > 0.1, especially for DC

Ground-Level Values Necessary to Match AERONET AAOD

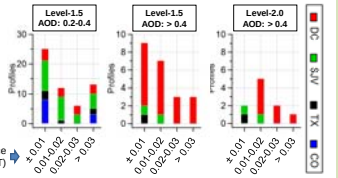
	Absorption (Mm^{-1})	*BC mass ($\mu g\ m^{-3}$)*
DC/Baltimore	46.8 ± 90.6	3.5 – 7.0
San Joaquin Valley	69.0 ± 36.6	5.2 – 10.4
Houston, TX	37.3 ± 76.4	2.8 – 5.6
Colorado	104.1 ± 87.2	7.8 – 15.6

- AERONET AAOD consistently exceeds in-situ by ~2x (L-1.5) and ~4x (L-2.0) for both wavelengths (above)
- Linear correlation between AAOD measurements is weak
- Significant absorption coefficients (and unrealistic BC mass concentrations) would be necessary at the surface to explain AERONET discrepancy (left)

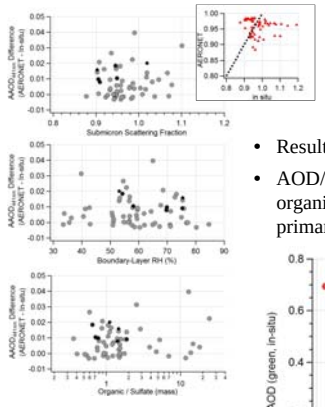
4. Influencing Factors



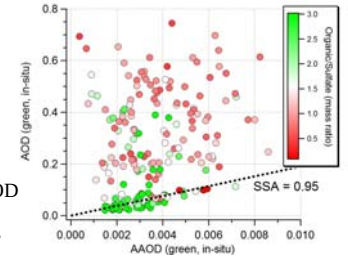
- AAOD difference (AERONET – in situ) is generally within 0.01 (L-1.5)
- Difference is larger for L-2.0
- Small AAOD difference can manifest as large difference in SSA



DC / Baltimore



- AAOD-difference did not depend on presence of dust, relative humidity (RH), or chemical composition (left).
- Results are consistent with other sites
- AOD/AAOD was only correlated for organic-dominated aerosols, likely primary emissions (below)



- Transport of sulfate to the region yields no AOD/AAOD correlation (right)
- L-2.0 retrievals are only for high-SSA cases (right)