

Field test of a new instrument to measure UV/Vis (300-700 nm) ambient aerosol extinction spectra in Colorado during DISCOVER-AQ

C. Jordan¹, B. Anderson², A. Beyersdorf², J. Dibb¹, M. Greenslade¹, R. Martin², E. Scheuer¹, M. Shook², L. Thornhill², D. Troop³, E. Winstead², and L. Ziemba²

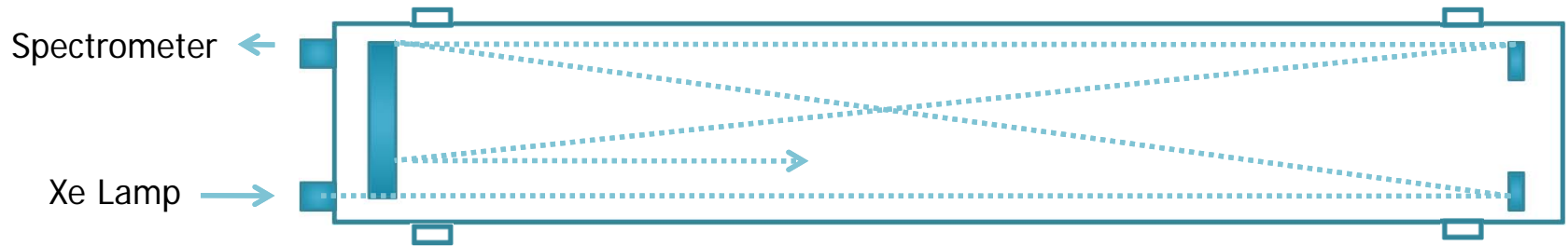
¹Institute for the Study of Earth, Oceans, & Space, University of New Hampshire, Durham, NH;

²NASA Langley Research Center, Hampton, VA;

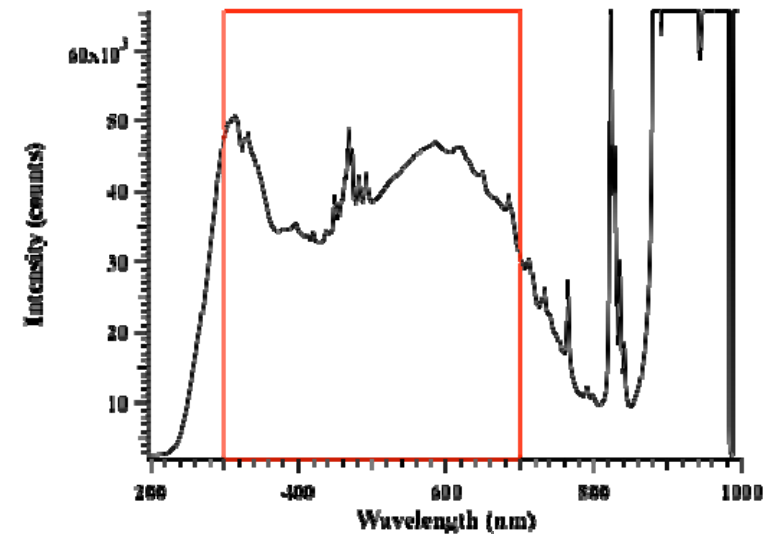
³Southwest Research Institute, Durham, NH

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Spectral Aerosol Extinction (SpEx) instrument



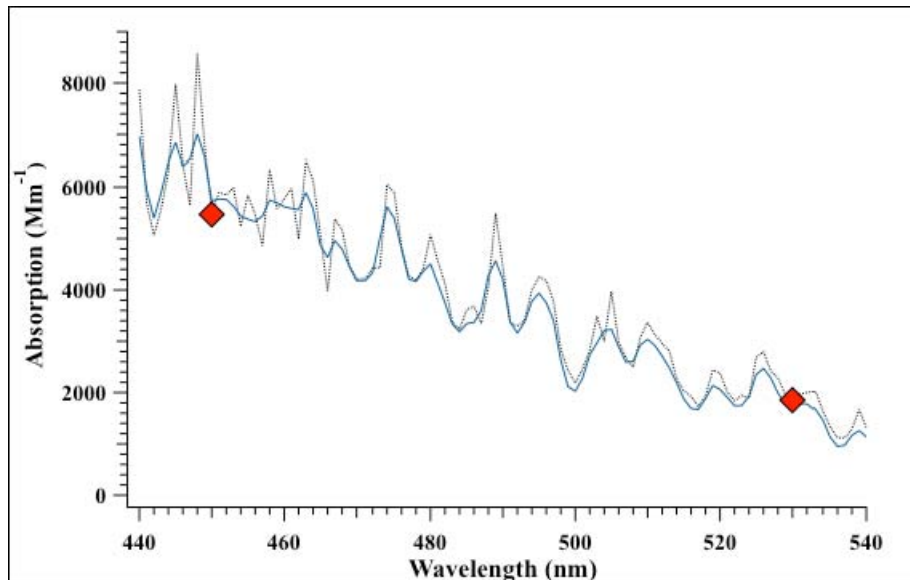
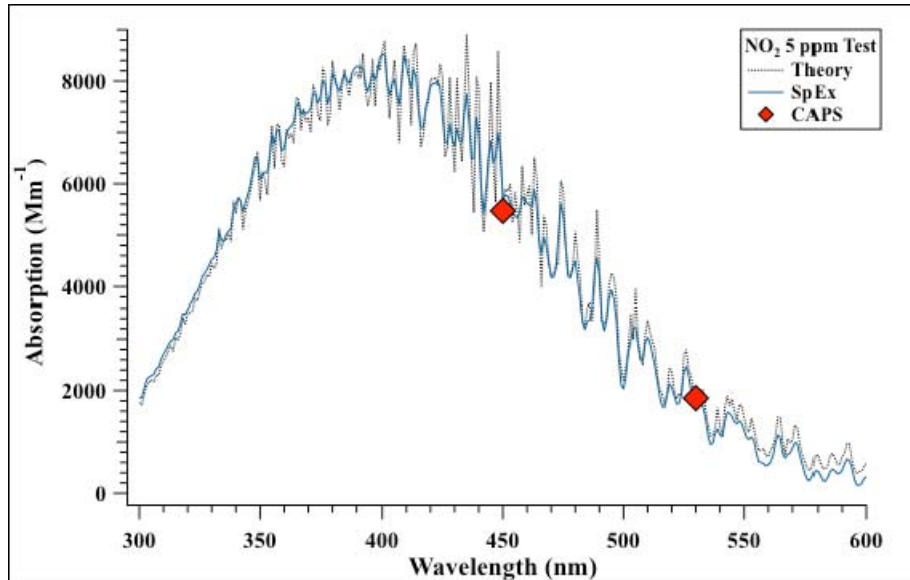
$$Extinction = -\frac{\ln\left(\frac{I}{I_0}\right)}{L}$$



Typical operating parameters:

- optical path length 39.4 m
- internal volume ~ 17 l
- flow rate ~ 80 lpm
- flush time 90 s
- integration time ~ 20-50 ms
- sample time 30 s

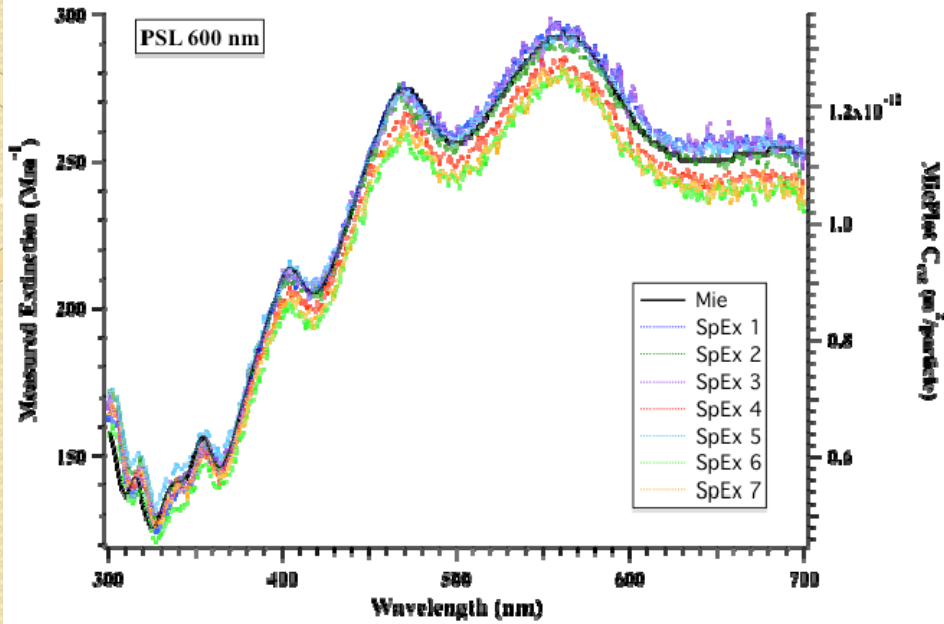
Gas-phase Laboratory Tests



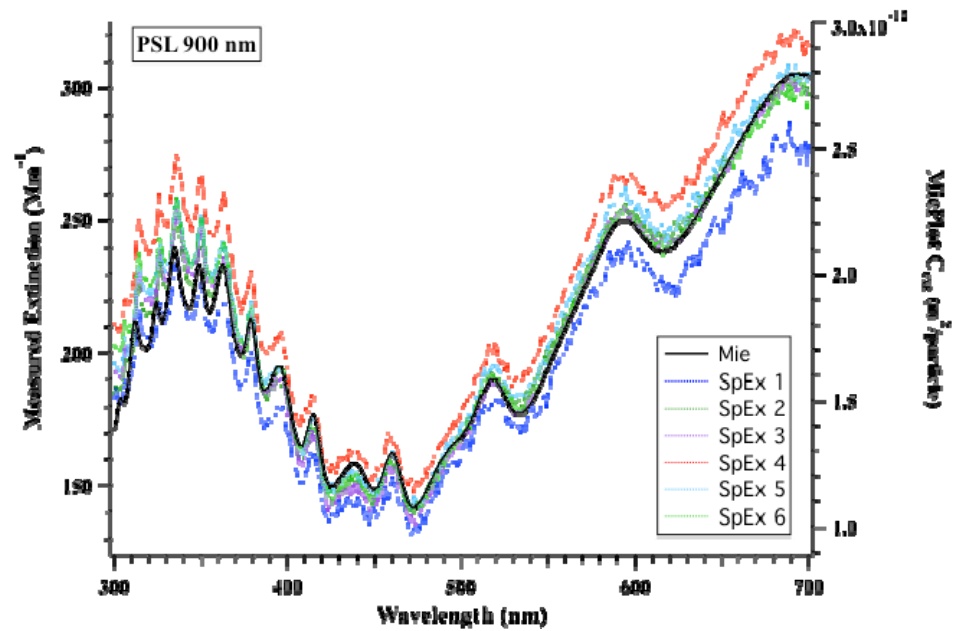
- No evidence of O₃ production nor NO₂ loss in light beam of optical cell with 80 lpm flow
- No loss of NO₂ through the filter in the reference inlet line

***SPEX MEASURED
NO₂ SPECTRUM
AGREES WELL WITH THEORY***

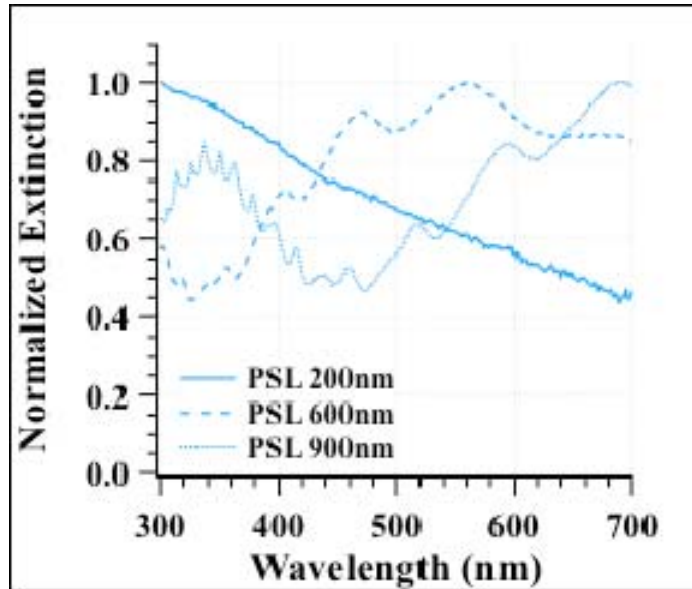
SpEx PSL Spectra & Mie Theory



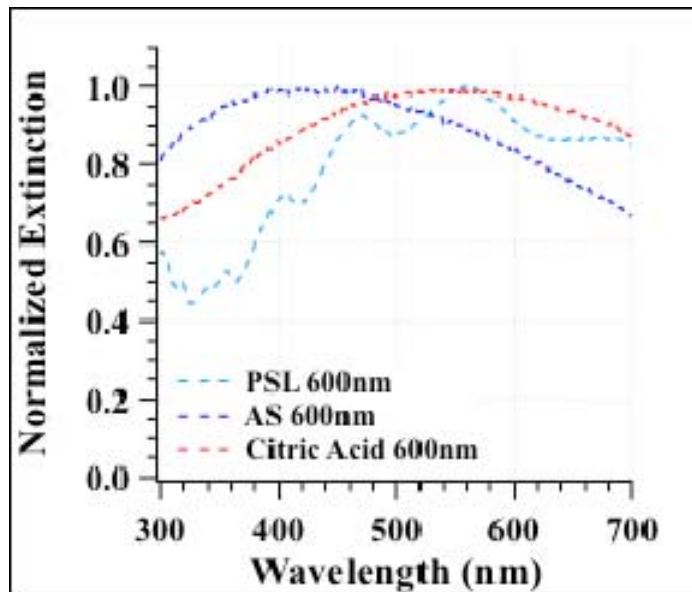
*SPEx MEASURED
AEROSOL SPECTRA
AGREE WELL WITH
MIE THEORY*



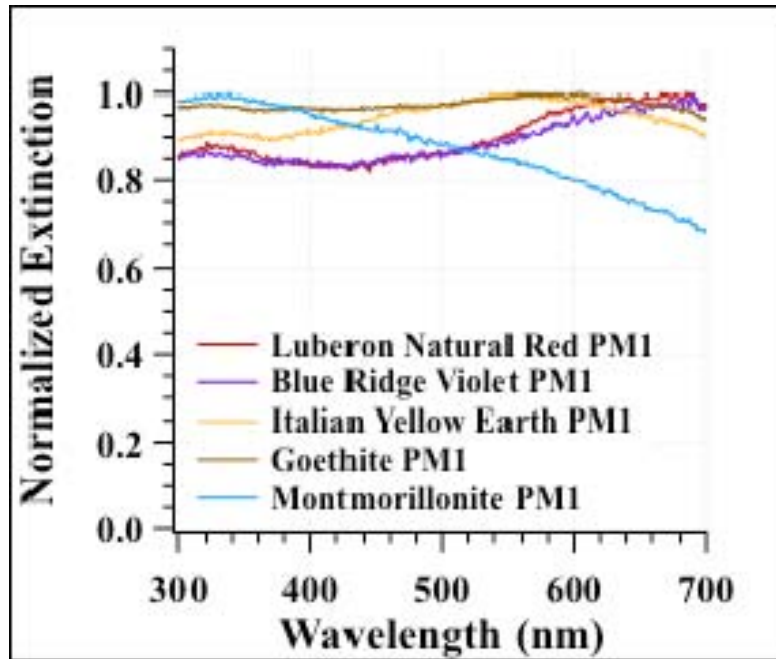
Normalized Mean Spectra



- Peak extinction decreases with particle size
- Spectral shape depends on particle composition, as well as, size

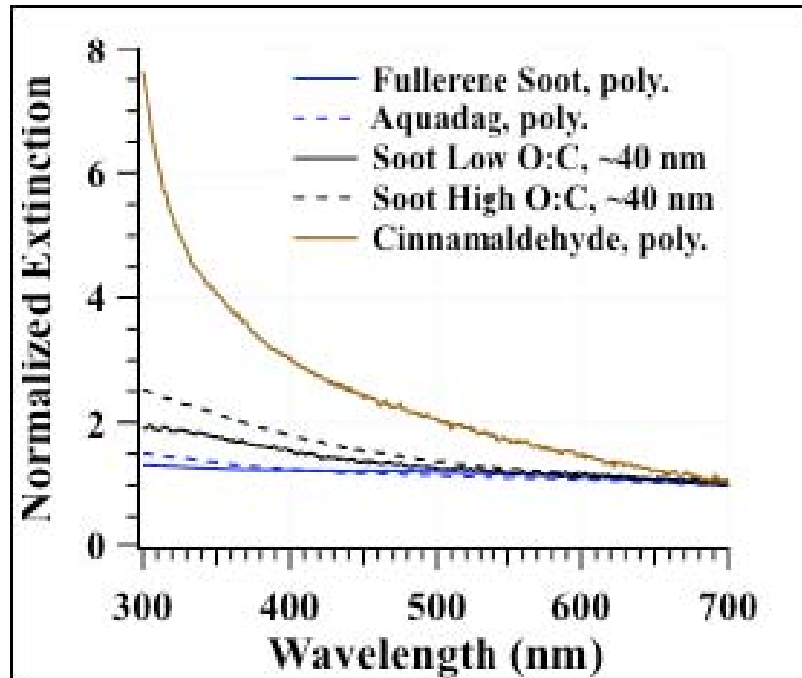


Normalized Mean Spectra: PM1 Dust



- PM1 Dust Spectra show little wavelength dependence
- Pigments influence spectral shape

Normalized Mean Spectra: scaled to 700 nm



•Uncoated soot compared to:
BC surrogates:

Fullerene soot
Aquadag

BrC surrogate:

Cinnamaldehyde

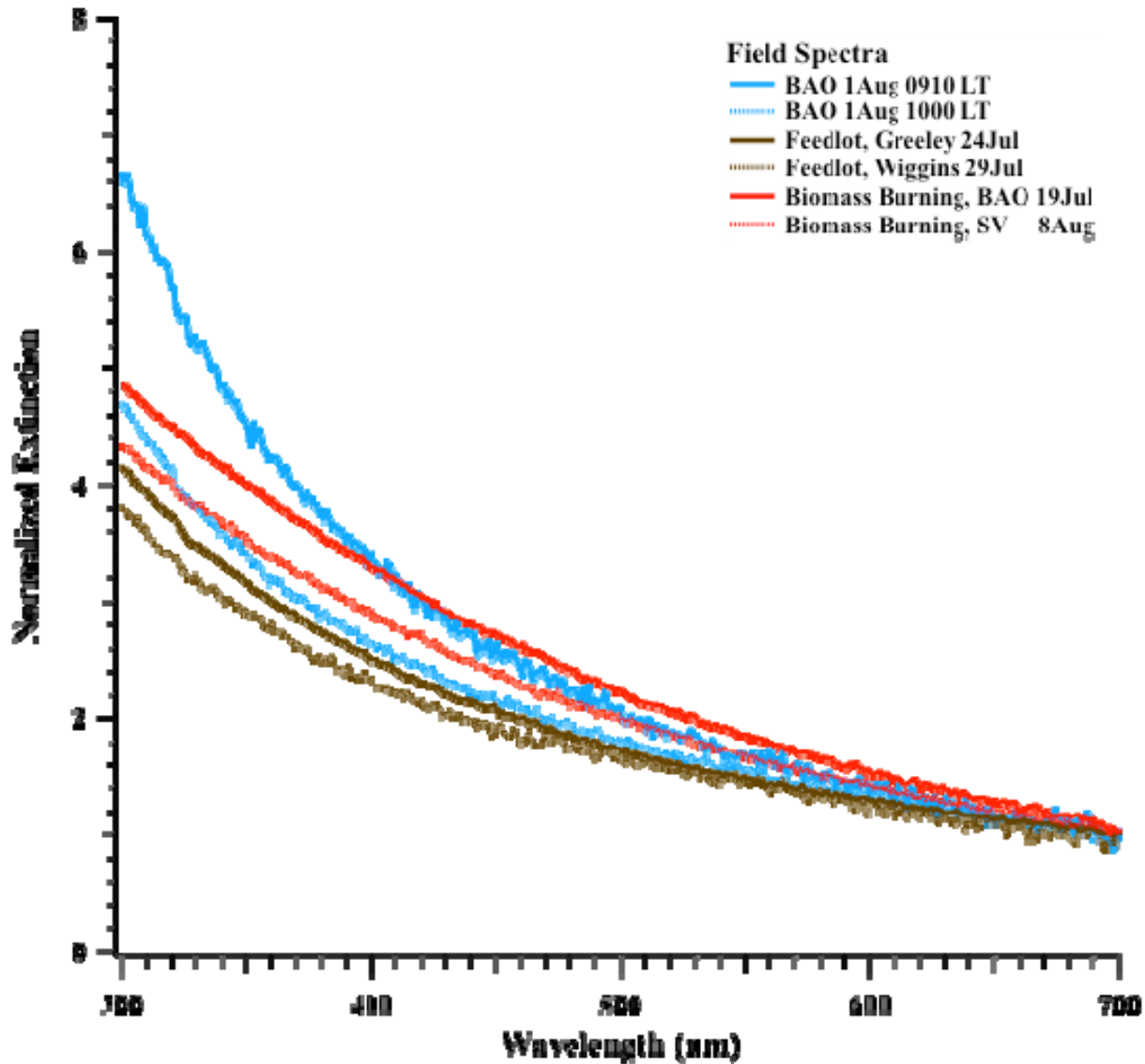
•UV extinction of uncoated soot
found in range between BC &
BrC

•Little variability among soot &
BC samples from 500-700 nm

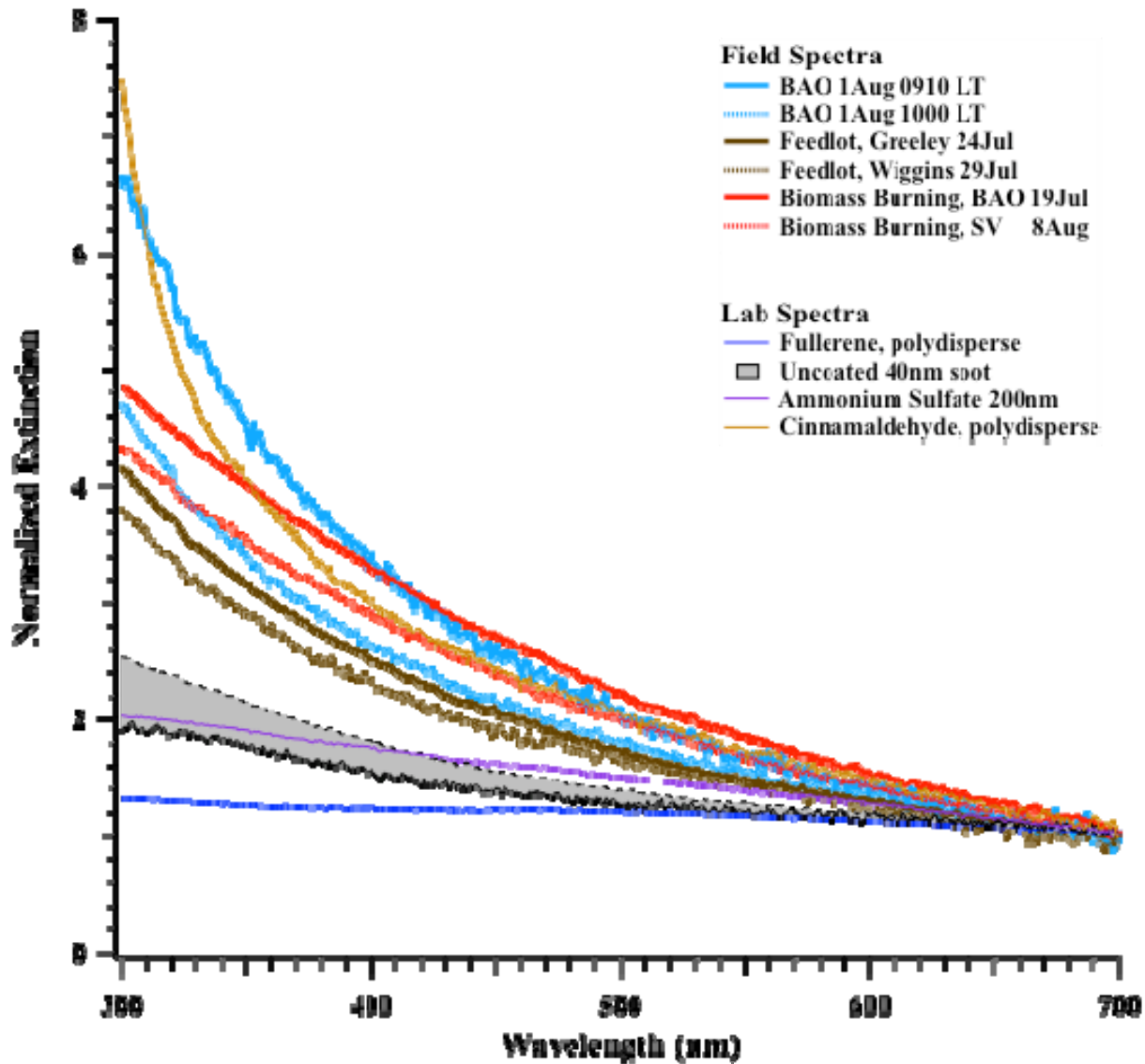
DISCOVER-AQ Colorado (& Idaho) Sample Sites



Normalized Mean Spectra: scaled to 700 nm Laboratory & Preliminary DISCOVER-AQ: Colorado



Normalized Mean Spectra: scaled to 700 nm Laboratory & Preliminary DISCOVER-AQ: Colorado



Concluding Remarks

SPeX

- *in situ* ambient aerosol extinction spectra, 300 – 700 nm
- expands *in situ* measurement capability beyond 3 wavelengths available from other methods
- obtains good agreement with theory
- provides unique data into UV range
- spectra contain information about aerosol size distributions & composition

NEW TOOL FOR

ambient aerosol extinction characterization
study of extinction evolution in the atmosphere
contributing to closure studies
future calibration/validation for remote sensors

ACKNOWLEDGMENTS

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Additional Slides

The Value of a Spectral Extinction Measurement

- Aerosol interaction with light is wavelength dependent
 - often characterized by a power law: $p(\lambda) = \lambda^{-\alpha}$
 - where, α is known as Angstrom exponent
 - p can be any optical property that is described by a power law, e.g., scattering, absorption, extinction, etc.
- Commercially available instruments often target a few λ s, such that Angstrom exponents are calculated from these few wavelengths, e.g.,

$$\alpha(\lambda_1, \lambda_2) = -\frac{\ln(p(\lambda_1)/p(\lambda_2))}{\ln(\lambda_1/\lambda_2)}$$

- Additional wavelength-dependent parameters include
 - refractive indices, $m(\lambda) = n(\lambda) + k(\lambda)$
 - single scatter albedo, $\omega(\lambda) = \beta(\lambda) / \gamma(\lambda)$
 $= \beta(\lambda) / (\beta(\lambda) + \alpha(\lambda))$

