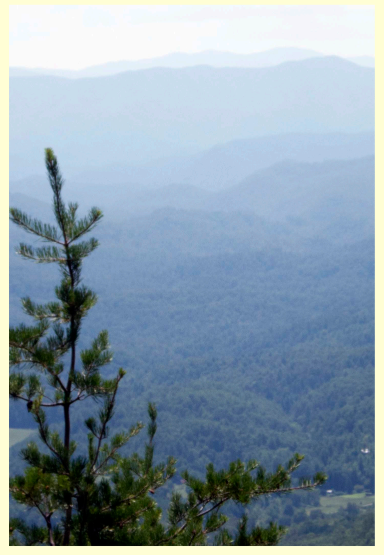
Ambient Aerosol Light Extinction in Great Smoky Mountains National Park

Timothy D. Gordon[1], G. McMeeking[1], J. Renfro[2], E. McClure[2], A. Prenni[3], T. Onasch[4], A. Freedman[4], P. Chen[1]

[1]Handix Scientific, Boulder, CO [2]National Park Service, Gatlinburg, TN [3]National Park Service, Denver, CO [4]Aerodyne Research, Billerica, MA



Abstract

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program reconstructs light extinction from filter measurements and humidification growth factors. Under many atmospheric conditions reconstructions compare favorably with measurements; however, there are several possible sources of discrepancy. First, the IMPROVE reconstructions are based on 24 h averaged filter measurements taken once every four days; thus, important transient events may not be well resolved. Second, at high relative humidities (RH) extinction is sensitive to RH perturbations; thus, under such conditions humidification growth factors are highly uncertain.

During the majority of the campaign ambient extinction measured with an Open-Path Cavity Ringdown Spectrometer (OPCRDS) agreed closely with the GSM nephelometer and the reconstructed extinction. However, coarse-mode particles, and several high RH events were not resolved by the reconstructed extinction. Extinction calculated with the revised reconstruction algorithm (IMPROVE-2) was about 12% lower than the values calculated from the original algorithm and provided a slightly better fit to the OPCRDS data.

Reconstructed aerosol extinction: IMPROVE

Initially, the IMPROVE program estimated extinction from measurements of several species and growth factors (f(RH)).

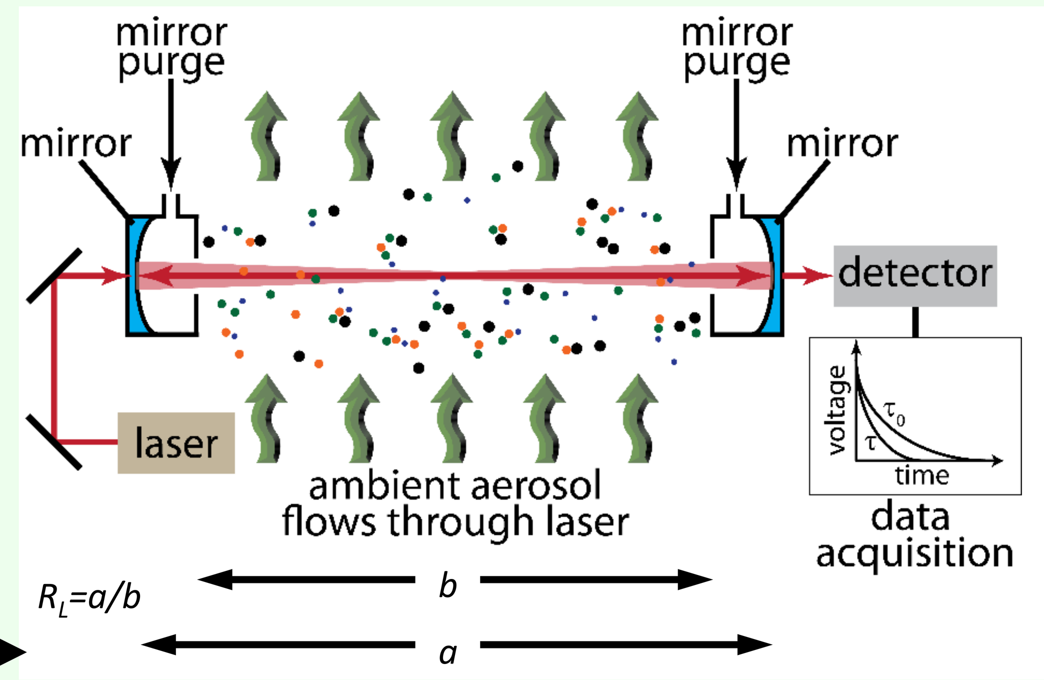
IMPROVE-1: $\alpha_{extinction}$ = *3xf(RH)x[Sulfate] + 3xf(RH)x[Nitrate] + 4x[OM] + 10x[EC] + [Fine Soil] + 0.6x[Coarse Mass]*

Recently, the IMPROVE equation was modified to incorporate additional species, two particle size modes and other changes.

IMPROVE-2: similar but more complicated

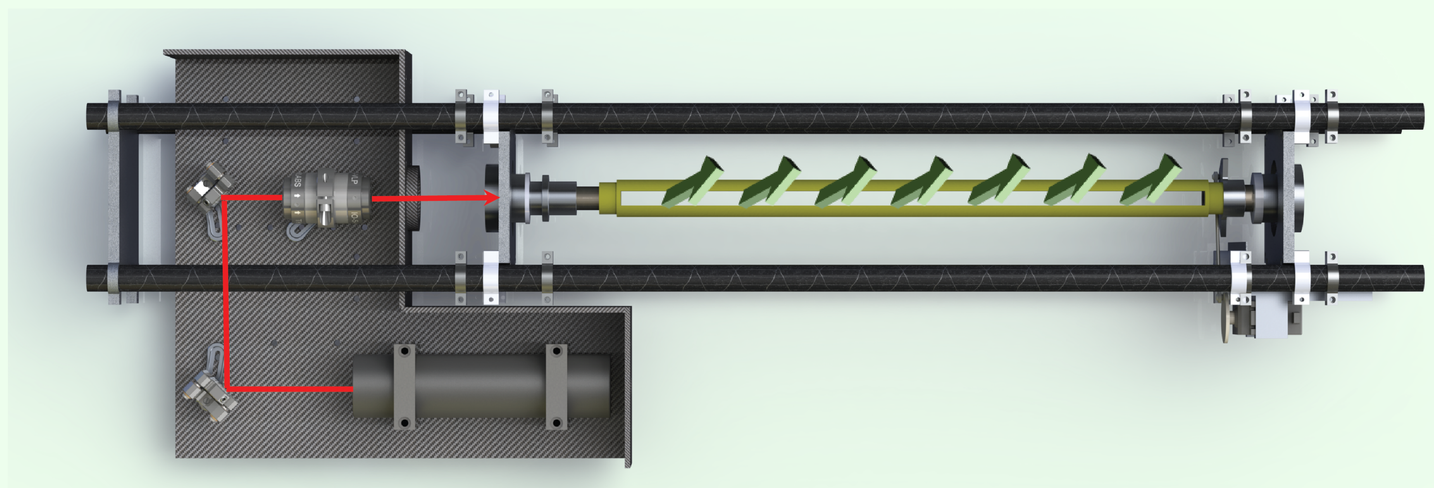
Compare reconstructions to measurements

Measured aerosol extinction: Open-path Cavity Ringdown Spectrometer (OPCRDS)

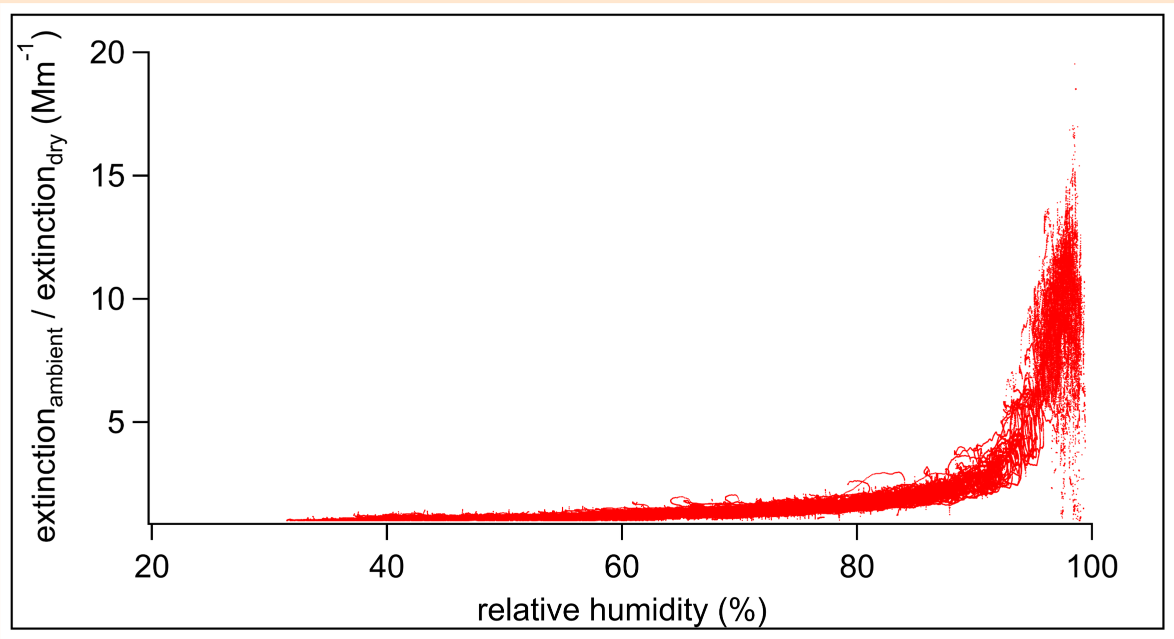


The extinction coefficient $\alpha_{extinction}$ is a function of the decay rate of light with and without particles (τ and τ_0, respectively) in the cavity.

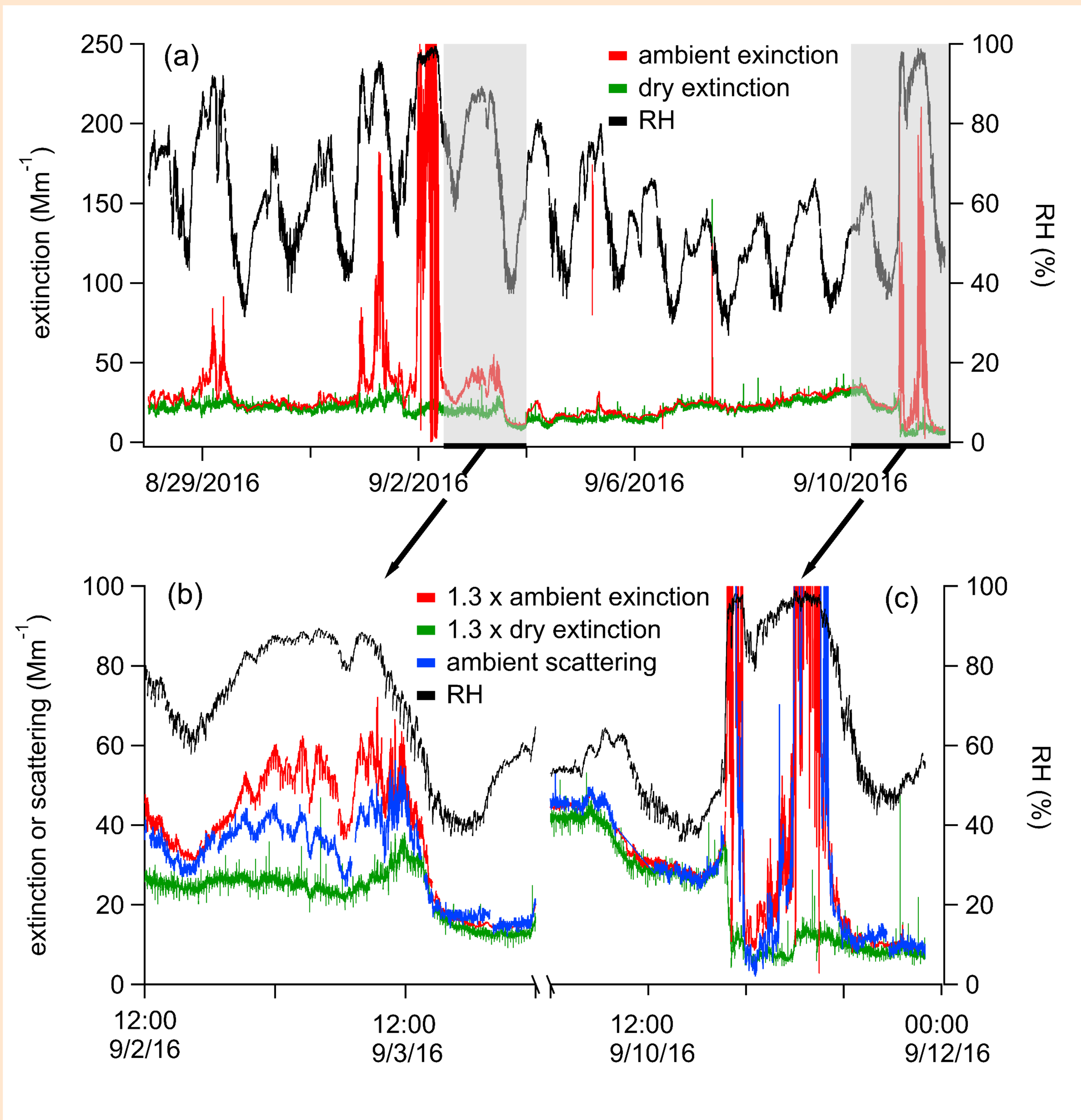
$$\alpha_{extinction} = \frac{R_L}{c}\left(\frac{1}{\tau} - \frac{1}{\tau_0}\right)$$



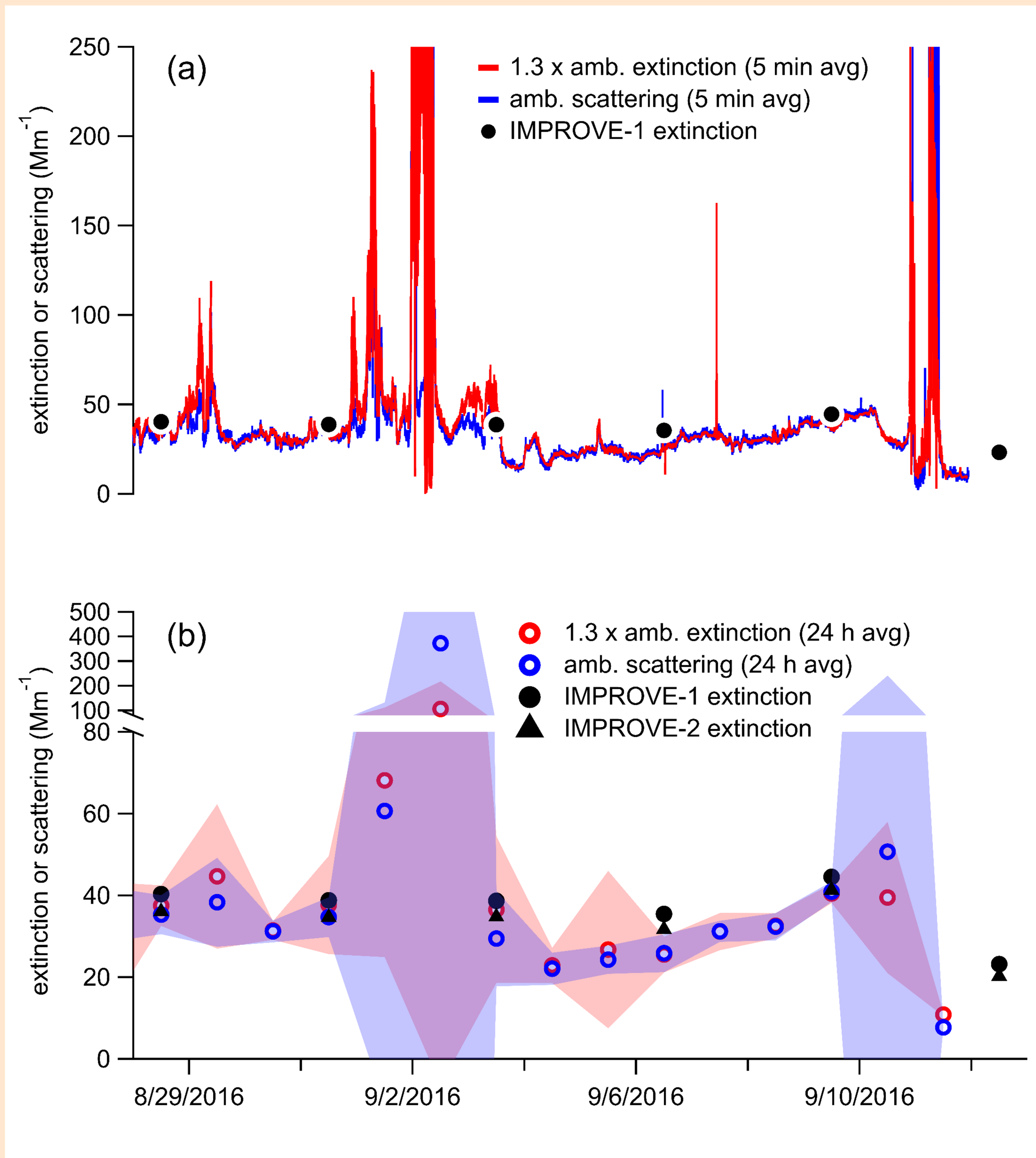
Measurements were conducted at Great Smoky Mountains National Park.



Hygroscopic aerosol growth during the 16-day measurement period.



(a) Ambient extinction, dry extinction and RH during the field campaign. The first shaded period (enlarged in (b)) indicates possible coarse particle effects. The second period (enlarged in (c)) shows the impact of high RH on extinction.



Comparison of aerosol extinction calculated from IMPROVE-1 and (a) 5-minute average ambient extinction/scattering and (b) 24-h average ambient extinction/scattering and extinction calculated with IMPROVE-2.

Results and Conclusions

- Both IMPROVE extinction reconstructions agree well with measured ambient extinction (OPCRDS).
- IMPROVE-2 reconstruction is ~12% lower than IMPROVE-1 during this time period at GSM.
- Ambient extinction agrees closely with ambient scattering after wavelength correction.
- Coarse particle effects and/or high RH events may not be resolved by filters/IMPROVE.
- High RH (> ~98%) transients lead to 20x increase in extinction; these events are resolved by the OPCRDS but not by filter measurements.

Future Prospects

- Find collaborators (**you?**) with complimentary instrumentation (e.g., closed-path optical, chemical composition, etc.) and deploy the OPCRDS in environments that have previously been difficult to characterize
  - coarse particle/dust dominated
  - high RH
  - marine
- Deploy the OPCRDS at long term monitoring sites

Contact: Tim Gordon (tim@handixscientific.com)