Synthesis of aerosol physical, chemical and radiative properties from various sources: consistency and closure

Hagen Tiel1,2, Graham Feingold3, Evgenii Kassianov3, Connor Flynn1, Jerome Fast1, and Alison McComiskey2
(1) CIRES, University of Colorado, Boulder, CO (2) NOAA Earth System Research Laboratory, Boulder, CO (3) PNNL, Atmospheric Measurement & Data Sciences, Richland, WA

Introduction
- Provide greater confidence in the characterization of aerosol optical properties in different regimes in order to better constrain observation-based and modelled aerosol radiative forcing estimates.
- Aerosol optical depth and size distribution is derived from a set of aerosol optical properties — aerosol optical depth, single scattering albedo, and asymmetry parameter — which can be obtained from a range of different measurement techniques. Given that a small fraction of these observations are most widely used for climate change studies, a comprehensive assessment of the interrelationship among all measurements would be of benefit.
- Understanding how aerosol optical properties and radiative forcing vary and covary, in different regions of the globe can improve assumptions required for retrievals and products from satellite-based observations.

Method
- We present data for scattering coefficients, hemispheric backscattering ratio, and hygroscopicity ($f(RH)_{45\%}$) for ARM’s SGP site for a period of time from 2011 to 2013. These quantities are both measured and calculated from different sources for the purpose of comparing the optical properties that are used for radiative forcing estimates.
- Aerosol optical properties are derived from size distributions using Mix theory. Here the index of refraction is derived from the electrolyte composition using a volume mixing rule. Electrolyte composition is calculated using the equivalent fractions for cations and anions.
- $f(RH)_{45\%}$ is derived from size distributions by calculating scattering efficiencies after applying growth factors $g_f$ at RH of 40 and 85%. $g_f$ is obtained by averaging $g_f$ distributions for 400 nm particle diameters. We correct $g_f$ for the desired RH applying a $k$ parameterization.
- ARM products are limited to good and intermediate data quality.
- Aerosol optical properties are for a wavelength of 550 nm and diameters of up to 1 μm.

Scattering coefficient

- NEP measured scattering and TDMA calculated scattering. Chemical composition is derived from ACSM.
- General trends in both data sets are well correlated.
- Most of the time TDMA is biased low compared to NEP. $\Delta$ median (the ratio) = 0.66.
- A lot of uncorrelated variations $\rightarrow$ mad (the ratio) = 0.19

Hemispheric backscattering ratio

- NEP measured backscattering and TDMA calculated backscattering. Chemical composition is derived from ACSM.
- General trends in both data sets are well correlated.
- TDMA is biased low most of the time which agrees with the finding of an underestimated n. $\rightarrow$ median (the ratio) = 0.95
- Deviation is lower than in case of scattering. $\rightarrow$ mad (the ratio) = 0.07

Hygroscopicity — $f(RH)_{45\%}$

- NEP measured and TDMA calculated $f(RH)_{45\%}$. Chemical composition is derived from ACSM.
- Most of the time general trends in the two data sets are correlated.
- While values seem to agree on average. mean (the ratio) = 0.96, many values deviate significantly mad (the ratio) = 0.21.

Conclusions
- 50% of the time the data quality (or availability) of at least one of the processed data products was not meeting our requirements.
- Although general trends are well correlated we find significant short and long-term deviations between different retrievals of the same aerosol properties.
- We can correlate refractive index retrievals from chemical composition data to some deviations.
- We find fit results for $f(RH)$ data to be systematically affected by the RH inside the dry nephelometer.
- Aerosol direct radiative forcing and we will continue to explore the parameters space for further correlation.