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

Hagen Telg[1,2], Graham Feingold[2], Evgueni Kassianov[3], Connor Flynn[3], Jerome Fast[3], and Allison McComiskey[2]
(1) CIRES, University of Colorado, Boulder, CO (2) NOAA Earth System Research Laboratory, Boulder, CO (3) PNNL, Atmospheric Measurement & Data Sciences, Richland, WA

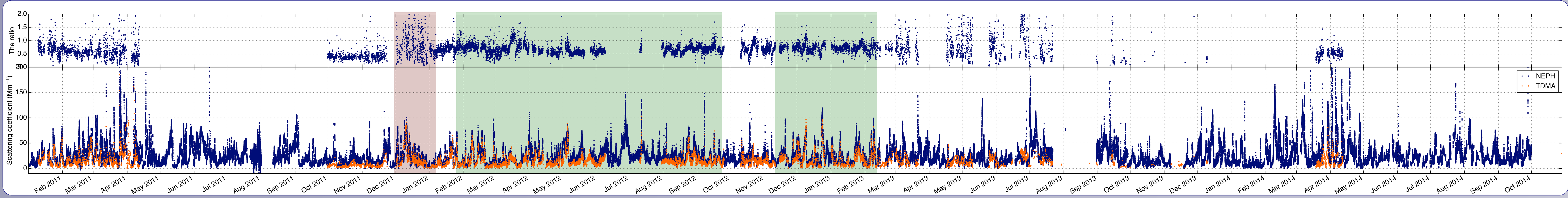
Introduction

- Provide greater confidence in the characterization of aerosol optical properties in different regimes in order to better constrain observationally-based and modeled aerosol radiative forcing estimates.
- Aerosol direct radiative forcing is determined from a set of 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

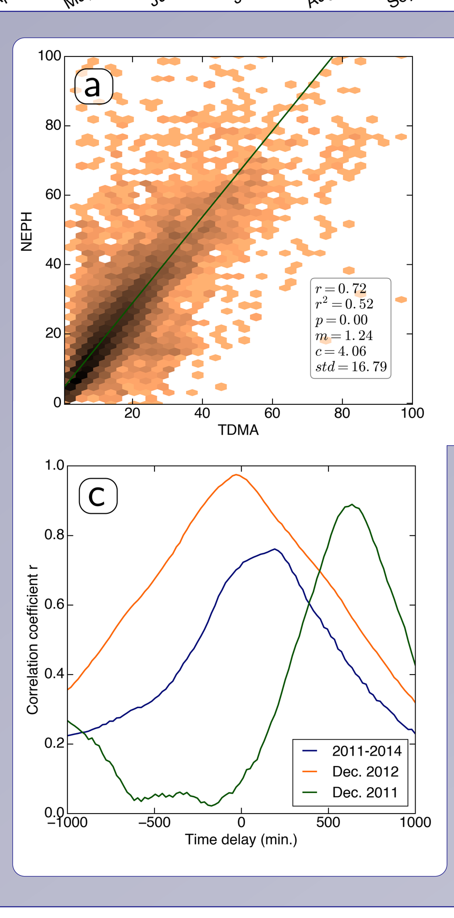
- We present data for scattering coefficients, hemispheric backscattering ratio, and hygroscopicity ($f(RH)|_{85,40}$) for ARM's SGP site for a time period of 4 years between 2011 and 2015. These quantities are both measured and calculated from different sources for the purpose of comparing the optical properties that are used for radiative forcing estimates.
- Aerosol optical properties are derived from size distributions using Mie theory. Here the index of refraction n is derived from the electrolyte composition using a volume mixing rule. Electrolyte composition is calculated using the equivalent fractions for cations and anions.
- $f(RH)|_{85,40}$ is derived from size distributions by calculating scattering efficiencies after applying growth factors gf at RH of 40 and 85 %. gf is obtained by averaging gf distributions for 400 nm particle diameters. We correct gf for the desired RH applying a κ 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.

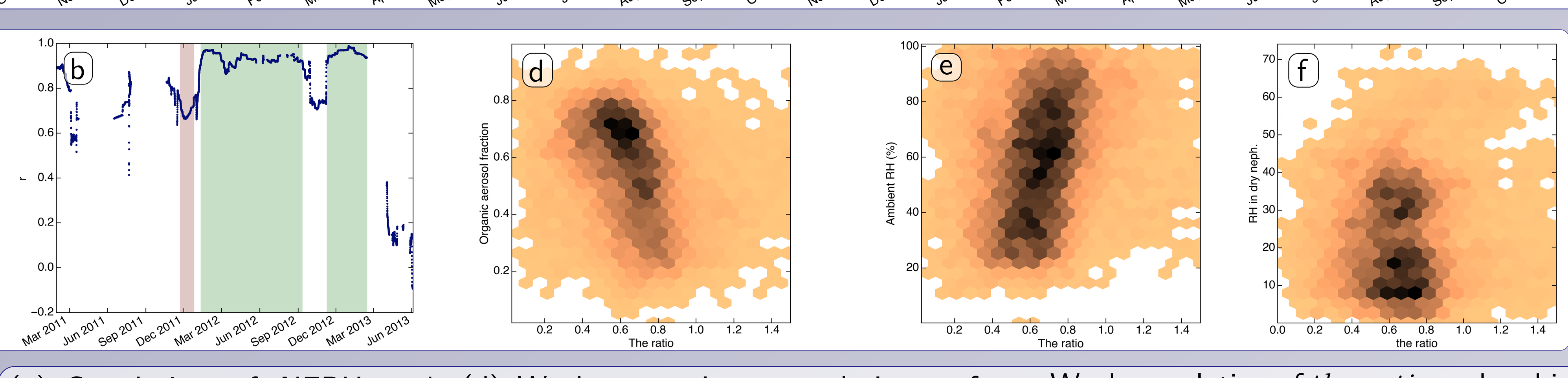
Scattering coefficient



- NEPH 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 NEPH. ↔ median(The ratio) = 0.66
- A lot of uncorrelated variations ↔ mad(The ratio) = 0.19

tested correlations: ambient RH (↗), ambient temp. (–), absorption (–), chemical composition (OA:↘, NH_4^+: ↗, SO_4^{2-}: –, Cl^-: –), refractive index (↗), mass conc. (acsm; –), mass conc. (tdma+acsm; ↗), volume conc. (tdma; –)



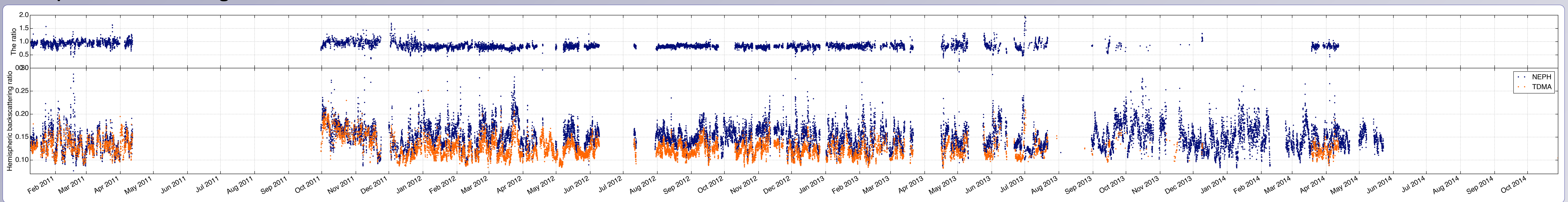


(a) Correlation of NEPH and TDMA scattering coefficients
(b) 30 day rolling correlation → quality varies
(c) Time lag correlation → time not always synchronous
(d) Weak negative correlation of *the ratio* and the organic aerosol fraction
→ n of organic aerosols is particularly hard to determine. Results indicate that the value we used (1.48) might be too small.
→ small n explains why *the ratio* < 1

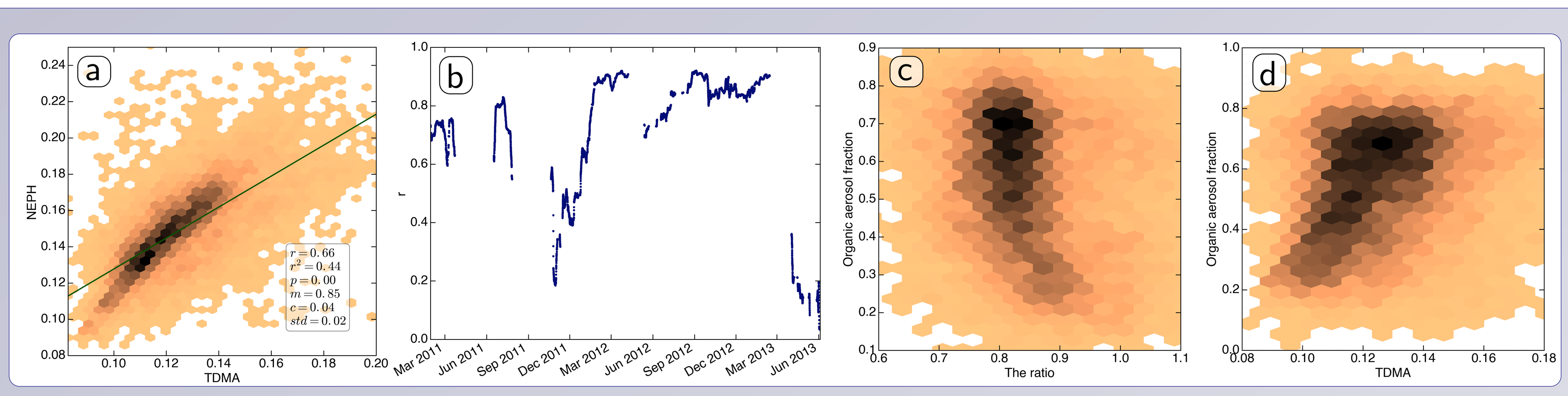
- Weak correlation of *the ratio* and ambient RH (e) but no correlation of the ratio and RH inside the dry nephelometer (f)

→ Correlation to ambient RH is result of correlation between ambient RH and organic aerosol fraction.
→ Dry nephelometer RH up to ~40 % does not effect scattering coefficient.

Hemispheric backscattering ratio



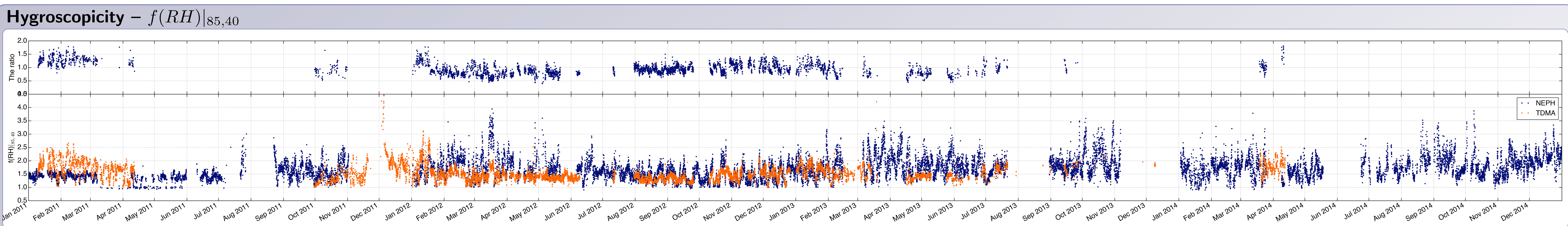
- NEPH measured backscattering and TDMA calculated backscattering. Chemical composition is derived from ACSM.
- General trends in both data sets are well correlated.
- TDMA is biased low most of the time which agrees with the finding of an underestimated n. ↔ median(*the ratio*) = 0.85
- Deviation is lower than in case of scattering. ↔ mad(*the ratio*) = 0.07



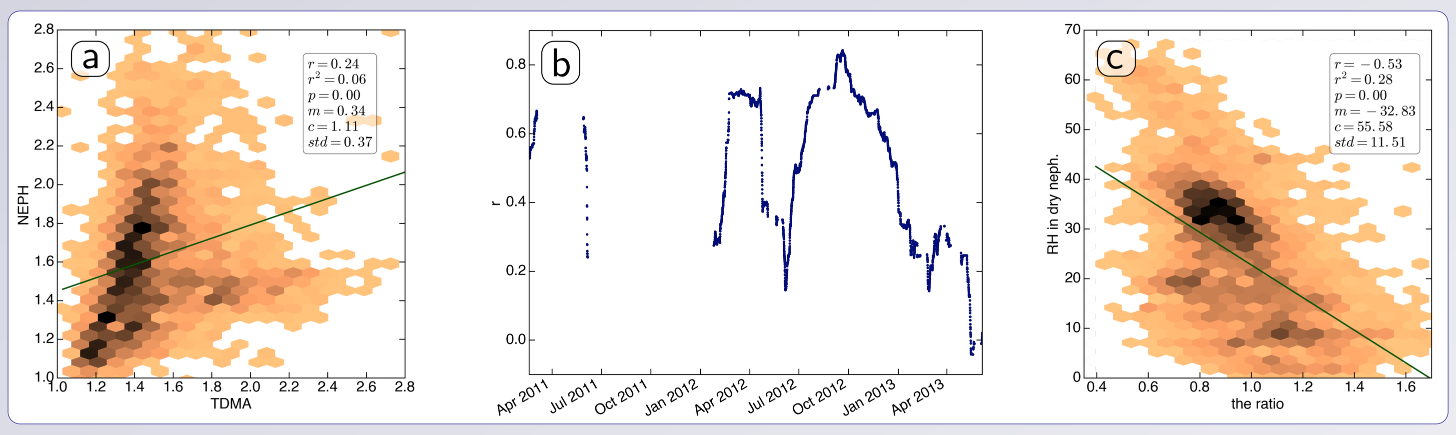
(a) Correlation between NEPH and TDMA hemispheric backscattering ratio. Correlation seems nonlinear.
(b) 30 day rolling correlation shows good and bad correlation at similar dates as scattering.
(c) Weak negative correlation of organic aerosol fraction and *the ratio*
→ As above this can be attributed to a low n for organic aerosols.
(d) The positive correlation between organic aerosol fraction and hemispheric backscattering explains the nonlinear correlation in (a).

tested correlations: ambient RH (↗), ambient temp. (↘), absorption (–), chemical composition (OA:↘, NH_4^+: ↗, SO_4^{2-}: –, Cl^-: –), refractive index (↗), mass conc. (acsm; ↗), mass conc. (tdma+acsm; ↗), volume conc. (tdma; –)

Hygroscopicity – $f(RH)|_{85,40}$



- NEPH measured and TDMA calculated $f(RH)|_{85,40}$. Chemical composition is derived from ACSM.
- Most of the time general trends in the two data sets are correlated.
- While values seam to agree on average, median(*the ratio*) = 0.96, many values deviate significantly, mad(*the ratio*) = 0.21.



(a) Weak correlation of NEPH and TDMA hygroscopicity.
(b) 60 days rolling correlation shows that time periods exist where the data sets correlate well.
(c) *The ratio* has a significant negative correlation to the RH inside the dry nephelometer.
→ Fit results are systematically effected by smaller number of data points.

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 effected by the RH inside the dry nephelometer.
- Our findings can not explain the majority of deviations and we will continue to explore the parameters space for further correlation.