Relating Chemical and Optical Aerosol Properties at the Mauna Loa Observatory

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Introduction

Different elements tend to be associated with different aerosol types (e.g., sea salt, biomass burning, etc.), providing potential insight into air mass sources. Here, we investigate the relationship between PM10 aerosol optical (scattering and absorption coefficients) and microphysical (number concentration) parameters, with aerosol mass concentrations for PM2.5 and 24 elements obtained from multiple X-ray analysis techniques.

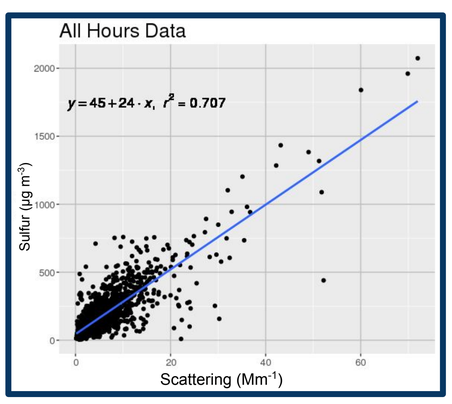
Background

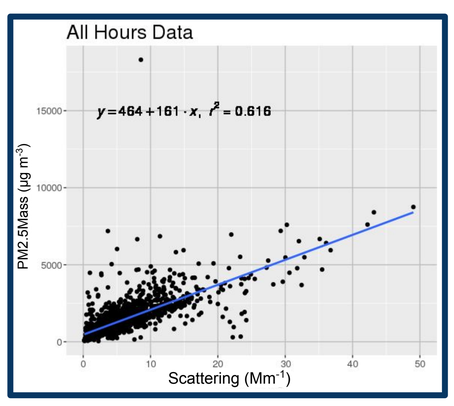
Mauna Loa is a volcano located on the island of Hawaii. The observatory, established in 1957, is located on the northern flank of the mountain at 3,397 m above sea-level. NOAA's Global Monitoring Division (GMD) has been making aerosol measurements at Mauna Loa Observatory (MLO) since the 1970's while the Interagency Monitoring of Protected Visual Environments (IMPROVE) began their aerosol measurements in 1988.

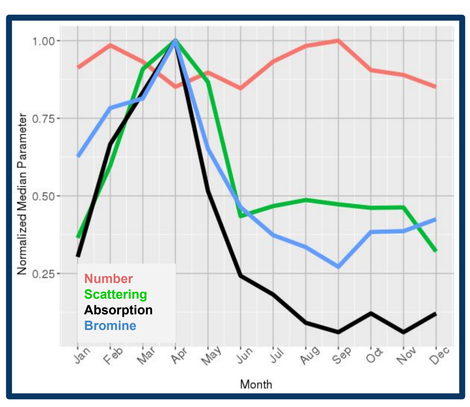
Methods

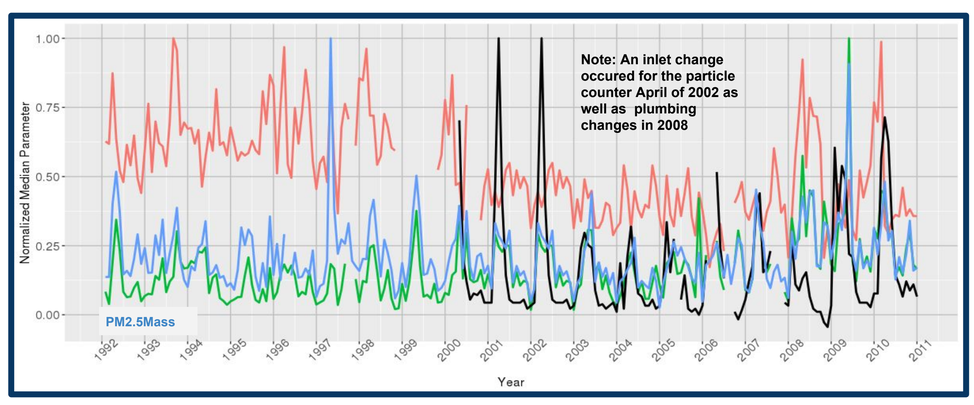
With aerosol composition data collected through the IMPROVE program (Hyslop et al., 2013) and aerosol optical data collected through NOAA GMD, two analyses were performed:

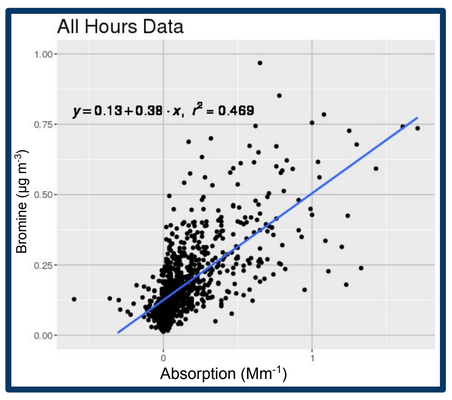
1. Evaluation of correlation between aerosol chemical and optical parameters
2. Comparison of temporal cycles of chemical and optical parameters

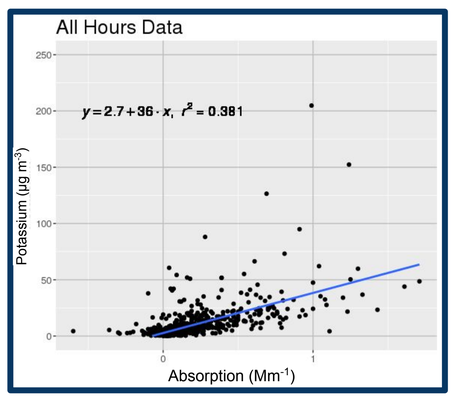


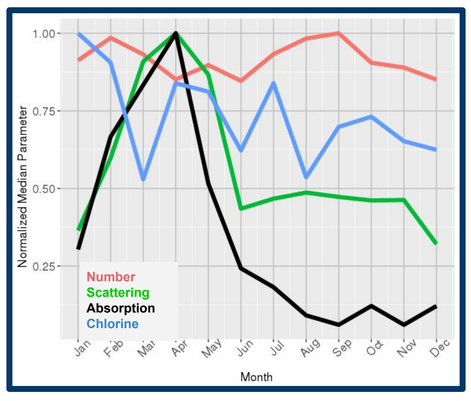


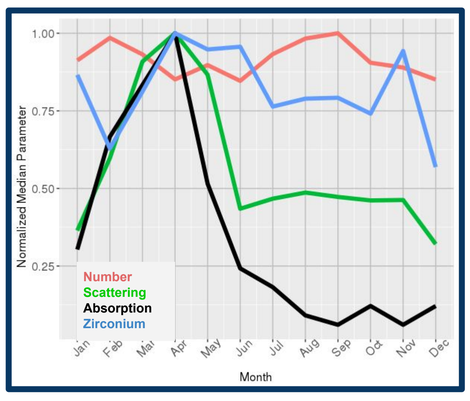


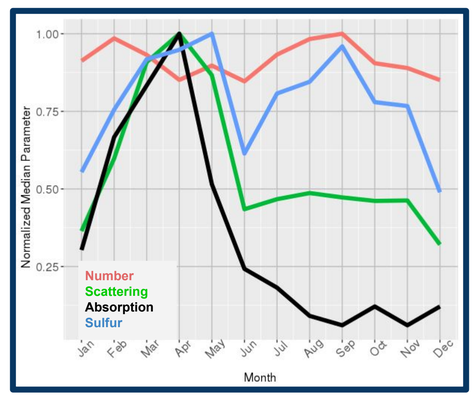












Relationship between selected optical properties and PM2.5 or elemental mass concentrations. These plots are for some of the highest R^2 found amongst all comparisons in the all hours data set which encompasses both upslope and downslope wind conditions.

The monthly cycle plots and time series plot compare the temporal co-variability of number concentration, scattering and absorption with individual mass concentrations. A common trend among the data is the tendency for the measurements to peak in springtime.

Selected correlation coefficients (R^2)

All Hours Data	Num. Conc.	Scattering	Absorption
PM2.5Mass	0.122	0.616	0.0279
Na	0.0204	0.341	0.0451
S	0.195	0.707	0.0027
Cl	0.122	0.0015	0.0039
K	0.0012	0.0597	0.381
Fe	0.0019	0.0308	0.262
Pb	0.0128	0.273	0.15
Se	0.104	0.443	0.0063
Br	0.0092	0.0077	0.469

Table provides comparisons with relatively strong correlations of aerosol chemical and optical parameters taken from the 'all hours' data set. Green boxes highlight the highest correlations in the data for number concentration, scattering and absorption. Elements not mentioned in this table had correlations less than 0.09 with more than one aerosol/optical parameter

Summary

- 'All hours' and 'night hours only' data exhibit similar co-variability with optical properties
- Correlations for 'night hours only' data are not as strong as for 'all hours' data
- Strongest correlations were between scattering and sulfur, scattering and PM2.5, absorption and bromine, and absorption and potassium
- The absorption/K relationship suggests MLO is impacted by biomass burning as K is a marker for smoke
- The absorption/Br relationship is surprising and requires further study
- The seasonal cycle of the majority of elements peaked in spring months, primarily April
- Elements that did not follow this cycle include S, Zr, Cr, P, Cl and Se

Acknowledgements:

This study and analysis could not have been completed without the diligent work of the technicians on the Mauna Loa Observatory.

References:

Hyslop, N., Trzepla, K., Wallis, C.D., Matzoll, A.K., and White, W.H., Atmos. Environ., 80, 259-263, 2013.