Summary

Motivation: The atmospheric lifetime of black carbon (BC) is controlled by wet and dry deposition, which are poorly constrained by observations.

Method: The single particle soot photometer (SP2) can measure surface-atmosphere exchange fluxes of refractory BC (rBC) particle mass and number by eddy covariance.

Results: Field measurements of rBC dry and wet deposition rates during summer 2017 at the Southern Great Plains site in Oklahoma allowed us to estimate dry deposition velocities ($V_{dep}$) of rBC mass ($u_g = 1.6; \sigma_g = 3.3 \text{ mm s}^{-1}$) and particle number ($u_g = 0.6; \sigma_g = 3.1 \text{ mm s}^{-1}$).

Conclusion: We estimate a wet deposition flux of 2600 ng m$^{-2}$ hr$^{-1}$ over the 148.5 mm of rainfall observed. During the campaign, dry deposition constitutes 12% ($\sigma_g = 2.6$) of total deposition. These data indicate a rBC lifetime of 11 ($\sigma_g = 3.3$) days for dry deposition and 1-3 days for wet deposition at this site during this campaign.

SP2 for eddy covariance flux measurement

To demonstrate the ability of the SP2 to measure rBC mass and particle count fluxes, we use:

1. spectral analysis to demonstrate that the SP2 meets the instrumental requirements for eddy covariance flux measurements (Fig.1, left);

2. quantitative constraints on uncertainty and detection limits of the flux measurement:
   - $\text{LOD}_{\text{mass}} = 0.04 \text{ ng m}^{-2} \text{s}^{-1}$
   - $\text{LOD}_{\text{counts}} = 3 \text{ # cm}^{-2} \text{s}^{-1}$

3. internal comparison of rBC mass and particle fluxes.

Figure 1: Cospectra of density of (a) rBC mass fluxes, (b) rBC particle count fluxes, and (c) corresponding ogives. Data is shown in comparison to sensible heat for the same time period and an example instrument zero (i.e.). Datapoints shown represent the absolute value of averages of 25 logarithmically spaced bins. Ogives are normalized cumulative contributions to the flux based on integrated cospectral density. Points are medians of all quality controlled data for each frequency across the shown range. Curve fits are Hill Functions.

BCADS: Black Carbon Aerosol Deposition Study

BCADS 2017 took place at the Department of Energy Atmospheric Radiation Measurement Southern Great Plains (SGP) site in Lamont, Oklahoma, USA from 12 June to 23 July 2017.

BCADS measurements included: SP2 measurements of refractory Black Carbon (rBC); UHSAS (ultra high sensitivity aerosol spectrometer) measurements of aerosol size distribution; precipitation collection for offline rBC measurements by SP2.

Dry vs Wet Deposition as a sink of rBC

- Observed deposition velocities during BCADS (rBC mass 1.6 mm s$^{-1}$, $\sigma_g = 3.3$ and rBC particle number 0.6 mm s$^{-1}$, $\sigma_g = 3.1$) are consistent with current global model approaches and represent the first in situ measurements of rBC deposition velocities.

- Dry deposition represents 12% ($\sigma_g = 2.6$) of the total rBC mass deposition, within the typical 5-20% assumed in global climate models [Koch et al., 2009]. However, this value is highly dependent on precipitation rates, and assumes that observed wet deposition at the site represents removal of the same air mass observed in dry deposition.

- Future Work will focus on the role of size and coatings in controlling deposition velocity, and the role of surface properties, precipitation and mass loading in controlling $V_{dep}$.

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