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Interactive Comment

Interactive comment on "Contributions of dust and biomass-burning to aerosols at a Colorado mountain-top site" *by* A. G. Hallar et al.

A. G. Hallar et al.

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Reviewer 2:

The paper presents a long-term data-set of AOD and scattering data collected at the Storm Peak Laboratory in Colorado, at about 3200 m above sea level. The analysis focused mostly on dust and biomass burning smoke. Overall the paper is clear, very well written and provides a useful dataset that could be important for understanding decadal changes in the Western United States. I therefore suggest the paper to be published. I would appreciate some clarifications and maybe some mostly minor changes

The authors greatly appreciate the feedback and positive response from this reviewer. We are pleased that the reviewer found the research worthy of publication and thank the reviewer for the critical and professional feedback. Please find our response to each of the comment from the reviewers below.

1. The authors refer to the availability of absorption measurements, but then do not use the data in the analysis (see specific comments below). If absorption data are available even only for specific time-periods and if they are available for different wavelengths then the data could also be used to reinforce (or reject) some of the findings and interpretations in this paper. The absorption together with the scattering data could be used to provide single scattering albedo data, a parameter of interest to the community and used for radiative forcing calculations.

The reviewer is correct that including the absorption data could provide information on single scattering albedo (SSA). The reason the absorption data were not included is we were primarily focused on using parameters common to both the MFRSR column measurement and the in-situ nephelometer measurement (this is the same reason that backscattering data from the nephelometer (mentioned in point 4) were not presented. We were not intending to present a climatology of all aerosol parameters measured at SPL. That said, we have generated plots of the SSA and backscatter fraction (BFR) similar to the plots in Figure 3 for the response to this review, as shown at the end of this document. We do not see seasonality in the BFR. There is some seasonality indicated in the SSA with darker aerosol (lower SSA) occurring in the winter months. We do not plan to include this result in the paper as neither BFR nor SSA can be retrieved from the MFRSR data at SPL. For reference, the SSA can be calculated for completely clear conditions using the diffuse irradiance of MFRSR, but this requires an ancillary measurement of the surface reflectivity using a wavelength matched MFRSR looking downward. This instrument was not installed at SPL for this experiment. Further, measurements of albedo in the non-uniform terrain of a ski area would have been difficult to interpret. We have also calculated mean values of scattering, absorption, SSA and BFR for the individual events listed in Table 1 (see below) from the nephelometer. As noted above, we are unable to calculate these parameters from the MFRSR measurement, but this Table is now included in the supplemental materials of the paper.

2. Maybe CALIOP data (even only for specific, limited events) could be used to support the interesting discussion about the vertical distribution of the aerosols? 3. I think most of the discussion on the vertical distribution is focused on dust, but can the authors discuss also the biomass burning smoke vertical distribution? Could they use CALIOP here as well for selected events to strengthen the analysis?

We agree with the reviewer that CALIOP data would provide an interesting addition to the discussion of aerosol vertical distribution. CALIOP data has been explored for these purposes at other sites. Our plan is to use the now quality assured MFRSR data for these comparisons in the future. We'd like to use the AOD from the MFRSR as a validation product for CALIOP and MODIS, similar to the paper referenced below. At this point evaluating CALIOP data is outside of the scope of the current paper.

Bibi, Humera, et al. "Intercomparison of MODIS, MISR, OMI, and CALIPSO aerosol optical depth retrievals for four locations on the Indo-Gangetic plains and validation against AERONET data." Atmospheric Environment 111 (2015): 113-126.

4. The nephelometer should also be able to measure the back-scattering, I believe. If so, it could be interesting to present also the backscattering fraction data as that is an important parameter for radiative forcing calculations and the community could benefit from sharing these data.

The reviewer is correct that the nephelometer can measure hemispheric back-scattering of the aerosol from which, in conjunction with total scattering, estimates of parameters like upscatter fraction, backscatter fraction and asymmetry can be calculated (e.g., Andrews et al., 2006). The reason the back-scatter data were not included is we were primarily focused on using parameters common to both the MFRSR column measurement and the in-situ nephelometer. That said we have generated a plot of the backscatter fraction (BFR) similar to the plots in Figure 3 for your reference. It is pasted at the end of this document below. - Methodology, page 21305, line 17: the authors mention "absorption instrument". Maybe I missed it, but what instrument do they refer to? Using also the absorption data – if available – would add great value to the paper and help with the identification of smoke and dust, if data are available at different wavelengths. Why were the data not used? Please clarify. We didn't describe the instrument because we didn't use the data from it – we probably should not have mentioned it at all for simplicity. As mentioned above, we were focusing on similarities between the MFRSR and nephelometer, rather than presenting a climatology of all the aerosol measurements at SPL. The absorption instrument at SPL is a continuous light absorption photometer (CLAP) made in-house by NOAA – it is virtually identical to the Radiance Research particle soot absorption photometer (PSAP) except that instead of 1 spot it can cycle through 8 spots allowing for much longer measurement period before the filter needs to be changed which is great for remote places like SPL which aren't visited every day. (A version of the CLAP is now being manufactured by Brechtel Inc. – they are calling it 'tri-color absorption photometer' (TAP)). A description of the CLAP is now included in the paper under the section titled "Nephelometer and Continuous Light Absorption Photometer". There is now a supplemental table with the absorption data and SSA for each event. - Methodology, page 21308, line 10: explain why the nephelometer needed to be zeroed so frequently and how long each zero lasted. The nephelometer is zeroed at the top of each hour and the zero lasts 6 minutes. This frequency of zeroes is standard operating procedure at all NOAA collaborative network surface sites. GAW report No. 153 on Aerosol measurement procedures, guidelines and recommendations notes: The schedule for air calibrations controls the precision of the determination of the Rayleigh scattering coefficient of air, which is subtracted from the measurements to obtain the aerosol light scattering coefficient; any error here gravely affects the detection limit of the instrument."

- Methodology, page 21309, line 5: explain why this pair of wavelengths was chosen. The neph wavelengths were chosen to get as close to the MFRSR wavelengths as possible (the neph has a narrower spectral range than MFRSR).

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New Table now included in the paper's supplemental materials.

Table of statistics for fire and dust events from nephelometer and CLAP measurements of aerosol scattering and absorption. α_{Neph} = Ångström exponent calculated from scattering (λ1=450 nm, λ2=700 nm), BFR=backscatter fraction (back-scattering/total scattering, SSA=single scattering albedo at 550 nm. #scat=number of hours of data for scattering, #abs=number of hours of data for absorption.

Fire statistics (means)							
Event Origin	Scat (Mm^{-1})	Abs (Mm^{-1})	α_{Neph}	BFR	SSA	#scat	#abs
Wallow	65.25	NA	1.75	0.12	NA	68	0
Waldo/ HighPark	46.45	4.20	2.40	0.15	0.92	100	100
NW US 2	62.11	4.80	2.14	0.13	0.92	114	114
NW US3	117.80	7.41	2.03	0.11	0.94	49	49
Mean	***72.90***	***5.47***	***2.08***	***0.13***	***0.93***		
Dust statistics (means)							
Event Start Date	Scat (Mm^{-1})	Abs (Mm^{-1})	α_{Neph}	BFR	SSA	#scat	#abs
4/22/11	16.12	NA	1.58	0.13	NA	26	0
5/1/11	7.56	NA	1.84	0.15	NA	66	0
5/5/11	14.32	NA	1.14	0.14	NA	141	0
5/27/11	8.29	NA	1.30	0.14	NA	42	0
3/7/12	17.63	1.70	1.17	0.13	0.92	48	48
3/20/12	4.85	0.30	2.04	0.17	0.94	39	39
3/27/12	18.63	1.39	0.63	0.12	0.93	42	42
4/2/12	3.88	0.19	1.85	0.18	0.95	14	14
4/7/12	18.23	1.58	1.14	0.13	0.92	90	90
5/20/12	17.18	0.93	1.59	0.13	0.95	86	86
5/24/12	23.22	1.16	1.52	0.13	0.95	178	178
4/16/13	7.88	0.72	1.64	0.15	0.91	78	78
5/25/13	13.16	0.92	1.14	0.13	0.93	18	18
Mean	***13.15***	***0.99***	***1.43***	***0.14***	***0.94***		

Table observations: Dust events tend to have lower loading (scat and abs) than fire events; Dust events tend to have lower scattering Ångström exponent than fire events (dust has bigger particles); no noticeable difference between dust events and fire events for BFR and SSA.

Fig. 1.

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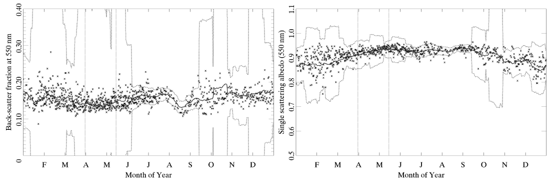

Figure showing BFR and SSA seasonality (not included in paper or supplemental materials).

Fig. 2.

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