

Interactive
Comment

Interactive comment on “Measured black carbon deposition on the Sierra Nevada snow pack and implication for snow pack retreat” by O. L. Hadley et al.

O. L. Hadley et al.

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We thank the reviewer for their thoughtful comments and suggestions. We made several changes to the manuscript, which we detail below following each of the reviewer's comments.

Reviewer 2 This is generally a nicely presented paper with careful attention to observational detail. It would be useful to clarify how large a reduction in the snow albedo is predicted by these observations as there is still some controversy about how BC/EC from TOA applies to results based on IP photometer measurements such as those of Bond et al. In particular, some TOA analyses seem to give lower values of EC/BC

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and imply higher mass absorption coefficients. A consistent treatment here is recommended. Subject to a discussion of this sort and clarification of the points raised in the specific comments, I recommend publication in ACP.

Pg 1 2-13 aren't particularly high levels of BC concentration – what sort of albedo decrease do you predict for these? Is it the same $\sim 1\%$ in the visible spectrum as predicted by the sources you cite. Based on your 2008 paper, you obtain rather different MAE results than were generally used in the previous studies.

Author reply (AR): On line 188, we estimated a 0.3% reduction and a 1.2% reduction in albedo for the upper and lower bounds, respectively, for this range of BC concentration. Expected albedo reductions are tricky as they depend on snow grain effective radius, which changes daily as the snow undergoes metamorphosis, and BC transport in snow. We use the model result for fresh snow at approximately 100 micron effective radius. Our MAE results are derived directly from the direct carbon measurement and change in light transmission through the filter. The range of MAE values (10 - 20 m²/g) are somewhat higher than those found in previous studies, which may be b/c the filtering of water carries the BC particles deeper into the filter and increases the multiple scattering-included absorption enhancement of the filter compared to the filtering of BC from air (about which prior reports of MAE are based).

Pg 6 – three filters in series. A most excellent precaution as recent studies by the Norwegians have confirmed the low collection efficiency of the quartz fiber filters with significant implications for reported EC retrievals.

AR: Thank you.

Pg 8 Why do greater snow deposition rates cause an underestimate of the true average concentration of BC in the falling snow. Although the concentration is diluted, you can simply collect and process more snow, and the uncertainty in the snow volume would if anything be less and the amount of BC collected greater.

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AR: There may be a misunderstanding here. We are able to collect sufficient water for the diluted samples because of the heavy precipitation that is diluting the concentrations. It is for the lightest events for which we are unable to capture enough sample water, and these samples may or may not be more concentrated in BC.

Visible albedo includes the wavelength range 400-700 nm rather than 200-700 nm. –

AR: We corrected this in the manuscript.

What do you mean by grain size? You've discussed grain diameter above (PM_{2.5}), but the calculations you refer to, for example the modeling by Warren and Wiscombe, are using grain radius.

AR: To avoid any misunderstanding, we now refer specifically to effective radius rather than grain size.

Julian day – change to Day of Year or something less ambiguous? The usual definition of Julian day is given by the astronomers, and the current Julian day is 2455270 plus a bit.

AR: We changed to Day of Year, consistent with the figures.

Pg 9 'This effect is not considered here' – I think Flanner et al. do take this into account. You might point out that your local surface forcing values are locally applicable only and subject to the large variability in the area covered by snow in California, whereas the regional value of 1.6 is a regional/large scale value.

AR: We have removed the statement and clarified that the local forcing is regional and highly variable.

Pg 10 'and included in ice nuclei' – you should be a little bit more definite about why you think this is true as it has significant ramifications for the absorption properties of the snow-BC system as it were.

AR: On line 219, we rewrote this this statement to be more clear: "The ambient drop in

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BC during snow events and the high correlation between ambient BC prior to a snow event with the total amount removed during the event suggest that the dominant portion of BC measured in the snow was scavenged below the cloud as opposed to nucleated in the precipitating cloud.”

‘fractional contribution was zero’ – was assumed to be zero? No doubt there is some uncertainty in this, and I don’t see any values of zero in figures 4 or 5, for example. –

AR: Agreed, we changed this statement to note that we “assumed” it to be zero.

‘The average Asian BC contribution to BC mass.’ -> The average Asian BC contribution to total BC mass. ‘Assuming that a proportionate amount of Asian BC is transported along with the dust’ – Aren’t the dust particles generally larger than BC so that it might tend to settle out more rapidly particularly considering the long distances involved? In fact, I’d expect to see a clearer separation in figure 4 between the data for PM 0.75 and PM 2.5, where you select for different sized (and rather large) particle thresholds. Please comment on these points.

AR: We added a statement to this effect on line 269 that dust may settle out more quickly than BC, thus the estimation is conservative.

Pg 13 I don’t see how figure 5 shows that the values at your locations are spatially and temporally representative of the mountains of Northern California. I think you need to justify this statement a bit more.

AR: This conclusion is based on the relative uniformity of aerosol species concentration and annual variability for 3 Northern California Mountain sites that are separated from each other by 50 to over 100 miles.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 10463, 2010.

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