The Cryosphere Discuss., 6, C968–C971, 2012
www.the-cryosphere-discuss.net/6/C968/2012/

The Cryosphere Discussions

Interactive comment on "Retention and radiative forcing of black carbon in Eastern Sierra Nevada snow" *by* K. M. Sterle et al.

Anonymous Referee #1

Received and published: 9 July 2012

This paper is nearly identical to a paper by the same authors, with the same title, which I rejected last year for Geophysical Research Letters. Therefore, my review of the revised manuscript is correspondingly similar to my earlier review.

The authors start with a reasonable hypothesis, namely that insoluble particles (dust and soot) are left behind at the surface as a snowpack melts. They then set out to collect data in the Sierra Nevada of California to test the hypothesis and quantify it. Their measurements were apparently done carefully, and the techniques are well documented. It turns out that their data do not support the hypothesis, but it is premature to draw any conclusion, because the data analysis was botched, as described below.

The snowpack reached its maximum depth of 2 meters on 29 April, and after this date the snowpack was melting. Vertical profiles were obtained occasionally during March

and April, and then weekly during May as the snow depth diminished by 35%. The measurements were terminated on 30 May, when 65% of the maximum snow depth still remained (1.3 m).

Reading values for the top 2 cm from the vertical profiles in Figure 1, I find the surface black carbon (BC) values for April 29, May 10, 17, 23, and 30 are approximately 18, 10, 73, 58, and 6 ng/g respectively. The surface concentrations do increase from 29 April to 17 May, but the last value on 30 May is the lowest. Furthermore, the highest BC content found during the entire experiment was 94 ng/g, during the accumulation season on 28 March. On that date there was extreme variability in the upper layers (again reading from Figure 1): 0-1 cm, 9 ng/g; 2-4 cm, 1.5 ng/g; 4-8 cm, 94 ng/g. Variability in the near-surface snow concentrations may be due to other possible causes besides incomplete scavenging of the BC with melt, such as temporal or spatial variability of deposition (e.g. from nearby vehicle traffic). While previous studies have indicated that BC is indeed preferentially left at the snow surface during melt, (a) the data shown here do not definitively show this (and instead appear to show the opposite in late May); and (b) the high variability in concentrations before 29 April indicate that deposition is driving some of the variations.

Faced with this puzzling dataset, the authors somehow decide that their hypothesis is validated. To show this, in Figure 2a they plot the surface BC values, but for only 5 selected dates instead of all 8, and these five do seem to show a rise in the BC values with time. But even these five values are in gross disagreement with values in Figure 1: The values for 28 February, 18 April, 10 May, 17 May, and 23 May, respectively, are 11, 6, 10, 73, and 62 ng/g, as best I can read them from Figure 1; but 21, 54, 90, 223, and 173 ng/g in Figure 2a. I am puzzled that not one of the five authors insisted on correcting this disconnect, even after I pointed it out in my GRL review last year, and that all five signed on again to this new submission with identical figures.

The authors also present results in Table 1 which seem to support their hypothesis, but Table 1 disagrees with Figure 1. The section of the original table that was in error by a factor 3000 has been deleted in this manuscript, but the table is still full of errors. The table gives a range of 20-429 ng/g for the upper 2 cm in May; Figure 1 gives a range of 6 (on 30 May) to 73 (on 17 May). The statement in the abstract "concentrations of rBC were enhanced seven fold in surface snow ($\sim$25 ng/g) compared to bulk values in the snow pack ($\sim$3 ng/g)" apparently comes from the table's values of geometric means for January-April of 25 and 3. But this stated geometric mean of 25 (and the corresponding range of 3-81) for the top 2 cm is inconsistent with the data plotted in Figure 1, which show values 11, 10, 6, 18 for the top 2 cm; i.e., a range of 6-18, not 3-81.

Since we do not know which set of BC values is correct, and whether the erroneous values were used to compute Figure 3, the radiative forcing values in Figure 3 are not to be believed.

Another example of where the authors' writing contradicts their own data is in the statement in Section 3.3: "Concentrations of continental dust and rBC measured in the upper 30 cm of the snow pack showed similar patterns (Fig. 2c)". But except for the first and last points, the patterns of dust and BC in Figure 2c are nearly mirror images of each other: when BC goes down, dust goes up (before 29 April); when BC goes up, dust goes down (after 29 April).

In the text the authors explain the astonishingly low surface value of BC on May 30 as the result of "rapid flushing during the fourth week of May", described in the abstract as a "final flush". But on May 30, the last day of measurement, 65% of the snowpack still remained. Furthermore, the decrease in the snowpack depth between 23 and 30 May was only 12 cm, smaller than for the preceding weekly intervals 10-17 May and 17-23 May (38 cm and 19 cm, respectively), so of all the "flushes", it was the smallest. No explanation is given for why BC's behavior would transition on 23 May from being preferentially left at the surface to being preferentially washed out. When one simply looks at the data and finds the lowest surface BC at the end of May, one has to conclude that the authors' hypothesis is invalidated, or must at least be qualified. In any case,

the "flush" demands explanation; for example, was there a heavy rainstorm between May 23 and 30?

In fact, the term "flush" is invoked to describe just one point in a noisy dataset. Such a description is unjustified without evidence or a plausible mechanism. Otherwise there is the risk that climate modelers will seize on this datapoint to flush BC out of their model snowpacks globally whenever 35% of the snowpack has melted. Ideally another melt season will be monitored at the Mammoth Mountain site to see how frequent these "flushes" are, and what causes them.

Interactive comment on The Cryosphere Discuss., 6, 2247, 2012.