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Interactive comment on "Soot on snow experiments: light-absorbing impurities effect on the natural snowpack" *by* J. Svensson et al.

Anonymous Referee #2

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The work presented by Svensson et al. focus on the impact of black carbon (BC) in snow on the albedo and the snow melting. They artificially doped the snow with BC and measure the snow albedo, the BC content and the snow physical properties. The experiments were performed with a different setup each time and at three different location and during three different periods of the year. The authors concluded that in general albedo measurements and simulations using SNICAR agree. BC in snow has been studied since a few decades now but still our knowledge about its potential climate impact is poor. Of a particular interest is the melting season and the behavior of BC: would it stay at the surface or not? Does BC affect the physical properties of snow? This question is crucial and such experiment as the one conducted by Svensson et al is one of the first step in understanding such issue. Unfortunately, the presented experiments and the data analyses is very limited. In short, there is everything in that

work: BC measurement, albedo measurement, snow physical measurement but there is never all in once and some aspects of the sampling protocol are very questionable. It is either some BC measurements, but the snow profile is made one week before, the snow physical data are not presented and there is no albedo measurement on the site used for following the BC concentration at the surface (Site 5 and 7). Even if the topic and the experiment is interesting and very few group are focusing on that, the results presented by the group do not bring new knowledge to the snow BC community and I can only recommend to refuse this paper for publication in TC.

Some specific comments below:

Page 1229, line 26: The authors wrote that they wish to focus on the effect of soot on snow properties but in the current paper, even if physical properties of snow such as density and snow SSA are claimed to be measured, there is no value presented at all.

Page 1233: the three experiments have been run using different sites each time, with different snow depth and some most likely not optically semi-infinite for good albedo measurements and also at 3 different period of the year. This is of course not always easy to organize experiments but as all three experiments are in a way different and with different amount of incoming solar energy, this render the comparison event more difficult.

Page 1234: line 10. Where are the images? At least one would have be interesting to see the type of soot you have been using compared to what is found in the Arctic.

Page 1238: Albedo measurements. What was the height of the sensor? What was the conditions during measurements, meaning is there any visible differences between cloudy and clear sky conditions on albedo data? The second paragraph describing the BRF measurements is useless in that paper as the data are not used but if you have been measuring spectral albedo, it can be interesting to: 1/ compared with the broadband value; 2/ used for albedo calculations together with the snow SSA and the BC profiles but a multi-layer model should be used for that (not the online SNICAR version you used, see comment below)

Page 1238: Snow physical properties. Where are all the data mentioned to be measured?

Page 1239-1240: The use of Snicar: you have been using a single value for the snow grain size and for the BC then as SNICAR is a single layer model. Why using that model if you have been measuring vertical profile of BC? You mention you have been using 270 or 750 microns for the snow surface optical grain radius. This is quite old snow considering the size of the grain, it gives a snow SSA lower than 15 m2 kg-1, this is the range for metamorphosed snow or depth hoar. You also mention a density of 200 kg.m-3, this is quite low and it does not fit very much to the size of the snow grain you have been using. However, the equation 1 you have been using is not for the optical grain radius, but for the diameter. The correct formula to get the snow optical radius from the SSA is 3/(ice*SSA). Maybe it explains something...

Page 1241: how accurate is a measurement of 29 000 ppb of soot in snow using thermo-optical method? You probably only need a few milliliter of melted water to not saturate the instrument and as your deposition method is fairly heterogeneous in 2011, how this can represent the BC value at the snow surface?

Page 1241: why there is no albedo measurement conducted on spot 5 and 7 while these spots are used to make the temporal evolution? Why don't you measure the albedo before deposition as well? Why don't you measure the albedo of the ground as well once the snow is melted and use the correct value as input in the model?

Page 1242 and Table 2: Why does the sampling has been done in the 5 top cm and then the 7 top cm? How can you sum up the BC values together in the snowpack? Simply doubling the amount of measurements would then give you twice more BC then! In fact, you should have sampled the entire snow column (in several samples) and this is the only way to compare things and see if the BC is moving or not. Did you sample to the bottom? We do not know how thick the snow is on that date but I guess

you are not at the bottom at 25 cm depth since they were still roughly 50 cm on 10 April (Stratigraphy data).

Page 1243: albedo measurements. Why are you discussing the data from 2011 while there are no BC measurements presented in the paper? Why fig 3 comes before fig 2? If you visually observed that the particles have been sinking into the snow, this should have been sampled and would have been interested for your purpose. How can happen that the precipitation event of 14 April brings the albedo of the most contaminated site higher than all others site, even the reference one? About the 18-19 April, following your hypothesis, liquid water lowers the snow density or wash out some BC, resulting in an increase of the snow albedo. How do you explain that all the albedo data are increasing of about 0.05? If the BC is washed out, the site with the highest BC content should increase the most. Else, if the density is decreasing, even if you have smaller optical snow radius, the radiation penetrates deeper in a lower dense media, so this could counterbalance the effect of the decrease of snow grains radius; and if the radiation penetrates deeper in the snow, it can encounter as well more BC particles... Again, your hypothesis could have been verified using the density data, claimed to be measured but not presented. When you discuss snow albedo, the snow depth is never mentioned.

Page 1245: snow physical properties. Finally you present a value of density, in the range of 340-400 kg.m-3 for the two snowpits made, so why have you been using 200 kg.m-3 in the modelling work? Where are all the snow physical data? Fig 2C is 2D. Figs 2D, E, F and G present the thickness of the layer and not the depth!

Page 1247-1248: Using this model only allow you a single layering! Using you parameterization of equation 3 gives an albedo of 0.86 with 100 ppb of BC and 0.92 for 50 ppb of soot, so there is also a lower limit in your work. How did you end up with a linear regression fit while all precedent work, and the SNICAR model as well, showed a non-linear relation between BC and snow albedo? I also do not think that 7 points are sufficient for such sensitive topic as BC on snow.

Interactive comment on The Cryosphere Discuss., 9, 1227, 2015.