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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Unexpected increase in elemental carbon values over the last 30 years observed in a Svalbard ice core" *by* M. M. Ruppel et al.

Anonymous Referee #2

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Ruppel et al analyzed a Svalbard ice for elemental carbon using a thermal optical method. Overall this paper contributes to our understanding of temporal variations in BC deposition in the Arctic, and provides valuable discussion of the factors controlling BC deposition at Svalbard. Detailed comments are provided below, including suggestions for revisions to the manuscript to clarify the interpretation of the record and more fully acknowledge uncertainties in the analytical technique.

Title should omit 'Unexpected' and preferably refer to the year that the increase started rather than 'last 30 years.' Since the core was drilled in 2005, the last 30 years can be misinterpreted. As discussed below, it is misleading to state that there has been an

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increase since 1970.

Abstract: See comments below claiming increase since 1970, and fix accordingly. l. 15 Sentence starting 'Several hypotheses' is difficult to follow and needs revision. l. 22 omit the in 'in the recent decades'. This should be changed however as referred to in the title comment.

Introduction Writing in opening sentence can be improved (fix 'which has been suggested to be explained by changes. . .')

p. 13200 l27 expand on statement that Svalbard glaciers are expected to have a different source attribution than Greenland.

2.3 Uncertainties p13204 l6 The discussion on the filter efficiency of the filters is misleading in that it leads the reader to think that that there was no filter efficiency issue. Torres 2014 showed that there was undercatch using quartz fiber filters, but that filtration could be greatly improved with the addition of salts. I've tested this in my own laboratory and have found that filtration of snow and ice samples using quartz fiber filters is improved considerably when using salts. Additionally when using thermal optical analyses we use three filters in line (separated, not stacked on top of one another) following the approach of Odelle Hadley that also improves filter efficiency. While Schwarz et al 2013 shows that BC particles in snow can shift to larger size particles, considerable mass of BC in snow is below .5 um. Schwarz also demonstrates that the mass absorption cross section of smaller BC particles is much greater than for large particles (see Fig 1 of Schwarz 2013), so if albedo is of interest (which it is for this study), the smaller particles, which aren't being filtered efficiently, are certainly of interest. Ideally the authors would quantify the EC not captured on the filters. At a minimum this section needs revising to fully disclose these issues.

Results and Discussion p. 13205 l1 'are show clearly' fix writing.

p. 13206 l3 While from 1970 to the top of the record EC does increase, EC in the

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1970s and 1980s is still within the range of concentrations earlier in the 20th century. It is only the very top of the record (1990s-2004) that EC exceeds concentrations earlier in the record. The discussion should be revised to not suggest that the 1970-1980s were anomalously high for the record. The same applies later in the record when EC deposition trends are discussed.

l. 5 It would be useful to plot the atmospheric BC records from 1989 along with the ice core record. It appears the ice core EC peaks around 2000, but is lower since then. Is the timing consistent between the records? l. 24 the discussion on trends from the European Alps would be easier to interpret if the studies were referred to by their locations rather than just authors.

p. 13206 For dusty sites like the Himalayas the dust causes interference with the thermal optical method (e.g., see work by Wang Mo), causing additional problems comparing records.

p. 13207 l.22 Xu 2012 showed that under conditions of strong melt that BC is enriched even more so over the superimposed ice layer than at the surface.

P13208 l. 10 I'm not following the logic of the interpretation here. Snow accumulation is stated to be lower during 1930-1960, but that isn't what the data in Fig 3c shows. If accumulation is higher during that period and EC was constant in the atmosphere, lower EC concentrations would be expected, but this isn't what the data shows. That EC is higher (Fig 3b) during the 1920-1970 period, which corresponds to a period of relatively higher snow accumulation would suggest that EC in the atmosphere was higher during this time.

l. 14 include plots of the Greenland ice core BC data in Fig 3. to compare timing between records.

13209 l. 8 why specifying N. America? If the majority of EC is thought to originate from N. America this would make sense, but this isn't stated. For this section it would be

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useful to plot the regional emission inventory data from Novakov and/or Bond. These are based on fossil fuel inventories, so some attention should also be given to the idea that the emission inventory estimated don't capture all sources.

p 13212 l15-21 The discussion on scavenging efficiency and its link to temp and precipitation needs to be referenced to the source of this information.

p. 13214 l17 same as discussion on increase in EC from 1970s. Stating that temp increased from 1960 is misleading since the temp record actually shows that temp in 1960 was cooler. Revise wording.

l. 22 awkward start to sentence. Omit 'Though.' The intensifying summer melt leads the EC concentration by numerous years, which should be made clear when discussing that the two records correspond. If the melt index isn't reliable as a melt index post 1990, the data shouldn't be presented for this section of the record. What did the visual record of the ice core show re: melt layers? Is there a record of melt layers from the core that can be included here?

p. 13215 l. 15 Xu 2012 showed that with high amounts of melt the BC can move through the snowpack.

l. 28. Also importantly during the summer greater dry deposition would occur which would also lead to higher concentrations.

p. 13216 l. 7 Recommend saying it differs from rather than contradicts. As stated above, more attention should be given to the regional changes in emissions for comparison with the ice core record.

p. 13216 l don't expect that the difference in the trends between Greenland and Svalbard are related to the analytical methods. Different trends were observed at cores near each other in the Himalayas likely due to differences in analytical techniques, but this is likely because of the high dust concentrations in snow and ice in this regions that cause interference with the thermal-optical method. For relatively clean Arctic

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cores I don't think the trends would differ much due to analytical differences (however the measured concentrations will differ).

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 13197, 2014.