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Interactive comment on "Location and distribution of micro-inclusions in the EDML and NEEM ice cores using optical microscopy and in-situ Raman spectroscopy" *by* J. Eichler et al.

A. Svensson (Referee)

as@gfy.ku.dk

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General comments:

The manuscript describes the distribution and properties of individual micro-impurities in four ice core samples from the Antarctic EDML and the Greenland NEEM ice cores. The dataset is compared to various other impurity datasets and the implications of findings are discussed.

The study is very solid, carefully carried out, and well presented. The issue of impurities in natural ice is complex and has importance for a variety of ice and climate related fields as mentioned in the introduction. The presented work pushes the discussion one

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important step forward and it fits well within the scope of TC.

Whereas I appreciate the time-consuming experimental work presented in the manuscript, the weakness of the study clearly is the very limited diversity of analyzed samples. Only samples of very 'clean' ice-sheet ice have been analyzed and so we are still not able to answer important questions about the location of ice core impurities within the ice structure, possible pinning, and ice flow in more 'dirty' glacial ice. I suspect, however, this will be the topic of forthcoming papers by the authors now the technique has been firmly established.

Specific comments:

I would mention the climatic periods the samples are obtained from in the abstract. NGRIP Holocene and EDML MIS 5.5

Please define what is meant by 'second phase inclusions' that are mentioned several times.

Would you have a reference for the statement on p. 3 l. 14-15 that CPO varies with impurity concentrations of the ice?

You refer to a study by Della Lunga et al., 2014, where impurities are stated to be found in grain boundaries in 'clean' ice. Could you have a more quantitative estimate of the 'cleanness' of those samples as compared to the ice investigated in the present study? In other words, are the samples of the two studies directly comparable or could it potentially be that the conclusions of both studies are correct?

As support to the conclusion of the manuscript, that impurities stay within the ice at the position where they are deposited rather than being dragged around by migrating crystal boundaries, I would like to mention a paper of my own (Svensson et al., 2011), where we identify clear annual layering in impurities within large ice crystals of NGRIP Eemian ice. In this clean ice the annual banding, and thus the micro-inclusions I suspect, is sometimes visible to the naked eye.

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In my opinion, the comparison of the micro-inclusions to that of CFA records could be somewhat improved. First, the micro-inclusions include both insoluble dust and chemical particles. Therefore, it would make sense to compare the distribution of micro-inclusions not only to insoluble dust, but also to chemical concentrations such as Ca, if they are available. Second, if I got it right, you need the micro-inclusions to be larger than 2-3 micros in order to detect them? The Abacus CFA dust analyzer, however, will typically detect particles larger than 1 micron. With the insoluble dust size distribution centered around a few microns you are likely to miss out a large fraction of the dust particles in your observations. Those two issues taken together, it is not surprising that the numbers in Table 1 obtained by your method and by the Abacus do not agree so well. A way of making a more detailed comparison of your counts to that of the CFA records would be to plot the CFA profiles on a depth scale along with the samples in Figures 3+4+5 or alternatively in a separate figure. On p. 6 l. 28 you state that you have made this comparison, so why not show it? One question is of course if the CFA profiles have sufficiently high depth resolution to resolve the details of the banding in your samples.

It would also be of interest if you could provide an estimate of the annual layer thickness of the investigated ice sections. Is the stratigraphy of the micro-inclusions, as evidenced in figures 3, 4, and 5, related to the seasonal variations of impurity deposition?

P. 6. l. 1, please define z-position.

Figure 3: Why is there apparently such poor correspondence between the derived crystal boundaries in a) and c) ?

Reference:

Svensson, A., Bigler, M., Kettner, E., Dahl-Jensen, D., Johnsen, S., Kipfstuhl, S., Nielsen, M., and Steffensen, J. P.: Annual layering in the NGRIP ice core during the Eemian, Clim. Past., 7, 1427-1437, 2011.

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