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Interactive comment on "Fabric measurement along the NEEM ice core, Greenland, and comparison with GRIP and NGRIP ice cores" *by* M. Montagnat et al.

C. Martin (Referee)

cama@bas.ac.uk

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The paper presents the distribution of ice crystallographic orientation (fabric) along the NEEM ice-core and shows a first order comparison with another two Greenland ice cores, GRIP and NGRIP. The main findings are that the fabric at NEEM is slightly anisotropic near the surface, its strength is correlated to paleo-climate, it follows the folding of the isochronous layers observed in the ice core and also, by comparison with the other two ice cores, the authors analyse the possible influence of lateral shear in the development of a vertical-girdle fabric in the top area of the ice-core.

I believe that the fabric distribution presented in this paper is very important because

fabric information within ice-sheets is very scarce and necessary in order to understand flow dynamics and recover climatic records from ice cores. The data is clearly presented and I don't have any major objections with the paper but I believe that the paper skip a few points that I describe bellow, relating to the interpretation of the data, only mentioning them casually and as facts in the discussion section. I recommend its publication in The Cryosphere.

General Comments

The influence of paleo-climate in fabric has been observed before (e.g., Durand 2007) but unless I am missing some recent information the cause has never been clear. For example, Durand et al, 2007, make different hypothesis for the relation between fabric and climatic transitions: change in recrystallization process, change in the initial fabric at the time of deposition, change in the shape of the dome and change in the effective viscosity. The authors seem to only consider the last one (based on Patterson 1991) but, as far as I know, there is no clear evidence to forget the other ones (for example Kennedy et al 2013(J. of Glaciology 59 (214)), similarly to Durand 2007, shows how initial fabric information near the surface could be related to climate and could be kept as ice is buried). I think that this point should be discussed further.

I find that the Results Section is very clinical only describing the figures. (I totally agree with the other reviewer suggesting that Figures should support the Results Section and not the other way around.) And in a few instances there is a logical jump between the results presented and the interpretation in the discussion. I have mentioned below, in the specific comments, Sections 3.2, 3.3 and 3.4. In 3.2 the authors compare estimations of shear and vertical strain rates along the three ice cores and in the Discussion Section they state that that explain the distribution of girdle fabric along two of the ice-cores. In Section 3.3, only present variability of fabric in samples but I fail to see any discussion of the significance of this data. In Section 3.4, the authors describe discontinuities in fabric but is only in the discussion where we are reminded that one of the transitions doesn't coincide with a transition in the isochronous layer.

Finally, I am just wondering why the comparison between the three ice-cores haven't been plotted in fabric vs age in addition to the fabric vs depth presented. I suggest this as I believe the time-scales for the three ice-cores exist and are available and it will be clearer to compare like for like in the fabric, and the fabric vs depth could be difficult to interpret as the three ice-cores have different thickness and accumulation rates.

Specific Comments

- Title: I must confess that I have read the other reviewer comments and I agree that the word 'measurement' in the title could be confusing.

- P309 L10-12. I find confusing the way of explaining the sharp increase in fabric strengthening: positive feedback between changes in ice viscosity and the impact of a shear component of stress. Durand et al 2007 describe a positive feedback between ice becoming softer for shear and fabric development, as each one leads to the other in the presence of of horizontal shear. Is that positive feedback the one that the authors is referring?

- P309 L14. My understanding is that the folding of the layers at NEEM is a fact and that Dahl-Jensen et al 2013 hypothesis is related to the cause of the folding and the reconstruction of the climatic records. If I am correct I would suggest saying that their positions are in good agreement with the observed folding layers in Dahl-Jensen et al 2013.

-P310 L3-6. I would say that those are not only the typical deformation conditions for ice divides as the authors describe the general conditions in an ice-sheet.

-P310 L8-9. I am missing something here, in a perfect dome ice deforms by uni-axial compression, right, but are the authors forgetting to say the influence of that on the fabric, otherwise the rest of the paragraph doesn't make much sense to me in relation to this sentence.

-P310 21-24. As before, I don't understand the use of 'positive feedback between

viscosity and the impact of a shear component of stress'.

-P313 Eq 5. I would suggest using "vertical girdle" as it is a little bit more specific. I find a bit confusing Eq 5b as for a vertical girdle a1>a2>a3 and a2$\sim$1/3. That is a2 is normally smaller than 1/3 (Fig 2) and not larger.

-P315 L10. I would certainly start a new paragraph "The fabric is mainly related..."

-P315 L14-25. I find this paragraph surprisingly difficult to understand. The idea is compare vertical with shear strain-rates at three sites. My first question is why to use an average of the three vertical strain-rates instead of the three measured ones. Wouldn't it make more sense when you are comparing with 3 estimations of shear strain-rate? Not that matters, but it will help to understand the logic of the section. If the authors decide to use the average value, I would suggest to write that they are using the average value. It sounds a bit hash to explain, we have three rough estimates and also two vertical strain-rate measurements and one estimation but we use 10e-5 yr-1. More importantly, the three ice-cores have different depth, and that will affect the shape in the DJ formulation. In addition, now that we have two vertical strain-rate measurements and one estimation I will included in Table 1 for reference.

- P315 L14-25 (II). The most intriguing thing is that once that I understood that Figure 6 shows an estimation of the distribution of shear and vertical strain-rate in the three locations, there is no explanation of what the authors are trying to show with it, and the only reference to the comparison is a paragraph in the discussion that I don't fully understand. Depth at which shear is dominant over compression is higher at NEEM that at NorthGRIP and that one is higher than the one at GRIP. But GRIP doesn't show girdle fabric (according to Introduction) and NorthGRIP girdle fabric is stronger than the one at NEEM. I may be missing something but authors could explain better what figure 6 is showing in Section 3.2.

- Section 3.3 As the previous section, I find it a bit raw. I follow what the authors are doing but I fail to see the significance or the interpretation of the data. Authors say that

variability is bias because 55cm don't cover periods of the same length (even worst for the argument) but variability look smaller during the last glacial period, is that right? Is it related to grain-size? A sort discussion or explanation would be appreciated.

-P317 L6. 'obviously' is unnecessary.

-P317 L18. Remove the exclamation mark.

-P319 L28 - P320 L11. That paragraph doesn't belong to the discussion. I would suggest moving it to the Introduction.

-P320 L13. Again the word 'clear' is not needed. We all believe that there is folding.

-P320 L23-25. I don't disagree with the contents, that is the influence of basal temperature and shear on the thinning and folding of basal layers, and that that could come from the comparison of the three ice-cores. But that certainly hasn't been discussed in the paper or at least not clearly. I would either expand the discussion stating basal conditions and relative shear component and why that could induce folding, or I would rewrite the sentence referring to a paper where that has been discussed, or I would state all the possible causes for this folding (why only those two?).

-P321 v. As in the discussion earlier, I don't think the authors explained this point very clearly. In any case, I would summarize here what are the main similarities/dissimilarities in the fabric and what the authors think is the cause.

Figure 2, 4 and 5. I will find useful a line at aii=1/3 as a reference

Figure 3 and 8. I must be getting old but I find difficult to see the small colour wheel.

Figure 4 and 5. Wouldn't it be more interesting to compare fabric vs time as the depths are different in the 3 ice-cores.

Figure 4 and 5. This is always controversial but as authors have used colours in other figures... wouldn't it be clearer if the 3 eigenvalues of the orientation tensor where plotted in different colours for different ice-cores?

Figure 8. I will find very useful in order to follow the text (Section 3.4) either put in the left panel the depth of the transitions or arrows connecting to the transitions in the right side. I will find very useful if the 2329.4-2329.6 transition was pointed in the stable isotope record.

Interactive comment on The Cryosphere Discuss., 8, 307, 2014.