The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-135-RC1, 2020

The Cryosphere Discussions
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Interactive comment on "Electron backscatter diffraction (EBSD) based determination of crystallographic preferred orientation (CPO) in warm, coarse-grained ice: a case study, Storglaciären, Sweden" *by* Morgan E. Monz et al.

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Received and published: 2 July 2020

Review of paper by Monz et al. 2020 Title: Electron backscatter diffraction (EBSD) based determination of crystallographic preferred orientation (CPO) in warm, coarse-grained ice: a case study, Storglaciären, Sweden Author(s): Morgan E. Monz et al. MS No.: tc-2020-135 MS Type: Research article The Cryosphere

The paper, entitled "Electron backscatter diffraction (EBSD) based determination of crystallographic preferred orientation (CPO) in warm, coarse-grained ice: a case study,

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Storglaciären, Sweden" suggest a method adapted to estimate the crystallographic preferred orientation (CPO) of samples with very large grains extracted from the margin of a glacier located in Sweden. The adapted method aims to respond to the well known limitation for good statistical CPO measurements owing to a too limited number of grains on classical thin sections or EBSD samples. The main conclusions of the paper are first that multimaxima CPO classically observed in large grain samples are very likely due to a too limited number of grains in the sample area studied, and then that grain boundary migration may dominate the recrystallization processes in the conditions encountered in the glacier.

The method presented in this paper, by creating a composite sample out of a large block of ice, seems to be suitable to increase the number of different orientations measured in one single EBSD sample of limited size. The scientific conclusions provided in the paper are not new and far too weak for the expectations of a standard research paper in The Cryosphere. Therefore I would suggest to reject the paper in TC, but I would encourage the authors to submit it in a journal with a specific section for "Instrument and methods", deepening the method description, and increasing the work to validate it. In the following, I give more detailed explanations for this evaluation.

- The method described, although sounding interesting, is not compared to any other type of measurements (for instance, many sample analyses over a continuous part of a core, or of a block of ice in order to provide enough grains for a good statistics) in order to assess its statistical representativity and it robustness. For instance, are we sure not to measure several times the same large crystal coming from the depth of the block, since some crystals are more than 90mm large? Owing to the fact that exact shape and location of grains are lost, there is no way to verify such a situation, as is done in figure 2 for instance. The introduction pretends that the use of a-axes measurements could provide supplementary information to check the belonging of measured areas to one single crystal or several, but this procedure is not used neither described later... There is only a very weak discussion about the orientation error produced by this multi-slicing

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technique... Although it could be quite strong, and add on at each slicing step.

- The too limited number of measured crystals is attributed solely to the measurement techniques (AITA or EBSD) imposing too small samples. This is not so true since it is possible to measure several contiguous samples from a ice core (see Dahl-Jensen et al. 2013, Montagnat et al. 2014 for instance were analyses along contiguous samples from 1 m long core sections were done). In many cases, the limitation is due to the limited size of the core extracted.

- One of the main conclusions is related to the observation, in some previous studies, of multi-maxima, and there attribution to a too limited number of crystals. This result is not so new and was intuited by most of the authors responsible for the mentioned studies. Experimental observations (such as the ones from Qi et al. 2019 shown in the paper) enabled to confirm this intuition already since, with a larger number of grains, the multi-maxima texture do not exist anymore. Although there is one dominating orientation in the combination of samples presented on figure 8, the multi-maxima remains, with 3 main orientations. So the result is not so obvious and can not lead to such a firm conclusion. Moreover, to be more affirmative, one would have needed more results, on various samples, what is not shown in this study.

- The other conclusion related to the grain boundary migration dominating dynamic re-crystallization processes in the studied conditions is not new at all, and simply confirm the observations by most authors working on dynamic recrystallization mechanisms in warm conditions (see for instance De la Chapelle et al. 1998, but also the laboratory work by Jacka and co-authors, or the most recent work by Journaux et al. 2019).

- I would like to add another important comment related to the references provided in the text. Although the authors used the review papers by Faria and co-authors (2014), it is necessary to provide the references of the original works to whom the credit should be given. Otherwise, the community will little by little loose track of these original works, and the credit will go only to the one who wrote the review. This is not fair, and also

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not respecting the ethical rules of citations in publications. For instance, line 50, p2: you could cite Van der Ween and Whillans, 1990, Mangeney et al. 1997 among others (original citations are provided in Faria et al. 2014). line 62, p2, Russell-Head et al. 1979, Azuma and Higashi 1985, Alley 1988, Gow et al. 1997, Castelnau et al. 1998, etc. would be more appropriate. Again line 117, p3

- About open cones CPO in polar bore holes. Once again, the citation of Faria et al. 2014 is inappropriate, since Faria and co-authors did not make any measurement along deep ice cores, and this is not true, I think, that this type of CPO is not observed along polar ice cores. Also less clear than in experimental work, some CPO very close to open cones are observed in the bottom of the GRIP, GISP2, BYRD cores for instance.

- Line 118: the multi-maxima CPO is not enigmatic and some hypothesis were given by different authors... See for instance De La Chapelle et al. 1998.

- Part 6.3: lines 430 to 436, the dynamic recrystallization processes are mentioned as a likely difference between the experimental and natural conditions, owing to the difference in strain rate. Although already in the experimental conditions is dynamic recrystallization very active (especially at this high temperature), and the driving force for GBM is even stronger since it is associated to the storage of dislocations at GB, the latter being expected to be stronger at high relative strain rate. At lower strain rate, we expect the dislocation storage to be slower relative to GB mobility.

N. Azuma and A. Higashi. Formation processes of ice fabric pattern in ice sheets. Ann. Glaciol., 6:130– 134, 1985. O. Castelnau, H. Shoji, A. Mangeney, H. Milsch, P. Duval, A. Miyamoto, K. Kawada, and O. Watanabe. Anisotropic behavior of GRIP ices and flow in Central Greenland. Earth and Planetary Science Letters, 154(1-4):307 – 322, 1998. S. de la Chapelle, O. Castelnau, V. Lipenkov, and P. Duval. Dynamic recrystallization and texture development in ice as revealed by the study of deep ice cores in Antarctica and Greenland. J. Geophys. Res., 103(B3):5091–5105, 1998. Dahl-Jensen, and co-authors. Eemian interglacial reconstructed from a Greenland folded ice core. Nature,

493:489–494, 2013. M. Montagnat, N. Azuma, D. Dahl-Jensen, J. Eichler, S. Fujita, F. Gillet-Chaulet, S. Kipfstuhl, D. Samyn, A. Svensson, and I. Weikusat. Fabric measurement along the NEEM ice core, greenland, and comparison with GRIP and NGRIP ice cores. The Cryosphere, 8(4):1129–1138, 2014. D. S. Russell-Head and W. F. Budd. Ice-sheet flow properties derived from bore-hole shear measurements combined with ice-core studies. Geol. Soc. Australia, 64:159, 1979.

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