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The Cryosphere Discussions

Interactive comment on "Large-scale englacial folding and deep-ice stratigraphy within the West Antarctic Ice Sheet" *by* Neil Ross et al.

Anonymous Referee #2

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Review "Large-scale englacial folding and deep-ice stratigraphy within the West Antarctic Ice Sheet" by Neil Ross et al.

This paper presents an extensive data set of airborne radar across the tributaries of the Institute Ice Stream. The high-quality data makes it possible to track folds in the lower part of the ice column and investigate the nature of a particular reflector band with a directional dependency of reflection strength, indicating crystal anisotropy in the lower layers of ice. Different ice rheology due to anisotropy and the redistribution of this ice in the folding process is identified as playing a role for the organization of inflow to the ice stream. This is an interesting data set, with most profiles published in the supplements, and highlights the importance of considering ice rheology and anisotropy when trying to understand large scale ice flow.

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Technically the manuscript is sound and well written. But I would like to raise some points which could be improved in the final version. My main concern is how the anisotropy of the ice crystal fabric is discussed. It is known from ice core data, seismic studies and also from numerical modelling that anisotropic ice is to be expected in ice sheets, and that this is linked to the dynamic setting and the deformation the ice has been subject to, as well as the influence of impurities in the ice. This is briefly mentioned here. However, there are different types of anisotropy, which are again linked to certain deformation regimes. To me it is not clear from this manuscript what kind of change in crystal fabrics is causing the reflection package described. The directional dependency of the reflector strength would indicate that it is a girdle type, typical for extensional flow, as a single maximum distribution (typical for shear) is symmetric to the vertical and therefore would not be different in profiles at different angles. I think it would be essential to discuss the different types of anisotropy and how they are linked to dynamics, to be able to interpret the influence on ice stream flow of the anisotropic ice package. As it stands now I would not agree that the data support the strong conclusion that is has been shown how anisotropy in the lower layers "modulates ice stream position, structure and dynamics). I do not disagree in general, I just think the authors have to be more convincing in their line of arguments. In summary I think there is need for a better interpretation of the links between anisotropy, ice dynamic setting, and folding structures.

Some smaller points: Lines 27-30: Folds can be generated in an anisotropic material by lateral compression, there is no need for a rheology contrast between two layers. Buckle folding, when a hard layer is embedded in a softer matrix, produces different kinds of folds (parallel folds), and the rheology contrast needed for this is much bigger than the range expected in natural ice. The paragraph reads as if the contrast in rheology is the origin of folding.

Lines 103-104: to interpret the fold here as a natural boundary for the stream is a bit circular. The folding is linked to dynamics, so the fold where the dynamic setting is right

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(shear margin).

Line 109, Comment on the supplementary figures: It is great to be able to see all the data, but would be really helpful would be a way to quantify the difference between the two profile directions in the relevant depth range and then plot this color-coded on a map.

Lines 112-113: Maybe this is the place to describe what kind of anisotropy you would expect and why.

Line 150: Do you mean a band of ice, that is in the lower part the ice should be isotropic again? Or is it a thick basal layer?

Line 155: As mentioned above, how can you conclude that the fold is influencing the location of the shear margin? In the shear margin there is in general a compressive stress across flow, so it would be the other way around.

Line 165: I don't think that it would be possible to form fractures at the base of an ice sheet. The publication which is cited is about a mountain glacier, only a few hundreds of meters thick. This must be some other form of ductile entrainment of bottom material.

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