

Review of Zeising et al., TC, 2022

The authors introduce a method for inferring the bulk horizontal anisotropy of glacier ice fabrics with depth from travel-time differences between radar waves with orthogonal polarizations.

The time-lagged cross-correlation method between the two waves represents an improvement over previous methods, which are discussed, and the case-study comparison with the (existing) EGRIP ice-core fabric profile is very convincing.

The structure and figures of the manuscript is/are well chosen, and I believe the advancements made will be received with great interest in the glaciological community.

In the end I have only minor comments in addition to the major issues #1 and #2 already raised by reviewer T. Jordan, which you may consider as you prepare the final manuscript.

Kind regards,

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Minor comments:

L1: I think it should be “ice c-axis fabric” (might be wrong).

L13: I would suggest “deformation history that can influence”.

L14: I would delete the comma after “magnitude”.

L17: I would replace “obstructed” with “challenged”.

L21: I would add a comma after “Antarctica”.

L23: Maybe mention again here that “[...] for improving ice-flow models and determining past flow/deformation”.

L24-25: I would suggest rephrasing this slightly to something along:

“This means that ice crystals are dielectrically anisotropic, in addition to being mechanically anisotropic, and thus allow the horizontal fabric asymmetry to be determined from radar surveys [...]”.

L28: I would replace “achieve” with “conduct”, and “good” with “greater”.

L36: I would delete “severely”.

L54: I would suggest “ice fabric from polarimetric measurements”.

L60: More specifically I suppose you mean Fig. 1c .

L71: Not exactly clear what this means. Maybe consider reformulating this sentence?

L73: Would replace “c-axis” with “samples c-axes”, and “by a second order” with “by the second-order”.

L75: Would replace “correspond to the length of the three principal axes” with “quantifies the strength of the three principal fabric (c-axis) directions”. Would also replace “derive” with “determine”.

Eqn. 2, 4, 6, 7, 8, 10, Fig. 3, and other in-text occurrences:

While I appreciate the notational rigor, I think you could benefit (readability-wise) from dropping the $x'y'$

subscripts in Δt , $\Delta \epsilon$, and $\Delta \lambda$ (since you are only considering horizontal anomalies in this work anyway). Your single-crystal dielectric anisotropy could then be $\Delta \epsilon_c$ (or some other subscript).

L85: Would replace “of the corresponding” with “in the corresponding”.

Eqn. 5 and 6: I think you need to unfold this a bit more for the reader. How do these equations come about?

L90: “bulk” horizontal anisotropy.

Eqn. 7: Maybe note that this assumes wave lengths much longer than the average grain size. Also, for context, I think it is worth mentioning (possibly elsewhere) that the eigenvalues represent only the strength of the *coarsest* degree of fabric anisotropy, and that finer fabric structure may exist although it cannot necessarily be detected with polarimetric radar (e.g. Hargreaves, 1978, or Rathmann et al., 2022).

L94: Do you mean to say this value applies for radar frequencies similar to those used by you? It can differ quite a bit (Fujita et al., 2000).

L100: Would add commas around “and advantage of”.

L100-101: I am not entirely sure how to understand this. I would suggest you to rephrase it a bit.

L104-105: Please define what s_{ij} is already here for the reader less familiar with the radio-glaciological nomenclature.

Eqn. 9: I find the summation limits a bit confusing. Normally, summation variables are indices (e.g. $j=1,2,3, \dots$), but you seem to mix it with the (discrete) depth variable, e.g. the upper limit $z_n + N$ is adding two quantities with different units?

L128: Would replace “we adopted” with “we changed”.

L149: Would it be more accurate to replace “vertical distribution” with “vertical profile”?

L150: What uncertainty, precisely?

L161: Would delete “the” before “previous methods”.

L169: Would delete “the” before “previous coherence method”.

L179: Do you mean to say that the inverse method cannot handle such cases of rotation?

L180: Would re-phrase this more carefully as e.g. “[...] was unsuccessful and is another reason why we regard our method as an improvement [...]”.

L186: “at much greater depth”.

L194: As this stands, I’m not sure it is sufficiently clear why this is the case. Maybe you could elaborate slightly.