

Authors' response to the second review of **Polarimetric radar reveals the spatial distribution of ice fabric at domes and divides in East Antarctica**

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**Editor: Adam Booth**

**Referee #1: Thomas Jordan 24.10.2021**

**Referee #3: Emma C. Smith 24.11.2021**

Dear editor and reviewers,

thank you for the second round of insightful reviews. We have answered (AC) all of the reviewer's comments (RC) and implemented most of them. For brevity, we exclusively list non-editorial comments & answers below and mark the editorial remarks additionally in the track changes version. We thank all the reviewers and the editors for the detailed remarks throughout this review. Given that the last round of comments contained only minor points, this revision's core message remains unchanged.

On behalf of all co-authors,  
M. Reza Ershadi  
(University of Tübingen) 01.02.2022

**AC to RC1 (Tome Jordan):**

**RC.** *Anisotropic scattering parameter.* This has now been implemented by taking the positive square-root of the intensity ratio (eq. 19). I agree this is an improvement from before, as the scattering parameter is now linear w.r.t. the eigenvalue difference, and is therefore consistent with the matrix model scaling relationship. I am also happy to see that the suggested change did not have an adverse effect on the previous conclusions. *However, notation-wise I still think eq. (6) (where  $r$  is complex number) an eq. (19) (where  $r$  is a scalar) are inconsistent.* My recommendation would be to use  $|r|$  instead of  $r$  in eq. (19) (and all subsequent usage) and be clearer throughout the MS that it represents a magnitude.

**AC.** Thanks for bringing this up. We further clarified this in the revised MS (line 153). As mentioned in Appendix B of the MS (line 465), we follow Ackley and Keliher (1979) and Fujita (2006) and neglect the conductivity term using only the real part of the complex amplitude reflection coefficients ( $\Gamma_X$  and  $\Gamma_Y$ ). Therefore, equation 6 in the MS is also scalar (same as eq 19 in the MS). We hope this solves the apparent inconsistency between equations 6 and 19.

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**RC.** *Significance of recovering the vertical eigenvalue for ice-flow modeling.* I think this could be made more explicit, as this is a key step forward for what the radar can provide to ice-sheet models (and it is considerably more useful than the 'horizontal eigenvalue difference' in constraining rheology). Ice-sheet modelers' will be interested in this result, as the strength of the vertical eigenvalue is a strong control on how soft ice is to shearing within the ice column - e.g. see: Azuma 1996 - <https://www.cambridge.org/core/journals/annals-of-glaciology/article/an-anisotropic-flow-law-for-icesheet-ice-and-its-implications/A9AC75ED14AD578C809CCF9752BF1D20>

**AC.** We added this point and the mentioned reference to the revised MS abstract (line 6) and conclusion (line 438).

**AC to RC3 (Emma Smith):**

Thank you for the editorial corrections and the very constructive comments. We implemented most of the suggested editorial changes, which you can find in the track change version. The parts with comments and questions are answered below.

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**RC.** I would like to see a sentence here introducing the radar method briefly. As it is, it feels like it jumps into the technical part too quickly and I found it a bit tricky to understand what was going on until later into the abstract.

**AC.** We changed the radar polarimetry to co- and cross-polarized phase-sensitive radar data to clarify the radar method in revised MS (line 4).

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**RC.** You mention this here, but don't go on to say why your method is comparatively advantageous, as you do with cores and borehole measurements. For completeness, it would make sense to mention the advantages of radar over surface seismic methods in the next paragraph.

**AC.** We added this point to the revised MS (line 46).

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**RC.** It seems as though you refer to Dome C/EDC and Kohnen/EDML interchangeably in this section and later on in the manuscript. It is a little confusing, I would suggest you check for consistency throughout. There may be a reason to use a specific term in some places but it isn't completely clear to me.

**AC.** Excellent point. Thanks for mentioning it. In this paper, we have two radar sites at the location of the ice cores. EPICA Dome C, which we refer to as EDC and EPICA Dronning Maud Land, which we refer to as EDML. For Dome C, we also have another 19 radar sites. When we use Dome C, we mean the Dome C area and all the radar sites, but when we mention EDC, that means only the EPICA Dome C. For EDML, we do not have this because there is only one radar site. We went through the MS to make sure we correctly used these terms.

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**RC.** Would be visually helpful if the site names were written at the top of each panel - for quick reference.

**AC.** We decided not to add any more information to figure 1 since it already shows the sites' names with the coloured stars.

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**RC.** A single ice crystal requires 60 times more stress to deform it in a non-basal direction, than along the basal plane (basal slip). This will not directly translate to a bulk ice fabric - I would suggest rephrasing this sentence to reflect this more accurately.

**AC.** This part has been rephrased in the revised MS (line 87).

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**RC.** Is this because there is abrupt variability with depth at EDML? If so, state here.

**AC.** Yes and we added this to the revised MS (line 236).

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**RC.** State briefly why you compare to Dome Fuji here.

**AC.** Simply because it is another ice dome. As the contrasting flow regimes are elaborated on later in the MS, we left it here as is.

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**RC.** Could you comment on ice flow environments where you might get a strong change in orientation with depth and how this limits the current method, in terms of environments where this can be applied?

**AC.** At the moment, it is not fully clear to us if a changing ice-fabric orientation should be interpreted as an ice dynamic signal of the current flow regime or if it indicates a temporal change of the flow regime at this location. Therefore it is difficult to single out specific cases where this method may not be applicable.

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**RC.** Confusing sentence, I am not sure what you are referring to by "bulk of the fabric" - do you mean bulk ice fabric? Please clarify and rephrase.

**AC.** Yes. We meant bulk ice fabric, and it is rephrased in the revised MS (line 413).