Failure strength of glacier ice inferred from Greenland crevasses

Addressed Comments for Publication to
EGUSphere (The Cryosphere)
by
A. Grinsted, N. Rathmann, R. Mottram, A. M. Solgaard, J. Mathiesen, and C.S. Hvidberg

Response to RC2

> **General Comments.** This is an excellent paper, addressing an under-studied but important issue in glaciology in an elegant and rigorous manner. The methods and results are presented efficiently and clearly, with enough detail to address the important issues but without clutter or un-necessary material. It is pleasing to see such clear patterns emerge from the data, despite the many potential issues with data resolution. My only substantial criticism is that the crevasse onset criteria should also be presented in terms of strain rates, rather than stress metrics alone. As the authors clearly state, the calculated stresses depend on the choice of rheology. Standard values have been used, and the prefactor A has been scaled to temperature; this is all good, and aligns with standard practice in glaciology. However, major sources of uncertainty remain, including the true temperatures at crevasse-initiation depth, non-temperature influences on A, and the possibility (indeed, likelihood) of varying n across the very large study area. For these reasons, the calculated stresses are not absolute, but parameter-dependent. The authors have done an excellent job of highlighting these issues in the text, and I have no issue with that. However, it would be very useful to present the raw strain rate values – these are the observations, and are hence free from any assumptions regarding the rheology. Including the strain rate data will offer researchers greater flexibility in how they interpret and use the results presented in this paper. I do not see any need to adjust what is already written in the paper, simply to add a section (and a Figure) on the strain rates.
>
> I found only one typo. On line 82, one 'principle' sneaked into the text. As is the case elsewhere in the paper, this should of course be 'principal'.
>
> The author team are to be congratulated on a fine study. The paper is likely to be widely cited: I shall certainly find it very useful for my work on the role of crevasses in calving.
>
> Doug Benn

Response: Thank you for the kind words. We hope our work will be useful.

We have made a preliminary attempt at a strain rate figure as requested (fig. R1). It is certainly interesting. However, we are not entirely happy with how it has turned out. 1) The 2d histogram below the plot is nearly invisible because of the very long tailed strain rate distribution. 2) It is very dependent on temperature which makes it difficult to choose an appropriate "zoom" level.
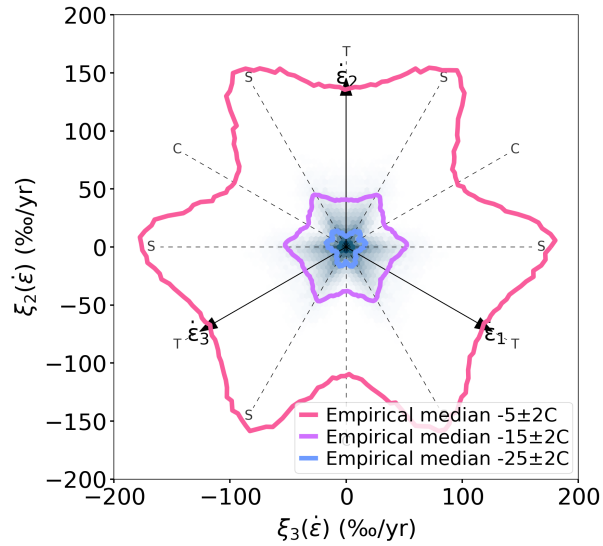
Figure R1. Empirical failure map showing a π-plane density map of strain rates in crevasse onset regions with steady flow. The empirical median in $10°$ windows for three different temperatures is shown as fat lines; Tensile, Compressive and Shear directions have been labelled with T, C, and S.

We intend to make the following changes to the manuscript during revision:

– We will fix the typo.

– We are undecided if we want to add strain rate figure to the appendix as is above – One the one hand we would like to keep the tight focus of the manuscript, on the other then fig. R1 is interesting (but it requires some explanation). We will discuss this in the author group, but we hope to improve the visualization first.