

## Response to comments of referee #2 (David Prior)

We would like to thank the referee for their detailed comments on the paper, which are perceptive and very helpful. We have largely implemented the suggestions from the referee in the revised manuscript.

### Referee's first comment

*The mistake in the Goldsby & Kohlstedt composite flow law*

**Authors response** We acknowledge that the way this correction was written down could be confusing to readers of the paper. We added in section 3 that the discrepancy between the results of the calculated strain rate and the experimental data points was identified and confirmed by Goldsby and Prior.

Figure 7 was removed from the manuscript and all discussion about the flow law parameters for dislocation creep was moved to section 3. In the end of section 3 it was also added that dislocation creep is 15 to 20 times slower with the new flow law parameters compared to the old flow law parameters.

The flow law parameters for dislocation creep in Table 2 have been named " $G\&K_{\text{mod}}$  dislocation creep" in order to distinguish between the correction made to the flow law parameters in this paper and the companion paper (tc-2018-275).

### Referee's second comment

*A schematic overview at start*

**Authors response** A schematic overview was added in the beginning of the paper. The figure shows (a) the three CPO eigenvalues, (b) the grain area and (c) the in-situ temperature. The figure also shows the three depth regimes (Holocene, glacial and Eemian ice) in the NEEM ice core. The grain size and temperature data was taken out of Figure 7 and 8 (of which only figure 8 is left now).

### Referee's third comment

*"Accommodated" by*

**Authors response** The explanation on line 7 has been removed and this has been corrected for. Throughout the entire paper (and the companion paper tc-2018-275) we have adopted the 'rate limiting' terminology instead of the 'accommodated by' terminology. The two bullet points are incorporated in the methods now (Equation 4 and 5 in the new version).

### Referee's fourth comment

*The "Glen" law*

**Authors response** We mentioned that 'the most often used for of Glen's flow law' has a value of  $n=3$ . This is introduced just below Equation 1. The value of  $n=3$  was taken from Paterson (1994) and has been cited accordingly.

### Referee's fifth comment

*Discussion*

**Authors response** The discussion has been shortened. Most of the shortening was accomplished by moving the discussion about the flow law constants for dislocation creep to section 3 and removing the discussion of the results obtained using the original flow law constants (Figure 7 in older version).

### Referee's sixth comment

*Put all the discussion of the modified flow law in one place*

**Authors response** All the discussion of the modification of the flow law parameters for dislocation creep has been moved to section 3.

**Referee's seventh comment**

*Put the discussion of the micro scale constant stress and constant strain rate models in one place.*

**Authors response** Figure 9 (Figure 8 in new version) has been put before Figure 8 (Figure 9 in new version). The results and discussion have been reordered accordingly.

**Referee's eighth comment**

*Grain size: mean diameter vs mean area*

**Authors response** We have mentioned that the equivalent diameter calculated from mean area is larger than the mean diameter in section 2.3 on page 7 lines 23-26.

**Referee's ninth comment**

*Girdle*

**Authors response** We described the shape of the CPO in the Holocene ice as 'great circle "girdle" distribution' (page 4 line 19). The CPO eigenvalues (Figure 1a in new version) will also help to clarify the type of the CPO.

**Referee's tenth comment**

*Recovery and recrystallization*

**Authors response** *we agree that Recovery and recrystallization are important processes in glacial ice. In section 5.6 we suggest that dynamic recrystallization by SIBM is one reason why the predicted deformation mechanisms from the composite flow law models are not consistent with the microstructures developed in the Holocene ice. The role of SIGM is discussed extensively in the manuscript and we have now added the wording of "recrystallization by SIBM".*

**Referee's eleventh comment**

*Strain rate*

**Authors response** *The methods are described in the references of Gillet-Chaulet et al., 2011; Montagnat et al., 2014, so we have not added any further details here.*

**Referee's twelfth comment**

*CPOs during GBS in ice*

**Authors response** The reference to Craw et al. (2018) was added to the manuscript in section 5.5.

**Referee's thirteenth comment**

*Figure Captions*

**Authors response** On a few occasions a sentence was removed in the figure caption. However, for most of the figures the caption did not change. For these figures we think that the caption explained well what was in the figure and shortening the caption would have been undesirable.

**Referee's fourteenth comment**

*Figure 8 layout*

**Authors response** The comments in all five bullet points were included when adjusting the figure. We agree that these adjustments make the figure clearer and easier to interpret.

**Referee's fifteenth comment**

*Some refs I think you should have in there:*

**Authors response** Four out of the six papers were cited were appropriate and added to the reference list in the manuscript.