

Dear Editor Karlsson,

We sincerely appreciate your comments on March 23, 2025 to improve further the manuscript. We apologize for the oversight regarding the interactive discussion section, which we neglected to address before submitting our revision on April 24, 2025. To ensure clarity and minimize any potential influence from your review, we have included our revised sections in blue within the manuscript, differentiating them from the previously highlighted red portions in the April submission. Please find our responses below in black font, and your comments in blue font.

#### Interactive discussion

23 Mar 2025

Editor decision: Publish subject to revisions (further review by editor and referees)

by Nanna Bjørnholt Karlsson

Public justification (visible to the public if the article is accepted and published):

Dear Yuan Li and co-authors,

Thank you for your response to the referee reports. In addition to the changes you have outlined, I ask you to consider the following points below.

I look forward to seeing a revised version of your manuscript.

Best,

Nanna B. Karlsson

Please separate the references in the Introduction paragraph such that it is clear which studies only relate to ice, firn or both, e.g.:

"Numerous studies of firn deformation (REFs), ice deformation (REFs) or both (REFs) have been conducted, but there are few reports about the mechanical behaviour at different temperatures. "

Modified.

*"Numerous studies of firn and ice deformation (e.g. Steinemann, 1954; Glen, 1955; Landauer, 1958; Mellor, 1975; Salm, 1982; Maeno and Ebinuma, 1983; Jacka, 1984; Ambach and Eisner, 1985; Budd and Jacka, 1989; Li et al., 1996; Meussen et al., 1999; Petrenko and Whitworth, 1999; Bartelt and von Moos, 2000; Jacka and Li, 2000; Durham et al., 2001; Goldsby and Kohlstedt, 2001; Hooke, 2005; Song et al., 2006a, 2006b, 2008; Theile et al., 2011; Treverrow et al., 2012; Hammonds and Baker, 2016, 2018; Li and Baker, 2021, 2022a) have been conducted, but there are few reports about their mechanical behaviors at different temperatures."*

Please see Lines 43–49.

"Temperature is a key component of firn and ice-flow models, as the deformation of firn, polythermal

glaciers, and temperate glaciers is significantly influenced by the temperature."

I would argue that temperature also significantly influences cold ice, so the sentence could simply be shortened:

"Temperature is a key component of firn and ice-flow models, as the deformation of firn and ice is significantly influenced by the temperature."

Corrected.

*"Temperature is a key component of firn and ice-flow models, as the deformation of firn and ice is significantly influenced by the temperature."*

Please see Lines 50–51.

Please split up the paragraph below. It is very hard to decipher as it is:

"Additionally, tertiary creep occurs both during quasi-steady state deformation (from the  $-5^{\circ}\text{C}$  specimens at 40 m and 60 m) and in the ascending stage (from the  $-5^{\circ}\text{C}$  and  $-18^{\circ}\text{C}$  specimens at 20 m and the  $-18^{\circ}\text{C}$  specimen at 40 m) more easily with lower firn density, greater effective stress, and higher creep temperature, e.g. from the  $-5^{\circ}\text{C}$  specimens at 20 m, where the strain softening is primarily due to either recrystallization (Duval, 1981; Jacka, 1984; Jacka and Li, 2000; Song et al., 2005; Faria et al., 2014) or the activated easy slip systems (Jonas and Muller, 1969; Duval and Montagnat, 2002; Alley et al., 2005; Horhold et al., 2012; Fujita et al., 2014; Eichler et al., 2017)."

*"Additionally, tertiary creep is observed during both quasi-steady state deformation, particularly in the  $-5^{\circ}\text{C}$  specimens at depths of 40 m and 60 m, and in the ascending stage, as seen in the  $-5^{\circ}\text{C}$  and  $-18^{\circ}\text{C}$  specimens at 20 m, along with the  $-18^{\circ}\text{C}$  specimen at 40 m. This mechanical behavior is facilitated by lower firn density, increased effective stress, and elevated creep temperatures. For instance, in the  $-5^{\circ}\text{C}$  specimens at 20 m, strain softening primarily results from recrystallization (Duval, 1981; Jacka, 1984; Jacka and Li, 2000; Song et al., 2005; Faria et al., 2014). Also, the activation of easy slip systems contributes to this process (Jonas and Muller, 1969; Duval and Montagnat, 2002; Alley et al., 2005; Horhold et al., 2012; Fujita et al., 2014; Eichler et al., 2017)."*

Please see Lines 404–412.

I am missing a sentence that reports: "This is in contrast to/in agreement with the findings of X, who report that ... implying that ..."

*"It is noteworthy that Jacka and Li (1994) observed that steady-state tertiary ice creep, which is marked by stable grain size, is influenced more by applied stresses than by temperature. This finding suggests that there exists a balance between the activation energies required for grain growth and subdivision at a specific temperature."*

Please see Lines 412–416.

Response to the referee's questions re. 3.4 Relationship of strain rate to strain and 3.5 Apparent activation energy for creep:

Please ensure that the referee's question is addressed appropriately. I cannot assess from the reply which details you intend to add to the manuscript to clarify the necessity of calibration and whether there will be a discussion of the range of results due to different calibration methods.

Please see our responses about these two points addressed in the response letters.

Please add a sentence explaining why the use of the hydrostatic pressure is appropriate to determine the loading stress.

We've added a sentence in the text:

*"The hydrostatic pressure,  $p$ , which varies with temperature, along with the cohesion of the ice and the friction angle between snow particles, plays a significant role in determining the apparent activation energy and, consequently, the strength of the ice (Fish, 1991)."*

Please see Lines 646–648.

Upon attempting to submit our updated revision, we noted a reminder in the Interactive Discussion stating, "Attention: please do NOT submit your revised manuscript here as supplement." Consequently, we have only submitted our response letter to the Editor, titled "Revision Complement." We remain dedicated to revising our manuscript as outlined in our correspondence.

Sincerely,

Yuan Li, Kaitlin Keegan, and Ian Baker