

Dear Prof. Karlsson,

We thank you so much for your comments to improve the manuscript again. Please find your comments below in blue font and our responses in black font. The manuscript contains relevant revisions that have been marked in red.

Dear authors,

Thank you for submitting a revised manuscript. I think we are getting closer to a consensus about your study but given the fairly critical comments from the referees and the fact that I am not a topic expert, I am going to send the manuscript out for review again.

In addition to the changes you have already implemented, I ask that you make the following changes:

Lines 34 - 37: Please cite more appropriate studies that exemplify the importance of firn models in the applications you mention. Citations should be chosen as either the first known example of the application or a very well-known/widely cited example. In view of the fact that this is a TC manuscript, the studies should be glaciological or climatological rather than focused on material sciences.

The revised text is included below.

“Understanding firn compaction and densification experimentally is critical for developing physics-based firn models that are necessary for many glaciological applications. For example, such models are essential for reconstructing ice-core paleoclimate records by simulating the lock-in depth of gases and the smoothing of climate signals (Schwander et al., 1997; Goujon et al., 2003). They are also crucial for interpreting ice-mass changes from satellite altimetry data, as they allow for the accurate correction of firn air content and surface elevation changes not related to underlying ice dynamics (Ligtenberg et al., 2011; Simonsen et al., 2013).”

Please see Lines 34–40.

Lines 52 - 56: Please rephrase this from a quote to a summary of the sentence.

The revised text is included below.

“The experimental observations are interpreted by drawing parallels between firn deformation and the mechanical properties of its constituent material, polycrystalline ice. This connection is formalized through a poromechanics approach, where the behavior of the porous firn is derived from that of the ice skeleton using continuum mechanics and homogenization principles (Scapozza and Bartelt, 2003; Gagliardini and Meyssonier, 2000; Coussy, 2004; Hutter and Johnk, 2004; Srivastava et al., 2010; Theile et al., 2011).”

Please see Lines 56–60.

Lines 57 - 62: Split up references so that the sentence reads: "While numerous studies have investigated ice deformation (REFs) and firn/ice deformation (REFs), existing firn data are sparse and fragmented (REFs)"

The revised text is included below.

"While numerous studies have investigated ice deformation (e.g. Steinemann, 1954; Maeno and Ebinuma, 1983; Li et al., 1996; Jacka and Li, 2000; Song et al., 2006a, 2006b, 2008; Treverrow et al., 2012; Hammonds and Baker, 2016, 2018) and firn deformation (e.g. Landauer, 1958; Mellor, 1975; Salm, 1982; Ambach and Eisner, 1985; Meussen et al., 1999; Bartelt and von Moos, 2000; Theile et al., 2011; Li and Baker, 2021, 2022a), existing firn data are sparse and fragmented."

Please see Lines 60–65.

Fig 3: Move legend to the top figures for readability.
 The revised figure is included below.

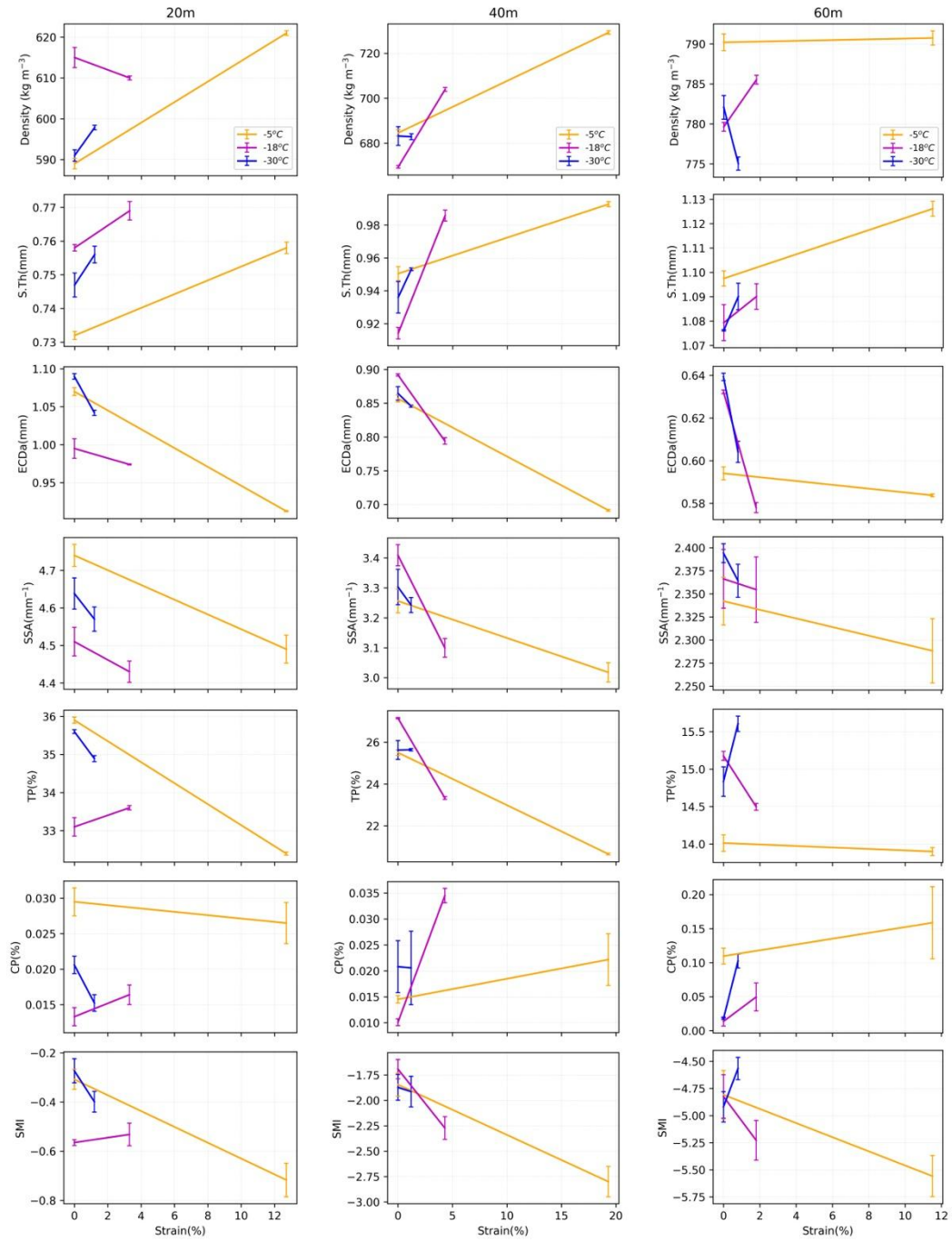
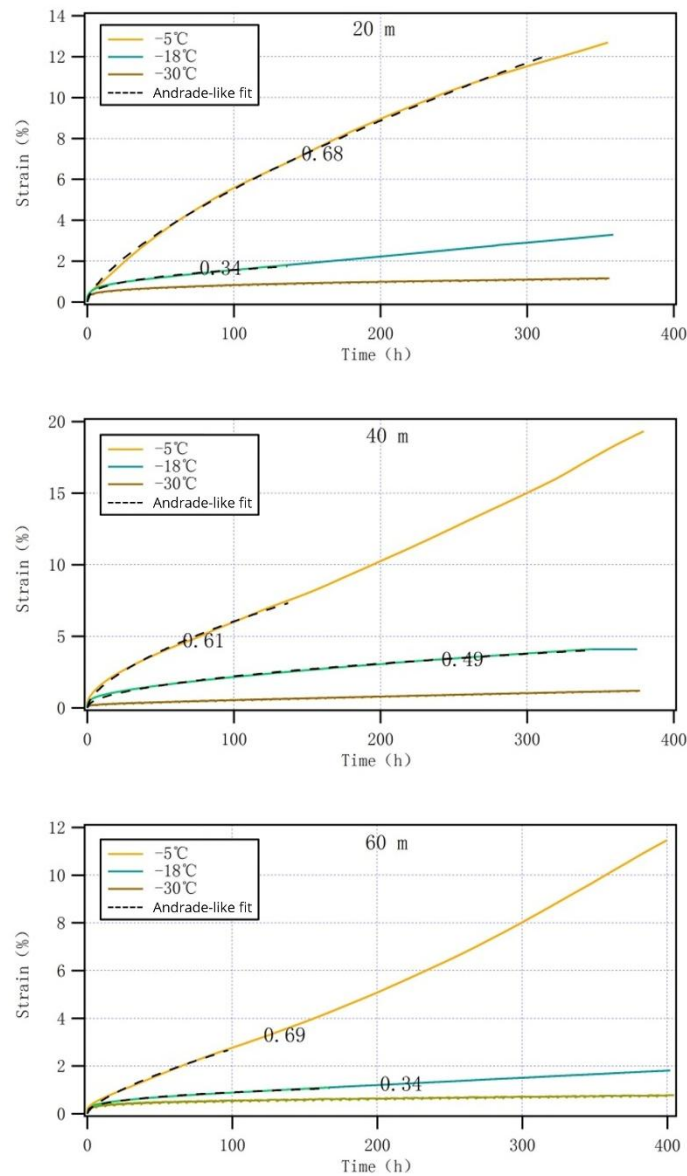


Fig 5: Please include the dashed line in the legend. Please add in the caption that the y axes have different limits. Consider if some of the figures can use the same limits? The revised figure is included below.



“Figure 5: Strain vs. time for firn specimens at -5°C (yellow lines), -18°C (blue lines), and -30°C (brown lines), from depths of 20 m (applied stress 0.21 MPa), 40 m (0.32 MPa) and 60 m (0.43 MPa). The black dashed curves represent fits to a modified Andrade-like equation with the time exponents indicated on the curves, if any. Note: The y-axis limits vary across the subfigures.”

The caption now notes the differing y-axis limits. A common y-axis scale for all subfigures is not practicable, as it would obscure key data trends. Consequently, the original configuration has been maintained.

Lines 376-379: Are the manuscripts cited here the only studies to report on the k-value? If not, please include citations to those studies too, and note what their findings were.

Yes. The revised text is included below.

“The k values derived for firn are generally higher than those for polycrystalline ice, implying that the higher firn deformation rates compared to those of ice ($k = \sim 0.33$; Cuffey and Paterson, 2010, and references therein) are likely related to the fewer grain-boundary constraints with more void space in firn (Li and Baker, 2022a; Li, 2023b).”
Please see Lines 377–381.

Line 385-386: Word missing: "However, the steady decrease of k values from -5°C to -18°C remains further investigation."

The revised text is included below.

“The identified trend of steadily declining k values across the temperature range of -5°C to -18°C , however, represents a significant gap in our current understanding, necessitating a dedicated investigation into the microstructural or metamorphic causes.”
Please see Lines 386–389.

Sincerely,
Yuan Li, Kaitlin Keegan, Ian Baker