**Review of Sheng Fan et al.'s - The Cryosphere preprint:- tc_2022-228**

**Grain growth of natural and synthetic ice at 0ºC**

**General comments on the manuscript**

This preprint by Fan et al. suggests grain growth in natural ice is much slower than synthetic ice and is based on two sets of experiments. The authors successfully obtain high-resolution EBSD data that provide insights into microstructural and CPO changes. The paper is generally well written, but suffers from some inconsistencies and repetitions and some minor rearrangement, shortening and streamlining of the text is required. There are far too many one sentence paragraphs or subsections in this manuscript that do not let the reader to obtain a good sense of flow. If substantial modifications are undertaken then it would be suitable for The Cryosphere.

**Specific comments for the author's consideration**

- This papers introduction (lines 33-44) contains general statements on the mechanical behaviour of ice which are not relevant to their annealing story. I would suggest it would be better to highlight why there is a need to better understand grain growth in ice and formulate the aims of the paper more clearly.
- In the Abstract and also in introduction it would be good to point out that these are both short- and long-term annealing experiments. In the text it would also be an idea to say how these compare with the time frame summarized in the plot (Fig. 13) in Wilson et al (2014).
- Annealing times are used inconsistently throughout the manuscript. Days are used in Fig. 2; Hours in Figs. 4 & 5; Seconds in Fig. 7; Hours in Figs 8, 9. On some of the plots it may be worth having two timescale bars included. Hours used on lines 404, and months on line 474.
- The results section is very disjointed and in need of some consolidation. E.g. Why not combine sections 3.2.1 and 3.2.2; 3.3.1 and 3.3.3 and the subheading "3.3.2 Bubbles" could be better identified.
- There is no proper introduction to the Discussion' section (4). It would be good if there is a summary that sets the scene for the following subsections. In fact much of section 4.1.1 could be removed as many of the equations have little bearing on the discussion in section 4.1.2.
- The section on evaluating the bubbles in the Priestley ice (4.2) needs to be considerably shortened and unnecessary referencing needs to be scaled back.
- The section 4.3 could also be significantly shortened and the discussion and referencing of previous work (e.g. lines 430-435) is out of place and could be deleted.
- Nowhere in this manuscript has there been a discussion of strain energy and its role as a contributor to grain boundary migration.
- Overall, this paper presents some high-quality experimental data. However, conclusions are too focused on the Priestley glacier and do not suggest the significance of this work and how it compares with Azuma's research and how it could be applied to other ice sheets or glaciers.

- **Editorial comments keyed to line numbers**

55- It would be good to see some specific references to papers that demonstration how dust and dissolved salts effect the ice microstructure.

105- I have difficulty relating text statements referring to the ice flow plane with Fig. 1a? Why isn't the flow plane clearly identified in the figure? In the natural ice was there any suggestion of a grain shape alignment parallel to the flow plane?

Table 1. - I feel the caption could be expanded to better identify what S_M_A P_B etc sand for and shorten the text between lines 155-158.

162 - The sentence "For a few….. (Table 1" could be removed as this is already said on line 145 at bottom of Table.

185 & 195 - Is it necessary to have (SE) in the text and caption. It would be better to write it out in full.

213 – Why write out CPO in full again when it was used on lines 44, 46, 60 etc.

221 – Why repeat the spelling out of SPO when this was undertaken on line 219? Again it is repeated on line 279, 289 (in caption) and elsewhere in the paper, e.g. line 360.

225 – 235 – These two sections should be removed from here as they repeat material that should be in the methods section. This will then require renumbering and possibly renaming the following sections.

243 – delete 'experiment'.

278 – SPO problem.

279 – Remove unnecessary parenthesis.

306 – Why is it really necessary to have subsections 4.1 and 4.1.1 ? you need to reorganize subheadings.

310-331 – Except for the first paragraph, the rest of this section does not contribute anything to this highly descriptive paper. The parameters *n, k and* $t_0$ are not really defined. There are equations, which are really not used and their relevance is unclear. Why not explain these parameters in the figure caption to Fig. 7?

318 – change 'and others' to et al.

339-340 – Why not combine these two paragraphs and shorten them in the light of writing a new introduction to the "Discussion" section.

Fig. 7b – The significance of this figure and the rate constant, *k,* needs to be better clarified in a new introduction to the "Discussion". Or this figure could be removed.

364 – References not in reference list. Are they necessary?

365-375 Much of this discussion and references are irrelevant to the origin of bubbles, and could be deleted.

380-395 and to 425 – This section can be considerably condensed.

420 – The sentence "Further studies…natural ice" could be deleted and especially the word "elle" is not required.

485-490 – This conclusion has not been supported by any data in this manuscript.

## References

Azuma et al., 2012, Impeding effects of airbubbles on normal grain growth, JSG 42, 184-193.

Wilson, C.J.L., Peternell, M., Piazolo, S., and Luzin, V., 2014. Microstructure and fabric development in ice: lessons learned from *in situ* experiments and implications for understanding rock evolution. *Journal of Structural Geology* **61**, 50-77. http://dx.doi.org/10.1016/j.jsg.2013.05.006.