Review of Refinement of the fluidity parameter range with a stress exponent of four in Glen's law: insights from Antarctic bed topography model

General Comments

Based on recent work (Millstein et al., 2022; Ranganathan et al., 2021) there is increasing interest in using n=4 rather than n=3 in ice sheet modelling. This paper uses 2D full-Stokes simulations with n=4 to provide order-of-magnitude constraints on the value of the fluidity parameter when n=4. They reduce the range of A from 6 orders of magnitude to 1. Generally, I think the paper provides a useful contribution to the community and should be published after the inclusion of a few more clarifying figures and paragraphs.

Originality: The paper performs simple 2D simulations of regions of ice sheets. The novelty comes from using the value of n = 4 and exploring the range of A values in the rheology which give reasonable results. The main contribution is new constraints on the value of A to use when using n=4. This will be useful to ice sheet modellers interested in using this value of n, of which there is increasing interest in.

Scientific Quality: The authors use 2D full-stokes simulations to constrain appropriate value of A which give predictions which match observed velocities. The use of full-Stokes is good, and I am also pleased the authors demonstrate that the results are robust to a range of sliding exponents.

One concern I have about the final range of A values given is that it may over-constrain A. The final range of A values stated, 4 to 16×10^{-32} $\mathrm{Pa}^{-4}\mathrm{s}^{-1}$, is found by simply combining the A values which give reasonable results for each case studied. One could imagine that if more ice shelves were included in this study, this method would give no A value which gave reasonable results for all. This is not a criticism of the work, which I think is valid, but just the calculation procedure used at the end.

The Shackelton Ice shelf in particular is an outlier in terms of the appropriate range of A values. It would be useful to explore in the discussion what the suggested range of A values would be without this case and have some statistical analysis and a final summarizing figure showing the suggested A values for each case examined.

There is also likely sufficient unaccounted for physics implicit in A, such as temperature variation, fabric induced anisotropy, grain size etc. which would give an order of magnitude variation at least in the true value. This should also be mentioned in the discussion.

Significance: The paper will be useful to ice sheet modellers in general, and hopefully encourage more studies using n=4.

Presentation quality: The paper is generally well written and concise. The title provides a clear summary of the work, and the abstract communicates the main results, though I think it should be noted in the abstract that this is a 2D study.

Specific Comments

- I would like to see at least one 3D simulation alongside the 2D cases for the idealised configuration explored here, to ensure that the same range of A values are found in 2D and the

3D cases. The limitation of 2 dimensions and how things may change in 3D should also be included in the discussion.

- There should be a demonstration of the mesh independence of the results, especially considering the saw-tooth oscillations in Fig 2., for both the idealised and realistic cases. This can just be included as a supplementary figure.
- The definition in Eq. 6 and your values of m = 3,5,7,9 later are inconsistent: with these m values Eq. 6 should read 1/m not m.

Technical Comments

Line 30-31: By incorporating geodetic creep data… I'm not sure what is meant precisely by this phrase. Furthermore, while the Cuffy and Behn do support n=3, it would be relevant to say here that n=3 has been used since Glen's classic experiments (Glen, 1952).

Throughout the manuscript mathematical variables in the text should be written in math mode, i.e. A and $n = 4$ rather than A and n=4.

Line 85: should be lowercase p for pressure

Around Eq. 4 and 5 ε_e should be defined or the table should be referenced

The range of Fluidity parameters in Fig 2 should be expressed in exponent notation (i.e. 10^-29 rather than 0.001 x 10^-32)

Line 150 of the text references dotted lines showing the positing of BedMap2 grounding lines in Fig 3, yet I cannot see them in this figure.