

Response to Reviewer 1 of article entitled “Surging of a Hudson Strait Scale Ice Stream: Subglacial hydrology matters but the process details don’t”

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Reviewer 1 has identified a number of improvements to this manuscript and we are grateful to their detailed examination and thoughtful suggestions. We agree that the paper is rather long. However, like Reviewer 1, we are reticent to remove any parts and emphasize the importance of model testing and description so that the results are interpretable and trustworthy.

Reviewer 1 is unsure to which model configurations the efficient drainage was applied – this drainage was applied to both mass conserving models (linked-cavity and poro-elastic), but not the non-mass conserving, zeroth order “leaky bucket” model. In this sense the similarity in of results between the three hydrology setups demonstrates the lack of importance (for a Hudson Strait scale ice stream) of process details as important as mass-conserving lateral transport and efficient drainage for surge frequency (fig. 10 a), surge speed up (fig. 10 b), importance of effective pressure in the basal velocity calculation (rNeffFact, fig. 12). Even comparing the surge duration and sliding velocity/effective pressure distribution between poro-elastic (mass-conserving with efficient drainage) and leaky-bucket (non-mass conserving without efficient drainage) – which have the same pressure closure – does not yield appreciable difference. It is surprizing that these two process differences – the main process details – do not matter for the given context. The comparison between these two systems with similar pressure closure but differences in the main process details is not made clear enough in our submission and will receive more attention in the revised manuscript.

Current runs are underway to show the model output under both SHMIP scenarios A3 and A5 to compare the behaviour of the efficient system in BraHms to that of GlaDS and will appear in the final manuscript.

We will implement all changes suggested by Reviewer 1 unless otherwise stated. Below we respond to the specific comments and some of the more technical suggestions.

- Section 2: We will elaborate the description of the efficient drainage and explicitly state that it applies to both of the mass-transporting systems (poro-elastic and linked-cavity). We will also be including further justification of this choice of diagnostic (non-dynamical) efficient drainage model as Reviewer 2 has suggested.
- Section 3: As stated above, we are currently running an additional comparison to the GlaDS output for scenario A5.
- Discussion: The context for our conclusions is given in the title and caveats as to other applications where the subglacial hydrology process details might be important are given in the discussion (*e.g.* line 573). We will underline caveats and model limitations in the discussion of the revised manuscript.

- Line 19: We are not saying that the role of subglacial hydrology at time scales longer than a season is clear, but are making the more limited statement that subglacial hydrology’s role at time scales longer than multi-decadal (if not less) is *not* clear. We will leave this sentence as is in the revision.
- line 358: T_{bp} is the basal temperature as stated earlier in the paragraph (line 357). We will leave this as is in the revised manuscript.

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