

Detailed response to the editor on revised manuscript tc-2018-252

“Scaling of instability time-scales of Antarctic outlet glaciers based on one-dimensional similitude analysis”

by Anders Levermann and Johannes Feldmann

Dear Editor,

We would like to thank you again for handling of the review process of our manuscript. We are delighted by the very positive assessments of the two reviewers and are glad to hear that the manuscript might be suitable for publication after minor revisions. We gladly implemented the valuable comments and suggestions by the two reviewers.

Please find below the *reviewers' comments in italics* and [our detailed response in blue](#). We have further attached a revised manuscript that highlights the changes in the submission, as well as a clean revised version.

Best wishes,

Anders Levermann and Johannes Feldmann

Anonymous Referee #1

Scaling, similitude and dynamic analysis using simple relationships comprises the powerful bedrock of scientific inference that is all too often ignored in favor of "whiz-bang computational codes" and the glories of tedious algebraic solutions to highly approximated fluid dynamic problems. The best example of where this plays out is when G.I. Taylor, the great UK polymath and fluid dynamicist, determined the energy of the exploding atom bomb at Almorogordo, New Mexico from a picture of the explosion on the cover of Time Magazine (and completely out-performed the more rigorous physics approaches that were top-secret at the time). Taylor used similitude analysis and the Buckingham Pi theorem to do the work. <http://chalkdustmagazine.com/features/the-buckingham-pi-theorem-and-the-atomic-bomb/>

*The significance of the work presented here is that it gives an overarching target for numerical modeling and other more complex approaches to be compatible with. (They may turn out to disagree, and if this happens, the similitude analysis will undoubtedly respond by improvement or by changing a scaling assumption.) More than just providing a "overview" of computational approaches to prediction, the method and the presentation in this manuscript offers a guide to *field glaciologists* who are interested in ensuring that their studies cover the range of ice stream and glacier behaviors and conditions rather than being stuck just focussing on dynamically similar systems that offer no independent insights (e.g., studying the same exact thing).*

I regard this work to be of interest to anyone who, by any method, would attempt to pursue a prediction of future response of the West Antarctic Ice Sheet to current conditions and future warming.

We would like to thank the reviewer for the effort to review our manuscript and are glad to receive such a positive assessment. The comments were very useful and constructive and we gladly implemented the suggestions.

P1 L4: Insertion of comma.

Done.

P1 L6-9, L13, L15-16: Abstracts should be "just the minimum to understand" with no elaboration.

We followed the suggestion of the reviewer and took the respective sentences out of the abstract.

P1 L21: Why not also refer to the original discovery by Bentley et al.? Look up the reference...

We thank the reviewer for this hint and included the reference.

P2 L2: It is important to also acknowledge that the instability mechanism also implies an unstable

advance or negative-ice-loss feedback too.

We appreciate the reviewer's suggestion. However, we would like to refrain from discussing (un-)stable ice-sheet advance here since such a situation is not part of our analysis. Our study exclusively focuses on topographic configurations that could lead to unstable ice-sheet retreat and thus we feel that elaborating on ice-sheet advance might distract the reader and disturb the reading flow.

P2 L20-22: Comma deletion/insertions and slight rewording.

Done.

P2 L24: it might be worth referring to Buckingham's Pi Theorem...

Thanks for the suggestion. We agree with the reviewer that a reference to the theorem makes a lot of sense here and included the citation.

P2 L30-31: rewording

We picked up the suggestion of the reviewer and modified the statement.

P3 L9: Insertion

Done.

P5 L25-27: This sentence is hard to understand, rewrite.

We reworded this sentence and splitted it into two for better understandability.

*P6 L15 (discussion and conclusion sections): Just a side comment: Similarity analysis also helps observationalists understand what glaciers or ice streams to study, i.e., they should study ones which are *different* in similitude, so as to not be simply "studying the same dynamic regime". perhaps this should be added to conclusion or introduction.*

Again, this study also shows where field-work will yield the most "independent" information about the full spectrum of ice-stream and glacier dynamics... Eg. studying two glaciers that have the exact same similitude seems like a waste of time, whereas, studying two which have widely varying similitude would give insight.

We thank the reviewer for making this valuable additional point. We added two sentences to the conclusions section according to the suggestion of the reviewer.

Reviewer #2:

Dear colleagues,

This is a very nice paper which is a pleasure to read. There is not much to criticize as Figures and Text are well crafted. Compared to the rest, I found the Discussion unfocused and rather weak. This part would profit from some comparisons with model parameter studies.

Overall, I think the paper should be published after the few minor comments below have been addressed.

Sincerely, Martin Lüthi

We thank the reviewer for taking the time and effort to review our manuscript and are delighted by the reviewer's very positive evaluation. We incorporated all of the reviewer's very helpful and constructive comments and suggestion. We also reshaped the discussion section to make it more focused.

Specific comments

1,9 "responses time": something's wrong here (also 10), maybe should be "response times"?

Done.

3,10 and other places: Please refrain from "full-Stokes" (an Elmer-Ice invention). Either these are the Stokes equations, or some approximation, e.g. SSA or SIA (where the "A" already means "approximation").

Thanks for the hint! We removed the "full-" part. Good to know that, also for the future.

3,14 The horizontal ice flux divergence.

Done.

3,21 The reader should be informed that b is the part of the ice sheet below ocean (which is obvious, but not clear until looking at Fig. 1). Where is b measured? is it an average? (OK, it's given later, but maybe it could be indicated here?)

Thanks for pointing this out. We modified the phrase accordingly and added a sentence for more clarity.

3,29 "transsects"? (plural)

Done.

3,32 Is there a rationale for PIG? How would the results look if some other glacier were chosen?

We now give a reasoning for the choice of PIG as the reference tributary in this study. Also, we

point out that the results are independent of the choice of the reference by definition of the used method.

13,15 one comma too much in the citation.

Done.

13,17 *What should the meaning be of this error comparison. An error of several 1000 m for bedrock would be, indeed unusable. Since everything is shallow, the errors should be discussed with respect of the respective scales, which differ by one to two orders of magnitude.*

Reading this paragraph again, we agree with the reviewer that this error comparison might not be very meaningful but could confuse the reader. We therefore took the phrase out of the manuscript.