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Interactive comment on "Dynamic response of Antarctic ice shelves to bedrock uncertainty" *by* S. Sun et al.

Anonymous Referee #3

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In this study, the authors investigate the influence of bedrock uncertainties on real ice sheet dynamics using a state-of-the-art ice sheet model that is run over 200 years from the present day. They perturb the best available bedrock by adding noise with 3 different length scales (from 1 to 10 kms or so) and different amplitudes depending on the bedrock uncertainties. For each length scale in the noise, they explore the statistical variability by testing 50 different realizations. The most important conclusion is twofold for me: (i) the lowest the noise frequency, the highest variability on dynamic changes in the ice sheet, and (ii) in terms of average, the uncertainty considered does not really change the dynamic compared to the noiseless bedrock.

I find the approach novel and therefore, I definitely think that this work deserves to be published. The paper is easy to read, except maybe the 3.2 results section about the

LA system, and the sequence of sections is logical. I find the 2.1 section particularly interesting and useful for the understanding of the paper.

However, I have some concerns and I would like them to be addressed, most of them minors and two majors, even though I do think that it should not be a problem for the authors to answer them.

MAJOR COMMENTS

1- As already done by the two other reviewers, I questioned the ability of the L1L2 model to feel correctly the smallest (about 1 km) length scales undulations added to your bedrock for the highest frequency experiments. Even though all your experiments give you an indication on the sensitivity to errors I don't think that you can be too much affirmative in your conclusion saying that "low frequency noise on the bedrock plays a more important role on the ice sheet retreat than high frequency noise". It is true but only in the scope of your L1L2 model, which is also a nice result in itself. To give more weight to your study and be able to extrapolate to the reality, I think the proposition of Dan Goldberg to perform full-Stokes experiments along a flowline for the highest frequency noise is to be done.

2-

I would like to see more precisions about how you build your initial state, because there is a lack of details in the text. First of all, did you infer your basal friction for each modified bedrock, I don't think it is stated in the text. If you did not, then that would be an issue to me because it would change the variability of your results. Some uncertainties are rather large, it can modify your bedrock by hundreds of meters so it must be taken into account. If you did, you should make it clear in the text.

Also, once you have added your noise to the bedrock, do you perform a relaxation or do you start your 200 years prognostics directly? Again, your bedrock may change substantially after adding the noise, and could make large differences already at the beginning of the prognostic simulation (if you didn't make any relaxation) that could also explain the final variability coming from the lowest frequency noise.

SPECIFIC COMMENTS

p479 l2: Influences instead of influence

p481 l5: Using the Shepherd reference it should be -71 +/- 53 * 20 = -1420 +/- 1060 instead of 1350 +/- 1010 (20 years instead of 19)

p481 p1: In that first paragraph you seems to focus already on very specific process such as the influence of calving and melting on ice sheet dynamics. I think that you gave too much space for those processes (also in p3 of the same page) compared to how much you study them.

p481 l28: This sentence is not well written to me. The reverse sloping bedrock actually leads to positive feedback, which is modulated by the buttressing coming from the sides. This modulation can then be large enough to stop the retreat of the grounding line in case of a previous retreat. I don't feel like your sentence is reflecting that idea, could you rephrase ?

p482 p1: In this paragraph, I understand more or less that you want to discuss the influence of bedrock uncertainties that have been investigated previously using numerical models. However, it does not appear logical nor clear to me. Could you rewrite it?

p484 l2: In the work made in Durand et al, they also introduced noise in their bedrock. In their second set of experiments they randomly modified an ideal bedrock at different length scales. Therefore I find that sentence not correct and would like it to be rewritten.

p484 l6: I didn't quite understand what is red noise. Is it related to the sentence in l7-l8? Could you clarify it?

p486 l16: Does it mean that a grounded point remains grounded after adding the noise? Could you confirm?

p487 l14: Here you talk about numerics, but is there a relationship between the rate of retreat and the computation time for each iteration. That is just about curiosity, you don't need to discuss it in the text.

p487 l18: Do you perform an inversion of your basal friction for each modified bedrock? If not I think that is an issue that would affect the relevance of your results, if yes, I think that should at least be mentioned.

p489 l3: That would be worth explaining in the text why the retreat accelerates from 0.1 mm/yr to 0.25 mm/yr equivalent. That would help the reader to understand the processes that are involved in the ice sheet retreat even if it is not the main point of the paper.

p489 l11: Is there any reason here to use the simple future while you have been using present tenses all over the paper?

P489 l26: Here, you must talk about the fastest part of LA but it is not written, could you write it down?

P489 l27: "since after we added the noise, some floating areas become grounded": here you talk about the initial step. Is that the only reason of having a higher VAF compared to the noiseless control experiment? For example for the highest frequency experiments, it seems to me that the initial difference in the VAF between noiseless and noisy experiments increases along time. Could you make a comment on that? There is another thing here: it looks like the highest frequency noise has more influence than the lowest frequency compared to the noiseless result, which was the opposite for PIG. Could you comment on that on the text? In a general way I think that section on the LA system poorly commented in the paper.

p489 l28: Once you have defined VAF as the Volume Above Flotation, you should use it for every occurrence.

Fig 1: - "topg" is not really a common notation, could you use something like "Bed elevation" instead. - Could you modify your boxes to make them consistent with the areas shown in Fig 2?

Fig 4: last line : "across"

Fig 5: Could you increase the quality of your plots and also the legend ?

Fig 6: - Could you be consistent with you notation of mm/y, it is mm y-1 in the rest of the text - Here there are three accelerations in the increase of the SLR, at 50, 80 and 170 years or so. I think we can figure out the first one in Fig 5, but I hardly see the two others in Fig 5. Do you have an explanation for this? I don't think you should put it in the text but I would like to know the reason. Maybe it is too slow acceleration to be seen in the plot...

Fig 7 : - I don't understand why the ice velocity is so low in the main ice stream once you have passed the initial grounding line. If I read well the scale, it is around 600 m/a there whereas upstream the ice velocity reaches 2400 m/a for an ice that must be way thicker than at the front. Is there an explanation to this, is this an effect of the acceleration that seems to be produced at the year 175 or so after a stagnation between 100 and 175 years (Fig 6)? Could you add some precisions about it in the text? - Is your velocity maps coming from an average of all your simulations in the same type of frequency? For the highest frequency experiments, the ice velocity variability between experiments should be very little, but is that also the case for the lowest frequency experiments? Could you add some precisions about it?

Fig 10 : Could you increase the quality of the plots and the legend?

Interactive comment on The Cryosphere Discuss., 8, 479, 2014.