

Response to final review comments

September 16, 2015

NOTE: the manuscript pdf has all diffs from the previous submission indicated

1 Reviewer #1, Fuyuki SAITO

The revised manuscript are really improved than the previous one. There are still, however, minor issues to be revised in order to better clarify the work.

Abstract: define ‘CG’.

"each CG" has been replaced by "each coarse grid (CG)".

Sect. 2.1.1: In principle, at the extreme end, it is still possible to have empty bins using the procedure of this paper. How to avoid them? Or the DEM in this paper just does not have such distribution at all?

"Then, to avoid empty bins, the surface elevation range of each empty bin is expanded (consequently decreasing the elevation ranges of the higher and lower adjacent bins) until these three consecutive bins represent approximately the same surface area." is modified to "Then, to avoid empty bins, the surface elevation range of each empty bin is expanded (consequently decreasing the elevation ranges of the higher and lower adjacent bins) using as many adjacent bins as necessary until these bins represent approximately the same surface area. This process is repeated from the highest bin to the lowest as many times as necessary."

p6: W should be W_k in order to explicitly denote the bin dependencies at least at the first appearance. W of each hypsometric bin" is replaced by " W_k of each hypsometric bin".

Eq. 3: Sorry, I did not realize this point in the review of GMDD. Usually the left hand side is the time derivative of ‘thickness’, not surface elevation, because of the time derivative of the bedrock elevation. It seems, from the Eq. (5), the bedrock evolution is neglected (i.e., $h_{b,k}^t$ is cancelled in the left hand side). This should be better explained. Relating to this, how the bedrock elevation is treated in SG model? Kept constant through the time, or kept constant during one-time step but update step by step (i.e., $h_{b,k}^t \neq h_{b,k}^{t+1}$ but assume no evolution in Eq. 3), or other ways? If the first, then $h_{b,k}^t$ should be written as $h_{b,k}$ because it does not depends on time.

Eq.s 3 and 5 have been corrected with the LHS now $\partial H / \partial t$ (c.f. diff file) (along with correction of a sign

error). Basal elevation h_b is kept constant during a sub-grid call and is updated every 100 years as stated in section 2.2 and 2.3: "The visco-elastic bedrock response is asynchronously coupled to the GSM with a 100 years interval." and "Glacial isostatic adjustment from the CG level is imposed on the SG basal topography."

3.1.1 The maximum basal elevation seems to be 800m in Fig.S1, not 750 as in the text.

You are correct. The value has been modified in the text.

Figure 1: As far as I understand, information of some grid cells are not used in the computation of the effective width: left-top 5, left-bottom 8, right-bottom 5 of the left block; left-bottom 9, right-top 5, right-bottom 8 of the upper-right block; left-top 8, left-bottom 8, right-bottom 6 of the lower-right block. These are all diagonal grid cells of some of the target 7th hypsometric cells. These should be removed from the figure.

These have been removed from the figure.

Figure 2: lower second figure: a little bit difficult to distinguish green and blue. Since SG is based on 'bins', how about to replace the line graph by 'bar graphs'?

As the hypsometric curve are represented a line graph in the other figure we kept the lines and change the colours and thickness to make the figure clearer.

Figure 7: Need description of Para 1 and Para 2 (Eqs. 6 and 7, respectively).

This has been added in the caption of figure 7.

2 Reviewer #2, anonymous

Overall, I am fine with the paper now. Here, are only some technical corrections.

1. Equation (3) and the text under the equation: I do not think that you made a decomposition of the flux, i.e., one gradient term is sufficient here. Only the gradient term with the diffusivity should appear, what corresponds with Eq. (5) then. On the left hand side of Eq. (3) ordinarily thickness appears; possibly there is no bedrock sinking of the hypsometric level and it does not matter whether ice thickness or surface elevation changes in time.

"Decompose" was a poor choice of word and has been modified as follow: "To solve the equation semi-implicitly, we decompose the flux uH to dS where d is the ..." was replaced by "The effective diffusivity D is given by". We actually solve the ice thickness evolution so the left hand side should have been the ice thickness. This has been modified.

2. Equation (4): The ice thickness must have the power $n+2$, not $n+1$. I would use a negative sign here and change the sign of the respective gradient term in Eq. (3) accordingly. This correspond to the standard definition of diffusivity then.

The $n+1$ power was a typo and has been updated to $n+2$. As diffusivity is generally > 0 we kept the same sign in equation 4 but corrected the sign of the last term of equation 3.

3. Page 15: Replace full stokes with full Stokes.

This has been updated.

4. Page 16, section 3.1, last sentence. The problem is not only about surging, its is generally about sliding, which can be a considerable portion of movement of glaciers.

"As glaciers can experience surging (via significant sliding) in this type of region,..." has been change to

"As glaciers can experience sliding in this type of region,..."