Review of "Models for polythermal ice sheets and glaciers" by Hewitt & Schoof

December 18, 2016

The manuscript under review is the long awaited extension and refinement of Aschwanden et al. (2012). I've never been satisfied with using a Fick-type diffusion for the water flux and I'm very delighted that Hewitt and Schoof present a more physical Darcy-type model. Hewitt and Schoof's work draws upon earlier work by Fowler (1984) but goes beyond because it describes two Darcy models that are suitable for implementation in existing models, making the manuscript an even more useful contribution. I agree with the authors that it is not obvious how much the new methods will improve realistic ice sheet models simulations, especially with the sparse observations available for validation in mind. I anticipate we will implement the modified enthalpy gradient method some time next year. One thing that is not quite clear to me is if, in a coupled model, it will be necessary to implement a cap on the porosity to avoid reaching nonphysical values in areas with high strain heating.

The paper is well written and easy to follow; it is basically publishable as-is, I only have a few trivial comments below.

Cheers, Andy Aschwanden

Technical Comments

L18 "polythermal ice masses"

Eq. 14 and 15 Maybe use `\left(...\right)` to make the outer parentheses a bit bigger?

Figures The figures are of high quality and, in general, easy to read. Adding a legend to Figs 2,3 would further increase readability (while the information which line is which is in the caption, a legend makes it more straightforward)

References

Aschwanden, A., E. Bueler, C. Khroulev, and H. Blatter (2012). An enthalpy formulation for glaciers and ice sheets. *J. Glaciol.*, **58**(209), 441–457. doi: 10.3189/2012JoG11J088.

Fowler, A. C. (1984). On the transport of moisture in polythermal glaciers. *Geophys. Astro. Fluid*, **28**(2), 99–140. doi: 10.1080/03091928408222846. URL http://www.informaworld.com/openurl?genre=article&doi=10.1080/03091928408222846&magic=crossref%7C%7CD404A21C5BB053405B1A640AFFD44AE3.