

Review of ‘A confined-unconfined aquifer model for subglacial hydrology and its application to the North East Greenland Ice Stream’, v2

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Specific Comments

Physical Validity

The authors have addressed many of my original complaints, and I am convinced that their model is implemented and solved correctly. However I am still not convinced that this model is physically justified. The authors give the classic derivations for the equations that govern changes in channel area by dissipative heating and by creep closure. These are not at all controversial. What is controversial is implicitly stating that

$$K = A_c,$$

or that bulk hydraulic conductivity is equal to the area of a hypothetical channel. These things don’t even have the same units. A_c is cross sectional area with units m^2 . K is hydraulic conductivity, with units $m s^{-1}$. They clearly cannot be equal, yet looking at equation A10 versus A11, that is apparently the exact assumption that is being made. It also implies that the first term on the right hand side of Eq. A11 has incorrect units ($m s^{-1}$, while the other two terms have units $m s^{-2}$). Even if a constant were included to deal with the unit problem, I still need to understand why hydraulic conductivity should scale linearly with channel cross-sectional area, when it’s typically thought that transmissivity is a non-linear function of channel cross-sectional area.

Inclusion of sliding

Fowler (1987) does not necessarily justify the neglect of cavity opening, particularly near the margins. The specific line in Fowler (1987) stating that cavitation is unlikely for ice sheets also assumes low water pressure, which is likely not the case for NEGIS. Similarly, it is mostly unknown whether bedrock undulations are actually longer wavelength in the sub-stream environment than elsewhere. The low slope component of Fowler’s conclusion (namely that slopes are around 10^{-3} are also not valid here, especially near the margins, where surface slopes are closer to 2.5×10^{-2} , not so different from a mountain glacier. Finally, there

are many observations from boreholes in Greenland that seem to be consistent with a linked cavity system. Ignoring it seems unjustified to me, regardless of the lack of parameter knowledge.

Parameter Choices

I cannot accept the conclusion that because the system being modelled is imaginary, that including parameters from two other physically justifiable models at the same time somehow makes this model capable of capturing the behavior of both.

Technical corrections

P19L14 What does 'empirical nature' mean? Doesn't look like the correction made it into the next version.