

Interactive comment on “Connected subglacial lake drainage beneath Thwaites Glacier, West Antarctica” by Benjamin E. Smith et al.

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Response to reviewer 1.

We thank the referee for the encouraging assessment of our paper, and respond to his or her comments below. Referee 1's comments are prefixed by "R1:", our responses by "Au:"

R1: One question that I had, however, was what the return looks like in the radar data from the AGASEA/Icebridge surveys in this area? I assume there are survey lines that cross these lakes? Is there any evidence supporting the existence of the lakes? Given the timescales of filling and draining in the paper the lake should have been existent at the time of the AGASEA survey? Au: The AGASEA radargrams are not, to our knowledge, publically available, and our cursory examination of the IceBridge

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radargrams did not show anything remarkable close to the lakes. This is not unusual: Authors who have looked at radargrams over active subglacial lakes (e.g Siegert et al., 2014) have often not seen strong radar signatures. This is likely because the roofs of lakes in fast-flowing areas retain the imprint of the last bed topography the ice encountered before it moved over the lake, so the bottom of the ice over the lake is not as smooth as it would be if the ice were moving slowly and the ice sole had time to flatten. This discussion is outside the scope of our paper however, so we do not include it.

R1: Secondly, I find that the conclusion makes a number of unqualified statements about subglacial hydrology in general from the conclusions from the Thwaites Glacier observations. You have observations from one system over one period of time which you then use to make sweeping statements about the importance of subglacial hydrology in general. I suggest you modify the conclusion to qualify some of these statements. In particular, page 9 lines 37- page 10 line 2. Au: We have narrowed these conclusions in response to both reviewers' comments, and now say: While our data suggest water is routed in ways not presently accounted for in most ice sheet models, it also indicates that changes of this type in the basal hydrological system may not matter much. The basal water system is able to sequester large volumes of water over years which it then releases rapidly with little or no apparent change in glacier speed. This insensitivity suggests that the details of the basal hydrological system may not be the most important feature of the ice sheet for models to capture, especially now that data assimilation techniques allow us to infer the dynamic properties of the bed (e.g., the coefficients in a sliding law) directly (Joughin et al., 2010; Morlighem et al., 2010). At least at the decadal scale, fixed bed parameters can reasonably reproduce observed behaviour (Joughin et al., 2010; Joughin et al., 2014), despite large increases in water-layer thickness that accompany a speedup and lake drainages. The lack of sensitivity is probably related to the patchy structure of basal drag beneath TWG, and the limited time over which lake drainages supply water. As previous studies have noted (Joughin et al., 2009; Sergienko and Hindmarsh, 2013) much of the drag restraining the ice flow

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is concentrated in small patches or bands, and if changes in water pressure reduce the drag in the low-drag areas between these patches, the speed of the glacier is unlikely to change significantly. Further, a short-duration drainage, even of a large volume of water, cannot cause a large change the long-term average discharge of a fast-flowing glacier like THW. With only a few examples of changes in water availability to Antarctic glaciers documented, data are too sparse at present to say definitively whether an evolving hydrological system is an essential part of a predictive ice sheet model. Nevertheless, the data that do exist suggest that such sensitivity to hydrological evolution may be small.

R1: Page 1, line 22: Add some references for the AGASEA and IceBridge campaigns.
Au: We did not have references to the AGASEA and IceBridge campaigns in the original draft of the paper, but have added them in section 2 (the data description).

R1: page 3, line 18: remove the second “was generated” from this sentence Au: Fixed.

R1: page 4, end of line 7: remove “a” Au: We changed “Bed DEMs” to “Bed DEM,” which fixed the problem.

R1: page 4, line 10: add high <to> low Au: Fixed

R1: page 5, line 14: remove “we derived” Au: Fixed.

R1: page 8, line 5: change “lakes drainage” to “lake drainage” Au: Fixed.

R1: page 8, line 14: change “its” to “it is” Au: Fixed.

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