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The Cryosphere Discussions

Interactive comment on "Density assumptions for converting geodetic glacier volume change to mass change" *by* M. Huss

Dr. Colgan

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Dr. Huss – I enjoyed your paper on the influence of firn density in estimating mass changes. I am interested in the potential ice flow modelling implications of changes in bulk density over time. As you may be aware, continuum-mechanics based ice flow models are obliged to assume spatially and temporally invariant density. In a recent paper (Colgan et al., 2012), I found this was problematic at tidewater glaciers like Columbia Glacier, which have experienced a difficult to quantify increase in crevassing due to accelerated ice flow.

I see you mention crevasses in your discussion section. I was wondering if you might be able to provide a first-order theoretical estimate of the possible decrease in effective density anticipated from theoretical (but realistic) increases in crevasse volume?

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Interactive Discussion

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Presumably density decreases due to crevasses cannot possibly cancel out density increases due to surface processes? It would be nice for the volumetric change community to see that assumption demonstrated.

I don't know if it's a helpful starting point, but we found that crevasse extent was increasing at about 0.5 %/year in a highly dynamic (i.e. upper limit) study site in West Greenland (Colgan et al., 2011). Perhaps multiplying that rate of increase, or some variant, by an assumed range of crevasse bulk porosities might form an upper limit for the crevasse-induced bulk density change, which can be compared against firn-induced bulk density?

Colgan, W.; Steffen, K.; McLamb, W.; Abdalati, W.; Rajaram, H.; Motyka, R.; Phillips, T. & Anderson, R. An increase in crevasse extent, West Greenland: Hydrologic implications. Geophysical Research Letters, 2011, 38, doi:10.1029/2011GL048491.

Colgan, W.; Pfeffer, W.; Rajaram, H.; Abdalati, W. & Balog, J. Monte Carlo ice flow modeling projects a new stable configuration for Columbia Glacier, Alaska, c. 2020. The Cryosphere, 2012, 6, 1395-1409.

Interactive comment on The Cryosphere Discuss., 7, 219, 2013.