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Interactive comment on "Ice island thinning: Rates and model calibration with in situ observations from Baffin Bay, Nunavut" *by* Anna J. Crawford et al.

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General comments

The article "Ice island thinning: Rates and model calibration with in situ observations from Baffin Bay, Nunavut" presents thickness and ablation rates data collected from an ice island, and uses those measurements to calibrate a coefficient present in an equation used to calculate iceberg basal melt in numerical models. The paper is in general very well-written and brings some much-needed iceberg observations to the scientific community. My biggest concern is the definition of temperature gradient used here, which differs from the traditional $T_{ocean} - T_{ice}$. If ice temperature was taken into

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consideration, their calibrated value for C would probably be an order of magnitude smaller. Because of that, I recommend this paper for publication in The Cryosphere after major revisions.

Specific comments

1. Lines 28-29: *"Approximately 30 to 60 % of the freshwater flux from the Greenland Ice Sheet is in the form of solid ice discharge, i.e. iceberg calving"*

   Actually, solid ice discharge is not equivalent to iceberg calving. As described by Bamber et al. (2018, JGR Oceans 123(3),1827-1837), "Solid ice discharge is the product of surface velocity and ice thickness along an outlet glacier flux gate, typically located near and upstream of the grounding line". While possibly most of it will be calved, part of this solid ice will be subjected to submarine melting as well.

2. Section 3.1:

   (a) You mention first that ice thickness was recorded daily. Then you say the ice thickness was linearly interpolated between dates used as calibration intervals (6 of them). Why do you have only 6 points for daily data spanning almost a year? Does that mean that the thickness recorded daily had step-changes from one day to another, say, measuring 105.5 m constantly from December 2015 until it suddenly changed to about 105 m in February 2016 (Fig 3a)? I imagine this is due to the instrument precision (0.67 m),

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but it would be good to clarify this.

(b) Did you compare the sonic ranger measurements of surface ablation to the stakes' data? I imagine retrieving ablation rates from the stakes has a degree of uncertainty that maybe the SR data could constrain.

3. Section 3.2.2:

(a) If M_b is in m/day and the other variables have units in seconds, you need to include, on the right-hand side of equation 1, a multiplying factor of 86400.

(b) You calculate ΔT as the difference between the ocean temperature at the keel depth (ocean temperature) and the **melting point** of ice. Why? The original equation defines ΔT as the difference between the ocean temperature and ice temperature. While FitzMaurice et al. (2017) assume $T_{ice} = -15°C$, in models, ice temperature is generally assumed -4°C. If you use $T_{ice} = -4°C$ and considering the temperatures you normally have at the keel (as per Fig 4a), you will have $\Delta T = T_{ocean} - T_{ice} = -1.5 + 4 = 2.5°C$, which is an order of magnitude larger than your usual ΔT (Table 2). If ΔT, in turn, is one order of magnitude larger, using the same M_b, you will get a C one order of magnitude smaller (10^{-6}) which is consistent with the value given by Weeks and Campbell (1986).

4. Lines 273-276: *"While intervals 3, 4 and 5 were characterized by relatively low Θ along with high S_A and u values (Fig. 4), it is difficult to draw conclusions regarding the alignment of oceanographic conditions and C_i values due to the*

low resolution of the sIPR thickness measurements."

In fact, the theoretical way to calculate C is through

$$C = \frac{kPr^{1/3}\alpha}{\rho_i \Gamma \nu^m} \quad (1)$$

where α and m are dependent on iceberg shape, k is the thermal conductivity, Pr is the Prandtl number (function of k), ρ_i is the ice density, Γ is the latent het of ice and ν is the kinematic viscosity (see Supporting Information for FitzMaurice et al. 2017). So, although some of these variables are dependent on temperature and salinity, I would not expect a straightforward relationship between C and oceanographic parameters.

5. Lines 315-316: *"The volume of PII-A-1-f was 1.4 $\pm$ 0.01 km^3 when it was first visited in October 2015. By September 2016, the volume and areal extent decreased by 0.4 $\pm$ 0.01 km^3 and 3.4 $\pm$ 0.1 km^2, respectively."* - What was its area by the time of the first visit?

6. Line 345: Take a look at FitzMaurice et al. (2017, Geophys. Res. Lett., 44, 5637-5644, doi:10.1002/2017GL073585). They discuss a new parameterization of iceberg melting due to the influence of attached/detached plumes. This paper is very relevant for your discussion.

7. Lines 348-350: *"It is possible that the adjustment to the melting point of ice (M_p) to account for the influence of the meltwater plume is not necessary and M_p will simply equal the far field ocean temperature (Θ_f)"* - If M_p was the far field

temperature and your ΔT is $T_{keel} - M_p$, then the basal melt would be close to zero! Once again, it makes more sense to use the temperature of ice. Maybe what you had in mind is to use M_p instead of T_{keel}, and do $M_p - T_{ice}$ to calculate ΔT.

8. Lines 350-352: *"Determining this will require concerted study of the difference in the basal boundary layer conditions of grounded versus drifting ice islands. Observations of Δu for the drifting ice island case are rare but would be useful for this work and for correctly assigning values to this variable in Eq. (1)."* - It would also be useful to have an estimate of the plume's vertical velocity, according to FitzMaurice et al. (2017).

9. Lines 354-355: It is worth mentioning that those exponents are related to the shape of the iceberg (in this case, taken as a flat plate).

10. Lines 386-387: *"and the protection of a meltwater plume"* - Again, it depends on the vertical velocity of the plume in relation to Δu (FitzMaurice et al., 2017). You could have a detached plume in a drifting iceberg.

Technical corrections

Line 16: *"(...) thereby increasing the risk to marine transport and infrastructure as well as* **[affecting, impacting]** *the distribution of freshwater from the polar ice sheets."*

Lines 19-20: *"The majority of thinning (73 %) resulted from basal ablation, but the associated volume loss was 12 times less than that caused by areal reduction"* - It is

not clear to me if the "associated volume loss" refers to the total thinning or only to the thinning caused by basal ablation.

Lines 34-35: *"(...) and impact the biological and physical characteristics of ocean waters in their vicinity* **due to meltwater input and latent heat uptake** *resulting from their deterioration"*

Lines 57-61: *"PII-A-1-f was a fragment of the 130 km2 PII that calved from the Petermann Glacier in northwest Greenland on 5 August 2012 (Crawford et al., 2018a). After calving, the Canadian Ice Service (CIS; Environment and Climate Change Canada) tracked the ice island with RADARSAT-2 synthetic aperture radar (SAR) acquisitions. Between August 2012 and November 2014 the ice island drifted through Nares Strait and Baffin Bay, though it also experienced 60 periods of stagnation while grounded in Kane Basin and northern Baffin Bay (Fig. 1a)"* - I assume that the one that "calved from Petermann Glacier in northwest Greenland on 5 August 2012" is the PII. In this case, which ice island are you referring to in the next sentences? PII or its fragment PII-A-1-f?

Line 137: *"ablation rate (M_b; m d^{-1})"* - there is a minus sign missing from d exponent

Line 139: *"C ($m^{2/5}$ $s^{-1/5}$ $^{\circ}C^{-1}$)"* - there is a minus sign missing from °C exponent

Line 142: *"melting point (M_p; °C)"* - remove semicolon after °C

Equation 1: using fractional exponents makes the layout of this equation confusing (it looks like ΔT is part of the 4/5). I suggest using the typical notation:

$$M_b = 86400 C \Delta u^{0.8} \frac{\Delta T}{L^{0.2}} \quad (2)$$

Line 150: I would rephrase that as *"Values of C were obtained for each calibration interval i (C_i)"*, since up to that point you have only defined C.

Line 180: I think you meant *"t is the time between the recording of the air and reflect**ed** waves by the receiver"*

Line 184: *"However, an insufficient number (...)"* - Since you use "However," again on line 187, you could remove this one without losing any meaning.

Line 195: *"the locations recorded by the mIPR onboard GPS were replaced with those recorded by a Hiper V dual-frequency GPS"* - Remove first "GPS"

Lines 267-268: *"were an order-of-magnitude larger than those that have been previously calibrated or theoretically derived (Weeks and Campbell, 1986; White et al., 1980)."* - I think you should mention here what the theoretically derived value is, so the reader can readily compare it with the following C_i values

Line 308: *"The magnitude of thinning (3 to 4 m) **observed** over this thin section **observed** along transect segment AB"* - Perhaps replace the second "observed" with "present"

Lines 344 and 347: *"(...) model skill would likely improve if Eq. (2) was calibrated for drifting vs. grounded ice islands. (...) different parameterizations of Eq. (2) are likely*

required for predicting the basal ablation of drifting versus grounded ice islands" - I would change the first sentence (even remove it) to avoid repeating information a few lines below.

Line 375: improv**ed**

Line 388: *"(...) also contributed to the high, 13.5 m month^{-1} basal ablation rate that* ***Jansen et al. (2007)*** *estimated (...)"*

Line 409: *"that on-ice data."* - ... were collected (?)

Table 1: Check the "Dates" column on the first and second ablation periods. I believe it should be 2015-12-04 and 2015-12-05 instead of 2016.

Table 3 caption: *"over the time period that basal ablation was derived with each incremental increase in the value assigned to a given variable."* - I found this sentence very confusing

Figure 5 caption, line 642: There is a "(" missing from "b)"