

## ***Interactive comment on “Melting and fragmentation laws from the evolution of two large southern ocean icebergs” by Nicolas Bouhier et al.***

**Anonymous Referee #1**

Received and published: 14 December 2017

### **GENERAL COMMENTS:**

This manuscript presents an interesting analysis of the decay of two large icebergs, as tracked from satellite imagery and from altimetry. The ice bergs both decrease in size over time. The data products together show thickness and horizontal extent of the ice bergs, so the investigators are able to distinguish mass loss due to melt (change in thickness) vs fragmentation (changes in surface area). Results show that fragmentation is the major source of mass loss for large ice bergs. The study then assesses the details of melting and fragmentation. The authors compare two melt models, one associated with thermodynamics and a second based on thermodynamics, and find that the turbulent thermodynamic model better represents the observations. They then examine the statistics of fragmentation by looking at pdfs of ice berg sizes. I particularly

C1

appreciate the assessment of the results in the context of both melting and fragmentation theories.

The analysis is thorough and the results are likely to attract broad interest. However, it will require more careful editing prior to publication. My detailed comments follow:

I have reviewed the list of 15 questions in the instructions for reviewers, and of these questions, only a handful raise concerns, as follows:

(5) Are the results sufficient to support the interpretations and conclusions? For the most part results are sufficient. It would be preferable to include formal uncertainty estimates in the figures, where possible.

(11) Is the language fluent and precise? As noted below, the language could be improved.

(12) Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? As noted below, mathematical symbols have suffered from a font substitution problem, which should be corrected if possible in future pdf versions.

### **..... SPECIFIC COMMENTS:**

(1) For this assessment of time series of iceberg properties, assessment of uncertainty are important and should be included. In particular, some of the quantities in Figures 4 and 5 should be plotted with uncertainties. Others might be OK with uncertainties indicated in the figure caption.

(2) The summary raises some interesting points about possible overestimates in previous studies of freshwater flux due to icebergs. But I haven't found a clear estimate of freshwater flux in this study. Is it possible to provide a concrete number?

(3) Mathematical notation is not type-set with embedded fonts. My print out has "square root" symbols in place of "less than or equal" and "greater than or equal" signs for the inequalities on line 6 of p. 2. Likewise, vectors in equation (3 have lost their arrowheads

C2

in my printout. For a journal that people read from downloaded pdfs, this is especially challenging. I admit that the cryosphere models are outside my domain of expertise, and I have trusted the authors on these and have not attempted to work through the background literature to evaluate their appropriateness.

#### DETAILED COMMENTS:

(4) References are not cited correctly in many places, and a number of references that should be in the main text have been embedded in parentheses. This needs to be proofread carefully for citation style.

(5) The writing, while generally OK, includes passages that are difficult to understand. I cannot possibly identify everything, and I encourage the authors to locate a native English speaker who can help them proofread in detail.

(a) Here is my suggested rewriting of the abstract:

The evolution of the thickness and area of two large Southern Ocean icebergs that have drifted in open water for more than a year is estimated through the combined analysis of altimeter data and visible satellite images. The observed thickness evolution is compared with iceberg melting predictions from two commonly used melting formulations, allowing us to test their validity of large icebergs. The first formulation, based on a fluid dynamics approach, tends to underestimate basal melt rates, while the second formulation, which considers the thermodynamic budget, appears more consistent with observations. Fragmentation leads melting as the major process responsible for the decay of large icebergs. Despite its importance, fragmentation remains poorly documented. The correlation between the observed volume loss of our two icebergs and environmental parameters highlights factors most likely to promote fragmentation. Using this information, a bulk model of fragmentation is established that depends on ocean temperature and iceberg velocity. The model is effective at reproducing observed volume variations. The size distribution of the calved pieces is estimated using both altimeter data and visible images and is found to be consistent

C3

with previous results and typical of brittle fragmentation processes. These results are valuable in accounting for the freshwater flux constrained by large icebergs in models.

(b) p. 1, lines 17 and 18. What is meant by "buffer"? What is meant by "diffuse"? Should it be "diffusive"?

(c) Language is in places too informal, with the use of contractions. For example, line 9 of p. 2: "can't" should be "cannot" in formal writing.

(d) p. 2m lines 23-25. Change wording and punctuation to clarify:

"identified three styles of calving during the drift: "rift calving", which corresponds to the calving of large daughter icebergs by fracturing along preexisting flaws; "edge wasting", the calving of numerous small edge-parallel, sliver-shaped small icebergs; and "rapid disintegration", which is characterised by the rapid calving of numerous icebergs."

(e) p. 2, line 34. "allow to" → "allow us to"; also p. 9, line 20. (It's a transitive verb.) Likewise for p. 4, line 19. "enables" → "enables us"

(f) "ones" should not be used as a substitute noun in a comparison. For example, on p. 4, just before heading 2.2, you can say "For example, B17a was sampled by 152 altimeter passes during its drift and C19a by 258 passes." The word "ones" is unclear and non-standard English. Another example on p. 9, line 17: "measured one" → "measured loss".

(g) p. 9, line 3. Does it take several years for the iceberg surface temperature to depend on the ablation rate? Or should this say, "Icebergs can sometimes float for several years. After initial adjustment, the iceberg surface temperature depends on the ablation rate."

(h) p. 1, line 16. Rewrite to say, "However, their melting accounts for less than 20% of their mass loss, and the majority of ice loss (80%) is achieved through breaking into smaller icebergs (Tournadre et al., 2016)."

C4

- (i) p. 1, line 21. The word "between" doesn't seem clear hear. Perhaps the authors mean, "differ in their basal ice-shelf and iceberg melting" or "achieve different relative balances of basal ice-shelf and iceberg melting"?
- (j) p. 2, line 13. "law" → "laws"
- (k) p. 3, line 10. Capitalize "Southern Ocean"
- (l) p. 3, line 11. Not clear if this is a singular or plural noun. To clarify perhaps, "area, size, and shape have been estimated".
- (m) p. 3, line 14. By saying "that drifted", this implies that there are a number of other icebergs that drifted for more than two years in the South Pacific. I think the meaning would be clearer if "that" were replaced with "and".
- (n) p. 3, line 15. "a relatively small 200 km<sup>2</sup> one drifting" → "relatively small (200 km<sup>2</sup>) and drifted"
- (o) p. 3, line 15. To clarify the distinction between the plums and the big icebergs, say "both large icebergs".
- (p) p. 3, line 5(2nd case). "confronted to" → "confronted with".
- (q) p. 4, line 21. "small icebergs location" → "small iceberg locations". (The word "iceberg" is used as an adjective, and nouns used as adjectives are nearly always singular.)
- (r) p. 4, line 8. "ones" → "passes"
- (s) p. 4, line 20. "constrains" → "constraints"
- (t) p. 4, line 18. "as iceberg" → "as an iceberg"
- (u) p. 5, line 17. Try "For each image with good cloud cover and light conditions ...."
- (v) p. 5, line 28. "proxy of" → "proxy for"

C5

- (w) p. 9, line 4. Try "can theoretically warm up to ...."
- (x) p. 9, line 9. "shows" → "show" .... "ones" → "velocities"
- (y) p. 9, line 10. "thus considered as" → "treated as"
- (z) p. 9, line 17. "one" → "loss"
- (aa) p. 9, line 25. Try "The second model parameter  $T_i$  (see Figures 6-c and 7-c) varies between -20°C and -0.6°C for B17a, with a  $-10.9 \pm 7.1$ °C mean for B17a. For C19a, it is between -9°C and 1°C, with a  $-10.6 \pm 5.8$ °C, although the model sometimes fails to converge to realistic iceberg temperature, i.e. for  $T_i < 0$ °C. This occurs ...."
- (bb) p. 9, line 34. "fail" → "fails"
- (cc) p. 11, line 29 Try "calving of icebergs from glaciers or ice shelves"
- (dd) p. 12, line 13. "exist" → "exists"
- (ee) p. 12, line 17. "We investigate this matter by progressively including the dependence on environmental parameters ...."
- (ff) p. 12, line 23. "ones" → "loss"
- (gg) p. 13, line 13. Clearer wording perhaps: "tested but brought no improvement".
- (hh) p. 13, line 35. Missing superscript for km<sup>2</sup>
- (ii) p. 13, line 17. "fragments" → "fragment"
- (jj) p. 14, line 22. "in open ocean" → "in the open ocean"
- (kk) p. 14, line 22 "relatively" → "are relatively"
- (ll) p. 14, line 24. "get" → "obtain" (The word "get" sounds too colloquial for formal writing.)

C6

(mm) p. 14, line 29 Try "the first is more dynamically based, and the second results from a thermodynamic balance"

(nn) p. 15, line 7. "chose to carry" → "carried", "find out which" → "identify the", "parameters are more likely to" → "parameters that likely favour"

(oo) p. 15, line 23 onward. I'm not sure what is meant by this discussion. Change to "small iceberg bias". Does the "them" in "To include them" refer to small or large icebergs? The context suggests large icebergs, but the wording implies small icebergs. The word "still" should be removed.

(pp) p. 15, line 5-7. I would remove the "On the one hand" / "On the other hand" structure. It's a bit informal and doesn't clarify the meaning. The second sentence can begin "It also has demonstrated ...."

---

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2017-208>, 2017.