

## Response to Reviewer 1 (Adrian Luckman)

*Thanks for these comments, which greatly improved the paper.*

This paper presents a comprehensive set of data describing the behaviour of Jakobshavn Isbrae over the last decade. Surface velocities, DEMs, terminus position and ocean temperatures are examined together to investigate recent variability, the role of water temperature and ice-melange on calving, and the potential for the 'ice-cliff instability' to be operating in this location.

I find this paper to be very well presented and written, to make good use of the novel, high quality and comprehensive datasets presented, and to provide a valuable contribution to the literature around calving and outlet glacier stability. The figures are especially well conceived. I recommend that it be published subject to some minor corrections below.

*Thanks for the commentary – no specific action so no change.*

The volume of papers being published in this scientific area has grown very quickly in recent years, so the authors should be forgiven for overlooking some highly relevant works or for missing important citations. Nevertheless, because it directly addresses the issue of melange rigidity on calving, is generally in agreement on the issue, and is also published recently in *The Cryosphere*, I feel that the recent article by Bevan, myself and others (<https://www.thecryosphere.net/13/2303/2019/>), should be mentioned and cited through the text. The authors may also like to consider looking at <https://doi.org/10.1016/j.epsl.2015.01.031> which is highly relevant to parts of the discussion on seasonal thinning/thickening.

*We did not include the Helheim paper along with a good number of other papers that could be considered relevant (I think we are at 59 references). The Kanger paper, however, was highly relevant and we thank you for calling it to our attention. We have also added another half dozen or so references in response to other comments.*

I find the phrase "correct velocity is reported at the wrong location" (page 3 paragraph 1, used twice) to be rather confusing. The issue is important, valid and usually insurmountable, but the way it is described could be clearer. I suggest something like "...so that the .. true geographic location for the retrieved velocity can be displaced by up to 50m from the selected image location leading to a bias in velocity which depends on the velocity gradient" (I'm sure you can do better).

*Not sure if this does the trick, but we have reworded to* "With the relatively accurate DEMs we used, the errors should tend toward the low end of this range in most instances. Exceptions may occur where large temporal fluctuations in slope occur near the terminus as

discussed below. Another issue is geolocation error since errors in DEM elevation directly translate into horizontal position errors. Although we generally update the DEM annually, large intra-annual changes can introduce absolute geolocation errors of up to ~50 m. In such cases, an otherwise correct velocity measurement is posted at the wrong location, which in a gridded product is equivalent to an additional source of velocity error, especially where velocity gradients are strong. This problem can be exacerbated when comparing data acquired from differing imaging geometries (e.g., from ascending and descending passes), since the DEM-induced location shifts can occur in opposing directions to produce a relative geolocation error of ~100 m.”

**Line 109: adding constant → adding a constant**

*Done.*

**Line 155: “there appear to be few, if any, instances of missed detections”. This seems unnecessarily vague. Either rigid melange was detected (using the proposed method) or it wasn’t - “appear” and “few, if any” make this whole process sound too hit-and-miss (which I don’t believe it is).**

*Actually “missed detections” was used purposely. There are two types of errors “missed detections” or “false alarms” (aka false positives). We are not particularly worried about the latter – its hard to get a coherent match when the data are incoherent. We do worry about the former, which is why we did some visual inspection. We did remove “appear” and changed to “are” to make a little less vague.*

**5) Line 163: “Melange was particularly sparse”. I think this needs clarifying since up to now the discussion has been about absence/presence and rigid/non-rigid. What do you mean by sparse (time/space)?. Does the Jakobshavn fjord ever really have open water in it?**

*Good point, especially re sparse. Changed to “The occurrence of rigid mélangé was particularly infrequent in both 2011 and 2012”*

**6) Line 164: “melange-free”. As above. I don’t think you mean free of melange, but you probably mean free of rigid melange. I suggest that you make the language a bit tighter here, because it is important.**

*Agreed. Changed to “rigid-melange-free”*

**7) Line 194: meter → meters**

*Done*

**8) Line 228: Rather than referring to a “closed white contour” (of which there are several in different panels), I recommend labelling exactly the features you are discussing.**

*Added a blue diamond in one panel to serve as reference point. Updated text accordingly.*

**9) Line 415: “more than 130m”. This is the first mention of critical cliff heights. I suggest that you refer to a figure here to show that such high cliffs are clearly present in your data.**

*Added “(see Fig. 7)”, which most clearly indicates this is the case.*

**10) Line 470: “correlate well with . . . AMO”. This seemed to be the first mention of such a comparison, so should be in the results or discussion, not left until the conclusion.**

*We are inclined to leave this here. In the discussion we more focus on the relation between water temperature and stability without getting into the climate aspect. In the conclusion we are more presenting a broader outlook for going forward and this seems a good note on which to end the paper.*

**Otherwise, great job!**

*Thanks*