Review of Grounded ridge detection and characterization along the Alaskan Arctic coastline using ICESat-2 surface height retrievals by Lange et all.

Responses in blue text.

In this paper, the authors introduce a novel method for detecting grounded sea ice ridges. They compare characteristics of grounded ridges in the Chukchi Sea with the ones of grounded ridges in the Beaufort Sea. They show that many ridges are grounded in water significantly shallower that the traditional stamuki zone.

I find this novel approach very interesting. As stated by the authors, this new method could have many useful applications. Overall, I find that the paper is well written. At a few places, however, I would like the authors to clarify the text and to use more appropriate terms. For example, ridge depth is confusing while sail height and keel depth are more clear. Also, I think that often they just use the word 'ice' when they should use the expression 'level ice'.

Below the authors will find a few more major comments and a list of minor comments.

I recommend major revisions (to give them more time) but the authors should really see it as moderate revisions.

We thank the reviewer for their kind words and helpful comments. Individual comments are addressed below:

MAJOR COMMENTS

1) I think Fig.8 should be improved. The panels should show PDFs instead of histograms. It would then be easier to compare the distributions of grounded ridges in the Chukchi Sea to the ones in the Beaufort Sea.

Figure 8 will be revised to reflect your suggestions: we show PDFs instead of histograms. Consistent with other reviewer recommendations, we have also added background lines to indicate the pdfs for low and medium-confidence grounded ridges in addition to the high-confidence ridges.

2) The authors discuss the limitations of their approach in section 4.5 and acknowledge the uncertainty associated with their bathymetry data. First of all, I think there should be some clarifications on how they estimate the uncertainty in the bathymetry data. I don't think this

is mentioned (Fig.5-7). Given their low resolution bathymetry data, I think a possible improvement to their detection algorithm would be to consider a distribution of bathymetry at the location of possible grounded ridges. The mean of the distribution could come from the low resolution GEBCO data and the distribution around the mean could be estimated from the NCEI high resolution data. The algorithm could then estimate the probability of contact between the keels and the sea floor. I know this is beyond the scope of this paper but I think this should be discussed and presented as a possible improvement to the existing algorithm. I think the authors should have a look at this paper which introduces this idea for a model grounding parameterization:

Dupont et al., A probabilistic seabed–ice keel interaction model, the Cryosphere, 2022.

Thank you for this suggestion! While a probabilistic model of seabed interaction is outside the scope of this paper, we will consider it in future work based on the approach described here. In the updated manuscript, we have added discussion acknowledging the potential of this approach.

We have removed the bands in Figure 5-7 indicating the width of the pixels in the GEBCO data (consistent with other reviewer comments) but added discussion in this section in order to address the position uncertainty associated with the coarse product. The updated approach considers a range of possible keel depths associated with each ridge: we have edited the language throughout the manuscript to better reflect the uncertainty in both keel depth estimate and bathymetric depth.

3) I really like Fig.10. The fact that there is landfast ice seaward of the "last" grounded ridges is an indication that sea ice has some tensile strength (or cohesion). I see an interesting study that could be conducted: the data of grounded ridges along with maps of landfast ice (the blue shading) could be used to estimate the tensile strength of sea ice. Again this is beyond the scope but could be discussed by the authors if they want to. The authors could have a look at this paper which describes how the viscous-plastic sea ice rheology can be modified in order to add tensile strength:

Konig and Holland, Modeling Landfast Sea Ice by Adding Tensile Strength, Journal of Oceanography, 2010.

This is also a very helpful comment for future work – we will address this idea in the conclusions of the paper.

MINOR COMMENTS

The minor comments will be addressed individually in the paper, most of which are small changes in wording and phrasing. We appreciate your attention to detail on these comments – they certainly make it a better paper! We will make the recommended changes for language/grammar/minor organization. More substantive minor comments are addressed individually below.

1) Abstract line 3: remove 'to describe an approach'.

2) line 27: It is not clear what you mean by 'unstable ice conditions' and the link with later freeze-ups and earlier thaws.

We have re-written this whole paragraph to make it more clear (consistent with other reviewer comments):

"An increase in ice breakout events and shorter shorefast ice seasons during recent years endangers hunters whose safety depends on knowledge of ice dynamics (Gearheard et al., 2006; Mahoney et al., 2014; George et al., 2004). Since 1980, the volume of ice in the Arctic Ocean is thought to have declined by 75% (Overland et al., 2014), and observations show that later ice freeze-ups and earlier thaws are occurring throughout the Arctic as a result of shortening winters (Mahoney et al., 2014; Stammerjohn et al., 2012) and thinning ice (Kwok et al., 2009; Rothrock et al., 1999; Laxon et al., 2013; Mahoney et al., 2009; Howell et al., 2016; Gerland et al.,2008). Mahoney et al. (2014) show that dates of first ice, break-up and ice-free conditions for landfast ice in the Beaufort and Chukchi Seas are changing up to 1 week/decade with later formation and earlier breakup dates each year, excluding break-up in the Beaufort which shows no conclusive trend."

3) lines 30-38: This paragraph needs to be reworked. After the reference to Eicken et al. the first sentence should be 'Grounded ridges form either when a compression ridge drifts into shallower waters and gets stuck in the sea floor or from an in situ collision between the shorefast ice and drifting pack ice'. Then the next sentence could start by 'Figure 1A describes how grounded ridges are created from the collision of the drifting sea ice with the shorefast ice'...

4) line 40: replace 'for the ice to reach' by 'for the keel to reach'.

5) line 40: 'the thickness of the ice'...do you mean 'the thickness of the level ice'? Please clarify.

6) line 44: 'Assuming some typical sea ice thickness...' are you referring to level ice again?

7) line 56: Shouldn't you remove 'spring' in 'spring shore-fast ice season'?

8) line 64: replace 'is likely to be grounded in the sea floor' by 'is likely to include grounded ridges as anchoring points'.

9) line 97: remove one 'using'.

10) line 115: replace 'therefor' by 'therefore'.

11) Title for section 3.1: Should it be: 'Freezing degree day model to estimate level ice thickness'?

12) Section 3.1: What about snow in your freezing degree day model?

13) line 190: Are you sure about citing Yu et al. 2014? I don't remember that they discuss the ratio of sail height to keel depth (and that it varies with the geographical location).

Good catch, this should have been Strub-Klein and Sudom, 2012. We have fixed this in the manuscript.

14) lines 212-214: rephrase. Just say that the bathymetry is interpolated to the center (?) of the keel or something like that.

We have revised the test to clarify that the bathymetric depth recorded for each ridge is the interpolated bathymetric depth at the location of the maximum sail height.

“We then record several characteristics of the identified grounded ridges. The right panel of Figure 5 shows how we characterize each grounded ridge feature: the start and end of the ridge in the horizontal direction is used to calculate width, height of the sail, and depth of the bathymetric contour where it intersects the keel depth estimate. Bathymetric depth is interpolated to the center of the predicted keel location.”

15) line 213: replace 'defined' by 'define'.

16) line 233: replace 'suggest' by 'suggests'.

17) line 335: You mean 'keel depth' instead of ridge depth? By the way you should change the labels in Fig.8 and 10. It should be sail height and keel depth.

We have updated the labels to sail height and keel depth.

18) line 350: rephrase

19) line 352: you should add that some of these ridges could drift in these shallow areas and get grounded.

Yes! We will specify that it is possible for a drifting floe containing a ridge to ground near shore and get stuck, especially if there are fluctuations in water level related to wind direction. We've added to Figure 1 to better reflect this mechanism.

20) Fig.9: Would it be good to have a second column showing the maximum instead of just the mean?

Great suggestion. We have updated the figure to include maximums and means for each of the ridge geometry parameters.

21) line 423: '...seasonal landfast ice variability...' do you mean '...interannual landfast ice variability...'?

22) lines 427-428: Should you move up this sentence where you discuss models (line 423 for example)? It should also be rephrased. I am not sure I understand what you mean.

We have rephrased this and rearranged the discussion of grounded ridges in models to be more clear:

"A wider application of this approach to shorefast ice observation could be used to validate modeling efforts at capturing landfast ice dynamics (e.g., (Lemieux et al., 2015)).Grounded ridge formation occurs at sub-grid scale in current sea ice models, though these ridges impact larger scale ice movement and near-shore dynamics. Modern models are incapable of reflecting interannual landfast ice variability which impacts sea ice thickness and concentration results, halocline stability (Itkin et al., 2015), upwelling estimations (Kasper and Weingartner, 2015), and brine expulsion (Selyuzhenok et al., 2015). Shorefast ice also blocks momentum flux between the atmosphere and ocean, isolating the ocean from wind-driven mixing and limiting upwelling, and causes river plumes to extend to further distances under the ice (Granskog et al., 2005). Ultimately, the approach outlined in this study creates opportunities to observe grounded ridge properties across much larger spatial scales, opening potential avenues for improved understanding of coastal Arctic processes."

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