The Cryosphere Discussions

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Comment on tc-2021-360

Anonymous Referee #1

Referee comment on "Review article: Existing and potential evidence for Holocene grounding line retreat and readvance in Antarctica" by Joanne S. Johnson et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-360-RC1, 2022

Manuscript Review: Cryosphere Discussions
Review article: Existing and potential evidence for Holocene grounding-line retreat and readvance in Antarctica
J. S. Johnson et al.

Summary:

This article presents a summary of, mostly recent, work focused on investigating the potential readvance of the Antarctic Ice Sheet in the late Holocene. Although it is widely agreed that the ice sheet has retreated since the LGM, its behaviour within the past few thousand years is less certain. The manuscript is structured into four sections; (i) introduction, (ii) summary of the concept of readvance, (iii) methods and results for evidence of readvance, and (iv) conclusion.

The largest section is dedicated to geological and glaciological methods for investigating readvance; subglacial bedrock and sediments, marine sediment cores, relative sea-level records, ice-penetrating radar and ice cores. The authors identify subglacial bedrock and sediments as providing direct evidence of past grounding line position, while the other methods providing indirect evidence.

In large part, the article is mainly focused on methods and their potential use to investigate readvance. There is less focus on formulating a conclusion from the existing evidence, but rather a central takeaway is; although evidence exists that the ice sheet was smaller than present during the late Holocene, further work is needed to provide a more comprehensive picture and to better understand the drivers of this change. The authors conclude that improvements in our understanding are most likely to result from a multi-discipline approach.

The manuscript is well structured and well written. I believe it will be of interest to many within the cryospheric community and surrounding fields. It will be of particularly interest to students and those new to the topic of ice sheet history, and as such, I believe it will be well cited.

I have a number of fairly minor comments which I list below. I also include an attached PDF with line-by-line comments.

Main Comments:

My most critical comments are in relation to the ice-penetrating radar section (3.3.1), which I believe can be significantly improved:

- Firstly it is important to specify that the internal structure of the ice sheet is the cumulative result of accumulation, flow and ablation (surface or basal). In order to use the englacial structure to interpret ice-sheet history each of this processes should be accounted for.

- The use of references is limited, with many possible relevant citations missing. (see attached PDF)
- Lines 317-321: It is unclear how this information relates to ice-sheet readvance.
- Lines 342-344: Again it is unclear how this information relates to readvance. This needs to be more clearly justified.
- Line 354: More recent references to ice-divide studies are missing.
- Lines 355-356: "For example, significant thinning followed by readvance and ice thickening might produce an unconformity visible within radar stratigraphy" – see Kingslake et al., 2018 and Wearing et al., 2019 for an example of this.

Discussing the analytical and logistical limitations and challenges is identified as one of the key outputs of this work. However, this doesn't seem to be included in some sections. It is most visible in the subglacial bedrock section. It would be good to mention in the summary that challenges that apply to all methods include logistical access to remote locations, presence of suitable sites (i.e. bedrock close to ice surface) and the difficulty in surveying large areas (with the possible exception of radar).

There is no mention of GPS uplift rates as a method for investigating readvance, such as the study from Bradley et al., (2015). Uplift and GIA are mentioned in relation to relative sea level, but not in this context. There is also no mention of how the less viscous mantle underlying West Antarctica potentially makes it more susceptible to GIA induced uplift (and readvance) in comparison with East Antarctica

Lines 102-103: "Retreat of the grounding line would be accompanied by dynamic thinning upstream, assuming reasonable limits on surface mass balance changes." This point is key when interpreting exposure age data as thickness change is being used as a measure of grounding line retreat/readvance. However, these properties (grounding line position and ice thickness) cannot be directly compared, thinning is likely to vary throughout the catchment and may adjust over many years. There's potentially a need to consider ice-sheet modelling to interpret these processes. (Similar point can be made when interpreting other indirect evidence (radar, ice cores, etc).)

Line 176: “Slowing rates of change” can you be more specific here? Do you mean a reduction in the rate of sea level rise or fall?

References:

Bradley, S. L., Hindmarsh, R. C. A., Whitehouse, P. L., Bentley, M. J., & King, M. A. (2015). Low post-glacial rebound rates in the Weddell Sea due to Late Holocene ice-sheet readvance. Earth and Planetary Science Letters, 413, 79–89. https://doi.org/10.1016/j.epsl.2014.12.039

Kingslake, J., Scherer, R. P., Albrecht, T., Coenen, J., Powell, R. D., Reese, R., Stansell, N. D., Tulaczyk, S., Wearing, M. G., & Whitehouse, P. L. (2018). Extensive retreat and re-advance of the West Antarctic Ice Sheet during the Holocene. Nature, 558(7710), 430–434. https://doi.org/10.1038/s41586-018-0208-x

Wearing, M. G., & Kingslake, J. (2019). Holocene Formation of Henry Ice Rise, West Antarctica, Inferred From Iceâ□□Penetrating Radar. Journal of Geophysical Research: Earth Surface, 124(8), 2224–2240. https://doi.org/10.1029/2018JF004988

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2021-360/tc-2021-360-RC1-supplement.pdf