

Interactive comment on “Observing traveling waves in glaciers with remote sensing: New flexible time series methods and application to Sermeq Kujalleq (Jakobshavn Isbræ), Greenland” by Bryan Riel et al.

Anonymous Referee #2

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Review of “Observing traveling waves in glaciers with remote sensing: New flexible time series methods and application to Sermeq Kujalleq (Jakobshavn Isbræ), Greenland” by Riel et al.

Riel et al. present a thorough framework for creating temporally uniform velocity time series from sparse/noisy observations that effectively preserve underlying signals over multiple timescales (seasonal to multiyear). From this method of time series decomposition, velocity variability is compared to other dynamic variables (i.e. changes at the front), allowing for robust interpretations of glacier properties and driving geophysical

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mechanisms. The study uses B-splines to separate multiyear signals from seasonal variability and shows how various properties of seasonal variability and signal propagation vary between distinct speed up and slow down events at Jakobshavn Isbræ. The authors then combine velocity observations with concurrent changes in elevation and suggest that the observed traveling waves are kinematic in nature, given how dynamic thinning accompanied increases in multiyear velocity and seasonal amplitude. The manuscript is very well-written and is presented in a logical manner, with the description of the framework/tools first presented, followed by a practical implementation of the technique and finally physical interpretations/limitations. The study is well motivated, and the robust framework described has potential to improve how we treat and interpret time series to better resolve the various underlying dynamic signals and understand how glaciers respond to various perturbations over multiple timescales. I found no major scientific/methodological flaws in the manuscript and think it would be a valuable contribution to TC. However, I did find some elements confusing and would like to see several concepts more thoroughly described/addressed. I list the more pertinent points first below, followed by minor and technical points.

Main Comments

My main criticism is that it was difficult to follow why and how different time periods were used for various analysis throughout the paper. I would like to see either more coherence in selected time periods used, or more description up front in the introduction/motivation to explain why various subsets of the time period are used at different points throughout the text. For example, the abstract and introduction refer to a 2009-2019 decadal study, shown in completeness Figure 1. However, Figure 2 then only shows 2011-2018, and subsequent analysis average similarly segmented time periods. As another example, mean time of peak seasonal velocity and phase velocities seem to be computed using only 2011-2018 velocity data.

Reference point used for correlation analysis: Why is a point 1.4 km upstream of the pinning point used specifically for comparison to velocity? I see that you found the high-

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est temporal coherence between maximum retreat and maximum seasonal velocity at this location, but it would be helpful to have more information on how this coherence was derived, and why then it serves as an ideal reference point.

Please also include a map view of the reference point and pinning point on the map. I found it hard to follow why sometimes the point 1.4 km upstream of 2017 front was used, versus the pinning point, as reference in the figures. What information is lost if, as a suggestion, the pinning point is used as the single point of reference throughout the text?

Multiyear variations in surface elevation: It would be helpful to have more text describing the motivation for selecting the particular time epochs shown in Figure 6. Each of the 4 panels represent elevation changes over time intervals of varying lengths, from ~ 1.5 years to ~ 2.5 years. The selected intervals also exclude July 2015-December 2015. There may be a reason for this, but without more context it seems too arbitrary.

Discussion: I would like to see the discussion expanded to include considerations/limitations of this framework when applied to other glacier sites outside of Jakobshavn Isbræ (for example, in areas with notably lower SNR than Jakobshavn). Do you anticipate reduced SNR would limit the feasibility of this technique (and how may opting to enforce spatial coherency impact interpretations of phase velocity, propagation delay, etc).

Minor comments

Figure 2: Not a critique, but comment: This is a great figure that illustrates a lot of information in a concise way, clearly showing interannual variations in amplitude and inland propagation of signals from the front. The figure caption also included an excellent description of how phase velocity was extracted from the tangent angle.

Figure 3a: I suggest scaling the y-axes such that a range of the same magnitude is shown for both. This would allow the reader to quickly compare relative changes in

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slope with distance between mean velocity without amplitude.

Figure 4: why are data from 2016 excluded from either group?

Figure 5: Please add a note to caption to remind reader that red lines delineate winter 2017 reference calving position.

Figure 7a and c: It is very difficult to differentiate between years 2009/2019 and 2017/2018. If keeping the same color scale is preferred, I suggest making 2009/2010 dashed rather than solid lines to make years more distinct.

Figure 7d and correlation analysis: Are the velocity values shown here (and used for correlation analysis) taken from the continuous fitted time series? If so, what is the sampling frequency from these curves (every week, every month?) Are the extracted velocity values uniformly spaced in time?

Line 334: "A comparison of time series for points on and off the glacier suggest that much of the ice in the surrounding areas has been lowering since before the observation period, which is associated with a period of exceptionally high surface melt starting around 2009." Can you include a citation for this?

Line 387: "After the disintegration of the ice tongue between 1998 and 2004, the front rapidly retreated about 4 km over the period from 2004 to 2011." Please include a citation for this, as front analysis used in this study did not start until 2009.

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