The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-122-RC1, 2020

The Cryosphere Discussions

Interactive comment on "Detecting seasonal ice dynamics in satellite images" *by* Chad A. Greene et al.

Anonymous Referee #1

Received and published: 23 June 2020

The authors have proposed a method to characterize the magnitude and timing of seasonal glacier ice velocity signals by fitting the best possible sinusoid to the velocity data obtained from optical remote sensing. It is well known that the optical data has obvious data gaps in polar regions during winters and is affected by cloud cover. This method is proposed to resolve seasonal velocity variations from such a dataset, but needs a large number of (>1000) multi-year velocity observations. The manuscript is well written, but I have a couple of points that may be useful to further improve this work. My major concern is about the applicability of this method to regions other than polar areas.

Major comments:

P5. I did not understand how observations over finite integration times make it difficult to resolve seasonal variability in case of repeat SAR imagery. For instance, Sentinel-1 SAR data is available throughout the year with a 6-day temporal cycle and a number of studies have resolved seasonality using SAR data (e.g. Sentinel-1, TanDEM-X). I think the focus of this paper should be optical data, its limitations during polar winters and cloud cover and how your method can still resolve seasonality using optical data.

P30-35. The authors should highlight these significant gaps which still limit our understanding of ice dynamics change on different time scales. I agree that a number of studies on the seasonal ice dynamics of glaciers in Arctic, Antarctic and other glaciated regions are available in bits and pieces, but they do provide a great degree of evidence that help us understand the physical processes which govern the ice dynamics on different time scales. I can't imagine how a consistent global mapping of seasonal ice dynamics looks like, which the authors have pointed to and how, if accomplished, they better our understanding. It is also not clear why such an approach relies on optical imagery, even though we have a year-around consistent and global SAR imagery by missions like Sentinel-1. These points should be addressed in the Introduction to better form a basis or need for this study.

Figure 7. Nice figure. But when I compared this with Figure 4, I drew a couple of points that need to be addressed. ITS_LIVE velocity data for Russel Glacier in Greenland is much more dense and appears to be well distributed around the year as compared to Byrd Glacier, Antarctica. I wonder how such a large number of wintertime velocities are available in Greenland using optical data. Are they averaged for the entire polar wintertime? I expect that this dense and well distributed velocity data is the main reason why you have a great sinusoidal fit here, isn't it? Because ideally the method should resolve the missing velocities in winters using the data points for the rest of the year. By the way, it appears to me that ITS_LIVE observations in case of Russel Glacier are already resolving seasonal variations without applying your proposed method. An example, where velocity data is sparse like for Byrd Glacier, would be much more convincing how well your proposed method can resolve seasonality. Russel Glacier is

the best case scenario (P270). An example from any mountain glaciers from Alaska, European Alps and high Asia would enhance the applicability of the proposed method. The optical data is available around the year in these regions and is only affected by cloud cover. At present the method is proposed to work in these regions, but the potential challenges are not highlighted.

Minor comments:

P5,25 or elsewhere. Instead of using “accelerations”, I would recommend to use “velocity variations” because both acceleration and deceleration are governed by physical processes. P25. Can your approach resolve velocity changes during such short time-scales? If yes, you should highlight in the paper what additional information is required in your method in order to retrieve such signals. If not, there is no need to include it in the Introduction.

Figure 1. Example-1 shows a hypothetical scenario, especially the velocity time series shown in blue. We have plenty of SAR data and derived ice velocities for the polar glaciers. What about showing a real case here?

P45: satellite image pairs » optical remote sensing image pairs

P85: It is not clear how the weights are assigned here. Are these based on residuals?

Figure 4: The colors (blue and green) in the legend and fits are inconsistent.

P105. “Instead, we operate on the displacements associated with each image pair, taken as the integrals of velocities” should be shown as a different figure as this is an important step of the paper. It would be better to see how various displacement estimates at different epochs ranging from days to years are prepared for any sinusoidal fit.

P130. I recommend the authors to make a relationship between Va and Vs here. In other words, the authors should derive equation 4 from above equations or make a relationship between them. What is the goal here? Minimizing the Va?

P145. What about showing an additional inset figure here, which zooms in velocity variability for a particular year with X-axis showing weeks or months of that year.

P165. I didn't quite understand why a synthetic seasonal velocity signal can't be created that depicts nature. I would rather insist the authors to do the same or make use of SAR-based year-around velocity observations to create one (e.g. NASA MeASUREs monthly mean ice velocity mosaics by Ian Joughin). Also shouldn't the goal of your study be to resolve seasonality from a number of observations spaced in time?

P230. reported in van de Wal et al., (2015)

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