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Interactive comment

Interactive comment on "Measuring the state and temporal evolution of glaciers using SAR-derived 3D time series of glacier surface flow" *by* Sergey Samsonov et al.

Anonymous Referee #1

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Review of Measuring the state and temporal evolution of glaciers using SAR-derived 3D time series of glacier surface flow

By Sergey Samsonov, Kristy Tiampo, and Ryan Cassotto

This paper present a technique for producing times series of the 3D glacier motion using ascending/descending data.

Overall it's a good paper, and the technique seems sound. That said, though I would like to see a better technical discussion with respect to errors and temporal/spatial resolution as noted below. The discussion needs some work make it clear what the data is actually showing, especially with respect to what is the source of the vertical

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displacement (see below).

General points I don't see much discussion of errors. Typically, with 6-day sampling and azimuth offsets, you are going to get about errors of about 20-m/yr. The vertical velocities are more driven by range offsets, but the time everything is solved for, some of those errors are going to fold into the vertical solution.

Vertical motion is a combination of the vertical motion due to surface parallel flow other factors (e.g., submergence/emergence velocity or subsidence/inflation due to subglacial water flow). In general, the surface parallel vertical displacement will be the dominant term and it will vary with the horizontal speed, especially for mountain glaciers with relatively steep slopes. The other forms of vertical displacement are the more interesting terms though. So, it would make sense to compute the surface parallel component and remove it to isolate the other types of vertical motion. Otherwise statements like "The predominately downward flow of ice observed throughout the Malaspina Glacier's massive lobe (Figure 4b,c) indicates that ablation rates have exceeded emergence velocities during our 4 year study period, implying" are potentially incorrect or at least presented without proper context. I have no reason not to believe the glacier is wasting down faster than the emergence velocity, but in general glaciers flow downhill, so that could largely due to the surface parallel flow component. Moreover, from image to image, the glacier is largely measuring the same coherent patch of speckle, which would record motion of the surface due to ice dynamics. It should not be measuring downward motion of the surface due to direct ablation (unless you phase of the ablated layer is accounted for, which does not seem to be happening here). In other words, this is like measuring the downward motion of a GPS on a pole sunk in the ice, which will not measure ablation, vs a GPS placed on the surface, which will measure ablation. Distinctions such as these need to made in the discussion.

There is some discussion about penetration effects, but it is import to note you can get some really strange offset patterns when you have soaked firn, which can be spatially coherent over large distances (can map into errors of several hundred m/yr). I am not sure that some of what's being seen is this kind of effect (e.g. blue patches Fig. 4b).

Point, P2, seems to exhibit a seasonal cycle not seen in the other data. It also happens to be near a marginal lake. I wonder if pressure variations as the lake fills and drains are contributing to the seasonal up and down motion. Some discussion as to why this point has a strong seasonal signal would be good.

Specific points Line 48: "However, the SPF constraint is only applicable to glaciers in steady state." This statement is not correct, the SPF assumption ignore the submergence and emergence velocity and other vertical motion, which is true whether or not the glacier is in steady state. And if the glacier is not in steady state, it will still measure vertical velocity variations that are parallel to the surface.

Line 84: A 256x256 sampling window (both patches???) will provides about 3.5km resolution (256 * 13.9 m azimuth resolution), which is further degraded by a 2-km median filter. In addition to the lack of resolution, this can cause problems where the matcher will lock on stationary rock areas more easily than the glacier to report zero velocities a km or 2 inboard of the margin. How is this dealt with. There should be some discussion of what the spatial resolution is. Certainly, the ground resolution is not 200-m as stated, even if the data posted are at 200 m.

Line 85: What corrections were applied for baseline and to calibrate the data (e.g., were control points used to remove biases).

Equation 1 – please break separate into two equations (put the cumulative as a different equation).

117 "temporal smoothing" What is the temporal resolution after regularization.

Line 224-226. I would like to see the surface parallel flow components removed before seeing discussion about kinematic waves.

Figures. The x-axis of the vector profile plots could be lined up with the color times series plots. The vector plots while pretty, don't really give a good idea of the magnitudes

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of the vertical velocity. Please show the profiles also on the b panels since that actually shows magnitudes of vertical motion. Also use some kind of symbol on the c and d plots to indicate where the points PX are.

Would be helpful to see the color panels broken out separately as horizontal and vertical magnitudes. The alternating patches of slow and fast flow are strange.

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