

Dear Dr. MacGregor

Thank you very much for the opportunity to revise our manuscript. We successfully addressed all the comments. Below, please find our response to your comments in italic font.

Best regards,

Sergey Samsonov, Kristy Tiampo, and Ryan Cassotto.

Editor Decision: Publish subject to minor revisions (review by editor) (26 Jul 2021) by [Joseph MacGregor](#)

Comments to the Author:

Dear Dr. Samsonov et al.,

Thanks for your thorough revisions to your revised MS following the three referee reports. Your MS generated more intense feedback from the referees than I had initially anticipated, but all in cases they have stayed engaged with the peer review process and your MS has improved substantially. So, even though there is still some disagreement in approach between yourselves and the referees, it has been fairly debated and your MS will undoubtedly motivate further investigations into velocity time series from large volumes of SAR imagery. I will accept your MS to *The Cryosphere* once you address the following comments below.

Reply: Thank you for your time and effort.

NB1: Note that line numbers are in reference to your track changes version (tc-2021-257-ATC2.pdf).

NB2: WRT line 396, I *will not* accept this MS if the full data/code repository is not available for inspection beforehand. Include the final *public* URL in your next revision.

Reply: We added url as requested.

Abstract: Given that the primary advance of the MS is IMO the application of a new-ish method to a large volume of data regarding glacier flow, the abstract ought to give some clue as to what that method's key advance actually *is*. Also, given the ferocity of the debate amongst the reviewers on this point, the abstract ought to address its uncertainty relative to earlier or contemporaneous methods. As it stands, the abstract is devoid of these highly relevant high-level concerns, which strike me as more important than satellite revisit times.

Reply: We made a few changes to the abstract. We believe it now better describes the key advances.

13: “Glacier dynamics” cannot be reduced solely to surface velocity. Strictly speaking their “dynamics” concern the evolving force balance. The downstream effects listed are an odd mix and not well supported when only considering surface velocity. Rethink this whole first sentence.

Reply: Corrected.

13: “intensity” is simply the wrong word here. “magnitude and direction” is in much more common

usage and physically clearer. A referee brought this up previously and you responded that it was “corrected”... but it wasn’t.

Reply: Corrected.

38: “specifically” makes more sense here than “especially”

Reply: Corrected.

42: The GNSS acronym was introduced earlier, and GPS is left undefined. Use GNSS instead.

Reply: Corrected.

44: combined using the MSBAS technique.

Reply: Corrected.

59: remove “But”

Reply: Corrected.

61: Riel et al. (2021), who adopted some of the methods of Riel et al. (2014, 2018) and applied them

Reply: Corrected.

72: Figures should be referenced in the order they are presented. Either Figure 4 should move up to #1 or not be referenced here. I suggest the later approach.

Reply: Corrected.

77: using the speckle

Reply: Corrected.

91: incidence angle. (IMO “azimuth” does not need to be qualified with “angle”)

Reply: Corrected.

141: Passive voice. “We used a value of 0.1 for lambda.” Was this value selected using L-curve?

Reply: Corrected.

151: hundreds and often thousands of columns

Reply: Corrected.

156: “called from C++ code” does not seem relevant here

Reply: Corrected.

162: Passive voice

Reply: Corrected.

164: in the respective legends

Reply: Corrected.

165: 10% of what? I assume the harmonic's amplitude but this origin should be made explicit here not just legend.

Reply: Corrected. Let's say the ice flows with the velocity 1 m/day. This means that when sampled every 12 days (Sentinel-1 revisit period) the individual speckle offset map will detect 12 m of displacement. Then we take 10% (or 1.2 m) of that as a noise. The annual amplitude is not a good reference for an error because it does not account for the data sampling rate (e.g. 12 days).

168: Now I'm confused. Did you add 10% of amplitude noise or 0/10/30? Reconcile with 165.

Reply: There are three grouped tests, labeled in the text as First, Second, Third. The first test was done with 0/10% noise and two latter tests were done with 0/10/30%. The first test used only one value of noise to preserve paper space, it produced three times more figures, one for each component.

184: Is "cross-feed" the best term here? Not sure

Reply: Corrected. Deleted this part of the sentence.

186: Overall these tests indicate that

Reply: Corrected.

193: RGI Consortium

Reply: Corrected.

196: "pale in comparison" is strong language, especially given that parity is now effectively reached via ITS_LIVE and other international efforts. Reconsider this phrasing.

Reply: Corrected.

225: Does "lower" here mean "coarser" (larger value) or "finer" (smaller value)? Unclear.

Reply: Corrected. Coarser.

228: A pers. comm. citation from the GAMMA developers is appropriate here.

Reply: Corrected.

229: using the TerraSAR-x

Reply: Corrected.

231: Filter width

Reply: Corrected.

236: This statement about data volume is odd and should either be further specified somehow or removed.

Reply: Corrected.

239-240: I don't understand what "approximated to the actual glacier flow pattern" means. I assume OGGM uses a DEM for the flowlines, whereas you have actual surface velocities available. Clarify this statement.

Reply: Deleted this sentence. The idea was to say that the location of flow lines derived using coarse DEM is approximate. I think it is clear without saying. All numerical results are approximate.

243: intensity -> backscatter?

Reply: Corrected.

251: direction or sign?

Reply: We believe that the direction of flow can be seen in the flow velocity vector map.

303: Unless the authors have checked, it is unlikely that there are no GNSS stations on any of the studied glaciers during at least some part of the 5-year period. If not checked, I recommend moderating this statement to something like "we did not compare against GNSS")

Reply: We checked, there is no freely available GNSS data for these glaciers.

305: "≈4 m" not "four meters"

Reply: Corrected.

318: "they still show some agreement" -> "

Reply: Corrected.

334-347: As a referee pointed out, offending the solid earth community by implying they don't understand Lagrangian vs. Eulerian reference frames is a strange and unnecessary stance. In recalling my own education, scientists in those disciplines learned these concepts right alongside myself. This paragraph should be shortened substantially by assuming that the likely reader is a glaciologist who is familiar with the two reference frames and by focusing on the argument the authors seek to make on the links between GNSS and SAR flow displacement time series for *glaciers*. A distinction for that link over deglaciated tectonically deforming surfaces should be made only as a final aside.

Reply: Corrected. We removed this part of the discussion.

348-365: As the referees pointed out more than once, the ability to recover credible vertical displacements concurrent with horizontal displacements from large data volumes with MSBAS is a potentially valuable advance. However, the very large magnitudes reported (e.g., >200 m/yr) *require* further explanation, some of which was provided in the response to reviewers (e.g., ArcticDEM not available at coincident times, sparser ICESat-2 data). Without that further explanation, there is a risk of casual misinterpretation of the reported vertical velocities as rates of elevation change rather than evolving submergence/emergence velocities indicative of broader (and faster) changes in dynamic configuration than previously understood (and also much greater than short-term SMB fluctuations). This paragraph appears to be the right place for that clarification, as the discussion concerning Malaspina Glacier mostly works.

Reply: Corrected.

351: “is more concerning” reframe this qualification as it is already well established that most Alaskan glaciers are losing mass rapidly (e.g., Larsen et al., 2015).

Reply: Corrected.

367: Move Meier and Post (1969) citation to the group at the end of the sentence.

Reply: Corrected.

384, 395: Please be clearer here as to what you mean by “data”. The data you use are SLC Sentinel-1 images, but you’re probably not archiving those with the MS as they’re already at ASF. I believe the velocity dataset (over space AND time) is what is meant.

Reply: Corrected.

Figures throughout MS: It is odd to use the standard abbreviation for meters (m) but not that for year (yr) when showing speeds. Recommend changing unit abbreviation from m/year to m/yr.

Reply: Corrected.

Figure 4: Add a red arrow in inset map of North America so that small red box is more easily spotted.

Reply: Corrected.

Thanks again for choosing The Cryosphere for your work,

Joe MacGregor
NASA/GSFC