

Interactive comment on “Evolution of surface velocities and ice discharge of Larsen B outlet glaciers from 1995 to 2013” by J. Wuite et al.

Anonymous Referee #2

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Evolution of surface velocities and ice discharge of Larsen B outlet glaciers from 1995 to 2013

This study presents a very thorough and probably the most careful and complete analysis of variations in ice discharge of outlet glaciers into the former and remnant parts of the Larsen B ice shelf so far. Based on satellite measurements of ice dynamics over various time periods and measurements or estimations of ice thickness at flux gates it is a significant and important addition to previous studies which have been primarily or solely based on change in surface elevation. Elevation change methods provide information of total ice mass change, whereas the budget (or input/output) method like the one presented allows much better insight into underlying processes. Although the information on surface mass balance in this area is very limited, I see the outcome

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of this observational study as an important contribution for a better understanding of changes in ice dynamics during and post ice shelf collapse. The results are clearly summarized and presented in the tables and are likely to find uptake in future studies. The paper is well structured and written. I have three major comments, and several minor comments about the analysis, description of methods, wording, and figures, but recommend full publication once this is considered.

Major comments:

1/ Baseline for the surface velocity fields are one day repeat pass interferograms in 1995 and 1999. There are meanwhile quite a few examples and theoretical studies that velocities over such short repeat pass intervals are not representative for mean velocities. E.g. Marsh et al. (2013) report that tides produce horizontal velocity variations of > 50% around the mean velocity near the grounding line at the Beardmore Glacier, which are still around 5% about 15 km upstream. However, daily fluctuations rapidly smooth out over time. It seems that the authors did either ignore or did not observe such fluctuations at the Larsen B ice shelf. In any case it needs either to be mentioned (that such fluctuations are ruled out) or at least taken into account in larger errors bars for the ice discharge in 1995 and 1999. The comment on p 6279 (line 25-27) is insufficient, as it is about the uncertainties related to vertical tidal displacements in the interferograms rather than horizontal velocity fluctuations. This could be mentioned in various places, like in section 3.1/3.2, the discussion, or in the introduction.

2/ As the authors describe, there has been a significant change in surface topography post ice shelf disintegration, and the DEM used in the interferometric analysis is therefore not representative. What is the introduced error in the InSAR analysis?

3/ It would be good to show the velocity differences as a figure (the difference between Figure 2 left and right) to illustrate how far upglacier velocity acceleration was detected.

Minor comments

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6272, Abstract

SCAR Inlet: I suggest capital letters for SCAR (often neglected in the literature, but it is an acronym for the Scientific Committee for Antarctic research, it has nothing to do with a scar) like in the heading for 3.2, but be consistent throughout the manuscript.

Change wording in last sentence, use e.g.: In 2013 their discharge was 38% (Flask Gl.) and 45 % (Leppard Gl.) higher than in 1995.

6272, 26: remove 'calving'

6273, 4/5: change wording, maybe: ... and its interaction with grounded ice.

6: 'Larsen Ice Shelf' as it is a geographic name change to capital letters throughout the manuscript.

18: wording. Maybe change to: "... tributary glaciers continued at almost the same rate over the period..."

21: use past tense in 'inferred'.

6274, 14: ..., defined by the ASTER...

16/17: ...vectors are provided in South polar stereographic ...

6275, 5: ...from the velocity vectors ...

17/18: ...with a typical accuracy of 0.1 fringes ...

19: For a one day ...

22: ... uncertainty for the retrieval of the displacement is in the order ...

6276, 3 (equation (1)): instead of an integral I suggest using a summation sign (with $i=0,N$) and discrete step size with (greek) Δy , as the authors were summing up a finite number of pixels across the flux gate.

8-10: based on Paterson (1994), what are the assumptions made to come up with the
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value 0.95?

24: clarify if the 5% uncertainty is for the satellite measured surface velocity or the vertically averaged ice velocity. It is probably OK for the measured velocity, but because of additional assumptions likely too conservative for U_m in equation (1).

6277, 21 (wording): ...break up of increasingly large areas ...

6277 (27-28)-6278 (1-2): I do not see the connection between the mass turnover and sensitivity; the cited reference (Rott et al., 2011) is also unclear about this and inadequate. If this is true, why do the authors assume that the mass turnover of e.g. Mapple Glacier is different to e.g. Punchbowl Gl.? The catchment basins look very similar in size and distance from the plateau (Fig. 1).

6278, 3-12: why is e.g. Punchbowl so different to Mapple Gl. ? See also previous comment.

13-23: in this paragraph any observations of daily variations are missing, see also major comments.

6279, 27: I agree to exclude the velocities at the grounding line, but also for other additional reasons; see also major comments;

6280, 24: Because of the retreat ...

6281, 8: ... inland of the ice front ...

10: Change 'For June...' to e.g. 'Based on the June 2007 analysis ...'. This sentence is not correct, as the flux is given for a whole year.

23: ... difference compared to 1995.

6282, 1-3: Is the value of 0.78 Gt a-1 for both glaciers? Change wording (see also comment in the abstract for the usage of 'respectively').

line 26 to 6283, 1-2: how far upglacier and how fast (implied by 'moving upward') was

the acceleration detected? This could be nicely evaluated and illustrated by a figure showing the difference in velocities. See also major comments. Reword the sentences; e.g. '...caused flow acceleration moving upstream. Our analysis of new velocity data also shows that ...'

9: '... for six periods between ...'

15: '... the ratio between driving stress and lateral shear ...'

6285, 15-19: Reword and shorten this sentence. It is especially unclear what is meant by '... shear zones vs. slowly moving ice...'

Figures:

Figure 1: change 'coastline' to 'ice edge' or 'ice front'

Figure 3: increase font size

Figure 4: use different color (preferably white) for flux gate lines;

Figure 5: What are the yellow arrows? Increase font size. Yellow sections of ICESat track hardly visible.

Figure 6: move arrow up too the curve, increase font size;

Figure 7: increase font size;

References:

Marsh, O.J., W. Rack, D. Floricioiu, N.R. Golledge, and W. Lawson. (2013). Tidally induced velocity variations of the Beardmore Glacier, Antarctica, and their representation in satellite measurements of ice velocity. *The Cryosphere* 7: 1375-1384. doi:10.5194/tc-7-1375-2013.

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