

Interactive comment on “Monitoring ice shelf velocities from repeat MODIS and Landsat data – a method study on the Larsen C ice shelf, Antarctic Peninsula, and 10 other ice shelves around Antarctica” by T. Haug et al.

T. Haug et al.

torborg.haug@geo.uio.no

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Answer to Anonymous Referee 2

We appreciate very much the very detailed and careful review and the constructive suggestions. They will certainly improve the paper substantially. We were in principle aware of the VELMAP project, but didn't follow it recently. We plan to respond to your comments as follows:

I think the paper would be easier to read if it was shortened. It is mainly a technical

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(and not a thematic) contribution and we do not learn a lot here about the glaciological changes of the Larsen ice shelves (remnant of B and C). Thus, I suggest reducing considerably the part of the introduction (p35 and p36) that deals with past changes that experienced these ice shelves.

The introduction will be shortened to concentrate more on the technique. E.g. line 8-13 page 36 will be deleted so that this paragraph is only on velocity changes.

The structure of the paper could also be improved. The fact that the result and discussion sections are separated (which generally is a good thing), implies that the authors had to disconnect (and to some extent repeat) the description of points which are quite similar (8 bits vs. 12 bits, 2 types of correlation technique, 10 others ice shelves, : : :). The authors may consider having a single (rather large : :) results discussion section with 3 or 4 subsections.

We suspect that this would create a very large and complicated section, and therefore would rather avoid combining results and discussion. We will, however, carefully revise both sections and more clearly and carefully distinguish between results and their discussion.

If the 10 ice shelves part of your paper was strengthened (for example with more detail Landsat ASTER analysis of regions where MODIS suggest a velocity change), I think it would deserve an original paper itself.

We agree with that. The purpose of including the other ice shelves in this contribution was to assess the robustness and strength of this method on Antarctic ice shelves in general. We think it is important to ensure that our method works not only on Larsen. For the same reason we limited the amount of glaciological interpretation and inclusion of many other data, but agree very much that this is a next step after this more technical paper.

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Some velocity fields (mainly derived from Landsat images) have been published for some ice streams and ice shelves of Antarctica (more than you cited) and are available for download through the VELMAP project (data available at NISDC). You could use them to compare to your MODIS velocity field. Velocity field available for the Mertz glacier for the 1990s and early 2000s may help you to see if the acceleration you observed is a long term trend or not.

Thanks for this very useful hint! The VELMAP project will be checked out, referred to and compared to where possible.

Correlation of low resolution (MODIS) images is certainly a good mean to first detect regions that have experienced changes and thus can guide where dedicated studies should be performed by collecting time series of higher resolution images (that will provide a much better accuracy and a better temporal resolution of the velocity changes). I think this is a philosophy the authors could describe better in the introduction as it really gives some strength to their approach.

This will be better pointed out in the introduction.

It would be good to have a more quantitative assessment of the % of the ice-shelf area covered using the different correlation techniques (for example, each correlation vector could be associated with the area covered by the correlation windows). You could also use this metric on the sub-areas covered using Landsat images to compare the different coverage achieved using MODIS and Landsat matches (using different window sizes). On the vector maps, it is sometime difficult to assess which methods has the best spatial coverage.

We will try to better point out the differences between the different techniques and satellite data in terms of area covered. So far we relied as a metric mostly on the number of correct matches. However, an area metric might be a bit misleading because we chose the window sizes to be comparable in order to have comparable results, rather than choosing window sizes to maximize the num-

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bers of matches and their area covered. The latter strategy would be useful for applied glaciological studies, rather than the method study aimed at here.

SPECIFIC COMMENTS p33 L15: Why excluding Greenland here? Paper by (Luckman and Murray, 2005) and (Howat et al., 2005) or (Stearns et al., 2005) could be cited for example (among many others and maybe some earlier works that would be more relevant). The paper by (Strozzi et al., 2002) is also relevant to your introduction because it discussed the coherence over glacier surfaces from different SAR techniques.

Strozzi et al., (2002) and Howat et al., (2005) will be cited.

p33 L18: Reference to the Velmap (see NSIDC) effort could be mentioned here p37 L5. Could you give the wavelength of the MODIS Bands? Why did you use two different bands (1 and 2)? Are the MODIS images acquired vertically (without any across or along track pointing) which would justify the fact that images were not orthorectified? Are the correlated images from the exact same orbit?

See response to other referee, W. Rack.

p38 L18. Unnecessary to cite those studies dealing with rockglaciers (furthermore one of those is just in preparation).

These studies give general information on the NCC method, and for readers unfamiliar with this method it can be useful to read these papers.

P41 L13 "Only zeroth order trends". The word "trend" is a bit misleading? Why not using simply "mean horizontal shifts". Could you report the values of these mean shifts somewhere in the text? I did not find them. Is the mean shift the same for all stable areas?

The approximate shifts will be given in the text. Mean horizontal shifts will be written in the parenthesis.

P41 L23: what do you mean by "align". It was not clear to me.

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We will use “coregister” instead.

P45 L10. The difference in mean velocity for the same area between the different correlation techniques is a bit worrying (although it is still within the nominal error bars). Do you have some explanations for this difference? Is it because one of the two correlation techniques better sampled a faster part of the ice shelf? From different correlation techniques, I would intuitively expect differences in RMS but not in mean values.

This is probably because the matching methods work differently. The matching result will for instance be different if there is one strong contrast feature in the image. NCC will then match this feature, but OC is dependent on several features with different frequencies and with the same displacement. This explanation will be added in the paper.

P45 L23. Could you discuss here whether NCC also detected the acceleration of the Larsen B remnant and if the magnitude of the acceleration is (hopefully) the same?

This will be examined more closely and included in the revised manuscript.

P46 L15. Could you better describe how streamlines are derived from the velocity field? I was surprised that the lines did not seem to really follow the velocity vectors in Figure 10.

This will be described in more detail.

P47 L5. The discussion is a bit weak here because you cannot exclude that systematic errors in the MODIS-derived flow directions could create a fortuitous agreement with the flowlines.

This point will be discussed in more detail. We did such assessment, but didn't include so far.

P48 L28. What do you mean by “manual inspection”?

Will be replaced with manual matching.

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P49 L5. “satisfactory”. Well, it depends on what your needs (in term of accuracy) are:
: :

The sentence will be deleted.

P49 L17. The geolocation to which the velocity measurement should be attributed is an important issue. If you want to measure the velocity changes over time period of different length I think the best is to attribute the velocity measurement to the centre of the velocity vector (to avoid the problem of horizontal gradient in velocities that you discussed).

We will estimate the potential impact of such difference in reference of a velocity measurement in our case, and, if necessary, change this velocity measurement georeference as you propose.

P52 L16. Reduced back-stress is generally invoked to explain the acceleration of upstream glacier. Does it apply to the ice-shelf itself? Do you have some reference for that?

See response to 2nd comment by M. Pelto.

TECHNICAL COMMENTS

All technical comments will be followed.

Interactive comment on The Cryosphere Discuss., 4, 31, 2010.