The Cryosphere Discuss., 4, C41–C47, 2010
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The Cryosphere Discussions

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.

Anonymous Referee #2

Received and published: 11 March 2010

In their paper, Haug et al correlated repeat 250-m resolution MODIS imagery to map the velocity field of Antarctic ice shelves. The methods is presented and validated over the Larsen C ice shelf. It is then successfully applied to 10 others ice shelves around Antarctica.

The possibility to retrieve the velocity from low resolution sensors (with a short revisit period) is an important advance for glaciologists. It will greatly enhance the archive of useful images and will strengthen our capability to monitor the dynamic structure (and its evolution) at the margins of the Antarctic ice sheet. By necessity, the velocity fields

are derived over a relatively long time period (3 to 4 year) but it may also be regarded as an advantage because velocity field (and changes) measured during these multi-year periods are certainly more relevant to study the mass balance of the ice sheet rather than 1-day velocity field derived from InSAR (the latter can be strongly influenced by short term velocity change).

I thus recommend publication of this well-written contribution, as soon as the revisions below are taken into account.

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GENERALS COMMENTS

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

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.

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

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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.

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.

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.

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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.

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

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or along track pointing) which would justify the fact that images were not orthorectified? Are the correlated images from the exact same orbit?

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

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?

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

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.

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?

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.

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.

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

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

P49 L17. The geolocation to which the velocity measurement should be attributed is

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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).

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?

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TECHNICAL COMMENTS (? = proposition, I am not 100% sure of my advice)

P32 L23: a → year

P33 L6: to avoid coherence degradation → to avoid coherence degradation on the rapidly changing snow/ice surface

P34 L27: "to validate the measurements based on low resolution data" not needed

P34 L28: remains → remnants (?, more common in the literature I think). The same apply elsewhere in the paper

P40 L19: implies → assumes (?)

P41 L12: "are searched for trends" awkward wording

P42 L25: to not remove → to avoid removing (or removal of)

P43 L20: the average displacement → the 7-year average displacement

P44 L15: I would move the sentence "In our... artefacts" at the beginning of the paragraph

P45 L23. I would change to a new section here

P45 L26: "in order to assess differences between using 12 bit images instead of 8 bit

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images for matching”→ “in order to assess matching differences between 12 bit images and 8 bit images”

P46 L17: I do not think “applied” is the right word to use here.

P47 L4: “ice sheet” → “ice shelf”

P47 L16: “match other” → “match MODIS images of other”

P47 L24: Mertz Glacier. In fact most (if not all) of your velocity measurements are seaward of the grounding line of the Mertz Glacier (Legresy et al., 2004) so you can also call it “tongue” or “shelf” also.

P47 L26: make it really clear that this is for the slow part of the ice shelf

P49 L28: I would use “the large wavelength of the contrast features” rather than density.

P50 L15: What do you mean by sub-pixel accuracy of the Landsat sensor?

P51 L10-14. This part is not clear.

P51 L15-18. This part is probably useless.

P51 L19. Aligning. Do you mean coregistrating?

P52 L10. “We measure velocities of 670ma−1”, give the time period.

P53 L18. “Short time separation”. One reader could think that this is the separation between the correlated MODIS images so make it clear that this is the separation between MODIS and Landsat scenes.

Table 3. 1. period → 1st period

Figure 11. Make sure that all background images are clear enough so that we can see the red arrows (and panel letters), in particular for Ross (east). In the legend “left” → “right”. And only 3 ice-shelves (if Ronne-Filchner is considered as one) not 9 (in Figure 12, only 6 ice shelves)

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REFERENCES for my review

Howat, I.M., Joughin, I., Tulaczyk, S. and Gogineni, S., 2005. Rapid retreat and acceleration of Helheim Glacier, east Greenland. Geophysical Research Letters, 32(22). Legresy, B., Wendt, A., Tabacco, I., Remy, F. and Dietrich, R., 2004. Influence of tides and tidal current on Mertz Glacier, Antarctica. Journal of Glaciology, 50(170): 427-435. Luckman, A. and Murray, T., 2005. Seasonal variation in velocity before retreat of Jakobshavn Isbrae, Greenland. Geophysical Research Letters, 32(8). Stearns, L.A., Hamilton, G.S. and Reeh, N., 2005. Multi-decadal record of ice dynamics on Daugaard Jensen Gletscher, East Greenland, from satellite imagery and terrestrial measurements. Annals of Glaciology, 42: 53-58. Strozzi, T., Luckman, A., Murray, T., Wegmuller, U. and Werner, C.L., 2002. Glacier motion estimation using SAR offset-tracking procedures. Ieee Transactions on Geoscience and Remote Sensing, 40(11): 2384-2391.

Good luck with the revision of your work,

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