Earth **Surface**
Dynamics
Discussions

Open Access

EGU

Interactive comment on "Determination of high resolution spatio-temporal glacier motion fields from time-lapse sequences" *by* Ellen Schwalbe and Hans-Gerd Maas

Anonymous Referee #1

Received and published: 5 July 2017

The authors present a summary of their methodological developments in terrestrial photogrammetry for glacier monitoring. Unfortunately, most of the material in the manuscript has already been presented in a previous paper by the authors (Rosenau et al. 2013). Since the authors provide the reference to their previous study only on page 23 I was left with the impression to read through original material and spend the better part of a day on this review!

Detailed comments:

The introduction provides a historical perspective on the use of terrestrial photogrammetry for glacier studies but I feel it leaves out some significant recent advances in the

field of environmental monitoring with photogrammetric methods including the monitoring of glacier (e.g. Messerli and Grinsted 2015), landslides (e.g. Travelletti et al. 2013) or discharge monitoring (e.g. Stumpf et al. 2016). Some of those tools are readily available in the public domain and can be used for the proposed applications. It would therefore be helpful to explain briefly possible shortcomings of available methods and how the proposed method addresses those issues.

Addtitional references:

Messerli, A. and Grinsted, A.: Image GeoRectification And Feature Tracking toolbox: ImGRAFT, Geosci. Instrum. Method. Data Syst., 4, 23-34, 2015, doi:10.5194/gi-4-23-2015

Travelletti, Julien, et al. "Correlation of multi-temporal ground-based optical images for landslide monitoring: Application, potential and limitations." ISPRS Journal of Photogrammetry and Remote Sensing 70 (2012): 39-55.

Stumpf, André, et al. "Photogrammetric discharge monitoring of small tropical mountain rivers: A case study at Rivière des Pluies, Réunion Island." Water Resources Research 52.6 (2016): 4550-4570.

p.3, l.12: 'translation into object space' Maybe 'transformation' or 'mapping' would be more adequate than 'translation' here

p.5; l.9: "This can be achieved by establishing a local photogrammetric network (consisting of several convergent images taken from different positions as shown in Figure 2)"

As I understand this, this authors suggest a single 3D reconstruction of the glacier surface for a single time steps as opposed to the time-lapse camera which will acquire time-series for the motion measurements? This implicitly comprises the hyphothesis that the glacier surface topography will not undergo large changes during the monitoring period. In particular for the observation of calving event this appears as a rather

C2

strong assumption which should be explained in greater detail.

General comment on 2.2 Measurement Setup: While the section clearly describes several options for the measuring setup and states requirements (e.g. "should be replaced by differential GNSS measurements." "an elevated camera position is required", "it is necessary to have static points", "it is recommendable to use redundant information in the process of geo-referencing"). While I agree with those considerations it is still not clear for me which (similar or different setups and strategies were used in the study. I would encourage the authors to provide more explicit information on the actually realized setups.

p. 8: "Thus, the first strategy might be applied when tracking signalised points" Similar to my previous comment, please avoid hedging, and state what has been actually done.

p. 12, l.7: 'higher than the single standard deviation' The standard deviation of the gray values within the search patch? This automatically assign several pixels as shadow pixels even if not shadows are present at all. It seems to me that on a glacier this might mask many areas with important texture and could leave you only with the areas that are difficult to match? Please comment.

p.13, l.2: "error influence on the motion vectors" This sounds a bit awkward. I suggest something like 'error source that might impact'...

p.14, l.9: "two image shift parameters and the rotation parameter" If you are only considering those two parameters you will estimate a rigid transformation and won't need to invoke an affine transformation. Please clarify.

p.16, l.10: "Going a step further and calculating the sparse cloud while providing the measured camera positions to PhotoScan, the thus determined 3D coordinates of object points can also be exported and used as approximate values for the bundle block adjustment."

I do not understand the purpose of this step. Errors in the internal and external cal-

ibration parameters plus matching errors will propagate into the sparse point cloud. Running another bundle adjustment with the resulting 3D points will hence certainly suffer from those errors? Please clarify.

Similar too my previous comments p.16 comprises a lot of ambiguity. Some example: "we predominantly used structure from motion (SFM) tools we predominantly used structure from motion (SFM) tools (such as Agisoft PhotoScan)"

Which other SFM tools where used and for what?

"It can be adapted to different types of control points as well as different sets of camera calibration parameters, scale conditions can be defined, and it provides the possibility to define each variable as fix or parameter to be estimated."

Which type of cameras and camera calibration models where used? How did you adapt the tool and the free parameters and based on which criteria?

"Since many SFM tools are rather optimized for fast processing and 3D-visualization than for accurate measurement purposes, some limitations may have to be taken into account, when applying them for measurement tasks."

Which tools are you talking about? Can you back this with numbers or previous studies?

"However, when not using a reduced measurement setup it is also possible to determine object coordinates and camera orientation parameters solely using PhotoScan."

What is a reduced measurement setup? Is this an option or something you have done in this study?

"Thus, it is recommendable to measure the cameras positions in the field and to pre-calibrate the cameras..." I agree, but it is again not clear if that is a recommendation or something you implemented in this study.

I there are more examples like this.

p.17, l.13: "In case of using PhotoScan, the exterior camera orientation parameters and a depth map can be exported for the time-lapse image."

Above you explained that you use you own in-house bundle adjustment and in combination with pre-calibration of the internal parameters. Why would you then export these parameters from Photoscan?

p.18, l. 12: "The glacier flow direction can e.g. be obtained via flow-line patterns that are visible in satellite orthophotos.

Does this imply that the glacier flow direction is constant across the scene (as shown in Fig 12A)? This would be a rather strong assumption for observations in areas where the glacier flow is bending with the topography. Please clarify and state possible limitations that may arise from this assumption.

p.19, l. 16: "For a sample trajectory from an image sequence measurement at Jakobshavn Isbræ in May 2010"

I feel it would be helpful to first introduce the study sites with their respective measurement setups before providing results on the accuracy. At this point it is rather difficult for the reader to understand if the error budget estimation is representative for all sites.

p.20, l.20: "These individual errors were propagated into a mean total error of 9.2 cm "

It might be useful to provide the formula for the error propagation. Why did you not also assess the measured velocities against independent in-situ measurements?

General comment related to section 3 Assessment of glacier motion fields: four case studies.

I feel that a lot of important information regarding the case studies is missing including maps of the measurements setup, the type of deployed cameras, the duration and frequency of the acquisitions of monoscopic images as well as stereo views. Introducing the particularities of the study sites might also help the readers to understand

which specific choices were made following the rather generic description in section 2.2. Another interesting aspect that might deserve some further considerations is the operation of the camera systems in the those rather harsh environmental conditions (e.g. power supply, data storage and submission, etc.).

3.1 Horizontal glacier motion

Is the glacier motion in the presented case studies purely horizontal? If not your measurements may also comprise a vertical component. Please clarify.

3.1.1 Glacier motion velocity fields

Considering all the effort for setting up a time-lapse system it is more than unfortunate that you only present the aggregated means. Surely you derived some interesting time-series that you could present? What can we learn from those time-series regarding the process of glacier flow? Section 3.1.2 is much more mature in this regard.

p. 23, l 14: "velocity increase decreased with increasing" There is a lot of increase and decrease here. Please reformulate.

Figure 16: I would be helpful to provide a scale for the upper figure (e.g. distance between to arbitrary points on the stable terrain). Please also provide the details on the smoothing filter (e.g. rolling mean with a window size of x?) used.

1.1 Vertical glacier motion Something went wrong with the section numbering here.

1.1.1 Grounding line determination

There are several issues in this section.

The caption of Figure 17 refers to only two of the 3 subfigures and raises the impression that all the results presented originate from other studies. The letters A-C used to number the subfigures are not used at all. In Fig 17 A it is not clear which measurement is from which source. The y-axis gives the impression that both curves show the tidal range while one of them shows (I assume) the vertical component of the glacier motion.

"Figure 17 (A) shows the vertical motion component of a single trajectory compared to tidal height measured by a pressure gauge."

Neither from the text nor in the figure it is clear which measurement is which.

"In particular, the scale factor in vertical direction" The paper is not really self-contained here. Please explain how the scale factor is computed.

"Multiple time lapse measurements at Jakobshavn Isbræ in 2004, 2007 and 2010 even allowed for the documentation of the migration of the glaciers grounding line (Figure 17, C) (Rosenau et. al., 2013)."

I finally had a look at the study by Rosenau et al. 2013 and came to realize that an important part of the presented material has already been published in this previous paper by the authors. This includes the measurements on the Jakobshavn Isbrae glacier, the corrections for camera movement, the projection into object-space, estimation of the error budget, the delineation of the grounding line, and the documentation of the calving event. I stop the review here.

Interactive comment on Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2017-33, 2017.