Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2018-145-RC1, 2019

Open Access Earth System Science Data Discussions

Interactive comment on "A high-frequency and high-resolution image time series of the Gornergletscher – Swiss Alps – derived from repeated UAV surveys" *by* Lionel Benoit et al.

Anonymous Referee #1

Received and published: 11 January 2019

The authors present an elevation and velocity dataset over the lower part of the Gorner glacier in Switzerland. These products are generated from several field campagnes during the summer of 2017. Making this dataset available to a large community is of interest, as the evolution of surface features can be observed in great detail. It can therefore be of interest to geomorphology and glaciology.

In general the article is well written, and the processing steps of the workflow are described sufficiently. However, the motivation for several processing steps are lacking explanation, and implications of such decisions not mentioned. Two concerns are currently present in the manuscript, which need to be addressed, in order to have its full

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potential for other users.

The first concern is based on the relative geo-referencing, the authors have chosen not to use real ground control points. While they have chosen one common bundle-adjustment as master, to "stitch" other control against it. It is common in photogrammetry to distribute GCP's and have them placed especially at the outer ends. This reduces "banana" bending, caused by imperfections in the lens model. However, this is not done in this study, thus one can assume such effects are here at hand as well. I am well aware of the logistics within such terrain, thus I am not asking to do this procedure. Nevertheless, I propose the authors put a bit more emphasis into describing the potential errors associated with this effect/shortcoming. I hope if this is done rightfully, it will reduce the mistake of over interpretation by other users of this data.

My second concern is focused around the matching maps, which are less standard products, and therefore implementation details need to be discussed more. Although not standard, there do exist best-practices, and because the authors deviate from this I highlight some steps which may need more clarification, or adjustments, in order to improve the resulting matching map product or get a better understanding why certain steps are taken.

- The similarity score is "maximum absolute error" on grayscale images. This is a peculiar choice as throughout the season and throughout the day the sun has changing illumination directions. Though this similarity measure is very sensitive towards such effects. Commonly, the normalized cross correlation is used, and the images are either pre-filtered with a high-pass-filter [Fahnestock 2016] or a Wallis-filter [Dehecq 2018]. I expect this will improve the results considerable. Also the use of orientation-correltation [Heid 2012] or COSI-CORR [leprince 2007] might be a more robust procedure. - The matching maps seem to have an integer displacement, and no sub pixel localization is applied. While these procedures are able to increase the precision considerably. This will result in highly precise maps, where strain rates and other derivatives can be extracted more precisely. Therefore, I wonder why this is not done. - The spacing of ve-

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locity product is at pixel level, though in products like GoLIVE for example, the spacing of the grid is as large as the template size (in this case 300 meters). Similar processing in SAR speckle tracking is done with only 50% overlap [van wychen 2018]. This is done to have independent measurements, but now there will be a large smearing effect. It is possible to get to the resolution of a pixel, when pyramidal matching is applied, up to a point where optical flow can to be implemented.

p = page; l = line; -> = consider changing to;

minor comments:

p1 l1 high-frequency -> inter-seasonal

p1 l1 image -> elevation and velocity

p1 l13 new dataset -> new topographic dataset

p1 l13 intensive: subjective text, I am aware this is hard work but not necessary information for the abstract

p1 l14 summer 2017 -> summer of 2017

p1 l17 displacements and velocity, choose one as these are two words for the same thing

p2 l7 summer 2017 -> summer of 2017

p2 l8 -> "10 consecutive DEMs and associated ortho-mosaics"; you first need to make a DEM in order to be able to make a mosaic

p2 l9 surface evolution

p2 l17 displacements and velocities; choose one

p2 l23 "ice flow dynamics at the surface" I think the emergence velocity by [Brun 2018] is also a good example of a process. Furthermore, mentioning the use of multitemporal DEM's as in [Wang , Berthier] might be worth it as well.

p3 l1 "6%" maybe also specify in degrees

p3 l4 "mainstream" -> central flowline?

p3 l19 maybe include the lake location, which drains, and also include the ELA?

p5 l3 pix4D, please give the version

p5 l7 swap orthomosaic and DEMs

p5 l9 UTM_zone32 -> Universal Transverse Mercator (UTM zone 32)

p5 l12 I assume all flights are nadir, or did the UAV also took oblique imagery. This is of interest, as it enhance the separation between internal parameters [james 2014].

p6 l1 "GCPs" is maybe not the correct term, as they are not real ground control, hence (manual) tie-points might be more correct.

p6 l10 51x51 pixels , also include the metric size, that is roughly 5 meters right?

p6 l12 2000 pixels, see former comment

p7 l10 "locations with strong spatial gradients", this is not a very effective post-processing step. It is very local and isolated inliers will also be removed. More advanced post-processing techniques are possible [maksymiuk 2016], but I am not asking to do this, just so you are aware of such studies.

p7 l16 "are interpolated", which type/method?

p7 l16 "reliable measurements", not correct wording, there is no real testing, thus reliable is misplaced here.

p8 l1 the east and northward components do not seem to be the same....? also, why is the displacement given in pixel and not in a metric scale?

p8 l14 There seem to be multiple flights per campaign. Because a fixed wing is used, the landing must have had an impact. Hence, internal camera parameters might have

been different between different flights. Thus, are these groups of data also separated in the camera optimization?

p9 l3 are due -> can be

p10 l11 "smooth out local variability", why is this done? and why is the mean taken, and not more robust measures like the median?

p11 l12 why are single points used as validation, it might be good to look at stable terrain as well. The Randolph glacier mask can exclude glacial terrain, the rest can be used to create a histogram of displacements.

p11 l12 "since the area of interest", is only the icefall of interest? Are other features on the glacier tongue of interest as well (meander evolution of supra glacial streams, emergence velocity ....)?

p13 l4 "for almost any glacier mapping task", not specific and does not hold either, please rephrase.

[berthier 2016] Decadal region-wide and glacier-wide mass balances derived from multi-temporal ASTER satellite digital elevation models. Validation over the Mont-Blanc area

[brun 2018] Ice cliff contribution to the tongue-wide ablation of Changri Nup Glacier, Nepal, central Himalaya

[dehecq 2018] Twenty-first century glacier slowdown driven by mass loss in High Mountain Asia

[fahnestock 2016] Rapid large-area mapping of ice flow using Landsat 8

[heid 2012] Evaluation of existing image matching methods for deriving glacier surface displacements globally from optical satellite imagery

[james 2014] Mitigating systematic error in topographic models derived from UAVand

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ground-based image networks

[leprince 2007] Co-registration of optically sensed images and correlation (COSI-Corr): An operational methodology for ground deformation measurements

[maksymiuk 2016] Velocity estimation of glaciers with physically-based spatial regularizationâĂŤExperiments using satellite SAR intensity images

[van wychen 2018] Surface Velocities of Glaciers in Western Canada from Speckle-Tracking of ALOS PALSAR and RADARSAT-2 data

[wang 2015] Modeling glacier elevation change from DEM time series.

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