The Cryosphere Discuss., 9, C592–C599, 2015
www.the-cryosphere-discuss.net/9/C592/2015/

The Cryosphere Discussions
Open Access

Interactive comment on "Four decades of glacier variations at Muztag Ata (Eastern Pamir): a multi-sensor study including Hexagon KH-9 and Pléiades data" *by* N. Holzer et al.

Anonymous Referee #1

Received and published: 27 April 2015

General comments

The paper "Four decades of glacier variations at Muztag Ata (Eastern Pamir): a multi-sensor study including Hexagon KH-9 and Pléiades data" aims at complete quantitatively the study of the Muztag Ata glaciers, located in the Eastern Pamir mountain range (Central Asia), between 1973 and 2013. The methodology is based on the use of remote-sensing data acquired from multi-missions: Hexagon KH-9 (1973), Landsat 7 ETM+/ SRTM-3 (2000), ALOS-PRISM (2009), and Pléiades (2013). The study presents the geodetic mass balance and the area variations of the glacierized area (all glaciers), and focuses on the detailed variations of the thirteen largest glaciers. The glacier indicators highlight some marked discrepancies in space

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

and time but exhibit a nearly balanced budget for the last forty years. Precipitation, mainly due to the westerlies, are suspected to be the mean driver here, relativizing the influence of the air temperature changes. A special attention is paid on the misleading stagnancy of debris-covered glacier tongues. Surface velocities of the largest glacier of Muztag Ata, Kekesayi Glacier, is generated by TerraSAR-X (2011) amplitude tracking. Compared to the surface elevation change, both indicators confirm a down-wasting state in the glacier terminus while the area changes are nearly absent.

This study exploits an interesting set of satellites images. The declassified data from the photo-reconnaissance satellite systems of the “Key Hole”- series (Corona, Hexagon..) have been already successfully used in previous glaciers studies to reconstruct historical variations at metric or decametric resolution. Recent Pléiades twin satellites have confirmed their potential to provide very high resolution DEM in glaciology. Due to its almost-global coverage and its accuracy widely studied, SRTM data are often used both as reference and dataset, even if the coarse resolution and the band radar penetrations into snow and ice lead to some problems (considered in this study). Given that the methods applied are valid and suitable, this study provides a new and highly valuable dataset of glacier indicators over the Eastern Pamir glaciers. The importance given to the uncertainties estimations, which are of paramount importance in such estimations, confirms the high overall quality of this study. Beyond the technical aspects, glacier studies in that part of Central Asia are of particular relevance for the hydro-climatic issues. In the context of contrasted pattern identified recently in Central Asia, this study provides a temporal depth both at a massif and an individual scales. This contribution is therefore highly valuable and should be published in TC.

Before its publication in TC, however, some structural aspects should be considered. As highlighted in the title, the paper has a tendency to focus a little bit more on technical aspects, which are greats, but thematic insights should remain dominant and

TCD
9, C592–C599, 2015

be emphasized. The sections Introduction and Study site should be reconsidered. The section Data could be shorten. In the discussion part, the subsection 8.6 does not provide a lot of new informations and could be merged with 5.2.2. The linkage with climate drivers is probably the weaker part, due to the difficulty to have long-term in situ measurements and the lack of previous studies.

Specific comments

Introduction:

P.1814. Please reconsider the structure of the introduction. The precise description of the Muztag Ata massif (L1-5) should be displaced to the study site. The introduction could open on what we know about the glaciers of the (East) High Mountain of Asia (your review, L10-20), highlighting the difficulties to know something (lack of glaciological data, lack of temporal depth, observed contrasted pattern, "anomalies" respect to temperature changes/other glaciers behavior...). By insisting a little bit more on the relative location of the (East) Pamir massif over Central Asia, the interest of studying the glaciers of Muztag Ata massif could be strengthen (water resources, climate proxy, temperature and precipitation variations...). Same remark for the (great) interest in having a dataset which allows a reconstruction back to 1973. It is also difficult to have an idea of the relative importance of the Muztag Ata glaciers compared to the East-Pamir or Pamir glacierized area (e.g., you can give a proportion by area).

L 20. Please change paragraph when you address the issue of the climatic drivers.

Study site:

P. 1815. Given the lack of in situ meteorological measurements, you could exploit here the equilibrium-line altitude data to improve the description of the study site. Apparently, this ELA data are not used in the result/discussion sections. Section 8.4 L9-12 contains useful informations about mean annual precipitation at glacier site which should be cited here. Conversely, L26 to L29 or even to P1816 L7 could be reserved

TCD
9, C592–C599, 2015

for section 8.4 (“climate change”). In Duan et al, 2007, some analyses performed on the extracted ice core (mentioned here) propose a snow accumulation reconstruction, which could be of some interest for that study (particularly in subsection 8.4).

Data:
P1816. I guess than this section could be slightly shorten (e.g. P1817. L5-10; L22-26).
P1817. Pléiades Data. Please distinguish the accuracy between Pléiades 1A and 1B as mentioned in Berthier et al., 2015 :“Without ground control points (GCPs), the horizontal location accuracy of the images was estimated at 8.5m (CE90, Circular Error at a confidence level of 90 %) for Pléiades-1A and 4.5m for Pléiades-1B (Lebègue et al.,2013).”
P1817 Line 15: this sentence is unclear to me. What zone does the image of 3 August 2013 cover ?

Data processing:
P1820. Could you precise the proportion of GCPs extracted from ICESat, and SRTM respectively, and the number of checkpoints for each source.
P1822.L4 Which software or programming environment did you use to perform the analytical approach ?

Assessment of glacier variations:
p1823. L14. How many glaciers do represent “all glaciers” ? If you generated the inventories from the Pléiades data first (2013), I therefore suppose you that you did not notice any complete glaciers disappearance since 1973 ? Have you in mind to propose this inventory to the WGS, GLIMS or RGI databases ?
P1824. The sentences from L5 “All three [...]” to L11 should be move to subsection 4.2.2. You selected thirteen glaciers according to their orientation and size. Which is the representativity compared to the elevation range ? I guess that an extra figure

TCD
9, C592–C599, 2015

showing area vs. hypsometry of the all glacierized area could help. Which proportion is windward or leeward, according to the north-south “natural” separation ?
P1824. L20 You could also have consider the mean of the glacier sizes for the two dates (Zemp et al., 2013).
P1825 L24 By ice, do you mean “summer surface” (see Cogley et al.,2011) ?
P1826 L2 Could you check the sign of the offsets ? I am probably wrong on that, but I would have say the contrary.

Discussion:
P1831 L1 to 4: the end of the sentence is unclear to me. Why do you expect less glacier shrinkage at Muztag Ata ?
P1830. Surges are not linked with mass gain. Surges complicate the interpretation of glacier variations, but in my opinion it should not be directly “opposed” to the glacier shrinkage. Such ambiguously formulation is also present in the introduction (P1814 L15: “but”). Apparently, you did not observe surges in your glacier indicators variations ? If it is true, you could mention it.
P1831: it should be interesting to say something about mass-balance variations along a vertical profile.
P1832 L3 to 11: this sounds very interesting. Being very careful, do you think we can make any assumptions about common (topo-)climatic (or meteorological, given the short period) drivers (“strengthening werterlies” ?) to make a link with section 8.4 ? Maybe some regional meteorological datasets could help (CRU/GPCP), and some references: a short review on that question (in French): (Berthier, 2015), about Global Precipitation Climatology Project (GPCP): (Adler et al., 2003), about the seasonality of the observed precipitation trends: (Fujita, 2008; Kapnick et al., 2014), and eventually about the elevation influence: (Hewitt, 2011).
P1832 : maybe you can cite Zhou et al., 2013 to complete the comparison on glacier surface dynamics ?
P1833 L27 to P1834 L3: due to the very different time periods considered, I think that

TCD
9, C592–C599, 2015

it is out of the scope of this study. You can move it to the introduction section or simply remove it.
P1834 L20: Is it possible to better characterize this “cooling period” in temperature and precipitation changes ?

Conclusion:
The conclusion should tell something about the possibility of a wide-regional “positive anomaly” (from section 8.2 and 8.4).

Table 1: please precise which images are from Pléiades 1A or 1B.
Table 4: you should consider a more classical chronological way: 1973-1999; 1973-2009 and so on.
Figure 1: this figure is a little bit dense. Glacier extents variations are difficult to read (particularly 2009 outlines, in blue). You should propose a new figure, highlighting the location of Muztag Massif in a “regional” context (with Taxkorgan meteorological station location and hydrological network for example). Extracted ice core location could be also mentioned.
Figure 2 is constituted by two type of images: please split it into two figures or choose between one type of data. Distortion vectors image (KH-9) is maybe less common.
Figure 3: maybe the title should be remove; Muztag Ata is also a glacier, so it is a lit bit confusing.
Figure 4 to 6: you should consider a more classical chronological way, starting from 1973 (see also table 4).

Technical corrections
P1813 Line 10: you should precise the year (2011) for the TerraSAR-X amplitude tracking.
P1813 Line 11: you should precise: “[...] temporal glacier variations [...]”.

TCD
9, C592–C599, 2015

P1815 Line 18: when introducing Kekeyasi Glacier for first time, please precise that the number into parenthesis is a GLIMS Id. The word “Glacier” is missing after Kekeyasi.
P1816 Line 13: please precise that the number into parenthesis refer to the mission Id.
P1818 Line 5 : it is maybe clearer if you give the date information first : “The data was acquired on 10 September 2009, and provided with RPC”.
P1827 Line 12: is the verb “be” correctly located ?
P1832 Line 3: please change paragraph.
P1836 Line 23:”eventually”should be replace by “possible” or an equivalent adjective (this confusion seems to appear in some other parts of the text).
P1837 Line 13 to 15: is the verb “present” correctly located ?

Publications cited in this review:

Adler, R. F. et al. (2003), The Version-2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present), J. Hydrometeor, 4(6), 1147–1167, doi:10.1175/1525-7541(2003)004<1147:TVGPCP>2.0.CO;2.
Berthier E. Evolution récente des glaciers. Que nous apprennent les satellites ? Habilitation à Diriger les Recherches, Université Paul Sabatier, 1st April 2015 . http://etienne.berthier.free.fr/articles.htm (last access 27 April 2015).
Berthier, E., Vincent, C., Magnússon, E., Gunnlaugsson, Á., Pitte, P., Le Meur, E., Masiokas, M., Ruiz, L., Pálsson, F., Belart, J. M. C., and Wagnon, P.: Glacier topography and elevation 15 changes derived from Pléiades sub-meter stereo images, The Cryosphere, 8, 2275–2291, doi:10.5194/tc-8-2275-2014, 2014. 1817
Cogley, J. G., Hock, R., Rasmussen, L. A., Arendt, A. A., Bauder, A., Braithwaite, R. J., ... Zemp, M. (2011). Glossary of glacier mass balance and related terms, IHP-VII technical documents in hydrology No. 86, IACS Contribution No. 2. International Hydrological Program, UNESCO, Paris.
Duan, K. Q., Yao, T. D., Wang, N. L., TIAN, L. D., XU, B. Q., WU, G. J. (2007). Records of precipitation in the Muztag Ata Ice Core and its climate significance to glacier water

resources. Journal of Glaciology and Geocryology, 29(5), 680-684.
Hewitt, K. (2005), The Karakoram anomaly? Glacier expansion and the "elevation effect," Karakoram Himalaya, Mountain Research and Development, 25(4), 332–340.
Kapnick, S. B., T. L. Delworth, M. Ashfaq, S. Malyshev, and P. C. D. Milly (2014), Snowfall less sensitive to warming in Karakoram than in Himalayas due to a unique seasonal cycle, Nature Geosci, advance online publication.
Fujita, K. (2008), Effect of precipitation seasonality on climatic sensitivity of glacier mass balance, Earth and Planetary Science Letters, 276, 14–19, doi:10.1016/j.epsl.2008.08.028.
Lebègue, L., Greslou, D., Blanchet, G., De Lussy, F., Fourest, S., Martin, V., Latry, C., Kubik, P., Delvit, J.-M., Dechoz, C., andAmberg, V.: PLEIADES satellites image quality commissioning, Proc. SPIE 8866, Earth Observing Systems XVIII, 88660Z (23 September 2013), doi:10.1117/12.2023288, 2013.
Zemp, M., Thibert, E., Huss, M., Stumm, D., Rolstad Denby, C., Nuth, C., Nussbaumer, S. U., Moholdt, G., Mercer, A., Mayer, C., Joerg, P. C., Jansson, P., Hynek, B., Fischer, A., Escher-Vetter, H., Elvehøy, H., and Andreassen, L. M.: Reanalysing glacier mass balance measurement series, The Cryosphere, 7, 1227-1245, doi:10.5194/tc-7-1227-2013, 2013.
Zhou, J., Li, Z., Guo, W. (2014). Estimation and analysis of the surface velocity field of mountain glaciers in Muztag Ata using satellite SAR data. Environmental earth sciences, 71(8), 3581-3592.

Interactive comment on The Cryosphere Discuss., 9, 1811, 2015.