

# ***Interactive comment on “Assessment of Glacier Area Change in the Tekes River Basin, Central Tien Shan, Kazakhstan Between 1976 and 2013 Using Landsat and KH-9 Imagery” by Z. Usmanova et al.***

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We are grateful to the Reviewers' and Editor's comments and particularly to Dr. Paul's suggestions which we find very helpful. We agree with two main points that the number of glaciers is small and that additional imagery can be used. We will expand the study to the whole of the Tekes basin and use Landsat 1989 and KH4 for the whole of the Tekes basin to improve the coverage.

Comments by Dr. Paul. The selection of the relatively small area for mapping is due to the fact that there is no information on this specific region while work has been done

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on the neighbouring areas. It also provides input data to modelling discharge in rivers Bayankol and Tekes (within the borders of Kazakhstan before it flows into China) and this is an important practical consideration behind this work. We used Landsat 1992 imagery and we accept that the 1989 image is of better quality. Regrettably, it was published quite late into the study and not used for this reason (except an unfortunate mistake in Fig. 3). A comparison of glacier area derived from both images, however, shows that the difference is small – 1.6% - and this is well within the uncertainty of measurements. The fact that most glaciers have northern aspect does not disqualify this study. Various ranges in the Tien Shan have glaciers with predominant aspect, e.g. northern aspect predominates in the ZailiiskiyAlatay to which comparisons are made and in this case, it's glacier size that is a controlling factor. However, we accept that maybe a more detailed analysis of the published literature and comparisons with other regions based on aspect are required. We reject the comments on uncertainty assessment. The uncertainty of measurements results from the uncertainty of mapping by individual operator and geolocation and the buffer methods modified by Bolch et al. (2010) from Granshaw and Fountain (2006) is an accepted way of quantifying the latter. While geolocation may be ignored when glacier areas are mapped using imagery for a single year, neglecting it when measuring glacier change using different images from different years, sensors, etc is plain wrong as there will always be an uncertainty term, resulting from mis-registration of two images because of their different geometry, etc. Even when working with ASTER from 2000 and 2010 where there was no change in sensor, assessment of uncertainty on co-registration was required because different DEMs were used in 2000 and 2010 (Shahgedanova et al., 2014). So the correct way is to calculate the difference between the scalar area values as Dr. Paul suggested and add an uncertainty term on image co-registration calculated for both images although this will inevitably lead to higher uncertainty.

Comments by Reviewer 1 We thank Reviewer 1 for the suggestion to use KH4 imagery. Unfortunately, this imagery was not freely available at the time of data processing. It is of better quality than KH9 and will be used for mapping of the whole Tekes

basin. We reject comments by Reviewer 1 on the style of the paper as their command of English language does not qualify them to make such assessments. We point out that the style is offensive and this is both undeserved and unacceptable.

References Bolch, T., Menounos, B. and Wheate, R.: Landsat-based inventory of glaciers in western Canada, 1985-2005, *Remote Sens. Environ.*, doi:10.1016/j.rse.2009.08.015, 2010. Granshaw, F. D. and Fountain, A. G.: Glacier change (1958-1998) in the North Cascades National Park Complex, Washington, USA, *J. Glaciol.*, 52(177), 251–256, doi:10.3189/172756506781828782, 2006. Shahgedanova, M., G. Nosenko, S. Kutuzov, O. Rototaeva, and T. Khromova: Deglaciation of the Caucasus Mountains, Russia/Georgia, in the 21st century observed with ASTER satellite imagery and aerial photography. *The Cryosphere*, 8, 2367-2379, 2014.

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