Review of

"Satellite monitoring of glaciers in the Karakoram from 1977 to 2013 ……..

by R. M. Brahmbhatt et al., submitted to The Cryosphere

Dear Reviewer,

We sincerely thank referee for spending their valuable time in going through the manuscript and providing useful and valuable suggestions. A reply for each comment has been given in following pages.

Comments by Referee 2

Brahmbhatt et al. analyzed glacier changes in the Karakoram using satellite time series. They found that the majority of the glaciers remained stable between 1977 and 2013 based on the investigation of termini position changes. They present area changes of stable, retreating and advancing glaciers covering several time periods. The authors identified some surge-type glaciers based on annual area changes. The work is of general interest to the region, however some considerable shortcoming are obvious.

The authors do not manage to resolve contrasting findings of previous studies as stated in the introduction (P1558L24) nor are their methods really new as stated (P1557L20). The three examples of surge-type glaciers are very well known from literature.

The present study does not make the novelty of the findings clear and its impact for glacier research in the Karakoram. The analysis shown has been included in previous publications that haven been cited by the authors. The authors do not make clear where their advance in regard to these studies emerge besides that they provide area changes and not only frontal changes (e.g., Rankl et al., 2014; Copland 2011; Scherler et al., 2011). The resulting pattern of stable, advancing or retreating glaciers is basically the same. A more profound analysis in regard to glacier types would be required.

As far as the point that what is new in this study, every study is independent in terms of data, time, locations, etc. Opinion by the different research groups helps in drawing bold conclusions which cannot be done based on a single study. For example in one of the study it is shown that debris covered glaciers show lesser loss in glacier area than clean ice glacier (Brahmbhatt, et al., 2012; 2015). But this is otherwise known from so many literatures. In Himalayan region, there have been large number of studies on monitoring of glaciers, but in Karakoram, the numbers of studies are scanty.

Rankl, et al., has carried out monitoring of glaciers from 1976 to 2012 which is only case similar to our study. In their work, the intermediate intervals have not been shown. In this study resolutions of monitoring have been improved. Annual changes between 2000 and 2013 which help in finding behavior of glaciers more closely is new element of this study. Spatial distribution of changes in different intervals shown in the maps is a new element. Each glacier in terms of its movement at snout has been presented in our Figure 4 of the manuscript (tree of glacier movement) which we have not observed in any previously published work. This tree (about evolution of glacier) is a unique element which clearly indicates the behavior of so many glaciers in one diagram. Another significant outcome from this study is that fragmented glaciers

have shown advancement or surging and merged into main trunk glaciers. The number of stable, retreated, advanced glaciers in each decade has been brought out.

The discussion lacks any relation to previous publications and do not place the authors observation into a large context. Substantial new conclusions are not made.

The discussion and conclusion section has been reworked and modified as per the comments and the linkage to previous publications has been incorporated in the manuscript.

The presentation of the material must be considerably improved. In particular the maps from Fig. 7-13 cannot be read in the present version.

The figures are modified for clearer picture.

The connection made of surge-type glaciers to climatic changes need to be reconsidered. Unfortunately, the sentences are sometimes misleading and grammatically incorrect. The paper needs a thorough English proof reading and a revision of the structure.

In this paper, climate related conclusions have been removed. The English of the manuscript has been improved

Detailed comments and its reply

Comment: P1557L18: Gardelle et al. (2013) did not use gravimetry for their measurements.
It has been modified as per the suggestion.

Comment: P1558L2 and below: the citation is not correct. It should be Mayer et al. (2004) has carried out...

We have rechecked with the citation mentioned by referee. However we found that it is done by Hewit et al., 2005 and we couldn't find any article of 2004 published by Mayer.

Comment: P1558L11: it should be 'area changes' P1558L18: I don't think that all the data on glacier inventories, velocities etc. are available in GLIMS.

The structure of the introduction has been reworked and it has been rewritten as per the suggestions. The findings of the key researchers have been discussed mainly focusing on glacier

monitoring, status of mass balance using different approaches and glacier dynamics for Himalaya-Karakoram region.

Comment: P1558L20ff: It is not really clear what the satellite images were analyzed for. What was the goal of this study?

We regret that we do not agree with referee's comments because it is clear from the manuscript that images have been analyzed for finding changes in glacier extents for various time frames and to compare their behavior with other glaciers of adjacent other mountain ranges.

Comment: P1558L23: Please make clear what is new in your study in regard to previous ones P1560L18: Although your glacier mapping was done by one author only, it might be influenced by subjective errors. This kind of error is not eliminated by choosing only one person who does the mapping. I think your interpretation of Raup et al. (2014) might be misunderstood.

We have stated in above pages about the novelty of our study.

In all the applications of remote sensing the accuracy of mapping remain about 90% because of mixed pixels which are either on the periphery of each class or within classes for heterogeneous land cover which has been reported in literatures by various researchers.

In our study the mapping of the glacier has been done along with an experienced team in the field of remote sensing and glaciology. The section of uncertainty has been revised and compressed. Subjective errors differ from one study to another however it is assumed that the interpretation of images for particular theme has been done by experienced people. There is always a scope of variation of the results in all the applications of remote sensing and not only in glaciology.

Comment: P1565L20: Reconsider the wording 'deglaciation/glaciation' for describing retreating/advancing glaciers, respectively!

It has been modified in the manuscript.

Comment: P1565L23: What is described here, are the surges of the tributary glaciers into Panmah/Nobande Sobonde Glacier. It has been already studied in detail by Hewitt (2007). The main trunk glacier is called Panmah Glacier and it was already there and not formed out of the

surging tributary. P1565L22-27: The examples of surging glaciers described here are all well known from previous literature (e.g., Bhambri et al., 2013; Hewitt 1998, 2007; Copland et al., 2011 etc).

Yes, it might be published but the aim of entire paper is not to prove the surging (hardly 10 glaciers from 607 glaciers) but to demonstrate by another set of examples that the glaciers of Karakoram are not in similar state as in adjacent Himalayan region. And this kind of monitoring in different intervals and clear presentation of change in glaciers in map format has not been reported earlier.

Comment: P1566 Discussion: The discussion section does not really discuss the results. It looks more like a collection of assumptions on the behavior of different types of glaciers. The section repeats findings of previous studies without referencing them.

The section “Discussion” is merged with results to avoid the repetition in the manuscript. Moreover, our results are discussed with other available results also.

Comment: Table 2: The periods of investigation differ from these mentioned in the introduction

It has been modified

Comment: (P1558L21). Figure7: reconsider using a stretched color bar in order to show the distribution of 3 discrete classes in the map! What is the difference between red and orange pixels? Figure 17: It would be nice to see the location of these glaciers in an overview map.

The figures have been modified as per the comments. The location of these glaciers is given in Figure 17 as per the suggestions. Red represents the higher retreat in comparison to orange pixel. However, all the figures have been reworked and modified to increase the clarity for readers. This has been incorporated in the manuscript.