



## Reply on RC2

Shakil Ahmad Romshoo et al.

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Author comment on "Evaluation of the global and regional glacier inventories and assessment of glacier elevation changes over the north-western Himalaya" by Shakil Ahmad Romshoo et al., Earth Syst. Sci. Data Discuss.,  
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### Reviewer #2

**General Comment:** This is a useful contribution and in general seems a well-conducted assessment. Avoiding measurement bias is paramount for geodetic mass balance in particular, and some more evidence is needed to demonstrate that this has been achieved.

**Response:** We express our gratitude to the reviewer for the very useful review of the manuscript. The valuable comments and suggestions provided by the reviewer have improved the contents of the manuscript. We have responded point-by-point to all the comments and suggestions of the reviewer. The concerns of the reviewer about error estimates have been addressed entirely to the best of our ability and knowledge. The revised manuscript looks significantly improved. The point-by-point response to the detailed comments and suggestions raised by the reviewer are provided as follows:

**Comment#1:** Sections 2.1, 2.2 and 2.3: please check the Jhelum minimum temperature - should be negative? Please provide consistent descriptive stats, e.g. annual precip in each case rather than mixing monthly and annual.

**Response:** Thanks for the suggestion, we rechecked the mean minimum temperature and found it above zero, this has been previously reported. These sections have been however revised providing temperature and precipitation on same time scales.

**Comment#2:** Line 279 - area calculation in 'ArcGIS environment' - what projection was used? Please ensure that an area-preserving projection is used when defining the glacier areas and, by extension, their volume changes.

**Response:** In the present study we used the Mercator projection system considered suitable for use in areas between 84°N to 80°S. Also since all the inventories under consideration use the same projection system, therefore, it is assumed that any distortion in area would be same for all the inventories and would not affect the comparative analyses of the inventories evaluated in this study.

**Comment#3:** Equation 6: good error quantification is vital in geodetic mass balance calculations. Please explain the  $\sigma_z$  DEM uncertainty term. Is this a generic estimate of DEM quality, or is it specifically applicable to snow-covered surfaces and steep slopes? These are notoriously difficult to map topographically, particularly in optical images. The voidfill error term is not defined. Please explain and justify using the penetration error as a random, uncorrelated error in this case. If penetration is wrong, it will be a systematic error and so should be added and not combined in quadrature.

**Response:** Thanks for the comment and suggestions. The  $\sigma_z$ ,  $\sigma_{void}$ , and  $\sigma_{pen}$  are uncertainty of DEM differencing, uncertainty due to void filling (Since the DEMs especially SRTM has voids over the study area as such the DEMs coverage for each having voids >30% were excluded from the analysis whereas, the glaciers with <30% voids were filled with natural neighbor interpolation algorithm), temporal uncertainty of TanDEM-X and uncertainty of radar signal penetration respectively.

was calculated using the widely accepted approach, considering the spatial autocorrelation as:

where  $\sigma_{\Delta h}$  is the off-glacier NMAD,  $A$  is the glacier area analyzed and  $A_{cor} = \pi d^2$ , with  $d$  being the decorrelation length, we used a  $d=950$  m observed for Jammu and Kashmir Himalaya, encompassing the present study area (Abdullah et al. 2020). For the estimation voidfill uncertainty we again followed (Abdullah et al. 2020) where a set of glaciers (void free) distributed across the study region were selected and >30% voids were artificially created. The artificially created voids were then filled using different interpolation algorithms and the results were compared with the original values (glacier without voids). The voids filled with using natural neighbor algorithm were found in good agreement with the original values with just  $\pm 0.07$  difference between the original and interpolated values. The difference of  $\pm 0.07$  introduced due to the void filling was therefore considered as uncertainty due to voidfill (Abdullah et al. 2020). The penetration bias was calculated using the following exponential function determined for the neighboring Lahaul-Sipti region by Vijay and Braun, 2016:

where 'x' is absolute surface elevation and 'y' is the relative penetration bias between SRTM X and C band. The uncertainty of each of the individual parameter is described in detail in the revised manuscript.

**Comment#4:** Line 342: error assessment in off-glacier areas is good to do, but this is not reported or shown in the  $dh/dt$  figures. If it reveals systematic biases then these should be corrected to zero. This requires assessment at as many off-glacier locations as possible, at a range of altitudes, as the DEM biases are often not uniform across a scene. The initial and corrected off-glacier stats should be reported and shown in the figures.

**Response:** The elevation change estimates are based on Abdullah et al. 2020 where the error estimation is described in detail including the off glacier biases in various  $5^\circ$  slope bins. The study reported mean off-glacier elevation difference of  $0.06 \text{ m a}^{-1}$ .

**Comment#5:** Table 2: KUGI glacier volumes - the calculation of volume is not trivial and is not explained. Where do these come from?

**Response:** The glacier volume was estimated using the slope-dependent volume estimation approach (Haeberli and Hoelzle, 1995). The methodology to estimate volume has been incorporated in the revised manuscript.

**Comment#6:** Figures 2 and 3: please show a background map, scale bar and the apparent  $dh/dt$  values off-glacier.

**Response:** As suggested, the figures have been modified in the revised manuscript.