*Supplement of*

**An estimate of glacier mass balance for the Chandra basin, western Himalaya for the period 1984-2012**

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**Supplement**

**S1. Limitations of the climate data**

Meteorological variables used in the present analysis for 1984–2012 are from Kaza station. Both Kaza station and the Chandra basin are located in the orogenic interior in the valley of Lahaul–Spiti district. To assess if reanalysis products could be used for the period 2013-16 to fill the data gap, we analyse precipitation data from CRU (Climatic Research Unit), APHRODITE (Asian Precipitation – Highly-Resolved Observational Data Integration Towards Evaluation) and GMFD (Global Meteorological Forcing Dataset) at the grid point in which Kaza station is located for the period 1984-2005 (Fig. S1). We find that these data products show a large phase shift in annual precipitation cycle. This could significantly affect our results, i.e. accumulation and hence mass balance. Therefore, we have decided to use only the data from Kaza station (1984-2012).



**Figure S1.** The seasonal cycle of precipitation (mm d−1) at Kaza station averaged over the period 1984-2005. The precipitation from the CRU, APHRODITE and GMFD datasets at the grid point where Kaza station is located are also shown.

**S2. Mass balance estimates from TI model**

Mass balance estimates from the TI model are now added to table 5 of Tawde and others (2016) using climate data from 2010-12 and are shown as Table S1. In this table, we compare our model-derived mass balance with the geodetic and TI model estimates for eight selected glaciers in Tawde and others (2016). As the performance of the TI model is dependent on input parameters, we consider two scenarios. In the first scenario, the inputs for the TI model, i.e. lapse rates, precipitation gradient and snow melt factors, are taken from our present analysis. An ice melt factor of 9.35 mm °C–1 d–1 is used considering ice density as 850 kg m-3 to maintain uniformity with the geodetic analysis, and an ELA value of 5400 m a.s.l is used. In the second scenario, the tuned input parameters over Chhota Shigri glacier and from Bhuntar station data (Azam and others, 2014) are applied, but the meteorological variables are obtained from Kaza station.

 The model-derived and geodetic mass balance estimates are in agreement, as discussed in Tawde and others (2016), but the TI model overestimates mass loss in both scenarios. The large deviation in mass balance estimates by the TI model could be because of (1) extrapolation of input parameters from glacier to basin/regional scale and (2) differing climatology at different meteorological stations from which the climate variables and parameters are derived. Further investigation to understand the disagreement between the TI model and our methodology is needed in the future.

**Table S1**

Comparison of modelled mass balance (m w.e. a-1) with geodetic mass balance (Gardelle and others, 2013; Vijay and Braun, 2016) and the TI model for eight glaciers in the basin during 1999-2012. The selected eight glaciers are from Tawde and others (2016)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Glacier name/ number** | **Present study** |  | **Geodetic method** | **TI model** |
| Conventional AAR method\* | **Gardelle and others (2013)**† | **Vijay and Braun (2016)** | **Scenario 1** | **Scenario 2** |
| ChhotaShigri | -0.76 ± 0.46 | -0.04 ± 0.50 | -0.39 ± 0.15 | -0.46 | -5.52 | -4.00 |
| Hamtah | -1.22 ± 0.46 | -0.78 ± 0.50 | -0.45 ± 0.15 |  | -9.96 | -9.66 |
| 20689 | -0.65 ± 0.46 | 0.02 ± 0.50 | -0.87 ± 0.15 | -0.93 | -3.29 | -1.64 |
| 20313 | -0.59 ± 0.46 | 0.13 ± 0.50 | -0.26 ± 0.15 | -0.50 | -2.46 | -1.34 |
| 20770 | -0.65 ± 0.46 | -0.02 ± 0.50 | -0.49 ± 0.15 |  | -3.22 | -1.60 |
| 20739 | -0.66 ± 0.46 | -0.04 ± 0.50 | -0.59 ± 0.15 | -0.60 | -4.11 | -2.87 |
| 21887 | -0.20 ± 0.46 | 0.02 ± 0.50 | -0.5 ± 0.15 |  | -0.6 | 0.84 |
| 20986 | -0.26 ± 0.46 | 0.12 ± 0.50 | -0.51 ± 0.15 |  | -0.73 | 0.71 |
| **Mean** | **-0.62 ± 0.46** | **-0.07 ± 0.50** | **-0.54 ± 0.15** | **-0.62** | **-3.74** | **-2.45** |

\* The conventional AAR method has a data gap at year 2003.

† The mass balance estimates are during the period of 1999-2011.