Supplement of The Cryosphere, 18, 5653–5672, 2024
https://doi.org/10.5194/tc-18-5653-2024-supplement

The Cryosphere Open Access EGU

Supplement of

Reanalysis of the longest mass balance series in Himalaya using a nonlinear model: Chhota Shigri Glacier (India)

Mohd Farooq Azam et al.

Correspondence to: Mohd Farooq Azam (farooqazam@iiti.ac.in, farooqaman@yahoo.co.in)

Table S1: Details of point mass balance data collection since 2002.

Year	Abl. PMBs	Acc. PMBs (east)	Acc. PMBs (west)	Acc. Point MBs	Total Point MBs	Date for measurements	Elevation of lowest/highest abl. PMBs	Elevation of lowest/highest acc. PMBs	Comment
2002	-	-	-	-	-	1-7 October 2002	4357/4932	-	1
2003	12	3	0	3	15	1-8 October 2003	4360/4886	5180/5500	2
2004	20	3	0	3	23	19-24 September 2004	4355/4976	5180/5500	2
2005	28	2	0	2	30	1-7 October 2005	4355/4884	5180/5500	2
2006	22	1	0	1	23	28 Sept -4 October 2006	4363/5090	5170	3
2007	16	1	0	1	17	27 Sept -5 October 2007	4363/4913	5180	3
2008	15	1	0	1	16	2-13 October 2008	4363/5090	5171	3
2009	10	5	2	7	17	3-14 October 2009	4423/4806	5090/5550	-
2010	25	3	2	5	30	2-13 October 2010	4365/4881	5160/5300	3
2011	25	4	2	6	31	5-13 October 2011	4390/4906	5160/5520	-
2012	15	3	2	5	20	7-15 October 2012	4496/4902	5160/5303	3
2013	22	3	2	5	27	27 Sept-07 Oct 2013	4351/4897	5158/5303	3
2014	21	3	0	3	24	2-8 October 2014	4394/4991	5180/5200	3
2015	13	0	2	2	15	4-12 October 2015	4382/4927	5150/5100	4
2016	16	2	1	3	19	2-7 October 2016	4426/4900	5150/5285	3
2017	16	4	2	6	22	4-8 October 2017	4326/4771	5161/5266	3
2018	15	0	0	0	15	12-16 September 2018	4276/4786	-	5
2019	14	3	2	5	19	15-19 September 2019	4276/4794	5170/5310	3
2020	2	0	0	0	2	06 October 2020	4739/4764	-	6
2021	0	0	0	0	0	-	-	-	7
2022	23	1	2	3	26	3-10 October 2022	4263/4893	5150/5215	3
2023	23	1	2	3	26	12-17 September 2023	4263/4893	5206/5300	3

1. A total of 14 stakes were installed in the ablation area to initiate the mass balance observations.
2. Accumulation in western tributary glacier was assumed to be similar as in the eastern side.
3. No accumulation measurement was done at 5500 and it was extrapolated from previous years.
4. No accumulation measurement was done in east part, and it was extrapolated from previous years.
5. No accumulation measurement was done, and it was extrapolated from previous years.
6. No accumulation measurement was done, and only two stakes were observed so mass balance could not be estimated.
6. No field measurements were done hence mass balance could not be estimated.

Table S2: The modelled spatial terms (α_i and γ_i) for each location.

Easting	**Northing**	**Elevation (m a.s.l.)**	α_i	γ_i
738200	3572100	4339	-4.33	0.96
738200	3571900	4359	-4.29	0.95
738000	3571900	4373	-4.49	0.95
738000	3571700	4410	-4.40	0.93
738000	3571500	4415	-4.62	0.93
737800	3571300	4444	-4.04	0.92
738000	3571300	4464	-4.19	0.91
737800	3571100	4490	-3.81	0.90
737600	3570900	4496	-4.11	0.90
737600	3570700	4541	-3.74	0.88
737600	3570500	4558	-3.71	0.88
737400	3570100	4575	-3.04	0.87
737400	3570500	4581	-3.32	0.87
737200	3570500	4586	-3.77	0.87
737400	3570300	4600	-3.41	0.86
737200	3570300	4620	-3.22	0.85
737000	3570100	4624	-3.28	0.85
736800	3569700	4655	-3.34	0.84
737000	3569900	4661	-3.37	0.83
737200	3569700	4671	-3.27	0.83
737000	3569300	4672	-2.95	0.83
736600	3568900	4714	-2.96	0.81
737000	3569100	4715	-2.73	0.81
736800	3569300	4716	-3.06	0.81
736800	3568700	4726	-2.64	0.81
736600	3568500	4747	-2.69	0.80
736600	3568700	4749	-2.55	0.80
736800	3568500	4754	-2.67	0.79
736800	3568300	4760	-2.21	0.79
736600	3568300	4765	-1.95	0.79
736400	3568300	4778	-1.91	0.78
736800	3568100	4782	-2.24	0.78
736600	3568100	4784	-1.93	0.78
736400	3568100	4802	-1.86	0.77
736800	3567900	4813	-1.41	0.76
736200	3568100	4825	-1.98	0.76
737000	3567700	4835	-1.32	0.75
736000	3568500	4861	-1.74	0.74
737000	3567300	4870	-1.33	0.74
736000	3568300	4876	-1.24	0.73
735800	3568300	4882	-1.29	0.73
737000	3567100	4893	-1.09	0.72
737000	3566900	4903	-0.48	0.72

735800	3568500	4907	-1.60	0.72
737400	3566100	4984	-0.18	0.68
735600	3569900	5090	-0.67	0.62
737800	3565300	5158	1.11	0.57
737800	3565500	5162	0.95	0.57
738000	3565700	5175	0.70	0.56
738000	3565500	5205	0.80	0.55
735200	3569100	5207	0.81	0.54
735000	3569500	5299	0.93	0.48
738600	3565900	5405	1.91	0.41
738600	3566300	5514	1.36	0.33

Table S3: The modelled temporal term (β_t) for each year. The point MBs for each location and year can be calculated using the spatial terms from Table S2 and temporal term from this table following equation no 2 for each location and year.

Year	$\boldsymbol{\beta_t}$
2003	-0.86
2004	-0.92
2005	1.59
2006	-0.93
2007	-0.58
2008	-0.21
2009	1.27
2010	1.50
2011	0.57
2012	0.17
2013	-0.60
2014	0.75
2015	0.52
2016	-0.79
2017	-0.83
2018	-1.04
2019	1.42
2020	-0.52
2021	0.66
2022	-2.08
2023	0.93

Geodetic mass balance over 2003-2020:

In the main manuscript, the geodetic mass balances (MBs) for Chhota Shigri Glacier have been estimated over two periods of 2003–2014 and 2014–2020 using satellite stereo images from ASTER (08/10/2003) and Pléiades (26/09/2014 and 12/09/2020). Here, the MB is also estimated over the full period of 2003–2020 using ASTER (08/10/2003) and Pléiades (12/09/2020) DEMs and used to calibrate MBs from nonlinear model and traditional glaciological method. The estimated geodetic MB over 2003–2020 is –0.45 ± 0.10 m w.e. a^{-1} (equivalent to a total mass wastage of –7.62 m w.e.), slightly different from the weighted average MB of –0.43 m w.e. a^{-1} (equivalent to a total mass wastage of –7.33 m w.e.) of 2003–2014 and 2014–2020 periods. Figure S2 shows the calibration results using geodetic MB estimates over two periods (2003–2014 and 2014–2020) and one single period (2003–2020).

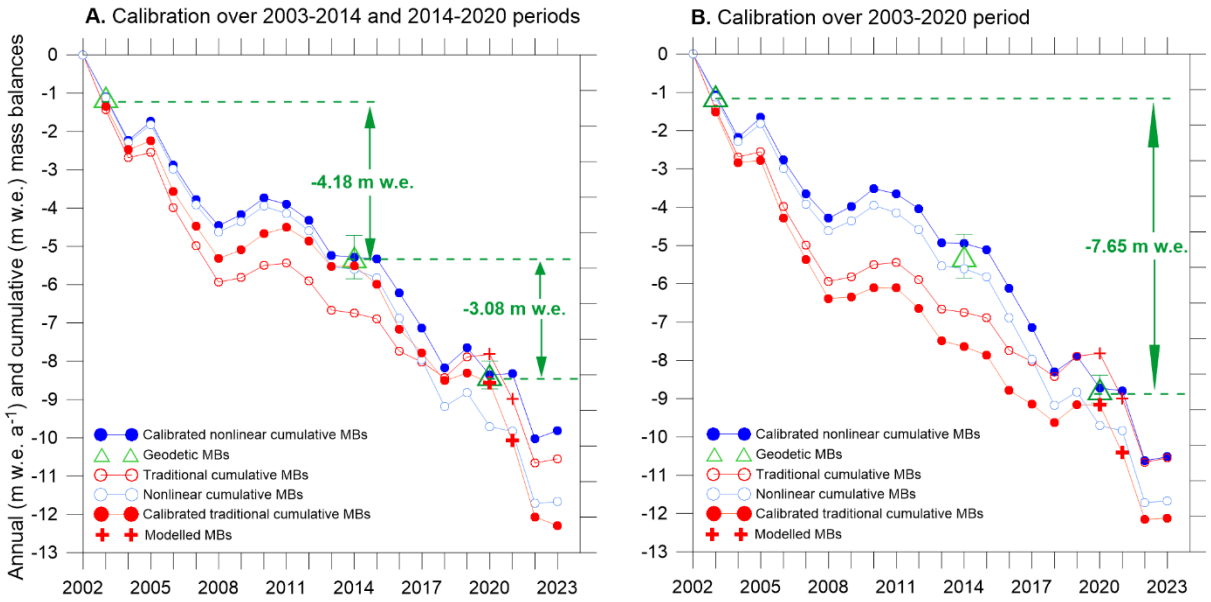

Figure S1: The calibration of homogenized glacier-wide MBs from traditional and nonlinear model using geodetic MBs over two periods over 2003-2014 and 2014-2020 (A) and one period (B) 2003-2020.

Comparison of all in-situ, extrapolated and modelled point-MBs over 2003-2023:

Figure S2 shows the in-situ point-MBs (including the erroneous measurements), all extrapolated MBs (used in glacier-wide MBs estimated in the previous studies) and the modelled point-MBs against their corresponding elevations for each year between 2002 and 2023.

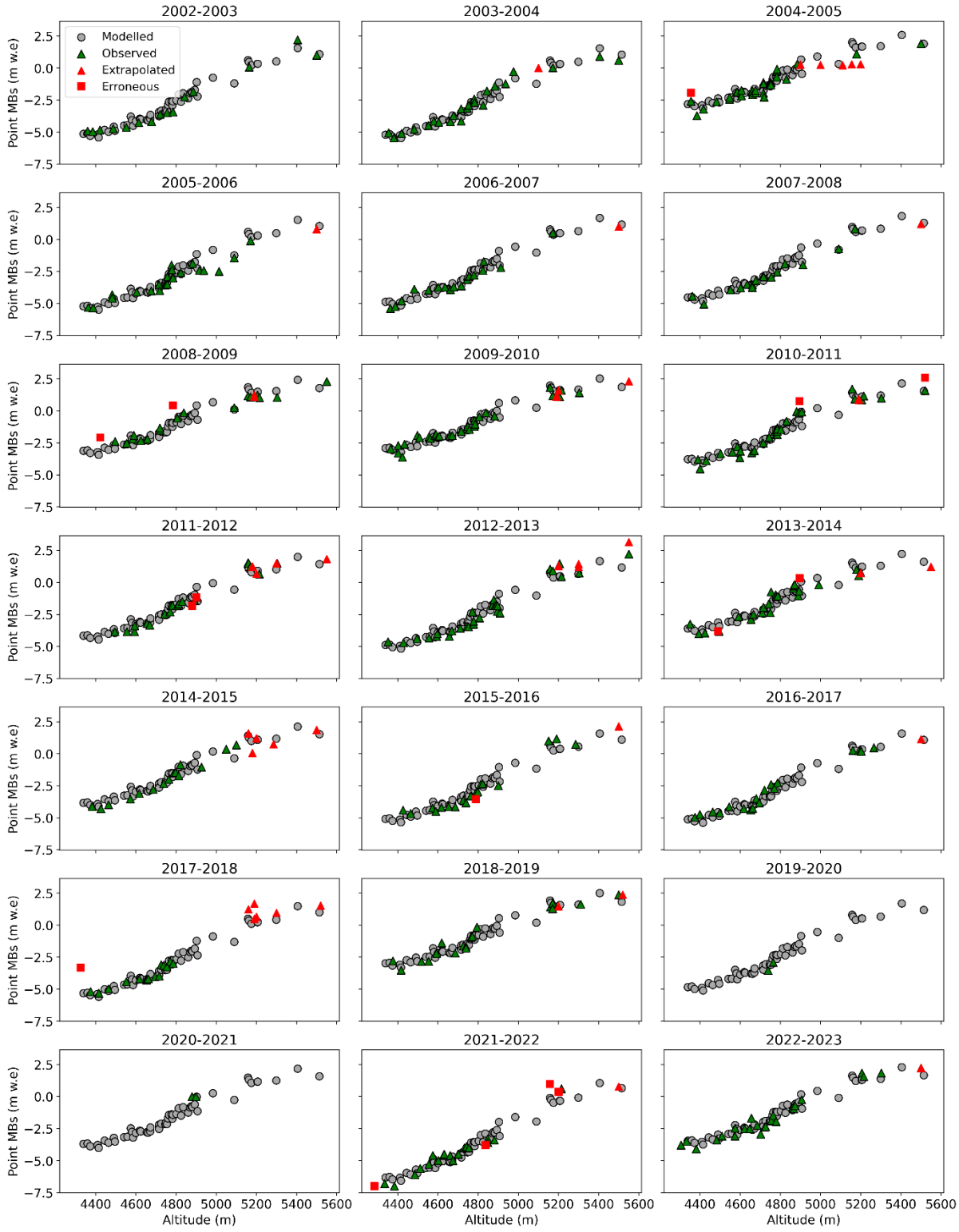

Figure S2: The observed (green triangles) and modelled (grey circles) point MBs against their corresponding elevations for the hydrological years between 2002 and 2023. The extrapolated (red triangles) and erroneous (red squares) point MBs are also shown.

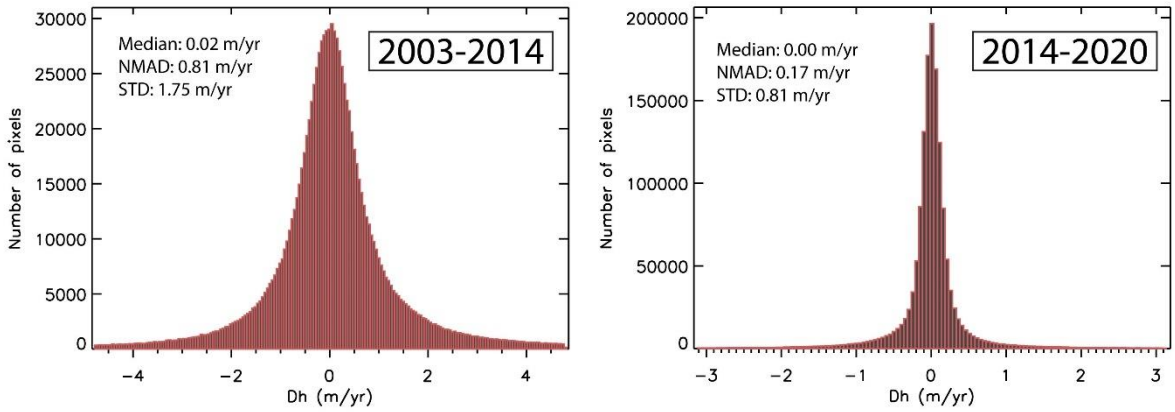

Figure S3: Histograms of the elevation differences off glacier for 2003-2014 and 2014-2020. Simple statistics are also provided.