

Title: Processes governing the mass balance of Chhota Shigri Glacier (Western Himalaya, India) assessed by point-scale surface energy balance measurements

Major comments:

This study presented a point-scale surface energy balance analysis using in-situ meteorological data from the ablation zone of Chhota Shigri Glacier over two separate periods. The impact of Indian summer monsoon on Chhota Shigri Glacier mass balance also assessed. However, there are several misconceptions have given in the manuscript. Most important issue is related with Bunter meteorological data. Authors used meteorological data (T_{air} and precipitation) of Bhuntar as the representative for the 2012/2013 hydrological year because this station is about 50 km from the Chhota Shigri Glacier. However orographic barrier separate the Beas basin (Bhuntar meteorological station) and Chandra basin (Chhota Shigri Glacier) (Fig 1). Effect of orographic barrier on vegetation distribution and geomorphic process in both basins (Chandra and Beas basins) suggests that Chandra basin is located in monsoon arid zone (monsoon rain shadow area) and Beas basin in monsoon dominated region (Bookhagen et al. 2005; Collins and Hasnain 1995; Srivastava et al. 2013). Thus, is it scientifically correct to use summer monsoon dominate station metrological data as a hydrological representative for Chhota Shigri Glacier which is located in monsoon–arid transition zone? Authors also mentioned on Page 2877, line 16-21 ‘the winter westerlies predominantly undergo orographic capture at higher elevations in the orogenic interior providing high precipitations at Chhota Shigri Glacier (79% of annual precipitation) compared to Bhuntar meteorological station in windward side (49% of annual precipitation). Thus, Chhota Shigri Glacier seems to be a winter-accumulation type glacier receiving most of its annual precipitation during winter season.’ If the precipitation pattern by ISM and MLW is highly variable between Chhota Shigri base camp and Bhuntar meteorological stations (i.e inside the airport, and just 4 kilometers from the confluence of Beas and Parbati Rivers) then the question rises here, how valid is **the re-constructed mass balance for Chhota Shigri Glacier** (monsoon–arid zone) using meteorological data of Bhuntar station (monsoon dominated region) (**Azam et al. 2014 AoG paper**)? Authors have also hid orographic barrier on map in Azam et al. 2014 TCD and Azam 2014 AoG. We believe this is questionable and this can mislead the readers.

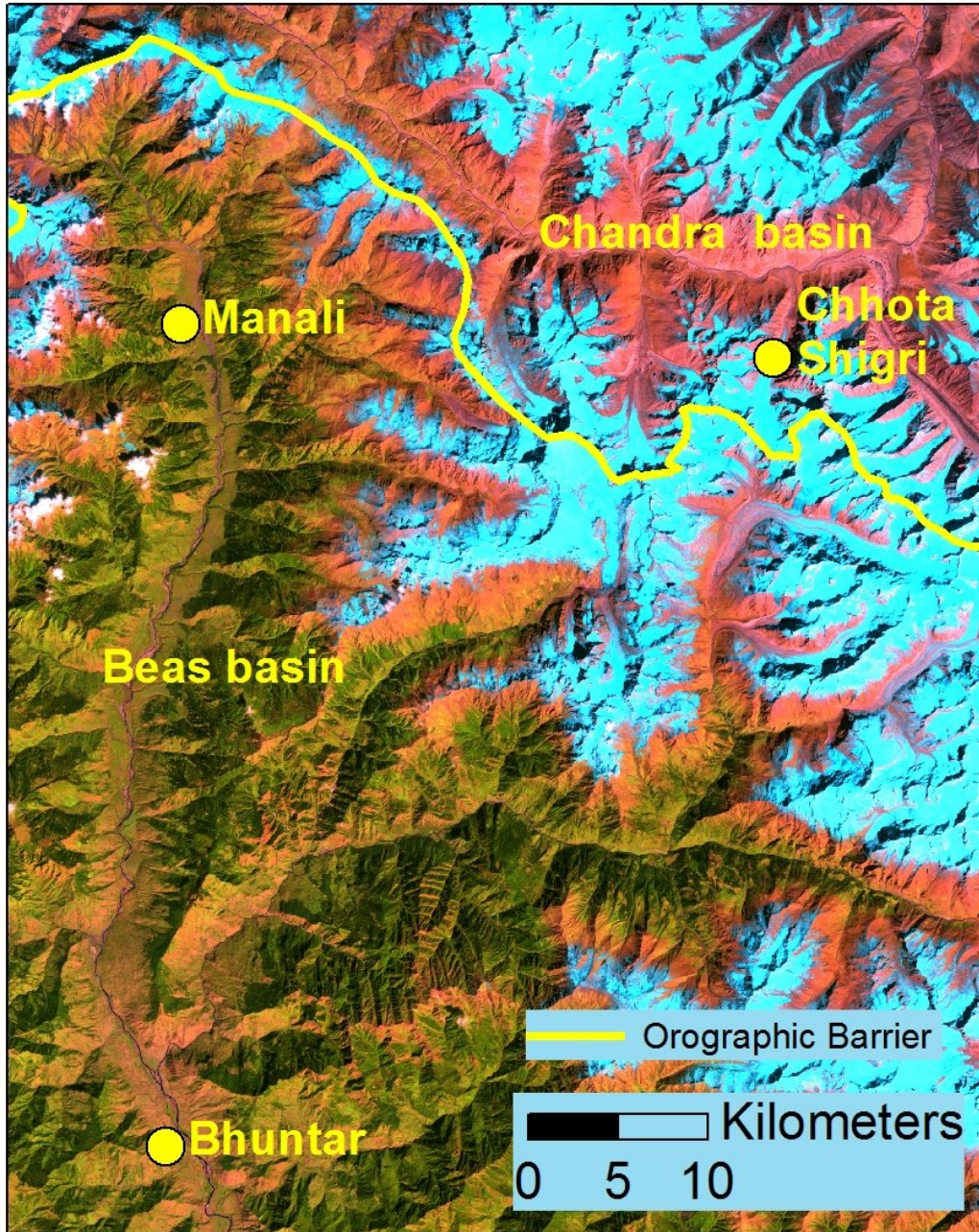


Fig1. Orographic barrier (watershed divide) between Chandra and Beas basins.

Other comments

1. Page 2868, line 1-2 'Recent studies revealed that Himalayan glaciers have been shrinking at an accelerated rate since the beginning of the 21st century.' But studies on Chhota Shigri Glacier show 4 years positive mass balance during 2003-2011.
2. Page 2868, line 5-8 'In this study, a point-scale surface energy balance analysis was performed using in-situ meteorological data from the ablation zone of Chhota Shigri Glacier over two separate periods (August 2012 to February 2013 and July to October 2013) in order to understand the response of mass balance to climate change.' As per the IPCC definition (2011) of climate change a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Authors used about one year meteorological data how they understood the response of mass balance to climate change. This needs to be clarified.
3. Page 2868, line 5-8 'The impact of Indian summer monsoon on Chhota Shigri Glacier mass balance has also been assessed. This analysis demonstrates that the intensity of snowfall events during the summer-monsoon season plays a key role on surface albedo, in turn on melting, and thus is among the most important drivers controlling the annual mass balance of the glacier.' What impact? It delays the melting? Or enhance the melting? This needs to be clarified in abstract.
4. Page 2869, line 4-7 'Some recent studies have found negative mass balances over Himalayan glaciers (e.g., Azam et al., 2012; Bolch et al., 2012; Kääb et al., 2012; Gardelle et al., 2013), with the fact that the Himalayan glaciers (22 800 km²) have been shrinking at an accelerated rate since the beginning of 21st century (Bolch et al., 2012; Azam et al., 2014).' Azam et al., 2012; 2014 references are based on single Chhota Shigri Glacier whereas authors have given statement on whole Himalayan glaciers. There are many other references on single Himalayan glacier mass balance. So should include other references on single Himalayan glacier mass balance or omit Azam et al., 2012; 2014.
5. Page 2869, line 11-13 'Unfortunately, data on recent glacier changes are sparse and even sparser as we go back in time (Cogley, 2011; Bolch et al., 2012) and, thus, the rate at which these glaciers are changing remains poorly constrained (Vincent et al., 2013).' This

statement doesn't show authors are explaining glacier changes are sparse for Rockies/Andes/Alps or Himalaya.

6. Page 2869, line 13-20 'The erroneous statement in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007) about the future of Himalayan glacier has highlighted our poor understanding of the behavior of the region's glaciers to climate. However, the IPCC Fifth Assessment Report (IPCC, 2013) stated "Several studies of recent glacier velocity change (Azam et al., 2012; Heid and Kääb, 2012) and of the worldwide present-day sizes of accumulation areas (Bahr et al., 2009) indicate that the world's glaciers are out of balance with the present climate and thus committed to losing considerable mass in the future, even without further changes in climate".' In a first statement authors criticized the work of IPCC without any citation and in second statement they referred IPCC Fifth Assessment Report as one of the authors paper was cited in this report. This needs to be corrected.
7. Page 2870, line 18 'Chhota Shigri Glacier is one of the best studied glaciers in Indian Himalaya.' In terms of what?
8. Page 2870, line 8-9 'Unfortunately glacier SEB studies from Indian Himalaya (covering Western, some Central and Eastern parts of Himalaya) are not available. Here what is "some" mean? Is that the area covered in Indian Himalaya or the SEB studies commenced over some part of the Central Himalaya? Need to be clarified.
9. Page 2870, line 19 to 30 and Page 2871, line 1 to 7 purely literature review. What is the output of this paragraph? There is need to be improved.
10. Page 2871, line 18-21 'It involves two main objectives: (1) the glacier's microclimate is analyzed' As per WMO climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over at least 30 years of time. Authors used about one year meteorological data how they analyzed the glacier's microclimate. Use correct terminology. Also the objectives defined here and the statement at page 2868, line 5-9 "In this study, a point-scale surface energy balance analysis was performed using in-situ meteorological data from the ablation zone of Chhota Shigri Glacier over two separate periods (August 2012 to February 2013 and July to October 2013) in order to understand the response of mass

balance to climate change” is not perspective to each other. See comments for Page 2868, line 5-8 above.

11. Page 2871, line 26 'It lies ~25 km from the nearest city of Manali.' Aerial distance?
12. Page 2872, line 9 'The equilibrium line altitude (ELA) for a zero net balance is close to 4900ma.s.l. (Wagnon et al., 2007).' Why used equilibrium line altitude (ELA) for a zero net balance based on 4 years data? Why not used Azam et al. 2012 JoG; Ramanathan (2011) mass balance data to calculate ELA0 and AAR0.
13. Page 2876, line 23-25 'Surprisingly, the months with minimum precipitation was July to November (mean value of 16 mm) and those with maximum precipitation were January and February (183 and 238mm, respectively).' Why authors feel surprise? This is fact that Chhota Shigri Glacier is located in monsoon–arid transition zone. Authors knew this and mentioned in several places. See Dobhal et al. (1995); Azam et al. 2014 TCD Page 2872, line 10; Azam et al. 2014 AoG Page 70; Ramanathan (2011) page 13; 73; 78.
14. Page 2877, line 5 “this station is only about 50 km from Chhota Shigri Glacier.' Aerial distance?

References

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