Comments on “Estimating the avalanche contribution to the mass balance of debris covered glaciers” by A. Banerjee and R. Shankar

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The present study raises a serious question on mass balance results of debris-covered Hamtah Glacier derived from glaciological method conducted by Geological Survey of India (GSI). Authors compared these results with geodetic mass balance for this glacier performed by Vincent et al. (2013). Authors explained the discrepancy between values of glaciological and geodetic net mass balance for Hamtah Glacier using their flow line model. In simple words, authors believed that Vincent et al. (2013) and other studies by similar group (Wagnon et al, 2007; Azam et al. 2012) is absolutely correct and can be used as a reference data for comparison with glaciological method on Hamtah Glacier carried out by GSI. However, there are several following limitations in discussion paper:

1. The glaciological and geodetic net mass balance is two different methods and conducted by two different agencies. This is well known that geodetic methods can differ significantly from estimates using direct glaciological field-based measurements (e.g. Krimmel, 1999; Østrem and Haakensen, 1999; Cogley, 2009; Haug et al. 2009; Rolstad et al. 2009; Fischer 2011). Rolstad et al. (2009) reported the cumulative traditional mass balance was 22 m w.e in Engabreen drainage basin, Norway during 1970– 2002 whereas the geodetic mass balance for the period 1968–85 was –2.1±1.2 m w.e., and from 1985 to 2002 it was –0.3±2.6 m w.e. The discrepancy between these results could be due to several reasons such as different assumptions for density of ice loss, wind effect in accumulation and number of *stakes* and *pits* measurement (Huss 2013) and different methodologies adopted for utilization of satellite data/Arial photographs for DEM generation (Fischer 2011; Zemp et al. 2013). Therefore, difference in mass balance of Hamtah Glacier by two different methods cannot justify with avalanches alone. Moreover, sometimes geodetic mass balance conducted by different research groups doesn’t accord in similar region. The geodetic mass balance results in Everest Himalayan region by three different research groups doesn’t match with each others (Bolch et al. 2011; Nuimura et al. 2012; Gardelle et al. 2013). The discrepancy between these results could be due to different methodology and datasets.

2. There is need to describe the details of glaciological mass balance data collection procedures to understand the discrepancy in mass balance observations. What is the location of stakes and pits? What are the number of stakes and pits? What are the distribution of avalanches? What are the distribution of debris cover? The detailed map can explain all these issues. However, there is no map shown in study.

3. We also disagree with author's preliminary response to comments by the referees. They claimed that Page 2, line 30; "in neighboring Chotta Shigri Glacier, this kind of localised accumulation is not seen in the mass balance profile (Wagnon et al, 2007) as the topography there disallows such strong avalanche activity". But we found this kind of localised accumulation in neighboring Chhota Shigri Glacier in government report published by Ministry of Science and Technology, Indian Government (Ramanathan 2011). We believe authors overlooked the interesting facts about the Chhota Shigri Glacier mass balance as they referred this reference. At the almost same elevation (range 4800-5000m) one stake/pit of Chhota Shigri Glacier accumulated by 20cm (0.65 feet) firn w.e. during 2009-2010 whereas another stake/pit accumulated by 9 times more firn i.e. 180 cm (5.9 feet) w.e. (Ramanathan 2011, fig 2.7, page 41). The period of 2009-2010 is reported positive balance (+0.33 m w.e) (Ramanathan 2011; Azam et al. 2012). This could be due to avalanche or may be wind driven effect in accumulation zone. Similarly in years 2006-07 and 2007-08 data show single pit for accumulation and there is no pit measurements for accumulation in 2005-06. Since there is no pit measurements (2005-06; MB -1.4 m w.e) or single pit for accumulation those years show surprisingly high negative mass balance values (2006-07; MB -1.3 m w.e; 2007-08; MB -0.93 m w.e) (Ramanathan 2011, Table 2.6, page 40). Unfortunately, this detailed figure 2.7 has not published or mentioned by Wagnon et al, (2007) or Azam et al. (2012) or Vincent et al. (2013) and therefore significant observations were not come out in scientific community. This figure also raise question on Chhota Shigri Glacier positive balance years (e.g. 2009-2010) due to this localized accumulation and show serious biases in mass balance observations (2002-2010).

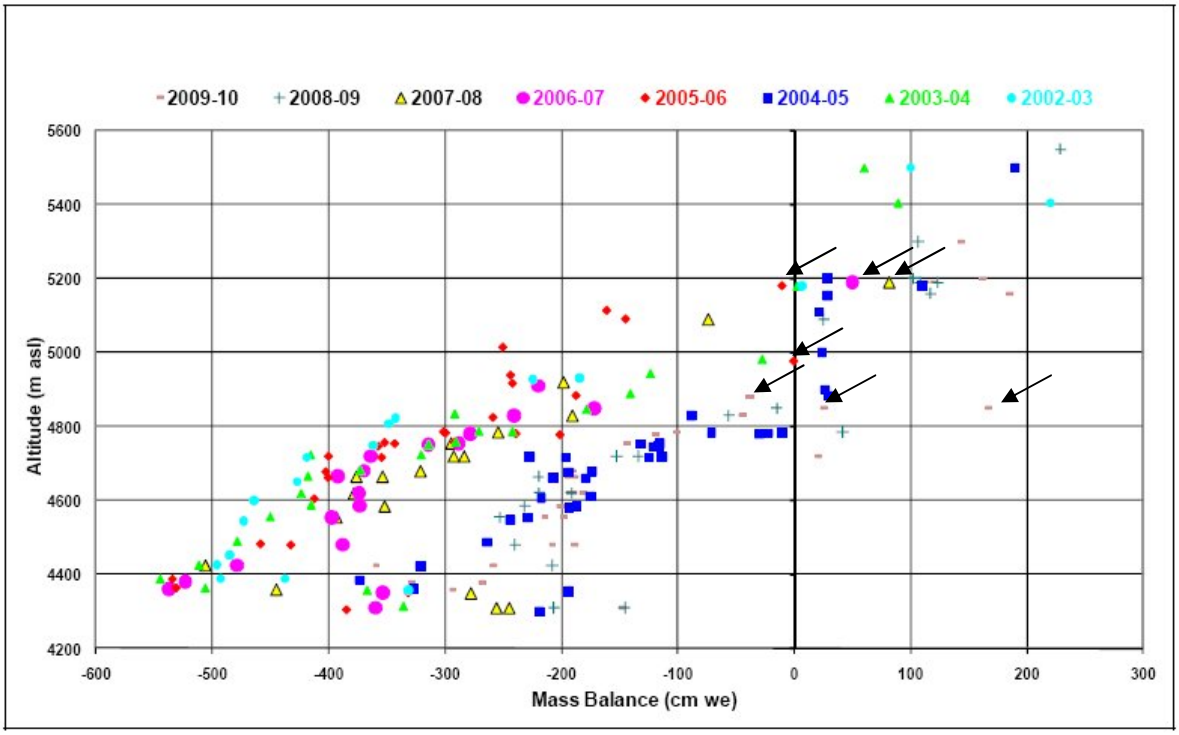

Figure 2.7 Mass balance of Chhota Shigri glacier from 2002 to 2010 *(Wagnon et al,. 2007; JNU-SAC, 2008 ; JNU- IFCPAR, 2009,2010; JNU- DST, 2011)*

Source: Ramanathan (2011), fig 2.7, page 41; We used black arrows for highlighting the problems in mass balance observations (http://www.serb.gov.in/pdfs/Publications/Chhota-Shigrii.pdf)

Table 2.6 Specific mass balance for 2002 – 2010 *(Wagnon et al,. 2007; JNU-SAC, 2008 ; JNU- IFCPAR, 2009,2010; JNU- DST, 2011)*

Year	Specific Balance (m weq)
2002 – 2003	-1.4
2003 – 2004	-1.2
2004 – 2005	0.1
2005 – 2006	-1.4
2006 – 2007	-1.3
2007 – 2008	-0.93
2008-2009	0.13
2009-2010	0.33

Source: Ramanathan (2011), Table 2.6, page 40 (http://www.serb.gov.in/pdfs/Publications/Chhota-Shigrii.pdf)

4. Authors used different assumed datasets for flow line model without any justifications. See page 646, line 24: bedrock with constant slope of 0.1 and the highest elevation of the bedrock is 4525m. Similarly, page 647, line 4: Ice thicknesses assumed as 100m. Authors tried to explain discrepancy in ground based and geodetic mass balance with flow line model which is based on assumed datasets.

5. Most important issue is related with scientific ethics. Authors used hospitality and other facilities from the GSI. However, unfortunately authors presented this paper without considering and understanding of 10 years ground based mass balance data collection by GSI.

Therefore, in the light of above points we believe that proposal of this paper is inappropriate and conceptually incorrect. Also encourage anyone to raise questions on results of any study conducted by different groups in same region and can provide erroneous message to scientific community.

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