The Cryosphere Discuss., 7, C613–C617, 2013
www.the-cryosphere-discuss.net/7/C613/2013/

The Cryosphere
Discussions
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Interactive comment on "The effect of black carbon on reflectance of snow in the accumulation area of glaciers in the Baspa basin, Himachal Pradesh, India" *by* A. V. Kulkarni et al.

Anonymous Referee #2

Received and published: 22 May 2013

General comments

In their study, the authors observe between 2000 and 2012 the changes in the spring reflectance decrease between 10-15 April and 1-5 May of the accumulation areas of glaciers (Fig 5) using satellite imagery (MODIS products and AWiFS sensor of the Indian Remote Sensing Satellite). They explain that this reflectance decrease cannot be solely explained by dust deposition (Fig 8 and Fig. 9) or the presence of liquid water (p 1367, last paragraph). They conclude that BC deposition (due to forest fires) is mainly responsible for this reflectance decrease, and has consequently a strong impact on glacier melting in this region. I agree that BC deposition might have an influence on snow albedo but I doubt that the methodology applied here is accurate

enough to properly quantify the effect of BC on snow albedo.

I am surprised that there is no discussion regarding precipitation. Indeed, between 10-15 April and 1-5 May, surface reflectance in accumulation areas of glaciers may depend on how frequent and significant snowfalls are in these areas during this period. And precipitations are usually significant in April in western Himalaya, and very variable from year to year, which may undoubtedly significantly explain the interannual variability observed for spring reflectance changes. I think that a discussion regarding this is needed, but I believe that it will be difficult to extract a signal of reflectance decrease only. In Fig 5 caption, the authors explain that no reflectance decrease has been reported for 2004, because of "unusual snowfalls". What does "unusual snowfalls" mean? And I am sure that usual but year-to-year variable snowfalls have also a significant influence that is not easy to assess without in-situ measurements. For instance, in 2005, there is an increase in surface reflectance between 10-15 April and 1-5 May, probably explained by fresh snow deposition.

Reflectance is very dependent on snow metamorphism and melting can have a significant impact. The authors make a short analysis on daily air temperature (p1367 last paragraph and Fig 10) to state that there is no melting, since daily temperature stay below the freezing point (approximately between -10 and -5°C at 5000 m asl for the period 10-15 April to 1-5 May; Fig 10). Actually, more details are needed here (which lapse rate is used for instance?) because at infra-daily time step, temperature may reach the melting point (at least during the hottest hours of the day, even though mean daily temperature is as low as -10°C), and this may have a significant impact on reflectance.

In abstract and introduction, the authors provide a quick (and erroneous) state of the art on glacier mass trends or ELA variations in Himalaya, over the last two decades. Even though it is sometimes unclear to which part of the Himalayas they are referring to, and to which time period (mainly in introduction), they are reporting that "the glaciers in the Pir Panjal and Greater Himalayan mountain ranges are losing mass at a rate of almost

a meter per year. The ELA has also shifted upward by 400 m in the last two decades" (p1360, lines 5-7 in introduction as well as p 1369, lines 2-3 in conclusion). These figures are supported by Sangewar and Kukarni (2011 : technical report from DST), Dobhal et al. (2008: 6 years of mass balance of Dokriani 1992-95 and 1997-2000) and Heaberli et al (2001 : report from WGMS) (p 1361, line 23) which is weak, and incomplete. The authors write that "Measurements of the mass budget for glaciers in the Himalayas are relatively few and only of short duration" p1361, line 20. I agree with this statement but the authors are probably aware that the longest continuous mass balance record ever published in India (and more generally in the Himalayas) comes from Chhota Shigri Glacier in Pir Panjal Range, not far from their study area (some tenths of kms towards north west) (Dobhal et al., 1995; Wagnon et al., 2007; Berthier et al., 2007; Azam et al., 2012; Vincent et al. 2013). None of these papers are quoted in this present study and we kindly invite the authors to refer to these papers to revise their figures. Indeed, Vincent et al. (2013) recently showed that Chhota Shigri Glacier is representative of western Himalaya, and experienced balanced (or even slightly positive) conditions in the nineties before starting to lose mass at a moderate rate (–0.17 $\pm$ 0.09 m w.e. yr$-$1 for the period 1988-2010, and –0.44$\pm$0.16 m w.e. yr$-$1 between 1999 and 2010, far from -1 m w.e. yr-1). For a wider overview across the Himalayas, Karakoram and Pamir regions, the authors are invited to read additional papers like Kääb et al. (2012), Gardelle et al. (2013) among others. These papers show that the response of glaciers along these large ranges is much contrasted, because they are influenced by different climatic regimes. In western Himalaya, glaciers are not retreating as fast as stated by Kulkarni et al in this present manuscript. See Vincent et al (2013) for a review of all available mass balance measurements in Northern India (Western Himalaya).

The paper is often not well-structured. The abstract does not properly reflect the findings of this study, the introduction provides neither a good state of the art nor the objectives of the paper, some general statements are not fully supported, the methodology is not clearly described, and the results are not adequately discussed... (see

specific comments).

For all these reasons, I believe that the conclusions of this paper are not relevant and I recommend rejection of this paper.

Specific comments

- The abstract is not well-structured and does not properly reflect the content of this paper. It provides some general statements, not directly related to the work performed in this study, which are not suitable in the abstract section, but more adequate into the introduction for instance. Moreover, some of these general statements (concerning the rate of mass loss or the shift of the ELA in the last two decades for glaciers in Pir Panjal and Greater Himalaya) are erroneous (see general comments).

- P 1362, line 15: the albedo of snow/ice surfaces is very variable, and not always close to 1. For glacier ice, values can reach values as low as 0.2 or even 0.1.

- P1362, lines 26-29 : any references to support this statement?

- Fig. 1 is of poor quality.... no borders, no country names, no oceans, no limits between mountain ranges, rivers are not well designed..

- The description of the study area and the data is pretty rapid and more details about field set-up and instruments would be welcome even though the reader is invited to refer to Singh et al (2011).

- Fig 3 : legend of y-axis, add "area" before "affected"

- The methodology section is lacking details and information

- Specific comments are not needed for the results and discussion sections as these sections are not relevant (see genera comments)

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