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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simulations of black carbon (BC) aerosol impact over Hindu-Kush Himalayan sites: validation, sources, and implications on glacier runoff" *by* Sauvik Santra et al.

Anonymous Referee #1

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The study estimates the implication of black carbon (BC) deposition on annual snow melting of some representative Himalayan glaciers (Table 1). It uses GCM modelled values of BC in atmosphere to estimate corresponding BC concentration in snow. Subsequently, associated snow albedo reduction (SAR) values using SNICAR offline model is calculated over these glaciers. While these approaches and estimates are not entirely new, two interesting parts of the study are the increasing trend in BC concentration in snow over these glaciers and the estimates of the annual runoff increase due to BC deposition. Largely, the manuscript is well organized and logically analysed, but,

needs clarification/addition at various places.

It is worth publication after addressing the following major concerns:

1) Only SPRINTARS is used beyond Figure 2 in the study mainly because it provides the longest model dataset. Therefore, It sometimes becomes confusing about the purpose of GCM-INCA and GCM-indemiss in the study. The authors could mainly focus on evaluation of SPRINTARS output (collocated with observations) and proceed with further analysis. Moreover, GCMs are for different years. Please clarify. The authors may consider to shorten Section 2.1.

2) The methodology leading to ARI calculation (Section 2.4) should be elaborated. For atmospheric researchers not expert with glacier mass balance presently many things are not clear. For example,

a) Two annual runs are made for each glacier with Glacier MB model; One with ambient albedo simulated by ERA-interim and the other reduced to 0.5 for all the days in a year for each of the 35 years separately?

b) What is the ambient albedo values used in MB model and Why is it reduced to 0.5 particularly (i.e. not something else like 0.75 ?). Realistic snow albedo over Glaciers are $\sim$0.8 during early summer. If it is reduced to 0.5, then a reduction of 0.3 ($\sim$30%) is simulated which is manifold higher than the SAR estimates of $\sim$5 %. Thus, please clarify with example the calculations.

c) What is the X-axis in figure 3C? Is it summer mean albedo or reduction in albedo in the mass balance model (confused with Line 23 page 14). Also include in caption clearly.d) Elaborate more on how ARI is calculated using SAR estimates (Line 9 page 10).

3) The spatial resolution of the models used in the study is relatively very coarse compared to the spatial extend of the glaciers which affects the life cycle of BC estimates due to misrepresentation in terrain and surface emissions. This can contribute a lot to

the differences seen in the observation and model values as well as favors the better performance of PA approach than RA approach because of inclusion of vertical profiles. Please include appropriate discussions in relevant places (like $\sim$ Page 11 Line 5).

4)A major concern is that the study uses coarse model simulations and offline approaches to estimate SAR, but, eventually uses it to compare and contrast the ARI at very fine spatial (glacier) level. In this view, the quantitative differences reported in this study in estimates of ARI, SAR, BC between the glaciers may be very uncertain. The authors have mentioned about the uncertainties in various steps used in this study for example uncertainties in BC in atmosphere estimates (45%), BC in snow estimates (50-70%) and SAR estimates (20-30%). In a sense, all these processes contribute serially to calculation of increase in snowmelt runoff. Moreover, there is uncertainties involved in the process of calculating snowmelt runoff increase from glacier mass balance model also. At the same time, the variability in ARI of various glaciers is within 150 mm w.e. y-1 (Figure 3b), which is $\sim$50% of the mean ARI over Himalayas. Please include a discussion on these issues towards end of the study.

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