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The Cryosphere Discussions

Interactive comment on "Black carbon in snow in the upper Himalayan Khumbu Valley, Nepal: observations and modeling of the impact on snow albedo, melting, and radiative forcing" *by* H.-W. Jacobi et al.

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Reply to referee 2 (Referee's comments in italic)

Black carbon and other light-absorbing constituents are extremely concerned by the communities for possibly enhance the melting of Himalayan glaciers and the consequent water-crisis issues, described by the modelling hypothesis. This work presents the in situ black carbon concentrations in the snow and atmospheric samples from the highly elevated Himalayan sites, and therefore the impacts of black carbon on the re-

duction of snow albedo and melting, associated with the modelling data. This is an interesting approach to combine the sampling and simulating together and to interpret the impact of black carbon on snow. The authors shall address some important issues raised before it can be accepted for publication.

We thank Referee 2 for the review. We respond to the major comment below.

My major concern is that the model Crocus seems to fail to simulate the snow albedo, seeing Figure 4 and Figure 5. In Figure 4, the differences between the observed and simulated albedos are very large under standard and different BC concentrations. In Figure 5, the model seems to be not able to correctly describe the albedo decay with BC involved, and even in the area around 1/2/2005, the figure does not clearly clarify the observed albedo and simulated albedo with BC, which should be amplified and further described after comparisons. If the model does fail to simulate the snow albedo, all the discussions regarding the impact of BC on albedo will make no senses, which should be carefully addressed.

We are surprised that the referee judges the differences between observed and simulated albedo in Fig. 4 as "very large". We calculated the average differences between simulated and observed albedo for the period shown in Figure 4 (22 – 31 January 2005). The average differences for the entire period are 1.9, -1.2, and -5.1 In contrast, we fully agree that the differences in the observed and simulated albedo shown in Figure 5 are large for the period beginning around mid-February and they are very large at least for the period after early March. In our opinion there are multiple reasons that explain these differences as described in the reply to a similar comment of referee 1, which is repeated here. The large discrepancy is mainly linked to the overestimation of the duration with snow on the ground and the snow height. While the maximum observed snow height remained below 40 cm, the simulated maximum heights were in most runs higher. As a result, the simulated snow remained much longer on the ground compared to the observations causing the large differences in the albedo later in the winter season. The overestimation of the snow height and duration can be due to many different reasons, the most important may be an overestimation of the precipitation and/or an overestimation of the fraction of solid precipitation. Other factors may also contribute like the spatial variability as mentioned in the manuscript, the ground heat flux as raised by the referee, or a bias in the simulations of the turbulent fluxes. Further modifications and applications of the Crocus model are certainly needed before it can be considered as a fully validated model for the Himalayas. However, these tests are beyond the scope of this manuscript. The deviations between the simulated snow properties and the observations certainly introduce additional uncertainty into the simulated snow cover duration and radiative forcing. We will further underline this in a revised manuscript. Nevertheless, we believe that the presented observations, new model developments and applications contribute to a better understanding of how the seasonal snowpack reacts to the presence of absorbers and how these processes may impact the regional climate in the high altitude region of the Himalayas.

Interactive comment on The Cryosphere Discuss., 8, 5035, 2014.