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Investigating the effect and uncertainties of light absorbing impurities in snow and ice on snow melt and discharge generation using a hydrologic catchment model and satellite data

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Light absorbing impurities in snow and ice (LAISI) originating from atmospheric deposition enhance snow melt by increasing the absorption of short wave radiation. The consequences are a shortening of the snow cover duration due to increased snow melt and, with respect to hydrologic processes, a temporal shift in the discharge generation. However, the magnitude of these effects as simulated in numerical models have large uncertainties, originating mainly from uncertainties in the wet and dry deposition of light absorbing aerosols, limitations in the model representation of the snowpack, and the lack of observable variables required to estimate model parameters and evaluate the simulated variables connected with the representation of LAISI. This leads to high uncertainties in the additional energy absorbed by the snow due to the presence of LAISI, a key variable in understanding snowpack energy-balance dynamics.

In this study, we assess the effect of LAISI on snow melt and discharge generation and the involved uncertainties in a high mountain catchment located in the western Himalayas by using a distributed hydrological catchment model with focus on the representation of the seasonal snow pack. The snow albedo is hereby calculated from a radiative transfer model for snow, taking the increased absorption of short wave radiation by LAISI into account. Meteorological forcing data is generated from an assimilation of observations and high resolution WRF simulations, and LAISI mixing ratios from deposition rates of Black Carbon simulated with the FLEXPART model. To asses the quality of our simulations and the related uncertainties, we compare the simulated additional energy absorbed by the snow due to the presence of LAISI to the MODIS Dust Radiative Forcing in Snow (MODDRFS) algorithm satellite product.