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A parameterization on snow/ice albedo with cryoconite considered built on Urumqi Glacier No. 1, Tian Shan, Northwest China

Huilin Li

Northwest Institute of Eco-Environment and Resources, CAS. Lanzhou, China (lihuilin@lzb.ac.cn)

The albedo of snow depends on the grain size of snow, snow depth, cloud cover, cloud optical thickness, solar zenith angle and impurities. In most existing melting models, the albedo of ice is fixed as a constant, whereas it is significantly influenced by the impurities inside or overlay and can vary in a relatively wide range. The impurities include black carbon, mineral dust, and organic matter. Mixtures and/or aggregates of these biotic and abiotic impurities on glacial ice are called “cryoconite”, which appears on glacier surface globally. Due to its diversity and complicated propagation and accumulation processes, how cryoconite affects the surface albedo and the corresponding mechanisms are still not clear.

In the present study, the surface albedo at specific points along the main flow-line of Urumqi Glacier No. 1 was observed in August of 2006. Samples of cryoconite were collected simultaneously and analyzed in laboratory to quantify its composition, size and abundance (g/m2). The characteristics of glacier surface (color, crystal size and water content), meteorological parameters (mainly air temperature and cloud cover) and time for observation were recorded at the same time to assist the analysis on the influence of cryoconite on solar radiation reflection.

According to the results, there’s a rough inverse correlation between cryoconite abundance and albedo. For snow, the cryoconite abundance was quite low and the corresponding albedo was as high as around 0.6. For ice, most cryoconite abundance was concentrated in the range of 200 $\sim$ 500 g/m2 and albedo was decreased to <0.2. The emergence of singular points was noticed, i.e. quite low albedo was found at sites with small cryoconite abundance and cryoconite with extremely high abundance exerted ignorable effect on surface albedo. To investigate the reason for those singularities, a parameterization of albedo with snow crystal size, snow depth, cloud cover, solar zenith angle, and especially the abundance, size and color of cryoconite as variables was developed. The simulated albedo was compared with results obtained by existing models without consideration on cryoconite. The effect of cryoconite and the combination effect of cryoconite with other mineral impurities on the surface albedo and melting of glaciers were discussed.