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A low-cost albedometer for snow and ice measurements – Theoretical results and application on a tropical mountain in Bolivia

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This study presents a new instrument called a low-cost albedometer (LCA) composed of two illuminance sensors that are used to measure in-situ incident and reflected illuminance values on a daily timescale. The ratio between reflected vs. incident illuminances is called the albedo index and can be compared with actual albedo values. Due to the shape of the sensor, the direct radiation for zenith angles ranging from 55° to 90° is not measured. The spectral response of the LCA varies with the solar irradiance wavelengths within the range 0.26 to 1.195 μm, and the LCA detects 85% of the total spectral solar irradiance for clear sky conditions. We first consider the theoretical results obtained for 10 different ice and snow surfaces with clear sky and cloudy sky incident solar irradiance that show that the LCA spectral response may be responsible for an overestimation of the theoretical albedo values by roughly 9% at most. Then, the LCA values are compared with two “classical” albedometers over a one-year measurement period (2013) for two sites in a tropical mountainous catchment in Bolivia. One site is located on the Zongo Glacier (i.e. snow and ice surfaces) and the second one is found on the right-hand side lateral moraine (bare soil and snow surfaces). The results, at daily time steps (256 days), given by the LCA are in good agreement with the classic albedo measurements taken with pyranometers with R2 = 0.83 (RMSD = 0.10) and R2 = 0.92 (RMSD = 0.08) for the Zongo Glacier and the right-hand side lateral moraine, respectively. This demonstrates that our system performs well and thus provides relevant opportunities to document spatio-temporal changes in the surface albedo from direct observations at the scale of an entire catchment at a low cost. Finally, during the period from September 2015 to June 2016, direct observations were collected with 15 LCAs on the Zongo Glacier and successfully compared with LANDSAT images showing the surface state of the glacier (i.e. snow or ice). This comparison illustrates the efficiency of this system to monitor the daily time step changes in the snow/ice coverage distributed on the glacier.