LOW COST ALBEDOMETER FOR SNOW AND ICE MEASUREMENTS – THEORETICAL RESULTS AND APPLICATION ON A TROPICAL MOUNTAIN IN BOLIVIA

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Abstract

Albedo is a key variable controlling the surface energy balance, through the shortwave radiation budget. This study presents a new instrument called Low Cost Albedometer (LCA) composed by two illuminance sensors that allow the measurement at daily timescale of in-situ values of reflected and incident illuminances. The ratio between reflected vs incident illuminances is called albedo index and can be compared with actual albedo's values. Due to the shape of the sensor, direct radiation for zenithal angles ranging from 55° to 90° is not measured. Theoretical results obtained by considering eight different ice and snow surfaces show that the LCA tends to overestimate the theoretical values by around 9%. Then, the LCA values are compared with two albedometers over a 1-yr 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 on its right-hand side lateral moraine (bare soil and snow surfaces). Results, at daily time steps, given by the LCA are in good agreement with classical measurements of albedo (R2=0.84 and RMSD=0.1 for 256 daily values) showing the good performances of our system, and thus providing relevant opportunities to document the spatio-temporal changes in surface albedo from direct observations at the scale of an entire catchment at a lower cost than using classical sensors.

MANAGING NEW AND FUTURE LAKES IN THE VILCANOTA-URUBAMBA CATCHMENT

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Abstract

In the Andes of Peru, strong glacier shrinkage has uncovered many glaciated areas below 5000 m asl. within the last decades which has triggered the formation and growth of glacier lakes. On the one hand, this process can result in more likely conditions for the occurrence of disasters, such as Glacier Lake Outburst Floods (GLOFs). These mass movements have caused a large number of human and material losses but hazard-based data collection and implementation of lake monitoring programs are scarce in this region. On the other hand, new lakes represent important reservoirs for drinking water, agricultural use and energy supply attenuating negative impacts of retreating glaciers in the hydrological cycle. This study focuses on an integrative assessment in the Vilcanota-Urubamba catchment (Cordilleras Vilcanota-Urubamba-Vilcabamba, Cusco) by evaluating GLOF-associated hazards, hydrological risks and the potential of (new) lakes as reservoirs. A multi-temporal Normalized Difference Snow Index (NDSI) analysis with Landsat TM 5 and Sentinel 2A imagery for 1988-2016 reveals strong glacier reduction from 229 km^2 (1988) to 151 km^2 (2016). However, the annual loss rate has decreased from 1.9% to 0.6% in the same period. Contrariwise, applying a semi-automatic Normalized Difference Water Index (NDWI) model, an accelerated formation of lakes in both number (from 0.1% to 2.4%) and surface (from 0.3% to 0.6%) has been determined. In total, 135 new lakes have formed, particularly in the altitudinal level of 4800-5200 m asl. where the new geomorphological situation from recent deglaciation favors natural damming of considerable water volume. A combined risk-opportunity assessment facilitated the identification of several key lakes which should be embedded into disaster risk reduction (DRR) and future integrative and adaptive water resources management (I/AWRM) planning. These findings have a particular implication in the context of current efforts of local policies to identify and exploit new reservoirs and mitigate adverse effects of deglaciation in the region.

Keywords: *glacier shrinkage, glacier lakes, water management, hydrological risks, GLOF.*