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Conditions of formation of glacial lakes in Mt Everest region

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Mount Everest (southern central Himalayas) is the region most characterized by glacial lakes in the Hindu Kush-Himalaya range and also by wide debris-covered glaciers. This study provides a complete mapping of both these water resources (October 2008). Considering that these kind of measurements are essential in recent climate change impact studies, the analysis on uncertainty of measurements is discussed with the aim of proving a reference study when lakes are delineated using remote sensing imagery. Moreover, attention is focused on the conditions of formation of lakes, the greatest evidence of climate change impact at high altitudes characterized by debris covered glaciers. To achieve this goal, an ALOS image (October 2008) with medium-high resolution (10 m) was used. A total of 29 glaciers (356.2 $\pm$2% km2) was plotted. The total number of lakes is 624, corresponding to an overall surface area of 7.43 ($\pm$18%) km2. We examine the analysis in depth, underlining the capability of ALOS imagery to properly characterize 64% of lakes (error <15%) in terms of surface whereas, concerning glaciers, this sensor allows correctly characterizing the whole resource (error 2%). Concerning the surfaces of lakes not directly connected with glaciers (unconnected-glacial lakes), we found they are correlated with the dimension of their drainage basin, while no correlation was found with the glacier cover in the basin. Considering the evaporation/precipitation ratio at these altitudes is around 0.34 the evolution of these lakes appears to be a helpful sign for detecting the precipitation trend. Regarding the formation process of supraglacial lakes on debris-covered glaciers, the main factors which seem responsible are the low velocity and high ablation rates at the glacier terminus. Our findings confirm that the slope of the glacier where lakes are located, mainly influencing the first factor, provides the boundary condition favourable for lake formation. Otherwise the novelty of this study is to have pointed out a further boundary condiction. The slope of the glacier upstream is able to influence both of these. In fact the imbalance between the two glacier zones generates the down-slope passage of debris, snow and ice. We found the slope of glacier upstream is inversely correlated with the relevant total surface of the lakes downstream and the multiple regression model developed in this study, considering both slopes of the two glacier areas distinctly, has been able to predict 90% of the supraglacial lake surfaces. With regards to proglacial lakes, their formation is closely connected with the supraglacial ones. In fact they can be considered a precursor of terminus disintegration by growing and coalescing, to culminate in large proglacial lakes. In this study we define the condition of formation of supraglacial lakes and therefore of proglacial ones, thus contributing to relevant hazard management, although we agree with those authors who consider the enlargement phenomena of these lakes could be explained on a local scale only, allowing the peculiarity of the single lake to emerge.