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Evaluation of Digital Elevation Models as a tool for the study of glacier mass variations in the Tropical Andes. Antisana, Ecuador

Ruben Basantes (1), Antoine Rabatel (2), and Bernard Francou (1)
(1) UJF-Grenoble 1 / IRD / CNRS / G-INP, LTHE, Grenoble, France , (2) UJF-Grenoble 1 / CNRS, LGGE, Grenoble, France

Since the seventies an important increase in atmospheric temperature testifies of the global climate change. In relationship with this temperature increase a significant recession of tropical glaciers has been observed. However, the timing and magnitude of glacier change at a regional scale remain poorly studied because of the insufficiency of direct measurements. In Ecuador, only two glaciers are monitored since 1994 (glaciers 12 and 15 of the Antisana Volcano) with mass balance and surface energy balance measurements. These long-term data series allowed to better understand the relationship between glacier changes and climate forcings. Nevertheless these results cannot be directly extrapolated to other glaciers where no field measurements are available. This constitutes an important limitation to understand the glacier sensitivity to topographical factors, and to have an accurate estimation of the contribution of glacier runoff to the hydrological functioning of high altitude watersheds. Fortunatly, glaciers Digital Elevation Models (DEMs) computation from aerial photographs provides an alternative and accurate technique to study both temporal and spatial changes in glacier volume in terms of water resources.
This study aims at reconstructing the glacier mass balance at the scale of the Antisana Massif (17 glaciers) using the geodetic method for five dates since the mid-20th century by computing DEMs from aerial photographs, to better understand the glacier variations at regional scale and interpret these variations regarding the climate and topographical forcings. The stereo-preparation of the aerial photographs was first performed using ground control points from a GPS network well distributed around the volcano. The aero-triangulation process gives a root mean square error (RMSE) between $\pm$0.5 m y $\pm$4 m in both the horizontal and vertical components. Photogrammetric restitution of isolated points was then performed to measure their elevation and create a point cloud on a stereographic couple of photos which later on allowed to build the DEMs. For the DEMs construction five different interpolators were tested: Triangulated Irregular Network (TIN), TOPOGRID, Minimun Curvature, Radial Basis Function and Kriging. In the current study, we present the results of this test which allowed us to select the best interpotalor and the best pixel sizes that needs to be considered. The minimun curvature method (with a 15 m pixel size resolution) results to be the most accurate technique, according to: 1) the statistical analysis of the residuals of the comparison between the generated DEMs and field topographical measurements performed on non-glaciated areas; 2) the capacity of the DEMs to represent morphological features; and 3) processing time with the different algorithms.