

ZONGO 1983–2006, BOLIVIA (1:10000)

(Ortho-Photo Map)

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In 1991, the French Institute for Development (IRD) initiated glaciological investigations on tropical glaciers using Zongo (16°S) as the principal monitored glacier in Bolivia. Mass balance calculations require a precise hypsometric map to integrate the mass balance by altitudinal sections along the glacier. In Bolivia, six photogrammetrical flights were carried out over Zongo Glacier, that is, in 1956, 1963, 1975, 1983, 1997 and 2006. Between 1991 and 2001 the glacier mass balance was calculated using a manual digitalization of the cartographic map of the Bolivian Army, based on 1963 photographs (planimetry: UTM – PSAD56 Zone 19S; altimetry: International Geoid, assumed precision between 10 to 15m). Due to the poor quality of the Bolivian Army map, in 2002, IRD has selected the 1983 pictures to carry out another base map of Zongo Glacier. The 1983 picture presents the best contrast quality which allows the photogrammetric restitution over snow-covered regions. A digital elevation model was elaborated in an analytical stereoplotter Planicom (Zeiss) with a regular grid of 50 x 50 m (planimetry: UTM – WGS84 Zone 19S; altimetry: EGM96 Geoid), but the accuracy of the model and the number of GCP (Ground Control Points) points were not known. Finally in 2006, IRD in cooperation with their local partners started a program to observe by aerial photogrammetry the evolution of several glaciers around La Paz city. The selected planimetry and altimetry were the UTM-WGS84 and the Ellipsoid-WGS84 respectively, because the geometric leveling of GCP points was not possible in remote areas.

The map aims at describing the new hypsometry and ortho-photo map of Zongo glacier based in 1983 photographs and, moreover, the glacier extension in 2006. The geometric distortion inherent to the corners of aerial images is removed by the ortho re-sampling process also called “ortho-rectification”.

The 1983 photogrammetric flight was carried out by the Bolivian cartography army corps on June 20th using a Wild RC10 metric camera. Due to the size of the glacier (less than 2.5 km²) and the flight height, resulting in a scale of 1:45000, only one stereo-pair (stereo-pair: 0295-0296) was required to generate the digital elevation model. A copy of negatives was scanned using a VEXEL Ultra Scan 5000 with a pixel size of 14 µm, which cor-

responds to an average ground resolution of 0.70 m. The aero-triangulation process was performed with 20 tie points and 9 GCP points using the Orima DP software. The precision of the model was Σ_0 : 9.7 μm ; RMSX: 0.75 m; RMSY: 0.97 m; RMSZ: 0.65 m. 12300 points were restituted manually with a 25 x 25 m regular grid in the Stereo Analyst for ArcGIS software and edited using the Terrain Editor of the Leica Photogrammetry Suite software (LPS). The DEM was interpolated linearly to 1m pixel size raster DEM format in ArcGIS. Finally, the ortho-photography (photography 0296) was ortho-rectified using the 1 m pixel size DEM in the LPS software.

In conclusion, the Zongo glacier consists now of six digital elevation models between 1956 and 2006 and in the future the glacier mass balance will be recalculated taking into account the hypsometric variation between 1983 and 2006.

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