

# Modeling the energy balance of high altitude glacierised basins in the Central Andes

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## Abstract

Water as a result of snow and glacier melt is an important resource in the Central Andes of Chile and Argentina, which in terms of precipitation are close to climatic deserts, yet they support large populations and a rich agriculture. In spite of this, little is known of the processes at play and the variability over time. In particular, the specific mechanisms of energy balance and melt on high altitude glaciers in this region have been the subject of limited research. Another particularity of the region is the ablation of most of the snow cover into penitentes or pinnacles of snow and ice about 2m in height.

Meteorological data from one automatic weather station installed on two different glaciers at 3335m and 4667m in the Chilean Central Andes demonstrate the relative importance of turbulent heat transfer in the energy balance equation, accounting for 10 to 20% of the net energy balance. Intense evaporation, together with effective radiative cooling, dew point well below freezing and intense solar radiation favour differential ablation of the snow surface, which results in the formation of snow penitentes, these unique forms result in a further modification of the energy balance. Stable conditions and a clear atmosphere permit effective incorporation of fully distributed solar radiative models with good results. Melt rates are compared with theoretical models, showing that while evaporation is enhanced in the Andes, surface morphology decreases total ablation. Modeling work suggests that penitentes enhance conservation of snow cover and the consequences of their loss, due to changes in the initial climatic conditions, might be increased ablation over the whole season, decreased glacier mass balance and faster depletion of water resources.

To implement distributed energy balance models both at the basin scale and at the microtopography scale, two additional tools were developed. One is a set of algorithms for the computation of terrain parameters from digital elevation

models (DEMs) suitable for rough topography. These algorithms, together with those developed for shading and insolation, permit the treatment of overhanging surfaces, such as the penitentes. Another tool is a flexible and inexpensive remote sensing tool for albedo estimation using conventional terrestrial photography. The technique consists in georeferencing oblique photographs to a digital elevation model (DEM), defining a mapping function between the pixel of the image and the corresponding cell on the DEM. Once the image is georeferenced, the reflectance values recorded by the film or digital camera are corrected for topographic and atmospheric influences and for the effect of the photographic process. By comparing these to a surface of known albedo, the spatial distribution of albedos is calculated. The validation of the technique on Alpine terrain shows good agreement with measured values.

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## Notes to authors

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(pdf file 12,418kb)

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