Glacier inventory of the upper Huasco valley, Norte Chico, Chile: glacier characteristics, glacier change and comparison with central Chile

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ABSTRACT. Results of a new glacier inventory of the upper Huasco valley, which lies within the arid Norte Chico zone of the Chilean Andes, are presented for 2004. Despite the high altitude, the glaciation in this region is limited in extent and is not classical mountain glaciation, which poses difficulties in completing standard inventory attribute tables. Small cornice-style ridgeline features constitute a large number of the non-transient ice bodies identified, and glaciers with surface areas <0.1 km² comprise 18% of the glacierized area and 3% of the water resource stored as glacier ice within the Huasco valley. Rock glaciers are an important component of the cryosphere, comprising 12% of the total water volume stored in glacial features. Changes in glacier area over the last ~50 years are in line with those for glaciers in central Chile despite the contrasting climate conditions. Projections of glacier area change based on glacier hypsometry and zero isotherm shifts predicted using the PRECIS regional model temperature change for IPCC scenario B2 conditions suggest that the survival of 65% of glacier area and 77% of active rock-glacier area will be threatened under forecast conditions for the end of the 21st century.

INTRODUCTION

In the semi-arid Norte Chico region of Chile (27°–33°S), the evolution of the cryosphere is of concern for local populations because of its role in local water resources. Although the region contains peaks in excess of 6000 m a.s.l., low precipitation and strong ablation, a large portion of which can be sublimation (Ginot and others, 2002), mean that glaciers are limited in both number and extent (total ice coverage in Norte Chico administrative regions of 73.85 km² (Garín, 1987; Rivera and others, 2000)). Despite the limited glacier extent, glacial meltwaters, when combined with snowmelt, are an important component of the hydrological resources (Favier and others, 2009) providing water that is vital for the regional economy.

The mountain climate is characterized by persistent low temperatures and humidity levels and generally clear skies. Meteorological conditions measured over 7 years at the Pascua-Lama mine exploration site (29°S, 70°W, ~5000 m a.s.l.) show that monthly mean temperature remains negative year-round, monthly mean relative humidity is 34–54%, precipitation is concentrated in the winter season between May and August, and monthly mean wind speed remains above 4 m s⁻¹. Synoptic-scale winds are predominantly westerly but are deflected southward along the Andean range (Kalthoff and others, 2002). Prevailing wind direction at the Pascua-Lama meteorological stations is from the northwest to north-northwest.

The glaciers of northern Chile (18°–32°S), including Norte Chico, were inventoried using aerial photographs from 1955 and 1961 (Garín, 1987). The report for this inventory highlights that in northern Chile: (1) it is not usually possible to separate permanent accumulations of snow from ice because glaciers show few surface signs of flow; (2) permanent snow patches were likely to be a significant hydrological resource; (3) the glacial group at Los Tronquitos (28°32′S) is the most significant concentration of ice in northern Chile; (4) clearly defined moraine forms were absent; and (5) rock-glacier features present in Norte Chico were difficult to identify as some did not show surface flow features. Rivera and others (2000) noted that as this inventory was not well associated with watersheds, more detailed work was required to make better hydrological assessments.

This paper presents the findings of a new inventory of the upper Huasco valley (Fig. 1) based on Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images from 2004, presents an assessment of glacier type and glacier evolution in this watershed, and compares the results with those from a similar study in the upper Aconcagua valley (33°S), central Chile (Bown and others, 2008).

METHODS

Images and image treatment

All the materials used in this study are presented in Table 1. The inventory work was carried out using ASTER images from 2004 (Fig. 1), but the orthorectification process used images from 2002 and 2003 as well. A 15 m digital terrain model (DTM) was generated from the ASTER images using the ASTER DTM module for ENVI. The same module was