Introduction

Glacier changes provide some of the clearest evidence of climate change (UNEP/WGMS, 2008). In general, the glaciers in Argentina and Chile show area loss and frontal recession from the late 19th century or the beginning of the 20th century to the present (Massoia et al., in preparation, among others). In the study area, previous work (Espizua et al., 2006) has shown area and length fluctuations of small glaciers based on remote sensing and fieldwork, in the period 1959-2005. The study of these small glaciers is relevant because they are key water resources in this hyper arid region (Liboutry, 1999).

Objective

The aim of this work is the study of recent glacier variations in the Andes Cordillera of San Juan (29°20’S) Argentina, from 1959 to 2007. Another goal is to explore the dominant controls of glacier changes, specifically precipitation and temperatures.

Methods

The materials used are presented in Table 1. All images were rectified with the image to image method, based on an orthorectified aerial image of 2005. Ice and snow surfaces were detected by NDSI on Landsat images, and hand-digitized on the aerial photos and the IKONOS 2005. In the IKONOS 2007, supervised classification was used. Two errors were considered: A) The Rectification error was estimated by means of RMS (Root Mean Square Error, Table 2). The RMS was used to calculate the maximum theoretical error in area measurements derived from the dilatation of the perimeter pixels. B) The classification error in Landsat TM images was measured by means of a comparison of the area obtained between a Landsat and an IKONOS image, both of 2005. The error found was corrected on the Landsat scenes of 1986 and 1997.

Meteorological data were obtained from 4 meteorological stations (Fig. 1, Table 2). Two stations, Lama and Frontera, are located in the arroyo Turbo basin, and have temperature and precipitation records, with some gaps. El Indio station is located 80 km southwards, in Chile, and has temperature and precipitation record, with minor gaps. La Serena is a coastal station located 130 km to the NW and has a complete 140 years precipitation record. The significant correlation, r=0.46, between El Indio and La Serena station enables a comparison of both precipitation series and also an extension of the record. The 650 m elevation difference between stations Lama and Frontera, allowed the calculation of the thermal gradient. Owing to the gaps existing in the record, a mean gradient value was calculated. This thermal gradient allowed the estimation of the mean annual and summer 0°C isotherm elevation for the period 1986-2007.

Glacier fluctuations and its relation with climate

Updated glacier fluctuations show a significant recession for the 2005-2007 period with a loss of 0.27 km² of total glacier area (4.5%). Enhanced ablation is confirmed in the image of 2007 by the presence of ponds on glacier Guanaco at 5140 m asl and on some minor snowfields at 5320 m asl. For the first time in the available record (Fig. 2) also by the decay of glacier Canario area, which is greater in its higher reaches. Total glacier area behavior is strongly influenced by the rapid decay of glacier Canario, which has lost 40% of area since 1959 (Fig. 3). Explanation for this behavior should come from temperature and precipitation.

Temperature data of the area is plotted in Fig. 5. The thermal gradient found is -0.80 °C/100 m. Temperature in the study area does not show a clear trend and mean annual 0°C isotherm appears to increase. Information since 1981 from nearby El Indio station indicates an initial warming in the early 90’s followed by a return to cooler condition in the mid 2000’s, but there are certain gaps.

Available precipitation data is of rather good quality and covers a reasonable period to account for possible glacier response time. The precipitation has a negative non-significant trend and even appears to have increased slightly in recent decades. Work by Viale and Milana (2007) also showed a negative trend in precipitation in La Serena and nearby Ovalle stations. Other analysis by Carrasco et al. (2006) indicates that no significant changes in precipitation occurred after the 1975-1977 PDO shift. This suggest that observed ELA rise in this region is mostly driven by 0°C isotherm rise, detected with 50 years radiosonde data. Results from the study area appear to back this hypothesis.

Conclusions

Glaciers in the Desert Andes (29°20’S) have lost area in the observed period 1959-2007. Enhanced area loss has occurred since the early 90’s and the last observed period 2005-2007 shows a 4.5% shrink of the total glacier area. The precipitation has a non significant negative trend and even appears to have a slight increase in recent decades. Information since 1981 from nearby El Indio station, indicates an initial warming in the early 90’s followed by a return to cooler condition in the 2000’s, but there are certain gaps. Preliminary results from the study area indicate that changes in temperature have a major role in these glaciers behavior, but a longer temperature data set is required.