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GLACIER VARIATIONS IN THE SOUTHERN PATAGONIA ICEFIELD AND THEIR RELATION WITH CLIMATE

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1. INTRODUCTION

The Southern Patagonia Icefield (SPI), with an area of 13,000 km^2 (Aniya, 1996), is the largest ice mass in the southern hemisphere outside of Antarctica. As such, its behavior is relevant for sea level changes and climate studies. SPI has a length of 350 km (48-51°S) and an average width of 50 km, with 48 major outlet glaciers (Aniya, 1997) which flow from the upper plateau at 1500-2000 m.a.s.l. to the western fjords, calving at sea level, and to the eastern piedmont lakes, calving at ca. 200 m.a.s.l. Here we present a review of glacier variations of SPI and their relation with climate.

2. METHOD

Glacier variations have been assessed based mainly on aerial photographs, satellite imagery and historical data. Aerial photographs from 1944, 1955, 1975 and 1995 are available. A Landat-TM image of 1986 covering the whole SPI was used by Aniya et al. (1997) to detect glacier variations.

In several cases, frontal variations have been mapped based on field observations. Such is the case of glaciar Upsala (Warren and Sugden, 1993) and glaciar Pio XI (Rivera and Casassa, 1999), among others.

More difficult to detect are ice thickness changes, which have been assessed mainly from repeat measurement of transects in the ablation area using topographic techniques, and also from comparison of digitized maps and the use of photogrammetric techniques.

3. FRONTAL VARIATIONS AND AREA CHANGE

Most of the 48 major outlet glaciers show a retreat of their terminus during the last century (Aniya et al., 1997). The largest retreat is that of glaciar O'Higgins, which retreated 14.6 km between 1896 and 1995 (Casassa et al, 1997). A few glaciers have shown relatively stable fronts during the last decades, as is the case of Oriental and Calvo glaciers. Only two glaciers have advanced during the last century, Perito Moreno (Warren and Sugden, 1993) and especially Pio XI. Glaciar Pio XI advanced ca. 10.5 km between 1830 and 1925, later retreated and advanced again in the periods 1945-1951 and 1992-1994 (Rivera and Casassa, 1999). As a result, the glacier has dammed a large area adjacent to the northern front, creating a lake of 240 km^2 (Lago Greve). After 1994, glaciar Pio XI has shown a slow retreat.

In terms of area change, there has been a net loss of surfa area of 500 km^2, or 4% of the total area of SPI in the 41-y period between 1944 and 1986 (Aniya et al., 1997), with maximum annual rate of 1.7 km^2 a^{-1} for glaciar O'Higg (Casassa et al., 1997).

Spatial analyses of the glacier variations shows that glaciers located in the northern half of SPI have retreat more rapidly than those of the southern half. In addition, glaciers located on the eastern margin of SPI have shown larger retreat than those of the western margin.

4. ICE THICKNESS CHANGES

Data of ice thickness changes exist for only 8 glaciers of S which are presented in Table 1. More details have be presented elsewhere (Rivera et al., submitted). Six glaci have experienced thinning, which is especially enhanced Upsala and O'Higgins glaciers, both located on the east margin of SPI. The longest measurement records are tho of Upsala, O'Higgins and Tyndall glaciers, which show in cases an increased thinning rate during the last decad Glaciar Perito Moreno shows no thickness change, wh glaciar Pio XI is the only case where thickening has be observed.

Table 1. Ice thickness changes

Glacier name	Thinning (-) and thickening (+) rates in m a^{-1}	Measurement period
O'Higgins	-3.2	1914 – 1933
	-6.7	1933 – 1960
	-2.5 a –11	1975 – 1995
Pio XI	+2.2	1975 – 1995
Upsala	-3.6	1968 – 1990
	-9.5 a –14	1991 – 1993
Ameghino	-2.3	1949 – 1993
Perito Moreno	No change	1991 – 1993
Dickson	-2.5 a -8.1	1975 – 1998
Grey	-2.3	1975 – 1995
Tyndall	-2.0	1945 – 1993
	-1.7	1975 – 1985
	-4.0	1985 – 1990
	-3.1	1990 – 1993

5. GLACIER VARIATIONS AND CLIMATE CHANGES

The generalized frontal retreat of glaciers, area loss and predominant thinning can be explained by the regional warming observed in western and eastern Patagonia during the past century (Rosenblüth et al., 1995 and 1997). In addition to this warming, inspection of precipitation time series shows a rainfall decrease of ca. 25% during the last century, which probably also contributes to glacier loss.

In the case of glaciar Upsala, the large thinning rates detected during the 90's cannot be explained only by temperature increase, but are probably due as well to dynamic factors related to the reduction of the emerging ice flow at the terminus (Naruse et al. 1997).

The advance and thickening of glaciar Pío XI suggest this might be a surging-type glacier, with a corresponding adjustment of its longitudinal profile (Rivera and Casassa, 1999). Several causes have been proposed to explain this anomalous behavior, such as the special hypsometric curve of glaciar Pio XI, the presence of nearby volcán Lautaro and glaciodynamic reasons at the calving front.

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