



Shrinking Patagonian Glaciers

This webpage is a shortened and simplified version of the [Davies and Glasser 2012](#) paper published in [Journal of Glaciology](#).

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Introduction

The Little Ice Age

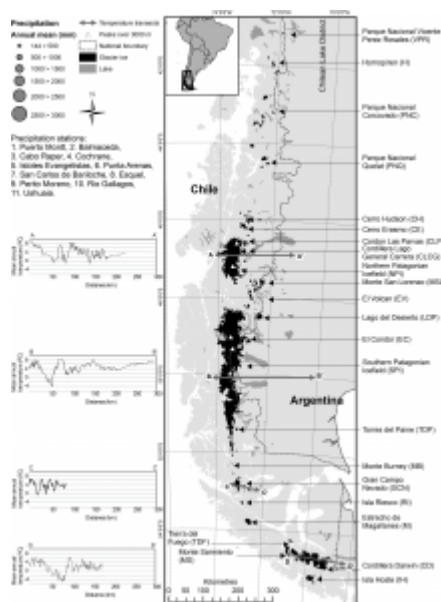


Figure 1. Map of the glaciers of the Patagonian Andes. Note the precipitation gradient west and east across the mountain range.

The Little Ice Age (LIA) is widely recognised in places like the Alps in the northern hemisphere, where glaciers expanded and formed prominent moraines around 150 years ago. During this period of cooler temperatures, there were Frost Fairs on the Thames, which regularly froze over. This period of cooler temperatures also resulted in widespread glacier advances across the Andes in Patagonia, with many glaciers forming prominent moraines. Inside the moraines, the ground remains ice-scoured and relatively bare of vegetation. These geomorphological features can be seen by satellite, which means that it is possible to map the extent of the glaciers during the Little Ice Age across Patagonia. In combination with trimlines, which show the vertical extent and thickness of the glaciers during the Little Ice Age, it has been possible to map changes in glacier volume from the LIA to the present day (see [Glasser and others, 2011, Nature Geoscience](#)¹). The LIA has also been recorded in the Antarctic Peninsula (with large moraines formed on James Ross Island, for example).

Measuring change by satellite

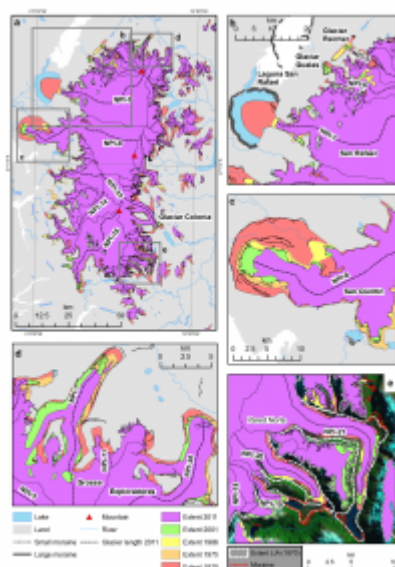


Figure 2. Mapping the glaciers of the Northern Patagonian Icefield.

Satellite measurements of the Patagonian icefields suggest that they are currently rapidly receding and thinning, with a measureable contribution to eustatic sea level rise². Many workers argue that the glaciers of the Patagonian Andes are now shrinking at an increased rate as a result of recent climate change³⁻⁵. However, these assessments of change are restricted by the availability of maps (last 60 years) and satellite images (last 40 years). In this study (from 40° to 56° South), we used geomorphological evidence of glacier extent during the LIA (~AD 1870) and satellite images to map glacier extent across the Andes over the last 140 years, in 1870, 1975, 1986, 2001 and 2011.

Results

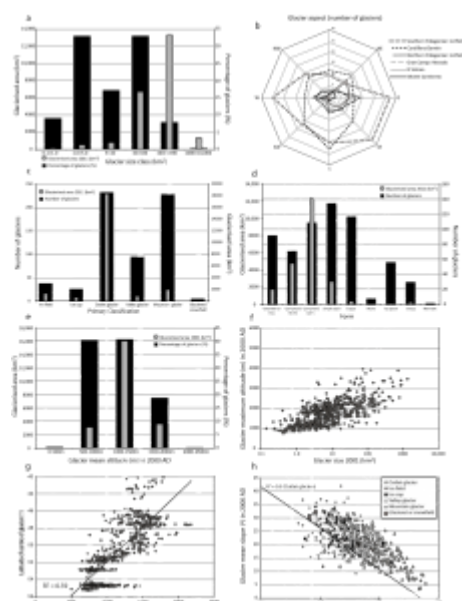


Figure 3. Glacier inventory data from the Patagonian inventory from the year 2011.

We mapped 626 glaciers across the Patagonian Andes, of which 386 drained the major icefields (North Patagonian Icefield, South Patagonian Icefield, Gran Campo Nevado, Cordillera Darwin). A few large glaciers made up the majority of the glacierised area. The remainder were smaller icefields and glaciers in the Chilean Lake District and on volcanoes and mountains. 100 of these glaciers ended in lakes or in the sea. 640 glaciers were mapped during the LIA (the remainder having entirely disappeared).

This data is available to download from the [GLIMS database](https://glaciers.org/). The full inventory and analysis is available in Davies and Glasser 2012 (*Journal of Glaciology*).

Glacier change

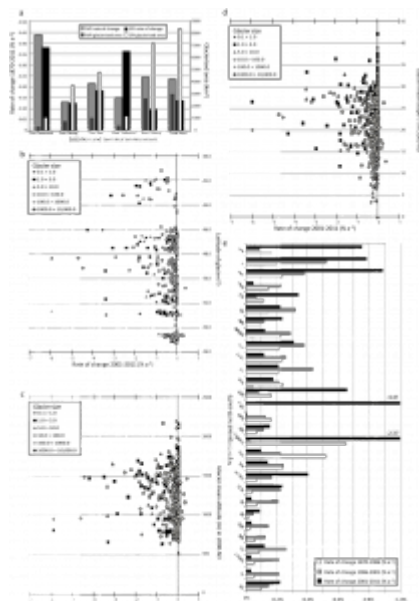


Figure 4. Graphs illustrating glacier change across Patagonia.

Overall, 90.2% of glaciers shrank between the end of the LIA (approx. 1870) and 2011, 0.3% advanced and no change was observed in 9.5% of the glaciers. These small advances were generally short term, and limited to tidewater glaciers. All regions have suffered extensive glacier loss. The greatest annual rates of shrinkage were observed in the small (less than 5 km² in size) land-terminating glaciers.

Annual rates of shrinkage across the Patagonian Andes increased in each time segment analysed (1870-1986, 1986-2001, 2001-2011), with annual rates of shrinkage twice as rapid from 2001-2011 as from 1870-1986 (0.10% a⁻¹ from 1870-1986, 0.14% a⁻¹ from 1986-2001, and 0.22% a⁻¹ from 2001-2011).

Change in the North Patagonian Icefield

The North Patagonian Icefield experienced rapid recession over the time period, with fastest rates of recession from 2001 to 2011.



Recession of the North Patagonian Icefield, AD 1870 (Little Ice Age) to 2011.

Faster rates of change in different places and different times

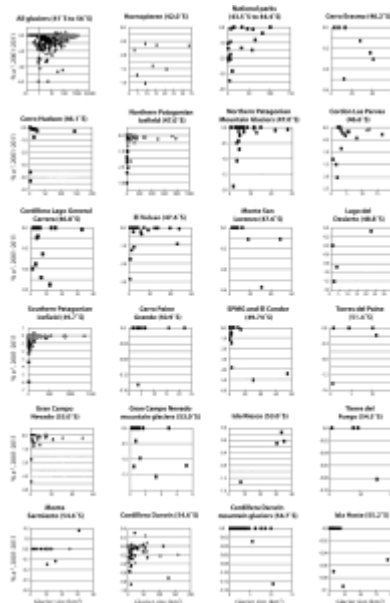


Figure 5. These scatter plots show how glaciers are behaving differently at different latitudes, and that land-terminating glaciers are shrinking fastest. Circles represent calving glaciers, and squares represent land-terminating glaciers.

In general, rates of change were fastest from 2001-2011 in more northerly glaciers, with the glaciers in the Chilean Lake District and the Northern Patagonian Icefield shrinking particularly rapidly. The more southerly glaciers, in the Cordillera Darwin, Monte Sarmiento, Isla Riesco and Tierra Del Fuego, shrank fastest from 1986-2001.

This data suggests that the Patagonian glaciers are indeed shrinking faster now than they did in the last century. For example, our calculated rates of area loss from the Northern Patagonian Icefield suggest that there was an increase in annual area loss rates from $0.09\% \text{ a}^{-1}$ in the 116 years between AD 1870 and 1986, to $0.12\% \text{ a}^{-1}$ in the 15 years between 1986 and 2001, to $0.23\% \text{ a}^{-1}$ from 2001 to 2011.

Conclusions

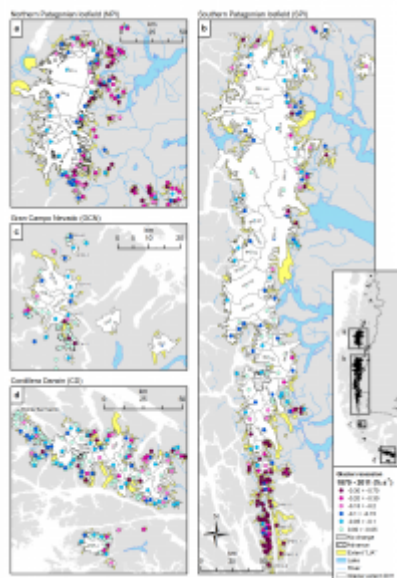


Figure 7. Annual overall rates of shrinkage for glaciers across Patagonia.

The figures opposite and above show that latitude, terminal environment (calving or ending on land) and size exert the strongest controls on glacier shrinkage, with the more northerly, land-terminating, smaller (less than 5 km^2) glaciers shrinking fastest. Calving glaciers have been observed to be thinning⁶⁻⁸, but their recession is strongly controlled by calving dynamics. Worldwide, small ice caps and glaciers have reacted particularly dynamically to worldwide increases in temperatures⁹⁻¹¹, and it has been proposed that the volume loss from mountain glaciers and ice caps like these is the main contributor to recent global sea-level rise¹².

On a regional scale, the large icefields and small icecaps and glaciers north of 56°S suffered particularly rapid shrinkage from 2001-2011, presumably as a result of the decreased precipitation and warmer tropospheric air temperatures observed in this region^{2,13-16}. The glacierised summits lie in this altitudinal zone, so warming is likely to have a significant control on the mass balance of the glaciers.

There is considerable inter-catchment variability in the behaviour of the glaciers across the Andes, with calving dynamics, latitude and size resulting in glaciers shrinking at different rates. However, overall, annual rates of shrinkage were far faster from 2001-2011 than from 1870-1986 or 1986-2001.

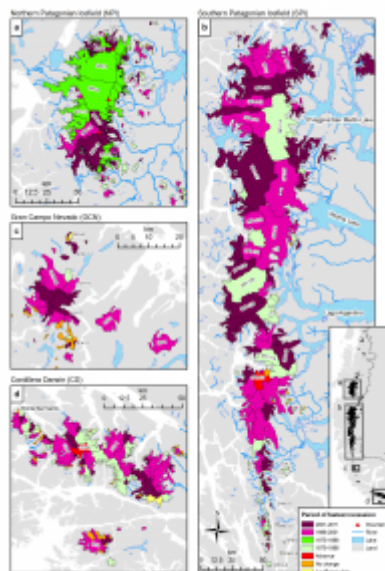


Figure 8. Period of fastest recession for Patagonian glaciers.

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Citation

[Davies, B.J. and Glasser, N.F. 2012. Accelerating shrinkage of Patagonian glaciers from the Little Ice Age \(~AD 1870\) to the present day. *Journal of Glaciology*, **58** \(212\), 1063-1084.](#) Please use this reference if citing.

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