Weather and Climate (1991) 11: 52-53

ATMOSPHERIC CIRCULATION CHANGES IN THE SOUTH WEST PACIFIC 1911-1985 AND THEIR EFFECT ON GLACIER BEHAVIOUR

B. B. Fitzharris* and J. E. Hay**
***Department of Geography, University of Otago**
****Environmental Science, University of Auckland**

Extended Abstract

In the current debate on global climate change, temperate glaciers are receiving increasing attention. They are sensitive indicators of such changes and palaeo-studies provide much information of their past behaviour, while the relationship between glacier behaviour and climate has long been a central issue of glaciology. With the real possibility of global warming, the reaction of glaciers to circulation changes and their impact on global sea levels is now a crucial question.

Although small in total areal extent, New Zealand's 3150 glaciers can make an important contribution to our understanding of global change because we are one of few places in the southern hemisphere that have good historical records. In addition, New Zealand glaciers appear to be highly sensitive to climate variations, responding rapidly to large scale changes in the atmospheric circulation.

Because New Zealand lies between latitudes 34 S and 47 S in the South West Pacific, it is well placed to detect and document glacier variations caused by circulation changes. Surrounded by ocean, its main axial ranges trend across the prevailing westerlies, and are the most extensive mountains in the Southern Hemisphere outside of South America and Antarctica. At the same time the subtropical high pressure zone influences the northern part of the country, while recent research has highlighted the role of the El Nino - Southern Oscillation phenomena in modulating New Zealand weather and climate.

There is considerable controversy about the relationship between the behaviour of New Zealand glaciers and climate. Some researchers of eastern glaciers believe that rising temperatures, particularly this century, have been largely responsible for their wholesale retreat. Others show that for western glaciers, correlations with temperature are not significant, and that changes in precipitation are probably responsible. This controversy is probably best resolved with studies of ablation and accumulation process and the relationship of these to synoptic climatology.

Our studies began by demonstrating a strong link between synoptic weather patterns, ablation and the energy budget over the Ivory glacier. During 53 days over two successive summers, measured ablation averaged 38 mm/d, but showed large variations from less than 10 mm/d to over 70 mm/d, depending on the synoptic weather situation. The larger scale atmospheric circulation also controlled the relative contributions to melt of the terms of the energy budget. Net radiation dominated the melt budget during southerly flows, but the convective fluxes and associated nocturnal melt became more important with airflows from the northwest to northeast.

These findings of glacier ablation over two summers suggest that their long term behaviour depends on the frequency of synoptic weather types. Trends in frequency of summer weather types might produce changes in ablation, net balance, and hence response, especially when the glacier is small and controlled by a high input/output system. These issues cannot be answered until the linkage between atmospheric circulation patterns and glacier behaviour are examined, this being the objective of our current research.

Past climatic change can be better understood if there are long series of pressure data that facilitate derivation of circulation maps or indices. Pressure observations are available for some stations in the South West Pacific region from last century, but before they can be used two steps are necessary. First, techniques must be applied to assess the homogeneity of the pressure series at each station and second, pressure patterns of the past must be reconstructed from the station point data. Our paper examines regional circulation regimes based on reconstructed variations of sea level pressure patterns back to 1911 (Jones, 1989) at 65 grid points over an area between 20 S 100 E, 60 S 100 E, 20 S 140 W, 60 S 140 W.

The reconstructions were compared with actual gridded sea level pressure data for 1972-1985 obtained from the World Meteorological Centre in Melbourne, Australia. In winter they explain 90% of the variance over most of Australia and New Zealand, falling off to 70% in the Southern Ocean and to the west of Australia. Mean variances explained over the whole region were 75% (summer), 74% (autumn), 81% (winter) and 80% (spring).

Mean circulation patterns for winter and summer show that seasonal changes in pressure patterns over the Australian area have important downstream consequences for New Zealand. The main features are the development of a thermal, monsoonal low in northern Australia in summer, and an intensification of the westerlies near the south of the South Island. The subtropical high extends from the Indian Ocean across southern Australia to the northern part of New Zealand, where the mean 1014 hPa isobar is at latitude 37 S. During winter, the mean pressure distribution shows some important differences. The thermal trough over Australia is replaced with a thermal anticyclone which extends a weak ridge over the Tasman Sea and the South Island, and as a consequence the flow over New Zealand is weaker and more southwesterly.

Our approach is to examine seasonal anomalies of surface pressure over periods of a decade or more from their long term means so as to identify shifts in atmospheric circulation since 1910. In addition, circulation indices based on pressure differences between stations are chosen to show trends in the main circulation features since the latter part of the 19th Century. These show considerable fluctuation in summer, with stronger westerly flow over the Southern Alps about the 1910s, 1940s and 1980s, and increased northerly flow about the mid 1920s to mid 1940s, and in the 1960s to mid 1970s. The indices indicate that atmospheric circulation has altered considerably over this century. Substantial changes in rates at which New Zealand glaciers are retreating and down-wasting are found to be associated with subtle variations in atmospheric circulation patterns in the South Pacific, particularly the poleward shift of the subtropical high in summer.

Reference:

Jones, P.D., 1989: Early instrumental data for the Southern Hemisphere its usefulness for the reconstruction of climate. *Proceedings of the Fourth Annual Meeting on Statistical Climatology, Rotorua, March 1989.*