Short note

Icebergs near New Zealand and related phenomena

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Abstract

Icebergs were seen in the Southern Ocean between Campbell and Antipodes Islands in late December 2004. This note lists other times when icebergs were sighted near New Zealand, in the 19th and 20th centuries. In the South Island cold weather patterns, exceptional snowfalls, massive snow avalanching and glacier expansion episodes were broadly coincidental with the times of iceberg appearance relatively close to our shores.

Keywords: Icebergs - Southern Ocean - Subantarctic Islands - Chatham Islands - southerly windstreams - 19th and 20th centuries - Antarctica - Antarctic Circumpolar Current - Southern Alps - major snowfalls - snow avalanches - glacier expansion.

Introduction

Just before Christmas 2004 there was a report of icebergs up to 3 km wide drifting in the Southern Ocean between Campbell and Antipodes Islands, the northernmost at 51° S, 240 km southwest of the Antipodes. (L. Carter, NIWA, 6 January 2005 media release). This event, with icebergs extending well north of their usual limit at about 60° S, was preceded by persistent, strong, cold southerly to south-westerly airflow onto New Zealand - the most sustained period of such airflow on record (NIWA 2004). In the same period snowfalls occurred frequently and to relatively low levels in the South Island (300 m in Southland-Otago and 500 m in Canterbury).

The cold airstreams were associated with intense cyclonic weather systems centred over the ocean west and east of the southern South Island as well as strong anticyclones centred further west in the Tasman Sea (The Press, Christchurch, 10-20 December 2004, weather pages). As a result New Zealand had its coldest December since 1945 and one of the coldest on record (NIWA 2004).

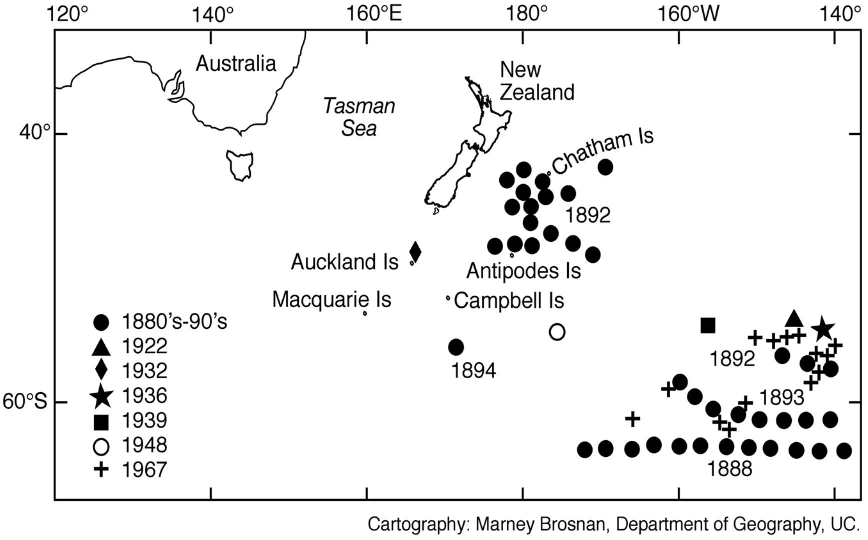


Figure 1. Iceberg sightings near New Zealand in the 19th and 20th centuries AD (after Brodie & Dawson 1971, Gaskin 1972) (also see text for other records).

The 19th and 20th Century Records

Historic data, summarised in Brodie & Dawson (1971), Gaskin (1972), and Burrows (1976a) reveal that icebergs were seen near the New Zealand Subantarctic Islands three times in the 20th century (1902, 1931, 1948) (Figure 1). In 1902 bergs drifted between Antipodes and Chatham Islands. The 1931 event brought a berg to the coast of South Otago and another to the Auckland Islands. In 1922, 1936, 1938, 1939 and 1967 large numbers of bergs were seen further to the east, at about 55° S, and between longitudes 160° W and 140° W (Figure 1) (Brodie & Dawson 1971, Gaskin 1972).

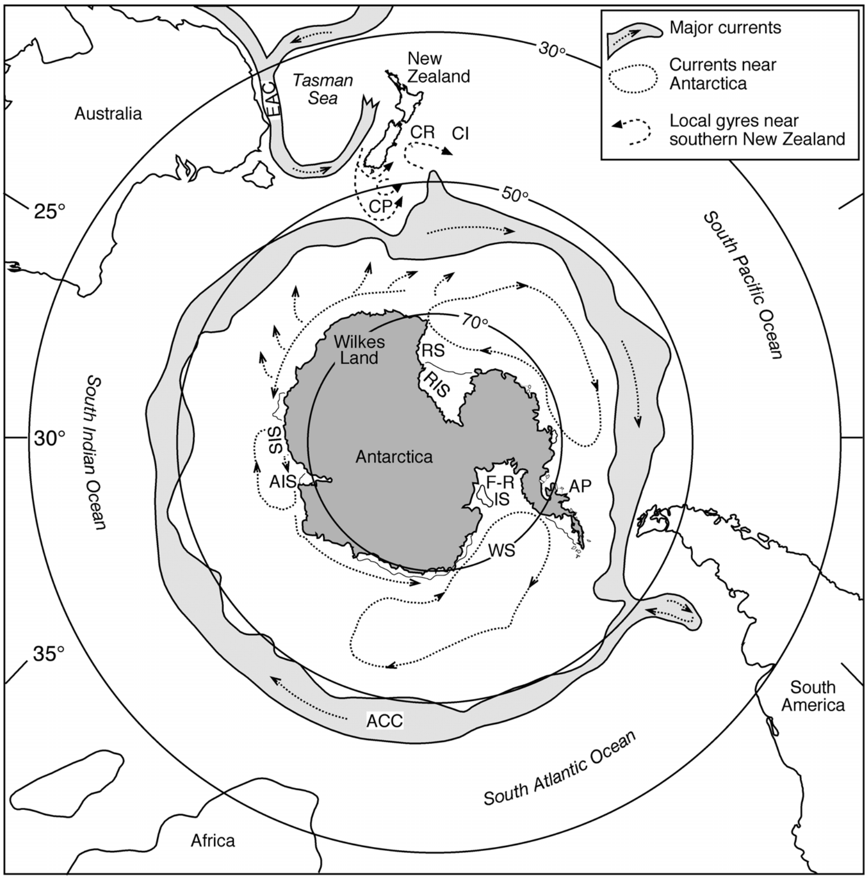
During the 19th century there were occasions when bergs were much more abundant and travelled much further north than at any time since. The northernmost recorded sighting near New Zealand, in 1855, was at 40° S and 170° W (c. 1,100 kilometres east of Hawkes Bay). At the same time other bergs were seen close to the Chatham Islands (Russell 1895, 1897).

In the summer of 1892 a major influx of icebergs, the northernmost at 42° 20′S was observed around the Chatham Islands. More bergs drifted around the Antipodes and Bounty Islands. At this time (1892-1893) there were many berg sightings about or north of the 60th parallel between 170° and 140° W. Again, in the summers of 1894, 1897 and 1898 there were many icebergs around Bounty and the Antipodes Islands.

Origin of the Icebergs

According to Carter *et al.* (2002) many icebergs that originate in Antarctica at first are transported in cyclonic gyres north of the big ice-shelves, Ross (long. 170° E - 160° W); Filchner-Ronne (60° W - 40° W); and Shackleton (90° 30′E - 100° 30′E). They will be trapped in the Antarctic pack ice in winter and released as the pack breaks up in summer. Some bergs drift far enough north to be caught up, about 65° to 50° S latitude, in the eastward-flowing Antarctic Circumpolar Current and begin a long journey around the continent before they melt (Figure 2). These authors indicate that the bergs seen near New Zealand are most likely to originate not from the Ross Sea area, but from the Weddell Sea area, or from ice shelves and big tidewater glaciers around the continental margin between the Weddell Sea and the Ross Sea, especially from the Shackleton Ice Shelf and the coast of Wilkes Land (cf. Bamber *et al.* 2000).

Near New Zealand the northern edge of the Antarctic Circumpolar Current is directed northward by the Campbell Plateau margin, with minor branch gyres



Cartography: Marney Brosnan, Department of Geography, UC

Figure 2. Ocean currents in middle and higher latitudes of the Southern Hemisphere that affect the dispersal of icebergs. Note the small gyres south and south-east of South Island, New Zealand. ACC Antarctic Circumpolar Current (its northern limit is the Antarctic oceanic convergence zone); AP Antarctic Peninsula; AIS Amery Ice Shelf; CI Chatham Islands; CP Campbell Plateau (undersea); EAC East Australian Current; F-RIS Filchner-Ronne Ice Shelf; RIS Ross Ice Shelf; RS Ross Sea; SIS Shackleton Ice Shelf; WS Weddell Sea (after Knox 1994; Carter *et al.* 2002). The undersea Chatham Rise is between New Zealand and the Chatham Islands.

south and southeast of the South Island (one, clockwise, in the Bounty Trough and along the southern edge of the Chatham Rise) (Carter *et al.* 2002). Sometimes, as a result, icebergs float relatively close to this country.

As a general rule icebergs are impelled by the main ocean currents. However, wind-driven surface currents can also influence the direction of their movements (Herdman 1948, 1953, Burling 1961, Carter & Herzer 1979). The strong southerly windflow pattern, mentioned above in connection with the December 2004 iceberg event, was also noted by observers of earlier events. For example, Shand (1893) wrote of his Chatham Islands experience, in October 1892, that prior to the arrival of a flotilla of bergs the wind had, for two or three days been blowing very hard from the south and south-south-west. As well as being strong the wind was very cold. A regular south to southwest windflow pattern has been recorded across the Chatham Rise (Reid & Collen 1983).

Iceberg occurrences near New Zealand during the Otira Glaciation (and the Kaihinu Interglacial before it) are inferred from the presence of ice-rafted stony debris in sediments on the seafloor of the Campbell Plateau and Chatham Rise (43° S latitude) (Carter *et al.* 2002). Shallowing of the sea over the central Chatham Rise in glacial times allowed icebergs to score gouges in soft rocks on the seafloor. These are orientated north-south and northeast-southwest.

Most icebergs observed near New Zealand have been irregular in shape and relatively small (up to about 25 m high and a few hundred metres long). However, some were large, tabular bergs, up to 8 km long (Russell 1895). The estimated emergent heights have been up to 150 m (Shand 1893, A. S. Moys 1897, in Brodie & Dawson 1971). As the seaward margin of the Ross Ice shelf is 200-400 m thick tabular bergs derived from it should stand no more than 50 m above the sea (pers. comm. T. Chinn). Presumably this applies also to bergs from other ice shelves. Taller, irregular-shaped bergs could originate from thicker glacier tongues that calve into the sea (pers. comm. T. Chinn). Many small bergs seen near New Zealand probably were partly-melted remnants of once-larger bergs. Some could also have been overturned. If the sources of some of the smaller bergs were locations along the coastline of Wilkes Land, west of the Ross Sea, they could have been derived from tidewater glaciers.

Other Associated Effects

Iceberg Irruptions in Other Parts of the Southern Hemisphere

During the 19th century in the periods when icebergs approached our shores there were several other correlative events. Among them were exceptional occurrences of masses of icebergs far north of their usual limits in each quadrant of the Southern Hemisphere (0-90° E, 90-180° E, 180-90° W, 90-0° W). The outstanding episodes were in 1850-1860 and 1891-1898. The great circle shipping routes in the South Atlantic, Southern Indian and South Pacific Oceans, between Australia-New Zealand and both the Cape of Good Hope and Cape Horn were severely affected and some ships were lost (Russell 1895, 1897). During these episodes, icebergs were being entrained in northward-flowing branches of the Antarctic Circumpolar Current and it is likely that the Antarctic oceanic convergence zone and subantarctic belt of westerly winds moved slightly northward of their usual location.

These iceberg outbreaks were not totally unprecedented; similar events had been observed in the South Atlantic and south of South Africa in 1772-1775 (Herdman 1959). A lesser event occurred in the mid 1860s. There were also icebergs well north in the South Atlantic quadrant 1902-1939 (Burrows 1976a). No icebergs were ever recorded from the Tasman Sea. This is because of the strong influence of the East Australia Current that brings subtropical water southward, flowing south near Australia, east across the Southern Tasman Sea at about 40° to 45° S latitude and north near the South Island's west coast.

Exceptional Snowfalls in the South Island

In the 19th century frequent heavy winter snowfalls were experienced east of the Main Divide of the South Island's Southern Alps. From 1860-1895 the pastoral industry was hit many times by such events, often with several damaging storms in a year. Economically crippling stock losses occurred. Fewer severe snow years were experienced early in the 20th century, but nevertheless the farming industry suffered devastating damage at times. Single major snowstorms occurred in 1945, 1967 and 1992 (Burrows 1976b and unpublished data).

The heaviest winter snowfalls occur in the eastern South Island when cold air in the southerly flow between cyclonic systems centred east or south-east of New Zealand and anticyclones to the west interacts with warmer air masses (Coulter 1969). The warm air is associated with the relatively warm water of the East Australia Current. Sometimes the air over the South Island was so cold, as the anticyclones drifted onto the country in the aftermath of these events, that thin ice formed on the sea in sheltered coastal sites (for example, in Lyttelton Harbour 1878, 1895 and in Otago Harbour at various times).

Major Snow Avalanche Events

Associated with the major snowfall episodes in the South Island in the 19th and 20th centuries were substantial snow avalanche events in the mountains. Some avalanches were exceptionally large and destroyed extensive areas of forest. Julius Haast, the first scientist to visit the central Southern Alps, recorded very abundant snow avalanche debris, still evident in late summer and autumn, in the upper Rangitata, Lake Ohau and Rakaia catchments during his scientific expeditions each year from 1861 to 1866 (cf. Burrows 2005). Snow avalanche damage in *Nothofagus solandri* forests of the Craigieburn Range, Waimakariri catchment, between 1876 and 1930 was most severe in 1895, 1898, 1902, 1912, 1919 and 1924 (Conway 1977). Avalanche rock debris heaps deposited at the foot of slopes in the 19th century in many parts of the Canterbury high country are now well-vegetated. Avalanche debris ramparts at the foot of steep mountainside gullies are now free of snow in winter and also well-vegetated (Burrows 2005). More recently, avalanching has been less extensive and less destructive. However, the exceptional 1945 snowfall caused major damage from which the forests have only recently recovered. General conclusions from the field evidence are that avalanching in the Southern Alps was of greater magnitude during the 19th Century and temperatures lower at times than they are today.

Glacier Expansion

The iceberg occurrences near New Zealand were spring, summer and autumn phenomena (Russell 1895, 1897; Brodie & Dawson 1971, Gaskin 1972). This is of interest in relation to a further effect of cold airflow onto the South Island over the same period, namely the expansion of glaciers of the Southern Alps. Most of these glaciers have their névés along the Main Divide.

The records of the state of the glaciers left by Julius Haast 1861-1878 show that all of the central South Island glacier termini were well-advanced and glacier surfaces high (with large ice volumes) during his travels in the mountain regions (Haast 1879). Later observers noted that there was a period of glacier expansion in the 1880s and 90s. The glacier termini remained well forward and surfaces of their trunks high until about 1900, when shrinkage began. They have declined ever since with a few halts in recession or small advances in the 20th century (Fitzharris *et al.* 1992, Chinn 1996, Burrows 2005).

Nourishment of these glaciers is by snowfalls from storms with windflow trajectories from southwest or south. For snow to fall the freezing level must be relatively low. For glaciers to maintain high volume (and to push forward) there must be positive mass balance (an excess of ice entering the névé area over the amount being lost by ablation over the whole glacier). Apart from requiring consistently heavy winter snowfall (when ablation is least) glacier expansion is enhanced when snowfalls in spring, summer and autumn shorten the normal, warmer season ablation period. Cold airflow from the south, impacting on warmer, moist air associated with the anti-clockwise gyre of the East Australia current in the southern Tasman Sea is likely to bring snow (and lowered freezing level) to the glacier névés and this will have an ablation-limiting effect. That is the situation which appears to have been occurring in the 19th century when there was positive mass balance of South Island glaciers, heavy snowfalls to low levels were frequent in the sheep country of Otago, Canterbury and Marlborough and when icebergs were abundant near our shores at times. Analysis of past climate patterns around New Zealand (Fitzharris *et al.* 1992, Chinn 1996) is consistent with these views on the connection between persistent cold southerly airflow, and other indicators of cool conditions in the Southern Alps including extension of glacier termini (cf. Burrows 2005). Note that heavy snowfall precedes glacier expansion by a few years (steep glaciers like the Franz Josef) to at least a few decades (low-gradient glaciers like the Tasman), (Chinn 1999).

The Present Situation

When the world is experiencing generally warmer conditions, with clear signs of major shrinkage of many Antarctic glaciers, as well as those in New Zealand and elsewhere, the December 2004 event demonstrates that there can still be episodes of cold airflow that bring icebergs relatively close to our shores. Iceberg production in Antarctica appears to have been increased by recent disintegration of some glacier and ice shelf termini (Carter *et al.* 2002).

The steep Franz Josef (Westland) and Stocking (Canterbury) glacier termini receded and their surfaces shrank down progressively, between 1910 and 1982. The Franz Josef terminus receded almost 3 km in this period. However, there were reversals of the trend, with small readvances of both glaciers 1925-1935, 1945-1950, 1965-1967. None of these advances regained the ground lost during the prior shrinkage and, after 1967, the glacier termini receded to their furthest recorded upvalley positions (Burrows 2001, 2005).

In the past two decades, however, the Southern Alps glaciers have experienced a remarkable, sustained period of positive mass balance (Chinn 1999, Clare *et al.* 2002). Annual autumn photosurveys, by air, of 111 glaciers, to record the snowline altitude, show a surplus of ice input over ablation in the névés in most years since 1982. In some glaciers no clear increase in ice volume of the glacier trunks is yet evident. The termini of relatively low gradient glaciers that end in lakes, such as the Tasman and Godley (Canterbury) continue to melt back. However steep, fast-reacting glaciers such as the Franz Josef, Fox (Westland) and Stocking (Canterbury) have experienced increased ice volume of their trunks and their termini have pushed forward. Since about 1982 the Franz Josef terminus has advanced more than a kilometre (Burrows 2005).

The relationships of the lowered glacier snowlines in the Southern Alps between 1982 and 2002 with parameters of the atmospheric circulation and sea surface temperatures in our region have been analysed by Clare *et al.* (2002). Strong westerly and southerly airflows over the Southern Alps, as well as relatively low pressures south-east of New Zealand and cool sea surface temperatures in the surrounding ocean, are correlated with the glacier phenomena. These effects contrast with those of the decades before 1980.

Occurrence of icebergs between Campbell and Antipodes Islands in December 2004, though a minor event of its kind, is consistent with the glacier evidence for lowered freezing levels affecting positive mass balance. We can expect to see extension of the more sensitive Southern Alps glaciers (and sometimes icebergs near our shores) whenever the south winds bringing frigid air from the Antarctic region blow frequently and strongly.

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