Glacier Snowline Survey, 1996

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ABSTRACT

The end-of-summer snowline survey of 48 "index" glaciers of the Southern Alps, undertaken in March 1996, indicated that 1995-96 continued the trend to positive glacier balances of the past decade.

KEYWORDS: Snowline, glacier fluctuations, climate change, Main Divide fault.

1. INTRODUCTION

This aerial survey continued a glacier/climate monitoring programme commenced in 1977 for the New Zealand Glacier Inventory, where the position (altitude) of the end-of-summer snowline is photographed annually on a set of some 48 selected glaciers arranged in transects across the Southern Alps (Fig. 1). Glacier snowline altitudes give a direct value for glacier health and balance, whereas glacier frontal positions are modified by response times and glacier dynamics.

During the flight various additional glacial and geological features were photographed. This year the survey was again highly successful in that all but one of the index glaciers of the Southern Alps, ranging from southern Fiordland to Nelson Lakes mountains, were photographed.

2. METHOD

The method involves taking simple oblique photographs of the position of the end-of-summer glacier snowlines. Topographic maps then are compared with the photographs to derive snowline altitude. A folder of maps showing the glacier locations, together with copies of past photos of each glacier, is held by the navigator seated beside the pilot. The photographer operates from the back seat, shooting from both sides of the aircraft. At each glacier, previous photographs are duplicated closely to assist comparisons from year to year. This year, in addition to the index glaciers, a number of small, insignificant glaciers not previously photographed for the N.Z. Glacier Inventory, were photographed for the inventory archive, and a set of 1:63,360 scale inventory maps was carried for this purpose.

The photographs are analysed by ranking all photographs of each glacier in ascending order of snowline elevation and inserting this year's snowline elevation photo in its position in this sequence. The equilibrium line altitude is then interpolated both from the values of previous years, and from mapped contours.

3. PREPARATIONS

The flight should be made on the elusive "last perfect day before the first winter snowfall", at the end of significant summer melt. The flight was planned for the first clear weather commencing in March, and took the opportunity of the second anticyclone to pass on to the country for many weeks (Fig. 2) . This system was apparent in the forecast of Sunday, March 3, and the flight was planned for the following Tuesday and Wednesday. The flight was made in a Cessna Cardinal 177, DMI, chartered from Aspiring Air at Wanaka airfield. This high wing aircraft is eminently suitable as it has

no obstructing wing struts and a relatively high cruising speed. The pilot, Andy Woods, being an ex-mountaineer with previous experience of work on glacier research, had a wide knowledge of the mountains and required no instructions to position the aircraft appropriately. Jane Forsyth was the navigator and Trevor Chinn was the photographer. The combined detailed mountain knowledge of the party permitted direct "front window" navigation without any flying time lost to searching for our positions on the maps.

In recent years it has been a policy not to take passengers on this very popular flight, to allow efficient use of both sides of the aircraft for photographing, but this year Simon Cox, an Otago University postgraduate structural geologist, was included on the flight. The flight provided him with an excellent opportunity to supplement his study of the structure of the "Main Divide fault" of the Southern Alps. The Otago University also contributed to the cost of the flight. Only minor deviations were made from the glacier itinerary to observe structures, and it was found that in the Cardinal aircraft, two people in the rear seats did not hinder access to the windows either side to any great extent.

4. ITINERARY

The flight was made mainly at 10,000 ft altitude which has been found to give the best angle on the glacier snowlines, with some descents to 8,500 ft to pass beneath Civil Aviation air corridors.

The flight commenced at 8:30 on the morning of Tuesday 5 March, 1996, from Wanaka airfield (Fig. 3) while remnants of an altostratus cloud blanket within the anticyclone were still evident (Fig.2, satellite image). Fiordland was chosen to be covered on the first leg, commencing with the Dart-Shotover-Arawata section and then south to southern Fiordland. The Dart Glacier was under low cloud. The leg was completed in 3.5 hrs.

The second leg west of the Main Divide to Arthurs Pass was made in the afternoon and encountered increasing cloud cover which finally obscured all the glaciers in the Arthurs Pass area. This leg was completed in 2.4 hrs, and an overnight stop made at Hokitika.

On 6 March, the weather remained clear for the flight over Lewis Pass while regaining an altitude of 10,000 ft. to cover the glaciers of the Nelson Lakes region, with a turn-around over some un-photographed glaciers on Mt. Hopeless. The long extension to Mt. Tapuaenuku was not made. On the return to Hokitika (a much closer refuelling stop than Rangiora, used in past years) the Arthurs Pass glaciers were found clear of cloud and the leg completed in 2.2 hrs.

The remaining eastern glaciers from Whitcombe Pass to Hawea were covered in 2.4 hrs without any further problems with cloud, and the return to L. Hawea at 3 pm completed in 1.9 hrs. For the record, the "first winter snow fall" occurred on 9 March, two days after the flight was completed.

5. RESULTS

This year the survey was again highly successful in that very favourable weather permitted a coverage of the entire Southern Alps, although to minimise the possibility of costs exceeding a close budget, the Inland Kaikoura Range glacier was not visited. The project took a total of 10 hrs flying time. Small diversions to photograph structural features contributed about 0.5 hr. The flight time was less than for last year (10.8 hrs) mainly because the long leg to the Inland Kaikoura Range was not made. A few orbits were made to allow film changes at times when the three cameras ran out of film simultaneously. Although various aggravating incidents of camera malfunction, including erroneous exposure readings and jamming film, were experienced, records are available for all the glaciers visited. The programme used three slide films, seven 35mm print films and nine ten-shot 120 films.

This year, the majority of the snowlines were again low, indicating a year of dominantly positive balance on the glaciers, although a few instances of negative balance were recorded. Results for individual glaciers are summarised in the histograms for each glacier in Figures 4 to 13, where they are given as departures from the estimated equilibrium line altitude - the snowline position to maintain the glaciers in balance with their present size. For glaciers in balance this would normally be the mean of many years' readings, but as the glaciers have been dominated by positive balances since this programme commenced, this altitude has been estimated from glacier morphology. These results are summarised in Figure 14. Values below the zero ELA datum indicate depressed snowlines and therefore positive mass balances. Figure 15 compares the 1996 mean snowline elevation with those of preceeding years, while Figure 16 gives the areal variation of the 1996 snowline trend surface.

Structural features east and west of the Main Divide in the Mount Cook - Westland National Parks region were photographed and positions plotted by Simon Cox. These included major faults (especially the 'Main Divide Fault') and distinctive continuous greywacke/schist units. Two large fault systems with Quaternary traces, not previously mapped, are:

1) Spenser Mountains; ridge south of Mt. Ella, to Matakitaki River, through and west of David Saddle, some 5 km long.

2) Headwaters of Ahaura River; ridge between Waikiti and Trent rivers, extending to Taramakau River, some 10 km long.

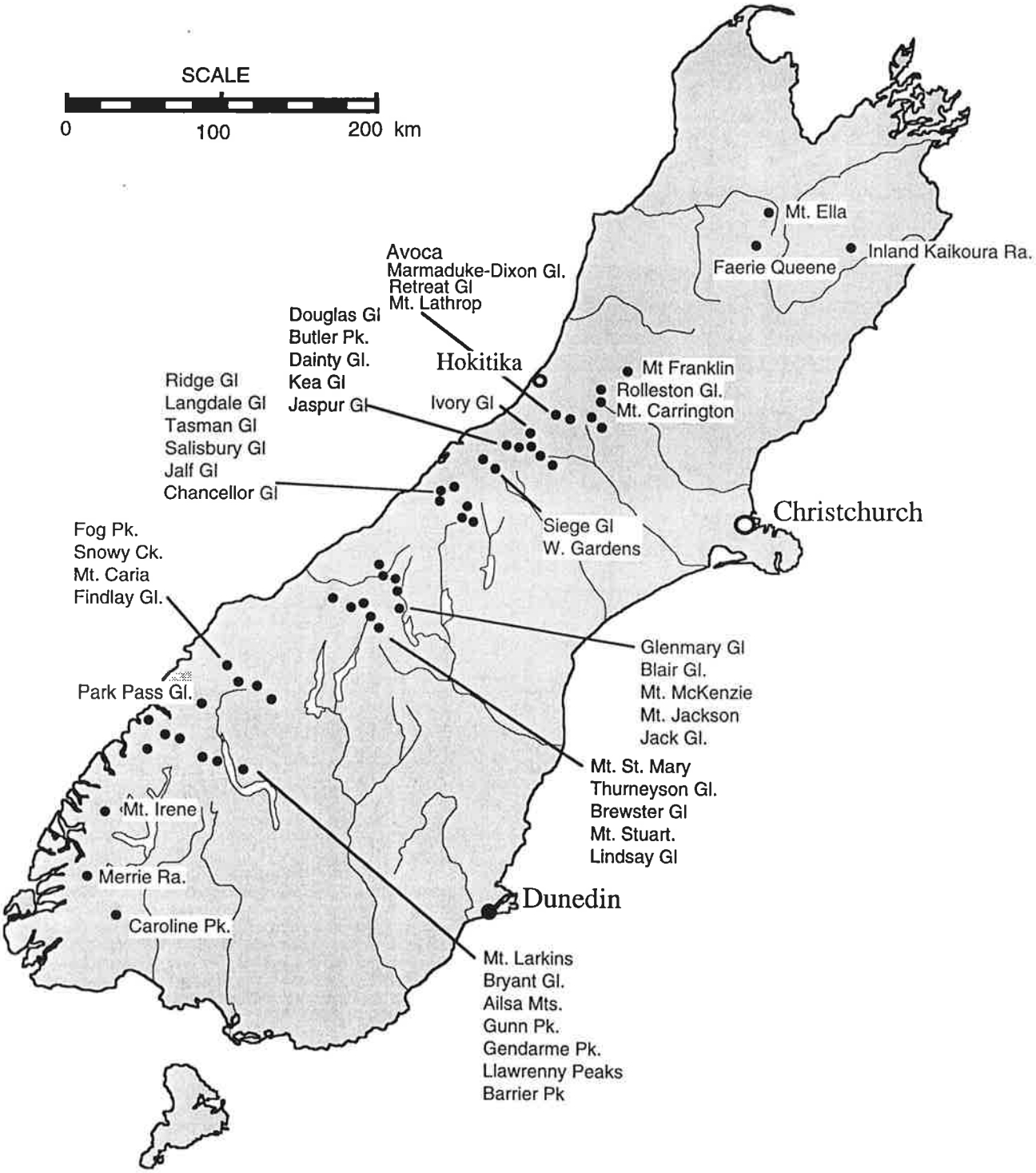
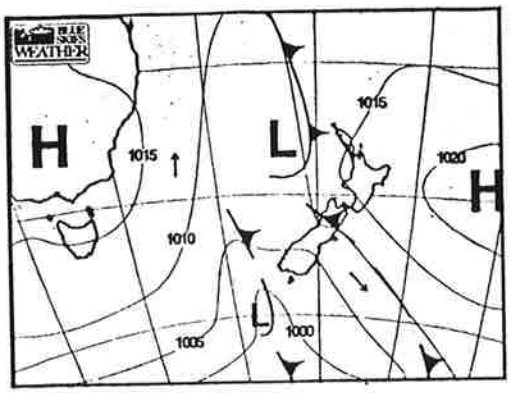


Figure 1. Location of the Index Glaciers

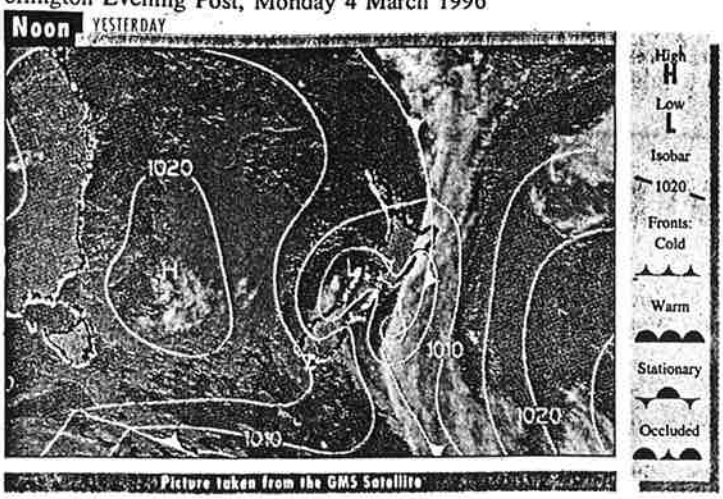
Otago Daily Times, Saturday, March 2, 1996–

Noon forecast



Situation for Sunday, 3 March, 1996

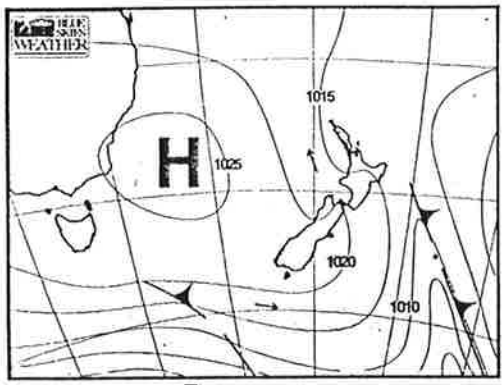
Wellington Evening Post, Monday 4 March 1996



Otago Daily Times, Monday 4 March 1996

WEATHER REPORT

Noon forecast



REGIONAL FORECASTS

Fiordland, coastal Southland: Mostly fine with sunny periods and some cloud at times. Rather cool, with moderate to fresh westerly winds. Outlook for tomorrow: Similar weather.

Marlborough, Canterbury, Otago, inland Southland: Inland, mostly fine and sunny with cool southerlies dying out. A chance of light ground frosts tonight. Nearer the coast cloud and any remaining showers clearing with long sunny periods developing during the day. Still rather cold, with southerlies decreasing. Outlook for tomorrow: Mostly fine and sunny with light winds; milder.

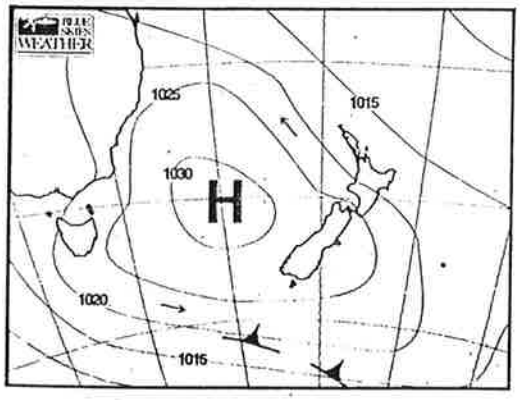
LONG RANGE FORECAST

Situation: A depression is moving quickly away to the east of the South Island with a cold gusty southerly airflow over New Zealand easing. A large intense anticyclone in the Tasman Sea is forecast to move across New Zealand on Wednesday, followed by a warmer northerly airflow until next weekend.

South Island: Today, cloud and any remaining showers clearing in the east from Otago to Marlborough with mostly fine sunny weather developing during the day. Cold southerly winds dying out. Fine and sunny in Nelson, on the West Coast, and in inland Southland and Otago. Cool, with light winds. Some cloud on the south coast with cool westerlies freshening. Tomorrow and Wednesday, expect mostly fine sunny weather in all areas, with light winds. Cool at night, but mild afternoon temperatures. On the south coast, some cloud at times with moderate westerlies. From Thursday to Saturday, skies often cloudy in Nelson, on the West Coast and ranges with some drizzle patches at night, and more general rain likely by Saturday. Warm and humid with northerlies freshening. In the east from Marlborough to Southland, mostly fine with sunny periods and some high cloud at times. Areas of low cloud likely at night, especially near the coasts. Becoming warmer, with northerly or northeasterly winds freshening.

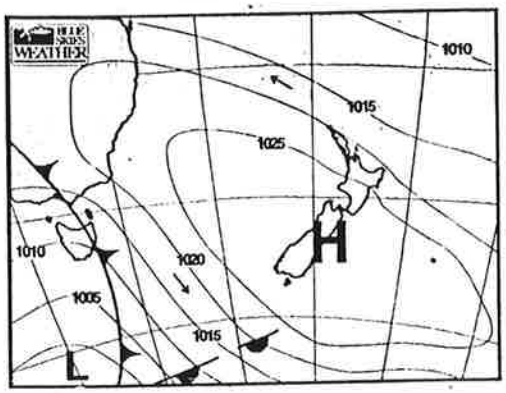
Otago Daily Times, Tuesday, March 5, 1996–

Noon forecast



Otago Daily Times, Wednesday, March 6, 1996–

Noon forecast



Otago Daily Times, Thursday, March 7, 1996–

Noon forecast

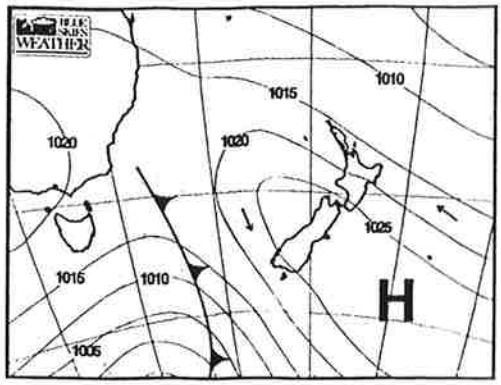


Figure 2. Weather maps associated with the 1996 flight, made on March 5

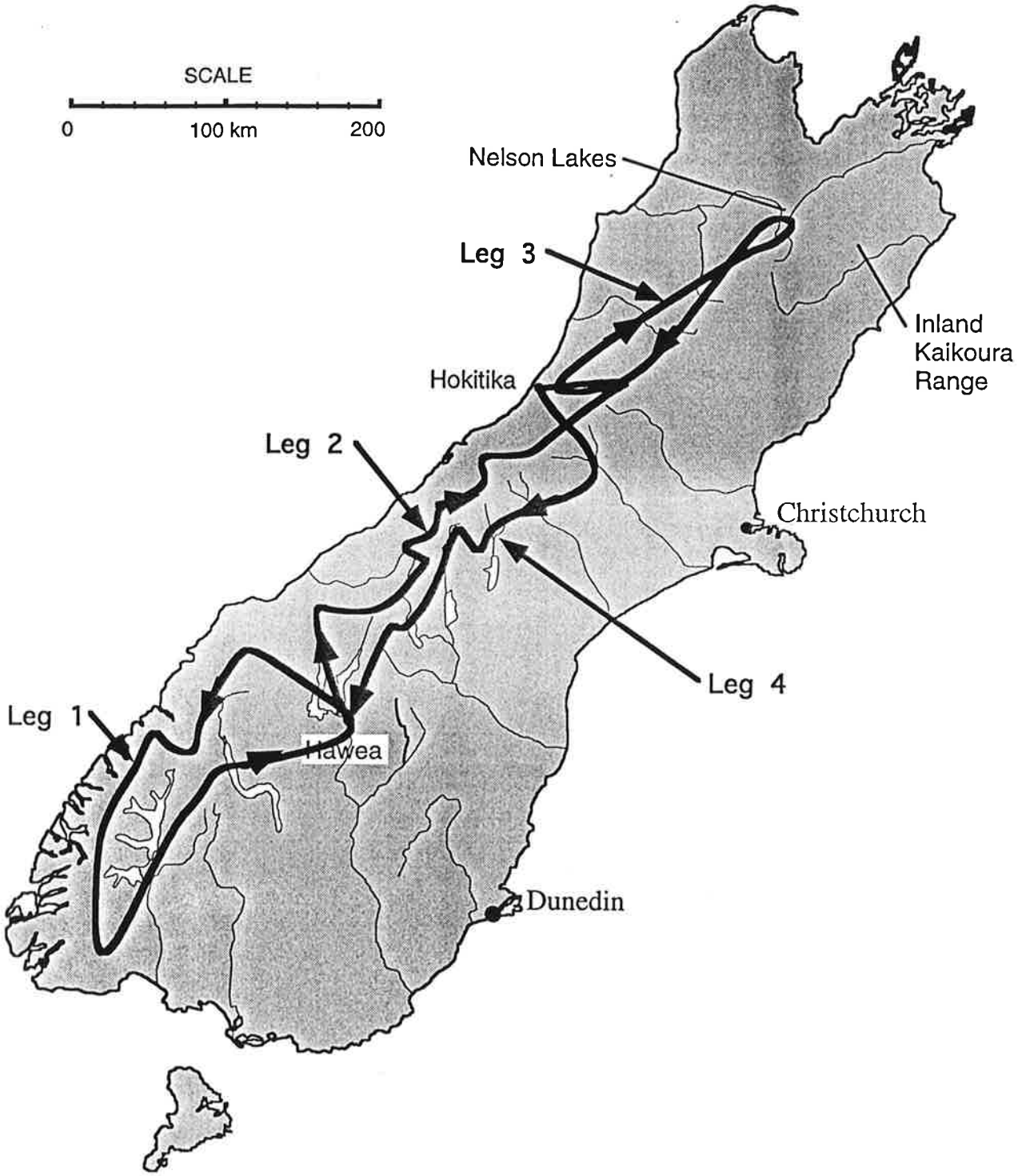
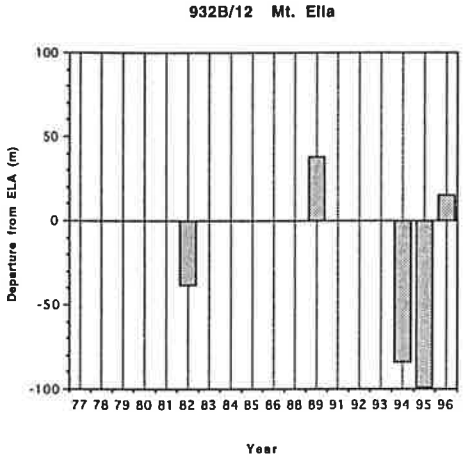
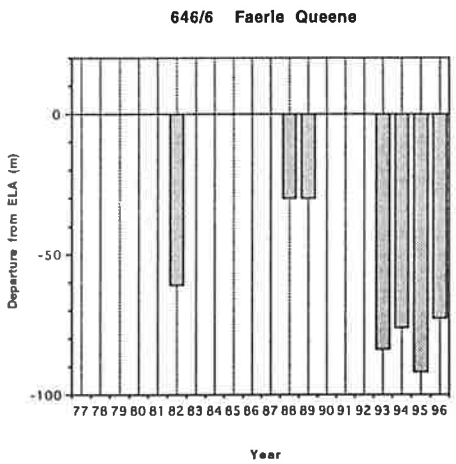
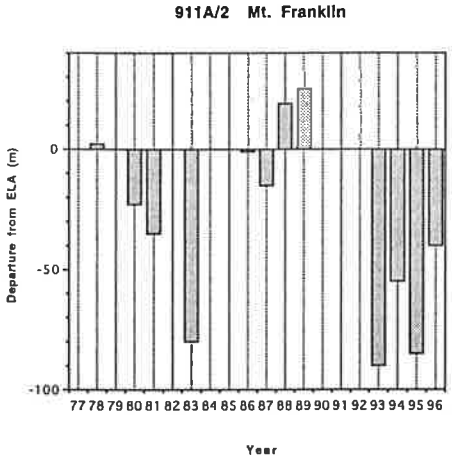


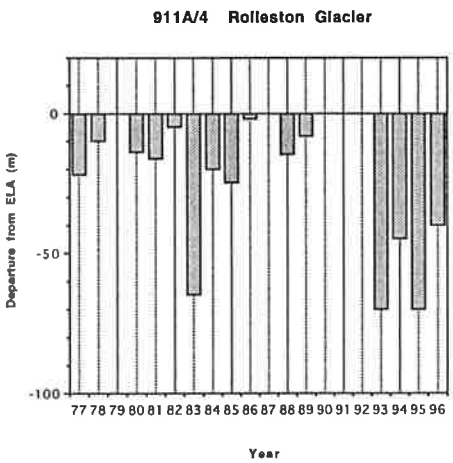
Figure 3. The flight paths for the 1996 glacier snowline survey.

NORTHERN GLACIERS









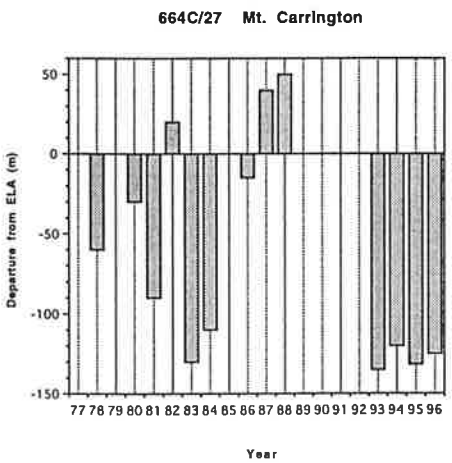


Figure 4. Snowline elevation departures from the estimated steady-state ELA values for each of the Northern Glaciers. Missing values indicate years when the glacier was not surveyed.

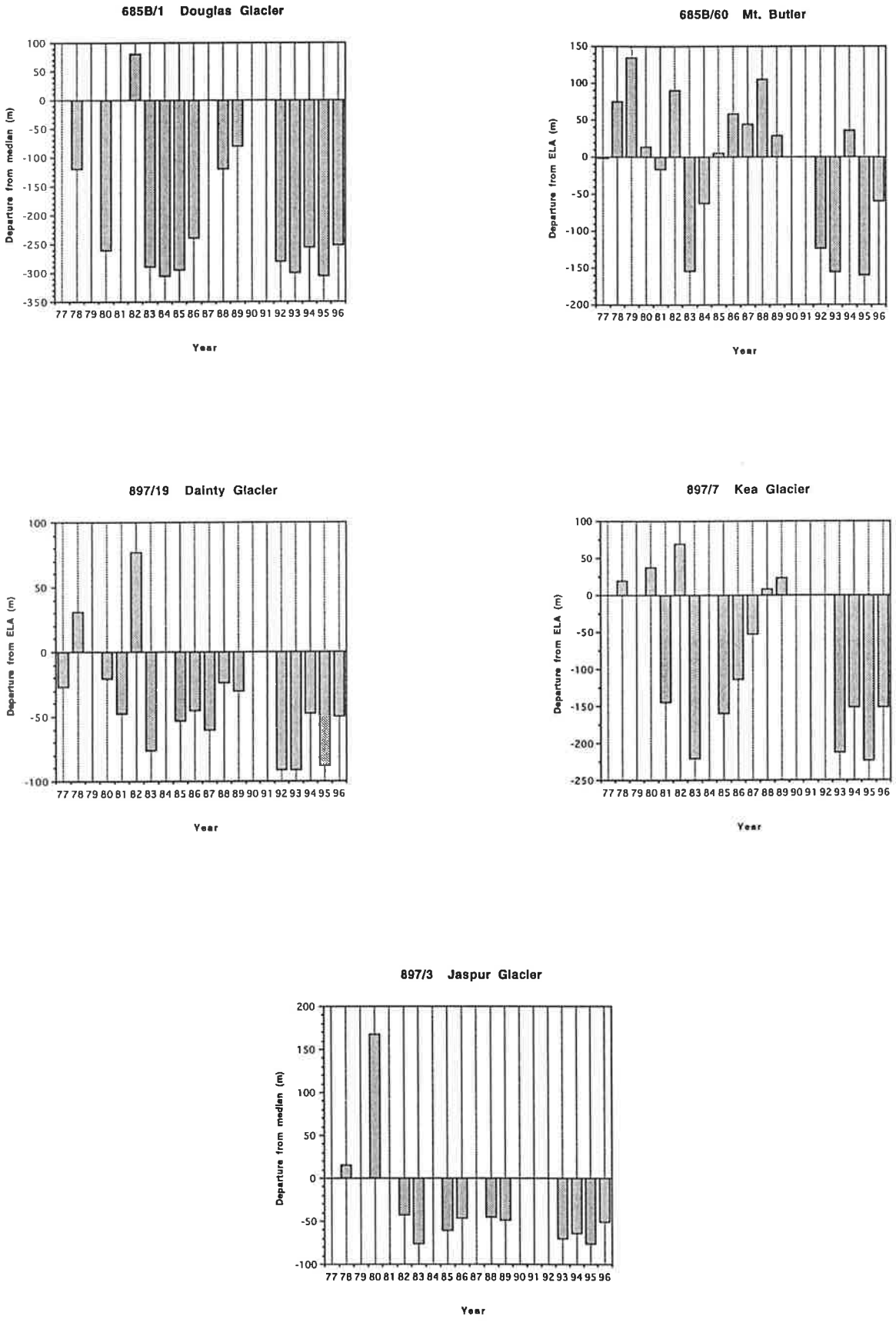
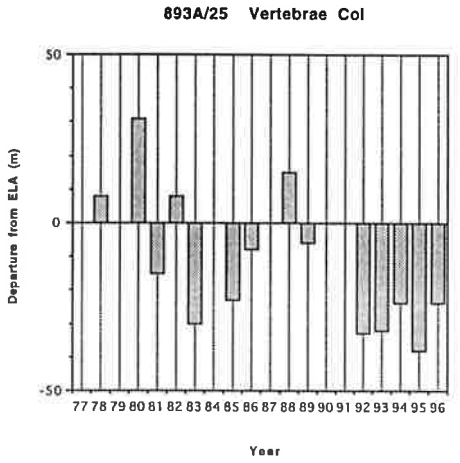


Figure 6. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 2. Missing values indicate years when the glacier was not surveyed.

Intermediate, GARDENS & ADAMS



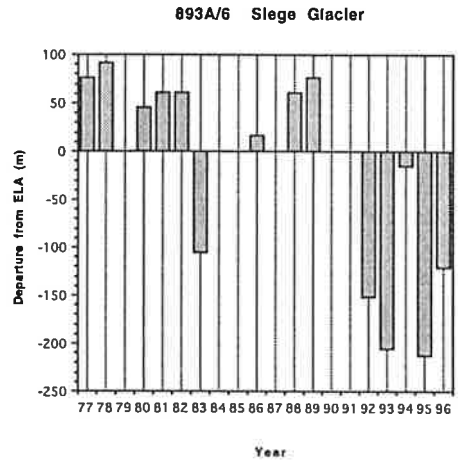


Figure 7. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers intermediate between Sections 2 and 3. Missing values indicate years when the glacier was not surveyed.

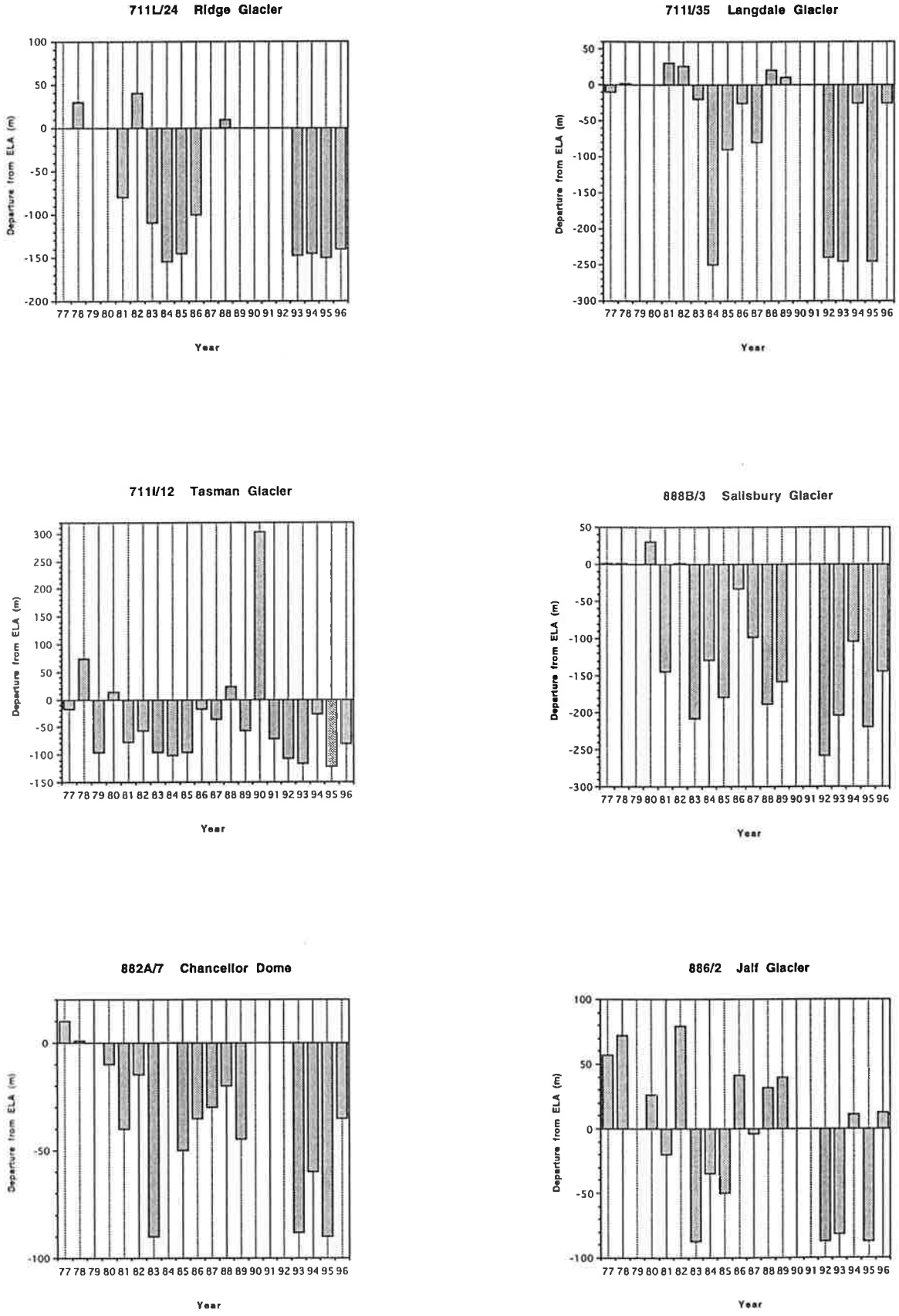


Figure 8. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 3. Missing values indicate years when the glacier was not surveyed.

SECTION IV DOBSON - PARINGA

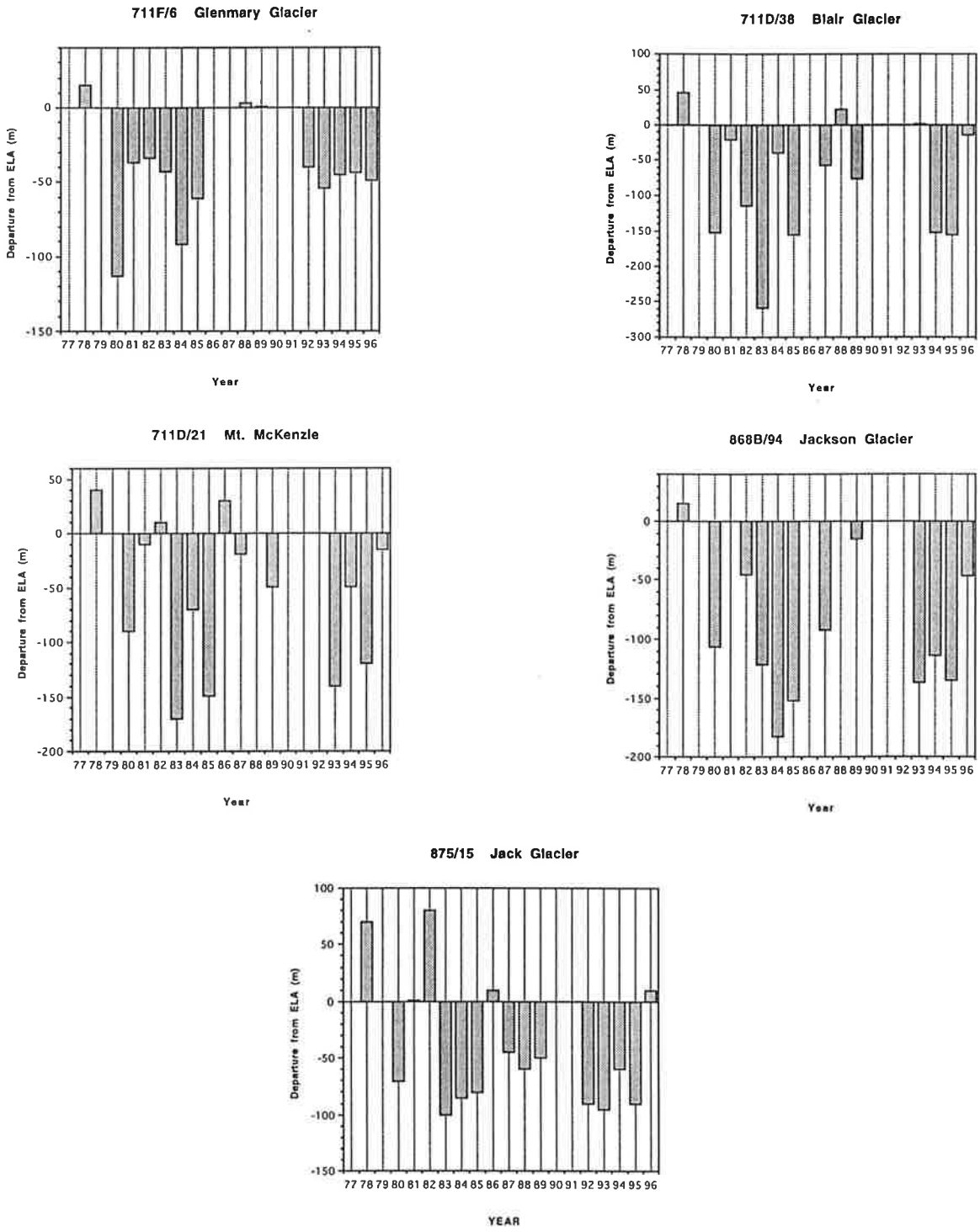


Figure 9. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 4. Missing values indicate years when the glacier was not surveyed.

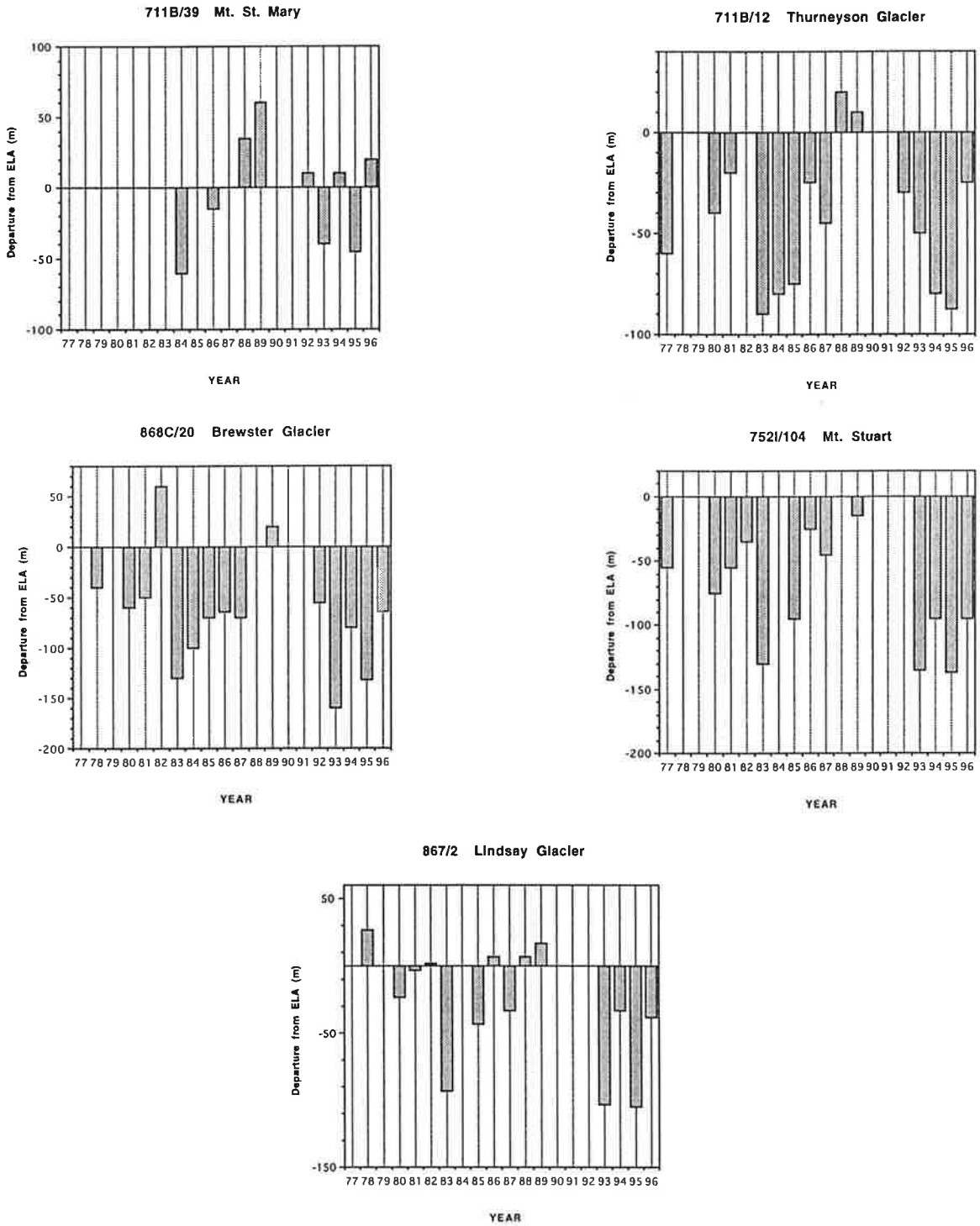


Figure 10. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 5. Missing values indicate years when the glacier was not surveyed.

SECTION VI SHOTOVER - ARAWATA

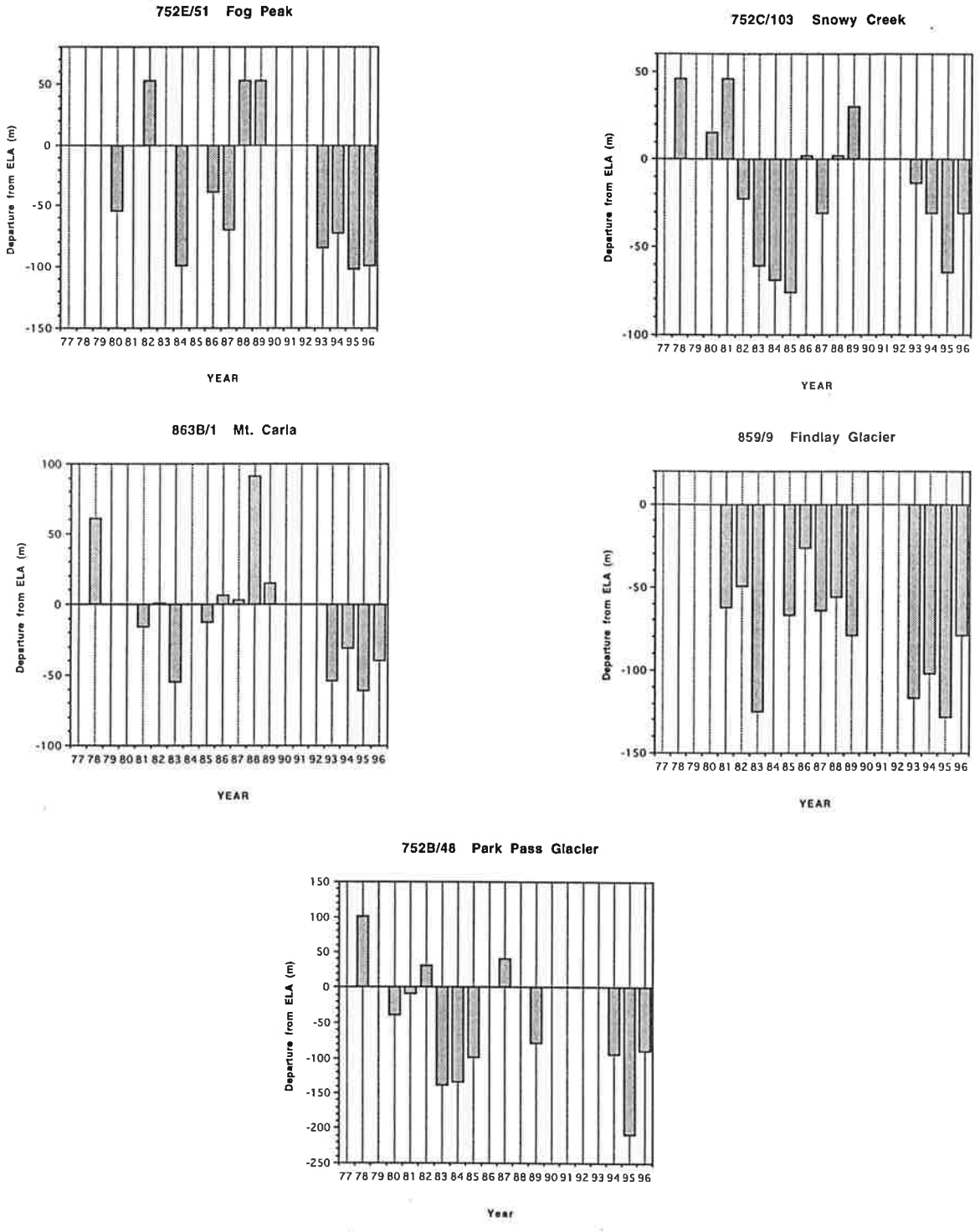


Figure 11. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 6. Missing values indicate years when the glacier was not surveyed.

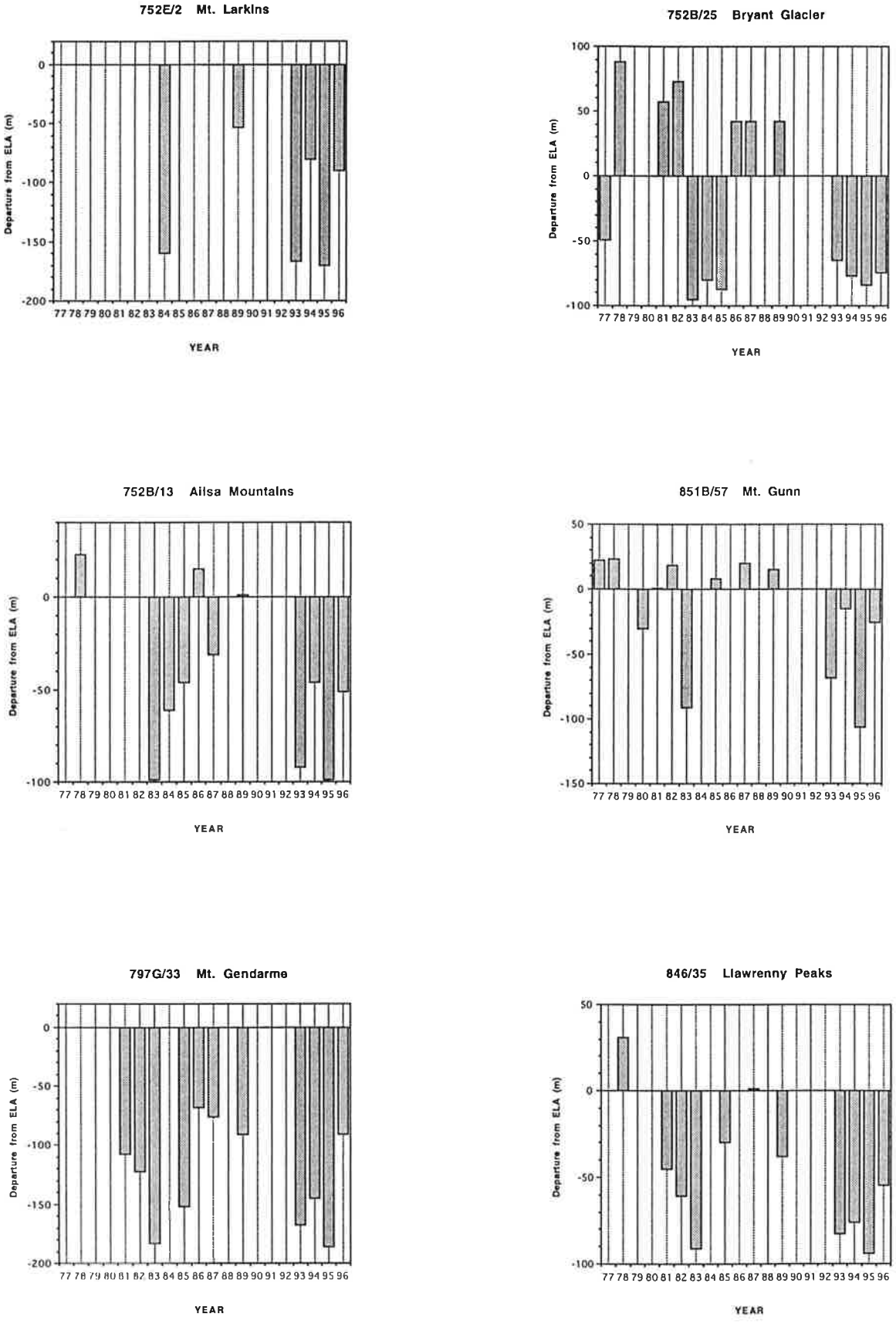


Figure 12. Snowline elevation departures from the estimated steady-state ELA values for each of the glaciers of Section 7. Missing values indicate years when the glacier was not surveyed.

SOUTHERN GLACIERS

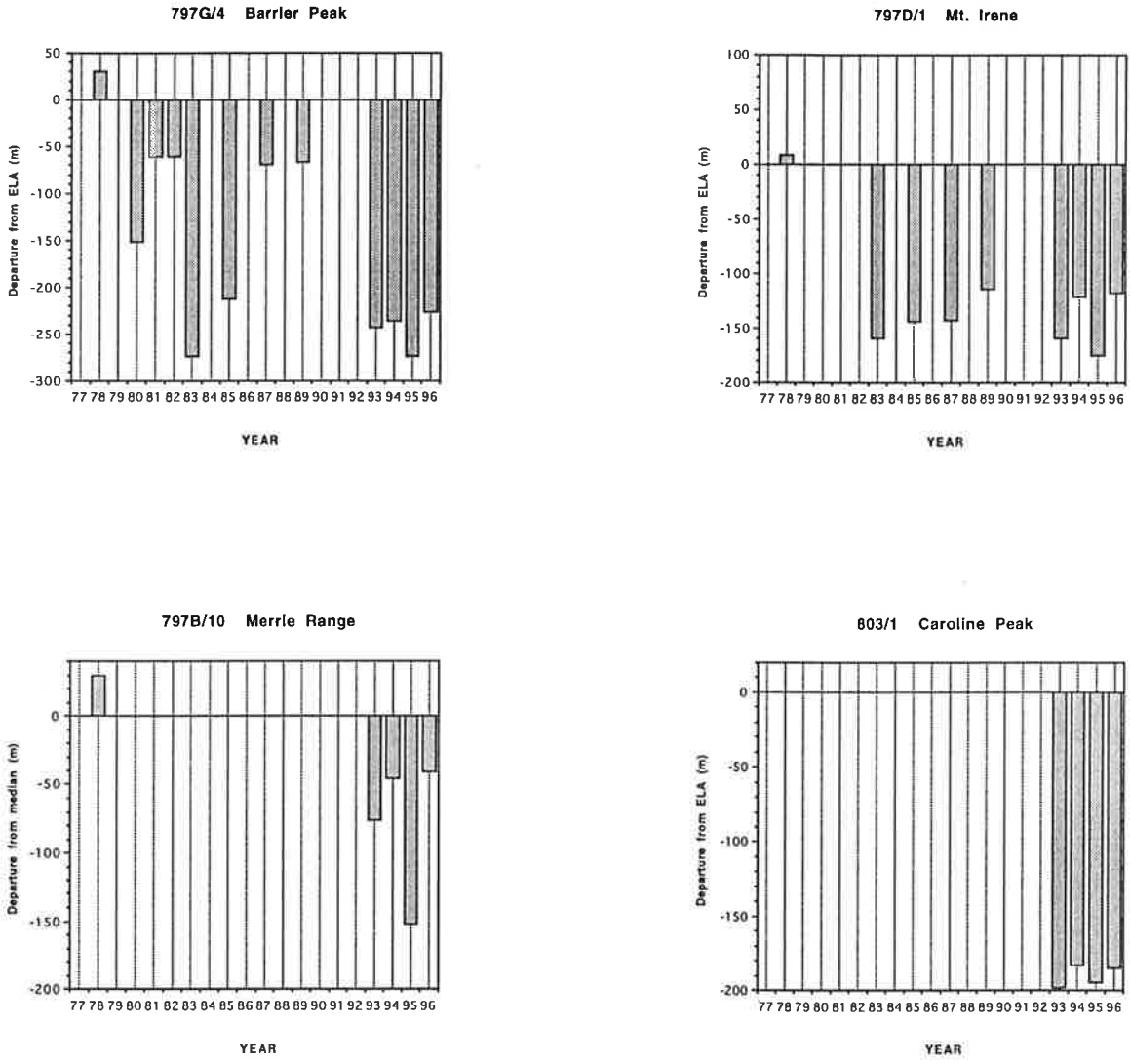


Figure 13. Snowline elevation departures from the estimated steady-state ELA values for each of the mid-south Fiordland glaciers. Missing values indicate years when the glacier was not surveyed.

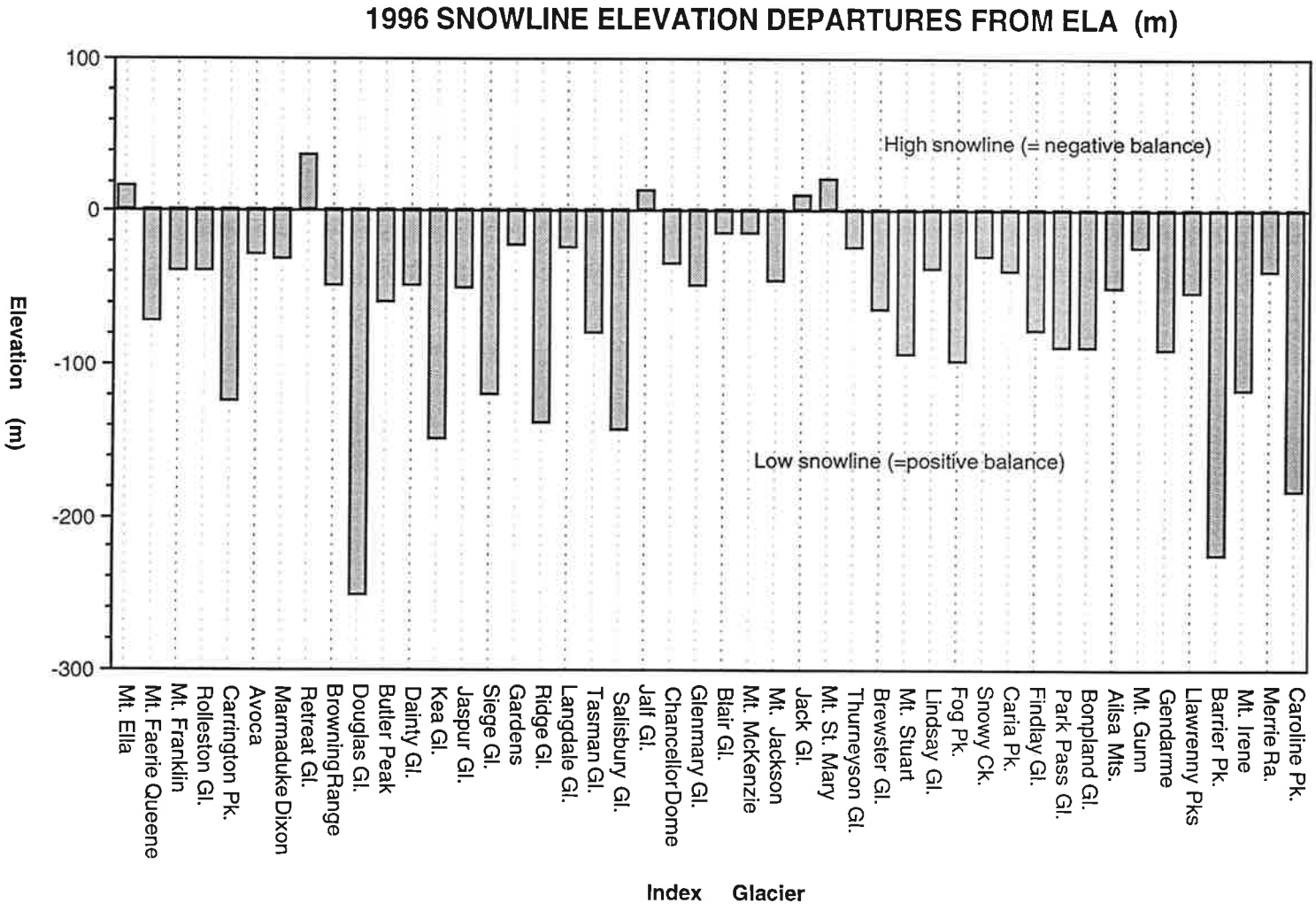


Figure 14. Summary of the 1996 snowline elevations

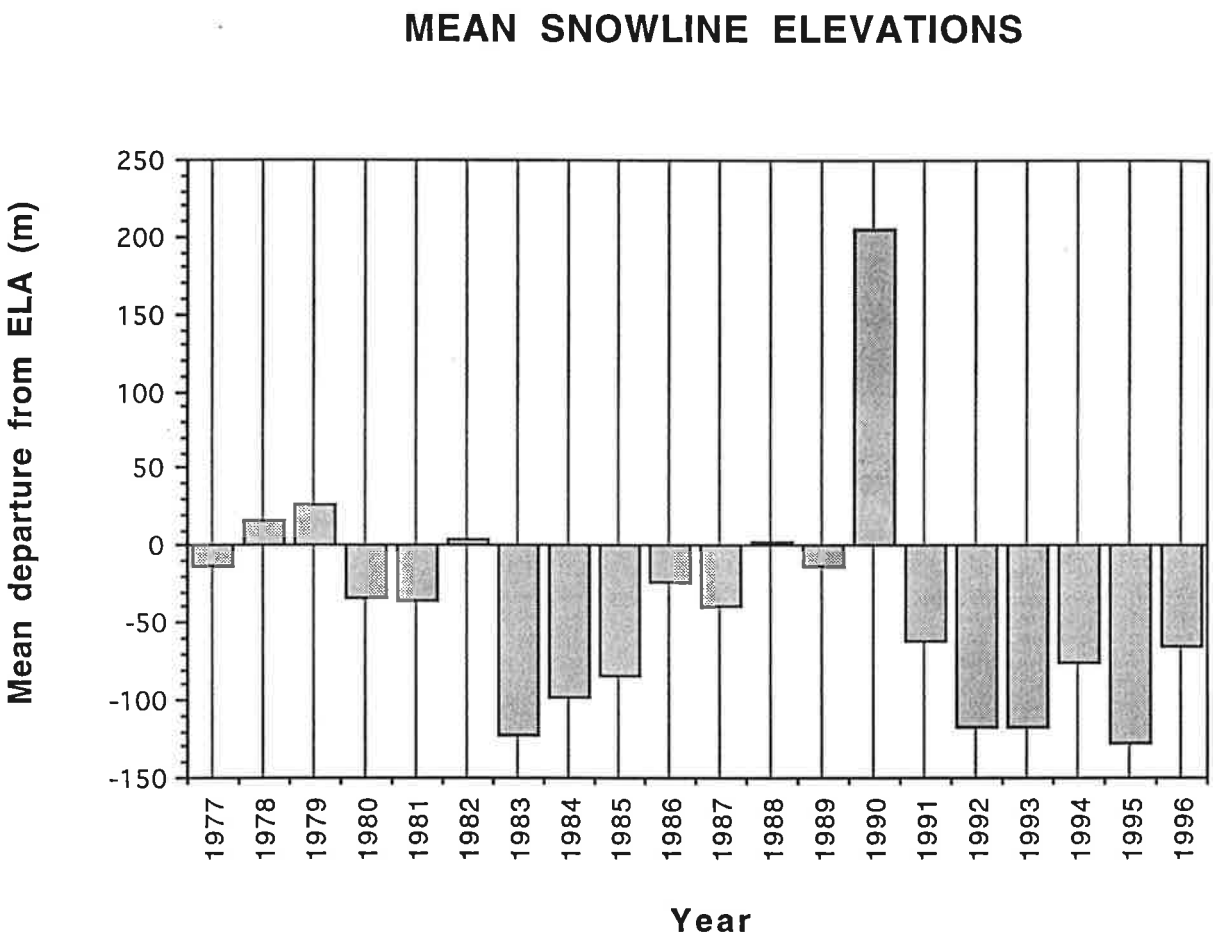


Figure 15. Mean annual snowline elevation departures from the steady-state ELA, for 1977 to 1996.

1996 SNOWLINE ELEVATION DEPARTURES FROM ELA

ON DIAGRAMMATIC DISTRIBUTION OF INDEX GLACIERS

Plotted with respect to distance from the Main Divide, Lateral exageration X10

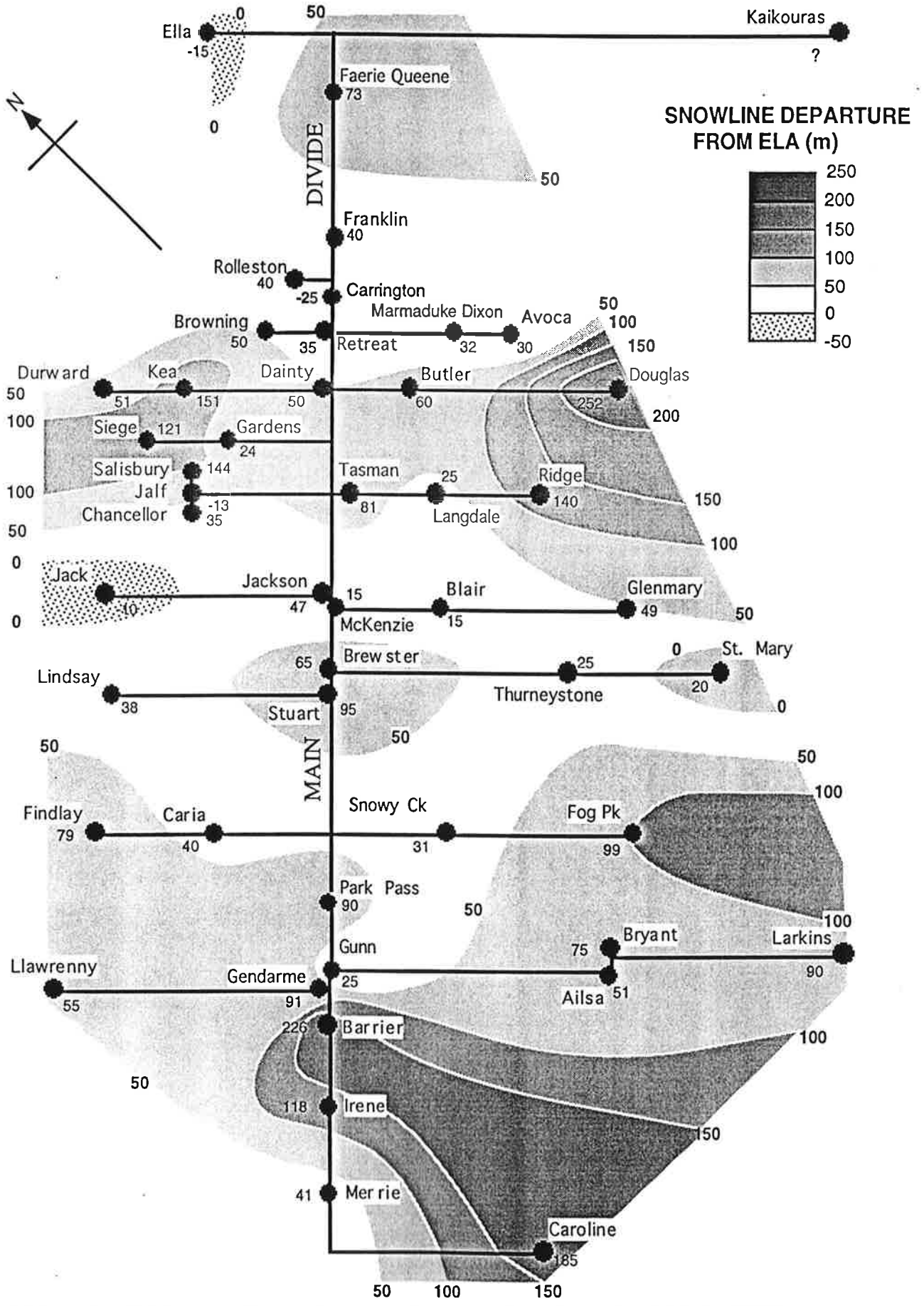


Figure 16. Distribution of snowline elevation departures from the ELA for 1996.