New Zealand Glacier Monitoring: End of Summer Snowline Survey 2010

NIWA Client Report: CHC2010-113
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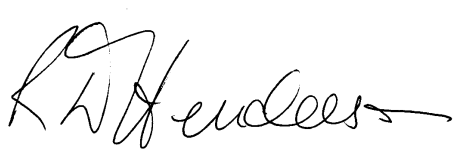

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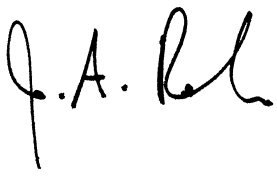

James Renwick

Executive Summary

Glaciers of New Zealand respond to the changing climate, and an integral of these changes are recorded by annual aerial surveys. These surveys measure the altitudes of the snowlines of 50 glaciers at the end of summer, as a surrogate for annual glacier mass-balance. The survey has been made in most years since 1977, but rarely do conditions permit all of the 50 index glaciers to be surveyed each year. The surveys are carried out by hand-held oblique photography taken from a light aircraft. Both the absolute and relative positions of the snowlines are recorded and this provides a time series of glacier-climate interaction back to 1977. On average, the latest survey indicated very slight positive mass balance for the index glaciers for the 2009/2010 glacier year, i.e. the snowlines, the equilibrium line altitudes (ELAs), were slightly lower than average. There was noticeable variation across the Southern Alps this year with lower snowlines apparent in the Southern and Western regions, but higher snowlines in the Northern and Eastern regions.

The very small amount of net gain in the derived mass balance (i.e. lowering of the ELAs) in the 2009/10 season was the integrated effect of strongly varying climate and circulation conditions during the year. El Niño development in the tropical Pacific during spring 2009 helped to reinforce more southwesterly circulation, with normal to below normal temperatures during the onset of the glacial year through summer 2009/10 and autumn 2010. At the beginning of the glacial year in March-May 2009 there were more frequent southerly and southwesterly winds (with the exception of April) that contributed to mostly below average temperatures for most of the country. Frequent frost occurrences and colder than normal temperatures were recorded in June 2009. Above normal to well above normal (with some record high) precipitation fell in the central part of the Southern Alps during the April-June 2009 interval. During July 2009, more frequent southwesterly flow brought several significant snowfall events and cold temperatures, but this pattern was punctuated by frequent northerly flow and record warmth during August 2009, making June-August 2009 temperatures close to average for many regions. Overall for July-September 2009, precipitation was near normal across Southland, Fiordland and the central axis of the Southern Alps, and precipitation was above normal in Westland. The October-December 2009 period had stronger than normal southwesterly winds occurring over the country. This pattern generated near to below normal rainfall for many areas during October-December 2009, with record or near-record low spring rainfalls in Westland and along the Main Divide. Summer 2009/10 was characterised by stronger than normal southwest winds over the country that brought well above normal rainfall for parts of Southland and the West Coast. The onset of summer saw record cold temperatures in early December but finished with heat waves and above average temperatures in February 2010.

This shift to near neutral mass balance is a change from the strong negative mass balance of the previous two years (2007/2008, 2008/2009). The glaciers have shown a varying pattern of positive (22 years) and negative (12 years) mass balance over the 34 year monitoring period. However, some of the index glaciers with well-defined permanent ice areas have clearly lost ice during the course of the 34 year monitoring period. This mass loss has occurred during large negative mass balance years and has not been replaced during the positive mass balance years.

1. Introduction

The results presented in this report continue an annual glacier/climate photographic monitoring programme, begun in 1977, of the position (altitude) of the end-of-summer snowline on 50 selected index glaciers, arranged in several rough transects across the Southern Alps (see Figure 1).

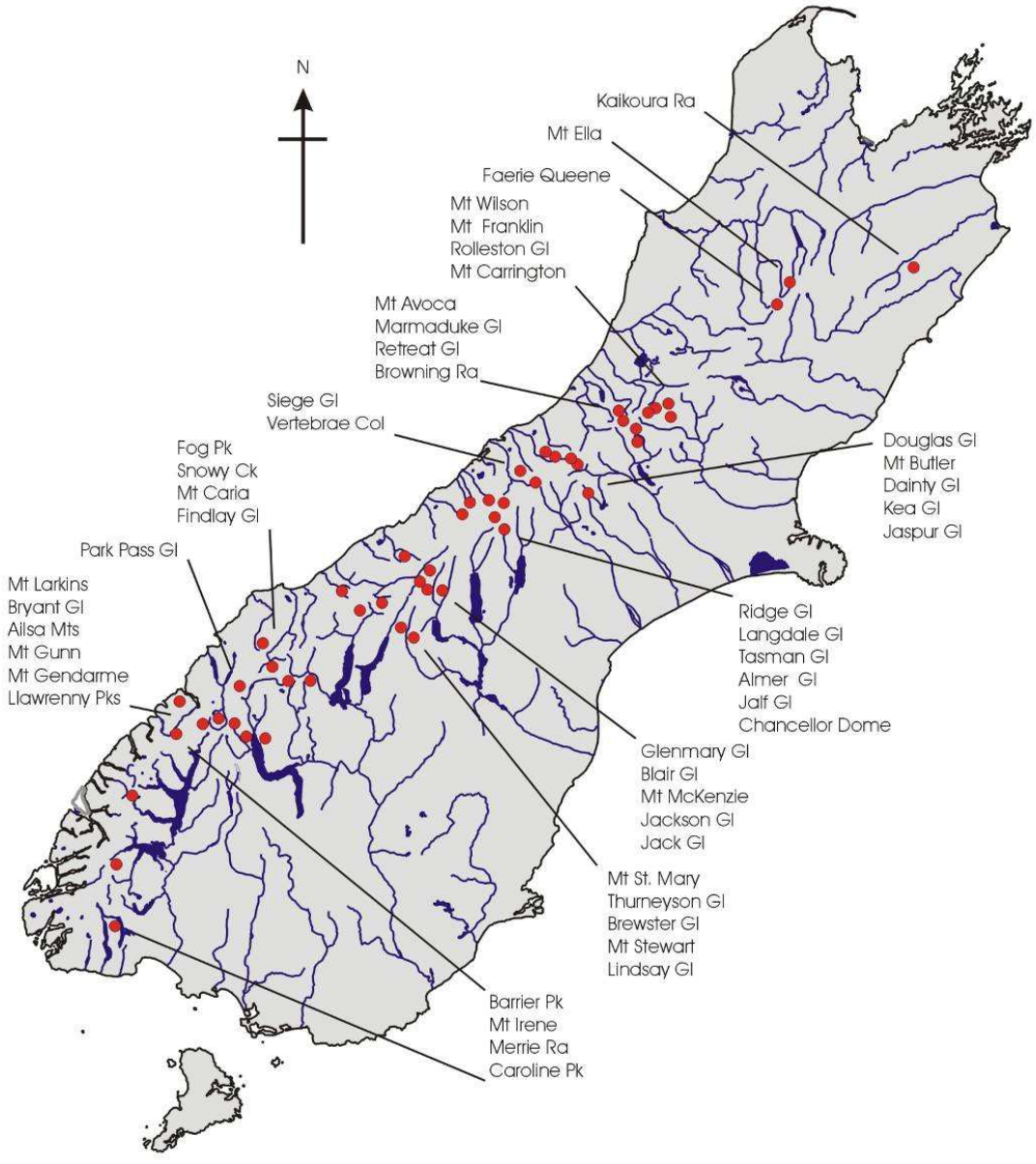

Figure 1: Location of the 50 index glaciers across the South Island of New Zealand.

Between 1977 and 1985, a New Zealand glacier inventory was undertaken from Mount Ruapehu in the North Island at 39° 15' S to southern Fiordland at 45° 57' S. A total of 3144 glaciers were identified for the inventory, where a glacier was defined as a permanent area of snow greater than 0.01 km^2 (Chinn, 1989). In the South Island, average peak summits range from 1850 m in Fiordland to 3000 m in the central Southern Alps and descend to 2000 m in the north-central Southern Alps. To the north east, the Kaikoura ranges reach to over 2700 m, where active rock glaciers have developed under the relatively dry climate. Three North Island volcanic cones reach close to the permanent snowline, but only Mount Ruapehu, with a summit at 2752 m, supports glaciers. Logistics of the glacier overflights do not currently allow the North Island region to be included in annual surveys because of the distances involved.

New Zealand has a humid maritime climate, with the Southern Alps lying across the path of the prevailing westerly winds. Mean annual precipitation rises rapidly from 3000 mm along the narrow western coastal plains to a maximum of 15,000 mm or more in the western part of the Alps close to the Main Divide. From this maximum, precipitation diminishes to about 1000mm in the eastern ranges over less than 30km from the divide. This creates a steep west-east precipitation gradient across the Southern Alps, and the mean altitudes of the glaciers closely follow this gradient (Chinn and Whitehouse 1980).

1.1. Glaciers and climate change

Glacier fluctuations are amongst the clearest signals of climate change, because glaciers are highly sensitive indicators of the earth's surface energy balance. Glaciers register distinct signals of past climate change on scales from decades to millennia. Atmospheric changes are signalled by direct, immediate changes in annual mass balance, which are filtered, smoothed and enhanced before they become apparent at the glacier front. Glacier snowline altitudes provide a direct value for annual glacier health and balance. Changes indicated by glacier frontal positions can be severely modified by glacier response times and other dynamics related to climate variability over longer time scales than a single year.

1.2. The Equilibrium Line Altitude (ELA)

The winter snowpack normally covers the entire glacier in a wedge shape, with the greatest snow depths near the highest altitudes, tapering to zero at the lower edge (Figure 2). This lower margin, or transient snowline, of the snowpack retreats up-glacier as summer melt progresses, until it reaches a maximum altitude for the year at the end of summer (March - April). Located somewhere near the mid-point of the glacier, the end-of-summer snowline indicates where snowfall exactly equals snow

loss over the past glacial year (Figure 2). This line of demarcation is termed the equilibrium line, which is normally visible as a contrast on the glacier surface between discoloured dust on firn (below the equilibrium line) and the clean snow of the previous winter (above the equilibrium line). It is the altitude of this glacial feature that is defined as the Equilibrium Line Altitude (ELA) by Meier and Post (1962). The ELA is measured each year by the snowline survey. The higher the altitude of the ELA, the less the amount of snow remaining to nourish the glacier after summer melt, indicating a lower mass balance. Conversely, a low annual ELA indicates a large amount of residual snow remaining at the end of summer and a positive mass balance. It follows that there is a unique position for the ELA across the glacier where the volume of snow accumulated over the past year exactly balances the total volume of snow and ice lost during the year. If the ELA were to lie at (or maintain an average of) this altitude for many years, then there would be no change to the mass or size of the glacier (assuming no other processes are involved, e.g. ice-margin lake development and calving). This unique position of the snowline, which indicates that the glacier is in equilibrium with the climate, is defined as the steady-state Equilibrium Line Altitude (ELAo). A snowline of this altitude will indicate zero change to the balance of the glacier. To avoid confusion between the annual and the long-term ELAs, some authors have also referred to the altitude of the annual glacier snowline as the end-of-summer snowline or EOSS. However, in this report we will only use ELA and ELAo.

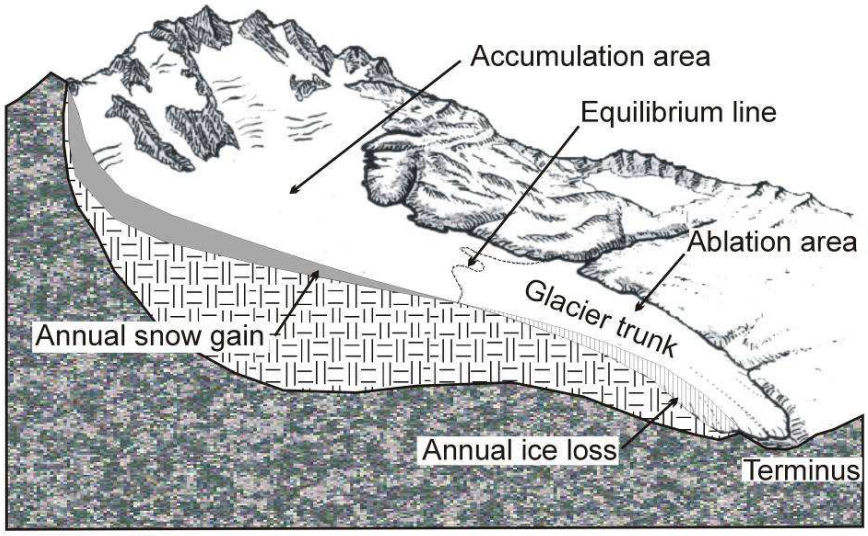

Figure 2: Basic parameters of a glacier.

A shift in climate can change the glacier mass balance and alter the altitude of the annual ELA. Thus the annual snowline position with respect to the long-term average or steady-state ELAo (see section 3) is used as a surrogate for annual balance changes at each glacier (Chinn, 2005; Chinn, 1995). It is the departure of the glacier snowline

from the steady-state ELAo, ie. ELAo–ELA, that is reported here. These ELA departure values provide a measure of mass balance changes.

Glacier studies worldwide (e.g. Haeberli et al., 2007) have demonstrated that, on average, the accumulation area is about twice that of the ablation area so that the ELAo lies at an altitude where the ratio of the accumulation area (AAR) to the total glacier area has an average value close to 0.66. For this programme, the steady-state ELAo was initially estimated using AAR values of 0.66 for each glacier, then, as more ELA data was obtained, these approximate values have been progressively adjusted for most index glaciers as outlined in Section 3 below.

2. Field methods

Collection of field data involves flying over the glaciers in a light aircraft to take oblique photographs of the position of the end-of-summer glacier snowlines. A GPS with waypoints has been used since 2007 and this has ensured that the oblique photographs have been taken from a similar position every time. It is worth noting here that the GPS waypoints are not of the glacier snow line itself, but of the position in the air above the glacier, to achieve the same oblique photo. The snowlines visible on the photographs have historically been sketched on to a map of each glacier and the resulting accumulation or ablation areas mapped and measured by digitisation. Since 2008 the area interpretation has been done for selected glaciers by rectifying the oblique photos then mapping the accumulation or ablation areas. The 'snowline altitude' can then be accurately assessed from the glacier area-altitude curve or directly from a digital elevation model (DEM). The more recent the DEM the more accurate the ELA elevation will be, as some glaciers have lost significant mass and therefore elevation in these areas.

2.1. The survey flights

On the flights, the "navigator" seated beside the pilot holds a folder of photographs of each glacier. These photographs are used to closely duplicate the position from where previous photographs were taken. Photographs are taken by small- and medium-format SLR cameras, and since the 2001 flight, in digital format. Data on selected glacier termini, geomorphic features, such as moraines and supra-glacial lakes, are recorded in addition to the index glacier end of summer snowlines. The flights are generally flown between 9,000 ft (2,700 m) and 10,000 ft. (3,000 m). The upper limit is determined by civil aviation regulations.

Significant snow melt continues throughout February and March, but by April there is a high probability that the first winter snowfall in the Southern Alps will have

occurred. Experience has shown that although successful surveys have been made in April, there is about a 1 in 4 probability of snow before this time. Every year the challenge of the survey is to measure the highest altitude reached by the rise of the glacier snowline as ablation losses precede, before the first "winter" snowfall. A light fall of fresh snow will conceal the position of the snowline as effectively as a coat of paint. The problem has been standardised by setting the earliest date for the flight at March 1.

'Suitable' weather to fly the entire Southern Alps demands particularly settled conditions. A successful survey cannot be guaranteed as there is a 1 in 10 probability that there will be no suitable flying weather in the month of March, before a fresh snowfall occurs, because of the unsettled nature of the prevailing westerly circulation.

2.2. March 2010 fieldwork details

On Friday 5th March the first leg of the survey flight departed Wanaka in Flightseeing's Cessna 206 piloted by G. Lloyd, with T.Chinn, J.Hendrikx (NIWA Christchurch), and A. Willsman (NIWA Dunedin). This flight headed North East to the Thurneyson Glacier in the Ahuriri River catchment and then continued up the eastern side of the Alps. Some southerly frontal cloud and rain was encountered between the Ahuriri and Mt Cook region and some short detours were required to fly around thick cloud patches. The index glaciers in this region on the eastern side were photographed in clear patches although with overcast conditions. Leg one continued up the eastern side of the Alps until Mt Franklin then turned west to finish at Greymouth. From the Ohau region north the winter snow was noticeably discoloured with a brown tinge presumed to be dust from the very large dust storm in Australia during September 2009. These Australian dust storms were the largest for 70 years and at the time satellite images detected drift of dust across the Tasman Sea to New Zealand. After refuel and lunch, Leg 2 was flown in clear conditions to the Spencer Mountains, Ella Range with a turn-around at the Kaikouras and then back into a humid frontal system that had now covered the western glaciers in low cloud and provided a rainbow on landing at Hokitika for the night. On Saturday the 6th March the flight returned to Wanaka down the western side of the Main Divide of the Southern Alps in clear conditions with snowlines present on most of the index glaciers. After a refuel in Wanaka, Leg 4 went West across the Matukituki to Arawata transect of index glaciers then down to the Fiordland glaciers. Some fine weather cumulus cloud was covering the Findlay glacier so only the lower third of this glacier was photographed. The remaining glaciers were mostly unaffected by this cumulus cloud and the remainder of this leg presented no problems. Figure 3 presents an overview of the glacier flight path for 2010. The survey was completed with all of the index glaciers being photographed. The weather situation for the two days is shown in Figure 4.

Subsequent to the glacier survey flight, the "first winter snowfall" fell on 21st March and was followed by continuing mild weather which melted most of the new snow. Subsequent mild weather is likely to have removed enough new snow that a successful partial survey could have been made as late as the last week of April.

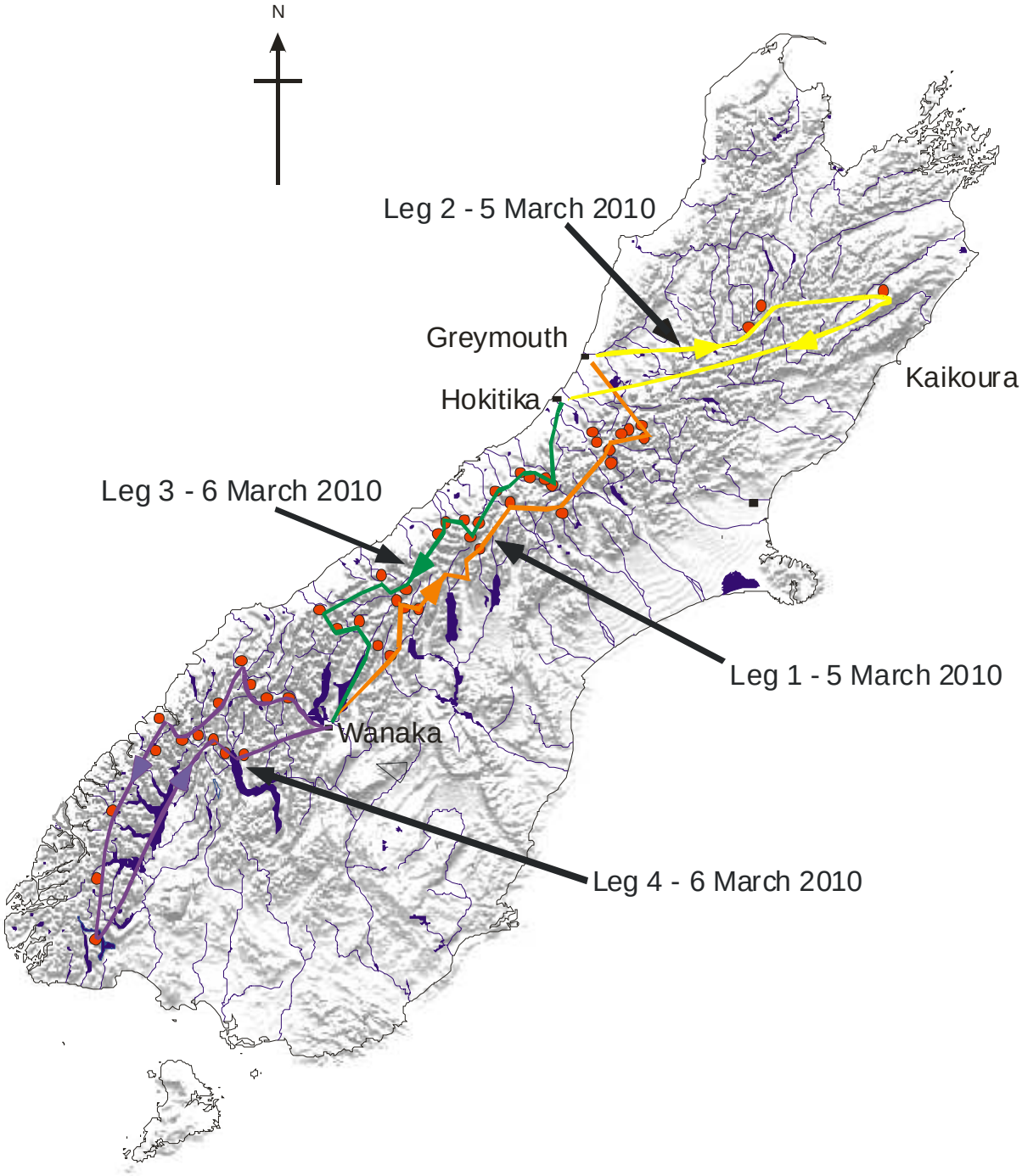

Figure 3: Flight paths for the four flights of the 2010 glacier survey.

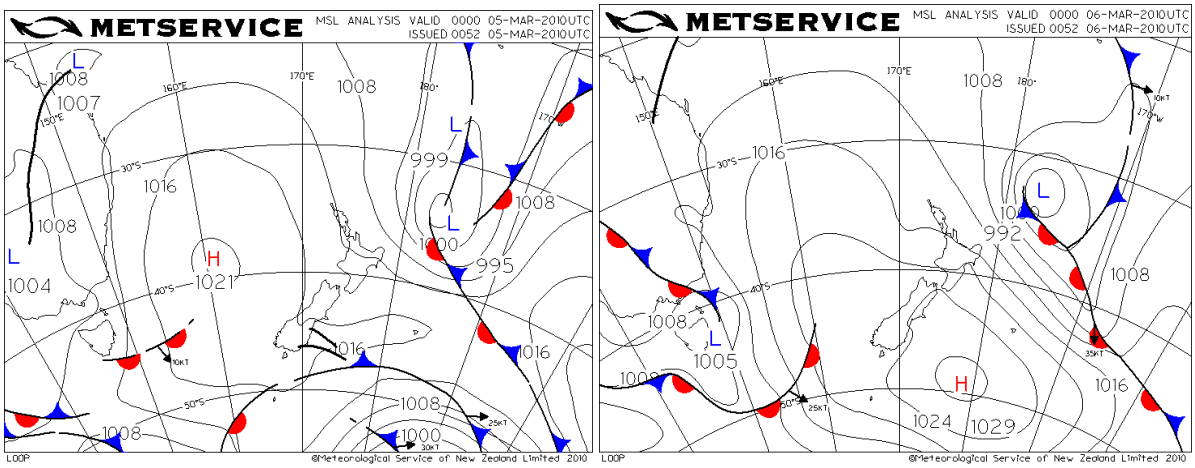

Figure 4: Weather map for the 5th March (left) and the 6th March 2010.

3. Derivation of the glacier snowline

Data in this report are presented as "departures from the ELAo" which represents "departure of the climate of the year from the mean climate for glacier equilibrium". Thus an accurate estimate of the position of the ELAo is an important part of the programme. Associated glacier parameters used are accumulation area (Ac) and ablation area (Ab) (see Figure 2); total glacier area A, or Ab +Ac; and accumulation area ratio (AAR) the ratio of the accumulation area to the entire area of the glacier, Ac/(Ac+Ab).

At the commencement of this project, the value of the ELA was gained by plotting the observed snowline directly on to a topographic map:-

Map + snowline ⟶ ELA

On the average glacier, the long term Equilibrium Line Altitude (ELAo) divides the accumulation and ablation areas by a rough ratio of 2:1 (AAR value of 0.67). This position was estimated on small glaciers, and derived from the area-altitude curve on the larger glaciers. As the number of years of data increased, many of the ELAo values were subjectively adjusted (see section 3.5 for details of the adjustment methods):-

Est. AAR @ 0.67⟶ ELAo, + adjustment ⟶ refined ELAo.

Leading to small annual changes to:-

ELA – ELAo ⟶ Departure value

The use of a GIS mapping system with digitised areas has added significant accuracy and precision to the data by supplying measured glacier and accumulation or ablation areas:-

Digitised (Ac or Ab) + Area Curve → accurate ELA

Digitised Ac + Glacier Area → accurate AAR

In addition, with the increased number of annual photographs it is frequently more accurate and efficient to directly interpolate ELA values between those of previous years (as described below), than it is to repeat the above methodology. More than half of the ELA values have been derived by this interpolation method:-

Interpolation → direct ELA

Where ELA – ELAo → Departure

and ELA + Area Curve → AAR

Steps two and three above are performed to double check the interpolation of the ELA. The most significant problems in processing the results are recognising the position of the true end-of-summer snowline (Figure 5), especially when;

- There has been a recent summer snowfall, which effectively "paints out" the snowline.
- The snowline has been only partially recorded due to cloud cover, backlighting or other reasons.
- The current snowline is obscure or ambiguous due to limited discolouration of snowpacks of previous years.
- A wavy or patchy snowline.

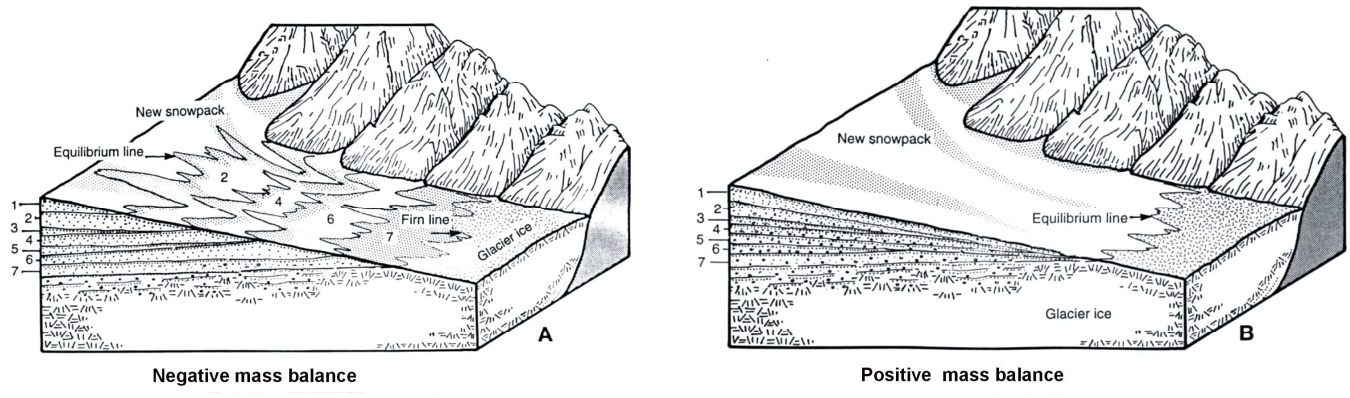

Figure 5: Schematic diagrams of stratigraphy at the glacier equilibrium line. (A) for a year of negative balance (high ELA) and (B) for a year of positive balance (low ELA). Numbers indicate age in years of past firn layers.

Glacier snowline elevations are normally obtained from detailed mass balance studies where the snowline is mapped as the zero isohyet on the annual mass balance map. In this study the snowlines are derived from oblique aerial photographs by one of "three" methods, depending on the snow cover conditions at the end of summer. Firstly by digitising either the accumulation or ablation area to provide a definitive ELA; secondly by interpolating between photographs of past years where a number of snowlines are close in altitude; and thirdly by comparing the sizes of adjacent snow patches when fresh snow or cloud obscures the snowline of the index glacier. These procedures are given in Chinn (1995) and in Chinn and Salinger (1999).

3.1. ELAs derived by digitising

This method gives the definitive ELA values upon which the interpolation and snow patch methods rely. Here the end-of-summer snowline positions are carefully sketched from the oblique photographs onto detailed base maps of each glacier. The mapped accumulation or ablation zones are then digitised using a GIS programme to accurately measure the areas. From 2009 on, however, some of the oblique digital images have been rectified using the Photogeoref software (Corripio 2004). This software utilised the camera position (GPS input), focal length, image size, NZ Digital Elevation Model, and ground control points (clearly observed features identifiable on the NZMG topographic map sheets) to rectify the image. From the total ablation area for each glacier, the snowline elevation is then read off an area-altitude curve constructed for each glacier. If the accumulation area was measured, the ablation area is found by subtracting the accumulation area from the total glacier area. This method provides a single figure for the glacier ELA for the year, regardless of the shape of the measured area, as it eliminates subjective estimation of the altitude of the snowline. This digital method has been shown to compare well with the more subjective method described above, but is more repeatable and less subjective. The difference between this altitude and that of the long-term ELAo indicates the annual mass balance of the glacier. Positive values or high snowline elevation signifies less snow and therefore a negative balance.

3.2. ELAs derived by interpolation

With the many photos now available, for many glaciers it may be more accurate and efficient to obtain the ELA value by interpolation. For each glacier, photos for all years are arranged in increasing area of snow cover (descending order of ELAs). The current year's photograph is then carefully compared and inserted into its appropriate place in the sequence. It has been found that very small differences in snow cover can easily be recognised and a high level of discrimination is possible. The ELA value is then interpolated from the ELA values of the adjacent years. Depending on the

similarity of the ELAs, this method frequently places the value of the ELA within a few metres.

3.3. ELAs derived by snow-patch size when the snowline is obscure

Where the true end-of-summer snowlines are obscured by fresh snow, cloud or other reasons, the hidden snowline may be interpolated from the degree of snow cover surrounding the glacier, i.e. the size of the intermittent snow patches. Fresh snow on rock has quite a different appearance from fresh snow on existing snow, and it is commonly possible to "see" the snow-patch outline beneath a light cover of new snow. As in the previous method, photographs of the glacier for all years are arranged in order of increasing snow cover on the glacier, which is also the sequence of the size of the snow-patches surrounding the glacier. The photograph from the latest survey is then slotted into its appropriate place in the snow-patch sequence. The ELA values for this glacier are interpolated from those of adjacent years as described above. This subjective assessment has proved to be surprisingly consistent (see Chinn et al, 2002).

3.4. Accuracy of values associated with ELA measurements

Accuracy of the data is dependent on the accuracy of the digitised Ac and/or Ab areas, glacier area and its area curve. Normally all of these values are measured with a high degree of accuracy provided the glacier maintains a constant size. However many of the smaller glaciers have undergone large variations of size, implying that both the area and associated area-altitude curve should be re-measured for each year of change. Associated with small glaciers and area changes are the problems of when the snowline (ELA) rises above the glacier or falls below the glacier terminus. When the ELA falls below the glacier, the ELA can be estimated, but the AAR becomes >1 which gives statistical problems. When the ELA rises above the glacier, it is not possible to extrapolate its value and the AAR becomes negative. If this starts to occurs regularly on a glacier, then a suitable nearby replacement glacier will need to be sought, with a higher elevation range to capture these very negative mass balance years.

3.5. Derivation of the Long-term or Steady-state ELAo value

Glacier studies worldwide have demonstrated that the ELAo lies at an altitude which divides the accumulation area from the ablation area in a ratio of near 2:1, and this ratio has been used extensively for the derivation of paleo-snowline altitudes (Maisch, 1992). This accumulation area ratio (AAR) of accumulation area to the total glacier area has an average value close to 0.6 (Paterson, 1994). However, accumulation ratios can range from about 0.25 to 0.75 (Haeberli, Hoelzle, and Zemp, 2007) with the largest deviations occurring for abnormally shaped glaciers (Table 1).

The 2:1 ratio of the accumulation to ablation areas, or AARo, of 0.67 was tested and found to apply to New Zealand glaciers without debris cover, terminal lake or an abnormal shape. The test uses the snowline data from the index glaciers as determined from 29 years of monitoring given in Hoelzle, et al. (2007). Values of the AARo for each index glacier in Appendix 2 are found from the ELA vs AAR regression results. They vary considerably with the type of glacier, from 0.09 to 0.84. Closer examination shows that the largest deviations are for glaciers with extensive debris cover, and for those with pro-glacial lakes. The results of Table 1 show what happens as these are progressively rejected. The nearer the selection to the morphology of a "normal" glacier, the closer the accumulation area ratio approaches the 0.67 mean. Initial observations of the index glacier AAR values suggest that the most significant of the topographic controls for raising the AAR value (lowering the ELA) appear to be the surface gradients below the ELA and any divergence of ice flow. Conversely any flattening of the glacier tongue lifts the ELA to drive a low AAR value. Surprisingly, parallel flow as is common in ice aprons does not appear to affect the AAR

Table 1: Derived AARo values for New Zealand glaciers

Sample	Number	Mean AARo	Std Dev
All index glaciers	50	0.57	0.18
Without (a) rock glaciers	46	0.59	0.16
Without (a) and (b) lakes	39	0.63	0.12
Without, (a),(b), and (c) abnormal shapes	26	**0.65**	0.10

Mass balance (the specific depths of mass gain or loss over a balance year) does not follow an even change along the glacier profile, and for simplification, mid-latitude glaciers are usually assumed to have a single linear gradient along the longitudinal profile of the glacier. However, for equilibrium, the volume of snow gained during the glacier year equals the volume of the ice lost (using water equivalents). Due to the 2:1 rule used here, the accumulation area is twice the ablation area. Thus for the purposes of this work, it is assumed that the ablation mass balance gradient is twice the accumulation gradient.

Values for the long-term ELAo were initially derived by applying an AAR value of 0.67 (Gross, et al. 1976) to the area-altitude curve for each glacier. The ELAo is read off the glacier area curves at 0.4 of the area up from the glacier terminus.

Initially the ELAo values were approximate estimates only, as measured AARs on glaciers in equilibrium vary from 0.5 to 0.75, depending on glacier topography and other factors. The ELAo may then be adjusted using the record of annual ELAs and the annual mean ELA for all index glaciers. The method assumes that the ELAo

indicates the snowline position for a zero mass balance, and that ELA changes each year on an individual glacier are linearly proportional to the average change over the entire Southern Alps.

The regression plots for each of the index glaciers are given in Appendix 2, where the annual departures for each glacier are regressed against the annual mean for the Alps without the glacier in question. The correlation and representativeness indicated by these regressions is discussed below. At the zero intercept, which indicates a zero average mass balance for the Alps, the mass balance of the individual glacier should also be zero. The adjustment of the ELAo from its estimated value to a precise value indicated by the dataset is carried out using the constant of the regression equation.

The slope of the regression line indicates the character of the response of the glacier to the climate. The average climate response is given by the mean for the Southern Alps, so that any deviation from a 45^{o} slope is an indicator of the individual characteristics of the glacier. Since each year's climate is thought to be similar over all of the Southern Alps, with the noted exception of the Kaikoura Ranges, which lie in a distinctly different climate district (Kidson, 2000), the regression slope changes must represent a topographic signal in the ELA values. Similarly, the range of the highest and lowest ELA values is also influenced by the glacier topography. The significance of these properties has yet to be analysed and warrants further investigation.

4. The 2010 snowline results

4.1. Photographic coverage of the index glaciers

There was generally no trouble with cloud over most of the glaciers, with only a slight obstruction of the photographs of the Gunn and Ailsa Glaciers, and nearly 70% obstruction of the Findlay Glacier.

The photographs were taken digitally with a Nikon D200 (sensor size = 23.6 x 15.8 mm, effective pixels = 10 MPix) linked to a Garmin GPSmap 60Csx with an external aerial on the windscreen of the plane. Each digital image has the GPS photograph location (latitude and longitude WGS84 datum) and focal length embedded in the EXIF information part of the digital photograph. The GPS used on the 2008 and 2009 surveys was set to the NZMG projection system and was displaying these values on screen, but was outputting WGS84 latitudes and longitudes through the serial interface to the digital camera. These photographs were taken as both compressed jpegs, and raw Nikon NEF file formats. A second set of digital photos were taken with a Pentax K100D (sensor size = 23.5 x 15.7 mm), but this camera did not have a GPS connected to it.

Nearly all of the glaciers had obvious snowlines and these were generally around the ELAo position on the glaciers, although there was considerable variation between index glaciers this year as some had noticeable high snowlines, and others relatively low snowlines. There was a possibility that some of the eastern and southern glaciers had a light dusting of fresh snow that had fallen earlier in the week. On these glaciers the snowline was partially masked so the snow patch method was used to determine the snowline elevation. Glaciers around and north of the Mt Cook region had noticeable brown discolouration of the winter snowpack and this is assumed to be dust from the large Australian dust storms in September 2009.

4.2. Snowline elevation departures

Monitoring results for the 50 index glaciers for the 2009/2010 glacial year, together with the means for all measured years from 1977 to 2010 are shown in Figure 6 and Figure 7 respectively.

The individual departure response of each index glacier varies due to topographic factors (discussed in section 3.5) and this variation can be scaled to consistent values by applying the slope from the regression between the annual departure and the annual mean alps value (regression slope values in Appendix 2). The derived slope values are considered to be reasonably valid as there are now a considerable number of observations, with 40 index glaciers having 25 or more annual observations (the least number of annual observations for any one glacier is 17). Figure 6 presents the raw and scaled departure values from ELAo for the index glaciers over the 2009/2010 glacial year. The effect of scaling is minimal for most of the index glaciers which have a near 1:1 ratio response to the Alps mean. Scaling does have the effect of reducing the magnitude of the offset for some of the glaciers with large offset or range of ELA values. It is assumed that the most inconsistent ranges in ELA values were those for "snow-patch" glaciers which do not have the conventional glacier elevation range, nor an ELA position. Up until now these values have been assigned as theoretical values and application of scaling has brought these difficult sites into line with normal glaciers. For example the 2010 departures for Mt Larkins and the Douglas Glacier are halved after the topographic scaling is applied. This scaling for each glacier is especially important when aggregating the results for the full length of record for the whole of Southern Alps, as it accounts for the irregular sample size and the impact of individual glaciers with high sensitivities.

The unscaled snowline departure results for this year averaged 3 m below the long-term mean ELAo position, and scaled offset was a very similar 4m below the long-term mean ELAo position. There was significant variability around the mean this year and there are indications that there may be some geographic linkages to this with a

tendency to have lower snowlines in the southern Fiordland glaciers, and the majority of the higher snowlines on the eastern side of the Southern Alps (Figure 6).

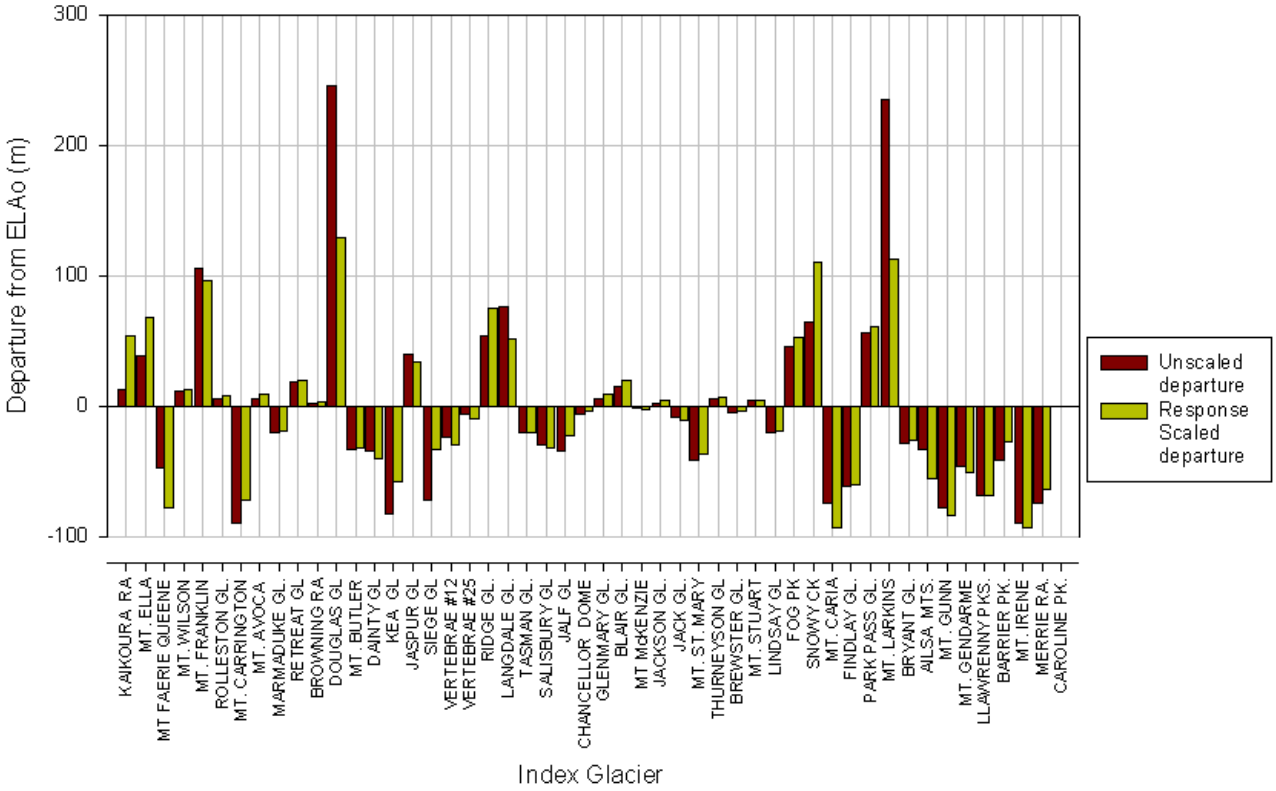

Figure 6: **Histogram plot giving the 2010 snowline departures (unscaled and response scaled) for each index glacier from the long-term ELAo.**

Annual data for all measured glacier ELA departures from the long-term ELAo from 1977 to 2010 are given in the matrix of Appendix 1 and are presented in Figure 7. The strong negative departures over the previous two balance years (2007/2008, 2008/2009) contrast with the near neutral response over the 2009/2010 glacial year. The mean annual departures are presented as scaled and unscaled amounts and interestingly the results are similar as the effect of the outliers on the entire dataset is very small in most years. The largest change due to scaling occurred during 1992 where the mean annual departure is reduced by 19m from -125m to -106m, due to a small sample size of 15 index glaciers in which strongly sensitive index glaciers were over-represented by comparison with other years.

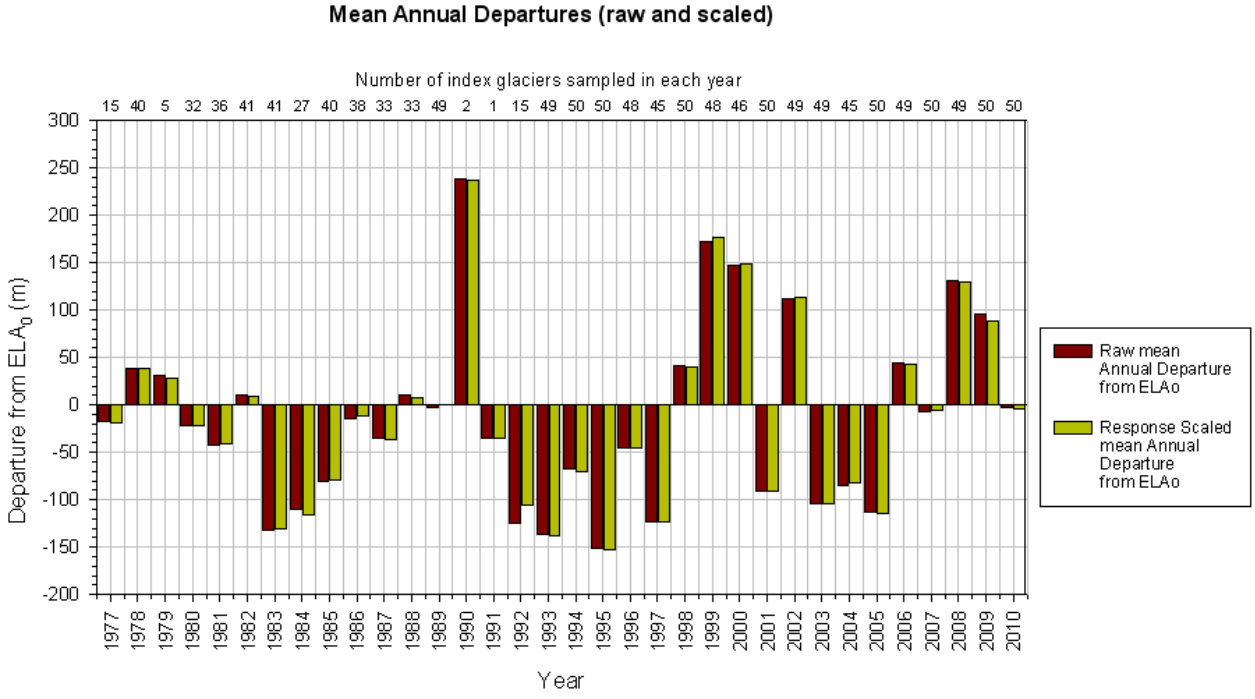

Figure 7: **Mean annual departures (raw and response scaled) from the ELAo for all measured glaciers for the entire period of these surveys.**

Appendix 2 gives a data table, map and histograms of all measured snowline fluctuation histories as metres of departure from the steady-state ELAo for each index glacier. On the annual departure plots, missing values are years of no survey. The data table provides essential glacier data, snowline data statistics and a table of all measurements and derived values. Photographs of each glacier are available in the 1999 report, (Chinn and Salinger, 1999) and are reproduced in low resolution in this report.

4.3. Glacier representativeness

The "representativeness" of each glacier as an indicator of the overall annual climate of the Southern Alps may be assessed by how well the annual values for an individual glacier correlate with the mean value of the 50 index glaciers over the Southern Alps. Correlation coefficients of individual snowline departures for each glacier correlated against the mean of all remaining values for each year are given in Table 2. The correlation plots for each glacier are given in the Appendices. The correlations give a surprising result where representativeness appears to be independent of size, gradient and topography. The high correlations indicate that the ELA surface of individual glaciers has a strong relationship with the "mean ELA" over the whole alpine range. This follows the finding of Clare et al. (2004) where it was demonstrated that the entire Southern Alps behaves as a single climatic unit. However the consistently low correlation of the Kaikoura Range glacier suggests that the behaviour of this range is

that of a separate climate zone, while it is assumed that accumulation on the low correlation Langdale glacier is dominated by wind redistribution.

Table 2: Correlation coefficients of individual snowline departures for each glacier correlated against the mean of all remaining values for the period 1977 - 2010.

GLACIER	Correlation Coefficient
BARRIER PK.	0.93
FINDLAY GL.	0.91
JALF GL	0.91
LLAWRENNY PKS.	0.91
VERTEBRAE #25	0.89
SIEGE GL	0.88
JACKSON GL.	0.88
THURNEYSON GL	0.88
MT. STUART	0.88
MT. BUTLER	0.88
BRYANT GL.	0.88
LINDSAY GL	0.87
MARMADUKE GL.	0.87
MT. LARKINS	0.86
CHANCELLOR DOME	0.86
KEA GL	0.86
CAROLINE PK.	0.86
JASPUR GL	0.86
SALISBURY GL	0.86
MT. ST. MARY	0.86
MT McKENZIE	0.85
MT. GENDARME	0.85
TASMAN GL.	0.85
MT. CARRINGTON	0.84
MERRIE RA.	0.83
FOG PK	0.83
MT. FRANKLIN	0.83
JACK GL.	0.83
MT. ELLA	0.82
DAINTY GL	0.82
MT. IRENE	0.81
BREWSTER GL.	0.81
AILSA MTS.	0.81
PARK PASS GL.	0.80
DOUGLAS GL	0.80
VERTEBRAE #12	0.80
BROWNING RA	0.79
MT. WILSON	0.79
MT. AVOCA	0.78
MT. GUNN	0.77
MT. CARIA	0.76
BLAIR GL.	0.76
RIDGE GL.	0.74
ROLLESTON GL.	0.73
GLENMARY GL.	0.72
RETREAT GL	0.72
LANGDALE GL.	0.70
MT FAERIE QUEENE	0.68
SNOWY CK	0.66
KAIKOURA RA	0.59

4.4. The 2009/2010 glacial climate

At the onset of the 2009/2010 glacial year, New Zealand temperatures were mostly below average for most of the country, except for Southland and Fiordland where Autumn 2009 temperatures were near average. Near average temperatures occurred in many regions for Winter 2009 (but with record warmth in August), while near average temperatures occurred in the Lakes District during spring 2009. Overall, the New Zealand national average temperature for summer 2009/10 was near normal, with an extremely cold start in early December, but heat waves and above average temperatures in February 2010.

At the start of the glacial year in April 2009, the equatorial and sub-tropical Pacific Ocean was experiencing the tail end of La Niña. The tropical Pacific atmospheric circulation was in a near-normal state during this time. During late autumn 2009, many climate projections that were being monitored by the National Climate Centre had indicated a shift toward El Niño would occur at the onset of the Austral spring. The Southern Oscillation Index (SOI) was near neutral during April-June 2009 (3-month mean ~+0.0). March and April 2009 were dominated by the slow movement of anticyclones passing over New Zealand from the west. In March, these highs tended to stall over the Tasman Sea, and resulted in more south to south-westerly air flows than normal over the country, while in April they persisted to the east of the North Island and resulted in more northerly air flows than normal. Beginning in May 2009, the SOI began a move toward negative values, indicative of the impending onset of El Niño. During this period, the anticyclones tended to persist over southern Australia resulting in more southerly air flows than normal over New Zealand. An increased frequency of depressions ("lows") over and to the east of New Zealand in May also helped to contribute to the cold and wet conditions experienced in many eastern areas. June 2009 was dominated by higher-than-normal pressures over the country, resulting in more frosts and much colder than normal temperatures everywhere (Figure 8). The circulation pattern in late autumn contributed to colder than average conditions (by between 0.5 and 1.5°C) for most of the country, with the exception of Southland and Fiordland where temperatures were near average, as a result of an April with warmer than average temperatures. Overall, precipitation was close to normal for Westland, near to below normal for Fiordland and Southland, and above normal to well above normal (with some record high precipitation) in the central part of the Southern Alps for April-June 2009.

During July 2009, there was a transition towards more southwesterly winds, but this circulation pattern was punctuated by frequent northerly flow and record warm temperatures during August 2009. There were several significant snowfall events that occurred during winter 2009, the first registering on 16 June in Otago and Southland, which was followed by another on 29 June in the central South Island that affected many alpine areas. On 2-5 July, a significant snowfall event closed the Haast Pass and

affected Central Otago. Freezing temperatures followed two weeks later on 13-14 July, which saw Otago and South Canterbury affected by black ice. On 19 July, a freezing front brought snow, hail, sleet and icy winds to Otago and Southland. This period of dramatic cold was then punctuated by record warmth in August, which also saw damaging avalanches occur in Fiordland early in the month. For July-September 2009, precipitation was near normal across Southland, Fiordland and the central axis of the Southern Alps, and above normal in Westland.

From October 2009 through March 2010, the SOI remained strongly negative with the running 3-month average exceeding -1.0 during this period. El Niño developments were responsible for regional climate anomalies experienced in New Zealand during this time, with stronger than normal southwest winds occurring over the country as a result of below normal pressures to the southeast of the South Island. It was an extremely dry spring over much of the South Island, with near to below normal rainfall for many areas during October-December, and record or near-record low spring rainfalls in Westland and along the Main Divide. Arthurs Pass experienced its driest spring ever (since records began in 1906). Overall, the New Zealand national average temperature for spring 2009 was 11.6°C, which was 0.4°C below the long-term seasonal average.

Summer 2009/10 was characterised by more 'highs' in the Tasman Sea and over northern New Zealand, resulting in stronger than normal southwest winds over the country (Figure 9). It started out extremely cold as a result of El Niño being in place, with record cold temperatures in early December. However, the season finished with heat waves and above average temperatures in February. Overall, the New Zealand national average temperature for summer was near normal (16.6°C, 0.1°C below the long-term seasonal average), but was highly variable across this season and between regions. Summer temperatures were above average (between 0.5°C and 1.2°C above average) for Northland, Auckland, Coromandel, and the Bay of Plenty, as well as in inland and western areas of the South Island. Below average temperatures (between 1.2°C and 0.5°C below average) were observed about coastal Otago. Elsewhere, summer temperatures were close to normal. Summer rainfalls were well above normal in parts of Southland and the West Coast as a result of the frequent southwesterly flow, but mostly near normal across major portions of the South Island.

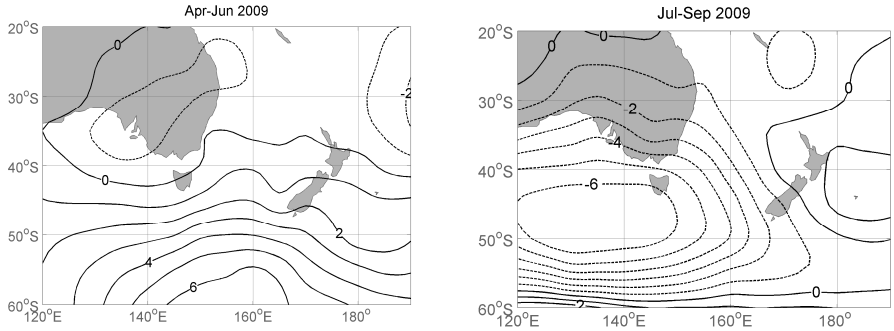

Figure 8: **Mean sea level pressure anomalies April - June 2009 (left) and July – September 2009 (right).**

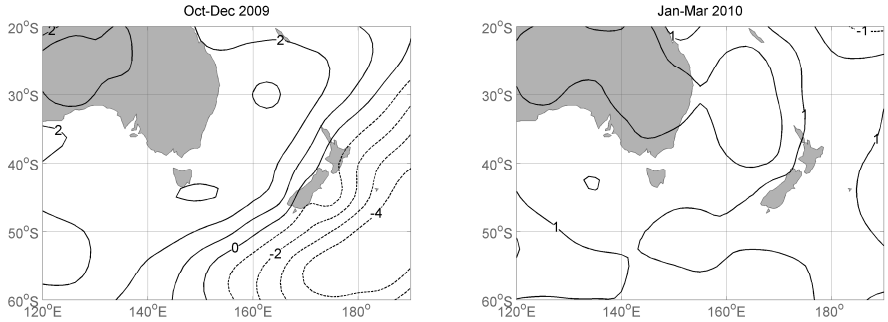

Figure 9: **Mean sea level pressure anomalies October - December 2009 (left) and January – March 2010 (right).**

5. Discussion

5.1. Ice gain and loss

Glaciers accumulate the mass changes of net annual balance variations over years to decades. The effects of yearly climate variations are smoothed and distorted before being delivered to the terminus over delay times that are dependent on individual glacier response times. The index glaciers record the annual climate-related mass gains and losses with some degree of accuracy as the majority of these glaciers are small and steep with relatively fast response times, and have areas that are in equilibrium with the climate of recent decades. The large valley glaciers with long, near 100 yr response times have large surface areas inherited from a previous climate, and all are in a state of ongoing recession mainly by downwasting of their debris-covered trunks, but recently ice loss has accelerated by the formation of proglacial lakes. For these glaciers, the ELA changes measure ONLY the mass balances of a smaller area that would be in equilibrium with the present climate. Ice mass changes in these glaciers are accounted for in Chinn et al. (2010, submitted).

To assess the mass changes in response to climate fluctuations a cumulative plot of the "mass balance indices" (MBI) is presented in Figure 10. The raw MBI is the negative equal (i.e. X *-1) of the mean annual departure value, and this represents the mean departure from steady state (ELAo). Snowline departure changes with negative ELA (i.e. lower snowline) result in an equally positive MBI. The reliability of use of the ELA as an indicator of mass balance change has been investigated by Chinn et al (2005), where the correlations between the ELA and measured mass balance had an average value of 0.9 with a standard deviation of 0.07.

The annual trends in the raw MBI as shown in Figure 10 agree with the generalised climates given in Table 3. However, the cumulative total of the raw MBI on the plot does not agree with the obvious ice volume decrease at most of the index glaciers. Over the course of the 34 year monitoring period, there has been permanent ice loss during large negative mass balance years that has not been recovered during a number of positive mass balance years. A negative mass balance year has a greater impact on ice volume than a positive mass balance year for MBIs of the same magnitude. This is due to ablation rates typically being almost twice the accumulation rates on most alpine glaciers (e.g. Kaser, 2006).

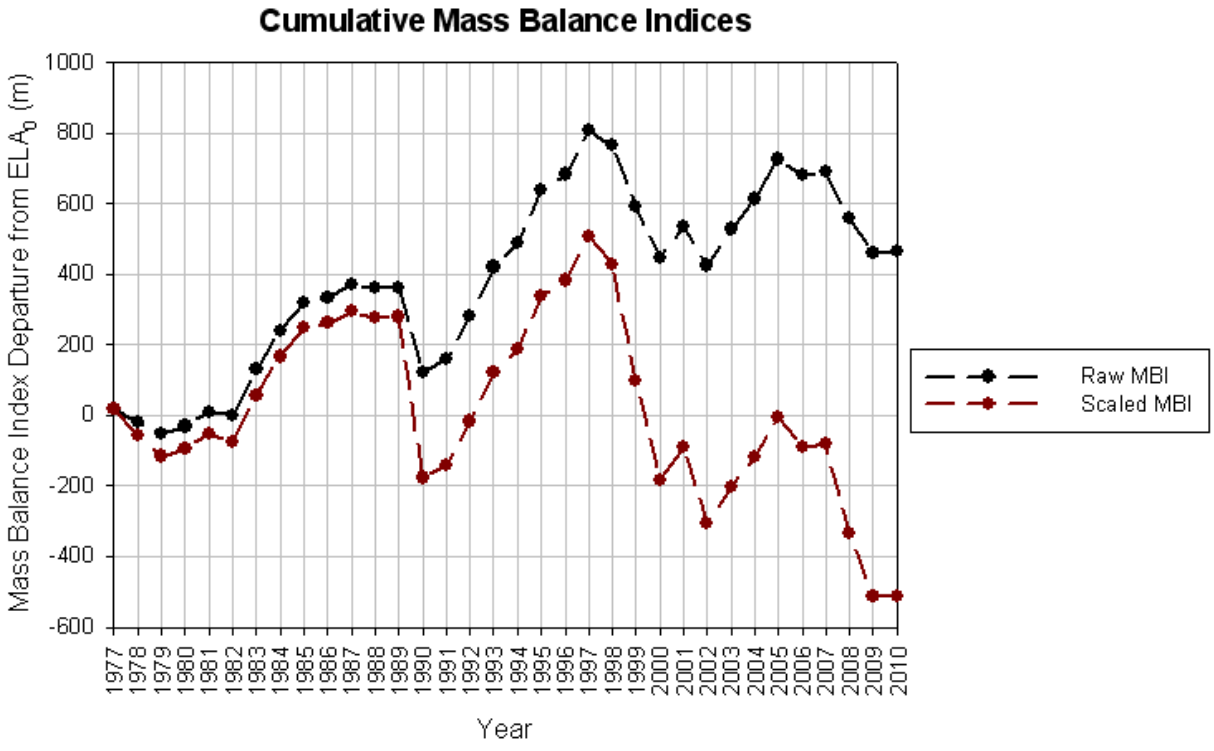

Figure 10: Raw and Scaled Cumulative Mass Balance Indices for the index Glaciers.

Table 3: Generalised climate for 2009/2010 year and previous 12 years in Southern Alps and inferred glacier snow input.

Glacier Year	Generalised Climate	Inferred glacier snow input
1997/1998	Higher frequency of anticyclones and westerly winds over the south, southerlies further north. Temperatures 0.2 C below normal, but a very warm summer.	Average
1998/1999	Stronger westerly and northwesterly winds over New Zealand, temperatures 0.8℃ above average, with above normal precipitatio n on the West Coast.	Low
1999/2000	Very anticyclonic, with weaker westerlies than normal. Temperatures 0.7 C above normal, and rainfall slightly below normal.	Low
2000/2001	More northwesterlies over the South Island, temperatures 0.2 C above normal. Rainfall close to average.	Average-High
2001/2002	Higher than normal pressures and more easterlies over the South Island, temperatures 0.3^{o}C above normal, well below average rainfall.	Low
2002/2003	Persistent westerlies and southwesterlies over New Zealand. Cooler spring, rainfall slightly above average in the west and south.	Average-High
2003/2004	More cyclonic westerlies and south westerlies over the South Island from September.	Higher
2004/2005	Cool westerlies during autumn and early winter (temperatures 0.4℃ below normal), then strong cold cyclonic southwesterlies through to December (temperatures 0.6℃ below normal), precipitation ov erall close to average.	High
2005/2006	More anticyclones and mild westerlies and northwesterlies during autumn and winter (winter temperatures 0.7℃ above normal), th en more frequent southeasterlies during spring bringing low precipitation.	Low
2006/2007	More southwesterlies June – November bringing increased accumulation, but then anticyclones and south easterlies December – March with low precipitation and increased ablation. Temperatures near average overall, and precipitation above average.	Average
2007/2008	Variable circulation April – August with little accumulation. From September on, mainly easterly circulation, and especially warm (1.0℃ above normal) from December with low precipitation and much increased ablation.	Very low
2008/2009	Northerly and easterly quadrant flow anomalies related to La Nina, with associated normal to above normal temperatures, except during Spring. Below normal precipitation during late Winter and Summer.	Low
2009/2010	Highly variable year with regard to temperature and precipitation swings within and between seasons, particularly for winter 2009 and summer 2010. More frequent southwesterly flow as a result of El Nino development from spring was opposed to record high temperatures in August 2009 and February 2010.	Average

To account for this difference in ablation vs. accumulation rates, a scaled mass balance index is also shown in Figure 10 where negative mass balance years have been scaled by 1.92 and positive mass balance years are left unchanged. The scale factors are averages of published mass balance gradient rates (shaded values in Table 4) from studies on the Tasman (Anderton, 1975) and Ivory Glaciers (Anderton and Chinn, 1978). The assumption that we have made here is that these averaged mass balance gradients apply to the averaged annual departure value for all the index glaciers. Ideally, we would used averaged mass balance gradients obtained individually for each of the index glaciers, but unfortunately this (potential) wealth of data is not available. Therefore, to examine the sensitivity of our assumption, and its impact on the cumulative scaled mass balance we have used a range of values for the negative mass balance of 1 (equal to the raw MBI), 1.5, 2 and 3 as shown in Figure 11.

Table 4: Vertical gradients of mass balance as measured for Ivory and Tasman glaciers (mm/m). * is an estimated value.

Zone year	Ivory Glacier Ablation	Ivory Glacier Accumulation	Tasman Glacier Ablation	Tasman Glacier Accumulation	Both Glaciers Ablation	Both Glaciers Accumulation
1966-67				6		
1967-68				8.6		
1968-69				7.5		
1969-70	26.3			5.4		
1970-71	35.5		11.7	5		
1971-72	20.8		13.7	7.4		
1972-73	28.9		12.4	10.1		
1973-74	28		14.3	7		
1974-75	15.4		10.4	6.6		
Mean	**25.8**	**12.9***	**12.5**	**7.1**	**19.2**	**10**

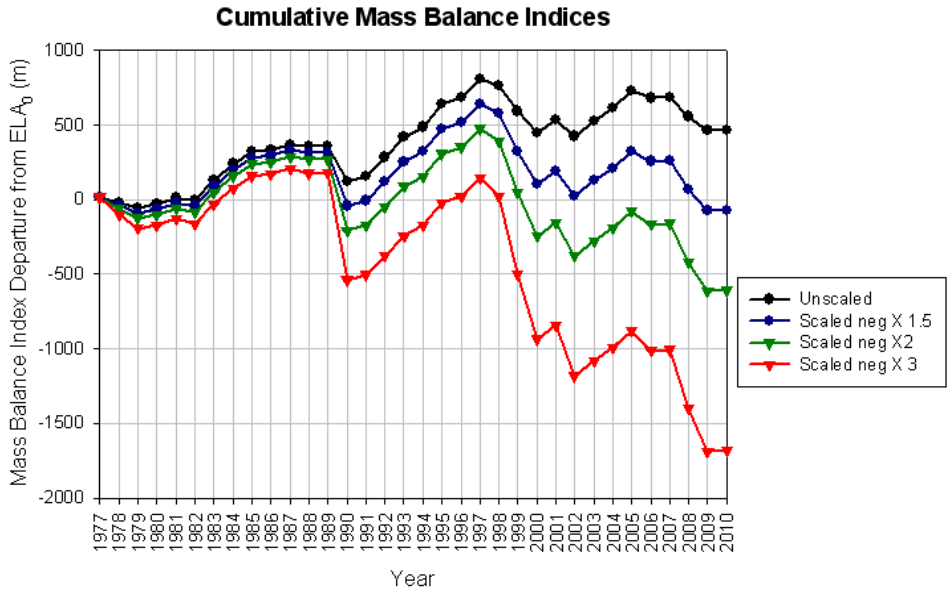

Figure 11: Scaled Cumulative Mass Balance Indices for the index Glaciers using a range of scaling factors from 1 to 3.

Figure 11 clearly shows the impact on the cumulative mass balance index depending on the value selected to scale the negative values in the raw mass balance index. This figure has been shown to highlight the sensitivity of the cumulative mass balance to the assumed scaling factor selected. However it must be noted that the selected scaling value of 1.92 for the negative values, has been obtained from the published data based on field observations on New Zealand glaciers. Ideally, we would have used averaged measured mass balance gradients for each of the individual index glaciers rather than assuming an average value for the whole data set from two individual glaciers. Again, this potential wealth of data is not currently available. We are optimistic that there will be additional glacier monitoring in New Zealand in the future and that this will result in more directly-observed mass balance gradients from different glaciers. This would improve the pool of mass balance observations over time and thereby reduce the uncertainty in the scaling factor used.

Despite these limitations, it is interesting to note that the cumulative scaled mass balance index (as presented in figure 10) is consistent with the calculated volume changes for the New Zealand glacier as documented by Chinn (submitted). Furthermore, the observed trend in permanent ice area in many of the index glaciers agrees more closely with the cumulative *scaled* mass balance index (as presented in Figure 10), rather than the cumulative *raw* mass balance index which does not account for a key factor, the mass balance gradient.

6. Acknowledgement

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Glossary

Ablation All processes by which snow and ice are lost from a glacier

Accumulation All processes by which snow and ice are added to a glacier.

Accumulation Area Ratio (AAR) The ratio of the accumulation area above the equilibrium line, to the entire area of the glacier.

Departure of the ELA The elevation difference between the long-term ELAo and the annual snowline altitude. Positive departures mean a higher snowline and therefore a negative mass balance.

ELA The mean altitude of the snowline or equilibrium line across a glacier at the end of summer.

ELAo The long-term or steady-state altitude of the ELA which will maintain the glacier in equilibrium with the climate.

Mass balance index The negative of the ELA departure value. This gives values for annual changes with the same sign as the mass balance changes.

Shaded cells Areas which have been measured by digitising.

Snowline elevation The snowline elevation is synonymous with ELA when measured at the end of summer. All other snowline elevations apply to a transient seasonal snowline..

Total Area The entire area of the glacier. This may change from year to year, especially on the smaller glaciers.

Appendix 1:

Index Glacier ELAs (1977 – 2010)

GLACIER	GL.IN. No	ELAo	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
KAIKOURA RA	621/001	2490						5		-30				-5
MT. ELLA	932B/012	2142						12						
MT FAERIE QUEENE	646/006	2030						-45						5
MT. WILSON	None	1912	-37	-11			15		-115	-141	-63	41	-89	68
MT. FRANKLIN	911A/002	1814		-12	122	-41	-74		-148			-18	-54	35
ROLLESTON GL.	911A/004	1763	-8	7	-8	6	-3	10	-123	-8	-8	13	15	-1
MT. CARRINGTON	646C/027	1715		-45		-22	-87	25	-150	-115		-10	45	55
MT. AVOCA	685F/004	1965		-55				-15		-95	-55	-5		10
MARMADUKE GL.	664C/012	1830	-43	-35	78	2	-28	30	-136	-122	-50	9	-5	65
RETREAT GL	906A/004	1742		-4		38	-50	14	-252		-4	20		
BROWNING RA	906A/001	1598		7		10	-34	7	-113		-2	17		
DOUGLAS GL	685B/001	2040		91		-163		-18	-214	-240	-223	-128		91
MT. BUTLER	685C/060	1840	-55	112	55	-34	-40	28	-200	-65	-70	10	-9	42
DAINTY GL	897/019	1954	-32	36		-7	-77	93	-99		-81	-73	-84	-12
KEA GL	897/007	1820		65		44	-85	134	-230		-120	-82	-83	-58
JASPUR GL	897/003	1725		43		63		-15	-155		-105	-42		-42
SIEGE GL	893A/006	1736	-64	-24		-76	-70	-46	-268		-94	35		-70
VERTEBRAE #12	893A/012	1864		7		36	-51	-14	-64		-56	-44		7
VERTEBRAE #25	893A/025	1840		30		25	-39	0	-62		-50	-27		3
RIDGE GL.	711L/024	2226		79			2	10	-15	-141	-32	-9		59
LANGDALE GL.	711I/035	2186	34	89			79	119	-1	-226	-221	14	-1	4
TASMAN GL.	711I/012	1790	-10	85	-90	20	-35	-30	-80	-95	-90	-10	-29	50
SALISBURY GL	888B/003	1810	17	17		32	-58	17	-92	-51	-76	-1	-35	-81
JALF GL	886/002	1790	-15	-10		-32	-65	5	-230	-78	-146	-20	-51	-32
CHANCELLOR DOME	882A/007	1756	96	95		77	-93	92	-211		-147	-78	-28	52
GLENMARY GL.	711F/006	2175		57		-95	-45	6	-40	-155	-67			5
BLAIR GL.	711D/038	1938		74		-75	-13	-51	-126	-80	-85		-68	17
MT McKENZIE	711D/021	1904		46		6	-16	-2	-184	-62	-124	13	-14	
JACKSON GL.	868B/094	2070		28		-20		8	-38	-80	-56		-9	
JACK GL.	875/015	1907		31		23	-22	44	-157	-79	-32	28	-2	-32
MT. ST. MARY	711B/039	1926								-171		-91		-19
THURNEYSON GL	711B/012	1970	-40			-44	-27		-105	-88	-65	-32	-52	-20
BREWSTER GL.	868C/020	1935		25		-89	-80	36	-141	-135	-139	-93	-107	
MT. STUART	752I/104	1673	-86	57		-23	-67	3	-135		-53	-13	5	
LINDSAY GL	867/002	1730		8		-78	-49	51	-170		-64	38	-115	42
FOG PK	752E/051	1987				-71		35		-96		-57	-85	35
SNOWY CK	752C/103	2092		64		-68	66	-54	-59	-68	-72	-56	-67	-55
MT. CARIA	863B/001	1472		-30			-59	-48	-100		-49	53	-50	28
FINDLAY GL.	859/009	1693					-89	42	-111		-64	32	-71	-8
PARK PASS GL.	752B/048	1824		79		-16	-46	34	-62	-59	-122	39	19	
MT. LARKINS	752E/002	1945								-265		-53		105
BRYANT GL.	752B/025	1783	-43	101			-20	-3	-163	-163	-173	-13	-20	
AILSA MTS.	752B/013	1648		-5					-88	-53	-53	1	-23	
MT. GUNN	851B/057	1593	22	45		-64	-62	17	-115		-53		-38	
MT. GENDARME	797G/033	1616					-46	-43	-136		-94	59	34	
LLAWRENNY PKS.	846/035	1476		4			-68	-4	-132		-36		-22	
BARRIER PK.	797F/004	1596		116		-51	-73	-31	-218		-72		-41	
MT. IRENE	797D/001	1563		137					-156		-37		-37	
MERRIE RA.	797B/010	1515		140										
CAROLINE PK.	803/001	1380												
NUMBER		50	15	40	5	32	36	41	41	27	40	38	33	33
MEAN		1836	-18	39	31	-21	-42	11	-132	-110	-80	-14	-35	10
STD. DEV.		215	46	50	83	53	39	43	64	63	51	45	40	46
No. below ELA (+ve balance)			9	6	1	19	29	17	40	25	32	19	19	19
% with +ve M.B.			60	15	20	59	81	41	98	93	80	50	58	58

Shaded columns indicate years of positive mass balance (averaged over the whole of the Southern Alps)

GLACIER	GL.IN. No	ELAo	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
KAIKOURA RA	621/001	2490	50				-57	-30	-60			30	15
MT. ELLA	932B/012	2142	28				-87	-72	-142	-15		17	108
MT FAERIE QUEENE	646/006	2030	5				-62	-57	-65	-57		-50	145
MT. WILSON	None	1912	93				-167	-102	-154		-149	41	113
MT. FRANKLIN	911A/002	1814	52				-164	-109	-156	-82		122	164
ROLLESTON GL.	911A/004	1763	7				-143	-18	-143	-13	-123	40	87
MT. CARRINGTON	646C/027	1715	5				-170	-128	-158	-125	-137	-39	190
MT. AVOCA	685F/004	1965	6				-115	-25	-45	12	-75	70	115
MARMADUKE GL.	664C/012	1830	-13	168			-175	-75	-155	-82	-129	143	164
RETREAT GL	906A/004	1742	36				-73	-120	-277	16	-97	47	146
BROWNING RA	906A/001	1598	14				-116	-71	-118	-28	-108	30	
DOUGLAS GL	685B/001	2040	172			-197	-260	-154	-231	-150	-223	220	240
MT. BUTLER	685C/060	1840	-34			-95	-136	-28	-190	-60	-176	68	98
DAINTY GL	897/019	1954	-32			-103	-176	-73	-111	-12	-92	98	176
KEA GL	897/007	1820	-36				-230	-92	-250	80	-152	78	200
JASPUR GL	897/003	1725	-29				-150	-120	-145	-90	-100	43	
SIEGE GL	893A/006	1736	-64			-323	-386	-116	-396	-72	-203	214	414
VERTEBRAE #12	893A/012	1864	-39			-96	-86	-57	-86	-57	-73	-9	226
VERTEBRAE #25	893A/025	1840	-20			-94	-84	-54	-84	-54	-71	-5	125
RIDGE GL.	711L/024	2226	51				-126	-56	-94	-88	-136	9	109
LANGDALE GL.	711I/035	2186	69			-226	-231	14	-226	-1	-226	142	134
TASMAN GL.	711I/012	1790	-30	310	-35	-100	-108	-20	-124	-35	-102	63	186
SALISBURY GL	888B/003	1810	-66			-129	-100	-38	-165	-58	-84	42	220
JALF GL	886/002	1790	-31			-210	-220	-38	-240	-8	-191	-3	260
CHANCELLOR DOME	882A/007	1756	-78				-206	-147	-211	-36	-176	92	209
GLENMARY GL.	711F/006	2175	5			-15	-68	-30	-35	-45	-130	20	115
BLAIR GL.	711D/038	1938	-62				15	-73	-85	2		34	152
MT McKENZIE	711D/021	1904	8				-122	8	-99	6	-189	31	174
JACKSON GL.	868B/094	2070	10				-78	-25	-52	2	-54	12	95
JACK GL.	875/015	1907	-9			-90	-142	-27	-152	51	-102	33	101
MT. ST. MARY	711B/039	1926	46			-76	-141	-76	-156	-71	-84	-37	199
THURNEYSON GL	711B/012	1970	0			-40	-60	-66	-102	-32	-70	-5	142
BREWSTER GL.	868C/020	1935	-17			-84	-185	-145	-158	27	-156	47	345
MT. STUART	752I/104	1673	-10				-138	-33	-158	39	-106	-17	132
LINDSAY GL	867/002	1730	34				-175	-120	-180	45	-85	70	145
FOG PK	752E/051	1987	45				-93	-87	-99	-93	-97	111	135
SNOWY CK	752C/103	2092	11				-34	-58	-62	-35	-72	66	148
MT. CARIA	863B/001	1472	-43				-97	-72	-106	-82	-77	-55	178
FINDLAY GL.	859/009	1693	-51				-118	-59	-132	-61	-113	87	197
PARK PASS GL.	752B/048	1824	-30					-41	-189	-16	-79	56	131
MT. LARKINS	752E/002	1945	91				-275	-95	-315	-163	-312	105	270
BRYANT GL.	752B/025	1783	-30				-108	-55	-153	-103	-113	-5	227
AILSA MTS.	752B/013	1648	-36				-84	-52	-93	-64	-55	-27	182
MT. GUNN	851B/057	1593	-59				-108	-64	-122	-86	-73	-34	209
MT. GENDARME	797G/033	1616	-36				-114	-64	-198	-100	-126	32	188
LLAWRENNY PKS.	846/035	1476	-47				-116	-68	-176	-15	-155	2	194
BARRIER PK.	797F/004	1596	-71				-168	-118	-236	-126	-132	86	304
MT. IRENE	797D/001	1563	-26				-156	-51	-163	-65	-103	49	95
MERRIE RA.	797B/010	1515	30				-135	-95	-165	-90	-130	-70	173
CAROLINE PK.	803/001	1380					-160	1	-150	-78	-130	2	182
NUMBER		50	49	2	1	15	49	50	50	48	45	50	48
MEAN		1836	-3	239	-65	-125	-136	-67	-151	-45	-124	42	172
STD. DEV.		215	49	100		80	68	40	70	53	52	62	70
No. below ELA (+ve balance)			26	0	1	15	48	47	50	38	45	13	0
% with +ve M.B.			53	0	100	100	98	94	100	79	100	26	0

GLACIER	GL.IN. No	ELAo	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
KAIKOURA RA	621/001	2490	10	-15	25			-25		14	50	5	13
MT. ELLA	932B/012	2142	60	-22	46	-64		-77	17	27	38	30	38
MT FAERIE QUEENE	646/006	2030	160	-55	55	-54		-60	-48	-33	55	45	-47
MT. WILSON	None	1912	108	13	93	-121	-92	-82	93	40	93	88	11
MT. FRANKLIN	911A/002	1814	136	-104	121	-70		-106	126	-23	126	124	106
ROLLESTON GL.	911A/004	1763	105	-8	97	-94	-1	-23	37	32	52	51	5
MT. CARRINGTON	646C/027	1715	237	-135	210	-84	-120	-137	135	-45	155	155	-90
MT. AVOCA	685F/004	1965	65	-52	88	-52	-20	-53	35	3	85	10	5
MARMADUKE GL.	664C/012	1830	153	-57	140	-117	-27	-130	145	13	160	140	-20
RETREAT GL	906A/004	1742	133	-60	93	-78	18	-132	48	-22	68	63	18
BROWNING RA	906A/001	1598		-30	62	-77	-28	-110	12	21	27	22	2
DOUGLAS GL	685B/001	2040	250	-40	245	-134	-35	-163	240	-44	340	243	245
MT. BUTLER	685C/060	1840	148	-95	90	-147	-80	-176	75	-2	120	85	-33
DAINTY GL	897/019	1954	74	-58	126	-67	-44	-94	-9	-12	116	41	-34
KEA GL	897/007	1820	190	-150	195	-159	-90	-155	78	-36	150	200	-83
JASPUR GL	897/003	1725		-95	195	-74	-95	-125	35	-41		195	40
SIEGE GL	893A/006	1736	279	-126	239	-160	-116	-203	-72	-18	394	224	-72
VERTEBRAE #12	893A/012	1864	121	-59	131	-48	-57	-74	-34	-8	166	60	-24
VERTEBRAE #25	893A/025	1840	70	-33	80	-51	-45	-75	-6	-16	110	19	-6
RIDGE GL.	711L/024	2226	79	-116	74	-63	2	-61	84	30	99	79	54
LANGDALE GL.	711I/035	2186	129	-226	99	-226	-1	-221	109	74	394	129	76
TASMAN GL.	711I/012	1790	110	-80	105	-80	-40	-40	60	6	235	175	-20
SALISBURY GL	888B/003	1810	172	-95	50	-95	-78	-95	40	0	140	140	-30
JALF GL	886/002	1790	265	-85		-190	-170	-190	-5	2	260	250	-35
CHANCELLOR DOME	882A/007	1756	204	-186	104	-186	-151	-181	94	43	109	109	-6
GLENMARY GL.	711F/006	2175	70	-37	35	-60	-30	-65	30	15	105	35	5
BLAIR GL.	711D/038	1938	147	-96	67	-93	-88	-88	22	34	132	34	15
MT McKENZIE	711D/021	1904	148	-99	56	-134	-122	-132	6	15	111	31	-2
JACKSON GL.	868B/094	2070	63	-54	33	-55	-54	-56	15	14	93	12	2
JACK GL.	875/015	1907	85	-109	78	-147		-112	28	16	83	73	-9
MT. ST. MARY	711B/039	1926	204	-146	189	-131	-71	-126	-31	-16	194	74	-41
THURNEYSON GL	711B/012	1970	162	-92	135	-97	-35	-70	10	-7	140	130	5
BREWSTER GL.	868C/020	1935	220	-165	115	-141	-155	-155	-65	-120	335	55	-5
MT. STUART	752I/104	1673	177	-83	142	-103	-108	-108	52	-66	127	117	4
LINDSAY GL	867/002	1730	140	-90	142	-123	-122	-118	50	-30	130	80	-20
FOG PK	752E/051	1987	121	-92	125	-25	-95	-97	45	13	118	45	45
SNOWY CK	752C/103	2092	68	-88	28	-51	-58	-72	68	-2	66	64	64
MT. CARIA	863B/001	1472	188	-52	153	-50	-92	-98	43	-17	48	48	-74
FINDLAY GL.	859/009	1693	152	-73	132	-81	-115	-113	-3	-32	139	112	-61
PARK PASS GL.	752B/048	1824	111	-76	86	-163	-159	-154	76	26	86	86	56
MT. LARKINS	752E/002	1945	255	-280	150	-205	-255	-285	125	145	245	244	235
BRYANT GL.	752B/025	1783	182	-118	87	-117	-108	-118	17	-8	167	-8	-28
AILSA MTS.	752B/013	1648	137	-55	37	-65	-58	-68	-3	-35	22	27	-33
MT. GUNN	851B/057	1593	217	-78	42	-68	-108	-108	17	-43	52	197	-78
MT. GENDARME	797G/033	1616	159	-131	34	-96	-133	-129	32	-40	33	34	-46
LLAWRENNY PKS.	846/035	1476	181	-71	137	-100	-96	-76	9	-37	104	124	-68
BARRIER PK.	797F/004	1596	207	-108	194	-148	-131	-131	104	-17	119	194	-41
MT. IRENE	797D/001	1563	100	-162	170	-146	-130	-160	70	-85	50	68	-90
MERRIE RA.	797B/010	1515		-103	175	-100	-110	-105	150	-56	155	160	-75
CAROLINE PK.	803/001	1380		-105	195	-89	-110	-125	30	-44	50	40	0
NUMBER		50	46	50	49	49	45	50	49	50	49	50	50
MEAN		1836	147	-91	112	-104	-85	-113	45	-7	132	95	-3
STD. DEV.		215	62	54	58	46	54	51	59	41	89	70	67
No. below ELA (+ve balance)			0	49	0	49	43	50	10	29	0	1	28
% with +ve M.B.			0	98	0	100	96	100	20	58	0	2	56

Appendix 2:

Index Glacier details

No. 621/1

KAIKOURA RANGE

NZMS 260 sheet O 30

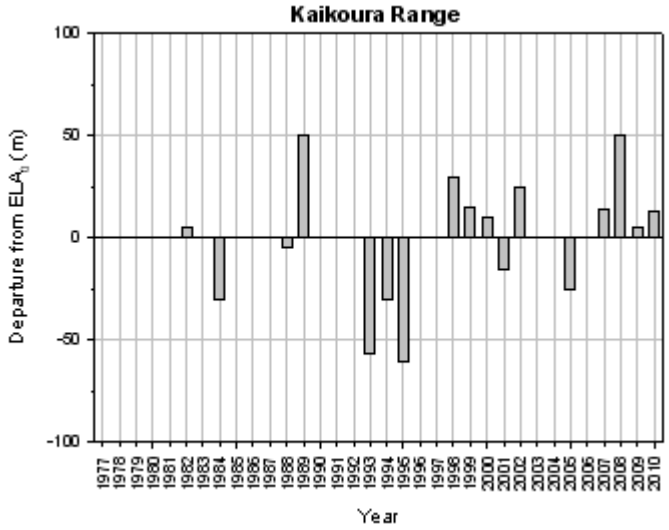
Rock Glacier

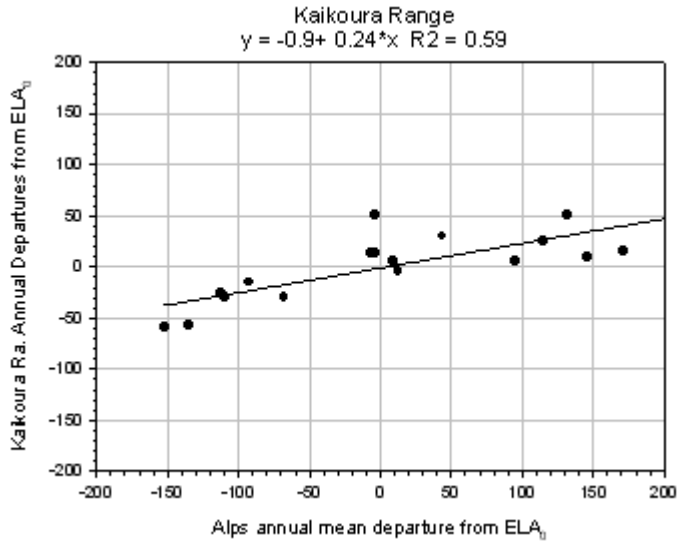
GLACIER DATA		
AREA	45.42	ha
Debris area	41.66	ha
Max Elev	2640	m
Min Elev	2200	m
Mean Elev	2420	m
Length	1.4	km
Elev Range	440	m
Gradient	0.31	

SNOWLINE DATA		
Aspect	S	
ELAo	**2490**	m
Max SL	2540	m, 1989
Min SL	2430	m, 1995
Mean SL	2490	m
SL Range	110	m
No. surveys	13	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS DEBRIS ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**2490**	**0**	**3.88**	**41.66**	**45.54**	**0.09**	**0**
1977							
1978							
1979							
1980							
1981							
1982	2495	5	3.90	41.64	45.54	0.09	-5
1983							
1984	2460	-30	6.74	38.80	45.54	0.15	30
1985							
1986							
1987							
1988	2485	-5	5.14	40.40	45.54	0.11	5
1989	2540	50	0.90	44.64	45.54	0.02	-50
1990							
1991							
1992							
1993	2433	-57	12.84	32.70	45.54	0.28	57
1994	2460	-30	6.74	38.80	45.54	0.15	30
1995	2430	-60	13.29	32.25	45.54	0.29	60
1996					no visit		
1997					cloud		
1998	2520	30	2.29	43.25	45.54	0.05	-30
1999	2505	15	2.74	42.80	45.54	0.06	-15
2000	2500	10	3.44	42.10	45.54	0.08	-10
2001	2475	-15	6.52	38.90	45.42	0.14	15
2002	2515	25	2.32	43.10	45.42	0.05	-25
2003					No visit	cloud	
2004					No visit	cloud	
2005	2465	-25	6.74	38.80	45.54	0.15	25
2006					no visit		
2007	2504	14	2.84	42.70	45.54	0.06	-14
2008	2540	50	0.90	44.64	45.54	0.02	-50
2009	2495	5	3.90	41.64	45.54	0.09	-5
2010	2503	13	3.34	42.20	45.54	0.07	**-13**
MEAN	**2490**	**-0.29**	**4.98**	**40.55**	**45.53**	**0.11**	**0**





Photograph 1: Kaikoura Range 5 March 2010, resolution reduced to 200dpi.

No. 932B/12

Mt ELLA

NZMS 260 sheet M30

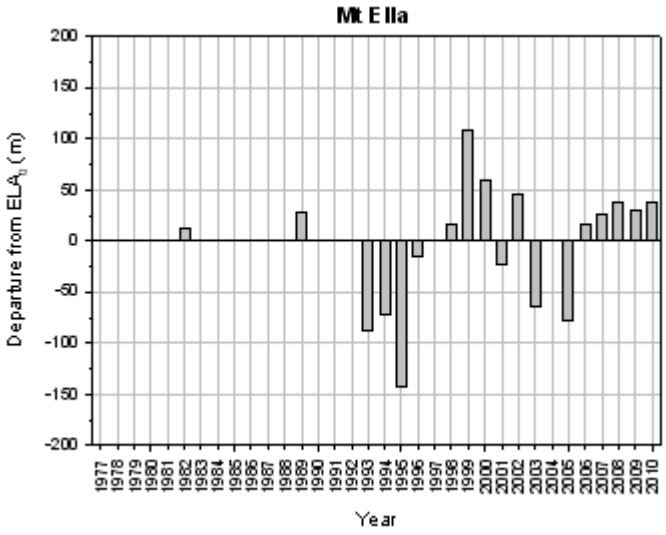
Glacierette

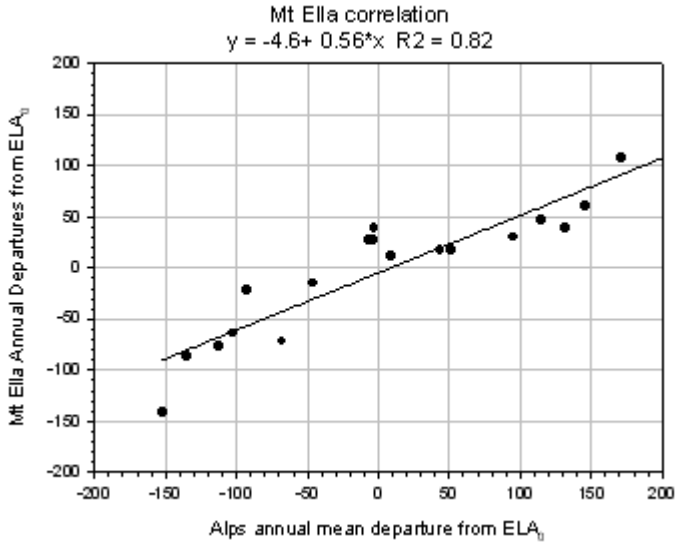
GLACIER DATA		
Aspect	E	
AREA	5.32	ha
Max Elev	2250	m
Min Elev	2080	m
Mean Elev	2165	m
Length	0.34	km
Elev Range	170	m
Gradient	0.5	

SNOWLINE DATA		
ELAo	**2142**	m
Max SL	2250	m, 2000
Min SL	2000	m, 1995
Mean SL	2139	m
SL Range	250	m
No. surveys	17	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**2142**	**0**	**3.19**	**1.45**	**5.32**	**0.60**	**0**
1977							
1978							
1979							
1980							
1981							
1982	2154	12	5.32	0.00	5.32	1.00	-12
1983							
1984							
1985							
1986							
1987							
1988							
1989	2170	28	2.17	3.15	5.32	0.41	-28
1990							
1991							
1992							
1993	2055	-87	5.91	0.00	5.91	1.11	87
1994	2070	-72	5.74	0.00	5.74	1.08	72
1995	2000	-142	15.10	0.00	15.10	2.84	142
1996	2127	-15	4.42	0.90	5.32	0.83	15
1997					In cloud		
1998	2159	17	2.92	2.40	5.32	0.55	-17
1999	2250	108	0	5.17	5.17	0.00	-108
2000	2202	60	0.1	2.46	2.56	0.04	-60
2001	2120	-22	4.57	0.75	5.32	0.86	22
2002	2188	46	0.33	1.61	1.94	0.17	-46
2003	2078	-64	5.32	0.00	5.32	1.00	64
2004					No visit	cloud	
2005	2065	-77	5.80	0.00	5.80	1.00	77
2006	2159	17	2.92	2.40	5.32	0.55	-17
2007	2169	27	2.20	3.10	5.30	0.42	-23
2008	2180	38	0.74	2.20	2.94	0.25	-23
2009	2172	30	1.14	1.80	2.94	0.39	-23
2010	2180	38	2.44	0.50	2.94	0.83	-23
MEAN	**2139**	**-3**	**3.73**	**1.47**		**0.73**	**7**





Photograph 2: Mt Ella 5 March 2010, resolution reduced to 200dpi.

No. 646/6

FAERIE QUEENE

NZMS 260 sheet M 31

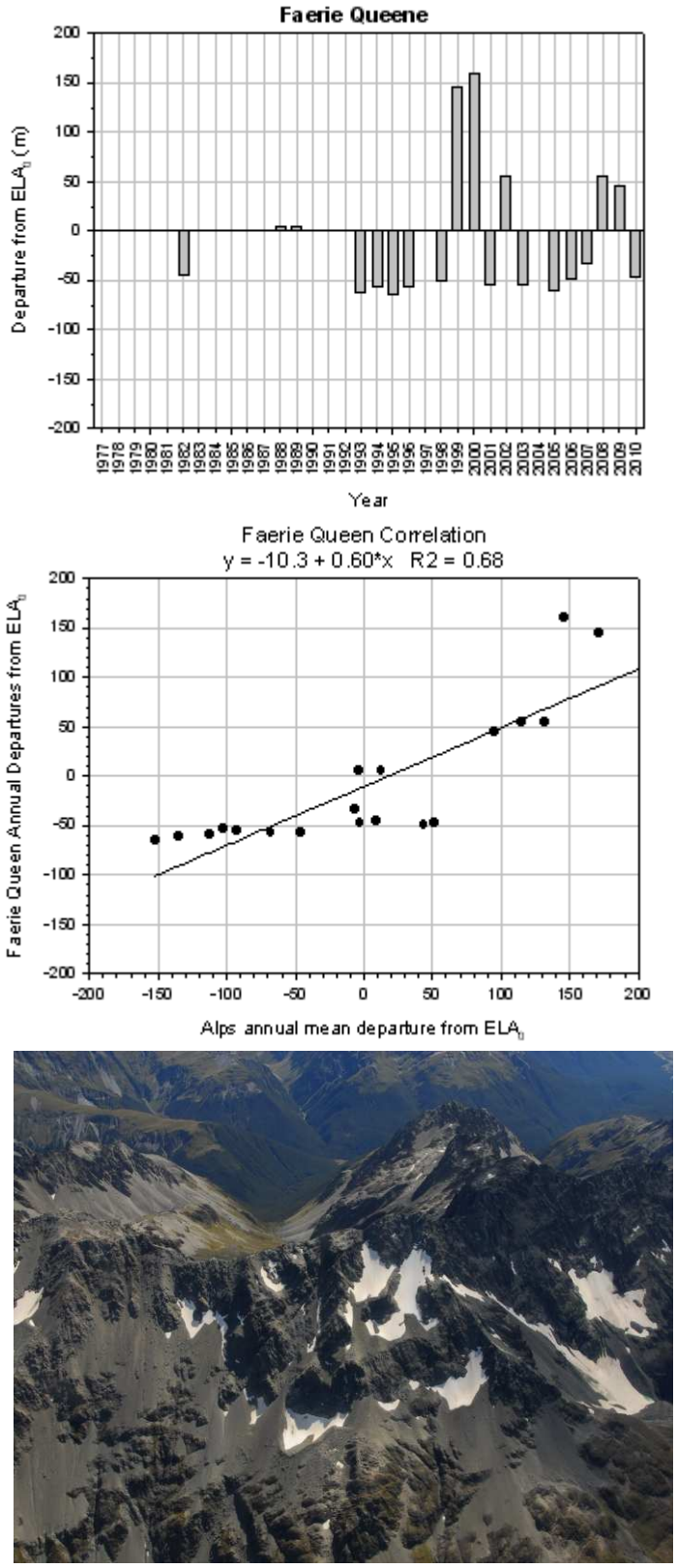
Glacierette

GLACIER DATA		
Aspect	SE	
AREA	5.74	ha
Max Elev	2200	m
Min Elev	1940	m
Mean Elev	2070	m
Length	0.36	km
Elev Range	260	m
Gradient	0.72	

SNOWLINE DATA		
ELAo	**2030**	m
Max SL	2145	m, 2000
Min SL	1920	m, 1995
Mean SL	1976	m
SL Range	225	m
No. Surveys	14	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELA	**2030**	**45**	**3.44**	**2.30**	**5.74**	**0.60**	**0**
1977							
1978							
1979							
1980							
1981							
1982	1940	-45	5.74	0.00	5.74	1.00	45
1983							
1984							
1985							
1986							
1987							
1988	1990	5	4.55	1.19	5.74	0.79	-5
1989	1990	5	4.55	1.19	5.74	0.79	-5
1990							
1991							
1992							
1993	1923	-62	6.09	0.00	6.09	1.00	62
1994	1928	-57	5.99	0.00	5.99	1.00	57
1995	1920	-65	8.04	0.00	8.04	1.00	65
1996	1928	-57	5.99	0.00	5.99	1.00	57
1997							
1998	1935	-50	5.84	0.00	5.84	1.00	50
1999	2130	145	0.00	5.74	5.74	0.00	-145
2000	2145	160	0.00	5.74	5.74	0.00	-160
2001	1930	-55	4.57	0.00	4.57	1.00	55
2002	2040	55	3.09	2.65	5.74	0.54	-55
2003	1931	-54	4.57	0.00	4.57	1.00	54
2004					no visit	cloud	
2005	1925	-60	6.09	0.00	6.09	1.00	60
2006	1937	-48	5.74	0.00	5.74	1.00	48
2007	1952	-33	5.44	0.30	5.74	0.95	33
2008	2040	55	0.60	2.80	3.40	0.18	-55
2009	2030	45	1.10	2.30	3.40	0.32	-45
2010	1938	-47	3.46	0.00	3.46	1.00	47
MEAN	**1976**	**-9**	**4.29**	**1.15**		**0.78**	**9**



Photograph 3: Faerie Queen 5 March 2010, resolution reduced to 200dpi.

Not numbered

Mt WILSON

Snow patch

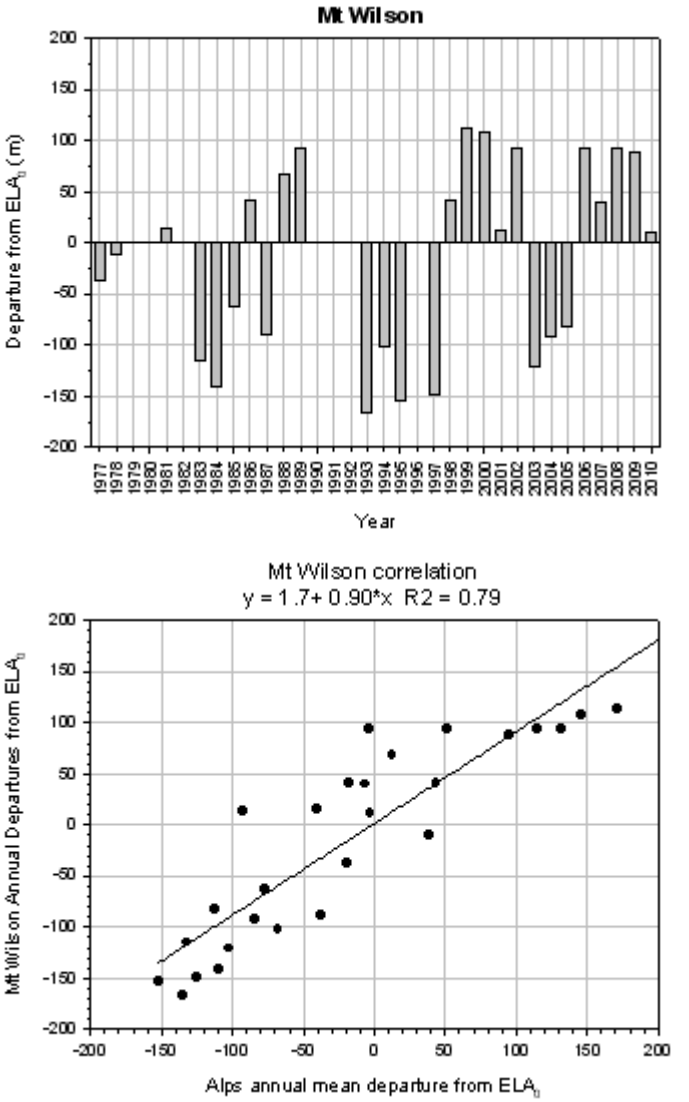
NZMS 260 sheet K33

GLACIER DATA		
Aspect	S	
AREA	17.58 to 0.68	ha
Max Elev	2030	m
Min Elev	1740	m
Mean Elev	1885	m
Length	N/A	
Elev Range	290	m
Gradient		

SNOWLINE DATA		
ELAo	**1912**	@ 7.03 ha
Max SL	2025	m, 1999
Min SL	1745	m, 1993
Mean SL	1897	m
SL Range	280	m
No. Surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	N/A	ha	(AAR)	INDEX
ELA	**1912**		**10.55**	N/A	**7.03**	N/A	
1977	1875	-37	6.28		6.28		37
1978	1901	-11	4.68		4.68		11
1979							
1980							
1981	1927	15	3.28		3.28		-15
1982							
1983	1797	-115	4.88		4.88		115
1984	1771	-141	14.78		14.78		141
1985	1849	-63	8.38		8.38		63
1986	1953	41	2.28		2.28		-41
1987	1823	-89	10.48		10.48		89
1988	1980	68	1.48		1.48		-68
1989	2005	93	0.70		0.70		-93
1990							
1991							
1992							
1993	1745	-167	17.13		17.13		167
1994	1810	-102	11.38		11.38		102
1995	1758	-154	15.98		15.98		154
1996							
1997	1763	-149	15.48		15.48		149
1998	1953	41	2.28		2.28		-41
1999	2025	113	0.13		0.13		-113
2000	2020	108	0.68		0.68		-108
2001	1925	13	3.56		3.56		-13
2002	2005	93	0.63		0.63		-93
2003	1791	-121	4.40		4.40		121
2004	1820	-92	10.55		10.55		92
2005	1830	-82	10.48		10.48		82
2006	2005	93	0.65		0.65		-93
2007	1952	40	2.25		2.25		-40
2008	2005	93	0.65		0.65		-93
2009	2000	88	0.88		0.88		-88
2010	1923	11	3.45		3.45		-11
Mean	**1897**	**-15**	**5.84**		**5.84**		**15**



Photograph 4: Mt Wilson 5 March 2010, resolution reduced to 200dpi.

No. 911A/2

Mt. FRANKLIN

NZMS 260 sheet K33

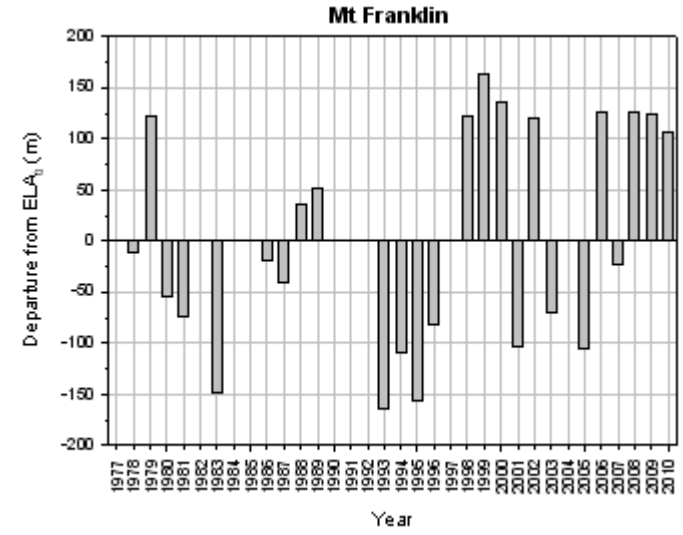
Cirque

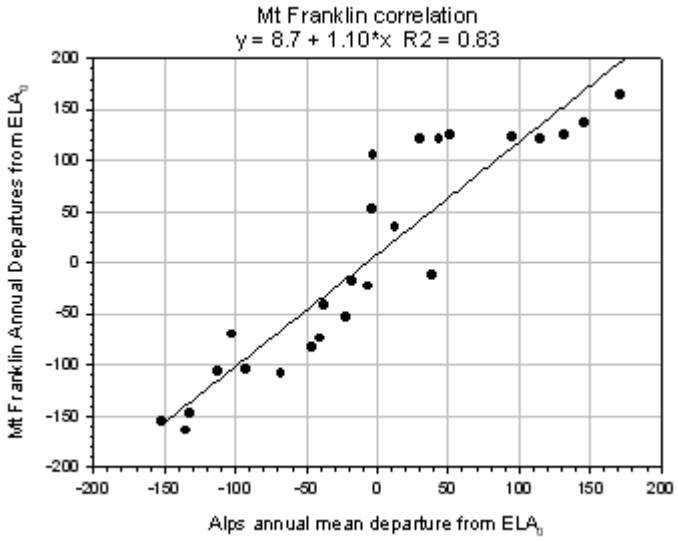
GLACIER DATA		
Aspect	E	
AREA	8.85	ha
Max Elev	2010	m
Min Elev	1680	m
Mean Elev	1845	m
Length	0.5	km
Elev Range	330	m
Gradient	0.66	

SNOWLINE DATA		
ELAo	**1814**	m
Max SL	1978	m, 1999
Min SL	1650	m, 1993
Mean SL	1817	m
SL Range	328	m
No. Surveys	24	

MEASUREMENTS

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1814**	**0**	**7.45**	**1.40**	**8.85**	**0.84**	**0**
1977							
1978	1802	-12	7.74	1.11	8.85	0.87	12
1979	1936	122	0.84	8.01	8.85	0.09	-122
1980	1773	-41	8.30	0.55	8.85	0.94	41
1981	1740	-74	8.60	0.25	8.85	0.97	74
1982							
1983	1666	-148	?	0.00			148
1984							
1985							
1986	1796	-18	8.00	0.85	8.85	0.90	18
1987	1760	-54	8.40	0.45	8.85	0.95	54
1988	1849	35	5.30	3.55	8.85	0.60	-35
1989	1866	52	4.62	4.23	8.85	0.52	-52
1990							
1991							
1992							
1993	1650	-164	13.04	0.00	13.04	1.47	164
1994	1705	-109	8.80	0.05	8.85	0.99	109
1995	1658	-156	12.00	0.00	12.00	1.38	156
1996	1732	-82	8.65	0.20	8.85	0.98	82
1997					cloud		
1998	1936	122	0.84	8.01	8.85	0.09	-122
1999	1978	164	0.26	8.59	8.20	0.03	-164
2000	1950	136	0.57	8.28	7.90	0.07	-136
2001	1710	-104	8.85	0.00	7.90	1.12	104
2002	1935	121	0.87	6.88	7.75	0.11	-121
2003	1744	-70	7.50	0.25	7.75	0.97	70
2004					cloud		
2005	1708	-106	7.75	0.00	7.75	1.00	106
2006	1940	126	0.85	6.90	7.75	0.11	-126
2007	1791	-23	7.75	0.00	7.75	1.00	23
2008	1940	126	0.85	6.90	7.75	0.11	-126
2009	1938	124	0.80	6.95	7.75	0.10	-124
2010	1920	106	6.50	1.22	7.72	0.84	-106
Mean	**1817**	**3**	**5.74**	**2.93**		**0.68**	**-3**





Photograph 5: Mt Franklin 5 March 2010, resolution reduced to 200dpi.

No. 911A /4

ROLLESTON GL.

NZMS 260 sheet K33

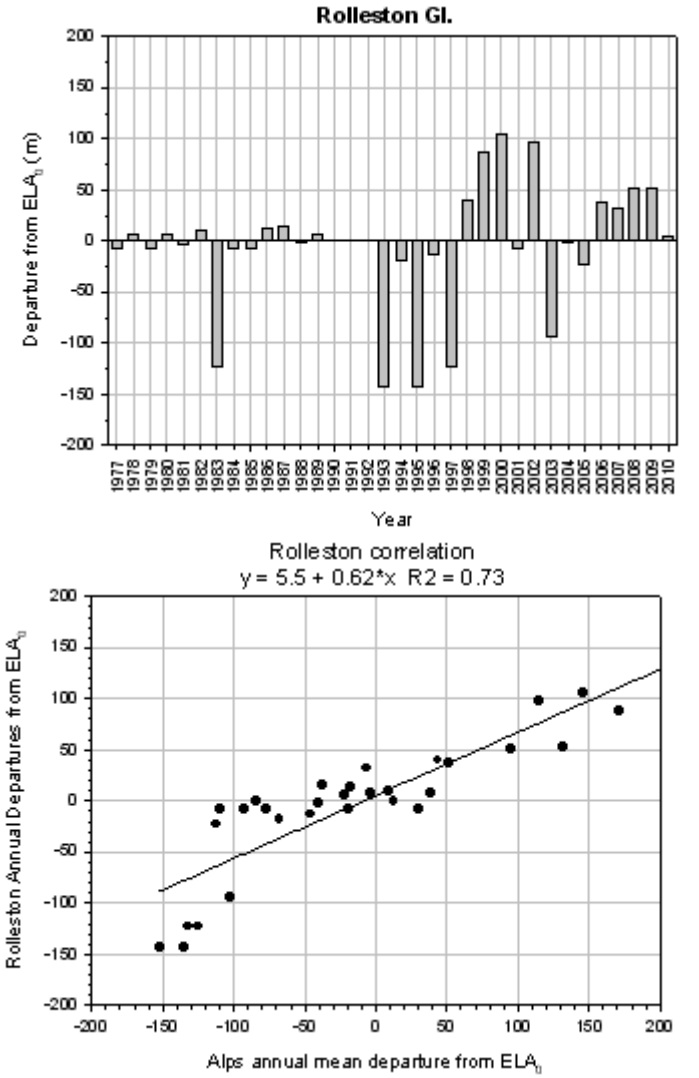
Cirque glacier

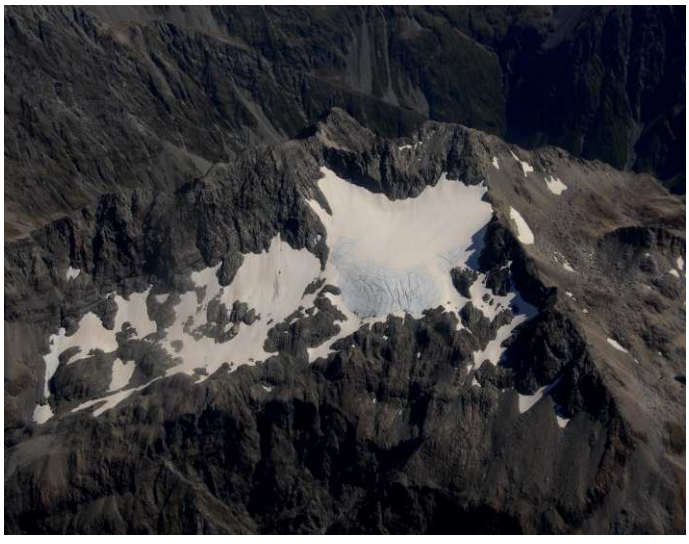
GLACIER DATA		
Aspect	SE	
AREA	10.8	ha
Max Elev	1900	m
Min Elev	1710	m
Mean Elev	1805	m
Length	0.36	km
Elev Range	190	m
Gradient	0.53	

SNOWLINE DATA		
ELAo	**1763**	m
Max SL	1868	m, 1993, 95
Min SL	1620	m, 2000
Mean SL	1758	m
SL Range	248	m
No. Surveys	30	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
1955	1800	29					
1960	1800	29					-29
ELAo	**1763**	**0**	**8.09**	**2.65**	**10.74**	**0.75**	**0**
1977	1755	-8	9.10	1.64	10.74	0.85	8
1978	1770	7	8.19	2.55	10.74	0.76	-7
1979	1755	-8	9.10	1.64	10.74		8
1980	1769	6	8.19	2.55	10.74	0.76	-6
1981	1760	-3	8.60	2.14	10.74	0.80	3
1982	1773	10	8.09	2.65	10.74	0.75	-10
1983	1640	-123	10.74	0.00	10.74	1.00	123
1984	1755	-8	9.10	1.64	10.74	0.85	8
1985	1755	-8	9.10	1.64	10.74	0.85	8
1986	1776	13	7.94	2.80	10.74	0.74	-13
1987	1778	15	7.84	2.90	10.74	0.73	-15
1988	1762	-1	8.54	2.20	10.74	0.80	1
1989	1770	7	8.19	2.55	10.74	0.76	-7
1990							
1991							
1992							
1993	1620	-143	10.74	0.00	10.74	1.00	143
1994	1745	-18	9.90	0.84	10.74	0.92	18
1995	1620	-143	10.8	0.00	10.74	1.01	143
1996	1750	-13	9.49	1.25	10.74	0.88	13
1997	1640	-123	10.74	0.00	10.74	1.00	123
1998	1803	40	4.98	5.76	10.74	0.46	-40
1999	1850	87	1.3	9.44	10.74	0.12	-87
2000	1868	105	0.41	10.33	10.74	0.04	-105
2001	1755	-8	9.10	1.64	10.74	0.85	8
2002	1860	97	0.61	10.13	10.74	0.06	-97
2003	1669	-94	10.74	0.00	10.74	1.00	94
2004	1762	-1	8.54	2.20	10.74	0.80	1
2005	1740	-23	10.14	0.60	10.74	0.94	23
2006	1800	37	6.00	4.74	10.74	0.56	-37
2007	1795	32	6.31	4.43	10.74	0.59	-32
2008	1815	52	4.32	6.42	10.74	0.40	-52
2009	1814	51	4.39	6.35	10.74	0.41	-51
2010	1768	5	8.24	2.50	10.74	0.77	-5
MEAN	**1758**	**-5**	**7.72**	**3.02**		**0.71**	**5**





Photograph 6: Rolleston Glacier 5 March 2010, resolution reduced to 200dpi.

No. 664C/21 **Mt CARRINGTON** NZMS sheet K33

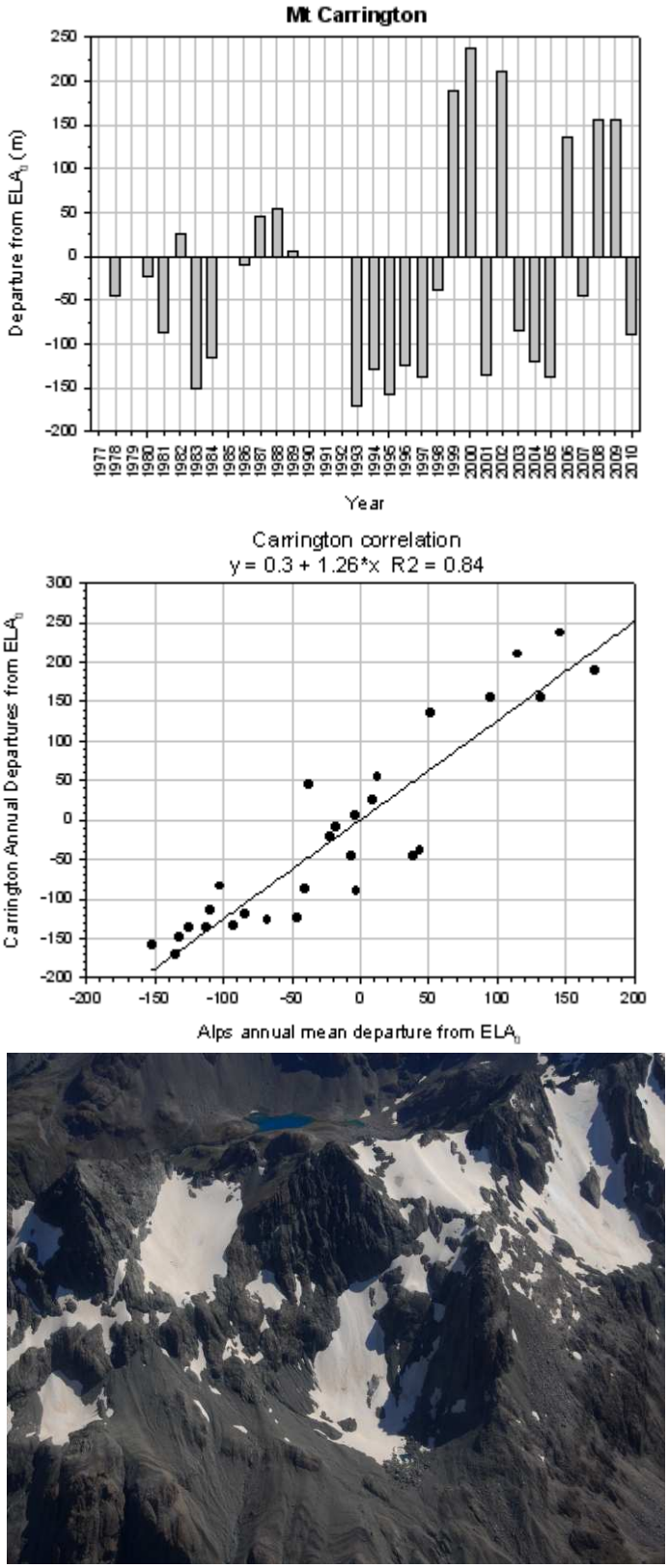
Cirque glacier

GLACIER DATA		
Aspect	S	
AREA	15.5	ha
Max Elev	1960	m
Min Elev	1595	m
Mean Elev	1778	m
Length	0.71	km
Elev Range	365	m
Gradient	0.51	

SL DATA		
ELAo	**1715**	m
Max SL	1952	m, 2000
Min SL	1545	m, 1993
Mean SL	1694	m
SL Range	407	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM.	AREAS ABL.	TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1715**	**0**	**7.00**	**8.5**	**15.5**	**0.45**	**0**
1977							
1978	1670	-45	8.86	6.64	15.50	0.57	45
1979							
1980	1693	-22	7.70	7.80	15.50	0.50	22
1981	1628	-87	11.60	3.90	15.50	0.75	87
1982	1740	25	6.50	9.00	15.50	0.42	-25
1983	1565	-150	18.50	0.00	15.50	1.19	150
1984	1600	-115	14.50	1.00	15.50	0.94	115
1985							
1986	1705	-10	7.20	8.30	15.50	0.46	10
1987	1760	45	6.00	9.50	15.50	0.39	-45
1988	1770	55	5.80	9.70	15.50	0.37	-55
1989	1720	5	6.90	8.60	15.50	0.45	-5
1990							
1991							
1992							
1993	1545	-170	20.55	0.00	15.50	1.33	170
1994	1587	-128	15.70	0.00	15.50	1.01	128
1995	1557	-158	16.60	0.00	15.50	1.07	158
1996	1590	-125	14.90	0.60	15.50	0.96	125
1997	1578	-137	17.43	0.00	15.50	1.12	137
1998	1676	-39	8.69	6.81	15.50	0.56	39
1999	1905	190	2.94	12.56	15.50	0.19	-190
2000	1952	237	0.48	15.02	15.50	0.03	-237
2001	1580	-135	17.30	0.00	15.50	1.12	135
2002	1925	210	1.30	6.70	8.00	0.16	-210
2003	1631	-84	6.60	1.40	8.00	0.83	84
2004	1595	-120	8.00	0.00	8.00	1.00	120
2005	1578	-137	17.43	0.00	15.50	1.12	137
2006	1850	135	4.20	11.30	15.50	0.27	-135
2007	1670	-45	8.86	6.64	15.50	0.57	45
2008	1870	155	3.70	11.80	15.50	0.24	-155
2009	1870	155	3.70	11.80	15.50	0.24	-155
2010	1625	-90	12.20	3.30	15.50	0.79	90
MEAN	**1694**	**-21**	**9.79**	**5.44**		**0.67**	**21**



Photograph 7: Carrington 5 March 2010, resolution reduced to 200dpi.

No. 685F/4

Mt AVOCA

Glacierette

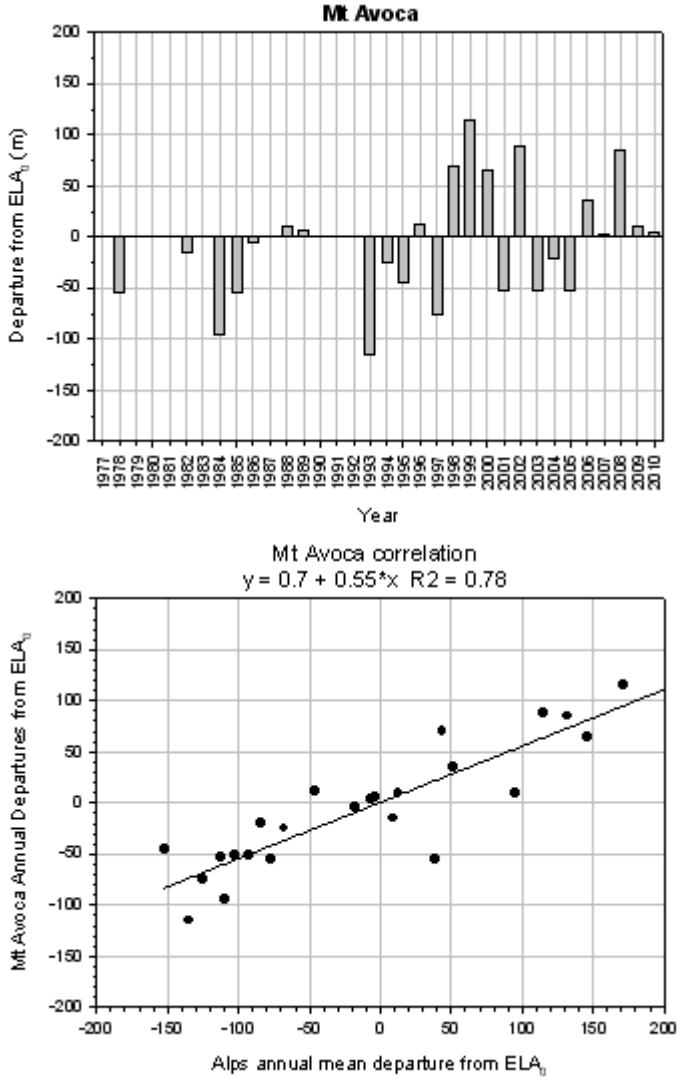
NZMS sheet K34

GLACIER DATA		
Aspect	E	
AREA	9.803	m
Max Elev	2080	m
Min Elev	1890	m
Mean Elev	1985	m
Length	0.36	km
Elev Range	190	m
Gradient	0.53	

SNOWLINE DATA		
ELAo	**1965**	m
Max SL	2080	m, 1999
Min SL	1850	m, 1993
Mean SL	1959	m
SL Range	230	m
No. Surveys	25	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELA	**1965**	**0**	**4.40**	**5.40**	**9.80**	**0.45**	**0**
1977							
1978	1910	-55	9.20	0.60	9.80	0.94	55
1979							
1980							
1981							
1982	1950	-15	5.88	3.92	9.80	0.60	15
1983							
1984	1870	-95	10.50	0.00	9.80	1.00	95
1985	1910	-55	9.20	0.60	9.80	0.94	55
1986	1960	-5	4.85	4.95	9.80	0.49	5
1987							
1988	1975	10					-10
1989	1971	6	3.97	5.83	9.80	0.40	-6
1990							
1991							
1992							
1993	1850	-115	11.38	0.00	11.38	1.16	115
1994	1940	-25	7.20	2.60	9.80	0.73	25
1995	1920	-45	8.80	1.00	9.80	0.90	45
1996	1977	12	3.57	6.23	9.80	0.36	-12
1997	1890	-75	9.80	0.00	9.80	1.00	75
1998	2035	70	0.98	5.33	6.31	0.16	-70
1999	2080	115	0.00	3.22	3.22	0.00	-115
2000	2030	65	1.11	2.47	3.58	0.31	-65
2001	1913	-52	0.00	7.13	7.13	0.00	52
2002	2053	88	0.44	3.14	3.58	0.12	-88
2003	1913	-52	0.00	7.13	7.13	0.00	52
2004	1945	-20	6.50	3.30	9.80	0.66	20
2005	1912	-53	0.00	7.13	7.13	0.00	53
2006	2000	35	1.78	1.80	3.58	0.50	-35.00
2007	1968	3	2.38	1.20	3.58	0.66	-3.00
2008	2050	85	0.45	3.13	3.58	0.13	-85.00
2009	1975	10	2.28	1.30	3.58	0.64	-10.00
2010	1970	5	2.31	1.27	3.58	0.65	-5.00
MEAN	**1959**	**-6**	**4.27**	**3.05**		**0.51**	**6**



Photograph 8: Mt Avoca 5 March 2010, resolution reduced to 200dpi.

No. 664C/12

MARMADUKE DIXON GL

NZMS 260 sheet K33

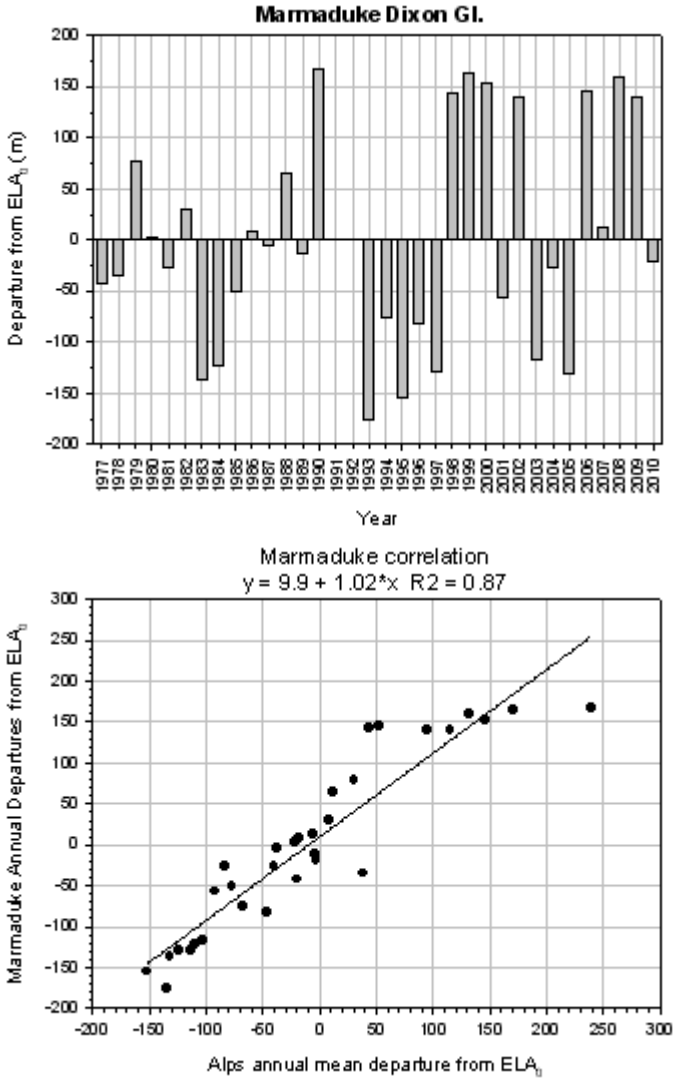
Mountain glacier

GLACIER DATA		
Aspect	E	
AREA	93	m
Max Elev	2100	m
Min Elev	1615	m
Mean Elev	1858	m
Length	1.7	km
Elev Range	485	m
Gradient	0.285	

SNOWLINE DATA		
ELAo	**1830**	m
Max SL	1998	m, 1990
Min SL	1655	m, 1993
Mean SL	1830	m
SL Range	343	m
No. Surveys	32	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM.	AREAS ABL.	TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1830**	**0**	**64**	**29**	**93**	**0.69**	**0**
1977	1788	-43	73.02	19.50	92.52	0.79	43
1978	1795	-35	71.52	21.00	92.52	0.77	35
1979	1908	78	44.50	48.02	92.52	0.48	-78
1980	1832	2	63.52	29.00	92.52	0.69	-2
1981	1803	-28	69.72	22.80	92.52	0.75	28
1982	1860	30	49.65	42.87	92.52	0.54	-30
1983	1694	-136	86.72	5.80	92.52	0.94	136
1984	1708	-122	85.52	7.00	92.52	0.92	122
1985	1780	-50	73.97	18.55	92.52	0.80	50
1986	1839	9	61.72	30.80	92.52	0.67	-9
1987	1825	-5	64.77	27.75	92.52	0.70	5
1988	1895	65	48.02	44.50	92.52	0.52	-65
1989	1818	-13	67.02	25.50	92.52	0.72	13
1990	1998	168	22.52	70.00	92.52	0.24	-168
1991							
1992							
1993	1655	-175	90.34	2.18	92.52	0.98	175
1994	1755	-75	78.48	14.04	92.52	0.85	75
1995	1675	-155	92.14	0.38	92.52	1.00	155
1996	1748	-82	82.22	10.30	92.52	0.89	82
1997	1701	-129	91.87	0.65	92.52	0.99	129
1998	1973	143	26.81	65.71	92.52	0.29	-143
1999	1994	164	21.50	71.02	92.52	0.23	-164
2000	1983	153	23.75	68.77	92.52	0.26	-153
2001	1773	-57	75.32	17.20	92.52	0.81	57
2002	1970	140	28.38	53.42	81.80	0.35	-140
2003	1713	-117	74.50	7.30	81.80	0.91	117
2004	1803	-27	66.48	19.37	85.85	0.77	27
2005	1700	-130	91.87	0.65	92.52	0.99	130
2006	1975	145	27.80	54.00	81.80	0.34	-145
2007	1843	13	54.00	27.80	81.80	0.66	-13
2008	1990	160	26.80	55.00	81.80	0.33	-160
2009	1970	140	28.38	53.42	81.80	0.35	-140
2010	1810	-20	61.00	20.80	81.80	0.75	20
MEAN	**1830**	**0**	**60.09**	**30.14**		**0.66**	**0**



Photograph 9: Marmaduke Dixon 5 March 2010, resolution reduced to 200dpi.

No. 906A/4

RETREAT GL.

NZMS 260 sheet K33

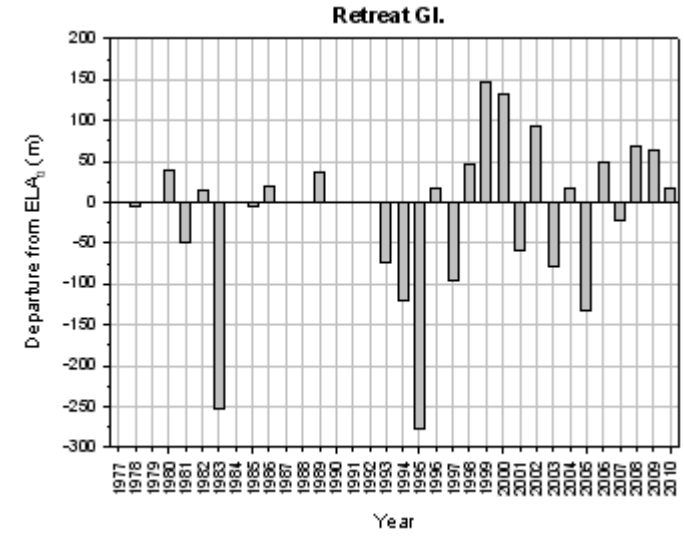
Moutain glacier

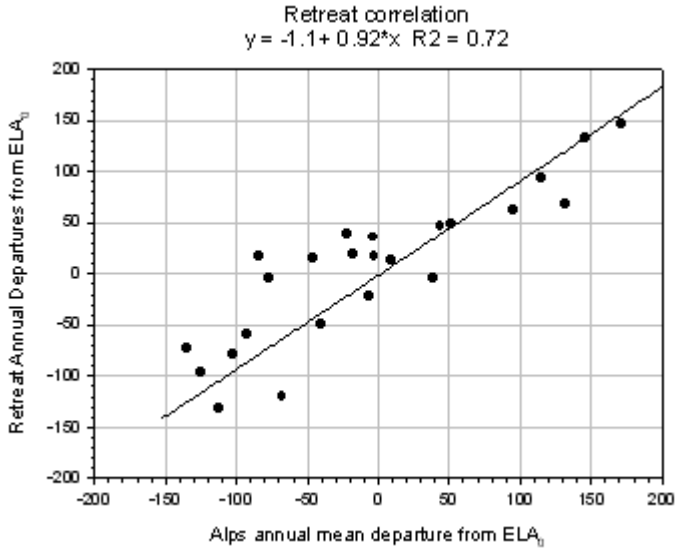
GLACIER DATA		
Aspect	SW	
AREA	28.7	ha
Max Elev	1930	m
Min Elev	1570	m
Mean Elev	1750	m
Length	1.05	km
Elev Range	360	m
Gradient	0.343	

SNOWLINE DATA		
ELAo	**1742**	m
Max SL	1888	m, 1999
Min SL	1465	m, 1995
Mean SL	1726	m
SL Range	423	m
No. Surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1742**	**0**	**13.90**	**14.80**	**28.70**	**0.48**	**0**
1977							
1978	1738	-4	14.70	14.00	28.70	0.51	4
1979							
1980	1780	38	8.29	20.41	28.70	0.29	-38
1981	1692	-50	20.30	8.40	28.70	0.71	50
1982	1756	14	13.30	15.40	28.70	0.46	-14
1983	1490	-252	31.59	-2.89	28.70	1.10	252
1984							
1985	1738	-4	14.83	13.87	28.70	0.52	4
1986	1762	20	10.78	17.92	28.70	0.38	-20
1987							
1988							
1989	1778	36	8.87	19.83	28.70	0.31	-36
1990							
1991							
1992							
1993	1669	-73	22.82	5.88	28.70	0.80	73
1994	1622	-120	27.20	1.50	28.70	0.95	120
1995	1465	-277	32.41	-3.71	28.70	1.13	277
1996	1758	16	11.65	17.05	28.70	0.41	-16
1997	1645	-97	25.20	3.50	28.70	0.88	97
1998	1789	47	7.28	21.42	28.70	0.25	-47
1999	1888	146	1.91	26.79	12.31	0.16	-146
2000	1875	133	2.39	11.40	13.79	0.17	-133
2001	1682	-60	21.43	7.27	28.70	0.75	60
2002	1835	93	2.88	9.43	12.31	0.23	-93
2003	1664	-78	11.51	0.80	12.31	0.94	78
2004	1760	18	6.51	5.80	12.31	0.53	-18
2005	1610	-132	10.81	1.50	12.31	0.88	132
2006	1790	48	4.71	7.60	12.31	0.38	-48
2007	1720	-22	9.41	2.90	12.31	0.76	22
2008	1810	68	3.71	8.60	12.31	0.30	-68
2009	1805	63	3.91	8.40	12.31	0.32	-63
2010	1760	18	6.51	5.80	12.31	0.53	-18
MEAN	**1726**	**-16**	**12.88**	**9.57**		**0.56**	**16**





Photograph 10: Retreat Glacier on 5 March 2010, resolution reduced to 200dpi.

906A/1

BROWNING RA.

NZMS 260 sheet J33

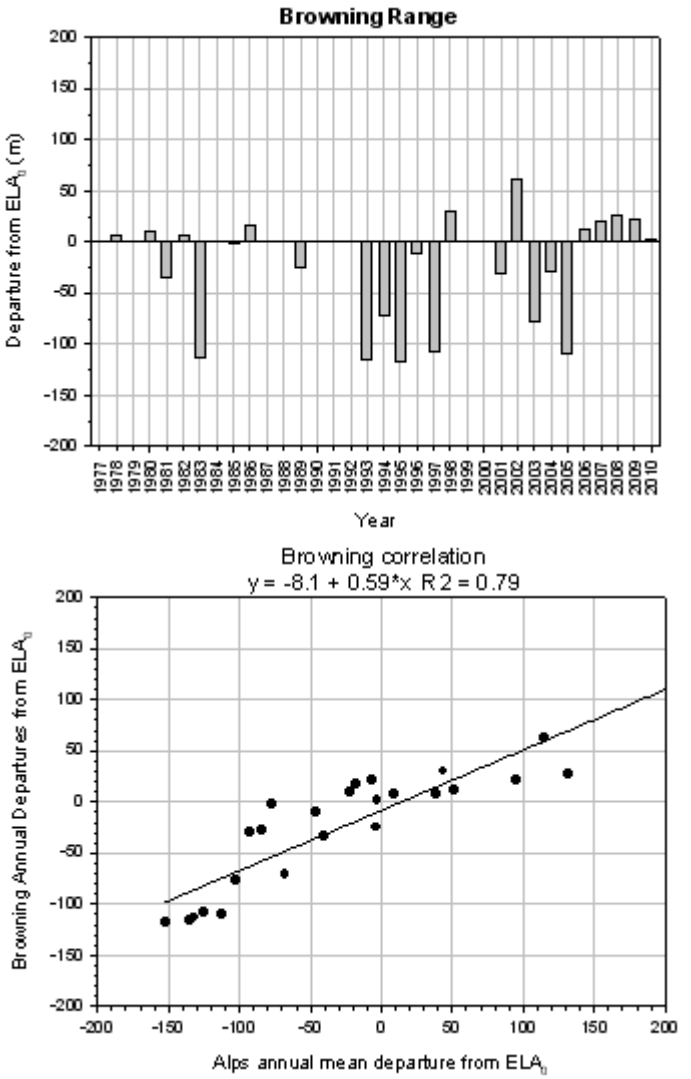
Small cirque

GLACIER DATA		
Aspect	S	
AREA	4.08	ha
Max Elev	1700	m
Min Elev	1530	m
Mean Elev	1615	m
Length		km
Elev Range	170	m
Gradient		

SNOWLINE DATA		
ELAo	**1598**	m
Max SL	1660	m, 2000
Min SL	1480	m, 1995
Mean SL	1573	m
SL Range	180	m
No. Surveys	26	

MEASUREMENTS Digitised values in bold type

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1598**	**0**	**1.01**	**3.07**	**4.08**	**0.25**	**0**
1977							
1978	1605	7	0.78	3.3	4.08	0.19	-7
1979							
1980	1608	10	0.74	3.34	4.08	0.18	-10
1981	1564	-34	2.45	1.63	4.08	0.60	34
1982	1605	7	0.78	3.3	4.08	0.19	-7
1983	1485	-113	7.48	0	7.48	1.00	113
1984							
1985	1596	-2	1.01	3.07	4.08	0.25	2
1986	1615	17	0.68	3.4	4.08	0.17	-17
1987							
1988							
1989	1612	14	2.01	2.07	4.08	0.49	-14
1990							
1991							
1992							
1993	1482	-116	2.03	2.05	4.08	0.50	116
1994	1527	-71	4.33	0	4.33	1.06	71
1995	1480	-118	20.38	0	20.38	5.00	118
1996	1570	-28	1.38	2.7	4.08	0.34	28
1997	1490	-108	12.81	0	12.81	1.00	108
1998	1628	30	0.55	3.53	4.08	0.13	-30
1999	>>1790		0	above gl	2.27	0.00	
2000	>>1790		0	above gl	1.38	0.00	
2001	1568	-30	2.18	1.9	3.58	0.61	30
2002	1660	62	0	1.14	1.14	0.00	-62
2003	1521	-77	4.08	0	4.08	1.00	77
2004	1570	-28	3.58	0	3.58	1.00	28
2005	1488	-110	12.81	0	12.81	1.00	110
2006	1610	12	0.33	3.25	3.58	0.09	-12.00
2007	1619	21	0.08	3.5	3.58	0.02	-21.00
2008	1625	27	0.05	3.53	3.58	0.01	-27.00
2009	1620	22	0.05	3.5	3.58	0.01	-22.00
2010	1600	2	0.38	3.2	3.58	0.11	-2.00
MEAN	**1573**	**-25**	**3.11**	**2.02**		**0.58**	**25**



Photograph 11: Browning Range 5 March 2010, resolution reduced to 200dpi.

No. 685B/1

DOUGLAS GL

NZMS 260 sheet J35

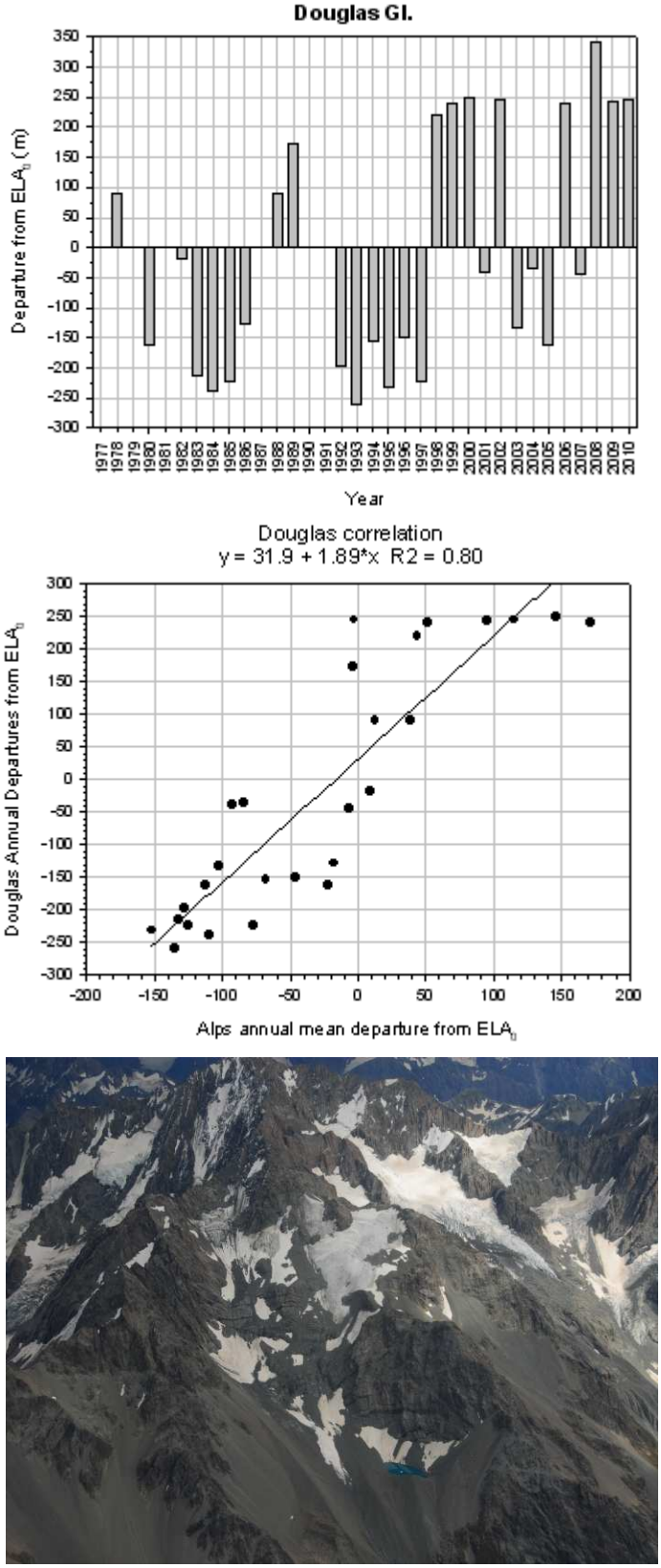
Small mountain glacier

GLACIER DATA		
Aspect	SE	
AREA	33.93	ha
Max Elev	2440	m
Min Elev	1820	m
Mean Elev	2130	m
Length	1.18	km
Elev Range	620	m
Gradient	0.508	

SNOWLINE DATA		
ELAo	2040	m
Max SL	2380	m, 2000
Min SL	1780	m,1993
Mean SL	2031	m
SL Range	600	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
1974	2450				14.04		
ELAo	**2040**	**0**	**24.73**	**9.20**	**33.93**	**0.73**	**0**
1977							
1978	2131	91	19.93	14.00	33.93	0.59	-91
1979							
1980	1877	-163	32.03	1.90	33.93	0.94	163
1981							
1982	2022	-18	25.80	8.13	33.93	0.76	18
1983	1826	-214	33.73	0.20	33.93	0.99	214
1984	1800	-240	35.73	-1.80	33.93	1.05	240
1985	1817	-223	34.23	-0.30	33.93	1.01	223
1986	1912	-128	30.13	3.80	33.93	0.89	128
1987							
1988	2131	91	19.93	14.00	33.93	0.59	-91
1989	2212	172	15.74	18.19	33.93	0.46	-172
1990							
1991							
1992	1843	-197	33.13	0.80	33.93	0.98	197
1993	1780	-260	42.42	-8.49	33.93	1.25	260
1994	1886	-154	31.23	2.70	33.93	0.92	154
1995	1809	-231	35.43	-1.50	33.93	1.04	231
1996	1890	-150	31.43	2.50	33.93	0.93	150
1997	1817	-223	34.23	-0.30	33.93	1.01	223
1998	2260	220	10.71	23.22	33.93	0.32	-220
1999	2280	240	8.91	25.02	33.93	0.26	-240
2000	2290	250	7.96	25.97	33.93	0.23	-250
2001	2000	-40	22.21	6.60	28.81	0.77	40
2002	2285	245	3.31	25.50	28.81	0.11	-245
2003	1906	-134	25.61	3.20	28.81	0.89	134
2004	2005	-35	22.20	7.20	28.81	0.77	35
2005	1877	-163	28.80	0.00	28.80	1.00	163
2006	2280	240	8.91	19.90	28.81	0.31	-240
2007	1996	-44	22.41	6.40	28.81	0.78	44
2008	2380	340	21.20	0.90	22.10	0.96	-340
2009	2283	243	3.30	18.80	22.10	0.15	-243
2010	2285	245	3.97	25.55	22.06	0.18	-245
Mean	**2031**	**-9**	**23.02**	**8.65**		**0.72**	**9**



Photograph 12: Douglas Glacier 5 March 2010, resolution reduced to 200dpi.

No. 685C/60

Mt BUTLER

NZMZ 260 sheet J34

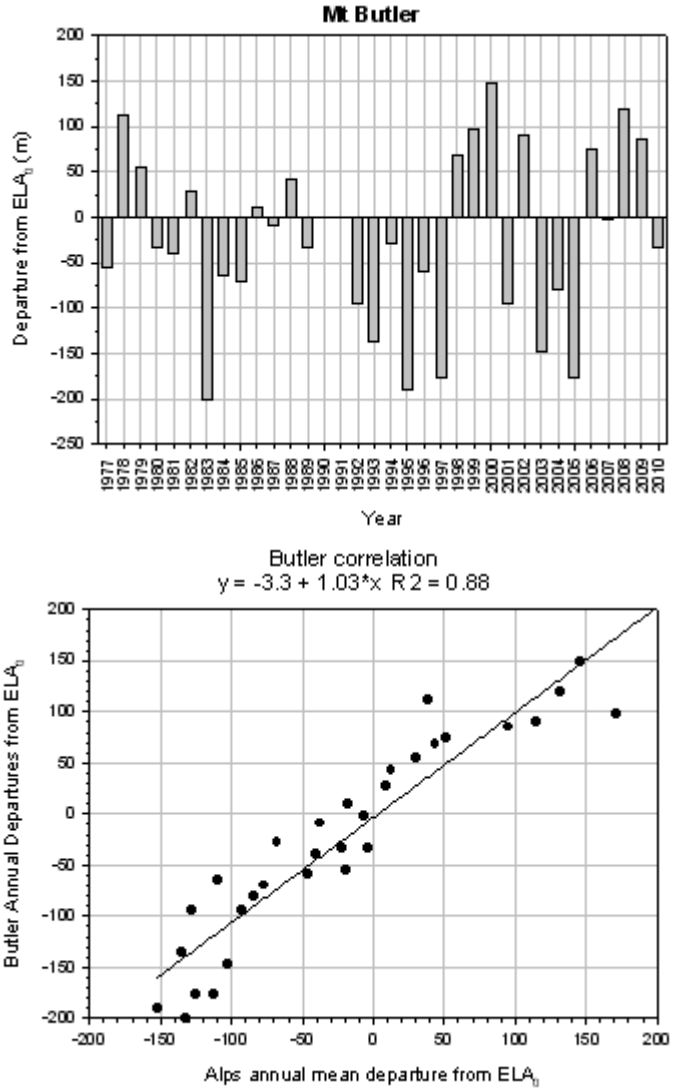
Shelf glacier

GLACIER DATA		
Aspect	E	
AREA	75	ha
Max Elev	2040	m
Min Elev	1680	m
Mean Elev	1860	m
Length	1	km
Elev Range	360	m
Gradient	0	

SL DATA		
ELAo	1840	m
Max SL	1988	
Min SL	1640	m, 1995
Mean SL	1815	m
SL Range	348	m
No. surveys	32	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1840**	**0**	**42.76**	**31.80**	**74.56**	**0.57**	**0**
1977	1785	-55	60.69	13.87	74.56	0.81	55
1978	1952	112	6.39	68.17	74.56	0.09	-112
1979	1895	55	21.46	53.10	74.56	0.29	-55
1980	1806	-34	55.76	18.80	74.56	0.75	34
1981	1800	-40	57.44	17.12	74.56	0.77	40
1982	1868	28	32.10	42.46	74.56	0.43	-28
1983	1640	-200	89.56	0.00	89.56	1.00	200
1984	1775	-65	62.66	11.90	74.56	0.84	65
1985	1770	-70	63.61	10.95	74.56	0.85	70
1986	1850	10	39.36	35.20	74.56	0.53	-10
1987	1831	-9	46.76	27.80	74.56	0.63	9
1988	1882	42	26.56	48.00	74.56	0.36	-42
1989	1806	-34	55.76	18.80	74.56	0.75	34
1990							
1991							
1992	1745	-95	67.36	7.20	74.56	0.90	95
1993	1704	-136	72.06	2.50	74.56	0.97	136
1994	1812	-28	53.56	21.00	74.56	0.72	28
1995	1650	-190	94.10	0.00	74.56	1.26	190
1996	1780	-60	62.06	12.50	74.56	0.83	60
1997	1664	-176	76.56	0.00	76.56	1.00	176
1998	1908	68	16.05	58.51	74.56	0.22	-68
1999	1938	98	8.04	66.52	74.56	0.11	-98
2000	1988	148	3.58	70.98	74.56	0.05	-148
2001	1745	-95	67.30	7.26	74.56	0.90	95
2002	1930	90	8.72	65.84	74.56	0.12	-90
2003	1693	-147	73.36	1.20	74.56	0.98	147
2004	1760	-80	66.43	8.13	74.56	0.89	80
2005	1664	-176	76.56	0.00	76.56	1.00	176
2006	1915	75	14.56	62.00	76.56	0.19	-75
2007	1838	-2	43.96	30.60	74.56	0.59	2
2008	1960	120	6.56	68.00	74.56	0.09	-120
2009	1925	85	9.56	65.00	74.56	0.13	-85
2010	1807	-33	55.66	18.90	74.56	0.75	33
Mean	**1815**	**-25**	**46.69**	**29.13**	**75.22**	**0.62**	**25**



Photograph 13: Mt Butler 5 March 2010, resolution reduced to 200dpi.

No. 897-19

DAINTY GL.

NZMS sheet J34

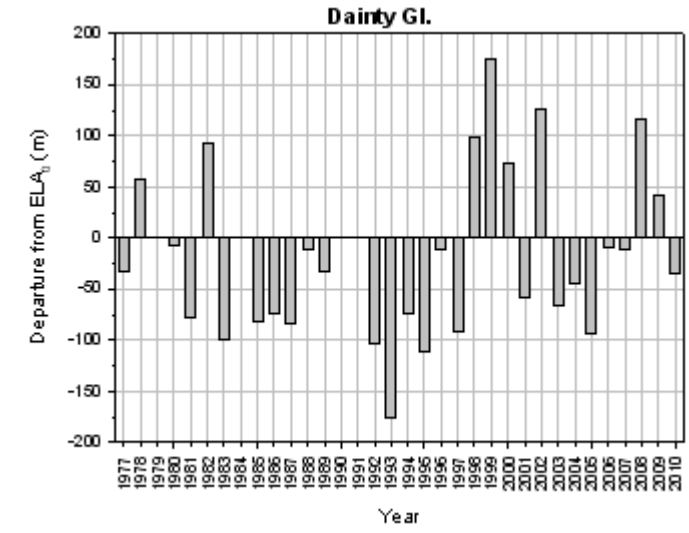
Mountain gl, reliability A

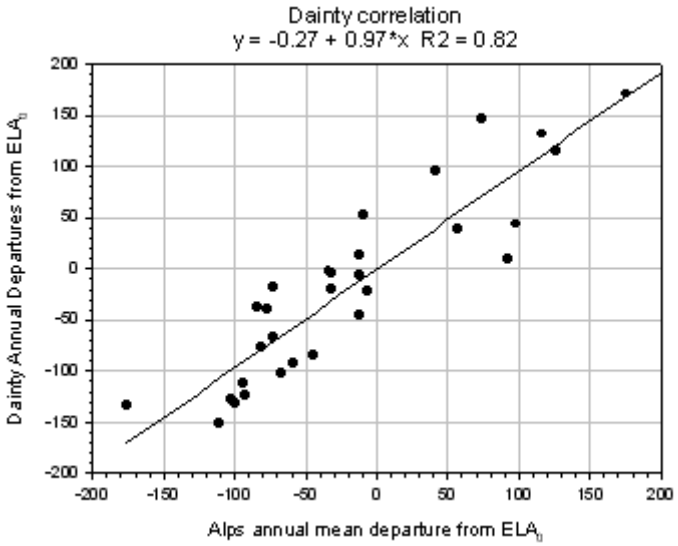
GL DATA		
Aspect	W	
AREA	45.29	ha
Max Elev	2330	m
Min Elev	1750	m
Mean Elev	2040	m
Length	1.45	km
Elev Range	580	m
Gradient	0.4	

SL DATA		
ELA	1954	m
Max SL	2130	m, 1999
Min SL	1778	m, 1993
Mean SL	1933	m
SL Range	352	m
No. Surveys	30	

MEASUREMENTS Digitised values in bold type

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELA m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATI (AAR)	MASS BALANCE INDEX
1955	2100						
ELAo	**1954**	**0**	**18.29**	**27**	**45.29**	**0.40**	**0**
1977	1922	-32	25.81	19.48	45.29	0.57	32
1978	1990	36	14.79	30.5	45.29	0.33	-57
1979							
1980	1947	-7	20.19	25.1	45.29	0.45	7
1981	1877	-77	37.59	7.7	45.29	0.83	77
1982	2047	93	10.49	34.8	45.29	0.23	-93
1983	1855	-99	40.89	4.4	45.29	0.90	99
1984							
1985	1873	-81	38.29	7	45.29	0.85	81
1986	1881	-73	36.92	8.37	45.29	0.82	73
1987	1870	-84	39.09	6.2	45.29	0.86	84
1988	1942	-12	20.96	24.33	45.29	0.46	12
1989	1922	-32	25.81	19.48	45.29	0.57	32
1990							
1991							
1992	1851	-103	41.39	3.9	45.29	0.91	103
1993	1778	-176	43.71	1.58	45.29	0.97	176
1994	1881	-73	36.92	8.37	45.29	0.82	73
1995	1843	-111	41.94	3.35	45.29	0.93	111
1996	1942	-12	20.96	24.33	45.29	0.46	12
1997	1862	-92	40.29	5	45.29	0.89	92
1998	2052	98	10.23	35.06	45.29	0.23	-98
1999	2130	176	4.15	41.14	45.29	0.09	-176
2000	2028	74	11.79	33.5	45.29	0.26	-74
2001	1896	-58	32.95	12.34	45.29	0.73	58
2002	2080	126	8.25	37.04	45.29	0.18	-126
2003	1887	-67	36.09	9.2	45.29	0.80	67
2004	1910	-44	29.05	16.24	45.29	0.64	44
2005	1860	-94	40.89	4.4	45.29	0.90	94
2006	1945	-9	20.2	25.09	45.29	0.45	9
2007	1942	-12	20.96	24.33	45.29	0.46	12
2008	2070	116	8.99	36.3	45.29	0.20	-116
2009	1995	41	13.55	31.74	45.29	0.30	-41
2010	1920	-34	26.29	19	45.29	0.58	34
MEAN	**1933**	**-21**	**26.65**	**18.64**	**45.29**	**0.59**	**20**





Photograph 14: Dainty Glacier 6 March 2010, resolution reduced to 200dpi..

No. 897/7

KEA GL

Cirque

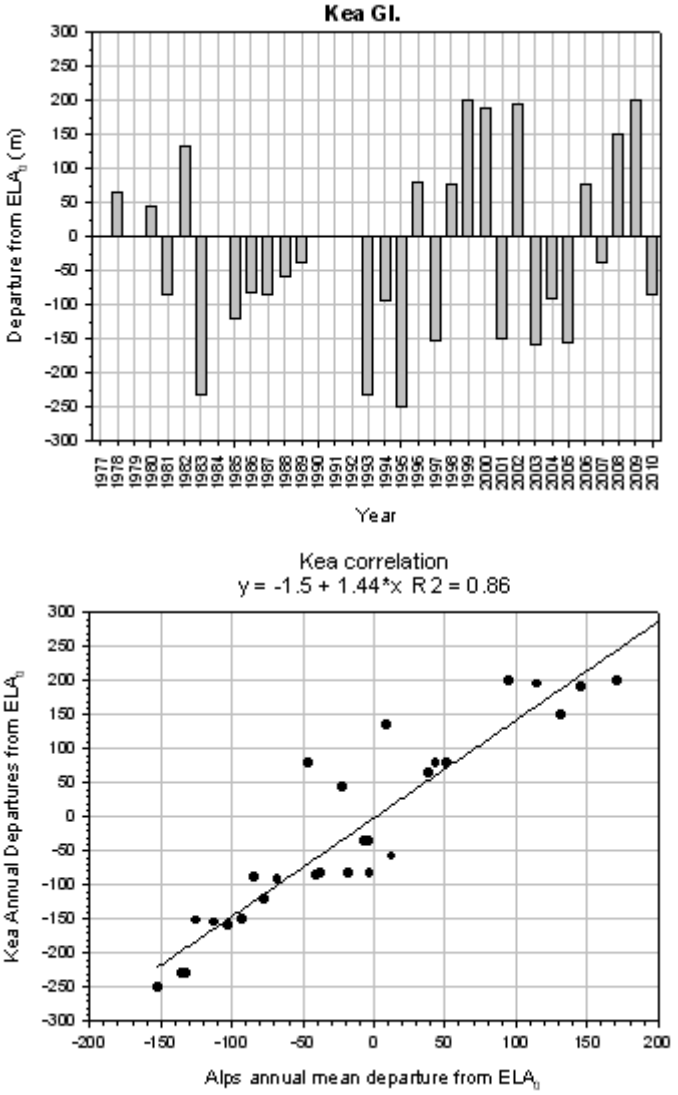
NZMS 260 sheet J34

GL DATA		
Aspect	S	
AREA	76.94	ha
Max Elev	2030	m
Min Elev	1650	m
Mean Elev	1840	m
Length	0.95	km
Elev Range	380	m
Gradient	0.453	

SL DATA		
ELAo	1820	m
Max SL	2020	m, 1999
Min SL	1570	m, 1995
Mean SL	1796	m
SL RANGE	450	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATI (AAR)	MASS BALANCE INDEX
ELAo	**1820**	**0**	**43.62**	**23.5**	**67.12**	**0.65**	**0**
1977							
1978	1885	65	34.25	42.69	76.94	0.45	-65
1979					no flight		
1980	1864	44	39.34	37.6	76.94	0.51	-44
1981	1735	-85	66.64	10.3	76.94	0.87	85
1982	1954	134	16.53	60.41	76.94	0.21	-134
1983	1590	-230	96.44	19.5	115.94	0.83	230
1984							
1985	1700	-120	73.1	3.84	76.94	0.95	120
1986	1738	-82	66.54	10.4	76.94	0.86	82
1987	1737	-83	66.59	10.35	76.94	0.87	83
1988	1762	-58	60.94	16	76.94	0.79	58
1989	1784	-36	56.43	20.51	76.94	0.73	36
1990							
1991							
1992							
1993	1590	-230	94.83	17.89	112.72	0.84	230
1994	1728	-92	68.13	8.81	76.94	0.89	92
1995	1570	-250	100.75	23.81	124.56	0.81	250
1996	1900	80	31.26	45.68	76.94	0.41	-80
1997	1668	-152	80.79	3.85	84.63	0.95	152
1998	1898	78	31.74	45.2	76.94	0.41	-78
1999	2020	200	1.47	75.47	76.94	0.02	-200
2000	2010	190	2.3	74.64	76.94	0.03	-190
2001	1670	-150	76.94	0	76.94	1.00	150
2002	2015	195	0.92	66.2	67.12	0.01	-195
2003	1661	-159	67.12	0	67.12	1.00	159
2004	1730	-90	58.32	8.8	67.12	0.87	90
2005	1665	-155	67.12	0	67.12	1.00	155
2006	1898	78	31.74	35.38	67.12	0.47	-78
2007	1784	-36	46.62	20.5	67.12	0.69	36
2008	1970	150	5.62	61.5	67.12	0.08	-150
2009	2020	200	1.47	65.65	67.12	0.02	-200
2010	1737	-83	59.12	8	67.12	0.88	83
MEAN	**1796**	**-24**	**51.63**	**27.67**		**0.64**	**24**



Photograph 15: Kea Glacier 6 March 2010, resolution reduced to 200dpi.

No. 897/1 to 5

JASPUR GL.

Glacierette group

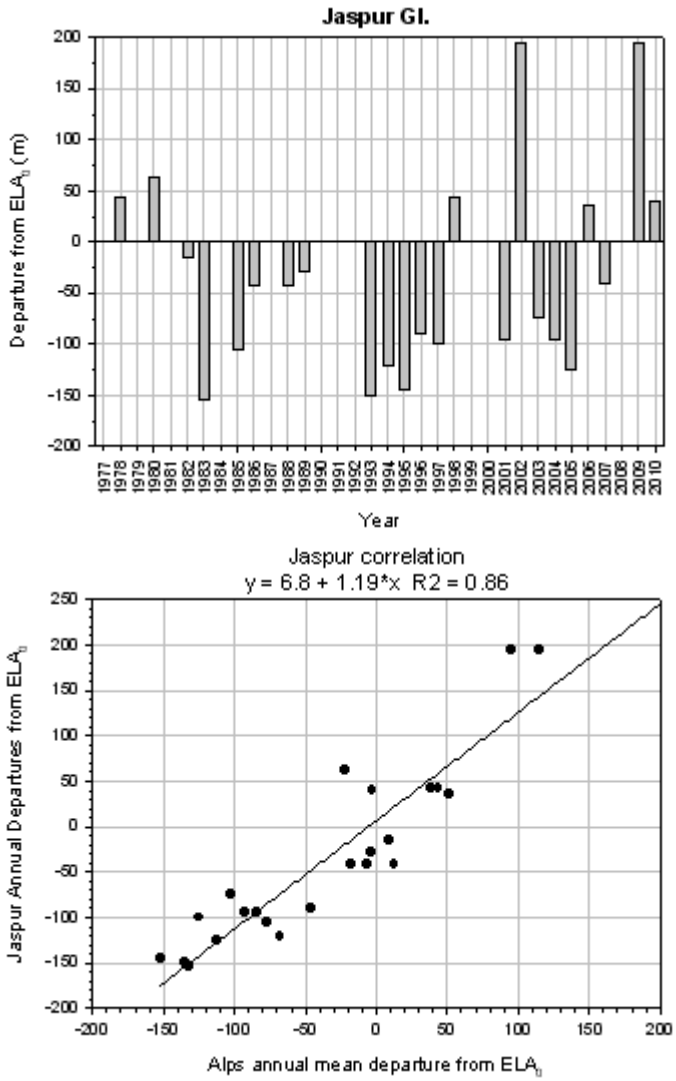
NZMS sheet I34

GLACIER DATA		
Aspect	SW	
AREA	14.09	ha
Max Elev	1920	m
Min Elev	1600	m
Mean Elev	1760	m
Length		km
Elev Range	320	m
Gradient		

SNOWLINE DATA		
ELAo	1725	m
Max SL	1920	m, 2000
Min SL	1570	m, 1983
Mean SL	1674	m
SL Range	350	m
No. Surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1725**	**0**	**9.39**	**4.7**	**14.09**	**0.67**	**0**
1977							
1978	1768	43	6.49	7.6	14.09	0.46	-43
1979					no flight		0
1980	1788	63	4.29	9.8	14.09	0.30	-63
1981							0
1982	1710	-15	10.34	3.75	14.09	0.73	15
1983	1570	-155	14.09	0	14.09	1.00	155
1984							0
1985	1620	-105	14.09	0	14.09	1.00	105
1986	1683	-42	11.84	2.25	14.09	0.84	42
1987							0
1988	1683	-42	11.84	2.25	14.09	0.84	42
1989	1696	-29	11.23	2.86	14.09	0.80	29
1990					no flight		0
1991					no flight		0
1992							0
1993	1575	-150	25.59	0	25.59	1.00	150
1994	1605	-120	17.39	0	17.39	1.00	120
1995	1580	-145	19.24	0	19.24	1.00	145
1996	1635	-90	13.59	0	13.59	1.00	90
1997	1625	-100	16.55	0	16.55	1.00	100
1998	1768	43	5.77	8.32	14.09	0.41	-43
1999	>1950			14.09	14.09	0.00	0
2000	>1950			7.84	7.84	0.00	0
2001	1630	-95	13.89	0.2	14.09	0.99	95
2002	1920	195	0	7.84	7.84	0.00	-195
2003	1651	-74	13.59	0	13.59	1.00	74
2004	1630	-95	13.39	0.2	13.59	0.99	95
2005	1600	-125	17.39	0	17.39	1.00	125
2006	1760	35	6.39	7.7	14.09	0.45	-35
2007	1684	-41	11.79	2.3	14.09	0.84	41
2008	> 1950		0	14.09	14.09	0.00	0
2009	1920	195	0	14.09	14.09	0.00	-195
2010	1765	40	6.09	8	14.09	0.43	-40
MEANS	**1690**	**-35**	**11.04**	**4.35**	**14.54**	**0.66**	**25**



Photograph 16: Jaspur Group 6 March 2010, resolution reduced to 200dpi.

No. 893A-6

SIEGE GL.

NZMS 260 sheet I35

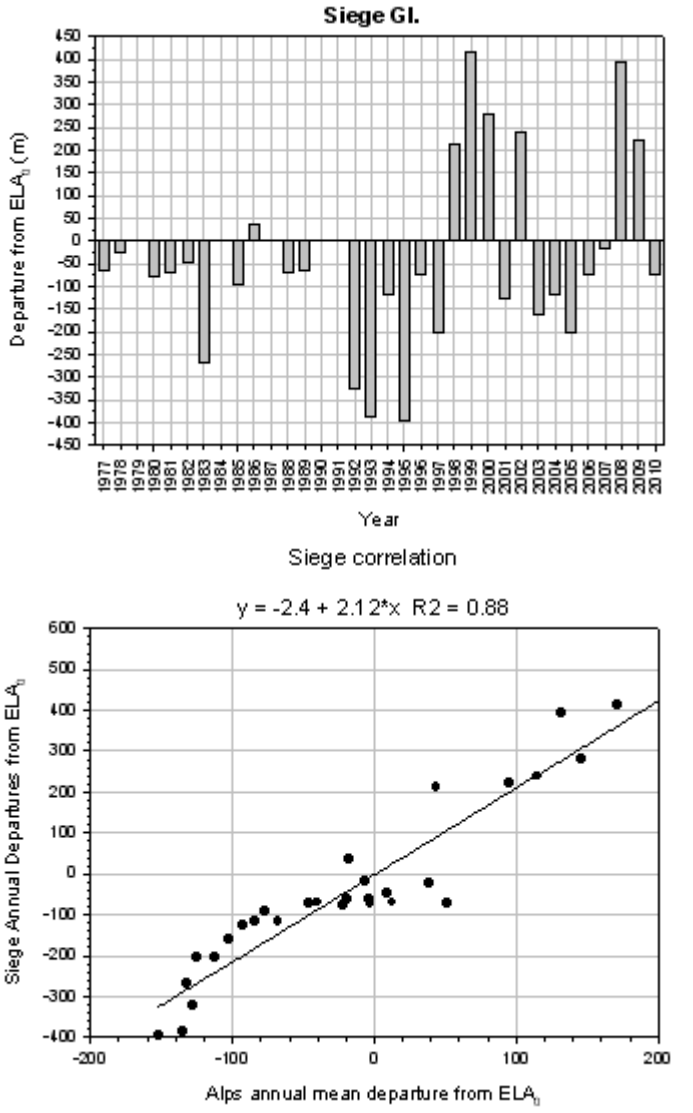
Valley glacier

GLACIER DATA		
Aspect	SE	
AREA	151.9	ha
Max Elev	2130	m
Min Elev	1370	m
Mean Elev	1750	m
Length	3.186	km
Elev Range	760	m
Gradient	0.239	

SNOW LINE DATA		
ELAo	1736	m
Max SL	2150	m, 1999
Min SL	1340	m, 1995
Mean SL	1675	m
SL Range	810	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1736**	**0**	**61.4**	**90.5**	**151.9**	**0.40**	**0**
1977	1672	-64	78.9	73	151.9	0.52	64
1978	1712	-24	67.66	84.24	151.9	0.45	24
1979					no flight		
1980	1660	-76	82.19	69.71	151.9	0.54	76
1981	1666	-70	80.4	71.5	151.9	0.53	70
1982	1690	-46	80.4	71.5	151.9	0.53	46
1983	1468	-268	130.57	21.33	151.9	0.86	268
1984							
1985	1642	-94	87.96	63.94	151.9	0.58	94
1986	1771	35	48.32	103.58	151.9	0.32	-35
1987							
1988	1666	-70	80.4	71.5	151.9	0.53	70
1989	1672	-64	78.81	73.09	151.9	0.52	64
1990					no flight		
1991					no flight		
1992	1413	-323	141.9	10	151.9	0.93	323
1993	1350	-386	153.9	0	153.9	1.00	386
1994	1620	-116	78.4	73.5	151.9	0.52	116
1995	1340	-396	155.4	0	155.4	1.00	396
1996	1664	-72	80.47	71.43	151.9	0.53	72
1997	1533	-203	116.4	35.5	151.9	0.77	203
1998	1950	214	30.83	121.07	151.9	0.20	-214
1999	2150	414	4.36	147.54	151.9	0.03	-414
2000	2015	279	24.27	127.63	151.9	0.16	-279
2001	1610	-126	97.61	54.29	151.9	0.64	126
2002	1975	239	28.9	123	151.9	0.19	-239
2003	1576	-160	107.4	44.5	151.9	0.71	160
2004	1620	-116	94.9	57	151.9	0.62	116
2005	1533	-203	116.4	35.5	151.9	0.77	203
2006	1664	-72	80.47	71.43	151.9	0.53	72
2007	1718	-18	66.2	85.7	151.9	0.44	18
2008	2130	394	5.8	146.1	151.9	0.04	-394
2009	1960	224	30.1	121.8	151.9	0.20	-224
2010	1664	-72	80.47	71.43	151.9	0.53	72
MEANS	**1693**	**-43**	**79.65**	**71.98**		**0.52**	**43**



Photograph 17: Seige Glacier 6 March 2010, resolution reduced to 200dpi.

893A-12

VERTEBRAE COL No 12

NZMS 260 sheet I35

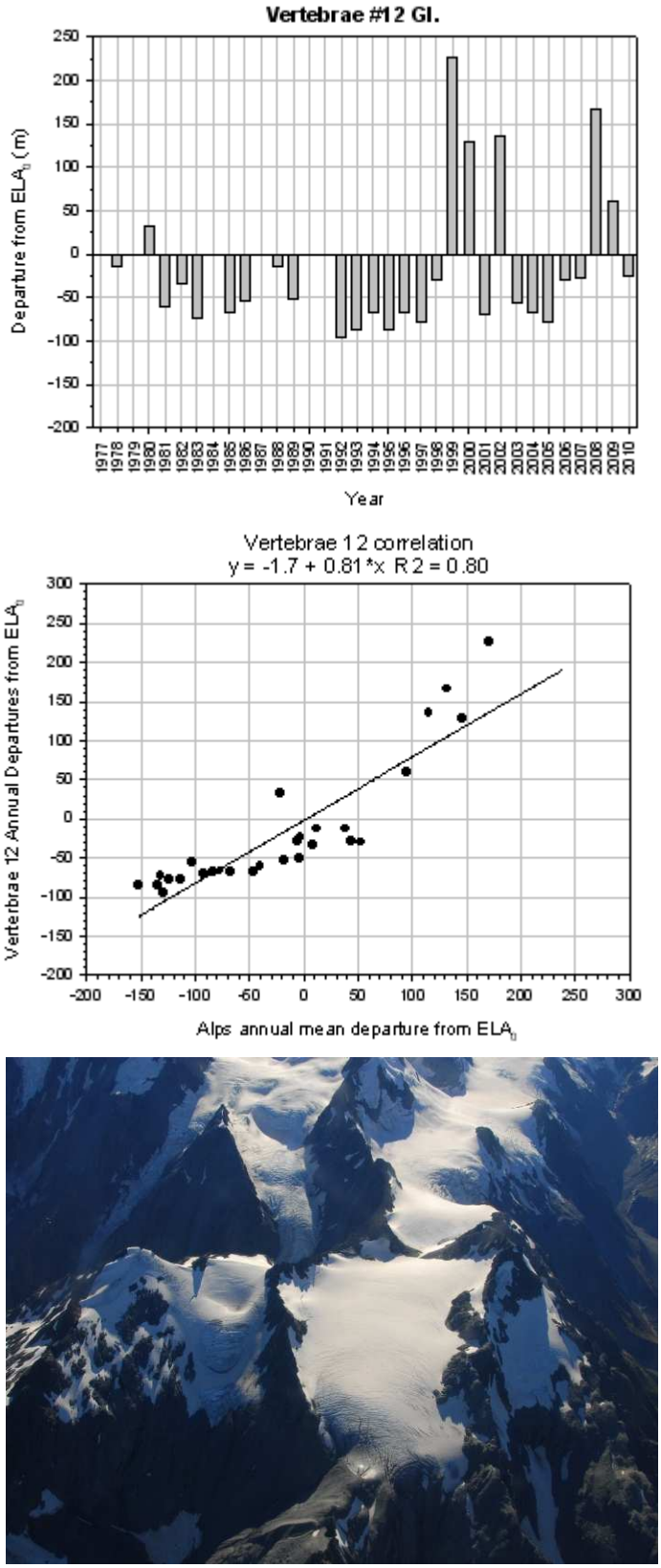
Cirque glacier

GLACIER DATA		
Aspect	SW	
AREA	20.64	ha
Max Elev	2100	m
Min Elev	1730	m
Mean Elev	1915	m
Length	0.63	km
Elev Range	370	m
Gradient	0.592	

SNOWLINE DATA		
ELAo	1864	m
Max SL	2090	m, 1999
Min SL	1768	m, 1992
Mean SL	1854	m
SL Range	322	m
No. surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM.	AREAS ABL.	TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1864**	**0**	**15.04**	**5.60**	**20.64**	**0.73**	**0**
1977							
1978	1871	7	14.74	5.90	20.64	0.71	-7
1979					no flight		
1980	1900	36	12.94	7.70	20.64	0.63	-36
1981	1813	-51	17.54	3.10	20.64	0.85	51
1982	1850	-14	15.84	4.80	20.64	0.77	14
1983	1800	-64	18.27	2.37	20.64	0.89	64
1984							
1985	1808	-56	18.01	2.63	20.64	0.87	56
1986	1820	-44	17.34	3.30	20.64	0.84	44
1987					no visit		
1988	1871	7	14.74	5.90	20.64	0.71	-7
1989	1825	-39	26.96	3.49	20.64	1.31	39
1990					no flight		
1991					no flight		
1992	1768	-96	19.54	1.10	20.64	0.95	96
1993	1778	-86	19.14	1.50	20.64	0.93	86
1994	1807	-57	18.04	2.60	20.64	0.87	57
1995	1778	-86	19.13	1.51	20.64	0.93	86
1996	1807	-57	18.04	2.60	20.64	0.87	57
1997	1791	-73	18.64	2.00	20.64	0.90	73
1998	1855	-9	15.69	4.95	20.64	0.76	9
1999	2090	226	0.73	19.91	20.64	0.04	-226
2000	1985	121	5.53	15.11	20.64	0.27	-121
2001	1805	-59	18.06	2.58	20.64	0.88	59
2002	1995	131	4.94	15.70	20.64	0.24	-131
2003	1816	-48	17.49	3.15	20.64	0.85	48
2004	1807	-57	18.04	2.60	20.64	0.87	57
2005	1790	-74	18.66	1.98	20.64	0.90	74
2006	1830	-34	16.74	3.90	20.64	0.81	34
2007	1856	-8	15.54	5.10	20.64	0.75	8
2008	2030	166	3.14	17.50	20.64	0.15	-166
2009	1924	60	8.39	12.25	20.64	0.41	-60
2010	1840	-24	16.44	4.20	20.64	0.80	24
MEAN	**1854**	**-10**	**15.30**	**5.69**	**20.64**	**0.74**	**10**



Photograph 18: Vertebrae Glaciers 12 (left) and 25 (right) 6 March 2010, resolution reduced to 200dpi.

893A/ 25

VERTEBRAE COL No. 25

NZMS 260 sheet I35

Mountain glacier

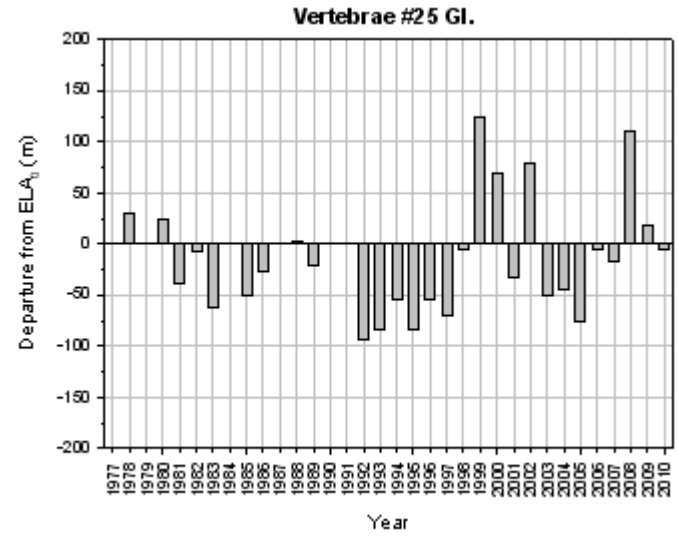
GLACIER DATA		
Aspect	SW	
Area	75.55	ha
Max Elev	2040	m
Min Elev	1700	m
Mean Elev	1850	m
Length	1.15 Km	km
Elev Range	360 m	m
Gradient	0.313	

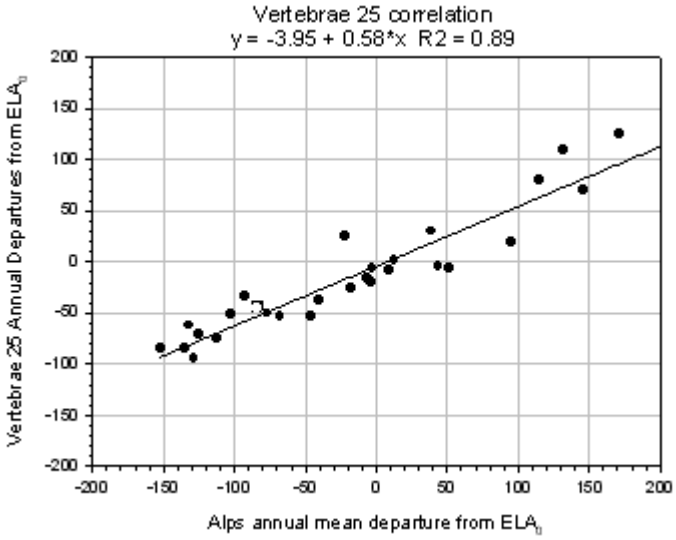
SNOWLINE DATA		
ELAo	**1840**	m
Max SL	1965	m, 1999
Min SL	1746	m, 1992
Mean SL	1825	m
SL Range	219	m
No. surveys	28	

No 25

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1840**	**0**	**45.33**	**30.22**	**75.55**	**0.60**	**0**
1977							
1978	1870	30	49.49	26.06	75.55	0.66	-30
1979							
1980	1865	25	52.12	23.43	75.55	0.69	-25
1981	1802	-39	70.44	5.11	75.55	0.93	39
1982	1840	0	65.53	10.02	75.55	0.87	0
1983	1778	-62	71.55	4.00	75.55	0.95	62
1984							
1985	1790	-50	70.55	5.00	75.55	0.93	50
1986	1813	-27	67.05	8.50	75.55	0.89	27
1987							
1988	1843	3	60.35	15.20	75.55	0.80	-3
1989	1820	-20	65.56	9.99	75.55	0.87	20
1990							
1991							
1992	1746	-94	73.65	1.90	75.55	0.97	94
1993	1756	-84	73.08	2.47	75.55	0.97	84
1994	1786	-54	71.05	4.50	75.55	0.94	54
1995	1756	-84	73.08	2.47	75.55	0.97	84
1996	1786	-54	71.05	4.50	75.55	0.94	54
1997	1770	-71	72.25	3.30	75.55	0.96	71
1998	1835	-5	61.98	13.57	75.55	0.82	5
1999	1965	125	2.64	72.91	75.55	0.03	-125
2000	1910	70	18.08	57.47	75.55	0.24	-70
2001	1807	-33	68.03	7.52	75.55	0.90	33
2002	1920	80	12.55	63.00	75.55	0.17	-80
2003	1789	-51	70.75	4.80	75.55	0.94	51
2004	1795	-45	70.55	5.00	75.55	0.93	45
2005	1765	-75	72.25	3.30	75.55	0.96	75
2006	1834	-6	61.98	13.57	75.55	0.82	6
2007	1824	-16	64.85	10.70	75.55	0.86	16
2008	1950	110	4.75	70.80	75.55	0.06	-110
2009	1859	19	36.72	38.83	75.55	0.49	-19
2010	1834	-6	61.98	13.57	75.55	0.82	6
MEAN	**1825**	**-15**	**57.64**	**17.91**		**0.76**	**15**


Vertebrae #25 Gl.
Departure from ELA0 (m)
Year


Vertebrae 25 correlation
y = -3.95 + 0.58*x R2 = 0.89
Vertebrae 25 Annual Departures from ELA0
Alps annual mean departure from ELA0

711L-24

RIDGE GL.

NZMS sheet L24

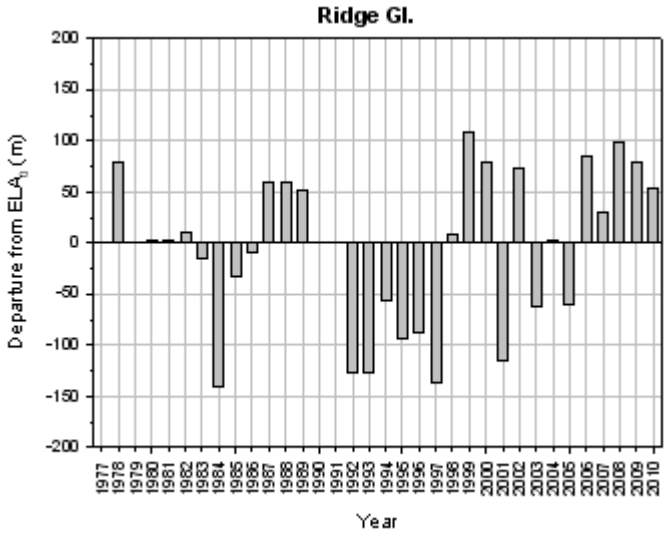
Mountain glacier

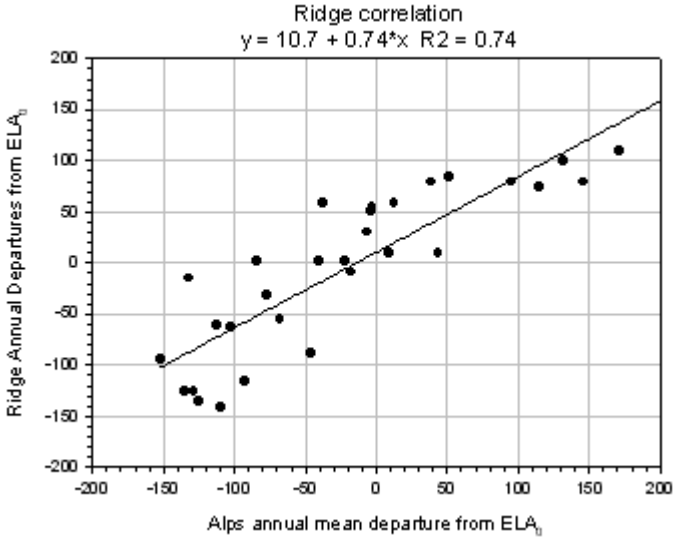
GLACIER DATA		
Aspect	SE	
AREA	68.00	ha
Max Elev	2490	m
Min Elev	2110	m
Mean Elev	2300	m
Length	1.04	km
Elev Range	380	m
Gradient	0.365	

SNOWLINE DATA		
ELAo	**2226**	m
Max SL	2335	m,1999
Min SL	2085	m,1984
Mean SL	2222	m
SL Range	250	m
No. surveys	27	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**2226**	**0**	**51.72**	**21.80**	**73.52**	**0.70**	**0**
1977							
1978	2305	79	22.22	51.30	73.52	0.30	-79
1979					no flight		
1980							
1981	2228	2	49.41	24.11	73.52	0.67	-2
1982	2236	10	47.98	25.54	73.52	0.65	-10
1983	2211	-15	56.32	17.20	73.52	0.77	15
1984	2085	-141	73.52	0.00	73.52	1.00	141
1985	2194	-32	60.40	13.12	73.52	0.82	32
1986	2217	-9	55.02	18.50	73.52	0.75	9.1
1987							
1988	2285	59	27.82	45.70	73.52	0.38	-59
1989	2277	51	30.01	43.51	73.52	0.41	-51
1990					no flight		
1991					no flight		
1992							
1993	2100	-126	73.52	0.00	73.52	1.00	126
1994	2170	-56	66.32	7.20	73.52	0.90	56
1995	2132	-94	70.83	2.69	73.52	0.96	94
1996	2138	-88	70.01	3.51	73.52	0.95	88
1997	2090	-136	73.52	0.00	73.52	1.00	136
1998	2235	9	47.02	25.50	72.52	0.65	-9
1999	2335	109	19.92	52.00	71.92	0.28	-109
2000	2305	79	25.85	44.87	70.72	0.37	-79
2001	2110	-116	70.12	0.00	70.12	1.00	116
2002	2300	74	22.52	47.00	69.52	0.32	-74
2003	2163	-63	62.42	6.50	68.92	0.91	63
2004	2228	2	50.04	18.46	68.50	0.73	-2
2005	2165	-61	61.70	6.30	68.00	0.91	61
2006	2310	84	20.00	48.00	68.00	0.29	-84
2007	2256	30	38.30	29.70	68.00	0.56	-30
2008	2325	99	17.48	50.52	68.00	0.26	-99
2009	2305	79	34.11	44.87	68.00	0.50	-79
2010	2280	54	27.20	40.80	68.00	0.40	-54
MEAN	**2222**	**-4**	**47.17**	**24.70**		**0.66**	**4**





Photograph 19: Ridge Glacier 5 March 2010, resolution reduced to 200dpi.

No. 711 I/35

LANGDALE GL.

NZMS 260 sheet H36

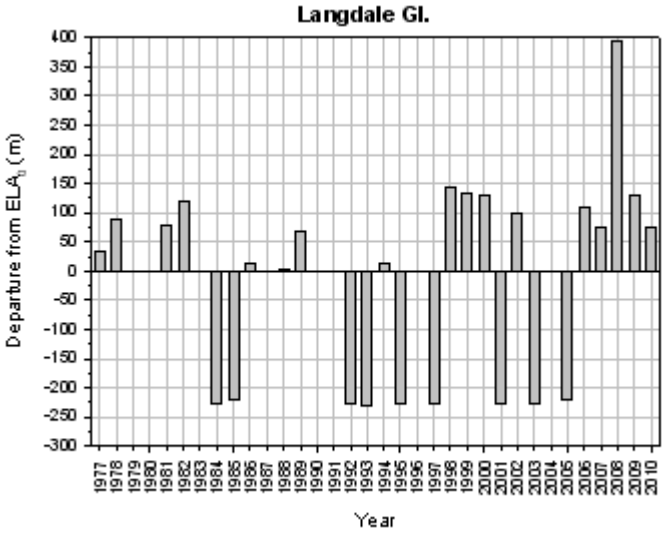
Cirque glacier

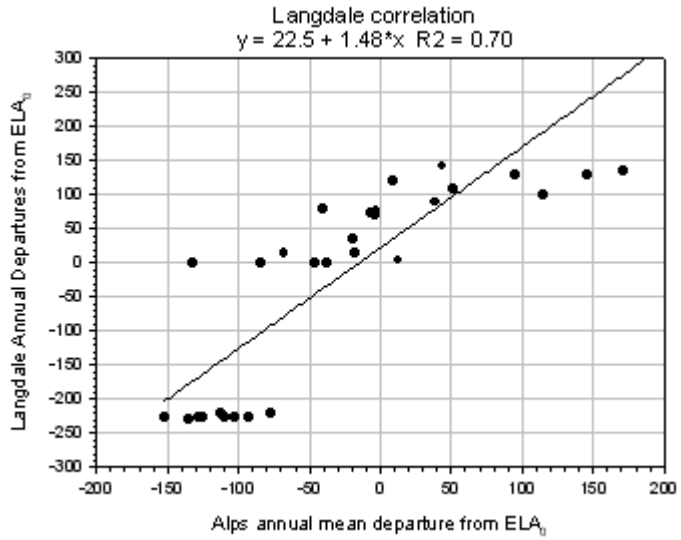
GLACIER DATA		
Aspect	NW	
AREA	34.10	ha
Max Elev	2580	m
Min Elev	2090	m
Mean Elev	2335	m
Length	1.03	km
Elev Range	490	m
Gradient	0.478	

SNOWLINE DATA		
ELA	**2186**	m
Max SL	2328	m,1998
Min SL	1955	m,1984
Mean SL	2175	m
SL Range	373	m
No. surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELA	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**2186**	**0**	**29.42**	**11.00**	**40.42**	**0.73**	**0**
1977	2220	34	32.62	7.80	40.42	0.81	-34
1978	2275	89	19.09	21.00	40.09	0.48	-89
1979					no flight		
1980							
1981	2265	79	15.12	24.31	39.43	0.38	-79
1982	2305	119	23.26	16.17	39.43	0.59	-119
1983	2185	-1	32.73	6.70	39.43	0.83	1
1984	1960	-226	39.43	0.00	39.43	1.00	226
1985	1965	-221	37.74	1.69	39.43	0.96	221
1986	2200	14	35.23	4.20	39.43	0.89	-14
1987	2185	-1	36.53	2.90	39.43	0.93	1
1988	2190	4	26.60	12.50	39.10	0.68	-4
1989	2255	69	18.37	20.73	39.10	0.47	-69
1990					no flight		
1991					no flight		
1992	1960	-226	38.11	0.00	38.11	1.00	226
1993	1955	-231	38.11	0.00	38.11	1.00	231
1994	2200	14	13.85	24.26	38.11	0.36	-14
1995	1960	-226	38.11	0.00	38.11	1.00	226
1996	2185	-1	32.11	6.00	38.11	0.84	1
1997	1960	-226	38.11	0.00	38.11	1.00	226
1998	2328	142	5.40	32.27	37.67	0.14	-142
1999	2320	134	6.68	30.00	36.68	0.18	-134
2000	2315	129	6.39	29.30	35.69	0.18	-129
2001	1960	-226	35.69	0.00	35.69	1.00	226
2002	2285	99	8.78	26.00	34.78	0.25	-99
2003	1960	-226	34.78	0.00	34.78	1.00	226
2004	2185	-1	26.00	8.78	34.78	0.75	1
2005	1965	-221	34.78	0.00	34.78	1.00	221
2006	2295	109	6.80	27.70	34.50	0.20	-109
2007	2260	74	14.50	20.00	34.50	0.42	-74
2008	2580	394	0.00	34.10	34.10	0.00	-394
2009	2315	129	6.39	27.71	34.10	0.19	-129
2010	2262	76	13.20	20.90	34.10	0.39	-76
MEAN	**2175**	**-11**	**24**	**13.50**		**0.63**	**11**





Photograph 20: Langdale Glacier 6 March 2010, resolution reduced to 200dpi.

No. 711I/12

TASMAN GL.

NZMS 260 sheet

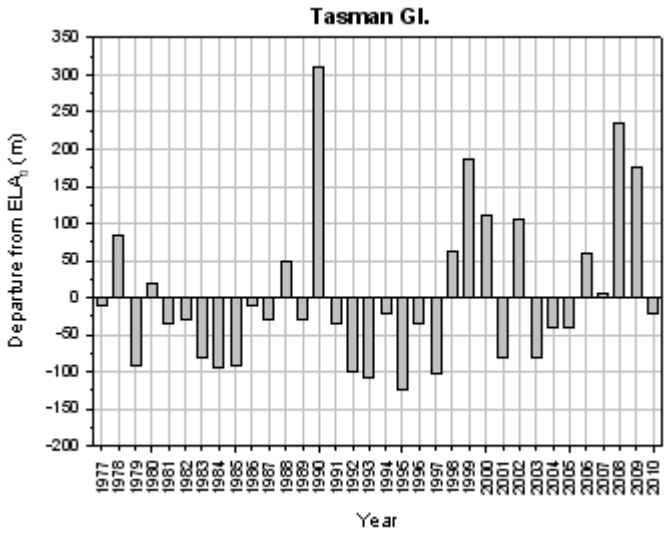
Valley glacier

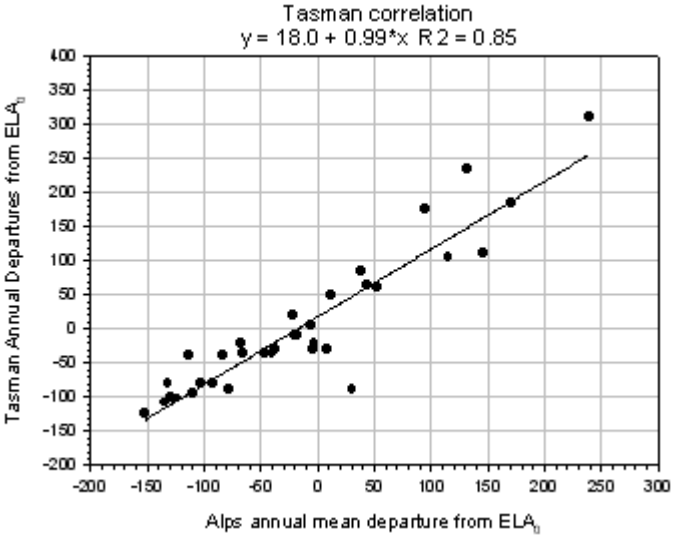
GLACIER DATA		
Aspect	SW	
Max Elev		
Min Elev		
Mean Elev		
Elev Range		
Length		
Gradient		
Gradient @ S	0.096	

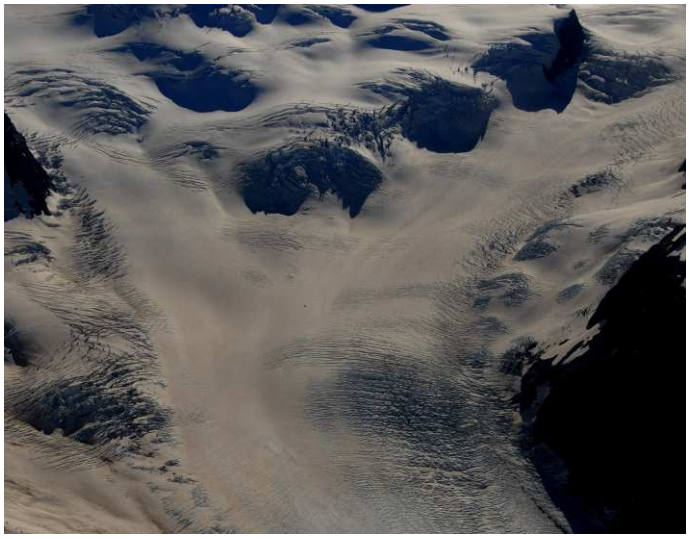
SNOWLINE DATA		
ELAo	**1790**	1955 to '01
ELA	1794	1977 to '01
Max SL	2100	m, 1990
Min SL	1666	m, 1995
Mean SL	1794	m
SL Range	434	m
No. surveys	34	

MEASUREMENTS Values from contour counts shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELA	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1790**	Too large to measure					
1977	1780	-10					10
1978	1875	85					-85
1979	1700	-90					90
1980	1810	20					-20
1981	1755	-35					35
1982	1760	-30					30
1983	1710	-80					80
1984	1695	-95					95
1985	1700	-90					90
1986	1780	-10					10
1987	1761	-29					29
1988	1840	50					-50
1989	1760	-30					30
1990	2100	310					-310
1991	1755	-35					35
1992	1690	-100					100
1993	1682	-108					108
1994	1770	-20					20
1995	1666	-124					124
1996	1755	-35					35
1997	1688	-102					102
1998	1853	63					-63
1999	1976	186					-186
2000	1900	110					-110
2001	1710	-80					80
2002	1895	105					-105
2003	1710	-80					80
2004	1750	-40					40
2005	1750	-40					40
2006	1850	60					-60
2007	1796	6					-6
2008	2025	235					-235
2009	1965	175					-175
2010	1770	-20					20
MEAN	**1794**	**4**					**-4**







Photograph 21: Tasman Glacier 6 March 2010, resolution reduced to 200dpi.

No. 888B/3

SALISBURY SNOWIELD

NZMS 260 sheet H35

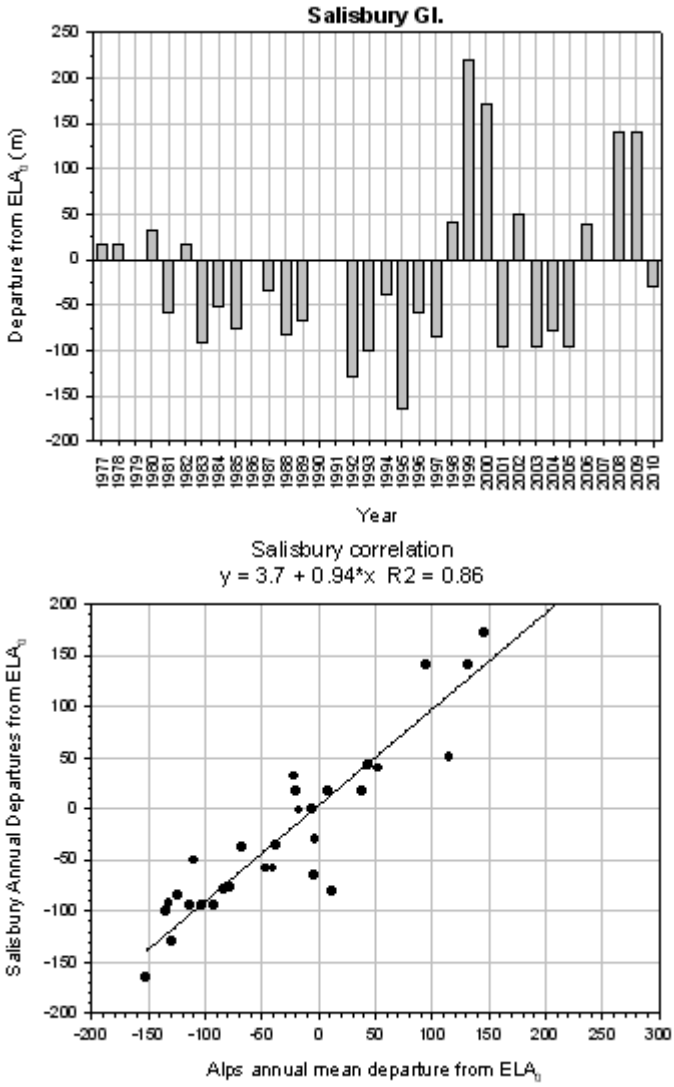
Mountain glacier

GLACIER DATA		
Aspect	SW	
AREA	311.90	ha
Max Elev	2390	m
Min Elev	1340	m
Mean Elev	1865	m
Length	2.98	km
Elev Range	1050	m
Gradient	0.352	

SNOWLINE DATA		
ELAo	**1810**	m
Max SL	2030	m, 1999
Min SL	1645	m, 1995
Mean SL	1793	m
SL Range	385	m
No. surveys	31	

MEASUREMENTS Digitised values shaded

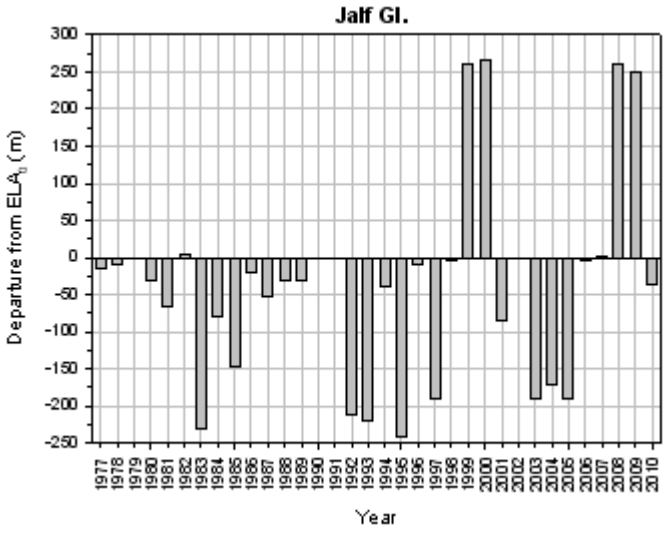
YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1810**	**0**	**246.90**	**65.00**	**311.90**	**0.79**	**0**
1977	1827	17	239.90	72.00	311.90	0.77	-17
1978	1827	17	239.90	72.00	311.90	0.77	-17
1979					No flight		
1980	1842	32	228.51	83.39	311.90	0.73	-32
1981	1752	-58	268.90	43.00	311.90	0.86	58
1982	1827	17	239.90	72.00	311.90	0.77	-17
1983	1718	-92	279.56	32.34	311.90	0.90	92
1984	1760	-51	266.90	45.00	311.90	0.86	51
1985	1734	-76	275.90	36.00	311.90	0.88	76
1986	1809	-1	250.90	61.00	311.90	0.80	1
1987	1775	-35	261.90	50.00	311.90	0.84	35
1988	1729	-81	268.90	43.00	311.90	0.86	81
1989	1744	-66	271.90	40.00	311.90	0.87	66
1990					No flight		
1991					No flight		
1992	1681	-129	289.90	22.00	311.90	0.93	129
1993	1710	-100	279.90	32.00	311.90	0.90	100
1994	1772	-38	228.96	82.94	311.90	0.73	38
1995	1645	-165	296.67	15.23	311.90	0.95	165
1996	1752	-58	267.90	44.00	311.90	0.86	58
1997	1726	-84	276.90	35.00	311.90	0.89	84
1998	1852	42	223.24	88.66	311.90	0.72	-42
1999	2030	220	116.70	195.20	311.90	0.37	-220
2000	1982	172	132.50	179.40	311.90	0.42	-172
2001	1715	-95	281.66	30.24	311.90	0.90	95
2002	1860	50	219.00	92.00	311.00	0.70	-50
2003	1715	-95	279.90	32.00	311.90	0.90	95
2004	1732	-78	275.90	36.00	311.90	0.88	78
2005	1715	-95	281.66	30.24	311.90	0.90	95
2006	1850	40	223.24	88.66	311.90	0.72	-40
2007	1810	0	248.90	63.00	311.90	0.80	0
2008	1950	140	156.90	155.00	311.90	0.50	-140
2009	1950	140	156.90	155.00	311.90	0.50	-140
2010	1780	-30	259.90	52.00	311.90	0.83	30
Mean	**1793**	**-17**	**245**	**67**		**0.78**	**17**

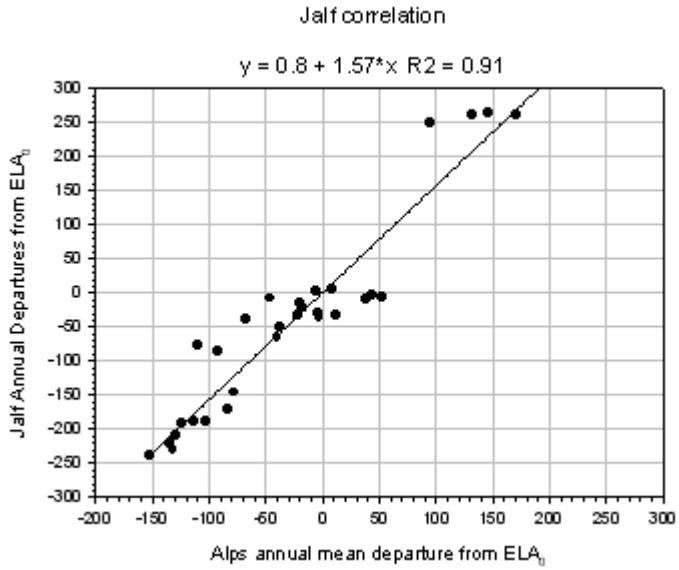


Photograph 22: Salisbury Snowfield 6 March 2010, resolution reduced to 200dpi.

No. 886/2 & 888B/7			JALF GL. and Baumann Gl.			NZMS 260 sheet H35	
			Small saddle glacier				
	GLACIER DATA (2008)				**SNOWLINE DATA**		
	Aspects	N &S, E & W					
	AREA	41.50	ha		**ELAo**	**1790**	m
	Max Elev	1880	m		Max SL	2055	m, 2000
	Min Elev	1600	m		Min SL	1550	m, 1995
	Mean Elev	1740	m		Mean SL	1748	m
	Length	na			SL Range	505	m
	Elev Range	280	m		No. surveys	30	
	Gradient	na					
Glacier area has reduced since the first map in 1977							
MEASUREMENTS		Digitised values shaded					

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1790**	**0**	**14.10**	**88.00**	**102.10**	**0.14**	**0**
1977	1775	-15	21.30	80.80	102.10	0.21	15
1978	1780	-10	19.10	83.00	98.61	0.19	10
1979					*95.12*	no visit	
1980	1758	-32	36.41	58.71	95.12	0.38	32
1981	1725	-65	55.63	36.00	91.63	0.61	65
1982	1795	5	2.63	89.00	91.63	0.03	-5
1983	1560	-230	91.63	0.00	91.63	1.00	230
1984	1712	-78	72.96	18.67	91.63	0.80	78
1985	1644	-146	91.63	0.00	91.63	1.00	146
1986	1770	-20	13.93	77.70	91.63	0.15	20
1987	1739	-51	45.63	46.00	91.63	0.50	51
1988	1758	-32	22.14	66.00	88.14	0.25	32
1989	1759	-31	21.66	66.48	88.14	0.25	31
1990					no visit		
1991					no visit		
1992	1580	-210	77.67	0.00	77.67	1.00	210
1993	1570	-220	77.67	0.00	77.67	1.00	220
1994	1752	-38	17.04	60.63	77.67	0.22	38
1995	1550	-240	77.67	0.00	77.67	1.00	240
1996	1782	-8	17.25	60.42	77.67	0.22	8
1997	1599	-191	75.11	2.56	77.67	0.97	191
1998	1787	-3	15.82	57.20	73.02	0.22	3
1999	2050	260	0.00	102.10	62.55	0.00	-260
2000	2055	265	0.00	102.10	52.08	0.00	-265
2001	1705	-85	26.04	26.04	52.08	0.50	85
2002					43.00		
2003	1600	-190	43.00	3.00	43.00	1.00	190
2004	1620	-170	42.80	0.20	43.00	1.00	170
2005	1600	-190	40.00	3.00	43.00	0.93	190
2006	1785	-5	5.59	37.18	42.77	0.13	5.00
2007	1792	2	0.00	42.77	42.77	0.00	-2.00
2008	2050	260	0.00	41.50	41.50	0.00	-260.00
2009	2040	250	0.00	41.00	41.00	0.00	-250.00
2010	1755	-35	3.50	37.50	41.00	0.09	35.00
MEAN	**1748**	**-42**	**34**	**41.32**		**0.45**	**42**



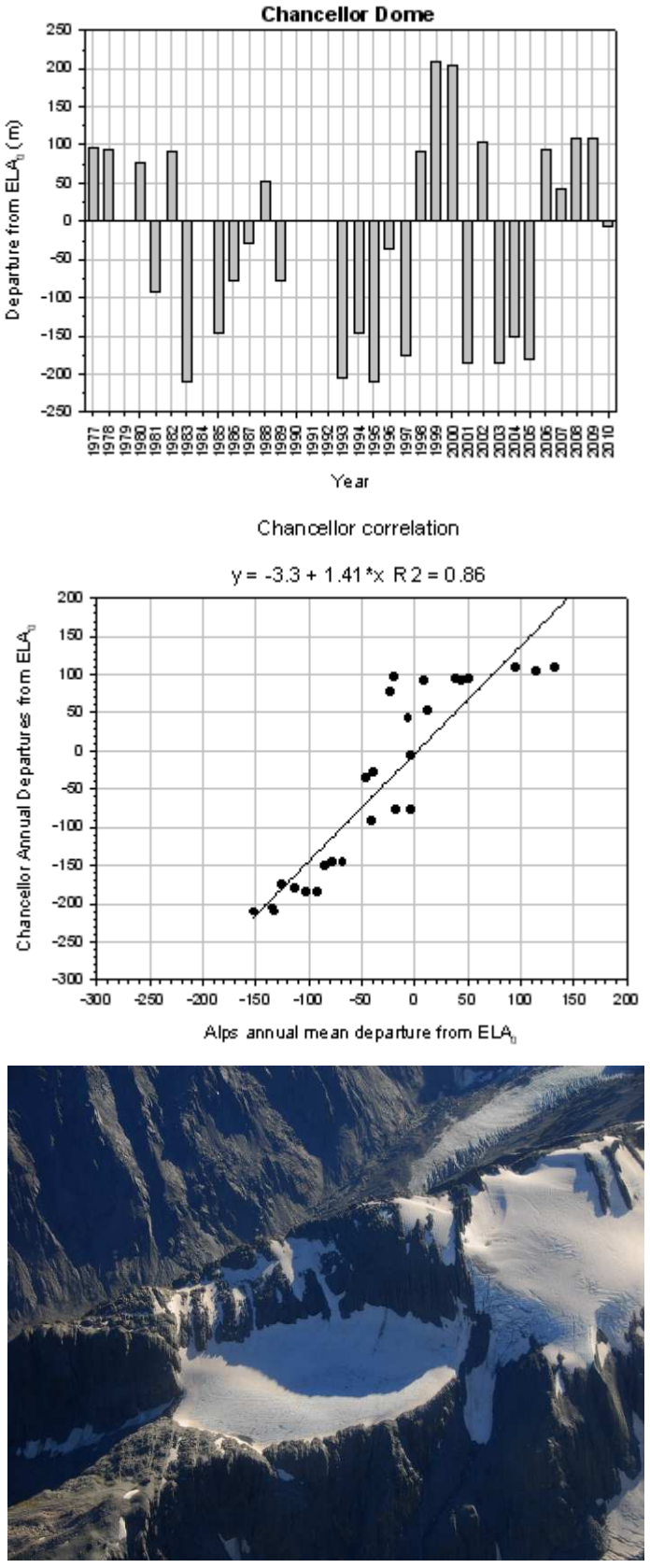


Photograph 23: Jalf Glacier 6 March 2010, resolution reduced to 200dpi.

No. 882A/7			CHANCELLOR DOME			NZMS 260 sheet H35 & H36	
				Cirque glacier			
	GLACIER DATA				**SNOWLINE DATA**		
	Aspect	SW					
	AREA	17.51	ha		**ELAo**	**1756**	m
	Max Elev	1960	m		Max SL	1965	m, 1999
	Min Elev	1660	m		Min SL	1545	m, 1995
	Mean Elev	1810	m		Mean SL	1730	m
	Length	0.55	km		SL Range	420	m
	Elev Range	300	m		No. surveys	29	
	Gradient	0.436					

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ACCUM.	AREAS ABL.	AREAS TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1756**	**0**	**18.83**	**5.25**	**24.08**	**0.78**	**0**
1977	1852	96	9.45	14.63	24.08	0.39	-96
1978	1851	95	9.63	14.45	24.08	0.40	-95
1979							
1980	1833	77	13.85	10.23	24.08	0.58	-77
1981	1663	-93	21.05	3.03	24.08	0.87	93
1982	1848	92	10.67	13.41	24.08	0.44	-92
1983	1545	-211	28.90	0.00	28.90	1.20	211
1984							
1985	1609	-147	22.95	1.13	24.08	0.95	147
1986	1678	-78	20.65	3.43	24.08	0.86	78
1987	1728	-28	19.33	4.75	24.08	0.80	28
1988	1808	52	17.33	6.75	24.08	0.72	-52
1989	1678	-78	20.59	3.49	24.08	0.86	78
1990							
1991							
1992							
1993	1550	-206	24.08	0.00	24.08	1.00	206
1994	1609	-147	22.95	1.13	24.08	0.95	147
1995	1545	-211	28.90	0.00	28.90	1.00	211
1996	1720	-36	7.42	16.66	24.08	0.31	36
1997	1580	-176	24.08	0.00	24.08	1.00	176
1998	1848	92	10.67	13.41	24.08	0.44	-92
1999	1965	209	0.00	17.51	17.51	0.00	-209
2000	1960	204	0.00	17.51	17.51	0.00	-204
2001	1570	-186	17.51	0.00	17.51	1.00	186
2002	1860	104	1.50	16.01	17.51	0.09	-104
2003	1570	-186	17.51	0.00	17.51	1.00	186
2004	1605	-151	17.51	0.00	17.51	1.00	151
2005	1575	-181	17.51	0.00	17.51	1.00	181
2006	1850	94	10.00	16.10	17.51	0.57	-94
2007	1799	43	3.31	14.20	17.51	0.19	-43
2008	1865	109	1.30	16.21	17.51	0.07	-109
2009	1865	109	1.30	16.21	17.51	0.07	-109
2010	1750	-6	10.51	7.00	17.51	0.60	6
MEAN	**1730**	**-26**	**14.76**	**7.56**		**0.63**	**26**



Photograph 24: Chancellor Glacier 6 March 2010, resolution reduced to 200dpi.

No. 711F/6

GLENMARY GL.

NZMS 260 sheet H37

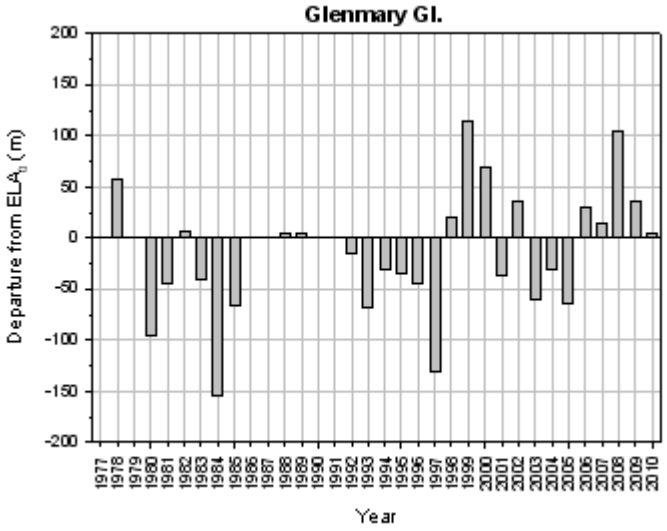
Cirque glacier

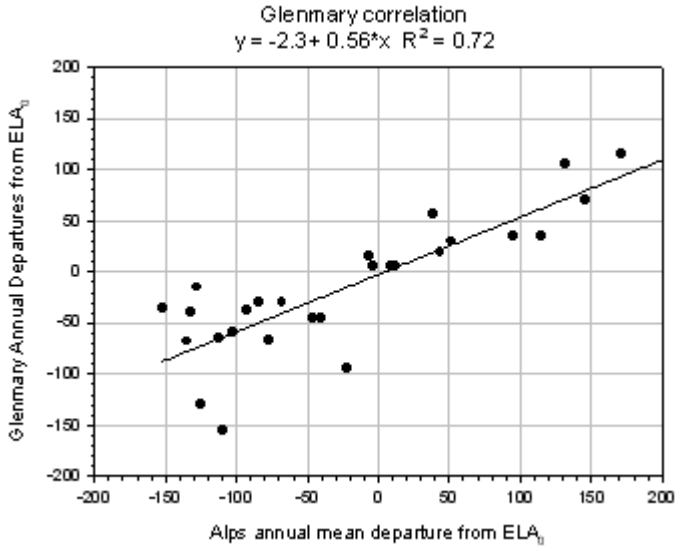
GLACIER DATA		
Aspect	S	
AREA	58.51	ha
Max Elev	2380	m
Min Elev	2040	m
Mean Elev	2210	m
Length	1.19	km
Elev Range	340	m
Gradient	0.277	

SNOWLINE DATA		
ELAo	**2164**	m
Max SL	2290	m, 1999
Min SL	2020	m, 1984
Mean SL	2160.214286	m
SL Range	270	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**2175**	**0**	**35.41**	**19.00**	**54.41**	**0.65**	**0**
1977							
1978	2232	57	22.93	31.48	54.41	0.42	-57
1979							
1980	2080	-95	48.50	5.57	54.07	0.90	95
1981	2130	-45	42.20	11.53	53.73	0.79	45
1982	2181	6	36.00	17.73	53.73	0.67	-6
1983	2135	-40	41.76	11.97	53.73	0.78	40
1984	2020	-155	53.73	0.00	53.73	1.00	155
1985	2108	-67	49.30	4.43	53.73	0.92	67
1986					53.73		
1987					53.73		
1988	2180	5	36.02	17.37	53.39	0.67	-5
1989	2180	5	36.02	17.37	53.39	0.67	-5
1990					52.39		
1991					52.39		
1992	2160	-15	37.80	14.59	52.39	0.72	15
1993	2107	-68	45.50	6.89	52.39	0.87	68
1994	2145	-30	40.00	12.39	52.39	0.76	30
1995	2140	-35	40.70	11.69	52.39	0.78	35
1996	2130	-45	42.25	10.14	52.39	0.81	45
1997	2045	-130	50.51	1.88	52.39	0.96	130
1998	2195	20	32.34	19.73	52.07	0.62	-20
1999	2290	115	7.70	43.92	51.62	0.15	-115
2000	2245	70	20.19	30.98	51.17	0.39	-70
2001	2138	-37	41.10	10.07	51.17	0.80	37
2002	2210	35	30.01	20.84	50.85	0.59	-35
2003	2115	-60	44.50	6.33	50.83	0.88	60
2004	2145	-30	40.00	10.81	50.81	0.79	30
2005	2110	-65	45.10	5.70	50.80	0.89	65
2006	2205	30	31.12	19.68	50.80	0.61	-30
2007	2190	15	32.40	18.40	50.80	0.64	-15
2008	2280	105	9.74	41.06	50.80	0.19	-105
2009	2210	35	29.96	20.84	50.80	0.59	-35
2010	2180	5	34.30	16.50	50.80	0.68	-5
Mean	**2160**	**-15**	**36.5**	**15.7**		**0.70**	**15**





Photograph 25: Glenmary Glacier on 5 March 2010, resolution reduced to 200dpi.

No. 711-D/38

BLAIR GL.

NZMS 260 sheet H37 & G37

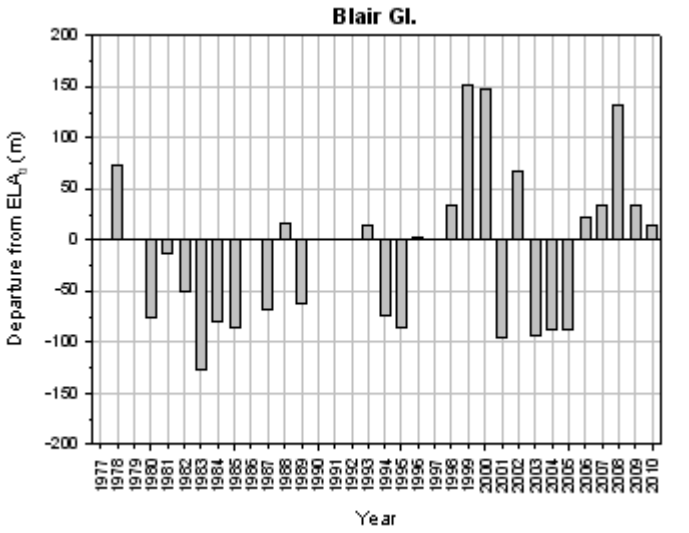
Mountain glacier

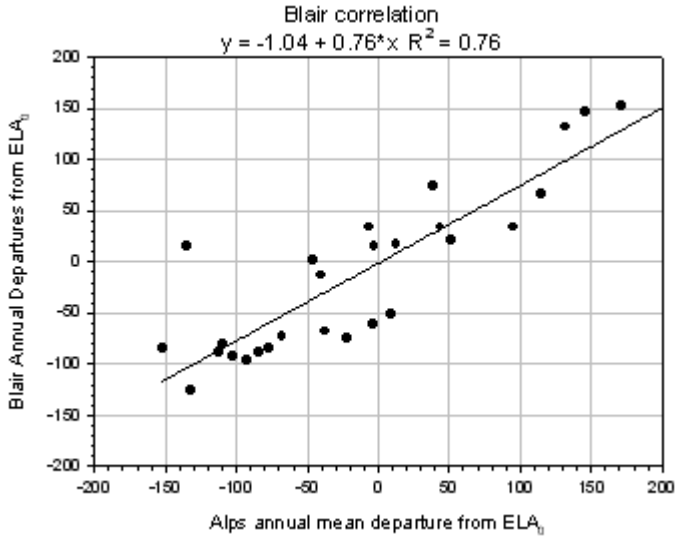
GLACIER DATA		
Aspect	SE	
AREA	24.62	ha
Max Elev	2240	m
Min Elev	1790	m
Mean Elev	2015	m
Length	0.63	km
Elev Range	450	m
Gradient	0.71	

SNOWLINE DATA		
ELAo	**1938**	m
Max SL	2090	m, 1999
Min SL	1812	m, 1983
Mean SL	1925	m
SL Range	278	m
No. Surveys	27	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1938**	**0**	**18.52**	**7.90**	**26.42**	**0.70**	**0**
1977							
1978	2012	74	13.42	13.00	26.42	0.51	-74
1979							
1980	1863	-75	22.82	3.60	26.42	0.86	75
1981	1925	-13	19.23	7.19	26.42	0.73	13
1982	1887	-51	21.52	4.90	26.42	0.81	51
1983	1812	-126	25.28	1.14	26.42	0.96	126
1984	1858	-80	23.12	3.30	26.42	0.88	80
1985	1853	-85	23.28	3.14	26.42	0.88	85
1986							
1987	1870	-68	22.43	3.99	26.42	0.85	68
1988	1955	17	17.80	8.62	26.42	0.67	-17
1989	1876	-62	22.10	4.32	26.42	0.84	62
1990							
1991							
1992							
1993	1953	15	17.69	8.73	26.42	0.67	-15
1994	1865	-73	22.72	3.70	26.42	0.86	73
1995	1853	-85	23.28	3.14	26.42	0.88	85
1996	1940	2	18.44	7.98	26.42	0.70	-2
1997							
1998	1972	34	16.36	10.06	26.42	0.62	-34
1999	2090	152	6.04	20.38	26.42	0.23	-152
2000	2085	147	6.17	20.25	26.42	0.23	-147
2001	1842	-96	23.75	2.67	26.42	0.90	96
2002	2005	67	14.02	12.40	26.42	0.53	-67
2003	1845	-93	23.62	2.80	26.42	0.89	93
2004	1850	-88	23.28	3.14	26.42	0.88	88
2005	1850	-88	23.28	3.14	26.42	0.88	88
2006	1960	22	17.60	8.82	26.42	0.67	-22
2007	1972	34	16.36	10.06	26.42	0.62	-34
2008	2070	132	7.92	18.50	26.42	0.30	-132
2009	1972	34	16.36	10.06	26.42	0.62	-34
2010	1953	15	17.69	8.73	26.42	0.67	-15
MEAN	**1925**	**-13**	**18.73**	**7.69**		**0.71**	**13**





Photograph 26: Blair Glacier on 5 March 2010, resolution reduced to 200dpi.

No. 711D/21

Mt. McKENZIE

NZMS 260 sheet G37

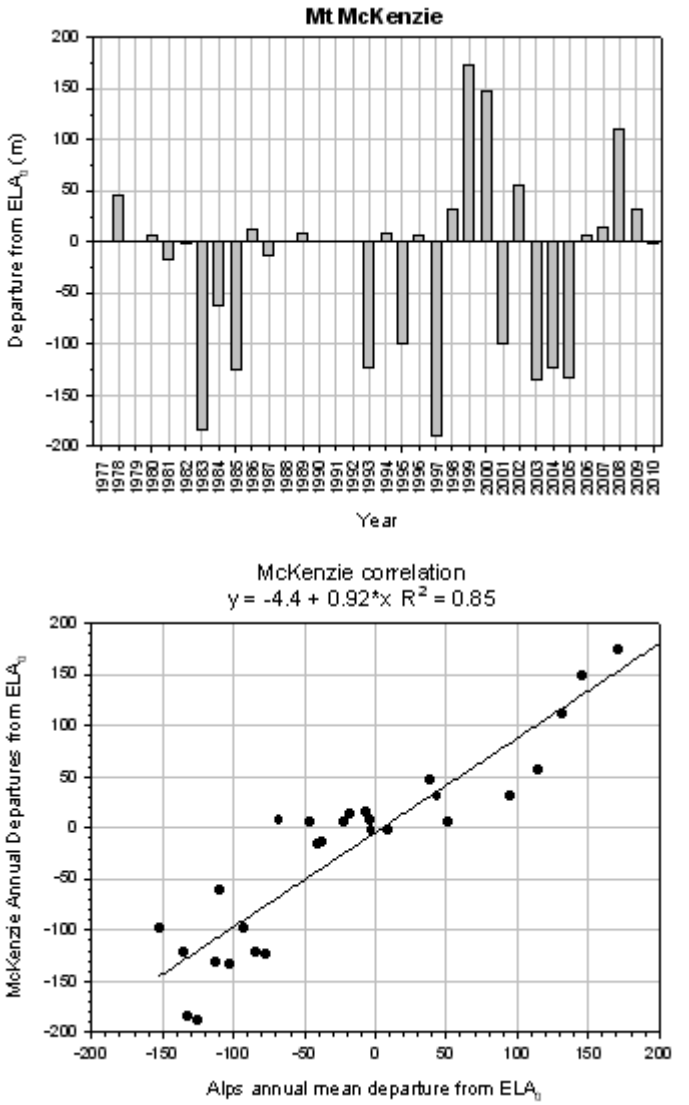
Mountain glacier

GLACIER DATA		
Aspect	S	
AREA	48.67	ha
Max Elev	2100	m
Min Elev	1760	m
Mean Elev	1930	m
Length	0.69	km
Elev Range	340	m
Gradient	0.49	

SNOWLINE DATA		
ELAo	**1904**	m
Max SL	2078	m, 1999
Min SL	1715	m, 1983
Mean SL	1881	m
SL Range	363	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1904**	**0**	**30.87**	**17.80**	**48.67**	**0.63**	**0**
1977							
1978	1950	46	22.78	25.89	48.67	0.47	-46
1979							
1980	1910	6	29.86	18.81	48.67	0.61	-6
1981	1888	-16	33.48	15.19	48.67	0.69	16
1982	1902	-2	31.35	17.32	48.67	0.64	2
1983	1720	-184	60.63	-11.96	48.67	1.25	184
1984	1842	-62	39.64	9.03	48.67	0.81	62
1985	1780	-124	48.67	0.00	48.67	1.00	124
1986	1917	13	28.87	19.80	48.67	0.59	-13
1987	1890	-14	33.23	15.44	48.67	0.68	14
1988							
1989	1912	8	29.70	18.97	48.67	0.61	-8
1990							
1991							
1992							
1993	1782	-122	46.35	2.32	48.67	0.95	122
1994	1912	8	29.70	18.97	48.67	0.61	-8
1995	1805	-99	43.86	4.81	48.67	0.90	99
1996	1910	6	29.86	18.81	48.67	0.61	-6
1997	1715	-189	60.63	-11.96	48.67	1.25	189
1998	1935	31	25.53	23.14	48.67	0.52	-31
1999	2078	174	2.81	45.86	48.67	0.06	-174
2000	2052	148	5.83	42.84	48.67	0.12	-148
2001	1805	-99	43.87	4.80	48.67	0.90	99
2002	1960	56	20.67	28.00	48.67	0.42	-56
2003	1770	-134	47.72	0.95	48.67	0.98	134
2004	1782	-122	46.35	2.32	48.67	0.95	122
2005	1772	-132	47.72	0.95	48.67	0.98	132
2006	1910	6	29.86	18.81	48.67	0.61	-6
2007	1919	15	28.67	20.00	48.67	0.59	-15
2008	2015	111	11.10	37.57	48.67	0.23	-111
2009	1935	31	25.53	23.14	48.67	0.52	-31
2010	1902	-2	31.35	17.32	48.67	0.64	2
MEAN	**1881**	**-23**	**33.42**	**15.26**		**0.69**	**23**



Photograph 27: McKenzie Glacier on 5 March 2010, resolution reduced to 200dpi.

No. 868B/94

JACKSON GL

NZMS 260 sheet H37

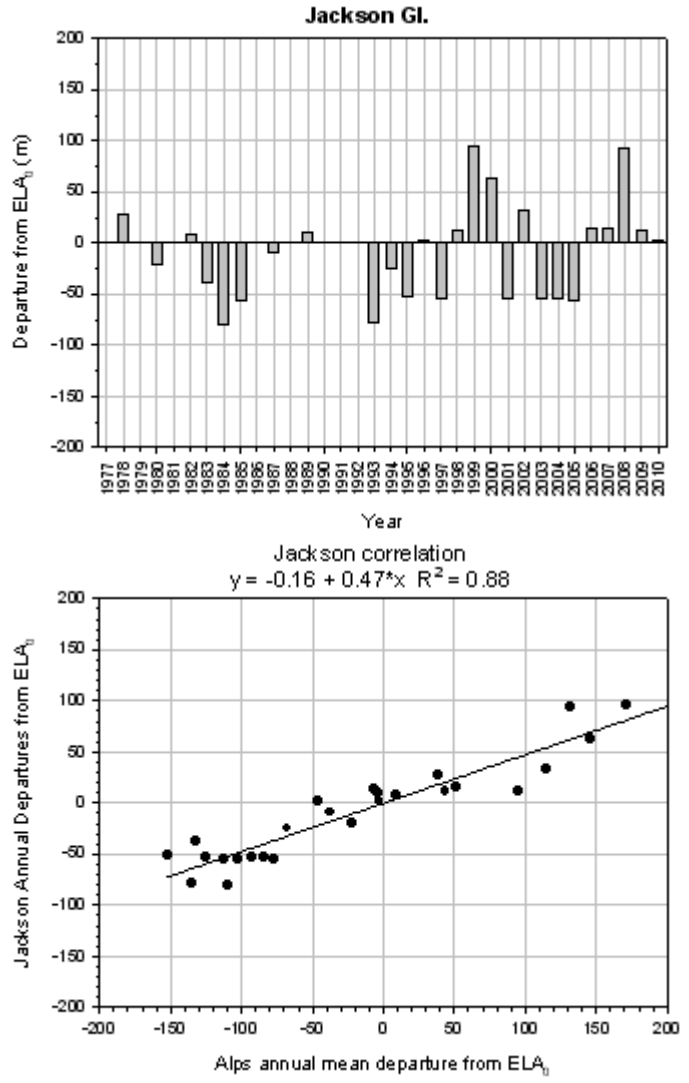
Mountain glacier

GLACIER DATA		
Aspect	NW	
AREA	52.15	ha
Max Elev	2300	m
Min Elev	1920	m
Mean Elev	2110	m
Length	0.5	km
Elev Range	380	m
Gradient	0.76	

SNOWLINE DATA		
ELAo	**2070**	m
Max SL	2165	m, 1999
Min SL	1990	m, 1984
Mean SL	2061	m
SL Range	175	m
No. Surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
55	2100						
ELAo	**2070**	**0**	**30.15**	**22.00**	**52.15**	**0.58**	**0**
1977							
1978	2098	28	23.37	28.78	52.15	0.40	-28
1979							
1980	2050	-20	35.65	16.50	52.15	0.62	20
1981							
1982	2078	8	28.15	24.00	52.15	0.49	-8
1983	2032	-38	41.85	10.30	52.15	0.72	38
1984	1990	-80	49.05	3.10	52.15	0.85	80
1985	2014	-56	45.32	6.83	52.15	0.78	56
1986							
1987	2061	-9	32.71	19.44	52.15	0.56	9
1988							
1989	2080	10	27.75	24.40	52.15	0.48	-10
1990							
1991							
1992							
1993	1992	-78	48.97	3.18	52.15	0.85	78
1994	2045	-25	37.12	15.03	52.15	0.64	25
1995	2018	-52	44.31	7.84	52.15	0.77	52
1996	2072	2	29.97	22.18	52.15	0.52	-2
1997	2016	-54	44.85	7.30	52.15	0.77	54
1998	2082	12	27.05	25.10	52.15	0.47	-12
1999	2165	95	8.64	43.51	52.15	0.15	-95
2000	2133	63	15.49	36.66	52.15	0.27	-63
2001	2016	-54	45.00	7.15	52.15	0.78	54
2002	2103	33	22.77	29.38	52.15	0.39	-33
2003	2015	-55	50.65	1.50	52.15	0.87	55
2004	2016	-54	45.00	7.15	52.15	0.78	54
2005	2014	-56	45.32	6.83	52.15	0.78	56
2006	2085	15	27.00	25.15	52.15	0.47	-15
2007	2084	14	27.02	25.13	52.15	0.47	-14
2008	2163	93	9.10	43.05	52.15	0.17	-93
2009	2082	12	27.05	25.10	52.15	0.52	-12
2010	2072	2	29.97	22.18	52.15	0.57	-2
MEAN	**2061**	**-9**	**33.43**	**18.72**		**0.58**	**9**



Photograph 28: Jackson Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 875/15

JACK GL.

NZMS 260 sheet G37

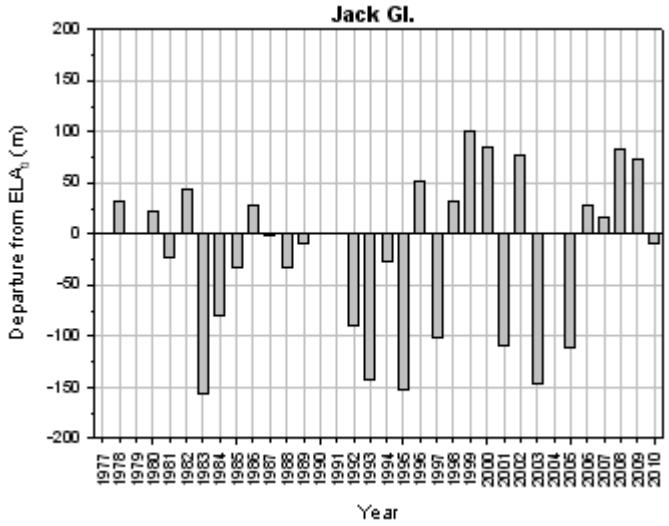
Small cirque glacier

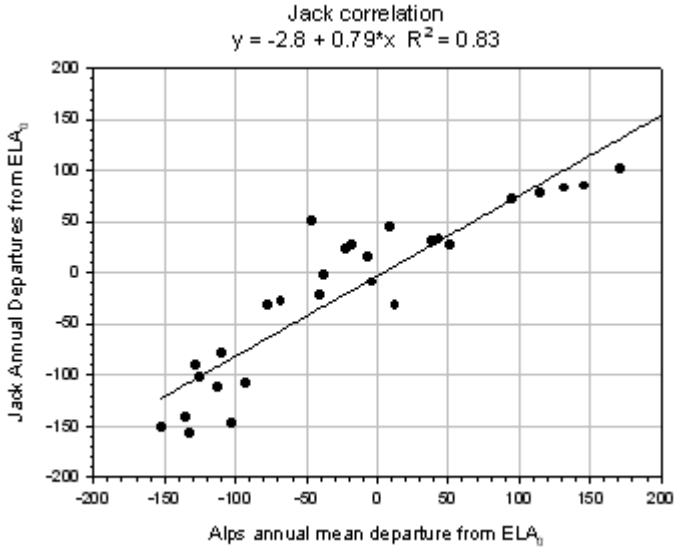
GLACIER DATA		
Aspect	W	
AREA	21.48	ha
Max Elev	2280	m
Min Elev	1800	m
Mean Elev	2040	m
Length	0.337	km
Elev Range	480	m
Gradient	1.42	

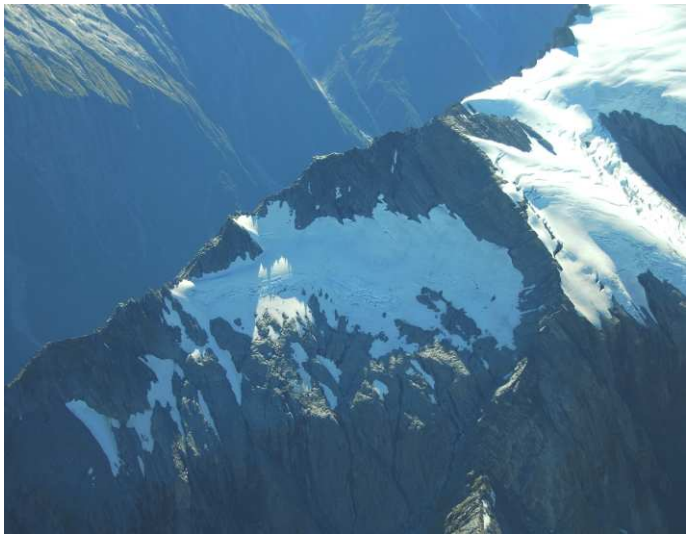
SNOWLINE DATA		
ELAo	**1907**	m
Max SL	2008	m, 1999
Min SL	1750	m, 1983
Mean SL	1888	m
SL Range	258	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1907**	**0**	**15.68**	**5.80**	**21.48**	**0.73**	**0**
1977							
1978	1938	31	11.48	10.00	21.48	0.53	-31
1979							
1980	1930	23	12.88	8.60	21.48	0.60	-23
1981	1885	-22	**17.35**	**4.13**	21.48	0.81	22
1982	1951	44	**9.00**	**12.48**	21.48	0.42	-44
1983	1750	-157	**29.77**	**-8.29**	21.48	1.39	157
1984	1828	-79	19.68	1.80	21.48	0.92	79
1985	1875	-32	17.88	3.60	21.48	0.83	32
1986	1935	28	11.98	9.50	21.48	0.56	-28
1987	1905	-2	15.88	5.60	21.48	0.74	2
1988	1875	-32	17.88	3.60	21.48	0.83	32
1989	1898	-9	**16.55**	**4.93**	21.48	0.77	9
1990					no visit		
1991					no visit		
1992	1817	-90	19.88	1.60	21.48	0.93	90
1993	1765	-142	21.13	0.35	21.48	0.98	142
1994	1880	-27	17.68	3.80	21.48	0.82	27
1995	1755	-152	**26.98**	**0.49**	27.47	1.26	152
1996	1958	51	**7.63**	**13.85**	21.48	0.36	-51
1997	1805	-102	**20.19**	**1.29**	21.48	0.94	102
1998	1940	33	**11.15**	**10.33**	21.48	0.52	-33
1999	2008	101	**1.96**	**19.52**	21.48	0.09	-101
2000	1992	85	**2.86**	**18.62**	21.48	0.13	-85
2001	1798	-109	**20.40**	**1.08**	21.48	0.95	109
2002	1985	78	3.68	17.80	21.48	0.17	-78
2003	1760	-147	21.48	0.00	21.48	1.00	147
2004					cloud		
2005	1795	-112	20.40	1.08	21.48	0.95	112
2006	1935	28	11.98	9.50	21.48	0.56	-28.00
2007	1923	16	13.68	7.80	21.48	0.64	-16.00
2008	1990	83	3.08	18.40	21.48	0.14	-83.00
2009	1980	73	4.18	17.30	21.48	0.19	-73.00
2010	1898	-9	16.55	4.93	21.48	0.77	9.00
MEAN	**1888**	**-19**	**14.66**	**7.02**		**0.68**	**19**







Photograph 29: Jack Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 711B/39

Mt. St. MARY

NZMS 260 sheet G38

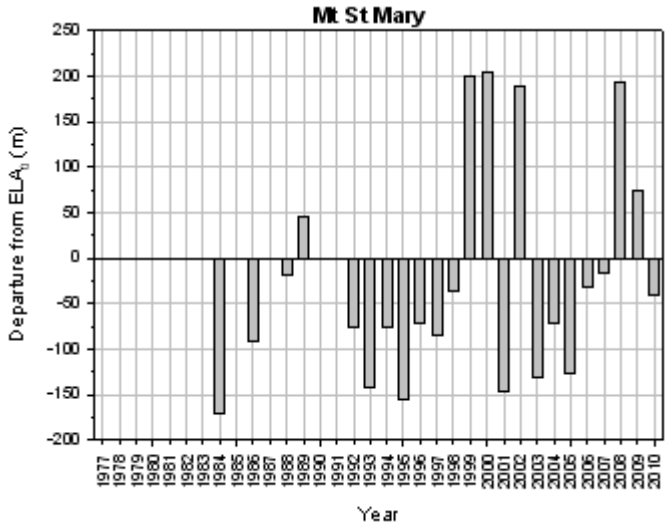
Rock glacier

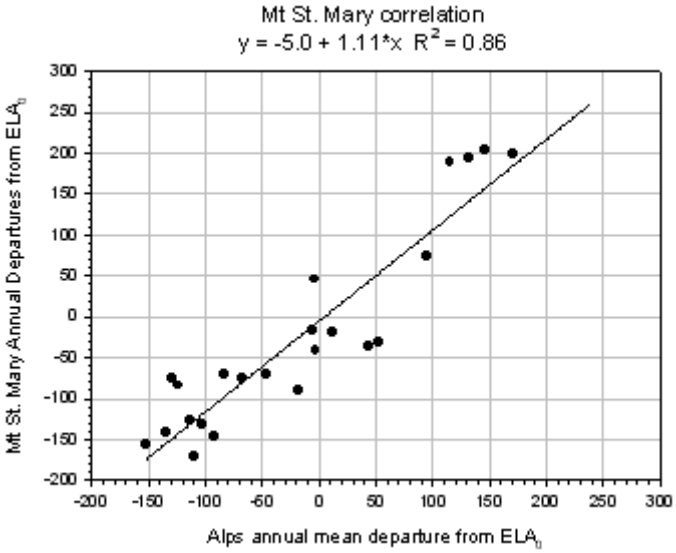
GLACIER DATA		
Aspect	SE	
AREA	28.32	ha
Max Elev	2200	m
Min Elev	1760	m
Mean Elev	1980	m
Length	0.7	km
Elev Range	440	m
Gradient	0.629	

SNOWLINE DATA		
ELAo	**1926**	m
Max SL	2130	m, 2000
Min SL	1755	m, 1984
Mean SL	1901	m
SL Range	375	m
No. Surveys	23	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1926**	**0**	**6.52**	**21.80**	**28.32**	**0.23**	**0**
1977							
1978							
1979							
1980							
1981							
1982							
1983							
1984	1755	-171	20.32	8.00	28.32	0.72	171
1985							
1986	1835	-91	12.33	15.99	28.32	0.44	91
1987							
1988	1907	-19	7.92	20.40	28.32	0.28	19
1989	1972	46	4.41	23.91	28.32	0.16	-46
1990							
1991							
1992	1850	-76	11.32	17.00	28.32	0.40	76
1993	1785	-141	16.69	11.63	28.32	0.59	141
1994	1850	-76	11.32	17.00	28.32	0.40	76
1995	1770	-156	18.39	9.93	28.32	0.65	156
1996	1855	-71	11.08	17.24	28.32	0.39	71
1997	1842	-84	11.75	16.57	28.32	0.41	84
1998	1889	-37	8.93	19.39	28.32	0.32	37
1999	2125	199	0.42	27.90	28.32	0.01	-199
2000	2130	204	0.37	27.95	28.32	0.01	-204
2001	1780	-146	17.22	11.10	28.32	0.61	146
2002	2115	189	0.52	27.80	28.32	0.02	-189
2003	1795	-131	15.72	12.60	28.32	0.56	131
2004	1855	-71	11.08	17.24	28.32	0.39	71
2005	1800	-126	15.72	12.60	28.32	0.56	126
2006	1895	-31	8.52	19.80	28.32	0.30	31
2007	1910	-16	7.62	20.70	28.32	0.27	16
2008	2120	194	0.42	27.90	28.32	0.01	-194
2009	2000	74	3.22	25.10	28.32	0.11	-74
2010	1885	-41	9.12	19.20	28.32	0.32	41
MEAN	**1901**	**-25**	**9.76**	**18.56**		**0.34**	**25**

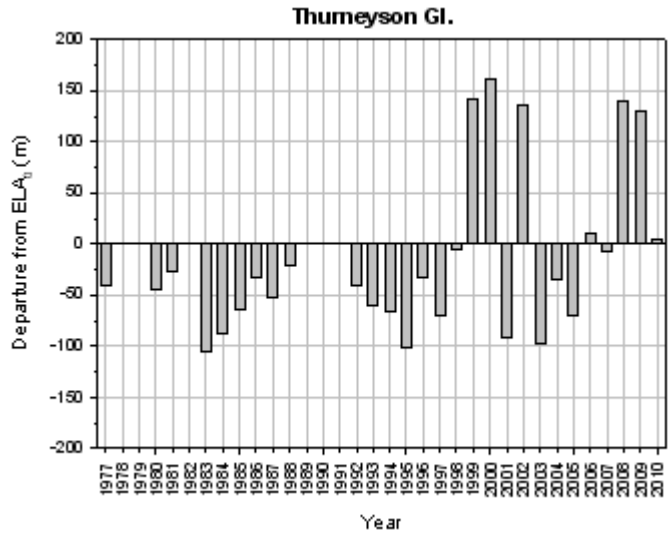


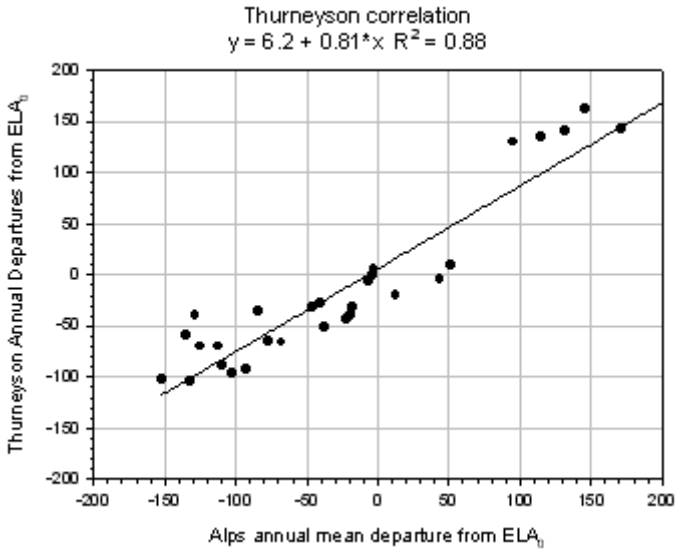


Photograph 30: Mt St Mary on 5 March 2010, resolution reduced to 200dpi.

No. 711B/12			THURNEYSTON GL.			NZMS 260 sheet G38	
			Mountain gl, reliability C				
	GLACIER DATA				**SNOWLINE DATA**		
	Aspect	S					
	AREA	117.8	ha		**ELA**	**1970**	m
	Max Elev	2450	m		Max SL	2132	m, 2000
	Min Elev	1720	m		Min SL	1865	m, 1983
	Mean Elev	2085	m		Mean SL	1955	m
	Length	1.23	km		SL Range	267	m
	Elev Range	730	m		No. Surveys	29	
	Gradient	0.59					
MEASUREMENTS		Digitised values shaded					

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELA m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1970**	**0**	**84.60**	**33.20**	**117.80**	**0.72**	**0**
1977	1930	-40	95.30	22.50	117.80	0.81	40
1978							
1979							
1980	1926	-44	98.00	19.80	117.80	0.83	44
1981	1943	-27	92.80	25.00	117.80	0.79	27
1982							
1983	1865	-105	109.80	8.00	117.80	0.93	105
1984	1882	-88	107.00	10.80	117.80	0.91	88
1985	1905	-65	103.40	14.40	117.80	0.88	65
1986	1938	-32	94.08	23.72	117.80	0.80	32
1987	1918	-52	100.30	17.50	117.80	0.85	52
1988	1950	-20	90.80	27.00	117.80	0.77	20
1989	1970	0	84.60	33.20	117.80	0.72	0
1990							
1991							
1992	1930	-40	95.30	22.50	117.80	0.81	40
1993	1910	-60	101.90	15.90	117.80	0.87	60
1994	1904	-66	103.40	14.40	117.80	0.88	66
1995	1868	-102	109.40	8.40	117.80	0.93	102
1996	1938	-32	94.08	23.72	117.80	0.80	32
1997	1900	-70	103.85	13.95	117.80	0.88	70
1998	1965	-5	85.28	32.52	117.80	0.72	5
1999	2112	142	38.69	79.11	117.80	0.33	-142
2000	2132	162	31.67	86.13	117.80	0.27	-162
2001	1878	-92	107.84	9.96	117.80	0.92	92
2002	2105	135	40.80	77.00	117.80	0.35	-135
2003	1873	-97	108.60	9.20	117.80	0.92	97
2004	1935	-35	95.30	22.50	117.80	0.81	35
2005	1900	-70	103.85	13.95	117.80	0.88	70
2006	1980	10	81.80	36.00	117.80	0.69	-10
2007	1963	-7	85.70	32.10	117.80	0.73	7
2008	2110	140	39.80	78.00	117.80	0.34	-140
2009	2100	130	42.80	75.00	117.80	0.36	-130
2010	1975	5	82.80	35.00	117.80	0.70	-5
MEAN	**1955**	**-15**	**87**	**30.60**		**0.74**	**15**





Photograph 31: Thurneyson Glacier on 5 March 2010, resolution reduced to 200dpi.

No. 868C-20

BREWSTER GL.

NZMS 260 sheet G38

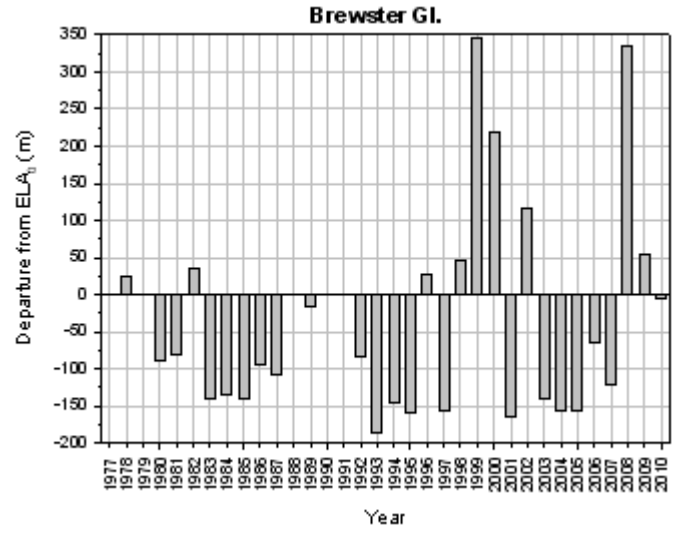
Mountain glacier

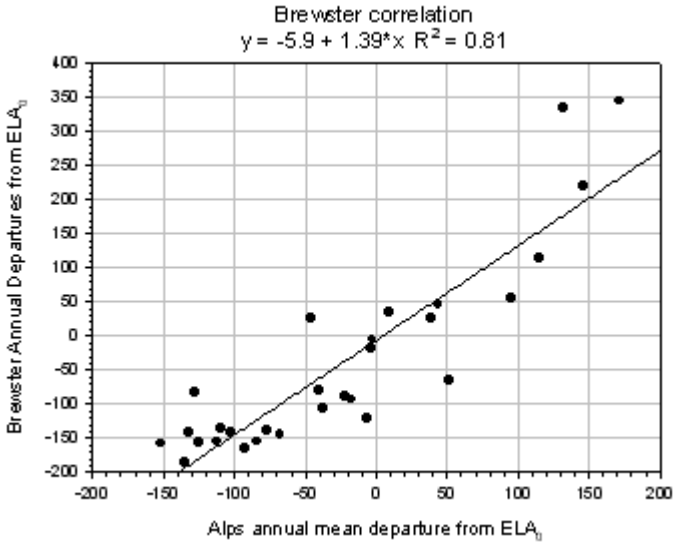
GLACIER DATA		
Aspect	S	
AREA	249.5	ha
Max Elev	2390	m
Min Elev	1655	m
Mean Elev	2023	m
Length	2.69	km
Elev Range	735	m
Gradient	0.27	

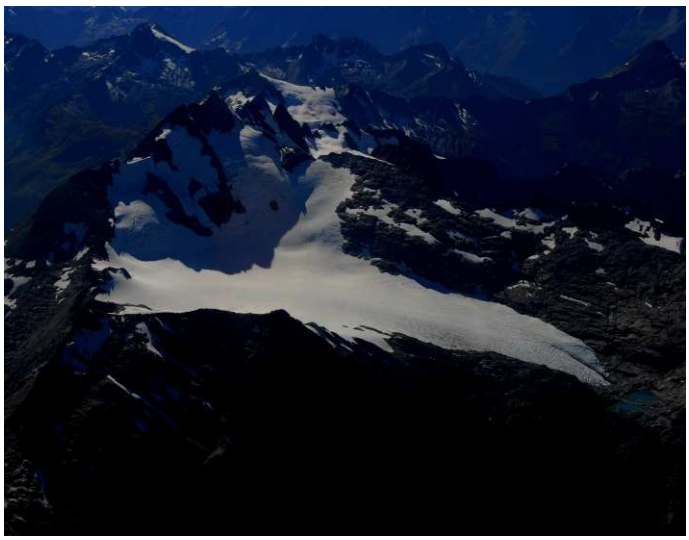
SNOWLINE DATA		
ELAo	**1935**	m
Max SL	2280	m, 1999
Min SL	1750	m, 1993
Mean SL	1896	m
SL Range	530	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM.	AREAS ABL.	TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1935**	**0**	**125.6**	128.0	**253.6**	**0.50**	**0**
1977							
1978	1960	25	98.7	154.9	253.6	0.39	-25
1979							
1980	1846	-89	193.5	60.1	253.6	0.76	89
1981	1855	-80	188.5	65.1	253.6	0.74	80
1982	1971	36	80.2	173.4	253.6	0.32	-36
1983	1794	-141	221.3	32.3	253.6	0.87	141
1984	1800	-135	218.4	35.2	253.6	0.86	135
1985	1796	-139	220.5	33.1	253.6	0.87	139
1986	1842	-93	195.5	58.1	253.6	0.77	93
1987	1828	-107	205.6	48.0	253.6	0.81	107
1988							
1989	1918	-17	140.4	113.2	253.6	0.55	17
1990							
1991							
1992	1851	-84	190.5	63.1	253.6	0.75	84
1993	1750	-185	234.7	18.9	253.6	0.93	185
1994	1790	-145	222.5	31.1	253.6	0.88	145
1995	1777	-158	227.6	26.0	253.6	0.90	158
1996	1962	27	89.9	163.7	253.6	0.35	-27
1997	1779	-156	226.3	27.0	253.3	0.89	156
1998	1982	47	67.0	186.1	253.1	0.26	-47
1999	2280	345	8.2	244.6	252.8	0.03	-345
2000	2155	220	29.2	223.4	252.5	0.12	-220
2001	1770	-165	228.7	20.8	252.2	0.91	165
2002	2050	115	203.0	49.0	252.0	0.81	-115
2003	1794	-141	222.7	29.0	251.7	0.88	141
2004	1780	-155	227.4	24.0	251.4	0.90	155
2005	1780	-155	227.4	23.7	251.1	0.91	155
2006	1870	-65	179.1	71.8	250.9	0.71	65
2007	1815	-120	211.8	38.8	250.6	0.85	120
2008	2270	335	8.4	241.1	249.5	0.03	-335
2009	1990	55	62.8	186.7	249.5	0.25	-55
2010	1930	-5	130.1	119.4	249.5	0.52	5
MEAN	**1896**	**-39**	**164**	**88**		**0.65**	**39**







Photograph 32: Brewster Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 752 I-104

Mt. STUART

NZMS 260 sheet G38

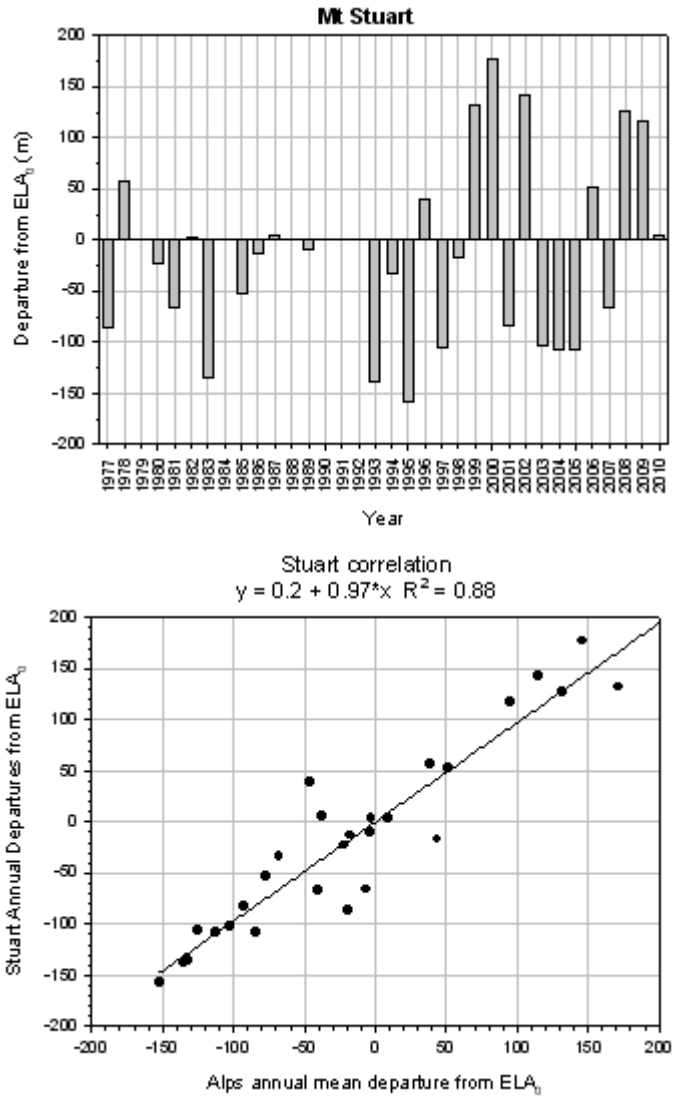
Moutain glacier

GLACIER DATA		
Aspect	SE	
AREA	31.55	ha
Max Elev	1860	m
Min Elev	1570	m
Mean Elev	1715	m
Length	0.54	km
Elev Range	290	m
Gradient	0.54	

SNOWLINE DATA		
ELAo	**1673**	m
Max SL	1850	m, 2000
Min SL	1515	m, 1995
Mean SL	1657	m
SL Range	335	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1673**	**0**	**21.05**	**5.00**	**26.05**	**0.81**	**0**
1977	**1587**	-86	30.86	0.69	31.55	0.98	86
1978	**1730**	57	18.53	13.02	31.55	0.59	-57
1979							
1980	**1650**	-23	27.25	4.30	31.55	0.86	23
1981	**1606**	-67	29.85	1.70	31.55	0.95	67
1982	**1676**	3	25.33	6.22	31.55	0.80	-3
1983	**1538**	-135	31.55	0.00	31.55	1.00	135
1984							
1985	**1620**	-53	29.10	2.45	31.55	0.92	53
1986	1660	-13	26.55	5.00	31.55	0.84	13
1987	**1678**	5	25.07	6.48	31.55	0.79	-5
1988							
1989	**1663**	-10	26.32	5.23	31.55	0.83	10
1990							
1991							
1992							
1993	**1535**	-138	31.55	0.00	31.55	1.00	138
1994	1640	-33	27.95	3.60	31.55	0.89	33
1995	**1515**	-158	31.55	0.00	31.55	1.00	158
1996	**1712**	39	21.20	10.35	31.55	0.67	-39
1997	**1567**	-106	31.55	0.00	31.55	1.00	106
1998	**1656**	-17	26.87	4.68	31.55	0.85	17
1999	**1805**	132	5.46	26.09	31.55	0.17	-132
2000	1850	177	0.95	25.10	26.05	0.04	-177
2001	**1590**	-83	25.09	0.96	26.05	0.96	83
2002	1815	142	4.45	21.60	26.05	0.17	-142
2003	1570	-103	26.05	0.00	26.05	1.00	103
2004	1565	-108	26.05	0.00	26.05	1.00	108
2005	1565	-108	26.05	0.00	26.05	1.00	108
2006	1725	52	16.85	9.20	26.05	0.65	-52
2007	1607	-66	24.65	1.40	26.05	0.95	66.00
2008	1800	127	6.35	19.70	26.05	0.24	-127.00
2009	1790	117	7.65	18.40	26.05	0.29	-117.00
2010	1677	4	20.45	5.60	26.05	0.79	-4.00
MEAN	**1657**	**-16**	**22.54**	**6.85**		**0.76**	**16**



Photograph 34: Stuart Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 867/2

LINDSAY GL.

NZMS 260 sheet F37

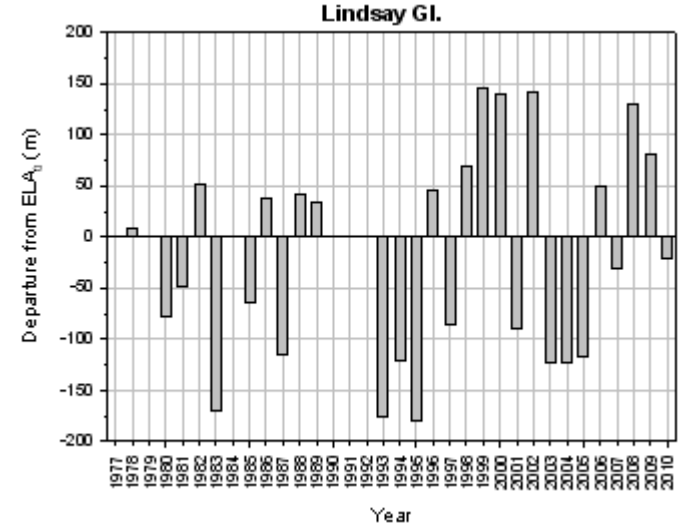
Mountain shelf glacier

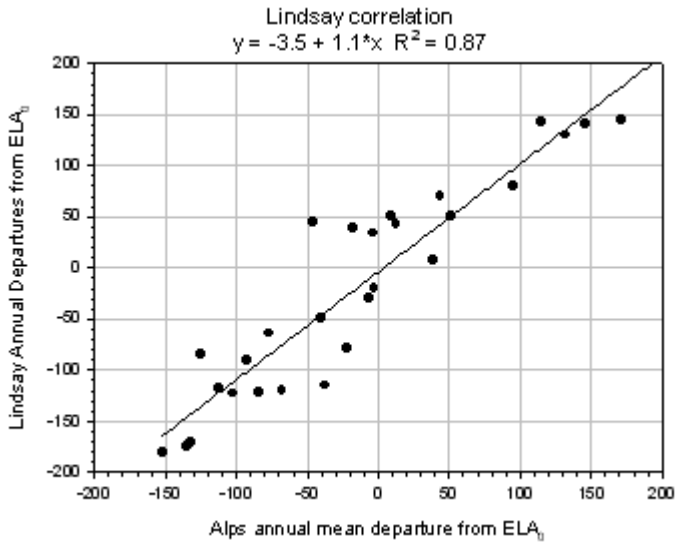
GLACIER DATA		
Aspect	S	
AREA	52.53	ha
Max Elev	1880	m
Min Elev	1610	m
Mean Elev	1745	m
Length	0.57	km
Elev Range	270	m
Gradient	0.47	

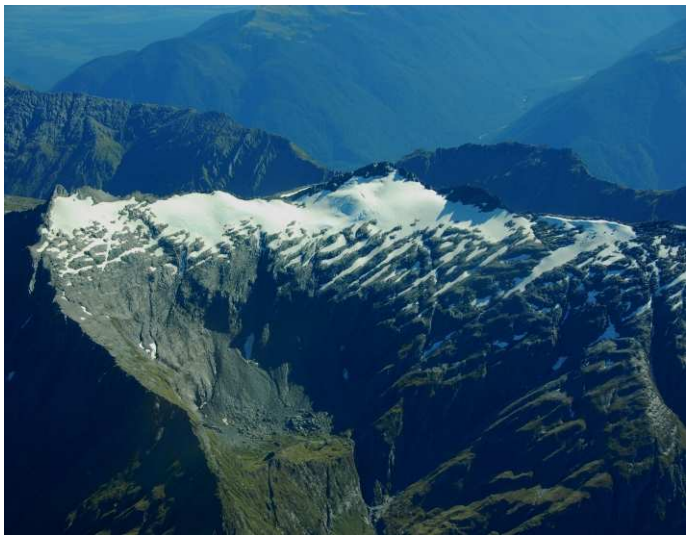
SNOWLINE DATA		
ELAo	**1730**	m
Max SL	1875	m, 1999
Min SL	1550	m, 1995
Mean SL	1710	m
SL Range	325	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1730**	**0**	**39.23**	**13.30**	**52.53**	**0.75**	**0**
1977							
1978	1738	8	37.09	15.44	52.53	0.71	-8
1979							
1980	1652	-78	50.51	2.02	52.53	0.96	78
1981	1681	-49	48.60	3.93	52.53	0.93	49
1982	1781	51	22.41	30.12	52.53	0.43	-51
1983	1560	-170	65.66	0.00	65.66	1.25	170
1984							
1985	1666	-64	49.63	2.90	52.53	0.94	64
1986	1768	38	27.53	25.00	52.53	0.52	-38
1987	1615	-115	52.33	0.20	52.53	1.00	115
1988	1772	42	24.63	27.90	52.53	0.47	-42
1989	1764	34	28.49	24.04	52.53	0.54	-34
1990							
1991							
1992							
1993	1555	-175	69.94	0.00	69.94	1.33	175
1994	1610	-120	52.53	0.00	52.53	1.00	120
1995	1550	-180	73.50	0.00	73.50	1.40	180
1996	1775	45	24.47	28.06	52.53	0.47	-45
1997	1645	-85	69.00	1.65	70.65	1.31	85
1998	1800	70	14.45	38.08	52.53	0.28	-70
1999	1875	145	0.94	51.59	52.53	0.02	-145
2000	1870	140	1.47	51.06	52.53	0.03	-140
2001	1640	-90	51.09	1.44	52.53	0.97	90
2002	1872	142	1.05	51.48	52.53	0.02	-142
2003	1607	-123	52.53	0.00	52.53	1.00	123
2004	1608	-122	52.53	0.00	52.53	1.00	122
2005	1612	-118	51.53	1.00	52.53	0.98	118
2006	1780	50	22.40	30.13	52.53	0.43	-50
2007	1700	-30	46.43	6.10	52.53	0.88	30
2008	1860	130	2.53	50.00	52.53	0.05	-130
2009	1810	80	11.93	40.60	52.53	0.23	-80
2010	1710	-20	44.53	8.00	52.53	0.85	20
MEAN	**1710**	**-20**	**37.49**	**17.53**		**0.71**	**20**







Photograph 35: Lindsay Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 752 E/51

FOG PK.

NZMS 260 sheet F39

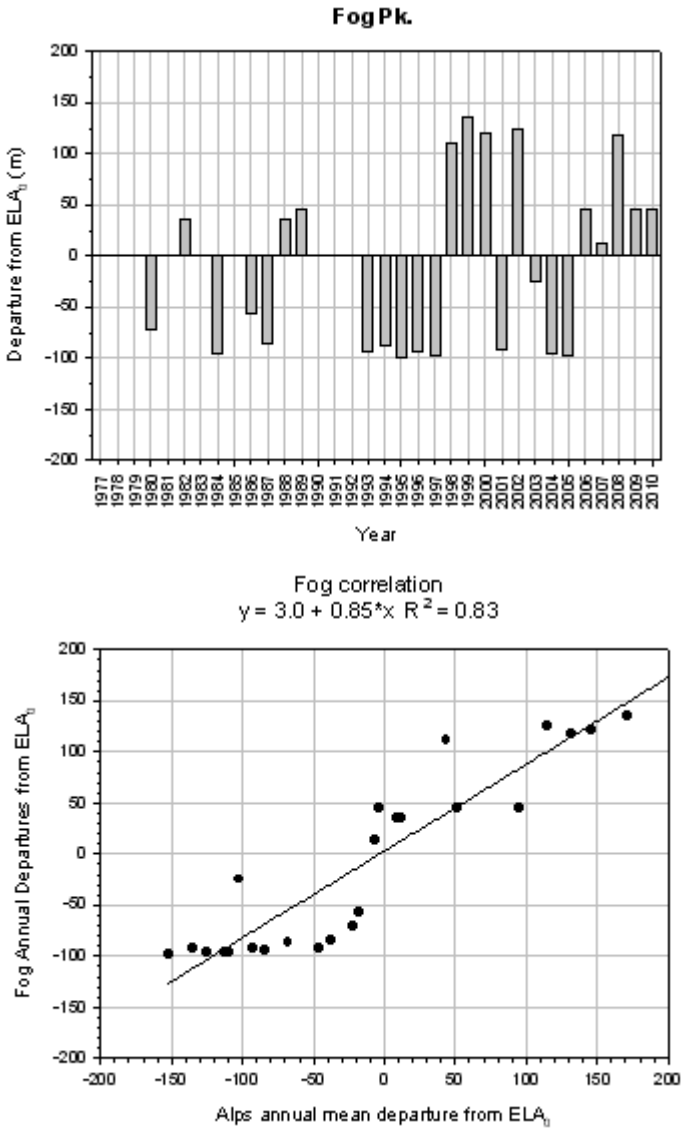
Cirque glacier

GLACIER DATA		
Aspect	SE	
AREA	18.22	ha
Max Elev	2150	m
Min Elev	1840	m
Mean Elev	1995	m
Length	0.4	km
Elev Range	310	m
Gradient	0.775	

SNOWLINE DATA		
ELAo	**1987**	m
Max SL	2122	m, 1999
Min SL	1888	m, 1995
Mean SL	1978	m
SL Range	234	m
No. Surveys	25	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1987**	**0**	**12.02**	**6.20**	**18.22**	**0.66**	**0**
1977							
1978							
1979							
1980	1916	-71	34.40	0.00	34.40	>1	71
1981							
1982	2022	35	14.75	3.47	18.22	0.81	-35
1983							
1984	1891	-96	42.80	0.00	42.80	>1	96
1985							
1986	1930	-57	30.40	0.00	30.40	>1	57
1987	1902	-85	39.00	0.00	39.00	>1	85
1988	2022	35	14.75	3.47	18.22	0.81	-35
1989	2032	45	6.62	11.60	18.22	0.36	-45
1990							
1991							
1992							
1993	1894	-93	37.80	0.00	37.80	>1	93
1994	1900	-87	17.58	0.64	18.22	0.96	87
1995	1888	-99	44.36	0.00	44.36	>1	99
1996	1894	-93	41.70	0.00	41.70	>1	93
1997	1890	-97	43.25	0.00	43.25	>1	97
1998	2098	111	1.77	16.45	18.22	0.10	-111
1999	2122	135	0.74	17.48	18.22	0.04	-135
2000	2108	121	1.28	16.94	18.22	0.07	-121
2001	1895	-92	17.42	0.80	18.22	0.96	92
2002	2112	125	1.13	17.09	18.22	0.06	-125
2003	1962	-25	15.40	2.82	18.22	0.85	25
2004	1892	-95	18.22	0.00	18.22	1.00	95
2005	1890	-97	18.22	0.00	18.22	1.00	97
2006	2032	45	6.62	11.60	18.22	0.36	-45
2007	2000	13	10.22	8.00	18.22	0.56	-13
2008	2105	118	1.42	16.80	18.22	0.08	-118
2009	2032	45	6.62	11.60	18.22	0.36	-45
2010	2032	45	6.62	11.60	18.22	0.36	-45
MEAN	**1978**	**-9**	**19.44**	**5.78**		**0.52**	**9**



Photograph 36: Fog Peak on 6 March 2010, resolution reduced to 200dpi.

No. 752C/103

SNOWY CK

NZMS 260 sheet E40

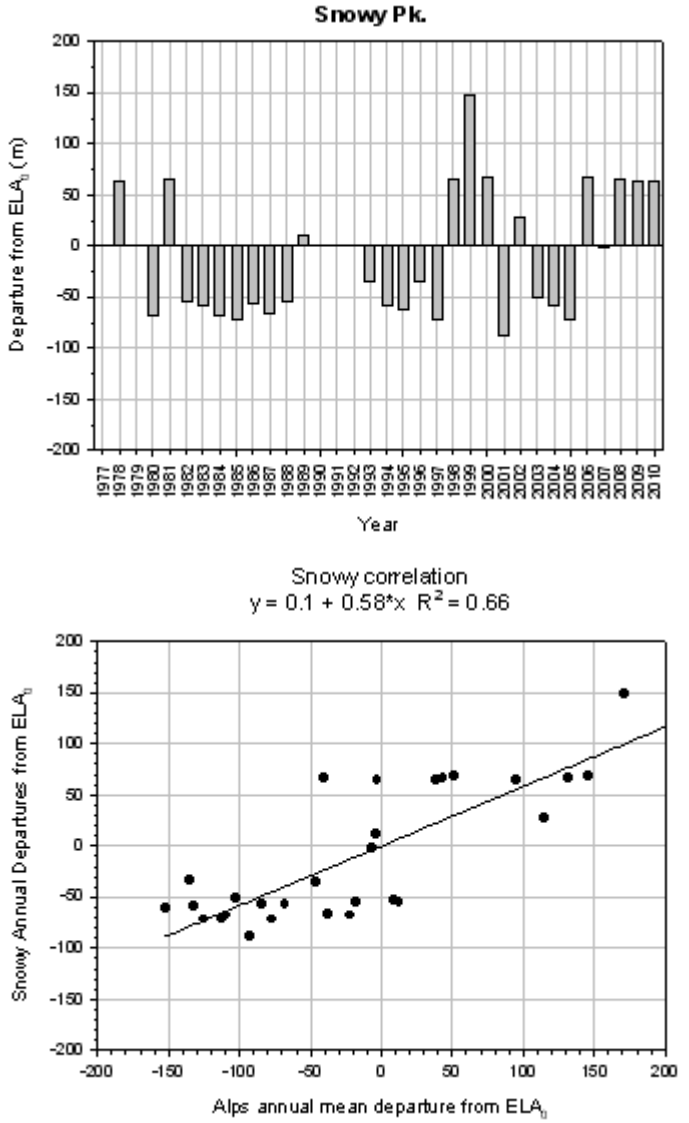
Small mountain glacier

GLACIER DATA		
Aspect	W	
AREA	53.13	ha
Max Elev	2210	m
Min Elev	2000	m
Mean Elev	2105	m
Length	0.73	km
Elev Range	210	m
Gradient	0.29	

SNOWLINE DATA		
ELAo	**2092**	m
Max SL	2240	m, 1999
Min SL	2004	m, 1997
Mean SL	2081	m
SL Range	236	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**2092**	**0**	**31.88**	**21.25**	**53.13**	**0.60**	**0**
1977							
1978	2156	64	6.86	46.27	53.13	0.13	-64
1979							
1980	2024	-68	48.36	4.77	53.13	0.91	68
1981	2158	66	6.42	46.71	53.13	0.12	-66
1982	2038	-54	45.43	7.70	53.13	0.86	54
1983	2033	-59	53.13	0.00	53.13	1.00	59
1984	2024	-68	48.33	4.80	53.13	0.91	68
1985	2020	-72	49.13	4.00	53.13	0.92	72
1986	2036	-56	45.93	7.20	53.13	0.86	56
1987	2025	-67	48.19	4.94	53.13	0.91	67
1988	2037	-55	45.93	7.20	53.13	0.86	55
1989	2103	11	28.18	24.95	53.13	0.53	-11
1990							
1991							
1992							
1993	2058	-34	40.69	12.44	53.13	0.77	34
1994	2034	-58	46.13	7.00	53.13	0.87	58
1995	2030	-62	47.13	6.00	53.13	0.89	62
1996	2057	-35	41.04	12.09	53.13	0.77	35
1997	2020	-72	64.34	-11.21	53.13	1.21	72
1998	2158	66	6.42	46.71	53.13	0.12	-66
1999	2240	148	53.13	0.00	53.13	1.00	-148
2000	2160	68	6.13	47.00	53.13	0.12	-68
2001	2004	-88	52.73	0.40	53.13	0.99	88
2002	2120	28	21.83	31.30	53.13	0.41	-28
2003	2041	-51	44.73	8.40	53.13	0.84	51
2004	2034	-58	53.13	0.00	53.13	1.00	58
2005	2020	-72	50.13	3.00	53.13	0.94	72
2006	2160	68	6.13	47	53.13	0.12	-68
2007	2090	-2	32.13	21.00	53.13	0.60	2
2008	2158	66	6.73	46.40	53.13	0.13	-66
2009	2156	64	6.86	46.27	53.13	0.13	-64
2010	2156	64	6.86	46.27	53.13	0.13	-64
MEAN	**2081**	**-11**	**35.90**	**17.23**		**0.68**	**11**



Photograph 37: Snowy Peak on 6 March 2010, resolution reduced to 200dpi.

No. 863B/1

Mt. CARIA

NZMS 260 sheet E39

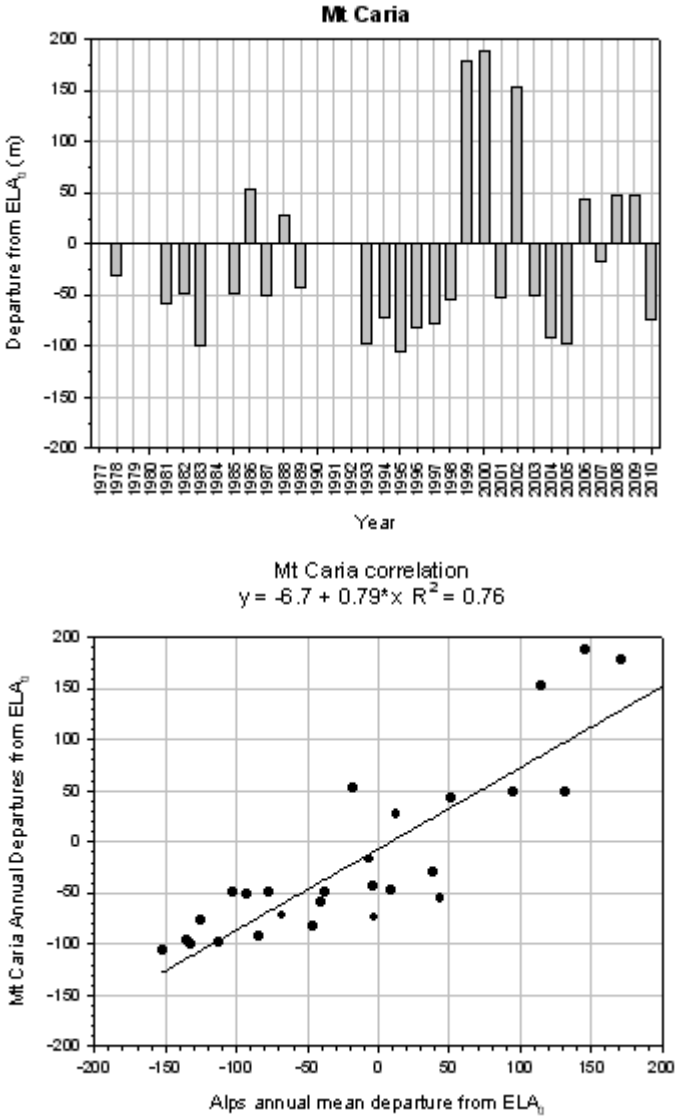
Small cirque

GLACIER DATA		
Aspect	SE	
AREA	17.13	ha
Max Elev	1600	m
Min Elev	1400	m
Mean Elev	1500	m
Length	0.3	km
Elev Range	200	m
Gradient	0.67	

SNOWLINE DATA		
ELAo	**1472**	m
Max SL	1660	m, 2000
Min SL	1366	m, 1995
Mean SL	1453	m
SL Range	294	m
No. Surveys	27	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1472**	**0**	**2.83**	**14.30**	**17.13**	**0.17**	**0**
1977							
1978	1442	-30	7.05	10.08	17.13	0.41	30
1979							
1980							
1981	1413	-59	13.66	3.47	17.13	0.80	59
1982	1424	-48	10.74	6.39	17.13	0.63	48
1983	1372	-100	42.80	0.00	42.8	2.50	100
1984							
1985	1423	-49	10.84	6.29	17.13	0.63	49
1986	1525	53	9.80	7.33	17.13	0.57	-53
1987	1422	-50	11.06	6.07	17.13	0.65	50
1988	1500	28	6.43	10.70	17.13	0.38	-28
1989	1429	-43	9.80	7.33	17.13	0.57	43
1990							
1991							
1992							
1993	1375	-97	35.98	0.00	35.98	2.10	97
1994	1400	-72	17.13	0.00	17.13	1.00	72
1995	1366	-106	54.48	0.00	54.48	3.18	106
1996	1390	-82	22.00	0.00	22	1.28	82
1997	1395	-77	19.50	0.00	19.5	1.14	77
1998	1417	-55	12.46	4.67	17.13	0.73	55
1999	1650	178	0.00	17.13	17.13	0.00	-178
2000	1660	188	0.00	8.74	8.74	0.00	-188
2001	1420	-52	9.15	3.50	12.65	0.72	52
2002	1625	153	0.00	8.74	8.74	0.00	-153
2003	1422	-50	8.14	0.60	8.74	0.93	50
2004	1380	-92	8.74	0.00	8.74	1.00	92
2005	1374	-98	35.98	0.00	35.98	1.00	98
2006	1515	43	0.74	8.00	8.74	0.08	-43
2007	1455	-17	3.74	5.00	8.74	0.43	17
2008	1520	48	0.44	8.30	8.74	0.05	-48
2009	1520	48	0.44	8.30	8.74	0.05	-48
2010	1398	-74	8.74	0.00	8.74	1.00	74
MEAN	**1453**	**-19**	**13.33**	**4.84**		**0.80**	**17**



Photograph 38: Mt Caria on 6 March 2010, resolution reduced to 200dpi.

No. 859/9

FINDLAY GL.

NZMS 260 sheet E39

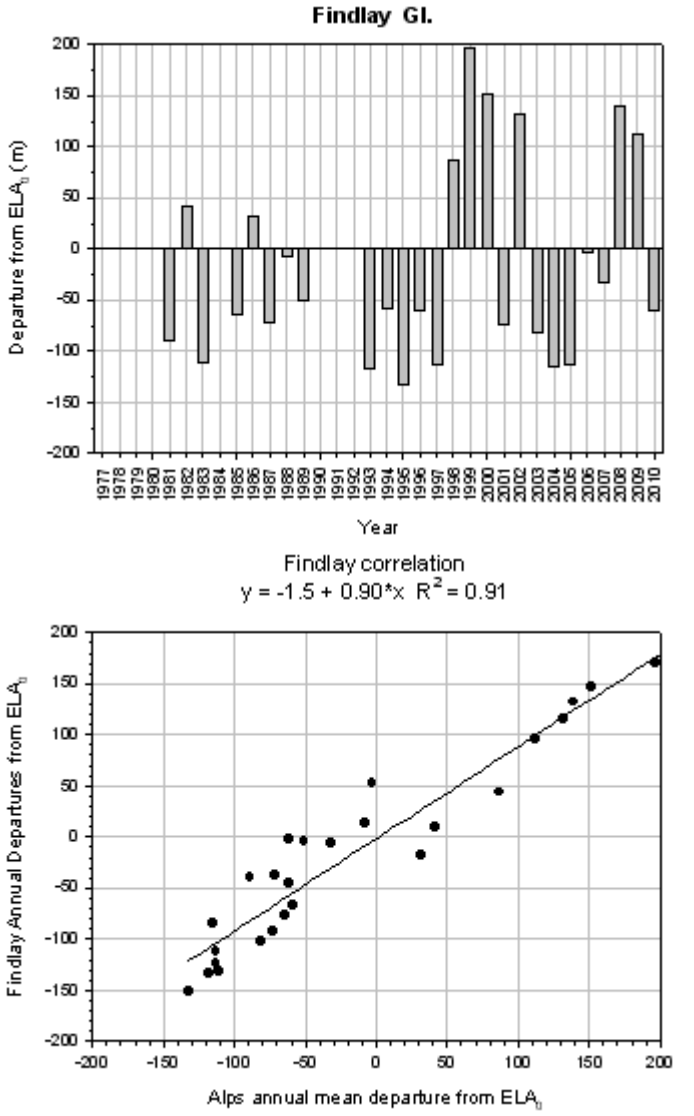
Cirque glacier

GLACIER DATA		
Aspect	SW	
AREA	67.15	ha
Max Elev	1900	m
Min Elev	1550	m
Mean Elev	1725	m
Length	0.875	km
Elev Range	350	m
Gradient	0.4	

SNOWLINE DATA		
ELAo	**1693**	m
Max SL	1890	m, 1999
Min SL	1561	m, 1995
Mean SL	1675	m
SL Range	329	m
No. Surve	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1693**	**0**	**35.95**	**31.2**	**67.15**	**0.54**	**0**
1977							
1978							
1979							
1980							
1981	1604	-89	57.53	9.62	67.15	0.86	89
1982	1735	42	25.85	41.30	67.15	0.38	-42
1983	1582	-111	61.52	5.63	67.15	0.92	111
1984							
1985	1629	-64	48.89	18.26	67.15	0.73	64
1986	1725	32	27.95	39.20	67.15	0.42	-32
1987	1622	-71	51.05	16.10	67.15	0.76	71
1988	1685	-8	35.15	32.00	67.15	0.52	8
1989	1642	-51	44.15	23.00	67.15	0.66	51
1990							
1991							
1992							
1993	1575	-118	62.90	4.25	67.15	0.94	118
1994	1634	-59	46.87	20.28	67.15	0.70	59
1995	1561	-132	65.17	1.98	67.15	0.97	132
1996	1632	-61	47.54	19.61	67.15	0.71	61
1997	1580	-113	62.00	5.15	67.15	0.92	113
1998	1780	87	22.91	35.49	58.4	0.39	-87
1999	1890	197	2.11	51.44	53.55	0.04	-197
2000	1845	152	7.28	44.32	51.6	0.14	-152
2001	1620	-73	45.36	8.80	54.16	0.84	73
2002	1825	132	10.79	46.63	51.6	0.21	-132
2003	1612	-81	42.40	11.80	54.2	0.78	81
2004	1578	-115	49.80	4.40	54.2	0.92	115
2005	1580	-113	49.80	4.40	54.2	0.92	113
2006	1690	-3	31.95	22.21	54.16	0.59	3
2007	1661	-32	35.06	19.10	54.16	0.65	32
2008	1832	139	8.50	45.66	54.16	0.16	-139
2009	1805	112	14.96	39.20	54.16	0.28	-112
2010	1632	-61	41.66	12.50	54.16	0.77	61
Mean	**1675**	**-18**	**39.27**	**22.11**		**0.63**	**18**



Photograph 39: Findlay Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 752 B/48

PARK PASS GL.

NZMS 260 sheet E 40

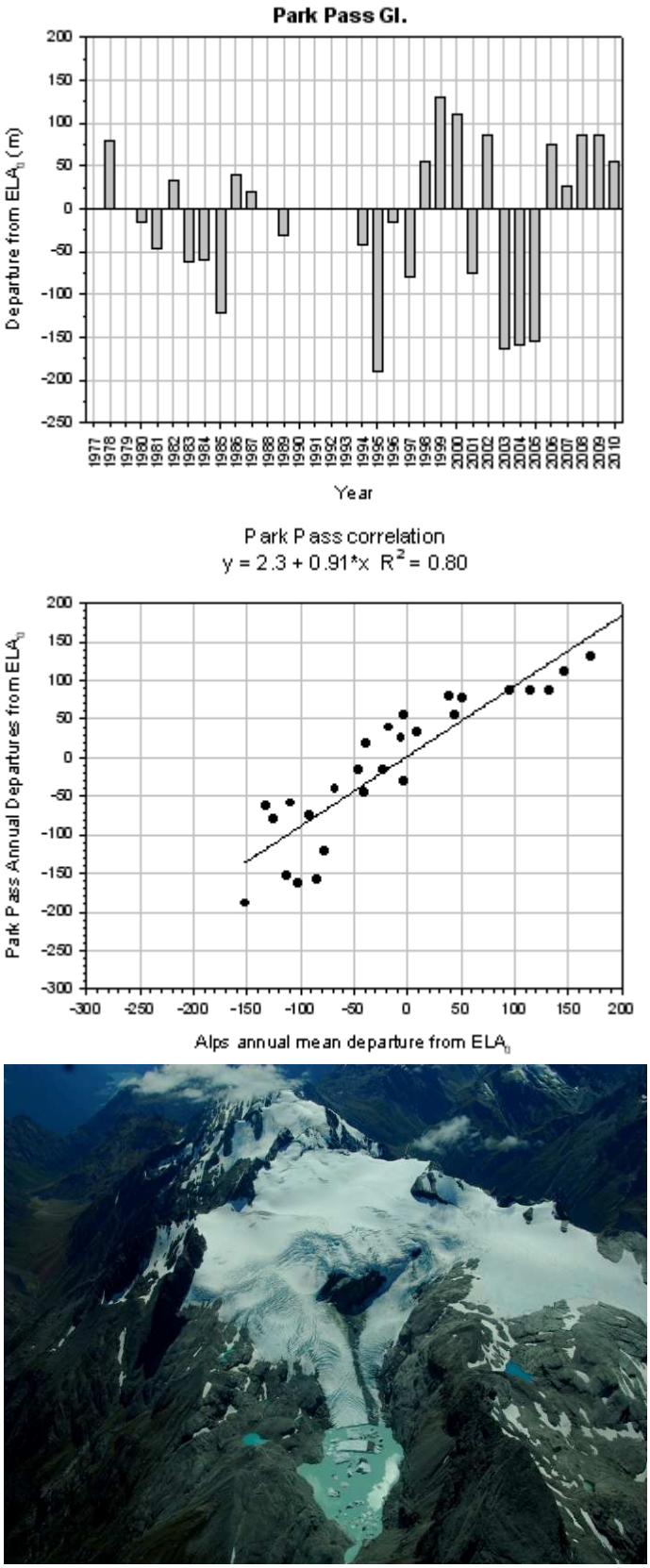
Valley glacier

GLACIER DATA		
Aspect	S	
AREA	191.2	ha
Max Elev	2200	m
Min Elev	1500	m
Mean Elev	1850	m
Length	2.63	km
Elev Range	700	m
Gradient	0.267	

SNOWLINE DATA		
ELAo	**1824**	m
Max SL	1955	m, 1999
Min SL	1635	m, 1995
Mean SL	1812	m
SL Range	320	m
No. Surveys	27	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1824**	**0**	**127.90**	**85.70**	**213.60**	**0.60**	**0**
1977							
1978	1903	79	91.29	122.31	213.60	0.43	-79
1979							
1980	1808	-16	131.60	82.00	213.60	0.62	16
1981	1778	-46	139.20	74.40	213.60	0.65	46
1982	1858	34	112.40	101.20	213.60	0.53	-34
1983	1762	-62	142.67	70.93	213.60	0.67	62
1984	1765	-59	141.60	72.00	213.60	0.66	59
1985	1702	-122	156.60	57.00	213.60	0.73	122
1986	1863	39	110.10	103.50	213.60	0.52	-39
1987	1843	19	117.60	96.00	213.60	0.55	-19
1988							
1989	1794	-30	134.60	79.00	213.60	0.63	30
1990							
1991							
1992							
1993							
1994	1783	-41	151.40	55.00	206.40	0.73	41
1995	1635	-189	187.60	18.30	205.90	0.91	189
1996	1808	-16	147.17	58.23	205.40	0.72	16
1997	1745	-79	160.20	44.10	204.30	0.78	79
1998	1880	56	105.80	95.60	201.40	0.53	-56
1999	1955	131	62.07	136.03	198.10	0.31	-131
2000	1935	111	71.34	124.66	196.00	0.36	-111
2001	1748	-76	149.44	45.36	194.80	0.77	76
2002	1910	86	82.82	111.18	194.00	0.43	-86
2003	1661	-163	166.80	26.50	193.30	0.86	163
2004	1665	-159	162.60	30.00	192.60	0.84	159
2005	1670	-154	161.00	31.00	192.00	0.84	154
2006	1900	76	86.20	105.00	191.20	0.45	-76
2007	1850	26	109.50	80.40	189.90	0.58	-26
2008	1910	86	81.20	107.30	188.50	0.43	-86
2009	1910	86	79.80	107.30	187.10	0.43	-86
2010	1880	56	95.20	91.50	186.70	0.51	-56
Mean	**1812**	**-12**	**123.62**	**78.73**		**0.61**	**12**



Photograph 40: Park Pass Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 752 E/2

MT. LARKINS

NZMS sheet E 41

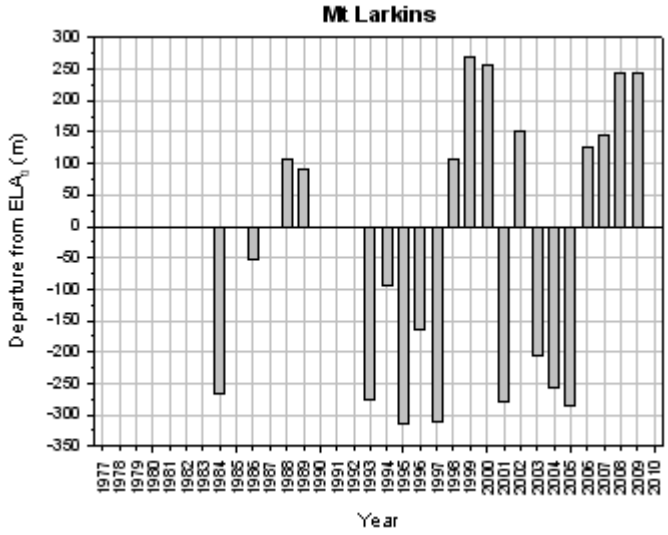
Glacierette

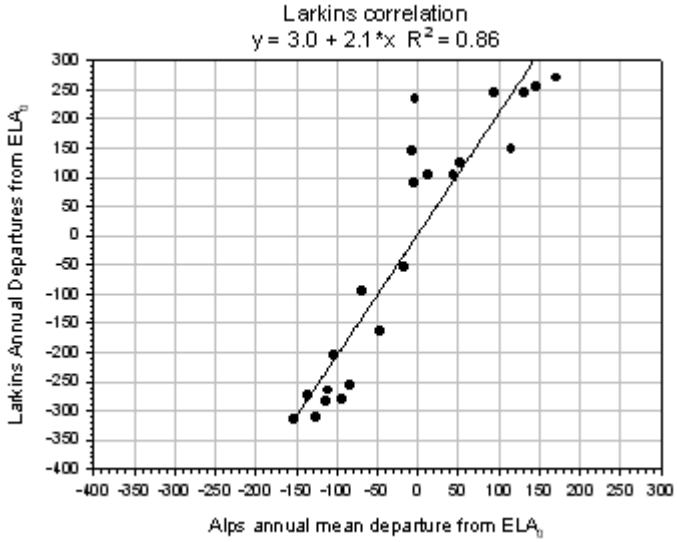
GLACIER DATA		
Aspect	SE	
AREA	27.47	ha
Max Elev	2220	m
Min Elev	1680	m
Mean Elev	1950	m
Length	0.5	km
Elev Range	540	m
Gradient	1.08	

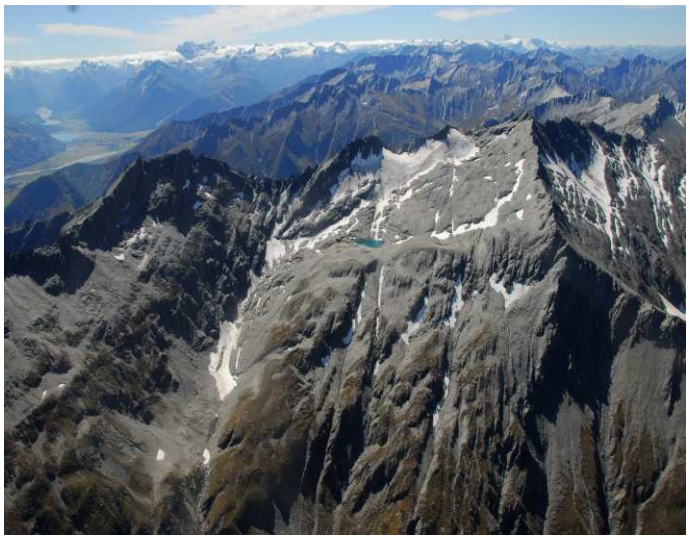
SNOWLINE DATA		
ELAo	**1945**	m
Max. SL	2215	m, 1998
Min. SL	1630	m, 1995
Mean SL	1921	m
SL Range	585	m
No. surveys	23	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1945**	**0**	**17.67**	**9.80**	**27.47**	**0.64**	**0**
1977							
1978							
1979							
1980							
1981							
1982							
1983							
1984	1680	-265	33.82	0.00	33.82	1.23	265
1985							
1986	1892	-53	33.82	0.00	33.82	1.23	53
1987							
1988	2050	105	9.47	18.00	27.47	0.34	-105
1989	2036	91	10.84	16.63	27.47	0.39	-91
1990							
1991							
1992							
1993	1670	-275	39.50	0.00	39.50	1.44	275
1994	1850	-95	23.40	4.07	27.47	0.85	95
1995	1630	-315	43.61	0.00	43.61	1.59	315
1996	1782	-163	27.47	0.00	27.47	1.00	163
1997	1633	-312	36.80	0.00	36.80	1.34	312
1998	2050	105	0.92	26.55	27.47	0.03	-105
1999	2215	270	0.95	26.52	27.47	0.03	-270
2000	2200	255	1.46	14.75	16.21	0.09	-255
2001	1665	-280	27.47	0.00	27.47	1.00	280
2002	2095	150	2.17	14.04	16.21	0.13	-150
2003	1740	-205	15.51	0.70	16.21	0.96	205
2004	1690	-255	27.47	0.00	27.47	1.00	255
2005	1660	-285	27.47	0.00	27.47	1.00	285
2006	2070	125	1.46	14.75	16.21	0.09	-125
2007	2090	145	2.20	14.01	16.21	0.14	-145
2008	2190	245	1.50	14.62	16.12	0.09	-245
2009	2189	244	1.60	14.52	16.12	0.10	-244
2010	2180	235	2.20	13.92	16.12	0.14	-235
MEAN	**1921**	**-24**	**16.87**	**8.78**		**0.65**	**24**







Photograph 43: Mt Larkins on 6 March 2010, resolution reduced to 200dpi.

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No. 752B/25

BRYANT GL.

NZMS sheet E41

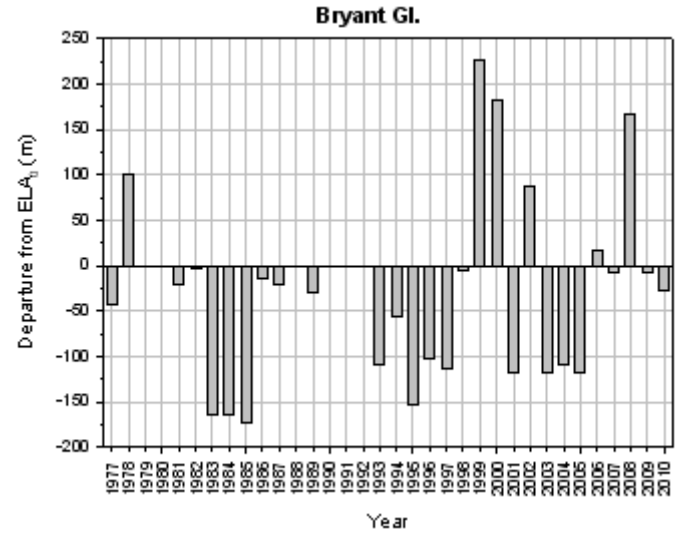
Mountain glacier

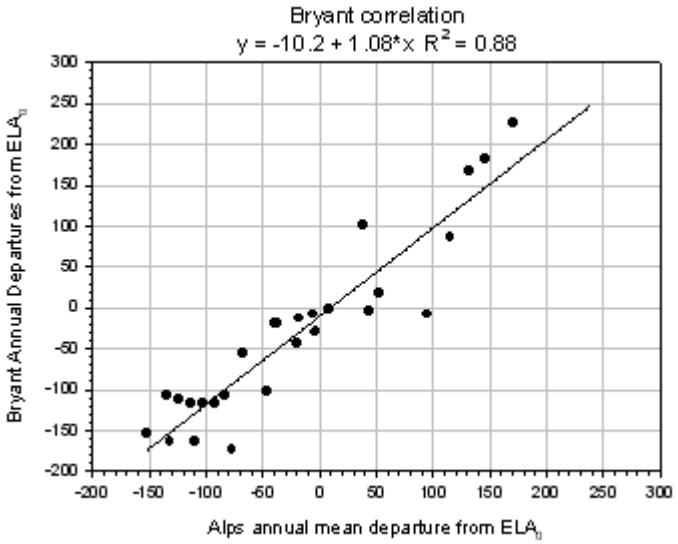
GLACIER DATA		
Aspect	SE	
AREA	29.7	ha
Max Elev	2180	m
Min Elev	1660	m
Mean Elev	1920	m
Length	0.94	km
Elev Range	520	m
Gradient	0.55	

SNOWLINE DATA		
ELAo	**1783**	m
Max. SL	2010	m, 1999
Min. SL	1610	m, 1995
Mean SL	1751	m
SL Range	400	m
No. surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1783**	**0**	**12.20**	**17.50**	**29.7**	**0.41**	**0**
1977	1740	-43	20.90	8.80	29.7	0.70	43
1978	1884	101	4.90	24.80	29.7	0.16	-101
1979							
1980							
1981	1763	-20	15.70	14.00	29.7	0.53	20
1982	1780	-3	12.70	17.00	29.7	0.43	3
1983	1620	-163	34.50	0.00	29.7	1.00	163
1984	1620	-163	31.80	0.00	29.7	1.00	163
1985	1610	-173	37.30	0.00	29.7	1.00	173
1986	1770	-13	14.08	15.62	29.7	0.47	13
1987	1763	-20	15.70	14.00	29.7	0.53	20
1988							
1989	1753	-30	17.40	12.30	29.7	0.59	30
1990							
1991							
1992							
1993	1675	-108	17.20	12.50	29.7	0.58	108
1994	1728	-55	23.40	6.30	29.7	0.79	55
1995	1630	-153	40.17	0.00	29.7	1.00	153
1996	1680	-103	29.10	0.60	29.7	0.98	103
1997	1670	-113	29.01	0.69	29.7	0.98	113
1998	1778	-5	13.16	16.54	29.7	0.44	5
1999	2010	227	0.97	28.73	29.7	0.03	-227
2000	1965	182	1.85	27.85	29.7	0.06	-182
2001	1665	-118	29.20	0.50	29.7	0.98	118
2002	1870	87	5.50	24.20	29.7	0.19	-87
2003	1666	-117	28.80	0.90	29.7	0.97	117
2004	1675	-108	29.06	0.64	29.7	0.98	108
2005	1665	-118	28.80	0.90	29.7	0.97	118
2006	1800	17	10.10	19.60	29.7	0.34	-17
2007	1775	-8	13.50	16.20	29.7	0.45	8
2008	1950	167	2.30	27.40	29.7	0.08	-167
2009	1775	-8	13.50	16.20	29.7	0.45	8
2010	1755	-28	17.70	12.00	29.7	0.60	28
MEAN	**1751**	**-32**	**19.23**	**11.37**		**0.62**	**32**





Photograph 45: Bryant Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 752B-13

AILSA MTS

NZMS 260 sheet D40

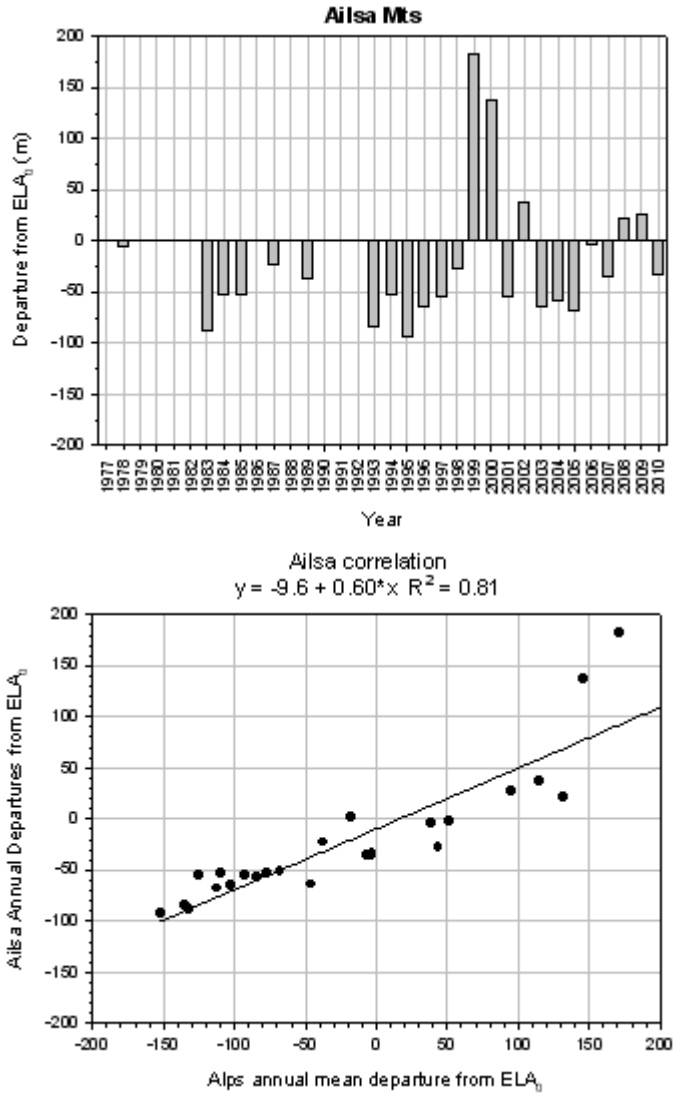
Cirque glacier

GL DATA		
Aspect	S	
AREA	22.91	ha
Max Elev	1830	m
Min Elev	1530	m
Mean Elev	1680	m
Length	0.75	km
Elev Range	300	m
Gradient	0.4	

SNOWLINE DATA		
ELAo	**1648**	m
Max SL	1830	m, 1999
Min SL	1555	m, 1995
Mean SL	1626	m
SL Range	275	m
No. surveys	25	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1648**	**0**	**7.72**	**10.50**	**18.22**	**0.42**	**0**
1977							
1978	1643	-5	9.32	13.59	22.91	0.41	5
1979							
1980							
1981							
1982							
1983	1560	-88	17.65	3.70	21.35	0.77	88
1984	1595	-53	13.20	8.00	21.2	0.58	53
1985	1595	-53	13.10	8.00	21.1	0.57	53
1986	1649	1	8.57	12.23	20.8	0.37	-1
1987	1625	-23	11.48	8.72	20.2	0.50	23
1988							
1989	1612	-36	9.97	10.13	20.1	0.44	36
1990							
1991							
1992							
1993	1564	-84	15.43	4.10	19.53	0.67	84
1994	1596	-52	11.06	8.20	19.26	0.48	52
1995	1555	-93	15.87	3.12	18.99	0.69	93
1996	1584	-64	12.06	6.64	18.7	0.53	64
1997	1593	-55	12.16	6.28	18.44	0.53	55
1998	1621	-27	11.91	4.99	16.9	0.52	27
1999	1830	182	0.00	22.91	15.3	0.00	-182
2000	1785	137	0.77	22.14	14.79	0.05	-137
2001	1593	-55	9.51	5.28	14.79	0.64	55
2002	1685	37	4.35	13.87	14.5	0.30	-37
2003	1583	-65	12.20	2.00	14.2	0.86	65
2004	1590	-58	11.74	2.31	14.05	0.84	58
2005	1580	-68	11.99	1.96	13.95	0.86	68
2006	1645	-3	6.90	7.00	13.9	0.50	3
2007	1613	-35	9.80	4.10	13.9	0.71	35
2008	1670	22	3.70	10.20	13.9	0.27	-22
2009	1675	27	3.30	10.60	13.9	0.24	-27
2010	1615	-33	9.90	4.00	13.9	0.71	33
MEAN	**1626**	**-22**	**9.84**	**8.16**		**0.52**	**22**



Photograph 47: Ailsa Glacier on 6 March 2010, resolution reduced to 200dpi.

No. 851B/57

Mt. GUNN

NZMS 260 sheet D40

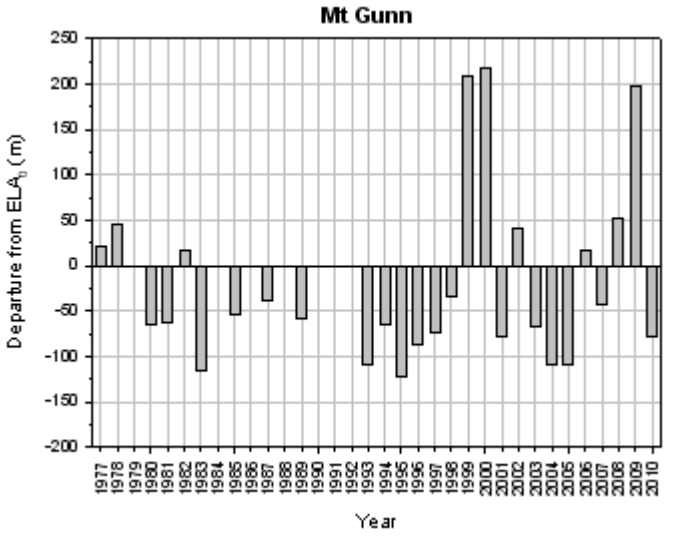
Cirque glacier

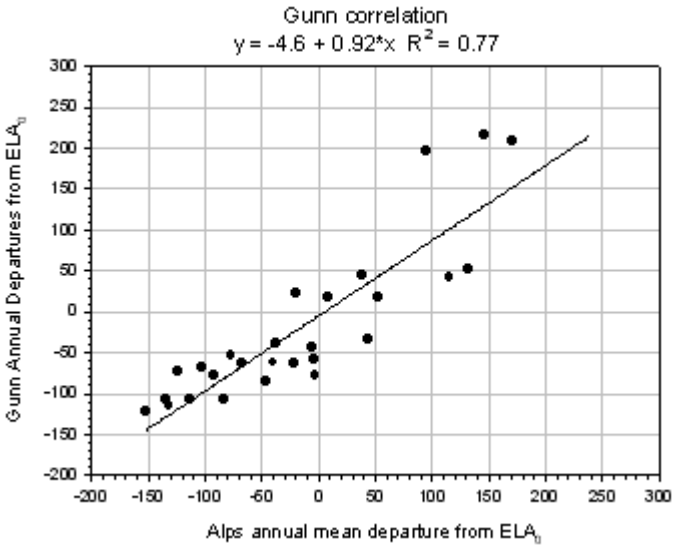
GLACIER DATA		
Aspect	SE	
AREA	53.72	ha
Max Elev	1860	m
Min Elev	1470	m
Mean Elev	1665	m
Length	0.75	km
Elev Range	390	m
Gradient	0.52	

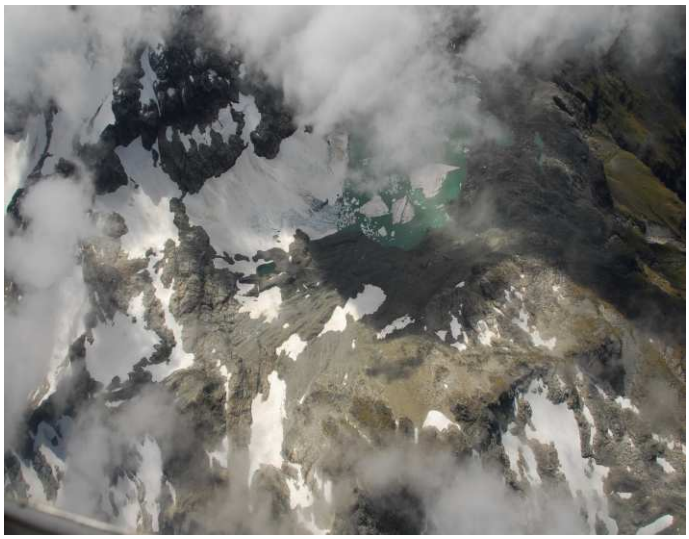
SNOWLINE DATA		
ELAo	**1593**	m
Max SL	1810	m, 2000
Min SL	1471	m, 1995
Mean SL	1573	m
SL Range	339	m
No. surveys	27	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM.	AREAS ABL.	TOTAL	ACCUM. AREA RATIO	MASS BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	**1593**	**0**	**14.67**	**21.00**	**35.67**	**0.41**	**0**
1977	1615	22	14.72	39.00	53.72	0.27	-22
1978	1638	45	12.11	41.61	53.72	0.23	-45
1979							
1980	1529	-64	33.40	20.32	53.72	0.62	64
1981	1531	-62	32.44	21.28	53.72	0.60	62
1982	1610	17	15.50	38.22	53.72	0.29	-17
1983	1478	-115	51.31	2.41	53.72	0.96	115
1984							
1985	1540	-53	30.24	23.48	53.72	0.56	53
1986							
1987	1555	-38	26.32	27.40	53.72	0.49	38
1988							
1989	1534	-59	31.84	20.60	52.44	0.59	59
1990							
1991							
1992							
1993	1485	-108	48.12	2.68	50.80	0.90	108
1994	1529	-64	33.40	16.58	49.98	0.62	64
1995	1471	-122	54.00	0.00	49.00	1.01	122
1996	1507	-86	40.12	7.58	47.70	0.75	86
1997	1520	-73	36.19	10.01	46.20	0.67	73
1998	1559	-34	25.42	19.29	44.71	0.47	34
1999	1802	209	0.77	41.73	42.50	0.01	-209
2000	1810	217	0.49	40.49	40.98	0.01	-217
2001	1515	-78	33.93	6.80	40.73	0.83	78
2002	1635	42	8.83	31.65	40.48	0.22	-42
2003	1525	-68	32.63	7.60	40.23	0.81	68
2004	1485	-108	37.88	2.10	39.98	0.95	108
2005	1485	-108	37.63	2.10	39.73	0.95	108
2006	1610	17	22.18	17.30	39.48	0.56	-17
2007	1550	-43	28.60	9.50	38.10	0.75	43
2008	1645	52	19.00	18.00	37.00	0.51	-52
2009	1790	197	7.10	28.55	35.65	0.20	-197
2010	1515	-78	33.30	0.70	34.00	0.98	78
MEAN	**1573**	**-20**	**27.47**	**19.09**		**0.57**	**20**



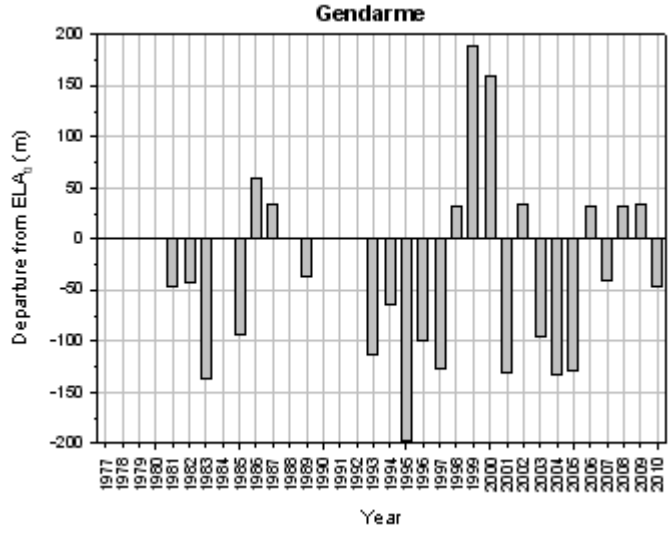


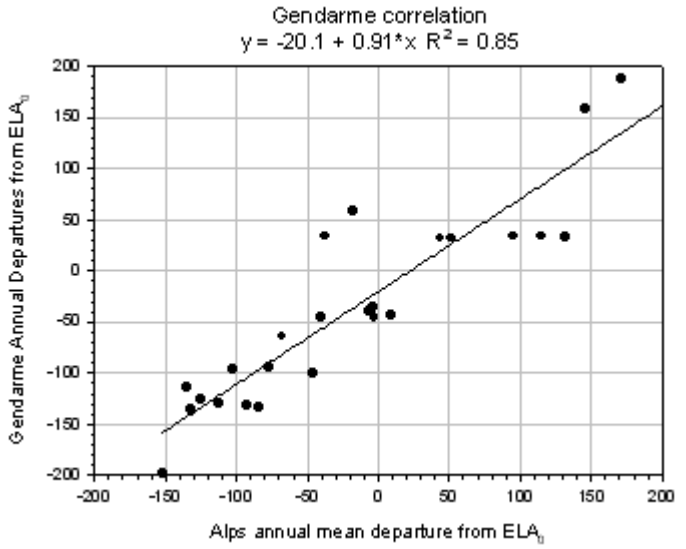


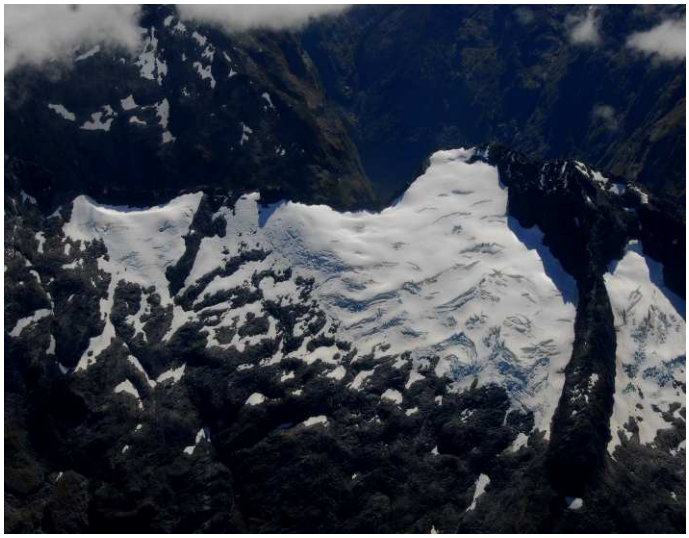
Photograph 48: Mt Gunn on 6 March 2010, resolution reduced to 200dpi.

No. 797G/33			**Mt. GENDARME**			NZMS sheet D40 & 41	
			Mountain gl, reiability B				
	GLACIER DATA				**SNOWLINE DATA**		
	Aspect	S					
	Area	49.35	ha		**ELA**	**1616**	m
	Max Elev	1900	m		Max SL	1804	m, 1999
	Min Elev	1440	m		Min SL	1418	m, 1995
	Mean Elev	1670	m		Mean SL	1579	m
	Length	0.525	km		SL range	386	m
	Elev Range	460	m		No. surveys	25	
	Gradient	0.88					
MEASUREMENTS		Digitised values shaded					

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELA m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1616**	**0**	**31.85**	**17.50**	**49.35**	**0.65**	**0**
1977							
1978							
1979							
1980							
1981	1570	-46	38.36	10.99	49.35	0.78	46
1982	1573	-43	37.85	11.50	49.35	0.77	43
1983	1480	-136	55.97	0.00	55.97	1.13	136
1984							
1985	1522	-94	44.53	4.82	49.35	0.90	94
1986	1675	59	21.95	27.40	49.35	0.44	-59
1987	1650	34	25.87	23.48	49.35	0.52	-34
1988							
1989	1580	-36	35.50	13.85	49.35	0.72	36
1990							
1991							
1992							
1993	1502	-114	46.42	2.93	49.35	0.94	114
1994	1552	-64	40.55	8.80	49.35	0.82	64
1995	1418	-198	58.67	0.00	58.67	1.19	198
1996	1516	-100	45.20	4.15	49.35	0.92	100
1997	1490	-126	47.25	2.10	49.35	0.96	126
1998	1648	32	26.45	22.90	49.35	0.54	-32
1999	1804	188	2.33	47.02	49.35	0.05	-188
2000	1775	159	6.08	43.27	49.35	0.12	-159
2001	1485	-131	48.45	0.90	49.35	0.98	131
2002	1650	34	25.85	23.50	49.35	0.52	-34
2003	1520	-96	47.95	1.40	49.35	0.97	96
2004	1483	-133	49.35	0.00	49.35	1.00	133
2005	1487	-129	49.35	0.00	49.35	1.00	129
2006	1648	32	26.45	22.90	49.35	0.54	-32
2007	1576	-40	37.35	12.00	49.35	0.76	40
2008	1649	33	25.90	23.45	49.35	0.52	-33
2009	1650	34	25.85	23.50	49.35	0.52	-34
2010	1570	-46	38.36	10.99	49.35	0.78	46
MEAN	**1579**	**-37**	**36.31**	**13.67**		**0.74**	**37**







Photograph 50: Mt Genderme on 6 March 2010, resolution reduced to 200dpi.

No. 846/35

LlAWRENNY PKS.

NZMS 260 sheet D40

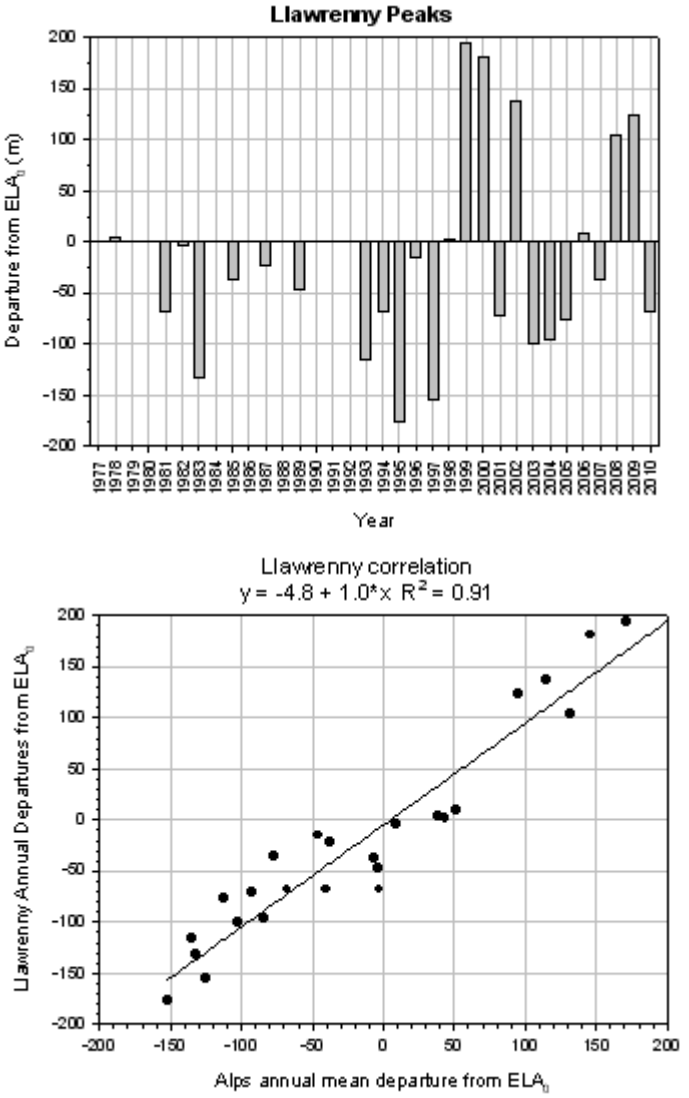
Cirque glacier

GLACIER DATA		
Aspect	SW	
AREA	18.06	ha
Max Elev	1680	m
Min Elev	1310	m
Mean Elev	1495	m
Length	0.75	km
Elev Range	370	m
Gradient	0.49	

SNOWLINE DATA		
ELAo	**1476**	m
Max SL	1670	m, 1999
Min SL	1300	m, 1995
Mean SL	1455	m
SL Range	370	m
No. surveys	25	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	AREAS ACCUM. ha	AREAS ABL. ha	AREAS TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1476**	**0**	**9.26**	**8.80**	**18.06**	**0.51**	**0**
1977							
1978	1480	4	8.96	9.10	18.06	0.50	-4
1979							
1980							
1981	1408	-68	15.56	2.50	18.06	0.86	68
1982	1472	-4	9.35	8.71	18.06	0.52	4
1983	1344	-132	17.46	0.60	18.06	0.97	132
1984							
1985	1440	-36	12.77	5.29	18.06	0.71	36
1986							
1987	1454	-22	11.40	6.66	18.06	0.63	22
1988							
1989	1429	-47	13.96	4.10	18.06	0.77	47
1990							
1991							
1992							
1993	1360	-116	17.12	0.94	18.06	0.95	116
1994	1408	-68	15.60	2.46	18.06	0.86	68
1995	1300	-176	27.80	0.00	27.8	1.54	176
1996	1461	-15	10.54	7.52	18.06	0.58	15
1997	1321	-155	17.70	0.36	18.06	0.98	155
1998	1478	2	9.17	8.89	18.06	0.51	-2
1999	1670	194	0.28	17.78	18.06	0.02	-194
2000	1657	181	0.63	17.43	15.73	0.03	-181
2001	1405	-71	15.72	2.34	18.06	0.87	71
2002	1613	137	2.07	12.52	14.59	0.11	-137
2003	1376	-100	16.96	1.10	18.06	0.94	100
2004	1380	-96	17.06	1.00	18.06	0.94	96
2005	1400	-76	15.72	2.34	18.06	0.87	76
2006	1485	9	9.00	9.06	18.06	0.50	-9
2007	1439	-37	13.95	5.10	18.06	0.77	37
2008	1580	104	3.26	14.80	18.06	0.18	-104
2009	1600	124	2.46	15.60	18.06	0.14	-124
2010	1408	-68	15.60	2.46	18.06	0.86	68
MEAN	**1455**	**-21**	**12.00**	**6.35**		**0.66**	**21**



Photograph 51: Llawrenny Peaks on 6 March 2010, resolution reduced to 200dpi.

No. 797F/4

BARRIER Pk.

NZMS 260 sheet D41

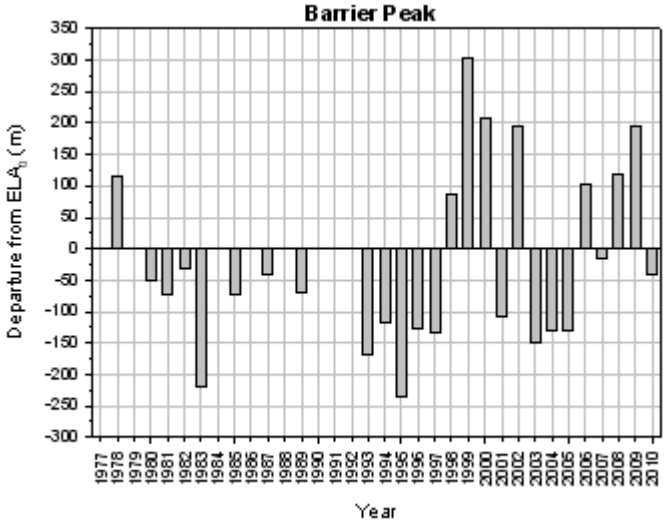
Mountain glacier

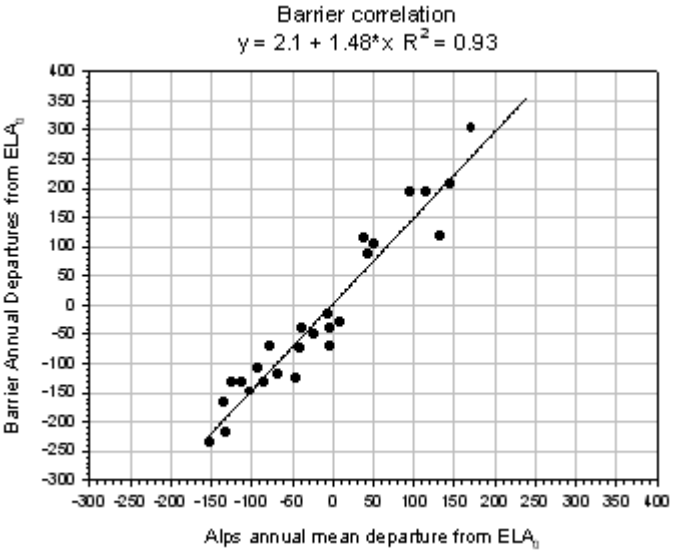
GLACIER DATA		
Aspect	S	
AREA	57.56	ha
Max Elev	1900	m
Min Elev	1420	m
Mean Elev	1660	m
Elev Range	480	m
Length	0.75	km
Gradient	0.64	

SNOWLINE DATA		
ELAo	**1596**	m
Max SL	1900	m, 1999
Min SL	1360	m, 1995
Mean SL	1573	m
SL Range	540	m
No. Surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1596**	**0**	**40.36**	**17.20**	**57.56**	**0.70**	0
1977							
1978	1712	116	20.06	37.5	57.56	0.35	-116
1979							
1980	1545	-51	48.56	9	57.56	0.84	51
1981	1523	-73	51.23	6.33	57.56	0.89	73
1982	1565	-31	45.36	12.2	57.56	0.79	31
1983	1378	-218	63.9	0	63.9	1.11	218
1984							
1985	1524	-72	51.19	6.37	57.56	0.89	72
1986							
1987	1555	-41	46.86	10.7	57.56	0.81	41
1988							
1989	1525	-71	50.96	6.6	57.56	0.89	71
1990							
1991							
1992							
1993	1428	-168	60.7	0	60.7	1.05	168
1994	1478	-118	55.23	2.33	57.56	0.96	118
1995	1360	-236	65.03	0	65.03	1.13	236
1996	1470	-126	55.51	2.05	57.56	0.96	126
1997	1464	-132	56.75	0.81	57.56	0.99	132
1998	1682	86	25.14	32.42	57.56	0.44	-86
1999	1900	304	0	57.56	57.56	0.00	-304
2000	1803	207	3.28	54.28	57.56	0.06	-207
2001	1488	-108	54.56	3	57.56	0.95	108
2002	1790	194	5.36	52.2	57.56	0.09	-194
2003	1448	-148	56.56	1.00	57.56	0.98	148
2004	1465	-131	56.75	0.81	57.56	0.99	131
2005	1465	-131	56.75	0.81	57.56	0.99	131
2006	1700	104	20	37.56	57.56	0.35	-104
2007	1579	-17	43.36	14.2	57.56	0.75	17
2008	1715	119	19.56	38	57.56	0.34	-119
2009	1790	194	5.36	52.2	57.56	0.09	-194
2010	1555	-41	46.86	10.7	57.56	0.81	41
MEAN	**1573**	**-23**	**40.96**	**17.26**	**58.21**	**0.71**	**23**





Photograph 52: Barrier Peak on 6 March 2010, resolution reduced to 200dpi.

No. 797D/1

Mt. IRENE

NZMS 260 sheet C42

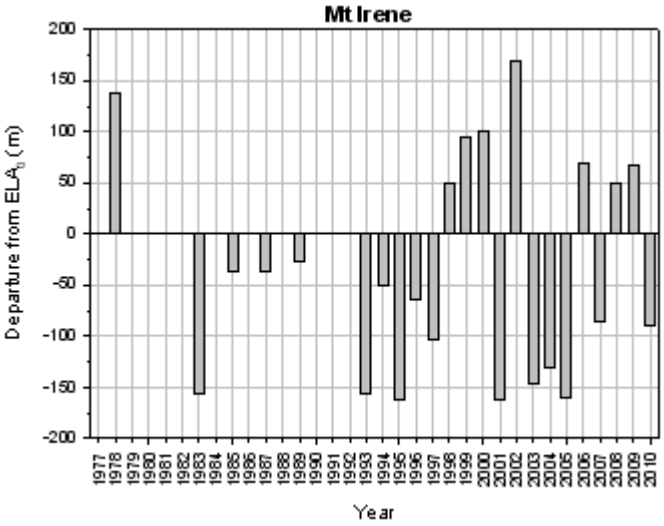
Glacierette

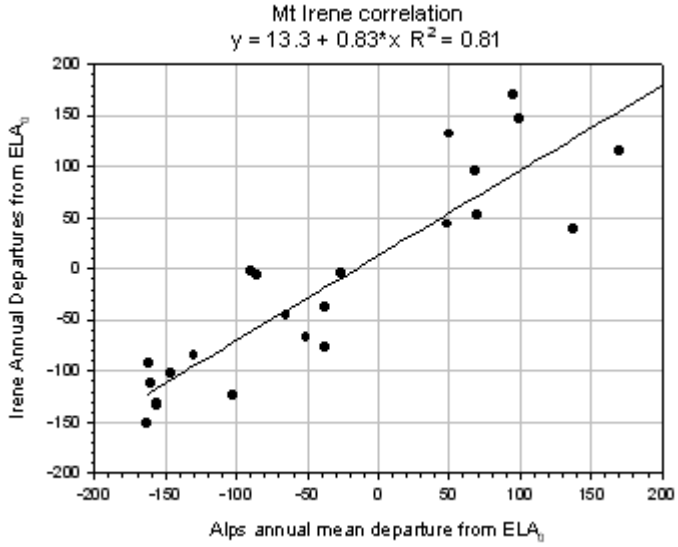
GLACIER DATA			
	1977 to 1999	**2002 on**	
Aspect	E		
Permanent Ice Area	17.95	7.75	**ha**
Max Elev	1800	1770	**m**
Min Elev	1450	1510	**m**
Mean Elev	1625	1640	**m**
Elev Range	350	260	**m**
Length	0.5	0.43	**km**
Gradient	0.7	0.6	

SNOWLINE DATA		
ELAo	**1563**	m
Max SL	1770	m, 1978
Min SL	1400	m, 1995
Mean SL	1546	m
SL Range	370	m
No. Surveys	23	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	Permanent ice Outline Total ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo 1977 to 1999	**1563**	**0**	**7.55**	**10.40**	**17.95**	**0.42**	**0**
ELAo 1999 on	**1600**	**0**	**3.25**	**4.50**	**7.75**	**0.42**	**0**
1977							
1978	1700	137	0.83	17.12	17.95	0.05	-137
1979							
1980							
1981							
1982							
1983	1407	-156	17.95	0.00	17.95	1.00	156
1984							
1985	1526	-37	10.05	7.90	17.95	0.56	37
1986							
1987	1526	-37	10.05	7.90	17.95	0.56	37
1988							
1989	1537	-26	9.25	8.70	17.95	0.52	26
1990							
1991							
1992							
1993	1407	-156	31.25	0.00	17.95	1.00	156
1994	1512	-51	11.05	6.90	17.95	0.62	51
1995	1400	-163	32.65	0.00	17.95	1.00	163
1996	1498	-65	12.13	5.82	17.95	0.68	65
1997	1460	-103	17.95	0.00	17.95	1.00	103
1998	1612	49	4.73	13.22	17.95	0.26	-49
1999	1695	95	0.84	7.75	8.59	0.05	-95
2000	1700	100	0.83	7.27	8.1	0.10	-100
2001	1438	-162	17.60	0.36	8.1	1.00	162
2002	1770	170	0.34	7.41	7.75	0.04	-170
2003	1454	-146	15.85	0.00	7.75	1.00	146
2004	1470	-130	14.77	0.00	7.75	1.00	130
2005	1440	-160	17.55	0.00	7.75	1.00	160
2006	1670	70	1.80	5.95	7.75	0.23	-70
2007	1515	-85	11.05	0.00	7.75	1.00	85
2008	1650	50	2.60	5.15	7.75	0.34	-50
2009	1668	68	1.85	5.90	7.75	0.24	-68
2010	1510	-90	7.75	0.00	7.75	1.00	90
MEAN	**1546**	**-36**	**10.90**	**4.67**		**0.62**	**36**





Photograph 53: Mt Irene on 6 March 2010, resolution reduced to 200dpi.

No. 797 B/10

MERRIE RA

NZMS 260 sheet C44

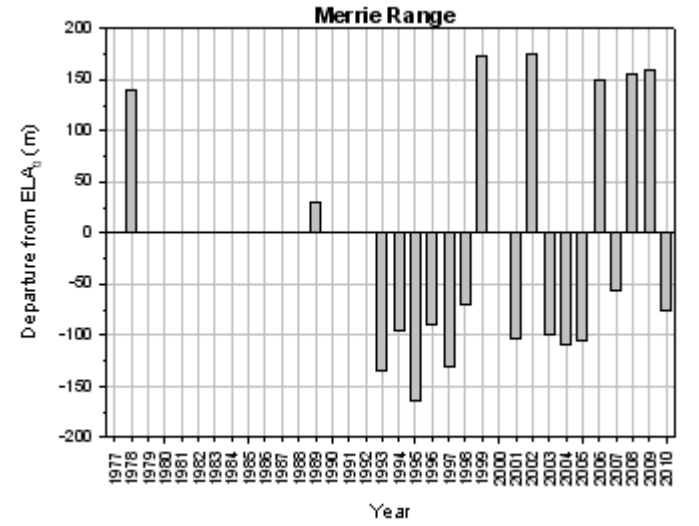
Patchy glacierette

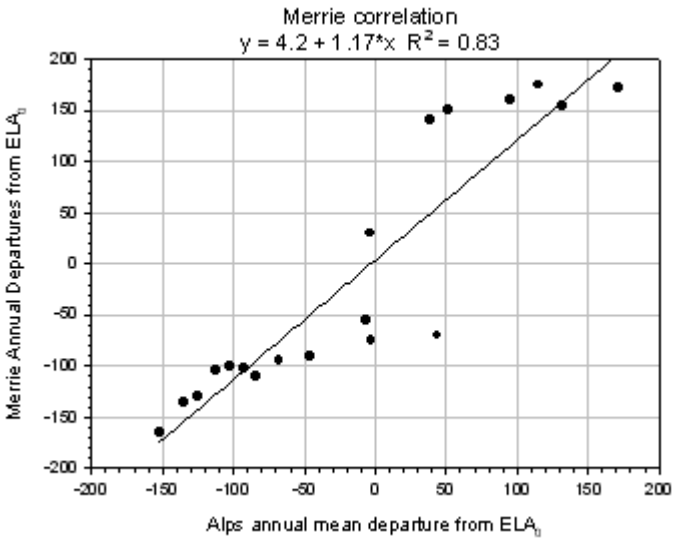
GLACIER DATA		
Aspect	E	
AREA	12.78	ha
Max Elev	1700	m
Min Elev	1400	m
Mean Elev	1550	m
Elev Range	300	m
Length	0.5	km
Gradient	0.6	

SNOWLINE DATA		
ELAo	**1515**	m
Max SL	1690	m, 1999
Min SL	1350	m, 1995
Mean SL	1502	m
SL Range	340	m
No. Surveys	21	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1515**	**0**	**7.13**	**5.65**	**12.78**	**0.56**	**0**
1977							
1978	1655	140	1.34	2.16	3.5	0.10	-140
1979					No visit		
1980					No visit		
1981					No visit		
1982					No visit		
1983					No visit		
1984					No visit		
1985					No visit		
1986					No visit		
1987					No visit		
1988					No visit		
1989	1545	30	5.83	6.95	12.78	0.46	-30
1990					No visit		
1991					No visit		
1992					No visit		
1993	1380	-135	16.20	0.00	16.2	1.27	135
1994	1420	-95	11.73	1.05	12.78	0.92	95
1995	1350	-165	19.34	0.00	19.34	1.51	165
1996	1425	-90	11.53	1.25	12.78	0.90	90
1997	1385	-130	15.65	0.00	15.65	1.22	130
1998	1445	-70	10.67	2.11	12.78	0.83	70
1999	1688	173	0.47	1.93	2.4	0.04	-173
2000					In cloud		
2001	1412	-103	12.38	0.4	12.78	0.97	103
2002	1690	175	0.42	1.76	2.18	0.03	-175
2003	1415	-100	11.88	0.9	12.78	0.93	100
2004	1405	-110	14.2	0	14.2	1.11	110
2005	1410	-105	12.38	0.4	12.7	0.97	105
2006	1665	150	1.3	1.7	3.0	0.10	-150
2007	1459	-56	8.3	2.7	11.0	0.65	56
2008	1670	155	1.1	1.4	2.5	0.09	-155
2009	1675	160	1.1	1.4	2.5	0.09	-160
2010	1440	-75	10.93	1.85	12.8	0.86	75
MEAN	**1502**	**-13**	**8.78**	**1.47**		**0.69**	**13**





Photograph 54: Merrie Range on 6 March 2010, resolution reduced to 200dpi.

No. 803/1

CAROLINE Pk.

NZMS 260 sheet C45

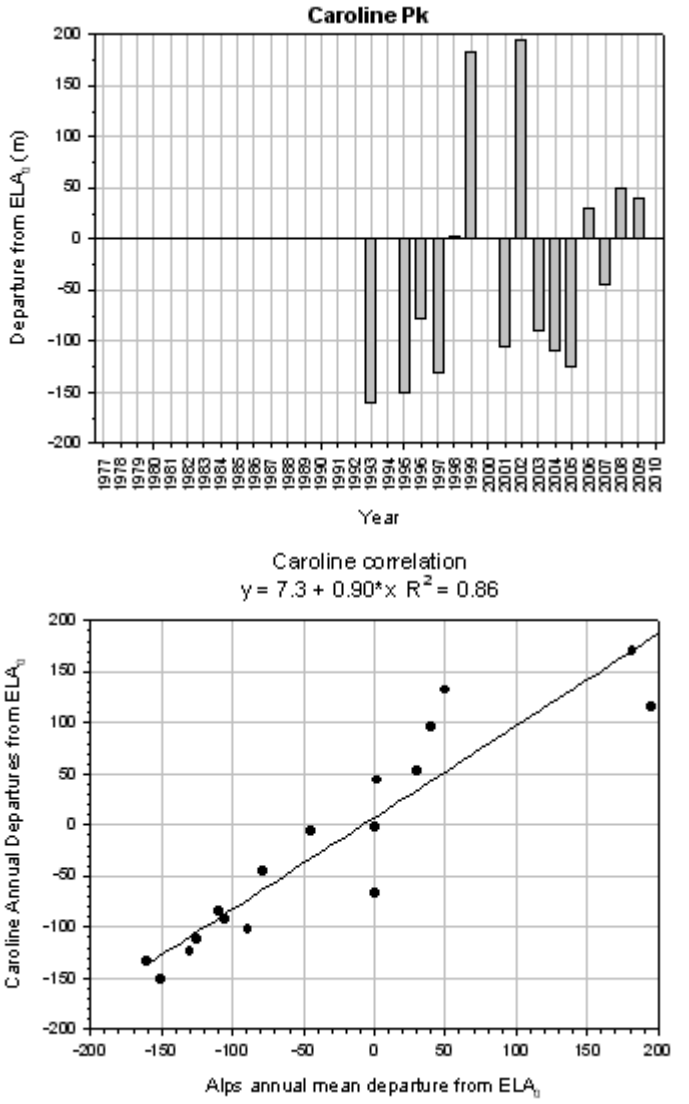
Patchy glacierette

GLACIER DATA		
Aspect	SE	
AREA	9.99	ha
Max Elev	1600	m
Min Elev	1260	m
Mean Elev	1430	m
Elev Range	340	m
Length	0.5	km
Gradient	0.68	

SNOWLINE DATA		
ELAo	**1380**	m
Max SL	1575	m, 1999
Min SL	1220	m, 1993
Mean SL	1351	m
SL Range	355	m
No. Surveys	17	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION m	DEPARTURE FROM ELAo m	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
ELAo	**1380**	**0**	**7.50**	**2.50**	**10**	**0.75**	**0**
1977					No visit		
1978					No visit		
1979					No visit		
1980					No visit		
1981					No visit		
1982					No visit		
1983					No visit		
1984					No visit		
1985					No visit		
1986					No visit		
1987					No visit		
1988					No visit		
1989					No visit		
1990					No visit		
1991					No visit		
1992					No visit		
1993	**1220**	-160	15.79	0.00	15.79	1.00	160
1994	1381	1	8.95	1.04	7.60	1.18	-1
1995	1230	-150	14.90	0.00	14.90	1.00	150
1996	**1302**	-78	8.92	1.07	10.00	0.89	78
1997	1250	-130	13.30	0.00	13.30	1.00	130
1998	**1382**	2	7.43	2.56	9.99	0.74	-2
1999	1562	182	0.69	2.76	3.45	0.20	-182
2000					In cloud		
2001	1275	-105	9.40	3.60	13.00	0.72	105
2002	1575	195	0.46	2.27	2.73	0.17	-195
2003	1291	-89	9.10	3.00	12.10	0.75	89
2004	1270	-110	9.70	3.40	13.10	0.74	110
2005	1255	-125	9.75	3.55	13.30	0.73	125
2006	1410	30	6.60	0.60	7.20	0.92	-30
2007	1336	-44	8.30	1.90	10.20	0.81	44
2008	1430	50	5.80	1.00	6.80	0.85	-50
2009	1420	40	6.33	0.66	6.99	0.91	-40
2010	1380	0	7.38	0.34	7.72	0.96	0
MEAN	**1351**	**-29**	**8.61**	**1.78**		**0.78**	**29**



Photograph 55: Caroline Peak on 6 March 2010, resolution reduced to 200dpi.