

New Zealand Glacier Monitoring: End of summer snowline survey 2013

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Photograph: Glenmary Glacier, Naumann Range, Lake Ohau catchment on 12 March 2013
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Executive summary

Glaciers of New Zealand respond to the changing climate, and an integration of these changes over time 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 surveys have 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 of index glaciers indicated a small positive mass balance for the 2012/2013 glacier year (March 2012 to March 2013), i.e., the snowlines, the equilibrium line altitudes (ELAs), were slightly below their average elevation. Winter snow on most of the index glaciers was covering approximately two-thirds of their respective areas. There was some variation in the index glaciers across the Southern Alps this year but this seemed due to variability in index glacier response rather than any geographical trend.

Neutral ENSO conditions were present in the southwest Pacific across the glacial year. Anticyclones ('highs') dominated at the start of the season, with intense ridges of high pressure east of the Chatham Islands extending back over the South Island persisting in the late season. Late spring and early summer were characterized by more Southwesterly winds. Two to three months early in the glacier year had below normal precipitation, and many sunshine hours and high temperature records were broken near the end of the year. Regional sea surface temperatures were near or above normal at the start and end of the year, and near normal at other times. Based on the climate summary information, the input from snowfall was estimated as average to low for this season.

The small positive mass balance this year is a change from the large negative mass balance conditions the previous two years (2010/2011, and 2011/2012). A neutral mass balance year occurred in 2009/2010. Prior to this there had been two further years of strong negative mass balance (2007/2008, 2008/2009). The glaciers have shown a varying pattern of positive (23 years) and negative (14 years) mass balance over the 37 year monitoring period. However, many of the index glaciers with well-defined permanent ice areas have clearly lost ice during the course of the 37 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 transects across the Southern Alps (see Figure 1-1).

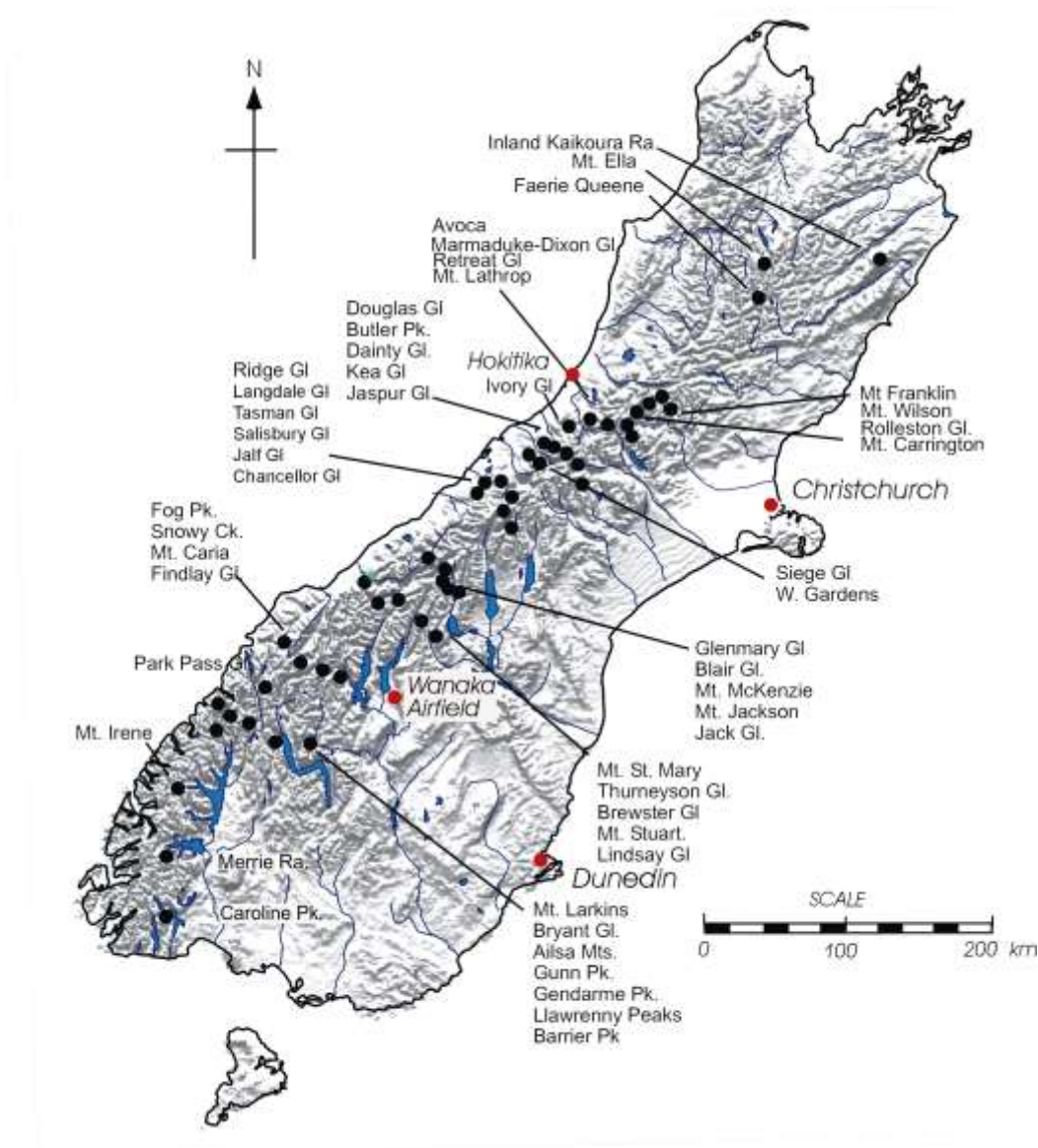


Figure 1-1: Location of the 50 index glaciers across the South Island of New Zealand.

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 km² (one hectare). 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 over flights 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 1000 mm in the eastern ranges over less than 30 km from the divide. This creates a steep west-east precipitation gradient across the Southern Alps, and the mean altitude of the glaciers closely follows 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, and smoothed 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 are strongly modulated by glacier response times and dynamics related to climate variability, so determination of annual glacier change using frontal positions is problematic.

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 1-2). 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 1-2). 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.

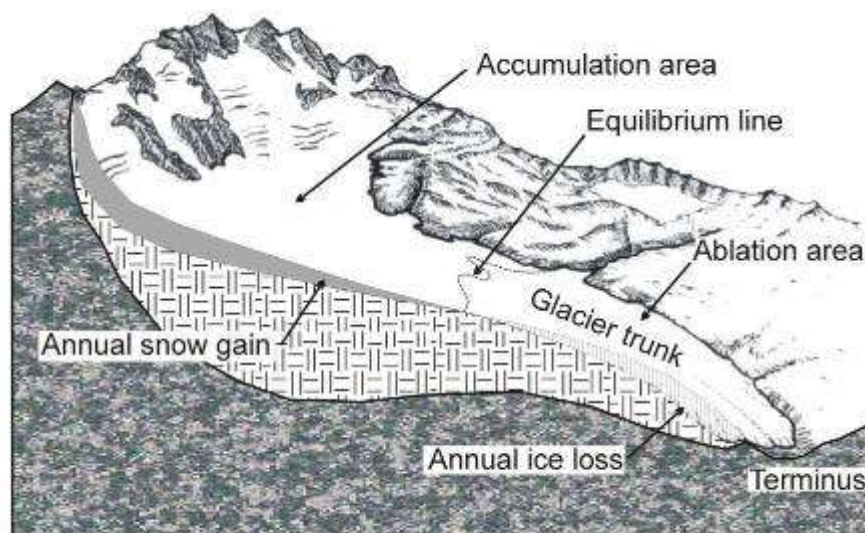


Figure 1-2: Basic parameters of a glacier.

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 were 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 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 are mapped and measured by digitisation. Since 2008 the area interpretation has been done for selected glaciers by digitally 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.

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, by digital SLR cameras. 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 a snowfall 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.

A successful survey cannot be guaranteed as there is also 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 prevailing westerly circulation.

As well, 'suitable' weather to fly the entire Southern Alps demands particularly settled cloud free conditions.

2.2 March 2013 fieldwork details

A decision was made before the fieldwork commenced to do a one day flight over the central section of the Alps during early March. This region from north of Wanaka to Arthurs Pass contains 36 of the 50 index glaciers, and it is possible to fly this in one day. Then if melt conditions continued into late March and April an extended two day survey of all 50 index glaciers would be conducted to capture this late season melt.

On Tuesday 12 March the first leg of the one day survey flight departed Queenstown in a Milford Sound Flights Cessna 206 piloted by Andy Woods, with Trevor Chinn, Andrew Willsman (NIWA Dunedin), and Heather Purdie (University of Canterbury). This flight headed

north to the Thurneyson Glacier and continued up the eastern side of the Alps to the Arthurs Pass glaciers. Conditions were very good for photographing the glaciers with clear skies and obvious clear snowlines present on all the glaciers. Thick low cloud covered the Canterbury plains, inland basins and many of the valleys, but this cloud was well below the elevation of the glaciers. After photographing the Arthurs Pass glaciers we diverted to Hokitika for lunch and a fuel stop. The return trip to Wanaka was down the western side of the Alps. Fine weather afternoon cumulus cloud thickened south of Mt Whitcombe, and this either partially or completely obscured some of the index glaciers. The index glaciers on this western side had obvious clear snowlines at relatively low elevations on their respective areas. After photographing the glaciers on the Haast Pass transect we continued southwest to the index glaciers on the Arawhata to Matukituki transect. The Findlay glacier was completely covered in thick cloud but the remaining glaciers to the east were clear of the cloud. Leg 2 of the survey finished at Wanaka and Trevor and Heather departed here. Andy Woods was then asked by Milford Sound Flights to pick up passengers from Milford Sound and bring them back to Queenstown. He offered to take Andrew along to photograph any index glaciers that were on the route from Wanaka, Milford to Queenstown route. Good photographs were taken of Park Pass, Llawrenny Peaks, Genderme, Ailsa and Bryant Glaciers on this leg. The four index glaciers in southern Fiordland were not visited. Photographs were taken of 41 of the 50 index glaciers on this one day flight.

The second flight planned for late-March or April did not happen due to indifferent disturbed weather over the month bringing light dustings of new snow across the Alps. We did not get the combination of another settled cloud-free weather window, and snowlines on the glaciers that were not obscured by new snow.

A photograph of the index glacier on Mt Larkins was collected on the 18 April during a visit to the plateau immediately below the glacier to install the foundations for a new climate station. The snowline was still visible in this photograph although a day after this visit a snowfall obscured snowlines on this glacier and on many others across the Alps.

Figure 2-1 presents an overview of the glacier flight path for 2013. The weather situations for the two flights are shown in Figure 2-2.

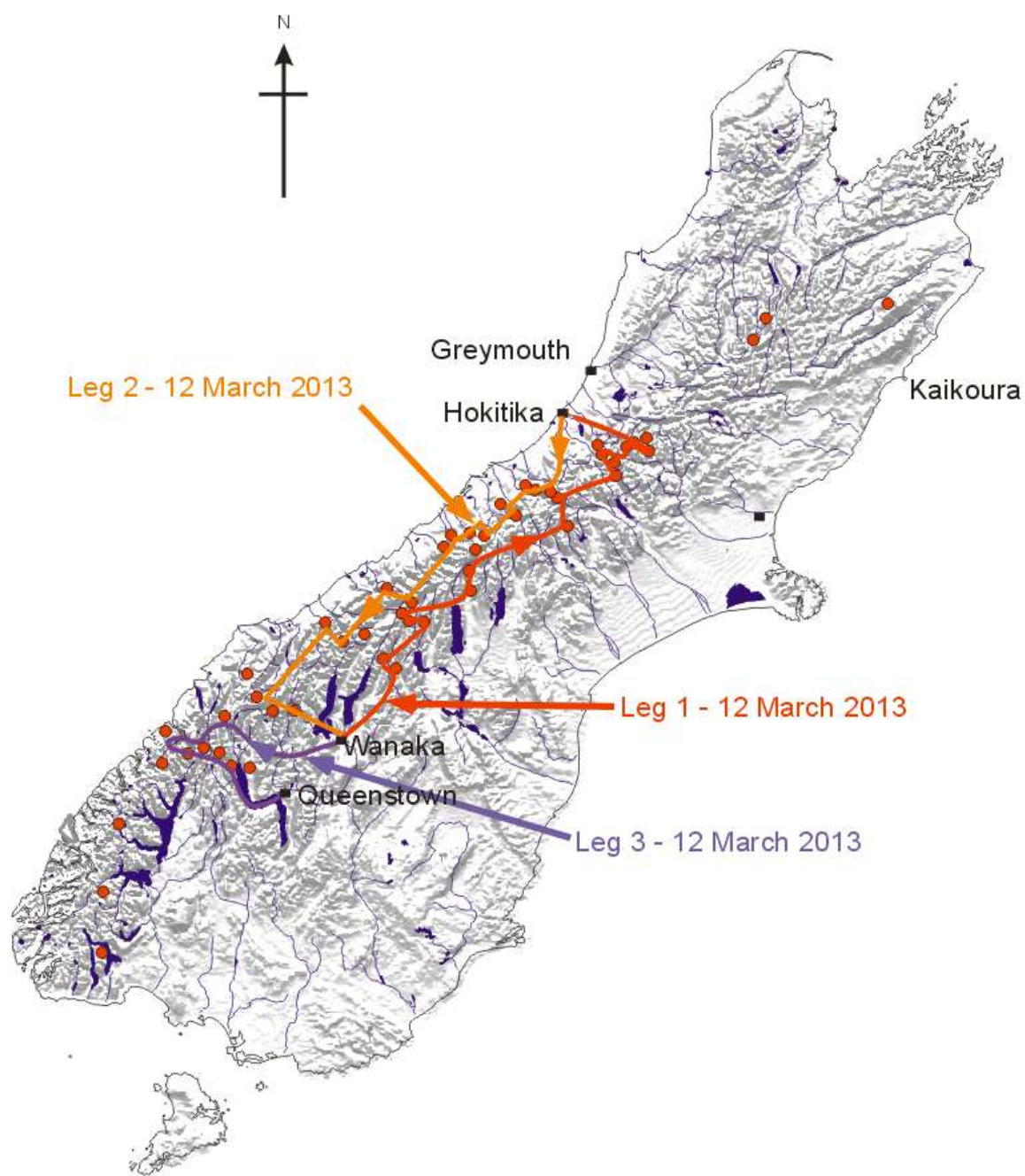


Figure 2-1: Flight paths for 2013 glacier snowline survey.

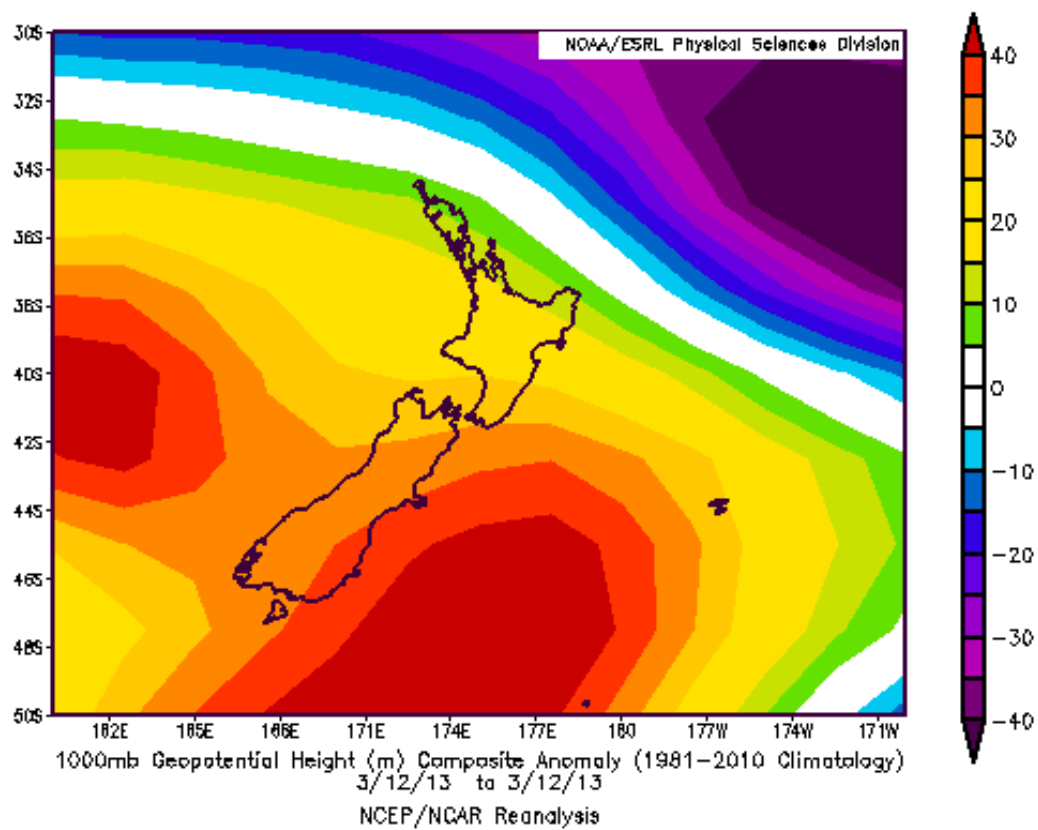


Figure 2-2: Geopotential height anomaly map at the 1000hPa level for the flight on 12 March 2013. Courtesy of NCEP/NCAR reanalysis. Anomalies are relative to the 1981-2010 average conditions.

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 (A_c of Figure 3-1) and ablation area (A_b of Figure 3-1); total glacier area A , or $A_b + A_c$; and accumulation area ratio (AAR) the ratio of the accumulation area to the entire area of the glacier, $A_c/(A_c + A_b)$.

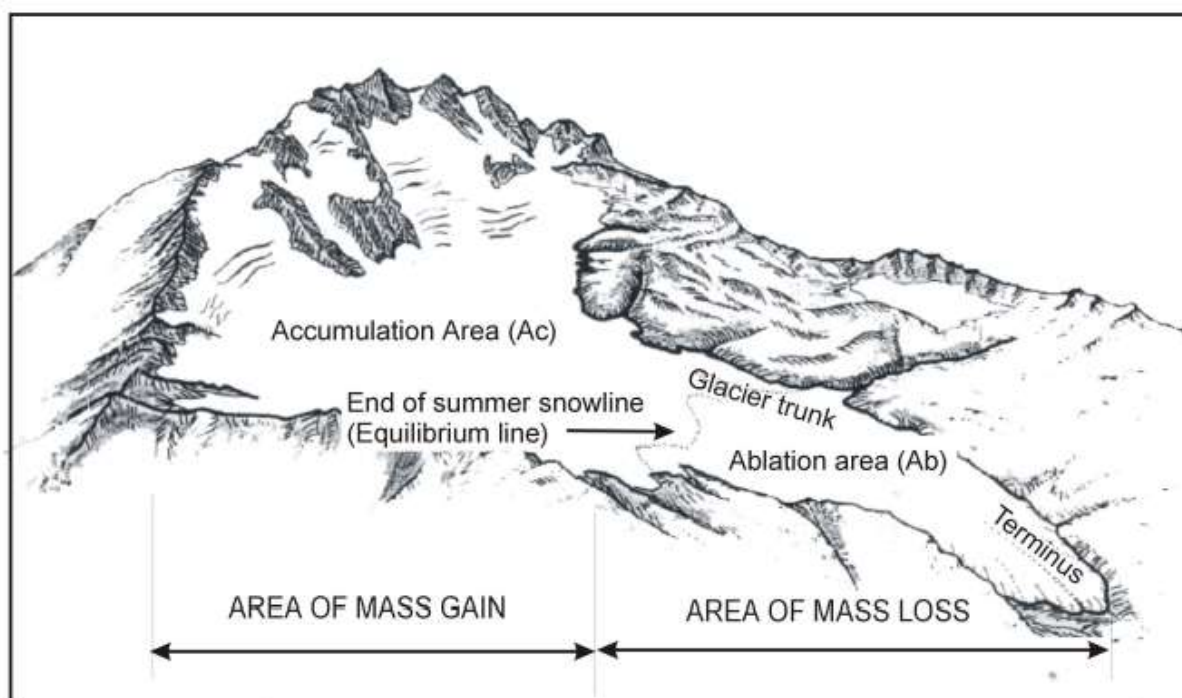


Figure 3-1: Schematic diagrams of stratigraphy at the glacier equilibrium line. (A) for a year of negative balance (high ELA) and (B) for a year of positive balance (low ELA). Numbers indicate age in years of past firm layers.

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 EOSS (ELAo) divides the accumulation and ablation areas by an approximate ratio of 2:1 (AAR value of 0.66). 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 @ 0.6 → ELAo, + adjustment → refined ELAo.

Leading to small annual changes to:-

ELA – ELAo → Departure value

The use of a GIS mapping system associated with digitised areas has added significant accuracy 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 a longer time series of annual photographs it is frequently more efficient to directly interpolate ELA values between those of previous years which bracket the current year's snowline (described below), and more than half of the ELA values have been derived by this method:-

Interpolation → direct ELA

Where $ELA - ELA_o$ → Departure

and $ELA + Area Curve$ → AAR

The most significant problems in processing the results are recognising the position of the true end-of-summer snowline (Figure 3-1), 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.
- There is a wavy or patchy snowline.

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. Results from glaciers around the world where this technique is used are published in the Glacier Mass Bulletin (WGMS, 2011). 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:

1. Digitalisation method: Digitising either the accumulation or ablation area to provide a definitive ELA;
2. Interpolation method: Interpolating between photographs of past years where a number of snowlines are close in altitude;
3. Snow patch method: 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 GIS techniques to accurately measure the areas. From 2009 on, however, some of the oblique digital images are now 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. Once the accumulation area is 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. The difference between this altitude and that of the long-term ELA_0 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 that two photos separated by many years can have identical snow coverage. The ELA value is 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 discern the snow-patch outline beneath a light cover of new snow. As in the interpolation 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 A_c and/or A_b 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 glacier have undergone large variations of size and both the area and associated area-altitude should be re-measured 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 causes mathematical problems. When the ELA rises above the glacier, it is not possible to extrapolate its value and the AAR becomes negative.

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). The 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 3-1).

The 2:1 ratio of the accumulation to ablation areas, or AARo of 0.66, 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 AARo for each index glacier in Appendix B are estimated from the accumulation and ablation areas on the area elevation curve at the ELAo elevation. 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 3-1 show what happens to the mean AARo for the index glaciers as the classification is changed. The nearer the selection to the morphology of a “normal” glacier, the closer the accumulation area ratio approaches the 0.66 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 3-1: 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, do 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 approximately 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 0.66 (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 B, 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, within the constraints of the assumptions of linearity. The average climate response is given by the mean for the Southern Alps, so that any deviation from a 45° 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 lies in a distinctly different climate district (Mullan, 1998; Mullan and Thompson, 2006)), 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 2013 snowline results

4.1 The 2012/2013 glacial climate

A summary of key regional and local climate conditions taken from the National Climate Centre's monthly summaries from April 2012-March 2013 is found below, broken down by season within the glacier mass balance year (April-March). Overall, the atmospheric circulation pattern was typified by more frequent anticyclones ('highs') in the early and late season, with more southwesterlies during late spring and early summer.

April-June 2012

- MSLP during the early part of the glacial year changed from highs over the South Island in April in mid-autumn to an increased frequency of low pressures at the onset of winter. Overall, this three-month period had subtly higher pressures than normal over northern and western regions
- Winds changed from relatively calm conditions that accompanied highs to more southwesterly flow by the end of the season
- Precipitation was below normal for the first two months of the season and near normal for the Southern Alps in June
- Air temperatures were mostly above normal at the start of the season and transitioned to very cool (below normal) for alpine regions of the South Island.
- Regional SSTs were near normal or above normal surrounding the South Island and above normal in the central Tasman Sea
- Snowfall occurred at the end of April, one notable event in May, and significant events in the central and southern South Island happened on 5-6 June and 25-27 June

July-September 2012

- MSLP for July and September saw lows over the north and central Tasman Sea and highs to the SE of New Zealand. For the three month period, 'anticyclones' over the Chatham Island and east of the South Island were very pronounced
- Winds were mostly from the northerly quarter for this season, and predominantly from the northeast for July and August
- Precipitation was mostly normal or above normal during this time
- Temperatures were above average for most of the three-month period, with near-record mean maximum air temperatures at Milford Sound and Mt. Cook in July and record or near-record mean air temperatures in central and southern South Island locations.
- SSTs were near normal around most of the South Island and in the central Tasman Sea

- Several snowfall events occurred in August, and warm conditions generated snowmelt-induced avalanches in early September

October-December 2012

- Near-surface pressures were much lower than normal southeast of New Zealand, and slightly higher than normal in the west-central Tasman Sea for the three month period
- The regional atmospheric circulation pattern produced more southerly and southwesterlies for a majority of the time, with a change to northerly and NW winds in December
- Precipitation was changeable from October-December, with very wet conditions recorded in the central Southern Alps in October (with record rainfall in Hokitika), while normal or below normal rainfall occurred in November and December
- Temperatures were below normal for October and November in southern and western regions, returning to near normal by the end of the year.
- Regional sea surface temperatures were near normal around most of the South Island.
- Significant snowfall events were restricted to October

January-March 2013

- The end of the glacial year was characterized by highs that continued to build from late January and largely persisted through March. The regional atmospheric circulation pattern saw strong and persistent highs over the Chatham Islands and east of NZ which stretched back over the country and into the Tasman Sea.
- Winds were mostly settled in the mid-to-late part of this season
- Precipitation was well above normal in the beginning of January due to a couple of weeks of disturbed NW flow, producing the highest monthly total for Milford Sound (1018mm) since records began in 1928. This was followed by the driest February on record at the same site, and two months in a row with record or near-record high sunshine hours
- Temperatures were below normal in Westland and Fiordland in January, but followed by above average temperatures in February and near-record mean maximum air temperatures across the South Island.
- Near-to-above normal SSTs surrounded the South Island during January-March
- One late snowfall event was recorded as low as the Lindis Pass in January

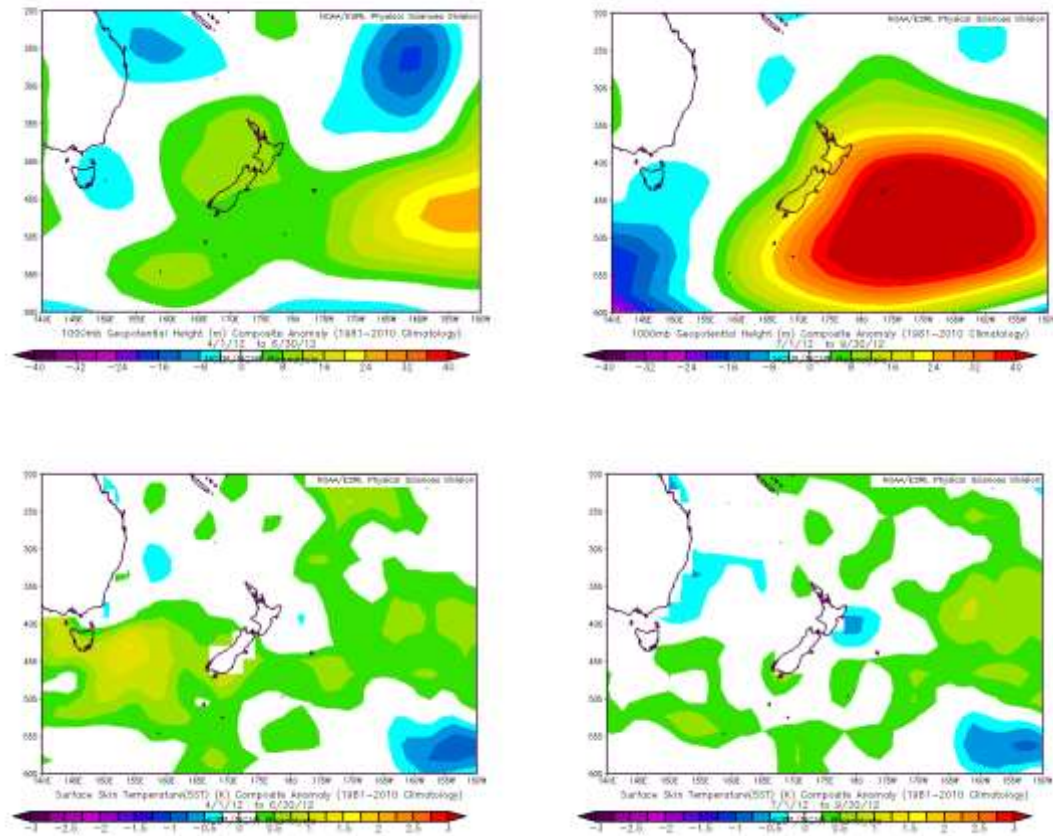


Figure 4-1: Southwest Pacific anomalies at the 1000hPa geopotential height (top row) April-June 2012 (left) and July-September 2012 (right). Geopotential indicates areas of relatively high or low pressure (green/red shades indicating 'highs', blue/purple shades indicating 'lows'). The bottom row shows the corresponding sea surface temperature (SST) anomalies across the New Zealand sector for the same time period (green/red shades indicating warmth, blue/purple shades indicating cool).

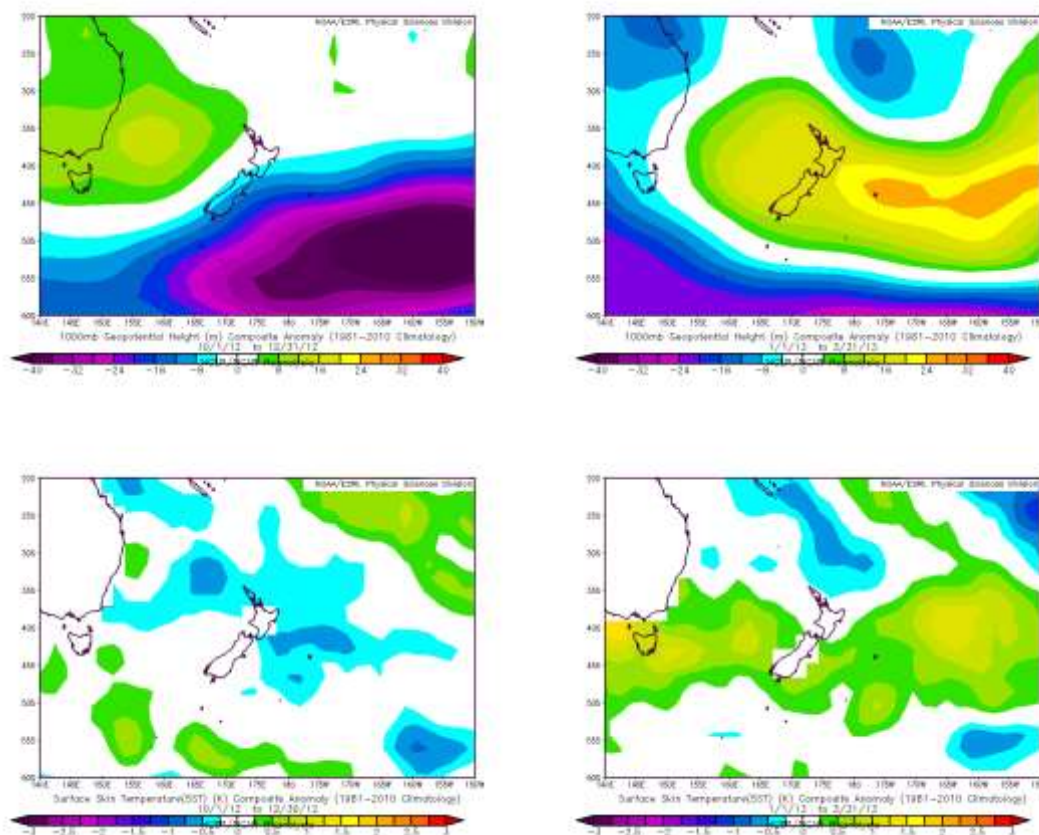


Figure 4-2: Southwest Pacific anomalies at the 1000hPa geopotential height (top row) October-December 2012 (left) and January-March 2013 (right). See Figure 4-3 for details about contours.

4.2 Photographic coverage of the index glaciers

Forty two of the fifty index glaciers were photographed this year. All but one of these were photographed during the survey flight, an additional photograph of the glacier on Mt Larkins was taken in mid-April on visit to a climate station at the base of the glacier. Thirty one glaciers were photographed from their standard waypoints, the remaining are taken exceptions were in the best location available to avoid cloud on or around the glaciers. The glaciers north of Lewis Pass and in Fiordland south of Lake Te Anau were not visited. A low resolution image of each index glacier photograph is in Appendix B.

The photographs were taken with a Nikon D200 digital camera (sensor size = 23.6 x 15.8 mm, 3872 pixels x 2592 pixels, effective pixels = 10 megapixels) linked to a Garmin GPSmap 60Cxs with an external aerial on the windscreen of the plane. Each digital image has the GPS location (latitude and longitude WGS84 datum) and focal length embedded in the EXIF information part of the digital photograph. The GPS used on the survey 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 are available as compressed jpegs from the digital archive.

All the glaciers had obvious snowlines at relatively low elevations on their respective areas.

4.3 Snowline elevation departures

Monitoring results for the 42 index glaciers for the 2012/2013 glacial year, together with the means for all measured years from 1977 to 2013 are shown in Figure 4-1 and 4-2 respectively. Annual data for all measured glacier ELA departures from the long-term ELAo from 1977 to 2013 are given in the matrix of Appendix A and are presented in Figure 4-2.

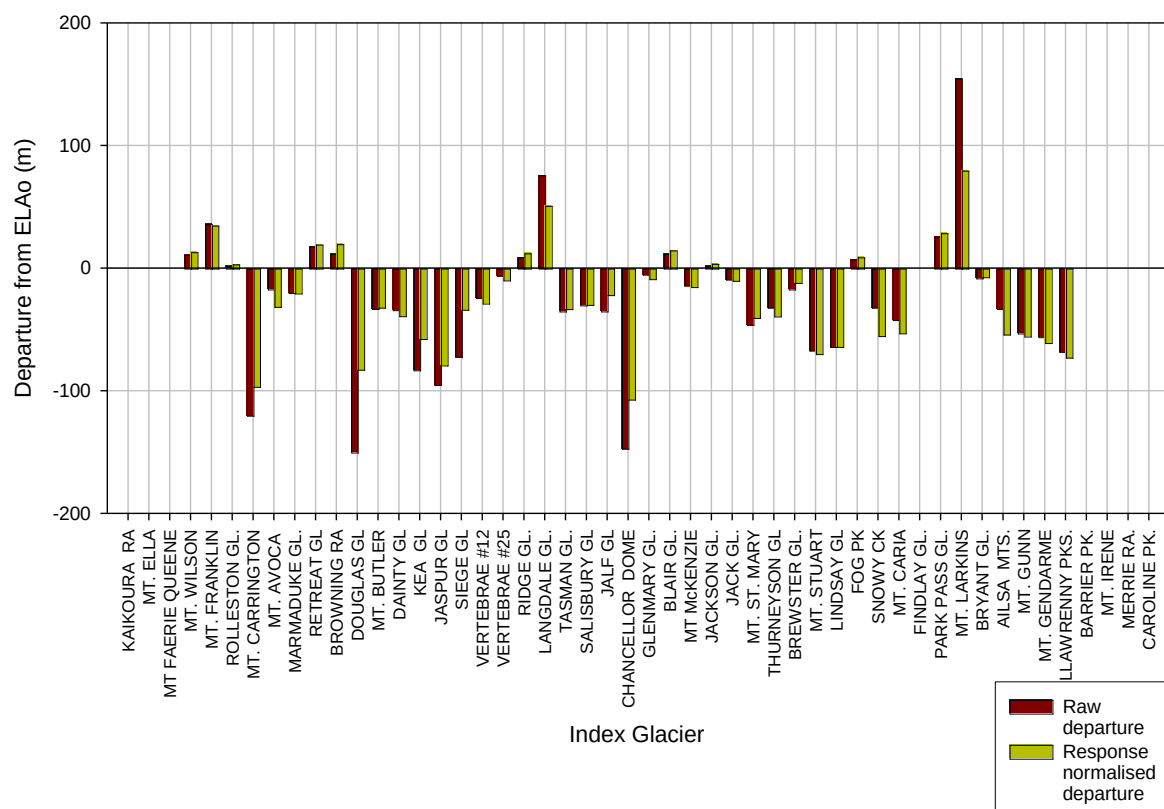


Figure 4-3: Histogram plot of the 2012/2013 snowline departures (raw and response normalised) for each index glacier from the long-term ELAo.

Thirty individual index glaciers for 2012/2013 have raw and normalised ELA departures that are below the long-term mean ELAo position (Figure 4-1), of these 27 are in the range between 0 and 100m below the ELAo position. The 3 outliers greater than 100m below the ELAo position did appear to have snowlines very low on their respective areas. Twelve glaciers have ELA departures above the long-term mean ELAo position, and of these 10 are within 50m of the mean position. Two individual index glaciers have departures greater than 50m above the long-term mean ELAo position. Of these Langdale Glacier has been problematic over the years as area changes and wind distribution of snow have effected snowline elevations. Mt Larkins has a large departure above the mean position, and this is possibly a combination of the large vertical patchy distribution of its glacier area making it difficult to determine the snowline elevation and the long term mean ELAo position, and it may also reflect that this photograph taken on the 18 April a month later than the remaining glaciers.

The individual departure response of each index glacier varies due to topographic factors (discussed in section 3.5) and this variation can be normalised 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 27 or more annual observations and the least number of annual observations is 18.

Figure 4-1 presents the raw and normalised departure values from ELA₀ for the index glaciers over the 2012/2013 glacial year. The effect of normalising is minimal as most of the index glaciers which have a near 1:1 ratio response to the Alps mean. Normalising does have the effect of reducing the magnitude of the offset for some of the glaciers with a large 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 normalising has brought these difficult sites into line with normal glaciers. For example the 2013 departures for Mt Larkins and the Douglas Glacier are almost halved after the topographic normalising is applied. This normalising 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. Some variability exists between index glaciers after normalisation of departures and this is possibly due to a combination of geographical variability and measurement uncertainty.

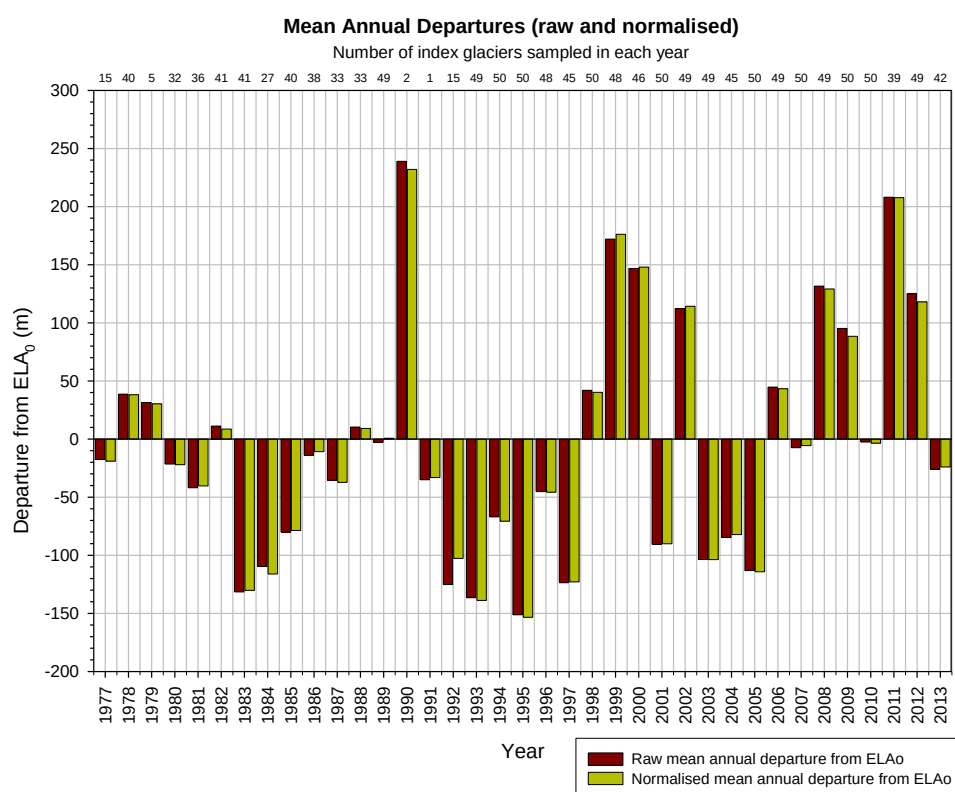


Figure 4-4: Mean annual departures (raw and normalised) from the ELA₀ for all measured glaciers for the entire period of the surveys.

The raw mean snowline departure for this year (2012/2013), that is the average of all 42 ELA index glacier departures, was 26 m below the long-term mean ELA₀ position (Figure 4-2).

The average of the normalised 2012/2013 observations was 24 m below the long-term mean ELAo position.

The 2012/2013 raw departure of 26 m below the long term mean ELAo position, indicates snowlines relatively low on the glaciers with a reasonable amount of winter snowpack remaining on the index glaciers. This equates to a small gain of snow and ice to the glaciers.

Snowline departures have tended to be above or around the ELAo position for the 7 years (2006 to 2012) prior to this year indicating loss of snow and ice and negative mass balance. This loss of snow and ice is apparent at many of the index glaciers as loss of permanent ice area and fragmentation of previously continuous ice into smaller discrete areas. This reduction is particularly noticeable at some of the smaller index glaciers.

The mean annual departures are presented in Figure 4-2 as raw and normalised amounts, and interestingly the results are similar as the effect of the outliers is relatively small when nearly all glaciers are sampled. The largest change due to normalisation occurred during 1991/1992 where the mean annual departure is reduced by 22 m from -125 m to -103 m, due to a small sample size of 15 index glaciers that contained some strongly sensitive glaciers.

Full data records for each individual index glacier are given in Appendix 2. Missing values are years of no data for the particular glacier.

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 immediate derived values. Photographs of each glacier are available from the digital archive and are included in low resolution in Appendix 2.

4.4 Glacier representivity

The “representativeness” of each glacier as an indicator of the overall annual climate of the Southern Alps is indicated by how well the annual values for an individual glacier correlates 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 4-1. The correlation plots for each glacier are given in Appendix B. The correlations give a surprising result where representativeness appears to be independent of size, gradient or topography. The high correlations coefficient values indicate that the ELA surface of individual glaciers have 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. The low correlation of Faerie Queen, Snowy and Retreat are assumed to be due to difficulties in mapping these small area low elevation range glaciers.

Table 4-1: Correlation coefficients of individual snowline departures for each glacier correlated against the mean of all remaining values for the period 1977-2013.

GLACIER	Correlation Coefficient
BARRIER PK.	0.93
JALF GL	0.92
FINDLAY GL.	0.91
VERTEBRAE #25	0.91
SIEGE GL	0.90
THURNEYSON GL	0.90
MT. BUTLER	0.89
MT. STUART	0.89
BRYANT GL.	0.89
JACKSON GL.	0.89
MT. ST. MARY	0.88
SALISBURY GL	0.88
LINDSAY GL	0.87
MARMADUKE GL.	0.87
TASMAN GL.	0.87
MT. CARRINGTON	0.86
CAROLINE PK.	0.86
CHANCELLOR DOME	0.85
KEA GL	0.85
DAINTY GL	0.85
FOG PK	0.85
MT McKENZIE	0.85
JASPUR GL	0.84
MT. GENDARME	0.84
MERRIE RA.	0.84
MT. LARKINS	0.83
PARK PASS GL.	0.83
LLAWRENNY PKS.	0.83
BREWSTER GL.	0.83
JACK GL.	0.83
MT. IRENE	0.83
VERTEBRAE #12	0.83
MT. ELLA	0.82
MT. FRANKLIN	0.81
DOUGLAS GL	0.81
BLAIR GL.	0.81
MT. AVOCA	0.81
MT. GUNN	0.81
MT. WILSON	0.78
GLENMARY GL.	0.76
ROLLESTON GL.	0.75
AILSA MTS.	0.75
RIDGE GL.	0.75
BROWNING RA	0.74
MT. CARIA	0.74
LANGDALE GL.	0.71
MT FAERIE QUEENE	0.71
RETREAT GL	0.71
SNOWY CK	0.67
KAIKOURA RA	0.59

5 Discussion

5.1 Ice gain and loss

Glaciers accumulate the mass changes of net annual balance variations over years to decades. These effects of yearly climate variations are delayed and distorted before being delivered to the terminus after individual glacier response times have elapsed. The index glaciers records 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 year response times have large surface areas inherited in a previous climate, and all are in a state of on-going recession mainly by downwasting of their debris-covered trunks, but recently ice loss has accelerated by the formation of pro-glacial 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. (2012).

To assess the mass changes in response to climate fluctuations a cumulative plot of the “mass balance indices” (MBI) is presented in Figure 5-1. The raw MBI is the inverse 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 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 r (correlation) values between the ELA and measured mass balance had an average of 0.9 with a standard deviation of 0.07.

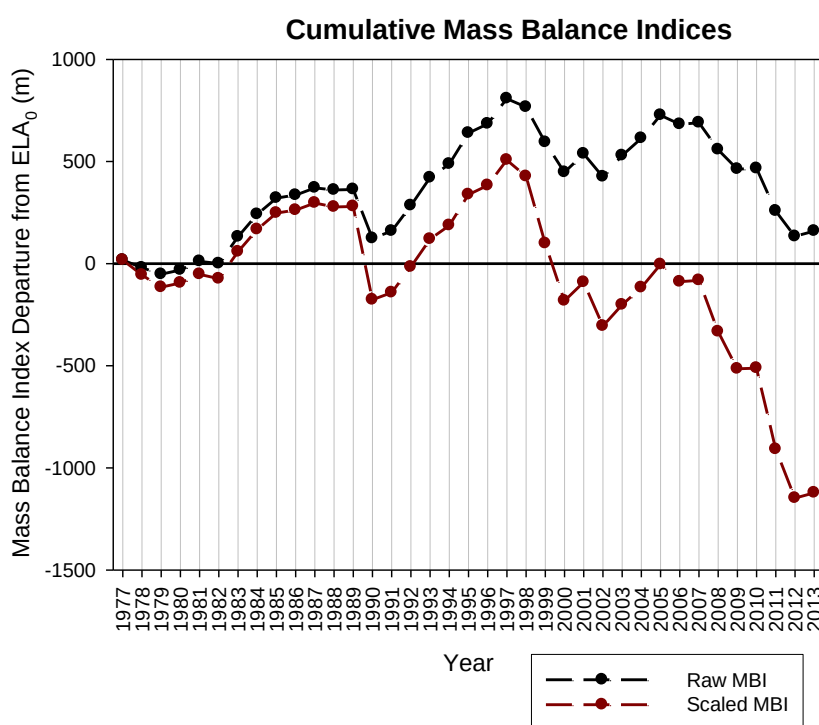


Figure 5-1: Raw and Scaled Cumulative Mass Balance Indices for the index Glaciers.

The annual trends in the raw MBI as shown in Figure 5-1 agree with the generalised climates given in Table 5-1. 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 37 year monitoring period, there has been permanent ice loss during large negative mass balance years that has not been recovered after a cycle 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 glaciers.

To account for this difference a scaled mass balance index is also shown in Figure 5-1 where negative mass balance years have been scaled by 1.92 and a positive mass balance year departures scaled by 1 (i.e., left unchanged). The scale factors are averages of published mass balance gradient rates (Table 5-2) from studies on the Tasman (Anderton, 1975) and Ivory Glaciers (Anderton and Chinn, 1978) for the period 1966-1975. The assumption is that these averaged mass balance gradients apply to the average annual departure values for the index glaciers.

The trend in permanent ice area in many of the index glaciers agrees with the cumulative scaled (1.92) mass balance index rather than the cumulative raw mass balance index which does not account for the mass balance gradient. Further work needs to be done to determine what scaling is appropriate for the index glaciers.

Table 5-1: Generalised climate for 2012/2013 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°C above average, with above normal precipitation 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°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°C below normal), then strong cold cyclonic southwesterlies through to December (temperatures 0.6°C below normal), precipitation overall close to average.	High
2005/2006	More anticyclones and mild westerlies and northwesterlies during autumn and winter (winter temperatures 0.7°C above normal), then 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°C above normal) from December with low precipitation and much increased ablation.	Very low
2008/2009	Northerly and easterly quadrant flow anomalies related to La Niña, 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 Niño development from spring was opposed to record high temperatures in August 2009 and February 2010.	Average
2010/2011	One of the strongest La Niñas in the last 50 years induced more frequent anticyclones (settled conditions) than normal across New Zealand during summer and autumn. ‘Highs’ were prominent across the South Island during the ablation season, with warmer than normal temperatures as a whole, elevated sunshine hours, and reduced rainfall.	Very Low
2011/2012	Residual La Niña conditions in the Southwest Pacific through winter, with redevelopment of a weak La Niña in spring. More prevalent northerly and easterly quadrant winds on a seasonal scale, except for July-September (more frequent southwesterlies). Month-to-month saw variable circulation patterns that produced both positive and negative temperature anomalies for the Southern Alps, and the warmest May on record. Precipitation was mostly below normal, particularly for the second half of the season, with intermittent snowfall events.	Low
2012/2013	Neutral ENSO conditions in the southwest Pacific across the glacial year. Anticyclones (‘highs’) dominant at the start of the season, and intense ridges of high pressure east of the Chatham Islands extending back over the South Island persisted in the late season. Late spring and early summer characterized by more southwesterly winds. 2 of 3 months in each glacier year season had below normal precipitation, and many sunshine hours and high temperature records were broken. Regional SSTs were near or above normal at the start and end of the year, and near normal at other times.	Average-Low

Table 5-2: 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

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7 References

- Anderton, P.W. (1975) Tasman Glacier 1971-73. *Hydrological Research. Annual Report* No. 33. Ministry of Works and Development for the National Water and Soil Conservation Organisation, Wellington, New Zealand. 28p
- Anderton, P.W.; Chinn, T.J.H. (1978) Ivory Glacier, New Zealand, an IHD basin study. *Journal of Glaciology*, 20(82): 67–84.
- Chinn, T.J.H. (1995) Glacier fluctuations in the Southern Alps of New Zealand determined from snowline elevations. *Arctic and Alpine Research*, 27(2): 187—197.
- Chinn, T.J.H., Heydenrych, C., Salinger, M.J. (2002) New Zealand Glacier Snowline Survey 2002. *NIWA Client Report*, AKL2003- 023. 20 p. National Institute of Water and Atmosphere, Auckland.
- Chinn, T.J.H., Heydenrych, C., Salinger, M.J. (2005) Use of the ELA as a practical method of monitoring glacier response to climate in the New Zealand's Southern Alps. *Journal of Glaciology*, 51(172): 85-95.
- Chinn, T.J.H., Salinger, M.J. (1999) New Zealand Glacier Snowline Survey 1999. *NIWA Technical Report*, 68. 119 p. National Institute of Water and Atmosphere, Wellington.
- Chinn, T.J.H., Fitzharris, B.B., Willsman, A.P.; Salinger, M.J. (2012) Annual ice volume changes 1976-2008 for the New Zealand Southern Alps, *Global and Planetary Change*, 92-93: 105-118.
- Chinn, T.J.H., Whitehouse, I.E. (1980) Glacier snow line variations in the Southern Alps, New Zealand. pp. 219—228. *In: World Glacier Inventory. International Association of Hydrological Sciences*, Publication No. 126.
- Clare, G.R.; Fitzharris, B.B., Chinn, T.J.H., Salinger, M.J. (2002) Interannual variations in end-of-summer-snowlines of the Southern Alps of New Zealand, and relationships with Southern Hemisphere atmospheric circulation and sea surface temperature patterns. *International Journal of Climatology*, 22: 107-120.
- Corripio J.G. (2004) Snow surface albedo estimation using terrestrial photography. *International Journal of Remote Sensing*, 25(24): 5705-5729.

- Gross, G., Kerscher, H., Patzelt, G. (1976) Methodische Untersuchungen über die Schneegrenze in alpinen Gletschergebieten. *Zeitschrift für Gletscherkunde und Glazialgeologie*, 12: 223-251.
- Haeberli, W., Hoelzle, M., Zemp, M. (2007) *Glacier Mass Balance Bulletin*, Bulletin No. 9 (2004-2005) WGMS, 99 p. Staffel Druck Press, Zurich..
- Hoelzle, M., Chinn, T.J.H., Stumm, D., Paul, F., Zemp, M., Haeberli, W. (2007) The application of inventory data for estimating characteristics of and regional past climate-change effects on mountain glaciers: a comparison between the European Alps and the New Zealand Alps. *Global and Planetary Change*, 56: 69-82.
- Kidson, J.W. (2000) An analysis of New Zealand synoptic types and their use in defining weather regimes. *International Journal of Climatology*, 20: 299-316.
- Maisch, M. (1992) *Die Gletscher Graubuündens*. Geographisches Institut der Universität Zürich.
- Meier, M.F., Post, A.S. (1962) Recent variations in mass net budgets of glaciers in western North America. pp. 63—77. *In: Proceedings of Obergurgl Symposium, International Association of Hydrological Sciences Publication 58*.
- Mullan, A.B. (1998) Southern Hemisphere sea surface temperatures and their contemporary and lag association with New Zealand temperature and precipitation. *International Journal of Climatology*, 88: 817-840.
- Mullan, A.B., Thompson, C.S. (2006) Analogue forecasting of New Zealand climate anomalies. *International Journal of Climatology*, 26: 485-504.
- Paterson, W.S.B. (1994) *The Physics of Glaciers*. Third edition, Oxford, Pergamon Press. 480 p.
- WGMS (2011) *Glacier Mass Balance Bulletin No.11 (2008-2009)*. Zemp, M., Nussbaumer, S.U., Gartner-Roer, I., Hoelzle, M., Paul, F., and Haeberli, W. (eds.), World Glacier Monitoring Service, Zurich, Switzerland, 102 p.

8 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 A Index Glacier ELAs (1977-2013)

GLACIER	GL.IN. No	ELAo	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
KAIKOURA RA	621/001	2490						5		-30				-5	50
MT. ELLA	932B/012	2142						12							28
MT FAERIE QUEENE	646/006	2030						-45						5	5
MT. WILSON	None	1912	-37	-11			15		-115	-141	-63	41	-89	68	93
MT. FRANKLIN	911A/002	1814		-12	122	-41	-74		-148			-18	-54	35	52
ROLLESTON GL.	911A/004	1763	-8	7	-8	6	-3	10	-123	-8	-8	13	15	-1	7
MT. CARRINGTON	646C/027	1715		-45		-22	-87	25	-150	-115		-10	45	55	5
MT. AVOCA	685F/004	1965		-55				-15		-95	-55	-5		10	6
MARMADUKE GL.	664C/012	1830	-43	-35	78	2	-28	30	-136	-122	-50	9	-5	65	-13
RETREAT GL	906A/004	1742		-4		38	-50	14	-252		-4	20			36
BROWNING RA	906A/001	1598		7		10	-34	7	-113		-2	17			14
DOUGLAS GL	685B/001	2040		91		-163		-18	-214	-240	-223	-128		91	172
MT. BUTLER	685C/060	1840	-55	112	55	-34	-40	28	-200	-65	-70	10	-9	42	-34
DAINTY GL	897/019	1954	-32	36		-7	-77	93	-99		-81	-73	-84	-12	-32
KEA GL	897/007	1820		65		44	-85	134	-230		-120	-82	-83	-58	-36
JASPUR GL	897/003	1725		43		63		-15	-155		-105	-42		-42	-29
SIEGE GL	893A/006	1736	-64	-24		-76	-70	-46	-268		-94	35		-70	-64
VERTEBRAE #12	893A/012	1864		7		36	-51	-14	-64		-56	-44		7	-39
VERTEBRAE #25	893A/025	1840		30		25	-39	0	-62		-50	-27		3	-20
RIDGE GL.	711L/024	2226		79		2	10	10	-15	-141	-32	-9		59	51
LANGDALE GL.	711L/035	2186	34	89		79	119	119	-1	-226	-221	14	-1	4	69
TASMAN GL.	711L/012	1790	-10	85	-90	20	-35	-30	-80	-95	-90	-10	-29	50	-30
SALISBURY GL	888B/003	1810	17	17		32	-58	17	-92	-51	-76	-1	-35	-81	-66
JALF GL	886/002	1790	-15	-10		-32	-65	5	-230	-78	-146	-20	-51	-32	-31
CHANCELLOR DOME	882A/007	1756	96	95		77	-93	92	-211		-147	-78	-28	52	-78
GLENMARY GL.	711F/006	2175		57		-95	-45	6	-40	-155	-67			5	5
BLAIR GL.	711D/038	1938		74		-75	-13	-51	-126	-80	-85		-68	17	-62
MT McKENZIE	711D/021	1904		46		6	-16	-2	-184	-62	-124	13	-14		8
JACKSON GL.	868B/094	2070		28		-20		8	-38	-80	-56		-9		10
JACK GL.	875/015	1907		31		23	-22	44	-157	-79	-32	28	-2	-32	-9
MT. ST. MARY	711B/039	1926								-171		-91		-19	46
THURNEYSON GL	711B/012	1970	-40			-44	-27		-105	-88	-65	-32	-52	-20	0
BREWSTER GL.	868C/020	1935		25		-89	-80	36	-141	-135	-139	-93	-107		-17
MT. STUART	752I/104	1673	-86	57		-23	-67	3	-135		-53	-13	5		-10
LINDSAY GL	867/002	1730		8		-78	-49	51	-170		-64	38	-115	42	34
FOG PK	752E/051	1987				-71		35		-96		-57	-85	35	45
SNOWY CK	752C/103	2092		64		-68	66	-54	-59	-68	-72	-56	-67	-55	11
MT. CARIA	863B/001	1472		-30			-59	-48	-100		-49	53	-50	28	-43
FINDLAY GL.	859/009	1693					-89	42	-111		-64	32	-71	-8	-51
PARK PASS GL.	752B/048	1824		79		-16	-46	34	-62	-59	-122	39	19		-30
MT. LARKINS	752E/002	1945								-265		-53		105	91
BRYANT GL.	752B/025	1783	-43	101			-20	-3	-163	-163	-173	-13	-20		-30
AILSA MTS.	752B/013	1648		-5					-88	-53	-53	1	-23		-36
MT. GUNN	851B/057	1593	22	45		-64	-62	17	-115		-53		-38		-59
MT. GENDARME	797G/033	1616					-46	-43	-136		-94	59	34		-36
LLAWRENNY PKS.	846/035	1476		4			-68	-4	-132		-36		-22		-47
BARRIER PK.	797I/004	1596		116		-51	-73	-31	-218		-72		-41		-71
MT. IRENE	797D/001	1563		137					-156		-37		-37		-26
MERRIERA.	797B/010	1515		140											30
CAROLINE PK.	803/001	1380													
NUMBER		50	15	40	5	32	36	41	41	27	40	38	33	33	49
MEAN		1836	-18	39	31	-21	-42	11	-132	-110	-80	-14	-35	10	-3
STD. DEV.		215	46	50	83	53	39	43	64	63	51	45	40	46	49
No. below ELA (+ve balance)			9	6	1	19	29	17	40	25	32	19	19	19	26
%with +ve M.B.			60	15	20	59	81	41	98	93	80	50	58	58	53

Shaded columns indicate years of ELA departures below the long term ELAo

GLACIER	GL.IN.No	ELAo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
KAIKOURA RA	621/001	2490				-57	-30	-60			30	15	10	-15	25
MT. ELLA	932B/012	2142				-87	-72	-142	-15		17	108	60	-22	46
MT FAERIE QUEENE	646/006	2030				-62	-57	-65	-57		-50	145	160	-55	55
MT. WILSON	None	1912				-167	-102	-154		-149	41	113	108	13	93
MT. FRANKLIN	911A/002	1814				-164	-109	-156	-82		122	164	136	-104	121
ROLLESTON GL.	911A/004	1763				-143	-18	-143	-13	-123	40	87	105	-8	97
MT. CARRINGTON	646C/027	1715				-170	-128	-158	-125	-137	-39	190	237	-135	210
MT. AVOCA	685F/004	1965				-115	-25	-45	12	-75	70	115	65	-52	88
MARMADUKE GL.	664C/012	1830	168			-175	-75	-155	-82	-129	143	164	153	-57	140
RETREAT GL	906A/004	1742				-73	-120	-277	16	-97	47	146	133	-60	93
BROWNING RA	906A/001	1598				-116	-71	-118	-28	-108	30			-30	62
DOUGLAS GL	685B/001	2040			-197	-260	-154	-231	-150	-223	220	240	250	-40	245
MT. BUTLER	685C/060	1840			-95	-136	-28	-190	-60	-176	68	98	148	-95	90
DAINTY GL	897/019	1954			-103	-176	-73	-111	-12	-92	98	176	74	-58	126
KEA GL	897/007	1820				-230	-92	-250	80	-152	78	200	190	-150	195
JASPUR GL	897/003	1725				-150	-120	-145	-90	-100	43			-95	195
SIEGE GL	893A/006	1736			-323	-386	-116	-396	-72	-203	214	414	279	-126	239
VERTEBRAE #12	893A/012	1864			-96	-86	-57	-86	-57	-73	-9	226	121	-59	131
VERTEBRAE #25	893A/025	1840			-94	-84	-54	-84	-54	-71	-5	125	70	-33	80
RIDGE GL.	711L/024	2226				-126	-56	-94	-88	-136	9	109	79	-116	74
LANGDALE GL.	711W/035	2186			-226	-231	14	-226	-1	-226	142	134	129	-226	99
TASMAN GL.	711W/012	1790	310	-35	-100	-108	-20	-124	-35	-102	63	186	110	-80	105
SALISBURY GL	888B/003	1810			-129	-100	-38	-165	-58	-84	42	220	172	-95	50
JALF GL	886/002	1790			-210	-220	-38	-240	-8	-191	-3	260	265	-85	
CHANCELLOR DOME	882A/007	1756				-206	-147	-211	-36	-176	92	209	204	-186	104
GLENMARY GL.	711F/006	2175			-15	-68	-30	-35	-45	-130	20	115	70	-37	35
BLAIR GL.	711D/038	1938				15	-73	-85	2		34	152	147	-96	67
MT McKENZIE	711D/021	1904				-122	8	-99	6	-189	31	174	148	-99	56
JACKSON GL.	868B/094	2070				-78	-25	-52	2	-54	12	95	63	-54	33
JACK GL.	875/015	1907			-90	-142	-27	-152	51	-102	33	101	85	-109	78
MT. ST. MARY	711B/039	1926			-76	-141	-76	-156	-71	-84	-37	199	204	-146	189
THURNEYSON GL	711B/012	1970			-40	-60	-66	-102	-32	-70	-5	142	162	-92	135
BREWSTER GL.	868C/020	1935			-84	-185	-145	-158	27	-156	47	345	220	-165	115
MT. STUART	752V/104	1673				-138	-33	-158	39	-106	-17	132	177	-83	142
LINDSAY GL	867/002	1730				-175	-120	-180	45	-85	70	145	140	-90	142
FOG PK	752E/051	1987				-93	-87	-99	-93	-97	111	135	121	-92	125
SNOWY CK	752C/103	2092				-34	-58	-62	-35	-72	66	148	68	-88	28
MT. CARIA	863B/001	1472				-97	-72	-106	-82	-77	-55	178	188	-52	153
FINDLAY GL.	859/009	1693				-118	-59	-132	-61	-113	87	197	152	-73	132
PARK PASS GL.	752B/048	1824					-41	-189	-16	-79	56	131	111	-76	86
MT. LARKINS	752E/002	1945				-275	-95	-315	-163	-312	105	270	255	-280	150
BRYANT GL.	752B/025	1783				-108	-55	-153	-103	-113	-5	227	182	-118	87
AILSA MTS.	752B/013	1648				-84	-52	-93	-64	-55	-27	182	137	-55	37
MT. GUNN	851B/057	1593				-108	-64	-122	-86	-73	-34	209	217	-78	42
MT. GENDARME	797G/033	1616				-114	-64	-198	-100	-126	32	188	159	-131	34
LLAWRENNY PKS.	846/035	1476				-116	-68	-176	-15	-155	2	194	181	-71	137
BARRIER PK.	797I/004	1596				-168	-118	-236	-126	-132	86	304	207	-108	194
MT. IRENE	797D/001	1563				-156	-51	-163	-65	-103	49	95	100	-162	170
MERRIE RA.	797B/010	1515				-135	-95	-165	-90	-130	-70	173		-103	175
CAROLINE PK.	803/001	1380				-160	1	-150	-78	-130	2	182		-105	195
NUMBER		50	2	1	15	49	50	50	48	45	50	48	46	50	49
MEAN		1836	239	-65	-125	-136	-67	-151	-45	-124	42	172	147	-91	112
STD. DEV.		215			80	68	40	70	53	52	62	70	62	54	58
No. below ELA (+ve balance)			0	1	15	48	47	50	38	45	13	0	0	49	0
% with +ve M.B.			0	100	100	98	94	100	79	100	26	0	0	98	0

GLACIER	GL.IN. No	ELAo	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
KAIKOURA RA	621/001	2490			-25		14	50	5	13	30		
MT. ELLA	932B/012	2142	-64		-77	17	27	38	30	38		38	
MT FAERIE QUEENE	646/006	2030	-54		-60	-48	-33	55	45	-47		45	
MT. WILSON	None	1912	-121	-92	-82	93	40	93	88	11	98	88	11
MT. FRANKLIN	911A/002	1814	-70		-106	126	-23	126	124	11	166	124	36
ROLLESTON GL.	911A/004	1763	-94	-1	-23	37	32	52	51	5	102	50	2
MT. CARRINGTON	646C/027	1715	-84	-120	-137	135	-45	155	155	-90	245	155	-120
MT. AVOCA	685F/004	1965	-52	-20	-53	35	3	85	10	5	105	65	-17
MARMADUKE GL.	664C/012	1830	-117	-27	-130	145	13	160	140	-20	164	150	-20
RETREAT GL	906A/004	1742	-78	18	-132	48	-22	68	63	18		58	18
BROWNING RA	906A/001	1598	-77	-28	-110	12	21	27	22	2		22	12
DOUGLAS GL	685B/001	2040	-134	-35	-163	240	-44	340	243	245	330	310	-150
MT. BUTLER	685C/060	1840	-147	-80	-176	75	-2	120	85	-33	215	120	-33
DAINTY GL	897/019	1954	-67	-44	-94	-9	-12	116	41	-34	216	116	-34
KEA GL	897/007	1820	-159	-90	-155	78	-36	150	200	-83		140	-83
JASPUR GL	897/003	1725	-74	-95	-125	35	-41		195	40		135	-95
SIEGE GL	893A/006	1736	-160	-116	-203	-72	-18	394	224	-72	444	394	-72
VERTEBRAE #12	893A/012	1864	-48	-57	-74	-34	-8	166	60	-24	226	156	-24
VERTEBRAE #25	893A/025	1840	-51	-45	-75	-6	-16	110	19	-6	155	100	-6
RIDGE GL.	711L/024	2226	-63	2	-61	84	30	99	79	54		99	9
LANGDALE GL.	711L/035	2186	-226	-1	-221	109	74	394	129	76		214	76
TASMAN GL.	711L/012	1790	-80	-40	-40	60	6	235	175	-20	320	210	-35
SALISBURY GL	888B/003	1810	-95	-78	-95	40	0	140	140	-30	285	170	-30
JALF GL	886/002	1790	-190	-170	-190	-5	2	260	250	-35	370	260	-35
CHANCELLOR DOME	882A/007	1756	-186	-151	-181	94	43	109	109	-6	244	109	-147
GLENMARY GL.	711F/006	2175	-60	-30	-65	30	15	105	35	5	130	70	-5
BLAIR GL.	711D/038	1938	-93	-88	-88	22	34	132	34	15	222	122	12
MT MCKENZIE	711D/021	1904	-134	-122	-132	6	15	111	31	-2	181	46	-14
JACKSON GL.	868B/094	2070	-55	-54	-56	15	14	93	12	2	160	70	2
JACK GL.	875/015	1907	-147		-112	28	16	83	73	-9	293	73	-9
MT. ST. MARY	711B/039	1926	-131	-71	-126	-31	-16	194	74	-41	254	194	-46
THURNEYSON GL	711B/012	1970	-97	-35	-70	10	-7	140	130	5	180	140	-32
BREWSTER GL.	868C/020	1935	-141	-155	-155	-65	-120	335	55	-5	350	335	-17
MT. STUART	752I/104	1673	-103	-108	-108	52	-66	127	117	4	185	177	-67
LINDSAY GL	867/002	1730	-123	-122	-118	50	-30	130	80	-20	148	120	-64
FOG PK	752E/051	1987	-25	-95	-97	45	13	118	45	45	135	143	7
SNOWY CK	752C/103	2092	-51	-58	-72	68	-2	66	64	64		66	-32
MT. CARIA	863B/001	1472	-50	-92	-98	43	-17	48	48	-74		48	-42
FINDLAY GL.	859/009	1693	-81	-115	-113	-3	-32	139	112	-61	177	97	
PARK PASS GL.	752B/048	1824	-163	-159	-154	76	26	86	86	56	181	116	26
MT. LARKINS	752E/002	1945	-205	-255	-285	125	145	245	244	235	270	250	155
BRYANT GL.	752B/025	1783	-117	-108	-118	17	-8	167	-8	-28	267	182	-8
AILSA MTS.	752B/013	1648	-65	-58	-68	-3	-35	22	27	-33	132	-33	-33
MT. GUNN	851B/057	1593	-68	-108	-108	17	-43	52	197	-78	227	192	-53
MT. GENDARME	797G/033	1616	-96	-133	-129	32	-40	33	34	-46	184	34	-56
LLAWRENNY PKS.	846/035	1476	-100	-96	-76	9	-37	104	124	-68	124	-21	-68
BARRIER PK.	797I/004	1596	-148	-131	-131	104	-17	119	194	-41	259	119	
MT. IRENE	797D/001	1563	-146	-130	-160	70	-85	50	68	-90	170	65	
MERRIE RA.	797B/010	1515	-100	-110	-105	150	-56	155	160	-75		154	
CAROLINE PK.	803/001	1380	-89	-110	-125	30	-44	50	40	0	170	45	
NUMBER		50	49	45	50	49	50	49	50	50	39	49	42
MEAN		1836	-104	-85	-113	45	-7	132	95	-4	208	125	-26
STD. DEV.		215	46	54	51	59	41	89	70	65	83.96	85.68	53.69
No. below ELA (+ve balance)			49	43	50	10	29	0	1	28	0	2	30
% with +ve M.B.			100	96	100	20	58	0	2	56	0	4	71

Appendix B Index Glacier details

Rock Glacier

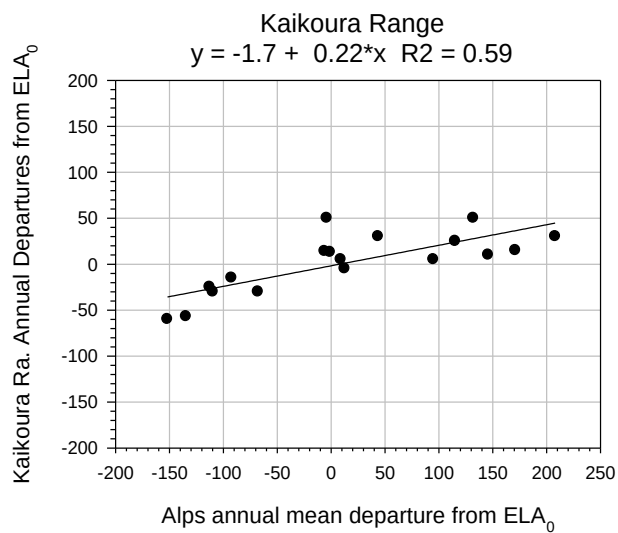
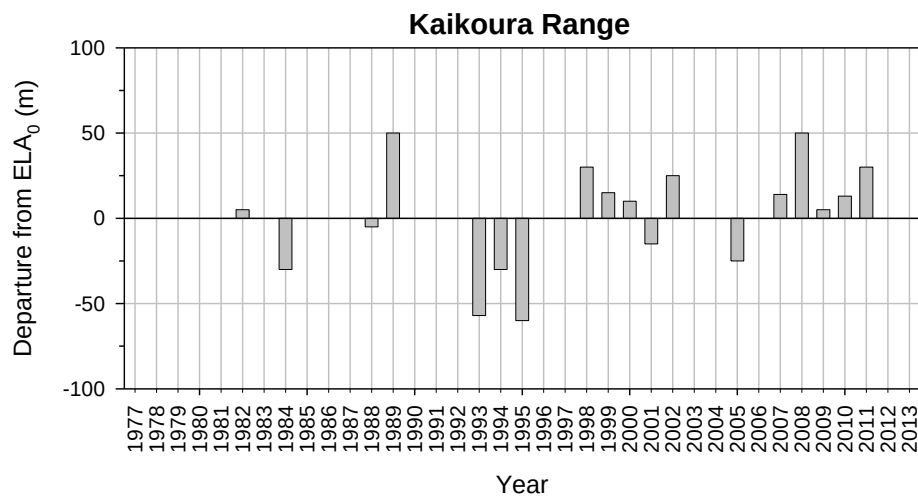
GLACIER DATA		
AREA	45.42	ha
Debris area	41.66	ha
Max Elev	2640	m
Min Elev	2200	m
Mean Elev	2420	m
Length	1.4	km
Elev Range	440	m
Gradient	0.31	

SNOWLINE DATA		
Aspect	S	
ELAo	2490	m
Max SL	2540	m, 1989
Min SL	2430	m, 1995
Mean SL	2491	m
SL Range	110	m
No. surveys	18	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. DEBRIS	AREAS	TOTAL	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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
2011	2520	30	2.29	43.25	45.54	0.05	-30
2012					no visit		
MEAN	2491	1.39	4.83	40.70	45.53	0.11	-1



No photograph as this glacier was not visited

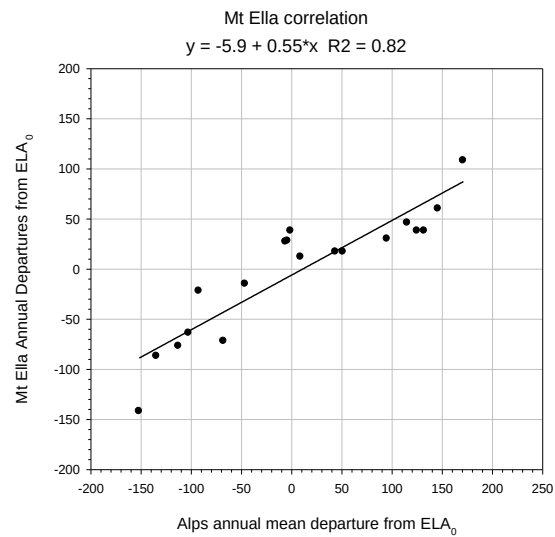
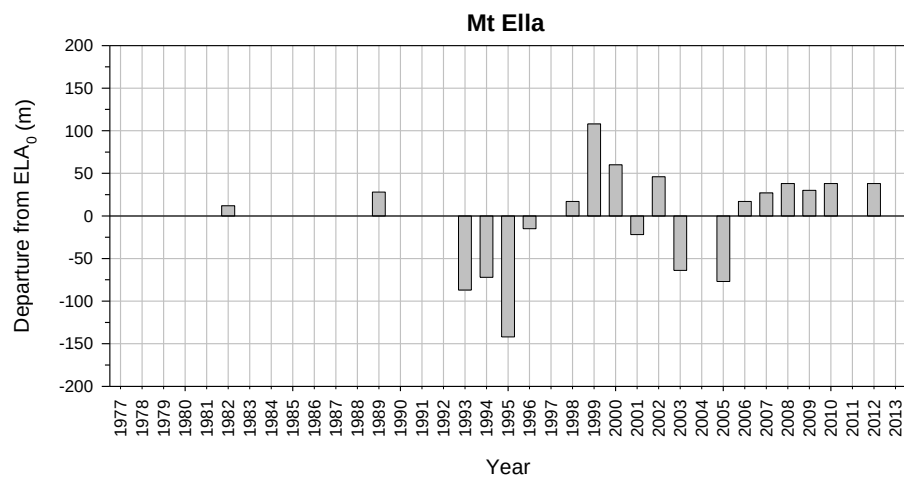
Glacierette

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, 2011
Min SL	2000	m, 1995
Mean SL	2139	m
SL Range	250	m
No. surveys	20	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. AREA	AREAS ABL.	TOTAL AREA	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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
2011	>2250		0.00	1.20	1.20	0.00	-23
2012	2180	38	0.00	1.20	1.20	0.00	-23
MEAN	2139	-3	3.36	1.44		0.73	7



No photograph as this glacier was not visited

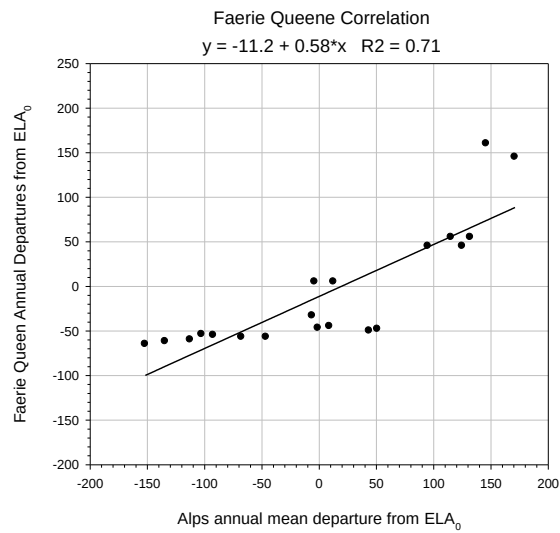
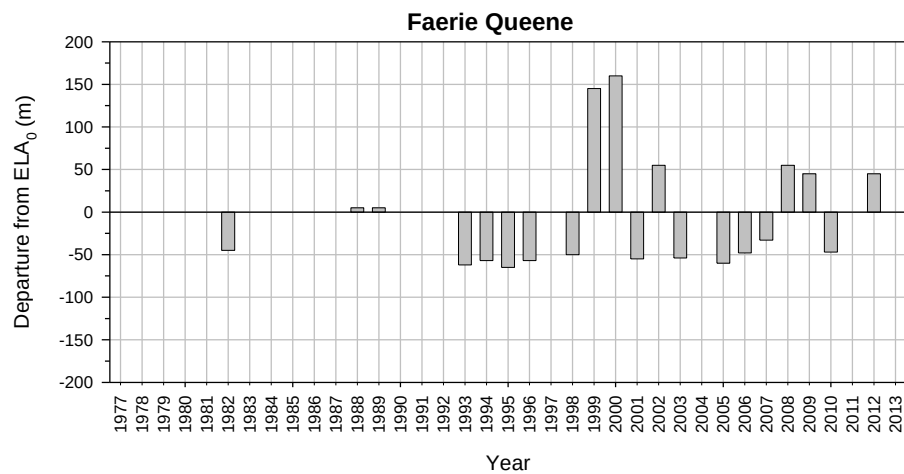
Glacierette

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	>2200	m, 2011
Min SL	1920	m, 1995
Mean SL	1979	m
SL Range	280	m
No. Surveys	21	

MEASUREMENTS Digitised values shaded

MEAN SNOWLINE DEPARTURE AREAS ACCUM. MASS							
YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELA	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	3.80	0.00	-145
2000	2145	160	0.00	2.90	2.90	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
2011	>2200		0.00	2.72	2.72	0.00	0
2012	2030	45	1.10	2.30	3.40	0.32	-45
MEAN	1979	-6	3.93	1.15		0.71	6



Not numbered

Mt WILSON

NZMS 260 sheet K33

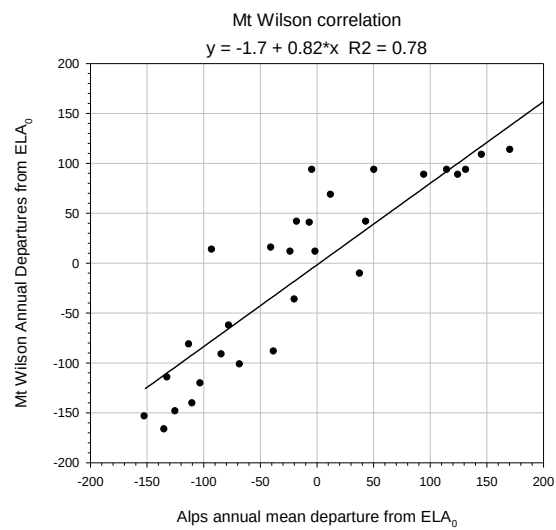
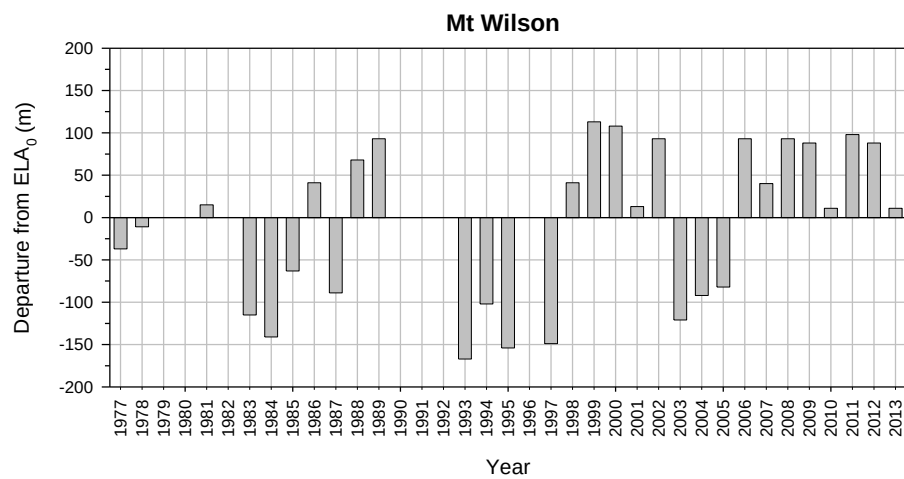
Snow patch

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	1905	m
SL Range	280	m
No. Surveys	30	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS	ACCUM.	MASS
	m	m	ABL.	TOTAL	AREA RATIO
	m	m	ha	ha	(AAR)
ELA	1912		10.55	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
2011	2010	98	0.63	0.63	-98
2012	2000	88	0.88	0.88	-88
2013	1923	11	3.45	3.45	-11
Mean	1905	-7	5.42	5.42	7



Photograph 4: Mt Wilson 12 March 2013.

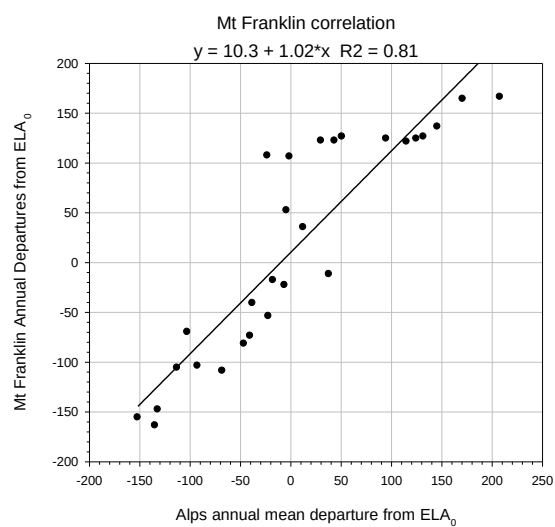
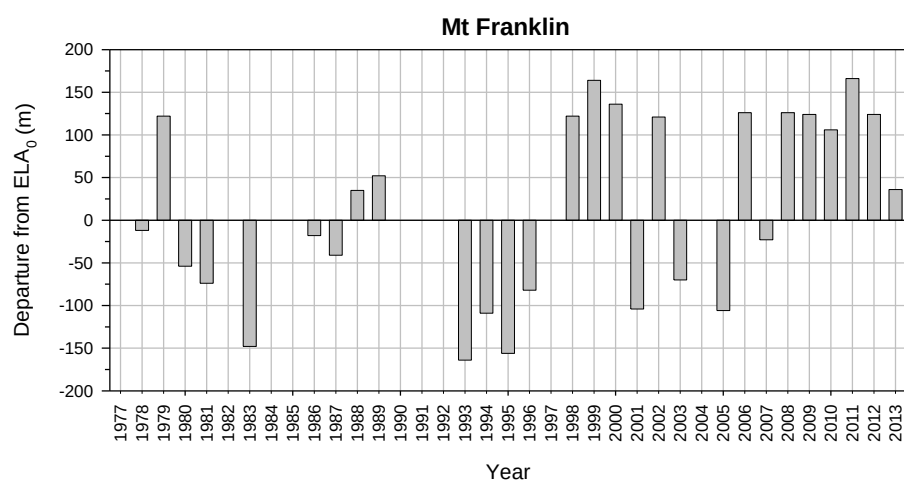
Cirque

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	1980	m, 2011
Min SL	1650	m, 1993
Mean SL	1825	m
SL Range	330	m
No. Surveys	28	

MEASUREMENTS

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	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	1825	11	5.65	1.22	6.87	0.82	-11
2011	1980	166	0.10	6.77	6.87	0.01	-166
2012	1938	124	0.80	6.07	6.87	0.12	-124
2013	1850	36	4.37	2.50	6.87	0.64	-36
Mean	1825	11	5.30	3.19		0.63	-11



Photograph 5: Mt Franklin 12 March 2013.

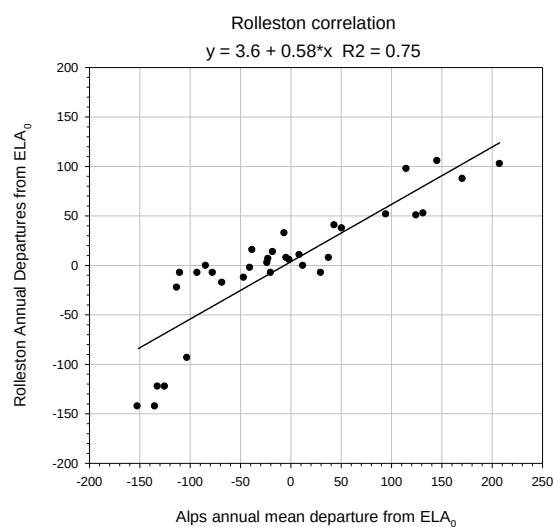
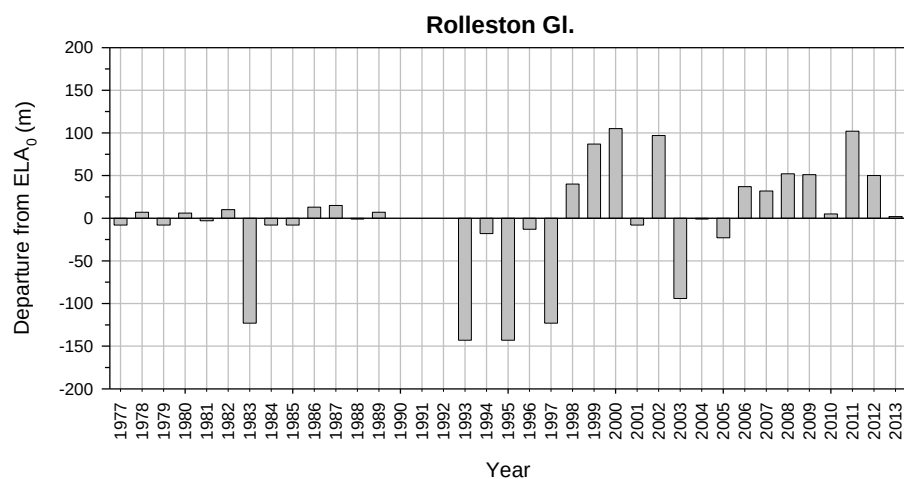
Cirque glacier

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	1763	m
SL Range	248	m
No. Surveys	34	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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
2011	1865	102	0.50	10.00	10.5	0.05	-102
2012	1813	50	4.40	6.03	10.43	0.42	-50
2013	1765	2	8.13	2.30	10.43	0.78	-2
MEAN	1763	0	7.41	3.32		0.68	0



Photograph 6: Rolleston Glacier 12 March 2013.

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	

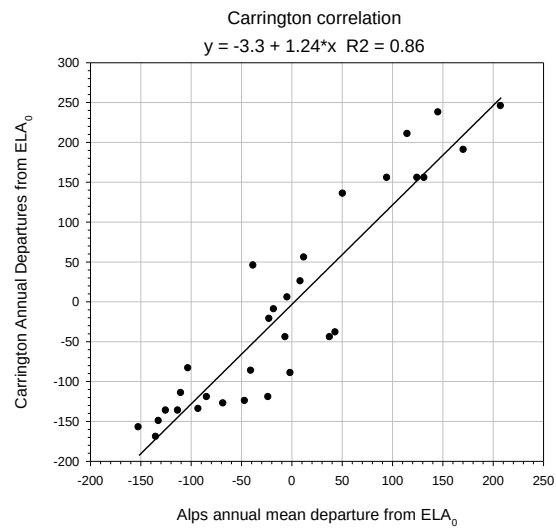
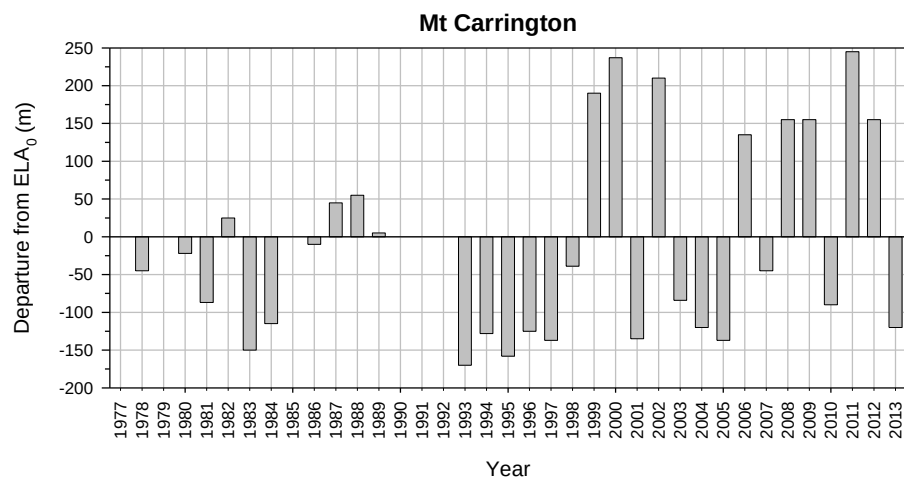
SL DATA		
ELAo	1715	m
Max SL	1960	m, 2011
Min SL	1545	m, 1993
Mean SL	1705	m
SL Range	415	m
No. Surveys	31	

MEASUREMENTS Digitised values shaded

MEASUREMENTS

Digitized values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELA ₀	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELA ₀	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
2011	1960	245	0.10	7.40	7.50	0.01	-245
2012	1870	155	3.20	4.30	7.50	0.43	-155
2013	1595	-120	7.50	0.00	7.50	1.00	120
MEAN	1705	-10	9.25	5.47		0.64	10



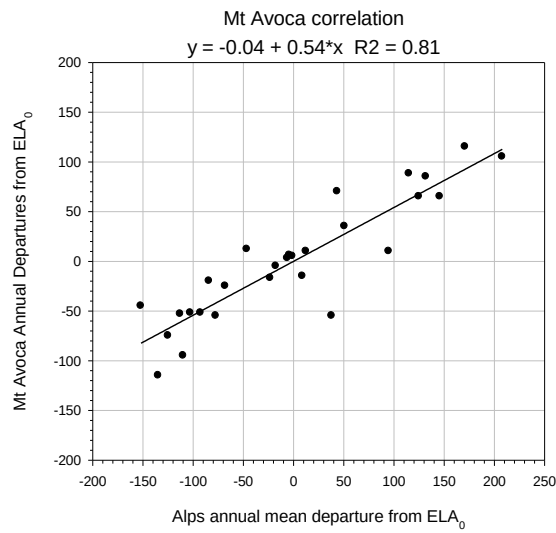
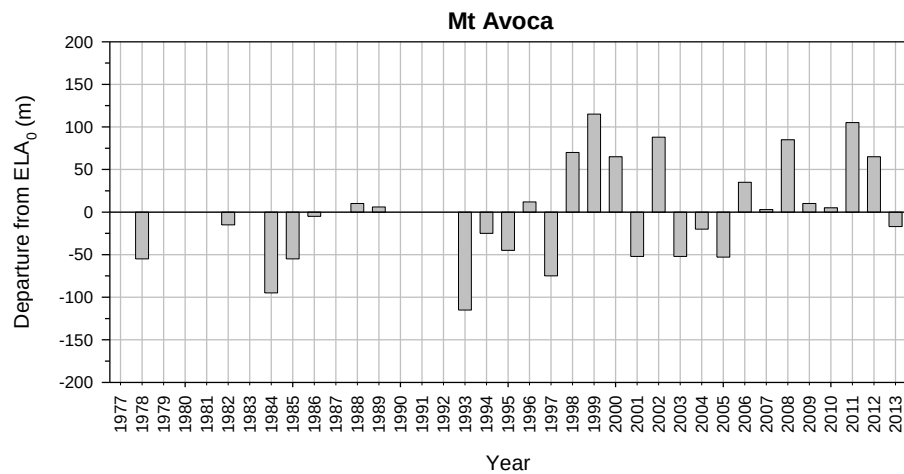
Photograph 7: Carrington 12 March 2013.

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		
ELA ₀	1965	m
Max SL	2080	m, 1999
Min SL	1850	m, 1993
Mean SL	1965	m
SL Range	230	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELA ₀	ACCUM. ha	AREAS ABL. ha	ACCUM. TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	2070	105	0.10	0.97	1.07	0.09	-105.00
2012	2030	65	0.30	0.77	1.07	0.28	-65.00
2013	1948	-17	3.50	0.00	1.07	1.00	17.00
MEAN	1965	0	3.94	2.78		0.51	0



Photograph 8: Mt Avoca 12 March 2013.

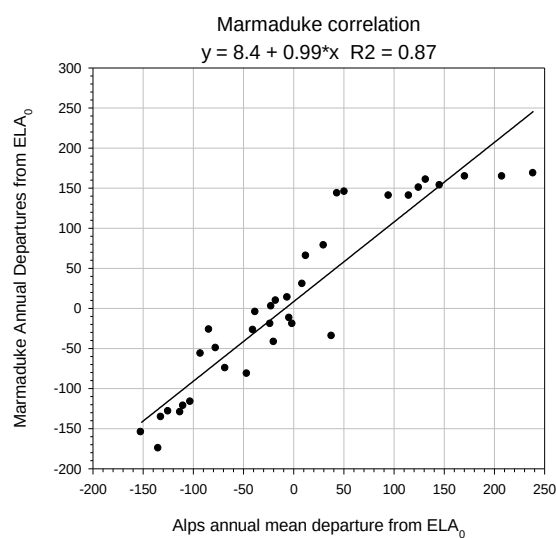
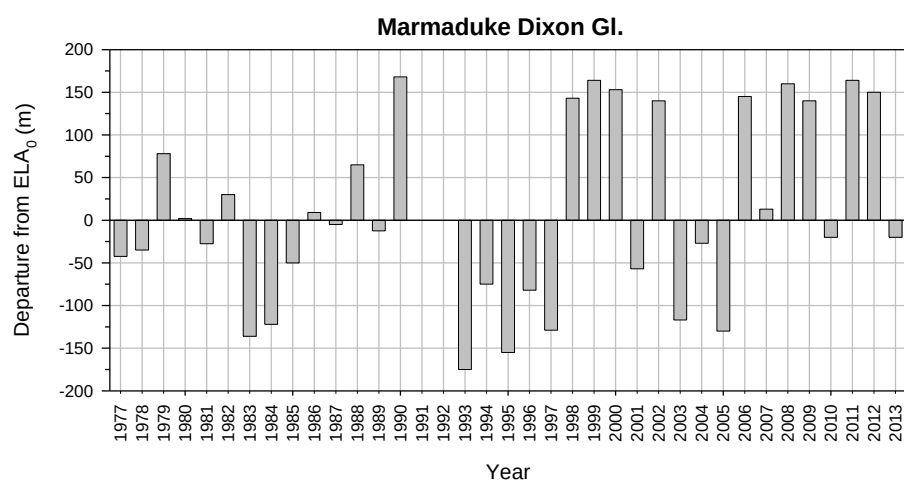
Mountain glacier

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	1839	m
SL Range	343	m
No. Surveys	35	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE	AREAS	ACCUM.	MASS
	ELEVATION	FROM ELAo	ABL.	TOTAL	AREA RATIO
	m	m	ha	ha	(AAR)
ELAo	1830	0	64	29	93
					0.69
1977	1788	-43	73.02	19.50	92.52
1978	1795	-35	71.52	21.00	92.52
1979	1908	78	44.50	48.02	92.52
1980	1832	2	63.52	29.00	92.52
1981	1803	-28	69.72	22.80	92.52
1982	1860	30	49.65	42.87	92.52
1983	1694	-136	86.72	5.80	92.52
1984	1708	-122	85.52	7.00	92.52
1985	1780	-50	73.97	18.55	92.52
1986	1839	9	61.72	30.80	92.52
1987	1825	-5	64.77	27.75	92.52
1988	1895	65	48.02	44.50	92.52
1989	1818	-13	67.02	25.50	92.52
1990	1998	168	22.52	70.00	92.52
1991					
1992					
1993	1655	-175	90.34	2.18	92.52
1994	1755	-75	78.48	14.04	92.52
1995	1675	-155	92.14	0.38	92.52
1996	1748	-82	82.22	10.30	92.52
1997	1701	-129	91.87	0.65	92.52
1998	1973	143	26.81	65.71	92.52
1999	1994	164	21.50	71.02	92.52
2000	1983	153	23.75	68.77	92.52
2001	1773	-57	75.32	17.20	92.52
2002	1970	140	28.38	53.42	81.80
2003	1713	-117	74.50	7.30	81.80
2004	1803	-27	66.48	19.37	85.85
2005	1700	-130	91.87	0.65	92.52
2006	1975	145	27.80	54.00	81.80
2007	1843	13	54.00	27.80	81.80
2008	1990	160	26.80	55.00	81.80
2009	1970	140	28.38	53.42	81.80
2010	1810	-20	61.00	20.80	81.80
2011	1994	164	21.50	60.30	81.80
2012	1980	150	24.00	57.80	81.80
2013	1810	-20	61.00	20.80	81.80
MEAN	1839	9	58.01	31.26	0.65
					-9



Photograph 9: Marmaduke Dixon 12 March 2013.

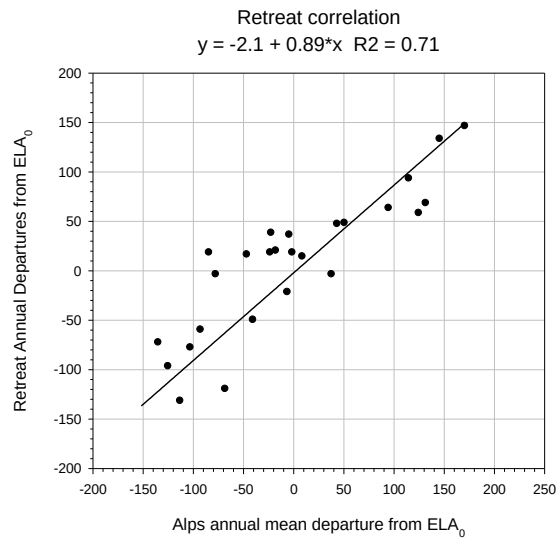
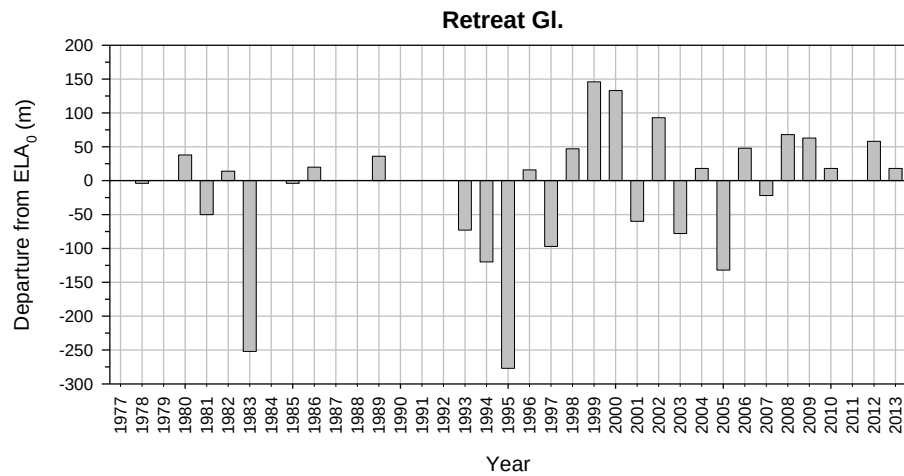
Mountain glacier

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	1730	m
SL Range	423	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. FROM ELAo	AREAS ABL.	TOTAL AREA	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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	5.57	7.96	0.30	-133
2001	1682	-60	0.69	7.27	7.96	0.09	60
2002	1835	93	2.88	5.08	7.96	0.36	-93
2003	1664	-78	7.16	0.80	7.96	0.90	78
2004	1760	18	2.16	5.80	7.96	0.27	-18
2005	1610	-132	6.46	1.50	7.96	0.81	132
2006	1790	48	0.36	7.60	7.96	0.05	-48
2007	1720	-22	5.06	2.90	7.96	0.64	22
2008	1810	68	0.64	7.32	7.96	0.08	-68
2009	1805	63	0.90	6.60	7.50	0.12	-63
2010	1760	18	1.70	5.80	7.50	0.23	-18
2011	>1888		0.00	5.25	5.25	0.00	0
2012	1800	58	1.15	4.10	5.25	0.22	-58
2013	1760	18	3.55	1.70	5.25	0.68	-18
MEAN	1730	-12	9.87	8.51		0.47	12



Photograph 10: Retreat Glacier on 12 March 2013.

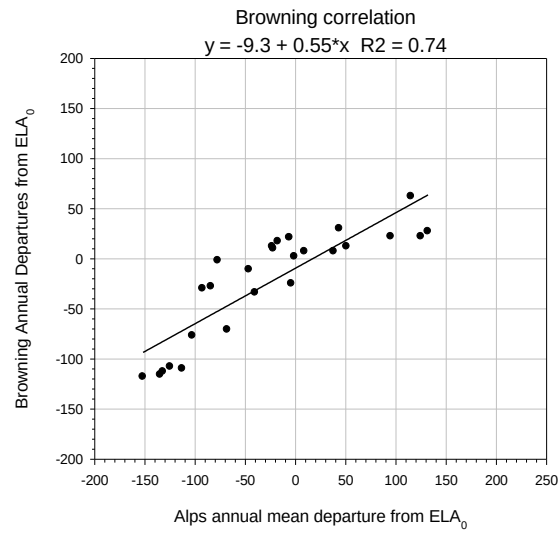
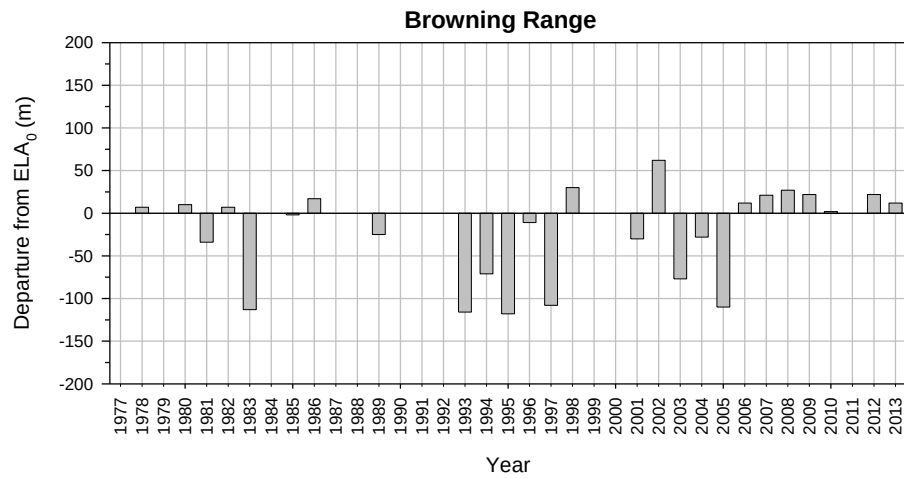
Small cirque

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	>1790	m, 2000
Min SL	1480	m, 1995
Mean SL	1576	m
SL Range	220	m
No. Surveys	29	

MEASUREMENTS Digitised values in bold type

MEASUREMENTS							
YEAR	SNOWLINE	DEPARTURE	AREAS	ACCUM.	MASS		
	ELEVATION	FROM ELA _o	ABL.	TOTAL	AREA RATIO	BALANCE	
	m	m	ha	ha	(AAR)	INDEX	
ELA _o	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	2.55	2.60	0.02	-27.00
2009	1620	22	0.05	2.45	2.50	0.02	-22.00
2010	1600	2	0.10	1.49	1.59	0.06	-2.00
2011	>1790		0.00	0.88	0.88	0.00	
2012	1620	22	0.05	2.45	2.5	0.02	-22.00
2013	1610	12	3.58	0	3.58	1.00	-12.00
MEAN	1576	-22	2.91	1.78		0.55	22



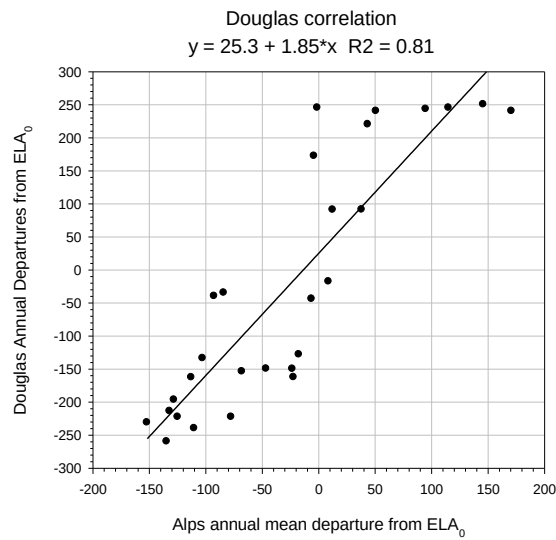
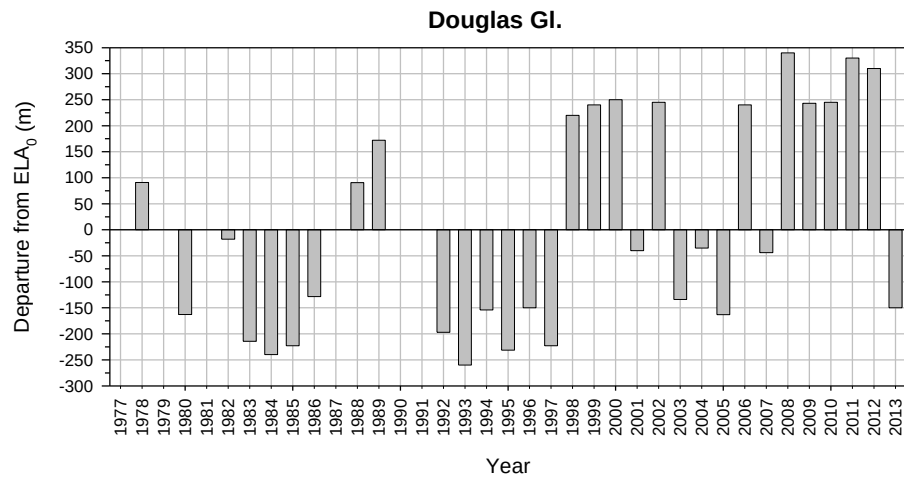
Photograph 11: Browning Range 12 March 2013.

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, 2008
Min SL	1780	m, 1993
Mean SL	2050	m
SL Range	600	m
No. Surveys	31	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ACCUM.	AREAS ABL.	ACCUM. TOTAL	MASS AREA RATIO (AAR)	BALANCE INDEX
	m	m	ha	ha	ha		
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	2340	300	3.97	25.55	22.06	0.18	-300
2011	2370	330	1.83	20.23	22.06	0.08	-330
2012	2350	310	2.10	19.96	22.06	0.10	-310
2013	1890	-150	19.46	2.60	22.06	0.88	150
Mean	2050	10	21.55	9.19		0.68	-10



Photograph 12: Douglas Glacier 12 March 2013.

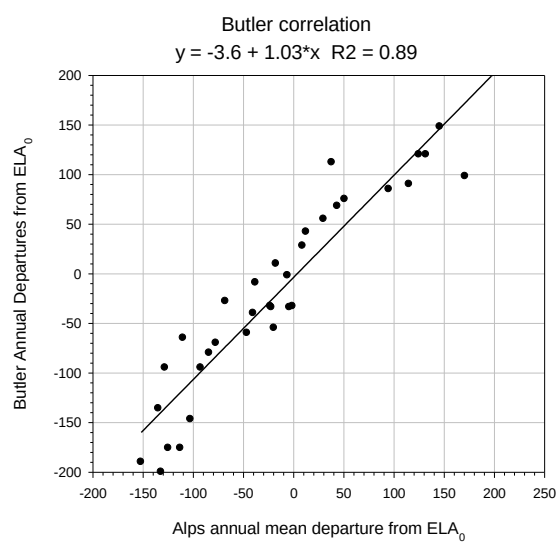
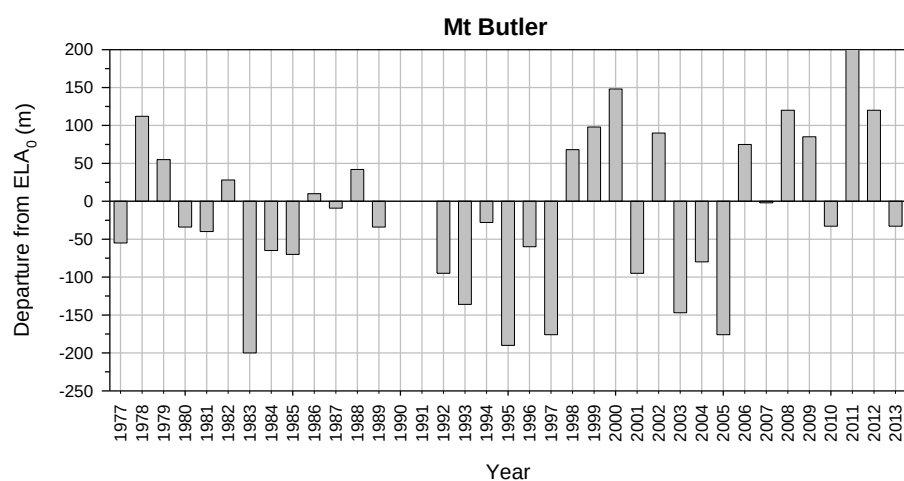
Shelf glacier

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	2055	
Min SL	1640	m, 1995
Mean SL	1827	m
SL Range	415	m
No. surveys	35	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ABL.	ACCUM. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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	53.66	61.70	0.13	-98
2000	1988	148	3.58	58.12	61.70	0.06	-148
2001	1745	-95	54.44	7.26	61.70	0.88	95
2002	1930	90	8.72	52.98	61.70	0.14	-90
2003	1693	-147	60.50	1.20	61.70	0.98	147
2004	1760	-80	53.57	8.13	61.70	0.87	80
2005	1664	-176	61.70	0.00	61.70	1.00	176
2006	1915	75	14.70	47.00	61.70	0.24	-75
2007	1862	22	34.44	16.43	50.87	0.68	-22
2008	1960	120	13.87	37.00	50.87	0.27	-120
2009	1925	85	10.37	40.50	50.87	0.20	-85
2010	1807	-33	45.17	5.70	50.87	0.89	33
2011	2055	215	0.32	39.61	39.93	0.01	-215
2012	1960	120	2.93	37.00	39.93	0.07	-120
2013	1807	-33	36.93	3.00	39.93	0.92	33
Mean	1827	-13	41.98	25.01	66.43	0.61	13



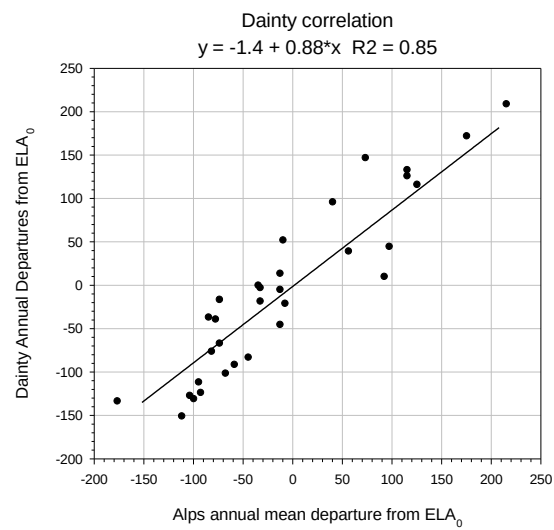
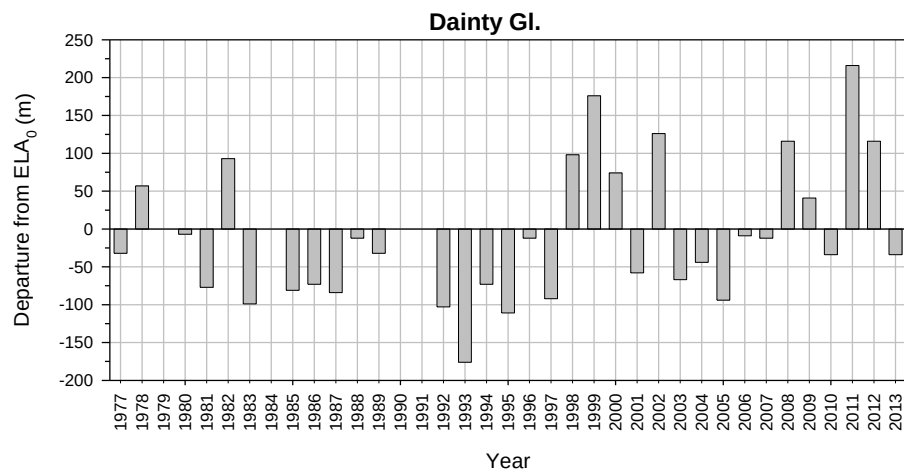
Photograph 13: Mt Butler 12 March 2013.

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	2170	m, 2011
Min SL	1778	m, 1993
Mean SL	1944	m
SL Range	392	m
No. Surveys	33	

MEASUREMENTS Digitised values in bold type

YEAR	SNOWLINE ELEVATION	DEPARTURE		AREAS		ACCUM.	MASS
	m	FROM ELA	ACCUM.	ABL.	TOTAL	AREA RAT (AAR)	BALANCE INDEX
1955	2100						
ELA	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
2011	2170	216	3.29	42	45.29	0.07	-216
2012	2070	116	8.99	36.3	45.29	0.20	-116
2013	1920	-34	26.29	19	45.29	0.58	34
MEAN	1944	-10	25.39	19.90	45.29	0.56	9



Photograph 14: Dainty Glacier 12 March 2013..

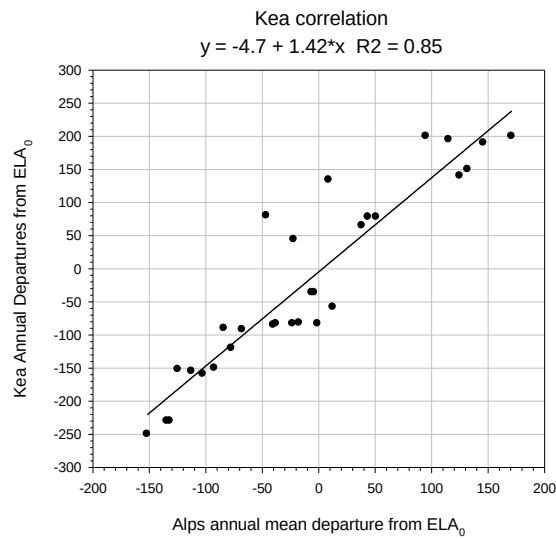
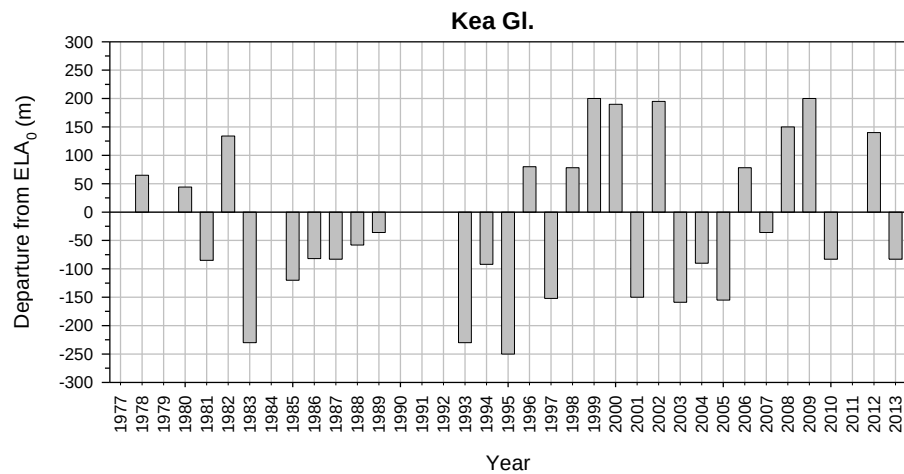
Cirque

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	1799	m
SL RANGE	450	m
No. Surveys	31	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ABL.	ACCUM. TOTAL	ACCUM. AREA RATE (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha	
ELAo	1820	0	43.62	23.5	67.12	0.65
1977						
1978	1885	65	34.25	42.69	76.94	0.45
1979					no flight	
1980	1864	44	39.34	37.6	76.94	0.51
1981	1735	-85	66.64	10.3	76.94	0.87
1982	1954	134	16.53	60.41	76.94	0.21
1983	1590	-230	96.44	19.5	115.94	0.83
1984						
1985	1700	-120	73.1	3.84	76.94	0.95
1986	1738	-82	66.54	10.4	76.94	0.86
1987	1737	-83	66.59	10.35	76.94	0.87
1988	1762	-58	60.94	16	76.94	0.79
1989	1784	-36	56.43	20.51	76.94	0.73
1990						
1991						
1992						
1993	1590	-230	94.83	17.89	112.72	0.84
1994	1728	-92	68.13	8.81	76.94	0.89
1995	1570	-250	100.75	23.81	124.56	0.81
1996	1900	80	31.26	45.68	76.94	0.41
1997	1668	-152	80.79	3.85	84.63	0.95
1998	1898	78	31.74	45.2	76.94	0.41
1999	2020	200	1.47	75.47	76.94	0.02
2000	2010	190	2.3	74.64	76.94	0.03
2001	1670	-150	76.94	0	76.94	1.00
2002	2015	195	0.92	66.2	67.12	0.01
2003	1661	-159	67.12	0	67.12	1.00
2004	1730	-90	58.32	8.8	67.12	0.87
2005	1665	-155	67.12	0	67.12	1.00
2006	1898	78	31.74	35.38	67.12	0.47
2007	1784	-36	46.62	20.5	67.12	0.69
2008	1970	150	5.62	61.5	67.12	0.08
2009	2020	200	1.47	65.65	67.12	0.02
2010	1737	-83	59.12	8	67.12	0.88
2011	>2030		0	67.12	67.12	0.00
2012	1960	140	12.12	55	67.12	0.18
2013	1737	-83	59.12	8	67.12	0.88
MEAN	1799	-21	47.56	29.78		0.60
						20



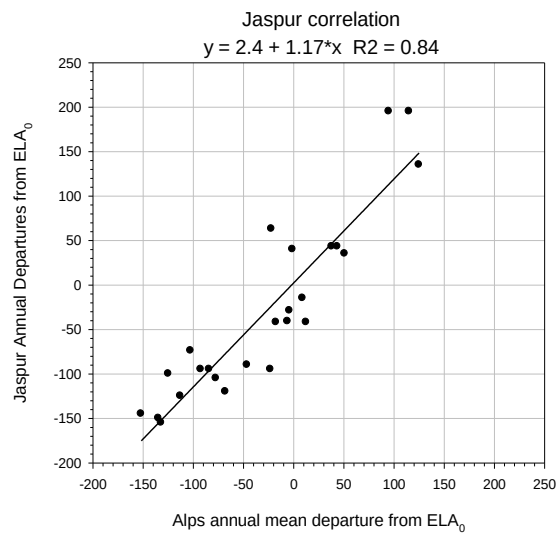
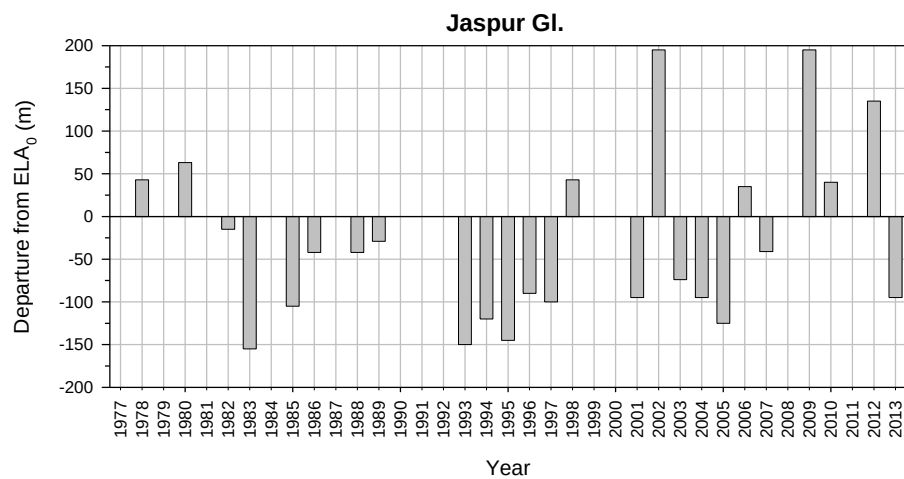
Photograph 15: Kea Glacier 12 March 2013.

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	>1950	m, 2011
Min SL	1570	m, 1983
Mean SL	1674	m
SL Range	350	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	ACCUM. TOTAL ha	MASS 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
2011	> 1950		0	14.09	14.09	0.00	
2012	1860	135	0.5	13.59	14.09	0.04	-135
2013	1630	-95	14.09	0	14.09	1.00	95
MEANS	1694	-31	10.35	4.86	14.49	0.62	22



Photograph 16: Jaspur Group 12 March 2013.

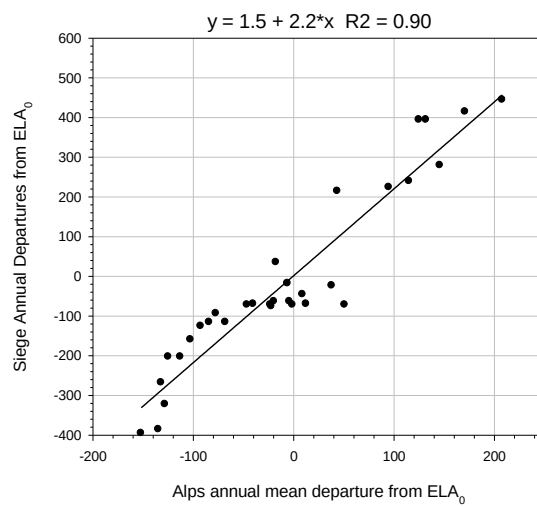
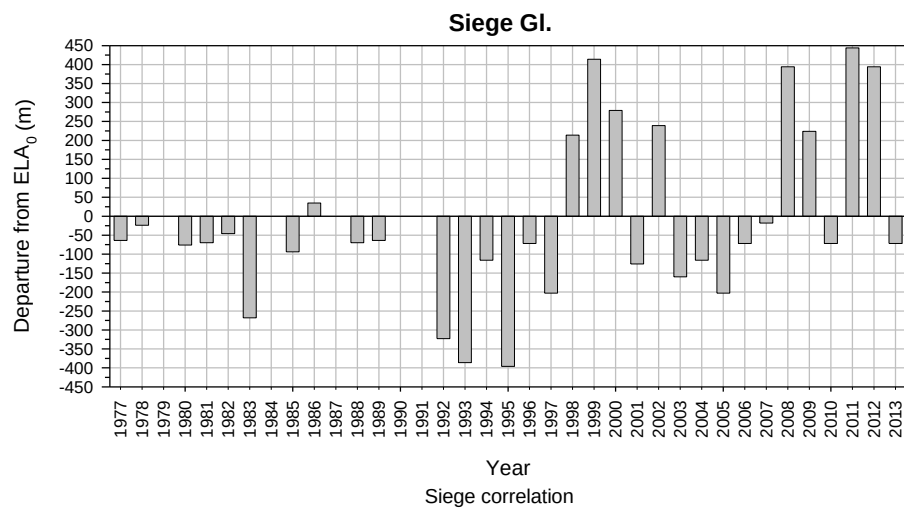
GLACIER DATA		
Aspect	SE	
AREA	151.9	ha
Max Elev	2130	m
Min Elev	1370	m
Mean Elev	1750	m
Length	3.186	km
Elev Range	760	m
Gradient	0.239	

SNOW LINE DATA		
ELAo	1736	m
Max SL	2180	m, 2011
Min SL	1340	m, 1995
Mean SL	1675	m
SL Range	810	m
No. Surveys	32	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. AREA	AREAS ABL.	ACCUM. TOTAL AREA	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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
2011	2180	444	1.65	150.25	151.9	0.01	-444
2012	2130	394	7.9	144	151.9	0.05	-394
2013	1664	-72	80.47	71.43	151.9	0.53	72
MEANS	1721	-15	74.99	76.98		0.49	15



Photograph 17: Seige Glacier 12 March 2013.

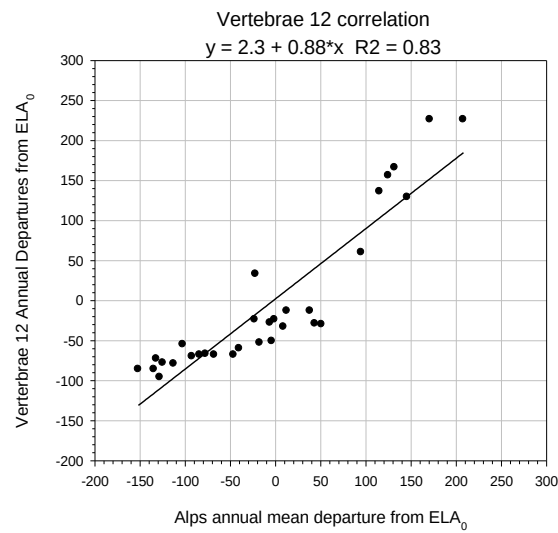
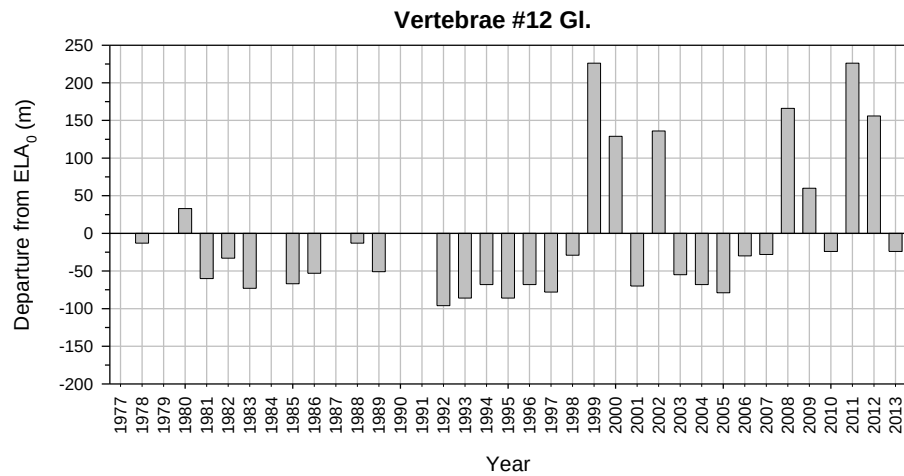
Cirque glacier

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	1866	m
SL Range	322	m
No. surveys	31	

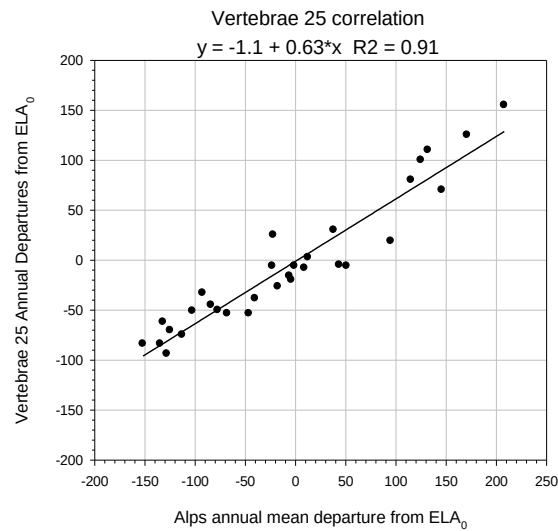
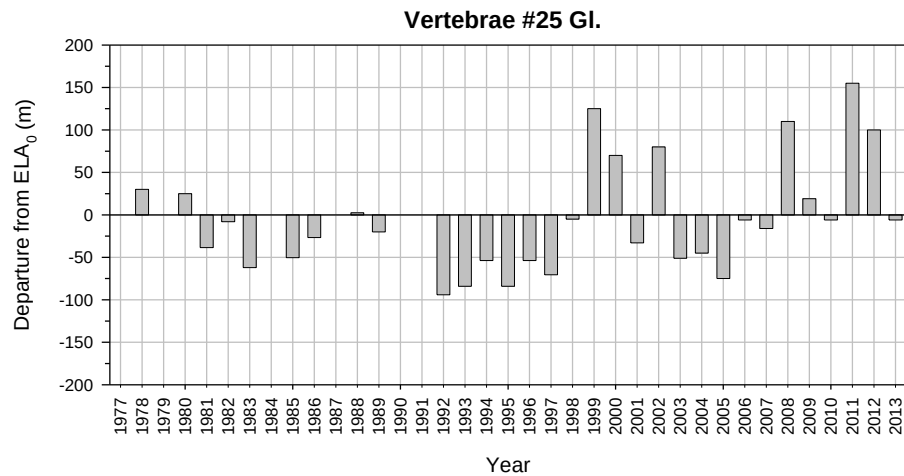
MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ACCUM.	AREAS ABL.	ACCUM. TOTAL	MASS AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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	2085	221	0.73	19.91	20.64	0.04	-221
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
2011	2090	226	0.53	20.11	20.64	0.03	-226
2012	2020	156	3.54	17.10	20.64	0.17	-156
2013	1840	-24	16.44	4.20	20.64	0.80	24
MEAN	1866	2	14.48	6.48	20.64	0.70	-2



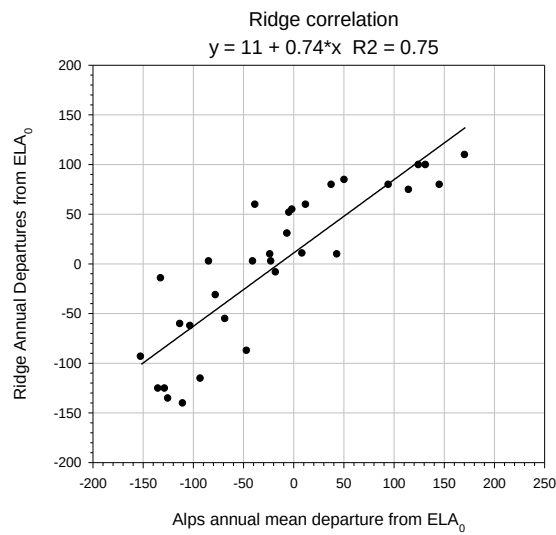
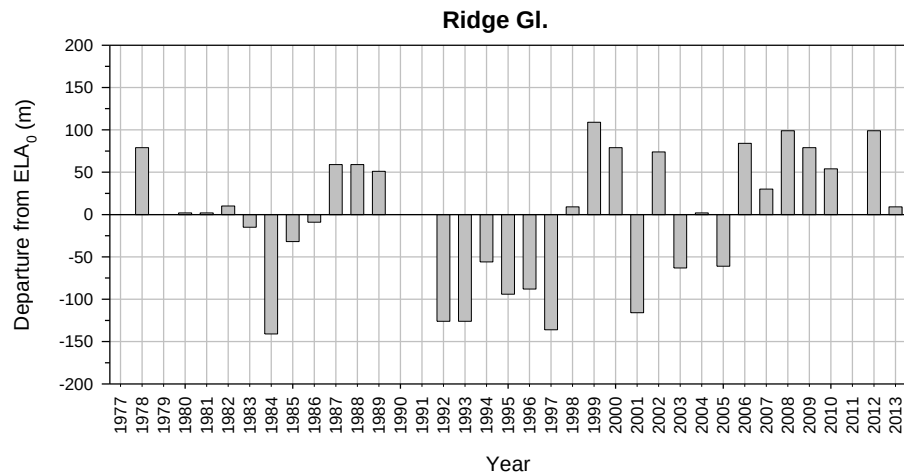
Photograph 18: Vertebrae Glacier 12 (partially obscured on the left) 12 March 2013.

893A/ 25	VERTEBRAE COL No. 25				NZMS 260 sheet I35		
	Mountain glacier						
	GLACIER DATA				SNOWLINE DATA		
	Aspect	SW					
	Area	75.55	ha		ELAo	1840	m
	Max Elev	2040	m		Max SL	1995	m, 1999
	Min Elev	1700	m		Min SL	1746	m, 1992
	Mean Elev	1850	m		Mean SL	1835	m
	Length	1.15 Km	km		SL Range	249	m
	Elev Range	360 m	m		No. surveys	31	
	Gradient	0.313					
	No 25						
MEASUREMENTS		Digitised values shaded					
YEAR	SNOWLINE DEPARTURE	AREAS		ACCUM.	MASS		
	ELEVATION FROM ELAo	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
2011	1995	155	0.64	74.91	75.55	0.01	-155
2012	1940	100	17.75	57.80	75.55	0.23	-100
2013	1834	-6	61.98	13.57	75.55	0.82	6
MEAN	1835	-5	54.65	20.90		0.72	5



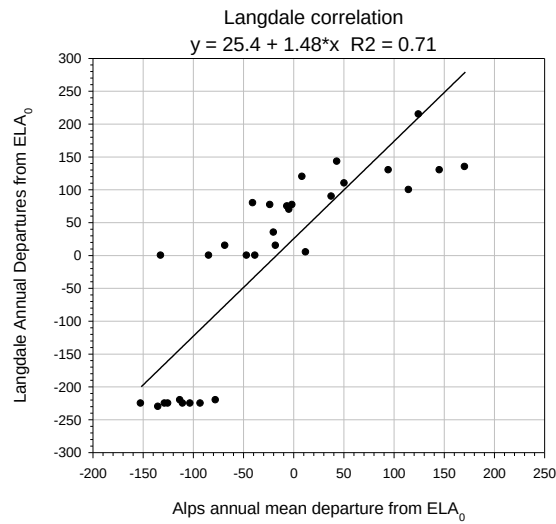
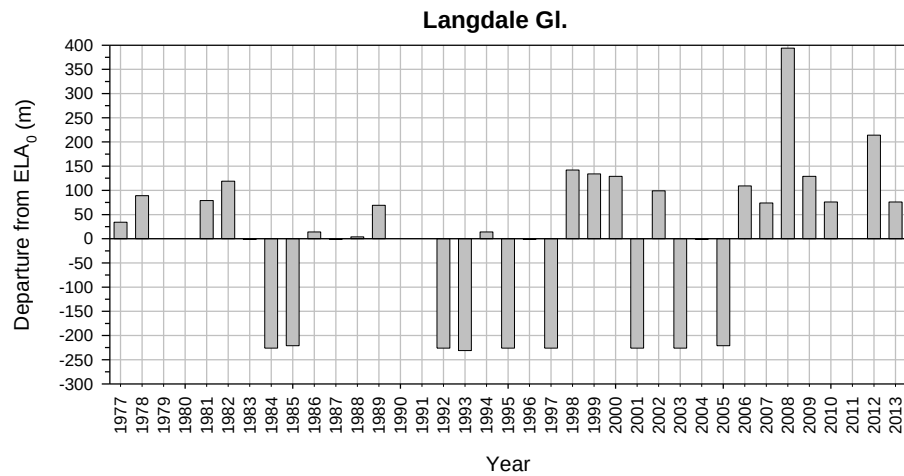
Photograph 19: Vertebrae Glacier 25 (clear of cloud in the centre) 12 March 2013.

711L-24			RIDGE GL.			NZMS sheet L24	
			Mountain glacier				
	GLACIER DATA				SNOWLINE DATA		
	Aspect	SE					
	AREA	68.00	ha		ELAo	2226	m
	Max Elev	2490	m		Max SL	>2490	m,2011
	Min Elev	2110	m		Min SL	2085	m,1984
	Mean Elev	2300	m		Mean SL	2226	m
	Length	1.04	km		SL Range	405	m
	Elev Range	380	m		No. surveys	30	
	Gradient	0.365					
MEASUREMENTS Digitised values shaded							
YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	AREAS ACCUM.	ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE INDEX
	m	m	ha	ha	ha		
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
2011	>2490		0.00	68.00	68.00	0.00	
2012	2325	99	17.48	50.52	68.00	0.26	-99
2013	2235	9	47.00	21.00	68.00	0.69	-9
MEAN	2226	0	44.60	26.88		0.62	0



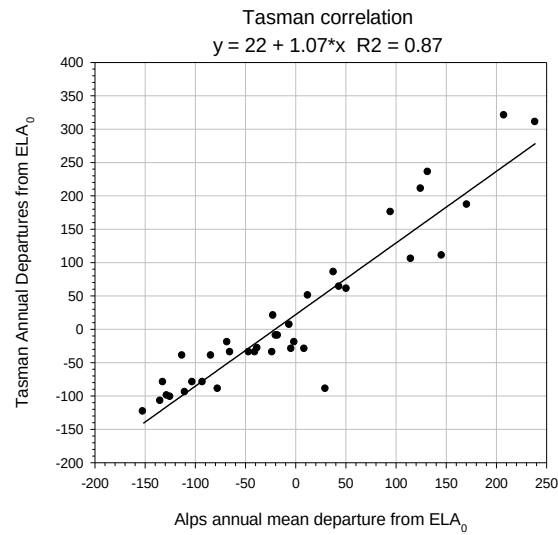
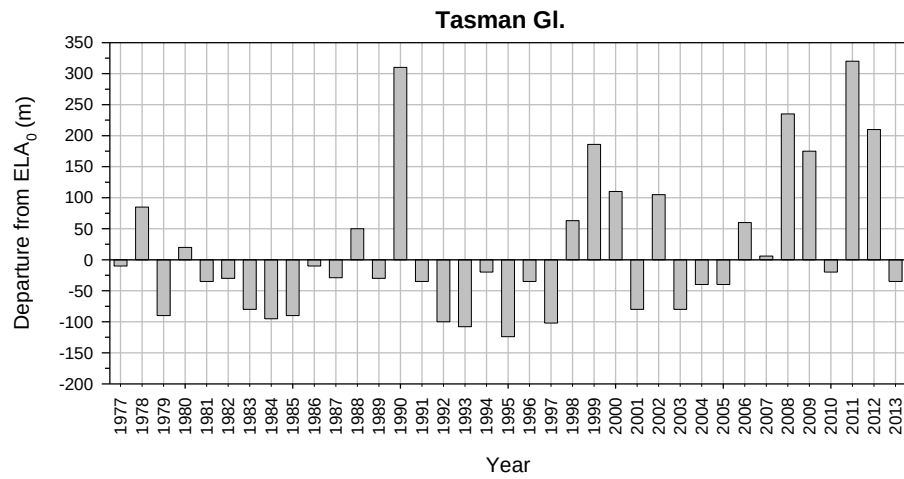
Photograph 20: Ridge Glacier 12 March 2013.

No. 711 I/35		LANGDALE GL.			NZMS 260 sheet H36		
		Cirque glacier					



Photograph 21: Langdale Glacier 12 March 2013.

No. 711I/12			TASMAN GL.			NZMS 260 sheet	
			Valley glacier				
	GLACIER DATA				SNOWLINE DATA		
	Aspect	SW					
	Max Elev				ELAo	1790	1955 to '01
	Min Elev				ELA	1807	1977 to '01
	Mean Elev				Max SL	2110	m, 2011
	Elev Range				Min SL	1666	m, 1995
	Length				Mean SL	1807	m
	Gradient				SL Range	444	m
	Gradient @	0.096			No. surveys	37	
MEASUREMENTS			Values from contour counts shaded				
YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELA	AREAS ACCUM.	AREAS ABL.	ACCUM. TOTAL	MASS AREA RATIO (AAR)	BALANCE INDEX
	m	m	ha	ha	ha		
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
2011	2110	320					-320
2012	2000	210					-210
2013	1755	-35					35
MEAN	1807	17					-17



Photograph 22: Tasman Glacier 12 March 2013.

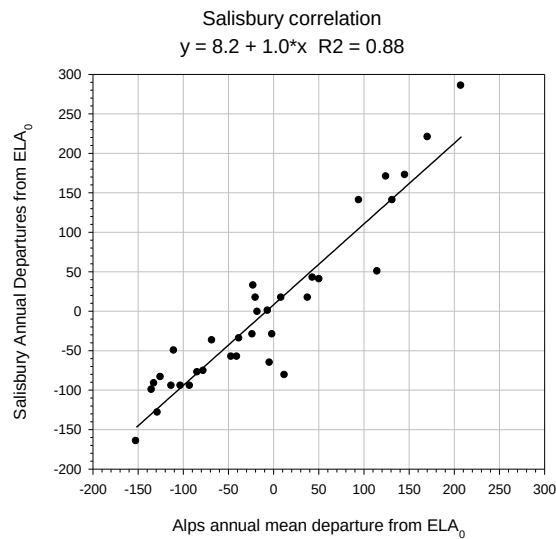
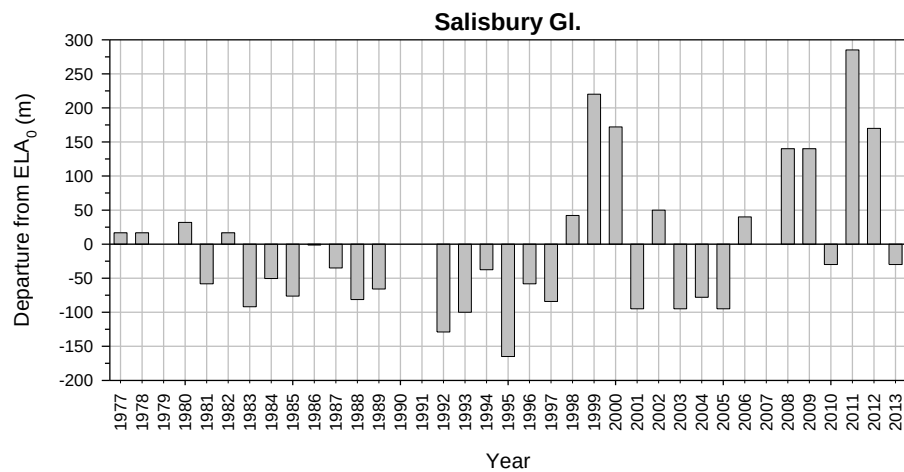
Mountain glacier

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	2095	m, 1999
Min SL	1645	m, 1995
Mean SL	1807	m
SL Range	450	m
No. surveys	34	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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
2011	2095	285	61.84	250.06	311.90	0.20	-285
2012	1980	170	133.90	178.00	311.90	0.43	-170
2013	1780	-30	259.90	52.00	311.90	0.83	30
Mean	1807	-3	237	75		0.76	3



Photograph 23: Salisbury Snowfield 12 March 2013.

Small saddle glacier

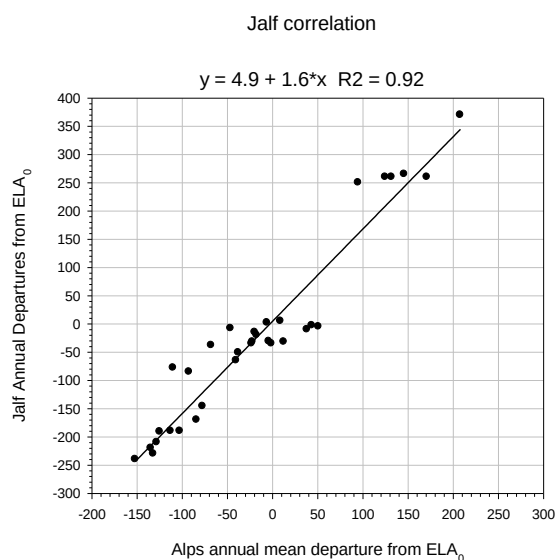
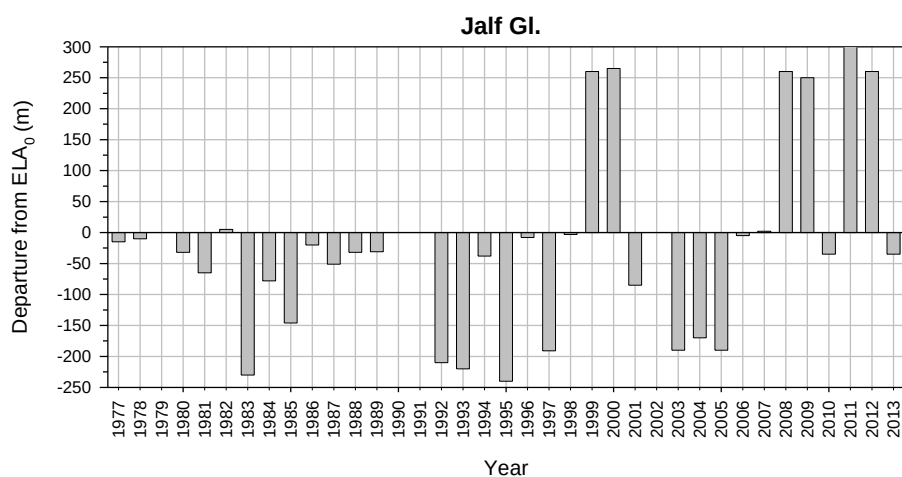
GLACIER DATA (2008)		
Aspects	N & S, E & W	
AREA	41.50	ha
Max Elev	1880	m
Min Elev	1600	m
Mean Elev	1740	m
Length	na	
Elev Range	280	m
Gradient	na	

SNOWLINE DATA		
ELAo	1790	m
Max SL	2160	m, 2000
Min SL	1550	m, 1995
Mean SL	1770	m
SL Range	610	m
No. surveys	33	

Glacier area has reduced since the first map in 1977

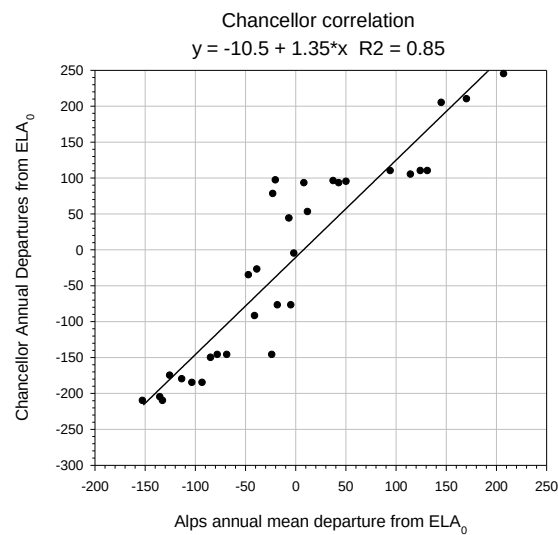
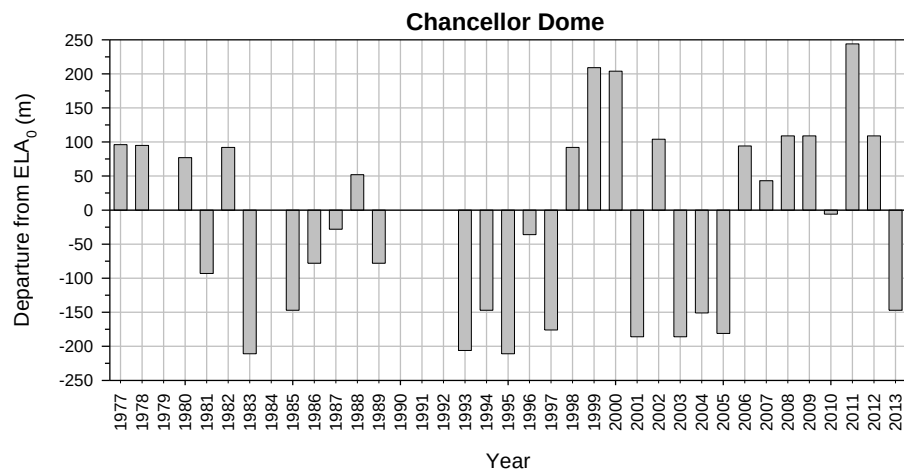
MEASUREMENTS Digitised values shaded

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	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	37.00	37.00	0.00	-250.00
2010	1755	-35	3.50	33.50	37.00	0.09	35.00
2011	2160	370	0.00	31.00	31.00	0.00	-370.00
2012	2050	260	0.00	29.40	29.40	0.00	-260.00
2013	1755	-35	3.50	25.90	29.40	0.12	35.00
MEAN	1770	-20	31	39.94		0.42	20



Photograph 24: Jalf Glacier (obscured under cloud on left) 12 March 2013. Snowline elevation determined from the Fritz Range glaciers in this photo.

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	2000	m, 2011
	Min Elev	1660	m		Min SL	1545	m, 1995
	Mean Elev	1810	m		Mean SL	1739	m
	Length	0.55	km		SL Range	455	m
	Elev Range	300	m		No. surveys	32	
	Gradient	0.436					
MEASUREMENTS		Digitised values shaded					
YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	2000	244	0.00	17.51	17.51	0.00	-244
2012	1865	109	1.30	16.21	17.51	0.07	-109
2013	1609	-147	16.38	1.13	17.51	0.94	147
MEAN	1739	-17	13.38	8.19		0.61	17



Photograph 25: Chancellor Glacier 12 March 2013.

Cirque glacier

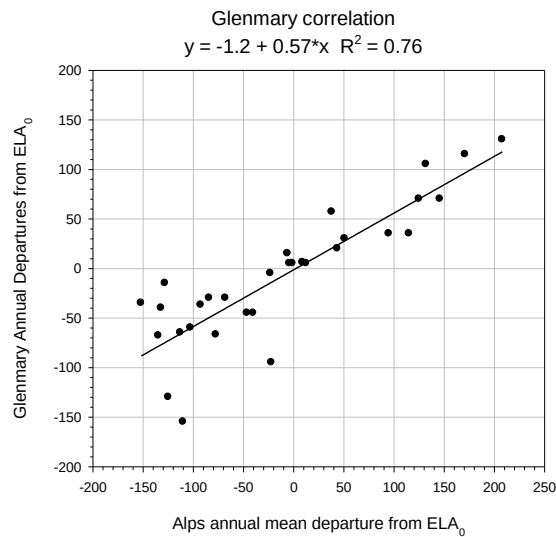
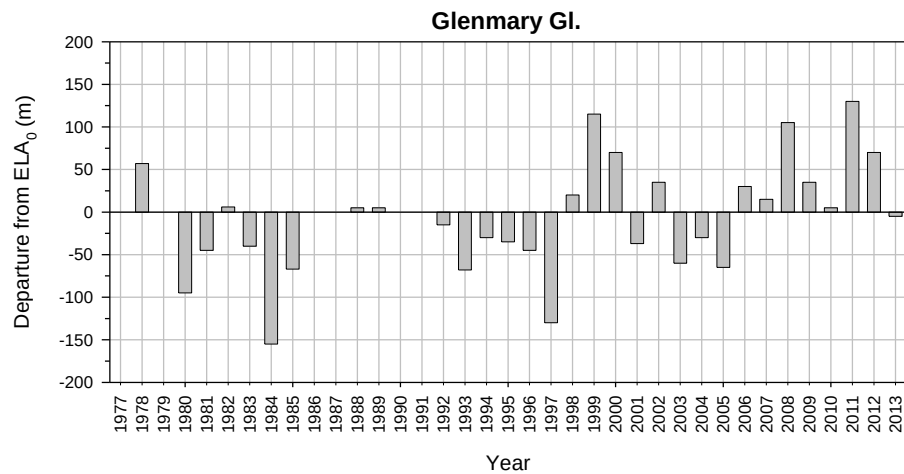
GLACIER DATA		
Aspect	S	
AREA	58.51	ha
Max Elev	2380	m
Min Elev	2040	m
Mean Elev	2210	m
Length	1.19	km
Elev Range	340	m
Gradient	0.277	

SNOWLINE DATA		
ELAo	2164	m
Max SL	2305	m, 2011
Min SL	2020	m, 1984
Mean SL	2168	m
SL Range	285	m
No. Surveys	31	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	2305	130	5.26	45.54	50.80	0.10	-130
2012	2245	70	20.10	30.70	50.80	0.40	-70
2013	2170	-5	36.00	14.80	50.80	0.71	5
Mean	2168	-7	34.9	17.1		0.67	7



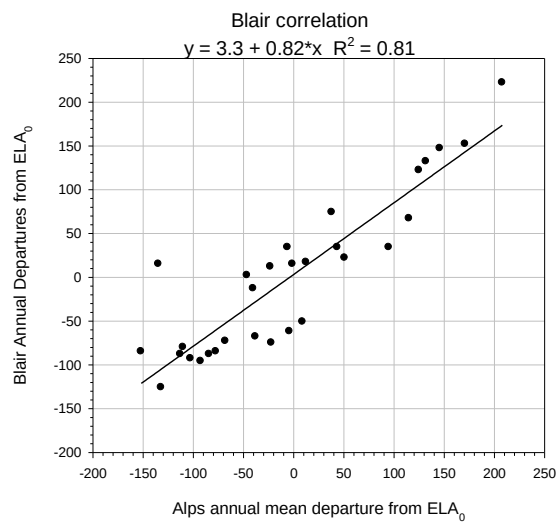
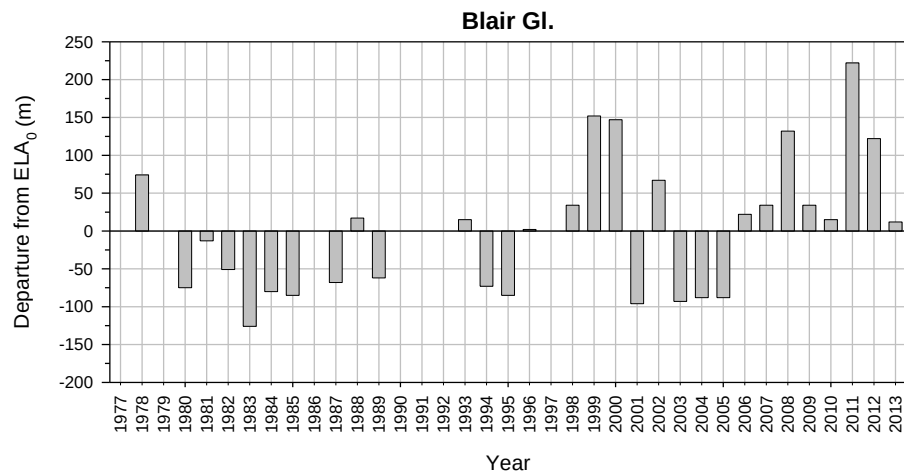
Photograph 26: Glenmary Glacier on 12 March 2013.

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	2160	m, 2011
Min SL	1812	m, 1983
Mean SL	1939	m
SL Range	348	m
No. Surveys	30	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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
2011	2160	222	2.52	23.90	26.42	0.10	-222
2012	2060	122	8.92	17.50	26.42	0.34	-122
2013	1950	12	17.82	8.60	26.42	0.67	-12
MEAN	1939	1	17.83	8.59		0.67	-1



Photograph 27: Blair Glacier on 12 March 2013.

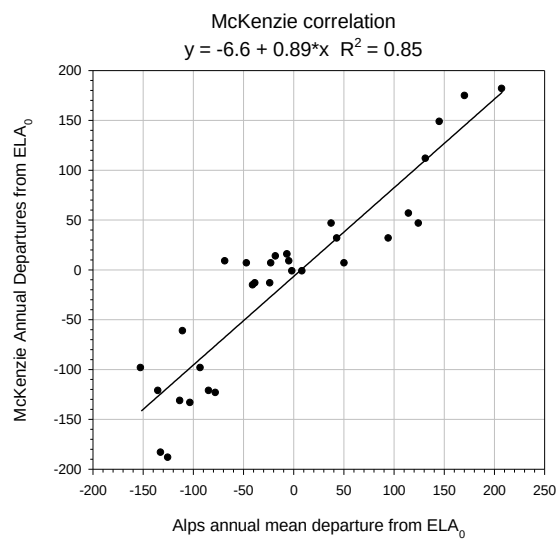
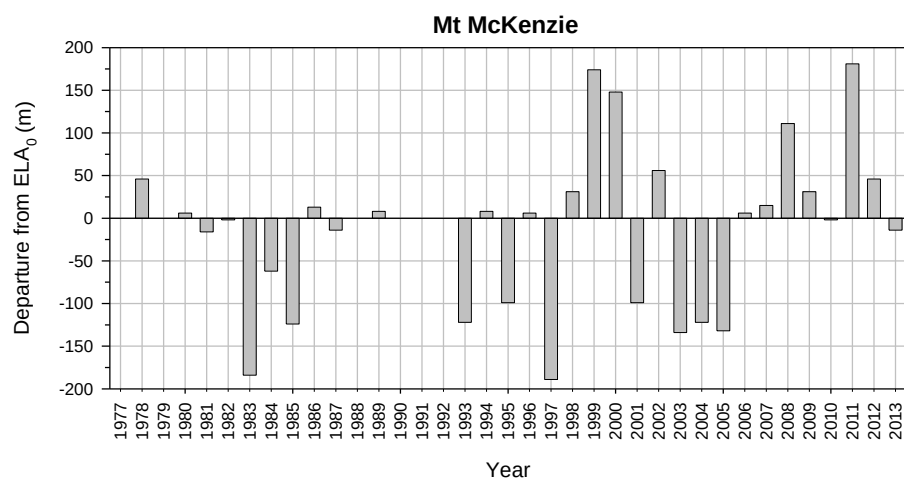
GLACIER DATA		
Aspect	S	
AREA	48.67	ha
Max Elev	2100	m
Min Elev	1760	m
Mean Elev	1930	m
Length	0.69	km
Elev Range	340	m
Gradient	0.49	

SNOWLINE DATA		
ELAo	1904	m
Max SL	2085	m, 2011
Min SL	1715	m, 1983
Mean SL	1890	m
SL Range	370	m
No. Surveys	31	

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	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
2011	2085	181	1.64	47.03	48.67	0.03	-181
2012	1950	46	22.78	25.89	48.67	0.47	-46
2013	1890	-14	33.23	15.44	48.67	0.68	14
MEAN	1890	-14	32.04	16.63		0.66	14



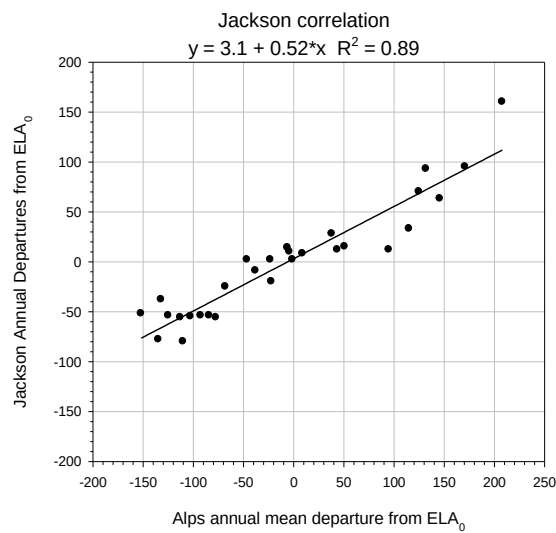
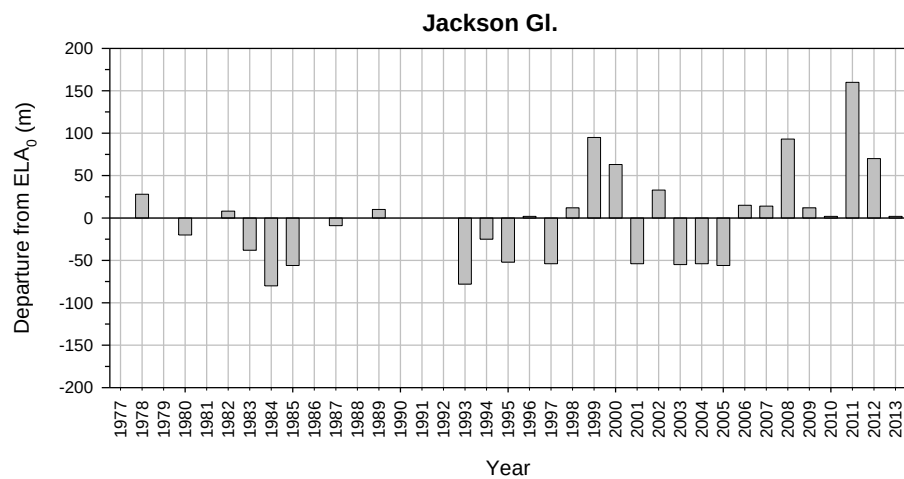
Photograph 28: McKenzie Glacier on 12 March 2013.

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	

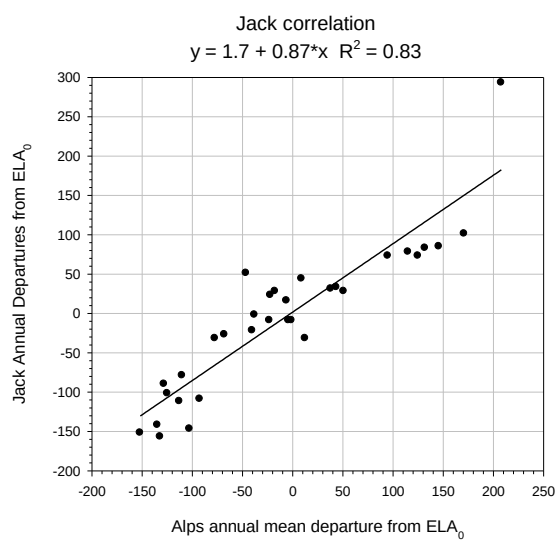
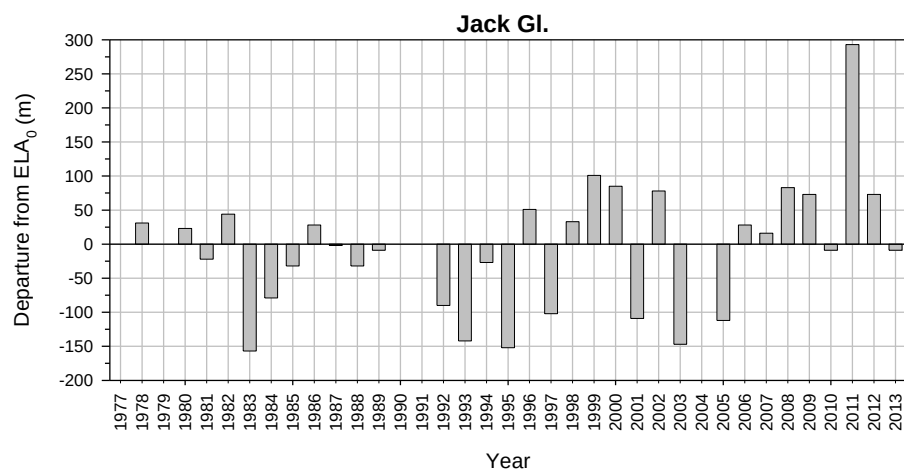
SNOWLINE DATA		
ELAo	2070	m
Max SL	2230	m, 2011
Min SL	1990	m, 1984
Mean SL	2068	m
SL Range	240	m
No. Surveys	29	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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	2075	5	29.15	23.00	52.15	0.50	-5
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	2075	5	29.15	23.00	52.15	0.50	-5
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	2075	5	27.05	18.45	45.50	0.47	-5
1999	2165	95	8.64	31.86	40.50	0.15	-95
2000	2115	45	15.49	23.01	38.50	0.27	-45
2001	2016	-54	32.40	6.10	38.50	0.56	54
2002	2103	33	22.77	15.33	38.10	0.39	-33
2003	2015	-55	36.60	1.50	38.10	0.63	55
2004	2016	-54	36.59	1.51	38.10	0.63	54
2005	2014	-56	36.61	1.49	38.10	0.63	56
2006	2085	15	22.60	15.50	38.10	0.39	-15
2007	2084	14	22.61	15.49	38.10	0.39	-14
2008	2145	75	9.10	28.50	37.60	0.24	-75
2009	2082	12	23.10	14.50	37.60	0.61	-12
2010	2072	2	26.30	11.30	37.60	0.70	-2
2011	2230	160	2.54	33.91	36.45	0.07	-160
2012	2140	70	11.35	25.10	36.45	0.31	-70
2013	2072	2	25.15	11.30	36.45	0.69	-2
MEAN	2068	-2	29.32	15.22		0.54	2



Photograph 29: Jackson Glacier on 12 March 2013.



Photograph 30: Jack Glacier under cloud (on the left) on 12 March 2013. Snowline elevation determined from the Hooker Glacier in this photo.

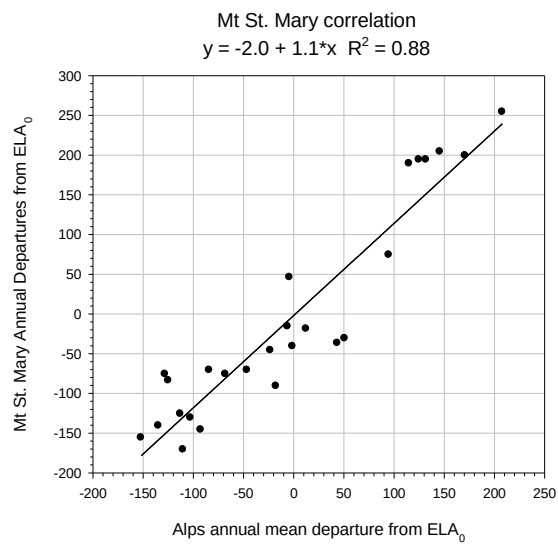
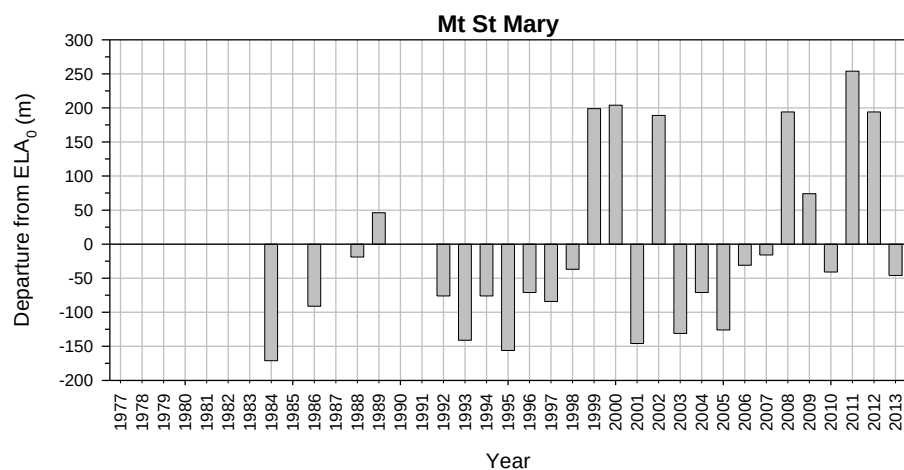
Rock glacier

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	2180	m, 2011
Min SL	1755	m, 1984
Mean SL	1919	m
SL Range	425	m
No. Surveys	26	

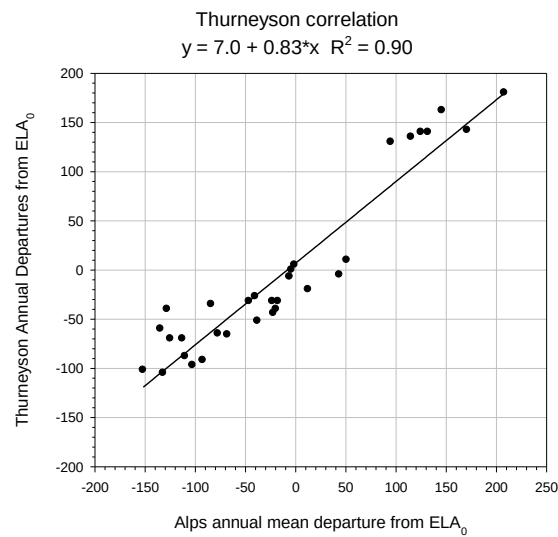
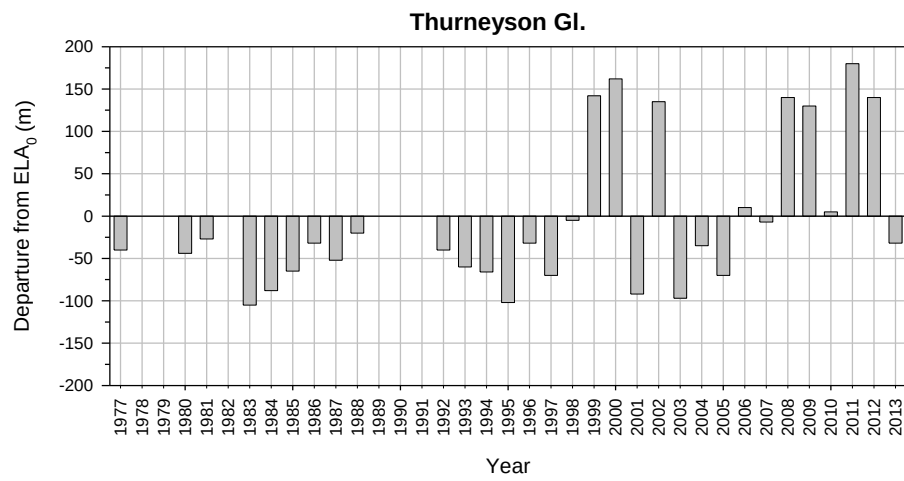
MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE		AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	TOTAL	AREA RATIO	BALANCE
	m	m	ha	ha	ha	(AAR)	INDEX
ELAo	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
2011	2180	254	0.00	28.32	28.32	0.00	-254
2012	2120	194	0.42	27.90	28.32	0.01	-194
2013	1880	-46	9.42	18.90	28.32	0.33	46
MEAN	1919	-7	9.01	19.31		0.32	7



Photograph 31: Mt St Mary on 12 March 2013.

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	2150	m, 2000	
	Min Elev	1720	m	Min SL	1865	m, 1983	
	Mean Elev	2085	m	Mean SL	1966	m	
	Length	1.23	km	SL Range	285	m	
	Elev Range	730	m	No. Surveys	32		
	Gradient	0.59					
MEASUREMENTS		Digitised values shaded					
YEAR	SNOWLINE	DEPARTURE	AREAS	ACCUM.	MASS		
	ELEVATION	FROM ELA	ABL.	TOTAL	AREA RATIO	BALANCE	
	m	m	ha	ha	(AAR)	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
2011	2150	180	24.80	93.00	117.80	0.21	-180
2012	2110	140	39.80	78.00	117.80	0.34	-140
2013	1938	-32	94.08	23.72	117.80	0.80	32
MEAN	1966	-4	84	33.81		0.71	4



Photograph 32: Thurneyson Glacier on 12 March 2013.

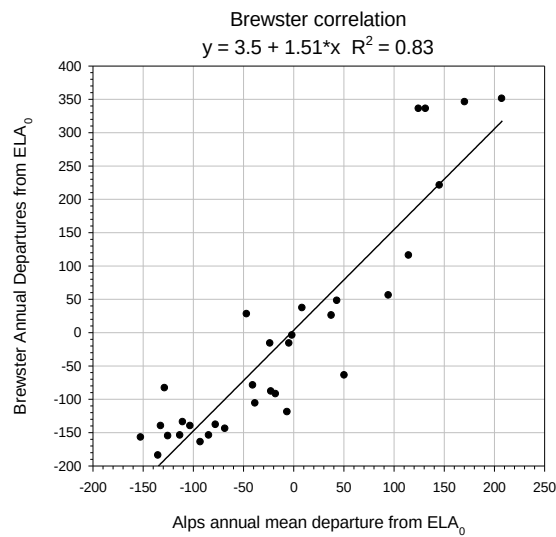
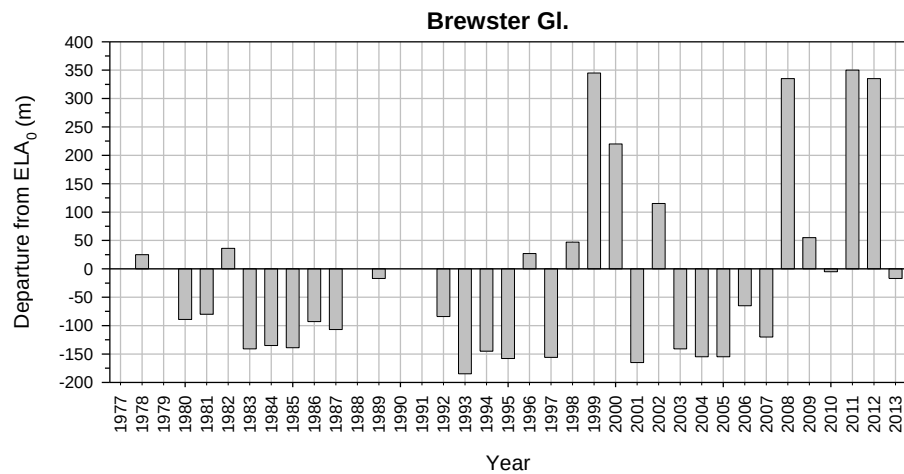
Mountain glacier

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	2285	m, 2011
Min SL	1750	m, 1993
Mean SL	1921	m
SL Range	535	m
No. Surveys	32	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	2285	350	3.5	246.0	249.5	0.01	-350
2012	2270	335	8.4	241.1	249.5	0.03	-335
2013	1918	-17	136.5	113.0	249.5	0.55	17
MEAN	1921	-14	153	99		0.61	14



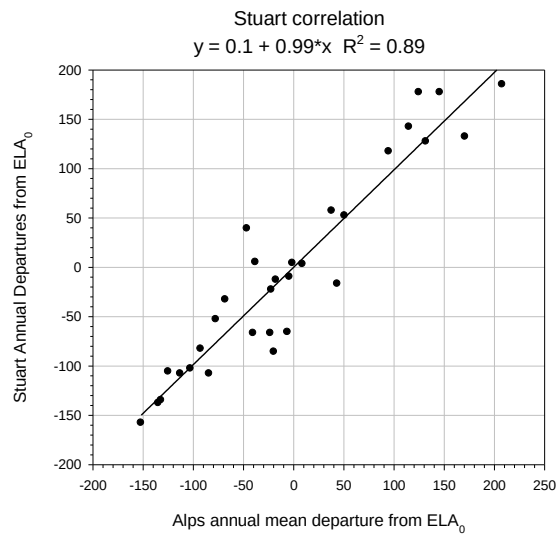
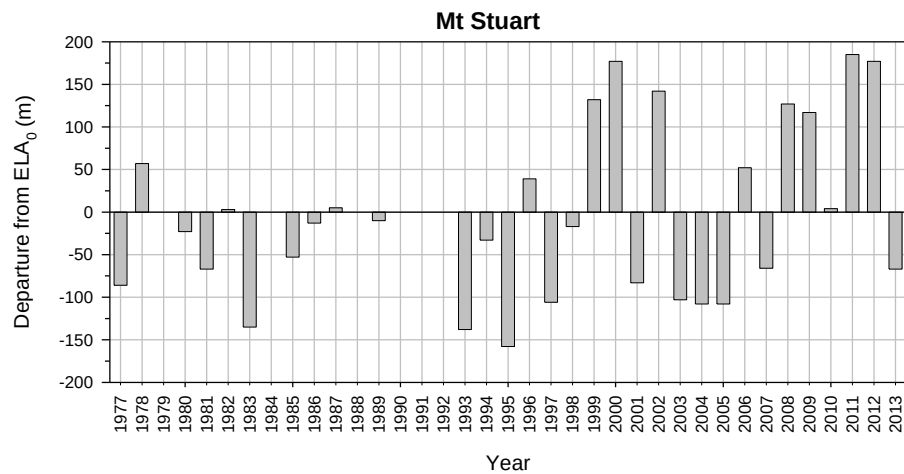
Photograph 33: Brewster Glacier on 12 March 2013.

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	1858	m, 2011
Min SL	1515	m, 1995
Mean SL	1668	m
SL Range	343	m
No. Surveys	31	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE	DEPARTURE	AREAS		ACCUM.	MASS
	ELEVATION	FROM ELAo	ACCUM.	ABL.	Glacier Ice Area	BALANCE
	m	m	ha	ha	ha	INDEX
ELAo	1673	0	21.05	5.00	26.05	0.81
1977	1587	-86	30.86	0.69	31.55	86
1978	1730	57	18.53	13.02	31.55	-57
1979						
1980	1650	-23	27.25	4.30	31.55	23
1981	1606	-67	29.85	1.70	31.55	67
1982	1676	3	25.33	6.22	31.55	-3
1983	1538	-135	31.55	0.00	31.55	135
1984						
1985	1620	-53	29.10	2.45	31.55	53
1986	1660	-13	26.55	5.00	31.55	13
1987	1678	5	25.07	6.48	31.55	-5
1988						
1989	1663	-10	26.32	5.23	31.55	10
1990						
1991						
1992						
1993	1535	-138	31.55	0.00	31.55	138
1994	1640	-33	27.95	3.60	31.55	33
1995	1515	-158	31.55	0.00	31.55	158
1996	1712	39	21.20	10.35	31.55	-39
1997	1567	-106	31.55	0.00	31.55	106
1998	1656	-17	26.87	4.68	31.55	17
1999	1805	132	5.46	26.09	31.30	-132
2000	1850	177	0.50	27.70	28.20	-177
2001	1590	-83	27.24	0.96	28.20	83
2002	1815	142	4.60	23.60	28.20	-142
2003	1570	-103	31.10	0.00	28.20	103
2004	1565	-108	31.50	0.00	28.20	108
2005	1565	-108	31.50	0.00	28.20	108
2006	1725	52	19.60	8.60	28.20	-52
2007	1607	-66	29.55	0.30	28.20	66.00
2008	1800	127	6.70	21.50	28.20	-127.00
2009	1790	117	8.30	19.90	28.20	-117.00
2010	1677	4	24.40	3.80	28.20	-4.00
2011	1858	185	0.29	25.51	25.80	-185.00
2012	1848	175	0.50	20.80	21.30	-175.00
2013	1606	-67	29.65	0.20	21.30	67.00
MEAN	1668	-5	22.32	7.83		0.72
						5



Photograph 34: Stuart Glacier on 12 March 2013.

Mountain shelf glacier

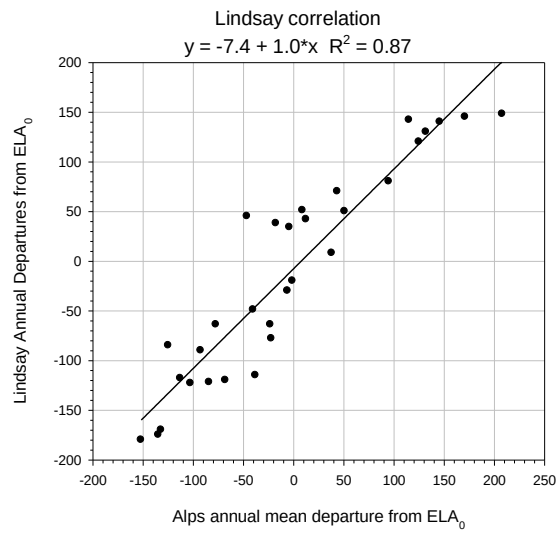
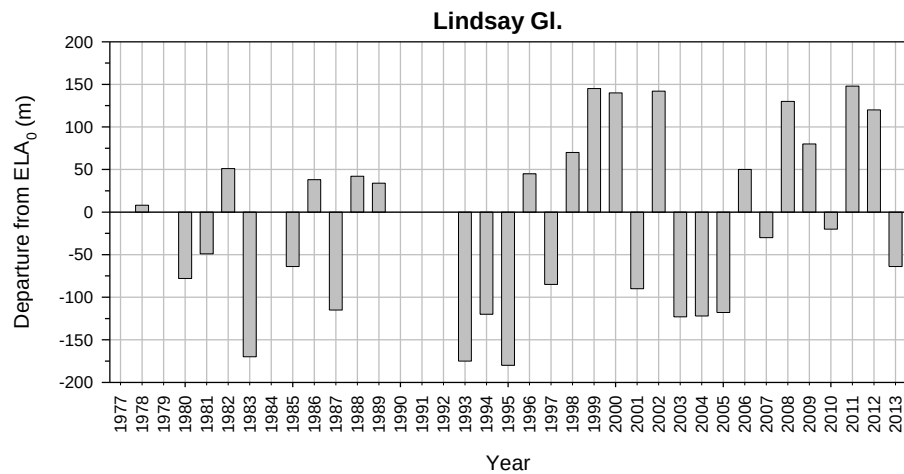
GLACIER DATA		
Aspect	S	
AREA	52.53	ha
Max Elev	1880	m
Min Elev	1610	m
Mean Elev	1745	m
Length	0.57	km
Elev Range	270	m
Gradient	0.47	

SNOWLINE DATA		
ELAo	1730	m
Max SL	1878	m, 2011
Min SL	1550	m, 1995
Mean SL	1718	m
SL Range	328	m
No. Surveys	31	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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
2011	1878	148	0.53	52.00	52.53	0.01	-148
2012	1850	120	4.33	48.20	52.53	0.08	-120
2013	1666	-64	50.51	2.02	52.53	0.96	64
MEAN	1718	-12	35.65	19.13		0.68	12



Photograph 35: Lindsay Glacier on 12 March 2013.

Cirque glacier

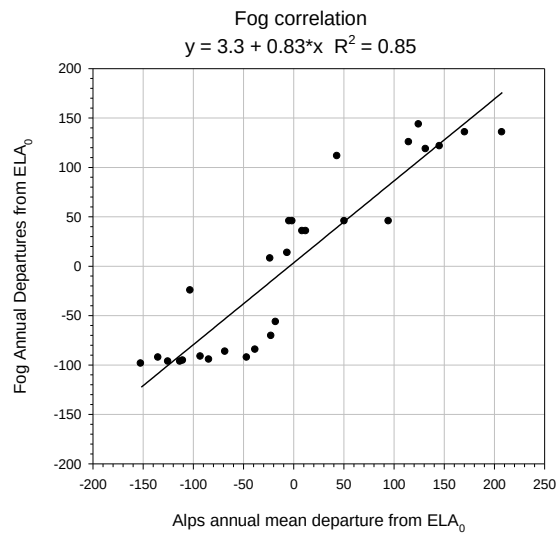
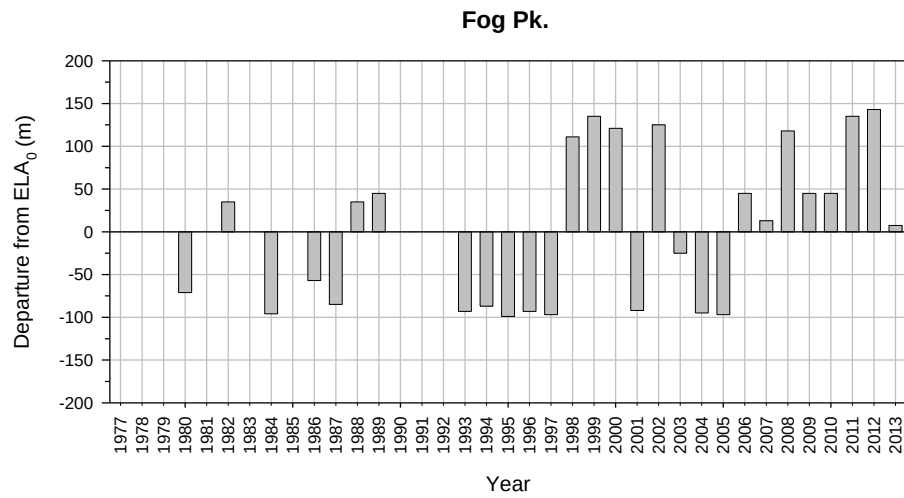
GLACIER DATA		
Aspect	SE	
AREA	18.22	ha
Max Elev	2150	m
Min Elev	1840	m
Mean Elev	1995	m
Length	0.4	km
Elev Range	310	m
Gradient	0.775	

SNOWLINE DATA		
ELAo	1987	m
Max SL	2135	m, 1999 2011
Min SL	1888	m, 1995
Mean SL	1995	m
SL Range	247	m
No. Surveys	28	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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	18.22	>1	71
1981							
1982	2022	35	14.75	3.47	18.22	0.81	-35
1983							
1984	1891	-96	42.80	0.00	18.22	>1	96
1985							
1986	1930	-57	30.40	0.00	18.22	>1	57
1987	1902	-85	39.00	0.00	18.22	>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	18.22	>1	93
1994	1900	-87	17.58	0.64	18.22	0.96	87
1995	1888	-99	44.36	0.00	18.22	>1	99
1996	1894	-93	41.70	0.00	18.22	>1	93
1997	1890	-97	43.25	0.00	18.22	>1	97
1998	2098	111	1.77	16.45	18.22	0.10	-111
1999	2135	148	0.74	11.55	12.29	0.06	-148
2000	2125	138	1.28	9.21	10.49	0.12	-138
2001	1895	-92	17.32	0.00	10.49	>1	92
2002	2120	133	1.13	8.37	9.50	0.12	-133
2003	2055	68	6.68	2.82	9.50	0.70	-68
2004	1892	-95	17.42	0.00	9.50	>1	95
2005	1890	-97	17.50	0.00	9.50	>1	97
2006	2032	45	7.95	1.55	9.50	0.84	-45
2007	2000	13	9.15	0.35	9.50	0.96	-13
2008	2105	118	1.90	7.60	9.50	0.20	-118
2009	2032	45	7.95	1.55	9.50	0.84	-45
2010	2032	45	7.95	1.55	9.50	0.84	-45
2011	2135	148	0.80	7.10	7.90	0.10	-148
2012	2130	143	1.00	6.90	7.90	0.13	-143
2013	2015	28	7.40	0.50	7.90	0.94	-28
MEAN	1995	8	16.98	3.38		0.52	-8



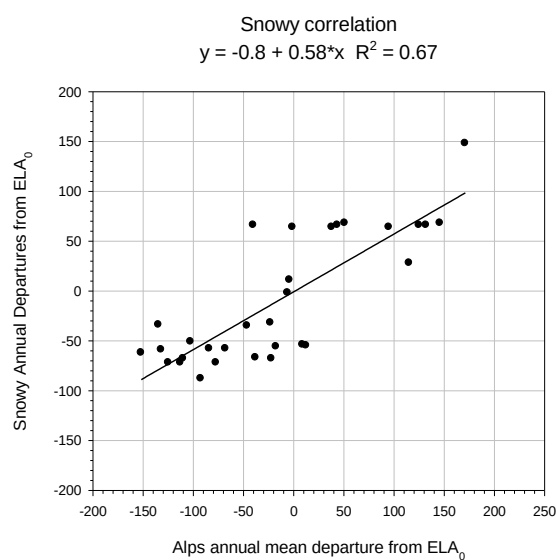
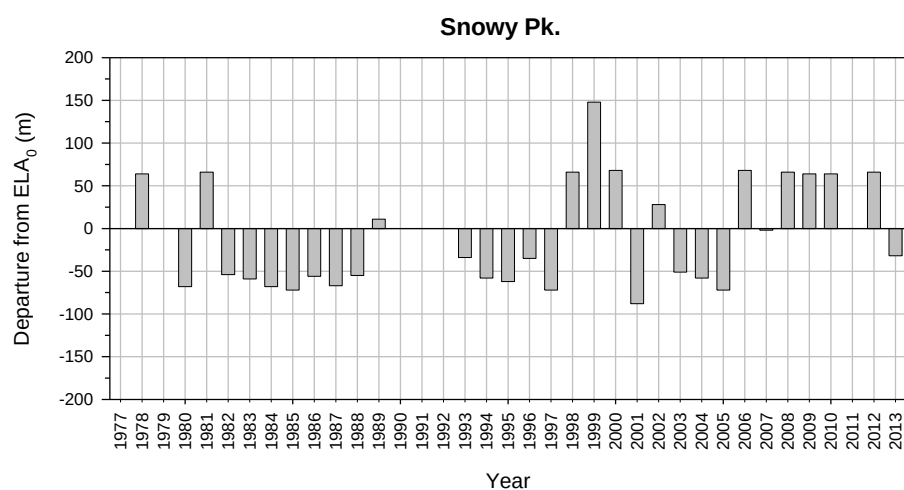
Photograph 36: Fog Peak on 12 March 2013.

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, 2011
Min SL	2004	m, 1997
Mean SL	2083	m
SL Range	206	m
No. Surveys	32	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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
2011	>2210		0.00	53.13	53.13	0.00	0
2012	2158	66	6.73	53.13	53.13	0.13	-66
2013	2060	-32	40.33	12.80	53.13	0.76	32
MEAN	2083	-9	33.10	20.24		0.62	9



Photograph 37: Snowy Peak on 12 March 2013.

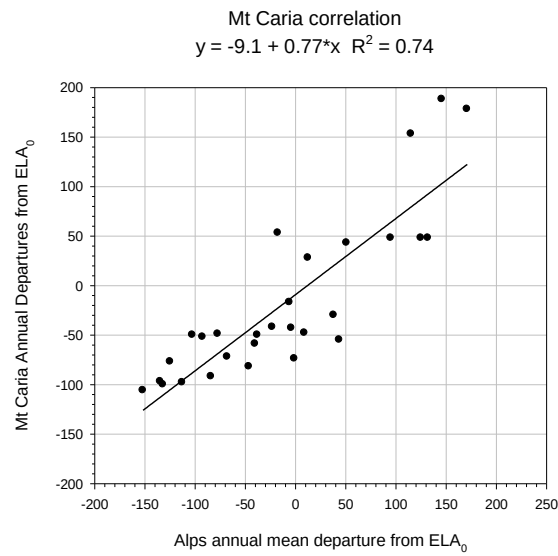
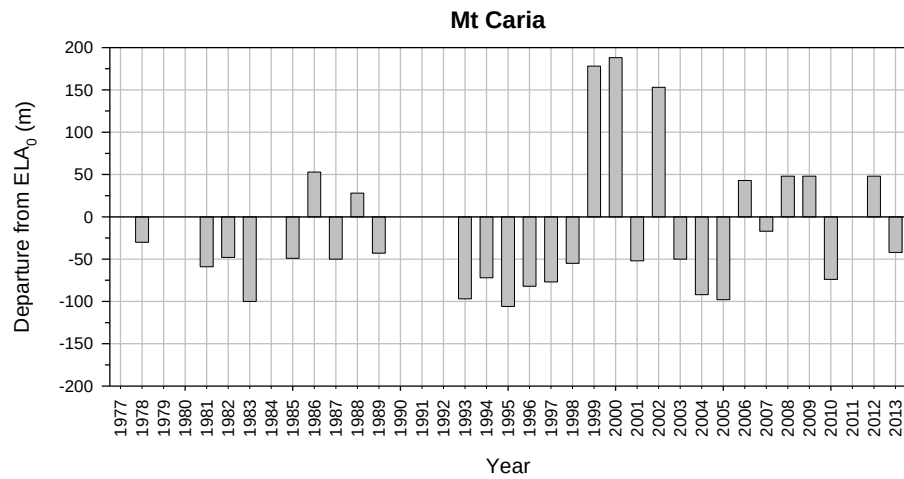
Small cirque

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, 2011
Min SL	1366	m, 1995
Mean SL	1455	m
SL Range	234	m
No. Surveys	30	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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
2011	>1660		0.00	8.74	8.74	0.00	0
2012	1520	48	0.44	8.30	8.74	0.05	-48
2013	1430	-42	5.74	3.00	8.74	0.66	42
MEAN	1455	-17	12.20	5.02		0.75	17



Photograph 38: Mt Caria on 12 March 2013.

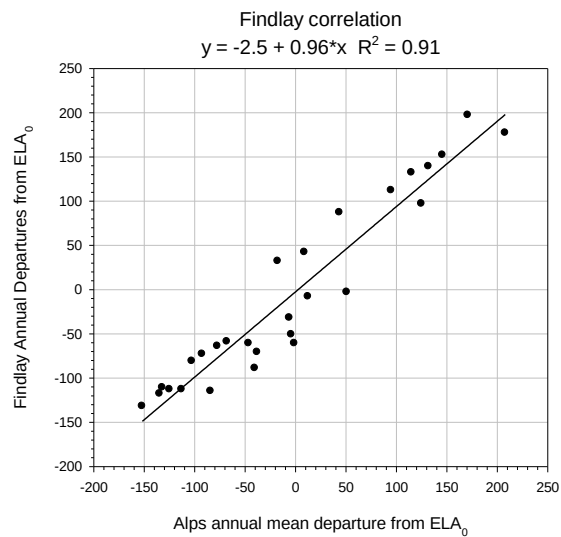
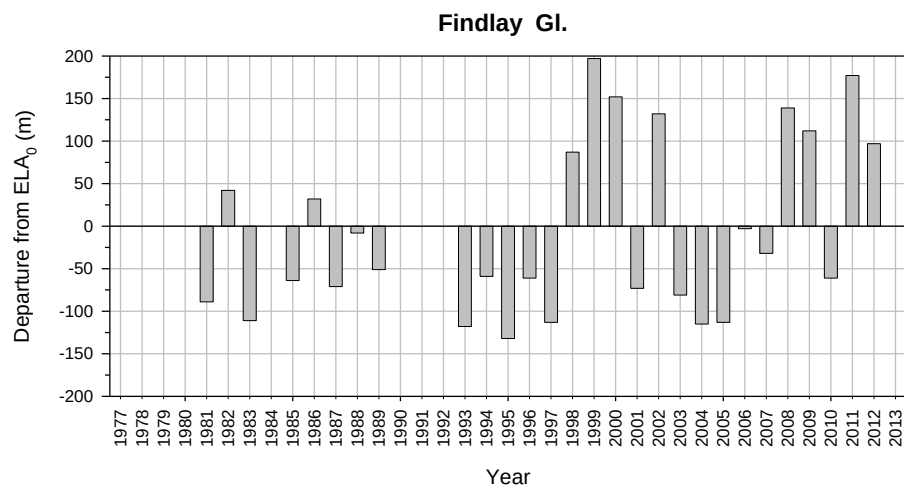
Cirque glacier

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	1686	m
SL Range	329	m
No. Surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	ACCUM. 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
2011	1870	177	4.36	49.80	54.16	0.08	-177
2012	1790	97	16.86	37.30	54.16	0.31	-97
2013							
Mean	1686	-7	36.44	23.91		0.59	7



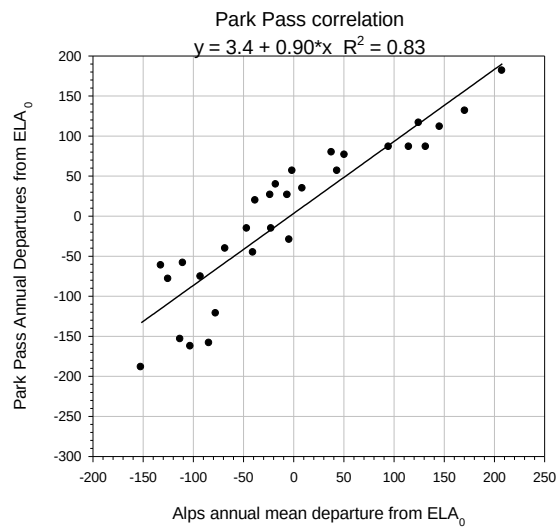
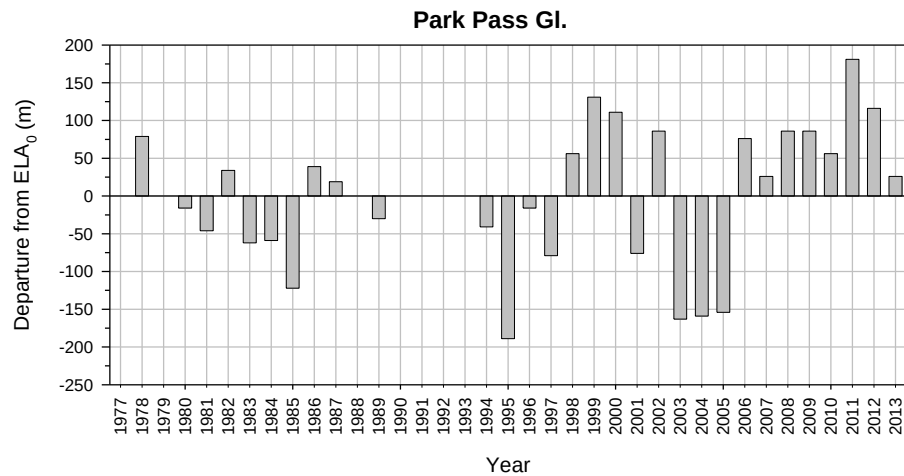
No photograph as this glacier was not visited

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	2005	m, 2011
Min SL	1635	m, 1995
Mean SL	1824	m
SL Range	370	m
No. Surveys	30	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	ACCUM. TOTAL ha	MASS AREA RATIO (AAR)	MASS BALANCE 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
2011	2005	181	35.88	148.52	184.40	0.19	-181
2012	1940	116	64.20	120.20	184.40	0.35	-116
2013	1850	26	109.50	74.90	184.40	0.59	-26
Mean	1824	0	118.25	82.31		0.59	0



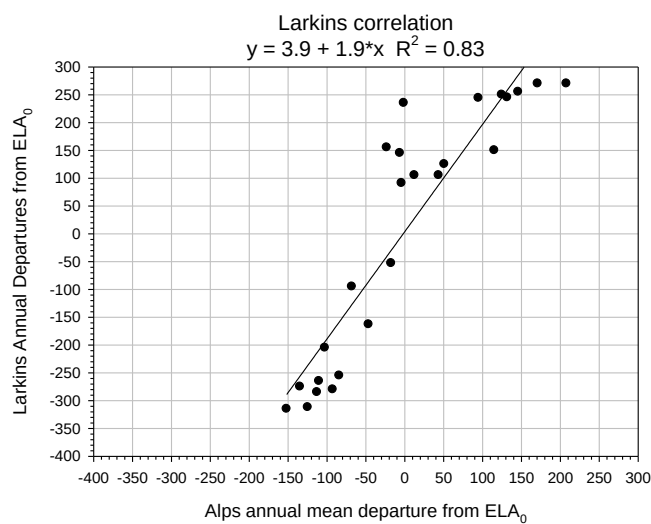
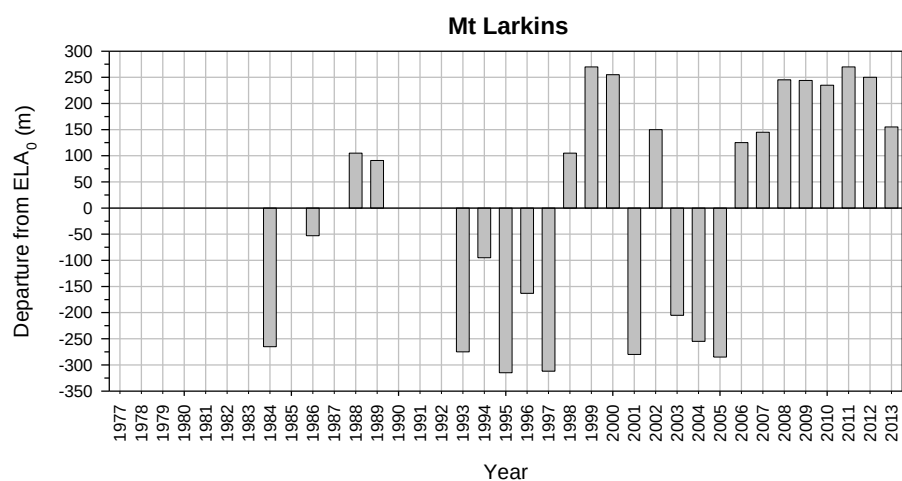
Photograph 40: Park Pass Glacier on 12 March 2013. Lower terminus covered by cloud (left hand side of photo).

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 2011
Min. SL	1630	m, 1995
Mean SL	1951	m
SL Range	585	m
No. surveys	26	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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
2011	2215	270	0.90	15.22	16.12	0.06	-270
2012	2195	250	1.40	14.72	16.12	0.09	-250
2013	2100	155	2.10	14.02	16.12	0.13	-155
MEAN	1951	6	15.02	9.48		0.58	-6



Photograph 43: Mt Larkins on 28 April 2013. Taken from the ground at the site of the climate station.

Mountain glacier

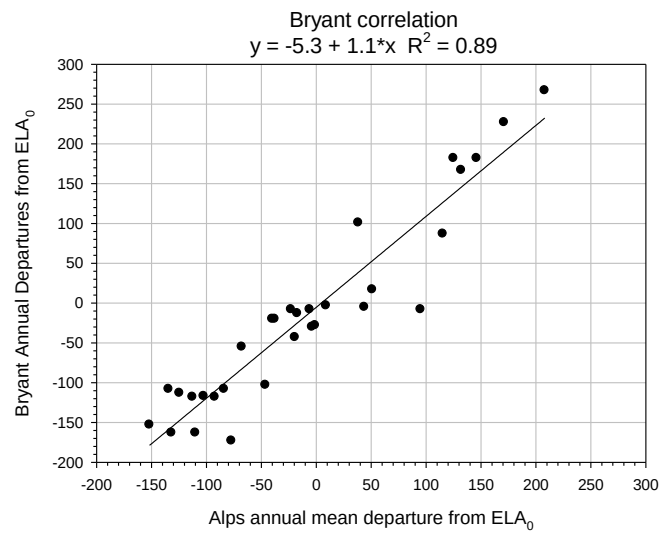
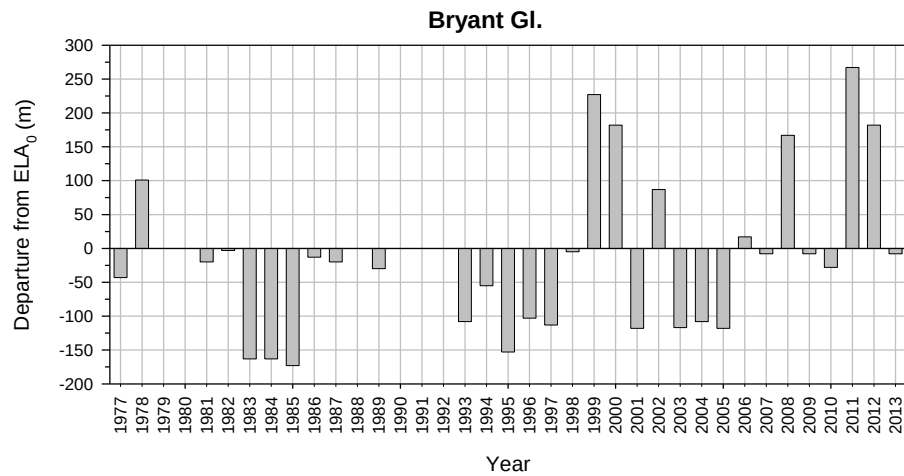
GLACIER DATA		
Aspect	SE	
AREA	29.7	ha
Max Elev	2180	m
Min Elev	1660	m
Mean Elev	1920	m
Length	0.94	km
Elev Range	520	m
Gradient	0.55	

SNOWLINE DATA		
ELAo	1783	m
Max. SL	2090	m, 2011
Min. SL	1610	m, 1995
Mean SL	1770	m
SL Range	480	m
No. surveys	31	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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	1.35	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	2030	247	0.97	27.74	28.71	0.03	-247
2000	1965	182	1.85	26.25	28.1	0.07	-182
2001	1665	-118	0.10	28.00	28.1	0.00	118
2002	1870	87	5.90	22.20	28.1	0.21	-87
2003	1666	-117	27.99	0.11	28.1	1.00	117
2004	1675	-108	27.70	0.40	28.1	0.99	108
2005	1665	-118	28.00	0.10	28.1	1.00	118
2006	1800	17	11.50	16.60	28.1	0.41	-17
2007	1775	-8	14.70	13.40	28.1	0.52	8
2008	1950	167	2.80	25.30	28.1	0.10	-167
2009	1775	-8	14.70	13.40	28.1	0.52	8
2010	1755	-28	18.60	9.50	28.1	0.66	28
2011	2090	307	0.70	22.67	23.37	0.03	-307
2012	1965	182	2.97	20.40	23.37	0.13	-182
2013	1775	-8	13.57	9.80	23.37	0.58	8
MEAN	1770	-13	17.07	12.23		0.57	13



Photograph 45: Bryant Glacier on 12 March 2013.

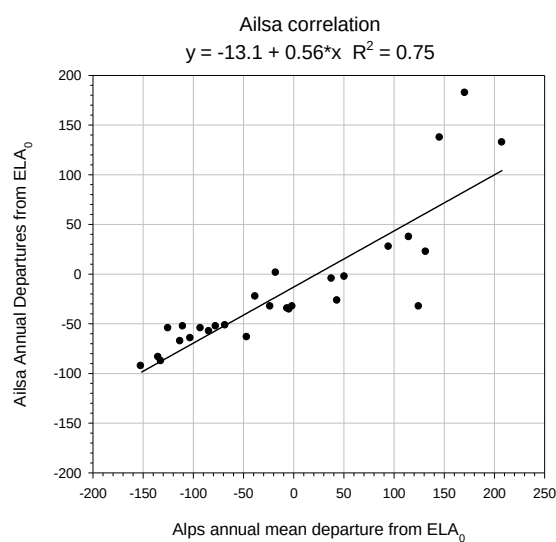
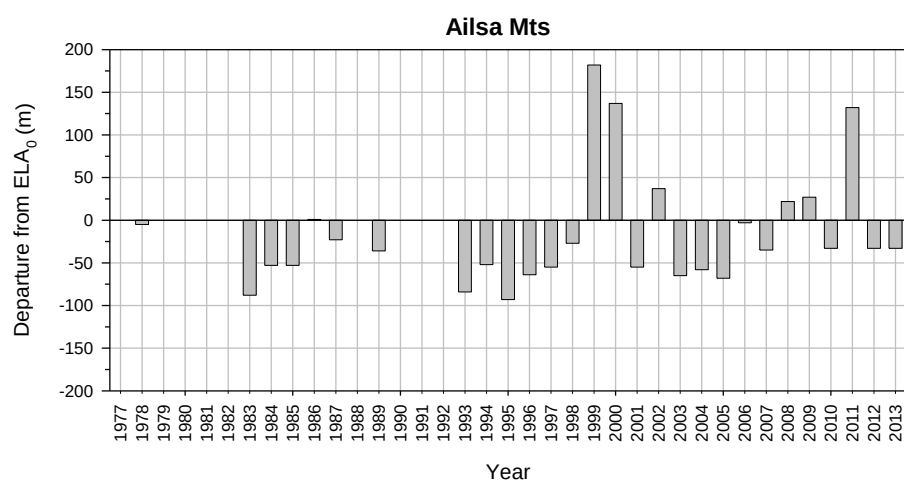
Cirque glacier

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	1631	m
SL Range	275	m
No. survey	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	1780	132	0.89	12.81	13.7	0.06	-132
2012	1615	-33	9.90	3.80	13.7	0.72	33
2013	1615	-33	9.90	3.80	13.7	0.72	33
MEAN	1631	-17	9.52	8.02		0.52	17



Photograph 47: Ailsa Glacier on 12 March 2013.

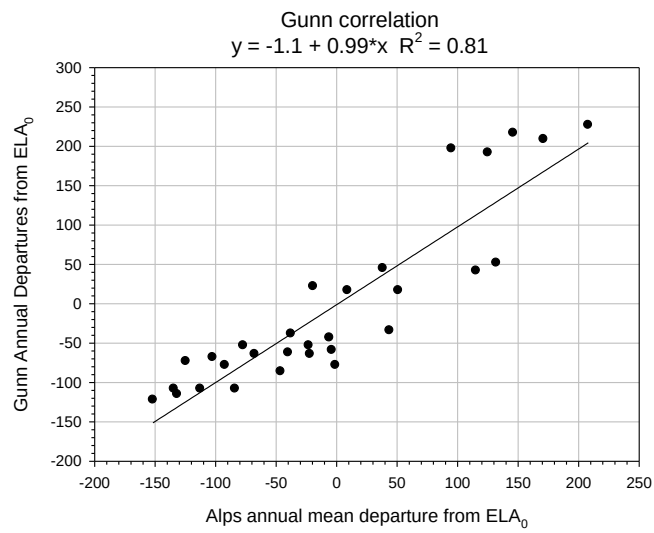
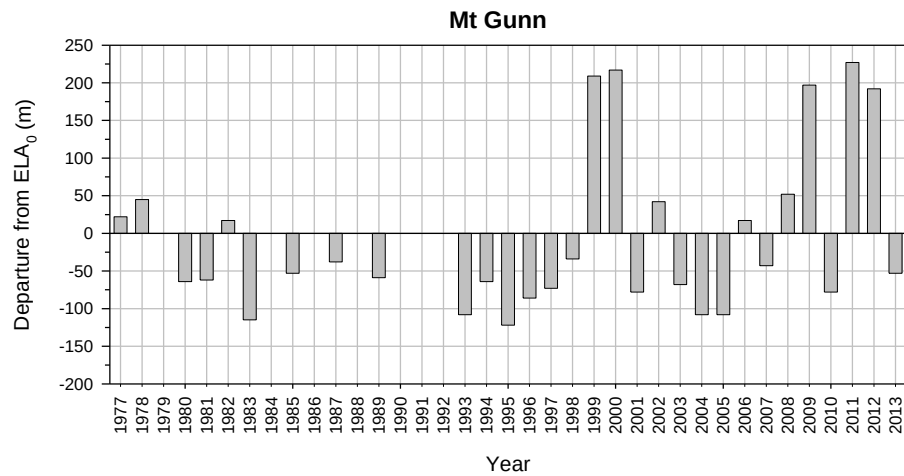
GLACIER DATA		
Aspect	SE	
AREA	53.72	ha
Max Elev	1860	m
Min Elev	1470	m
Mean Elev	1665	m
Length	0.75	km
Elev Range	390	m
Gradient	0.52	

SNOWLINE DATA		
ELAo	1593	m
Max SL	1820	m, 2011
Min SL	1471	m, 1995
Mean SL	1587	m
SL Range	349	m
No. survey	30	

MEASUREMENTS

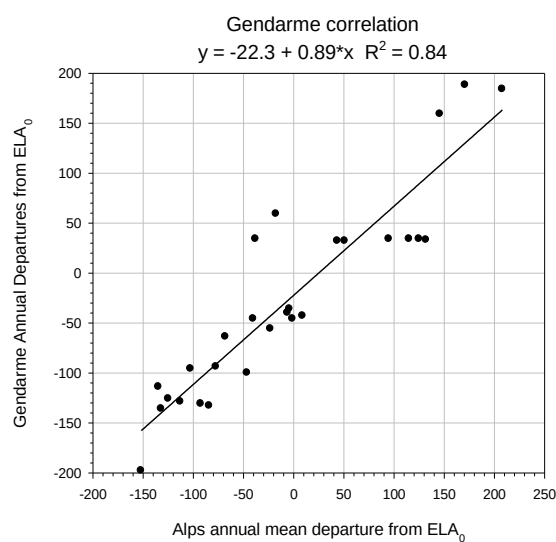
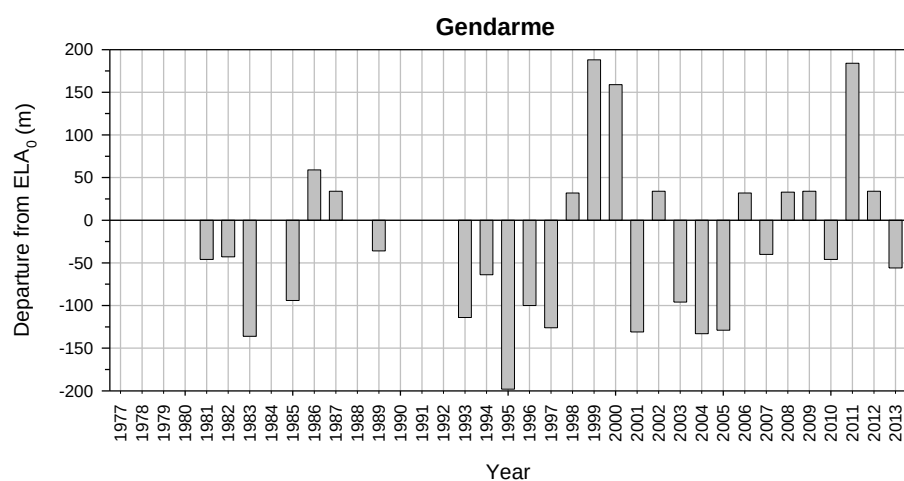
Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	TOTAL ha	ACCUM. AREA RATIO (AAR)	MASS BALANCE 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
2011	1820	227	1.10	19.00	20.10	0.05	-227
2012	1785	192	2.24	17.78	20.02	0.11	-192
2013	1540	-53	15.22	4.80	20.02	0.76	53
MEAN	1587	-6	25.53	17.95		0.56	6



Photograph 48: Mt Gunn on 12 March 2013.

No. 797G/33	Mt. GENDARME				NZMS sheet D40 & 41		
	Mountain gl, reliability 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	1589	m
	Length	0.525	km		SL range	386	m
	Elev Range	460	m		No. surveys	28	
	Gradient	0.88					
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	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	49.35	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	1.10	33.48	34.58	0.03	-188
2000	1775	159	4.82	28.71	33.53	0.14	-159
2001	1485	-131	33.56	0.00	33.53	1.00	131
2002	1650	34	25.53	8.00	33.53	0.76	-34
2003	1520	-96	32.13	1.40	33.53	0.96	96
2004	1483	-133	33.53	0.00	33.53	1.00	133
2005	1487	-129	33.53	0.00	33.53	1.00	129
2006	1648	32	25.43	8.10	33.53	0.76	-32
2007	1576	-40	31.73	1.80	33.53	0.95	40
2008	1649	33	25.48	8.05	33.53	0.76	-33
2009	1650	34	23.50	8.00	31.50	0.75	-34
2010	1570	-46	30.00	1.50	31.50	0.95	46
2011	1800	184	2.43	24.10	26.53	0.09	-184
2012	1650	34	20.73	5.80	26.53	0.78	-34
2013	1560	-56	25.83	0.70	26.53	0.97	56
MEAN	1589	-27	31.21	9.38		0.77	27



Photograph 50: Mt Genderme on 12 March 2013.

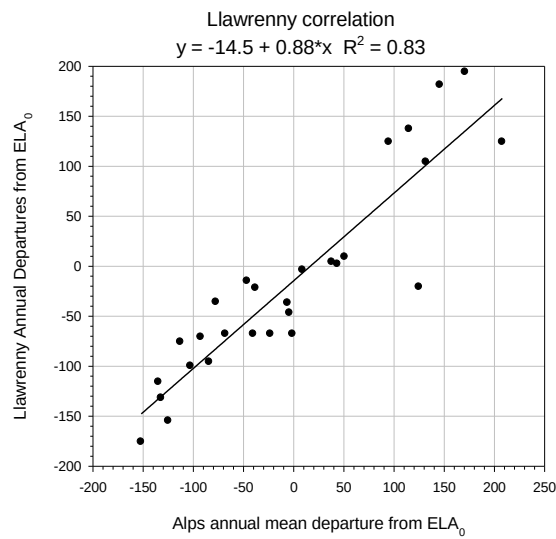
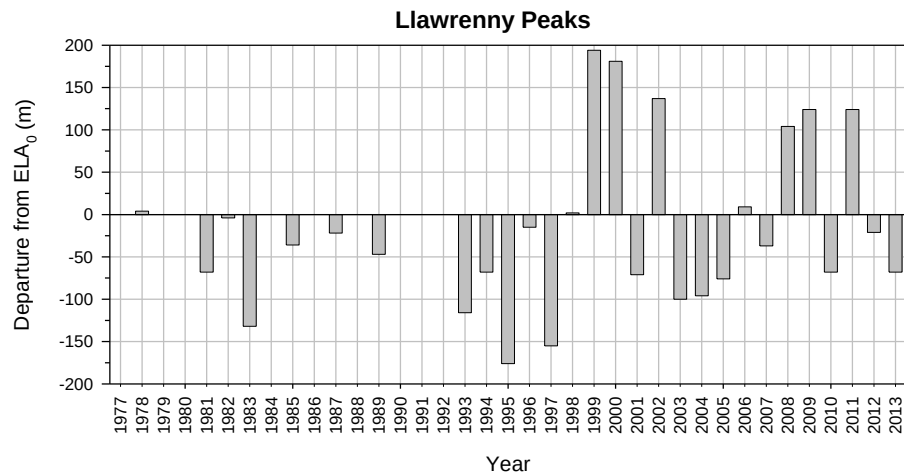
Cirque glacier

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	1458	m
SL Range	370	m
No. surveys	28	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	ACCUM. ha	AREAS ABL. ha	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	1.00	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	0.04	-181
2001	1405	-71	13.39	2.34	15.73	0.85	71
2002	1613	137	2.07	12.52	14.59	0.14	-137
2003	1376	-100	13.84	0.75	14.59	0.95	100
2004	1380	-96	13.79	0.80	14.59	0.95	96
2005	1400	-76	13.09	1.50	14.59	0.90	76
2006	1485	9	6.29	8.30	14.59	0.43	-9
2007	1439	-37	10.09	4.50	14.59	0.69	37
2008	1580	104	1.84	11.60	13.44	0.14	-104
2009	1600	124	1.39	10.90	12.29	0.11	-124
2010	1408	-68	10.04	1.10	11.14	0.90	68
2011	1600	124	1.24	9.90	11.14	0.11	-124
2012	1455	-21	6.75	4.39	11.14	0.61	21
2013	1408	-68	9.74	1.40	11.14	0.87	68
MEAN	1458	-18	10.42	5.80		0.63	18



Photograph 51: Llawrenny Peaks on 12 March 2013. Upper parts of this glacier are visible on the left side of the photograph.

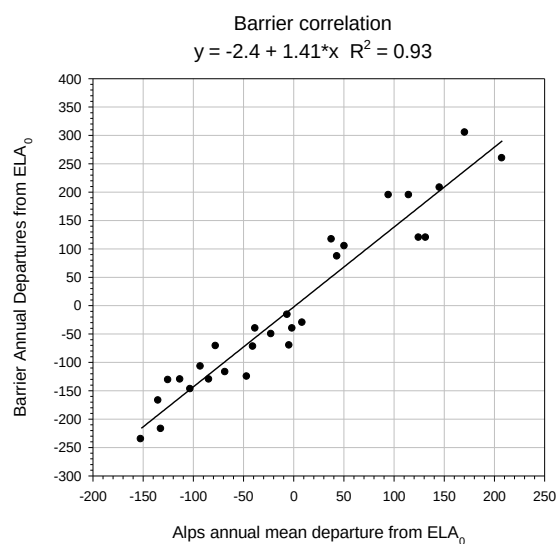
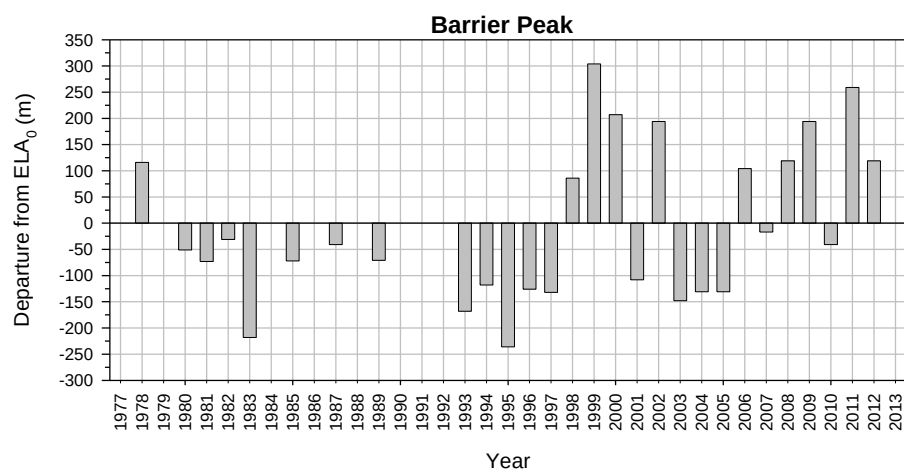
GLACIER DATA		
Aspect	S	
AREA	57.56	ha
Max Elev	1900	m
Min Elev	1420	m
Mean Elev	1660	m
Elev Range	480	m
Length	0.75	km
Gradient	0.64	

SNOWLINE DATA		
ELAo	1596	m
Max SL	1900	m, 1999
Min SL	1360	m, 1995
Mean SL	1589	m
SL Range	540	m
No. Surveys	28	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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	37.50	57.56	0.35	-116
1979							
1980	1545	-51	48.56	9.00	57.56	0.84	51
1981	1523	-73	51.23	6.33	57.56	0.89	73
1982	1565	-31	45.36	12.20	57.56	0.79	31
1983	1378	-218	63.90	0.00	57.56	1.11	218
1984							
1985	1524	-72	51.19	6.37	57.56	0.89	72
1986							
1987	1555	-41	46.86	10.70	57.56	0.81	41
1988							
1989	1525	-71	50.96	6.60	57.56	0.89	71
1990							
1991							
1992							
1993	1428	-168	60.70	0.00	60.7	1.05	168
1994	1478	-118	55.23	2.33	57.56	0.96	118
1995	1360	-236	65.03	0.00	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	0.00	57.56	57.56	0.00	-304
2000	1803	207	3.28	31.52	34.8	0.06	-207
2001	1488	-108	31.80	3.00	34.8	0.55	108
2002	1790	194	5.36	29.44	34.8	0.09	-194
2003	1448	-148	34.80	0.00	34.8	0.60	148
2004	1465	-131	34.80	0.00	34.8	0.60	131
2005	1465	-131	34.80	0.00	34.8	0.60	131
2006	1700	104	20.00	14.80	34.8	0.35	-104
2007	1579	-17	20.60	14.20	34.8	0.36	17
2008	1715	119	15.00	19.80	34.8	0.26	-119
2009	1818	222	1.82	32.98	34.8	0.03	-222
2010	1555	-41	34.00	0.80	34.8	0.59	41
2011	1855	259	1.12	25.69	26.81	0.02	-259
2012	1715	119	15.01	11.80	26.81	0.26	-119
2013							
MEAN	1589	-7	33.89	13.14	46.80	0.59	7



No photograph as this glacier was not visited

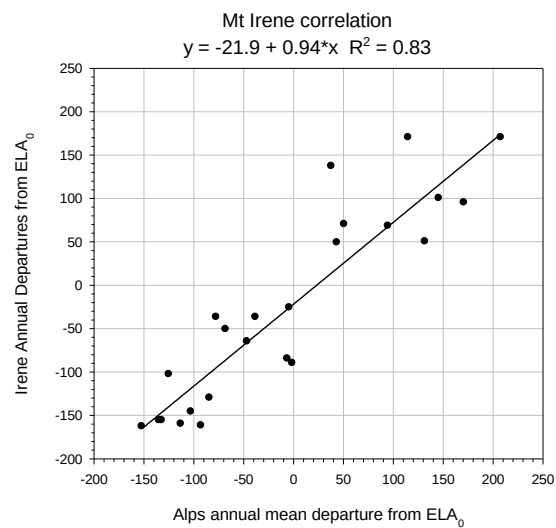
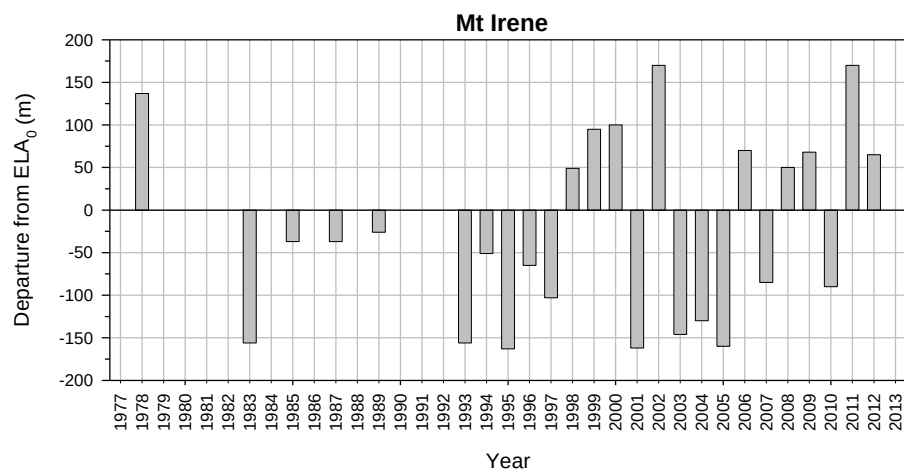
GLACIER DATA			
	1977 to 1999	2002 on	
Aspect	E		
Permanent Ice Area	17.95	7.75	ha
Max Elev	1800	1770	m
Min Elev	1450	1510	m
Mean Elev	1625	1640	m
Elev Range	350	260	m
Length	0.5	0.43	km
Gradient	0.7	0.6	

SNOWLINE DATA		
ELAo	1563	m
Max SL	1770	m, 2011
Min SL	1400	m, 1995
Mean SL	1560	m
SL Range	370	m
No. Surveys	25	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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
2011	1770	170	0.34	7.41	7.75	0.04	-170
2012	1665	65	0.45	7.30	7.75	0.06	-65
2013							
MEAN	1560	-24	10.06	4.88		0.57	24



No photograph as this glacier was not visited

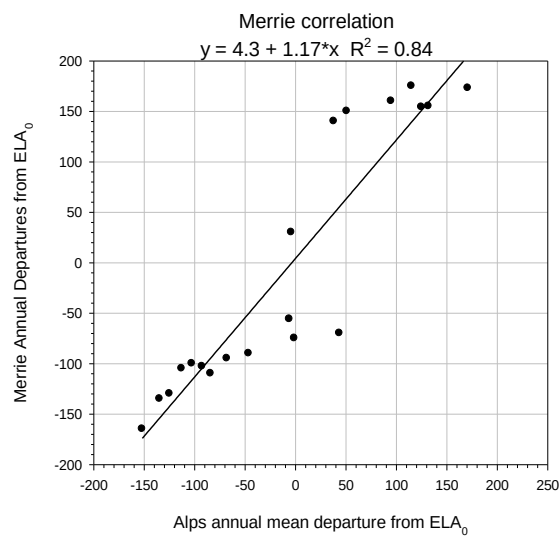
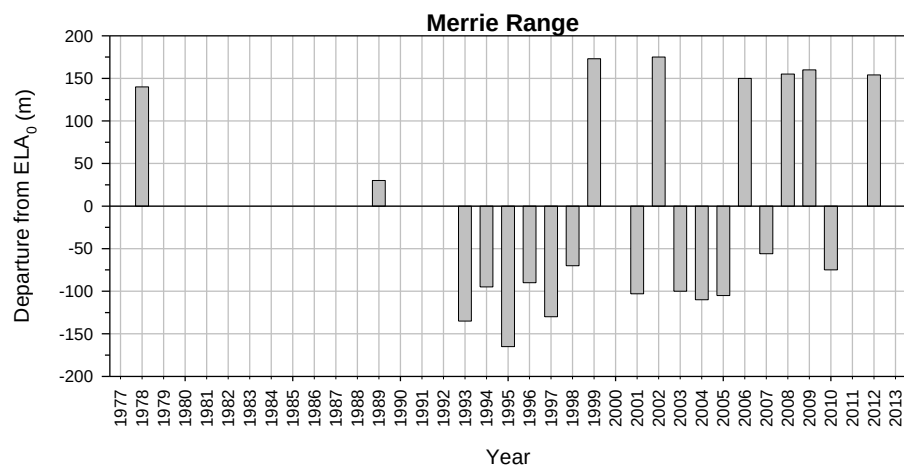
Patchy glacierette

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	>1700	m, 2011
Min SL	1350	m, 1995
Mean SL	1510	m
SL Range	350	m
No. Surveys	23	

MEASUREMENTS Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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	0.20	-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	0.19	-175
2003	1415	-100	11.88	0.9	12.78	0.93	100
2004	1405	-110	14.2	0	14.2	1.00	110
2005	1410	-105	12.38	0.4	12.7	0.97	105
2006	1665	150	1.3	1.7	3.0	0.43	-150
2007	1459	-56	8.3	2.7	11.0	0.65	56
2008	1670	155	1.1	1.4	2.5	0.45	-155
2009	1675	160	1.1	1.4	2.5	0.44	-160
2010	1440	-75	10.93	1.85	12.8	0.86	75
2011	>1700		0	2.5	2.5	0.00	0
2012	1669	154	1.1	1.4	2.5	0.44	-154
2013							
MEAN	1510	-5	7.99	1.51		0.70	5



No photograph as this glacier was not visited

Patchy glacierette

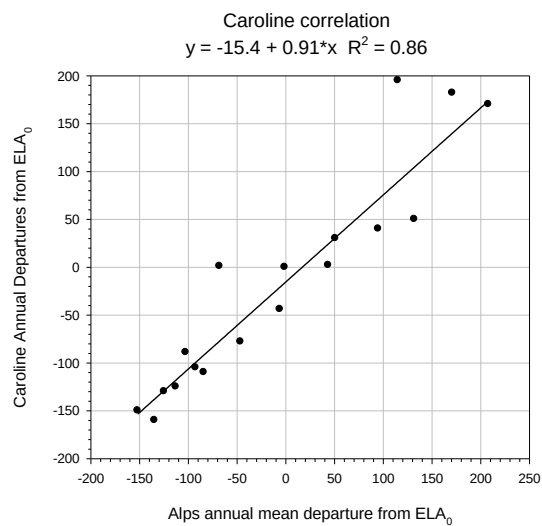
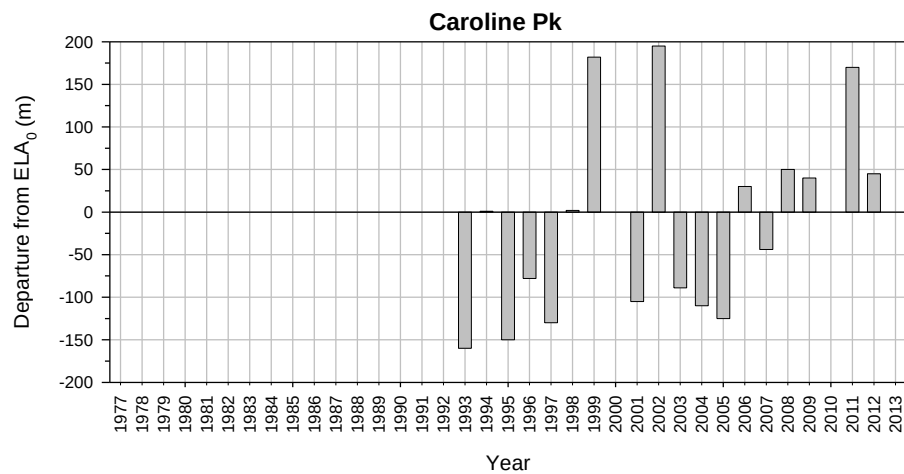
GLACIER DATA		
Aspect	SE	
AREA	9.99	ha
Max Elev	1600	m
Min Elev	1260	m
Mean Elev	1430	m
Elev Range	340	m
Length	0.5	km
Gradient	0.68	

SNOWLINE DATA		
ELAo	1380	m
Max SL	1575	m, 2002
Min SL	1220	m, 1993
Mean SL	1365	m
SL Range	355	m
No. Surveys	19	

MEASUREMENTS

Digitised values shaded

YEAR	SNOWLINE ELEVATION	DEPARTURE FROM ELAo	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
2011	1550	170	0.90	2.60	3.50	0.26	-170
2012	1425	45	6.40	0.50	6.90	0.93	-45
2013					No visit		
MEAN	1365	-15	7.90	1.62		0.78	15



No photograph as this glacier was not visited