Ka Roimata o Hine Hukatere *Franz Josef Glacier*
Glacier monitoring report: 2009/2010

Overview: Glacier year 2009/2010

Ice volume	↓	The 2009/2010 balance year was negative – i.e. the glacier lost mass and ice volume.
Glacier length	↓	After the most recent advance which culminated in mid-2008 the glacier has slow started retreating
Ice velocity	↓	The glacier is slowing near the terminus as the glacier thins and retreats

The World Glacier Monitoring Service reported in its most recent annual 'Mass Balance Bulletin' (www.geo.unizh.ch/wgms) that ice loss from glaciers monitored around the world is accelerating. New Zealand is also losing ice mass at a rapid rate, with 61% lost since 1850 (Hoelzle et al. 2007), and 11% in the last 30 years (T. Chinn, pers. comm.).

Most of this loss is from the large glaciers calving into pro-glacial lakes, such as the Tasman Glacier. This lake formation is the result of glacier thinning in response to climatic warming in the 20th century. As well as these large dynamic changes in glacier volume, there are smaller annual changes in volume due to changes in the amount of snow accumulation and snow and ice melt. An idea of how much mass is lost or gained each year throughout the Southern Alps is given by measurements of the end-of-summer snowlines since 1977. These measurement indicate that there have been positive mass balances at times during this period balance (Chinn et al. 2008) and the very sensitive and responsive Franz Josef and Fox Glaciers have advanced as a result. However the ice loss on the large, low angled, debris covered glaciers far outweighs these gains in the overall picture.

The 2009/2010 glacier mass balance year was characterised by cold weather and heavy snowfalls in early winter 2009, a cold winter and very windy and unsettled spring weather. The result was large amounts of snow accumulation. Summer 2009 started off quite cold, but overall above average temperatures were recorded.

This monitoring report updates the current state of Franz Josef Glacier *Ka Roimata o Hine Hukatere*.

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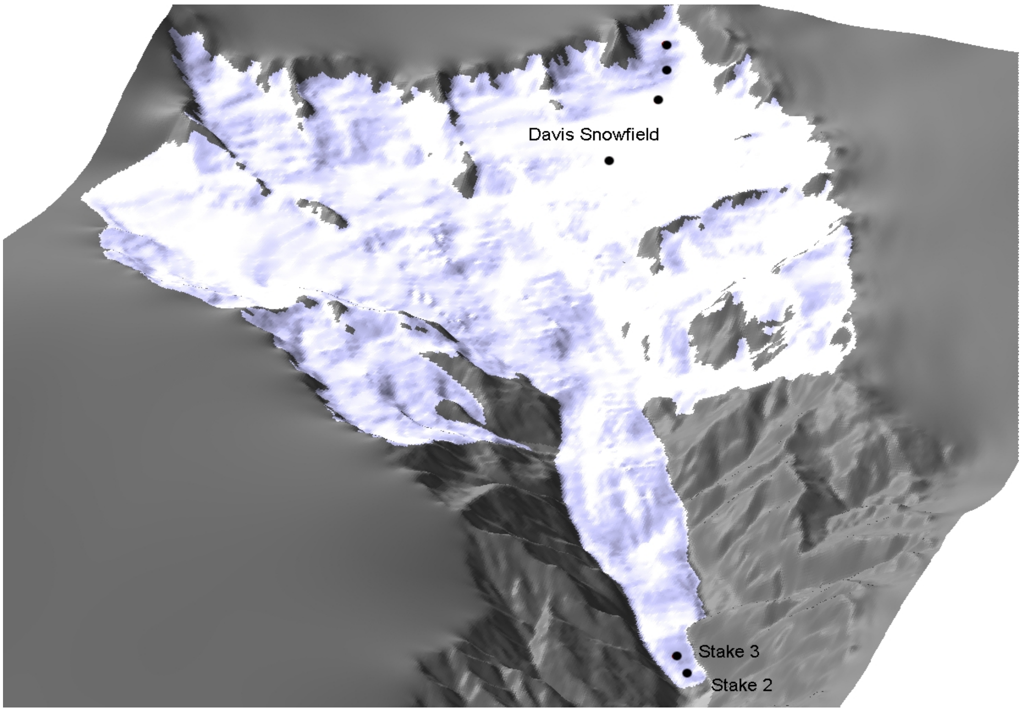

Figure 1. A view of Franz Josef Glacier showing the location of stakes 2 and 3 near the terminus and the location of the four points in the Davis Snowfield through which the surface elevation profile is recorded.

Is the glacier losing or gaining mass?

Franz Josef Glacier is not suited to a traditional mass balance programme (where the inputs of snow and outputs of melt are measured over the entire glacier surface) due to its many steep and crevassed areas. However, measurements of net snow accumulation at the end of summer, repeat surveys of glacier surface elevation and measurement of total melt near the terminus of the glacier give a good indication of whether the glacier is losing or gaining mass.

Net snow accumulation

Direct measurements of net accumulation (the amount of snow left in the accumulation area after the summer melt) in early April 2010 show that this balance year is continuing a trend of lower snow input to the glacier. The snowline elevation (where net accumulation is zero) was at ~1740 m asl.

Figure 2. Inter-annual variation in mass balance measurements. Net accumulation measurements (blue bars) averaged over the accumulation area of the glacier show a generally decreasing trend after some high accumulation years at the start of the decade. Total melt at the terminus, measured using ablation stakes (red and green lines), show that the total melt is quite variable from year to year.

Surface elevation changes

The elevation of the Davis Snowfield (Figure 1) has been measured since 2001 (Figure 3). During this time, the glacier has been thinning as snow accumulation fails to balance ice flow to lower elevations. If the glacier was in balance, the thickness of the glacier would stay the same, when measured annually at the same time of year, as accumulated snow turns to ice and flows down the glacier to support ablation further down. However, between 2001 and 2010 the glacier has lowered by ~ 8 m. The elevation was reasonably stable until 2003, but has dropped rapidly since then, with some recovery in the 2008/2009 year.

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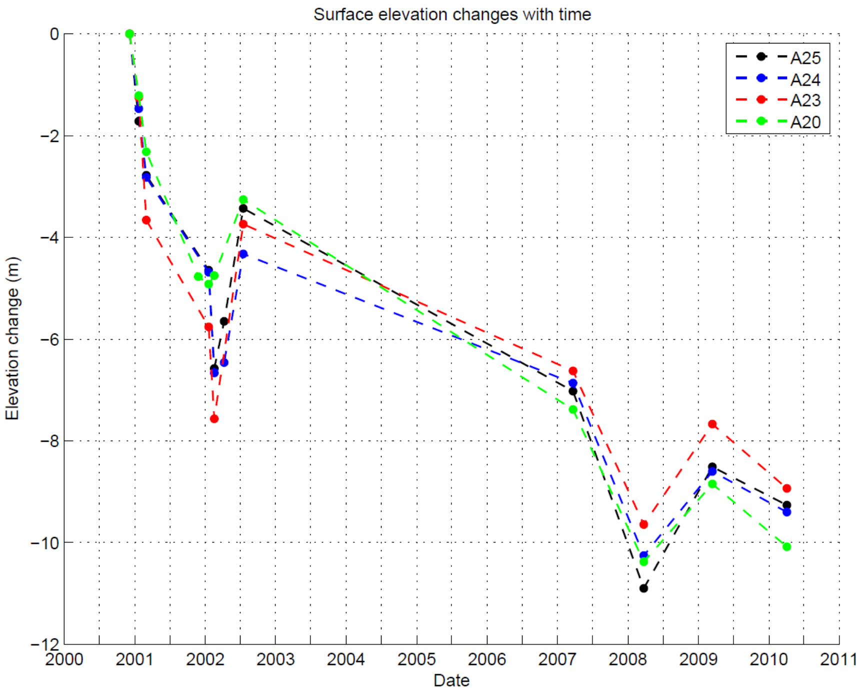


Figure 3. Elevation changes of annual profiles down the centre of the Davis Snowfield relative to the elevation at 28 February 2001 (right axis). Note that measurements, plotted at four sites down the profile and demoted by coloured dots, do not exist for every year.

Total melt rates at the terminus

Melt rates at the terminus show a large interannual variation at ~20 m/a w.e. These melt rates are the highest recorded in the international literature. Since the ablation area of the glacier is only ~ 6 km^2 compared to the ~30 km^2 of the accumulation area these melt rates have little influence on the overall glacier behaviour. It should be noted that since the snow accumulation measurements are taken at the end of summer they also include a large melt component.

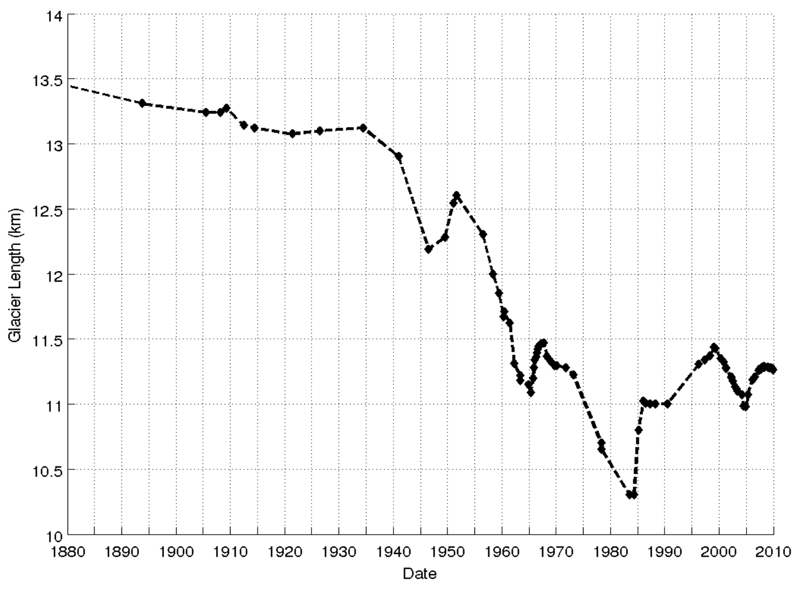
Ice Velocity

The velocity record shows a peak velocity at Stake 3 (see Figure 1 for location) in early 2007 of 1.1 m/day, with Stake 2 also at its highest speed in recent years, 0.9 m/day, at the same time. Since then velocities have been slowing with the latest measurement (February – March 2010) recording 0.65 m/day and 0.48 m/day for Stakes 3 and 2 respectively. These dynamic changes are consistent with a lower ice flux coming from the accumulation area with lower accumulation in recent years.

Is the glacier advancing or retreating?

The glacier has been in a general advance phase since about 1984, bought about by more El Niño events and stronger westerly winds over New Zealand associated with a change in phase of the Inter-decadal Pacific Oscillation in 1977. The glacier began its advance a few years later and, with a few short retreat phases, has continued to the present. The behaviour of Franz Josef Glacier in the last decade or so has been characterised by sharp transitions from an advance to a retreat phase, and vice-versa.

(a)



(b)

Figure 4. Franz Josef Glacier length, (a) measured usng GPS since 1996, and (b) the complete record since 1867. The glacier shows rapid transitions from an advance to retreat phase, and *vice-versa*. In contrast, the last year has shown a gentle slowing of the advance.

The advance of the terminus has finished for the moment. Franz Josef Glacier was been advancing fairly steadily since late 2004, with the exception of a brief period in the winter of 2007 (Figure 3). The advance culminated in mid-2008 with a glacier length of 11.29 km. Since then the glacier has been retreating rather gently, slowed by the retarded melt underneath the supra-glacial debris that was deposited by the flooding from the "black hole" in 2003 (Goodsell et al. 2003).

While it is not possible to predict the precise behaviour of the glacier, the retreat is likely to continue as the last few years have seen thinning in the accumulation area, and the annual accumulation measurements show a decrease in the amount of snow feeding the glacier.

Conclusion

The advance of Ka Roimata o Hine Hukatere *Franz Josef Glacier* since 1984 has been extraordinary given the global pattern of receeding glaciers during this period. Recent work has confirmed the very sensitive nature of this glacier – that is it advances or retreats a large amount for a small change in climate (Anderson et al. 2006; Anderson et al. 2008). Combined with its very short response time this explains the large variations in glacier length observed in the last decade.

All of the indications are that Franz Josef Glacier has lost mass in recent years, particularly in 2008, and 2010. We do not have enough measurements to calculate an annual mass balance, but the combination of thinning in the accumulation area and lower amounts of net accumulation observed indicate a negative mass balance. This makes it likely that the recently-started retreat will continue.

References

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