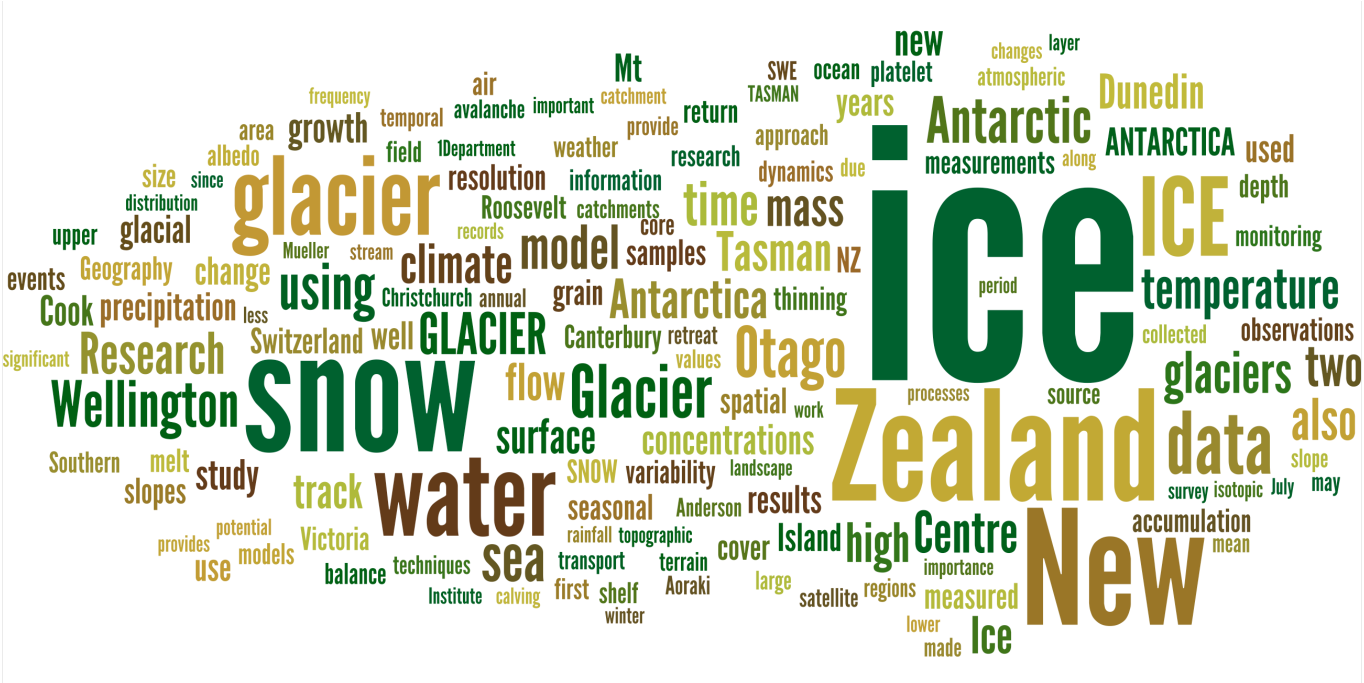
Snow and Ice Research Group, New Zealand

Annual Workshop
Unwin Lodge, Aoraki Mt Cook Village
July 2nd-July 4th 2014



Programme
June 27th, 2014

Co-sponsored by:

The National Institute of Water and Atmospheric Research (NIWA)
Antarctic Research Centre, Victoria University of Wellington
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Welcome to SIRG2014. The following programme outlines what promises to be a great two days of presentations. All abstracts are appended in alphabetical order. At the back of this programme is an announcement for a public talk session scheduled for Thursday July 3rd. Also appended is a selection of excursions for Friday July 4th. We look forward to seeing you all at Unwin Lodge. – Huw Horgan and Brian Anderson.

(Note that we will be distributing printed schedules for all participants but to avoid waste we will not be printing the full abstract booklet. A few printed copies will be available to share but if you would like your own copy please print it and bring it along.)

WEDNESDAY		
12:00	**LUNCH**	
13:20	**WELCOME**	SESSION ONE
13:30	McColl, Sam	WHEN THE ICE GIVES WAY: DEFORMATION OF ICE-BUTTRESSED SLOPES
13:45	Bell, Jeremy	AVALANCHE RISK MITIGATION AND THE PERCEPTION OF HAZARDS
14:00	Anderson, Brian	MEASURING GROUND DEFORMATION FROM TIME-LAPSE PHOTOGRAPHY – EXAMPLES FROM FRANZ JOSEF AND FOX GLACIERS
14:15	Still, Holly	RESOLVING THE TEMPORAL AND SPATIAL VARIABILITY OF GLACIER SURFACE ALBEDO USING MODIS DATA
14:30	Short Introductions	
15:00	**BREAK**	SESSION TWO
15:30	Hulbe, Christina	AS YOU LIKE IT: MEASUREMENTS OF CHANGE ON ICE STREAMS D AND E, WEST ANTARCTICA
15:45	Dadic, Ruzica	HIGH-DEGREE SNOW METAMORPHISM IN THE ALAN HILLS, ANTARCTICA
16:00	Rack, Wolfgang	SATELLITE MELANGE: ICE DYNAMICS OF SKELTON GLACIER, ANTARCTICA
16:15	Jones, Richard	RAPID THINNING OF AN EAST ANTARCTIC OUTLET GLACIER DURING STABLE HOLOCENE CLIMATE
16:30	Goodsell, Becky	PSYCHOLOGY, GEOPOLITICS AND A TINY BIT OF SCIENCE; WINTERING-OVER AT SCOTT BASE, ANTARCTICA
17:00	**IGS ICEBREAKER**	Old Mountaineers Cafe - Aoraki Mt Cook
19:00	**DINNER**	

THURSDAY		SESSION THREE
9:00	Dykes, Robert	SEISMIC DETECTION AND ANALYSIS OF CALVING EVENTS AT A WATER-TERMINATING GLACIER, TASMAN GLACIER
9:15	Horgan, Huw	RAIN INDUCED UNSTABLE SLIDING – TASMAN GLACIER
9:30	Arese, Maura	TASMAN GLACIER: ANALYSIS OF A GLACIER THROUGH THE REMOTE SENSING
9:45	Sirguey, Pascal	THE GEODETIC MASS BALANCE OF THE NORTHERN ICEFIELD OF KILIMANJARO
10:00	**BREAK**	SESSION FOUR
10:30	Zammit, Christian	UPDATE ON NIWA SNOW AND ICE NETWORK AND SPICE EXPERIMENT
10:45	Jobst, Andreas	ROBUST TEMPERATURE AND PRECIPITATION FIELDS FOR THE UPPER CLUTHA
11:00	Kees, Lawrence	END OF SEASON SNOW CONTRIBUTION TO THE ORETI AND MARAROA CATCHMENTS
11:15	Frei, Prisco	A COMPARISON BETWEEN SNOW-RICH AND SNOW-POOR WINTERS
11:30	Zawar-Reza, Peyman	TOWARDS A COUPLED WEATHER--SNOW COVER FORECASTING SYSTEM FOR THE NEW ZEALAND SOUTHERN ALPS
11:45	TBC	
12:00	**LUNCH**	SESSION FIVE
13:30	Kungl, Akos	MEASURING OCEAN FRAZIL ICE WITH SONAR: SCATTERING OF SOUND FROM A SINGLE FRAZIL ICE CRYSTAL
13:45	Wongpan, Pat	SIMULATION OF THE CRYSTAL GROWTH OF PLATELET SEA ICE WITH DIFFUSIVE HEAT AND MASS TRANSFER
14:00	Neff, Peter	LANTHANIDE ELEMENT STUDIES OF AEROSOL PARTICLES IN AN ICE CORE FROM ROOSEVELT ISLAND, ANTARCTICA
14:15	Tuohy, Andrea	SUMMER STORMS AND HEAVY METAL VARIABILITY AT ROOSEVELT ISLAND, ANTARCTICA
14:30	Emanuelsson, Dan	CLIMATE INFORMATION PRESERVED IN WATER STABLE ISOTOPES FROM A COASTAL WEST ANTARCTIC ICE CORE (ROOSEVELT ISLAND)
14:45		
15:00	**BREAK**	SESSION SIX
15:30	Lilly, Kat	MAPPING ICE MICROSTRUCTURE USING ELECTRON BACKSCATTER DIFFRACTION
15:45	Becroft, Leeza	GRAIN GROWTH KINETICS OF ICE FROM EXPERIMENTS USING SUPERFINE ICE
16:00	Welter, Jeff	SOLID LANDSCAPE MODELS IN THE TWENTY-FIRST CENTURY – A BALANCED APPROACH
16:15	Purdie, Heather	THE PHYSICAL AND SOCIAL IMPLICATIONS OF RAPID GLACIAL RETREAT: A CASE STUDY FROM FOX AND FRANZ JOSEF GLACIERS, SOUTH WESTLAND, NEW ZEALAND
16:30	Chinn, Trevor	WHEN DEAD ICE IS NOT STAGNANT
16:45	SIRG Discussion	
18:00	**DINNER** PUBLIC TALKS	
19:30	Anderson, Brian	WHAT'S HAPPENING TO OUR GLACIERS?
19:50	Sirguey, Pascal	AORAKI2013: THE SURVEY OF AORAKI/MT COOK
20:10	Morris, Jane	AORAKI ADVENTURES
POSTERS	Arese, Maura	TASMAN GLACIER: ANALYSIS OF A GLACIER THROUGH THE REMOTE SENSING
	Wu, Xiaolin	SEASONAL TRENDS OF PERSISTENT ORGANIC POLLUTANTS IN A GLACIAL LAKE IN NEW ZEALAND
ATTENDING	Pauling, Andrew	ICE SHELF BASAL MELTING IN A GLOBAL CLIMATE MODEL
	Langhorne, Pat	INTERDEPENDENCY OF SEA ICE AND ICE SHELVES
	Chandrakumar, Nathanael	
	Ryan, Michelle	FOURIER DECONVOLUTION ON GPR DATA COLLECTED IN ANTARCTIC DRY SNOW AND SEA ICE ENVIRONMENTS
	Lui, Ed	SURFACE-FLOW VELOCITY AND ICE-FLOW DYNAMICS OF THE TASMAN GLACIER

SIRG 2014
ABSTRACTS

MEASURING GROUND DEFORMATION FROM TIME-LAPSE PHOTOGRAPHY – EXAMPLES FROM FRANZ JOSEF AND FOX GLACIERS

Anderson, B.[1]

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Deformation of ice and sediment bodies can be measured at high spatial and temporal resolution through the use of time lapse photography from fixed ground locations. To convert pixel displacements from a single camera into three-dimensional displacement vectors a high resolution digital elevation model (DEM), and an assumption about flow direction, is required. Two examples of this method are presented. The first is a time series of images of ice flow at Franz Josef Glacier between February 2013 and June 2014. Direction of flow is assumed to be the same as in satellite-derived flow fields from 2013. The timeseries is compared to continuous GPS measurements and shows short-term variability in flow velocity, related to rainfall and melt events, superimposed upon a seasonal velocity signal. The second example is from Fox Glacier, where glacier thinning and recession has resulted in a complex interaction of slope failure and ice flow. In this case slope failure is initiated by destabilisation of a moraine wall through the removal of ice at its toe. Once initiated, the flow velocity of the slip is controlled by rainfall events. Together these examples show how the dynamics of ground motion can be cheaply, easily and safely measured in near real time.

TASMAN GLACIER: ANALYSIS OF A GLACIER THROUGH THE REMOTE SENSING

M. Arese

Università di Roma La Sapienza
Supervisors: Prof. Gino De Vecchis
Prof. Giampaolo Galdieri

The objective of this work is monitoring a glacier located in the South Island of New Zealand: the Tasman Glacier. Through the *Remote Sensing* techniques of satellite and analysis of information obtained from georeferenced images, we have tried to interpret the changes undergone by the landscape of this remote and fascinating area of the Earth. Is the Tasman Glacier retreating? Is the proglacial lake at its foot expanding? Having reliable data on the performance of these two elements of nature it means having an overview on the trend of the entire area of the Southern Alps of New Zealand, and more generally on the assumption of dissolution of the worldwide glaciers.

The Tasman Glacier (43° 36' 56'' S; 170° 11' 55 '' E) is located within the Aoraki Mount Cook National Park, a UNESCO World Heritage Site since 1990. Being 27 km long, the Tasman Glacier is the longest glacier in the southern temperate hemisphere. Formed about 15,000 years ago, the Tasman Glacier advanced and retreated many times leaving important moraine deposits and forming the basin where the immense Lake Pukaki is found today. About 20,000 years ago the glacier was joined to the nearby Murchison, Hooker and Muller, extending for 115 km. Its massive profile is inserted in a landscape of valleys, made of gravel and framed by snow-capped peaks. As in the past, the glacier retreat has given birth to a new lake, Lake Tasman (43° 41' 28 ''S, 170° 11' 00 '' E) which expanded over a few years.

The Tasman Glacier has been retreating since 1987. This process has accelerated since 2000 giving rise to Tasman Lake. Other proglacial lakes, are also expanding in the area of *Southern Alps*. This evolution, shows how glaciers modify the landscape. To study glaciers through new techniques of remote sensing is a great opportunity for the purpose of environmental monitoring.

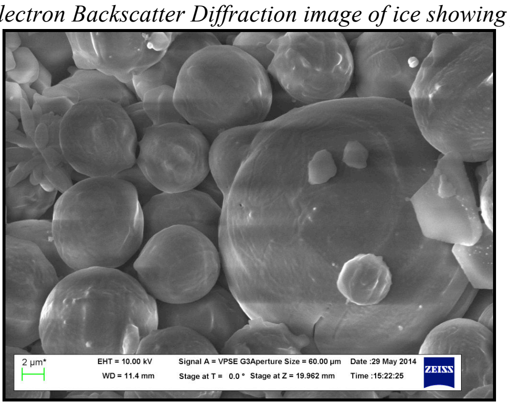
GRAIN GROWTH KINETICS OF ICE FROM EXPERIMENTS USING SUPERFINE ICE

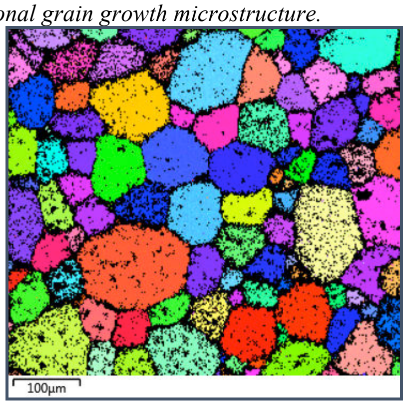
Becroft, L.[1], Seidemann, M.[1], Lilly, K.[1], Prior, D.J.[1], Easingwood, R.E.[2], Golding, N. [3], Durham, W.B.[3], Strauss. M. [2,4]

[1]Department of Geology, University of Otago, Dunedin, New Zealand
[2]Otago Center for Electron Microscopy, University of Otago, Dunedin, New Zealand
[3]Earth, Atmospheric and Planetary Sciences, MIT, Cambridge MA, USA.
[4]Biological Chemistry and Molecular Pharmacology, Harvard University, Boston, MA, U.S.A

Grain growth is the increase in mean grain size in polycrystalline materials when exposed to low stress and high temperature conditions, and is described by the mean field equation: $D^n-D_0^n = kt$. D is the mean grain diameter after time t, D_0 is the initial mean grain diameter and k is the product of intrinsic diffusivity and the Arrhenius relationship of temperature. The growth exponent n reflects the microscale physics of the grain growth process, and is poorly understood in geologic materials including ice. Knowing the growth exponent for ice is important to interpretation of ice-core grain size data. High n values mean that grain-sizes converge more rapidly with time. For example, zones of anomalously small grain size that may be generated by localized creep could be made less significant by grain growth and part of the history of the ice sheet will be missed. Growth exponents in ice are traditionally set at 2, corresponding to one theoretical grain-growth model: some new data (Azuma *et. al.,* 2012) suggest that they are closer to 4. Estimation of n-values from ice cores or experiments have often been limited by very small differences between D and D_0 so that there are potentially large errors in n that cannot be de-convolved from errors generated by uncertainty in the thermal history. This study uses a new approach: two samples that differ only in grain-size are subjected to a single thermal history cancelling out uncertainties in the thermal history and allowing n to be calculated by the relative grain growth of the two samples. To give well-constrained n values the approach requires very fine-grained starting materials. To date we have made progress in generating starting materials, testing the experimental approaches and collecting pilot data. Fine-grained starting materials have been generated by cycling coarser grained ice through the ice 1h to ice II phase transformation (generating ice with ~ 10 to 20 micrometre mean grain size). We have also experimented with a ‘printing’ superfine ice: using an inkjet printer to spray fine water droplets into liquid nitrogen. The resulting powders are then pressed at dry ice temperatures to produce dense (no porosity) fine-grained polycrystalline ice. The ‘printing’ results in sub micrometre to 20 micrometre spheres (Fig. 1) that are internally polycrystalline (up to 5 micrometres) and we hope that the pressed samples will have mean grain-sizes less than 5 micrometres. Grain sizes are measured using Cryo-Electron Backscattered Diffraction (Fig 2). Preliminary experiments give n values of 2.

Figure 1 (left): Variable pressure secondary electron detector image of ice printed using Epson TX100 modification. Figure 2 (right): Electron Backscatter Diffraction image of ice showing polygonal grain growth microstructure.





AVALANCHE RISK MITIGATION AND THE PERCEPTION OF HAZARDS

Bell, J.L[1], Cullen, N.J[2]

[1]University of Otago
[2]University of Otago (Department of Geography)

Avalanche accidents in New Zealand are becoming more frequent as a result of increasing use of alpine terrain. Currently there is a large database of information regarding the demographics of avalanche victims however, there is very little information regarding the numbers of people who use alpine terrain. The focus of this research will be on the perception of avalanche risk and the preparedness of users of avalanche terrain. Over the next two winter seasons, information regarding the numbers of people using back-country areas, along with associated demographics, will be collected. Information will also be gathered about the levels of education among these users, and how they use the information that is given to them, such as avalanche reports and warnings. From these data the preparedness of users will be ascertained and strategies to reduce avalanche risk in the future will be considered. A focus of the research will be to ascertain what back-country users do with information that is given to them, and how this is related to their level of education and/or experience.

If people are not prepared for the risk associated with the backcountry terrain that they are accessing, then a key question that needs to be asked is why? It is hoped that this work will help identify the relative importance of issues related to the cost and weight of gear, lack of knowledge, lack of awareness of risk, peer pressure, careless behaviour, over-exuberance, ignorance and/or over-familiarity with conditions. By obtaining information about these different controls it is anticipated this research will offer new insights into user behaviour in hazardous terrain, which may help in developing strategies to reduce risk.

WHEN DEAD ICE IS NOT STAGNANT

[1]Trevor Chinn, [2]Heather Purdie and [3]Brian Anderson.

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[2] Department of Geography, University of Canterbury, Private Bag 4800, Christchurch, New Zealand (NZ).
[3]Antarctica Research Centre, Victoria University of Wellington, PO Box 600, Wellington, NZ.

Glacial processes can be complex and difficult to understand and this can lead to misinterpretation of some activities of glaciers. For instance, immediately debris covered ice becomes separated by outwash gravels, it is classified as being dead. The Fox Glacier has presented a fine example of both the thermokast retreat with a readvance. A dwindling of the 1930s and 1940s ice with increasing debris concentration on the trunk.decayed into a stagnant ice paddock believed to be disconnected from the upper glacier. With the approach of the re-advance wave, the lower thermokarst limit continued retreating, providing simultaneous advance and retreating fronts. To measure the glacier front position, one has to deceide when to make the jump from the decaying thermokast front to the to ‘normal’ active frontal ice.

When 1968 re-advance was recorded by monitoring from fixed camera posts, the photographs showed that the nearby dead" ice had begun to move with the advance. But not only did it move, it also refused to shrink and for 50 years the big ice cored moraine mound opposite Cone Rock barely changed in size, even with the river exposing ice on the upstream side. Why? Since no amount of gravel cover can cause ablation to cease, if the top of the mound didn't go subside, the bottom must have been floating upwards. This implies a very deep channel at this position, and that the ablation rate can be used to calculate its depth.

Thermocarst development at Fox Glacier in 1957

Ref: Purdie, Anderson, Chinn, Owens Mackintosh and Lawson, Twentieth and early 21st century length change at Franz Josef and Fox Glaciers, New Zealand. In Press, Global and Planetary Change

HIGH-DEGREE SNOW METAMORPHISM IN THE ALAN HILLS, ANTARCTICA

Dadic R. [1], Schneebeli M. [2], Bertler N. [1], Matzl M. [2] and Schwikowski M. [3]

[1]Victoria University of Wellington, New Zealand
[2]WSL Snow and avalanche research institute SLF, Davos
[3]Paul Scherrer Institute, PSI, Villigen, Switzerland

Snow metamorphism is a primary driver of the transition from snow to ice. High degree snow metamorphism, which results in major structural changes, is little studied but has been identified in certain places in Antarctica. Albert et al. [2004] and Courville et al. [2007] described the structural properties of such metamorphosed snow in the megadunes of East Antarctica. Here we report on a 5-m firn core collected adjacent to a blue-ice field in the Allan Hills (-76.67°, 159.23°) in January 2011. This entire core showed a high degree of snow metamorphism, and little densification. We determined the physical properties of the snow using computer tomography and measured the isotopic composition of ∂H and ∂18O, as well as 210Pb activity. The micro-CT measurements show a homogenous and stable structure throughout the entire core as opposed to the more variable structure pattern of seasonal snow observed elsewhere in Antarctic and in alpine regions. This implies that the snow has undergone high-degree metamorphism, which is likely to have been caused by decades of temperature gradient driven metamorphic growth in the near surface due to prolonged exposure to seasonal temperature cycling. Such metamorphism is likely to be accompanied by altered isotopic compositions and chemical species concentration. 210Pb has a short half-life of 22.3 years and can thus be used to detect changes in accumulation rates that occurred within the last century. Except for the top 0.3 m, our 5-m core has no detectable 210Pb activity. This implies that most of the snow is older than 100 years. The measured isotopic compositions require high vapor transport and can thus also be linked to prolonged exposure of snow to seasonal temperature cycling and very low accumulation rates. For ice core research, this means that cores from near-zero accumulation areas can help better understand the ranges of isotopic composition during ice ages, when accumulation rates were lower than today.

Albert, M., C. Shuman, Z. Courville, R. Bauer, M. Fahnestock, and T. Scambos (2004), Extreme firn metamorphism: impact of decades of vapor transport on near-surface firn at a low-accumulation glazed site on the East Antarctic plateau, Annals of Glaciology, 39(1), 73–78, doi:10.3189/172756404781814041.

Courville, Z. R., M. R. Albert, M. A. Fahnestock, L. M. Cathles IV, and C. A. Shuman (2007), Impacts of an accumulation hiatus on the physical properties of firn at a low accumulation polar site, Journal of Geophysical Research, 112(F2), 1–11, doi:10.1029/2005JF000429.

SEISMIC DETECTION AND ANALYSIS OF CALVING EVENTS AT A WATER-TERMINATING GLACIER, TASMAN GLACIER

Dykes, R.C. and Lube, G.

Institute of Agriculture and Environment, Massey University

Iceberg calving events generate measurable seismic energy (termed "icequakes"). In this study, individual calving events, and their associated seismicity, from the terminus of Tasman Glacier were analysed to investigate intra-event dynamics and how icequakes vary across size and style of event. Over the study period (February to April 2012) all calving events recorded at Tasman Glacier generated seismic signals consisting of an emergent onset of weak frequencies above 5 Hz, followed by a high amplitude phase with frequency content between 1 and 5 Hz and a protracted coda. Two types of icequake were distinguished from differences in the signal duration, amplitude, number of peaks and energy released. These distinct icequake types have been linked to two sub-groups of calving event: (1) events originating from the subaerial ice cliff; and, (2) higher-magnitude buoyancy and subaqueous calving events. This analysis also highlighted several potential relationships between calved iceberg size and seismic parameters (e.g., signal duration, peak amplitude and integrated amplitude) that could potentially be used to remotely assess the frequency, style and order-of-magnitude differences in calving event size and style. Although the development of reliable relationships between seismic parameters and iceberg size will be challenging due to the continuum of spatial and temporal scales over which calving operates, this study provides a forward-step in achieving this capability.

CLIMATE INFORMATION PRESERVED IN WATER STABLE ISOTOPES FROM A COASTAL WEST ANTARCTIC ICE CORE (ROOSEVELT ISLAND)

Emanuelsson B.D.[1,2], Bertler N.A.N.[1,2], Baisden W.T.[2] and Keller E.D.[2]

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The objective of my PhD study is to establish a high-resolution $\delta^{18}O$ and δD water isotope record for the past 2,000 years from an ice core retrieved from Roosevelt Island, Antarctica.
At SIRG I will present results from the modern part of the ice core record (1979 AD to present) where isotopes has been correlated with meteorological reanalysis ECMWF Interim Re-Analysis (ERA-Interim) data to identify air mass trajectories and moisture source regions for precipitation at Roosevelt Island. We investigate the importance of local sources (Ross Sea polynya) versus remote regions (Southern Ocean) and the influence of their air mass trajectory on the fractionation pathway of the water vapor. Moreover, we identify relationship of the transport pathway with the El Nino Southern Oscillation (ENSO) and the Southern Annular Mode (SAM) as main drivers of the air mass trajectories to Roosevelt Island.
The water isotope data were measured using a LGR IWA-35EP analyzer, manufactured by Los Gatos Research (LGR). We developed the first experimental design applying off-axis integrated cavity output spectroscopy (OA-ICOS) to continuously analyze water isotopes from an ice cores. A Water Vapor Isotopic Standard Source (WVISS) calibration unit, was modified to decrease the response time, which allows us to efficiently perform multi-standard calibrations and make continuous high resolution $\delta^{18}O$ and δD measurements with less attenuation introduced by the experimental design. At AGU I also aim to share the knowledge that we gained from setting up and characterizing the vaporizer and laser spectroscopy system described above.

A COMPARISON BETWEEN SNOW-RICH AND SNOW-POOR WINTERS FROM 1979-2012 IN SWITZERLAND

Frei P., Pfahl S. and Wernli H.

ETH Zurich, Switzerland

In Switzerland, snow is a resource of economic and social value (tourism, drinking water, electricity, etc.). We analyse two atmospheric parameters (temperature and precipitation distribution), as well as two weather systems (frequencies of extratropic cyclones and stratospheric streamers) between 1979—2012, to understand which climatic conditions lead to snow-rich winters and which lead to snow-poor winters. First, we identify the three snow-richest and the three snow-poorest winters trough the SnowDayIndex. Then we compile and analyse the two atmospheric parameters and the two weather systems from ERA-Interim data. We correlate the SnowDayIndex with the ERA-Interim data. The snow variability can be well reproduced by variations in temperature and precipitation. Snow-rich winters in Switzerland, in contrast to snow-poor winters, are characterized by higher cyclone frequencies in the Mediterranean area as well as by lower temperatures and more precipitation in Switzerland. These higher cyclone frequencies could be explained by the baroclinity but not by the streamer frequencies. Despite the good correlation between the cyclone frequency (Mediterranean area) and the temperature (Switzerland) it wasn't possible to differentiate between "cause" and "effect". Furthermore, there is no direct correlation between the frequency of Mediterranean cyclones and the amount of precipitation in Switzerland. Thus we conclude that the frequency of Mediterranean cyclones is a key driver for annual snow variability in Switzerland.

PSYCHOLOGY, GEOPOLITICS AND A TINY BIT OF SCIENCE; WINTERING-OVER AT SCOTT BASE, ANTARCTICA

B. Goodsell[1]

[1]Antarctica New Zealand

The career path for glaciologists can be variable and interesting. Although a winter in Antarcica provides little to no glaciology, the skills learnt as a glaciologist can be applied to the long dark winter months in Antarctica. In particular, the group dynamics experienced in glaciological field teams around the world are similar to the group dynamics found in the winter-over crew of Scott Base. The geopolitics involved in different nations working together in Antarctica is also somewhat similar to the politics experienced by international research projects. In contrast, individual personalities and the psychological make-up of an over-winterer tends to be significantly different to that of a typical glaciologist. This talk presents some photographic observations made during the 2013 winter in Antarctica from the perspective of Winter Leader/Winter Domestic at Scott Base, and hopes to provide answers to common questions such as 'Is it really dark?' and 'Did anyone go mental'?

RAIN INDUCED UNSTABLE SLIDING – TASMAN GLACIER

Horgan, H.J.[1], Anderson, B.[1], Dykes, R.C.[2]

[1] Antarctic Research Centre, Victoria University of Wellington
[2] Institute of Agriculture and Environment, Massey University

Alpine glaciers and ice caps are anticipated to contribute significantly to sea level rise over the coming century [Meier et al., 2007]. This contribution will take place due to changes in surface mass balance and dynamic discharge. The potential for discharge acceleration has been highlighted as a major source of uncertainty in sea level rise predictions [IPCC, 2007]. Estimating the upper bound of potential accelerations is of particular interest as it allows the limits of realistic scenarios of sea level rise to be determined (e.g. Pfeffer et al. [2008]). Implicit in this approach, however, is the assumption that we have observed, or can predict, the full spectrum of glacier behavior.

Changes affecting basal slip can cause the flow of glaciers and ice sheets to accelerate rapidly. During times of heavy rainfall, Tasman Glacier in the Southern Alps of New Zealand accelerates to speeds of up to 40 times its normal speed (from 40 to 1600 m a^{-1}). Peak speeds are maintained for periods of less than 12 hours before the glacier velocity returns to close to background levels.

These observations, which were obtained using continuously recording GPS, greatly expand the observed range of glacier speed ups in response to water inputs, and likely represent a state of unstable sliding. The velocity of Tasman Glacier is shown to be proportional to the 24-hour rainfall magnitude in the surrounding catchment and peak velocities correspond with the peak rate of glacier surface uplift. The sensitivity of glacier speed to water input is increased by glacier down wasting, which lowers the effective pressure at the bed, indicating that rain induced speed-up events will become increasingly common on Tasman Glacier.

AS YOU LIKE IT: MEASUREMENTS OF CHANGE ON ICE STREAMS D AND E, WEST ANTARCTICA

Hulbe, C.H. [1], Scambos, T.A. [2], Klinger, M. [2]

[1]National School of Surveying, University of Otago, Dunedin, NZ
[2]National Snow and Ice Data Center, Boulder, CO, USA

The West Antarctic Ice Sheet has the potential for rapid and significant change due to its marine character and fast-flowing ice streams. This makes modern change detection of particular interest. That objective is complicated in the Ross Sea sector of the ice sheet by internally-driven flow variability on time scales ranging from annual to multi-century. Even worse, the sense of change (slowing and thickening or speeding and thinning) detected by direct observation may change from one observation epoch to the next. The opportunities for contrary and incompatible interpretations are excellent.

Here, observations of change in the flow of Ice Streams D and E are made over a variety of intervals starting in the 1970s with RIGGS and ending in 2014 with Landsat 8. The sense of change varies over time and is variable both along and across flow. An attempt is made to reconcile these observations using structural features of the ice.

ROBUST TEMPERATURE AND PRECIPITATION FIELDS FOR THE UPPER CLUTHA

Jobst A. M.,[1] Kingston D. G.,[1] Cullen N. J.[1]

[1] Department of Geography, University of Otago

Hydrological modelling studies in complex terrain require accurate temperature and rainfall fields in order to produce authoritative results. In the upper catchment, large amounts of precipitation are stored as seasonal snow, which significantly alters the annual discharge regime of the headwaters. A correct representation of high elevation temperature was found to be of fundamental importance in order to simulate the melt regime realistically. The sparse temperature network in the upper Clutha, with only two climate sites above an altitude of 1000m and short temporal records makes this a challenging task. Different interpolation techniques were assessed for maximum and minimum temperature respectively, while their accuracy was investigated with the use of independent climate records. A combination approach of a thin plate spline and spatially varying monthly lapse rates resulted in the best accuracy and proved to be significantly better than the use of a fixed standard lapse rate. The processing of the precipitation fields was based on a trivariate spline and the 30 year rainfall normal surface (NIWA). A water balance validation approach was used which highlighted the need for modification of the rainfall normal surface inside the study domain. The new daily climate grids have a spatial resolution of 1 km^2 and will serve as the key input into a fully distributed hydrological model of the Upper Clutha catchment, which should lead to all hydrologic processes being resolved more realistically.

RAPID THINNING OF AN EAST ANTARCTIC OUTLET GLACIER DURING STABLE HOLOCENE CLIMATE

Jones, R.S.[1,2], Mackintosh, A.N.[1,2], Norton, K. P.[2], Golledge, N. R.[1,3], Fogwill, C.[4]

[1]Antarctic Research Centre, Victoria University of Wellington, Kelburn, Wellington
[2]School of Geography, Earth and Environmental Sciences, Victoria University of Wellington, Wellington
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Ice-sheets that are grounded on overdeepened beds below sea-level are potentially vulnerable to collapse. Outlets of the West Antarctic Ice Sheet that occupy reverse bed slopes are currently in negative mass balance. New ice-penetrating radar data reveal that large overdeepened basins and reverse bed slopes exist under parts of the East Antarctic Ice Sheet, raising concern for its future behaviour. Retreat of the Antarctic ice sheet from the Last Glacial Maximum (LGM) to its present configuration provides an opportunity to assess ice-sheet response to climate forcing and ice-dynamic feedbacks. Here we report 44 surface-exposure ages from two nunataks in the lower reaches of Mackay Glacier, an outlet of the East Antarctic Ice Sheet. Four transects record surface lowering from the LGM to 200 years ago. Rapid thinning of at least ~200 m occurred during the early/mid-Holocene at a rate of 130+/-83 cm/yr for ~800 years. This was was coeval with retreat of the grounding-line through an overdeepening on the inner continental-shelf, and the disintegration of a buttressing ice-shelf. A 1-d numerical flowline model was used to investigate the amount of upstream thinning from grounding-line retreat. The magnitude and timing of ice-dynamic thinning recorded at Mackay Glacier also occurred more widely, for example on the West Antarctic and Peninsula ice-sheets, at a time of relative climatic and oceanic stability after grounding-lines had retreated to the inner continental-shelf. These results imply that significant ice-sheet thinning in the early/mid Holocene arose from topographic feedbacks rather than from significant environmental forcing.

END OF SEASON SNOW CONTRIBUTION TO THE ORETI AND MARAROA CATCHMENTS

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Contributions of snow melt to stream and aquifer inflows in Southland are not well understood, although annual estimates indicate a relatively small proportion (6%) of snow melt to the annual flow of the Oreti River at Lumsden (Kerr et al. 2013). Discharge of high altitude water is thought to play a critical role in the dilution of lowland contaminants that enter the ground and surface water network via intensive landuse across the northern plains of Southland. To address this issue we develop a seasonal snow water equivalent (SWE) volume for the Mararoa and Oreti catchments and characterise the isotopic and chemical composition of the snow pack and melt waters. Snow depth data were collected on the 7th of September 2012 using a Pulse Ekko Ground Penetrating Radar (GPR) system at a transmitting frequency of 500MHz. Surveys were made at two sites creating a gradient of snow distribution across the upper Mararoa and Oreti catchments, between elevations of 1800 m asl and 1400 m asl. Manual probing of snow depth along the radar transect provided the basis for the calibration of radar wave travel times. Snow samples were collected above the headwater tributaries of the Mararoa and Oreti catchments for stable isotopic determination of δ18O, δD of H2O and δ13C-DIC. Headwater streams draining each catchment were also sampled. The measured pattern of snow distribution from climate station records and GPR-derived SWE indicate an overall NW-SE gradient in keeping with expected patterns of snow distribution. Preliminary results suggest that the seasonal influence of snowmelt on stream discharge and groundwater recharge is considerably greater than annual contributions suggest. A clear mixing relationship between the isotopic composition of the snowpack/stream water and groundwater sampled from lowland wells supports a significant snowmelt signature. Contributions from high altitude recharge may be as high as 90% of the volume of some aquifers within the northern plains. This work suggests that seasonal melt moves through sediment-infilled valleys to recharge lowland groundwater reservoirs which then discharge as base flow. Future work aims to better quantify the volume of high altitude inputs to regional catchments.

MEASURING OCEAN FRAZIL ICE WITH SONAR: SCATTERING OF SOUND FROM A SINGLE FRAZIL ICE CRYSTAL

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Frazil ice is the name given to the ensemble of small disc-like ice crystals which are created in turbulent, slightly supercooled water. They appear in rivers and oceans and play a role in several processes. Despite of their importance quantitative measurements of ocean frazil are scarce. In the ice physics group at the University of Otago a measurement method is being developed, which uses a 4-channel monostatic sonar to detect frazil ice. As part of this measurement my project aims at improving the sound scattering models from single frazil ice particles. Scattering of sound from objects of high diameter to thickness ratio is still a challenging problem. Therefore in environmental physics and oceanography simplifications are used which might disregard the effect of the shape of the frazil. In this talk first a brief outline of the measurement will be given. Further, the ideas will be presented to calculate the backscattered sound from frazil ice using oblate spheroidal coordinates.

INTERDEPENDENCY OF SEA ICE AND ICE SHELVES

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Around coastal Antarctica, sea ice often grows in water that has been supercooled by interacting with an ice shelf. This causes sea ice to lose heat to the ocean, as well as to the atmosphere. Hence the sea ice is thicker than it would be without the ice shelf. Tiny frazil crystals in the supercooled water column accumulate under the sea ice where they form a porous layer of crystals in an evolving state of consolidation. This results in a modified crystallographic structure that leaves a detectable signature frozen into the sea ice cover, through the formation of incorporated platelet ice.

Here we extend some of the longest available, century-old, Antarctic ice-ocean observational records near the combined Ross and McMurdo Ice Shelves in southern McMurdo Sound. Over that time it appears that the regulating influence of basal melting in the ice shelf cavity has held the temperature of the upper ocean just below its freezing point. We use the ability of sea ice to integrate the effect of ocean heat flux over its annual growth to interpret crystallographic records from a historical time series of sea ice cores. The distribution of platelet ice (and hence negative ocean heat flux) is strongly linked to the circulation in McMurdo Sound. Although variable, there is no evidence to suggest that the abundance of platelet ice has changed since 1902. These multiple sources of data are extended around coastal Antarctica to provide estimates of the influence of ice shelf-conditioned surface water on sea ice.

MAPPING ICE MICROSTRUCTURE USING ELECTRON BACKSCATTER DIFFRACTION

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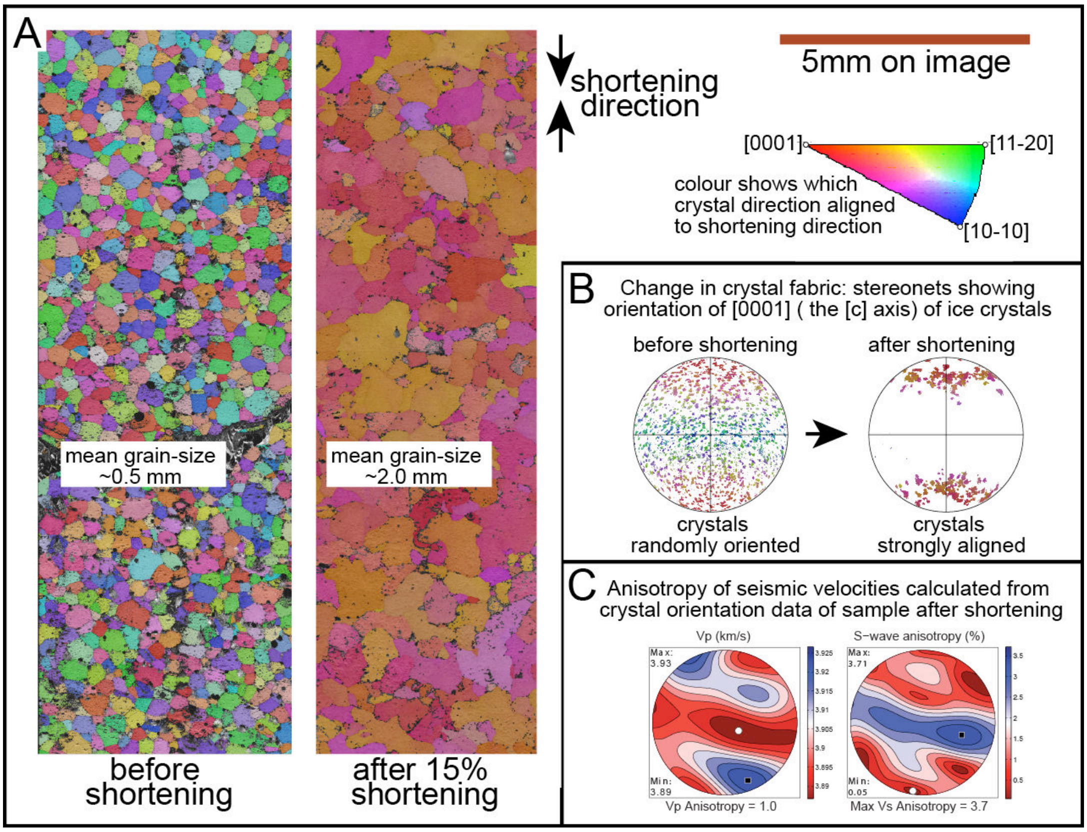
Electron backscatter diffraction (EBSD) is a scanning electron microscope based technique that allows us to reconstruct the microstructure of a crystalline sample from individual diffraction patterns collected on a grid. The data provide a quantitative picture of fabric (preferred orientation) and microstructure. The first successful EBSD of ice was in 2005 and although other studies have followed, the method has not become routine. We have developed the sample preparation, sample handling, SEM and EBSD protocols with three major technological outcomes. 1) The method is now routine and has a very low failure rate. 2) We can now work on fine grained ice (less than 10 micrometres) that is important in experimental work 3) We can analyse much larger samples: up to 30 by 30mm (four times this area may be possible with no further hardware modifications). This is important if the technique is to be applied routinely to natural glacial ice, which has large grain sizes. We will outline the sample preparation and data acquisition methods and we will show microstructural data related to ice deformed in a variety of laboratory experiments. Part A of the figure shows example EBSD maps collected on synthetic starting material and on a sample after deformation at -3˚C in the Otago ice deformation laboratory. Ice c-axes, calculated from the EBSD data, are shown in B and directional dependence of seismic velocities (derived from the EBSD data and ice single crystal elasticity data) are shown in C.



SURFACE-FLOW VELOCITY AND ICE-FLOW DYNAMICS OF THE TASMAN GLACIER

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Tasman Glacier is the largest lake-calving glacier in the Southern Alps of New Zealand. Following the formation of the pro-glacial lake around the 1990s, an acceleration of glacial retreat has been observed and has spurred renewed interest in this unique geomorphic feature of NZ. My personal interests lie in understanding the response of glaciers to increasing atmospheric warming, particularly in the spatial/temporal hydrological dynamics of valley glaciers.

Our work on the Tasman Glacier entails analysis of real-time hourly photos captured from a nearby valley wall overlooking the terminus and pro-glacial lake interface. Using this high-frequency photographic technique, a reliable time-series of glacial dynamics has been developed over the last 18 months. The images require correction for uncertainties presented by camera distortions and movement as well as errors generated from cloud cover, shadowing and varying coloration that may affect our results. Image-correlation of supra-glacial features has provided an accurate matrix of pixel displacements, which represent glacial-surface flow velocities and provides insights into the dynamics during, before and after observed calving events. In addition, correlations with daily precipitation have been analyzed and provide insights on coupling short-term climate changes and ice responses through basal velocity feedbacks.

Little is currently known about the mechanics of sub-glacial hydrology regime and its influence on surface velocity and it is the hope of this work to illuminate on this complex but fascinating topic.

WHEN THE ICE GIVES WAY: DEFORMATION OF ICE-BUTTRESSED SLOPES

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Glaciers are intimately connected to their valley slopes. For example, a glacier helps to shape a slope through erosion, but the shape of a slope also influences glacier flow. Glaciers also affect their valley slopes by destabilising them through erosion and subsequent glacier thinning, sometimes leading to collapse of these slopes. Slopes which collapse onto the top of the glacier can change mass balance. However, it is unknown what the effects are for when slopes collapse into, rather than onto, a glacier. Theoretical and field observations have begun to show that buttressing of valley slopes by glaciers, beyond a critical level, does not prevent slope movement. Therefore, slopes may become unstable and begin to move downslope prior to complete withdrawal of a receding glacier. The resulting slope movements have the potential to deform the glacier as they push their way into the ‘buttressing’ ice mass, consequently delivering a source of sediment directly to the englacial or basal transport pathways, and modifying the flow of the glacier. This presentation will:

(i) Provide geomorphic evidence of rock slopes deforming into their ‘buttressing’ glaciers, from observations in New Zealand and overseas;

(ii) Present slope movement data and a model for the movement of the Mueller Rockslide into the Mueller Glacier; and

(iii) Outline a proposal to investigate the timing of slope movement of the Mueller Rockslide using time-lapse photography and its effect on the sub-ice-surface geometry of the sliding mass using Ground Penetrating Radar.

LANTHANIDE ELEMENT STUDIES OF AEROSOL PARTICLES IN AN ICE CORE FROM ROOSEVELT ISLAND, ANTARCTICA

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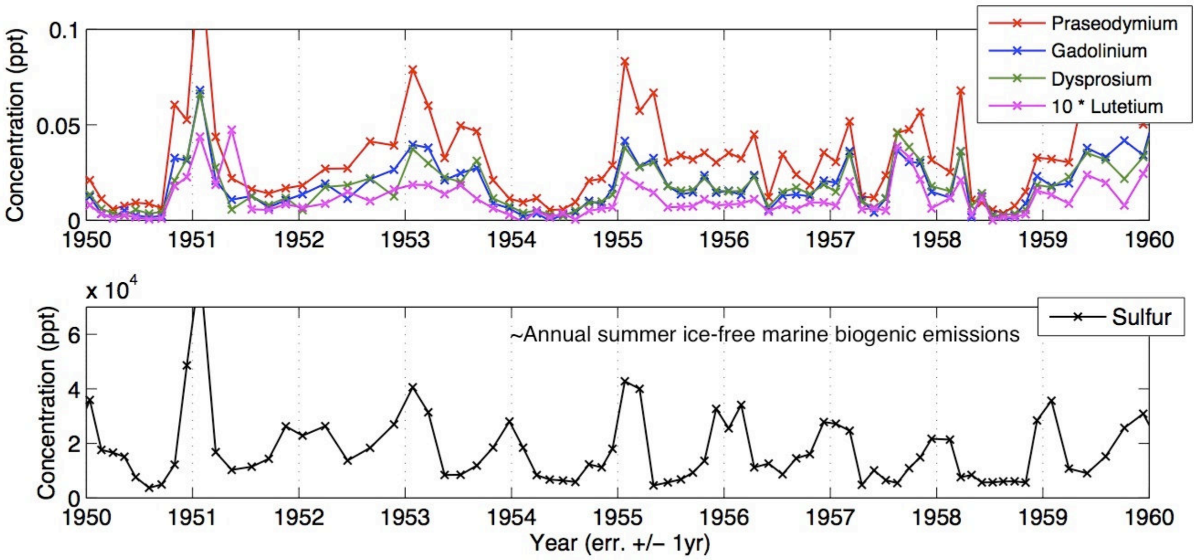
Snowfall preserved in Antarctic ice is known to provide well-dated, continuous and high-fidelity paleoclimate proxy records. Ice core proxy records have revealed much about the past composition of the atmosphere, regional and global environmental conditions, and dynamics of the global climate system. Records of mineral dust particles contained within these cores are foundational to understanding of global-scale shifts in environmental conditions and atmospheric circulation, but also can elucidate atmospheric transport processes on shorter temporal and spatial scales (e.g. changes in strength and position of the Antarctic circumpolar westerly winds). In a new ice core recovered from Roosevelt Island, Ross Sea region, Antarctica, the first annual to seasonal resolution measurements of the fourteen Lanthanide elements have been performed using inductively-coupled plasma mass spectrometry with sub-part-per-quadrillion sensitivity (Thermo Element XR, Curtin University). The Lanthanides (Lanthanum-57 to Lutetium-71) are ubiquitous in crustal material, with relative abundance varying depending on lithology. As Lanthanides are highly insoluble and immobile in the crust, dust deflated from extra-Antarctic regions may retain a signature of its source lithology—allowing for improved constraints on the source region(s) of mineral particles deposited in Antarctica. Combining these first measurements of Lanthanide concentrations in modern Antarctic snow with climate reanalysis data products spanning the satellite era (1979-present), we explore atmospheric transport pathways and possible source regions for mineral dust aerosol particles preserved in snow and ice at Roosevelt Island. Measured samples extend this record to the late-19th century at annual resolution, and span the last two millennia at approximately 3-year resolution.



ICE SHELF BASAL MELTING IN A GLOBAL CLIMATE MODEL

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The interaction between ice shelves, the ocean and sea ice is an important physical process when investigating the role of polar regions in the global climate. Coupled Global Climate Models (GCMs) are the best tool we have for investigating the global climate sytem, and at present their predictions for sea ice extent and other polar processes match poorly with observations. Currently, the representation of ice shelves in GCMs consists of land with a 1m thick cover of snow, thus not allowing for interaction between the ocean and ice shelf cavity. Particularly important is the effect of basal melting of ice shelves, where intrusion of relatively warm water into the ice shelf cavity causes melting of the underside of the shelf. The resulting relatively fresh, buoyant plume of water then rises along the bottom of the shelf and out into the open ocean, where it is then able to interact with sea ice. The aim of this research is to add a freshwater flux, based on recent estimates, at depth at the front of ice shelves around the Antarctic continent to the CESM-CAM5 model, a member of the CMIP5 ensemble of GCMs. Results of a first attempt consisting of introducing this freshwater at the surface, distributed according to the iceberg distribution obtained from the GFDL model will be presented. Current progress on adding the freshwater flux at depth, distributed according to ice shelf location will also be presented.

THE PHYSICAL AND SOCIAL IMPLICATIONS OF RAPID GLACIAL RETREAT: A CASE STUDY FROM FOX AND FRANZ JOSEF GLACIERS, SOUTH WESTLAND, NEW ZEALAND

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Rapid glacial retreat has seen two iconic glaciers in New Zealand, the Fox and Franz Josef Glaciers, loose around 500 m in length and experienced significant ice thinning in their lower regions since the culmination of their most recent advance in 2008/09. This rapid glacial retreat has the potential to impact the regional economy. In 2013 over 400,000 international travellers visited the west coast region – the majority of whom visited the glaciers. Our research aimed to explore the implications that glacial retreat had on the visitor experience. To do this we applied a multidisciplinary approach, combining glaciological survey with face-to-face semi-structured interviews with local tourism stakeholders (*n*=13) and visitor interviews (*n*=500). It was found that shortening and thinning has either restricted, or eliminated, guided walking access from the valley floors – resulting in the increased use of helicopters. In addition, the Fox Glacier is becoming increasingly debris-covered, due to melt-out of englacial debris and increased rockfall from the surrounding recently exposed valley slopes. Feedbacks associated with increased surface debris-cover means that the previously convex glacier cross-profile has flattened and modelling has demonstrated that falling rocks can now travel up to 50 m further out onto the glacier surface than was the case in 2008/09 – potentially into regions utilised for guided glacier walks. Overwhelmingly, the majority of the visitors surveyed expected the glaciers to get smaller in the future, and a number identified the importance of seeing the glaciers before they disappeared due to climate-related change. Despite the recent physical changes, the visitor's glacier experience, in relation to size and appearance of the ice, closely matched their expectations, although over half of the respondents indicated that the glacier(s) were not as big as expected. When tourists were asked if they would still visit the glaciers even if the only way to see them was by helicopter, over one-half of respondents indicated they would still visit. By integrating physical and social perspectives we gain greater understanding of the implications that climate change will have on glacier tourism in New Zealand.

SATELLITE MELANGE: ICE DYNAMICS OF SKELTON GLACIER, ANTARCTICA

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The Transantarctic Mountains (TAM) sit right in between the East and West Antarctic Ice Sheet. Relatively rich in glacial moraines they provide evidence of episodes of increased ice extent for both ice sheets. However, ice dynamics of TAM glaciers, especially the smaller ones, are poorly understood, and interpretation of ice sheet extent and timing a matter of debate. In this study we present the spatial and temporal variability in ice flow of the Skelton Glacier (78.7 S, 161.6 W) based on satellite data. We make use of older ERS data from the 1990s, not well constrained because of technical limitations of the time, rectified by new and more precise satellite information. We also use field data for ice flow and two longitudinal thickness profiles acquired during field work in 2011 as a reference to investigate modern day changes in ice dynamics and overall mass balance. The catchment basin is 6600 km^2 large, and the mass flux at the grounding line is calculated with 1.2 Gt a^{-1}. Assuming a glacier in mass balance equilibrium, a mean annual snow accumulation of about 185 mm a^{-1} w.e. in the catchment basin is expected. This is significantly different to current mass balance estimates from climate models and satellite based accumulation maps, even when taking uncertainties in our analysis into account. It is concluded that further improvements in overall mass balance estimate can be primarily obtained by a better knowledge of ice thickness and snow accumulation.

FOURIER DECONVOLUTION ON GPR DATA COLLECTED IN ANTARCTIC DRY SNOW AND SEA ICE ENVIRONMENTS

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University of Canterbury

In this presentation I describe the main results of a summer internship in 2013/14 at Gateway Antarctica, University of Canterbury. Fourier deconvolution (FD) is implemented to remove effects of the carrier wave from Ground Penetrating Radar (GPR), operating at a frequency of 1000MHz, collected near Ross Island, Antarctica. The validity of FD as a processing method is examined for three distinct environments: dry snow which has little to no conductivity, multi-year sea ice, and first year sea ice with a higher conductivity. The results display a significant sharpening of internal layers in all cases. For GPR to be used to estimate snow thickness on sea ice, the layer of overlying snow must be at least 30cm. There is a complex air-ground surface interaction region, with an effective depth of roughly 30cm, at the onset of the reflection which is not fully removed during processing. If the snow-sea ice boundary lies within this region its depth cannot be accurately extracted.

THE GEODETIC MASS BALANCE OF THE NORTHERN ICEFIELD OF KILIMANJARO

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Kibo, the highest of three peaks of Kilimanjaro, has not benefited from a medium to large scape topographic mapping in about 50 years. The rapidly changing topography associated with the glacier retreat and the fact that the slopes of Kibo attract about 40,000 climbers each year (UIAA, 2013) thus justify the need to develop a new topographic survey of this outstanding landmark, designated a UNESCO World Heritage Site in 1987. In this context, the application of the photogrammetric principles to the latest generation of very high resolution spaceborne optical sensors (VHRS) offers new surveying opportunities by enabling the topographic mapping with unprecedented spatial resolution.

This study reports on the creation of a 50-cm resolution Digital Surface Model (DSM) of Kilimanjaro via photogrammetry of GeoEye-1 imagery. This allowed the total volume of the ice remnants to be estimated. Finally, the new DSM was compared with the SRTM DEM of February 2000. The difference between both surfaces permitted the volume lost by the Northern Ice Field over 12.7 years to be estimated, as well as spatial pattern of the thinning to be revealed.

Figure 1. Northern Ice Field of Kibo, Kilimanjaro as seen from GeoEye-1, 23 October 2012

RESOLVING THE TEMPORAL AND SPATIAL VARIABILITY OF GLACIER SURFACE ALBEDO USING MODIS DATA

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The energy and mass balance of a glacier is sensitive to the temporal and spatial variability of surface albedo. Continuous ground-based measurements of the albedo of New Zealand's glaciers only extend for a limited time period and are not spatially representative of the full extent of a glacier. An alternative approach, using satellite remote sensing, has the potential to resolve the spatial and temporal variability of albedo, however, satellite remote sensing techniques have not yet been applied to New Zealand glaciers for this purpose. To address this, imagery acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor is used to resolve the spatial and temporal variability of the albedo of Brewster glacier, Southern Alps, New Zealand. An albedo retrieval algorithm is applied to MODIS imagery captured between 1st January and 31st December, 2011. The retrieval method includes corrections for atmospheric and topographic effects, while accounting for the anisotropic reflectance of snow and ice. To assess the accuracy of the albedo retrieval algorithm, observations from an automatic weather station deployed in the ablation zone of Brewster glacier are compared to an albedo time series composed from the MODIS data. The MODIS-derived measurements are in close agreement with the ground-based albedo observations (root-mean-square deviation = 0.061), thus confirming the validity of the retrieval algorithm. These findings indicate that satellite remote sensing is a useful technique for resolving the spatial variability of albedo over the full extent of a glacier for an extended time period.

SUMMER STORMS AND HEAVY METAL VARIABILITY AT ROOSEVELT ISLAND, ANTARCTICA

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Heavy metal concentrations in snow and ice from Antarctica can be used as tracers of human pollution and give an indication of the global impact of industrial activities on the environment. Polar records of these elements have become more common over the last few decades as analytical technology and clean handling techniques have improved our ability to measure concentrations into the parts per trillion and below. Roosevelt Island is located on the eastern side of the Ross Ice Shelf and is isolated from major local dust sources. From this, we infer that heavy metal concentrations are derived from transported material. Hence, the modern variablility of heavy metal elements in surface snow from Roosevelt Island relates to the atmospheric transport and deposition processes of particulates.

Snowfall samples from storms were collected from Roosevelt Island during the 2011-2012 field season. The samples span a time period of eight weeks, during which there was daily sampling of snow from pre-cleaned trays positioned upwind from Roosevelt Island camp. As storms passed over the field area the samples could include fresh snowfall, blowing snow and rime ice growth. The use of HYSPLIT to reconstruct the back trajectories of the storms recorded at Roosevelt Island will allow an investigation into the variability of heavy metal concentrations seen in the surface snow samples. This will inform a discussion comparing the influence of different storm tracks with the evolution of fresh snow to wind blown snow and rime on the concentrations of a range of transition metal elements.

SOLID LANDSCAPE MODELS IN THE TWENTY-FIRST CENTURY – A BALANCED APPROACH

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Cartography in general, and building solid landscape models in particular, requires an interdisciplinary set of skills in order to be done well. Traditional handcrafted construction methods provide quality results, but are extremely labour-intensive and therefore costly. Modern methods using digital terrain models (DTMs) and computer numerical control (CNC) milling are fast and accurate, but the finished models are visually less than optimal. Solutions are proposed using DTMs and CNC milling to create landscape models in which the initial shaping is done mechanically and the fine details are carved by hand. This 'balanced approach' to landscape modeling combines the time- and cost-advantages of modern digital technology with the quality of traditional handcrafted techniques resulting in highly accurate landscape models which still retain the artistic 'feel' of the human touch.

SIMULATION OF THE CRYSTAL GROWTH OF PLATELET SEA ICE WITH DIFFUSIVE HEAT AND MASS TRANSFER

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Antarctic coastal sea ice often grows in water that has been supercooled by interaction with an ice shelf. Ice crystals that originate in the upper ocean, rise and deposit under the sea ice cover to form a porous layer in an evolving state of consolidation. The least consolidated portion is called the sub-ice platelet layer. Congelation growth eventually causes the sub-ice platelet layer to become frozen into the sea ice cover as incorporated platelet ice. These processes are simulated in three dimensions using Voronoi dynamics to govern crystal growth kinetics. Platelet deposition, in situ growth and incorporation into the sea ice cover are integrated into the model. Heat and mass transfer are controlled by diffusion. Spatial-temporal distributions of porosity, salinity, temperature and crystallographic c-axes are extracted and compared with observations from McMurdo Sound, Antarctica. The model captures the crystallographic structure of incorporated platelet ice as well as the topology of the sub-ice platelet layer. The solid fraction of the sub-ice platelet layer is poorly con- strained in spite of its importance for biological measurements and the freeboard-thickness relationship around Antarctica. Simulations yield a solid fraction of ≈ 0.22. This is in good agreement with an earlier estimate of 0.25 ± 0.06.

SEASONAL TRENDS OF PERSISTENT ORGANIC POLLUTANTS IN A GLACIAL LAKE IN NEW ZEALAND

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Persistent organic pollutants (POPs) persist in the environment, bioaccumulate and biomagnify through food webs and are toxic to humans and wildlife. In addition, POPs can undergo long-range atmospheric transport to remote ecosystems far away from their original source areas and tend to accumulate in cyrospheric compartments, such as snow and glacial ice. Previous research has shown that melting glaciers are a secondary source of POPs to the surrounding environment[1, 2]. As glacial melt is predicted to accelerate over the next several decades[3], it is important that the fate of chemicals released from melting glaciers be investigated.

In this study, we are investigating POPs in Lake Brewster, which is the terminal lake of Brewster Glacier and is located west of the main divide in the Southern Alps of New Zealand. This study includes five sampling trips between March 2014 and March 2015 to evaluate seasonal trends in POPs concentrations in air, glacial melt water, stream water, lake water and lake sediment. The target analyte list includes eleven current-use pesticides, twenty-six historic-use pesticides, forty-two polychlorinated biphenyls, and fourteen polybrominated diphenyl ethers. Analytes are being extracted from sampling matrices with pressurized liquid extraction and quantified by gas chromatography with mass selective detection. A multi-compartment chemical fate model consisting of air, water and sediment compartments was developed. The measured concentrations in air, glacial melt water and stream water are being used as inputs to the model; the measured concentrations in lake water and sediment are being used for independent model validation. The model is being run for a selection of the ten most commonly detected POPs using their measured input concentrations. In addition, the effects of predicted future air temperature, precipitation and glacial/stream runoff are being investigated.

The input concentrations of all chemicals are set to 3 pg/m^3 in air, 10 pg/L in glacial melt water and 1 pg/L in stream water. Initial model results show high concentrations in the lake during summer and low concentrations during winter, followed by a peak during the melting period of the ice cover. This trend is caused by seasonal trends in air temperature, glacial melt and stream water, wet deposition and temporary storage in the ice cover. An increase in air temperature between 0.7 and 1.0 degrees, which has been predicted for New Zealand's west coast over the next 30 years[4], induces a decrease in concentration in water for hydrophilic chemicals (log K_{AW} < -5, log K_{OW} <5). In contrast, there are no indications for effects for less hydrophilic chemicals.

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UPDATE ON NIWA SNOW AND ICE NETWORK AND SPICE EXPERIMENT

Zammit, C. Harper, A, Rutherford, J, Willsman, A, Mc Dermott, H., Newland, R, Hay, R.

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Monitoring plays a pivotal role in determining sustainable strategy for efficient overall management of the water resource. Though periodic monitoring provides some information, only long-term monitoring can provide data sufficient in quantity and quality to determine trends and develop predictive models. These can support informed decisions about sustainable and efficient use of water resources in New Zealand. However the development of such strategies is underpinned by our understanding and our ability to measure all inputs in headwaters catchments, where most of the precipitation is falling.

Historically New Zealand has had little to no formal high elevation monitoring stations for all climate and snow related parameters. This leads to sparse and incomplete archived datasets. Due to the importance of these catchments to the New Zealand economy (eg irrigation, hydro-electricity generation, tourism) NIWA has developed a climate-snow and ice monitoring network (SIN) since 2006. This network extends existing monitoring by Meridian Energy. In 2013 the network comprises 13 stations located at elevation above 700masl.

As part of the WMO Solid Precipitation Intercomparison Experiment (SPICE), NIWA is carrying out an intercomparison of precipitation data over the period 2013-2015 at Mueller Hut. The site was commissioned on 11 July 2013 and comprises two Geonor weighing bucket raingauges, one shielded and the other un-shielded, in association with a conventional tipping bucket raingauge and conventional climate measurements (temperature, wind, solar radiation, and relative humidity).

The presentation aims to outline the state of the current monitoring network, and present preliminary results obtained part of SPICE experiment over the period July 2013-January 2014.

TOWARDS A COUPLED WEATHER-SNOW COVER FORECASTING SYSTEM FOR THE NEW ZEALAND SOUTHERN ALPS

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The Southern Alps are located in a maritime climate zone and can experience high precipitation amounts and strong winds causing heavy winter storms with exceptional deposition. In addition, frequent rain-on-snow events can cause widespread avalanching making hazards warning a challenging task. Avalanche warning requires a) knowledge of the state of the snow cover and b) an accurate weather forecast. Obtaining snow profiles or conducting stability tests to assess the snow pack is time consuming and often not possible/practical. Additionally, weather forecasting, particularly for snow precipitation in complex alpine terrain is a challenging task due to perturbations introduced by topography. This project will ultimately provide decision support for avalanche forecasters by coupling a snow cover model (SNOWPACK) with a numerical weather prediction (NWP) model. While SNOWPACK is recognized to be a reliable snow cover model, the biggest challenge proves to be the correct simulation of the freezing line with NWP models since it depends on proper specification of the microphysical schemes and is also sensitive to the correct placement and propagation of the low-pressure center by the model. The open-source Advanced Regional Prediction System (ARPS) is well suited for small-scale (sub-kilometer) weather dynamics and was used in this study. NWP-modeling was performed for one case study with a horizontal resolution down to 1 km. We showcase model validation metrics using a variety of initialization techniques based on assimilation of Global Forecasting System (GFS) and Re-analysis (FNL) into the ARPS simulations.

Snow and Ice Research Group

Public Talks
Unwin Lodge, Aoraki Mt Cook
Thursday July 3rd, 2014
7:30 pm – 8:30 pm

WHAT'S HAPPENING TO OUR GLACIERS?
Brian Anderson
Antarctic Research Centre, Victoria University of Wellington

AORAKI2013: THE SURVEY OF AORAKI/MT COOK
Pascal Sirguey
National School of Surveying, University of Otago

AORAKI ADVENTURES
Jane Morris
Alpine Guides - Aoraki Mt Cook

NIWA Taihoro Nukurangi
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI VICTORIA UNIVERSITY OF WELLINGTON
meridian

AORAKI2013: THE SURVEY OF AORAKI/MT COOK

Sirguey, P.[1]

[1]National School of Surveying, University of Otago, Dunedin, New Zealand

In 1882, Rev. W. S. Green and his climbing party were the first to come near the summit of Aoraki/Mt Cook, the highest peak of New Zealand. Based on a barometric measurement taken just before being forced by the weather to turn back, Green estimated that they had reached 3,755 m (12,319 feet). This was only 9 m (30 feet) lower than the summit height of 3764 m established the previous year by surveyor George J. Roberts. This remained the official height of Aoraki/Mt Cook until 14 December 1991, when a massive rock avalanche roared down the East Face. Short after the event, the Department of Survey & Land Information (now LINZ) reassessed the height of the summit by using photogrammetry on the basis of aerial stereo photos captured shortly after the event. A new official height of 3754 m was estimated and new topographic contours were derived for the affected area.

As an outcome of recent photogrammetric processing of a aerial photographs captured in February 2008, it was observed that the height of the highest point of New Zealand had changed substantially. This provided the rationale and motivation to conduct a new survey of New Zealand's highest mountain, as well as an opportunity to combine survey techniques such as photogrammetry and GPS to respect the tapu status of Aoraki.

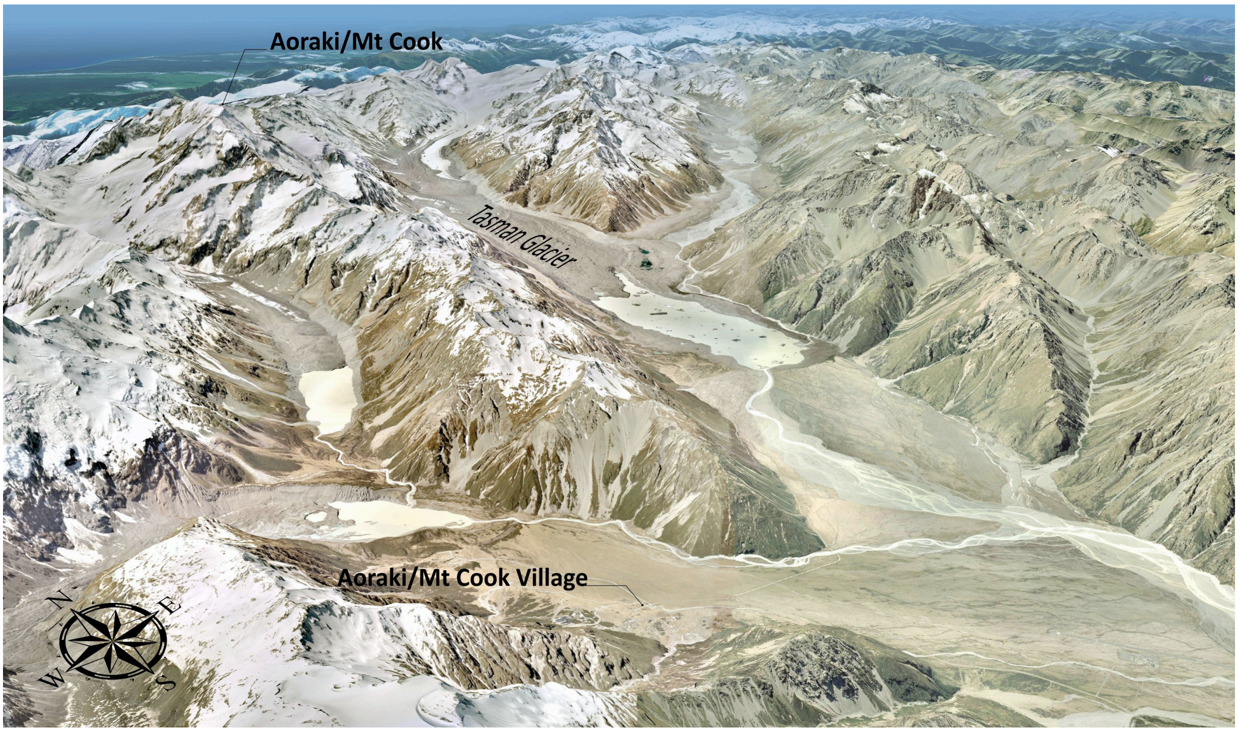
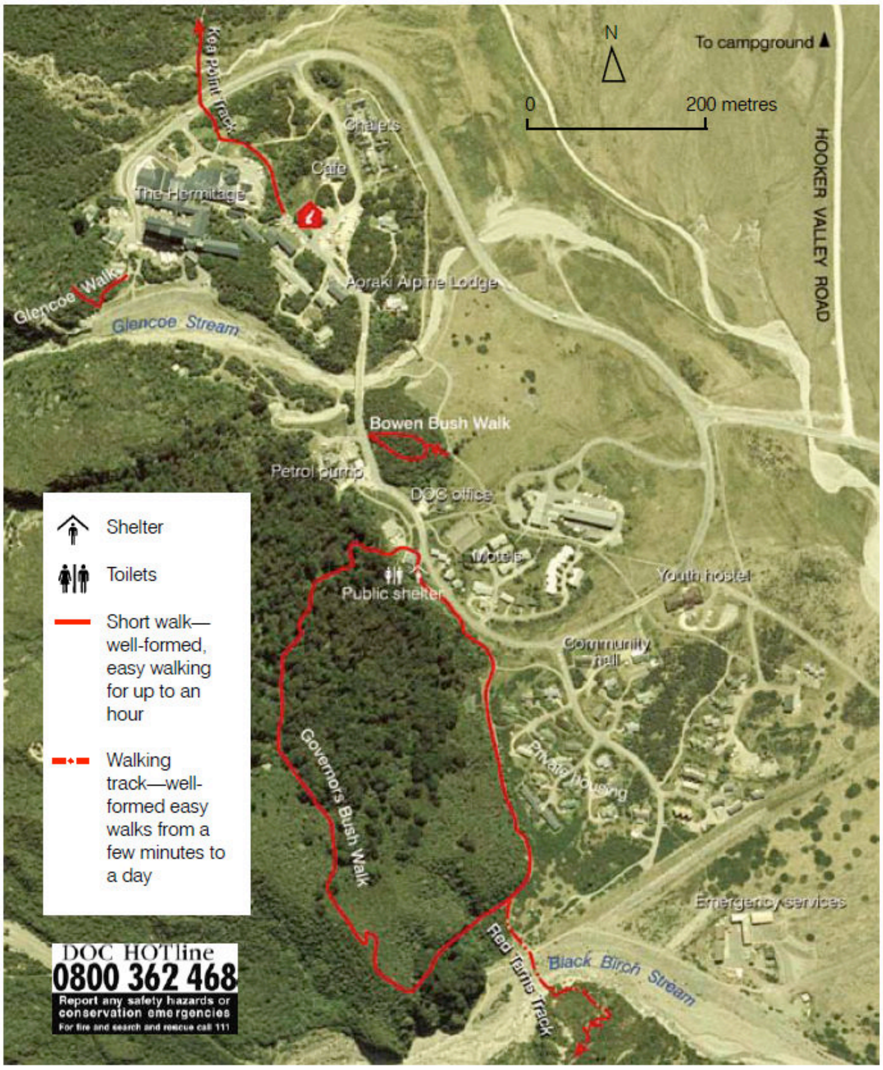


Figure 2. Aoraki Mt Cook, February 2008.

SIRG 2014 Aoraki Mt Cook - Excursion Options (With thanks to Andrea Tuohy!)

Local Village Walks:

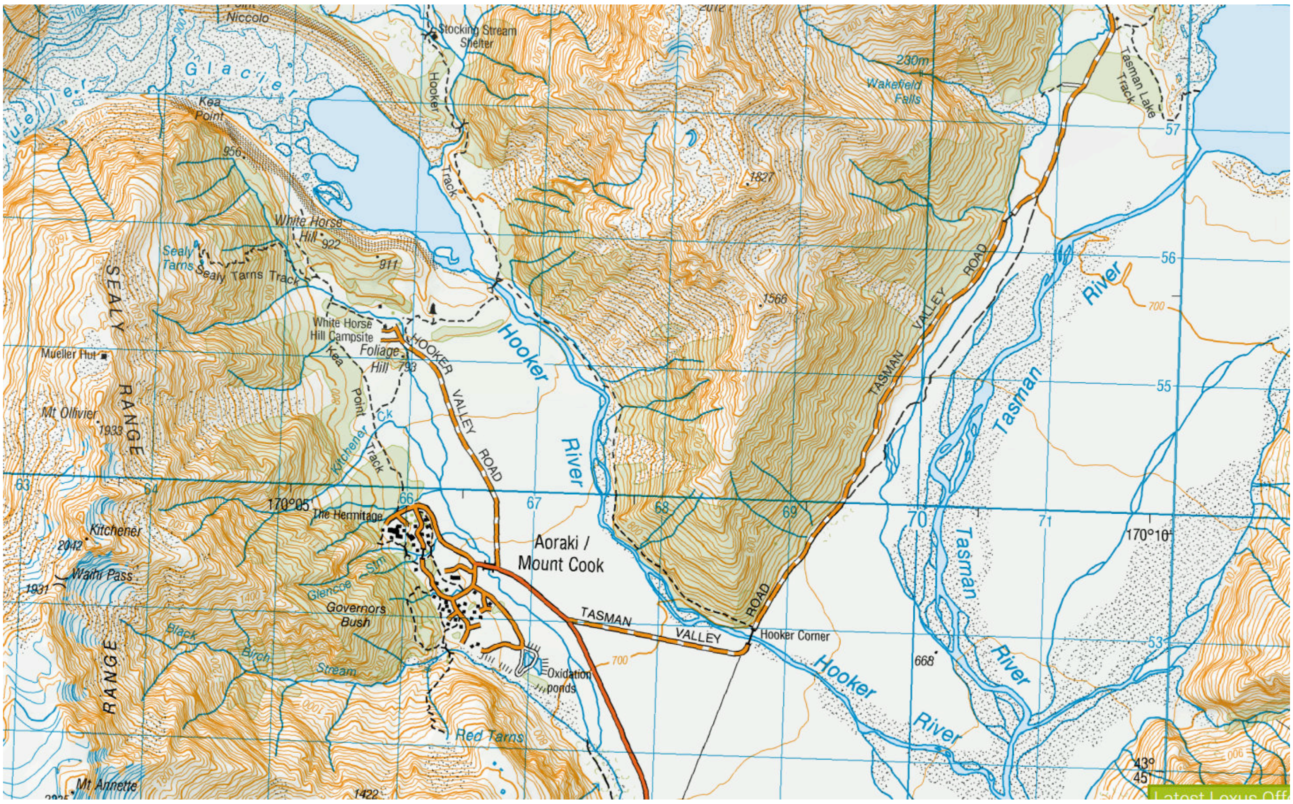


Govenors Bush Walk – 45min return.
Starts at the public shelter opposite the DOC field office in the village. A bush track climbs to a lookout/viewpoint, then loops around back to the shelter.

Kea Point Walk – 1hr return from the campground/2hr return from the village (Hermitage lawn). A relatively flat track that crosses sub-alpine grass and scrub to a viewing deck over the lower Mueller Glacier.

Red Tarns Track – 2hr return
Start at the public shelter in the village and follow the path to Black Birch Stream. Cross a bridge, then the track climbs quite steeply up to the Red Tarns. A bit of a puffer, but well worth it to see the tarns and the views.

Hooker Valley Track
Several options for track length (as you go there and back on the same track/no loops). Track begins from Whitehorse Hill campground.
Times: 1st swingbridge – 1hr return, 2nd swingbridge – 2hr return, Stocking Stream shelter – 3hr return, Hooker Lake – 4hr return
The Hooker Valley track is the classic walk in Mt Cook Village, the track is relatively flat and passes through native alpine herbfields. The swingbridges are particularly scenic, and the shelter provides a good snack stop. Great views up the Hooker and the Mueller valleys.



Longer Tramps/Climbs

Sealy Tarns Track – 3-4hr return
Begin from Whitehorse Hill Campground and branch off the Kea Point track up the Sealy Tarns/Mueller Hut track. The track climbs fairly steeply, but gets you higher than the Red Tarns. There may be quite a lot of snow in July. More adventurous people with mountaineering equipment (ice axes/crampons) can continue up this track (which is marked by warratahs with orange triangles towards the top) to Mueller Hut.

Ball Flat Track – about 3hrs one way/6hrs return
This is the only track up the side of the Lower Tasman Valley. Starts at the Blue Lakes Carpark at the end of the Tasman Valley Road, and follows a 4x4 track for about 5km along the top of the moraine wall. The track continues for another ~3km as a walking track past the end of the 4x4 road to Ball Shelter which is close to where the Ball Glacier meets the Tasman. Nice views towards the Upper Tasman. There is a mostly-marked track from near Ball Shelter (it is the end of the Ball Pass Route) that climbs up to the spur, and will allow you to get fantastic views of the Caroline Face of Mt Cook – as long as there isn't too much snow on the route and the weather is fine. **Note:** Be very careful about approaching the edge of the moraine wall anywhere along the route. The edge is very unstable, and has been collapsing regularly.

Wet Weather Options

Mt Cook Visitor Centre – Open all year round, refurbished about 5 years ago, and has won awards for its interior architecture. Free entry with lots of interesting informative exhibits, and artwork displays. Well worth a visit.

The Sir Edmond Hillary Alpine Centre at The Hermitage Hotel – A cross between a museum and a theatre, the Alpine Centre focusses on the history of the Mt Cook area. It also has a Digital Dome Planetarium and several documentary movies. Outside are telescopes for those wanting to star-gaze on clear nights. The Alpine Centre is open from 8am to 7pm in winter, and entry cost is $20.

Maybe?
Mt John Observatory – Just up the hill from Tekapo is the Mt John Observatory, which is operated by the University of Canterbury. On a clear day, the top of the hill provides a panoramic view of the Mackenzie Basin and glacial landforms.
((**This would be dependent on some people having cars and being willing to drive a group over to Tekapo. If this is potentially an option I can ask some people about organising a tour)).