Proceedings of the 2005 NZ-INTIMATE Meeting, GNS-Rafter Laboratory, Wellington: July 4-5, 2005

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July 2005

by B.V. Alloway and J. Shulmeister (editors)

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For further information and details, go to the New Zealand paleoclimate research website at: www.paleoclimate.org.nz

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ABSTRACT

The 2004 NZ-INTIMATE Meeting[1] was important turning point for the NZ-paleoclimate research community in that it galvanised the community to work towards a common theme of unravelling climate over the last 30,000 years. At the 2004 Meeting there was unanimous agreement that as outcomes of the NZ-INTIMATE initiative **TWO POSTERS** should be produced for both the NZ and international INTIMATE communities. **Poster-1** originally intended to deal with continuous proxy records spanning 30 ka to late Holocene (pre-Polynesian arrival) and **Poster-2** is intended to develop an event stratigraphy for NZ based on the continuous high resolution proxy NZ records presented in Poster-1.

Poster-1 was completed in March, 2005 and was entitled: "*Towards a climate event stratigraphy for New Zealand over the past 30,000 years*." This poster (with Science Report)[2] was circulated to all NZ-INTIMATE members. Now that Poster-1 has now been completed - efforts can now focus on the production of Poster-2 as well the production of an international review paper that outlines the contents of Poster-1.

This 2005 NZ-INTIMATE workshop aims to continue on with the themes and objectives as collectively agreed upon at the 2004 Meeting. Now that various records have been assembled and placed on the same time-scale - various terrestrial and marine records will be discussed and prioritised in order to establish a climate event stratigraphy for New Zealand over the last 30,000 years. This outcome will assist in the correlation of New Zealand records with those from the wider Australasian region and elsewhere. Seventeen papers will be presented at the 2005 Meeting that describe the very latest NZ INTIMATE-related research. There will also be an opportunity to collectively discuss key issues that affect high resolution correlations between key records (i.e. tephra ages) as well as highlight gaps in our records and deficiencies in our understanding so that we can target both a limited number of new records to develop and to re-examine some existing key records.

The ultimate goal is the establishment of an Australasian-INTIMATE climate event stratigraphy by the NZ and Australian paleoclimate research communities for presentation at the 2007 INQUA Cairns Symposium.

KEYWORDS

Andisols, Antarctic Cold Reversal, Auckland maars, carbon isotopes, Campbell Is., climate events, fluvial aggradation, glaciers, Holocene, INTIMATE, ice-core records, interglacial, Kaipo, Last Glacial Maximum, last deglaciation, late-glacial, loess, marine core, MD97-2121, New Zealand, Okarito, Otamangakau, oxygen isotopes, paleoclimate, precipitation, pollen, Quaternary, radiolarian, Rakaia, sea-surface temperature, Southern Alps, speleothems, temperature, tephra, Wairarapa, Younger Dryas.

INTRODUCTION

Objectives

- Identify and prioritise New Zealand onshore and offshore reference records for OIS 2 and 2/1 transition
- Promote ways to improve procedures for establishing the precise ages of, and effecting high resolution correlations between, these key NZ onshore and offshore reference records.

Background

The 2004 NZ-INTIMATE Meeting[1] was important turning point for the NZ-paleoclimate research community in that it galvanised the community to work towards a common theme of unravelling climate over the last 30,000 years. At the 2004 Meeting there was unanimous agreement that as outcomes of the NZ-INTIMATE initiative **TWO POSTERS** should be produced for both the NZ and international INTIMATE communities. **Poster-1** originally intended to deal with continuous proxy records spanning 30 ka to late Holocene (pre-Polynesian arrival) and **Poster-2** is intended to develop an event stratigraphy for NZ based on the continuous high resolution proxy NZ records presented in Poster-1.

Poster-1 was completed in March, 2005 and was entitled: *"Towards a climate event stratigraphy for new Zealand over the past 30,000 years*." This poster (with Science Report)[2] was circulated to all NZ-INTIMATE members. Now that Poster-1 has now been completed - efforts can now focus on the production of Poster-2. Other outcomes of the 2004 meeting include: the construction of a NZ-Paleoclimate website (www.paleoclimate.org.nz) and nz-paleoclimate community e-discussion group in a protected spam-free environment (http://groups.yahoo.com/group/nz-paleoclimate-community).

The 2005 NZ-INTIMATE workshop aims to continue on with the themes and objectives of the 2004 Meeting. Now that various records have been assembled and placed on the same time-scale - its 'time' for us to discuss the various records we have, prioritise them, and decide which of the records should become our NZ reference sections. There is opportunity at the workshop to discuss issues that affect high resolution correlations between key records (i.e. tephra ages). This workshop can also be a forum to promote ongoing or new INTIMATE-related research. The planned production of a paper outlining the contents of Poster-1 will also be discussed. JQS is suggested since this journal already has strong connections with the Nth Atlantic INTIMATE group. Authorship should also be modelled on the Nth Atlantic group papers where contributing authors are listed at the start of the paper followed by mention of the "INTIMATE group". We can discuss clarify contributions and authorship details relating to this review paper at the 2005 meeting.

WORKSHOP CONTRIBUTIONS (in alphabetical order)

PROGRAMME

Monday 4th, July
(All presentations c.15 minutes duration followed by 5 minutes discussion)

09.00-09.30 am	**NZ-INTIMATE Objectives and Overview** Jamie Shulmeister & Brent Alloway	

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09.50-10.10 am	**OCEAN CHANGE OFF NEW ZEALAND DURING ANTARCTIC COLD REVERSAL - YOUNGER DRYAS TIME** Lionel Carter and Barbara Manighetti	10

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10.30-10.50 am	**PALAEOCLIMATIC EVENTS AND CYCLES DETERMINED FROM LATE PLEISTOCENE TO HOLOCENE SPELEOTHEM ^{18}O AND ^{13}C RECORDS FROM CENTRAL NEW ZEALAND** Paul W.Williams, Darren N.T. King, H. Neil, and Jian-xin Zhao	11
10.50-11.10 am	**TIMING OF LATE-GLACIAL CLIMATE EVENTS AT KAIPO BOG** David J. Lowe, Rewi M. Newnham, and Irka Hajdas	12
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2.00-2.20 pm	**IMPROVING TEPHRA ISOCHRONS FOR NZ-INTIMATE** David J. Lowe, Irka Hajdas, Rewi M. Newnham, Brent V. Alloway, and Alan G. Hogg	18
2.20-2.40 pm	**AUCKLAND MAAR LAKE RECORDS: TOWARDS A CLIMATE EVENT STRATIGRAPHY FOR NEW ZEALAND FROM 30-0 KA** Paul Augustinus, James Shulmeister, Phil Shane, Rewi Newnham, and Brent Alloway	19

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3.00-4.30 pm	**DAY-1 DISCUSSION**

Tuesday 5th, July

(All presentations c.15 minutes duration followed by 5 minutes discussion)

10.50-11.10 am	**RADIOLARIAN-BASED ESTIMATES OF SEA-SURFACE TEMPERATURE VARIATION THROUGH THE LAST DEGLACIATION: IMAGES CORE MD97-2121, OFFSHORE WAIRARAPA** Chris Hollis, Vanessa Lüer , George Scott, Helen Neil and Barbara Manighetti	25
11.10 – 11.30 am	**SHALLOW OCEANIC RECORDS OF PLANKTIC FORAMINIFERAL & SEA-SURFACE TEMPERATURE VARIABILITY SPANNING OIS 12-1: A CONTEXT FOR UNDERSTANDING NEW ZEALAND LATE QUATERNARY CLIMATE** Martin P. Crundwell, George H. Scott, Tim R. Naish and Helen L. Neil	27
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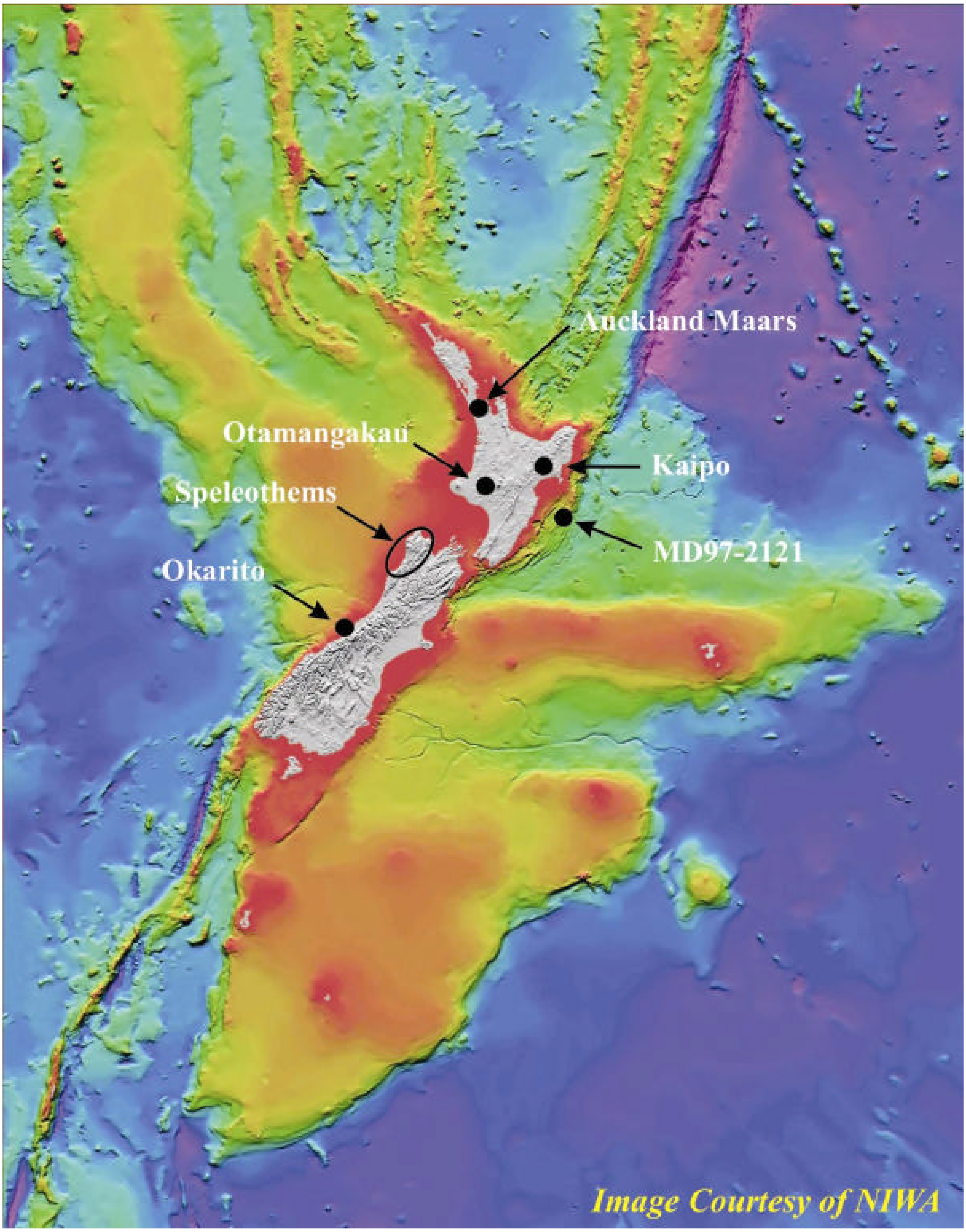
12.00-1.00 pm *LUNCH - IRL Café*

1.00 – 3.00 pm	**SUMMARY/CONCLUSIONS**	

MEETING ABSTRACTS (in order of presentation)



ANTARCTIC / GREENLAND ICE CORE RECORDS

Tim R. Naish [1, 2] and Nancy A.N. Bertler [2]

[1] Institute of Geological and Nuclear Sciences (GNS), Lower Hutt, NZ
[2] Antarctic Research Centre, Victoria University, PO Box 600, Wellington, NZ

"Ice Cores provide the most direct and highly resolved records of (especially) atmospheric parameters for the last 1,000,000 years" (EPICA Community Members, 2004). However, ice core records vary significantly in resolution, dating uncertainty and their spatial climatic representation depending on their location and glaciological characteristics, such as average annual accumulation and temperature. In Greenland two ice cores – GISP II and GRIP – provide exceptionally well dated, high resolution reference records. The two data series are extremely similar apart from the bottom part of the cores (~3100 m). The last 30,000 yr are contained in the upper ~2000 m with an age uncertainty of 2%. Either core is therefore suitable as northern hemispheric reference record.

In Antarctica the records show larger differences. While e.g. Vostok, Taylor Dome, and Siple Dome show large age uncertainties due to their low accumulation rates (Vostok ~3 cm ice equivalent per year), Byrd and especially Law Dome records have well constraint age models due to higher accumulation rates (Law Dome ~70 cm ice equivalent per year). However, the Law Dome ice core is only 1200 m deep. While the last ~7000 yr are contained in the upper ~1010 m, the remaining 80,000 yr are contained in the lower 100 m. Therefore the age uncertainty associated with the depths around the last deglaciation or the ACR (Antarctic Cold Reversal) suffers from similar error bars as other Antarctic ice core records. The EPICA Dome C record has a significantly lower annual accumulation rate (~3 cm) than Law Dome, but is much deeper (3233 m) and was measured with higher resolution than e.g. Vostok. While the ACR is found in just 3 m of the Law Dome record, it reaches across 30 m in the EPICA Dome C record. Overall, the last 27,000 yr are contained in the upper 590 m of the EPICA Dome C core and has a sampling resolution of 20 years through the Holocene and 50 yr through the last glacial. The associated age uncertainty is estimated to 10 yr for 0 to 700 yr BP, up to 200 yr back to 10,000 yr BP, and up to 2,000 yr back to 41,000 yr BP. Overall, EPICA Dome C contains the record of the last eight glacial cycles. The second, deep (2882 m) EPICA core – EPICA DML (Dronning Maud Land) is from a higher accumulation sites (~6 cm ice equivalent per year) and is expected to provide a significantly higher resolution record for the last ~160,000 yr than EPICA Dome C. However, the core is still being drilled and it will take some time before the data will be available.

In the meantime, we suggest the NZ INTIMATE project utilise GISP II (or GRIP) record as the northern hemisphere reference record and EPICA Dome C as the southern hemisphere record until EPICA MDL data are available. Law Dome should also be included as a Holocene reference record, where it offers the highest resolution and most precisely dated record in Antarctica and possibly the Southern Hemisphere.

References:

EPICA Community Members. 2004. Eight glacial cycles from an Antarctic ice core. *Nature*, **429**, 623-628.

OCEAN CHANGE OFF NEW ZEALAND DURING ANTARCTIC COLD REVERSAL -YOUNGER DRYAS TIME

Lionel Carter [1] and Barbara Manighetti [1*]

[1] National Institute of Water and Atmospheric Research (NIWA), PO Box 14-901, Wellington, NZ
[1*] formerly NIWA; now Victoria University of Wellington, NZ

Stable isotopes from 1 benthic and 3 planktic species of foraminifera preserved in the giant piston core, MD97 2121, from 2314 m deep off Hawke Bay, provide a record of ocean change during the last deglacial period. Time control from 9 tephra- and 23 AMS-based ages, allow resolution of surface and deep ocean change at decadal to centennial scales. This permits a realistic comparison with ice core records from Antarctica [EPICA] and Greenland [GISP 2], and with local palaeoclimate records compiled by the New Zealand INTIMATE Group.

Following the last glacial maximum, the surface ocean began to warm ~20 ka, in phase with the Antarctic ice record. The deep ocean, however, began to warm at 18 ka suggesting that polar bottom water formation was little affected by any ice retreat. Warming continued throughout the water column with a pronounced peak in uppermost surface waters at ~15.5 ka, as recorded by *Globigerina ruber*. This marked an initial incursion of subtropical waters, possibly associated with a warming phase responsible for Meltwater Pulse 1A from Antarctica. Warming of surface and bottom waters reduced at 14.1 ka with the start of the Antarctic Cold Reversal [ACR]. $\delta^{18}O$ profiles of shallow and deep dwelling planktonic foraminifers [0 - 400 m] merged suggesting strong mixing of the upper ocean; a process consistent with increased windiness of cool periods. Elsewhere in New Zealand, the ACR was marked by [1] a prolonged still stand of sea level [–56 m] about ~12.5 ka, [2] an increase in grass and shrub lands, and [3] an advance of west coast, South Island glaciers. Collectively, these events point to a phase of strong El Niño events with marked W to SW winds, increased precipitation on western coasts, dry conditions in the east, and reduced sea surface temperatures caused wind-induced upwelling.

Warming of bottom waters resumed with the end of the ACR at 12.5 ka. In contrast, surface waters remained cool and well mixed until 11.5 ka. Rather than invoking a *direct* link with the Younger Dryas [12.8-11.5 ka], the surface waters may have been responding to a continuation of the vigorous El Niño phase. That this phase was *indirectly* related to the Y-D is not discounted. From 11.5 – 5 ka, increased warming of the water column resumed, accompanied by the formation of well stratified surface waters.

PALAEOCLIMATIC EVENTS AND CYCLES DETERMINED FROM LATE PLEISTOCENE TO HOLOCENE SPELEOTHEM ^{18}O AND ^{13}C RECORDS FROM CENTRAL NEW ZEALAND.

Paul W.Williams [1], Darren N.T. King [2], H. Neil [3], and Jian-xin Zhao [4]

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[2] National Institute of Water & Atmospheric Research (NIWA), PB 109695, Auckland, NZ
[3] NIWA, PB 14901, Wellington, NZ
[4] Dept. of Earth Sciences, University of Queensland, Brisbane, QLD 4072, Australia

Two composite records of δ^{18}O and δ^{13}C are produced from 9 stalagmites from northwest South Island (NWSI) and from 6 stalagmites from Waitomo. The NWSI record extends to 25.400 ka and the Waitomo record to 14.317 ka BP. Each series has a variable data density, but average resolutions of 41 and 37 years respectively. The NWSI chronology is underpinned by 51 TIMS uranium series ages and the Waitomo chronology by 24 TIMS ages. Both records are adjusted for the ice volume effect. Speleothem calcite δ^{18}O values show a positive relationship to temperature, with precipitation having a minor negative influence. Delta ^{13}C responds negatively to water surplus, increases in biological activity, and atmospheric CO_2 concentration. The NWSI δ^{18}O record shows late-glacial climatic amelioration commencing ~18 ka and culminating at 14.8 ka. Following this a negative excursion took place centred on 12.69 ka which, if defined between the mid-points of falling and rising limbs, occurred from 13.21-11.69 ka. This overlapped the ACR; spanned the Kaipo cold event and the YD. The Waitomo series also shows the reversal, but less strongly. The Holocene δ^{18}O record commences with a culmination (climatic optimum) at Waitomo from 11.3-10.6 ka and in NWSI from 11.7-10.7 ka. Waitomo has an oscillating negative trend until 3 ka, whereas NWSI shows variability about a roughly horizontal trend. In the late Holocene both have positive δ^{18}O excursions; at 1-0.5 ka (Waitomo) and 0.7 -0.6 ka (NWSI).

In NWSI δ^{13}C values were high from 23.2–17.9 ka and then abruptly decreased to 17.2 ka at the end of the Last Glaciation. A slower decline continued to 10.97 ka (10.9 ka at Waitomo). Both series show a gradually rising trend throughout the Holocene. Seven climatic events can be identified: (1) LGM; (2) late-glacial warming ~18.2-14.77 ka; (3) late-glacial optimum 14.77-13.21 ka; (4) late-glacial reversal 13.21-11.69 ka; (5) early Holocene optimum 11.1-10.8 ka; (6) mid-Holocene variability; and (7) late Holocene warm interval 1-0.5 ka.

Statistically significant cyclicity at decadal-to-century and millennial scales is a characteristic of all records. In the NWSI δ^{18}O record for 25.4 ka and 15 ka, three periodicities are prominent: 3470-3420, 155, and 100-95 years, while over the last 6 ka the last two appear as 145 and 90 years. Spectral analysis of the noisier δ^{13}C series confirms these periodicities, with an additional 70 year peak shown in the 6 ka period. In the shorter Waitomo δ^{18}O record, spectral variance over the last 15 ka shows strong periodicities at 3816 and 80 years, as well as a significant 65 year peak in the last 6 ka. These frequencies are exhibited in the corresponding δ^{13}C time series.

TIMING OF LATE-GLACIAL CLIMATE EVENTS AT KAIPO BOG

David J. Lowe [1], Rewi M. Newnham [2], and Irka Hajdas [3]

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[2] School of Geography, University of Plymouth, Plymouth, PL4 8AA, UK
[3] ETH/PSI AMS ^{14}C Laboratory Hönggerberg, HPK H27, 8093 Zurich, Switzerland

The start of the late-glacial climate reversal at Kaipo bog, evident as a decline in tree/shrub pollen relative to grass pollen and in carbon content, was dated in our initial study (2000) at *c*. 13,600 cal yr BP, ~200 years after deposition of Waiohau Tephra (WT). The end of cooling, marked by a resumption of peat accumulation and sustained increase in the tree/shrub pollen relative to grass ratio, was dated at *c*. 12,600 cal yr BP. The cooling seemed to overlap the later part of the ACR and the early part of the YD chron. Subsequently, pollen records from NZ (Kettlehole, Otamangakau) and Chile (Huelmo) and Argentina (Mascardi) have shown a similar 'early' reversal. The original Kaipo chronology comprised 34 tephrochronological (n = 14) and radiometric (n = 20) ages spanning the interval from Rerewhakaaitu T. (14,700 ^{14}C yr BP) to Waimihia T. (3230 ^{14}C yr BP). We have added 20 AMS-derived ^{14}C ages from samples between Rerewhakaaitu and Opepe T. (9050 ^{14}C yr BP), hence providing a fine-resolution chronology of 51 independently dated points from 14,700 to 3000 ^{14}C yr BP. The Holocene sediments were dated to provide a longer overlap with the more robust tree-ring part of the calibration curve. After correction for interhemispheric offset, ages were together wiggle-match fitted against INTCAL04 via the OxCal (version 3.10) sequence calibration that incorporates known parameters into the fitting procedure. Several reversals in the conventional ^{14}C ages are not apparent in the calibrated ages obtained via OxCal, suggesting that the 'reversals' may reflect variations in atmospheric ^{14}C content instead. The model indicated low probabilities of fit for three ages, described as outliers, including for WT. However, removing these outliers had little effect on the whole chronology because they fell within dating errors in the sequence. The close agreement between ages of the independently-dated tephra layers (except WT) and the AMS and radiometric dates shows that the sequence is free of reservoir effects and reflects atmospheric ^{14}C content during the late-glacial and part Holocene. Kaipo cooling began 13,820–13,590 cal yr BP and ended 12,780–12,390 cal yr BP, i.e. between 13,800 and 12,400 cal yr BP (2σ range), in agreement with our previous estimates. The timing of the cool reversal matches the coolest phase of the ACR in Byrd, Law Dome and EPICA ice cores, but the onset at Kaipo seems to postdate the onset of the ACR (*c*. 14,500 cal yr BP) by *c*. 700 years. The start of cooling corresponds with that recorded from speleothems in the South Island at *c*. 13,600 yr BP although the speleothem records indicate that cooling persisted to *c*. 11,600 cal yr BP. At Kaipo, conditions remained cool but warming until *c*. 11,900 cal yr BP (marked by Konini Tephra). This apparent difference in timing for the end of cooling may reflect spatial differences in climate response, variable sensitivity to climate response between the different proxies, or possibly simply that the arbitrary boundaries were drawn using different criteria. The end of the reversal and resumption of warming at Kaipo coincides approximately with the onset of YD cooling in the Northern Hemisphere.

OTAMANGAKAU (TONGARIRO), DURHAM RD (TARANAKI) AND THE CLIMATIC INTERPRETATION OF THE LATE-GLACIAL CENTRAL NORTH ISLAND VEGETATION RECORD

Matt S. McGlone [1], Chris S. M. Turney [2] and Janet M. Wilmshurst [1]

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[2] GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia.

Otamangakau (600 m) and Durham Rd (260 m) are two well-dated central North Island pollen sequences spanning the late-glacial. As forest was not excluded by LGM climates from the central North Island, merely much reduced in abundance, it should be expected that the reafforestation sequence reflected, with only small delays relating to spread and population growth, the amelioration of climates between 18 000 and 11 500 cal BP.

The forest sequence at both sites begins with a conifer scrub-grassland dominated by *Halocarpus* and *Phyllocladus*; followed by matai-cedar forest; and then by rimu/tree fern forest. Climates were suitable for montane forest by 18 000 cal BP. Mean annual temperatures (MATs) rose between 18 000 and 11 500 cal BP but, on the basis of the vegetation sequence alone, we can only give broad limits. MAT was within 3°C of the present by 17 000 cal BP, and within 2°C by 14 000 cal BP. Rising winter temperatures rather than summer temperatures exerted most control over vegetation changes. Both sites indicate a slow-down in the rate of change, or a reversal between 15 000 and 13 500 cal BP. After this, frost- and drought-sensitive warm-temperate elements enter the forests and are dominant by 12 000 cal BP. The Younger Dryas Chronozone is thus represented by climate warming.

Volcanic eruptions and tephra fall can mimic or intensify the effects of adverse climate episodes through promoting secondary or primary vegetation dominated by grasses and scrub. The effects of an individual tephra fall might be prolonged during a cool period through promoting instability and reworking of soils. Tephra fall can also promote change from one vegetative state to another through destroying the previous vegetation. At Otamangakau, an unusually deep profile demonstrates that the late-glacial vegetation was constantly disturbed by eruptions which may have accelerated, facilitated or magnified climate-related changes. However, after c. 13 000 cal BP, rather than grasses and the cold-tolerant, slow-growing shrub *Halocarpus bidwillii* dominating after a tephra fall, fast-growing shrubs became the major successional vegetation, adding to the evidence that a cool, frost-basin environment became significantly warmer in winter.

THE OKARITO POLLEN RECORD AND CLIMATE CHANGE FOR THE INTERVAL 30 -8 KA

Chris Hendy [1], Marcus Vandergoes [2], and Rewi Newnham [3]

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[2] Climate Change Institute, 5726 Environmental Sciences Lab., University of Maine, Orono, ME 04469-5726, USA
[3] School of Geography, University of Plymouth, Plymouth PL4 8AA, UK

A pollen record from Okarito Pakihi Bog in south Westland, New Zealand spans the full last glacial-interglacial cycle and extends partly into Marine Isotope Stage (MIS) 6. For the time period of interest to INTIMATE (30 -8 ka) chronological control was obtained by AMS radiocarbon dating of organic sediments with a unique tie point provided by the ca 26.5 cal ka Kawakawa Tephra. The basin developed as a moraine-dammed proglacial lake and remained lacustrine until the early Holocene, when a peat bog developed. Survival of the basin through subsequent multiple ice advances, unusual in a glaciated landscape, was probably assisted by lateral displacement of the basin, relative to its source area, across the Alpine Fault.

There is good correspondence between inferred periods of substantial treeline depression and the record for ice advance in this region. The pollen record also shows broad consistency with the MIS record and hence with the Milankovitch orbital forcing model, but with some departures, including an early onset to the last glacial maximum (LGM). Marked warming accompanying deglaciation occurs at 17 – 18 cal ka. Several sub-Milankovitch scale events are also evident, including a mid-LGM warming and minor late-glacial reversal. Although the precise timing of these events are not well-constrained, the presence of Kawakawa Tephra and good correspondence with the glacial geomorphic record provide good opportunities for correlating the Okarito pollen record with other important climate proxy records. Additional advantages of this record include its generally high sampling resolution, with opportunities for further refinement and improved dating, and its length, which allows the INTIMATE interval to be set in context of the last two glacial-interglacial cycles.

GLACIER EXTENT IN NEW ZEALAND OVER THE PAST 30,000 YEARS

David J.A. Barrell [1], R. Patrick Suggate [2], Peter C. Almond [3], and Henrik Rother [4]

[1] Geological & Nuclear Sciences (GNS), Dunedin, NZ
[2] GNS, Lower Hutt, NZ
[3]Agriculture and Life Sciences Division, Lincoln University, Canterbury, NZ
[4] Department of Geological Sciences, University of Canterbury, Christchurch, NZ

Glaciers were widespread in the mountain regions of New Zealand during the Last Glacial Maximum (LGM), but many of these areas became ice-free during the Last Glacial-Interglacial Transition. Today, glaciers persist only in the higher parts of the Southern Alps and at a few other scattered locations (e.g. Fiordland, Mt Ruapehu).

Moraines and outwash surfaces, and associated glaciogenic deposits, provide physical evidence of glacial advances, still-stands or retreats. We collated information from the central Southern Alps, where glaciers persist to the present day, using the best radiocarbon and surface-exposure dated glacial sequences to construct a fragmentary record of glacial events for the past 30,000 years in the Southern Alps (Barrell *et al.* 2005, and references therein). The key events recorded are: (i) advance to near full-LGM extent, predating Kawakawa tephra (~26,500 cal.y.BP); (ii) unknown amount of retreat, (iii) formation of multiple moraines at or inside the full LGM extent, between ~23,500 and 19,000 cal.y.BP; (iv) rapid retreat, glacier areas reduced by between at least 60 and 100%; (v) locally extensive "late-glacial" advance in some high-altitude catchments, within the period 14,000 to 11,400 cal.y.BP, followed by unknown amount of retreat; (vi) persistent glacier presence in high-altitude catchments, with multiple advances and retreats of uncertain extent, after ~5,500 cal.y.BP; (vii) Rapid retreat since the late 19th century.

This is a sample of the evidence for the extent and timing of glacier fluctuations in New Zealand's Southern Alps in the past 30,000 years. Other information exists, and is being added to, from the Rakaia valley (e.g. Marra 2003), Northwest Nelson (e.g. Shulmeister *et al.* 2005) and Fiordland (Williams 1996, Williams & Fink, in prep), and elsewhere.

References:

Barrell DJA, Suggate RP, Almond PC, Rother H (compilers) 2005. Glacial sequences. *in* Barrell DJA, Alloway BV, Shulmeister J, Newnham RM (eds.) 2005. Towards a climate event stratigraphy for New Zealand over the past 30,000 years. GNS science report 2005/07.

Marra MJ 2003. A last interglacial beetle fauna from New Zealand. Quat.Res. 59:122-131.

Shulmeister J, Fink D, Augustinus PC 2005. A cosmogenic nuclide chronology of the last glacial transition in North-West Nelson, New Zealand - new insights in Southern Hemisphere climate forcing during the last deglaciation. EPSL: in press.

Suggate RP, Almond PC 2005. The Last Glacial Maximum (LGM) in western South Island, New Zealand: implications for the global LGM and MIS 2. QSR: in press.

Williams PW 1996. A 230 ka record of glacial and interglacial events from Aurora Cave, Fiordland, New Zealand. NZJGG 39: 225-241.

Williams & Fink: in prep. Cosmogenic dating of moraines at Te Anau, New Zealand.

EXTRACTING A CLIMATE EVENT STRATIGRAPHY FROM LOESS FOR THE 0-30,000 YEAR PERIOD: A SOUTH ISLAND PERSPECTIVE

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Conventionally, climate event records are extracted from loess by way of qualitative measures of loess accumulation rate. In loess stratigraphic sequences periods of fast accumulation correspond with the loess sheets themselves whereas periods of slow or no accumulation are represented by buried soils formed in the loess. Changes in accumulation rate are linked by inference to geomorphic responses, commonly of climatic origin, that alter loess production rate or erosion rate. For instance, loess of basal age T_1 sitting on a buried soil on a flat land surface implies loess accumulation rate increased T_1 years ago, perhaps as a response to river aggradation and a consequent increase in loess source area. Loess on a hillslope may represent the combined effects of a climatically induced decrease in soil transport rate and an increase in loess accretion rate. By contrast, a loess sitting directly on river terrace gravels with no intervening buried soil speaks only of the timing of abandonment of that surface by the river, which itself may or may not be climatically related.

The loess record on the INTIMATE poster (Litchfield et al. 2005) is constructed with this kind of interpretation in mind. Because climatic inferences based on loess are indirect, loess paleoclimate records have greatest value where the deposits can be stratigraphically related to landforms more directly linked to climate events, such as moraines or outwash fans. Loess, because of its slow accumulation, is intrinsically a deposit of stable parts of the landscape. It has the advantage potentially of recording events lost in the more dynamic fluvial or glacial systems.

Less commonly, climatic interpretations are made from the characteristics of loess itself, or from the spatial patterns of loess in the landscape. We identify climate events and present proxies of past rainfall, temperature and wind speed, derived from pedological, geochemical, and physical characterisitics, and palaeontological content of primary and redeposited loess from the west and east coasts of the South Island. These records and others like them will contribute in future to the Southern Hemisphere INTIMATE programme.

Chronology is fundamental to an event stratigraphy. A number of problems have arisen in dating loess in the South Island. Contamination by modern carbon is a serious problem for radiocarbon dating on the West Coast. Kawakawa Tephra is the only widespread tephra so far identified in the South Island in the 0-30,000 year period. Significant discrepancies between the accepted age of the tephra and luminescence ages of loess that encompasses it need to be resolved.

References:

Litchfield, N.J., et al. (compilers) 2005: Loess accumulation. *in* Barrell, D.J.A. et al. (eds.) 2005: Towards a climate event stratigraphy for New Zealand over the past 30,000 years. *Institute of Geological & Nuclear Sciences science report 2005/07*.

FLUVIAL AGGRADATION AND DEGRADATION AND LOESS ACCUMULATION FROM 30-0 KA: A NORTH ISLAND PERSPECTIVE

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A fragmentary record of fluvial aggradation and degradation (North Island) is provided by radiocarbon and OSL ages of fluvial terrace deposits in the eastern North Island. OSL ages of fluvial aggradation silt from three Hawkes Bay and Gisborne rivers confirm that river aggradation was widespread throughout the LGM. These dates are corroborated by the presence of the Kawakawa Tephra within aggradation deposits at several localities. Widespread switch to incision occurred at approximately the Last Termination, marked by the presence of the Rerewhakaaitu Tephra resting on the LGM aggradation or earliest degradation fluvial deposits north of Hawke Bay. A record of post-glacial incision has been obtained from radiocarbon dates of peats within abandoned meanders on a sequence of post-glacial degradation terraces in the Waihuka River tributary of the Waipaoa River (Gisborne Region).

Loess accumulation was most extensive during the LGM. Throughout the North Island, LGM loess contains the Kawakawa Tephra, and is correlated to the Ohakean Loess first described in the Rangitikei Valley. OSL ages for loess from the southern Wairarapa and central Hawkes Bay range from 30-11.6 ka, suggesting widespread loess deposition continued into the early post-glacial period. OSL ages for loess in the southern Wairarapa suggest localised loess deposition occurred during the early Holocene.

Fluvial and loess fragmentary records are limited by the scattered preservation of fluvial terraces and loess deposits, as well as the exposure of dateable sequences and presence of dateable material. In the North Island, the presence of tephra, (especially north and northeast of the TVZ) provides key marker horizons for correlation of fluvial terraces and loess. Terrace and loess preservation, and the number of terraces is also (at least in part) a function of tectonic uplift rate. Thus, high uplift rate areas such as the Gisborne Region provide a more expanded record of fluvial processes throughout the last 30 ka. Conversely, low uplift areas (i.e., with relatively low erosion rates) such as the Wairarapa Region, preserve a more complete record of loess accumulation.

IMPROVING TEPHRA ISOCHRONS FOR NZ-INTIMATE

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The NZ-INTIMATE project has highlighted the need for better accuracy and precision for ages associated with tephras, especially those older than 12,400 cal yr BP (e.g. Kawakawa, Te Rere, Okereka, Rerewhakaaitu) and those on or near plateaux in the ^{14}C calibration curves (e.g. Konini, Poronui, Karapiti). Previously, calendar ages were estimated by calibrating error-weighted mean ages associated with each tephra, an approach that may give flawed results. As part of a study to corroborate the timing of the late-glacial climate reversal reported for Kaipo bog we obtained a new high-resolution AMS ^{14}C chronology for the Kaipo sequence. The AMS dates and those obtained previously were wiggle-match fitted against INTCAL04 using OxCal that incorporates Bayesian statistics. This gave a continuous sequence of calendar ages with no reversals. Of the 51 age points used in the wiggle match, three were identified as outliers, one being that for Waiohau Tephra. New calendar ages were derived for late-glacial and early Holocene tephras (2σ range, cal yr BP): Rerewhakaaitu 18,250–17,200, Rotorua 15,750–15,100, Waiohau 13,800–13,470, Konini 11,940–11,500, Okupata 11,810–11,430, Karapiti 11,600–11,220, Poronui 11,270–11,110, and Opepe 10,230–9920. The Bayesian approach stems from the seminal work of Thomas Bayes (1702-1761) published in 1763. It is attractive because it allows the inclusion mathematically of stratigraphic or other data alongside chronometric data (usually ^{14}C ages) via a probability distribution, and it deals with errors and outliers in a coherent way. The work at Kaipo and elsewhere demonstrates the potential of undertaking Bayesian analysis on stratigraphic sequences of multiple dated tephra layers to ‘sharpen’ tephra isochrons to help meet NZ-INTIMATE aims. Other approaches include applying new dating methods to key marker beds such as Kawakawa Tephra, either via high-precision ^{14}C dating on appropriate material or new radiometric techniques (e.g. U-Th/He), or from the identification of such tephras in ice cores or laminated sediments (e.g. Onepoto, Pukaki maars) for which calendar-age models have been constructed. Wiggle-match dating using tree-ring calibration curves also holds potential as shown for Kaharoa Tephra. Improved ways of discriminating tephras that have ambiguous fingerprints are needed, mainly via analyses of glass or mineral phases such as biotite, hornblende, or Fe-Ti oxides where available. Recent work by Phil Shane and others has shown that some eruptives are not homogenous compositionally (e.g. Rerewhakaaitu, Rotorua, Kaharoa eruptives), but such variations in chemical characteristics of glass, once recognised, enhance the potential for correlation by increasing the fingerprinting parameters. The successful application of laser ablation ICP-MS to the analysis of single shards offers potential for distinguishing tephra beds using trace element data where major element data have been unable to separate them.

AUCKLAND MAAR LAKE RECORDS: TOWARDS A CLIMATE EVENT STRATIGRAPHY FOR NEW ZEALAND FROM 30-0 KA

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High-resolution Late Quaternary paleoclimate archives are preserved in the sedimentary records of Auckland maars. Furthermore, the presence of numerous identifiable well dated rhyolitic tephras of TVZ provenance, combined with AMS ^{14}C age, allows a detailed absolute chronostratigraphy to be developed. Onepoto and Pukaki Maars contain high-resolution sediment records and chronological control for the period from 30 ka to ca 8 ka. The early Holocene to recent component of the record is contained in Lake Pupuke, and we plan to extract long cores from the lake that should provide a high-resolution paleolimnological and regional paleoenvironmental record spanning at least the past 50 ka.
Existing work on the maar records has identified several major lines of investigation that are yielding high-resolution climate records:

1. Pollen analysis has been carried out on Onepoto and Pukaki cores spanning ca.29-8 ka and show a consistent pattern of warming starting ca 17.7 ka marked by the expansion of podocarp forest at the expense of beach forest, shrub and grassland. The Holocene record from Lake Pupuke indicates environmental stability and shows little change throughout the pre-human Holocene. Freeze-cores spanning the past ca 200 years provide a high resolution record of European impacts on the lake and catchment marked especially by the first appearance of exotic pollen and abrupt limnological changes indicated by diatom assemblages.
2. Short sections of core from Onepoto Maar have had their individual laminae counted and measured. Lamina thickness is taken as a proxy for biological productivity in the paleo-lake. Results appear to demonstrate a variable role for the El Nino Southern Oscillation and for the Inter-decadal Pacific Oscillation between the LGM and the early Holocene. These records have the potential to be reported at sub-decadal, and perhaps annual resolution.
3. A wide range of other proxies have been measured from the maar crater records such as: magnetic susceptibility, grain size, major oxide and trace element geochemistry, total organic matter, elemental C/N ratios, d^{13}C and d ^{15}N from bulk organic matter and biogenic silica. These proxies allow us to infer paleoenvironmental changes in the lakes and their catchments that suggest a climate forcing. These data need to be refined to sub-decadal, preferably annual resolution.

The Auckland maars already provide one of the key reference sections for the Australasian INTIMATE project, although considerable scope remains for further enhancement of these records.

ARE THE ANDISOLS IN TARANAKI TELLING US SOMETHING ABOUT PALEO-WIND & -PRECIPITATION CONDITIONS OVER THE LAST 30,000 YEARS ?

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Quartz in soils derived from basaltic and andesitic volcanic ash has been demonstrated to be of eolian origin. Thus, variations in the total quartz content and accumulation rate of quartz within well-dated, cover-beds deposits of non-quartzose andesitic provenance on the western North Island provides a unique proxy record of climate that has been linked with deep-sea and ice core records of atmospherically transported sediment. Aerosolic quartz flux determined by quantitative X-ray diffraction from inland and coastal Taranaki sites (Waitui and Onaero) record two peaks of elevated quartz content that are enveloped by Egmont-sourced tephra beds and the c. 26. 5 cal. ka B.P. Kawakawa Tephra sourced from Taupo Volcanic Centre. An initial quartz peak occurs at c. 27 cal. ka B.P. just prior to the deposition of Kawakawa Tephra. Another more substantial quartz peak culminates between 20 and 21 cal. ka B.P. Quartz values then rapidly decrease to c. 14.7 ka. From 14.7 ka quartz content gradually declines to present-day. No late glacial climate reversal or even Holocene variability can be observed from the quartz record. Presumably coarse (c. 10-cm) sampling may have obscured any fine-scale record over these intervals. Interestingly, both Taranaki quartz peaks appear to broadly coincide in magnitude, duration and age with herb peaks recorded from the Okarito wetland core. These similarities lend weight to the possibility of at least a two-fold subdivision of the LGM. Finer scale sampling and tighter age control of andesitic tephra inter-beds is likely to significantly improve the resolution of the Taranaki quartz record.

The Taranaki quartz peaks either relate to intensification of the wind system tracking across the region, increased sediment flux or a combination of both factors. The most likely quartz-rich dust at these times is the continental shelf of the southern North Island, then extensively exposed (to the south-west of Taranaki) by low sea level. Quartz of Australian provenance may also be represented but has yet to be proven.

In addition to quartz additions to Andisols providing a useful proxy climate record, differences in both the physical and chemical properties of Andisols have proved equally useful in determining the influence of climate on their weathering characteristics. For instance, variations in 15-bar water retention of both field moist and air dry samples have been used as a measure of the previous drying history of Andisol deposits and Al/Si ratio of allophane in volcanic soils have been related to mean annual rainfall and level of Si in soil solution. In LGM to late glacial Andic deposits low air-dried 15-bar water contents and Al/Si ratios indicate that allophane formation underwent irreversible drying during an interval of apparently low mean annual rainfall. However, consistently higher air dried 15-bar water contents and Al/Si ratios occur in early to middle Holocene Andic deposits suggest that allophane formation occurred without drying during an interval of higher mean rainfall. The Andisol record in Taranaki seems to indicate drier but not necessarily windier conditions existed during the LGM to late-glacial in contrast to wetter and perhaps as equally as windy conditions that prevailed during the Holocene.

GLACIAL SEDIMENTOLOGY AND CHRONOLOGY IN THE RAKAIA AND HOPE VALLEYS, CANTERBURY, NEW ZEALAND

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This paper summarises some recent advances in understanding the nature of glaciation in some of the valley systems in Canterbury, during the last glacial cycle. In the Hope Valley, the Glen Wye (LGM) moraines are very narrow and shallow moraines capping tens of metres of outwash gravel. In the Rakaia Valley, the Acheron, Bayfields (LGM) and Tui Creek terminal moraines are all narrow and very shallow. The moraines contain only slightly modified fluvial material and are distinguished from outwash largely on a higher matrix content which gives them a brown colour and slightly coarser clasts. Again they cap tens to a hundred metres of (glaci)fluvial outwash material. In both cases the fluviglacial outwash overlies lacustrine, fluvial or glacial materials of some antiquity and in both valleys, glacial sediments of OIS 6 age are preserved under OIS 2 deposits.

The chronology of the buried deposits is largely too old to concern the Australasian INTIMATE project. Their importance lies in the fact that they preclude significant glacial erosion of these valley reaches during the LGM. This is in stark contrast to OIS 6 advances in both the Hope and Rakaia Valleys which were thick and pervasive, scouring the valleys to at least the modern valley floor depth and emplacing tens to hundreds of metres of sub- and proglacial sediments. The presence of c. 200 ka old sediments at modern valley floor depths in both valleys, requires a tectonic justification as uplift would be expected. Of more concern here, however, is the clear implication that glaciation during OIS2 is of minor extent and comprises very thin ice in these valley reaches by comparison with earlier phases of glaciation.

We will present a conceptual model for glaciation in these valleys under small and large glacial scenarios. This model will be related a model of glacial forcing to elucidate conditions during advances in the last 30 ka.

THE LATE-GLACIAL TRANSITION AT CURRENT TREE LINE ON SUBANTARCTIC CAMPBELL ISLAND, NEW ZEALAND REGION

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The subantarctic islands offer some of the best opportunities in the New Zealand region for charting fluctuations in climate. These peat-covered islands lie within the current treeline ecotone and are therefore highly sensitive to fluctuations in summer temperatures. The restricted pollen and spore flora and the close correlation of pollen and spore spectra with local vegetation composition, plus the ability to recover long high resolution records from anywhere on the islands offer extraordinary precision in vegetation reconstruction.

Campbell Island (52°S) represents the lowest tree line in the New Zealand region (c. 100 m). It was extensively glaciated during the LGM and mean annual temperature (MAT) was c. 5°C lower than now. Retreat of glaciers began c. 18,000 cal BP. A 4-m deep peat soil profile from a site (Homestead Scarp) at 30-m a.s.l. records detailed vegetation change over the last 17,000 cal BP years. From 17,000 to 14,300 cal BP, upland tundra of macrophyllous forbs, typical of that presently growing at altitudes of 300 m or more on the island, dominated, indicating MATs at least 3°C lower than now. *Aciphylla*, the dominant tundra macroforb immediately after deglaciation, was partly replaced by *Pleurophyllum hookeri* by 15,400 cal BP, suggesting a moderate warming trend beginning c. 16,000 cal BP. Between 15,400 and 14,300 cal BP, *Aciphylla* recovered ground, suggesting a return to coolish conditions Grassland steadily supplanted tundra between 14,300 and 11,500 cal BP, indicating a progressive warming culminating in a MAT within 0.7-0.9°C of the present. *Myrsine* scrub established by 11,000 cal BP. However, this brief scrub period was followed by a reversal to grass dominance that lasted until 10,800 cal BP, with *Dracophyllum* scrub expanding into the grassland, a similar-to-present *Dracophyllum* scrub-grassland establishing at the site by 9,400 cal BP, and presumably a similar climatic regime.

The Campbell Island sequences are unusual for the New Zealand region because they are punctuated by clearly marked vegetation fluctuations that can be attributed to climatic change. Dating is currently underway to confirm the timing of the ACR-like interval of cooler climates between 15,400 and 14,300. From dating already carried out, we can be confident that, in the southern ocean, the Younger Dryas Chronozone was mainly characterised by warming, although it is hard to study because of the general slow down in peat growth. The early Holocene period is enigmatic, but the presence of unusually high levels of fern spores and bog plant pollen at this presently well drained site suggests high humidity, and greatly reduced evapotranspiration that prevented establishment of a scrub cover similar to that of the present until late in the sequence.

AN INVESTIGATION INTO NEW ZEALAND'S CLIMATE DURING THE LAST GLACIAL MAXIMUM: A CLIMATE MODELLING APPROACH

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New Zealand's climate during the LGM is investigated using a Regional Climate Model (RCM) that is embedded within an atmospheric General Circulation Model (GCM). Sea Surface Temperatures (SSTs) and sea ice were computed by a coupled climate model run under glacial conditions as specified by PMIP. The GCM used Peltier's ice-sheets, and the extent and thickness of New Zealand's ice-sheets in the RCM were given "best estimated values".

The annual mean cooling over New Zealand was 4.5°C-5.0°C, but this was largely influenced by the very strong cooling over the Southern Alps in the simulation. Removing this region from the analysis shows that New Zealand during the LGM was colder than the present day by 2.5°C-4.0°C. The largest cooling occurred during the winter, and in the South Island.

Precipitation was reduced almost everywhere, with the exception of the east coast of the South Island. The main band of precipitation shifted westward along the West Coast of the South Island, as the result of the large expansion of the glaciers.

The change in wind patterns influenced both the temperature and precipitation patterns. There was an increase in westerlies over the North Island, but a reduction in the westerly wind in the east of the South Island. The weaker westerly wind in the east of the South Island, as well as in the east of the North Island during JJA, allowed moist easterly winds to come ashore more easily, offsetting the general reduction in precipitation due to the colder temperatures. There was an increase in the number of southerlies as well as in their strength, affecting temperature particularly in the South Island. These changes enhanced the geographical differences and seasonality in New Zealand during the LGM.

TEPHRA DISPERSAL EAST OF NEW ZEALAND: NEW INSIGHTS FROM THE MARCH 2005 ROGER REVELLE CRUISE

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During March 2005, the Scripps Institute of Oceanography ship Roger Revelle collected a suite of jumbo piston cores from 31 sites on the Chatham Rise, Hawkes Bay and Bay of Plenty. The primary aim of the cruise was to investigate paleo-ventilation of the ocean through radiocarbon dating. The approach is to date foraminifera near tephra layers of known terrestrial age, and thus obtain surface- and deep-water- reservoir ages over a variety of time slices at various depths. The target interval includes the temporal focus of INTIMATE studies. A total of ~200 m of hemipelagic and calcareous ooze core was obtained. The longest was ~12 m, and many extend back to ~50-70 ka. A high resolution record of rhyolitic, andesitic and peralkaline tephra layers were recovered from various sites recording activity from the Taupo region, White Island and Mayor Island. The age of tephra layers provide estimates of sediment accumulation rates that vary from 8 to 30 cm/kyr at different sites.

The cores provide new insights to tephra dispersal east of New Zealand. In addition in Oruanui tephra (26 ka), Omataroa (~32 ka), Mangaone (~33 ka) and Rotoiti (~50 ka) tephra layers are particularly thick and widely dispersed off-shore of Hawkes Bay. In the Bay of Plenty (up to a latitude of ~36^{o}S), Maketu (~36 ka) and Hauparu (~35 ka) tephra layers are particularly prominent. The cores provide evidence for at least 7 Mayor Island tephra beds with preliminary age estimates of ~60 ka, ~40 ka, 36 ka, 20 ka, ~14 ka, 8 ka, and 7 ka. Some are thick layers (2-10 cm) that are widely dispersed across the Bay of Plenty. They will provide new insights to the geochemical and volcanological evolution of Mayor Island, and are valuable new marker beds for the last glaciation and transition period.

RADIOLARIAN-BASED ESTIMATES OF SEA-SURFACE TEMPERATURE VARIATION THROUGH THE LAST DEGLACIATION: IMAGES CORE MD97-2121, OFFSHORE WAIRARAPA

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Radiolarians are a diverse group of microzooplankton that construct ornate tests of opaline silica, which are commonly preserved in marine sediments. The group is widely used in paleoceanographic studies, but has been underutilised in the South Pacific. We have undertaken quantitative analysis of radiolarian assemblages in Pleistocene-Holocene sediment cores from three sites north of the Chatham Rise: ODP sites 1123 and 1124 and IMAGES site MD97-2121. The radiolarian assemblages consist of a mixture of subtropical, subantarctic and transitional species, typical of temperate waters. Some 300 radiolarian species or higher level categories have been identified and most samples contain over 80 taxa.

In this study we compare late Pleistocene faunal changes within MD97-2121 with local modern radiolarian distributions in surface sediments to determine how climatic changes associated with the last deglaciation may have affected oceanographic conditions and sea surface temperatures on the continental slope, offshore Wairarapa. We present preliminary SST determinations based on MAT and neural network methodologies. These results and other faunal changes indicate that in this coastal region the last deglaciation was characterised by steady and progressive warming and decreasing biosiliceous productivity. Perhaps, the interaction of the subtropical East Cape Current and subantarctic waters jetting northward through Mernoo Gap served to promote biological productivity in this near-coastal region in glacial times.

SHALLOW OCEANIC RECORDS OF PLANKTIC FORAMINIFERAL & SEA-SURFACE TEMPERATURE VARIABILITY SPANNING OIS 12-1: A CONTEXT FOR UNDERSTANDING NEW ZEALAND LATE QUATERNARY CLIMATE

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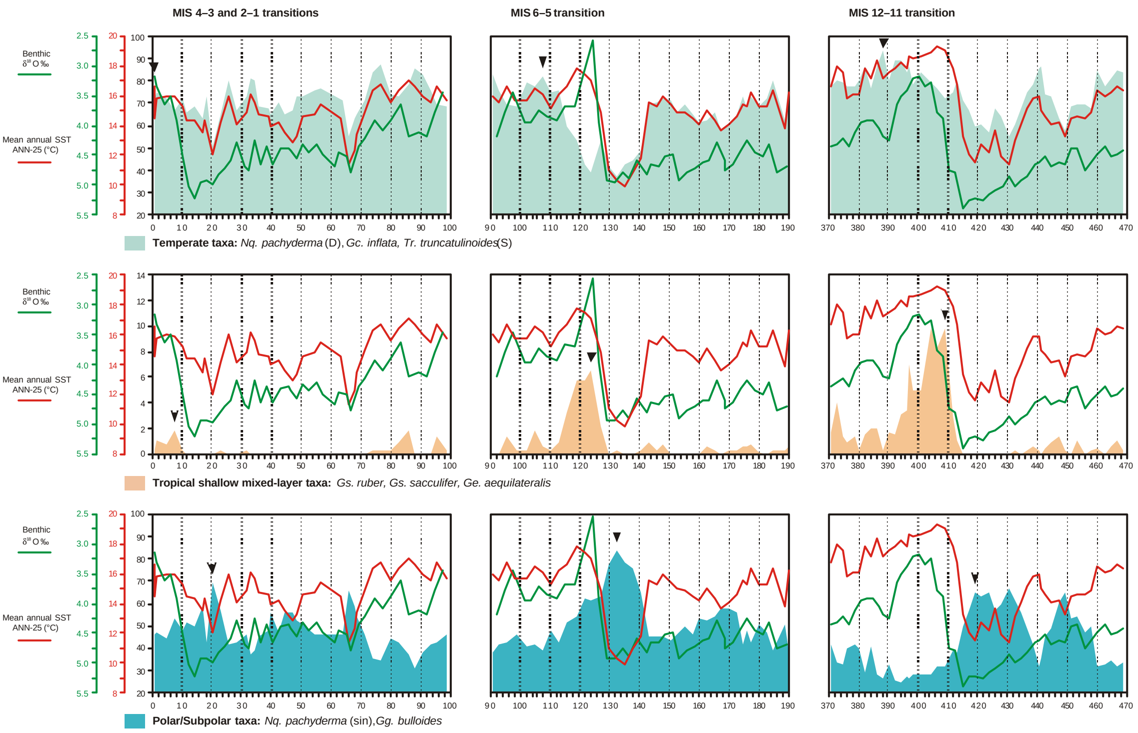
Artificial neural network (ANN) estimates of sea-surface temperature (SST) derived from planktic foraminiferal assemblages at Site 1123, located 1100 km east of New Zealand on the northern side of the STF, suggest climate forcing plays a major role in glacial-interglacial (G–I) variations in surface circulation of the Southwest Pacific Ocean and the dynamics of the Subtropical Front (STF) during the Late Quaternary. Although the general pattern and tempo of planktic foraminiferal changes are clearly dictated by climate forcing, suborbital-scale faunal variations and phase relationships between SST, faunal, and benthic $\delta^{18}O$ records, reflect a complex local history of surface circulation and frontal dynamics, tempered by Chatham Rise bathymetry, and competing subantarctic and subtropical gyres.



A similar pattern of faunal variability is evident in all G–I cycles, although the MIS 2-1 transition stands out as somewhat unusual. It has small, poorly defined peaks in subantarctic and subtropical taxa, and the increase in SST is far more gradual than during earlier G–I transitions, except MIS 10-9. Such features place a cautionary caveat on the use of ancient analogs to model future climate.

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REFERENCES

[1] Alloway, B.V. 2004 NZ-INTIMATE Meeting, GNS Rafter Laboratory, Wellington: 23-24 August 2004. *Institute of Geological & Nuclear Sciences science report* 2004/22. 43 p.

[2] Barrell, D., Alloway, B.V., Shulmeister, J., Newnham, R., (editors) 2005: *Towards a climate event stratigraphy for the last 30,000 years in New Zealand.* Institute of Geological & Nuclear Sciences science report 2005/07. 12 pages & poster.