Australasian Quaternary Association Inc.

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AQUA

AQUA Biennial Conference

JG Crawford Building, Australian National University, Canberra

Australian National University

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for Australian Biodiversity and Heritage

AQUA 2018

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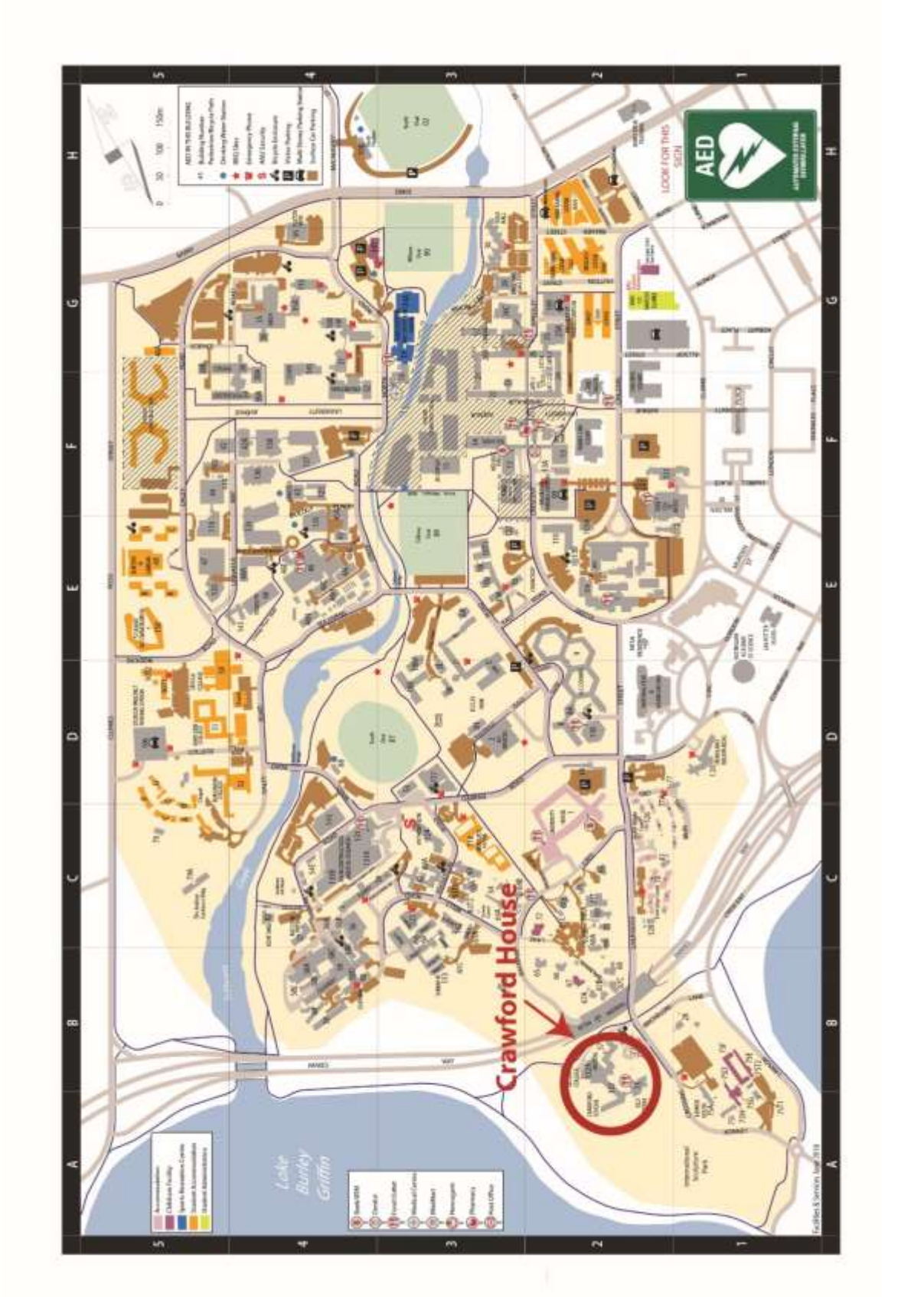
Australian National University Map



General Schedule

	Sunday 9th Dec	Monday 10th Dec	Tuesday 11th Dec	Wednesday 12th Dec	Thursday 13th Dec	Friday 14th Dec
8.00 - 8:30		Registration				
8:30 - 9:00			Registration	Registration		
9:00 - 9.30		Opening / Presidents Welcome	**Long Records** Chair: Heather Haines	**Speleothem records** Chair: Stacey Priestly	**Arid environments** Chair: Nicola Stromsoe	**Lake George Overview** Chair: Elyssa De Carli
9.30 - 10.00		**Long Records** Chair: Rebecca Hamilton				
10.00 - 10.30						
10.30 - 11:00		Morning Tea	Morning Tea	Morning Tea	Morning Tea	Morning Tea
11.00 - 11.20		**Geomorphology** Chair: Georgy Falster	**Lake Records** Chair: Michela Mariani	**New Methods** Chair: Kelsie Long	**Dating:** Chair: Valerie van den Bos	**Lake George Adventure**
11.20 - 11.40						
11.40 - 12:00						
12.00 - 12.20						
12.20 - 12.40						
12.40 - 1:30		Lunch	Lunch	Lunch	Lunch	
1.30 - 1.50		**Isotope methods** Chair: Haidee Cadd	**Lake Records** Chair: Leoni Peti	**New Methods** Chair: Tegan Hall	**New Methods** Chair: Katie Coleborn	
1.50 - 2.10						
2.10 - 2.30						
2.30 - 2.50						
2.50 - 3.10		Afternoon Tea	Afternoon Tea	Afternoon Tea	Afternoon Tea	
3:10 - 4:00		Keynote - Penny Whetton	Keynote - Jonathan Tyler	Keynote - Laura Weyrich	Keynote - Zoe Thomas	
4:00 - 4:30	Icebreaker		Keynote - Tasman van Ommen			
4:30 - 5: 15		John Chappell Memorial Lecture				
Evening		Poster session	ECR themed event	Conference Dinner		

Social Event	Oral Presentations	Poster Sessions	Keynote Speeches	Offsite Field Trip	Onsite Field Trip talks

Calendar of Events

Sunday 9th December

Icebreaker 4pm – 6pm

Complete your registration and meet your fellow AQUA conference attendees before the conference begins. Drinks and nibbles will be provided at Bent Spoke in Braddon from 4pm.

Monday 10th December

Posters, Pizzas and Beers 5pm – 8pm

Peruse some wonderful posters while enjoying a slice of pizza and a beverage or two. This session will run from the conclusion of the presentations on Monday at Crawford House.

Tuesday 11th December

Early Career Researcher (ECR) Evening 6pm – 8pm

Come along to meet and get to know the wonderful AQUA ECR's. Nibbles will be supplied and drinks will be available at bar prices. All are welcome to attend this event.

Wednesday 12th December

Conference Dinner 5pm – late

The conference dinner will be held at the Canberra Rugby Union Club (RUC), commencing at 5pm with barefoot bowls. Compete against your fellow Quaternarists for bowling glory. Dinner will commence at 7pm with a traditional AQUA trivia intermission between courses.

Friday 14th December

Lake George Adventure

Meet at Crawford House at 9am to hear about some of the exciting new research currently underway at Lake George as well as getting an insight into the history of research at the site. From 11 am onwards we will be departing Crawford house for an adventurous day including picnic lunch and cricket.

A short history of the future: Projecting climate change in Australia 1989-2015

Over the past three decades, CSIRO has led the provision of national climate change projections for Australia. Amongst a broader range of products, National Statements on Australia's future climate were released in 1992, 1996, 2001, 2007 and 2015 (the last two in collaboration with BoM). These projections have been widely cited and used in Australian climate change and assessment and adaptation work. I had a leading role in the production of these products since 1992 and led the research team in CSIRO responsible for these projections from 1999 to 2014.

Climate projection work lies at the interface between climate modelling and the research and management of climate impacts. Traditionally it is viewed by both those fields as a service role, whereas in actual fact it generates a range of unique scientific and ethical challenges which are often underappreciated. This presentation will be a reflection on my experience in this role, and how the approach used, and the projections themselves, have evolved over the years. This will include a focus on key challenges and on the guiding principles that were developed to deal with them.

The issues typically include finding a balance between competing approaches and objectives. For example, is this task primarily about the research perspective of improving knowledge of how regional climate will change, or is about providing detailed projection data sets for use in applications (knowledge versus data)? Should broad ranges of uncertainty be presented to users, or do the projection providers have a responsibility to identify and focus on the most likely changes, and how should they do that? Is there a difference between 'scenarios' and 'projections', and do providers and users understand the difference? And is the role of projections evolving as climate change progresses and regional changes to climate change are increasingly revealed in the real world.

Dr. Penny Whetton

CSIRO

Penny Whetton formerly worked with CSIRO on the development of regional scenarios of future climate change for use in impact and adaptation. Dr Whetton was also a lead author of the regionalisation and climate scenarios chapters of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the regional projections chapter of the Fourth Assessment Report of IPCC, and of the Australasia chapter of the Fifth Assessment Report. Currently, Dr Whetton is an Honorary Research Fellow with CSIRO Ocean and Atmosphere and the School of Earth Sciences at the University of Melbourne. She is also currently serving for the Victorian Government (DELWP) on the Interim Emissions Target Expert Panel, and as part of the Technical Reference Group for DELWP's high-resolution climate change projections project.

Identifying common patterns and periodicities in time-uncertain palaeoclimate records

Dr. Jonathan Tyler

The University of Adelaide

Dr. Jonathan Tyler is a senior lecturer in the Department of Earth Sciences, University of Adelaide. He completed his PhD at University College London before holding postdoctoral positions at the Universities of Tokyo, Oxford and Melbourne. His research involves the application of isotope and elemental geochemistry to address past climate variability, with a particular focus on developing and calibrating geochemical proxies, modelling the interface between climate and lake sediment geochemistry and the development of numerical approaches for interrogating time-uncertain palaeoclimate data.

Ice core climate records: From seasonal- to glacial-scale

Ice cores provide one of the richest sources of past climate information over the late Pleistocene, uniquely recording the major climate forcings and responses. This presentation will provide a review of some of the major findings from the field of ice core sciences, highlight current issues and discuss future directions. This will include the speakers own research using the Law Dome ice core and cores from other near coastal high snow accumulation locations. These highly resolved records have provided critical new insights through calibration and intercomparison with meteorological records. Key findings have included reconstruction of past sea-ice extent, continental- and regional-scale temperatures, and the identification of teleconnections between Australian hydroclimate and Antarctic climate parameters such as snowfall and winds. At the other end of the time-spectrum, ice cores have revealed the grand view of the coupling between carbon dioxide and temperatures on glacial-interglacial time-scales. This will be discussed in the context of the international thrust to recover the 'Oldest Ice' core from Antarctica, extending beyond the mid-Pleistocene to well over a million years before present. The Australian Antarctic Program has committed to leading a deep ice drilling project in the first part of the next decade, as part of collaborative and multi-national efforts to obtain, ideally, replicated ice core records of the mid-Pleistocene transition.

Dr. Tas van Ommen

Australian Antarctic Division

Dr Tas van Ommen leads the Climate Processes and Change Theme within the Australian Antarctic Program. He is a Senior Principal Research Scientist with the Australian Antarctic Division in Hobart where he has worked for over 24 years. Tas's main research interests centre on ice core palaeoclimate and Antarctic glaciology. His research on high resolution ice cores has provided new insights into teleconnections with Australian climate and drought. His glaciological research, using airborne geophysical studies of the ice sheet has helped reveal extensive subglacial basin network in East Antarctica and develop understanding of the stability and future state of the ice sheet. Tas is also co-chair of the International Partnerships in Ice Core Sciences (IPICS), which is an 24-national coordinating and planning body for the ice core community.

Reconstructing ancient environmental microbes as proxies for the past

Understanding climatic changes and variability in the past will be critical in predicting how earth's climate will change in the future. While most climatic reconstructions are focused on geochemical data, biological markers of climate change can provide complimentary information on past climate change. However, very few studies have applied ancient DNA to examine how past microorganisms have responded to the climate over time. Here, we use novel metagenomic sequencing approaches, coupled with strict ancient DNA methodologies, to obtained bacterial and archaeal DNA from diverse Antarctic samples, including marine sediments, ancient calcite deposits, and large blue ice samples. Results from each location reveal unique biological patterns that change through space and time. By using detailed geochemical, morphological, and geospatial data, we are able to interpret the presence of specific microbial species trapped in ancient Antarctic samples to help inform large-scale climate models. For example, ancient metagenomic analysis revealed potentially thermophillic microorganisms preserved within ancient calcite deposits alongside geochemical and morphological evidence to support past hydrothermal activity. This finding suggests that volcanism contributed to Antactic, glacial melt over 20,000 years ago, which had the potential to impact global cycling patterns. Detailed examinations of bacterial community structure and species introductions can provide critical supporting evidence to understand past climate change in greater detail.

Dr. Laura Weyrich

The University of Adelaide

Dr. Weyrich received a PhD in Microbiology and Bioethics from Penn State, studying how respiratory infections alter the microbiome. In 2012, she moved to the University of Adelaide and established a research team at The Australian Centre for Ancient DNA that uses calcified dental plaque to reconstruct ancient human oral microbiomes. Her team was the first to reconstruct the microbiome of an extinct species - Neandertals - and has reassembled the oldest microbial genome to date at 48,000 years old. Her team's research has been featured by the BBC, NPR, *Science*, *Nature*, *New Scientist*, *NY Times, Smithsonian Magazine, National Geographic*, and many others, and has even had a Buzz Feed quiz written about it. Her team is now reconstructing the evolutionary history of the human oral microbiome on six continents, obtaining insight into how the lifestyles and diets of our ancestors impact our health today.

Tipping points, thresholds, and feedbacks in the Earth System: a palaeo perspective

Irreversible shifts of large-scale components of the Earth system (so-called 'tipping elements') are of significant concern for future climate change. Many of these systems are vulnerable to abrupt change due to a non-linear response to gradual forcing, as a result of underlying system dynamics. One of the best ways to identify and potentially predict threshold behaviour in the Earth system is through analysis of natural ('palaeo') archives. Specifically, on the approach to a tipping point, early warning signals can be detected as characteristic fluctuations in a time series as a system loses stability. Testing whether these early warning signals can be detected in highly complex real systems is a key challenge, since much work is either theoretical or only tested with simple models. This is particularly problematic in palaeoclimate and palaeoenvironmental records with low resolution, non-equidistant data, which can limit accurate analysis. A range of different datasets are examined here to explore generic rules that can be used to detect such dramatic events, focusing particularly on the warmer periods in the geological past. Since instrumental records do not capture the full range of the projected climate scenarios, natural archives from previous interglacials can be used to identify responses to forcing and modes of climate variability, providing a comparison to long-term projected simulations. In addition to threshold effects, positive feedbacks within the climate system can also amplify global change; the inter-connection of various earth system feedbacks is thought to result in 'domino dynamics', where the tipping of one sub-system into a different state may trigger the collapse of an inter-connected sub-system. Here we synthesise the nature and timing of selected high-latitude Last Interglacial 'tipping elements' including sea ice, boreal forest, permafrost, ocean circulation and ice sheets/sea level, and review the thresholds and feedbacks that likely operated at this time. Quantifying and documenting qualitative regional changes during the Last Interglacial can help predict future changes in important tipping elements that could have global impacts through a tipping cascade.

Dr. Zoë Thomas

University of New South Wales

Zoë Thomas currently works as a postdoctoral research associate at the University of New South Wales, Australia, specialising in abrupt climate change and palaeoclimate reconstruction over the late Pleistocene. Her interest in abrupt environmental change was initially piqued during her undergraduate degree at the University of Oxford, UK where she first came across the concept of 'critical slowing down'; a phenomenon that often precedes abrupt shifts in climate and ecosystems. During her PhD at the University of Exeter, UK (awarded in August 2014), her research aimed to find generic indicators of 'tipping point' in natural systems. The prospect of identifying systems vulnerable to abrupt change or "tipping points" in the future has driven much of her research, with the analysis of palaeoenvironmental archives resulting in advances in the mechanistic understanding of these systems. Ongoing work explores the further development and potential of these techniques in a range of data archives, with particular focus on Southern Hemisphere atmospheric circulation changes and impacts in the recent geological record.

John Chappell Memorial Lecture

Monday 10th December 4:30 – 5:15pm

Emeritus Professor John Chappell was unquestionably one of the world's most well-known and accomplished Quaternary scientists of the past ~40 years or more. Described by Prof Bruce Thom as "the father of Quaternary research in Australia" John Chappell's contributions to Quaternary research have been recognized by national and international awards. In 2011 AQUA nominated John for an Honorary Life Fellowship of INQUA in recognition of his valuable contributions.

Oral presentation Schedule

Monday 10th		
8.00 - 9.00	Registration	
9:00 - 9.30	Opening Presidents Welcome	
		Session: Long Records **Chair**: Haidee Cadd
9.30 - 10.00	Patrick De Deckker	Marine Isotope Stage 4 in Australasia: a full glacial culminating 65,000 years ago – global connections and implications for human dispersal
10.00 - 10.30	Valerie van den Bos	A terrestrial palynological record for the last ~100 kyr from Orakei Basin, northern New Zealand
10.30 to 10.55	Morning tea (25 min)	**Session**: Geomorphology **Chair**: Georgy Falster
11.00 - 11.20	Tim Barrows	Glacial history of the Franz Josef moraine complex, West Coast, New Zealand
11.20 - 11.40	Lisa Dowling	The Holocene Glacial History of Dart Glacier, Southern Alps, New Zealand
11.40 - 12:00	Elyssa De Carlie	The intersection between engineering and Quaternary science: an example from the River Murray
12.00 - 12.20	Nuria Lahuerta Pineiro	Late Quaternary relative sea-level changes and evolution of the Lacepede Shelf, southern Australia
12.20 - 12.40	Deirdre Ryan	Introducing WALIS – The World Atlas of Last Interglacial Shorelines
12.40 - 1:30	Lunch (50 min)	**Session**: Isotope Methods **Chair**: Rebecca Hamilton
1.30 - 1.50	Cesca McInerney	Reading the tea leaves: Leaf waxes as recorders of palaeovegetation
1.50 - 2.10	Amy Prendergast	Pipi shells: a new high-resolution palaeoenvironmental archive for south-eastern Australia
2.10 - 2.30	Georgia Roberts	Modern Australian Isotopic Baselines: Implications for the Expansion of Isotope Research in Australian Archaeology
2.30 - 2.50	Georgy Falster	Leaving a trail: reconstructing past climates from stable and clumped isotope analysis of snail shells
2.50 - 3.20	Afternoon tea (30 min)	
3.30 - 4.30	Penny Whetton	A short history of the future: Projecting climate change in Australia 1989-2015
4.30 - 5.15	Brad Pilans	John Chappell Memorial Lecture
5.15 - 8.00 pm	Poster, Pizza & Drinks	

Tuesday 11th		
8.30 - 9.00	Registration	**Session:** Long Records **Chair:** Heather Haines
9:00 - 9.30	Fiona Hibbert	Searching for structure in sea-level records
9.30 - 10.00	Janelle Stevenson/ Rebecca Hamilton	600,000 years of change in a biological hotspot
10.00 - 10.20	Katharine Grant	Reconstructing 'Green Sahara Periods' over the Plio-Pleistocene
10.20 -10.40	Chris Kemp	A new >200,000 year Australian climate record from Fern Gully Lagoon, sub-tropical eastern Australia
10.40 - 11.00	Morning tea (20 min)	**Session:** Lakes **Chair:** Michela Mariani
11.00 - 11.20	Cameron Barr	Hydrological change in subtropical Australia from 80–40 kyr
11.20 - 11.40	Haidee Cadd	Millennial scale climate and environmental change from Welsby Lagoon, North Stradbroke Island for the past 80,000 years.
11.40 - 12 noon	Tim Cohen	The evolution of Thirlmere lakes: a long-term sedimentary record of climate and fire dynamics in the Sydney Basin
12.00 - 12.20	Matt Forbes	Palaeoenvironmental reconstruction of Lake Couridjah (Thirlmere) across the Pleistocene and Holocene using isotopic and geochemical proxies
12.20 - 12.40	Simon Haberle	A ~30ka pollen and charcoal record from the Mitchell Plateau, The Kimberley: implications for past climate, fire and human activity NW Australia.
12.40 - 1:30	Lunch (50 min)	**Session:** Lakes **Chair**: Leoni Peti
1.30 - 1.50	Nicola Stromsoe	Late Holocene climate variability In the Australian Alps: can sedimentary and geochemical tracers track fine scale palaeo-environmental change?
1.50 - 2.10	Nicky Wright	Did solar forcing influence the Southern Annular Mode over the Last Millennium?
2.10 - 2.30	Joeseph Alexander	Southern westerlies and CO2 during the Antarctic Cold Reversal
2.30 - 2.50	Zoe Thomas	A dynamical link between Snowy Mountains temperatures and the Southern Hemisphere westerly winds over the late Holocene
2.50 - 3.10	Afternoon tea (20 min)	
3.25 - 4.05	Jon Tyler	Identifying common patterns and periodicities in time-uncertain palaeoclimate records
4.10 - 5.10	Tas van Ommen	Ice core climate records: From seasonal- to glacial-scale
Evening	ECR-themed event at Fellows Bar	

Wednesday 12th		
8.30 - 9.00	Registration	**Session:** Speleothem Records **Chair**: Stacey Priestly
9.00 - 9.30	Andy Baker	Reconstructing Australia's fire history from cave stalagmites
9.30 - 9.50	Andrea Borsato	Solar forcing and inter-annual precipitation variability reconstructed from a Cook Islands stalagmite record
9.50 - 10.10	Pauline Treble	Past hydroclimatic variability from southwest Australian speleothems during the last millennium
10.10 - 10.30	Xianglin Zheng	The reconstruction of moisture availability over the past 2800 years in south-eastern Australia using testate amoebae
10.30 - 10.55	Morning tea (25 min)	**Session:** New Methods **Chair:** Tegan Hall
11.00 - 11.20	Al Williams	The first use of Optically Stimulated Luminescence Dating at a colonial site in Australia
11.20 - 11.40	Jacinta Greer	Experimental degradation of leaves: Implications for palaeoclimate reconstructions
11.40 - 12 noon	Kelsie Long	Oxygen isotopes and trace elements in fish otoliths: modern validations and ancient applications
12.00 - 12.20	Lynda Petherick	Cyanobacteria secondary metabolites: New proxies for past climate change
12.20 - 12.40	Heather Haines	Developing Tree-Ring Chronologies and Climate Reconstructions from Moisture Sensitive Araucariaceae Trees in Tropical and Subtropical Australia
12.40 - 1:30	Lunch (50 min)	**Session:** New Methods **Chair:** Kelsie Long
1.30 - 1.50	Tony Dossetto	News from the Periodic Table: Quaternary landscapes and ecosystems viewed from the perspective on an atom (or two)
1.50 - 2.10	Michela Mariani	From pollen to land-cover: new modelling approaches from Tasmania, Australia
2.10 - 2.30	Michael-Shawn Fletcher	Understanding human-environment interactions in space and time: 3 case studies from the Holocene in Australia
2.30 - 2.50	Jess Reeves	Living Bung Yarnda (Lake Tyers)
2.50 - 3.10	Afternon tea (20 min)	
3.15 - 4.15	Laura Weyrich	DNA in Quaternary Research
5:00	Twilight bowling	
>7pm	Conference dinner	

Thursday 13th		
8.30 - 9.00	Registration	**Session:** Arid Records **Chair**: Nicola Stromsoe
9.00 - 9.30	Paul Hesse	The Desert Dilemma
9.30 - 9.50	Adrian Fisher	Using satellite imagery to improve our understanding of longitudinal dunes as paleoclimate records
9.50 - 10.10	Elise Thornton	Investigating the past hydrology of Lake Mungo: a multiproxy approach.
10.10 - 10.30	Nathan Jankowski	Preliminary results from high-resolution single-grain OSL dating and soil micromorphology at Lake Mungo, NSW
10.30 - 10.55	Morning tea (25 min)	**Session:** Dating methods **Chair**: Valerie van den Bos
11.00 - 11.20	Mark Constantine	Getting more from charcoal: using ATR-FTIR to quantify pyrolysis intensity as a proxy for fire severity in eastern Australia
11.20 - 11.40	Leonie Peti	Integrated age modelling of numerical, correlative and relative dating of a long lake sediment sequence from Orakei maar paleolake, Auckland, NZ
11.40 - 12 noon	Peter Almond	Implications of soil particle transport and mixing for OSL ages
12.00 - 12.20	Rachel Wood	Towards a pretreatment for radiocarbon dating tooth enamel
12.20 - 12.40	Julien Lubeek	Determining the cause of Gigantopithecus blacki's demise using dental microwear, micromorphology and luminescence dating
12.40 - 1:30	Lunch (50 min)	**Session:** New Methods **Chair:** Katie Coleborn
1.30 - 1.50	John Jansen	Cosmogenic 14C reveals catastrophic soil-loss coincided with early agro-pastoralism in the Andes altiplano
1.50 - 2.10	Chris Gouramanis	Comparison of Recent Storm and Tsunami Deposits from the South-Eastern Coastline of India
2.10 - 2.30	Martin Akor	Hydrologic and isotopic modelling of lakes: towards mechanistic understanding of proxy data.
2.30 - 2.50	Sam Marx	Atmospheric dust concentrations are a key indicator of palaeo-environmental conditions through the Quaternary.
2.50 - 3.10	Afternnon tea (20 min)	
3.15 - 4.00	Zoe Thomas	Tipping points, thresholds, and feedbacks in the Earth System: a palaeo perspective
4.00 - 5.00	AQUA Meeting. Issues in AQUA (President)	

Friday 14th		
9.00 - 9.30	Brad Pilans	Lake George overview
9.30 - 9.50	Simon Haberle	Lake George pollen
9.50 - 10.10	Bradley Opdyke	Lake Gearge and the Impact of the Mid-Pleistocene Transition
10.10 - 10.30	Tim Cohen	Lake George highstands: more evidence for deep lakes in cold periods
10.30 -10.50	Amy Way	The archaeology of Weereewaa (Lake George)
10.50 -11.15	Morning tea (25 min)	
11.20 to lunch	Lake George adventure	

Poster presentation schedule

Poster	Name	Poster Title
1	Martin Ankor	Development of an autonomous, monthly and daily, rainfall sampler for isotope research
2	Andy Baker	Preliminary results of the SISAL database
3	Andy Baker	Global distribution and controls on cave drip water oxygen isotope composition
4	Andy Baker	High-resolution stalagmite evidence of paleoclimatic change in Ethiopia around the last interglacial
5	Andy Baker	GDGT distributions from soil to cave: refining the speleothem paleothermometer
6	Fabian Boesl	Boulder transport along the coast of Eastern Samar (Philippines) – Implications for Holocene extreme-wave events
7	Valerie van den Bos	Density separation in pollen preparation: how low can you go?
8	Haidee Cadd	SHeMax: A regional perspective on the timing of the Last Glacial Maximum in Australia
9	Katie Coleborn	Sulphur: a proxy for wildfires in stalagmites
10	Yuhao Dai	Carbon Cycle Changes in the Deep Southern Ocean during the Last Deglacial Period
11	Amy Dougherty	Utilizing GPR, OSL, and LiDAR (GOaL) to infer climate variations from raised beach ridges around Lake George
12	Megan Ensor	Hearth investigations at Lake Mungo using FTIR analysis and soil micromorphology
13	Mohammadali Faraji	Dripwater monitoring and calcite farming experiments as a key to interpret the paleohydrological record in stalagmites from Atiu caves (Cook Islands)
14	Michael-Shawn Fletcher	A high-resolution continuous multi-proxy palaeoecological record of the last two glacial cycles from Lake Selina, Tasmania.
15	Michael-Shawn Fletcher	What determines resilience to fire in Tasmanian montane rainforest? - A novel application of palaeo- and neo-ecological approaches to a critical problem.
16	Matt Forbes	Reconstructing a palaeoenvironmental record for the LGM period – sedimentary analysis of the Riverine palaeochannels
17	Alexander Francke	Using the sediments of Lake George's depo-centre as a sensitive rainfall gauge in SE Australia
18	Reka-H Fulop	Exploring sediment dynamics from source to sink in the Murray-Darling river basins using cosmogenic 14C, 10Be, and 26Al
19	Simon Haberle	A new record of human settlement and past environmental change of the Comoros, far western Indian Ocean
20	Heather Haines	Understanding the Effect of Climate Variability on Forest Composition: A case study of four co-occurring pine species on Norumbega Mountain, Acadia National Park, Maine, U.S.A.
21	Tegan Hall	An integrated palaeoenvironmental record of industrial pollution within Angkor Thom, Angkor
22	Rebecca Hamilton	SpeciCount: A web application for counting and analysing palaeoecological data

23	Feli Hopf	Late Glacial and Holocene Palaeoecology of the Lake St Clair Region, Tasmania
24	Xuan Ji	Deep Atlantic Carbon Sequestration during Last Glacial Inception
25	Christopher Kemp	Problems with normalising scanning micro-XRF data for palaeoclimate use
26	Justine Kemp	Sedimentation and vegetation change through the last glacial cycle at Echo Lake, Fraser Island
27	Richard Lewis	Independent Bayesian age modelling in subtropical wetlands to assess the influence of global climate drivers across Aus
28	Agathe Lise-Pronovost	Scientific drilling at Darwin Crater and Lake Selina: long continental sedimentary archives from Tasmania
29	Kelsie Long	Oxygen isotopes in fish remains from Lake Kutubu, PNG
30	Andrew Lorrey	Evaluation of pre-instrumental Southern Hemisphere climate mode history and impacts on New Zealand using the Past Interpretation of Climate Tool (PICT)
31	Andrew Lorrey	Environmental history from New Zealand swamp kauri (Agathis australis) - recent progress on sample collection and radiocarbon dating
32	Charles Maxson	A Holocene isotope hydroclimate record from Karboora, Minjerribah, Queensland
33	Sarah McDonald	An 8,000-year climate record from Lake Motosu, Japan: Implications for the East Asian Monsoon
34	Stephanie Mills	The timing of Late Pleistocene glaciation at Mount Wilhelm, Papua New Guinea
35	Leonie Peti	Orakei maar paleolake (Auckland, NZ): A multi-method approach to the composite stratigraphy of a long lake sediment core
36	Stacey Priestley	Groundwater isotopic record in southwest Australia: links to recharge variations and climatic conditions
37	Will Reynolds	History of vegetation and moisture change across northern Australia during the last 120,000 years.
38	Susan Rule	Lake George (Weereewa): a multi-proxy record spanning the past 100,000 years
39	Yuexiao Shao	Stable and Radiogenic Strontium Isotope Systematics in Hypersaline Coastal Environments: Constraints for Paleo-Hydrology in the Coorong, South Australia.
40	Martin Smith	Post-LGM evolution of the lower Ord River, WA, constrained by luminescence and cosmogenic radionuclide dating
41	Carol Tadros	Trace elements: from sources to cave drip water, south-eastern Australia
42	Alexander Wall	Late Quaternary palaeoenvironments of eastern Indonesia
43	Jiade Wu	Abrupt Changes in the Northern Source Water during Dansgaard-Oeschger Events
44	Thomas Oliver	Last interglacial (LG) sea level and Last Glacial Maximum (LGM) dune activity in the Gippsland region, southeastern Australia

Abstracts - Posters

Development of an autonomous, monthly and daily, rainfall sampler for isotope research

Martin Ankor[1] (martin.ankor@adelaide.edu.au)

[1]University of Adelaide

Modern isotope data is an essential baseline for palaeo-climate studies. For studies reliant upon hydrogen and oxygen isotopes, the isotopic composition of precipitation can be an important starting point. An autonomous, cost effective and open source rainfall sampler has been developed for hydrogen and oxygen isotope research, able to sample daily and monthly for 60 days of rainfall, over a three month period. The sampler is designed to use modern fabrication methods such as 3D printing and laser cutting to minimise the need for complex, skilled, construction. The sampler can use either paraffin oil or inlet tubes to prevent evaporation, with the use of the inlet tube method facilitated by 3D printed bottle caps. The effectiveness of both paraffin oil and the inlet tube method for preventing evaporation was quantified, with paraffin identified as being the most effective at present. During a 90 day outdoor experiment, the 18O/16O vs. 2H/1H composition of some water samples evolved along a local evaporation line, with increased isotopic enrichment of samples correlating to water loss. A coupled hydrologic-isotopic model was applied to these data, and simulations to predict the change in isotope ratio based on the amount of water lost from each sample were successful. This modelling approach, combined with daily and monthly sample collection and quantification of evaporation rates within the sheltered environment of the sampler allows for back calculation of the original volume and isotopic composition of daily and monthly rainfall samples. The rainfall sampler thus facilitates cost - and time - effective remote monitoring of the geochemistry of precipitation to support an array of Earth system research.

Preliminary results of the SISAL database

Laia Comas-Bru[1,2], Sandy P. Harrison[1,2], Andrew Lorrey[3], John-Mark Woolley[3], Bronwyn Dixon[1,2,4] Andy Baker[5], and SISAL group members

[1]School of Archaeology, Geography and Environmental Sciences, University of Reading, United Kingdom
[2]Centre for Past Climate Change. University of Reading, United Kingdom
[3]National Institute of Water and Atmospheric Research Ltd, Auckland, New Zealand
[4]School of Geography, University of Melbourne, Carlton, Victoria, 3053, Australia
[5]School of Biological, Earth, and Environmental Sciences, UNSW Sydney, Australia

Speleothems (cave carbonates) can provide highly resolved records of changes in both climate and atmospheric composition. These records have the potential to be used to document regional changes in mean climate and climate variability on annual to centennial timescales. They can also be used to refine our understanding of regional changes in climate forcings, such as dust and volcanic aerosols, through time. Many climate models now explicitly include isotopic tracers, and thus the isotopic records from speleothems have the potential to be used for model evaluation. Previous attempts to compile speleothem data have not provided a globally-comprehensive synthesis, nor have they provided assessments of measurement, chronological or interpretation uncertainties. SISAL (Speleothem Isotopes Synthesis and Analysis) is a new community-based working group sponsored by Past Global Changes (PAGES) to synthesise the 500+speleothem isotopic records available globally and develop a public-access database, that can be used both to explore past climate changes and in model evaluation. The first version of the SISAL database (Atsawawaranunt et al., 2018; https://doi.org/10.5194/essd-10-1687-2018) is the first global database of speleothem data containing a comprehensive array of metadata to allow quality control and reliability assessment of the records. This presentation will showcase the preliminary results of the SISAL database, with a focus on the current state of records in the Oceania region (Australia, New Zealand, Indonesia, and the Pacific Islands). New age modelling approaches allow for revision of regional master δ18O and δ13C records, as well as more detailed understanding of cave - and regional-scale speleothem stable isotope interpretations. This will facilitate further comparison between speleothem-derived palaeoclimate records and isotope-enabled climate models on regional and global scales.

Global distribution and controls on cave drip water oxygen isotope composition

Andy Baker[1] (a.baker@unsw.edu.au)

Andreas Hartmann[2,3], Wuhui Duan[4,5,1], Stuart Hankin[6], Laia Comas-Bru[7], Mark O. Cuthbert[8,1], Pauline C. Treble[6,1], Jay Banner[9], Dominique Genty[10], Lisa Baldini[11], Miguel Bartolomé[12], Ana Moreno[12] and Carlos Pérez-Mejías[12]

[1]Connected Waters Initiative Research Centre, UNSW Sydney, Sydney 2052, Australia.
[2]Faculty of the Environment and Natural Resources, University of Freiburg, Germany.
[3]Department of Civil Engineering, University of Bristol, UK.
[4]Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, 100029, China.
[5]CAS Center for Excellence in Life and Paleoenvironment, Beijing, 100044, China.
[6]Australian Nuclear Science and Technology Organisation, Lucas Heights 2234, Australia.
[7]School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland.
[8]School of Earth and Ocean Sciences, Cardiff University, Cardiff, UK.
[9]Jackson School of Geosciences, The University of Texas at Austin, USA.
[10]Laboratoire des Science du Climat et de l'Environment, CNRS, L'Orme des Merisiers, 91191 Gif-sure-Yvette Cedex, France.
[11]Dept of Geography, Durham University, South Road, Durham, DH1 3LE, UK.
[12]Dpto. de Procesos Geoambientales y Cambio Global, Instituto Pirenaico de Ecología-CSIC, Avda. Montañana 1005, 50059 Zaragoza, Spain.

The oxygen isotope composition of speleothems is a widely utilised paleoclimate proxy that is responsible for the current state-of-knowledge of past Asian monsoon dynamics, the timing of glacial-interglacial cycles, and the insolation control on inter-tropical convergence zone position, among other climate processes. Because speleothems are deposited by cave drip water, and this is derived from meteoric precipitation, it is critical to understand the empirical relationship between precipitation and cave drip water d18O. Here, we present the first global analysis, based on data from 148 drip sites, 38 caves, and five continents. Globally, drip water d18O is most similar to the amount-weighted precipitation d18O where mean annual temperature (MAT) is < 10 °C. For seasonal climates with MAT > 10 °C and < 16 °C, we demonstrate that drip water d18O records the recharge-weighted d18O. Our analysis implies that speleothems (formed in near isotopic equilibrium) are most likely to have d18O that directly reflect meteoric precipitation only in cool climates. In warmer and drier environments, speleothems will have a seasonal bias toward the precipitation d18O of recharge periods and, in some cases, the extent of evaporative fractionation of stored karst water. We highlight the implications of our analysis for the interpretation of oxygen isotope records in Australasian speleothems.

High-resolution stalagmite evidence of paleoclimatic change in Ethiopia around the last interglacial

Andy Baker[1],

Asfawossen Asrat[2], *, Melanie J. Leng[3], John Hellstrom[4], Gregoire Mariethoz[5], Ian Boomer[6], Dorothy Yu[7], Catherine N. Jex[8], John Gunn[6], Wuhui Duan[9]

[1]PANGEA Research Centre, School of Biological, Earth and Environmental Sciences, UNSW Sydney, Sydney, NSW 2052, Australia; and ARC Centre of Excellence for Australian Biodiversity and Heritage
[2]School of Earth Sciences Addis Ababa University, P. O. Box 1176, Addis Ababa, Ethiopiac
[3]NERC Isotope Geosciences Facility, British Geological Survey, Keyworth, UK; and School of Biosciences, University of Nottingham, UK
[4] School of Earth Sciences, University of Melbourne, Parkville, VIC 3052, Australia
[5]Institute of Earth Surface Dynamics, University of Lausanne, CH-1015, Switzerland
[6]School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, UKg Mark Wainwright Analytical Centre, UNSW Sydney, Sydney 2052, Australia
[7]ScienceNordic, Carl Jacobsens Vej 16, 2500 Valby, Copenhagen, Denmark
[8]Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China, 100029

Oxygen and carbon (d18O/d13C) isotope, growth rate and trace element data are reported for a U-Th dated, annually-laminated stalagmite, GM1 from Goda Mea Cave, Ethiopia. The stalagmite grew intermittently around the last interglacial. The proxy records are used to develop a conceptual growth model of the stalagmite and to assess its potential for revealing a climate signal in this climatically sensitive northeastern African region during an important period in the evolution of Homo sapiens and dispersal of Anatomically Modern Humans out of Africa. Speleothem deposition is of short-duration occurring at ~129 ka, ~120 ka, in an undated growth phase, and at ~108 ka; probably due to tectonic activity. d18O composition is very stable within growth phases (1s variability < 0.76‰), as are Mg/Ca, Sr/Ca and Ba/Ca, all indicative of wellmixed source-waters. A shift to positive d18O values and increased variability in Mg/Ca, Sr/Ca and Ba/Ca prior to growth hiatuses is observed, indicating a loss of the well-mixed water source prior to growth cessation. Mean d18O composition (–3.82 to –7.77‰) is lower than published modern and Holocene stalagmites from the region. Geochemical data, statistical analyses, and a conceptual model of stalagmite growth, demonstrate that climatic conditions recorded by GM1 were wetter than the Holocene. The ~129 ka growth phase particularly presents an annual record of the Intertropical Convergence Zone (ITCZ) migration. The GM1 record, the oldest high-resolution continental climate record from Ethiopia so far published, presents evidence that any early human migrations which occurred during MIS 5 are likely to have occurred during a wet event in northeast Africa.

GDGT distributions from soil to cave: refining the speleothem paleothermometer

Andy Baker[1]

Alison Blyth[2], Catherine N. Jex[1], James A Mcdonald[3], Martijn Woltering[4] and Stuart J Khan[1,3]

[1]Connected Waters Initiative Research Centre, University of New South Wales, NSW
[2]School of Earth and Planetary Sciences, Curtin University, WA 6845, Australia
[3]Water Research Centre, School of Civil and Environmental Engineering, University of New South Wales, NSW
[4]CSIRO Earth Science and Reservoir Engineering, Kensington WA 6151, Australia.

The GDGT paleothermometer has potential application as a speleothem paleoclimate proxy. However, the source of GDGTs found in speleothems is poorly understood, with multiple potential sources of GDGTs from the soil to the speleothem surface. Here we analyse GDGTs in soils, soil leachates, in-cave surfaces and cave drip waters at two Australian montane caves. We observe significantly different GDGT distributions between soils, soil leachates, in-cave surfaces and drip waters, and significant spatial differences in in-cave GDGT distributions. Comparison with published modern in-cave and karst groundwater GDGT datasets from Australia, Europe and China shows that speleothem GDGTs distributions are different from those of all potential sources. We hypothesise that speleothem surfaces have an oxic, wet, carbon-available energy environment that supports a microbial community that is different from other possible karst GDGT sources. We propose that the presence of GDGTs related to anoxic or methanogenic conditions (GDGT 0, GDGT III), and observed in cave drip water and in-cave surfaces, can be used to identify GDGTs from these sources. We confirm that TEX86 based paleothermometers are robust speleothem GDGT paleothermometers, whose calibration can be further refined through improved understanding and measurement of cave temperatures.

Boulder transport along the coast of Eastern Samar (Philippines) – Implications for Holocene extreme-wave events

Fabian Boesl[1,2] (fabian.boesl@gmx.de)

Max Engel[1,3], Rodrigo C. Eco[4], Jam A. Galang[5], Lia A. Gonzalo[6], Francesca Llanes[6], Eva Quix[1], Andrea Schröder-Ritzrau[7] and Helmut Brückner[1]

[1]Institute of Geography, University of Cologne, Cologne, Germany
[2]current affiliation: ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH), School of Earth and Environmental Sciences, University of Wollongong, Wollongong, Australia
[3]current affiliation: Geological Survey of Belgium, OD Earth and History of Life, Royal Belgian Institute of Natural Sciences, Brussels, Belgium
[4]National Institute of Geological Sciences, University of the Philippines Diliman, Quezon City, Philippines
[5]Geosciences Division, Mines and Geosciences Bureau – MIMAROPA Regional Office, Manila, Philippines
[6]NOAH Center, University of the Philippines Diliman, Quezon City, Philippines
[7]Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany

The Eastern Visayas region in the Philippines is significantly exposed to high-energy marine inundation events. It gets regularly hit by some of the strongest tropical cyclones on Earth, recently by Typhoon Haiyan (2013) or Typhoon Hagupit (2014), causing extreme waves at the coastline. The region is also closely located to the Philippine Trench and experienced several tsunamis in the historical past, therefore flooding through extreme-wave events represents a strong hazard to the coastal population. As there is not much known about frequency-magnitude relationships or maximum magnitudes of coastal flooding events over larger timescales, geological archives such as subaerial boulder deposits can derive information on occurrence patterns of extreme-wave events over centennial to millennial scale. To understand the mechanisms of boulder transport and the underlying extreme-wave events, we study a large boulder field in San Policarpo, Eastern Samar. A multi-temporal analysis of satellite images is conducted to quantify recent boulder movement during the typhoons Haiyan and Hagupit. In a systematic geomorphic mapping campaign, we recorded location, size, shape, morphological features and also lengths and orientation of the main axes of 269 boulder with a-axes between 1.5 m and 10.7 m to estimate spatial extent, height, velocity and direction of flow during extreme-wave events. The boulder field was also mapped by an unmanned aerial vehicle (UAV) to create Structure from Motion (SfM) models to improve inverse modelling of transport flows of recent and past events. A poorly developed exponential fining landward of the clasts and their landward distribution way beyond the limit proposed for storm boulders in literature suggest the occurrence of very strong events such as tsunamis or infra-gravity waves in the past. The latter were associated with Typhoon Haiyan elsewhere in Eastern Samar and locally shifted some of the largest boulders ever documented for storms. In order to date possible events, samples of post-depositional, secondary calcite flowstones and pre-depositional coral were taken for U-Th and 14C dating.

Density separation in pollen preparation: how low can you go?

Valerie van den Bos [1] (valerie.vandenbos@vuw.ac.nz)

Andrew Rees[1], Lisa Woods[2], Rewi Newnham[1]

[1]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, New Zealand
[2]School of Mathematics and Statistics, Victoria University of Wellington, New Zealand

Palynological methods have evolved over time, but there is little literature on some of the newer practices that are now considered standard, such as density separation. In a study on the Holocene-age sediments of Lake Pupuke, northern New Zealand, we find that varying the density of the heavy liquid used to separate pollen from the minerogenic fraction within the range of reported practice affects outcomes: when a relatively low density is used (2.0 g/cm3) buoyant pollen grains (such as Prumnopitys taxifolia and Dacrydium cupressinum) are overrepresented, while small, compact pollen grains (such as Libocedrus and Metrosideros) are underrepresented. Additionally, exotic Lycopodium spores (which are added to allow calculation of concentrations) are underrepresented, leading to calculated concentrations that are too high. This result should raise wider concerns, as heavy liquid densities reported in literature range from 1.88 to 2.1 g/cm3. We draw attention to this problem and recommend steps palynologists can take to ensure that their pollen assemblages are representative and do not lead to spurious interpretations.

SHeMax: A regional perspective on the timing of the Last Glacial Maximum in Australia

Haidee Cadd[1] (haidee.cadd@adelaide.edu.au)

Lynda Petherick[2], Jonathan Tyler[1], Annika Herbert[3], Timothy Cohen[4], Timothy Barrows[4], Justine Kemp[5], Reka Fulop[4], Kale Sniderman[6], James Shulmeister[7], Jasper Knight[8]

[1]Department of Earth Sciences and Sprigg Geobiology Centre, University of Adelaide, SA, Australia
[2]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, New Zealand
[3]Department of Biological Sciences, Macquarie University, NSW, Australia
[4]School of Earth and Environmental Sciences, University of Wollongong, NSW, Australia
[5]Australian Rivers Institute, Griffiths University, QLD, Australia
[6]School of Earth Sciences, University of Melbourne, VIC, Australia
[7]School of Earth and Environmental Sciences, University of Queensland, QLD, Australia
[8]University of the Witwatersrand, Johannesburg, South Africa

It has long been hypothesised that the Last Glacial Maximum (LGM) in Australia occurred over multiple stages and at different times geographically, however this hypothesis has yet to be tested objectively. Such an objective comparison is complicated by several factors, including variety in the sedimentary archives, palaeoenvironmental tracers and dating techniques employed. In addition, recent refinement of the Southern Hemisphere radiocarbon calibration curves, plus advances in Bayesian age modelling and time-uncertain time series methods requires an approach that treats all data consistently. In order to gain a greater understanding of the timing of changes during the LGM period we have compiled proxy records of climate variability from across Australia to examine spatial and temporal patterns of climate change during the period 35 – 15 ka. Continuous records covering at least 10,000 years, as well as discontinuous records of fluvial and glacial activity were selected for inclusion in the synthesis. For each record, a revised age-depth model was developed using Bayesian age modelling techniques. A Principle Curve was fitted through compositional community data (ie. pollen data) records to provide a non-linear summary of patterns of change in the full data-set. Monte-Carlo change point analyses of each proxy record was then used to identify the timing of major changes within each record, along with the uncertainty around that date. Here we focus on the pollen records in our database. We assess the spatial heterogeneity of the timing of the major climatic changes during the LGM period 35 – 15 ka according to these pollen records, and determine the probability of common timing of change for Australia. Explicitly incorporating the age uncertainties associated with each record allows for a more robust interpretation of synchronous periods of change. Further expansion of our analyses to include multiple proxy records will allow interrogation of both spatial and temporal synchronicity and coherency of the most recent and extreme climate and hydrological changes in Australia.

Sulphur: a proxy for wildfires in stalagmites

Katie Coleborn[1] (k.coleborn@unsw.edu.au)

Andy Baker[1], Pauline Treble[1,2], Peter Wynn[3]

[1]School of Biological, Earth and Environmental Sciences, UNSW Sydney, Kensington, NSW 2052 Australia
[2]ANSTO, Lucas Heights, NSW 2234 Australia
[3]Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, UK

Bushfires are a global hazard that can have catastrophic impacts on communities and ecosystems. However, there is limited baseline data on how fire frequency and intensity have responded to climate change in the past. A speleothem-based bushfire record will allow us to determine long-term natural fire regimes and better understand the relationship between bushfires and climate. Recent research has demonstrated the potential of using sulphur as a speleothem paleofire proxy1 but a full characterisation of S in the karst environments of SW Western Australia is lacking. Here, we quantify the relative contributions of different sources of sulphur in a modern cave environment through the characterisation of rainfall, soil, bedrock, vegetation and cave drip water sulphate concentration and isotopic values (δ18O- SO4 and δ34S- SO4) to assess the role of sulphur cycling through the biomass in response to burn events at this site. This information will be used to interpret the SO4 isotope record, supported by other proxies in a 2-12 ka speleothem from SW Western Australia. This is the first speleothem SO4 isotope study in the southern hemisphere and the first in the world to use speleothem S isotopes in a paleofire context.

[1] Treble, P.C., Fairchild, I.J., Baker, A., Meredith, K.T., Andersen, M.S., Salmon, S.U., Bradley, C., Wynn, P.M., Hankin, S.I., Wood, A., McGuire, E., 2016. Roles of forest bioproductivity, transpiration and fire in a nine-year record of cave dripwater chemistry from southwest Australia. Geochim. Cosmochim. Acta 184, 132–150.

Carbon Cycle Changes in the Deep Southern Ocean during the Last Deglacial Period

Yuhao Dai[1] (yuhao.dai@anu.edu.au)

Jimin Yu[1], Zhangdong Jin[2], Bradley Opdyke[1]

[1]Research School of Earth Sciences, The Australian National University, Canberra, ACT 2601, Australia
[2]Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710061, China

The mechanism for the atmospheric carbon dioxide concentration (pCO2) rises of about 100 parts per million (ppm) during deglacial periods is not fully understood. The Southern Ocean has been suggested to significantly contribute to the deglacial pCO2 rise by releasing carbon sequestered in the deep ocean. However, to date, there are few palaeoclimate reconstructions for the deep Southern Ocean carbon cycle changes. Here, we present multi-proxy records from a sediment core in the South Tasman Rise at 3.3 km. We demonstrate that during two major pCO2-increasing periods (Heinrich Stadial 1 and Younger Dryas), dissolved inorganic carbon in the deep Southern Ocean decreased, possibly due to changes in biological pump efficiency. Our data provide crucial evidence for the deep Southern Ocean's role in the deglacialpCO2 rise.

Utilizing GPR, OSL, and LiDAR (GOaL) to infer climate variations from raised beach ridges around Lake George

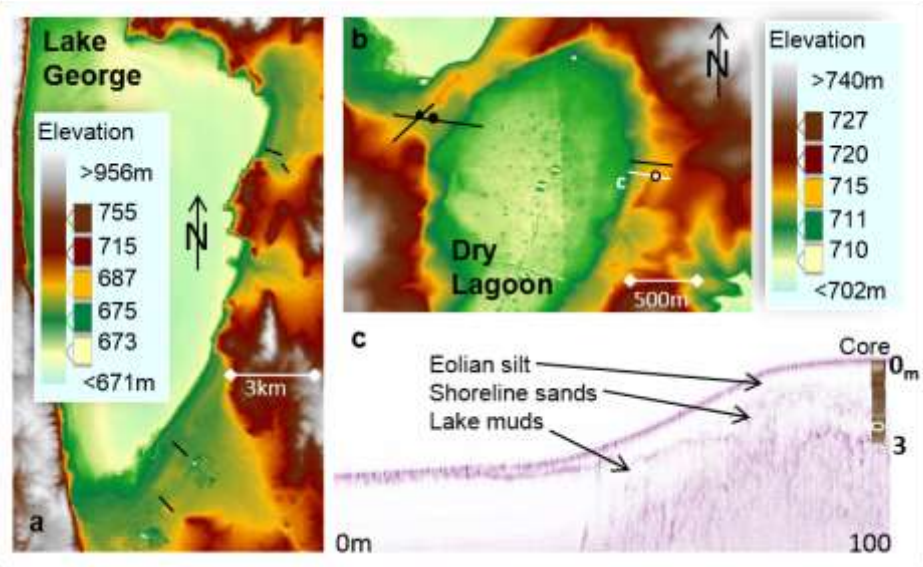
Amy Dougherty[2] (adougher@uow.edu.au)

Brad Pillans[1], Alexander Francke[2], Tim Cohen[2], Nathan Jankowski[2], Iain McCulloch[1] and Anthony Dosseto[2]

[1]Research School of Earth Sciences, Australian National University, Canberra

[2]School of Earth and Environmental Sciences, University of Wollongong, Australia

Lake George provides one of the most complete archives of long term climate history in south eastern Australia. Its ephemeral nature over historic and geologic timescales has intrigued local and scientific communities alike. In closed lake systems, variation in water volumes is driven by precipitation and evaporation. Beach ridge deposits are an ideal proxy for reconstructing past lake levels as their location indicates the position of paleo-shorelines. Therefore, a series of beach ridges can be regarded as a natural hyetometer and detailed studies of these features can provide proxy data for relative change in precipitation linked to climate. Combining high-resolution geophysics, geochronology, and remote sensing techniques offers an optimal way to extract these records. These methods include: 1) Light Detection and Ranging (LiDAR) to identify and map beach ridges in three dimensions, 2) Ground Penetrating Radar (GPR) to image their stratigraphy and subsurface extent, and 3) Optically Stimulated Luminescence (OSL) to date the deposition of these paleo-shorelines. A combined GPR, OSL, and LiDAR (GOaL) dataset of beach ridges at Lake George and Dry Lagoon (located ~20km to the north) is currently being constructed. Here we present preliminary data acquired for this study. The LiDAR data was collected and processed by Geoscience Australia for this project. Digital elevation models of 1m and 5m resolution delineate a series of beach ridges at both Lake George and Dry Lagoon (Figure). Within GPR profiles stratified shoreline sands produce a medium amplitude signal with dipping reflections representing the beach ridge stratigraphy. Underlying and in between the beach ridges, there is a strong, flat-lying to undulating reflection below which the signal attenuates. This reflection represents fine-grained lacustrine sediments deposited on the lake floor. Most beach ridges are overlain by a low-amplitude, homogenous signature that represents a massive bed of uniform eolian silt. Beach ridges proximal to bedrock promontories display a distinct geophysical signature as individual rocks incorporated in or on top of the shoreline sands cause ringing displayed in the data as hyperbolae.Figure: a) Lake George 5m LiDAR. b) Dry Lagoon 5m LiDAR. Note lines represent GPR transect locations. c) Sample of GPR data with core overlay (white circle indicates sample targeted for OSL).



Hearth investigations at Lake Mungo using FTIR analysis and soil micromorphology

Megan Ensor[1] (mre483@uowmail.edu.au)

Nathan R. Jankowski[1], Zenobia Jacobs[1], Nicola Stern[2]

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, NSW
[2]Department of Archaeology and History, La Trobe University, Bundoora, VIC 3086, Australia

Lake Mungo in western NSW is home to some of the earliest and most significant archaeological sites in Australia. This unique landscape not only provides insights into the everyday lives of people living within the region, but also provides a record of both environmental change and how these people interacted with, and adapted to, this changing environment. Several in-situ hearth features have been exposed by gully erosion within the crescentic, source-bordering dune (or lunette) on the eastern side of the lake. Although considered hearths, no systematic investigation of their physical structure and heating histories has been undertaken. Fourier transform infrared (FTIR) spectroscopy and soil micromorphological techniques were used to test this assumption by examining their heating histories and physical structure.In this poster we present preliminary results from our soil micromorphological and FTIR investigation of selected excavated hearth blocks from Lake Mungo. The heating histories of the hearth features were investigated by examining the FTIR spectra from the fine fraction (< 90 μm) subsampled systematically through the hearth itself and the underlying sediments in 5 mm increments. These spectra were then compared to those produced from a controlled heating experiment to obtain an estimate of likely heating temperature. Thin sections were then examined using soil micromorphological techniques to determine the physical structure and identify the processes of formation both during and following deposition. The combined results provide higher resolution insights into the formation processes responsible for these feature beyond macroscopic observations. This research forms part of the ongoing ARC funded Mungo Archaeology Project (MAP).

Dripwater monitoring and calcite farming experiments as a key to interpret the paleohydrological record in stalagmites from Atiu caves (Cook Islands)

Mohammadali Faraji[1] (mohammadali.faraji@uon.edu.au)

Silvia Frisia[1], Andrea Borsato[1], Adam Hartland[2], John Hellstrom[3], Garry K. Smith[4]

[1]School of Environmental and Life Sciences, University of Newcastle, Australia
[2]School of Science and Engineering, University of Waikato, Hamilton, New Zealand
[3]School of Earth Sciences, The University of Melbourne, Australia
[4]Newcastle & Hunter Valley Speleological Society, Newcastle, Australia

Stalagmite records from tropical Pacific Islands can provide information on the position and intensity of the South Pacific Convergence Zone (SPCZ) and changes in the regional ocean-atmospheric circulation. Having the present as the key to the past, we monitored calcite precipitation under several drip systems in two caves on Atiu (Southern Cook Islands) developed within highly porous Pleistocene reef limestone, in order to provide a robust benchmark for the interpretation of the paleoclimate signal encoded in the stalagmites. Temperature, relative humidity, air pCO2, drip rates and dripwater hydrochemistry were monitored/measured at different drip sites and compared with the local temperature and rainfall record. This latter exhibits a strong seasonality with 70% of the mean Total Annual Rainfall (TAR = 1930±365 mm/yr) occurring from December to May. The studied sites vary between fast/variable and slow/constant drip rate end members, and the corresponding active forming stalagmite fabrics vary from translucent compact columnar calcite reflecting constant drips and low-impurity content to opaque porous calcite reflecting variable drip rates and/or a higher load of impurities. High and stable cave temperature (~23°C), and high drip water mineralization are responsible for high saturation with respect to calcite and fast calcite precipitation within the two caves. Moreover, the results from the calcite farming experiment suggest that fabrics are indeed influenced by driprates and dripwater composition while no calcite precursors such as vaterite or aragonite, which may influence fabric and trace element incorporation, were detected. These conditions make the studied caves a perfect platform to test the seasonal incorporation of palaeohydrological proxies such as trace elements and calcite fabric in stalagmites, and offer the opportunity to develop robust quantitative transfer functions between the studied proxies and the actual infiltration. This information will be eventually utilised to extrapolate paleohydrological data from Atiu's stalagmites in order to investigate rainfall amount and seasonality during the Holocene as a result of changes in the position and/or intensity of the SPCZ.

A high-resolution multi-proxy palaeoecological record of the last two glacial cycles from Lake Selina, Tasmania.

Michael-Shawn Fletcher[1]

Agathe Lise-Pronovost[2], Michela Mariani[1], Feli Hopf[3], Patricia Gadd[4], Henk Hiejnis[4]

[1] School of Geography, University of Melbourne
[2] School of Earth Sciences, University of Melbourne
[3] Archaeology and Natural History, Australian National University
[4]Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights, Australia

Here we present the results of a continuous high resolution multi-proxy data set spanning the last two glacial cycles (ca 230,000 years) from Lake Selina, Tasmania. The data set includes pollen, charcoal, geochemistry and magnetic properties. We compare and discuss ecological trends between the Last Interglacial and the Holocene, reflecting on the role of people in radically altering the vegetation landscape. We also present tantalising data suggesting a possible Antarctic Cold Reversal-like shift through the penultimate Glacial Termination (T2).

What determines resilience to fire in Tasmanian montane rainforest? - A novel application of palaeo- and neo-ecological approaches to a critical problem.

Michael-Shawn Fletcher[1] (michael.fletcher@unimelb.edu.au)

Michela Mariani[1],Haidee R Cadd[2], David DMJS Bowman[3], Simon G Haberle[4], Hahjung Chin[4]

[1]School of Geography, University of Melbourne
[2]School of Physical Sciences, University of Adelaide
[3]School of Natural Sciences, University of Tasmania
[4]Archaeology and Natural History, Australian National University

Recent catastrophic wildfires in the Tasmanian highlands herald a significant threat to the future of endangered fire-sensitive ecosystems. One such ecosystem is the montane rainforest community dominated by Athrotaxis spp. and Nothofagus gunnii, an endemic and hyper fire sensitive rainforest community that occupies upper-montane areas of this topographically complex island. Wildfires following the British invasion have reduced the distribution of montane rainforest by around 50%, and there is little evidence for post-fire recovery of these systems. Here, we use palaeoecology, species distribution modelling and remote sensing to unpack the various factors governing the resilience of this community to fire. We draw on the concepts of “relaxation time” and “extinction debt” to argue that climate change over millennia has acted as a press disturbance that has reduced the resilience of this ecosystem to pulse disturbance events. Further, we contend that both landscape heterogeneity in complex topographic landscapes and flammable species invasion can over-ride the effects of regional climate on ecosystem dynamics and resilience to fire in rainforest systems. We argue that Holocene and projected climatic change (drying and warming) acts to decrease the rate of recovery of rainforest from disturbance by fire, thus, bringing these ecosystems closer to points of critical transition (i.e. tipping points of collapse). Whether a critical transition occurs is, at least in part, dependent on the presence or absence of species that can initiate positive feedbacks that can shift an ecosystem to an alternate state. We conclude with a provocation: should we say goodbye to Gondwanan forests in Australia or should we use this data to focus our efforts in areas of greatest reward for effort?

Reconstructing a palaeoenvironmental record for the LGM period – sedimentary analysis of the Riverine palaeochannels

Matt Forbes[1] (mforbes@uow.edu.au)

Tim Cohen[1,5], Daniella Mueller[2], Nathan Jankowski[1], Felicitas Hopf[1,3], Simon Haberle[1,3], Zenobia Jacobs[1,6], Michael Bird[1,4].

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, Wollongong, NSW.
[2]Institute for Earth and Environmental Sciences, Albert-Ludwigs-Universitat, Germany.
[3]College of Asia and the Pacific Australian National University, Canberra, ACT.
[4]Centre for Tropical Environmental and Sustainable Studies, James Cook University, Cairns, QLD.
[5]GeoQuest Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW.
[6]Centre for Archaeological Science, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW.

Palaeochannels associated with the Riverine Plain NSW, Australia provide evidence of past runoff conditions throughout the last glacial cycle during the generally cold and often inferred to be dry Last Glacial Maximum (LGM; 20-17 ka BP). OSL and TL dating of fluvial deposits (Mueller et al. 2018) of the Yanco (41-29 ka BP) and Gum Creek (29-18 ka BP) palaeochannels suggest that these periods were times of increased discharge. Despite better constraints on the timing and nature of runoff, little evidence exists for whether the plains were forested in these periods of elevated runoff. Pollen analyses in five different stratigraphic profiles highlight that preservation is restricted to the Holocene age, upper 2-3 m of fine organic sediment that caps the LGM channel deposits. Below this depth poor to no pollen preservation exists. Over this same depth interval Total Organic Carbon (TOC) content drops from 1-4% to below 0.1% and is generally below 0.05% in the fluvial and basal fine sediments. Comparisons of pollen components between the surface and 2-3 m depth intervals in the Gum Creek facies identifies a shift from dominance by Poaceae to Eucalytpus. □13Csom analysis is predominantly C3 signature (-28‰ and -22‰) across the same interval. C4 vegetation estimations suggests that grass contributions to the overall Riverine vegetation mosaic decreased by 10-30% across the Holocene. Hence, we suggest that since these periods of elevated discharge that the Riverine Plain experienced a period of landscape stability across the Holocene where a more open vegetation mosaic with a high representation of grasses was replaced by woodlands and forests. On-going OSL chronological analysis will confirm the exact time frame of this vegetation shift across the sites.

Mueller, D., Jacobs, Z., Cohen, T.J., Price, D.M., Reinfelds, I.V., Shulmeister, J., 2018 Revisiting an arid LGM using fluvial archives: a luminescence chronology for palaeochannels of the Murrumbidgee River, southeastern Australia. Journal of Quaternary Science. In Press

Exploring sediment dynamics from source to sink in the Murray-Darling basin using cosmogenic 14C, 10Be, and 26Al

R-H. Fülöp[1,2] (rfulop@uow.edu.au)

A.T. Codilean[2], S. Marx[2], Cohen, T.[2], D. Fink[1], B. Yang[1], A. Smith[1], K. Wilcken[1], T. Fujioka[1], L. Wacker[3], T.J. Dunai[4]

[1]Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights NSW, Australia
[2]School of Earth and Environmental Sciences, University of Wollongong, 2522, Wollongong, Australia
[3]Institute of Geology and Mineralogy, University of Cologne, 50674 Cologne, Germany
[4]Ion Beam Physics, ETH Zürich, 8093 Zürich, Switzerland

The relatively short half-life of 14C, namely, 5730 years, means that, compared to the other cosmogenic nuclides, it is substantially more sensitive to short term variations in process rates. Both the erosion of steep mountains and the dynamics of sediment transport, storage and recycling occur over timescales that are too short to be detectable by the cosmogenic nuclides that are currently used routinely, namely 10Be and 26Al. In situ 14C on the other hand is ideally suited for these short timescales, and used in combination with 26Al and 10Be, it will allow for rapid fluctuations in process rates and/or the relatively short timescales that characterise sediment transfer and storage to be measured accurately. The above make in situ 14C an important addition to the cosmogenic radionuclide toolkit. We present results of in situ cosmogenic 14C system blank and calibration sample measurements obtained with the recently established ANSTO/UOW in situ 14C extraction system. The 14C extraction scheme follows the design of the University of Cologne, which exploits the phase transformation of quartz to crystobalite to quantitatively extract the carbon as CO2. Offline high-temperature furnace extraction allows a relative rapid sample throughput and can accommodate samples ranging between 0.5 to 4 grams of clean quartz. Following extraction and isolation, the CO2gas is graphitised using a micro-furnace and then measured using AMS similarly to routine small radiocarbon samples. We also present results of 14C, 26Al, and 10Be analyses from sediment samples collected from Australia's largest river system, the Murray-Darling basin. We use the downstream changes in the ratios of the three radionuclides in samples collected at key locations along the rivers to quantify sediment mixing and sediment storage times in the river basin. Substantial 26Al/10Be 'burial' signal is observed in downstream Murray and Darling samples, while in situ 14C suggests complex burial-exposure histories in these samples. This could have implication of interpreting geochemical proxies at the outlet of Murray-Darling Basin for identification of paleo-climate driven sediment sources (i.e. Monsoon vs. Westerlies).

A new record of human settlement and past environmental change of the Comoros, far western Indian Ocean

Haberle, S.G.[1,2] (simon.haberle@anu.edu.au)

Rule, S.[1,2], Roberts, G.[2,3]

[1]Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University, ACT, Australia
[2]ARC Centre of Excellence for Australian Biodiversity and Heritage, Australian National University, Canberra, ACT, Australia
[3]Indigenous Studies Centre, Monash University, Clayton, Victoria 3800, Australia

As humans have colonized new places, they often initiate dramatic environmental change, even in the distant past. On remote islands, where levels of endemism are high, species and environments are often particularly vulnerable to the effects of introduced species like humans, and the plants and animals they deliberately or accidentally bring with them. The first study of the environmental history of the Comoros, a volcanic archipelago in the far western Indian Ocean, was conducted in 2016 in order to test the hypothesis that the Comoros were stepping stones for prehistoric human migration from east Africa to Madagascar. This research will contribute to our understanding of patterns and chronologies of human colonisation, as well as the environmental impacts that humans have had. The pollen and charcoal records show dramatic changes in vegetation and fire regimes in the last 1500 years that are best explained through the influence of human settlement. Such studies of the past are extremely useful for better understanding and mitigating the effects of human-induced environmental change today.

Understanding the Effect of Climate Variability on Forest Composition: A case study of four co-occurring pine species on Norumbega Mountain, Acadia National Park, Maine, U.S.A.

Haines, Heather A.[1] (h.haines@griffith.edu.au)

Muñoz Delgado, Bethany L.[2], Rooney, Molly[3], Foard, Meghan, B.[4], Stotts, Stephanie, N.[5,6,7], van Akker, Lara[8], Brown, Peter M.[9]

[1]Australian Rivers Institute, Griffith University, Brisbane, Australia
2 U.S. Forest Service, Northern Research Station, Maine, USA
3 Department of Forestry, University of Missouri, Columbia, Missouri, USA
4 Department of Water Resources, University of Idaho, Idaho, USA
5 Wesley College, Delaware, USA
6 Delaware Space Grant Consortium, University of Delaware, Delaware, USA
7 Delaware EPSCoR, Delaware Environmental Institute, Delaware, USA
8 Canadian Forest Service, Pacific Forestry Centre, British Columbia, Canada
9 Rocky Mountain Tree-Ring Research, Inc., Fort Collins, Colorado, USA

The forest ecotones of the northeastern U.S.A. are ecologically sensitive areas that consist of tree species which are known to be affected by changes in climatic conditions. The 2015 North American Dendroecological Fieldweek Climate II Group targeted a high elevation site on Norumbega Mountain in Acadia National Park to analyse climate-growth relationships over the past century of four co-occurring pine species: pitch pine (*Pinus rigida*), jack pine (*P. banksiana*), red pine (*P. resinosa*), and white pine (*P. strobus*). This site is unique as it sits at the northernmost limit of pitch pine and the southernmost limit of jack pine, allowing for an opportunity to understand how climate is affecting these four species at this single location, and how future climate scenarios may change the species distribution. A total of 134 tree cores from 62 trees across the four target species were dendrochronologically analysed for their climatic relationships. Results indicate that for all species growth is a response to temperature conditions while increasing early season temperatures were favoured by pitch, jack, and red pine. Pitch and red pine also were negatively affected by drought conditions during the growing season. The climate-growth relationships were generally found to be stable through time; however, the drought signal in red pine had a marked shift in the middle of the 20th century. Gall rust infestations were also seen on a subset of the jack pine trees which complicates management of this species into the future. Results from this study indicate that under current climate conditions white pine is the dominant tree species at this site, but under predicted warmer and drier future climate scenarios pitch and/or red pine are likely to become dominate at this site.

An integrated palaeoenvironmental record of industrial pollution within Angkor Thom, Angkor.

Tegan Hall[1] (tegan.hall@sydney.edu.au)

Dan Penny[1], Brice Vincent[2], Martin Polkinghorne[3]

[1]University of Sydney
[2]Ecole française d'Extrême-Orient
[3]Flinders University

Between the late 14th and 15th centuries C.E., severe climate stress drove the political elite from Angkor – the administrative and ceremonial hub of the ancient Khmer kingdom in Southeast Asia – toward smaller port cities south of the Tonle Sap lake. The nature and timing of this migration remains contested however, and recent research suggests that urban populations persisted at Angkor beyond its political abandonment. This paper presents a multi-proxy analysis of environmental change from Angkor Thom, the 12th century citadel located in the heart of Angkor, to reconstruct land use history during this transition. We utilize geochemistry, palynology, sedimentology and fire history records to reveal a distinct period of elevated metal pollution between c. 1300 and 1600 C.E., demarcated particularly by several episodes (c. 1320, 1470, 1494, and 1540 C.E) of elevated concentrations of lead and copper in the sediment archive. These results reveal periods of artisanal activity within the ceremonial core of Angkor Thom that can be linked to known sites of copper-based metallurgy adjacent to the Royal Palace in Angkor Thom. Palaeoecological results also reveal that the attenuation of land management, potentially for urban or agricultural uses, and the recovery of secondary forest within the city was less abrupt than the wholesale migration of an urban population would suggest. Together, these results imply that the decline of Angkor was protracted and complex, and that activity in these ateliers continued uninterrupted throughout this period of supposed demise of the city, in keeping with industrial metal working in other Khmer centres during this period.

SpeciCount: A web application for counting and analysing palaeoecological data

Niven, A.[1]

Brown, P.[1], Knill, M.[1], Wagener, E.[1], Wang, Z[1]., Lu, K.[1], Sekoranja, J.[1], Stevenson, J.[2], Proske, U.[2], Hamilton, R.[2]

[1]College of Engineering & Computer Science, The Australian National University, Acton, ACT, 2601, Australia
[2] School of Culture, History & Language, College of Asia & the Pacific, The Australian National University, Acton, ACT, 2601, Australia

Pollen analysis – a technique used in palaeoecology, pollination biology and immunology – is a multistep process requiring the description, identification and enumeration of plant microfossils on microscope slides, and manual entry of these data into analytical software for graphing and statistical analysis. Over recent years, attempts have been made to streamline this workflow though automation of pollen identification using image recognition technology. While these techniques have proven successful for enumeration and analysis of datasets with fewer than ~20 taxa, they are not yet applicable to more complex (i.e. diverse or degraded) pollen assemblages. Furthermore, many palynologists do not have access to either the technology or the necessary reference datasets necessary to incorporate image recognition techniques into their workflow. Consequently, there is still a heavy reliance on traditional techniques for the enumeration and analysis of plant microfossils. SpeciCount is a web based app, developed using php and MySQL database, designed to optimise the workflow for pollen analysis. This is achieved through providing a single, user-friendly platform for:1) the efficient upload, description and cataloguing of different pollen taxa using consistent, searchable tags;2) counting pollen taxa and exporting datasheets;3) numerical and statistical analysis of the resultant datasets, including generation of a species accumulation curve, which permits rapid assessment of taxonomic diversity in real time, and;4) easily sharing projects and catalogued pollen taxa between project collaborators. The design of SpeciCount is such that it can be easily reconfigured for use in other applications, particularly for other ecological/ paleoecological studies. SpeciCount is free to use and accessible http://www.specicount.anu.edu.au/.

Late Glacial and Holocene Palaeoecology of the Lake St Clair Region, Tasmania

Feli Hopf[1] (felicitas.hopf@anu.edu.au)

Simon Haberle[1]

[1]Australian National University

Deglaciation of Lake St Clair was complete by c. 18.3 cal kyr BP and subsequent replacement of an early mosaic of alpine vegetation types, by subalpine Athrotaxis cupressoides and Diselma archeri dominated rainforest and/or woodland in response to rapidly rising temperatures and precipitation, is in sync with postglacial Antarctic warming and rising sea surface temperatures. A 900-year period of renewed grassland expansion is inferred to represent slightly cooler/drier conditions leading into the Antarctic Cold Reversal, abruptly ended by strong increases in rainforest mid-way through the Antarctic Cold Reversal suggesting a shift to a wetter and warmer climate leading to the establishment of *Phyllocladus aspleniifolius-Nothofagus cunninghamii* rainforest. The abrupt decline in *Phyllocladus aspleniifolius* at c. 12.4 cal kyr BP marks the expansion of Nothofagus cunninghamii-*Atherosperma moschatum* callidendrous rainforest growing under optimal conditions during the Early Holocene, which becomes more complex between c. 10-8 cal kyr when *Phyllocladus aspleniifolius* returns to high values, together with a secondary peak of *Athrotaxis/Diselma* under an inferred wetter and warm climate. At c. 8 cal kyr BP, the rainforest taxon *Anodopetalum/Eucryphia* becomes important and the remainder of the Holocene sees an overall decline in rainforest taxa and increase in sclerophyll and herbaceous taxa and fire activity, which intensifies during the late Holocene. The observed changes in the record are consistent with the onset of ENSO and a more variable climate from c. 8 cal kyr BP and an intensification and cooling temperatures from c. 5 cal kyr BP.

Deep Atlantic Carbon Sequestration during Last Glacial Inception

Xuan Ji[1] (u5897626@anu.edu.au)

[1]The Australian National University

The concentration of atmospheric carbon dioxide dramatically declined during the last glacial inception at around 116 to 108 thousand years ago (ka). The carbon lost from the atmosphere is thought to be stored in the deep ocean. However, evidence for the carbon inventory increase in the deep ocean is limited for this time period. In this study, deep Atlantic Ocean carbonate ion concentration are reconstructed using B/Ca ratios of benthic foraminiferal shells from sediment core MD95-2039. Based on carbonate ion reconstructions, carbon sequestration in the deep Atlantic Ocean is quantified. It is found that carbonate ion concentrations in the deep Atlantic Ocean decreased by around 18 µmol/kg from 116 ka to 108 ka. This carbonate ion concentration decrease indicates at least about 31 Gigaton of carbon was sequestered in the deep Atlantic Ocean, equivalent to around 16 ppm carbon dioxide drop in the atmosphere. This suggests that for the 40-ppm decline of atmospheric carbon dioxide, at least 40% of carbon lost from the atmosphere was sequestered in the deep Atlantic Ocean during the last glacial inception.In addition, three hypotheses that may result in carbon sequestration were tested in this study. Firstly, ocean circulation changes were tested using an ocean circulation proxy neodymium isotopes (εNd). Secondly, changes of biological pump efficiency were evaluated using reconstructed nutrient and oxygen levels based on benthic foraminiferal Cd/Ca and U/Mn ratios, respectively. Thirdly, the efficiency of solubility pump was deduced using reconstructed bottom water temperatures from two temperature proxies (benthic oxygen isotopes and Mg/Ca ratios). The results suggest that the solubility pump was likely to be the major reason for the carbon sequestration in the deep Atlantic Ocean, while the ocean circulation and biological only played a relatively minor role in the carbon sequestration during the last glacial inception.

Problems with normalising scanning micro-XRF data for palaeoclimate use

Christopher Kemp[1] (christopher.kemp@adelaide.edu.au)

[1] University of Adelaide

Scanning micro-XRF systems such as Itrax and Avaatech are increasingly used to determine the concentration of elements in sediments. Common applications include measuring the level of detrital or aeolian input into wetlands, defining changing detrital sources for river systems, and identifying tephra layers in sediment for follow-up analysis.While the relative concentration of elements within sediments can be defined by micro-XRF analysis (after correcting for the closed-sum effect), the bulk of studies published during the past ten years have not attempted any form of normalisation. Instead, many records continue to infer changing climate from uncorrected micro-XRF records, which vary due to elemental dilution as well as sediment water and organic content. Similarly, while many normalisation methods have been proposed to improve micro-XRF data correlation with verifying WD-XRF or ICP-MS, there is little agreement as to the best method. This poster establishes a brief history of the use of scanning micro-XRF technologies on sediment cores during the past ten years and introduces several of the established correction techniques. A case study using sediment cores from Fern Gully Lagoon, North Stradbroke Island, is used to discuss the differences found when utilising eight established correction methods for Itrax data by verification with 20 WD-XRF samples. The case study indicates that many of the established correction methods result in poor correlation with the verified quantities of elemental oxides within the sediments. In highly organic sediments, there appear to be only a small number of light elements (including Zr, Si, Ca, K, Ti, Br, Ca and S) that can be accurately inferred. Similarly, poor correlation between the widely used Itrax proxy for organic content (incoherent/coherent scatter) and organic matter determined by loss on ignition indicates that incoherent/coherent scatter should be used with caution.

Sedimentation and vegetation change through the last glacial cycle at Echo Lake, Fraser Island.

Justine Kemp[1] (j.kemp@griffith.edu.au)

Henk Heijnis[2], Maureen Longmore[3,4], Patricia Gadd[2], Nigel Spooner[4], Danielle Questiaux[4]

[1]Australian Rivers Institute, Griffith University, Nathan, Qld 4111;
[2]ANSTO, Lucas Heights, NSW, 2234
[3]Department of Geography, University of Adelaide, Adelaide, 5005
[4]Research School of Pacific and Asian Studies, The Australian National University, Canberra, 0200

Echo Lake is an ephemeral swamp perched above the groundwater table within the subtropical dunes of Fraser Island at 100 m above sea level. A 12 metre core was extracted in 1997-1998, with preliminary pollen analysis and dating suggesting the site preserved a palaeoenvironmental record beginning at 2 ka and spanning most of the last glacial cycle. However, the chronology has been problematic and sedimentation may have been interrupted or lost through drying and burning of the surface. Radiocarbon and optically stimulated luminescence (OSL) dating suggested an age for the base of the sedimentary sequence of at least 100 ka. Here we present a new chronology based on OSL on lake sediments together with ITRAX-XRF proxies for palaeoenvironmental change.

Independent Bayesian age modelling in subtropical wetlands to assess the influence of global climate drivers across Australia

Lewis R[1,2] (richard.lewis@adelaide.edu.au)

Tibby J[2,3], Arnold L[1,2], Barr C[2,3], Marshall J[4], McGregor G[4], Gadd P[5]

[1]Department of Earth Sciences, University of Adelaide, North Terrace, South Australia, 5005, Australia
[2]Sprigg Geobiology Centre, University of Adelaide, North Terrace, South Australia, 5005, Australia
[3]Department of Geography, Environment and Population, University of Adelaide, North Terrace, South Australia, 5005, Australia
[4]Queensland Department of Environment and Science, GPO Box 5079, Brisbane, Queensland, 5078, Australia
[5]Australian Nuclear Science & Technology Organisation, Lucas Heights, Australia

Rigorously dated, continuous sedimentological records capturing multiple glacial/interglacial cycles are important for evaluating the magnitude and range of drivers influencing ecosystem change in Australia. Multi-proxy palaeoenvironmental reconstructions are commonly used to identify changes in long-term environmental conditions, particularly when exploring the climatic backdrop to Australia's large scale faunal extinctions. However, interpretations of these records may not be straightforward as local and regional climate signals are often mixed in proxy records. In order to evaluate whether improved temporal constraint can help with differentiating such convoluted signals, thereby increasing the confidence placed in the role of teleconnections across the Southern Hemisphere, we present a comprehensively dated 12.7 m (basal age ~130 ka) wetland core consisting of 21 optically stimulated luminescence and seven radiocarbon ages from North Stradbroke Island. The amalgamation of stratigraphic information and independent age constraints within a Bayesian framework, highlights the complex depositional history of Welsby Lagoon between late MIS 5 and MIS 2. ITRAX core scanning data reveals fluctuations in elemental abundance through time, in particular the decrease in the amount of aeolian sediment following MIS 3. Variability is attributed to regional environmental regime changes controlled by global drivers, including Heinrich events, and the influence of moisture across mainland Australia. The comprehensive dating approach undertaken at Welsby Lagoon highlights the role that the terrestrial palaeoenvironmental records of North Stradbroke Island can play in assessing long-term climate drivers across continental Australia, without relying exclusively on isotopic tuning of remote (ice core or marine) records.

Scientific drilling at Darwin Crater and Lake Selina: long continental sedimentary archives from Tasmania

Agathe Lise-Pronovost[1,2] (agathe.lise@unimelb.edu.au)

Michael Fletcher[3], Michela Mariani[3], Quentin Simon[4]

[1]University of Melbourne, School of Earth Sciences, Melbourne, Australia
[2]La Trobe University, The Australian Archaeomagnetism Laboratory, Department of Archaeology and History, Melbourne Campus, Bundoora, 3086, VIC, Australia
[3]University of Melbourne, School of Geography, Melbourne, Australia
[4]CEREGE UM34, Aix Marseille Univ, CNRS, IRD, INRA, Coll France, 13545 Aix en Provence, France

Long sediment records of Pleistocene glacial/interglacial cycles were recovered from western Tasmania, including a 70 meters core from Darwin Crater and a 5.5 meters core from Lake Selina. Lake Selina is still a lake today and Darwin Crater, at 50 km distance, is a meteorite impact crater and a paleolake now in a forested environment. The aim is to combine the two records to form the oldest continuous continental record in Australia, and one of the oldest in the Southern Hemisphere. Here we report on the recent drilling operations at Darwin Crater and present the first results from multi-sensor whole core logging, sediment description and multi proxy pilot analysis of core end samples (including spectrophotometry, particle size, natural gamma ray, paleo- and rock-magnetism, loss-on-ignition and pollen analyses). The Darwin Crater sedimentary sequence includes pre- and post-lake deposits, and the complete lake sediment succession accumulated over several climate cycles in the ~816 ka old meteorite impact crater. The results provide clear signatures for alternating glacial and interglacial sediment facies forming a succession of seven inferred glacial cycles. Initial paleomagnetic analysis indicate normal magnetic polarity in the deepest sediments drilled at Hole B. If the magnetic remanence is depositional, this result constrains the sediment 2.5 m below commencement of lacustrine deposition to an age younger than the Matuyama-Brunhes geomagnetic reversal ~773 ka. High-resolution multi-disciplinary analysis of the Darwin Crater record are underway with a primary focus on dating and paleoclimate. We also present the paleomagnetic record from Lake Selina, which is derived from depositional remanent magnetisation and cosmogenic nuclide beryllium-10 (^{10}Be). The paleomagnetic data from western Tasmania can be used for relative dating, site correlation, and documenting geomagnetic field behaviour and Brunhes excursions in the Australian region, and ultimately contribute developing paleomagnetic dating for Quaternary research in Australia.

Oxygen isotopes in fish remains from Lake Kutubu, PNG

Kelsie Long[1,2] (kelsie.long@anu.edu.au)

Simon Haberle[1,2], Larissa Schneider[1,2], Rachel Wood[2,3], Stewart Fallon[2,3]

[1]School of Culture, History and Language, ANU
[2]ARC Centre of Excellence for Australian Biodiversity and Heritage, ANU
[3]Research School of Earth Sciences, ANU

Here we present a project that will investigate landscape change, human impacts and palaeoclimate characteristics of southern Papua New Guinea during the late Quaternary period. The region derives its high annual rainfall from the Northwest Monsoon and Southeast Trade Winds throughout the year and is sensitive to changes in the strength of Indian Ocean Dipole and El Niño-Southern Oscillation.
This project focuses on exploring the potential of deriving a long-term and continuous stable isotope (δ18O) record from fish remains preserved in Holocene sediments cores from Lake Kutubu - the largest carbonate catchment freshwater lake in the island of New Guinea. This record has the potential to expand our understanding of past palaeoclimate drivers and landscape dynamics, all of which would have influenced patterns of human occupation, dispersal and environmental interactions through time. In the first stage of the project we will measure oxygen isotopes across the age increments of modern fish otoliths from Lake Kutubu to see if major climatic fluctuations are preserved. Then we will extend this record to ancient fish remains (scales and vertebrae) found throughout lake sediment cores (~1000 – 5000 years BP).

Evaluation of pre-instrumental Southern Hemisphere climate mode history and impacts on New Zealand using the Past Interpretation of Climate Tool (PICT)

Andrew Lorrey[1] (a.lorrey@niwa.co.nz)

Jonathan Palmer[2], Nicolas Fauchereau[1], Chris Turney[2], Gretel Boswijk[3], Pavla Fenwick[4], Anthony Fowler[3], and James Renwick[5]

[1]National Institute of Water and Atmospheric Research, Auckland New Zealand
[2]Climate Change Research Centre, University of New South Wales
[3]School of Environment, University of Auckland, New Zealand
[4]Gondwana Tree Ring Laboratory, Little River, New Zealand
[5]School of Geography, Environment and Earth Sciences, Victoria University Wellington, New Zealand

Previous work has described how different climate modes interact to change synoptic-scale circulation over New Zealand. The proportional influence of these modes, how they operate, and how they are teleconnected to New Zealand are highly relevant for dictating seasonal climate conditions. Yet, little detail is available at present that describes the long-term history of those modes and their conjoint impacts on New Zealand hydroclimate (including droughts and pluvials).

We explore the use of the Past Interpretation of Climate Tool (PICT) to determine how useful modern analogs are for assessing past Southern Hemisphere climate mode activity. Our investigation has made use of calendar-dated New Zealand pink pine (Halocarpus biformis) tree ring chronologies that extend back several hundreds of years prior to local instrumental observations. New correlation functions between a network of pink pine tree ring chronologies that were standardised using the "signal free" method and the NIWA 5km2-resolved Virtual Climate Station Network show significant correlations to potential evapotranspiration (PET), mean temperature (Tmean) and earth temperature (Tearth) for austral summer. Transfer functions based on linear regression equations were used to produce quantitative reconstructions of past summer PET, Tmean and Tearth based on pink pine chronologies.

The network of pink pine climate reconstructions were fed into PICT and used as the basis for ensemble mean DJF climate patterns back to 1700CE. We discuss the emergent atmospheric circulation patterns (including synoptic type frequency changes) that drove inter-site similarities and differences for past surface climate anomalies. PICT outputs for national-scale precipitation, temperature, and the co-evolution of several climate modes (SAM, PSA, ZW3, ENSO) along with limitations of the PICT approach are being evaluated.

Environmental history from New Zealand swamp kauri (*Agathis australis*) - recent progress on sample collection and radiocarbon dating

Andrew Lorrey[1] (a.lorrey@niwa.co.nz)

Alan Hogg[2], Jonathan Palmer[3], Chris Turney[3], Gretel Boswijk[4], Anthony Fowler[4], John-Mark Woolley[1] and John Ogden[5]

[1]National Institute of Water and Atmospheric Research LTD
[2]Radiocarbon Dating Laboratory, University of Waikato, Hamilton
[3]School of Biological, Earth and Environmental Sciences, ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH), University of New South Wales
[4]School of Environment, University of Auckland
[5]Emeritus, University of Auckland

Recent work that reviewed the scientific value and potential of New Zealand swamp kauri (*Agathis australis*) has demonstrated the uniqueness of this tree-ring resource for global change research. Kauri trees commonly reach ages in excess of 600 years, and many measured swamp kauri tree-ring sequences form the basis of chronologies >1000 y length. Annually-resolved swamp kauri tree ring chronologies provide material for improving the resolution of existing 14C curves for the Holocene, the late glacial, and Marine Isotope Stage 3 (MIS3). High-resolution 14C structure outlined from swamp kauri chronologies, with infallible internal age control, means "floating" kauri chronologies and calibration curves can be precisely wiggle matched to ice core 10Be sequences. This capability places kauri in a unique position of acting as a cipher to translate 14C calibrations to equivalent ice core ages so evidence can be aligned on a common global time scale. Our recent work has focused on expanded dating of the NIWA Ancient kauri archive, which is the largest repository of MIS3 swamp kauri wood. Several new "supersite" collections (>60 samples per site) have been added since 2016, and 85 new range finder liquid scintillation spectroscopy ages have been conducted on a cross-section of those sites. The new dates are combined with an existing 14C kauri data set that was summarised in early 2018. Probability density function analysis of the swamp kauri 14C ages indicates a strong relationship with long-term environmental variability and change of northern New Zealand. We note wider hemispheric and global connections to the waxing and waning distribution of 14C dates (also a proxy for forest disturbance and tree preservation intervals).A new project using swamp kauri is focused on dating early MIS2 swamp kauri wood, which shows more detail in the global 14C curve than previously known. We are exploiting a ~1600-year long bi-decadally resolved swamp kauri 14C sequence as an anchor chronology to improve the date on a key a volcanic eruption in the Auckland Volcanic Field during the early LGM. Our collective efforts on swamp kauri 14C dating and palaeoclimatology are aimed at improving global calibration curves, and leaving a lasting legacy for Quaternary research.

A Holocene isotope hydroclimate record from Karboora, Minjerribah, Queensland

Charles Maxson[1,2,3] (charles.maxsoniv@adelaide.edu.au)

John Tibby[1], Cameron Barr[1], Jonathan Tyler[1], Melanie Leng[2,3], Jonathan Marshall[4], Glenn McGregor[4], Cameron Schulz[4]

[1]University of Adelaide
[2]British Geological Survey
[3]University of Nottingham
[4]Queensland Government Department of Environment and Science

Karboora (a.k.a. Blue Lake) on Minjerribah (a.k.a. North Stradbroke Island), Queensland, is a groundwater window lake of major ecological and cultural significance. The strong connectivity with the regional groundwater underpins a stable aquatic ecology which makes Karboora sediments an ideal tracer of subtle changes in the climate and regional environment. Here, we report a new, ~7,500 year high resolution C/N and carbon isotope record from Karboora, which shows an abrupt shift at ~4 ka from terrestrially-dominated sources of organic matter to predominantly in-lake sources. This shift is interpreted to reflect a decline in rainfall on the island, as is evident in a quantitative rainfall reconstruction from nearby Swallow Lagoon. This carbon isotope record is the starting point for further contemporary and palaeoclimatic research at the site. Ongoing monitoring aims to quantify the relationship between climate, hydrology, and the isotopic composition of Karboora sediments. The modern process study is focused on oxygen isotope variation and will quantify the hydrology of the system: from initial precipitation to uptake by plants in the lake. Using this as a foundation, we will create a high resolution palaeo-rainfall record from Karboora that will look to build on previous studies of pollen, macrophytes, and diatoms from around Minjerribah and Eastern Australia which suggest a mid-Holocene shift in rainfall patterns. Quantitatively defining such a shift will enable a more thorough investigation into the impacts of climate drivers such as ENSO in Eastern Australia.

An 8,000-year climate record from Lake Motosu, Japan: Implications for the East Asian Monsoon

Sarah A. McDonald[1] (sarah.a.mcdonald@student.adelaide.edu.au)

Jonathan J. Tyler[1], Stephen Obrochta[2], Yusuke Yokoyama[3] and the QuakeRecNankai Team

[1]Department of Earth Sciences, The University of Adelaide
[2]Graduate School of International Resource Science, Akita University
[3]Atmosphere and Ocean Research Institute, The University of Tokyo

The East Asian Summer Monsoon controls the timing and amount of rainfall for around a third of the world's population. An understanding of past changes in monsoon strength is crucial for placing current events in context and characterising future climate risk. Despite numerous studies focusing on the East Asian Summer Monsoon, debates remain surrounding the timing, spatial patterns and drivers of Holocene monsoon variability. Here, we present a well-dated, 8000-year climate record for central Japan using a lacustrine sedimentary sequence recovered from Lake Motosu, Mt. Fuji. Variations in the amount and isotopic composition of carbon and nitrogen in bulk organic matter, and the oxygen isotopic composition of sedimentary cellulose, are used to infer changes in past monsoon rainfall between 8-3 ka. However, major catchment disturbance by volcanism confounds the interpretation of sediments younger than 3 ka. Including the Lake Motosu record, we undertake a systematic synthesis of 18 Holocene palaeoclimate records from East Asia using Monte Carlo Empirical Orthogonal Function (MCEOF) analysis to account for chronological uncertainties in each component record. This analysis highlights two major patterns of change in East Asia with a clear divide between maritime and inland records. Our analyses suggest that sites in coastal East Asia are more sensitive to changes in Pacific Ocean conditions than sites in continental Asia, with implications for future monsoon variability in this socially and economically important region.

The timing of Late Pleistocene glaciation at Mount Wilhelm, Papua New Guinea

Stephanie C. Mills[1] (smills@uow.edu.au)

Timothy T. Barrows[1], Geoff Hope[2], Brad Pillans[3], L. Keith Fifield[4]

[1]School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW, 2522
[2]Department of Archaeology and Natural History, College of Asia and the Pacific, The Australian National University, Canberra, ACT, 2601
[3]Research School of Earth Sciences, The Australian National University, Canberra, ACT, 2601
[4]Department of Nuclear Physics, Research School of Physics and Engineering, The Australian National University, Canberra, ACT, 2601, Australia

The mountains of New Guinea were the most extensively glaciated area in the Asian tropical region during the Late Pleistocene. Evidence for glaciation is widespread on most of the peaks above ~3500 m. Glacial landforms include both valley and ice cap forms, but the timing of glaciation remains constrained to only a few local areas. This paper focuses on Mount Wilhelm, which is situated in the central southern region of Papua New Guinea at 5.78ºS and is the highest peak (4510 m a.s.l.) We focus on a south easterly valley (Pindaunde Valley), where large moraines indicate the maximum ice extent of a valley glacier ~5 km long. Within this extensive moraine complex, recessional moraines document the retreat of the glacier towards the summit region. In order to determine the timing of deglaciation, we collected samples for surface exposure dating using 36Cl and 10Be from granite boulders positioned on moraine crests. The ages indicate that maximum ice extent was attained during the last glacial maximum (LGM) and that ice remained near its maximum extent until after 15 ka but persisted at higher elevations almost until the Holocene. These results are similar to those described from Mt Giluwe to the northwest of Mount Wilhelm, where an ice cap reached its maximum extent at the LGM and remained there for around 3-4,000 years. This indicates that full glacial conditions were only brief in this region of the tropics.

Orakei maar paleolake (Auckland, NZ):A multi-method approach to the composite stratigraphy of a long lake sediment core

Leonie Peti[1] (lpet986@aucklanduni.ac.nz)

Paul Augustinus[1], Craig Woodward[2,3]

[1]School of Environment, The University of Auckland, New Zealand
[2]Australian Nuclear Science and Technology Organisation (ANSTO), Sydney, Australia
[3]School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Australia

The development of records of Quaternary environmental and –climatic changes relies largely on long, complete sediment sequences. However, coring techniques do not allow extraction of one continuous record of sedimentation to be recovered from a single drill hole. In order to reconstruct a complete record, it is common practice to drill two or more overlapping cores with a depth offset to overcome coring-induced loss and disturbance and then stitch these records together using stratigraphic markers to produce a master stratigraphy. However, details of the process used and critical uncertainties are rarely reported despite the fact that spurious correlations may alter subsequent paleoenvironmental interpretations. Here we detail the procedure employed to build a composite stratigraphy from three overlapping long lake sediment cores from Orakei maar paleolake (Auckland). Orakei maar was created by a phreato-magmatic eruption to forming a lake basin of a low surface-to-depth ratio and virtually no catchment. The accumulated sediment can be considered a direct recorder of climatic and environmental changes over the Last Glacial Cycle in the Southern Hemisphere mid-latitudes, a crucial but under-studied part of the global climatic system. Finely-laminated sediment in the Orakei record can be aligned and correlated along visually distinct marker horizons, as well as tephra layers (Fig. 1), with sub-cm to mm resolution, supplemented by µ-XRF core scanning elemental and X-ray density variability. Complications arise from lateral inhomogeneities in sedimentation along the lake bottom and hence, larger differences between the three cores. These sections, usually of coarser grain size, likely caused by local landslides from the crater rim, are correlated based on: visual logging, common pattern in µ-XRF elemental and X-ray density variation, and typical depth offset between the observed debris flows in the cores.

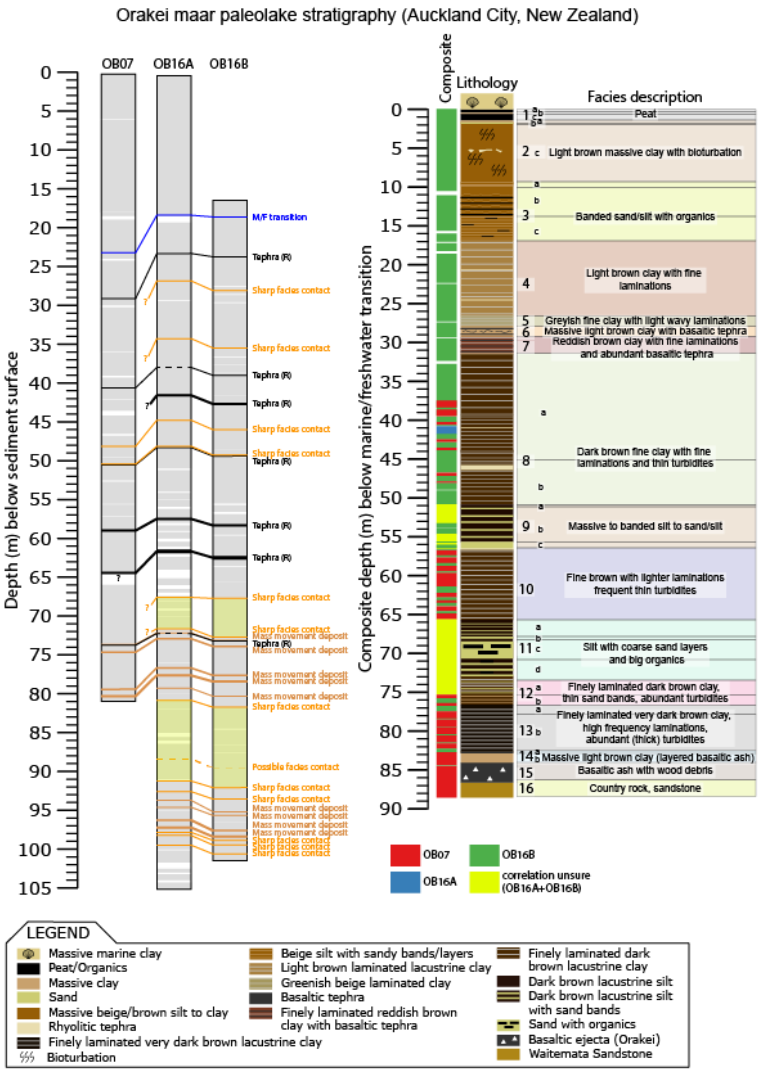


Figure 1: Composite stratigraphy and lithology of Orakei maar paleo-lake record built from three overlapping sediment cores.

Groundwater isotopic record in southwest Australia: links to recharge variations and climatic conditions

Stacey Priestley[1] (stacey.priestley@ansto.gov.au)

[1] ANSTO

Groundwater resources are a reliable and important source of water. Considering most large groundwater basins can contain 'old' groundwater where extraction exceeds groundwater recharge, knowledge of the past conditions and timing under which groundwater was recharged is needed to sustainably manage groundwater resources. Applying isotopic tools to groundwater contained in regional aquifer systems can provide low-resolution information on recharge intensity, recharge source and past climatic conditions for the region. Furthermore, an understanding of how groundwater recharge and climate have been connected in the past can be used to inform climate adaptation strategies for sustaining groundwater resources during climate change.

Large regional groundwater systems, contained within the Perth Basin in southwest Australia were investigated in this study to provide information on groundwater recharge and climate over the past 35,000 years. Regional scale databases containing groundwater age and isotopic records are not commonly developed in Australia and are generally more site specific. Therefore, this Perth Basin database provides a unique opportunity to study and interpret a low-resolution palaeo-archive of groundwater recharge for southwest Australia. Groundwater ages (14CDIC) and stable O isotopes of water (δ18O) from two regional groundwater systems within the Perth Basin have been collated and groundwater ages calculated. The trends δ18O over time in the regional groundwater data are consistent with the groundwater flow line data supporting our hypothesis that groundwater δ18O is a proxy for palaeo-recharge. The Southern Perth Basin groundwater isotope record is interpreted to be a low resolution archive of recharge driven by changes in the relative intensity of past rainfall and recharge thresholds. This long-term stable isotopic recharge record provides a greater understanding of groundwater palaeo-recharge, as well as how recharge and climate have been connected in the past.

Variations in climate and moisture availability over the previous 120,000 years in northern Australia.

Will Reynolds[1] (wgr299@uowmail.edu.au)

Tim Cohen[1], Sam Marx[1] and Michael Bird[2]

[1] ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong
[2] ARC Centre of Excellence for Australian Biodiversity and Heritage, James Cook University

Large uncertainty surrounds our understanding of past changes in climate and moisture availability across northern Australia. The geological record shows high lake levels existed at times when the main source of moisture, the monsoon was inactive. Resolution of this apparent contradiction of high lake levels at times of low moisture availability has been hampered by the lack of high-resolution paleoclimate records from the arid interior of the continent. Poor preservation of organic fossils in the highly oxidising environment of tropical Australia has prevented application of most of the analytical tools used in temperate environments to reconstruct past climates. The aim of this research project is to apply techniques which until now have been underutilized in arid land research to previously unstudied sites to detect past changes in vegetation which were driven by climate. The contemporary distribution of vegetation communities in northern Australia is governed by the diminishing penetration of monsoon rains as the monsoon moves inland from the coast. By reconstructing past changes in the distribution of vegetation communities along a transect from the Darwin to Alice Springs, changes in the strength and penetration of monsoon rain may be determined. Analysis of lake sediments will be focussed on microfossils which are relatively resistant to oxidation. Stable isotope signals of carbon and nitrogen preserved in charcoal will be explored to derive changes in abundance of C3 and C4 vegetation. Stable oxygen isotope values of ostracods and sponge spicules will be examined for signs of a monsoon fingerprint and changes in temperature. The relative abundance of phytoliths formed by mesic and drought tolerant plants will be examined. The results of this research have broad implications for several branches of quaternary science. Insights into the apparent contradiction of high lake levels at times of low monsoon strength may be gained. In archaeology there is uncertainty about the pattern and timing of human migration into the Australian continent. By characterising the environment encountered by early settlers the results of this project may inform our understanding of early human migration patterns. Because changes in the boundaries between biomes are driven by past climate changes, inferences may be made about changes in the position of the Intertropical Convergence Zone which will inform our understanding of the complex interactions between components of the monsoon system. This greater understanding of the mechanism of monsoon dynamics may allow more accurate projections of the future climate of tropical Australia.

A new record of human settlement and past environmental change of the Comoros, far western Indian Ocean

Haberle, S.G.[1,2] (simon.haberle@anu.edu.au)

Rule, S.[1,2], Roberts, G.[2,3]

[1]Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University, ACT, Australia
[2]ARC Centre of Excellence for Australian Biodiversity and Heritage, Australian National University, Canberra, ACT, Australia
[3]Indigenous Studies Centre, Monash University, Clayton, Victoria 3800, Australia

As humans have colonized new places, they often initiate dramatic environmental change, even in the distant past. On remote islands, where levels of endemism are high, species and environments are often particularly vulnerable to the effects of introduced species like humans, and the plants and animals they deliberately or accidentally bring with them. The first study of the environmental history of the Comoros, a volcanic archipelago in the far western Indian Ocean, was conducted in 2016 in order to test the hypothesis that the Comoros were stepping stones for prehistoric human migration from east Africa to Madagascar. This research will contribute to our understanding of patterns and chronologies of human colonisation, as well as the environmental impacts that humans have had. The pollen and charcoal records show dramatic changes in vegetation and fire regimes in the last 1500 years that are best explained through the influence of human settlement. Such studies of the past are extremely useful for better understanding and mitigating the effects of human-induced environmental change today.

Stable and Radiogenic Strontium Isotope Systematics in Hypersaline Coastal Environments: Constraints for Paleo-Hydrology in the Coorong, South Australia.

Yuexiao Shao[1,2]

Juraj Farkaš[1,2], Jonathan Tyler[1,2], Bronwyn Gillanders[2,3], Briony Chamberlyane[1,2], Deborah Haynes[1,2]

[1]Department of Earth Sciences, University of Adelaide, SA 5005, Australia
[2]Sprigg Geobiology Centre, University of Adelaide, SA 5005, Australia
[3]Department of Ecology and Environmental Science, University of Adelaide, SA 5005, Australia

Strontium (Sr) isotopes have been widely used in large-scale ecosystem and hydrological studies. Specifically, the 87Sr/86Sr is commonly used for tracing radiogenic processes such as water source mixing, while the newly employed stable 88Sr/86Sr (noted as δ88/86Sr) is sensitive to isotope fractionation processes such as carbonate formation. Combining the two isotope signatures in carbonate sediment archives and ambient water adds potential to reconstruct paleo-hydrology in carbonate-producing coastal environments. Importantly, the stable 88Sr/86Sr has been applied in recent years in coastal environments with fresh to marine salinity conditions, very few studies were conducted in hypersaline environments. The Coorong hydrological system, located ~100 km southeast to Adelaide, represents a unique 'natural laboratory' to calibrate novel and traditional isotope tracers in due to its unique geomorphology and large salinity gradient in water bodies ranging from fresh to hypersaline (from ~0 PSU to ~120 PSU). This study aims to assess the radiogenic and stable Sr isotope ratios (i.e., 87Sr/86Sr and δ88/86Sr) in the Coorong lagoon waters, inorganic carbonates and bivalve shells Arthritica helmsi from sediment cores, and hence explore the potential of these isotope tracers to be used to reconstruct the paleo-hydrology in the Coorong throughout the recent thousands of years.

Post-LGM evolution of the lower Ord River, WA, constrained by luminescence and cosmogenic radionuclide dating

M. L. Smith1 (martin.smith@ga.gov.au)

A. A. McPherson[1], M. L. Cupper[2], T. Fujioka[3], K. Wilcken[3]

[1]Geoscience Australia,
[2]University of Melbourne,
[3]ANSTO

The landscape history of northern Australia is significant for understanding both environmental and human history. In this region the Upper Pleistocene to Holocene represents a period of major flux in response to external drivers such as climate variation and sea-level change. The influence of these drivers has been profound, and they have exerted significant controls on landscape form and composition along Australia's northern margin. This also has implications for groundwater resources and quality.

This study investigates the lower Ord River system, a bedrock-dominated catchment in the East Kimberley region of northwest Western Australia. Geochronological and geomorphological investigations of landforms of the lower Ord plain, and its paleo-floodplain within the central Ord River valley, highlight the significance of the terminal stages of the Last Glacial Maximum (LGM) as a control on regional base level and consequently on landscape change.

The timing of capture of the Ord River from its northeast-draining paleo-valley to its present westerly course is constrained by cosmogenic radionuclide bedrock exposure ages from Tarrara Bar - the likely location of capture by westward flowing drainage at ca. 15 ka. Optically-stimulated luminescence ages from scroll plains on the lower Ord River downstream of Tarrara Bar are younger than 7 ka, suggesting that their evolution is tied to regional climatic variation affecting sediment supply to these lower reaches of the system post-LGM sea-level stabilisation.

This landscape history is significant in that it controls the distribution and nature of alluvial materials within both the current and paleo-valley systems, and has implications for the properties of depositional units that may influence the distribution and quality of groundwater.

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Trace elements: from sources to cave drip water, south-eastern Australia

Carol V. Tadros[1,2] (Carol.Tadros@ansto.gov.au)

Pauline C. Treble[1,2], Andy Baker[2]

[1]ANSTO, Locked Bag 2001, Kirrawee DC, NSW 2232, Australia
[2]Connected Waters Initiative Research Centre, UNSW Sydney, Sydney, NSW, Australia

Speleothem trace element time series are constructed from the infiltrating drip water geochemistry, and hence are examined under contrasting rainfall conditions associated with El Niño and La Niña phases of ENSO. The aim was to identify suitable inorganic element proxies for palaeoclimate interpretation in speleothem records from Harrie Wood Cave, Yarrangobilly. The drip water chemical composition at the stalactite tip reflects a contribution from different endmembers and processes; therefore it is necessary to study the different sources, pathways and processes that occur as water migrates through the atmosphere-soil-karst system. Here we present high resolution aerosol, rainfall and drip water □18O and inorganic drip-water datasets. Analysis of aerosol samples above the caves reveals the atmosphere supplies a suite of elements from automobile emissions, windblown soil, smoke, secondary sulfate and aged sea salt sources. The bedrock and aerosols were identified as contributory sources of solutes to the drip water. The clay-rich soil zone was recognised as a sink for inorganic elements, and a secondary source for Zn. In soil, a number of processes were demonstrated to modify the chemical composition of the resultant drip waters. The drip water chemistry is driven by the long-term gradient in the cumulative water balance. The flow paths feeding the drip sites were shown to be fracture flow, from a ventilated well-mixed pocket within the epikarst storage reservoir. Dilution and reduced prior calcite precipitation (PCP) controlled the drip-water chemistry during the La Niña/wet years whereas enhanced PCP was observed during the El Niño and dry periods. Mg and Sr show particular promise as paleoclimate proxies for drought and flood events, while with further research Na, K and Zn may also be reliably used. These findings will be applied in a modern speleothem record.

Late Quaternary palaeoenvironments of eastern Indonesia

Alexander F. Wall[1] (afw541@uowmail.edu.au)

Fabian Boesl[1]

[1]School of Earth and Environmental Science, University of Wollongong, Wollongong, Australia

The palaeoenvironments of Indonesia were extremely dynamic during the late Quaternary. The changing regional geology (e.g. ongoing subduction, uplift and associated volcanism) and global climate interacted to create complex and localized environmental changes. For example, because the Sunda shelf includes large areas near sea level, a change in sea level dramatically affects the land area, the exchange between the Indian and Pacific Oceans and the volume of the Indo Pacific Warm Pool. These dynamics are important for understanding the past and future of climate change in the region. The environment of the late Quaternary also paints the setting for the diversity of hominins in the area, including the intrepid ancestors of the first Australians. This poster presents a variety of data from published sediment records marine and terrestrial settings in Maritime Southeast Asia and northwestern Australasia over the last full glacial cycle. Data drawn from stable isotopes, pollen, trace elements, and sedimentological features describe different aspects and different resolutions of the palaeoenvironmental story. We also synthesize an overview of the current interpretations and disagreements, as well as highlight informational gaps. Finally, we describe our plan to target specific sites in Indonesia for field work as an undersampled area that has also been proposed as a crucial stepping stone for the first people on their way to Australia.

Abrupt Changes in the Northern Source Water during Dansgaard-Oeschger Events

Jiade Wu[1] (jiade.wu@anu.edu.au)

Jimin Yu[1], Laruie Menviel[2], Zhangdong Jin[3]

[1]The Australian National University
[2]University of New South Wales
[3]Institute of Earth Environment, Chinese Academy of Sciences

Abrupt climate changes, Atlantic Meridional Overturning Circulation (AMOC) and carbon cycle variations are thought to be closely associated during the Marine Isotopic Stage (MIS) 3 millennial-scale oscillations [1], namely Dansgaard-Oeschger events. Evidence suggests a strong correlation between climate and AMOC changes [2], but unambiguous evidence for the correlation between circulation and carbon cycle is still limited, especially in the subpolar mid-depth North Atlantic. This study takes advantage of a high-resolution core, ODP 984 (61.25°N, 24.04°W, 1648 m), using a multi-proxy approach and robust age control to resolve the carbon footprint associated with abrupt climate changes. Our result shows rapid and remarkable increases in mid-depth North Atlantic [CO32-] during Heinrich events 2 to 5 and some non-Heinrich stadials. Increase d13C and decrease Psw are also observed during some of these stadials. Model simulations propose that the millennial-scale changes in carbon and nutrient level can be explained by the southward shift of deep-water formation region and enhanced overflow of high alkalinity waters from Nordic Seas. This overflow introduced additional alkalinity to the Atlantic, likely acting as a negative feedback to the Southern Ocean CO2 leakage induced by weaker AMOC and enhanced upwelling [3], contributing to maintaining relatively stable atmospheric CO2 during MIS 3.

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A northward shift of the southern westerlies during the Antarctic Cold Reversal: evidence from Tasmania

Joseph Alexander[1] (josephaa@student.unimelb.edu.au)

Michael-Shawn Fletcher[1], Joel Pedro, Michela Mariani[1], Kristen Beck, Maarten Blaauw, Dominic Hodgson, Henk Heijnis, Patricia Gadd, Agathe Lise-Pronovost[1]

[1] The University of Melbourne

The Last Glacial Termination (LGT) was interrupted in the Southern Hemisphere by the Antarctic Cold Reversal (ACR; 14.7 to 13 ka), a millennial-scale cooling event that coincided with the Bølling–Allerød warm phase in the North Atlantic (14.7 to 12.7 ka). This inter-hemispheric asynchrony of climate change through the LGT, the bipolar seesaw, has been theoretically linked to latitudinal shifts in the southern westerly wind belt (SWW) and their proposed influence over the global carbon cycle via wind-driven upwelling of CO_2 rich deep waters in the Southern Ocean (SO). However, while climate models and theory predict a northward shift of the SWW during the ACR in response to ocean-atmosphere heat dynamics, proxy-based reconstructions disagree on the behaviour of the SWW through this interval, and the role of the SWW during the LGT remains contested. Here we present terrestrial proxy palaeoclimate data (pollen, µXRF geochemistry, charcoal) from multiple lakes across Tasmania (40-44^{o}S), an island located at the northern edge of the SWW. Our data reveal a clear SWW increase over Tasmania during the ACR, synchronous with reduced SWW-driven upwelling in the SO at the southern edge of the SWW. When combined with evidence from Antarctic ice cores and terrestrial records from New Zealand and Patagonia our results suggest a hemisphere-wide migration of the SWW during the LGT, lending support to the hypothesis that changes in wind-driven ventilation of CO_2 from the Southern Ocean were a key driver of the global carbon cycle during the LGT.

Implications of soil particle transport and mixing for cosmogenic nuclide and OSL tracer age distributions.

Peter Almond[1] (peter.almond@lincoln.ac.nz)

David Furbish[2], Joshua Roering[3], Amanda Keen-Zebert[4], Tyler Doane[5]Rina Schumer[6]

[1]Lincoln University, New Zealand
[2]Vanderbilt University, USA
[3]University of Oregon, USA
[4]Desert Research Institute, USA
[5]Vanderbilt University, USA
[6]Desert Research Institute, USA

For the purposes of dating, often simple assumptions are made about the bleaching history of luminescence-sensitive grains when they are deposited on the land (soil) surface. However, mixing by soil disturbance processes is almost ubiquitous and hence the time of deposition and the luminescence age a grain acquires after deposition are not necessarily the same. Here we explore the influence of mixing and soil transport near hillslope crests on the age distribution of luminescence-sensitive grains. Soil mixing and transport is simulated by way of an algorithm that generates depth-dependent mixing by random Gaussian fluctuations. These motions are superimposed on a mean downslope velocity field that linearly increases from the soil/bedrock interface towards the soil surface. Our algorithm allows us to track particles and the time since they last visited the soil surface, where bleaching is assumed to be perfect, from which the steady state vertical distribution of grain luminescence ages is simulated. With weak mixing, depth-interval-averaged OSL ages increase linearly with depth but only reach around 60% of the soil residence time near the base of the soil. Where mixing is strong, depth-interval-averaged OSL ages are uniform to the base of the soil and less than 10% of the soil residence time. The translation of these findings to loess accumulating at steady state, and the potential for OSL ages to underestimate depositional age are discussed.

Hydrologic and isotopic modelling of lakes: towards mechanistic understanding of proxy data.

Martin Ankor[1]

[1]University of Adelaide

Lakes sediments are an excellent source of terrestrial hydroclimate records, particularly via reconstructions of lake depth, lake water salinity and the stable oxygen isotope composition of palaeo- lake waters. However, lakes are complex systems, and the hydrological and geochemical response of lakes to climate is often non-linear, multifactorial and variable between sites. This complexity limits attempts to translate lake sediment records into quantifiable climate estimates, such as the amount of regional precipitation or evaporation. Coupled hydrologic-isotopic models - also known as 'proxy system models' - provide one means of addressing this complexity to constrain the interpretation of palaeoclimate proxies. Furthermore, such models facilitate a deeper understanding of the interaction between lakes, meteorology, and catchment/subsurface hydrology with value for addressing how lake ecosystems behave under past and future climate regimes.A general lake model – CHIMBLE – coupling lake hydrology, groundwater, stratification, isotopes, water chemistry and meteorology is being developed to try and resolve these challenges. CHIMBLE has been applied to the maar lakes Bullen Merri and Gnotuk in the Newer Volcanic Province (Victoria). These lakes (and 10 other lakes across the Newer Volcanic Province) have been monitored for the last 3 years for depth, chemistry and stable isotopes. Modelling and monitoring results demonstrate that for many lakes a simple lake model is insufficient and that there is a requirement to couple the lake hydrology to the surrounding catchment and subsurface flows.

Past hydroclimatic variability from southwest Australian speleothems during the last millennium

Treble, P[1,2] (pauline.treble@ansto.gov.au)

Baker, A[2], Griffiths, A[1], Hellstrom, J[3], Bajo, P[1,3], Abram, N[4], Fairchild, I[5], Borsato, A[6], Markowska, M[1], Gagan, M[1,7]

[1]ANSTO, NSW, Australia
[2]UNSW Sydney, NSW, Australia
[3]University of Melbourne, VIC, Australia
[4]Australian National University, ACT, Australia
[5]University of Birmingham, United Kingdom
[6]University of Newcastle, NSW, Australia
[7]University of Queensland, QLD, Australia

Speleothems from Golgotha Cave in SW Western Australia have been investigated to extend our knowledge of past climate variability for this region during the last millennium. O isotopic datasets, the primary paleoclimate proxy used for speleothems, were constructed for four stalagmites. A challenge in their interpretation has been the disagreement between these records, despite representing coeval growth from within the same cave. Resolving this conundrum has necessitated the characterisation of the hydrology[1-5], hydrochemistry[5,6], rainfall isotopes[7] and development of proxy system forward models[1,8] for Golgotha Cave. The findings of these studies will be summarised as a conceptual model in order to present the main karst hydrological features that give rise to each stalagmite's isotopic response to hydroclimatic forcing. The paleoclimate interpretation will focus on the two continuous stalagmite records that were fed predominately by diffuse flow. This will be supported by evidence from the two stalagmites predominantly fed by fracture flow, which has resulted in a non-linear response to hydroclimatic forcing.

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Hydrological change in subtropical Australia from 80–40 kyr

Cameron Barr[1] (cameron.barr@adelaide.edu.au)

John Tibby[1], Melanie Leng[2,3], Jon Tyler[4], Haidee Cadd[4], Lee Arnold[4], Jon Marshall[5], Glenn McGregor[5]

[1] Department of Geography, Environment and Population, The University of Adelaide, SA, Australia
[2] NERC Isotope Geosciences Facility, British Geological Survey, Nottingham, UK.
[3] Centre for Environmental Geochemistry, University of Nottingham, Nottingham, UK.
[4] Department of Earth Sciences, The University of Adelaide, SA, Australia
[5] Queensland Department of Environment and Science. Ecosciences precinct, Boggo Road, Dutton Park, Queensland, 4102

There are very few continuous palaeoclimate records of the period when humans first colonised Australia 50–60,000 years (50–60 kyr) ago, or during the extinction of Australia's megafauna between 51 and 40 kyr. The studies that exist primarily employ palynological techniques; however, the interpretation of terrestrial vegetation records becomes complex within the nexus of combined human, fire, climate and mega-herbivore influences. An incomplete understanding of Australian climate variability during this period means the role of climate in the extinction of megafauna remains contentious. Here we present a palaeoohydrological record from Welsby Lagoon, a wetland in the Australian subtropics recently discovered to be over 100,000 years old. We use the oxygen isotopes of aquatic cellulose preserved in the sediment – which reflect the isotopic composition of the lake water – to infer hydrological variability between 85 and 40 kyr independent of changes in terrestrial vegetation. Results demonstrate substantial hydrological variability during this period, with an apparent link to Antarctic temperatures at millennial timescales. We find evidence of a notable shift towards drier conditions during the megafauna extinction window at around 45 kyr, aligning with findings from elsewhere on the continent and more broadly. Though the magnitude of this shift is not exceptional in our record, it does imply that, in the subtropics at least, climatic change may have played a contributing role in the demise of the megafauna.

Glacial history of the Franz Josef moraine complex, West Coast, New Zealand

Barrows, T.T.[1]

Mills, S.C.[1], Rowan, A.[2], Almond, P.[3]

[1]School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522
[2]Department of Geography, University of Sheffield, Sheffield, S10 2TN
[3]Soil and Physical Sciences, Faculty of Agriculture and Life sciences, Lincoln University, Lincoln 7647

During the late Pleistocene, large piedmont lobes descended from the Southern Alps icefield of New Zealand onto the coastal plain. These glaciers deposited vast moraine complexes and provide one of the most complete records of glaciation in the Southern Hemisphere. Dating the moraines has proven problematic. There are relatively few exposures with organic material suitable for radiocarbon dating meaning that existing chronologies are restricted to a few sites only. Without satisfactory dating, it is problematic to explore the climate change responsible for the series of glacier advances and retreats. In this paper we present new dating in the form of cosmogenic nuclide exposure ages and tephrochronology to constrain the ages of the moraine complex deposited by the Franz Josef Glacier. Unlike the Waiho Loop, moraines seaward of Lake Mapourika have broader crests and are less affected by fluvial undercutting, making crest preservation more likely. To determine the likely range of climate variables responsible for each dated glacier advance over the last glacial cycle, we reconstructed the positions of the glacier using a 2-D glacier energy–mass balance and ice flow model. The glacier model was applied using present-day climate relationships and tuned to simulate the observed glacier extent and estimated ice thickness and modern equilibrium line altitude. To discover the optimal values for each of the climate variables defined as model inputs, we performed sensitivity experiments using a realistic range of values for each variable based on those observed for the Franz Josef Glacier region. To simulate palaeoglacier extent and ice thickness in the past, we imposed step changes in mean annual air temperature and precipitation amount, and compared these results with glacier extents indicated by the position of terminal moraine crests. Maximum cooling of 6 °C to 7 °C without precipitation change is required to advance the ice to the maximum extent on the coastal plain. Our data-model comparison allows us to test some of the existing paradigms concerning temperature- versus precipitation-dominated glacier forcing in New Zealand.

Solar forcing and inter-annual precipitation variability reconstructed from a Cook Islands stalagmite record: insights on SPCZ localisation and ENSO dynamic during the last 3000 years

Andrea Borsato[1] (andrea.borsato@newcastle.edu.au)

Silvia Frisia[1], John Hellstrom[2], Adam Hartland[3], Mohammadali Faraji[1], Dave Mattey[4], Jian-xin Zhao[5], Petra Bajo[6], Alan Greig[2]

[1] School of Environmental and Life Sciences, University of Newcastle, Australia
[2] School of Earth Sciences, The University of Melbourne, Australia
[3] School of Science and Engineering, University of Waikato, Hamilton, New Zealand
[4] Department of Earth Sciences, Royal Holloway University of London, UK
[5] School of Earth and Environmental Sciences, The University of Queensland, Australia
[6] School of Geography, The University of Melbourne, Australia

Stalagmite records from tropical Pacific Islands provide a powerful means to investigate the position and intensity of the South Pacific Convergence Zone (SPCZ) and changes in regional coupled ocean-atmospheric circulation. Rainfall in Atiu (Southern Cook Islands) exhibits a strong seasonality with 70% of the mean Total Annual Rainfall (TAR = 1930 ±365 mm/yr) occurring from December to May. However, during the drier season (June – November) strong rainfall events are not unusual, and some years are characterised by almost continuous infiltration through the highly porous Pleistocene reef limestone, wherein caves developed. Interannual rainfall is strongly modulated at decadal timescales by El Niño-Southern Oscillation (ENSO), with lower rainfall associated with La Niña events.We present a composite stalagmite record from four stalagmites dated by U-Th series and annual laminae counting, characterised by slow to intermediate growth rates (20 – 200 μm/yr) and closed- to open- columnar fabric, collected from three different caves.The studied 'solution maze' caves are characterised by stable temperature (~23°C), low air CO2 concentration, high dripwater mineralization and high calcite saturation.High-resolution Synchrotron-Radiation based micro X-ray fluorescence and trace element LA-ICP-MS analyses reveal centennial, quasi-decadal (ENSO type) and annual periodicity.Annual cycles are well developed in faster growing stalagmites and are characterised by lamina couplets composed of alternating compact and porous calcite layers reflecting seasonal changes in infiltration. Throughout the last 3000 years, stalagmites are characterised by a positive correlation between Mg and Sr that can be confidently used as palaeo-hydrological proxy. Despite small scale differences and peculiarities, Mg and Sr records from Pouatea and Nurau caves, respectively on the Western and Eastern sides of the island, show similar trends and features and display a good correlation with Total Solar Irradiance (TSI), where high-Mg high-Sr peaks (drier conditions) correspond to positive peaks in the TSI.

A terrestrial palynological record for the last ~100 kyr from Orakei Basin, northern New Zealand

Valerie van den Bos [1] (valerie.vandenbos@vuw.ac.nz)

Rewi Newnham[1], Andrew Rees[1], Leonie Peti[2], Jenni Hopkins[1], Janet Wilmshurst[2,3], Paul Augustinus[2]

[1]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand
[2]School of Environment, The University of Auckland, PB 92019, Auckland, New Zealand
[3]Landcare Research, PO Box 69040, Lincoln, New Zealand

Continuous terrestrial records that reach beyond the Last Glacial are generally rare, especially in the Southern Hemisphere. In regions prone to glaciation, i.e. southern regions, any depositional basins or other records of previous glacials are likely to be overprinted by the most recent glacial advances. In northern regions, records tend to be discontinuous due to pauses in deposition during dry periods. There are some exceptions, e.g. Lynch's Crater in north-eastern Australia, Lake Selina in western Tasmania, and Okarito Bog in south-western New Zealand. We present a new palynological record from Orakei Basin, northern New Zealand, that may also be viewed in this category. Orakei Basin is one of the maars in the Auckland Volcanic Field (AVF) that formed in a crater aged ~126 kyr BP. Its pollen record covers the period from MIS 5 to the start of the Holocene (~9 kyr BP). A pollen record from nearby Lake Pupuke partially overlaps with the Orakei record and fills in the history for the remainder of the Holocene. The AVF is a well-studied area and contains many maars that have proved to be excellent depositional environments, but there are no published records from the AVF that reach beyond ~30 kyr BP. The combined Orakei Basin and Lake Pupuke records tie together all existing fragmentary records that cover certain sections of the last ~100 kyr from the North Island, to provide a robust regional picture of vegetation and climate change in northern New Zealand since the last Interglacial.

Millennial scale climate and environmental change from Welsby Lagoon, Minjerribah (North Stradbroke Island) for the past 80,000 years.

Haidee R. Cadd[1,2,9] (haidee.cadd@adelaide.edu.au)

John Tibby[2], Cameron Barr[2], Jonathan Tyler[1], Lilian Unger [3], Melanie Leng[4, 5], Jonathan Marshall [6, 7], Glenn Mcgregor [6], Richard Lewis [1], Lee J. Arnold [1] ,Tara Lewis [8], Jeff Baldock[9] , Yuseke Yokoyama[10]

[1]Department of Earth Sciences, The University of Adelaide, SA, Australia
[2] Department of Geography, Environment and Population
[3]Department of Geography, University College London, London, WC1E 6BT, UK
[4] NERC Isotope Geosciences Facilities, British Geological Survey, Nottingham, Centre for Environmental Geochemistry, University of Nottingham, Nottingham, UK
[5]Centre for Environmental Geochemistry, School of Biosciences, Sutton Bonington Campus, University of Nottingham, Loughborough, LE12 5RD, UK
[6]Queensland Department of Environment and Science, GPO Box 5079, Brisbane, Queensland, 5078, Australia
[7]Australian Rivers Institute, Griffith University, Kessels Road, Nathan, Queensland, 4111, Australia
[8]School of Life and Environmental Sciences, Deakin University, Geelong, 221 Burwood Highway, Burwood, Victoria, 3125, Australia
[9] CSIRO Agriculture, Urrbrae, SA, Australia
[10] Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan

Records of terrestrial environmental and climatic variability that extend beyond the Last Glacial Maximum (LGM) in Australia are rare. This paucity of terrestrial archives is further hampered by poor age constraints and low sample resolution. Here we present, for the first time, a high-resolution, well-dated, multi-proxy record of climate, vegetation and fire history covering the past ca. 80,000 years from Welsby Lagoon, Minjerribah (North Stradbroke Island). The Welsby Lagoon chronology has been developed from 21 OSL ages and 20 ^{14}C dates and spans the regionally significant periods of Marine Isotope Stage (MIS) 3, MIS4 and the LGM. In order to adequately reconstruct environmental and hydrological change we utilise a variety of proxies reflecting within wetland change (plant macrofossils, $\delta^{15}N$, aquatic pollen, plant lignin photosynthetic pigments) to reconstruct the evolution of the wetland. Since its inception, Welsby Lagoon has undergone a progressive change from an open-water lacustrine system to a macrophyte-dominated palustrine swamp, becoming dominated by aquatic macrophytes after ca. 40 ka. A thorough understanding of the development of this site allows greater confidence and robust interpretations of climatic and landscape changes. Centennial scale climate variations are evident in the carbon isotope ($\delta^{13}C$) record, while changes in vegetation composition occur in response to a variety of drivers. This high-resolution, independently dated record extending to the beginning of MIS4 has the potential to provide an advancement in our understanding of millennial to centennial scale climate and ecological variability during significant time periods in subtropical Australia.

The intersection between engineering and Quaternary science: an example from the River Murray

Elyssa De Carli[1] (elyssa.decarli@sydney.edu.au)

Ian Rutherfurd[2], Dan Penny[1], Tom Hubble[1]

[1]School of Geosciences, The University of Sydney, Sydney, NSW 2006 Australia.
[2]School of Geography, The University of Melbourne, Victoria 3010, Australia.

Much of Quaternary science is about the genesis of sedimentary deposits. These are the deposits and legacy environments that civil engineers then work and build in (floodplains, coastal deposits, slope-deposits). In the northern hemisphere, there is a long relationship between engineers and Quaternary scientists around glacial and peri-glacial deposits, where Quaternary science helps to explain the spatial distribution and mechanical behaviour of engineering materials (Groot & Griffiths, 2001). In Australia, this intersection is less common and obscured by nomenclature, with much of the overlap found in the 'regolith' literature (e.g. Taylor & McNally, 2001). During very low river levels in the Millennium Drought (1997-2011), long sections of river bank along the lower River Murray in South Australia collapsed, threating many social and economic assets. Not only did these failures represent rapid geomorphic change in a reach that is normally considered extremely stable, but they also occurred during long periods of extremely low flows, unusual considering failure is typically associated with the recession of high-energy floods. Geotechnical investigation found a fine-grained (soft clay) deposit in the riverbank stratigraphy at four sites, concluding that "during periods of low river level it should be assumed that riverbank collapse could occur where the riverbanks are underlain by the soft clay" (SKM, 2010; Coffey, 2012). The origin of the fine-grained deposit and its regional extent was unknown. Subsequent drilling revealed a fine-grained and laminated deposit characterised the Holocene upper valley-fill as a single stratigraphic unit over an 80km reach of river, between 10 to >50m thick in its down-valley extent. When placed within the context of the late Quaternary environment (an incised valley system), interpretation of physical and mechanical properties of the deposit identified a central basin environment evolving under highstand conditions. Mapping the extent of the stratigraphic unit within this framework allowed us to determine the extent of the riverbank collapse hazard and predict where future bank-failures will take place along the lower River Murray. Understanding Quaternary deposits is particularly useful to engineers at the interface of coastal and fluvial environments, considering that these environments and stratigraphic units form the building foundations for most of the worlds cities.

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The evolution of Thirlmere lakes: a long-term sedimentary record of climate and fire dynamics in the Sydney Basin

Tim Cohen[1,2] (tcohen@uow.edu.au)

Sam Marx[2], Emily Barber[2], Matt Forbes[1], Patricia Gadd[3], Jon Tyler[4], Heather Haines[5], Craig Woodward[3], Andres Zamora[2], Scott Mooney[6], Mark Constantine[6]

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong.
[2]GeoQuest Research Centre, University of Wollongong.
[3]Australian Nuclear Science and Technology Organisation
[4]University of Adelaide5Griffith University6University of New South Wales

The Thirlmere lakes are located 40 km from the coast and are at ~300 m elevation and fall within the Greater Blue Mountains World Heritage area. The series of five lakes sit within a narrow and sinuous former river valley within the Hawkesbury sandstone with surrounding dry sclerophyll forest. Recent declines in water levels have prompted the NSW Office of Environment and Heritage to fund research about the history of Thirlmere lakes, the sub-surface characteristics and the potential frequency of past drying. This research builds on some existing work and has highlighted the extraordinary potential for the region for a long-term archive for palaeoenvironmental research.To date we have taken multiple vibracores across three lakes to depths of 7 m and we have supplemented this with some preliminary deep drilling to depths of 14 m. Our initial chronology is based on radiocarbon and OSL and we have employed a raft of geochemical and palaeoecological techniques to investigate changes through time. The lakes contain excellent organic preservation with deposition of the 'modern' peat environments commencing ~11 ka across two of the lakes investigated. This phase is represented by the upper 2 -3 m of organic rich peat (50% TOC). The underlying sediments are a mix of weakly bedded organic clays and oxidised clay facies that represent lake-wide drying intervals, a sequence that is repeated down profile. All five lakes are separated by alluvial sills that are comprised of medium to well-sorted sands, interbedded with organic 'marker' horizons that indicate these separate lakes were once joined, prior to the Last Glacial Maximum. The sandy sills that separate the lakes are derived from tributary alluvial fans accumulating progressively over the Holocene and effectively blocking and separating the lakes into their current configuration. This paper provides a preliminary overview of the chrono-stratigraphic history of Thirlmere lakes.

Lake George highstands: more evidence for deep lakes in cold periods

Tim Cohen[1,2],

Nathan Jankowski[1],Anngret Larsen[3], Josh Larsen[4], Jan-Hendrik May[5], Laura Mogensen[2], Amy Dougherty[2], Brad Pillans[6].

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong.
[2]GeoQuest Research Centre, University of Wollongong.
[3]Department of Geography, University of Manchester, UK
[4]School of Geography, Earth and Environmental Science, University of Birmingham, UK
[5]University of Melbourne, Australia
[6]Research School of Earth Sciences, Australian National University, Canberra, Australia

Lake George is an iconic lake in south-eastern Australia and since the late 18th and early 19th centuries researchers have been investigating the natural variability of water levels in an environment that is more often used as a sheep paddock than a lake. Since the 1960s early and influential Quaternary research has investigated both lake-floor and shoreline sedimentary sequences. We returned to the eastern shoreline at Rocky Point and undertook a series of excavations and ground-penetrating radar on a shoreline transect, with shorelines located up to 18.7 m (692 m AHD) above the 2012 water level (673.7 m AHD). The objective of this was to investigate in more detail the Holocene record of lake-level variability. The results are surprisingly different to what was expected, but supportive of some of the earlier research. Seventeen single grain OSL samples from beach, nearshore lacustrine and aeolian facies record a history of filling (and emptying) that dates from 40 ka to the late 19th century. The transect records lake filling of nearly 19 m water depth episodically between 40 – 27 ka and the lower lake margin is capped by lower level Holocene beach facies. The older units underlie the entire Rocky Point transect and indicate that late Marine Isotope Stage (MIS) 3 and early MIS 2 was a period of deep lake conditions at Lake George. The eight excavations record a lake transgression/regression throughout this period, but we have most likely not sampled the peak Late Quaternary high-stand which is ~37 m above lake empty (673 m AHD). Our data suggests that throughout the early Holocene Lake George has episodically re-filled, but to depths of no greater than 8 m (681 m AHD). Additional Holocene sand deposits cap the upper parts of the profiles of the highest shorelines but the lack of stratigraphic integrity precludes us from confirming their depositional history. We interpret these Holocene structure less sands as being windblown from the stratified lake sequences lower on the transect. The MIS3/MIS2 lake deposits show considerable post-depositional modification with significant pedogenesis.

Getting more from charcoal: using ATR-FTIR to quantify pyrolysis intensity as a proxy for fire severity in eastern Australia

Mark Constantine[1]

Patrick Baker[2], Michael Bird[3], Tim Cohen[4], Brynn Hibbert[5], Chris Marjo[6], Anna McBeath[3], Anne Rich[6], Xianglin Zheng[1], Scott Mooney[1]

[1]School of Biological, Earth and Environmental Sciences, The University of New South Wales, Sydney 2052
[2]Department of Forest and Ecosystem Science, University of Melbourne, Parkville 3010
[3]College of Science & Engineering, James Cook University, Smithfield 4878
[4]ARC Centre of Excellence for Australian Biodiversity and Heritage, School of Earth and Environmental Sciences, University of Wollongong, Wollongong 2522
[5]School of Chemistry, The University of New South Wales, Sydney 2052
[6]Mark Wainwright Analytical Centre, The University of New South Wales, Sydney 2052

There is significant uncertainty regarding (the past, present and potential future) fire regimes in eastern Australia, and many of these questions require a longer baseline than is available from instrumental or historic records. Addressing such questions is also clearly hindered by the ambiguity of charcoal as a proxy for fire. Charcoal formation is variable, taphonomy is uncertain and can be dependent on the nature of the fire (severity, extent, distance to deposition site) and post-fire events. The inter-connected components of a fire regime can also influence charcoal accumulation and hence confuse the interpretation of any given record. Here we apply attenuated total reflectance (ATR) Fourier-transform infrared (FTIR) spectroscopy to oven-produced charcoal, formed at different temperatures, to show that we can discriminate spectra (using partial least squares regression) from these different 'pyro-intensities'. We then apply these techniques to charcoal (>250 micron) isolated from well-dated sedimentary sequences to consider 'pyro-intensity' over two temporal scales: (1) the last full glacial cycle at Thirlmere Lakes; and (2) over the last 500 years in Kosciuszko National Park. The methods outlined represent a novel use of charcoal for considering changes to fire intensity.

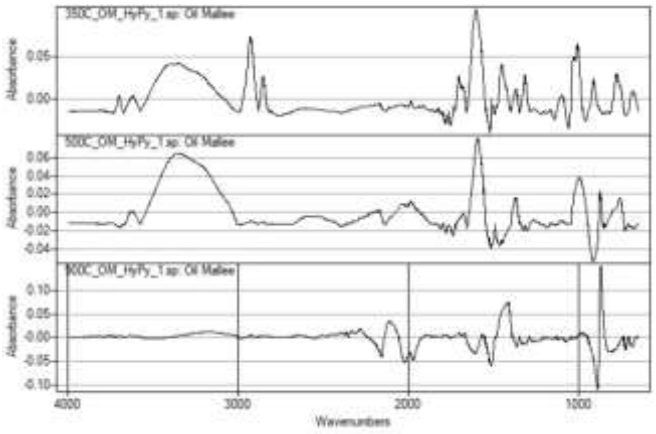


Figure 1. FTIR spectra of charcoal produced using three different oven temperatures

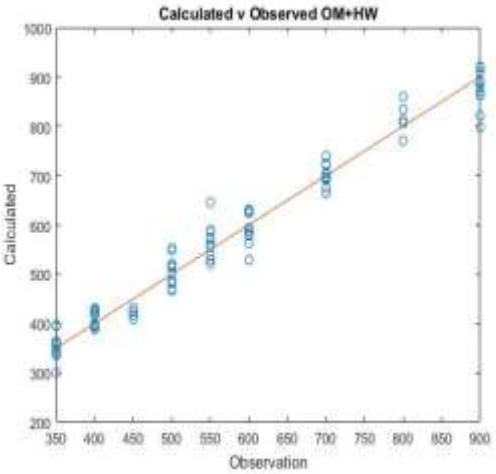


Figure 2. A comparison of predicted and actual temperature of charcoal formation, using PLS regression

Marine Isotope Stage 4 in Australasia: a full glacial culminating 65,000 years ago – global connections and implications for human dispersal

Patrick De Deckker [1] (patrick.dedeckker@anu.edu.au)

Lee J. Arnold [2], Sander van der Kaars [3,4], Germain Bayon [5], Jan-Berend Stuut [6], Kerstin Perner [7,8], Raquel Lopes dos Santos [9], Ryu Uemura [10], Martina Demuro [2]

[1]Research School of Earth Sciences, The Australian National University, Canberra ACT 2601, Australia
[2]School of Physical Sciences, the Environment Institute and the Institute for Photonics and Advanced Sensing, University of Adelaide, Adelaide, South Australia 5005, Australia.
[3]School of Earth, Atmosphere and Environment, Monash University, Clayton VIC 3800, Australia
[4]Cluster Earth & Climate, Faculty of Earth and Life Sciences, Vrije Universiteit, 1081 HV Amsterdam, Netherlands
[5]IFREMER, Marine Geosciences Unit, CS 10070 - 29280 Plouzané, France
[6]NIOZ - Royal Netherlands Institute for Sea Research, and Utrecht University, P.O. Box 59, 1790 AB Den Burg, The Netherlands
[7]Uni Research Klima & Bjerknes Centre for Climate Research, Jahnebakken 5, 5033 Bergen, Norway
[8]Leibniz Institute for Baltic Sea Research, 15 Seestrasse, 18119 Rostock, Germany
[9]British Geological Survey, Centre for environmental geochemistry, Keyworth, Nottingham, NG12 5GG, UK10
[10]Department of Chemistry, Biology, and Marine Science, University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa, 903-0213, Japan

Over the last four decades of palaeoclimate research, significant emphasis has been placed on the Last Glacial Maximum (LGM) spanning 26.5–19 thousand years ago (ka), a period that saw significant (~125 m) sea-level reductions and major ice caps adorning large parts of the Northern Hemisphere. Here, we present evidence for another major glacial period spanning 71–59 ka (Marine Isotope Stage 4: MIS4) from a well-dated marine sequence offshore South Australia. The astronomically-tuned chronology of this deep-sea core is confirmed using single-grain optically stimulated luminescence dating (OSL), providing confidence in our high-resolution age model. Our approach to the study of our MD03-2607 core has been to employ many different proxies. These are: 18O of both planktic and benthic foraminifera for stratigraphic purposes, faunal counts of planktonic foraminifera to reconstruct the position of oceanic fronts and currents, alkenone palaeothermometry, XRF core scanning to determine the presence of aeolian dust, and Nd isotope to identify fluvial discharge over the core site. We compare our new proxy findings with other archives for mainland Australia and Tasmania.

Our multi-proxy palaeoclimate reconstructions are consistent with other marine, terrestrial and cryosphere archives across the Southern Hemisphere and suggest, for the first time, that MIS 4 was almost as dramatic as the LGM. During MIS4, global sea-level was reduced by ~100 m, glaciers across Australasia were more significant compared to the LGM, and sea-surface temperatures were much reduced. These glacial conditions uniformly peaked around 65 ka. Global comparisons show major glacial conditions and vegetation shifts elsewhere during MIS4, but many are poorly dated. The significant environmental changes taking place during this glacial period were paralleled by waves of human dispersal across Eurasia and the earliest evidence of human occupation in northern Australia at 65 ka.

News from the Periodic Table: Quaternary landscapes and ecosystems viewed from the perspective on an atom (or two)

Anthony Dosseto[1] (tonyd@uow.edu.au)

[1]Wollongong Isotope Geochronology Laboratory, School of Earth & Environmental Sciences, University of Wollongong

As the outer layers of our planet experience changes faster than a pubescent teenager, we need tools to understand how environments and ecosystems respond to changes in the atmosphere and hydrosphere. The application of novel isotopic techniques to sedimentary archives, in combination with other approaches, furthers our understanding of the links between climate, landscape and ecosystems. Uranium isotopes inform on how hillslope erosion changes over time. They showed that in highland areas of France and New Zealand, the response to wetter conditions is antipodal: in France this results in a decreased erosion, while it is enhanced in New Zealand. Lithium isotopes can provide insights on changes in soil formation. In southern Europe, soil formation progressively increased since the onset of the Holocene before being reset by Alexander's ancestors. In western Europe, it has been tightly coupled to changes in vegetation cover over the past 100,000 yr. Boron isotopes provide a record of past bushfires. Combined to charcoal analysis, the application of this technique to speleothems and sediments brings prospect of a detailed understanding of how fire regimes respond to climate variability. Strontium isotopes in teeth and bones act as a GPS tracker on past migrations of humans and animals. Like a protective mother wanting to do her child's every movement, we can use Sr isotopes show how ecosystems responded and adapted to past changing climatic conditions. Calcium isotopes in teeth and bones provide a record of who was eating what… and who. Like migratory studies, trophic level and diet reconstructions are also critical to help us understand how ecosystem structures have shifted during the Quaternary. Altogether, the Isotopic Toolbox paints a detailed picture of past environments. This artwork, if not shredded by 'Banksy' politics, will shed the light, like every form of art, on who we are (where we come from, and where we're going).

The Holocene Glacial History of Dart Glacier, Southern Alps, New Zealand

Lisa H. Dowling[1] (lisa.dowling@vuw.ac.nz)

S.R. Eaves[2], K.P. Norton1, A.N. Mackintosh[1,2], A.J. Hidy[3], S.R. Zimmerman[3], A.M. Lorrey[4], M.T. Ryan[1], L.J. Vargo[2], S.G. Tims[5]

[1]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, Wellington, New Zealand
[2]Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand
[3]Lawrence Livermore National Laboratory, Livermore, CA, USA
[4]National Institute Water and Atmospheric Research, New Zealand
[5]Australian National University, ACT, Australia

Understanding pre-industrial or natural climate variability provides an important context for assessing the impact of anthropogenic climate change. However, detection and attribution of human impact on the climate system is limited by short instrumental climate records, especially in the Southern Hemisphere. Mountain glaciers are sensitive climate indicators, thus geological records of their past variability offer the potential to augment instrumental climate records. Reconstructing glacial histories from the geological record requires: (i) well-preserved glacial geomorphology and (ii) accurate dating methods that are applicable to centennial timescales.Dart Glacier is situated in the Southern Alps and has a ~100 year history of observational records, one of the longest in New Zealand. The upper Dart Valley also contains a clear moraine record that delineates the extent of pre-historic ice geometries, thus offering the potential for an extended record of glacier-climate variability that immediately precedes anthropogenic climate forcing. Here we present results from detailed geomorphologic mapping and cosmogenic 10Be dating of Holocene moraines at Dart Glacier. Our findings contribute towards a better understanding of spatial-temporal patterns of Holocene glacier and climate fluctuations in New Zealand. Our new moraine chronology also provides valuable constraints for glacial modelling aimed at understanding drivers of recent natural climate variability.

Leaving a trail: reconstructing past climates from stable and clumped isotope analysis of snail shells

Georgina Falster[1] (georgina.falster@adelaide.edu.au)

Jonathan Tyler[1], Tobias Kluge[2], Florian Dux[3], Russell Drysdale[3] Allan Chivas[4], John Tibby[1], Liz Reed[1]

[1]University of Adelaide
[2]Heidelberg University
[3]University of Melbourne
[4]Wollongong University

The timing and nature of the Last Glacial Maximum in the Southern Hemisphere is not well constrained, particularly in the arid and temperate areas of southern Australia. New high-resolution records from temperate southern Australia that span the LGM indicate that the expression of the LGM in Australia is different to that of many Northern Hemisphere records. However, these records have generally been qualitative. Quantitative climate data from the arid and temperate zones are required to anchor these records, allowing for detailed comparison with both records from farther afield, and modern climates. A potential quantitative proxy for past climate is the stable isotope composition of land snail shells. Land snails live in a wide variety of Australian climate zones, and precipitate a durable aragonite shell. The carbon and oxygen stable isotope composition of these shells has been used as a palaeoclimate proxy in arid and temperate climates in the Northern Hemisphere, but not as yet in Australia. Snail shells may provide quantitative data, through use of the 'carbonate clumped isotope thermometer'. This is a novel technique, which relies on the thermodynamic tendency of the heavy stable isotopes of carbon and oxygen (18O and 13C) to 'clump' together in the carbonate mineral lattice. This tendency increases as temperature decreases, allowing estimation of the temperature at the time of carbonate precipitation. This is independent of both source water oxygen isotope composition (δ18O), and specific carbonate phase. However, the carbonate clumped isotope thermometer is still in the early stages of development, and has not been tested extensively in Australian environments. Here we present temperature and source water δ18O estimates from modern land snail shells, collected from a broad climate gradient across Australia, alongside a more extensive suite of stable isotope analyses. We compare the results with observed weather at the time of shell growth to determine the suitability of snail shells for palaeoclimate reconstruction.

Using satellite imagery to improve our understanding of longitudinal dunes as paleoclimate records

Adrian Fisher[1, 2] (Adrian.Fisher@unsw.edu.au)

Paul Hesse[3]

[1]Joint Remote Sensing Research Program, School of Earth and Environmental Sciences, University of Queensland, St Lucia, QLD
[2]School of Biological Earth and Environmental Sciences, University of New South Wales, Sydney, NSW
[3]Department of Environmental Sciences, Macquarie University, Sydney, NSW

Dated deposits from desert dunes throughout the world have been used as paleaoclimate records of dry conditions (e.g INQUA dunes atlas). Unfortunately, analysis of the Australian data has not revealed a clear relationship between past dry periods and dune development, but instead, the record is one of patchy activity, even during the last glacial maximum (LGM). To better understand the relationship between dune activity, vegetation cover and rainfall we examined the dunes of the northern Simpson Desert, central Australia. Although most dunes in arid Australia are currently stable, photographs from Madigan's 1939 expedition across this area show impressively active dunes. The analyses used two types of satellite images. Firstly, sporadic high-resolution DigitalGlobe imagery (0.3-0.6 m pixels) from 2006-2017 were used to classify dunes as active when slip faces were visible. Secondly, for a sample of dunes, Landsat seasonal fractional cover data was extracted from 1988-2018, revealing significant fluctuations in green and dead vegetation cover driven by rainfall and fire. In the last 30 years two fires burnt different patches of the study area in 2001 and 2012. Prior to the 2001 fire all dunes had similar vegetation cover. Dunes burnt in 2001 had dramatic reductions in vegetation cover and were visibly active in 2006 after 4.5 years of below average rainfall. Unburnt dunes showed a gradual reduction in vegetation cover during the period of below average rainfall, though they never became active despite similar vegetation cover. Dunes burnt by the fire in 2012 also did not become active, even after a subsequent period of 2.75 years of below average rainfall. Although the results show that fire was required to activate sand movement on dunes, conditions with at least 4 years of very low vegetation cover were also required. We speculate that if the large rainfall events of 2010-2011 did not occur, unburnt dunes would have become active. The active dunes encountered on Madigan's expedition occurred after 15 years of below average rainfall, which has only occurred once since 1900. Patchiness in dune activity, now and during the LGM, may be the result of patchy rainfall and patchy fire activity.

Understanding human-environment interactions in space and time: 3 case studies from the Holocene in Australia

Michael-Shawn Fletcher[1]

Anthony Romano[1], Michela Mariani[1], Atun Zawadski[2]

[1]School of Geography, University of Melbourne, Parkville, Victoria, Australia 3010
[2]Institute for Environmental Research, Australian Nuclear Science and Technology Organisation, Sydney, Australia

Understanding human-environment interactions has emerged as a prominent research agenda within both archaeology and palaeoecology. Palaeoenvironmental research has demonstrated the important role that climate has in determining the development and distribution of ecosystems, however the impact of humans on ecosystems and of environmental change on humans remains contentious, particularly when studies of environmental change are conducted in isolation from archaeology. Here we present three separate analyses of human-environment interactions through time in Australia that are focussed at range of spatial scales: local, regional and continental. We highlight a tight coupling between palaeoenvironmental change and human population dynamics at all of these scales in the case studies and attempt to disentangle the reciprocal relationships between environmental change and human activity. The governing question underpinning this presentation is: how does the information provided by palaeoecology and archaeology about human-environment interactions through time vary with the spatial and temporal scale of the primary data?

Palaeoenvironmental reconstruction of Lake Couridjah (Thirlmere lakes) across the Pleistocene and Holocene using isotopic and geochemical proxies.

Matt Forbes[1] (mforbes@uow.edu.au)

Emily Barber[2], Tim Cohen[1,6], Sam Marx[2], Jon Tyler[3], Mark Constantine[4], Andrés Zamora[5], Scott Mooney[4]

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, NSW.
[2]School of Earth and Environmental Sciences, University of Wollongong, NSW.
[3]Department of Earth Sciences, University of Adelaide, SA.
[4]School of Biological Earth and Environmental Sciences, University of New South Wales, NSW.
[5]School of Biological Sciences, University of La Serena, Chile.
[6]GeoQuest Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW.

The Thirlmere Lakes are comprised of five separate, but adjacent lakes within the Greater Blue Mountains World Heritage Area. They occur within an entrenched, but uplifted bedrock meander and reportedly contain +30 m of lacustrine sediment. In 2017, a 7 m core (LC2) was extracted from Lake Couridjah, with chronology determined via radiocarbon and OSL dating. The upper 2 m of the core (representing the Holocene) indicates a marked shift in the lake to sustained peat forming conditions, by comparison to the Pleistocene lacustrine sediments below. These organic rich peat sediments exhibit relatively consistent high total organic carbon (TOC) contents (20-30%), depleted δ13C values (-30 to -34‰), low δ15N values of <1‰, total nitrogen (TN) concentrations of 1-2% and consistent C/N ratios (15-25). In contrast, the Late Pleistocene sediments display much lower TOC (<10%) and TN (40), more depleted δ13C (-28‰) and higher Si/Ti than the units above and below it. This most likely represents a wetter Pleistocene period characterised by higher lake productivity and greater SOM inputs sourced primarily from C3 terrestrial vegetation. In comparison, phases 5 and 7 display more enriched δ13C values suggesting drier conditions. Despite consistent δ13C values, the presence of higher detrital elements and greater Sr/Ca ratios for phase 2 into 3 suggests greater evaporation and thus possible drier conditions than phases 4 and 5. Finally, comparisons of this sedimentary sequence with a suite of other palaeoenvironmental records from sites in Thirlmere Lakes system provides a long, and broader, record of past environmental change.

Comparison of Recent Storm and Tsunami Deposits from the South-Eastern Coastline of India

Chris Gouramanis.[1] (geogc@nus.edu.sg)

Switzer, A.D.[2,3], Srinivasalu, S.[4], Anandasabari, K.[5], Pham, D.T.[6], Carson, S.b,[3], Pilarczyk, J.[7], Hussain, S.M.[8], Yap, W.b[3], Jones, B.G.[9]

[1] Department of Geography, National University of Singapore, AS2-04-02, 1 Arts Link, Kent Ridge, 117570, Singapore
[2] Earth Observatory of Singapore, Nanyang Technological University, 50 Nanyang Avenue, 639798, Singapore
[3] Asian School of the Environment, Nanyang Technological University, 50 Nanyang Avenue, 639798, Singapore
[4] Department of Geology, Anna University, Chennai, 600025, India
[5] Centre for Earth Sciences, Indian Institute of Science, Bangalore 560012, India
[6] Viet Nam Institute of Meteorology, Hydrology and Climate Change - 23/62 Nguyen Chi Thanh, Ha Noi, Viet Nam
[7] Division of Marine Science, University of Southern Mississippi, 1020 Balch Blvd., Stennis Space Center, MS 39529-9904 USA
[8] Department of Geology, School of Earth and Atmospheric Sciences, University of Madras, Chennai, 600025, India
[9] School of Earth and Environmental Sciences, University of Wollongong, NSW 2522, Australia

Storm and tsunami deposits have been identified and described from many siliciclastic coastlines globally, but detailed comparison of both known storm and tsunami deposits from the same coastlines are lacking. An opportunity to compare storm and tsunami sedimentary deposits was recognised following sediment deposition by Cyclone Thane (25th to 31st December 2011) that were superimposed on sediments deposited during the Indian Ocean Tsunami (26th December 2004) in a pit (DPM3a) near Cuddalore, on the south-eastern Indian coastline. A second pit, at Silver Beach (SB1) was located 2 km south of Pit DPM3a, was examined for comparison with Pit DPM3a.

Pit DPM3a contained four distinct units, an oldest intertidal unit, the 2004 Indian Ocean Tsunami, and a reworked aeolian sand that is capped by the Cyclone Thane deposit. Pit SB1 contained an oldest intertidal deposit, an estuarine beach and capped by the Cyclone Thane deposit. The identification of these units was verified from satellite imagery. The pits were examined at 1cm increments for grainsize and grain shape characteristics, loss on ignition, heavy mineral concentrations and microfossils. Representative samples from each unit were collected for detailed mineralogy analysis using X-ray Diffraction.

A suite of statistical analyses, including exploratory data analysis techniques, analysis of variance and principal component analysis (PCA) and discriminant function analysis (DFA) was used to compare the measured parameters and the individual deposits within and between pits DPM3a and SB1. Individual deposits showed significant differences in many of the parameters, but no individual variable was diagnostic of the deposits. PCA of Pit DPM3a suggested that the proportion of heavy minerals was the strongest parameter to distinguish the storm deposit from the tidal, aeolian and tsunami deposit, but that significant overlap between the deposits occurred. The application of DFA showed that in Pit DPM3a, the storm deposit could be distinguished from the tsunami, tidal and aeolian deposits. However, applying the same data analysed from Pit SB1 showed a marked difference in unit characteristics, highlighting that the discriminant function models can only be applied to the training dataset (Pit DPM3a) and cannot be applied to nearby sites (e.g. Pit SB1).

Reconstructing 'Green Sahara Periods' over the Plio-Pleistocene

Katharine M. Grant [1] (katharine.grant@anu.edu.au)

Eelco J. Rohling [1,2], Jess Amies[1], Thomas Westerhold[3], Diederik Liebrand[3], Matthias Zabel[3], David Heslop[1], Tiuri Konijnendijk[4], Lucas Lourens[4]

[1]Research School of Earth Sciences, The Australian National University, Canberra, Australia
[2]Ocean and Earth Science, University of Southampton, National Oceanography Centre, Southampton, UK
[3]MARUM, University of Bremen, D-28359 Bremen, Germany
[4]Department of Earth Sciences, University of Utrecht, Utrecht 3584 CD, The Netherlands

Palaeo-monsoon reconstructions are essential for understanding long-term hydroclimate variability, and for providing an environmental context to human prehistory. For example, numerous archives document an expansion of vegetation and water bodies across the now arid Sahara desert during the early Holocene. This Green Sahara Period (GSP), also known as the African Humid Period, played a major role in human migration and settlement, and was linked to an intensification and northward displacement of the African monsoon rainbelt in response to orbitally driven insolation changes. Detailed records of earlier GSPs are sparser, however, due to the fragmentary nature of continental archives and/or dating issues, and relatively few marine records of the African monsoon prior to the last glacial cycle. Given the insights GSPs provide into long-term African monsoon dynamics, and their significance for hominin evolution and development, robust evidence of the timing and nature of GSPs through the Plio-Pleistocene is much needed. We recently established a new orbitally-tuned index of North African aridity/humidity, based on bulk geochemical and environmental magnetic records from Ocean Drilling Program Site 967 (Eastern Mediterranean). Our index reveals the timing of GSPs over the last 3 million years, and we are now extending the record back to 5 My, when global temperatures and atmospheric CO2 were comparable to present levels. This work will not only shed light on African monsoon variability under enhanced radiative forcing, but also allows us to highlight potential 'pan-African humid periods'; these may be of considerable importance for efforts to understand human evolution/migrations.

Experimental degradation of leaves: Implications for palaeoclimate reconstructions

J.S. Greer[1, 2] (jacinta.greer@adelaide.edu.au)

F.A. McInerney[1, 2], J. Tibby[2, 3], C. Schulz[4], C. Barr[2, 3], J. Marshall[4], G. McGregor[4]

[1] Department of Earth Sciences, University of Adelaide, SA 5005, Australia
[2] Sprigg Geobiology Centre, University of Adelaide, SA 5005, Australia
[3] Department of Geography, Environment and Population, University of Adelaide, SA 5005, Australia
[4] Department of Environment and Science, Brisbane, QLD 4000, Australia

The analysis of organic material preserved in sedimentary records has long been a useful tool in reconstructing past climatic conditions. While often overlooked, it is possible for early diagenetic processes to alter the carbon isotopic composition of plant material before, or during, its incorporation into the sediment due to the varying rates of degradation of different chemical constituents of the plant. It has been suggested through down-core observations in prior studies that initial diagenesis can cause a ~1 ‰ fractionation in the δ13C ratios. However, these observations have never been tested using a controlled field experiment. We have devised such an experiment, focusing on the tree species *Melaleuca quinquenervia* at Swallow Lagoon, Minjerribah (North Stradbroke Island). The *M. quinquenervia* growing on Minjerribah are the subject of ongoing study because preservation of their leaves in Swallow Lagoon enables species-specific stable isotope reconstructions through the Holocene. Leaves were collected from a single tree on the shore of the lagoon and cut in half, lengthways. One half of each leaf was dried after cutting and acted as a control, while the other half was left exposed to different conditions in, or around, the lagoon. One group was submerged in the deepest part of the lagoon, one in the shallows and one left out of the water among the leaf litter on dry land. One batch from each group was retrieved for analysis after 1, 3, 6, 9, 12 and 18 months. By measuring changes in leaf colour, mass, area, and δ13C, this study explores the implications of early diagenesis on potential palaeoclimate reconstructions. Preliminary results suggest that the largest change in leaf mass occurs within the first month and that leaves which are submerged in water lose more mass per area than leaves on land. It also appears that the depth of the water is important, with the relationship between the length of exposure and mass lost stronger at depth. Understanding exactly how early diagenesis changes the stable isotope composition of *M. quinquenervia* leaf material over time, and with varying conditions, will be invaluable for using this species as a reliable climate proxy.

A ~30ka pollen and charcoal record from the Mitchell Plateau, The Kimberley: implications for past climate, fire and human activity NW Australia.

Haberle, S.G.[1,2] (simon.haberle@anu.edu.au)

Rowe, C.[2,3], Rule, S.[1,2], Schneider, L.[1,2], Roberts, P.[1]

[1]Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University, Acton 2601, ACT, Australia
[2]ARC Centre of Excellence for Australian Biodiversity and Heritage, Australian National University, Canberra, ACT 2601, Australia
[3]College of Science, Technology and Engineering, Earth and Oceans Academic Group, James Cook University, PO Box 6811, Cairns 4870, Queensland, Australia

A new pollen and charcoal record from the Kimberley region of NW Australia has revealed the potential for detailed deep-time palaeocological research to be conducted successfully in a region critical to our understanding of the impact of fire and monsoon climate systems in the Australian Monsoon Tropics. This study on 2 small lakes in the Kimberley region, trapped within palaeochannels of the Lower Mitchell River, shows that pollen and charcoal is well preserved through the last glacial maximum (~30ka) and into the Holocene. The record shows that during the last glacial maximum vegetation in the Kimberley region was dominated by open grasslands with sparse tree cover consisting of Myrtaceae (mostly Eucalyptus-type) and a low level of burning. Nevertheless, rainforest allies such as Palms (Arecaceae), Pandanaceae, Loranthaceae, Boraginaceae together with a high diversity of plant taxa persist during this period, expanding in relative abundance during the Holocene. Fluctuations in the woody vegetation versus grassland cover appear to be responding to intensified strength of the Australian-Indonesian Summer Monsoon (AISM). A gap in the record (~16-14ka) corresponds to a period of extreme aridity and may relate to failure of the AISM and a persistent positive Indian Ocean Dipole (dry NW Australia).

Developing Tree-Ring Chronologies and Climate Reconstructions from Moisture Sensitive Araucariaceae Trees in Tropical and Subtropical Australia

Haines, Heather A.[1] (h.haines@griffith.edu.au)

English, Nathan B.[2], Hua, Quan[3], Olley, Jon M.[1], Gadd, Patricia, S.[3], Palmer, Jonathan G.[4], Kemp, Justine[1]

[1] Australian Rivers Institute, Griffith University, 170 Kessels Rd, Nathan, QLD, 4111, Australia
[2] School of Health, Medical and Applied Sciences, Central Queensland University, 538 Flinders St. West, Townsville, QLD, 4810, Australia
[3] Australian Nuclear Sciences and Technology Organisation, Locked Bag 2001, Kirrawee DC, NSW, 2232, Australia
[4] Palaeontology, Geobiology and Earth Archives Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW, 2052, Australia

Many parts of tropical and subtropical Australia lack both annually-resolved long-term instrumental climate data and proxy climate records. This limits our understanding of past climate patterns and impacts. There are however, remnant forest stands where dendroclimatology could be applied to extend the climate record. Tree species in these regions are known to be compromised by numerous ring anomalies and as such are understudied resulting in indistinct tree growth-climate relationships. Recent research of trees in the Araucariaceae family has attempted to address these issues with the goal being to develop long-term climate reconstructions across tropical and subtropical Australia. Araucariaceae trees are commonly found across northern and eastern Australia and are longer lived than many other local non-temperate species. They are known to produce growth rings that are mostly annual and their growth appears sensitive to climate, specifically to moisture conditions. Three Araucariaceae species, hoop pine (*Araucaria cunninghamii)*, bunya pine (*Araucaria bidwillii*) and purple kauri pine (*Agathis atropurpurea*) have been studied at five locations within the rainforests of eastern Queensland. Ring anomalies including false, faint, locally absent, and pinching or wedging rings, were identified. This was done by applying bomb-pulse radiocarbon dating and Itrax radiographic analysis to hoop pine trees from subtropical Lamington and D'Aguilar National Parks respectively. Additionally, dendrometers were installed on trees of all three species so that the climate variables influencing seasonal growth could be identified. It was found that moisture conditions drive annual growth in Araucariaceae trees but that the onset and cessation of the growth season is dependent on temperature. Forest elevation also needs to be considered as the growth season length is longer at lower elevation and there is an influence of cloud cover seen in the north Queensland rainforest, which is close to a cloud forest classification. Annual growth was confirmed for all species through this analysis and the suitability for their use in climate reconstruction proven. Following this, a 164-year drought reconstruction for Southeast Queensland was developed using hoop pine trees from the subtropical rainforest of Lamington National Park. Additional work is continuing to further develop a network of long-term Queensland tree-ring climate records.

The Desert Dilemma

Paul Hesse[1] (paul.hesse@mq.edu.au)

[1]Macquarie University, Sydney

Records of dust flux from Australia show consistent LGM peaks, in agreement with other global records, implying, perhaps, increased aridity. However, dunefields from central Australia do not show clear records of heightened LGM activity, also consistent with global records. Confusingly, dunefield records from the semi-arid margin do seem to show evidence of stronger LGM activity. In this paper I seek to explain and reconcile the divergence between these two proxies. Vegetation cover is key to limiting both sand movement and dust entrainment today and in the past. However, while today we perceive rainfall (or available moisture) as being the primary constraint on vegetation cover, in the LGM temperature and carbon dioxide levels played a much larger role and produced patterns quite different to today. These same variables also resulted in dramatically higher peak (bankfull) discharges in inland rivers, adding to the complexity of interpreting environmental proxies. The LGM desert was expanded, relative to today, but not clearly more 'arid', while the presently humid fringe was greatly contracted and more sparsely covered permitting enhanced aeolian activity and runoff.

Searching for structure in sea-level records

Fiona D. Hibbert[1] (fiona.hibbert@anu.edu.au)

Felicity, H. Williams[1], Malcolm Sambridge[1], Eelco J. Rohling[1]

[1] Research School of Earth Sciences, The Australian National University, Canberra, ACT, 2601, Australia.

Geological sea-level records provide context for recent environmental change, crucial data for ground-truthing climate models and insights into the potential contribution of continental scale ice sheets. Significant sea-level-rise contributions from both northern and southern ice sheets are known from the geological record, and the most recent ~500 ka offer a well-constrained range of natural scenarios from intervals during which ice volumes were similar to or smaller than present (i.e., interglacial periods), to intervals during which total ice volume was greater (i.e., glacial periods) that may help in finding the bounds of natural sea-level rise.

We present a new synthesis of sea-level indicators, with particular emphasis on the geological and biological context, as well as the uncertainties of each record. Using this new compilation and the novel application of statistical methods (trans-dimensional change-point analysis, which avoids "overfitting" of noise in the data), we will assess sea-level fluctuations for key intervals of the last 130 ka. Finally, we discuss the implications of these uncertainties on our ability to constrain past cryosphere changes.

Preliminary results from high-resolution single-grain OSL dating and soil micromorphology at Lake Mungo, NSW

Nathan R. Jankowski[1] (njankows@uow.edu.au)

Megan Ensor[1], Zenobia Jacobs[1], Nicola Stern[2]

[1]ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong, Australia
[2]Department of Archaeology and History, La Trobe University, Bundoora, VIC 3086, Australia

Lake Mungo in the Willandra Lakes Region World Heritage Area (WLRWHA) is a globally-renown site for both its archaeological and geomorphological records. Key to this significance is the long archaeological history preserved within the sediments that form the crescentic, source-bordering dune (or lunette) located on the eastern side of the now dry Lake Mungo. Furthermore, the changes in the sedimentary facies within this lunette, and others within the WLRWHA, have been used to reconstruct palaeoenvironmental change in the region throughout the last ~130 thousand years (ka). While these current frameworks provide a reliable foundation, their resolution, particularly with respect to chronological constraints, requires refining. We present here some preliminary results of the high-resolution dating and soil micromorphology analyses as part of an ongoing project at Lake Mungo. This study ultimately aims to integrate the archaeological, geological and climatic records preserved at Lake Mungo into one contiguous whole. Here, single-grain optically stimulated luminescence (OSL) dating was used to interrogate the timing of deposition of various sedimentary facies within the lunette. So far, close to 100 age estimates have been produced from 20 different stratigraphic sections within the Joulni (southern) area of the Lake Mungo lunette. This chronological investigation was teamed with soil micromorphological analyses of associated thin sections to provide detailed insights into both the syn- and post-depositional processes involved in dune formation. Using this high-resolution framework, it is now possible to integrate the Lake Mungo record more effectively into the Quaternary landscape evolution of the Murray Basin catchment.

Cosmogenic ^{14}C reveals catastrophic soil-loss coincided with early agro-pastoralism in the Andes altiplano

JD Jansen[1] (jdj@geo.au.dk)

K Hippe[2], DS Skov[1], M Lupker[3], S Ivy-Ochs[4], F Kober[5], G Zeilinger[6], JM Capriles[7], L Wacker[4], M Christl[4], C Maden[8], C Vockenhuber[4], DL Egholm[1]

[1] Dept of Geoscience, Aarhus University, Denmark; [2] Dept of Earth Science, Freie Universität Berlin, Germany;
[3] Geological Institute, ETH-Zürich, Switzerland; [4] Laboratory of Ion Beam Physics, ETH-Zürich, Switzerland;
[5] NAGRA, Switzerland; [6] Institute for Earth & Environmental Science, University of Potsdam, Germany;
[7] Dept of Anthropology, Pennsylvania State University, USA; [8] Institute of Geochemistry & Petrology, ETH-Zürich, Switzerland.

Soil thickness and distribution reflects weathering rates set by climate and tectonics subject to human impacts. Hence, while soils are the foundation of all civilizations, they also trace the course of environmental stewardship. Agriculture in the industrial age has thinned soils at rates that far outpace geological rates of soil production, yet global acceleration in soil loss is rooted in the rise of agro-pastoral civilizations ~ 12–10 ka. Cases of soil depletion preceding societal collapse are documented for Mesopotamia, the Mediterranean, and Mesoamerica, but long-term soil loss is always inferred indirectly via proxies, such as lake deposits. For the first time we quantify soil-loss directly on eroded hillslopes and in freshly eroded fluvial sediment using cosmogenic ^{14}C: an incisive new tool for quantifying soil depletion over millennial timescales.

We measured *in situ*-produced cosmogenic ^{14}C, ^{26}Al, and ^{10}Be radionuclides on soil-mantled hillslopes and river sediments of the Andean altiplano, a region with a long agro-pastoral history. Based on the offset between ^{14}C and the longer-lived ^{26}Al and ^{10}Be radionuclides, we deduce an abrupt acceleration in soil-loss over recent millennial-timescales relative to long-term (10^4–10^5 y) rates of soil erosion prior to human occupation. To identify the potential magnitude and timing of erosion responsible for the observed offset, we devised two limiting-case scenarios (**Fig. 1**):1) a simple step-change in erosion rate, and 2) an abrupt erosional spike over a constant background rate. We apply a Markov chain Monte Carlo (MCMC) inversion model to our multi-nuclide data to test the two limiting cases. Preliminary results for the 'step-change model' point to a major acceleration in erosion of one to two orders of magnitude. The amplitude of acceleration varies with the timing of the event, yielding a 58 to 109-fold increase in hill-crest erosion rates between 4.5 and 1.1 ka (modelled interquartile ranges, IQR) (**Fig. 1A**). Preliminary results for the 'spike model' suggest an erosion pulse that lowered hill-crests by ~ 1.1 to 1.9 m between 2.6 and 1.2 ka (IQR) (**Fig. 1B**). We cannot rule in favour of either limiting case, but for the three ^{14}C-^{10}Be pairs, both sets of MCMC simulations are compatible with a major perturbation in the Late Holocene involving at least a 27-fold increase in erosion rate or an abrupt surface lowering of a minimum of 0.64 m (i.e., the minimum modelled scenarios). Independent of our inversion modelling, radiocarbon dating indicates rapid valley-floor alluviation consistent with major landscape perturbation from ~ 3.4 to 1.2 ka. Sedimentary records support the notion that climate and human impacts on the eastern altiplano were entwined; wetter conditions after ~ 4.5 ka set the stage for intensified exploitation at the cost of catastrophic soil loss. The development of intensive agro-pastoral economies not later than 3.5 ka brought about displacement of natural flora and fauna by domesticated species and expansion of the human population, which in turn led to the large-scale transformation of hillslope and valley soils. Although central Andean civilizations of the last millennium (i.e., the Incas and the Spanish) may have continued to degrade soils, we suggest they inherited a resource that was already severely depleted.

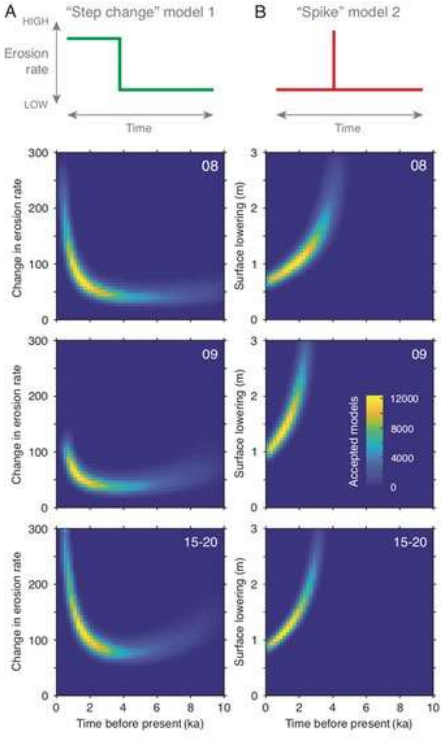


Fig. 1. Results of our Markov chain Monte Carlo-based inversion model, illustrating the two potential scenarios (A and B) of erosional transience for 3 samples in which we measured cosmogenic ^{14}C, ^{26}Al, and ^{10}Be. All 3 samples suggest major soil-loss in the late Holocene.

A new >200,000 year Australian climate record from Fern Gully Lagoon, sub-tropical eastern Australia

Chris Kemp[1] (christopher.kemp@adelaide.edu.au)

[1]The University of Adelaide

The >200,000 ky multi-proxy record from Fern Gully Lagoon fills a gap in the Australian palaeoclimate record, both temporally, as records of Australian climate prior to ~30 ka are rare, and spatially, as there is no other well-dated climate record for the past two interglacials on the central eastern coast of Australia. As the Fern Gully Lagoon record is situated in the mid-latitudes between the monsoon-dominated north, and the southwesterly wind dominated south, it can be used for testing for ENSO influences separate from these major climate drivers. Similarly, the high-resolution record allows testing for millennial-scale climate periodicity during the late MIS 7 and MIS 5 interglacials, confirmation of long-term Australian drying trend and comparison of glacial versus interglacial water availability. The Fern Gully Lagoon record indicates gradually drier interglacials over the past ~200,000 ky, a pattern observed in several Australian palaeoclimate records, most notably in central Australia. MIS 5e and late MIS 7 were warm and wet, with mid-MIS 6 and MIS 4 to MIS 2 being comparatively drier. However, the record also indicates a wet early MIS 6 glacial period, comparable to periods of lake-filling in central Australia, but at odds with climate records in northern Queensland. Interestingly, while the Fern Gully Lagoon MIS 5 interglacial pollen record indicates gradual drying and an initial warmer, wetter MIS 5e peak, the presence of increased Nothofagus and Asteraceae including *Tubuliflorides pleistocenicus* near the wetland during MIS 5 indicates a cooler period than observed in other Australian MIS 5 records.

Oxygen isotopes and trace elements in fish otoliths: modern validations and ancient applications

Kelsie Long[1,2,3] (kelsie.long@anu.edu.au)

Rachel Wood[1,3], Ian S. Williams[1], John Kalish[4], Wilfred Shawcross[5], Nicola Stern[6], Rainer Grün[1,7]

[1]Research School of Earth Sciences, ANU
[2]School of Culture, History and Language, ANU
[3]ARC Centre of Excellence for Australian Biodiversity and Heritage, ANU
[4]Australian Safeguards and Non-proliferation Office, Department of Foreign Affairs and Trade, ACT
[5]25 Fairfax Street, O'Connor ACT
[6]Department of Archaeology, La Trobe University, VIC
[7]Research Centre of Human Evolution, Environmental Futures Research Institute, Griffith University, QLD

This presentation will explore the use of the chemical and isotopic signatures in ear stones (otoliths) from modern and ancient golden perch to track the changing cycle of flooding and drying at one of the earliest sites of human occupation in Australia. By using modern otolith microchemical records and an understanding of isotope ecology we can 'ground truth' records from ancient samples and tell a more convincing story.

At the world heritage site of Lake Mungo, in north western New South Wales, lake shore dunes preserve a record of human occupation, and of alternating phases of wet and dry conditions in the adjacent lake. Golden perch are fish that can live up to 40 years, a period comparable to a human life span. As the fish grow so do their otoliths, preserving a record of the changing chemical and isotopic composition of the water in which the fish lived. Otoliths are abundant within the Lake Mungo lunettes, and can provide additional detail about lake level fluctuations and general environmental conditions as well as chronological information through radiocarbon dating.

Determining the cause of Gigantopithecus blacki's demise using dental microwear, micromorphology and luminescence dating

Julien K. Lubeek[1] (julien.lubeek@hdr.mq.edu.au)

Y. Zhang[2], R.L. Ciochon[3], M.W. Morley[4], S. Haberle[5] and K.E. Westaway[1]

[1]Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, NSW 2109, Australia
[2]Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences, Beijing, 100044, China
[3]Department of Anthropology, University of Iowa, Iowa City, IA 52242-1409, USA
[4]Centre for Archaeological Science, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia
[5]Department of Archaeology and Natural History, College of Asia & the Pacific, Australian National University, Canberra, ACT 0200, Australia.

Gigantopithecus (G. blacki, Von Koenigwald 1935) – literally 'giant ape' – was the largest ape that ever lived. It was a key member of the Stegodon-Ailuropoda fauna and roamed the subtropical forests of Asia from 1.5 million up to as recent as 300.000 years ago. Gigantopithecus is the only hominid to go extinct in the Pleistocene, while contemporary lineages of the Hominidae (family of great apes), like orang-utans, gorillas, chimpanzees and humans, survived. Its fossil record is limited, comprising of four fragmented mandibles and about 1500 teeth, of which the majority is found in caves sites across southern China. The cause of its extinction is a mystery and may be related to climate change or ecological stress, due to habitat alteration, reduction in vegetation and the arrival of Homo erectus (sensu lato) in the region. The aim of this research is to gain insight in the extinction of this giant by 1) analysing dental microwear patterns in fossil enamel to determine its palaeodiet; 2) using sediment micromorphology to complement other environmental records such as dung fungi, pollen, charcoal and phytoliths; and 3) applying luminescence dating techniques (OSL, IRSL) to cave sediments, to determine the timing associated with its extinction. Establishing a robust extinction window for this prehistoric 'King Kong' is not only relevant for understanding megafaunal extinction and reconstruction of past environmental conditions in the region, but equally important for preservation of extant biodiversity and global conservation of endangered megafauna like the giant panda and mountain gorilla.

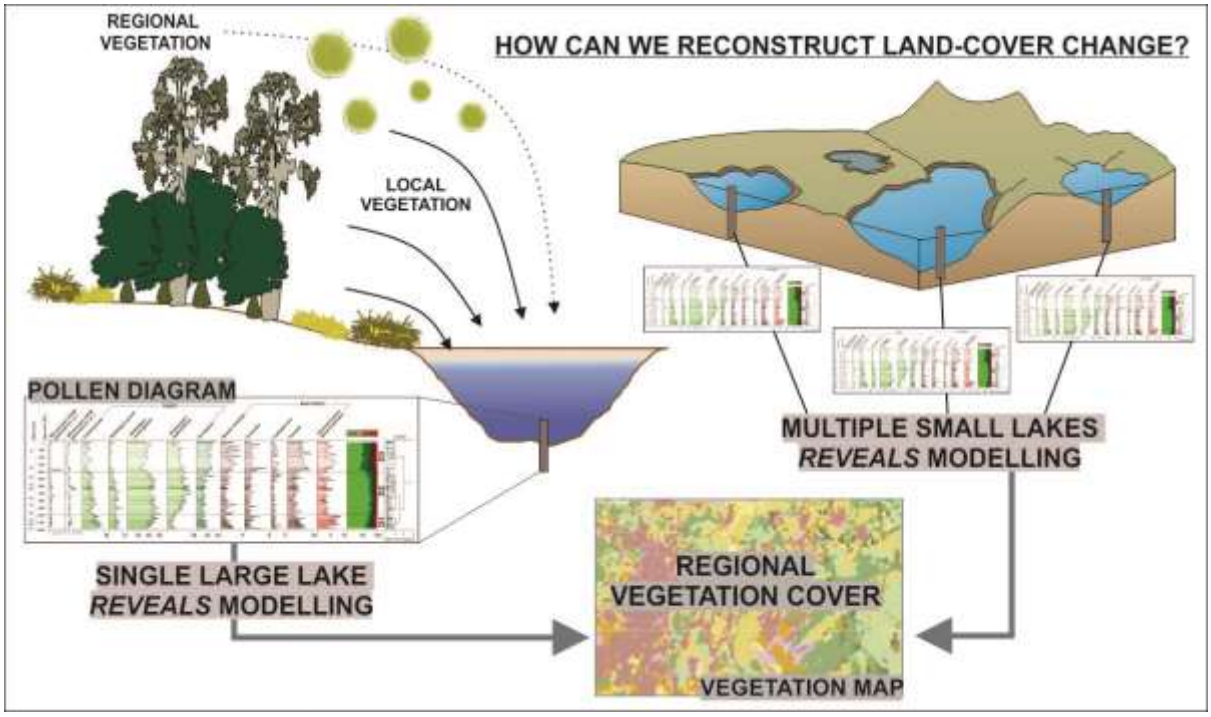
From pollen to land-cover: new modelling approaches from Tasmania, Australia

Michela Mariani[1] (michela.mariani@unimelb.edu.au)

Fletcher, M.-S.[1] Connor S.E.[2], Whitlock C.[3], Stahle L.[3], Haberle S.[4]

[1]School of Geography, University of Melbourne
[2]Maison des Sciences de l'Homme et de l'Environnement, Université Bourgogne Franche-Comté
[3]Department of earth sciences, Montana State University
[4]College of Asia and the Pacific, Australian National University

Creating effective land management approaches requires having a solid understanding of the degree of past landscape modification by climate change, wildfires and human activity. The quantification of past landscape alteration depends on our ability to reconstruct past land-cover changes. Fossil pollen is the key proxy used to track past changes in terrestrial environments, but pollen spectra suffer some important biases (e.g. taphonomy, pollen productivity, dispersal capabilities). For instance, often pollen records are dominated by a few high pollen-producing plant taxa, which may be masking the actual vegetation cover within a landscape. In turn, there is a non-linear relationship between pollen percentages and plant cover and estimating past vegetation cover from sedimentary pollen composition requires empirical-based modelling of this relationship across vegetation types. Pollen-based modelling techniques for vegetation reconstruction (e.g. REVEALS) have been applied in Europe in the last 10 years and they have been recently incorporated into Australian studies. These approaches are built on the evidence that basin size plays a major role in determining the pollen source area and large sites (ideally >1 km2) are the most suitable to reconstruct regional land-cover changes. There is a scarcity of large natural lakes in Australia, which limits the applicability of this methodology across the continent. However, model applicability can be tested by substituting single large lakes with a combination of multiple small sites. Here we show the first quantification of land-cover changes through the Holocene epoch using multiple small lakes from the Southern Hemisphere. The recent application of pollen-vegetation models from one large lake in the World Heritage Area of Tasmania has proven that treeless vegetation has been dominating the Holocene landscape in this region: will the multiple-sites approach give comparable results?



Variability in dust emissions over the Holocene: Contrasting dust production and transport in response to landscape variability across warm-arid and cold climate landscapes.

Sam Marx[1,2]

[1]GeoQuEST Research Centre
[2]School of Earth and Environmental Sciences, University of Wollongong

Atmospheric dust concentrations are a key indicator of palaeo-environmental conditions through the Quaternary. Changes in dust concentrations over millennial timescales (measured as deposition rates) have traditionally been attributed to changing patterns in aridity, with enhanced dust emissions attributed to increased aridity. Cold-climate dust sources are known to have been major dust sources during glacial periods, although the behaviour of high latitude dust sources during deglacial and interglacial conditions are less well understood. By comparison, variability in subtropical dust emissions during interglacial periods has largely been attributed to either changing aridity, or changing sediment availability (driven by climate variability. Thus the relative influence of factors may result in different dust contributions from different dust sources through time.In this study we explore the capacity of dust deposition to track landscape change through the Holocene in both cold-climate and subtropical environments. This is achieved by reconstructing dust deposition rates through time in peat deposits in New Zealand and from the sub-Antarctic Islands.

Reading the tea leaves: Leaf waxes as recorders of palaeovegetation

Francesca McInerney[1] (cesca.mcinerney@adelaide.edu.au)

Jacinta Greer[1], Jake Andrae[1], Sian Howard[1], Anthony P Hall[1], John Tibby[2], Cameron Barr[2], Andrew Henderson[3], Glenn McGregor[4], Jonathan Marshall[4], Cameron Schulz[4], Margaret Greenway[5]

[1] Department of Earth Sciences, University of Adelaide, Adelaide, AU
[2] Department of Geography, Environment and Population, University of Adelaide, Adelaide, AU
[3] School of Geography, Politics & Sociology, Newcastle University, Newcastle upon Tyne, UK
[4] Queensland Department of Environment and Science, Brisbane, QLD, AU
[5] Griffith School of Engineering and Built Environment, Griffith University, Brisbane, QLD, AU

Leaf wax compounds (e.g. long-chain n-alkanes) are long-lived in the sedimentary record and provide a critical view into past ecosystems. However, meaningful interpretation of leaf wax records in Australia requires an understanding of the factors that control their composition in modern systems. Leaf wax chain-length distributions have been postulated to reflect plant type (e.g. grasses versus woody vegetation) and also climate. Here we examine both of these sources of variation in leaf wax n-alkanes in Australia: variation among different plant types, and variation with climate within a single species (Melaleuca quiquenervia or paperbark tea tree).In a broad survey of dominant plants from a N-S transect across Australia, we find that plant type has a significant impact on chain length distribution. We show examples of how these distributions can be useful in reconstructing large-scale changes grass versus woody cover.A within-species comparisons of M. quinquenervia individuals from across Queensland shows correlations with climate, with longer, more-narrowly distributed chain-lengths associated with warmer and drier growing season, which fits theories about how n-alkanes prevent water loss through the cuticle. However, individuals of M. quinquenervia from a single site over 11 years, show no relationship with climate, suggesting that plants do not respond plastically to short-term climate changes. Instead, the observed spatial differences likely reflect the result of selection pressure over many generations. Similarly, sub-fossil leaves of M. quinquenervia from Swallow Lagoon, North Stradbroke Island, QLD, spanning the last 100 years show no correlation between chain-length distributions and climate. Together, these results indicate that within-species changes in leaf wax distribution of sub-fossil leaves likely represent large-scale changes in populations (e.g. migrations or selection) rather than short-term plastic responses to inter-annual climate variability.

Lake George and the Impact of the Mid-Pleistocene Transition

Bradley Opdyke[1] (Bradley.Opdyke@anu.edu.au)

[1]The Australian National University

A new core from central Lake George in New South Wales provides sedimentary evidence of a transition from long periods of the Lake being full to the playa lake we are familiar with today. This transition took place in the mid-Pleistocene. Laminated sediments indicating a deep lake persist until just before 1.05 million years ago. From 1.05 million years until the present the dominant sedimentary structures are mottled clays related to wetting and drying and soil formation. The mid-Pleistocene Transition spans roughly the time interval between 1.2 million years and 800,000 years ago. Dust records from the southern ocean show a ramping up of the dust flux from the early Pleistocene to the Late Pleistocene which mirror the lake level history at Lake George. We support the proposal that the rise of high mountains in the Papuan highlands lead to a dramatic reduction in the moisture flux from the Western Pacific Warm Pool to the southern Hemisphere generally and the Australian Continent specifically during the mid-Pleistocene. We are looking forward to sharing the sedimentary and geochemical evidence of the drying of Lake George during the mid-Pleistocene.

Cyanobacteria secondary metabolites: New proxies for past climate change

L.M. Petherick[1] (lynda.petherick@vuw.ac.nz)

R. Marquez[2], K.M. Rogers[3]

[1]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, NZ.
[2]School of Physical and Chemical Sciences, University of Canterbury, NZ
[3]National Isotope Centre, GNS Science, NZ.

We present a new proxy for past climatic and environmental variability based on cyanobacteria secondary metabolites (CSMs). This innovative and interdisciplinary research programme will be the first study of CSMs archived in anoxic lake sediments as a proxy for past climatic and environmental change.

Cyanobacteria are ubiquitous, tolerating climatic (e.g. temperature) and environmental (e.g. nutrient supply) variability more successfully than other organisms. This adaptability has made cyanobacteria one of the longest existing life-forms, with geologic evidence showing their existence since the Archaean (~3.5 billion yr. BP). Freshwater cyanobacteria produce a number of unique CSMs (e.g. microcystin, nodularins, moturporin). These species-specific secondary metabolites are easily identifiable and clearly distinguishable from those produced by other organisms. CSMs archived in lake sediment cores reflect varying diversity in populations of freshwater cyanobacteria through time.

Preliminary results have been obtained from a core from the dairy-surrounded Lake Kopureherehere, Horowhenua, lower North Island. The 2 m core (dated to ca. 2000 yr. BP) was sampled at low resolution for analysis of CSMs by gas chromatography mass spectrometry and high-performance liquid chromatography mass spectrometry. We compare these mass spectrometry results with pollen and stable isotopes (δ13C and δ15N). These initial results suggest that our new method for reconstructing past lake health is successful. Future analyses will be run at a higher temporal resolution to identify periods of abrupt change.

Integrated age modelling of numerical, correlative and relative dating of a long lake sediment sequence from Orakei maar paleolake, Auckland, New Zealand

Leonie Peti[1] (lpet986@aucklanduni.ac.nz)

Paul Augustinus[1], Craig Woodward[2,3], Andreas Nilsson[4]

[1]School of Environment, The University of Auckland, New Zealand
[2]Australian Nuclear Science and Technology Organisation (ANSTO), Sydney, Australia
[3]School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Australia
[4]Department of Geology, Lund University, Lund, Sweden

Accurate and precise chronologies are fundamental for any successful Quaternary paleo-climate/-environment reconstruction. Aside from varved lake sequences, all records depend on sediment core age models developed from a limited number of dated horizons, often with large errors. Hence, it is crucial to combine every piece of available information on the depositional history of the basin with modelling tools used for chronology development such as Bacon, a Bayesian age modelling package. Whilst sediment core chronology development has progressed from linear interpolation between dated horizons to considering uncertainties and Bayesian accumulation models, these age models rarely reach the resolution and precision desired for reliable paleo-climatic interpretations, especially in pre-Holocene sequences as errors increase and radiocarbon dating is not suitable anymore. We address this issue here in the context of Orakei maar paleolake sequence, Auckland, New Zealand. This record spans ca. 120 to 10 cal ka BP and is underpinned by tephrochronology, radiocarbon dating and relative changes in paleointensity of the earth magnetic field. Pre-40 cal ka BP, the age model relies on comparison with and correlation to the global PISO-1500 paleointensity stack through dynamic time warping (DTW in R). The chronology for the time interval ca. 50 to 10 cal ka BP has been estimated in Bacon (rBacon in R) with non-normal error distribution of un-calibrated ages, variable mean accumulation rates and accounting for many “slumps” (horizons of instantaneous deposition).The Orakei maar paleo-lake age model is a work in progress but serves as an example for extended age modelling from lake sediment sequences, particularly beyond the radiocarbon age limit. Furthermore, the Orakei maar sequence offers a high-resolution and continuous record of climatic variations that span much of the last glacial cycle and is one of the few from the mid-latitudes of the Southern Hemisphere. The rarity of records of this type makes Orakei maar a crucial record for development of an improved understanding of the global climate system because of its potential to be tied directly to the polar ice core and tropical lake and speleothem records.

Lake George overview

Brad Pillans[1]

[1]Research School of Earth Sciences, The Australian National University, Canberra, ACT, 2601

Lake George, or Weereewa, some 30-40 km north of Canberra, is an internally draining basin with no surface outlet. The lake is impounded on its western side by the Lake George Fault. Drilling by ANU and BMR, in the early 1980's revealed up to 165 m of sediment beneath the lake floor. The basal sediments were estimated to be possibly of Miocene age, based on magnetostratigraphy and biostratigraphy (Singh et al 1981; Truswell 1984). However, more recent work, using combination of magnetostratigraphy, biostratigraphy and cosmogenic nuclide burial dating indicates an age of ~4 million years (mid-Pliocene) for the base of the sequence (Macphail et al 2015).Over the last 200 years, water level fluctuations of approximately 7 - 8 m have occurred, largely controlled by the balance between rainfall and evaporation. At times, including in 2018, the lake has been completely dry. Coventry (1973) mapped shoreline deposits up to 37 m above the present lake floor, at which point the lake may have overflowed to the west through Geary's Gap, into the headwaters of the Murrumbidgee River. Using a Digital Elevation Model of the Lake George Basin, derived from LiDAR data, a second potential spill point has been identified to the north, at Dry Lagoon, into the Lachlan River catchment.In this talk I will give an overview of current research on Lake George which is funded through ARC Linkage Project LP140100911 "From ancient to modern environments in southeastern Australia: evidence from the unique natural archives of Lake George".

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Late Quaternary relative sea-level changes and evolution of the Lacepede Shelf, southern Australia

Nuria Lahuerta Piñeiro[1] (nlp999@uowmail.edu.au)

Murray-Wallace, C.[1], García A.[1]

[1]School of Earth and Environmental Sciences, University of Wollongong, NSW.

The River Murray of the Murray-Darling Basin, the largest in Australia reaching the sea (1,060,000km2), debouches onto the Lacepede Shelf, in SE South Australia. The Lacepede is a wide (180km), shallow (≤150m), tectonically stable shelf, part of the largest modern temperate cool-water carbonate depositional province in the modern world. During the Quaternary, the dominant geomorphological changes within the region have resulted from transgressive/regressive events with minimal isostatic effects in this far-field environment. During lower sea-level in the Middle and Late Pleistocene (>120m BPSL, Penultimate and Last Glacial Maxima;~130ka and ~20ka) much of the shelf was subaerially exposed, the former river extended ~200km farther south from the modern coastline. The Lacepede provides an excellent record of the history of the Murray during the last glacial cycle and the history of sea-level changes and the evolution of the former shorelines. Based on taxonomy, dating (14C-AMS and AAR) of foraminifera besides sedimentological and mineralogical data from three cores located within the palaeo-channels of the ancient river, show sea-level at 40-50m BPSL during the Holocene transition (~12ka) and 55-60m BPSL at ~45ka. In environmental terms, the river mouth (~120km away from the present mouth) represented an estuarine-lagoonal environment during colder/drier conditions (end of MIS3-MIS2). This is shown by an assemblage dominated by A. beccarii-E. excavatum, a predominance of Ammonia over Elphidium. During the LGM, the ancient Murray was restricted to a narrow palaeo-channel, transporting minimal terrigenous sediment to the shelf edge. Muscovite derived from the inland Cambrian Kanmantoo Trough and absence of benthic marine microfossils on the mid shelf, reveal the shelf was subaerially exposed until the transition to milder conditions and the beginning of the sea-level rise. During the transgression, the estuarine/lagoon system prevailed under more saline conditions, dominated by A.beccarii-E.advenum assemblage, with higher abundances of Elphidium in the inner shelf. E.advenum represented the dominant species on the mid-shelf, confirming a shallow marine environment. Finally, following the marine transgression, the character became more open marine, showing coarser grain, higher sedimentary carbonate and quartz levels, also higher abundance, richness and diversity, with B.translucens, C.refulgens, E.excavatum, R.globularis, T.oblonga, Q.incisa becoming the dominant taxa on the inner and mid-shelf.

Pipi shells: a new high-resolution palaeoenvironmental archive for south-eastern Australia

Amy Prendergast[1] (amy.prendergast@unimelb.edu.au)

[1] University of Melbourne

Oxygen isotope ratios from marine mollusc shells have been widely used to reconstruct sea surface temperature (SST) and seasonal shellfish foraging records from archaeological sites worldwide. However, the application of this technique to the Australian archaeological record has so far been limited to a few sites. Pipi shells (Donax deltoides) are common components of many archaeological sites in south-eastern Australia. One pioneering study in the 1980s (Godfrey 1988) employed oxygen isotope analyses of pipi shells to study the Holocene archaeological record of Discovery Bay in Victoria. However, this study was constrained by the technology and techniques of the time. Recent advances in mollusc shell growth increment analysis (sclerochronology) and high-resolution geochemical sampling as well as improvements in mass spectrometry technology have enabled the reconstruction of sub-monthly sea surface temperature records from intertidal mollusc shells, thus enabling more robust and reliable reconstructions. In light of these recent advances, we reassess the utility of pipi shells as archives for SST and seasonality information in south-eastern Australia.

To validate whether this species is a faithful year-round palaeoenvironmental recorder, we collected live D. deltoides from Discovery Bay, Victoria each month for a year. we analysed the intra-annual variability of δ18O in modern live-collected shells and sea water and compared δ18O-derived SST reconstructions with instrumental SST records. Shell-derived SSTs were highly correlated with instrumental SST records over the period of collection. This suggests that these shells are reliable palaeothermometers. This study demonstrates the utility of applying advanced sclerochronological techniques to Australian shell middens and shows that pipi shells hold great potential for reconstructing monthly-resolved SST records and seasonal foraging practices in south-eastern Australia.

Living Bung Yarnda (Lake Tyers)

Jess Reeves[1] (j.reeves@federation.edu.au)

[1]School of Health and Life Sciences, Federation University Australia

As palaeo-scientists, we pride ourselves on being able to reconstruct environments and climates based on dead things preserved in mud. But how does this correlate with the lived experience of place? Bung Yarnda (Lake Tyers) is a drowned river ICOLL estuary in East Gippsland, with a largely wooded catchment and a colourful past. It is home to the Lake Tyers Aboriginal Trust and site of the former mission, a large artist community and passionate recreational fishers. All people here are connected by their love for this beautiful corner of the world.This project seeks to develop a community led management plan for the environmental values of the lake – allowing the lake to speak through its people. In the first instance, we are developing a multi-proxy monitoring program to systematically record the observations that people are passionate about: a citizen science program, but utilising the community expertise, underpinned by the science. This will include regular monitoring of birds, fish, water quality, vegetation and aquatic invertebrate communities. We are also capturing people's lived experience of place – what they say, what has changed, what are their concerns. The data gathered will be integrated into a geospatial database, which we can use to track change over time and also data-mine to answer questions of concern. Threats to the system currently include artificial openings of the berm, decreased river inflow, deer populations, increased urban encroachment, fire (wild and planned), intensive fishing periods and proposed mining in the upper catchment. With time and trust, we are going to extend this record back through history, capturing people's stories as they flow. We can then compare this with the palaeo-record from a series of cores taken through the lake system. The proxies include charcoal, nutrients and microfaunal assemblages to assess changes in burning, catchment clearing and berm openings. This project is being developed with and for the community of Bung Yarnda (Lake Tyers) to ensure long-term sustainable management of this unique environment.

Modern Australian Isotopic Baselines: Implications for the Expansion of Isotope Research in Australian Archaeology

Georgia L. Roberts[1] (georgia.l.roberts@gmail.com)

Jacqueline Towers[2], Michael K. Gagan[3], Richard Cosgrove[4], Colin Smith[4]

[1]Monash University
[2]Bradford University
[3]University of Queensland
[4]La Trobe University

Although stable isotopic analyses are becoming more common in archaeological and palaeoecological studies, comparatively few investigations have been undertaken with the aim of identifying natural variation in modern populations in comparable contexts and this remains a significant criticism of the field. This is of particular relevance in Australia where the use of isotope analysis in both modern and archaeological research remains underutilised.Presented here is an example of the effective use of modern baseline data in an Australian archaeological context. Modern isotopic variation for the Tasmanian Common wombat (Vombatus ursinus tasmaniensis) has been identified at a range of scales, from the individual to local and regional populations. The study found significant variation in each of these samples, emphasising the need to account for individual behaviour in our interpretation of the isotopic data, rather than relying on a species level approach.

Introducing WALIS – The World Atlas of Last Interglacial Shorelines

Deirdre D. Ryan [1] (dryan@marum.de)

T. Lorscheid [1], E. Gowan [1,2], A. Rovere [1]

1 University of Bremen, MARUM Center for Marine Environmental Sciences, Germany
2 AWI Alfred Wegener Institute for Polar and Marine Research, Germany

The last interglacial (LIG) period is one of the most studied Pleistocene sea level highstands, not only due to the endurance of the physical record around the globe, but also because global mean sea level was higher and the contemporary climate system was operating under warmer conditions than present. For these latter reasons, the LIG record represents a process-analog to predicted global warming and ice sheet reduction, an understanding of which is vital for future global development. Any fossil coastal feature, interpreted to assess the environment where it formed, can be used as a direct proxy of palaeo relative sea level (RSL), as well as for studies of sea-level variability and neotectonics. Recent research has highlighted the previously unrecognised contribution of dynamic topography and glacial isostatic adjustment to the sea-level record, increasing uncertainty on estimates of mean global sea level during the LIG and the reconstruction of regional sea-level histories. It has also been recently recognised that additional uncertainty can be introduced from the methods used to measure and interpret RSL indicators. Currently in development is WALIS, is a globally comprehensive database of published LIG RSL indicators. The database will provide descriptions of the indicators, geographical context, and indicative meaning, as well as all associated geochronological data provided in the original work to facilitate reproduction and/or reassessment of the relative or numerical age as determined in the original study. WALIS will be an interactive global database of research previously completed, outline areas for further research, and serve as a repository for future work. This talk will serve to introduce WALIS to the Australasian earth science community, describe its construction, and provide opportunity for input to its development from the audience it is meant to serve.

600,000 years of change in a biological hotspot

Janelle Stevenson[1] (janelle.stevenson@anu.edu.au) & Rebecca Hamilton[1] (rebecca.hamilton@anu.edu.au)

Sarah Ivory[2] and James M. Russell[3]

[1]Australian National University, School of Culture History and Language, ANU College of Asia and the Pacific, Canberra, Australia
[2]PennState, College of Earth and Mineral Sciences, State College, USA
[3]Brown University, Department of Earth, Environmental, and Planetary Sciences, Providence, USA

The lowland tropics of Wallacea host some of the most diverse, biogeographically complex forest systems on earth, and are situated centrally within the Indo-Pacific Warm Pool – a key driver of global oceanic–atmospheric circulation. Long-term environmental data for this region are, however, scarce, making predictions of future landscape dynamics difficult.Recently recovered sedimentary sequences from two tectonic lakes (Lake Towuti and Lake Lantoa) in South Sulawesi preserve long-term records of palaeovegetation, landuse and climate change. These data reveal the persistence of a forested system over the last 600,000 years that is subject to significant compositional rearrangement in response to tectonic, fire and/or climatic drivers. Key shifts include:the establishment of tropical hardwood (Dipterocarp) forest at 550 ka,replacement of this forest type by a tropical oak (Fagaceae) forest at 40 ka,development of a conifer poor, seasonal/montane forest with expanded sedgelands from 33 ka, andreplacement by a conifer rich forest with a lowland ultramafic forest element from 9.7 ka.The data suggest that rainfall seasonality within the Last Glacial Maximum (LGM) was strong, and the hydroclimate during this period was dry relative to the previous 600,000 years. While these climatic conditions appear intense enough to instigate a significant reorganisation of forest taxa—notably the contraction of coniferous forest—they did not trigger ecosystem reorganisation from a closed- to open- forest state. Our results also show that though fire activity is low in the early and mid-Holocene, it is a variable, long-term (pre-human impact) feature of the record that contributes to shaping the compositional state and diversity of the forest. Of greatest note is that the vegetation of MIS-2 and the Holocene has no analogue in the preceding 600,000 years.

Late Holocene climate variability In the Australian Alps: can sedimentary and geochemical tracers track fine scale palaeo-environmental change?

Nicola Stromsoe[1] (nicola.stromsoe@cdu.edu.au)

Jorja Vernon[2], Sam Marx[2], Craig Woodward[3], Krystyna Saunders[3]

[1]College of Engineering, IT and Environment, Charles Darwin University
[2]GeoQuEST Research Centre - School of Earth and Environmental Sciences, University of Wollongong
[3]Australian Nuclear Science and Technology Organisation

The Australian Alps have experienced some of the most dramatic change in any Australian landscape over the last glacial cycle, i.e. shifting between cold-climate conditions, glacial growth and dominance of periglacial processes and present day (warm) conditions. While these large scale changes are well documented, less is known about how the Alps have responded to more minor palaeo-climate change during the Holocene. Minor temperature changes may result in a measurable landscape response because they would be expected to manifest in changes to the occurrence of cold-climate processes, such as freeze thaw or solifluction, or conversely, increased vegetation cover and landscape stability. Sedimentary records from cirque lakes, therefore offer the potential to examine palaeo-environmental change in the alpine region during the late Holocene. In this study we examine recent (late Holocene) changes in the Alpine region of Kosciuszko National Park using cores extracted from Blue Lake and Club Lake. The two short cores date from 3,500 and 1,900 cal. yr BP, respectively. At Blue Lake, there is relatively little change recorded over most length of the core with the exception of a minor period of changing sedimentation rates and increased charcoal at 2,200-2,800 cal. yr BP, implying possible increased fires and associated landscape instability. Similarly, the Club Lake core also records little variability, although a change in sediment geochemistry implies the addition of less weathered material to the lake during the Little Ice Age, implying a potential increase in physical weathering. The most substantial change in both cores occurred within the last 200 years, with the addition of finer, less organic and significantly more chemically weathered material to the lakes. This coincides with the onset of grazing in the alpine region. This change implies that there has been increase in the contribution of sediment derived from soil to the lakes and, in particular, an increased contribution from subsoil (which in the case of the Australian Alps are more weathered). Finally, there is evidence of recovery in the top few centimetres of the cores implying conditions in the Alps have recovered from the dramatic grazing era perturbation, with conditions now similar to those over most of the late Holocene.

A dynamical link between Snowy Mountains temperatures and the Southern Hemisphere westerly winds over the late Holocene.

Zoë Thomas[1,2,3] (z.thomas@unsw.edu.au)

Scott Mooney[1], Xianglin Zheng[1], Alan Hogg[4], Laura Weyrich[2,5], Raphael Eisenhofer[2,5], Chris Turney[1,2,3]

[1]Palaeontology, Geobiology and Earth Archives Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Australia
[2]Climate Change Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Australia
[3]ARC Centre of Excellence in Australian Biodiversity and Heritage (CABAH), School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, Australia
[4]Waikato Radiocarbon Laboratory, University of Waikato, Private Bag 3105, Hamilton, New Zealand
[5]Australian Centre for Ancient DNA, University of Adelaide, Australia

The alpine area of the Australian mainland is highly sensitive to climate and environmental change. Club Lake is a high altitude (1955 m above sea level) alpine lake in the Snowy Mountains, southeastern Australia, located 120 m above the regional timberline and preserves a multi-proxy palaeoclimate and palaeoenvironmental record. A temperature reconstruction was undertaken using the palaeothermometer technique GDGT, with pollen, charcoal, LOI, magnetic susceptibility and geochemistry also measured. Bulk sediment was sampled for radiocarbon analysis to derive a chronological framework for the Club Lake sequence using a deposition model in OxCal. The multi-proxy sequence reported here spans the last 3.5 ka. The temperature reconstruction shows a gradual increase from 3500 yr BP, peaking between ~1000-2000 years BP. Charcoal also peaks during this time period, suggesting increased fire. Using climate reanalysis we find a strong contemporary link between temperature at Thredbo (weather station near Club Lake) and the Southern Hemisphere Westerly Winds, where stronger westerlies to the south of Australia enable easterly airmasses to bring warmer conditions to the Snowy Mountains/wider southeastern Australian region. Evidence from New Zealand subantarctic islands (Campbell and Auckland) suggest westerly winds were stronger between 1-2 kyr, with similar trends found in the South Atlantic sector during this time, indicating a Southern Ocean-wide shift. There has been an observed intensification of Southern Hemisphere westerly winds in recent decades, linked to hemisphere-wide changes in the atmosphere–ocean–ice domains. However, the climate and environmental impacts of these changes over Australasia, in particular alpine areas, are unclear. Palaeoclimate reconstructions such as from Club Lake can help to elucidate these mechanisms of change.

Investigating the past hydrology of Lake Mungo: a multiproxy approach.

Elise Thornton[1] (juliaelise77@gmail.com)

Jessica Reeves[2], Georgia Roberts[1] and Stephen Carey[1]

[1]Federation University, School of Science, Engineering and Information Technology
[2]Federation University, School of Health and Life Sciences.

Lake Mungo, part of the Willandra Lakes Region World Heritage Area in southwest NSW, has been the focus of multidisciplinary research for the past 50 years since geomorphological survey and subsequent uncovering of the skeletal remains of Mungo I and Mungo III in the late 1960's. This research has focused on the sediments, fossils and artefacts from the adjacent sandy clay lunette. However, there has been very little research undertaken on the lake floor itself to determine what conditions were present within the lakeIn 1972, a 3m box-core sample was taken from the Shell Tank site at the depocentre of Lake Mungo by Prof Jim Bowler. This project aims to investigate the environmental record through the recovered sediment and well-preserved ostracod sub-fossils extracted from targeted depths within the core. The gathered data will include textural analysis, X-ray fluorescence (iTRAX), X-ray diffraction, ostracod species analysis, δ18O ratios and AMS radiocarbon dating to help to fill gaps in the present knowledge about the climate of the region, including the hydrology of the lake itself.The results from these combined methods are anticipated to illustrate significant variability in the condition of the lake through the Late Pleistocene as people colonised and were living in the region through the last Glacial Maximum (LGM). In particular, it is hoped that the high-resolution record will unravel hydrological fluctuations of the site on a human time-scale. This will help address questions such as what the conditions of the lake were like when people were visiting here. As the Willandra system is fed by the Lachlan system via Willandra Creek we can begin to draw parallels between this site, in the semi-arid region and Lake George, in the temperate headwaters. The faunal assemblages between the two sites show great similarity, hence a direct correlation can ultimately be made regarding the local hydrologic response to regional scale climate change.

Past hydroclimatic variability from southwest Australian speleothems during the last millennium

Treble, P[1,2] (pauline.treble@ansto.gov.au)

Baker, A[2], Griffiths, A[1], Hellstrom, J[3], Bajo, P[1,3], Abram, N[4], Fairchild, I[5], Borsato, A[6], Markowska, M[1], Gagan, M[1,7]

[1]ANSTO, NSW, Australia
[2]UNSW Sydney, NSW, Australia
[3]University of Melbourne, VIC, Australia
[4]Australian National University, ACT, Australia
[5]University of Birmingham, United Kingdom
[6]University of Newcastle, NSW, Australia
[7]University of Queensland, QLD, Australia

Speleothems from Golgotha Cave in SW Western Australia have been investigated to extend our knowledge of past climate variability for this region during the last millennium. O isotopic datasets, the primary paleoclimate proxy used for speleothems, were constructed for four stalagmites. A challenge in their interpretation has been the disagreement between these records, despite representing coeval growth from within the same cave. Resolving this conundrum has necessitated the characterisation of the hydrology[1-5], hydrochemistry[5,6], rainfall isotopes[7] and development of proxy system forward models[1,8] for Golgotha Cave. The findings of these studies will be summarised as a conceptual model in order to present the main karst hydrological features that give rise to each stalagmite's isotopic response to hydroclimatic forcing. The paleoclimate interpretation will focus on the two continuous stalagmite records that were fed predominately by diffuse flow. This will be supported by evidence from the two stalagmites predominantly fed by fracture flow, which has resulted in a non-linear response to hydroclimatic forcing.

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The archaeology of Weereewaa (Lake George)

Amy Mosig Way[1] (away6046@uni.sydney.edu.au)

[1]The University of Sydney

The Lake George environment is unique in Australia, as a massive, resource rich, upland freshwater lake that has fluctuated in size during the period of prehistoric occupation. This presentation examines the nature of prehistoric foraging in this landscape through the analysis of several large assemblages of stone artefacts which were excavated from three sites at various distances from the lake's current shoreline. The sites, which date to the mid-late Holocene, are all located in aeolian sand deposits. While sand is generally considered to hold poor stratigraphic integrity, these excavations have uncovered large and rich stone knapping events which display high levels of coherence. Discrete stone working activities which range from large-scale primary reduction to small tool re-sharpening episodes have been identified within the site assemblages using Event-based Analysis. Rare items in the assemblages include backed artefacts, anvils, ground edge axes and hammer stones. This research is part of ARC Linkage grant LP14010091: 'Landscape evolution, environmental change and human occupation history of Lake George – an outstanding natural archive'.

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The first use of Optically Stimulated Luminescence Dating at a colonial site in Australia

Alan N. Williams[1, 2] (awilliams@extent.com.au)

Phil S. Toms[3], David Marcus[4], Anita Yousif[1], James McGuinness[4], Ashley O'Sullivan[1], Laressa Barry[1], Tessa Bryant[1]

[1] Extent Heritage Pty Ltd, 3/73 Union Street, Pyrmont, NSW 2009, Australia
[2] ARC Centre of Excellence for Australian Biodiversity and Heritage, School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia.
[3] Luminescence Dating Laboratory, University of Gloucestershire, Swindon Road, Cheltenham, GL50 4AZ, United Kingdom.
[4] Austral Archaeology Pty Ltd, 1/92 Percival Rd, Stanmore NSW 2048, Australia.

Multi-phase compliance-based archaeological excavations of a new bridge crossing the Hawkesbury-Nepean River (northwest Sydney) identified a Last Glacial Maximum (LGM) aeolian deposit through which a colonial era drainage system had been excavated. Historical documents reveal the construction of the system occurred between 1814 and 1816 CE. An opportunistic range-finding Optically Stimulated Luminescence (OSL) age was obtained from trench fill – composed of reworked LGM deposits – immediately above the drainage system. Single-grain analysis provided a median age of 1826 CE (1806-1846 CE), and shows close agreement with the documented age of construction. These findings provide the first evidence of a colonial structure reliably dated using OSL techniques, and demonstrate the feasibility of applying OSL to other archaeological sites of the recent era (<250 a). We propose well-documented historical sites in Australia have the potential to provide a robust testing ground for methodological and experimental analysis in the improvement and refinement of OSL techniques.

Towards a pretreatment for radiocarbon dating tooth enamel

Rachel Wood[1] (rachel.wood@anu.edu.au)

Stephen Craven[2], Andre Fleury[3], Stephanie Weinert[4], Stewart Fallon[1]

[1]Research School of Earth Sciences, Australian National University
[2]School of Archaeology and Anthropology, Australian National University
[3]Department of Earth and Planetary Sciences, Macquarie University

Radiocarbon dating of bone of more than c.2000 years in Australia and South East Asia is hampered by the rapid degradation of collagen. In the best-case scenarios, a few bones with a little collagen can be found when large numbers of bones are screened. However, more often than not, no collagen remains. This means that in many contexts the only samples available for radiocarbon dating are poorly associated with the event of interest, such as charcoal from burial contexts, resulting in low quality chronologies. Enamel may provide an alternative skeletal material to radiocarbon date, but little work has examined diagenesis mechanisms, or how contaminating carbon can be removed. Dates are rarely accurate: typically at least 5-10% of the carbon in enamel is a contaminant after routine pretreatment.Routine protocols employed include reacting the enamel in either acetic acid or HCl, either as large pieces or as a hand-ground powder. Using teeth known to be more than 50 ka, this presentation will show that:of a range of acids tested, weaker acids produce older ages than strong acids, and acetic acid produces the oldest dates.the smaller the grain size, the older the date obtained, presumably because the majority of contamination lies in the pores between the apatite crystallites, or on their surface.Ages on tooth enamel can be drastically improved, but accurate dates are not obtained. Typically the equivalent of 1- 2% of the carbon in enamel is modern in age after the most successful pretreatment attempted and further studies into the diagenesis of tooth enamel are ongoing.

Did solar forcing influence the Southern Annular Mode over the Last Millennium?

Nicky M. Wright[1] (nicky.wright@anu.edu.au)

Claire Krause[2], Nerilie J. Abram[1], Steven J. Phipps[3]

[1]ARC Centre of Excellence for Climate Extremes and the Research School of Earth Sciences, The Australian National University, ACT, 2601
[2]ARC Centre of Excellence for Climate System Science, and the Research School of Earth Sciences, The Australian National University, ACT, 2601. Now at Geoscience Australia, ACT, 2609
[3]Institute for Marine and Antarctic Studies, University of Tasmania, TAS, 7001

The Southern Annular Mode (SAM), also known as the Antarctic Oscillation, is a primary mode of climate variability in the Southern Hemisphere and has major climatic influences for Australia. A positive trend in the SAM can be seen in recent decades in both observational records and climate simulations, and proxy reconstructions of the SAM over the last millennium show that the SAM is currently at its most positive value compared to the last 1000 years. However, it is difficult to reconcile proxy-based reconstructions for the SAM and climate model simulations of the past millennium, as these climate simulations fail to capture the structure, magnitude, and variability seen in reconstructions for the SAM.

Here we investigate the sensitivity of the SAM to variations in solar forcing in order to understand how changes in solar irradiance may have affected the SAM over the last millennium. We explore changes in the SAM using a fully coupled climate system model with a range of constant solar forcing values that correspond to strong solar irradiance (i.e., between 1358 and 1368 W/m2) and extreme solar irradiance (i.e., 1350, 1372, and 1400 W/m2) changes. We find that a solar constant of 1358 W/m2, which corresponds to a ~7 W/m2 reduction compared to modern-day values, results in a significant negative shift on the SAM index. In addition, we explore variations in the SAM using transient climate simulations for the last millennium forced with strong solar irradiance only, in an attempt to determine if the SAM responds significantly to large (but plausible) changes in solar irradiance, and to compare to our solar constant experiments and SAM reconstructions. Investigations into the influence of solar forcing on the SAM throughout the last millennium may help reconcile differences in proxy reconstructions and climate model simulations, and enhance our understanding of the natural variability of the SAM and how it may respond in the future.

The reconstruction of moisture availability over the past 2800 years in south-eastern Australia using testate amoebae: implications for sources of moisture variability

Xianglin Zheng[1]

Geoff Hope[2], Scott Mooney[1]

[1]School of Biological, Earth & Environmental Sciences, University of New South Wales, Australia
[2]Department of Archaeology and Natural History, Australian National University, Australia

Although it is well established that moisture availability in south-eastern Australia has been decreasing recently, the driver(s) of this trend are contentious, and our understanding of this is limited by a relatively short historic record. Testate amoebae have been widely used to reconstruct peatland hydrology in the Northern Hemisphere, but research in our region is relatively uncommon (McGlone and Wilmshurst 1999; Wilmshurst *et al.* 2003; Zheng *et al*., in press). At the Auckland biennial conference, we reported on the ecology of testate amoebae in several high-altitude mires in south-eastern Australia (Fig. 1). Water table depth (WTD) was the primary environmental variable determining testate amoebae assemblages and therefore transfer functions were developed for this parameter. We examined the performance of various all-species (traditional) and species-pruned (using informative taxa only) transfer functions, and while they all performed well, the all-species Modern Analogue Technique (MAT) was the best performing transfer function (with an RMSEP of 5.73 and R^2 of 0.86). We then applied these transfer functions to reconstruct WTD using the sub(fossil) testate amoebae isolated from sediments at Snowy Flat (35.5628°S, 148.7837°E, ~20.5 ha, at 1609 m asl), a *Sphagnum-Richea-Empodisma* shrub bog, located in the ACT. This reconstruction suggests (Fig. 2): periods of enhanced moisture availability around 2200, 1120, 930 and between 720-30 cal. yr BP; and, periods of reduced moisture availability between 2550-2350, around 1680, 1000, between 870-720 cal. yr BP and in the very recent past, of approximately the last 30 years. In contrast, the period between about 2000 and 1200 cal. yr BP seems remarkably consistent in terms of hydro-climate. Many of these periods of enhanced/reduced moisture availability have previously been identified in eastern Australia. We compare this Snowy Flat record to known sources of hydro-climatic variability (IPO, ENSO, SAM) and argue that it primarily reflects long-term IPO-mediated variability in moisture availability.

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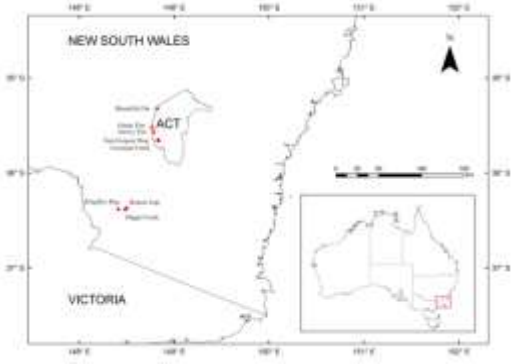

Figure 2. The location of the samples used in the modern training set and Snowy Flat.

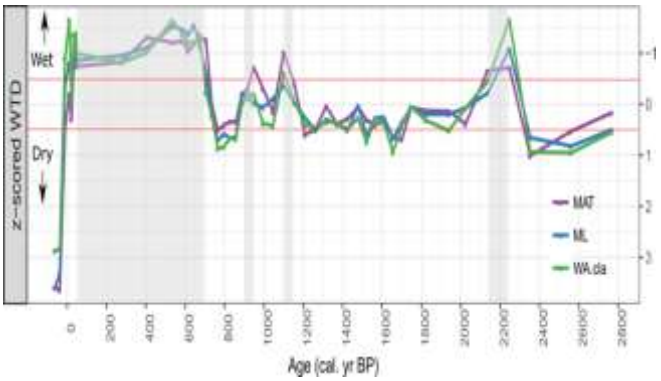

Figure 1. The reconstruction of WTD at Snowy Flat (using 3 transfer functions)