Alexandra Cave, Naracoorte Caves World Heritage Area, South Australia. Credit: ABC South East SA: Isadora Bogle

AQUA PROGRAM AND ABSTRACT BOOKLET

Adelaide 2022

Australasian Quaternary Association Inc.
ABN 78 458 664 047
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AQUA

A brief welcome from the organisers

Nina Marni all to the biennial AQUA conference.

It's very exciting to welcome so many people to Adelaide and to meet in person for the first time since 2018. Welcome, also, to those people joining online. It's lovely to think of seeing familiar faces once again. However, its particularly exciting that there is such a large number of student and early career researchers for whom this is their first AQUA meeting. Welcome and enjoy!

There is a massive number of people who have contributed to this conference, often in ways that are unseen. I want to thank them **enormously** for their contributions. Please approach any of us if you have questions during the meeting.

Looking forward to enjoying three fabulous days of Quaternary science.

Associate Professor John Tibby (he/him/his)

AQUA President and Organising Committee member on behalf of the organising committee:

Lee Arnold, Tiah Bampton, Kym Edwards, Alexander Francke, Charlie Maxson, Vanessa Nowinski, Jon Tyler, John Tibby

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AQUA 2022 Conference (6-8th December) program

Monday night (5th December)	
18:00 - 21:00	**Icebreaker** (with drinks and nibbles) *Roxie's Beer Garden. 182 Grenfell Street, Adelaide. http://www.roxies.com.au* NB: There will be an opportunity to register at the ice breaker (but also at other times on Tuesday – see below)

Day 1: Tuesday 6th December			
8:00 -8:30	**Registration** *Field Geology Room, Mawson Building* NB: There will be an opportunity to register at morning tea		
8:30 - 8:50	**Welcome to country** *Mawson Lecture Theatre*		
8:50 -9:00	**Conference opening** *Mawson Lecture Theatre*		
9:00 -9:30	**Keynote**	**Katharine Grant**	**Abrupt change in North African hydroclimate and landscape evolution 3.2 million years ago?**
9:30 -10:30	Session 1 - **"People, Dust and Late Quaternary Environments"** **A Memorial Session for Dr Lynda Petherick, AQUA President 2018-2022** *Mawson Lecture Theatre*		
9:30 -9:45	Rewi Newnham	Antarctic black carbon whodunnit	
9:45 -10:00	Sam Marx	Linking distal dust deposits with proximal lake records within the Kati Thanda-Lake Eyre (KT-LE) Basin: Examining the environmental conditions	

		responsible for Australian dust export and evaluating the role of aeolian processes in shaping KT-LE.
10:00 - 10:15	Kia Matley	A multi-proxy record of environmental change at a glacial *Nothofagus refugium*, Wyelangta, Victoria
10:15 - 10:30	Patrick Moss	Holocene Coastal Peatlands of the Tasmanian Wilderness World Heritage Area
10:30 - 10:45	**Morning tea** *Sprigg Room*	
11:00 - 13:00	Session 2 - **"Oceans and Coasts"** *Mawson Lecture Theatre*	
11:00 - 11:15	Vikki Lowe	Water mass history of the Southwest Pacific through the last 160,000 years using radiolarians
11:15 - 11:30	Amy Prendergast	Comparative sclerochronologies: evaluating gastropod shells and opercula as sea-surface temperature and seasonality archives for southeastern Australia
11:30 - 11:45	Colin V. Murray-Wallace	Sea-level changes and coastal landscape evolution in south-eastern Australia during the Last Interglacial (MIS 5e)
11:45 - 12:00	Helen McGregor	Millennial to seasonal scale views of El Niño-Southern Oscillation from central Pacific corals
12:00 - 12:15	Thomas Williams	Circulation history of the deep Indian sector of the Southern Ocean since MIS 6 as revealed by εNd
12:15 - 12:30	Juliet Sefton	Implications of anomalous relative sea-level rise for the peopling of Remote Oceania
12:30 - 12:45	Kotaro Shirai	Reconstruction of past climate and its effects on environment, ecology, and ecosystem using long-lived bivalve shell.
12:45 - 13:00	Quan Hua	Temporal variations in the marine radiocarbon reservoir effect during the Holocene – A review

13:00 - 14:00	**Lunch** Pizza *Outside the Mawson Building*	
14:00 - 15:00	**Lightning talks** *Mawson Lecture Theatre*	
14:00 - 14:05	Caroline Mather	Holocene records of environment and freshwater availability from tufa archives: implications for human occupation at Murujuga, NW WA
14:05 - 14:10	Simon Connor	A beginner's guide to turning pollen data into estimates of vegetation cover
14:10 - 14:15	Chloe Stringer	Window to past human-environment interactions? Preliminary results from a modern calibration study of freshwater mollusc species from the Central Murray River Basin
14:15 - 14:20	Felix Lauer	Revisiting aeolian sediments in the Wagga Wagga region
14:20 - 14:25	Andrea Johansen	High-resolution palaeodust archive from subantarctic Macquarie Island
14:25 - 14:30	Jonathan Tyler	Palaeoclimate data and hydroclimate risk assessment: the role of archives, proxies and time
14:30 - 14:35	Zuorui Liu	Investigations of Mammoth Teeth in Paleoenvironmental Reconstructions from Multiple Enamel Ridges
14:35 - 14:40	Harriet Magee	Old flames: the relationship between cultural burring and fire histories on Gunaikurnai Country, Victoria
14:40 - 14:45	Sam Marx	Reconstructing atmospheric particulate loads over the north-western Pacific Ocean during the mid to late Holocene: volcanism, dust and human perturbation of regional aerosol loads/composition.
14:45 - 14:50	Patrick Kennedy	Fuel loads and fire: A palaeoecological analysis of long-term fire and fuel dynamics in Bundjalung National Park, New South Wales, Australia.

15:00 - 17:30	**Poster session** *Sprigg Room* Afternoon snacks served during poster session 16:00 – 16:30
17:30	**CLOSE**
17:45 - 19:00	**Student and ECR event -** Animals Anonymous and UniBar gathering *Mawson Lecture Theatre and then Unibar* NB: For those people not students and ECRs please find your own entertainment

Posters.

*indicates a student poster which is eligible for a prize. Please vote for the best student poster using the slip provided

Number and Author		Title
1	Mahsa Alidoostsalimi *	Unlocking seasonal variations in climate and Indigenous seasonal foraging practices associated with paleo-ENSO in Great Barrier Reef using marine gastropod shells as a paleoclimate archive
2	Kathryn Allen	Spatiotemporal history of droughts and pluvials across eastern Australia's Natural Resource Management regions: a 600-year perspective.
3	Lee Arnold	Examining sediment infill dynamics at Naracoorte Cave megafauna sites using multiple luminescence dating approaches
4	Kelsey Boyd *	The potential of phytolith analysis in northern Australia.
5	Tomás Cortés	Unveiling tsunami history on the Atacama Desert coast (northern Chile) using geological evidence and hybrid tsunami modelling
6	Bianca Dickson *	Fossil pollen distributions in speleothems: an example from southwest Western Australia
7	Isabella Donato *	Putting a Name to a Face: assessing the utility of geometric morphometrics on classifying the fossil varanids of Naracoorte Caves World Heritage Area.
8	Kym Edwards *	Oxygen isotope ratios in plant phytoliths as a proxy for past climates and Environments
9	Alissa J Flatley	Deciphering the role of terrigenous sediment supply for headwater channels in the Pilbara, WA
10	Alexander Francke	Catchment vegetation and erosion controls soil carbon cycling in SE Australia during two Glacial-Interglacial complexes
11	Manoshi Hazra *	The assembly of plant microfossil assemblages: Characterizing pollen and phytoliths from plants and soils to improve palaeoecological interpretations
12	Molly Husdell *	Development of the Great Barrier Reef from the Last Glacial Maximum to present
13	Alysha Jones *	A Late Quaternary low-angle fan-delta complex, Lake George, NSW.
14	Justine Kemp	Late Quaternary river terrace development in subtropical Australia: climate change and human occupation
15	Alena Kimbrough	Validation of glacial-interglacial rainfall variations in southwest Sulawesi using Mg/Ca and δ18O in speleothems

16	Sam Marx	Reconstructing atmospheric particulate loads over the north-western Pacific Ocean during the mid to late Holocene: volcanism, dust and human perturbation of regional aerosol loads/composition.
17	Fletcher Nixon	Clumped isotope analysis of central Australian carbonates: A potential palaeoclimate proxy for Australia's arid interior
18	Ryan North *	Historic imagery reveals magnitude of glacier response to ice shelf debuttressing in the Larsen B Inlet, Antarctica
19	Vanessa Nowinski *	East Asian Monsoon response to abrupt global change during the last glacial period: evidence from the sediments of Lake Suigetsu, Japan.
20	Corey Port *	The timing of Termination IX in Italian lake sediments: a test of orbital theory
21	Juliet Sefton	A new Holocene sea-level database for Australia
22	Adrian Slee	Landslides and periglacial deposits in Northern New England provide evidence of past climate.
23	Yanjie Tian *	Environmental and Climate Controls on Late Quaternary Landscape Evolution along the Central Murray River, Australia
24	Lina Toben *	A 1000-year isotope-based record of climate variability inferred from the sediments of Lake Yukidori, East Antarctica
25	Nerita Turner *	Bite at the end of the tunnel: a quantitative literature review of the taphonomic effects of marsupial carnivores from Pleistocene Australia

Day 2: Wednesday 7th December			
8:15	**OPEN**		
8:30 -9:00	**Keynote**	**Kale Sniderman**	**Uniformitarianism's epic fail: the glacial aridity paradigm**
9:00 -10:00	Session 3 - **"The past two thousand years of hydroclimate: from mean states to climate extremes"** *Mawson Lecture Theatre*		
9:00 -9:15	Pauline Treble		Speleothem 'uptick' supports reduction in rainfall recharge to groundwater is unprecedented for last 800 years, SW Western Australia
9:15 -9:30	Tim Cohen		Extreme pluvials over the last two millennia detected using ephemeral lakes
9:30 -9:45	Sophie Grunau		Climate extremes recorded in playa lakes across continental Australia
9:45 -10:00	Maame Adwoa Maisie		Investigating the links between recent fire events and the accumulation and characteristics of charcoal in Temperate Highland Peat Swamps in the Blue Mountains of NSW
10:00 - 10:30	**Morning tea** *Sprigg Room*		
10:30 - 12:30	**Joint session with the Australian Archaeology Association (Darwin)** Session 4 - **Human-Environment Interactions** *Mawson Lecture Theatre (in person)*		
10:30 - 10.50	Michael Westaway		Investigating the Multi-Regional Emergence of Social and Economic Complexity Across Diverse Australian Environments
10:50 - 11:10	Ben Shaw		Human-Environment Interactions in the Far Eastern New Guinea Islands (Massim Region) Since the Last Glacial Maximum
11:10 - 11:30	Racheal Minos		Geomorphological Processes and Post-Depositional Movement on Stony Rises in Wurundjeri Country, Victoria

11:30 - 11.50	Lauren Cunningham	The Use of High-Magnification Microscopy in Identifying the Impacts of Carnivores in Faunal Assemblages
11:50 - 12:10	Vito Hernandez	The Microstratigraphy of Tam, Pà Ling Cave, Laos: Situating Early Humans Within the Changing Tropical Environment
12:10 - 12:30	Jonathan Benjamin	Recent Developments from the Submerged Cultural Landscape of Murujuga Sea Country, Northwest Shelf (Dampier Archipelago), Western Australia
12:30 - 13:30	**Lunch** *Sprigg Room* **OCTOPUS data base** ***Mawson Lecture Theatre***	
13:30 - 15:30	**Joint session with the Australian Archaeology Association (Darwin)** Session 5 - **Human-Environment Interactions** *Mawson Lecture Theatre (in person)*	
13:30 - 13.50	Rachel Popelka-Filcoff	ARCAS State of the Art: Archaeological Science in Australasia in 2022
13:50 - 14:10	Jessica Gibbs	Perched Springline Tufas Reveal a Warm-Wet Palaeoclimate for First Australians on the Late Quaternary Darling Downs, Southeast Queensland
14:10 - 14:30	Haidee Cadd *(in person)*	Proxies, Models, and People: Using Transient iTrace Climate Models to Disentangle Proxy and Archaeological Records During the Penultimate Deglacial in Australia
14:30 - 14.50	Emma Rehn *(in person)*	SahulArch: Age Determinations for Archaeological Sites from Sahul in the OCTOPUS Database
14:50 - 15:10	Rachel Rudd *(in person)*	Kimberley Monsoon Rainforests: New Holocene Palaeoenvironmental Records from Northwestern Australia

15:10 - 15:30	Meghan McAllister *(in person)*	Preservation Prevails at Tam Pà Ling, Laos: Reconstructing Palaeovegetation Dynamics via Higher Plant Biomarkers Offer New Insights into Environmental Variability Across MIS 3-MIS 1.
15:30 - 16:00	**Afternoon tea** *Sprigg Room*	
16:00 - 17:30	Session 6 - **"New insights into abrupt climate changes, tipping points and major transitions throughout the Quaternary"** *Mawson Lecture Theatre*	
16:00 - 16:15	Alexander Francke	East Asian Monsoon dynamics in Japan as inferred from the sediments of Lake Suigetsu
16:15 - 16:30	Ellen Corrick	Characterising the expression of sub-millennial scale climate events in western Europe during the early last glacial period using multi-proxy speleothem records
16:30 - 16:45	William Henriquez Gonzalez	Synchronous onset of the last glacial termination in the southern mid-latitudes
16:45 - 17:00	Helen Bostock	The Mid-Pleistocene Transition in the Southwest Pacific
17:00 - 17:15	Russell Drysdale	Last Interglacial cooling in New Zealand and its potential link to a West Antarctic meltwater pulse
17:15 - 17:30	Khairun Nisha Mohamed Ramdzan	Insights for restoration: Reconstructing the long-term responses, resilience and recovery time of vegetation, hydrology and peat condition to fire events in the Sebangau peatland, Central Kalimantan.
17:30	**CLOSE**	
19:00	Conference Dinner: Belgian Beer Café *Belgian Beer Café, 27/29 Ebenezer Place, Adelaide*	

Day 3: Thursday 8th December			
8:15	**OPEN**		
8:30 -9:00	**Keynote**	**Kathryn Allen**	**Summer and winter flow records for Tasmania derived from a local tree-ring network**
9:00 -10:30	Session 7 - **"Humans and ecosystems"** *Mawson Lecture Theatre*		
9:00 -9:15	Micheline Campbell		Towards the development of fire proxies in speleothems using geochemical signatures in ashes from bushfires
9:15 -9:30	Anthony Romano		Adding fuel to the fire: have fires in southeast Australia always burned so hot?
9:30 -9:45	Rebecca Ryan		Developing Novel Techniques for Reconstructing Past Fire Histories in South-Eastern Australia
9:45 -10:00	Sarah Cooley		Response, resilience and recovery of Tasmania's endangered Pencil Pine using a multi-archive palaeoenvironmental record
10:00 - 10:15	Lucinda Duxbury		Lake sedimentary ancient DNA reveals ecosystem response to fire and climate on Kangaroo Island (Karti), Australia
10:15 - 10:30	Michael Fletcher		Clear and Present Danger: the pure state of ignorance that has led to Australia's bushfire crisis
10:30 - 11:00	**Morning tea** *Sprigg Room*		
11:00 - 12:45	Session 8 - **"Humans and ecosystems, Climate and the Cryosphere"** *Mawson Lecture Theatre*		
11:00 - 11:15	Scott Mooney		Simple and fast methods for sediment-based quantification of macroscopic charcoal: solutions to recently identified problems

11:15 - 11:30	Johanna Hanson	Late Holocene environmental change of Te Whakaraupō | Lyttelton Harbour, New Zealand
11:30 - 11:45	Michael Reid	Sediment records suggest post British-invasion declines in diversity of wetland plant communities in the Koondrook-Perricoota Forest, Murray River, NSW
11:45 - 12:00	Jess Macha	Using ice core records to understand interannual -multidecadal trends in Antarctic Ice Sheet surface mass changes
12:00 - 12:15	Charles Maxson	A Holocene subtropical hydroclimate reconstruction from Karboora (Blue Lake), Minjerribah, Queensland
12:15 - 12:30	Asika Dharmarathna	A detailed study of Holocene climate variability in south-east Australia based on cellulose inferred lake water isotopes and monitoring and modelling approach at Lake Surprise, western Victoria.
12:30 - 12:45	Patrick De Deckker	The Holocene hypsithermal in the Australian region
12:45 - 13:00	**Special presentation and student poster prize presentation** Ms Michelle Durant, Managing Director of Australian Institute of Nuclear Science and Engineering ***AINSE opportunities for postgraduate students and early career researchers***	
13:00 - 14:00	**Lunch** *Sprigg Room* Poster session *redux*. We encourage poster authors to stand with their posters this lunch time	
14:00 - 16:00	Session 9 - **Climates and Humans** *Mawson Lecture Theatre*	
14:00 - 14:15	Calla Gould-Whaley	Last Glacial pluvial periods evident in subaqueous speleothems from Australia's southern arid-margin

14:15 - 14:30	Mohammad (Sepehr) Akhavan Kharazian	First geoarcheological study of a Palaeolithic site on the northern edge of the Iranian Central Desert: Mirak (Semnan, Iran)
14:30 - 14:45	Nathan Jankowski	Willandra Lakes re-revisited: preliminary results from Lake Arumpo, NSW
14:45 - 15:00	Peter D. McIntosh	Ancient shorelines of northwest Tasmania – a preliminary report
15:00 - 15:15	Timothy Barrows	The age and origin of block deposits in the Victorian Alps, Australia
15:15 - 15:30	Bohao Dong	Using giant clam shell geochemistry to understand past environmental change and human-environment interaction in the South Pacific
15:30 - 15:45	Cesca McInerney	Straight from the kangaroo's mouth: A quantitative relative humidity proxy
15:45 - 16:00	Louisa Sheridan	Tracking an anomaly: a MIS 6 warming event in Tasmania, Australia.
16:00 - 16:30	**Afternoon tea** *Sprigg Room*	
16:30 - 17:30	Session 10 - **Varied (but exciting!) talks** *Mawson Lecture Theatre*	
16:30 - 16:45	Richard Jones	Stability of the Antarctic Ice Sheet during the pre-industrial Holocene
16:45 - 17:00	Teresa Dixon	Monsoonal variations in the Kimberley since human arrival – clues from new palaeoenvironmental records
17:00 - 17:15	Tiah Bampton	Palaeodiet of Quaternary fossil rodents from Naracoorte Caves: implications for extinction and conservation
17:15 - 17:30	Rieneke Weij	Speleothem U-Th-Pb dating, pollen and charcoal reveal cave antiquity and fossil accumulation window at the Naracoorte Caves
17:30	**Conference close and presentation of awards**	
18:30	**Quiz night** *Unibar*	

Day 4: Friday 9th December
Field trip to the Coorong, lower lakes and Coorong coastal plain Depart 8:00 am Victoria Drive (C-9) on the map below Return 6:00 pm to the same location **NB: More details provided at the conference**

Length of presentations

Full length oral presentations: 12 min speaking time and 3 min for questions

Lightning presentations: 5 min (ideally 4 min with time for one question and answer)

Poster size and orientation

Posters should be no larger than A0 size (i.e. 841 x 1189 mm) and be oriented in **Portrait** format.

Student poster and talk prizes

Thanks to the generous sponsorship of both AINSE and UNSW's CHRONOS 14Carbon-Cycle Facility there are prizes for the best student talks and posters. Prizes will be awarded in honour of our late colleague Dr Lynda Petherick, AQUA President 2018-2022.

Venue locations – external

Icebreaker: Roxie's Beer Garden. 182 Grenfell Street, Adelaide. www.roxies.com.au.

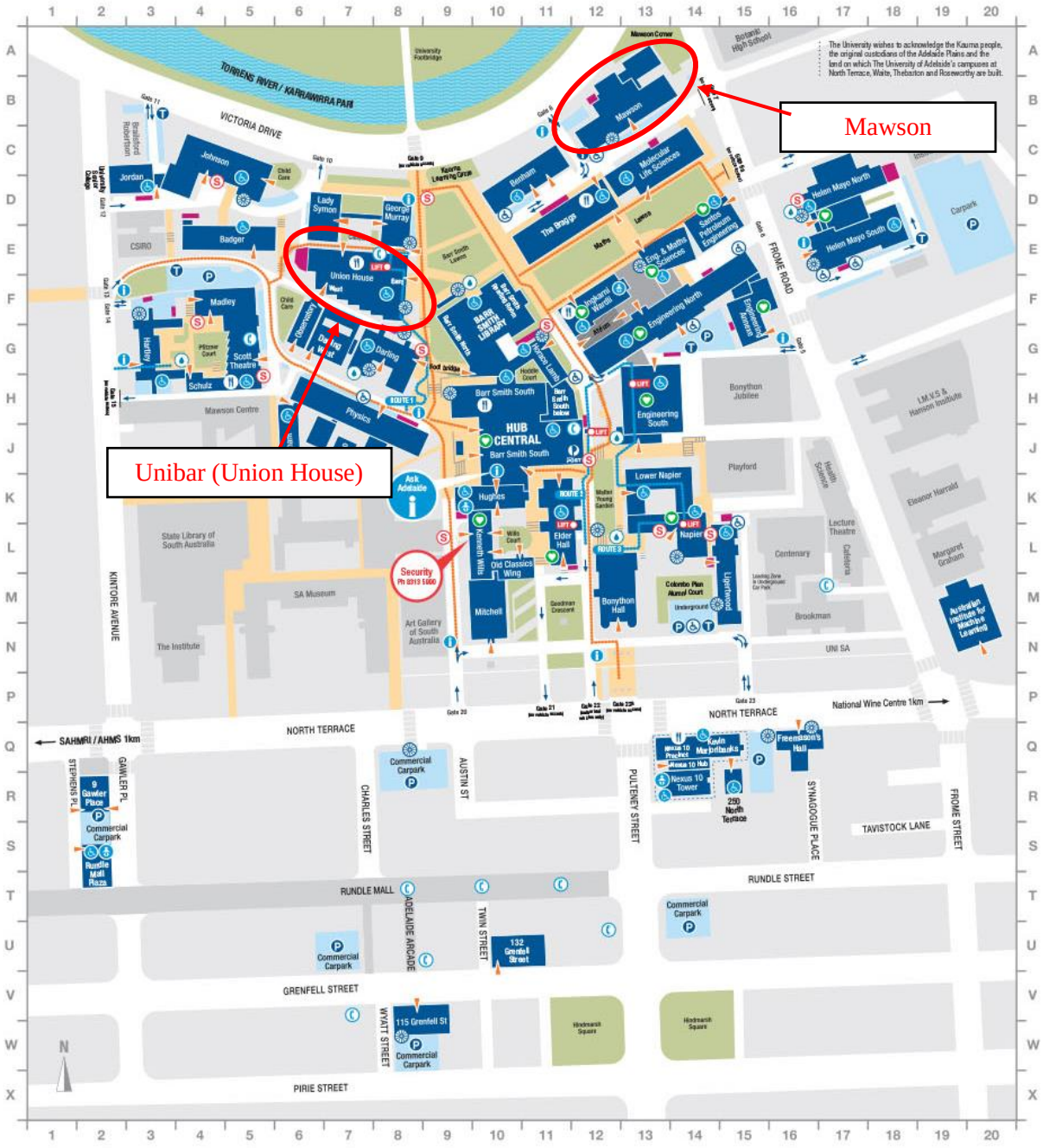
Dinner: Belgian Beer Café, 27/29 Ebenezer Place, Adelaide. www.oostende.com.au

Venue locations – University of Adelaide

Mawson Lecture Theatre– Ground Floor Mawson Building, University of Adelaide (B-13)

Sprigg Room – First Floor Mawson Building, University of Adelaide (B-13)

Unibar – Ground floor, Union House, University of Adelaide (E-7)



OCTOPUS Workshop

Wednesday lunchtime, Mawson Lecture Theatre

Dr Emma Rehn (James Cook University) and Dr Haidee Cadd (University of Wollongong)

OCTOPUS is an open-access database of age determinations and denudation rates from archaeological, sedimentary, fossil, and glacial archives. OCTOPUS' core collections are currently SahulArch (archaeological ^{14}C, OSL, and TL-derived ages), SahulSED (sedimentary OSL and TL-derived ages) and CRN (^{10}Be and ^{26}Al-derived catchment-averaged denudation rates). In 2023, OCTOPUS core collections will expand to include charcoal data from sedimentary archives (SahulCHAR), and ^{14}C dates from sedimentary archives (within SahulSED).

OCTOPUS database centralises data gathered from a broad array of sources, including published works and grey literature, which were lacking consistent reporting standards. OCTOPUS standardises these data with detailed metadata fields specific to each sub-collection. Data collection standards were determined through community input and expert advice for each dating method. OCTOPUS provides homogenised, curated datasets containing relevant metadata that can be used by researchers for a range of applications such as review, modelling, and assessment of chronometric robustness. The database is cloud-based and open access, meaning users can access data via a web interface or directly through software such as QGIS or R using the Web Feature Service.

This workshop will introduce participants to the OCTOPUS core collections and provide an interactive walk-through of accessing data through OCTOPUS via the web interface and Web Feature Service. The workshop is also an opportunity for open discussion, and feedback from the AQUA community, on how best to support the community to use and update OCTOPUS, and on the development of SahulCHAR.

To access the OCTOPUS web interface, visit https://octopusdata.org/

For more information on OCTOPUS visit:https://epicaustralia.org.au/resource/octopus/

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for Australian Biodiversity and Heritage

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THE AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING

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Centre of Excellence for Australian Biodiversity and Heritage

CHRONOS 14Carbon-Cycle Facility (UNSW)

ABSTRACTS

Key note speakers

Summer and winter flow records for Tasmania derived from a local tree-ring network

Allen, Kathryn[1]; Verdon-Kidd, Danielle[2]; Willis, Mark[3]; Maxwell, Carolyn[3]; Baker, Patrick[4]

[1] University of Tasmania; [2]University of Newcastle; [3] Hydro Tasmania; [4] University of Melbourne

To address questions around the availability of water resources into the future for renewable energy generation (a key focus for Tasmania) requires an awareness of past variability. Short term instrumental records are highly unlikely to represent the true range of natural variability in systems. We have developed four tree-ring based long flow records, two for western Tasmania and two for northern Tasmania. The summer (DJF) reconstructions extend over the past millennium while the winter (JA) reconstructions cover the past 450 years. According to the reconstructions, the north and west of the state experienced a very strong pluvial event in the 11th century, and severe and prolonged dry conditions from the late 15th to mid 16th century. The western summer reconstructions indicate that summers over the past century have generally been slightly drier than over much of the past millennium (late 15th-16th century excluded). Although very similar to one another there are important differences between the northern and western summer reconstructions around 1300 CE, middle of the 15th Century and latter part of the

18th Century. The winter reconstructions suggest that the most recent decades, especially in the north, have been steadily drying and are relatively unusual in the 1450-year context. The differences amongst the reconstructions highlight the importance of teasing out regional differences in our hydroclimate history, especially when 'high yield' dams are located in the central north of the state at higher elevations than typically much larger catchments in western Tasmania.

Sourced from https://earthsciences.anu.edu.au/

Abrupt change in North African hydroclimate and landscape evolution 3.2 million years ago?

Grant, K.M.[1]; Amarathunga, U.[1]; Amies, J.D.[1]†; Hu, P.[1]; Qian, Y.[1]; Penny, T.[1]; Rodriguez-Sanz, L.[1]; Zhao, X.[1]; Liebrand, D.[2]; Hennekam, R.[3,4]; Westerhold, T.[5]; Gilmore, S.[6]; Lourens, L.J.[4]; Roberts, A.P.[1]; Rohling, E.J.[1,2]

[1] Research School of Earth Sciences, Australian National University, Canberra; [2] University of Southampton, National Oceanography Centre, UK; [3] NIOZ Royal Netherlands Institute for Sea Research, Department of Ocean Systems, The Netherlands; [4] Department of Earth Sciences, University of Utrecht, The Netherlands; [5] MARUM, University of Bremen, Germany; [6] Geoscience Australia, Canberra; †Now at The Met Office, FitzRoy Road, Exeter EX1 3PB, United Kingdom

On orbital timescales, North African climate variability is characterised by Green Sahara Periods (GSPs) alternating with more arid periods. GSPs correspond to minima in Earth's orbital precession cycle and boreal summer insolation maxima, resulting in a more northerly and intensified African rainbelt. Reconstructing the timing and intensity of GSPs is therefore important for understanding past changes in Earth's albedo, land-vegetation feedbacks, and hominin migrations. However, there are few continuous, well-dated records of GSPs that extend beyond the Pleistocene. Here, we present the first continuous, astronomically dated GSP record back to 5.2 Ma from Eastern Mediterranean Ocean Drilling Program (ODP) Site 967, based on Ba/Al, Ti/Al, and planktic □18O. From the same site, we also present records of Saharan dust and riverine inputs, based on environmental magnetic and scanning x-ray fluorescence records, which have been converted into element concentrations by multivariate log-ratio calibration. We find that wind-blown dust inputs

increased sharply ~1.2 Myr ago, when global ice-ages intensified, whereas fluvial terrigenous inputs doubled abruptly 3.2 Myr ago, at the same time as a fundamental change in sapropel development. We evaluate different hypotheses (climatic vs tectonic) to explain this dramatic 3.2 Ma shift, and deduce that it likely indicates an abrupt state-transition to expanded Saharan aridity with extreme North African arid:humid variability. We further surmise that this critical North African landscape transition was in response to a global climate state-shift to icehouse conditions, as the timing closely coincides with the onset of intensified northern hemisphere glaciation. Preliminary simulations with the fully coupled GFDL CM2.1 climate model support our inferences.

Uniformitarianism's epic fail: the glacial aridity paradigm

Sniderman, Kale[1]; Weij, Rieneke[2]; Hellstrom, John[1]; Woodhead, Jon[1]

[1] University of Melbourne, Parkville, Victoria, Australia; [2] University of Cape Town, Cape Town, South Africa

For the past ~half century, the climate of the Last Glacial Maximum has usually been interpreted as substantially drier than today, in most low- to mid-latitude regions. This interpretation has been based largely on evidence from fossil pollen, indicating reduced vegetation biomass and/or treelessness, along with evidence of higher dust deposition rates and, in Australia, mobilisation of currently-stable sand dunes. However, there is an increasing understanding that the 'arid' character of LGM vegetation is partly an artefact of C3 plants' reduced water-use efficiency under low atmospheric CO2. Nevertheless, LGM vegetation, and dust- and dune-based indicators, continue to be widely interpreted as self-evidently indicating arid LGM climates.

In Australia, speleothems don't strongly support a glacial aridity paradigm, and may contradict it, where they clearly grew through the LGM. Nevertheless, evidence of speleothem growth during the Late Pleistocene has so far had little influence on narratives of LGM climate. U-Th-dated speleothem palynology – the analysis of fossil pollen preserved within speleothems – can permit the development of vegetation and climate records supported by firm radiometric age models, which may allow detailed interrogation of LGM hydroclimate even in regions where 'conventional' wetland-based palynology has failed for lack of suitable sediments, or is uninformative because the pollen records are typically dominated by a small number of widespread plant taxa.

Here, I will present new LGM speleothem pollen records from Naracoorte (South Australia) and Weelawadji caves (Western Australia). Both records show an expected, substantial

reduction in LGM vegetation biomass, but the presence of moisture-demanding taxa also demonstrates that current biomes persisted, rather than being replaced by more arid-adapted biomes. Quantitative reconstructions indicate that climatic moisture availability was similar to or higher than today, inconsistent with the idea of heightened LGM aridity.

Oral presentations

First geoarcheological study of a Palaeolithic site on the northern edge of the Iranian Central Desert: Mirak (Semnan, Iran)

Akhavan Kharazian, Mohammad [1]; Jamet, Guillaume [2,3]; Puaud, Simon [4]; Vahdati Nasab, Hamed[5]; Hashemi, Milad [5]; Guerin, Guillaume [6]; Heydari, Maryam [6]; Bahain, Jean-Jacques [4]; Berillon, Gilles [4]

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Mirak is a Palaeolithic site in Iran comprising several localities (“mounds”) scattered over a floodplain extending from the southern foothills of the Alborz Mountains to the northern edge of the Central Desert in the Semnan area. The area was studied by a team of Iranian-French researchers between 2015 and 2017. The geoarchaeological excavations carried out at the Mirak N°8 mound uncovered a 7 m-thick pedo-sedimentary section, in which two sequences corresponding to different depositional environments have been observed. Sequence I, comprising alternating horizons of poorly pedogenised clayey silt intercalated with sand layers, is interpreted as an alluvial pedo-sedimentary body deposited in an active floodplain during the Late Pleistocene, periodically interrupted by shallow sheet flooding deposits. According to the stratigraphy and OSL dating there is an extended sedimentary hiatus before the occurrence of sequence II which corresponds to calcareous aeolian deposits typical of a desert environment. The Mirak N°8 deposits were affected by several

stages of incipient aridisol formation with features implying a gradually increasing prevalence of more arid conditions. The Mirak N°8 was deposited from the Late Pleistocene to the Late Holocene (52ka to 0.4ka) and within it several distinct upper Palaeolithic levels were detected, and the most recent level is most likely made up of palimpsests resulting from repeated human occupations.

Elemental analyses show a homogenous mineralogy throughout the record regardless of the type of depositional regime, suggesting a local polygenic provenance. Both alluvial and aeolian accumulations were subjected to post-depositional pedogenesis processes indicated by pedofeatures characteristic of calcareous, gypsiferous aridisols (Bk, By). Colour differences between the two sequences at Mirak N°8 can be attributed to deposition in environments with varying oxidation/reduction conditions, presumably related to higher groundwater levels, especially for the units deposited during the late Pleistocene as opposed to the generally warm and dry conditions of the Holocene.

Palaeodiet of Quaternary fossil rodents from Naracoorte Caves: implications for extinction and conservation

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Understanding the dietary and habitat niche of past faunas is important for elucidating faunal community response to changes in climate and environment through time. Stable isotopic analysis of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) obtained from fossil remains is a useful tool for interpreting palaeoecology of both extinct and extant fauna. Here we report on a community stable isotope study of Quaternary fossil vertebrates from the Naracoorte Caves World Heritage Area (NCWHA). We conducted $\delta^{18}O$ and $\delta^{13}C$ analyses on fossil teeth of two native rodent species (*Pseudomys auritus* and *P. australis*), obtained from a palaeontological excavation in the third chamber of Blanche Cave (5U6). *P. auritus* became totally extinct shortly after European colonisation; probably in the 1850s. Consequently, little is known of its diet or habitat preference. We analysed $\delta^{13}C$ and $\delta^{18}O$ from the bioapatite of fossilised tooth material, using isotope ratio mass spectrometry. Isotopic signatures from $\delta^{13}C$ and δ18O were used to reconstruct palaeodiet and drinking behaviour for both species. These data were then compared with existing ecological records. A sample of modern *P. australis* was also analysed and compared to the data. The $\delta^{13}C$ data show that *P. auritus* was more of a dietary specialist when compared to *P. australis*. While the $\delta^{18}O$ indicate that the two species obtained their body water from a similar source. The modern *P. australis* shared the same diet between fossil and modern with a difference in $\delta^{18}O$ values. Our results suggest the key driver of extinction for *P. auritus* may have been habitat loss and degradation through land clearing and livestock grazing. Predation by feral cats compounded this impact. Understanding the diets of extinct and extant species present in Naracoorte fossil

deposits has useful applications for modern conservation and reintroduction of species regionally.

The age and origin of block deposits in the Victorian Alps, Australia

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Pleistocene glaciation was restricted in Australia to only the highest parts of the Snowy Mountains and Tasmania. However, periglacial activity was much more widespread. Periglacial landforms can be found down to 600 m in the Southern Tablelands and lower than this further to the south. Block deposits in the form of blockstreams and block slopes become common at higher elevations. The form and size of these deposits varies widely and their mode of formation is enigmatic. In Victoria, large-scale deposits occur above 900 m in the Mt Hotham region. In this talk we will describe the morphology of these deposits and their surface architecture. 3D modelling supports the idea that pits in the surface are ice segregation features. We present new exposure ages for blocks in these deposits using the cosmogenic nuclides ^{36}Cl and ^{10}Be. The re-establishment of forest at the end of the Pleistocene in the area is dated using radiocarbon. Weathering rind analysis is used on several deposits to explore its utility as a relative dating tool in the region. Lastly, based on modern analogues, we estimate that mean temperatures were at least 8 °C colder than at present when the deposits formed.

The Mid-Pleistocene Transition in the Southwest Pacific

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A Mid-Pleistocene Transition (MPT) in global climate is evident from a shift in the frequency and characteristics of glacial-interglacial cycles, from small amplitude symmetrical 41 kyr cycles to large amplitude asymmetrical 100 kyr cycles starting around 1.2 Ma. The reason for this shift is highly debated as there is no change in the long-term pattern of insolation at this time. There are several hypotheses for this transition including (and not mutually exclusive); enhanced CO_2 removal from the atmosphere; coeval timing of ice sheet expanse in the northern and southern hemisphere, deep ocean cooling and reduced ventilation in the Southern Ocean; and intensification of the tropical Pacific Ocean/atmosphere circulation.

To provide context for the Million Year Ice Core (MYIC) project that is being drilled at Little Dome C in East Antarctica over the next few years, we have developed two new Tasman Sea marine oxygen stable isotope records from Lord Howe Rise (DSDP591A) and east of Tasmania (ODP1172). We have also compiled the existing data covering the last 1.2 Myrs from marine cores from the Southwest Pacific Ocean.

Previous work largely focussed on sea surface temperature (SST) changes as the MPT evolved. These studies found a large increase in the glacial/interglacial SST amplitude across the subtropical front These data suggest there were broader changes in circulation in the Southwest Pacific across the MPT transition. These surface water oceanographic changes would have had a major influence on the climate of the region as indicated by pollen evidence from the marine cores. There is also evidence for a major benthic foraminifera extinction across this time period. Although the reason for this extinction is unknown, it may have been linked to changes in the deep-water characteristics and circulation or to a change in biological productivity.

Towards the development of fire proxies in speleothems using geochemical signatures in ashes from bushfires

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Our knowledge of past fire regimes is limited by short observational records. Proxy archives (such as sediment cores, ice cores, speleothems, and tree scars) are used to extend these records and develop a better understanding of past fire regimes. Recently, stalagmites (i.e., cave deposits), have been shown to record past fire events, and it is possible that they include other attributes of the fire regime (e.g. burn severity). Stalagmite fire proxies are both chemical (e.g. oxygen isotope composition of calcite, and nutrient and trace metal concentrations), and physical (e.g. growth rate, fabric). Trace metals and nutrients are leached from ash and subsequently transported to the stalagmite via hydrological pathways.

We collected ash from four Australian karst sites which experienced fires in recent years (2019 and 2022). Ash chemical composition was determined by analysis of leachates (inorganic chemistry) and by analysis of the ash itself (organic biomarker concentrations of a subset of the ash dataset). The concentrations of inorganic components (e.g. of trace metals strontium and magnesium) show a clear difference between more- and less-combusted materials, as inferred by ash colour. Common fire biomarker concentrations (e.g. polycyclic aromatic hydrocarbons and levoglucosan) showed no clear relationship with inferred burn severity. Together, this has implications for the use of both organic and inorganic fire proxies in stalagmites and other sedimentary proxy archives.

Inorganic ash geochemistry results will be used to contextualise changes in stalagmite geochemistry from Western Australian stalagmites (as measured by LA-ICP-MS and

Synchrotron micro-XFM) which experienced bushfires during the satellite era. We aim to determine whether stalagmite chemistry can be used as a proxy for burn severity.

Extreme pluvials over the last two millennia detected using ephemeral lakes

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The Australian continent is characterised by thousands of ephemeral lakes that only fill after extreme (daily or seasonal maxima) rainfall conditions. Many have little to no contributing/catchment area, while others drain up to one seventh of the continent (e.g. Kati Thanda-Lake Eyre [KT-LE], draining 1.14 M km^2). Here we use ephemeral lakes from diverse moisture sources across the Australian continent and with catchment areas varying over three orders of magnitude to reconstruct past pluvial phases over the last two millennia. We present preliminary chrono-stratigraphic data of beaches/palaeoshorelines that are all at or above the modern maximum, therefore representing extreme runoff conditions. Such landforms represent unambiguous evidence of pluvials that have occurred over the last 2000 years. Data from Lake Woods (Northern Territory), Kati Thanda-Lake Eyre, Lake George (NSW) and Lake Buchanan (Queensland) are discussed with the aim of assessing recurrence intervals for such wet extremes. These sedimentary archives, whilst discontinuous, add to the capacity to evaluate late Holocene climate change within context of the observational record.

Response, resilience and recovery of Tasmania's endangered Pencil Pine using a multi-archive palaeoenvironmental record

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The Tasmanian Wilderness World Heritage Area (TWWHA) is home to globally significant and highly valued flora with ancestries in the supercontinent of Gondwana. Anthropogenic climate change is shifting baseline conditions and increasing pressures on long-lived palaeoendemic tree species directly via increasing temperatures and aridity across southeast Australia and indirectly via increased frequency of lightning-ignited wildfires. During the summer of 2016 over 80 wildfires were ignited across the Central Plateau decimating stands of Gondwanan refuge in TWWHA, severely threatening core refugia of extremely fire-sensitive palaeoendemic conifer *Athrotaxis cupressoides* (Pencil Pine).

Despite significant funding to manage these threatened Tasmanian/Lutruwitan ecosystems, the long-term impact of climate change (and other factors) on the resilience of these systems remains poorly understood. Thus, there is a lack of understanding of how to apply the most efficient, impactful and cost-effective management strategy. Here, there is a need to develop a deep, long-term understanding of these long-lived ecosystems to execute well-informed land-management strategies for their future preservation.

This project takes a multi-proxy approach by applying both palaeoecological and geochemical analysis techniques on organic sediments extracted from lake and bog sites across the Central Plateau (Lutruwita) in conjunction with high-resolution palaeoclimatological speleothem analysis performed on a stalagmite section collected from nearby Kubla Khan Cave (Mole Creek). This ongoing research will provide a detailed multifaceted understanding of how historical species composition, fire regime and moisture variability has influenced the response, resilience and post-fire recovery of Pencil Pine dominated systems across the Central Plateau throughout the Holocene (ca ~11.7 kyrs to

present). Such findings aim to facilitate a holistic understanding of how best to target management efforts to preserve highly threatened Pencil Pine, and similar long-lived fire-sensitive ecosystems in the wake of the climate crisis.

Characterising the expression of sub-millennial scale climate events in western Europe during the early last glacial period using multi-proxy speleothem records

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Past abrupt climate changes act as critical analogues for understanding how the climate system may respond to future abrupt changes. One of the best examples of naturally occurring abrupt climate change is the series of millennial-scale Dansgaard-Oeschger (D-O) events that took place during the last glacial period (115,000 – 11,500 years ago). D-O events are clearly recorded in ice-cores from Greenland, with coincident climate changes detected in marine and terrestrial records spanning a range of climate zones. Greenland ice cores also record shorter-lived 'sub-millennial' scale events that occur within the main D-O event sequence, particularly during the early last glacial period. To what extent these sub-millennial events were expressed outside of Greenland is currently poorly understood. Here we characterise the response to sub-millennial scale climate changes in western Europe using five multi-proxy ($\delta^{18}O$, $\delta^{13}C$, Mg and Sr) speleothem records from Saint-Marcel and Orgnac Caves, France, that collectively span 127 – 87 kyr BP. The replicated speleothem records clearly preserve both millennial D-O events and sub-millennial events, demonstrating the strong coupling between the climate of south-east France and the North Atlantic across both millennial and sub-millennial timescales. Interestingly, the multiproxy record reveals a decoupling between broad temperature (indicated by $\delta^{13}C$) and precipitation changes (indicated by $\delta^{18}O$) during some of these sub-millennial scale events.

This suggests that climate teleconnections operating during sub-millennial events were in some ways different to those during the stronger millennial-scale D-O events.

The Holocene hypsithermal in the Australian region

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Close examination of key and well-dated Holocene sites, both on land and at sea in the Australian region indicate that at the very beginning of the Holocene, the region was locked into a continuous positive Southern Annular Mode (SAM) as a result of strong westerlies. After that period , the entire region switched to a negative SAM scenario and, during that time, the westerlies must have retreated further south of Australia. Afterwards, a period of time spaning ~8,200 to ~5,500 years ago, temperatures were higher than today, including in the oceans. We refer to this as the Holocene Hyspithermal. Coincident to this period, lake levels and postulated rainfall were extraordinarily high and vegetation spectra in places very different compared to today. The extent of this period varies by a few centuries between sites, but this may result from the level of resolution and also appears to be controlled by latitude. There is also clear indication that the influence of the westerlies was reduced over Australia during those two and a half millennia.

In contrast, air temperatures recognised in Antarctic ice cores are at the opposite to those recognised in Australia for the Australian hypsithermal, and atmospheric CO2 levels were at their lowest for the entire Holocene.

Climatic conditions then progressively deteriorated everywhere a bit after ~6,000 years BP until recent times as ENSO signals with alternating El Niño and La Niña conditions across the entire Pacific region as already described by Perner et al. (2018) based on the same cores studied here.

Brief mention is also made to the presence of humans in SE Australia during the Holocene. It seems that human activities changed well after the period of high temperatures and rainfall, with more sedentary activities along the major rivers, with an enhancement of food production in organized settings suggestive of villages.

A detailed study of Holocene climate variability in south-east Australia based on cellulose inferred lake water isotopes and monitoring and modelling approach at Lake Surprise, western Victoria.

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During the Holocene, southeast Australia experienced intense climate conditions including extended droughts. However, knowledge of the frequency and intensity of such episodes is restricted due to the scarcity of quantitative, high-resolution climate records from the region. Where conditions are possible, oxygen isotopes preserved in lake sediments are a useful tool for retracing the past climatic and environment. Here we present a well-dated, highly resolved Holocene record based on $\delta^{18}O$ values of aquatic cellulose, alongside organic carbon isotopes and carbon/nitrogen ratios from sediments at Lake Surprise in western Victoria. Our interpretation of the palaeo-data is supported by both monitoring of water and sediment accumulation and lake isotope mass balance modelling to track the modern hydrology of the lake. The lake is highly groundwater dependant alongside its evaporative enrichment of major ions and stable isotopes. The cellulose record indicates a trend of gradually increasing aridity towards the present day, with notable extreme wet periods prevailing from 10900 – 10000, 7600 – 7000 and 5600 – 4500 cal yr BP. the lake represent a significant climate transition to towards aridity at 4500 cal yr BP and remained consistent over the last 4000 years, along with the driest period recorded from 2000 – 1550

cal yr BP. while our record is consistent with other studies from western Victoria, we demonstrate a strong coherence with SWW variability suggesting that the southern Ocean processes were the dominant controls of Holocene climate change at least over the study area. Further, we suggest an increasing influence of ENSO and IOD during the last two millennia. Our record also agrees with the pattern of variation in solar forcing to some extent which may symbolize a connection to proxy data and climate drivers. However, detailed analyses focused on solar activity and climate modes are required to understand teleconnections among these climate drivers and their mechanisms.

Monsoonal variations in the Kimberley since human arrival – clues from new palaeoenvironmental records

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The wet-dry tropical climate of the Kimberley region in north-western Australia is characterised by the Indo-Australian Summer Monsoon (IASM). Variations in the strength and position of the monsoon are caused by its interaction with other regional climate drivers and have significant control on the vegetation of the region. Since the arrival of humans to Sahul, large-scale climatic changes, including Heinrich and Dansgaard–Oeshger events and the Last Glacial Maximum have influenced tropical Australasian climate phenomena. There are several intervals over the last 60,000 years, including Heinrich Stadials 5 and 1, during which the response of the IASM to these global and regional climatic events is unclear or debated, owing partly to the scarcity of records extending through this time in the Kimberley region.

We present a pollen, charcoal and geochemical record extending ~56,000 years, near to the first known arrival of humans to the continent around 60,000 years ago, collected from the southeast of the Kimberley region, on the northern edge of the Tanami Desert. The core's location in a low-lying, seasonally inundated floodplain is consistent with regular sedimentation, capturing an environmental signal from the present-day southern edge of monsoonal influence.

Preliminary results show variations in the regional environment, which indicate intervals of stronger and weaker monsoon activity. Variations in the proportion of taxa in the Amaranthaceae, Cyperaceae and Brassicaceae families alongside microcharcoal indicate changing water availability and precipitation patterns.

Using giant clam shell geochemistry to understand past environmental change and human-environment interaction in the South Pacific

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Climate change has been of consistent and considerable concern for the past decades and high-resolution paleoenvironmental proxies are increasingly providing critical baselines for understanding Earth's climate system.

Giant clams (Tridacnidae spp.) have a widespread distribution in the subtropical-tropical Pacific region. Compared with other archives, giant clams have advantages including high growth rate, clear increment bands and long lifespans, enabling long continuous paleoenvironmental reconstructions. The clear annual and daily shell increment bands can provide monthly, and even ultra-high daily resolution paleoenvironmental reconstruction.

By analysing the geochemical composition of giant clam shells, we can faithfully reconstruct paleoclimate records, including sea surface temperature (SST), sea surface salinity (SSS), dissolved inorganic carbon (DIC), daily light cycles, rainfall, river input, marine primary productivity and extreme weather events. In this study, we apply multiple traditional and novel techniques, including Microscopy, XRF, IRMS, ICP-AES and LA-ICP-MS, to investigate giant clam shells' growth patterns, geochemical compositions, surrounding seawater parameters and climate change in the Great Barrier Reef (GBR). Initial results show that the studied shell records 28~30 years of growth, with daily growth increments visible. The oxygen isotope-reconstructed temperature range mirrors local instrumental records, indicating that this species is a reliable paleothermometer. LA-ICP-MS trace element records show sub-annual climatic variability and extreme weather events in the GBR. We have

evaluated differences in proxy records between different parts of the shell and found that both inner and outer shell layers yield reliable records.

This project is providing calibrated proxies for ultra-high-resolution paleoenvironmental reconstructions from the GBR, giving insight into environmental change from the last 30 yrs, and ultimately the Holocene more broadly. This provides baselines for understanding long-term social-ecological systems in the GBR and data for the future management of the reef.

Last Interglacial cooling in New Zealand and its potential link to a West Antarctic meltwater pulse

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The Last Interglacial (LIG) was the last time when Earth's temperatures were warmer than present, making it an interesting target for understanding the consequences of global warming. Excess melting of polar ice sheets during the LIG produced sea levels 6 to 9 metres above present, but the source and timing of meltwater releases are debated. One way forward is to interrogate proxy records from the southern mid latitudes for evidence of a regional climate perturbation due to a high-latitude meltwater release, and test this against climate-model simulations.

Here we present a precisely dated speleothem record from Nettlebed Cave (NW Nelson, New Zealand) containing an uninterrupted growth phase spanning most of the LIG (~131 - 119 ka). The chronology is anchored by 63 U-Th ages, yielding an age model with an average 95% uncertainty of 500 years. Growth-rate and carbon and oxygen isotope data reveal a millennial-scale cooling event between ~127.4 and ~124. 6 ka. The timing is consistent with a sea-surface temperature reversal preserved in nearby Tasman Sea sediments, and is broadly synchronous with cooling over Antarctica immediately following the local LIG thermal optimum. Authigenic uranium changes in sediments from the Atlantic sector of the Southern Ocean indicate reduced bottom-water oxygen at this time, and suggest a shutdown of Antarctic Bottom Water, linking Antarctic cooling to an ice-sheet meltwater pulse.

We ran a LOVECLIM climate-model hosing experiment to test whether collapse of the West Antarctic ice sheet (WAIS) could trigger cooling over southern New Zealand. The results reveal depressed ocean temperatures in the likely moisture-source region south of Nettlebed Cave, consistent with the Tasman Sea SST decrease and with deuterium-excess-derived SST anomalies in the source region of Antarctic precipitation. The combined evidence not only potentially constrains the timing of a complete or partial melting of the WAIS during the LIG, but also indicates a southern mid-latitude climatic response to such melting. This has implications for regional climate impacts of a future WAIS collapse.

Lake sedimentary ancient DNA reveals ecosystem response to fire and climate on Kangaroo Island (Karti), Australia

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Increasingly hotter and drier climate combined with post-colonial changes in land management have led to more catastrophic fires across southern Australia in recent decades - threatening people and the environment. However, there is still a lot we don't understand about the complex interplay between climate, fire, ecosystems, and people - especially on longer timescales that pre-date British colonisation. Our study focuses on Kangaroo Island, where devastating bushfires decimated the island's unique ecosystems in 2019-2020. We used shotgun metagenomics of sedimentary ancient DNA (*sed*aDNA) to reconstruct the aquatic and terrestrial biodiversity within the green plants group (Viridiplantae) over the last ~ 7,000 years from the sediments of Lashmars Lagoon. We compared our *sed*aDNA record to a pollen record, charcoal-inferred fire history and geochemical proxies for catchment and climate processes to provide new insights into plant community responses to climate and fire. We found compositional changes statistically linked to fire history and climate change. Specifically, sediment calcite content (linked to drier climates) significantly explained changes in composition within the Viridiplantae. Statistical analysis further revealed that the major compositional change within the Viridiplantae, including a decrease in the Fabaceae family (which includes the genus *Acacia*), coincided with an inferred increase in fire activity at ~3.3 ka. Interestingly, we also found evidence for increased amounts of plant DNA during this period of increased biomass

burning and or more frequent fires, alluding to the role of fuel loads and vegetation density in controlling fire regimes. Overall, our study sheds new light on the way climate and fire have shaped past biodiversity on Kangaroo Island, providing insights relevant to future fire management and further contextualising the complex human history of Kangaroo Island. Finally, this study demonstrates the potential for the preservation of *sed*aDNA dating back to at least ~ 7,000 years in an Australian lake and encourages the application of this novel proxy in the region.

Clear and Present Danger: the pure state of ignorance that has led to Australia's bushfire crisis

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The dominant view of the causes driving many of the environmental challenges facing Australia is rooted in a misanthropic view of human-environment interactions. This view casts human activities as almost universally deleterious to the environment and posits that the antidote to our damage to the "natural" world is the removal/exclusion of humans. This view is grounded within a long history of dehumanising narratives that cast Aboriginal Australians as "intelligent parasites" who had no discernible influence on Australian environments, and thus much of Australia was in a "wilderness" state when the British invaded. Quaternary science provides the only means of empirically testing the "intelligent parasite" model, yet overly simplistic human-environment paradigms constructed from dehumanising narratives have and continue to be applied to the framing and interpretation of our data. One very real outcome of this cultural bias in science is the failure to recognise, understand and address the underlying causes of southeast Australia's bushfire crisis. Here, I critique the deep bias inherent in palaeoecology in Australia and how this loads the dice against identifying Aboriginal agency in our data. I then synthesise more than 10 years of data arising from our laboratory that unequivocally demonstrates that culture, not climate, underpins the current bushfire crisis in southeast Australia – the removal of cultural burning unleashed an explosion of Eucalypts across southeast Australia at a scale that now threatens our very survival on this continent. Finally, I will use this data to empirically challenge the "intelligent parasite" model, highlighting the urgent need for the meaningful incorporation of alternate world views in our disciplines.

East Asian Monsoon dynamics in Japan as inferred from the sediments of Lake Suigetsu

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The climatic drivers controlling the East Asian Summer Monsoon (EASM), which directly affects water resources and water-borne geohazards for over half of the Earth's population, are still highly debated. The long-proposed alignment between EASM and high latitude climate forcing suggested by the similarities between Greenland ice core records and speleothem archives from China is increasingly challenged by sedimentary terrestrial and marine records. But there are only a handful of palaeorecords with sufficiently accurate chronological constraints to provide insights into the lead and lag of EASM variability compared to global benchmarks, such as ice core records.

The annually layered sediments of Lake Suigetsu (Japan) provide a unique opportunity to study EASM variability during periods of rapid climate change at unprecedented precision. The chronologic framework for Lake Suigetsu is an integral component of the IntCal20 radiocarbon calibration, and sampling and chronological work follows strict protocols. Lake Suigetsu's location at the western coastline of Japan's main island, Honshu, makes it sensitive to climatic influences by the north-westerly winter monsoon, and summer to autumn south-western and Pacific monsoonal influences. Here, we aim to use the Lake Suigetsu sediments to untangle rapid EASM variability during the last glacial cycle. Hydrologic change is reconstructed by stable isotope analysis (oxygen, carbon) of non-traditional lake sediment material, namely biogenic silica (diatoms) and early diagenetic

siderite ($FeCO_3$); supported by FTIR (Fourier-Transform Infrared Spectrometry) estimates of sedimentary mineral composition.

More than 1,100 samples at 1 cm resolution (siderite isotopes) and 2 cm (diatom isotopes) have been sampled at sub-millimetre precision covering rapid climate oscillations during Heinrich events 4 (around 38 kilo years ago) and 5 (around 45 kilo years ago). Analytical work is ongoing but preliminary isotope and FTIR analyses, in concert with previously collected X-ray fluorescence and pollen data, imply a delayed hydrologic response in Japan at the end of Heinrich event 4 compared to the onset of Greenland Interstadial 8. Moreover, our preliminary results display some interesting similarities between the Suigetsu proxy data and Antarctic ice core records.

Last Glacial pluvial periods evident in subaqueous speleothems from Australia's southern arid-margin

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Archives from Kati Thanda (Lake Eyre) basin indicate at least three distinct periods of lake filling during the Last Glacial Period. The headwaters of the megalake lie as far north as -19 °, therefore filling events are indicative of increased intensity of the Indo-Australian Summer Monsoon (IASM). However, due to the nature of unconsolidated materials, these archives are limited in how precisely they can constrain the timing of Last Glacial pluvial periods, and they cannot capture millennial-scale climate variability. Speleothems from Mairs Cave (Flinders Ranges, South Australia), present an opportunity to address these issues.

The cave lies on the boundary between the arid and semi-arid regions and currently receives rainfall from both the Southern Hemisphere Westerly Winds (SHWW) and the IASM. The cave contains pendulites: stalactites with an external overgrowth of subaqueously precipitated calcite. The stalactites were initially submerged ~ 89 ka by rising groundwaters, which flooded the cave. From that point forward, the pendulites grew subaqueously during periods of regional groundwater recharge. Preliminary findings suggest periods of subaqueous growth align with higher Southern Hemisphere summer insolation, suggesting the site received enhanced tropical rainfall due to moisture delivery from the IASM. Growth rate and magnesium concentrations both appear to be responsive to millennial-scale climate change, exhibiting increases during both Heinrich events and the cold limbs of Dansgaard-Oeschger events. This is consistent with increased delivery of tropical moisture due to southerly incursions of the IASM.

The study site lies near the intersection of two ‘superhighways’ of early human expansion proposed by Crabtree et al. (2021). The cave is also 200 km directly south of the Warratyi shelter, one of the earliest sites of human occupation in southern-central Australia. Therefore, the palaeoclimate record to emerge from this research could potentially provide a more detailed climatic contextualisation for this period of human history.

Climate extremes recorded in playa lakes across continental Australia

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The recent flooding in Queensland and NSW has affirmed the impacts that extreme precipitation has on people's lives and their livelihood. To be better prepared for such extremes in the future we need to know how often and under which climatic circumstances they occur. However, climate models for Australia still involve high uncertainty in predicting precipitation extremes. This is attributed to the limited paleo record of magnitude and frequency of past extremes. Though efforts have been made to improve the terrestrial record of hydro-climatic paleo data in Australia, there still exists a gap in scientific knowledge, especially on the spatial scale. Our project tackles this challenge by utilising paleoenvironmental evidence collected from various ephemeral lakes across the country. Since filling events of ephemeral lakes are strongly linked to precipitation events the terrestrial record from lakes in key quadrants of the country allows the establishment of timing, magnitude, variability, and trend of precipitation extremes in the past. A timeframe of the last thousand years permits the comparison of frequency and magnitude to inter-annual variability. While previous studies have focused on high resolution at specific locations the large spatial scale of this project enables the analysis of spatial variability and thus will result in an improved understanding of the importance of varying climatic drivers in different regions across Australia. Ultimately, by comparing the importance of climatic drivers for precipitation extremes in different regions against global climate simulations uncertainty can be reduced and future predictions of precipitation extremes can be improved.

Late Holocene environmental change of Te Whakaraupō | Lyttelton Harbour, New Zealand

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Due to the increasing impacts of climate change, global sea levels and ocean temperatures have been rapidly increasing. One region which will be affected by these increased sea levels are the bays of Horomaka | Banks Peninsula on the east coast of the South Island, New Zealand. Horomaka is a poorly understood landscape that has been highly modified by human land management in both Māori and European times. This research will investigate the interactions between changes in the coastal system and the surrounding catchments which are deeply incised valleys in the flanks of an old volcanic complex. The work focusses on three locations: Te Whakaraupō | Lyttelton Harbour, Kawatea | Okains Bay and Te Wairewa | Lake Forsyth and uses a combination of micro-fossil, geochemical and sedimentological proxies to decipher ecological, hydrological and anthropomorphic changes in these catchments.

Here we present our preliminary findings from Te Whakaraupō | Lyttelton Harbour, where a 3.4 m shallow marine sediment core was collected from the mudflats of the innermost harbour. Foraminiferal records indicate a rapid infilling of the harbour with a shift in conditions from low intertidal to high intertidal to present day salt marsh. This change in sedimentation is reflected in our X-ray Fluorescence results, which show increased variability in terrigenous sediment and organic content at the top of the record. This research presents the first of its kind in Horomaka to reconstruct past environmental conditions over time.

Future research will include pollen and micro-charcoal analyses and grain size analysis to amplify the palaeoenvironmental data. This research will develop key information on changes in both marine and terrestrial environmental change and sedimentation rates over the late Holocene, which will help inform the management response to enhanced climate change and urban development in the harbour.

Synchronous onset of the last glacial termination in the southern mid-latitudes

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Detailed comparisons of Antarctic and Greenland ice core records suggest an inter-hemispheric asynchrony of climate change at the end of the last glaciation. The extent to which this climate variability, its timing and regional synchrony affected the southern mid-latitudes remains uncertain. Here we present a compilation of multiples selected terrestrial proxy paleoclimate data from key mid-latitude Southern Hemisphere landmasses spanning the last glacial-interglacial transition, focusing on the onset of the last termination (T1). Our results show that synchronous deglacial climate conditions induced terrestrial environmental shifts in Tasmania, New Zealand's southern Island and western Patagonia at the beginning of T1, consistent with the commencement of the deglacial warming revealed by Antarctic ice records following the Last Glacial Maximum.

Temporal variations in the marine radiocarbon reservoir effect during the Holocene – A review

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This paper presents a review of spatial and temporal radiocarbon (^{14}C) variations in the surface ocean for the Tropical and South Pacific. Radiocarbon has been recognised as a powerful transient tracer for the study of ocean circulation, and its variations associated with environmental and climatic changes. Investigation of radiocarbon changes in the surface ocean with time and space, thus, not only is crucial for accurate dating of marine samples but also delivers useful information on the carbon cycle and climatic systems.

Accurate and reliable dating of marine samples (e.g., shells, corals, coralline algae and foraminifers), is increasingly critical for correlating them with terrestrial and ice-core records, and consequently for better understanding of palaeoclimate. The dating, however, is not straightforward and involves estimates of the marine radiocarbon reservoir effect (or simply the marine reservoir effect, MRE), an aging effect of the surface ocean relative to the atmosphere. Traditionally, for a given location or region the MRE is generally assumed to be constant through time and its modern, pre-1950 value is used for calibrating marine ^{14}C ages. However, there is growing evidence that the effect is not constant but varies with time. Temporal MRE variability has been reported for a number of oceans and seas during the late Quaternary and Holocene. For the Tropical and South Pacific, large temporal changes in the MRE of several hundred to almost a thousand of years during the Holocene were documented for a number of sites across the basin. Mechanisms of these changes, and their implications for climate variability and changes in ocean circulation are discussed.

Willandra Lakes re-revisited: preliminary results from Lake Arumpo, NSW

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The Willandra Lakes Region is a key location for understanding both past environmental changes in south-eastern Australia and the Aboriginal heritage of the Australian continent. The landscape record here charts the interplay between fluctuating lake levels and lunette formation, while preserving the activity traces of generations of people who called this Country home. Despite ~60 years of study and the shear wealth of evidence available throughout the Willandra, the focus of geological research has remained almost entirely within the confines of the Lake Mungo basin. This study forms part on an ongoing ARC DECRA project that aims to systematically construct high-resolution chronological and stratigraphic records of landscape and vegetation change at critical locations throughout the Willandra. In this presentation, we revisit and present preliminary findings for two previously investigated locations within Lake Arumpo, downstream from Lake Mungo; Top Hut 1 (TH1) and Long Waterhole Gully (TH3).

The TH1 site is located within a blow out on the Outer Arumpo lunette. Here, a succession of clean quartz sand dunes were deposited between 50 and 40 ka over the top of a basal red dune. The quartz dune is then overlain by a series of interbedded clean quartz sands and pelletal clay beds, each ~20–30 cm thick, before being capped with a well-developed palaeosol and modern mobile quartz sands.

The now ~4m deep Long Waterhole Gully location was formed via catastrophic down-cutting of a drainage ditch excavated into the margin of Lake Arumpo's floor. Here, four distinct phases of sandier sediments, representing pulses of returning water to the lake basin, are

interbedded with both deflated pelletal clay beds and shallow water lacustrine deposits. Preliminary optical ages indicate a punctuated sequence of deposition at Long Waterhole Gully beginning at ~46–38 ka ago and terminating sometime after ~13–9 ka ago.

Stability of the Antarctic Ice Sheet during the pre-industrial Holocene

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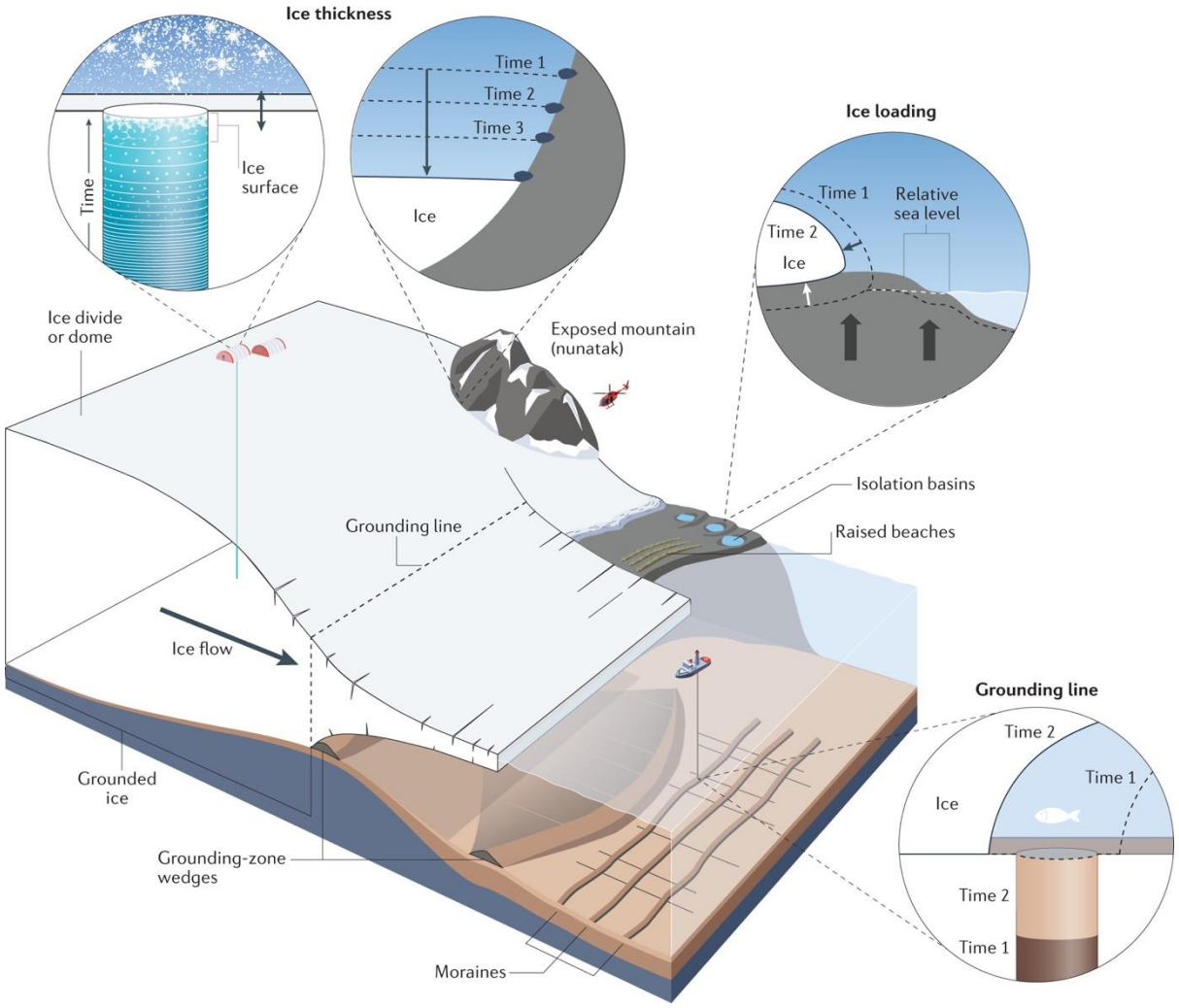
The rate and magnitude of the Antarctic Ice Sheet (AIS) contribution to global sea-level rise beyond 2100 CE remains highly uncertain. Past changes of the AIS, however, offer opportunities to understand contemporary and future ice sheet behaviour. Based on a review of evidence to date, here we outline how the AIS evolved through the pre-industrial Holocene, 11,700 years ago to 1850 CE. Three main phases of ice sheet behaviour are identified: a period of rapid ice volume loss across all sectors in the Early and Mid Holocene; a retreat inland of the present-day ice sheet margin in some sectors, followed by readvance; and continued ice volume loss in several sectors during the past few millennia, and in some areas up to and into the industrial era. Global sea levels rose by 2.4–12 m owing to the period of rapid Antarctic ice loss and possibly fell by 0.35–1.2 m owing to subsequent readvance. Changes in the AIS during the Holocene were likely driven by similar processes to those acting today and predicted for the future, which are associated with oceanic and atmospheric conditions as well as bed topography. Periods of both ice volume loss and ice volume gain would have influenced Southern Ocean circulation, with potential implications for Southern Hemisphere climate. More work is needed to better understand Antarctica's contribution to sea-level change and role in Southern Hemisphere climate variability during the Holocene.



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Reconstruction of past climate and its effects on environment, ecology, and ecosystem using long-lived bivalve shell.

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Bivalve shells can provide a unique opportunity to reconstruct past climate and its effects on the bivalve mollusc ecology and habitat coastal environment and ecosystem. Oxygen isotopic composition of the shell is a reliable proxy for ambient temperature and salinity. Shell growth pattern provides ecological information (e.g. growth) of bivalve mollusk, which is controlled by ambient environment (e.g. temperature) and ecosystem (e.g. food source). Geochemical signatures can also provide independent information from each proxy. The Stimpson's hard clam *Melcenaria stimpsoni* is a long-lived bivalve species that distributes around the north-eastern Pacific coast and is a suitable archive for such purposes. Oxygen isotope analysis of modern specimens demonstrated that the bivalve generally grew between spring to late-autumn, and maximum seawater temperature can be reconstructed. The timings of the growth cessation and re-start are likely to be affected by food availability and not solely controlled by temperature. The annual growth rate presented multi-decadal fluctuation, but its pattern was partly different from the Pacific Decadal Oscillation, likely because the dynamics of coastal productivity are slightly different from the physical oceanographic dynamics. The fossil specimens from MISs 5, 7, and 9 showed more rapid growth at the earlier ontogenetic stage, while the maximum size was smaller than the modern specimens. Reconstructed temperature suggested that the cold water Oyashio current was stronger during the MISs 5, 7 and 9, the interglacial periods.

Water mass history of the Southwest Pacific through the last 160,000 years using radiolarians

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It is widely accepted that the Southern Ocean plays a key role in global climate by influencing atmospheric carbon dioxide over a glacial cycle. However, questions remain regarding the changes in productivity and ocean circulation as they relate to Southern Ocean water masses. Polycystine radiolarians are a group of siliceous microplankton that inhabit the whole water column from surface to sea floor. They peak in abundance between 100 and 400 m depth and display significant diversity in the modern Southern Ocean, and their distribution is related to water masses and ocean circulation (Lawler et al., 2021; Lowe et al., 2022).

Here we present a history of Southwest Pacific water mass history over the last glacial cycle using a newly developed statistical approach. We apply the Southern Ocean Water Mass Method (SOWM) and Southern Ocean Sea Ice Index (SOSI) to a transect of sediment cores through the Southwest Pacific Sector of the Southern Ocean. The cores span from the Subtropical Front to the Polar Front and represent the last glacial cycle (160,000 years). We compare the results of the SOWM and SOSI with geochemical (stable isotopes, opal content elemental variations) and other microfossil data (diatom assemblages), on the same cores. We investigate the changes in ocean circulation and water mass structure over the glacial cycle and the implications of those changes on the climate and carbon cycle.

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Using ice core records to understand interannual- multidecadal trends in Antarctic Ice Sheet surface mass changes

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The Antarctic Ice Sheet (AIS) is currently losing mass and the causes of these changes are not fully understood. Satellite records extend 40 years, but ice sheets respond to climate from seasonal to centennial and longer timescales, meaning hundreds of years of observational data are required to understand the physical processes driving AIS surface mass balance change on interannual, decadal, multi-decadal and centennial timescales. Therefore, paleoclimate data is necessary to be able to characterise variability to differentiate between trends and variability in surface mass balance, as well as to understand the processes which drive changes in surface mass balance. This research addresses these critical gaps by characterising past variability in surface mass balance changes in Antarctic ice core accumulation records over the past 1000 years. Ice cores provide annually resolved records of accumulation changes and climate signals dating back through recent centuries. This study utilises regional composites of ice core data, which provide a helpful circum-Antarctic perspective. Regional (composite) differences as well as local (specific) ice core trends in snow accumulation are compared. Significant changes in accumulation trends are witnessed in pre-industrial and post-industrial periods, predominant frequencies of variability are identified. Distinct similarities in trends and variability in accumulation rates over the past 1000 years are witnessed across different regions of Antarctica. This study characterises present surface mass balance changes in the context of natural past variability and the anthropogenic influence on Antarctic surface mass balance changes.

Investigating the links between recent fire events and the accumulation and characteristics of charcoal in Temperate Highland Peat Swamps in the Blue Mountains of NSW

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Fire is the dominant ecological disturbance and a prominent natural hazard in south-eastern Australia and its management continues to pose a number of issues. Consideration about recent trends in fire (e.g., fire becoming more extreme, more hazardous) are hampered by a relatively short instrumental and historic record. Although the accumulation of charcoal in sedimentary archives continues to be the dominant proxy of past fire, and offer much longer temporal perspectives, links between fire and charcoal are not well established globally or in Australia. Here, I will be describing my research located in several Temperate Highland Peat Swamps on Sandstone (THPSS) located in the Blue Mountains. This research primarily uses high-resolution 14C dating and charcoal analysis to consider how recent fires (intensity, area burnt, distance from the sites) are represented in the THPSS sediments (e.g., charcoal accumulation, charcoal morphology). Our aims include investigating how fire regimes have evolved over the past 100 years and to consider drivers of fire including climatic variability and historic changes in natural resource management (e.g., hazard reduction fire). Ultimately our goal is to use this calibration exercise to quantify links between charcoal characteristics and fire regime, such that this can be used to better characterize fire regimes over the many thousands of years (also preserved in sediments of these THPSS mires).

Linking distal dust deposits with proximal lake records within the Kati Thanda-Lake Eyre (KT-LE) Basin: Examining the environmental conditions responsible for Australian dust export and evaluating the role of aeolian processes in shaping KT-LE.

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The lower Kati Thanda-Lake Eyre (KT-LE) Basin, including Kati Thanda-Lake Eyre (KT-LE) itself, is Australia's biggest dust source today and likely has been throughout the late Quaternary. Distal dust records from the Australian seaboard and marine basins indicate high variability in continental dust emissions, implying changing conditions in dust source areas (or changing source areas). Contemporary studies point to hydro-climate variability being the most significant control on dust activity. At KT-LE, palaeo-shoreline records indicate pronounced hydrological variability over the past glacial cycle, which could account for variability in dust emissions. This includes a generalised reduction in lake levels during the last 100 ka, particularly after 48 ka. Recent detailed revaluation of the iconic Williams Point sequence at KT-LE confirms this general pattern, but also indicates variability within this generalised drying trend. Previous work at Williams Point suggested a number of net dust deflation episodes, hypothesised to have resulted in lake-bed lowering. In this study we re-

examine the links between continental-scale dust emissions reconstructed along Australia's seaboard/marine basins and palaeo-environmental conditions at KT-LE. Results show long-term dust emissions are well linked to hydrological conditions at KT-LE throughout the last two glacial cycles. However, they imply that the formation of the substantive proximal Williams Point aeolian unit has little association within continental scale dust emissions, implying aeolian activity is not a uniform process across KT-LE. There is also little evidence of significant net-dust deflation events recorded downwind of KT-LE, with the exception of a dust pulse during the Last Glacial Maximum. In summary, we still have much to learn about dust emission processes at KT-LE.

A multi-proxy record of environmental change at a glacial *Nothofagus refugium*, Wyelangta, Victoria

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Despite its widespread use in palaeoecology, pollen-based reconstructions are limited by coarse taxonomic resolution. Pollen of narrow-range species that might be used as ecological indicators, for example, can be difficult or impossible to distinguish from the pollen of geographically widespread, and therefore less informative, taxa.

Plant macrofossils, by contrast, are routinely identified to species level, and a majority of the species present in Southeast Australia during the late Quaternary still exist today. These improvements to the taxonomic precision of palaeobotanical records allow for the use of bioclimatic niche models to quantitatively reconstruct palaeoclimate, based on fossil species' modern day climatic niches. Combining these two proxies, we are able to produce a more nuanced interpretation of late-Quaternary vegetation and climate.

We sampled for pollen and plant macrofossils at a known late Quaternary palynological site in the Otways, Victoria (McKenzie & Kershaw, 2000). Here, we present a detailed pollen record and use plant macrofossil remains to confirm species identifications and conduct bioclimatic niche modelling. Our study reveals that, although the site has remained a rare mainland refugium for *Nothofagus cunninghamii* throughout the entire period of the record, the regional vegetation has undergone significant environmental change.

By employing a multi-proxy approach that encompasses both pollen and macrofossil analysis, this study provides precise new estimates of the composition of Southeast Australian biotic communities and climates. These results contribute to the globally significant debate around the influence of the late Quaternary climate over the generation

and maintenance of terrestrial biodiversity, and to the increasingly urgent discussion of the degree of sensitivity of Australian plant taxa to changing climate in general.

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A Holocene subtropical hydroclimate reconstruction from Karboora (Blue Lake), Minjerribah, Queensland

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Holocene palaeoclimatology provides insights into the climate system, with particular relevance to the next century. This is especially true in sub-tropical Australia due to the under representation of the region in Holocene climate studies. Karboora (Blue Lake), on Minjerribah (North Stradbroke Island), Queensland, Australia is a groundwater window lake of major ecological and cultural significance. The lake's strong connection with the regional aquifer underpins lake level stability, rendering Blue Lake sediments an ideal tracer of subtle changes in climate. Here, we report a new 5,500-year oxygen isotope record from biogenic (diatom) silica ($\delta^{18}O_{BSi}$) that records variations in rainfall resulting from changes in Pacific atmospheric circulation. These interpretations are supported by modern monitoring over a 20 month period, including the $\delta^{18}O$ of lake water, rain water, plant cellulose, and biogenic silica. We link rain $\delta^{18}O$ to changes in El Niño Southern Oscillation (ENSO) phases, with phases showing distinct isotopic change that may be linked to tropical or extratropical sources of rainfall. On these grounds, we infer a dominance of extratropical rainfall from 5.5 kyr BP to 3.5 kyr BP, a period of transition from 3.5 kyr BP to 2.5 kyr BP dominated by neither tropical or extratropical rainfall, then a shift to tropically sourced rain from 2.5 kyr BP to the present. The early record (5.5 kyr BP – 3.5 kyr BP) most likely reflects a suppression of summer rainfall caused by a weakened ENSO. This is most likely linked to higher northern hemisphere insolation causing a northward shift in the intertropical convergence zone and westerly wind belt which in turn affected synoptic systems in the Coral and Tasman Seas. The increasing variability in the late record (3.5 kyr BP to present)

most likely represents an increase in summer rainfall driven by the intensification of ENSO in the late Holocene.

Millennial to seasonal scale views of El Niño-Southern Oscillation from central Pacific corals

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El Niño-Southern Oscillation (ENSO) is naturally highly variable on interannual to decadal scales making it difficult to detect a possible response to climate forcing. Despite the high variability, several lines of evidence from tropical corals, mollusc, lake sediments, and foraminifera suggest that 5,000-3,000 years ago ENSO variance was on average reduced by 60-80% compared to the present day. We investigate the seasonal-to-centennial variation in ENSO amplitude and tropical climate during this ENSO 'quiet period' 5,000-3,000 years ago using a new Sr/Ca SST record from a 175-year-long 4,300-year-old coral, and new d18O and Sr/Ca results from a similar-aged ~180-year-long Porites sp. coral. Both corals were discovered on Kiritimati (Christmas) Island, an optimal ENSO 'centre of action' in the central tropical Pacific. Together, these corals confirm a reduction in ENSO amplitude and that ENSO amplitude is modulated on multi-decadal scales. Composites of month-by-month changes in Sr/Ca-SST show an unprecedented view of ENSO and detail which seasonal-scale features of ENSO are an inherent part of the system, and which are subject to change under altered climate states. We also investigate the millennial timescale changes in ENSO variance using combine coral oxygen isotope ($\delta^{18}O$) data from central Pacific corals and a suite of forced and unforced simulations conducted using the CSIRO Mk3L and GFDL CM2.1 climate system models. On millennial timescales, the coral data reveal a statistically

significant increase in ENSO variance over the past 6,000 years. This trend is not reproduced by the unforced model simulations but can be reproduced once orbital forcing is accounted for. Together these views of past ENSO may contribute to advances in understanding the response of ENSO to future changes in climate forcings.

Straight from the kangaroo's mouth: A quantitative relative humidity proxy

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[1] University of Queensland; [2] University of Adelaide; [3] Flinders University

The oxygen isotope ratio of biominerals in kangaroos ($\delta^{18}O_k$) has long been recognised as varying with relative humidity (*h*) (Ayliffe and Chivas 1990), but a quantitative proxy for *h* from $\delta^{18}O_k$ has not been developed because of the perception that the underlying drivers were not fully understood (Kohn 1996) and that temperature was an important influence on the $\delta^{18}O_k$–*h* relationship (Murphy et al. 2007).

Here, we use newly developed leaf water isoscape (McInerney et al. In Review) in conjunction with a standard body water model for herbivores (Kohn 1996) to predict 787 $\delta^{18}O_k$ tooth enamel values taken from the literature. The modelled and observed $\delta^{18}O_k$ closely agree, with a regression slope of 1.05, intercept of 0.02‰ and R^2 of 0.53. The failure of previous attempts to model the $\delta^{18}O_k$–*h* relationship is attributable to underestimation of enrichment due to transpiration.

By explicitly linking body water and leaf water isotope models, we then predict *h* from 787 $\delta^{18}O_k$ values based entirely on first principles. The $\delta^{18}O_k$-derived *h* closely matches BOM annual daytime relative humidity for each location (RMSE of 8.7% for predictions of *h* >30%). Air temperature has only a small effect on predicted *h* values, falling within the uncertainty of predictions. Moreover, the theoretically-derived $\delta^{18}O_k$–*h* relationship closely matches the empirical one, supporting that the underlying factors driving the relationship are well characterised by the linked body water–leaf water model. The outcome of this modelling is that the oxygen isotope ratio of fossil kangaroo tooth enamel provides a quantitative proxy for past relative humidity.

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Ancient shorelines of northwest Tasmania – a preliminary report

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Prominent features of the northern and western coasts of northwest Tasmania are relict marine cliffs and associated flights of terraces up to 55 m above sea level (asl). Also present along the northern coast are dune systems parallel to the present coastline. Previous authors have suggested a Last Interglacial age for cliffs and terraces, implying a rapid rate of uplift, which is not supported by tectonic evidence. In this paper we present new geomorphological evidence for a marine transgression extending c. 28 km south of the present shoreline. Features identified include dunes (fine quartzose sands), beach ridges and spits (gravelly sands), cliffs, and recessional ridges (sandy loams) and lunettes (fine sands) around relict tidal flats (silty clays). The extensive marine transgression responsible for these features resulted in the higher land (the Christmas Hills predominantly formed in Cambrian siltstone/mudstone) lying between the Montagu catchment to the south and west, and the Duck catchment to the east, becoming an island. A TT-OSL age of c. 522±55 yr BP obtained on an inland dune at 44 m asl indicates that this extensive marine transgression occurred in MIS 13. A TT-OSL age of 104±6 yr BP for what appeared to be a recent foredune at Anthony Beach shows that this dune and the parallel dunes south of it formed in the Last Interglacial (MIS 5), not in the Holocene. The quartzose nature of the sediments mapped around the southern Christmas Hills indicates that the MIS 13 transgression reworked silica-rich alluvium derived from siliceous rocks, which in turn suggests that the Arthur River, having headwaters mostly in Precambrian quartzose schists, siltstones and cherty dolomite, may have once flowed northwards either side of the Christmas Hills rather than westwards as it does at present.

Insights for restoration: Reconstructing the long-term responses, resilience and recovery time of vegetation, hydrology and peat condition to fire events in the Sebangau peatland, Central Kalimantan.

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The palaeoecological and geochemical analysis of peat in the Natural Laboratory Peat-swamp Forest (NLPSF) has been used to identify the drivers of fire severity (FS) events and the associated responses, resilience and recovery time of this peatland system to aid in future restoration efforts in the Sebangau Peatland National Park (SPNP). From 4500 years BP to present, fire events have increased in severity and the drivers of FS included changes to sea level, increased frequency of El Niño events, increased biomass, and anthropogenic-driven degradation. The increased FS along with changes to the hydrology and peat condition over time have resulted in a vegetation turnover from mixed of peat forest and other vegetation types during the mid to late Holocene (4500 to 1201 years BP), to peat swamp forest (PSF) during the following ~800 years (1200 to 378 BP), lowland vegetation mixed with swamp forest (LMS) and open vegetation (OV) for the period between 377 and 134 years BP and finally, freshwater swamp forest (FSF) and OV in the last ~200 years (133 to -54 years BP) (Fig 1). From the Principal Component Analysis (PCA) and Generalised Linear Model (GLM), the changes to dominant vegetation types were due to changes in local hydrological conditions, as well as the fertilising effect from the combustion of organic matter (i.e. release of N and other minerals) and loss of soluble peat component during fire

events. This information, together with the thresholds and lags of the responses, provided the following restoration insights: 1) Vegetation species have different fire intensity tolerances and transition from PSF to LMS and OV required a higher threshold with recovery time of approximately 70 to 80 years; 2) PSF expanded with higher peat nutrients (i.e. TN) and required wet peat environments compared to FSF and LMS but some PSF species (i.e. *Eurya* and *Ilex*) were able to cope with slightly drier peat conditions ; 4) Future revegetation in SPNP can focus on species such as Araceae, Restionaceae *Myriophyllum*, and *Ficus* as they were able to withstand high FS, less acidic and minimally wet conditions, while sustaining carbon accumulation in degraded tropical peatlands.

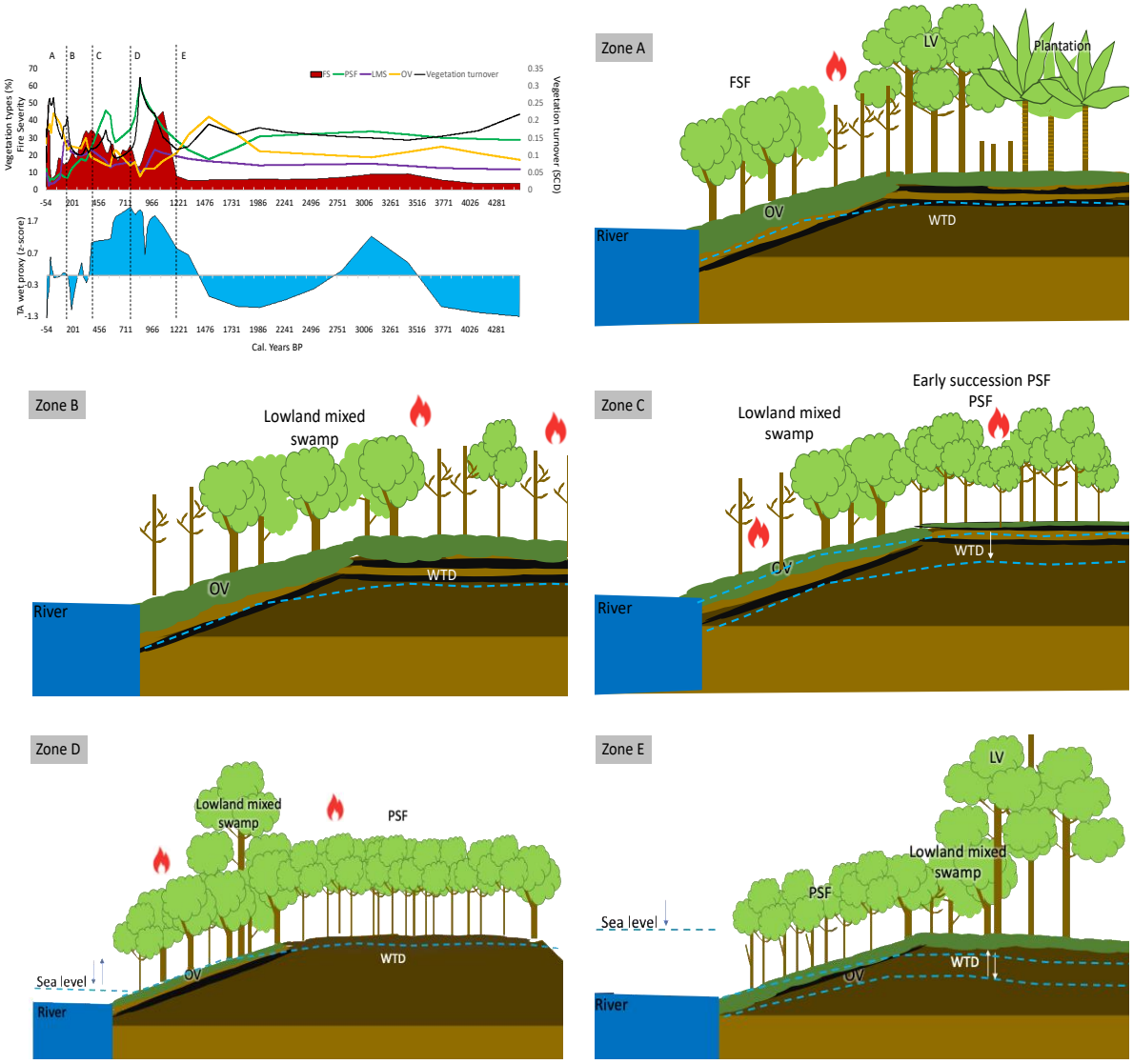

Figure 1: Changes in peatland ecosystems from zone A, B , C and D. Variations of fire severity, hydrological condition (testate amoeba (TA) wet proxy), and vegetation turnover are also included to provide understanding of the slight changes in vegetation types over the past 4500 years BP.

Simple and fast methods for sediment-based quantification of macroscopic charcoal: solutions to recently identified problems

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Fire is an important ecosystem process, concern of natural resource management and is involved in several issues regarding how people manage landscapes both in Australia and elsewhere. A *fire regime* is clearly a dynamic framework for considering fire, and in the absence of long instrumental or historic observations, proxies of past fire are needed. The use of charcoal in sediments as an indicator of past fires has a long history and there is no doubt that charcoal analysis has made significant progress over the last few decades: for example, the shift towards the quantification of 'macrocharcoal' and tools for image processing (e.g. CharTool) and the quantification of fire frequency (e.g. CharAnalysis). Nonetheless, some techniques have crept in without careful consideration of their effects on charcoal: as an example, it is commonly assumed that pyrolysis and oxidative heating produces materials that are resistant to environmental degradation and to our laboratory methods.

Here we demonstrate two *simple* laboratory processes that have significant influences on how charcoal is isolated and quantified in sediments: a) methods to estimate sample volume; and b) the use of an oxidant, which is commonly used for the removal of unoxidized organic material and thereby concentrate charcoal. We particularly highlight that charcoal formed in a low intensity fire is likely to be completely lost using even mild oxidants (Constantine & Mooney, 2021). We describe several (unpublished) solutions to these problems: for a) we routinely use a pycnometer to determine the bulk density of freeze-dried sediment samples; and for b) we have experimentally demonstrated that a vastly

reduced time in a dilute oxidant has a much-reduced effect on less-recalcitrant charcoal. Finally, we describe a new version of Chartool, which provides considerable improvements in the quantification of macrocharcoal isolated from sediments using wet-sieving. Our goal in this research is to provide simple and fast methods for extracting and quantifying charcoal from sediment, and that this charcoal provides an unbiased and faithful record of past fires.

Constantine M. IV and Mooney S.D. (2021) Widely used charcoal analysis method involving NaOCl results in loss of charcoal formed below 400°C. *The Holocene* https://doi.org/10.1177%2F09596836211041740

Holocene Coastal Peatlands of the Tasmanian Wilderness World Heritage Area

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Port Davey, Bathurst Harbour and Melaleuca Inlet in the southwest corner of Tasmania are key elements of a globally unique estuarine system, which forms an important part of the Tasmanian Wilderness World Heritage Area (TWWHA). The area contains distinctive coastal mires, consisting of fibrous peat (around 1 to 3 m in depth), as well as associated distinctive channelled estuarine features Little is known about when and how these wetland systems form, particularly in terms of the role of environmental factors, such as changing climates and sea level alterations, as well as depositional rates. Sediment cores were collected from three coastal mires in the region to examine formation process and responses to Holocene environmental change. Sedimentological, palynological and charcoal data will be presented for the three locations, which provide information on when these systems formed and how they have responded to climate, sea level and anthropogenic factors. The first site, 'Puffin Creek' is a sedgeland located near Melaleuca Inlet and a 207 cm sediment core, with a basal age of 3,625 cal. years BP was collected; the second site 'North River', a scrubby sedgeland, is situated near the mouth of the North River and a 275 cm core was collected with basal age of 7,540 cal. years BP; and the final site 'Old River' is a freshwater marsh system directly adjacent to the mouth of Old River and from which a 89 cm core was collected with a basal age of 740 cal. years BP. This information, together with data from the present wetland dynamics, along with the longer term palaeoecological and geochemical results, provides important findings for the management of these systems, particularly in terms of fire regimes and potential response to sea level rise.

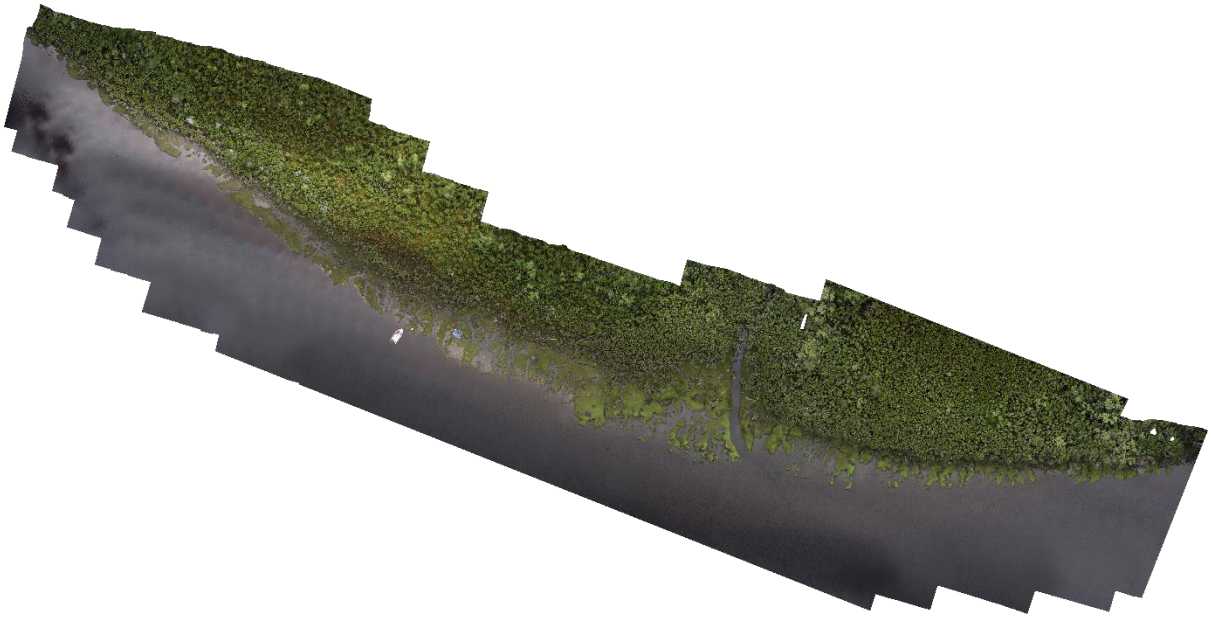

Figure 1. North Creek coring site, Bathurst Harbour, Tasmanian Wilderness World Heritage Area.

Sea-level changes and coastal landscape evolution in south-eastern Australia during the Last Interglacial (MIS 5e)

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The Last Interglacial maximum, termed Marine Isotope Substage 5e (MIS 5e) as originally defined in the oxygen isotope timescale, and dated at 128–116 ka, is a distinctive event in recent Earth history. The interglacial represents the warmest climatic interval over the past 128 ka and one of the warmest interglacials over the past 800 ka. The field relationships and morphostratigraphical characteristics of MIS 5e coastal successions is briefly reviewed from numerous sites in south-eastern Australia, extending from western Eyre Peninsula, South Australia to the Hunter Valley, New South Wales as well as sites in Tasmania and the Bass Strait Islands. Where possible, the palaeosea-level records are also described from several sites which question the notion of bipartite high sea-level stands during the interglacial. Differences in coastal palaeogeography between the Last Interglacial and the current Holocene interglacial, and the magnitude of relative sea-level rise required to affect these coastal landscape changes are also examined.

Antarctic black carbon whodunnit

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Refracted black carbon (rBC) measured from polar ice core records can be used to infer historic levels of biomass burning from terrestrial sources. McConnell et al (2021)[1] compare rBC levels from Antarctic ice-core records with selected paleoecological records from nearby Patagonia and more distant Tasmania and New Zealand to conclude that burning by early Polynesian (Māori) settlers in New Zealand dwarfed other preindustrial carbon emissions in the southern hemisphere mid-latitudes during the past 2,000 years. Yet, closer scrutiny of existing paleoecological records shows that all these terrestrial source regions were likely to be contributing to the peak rBC levels. This distinction is important because it enables the hemispheric scale environmental impacts on the remote Southern Hemisphere to be attributed to multiple societies that were engaged in biomass burning, rather than to a single cultural phase.

Reference:

McConnell, J.R., Chellman, N.J., Mulvaney, R. et al. Hemispheric black carbon increase after the 13th-century Maori arrival in New Zealand. *Nature* **598**, 82–85 (2021).

Speleothem ‘uptick’ supports reduction in rainfall recharge to groundwater is unprecedented for last 800 years, SW Western Australia

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Southwestern Australia relies significantly on groundwater for domestic and industrial purposes. As water availability has decreased and is projected to continue to decrease with climate change, it is critical to understand the impacts of climate change on groundwater recharge for this region. Speleothem (e.g. cave stalagmites) deposition is directly related to groundwater recharge, as they form from rainfall which has infiltrated into the vadose zone and represent periods of potential aquifer recharge. In this study, modern speleothems from five caves record a consistent response to a sustained decrease in rainfall across south-west Australia that began in the 1970s, characterised by an ‘uptick’ in the speleothem oxygen isotopic composition (Priestley et al., 2022). It is demonstrated that the ‘uptick’ is in response to the shallow karst aquifers becoming disconnected from rainfall recharge due to regional drying. As the coastal caves are located in highly permeable host rock along the wettest zone of the region, our findings imply that rainfall recharge to groundwater across the southwest Australian region may no longer be reliably occurring. The paleo-record for speleothems from south-west Australia (Treble et al., 2022) provides a longer-term context to assess the recent isotopic uptick against and confirms that no similar events are seen in the last 800 years in stalagmites from the region.

Priestley, S., et al. (2022). Caves provide early warning of unprecedented decrease in rainfall recharge of groundwater. *Research Square*. doi:https://doi.org/10.21203/rs.3.rs-1556439/v1

Treble, P. C., et al. (2022). Ubiquitous karst hydrological control on speleothem oxygen isotope variability in a global study. *Communications Earth & Environment, 3*(1), 29. doi:10.1038/s43247-022-00347-3

Comparative sclerochronologies: evaluating gastropod shells and opercula as sea-surface temperature and seasonality archives for southeastern Australia

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Oxygen isotope ratios from marine mollusc carbonates have been widely used for both high-resolution sea-surface temperature (SST) reconstructions, and to study the seasonality of shellfish foraging patterns from archaeological sites worldwide. Most studies have focused on obtaining high-resolution records from shells, by combining geochemistry with detailed analysis of growth patterns (sclerochronology). However, in some deposits, shells may be unsuitable for analysis due to fragmentation or dissolution. Opercula are structures that close gastropod shell apertures when the animals are retracted. Some species, such as *Lunella undulata* (the lightning turban shell), have hard, flat, and dense carbonate opercula that are better preserved than shells in archaeological and geological deposits. In this study, we compare oxygen isotope records obtained via high-resolution sclerochronological analysis of live-collected *Lunella undulata* shells and opercula. We found that $\delta^{18}O$-derived SST reconstructions compared favourably with instrumental SST records over the period of collection, suggesting that both archives are reliable palaeothermometers, however, annual SST ranges were slightly greater in shells than in opercula. Both archives were found to be able to reconstruct seasonal foraging information, however, shells provided more accurate data. This study shows the potential of *Lunella undulata* shells and opercula as palaeoclimate archives, and indicates that, where shells are fragmentary or unavailable, opercula can also provide reliable records. As remains of these molluscs are found in archaeological sites across southeastern Australia, this study demonstrates the potential of both shells and opercula for palaeothermometry and seasonal foraging studies.

Sediment records suggest post British-invasion declines in diversity of wetland plant communities in the Koondrook-Perricoota Forest, Murray River, NSW

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Floodplain wetlands support enormous biodiversity and range of other vital ecosystem services. However, these wetlands are threatened by a range of processes. In the Murray-Darling system of southeast Australia, these processes include altered wetting regimes, cropping, grazing, invasive species and even forestry. Detecting and monitoring changes to these systems is limited by poor benchmark data, which would otherwise provide the basis for establishing the degree and nature of changes as well as possible drivers. This study sought to establish benchmark conditions and temporal patterns of change in wetland plant communities by examining stratigraphic changes in preserved plant and animal remains. Sediments from 12 wetlands in the Koondrook-Perricoota Forest were sampled at 2 cm intervals to depths of 30 cm to 40 cm. Lead-210 dating of the sediment profiles suggest the upper 10 to 16 cm of these sediment sequences were deposited in the last 100 years. Identified remains included *Azolla* megaspores, charophyte oospores, bryozoan statoblasts, chironomid head capsules, cladoceran ephippia and orobatid mites.

The preserved remains assemblages of the pre and post-invasion period were generally distinct, though the degree of change varied among wetlands. In general, the post-invasion period is characterised by declining richness and diversity and to a lesser extent abundance in charophyte oospores in several of the wetlands. While there is no compelling evidence as to a specific cause of these changes, they are likely a response to declining frequency of flooding of the wetlands as a result of flow regulation and water abstraction. In the case of the apparent declines in charophytes, the impact of introduced grazers such as cattle could

well have been a factor given that trampling and increased turbidity arising from their presence in and around the wetlands is likely to have been detrimental to the persistence of these submerged plants.

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Adding fuel to the fire: have fires in southeast Australia always burned so hot?

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Prior to colonisation by Europeans, many landscapes around the world had been deliberately shaped, maintained and cared for by First Nations peoples using skilful land-management practices. These land management practices were supressed and eradicated via colonisation; subsequently replaced with the imposition of European landscape ideals. This shift in management has led to a broad set of environmental consequences that pose contemporary challenges, many of which are now being compounded by the impacts of climate change. Recent catastrophic wildfires have kindled discussion about the return and expansion of Indigenous cultural burning practices to mitigate against climate-driven catastrophic bushfires across these landscapes.

Catastrophic bushfires in southeast Australia are framed around four themes: 1. climate change; 2. ignitions; 3. fuels; and 4. risk-adverse policy frameworks. Compounded with these are wilderness ideologies, which have allowed for policy and research to ignore past ecological conditions and ignore and supress a wealth of Indigenous knowledge of healthy landscape management. Here, a synthesis of our palaeoecological research from across Gunaikurnai (Gippsland, VIC) and Bundjalung (Northern Rivers, NSW) Countries is discussed to highlight coherent trends of landscape change pre- and post-British Invasion. By doing so, we aim to understand the influence of Aboriginal management, namely fire, and the consequences of the removal of strategic and managed burning across southeast Australia. Through this research we can develop datasets of environmental change spanning the pre- to post-British Invasion period to create appropriate baselines and management

approaches that can guide future landscape management of the southeast Australian landscape.

Developing Novel Techniques for Reconstructing Past Fire Histories in South-Eastern Australia

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South-eastern Australia is notoriously fire-prone, leaving the landscape vulnerable to extensive erosion as vegetation cover is decimated and soil hydrophobicity is increased. As climate change continues to modify fire regimes at local to national scales, it is forecast that bushfires will increase in severity, intensity and area burned. However, our existing records rely primarily on satellite imagery, which is limited to the last 30-50 years, or charcoal and tree rings analysis, preventing the distinction of fire severity and characteristics. To better defend against the effects of bushfires in the future and determine whether events such as the Black Summer Bushfires of 2019-20 are the new normal standard, there is an urgent need to develop new techniques that can significantly extend our fire record. Boron (B) isotopes and Fourier Transform Infrared (FTIR) spectroscopy lend themselves as potential proxies due to their sensitivity to changes in vegetation cover and chemical bonds, respectively.

The Upper Blue Mountains in New South Wales (NSW) and Namadgi National Park in the Australian Capital Territory (ACT) are known fire hotspots and, therefore, ideal for proxy development. Sediments collected from swamps and large order streams capture a range of fire return intervals which can determine the resolution of each proxy. An age-depth model has been paired with results from these two proxies to formulate a hindcast model. Preliminary analysis of small order creek sediments shows an increase in the $\delta^{11}B$ value of sediment layers expected to record fires due to input of leaf material in ash which has a higher ^{11}B composition. This is accompanied by a relative increase in aromatic bonds, which are more temperature and decomposition resistant. If successful, these techniques have the

potential to be applied to global biodiversity and fire hotspots to allow improved mediation of and recovery from future fire events.

Implications of anomalous relative sea-level rise for the peopling of Remote Oceania

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In the equatorial Pacific Ocean, proxy evidence and geophysical models of relative sea level (RSL) demonstrate higher-than-present sea levels in the Mid-Holocene (6,000–3,000 years ago) and subsequent RSL fall to present day. The manifestation of this RSL highstand (>1 meter amplitude) has implications for the pattern of human migration and settlement of islands in Remote Oceania. Evidence of initial human settlement on atoll islands eastwards of New Guinea and the Philippine Islands is generally dated later than this RSL highstand, because falling RSL over the last few thousand years provided greater lowland coastal areas ideal for settlement. Post-settlement, complex political hierarchies emerged in the region in the era just prior to European contact, which is demonstrated by the construction of monumental architecture.

The Federated States of Micronesia hosts two significant sites of monument building: Nan Madol and Leluh, which are UNESCO World Heritage Sites on the islands of Pohnpei and Kosrae. The prevailing interpretation of Nan Madol is that the site was constructed on man-made islets surrounded by shallow waterways ('canals'): an interpretation that assumes a fall RSL during the Late Holocene. Previous studies and our observations show the preservation of ~4 m-thick mangrove sediments of Late Holocene age on Pohnpei and Kosrae. These radiocarbon-dated mangrove sediments indicate sustained sea-level rise because mangroves inhabit a narrow and quantifiable elevation range with respect to mean

tide level. Ongoing local-scale subsidence is the most likely cause of this sea-level rise, and suggests that sea level was ~1 m lower than present when Nan Madol was built and inhabited (~1180 AD). Our new mangrove-derived RSL reconstruction shows that island subsidence is occurring at a greater rate than incorporated into future RSL projections, and indicates that Nan Madol and Leluh may be more vulnerable to future sea-level rise than previously anticipated.

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Tracking an anomaly: a MIS 6 warming event in Tasmania, Australia.

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The Earth system is rapidly changing in response to anthropogenic climate change. Reliable modelling and climate predictions, which depend upon high-resolution and continuous paleoclimatic reconstructions, are crucial for future environmental management. In Australia, and indeed the southern hemisphere, continuous terrestrial records that stretch into the Pleistocene are extremely rare. The Darwin Crater of western Tasmania is an exception, offering ~70m of lacustrine sediment and ~800,000 years of paleoclimatic history. Darwin Crater therefore provides a unique opportunity to analyze deep-time southern hemisphere climate dynamics.

Numerous marine cores surrounding Tasmania suggest an anomalous oceanic warming during Marine Isotope Stage (MIS) 6, yet the limited data makes it difficult to draw conclusions. Analysis of the Darwin Crater core for this project has revealed a decoupling of Tasmanian and Antarctic climate during the same period (MIS 6). This anomaly raises questions about ocean-atmosphere teleconnections and vegetation response to climate change, as Tasmanian climate is generally very faithful to trends in Antarctic climate.

This project investigated pollen (read: vegetation) from across MIS 6 in the Darwin Crater terrestrial record and the Fr1/94-GC3 marine record (offshore Eastern Tasmania). Assisted by XRF data and U/Th dating on vivianite within the sediment, this project located the MIS 6 anomaly within the Darwin Crater record. Here, we explored the potential mechanism/s influencing this anomalous warming period in the marine and terrestrial records across Tasmania. By investigating both the marine and terrestrial records during MIS 6, this research has added critical information to the southern hemisphere palaeoclimate record, by highlighting the anomalous decoupling of climate between Tasmania and Antarctica.

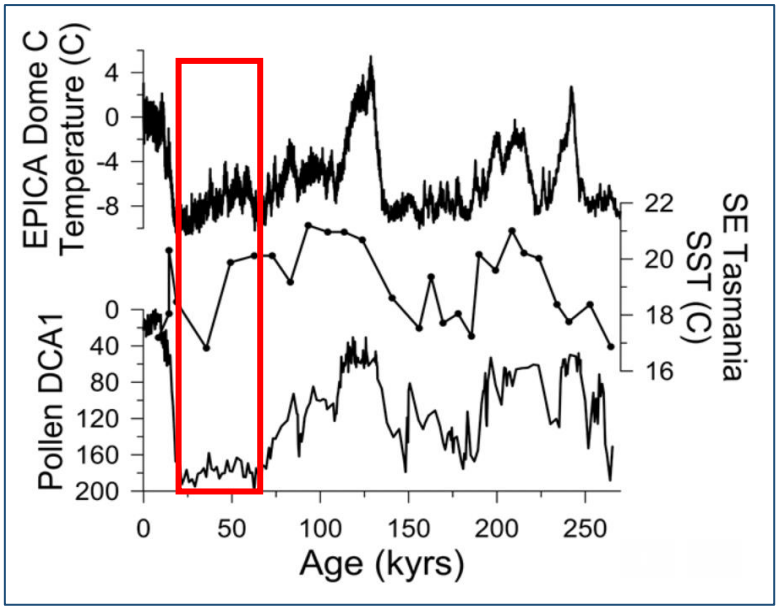

Figure 1) Epica Dome C Temperature, Se Tasmanian SST (°C) and pollen data from Lake Selina, Western Tasmania (source: Michael-Shawn Fletcher, unpublished). Note: the red box indicates the location of the Tasmanian terrestrial and marine anomaly, clearly asynchronous with the EPICA record.

Speleothem U-Th-Pb dating, pollen and charcoal reveal cave antiquity and fossil accumulation window at the Naracoorte Caves

Weij, Rieneke[1]; Woodhead, Jon[2]; Sniderman, Kale[2]; Hellstrom, John[2]; Reed, Liz[3,4]; Bourne, Steve[5]; Drysdale, Russell[2,6]; Pollard, Tim[2,6]

[1] University of Cape Town, Cape Town, South Africa; [2] University of Melbourne, Melbourne, Australia; [3] University of Adelaide, Adelaide, Australia; [4] South Australian Museum, Adelaide, Australia; [5] Limestone Coast Landscape Board, Mount Gambier, Australia; [6] Université de Savoie-Mont, Chambéry, France

Caves are important fossil repositories which provide records extending back over million-year timescales. While the physical processes of cave formation are well understood, the timing of initial cave development and opening - a more important parameter to studies of palaeontology, palaeoanthropology and archaeology - has proved more difficult to constrain. Here we investigate speleothems from the Naracoorte Cave Complex in southern Australia, with a rich record of Pleistocene vertebrate fossils (including extinct megafauna) and partly World Heritage-listed, using U-Th-Pb dating and analyses of their charcoal and pollen content. We find that, although speleothem formation began at least 1.34 million years ago, pollen and charcoal only began to be trapped within growing speleothems from 600,000 years ago. We interpret these two ages to represent the timing of initial cave development and the subsequent opening of the caves to the atmosphere respectively. These findings demonstrate the potential of U-Th-Pb dating combined with charcoal and pollen as proxies to assess the potential upper age limit of vertebrate fossil records found within caves.

Circulation history of the deep Indian sector of the Southern Ocean since MIS 6 as revealed by ε_{Nd}

Williams, Thomas J.[1,2,3]; Martin, Ellen E.[3]; Sikes, Elisabeth[4]; Starr, Aidan[4]; Umling, Natalie E.[5]; Glaubke, Ryan[4]

[1] UTAS Institute for Marine and Antarctic Studies; [2] Australian Centre for Excellence in Antarctic Science; [3] University of Florida; [4] Rutgers University; [5] American Museum of Natural History.

Southern Ocean deep circulation is thought to play a critical role in climate change on glacial-interglacial timescales in terms of both heat transport and ocean-atmosphere carbon exchange. Here, we reconstruct deep ocean circulation utilising Nd isotope measurements (ε_{Nd}) made on uncleaned planktic foraminifera. This widely used tracer is particularly sensitive to the proportion of deep Southern Ocean vs Atlantic deep waters mixing within the ancient Southern Ocean. We use this data to reconstruct circulation changes within the relatively poorly studied deep (3167 m and 2844 m) Indian sector of the Southern Ocean, between the penultimate glaciation (MIS 6; 140 ka) to the late Holocene.

We demonstrate a dramatic reduction in the proportion of deep waters sourced within the North Atlantic making their way into the deep Southern Ocean during the penultimate interglacial period, between MIS 5e to MIS 5d. We link these deep circulation changes to an expansion in Antarctic sea ice during the transition from MIS 5e to 5d, which resulted in increased density of Southern Ocean deep waters and increased stratification of the ocean interior. These changes may account for a portion of the ~30 ppm decline in atmospheric CO_2 from MIS5e-5d. Our data implicates the high latitude Southern Ocean as a key driver of glacial inception.

Australian Archaeological Association Annual Conference 2022

Recent Developments from the Submerged Cultural Landscape of Murujuga Sea Country, Northwest Shelf (Dampier Archipelago), Western Australia

Benjamin, Jonathan [1]; O'Leary, Michael [2]; McDonald, Jo [2]; Ulm, Sean [3]; Jeffries, Peter [4]; Bailey, Geoff [5]

[1]Flinders University; [2]The University of Western Australia; [3]James Cook University; [4]Murujuga Aboriginal Corporation; [5]University of York

In 2020, the Deep History of Sea Country project team published the discovery of two underwater archaeological sites in Murujuga Sea Country /the Dampier Archipelago, Western Australia. Further lab analysis and field-based observations have since been undertaken, and these contribute to our understanding of the submerged sites within the broader setting of this rich cultural landscape. An update to our initial field observations will be provided. A brief discussion will be undertaken regarding heritage protection, as these sites represent a case study application for the protection of Indigenous underwater cultural heritage, which was submitted to the Commonwealth for protection under the new *Underwater Cultural Heritage Act 2018*. A discussion on site significance and future considerations for the archaeological prospection of submerged Indigenous sites will be included.

Proxies, Models, and People: Using Transient iTrace Climate Models to Disentangle Proxy and Archaeological Records During the Penultimate Deglacial in Australia

Cadd, Haidee [1]; Turney, Chris [2]; Williams, Alan [3]; Mooney, Scott [3]; Cohen, Timothy [1]; Saktura, Wanchese [1]; He, Chengfei [4]; Otto-Bliesner, Bette [5]

[1]University of Wollongong; [2]University of Technology Sydney; [3]University of New South Wales; [4]Ohio State University; [5]National Center for Atmospheric Research

The climates of the last glacial cycle in Australia are poorly characterised. Conflicting evidence from spatially disparate continuous proxy records and discontinuous fluvial records has led to a lack of consensus of how climates responded during the LGM. In addition, Australia has been continuously inhabited by humans for at least the last 50,000 years and little is known about how people responded to changing climates during the most extreme periods of the last glacial cycle.

We use transient iTrace climate models, comparing modelled precipitation and temperature, to generate results of palaeoclimate proxy records from 21 - 11 ka. Multi-site comparison of continuous proxy records suggests an extended period of extreme conditions from 28.2 - 17.3 ka. These records show a change from non-woody herb and grassy taxa to woody arboreal and shrub taxa at 17.3 ± 2 ka, however no substantial changes are recorded in model outputs. In contrast, discontinuous records from fluvial archives suggest that some fluvial systems reached their maximum extent during this period. Increased monsoon activity, lower temperatures and reduced transpiration rates from non-woody vegetation may have led to increased fluvial transport through some fluvial networks. Kernel Density Estimates (KDE) of archaeological dates (C^{14}, OSL and TL) suggest no major changes in population density during the peak LGM and deglacial periods. Spatial distribution of these dates indicates some population movement, however widespread migration is not evident. The combination of transient climate models, proxy records and

archaeological data suggest the LGM and deglacial period in Australia may have been less arid in some regions than previously presumed. To further disentangle the complex changes between climate and humans, across such a broad continent with varying climate regimes, will require multiple lines of evidence with a broad spatial and temporal coverage.

The Use of High-Magnification Microscopy in Identifying the Impacts of Carnivores in Faunal Assemblages

Cunningham, Lauren[1]

[1]The University of Queensland

The cause of fragmentation in a faunal assemblage can inform archaeologists about the broader practices and processes that impacted upon a site. However, the wide range of factors that can result in such fragmentation make it difficult to identify the cause confidently. Identifying the impact of carnivores is further complicated by the low proportion of remains showing tooth marks, the most commonly used means of identifying and differentiating these actors. This paper discusses a pilot study to determine the utility of high-magnification stereoscopic light microscopy (HSLM), scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) to identify scat bones produced by *Sarcophilus harrisii* (Tasmanian devil) and *Dasyurus maculatus* (spotted-tailed quoll). Modern reference samples, collected from both captive and wild individuals, were examined for indications of carnivore involvement using traditional, low-magnification techniques, and then re-examined using HSLM, SEM and EDS. The results were compared to determine whether these alternative techniques provided indications of carnivore action that were not identified using low-magnification microscopy. At high magnifications, light microscopy and SEM both revealed the presence of surface grooves and cracking that were not detected using traditional techniques. They also showed the apparent redeposition of materials on the bone surface. EDS testing then focussed on comparing chemical signatures of the bone fragment and redeposited materials, and showed changes in chemical makeup between the two. While preliminary, these results suggest that these techniques may provide additional means of identifying carnivore impacted bones, and should be explored in further depth as a method of drawing more information from Australian faunal assemblages.

Perched Springline Tufas Reveal a Warm-Wet Palaeoclimate for First Australians on the Late Quaternary Darling Downs, Southeast Queensland

Gibbs, Jessica [1]; Leonard, Nicole [1]; Webb, Gregory [1]; Price, Gilbert [1]

[1]The University of Queensland

Developing a robust understanding of Australia's palaeoenvironmental variation through the Quaternary is critical for informing models of human arrival, megafauna extinction, and for debates surrounding their possible relationships. Despite continuous palaeoclimatic records available from Australia's coastal wetlands, there remains a dearth of terrestrial palaeoenvironmental records. This limits development of reliable models and impedes progress on these debates. Tufas, terrestrial carbonate spring deposits, are an underused palaeoenvironmental archive in Australia and could fill some of these gaps. Here, we analyse tufas from a significant fossil locality, Neds Gully, in southeast Queensland. Tufas do not form in the ephemeral water courses of the region today and it was hypothesised that they may have formed during the last interglacial (LIG), which was probably warmer and wetter than today. A wide range of tufa morphologies were analysed using optical and scanning electron microscopy. Delineation of the Neds Gully watershed was also undertaken to determine the extent of ground and surface water sources available for tufa deposition. Samples were dated using uranium-series. The range of tufa morphologies best match a perched springline hydrological model. With a total watershed of only 8.76 km^2, these tufas probably represent warm and wet conditions with abundant standing water, consistent with the LIG. However, despite the lack of tufa deposition today, the most reliable U-Th dates (7.8 ± 1 ka to 8.4 ± 1.4 ka) refute LIG timing and suggest the early- to mid-Holocene of the site was much wetter than today. A dryer climate may have developed in the late Holocene as ENSO became more El Niño dominated. This is consistent with sedimentological studies conducted both in Far North Queensland, on the Great Barrier Reef and downstream in the Murray-Darling catchment basin. This demonstrates the

potential contribution of Holocene tufas for understanding Australia's recent environmental history.

The Microstratigraphy of Tam, Pà Ling Cave, Laos: Situating Early Humans Within the Changing Tropical Environment

Hernandez, Vito [1]; Shackelford, Laura [2]; Bacon, Anne-Marie [3]; Duringer, Philippe [4]; Ponche, Jean-Luc [4]; Westaway, Kira [5]; Boualaphane, Souliphane [6]; Demeter, Fabrice [7]; Morley, Mike [1]

[1]Flinders University; [2]University of Illinois at Urbana-Champaign; [3]University of Paris; [4]University of Strasbourg; [5]Macquarie University; [6]Ministry of Information, Culture and Tourism, Laos; [7]University of Copenhagen

Early Modern Human (*Homo sapiens*) fossils have been recovered from sediments deposited in Tam Pà Ling Cave, north-eastern Laos. These fossils are some of the earliest evidence for Late Pleistocene dispersals of our species out of Africa and into Southeast Asia, with ages ranging from 70 - 46 ka. Tam Pà Ling is thus a critical site for investigating the timing and nature of modern human dispersals from mainland Southeast Asia towards island Southeast Asia and Australia. To date, no artefacts or archaeological stratigraphy have been found in association with the fossils, raising various scenarios for the taphonomic history of the fossils and the use of the site - or not - by humans. Given the fine-grained nature of the sediment infill and their cultural sterility, a program of geoarchaeology and microstratigraphic analyses was initiated in 2018 to examine the cave sediments at the microscopic level.

This presentation focuses on that part of the sediment sequence deposited between 51 - 29 ka from which three *H. sapiens* fossils were recovered. The preliminary results of this microstratigraphic work provide environmental context for human presence in the area, help reconstruct the taphonomic history of the fossils, and show that anthropogenic micro-traces do survive in the sediments, albeit in low quantities. These results raise the possibility that early modern humans occasionally used Tam Pà Ling Cave or the area immediately outside the site at this time.

Preservation Prevails at Tam Pà Ling, Laos: Reconstructing Palaeovegetation Dynamics via Higher Plant Biomarkers Offer New Insights into Environmental Variability Across MIS 3-MIS 1.

McAllister, Meghan [1]; Blyth, Alison [2]; McInerney, Cesca [3]; Tyler, Jonathan [4]; Holman, Alex [2]; Grice, Kliti [2]; Boualaphane, Souliphane [5]; Bacon, Anne-Marie [6]; Shackelford, Laura [7]; Demeter, Fabrice [8]; Morley, Mike [1]

[1]Flinders University; [2]Curtin University; [3]The University of Queensland, [4]The University of Adelaide, [5]Ministry of Information, Culture and Tourism, Laos, [6]University of Paris, [7]University of Illinois at Urbana-Champaign; [8]University of Copenhagen

Our current understanding of the local environmental conditions encountered by early *Homo sapiens* as they first arrived in Southeast Asia (Sunda, Wallacea) and Australia (Sahul) in the Late Pleistocene (Marine Isotope Stages (MIS) 5-2; 124-11.7 ka) is rather sparse. As a result, we do not yet fully understand the extent to which the environment influenced human migration patterns into and out of the region. In this paper we showcase some of the key findings in McAllister's PhD research, developing a high-resolution, quantitative palaeovegetation reconstruction of Tam Pà Ling, Laos, spanning MIS 3-MIS 1 (59-11.7 ka) by analysing plant wax lipid biomarkers (n-alkanes, n-alkanols, and n-alkan-2-ones) preserved in the cave sediments. Understanding the local palaeoenvironmental conditions at Tam Pà Ling is of particular interest as the site currently hosts the earliest evidence of *H. sapiens'* presence in mainland SEA, backdating their presence in the region to ~63±6 ka (MIS 4). The results suggest that the vegetation of the landscape was dynamic and susceptible to change as a result of variations in climatic conditions. The extent of these changes varied considerably; we will go on to explore these in relation to climatic events that took place across these particular periods. Given the humidity of the tropics and the subsequent rapid degradation and microbial reworking that often limits or hinders the development of palaeoenvironmental records, our research demonstrates the resilience of higher plant

biomarkers in these environments and seeks to promote their extraction in tandem with future archaeological excavations when possible.

Geomorphological Processes and Post-Depositional Movement on Stony Rises in Wurundjeri Country, Victoria

Minos, Racheal [1]; Goldfarb, Amanda [1]; Wandin, Allan [2]; Jones, Ron [2]; Mullins, Bobby [2]; Spry, Caroline [2]; Williamson, Christine [3]; Stephenson-Gordon, Grace [3]; Flatley, Alissa [1]; Lushey, Jonathan [1]; Tuncer, Erol [1]

[1]Jacobs; [2]Wurundjeri Woi wurrung Cultural Heritage Aboriginal Corporation; [3]Christine Williamson Heritage Consultants

The Western Volcanic Plains span over 23,000 square kilometres and boasts over 100 extinct volcanoes. It is on this extensive plain that thousands of basaltic, stony rise outcrops dot the landscape to the north and west of Melbourne, Victoria. These rises vary from small undulations to prominent features that can extend for hundreds of metres in length and for several metres above the ground surface. Aboriginal stone artefact scatters, in addition to rarer hearth features, have been found on these stony rise outcrops across the region. To the north of Melbourne, they are places of cultural importance for the Wurundjeri Woi wurrung people, and serve as reminders of a previous landscape that has been irrevocably altered through European settlement, agricultural use, and urban development. Through research undertaken for the Lockerbie Salvage Project, an investigation of the geomorphological and geological development of stony rises was completed. In addition, technological and refitting analysis of the assemblage was also used to map artefact displacement across one stony rise. This was used to gain greater insight into the potential taphonomic processes associated with continued stony rise development and artefact deposition from use by Wurundjeri Woi wurrung people. This paper presents the results of this investigation. This collaborative project is being delivered by Jacobs, Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation, Yarra Valley Water, and Christine Williamson Heritage Consultants.

ARCAS State of the Art: Archaeological Science in Australasia in 2022

Popelka-Filcoff, Rachel [1]; Shewan, Louise [2]; Prendergast, Amy [2]; Lise-Pronovost, Agathe [2]; Green, Helen [2]; Garvey, Jillian [3]; Kurpiel, Rebekah [3]

[1]Flinders University; [2]University of Melbourne; [3]La Trobe University

Archaeological science in Australasia takes a unique position on the world research stage. Researchers from diverse viewpoints in archaeology, anthropology, cultural heritage management and the natural sciences among others, co-develop state of the art archaeological science studies in the field and laboratory whilst leading in collaborative partnerships with First Nation communities, and the integration of traditional knowledges and western science. Developed techniques and applications are tailored to Australasian contexts, while also simultaneously developing cutting-edge technologies and methods for use in archaeological science research worldwide. The context for the research can be diverse; however similar inquiries about intertwined questions on provenance, age, landscapes, human-environmental interactions, and others underlie the research objectives.

This presentation will provide an overview on recent research trends in Australasian scientific approaches to archaeological research, with a focus on Indigenous Australian archaeology and insights from collaborative archaeological science. The Australasian Research Cluster for Archaeological Science (ARCAS), the professional organisation for archaeological science in Australia, is currently hosted at University to the University of Melbourne and is nationally represented.

SahulArch: Age Determinations for Archaeological Sites from Sahul in the OCTOPUS Database

Rehn, Emma [1]; Munack, Henry [2]; Saktura, Wanchese [2]; Linnenlucke, Lauren [1]; Codilean, Alexandru [2]; Jacobs, Zenobia [2]; Ulm, Sean [1]

[1]James Cook University; [2]University of Wollongong

Chronological data are critical for archaeological and sedimentological research to establish a timeline to compare changes observed across archaeological and palaeoenvironmental deposits. However, these chronological data, by nature of research activities, are scattered across a range of published as well as grey literature sources making comparisons and compilations challenging. The OCTOPUS database (https://octopusdata.org) addresses this challenge by providing open-access collections of age determinations with standardised data reporting and extensive metadata, enabling assessments of chronometric robustness and region-wide modelling within and between archaeological and sedimentological records.

This talk introduces one of the core collections of OCTOPUS: Sahul Archaeology (SahulArch). SahulArch currently contains over 10,000 radiocarbon, OSL, and TL ages from over 2,000 archaeological sites throughout Sahul. This builds on the substantial work of the earlier AustArch database, expanding data collection to capture a greater range of relevant metadata and extending the geographic scope beyond Australia to include Papua New Guinea, West Papua, and the Aru Islands.

This paper presents an overview of SahulArch v2 and serves as a brief introduction of how to access collections through OCTOPUS and how to include your own data in the database. These data collections are important data infrastructure for Indigenous communities, archaeologists, Quaternarists, and researchers working across both fields now and into the future.

Kimberley Monsoon Rainforests: New Holocene Palaeoenvironmental Records from Northwestern Australia

Rudd, Rachel [1]; Howie, Charmaine [1]; Dixon, Teresa [1]; Moss, Patrick [1]; McGowan, Hamish [1]

[1]The University of Queensland

Monsoon rainforests in the Kimberley region of northwestern Australia are small, discrete patches of diverse vegetation embedded in a eucalypt savanna landscape. These ecological communities are significant for their species richness, their role as a refuge and food source for fauna, and as a cultural resource for Aboriginal people. Kimberley monsoon rainforests are threatened by cattle, feral pigs, weed invasion and late dry season fire activity, with small patches, and those with little or no topographic protection from fire, particularly vulnerable. Rainforests have persisted in the Kimberley through arid periods in the past, as evidenced by rainforest taxa in the macrobotanical record from Carpenter's Gap for over 47,000 years (Dilkes-Hall et al. 2019). However, little is known about how the extent of these rainforests, and their consequent availability as a resource, has varied through time. The sediments accumulating at rainforest patches provide an opportunity to study not only variability in the rainforests themselves, but also the surrounding savanna environment.

Here, we present records of environmental variability from the sediments of three monsoon rainforests. These rainforests host taxa observed in the archaeological macrobotanic record including fig species and members of the *Terminalia* genus, which includes the Kakadu plum. Variability in the abundance of these taxa and changes in fire activity through time, inferred from pollen and charcoal preserved in the sediment, indicate changes in rainforest extent associated with regional environmental conditions. The sediments of these rainforests, which are not topographically sheltered, show different basal ages, suggesting that the rainforests emerged following the development of favourable local conditions. These records, in conjunction with previous speleothem and mound spring palaeoclimate records, provide insight into monsoon variability, and the environment experienced by inhabitants of the region in the Holocene.

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Human-Environment Interactions in the Far Eastern New Guinea Islands (Massim Region) Since the Last Glacial Maximum

Shaw, Ben [1]; Kewibu, Vincent [2]; Coxe, Simon [3]; Haro, Jemina [4]; Miamba, Kenneth [4]; Hawkins, Stuart [1]

[1]Australian National University; [2]University of Papua New Guinea; [3]Monash University; [4]National Muesum and National Gallery of Papua New Guinea

The Massim Islands in far eastern New Guinea have dramatically transformed in size and configuration prior to, during, and since the Last Glacial Maximum. The adaptive flexibility of modern and past populations living on these islands is readily apparent, reflected in a range of networks, technologies, and customs that are augmented in response to social and environmental challenges. Here we present results of recent archaeological work in the Massim Islands that has significantly expanded the known time depth of human occupation in the region, spanning the last 17,000 years, with evidence suggesting people may have been in the region for at least 40,000 years. We summarise adaptations to changing islandscapes since this time, including responses to developing coastlines in the Holocene and how this influenced later interactions between Indigenous and Lapita cultural groups.

Investigating the Multi-Regional Emergence of Social and Economic Complexity Across Diverse Australian Environments

Westaway, Michael[1]; Moss, Patrick[2]

[1]The University of Queensland; [2]University of Queensland

It is clear when we undertake a careful study of past Aboriginal society that across Australia economic systems were not uniform. A staggering variety of resources and associated environments were used by Aboriginal people. They held ceremonies of great complexity, often associated with resource productivity, and it is probable that at some sites dramatic intensification of labour demands were employed. Plants were translocated and, in several regions, cultivated, and many landscapes were culturally modified through burning and other practices to promote increased economic productivity. Some groups developed increasing sedentary societies living in seasonal villages, while elsewhere mobility provided the required flexibility to engage with the challenges of fluctuating environmental conditions. We need to attach greater importance to understanding diversity in economic and social systems if we are to produce a more authentic reconstruction of the Aboriginal past.

Over the past eight years multidisciplinary investigations in Queensland's Channel Country, Cape York, and more recently the mid north coast of NSW have generated important new data to test against emerging models that too often gloss over regional diversity. In the presentation we will provide results of research from a renewed multidisciplinary approach in the above mentioned three regions which is revealing an important insight into the non-uniform nature of Aboriginal societal change over the Holocene period.

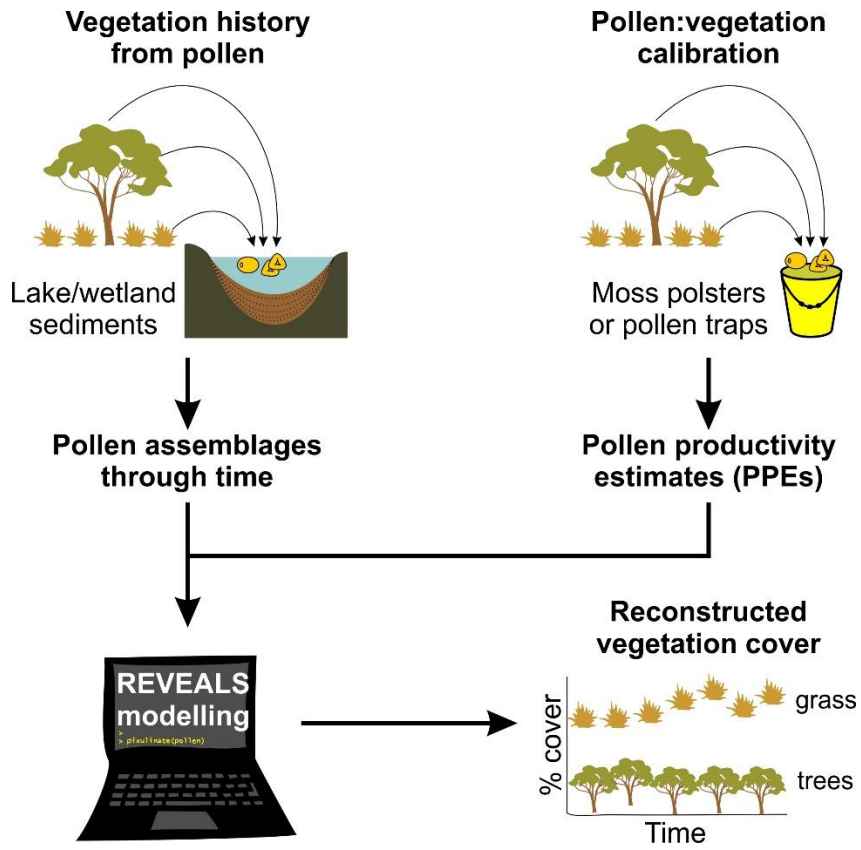
Lightning talks

A beginner's guide to turning pollen data into estimates of vegetation cover

Connor, Simon[1,2]; Mariani, Michela[3,2]; Romano, Anthony[4]

[1] School of Culture, History & Language, Australian National University; [2] ARC Centre of Excellence for Australian Biodiversity & Heritage, Australian National University; [3] School of Geography, University of Nottingham; [4] School of Geography, Earth & Atmospheric Sciences, University of Melbourne

Pollen data are the richest source of information on the past dynamics of ecosystems in response to long-term changes in fire regimes, climate and human interactions. That said, pollen data remain difficult to translate into meaningful outputs for managers, policymakers, modellers and communities. These stakeholders often want information that is directly relevant to their on-the-ground experience, or require quantitative data that can be incorporated into models and management plans. One way to achieve this is to use REVEALS modelling to estimate past vegetation cover. Pollen productivity estimates (PPEs) are now available for the main pollen taxa in southeast Australia, so any researcher can turn their pollen data into estimates of past vegetation cover. But how do you do it? This presentation will provide simple, step-by-step instructions for applying PPEs to pollen data and will discuss the surprising insights and research opportunities offered by the ability to quantify past vegetation cover.



Steps involved in estimating past vegetation cover from pollen data.

High-resolution palaeodust archive from subantarctic Macquarie Island

Johansen, Andrea [1,4]; Stromsoe, Nicola [2]; Saunders, Krystyna [3,4]; Marx, Sam [1]

1. GeoQuEST Research Centre, School of Earth, Atmosphere and Life Sciences, The University of Wollongong, NSW. 2. College of Engineering, IT & Environment , Charles Darwin University. 3. Australian Nuclear Science and Technology Organisation. 4. Securing Antarctica's Environmental Future

Mineral dust drives climate variability both during atmospheric transport and upon deposition. During transport, dust influences radiative forcing and cloud properties. Upon deposition, nutrients supplied by dust can drive primary productivity and subsequent drawdown of atmospheric carbon. Inputs of Australian dust may be especially critical in the nutrient-limited ecosystems of the South Pacific Southern Ocean and subantarctic islands. This study seeks to understand dust flux to Macquarie Island since the mid-Holocene, and the potential response of plants to changing dust inputs.

Peat cores from Macquarie Island were selected to reconstruct the dust flux history as peat plants can effectively capture dust and preserve the dust signal. Peats develop in water-saturated areas where plant decomposition is slowed in the anoxic and reduced conditions. As new growth accumulates over decaying plants, some elemental components of dust are preserved in place in the peat column.

We developed high-resolution age-depth models with ^{210}Pb, ^{239,240}Pu, and ^{14}C analysis. We applied ^{210}Pb dating to the top 25 cm of each core, with additional age-control from the peak concentration of anthropogenic ^{239,240}Pu identifying the Southern Hemisphere peak from nuclear weapons testing (about 1964). These data, along with radiocarbon ages to the mid-Holocene, were used to inform the age-depth model, which indicates variability in peat accumulation rates. The quantity and quality of organic matter (OM) were indicated by loss-on-ignition and Fourier-transform infrared (FTIR) spectroscopy. The δ^{15}N values indicated minimal animal inputs. Preliminary inductively coupled plasma mass spectrometry (ICP-MS) data indicates dust inputs by increases in the stable isotopes of Pb in the early and mid-20th century. Dust scavenges Pb during transport, and the Australian production of Pb increased

with the opening of the Broken Hill mine in 1885. Work is currently in progress to confirm these findings and extend the dust record prior to the 20th century.

Fuel loads and fire: A palaeoecological analysis of long-term fire and fuel dynamics in Bundjalung National Park, New South Wales, Australia.

Kennedy, Patrick[1]

[1] The School of Geography, Earth, and Atmospheric Sciences – The University of Melbourne

Catastrophic bushfires have increased in size, frequency, and intensity in eastern and south-eastern Australia over recent decades. Contemporary debates frame this as a climate change problem, with a very recent focus on landscape management providing a counterpoint to the climate change narrative. While both climate change and land management influence the amount, type, and condition of vegetation (i.e. fuel) present in landscapes, as well as the frequency and type of ignition required to start fires, they require different mitigation strategies to combat their causal relationship with catastrophic bushfires. There is an urgent need for long-term data on how fuels and fire respond to changes in climate, management, and other potential drivers if we are to find the appropriate solutions for the current trend.

This study analysed long-term fire and fuel dynamics in Bundjalung National Park, an area stretching from the eastern seaboard inland in northern New South Wales (NNSW), that was impacted by the large-scale 2019/2020 Black Summer Bushfires. The project focused on how fuel loads and fire respond to important local and regional drivers, such as changes in climate, sea level, and anthropogenic land management through the Holocene (and Anthropocene). A sediment core from Wangar Swamp in Bundjalung National Park was analysed using a set of palaeoecological approaches selected to assess changes in fuel loads and fire activity. This analysis allowed a reconstruction of the changes in fuel loads and fire activity through the Holocene to the present in this part of NNSW. The data was assessed against records of local and regional climatic changes, sea level fluctuations and human occupation to understand the relationships between changes observed in the data and

these drivers of environmental changes. The research provides a critical deep-time scientific understanding of fire and fuel load dynamics, in a data poor regions of significant cultural importance to the local Bundjalung Traditional Owners.

Revisiting aeolian sediments in the Wagga Wagga region

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Sedimentary sequences of aeolian origin mantle the Wagga Wagga region. First identification of these clay-rich sediments which blanket the landscape, led Butler (1956) to introduce the term Parna. Defined by its distinct properties and widespread abundance, it is thought to be fine grained sediment produced by exogenic processes and transported as stable aggregates by the prevailing westerly winds during the Quaternary. Likely source areas for Parna are primarily arid and semiarid river and lake systems of the western MDB. Even though the concept and terminology of Parna has been the subject of critical discussion for many years, follow-up research regarding the raised open questions has been limited while absolute dating of the aeolian sequences has been restricted to only a few sites.

Driven by the availability of source material, climatic properties, and vegetation cover, and altered by weathering and pedogenesis, the sediments store information about past environments. Such complex sequences require a multimethodological approach combining field observations, grain size analysis, micromorphology, geochronological and geochemical methods to investigate the processes, time frames of sedimentation and their provenance. This talk will outline initial results of optically stimulated luminescence (OSL) dating, showing the luminescence properties of the Brucedale Site (Beattie 1972). First geochemistry characteristics of this type location for Parna will help trace the source of the aeolian material, contributing to the understanding of landscape development in south-eastern Australia.

Investigations of Mammoth Teeth in Paleoenvironmental Reconstructions from Multiple Enamel Ridges

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Stable isotopes from mammoth tooth carbonate have been increasingly implemented in paleoenvironmental reconstructions in recent decades, with past studies obtaining paleoclimatic records of sub-annual resolutions by sampling temporally successive enamel powder along the enamel ridge. However, there has been little investigation into the paleoenvironmental records from multiple ridges of the same tooth. The molar teeth of woolly mammoths (*Mammuthus primigenius*) have typically more than twenty separate enamel ridges, and the formation time, rate and potential offsets between different enamel ridges remain unknown.

This study sequentially sampled mammoth tooth enamel following the dominant tooth growth direction and acquired time-series of oxygen isotopic compositions ($\delta^{18}O$) from six neighboring enamel ridges of the same tooth. The isotopic oscillations of each enamel ridge were then compared and overlapped with wiggle-matching methodologies. The results indicated that two neighboring enamel ridges were formed during approximately the same time with an offset of less than half a year. However, it is hard to merge the records from different ridges due to the variable enamel growth rate. These preliminary results enhanced our understanding of mammoth dental morphology and may help with decisions related to enamel ridge sampling in future studies. Importantly, by sampling multiple enamel ridges from the same mammoth tooth, researchers will fully exploit this archive's potential for paleoenvironmental reconstructions.

Old flames: the relationship between cultural burring and fire histories on Gunaikurnai Country, Victoria

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The *Black Summer* 2019–20 fires burned nearly half of the forest estate across Gunaikurnai Country (East Gippsland). How these catastrophic fires were caused — by climate change and/or land management — has been the subject of political and academic debates. These debates have emphasised the reinstitution of Aboriginal cultural burning to help mitigate such catastrophic bushfires. Aboriginal and Torres Strait Islanders have used cultural burning for millennia (amongst other purposes) to reduce fuel levels and the risk of high-intensity bushfires, akin to *Black Summer* fires. While the call to reinstate cultural burning is based on reservoirs of traditional knowledge and practice, there is limited empirical data on pre-British Invasion vegetation and fire dynamics. This data gap represents a barrier between this fire approach becoming policy and practice in a managed landscape. Changes in pre- to post-Invasion vegetation (i.e., fuel) and fire in Eucalypt-forest in the Point Hicks area, East Gippsland are investigated using palaeoecology and dendrochronology of fire-sensitive trees. I will analyse the fossil charcoal and pollen in the sediments of two proximal wetlands which are critically located in the *Black Summer* bushfire zone. Radiometric dating, geochemistry, and Fourier Transformed Infrared (FTIR) Spectroscopy will be used to anchor changes in time, understand erosion shifts and catchment dynamics, and infer fire temperatures from charcoal, respectively. To enhance the fire history reconstruction, I will use dendrochronology to investigate the influence of past fires on fire-sensitive pines (*Callitris rhomboidea*) stand dynamics. Here, I will present preliminary data of the FTIR spectra charcoal temperature analysis, palaeofire record, and dendrochronological analysis.

Reconstructing atmospheric particulate loads over the north-western Pacific Ocean during the mid to late Holocene: volcanism, dust and human perturbation of regional aerosol loads/composition.

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Atmospheric particulate transport over the North Pacific Ocean is known to be significant for regional biogeochemical processes and climate. For example, dust aerosol is known to fertilize phytoplankton, increasing the effectiveness of the biological C pump. Despite its importance, there has been little work tracing the changing sources and relative loads of particulate aerosols in this key region over the Holocene. The deserts of northern East Asia are the 2nd largest global dust source, while the eastern extent of East Asia forms part of the Pacific ring of fire, indicating tephra forms a significant, albeit episodic component of atmospheric particulate loads. Critically, East Asia has also undergone a significant transformation over recent decades, with widespread agricultural intensification and a massive increase in industrial activity, especially following China's Great Leap Forward from late 1950s. This has likely perturbed regional atmospheric aerosol characteristics. In this study, we use peat mires from the Daisetsuzan Mountains in central Hokkaido, Japan, to reconstruct the history of atmospheric particulate deposition over the mid to late Holocene. Results show that over the past 4 kyr mineral flux was relatively low and dominated by dust input from mainland China, as evidenced by the rare earth element (REE) and eNd composition of sediments deposited in the mire. Within the last millennium, particulate

fluxes changed more significantly, with the deposition of at least two major tephras. Further dramatic changes are recorded in the very top sections of the peat mire, where Chinese dust input becomes more geochemically significant. At the same time, the onset of nascent particulate matter is recorded by increasing concentrations of 'industrial' metals such as Pb and Cu. Collectively, this demonstrates the vast scale of human perturbation of atmospheric particulate, even within a region where the atmosphere is loaded with 'natural' particulate aerosol.

Holocene records of environment and freshwater availability from tufa archives: implications for human occupation at Murujuga, NW WA

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Murujuga in NW Western Australia is the world's largest rock art province, with over 1 million engravings. The art and other archaeological evidence in this landscape are an important record of human response to the changing climate following the last ice-age. 130 m of sea level rise following Last Glacial Maximum (LGM ~22 kya) transformed Murujuga from an inland range to a coastal archipelago. We discuss the potential of freshwater tufa as multi-proxy archives to inform on the local environmental and climatic change that impacted this region during the Holocene. Tufa, which are calcium carbonate deposits that form from freshwater springs and seeps in river channels, provide a proxy of past freshwater availability. Establishing the age and rate of tufa formation will enhance our understanding of the presence and permanence of water holes that would have been important for human occupation. Outcomes of this work will provide context to the extraordinary archaeological record documented in Murujuga rock art.

Figure 3. Example of extensive tufa cascades on Burrup Peninsula (Image – Patrick Morrison).

Window to past human-environment interactions? Preliminary results from a modern calibration study of freshwater mollusc species from the Central Murray River Basin

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The world over, molluscs have served as a proxy archive for environmental change from recent to ancient timescales. In part this has been through the approach known as sclerochronology, which involves the study of growth patterns and associated geochemistry (oxygen and carbon stable isotopes, trace elements) in the accretionary hard tissues of mollusc shells. When applied to shells excavated from archaeological contexts, sclerochronology can provide interannual, site-specific paleo-environmental data which can enable more robust interpretations of human-environment interactions. This is ideal for the Central Murray River Basin (CMRB) in North-West Victoria, the traditional lands of the Ngintait and First Peoples of the Millewa Mallee, where shell midden sites are common, but few paleoclimate records exist. However, before applying this technique to archaeological shell material, a modern calibration study needs to be completed.

This paper presents preliminary results of a modern calibration study of freshwater bivalve species *Alathyria jacksoni*, collected live from the CMRB in 2017 and 2021-2022. These specimens were analysed with various techniques, including SEM, SIMS (SHRIMP), IRMS and LA-ICP-MS, to understand how the growth and geochemistry of modern specimens relates to the surrounding environment and hydrochemistry of the current Murray-Darling system. It is also an essential step to better understanding the life history and behaviour of this species, which will not only strengthen interpretations of the archaeological material but may also aid current efforts to conserve freshwater mollusc populations. Given the species

range of *A. jacksoni*, the results of this study are applicable to paleoclimate research throughout the Murray Darling Basin.

Palaeoclimate data and hydroclimate risk assessment: the role of archives, proxies and time

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Palaeoclimate data are increasingly used to model and forecast the risk of hydroclimate extremes, particularly multi-decadal droughts and periods of enhanced flood or fire risk, that are not captured by instrumental climate records for the last century. Mainland Australia classically lacks a detailed coverage of annually resolved palaeoclimate records, such as those afforded by tree rings and corals, hence hydroclimate risk analyses are often conducted using remote proxy records, such as tree rings from Tasmania, corals from the northern tropical oceans or ice core records from Antarctica. Lake sediment records are also sparse, and they predominantly lack annual resolution or equivalent chronological precision. Lakes do, however, respond sensitively to hydroclimate, they occur across mainland Australia and their sediments sometimes preserve high resolution records of past hydrological change.

Preliminary analyses suggest that the amplitude and wavelength of inherent variability, particularly over longer timescales, is greater in lake sediment records compared to other annually resolved proxies of past hydroclimate. As a consequence, lake sediment archives suggest that the probability of multi-decadal climate extremes is greater than suggested by other proxy records. Understanding this disconnect is important, since mis-estimating the probability of decadal climate extremes has direct relevance for the building of new homes and infrastructure, the allocation of water resources and the long term sustainability of agriculture in Australia.

Here, I will present initial timeseries analyses of hydroclimate reconstructions from southern Australia, and compare the properties of different archives, proxy types and record lengths and their implications for hydroclimate risk assessment.

Poster presentations

Unlocking seasonal variations in climate and Indigenous seasonal foraging practices associated with paleo-ENSO in Great Barrier Reef using marine gastropod shells as a paleoclimate archive

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Using short-lived marine gastropod shells as a paleoclimate archive has been gaining momentum in recent decades by virtue of their application in reconstructing paleoclimatic and paleoenvironmental conditions at high-resolution and providing valuable information about human-environmental interactions. Considering that, this research will analyze the temporally successive oxygen isotope and trace elements from two short-lived marine gastropod species, *Rochia nilotica* and *Conomurex luhunaus* to find potential evidence of seasonal to sub-seasonal anomalies linked to the Mid-to-late Holocene ENSO (El Niño-Southern Oscillation) on the Lizard Island, Great Barrier Reef. In addition, considering that fossil shells collected from archeological sites, this research will also provide insight into the potential impacts of Paleo-ENSO on the pattern of shellfish foraging behavior of the Dingaal Aboriginal people on Lizard Island. The paired cultural-environmental records obtained from this study will provide us with baseline information about strategies used by the Dingaal Aboriginal people to have a long-term and sustainable marine resource under the climate variability of the Mid-to-Late Holocene. This may also further help us to understand and deal with the changes in productivity and availability of marine resources as a result of modern ENSO.

Spatiotemporal history of droughts and pluvials across eastern Australia's Natural Resource Management regions: 600-year perspective.

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Recent flood and drought extremes across Australia have raised questions about adequately quantifying their probability recurrence intervals. Because Australian hydroclimate is highly variable, short instrumental records are inadequate for understanding past extremes. Here, we use the 600-year spatial drought record for eastern Australia contained in the Australian and New Zealand Drought Atlas (ANZDA). We examine how recurrence intervals have changed across individual Natural Resource Management regions (NRMs) and identify how the information contained in the Atlas is also helpful for addressing questions around drought refugia. In general, the increased frequency of pluvial events in northeastern Australia has been unprecedented over the past 600 years. In contrast, the increasing frequency of drought conditions in the southeast does not appear exceptional in the 600-year context. We also highlight that, while some areas may appear to be refugia based on modern records, the longer-term record indicates that relying on these areas as refugia may be flawed. This has significant implications for risk assessments in resource and land management planning.

Examining sediment infill dynamics at Naracoorte Cave megafauna sites using multiple luminescence dating approaches

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The Naracoorte Cave Complex (NCC) represents Australia's richest Pleistocene megafaunal fossil locality, preserving extensive palaeontological records spanning the last 550 thousand years (ka). Little is known about the long-term sediment accumulation dynamics of NCC solution pipe cavities, and many of the megafauna-bearing infill deposits remain undated as they lie beyond radiocarbon and OSL age ranges. In this study, we assess the suitability of 'extended-range' luminescence dating signals (single-grain TT-OSL, multi-grain pIR-IRSL) for improving existing chronologies at six Late and Middle Pleistocene NCC sites. We additionally undertake multi-site examinations of NCC sediment infill dynamics using published chronological datasets.

Replicate luminescence dating comparisons performed on 22 sediment infill samples reveal consistent OSL, TT-OSL and pIR-IRSL ages over the last 300 ka, and broader agreement with independent and semi-independent age control (U–Th and ESR ages). Modern analogue samples collected above and beneath active solution pipe entrances confirm adequate OSL, TT-OSL and pIR-IRSL signal resetting down to low residual levels. Collectively, these results

demonstrate the potential usefulness of extended-range luminescence techniques for dating NCC deposits that exceed conventional OSL limits.

A detailed luminescence dating examination of solution pipe dynamics at Smoke Tortoise Cave (SMT) reveals a complex accumulation history focused on marine isotope stage (MIS) 9 and MIS 7 interglacial complexes, as well as the MIS 8e interstadial. The SMT case study highlights that NCC solution pipes are not simply associated with short-lived opening and sediment accumulation events, but may involve multiple, discontinuous deposition episodes and reactivation events.

An initial multi-site examination of published NCC infill chronologies (*n*=70) suggests preferential solution pipe development during relatively wet parts of interglacial or interstadial cycles. This non-uniform infill age distribution implies that NCC solution pipe dynamics may have exerted taphonomic biases on fossil accumulation, which should be taken into consideration when reconstructing long-term palaeoecological histories.

The potential of phytolith analysis in northern Australia

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Phytoliths, also known as plant biogenic silica, are rarely utilised for palaeoenvironmental reconstruction in Australian environments. This is despite their high potential to preserve in a wide range of environmental conditions, and their ability to discern grassland dynamics at a relatively fine scale. In order to effectively utilise this proxy in palaeoenvironmental research, we first need to develop systematic collections of phytoliths from modern vegetation and surface sediment samples – very few of which exist in Australia. This study will examine phytoliths from a range of tropical and arid grass species from the Northern Territory, and discuss how these results can be used for palaeoecological reconstruction in northern Australia.

Unveiling tsunami history on the Atacama Desert coast (northern Chile) using geological evidence and hybrid tsunami modelling

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An earthquake in 1420 CE triggered a large tsunami that affected lowlands in Japan and Hawaii. Some historical records suggested the tsunami came from northern Chile, but there is not enough information for establishing a source location and the earthquake magnitude of this event. Research off the coast of the Atacama Desert has revealed geological evidence for this event, such as a field of boulders weighing up to 40 tons on an 18.5 m cliff in Cisne Bay, and an angular unconformity and associated coarse-grained lenticular deposits in the shallow marine basin of Mejillones Bay which has been dated to AD 1409-1449. In this work, we reveal sandy layers bearing tsunami features from this and other events that have affected Arica and Tongoy in northern Chile, such as the 2015 and 1877 tsunamis. This sedimentary record allows us to a hybrid numerical modelling approach, using inverse and forward models, to estimate the source and magnitude of tsunamis by comparing them with field data. Using the grain size distribution, deposit thickness, and topography, we can estimate the flow velocity and wave amplitude along the flood using the inverse TSUFLIND model. Next, we use the forward model TELEMAC to compute the erosion, wave amplitude and speed of onshore flows according to different earthquake settings. By combining both models, we can estimate which is the most likely earthquake scenario that fits the field data. These hybrid methods have not been used to simulate and characterize tsunamis in the

area, so this research will demonstrate a novel way to improve tsunami hazard assessment in the Atacama Desert.

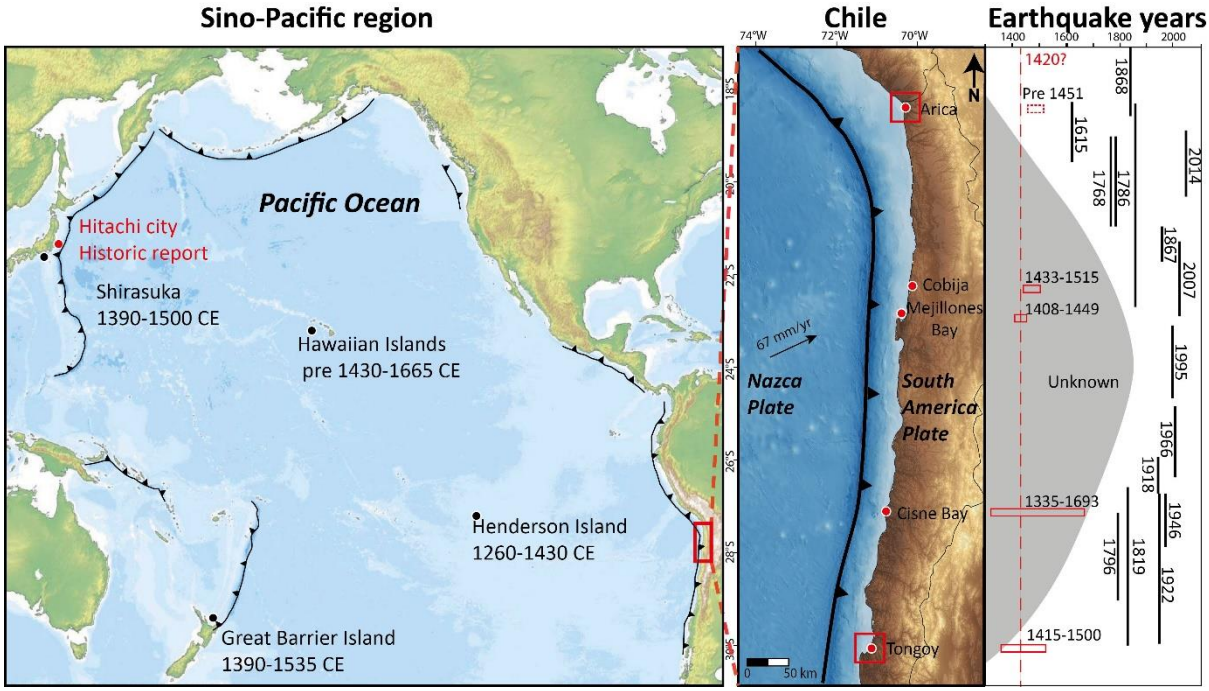

Figure 1. Tsunami deposits of the 1420 event in the Sino-Pacific region and Chile. Red squares indicate this project study area in Chile. The earthquake years graph shows historic events rupture length in northern Chile and red rectangles are radiocarbon dates.

Fossil pollen distributions in speleothems: an example from southwest Western Australia

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Pollen analysis is widely used to study past vegetation and climate change, yet we generally do not study pollen recovered from cave systems as it is widely assumed that they do not preserve pollen. Using novel processing techniques, we demonstrate that speleothem pollen records, which can be accurately dated with U-Th methods, can represent excellent floral and climatic archives. Moreover, we demonstrate that they can provide insight into the flora of regions, such as the Southwest Australian Floristic Region (SWAFR), where organic rich wetland deposits conventionally analysed for pollen are not available. The techniques developed include mapping the concentration of pollen grains and their taxa across and along growth axes within several stalagmites collected in caves in southwest Western Australia. We found that pollen grains and charcoal fragments were preferentially located on the side flanks of the stalagmites. This suggests that pollen grain and charcoal deposition on speleothems is influenced by transportation of detrital debris, including trace elements into cave chambers and the angle of the growth layers of stalagmites. Ultimately, the new records developed in this project have improved our understanding of speleothem palynology and taphonomy.

Putting a Name to a Face: assessing the utility of geometric morphometrics on classifying the fossil varanids of Naracoorte Caves World Heritage Area.

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[1] The University of Adelaide, [2] South Australian Museum.

Pleistocene fossil sites like Naracoorte Caves World Heritage Area offer unique insights into past biodiversity. The turnover of vertebrate species over time, both living and extinct, provides insights into past ecological responses to a changing climate, with implications for our understanding of the impact of present-day climate change. At Naracoorte, palaeoecological research has focused primarily on the mammalian fauna. However, a diverse range of herpetofaunal species are preserved in the cave deposits and, by virtue of their sensitivity to changes in temperature and precipitation, may provide detailed information on palaeoenvironmental change at Naracoorte.

Monitor lizards (Varanidae) are an ecologically important component of the Australian fauna and are abundant in the Naracoorte deposits, particularly the Middle Pleistocene Fossil Chamber in Victoria Fossil Cave. However, obstacles in reptile identification, due to their relatively low morphological variation, must be overcome to include them in palaeoecological research. Here we explore the use of geometric morphometrics to assess the taxonomic affinity of five varanid fossil specimens, represented by three dentaries and two parietals. The fossils were compared to modern species that are currently found in the area: *Varanus gouldii* (n= 12), *Varanus rosenbergi* (n= 9) and *Varanus varius* (n=12).

The specimens were CT scanned to obtain digital 3D models for analysis using three-dimensional geometric morphometrics. To represent the shape of each element, we placed 54 landmarks (12 fixed and 42 semi-landmarks) on homologous points of the parietals and 30 landmarks (7 fixed and 23 semi-landmarks) on the dentaries.

Dentaries and parietals belonging to *Varanus gouldii*, *Varanus rosenbergi* and *Varanus varius* could all be separated based on their morphology; fossil parietals and dentaries were confidently assigned to *Varanus varius*. The presence of *Varanus varius* just after the peak of the MIS 7 interglacial is consistent with the warm, wet conditions and forested environment preferred by this species.

Oxygen isotope ratios in plant phytoliths as a proxy for past climates and Environments

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Fossil silicate phytoliths – residual cellular structures from plants – are abundant in Australian sedimentary and archaeological deposits, presenting an opportunity to use the oxygen $^{18}O/^{16}O$ isotope ratios ($\delta^{18}O$) as a proxy for past climates and environments.

Previous studies have shown that precipitation oxygen isotope ratios, relative humidity, and temperature have major control on the oxygen isotope composition of phytoliths. It is hypothesised that relative humidity will have the strongest control on the oxygen isotope values of phytoliths sampled both in naturally growing plants and accumulated in topsoil since previous studies demonstrate its strong influence on leaf water isotopic composition, the source of biogenic silica bound oxygen.

Phytoliths were extracted from modern plant and topsoil samples which were collected across a large climate gradient across continental Australia. It was hypothesised that phytoliths from plants of different species growing at the same location should have similar $\delta^{18}O$ values and would show correlation with recent climate records. $\delta^{18}O$ of phytoliths from soils were expected to be similar to the plants at the same location, albeit with a better correlation to longer term climate, since phytoliths accumulate in soils over decades to centuries.

Measured $\delta^{18}O$ of phytoliths sampled from both modern plants and topsoil were correlated with local climate data and modelled $\delta^{18}O$ in leaf water and phytoliths. Preliminary results indicate that both temperature and the leaf water isotopic composition (controlled by relative humidity) influence the oxygen isotope values. Interestingly, there is a weaker correlation with $\delta^{18}O$ of phytoliths sampled directly from plants compared to $\delta^{18}O$ of soil

phytoliths. The oxygen isotope ratios of phytoliths from topsoil are not well correlated with annual average relative humidity but correlate well with relative humidity over the warmest months of the year (December-February). This is the first time that measured oxygen isotopes of plants and soils from the same sites have been compared to each other, providing a better understanding on how climate variability is recorded in plants and sediments.

Deciphering the role of terrigenous sediment supply for headwater channels in the Pilbara, WA

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Using a multi cosmogenic nuclide approach (^{10}Be and ^{26}Al) we investigate terrigenous sediment supply in catchments to provide much needed baseline denudation rates in the Pilbara region. Detailed analysis of catchment morphometric properties and lithology have been combined with cosmogenic nuclide measurements to improve our understanding of sediment pathways, residence times and storage in headwater catchments. Our results suggest that this region has some of the lowest erosion rates in the world, between 0.94-4.04 mMyr^{-1}, a range similar to previously measured channel bedrock rates in the region, but somewhat higher than results from outcrops on mesa summits previously measured using ^{53}Mn (0.8 ± 0.6 mMyr^{-1}). This apparent offset in erosion rates between horizontal bedrock surfaces and basin wide averages infers that the vast areas of iron-rich rock surfaces within the region are unlikely a major contributor of sediment to the system. Instead, vertical faces in the catchments have a role as a dominant sediment source and there is a complex erosional history of in-channel sediments within the headwater streams. Our results show ^{26}Al/^{10}Be ratios lower than the nominal production ratio, suggesting that the channel sediments are provided from either (or combination of) long-term, shallow buried regolith, or non-horizontal surfaces in the landscape (e.g., gorges and exposed cliffs). Erosion at the margins of the river channels is hence a key source of sediment supply and broadly the hillslope-headwater channel sediment conveyer is a minor contributor. Base-level stability and highly resistant nature of the prevailing lithology in the region results in these extremely low erosion rates in a high slope environment. Within these headwater catchments, sediment contributions are compounded by topographic inversion, increased albeit episodic fluvial activity and highly erosion resistant Banded Iron Formation. The study

demonstrates that a multi cosmogenic nuclide approach is useful, not only to evaluate denudation rates, but also to decipher the complex history of sediment production and transport.

Catchment vegetation and erosion controls soil carbon cycling in SE Australia during two Glacial-Interglacial complexes

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Soil Organic Carbon (SOC) represents up to 80% of the terrestrial carbon pool. However, it is highly debated if soil carbon is a net atmospheric carbon source or sink. This is mainly due to a paucity of information on the fate of SOC during soil erosion, which affects oxidation during the storage, transportation, and final deposition of SOC. The Southern Hemisphere may play a dominant role in the global SOC - atmosphere carbon cycle, since changing climates can cause the expansion or contraction of terrestrial biomass across vast continental areas, for example in temperate to semi-arid Australia.

Here, we investigate the interplay between catchment erosion (quantified by means of uranium isotopes), vegetation cover (pollen), the wetland response (diatoms), and lake carbon accumulation on glacial/interglacial time scales in south-eastern Australia. The analyses are applied to the sediments of Lake Couridjah (Thirlmere Lakes) SW of Sydney. The recovered lake sediments cover the time interval between ~135 ka and 107 ka, and

between ~17.6 ka and present day (Forbes et al., 2021). This offers an outstanding opportunity to study SOC cycling across different glacial/interglacial boundary conditions.

Partial Least-Square Regression (PLSR) analyses reveal robust phase-relationships between catchment erosion, vegetation density, and carbon and nitrogen cycling during both glacial-interglacial complexes. The data imply that the density of the catchment's sclerophyll mid- to understorey vegetation, and not the amount of rainfall, has the dominant effect over catchment erosion, and over SOC storage in the catchment. Wetter and warmer conditions promote the expansion of dense sclerophyll vegetation, reducing (increasing) catchment erosion while simultaneously increasing (decreasing) SOC storage as well as lake productivity and lake carbon storage. This would imply a positive relationship between warmer and wetter climates and atmospheric CO_2 sequestration in the Thirlmere catchment.

Forbes, M. et al., 2021. Comparing interglacials in eastern Australia: A multi-proxy investigation of a new sedimentary record. Quaternary Science Reviews, 252.

The assembly of plant microfossil assemblages: Characterizing pollen and phytoliths from plants and soils to improve palaeoecological interpretations

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Australian vegetation has transformed throughout geologic time with changes in woody cover and fire regime. To understand the drivers and consequences of vegetation transitions, new and integrated tools are needed that are calibrated in Australian ecosystems. Neogene phytolith assemblages have not yet been widely studied to reconstruct vegetation in Australia. This project will provide a modern phytolith reference collection and document how phytolith assemblages in soils and sediments relate to the plant communities that they are derived from. Plant and soils samples will be obtained from a wide array of bioregions from across Australia through the collections of the Terrestrial Ecosystems Research Network (TERN). Phytoliths, and pollen (where required) will be extracted from the dominant plants at each site by accessing plant tissue samples and herbarium sheets. Phytoliths, pollen, micro and macrocharcoal will be extracted from soils for each of the sites. Phytolith and pollen assemblages will be characterised through microscopy and micro- and macro-charcoal abundances will be analysed. Microfossil assemblages will be compared to plant survey data and ecoregions assignment, as well as compared to photography at each site documenting tree cover characteristics. The charcoal abundances will be compared to on fire regime characteristics. The relationships observed in modern soils will then be used to provide better reconstructions from the geologic past. Our initial observation of Pleistocene sediment core from Jumping grass (North Stradbroke Island) reveals the presence of pollen and phytolith from plants of subtropical affinity.

Development of the Great Barrier Reef from the Last Glacial Maximum to present

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The Great Barrier Reef (GBR) is located on the north-eastern continental margin of the Australian continent and is the largest tropical coral reef system in the world. Reefs are known to form on the continental shelf during interglacial sea level highstands and are exposed and die during glacial sea level lowstands. However, sonar and drilling studies have shown a series of backstepping fossilreefs migrated across the shelf edge during sea level transgression prior to the onset of the modern GBR at approximately 9 ka.

While cores drilled through reefs provide direct evidence of reef growth and composition at a fixed point, such cores are often temporally discontinuous. By contrast, distal marine sediment cores can provide a more continuous time series of the development of both reefs and sedimentary processes along the margin. This study focussed on the analysis of piston cores (FR4/92-11 and FR4/92-12) collected from the Queensland Trough. The cores were subsampled at regular intervals for elemental (XRF) and mineralogical (XRD) analyses, and planktic foraminifera (*Globigerinoides ruber*) for oxygen isotope measurements and radiocarbon dating.

A principal component analysis revealed four phases ('clusters') of development of the GBR margin from the Last Glacial Maximum to present. These represent 1) primarily hemipelagic carbonate sediments deposited during the glacial sea level lowstand, 2) mid-deglaciation sedimentation dominated by High Mg Calcite as sea level transgression and slope fossil-reefs initiated, 3) late deglaciation (11.8-8 ka) sedimentation dominated by a pronounced spike in terrigenous accumulation as sea level transgression reached the shelf break and 4) reef sedimentation dominated by Sr-rich aragonite in the early to late Holocene. Changes in

carbonate mineralogy likely reflect differences in the terrigenous sediment flux and reef assemblages (dominance of corals versus crustose coralline algae and microbialite) between the fossil-reefs and the modern reef system.

A Late Quaternary low-angle fan-delta complex, Lake George, NSW.

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The Lake George basin in NSW contains a near-continuous sedimentary record, to nearly 4 Ma, that is unparalleled in any other Australian terrestrial depositional system. Historical records show the lake has fluctuated from being entirely dry to having a maximum depth of ~7 metres since 1820. Older shorelines occur more than 30 m above the present lake floor, and at a depth of 37 m, water would spill through Gearys Gap into the headwaters of the Yass River.

The largest catchment in the basin, Butmaroo Creek, drains into the lake on the southeast side, forming a low-angle fan-delta complex. Sedimentary sections exposed along Butmaroo Creek and in the adjacent Bungendore Sands Quarry are useful in characterising Late Quaternary sediment deposition at the interface between fluvial and lacustrine environments. This depositional system includes point-bar deposition and beach deposits, with both occasionally draped in lacustrine sediment.

Outcrops were logged and described to characterise the stratigraphic architecture and construct a facies model. For chronologic control, optically stimulated luminescence and radiocarbon samples were collected.

Sections in the quarry and along the creek are more or less within the range of historical lake fluctuations, and well below the elevation of older, Holocene and Pleistocene shorelines – yet the sediments are overwhelmingly interpreted as fluvial. Where are the lacustrine sediments that were deposited during high lake stands?

Continual fluvial reworking, following a fall in lake level, is suggested as partly responsible for the lack of lacustrine sediments. A metre thick sequence of lacustrine sediment from early Marine Isotope Stage 3, between 50 and 60 ka, was, for example, reworked spectacularly into a mud-boulder conglomerate within the point-bar system. This quarry thus offers a unique glimpse into the rarely studied architecture of humid fan systems.

Late Quaternary river terrace development in subtropical Australia: climate change and human occupation

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Flights of river terraces along numerous catchments in eastern Australia preserve fluvial archives dating back to at least the Neogene. The causes of valley sedimentation and incision are often debated as representing climate change or the result of intrinsic controls within the river system. Ultimately, incison and aggradation depend upon the balance between sediment supply and stream power, which is directly influenced by catchment and riparian vegetation, soil type and weathering regime, and runoff characteristics. The complexity of the feedbacks, lags and controlling mechanisms make it difficult to ascribe a forcing mechanism to terrace development, especially in tropical and subtropical regions. Here we present results from a flight of terraces in the Brisbane River, a large catchment of ~13,000 km^2 which drains to Moreton Bay in southeast Queensland. Valley fill sediments were were augered to ~14 m. The chronology of incision and aggadation is based on 23 single-grain OSL samples across the terraces and the modern floodplain. These data suggest valley sedimentation beginning before MIS4, with incision events ~ 65 ka, ~10 ka, ~2.5 ka and 0.1 ka. The most recent phase of incision is associated with aggregate mining of sands and gravels from the floodplain and channel. The sedimentary history from the Brisbane Valley is explored in relation to regional indicators of vegetation, precipitation, temperature, and the human history of settlement and land use.

Validation of glacial-interglacial rainfall variations in southwest Sulawesi using Mg/Ca and $\delta^{18}O$ in speleothems

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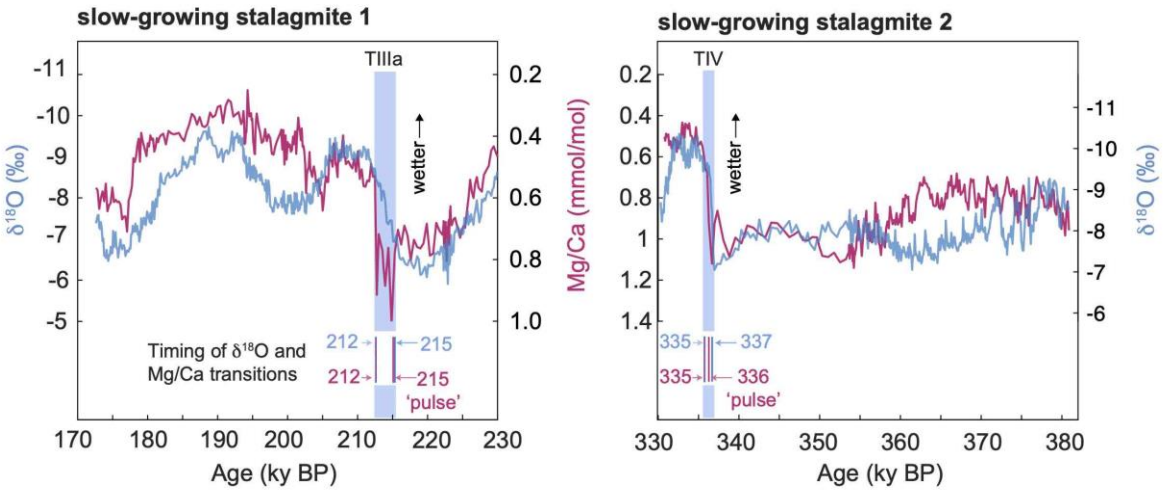
Speleothem $\delta^{18}O$ is widely used as a proxy for rainfall amount in the tropics on glacial-interglacial to interannual scales. However, uncertainties in the interpretation of this renowned proxy makes producing robust paleoclimate and environmental records difficult. For this reason, a multiple proxy approach in speleothem research is becoming increasingly valuable. Here, we present paired measurements of Mg/Ca and $\delta^{18}O$ for multiple stalagmites from Sulawesi, Indonesia. Collectively, the stalagmites span two glacial-interglacial transitions from 380 to 330 ky BP and 230 to 170 ky BP. The stalagmite Mg/Ca confirms that coupled measurements of $\delta^{18}O$ record major shifts in tropical rainfall in southwest Sulawesi over glacial-interglacial transitions.

We find that minor element ratios (Mg/Ca, Sr/Ca) deposited in the Sulawesi stalagmites are primarily sourced from bedrock and subsequently altered by prior calcite precipitation. In Sulawesi, Mg/Ca in slower-growing stalagmites is more sensitive to prior calcite precipitation, a reliable proxy for changes in karst infiltration and local rainfall. Mg/Ca systematically lags the corresponding $\delta^{18}O$ by 100s of years during glacial-interglacial

transitions, indicating a delay in karst recharge. When paired, the Mg/Ca and $\delta^{18}O$ corroborate the shifts from drier glacials to wetter interglacials in the core of the Australasian monsoon domain. Deviations between the two proxies may reveal concurrent changes in rainfall amount and moisture-transport pathways indicative of regional monsoon circulation.



Clumped isotope analysis of central Australian carbonates: A potential palaeoclimate proxy for Australia's arid interior

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Quantitative records of past temperature variability in arid environments are crucial for validating climate models and their ability to capture the full range of the Earth's climatic regions. However, arid zone temperature reconstructions are rare, particularly in the Southern Hemisphere, including Australia. The clumped isotope thermometer provides a novel approach to potentially address this demand by allowing the estimation of carbonate precipitation temperature independent of environmental water isotopic composition. Two types of carbonate materials offer potential for clumped isotope temperature reconstructions in arid central Australia: fossil mollusk shells deposited within the shoreline sediments of now dry lakes, and tufa deposits formed in mound springs fed by continuous discharge of Great Artesian Basin groundwater. Here we present preliminary clumped isotope analyses from tufa and shell samples from central Australia. We also discuss the use of micro-XRF scanning and XRD to evaluate sample suitability for both clumped isotope analysis and U-series dating.

Air temperatures inferred from tufa Δ_{47} measurements suggest mean annual air temperatures (MAAT) ~5°C cooler than present between 12-9 ka, which supports

palaeoclimate model based estimates for central Australia. Average air temperatures inferred from mollusk shells indicate MAAT at least 15°C cooler than present during 70-35 ka, suggesting a larger MAAT reduction than previously estimated. Carbonate $\delta^{18}O$ appears to have been largely driven by changes in environmental water $\delta^{18}O$ for lakes but not for mound springs, reflecting different hydrological controls on the two water sources. Agreement between temperatures and palaeoclimate models suggest clumped isotope analysis may function as a valuable quantitative palaeotemperature proxy in central Australia. Analysis of additional tufa and shell samples along with an investigation of the genesis of different tufa is ongoing.

Historic imagery reveals magnitude of glacier response to ice shelf debuttressing in the Larsen B Inlet, Antarctica

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The Antarctic Peninsula is one of the fastest warming regions on Earth. Since the 1950s, ~87% of its tidewater glaciers have retreated, many after ice shelf debuttressing. The dramatic collapse of the Larsen B ice shelf in 2002 has caused the thinning and acceleration of the former ice shelf tributaries. However, these glaciers were unmonitored prior to collapse which restricts assessments of the magnitude of recent thinning. Here, we calculate the total amount of ice drawdown since the collapse. To do this we determined the pre-collapse elevation of the glaciers and the adjoining ice shelf using archival aerial photography from 1968. We assume that the 1968 configuration is the same as before the collapse because this is the only complete set of photography available. Structure-from-motion photogrammetry was used to reconstruct a historic digital surface model (DSM), which was then differenced from a modern reference DSM ('Reference Elevation Model of Antarctica') to compare the surface elevation and volume of former Larsen B Ice Shelf tributaries ~34 years pre-collapse to ~15 years after their transition to tidewater glacier. Results indicate that the surface of the Crane glacier, the main tributary of the former Larsen B ice shelf, has lowered by ~56 m and by a maximum of ~180 m. Approximately 29 km^3 of glacier volume has been lost since 1968 which represents ~19% of its volume. Most of this mass was likely lost shortly after the ice shelf collapse in 2002. This study highlights the recent rapid contributions to sea level from glaciers that have been stable throughout the Holocene.

East Asian Monsoon response to abrupt global change during the last glacial period: evidence from the sediments of Lake Suigetsu, Japan.

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The East Asian Monsoon (EAM) impacts almost half of the world's population, however it's trajectory for the future remains largely unknown in light of current rapid climate change. This poster presentation will outline project plans and preliminary data with an aim to investigate the underlying mechanisms and long-term contributors to EAM variability. The project focuses on the sediments of Lake Suigetsu, Japan, and the episodes of abrupt global change leading into the last glacial maximum. Building on previous and ongoing research (see Francke et al., oral presentations), this study aims to analyse oxygen isotopes from both biogenic silica and siderite, as well as diatom microfossil species abundances, from Lake Suigetsu's precisely dated varved sediments to reconstruct climate and hydrological change from 50,000 – 20,000 years before present. The data will be interrogated in the context of regional climate reconstructions, as well as climate model simulations. By improving the understanding of long-term drivers of the EAM, this study will contribute to improved estimates of future change in the region.

The timing of Termination IX in Italian lake sediments: a test of orbital theory

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Termination IX (T-IX), occurring at the transition between Marine Isotope Stages 19 and 20, is one of two terminations of the last million years that lacks firm, radiometric age constraints. This is primarily due to the inherent difficulty of dating ocean sediments, which best preserve terminations. Here, we present a novel age constraint for T-IX using lake sediments from the Sulmona Basin, Central Italy. We test a recently published model of glacial terminations that implicates a persistent influence of Earth's tilt (obliquity) on their timing and duration. The lake record, comprising calcium carbonate content and stable isotope data ($\delta^{18}O$, $\delta^{13}C$), has been precisely anchored in radiometric time via tephrochronology, giving average age model uncertainties of around ±2 kyr. We synchronised this well-constrained lacustrine time series to a North Atlantic ocean record (Site U1385), which directly captures T-IX, allowing us to anchor the termination in radiometric time. We then assess the relative importance of obliquity, precession and various derived insolation metrics on the timing and duration of T-IX, and compare these results to those of 11 other terminations of the last million years. Our results evaluate the robustness of the obliquity model and contribute to the wider debate surrounding termination dynamics.

A new Holocene sea-level database for Australia

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The Holocene is the current interglacial period spanning the last 11,700 years, and is an important time interval that provides context for current and future environmental changes. Global mean sea level rose approximately 60 metres during this period, but this rise was not uniform in time or space. High-quality and standardized relative sea-level data, with sufficient temporal and geographical range, are required to assess local and regional drivers of sea-level change and vertical land movements over 100s and 1000s of years.

Previous studies have synthesized Holocene relative sea-level data from the coast of Australia (e.g., Haworth et al., 2002; Sloss et al., 2007; Lewis et al., 2013) and noted significant data gaps and shortcomings on some types of data. This presentation will address these limitations by constructing a new, internally-consistent database for Holocene relative sea-level data from the Australian coast using the standardized approach outlined by the international HOLSEA project. A new, open-access database will allow for the generation of sea-level histories at a local and regional scale across Australia. Using the new sea-level histories, spatio-temporal probabilistic models will be applied to assess local, regional, and global drivers of sea-level change. Assessing drivers of centennial and millennial change, as well as estimating the rate of change prior to the Industrial Era, will be valuable information for efforts to project future sea-level change, especially for locations without extensive tide gauge records.

Landslides and periglacial deposits in Northern New England provide evidence of past climate.

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Lying at altitudes of between 1275 m and 1100 m the Upper Gara Valley in the vicinity of Malpas Reservoir to the east of Guyra is a key landscape for interpreting past climate in the New England Tablelands of northern New South Wales. Near Malpas Reservoir numerous landslides of differing characteristics and periglacial landforms in the form of blockfields, block streams and scree occur. This poster presents an overview of the landforms in the valley focusing on two important sites: (1) the Guyra landslide and block streams that hint of pre-last glacial cycle mass movement and arguably last glacial nivation features; and (2) the Malpas block stream, a key site providing evidence of periglacial processes extending from late MIS 3 to the deglacial period. At Malpas some of the periglacial landforms display evidence of flow structures, sorting and patterned ground formation indicative of past seasonally frozen ground. The block streams have been dated by SED methods to the last glacial cycle.

Environmental and Climate Controls on Late Quaternary Landscape Evolution along the Central Murray River, Australia

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The Murray Darling Basin (MDB) is Australia's largest water catchment, covering approximately 1.07 million km^2 of the south-eastern Australian interior. Situated downstream of the Murray-Darling confluence, the Central Murray Valley (CMV) region acts as a 'funnel' receiving discharge from both the more temperate Murray River catchments and the sub-tropical catchments of the Darling River. The CMV also preserves a wealth of sedimentary settings including paleochannels, floodplains, oxbow lakes, dunes and lunettes that allow for the reconstruction of multi-regional scale paleoenvironment and hydrogeologic activity over the Quaternary. Initial dating indicates that lunette accretion in the CMV (and at sites further east) clustered at 50–45 ka, 26–21 ka and 17–14 ka. This timing is correlated with phases of enhanced fluvial activity during early MIS 3 and in MIS 2. These periods are likely associated with synoptic climatic systems shifts including mid-latitude westerlies and Australia's summer monsoon that influence the MDB. Active paleo-fluvial phases stand in contrast with the incised and relatively inactive river in the present day and again point to enhanced precipitation in the headwaters of the MDB likely associated with increased intensity of the westerly winds. To further investigate the climate forcing behind such landscape evolutions, sedimentological, geomorphological and geochemical methods as well as optically stimulated luminescence (OSL) dating techniques will be applied in this research to evaluate how changing climate conditions have influenced the riverine landscape along the CMV. The results of this research are expected to provide an integrated understanding of river dynamics in the MDB over the late Quaternary.

A 1000-year isotope-based record of climate variability inferred from the sediments of Lake Yukidori, East Antarctica

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Anthropogenic contributors to global warming are extensively altering climate and ice melt patterns in the polar regions. The Antarctic ice sheet is responsible for aspects of global climate regulation. It is vital to construct a comprehensive model of historical climate fluctuations and their consequences in the region, to effectively predict future scenarios under the current climate regime. To supplement detailed ice core records, Antarctic coastal lake sediments are a valuable paleoclimate and hydrological proxy, providing alternative indicators of environmental and climatic changes in ice-free areas. Here, we analysed a sediment core from Lake Yukidori on the Langhovde Peninsula of East Antarctica. The Yukidori sediments consist of organic rich sediments, mostly derived from aquatic mosses which grow on the lake floor. The lake itself is freely drained and freshwater, receiving water from snowmelt in a relatively small, mountainous catchment. Bulk sediment carbon and nitrogen concentration and carbon, nitrogen and oxygen stable isotope ratios were used to infer changes in lake primary productivity and the oxygen isotope composition of precipitation over the last 1000 years. The $^{18}O/^{16}O$ data exhibit marked centennial-scale variability and no marked change in the recent, post-industrial period. $^{15}N/^{14}N$ data, by contrast, suggest a notable increase in lake primary productivity in the last century, possibly a result of an increase in the seasonal ice-free period. Further work is needed to improve the chronology of the recent sediments at Lake Yukidori, and to validate these proxies in this remote environment.

Bite at the end of the tunnel: a quantitative literature review of the taphonomic effects of marsupial carnivores from Pleistocene Australia

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Marsupial carnivores played an important role in the accumulation and modification of large animal bones in Australia during the Pleistocene. Carnivores are known to influence bone representation and species composition in fossil assemblages, leading to biases. The recognition of these biases is critical for sound palaeoecological reconstruction from vertebrate fossil assemblages. Despite over a century of research into the taphonomic effects of Australian marsupial carnivores, to date, no comprehensive literature review has been published that synthesises this research. To help solve this issue, we undertook a quantitative, systematic literature review of research into the taphonomic effects of four Australian marsupial carnivores commonly identified as accumulators or modifiers of Pleistocene-aged large animal fossils: *Sarcophilus* spp. *Dasyurus* spp., *Thylacinus cynocephalus* and *Thylacoleo carnifex.* The primary aims of this review were to collate and summarise the existing literature and analyse temporal publication trends; analyse the distribution and environment of study sites; and analyse data on certain taphonomic features, such as tooth marks. Our review included journal articles, book chapters, conference proceedings and theses. The results of the review showed that carnivore-accumulated and carnivore–modified fossil sites are concentrated in the southern part of Australia, often around karst areas and volcanic caves. The majority of these fossil deposits are within relatively shallow caves and rock shelters with large accessible entrances. Tooth marks were the most commonly described feature of carnivore-accumulated and carnivore-modified fossil deposits and *Sarcophilus* spp. was the most commonly identified agent of accumulation or

modification. In addition to identifying important trends in the literature, our review also highlighted several knowledge gaps and areas in need of additional research.