JOURNAL OF QUATERNARY SCIENCE (2006) 21(7) 679–680

Published online in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/jqs.1072

Introduction: Integrating high-resolution past climate records for future prediction in the Australasian region

CHRIS S. M. TURNEY,[1]* A. PETER KERSHAW[2] and AMANDA LYNCH[2]
[1] GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, New South Wales, Australia
[2] School of Geography and Environmental Science, Monash University, Victoria, Australia

Turney, C. S. M., Kershaw, A. P. and Lynch, A. 2006. Introduction: Integrating high-resolution past climate records for future prediction in the Australasian region. *J. Quaternary Sci.*, **Vol. 21** pp. 679–680. ISSN 0267–8179.

Received 24 July 2006; Revised 26 July 2006; Accepted 26 July 2006

Recognising the challenge of human-induced climate change, the World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to assess our understanding of the scientific basis of risk of anthropogenic climate change and opportunities for adaptation and mitigation. Unfortunately, relatively widespread instrumental measurements only extend back to the mid-19th century. As a result, it has not yet proved possible to develop season-specific histories for different climate variables at a regional scale to unambiguously find a 'fingerprint' of climate response to increasing greenhouse gas emissions (Jones *et al.*, 2001). An alternative approach has been to focus efforts on large-scale changes in the average climate.

There exists a wealth of indicators of past climate that show rapid changes have taken place. Annually resolved climate proxies, such as tree-rings, corals, annually laminated lake sediments and historical climate datasets, have formed major contributors to such studies; typically, past surface temperatures have been inferred by calibrating to instrumental temperature data using statistical relationships. The best known is the so-called 'hockey stick' temperature reconstruction for the Northern Hemisphere (Mann *et al.*, 1998, 1999); the resulting curve sloped gently downward for most of the past millennium (the handle of the hockey stick), then rose sharply into the 20th century (the blade) until it topped the relative warmth of 800 to 1000 years ago. This reconstruction featured prominently in the 2001 IPCC report.

Although some criticism has been levelled at the reconstruction, the results have recently been supported by a National Research Council panel of the US National Academy of Sciences, but it was noted that more must be done to reduce uncertainties in the early part of the curve (Brumfiel, 2006) and in the Southern Hemisphere (Kerr, 2006). Some attempts have been made by the international scientific community to address the concerns highlighted by the US National Academy of Sciences. For instance, the dependence on annually and decadally resolved datasets has not always captured variability on the multi-centennial timescale. By combining low- and high-resolution proxies (which capture long- and short-term change respectively) and using a wavelet transform technique, Moberg *et al*. (2005) demonstrated larger multi-centennial variability than recognised in the hockey stick curve.

The Australasian region straddles several major atmospheric and oceanic boundaries (many of which are interconnected) that have the potential to be highly sensitive under a variety of future climate change scenarios (these include the Australian Monsoon, the Interdecadal Pacific Oscillation, El Niño–Southern Oscillation (ENSO), and the East Australian Current). Importantly, where the few comparisons have been made from proxy-generated climate reconstructions between the hemispheres, differences in the timing of the trends have been noted (Jones *et al.*, 2001; Mann and Jones, 2003): the Southern Hemisphere average shows greater recent warming than earlier in the twentieth century, with no evidence of the Little Ice Age (AD 1350 to 1880) or AD 1945 to 1975 cooling periods. The extent to which these differences are real is uncertain owing to the relative paucity of datasets used (three were combined for the Southern Hemisphere, of which only one came from Australasia; Mann and Jones, 2003).

Although research effort has largely concentrated on the past two millennia, considerable potential exists for extending reconstructions further into the past, providing a longer-term perspective of natural change. The need is an urgent one. Only by robustly reconstructing regional, hemispheric and global climatic change can we understand the natural level of variability, disentangle the differing roles of atmospheric and oceanic controls on climate, and allow investigations into the responses of past human populations, thereby providing a tool to guide interpretation of future scenarios.

On 27 and 28 June 2005, over 100 climatologists (palaeo and contemporary) attended 'Reconstructing past climates for future prediction: integrating high-resolution palaeo data for meaningful prediction in the Australasian region' at the Australian Academy of Sciences in Canberra. This workshop was principally funded by the Australian Greenhouse Office but was also supported by the Australian Academy of Sciences, the Australian Research Council 'Earth System Science' and 'Environmental Futures' Networks, Climate Variability and Predictability (CLIVAR), the GeoQuEST Research Centre, the International Union for Quaternary Research (INQUA) and Past Global Changes (PAGES). Further details (including a meeting

* Correspondence to: Chris S. M. Turney, GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia. E-mail: turney@uow.edu.au

report) can be obtained from the workshop website (http://www.uow.edu.au/conferences/canberra/).

The papers presented at the workshop demonstrated that there was a wealth of data from the Australasian region that might be used to address major gaps in reconstructing the past two millennia and beyond. A selection of the presentations from the meeting are reported here.

A major focus of research has been on the possibilities for temporally extending historical records of climate change. **Nicholls *et al.*** show what advances have been made in developing comprehensive instrumental climate datasets that are representative of the Australian region. In some locations, meteorological records extend back to AD 1840 but inconsistencies in techniques of observation in the early years means that comprehensive historical data (comparable to present-day observations) are only available from about the start of the 20th century. Bypassing this problem, **Cook *et al.*** report the annually resolved record of temperature preserved in the Huon pine from Mount Read in western Tasmania which spans the last 3602 years and compare this dataset to the millennia-long records of silver pine and kauri from New Zealand. **Pollack *et al.*** present a fascinating overview of the extensive borehole temperature reconstructions undertaken across Australia that provide a record of the last 500 years, and which demonstrate an increase in temperature of approximately 0.5°C over this period but with a cooling/slowdown in warming during the period of the Little Ice Age. **Gergis *et al.*** complement these studies by describing how an exciting multiproxy approach can be used to reconstruct past El Niño–Southern Oscillation activity.

In trying to reconstruct the past beyond precisely dated records linked to present day, **Cook and van der Kaars** describe the development of transfer functions derived from modern pollen climate relationships in northern and southeastern Australia that can be used to generate quantified climate reconstructions from fossil pollen records. A variety of longer records from ice, marine and terrestrial sequences are also presented. **Williams *et al.*** provide an important reconstruction of environmental change from eastern New South Wales spanning the past 75 000 years. **Turney *et al.*** summarise multiproxy analysed ice, marine and terrestrial sequences from across Australia over the period 30–8 ka, encompassing the Last Glacial Maximum and the transition into the Holocene; they demonstrate that significant differences exist across the region and to those recorded in the North Atlantic. **Moy *et al.*** report deep-water circulation for the past 160 ka over the South Tasman Rise and suggest that the Southern Ocean deep-water masses closely tracked those of the deep equatorial Pacific for this period. **Palmer *et al.*** describe the considerable potential of ancient kauri in New Zealand for high-resolution palaeoclimatic reconstruction and radiocarbon calibration for the past 60 000 years.

To help understand the mechanisms of past climate change, **Marshall and Lynch** report the first analyses of the Australian summer monsoon using the Fast Ocean Atmosphere Model. The results demonstrate that regional circulations, such as monsoon, are subject to interacting influences from interhemispheric and local forcing which vary in importance over time. This work illustrates the value of having a broad regional perspective to ascribe driving mechanisms at different times.

The extent to which climate has changed in the historic and prehistoric past provides a critical baseline against which to compare present and future warming. Although considerable progress has been made in developing a robust quantified reconstruction of temperature change for the Northern Hemisphere over the past two millennia, one for the Australasian region (and the Southern Hemisphere as a whole) requires considerably more work. The results presented in this special issue provide an important foundation on which future studies of anthropogenic climate change can build with confidence.

References

Brumfiel G. 2006. Academy affirms hockey-stick graph. *Nature* **441**: 1032–1033.

Cook EJ, van der Kaars , S. 2006. Development and testing of transfer functions for generating quantitative climatic estimates from Australian pollen data. *Journal of Quaternary Science* **21**: 723–733.

Cook ER, Buckley BM, Palmer JG, Fenwick P, Peterson MJ, Boswijk G, Fowler A. 2006. Millennia-long tree-ring records from Tasmania and New Zealand: a basis for modelling climate variability and forcing, past, present and future. *Journal of Quaternary Science* **21**: 689–699.

Gergis J, Braganza K, Fowler A, Mooney S, Risbey J. 2006. Reconstructing El Niño–Southern Oscillation (ENSO) from high-resolution palaeoarchives. *Journal of Quaternary Science* **21**: 707–722.

Jones PD, Osborn TJ, Briffa KR. 2001. The evolution of climate over the last millennium. *Science* **292**: 662–667.

Kerr RA. 2006. Yes, it's been getting warmer in here since the CO_2 began to rise. *Science* **312**: 1854.

Mann ME, Jones PD. 2003. Global surface temperatures over the past two millennia. *Geophysical Research Letters* **30**: DOI: 10.1029/2003GL017814.

Mann ME, Bradley RS, Hughes MK. 1998. Global-scale temperature patterns and climate forcing over the past six centuries. *Nature* **392**: 779–787.

Mann ME, Bradley RS, Hughes MK. 1999. Northern Hemisphere temperatures during the past millennium: inferences, uncertainties and limitations. *Geophysical Research Letters* **26**: 759–762.

Marshall AG, Lynch AH. 2006. Time-slice analysis of the Australian summer monsoon during the late Quaternary using the Fast Ocean Atmosphere Model. *Journal of Quaternary Science* **21**: 789–801.

Moberg A, Sonechkin DM, Holmgren K, Datsenko NM, Karlén W. 2005. Highly variable Northern Hemisphere temperatures reconstructed from low- and high-resolution proxy data. *Nature* **433**: 613–617.

Moy AD, Howard WR, Gagan MK. 2006. Late Quaternary palaeoceanography of the Circumpolar Deep Water from the South Tasman Rise. *Journal of Quaternary Science* **21**: 763–777.

Nicholls N, Collins D, Trewin B, Hope P. 2006. Historical instrumental climate data for Australia: quality and utility for palaeoclimatic studies. *Journal of Quaternary Science* **21**: 681–688.

Palmer JP, Lorrey A, Turney CSM, Hogg A, Baillie M, Fifield K, Ogden J. 2006. Extension of New Zealand kauri (*Agathis australis*) tree-ring chronologies into Oxygen Isotope Stage (OIS) 3. *Journal of Quaternary Science* **21**: 779–787.

Pollack HN, Shaopeng H, Smerdon JE. 2006. Five centuries of climate change in Australia: the view from underground. *Journal of Quaternary Science* **21**: 701–706.

Turney CSM, Haberle S, Fink D, Kershaw AP, Barbetti M, Barrows TT, Black , M, Cohen TJ, Corrège T, Hesse PP, Hua Q, Johnston R, Morgan V, Moss P, Nanson G, van Ommen T, Rule S, Williams NJ, Zhao J-X, D'Costa D, Feng Y-X, Gagan M, Mooney S, Xia Q. 2006. Integration of ice-core, marine and terrestrial records for the Australian Last Glacial Maximum and Termination: a contribution from the OZ INTIMATE group. *Journal of Quaternary Science* **21**: 751–761.

Williams NJ, Harle KJ, Gale SJ, Heijnis H. 2006. The vegetation history of the last glacial–interglacial cycle in eastern New South Wales, Australia. *Journal of Quaternary Science* **21**: 735–750.