Australian Government
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Australian Greenhouse Office

REPORT FOR 'RECONSTRUCTING PAST CLIMATES FOR FUTURE PREDICTION: INTEGRATING HIGH-RESOLUTION PALAEO DATA FOR MEANINGFUL PREDICTION IN THE AUSTRALASIAN REGION'

Australian Academy of Science

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Dr Chris Turney
GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Wollongong (turney@uow.edu.au)

Professor John Chappell
Research School of Earth Sciences, ANU, Canberra
Professor Peter Kershaw
School of Geography and Environmental Science, Monash University, Melbourne
Professor Amanda Lynch
School of Geography and Environmental Science, Monash University, Melbourne
Dr Mike Manton
Bureau of Meteorology Research Centre, Melbourne
Dr Neville Nicholls
Bureau of Meteorology Research Centre, Melbourne
Dr Tas van Ommen
Australian Antarctic Division and Antarctic Climate and Ecosystems CRC, Hobart
Professor Andy Pitman
Department of Physical Geography, Macquarie University, Sydney

ABSTRACT: A two-day workshop was held at the Australian Academy of Sciences to discuss how reconstructions of past climate change might be better applied to modelling future potential climate change. Recommendations included: (1) Construction of a record of temperature and precipitation changes for the last 500-2000 years over the Australian region; (2) Improved reconstruction by the development of quantified climate proxies; (3) Develop a national capacity for high-precision dating; (4) Develop a national capacity for palaeoclimate modelling; (5) Develop a land use and vegetation database for Australia for key time periods; and (6) Create a meta-database of palaeo data hosted in a permanent repository.

1. INTRODUCTION

There exists a wealth of indicators of past climate that show rapid changes have taken place. Such indicators could be used to understand the range of past, present and future climate variability. Nowhere is this more relevant than in the Australasian region that 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 (e.g. El Niño-Southern Oscillation, Interdecadal Pacific Oscillation, Australian Monsoon, East Australian Current, the Leeuwin Current and the mid-latitude westerlies).

The 2-day workshop bought together over 100 climatologists (palaeo and contemporary) and modellers working on a variety of different palaeoclimatic and historical datasets to discuss their results within the context of past and future change in the region. The workshop allowed the presentation of the latest different palaeoclimatic datasets and methods of analysis of relevance to the Australia and New Zealand region (from the ice, marine and terrestrial realms) and placed the results in a global context. The workshop also provided an opportunity for the scientific community to discuss ways in which this data can be used more effectively to help us understand climate mechanisms for predicting future climate change and its variability on the millennial, centennial, decadal and annual timescales.

2. AIM AND OBJECTIVES OF WORKSHOP

The aim of the workshop was to provide a forum for climatologists and modellers to focus on new ideas, observations, analyses and theories of climate change to highlight ways of improving the understanding and prediction of future climate change and variability in the Australasian region. There were three objectives of the meeting:

1. Comprehensive review of palaeoclimatic and historical datasets for the Australasian region including the quality of the observational data, site replication, spatial distribution of sites, chronologies and temporal resolution, calibration, qualitative vs. quantitative definition and extreme events
2. Role of modelling in integrating the palaeo and historical data to identify climatic mechanisms driving change across the Australasian region

3. Incorporation of climatic and modelling datasets to develop a record of climatic change in the Australasian region

3. OVERVIEW OF THE MEETING

Approximately a quarter of the scheduled two days comprised oral presentations of records from across the southwest Pacific region and further afield (a copy of the meeting programme and abstracts is provided on the workshop website at http://www.uow.edu.au/conferences/canberra/). The remaining time consisted of poster and discussion/working group sessions.

After an initial welcome and outline of the aims of the meeting by **Chris Turney** (University of Wollongong), **Kate Harle** (CSIRO) gave a comprehensive overview of the palaeo work that has been undertaken in the Australian region and its importance in understanding future climate change.

Following the above introduction, the workshop was divided into three periods of talks and two working groups, interspersed by extensive poster and discussion sessions. The first period of talks was centred around climate modelling in the Australasian region, and these were given by **Bryant McAvaney** (BMRC), **Matt Fischer** (ANSTO) and **Amanda Lynch** (Monash University). These talks outlined the important role that the modelling community could play in understanding the mechanisms of past climate change in the region and globally. **Alan Cooper** (University of Adelaide) then gave a fascinating overview of the role ancient DNA can play in understanding the environmental impacts of climatic change and disentangling the role humans and climate may have played in major phases of biological extinction.

In the afternoon of the first day, there were presentations on the possibilities for extending the historical records of climate change further back in time. **Neville Nicholls** (BMRC) showed what advances have been made in developing comprehensive climate datasets that are representative of the Australian region, but inconsistencies in observing techniques in the early years means that comprehensive historical data, comparable to present-day observations, are only available from about the start of the twentieth century. This was followed by **Ed Cook** (Lamont-Doherty Earth Observatory) who reported the extensive annually-resolved records of temperature preserved in the Huon pine from Mount Read in western Tasmania which spans the last 3,600-years and compared this dataset to the highly promising last 1000-year record of Silver pine from the west coast of South Island, New Zealand. **Joelle Gergis** (University of New South Wales) then complemented this by describing how an exciting multiproxy approach had been used to reconstruct past El Niño-Southern Oscillation activity for the past 3,722-years, using annually-resolved New Zealand kauri, and demonstrated several periods of weakened activity in the past (such as the 17^{th} and 18^{th} centuries). The final talk of this session was by **Henry Pollack** (University of Michigan) who presented a fascinating overview of the extensive borehole temperature reconstructions undertaken in Australia that provide a record of the last 500 years, and which demonstrates an increase of approximately 0.5˚C over this period. He compared this record with evidence from the Northern Hemisphere that showed a cooling/slowdown in warming during the period of the Little Ice Age.

There was an extensive range of important posters relevant to the above sessions. These included a demonstration of the considerable potential of ancient kauri in New Zealand for palaeoclimatic reconstruction and radiocarbon calibration (**Jonathan Palmer**, Canterbury), modelling of tree ring growth to reconstruct palaeoclimate from tree rings (**John Chappell**, ANU) and ultra-high resolution reconstruction of precipitation in southwest Australia using speleothems (**Pauline Treble**, ANU). The discussion session led by **Mike Manton** (BMRC) during the afternoon of the first day focussed on the role modelling might play in helping to understand mechanisms of past climate change and addressing misunderstandings the palaeo community had of the capabilities of models.

On the morning of the second day, after a brief overview of the climate programmes operated under the auspices of PAGES and INQUA by **Peter Kershaw** (University of Monash) and **Simon Haberle** (ANU), talks focussed on palaeodata from the terrestrial, marine and ice realms. **Chris Turney** (University of Wollongong) presented a transect of multi-proxy analysed sequences across the southwest Pacific that spanned the Holocene and compared these to records from the North Atlantic region. **Mike Gagan** (ANU) followed this by describing the exciting results being developed from the high-resolution coral data in the Pacific and Indian oceans. **Ron Thresher** (CSIRO) provided a fascinating contrast by demonstrating the considerable potential offered by deep-sea corals in the Tasman Sea. The end of the session was concluded by the latest exciting results from the NorthGRIP (Greenland), EPICA (Antarctica) (**J.P. Steffensen**, University of Copenhagen) and Law Dome (Antarctica) (**Tas van Ommen**, Australian Antarctic Division) ice cores. These results illustrated the critical importance of ice core records for understanding long-term climate change within the Australasian region. The NorthGRIP ice core record is annually resolved to 123,000-years ago providing an unprecedented opportunity for ultra-high precision correlations (and importation of this chronology) to the Antarctic records using ice gas content. This is crucial as the Law Dome results clearly illustrate the possibilities for Australasian climate reconstruction. For instance, this ice core record provides a seasonally-resolved record for the past 1000 years that have allowed comparisons and extension of the historical Australian meteorological datasets over this time.

There was a large number of high-quality posters relevant to the above session, including using pollen to quantify climate change (**Ellen Cook** and **Sander van der Kaars**, Monash University), Antarctic ice core gas content changes over the past 2000 years (**David Etheridge**, CSIRO), interannual changes in the Antarctic Annular Oscillation and its importance for reconstructing Australian winter rainfall (**Ian Goodwin**, University of Newcastle), the integration of Last Termination ice, marine and terrestrial (INTIMATE) records in Australia (**Simon Haberle**), decoupling human and climate controls on environmental change (**Peter Kershaw**), geochemical fingerprinting of dust from a 25,000-year Queensland record to reconstruct synoptic changes in atmospheric circulation over the longer-term (**Lynda Petherick** and **Hamish McGowan**, University of Queensland), environmental changes in the tropical Australasian region using speleothems (**Kira Westaway**, University of Wollongong) and reconstruction of environmental change in eastern New South Wales over the past 35,000-years (**Nikki Williams**, University of Sydney).

A discussion session chaired by **John Chappell** was then held on the palaeo talks and posters. Discussion included the possibilities for determining the changes in marine reservoir ages in the southwest Pacific (particularly where there are no visible tephras), the development of precisely-dated terrestrial records using comprehensive radiocarbon dated sequences that reconstruct the internationally-accepted calibration curve, the importance of developing quantified climatic parameters that could be used to test hypotheses of climate change and the importance of precipitation compared to temperature within an Australian context (particularly for the agricultural sector).

The afternoon of the second day commenced with a working group session led by **Neville Nicholls** who outlined a proposal for developing an annually-resolved Australian region average reconstruction of temperature and precipitation for the past 2000 years (focussing on the last 500 years in the first instance). Participants were invited to submit data to develop these records with the intention to publishing a high-profile multi-authored paper for comparison to the Northern Hemisphere curves reported by Mann *et al.* (1999, *GRL*, **26**, 759-762) and Moberg *et al*. (2005, *Nature*, **433**, 613-617). Data is to be sent to **Chris Turney** who will collate the datasets prior to analysis by **Neville Nicholls** in the first half of 2006.

It is intended that a selection of the papers will be incorporated into a Special Issue of the *Journal of Quaternary Science*.

4. WORKSHOP RECOMMENDATIONS

This workshop has shown that palaeoclimate studies have a clear role in understanding Australian regional climate, and in so doing, developing improved capacity for managing future climate change issues, in line with National Research Priorities. It is also apparent that realization of the potential advances in this regard is limited by several factors that should be addressed. These factors can be grouped in two categories.

1. Palaeodata exploitation, including dissemination of data and meta-data, understanding of proxy signal interpretation (calibration) and national capacities in modelling and laboratory analysis.
2. Palaeodata availability, including limited geographic coverage (especially relative to the Northern Hemisphere), limited temporal coverage (more records are needed with longer time-spans, finer time-resolutions and better cross-dated chronologies) and limited process sensitivity (e.g. precipitation sensitivity)

To address these, the workshop recommends several points of action, which arose from a discussion and recommendation session led by **Amanda Lynch**:

1. Construct high-resolution multi-proxy records from existing data for temperature and precipitation across the Australian region over the last 500-2000 years based

on existing data (consistent with PAGES and CLIVAR goals). Use this as the basis for a published study with immediate potential application to Australian climate policy, but also to clarify current limitations in data and hence improve rationale for new data collection.

2. Improve reconstructions by better quantification of proxy indicators through calibration with instrumental data and models and better description of transfer functions that capture climate signals in the various proxies.
3. Create a meta-database of palaeodata in Australia hosted in a permanent repository (e.g. ANSTO). Pre-existing datasets to build on include a database of papers published through Geoscience Australia, a sites database (this has not been updated since the late-1990's) and an Indo-Pacific pollen database (600 sites, not online). It is further recommended that palaeoclimate data should be submitted to the World Data Centre for Paleoclimatology for access by the global scientific community.
4. Develop a national capacity for palaeodata analysis. Key analysis capacities required include access to radiometric dating facilities, and ice-core gas extraction in order to meet chronological needs (see recommendation 2, above).
5. Develop a national capacity for palaeoclimate modelling. The modelling approach would identify key pilot projects to address specific science questions (e.g. spatial signatures of abrupt climate changes in the tropics, southwest Australian rainfall variability).
6. Develop and maintain a land use and vegetation database for Australia. At key timeslices, full model forcing datasets should be developed.
7. Increase knowledge of Australian carbon cycle, utilising climate modelling with chemical processes (e.g. CO_2, CH_4 and aerosols) to better understand mechanisms and constrain climate models.
8. Encourage and develop existing and new field studies for collecting palaeodata. Particular needs include longer time-spans, records with high resolution that can be calibrated against instrumental data, and proxies that respond to Australasian regional climate, from Antarctica to the tropics. Projects include further work in identifying seasonally-resolved speleothems, exploration of indicators that have not been exploited (e.g. beetles, midges), as well as established studies using corals, ice cores, tree-rings and sediment-cores.
9. Develop better chronologies for the establishment of high-precision correlation between records (especially the well-dated Northern Hemisphere records) on all timescales from sub-annual to orbital. This work requires comprehensive ^{14}C, ice core gas synchronization, volcanic/stratigraphic markers and other dating of sequences. This would aim toward improved integration of ice, terrestrial and marine records beyond the past two millennia on an absolute timescale to represent the full range of earth-ocean-atmospheric conditions (e.g. the Last Glacial Maximum, deglacial transition period and early Holocene).
10. Encourage multi-disciplinary collaboration and participation in international programs in order to raise the national and international profile of Australian palaeoscience.