

AUS2K Meeting

Australasia's past climate variability

STRENGTHS DRAWN FROM PALAEOCLIMATE AND MODEL DATA OVER THE LAST 2000 YEARS. AN OPEN WORKSHOP INCORPORATING THE PAGES AUS2K WORKING GROUP AND AUSTRALIAN CLIMATE CHANGE SCIENCE PROGRAM (ACCSP) PALAEOCLIMATE DATA–CLIMATE MODEL COMPARISON PROJECT VARIABILITY OF AUSTRALIAN CLIMATE OVER THE LAST 1000 YEARS IN COUPLED MODEL SIMULATIONS AND PROXY DATA

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The aim of the 3rd Aus2k workshop was to review progress made by the Aus2k community to date, and to develop specific plans to contribute Australasian science towards Phase 2 of the PAGES 2k Network. Around 40 palaeoclimatologists, meteorologists, hydrologists, and oceanographers attended the workshop, resulting in a very constructive and stimulating cross-disciplinary meeting.

The Aus2k working group took the opportunity to hold the workshop jointly with the Australian Climate Change Science Program (ACCSP), with participants presenting results of a palaeoclimate data–climate model comparison project *Variability of Australian climate over the last 1000 years in coupled model simulations and proxy data*. The intention was to engage the wider meteorological community with expertise in climate data–model comparison and diagnostic analyses, with the ultimate goal of understanding the mechanisms driving Australasian climate variability over the last 2000 years.

The specific goals of the 3rd Aus2k workshop are listed below in plain text. Sub-projects around each aim were agreed upon and coordinators are listed in italics.

1. Expand the Aus2k database to incorporate low-resolution material for the development of a common dataset for Australasian climate reconstructions;
Database to be frozen December 31 2014. Contacts: Bronwyn Dixon, Jonathan Tyler and Ben Henley
2. Develop guidelines for the future collection of climate proxy records based on spatial and temporal gaps in the Australasian palaeoclimate record;
Nerilie Abram and Russell Drysdale will lead the testing of the number and location of records required to reconstruct specific features of Australian climate and to deal with potential biases caused by non-stationarities.
3. Discuss existing multivariate data synthesis techniques being used by Aus2k and the global community, with a post-meeting goal of running a comparison exercise using different reconstruction methods;
An inter-comparison project with Australian and New Zealand data will be coordinated by Ben Henley, Mandy Freund and Andrew Lorrey.
4. Assess the feasibility of developing Australasian climate field reconstructions (temperature, precipitation, and geopotential height) to contribute towards the global PAGES 2k Network;
To be led by Joelle Gergis, Andrew Lorrey and Steven Phipps, and;
5. Foster linkages between the palaeoclimate and climate modeling communities, with the aim of closing the loop between proxy development, data synthesis and climate modeling.
Modelling contacts: Steven Phipps and Duncan Ackerley; Modern climate: Pandora Hope

Day 1 showcased recent research developments in regional data synthesis; opportunities for the future collection of new palaeoclimate records from the region; the reconstruction of climate drivers such as El Niño–Southern Oscillation (ENSO) and the Southern Annular Mode (SAM); and climate modelling being undertaken by the *Palaeoclimate Modelling Intercomparison Project* (PMIP), the Centre for Australian Weather and Climate Research (CAWCR) and university groups.

Co-manager of the ACCSP, Robert Colman, opened the workshop highlighting the importance of palaeoclimate data in understanding natural climate variability. He noted the untapped potential of using long-term palaeoclimate data, which extends centuries before instrumental weather observations become available in 1900, to evaluate regional climate model simulations and constrain the latest generation of Australian climate change projections.

During session 1, Joelle Gergis provided an overview of results achieved using the consolidated high-resolution dataset during Phase 1 of the PAGES 2k Network and outlined the global goals of Phase 2 (e.g. Neukom and Gergis, 2012). Jonathan Tyler presented progress and challenges for consolidating Australian multi-decadal sedimentary records and their importance for understanding past hydroclimate variability in the region.

Helen McGregor shared insights from consolidating low-resolution marine records as part of the Ocean2k working group. She emphasized the need to establish sensible selection criteria for the inclusion of records in regional synthesis efforts, the need to consider spatial biases present in the dataset and the value of withholding independent (in that case terrestrial) data for verification of the sea surface temperature reconstruction results.

In session 2, Karl Braganza reviewed the main climate drivers influencing Australian climate: the El Niño–Southern Oscillation, Indian Ocean Dipole and the Southern Annular Mode, calling for caution when representing coupled dynamical circulation features using simple climate indices. Pandora Hope then presented results of the ACCSP project *Variability of Australian climate over the last 1000 years in coupled model simulations and proxy data*, focusing on ENSO and its interactions with Australian climate. She showed that the ENSO–Eastern Australian teleconnection pattern is reasonably well captured by the model simulations, and noted fluctuations in the dominance of biennial and decadal variability of ENSO over the past millennium.

Nerilie Abram presented a recently published SAM reconstruction–climate model comparison study (Abram *et al.* 2014) using data consolidated by the LOTRED and Antartica2k working groups, as well as a new ice core

record from the Antarctic Peninsula. She noted that mean state of the SAM is now in its most positive phase for at least the last 1000 years.

Ailie Gallant's presentation on the issue of non-stationarity of climate teleconnection patterns (Gallant *et al.* 2013) generated much discussion, highlighting the need for critical thinking around estimating uncertainty associated with palaeoclimate reconstructions. She emphasized the need to develop spatially explicit climate reconstructions to allow for the evaluation of mean state changes and their expression in regional teleconnection patterns during the pre-instrumental period.

Session 3 was dedicated to discussing the role of climate modeling of the last 2000 years. Sandy Harrison highlighted recent progress with model evaluation of mid-Holocene and Last Glacial Maximum data, noting that the magnitude of future rainfall projections may be underestimated by up to 50% (Harrison *et al.* 2013). She noted that no model is good for all variables, but some are better or worse across a suite of evaluation metrics, and that multi-model ensembles incorporating different forcing are needed to account for forcing uncertainty over the last millennium.

Steven Phipps covered the key roles that climate models can play in studying the climate of the last 2000 years, including studying the roles of forced and unforced climate variability and testing dynamical hypotheses (Phipps *et al.* 2013). He also highlighted some of the current limitations, particularly uncertainties in our knowledge of past climate forcings. Sophie Lewis then spoke about the potential of using long-term palaeoclimate records for climate change and attribution studies. Tony Hirst gave the final talk of the session, highlighting the capabilities of the ACCESS (Australian Community Climate and Earth System Simulator) model and its potential use for palaeoclimate studies. He noted that ACCESS1.4 can run at 10 years per day on 384 cores suggesting that a last millennium run is feasible in under four months.

The rest of day 1 was spent discussing potential opportunities for collaboration between the Australasian palaeoclimate, climate modelling and meteorology communities. A range of projects, including testing the assumption of teleconnection stationarity, palaeoclimate runs with CAWCR's ACCESS model and pseudo-proxy model exercises to test the fidelity of palaeoclimate reconstructions, were discussed and collaborative contacts were made.

Day 2 of the workshop focused on the themes of i) Developing the database of Australasian low-resolution records: data consolidation and directions for future data

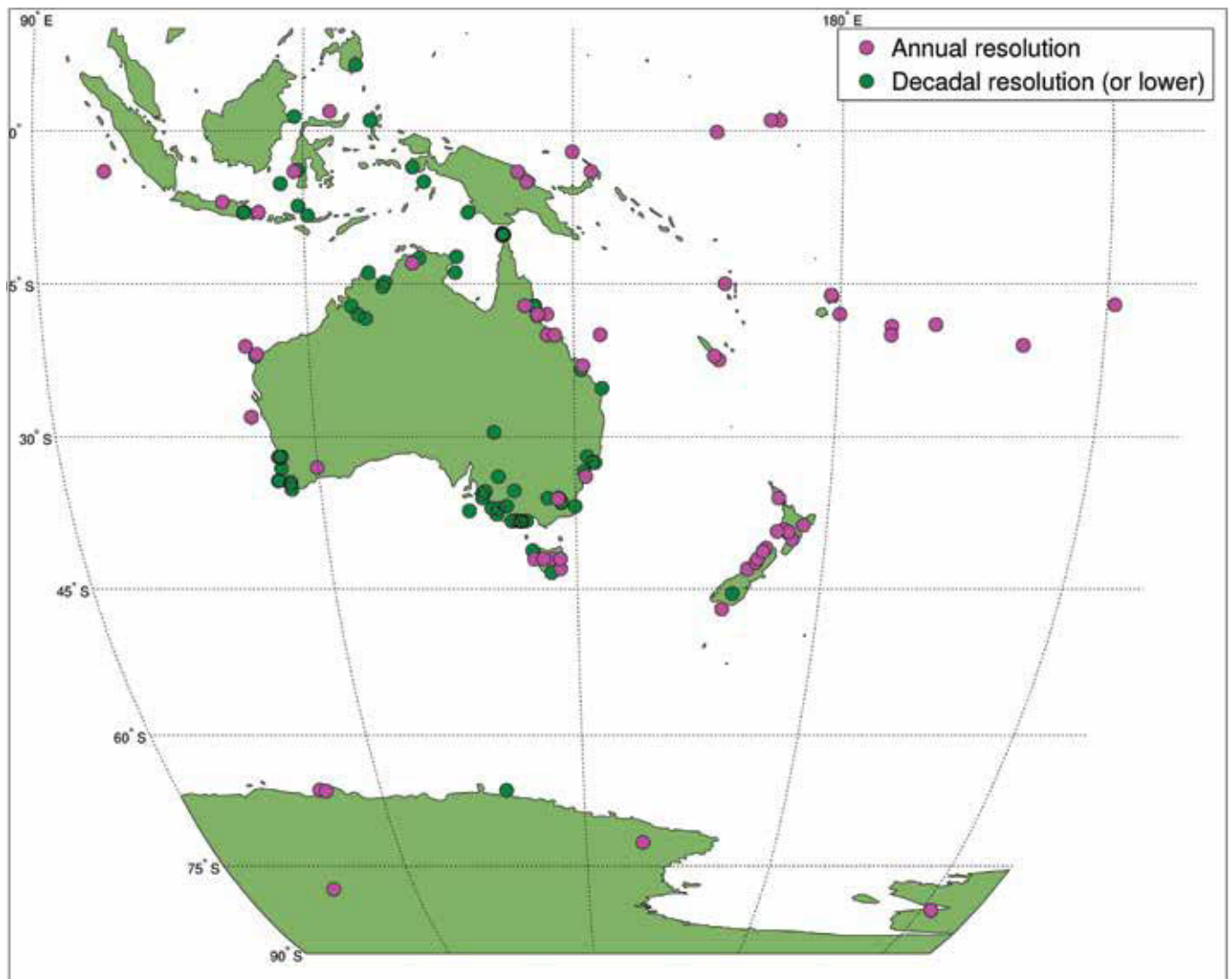


Figure 1: Locations of annually resolved and lower resolution palaeoclimate archives in the Australasian region.

collection; ii) Multi-archive data synthesis techniques being used by Aus2k and the PAGES 2k Network and iii) Climate field reconstructions and climate modeling.

In session 1, Jonathan Tyler outlined recent progress in systematically screening records using PAGES guidelines and recalibrating age models for a range of ‘high quality’ sedimentary records from Australia and Indonesia. A plan to incorporate material from New Zealand was discussed with Andrew Lorrey to consolidate the Australasian region’s ‘low resolution’ database for Phase 2 activities. It was agreed that the dataset would be frozen on 31 December 2014 to allow for consistency in subsequent climate analyses undertaken by the group.

Finally, Tas van Ommen shared his experience of working in the Antarctica 2k working group and IPICS initiatives, highlighting the utility of using spectral analysis to classify records for high or low frequency climate analysis.

Plans to develop guidelines for future data collection in Australasia were also discussed, including ideas around testing the number and location of records required to reconstruct specific features of the Australasian climate and to deal with potential biases caused by non-stationarities. The white papers produced by the PAGES Trieste meeting were also discussed (<http://www.ncdc.noaa.gov/paleo/reports/trieste2008/trieste2008final.pdf>). Nerilie Abram and Russell Drysdale agreed to take the lead on developing this initiative.

Session 2 focused on multi-archive data synthesis techniques being used by Aus2k and the global PAGES 2k Network. Andrew Lorrey demonstrated a synoptic type and geopotential height reconstruction technique based on modern analogs using the Past Interpretation of Climate Tool (PICT) (<http://content.niwa.co.nz/pict>, e.g. Lorrey *et al.* 2013). Ben Henley then provided

a summary of the material presented at the recent PAGES 2k Advances in Climate Field Reconstructions (CFRs) workshop held in Woods Hole in April 2014, and an Inter-decadal Pacific Oscillation (IPO) reconstruction that is currently under development.

The issue of incorporating records with higher time uncertainty into CFRs was discussed, and it was agreed that reconstructions based on this material should form an independent way to verify low frequency trends and variability identified from the more chronologically precise high-resolution material (Figure 1 shows the current spatial distribution of these two datasets). The group agreed to perform a comparison of all methods being used by the group on the regional Australasian dataset. A plan to undertake an inter-comparison project with Australian and New Zealand data was proposed and will be coordinated by Ben Henley and Andrew Lorrey.

Session 3 was dedicated to the discussion of climate field reconstructions and climate modelling. Joelle Gergis discussed proxy selection considerations and recent progress in developing a temperature CFR for Australia within the Phase 2 timeframe. This was followed by a presentation by Steven Phipps who considered how climate modelling can contribute towards efforts to develop CFRs for the Australasian region. He stressed that the models can be used to test the assumptions underlying palaeoclimate reconstruction techniques. He also presented results of a proof-of-concept data assimilation analysis using proxies from the Aus2k, LOTRED and Antarctica2k temperature reconstructions, highlighting the potential role of palaeoclimate data assimilation in developing and assessing CFRs. He also allowed a few participants to experience the issues that modellers can face due to natural variability and biases in their climate model (in this case, a cup of ten dice).

The workshop wrapped up with the development of sub-groups based around the five objectives of the workshop, and a clear direction forward that will help deliver Australasia's best available science for the Phase 2 of the global PAGES 2k Network. The next Aus2k workshop will be held in Auckland, New Zealand in the austral spring of 2015.

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