

## Using paleo-climate model/data comparisons to constrain future projections

Workshop proposed by the PAGES/CLIVAR Intersection Panel

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### Context

For the first time in climate modeling history, there is a substantial component of coordinated paleo-climate modeling being performed with the same models and with the same protocols as the projections of future climate change. We have heard for many years the claim that understanding paleo-climate is the key to understanding future potential changes, and indeed, much work has already been done (via PMIP 1 and 2, and many individual studies). However, there has been a lack of quantitative analysis that truly links the future simulations or forecasts with skill or sensitivity in the paleo-climate simulations, most often because paleo-simulations were not done with the same models currently being used for future projections and through a lack of suitable paleo-climate skill metrics.

As part of the CMIP5 protocol and archive, the paleo-component (PMIP3) consists of simulations for the Last Glacial Maximum (LGM), the Mid-Holocene (MH – 6000 yrs BP) and the Last Millennium (LM, specifically 850 AD-1850 AD) (Taylor et al, 2011). For this database, these simulations will be true 'out-of-sample' tests in that there will not have been enough time to 'tune' any of these models to produce better paleo simulations. (Note that this is not necessarily unwise, but it would complicate some of the potential analyses).

Many of issues highlighted in the IPCC AR4 report (such as sub-tropical rainfall changes, ENSO, the N. Atlantic meridional circulation, the fate of Arctic sea ice, etc.) can potentially be illuminated by targeted analyses of the paleo-climate simulations since many of these subsystems have changed in the past and left decipherable proxy records (Schmidt, 2010). Unfortunately, the majority of skill metrics taken from the historical (20<sup>th</sup> Century) simulations are not constraining the future projections (i.e. models that are either good or bad at simulating some aspect of modern climate – the climatology, seasonal cycle, or interannual variability – give essentially the same spread of future projections) (Santer et al, 2010; Knutti et al). Paleo-climate offers a substantially larger signal than climate changes in the 20<sup>th</sup> Century (albeit with substantial noise and difficulties in interpretation) and so is unique in potentially being able to constrain future change.

The problems in dealing with paleo-climate data are well-known but progress is being made. Issues related to proxy interpretation are being helped by the development of forward models for proxies, and by the using of multi-proxy approaches and new techniques of Bayesian inference. The increase in scope of coherent databases of paleo-climate information (including uncertainties) is helping push model-data comparisons away from metrics based on single proxies or merely qualitative comparisons towards global, multi-proxy quantitative comparisons.

The next IPCC report (AR5) is due in 2014 and 'in press' deadlines for papers to be assessed is July 31, 2013. Many of the studies that will be assessed for AR5 will use the initial contributions to the CMIP5 archive (though the archive itself will continue to grow until 2015). Thus the early part of 2012 is a key time period for thinking about and producing key work that will feature in the AR5 and set the agenda for similar studies and programs in the future.

## Workshop Aims

Given that the co-location of the paleo-simulations and future projections is a novelty in CMIP5, the successful use of this kind of information does not have much of a track record. Thus a workshop whose aims are to a) ensure that the community is aware of how suitable techniques should be assessed right from the start, b) highlight the rich range of possible analyses, and c) produce timely and informative summaries of the state of these analyses, is both welcome and necessary.

We envisage a directed and productive workshop that will be charged with assessing what has been done so far, where are the missing gaps, and what can be done better in the future. We want to highlight the unique aspects of the paleo-climate simulations for evaluating the models in time for further analyses to be done in time for AR5 (although this kind of approach is not solely tied to the IPCC process or questions deemed interesting by those authors).

We will aim to produce a number of products. Some of these will be concrete – such as a 'best practice' review paper by participants to help guide the wider community in these kinds of analyses, but also some less tangible products – such as fostering a greater appreciation from the CLIVAR/WGCM/WCRP communities of the benefits of considering paleo-climate data and models, and encouraging a greater discipline in the paleo-climate community when it comes to making the links to future changes, the importance of synthesis of paleo data and a better appreciation for what questions can be usefully posed to, and answered by, the modellers.

In order to start the workshop off on a productive note we will be asking participants to have looked at some key fields/diagnostics ahead of time. In particular, various aspects of the regional hydrological changes in the paleo-climate simulations and in the future projects will be processed ahead of time and made available for participants. These metrics will involve rainfall, lake levels, soil moisture, forward models for water isotopes etc. for which there is plentiful evidence (and gridded datasets) of change during the periods covered by the paleo simulations (i.e. LGM, Mid-Holocene and Last Millennium). Dealing with these diagnostics and comparison with available paleo-data will serve as a template for any proposed approaches and techniques. Key issues will be getting as wide a spread of models as possible, ensuring that the forcings for each model are appropriately characterised, making clear demonstrations that any chosen skill metric does actually correlate to differences in projections, and the establishment of 'perfect model' test protocols (i.e. does any technique for creating an improved projection actually work if one assumes that one of the models is 'truth'). Each of these issues were highlighted in the 'Good Practice Guide' arising from last year's IPCC Expert Meeting (Knutti et al., 2010).

By creating a standard in one particular case, we will hope to maintain these standards in studies that workshop participants will be doing individually, and that might get done elsewhere.

## References

- Knutti, R., et al. 2010: [Good Practice Guidance Paper on Assessing and Combining Multi Model Climate Projections](#). In: Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Assessing and Combining Multi Model Climate Projections [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, and P.M. Midgley (eds.)]. IPCC Working Group I Technical Support Unit, University of Bern, Bern, Switzerland.
- Santer et al. 2009: Incorporating model quality information in climate change detection and attribution studies. *Proc. Natl. Acad. Sci. USA*, 106, 14778-14783.
- Schmidt, G.A. 2010: [Enhancing the relevance of palaeoclimate model/data comparisons for assessments of future climate change](#). *J. Quaternary Sci.*, **25**, 79-87, doi:10.1002/jqs.1314.
- Taylor, K.E. et al. 2009: ["A Summary of the CMIP5 Experiment Design"](#)

## Location and Timing

We have selected the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> of March 2012 in Honolulu, Hawaii in order to benefit from people already traveling to the WGCM/CMIP conference that is taking place on the 5<sup>th</sup> - 9<sup>th</sup> March (organiser Jerry Meehl and the WGCM committee). Their agenda is focused on the general analysis of the CMIP5 simulations, which, on past form (CMEP conference Mar 2005) will be heavily weighted towards analyses of the 20<sup>th</sup> Century (historical) simulations and the RCPs. By having our workshop immediately prior with some overlap in participants we hope to raise the profile of the paleo-simulations within the wider community, and hopefully inspire further analysis by scientists who might not have considered the paleo-simulations as useful source material before-hand.



We have reserved rooms at the Bernice Pauahi Bishop Museum in Honolulu that includes space for break out sessions and facilities for caterers. The main hall of the Hale Wa'a (the house of the canoe) is pictured above.

## Budget

Assuming ~40 attendees, 3 days of workshops, 4 night stay, a group meal.

Participant travel: 40 x \$800 (this will be shared due to co-funding for attendance at the WGCM workshop, and indirect agency support): \$32 K (of which we will hope to fund over 50%).

Local hotels: 40 attendees x 4 nights x \$120 = \$19 K

Facilities (Bishop Museum): 3 days workshop venue \$3.7K

Catering (2 coffee/biscuit breaks per day, lunch): \$2K

Group Meal: 40 x \$60 = \$2.4 K

Total: \$43 K – \$57 K (depending on how much travel support can be provided).

## Funding

Application has been made for support from PAGES and CLIVAR workshop funds (\$10 K each), and initial support has been offered from NOAA (\$25K). We are seeking further funds specifically to support student/young researcher participation and participation from federal agency scientists. Requests are being made to NSF, DOE, and NASA in the US and potentially other funders elsewhere.

## Draft Agenda and Proposed Speakers/Discussants\*

### Thursday 1<sup>st</sup> March 2012:

Morning Session: *Discussion of general issues*

- The nature of the multi-member ensemble
- Role of out-of-sample evaluation of climate models
- Statistical framework – inference, inverse/forward models, initial condition/structural uncertainty
- Paleo-climate simulations in PMIP3/CMIP5
- Data syntheses

*Discussants: Gavin Schmidt, Martin Tingley, Wendy Parker, James Annan, Mike Mann, Hugues Goosse, Sandy Harrison, Pat Bartlein.*

Afternoon Session: *Hydrological climate test case*

- Regional rainfall
- ENSO variability and changes in mean state

*Discussants: Ben Cook, Richard Seager, Jo Brown, Micheal Gagan, Julien Emile-Geay, Kim Cobb*

### Friday 2<sup>nd</sup> March:

Morning Session: *Other AR4 uncertainties*

- Sea level rise/ice sheet sensitivity

*Discussants: Jonathan Overpeck, Betty Otto-Bleisner, Mark Sidall, Anders Carlson, Peter Clarke, Stefan Rahmstorf/Martin Vermeer, Dan Lunt, Ayako Abe Ouchi,*

- Meridional overturning circulation/sea ice

*Discussants: Anne de Vernal, Allegra LeGrande, Ane Wiersma, Axel Timmermann, Fidel Gonzalez-Ruoco, Guillaume Massé, Camille Li*

Afternoon Session: *AR4 uncertainties (cont.)*

- Climate sensitivity, lessons from volcanic/solar perturbations, polar amplification

*Discussants: Reto Knutti, Andreas Schmittner, Thomas Schnieder von Deimling, Peter Gleckler, Pascal Yiou, Julia Hargreaves*

- Biogeochemical feedbacks (carbon cycle, methane, dust, aerosols, ozone etc.)

*Discussants: Eric Wolff, Natalie Mahowald, Sandy Harrison, Carlo Barbante, Laurent Bopp, Nathaëlle Bouttes*

- Extreme events (i.e. paleo-tempestology, historical climate)

*Discussants: Jonathan Woodruff, Jeff Donnelly, Juerg Luterbacher*

Workshop dinner

### Saturday 3<sup>rd</sup> March:

Morning session: *Breakout groups*

- Breakout groups on progress so far and needed work

*Break out group leaders and respondents: TBD*

Afternoon session: *Drafting*

- Reports from breakout groups
- Drafting discussion of “best practice” white paper/hydrological climate example

End of meeting

\* Note names are yet to be confirmed although expressions of interest have been obtained from many (not yet all).