### WGOMD evolving to CLIVAR Ocean Model Development Panel (OMDP)

The CLIVAR Scientific Steering Group (SSG) decided to instate the CLIVAR Ocean Model Development Panel (OMDP) at its 20th Session in July 2014, in accordance with the evolution of the overall direction of CLIVAR. OMDP will serve an advisory role in support of the CLIVAR ocean basin panels, in the development of the ocean observing system, and for the CLIVAR Research Foci. OMDP is a CLIVAR global modelling group and will continue in the role of providing leadership in the wider WCRP context on issues related to modelling the ocean as a component of the climate system, in partnership with the WCRP Working Group on Seasonal to Interannual Prediction (WGSIP) and Working Group on Coupled Modelling (WGCM) global modelling groups, under the coordination of the WCRP Modelling Advisory Council (WMAC).

The following areas have been discussed as future OMDP activities, beyond new activities as part of the CLIVAR Research Foci:

- CORE-III systematic Greenland ice melt experiment, forced by a realistic ice melt distribution
- AMOC MIP around Greenland in coupled models, comparing AMOC estimates with coupled climate model response
- Salinity restoring approaches
- High resolution CORE, development of high resolution CORE forcing dataset suitable for high resolution models, e.g., ERA-sat product (<T511 over satellite period, available in 2015)
- Climate response function CORE-type experiments
- CORE experiments with different wind products
- Partial coupling and other new forcing approaches for ocean only models
- Southern Ocean wind MIP, AABW cell intercomparison
- Exploring the feasibility and use of very high resolution 'truth' idealized experiments against which to compare models, parameterizations
- Community collaboration, CPT approach in parameterisation development tests, CVMix extension
- Coordinated activities that target systematic biases

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# The International CLIVAR Climate of the 20th Century Plus (C20C+) Project: Report of the Sixth Workshop


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### Introduction

The International CLIVAR Climate of the 20th Century Project (C20C; Folland et al., 2002) held its Sixth Workshop on 5-8 November 2013 at the University of Melbourne, Australia. C20C brings together climate modelling and data analysis groups to study climate variations and changes over periods up to the last 150 years using observational data and general circulation models (GCMs). There is an emphasis on atmospheric GCMs (AGCMs) forced with observed values of atmospheric composition (concentrations of greenhouse gases, aerosols, etc.) and surface conditions (SST, sea ice, land surface vegetation, etc.) as well as on natural variations alone. As agreed at the fifth Workshop in Beijing in 2010 (Kinter and Folland, 2011), the new C20C core project involves research in collaboration with the International Detection and Attribution Group and the international Attribution of Climate-related Events activity into the influence of anthropogenic forcing on climatic events, particularly extreme climate events. This is partly to support new research on quasi-operational attribution. The goal of the Sixth Workshop was to review early progress in the new core activity, observational data sets that will support C20C activities, and other key C20C projects. As in previous C20C meetings, the forcing data sets being used in a new set of coordinated model experiments, including the

new Hadley Centre's SST and sea-ice analysis (HadISST2), were discussed including rapidly evolving arrangements for sharing the new experiments.

The 35 workshop participants from 18 institutions were welcomed by Prof. Janet Hergt, Dean of the Melbourne University Faculty of Science. A representative of the WCRP Working Group on Coupled Modelling, Dr Claudia Tebaldi, also attended. The Workshop enjoyed excellent hospitality from the University of Melbourne and the ARC Centre of Excellence for Climate System Science as well as the opportunity for a flutter on the prime local horse racing event of the year, the Melbourne Cup! The workshop web site (http://www.iges.org/c20c/dome.html) includes downloadable copies of most presentations and posters, and more detailed discussions of Workshop outcomes. A key decision was to rename the project C20C+ partly because of the new focus on research on operational attribution and because increasingly 21st century climate change is a crucial component of understanding variability and trend mechanisms. The projects and their progress are now described briefly.

### The C20C+ Detection and Attribution Project

The aims are to characterise historical trends and variability in characteristics of damaging weather and short-term climate events as well as to determine the contribution of anthropogenic emissions to contemporary occurrence of these events. A key focus is on underlying uncertainties in these estimates. This will involve at least a dozen modelling groups around the world running atmospheric models in a semi-coordinated study of weather risk attribution. The experimental design can be summarised briefly as:

**All-Hist**: Simulations run under observed variations in radiative forcing and surface boundary conditions.

**Nat-Hist**: Simulations run under variations that might have occurred in radiative forcing and surface boundary conditions had anthropogenic emissions never interfered with the climate system.

In addition, it is planned that some coupled global models, regional models and selected impacts models will be used. Observations and models will also supply key climate indices. Output from the main simulations is being published on the Earth System Grid Federation (ESGF, http://esg.nersc.gov) under the project name "c20c". The data will also be used by other C20C+ projects. An important component of future experiments will be use of HadISST2 as the surface boundary condition to force the AGCMs.

### HadISST

The Hadley Centre has developed an improved analysis of global SST and sea ice concentration so as to include more observations and attain greater accuracy and resolution. Titchner and Rayner (2014) describes the sea ice component. Key improvements of HadISST2 over HadISST1 are multiple (100) realizations (though only a small subset is likely to be used by C20C+), better resolution in time, new bias corrections to SST right up to the present, inclusion of AATSR satellite data and a considerably improved sea ice extent data set. Talks on the complex process used to create the SST and sea ice components of HadISST were presented at the Workshop.


Participants in the 6th Workshop of the International CLIVAR Climate of the 20th Century Plus (C20C+) Project

### Other Observational data sets

For the first time a C20C workshop highlighted key types of observational data sets of particular use to sub-projects other than HadISST2. The data sets included precipitation, reanalyses and a new extremes data set. The simulation of precipitation trends and events is a core C20C+ sub-project while the use of reanalyses to study changes in jet streams has already been important in atmospheric circulation studies. On the global scale there is much disagreement between precipitation data sets since 1979, and similarly there was much disagreement on the Indian Monsoon. Somewhat by contrast, six out of eight reanalysis data sets gave reasonably robust climatological characteristics of the main jet streams in the two hemispheres though, as might be expected, the 20th Century Reanalysis misses the existence of the near equatorial stratospheric jet associated with the QBO. HadISD is a new global sub daily data set underdevelopment that will be very useful for studying variations and trends studying daily and sub-daily extremes including storms (Dunn et al, 2012).

### Weather Noise and performance of AGCMs Core Project

A key question for C2OC+ is the extent to which AGCMs forced with observed SST and sea ice extents give reliable results when compared to their coupled model counterparts. This is also related to the problem of the relative contribution of SST forcing and weather noise to atmospheric variance. It is hypothesised that the information contained in detailed observational data sets like reanalyses can be best understood by identifying and comparing the weather noise and forced responses. The work has also been motivated by previously published results showing that AGCMs and CGCMs have different teleconnections. New results presented (e.g. Chen and Schneider, 2014) show that AGCMs can indeed be used to gain sights into teleconnections and SST forced responses as these are (almost) the same in the AGCMs and partner CGCMs. Some previous published results to the contrary appear to be strongly affected by model biases. However an exception is quantitative estimates of tropical precipitation where AGCMs clearly over-estimate responses to SST compared to CGCMs. The statistics of weather noise however appear to be similar in AGCMs and their coupled partners.

### Precipitation variability and trends Core Project

This topic attracted a considerable number of presentations on observed and modelled trends and variations in precipitation and their forcing factors including the PDO. Included was progress in understanding the mechanisms of the spatial structure of Indian monsoon rainfall using the very high resolution (16km) ATHENA model forced with observed SST. For this workshop, relationships between ENSO and Australian rainfall were of considerable interest, particularly after the recent (2011-12) exceptionally wet period. One study concluded that ENSO remains dominant over anthropogenic effects for attributing such events. Results were shown from a very large ensemble of HadAM3P simulations obtained via the weather@home citizen science

project. An interesting result is that HadAM3P can reproduce the asymmetric relationship between rainfall and ENSO over south east Australia in austral summer.

### Atmospheric and Oceanic Variability and Atmospheric Predictability

A variety of talks were given including tropical cyclone trends and the reductions in South Australian rainfall in the last few decades which is also seen in many CMIP5 models under enhanced greenhouse gases. A complex mathematical method, developed partly under the auspices of C20C over the last decade, which distinguishes forced and internal atmospheric modes (Grainger et al. 2011) was presented to study the veracity of atmospheric circulation modes CMIP3 and CMIP5 coupled model simulations. CMIP5 models were shown to be an improvement. Among a number of other atmospheric studies, a presentation on the expansion of the tropics concluded that the modelled rate of tropical expansion in CMIP5 models is towards the low end of the range of measurements. A core atmospheric circulation project is that on the summer North Atlantic Oscillation Progress since the 5th Workshop includes two major papers (Linderholm et al, 2011, 2013) and increasing evidence was presented that boreal European summer climate has strong links to Southern Hemisphere winter climate as well as to the Atlantic Multidecadal Oscillation. The project now makes regular contributions to the annual Bulletin of the American Meteorological Society supplement on the State of the Climate.

### New Early Career Scientist CLIVAR Initiative

Because of the number of young scientists present, Dr Sarah Perkins on behalf of CLIVAR presented a new initiative, the CLIVAR Early Career Scientist's Network. This is an international network involving website, conferences and social media that can include any climate scientist who considers themselves in the primary stages of their career, student, post-doc, or permanent research scientist. A full discussion of this evolving proposal is at: www.clivar.org/sites/default/files/ECS/Documents/CLIVAR_ECS_Survey_report.pdf.

### Key Plans for the development of C20C+

A relatively full discussion is at the summaries of the two Workshop Breakout Groups at http://grads.iges.org/c20c/home.html Here we review the main plans not mentioned above.

### Detection and Attribution Project

Project outputs will support the Bulletin of the American Meteorological Society's annual State of the Climate attribution supplement (Peterson et al, 2013). Before the next C20C+ Workshop, it is hoped to organise a journal special issue providing an overview of the first results from this subproject. More details can be found on the C20C+ web site http://grads.iges.org/c20c/home.html and at the subproject web site http://portal.nersc.gov/c20c/. Ideas for possible future experiments were discussed at the workshop, including a focus on the effects of specific forcings, a focus on projections for some future period, and a focus on geo-engineering problems.

### Atmospheric circulation, rainfall and atmospheric noise

The Atmospheric Circulation and Rainfall Working Group discussed the plans for remaining C20C+ projects and their proposed participants. Following several recent published papers, some listed below, the atmospheric noise project will look at long time-scales of climate variability. These may be forced (partly at least) by atmospheric noise due to coupled atmosphere-ocean processes or ocean internal variability. With the help of AMIP-type ensembles to estimate weather noise, the noise component of key drivers of decadal variability in CGCM control experiments and decadal prediction experiments will be studied using diagnostic models.

There is increasing evidence that state of the art models represent processes affecting European climate considerably better than in the past. The role of C20C+ will be particularly in studying forcing mechanisms in the summer and for winter half year UK and European droughts. The latter project is studying the mechanisms of European summer climate variability following a number of recent papers on the summer North Atlantic Oscillation. Particular emphases are tropical rainfall forcing, SST forcing including the AMO, and the effect of the decline in recent Arctic sea ice. The project is also reconstructing the SNAO over the last millennium (Linderholm et al, 2013) and using CMIP5 models to try to simulate SNAO variations over this long period. Reanalyses are important to this project; the SNAO essentially involves changes in the tropospheric jet stream and the reanalysis project is expected to provide further advice on suitable reanalyses. There is considerable further potential to uncover the relative variance of potentially predictable modes and internal variability in both hemispheres using the Grainger et al. (2011) statistical method mentioned above.

In the context of forcing factors for atmospheric circulation modes and for studies of rainfall data in their own right, there is a considerable need for a review of, and advice on, rainfall data sets to support C20C+ activities. Many such global or quasi-global data sets now exist. It is expected that using the core C20C+ model data, a much more extensive analysis will be done on trends and variations in global precipitation; this activity will also cast light the strengths and weaknesses of the many observed data sets. Further investigation of monsoon rainfall mechanisms will be done using the IFS 16km – T1279 1o ocean resolution model. A 50-member ensemble is available for 1980-2010.

Finally as a background to these activities, it was agreed to add to the C20C+ project an ongoing study of the time-varying causes of the slowdown in global warming, and how this might end. It was also agreed that the next workshop would be in 2016 or 2017 at the Center for Ocean-Land-Atmosphere Studies, Maryland, USA.

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