



Exchanges

- Selected Research Papers -

The Climate of the Twentieth Century Project

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The Climate of the Twentieth Century (C20C) project was originally established by the Hadley Centre in the early 1990s. Then, as now, the main purpose was to run many atmospheric general circulation models (AGCMs) in ensemble mode against a common sea surface temperature (SST) and sea ice extent data set to study climate variability and predictability on time scales of a season to many decades. C20C differs from the Atmospheric Model Intercomparison Project (AMIP) in several ways. Firstly the length of the integrations is considerably greater. Some integrations are carried out since the late nineteenth century, with a core period from 1950 onwards which has better verifying data. The C20C project is more about predictability than is AMIP and includes decadal time scales, though aspects of model evaluation are included. One of the important goals of C20C is to determine the extent to which atmospheric models are able to simulate the observed climate variations during the 20th century. Of particular importance is the potential ability of ensembles of AGCM runs to simulate specific historical events such as regional floods and droughts, the Dust Bowl in North America, the persistent drought in the Sahel and other extreme seasons. C20C is also concerned with simulating trends and so provides an interface with more formal climate change detection projects. Although use of AGCMs remains central to the project, coupled ocean-atmosphere general circulation models (CGCM)s now play an important role. They are used to explore the limitations of AGCM runs and to guide the design of AGCM climate variability analyses on longer time scales, e.g. for identifying possible thermohaline circulation-related climate variations.

The first workshop was held in late 1994 (Folland and Rowell, 1995) and its results used in the Climate Models - Evaluation chapter of the Second Assessment Report of IPCC published in 1996. In addition, a special C20C session was held at the First International AMIP Conference in 1995. Although this activity led to bilateral collaboration, in the late 1990s, the project was revitalised as a joint project of the Hadley Centre and the Center for Ocean-Land-Atmosphere Studies (COLA)

under CLIVAR auspices with administrative support from COLA. C20C now also reports to the Working Group on Numerical Experimentation (WGNE). A number of groups have consequently run experiments forced with the new Hadley Centre HadISST SST and sea-ice extent data set (Rayner et al., 2000, 2002).

A second workshop was held at COLA on 22-25 January 2002 to review progress and particularly to plan a more highly structured C20C project. The workshop was held just before a World Meteorological Organization (WMO) Global Climate Observing System (GCOS) Workshop on Advances in the Use of Historical Marine Climate Data (29 Jan - 1 February 2002), chaired by the first author, so that participants could communicate their ideas about further improvements to SST and sea ice data sets that might be used by C20C.

At the workshop two days of presentations were made by participating groups summarising the results from ensembles of runs forced with HadISST from the recent informal phase of C20C. Besides a number of diagnostic methods and new results on simulating 20th century climate, a presentation (Jim Hurrell, NCAR) was made on the question of how limited AGCMs may be in simulating the variance of climate adequately. A specially designed experiment was created whereby the Hadley Centre HadAM3 AGCM was forced in ensemble mode with daily SSTs from part of a very long control run of the CGCM HadCM3. The initial conclusion is that the variance of those quantities looked on seasonal to decadal time scales are not significantly less in the AGCM than in the CGCM. Small differences that did occur were, however, consistent with the notion of excessive thermal damping in AGCM simulations (Saravanan, 1998). This supports the general validity of the AGCM approach for many types of climate predictability and trend studies. However an unresolved issue is whether some specific modes are missing in the AGCM that are present in the CGCM due to the lack of coupling. This work is being extended to include another AGCM/CGCM pair.

The HadCM3 model was also used to show that natural variations in the thermohaline circulation exist in that model which may be reflected in SST data since the late 19th century. This appears particularly in the form of strong North Atlantic SST variability on a nearly 70-year time-scale with an interhemispheric component in

the Atlantic. If so, analyses of multidecadal variability may need to take this into account.

The workshop decided that more emphasis should be placed on including forcings in addition to SST. The need for this was shown by a presentation (David Sexton, Hadley Centre) on detecting the influence of individual time-varying forcings in AGCM experiments all forced with GISST3 using a sensitive method based on the general linear statistical model (Sexton et al., 2002). Specific additions of forcings other than those contained in SST and sea ice will have additional (significant) effects in recent decades on regional model temperatures from the surface to the lower stratosphere. Thus ozone depletion in recent decades is essential to simulating changing temperature of the latter and greenhouse forcing has additional effects on warming land surface air temperature to that contained in the SST. Because of uncertainties in some forcings, and their tendency to partially cancel, it was agreed to use the following forcings:

1. Data from the Hadley Centre on changes in carbon dioxide since 1871.
2. Volcanic stratospheric forcing from 1950 only, as data before then are more uncertain.
3. Changes in tropospheric and stratospheric ozone, the former based on an off-line chemistry model used by the Hadley Centre. The latter data start around 1975 the former cover the twentieth century.

Other explicit forcings are being ignored either because residual effects that are not included in SST are small and uncertain (like direct solar forcing) or for practical reasons. The neglect of increasing methane and the other trace greenhouse gases is seen as offsetting the neglect of increases in direct and indirect tropospheric aerosol forcing, remembering that a part of these effects is included in HadISST. Participants (where possible) will carry out a set of 6 such integrations for 1871-2002 and a further set of 10 from 1950-2002 giving an ensemble of 16 integrations from 1950-2002. HadISST will soon be updated in near real-time to make this possible. The latter period will allow analysis of two c.25 year periods on either side of the 1976 climate "jump". A significant issue in the workshop was the characterisation of naturally occurring modes that occur in the absence of interannual SST variations. Given that such modes may be model dependent, all participants will carry out a further 100-year control run forced with the 1961-90 climatology of HadISST.

At a later stage, the additional impact of land surface changes on recent regional climate change and variability will be explored. These integrations will probably start from about 1970. Three variables are being considered if data sets become available: observed changes in

surface vegetation, observed changes in soil moisture and observed changes in snow cover.

A series of standard diagnostics was agreed which will cater for many of the more specific investigations. A series of special possible topic investigations was also identified. Participants will have the freedom to choose which they are involved in and details of these investigations remain to be agreed. However since everyone will run a full set of integrations, considerable flexibility and choice is built into the programme.

The special topics fall broadly into the following categories:

1. Predictability of seasonal to decadal phenomena such as the 1930s USA droughts, the 1962-63 cold winter and the autumn 2000 floods in Europe, and decadal changes in interannual ENSO climate responses, particularly in Australasia.
2. Time series and trends of simulated quantities. Examples are the SOI index, the NAO index, the PNA index, rainfall in Asian monsoon regions, the Sahel and Northeast Brazil and the occurrence of the Madden Julian Oscillation. In addition each model's ability to simulate observed regional and global land surface air temperature changes will be investigated
3. Other topics such as validation of modelled river runoff.

A variety of validating data sets will be used. For the period since 1950, the NCEP and ERA40 reanalyses will be important, recognising that the former at least cannot be used to evaluate model trends. For atmospheric circulation before 1950 particularly, the monthly HadSLP data set will be used, a further development of the mean sea-level pressure data set described by Basnett and Parker (1997). A gridded set of daily mean sea level pressure data also exists back to the late nineteenth century for the extratropical Northern Hemisphere which will be enhanced through a new European Community funded project, "EMULATE". Over land, the Climatic Research Unit data sets of land surface air temperature and precipitation are readily accessible. Other data sets will be identified by project co-ordinators as needed.

For some projects a set of agreed statistical diagnostics will be made available or the methodology agreed. An example is the method of estimating forced variability using analysis of variance.

It is intended that model and observed data will be stored and exchanged through the COLA GrADS-DODS server (GDS). The GDS is a software system that facilitates the access to, and analysis and display of geophysical data distributed on the Internet (<http://>

www.iges.org/grads/gds/index.html). The total amount of data served at each participating center is expected to be at least several tens of gigabytes, making the distributed analysis model the most practical way of exchanging data. A C20C home page will be maintained at COLA (<http://www.iges.org/c20c/>), with links to C20C home pages of individual institutions where possible.

Finally it is intended to create links between the C20C group, the CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP), the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) and AMIP. A focus of the work will be a C20C meeting in spring 2004 and possible involvement in the International CLIVAR Conference in June 2004. A longer-term focus will be a likely input to the IPCC Fourth Assessment Report around 2006.

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