Climate Variability & Predictability
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Exchanges

- Supplementary Contributions -

20C3M: CMIP collecting data from 20th century coupled model simulations

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1. Background

Many modelling groups have completed or are in the process of performing simulations of the 20th century with ocean-atmosphere general circulation models. The simulations are driven with various combinations of external climate forcings, such as anthropogenic increases in greenhouse gases and sulphate aerosols, changes in solar radiation and forcing by explosive volcanism; and the different forcings are incorporated either into separate simulations or combined. These simulations have proven to be very valuable for our understanding of 20th century climate change (see, Figure 1; Stott et al., 2000; Meehl et al., 2003).

For example, efforts to detect climate change, attribute it to causes and estimate the contribution from different external climate influences generally rely on such simulations to derive "fingerprints" for the various factors contributing to climate change (see Mitchell et al., 2001). This use of 20th century simulations is not limited to understanding global scale surface temperature changes, but can also be applied to the detection of climate change in smaller spatial scales (e.g., Zwiers and Zhang, 2003) and other variables (c.f. Allen and Ingram, 2002). Since results are often sensitive to the model used (e.g. Hegerl et al., 2000) and details of the forcing, detection and attribution studies need to incorporate model uncertainty by using a range of models for reliable results (see Mitchell et al., 2001; Gillett et al., 2002). Also, results using a variety of models can help to derive uncertainty measures for future climate change based on the ability of the models to reproduce the 20th century (for example, Allen et al., 2000).

Simulations of the 20th century have also proven very helpful for understanding the difference between the surface and lower tropospheric temperature trends (Santer et al., 2000), for the study of changes in the probability distribution of climate variability (e.g. the North Atlantic Oscillation / Arctic Oscillation; Osborne, 2002, or El Niño) under similar conditions as observed. Furthermore, the validation of climate models has traditionally relied on comparing the output of "control simulations" without interannual changes in external forcing with observations. However, since the observations are probably influenced by external influences, a comparison between simulations and observations subject to the same external influences can often be more meaningful than a comparison with control simulations. Similarly, studies of climate variability will also benefit from the availability of data that can be directly compared with the observations.

Therefore, it was decided at the recent meeting of the Working Group on Coupled Models (WGCM, the parent committee of Coupled Model Intercomparison Project (CMIP)), to go forward with a new CMIP pilot project called "20th Century Climate in Coupled Models" (20C3M). The goal is to collect data from 20th century simulations from as many coupled ocean-atmosphere models as possible. The accessibility of the data to the user community will help in providing assessments of past and future climate change by a variety of methods, incorporating forcing and model uncertainty.

Previously CMIP was involved in idealized forcing experiments (1% CO_2 increase) that facilitate direct comparison. We recognize that the 20th century simulations will differ in which forcings are used, and in how the forcings are incorporated into the model (e.g. direct forcing by sulphate aerosols through changes in surface albedo; use of indirect sulphate aerosols or a fully interactive chemistry; see Cubasch et al., 2001). However, since our understanding of the size, spatial pattern, time evolution and relative importance of the forcings is limited, we consider the diversity in forcings a representation of forcing uncertainty. Therefore, the only stipulation of the 20C3M project is that there must be documentation of the forcings and forcing datasets used in the simulations.

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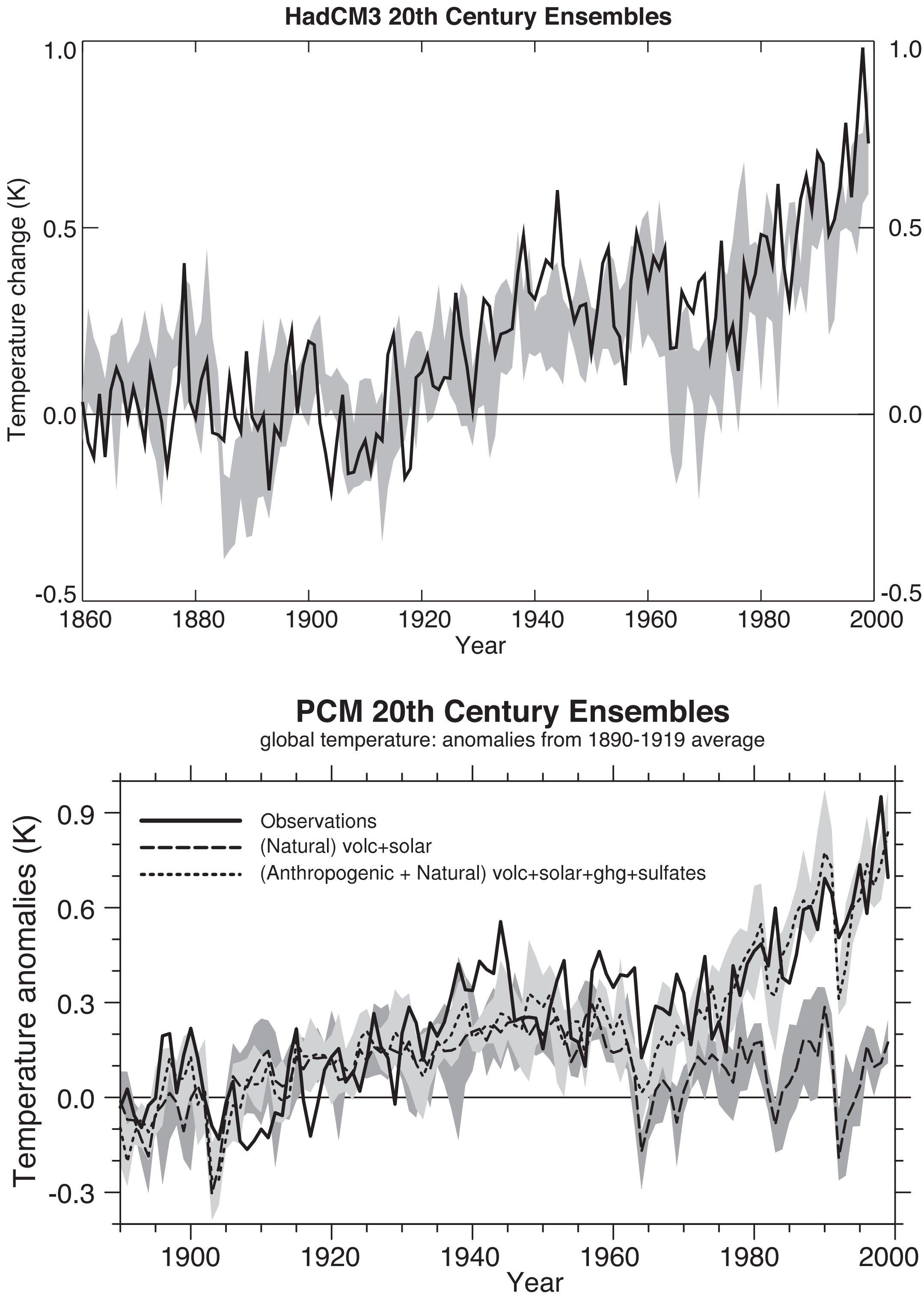

Figure 1: a) Global-mean near-surface temperatures as observed (solid line) and as modelled by HadCM3 (shaded band) when the HadCM3 simulations (4 ensemble members) include both anthropogenic and natural forcings due to well-mixed greenhouse gas increases, the direct and indirect effects of sulphate aerosols, tropospheric and stratospheric ozone changes, changes in solar output and stratospheric aerosol from explosive volcanic eruptions (c.f. Stott et al., 2000).
b) observations compared to ensemble average and uncertainty range from the Parallel Climate Model (PCM; Meehl et al., 2003; 5 ensemble members), forced with natural and anthropogenic forcings (short dashed, lighter shaded area) and natural forcings only (long dashed, darker shaded area).

2. Requirements for participation

We will collect simulations that represent the various groups' best effort to simulate 20th century climate. Since this is a pilot project, we are requesting only a limited subset of the model output (as opposed to CMIP2+ where all model output was collected). We recommend ensemble simulations of at least 3 members, but fewer or single simulations are also welcome. We request model data for a simulation period starting typically in the late 19th century and ending in 2000 (the minimum requirement is data for the period 1961-2000 to enable comparison with observations using the same climatology and sampling the emerging anthropogenic signal). Ideally, we request the following variables:

Monthly surface data

1. Sea level pressure
2. Precipitation
3. Surface air temperature
4. Sea level (of the ocean surface)
5. Sea surface temperature
6. Sea-ice extent
7. Sea-ice thickness
8. Soil moisture 1 according to AMIP: "mrsos" (soil water content in the upper 0.1 m)
9. Soil moisture 2 according to AMIP: "mrso" (total soil water content); both soil moisture fields in kg/m^2

Monthly 3-D data

1. 3-D cloud amount
2. 3-D atmospheric temperature (on standard AMIP pressure levels)
3. 3-D ocean temperature
4. 3-D ocean salinity

Daily data

1. Sea level pressure
2. Precipitation
3. Minimum surface air temperature
4. Maximum surface air temperature

Subsets (that should include monthly surface air temperature and sea level pressure) are also acceptable. The data should be sent in NetCDF format, following NetCDF Climate and Forecast (CF) Metadata Conventions (see http://www.cgd.ucar.edu/cms/eaton/netcdf/CF-current.htm)

Contributing coupled models should submit or have submitted control simulations to CMIP, and have made a 2 times CO_2 equilibrium run with a slab ocean configuration.

To enable comparison between model results, we request the following documentation:

1. List of anthropogenic forcings (e.g. CO_2, other greenhouse gases, sulphate aerosol) and/or natural forcings (e.g. solar, volcanic forcing)
2. Source and, if available, reference for forcing agent datasets
3. If possible, estimates of radiative forcing for individual forcing agents and net forcing (e.g. experiment minus control), annual or decadal means, globally averaged or with spatial pattern information
4. Initialization and spin-up procedure
5. Land-sea mask
6. Orography and bathymetry
7. Land surface characteristics (documentation of soil and vegetation scheme, if climatological or interactive)
8. Surface albedo characteristics and functional dependence (e.g. documentation of snow ageing and masking, ice ponding)

We request that data be sent as soon as possible. When a sufficient representation of 20th century data is available in the archive at PCMDI, we will send out a new subproject announcement soliciting analyses of the database as we have done for the other phases of CMIP.

If you are interested in submitting data and have any questions or problems, please contact Curt Covey at PCMDI (covey1@llnl.gov). He will be handling the archival of the model data. Please contact him also when you are ready to start transferring your model data.

References:

Allen, M.R., and W.J. Ingram, 2002: Constraints on future changes in climate and the hydrologic cycle. *Nature*, **419**, 224-232.

Allen, M.R., P.A. Stott, J.F.B. Mitchell, R. Schnur, and T. Delworth, 2000: Quantifying the uncertainty in forecasts of anthopogenic climate change. *Nature*, **407**, 617-620.

Cubasch, U., G. Meehl, G.J. Boer, R.J. Stouffer, M. Dix, A. Noda, C.A. Senior, S. Raper, and K.S. Yap, 2001: Projections of Future Climate Change. In: J.T. Houghton *et al.* (eds.) *Climate Change 2001. The Third Scientific Assessment*, Intergovernmental Panel on Climate Change (IPCC), 880pp.

Gillett, N.P., F.W. Zwiers, A.J. Weaver, G.C. Hegerl, M.R. Allen, and P.A. Stott, 2002: Detecting anthropogenic influence with a multi-model ensemble. *Geophys. Res. Lett.*, **29**, 10.1029/2002GL015836.

Hegerl, G.C., P.A. Stott, M.R. Allen, J.F.B. Mitchell, S.F.B. Tett, and U. Cubasch, 2000: Detection and attribution of climate change: Sensitivity of results to climate model differences. *Clim. Dyn.*, **16**, 737-754.

Meehl, G.A., W.M. Washington, C. Ammann, J.M. Arblaster, and T.M.L. Wigley, 2003: Combinations of natural and anthropogenic forcing and 20th century climate. *Geophys. Res. Lett.*, in preparation.

Mitchell J.F.B, D.J. Karoly, G.C. Hegerl, F.E. Zwiers , M. R. Allen, and J. Marengo, 2001: Detection of Climate Change and Attribution of Causes. In: J.T. Houghton *et al*. (eds.) *Climate Change 2001. The Third Scientific Assessment*, Intergovernmental Panel on Climate Change (IPCC), 880pp.

Osborn, T., 2002: The winter North Atlantic Oscillation: Roles of internal variability and greenhouse forcing. *CLIVAR Exchanges*, No. **25**, 54-58.

Santer, B.D., et al., 2000: Interpreting differential temperature trends at the surface and in the lower troposphere. *Science*, **287**, 1227-1231.

Stott, P.A., S.F.B. Tett, G.S. Jones, M.R. Allen, J.F.B. Mitchell, and G.J. Jenkins, 2000: External control of 20th century temperature by natural and anthropogenic forcings. *Science*, **15**, 2133-2137.

Zwiers, F.W., and X. Zhang, 2003: Towards regional climate change detection. *J. Climate*, accepted.