Canadian Centre for Climate Modelling and Analysis

Scientific Highlights - 1998/99

The Canadian Centre for Climate Modelling and Analysis (CCCma) models the full climate system, from the "bottom of the ocean" to the "top of the atmosphere". The Centre uses its models to study the mechanisms of climate variability and change and to project future climate. Both atmospheric and coupled models are in a constant state of development and testing, evolving to reflect advances in understanding of the underlying climate variables and processes. As work on one version of a model is frozen, development of the next generation model is begun. Once validation of the model is complete, scenario testing can begin. Model output for different scenarios is then transferred to the scientific community for use in a variety of other studies.

FY 1998/9 was a very productive year for CCCma. The division completed the development of a new atmospheric general circulation model (GCM3), launched the development of next generation versions of its atmospheric (GCM4) and coupled climate models (CGCM3) and made substantial progress in updating its diagnostics package. Papers describing the first generation coupled model (CGCM1), its climate, and its projections of future climate change were submitted to peer reviewed publications and analysis of a 1000-year control simulation with CGCM1 is underway. Two "stabilization" simulations, in which the atmospheric concentration of greenhouse gas and aerosol concentrations is fixed at levels projected for years 2050 and 2100, were completed and their analysis is also underway. An interim coupled model (CGCM2)[1], incorporating improved ocean physics and a dynamical sea ice model was brought into operation. Control and transient change simulations with this model are in progress.

The new atmospheric general circulation model, GCM3, is a spectral model that operates at T47 and T63 horizontal resolutions and has 32 levels in the vertical with a lid at 1 hPa. The Middle Atmosphere Model, which has 50 levels in the vertical, extends CGCM3 upwards to approximately 100 km. To reduce computational cost, GCM3 incorporates a "double transform" approach in which the physics are computed on the "linear" grid (which is 96x48 and 128x64 respectively for the T47 and T63 model configurations). Features incorporated into GCM3 include so called optimal topography which improves the representation of important orographic features, a new deep convection scheme, an improved 4-band radiation code, improved cloud and boundary layer parameterizations, an improved gravity wave drag scheme, a semi-Lagrangian tracer transport scheme, a much more sophisticated land surface scheme (CLASS: See report of the Climate Processes and Earth Observation Research Division) and a simple river routing scheme. Development work on a new CKD radiation code and a prognostic cloud water code is underway. This, and other improvements will form the basis for GCM4.

GCM3 will form the atmospheric component of a new coupled model called CGCM3, which will also include a new ocean model (NCAR's NCOM 1.3) and the Flato/Hibler dynamical sea-ice model. Atmosphere and ocean components of CGCM3 are both able to use multiple processors on the AES NEC supercomputers. Communication between the major model components will be performed with a "message passing interface" (MPI) based coupler that keeps all components in memory.

A very large amount of CGCM1 output has been distributed to the impacts research community from CCCma web site (http://www.cccma.bc.ec.gc.ca). Approximately 200 users registered to use CCCma model output during FY 98/9, and they downloaded data from the site a total of 1859 times. The site provides access to 1000 years of simulated climate data, including a 200-year segment of the CGCM1 control simulation, a 200-year simulation with transient greenhouse gas forcing, and an ensemble of three 200-year simulations with transient greenhouse gas and (direct effect) sulphate aerosol forcing. Work is underway to make a considerable quantity of daily model output available from the site as well.

[1] The numbering of CCCma coupled GCMs has been revised since publication of the 1997/98 Annual Report. In the 97/98 Annual Report, mention was made of an interim model CGCM1.1 that would couple GCM2 with a dynamic sea-ice model and incorporate improved ocean mixing parameterization. This model is now referred to as CGCM2. The advanced coupled model that uses the next generation atmospheric model (GCM3) and an improved ocean model (NCAR's NCOM 1.3) is now called CGCM3.

The division has also been very active in the analysis of its climate simulations. Control and transient climate change simulations have been analysed to better understand the variability of climate, the effect of ocean mixing and dynamical sea-ice on variability, and the response of climate to both transient forcing and stabilization of greenhouse gas and aerosol concentrations. An analysis of decadal scale variability has also been performed. Studies of North Atlantic variability (specifically the North Atlantic Oscillation and the closely related Arctic Oscillation) are under way. We also plan to examine other aspects of the simulated climate such as atmospheric transport, river runoff, climate extremes, ocean transport and the ocean carbon cycle.

The division is the focal point for the Canadian Climate Research Network, which engages researchers at 14 Canadian Universities and three government labs. Collectively the aim of the CRN is to improve Canada's ability to predict the rate, magnitude and regional characteristics of climate, climate variability and climate change in Canada. The Division also makes a strong contribution to international programs through its participation in cooperative programs aimed at undertaking model comparisons, improving the understanding climate variability and change, middle atmosphere research and cold climate research among other things.