Model Information of Potential Use to the IPCC Lead Authors and the AR4.

BCCR-BCM2.0

15 June 2005

I. Model identity:

A. Institution, sponsoring agency, country
   Bjerknes Centre for Climate Research (BCCR), Univ. of Bergen, Norway
B. Model name (and names of component atmospheric, ocean, sea ice, etc. models)
   Bergen Climate Model (BCM) Version 2
      Atmosphere/land: ARPEGE-CLIMAT Version 3
      Ocean/sea ice: NERSC largely modified version of MICOM Version 2.8, with NERSC Sea Ice Model
C. Vintage (i.e., year that model version was first used in a published application)
   2005
D. General published references and web pages
   www.bcm.uib.no
   www.bjerknes.uib.no
E. References that document changes over the last ~5 years (i.e., since the IPCC TAR) in the coupled model or its components. We are specifically looking for references that document changes in some aspect(s) of model performance.
   Not member of IPCC TAR
F. IPCC model version's global climate sensitivity ($KW^{-1}m^2$) to increase in CO_2 and how it was determined (slab ocean expt., transient expt--Gregory method, ±2K Cess expt., etc.)
   Not available yet
G. Contacts (name and email addresses), as appropriate, for:
   1. coupled model
      Asgeir Sorteberg (asgeir.sorteberg@bjerknes.uib.no)
      Helge Drange (helge.drange@nersc.no)
   2. atmosphere
      Nils Gunnar Kvamstø (nilsg@gfi.uib.no)
      Asgeir Sorteberg (asgeir.sorteberg@bjerknes.uib.no)
      Ina Thorstensen Kindem (ina@gfi.uib.no)
      Frode Flatøy (frode@gfi.uib.no)
   3. ocean
      Helge Drange (helge.drange@nersc.no)
      Tore Furevik (tore@gfi.uib.no)
      Mats Bentsen (mats.bentsen@nersc.no)
   4. sea ice
      Helge Drange (helge.drange@nersc.no)
      Mats Bentsen (mats.bentsen@nersc.no)
   5. land surface
      Nils Gunnar Kvamstø (nilsg@gfi.uib.no)
      Asgeir Sorteberg (asgeir.sorteberg@bjerknes.uib.no)
   6. vegetation
      Nils Gunnar Kvamstø (nilsg@gfi.uib.no)

Asgeir Sorteberg (asgeir.sorteberg@bjerknes.uib.no)

7. other?

II. Besides atmosphere, ocean, sea ice, and prescription of land/vegetated surface, what can be included (interactively) and was it active in the model version that produced output stored in the PCMDI database?

A. atmospheric chemistry?
   No
B. interactive biogeochemistry?
   No
C. what aerosols and are indirect effects modeled?
   The distributions of marine, desertic, urban aerosols, sulfate aerosols are specified. Marine and desertic aerosols are constant in all experiments. Urban aerosols vary according to estimates between 1850 and 2000. Sulfate aerosols are specified in all experiments according to Boucher and Pham (2002) data, see http://www-loa.univ-lille1.fr/~boucher/sres/ for more details. Note that only the direct effect of anthropogenic sulfate aerosols was taken into account.
D. dynamic vegetation?
   No
E. ice-sheets?
   Fixed

III. List the community based projects (e.g., AMIP, C4MIP, PMIP, PILPS, etc.) that your modeling group has participated in and indicate if your model results from each project should carry over to the current (IPCC) version of your model in the PCMDI database.

AMIP (older version)
CMIP (older version)
PMIP 6k BP simulation with former version of ARPEGE-Climat (older version)
PILPS with the ISBA land surface scheme (same as in the IPCC)

IV. Component model characteristics (of current IPCC model version):

A. Atmosphere
   1. resolution
      T63L31: A triangular truncation T63 with “linear” reduced Gaussian grid equivalent to T42 quadratic grid (2.8 °). See: Hortal and Simmonds (1991) for description of the linear reduced grid.
   2. numerical scheme/grid (advective and time-stepping schemes; model top; vertical coordinate and number of layers above 200 hPa and below 850 hPa)
      Semi-lagrangian semi-implicit time integration with 30 min time-step, 3 hour time-step for radiative transfer; top layer 10 hPa, progressive hybrid sigma-pressure vertical coordinate with 31 layers.
   3. list of prognostic variables (be sure to include, as appropriate, liquid water, chemical species, ice, etc.). Model output variable names are not needed, just a generic descriptive name (e.g., temperature, northward and eastward wind components, etc.)

4. name, terse descriptions, and references (journal articles, web pages) for all major parameterizations. Include, as appropriate, descriptions of:
    a. Clouds:
        - statistical cloud scheme for stratiform clouds based on Ricard and Royer (1993). Convective cloud cover based on the mass-flux transport
    b. Convection
        - mass-flux convective scheme with Kuo-type closure based on Bougeault (1985) boundary layer based on Louis et al. (1982) with modifications by Mascart et al. (1995). SW, LW radiation based on Fouquart and Morcrette parameterizations implemented in a former version of the ECMWF model (Morcrette JJ, 1990; Morcrette JJ, 1991)
    c. any special handling of wind and temperature at top of model:
        - relaxation of temperature, linear (Rayleigh) friction for wind

B. Ocean
1. resolution
    The model has 35 vertical layers and approximately square horizontal grid cells with 1.5° grid spacing along the equator. Near the equator the meridional grid spacing is gradually decreased to 0.5° at the equator.
2. numerical scheme/grid, including advection scheme, time-stepping scheme, vertical coordinate, free surface or rigid lid, virtual salt flux or freshwater flux
    Numerical grid: Arakawa C-grid.
    Momentum equation: PV-conserving (Sadourny 1975).
    Layer thickness advection: Flux corrected transport (Zalesak 1979).
    Tracer advection: MPDATA (Smolarkiwicz, 1984).
    Time-stepping: Leapfrog with Asselin time filtering.
    Vertical coordinate: Isopycnic interior layers with slab surface mixed layer.
    Free surface: Yes.
    Uses virtual salt flux.
3. list of prognostic variables and tracers
    Prognostic variables: Horizontal velocity components, layer thickness, temperature and salinity.
4. name, terse descriptions, and references (journal articles, web pages) for all parameterizations. Include, as appropriate, descriptions of:
    a. eddy parameterization
        Horizontal:
            Tracer: Laplacian diffusion with diffusivity proportional to grid spacing.
            Momentum: Combination of deformation dependent eddy viscosity (Smagorinsky 1963) and Laplacian diffusion with diffusivity proportional to grid spacing.
            Layer interfaces: Biharmonic diffusion with diffusivity proportional to grid spacing qubed.
        Vertical:
            Background mixing with diffusivity dependent on stability (Gargett 1984)
            Shear instability mixing (Large et at. 1994)
            Gravity current entrainment (Turner 1986)
            Momentum mixing with Prandtl number 10.
    b. bottom boundary layer treatment and/or sill overflow treatment

Bottom friction scaled with near bottom velocity squared.

c. mixed-layer treatment
Mixed layer depth modified according to the mixed layer turbulence parameterization of Gaspar (1988).

d. sunlight penetration
Uses parameters for red light surface absorbtion and blue light extinction assuming Jerlov type 1 water.

e. tidal mixing
NA

f. river mouth mixing
NA

g. mixing isolated seas with the ocean
NA

h. treatment of North Pole "singularity" (filtering, pole rotation, artificial island?)
There are no grid singularities in the ocean domain. Grid singularities are placed over Antarctica and Siberia.

C. sea ice

1. horizontal resolution, number of layers, number of thickness categories
Grid consists of 4 grid cells pr ocean grid cell.
One ice layer and one snow layer.
Single thickness category.
2. numerical scheme/grid, including advection scheme, time-stepping scheme,
Numerical grid: Arakawa B-grid.
Momentum equation: Daily updated steady state balance of forces.
Advection of concentration, ice thickness, snow and ice age using 3^{rd} order weighted essentially non-oscillatory scheme (Jiang and Shu, 1996) with 2^{nd} order Runge-Kutta time discretization.
3. list of prognostic variables
Prognostic variables: Velocity, concentration, ice thickness, snow thickness, ice age.
4. completeness (dynamics? rheology? leads? snow treatment on sea ice)
Rheology: Viscous-plastic (Hibler III, 1979) with modifications by Harder (1996).
Minimum lead fraction: 0.5%.
Assumes linear temperature profile in ice and snow.
Salinity dependent freezing temperature.
Ocean heat flux parameterized according to Maykut and McPhee (1995).
Snow is converted to ice due to aging and when flooded.
Minimum ice thickness of 0.5 m (Arctic)/0.3 m (Antarctic) at initial freezing.
5. treatment of salinity in ice
Assumes constant salinity of 6 psu in sea ice.
6. brine rejection treatment
Brine salt flux absorbed in mixed layer.
7. treatment of the North Pole "singularity" (filtering, pole rotation, artificial island?)
There are no grid singularities in the ocean domain. Grid singularities are placed over Antarctica and Siberia.

D. land / ice sheets (some of the following may be omitted if information is clearly included in cited references.

The land surface scheme ISBA (Interactions Soil Biosphere Atmosphere) developed initially by Noilhan and Planton (1989) has been updated and described by Mahfouf et al. (1995).

1. resolution (tiling?), number of layers for heat and water
   Hor. Res.: same as atmospheric grid. 4 soil layers for heat and 2 for water
2. treatment of frozen soil and permafrost
   Yes
3. treatment of surface runoff and river routing scheme
   The TRIP dataset (Oki and Sud, 1998) has been used to connect land grid cells to ocean runoff discharge coast grid cells. Runoff is stored in a reservoir which is drained with an e-folding time scale of 7 days.
4. treatment of snow cover on land
   - Prognostic scheme calculating: water equivalent in snowpack, snow surface albedo and snowpack density (Douville et al., 1995a, 1995b)
5. description of water storage model and drainage
   Force-restore approach
   Deep drainage as a relaxation toward field capacity + a residual subgrid drainage below field capacity
   VIC-type subgrid runoff
6. surface albedo scheme
   Ocean:
   - Constant albedo of 0.065 for diffusive light, zenith angle dependent albedo for direct light using a functional fit to observations of Payne (1972).

   Sea ice:
   - 0.85 with snow, 0.75 with melting snow, ice thickness dependent albedo for bare ice with maximum albedo of 0.70 for frozen ice and 0.60 for melting ice.

   Land:
   - snowfree albedo from ECOCLIMAP (Masson et al. 2003)
   - prognostic snow albedo (Douville et al. 1995a)
   - diagnostic snow fraction as a function of snow mass, vegetation roughness length and subgrid orography (Douville et al. 1995a and 1995b)
7. vegetation treatment (canopy?)
   prescribed vegetation map and prescribed phenology from ECOCLIMAP (Masson et al. 2003)
   no carbon cycle
8. list of prognostic variables:
   4-layer soil temperatures
   2-layer soil hydrology (liquid and solid)
   1-layer snow hydrology (prognostic snow mass, snow albedo and snow density)
   1 interception reservoir (liquid water on the canopy)
9. ice sheet characteristics (How are snow cover, ice melting, ice accumulation, ice dynamics handled? How are the heat and water fluxes handled when the ice sheet is melting?)
   Ice sheet are represented simply by prescribing initially a huge snow amount and applying to it the same snow parameterization as over the land surface.
   Ice dynamics is not included

E. coupling details

Coupling between atmosphere, ocean and sea ice models is done through the OASIS 2.2 coupler developed at CERFACS. Note that the sea ice model is included in the ocean model. For a reference of the coupling software, see Terray et al. (1998).

1. frequency of coupling
   Once per day.
2. Are heat and water conserved by coupling scheme?
   Yes.
3. list of variables passed between components:
   a. atmosphere – ocean
      Solar heat flux, non-solar heat flux, derivative of non-solar heat flux with respect to surface temperature, evaporation, liquid precipitation, solid precipitation, zonal wind stress, meridional wind stress, cloud cover
   b. atmosphere – land
      Internal treatment in atmosphere model.
   c. land – ocean
      Runoff.
   d. sea ice – ocean
      Internal treatment in ocean/sea ice model
   e. sea ice – atmosphere
      Surface temperature, ice concentration, albedo.
   f. ocean – atmosphere
      Surface temperature, albedo, surface velocities.

4. Flux adjustment? (heat?, water?, momentum?, annual?, monthly?).
   None.

References:

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V. Simulation Details (report separately for each IPCC simulation contributed to database at PCMDI):

Picntrl/Run_1

This preindustrial control simulation was initialized from an ocean at rest with temperature and salinity profiles specified from Levitus (1982). The BCM was then integrated for 80 year with preindustrial 1860 greenhouse gases concentrations as a spin-up. After this spin-up period results have been stored from years 1850 to 2100 (250 years)

20C3M/Run_1

This simulation was initialized from January/1850 of the Picntrl/Run_1 simulation Solar forcing was set at 1368 W/m2 and no solar or volcanic variability were included. The greenhouse gases annual global concentrations were specified based on observations as specified in the ENSEMBLES project webpage (http://www.cnrm.meteo.fr/ensembles/public/results/results.html). Sulfate aerosols are specified according to Boucher and Pham (2002) data (http://www-loa.univ-lille1.fr/~boucher/sres/). Results are given for the years 1850 to 2000

SRESA2/Run_1

This simulation was initialized from January/2000 of the 20C3M/Run_1 simulation. The greenhouse gases annual global concentrations were specified based on scenario SRES A2 as specified in the ENSEMBLES project webpage (http://www.cnrm.meteo.fr/ensembles/public/results/results.html). Sulfate aerosols are specified according to Boucher and Pham (2002) data (http://www-loa.univ-lille1.fr/~boucher/sres/). Results are given for years 2000 to 2100.

SRESA1B/Run_1

This simulation was initialized from January/2000 of the 20C3M/Run_1 simulation. The greenhouse gases annual global concentrations were specified based on scenario SRES A1B as specified in the ENSEMBLES project webpage (http://www.cnrm.meteo.fr/ensembles/public/results/results.html). Sulfate aerosols are specified according to Boucher and Pham (2002) data (http://www-loa.univ-lille1.fr/~boucher/sres/). Results are given for years 2000 to 2300.

SRESB1/Run_1

This simulation was initialized from January/2000 of the 20C3M/Run_1 simulation. The greenhouse gases annual global concentrations were specified based on scenario SRES B1 as specified in the ENSEMBLES project webpage (http://www.cnrm.meteo.fr/ensembles/public/results/results.html). Sulfate aerosols are specified according to Boucher and Pham (2002) data (http://www-loa.univ-lille1.fr/~boucher/sres/). Results are given for years 2000 to 2300.

1%to2x/Run_1

This simulation was initialized from January/2000 of the PIcntrl/Run_1 simulation. This initial state corresponds to year 1860 CO2 concentrations. The concentrations of greenhouse gases are held constant at preindustrial levels, except for CO2, which increases from its preindustrial level (286 ppm) at the rate of 1% per year, until the initial concentration is doubled.

From the time of doubling, the concentrations of all radiative forcing are held constant for 10 years. Results are given for years 2000 to 2080.