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

CNRM-CM3 (version used for IPCC AR4)

2 August 2005

I. Model identity:

A. Institution, sponsoring agency, country:
   Centre National de Recherches Météorologiques, Météo France, France
B. Model name (and names of component atmospheric, ocean, sea ice, etc. models):
   CNRM-CM3
   Atmosphere: ARPEGE-Climat version 3
   Ocean: OPA 8.1
   Sea-ice: GELATO 2
C. Vintage (i.e., year that model version was first used in a published application): 2004
D. General published references and web pages:
   http://www.cnrm.meteo.fr/scenario2004/references_eng.html
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.
   - descriptions of previous versions of the ARPEGE-Climat model can be found in the following publications:
     - Déqué et al., 1994
     - Déqué and Piedelièvre, 1995
     - Royer et al. , 2002
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 yet available
G. Contacts (name and email addresses), as appropriate, for:
     1. coupled model: David Salas y Melia, David.Salas@meteo.fr
     2. atmosphere : Michel Déqué, Michel.Deque@meteo.fr
     3. ocean : David Salas y Melia, David.Salas@meteo.fr
     4. sea ice: David Salas y Melia, David.Salas@meteo.fr
     5. land surface: Hervé Douville, Herve.Douville@meteo.fr
     6. vegetation: Hervé Douville, Herve.Douville@meteo.fr
     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?
   - Ozone transport with simplified chemistry as described in Cariolle and Déqué (1986) and Cariolle et al. (1990).
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 1860 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 with former versions and current version of ARPEGE-Climat
PMIP 6k BP simulation with former version of ARPEGE-Climat (different from the IPCC version)
PILPS with the ISBA land surface scheme (same as in the IPCC)
CMIP simulation was performed at CERFACS with a former coupled versions of ARPEGE-Climat and OPA

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

A. Atmosphere
   1. Resolution: triangular truncation T63 with "linear" reduced Gaussian grid equivalent to T42 quadratic grid (2.8 °)
   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 mn time-step, 3 hour time-step for radiative transfer;
      - top layer 0.05 hPa, progressive hybrid sigma-pressure vertical coordinate with 45 layers, 23 layers above 200 hPa, usually 7 layers below 850 hPa (less in regions of high orography)
   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.)
      - temperature, northward and eastward wind components, specific humidity, ozone concentration, surface pressure
   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: OPA 8.1 developped by LODYC (Madec et al. 1998)

1. Resolution: 182 x 152 grid (with resolution of about 2° in longitude, and resolution varying in latitude from near 0.5° at the equator to roughly 2° in polar regions).

2. Numerical scheme/grid, including advection scheme, time-stepping scheme, vertical coordinate, free surface or rigid lid, virtual salt flux or freshwater flux
   - Arakawa C grid, Advection scheme: upstream
   - time-stepping scheme: 15 time-steps per day. The non-diffusive part of the scheme is treated in leapfrog, whereas the differencing scheme of the diffusive part is implicit.
   - z-coordinate (31 vertical levels with 10 levels in the upper 100 m), rigid lid, freshwater flux.

3. List of prognostic variables and tracers:
   - temperature, salinity, vertical eddy viscosity (TKE scheme), zonal, meridional and vertical velocity components.

4. Name, terse descriptions, and references (journal articles, web pages) for all parameterizations
   - The ocean model is extensively described in : Madec et al. (1997)

5. Include, as appropriate, descriptions of:
   a. Eddy parameterization:
      - vertical : TKE
   b. horizontal :
      - isopycnal diffusion, with eddy viscosity of 40000 m2/s for momentum and eddy diffusivity equal to 2000 m2/s
   c. Bottom boundary layer treatment and/or sill overflow treatment
      - zero fluxes of heat and salt, and linear friction on momentum
   d. Mixed-layer treatment:
      - 1.5 turbulent closure scheme (Blanke and Delecluse, 1993). Sunlight penetration: downward irradiance formulated with two extinction coefficients (Paulson and Simpson, 1977) with values corresponding to a type I water in Jerlov's classification
   e. Tidal mixing:
      - no
   f. River mouth mixing:
      - distribution of freshwater fluxes from rivers over several ocean grid points
   g. Mixing isolated seas with the ocean:
      - none
   h. Treatment of North Pole "singularity" (filtering, pole rotation, artificial island?)

- no pole singularity in the chosen OPA grid (Madec and Imbard, 1996)

C. Sea ice

The GELATO, developed at CNRM by David Salas y Melia, is described in Salas-Mélia, D. (2002).

1. Horizontal resolution, number of layers, number of thickness categories
   - grid: same as OPA's. Number of layers: 4 in the ice part of the slab, 1 in the snow part of the slab. Number of thickness categories : 4, 0-0.3m, 0.3-0.8m, 0.8-3m, and 3m or more.
2. Numerical scheme/grid, including advection scheme, time-stepping scheme,
   - time-stepping scheme: leap frog, except for heat diffusion in the sea-ice/snow slab (implicit scheme).
   - advection scheme : semi-lagrangian (from CICE model), as described in Hunke et al. (2002)
3. list of prognostic variables
   - For this experiment, a reduced set of prognostic variables is produced: sea ice zonal and meridional velocity components, concentration, albedo, thickness, snow layer thickness, surface temperature, ocean flux, net heat flux weighted on the marine surface, net heat flux weighted on the different sea ice categories, virtual fresh water flux at the base of sea ice, net sea ice production field.

4. Completeness (dynamics? rheology ? leads? snow treatment on sea ice)
   - includes: elastic-viscous-plastic (EVP) rheology (Hunke and Dukowicz, 1997), leads and snow treatment on sea ice
5. Treatment of salinity in ice
   - sea ice salinity is constant in GELATO (6 psu)
6. brine rejection treatment
   - sea ice melting and freezing gives birth to a salt flux which is computed as a 'virtual freshwater flux'
7. treatment of the North Pole 'singularity' (filtering, pole rotation, artificial island?)
   - no pole singularity as GELATO grid is the same as OPA's.

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
   - 2.8°, 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
   - runoff is transported to the ocean with the river routing scheme TRIP developed by T. Oki (Oki, T. and Sud, Y.C., 1998; Oki, T., Wishimyra, T., Dirmeyer, P., 1999; Chapelon et al. 2002)
4. Treatment of snow cover on land:
   - snow parameterization described in Douville et al. (1995a and 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
   - 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
   - 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
   - Climatological calving of icebergs was taken into account around the Antarctic (not Greenland). During the summer season (october to march), a constant flux of ice (0.14 Sv) is calved at the coast. This climatological value was estimated from a preliminary coupled control run in which the average quantity of snow accumulated over the Antarctic was computed. The corresponding mass of snow was found to be close to current estimates of the total mass of ice calved in the Antarctic seas per year. This approximation is valid as long as ice sheets are in steady state, i.e. if they do not significantly shrink or spread, which we assume here.

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:
   - 24 hours
2. Are heat and water conserved by coupling scheme?
   - yes
3. list of variables passed between components:
   a. atmosphere – ocean :
      - temperature over sea, non solar heat flux, solar heat flux, water flux, zonal wind stress, meridional wind stress, evaporation flux, liquid precipitation, solid precipitation, non solar heat flux derivative
   b. atmosphere – land :
      - radiative and turbulent surface fluxes, temperature, albedo, surface roughness, soil moisture

c. land – ocean:
   - runoff et river outlet
d. sea ice – ocean:
   - sea surface temperature, salinity, currents, mixed layer depth, ice-> ocean momentum, freshwater and heat fluxes
e. sea ice – atmosphere:
   - temperature over sea-ice, sea-ice albedo, sea-ice concentration, non solar heat flux, solar heat flux, water flux, zonal wind stress, meridional wind stress, evaporation flux, liquid precipitation, solid precipitation, non solar heat flux derivative
f. Flux adjustment? (heat?, water?, momentum?, annual?, monthly?)
   - no flux adjustment

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

Picntrl/Run_1

This preindustrial control simulation was initialized from a coupled simulation of a previous version of CNRM coupled model initialized an ocean at rest with temperature and salinity profiles specified from Levitus (1982) climatology, integrated for 30 years with a relaxation of surface temperature to the monthly mean Reynolds climatology for 1950. The CNRM-CM3 version was then integrated for 70 year with preindustrial 1860 greenhouse gases concentrations as a spin-up. After this spin-up period results have been stored from nominal years 1930 to 2429.

20C3M/Run_1

This simulation was initialized from January/2040 of the Picntrl/Run_1 simulation Solar forcing was set at 1370 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/) interpolated at annual resolution. Results are given for the years 1860 to 2000.

Commit/Run_1

This simulation was initialized from January/2000 of the 20C3M/Run_1 simulation. The radiative forcing agents are fixed at their year 2000 value. Results are given for years 2000 to 2100.

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.univlille1.fr/~boucher/sres/) interpolated at annual resolution. 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/) interpolated at annual resolution. 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/) interpolated at annual resolution. Results are given for years 2000 to 2300.

1%to2x/Run_1

This simulation was initialized from January/2040 of the PIcntrl/Run_1 simulation. This initial state corresponds to nominal year 1860 of 1%to2x/Run1 experiment. The concentrations of greenhouse gases are held constant at preindustrial levels, except for CO2, which increases from its preindustrial level (286.2 ppm) at the rate of 1% per year, until the initial concentration is doubled. From the time of doubling (nominal year 1930 of the run), the concentrations of all radiative forcing are held constant for 150 years. Results are given for nominal years 1860 to 2080.

1%to4x/Run_1

This simulation was initialized from January/2040 of the PIcntrl/Run 1 simulation. This initial state corresponds to nominal year 1860 of 1%to2x/Run1 experiment. The concentrations of greenhouse gases are held constant at preindustrial levels, except for CO2, which increases from its preindustrial level (286.2 ppm) at the rate of 1% per year, until the initial concentration is quadrupled. From the time of quadrupling (nominal year 2000 of the run), the concentrations of all radiative forcing are held constant for 150 years. Results are given for nominal years 1860 to 2150.

AMIP/Run_1

The initial condition for this simulation was the 1 Dec 1977 of the 20C3M/Run_1. The year 1978 was used as a spin-up period before storing the results over 1979-2000

VI. References

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