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

ECHAM5_MPI-OM

31 January 2005

I. Model identity:

A. Institution, sponsoring agency, country: Max Planck Institute for Meteorology, Germany
B. Model name (and names of component atmospheric, ocean, sea ice, etc. models): ECHAM5/MPI-OM
C. Vintage (i.e., year that model version was first used in a published application): 2005
D. General published references and web pages: Jungclaus et al. (2005)
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. N/A
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.): Climate sensitivity parameter is 0.835 (estimated from slab ocean experiments: control and CO2 doubling: ΔT=3.35K; adjusted forcing at the tropopause: 4.01 Wm^{-2})
G. Contacts (name and email addresses), as appropriate, for:
   1. coupled model: Erich Roeckner (roeckner@dkrz.de)
   2. atmosphere: Erich Roeckner
   3. ocean: Johann Jungclaus (jungclaus@dkrz.de)
   4. sea ice: Uwe Mikolajewicz (mikolajewicz@dkrz.de)
   5. land surface: Erich Roeckner
   6. vegetation: Stefan Hagemann (hagemann@dkrz.de)
   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? Yes (not active)
B. interactive biogeochemistry? Yes (not active)
C. what aerosols and are indirect effects modeled? In the IPCC runs done so far, sulfate aerosol is prescribed (direct and first indirect effect). An experiment with interactive aerosols is in progress (A1B) including the first and second indirect effects as well as the semi-direct effect.
D. dynamic vegetation? No
E. ice-sheets? No

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 (yes)

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

A. Atmosphere (ECHAM5; Roeckner et al., 2003)
  1. resolution: T63 L31 (TAR = T42 L19)
  2. numerical scheme/grid (advective and time-stepping schemes; model top; vertical coordinate and number of layers above 200 hPa and below 850 hPa): Spectral, semi-implicit/leap-frog, flux form semi-Lagrangian scheme (Lin and Rood, 1996) for water components; top level at 10 hPa, 9 layers above 200 hPa, 5 layers below 850 hPa)
  3. list of prognostic variables: Vorticity, divergence, temperature, log surface pressure, water vapor, cloud liquid water, cloud ice. Model output variable names are not needed, just a generic descriptive name (e.g., temperature, northward and eastward wind components, etc.): N/A
  4. name, terse descriptions, and references (journal articles, web pages) for all major parameterizations. Include, as appropriate, descriptions of:
     a. clouds: Prognostic equations for the water phases (vapor, liquid, ice), bulk cloud microphysics (Lohmann and Roeckner, 1996), relative humidity based cloud cover parameterization. The microphysics scheme includes phase changes between water components and precipitation processes (autoconversion, accretion, aggregation). Evaporation/sublimation of rain/snow and melting of snow are considered as well as sedimentation of cloud ice.
     b. convection: Mass flux scheme for shallow, mid-level and deep convection (Tiedtke, 1989) with modifications for deep convection according to Nordeng (1994). The scheme is based on steady state equations for mass, heat, moisture, cloud water and momentum for an ensemble of updrafts and downdrafts including turbulent and organized entrainment and detrainment. Cloud water detrainment in the upper part of the convective updrafts is used as source term in the stratiform cloud water equations. For deep convection, an adjustment-type closure is used with convective activity expressed in terms of convective available potential energy.
     c. boundary layer: Surface fluxes are computed from bulk relationships with transfer coefficients according to Monin-Obukhov similarity theory. Transpiration is limi ted by stomatal resistance and bare soil evaporation by the availability of soil water. Eddy viscosity and diffusivity are parameterized in terms of turbulent kinetic energy and length scales involving the mixing length and stability functions for momentum and heat, respectively (Brinkop and Roeckner, 1995).
     d. SW, LW radiation: The SW scheme (Fouquart and Bonnel, 1980) uses the Eddington approximation for the integration over zenith and azimuth angles and the delta-Eddington approximation for the reflectivity of a layer. The scheme includes Rayleigh scattering, absorption by water vapor, ozone, and well-mixed gases. The scheme has four spectral bands, one for visible+UV range, and three for the near infrared. (TAR = one for near infrared). Single scattering properties of clouds are determined on the basis of Mie calculations using idealized size distributions for cloud droplets and ice crystals. The LW (RRTM) scheme (Mlawer et al., 1997), is based on the correlated-k method. Absorption coefficients were derived from the LBLRTM line-by-line model (Clough et al., 1989) and include the effect of the CKD2.2 water vapor

continuum. The RRTM scheme computes fluxes in the spectral range 10 cm^{-1} to 3000 cm^{-1}. The computation is organized in 16 spectral bands and includes line absorption by water vapor, ozone and well-mixed gases. For cloud droplets, the mass absorption coefficient is a function of the respective effective radius with coefficients independent of wavenumber as obtained from a polynomial fit to the results of Mie calculations. For ice clouds, an inverse dependency of the mass absorption coefficient on the ice crystal effective radius is assumed and the coefficients vary with wavenumber (Ebert and Curry, 1992).

e. any special handling of wind and temperature at top of model: Gradual increase of the horizontal diffusion coefficients in the top 5 layers.

f. gravity wave drag: The scheme (Lott and Miller, 1997) takes into account two main mechanisms of interaction between subgrid-scale orography and the atmospheric flow: momentum transfer from the earth to the atmosphere accomplished by orographic gravity waves, and the drag exerted by the subgrid-scale mountain when the air flow is blocked at low levels.

B. Ocean (Marsland et al., 2003)

1. resolution: 1.5 deg, conformal mapping grid with grid poles over Greenland and Antarctica, 40 vertical levels
2. numerical scheme/grid, including advection scheme, time-stepping scheme, vertical coordinate, free surface or rigid lid, virtual salt flux or freshwater flux: C-grid, semi-implicit solver for barotropic part, free surface, fresh water flux, z-coordinate with partial cells.
3. list of prognostic variables and tracers: u, v, w, t, s, surface elevation
4. name, terse descriptions, and references (journal articles, web pages) for all parameterizations. Include, as appropriate, descriptions of:
    a. eddy parameterization: Gent et al., 1995; Griffies, 1998.
    b. bottom boundary layer treatment and/or sill overflow treatment: Beckmann-Doescher like BBL parameterization with modifications (Marsland et al., 2003).
    c. Tracer advection: Sweby et al., 1984
    d. Isopycnal diffusion**:** Redi, 1982
    e. mixed-layer treatment: Vertical eddy viscosity and diffusion: Richardson-number dependent scheme of Pacanowski and Philander (1981). Additional wind mixing parameterization included. Wind stirring near the surface is proportional to the cube of the 10 m wind speed and decays exponentially with depth.
    f. sunlight penetration: exponential decay, constant e-folding depth.
    g. tidal mixing: N/A
    h. river mouth mixing: N/A
    i. mixing isolated seas with the ocean N/A
    j. treatment of North Pole "singularity": Pole rotation

C. sea ice

1. horizontal resolution, number of layers, number of thickness categories: same horizontal resolution as ocean, one layer (plus snow), one ice category.
2. numerical scheme/grid, including advection scheme, time-stepping scheme: C-grid as in ocean, implicit, upwind advection

3. list of prognostic variables: ice thickness, ice concentration, ice velocities (u,v), snow depth
4. completeness (dynamics?: YES rheology?: Hibler, 1979, thermodynamics: Semtner, 1976. Leads?: YES snow treatment on sea ice?: one snow layer, conversion of snow to ice)
5. treatment of salinity in ice: constant sea ice salinity (5psu)
6. brine rejection treatment: YES
7. treatment of the North Pole "singularity" (filtering, pole rotation, artificial island?): as in ocean component: pole rotation

D. land / ice sheets (some of the following may be omitted if information is clearly included in cited references.
   1. resolution (tiling?), number of layers for heat and water: The resolution is the same as for the atmosphere (no tiling). 5 layers for heat, 1 layer for water (bucket).
   2. treatment of frozen soil and permafrost: No special treatment of frozen soil, no permafrost.
   3. treatment of surface runoff and river routing scheme: Surface runoff and drainage depend on the heterogeneous distribution of field capacities within a grid-cell (Dümenil and Todini, 1992). The hydrological discharge is computed at a resolution of 0.5° (Hagemann and Dümenil Gates, 2001). Overland flow (fed by surface runoff) and riverflow are both represented by a cascade of n equal linear reservoirs, and baseflow (fed by drainage and grid box inflow) is represented by a single linear reservoir.
   4. treatment of snow cover on land: The snow cover is a function of snow depth and slope of terrain approximated by the subgrid-scale standard deviation of height. The snow cover of the canopy is defined as the ratio of snow depth at the canopy and the interception capacity which is a function of the leaf area index (Roesch et al., 2001)
   5. description of water storage model and drainage. Changes in soil water due to rainfall, evapotranspiration, snow melt surface runoff, and drainage are calculated for a single bucket with geographically varying field capacity. The amount of drainage is governed by the ratio of soil water and field capacity.
   6. surface albedo scheme: The albedo of snow and ice depends on surface temperature. Over snow covered land, the mean albedo of a grid-cell depends on fractional forest area, leaf area index, bare soil albedo, snow albedo, fractional snow cover at both ground and canopy and slope of terrain (Roesch et al, 2001). Ground albedo is obtained from allocation to global ecosystem types blended with satellite data over desert regions (Hagemann, 2002).
   7. vegetation treatment (canopy?) Vegetation cover, leaf area index, and forest fraction are prescribed for every month (Hagemann, 2002).
   8. list of prognostic variables: Soil temperature, snow at the canopy, snow at the surface, liquid water at the canopy, and soil water.
   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 sheets are prescribed. There is neither melting nor accumulation of snow, i.e. (snowfall-sublimation) is transferred to the ocean.

E. coupling details
   1. frequency of coupling: daily (atmosphere and ocean/sea ice)
   2. Are heat and water conserved by coupling scheme? yes

3. list of variables passed between components:
    a. atmosphere – ocean: heat, freshwater, momentum, 10m wind speed, solar radiation, sea surface temperature, ocean surface current (u,v components)
    b. atmosphere – land: single system (no flux coupler used)
    c. land – ocean: water flux to ocean (also from ice sheets)
    d. sea ice – ocean: single system (no flux coupler used)
    e. sea ice – atmosphere: conductive heat flux, residual heat flux (used for melting of sea ice), snowfall-sublimation, momentum, sea ice concentration, sea ice thickness, snow depth on ice, ice velocity (u,v components)
4. Flux adjustment? (heat?, water?, momentum?, annual?, monthly?). No

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

A. IPCC "experiment" name: PIcntrl
B. Initialized at year 300 of an experiment with a similar (but not identical) model version and present-day greenhouse gas concentrations. The model was then run for another 144 years (with minor changes) under pre-industrial conditions until it was 'frozen' in model year 2122 (note that only model years 2150-2655 are available in the database).
C. Well-mixed greenhouse gases (CO2, CH4, N2O) are constant (year 1860). Present-day ozone climatology (Fortuin and Kelder, 1998) and background aerosol (Tanre et al., 1984) is applied.

D. IPCC "experiment" name: 20C3M
E. Jan 2190 from PIcntrl (run1), Jan 2015 from PIcntrl (run2), Jan 2040 from PIcntrl (run3)
F. There are only anthropogenic forcings, i.e., CO2, CH4, N2O, F11 (effective), F12, ozone (Kiehl et al., 1999), and sulfate (http://www-loa.univ-lille1.fr/~boucher/sres/). Anthropogenic ozone is defined as the difference between the actual value in the respective year and the 'pre-industrial' value (year 1870).

G. IPCC "experiment" name: Commit
H. Continuation of 20C3M (runs1,2,3)
I. Concentrations as in 20C3M, but kept constant (year 2000) throughout the simulations

J. IPCC "experiment" name: SRESA2
K. Continuation of 20C3M (runs1,2,3)
L. CO2, CH4, N2O, F11 (effective), F12, anthropogenic ozone (stratosphere only), and anthropogenic sulfate (http://www-loa.univ-lille1.fr/~boucher/sres/).

M. IPCC "experiment" name: SRESA1B
N. Continuation of 20C3M (runs1,2,3)
O. CO2, CH4, N2O, F11 (effective), F12, anthropogenic ozone (stratosphere only), and anthropogenic sulfate (http://www-loa.univ-lille1.fr/~boucher/sres/). Constant concentrations after year 2100

P. IPCC "experiment" name: SRESB1

Q. Continuation of 20C3M (runs1,2,3)
R. CO_2, CH_4, N_2O, F11 (effective), F12, anthropogenic ozone (stratosphere only), and anthropogenic sulfate (http://www-loa.univ-lille1.fr/~boucher/sres/). Constant concentrations after year 2100

S. IPCC "experiment" name: 1%to2x
T. Jan 2190 from PIcntrl (run1), Jan 2015 from PIcntrl (run2), Jan 2040 from PIcntrl (run3)
U. 1% increase of CO_2 per year until CO_2 doubling (model year 1930) and stabilization thereafter (until model year 2080)

V. IPCC "experiment" name: 1%to4x
W. Jan 2030 from 1%to2x (run2)
X. 1% increase of CO_2 per year until CO_2 quadrupling (model year 2000) and stabilization thereafter (until model year 2150)

Y. IPCC "experiment" name: Slabcntl
Z. Jan 1978 from AMIP (run1) including precalculated Q-flux from AMIP (run1)
AA. Well-mixed greenhouse gases (CO_2, CH_4, N_2O, F11, F12) are constant (year 1985). Present-day ozone climatology (Fortuin and Kelder, 1998) and background aerosol (Tanre et al., 1984) is applied.

BB. IPCC "experiment" name: 2xCO_2
CC. Jan 1978 from AMIP (run1) including precalculated Q-flux from AMIP (run1)
DD. Instantaneous CO_2 doubling w.r.t. Slabcntl (model years 2001-2100 in database)

EE. IPCC "experiment" name: AMIP
FF. Jan 1978 (observed) for all 3 runs. Initial perturbations in runs2,3 are realized by small changes in the horizontal diffusion coefficients during the first month.
GG. Well-mixed greenhouse gases (CO_2, CH_4, N_2O, F11, F12) are constant (year 1985). Present-day ozone climatology (Fortuin and Kelder, 1998) and background aerosol (Tanre et al., 1984) is applied.

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