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

ECHO-G

27 August 2005

I. Model identity:

A. Institution, country: Meteorological Institute of the University of Bonn (Germany), Institute of KMA (Korea), and Model and Data Group.
B. Model name (and names of component atmospheric, ocean, sea ice, etc. models): ECHO-G = ECHAM4 + HOPE-G
C. Vintage: 2001
D. General published references and web pages: http://mad.zmaw.de/Models/Modelliste1_neu.html
E. The atmosphere is identical to the first release of ECHAM4 (ECHAM4.0) used for AMIP1 besides a flux aggregation method for cells containing sea ice (Grötzner et al. 1996).
F. IPCC model version's global climate sensitivity ($KW^{-1}m^2$) to increase in CO_2:
slab ocean:0.8 K $W^{-1}m^2$ with $2xCO_2$ (3.18 K temperature increase with $4W/m^2$ radiative forcing)
transient coupled: 20 yr (69-79) mean temperature difference centered at CO_2 doubling is 1.73 K

G. Contacts (name and email addresses), as appropriate, for:
1. IPCC experiments: Seung-Ki Min (skmin@uni-bonn.de)
2. coupling: Stephanie Legutke (legutke@dkrz.de)
3. atmosphere: Ulrich Schlese (schlese@dkrz.de)
4. ocean: Stephanie Legutke (legutke@dkrz.de)
5. sea ice: Stephanie Legutke (legutke@dkrz.de)
6. land surface: Ulrich Schlese (schlese@dkrz.de)
7. vegetation: Ulrich Schlese (schlese@dkrz.de)
8. aerosols scheme: Ulrich Schlese (schlese@dkrz.de)

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? Sulfate aerosol is treated as described in in Feichter et al. (1997) and includes direct and indirect effects.
D. dynamic vegetation? No
E. ice-sheets? No. Precipitation on ice sheets is converted to discharge into the ocean.

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.

AMIP1 (no)
CMIP2++ (yes)

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

A. Atmosphere (Roeckner et al., 1996)
   1. resolution: T30 L19
   2. numerical scheme/grid: spectral; hybrid sigma-pressure coordinate (Simmons and Strüfing, 1981); top level at 10 hPa (ca. 30 km); 7 layers above 200 hPa, 5 layers below 850 hPa; semi-implicit leap-frog time stepping; transport of water vapor, cloud water, and (optionally) tracers by a semi-lagrangian scheme (Williamson and Rasch, 1994);
   3. list of prognostic variables: vorticity, divergence, temperature, log surface pressure, water vapor, mixing ratio of total cloud water;
   4. major parameterizations:
      a. clouds: Sundquist(1978) type prognostic scheme for stratiform fractional clouds; optical cloud properties and cloud water determined by Mie theory (Rockel et al., 1991; Roeckner, 1995);
      b. convection: shallow, mid-level, and deep cumulus convection with Tiedke (1989) mass flux scheme and adjustment closure for deep convection as described by Nordeng (1996);
      c. boundary layer: surface fluxes of momentum, heat, water vapor, and cloud water calculated with Monin-Obukhov theory (Luis, 1979), with eddy diffusivity coefficients depending on roughness length and Richardson No.; above the surface layer, the coefficients depend on wind shear, thermal stability, and mixing length;
      d. SW radiation: Fouquart and Bonnel(1980), LW radiation: Morcrette et al. (1986) includes methane, nitrous oxide, and 16 CFC species, ozone (14.6 µm), and various types of aerosols (optional) effects; revised water vapor continuum (Giorgetta and Wild, 1995);

B. Ocean (Legutke and Maier-Reimer, 1999)
   1. resolution: even grid rows (E/W) correpond to a T42 Gaussian grid in high and mid latitudes; towards the equator the meridional distances decrease (min = 0.5 deg); 20 levels;
   2. numerical scheme/grid: Arakawa E grid; z-level coordinates with partial bottom cells (Adcroft et al., 1997); implicit solver for barotropic mode; free surface; freshwater fluxes;
   3. list of prognostic variables and tracers: potential temperature, salinity, zonal and meridional velocity, surface elevation;
   4. parameterizations:
      a. harmonic and shear-dependent eddy diffusion of tracers;
      b. tracer advection with a predictor-corrector central differencing scheme;

c. local strain-rate dependent eddy dissipation with memory; constant harmonic and biharmonic horizontal dissipation;
d. vertical mixing: constant background viscosity and diffusion; Richardson-number dependent scheme of Pacanowski and Philander (1981);
e. mixed-layer treatment: additional surface vertical diffusion/viscosity for weak surface stratification;
f. sunlight penetration: exponential decay, constant e-folding profile; max depth 100 m;
g. tidal mixing: No
h. river mouth mixing: No
i. mixing isolated seas with the ocean: there are no isolated seas
j. treatment of North Pole "singularity": artificial island with free-slip, no-flux, zonal smoothing;

C. sea ice (Wolff et al. 1997)
1. resolution: on ocean horizontal grid, 0-layer (Semtner, 1976) thermodynamics plus snow; two ice thickness categories;
2. numerical scheme/grid: E-grid as in ocean; implicit upwind advection of ice volume and concentration; implicit momentum equation with viscous-plastic rheology (Hibler 1979)
3. list of prognostic variables: ice volume, ice concentration, ice velocities (u,v), snow volume;
4. completeness of ice model:
   dynamics: YES, no momentum advection;
   rheology: Hibler (1979) reformulated on E-grid;
   thermodynamics: Semtner (1976) 0-layer;
   leads: ice concentration is a prognostic variable; it is passed to the atmosphere and momentum, freshwater, and heat fluxes are determined separately for the 2 surfaces (Grötzner et al. 1996).;
   snow treatment on sea ice: one snow layer, conversion of snow to ice when draft is larger than ice thickness;
5. treatment of salinity in ice: constant sea ice salinity (5psu)
6. brine rejection: YES
7. treatment of the North Pole "singularity": as in ocean

D. land / ice sheets (Roeckner et al., 1996)

1. soil/glacier: the horizontal resolution is the same as for the atmosphere (no tiling); 5 soil layers for heat diffusion with extra layer if snow is present (> 2.5cm lwe); no flux condition through lower boundary (10m); ice surface temperatures are representative for the upper 10cm of the slab;
2. soil: 1 layer for water (bucket) with reservoir split for evaporation in the non-vegetated part of a cell; snow layer
3. no special treatment of frozen soil except that all surface water on frozen soil immediately runs off
4. no permafrost
5. surface runoff accounts for subgrid scale variations of field capacity over inhomogenous terrain; routing scheme based on catchment considerations (Sausen et al., 1994)

6. treatment of snow cover on land: extra layer for land surface heat diffusion if snow is present (> 2.5cm lwe); canopy interception (skin reservoir) of snow as a function of monthly mean climatological leaf area index; heat budget for surface 2.5 cm lwe;
7. description of water storage model and drainage: changes in soil water due to rainfall, evaporation with reservoir split, snow melt, surface runoff, and drainage are calculated for a single bucket with geographically varying field capacity; precipitation on frozen soil runs off completely;
8. surface albedo scheme: albedo on ice and snow is a function of skin temperature; albedo on land is a function of ice/snow cover and their temperatures, fractional forest area and bare soil albedo (Robock, 1980; Matthews, 1983);
9. vegetation treatment: vegetation cover and leaf area index are prescribed (clim. mon. means);
10. list of prognostic variables: soil temperature, snow at the canopy, snow at the surface, liquid water at the canopy, and soil water.
11. ice sheet characteristics: ice sheet area is prescribed; ice sheet mass is conserved by discharging the net deposition into the ocean on a daily (exchange frequency) basis; the freshwater discharge is in the ice phase at freezing point and therefore is associated with a flux of latent heat and cools the upper ocean (simulating oceanic ice shelf melting); no ice sheet dynamics or thermodynamics;

E. coupling details (Legutke and Voss, 1999)
   1. frequency of coupling: daily exchange of time averaged fields
   2. heat and water are conserved by the coupling and interpolation scheme;
   3. list of variables passed between components:
      a. atmosphere –> ocean:
         conductive heat flux through sea ice; net heat flux over open water; liquid freshwater flux into upper ocean (includes solid flux over open water and liquid flux over sea ice), momentum flux, solar radiation for solar penetration into deeper layers;
      b. ocean -> atmosphere:
         sea surface temperature
      c. atmosphere <–> land:
         local runoff with spatially varying soil water holding capacity; reservoir split for evaporation; diffusive heat flux; interception of precipitation and snow fall in the canopy; stomatal control of evapotranspiration;
      d. land –> ocean:
         water flux to ocean calculated with a surface runoff routing scheme (Sausen et al., 1994); discharge from continental ice sheets assuming ice sheet mass is constant on a daily basis (Greenland/Antarctica) together with a corresponding flux of heat of fusion, assuming that all water flux from the continental ice sheets is in the ice phase at freezing temperature;
      e. sea ice <–> ocean:
         the sea ice growth modifies the upper layer water through salinity changes of the upper layer; it ‘warms’ the upper layer by consuming the heat corresponding to an increase of ocean temperatures to freezing point for ice growth; it modifies the surface windstress (the ice-ocean momentum flux is formulated with a quadratic drag law)
      f. sea ice –> atmosphere: sea ice concentration, effective sea ice thickness (incl. snow conductivity effect), snow depth on ice

g. atmosphere -> sea ice:
   residual heat flux (used for surface melting of sea ice/snow), net snowfall (precipitation-sublimation) over sea ice

4. Flux adjustment:
   Yes (heat, water, annual) outside sea ice region (climatological extent)

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

1. IPCC "experiment" name: PDcntrl
   A. 2034 yrs ocean forced spin-up with ECHAM4/T42 daily fields; 18 yrs atmos spin-up with lower boundary conditions from the last 100 yrs of the ocean spin-up run; 155 coupled spin-up with SST (40 W/m^2K) and SSS (30 day time scale for 20 m upper layer) relaxation; flux correction diagnosed from the last 100 yrs of the coupled spin-up run;
   B. year 311 of the continued run without relaxation but flux corrections is year 1 of the PDcntrl experiment;
   C. Present-day greenhouse-gas concentrations (at year 1990) are applied (CO2=353 ppm, CH4=1720 ppb, N2O=310 ppb).

2. IPCC "experiment" name: PIcntrl
   Ocean initialized with year 199 of a preindustrial control experiment with a model version without aerosols (restarted from Levitus climatology by Free University of Berlin, contact: Frank caspar, caspar@dkrz.de) and preindustrial greenhouse gas concentrations (CO2=286.20 ppm, CH4=805.60 ppb, N2O=276.69 ppb); 6 yrs coupled spin-up (ECHAM4 initialized with a climatology)
   A. Preindustiral ozone climatology and background aerosol (at year 1860) are applied (Roeckner et al. 1999).

3. IPCC "experiment" name: 20C3M
   A. Initialized at jan200 (run1), jan300 (run2), jan400 (run3) of a preindustrial control experiment with a model version without aerosols (restarted from Levitus climatology by Free University of Berlin, contact: Frank Kaspar, kaspar@dkrz.de); 6 yrs coupled spin-up; run4 [run5] is initialized with the same conditions as run1 [run2] on a different platform/compiler.
   B. Natural and anthropogenic forcing is applied. Natural (solar and volcanic) forcing is implemented through temporally varying solar constant (Crowley, 2000); Anthropogenic forcing is composed of emissions of greenhouse-gases (CO2, CH4, N2O, effective F11, F12; from ENSEMBLE project), tropospheric ozone and sulfate aerosols (Roeckner et al., 1999); Direct and first-indirect effects of aerosols are considered.

4. IPCC "experiment" name: Commit
   A. Continuation of 20C3M (runs1,2,3,4,5)
   B. Concentrations as in 20C3M, but kept constant (year 2000) throughout the simulations

5. IPCC "experiment" name: SRESA2
   A. Continuation of 20C3M (runs1,2,3)
   B. Greenhouse-gases and sulfate aerosols following SRES A2 scenario for 2001-2100; tropospheric ozone (interpolated linearly between 1985 and 2050 based on IS92a scenario, constant after 2050)

6. IPCC "experiment" name: SRESA1B
   A. Continuation of 20C3M (runs1,2,3)
   B. Greenhouse-gases and sulfate aerosols following SRES A1B scenario for 2001-2100 and constant after 2100; tropospheric ozone (interpolated linearly between 1985 and 2050 based on IS92a scenario, constant after 2050)

7. IPCC "experiment" name: SRESB1
   A. Continuation of 20C3M (runs1,2,3,4,5)
   B. Greenhouse-gases and sulfate aerosols following SRES B1 scenario for 2001-2100 and constant after 2100; tropospheric ozone (interpolated linearly between 1985 and 2050 based on IS92a scenario, constant after 2050)

8. IPCC "experiment" name: 1%_to2x
   A. same restart conditions and radiative forcing agents as PDcntrl in year 1;
   B. from year 2 up CO_2 concentration is increased by 1% / yr for 70 yrs and is kept constant from yr 71 up; the other GHG concentrations are constant;

9. IPCC "experiment" name: 1%_to4x
   A. same restart conditions and radiative forcing agents as PDcntrl in year 1;
   B. from year 2 up CO_2 concentration is increased by 1% / yr for 140 yrs and is kept constant from yr 141 up; the other GHG concentrations are constant;

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