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

CCSM3

31 January 2005

I. Model identity:
A. Institution, sponsoring agency, country

National Center for Atmospheric Research (NCAR),
NSF (a primary sponsor), DOE (a primary sponsor), NASA, and NOAA
USA

B. Model name (and names of component atmospheric, ocean, sea ice, etc. models)

Coupled model - Community Climate System Model, version 3.0 (CCSM3)
Atmosphere - Community Atmosphere Model, version 3.0 (CAM3)
Ocean - Parallel Ocean Program, version 1.4.3 (POP 1.4.3)
Sea ice - Community Sea Ice Model, version 5.0 (CSIM5)
Land - Community Land Model, version 3.0 (CLM3)

C. Vintage (i.e., year that model version was first used in a published application)

6irst control runs and IPCC runs were run and submitted for publication in 2004. First publication containing CCSM3 results will appear in 2005.

D. General published references and web pages

Main website - http://www.ccsm.ucar.edu

Publications submitted to a special issue of the Journal of Climate describing CCSM3 are available from http://www.ccsm.ucar.edu/publications/jclim04/Papers_JCL04.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.

There are a series of NCAR technical reports available from http://www.ucar.edu/communications/technotes/technotes401-.shtml

TN-455+STR The Sea Ice Simulation of the Community System Model, Version Two, B.P. Briegleb, E.C. Hunke, C.M. Bitz, W.H. Lipscomb, M.M. Holland, J.L Schramm, and R.E. Moritz, CGD. 38 pp. January 2004. NTIS #PB2004-105849.

TN-461+STR Technical Description of the Community Land Model (CLM), Keith

W. Oleson, Yongjiu Dai, Gordon Bonan, Mike Bosilovich, Robert Dickinson, Paul Dirmeyer, Forrest Hoffman, Paul Houser, Samuel Levis, Guo-Yue Niu, Peter Thornton, Mariana Vertenstein, Zong-Liang Yang, Xubin Zeng, CGD. 183 pp. May 2004, NTIS #PB2004-105836.

TN-463+STR Scientific Description of the Sea Ice Component in the Community Climate System Model, Version Three, B.P. Briegleb, C.M. Bitz, E.C. Hunke, W.H. Lipscomb, M.M. Holland, J.L. Schramm, and R.E. Moritz, CGD, 75 pp. June 2004, NTIS #PB2004-106574.

TN-464+STR Description of the NCAR Community Atmosphere Model (CAM 3.0), W.D. Collins, P.J. Rasch, B.A. Boville, J.R. McCaa, D.L. Williamson, J.T. Kiehl, B. Briegleb, C. Bitz, S.-J. Lin, M. Zhang, and Y. Dai, CGD, 214 pp. June 2004.

LANL technical reports:

Smith, R. D. and P. R. Gent, 2002: Reference manual for the Parallel Ocean Program (POP), ocean component of the Community Climate System Model (CCSM2.0 and 3.0). Technical Report LA-UR-02-2484, Los Alamos National Laboratory, available online at http://www.ccsm.ucar.edu/models/ccsm3.0/pop.

Refereed papers (partial list):

Bonan, G. B., K. W. Oleson, M. Vertenstein, S. Levis, X. Zeng, Y. Dai, R. E. Dickinson and Z.-L. Yang, 2002: The land surface climatology of the Community Land Model coupled to the NCAR Community Climate Model. J. Clim., 15, 3123-3149.

Bonan, G. B., S. Levis, L. Kergoat, and K. W. Oleson, 2001: Landscapes as patches of plant functional types: An integrating approach for climate and ecosystem models. Glob. Biogeochem. Cycles, 16, 5.1-5.23.

Boville, B. A. and C. S. Bretherton, 2003: Heating and dissipation in the NCAR Community Atmosphere Model. J. Clim., 16, 3877-3887.

Collins, W. D., 2001: Parameterization of generalized cloud overlap for radiative calculations in general circulation models. J. Atmos. Sci., 58, 3224-3242.

Collins, W. D., J. K. Hackney, and D. P. Edwards, 2002: A new parameterization for infrared emission and absorption by water vapor in the National Center for Atmospheric Research Community Atmosphere Model. J. Geophys. Res., 107, 8028, doi:10.1029/2000JD000032.

Connolley, W. M., J. M. Gregory, E. C. Hunke, and A. J. McLaren, 2004: On the consistent scaling of terms in the sea ice dynamics equation. J. Phys. Oceanogr., 1776-1780.

Kiehl, J. T. and P. R. Gent, 2004: The Community Climate System Model, Version Two. J. Clim., 17, 3666-3682.

Libscomb, W. H. and E. C. Hunke, 2004: Modeling sea-ice transport using incremental remapping. Mon. Wea. Rev., 132, 1341-1354.

Ohlmann, J. C., 2004: Ocean radiant heating in climate models. J. Clim., 16, 1337-1351.

Williamson, D. L., 2002: Time-split versus process-split coupling of parameterizations and dynamical core. Mon. Wea. Rev., 130, 2024-2041.

Zhang, M., W. Lin, C. B. Bretherton, J. J. Hack, and P. J. Rasch, 2003: A modified formulation of fractional stratiform condensation rate in the NCAR Community Atmosphere Model (CAM2). J. Geophys. Res., 108, 4035, doi:10.1029/2002JD002523.

F. IPCC model version's global climate sensitivity (KW-1m2) to increase in CO2 and how it was determined (slab ocean expt., transient expt--Gregory method, =B12K Cess expt., etc.)

2.7 K / (3.5 W/m^2), from a slab ocean experiment

G. Contacts (name and email addresses), as appropriate, for:

1. coupled model

William Collins, wcollins@ucar.edu

2. atmosphere

Philip Rasch, pjr@ucar.edu

3. ocean

Bill Large: wily@ucar.edu

4. sea ice

Marika Holland, mholland@ucar.edu

5. land surface

Gordon Bonan, bonan@ucar.edu

6. vegetation

Gordon Bonan, bonan@ucar.edu

7. other?

IPCC runs: Jerry Meehl, meehl@ucar.edu

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?

Qualified yes: two processes are active:
(1. Modification to GHG concentrations by chemical processes; and
(2. Conversion of SO_2 and DMS to sulfate aerosols (the sulfur cycle).

B. interactive biogeochemistry?

No

C. what aerosols and are indirect effects modeled?

No indirect forcing effects are included.

The semi-direct effect (reduction in cloud amount by aerosol heating) is included.

Aerosol species included:
(1. Sulfates
(2. Black and organic carbon
(3. Sea salt
(4. Soil dust
(5. Stratospheric volcanic aerosols

D. dynamic vegetation?

No

E. ice-sheets?

No (glaciers are specified, but there are no dynamic ice sheets)

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.

AOMIP -- no
Global Land-Atmosphere Coupling Experiment (GLACE): yes
AMIP: no
AMIP2: no
CMIP: no

C4MIP: possibly yes

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

A. Atmosphere

1. resolution

Lateral resolution from 85-wavenumber triangular spectral truncation of the dynamics. At the equator, the spatial resolution is approximately 1.4 degrees.

2. numerical scheme/grid (advective and time-stepping schemes; model top; vertical coordinate and number of layers above 200 hPa and below 850 hPa)

Numerical scheme - Eulerian spectral transform,
with semi-Lagrangian tracer transport
Grid - T85
Time stepping - semi-implicit leapfrog
Model top - 2.2 hPa
Vertical coordinate - generalized terrain-following hybrid coordinate,
26 levels
Number of layers above 200 hPa - 13
Number of layers below 850 hPa - 4

3. list of prognostic variables (be sure to include, as appropriate, liquid water, chemical species, ice, etc.)

a. Vorticity
b. Divergence
c. Temperature
d. Specific humidity
e. Surface pressure
f. Grid box averaged liquid condensate amount
g. Grid box averaged ice condensate amount
h. Nitrous Oxide
i. Methane
j. CFC11
k. CFC12
l. SO2
m. SO4
n. DMS
o. H2O2

4. name, terse descriptions, and references (journal articles, web pages) for all major parameterizations. Include, as appropriate, descriptions of:

a. clouds

Prognostic cloud condensate with diagnotic cloud amount

Rasch, P. J., and J. E. Kristjansson, A comparison of the CCM3 model climate using diagnosed and predicted condensate parameterizations, J. Climate, 11, 1587-1614, 1998.

Zhang, M., W. Lin, C. S. Bretherton, J. J. Hack, and P. J. Rasch, A modified formulation of fractional stratiform condensation rate in the NCAR community atmospheric model CAM2, J. Geophys. Res., 108 (D1), 2003.

Boville, B. A., P. J. Rasch, J. J. Hack, and J. R. McCaa, 2005: Representation of clouds and precipitation processes in the Community Atmosphere Model (CAM3). J. Clim., submitted.

b. convection

Deep convection:
Zhang, G. J., and N. A. McFarlane, Sensitivity of climate simulations to the parameterization of cumulus convection in the Canadian Climate Centre general circulation model, Atmosphere-Ocean, 33, 407-446, 1995.

Shallow convection:
Hack, J. J., Parameterization of moist convection in the National Center for Atmospheric Research Community Climate Model (CCM2), J. Geophys. Res., 99, 5551-5568, 1994.

c. boundary layer

Non-local atmospheric bounday layer scheme

Holtslag, A. A. M., and B. A. Boville, Local versus nonlocal boundary-layer diffusion in a global climate model, J. Climate, 6, 1825-1842, 1993.

Boville, B. A., and C. S. Bretherton, Heating and dissipation in the NCAR community atmosphere model, J. Climate, 16, 3877-3887, 2003.

d. SW, LW radiation

LW: absorptivity-emissivity method for clear-skies, plus Truncated Independent Column Approximation (TICA) for all-sky

SW: delta-Eddington with exponential-sum fit representation of near-IR, truncated ICA (TICA) for all-sky

pre-CCSM3: Kiehl, J. T., J. J. Hack, G. B. Bonan, B. B. Boville, D. L. Williamson, and

P. J. Rasch, The National Center for Atmospheric Research Community
Climate Model: CCM3, J. Climate, 11, 1131-1149, 1998.

Subsequent improvements:

Collins, W. D., Parameterization of generalized cloud overlap for radiative calculations in general circulation models, J. Atmos. Sci., 58, 3224-3242, 2001.

Collins, W. D., J. K. Hackney, and D. P. Edwards, A new parameterization for infrared emission and absorption by water vapor in the National Center for Atmospheric Research Community Atmosphere Model, J. Geophys. Res., 107 (D22), 2002.

e. any special handling of wind and temperature at top of model

Horizontal diffusion of temperature and wind with a del-squared diffusion operator is introduced in the top three layers of the model.

B. Ocean

1. resolution

nominal 1 degree displaced pole horizontal grid
320x384 horizontal grid points
40 vertical levels
1.125degx0.27deg resolution on the equator
northern pole in Greenland

2. numerical scheme/grid, including advection scheme, time-stepping scheme, vertical coordinate,
free surface or rigid lid, virtual salt flux or freshwater flux

third-order upwinding advection
3-time-level second-order modified leapfrog time stepping
40-level geopotential grid extending to 5500m, with resolution increasing from 10m at the surface to 250m in the deep ocean.
implicit free surface
virtual salt flux

3. list of prognostic variables and tracers

grid-oriented zonal and meridional velocity components
vertical velocity
pressure
density
potential temperature
salinity
ideal age
cfc's (included in some integrations, but not all)

4. name, terse descriptions, and references (journal articles, web pages) for all parameterizations.
Include, as appropriate, descriptions of:

Scientific description of POP ocean model available for download at:
http://www.ccsm.ucar.edu/models/ccsm3.0/pop/

a. eddy parameterization
Gent-McWilliams

Gent, P.R. and J.C. McWilliams, 1990: Isopycnal mixing in ocean circulation models. J. Phys. Oceanogr., 20, 150-155.

aa. horizontal viscosity
anisotropic with Smagorinsky-type coefficients

Large, W.G., G. Danabasoglu, J.C. McWilliams, P.R. Gent, and F.O. Bryan, 2001: Equatorial circulation of a global ocean climate model with anisotropic horizontal viscosity. J. Phys. Oceanogr., 31, 518-536.

Smith, R. and J.C. McWilliams, 2003: Anisotropic horizontal viscosity for ocean models. Ocean Modelling, 5, 129-156.

b. bottom boundary layer treatment and/or sill overflow treatment
None

c. mixed-layer treatment
KPP boundary layer mixing with modifications as described in Danabasoglu et al.

Large, W.G., J.C. McWilliams and S.C. Doney, 1994: Oceanic vertical mixing: A review and a model with a nonlocal boundary layer parameterization, Reviews of Geophysics, 32, 363-403.

Danabasoglu, G., W.G. Large, J.J. Tribbia, P.R. Gent, and B.P. Briegleb, 2005: Diurnal Ocean-Atmosphere Coupling, J. Climate, submitted.

d. sunlight penetration
shortwave penetration based on observed monthly chlorophyll distribution and parameterization developed by Carter Ohlmann.

Ohlmann, J.C., 2003: Ocean radiant heating in climate models, J. Climate, 16, 1337-1351.

Danabasoglu, G., W.G. Large, J.J. Tribbia, P.R. Gent, and B.P. Briegleb, 2005: Diurnal Ocean-Atmosphere Coupling, J. Climate, submitted.

e. tidal mixing
None

f. river mouth mixing
river runoff implemented as a surface freshwater flux, spread over active ocean grid points nearest the river mouth, with a falloff distance roughly compatible with

observed sea surface salinity distributions.

g. mixing isolated seas with the ocean

A pointwise freshwater balance in isolated seas diverts any excess/deficit freshwater flux to nearby active ocean regions as a surface flux.

h. treatment of North Pole "singularity" (filtering, pole rotation, artificial island?)

Northern grid pole displaced into Greenland to ~(80N,40W).
Timestep is small enough so that no filtering is necessary.

C. sea ice

Complete documentation available from:
http://www.ccsm.ucar.edu/models/ccsm3.0/csim/

1. horizontal resolution, number of layers, number of thickness categories

gx1v3 grid (nominally 1 degree, displaced pole grid. see ocean resolution)
number of layers - 4 layers in ice + a single snow layer
number of thickness categories - 5 ice plus one open water category

2. numerical scheme/grid, including advection scheme, time-stepping scheme,

advection scheme - incremental remapping (Lipscomb and Hunke, Mon Wea. Rev, 132, 1341-1354, 2004)

ITD solved using linear remapping (Lipscomb, 2001)

vertical heat equation solved using an implicit backwards-Euler space-centered scheme

3. list of prognostic variables

for each gridcell : sea ice velocity; stress tensor components (not resolved across the thickness distribution)

for each gridcell and each ice category: sea ice concentration, sea ice volume, snow volume, surface temperature

for each ice category and each ice level: sea ice internal energy

4. completeness (dynamics? rheology? leads? snow treatment on sea ice)

dynamics - elastic-viscous-plastic (Hunke and Dukowicz, 1997) with updates (Hunke, 2001; Hunke and Dukowicz, 2002; Hunke and Dukowicz, 2003)

thermodynamics - Bitz and Lipscomb (1999)

ITD present with linear remapping (see Bitz et al., 2001; Lipscomb, 2001)

snow treated as a single layer

lateral melting following Steele (1992)

5. treatment of salinity in ice
salinity fixed at constant 4ppt for ice/ocean exchange
salinity profile used for thermodynamic considerations (see Bitz and Lipscomb, 1999)

6. brine rejection treatment
brine rejection based on constant 4ppt salinity in the sea ice

7. treatment of the North Pole "singularity" (filtering, pole rotation, artificial island?)
pole is rotated into Greenland

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

An extensive technical description of the Community Land Model (CLM) can be found in:

Oleson, K.W. et al. 2004: Technical description of the Community Land Model (CLM), NCAR Technical Note NCAR/TN-461+STR, National Center for Atmospheric Research, Boulder,
Colorado, 173 pp.

1. resolution (tiling?), number of layers for heat and water

Spatial land surface heterogeneity is represented as a nested subgrid hierarchy in which grid cells are composed of multiple landunits, snow/soil columns, and plant functional types (PFTs). The specific landunits are glacier, lake, wetland, vegetation
The vegetation portion is divided into patches of up to 4 of 16 PFTs
types. All PFTs in a grid cell share a single soil column. Plant functional types and leaf area index are specified from satelllite data.

Soil water is predicted from a ten-layer model, in which the vertical soil moisture transport is governed by infiltration, surface and sub-surface runoff, gradient diffusion, gravity, and root extraction through canopy transpiration. Soil temperature is predicted from the same ten-layer model accounting for phase change.

2. treatment of frozen soil and permafrost

Explicit treatment of ice and liquid water in soil column.

3. treatment of surface runoff and river routing scheme

A conceptual form of TOPMODEL (Beven and Kirkby [1979]) is used to parameterize runoff. The River Transport Model (RTM) of Branstetter [2001], and Branstetter and Famiglietti [1999] is used to transport runoff from the land to the ocean

Beven, K.J., and Kirkby, M.J. 1979. A physically based variable contributing area model of basin hydrology. Hydrol. Sci. Bull. 24: 43-69.

Branstetter, M.L. 2001. Development of a parallel river transport algorithm and applications to climate studies. Ph.D. dissertation, University of Texas at Austin.

Branstetter, M.L., and Famiglietti, J.S. 1999. Testing the sensitivity of GCM-simulated runoff to climate model resolution using a parallel river transport algorithm. Preprints, 14th Conference on Hydrology, Dallas, TX, Amer. Meteor. Soc., 391-392.

4. treatment of snow cover on land

Snow is modeled with up to five layers depending on total snow depth accounting for ice and liquid water contents in each layer and liquid water movement between layers.

5. description of water storage model and drainage

Water is stored on land in the soil column, in wetlands, lakes and glaciers, and in snow. However, the areal extent of wetlands, lakes, and glaciers is constant in time. Runoff from land (surface runoff, sub-surface drainage) is routed to the river transport model as is runoff from wetlands, lakes, and glaciers, the latter being determined from the mass balance residual. All of this water is then distributed to the oceans based on the routing scheme.

6. surface albedo scheme

Radiative transfer within vegetative canopies is calculated from the two-stream approximation. Soil albedos are determined from soil color.

7. vegetation treatment (canopy?)

Vegetated surfaces are comprised of up to 4 of 16 possible plant functional types (PFTs). These PFTs differ in physiological and morphological traits along with climatic preferences. Sensible and latent heat fluxes from vegetated surfaces are derived from Monin-Obukhov similarity theory applied to the surface layer. Transpiration fluxes are predicted using a coupled canopy conductance-photosynthesis scheme.

8. list of prognostic variables

Multi-layer SNOW (up to five layers depending on total snow depth)
number of snow layers
thickness of snow layer (m)
depth of snow layer interface (m)
node depth of snow layer (midpoint) (m)
liquid water content of snow layer (kg m-2)
ice content of snow layer (kg m-2)
total snow depth (m)
total snow water equivalent (kg m-2)
snow age (influences snow albedo)
snow layer temperature (K)

Ten-layer SOIL
soil liquid water content (kg m-2)
soil ice content (kg m-2)
soil temperature (K)

Vegetation temperature (K)
Ground temperature (K)
Canopy water (kg m-2)

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?)

Glaciers are generally initialized as a column of pure ice with a depth equal to the soil column depth and a snow pack of 1000 kg/m2 snow water equivalent . Snow may melt or accumulate
but the snow is constrained to have a snow water equivalent of less than 1000 kg/m2. Glacier dynamics such as ice calving are not modeled.

E. coupling details

1. frequency of coupling

ocean coupled once per day, atm/lnd/ice coupled once per hour

2. Are heat and water conserved by coupling scheme?

yes

3. list of variables passed between components:

a. atmosphere - ocean
b. atmosphere - land
c. land - ocean
d. sea ice - ocean
e. sea ice - atmosphere

Atmosphere Model - Data recieved (* -> used for diagnostic purposes only)

states
o 2 meter reference air temperature* (merged lnd/ice/ocn)
o 2 meter reference specific humidity* (merged lnd/ice/ocn)
o albedo: visible direct (merged lnd/ice/ocn)
o albedo: near-infrared direct (merged lnd/ice/ocn)
o albedo: visible diffuse (merged lnd/ice/ocn)
o albedo: near-infrared diffuse (merged lnd/ice/ocn)
o surface temperature (merged lnd/ice/ocn)
o ocn sea surface temperature
o land snow height
o ice fraction
o ocean fraction
o land fraction

fluxes
o zonal surface stress (merged lnd/ice/ocn)
o meridional surface stress (merged lnd/ice/ocn)
o latent heat (merged lnd/ice/ocn)
o sensible heat (merged lnd/ice/ocn)
o longwave radiation upward (merged lnd/ice/ocn)
o evaporation (merged lnd/ice/ocn)

Ice Model - Data received

states
o ocn: temperature
o ocn: salinity
o ocn: zonal velocity
o ocn: meridional velocity
o ocn: dh/dx: zonal surface slope
o ocn: dh/dy: meridional surface slope
o atm: layer height
o atm: zonal velocity
o atm: meridional velocity
o atm: potential temperature
o atm: temperature
o atm: specific humidity
o atm: density

fluxes
o ocn: : heat of fusion or : melting potential
o atm: shortwave radiation: downward visible direct
o atm: shortwave radiation: downward near-infrared direct
o atm: shortwave radiation: downward visible diffuse
o atm: shortwave radiation: downward near-infrared diffuse
o atm: longwave radiation downward
o atm: precipitation: liquid
o atm: precipitation: frozen

Land Model - Data received

states
o atm layer height
o atm zonal velocity
o atm meridional velocity
o atm potential temperature
o atm specific humidity
o atm pressure
o atm temperature

fluxes

o atm precipitation: liquid convective
o atm precipitation: liquid large-scale
o atm precipitation: frozen convective
o atm precipitation: frozen large-scale
o atm longwave radiation downward
o atm shortwave radiation: downward visible direct
o atm shortwave radiation: downward near-infrared direct
o atm shortwave radiation: downward visible diffuse
o atm shortwave radiation: downward near-infrared diffuse

Ocean Model - Data received

states
o atm equivalent sea level pressure (only used for BGC work, non-IPCC?)
o atm 10m wind speed squared (only used for BGC work, non-IPCC?)
o ice fraction

fluxes
o atm shortwave radiation net
o atm latent heat
o atm sensible heat
o atm longwave radiation upward
o atm longwave radiation downward
o atm precipitation: rain
o atm precipitation: snow
o atm+ice zonal surface stress (merged over one grid cell)
o atm+ice meridional surface stress (merged over one grid cell)
o atm evaporation
o ice ocean heat (melting potential) used for melting
o ice salt flux
o ice melt water
o lnd coastal runoff

4. Flux adjustment? (heat?, water?, momentum?, annual?, monthly?).

none

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

A. IPCC "experiment" name

See the excel chart with the "Local Abbrev" column that I mailed you last week

B. Describe method used to obtain initial conditions for each component model

1. If initialized from a control run, which month/year.
2. For control runs, describe spin-up procedure.

See the excel chart with the "Local Abbrev" column that I mailed you last week

C. For pre-industrial and present-day control runs, describe radiative forcing agents (e.g., non-anthropogenic aerosols, solar variability) present=2E Provide references or web pages containing further information as to the distribution and temporal changes in these agents.

Still working on this...

D. For perturbation runs, describe radiative forcing agents (e.g., which greenhouse gases, which aerosols, ozone, land surface changes, etc.) present. Provide references or web pages containing further information as to the distribution and temporal changes in these agents.

Still working on this