The CSIRO Mk3L climate system model v1.0: PMIP2 experiments

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1 Model documentation

1.1 Standard reference

The standard reference for the CSIRO Mk3L climate system model is *Phipps* (2006a). A PDF of this report can be downloaded using the following URL:

`http://staff.acecrc.org.au/~sjphipps/publications/phipps2006a.pdf`

1.2 Short description

The CSIRO Mk3L climate system model v1.0 is a computationally-efficient coupled atmosphere-sea ice-ocean general circulation model, suitable for studying climate variability and change on millennial timescales. The atmospheric component of Mk3L comprises a spectral general circulation model, a dynamic-thermodynamic sea ice model, and a land surface model with fixed vegetation and soil types. A coarse horizontal resolution of R21 is employed throughout, giving zonal and meridional resolutions of 5.625° and ∼3.18° respectively. A hybrid vertical coordinate is used in the atmosphere, with 18 vertical levels. The oceanic component of Mk3L is a coarse-resolution, z-coordinate general circulation model. The horizontal grid matches the Gaussian grid of the atmosphere model, and there are 21 vertical levels.

1.3 Comparison with IPCC versions

The atmospheric, land surface and sea ice components of Mk3L are the same as those of the CSIRO Mk3 climate system model (*Gordon et al.*, 2002), which was used to produce simulations for AR4. However, the horizontal resolution is reduced from T63 to R21.

The oceanic component of Mk3L is the same as that of the CSIRO Mk2 coupled model (*Gordon and O'Farrell*, 1997; *Hirst et al.*, 2000), which was used to produce simulations for AR3.

1.4 Access to the model source code

The CSIRO Mk3L climate system model is freely available to the research community. Access to the source code can be obtained by completing the form at the following URL:

`http://www.tpac.org.au/main/csiromk3l`

2 Description of experiments

2.1 Spin-up procedure

2.1.1 Ocean model

The World Ocean Atlas 1998 (*National Oceanographic Data Center*, 2002) temperatures and salinities were used to initialise the model, with the velocities being set to zero. The model was forced with climatological NCEP-DOE Reanalysis 2 (*Kanamitsu et al.*, 2002) wind stresses, while the temperature and salinity of the upper layer were relaxed towards the World Ocean Atlas 1998 values using a relaxation timescale of 20 days.

The model was initially integrated to equilibrium using asynchronous timestepping, with a tracer timestep of 1 day and a momentum timestep of 20 minutes. Annual-mean surface boundary conditions were applied for the first 1,000 years, with seasonally-varying boundary conditions being applied thereafter. Equilibrium was attained after a total of 4,000 years of asynchronous timestepping, with the convergence criterion being that the rates of change in global-mean temperature and salinity on each model level must be less than 0.005°C/century and 0.001 psu/century respectively.

The model was then integrated to equilibrium under synchronous timestepping, with a timestep of 1 hour being used to integrate both the tracer and momentum equations. Although the convergence criterion was satisfied after 200 years, the model was integrated for a total of 500 years under synchronous timestepping in order to minimise any residual drift.

For the purposes of deriving flux adjustments, climatological surface fluxes were derived from the final 100 years of the spin-up run.

2.1.2 Atmosphere model

The atmosphere model was initialised from a previous spin-up run, and was then integrated for 50 years under pre-industrial boundary conditions. The atmospheric carbon dioxide concentration was set to 280 ppm, the solar constant

Boundary condition	Pre-industrial	Mid-Holocene
Vegetation	Modern	Modern
Ice sheets	Modern	Modern
Topography/coastlines	Modern	Modern
CO_2 concentration [ppm]	280	277
CH_4 concentration [ppb]	-	-
N_2O concentration [ppb]	-	-
Chlorofluorocarbons	-	-
O_3 concentration	Modern	Modern
Solar constant [Wm^{-2}]	1365	1365
Epoch [years BP]	0	6000
Eccentricity of Earth's orbit	0.016724	0.018682
Obliquity of Earth's axis [°]	23.446	24.105
Longitude of perihelion [°]	102.07	0.83

Table 1: Experimental design for the pre-industrial and mid-Holocene experiments.

was set to 1365 Wm^{-2}, and modern (AD 1950, i.e. 0 years Before Present) values were used for the Earth's orbital parameters.

The World Ocean Atlas 1998 (*National Oceanographic Data Center*, 2002) sea surface temperatures were applied as the bottom boundary condition, while the ocean currents required by the sea ice model were diagnosed from the final 100 years of the ocean model spin-up run.

For the purposes of deriving flux adjustments, climatological surface fluxes were derived from the final 40 years of the spin-up run.

2.1.3 Coupled model

The atmospheric and oceanic components of the model were initialised from their states at the end of the respective spin-up runs. The coupled model was then integrated for 100 years under pre-industrial boundary conditions, in order to overcome any initial coupling shock.

The mid-Holocene simulation was initialised from the state of the pre-industrial simulation at the end of year 100. Both simulations were then integrated for a further 100 years before beginning the PMIP2 experiments.

2.2 Experimental design

The experimental design for the pre-industrial and mid-Holocene experiments is summarised in Table 1, and is discussed below.

2.2.1 Topography and bathymetry

Modern topography and bathymetry were used for both experiments.

The following straits are open on the ocean model grid, with the sill depths being as follows:

Greenland-Scotland Sill	800 m
Indonesian Throughflow	1900 m
Drake Passage	3700 m

The following straits are closed on the ocean model grid:

Northwest Passage
Bering Strait
Hudson Strait
Strait of Gibraltar
Korea Strait
Torres Strait
Mozambique Channel
Bass Strait

2.2.2 Land surface

The land surface model used modern distributions of vegetation and soil types for both experiments, as well as the modern positions of the ice sheets. The vegetation, soil types and ice sheets remained fixed throughout the experiments.

2.2.3 Radiative gases

The radiation scheme in Mk3L does not account for the radiative effects of CH_4, N_2O or chlorofluorocarbons.

PMIP2 experimental design requires that identical concentrations of CO_2, N_2O and chlorofluorocarbons be used for both the pre-industrial and mid-Holocene experiments (280 ppm, 270 ppb and zero respectively). However, it also requires that the CH_4 concentration be reduced from 760 ppb for the pre-industrial experiment to 650 ppb for the mid-Holocene experiment. To represent the radiative forcing arising from this reduction, an *effective* CO_2 concentration of 277 ppm was used for the mid-Holocene experiment.

Modern ozone concentrations were used for both experiments.

2.2.4 Insolation

The solar constant was set to 1365 Wm^{-2} for both experiments.

Mk3L calculates the values of the Earth's orbital parameters at runtime, with the epoch being specified via the model's configuration file. The values calculated by the model for 0 and 6,000 years BP are shown in Table 1. The eccentricity and the obliquity of the Earth's axis agree, to the precision shown, with the values required by PMIP2 experimental design. The longitude of the perihelion differs from the values specified by PMIP2 by just $+0.03°$ and $-0.04°$ for the pre-industrial and mid-Holocene experiments respectively; these discrepancies are not considered to be significant.

2.3 Further documentation

The experiments are described in further detail by *Phipps* (2006b).

References

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