Model Descriptions

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1. Bern3D:

The Bern3D ocean model is a computationally-efficient, 3-dimensional coarse resolution (36 by 36 grid boxes with 32 vertical layers), frictional-geostrophic balance ocean model (*Müller et al.* [2005]). It is based on the ocean model developed by *Edwards et al.* [1998] and *Edwards and Marsh* [2005]. The Bern3D model has been updated to resolve the seasonal cycle and includes an implicit numerical scheme for vertical transport allowing time steps of the order of weeks and an updated convection scheme. The implementation of the formulation of eddy-induced transport (*Griffies* [1998]) used by *Edwards and Marsh* [2005] was modified to allow an independent tuning of the respective parameters for isopycnal mixing and eddy-induced transport.

The model was tuned using data-based metrics defined by *Matsumoto et al.* [2004]. These metrics include radiocarbon signatures for North Atlantic Deep Water, North Pacific Deep Water and Circumpolar Deep Water as well as inventories of CFC-11 in the Indo-Pacific north and south of 40S. The model simulates these five values within their data-based uncertainties. (*Müller et al.* [2005]).

2. ECCO : Estimating the Circulation and Climate of the Ocean

The ECCO (Estimating the Circulation and Climate of the Ocean) consortium contributed a model simulation driven by air-sea fluxes of heat, freshwater, and momentum estimated using ocean data assimilation (*Stammer et al.* [2004]). Specifically, surface fluxes were estimated from an adjoint-method 1992-2002 optimization using a quasi-global ocean configuration (80S-80N) of the MIT GCM with 23 vertical levels and 1 horizontal grid spacing. Data constraints include ERS-1, ERS-2, and TOPEX/Poseidon sea-surface height (SSH) anomalies, TOPEX/Poseidon time-mean SSH, Reynolds and Smith [1994] and TMI sea surface temperature, surface boundary fluxes (wind stress, heat, and fresh water) from the NCEP reanalysis, WOCE, XBT, and ARGO in-situ hydrography, the Levitus and Boyer [1994] climatologies of temperature and salinity, time-mean surface drifter data, and ERS/NSCAT/QSCAT estimates of wind stress. Tracer Green functions are computed on the 80S-80N, 23-level, 1 grid by perpetual cycling of the 1992-2002 surface fluxes estimated by ECCO.

3. MIT

The (Massachusetts Institute of Technology) GCM solves the incompressible Navier-Stokes equation on a C-grid with an optional hydrostatic equation. Mesoscale eddy transfer effects are represented using a scheme related to the *Gent and McWilliams* [1990] parameterization. This parameterization scheme reflects the strong regional variability of ocean eddy activity (*Visbeck et al.* [1997]) and employs variable mixing coefficients from *Green* [1970] and *Stone* [1972]. The convective adjustment scheme of *Large et al.* [1994] is used to represent vertical turbulent mixing in the surface mixed layer.

For this study, we use a model configuration that is very similar to the configuration used for OCMIP. The model has a horizontal resolution of 2.8° and 15 vertical levels. Since OCMIP, there have been three changes to the Model: the model code has been improved to allow for more integrated handling of tracers, the wind-stress forcing has been changed from *Hellerman and Rosenstein* [1983] to ECMWF climatology wind fields, and the bathymetry at the ocean floor has been changed from a partial-cell scheme, which represent ocean topography more accurately, to a full-cell only approach. The changes in the wind stress fields are expected to improve flow through the Drake passage and residual flow in the Southern Ocean, which will lead to changes in tracer uptake in the Southern Ocean. The bathymetric changes are expected to causes only minor differences in the deep flow at the coarse resolution used here.

4. NCAR

The NCAR (National Center for Atmospheric Research) modeling group used a coarse resolution version of the ocean model component of the Community Climate System Model (CCSM), which is based on the Parallel Ocean Program (POP) GCM (*Smith* [1992]; *Dukowicz et al.* [1993]; *Dukowicz and Smith* [1994]). Mesoscale eddy mixing is represented by the Gent-McWilliams parameterization scheme(*Gent*

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Paper number .
0886-6236/06/$12.00

and McWilliams [1990]; *Danabasoglu et al.* [1994]). The model also employs the *Large et al.* [1994] parameterization of the surface boundary layer dynamics, the anisotropic horizontal velocity of *Large et al.* [2000], and the bottom boundary layer dynamics of *Doney and Hecht* [2002]. The air-sea bulk forcing is based on satellite observations and NCEP reanalysis data (*Large et al.* [1997]).

The coarse resolution version of the model was used here, which has a horizontal resolution of 3.6°x 1.85 °and 25 vertical levels. This model has been compared with a range of other OGCMs in OCMIP (*Dutay et al.* [2002]; *Doney et al.* [2004]), and has been shown to effectively reproduce many major features of climatic relevance such as surface fluxes, water mass transformations and mixed layer depths, mean and seasonal water mass properties, high-latitude deep convection patterns, and meridional ocean heat and freshwater transports (*Gent et al.* [1998]).

5. PRINCE

The PRINCE (Princeton University) group contributed five different versions of the Geophysical Fluid Dynamics Laboratory Modular Ocean Model Version 3 (MOM3) (*Pacanowski and Griffies* [1998]). MOM3 is a seasonal model forced by seasonally varying wind-stress. Surface temperature and salinity fiends are forced with a hybrid between restoring boundary conditions to climatological values and flux boundary conditions based on the seasonally varying heat and freshwater fluxes of *da Silva et al.* [1994]. Lateral advection due to sub-gridscale eddies is parameterized following *Gent et al.* [1995] and implemented following *Griffies et al.* [1998]. The functional form of the explicit vertical diffusivities is prescribed following *Bryan and Lewis* [1979].

The five configurations of MOM3, which are described in detail by *Gnanadesikan et al.* [2002] and *Gnanadesikan et al.* [2004], share the same essential representation of model transport, but employ different parameters representing the vertical and along-isopycnal diffusivities, salinity restoring values, wind fields, and topography. These differences are summarized in the Configuration Summary Table, also included in this folder. *Matsumoto et al.* [2004] have shown that these five configurations of MOM generally span the range of models used in OCMIP with respect to transport of CFC's, radiocarbon, and anthropogenic carbon.The LL version was included in OCMIP (*Dutay et al.* [2002]; *Doney et al.* [2004]).

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(Received ______________________.)