TOWARDS A NEW ISOPYCNIC OCEAN CARBON CYCLE MODEL

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ABSTRACT

Numerical ocean carbon cycle models are the primary tools to predict the ocean's response to increasing atmospheric CO_2 concentration. So far most of these have been based of physical components with geometric vertical levels. While permitting an accurate computation of the horizontal pressure gradient driving geostrophic flow, vertical discretization on z-levels leads to spurious diapycnal mixing and upwelling. Isopycnic ocean models have an advantage over those with geometric vertical layers in that their vertical coordinate mimics the real structure of the water column as stratified layers of constant density, and thus avoid artificial mixing and advection in the ocean interior. Their disadvantages include the problem of massless layers, the necessity to add a mixed layer model to adequately represent surface processes, and the induction of a horizontal pressure gradient error by the sloping density surfaces. Models with different vertical schemes thus complement each other and can be used as one basis for an uncertainty assessment.

A new isopycnic biogeochemical ocean model is being developed using the Miami Isopycnic Coordinate Model [MICOM, *Bleck et al.* 1992] as the physical and the Hamburg Ocean Carbon Cycle model HAMOCC5 [*Meier-Reimer,* 1993] as the biogeochemical component. MICOM is used in a configuration as employed in the Bergen Climate Model [BCM, *Furevik et al.* 2003; *Bentsen et al.* 2004] and coupled to a dynamic-thermodynamic sea ice model with a viscous-plastic rheology [*Hibler*, 1979]. The physical ocean model is run on a global domain with a local horizontal orthogonal grid system. Placing one pole over North America and the other over the western part of Asia results in a horizontal grid resolution of 60-80 km over the North Atlantic. Initially the model will be forced with a monthly atmospheric climatology based on the NCEP-Reanalyses. HAMOCC5 is an ocean carbon cycle model of the NPZD (Nutrient-Phytoplankton-Zooplankton-Detritus) class and includes a semilabile pool of dissolved organic carbon. Its oceanic aqueous tracers are transported by the ocean model's advection and mixing routines. The model also contains a sediment scheme that allows accumulation and dissolution of particulate matter (organic carbon, calcium carbonate, silicate) and a simple atmospheric transport model. The biological model is based on a Redfield stochiometry for organic material. Phytoplankton growth is described by Michaelis-Menten kinetics with growth rates limited by temperature, wind speed, vertical mixing, and light intensity.

Since HAMOCC has previously been used coupled to a z-coordinate physical ocean model, it will be amended for use with an isopycnic vertical coordinate. Compartments for its biogeochemical tracers will

be added to the advection and mixing routines of the physical ocean model. A key concern in this context is to ensure that the transport scheme of the physical ocean model is conservative to minimize the uncertainties in atmospheric pCO_2 changes resulting from changes in oceanic DIC (Dissolved Inorganic Carbon) content. Other issues to be addressed in this context include, e.g., the sinking of particles through vertical layers that change location over time.

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