Abstract

About this manual and MRI.COM

This technical report is a manual of the Meteorological Research Institute Community Ocean Model (MRI.COM). MRI.COM is an ocean general circulation model developed and maintained at the Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA). It has been used for studying large scale oceanic phenomena and as the oceanic part of the coupled climate models developed at MRI. Recently, it is expanding its coverage to coastal small scale phenomena.

The current version of MRI.COM is version 4. Version 1 (developed around 2000) was intended to present a prototype. Efforts were devoted to combining the two ocean models used until then in MRI. For this reason, users at that time tended to be restricted to MRI research scientists who were committed to the development. Thus, users were deeply knowledgeable about the model.

Version 2 (early 2000s) was intended for use in the operational forecasting system in JMA. Since the number of users without direct experience in developing models was expected to increase, the developers decided to write a detailed manual for that version. The Japanese version was published in 2005 (Ishikawa et al., 2005) and eventually became the prototype of this manual.

Version 3 was intended for use as an oceanic component of the Earth System Model of MRI (MRI-ESM1; Yukimoto et al., 2011). One of the reasons for creating a new version was that the definition of vertical grid arrangement was modified during the development. MRI participated in the Coupled Model Intercomparison Project Phase 5 (CMIP5) using MRI-ESM1, and its results on the future projection were expected to be used by a wide range of communities, so a detailed description of its oceanic component was prepared in English (Tsujino et al., 2010).

Version 4 is intended for use as the oceanic part of the next operational forecasting systems of JMA as well as a new Earth System Model of MRI (MRI-ESM2) prepared for the Coupled Model Intercomparison Project Phase 6 (CMIP6). This version includes the following improvements.

- Tide producing potential and inverse barometer effect of surface atmospheric pressure are introduced into the depth-integrated (barotropic) equations, considering an application to coastal processes. The linear response of the system to the tide producing potential is calculated separately from the other processes, so that self-attraction and loading affect only tidal processes.
- A vertically rescaled height coordinate (z^* coordinate; Adcroft and Campin, 2004) has been introduced.
- Nesting function has been expanded. Off-line (parent and child models are executed serially) one-way, on-line (parent and child models are executed in parallel) one-way and two-way nesting become possible. In on-line two-way nesting, sea water volume and scalar quantities can be conserved for a system of parent and child models.
- Program files are classified into several packages to ease the maintenance. Each package is made as independent as possible from other ones and is controlled by a driver program, which is named as *package*_`ctl.F90`.
- The user interface is entirely revised. Specifically, monitoring and sampling functions have been expanded, several input and output files use a format different than the previous versions so that their contents can be checked easily, and the block names and the contents of namelists are renamed so that they are more self-explanatory. See READMEs for details.

Note that the purpose of this manual is to present a detailed description of a particular model system. The mathematical expressions of processes, the parameterization methods, and the numerical algorithms presented here follow those adopted in the latest code. They are largely state-of-the-art, but this does not necessarily mean that they are the complete reflections of physical, mathematical, and numerical integrity. Every method is subject to possible sophistication. We welcome critical comments and suggestions from any reader or user, which are necessary for further improvement.

For a more general or detailed description of OGCMs, please refer to textbooks by Griffies (2004) and Kantha and Clayson (2000). The former thoroughly describes the fundamentals of OGCMs, and the latter concisely summarizes the modeling of various oceanic processes such as tide and sea ice.

Organization

Chapter 1 introduces OGCMs and MRI.COM. It also presents the classification of OGCMs and the status of MRI.COM with respect to the state-of-the-art OGCMs.

Part I describes the model configuration. Governing equations are derived in Chapter 2, and the spatial grid arrangement is explained in Chapter 3.

Part II describes the solution procedures of diagnostic equations. Chapter 4 presents definition of the equation of state of sea water. Chapter 5 presents definition of the continuity equations for unit grid cells.

Part III describes the solution procedures of momentum equation. The method of solving the barotropic and the baroclinic part of the momentum equation are presented in Chapters 6 and 7, respectively.

Part IV describes the method of solving the advection-diffusion equation for tracers. Chapter 8 presents advection schemes. Subgrid-scale parameterizations for horizontal and vertical mixing are explained in Chapters 9 and 10, respectively. Biogeochemical models are presented in Chapter 11 and inert tracers are explained in Chapter 12. Chapter 13 explains usage of the tracer package.

Part V describes boundary processes. Surface fluxes are presented in Chapter 14. Surface mixed-layer models are presented in Chapter 15. Bottom boundary layer parameterization is explained in Chapter 16. Sea ice part is explained in Chapter 17. How to construct and run a pair of nested-grid models is presented in Chapter 18.

Part VI contains miscellaneous topics. Basics of the finite difference method are presented in Chapter 19, general orthogonal curvilinear coordinates and related calculus are introduced in Chapter 20, and finally user's guide to construct and run a model is presented in Chapter 21.

Each chapter is almost independent from other chapters. Thus the readers might be able to understand the contents of each chapter without referring to other chapters. However, reading Part I will give the readers the background to help understand the remainder of this manual.

The following are some comments about the notations used throughout this manual. The characters and expressions in `Courier` fonts are adopted from program codes. The subscripts and indices used in discrete equations are intended to express staggered grid arrangements. They do not necessarily correspond to the array indices in program codes.