Ocean modeling activities in Japan

Report to the CLIVAR Working Group for Ocean Model Development

Submitted by Hiroyuki Tsujino (JMA/MRI), May 2009

Acronyms:
CCSR: Center for Climate System Research, University of Tokyo
ES: Earth Simulator, JAMSTEC
ESC/JAMSTEC: Earth Simulator Center, JAMSTEC
RIGC/JAMSTEC: Research Institute for Global Change, JAMSTEC
JAMSTEC: Japan Agency for Marine-Earth Science and Technology
JMA/MRI: Japan Meteorological Agency Meteorological Research Institute
NIES: National Institute for Environmental Studies
COCO: CCSR Ocean Component Model
MRI.COM: MRI Community Ocean Model

1. Activities related to CMIP5

Most of the efforts made in past years by ocean climate modelers in Japan are devoted to updating OGCMs maintained by their institute or research group in preparation for CMIP5. Two research groups are planning to participate in CMIP5: a group of scientists from CCSR, JAMSTEC/RIGC, and NIES, and a group of scientists from JMA/MRI. Both groups maintain their ocean model (COCO; Hasumi 2006, and MRI.COM; Ishikawa et al. 2005, Tsujino et al. 2009). Some of the recent major developments made in common are:

- Formulation and discretization based on generalized orthogonal curvilinear coordinates and adoption of tri-pole grid arrangement for global model. This is to avoid the singularity at the North Pole and to retain the geographical (latitude-longitude) grids outside the arctic region.
- Use of the second order moment advection scheme (Prather 1986). This is reported to improve representation of the Equatorial thermocline and to alleviate the problem of spurious numerical diffusion that tracer advection schemes exhibit in eddying regimes.
- Thickness distribution of sea ice within a grid cell is represented by partitioning sea ice into several thickness categories. Sea ice in each thickness category is allowed to have heat capacity.
- Inclusion of marine bio-geochemical processes into model source codes so that they might be calculated on-line.

The group of CCSR-JAMSTEC/RIGC-NIES is developing two types of global models. The higher resolution one has a horizontal resolution of 1/4º in zonal and 1/6º in meridional direction and 50 vertical levels. This model is used for near-term (decadal) prediction starting from a state given by data assimilation.

The lower resolution one has a horizontal resolution of 1.4º in zonal and 0.5 ~ 1.4º in meridional direction and 50 vertical levels. The meridional resolution is increased near the Equator. This model is used for long-term projections.

The group of JMA/MRI is also developing two types of global models (Nakano et al. 2008). The lower resolution one has a horizontal resolution of 1º in zonal and 0.5º in meridional directions and 50 vertical levels with one-layer bottom boundary (Nakano and Suginohara 2002). This model is used for long-term simulations. The higher resolution model has a horizontal resolution of 1/8º in the zonal and 1/12º in the meridional direction and 50 vertical levels. This model is basically run as a stand alone ocean-ice model.

These two-groups are planning a comprehensive inter-comparison of CMIP5-class lower-resolution global ocean-ice models after the completion of their models in line with COREs. Results of an inter-comparison activity among high resolution models developed by Japanese modelers are presented by Suzuki et al. (2008).

2. Regional ocean modeling

Efforts of Japanese ocean modelers are also directed to high resolution simulations of the North Pacific Ocean and its western marginal seas.

A group of CCSR-JMA/MRI conducted simulations of the western North Pacific Ocean using high horizontal resolution models. One of them has a horizontal resolution of 1/36º in zonal direction and 1/54º in meridional direction (about 2 km) and 50 vertical levels. Large-scale features of simulated fields are improved with increasing horizontal resolutions while significant improvements are found from the transition from about 20 km to less than 10 km horizontal resolution. On transition from about 10 km to 2 km horizontal resolution, improvements are detected for coastal currents above continental slope.

A group of JAMSTEC/ESC is planning a 1/30º horizontal resolution simulation for the North Pacific Ocean using the updated ES (ES2) focusing on submesoscale features in the Kuroshio and the Oyashio current system (H. Sasaki, personal communication).

Modeling study for the Japan Sea is active in the Kyushu University. They focus on effects of the Japan Sea on climate (e.g., Hirose et al. 2008; Hirose et al. 2009). Modeling study for the Okhotsk Sea is active in the Hokkaido University. They focus on currents

along coasts and straits, sea ice processes, and dense water formation (e.g., Uchimoto et al. 2008).

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