Ocean modelling activities in the East Asia Region
Report to the CLIVAR Working Group for Ocean Model Development
Submitted by Hiroyuki Tsujino (MRI-JMA), August 2007

1. Ocean modeling activities in Japan (by Hiroyuki Tsujino, MRI-JMA)

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

There are three broad categories of activities that have been the focus of ocean climate modelers in Japan for the past years: (1) updating oceanic components of global climate models for the next IPCC future climate projections, (2) developing systems for seasonal to inter-annual (or longer) climate predictions, (3) updating regional ocean models for use in regional marine environment forecasts.

1) Oceanic components of global climate models

The groups that plan to participate in the next IPCC assessment report are now updating their models.

The FRCGC plans to perform centennial time-scale climate projections using an Earth System model in collaboration with CCSR and NIES. The ocean component includes an NPZD ocean eco-system model and the required additional ocean chemistry. The COCO is used for the physical component. The horizontal resolution has not been fixed yet but will be around 1 degree. Projections will be performed on the ES.

The CCSR plans to perform decadal time-scale ensemble climate projections using a high-resolution (about 60 km for atmosphere and about 20 km for ocean) coupled model in collaboration with NIES and FRCGC. Its ocean model is COCO. The basic configurations of the oceanic component are the same as those of IPCC AR4 version, but some updates (ice thermodynamics, tracer advection scheme, use of tri-polar grid, etc.) are planned. Projections will be performed on the ES. (See also 2.)

The MRI-JMA plans to perform centennial time-scale climate projections using an Earth System model. The ocean component includes a bio-geochemical model. The MRI.COM is used for the physical component. The horizontal resolution has not been fixed yet but will be around 1 degree. Their main contributions to the IPCC are also extended to assessment of regional impacts by performing time-slice experiments using a 20-km AGCM (on ES) with CGCM-projected SST and a regional Atmosphere-Ocean coupled model with CGCM-projected side boundary conditions. The oceanic component (MRI.COM) of the regional climate model has 10 km horizontal resolution.

2) Seasonal to inter-annual (or longer) time-scale climate predictions

Since seasonal, inter-annual, and decadal time-scale climate predictions are often regarded as initial value problems, data assimilation systems are usually developed along with prediction models.

The MRI-JMA uses a quasi-global (75ºS-75ºN, 1 degree) ocean model coupled with TL95L40 AGCM for ENSO forecasting. The ocean model is MRI.COM and a 3D-VAR data assimilation system (MOVE; MRI multivariate ocean variational estimation system) is implemented. The performance of the coupled model with on-line 3D-VAR ocean model is now being investigated.

The group of **CCSR and FRCGC** plans to perform ensemble decadal predictions as described in 1. They are thinking about implementing the Ensemble Kalman Filter (EnKF) to obtain initial values for predictions.

A group in **FRCGC** is operating seasonal climate prediction system using SINTEX-F (Scale Interaction Experiment-FRCGC) in collaboration with European Scientists. Its ocean component is OPA and has 2-degree resolution. This system uses T106 AGCM and SST nudging as data assimilation.

3) Regional modeling and marine environment forecasting

The FRCGC is operating “ocean weather forecast” in the western North Pacific region (i.e., around Japan) as part of the Japan Coastal Ocean Predictability Experiment (JCOPE). This system uses a nested-grid 1/12º degree horizontal resolution model based on Princeton Ocean Model (POM). This system is recently implemented for operational forecast in the Fisheries Research Agency.

The MRI-JMA develops the forecasting system for the marine environment of the western North Pacific region. This system uses a nested-grid 1/10º horizontal resolution model based on MRI.COM. This system is replacing the current operational forecast system of the Japan Meteorological Agency. They are now performing 2-3 km

horizontal resolution basin scale modeling for the North Pacific Ocean using ES.

The Research Institute for Applied Mechanics (RIAM) of Kyushu University is performing various marine environment modeling for the Sea of Japan using the model developed and maintained by them (RIAM Ocean Model (RIAMOM)). They are operating an ocean weather nowcast/forecast system for the Sea of Japan.

4) Earth Simulator

Resources of the ES are assigned to the qualified projects. Some of the resources are apportioned to the climate projection experiments as listed in 1.

The research groups of the Earth Simulator Center manage high resolution models such as OFES (H. Sasaki) and CFES (N. Komori) (OGCM and CGCM, respectively, for the ES).

Renewal of the ES is planned around 2009.

5) Model development

Some institutions and research groups (e.g., CCSR (H. Hasumi), MRI-JMA (H. Tsujino), RIAM (N. Hirose), Kyoto Univ. (Y. Ishikawa), and FRCGC (M. Tsugawa)) are developing and maintaining their own models. These models are basically MOM type z-coordinate models and use Arakawa-B grid. The COCO has velocity points at the coast, other models have tracer points at the coast. The COCO and MRI.COM are coupled with the AGCM of their institution (MIROC and MRI-CGCM, respectively).

6) CORE

The working group members are encouraging the Japan community to use CORE data sets for driving ocean-only (un-coupled) models. The group of CCSR and FRCGC is performing inter-annual forcing runs. The MRI-JMA is performing normal-year forcing runs.

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2. Ocean modeling activities for IPCC AR5 in China (with the help of Yongqiang Yu, LASG (the state key laboratory of numerical modeling for atmospheric sciences and geophysical fluid dynamics))

Much effort have devoted to development and application of OGCM during the past years in China, especially in two labs – the state key laboratory of numerical modeling

for atmospheric sciences and geophysical fluid dynamics (LASG) and Beijing Climate Center (BCC). The recent model's development and application will be introduced for LASG and BCC as follows.

1) Recent model activities in LASG

In order to prepare IPCC AR5 and the other research projects in China, they are improving or planning to improve the LASG ocean model named LICOM in the following aspects:

(1) To improve solar radiation penetration scheme in the upper ocean
(2) To introduce a new mixing scheme (Canuto's scheme)
(3) To introduce diurnal cycle in surface forcing
(4) To increase horizontal resolution to 1/10 degree in 3 years
(5) To establish a data assimilation system based on LICOM
(6) To introduce biogeochemistry processes in LICOM

2) Recent model activities in BCC

To better understand climate variability in East Asia and improve the short-term climate prediction, an eddy-permitting OGCM is established based on MOM4. The OGCM spans the global range and it has 40 vertical levels. The horizontal grid spacing is 1 degree in longitude. Meridionally, the grid spacing is also 1 degree outside the tropics but decreases to 1/3 degree near the Equator for improved resolution of equatorial processes. Real forcing results show that simulated climatology is close to the observation. Interannual signals of the Pacific and Indian Oceans are reproduced reasonably in this model. In the next two years, carbon cycle and simple biogeochemical processes will be introduced to BCC ocean model in order to prepare the experiments of the IPCC AR5.

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3. Ocean Modeling Activities in KORDI (Korea Ocean Research & Development Institute)

(with the help of Cheol-Ho Kim and Young-Ho Kim, KORDI)

Global Ocean Modeling: KORDI global ocean model is based on the GFDL MOM3 which has a horizontal resolution of 0.5 degree from the Antarctic to 85°N and 30 vertical levels. For the physical parameterizations it adopts QUICKer scheme for tracer advection, Smagorinsky's diffusion scheme for momentum, G-M scheme for tracer and

a partial cell topography scheme with corrected bottom topography especially for the several straits in the East Asian Marginal Seas (EAMS). It is integrated for 68 years at present with the restoring surface boundary condition using the Levitus climatology. Model MLD is compared with the observation for the model improvement.

Basin-scale Ocean Modeling: North Pacific Ocean model is being developed for the study of interaction between the EAMS and the Northwest Pacific based on MOM3. The horizontal grid resolution is enhanced from 1° in the North Pacific into 1/6° in the EAMS region. To obtain the realistic features for the regional distributions of tracer and current systems model responses are examined for the various surface forcing conditions such as restoring time scales for surface heat flux and resolution of wind stress dataset.

DA-ESROM : East/Japan Sea Regional Ocean Model based on the MOM3 (ver. 3.1) has been developed and the 3D-VAR data assimilation technique has been employed (hereafter, DA-ESROM). The background error covariance for the data assimilation has been simulated based on the correlation model with a generalized diffusion equation (Weaver and Coutier, 2001). The reanalysis through the DA-ESROM was performed from 1999 to 2002 for the Sea of Japan. For the present system, the SST from satellites and temperature profiles, taken by CREAMS (Circulation Research of the East Asian Marginal Seas), NFRDI (National Fisheries Research & Development Institute), JODC (Japan Oceanographic Data Center), and ARGO project, have been assimilated. Furthermore, the satellite altimeter data have been assimilated after validating by comparison with the observed sea level data at Ulleung and Dok Islands, Korea.

Hyoun-Woo Kang in KORDI is also working on a HYCOM based East Asian Marginal Seas Model for the ocean-typhoon interaction and regional impacts assessment of the climate change. The model domain covers the Northern Philippine Sea, the East China Sea, the Yellow Sea, and the Sea of Japan with the horizontal resolution of 1/12°. It has been configured as a stand alone regional ocean model and is still in a spin-up phase. This model will be extended to a coupled ocean-atmosphere model for the typhoon prediction system and the regional climate model.

There are four or five other modeling activities in Korea (mostly by individual effort) besides this report.