Operational use of regional ocean data assimilation system

Shiro ISHIZAKI, N. Usui, H. Tsujino, T. Umeda, and M. Kamachi
Japan Meteorological Agency (JMA) / Meteorological Research Institute (MRI)

1. Introduction

JMA started operational use of new ocean analysis / forecasting system for western north Pacific in March 2008. In this system, we use an ocean data assimilation and prediction system (MOVE/MRI.COM -WNP ; Multivariate Ocean Variational Estimation System / Meteorological Research Institute Community Ocean Model for Western North Pacific, Usui et al. 2006), developed by JMA/MRI. This system reproduces current ocean state well, and provides good forecast in the seas around Japan.

2. Outline of MOVE/MRI.COM-WNP and operational system

MODEL : MRI community ocean model (MRI.COM ; Ishikawa et al., 2005)
- region : 15°N-75°N, 117°E-160°W (Nested to North Pacific Model)
- resolution : 1/10°(lon.)x1/10°(lat.) within 15°N-50°N, 117°E-150°E
  1/6°(lon.) east of 150°E and 1/6°(lat.) poleward of 50°N
  54 vertical levels (23 levels in the upper 400m)
- vertical mixing scheme : Mellor & Blumberg (2004)
- isopycnal diffusion scheme : Gent McWilliams (1990)
- wind stress, and short and long wave fluxes :
  JCDAS (JMA's operational Climate Data Assimilation System ; Onogi et al., 2007)
- latent and sensible flux :
  bulk formula of Kondo (1975) with model SST

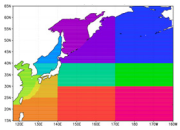

Fig.1. Model region and subregions divided for EOF modes.

ANALYSIS : multivariate 3DVAR scheme
using vertical coupled T-S EOF modes. (Fujii and Kamachi, 2003)
- Analysis is implemented every five day.
- Incremental Analysis Updates (IAU) technique is used
  to correct the model fields with the analysis result.
- observation data : in situ temperature and salinity measurement (ship, buoy, ARGO float)
  Satellite altimetry data (Jason-1, ENVISAT)
  Sea surface temperature analysis (MGDSST)

ANALYSIS / FORECASTING CYCLE (Operational system) :
- Analysis is started 50-day before.
- Forecasting period is one month.

REANALYSIS (Non-operational) :
- Period : Jan.1985 - Dec.2007
- Atmospheric forcing : JRA-25/JCDAS
- observation data : in situ temperature and salinity measurement (GTS, WOD01, GTSPP)
  Satellite altimetry data (Jason-1, ENVISAT, TOPEX/Poseidon, ERS-1/2)
  Sea surface temperature analysis (MGDSST : Japan GHRSST)

3. Comparison between REANALYSIS data and in situ observation

3.1 Comparison of temperature field

East of Japan is a confluent area of the Kuroshio warm water and the Oyashio cold water, and it is very difficult to reproduce ocean state adequately. Compared JMA's previous data assimilation system (COMPASS-K), MOVE/MRI.COM-WNP successfully reproduces the temperature field in this area (see Dr. Kamachi's presentation S3.16-069 for another example of the comparison).

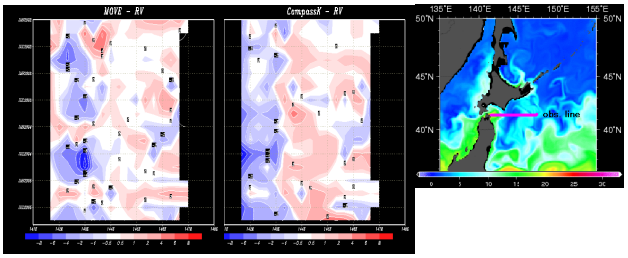

Fig.2. Time series of temperature differences of 100m-depth temperature between reanalysis data and in situ observation obtained by research vessel *Kohu-maru* along 41.5N (PH line). [Left] MOVE/MRI.COM-WNP. [Middle] COMPASS-K (previous system). [Right] Location of the observation line.

3.2 Comparison of current field

Ocean current data is not assimilated into MOVE/MRI.COM, so it is independent data for estimating a performance of the analysis system. MOVE/MRI.COM captured not only strong current such as the Kuroshio but also reproduces smaller scale current field, which is related meso-scale eddies.

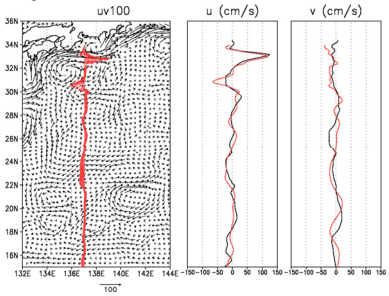

Fig. 3. [Left] 100m-depth current field in Jan.2004. Black arrows are result of the MOVE/MRI.COM reanalysis. Red arrows are observed current using ADCP sited on the research vessel *Ryohu-maru* along 137E. [Middle] Zonal velocity of 100m-depth current along 137E.Black line denoted MOVE/MRI.COM data and red line is from insitu observation. [Right] Same as middle panel except meridional velocity.

5. Performance of MOVE/MRI.COM forecasting

Using MOVE/MRI.COM-WNP, JMA provides temperature and current prediction in the seas around Japan for one month. This system successfully forecasts current field such as the Kuroshio perturbation and forecasting skill of sea surface temperature is well.
* Latest forecast can be found in http://www.data.kishou.go.jp/kaiyou/db/kaikyo/ocean/forecast/predict.html

5.1 Current field

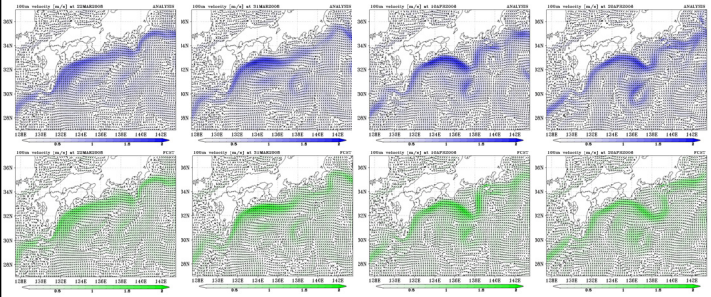

Fig.5. Time sequence of 100m-depth current field south of Japan. Arrows indicate only current direction (normalized by velocity) and shaded area denotes current velocity. [Upper panels] Operational analysis with MOVE/MRI.COM-WNP. [Lower panel] Operational forecasting initialized at 22Mar.2008.

5.2 Sea surface temperature field

Using the result of reanalysis, we implement forecasting experiment. Forecast is started at 1/1, 2/5, 3/2, 4/1, 5/1, 6/5. 7/5, 8/4, 9/3, 10/3, 11/2, 12/2 from 2000 to 2007 (96 case). Even in lead time at 30 days, RMS difference between forecasting field and reanalysis field is smaller than the variance of the reanalysis field. It implies that this system has a potential for 30-day SST prediction.

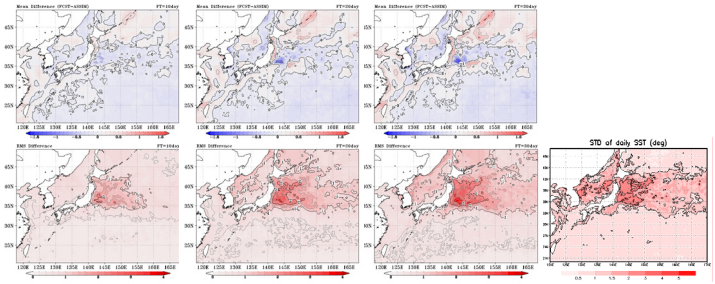

Fig.6. [Upper panels] Mean difference of sea surface temperature between result of forecast and reanalysis data. [Lower panel] Same as upper panel except RMS difference. Operational forecasting initialized at 22Mar.2008.

6. Applications using the result of MOVE/MRI.COM-WNP

6.1 Marine pollution prediction

JMA developed an oil spill model, which has recently been upgraded in order to use the result of the MOVE/MRI.COM-WNP (also see Dr. Hackett's (5.1) and Dr. Davidson's (5.2) presentation in the session 5).

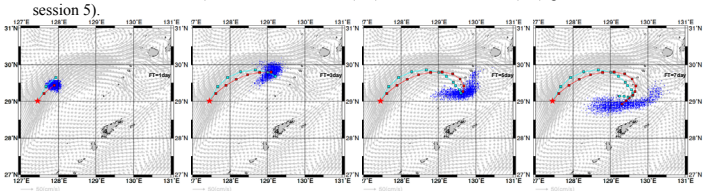

Fig. 7. Example of a result of an oil spill experiment. Red star indicates a location of oil spill and red line shows a trajectory of the drifting buoy as an alternate of spilled oil. Blue dots indicates distribution of spilled oil (represented by 3200 particles) and light green line denotes a trajectory of the center of the blue dots. Underlayed arrows corenspond to the surface current filed supplied by MOVE/MRI.COM-WNP.

6.2 Prediction of a distribution of the Sea ice in the Sea of Okhotsk

JMA developed an sea ice model, which uses climatological surface current as a boundary condition. It is planned to apply MOVE/MRI.COM-WNP current field to JMA's Sea ice model. It is found that MOVE/MRI.COM current improves the result of the sea ice model (see red circles in Fig. 8).

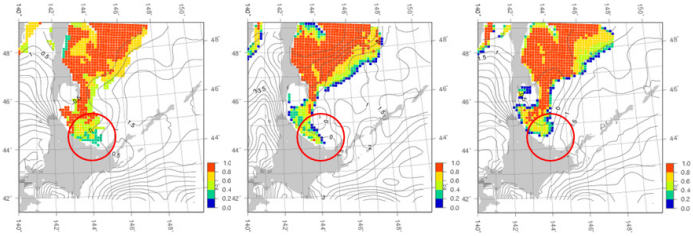

Fig. 8. Distribution of sea ice concentration (tiled) and sea surface temperature (contour) in 31Jan2004. [Left] Operational analysis (objective + subjective) sea ice distribution. [Middle] Result of sea ice model using MOVE/MRI.COM surface current (initialized at 25Jan2004). [Right] Same as Middle panel except using climatological surface current field (by courtesy of our colleague, Mr. Chikasawa).

7. Summary

JMA's new operational system for ocean analysis / forecasting (MOVE/MRI.COM-WNP) shows a good performance for both reproducing and forecasting ocean state (temperature and current filed). It is planed to use of the result of the MOVE/MRI.COM for some application such as oil spill model and sea ice model.