Second Argo Science Workshop, Mar. 15th – 18th, 2006, Venice, Italy

Salinity impacts and balance correction of wind stress and sea surface height in MRI-MOVE system.

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1. Introduction

MRI Multivariate Ocean Variational Estimation (MOVE) System is an ocean data assimilation system, and has been developed for monitoring, analysis and prediction of the ocean state and climate in JMA/MRI. Using MOVE system for global ocean (MOVE-G), reanalysis experiments are implemented, and found that salinity estimate is indispensable to reproduce realistic density and hence velocity field. We also attempt to correct the zonal wind stress forcing along the equator using analyzed temperature and salinity field.

2. Outline of MOVE-G and reanalysis experiment

MODEL : MRI community ocean model (MRI.COM ; Ishikawa et al., 2005)
- region : 75°S-75°N, global model
- resolution : 1°(lon.)x0.3°(lat.) within 6°S-6°N,
  1°(lon.)x1°(lat.) poleward of 15°N and 15°S
  50 vertical levels (23 levels in the upper 200m)
- vertical mixing scheme : Mellor & Yamada Level 2.5
- isopycnal diffusion scheme : Gent McWilliams (1990)
- wind stress, and short and long wave fluxes :
  NCEP/NCAR reanalysis (Kalnay et al., 1996)
- latent and sensible flux :
  bulk formula of Kara et al. (2000) with model SST

ANALYSIS : multivariate 3DVAR scheme
using vertical coupled T-S EOF modes.
(Fujii and Kamachi, 2003)
- Analysis is implemented once a month.
- 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
  (TOPEX/Poseidon, ERS-1/2, Jason-1, ENVISAT)

REANALYSIS PERIODS : 1993 January to 2004 December (12years)

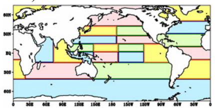


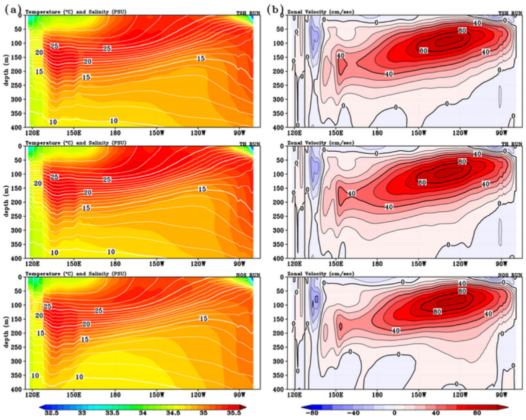
Fig.1. Model region and subregions divided for EOF modes.

Table 1. Reanalysis run of this experiment.

	Observation T	Observation S	Observation T/P	correct
TSH	○	○	○	T, S
TS	○	○	×	T, S
TH	○	×	○	T, S
NOS	○	×	○	T

3. Importance of correcting salinity field and use of altimetry data

3.1 Influence of correcting salinity field



TH : similar to TSH
MOVE-G reproduces salinity field without salinity observation

NOS : differ from TSH
(small vertical changes in temperature and salinity)
density instability
(cf. Troccoli et al., 2002)
affect velocity field

Fig.2. Mean vertical section of (a) temperature [°C] and salinity [psu], and (b) zonal velocity [cm/sec] along the equator from three experiments.

3.2 Effect of use of Altimetry data (Rossby wave propagation)

Satellite data has denser data in time and space than in situ observation. TSH run (altimetry data is used) captures smaller scale phenomena such as westward propagation of Rossby waves (west of the date line).

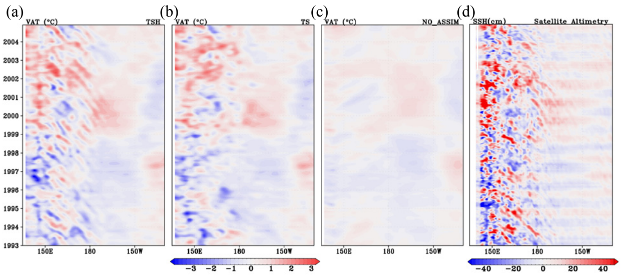


Fig. 3. Time series of anomalies of vertical averaged temperature between surface to 300m along 35°N from (a) TSH run, (b) TS run and (c) model run (not assimilated). Sea surface height anomaly derived from satellite altimetry is also showed ((d) in figures).

4. Uncertainty of zonal wind stress along the equator

differences among wind stress
→ uncertainty (errors)
errors (bias) in result of OGCM run
not balanced to observed density field

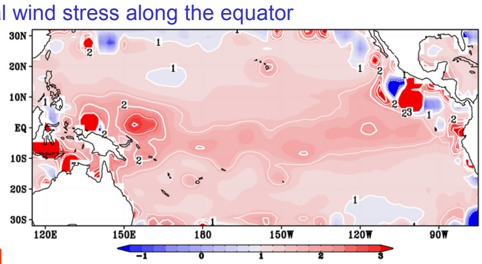


Fig. 4. Distribution of the ratio of the magnitude of zonal wind stress between ERA40 and NCEP reanalysis (ERA40/NCEP), averaged from January 1993 to December 2001.

5. Spurious circulation along the equator

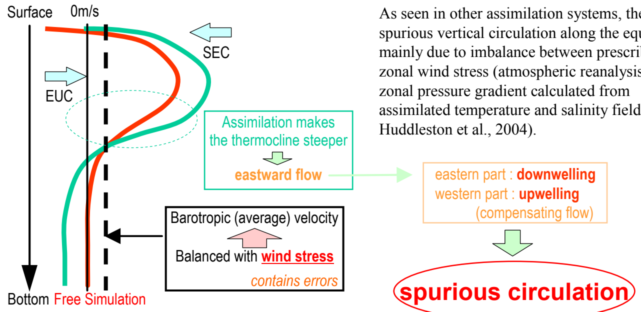


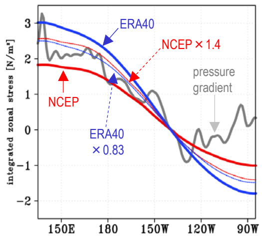
Fig.5. Schematic vertical profiles of the zonal current at the equator in the free simulation and assimilation runs.

As seen in other assimilation systems, there is spurious vertical circulation along the equator mainly due to imbalance between prescribed zonal wind stress (atmospheric reanalysis) and zonal pressure gradient calculated from assimilated temperature and salinity fields (cf. Huddleston et al., 2004).

6. Attempt to correct zonal wind stress along the equator

6.1 Decide correction coefficient

We compare zonal wind stress to zonal pressure gradient estimated from analyzed temperature and salinity fields around 165E and 140W, where the changes in pressure gradient are small. We then multiply zonal wind stress from NCEP reanalysis by 1.4 along the equator and apply it to MOVE-G in order to satisfy the main balance of zonal wind stress and pressure gradient.



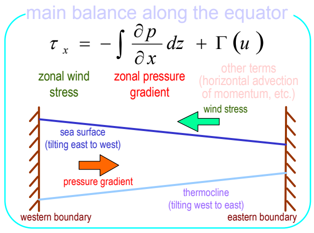


Fig.6. Distributions of zonal wind stress (red : NCEP, blue : ERA40; signs are reversed) and vertical integrated pressure gradient (gray line; effect of horizontal momentum advection is considered) along the equator averaged from January 1993 to December 2001. These values are integrated westward from 140W. Thick lines indicate original stress and dotted line indicate corrected value.

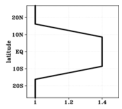


Fig.7. Meridional distribution of correction coefficient applied to zonal wind stress of NCEP reanalysis.

6.2 Result of wind correction run

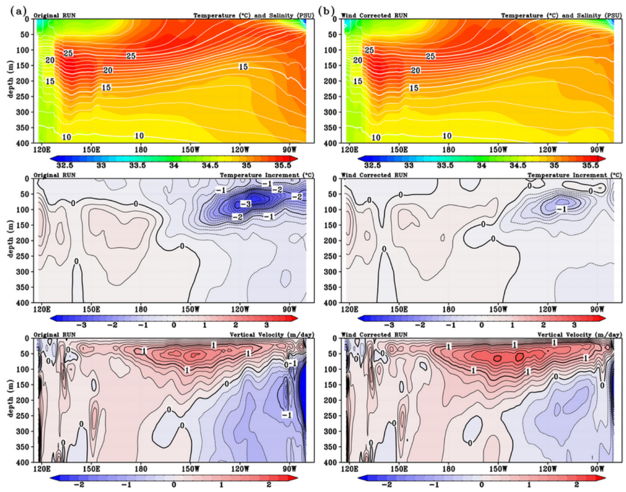


Fig. 8. Mean vertical section of temperature and salinity (top), analysis increment of temperature (middle) and vertical velocity (bottom) along the equator from assimilation run (a) without wind stress correction and (b) applied wind stress correction.

original (TSH) run : downward extension of warm water (eastern side)
→ downwelling
spurious circulation
large increment
wind stress correction is applied :
suppress spurious circulation
decrease increment (model error)

7. Summary

We found importance of salinity correction through multivariate analysis scheme and use of altimetry data in reproducing appropriate ocean state in ocean data assimilation system. We also showed a simplified balance correction technique for zonal wind stress. It is expected that this technique reduces an "Initial Shock" in El Nino forecasting model initialized using ocean data assimilation system. These application to the El Nino prediction is the next step.