

Three-Dimensional Analysis of Temperature and Salinity in the Equatorial Pacific Using a Variational Method with Vertical Coupled Temperature-Salinity EOF Modes

Yosuke FUJII (yufujii@mri-jma.go.jp), Shiro ISHIZAKI (sishizak@mri-jma.go.jp), and Masafumi KAMACHI (mkamachi@mri-jma.go.jp)
Japan Meteorological Agency / Meteorological Research Institute

Abstract

A method analyzing salinity, as well as temperature, is adopted in the equatorial Pacific without an Ocean General Circulation Model (OGCM). It is a Three-Dimensional Variational (3DVAR) method with vertical coupled temperature-salinity Empirical Orthogonal Function (EOF) modes. Sea surface height observation data from satellites can be adopted as well as *in-situ* temperature and salinity. A comparison with independent ship-observed data showed that the feature of the salinity field is estimated adequately with the method (Fig. 1). From the estimation with *in-situ* temperature, salinity and TOPEX/Poseidon altimetry data, we confirmed that interannual variabilities of the near surface salinity field and the barrier layer in the period of 1993-2000 in the analyses are consistent with former studies (Fig. 2-5). The fresh water is confined to the west, sea surface salinity in the central equatorial Pacific is relatively high, and the thick barrier layer develops in the western equatorial Pacific in La Nina periods. The fresh water spreads to the central equatorial Pacific and the thick barrier layer moves to the east in El Nino periods. The correlation between near surface temperature and the barrier layer thickness is also confirmed (Fig. 5, 6). The analysis fields presented here are thus quite adequate to study the salinity interannual variability. The method may be also enable to reconstruct longer time-scale variabilities of the salinity field.

Comparison with *in-situ* data

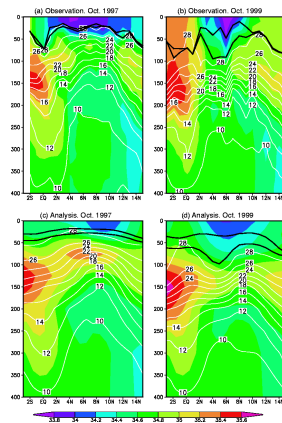


Fig. 1 Comparison of temperature ($^{\circ}\text{C}$, contour lines), salinity (psu, color shaded) fields, Mixed and Isothermal Layer Depths (MLD and ILD, black lines) in the depth-latitude section at 165°E . (a) Observation fields of October 1997 (El Nino). (b) Observation fields of October 1999 (normal). (c) Estimated fields of October 1997. (d) Estimated fields of October 1999. Observations are made by Ryofu-Maru, an observation vessel of JMA. Here, the estimations are conducted with *in-situ* temperature and TOPEX/Poseidon altimetry. It should be noted that observed salinity data is not adopted in the estimation.

The variabilities of near surface salinity, MLD, ILD, South Pacific Tropical Water (the depth and influence in the northern hemisphere) and the influence of the North Pacific Intermediate Water are adequately estimated.

Difference between El Nino and La Nina

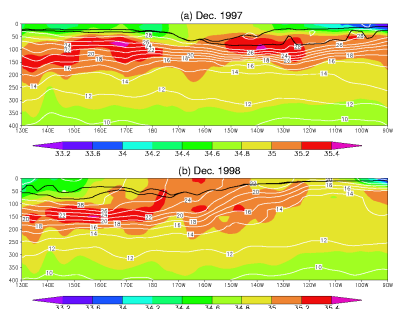


Fig.2 Depth-longitude sections of temperature ($^{\circ}\text{C}$, contour lines) and salinity (psu, color shaded) in the equator. The black lines denote MLD (upper) and ILD (lower). (a) December 1997 (El Nino). (b) December 1998 (La Nina).

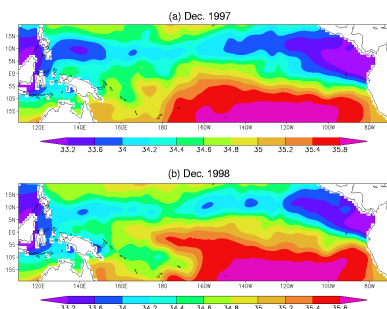


Fig.3 Horizontal fields of Sea Surface Salinity (SSS, psu). (a) December 1997 (El Nino). (b) December 1998 (La Nina).

Low SSS are dominated in the Western Equatorial Pacific and under the ITCZ in the El Nino Period.

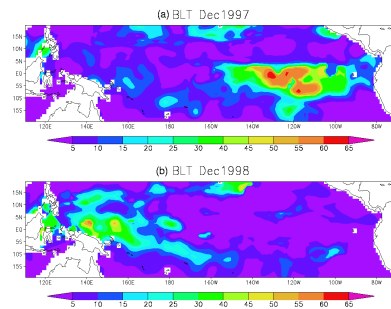


Fig.4 Horizontal distribution of Barrier Layer Thickness (BLT, m). (a) December 1997 (El Nino). (b) December 1998 (La Nina).

A thick barrier layer is seen in the Western (Eastern) Equatorial Pacific in the La Nina (El Nino) period.

Time-Variability in the Equator

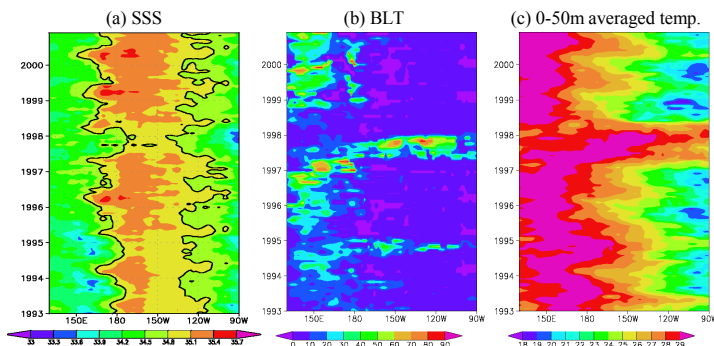


Fig.5 Time-longitude sections of (a) SSS (psu), (b) BLT (m), and (c) 0-50m depth averaged temperature ($^{\circ}\text{C}$) at the equator in the period of 1993-2000.

SSS decreased to less than 35.0 psu in the El Nino period. The thick barrier layer traveled to the east in the beginning of El Nino was followed by high near surface temperature.

Reference

Fujii and Kamachi (2003): Three-dimensional analysis of temperature and salinity in the equatorial Pacific using a variational method with vertical coupled temperature salinity empirical orthogonal function modes. *JGR*, 108(C9), 3297, doi:10.1029/2002JC001745.

Relation between BLT and Temperature

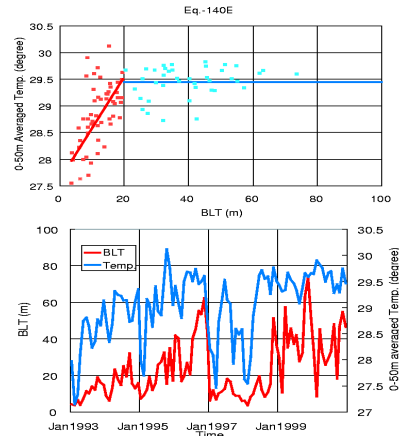


Fig.6 Relationship between BLT (m) and 0-50m averaged temperature ($^{\circ}\text{C}$) (top), and time series of BLT (m, red line) and 0-50m depth averaged temperature ($^{\circ}\text{C}$, blue line) (bottom) at the equator, 140°E , 1993-2000. The regression line (red line) for the elements whose BLTs are less than 20m (red squares) and the averaged line (blue line) for the elements whose BLTs exceed 20m (blue squares) are superimposed in the top figure.