

Variation of the South Pacific Tropical Water in an Ocean Data Assimilation System (MOVE System) and its Relation to ENSO

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1. Introduction

Examination of the variability of the South Pacific Tropical Water in the equatorial Pacific with an ocean data assimilation system (MOVE system) revealed that its change proceeds the change of surface temperature fields and even ocean heat content above 300m. We propose “SPTW oscillator”, a new scenario on the cyclic chain mechanism of ENSO from this analysis.

2. MOVE System (MOVE/MRI.COM-G)

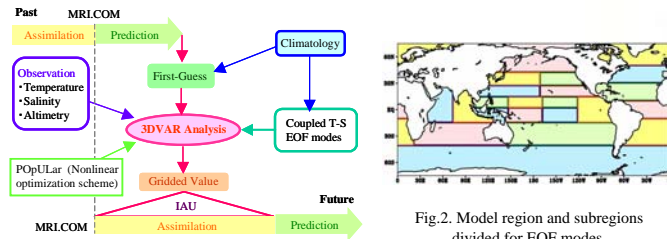


Fig. 2. Model region and subregions divided for EOF modes.

- 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) (Wind stress is corrected. See Ishizaki's poster)
 - latent and sensible flux : bulk formula of Kara et al. (2000) with model SST
- ANALYSIS :** multivariate 3DVAR scheme with 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.
 - observation data : In situ temperature and salinity measurement (ship, buoy, ARGO float) altimetry data (TOPEX/Poseidon, Jason-1, ERS-1/2, ENVISAT)
- REANALYSIS PERIODS :** 1993 January to 2004 December (12 years)

3. Warm water pool Heat Content (WHC)

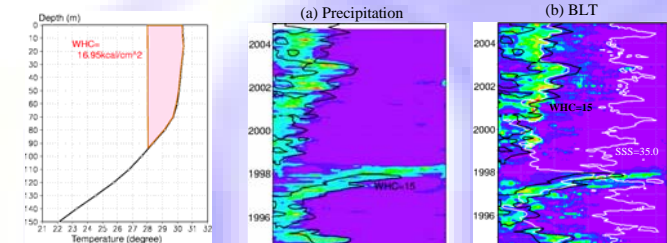


Fig. 3. Example of WHC. WHC is defined as the heat content relative to the depth of 28°C.

Fig. 4. Longitude-Time section of precipitation (from CMAP) and barrier layer thickness (BLT). The contour of WHC (=15cal/cm²) and SSS (=35.0psu) is overwritten. Figure (a) shows that high WHC is well correlated to the atmospheric deep convection area and becomes a good indicator of the impact of the ocean on the atmosphere. Barrier layer tends to increase WHC as shown Fig. (b).

4. South Pacific Tropical Water (SPTW)

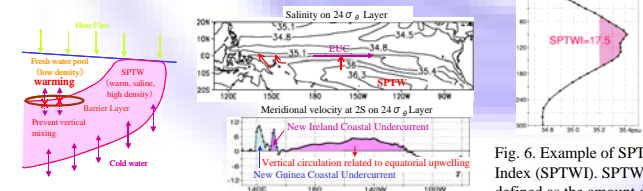


Fig. 5. Schematic figure of the relation between SPTW and ENSO (left) and the origin and passage of SPTW (right).

Fig. 6. Example of SPTW Index (SPTWI). SPTWI is defined as the amount of salinity in the water more than 35.2psu above 300m depths.

5. Indices and Analysis method

- Employed Indices other than WHC, SPTWI**
- BLT: Barrier Layer Thickness (isothermal layer depth – mixed layer depth)
 - OHC: The heat content (cal cm⁻²) above 300m
 - VSIN: Velocity on the 25 σ_θ surface across 5S from south to north.
 - τx: Zonal wind stress (Strength of the trade wind)

Analysis Method

All indices other than VSIN are averaged in 5S–5N, 125–240E at first. VSIN is averaged between 125–240E. Then high frequency components whose periods are less than 1.5 years are removed.

6. A new scenario of ENSO (SPTW Oscillator)

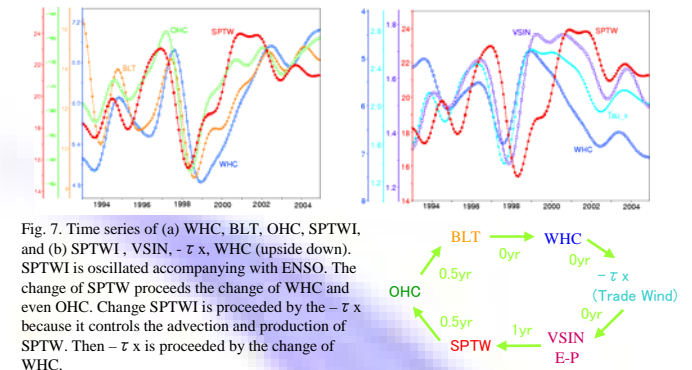


Fig. 7. Time series of (a) WHC, BLT, OHC, SPTWI, and (b) SPTWI, VSIN, -τx, WHC (upside down). SPTWI is oscillated accompanying with ENSO. The change of SPTW proceeds the change of WHC and even OHC. Change SPTWI is proceeded by the -τx because it controls the advection and production of SPTW. Then -τx is proceeded by the change of WHC.

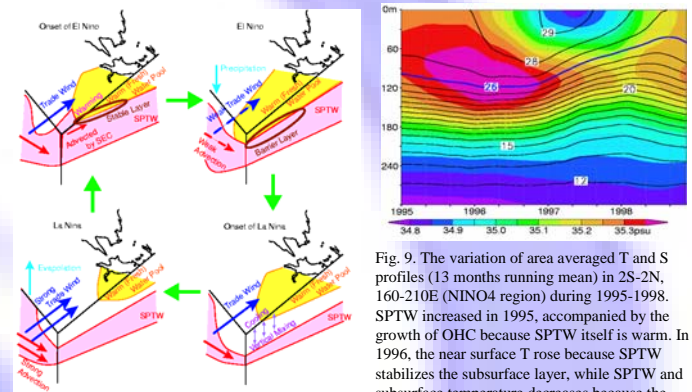
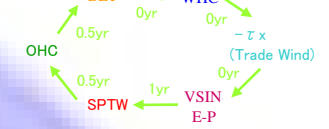


Fig. 8. Schematic figure of the SPTW Oscillator

Fig. 9. The variation of area averaged T and S profiles (13 months running mean) in 2S–2N, 160–210E (NINO4 region) during 1995–1998. SPTW increased in 1995, accompanied by the growth of OHC because SPTW itself is warm. In 1996, the near surface T rose because SPTW stabilizes the subsurface layer, while SPTW and subsurface temperature decreases because the supply of SPTW declined. After 1997, the surface temperature cooled down because subsurface layer is unstable with little SPTW.

7. Budget Analysis

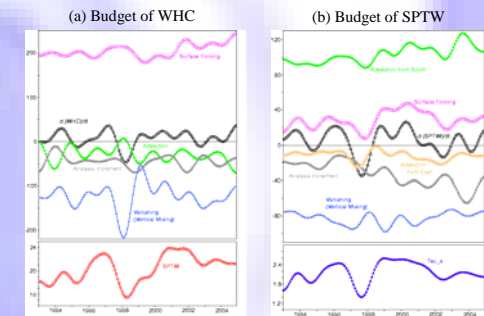
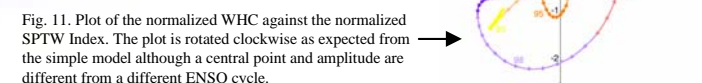


Fig. 10. Result of budget analysis of (a) WHC and (b) SPTW in the averaging area (5S–5N, 125–240E). The change of WHC is derived by vanishing (vertical mixing) and the rate of vertical mixing is correlated with SPTW Index. The change of SPTW Index is mainly caused by the variability of the advection rate from south and the surface forcing. They are correlated with the strength of the trade wind. These results support the hypothesis illustrated in Fig. 8.

8. Simplified model

$$\left. \begin{aligned} \frac{d(T - T_b)}{dt} &= \alpha(S - S_b) \\ \frac{d(S - S_b)}{dt} &= -\gamma\Delta U = -\beta(T - T_b) \end{aligned} \right\} \frac{d^2(T - T_b)}{dt^2} = -\alpha\beta\gamma(T - T_b)$$

T : WHC S : SPTWI T_b, S_b : Background state
 ΔU : Zonal wind stress anomaly (positive → westerly)
 α, β, γ : proportional constants (positive)



9. Summary

We proposed a new scenario on the mechanism of the oscillatory nature of ENSO (Fig. 8). SPTW (salinity) variability plays an important role there. We should therefore put more attention to salinity variability when we examine the seasonal–interannual variability of climate. In addition, the sustainable salinity observing system, including ARGO, is surely important.

10. Reference

Fujii, Y., and M. Kamachi, 2003: *J. Geophys. Res.*, **108**(C9), 3217, doi:10.1029/2002JC001745.
 Usui et al. 2006: *Adv. Spa. Res.*, in press.