On the Influence of Warm Pool SST Variability and Wind Stress Forcing on ENSO in SODA

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1. Introduction & Previous Study

• Details of the variability in the wind stress projection onto the oceanic baroclinic modes in the tropical Pacific with the ENSO decadal variability before and after the late 1970s (Moon et al. 2004)
• Formation of the western Pacific warm pool is fundamentally driven by ocean dynamics, but atmospheric processes also play an important role (Ramanathan and Collins 1991; Waliser and Graham 1993; Ramanathan et al. 1995; Schneider et al., 1996; Clement et al. 2000)
• Moon et al. (2004) showed the enhanced role of the higher-order baroclinic mode (due to change of the ocean thermal structure) after the 1980s, which induced longer period and stronger intensity of ENSO.
• Wang (2008) pointed out that the atmosphere-ocean change is associated with Indo-Pacific warm pool (IPWP). The intensity of the deep convection is very sensitive to the SST change over the warm pool region and the interannual variability of SST over the western Pacific warm pool has a positive feedback on the ENSO cycle.
• Atmospheric trade winds are weakened in the central and eastern tropical Pacific (Wai and Xie 2003, Vecchi et al. 2006)
• Previous studies mainly focused on the effect of wind-stress forcing on the period and intensity of ENSO, and reported that equatorial western Pacific warm pool is strongly related to ENSO modulation.

They found that the change in western Pacific warm pool and wind-stress may lead to a variation in ENSO, however, they failed to explain the causes of this change and the underlying mechanisms that describe the dynamics and mechanisms in detail, finding the source of the changes in wind is an important issue.

2. Data and Methodology

2.1 Data

• SODA version 2.0.2 (based on Modular Ocean Model version 2.0 MODM) of GFDL
• Resolution: 0.5°x0.5°/40 levels (with 10 m spacing near the surface)
• Variables: monthly ocean temperature, salinity, wind stress which is derived from SODA version 2.0.2.
• The constraint algorithm is based on optimal interpolation data assimilation. Assimilated data include temperature and salinity profiles from the World Ocean Atlas 2001
• Period: the 45-yr period from January 1958 to November 2005
• Hadley SST:
• The SODA system is useful to examine the oceanic variables in the subsurface layers and shows the characteristic changes of mean state in the ocean before and after the mid 1970s (Moon et al. 2004; Dewitte et al. 2009).

Therefore, it is appropriate to conduct the vertical modal decomposition using the temperature and salinity data in the SODA system. Since the focus of the paper is on the change in variability from before and after the late 70s, the analyzed period is 1958-1997.

2.2 Methodology

• Horizontal scale >> vertical scale in ocean: The variables represented motion of the ocean can be expressed as the summation of the normal mode.
• According to Cane (1986)’s suggestion, the ocean variables are expressed as vertical mode as follows. The barotropic mode m=0 was excepted.

\[
\{a_0, a_1, a_2, a_3, \ldots, p_0, p_1, p_2, p_3, \ldots\} = \sum_{n=0}^{\infty} \sum_{m=0}^{n} a_{n,m}(t,x,y) \phi_n(x) \phi_m(y)
\]

• \(a_n, a_0\): zonal and meridional currents, \(\phi_n, \phi_0\): pressure field and sea level height
• \(P_n\): the value of the wind stress projecting on the nth baroclinic mode
• \(\beta\): depends on the vertical structure functions
• Defined as in Lighthill (1969).

3. Results

3.1 Wind Stress Forcing Change

4. Summary

5. Fluctuation increase after the mid 1990s
6. Stabilizing a little bit earlier than the mid 1970s
7. It may lead the climate shift of tropical Pacific around the mid 1970s
8. Wind stress forcing in central Pacific is associated with ENSO.
9. ENSO variability in the central Pacific oceanic baroclinic modes on the central equatorial Pacific.
10. ENSO variability is evident in the central Pacific oceanic baroclinic modes on the central equatorial Pacific.