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Westerly wind events, diurnal cycle and central Pacific El Niño warming

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ABSTRACT

In the past three decades, the strongest central Pacific (CP) El Niño event was observed in 2009–2010 by satellites. When intensity of this CP El Niño reached its maximum, large diurnal variations of sea surface temperature (SST) were also observed from tropical atmosphere ocean moorings in the central equatorial Pacific. Solar radiation in the equatorial central Pacific is larger than 140 W/m^2, which leads to the amplitude of diurnal cycle of SST primarily determined by large-scale wind patterns. Intraseasonal westerly wind events (WWEs) can lead to an eastward displacement of the warm pool and also can weaken the trade winds in central Pacific. When the occurrence of equatorial WWEs is more than 20 days in a month, monthly mean wind speed in central equatorial Pacific has high possibility of wind speed less than 3 m/s, thus has pronounced diurnal cycle of SST. The diurnal cycle of SST will rectify daily mean SST. Reduced mixing at the base of the mixed layer and suppression of entrainment due to the accumulated effect of diurnal cycle may lead to warmer SST in the following month. This study suggests the occurrence of more diurnal SST events may contribute to the increasing intensity of the CP El Niño events.

1. Introduction

Classical El Niño events characterized by anomalous warming in the eastern equatorial Pacific Ocean, are referred as eastern Pacific (EP) El Niño. A different type of El Niño with maximum

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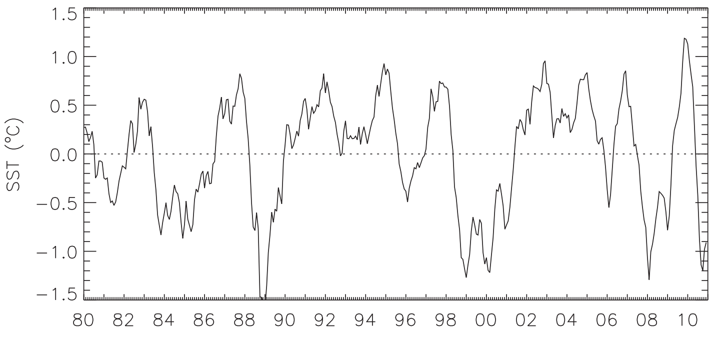

Fig. 1. Niño4 index representing monthly SST anomalies in central equatorial Pacific.

warm anomalies occurring in the central equatorial Pacific, known as central Pacific (CP) El Niño (Yu and Kim, 2010), warm pool El Niño (Kug et al., 2009), El Niño Modoki (Ashok et al., 2007), or dateline El Niño (Larkin and Harrison, 2005), has drawn a lot attention recently. CP type El Niño has different teleconnections and climatic impacts from classical El Niño (Weng et al., 2009). Recent studies show that the classical El Niño has become less frequent and CP type El Niño has become more common since the late twentieth century (e.g. Kug et al., 2009; Lee and McPhaden, 2010). The specific generation mechanism of CP El Niño is not fully understood. Zonal advection of heat in the upper ocean is considered to play a key role in developing the CP El Niño (Kug et al., 2009; Yu and Kim, 2010).

CP El Niño events described by the Niño4 index (160° E–150° W, 5° S–5° N, Fig. 1) show an increasing intensity and occurrence frequency of the CP El Niño events since the 1990s, with the strongest warming occurring in 2009–2010 in the past three decades (Lee and McPhaden, 2010). Before the CP El Niño reached its maximum in the boreal winter of 2009–2010, a series of diurnal events with day and night temperature difference more than 1 °C at 1 m depth were observed in central equatorial Pacific (Fig. 2).

Diurnal cycle is a fundamental mode of the climate system. Large areas of the global ocean exhibit a diurnal cycle of sea surface temperature (SST, Anderson et al., 1996; Stuart-Menteth et al., 2003; Ward, 2006). Large SST diurnal cycle occurs with increased solar radiation and decreased winds (Price et al., 1986). The diurnal variability of SST has a great impact on the time integrated air–sea heat flux calculations (Price et al., 1986), and has an important influence on mixed layer dynamics (Shinoda, 2005).

Diurnal cycle of solar radiation that modulates intraseasonal SST variability associated with the passage of Madden–Julian oscillation (MJO) in Indian Ocean and western Pacific Ocean is well documented (e.g., Bernie et al., 2005, 2007; Danabasoglu et al., 2006; Shinoda and Hendon, 1998; Shinoda, 2005). Diurnal cycle of insolation during the calm phase of MJO leads to a large diurnal cycle in SST (Weller and Anderson, 1996). SST rapidly increases during the daytime and a diurnal warmer layer

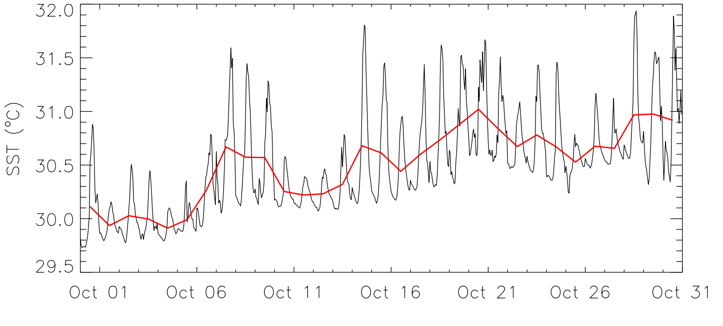

Fig. 2. Hourly (black line) and daily (red line) SST at 1 m depth at 180°, 2° N in October 2009.