

Observed splitting eastbound propagation of subsurface warm water over the equatorial Pacific in early 2014

Fei Zheng · Jiang Zhu

Received: 9 April 2014 / Accepted: 1 September 2014 / Published online: 30 December 2014
© Science China Press and Springer-Verlag Berlin Heidelberg 2014

Abstract El Niño, as characterized by above average sea surface temperatures in the equatorial tropical Pacific, is the largest source of natural climate variability from seasonal to interannual scales and can profoundly reshape the global weather patterns. Currently, the tropical Pacific Ocean appears to be primed for a potentially significant El Niño event, and some similarities exist between the oceanic and atmospheric states in early 2014 compared to the observations shortly before the onset of the 1997/1998 Super El Niño event. For example, as one of the most important early signs of El Niño, a splitting eastbound propagation of the subsurface warm water is evident over the equatorial Pacific since January 2014. In this study, the pulses of subsurface warm water are reflected by the Kelvin waves over the equatorial Pacific estimated from the satellite altimetry data. Results show that the current (i.e., March 2014) Kelvin wave over the equatorial Pacific has achieved the largest amplitude compared to those in the corresponding period prior to the El Niño events since the availability of satellite altimetry, and is even significantly larger than the one that preceded the 1997/1998 Super El Niño event. As the Kelvin waves can help induce El Niño conditions within about 2–4 months, the current fastest/strongest eastbound propagation of subsurface warm water indicates that the likelihood of an El Niño event will significantly increase during the next several months in 2014.

Keywords El Niño · Kelvin wave · Subsurface warm water · Eastbound propagation

1 Introduction

El Niño–Southern Oscillation (ENSO), which is one of the most striking interannual variabilities in the tropical Pacific, has been studied for several decades. Understanding the changes in its characteristics is still an important issue for worldwide environmental and socioeconomic interests [1, 2]. Our current understanding of the genesis of El Niño is based upon the work of Wyrtki [3], who hypothesized that a buildup of warm water in the western Pacific is required for an El Niño. And the zonal advection of heat via the east–west migration of the warm pool is also highlighted by Picaut et al. [4] to further understand the El Niños. As observed in each El Niño event, both an accumulation of warm water in the western equatorial Pacific and a following propagation of the warm water toward the east are the necessary preconditions for the initiation of an El Niño [5, 6]. Moreover, westerly wind anomalies in the western Pacific provide a trigger mechanism for this warm water to propagate to the east through the action of downwelling Kelvin waves [7]. During an El Niño, westerly wind bursts (WWBs) embedded within the Madden–Julian Oscillation (MJO) serve to move the warm pool east allowing longer fetch leading to stronger Kelvin waves [8, 9]. Energy received by the Kelvin wave is an integration of zonal wind stress along the characteristic line of Kelvin wave [10].

Within the past 20 years, a series of remote sensing satellites (e.g., sea surface temperature (SST) observed from the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites, and TOPEX/Poseidon altimetry satellite) provided a more accurate measurement of SST and sea level (SL) variations compared to the traditional in situ oceanographic observations. The operational Global Ocean Data Assimilation System (GODAS) [11] products also provide a unique opportunity to

F. Zheng · J. Zhu (✉)
International Center for Climate and Environment Science
(ICCES), Institute of Atmospheric Physics, Chinese Academy
of Sciences, Beijing 100029, China
e-mail: jzhu@mail.iap.ac.cn

investigate the subsurface structure of the oceans in an ever-improving view. These advances have allowed the real-time monitoring of recent El Niño events.

In this study, as alerted by an unusually eastbound propagation of the subsurface warm water over the equatorial Pacific since January 2014 (Fig. 1), the current condition in SL over the tropical Pacific is compared to the observations of the same period prior to the onset of the six El Niño events since 1993, to examine the precondition on favoring a possible El Niño and understand the rapid SST change in 2014 over the tropical Pacific. Through giving the unusual character of current tropical Pacific Ocean, specifically for the appearance of an estimated largest signal of downwelling Kelvin wave over the equatorial Pacific since the 1994/1995 El Niño, the results indicate the

increasing evidence of an upcoming change in the Pacific Ocean base state that can favor the development of an El Niño event in this year.

2 Dataset and analysis procedure

The monthly observations used in this study include SST and SL, as well as the subsurface ocean temperature. The monthly averaged altimeter products used for the observed SL signal are produced by Ssalto/Duacs and distributed by the Archiving, Validation, and Interpretation of Satellite Oceanographic (AVISO) data, with support from Cnes (<http://www.aviso.oceanobs.com/duacs/>). The altimeter products with on a 1° latitude \times 1° longitude grid are the merged sea level anomalies (SLA) measured by the satellite altimeter onboard (i.e., *Saral*, *Cryosat-2*, *Jason-1&2*, *T/P*, *Envisat*, *GFO*, *ERS-1&2*, and even *Geosat*) since October 1992 and are calibrated, merged, and archived by the AVISO project. The monthly SST data are version 2 of the NOAA optimum interpolation (OIv2) SST dataset at $1^\circ \times 1^\circ$ resolution [12], which blends all in situ temperature reports from ships, buoys, and satellite SST. The subsurface ocean temperatures are from the National Centers for Environmental Prediction (NCEP) GODAS [11] on a 0.333° latitude \times 1.0° longitude grid. The SST anomalies are formulated with respect to the seasonal cycle of a period from 1971 to 2000, and the climatological fields of GODAS subsurface temperature are generated based on the period of 1982–2004.

In order to quantify the impact of Kelvin wave propagation on the El Niño events, the AVISO SLA data are first converted to geostrophic currents using the methodology of Picaut and Tournier (1991) [13]. Next, the technique derived by Delcroix et al. [14] is used to separate the geostrophic current data into Kelvin component. To identify the signature of first baroclinic Kelvin wave, the zonal surface current anomaly is projected into equatorial orthogonal modes through restricting in the Kelvin mode (see Appendix in [14]). We present the results of only the first mode for Kelvin wave due to its dominant role in equatorial wave theory.

To compare the anomalous conditions of the tropical Pacific in March 2014 with those in the corresponding period of previous El Niño events, six El Niños since 1993 (i.e., 1994/1995, 1997/1998, 2002/2003, 2004/2005, 2006/2007, and 2009/2010) are selected according to the NOAA oceanic Niño index (ONI, available at http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml), which is defined as a 3-month running mean of SST anomalies over five consecutive months in the Niño-3.4 region (5°N – 5°S , 120° – 170°W).

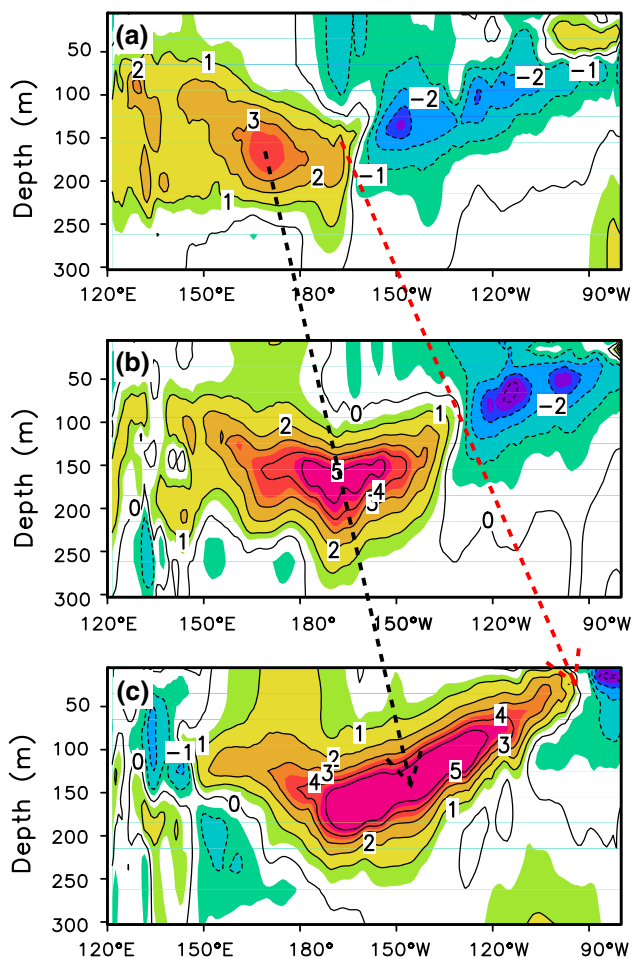


Fig. 1 GODAS subsurface temperature anomalies over the equatorial Pacific (averaged between 2°S and 2°N) in **a** January, **b** February and **c** March of 2014. The black dashed arrow represents the movement of the center of subsurface warm water, and the red dashed arrow represents the movement of the east edge of subsurface warm water. The contour interval is 1.0°C

Download English Version:

<https://daneshyari.com/en/article/5789354>

Download Persian Version:

<https://daneshyari.com/article/5789354>

[Daneshyari.com](https://daneshyari.com)