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Intraseasonal to interannual zonal displacements of the very oligotrophic waters of the Pacific warm pool: a multi-satellite approach

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The western equatorial Pacific warm pool (characterized by sea surface temperature (SST) > 29˚C and sea surface salinity < 35) is usually considered as a broad oligotrophic region with a nitrate exhausted and low chlorophyll (< 0.1 mg m^{-3}) surface layer. Nevertheless, ocean colour imagery shows that surface chlorophyll concentrations vary at the interannual, seasonal, and intraseasonal time-scales. In this study, we use the 2000-2007 SeaWiFS data together with QuikScat wind, TMI SST, altimetric sea level, and OSCAR satellite-derived surface currents to describe and understand the variability of the surface chlorophyll in the region.

We show that the eastern part of the warm pool is occupied by a quasi-persistent strip of very oligotrophic waters with chlorophyll concentrations close to those observed in the subtropical gyres (0.07 mg m^{-3}). It extends over about 20 degrees of longitude and its width varies seasonally and with the El Niño/La Niña phases. Overall, this very oligotrophic zone matches the well-documented region with the warmest SST (> 30˚C), thickest barrier layer (> 20 m), and highest sea level (> 220 cm) of the equatorial Pacific. Its eastern limit (marked by the 0.1 mg m^{-3} surface chlorophyll isoline) matches the eastern edge of the warm pool and moves zonally at seasonal and interannual time-scales. Its western edge is also defined by the 0.1 mg m^{-3} chlorophyll and its zonal motions occur mostly at intraseasonal and interannual time-scales.

We investigate the late-2001 to late-2002 El Niño period to explore two mechanisms responsible for the eastward displacement of the western edge of the very oligotrophic water strip. In the first one, local physical processes drive nutrient entrainment to the surface layer. For instance, the cyclonic pattern of the wind associated with the ascending thermocline at the 156˚E, 5˚N TAO/TRITON mooring suggests that Ekman pumping was at work in June 2002. As a result, nutrient-rich waters were brought toward the lighted layer allowing photosynthesis. The second mechanism is advection of nutrient- and phytoplankton-rich waters from the west by equatorial eastward surface currents associated with westerly winds. One source of such biologically-rich waters is the upwelling north of New Guinea that develops when westerly winds (northwest monsoon, westerly wind burst) are blowing. An illustration is given in December 2001 when relatively cool and chlorophyll-rich waters were upwelled near the coast, spread equatorward, and expanded eastward in the 0˚-2˚S latitudinal band with a pattern consistent with the surface circulation pattern.

In conclusion, we propose horizontal advection as a mechanism responsible for zonal displacements of the western edge of the very oligotrophic waters and that recurrent westerly wind events during El Niño may contribute to maintain the often reported positive anomaly of chlorophyll in the warm pool. Persistent very oligotrophic waters at the eastern edge of the warm pool are the consequence of deep nutrient pool below the euphotic depth, of thick barrier layers unfavorable to vertical nutrient input, and of remoteness from nutrient-rich waters in the west of the warm pool.