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Seasonal characteristics and formation mechanism of the thermohaline structure of mesoscale eddy in the South China Sea

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Abstract

The seasonal characteristics and formation mechanism of the thermohaline structure of mesoscale eddy in the South China Sea are investigated using the latest eddy dataset and ARMOR3D data. Eddy-centric composites reveal that the horizontal distribution of temperature anomaly associated with eddy in winter is more of a dipole pattern in upper 50 m and tends to be centrosymmetric below 50 m, while in summer the distribution pattern is centrosymmetric in the entire water column. The horizontal distribution of eddy-induced salinity anomaly exhibits similar seasonal characteristics, except that the asymmetry of the salinity anomaly is weaker. The vertical distribution of temperature anomaly associated with eddy shows a monolayer structure, while the salinity anomaly demonstrates a triple-layer structure. Further analysis indicates that the vertical distribution of the anomalies is related to the vertical structure of background temperature and salinity fields, and the asymmetry of the anomalies in upper 50 m is mainly caused by the horizontal advection of background temperature and salinity.

Key words: mesoscale eddy, thermohaline structure, seasonal characteristics, South China Sea

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1 Introduction

Eddy is a widespread mesoscale phenomenon in oceans with horizontal scale of tens to hundreds of kilometers and duration ranging from days to months (Chelton et al., 2007, 2011; Faghmous et al., 2015). Since most eddies rotate faster than their propagation speed (Chelton et al., 2011), they can capture a large volume of water during their migration and constantly keep the water moving, and thus play an important role in mass and energy transport (Zhang et al., 2014; Dong et al., 2014). In addition, eddy also has significant impacts on local horizontal and vertical distribution of marine substances through its primary physical processes such as stirring and pumping (Gaube et al., 2014). Eddy pumping can induce strong vertical exchange of many oceanic tracers (e.g., temperature, salinity, nutrients), causing rapid change in vertical distribution (Klein and Lapeyre, 2009), which may vary from region to region. For example, the salinity anomaly caused by eddy pumping shows a positive-negative double-layer vertical structure in the Southern Ocean (Frenger et al., 2015), but a monolayer vertical structure in the North Atlantic subtropical gyre (Amores et al., 2017a). The effects of eddy stirring and pumping have important implications on the air-sea interaction over eddy (Small et al., 2008) and marine organism inside eddy (Falkowski et al., 1991).

The South China Sea (SCS), the largest semi-enclosed marginal sea in the northwestern Pacific Ocean, is dominated by monsoon, and its circulation and temperature and salinity (TS) distribution have distinct seasonal characteristics (Wyrtki, 1961; Fang et al., 1996; Fang et al., 2012). The unique geographical feature and seasonal variation of environment dynamics make the eddies in the SCS quite different from those in open oceans (Wang et al., 2008; Zu et al., 2013; Chen et al., 2015), in particular the structure of eddy-induced TS anomaly. As illustrated by Sun et al. (2016), the horizontal distribution of eddy-induced sea surface temperature (SST) anomaly in the SCS presents a dipole pattern in winter and a monopole pattern in summer, and the accompanying local wind anomaly show similar seasonal pattern because of ocean-atmosphere coupling. However, their study focuses only on eddy-induced temperature anomaly at sea surface,

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