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Dynamical structure of the sea off the east coast of Peninsular Malaysia

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Abstract The regional ocean modelling system (ROMS), at a resolution of 9 km, is used to investigate the dynamics of the sea off the east coast of Peninsular Malaysia (ECPM). The model is configured with two, one-way nested domains. Two simulations are performed in order to understand the dynamical structure of the sea off ECPM. The first simulation is a control run, using climatological monthly mean wind stress, surface freshwater flux, heat and observational oceanic inflow and outflow at open boundaries. The second simulation is an experiment aimed at presenting the seasonally averaged effect of isolated forcing in the absence of wind stress. This procedure allows understanding of the upwelling mechanism in the absence of wind stress forcing within the region. The model simulated the oceanographic features in the region reasonably well, in particular the circulation and temperature patterns conformed to those of Simple Ocean Data Assimilation and observations. Results show the possibility of upwelling in the summer monsoon along the sea off ECPM. This is due to the strong long-shore wind stress, which coincided with lower sea surface height and high baroclinic instability. The strong positive horizontal transport in accordance with the positive vertical transport within 104.5° E and 105.5° E, at latitude 3° N suggests net offshore transport and the occurrence of upwelling. Moreover, results demonstrate that summer upwelling rate at corresponding latitude induced by the long-shore wind stress is 3×10^{-5} m/s larger than the vertical velocity of 0.5×10^{-5} m/s induced by the wind stress curl. This reflects the importance of the long-shore wind stress for inducing the coastal upwelling. High concentrations of phytoplankton biomass through the proxy of chlorophyll-*a* concentration and the observed upward motion of denser water at the sea surface are due to the upwelled nutrient-rich water.

Keywords Regional ocean modelling system · East coast of Peninsular Malaysia · Long-shore wind stress · Upwelling

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1 Introduction

A prominent feature in the southern region of the South China Sea (SSCS) is the sea off the East Coast of Peninsular Malaysia (ECPM). It is part of the Sunda Shelf that connects to the Gulf of Thailand from the north, Karimata Strait from the south and western Borneo from the east. The entire SSCS region is shallow with a maximum depth of approximately 100 m; however, the depth exceeds 1,000 m towards the central part of the South China Sea (SCS). Circulation and hydrodynamics in the SSCS are strongly influenced by the monsoonal winds, in conjunction with other factors, such as complex bathymetry, coastlines and the existence of large islands (for instance, the Natuna Islands (Wyrtki 1961; Shaw and Chao 1994; Chao et al. 1996; Chu et al. 1999; Hu et al. 2000; Cai et al. 2007)). During the winter of the northern hemisphere, the wind of the SSCS comes from the north-east; however, during the summer, the wind comes from the opposite direction. Throughout both the monsoon seasons (Daryabor et al. 2010, 2014; Tangang et al. 2011), the western boundary current along the ECPM is the