Terr. Atmos. Ocean. Sci., Vol. 25, No. 2, 233-254, April 2014 doi: 10.3319/TAO.2013.10.08.01(Oc)

Tidal Effects on Circulation in and near the East China Sea

Hung-Jen Lee[1,*], Shenn-Yu Chao[2], Kon-Kee Liu[3], Shih-Jen Huang[1], and Gwo-Ching Gong[4,5]

[1] *Department of Marine Environmental Informatics, National Taiwan Ocean University, Keelung, Taiwan*
[2] *Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, USA*
[3] *Institute of Hydrological and Oceanic Sciences, National Central University, Jhongli, Taiwan*
[4] *Institute of Marine Environmental Chemistry and Ecology, National Ocean Taiwan University, Keelung, Taiwan*
[5] *Taiwan Ocean Research Institute, Kaohsiung, Taiwan*

Received 24 July 2013, accepted 8 October 2013

ABSTRACT

We incorporate tidal currents into a previously validated, three-dimensional, subtidal circulation model to assess tidal effects on the circulation in and around the East China Sea. Of particular interest is the tide-enhanced Changjiang plume dispersal and circulation in the southern East China Sea. The modeling results show that without tides, the Changjiang plume in summer presents itself as a stagnant, expansive pool in regions bordering the northern East China Sea and Yellow Sea, too far north and too accumulating relative to observations. The winter plume dispersal pushed by the north-northeast monsoon follows the China coastline southeastward as a coastal current that matches more closely with observations with or without tides. Incorporating the effect of tides brings the model closer to observation, especially in summer. During summer the Taiwan Warm Current shifts to lower latitudes, enhances upwelling off southeast China and induces a southward tidal residual coastal flow off southeast China. Tides also induce the observed seaward detachment of the summer plume. In winter, the prevailing north-northeast monsoon suppresses the Taiwan Warm Current to the minimum. However, if the winter monsoon is weakened for a few weeks, the Taiwan Warm Current reappears and these three mechanisms begin to operate as in summer. CTD surveys and satellite observations south of the Changjiang River estuary contribute to a better understanding of the tidal effects on regional ocean currents.

Key words: Changjiang plume, Taiwan Warm Current, Tidal residual coastal flow

Citation: Lee, H. J., S. Y. Chao, K. K. Liu, S. J. Huang, and G. C. Gong, 2014: Tidal effects on circulation in and near the East China Sea. Terr. Atmos. Ocean. Sci., 25, 233-254, doi: 10.3319/TAO.2013.10.08.01(Oc)

1. INTRODUCTION

Off shore of eastern China, the three-sea (East China Sea, Yellow Sea, and Bohai) system over the continental shelf borders the deep western Pacific Ocean (Fig. 1a). The East China Sea is sufficiently open to the western Pacific Ocean. Farther north, the Yellow Sea and Bohai become increasingly landlocked due to the presence of Korean peninsula and Japanese land masses to the east. Both tidal and subtidal circulations are sufficiently strong in the three-sea system. The tidal circulation is mostly driven by the westward propagation of barotropic, astronomical tides in the Pacific Ocean. Shoaling bottom over the shelf amplifies tidal currents. Some tidal energy propagates northward into the Yellow Sea and Bohai in regions north of the Changjiang mouth. South of the Changjiang mouth, tides propagate southward as coastal Kelvin waves after impinging on the Chinese coast (Jan et al. 2002). The subtidal circulation arises from multiple sources, each having a varying degree of seasonal variation. The bordering Kuroshio over the continental slope, the East Asian monsoon, river runoff (most notably from Changjiang or Yangtze River) and the northward Taiwan Warm Current from the Taiwan Strait all come into play. Among all external forces, the East Asia monsoon (Figs. 1b and c) stands out as the dominant force driving the seasonal circulation of the East China Sea.

Previous numerical models of ocean circulation in this region have varied from subtidal (e.g., Lee and Chao 2003) to tidal (e.g., Lee and Beardsley 1999; Lefevre et al. 2000; Hu et al. 2010). A few intermediate models (Li and Rong 2012; Rong and Li 2012) examined interactions between

* *Corresponding author*
E-mail: lecgyver@mail.ntou.edu.tw