The Various Components of the Circulation in the Singapore Strait Region: Tidal, Wind and Eddy-driven Circulations and Their Relative Importance

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ABSTRACT

To obtain a better understanding of environment-related physical oceanography in Singapore Strait Region, numerical experiments are implemented to study the circulation in SSR. The three important components, tidal, wind and eddy-driven circulations are identified. It is shown that the tidal circulation is dominant in the region. Even though the wind and eddy circulations are relatively small, they may have significant effect on the local circulation and material transport.

KEY WORDS: circulation; tides; wind; eddy; Singapore Strait.

INTRODUCTION

The Singapore Strait Region (SSR) located between the Strait of Malacca in the west and the South China Sea in the east, is of significant importance within global shipping routes. Due to the increase of shipping and port activities, the marine environmental protection of the Singapore Strait has become more and more critical. Unfortunately, there are only few research activities focusing on this special region in the scientific literatures. The only joint broad survey in the strait was conducted thirty years ago (JTCS, 1979), and showed the potential interaction between the dominant M2 tide and other tidal components and the complex topography. The numerical studies of the hydrodynamics in SSR started with 2D models in 1980s (Shankar, et al. 1997), and have evolved to 3D modeling since last decade (Chen, et al. 1997, Zhang and Gin, 2000, Pang and Tkahich, 2003). These studies gradually increased the accuracy of prediction by improving the boundary conditions and refining the grid resolution, but they mainly concentrated on the tidal properties within the strait. As shown in Fig. 1, SSR includes many small islands resulting in an extremely complex topography. Even though the currents in SSR are predominantly driven by tides (Pang and Tkahich, 2003), they are influenced by topography as well as wind forcing and coastlines. All these factors contribute various components to the total circulation in the region. Therefore, thorough and deeper studies of the mechanisms of generations and interactions of these components are fundamental for the understandings of the dynamics of the circulation within SSR. Field observations include all these components which affect each other through linear or nonlinear interactions. It’s difficult to divide the field measurement data into each component. However, with numerical modeling, it is possible to quantitatively separate each component’s effect by an elaborated design of numerical tests.

This paper will present the numerical studies and their results in order to understand and quantify the various components of the circulations within SSR. It will facilitate the near future studies of the circulations in local region around Singapore coastlines as well as in far field region in South China Sea. The paper is organized as follows. The numerical model and numerical experimental set-up will be first introduced. The model validation follows by the comparison with experimental data. The subsequent section will introduce the different components of the circulation and present the numerical results for each component. A brief conclusion will be given in the last section.

NUMERICAL METHOD AND MODEL SETUP

The numerical simulation is carried out with an unstructured-grid, free-surface, 3-D primitive equation Finite Volume Coastal Ocean Model (FVCOM). Its horizontal grid is comprised of unstructured triangular