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Numerical Simulation of Barotropic Tides around Taiwan

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ABSTRACT

A 1/12°, 2-D barotropic tide model was used to examine the characteristics of barotropic tides and to improve the accuracy of predicting tidal sea levels and currents in the seas around Taiwan. The form ratio suggests that tides are predominantly semidiurnal in the northern reaches of the Taiwan Strait and mixed of diurnal and semidiurnal elsewhere around Taiwan. When the dominant M_2 wave enters the Strait from the north, its amplitude is magnified to ~2 m in the middle, and then decreases rapidly toward the south end of the Strait. The predominance of diurnal tides along the southwest to the south coast of Taiwan is attributed to the quasi-resonance of diurnal waves in the South China Sea. The tidal range is small and tidal currents are weak off the east coast of Taiwan. Barotropic tidal energy is mostly dissipated on the shallow banks of the southwestern Strait. Results summarized from sensitivity tests on the bottom drag coefficient (C_D) and horizontal eddy viscosity (A_M) indicate that C_D = 0.0015 - 0.00175 and A_M = 150 m^2 s^{-1} lead to the best model-data fit when compared to the observed tidal sea levels at ten reference tide-gauge stations around Taiwan. The averaged root-mean-squared (RMS) differences of the simulated tidal sea level for the six principal constituents of O_1, P_1, K_1, N_2, M_2, and S_2 are significantly reduced to 1.3, 0.7, 2.0, 1.6, 5.1, and 3.1 cm, respectively, compared to that calculated from a 0.5° resolution global tide harmonic constant database, NAO.99b (Matsumoto et al. 2000). The averaged RMS differences of barotropic tidal currents (U, V) for O_1, K_1, M_2, and S_2 are (0.92, 1.64), (1.17, 0.61), (3.88, 2.37), and (1.52, 1.20) cm s^{-1}. A database of tidal sea levels and current harmonic constants, TWTIDE08, for Q_1, O_1, P_1, K_1, J_1, OO_1, $2N_2$, μ_2, N_2, ν_2, M_2, L_2, T_2, S_2, and K_2 is established with this study.

Key words: Numerical model, Barotropic tide, Harmonic constant, Database, Taiwan

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1. INTRODUCTION

Barotropic tides in East Asian waters (Fig. 1) have been studied at great length using observed tidal sea levels and currents supplemented with numerical tide models. The purpose of these investigations can be categorized into two groups, an analysis of the dynamics responsible for tidal wave behavior (e.g., Ye and Robinson 1983; Yanagi and Takao 1998; Fang et al. 1999; Jan et al. 2002; Jan et al. 2004a); and improvement in the accuracy of the numerical tide model (e.g., Kang et al. 1998; Lefevre et al. 2000; Matsumoto et al. 2000; Jan et al. 2004b). As summarized from these studies, barotropic tidal waves are dominated by semidiurnal constituents in the Northwest Pacific Ocean which propagate essentially westward to the East China Sea (ECS) and to the semi-enclosed South China Sea (SCS). When the tidal waves propagate onto the shallow shelf of the ECS, the dominant waves remain semidiurnal and their amplitude is magnified due to quarter wave resonance. When the tidal waves propagate into the SCS through the Luzon Strait, the dominant waves become diurnal, which is also due to quarter wave resonance for diurnal tides in the SCS. The semidiurnal tidal waves in the ECS split into two directions as they approach the coast around the Chang River (*aka* Changjiang or Yangtze River) mouth, with one propagating northward

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