Applied Mathematics and Computation 217 (2011) 8640–8654

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

Study of storm surge due to Typhoon Linda (1997) in the Gulf of Thailand using a three dimensional ocean model

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ARTICLE INFO

Keywords:
Gulf of Thailand
Three dimensional ocean model
Storm surge
Typhoon Linda

ABSTRACT

Numerical integrations using the three dimensional ocean model based on the princeton ocean model (POM) were applied for the study of both sea level elevation and ocean circulation patterns forced by the wind fields during typhoons that moved over the Gulf of Thailand (GoT). The simulation concerned a case of Typhoon Linda which occurred during November 1–4, 1997. Typhoon Linda was one of the worst storms that passed the Gulf of Thailand and hit the southern coastal provinces of Thailand on November 3, 1997. It caused flooding and a strong wind covering large areas of agriculture and fisheries, which destroyed households, utilities and even human lives. The model is the time-dependent, primitive equation, Cartesian coordinates in a horizontal and sigma coordinate in the vertical. The model grid has 37×97 orthogonal curvilinear grid points in the horizontal, with variable spacing from 2 km near the head of the GoT to 55 km at the eastern boundary, with 10 sigma levels in the vertical conforming to a realistic bottom topography. Open boundary conditions are determined by using radiation conditions, and the sea surface elevation is prescribed from the archiving, validation and interpretation of satellite oceanographic data (AVISO). The initial condition is determined from the spin up phase of the first model run, which was executed by using wind stress calculated from climatological monthly mean wind, restoring-type surface heat and salt and climatological monthly mean freshwater flux. The model was run in spin up phase until an ocean model reached an equilibrium state under the applied force. A spatially variable wind field taken from the European Centre for Medium-Range Weather Forecasts (ECMWF) is used to compute the wind stress directly from the velocity fluctuations. Comparison of tendency between the sea surface elevations from model and the observed significant wave heights of moored buoys in the Gulf of Thailand under Seawatch project is investigated. The model predicts the sea level elevation up to 68.5 cm at the Cha-Am area located in the north of where the typhoon strands to the shore. Results of sea level elevation show that there is an area of peak set-up in the upper gulf, particularly in the western coast, and the effects of the storm surge are small at the lower gulf. During the entire period of this study, the surge in the gulf was induced by the northeasterly wind blowing over it.

1. Introduction

The Gulf of Thailand is located in Southeast Asia immediately to the west of the South China Sea (SCS). The gulf is a semi-enclosed sea that measures approximately 400- km by 800- km, covering an area of about 320,000 square km. Its location in

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0096-3003/$ - see front matter
doi:10.1016/j.amc.2011.03.105

the global map is between 6°N to 14°N latitudes and 99°E to 105°E longitudes surrounded by the kingdom of Cambodia, Malaysia, the kingdom of Thailand and the socialist republic of Vietnam (Fig. 1). It is a part of the sunda shelf which is a submerged connection between Southeast Asia, Malaysia, Sumatra, Java and Borneo, and is relatively shallow. The mean and maximum depths in the central part in the GoT are about 45 m and 80 m respectively. The living and non-living resources of the gulf are of great value to the people of four littoral countries.

The Gulf of Thailand is subjected to the monsoon system of the Western North Pacific Ocean or the South China Sea. Monsoons influence the surface currents, being clockwise during the southwest monsoon and counterclockwise during the northeast monsoon. There are several POM-based studied in the SCS connected to the GoT e.g. Yang et al. [5] used the POM to study the seasonal mean SCS circulation and its formation mechanisms. It reproduced well the observed sea surface height (SSH) annual cycle, and the sensitivity experiments show that the wind forcing dominates the seasonal variability of the SCS SSH, while the buoyancy forcing is of minor importance. The model also indicated that the Kuroshio current affects the SCS circulation by creating a loop current that exists throughout the year. Gan et al. [6] had studied the circulation and its seasonal variation in the SCS in response to the forcing of the Asian monsoon and the Kuroshio intrusion by using a three-dimensional ocean model. They found that the seasonal circulation in the SCS is mainly driven by the monsoonal wind stress and greatly influenced by the inflow from the Kuroshio intrusion.

Chu et al. [10] used POM to simulate the circulation and thermohaline variability for the SCS covering the GoT. They verified that the wind effect is the key factor for the generation of the SCS deep basin warm/cool eddy and that the lateral boundary forcing is the major factor for the formation of the strong western boundary currents. Afterwards, Chu et al. [11] simulated the SCS thermohaline structure, as well as the circulation, and investigated physical processes causing seasonal variability by using POM. They revealed that the POM model has the capability for simulating seasonal variations of the SCS circulation and thermohaline structure. The simulated SCS surface circulation is generally clockwise during the summer, and counterclockwise during the winter monsoon period with the strong western boundary currents.

In the early 1960's, a Typhoon name was not recorded for one that hit the Laem Talumpuk area located in Nakhon Si Thammarat province. This event was not announced in advance, hence it devastated human life and utilities. In 1989, Typhoon Gay originated in the southern part of GoT as a depression and then strengthened quickly to become a tropical storm. Typhoon Gay caused storm surge and enormous damage on the coast of Chumphon province and neighboring areas. Typhoon Linda in 1997 also caused a storm surge. Typhoon Linda, which formed in a westward pattern in the SCS, was one of the worst storms to hit Vietnam. Southern Vietnam was devastated by Typhoon Linda during the first two days of November 1997. The rapid development of the storm in the East Sea not far from the Vietnamese coast

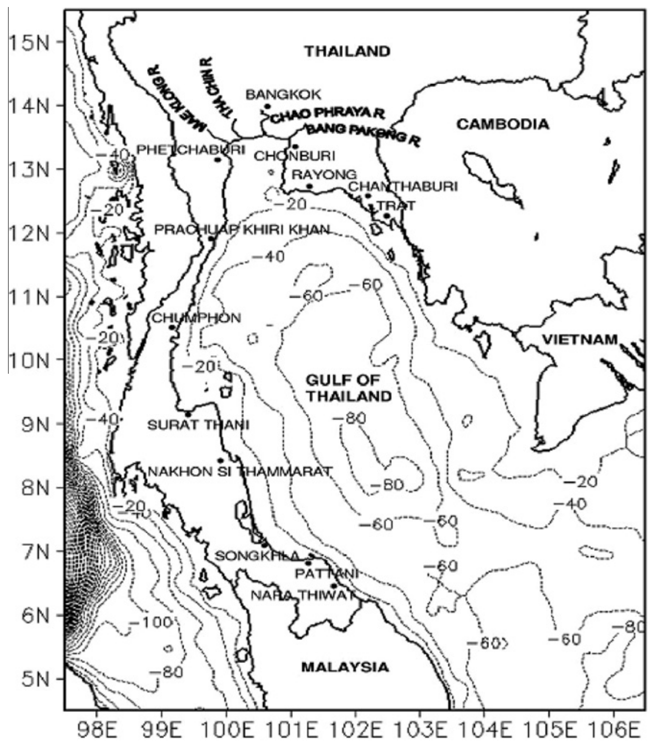

Fig. 1. Bathymetry (m) of the Gulf of Thailand.