Storm Surge Simulations of Typhoon Haiyan 2013 using A Parametric Wind and Pressure Model

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ABSTRACT

In the present study, the storm surge of Typhoon Haiyan in 2013 in the Philippines is simulated by a series of the simulations using the constant radius that is a key factor to calculate wind and pressure fields in typhoons in a parametric wind and pressure model. A series of the storm surge simulations is conducted using the wind speed-capped wave dependent drag at 30 m/s in a coupled surge and wave model. The simulation results show that the wind and pressure are 60 - 70 m/s and 910 hPa in the Leyte Gulf, respectively. The highest surge height at Tacloban ranges 6 m - 7m.

KEY WORDS: Typhoon Haiyan; storm surge; the wave dependent drag; coupled surge and wave model; parametric wind and pressure model

INTRODUCTION

Typhoon Haiyan on November in 2013 struck the coasts of the Leyte Gulf, Philippines. According to the National Disaster Risk Reduction and Management Council (NDRRMC), it confirmed 6,300 fatalities, 5,200 deaths and 26,000 in injury. During the whole life of the typhoon, it recorded the minimum depression of 895 hPa in the center sea level pressure and the maximum gust peak speed of 90 m/s.

Recent studies show that the wind drag, $C_D$, levels off at high wind speeds of 22 – 23 m/s (Black et al., 2007) and 33 m/s (Powell et al., 2003) for hurricane wind conditions. In storm surge models, bulk formulas are conventional ways to estimate the wind stress as a function of the wind drag coefficient. In coupled surge and wave models, the Charnock relationship is an alternative way in which the total stress of the wave induced stress and the wind stress is estimated in the presence of waves (1989; 1991). Then the wave dependent $C_D$ is explicitly obtained from the total stress, and used to simultaneously drive the surge and the wave in the coupled surge and wave model. However, the characteristic of the wind-capped wave dependent drag $C_D$ at high wind speed (20 - 33 m/s) is not well known under the extremely high wind condition. To consider leveling off at high wind speeds, we introduce the new method to cap the wave dependent drag at the specific wind speed (30 m/s) that drives the storm surge and the wave simultaneously in the coupled surge and wave model developed by Kim et al. (2008; 2010) to simulate the Typhoon Haiyan surges in 2013. In the present method, the wave dependent drag $C_D$ levels off at 30 m/s.

To simulate a storm surge wind and pressure fields are essential components. These can be calculated by a parametric wind and pressure model whose the radius from the typhoon center to the maximum wind speed is a key factor to reproduce wind and pressure fields in the typhoon. The radius is estimated based on observed sea level pressures. However, there are few observed sea level pressures along the Haiyan track. Because of lack of the observation, we took into account the constant radius for the whole typhoon life in the simulation to estimate the Haiyan wind and pressure field using Schloemer’s formula (1954) and Fujii and Mitsua’s formula (1986) for pressure and wind, respectively.

In the present study we investigate the appropriate radius for Typhoon Haiyan varying the constant radius in the leveling off at 30 m/s. With estimated atmospheric field, the storm surge is calculated and validated by the survey value (Tajima et al., 2014; Mori et al., 2014)

DESCRIPTION OF THE COUPLED SURGE AND WAVE MODEL

The coupled surge, wave and tide model (called SuWAT) has originally been developed by Kim et al. (2008). Here, the brief description is given. The tide module is ignored in this paper because the tidal range in the Leyte Gulf was small when the Haiyan surges occur (Mori et al., 2014).