Storm Surges Congress, Hamburg, Germany
13–17 September 2010
SSC2010-23

Storm surge due to Typhoon Maemi in Korea considering the impacts of wave breaking on surface currents

H.S. Lee (1), T. Yamashita (1), and J.-S. Shim (2)

(1) Department of development technology, Graduate School for International Developement and Cooperation, Hiroshima University, Higashi-Hiroshima, Japan (lee.hansoo@gmail.com, +81-82-424-4342), (2) Korea Ocean Research and Development Institute, Ansan, Korea

1. Introduction

Understanding on the air-sea interaction processes and implementation of such interaction model is very important in improvements of wave and current prediction, calculation of heat and water exchange, and turbulent mixing, material transport and many other applications. Recent researches on air-sea interaction using a coupled atmosphere-ocean model or a coupled wind-wave-current model consider it through a heat and water mass exchange, and a momentum transfer between air and sea. In general, the air-sea interaction in terms of the momentum transfer between wind waves and surface current is considered only in deep water through wave energy dissipation by whitecapping.

In this study, we proposed a new idea for the wind waves and currents interaction in terms of momentum transfer both in deep and shallow water with consideration of wave breaking due to whitecapping and depth-induced wave breaking, respectively (Lee and Yamashita, 2009; 2010). The new approach was implemented in our atmosphere-wind wave-ocean coupled model and applied to storm surge simulations due to Typhoon Maemi in Masan, Korea.

2. Momentum transfer from wind waves to surface currents

Even it is difficult to describe the waves and currents interaction in direct mathematical form, the description in some extent has been achieved due to spectral presentation of wind wave dynamics (Polnikov and Tkalich, 2006).

Due to the wave instability and breaking, some part of dissipated wave energy is generating turbulence in sea surface layer in both deep and shallow water. These intensive small scale motions are important in many applications dealing with air bubbles entrainment, vertical mixing of admixtures, heat and gas exchange, and many others (Tkalich and Chan, 2002a; Qiao et al., 2004). Here we assume the all dissipated wave energy is used for turbulent production in sea surface layer and for generating or enhancing the large scale motions such as currents. Therefore, the rest of the dissipated wave energy by wave breaking is changed into momentum to generate or enhance currents. Wave breaking phenomena considered in this study is whitecapping dominant in deep water and depth-induced wave breaking dominant in shallow water. Whitecapping mainly depends on the wave steepness whereas wave breaking in shallow water depends on water depth. Thus, wind wave energy dissipation due to whitecapping in deep water affects the upper layer of water column while the transformed momentum from dissipated wave energy due to depth-induced wave breaking in shallow water may have influence on the state of the entire water column.

We introduce a new method to consider the role of depth-induced wave breaking in shallow water separately from the whitecapping in deep water. In addition, dissipation coefficients are introduced to take into account the turbulence production in sea surface layer due to wave breaking both in deep and shallow water.

In the spectral action balance equation for spectral description of wind waves, the wind wave energy spectrum grows or decays corresponding to the energy balance in source and sink terms. Sink terms due to whitecapping ($S_{ds(w)}$) in deep water and depth-induced wave breaking ($S_{ds(dep)}$) in shallow water are estimated from the spectral action balance equation. Then the momentum flux induced by whitecapping and depth-induced wave breaking in deep and shallow water are determined by using both sink terms.