OPEN BOUNDARY CONDITIONS FOR FORCED WIND WAVES IN A COUPLED MODEL OF TIDE, SURGE AND WAVE

Soo Youl Kim，Tottori University, sooyoul.kim@sse.tottori-u.ac.jp
Yoshiharu Matsumi, Tottori University, matsumi@sse.tottori-u.ac.jp
Tomohiro Yasuda, Kyoto University, yasuda.tomohiro.4x@kyoto-u.ac.jp
Hajime Mase, Kyoto University, mase.hajime.5c@kyoto-u.ac.jp

INTRODUCTION

When modelling wind-driven long waves combined with tides, wind waves and surges under storm events in limited computational areas, values at open boundaries are the tidal current, the tidal water level, the wind and pressure-induced water level and current. These can be obtained from the extrapolation or the interpolation from large-scale models or observations. At the open boundary, the tide-induced water level and current are usually estimated by the astronomical tidal components. The combined wind and pressure-induced water level at the open boundary has been computed by barotropic law. However, the combined wind and pressure-induced current is ignored in most cases of modelling the wind-driven long wave combined with the tide, the wind wave and the surge. In the study, the method is proposed to estimate the combined wind and pressure-induced current at the open boundary and is described for the performance in the simple case and the real case in comparison with the Orlanski scheme modified by Miller and Thorpe (OSMT) and the passive form of the Flather's condition (FLA).

OPEN BOUNDARY CONDITIONS

- The present method

Two modes are assumed as follows:

1. The generation of the combined wind and pressure-induced water level

With simplifying the momentum equations, the Coriolis and nonlinear terms are ignored and it is obtained in the *x* direction:

$$gd\frac{\partial \eta}{\partial x} = -\frac{d}{\rho}\frac{\partial p_0}{x} + \frac{1}{\rho}\tau_s \quad (1)$$

where p_0 is the atmospheric pressure on the sea surface τ_s is the wind stress, η is the sea level, ρ is the water density, $d = h + \eta$; *h* is the local water depth and *g* is the gravity acceleration. With integrating Eq. (1), the sea level is given by the following equation.

$$\eta = -\left(p_0 - \tau_s / d\right)\rho g \quad (2)$$

2. The generation of the combined wind and pressure-induced current.

In the ignorance of the wind stress and the pressure gradient terms, inserting Eq. (2) into the momentum equation, the two-dimensional current, *U*, gives

$$\frac{\partial U}{\partial t} + gd\frac{\partial \eta}{\partial x} = 0 \quad (3)$$

After integrating Eq. (3) with time and neglecting the integration coefficient, the following equation for the current is obtained.

$$U = -gD\eta / \sqrt{gh} \quad (4)$$

These Eqs. (2) and (4) will be the prescribed values at the Flather's open boundary condition.

RESULTS AND DISCISSIONS

For the simple case, the numerical experiment was followed the way presented by Røed and Smedstad (1984) with the open and closed channel basins. A long wave was generated by forcing a wind of 14 m/s impulsively for 10 hours along the *y* direction over the lower portion in the closed and open basins. In the open basin, the constant wind of 14 m/s was forced for 30 days over the partial/whole portions. Although the oscillations with the range of ± 5 cm keeps on appearing in the sea level after forcing the wind from the results of OSMT and FLA conditions in the closed basin, the sea level becomes stable after 20 hours from those of the present method. The calculated current shows the same tendency with those of the sea level. From the results of the constant wind forcing, the similar trends are examined.

For the real case, the numerical simulations were conducted from 10:00 10th ~ 08:00 14th in Feb. 1999 Japanese Standard Time (JST) at the Toyama coast in Japan with three open boundary conditions. It can be seen from Fig. 1 that the present method acquires the stable sea level after even 1 day for the spin-up, while the OSMT and FLA conditions need at least 6 days for the spin-up calculations to be stable in sea level at Toyama.

From the results in the simple and real cases, it was found that the present method for the open boundary condition results in the more stable sea level and current. In addition, it showed that the duration of the spin-up calculation in implementing the present method is dramatically reduced compared to those in applying the OSMT and FLA conditions.

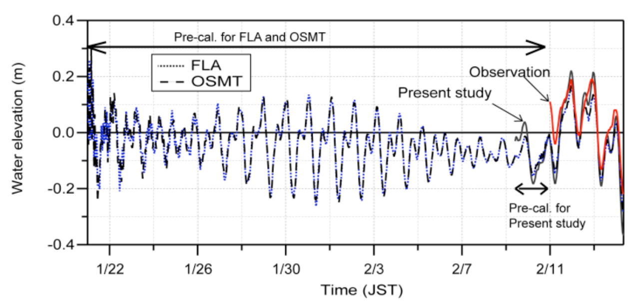

Figure 1 Comparisons between observations and calculations of open boundary conditions for the sea level at Toyama.

REFERENCES

Røed and Smedstad (1984): Open boundary conditions for forced waves in a rotating fluid, SIAM J. SCI. STAT. COMPUT., Vol. 5, pp. 414-426.