IMPACT OF RANDOM WAVE SPECTRA ON STOKES DRIFT IN COASTAL CURRENT MODELING

Yuki Imai, Kyoto University, imai.yuki.84z@st.kyoto-u.ac.jp
Junichi Ninomiya, Kanazawa University, jnino@se.kanazawa-u.ac.jp
Nobuhito Mori, Kyoto University, mori@oceanwave.jp

INTRODUCTION

The wave-induced velocity, known commonly as Stokes drift, plays an important role on upper ocean current system. However, in general, the depth profile tends to be estimated using a regular wave approximation like calculation from significant wave height in order to simplify the modeling. Breivik et al. (2014) proposed an improved Stokes drift profile to considering random waves but discussed limited to deep water. This study proposes a novel treatment of Stokes drift on random waves to consider full directional spectra and the approximated treatment is introduced into coupled ocean-wave model to apply for the depth-limited region. To validate the proposed treatment, Stokes drift velocity derived from the treatment is theoretically and empirically compared with some derived from regular wave approximation. Finally coastal current simulation is performed for Kii channel of Japan focusing on Tanabe bay by the coupled model with two-way-nesting scheme.

STOKES DRIFT ON RANDOM WAVES

Full directional spectrum can be calculated in a spectrum wave model (Simulating WAves Nearshore: SWAN) and the spectrum information is transferred to an ocean model (Regional Ocean Modeling System: ROMS) to be considered in vortex force terms of the ocean model. The mean velocity is return to wave model. Reducing the data transfer costs between SWAN and ROMS, the minimum spectrum information (direction and frequency spectrum parameters) is used to describe directional spectra based on two dimensional Gaussian distribution around the peak wave number (Mori et al., 2011). The random wave spectra can be approximately represented with the six parameters for computing Stokes drift velocity in ROMS.

OUTLINE OF STUDY

A series of comparisons were conducted to validate the Stokes drift velocity derived from directional spectra approximated as the 2D Gaussian spectra (referred to as Wave2d). First, the Stokes drift velocity profiles were compared random waves, approximated random waves and regular wave (referred to as Wave2d and Wave1d), theoretically. The random wave effects increases near surface Stokes drift velocity but decreases rapidly from the surface in comparison with regular waves. The directionality also plays important role to Stokes drift due to directional dispersion. The regular wave assumption gives strong mean velocity vertically.

Second, the numerical simulations were performed and validated for an ideal simple bathymetry (1/100 slope with wave diffraction due to breakwater) with the coupled ocean-wave model for Wave2d and Wave1d case. The results of Wave2d shows the direction of Stokes drift widely spread more and the magnitude of Stokes drift is smaller than Wave1d.

Third, the numerical simulation were performed reproduce coastal current are performed for Kii channel faced to the Pacific Ocean in Japan focusing on Tanabe bay with a two-way-nesting for Wave2d and Wave1d case.

Figure 1 shows spatial distribution of Hs, mean velocity, the frequency spectrum width parameter Q_p and directional spreading σ_θ. It is found that variability of Q_p is larger in coastal area than in open ocean due to the contribution by local directional spectrum changes but there are less variability of directional dispersion σ_θ. The effect of frequency dispersion variability appears in difference of mean velocity with and without random wave effects.

CONCLUSION

We proposed a new treatment of Stokes drift including full directional spectrum of random waves for coupled ocean-wave model. After the validation of the treatment of Stokes drift on random waves theoretically and empirically, coastal current analysis on Kii channel of Japan was implemented with the coupled ocean-wave model. It is found the large contribution of frequency dispersion variability especially in coastal area. That indicates importance of considering random wave effect in computing Stokes drift velocity in coastal current modeling. The validation by observed data will be presented at the conference.

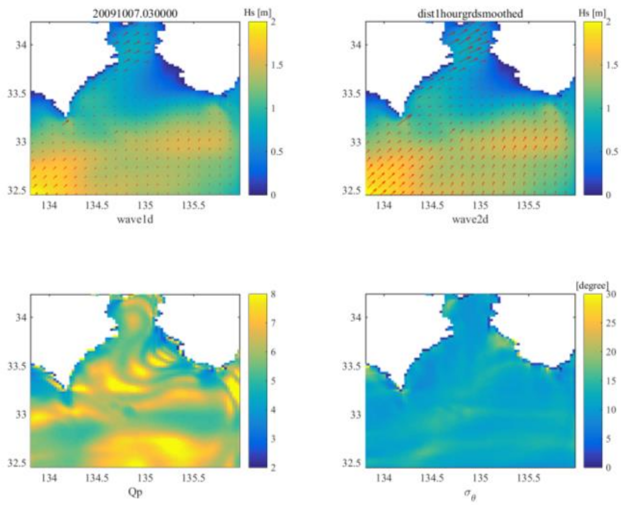

Figure 1. – One hour time averaged coastal currents and wave characteristics around Kii channel focusing on Tanabe bay. Upper left and right: mean velocity (vector) and wave height (shade) of Wave1d and Wave2d, lower left: the frequency spectrum width parameter Q_p, lower right: the directional dispersion σ_θ .

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