不規則波におけるStokes Drift効果を考慮した海洋・波浪結合モデルの構築
Development of the Coupled Ocean-Wave Model Considering Stokes Drift Effect on Random Wave

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1.Introduction
Much attention has focused recently on climate change of ocean areas in terms of coastal forcing and physical environments. IPCC AR5 (Intergovernment Panel on Climate Change, Fifth Assessment) published in a 2013 report the need for impact assessment for regional ocean environment, e.g. horizontal resolution of the order of 100m because of few ocean studies for that scale. Already little progress has been made in the development of numerical model applying to that ocean scale. This study develops the Coupled Ocean-Wave Model to carry out the calculation of regional ocean environments on a 500m horizontal resolution considering wave-induced transport on random waves incorporating the effect of Stokes Drift into the model. Two re-analysis calculations are performed, one considering the Stokes Drift on random wave and the other not, for Tanabe Bay in Wakayama as a verification of the model precision to compare with the field observation data.
2.Formulation of Stokes Drift on random waves
There is large interaction effect between currents and surface gravity waves in finite depth area such as in the coastal ocean. Wave-induced transport, a quantity known as Stokes Drift, on random waves is formulated to insert in the model. The Stokes Drift can be written as eq.1 (Kenyon et al., 1969). The distribution function of frequency spectrum and directional spectrum is approximated as the two-dimensional Gaussian spectrum and expressed as eq.2.
3.Test calculation on simple topography
Two runs are carried out for simple topography to confirm the effect of Stokes Drift on random waves. One (referred to as Wave2d) uses the model in which wave-induced transport is provided by random waves and the other (referred to as Wave1d) uses a model in which it is provided by regular wave. The topography has a single slit on middle of itself (fig.1). In comparison with Wave1d, in Wave2d Stokes Drift velocity on the large directional range is verified (fig.2).
Verification of model precision
Three runs are performed by horizontal resolution 500m and 20 vertical layers for Tanabe Bay in Wakayama prefecture. The additional run is carried out using only the Ocean model, i.e. not considering the effect of wave-current interaction. According to the comparison in velocity between these three results and observation data in, a correlation is observed between Wave2d and observation data (fig.3).
4.Conclusion
This study developed the Coupled Ocean-Wave Model to consider wave-current interaction on random wave. Wave2d simulation for Tanabe Bay was conducted and its output of velocity show qualitative correlation with observation data. This model can be adapted for accurate reproduction on a regional ocean scale, which can make it possible to project future climate on that scale.

キーワード：Stokes Drift、不規則波、波・流れ相互作用、領域スケール
Keywords: Stokes Drift, random wave, wave-current interaction, regional ocean scale

$$\mathbf{U}(z) = \frac{1}{\rho}\iint_{-\infty}^{\infty} F(\boldsymbol{k})\frac{\boldsymbol{k}}{\omega(k)}\frac{2k\cosh[2k(z+h)]}{\sinh(kh)}\mathrm{d}\mathbf{k} \qquad \text{(eq.1)}$$

ρ: water density, F: the two-dimensional energy spectrum, **k**: wave number vector, k: the magnitude of **k**, ω: angular frequency, h: total depth

$$\mathrm{E}(\omega,\theta) = \frac{m_o}{2\pi\sigma_\omega\sigma_\theta}\exp\{-\frac{1}{2}[\left(\frac{\omega-\omega_p}{\sigma_\omega}\right)^2 + \left(\frac{\theta-\theta_p}{\sigma_\theta}\right)^2]\} \qquad \text{(eq.2)}$$

ω, θ: frequency and direction, ω_p, θ_p: the principal frequency and direction, σ_ω, σ_θ : the deviation of frequency and direction, m_0: the variance of the surface elevation

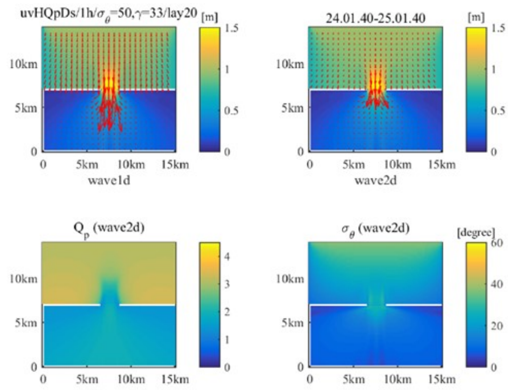

Fig.2: Stokes Drift Velocity: Upper left: Wave1d, Upper right: wave2d
Lower left: frequency deviation parameter, Lower right: directional deviation parameter

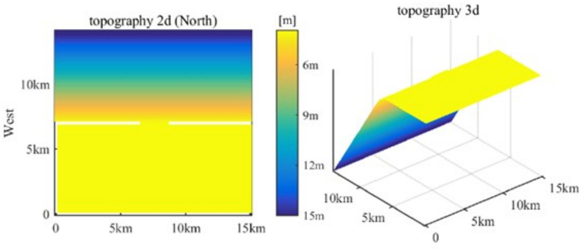

Fig.1: Topography data: left: 2 dimension, right: 3dimention

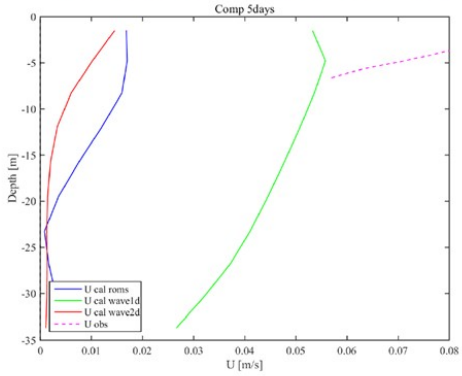

Fig.3: Velocity vertical profile: 5days mean: Blue: ROMS, Greem: Wave1d, Red: Wave2d, Magenta: Observation data

