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Surface gravity waves in the presence of an unsteady uniform current: application to tsunami warning

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In recent years, there has been an increased interest in the possibility for tsunami radar remote sensing, owing to the effects of tsunami-induced changes on the propagation of short sea waves. Well before microwave radars, HF radars have been investigated to detect tsunami induced- current effects on ocean surface waves (Barrick, 1979). Nonetheless no warning system has been proposed with a sufficiently short warning time, say between 5 and 20min depending on the shelf width, which is more adapted to tsunami early warning system in coastal regions. Alternatively, the potential use of Ultra High Frequency (UHF) radar technology has been suggested based on recent observations of modulation processes in radar echoes, which indicates the possibility for the short wind waves to be affected by the tsunami (Troïtskaya and Ermakov, 2005).

In addition to current-induced effects on short gravity waves, like for instance current-induced Doppler shift in the apparent wave frequencies, it is well known that short waves modulations could also arise from other mechanism interactions, such as wind-wave interactions and nonlinear wave-wave interactions. Thus the identification and quantification of the interaction between short waves and current-induced tsunami is very challenging, in particular for waves in the submetric range (high frequency).

To achieve these tasks, we use a Higher Order Spectral (HOS) method to simulate numerically the nonlinear evolution of gravity waves in the presence of a time-varying current but spatially homogeneous. The HOS formulation of the prognostic equations has been modified to account for the presence of a time-varying current, whereas numerical time integration has been improved by using both an integrating factor method (unconditionally linearly stable) and an embedded Runge-Kutta method with variable time steps. This paper presents initial numerical results obtained with our modified HOS model. To explore the signature of tsunami induced currents on surface waves, we have used our modified HOS model to study different wave dynamics in the presence of a time-varying current. In this paper, we present the results on wave dynamics obtained with realistic tsunami-induced currents that were computed using the tsunami propagation code GEOWAVES.

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