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Modulational instability and wave growth in finite water depth

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The main feature of waves dynamic is the existence of modulational instability, which is the result of nonlinear interaction between a steep carrier wave with amplitude $\boldsymbol{a}_0$ and wave vector $\boldsymbol{k}_0$ and two infinitesimal side-band disturbances with wave vector $\mathbf{k}_1$ and $\mathbf{k}_2$. In finite water depth, the interaction between waves and the ocean floor induces a mean current. This subtracts energy from wave instability and the modulational instability ceases for relative water depth $kh = 1.36$. On the other hand, in general, unstable disturbances propagate obliquely to the direction of the carrier wave. When the depth decreases, the instability area becomes narrow and therefore its area decreases. At present, the growth of the sidebands has been treated in terms of the amplification of weak modulation imposed on a harmonic wave. A higher order spectral method is used to perform simulations of the random sea surface in arbitrary water depth. Third and fifth order of non-linearity expansion has been used to investigate the effect of modulational instability on random wave fields. Several configurations are considered with disturbances oblique and collinear with the primary waves and this for different water depths. The analysis shows that in the collinear case there is suppression of modulation instability for relative water depth $kh=1.36$. However, amplifications are observed in longer simulations. For directional cases the destabilization of a primary wave train and subsequent growth of side band perturbations produces amplification of surface elevations.