Geophysical Research Abstracts
Vol. 19, EGU2017-4633, 2017
EGU General Assembly 2017

Steady rotational capillary-gravity waves of finite amplitude on arbitrary shear currents

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The effects of variable (in depth) shear currents (vorticity) on capillary-gravity waves, of permanent form and on finite depth, are addressed. To this end, a numerical method is developed for solving the full, two dimensional, Euler equations with a free-surface in the presence of both capillarity, gravity and shear currents. Based on the Dubreil-Jacotin transformation this method allows the exploration of a vast parameter space in which the amplitude, depth, vorticity and capillarity of the flow are arbitrary. This freedom is shown, in the case of non-linear solutions, to be limited by the apparition of recirculations under the wave crest at different values of the vorticity parameter depending on the depth, Bond number and vorticity distribution. The fully non-linear solutions presented herein also exhibit the multiple crested free-surface topology - Wilton ripples - for integer values of the Bond number. These bifurcations are shown to persist on flows with depth-dependent vorticity, γ, of the form $\gamma(\psi) = \exp(-\alpha\psi)$, where ψ, the stream-function, is used as an independent variable. Finally, the effect of vorticity and capillarity on the celerity, mass flux and potential and kinetic energy are studied. It is shown that for positive vorticity waves have more kinetic energy than potential energy. The contrary is true for negative vorticity. When the Bond number is increased, capillarity is in favor of equipartition of energy.