Geophysical Research Abstracts
Vol. 12, EGU2010-8306, 2010
EGU General Assembly 2010

Finite depth and freak waves: Hamiltonian form of the modified nonlinear Schrödinger equation. Can non-uniform bathymetry provoke freak waves?

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The commonly used forms of the modified nonlinear Schrödinger equations for deep water (Dysthe 1979) and arbitrary depth (Brinch-Nielsen & Jonsson 1986) do not conserve momentum and are not Hamiltonian. We show how these equations can be brought into Hamiltonian form, with the action, momentum and Hamiltonian being conserved. We derive the new fourth order nonlinear Schrödinger equation for arbitrary depth starting from the Zakharov equation enhanced with the new kernel of Krasitskii (1994).

It has recently been suggested that waves on finite depth with flat bathymetry will have decreasing kurtosis for decreasing depth, thus for flat bottom we may expect fewer freak waves. We have investigated how this picture may be modified when the effect of shoaling is taken into account. We find that the dynamic relaxation distance needed to reach a new equilibrium state after a change of depth can provoke values of kurtosis different from the equilibrium values expected for a flat bottom of the same given depth.