Geophysical Research Abstracts,
Vol. 11, EGU2009-2425, 2009
EGU General Assembly 2009

Simulation of limiting deep-water envelope solitons

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It has been shown recently by means of fully nonlinear potential Euler equation simulations [Zakharov et al, 2006; Dyachenko & Zakharov, 2008] that a solitary envelope wave solution known for the weakly nonlinear weakly modulated case (the nonlinear Schrodinger equation, NLS, approximation) is relevant even for the case when a nonlinear wave group contains Stokes waves with the limiting steepness. These extreme solitary waves are far from the nonlinear Schrodinger equation assumptions, and are represented only by a few oscillating individual waves; but may propagate for long surviving during collisions with other waves.
The question discussed in this paper is whether these limiting solitons are a specific feature of the fully-nonlinear approach, or may be relatively well described within the frameworks of approximate equations (in particular, the widely used Dysthe model). We simulate different model situations when very steep waves propagate and collide, using for the initial condition exact solutions of the NLS equation with 3-order nonlinear bound waves taken into account. We show that the Dysthe model with the full linear dispersion law may capture wave dynamics unexpectedly well even for quite steep waves. At the same time, “limiting“ solitary waves, which are of just few wave periods length, fail to be described within the approximate Dysthe model.

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