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Breaking of modulated wave trains: energy and spectra evolution

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The breaking of free surface waves plays an important role on the gas, heat, momentum and energy exchanges taking place across the air-sea interface. The breaking is also responsible for the dissipation of a large fraction of the wave energy, and it represents the most important dissipation term in wave forecasting approaches. In spite of its relevance, there are many aspects of the phenomenon which are still obscure. For the practical applications the dissipated energy fraction and the changes operated to the pre-breaking spectrum are the most interesting aspects. The progress in the understanding of the breaking was hindered by some inherent technical difficulties featuring its experimental investigation. Even laboratory experiments do not help substantially as most of them exploit the superposition of linear waves and the dispersive focusing to induce breaking and only few studies uses the modulational instability. The two breaking processes display substantial differences. In the dispersive focusing case the breaking occur as a single event and all the energy is dissipated within few wave periods after the onset. In the modulational instability case, the breaking happens in several events, each one lasting short fraction of the wave period Tp, with a recurrence period of about 2 Tp. Furthermore, the results available in litterature display a large scatter in the energy dissipation of each breaking event.
In order to achieve a better understanding of the phenomenon the breaking generated by modulational instability is here investigated numerically by the two-fluids approach using the open source Gerris code which solves the Navier-Stokes equations with a Volume of Fluid (VOF) technique to describe the interface dynamics. The solution is initialized as a fundamental wave component with two sideband disturbances and it is left to evolve in a computational domain with periodic boundary conditions.
It is shown that several breaking events occur before the breaking process is completed. At least for the conditions considered in the present study, the whole breaking process lasts 10-12 wave periods. Results are presented in terms of energy amount dissipated by the whole breaking process and changes operated to the pre-breaking spectra. Some analyses concerning the maximum wave steepness and the energy content of the single wave components are also presented with the aim of deriving a criteria which might explain the conditions leading the breaking to stop.