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Non-linear resonant instability of short surface waves as the first stage “bag-breakup” process at the air-sea interface at high winds

Dmitry Kozlov[1] and Yulia Troitskaya[1,2]
[1]Institute of Applied Physics of the RAS, Nonlinear Geophysical Processes, Nizhny Novgorod, Russian Federation (kozlov.dms@gmail.com)
[2]Nizhny Novgorod State University, Nizhny Novgorod, Russia

The recent experimental study [1], [2] identify “bag breakup” fragmentation as the dominant mechanism by which spume droplets are generated at hurricane wind speeds. These droplets can significantly affect the exchanging processes in the air-ocean boundary layer. In order to estimate spray-mediated heat, momentum and mass fluxes we need not only reliable experimental data, but a theoretical model of this process. The “bag-breakup” fragmentation is a strongly non-linear process, and we focus only on its first stage which includes the small-scale elevation of the water surface.

Our model of the bag’s initiation is based on a weak nonlinear interaction of a longitudinal surface wave and two oblique waves propagating at equal and opposite angles to the flow as it was done in [3], [4]. All of these waves have the same critical layer where cross velocities of oblique waves become infinite making inviscid analysis invalid. So we took into account viscous effects. As a result, it has been established that for a piecewise continuous velocity profile explosive growth of wave amplitudes is possible at the wind speeds exceeding the critical one.

The present model let us find the dependency of “bag’s” transverse size on the wind speed and estimate its lifetime.

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