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Laboratory investigation of spray generation mechanism in wind-wave interaction under strong wind conditions

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The sea spray is considered as a possible mechanism of the reduction of sea surface aerodynamic drag coefficient at hurricane conditions [1]. In this paper the mechanism of generation of spray in the near-surface layer of the atmosphere in a strong wind through the mechanism of «bag-breakup instability» was investigated in laboratory conditions with the help of high-speed video shooting.

The laboratory experiments were performed on the Thermostratified Wind-Wave Channel of the IAP RAS (length 10 m, cross section of air channel 0.4 x 0.4 m, wind velocity up to 24 m/s) [2]. Experiments were carried out for the wind speeds from 14 to 22 m/s. In this range spray generation characteristics change dramatically from almost no spray generation to so called catastrophic regime with multiple cascade breakups on each crest.

Shooting was performed with High-speed digital camera NAC Memrecam HX-3 in two different setups to obtain both statistical data and detailed spray generation mechanism overview. In first setup bright LED spotlight with mate screen the side of a channel was used for horizontal shadow-method shooting. Camera was placed in semi-submerged box on the opposite side of the channel. Shooting was performed at the distance of 7.5 m from the beginning of the working section. Series of short records of the surface evolution were made at 10 000 fps with 55 to 119 μm/px scale revealed the dominant mechanism of spray generation - bag-breakup instability. Sequences of high resolution images allowed investigating the details of this “bags” evolution. Shadow method provided better image quality for such conditions than side illumination and fluorescence methods. To obtain statistical data on “bags” sizes and densities vertical shadow method was used. Submerged light box was created with two 300 W underwater lamps and mate screen places at the fetch of 6.5 m. Long records (up to 8 seconds) were made with 4500 fps at 124-256 μm/px scales. Specially developed software allowed finding “bags” of the records and analyzing its geometrical characteristics. Significant increase of the number of bags was observed at equivalent wind velocities exceeding 25 m/s corresponding to change of regime of surface drag dependency on wind speed. Distributions of sizes, velocities and time of life of “bags” found were obtained for wind speeds up to 22 m/s.

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