Geophysical Research Abstracts
Vol. 16, EGU2014-7680, 2014
EGU General Assembly 2014

High speed video shooting with continuous-wave laser illumination in laboratory modeling of wind - wave interaction

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Three examples of usage of high-speed video filming in investigation of wind-wave interaction in laboratory conditions is described. Experiments were carried out at the Wind - wave stratified flume of IAP RAS (length 10 m, cross section of air channel 0.4 x 0.4 m, wind velocity up to 24 m/s) and at the Large Air-Sea Interaction Facility (LASIF) - MIO/Luminy (length 40 m, cross section of air channel 3.2 x 1.6 m, wind velocity up to 10 m/s).

A combination of PIV-measurements, optical measurements of water surface form and wave gages were used for detailed investigation of the characteristics of the wind flow over the water surface. The modified PIV-method is based on the use of continuous-wave (CW) laser illumination of the airflow seeded by particles and high-speed video. During the experiments on the Wind - wave stratified flume of IAP RAS Green (532 nm) CW laser with 1.5 Wt output power was used as a source for light sheet. High speed digital camera Videosprint (VS-Fast) was used for taking visualized air flow images with the frame rate 2000 Hz.

Velocity air flow field was retrieved by PIV images processing with adaptive cross-correlation method on the curvilinear grid following surface wave profile. The mean wind velocity profiles were retrieved using conditional in phase averaging like in [1].

In the experiments on the LASIF more powerful Argon laser (4 Wt, CW) was used as well as high-speed camera with higher sensitivity and resolution: Optronics Camrecord CR3000x2, frame rate 3571 Hz, frame size 259×1696 px. In both series of experiments spherical 0.02 mm polyamide particles with inertial time 7 ms were used for seeding airflow. New particle seeding system based on utilization of air pressure is capable of injecting 2 g of particles per second for 1.3 - 2.4 s without flow disturbance. Used in LASIF this system provided high particle density on PIV-images. In combination with high-resolution camera it allowed us to obtain momentum fluxes directly from measured air velocity fluctuations. This data was then compared to values retrieved from wind speed profiles [2].

Visualization of water surface structure and droplets under strong wind conditions was carried out at the Wind - wave stratified flume of IAP RAS with high-speed camera NAC Memrecam HX-3 having a record-breaking performance at the moment. Shooting was performed at frame rates over 4500 Hz in 1080p resolution (1920 x 1080 px). Experimental study of droplets under strong winds has discovered a “bag breakup” droplet-production mechanism (observed previously in technical devices for liquid disintegration [3]). The investigation on this mechanism in the laboratory can improve the parameterization of heat fluxes in the models of hurricanes and intense sea storms.

This work was supported by RFBR grants (project code 13-05-00865, 13-05-12093, 12-05-01064, 14-08-31740, 14-05-31415), President Grant for young scientists MK-3550.2014.5 and grant of the Government of the Russian Federation designed to support scientific research project implemented under the supervision of leading scientists at Russian institutions of higher learning (project code 11.G34.31.0048).

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