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Laboratory investigations of the air flow velocity field structure above the wavy surface for a wide range of wind flow rates and parameters of surface roughness by modified Particle Image Velocimetry technique

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Experiments devoted to measuring characteristics of the air flow above the waved water surface for the wide range of wind speeds were performed with the application of modified Particle Image Velocimetry (PIV) technique. Experiments were carried out at the wind-wave stratified flume of IAP RAS (length 10 m, cross section of air channel 0.4×0.4 m) for four different axial wind speeds: 8.7, 13.5, 19 and 24 m/s, corresponding to the equivalent 10-m wind speeds 15, 20, 30 40 m/s correspondingly. Intensive wave breaking with forming foam crest and droplets generations was occurred for two last wind conditions.

The modified PIV-method based on the use of continuous-wave (CW) laser illumination of the airflow seeded by tiny particles and with high-speed video. Spherical 20 μm polyamide particles with density 1.02 g/sm3 and inertial time 7•10-3 s were used for seeding airflow with special injecting device. Green (532 nm) CW laser with 4 Wt output power was used as a source for light sheet. High speed digital camera Videosprint was used for taking visualized air flow images with the frame rate 2000 Hz s and exposure time 10 ms.

Combination including iteration Canny method [1] for obtaining curvilinear surface from the images in the laser sheet view and contact measurements of surface elevation by wire wave gauge installed near the border of working area for the surface wave profile was used. Then 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 by averaging over obtained ensembles of wind velocity field realizations and over a wave period even for the cases of intensive wave breaking and droplets generation. To verify the PIV method additional measurements of mean velocity profiles over were carried out by the contact method using the Pitot tube. In the area of overlap, wind velocity profiles measured by both methods were in a good agreement.

The application of PIV method enabled us measuring wind velocity profiles much closer to water surface than in the case of contact method. As a result there exists the logarithmic parts in velocity profiles, which yield turbulent momentum flux from the slope and also the equivalent 10-m wind speed and the surface drag coefficient. It was shown that similarly to [2] the surface drag coefficient tends to saturate at wind velocities exceeding 25 m/s. The decrease of the water surface drag coefficient with wind velocity increase was not observed.

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References:

1. Canny, J. A. Computational approach to edge detection/ J.A. Canny// IEEE Trans. Pattern Analysis and Machine Intelligence. – 1986. – V. 8(6). – P. 679–698.
2. Troitskaya, Y. I., D. A. Sergeev, A. A. Kandaurov, G. A. Baidakov, M. A. Vdovin, and V. I. Kazakov Laboratory and theoretical modeling of air-sea momentum transfer under severe wind conditions J.Geophys. Res., 117, C00J21, doi:10.1029/2011JC007778.