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Laboratory modeling of air-sea interaction with modern visualization technique

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Wind-wave coupling is one of the most important factor of the atmosphere - ocean interaction in the boundary layers. The main aim of experimental studying in this field is accumulating data for subsequent statistical processing and obtaining bulk formulas for parameterization exchange processes for a wide range of the meteorological conditions. Wind friction velocity and aerodynamic drag are the keynote parameters characterizing these processes. The laboratory modeling is a good alternative of the field measurements especially for severe conditions. The main problems of carrying out measurements within laboratory modeling on the wind-wave channels concerned first of all with measurements wind flow parameters close to the water surface for intensive wave breaking and spray of droplets generation.

Complex approach using contact gauges and modern methods based on the visualization flow technique including modified PIV-methods was suggested in this research. New methods were used for comparing with classic contact methods such as Pitot tubes and wire gauges.

A series of experimental simultaneous measurements of the wind parameters and surface roughness properties were carried out on Thermostratified Wind-Wave Channel of IAP RAS for a wide range of the wind (up to 40 m/s equivalent wind speed) and wave conditions (up to strong breaking).

Aerodynamic resistance of the water surface was measured by the profile method with Pitot tube and by statistical averaging of the velocity fields obtained by PIV-method both. A profile method for data processing taking into account the hypothesis of the self-similarity of the wind profile. Modified PIV allowed us to obtain these parameters directly from the measurements flow parameters in turbulent boundary layer close to the water surface for the first time. New data for drag exceeds data obtained in the previous studies ([Donelan etl 2004, Troitskaya etl 2012]).

Parameters of surface roughness were obtained, by combining measurements with wire gauges (long wave part) and method of the wave profile visualization by laser sheet and high speed filming (short wave part) by the analogy with PIV measurements of the wind flow. Combining methods allowed us to obtain surface roughness parameters in the wide range of spatial scales including small scale disturbances during intensive wave breaking ($0.01<k<10$ 1/cm).

Analysis of the wind wave spectra showed tendency to saturation for mean square slope for wind speed exceeding 25 m/s simultaneously with the surface drag coefficient and linear dependence between surface drag coefficient and mean square slope. Video filming indicates onset of wave
breaking with white-capping and spray generation at wind speeds approximately equal to 25 m/s.

We compared the obtained experimental dependencies with the predictions of the quasi-linear model of the turbulent boundary layer over the waved water surface. New theoretical results are in good agreement with experiment.

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