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Wind-wave coupling in the atmospheric boundary layer over a reservoir: field measurements and verification of the model

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This paper presents the results of field experiments conducted at the Gorky Reservoir to test a quasi-linear model of the atmospheric boundary layer [1].

In the course of the experiment we simultaneously measured profiles of wind speed and surface wave spectra using instruments placed on the Froude buoy, which measures the following parameters: i) the module and the direction of the wind speed using ultrasonic wind sensor WindSonic Gill instruments, located on the 4 - levels from 0.1 x 5 m long; ii) profile of the surface waves with 3-channel string wave-gauge with a base of 5 cm, iii) the temperature of the water and air with a resistive sensor.

From the measured profiles of wind speed, we calculated basic parameters of the atmospheric boundary layer: the friction velocity u_*, the wind speed at the standard height of 10 m U_{10} and the drag coefficient C_D. Data on $C_D(U_{10})$, obtained at the Gorky Reservoir, were compared with similar data obtained on Lake George in Australia during the Australian Shallow Water Experiment (AUSWEX) conducted in 1997 - 1999 [2,3]. A good agreement was obtained between measured data at two different on the parameters of inland waters: deep Gorky reservoir and shallow Lake George.To elucidate the reasons for this coincidence of the drag coefficients under strongly different conditions an analysis of surface waves was conducted.Measurements have shown that in both water bodies the surface wave spectra have almost the same asymptotics (spatial spectrum - k^{-3}, the frequency spectrum ω^{-5}), corresponding to the Phillips saturation spectrum.These spectra are typically observed for the steep surface waves, for which the basic dissipation mechanism is wave breaking. The similarity of the short-wave parts of the spectra can be regarded as a probable cause of coincidence of dependency of drag coefficient of the water surface on wind speed.

Quantitative verification of this hypothesis was carried out in the framework of quasi-linear model of the wind over the waves [1]. In the calculations the input parameters are measured friction velocity of wind and surface wave spectrum. The appropriate wind speed at the standard height of 10 m and the resistance coefficient surface were calculated.

It is shown that at a wind speed of 6 m/s, the model reproduces the measurements. Significant difference of model predictions and measurements at lower values may be due to large measurement error caused by the nonstationarity of weak winds.

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