EMS Annual Meeting Abstracts
Vol. 12, EMS2015-31, 2015
15th EMS / 12th ECAM

Field investigation and numerical modeling of wind-wave interaction at the middle-sized water body

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This paper presents the results of field experiments on studying the wind and waves over inland waters, which were carried out at the Gorky Reservoir in 2011-2014. The sensors were positioned at the oceanographic Froude buoy including five two-component ultrasonic sensors WindSonic by Gill Instruments at different levels (0.1, 0.85, 1.3, 2.27, 5.26 meters above the mean water surface level), one water and three air temperature sensors, and three-channel wire wave gauge.

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 U10 and the drag coefficient CD. Parameters were obtained in the range of wind speeds of 1-10 m/s. For wind speeds stronger than 3 m/s CD values were lower than those obtained before under similar conditions (see eg. [1,2]) and those predicted by the bulk parameterization. In the range of wind speeds of 3-5 m/s CD values are even lower than the corresponding smooth flow. However, for weak winds (less than 2.5 m/s) CD values considerably higher than expected ones.

The main peculiarity of our measurements is very low location of the lowest sensor: 0.1 m against 0.22 m in [1] and 0.5 m in [2]. Moreover, the lowest sensor was not fixed on the mast, but was located on the float and followed the water surface. Analysis shows that the obtained parameters of profile are almost independent on the number of approximated wind speed levels if they include the lowest sensor. But excluding the lowest sensor gave larger values of CD similar to [1,2]. These results demonstrate importance of wind speed measuring close to the water surface. The new parameterization of surface drag coefficient was proposed on the basis of the obtained data.

The new surface drag parameterization was used in WAVEWATCH III model applied for modeling waves at the reservoir. 1-D spectra of the field experiment were compared with those obtained in the numerical experiments with different parameterizations of flux both provided in WAVEWATCH III and in the inserted suggested experimental parameterization. For the cases with default WAVEWATCH III flux parameterizations, wave amplitude characteristics were overestimated, and spectral maxima showed the downshifting comparing with the measured data. Insertion of the suggested parameterization of flux input improved the coincidence. The difference in the use of WAM3, WAM4 and Tolman & Chalikov source packages is discussed.

To conclude, we discuss the applicability of suggested flux parameterization: it increases the accuracy of the simulations and makes possible the application of this technique for getting the surface wind waves forecasts on the water bodies.

The work was supported by the RFBR under grants №15-45-02580, №14-05-31343, №15-35-20953, President Grant for young scientists MK-3550.2014.5, RSF 14-17-00667.

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