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Simultaneous measurements of gravity water waves at the surface and in the water bulk: analysis of the experimental records

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The data of simultaneous measurements of time series of the surface displacements and of the pressure beneath the water surface have been processed. The experiments comprise a reproduction of regular and irregular waves in a laboratory flume. Relatively deep water conditions were simulated ($kh = 1.7 \dots 3.6$, where k is the dominant wavenumber and h is the water depth) for the situations of weak and strong nonlinearities ($ka = 0.014 \dots 0.17$). The pressure fields were recorded at different depths – from the bottom up to the vicinity of the wave troughs. The surface wave profiles were reconstructed with the help of the hydrostatic and linear non-hydrostatic theories.
The hydrostatic approximation is capable of the wave shape reconstruction only when it is based on the records retrieved at the very vicinity of the wave troughs. The reconstruction with the help of linear non-hydrostatic solution exhibits good accuracy in all cases of uniform waves when the Hanning data mask is applied to regularize the Fourier transform. Steep waves could not be accurately reconstructed from deep-water horizons.
When the waves are irregular with embedded rogue wave, the reconstruction procedure becomes trickier. In particular, the high-frequency filtering affects the result of the reconstruction more significantly. Only small-amplitude waves were reconstructed accurately; steep wave crests were noticeably underestimated, while the troughs were overestimated. From the statistical point of view the values of skewness and kurtosis calculated based on the pressure record and the corresponding reconstructed surface displacement, exhibit nontrivial dependence on the depth of measurement. Close to the surface they differ significantly from the values of the Gaussian random process. The surface displacements reconstructed from deep horizons have statistical moments similar to the Gaussian field, though the pressure record at large depths possesses small skewness and large kurtosis.
The present study is directed towards the solution of the actual problem of recovery of the surface wave characteristics from the data of bottom pressure sensors.

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