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Cross-polarization microwave radar return at severe wind conditions: laboratory model and geophysical model function.

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Satellite remote sensing is one of the main techniques of monitoring severe weather conditions over the ocean. The principal difficulty of the existing algorithms of retrieving wind based on dependence of microwave backscattering cross-section on wind speed (Geophysical Model Function, GMF) is due to its saturation at winds exceeding 25 - 30 m/s. Recently analysis of dual- and quad-polarization C-band radar return measured from satellite Radarsat-2 suggested that the cross-polarized radar return has much higher sensitivity to the wind speed than co-polarized back scattering [1] and conserved sensitivity to wind speed at hurricane conditions [2]. Since complete collocation of these data was not possible and time difference in flight legs and SAR images acquisition was up to 3 hours, these two sets of data were compared in [2] only statistically. The main purpose of this paper is investigation of the functional dependence of cross-polarized radar cross-section on the wind speed in laboratory experiment. Since cross-polarized radar return is formed due to scattering at small-scale structures of the air-sea interface (short-crested waves, foam, sprays, etc), which are well reproduced in laboratory conditions, then the approach based on laboratory experiment on radar scattering of microwaves at the water surface under hurricane wind looks feasible.

The experiments were performed in the Wind-wave flume located on top of the Large Thermostratified Tank of the Institute of Applied Physics, where the airflow was produced in the flume with the straight working part of 10 m and operating cross section 0.40?0.40 sq. m, the axis velocity can be varied from 5 to 25 m/s. Microwave measurements were carried out by a coherent Doppler X-band (3.2 cm) scatterometer with the consequent receive of linear polarizations. Experiments confirmed higher sensitivity to the wind speed of the cross-polarized radar return.

Simultaneously parameters of the air flow in the turbulent boundary layer (friction velocity and roughness height) were retrieved by velocity profiling and subsequent data processing based on self-similarity of the turbulent boundary layer and 10-m wind speed was calculated. The wind wave field parameters in the flume were measured by three wire gauges. The measured data on wind waves were used for estimation of the short wave spectra and slope probability density function for "long waves" within composite Bragg theory of microwave radar return. Estimations showed that for co-polarized radar returns the difference between measurements and the predictions of the model is about 1-2 dB and it can be explained by our poor knowledge about the short wave part of the spectrum. For cross-polarized return the difference exceeds 10 dB, and it indicates that some non-Bragg mechanisms (short-crested waves, foam, sprays, etc) are responsible for the depolarization of the returned signal.

It seems reasonable then to suppose that the cross-polarized radar return in X- and C-bands will demonstrate similar dependence on wind speed. We compared the dependence of cross-polarized X-band radar cross-section on 10-m wind speed obtained in laboratory conditions with the similar dependence obtained in [2] from the field data for C-band radar cross-section and found out that the laboratory data follow the median of the field data with the constant bias -11 dB. Basing on laboratory data an empirical polynomial geophysical model function was suggested for retrieving wind speed up to 40 m/s from cross-polarized microwave return, which is in good agreement with the direct measurements.

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References

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