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Polarized X-band Doppler Radar Scatterometer for Investigation of Microwave Scattering of the Wavy Water Surface in Laboratory Conditions[1]

V. I. Abramov[1], E. M. Zuikova[2], D. A. Sergeev[2*], Yu. I. Troitskaya[2], A. V. Ermoshkin[2], and V. I. Kazakov[2]

[1]*Radiophysical Research Institute, Nizhny Novgorod, Russian Federation*
[2]*Institute of Applied Physics, Nizhny Novgorod, Russian Federation*
**e-mail: daniil@hydro.appl.sci-nnov.ru*

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Abstract—The paper describes an experimental model of continuous wave X-band Doppler radar scatterometer (sine frequency modulation) designed for physics investigation of radio waves scattering from sea surface in controlled conditions. The prototype is developed and fabricated at the IAP RAS. Its main feature is adaptation to the conditions of a laboratory modeling in the wind-wave flumes to investigate the dependence of the normalized radar cross-section (NRCS) on the wind speed. The design of the microwave and antenna systems allows measurement of scattered radiation power and its Doppler spectrum both at linear co- and cross-polarizations (in a sequential switching mode). This is important from the viewpoint of studying the waves at high wind speeds. The detailed description of the design and its specifications are presented. Also the problems of calibration and results of experimental operation on the high-speed wind-wave flume of IAP RAS are discussed.

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INTRODUCTION

Currently, distant Earth sounding is one of the main methods of ocean and atmosphere diagnostics. Theoretical approaches and methods of practical implementation of microwave electromagnetic scattering for investigations of hydrosphere surface were studied in a number of publications [1–5].

In practice, satellite radar systems, primarily scatterometers, are widely used for measurement of the velocity and direction of the driving wind (MetOp satellites, until November 2009 also QuikSCAT). Operational employment of driving wind fields, which are reconstructed using data from satellite synthetic-aperture radars (SAR), has commenced in certain regions. Algorithms CMOD4 [6–8] and CMOD5 [9, 10] utilize relation of the normalized radar cross-section (NRCS) to the wind speed to reconstruct the driving wind speed using NRCS readings.

One of the key problems of distant Earth sounding is that available reconstruction algorithms produce considerable uncertainties in atmospheric and oceanic parameter estimation in the presence of intense storms. This is linked to the saturation effect in the geophysical model function (GMF) expressing the dependence of sea surface NRCS on wind speed for wind speeds greater than 25 m/s. As a result data loss occurs for areas with maximum wind speeds.

Lately, the analysis of data acquired from RADARSAT-1 satellite in two and four polarizations is performed together with wind speed experimental data from oceanographic buoys NDBC [11–16]. It was shown that cross-polar NRCS retains sensitivity to wind speed change in contrast to equivalent co-polar NRCS, which tends to saturate. It is feasible to expect that reconstruction algorithms based on data processing of cross-polar scattering allow significant accuracy enhancement of driving wind speed reconstruction in the conditions of hurricanes and typhoons.

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