Geophysical Research Abstracts
Vol. 15, EGU2013-10941, 2013
EGU General Assembly 2013

Manifestations of internal wave on the wavy sea surface in the presence of surfactant films: laboratory and field experiment.

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Manifestations of internal wave on the wavy sea surface due to modulation of short wind gravity-capillary waves are analyzed using data of radar measurement in laboratory and field conditions. The modulation of Ka-band radar backscatter due to internal waves has been studied in the oval wind wave tank of the Institute of Applied Physics in presence of surfactant films of different surface concentrations. Two surfactants films were used, wind velocities were varied from about 2 m/s to 5 m/s. The wavelengths of internal waves were about 1 m, and the amplitudes were 0.25 - 0.5 cm. Two different physical mechanisms were taken into account to describe the modulation: hydrodynamic modulation of short waves due to wave straining and modulation of surfactant concentration. It is shown in experiment that the Modulation Transfer Function (MTF) magnitude in slicks can be several times larger than in non-slick areas. The phase of MTF is also changed in slicks. Theoretical estimates demonstrated that the effect cannot be explained using the mentioned mechanisms. The MTF values are assumed to be determined by the contribution of bound components of the short wind-wave spectrum, and the contribution of bound waves was estimated. The effect of enhanced surface waves modulation in slicks was also observed in field experiments. Surface waves were measured with X-band and Ka-band radars and with an optical spectrum analyzer operating in the cm and mm surface wavelength ranges; IW were measured with an STD-probe. Surface films were sampled in both slick and non-slick areas, and the film elasticity parameter and film concentration variations were estimated from these samples using laboratory measurements of capillary-gravity wave damping. The relative cm-mm-scale wave damping (contrast) in the slick bands exceeded an order of magnitude. Comparison of observed wave damping in the banded slicks with hydrodynamic modulation over IW in non-slicks has shown that the presence of surfactants strongly enhances the surface manifestation of the IW.
The work was supported by RFBR (projects 11-05-00295), the Program RAN Radiophysics, and by the Russian Government (Grants No. 11.G34.31.0048 and 11.G34.31.0078).