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Radar investigations of surface wave variability in shelf zone

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Complex ground-truth experiments were carried out in the north-eastern part of the Black Sea for several years. The main goal of the study was to record possible manifestations of nonuniform flows on the sea surface.
In the experiments, we employed shipboard-type radar stations (RS) Icom and Furuno of the X range and HH polarization, radio scatterometers of the X and Ka ranges and VV and HH polarizations, and synthetic aperture radar ASAR of the range and VV polarization, which was placed on the satellite Envisat of the European Space Agency. The probing angles of the devices are: 0 – 10 degrees relatively to the horizon of RS, 20 – 30 degrees of radio scatterometers, 60 – 70 degrees of SAR. The flow field and the atmosphere surface layer parameters were recorded synchronously with radar observations.
In the field study, we have detected a difference between the sea surface roughness above the shelf zone and the roughness at the deep bottom. The character of this difference depends on hydrometeorological conditions. Under stationary meteorological conditions, we observed regions of surface roughness attenuation (slicks) on the sea surface, which had the shape of strips with various radar contrasts extended approximately along the flow. Under definite conditions, we observed roughness amplification regions (rips) also having the shape of strips. Alongside with small-scale variability of sea surface roughness, we also observed large-scale fronts distinctly recorded by ASAR. The relation of the X-range HH-polarization radiation at grazing incidence angles, scattered by the sea surface to sear surface wind speed and sea roughness state is studied in detail. It is shown that the dependence of radar signal level on wind speed is a quasi-step function with two distinct states. The cases of difference between wind speed directions and maximum of radar signal scattergram are analyzed.
The observed effects can be theoretically described using a two-scale model of radio-frequency radiation scattering by the sea surface at the angles of 20 – 70 degrees, while at the grazing angles less than 10 degrees one should take into account an additional scale, i.e., steep breaking waves. Transformation of sea surface roughness spectrum on nonuniform flow for assigned wind field can be described within the framework of the energy balance equation for spectral density of wave action.
The technique of determining the kinematic characteristics of sea surface roughness such as length, period, velocity of energy-carrying wave and its propagation direction by radar data obtained from the ship is described.
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