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Sea surface Ka-band radar cross-section from field observations in the Black Sea

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An interest in Ka-band radar backscattering from the ocean surface is growing due to better spatial resolution and more accurate Doppler anomaly estimate. But, available empirical models of Ka-band cross-section are quite scarce and sometime controversial. Here we present multi-year (2009-2015) field measurements of Ka-band co-polarized (VV and HH) sea surface normalized radar cross-section (NRCS) from research platform in the Black sea collected in a wide range of observation and sea state conditions. The data are fitted by polynomial function of incidence angle, azimuth and wind speed with accounting for measured radar antenna pattern. This empirical NRCS is compared with published Ka- and Ku-band data. Our Ka-band NRCS is close to Ku-band, but is 5-7 dB higher than 'pioneer' measurements by Masuko et al. (1986).

Following the two-scale Bragg paradigm, the NRCS is split into polarized (Bragg) and non-polarized components and analyzed in terms of polarization ratio (VV/HH) and polarization difference (VV-HH) to estimate wave spectra at the Bragg wave number. Non-polarized component dominates at low incidence angles <30° due to specular reflection from regular surface. At larger incidence angles, the relative non-polarized contribution decreases, but grows again at HH-polarization approaching 0.7-0.8 at 65° for 10 m/s wind speed, suggesting that backscattering from breaking waves dominates HH NRCS at low grazing angles.

At high incidence angles (>60°) NRCS azimuth dependency is unimodal (upwind peak) for HH and bimodal (with up- and downwind peaks) for VV polarization. This again can be attributed to different backscattering mechanisms for VV and HH polarizations. With decreasing of incidence angle, up- to downwind ratio tends to 1, and under light wind conditions (4-6 m/s) can be less than 1. The same situation is observed for polarization difference, which reflects Bragg backscattering properties only. This effect can be explained by enhanced roughness on upwind (windward) face of the tilting wave.

Retrieval of Bragg roughness properties shows that omni-directional saturation spectra at ∼1000 rad/m are 2-3 times higher (0.01 at 10 m/s wind speed) than the spectra obtained from optical measurements of regular sea surface without wave breaking. This suggests that observed difference can arise due to backscattering from breaking waves.
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