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A nonlinear hydrodynamic mechanism of tsunami manifestation in satellite radar imagery

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The catastrophic tsunami of 26 December 2004 emphasized the need in a functioning global system of tsunami early warning. A space-borne system of tsunami monitoring would have been an ideal solution because of global coverage and instant access to the information. At present, the only known way of tsunami satellite remote sensing is via space-borne altimetry, which, unfortunately, is of limited practical value: to register a tsunami a satellite should be exactly above the wave in question. In this context, it would have been preferable to employ side-looking instruments providing large-scale panorama of the sea surface, for example, synthetic aperture radars. The latter are routinely used for registering signatures of atmospheric and oceanic phenomena caused by variations of the surface scattering properties mostly determined by the short wind waves ("sea roughness"). The key open question was, whether a tsunami can produce such a signature, that is, cause modulation of the short waves sufficient for instrumental registration. Here we report on the first experimental evidence for space-observed manifestation of the open ocean tsunami in the microwave radar backscatter (in C- and Ku-bands; wave-lengths 6cm and 2 cm respectively). Significant (a few dB) variations of the radar cross section synchronous with the sea level anomaly were found in the geophysical data record of the altimetry satellite Jason-1 for the track which crossed the head wave of the catastrophic tsunami of 26 December 2004. The simultaneous analysis of the available complementary data provided by the satellite three-channel radiometer enabled us to exclude meteorological factors as possible causes of the observed signal modulation. A possible physical mechanism of modulation of short wind waves due to transformation of the thin boundary layer in the air by a tsunami wave is discussed. The results open new possibilities of monitoring tsunamis from space.