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On possibilities of tsunami detection in radar and optical satellite images

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Satellite remote sensing methods are known to be very efficient for investigation of various oceanic processes, e.g. internal waves, currents, mesoscale vortices, fronts, etc. Inhomogeneous surface currents associated with these processes cause spatial variations of the wind wave spectrum and corresponding variations of intensity of optical and radar signals thus forming images of the sea surface. A number of mechanisms of the action of inhomogeneous surface currents on the wind wave spectrum has been developed, including kinematic (straining) mechanism [1], wind wave growth rate modulation [2], cascade wave modulation [3,4]. These mechanisms are efficient in different bands of the wind wave spectrum and can explain manifestations of ocean processes in different radar and optical bands.

Here first evidences of tsunami surface signatures are presented using optical and radar observations of the catastrophic tsunami in South-East Asia on 26/12/2004 in the area of Phuket island (satellite SPOT-4, an optical wavelength range of 0.61-0.68 μm), and in the Bengal Bay (the Envisat ASAR, C-band synthetic aperture radar).

The radar C-band images and the optical images in red light are determined essentially by centimeter-scale (Bragg) wind waves and by the slope variance, respectively. The main contribution to the latter is also due the small-scale waves (dm-to-mm-scale components of the wind wave spectrum). The spectrum of small-scale wind waves is influenced essentially by nonlinear effects, in particular, by parasitic ripples generated on a decimeter-scale wave profile. The cascade mechanism gives high levels of the ripple modulation even if the decimeter wave modulation is weak.

The efficiency of the mentioned mechanisms of modulation of short surface waves due to long (tsunami) waves is estimated. The cascade mechanism in combination

with the straining effect is shown to be the most efficient for moderate wind. For gentle wind conditions, near the threshold of wind wave generation, the mechanism of modulation of the growth rate of short wind waves can be domnant. The image of the south coast of India seems to be acquired under such conditions. Estimations are made in the framework of the quasi-linear model of wind-wave interaction in the presence of inhomogeneous flows at the water surface. They show that the flow in the atmospheric boundary layer associated with tsunami (the “tsunami wind”) can excite surface waves if the orbital velocity of the particles exceeds 30 cm/s, which corresponds to the depth 200 m for the conditions of the Indonesian tsunami of 26/12/2004.

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