Global Navigational Satellite System phase altimetry of the sea level: systematic bias effect caused by sea surface waves.

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Dramatic changes in the natural environment, observed in the present epoch, are threatening and can be dangerous for the future of the whole world human population. Systematic monitoring of these global changes is now critical for detection of long periodic variations and long term trends such as global warming, polar ice melting, raising of the ocean level etc. Extensively developing technologies of observation of the Earth from space provide excellent possibilities for remote measurements of key physical parameters of the atmosphere, ocean and land surface. GPS reflectometry is a relatively cheap technique for in situ measurements of the sea level surface, which can be implemented both at coastal stations of geodetic GPS-networks and specially organized observatories of global environmental monitoring. This technique, however, suffers from errors caused by sea surface perturbations. Surface waves are probably the most important source of random and systematic biases in the measured data.

In this study, this bias effect has been investigated both experimentally and theoretically. The reflections of radio waves of navigational space-borne radio beacons from undulating sea surface have been simulated numerically. Electromagnetic field at the main frequency of the Global Positioning System (GPS) L1 (1575.42 MHz) has been evaluated with the Finite Difference in Time Domain (FDTD) technique for different model spectra of the sea waves. Impact of the surface waves on the mean sea level estimate at the monitoring station location is investigated for low wave grazing angles, at which the interference between direct and reflected waves of GNSS is effectively observed with a single antenna.

The simulations predict that the bias of measured sea level is proportional to the surface wave height. Verification of this theoretical conclusion on the experimental data shows that for low and moderate wave profile heights (not exceeding the radio wave length) this systematic bias and the wave profile height are indeed proportional. Further increase of the wave profile height destroys the interference pattern, which prevents surface echo detection and estimate of the sea level. Nevertheless, for moderate surface waves the sea level measurements can be corrected for the bias effect, if the surface waves are independently registered and recorded.

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