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Contribution of vertical and horizontal ocean-bottom motions to near-bottom pressure variations during an earthquake

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In the 21st century, ocean bottom pressure sensors became known as an important means for forecasting and studying the tsunami. So it is necessary to have clear view what exactly is recorded and how to select the tsunami signal.

In our work we analyze a unique set of the simultaneous recording of ocean-bottom acceleration and pressure which were obtained during the 2011 Tohoku earthquake by a network of deepwater observatories DONET. Interpretation of data is based on that the nature of the pressue response to the ocean bottom oscillations with a frequency f is determined by its relation to a pair of critical frequencies f_g and f_{ac}. These frequencies are determined as $f_g = 0.3\sqrt{g/H}$ and $f_{ac} = c/(4H)$, where H - depth of the ocean, g - acceleration of gravity, c - sound speed in water. For $f < f_g$, gravitational waves are excited, with $f > f_{ac}$ - hydroacoustic waves. For $f_g < f < f_{ac}$ no waves arised by ocean bottom oscillations and the forced pressure variations are especially pronounced.

The main purpose of this study is to proof the existence of the range of forced oscillations. In this range, when the ocean bottom is flat and horizontal, the pressure variations and the vertical component of the ocean bottom movement acceleration must be related in accordance with Newton's second law by the formula $p = \rho H a_z$, where ρ is the density of water. Cross-spectral analysis shows a very good correlation between the measured signals p and a_z, i.e. nearly unit magnitude-squared coherence and nearly zero phase lag. However, in some cases the cross-spectra exhibit small deviations from the ideal correlation. The other purpose of this study is to test the hypothesis that these deviations are due to the contribution to the pressure variations of the horizontal movements of nearby underwater slopes.

It is established that the cross-spectral analysis taking into account horizontal components of the ocean bottom acceleration allows either to completely eliminate or substantially reduce the deviations from the ideal value in the range of forced oscillations, which confirms the suggested hypothesis.

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