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Waves in a fluid layer excited by pressure variations above the free surface

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Abstract. The aim of the paper was to study the problem of waves in a layer of incompressible fluid of constant depth. The interest in the problem arose due to the excitation and propagation of surface waves in the Pacific Ocean as a result of the powerful explosive eruption of the Hunga Tonga–Hunga Haapai volcano on January 15, 2022. Potential fluid motions were considered. The disturbances were induced in the form of a short-term pressure pulse above the free surface and in the form of pressure waves arising due to of the disintegration of the initial region of high pressure in the atmosphere (Lamb waves). Solutions were obtained for forced and free waves on the surface, as well as for forced and free pressure waves at the bottom of the fluid layer. In the long-wave approximation, the amplitudes of free surface waves and the amplitudes of free bottom pressure waves (in meters of water column) coincide, while the amplitudes of forced bottom pressure waves are greater than the amplitudes of forced surface waves. In cases where only the forced component is present in the pressure record, the use of a correction factor gives an adequate result for surface waves. If both components (forced and free) are present in the record, the use of the correction factor is unjustified, since it is impossible to separate the components. The estimation of surface wave amplitudes based on bottom pressure data may yield inadequate results. The results obtained are discussed in connection with the operational tsunami forecast based on the data from bottom sea level measurement stations. A proposal is formulated on a possible method for adequately estimating the amplitude of surface waves when excited by a moving region of variable pressure.

Keywords:
water waves, Lamb waves, forced waves, baric waves, free waves, gravity waves, tsunami, sea level measurements, operational tsunami forecast, tsunami warning services, Pacific Ocean

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