VALIDITY CRITERIA OF THE LONG-WAVE APPROXIMATION FOR DESCRIBING DISPERSIVE TSUNAMI WAVES

Nosov Mikhail* (1), Kolesov Sergey (2)

(1)M.V. Lomonosov Moscow State University, Faculty Of Physics, Moscow, Russian Federation, (2)Lomonosov Moscow State University

* m.a.nosov@mail.ru

The long-wave approximation is widely used for numerical simulation of tsunamis. Under assumption that wave length is large enough in comparison with water depth the original 3D hydrodynamic problem is reduced to a number of 2D problems which employ depth-integrated equations. The simplest version of the depth-integrated equations are referred as long-wave or shallow water equations. These equations describe non-dispersive waves which phase and group velocities are equal to each other and do not depend on wavelength or frequency. In contrast to the model object “long wave”, real tsunami waves clearly exhibit the phase dispersion. Manifestations of tsunami wave dispersion are well observed in measurements of tsunamis in the open ocean by bottom pressure sensors and satellite altimeters. When tsunamis propagate a rather long distance, dispersion, that exhibit the property of accumulating, are capable of essentially altering the amplitude and the structure of the wave perturbation. This is why the neglecting of phase dispersion represents a serious disadvantage of models based on shallow water equations. A more complicated kind of depth-integrated equations – known as Boussinesq equations – allow to describe slightly dispersive waves. However, Boussinesq equations as well as shallow water equations have their own restrictions in reproducing of tsunami waves. In this study we quantify these restrictions and specify validity criteria of shallow water equations and Boussinesq-type equations for describing dispersive tsunami waves. Our approach involves the concept of distance of dispersive destruction, i.e. the distance, at which manifestations of dispersion effects should turn out to be quite significant. This distance we determine as the product of the velocity of long waves by the time, required for a wave packet to lag behind the front at a distance equal to the wavelength. The sought validity criteria are formulated as a low limit for wave period which can be easily calculated from the size of calculating area and average ocean depth within this area. Ultimately, we compare results of numerical simulation of some recent tsunamis carried out within the framework of fully-dispersive model (3D potential theory) and non-dispersive model (2D shallow-water theory). This work was supported by the Russian Foundation for Basic Research, projects 16-05-00053.