# Numerical Modeling of Propagation of Landslide Generated Waves by Fully Nonlinear Boussinesq Equations


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## Introduction

Tsunamis are accounted as one of the most destructive natural disasters and so it is necessary to investigate to protect coasts. These long waves can be generated by tectonic displacements of sea floor, earthquakes, and volcanic eruptions in large area. These waves have feature intermediate between tides and swell waves in the spectrum of gravity water waves. The life of a tsunami is usually divided into three phases: the generation (tsunami source), the propagation and finally the inundation. The first phase of the dynamics of tsunami waves deals with the tsunami source that may be volcanic activity, coseismic sea floor displacement, underwater or subaerial landslides, and oceanic meteor strikes (watts, 2000). The second phase relates to the topography. The third stage deals with their breaking as they approach the shore, and depends greatly on the bottom bathymetry and on the coastline type; this phase is difficult phase of modeling.

In this study, a fully nonlinear and dispersive Boussinesq model (FUNWAVE) is used. This code includes wave breaking, boundary absorption and moving shoreline. At first, the result has been compared with the resulted wave height calculated by MIKE21 BW, and then has been used to simulate the wave generated by submarine mass failure.

## Governing Equation

The horizontal coordinates are denoted by *x* and *y*, and the vertical coordinate by *z*. The horizontal gradient is denoted by $\nabla := (\frac{\partial}{\partial x}, \frac{\partial}{\partial y})$, the horizontal velocity by $\vec{u}(x,y,z,t) = (u,v)$ and the vertical velocity by $w(x, y, z, t)$. The three-dimensional flow of an inviscid and incompressible fluid is governed by the conservation of mass (1) and by the conservation of momentum (2) and (3):

$$\vec{\nabla} \cdot \vec{u} + \frac{\partial w}{\partial z} = 0 \tag{1}$$

$$\rho \frac{D\vec{u}}{Dt} = -\nabla p \tag{2}$$

$$\rho \frac{Dw}{Dt} = -\rho g - \frac{\partial p}{\partial z} \tag{3}$$

Where $\rho$ is water density, $g$ is acceleration due to gravity, and $P(x,y,z,t)$ is pressure field.

The assumption that the flow is irrotational is commonly made to analyze surface waves. Then there exists a scalar function $\varphi(x, y, z, t)$ (the velocity potential) such that

$$\vec{u} = \vec{\nabla}\varphi, \qquad w = \frac{\partial \varphi}{\partial z} \tag{4}$$

So, the continuity equation (1) can be written as (5) and The equation of momentum conservation (2),(3) can be integrated into Bernoulli's equation (6) as follows;