

# APPLICABILITY OF HYBRID 2D AND 3D CALCULATION FOR TSUNAMI CAUSED BY SUBMARINE VOLCANIC ERUPTION

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## INTRODUCTION

The eruption of Hunga-Tonga Hunga-Ha'apai on January 15, 2022, caused extensive damage to the surrounding islands. Sudden atmospheric pressure changes accompanied by the eruption caused no small sea-level fluctuations around the world. On the other hand, the tsunami that hit the islands around the submarine volcanoes is mostly caused by the sea-level change due to the eruption. One paper claimed that the maximum sea-level rise during the eruption was about 90 m, which could explain the tsunami of more than 10 m that hit Tonga (Heidarzadeh et al., 2022). This is a description of the magnitude of the explosion, but the mechanism has not yet been elucidated. Research has also suggested that tsunamis are generated by the rise of the water surface due to eruptive currents and gases during eruptions.

The purpose of this study is to verify the relationship between the eruption scale and the depth of inundation around Tonga, by reproducing the eruption ejecta in three-dimensional calculations.

## NUMERICAL METHOD

The tsunami propagation was calculated using the multilayered nonlinear long wave equation (STOC-ML) assuming hydrostatic pressure, developed by Tomita and Kakinuma (2005). Coupled calculations with the single-phase Navier-Stokes equations (CADMAS-SURF/3D), which compute the sea surface using the VOF method, were also performed to reproduce the rise of the water surface due to eruptive currents and gases during eruptions. In the coupled calculation, the single-phase Navier-Stokes equations (STOC-IC), which calculate the sea surface from the continuity equation, are included as a buffer (Arikawa et al., 2019).

Fig. 1 shows the 3D calculation of the eruption on a simplified terrain. Fig.1 visualizes only the vertical velocity. Vertical upward flow velocity from the topographic surface is calculated as the eruption from the crater. The effluent area, effluent velocity, and effluent depth were used as parameters to calculate the effluent rate from the effluent area and effluent velocity, and a sensitivity analysis was performed by restricting the range of effluent rates.

We also performed 2D numerical calculation giving the initial water level as the sea-level rise due to the eruption, following Heidarzadeh et al (2022).

## RESULTS

Figure 2 shows the result of the tsunami propagation calculation. Tongatapu is the main island of Tonga. The inundation depths were compared with the results of the field survey at Tongatapu. The 3D calculations allowed the momentum to be taken into account and improved the reproducibility of the inundation depths.

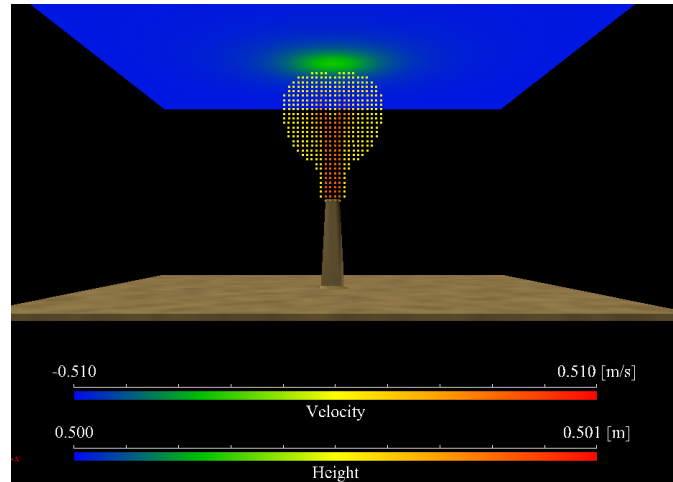


Figure 1 - 3D calculation on a simplified terrain

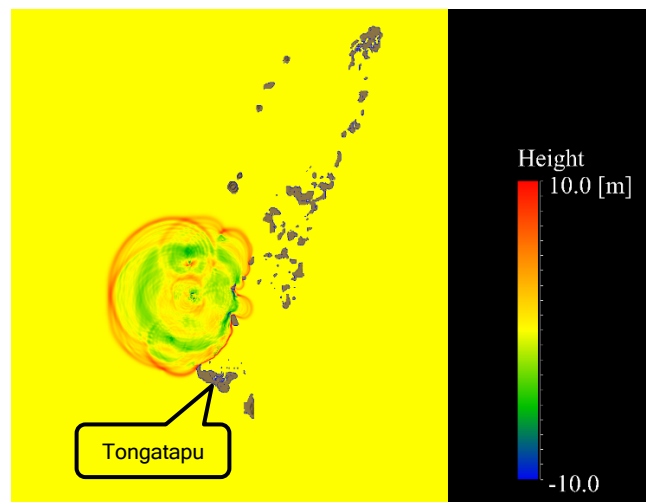


Figure 2 - Result of the tsunami propagation calculation

## REFERENCES

- Heidarzadeh, Gusman, Ishibe, Sabeti and Šepić (2022): Estimating the eruption-induced water displacement source of the 15 January 2022 Tonga volcanic tsunami from tsunami spectra and numerical modelling. *Ocean Engineering*. 10.1016/j.oceaneng.2022.112165.
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