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Finite-difference calculations of near-field long-period seismograms with 3D lakes at Taal volcano, Philippines

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Taal volcano, Philippines, located 60 km south of Metro Manila, has experienced mainly phreatic and phreatomagmatic explosions with a typical recurrence interval of 30 years. More than 30 years have passed since the last eruption in 1977, increasing a risk of near-future explosion. In order to better monitor and understand this volcano, an observational network was upgraded in the last November, including 5 new broadband seismometers, in cooperation with some other organizations including PHIVOLCS.

A problem to be solved in seismic analysis at Taal volcano may be an effect of lakes on the Green's functions. Taal holds a caldera filled with a lake (Taal Lake) with horizontal dimensions of 15 km (east-west) x 25 km (north-south) and with a maximum depth of 200 m, in which an active volcanic island exists. The island itself has another lake (Main Crater Lake), with a diameter of 1.2 km and a maximum depth of 80 m. A significant effect of a shallow low velocity layer on moment-tensor inversions of long-period (1-2 s) volcanic events have been indicated by Bean et al. (2008, JGR). Since the lake is regarded to be a special case of low velocity layer, the effect of the lake on calculations of the Green's functions is an important issue for seismic analysis at Taal volcano.

In order to investigate this problem, the finite-difference method (FDM) code of Maeda et al. (2011, GJI) was improved to deal with water domains such as lakes and the sea. The FDM code has the advantage in the following two points; (1) arbitrary 3D topography and structure can be considered, and (2) efficient absorbing boundary layers known as the perfectly matched layer (PML) are used. We used the algorithm of Okamoto and Takenaka (2005, J. Seism. Soc. Jpn.) to deal with the water domains.

Synthetic seismograms were generated by the improved code, using a 3D Digital Elevation Model (DEM) of Taal volcano, in which the lake-floor topographies of the both lakes were included. Calculations and comparisons were made among three cases, namely: the lake domain is filled with water (hereafter called "waterlake"), the lake domain is filled with solid having the same property as surroundings ("solidlake"), and the lake domain is dealt as a part of the vacuum domain ("vacuumlake"). Numerical tests were conducted for isotropic ricker wavelet sources with typical source durations of (a) 2 s, (b) 5 s and (c) 10 s at a depth of 500 m, and of 5 s at depths of (d) 200 m and (e) 2000 m under the crater center. Maximum differences between the results of waterlake and vacuumlake, within epicentral distances of 10 km, for calculations (a)-(e), were 43, 9, 3, 10 and 5 %, respectively. Those between waterlake and solidlake were 63, 21, 14, 24 and 13 %, respectively. These results indicate that the synthetics generated by shorter and shallower sources are more seriously affected by the lake. Although the presence of the water layer has a negligible effect on the waveforms generated by 5 s or longer sources, the lake-floor topography should not be neglected even for the source of as long as 10 s.

Additional tests to estimate their effects on the moment-tensor inversion results are now going on. In this presentation, the results of these calculations are presented.

Keywords: Taal volcano, Green's function, FDM, lake-floor topography