Forward analysis of seismic waves accompanied by tilt ground motion during the eruption of Mt. Motoshirane, Japan, on January 23, 2018

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Mt. Kusatsu-Shirane is an active volcano located in the northwestern part of Gunma Prefecture. It is composed of Mt. Shirane, Mt. Ainomine, and Mt. Motoshirane. Most of the recent activities of this volcano have been seismic activities and crustal deformations near Yugama crater lake (e.g., Japan Meteorological Agency (JMA), 2018, Report of Coordinating Committee for Prediction of Volcanic Eruptions), whereas the last known magmatic eruption at Mt. Motoshirane was 1500 years ago (Nigorikawa et al., 2016, JpGU; Terada, 2018). From 10:02 JST on January 23, 2018, a phreatic eruption occurred at Mt. Motoshirane. New craters were identified along the east-west direction at the northern rim of Kagamiike crater lake after the eruption. Yamada et al. (2019, The Volcanological Society of Japan) investigated the source process of this eruption based on a seismic wave analysis. They applied the moment tensor inversion method of Nakano and Kumagai (2005) to the data in the following two time windows with different frequency bands: a 180-s-long window from 9:59 with a 10-50 s band, and the following 80-s-long-window with a 10-30 s band. Their results from the former and latter time windows were consistent with an open crack at a depth of 700 m and inclined cylindrical focal mechanism at a depth of 1000 m immediately beneath Kagamiike north crater, respectively. The source processes of the signals with periods longer than 50 s have not been investigated yet. Horizontal motions with a period of ~300 s were recorded during the eruption, which seems to mainly represent a tilt motion taking into account the natural period of the seismometer of 240 s. We are planning to investigate the source processes in these long period bands using the waveform inversion method of Maeda et al. (2011), which can take into account both the translational and tilt motions recorded by seismometers. In this presentation, we show the results of our preliminary forward analysis, where the observed waveforms were compared with synthetic ones taking into account both translational and tilt motions caused by a given source mechanism.

In this study, we calculated Green's functions of translational and tilt motions at three station sites, N.KSHV (Hoshimata), N.KSNV (Nikenya), and N.KSYV (Yazawahara)of V-net operated by the National Research Institute for Earth Science and Disaster Resilience. We used a 3D finite-difference method with a mesh size of 40 ×40 ×40 m . We assumed a compressional wave velocity $Vp=2500$ m/s, a shear wave velocity $Vs=1443$ m/s, and a density $\rho=2500$ kg/m^3 as typical structures of Mt. Kusatsu-Shirane and other active volcanoes. As the source mechanism, we used a north-south opening (east-west striking) vertical crack at 1200 m above sea level below the craters, assuming a source time function that changes from inflation to deflation, and calculated the waveforms with a time constant of 250 s. We then convolved the Green's functions with the seismometer's translational and tilt responses to produce synthetic waveforms where the both types of motions are taken into account. Results showed that the shapes and time constants of the synthetic waveforms were consistent with those of observed ones low-pass filtered at 10 s, except for the NS component of N.KSHV and N.KSNV. Especially, the observation that the horizontal components have much larger amplitudes than vertical ones was reproduced by the synthetic waveforms. These results suggest that the characteristics of the observed horizontal and vertical waveforms can be explained by the superposition of translational and tilt motions.

However, the assumed source location and mechanism did not reproduce the observed amplitude ratios

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among the components and the polarities of several traces. We will try to explain them by investigating a better source location and mechanism using the waveform inversion method in the future.

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