Seismic velocity monitoring using ACROSS on landslide area

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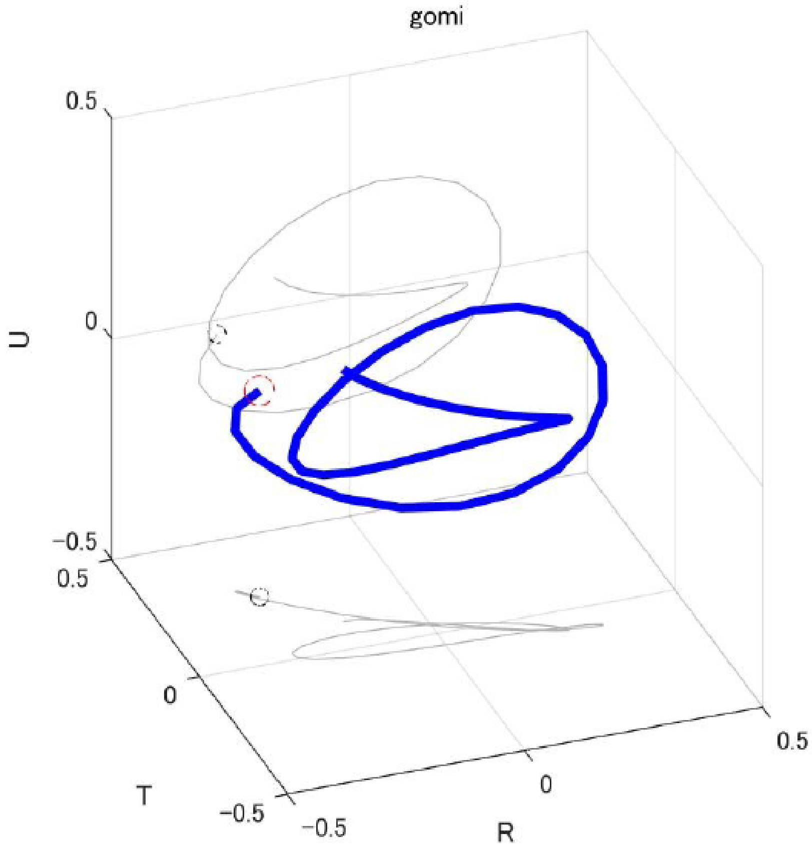
We monitored the landslide area using the seismic wave generated by Accurately Controlled Routinely Operated Signal System (ACROSS).

An ACROSS seismic source unit is installed in the Mori-town, Shizuoka prefecture, which continuously generates accurately controlled centrifugal force by rotating an eccentric mass around vertical axis. The main purpose of this study is monitoring landslide area to know how the propagation property of seismic signal changes in response to external disturbance. We found a landslide feature at 3 km northeast of the source according to J-SHIS Map and deployed two seismometers there; one on the surface of a tea field cultivated on the landslide plateau (Ocha-station) and the other on a normal place 400m away from the tea field as a reference (Gomi-station). We retrieved the ground motion velocity record of the two sites from October 2 to 23 in 2017 to monitor the travel time changes of the ACROSS signal. During the analysis period, the ACROSS source was operated at a rotation frequency of 5.51 Hz with modulation amplitude of 2 Hz and the modulation period of 50 s.

In ACROSS operation, the source changes the rotation direction every 2 hours. By stacking the records in different period of time corresponding to the opposite rotation direction, we can synthesize the seismometer response to a linear source motion along arbitrary horizontal directions. We defined six components of the transfer function –Ur, Rr, Tr, Ut, Rt, and Tt, where capital and lower-case letters show the components of seismometers and direction of source vibration, respectively. U(u), R(r), and T(t) mean up, radial, and transverse directions, respectively. From the particle motion of the transfer functions, we found that the arrival times of P, S, Love and Rayleigh waves are around 1.1, 1.8, 2.8 and 3.8 seconds, respectively. We estimated the temporal traveltime changes of these waves during the 3 weeks and found that the traveltime tends to delay corresponding to rainfall. We compared the traveltime change with the rainfall. The velocities of Love and Rayleigh waves changes in response to rainfall very well. Then, we took difference of the temporal traveltime variation between Ocha- and Gomi-stations. As a result, high correlations between the rainfall and the arrival of the Love and Rayleigh waves shown in Tt and Ur components, respectively disappeared. Instead, high correlation emerged in waves with time around the arrival of Love and Rayleigh but not in the components of Tt and Ur. For example, the wave which has Rr component and 2.3s traveltime. These components would contain some minor converted vibrations from these main surface waves. The high correlation and proportionality may reflect the difference of conversion efficiency response to the rainfall between Ocha and Gomi-stations. Continuous observation of these waves may detect the sign of landslide.

Keywords: ACROSS, landslide, rainfall, seismic velocity



震源装置をラジアル方向に加振した際の、Gomi 観測点での 3.8-4.2 秒（0.4 秒間）のパーティクルモーション。赤丸が 3.8 秒時を表している。U=上方向成分。R＝動径成分（震源から見た観測点方向）、T＝接線成分（震源から観測点を見て直交方向）。レイリー波的挙動をしている。