



HISTORY AND RECENT TOPICS OF STRONG-MOTION OBSERVATION AT THE EARTHQUAKE RESEARCH INSTITUTE, UNIVERSITY OF TOKYO

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ABSTRACT: The strong-motion observation system developed and maintained by the Earthquake Research Institute have focused on acquiring data from near earthquake sources and on studying local site effects on strong motion. The observation sites are mostly deployed between the Tokai and southern Kanto region, including the dense array in Ashigara valley.

Key Words: strong ground motion, array observation, near field, rock site, sediment site, local site effects

INTRODUCTION & SHORT HISTORY

The prototype of an earthquake strong-motion instrument in Japan was developed under the auspices of the Strong-Motion Accelerometer Committee (Takahashi, 1953). The instrument was called SMAC, associated with the Committee name. The first instrument was installed at the second basement in the former building of Earthquake Research Institute (ERI), University of Tokyo in 1953, and the first significant record (PGA: 70 cm/s/s) was retrieved from the Tokyo Bay, Japan earthquake ($M_{JMA}5.9$) in Feb. 14, 1956. Since then, ERI has maintained the strong-motion instruments installed mostly in buildings and published the annual report “Strong Motion Earthquake Records in Japan” from 1964 until 1972. The National Research Center for Disaster Prevention, Science and Technology Agency (the present National Institute of Earth Science and Disaster Prevention (NIED)), has then succeeded with the publication and the role of promoting strong motion observation, partly since 1970 and completely since 1972.

The Workshop on Strong Motion Instrument Array held in Hawaii (Iwan, 1978) has been a turning point for the strong motion observation system in ERI to focus on free-field array observation using digital accelerographs. The first instruments array was deployed along the coast of Suruga Bay and in the Izu peninsula region in 1981-1983 (Tanaka et al., 1984). The principal objectives of the array observation are to understand the generations and propagation of strong ground motion from the anticipated large earthquakes (Tokai earthquake) and to monitor the intense seismic and volcanic activities at the east coast of Izu peninsula. The sensors at all of the sites have been installed on rock outcrops, so as to acquire data with lesser effects of local site. On the other hand, the second array was established in 1987-1990 in and around Ashigara Valley to study local site effects on strong ground

motion (Kudo et al., 1988). A part of the arrays was used in the project promoted by the IAEE/IASPEI Joint Working Group on Effects of Surface Geology on Seismic Motion (JWG-ESG) for blind ground motion prediction.

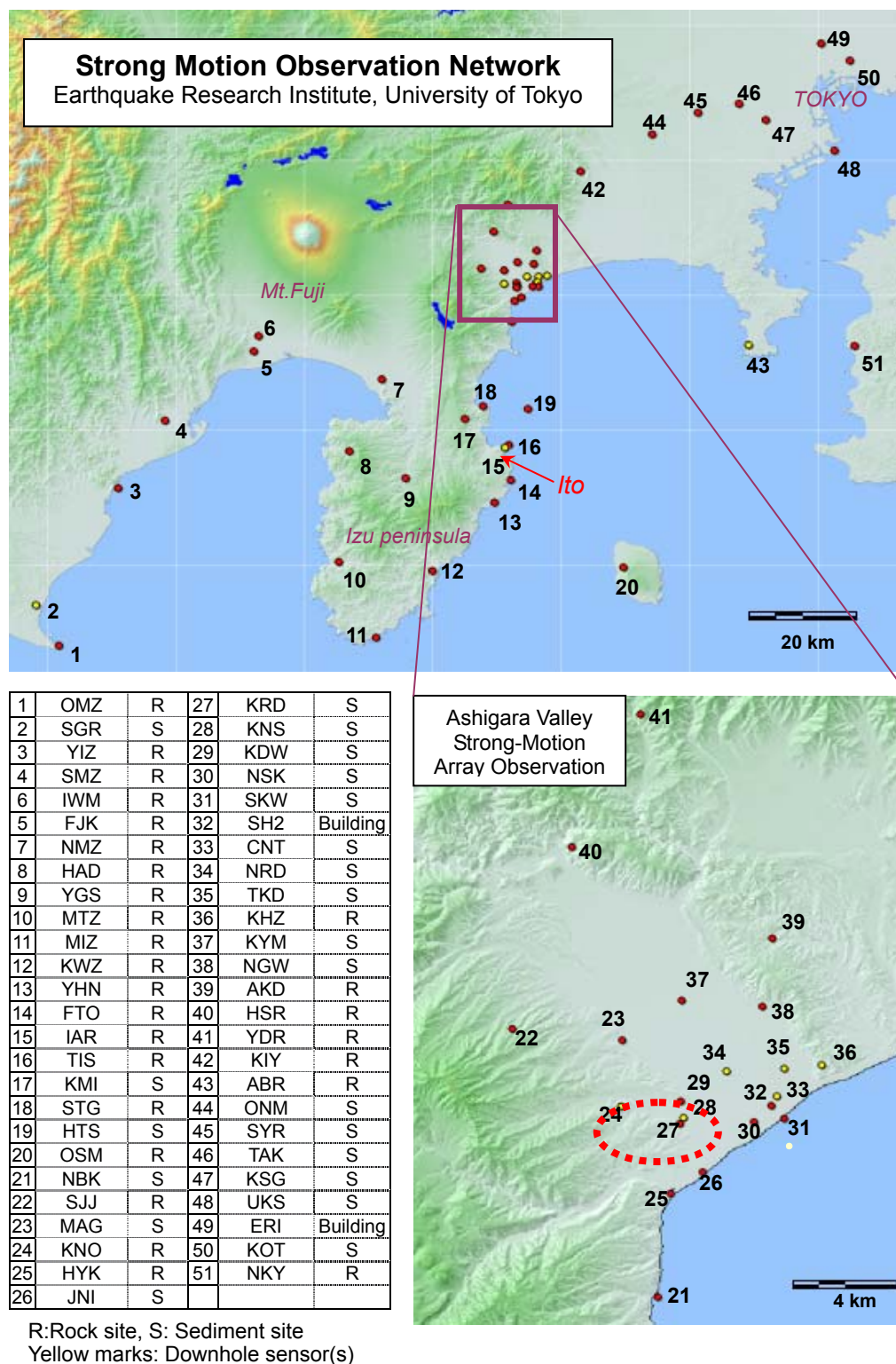


Figure 1. Strong-motion observation network run by Earthquake Research Institute.

CURRENT NETWORK

The location map of the strong motion instrument arrays maintained by ERI is shown in Figure 1. Some sites shown by yellow marks have down-hole sensor(s) at shallow or intermediate depths (30~250 m). Station 33 (CTS) in Ashigara valley is the densest down-hole array among our sites, with the sensors at depths of 467 m, 100 m, 30 m, 10 m, and at the surface. The others have one or two (like no. 27) down-hole sensors.

Most of these sites are linked by public telephone lines, and the data are retrieved through telephone lines. The instruments at two-thirds of the sites have been replaced by the K-net 95 type or other types of 24-bit resolution with time synchronization by GPS, while the remaining are still 16-bit accelerographs with time adjustment by NHK time signal.

SOME SIGNIFICANT RECORDS

Recent seismic activity in southern Kanto and Tokai district has been low, except for the earthquake swarms associated with the volcanic activity near Ito City, east coast of Izu peninsula. The seismic activity near eastern Izu peninsula has increased since the 1976 Izu-Hanto Oki earthquake. Moderately large earthquakes occurred near the coast in 1978 ($M_{JMA}7.0$), 1980 ($M_{JMA}6.7$), 1989 ($M_{JMA}5.5$), 1990 ($M_{JMA}6.5$) and others. The 1989 event was the closest one to land, Ito City (Figure 2). Very light damage to a few RC buildings was observed. We operated two temporal stations near the source at SOF and ITO. As an example, the retrieved waveform at SOF is shown in Figure 3. The earthquake magnitude was not so large and the ground motion level was not so high, but the distance to the source was particularly short (~2km).

Mobile observations have also been a major task for us and other university groups. We carried out temporal strong motion observations for an aftershock sequence from the 1993 Hokkaido Nansei Oki earthquake ($M_{JMA}7.8$) jointly with Hokkaido University and Kyoto University. In one of the sites, OTB, very high acceleration was retrieved from the Esashi Oki earthquake ($M_{JMA}6.5$) in August 8, 1993, as shown in Figure 4. The accelerograph was installed in the OTB site at the basement floor of a 2-story RC school building. The building had no damage, despite the very high acceleration. The high acceleration was due mostly to the local site effects by shallow soft soils over the hard rock and possibly the rock topography near the site (Kudo et al., 1994).

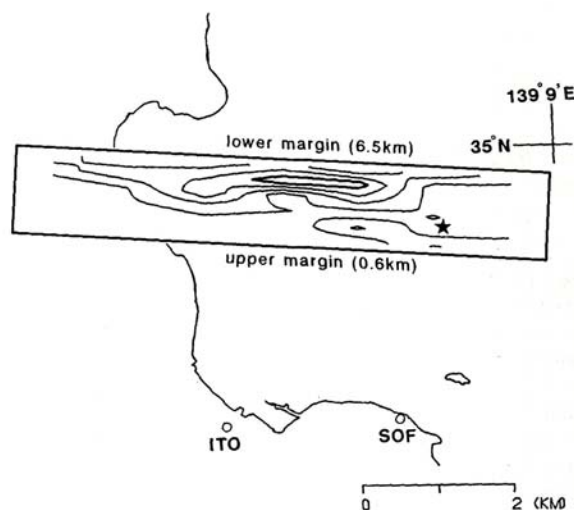


Figure 2. Slip distribution on the fault plane of the 1989 Ito Oki earthquake ($M_{JMA}5.5$) and the location of the submarine eruptions(★) observed 4 days after the earthquake.(Reproduced from Oura et al. , 1992).

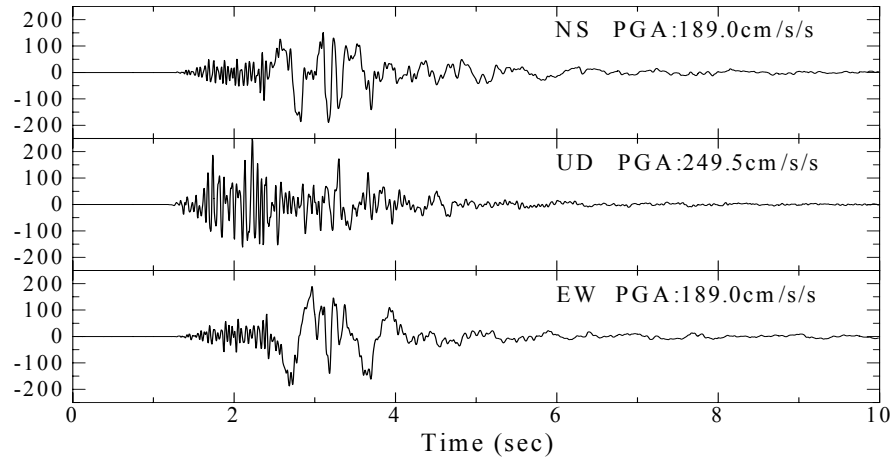


Figure 3. Strong motion accelerograms from the 1989 Ito Oki earthquake at rock site SOF.

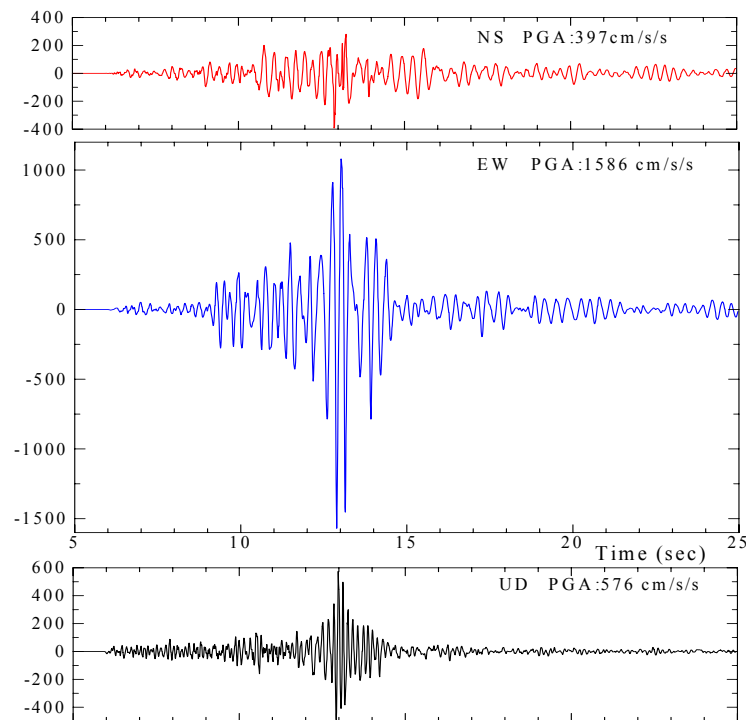


Figure 4. A high acceleration recorded at OTB from the 1993 Esashi Oki earthquake.

TEST SITE FOR THE STUDY ON EFFECTS OF SURFACE GEOLOGY ON SEISMIC MOTION

Ashigara Valley, located in the western Kanagawa Prefecture, is a middle-sized ($12 \times 5 \text{ km}^2$) sediment-filled valley. Cooperating with the activities of IAEE/IASPEI JWG-ESG, a part of Ashigara Valley was included as one of the test sites for the study of ESG. Fortunately, strong motion records were retrieved from the Odawara earthquake ($M_{\text{JMA}} 5.1$) in August 5, 1990. The earthquake occurred immediately beneath the test site, which is located near the west margin of Ashigara Valley. Simplified site geology at the test site, Kuno area, and the velocity waveforms integrated from the original acceleration are shown in Figure 5. These records were used for the blind prediction experiment organized by JWG-ESG.

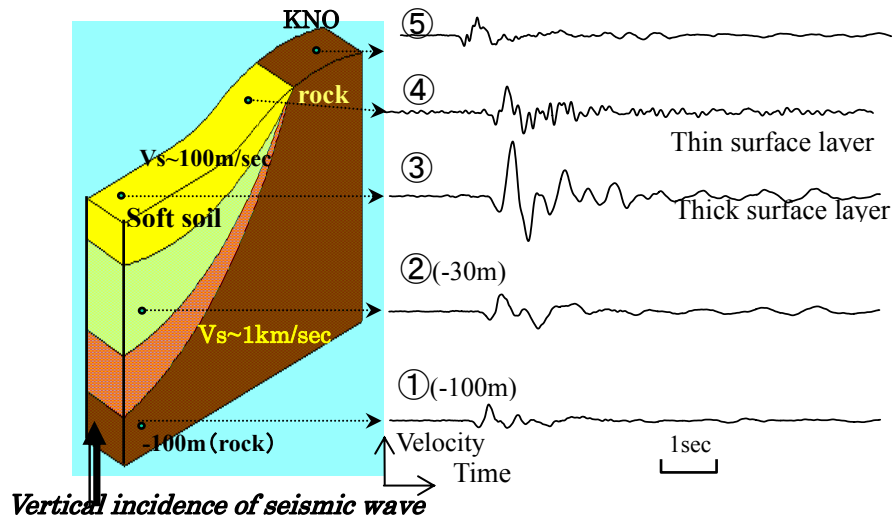


Figure 5. A schematic representation of the site geology and the velocity waveforms

Spectral Ratio

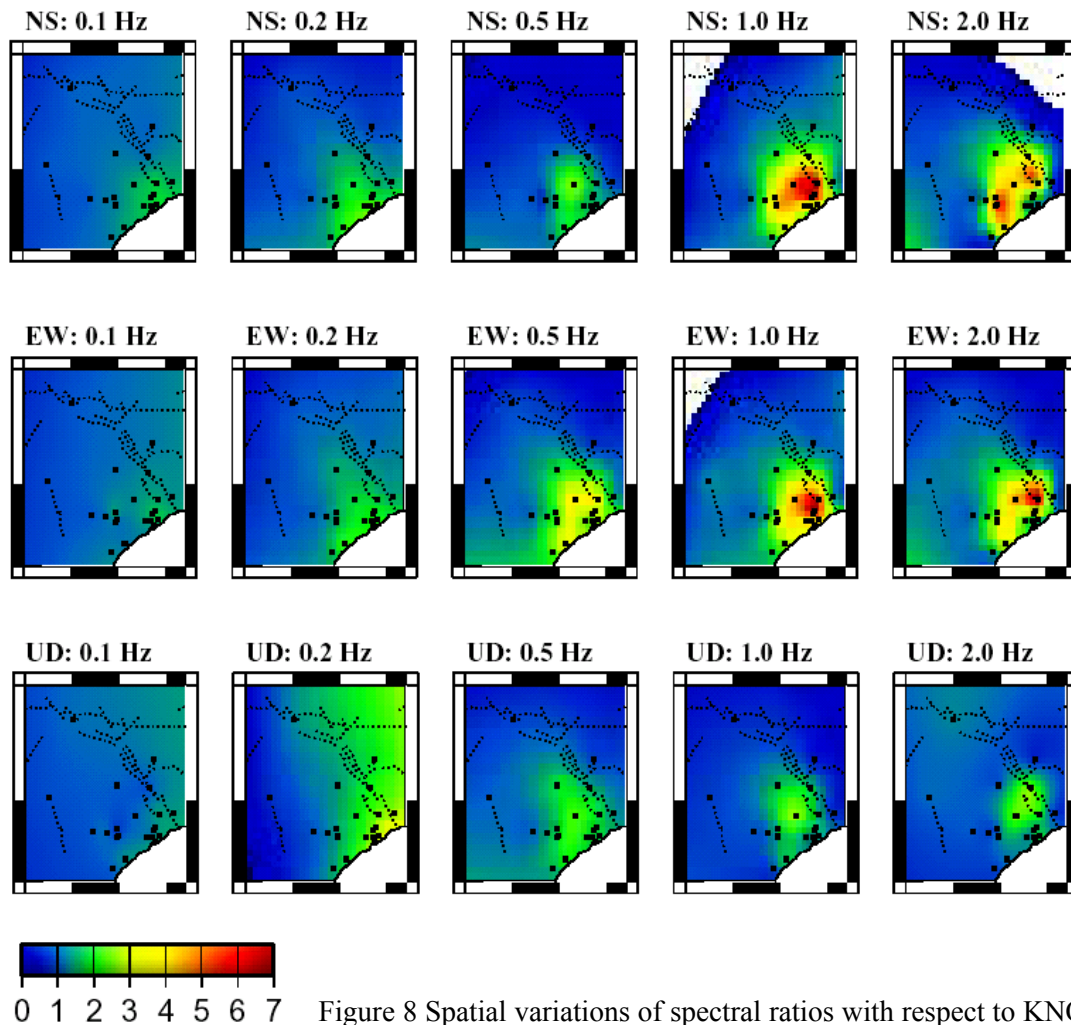


Figure 8 Spatial variations of spectral ratios with respect to KNO or site amplification factors in Ashigara valley. Solid squares are observation stations. (Reproduced from Uetake and Kudo, 2004)

EMPIRICAL SITE FACTORS IN ASHIGARA VALLEY

By running the Ashigara valley strong motion array observation for 15 years, we had an opportunity to retrieve the ground motions from five large ($>M7$) and remote ($>700\text{km}$) events, for comparison to the rock site motions as well as the responses of sediment sites.

The advantages of using large and remote events are that the source and path effects will be common with a sufficient approximation and that the ground motions will include a wide frequency-band. Ground motions at both sediment and rock sites are coherent in the frequency lower than 0.1 Hz. However, they are significantly incoherent at higher frequencies. Site amplification factors were determined by taking spectral ratios with respect to one rock site. The amplification factors of sediment sites deviate from 2 to 10 times with respect to a rock site in the high frequency range of over 0.1 Hz, in which significant peaks at around 1 to 2 Hz are found at most sites. The amplification factors below 0.2 Hz tend to be large toward the southeast of the valley and localized large factors are found in the high frequency range. Spatial distributions of the spectral ratios with respect to the rock site KNO, or amplification factors, are plotted in Figure 8. The reasons we could retrieve these records at most sites in Ashigara Valley, despite low ground accelerations, are because we used simultaneous recording systems using dedicated telephone lines for event-triggering (Kudo et al., 1988) and because we set a triggering level of 0.5-1.0 cm/s/s for rock sites and 1-4 cm/s/s for sediment sites. As an example, Figure 9 shows a record section where the original acceleration was integrated to velocity with band-pass filters. In the figure, capital letters show the site code at rock sites while the others stand for sediment.

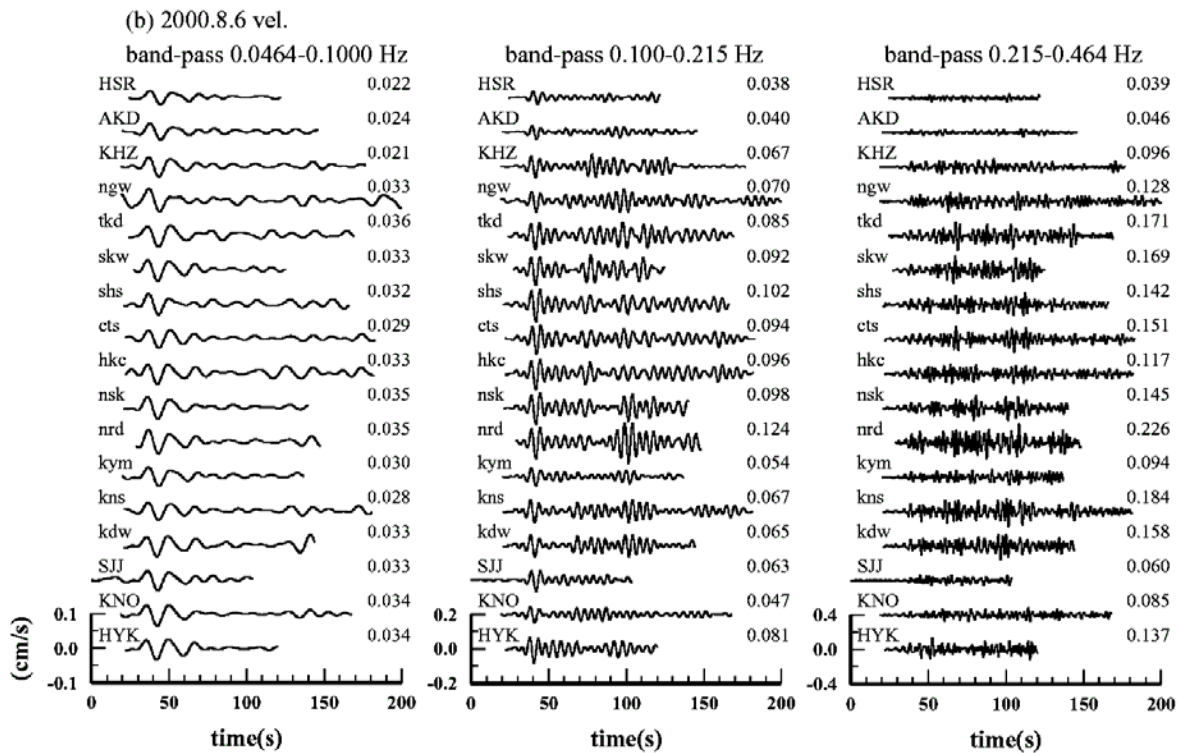


Figure 9. Integrated velocity seismograms of NS components from the Torishima earthquake (M_{JMA} 7.2) in August 6, 2000, filtered using three different frequency bands. (Reproduced from Uetake and Kudo, 2004).

CONCLUDING REMARKS

The observation sites in the regions of Suruga Bay and Izu Peninsula were oriented to retrieve strong rock motion during earthquakes. Moreover, the Ashigara valley observation network was established to study the effects of surface geology on seismic motion.

Data distribution was carried out as a test (<http://kyoshin.eri.u-tokyo.ac.jp/SMAD/>), although it only includes partial data. We are preparing to open a web page that will enable the download of the original data. The news will appear in the web page of the Strong-Motion Earthquake Observation Council (<http://www.k-net.bosai.go.jp/KYOUKAN/index/>), or in others, in the near future. Recent data can be found at <http://www.sknet.eri.u-tokyo.ac.jp/>. However, the download of data is limited to dedicated users.

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