GROUND ACCELERATION RECORDS OF 1993 KUSHIRO-OKI EARTHQUAKE

by

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On January 15, 1993, Hokkaido and the eastern half of Honshu (main) Island of Japan were hit by a strong earthquake. According to the Japan Meteorological Agency (JMA), the magnitude was 7.8 in the JMA scale, the focus was located at longitude 42° 51'N and latitude 144° 23'E with a depth of 107 km. The event was named the 1993 Kushiro-Oki (offshore) earthquake since Kushiro City is located only 14 km from the epicenter. This report describes the ground accelerations recorded during this event.

JMA is now constructing an accelerograph network in Japan using the new 87-type accelerographs (Hachimine, 1990). The new instruments could successfully record the main shock of the event at 34 locations shown in Fig. 1 (a). Figure 1 (b) shows the distribution of JMA seismic intensity determined by JMA based on people's feelings. The ground motion in Kushiro city was judged as intensity 6, which is the second largest level in the JMA intensity scale.

The authors conducted a basic analysis of the accelerograms provided by JMA. Table 1 summarizes the peak accelerations, velocities, displacements and spectrum intensities for the three components at 34 locations. The velocities and displacements were obtained from the acceleration records by integrations in the frequency domain. To remove long period noise, a cosine filter with lower cut-off frequency between 0.05 Hz and 0.08 Hz was employed in the integrations. The spectrum intensity (SI) was calculated as the average velocity response spectrum for the period range from 0.1 s to 2.5 s with 20 % damping ratio. Figures 1 (c) and (d) show the peak acceleration and SI value for the larger horizontal component. The peak acceleration at the JMA Kushiro station is as large as 0.94 g, which may be one of the biggest free-field records in the world.

The Port and Harbor Research Institute (PHRI) of the Ministry of Transport also has accelerograph stations at major ports in Japan as shown in Fig. 2 (a). Peak accelerations recorded by this network (Iai, 1993) are shown in Table 2 and Fig 2 (b). In Kushiro City, the peak acceleration at the PHRI station is much smaller than that of the JMA station. This fact

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may be explained by: 1) liquefaction occurred at PHRI station (Kushiro Harbor) and acceleration could not increase after that, and 2) the JMA station is located at the edge of a terrace and the ground motion there might be bigger than those at the other parts of the city.

Figures 3 to 5 show attenuation characteristics of peak horizontal acceleration, vertical acceleration and SI value as a function of the hypocentral distance. The hypocentral distance was used since the focus is very deep. Although no empirical attenuation formula exists for deep earthquakes, the recorded values look much bigger than those expected from the formulas for shallow earthquakes. Further investigation is necessary for this point.

Figure 6 shows the relationship between the peak accelerations and SI values. Unlike peak acceleration, the SI value is, in general, influenced by longer frequency contents, and it is considered to be a better index to predict structural damage (Katayama et al., 1988). However, since the figure is only for one event, linearity is seen between them.

Figures 7 to 11 show the time histories, Fourier spectra and response spectra for accelerograms recorded at five JMA stations where large accelerations were recorded.

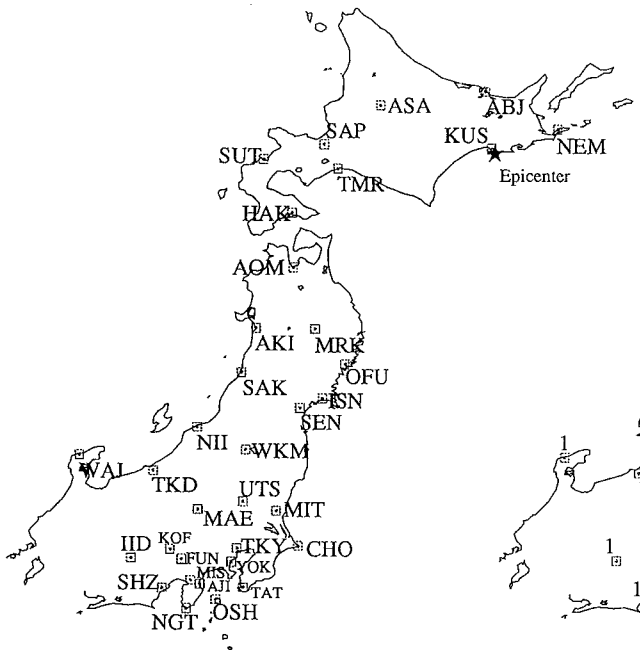
Since the earthquake ground motions recorded during the 1993 Kushiro-Oki are really interesting, the authors demonstrated the results of preliminary analysis in this quick report.

REFERENCE

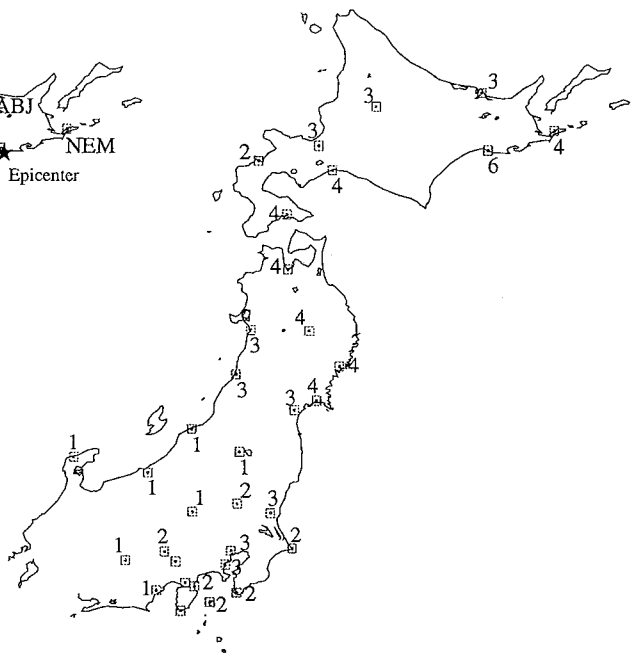
Hachimine, T. (1990) "Specifications of JMA 87-type accelerograph", Internal report of JMA (in Japanese).

Iai, S. (1993) "Strong motion records at ports and harbors by the 1993 Kushiro-Oki earthquake", Internal report of PHRI (in Japanese).

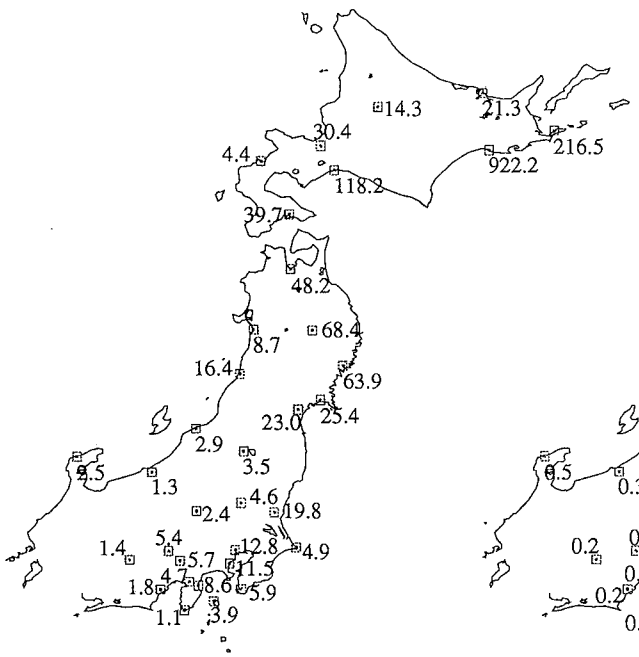
Katayama, T., Sato, N. and Saito, K. (1988) "SI-sensor for the identification of destructive earthquake ground motion", Proc. of the 9th WCEE, Vol. VII.



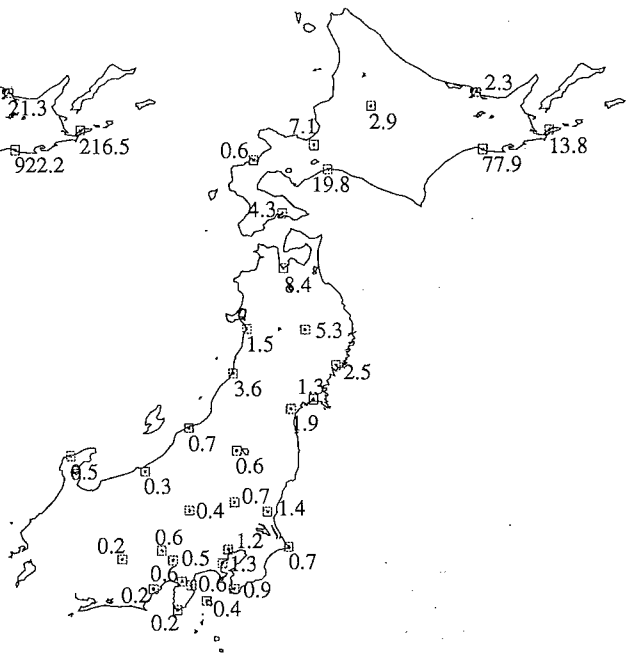
(a) JMA accelerograph station



(b) JMA seismic intensity



(c) peak horizontal acceleration

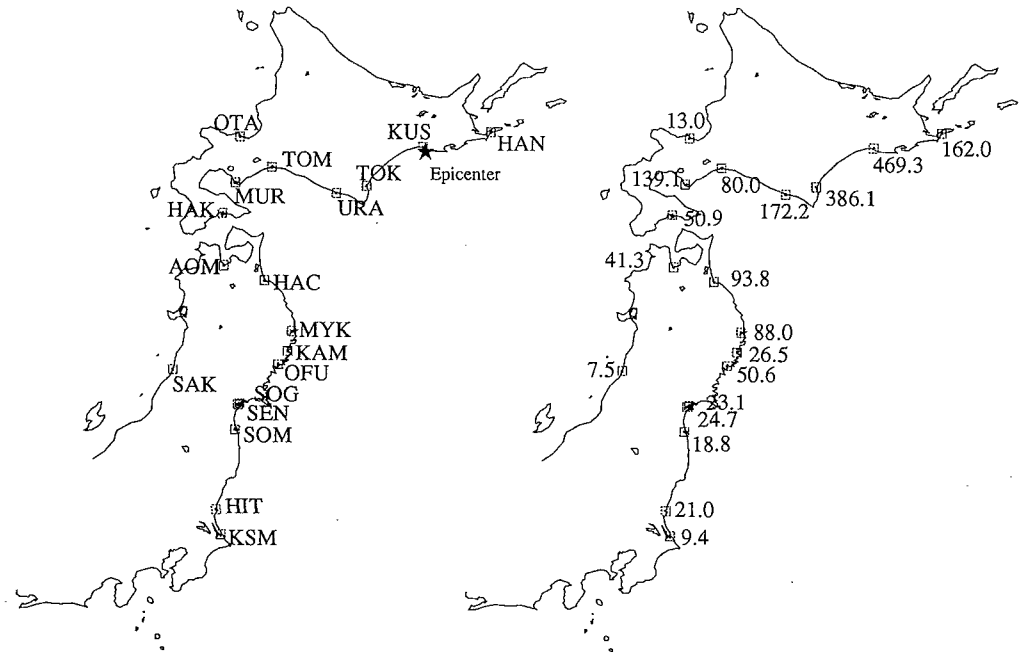


(d) spectrum intensity (SI)

Fig. 1 JMA intensities, peak ground accelerations and SI values recorded at JMA stations

Table 1 Peak ground accelerations, velocities, displacements and SI values at JMA stations

JMA station		Acceleration (cm/s/s)			Velocity (cm/s)			Displacement (cm)			Spectrum Intensity (cm/s)		
		EW	NS	UD	EW	NS	UD	EW	NS	UD	EW	NS	UD
ABASHIRI	(ABJ)	21.3	20.2	19.1	2.5	2.9	2.1	1.2	1.6	1.1	2.0	2.3	2.3
ASAHIKAWA	(ASA)	9.3	14.3	6.6	2.0	3.1	2.1	1.6	1.7	2.5	1.8	2.9	1.5
NEMURO	(NEM)	216.5	196.5	85.9	9.6	11.0	3.2	2.1	2.7	0.7	12.2	13.8	4.3
SAPPORO	(SAP)	30.4	27.8	11.2	10.1	6.1	2.9	4.6	2.7	1.0	7.1	6.5	2.5
KUSHIRO	(KUS)	922.2	817.4	466.9	60.0	67.3	23.1	5.9	9.3	2.1	77.9	75.3	23.9
SUTTSU	(SUT)	3.8	4.4	2.6	1.0	1.2	0.9	0.8	1.1	0.7	0.6	0.6	0.5
TOMAKOMAI	(TMR)	118.2	110.8	53.4	15.7	15.5	4.6	8.1	10.1	3.4	19.8	14.4	4.8
HAKODATE	(HAK)	38.0	39.7	15.3	4.3	4.4	2.3	1.1	1.5	0.5	4.3	4.1	1.9
AOMORI	(AOM)	48.2	44.8	21.4	6.0	5.6	2.9	1.9	2.0	0.9	8.4	6.8	3.5
AKITA	(AKI)	8.7	7.8	4.0	1.6	1.7	0.8	1.3	0.8	0.5	1.5	1.4	0.8
MORIOKA	(MRK)	68.4	63.9	27.6	4.4	3.6	1.5	0.5	0.4	0.5	5.3	4.3	1.8
OFUNATO	(OFU)	63.9	60.9	14.9	2.3	2.1	0.9	0.3	0.2	0.4	2.5	2.4	0.8
SAKATA	(SAK)	11.3	16.4	3.4	3.6	3.6	1.3	1.9	2.6	0.8	3.1	3.6	1.0
ISHINOMAKI	(ISN)	19.9	25.4	9.3	0.9	1.0	1.0	0.3	0.3	0.3	1.1	1.3	1.1
SENDAI	(SEN)	23.0	16.0	9.9	1.5	1.3	0.8	0.3	0.3	0.3	1.9	1.7	1.1
NIIGATA	(NII)	2.9	2.7	0.9	1.7	1.5	0.5	2.0	1.6	0.4	0.7	0.7	0.2
WAKAMATSU	(WKM)	3.5	3.0	2.4	0.7	1.1	0.6	0.4	0.6	0.3	0.6	0.6	0.6
WAJIMA	(WAJ)	2.0	2.5	0.7	0.4	0.4	0.2	0.2	0.1	0.1	0.5	0.5	0.1
TAKADA	(TKD)	1.3	1.2	0.4	0.3	0.4	0.1	0.3	0.3	0.2	0.3	0.3	0.1
UTSUNOMIYA	(UTS)	3.9	4.6	2.8	0.5	0.6	0.4	0.2	0.2	0.1	0.6	0.7	0.4
MAEBASHI	(MAE)	2.4	2.0	1.3	0.5	0.4	0.3	0.5	0.4	0.2	0.4	0.3	0.2
MITO	(MIT)	19.6	19.8	8.1	1.1	1.2	0.5	0.3	0.3	0.2	1.3	1.4	0.6
CHOSHI	(CHO)	4.6	4.9	2.4	0.5	0.4	0.2	0.2	0.2	0.1	0.7	0.6	0.2
TOKYO	(TKY)	10.1	12.8	3.8	0.8	0.9	0.4	0.6	0.5	0.3	1.0	1.2	0.4
KOFU	(KOF)	5.4	5.4	2.7	0.5	0.5	0.2	0.1	0.1	0.1	0.6	0.6	0.3
IIDA	(IID)	1.0	1.4	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1
KAWAGUCHIKO	(FUN)	3.3	5.7	1.6	0.3	0.3	0.2	0.2	0.1	0.1	0.5	0.4	0.2
YOKOHAMA	(YOK)	9.6	11.5	3.6	0.9	1.3	0.3	0.5	0.5	0.2	1.2	1.3	0.4
MISHIMA	(MIS)	4.3	4.7	1.6	0.5	0.4	0.2	0.2	0.1	0.1	0.6	0.6	0.2
AJIRO	(AJI)	8.6	8.0	2.2	0.5	0.4	0.1	0.2	0.2	0.2	0.6	0.5	0.1
TATEYAMA	(TAT)	5.6	5.9	4.0	0.7	0.9	0.4	0.4	0.5	0.2	0.7	0.9	0.4
SHIZUOKA	(SHZ)	1.8	1.7	0.5	0.3	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.1
OSHIMA	(OSH)	2.7	3.9	1.7	0.3	0.4	0.2	0.1	0.2	0.1	0.4	0.4	0.2
IROZAKI	(NGT)	1.1	0.8	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1



(a) PHRI accelerograph station (b) peak horizontal acceleration

Fig. 2 Peak ground accelerations recorded at PHRI stations

Table 2 Peak ground accelerations at PHRI stations

PHRI station		Accelerometer	Acceleration (cm/s/s)		
			EW	NS	UD
HANASAKI	(HAN)	ERS-F	162.0	147.0	92.0
OTARU	(OTA)	ERS-G	13.0	13.0	7.0
KUSHIRO	(KUS)	ERS-G	344.2	469.3	381.5
TOMAKOMAI	(TOM)	SMAC	50.0	80.0	18.1
MURORAN	(MUR)	ERS-G	139.1	108.7	51.5
TOKACHI	(TOK)	ERS-M	320.3	386.1	297.0
URAKAWA	(URA)	SMAC	129.0	172.2	49.2
HAKODATE	(HAK)	ERS-M	46.3	50.9	33.9
AOMORI	(AOM)	SMAC	41.3	35.6	15.6
HACHINOHE	(HAC)	SMAC	72.5	93.8	28.8
MIYAKO	(MYK)	ERS-G	88.0	82.0	39.0
KAMAISHI	(KAM)	ERS-M	26.5	25.6	22.3
OFUNATO	(OFU)	ERS-M	50.6	49.8	24.5
SAKATA	(SAK)	SMAC	7.5		4.4
SHIOGAMA	(SOG)	SMAC	23.1		17.5
SENDAI	(SEN)	ERS-M	24.7	17.2	8.2
SOMA	(SOM)	SMAC	17.5	18.8	5.6
HITACHI	(HIT)	ERS-F	21.0	18.0	8.0
KASHIMA	(KSM)	SMAC	9.4	6.9	3.1

SMAC and ERS-M : analog recording
ERS-F and ERS-G : digital recording

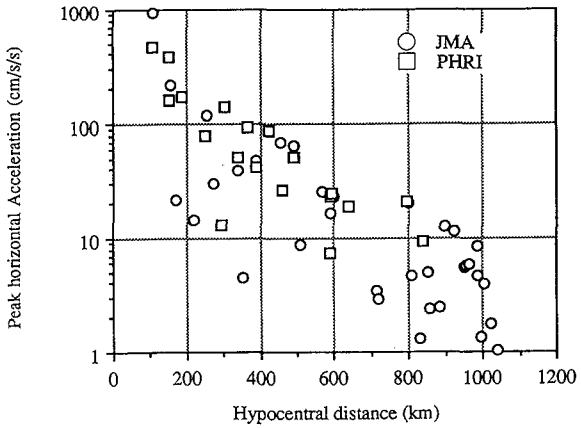


Fig. 3 Hypocentral distance vs. peak horizontal acceleration relationship

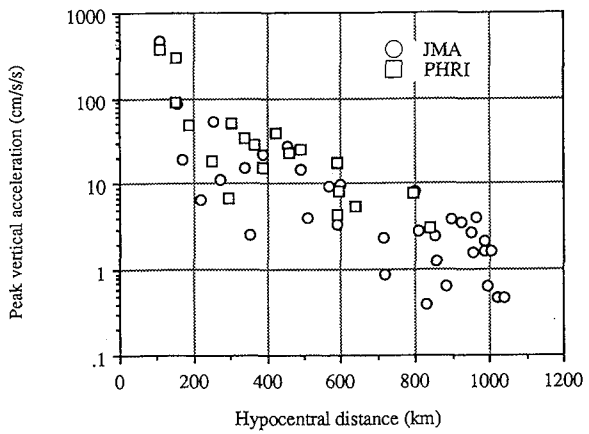


Fig. 4 Hypocentral distance vs. peak vertical acceleration relationship

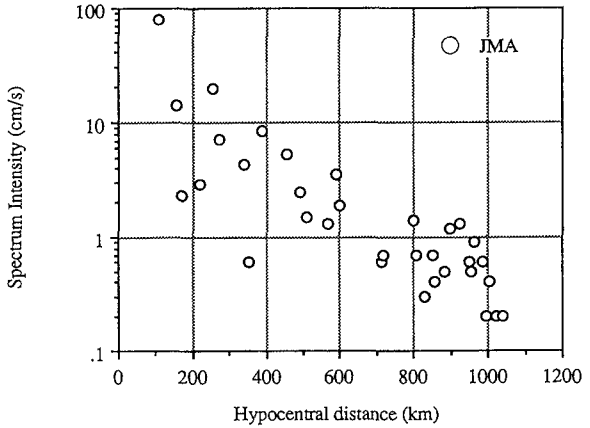


Fig. 5 Hypocentral distance vs. SI value relationship

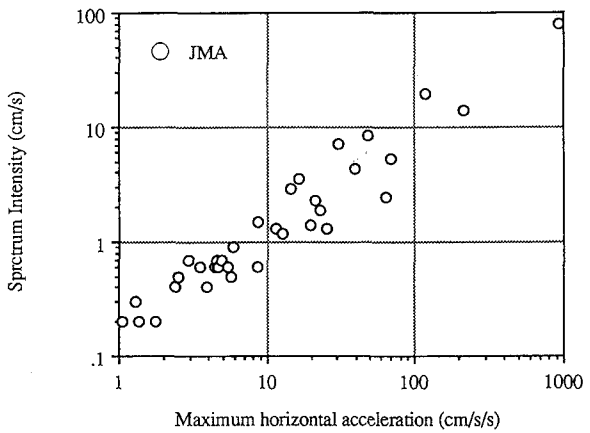


Fig. 6 Peak horizontal acceleration vs. SI value relationship

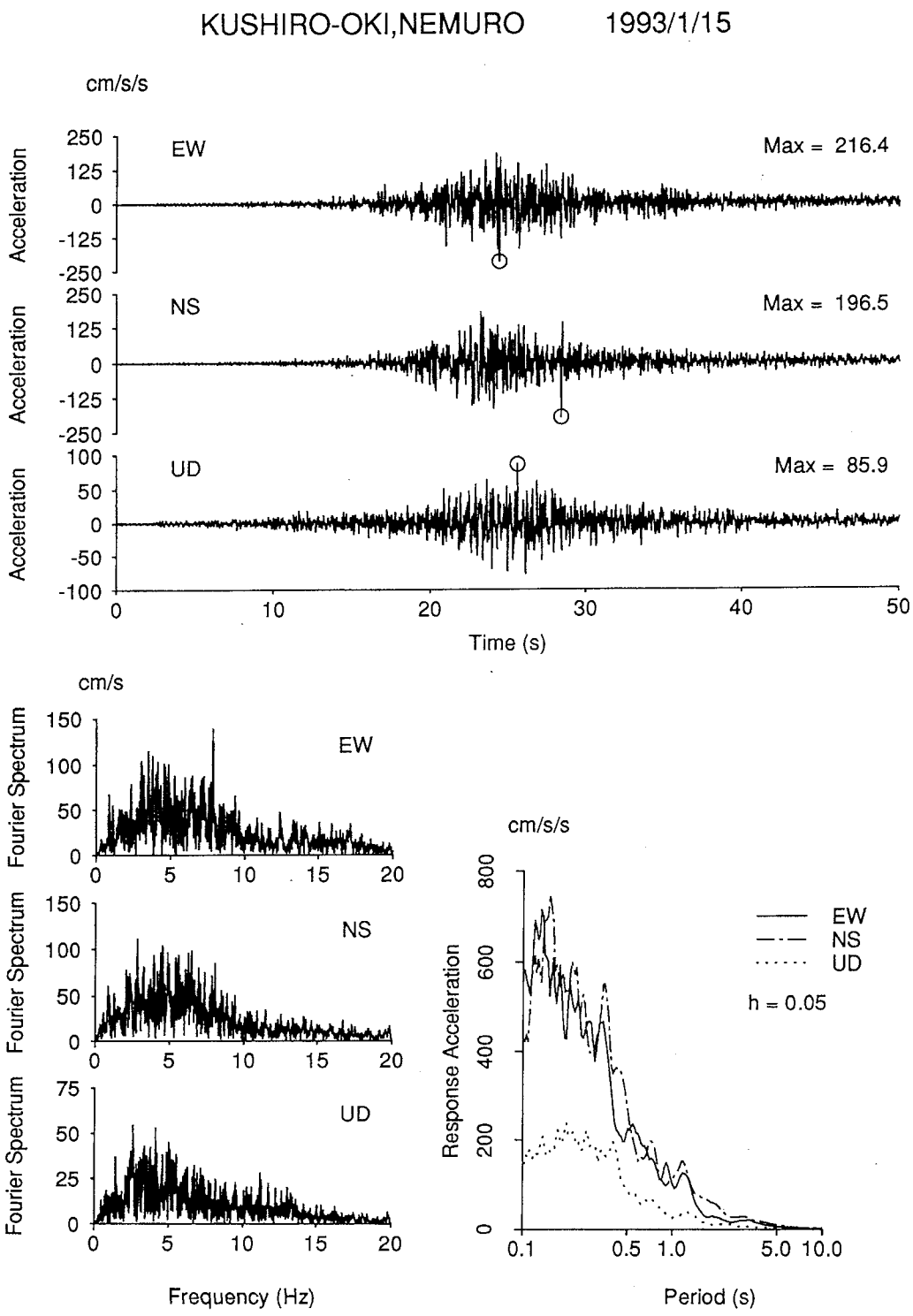


Fig. 7 Time histories, Fourier spectra and response spectra of accelerograms recorded at JMA Nemuro station

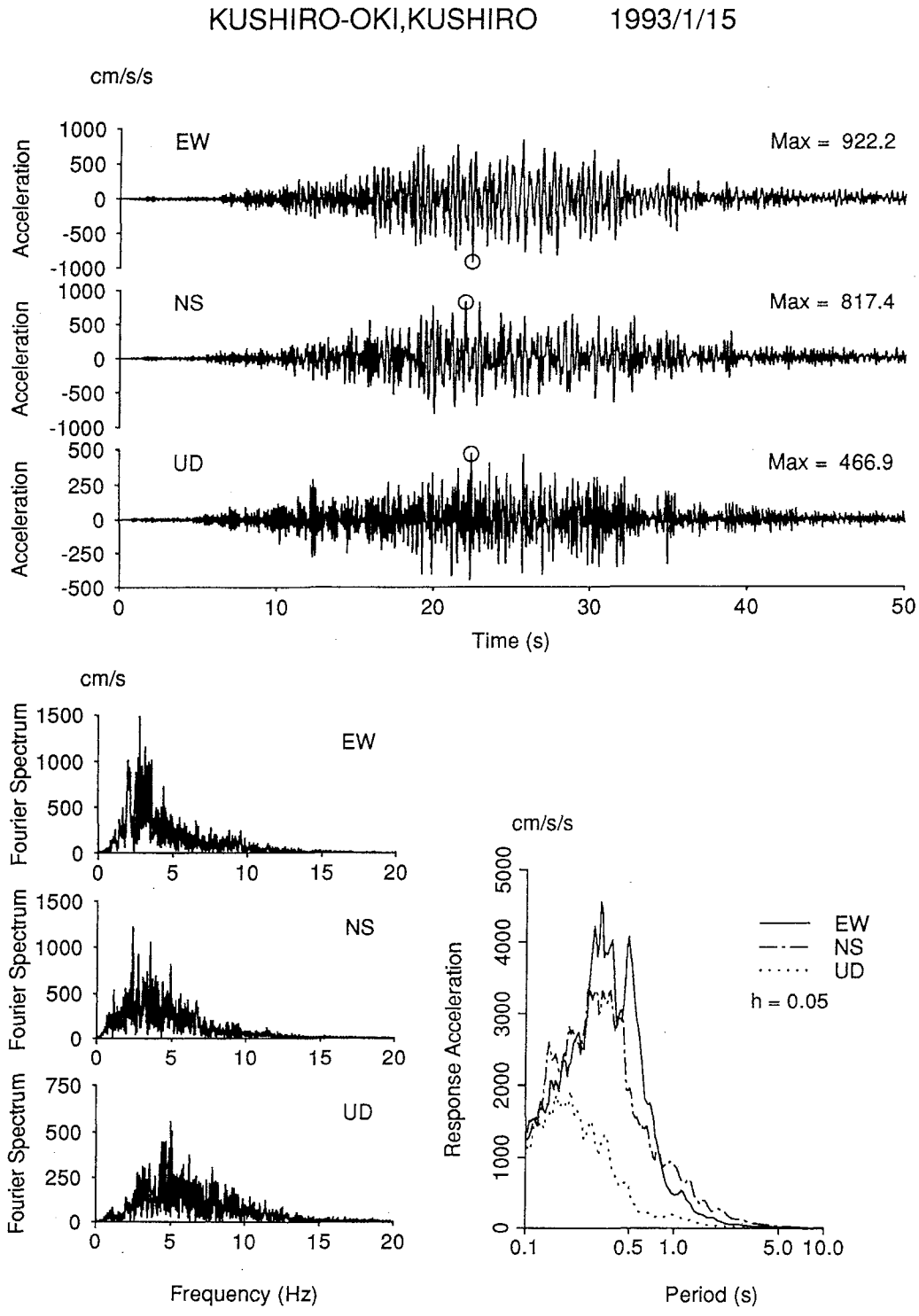


Fig. 8 Time histories, Fourier spectra and response spectra of accelerograms recorded at JMA Kushiro station

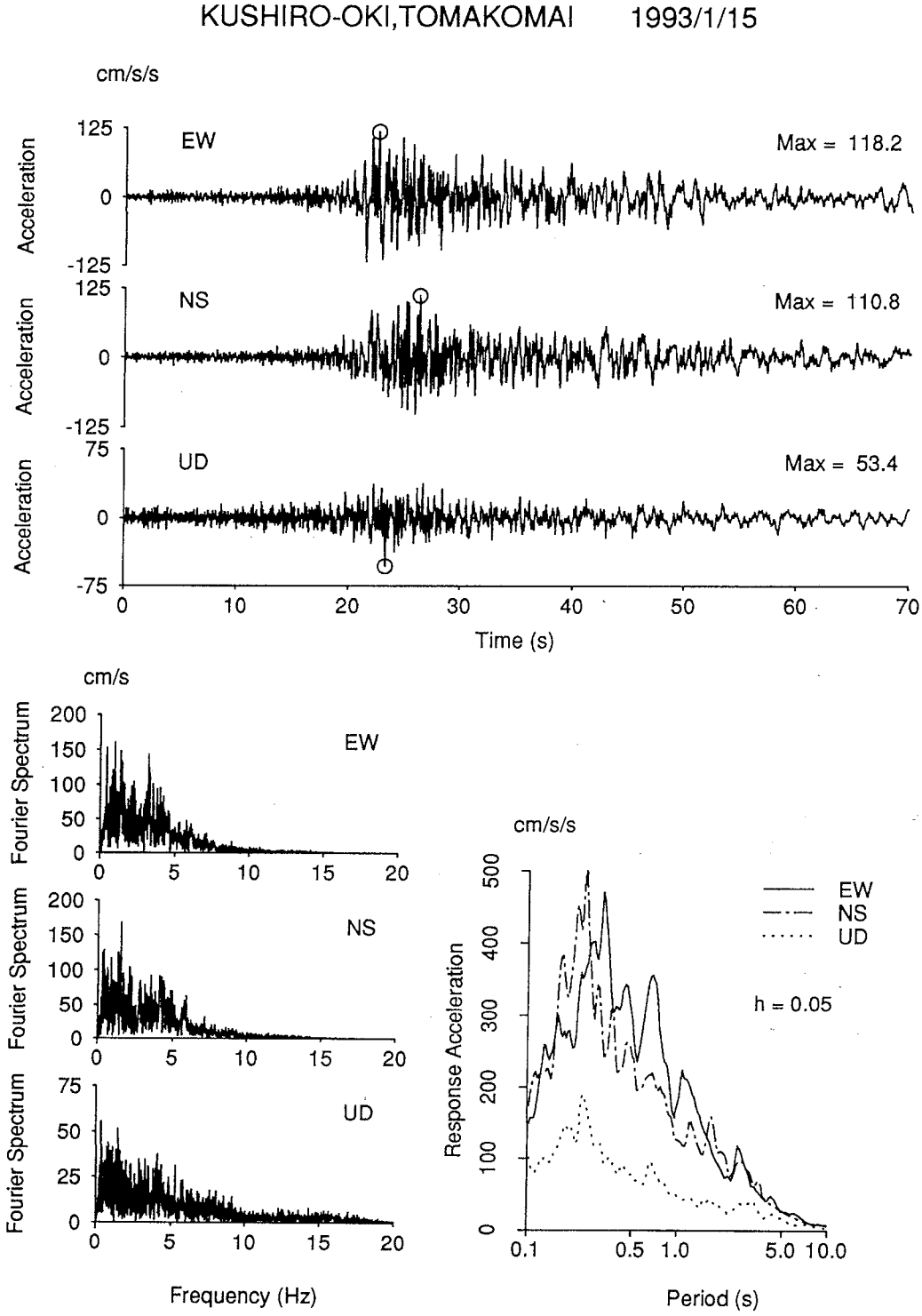


Fig. 9 Time histories, Fourier spectra and response spectra of accelerograms recorded at JMA Tomakomai station

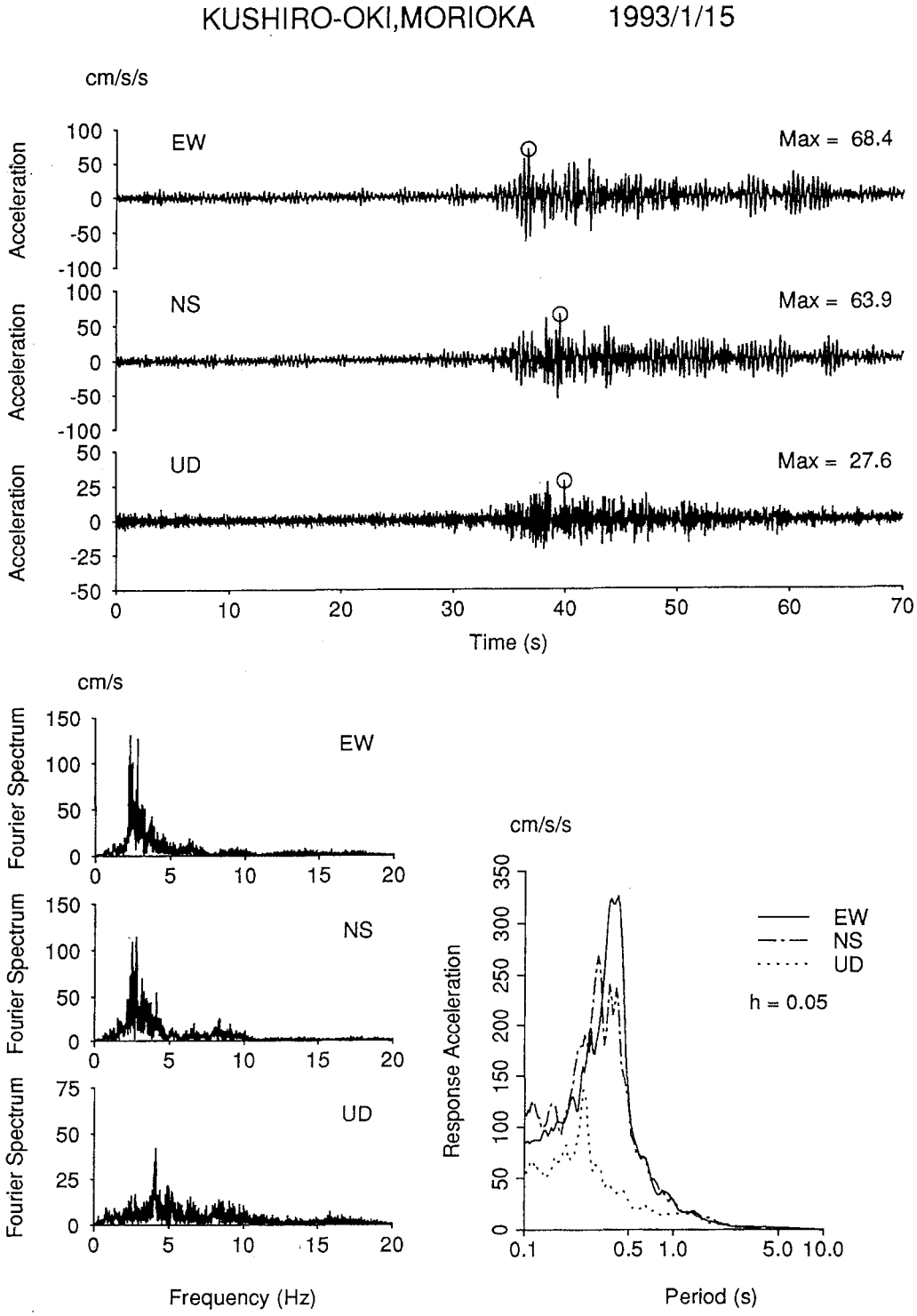


Fig. 10 Time histories, Fourier spectra and response spectra of accelerograms recorded at JMA Morioka station

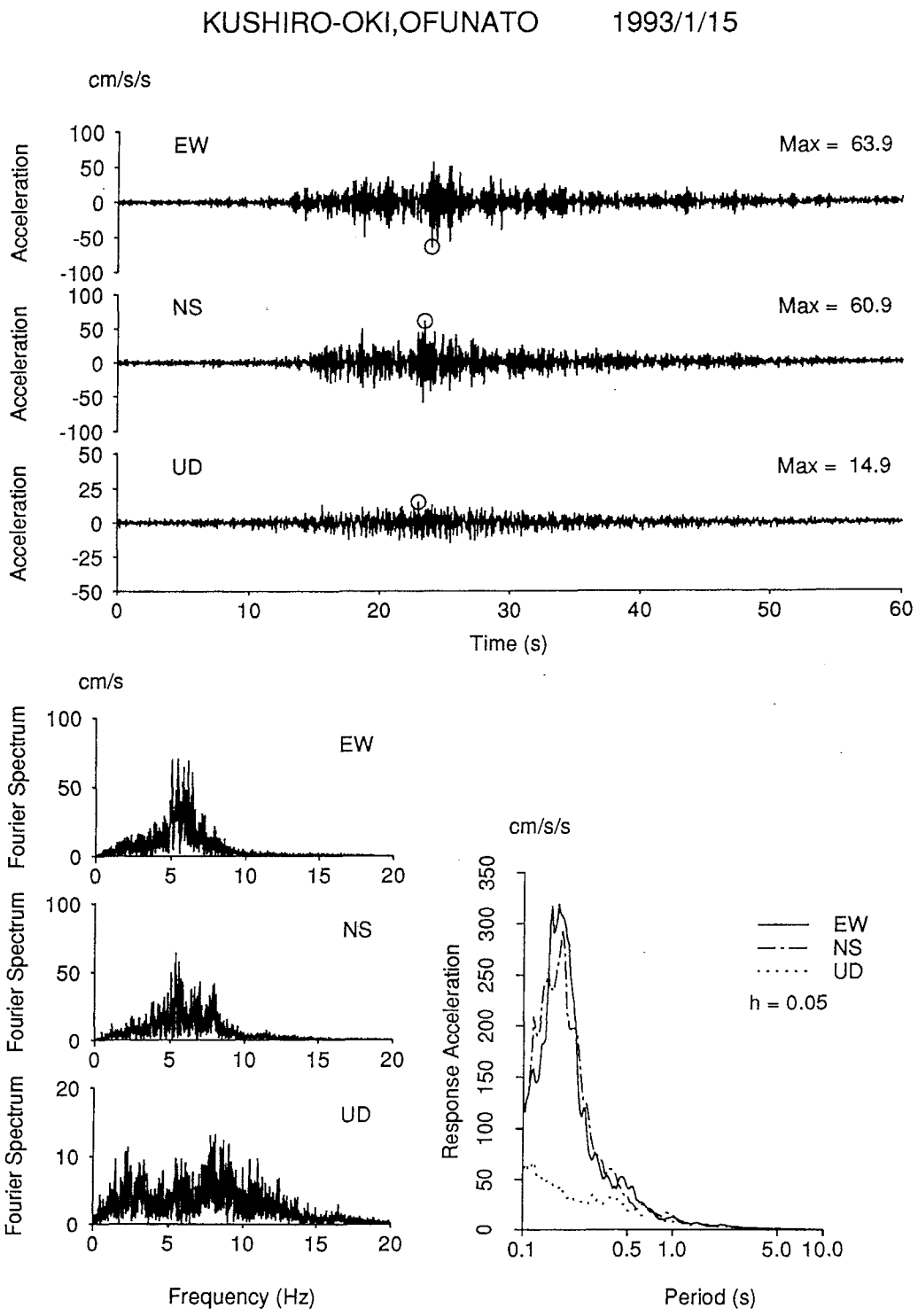


Fig. 11 Time histories, Fourier spectra and response spectra of accelerograms recorded at JMA Ofunato station