Observation of Co-seismic Electromagnetic Phenomena in VHF Associated with the Geiyo Earthquake in 2001

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ABSTRACT

We have detected VHF electromagnetic (EM) waves associated with the Geiyo EQ (M_J=6.4, d=51km) on March 24, 2001at Hiroshima City University 45km from the epicenter. We describe the detected two kinds of new phenomena associated with the earthquake. The one phenomenon is that the detected EM waves sharply rose up a peak level corresponding to the earthquake and slowly declined to a normal level about three hours later. The other phenomenon is that the EM waves had been fluctuated about one day before the earthquake, then, the fluctuations had disappeared right after the earthquake.

1. INTRODUCTION

Observations in electromagnetic fields associated with have been broadly carried out using from a direct current (DC) to ULF, ELF, VLF and LF band waves[1],[2]. Co-seismic geo-electrical potential changes have been reported [3]. Pre-seismic electromagnetic (EM) signals associated with EQs have also been reported in low frequency band [4],[5]. Unusual pulsed radio emissions at 22.2MHz were detected both before and after the Hyogo-ken-nanbu EQ (M_J=7.2, d=10km) in 1995 [6]. We have also been trying to detect EM waves associated with earthquakes in a very high frequency (VHF) band, 76MHz to 90 MHz.

We have developed the dual frequency observation method with synthesized FM tuners. Our observation method can identify whether a received signal is a broadband EM wave or an FM broadcasting wave. We had the Geiyo EQ (M_J=6.4, d=51km) in 2001. Our observation system detected broadband EM waves associated with the Geiyo EQ at Hiroshima City University (HCU) 45km far away from the epicenter.

In this paper, we describe the observation method and two kinds of new phenomena associated with the Geiyo EQ.

The one phenomenon is that the detected broadband EM waves sharply rose up a peak level corresponding to seismic swing arrival at HCU and slowly declined to a normal level about three hours later. The other phenomenon is that the detected EM wave fluctuations had been continued about one day before the Geiyo EQ, then, the fluctuations had just disappeared at the occurrence of the earthquake.

2. OBSERVATION METHOD

We are surrounded with a lot of EM waves such as broadcasting, communication usage and a lot of artificial, manmade noises, which may be higher intensity than that of seismic EM waves. So, we choose the FM broadcasting frequency band (from 76MHz to 90MHz) as our observation band in VHF. Because this frequency band is assigned for FM broadcasting exclusive use in Japan, so it is well administered against other EM interferences. Therefore, we can set up observation frequencies in the FM broadcasting frequency band, which is hardly influenced by artificial and urban EM noises compared with other lower frequency bands [7].

In the observation using the FM broadcasting frequency band, we have to realize an accurate observation method to identify seismic EM waves from FM broadcasting waves. So, we have developed the dual frequency observation method as shown in Fig.1 [8]. In our method, we select two different frequencies (fn and fr) for the observation channels, which have following characteristics;

fn: this frequency channel is selected from 80.8MHz to 81.2MHz, not assigned for any FM broadcasting use in Japan.

fr: this frequency channel is selected from 76MHz to 90MHz except from 80.8MHz to 81.2MHz. This frequency channel is used at a remote station far from the observation site, so the FM wave of fr channel is not usually received at the observation site.

Case 1: fluctuation only fr frequency; in this case, a received signal is considered as a reached FM broadcasting wave from a remote station.

Case 2: fluctuation both fn and fr frequencies; in this case, a received signal is considered as a broadband EM wave.

Then, we can identify whether a received signal is a broadband EM wave or an FM broadcasting wave by our observation method. The synthesize FM tuners has a receiving bandwidth of 100kHz/3dB and a noise figure of 2dB. Then, the limitation level of EM wave received by the FM tuner is about –120dBm. We have constructed the observation system based on the dual frequency observation method. In our EM waves observatory, four FM antennas are installed toward east, west, south and north, respectively. Each of antenna is connected with two synthesize FM tuners to receive the EM levels of fn and fr channels respectively. The half value of the antenna directivity is about 70 degrees. The observation data have been sampled each 10 seconds for all observation periods.

3. CO-SEISMIC ELECTROMAGNETIC WAVES APPEARED WITH THE EARTHQUAKE

The Geiyo earthquake of Magnitude 6.4 was occurred at 15h27m54s (JST) on March 24, 2001 near Hiroshima. The epicenter location is latitude 34.1 ° N and longitude 132.7 ° E and at a depth of 51km. It widely affected the seismic swings in the western Japan. Fig. 2 depicts a map of the EM waves observatory, the seismic swing observatory and the epicenter of the Geiyo EQ. Hiroshima City University (HCU), latitude 34.43 ° N and longitude 132.42 ° E, is about 45 km far away from the epicenter and the seismic swing K-net Hiroshima observatory, latitude 34.37 ° N and longitude 132.45 ° E is about 38 km from the epicenter. Fig. 3 shows the time variations of detected EM waves at HCU observatory. A sharp rise is followed by a slower decline in each direction. Both of the levels of fn and fr frequency channels were similarly fluctuated. Therefore, It is considered that the detected EM waves are broadband spectra. The maximum peak level of -98dBm was observed in the west direction. The detected levels slowly decreased and returned to the normal level about three hours later as well as the Tottori-ken-seibu EQ [8]. The peak levels of four directions are illustrated in Fig. 4. This figure suggests that the detected EM waves appeared with the earthquake are not from the epicenter.

Fig. 5 shows the detail time variations of detected EM waves and seismic swings from 15:26:00 to 15:31:00, JST on March 24, 2001. The seismic variations were detected at Hiroshima K-net observatory and the EM waves were detected at Hiroshima city university observatory. The seismic swings arrived at Hiroshima K-net observatory at 15h28m06s. In EM wave variations, the solid line shows received levels of 80.9MHz (fn) and the doted line shows received levels of 84.6MHz (fr) in the west direction. The EM waves rose up at 15h28m10s and the maximum level of -98dBm was recorded at 15h28m20s. After the seismic swing, the EM waves had still kept higher levels of around -100dBm and had slowly declined to normal levels as shown in Fig. 3. The peak levels of EM waves were detected at 15:28:20 after the occurrence time of the Geiyo EQ, 15:27:54. This result suggests that the detected EM wave rose up the peak level corresponding to the seismic swing arrival at HCU.

From these observation results, we hypothesize that the detected electromagnetic radiation may be produced by discharge of electrons generated by piezoelectric effect [9] due to the seismic swings on the surface around the observatory.

4. CO-SEISMIC ELECTROMAGNETIC WAVES DISAPPEARED WITH THE EARTHQUAKE

The most interesting EM phenomena associated with earthquakes are pre-seismic phenomena, which are expected as candidates for short-term earthquake prediction. So, a lot of scientific observations have been continued to detect these seismic phenomena. Some co-seismic disappeared EM waves have been reported in lower frequency bands [4]. In our VHF observation system, a co-seismic EM waves disappeared with the Geiyo EQ was detected at Hiroshima City University observatory as shown in Fig.6. This figure shows the time variation of fn channel (80.9MHz) in the east direction at HCU from March 22 to March 24, 2001 (JST). A small amplitude fluctuation of about 2 dB had been continued from about one day before the Geiyo EQ. Then, the fluctuation just disappeared at the occurrence of the Geiyo earthquake.

Fig. 7 shows the more detail time variations of differential levels of 80.9MHz (fn) detected from east, west, south and north directions during 6 hours including the occurrence time of the Geiyo EQ. The amplitude of the fluctuation in east direction is about 2 dB from peak to peak. Before the EQ, the higher fluctuations are detected from east and south directions. These fluctuations are reduced to less than 1dB right after the Geiyo EQ. This phenomenon is possibly associated with the earthquake, because the phenomenon is disappeared with the Geiyo EQ. Fig. 8 shows the scatter diagram of differential received levels in east, west, south and north directions. This figure shows the two dimension map of the differential levels of 80.9MHz during 3 hours before the occurrence time of the Geiyo EQ. The horizontal scale indicates the differential level (dB) between absolute values of east and west directions shown in Fig. 7. The vertical scale indicates the differential level (dB) between absolute values of north and south directions shown in Fig. 7. This scatter diagram suggests that these fluctuations were mainly detected from east and south directions.

From these observation results, we hypothesize that the detected electromagnetic fluctuations may be radiated on the surface by discharge of electrons that are produced by piezoelectric effect due to the fracture process [9] at the seismic center, then are supplied to the surface.

5. CONCLUSIONS

We have observed electromagnetic waves in VHF band using the dual frequency observation method with a synthesized FM tuner. In this paper, we describe the observation method and two kinds of new phenomena associated with the Geiyo EQ. Our observation results are summarized as follows:

(1) A co-seismic appeared EM phenomenon has been detected in VHF band. A sharp rise is followed by a slower decline in each direction. Both of the EM levels of fn and fr frequency channels were similarly fluctuated. Therefore, It is considered that the detected EM waves are broadband spectra. The maximum peak level of -98dBm was observed in the west direction not from the epicenter. The peak levels of EM waves were detected at 15:28:20 after the occurrence time of the Geiyo EQ, 15:27:54. The detected EM waves rose up the peak level corresponding to the seismic swing arrival at HCU observatory.

(2) From these observation results, we hypothesize that the detected electromagnetic radiation may be produced by discharge of electrons generated by piezoelectric effect due to the seismic swings on the surface around the observatory.

(3) A co-seismic disappeared EM phenomenon has been detected in VHF band. Amplitude fluctuations of EM levels were detected about one day before the Geiyo EQ. Then, the fluctuations just disappeared at the occurrence of the earthquake. The scatter diagram of differential levels suggests that these fluctuations were mainly detected from east and south directions, toward the epicenter direction.

(4) From these observation results, we hypothesize that the detected electromagnetic fluctuations may be radiated on the surface by discharge of electrons that are produced by piezoelectric effect due to the fracture process at the seismic center, and are supplied to the surface.

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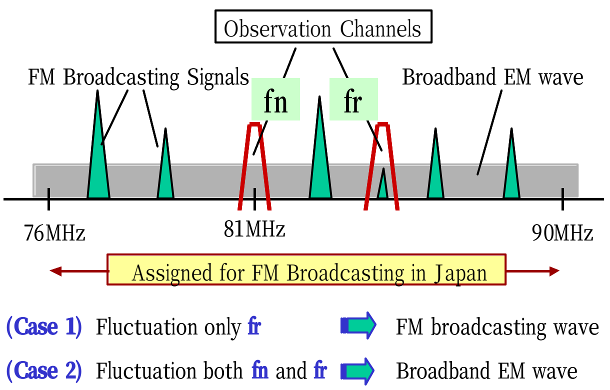

Fig. 1. Dual Frequency Observation Method in VHF band

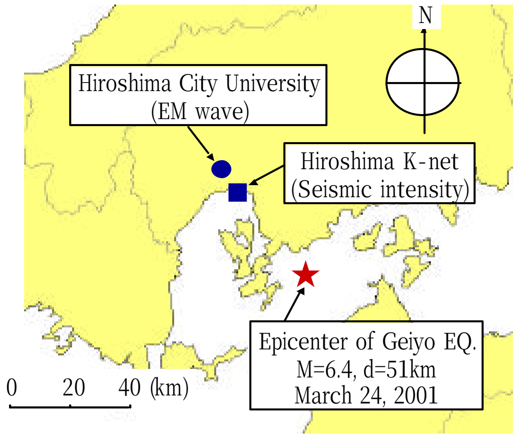

Fig. 2. Epicenter and Observatories at the Geiyo EQ.

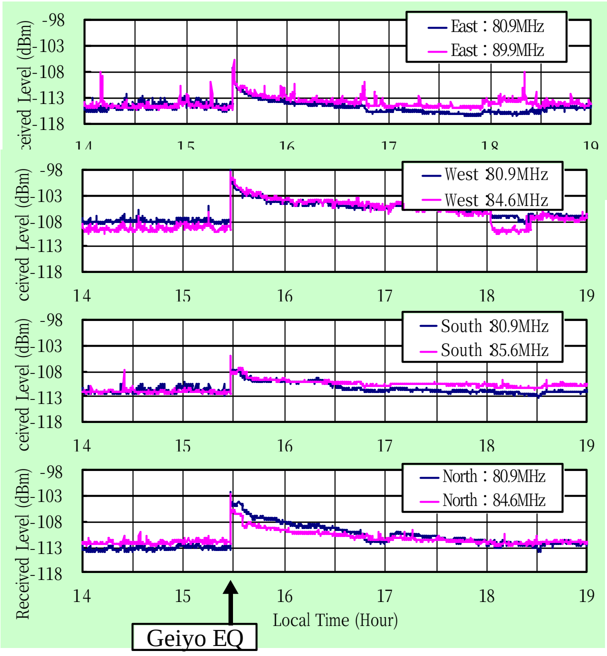

Fig. 3. Detected EM Waves at HCU on March 24, 2001

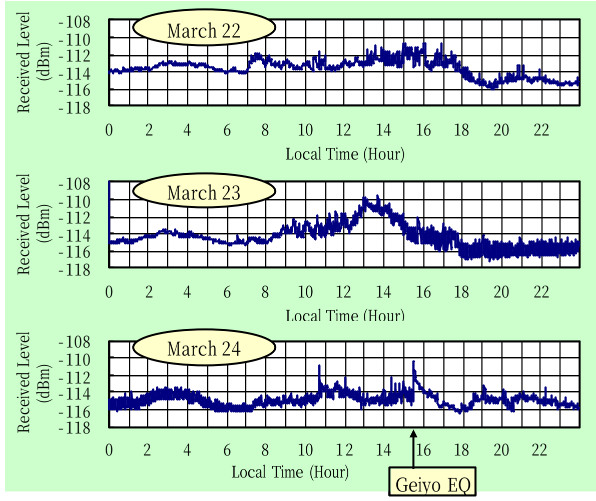

Fig. 6. Detected EM Waves at HCU from March 22 to 24

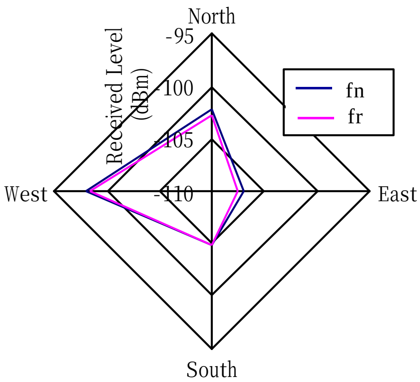

Fig. 4. Peak Levels for Detected EM Waves at HCU on March 24, 2001

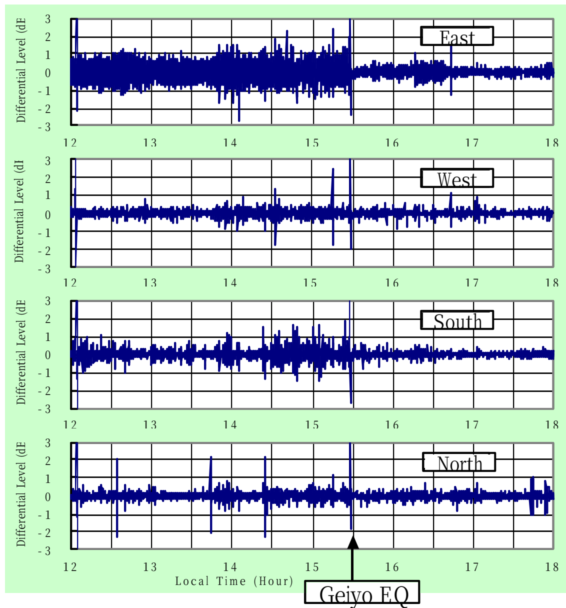

Fig. 7. Differential EM Levels Detected at HCU on March 24

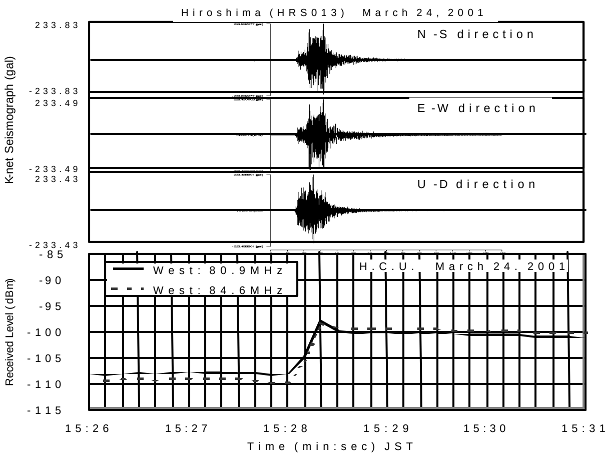

Fig. 5. Time Variations of Seismic Swings and Detected EM Waves at the Geiyo EQ.

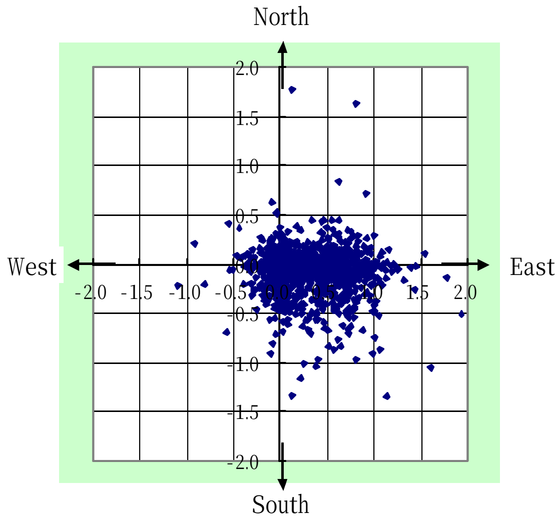

Fig. 8. Differential EM Levels for Four Directions