Detection of Earth-origin EM pulses

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Inserting a linear dipole sensor into a non-conductive bore-hole of 10 cm in diameter and 100 m in depth constructed in the campus of Kyoto Sangyo University, we have been observing EM noises in the earth [1]. The same type sensor was also installed above the ground in order to monitor the difference between noise behaviors detected above and under the ground. This system has made it possible to show various wave behaviors through frequency dynamic spectra displayed on the CRT of personal computer. By this system, we detected various noises. Electric noises generated by lightning and by air turbulent-irregularities of DC electric field normally formed near the ground surface are typical noise source often observed above the ground. On the other hand, in the earth, electric pulses caused by lightning near the observation site are sometimes dominantly detected noises as their penetrated components into the earth.

Under such the condition, we detected many strong EM pulse swarms above and under the ground since June 2000 and decaying in mid-September 2000. The both dynamic spectra on the CRT showed similar spectral forms although their intensities ware different from even to event. From the analysis of a representative dynamic spectra, we found that intensity of the pulses above the ground is about 14 dB weaker than those in the earth. The weaker intensity of the pulses detected above the ground is a conclusive evidence of leakage of the earth-origin electric pulses from the ground.

As another finding, both spectra exhibit clear lower frequency cutoffs (around 200 –300 Hz in the spectra of pulses under the ground). The appearance of the lower frequency cutoffs suggests the existence of a kind of wave-guide in the earth. In general, the wavelength of an EM wave with a cutoff frequency becomes equal to double the spacing between two conductive boundaries. From the observed cutoff frequencies 200 – 300 Hz, we have estimated the depth of the bottom conductive layer as a wave-guide boundary in the earth. Since the dielectric coefficient is a basic parameter of the medium and determines the wavelength of EM waves propagating there, the wavelength in the earth becomes 500 – 333 km for the observed cutoff frequencies when we use an averaged value 9 as the specific dielectric coefficient in the earth. Since double the spacing between two electrical conductive boundaries of wave-guide determines the maximal wavelength, the scale depth of the wave-guide in the earth was determined to be 250 – 176 km. This depth range is consistent with a highly electrical conductive layer formed in the deep earth, which was derived from the analysis of geomagnetic field data conducted by Rikitake [2]. These results are reported in GRL [3].

During this period from June to mid-September 2000, there was no large and noticeable earthquake, and the detections of the electric pulse swarms have no one-to-one relation with occurrences of normal earthquakes. However, it was released from the Geographical Survey Institute, Ministry of Land, Infrastructure and Transport, that the plate of the west Japan from Hokuriku district had moved about 1 cm toward east during the period from July to October. This fact is very important for the observational study shown here, because the present system is very sensitive for the movements of the earth crust.

[1] M. Tsutsui, A New System for Measuring EM Field in the Earth, XXVIth URSI General Assembly, EP.1, Toronto, Canada, 1999.

[2] T. Rikitake, Grobal electrical conductivity of the earth, Phys. Earth Planet Inter., Vol. 7, 245-250, 1973.

[3] M. Tsutsui, Detection of earth-origin electric pulses, in press, GRL, 2002.