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# A Possible Ionospheric Disturbance and its Spatial Scale in Association with 2004 Niigata Prefecture Earthquake, as Revealed from the Japanese VLF Network

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It has been recently becoming a general consensus that electromagnetic phenomena take place in possible association with an earthquake. Seimo-effect appears not only in the lithosphere, but also in the atmosphere and ionosphere. Recently, subionospheric VLF/LF propagation is widely used to study the ionospheric perturbations associated with earthquakes. Here we report on the possible detection of ionospheric perturbation in possible association with the 2004 Mid Niigata Prefecture Chuetsu earthquake (23 October 2004), whose magnitude is strong enough (M=6.2) and whose depth is small (10km). We anticipate that this large and shallow earthquake would induce some ionospheric perturbation. The seismo-ionospheric perturbation has been studied by means of the data from our VLF network. Our VLF network consists of seven receiving stations, and at each station we receive several subionospheric VLF/LF transmitters (including NWC, NLK, NPM, Japanese JJY and JJI). In this study, we have used 6 propagation paths from our VLF/LF network system ; from the transmitter JJI (Miyazaki, frequency=22.2kHz) in Japan to the receivers Moshiri (MSR), Chofu (CHO), Chiba (CBA), Kochi (KOC) and from the JJY (Fukushima, frequency=40kHz) to MSR and KOC. There have been proposed two methods for VLF analysis ; (1) terminator time method and (2) nighttime fluctuation method, but here we use the terminator time method. The following findings have emerged from the present study. (1) We have found significant terminator time shifts (terminator evening and morning) about one week before the earthquake only for the followinf four paths (JJI-CHO, JJI-CBA, JJY-MSR, and JJY-KOC). These propagation paths are found to be very close to the epicenter (as compared to two other paths). (2)Based on the comparison of terminator times fromm our VLF network, the spatial scale of the ionospheric perturbation found for this earthquake is of the order of 200-300 km (radius).