

The influence of lightning on the observation of seismic electromagnetic anomalies in VLF and LF ranges

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The electromagnetic anomalies forerunning earthquakes have been reported and the possibility to apply them to earthquake forecast has been studied. However, quantitative and detailed analysis of the electromagnetic anomalies generated by other natural phenomena and artificial origins has not been attempted yet. In this study, we describe a statistical analysis of the influence of lightning, which is considered as the natural phenomena generating the electromagnetic waves most often. Moreover, based on this result, we review the electromagnetic anomalies forerunning to the earthquakes that were suggested in previous studies.

In Kyoto University, we have observed the number of the LF and VLF electromagnetic noises and have reported many seismic electromagnetic anomalies for 20 years. Since 1997, we installed several observation stations in Tokai region and observed the electromagnetic anomalies in the LF and VLF ranges as a member of the International Frontier Research Group on Earthquake supervised by RIKEN. The lightning data are compared with the observed electromagnetic anomalies.

For the analysis of the statistical relationship between the observed electromagnetic anomalies and the lightning data, we use the number of the electromagnetic pulse noises observed in Tokai observation network and the lightning data provided by the Japan Lightning Detection Network of Franklin Japan. The correlation between both data is shown to be significant and the distance limit of the lightning detection is calculated. It is about 250 km in the LF range and about 420 km in the VLF range. These values are calculated for the average value of the lightning current (37 kA). The distance limit may become larger than the above value in the case of larger lightning. Therefore, the electromagnetic anomalies before earthquakes which have been reported for 20 years should be reexamined by comparing them with the lightning data.

It was reported that the increase in the number of the electromagnetic noises was observed just before the 1995 Hyogo-ken Nanbu earthquake which occurred on January 17, 1995. The possibility that the observed electromagnetic anomalies were the precursors of the earthquake was examined. We analyzed the continuous VLF electromagnetic waveforms recorded from 50 minutes before the earthquake. We classified waveforms and compared them with the lightning data provided by the lightning location positioning systems of electric power companies and we searched for the origin of each waveform. Most of the waveforms are explained by the electromagnetic waves generated by lightning. The increase in the number of the electromagnetic noises observed just before the earthquake is also explained by lightning activities in Shimane Prefecture, off Kochi Prefecture and other places. The electromagnetic anomalies before other earthquakes reported in previous studies were examined with lightning activities described in the Geographical Review. The passage of a low atmospheric pressure and lightning activities were reported within a distant of about 250 km from the observation station when the increase in the number of electromagnetic noises was observed. All of the observed electromagnetic anomalies may be considered as the influence of lightning activities.

The increases in the number of the electromagnetic noises in the LF and VLF ranges which were expected as the precursors of earthquakes were caused by lightning activities in almost all cases. Even if the electromagnetic waves accompany an earthquake, they would be much weaker than the influence of lightning activities and thus are difficult to be identified. Moreover, in the observation of the number of the electromagnetic pulse noises at Uji observation station, the success rate is very low and the hit rate is not significant. The application of the observed electromagnetic anomalies to the earthquake forecast cannot be considered as promising at least in the LF and VLF ranges.