Pre-earthquake early-warning signals of ULF geoelectric data and their earthquake forecasting probability: A case of Kakioka, Japan

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As laboratory rock experiments and field data analyses show, electromagnetic phenomena are believed to be candidates for the short-term prediction of large earthquakes. Moreover, among previous studies for the field data analyses, ULF electromagnetic signals are one of the most promising precursor methods due to deep skin depth observation. However, the previous studies were carried on through case-study analyses or one-phase optimizations (i.e., a training phase). Before the earthquake forecasting, the first intermediate step is to test relationships between the prescribed anomalies and an earthquake catalog. This is what machine learning scientists refer to as "the training phase". Once detecting anomalies of any earth science data, we have to define a specific algorithm relying on a limited set of unambiguous parameters, which associates those anomalies within a target space-time-magnitude window relative to an impending earthquake. This is the only way to quantify the skill of the tested model and its sensitivity to input parameters. After the training phase, true forecasts can be proposed, which consist in selecting the optimal model parameters and applying them to an independent dataset (i.e., a testing phase). In this study, we verify the relationship between electromagnetic anomalies and earthquakes through the two-phase optimization (i.e., a training phase and a testing phase). First, we analyze ULF geoelectric data at Kakioka, Japan each day and calculate three statistical moments (i.e., variance, skewness, and kurtosis) based on the early-warning signal theory (Scheffer, 2009). Second, we estimate the thresholds for variance, skewness, and kurtosis for the N- and E-components of the geoelectric data and define the anomalies for the three statistical moments of both components. Third, we set up a predictive model and optimize this model within a training phase. Fourth, we select the optimal model parameters and test those parameters within a forecasting phase following the training phase. Results show that the model performance for the forecasting phase has significance, implying that the pre-earthquake electromagnetic anomalies are true earthquake precursors, although the mechanism remains unclear. The present study is therefore intended to make contributions to the establishment of correctly examining correlations between anomalies of earth science data and earthquake catalogs.

Keywords: ULF geoelectric data, statistical moment, earthquake forecast

