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Identification of electromagnetic pre-earthquake perturbations from the DEMETER data by AI technologies

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Many examples of ionospheric perturbations observed in large seismic events were recorded by the low-altitude satellite DEMETER. In this paper, we explore 16 spot-checking classification algorithms, among which, the top classifier with low-frequency power spectra of electric and magnetic fields were used for ionospheric perturbation analysis. Satellite data spanning over about 6 years has been analyzed and about 8,760 earthquakes with magnitudes larger than or equal to 5.0 that occurred all over the world during the analyzed period have been included in the study. We discover that among these methods, gradient boosting based method called LightGBM outperforms the other state-of-the-art methods and achieves AUC (the Area Under the Curve) of 0.9859 and accuracy of 95.01% in a five-fold cross-validation test on the benchmarking datasets. In addition, the LightGBM method shows a strong capability in discriminating electromagnetic pre-earthquake perturbations over different earthquake databases. The results show that electromagnetic pre-earthquake data with the location in its circular region with its center at the epicenter and a radius given by the Dobrovolsky's formula and the time of a few hours before the shocks is more useful in discriminating electromagnetic pre-earthquake perturbations. Moreover, we observe that during nights, some low-frequency intervals of electric and magnetic fields are the dominant features as rendered by the trained LightGBM model. These observations support the viewpoint that the seismic activities lead to the enhancement of lightning activity and low frequency electromagnetic pre-earthquake data can help us to detect seismic events.