Statistical analysis of pre-earthquake electromagnetic anomalies in the Ultra
Low Frequency (ULF) range

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Assessing the statistical significance of electromagnetic anomalies observed prior to earthquakes is a necessary step towards determining whether these perturbations constitute actual earthquake precursors. A Statistical Epoch Analysis (SEA) was recently performed by Han
et al. [2014] to analyze earthquakes happening between 2001 and 2010 near the geomagnetic observatory of Kakioka, Japan; the authors found a statistically significant number of anomalies 6 to 15 days prior to the earthquake day in the region within 100km from the observatory, while no significant pre-earthquake activity was observed for the farther region located between 100km and 216km from the observatory. In the present work, we describe the application of our independent software implementation of their method. Despite using a different outlier rejection scheme, we manage to reproduce the results of Han et al. [2014] for the 2001-2010 interval.

We use our program to run multiple sensitivity studies. The original SEA was applied to a population of events comprising both crustal and mantle earthquakes, assumed to have different triggering mechanisms. We first restrict the analysis to only mantle earthquakes and find that the increased number of anomalies 6 to 15 days prior to the earthquake day is still observed for this subset of earthquakes.

Also, the study of Han et al. [2014] relied on an earthquake catalog maintained by the Japanese Meteorological Agency (JMA). In order to assess the robustness of their results, we use the International Seismological Center (ISC) catalog to independently establish a new list of qualifying “earthquake days”: we find that the anomalous pre-earthquake episode vanishes altogether when using this other catalog. We discuss the impact of source catalog on the results and suggest that future authors test their algorithms against multiple catalogs as a good practice.

Finally, we apply the SEA to a more recent interval, ranging from 2013 to 2018, and find that no significant pre-earthquake episode can be observed for this later time window. We highlight the influence of the March 11, 2011 Tohoku mega-earthquake on the number of qualifying earthquake days in the years following the earthquake and discuss how this may prevent direct comparison between the 2001-2010 interval and the following decade.

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