

## Spatiotemporal characteristics of the geomagnetic diurnal variation anomalies prior to the 2011 Tohoku earthquake (Mw9.0)

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Xu et al., 2013 and Han et al., 2015 have reported unusual behaviors of geomagnetic diurnal variation (GDV) in the vertical component prior to the 2011 off the Pacific coast of Tohoku earthquake (Mw 9.0). To make a better understanding of this phenomenon, temporal-spatial analyses of GDV have been applied in this study. Geomagnetic data of long-term observations at 17 stations in Japan have been analyzed using the same method in Han et al. 2015. Ratios of diurnal variation range between the reference station KAK and the target stations have been computed. After removing seasonal variations, the 15-day mean values of the ratios in the vertical component shows a clear anomaly exceeding the statistical threshold about 2 months before the mega event at both ESA and MIZ stations in the Tohoku Region. Locations of anomalies in spatial distribution show a good correlation with the epicenter of the Mw 9.0 earthquake. These spatiotemporal results are consistent with those obtained from other independent observations such as groundwater level and GPS displacements. The coupling of multiple pre-earthquake phenomena may help to understand the preparation process of a mega earthquake in the subduction zone.

Keywords: seismo-magnetic phenomena, anomalous geomagnetic diurnal variation, coupling of multiple pre-earthquake phenomena, the Tohoku earthquake