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Geoelectric Field at Kakioka, Kanoya, and Memambetsu

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Kakioka Magnetic Observatory, Japan Meteorological Agency (JMA) has continuously observed the geoelectric field at Kakioka, Kanoya, and Memambetsu for decades. I checked the JMA collection of the geoelectric field from a view point of applicability to studies on the geomagnetically induced current (GIC).

Two horizontal components (northward and eastward components) of the geoelectric field are obtained on the geographical coordinates at the three sites by measuring voltage differences between two pairs of electrodes. Details of the measurements such as locations and materials of the electrodes, baseline lengths, sampling intervals, and filtering responses of the systems differ time to time giving fluctuations on data quality.

I picked up a 11-year data segment ranging from Jan 1, 2000 to investigate the characteristics of the geoelectric field obtained by JMA.

It turned out that the geoelectric fields at three sites ware unstable on the long-term basis because the baseline lengths are as short as a few hundred meters and the instability of the electrodes are relatively noticeable. However, the electric field highly correlates with the geomagnetic field at periods from 100 sec to 1 day at any of three sites, suggesting the geoelectric field induced by a change of the geomagnetic field is successfully obtained at least on the short-term basis. Amplitudes of the geoelectric field are different among the sites. For instance, the eastward component of the field is about 10 times larger than the other at Kakioka, while the northward component is larger than the other at Memambetsu.

The MT response was computed at the three sites to evaluate the signal and infer effects of electrical conductivity structures. A robust procedure BIRRP (Chave and Thomson, 2004) was applied to 0.1 sec, 1 sec and 1min values of the geoelectric and geomagnetic fields at large-scale geomagnetic storms in 2003 and 2004 to estimate the MT response at periods shorter than 10000 sec. Since the 0.1 and 1 sec values of the geoelectric and geomagnetic fields are affected by system filters, shortest periods were not able to be included into the response estimation even after corrections of the filters were made. As for that at periods longer than 10000 sec, I verified a procedure to decompose a time series by Fujii and Kanda (2008) so that a noisy data set can be treated. Then, a trend with step-like anomalies and outliers were estimated from a 11-year segment of 1 hour values of the geoelectric field. Then, the MT response was estimated from the geoelectric field with the trend and outliers removed. In the end, the MT response was obtained at periods from several sec to 12 days. If this response is converted into the time domain by convolution, filter coefficients to estimate the geoelectric field from the geomagnetic field will be obtained.

Effects of local small-scale structures on the MT response were checked as a next step. The Zyx at Kakioka shows an unusually high value (~1000 ohm m) even at a period of 10days and the comparison with the C value by Fujii and Schultz (2002) suggests it is about 100 times amplified by the local small-scale structures.

Yanagihara and Yokouchi (1965) explained a biased distribution of the electric field at a short frequency range at Kakioka by heterogeneities of a near surface structure. If these affects even at very long periods, use of the geoelectric field at Kakioka for GIC or induction studies should be done with a certain caution.

The electric field at three sites basically reflects the induction as it is supposed to be, although the measurement system and procedure can be verified so that data of higher quality are obtained.

Keywords: geoelectiric field, induction, geomagnetically induced current, MT response