Preliminary results for the estimation of the tides in the geomagnetic field

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Magnetotelluric (MT) studies at periods from 10^4 to 10^5 seconds suffer the violation of 'the plane wave source assumption' because of the Sq variation (the ionospheric tide) and the oceanic tide. Those tides are often approximated as a group of sinusoidal waves and are removed from the geoelectric and geomagnetic field data by the least squares fitting so that a usual MT procedure can be applied to the residuals of the geoelectric and geomagnetic fields. However, the MT response functions tend to scatter at periods from 104 to 105 seconds after the sinusoidal tidal variation is removed. Shimizu et al. (2011) attribute that to remains of the Sq variation. In fact, the Sq is known to show day-to-day variations and long-term variations.

I attempt to estimate the tidal variation in the geomagnetic field at Kakioka by the use of the robust Kalman filter procedure developed by Fujii et al. (2015). The procedure can decompose time series data into a roughly periodic variation and a long-term trend. I test whether the roughly periodic term can accommodate the tidal variation.

The geomagnetic field data used in this study are a four-year segment of the hourly values from 2002 to 2005 observed at Kakioka. The period of the periodic term is 24 hours to contain the Sq and its harmonics as well as the oceanic tides if necessary.

The parameter to control the periodic term is the variance of the periodicity s^2. If s^2 gets larger, the periodicity is loosened. As three cases of $s^2=10^{-4}$, 10^{-2}, 10^0 are tested to the three vector components of the geomagnetic field, all cases fit the data better than the convectional sinusoidal model. The case of $s^2=10^0$ shows the best fit indicating that the tides are not strictly periodic or the period used is inadequate. However, the large s^2 cases contain rapid fluctuations and, as a result, they include variations of the magnetospheric origin, too. I choose the case of $s^2=10^{-4}$ as an optimum model of the tidal variation because it seems to include no magnetospheric variation.

The optimum model has some evident differences from the conventional sinusoidal model. For instance, the amplitude of the optimum model gets smaller with year, which is consistent with the solar activity. In addition, the optimum model shows less rapid fluctuations. These results imply that the day-to-day variation and long-term trend of the Sq is not fully represented by the conventional sinusoidal model and the residual of the geomagnetic field includes remains of the Sq variation.