

An internal/external separation of Sq geomagnetic daily variation on quiet days in January 2011 around Japan

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It is reported that preceding the 2011 off the Pacific coast of Tohoku earthquake (Mw 9.0), the geomagnetic daily variations on international quiet days in January 2011 around Japan were anomalous by internal/external separation of the geomagnetic field (Liu et al., 2019). The present study reassesses the result.

The 1-minute geomagnetic records at 21 geomagnetic observatories and stations in both the northern and southern hemispheres in the longitude range between 115 and 160 degrees are analyzed. The records on 240 days from the international 5 quiet days per month for 4 years from 2009 to 2012 are resampled to 30-minute records in the local time derived from the longitude. Using the natural orthogonal component (NOC) analysis, Sq components are identified for the north, east and downward components separately. Among the bases, it is found that the first basis represents the daily variations in summer, while the combination of the first and second bases can exhibit the Sq daily variation including its seasonal variation of the phase. In the present study, the combination up to the third basis is treated as the Sq daily variation.

For the internal/external separation, the slice method is adopted to the records in local time, and the equivalent current system is then estimated. In the spherical harmonic analysis, not only the point prediction but also the prediction interval are estimated. The truncation order and degree are chosen so that the mean prediction interval over all the components and the observation points is minimized, which can vary day to day.

The equivalent current systems for days in January and February 2011 do not show prominent difference between one another, especially the vortices below and above the Tohoku district in Japan in January 2011 as Liu et al. (2019) pointed out. The combination of synthetic daily variations with internal and external origins well explain the records considering the prediction interval with the significance level of 5%. Those variations do not show anomalous amplitudes as Liu et al. (2019) pointed out.

Three features of Liu et al. (2019) to consider the cause of the present result different from theirs can be pointed out. 1) Japan standard time is adopted to summarize the records at geomagnetic observatories and stations which distribute in the range of longitude of 45 degrees, instead of the local time depending on the longitude. 2) Only the first basis of the NOC analysis is adopted to represent the Sq daily variation. 3) In the spherical harmonic analysis, the truncation order and degree are so large that the standard error would be large due to the multicollinearity: degree and order up to 67 and 7, respectively.

Keywords: Sq daily variation, spherical harmonic analysis, natural orthogonal component analysis, the 2011 off the Pacific coast of Tohoku earthquake (Mw 9.0)