Long-term variation of ionospheric electric fields as seen in the amplitude of geomagnetic solar quiet daily variation

*Atsuki Shinbori[1], Yukinobu Koyama[2], Masahito Nose[3], Tomoaki Hori[4], Yuichi Otsuka[4]

1.Research Institute for Sustainable Humanosphere (RISH), Kyoto University, 2.Research Organization of Information and Systems (ROIS), 3.World Data Center for Geomagnetism, Kyoto University, 4.Institute for Space-Earth Environment Research (ISEE), Nagoya University

Geomagnetic solar quiet (Sq) daily variation is generated by the large-scale ionospheric currents flowing in the E-region of the ionosphere. The ionospheric currents produce positive and negative variations of the H-component of geomagnetic field around the noon in the equatorial and middle-latitude regions, respectively. According to Ohm's law, the dependent variables of the Sq amplitude consist of ionospheric conductivity, polarization electric field and dynamo field. Therefore, to investigate the long-term variation of the Sq amplitude is important for understanding the long-term variation in the ionosphere and upper atmosphere. Many researches of the long-term variation of the Sq amplitude on the basis of global observation and model have been made so far. However, characteristics of the long-term variation of global ionospheric Sq electric field remain unknown due to the shortage of long-term ionospheric conductivity analysis at many geomagnetic stations. In this study, we investigate the characteristics of long-term variation of global Sq ionospheric electric field using the geomagnetic field and ionospheric conductivity data from 1958 to 2015, and clarify the mechanism of long-term variation in the ionosphere and upper atmosphere. In the present analysis, we used geomagnetic Kp index and 1-hour geomagnetic field data archived in the database of WDC for Geomagnetism, Kyoto University. In order to investigate the solar activity dependence of the Sq ionospheric electric field, we referred to the monthly-mean solar F10.7 index. We also used two-dimensional ionospheric conductivities integrated in the height range of 85-140 km. We first selected geomagnetic field data corresponding to the solar quiet day when the Kp index is less than 4. Then, we identified the Sq variation as a deviation from the value at midnight in both the X and Y components of the selected geomagnetic field data. Finally, we obtained the Sq ionospheric electric fields by solving Ohm's equation with the monthly-mean height-integrated ionospheric conductivity and Sq variation of geomagnetic field. As a result, the long-term variation of the Sq variation and ionospheric conductivities at Guam and Memanbetsu around the noon showed a clear seasonal variation and 11-year solar activity dependence during 1958-2015. Both the Sq variation and ionospheric conductivities tended to increase during each high solar activity. The pattern of the seasonal variation of the Sq field was different from the different component of geomagnetic field, indicating that the X component becomes maximum in March equinox while the Y-component becomes maximum in September equinox. This feature could not be seen in the seasonal variation of ionospheric conductivities. The Sq ionospheric zonal and meridional electric fields also showed a clear seasonal variation and 11-year solar activity dependence. The zonal electric field was positively correlated with the F10.7 index at Guam near the equatorial region while it was negatively correlated at Menambetsu in the middle-latitude region. This result implies that the solar activity dependence of zonal electric field is different from different latitude. In order to check if this relationship can be seen at all geomagnetic stations, we analyzed the Sq zonal electric field at 83 geomagnetic stations. As a result, the global distribution of correlation coefficient between the F10.7 index and zonal electric field with no lag showed positive and negative values in the equatorial and middle-latitude regions, respectively, without depending on the geographical longitude. Therefore, it can be concluded that the solar activity dependence of the Sq zonal electric field around the noon is globally different

between the equatorial and middle-latitude regions. In future study, we investigate the solar activity dependence of the zonal electric field at all local times, and clarify a cause of the electric field depression during the high solar activity.

Keywords: Geomagnetic solar quiet daily variation, Solar activity, Ionospheric electric field, Seasonal variation, Upper atmosphere, Equatorial region

