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Upper atmospheric variation inferred from the long-term trend in the geomagnetic solar quiet daily variation

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It has been well-known that the amplitude of geomagnetic solar quiet (Sq) daily variation depends on the intensity of global ionospheric currents flowing in the E-region from middle latitudes to the magnetic equator. These currents are generated by dynamo process via interaction between the neutral wind and ionospheric plasma in a region of the thermosphere and ionosphere (85-125 km). The motion of the neutral particles is driven by heat convection due to solar irradiance and by tidal force of the sun and moon. According to the Ohm's equation, the ionospheric currents strongly are related to ionospheric conductivity, polarization electric field and neutral wind. Then, to investigate the Sq amplitude using the long-term observation data of geomagnetic field is essential for understanding the long-term variations in the ionospheric conductivity and neutral wind of the thermosphere and ionosphere. Recently, Elias et al. [2010] found that the Sq amplitude tends to increase by 5.4-9.9 % in the middle latitudes (Apia, Fredericksburg and Hermanus) in a period of 1961-2001. They mentioned that the long-term variation of ionospheric conductivity associated with geomagnetic secular variation mainly determines the Sq trend, but that the rest component is ionospheric conductivity enhancement associated with cooling effect in the thermosphere due to increasing greenhouse gas. In this talk, we try to clarify the characteristics of the long-term variation in the Sq amplitude using the long-term observation data of geomagnetic field and neutral wind. These observation data have been provided from the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which stated in facial 2009. In the present analysis, we used the F10.7 solar flux as a good indicator of the variation in the solar irradiance in the EUV and UV range, geomagnetic field data with time resolution of 1 hour observed at 184 geomagnetic stations. The definition of the Sq amplitude is the difference of the H-component between the maximum and minimum every day when the Kp index is less than 4. As a result, the Sq amplitude at all the geomagnetic stations shows a close correlation with the solar F10.7 index, and tends to be more enhanced during the high solar activities (19- and 22- solar cycles) than during the relatively low activity (20-solar cycle). This result implies that the Sq amplitude strongly depends on the solar activity. Therefore, in order to minimize the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 solar flux and Sq amplitude during 1950-2011, and examined the residual Sq field defined as the deviation from the fitting curve. The residual Sq amplitude at all the geomagnetic stations clearly showed increase and decrease trends with the periods of 20 years. The minimum and maximum of the residual Sq amplitude appear around 1970 and 1990. The residual Sq amplitude around 2010 is almost the same level as that around 1970. Moreover, the similar tendency can be seen in the diurnal variation of geomagnetic field in the auroral zone and polar cap (Sqp field) driven by the twin vortex of ionospheric currents associated with energy input of solar wind into the ionosphere. Then, it seems that the trends in the residual Sq and Sqp fields are related to the long-term variation in the ionospheric conductivities associated with the secular variation of the ambient magnetic field and the upper atmosphere (for example, plasma and neutral densities associated with increasing concentrations of greenhouse gases). In order to verify qualitatively the above signatures, we need to investigate the long-term variation in the ionospheric conductivities calculated using the IRI-2007 and MSIS-00 models.

Keywords: Solar activity, Sq variation, Ionospheric cunductivity, Electron density, Geomagnetic secular variation, Global warming