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Long-term variation in the solar quiet geomagnetic field variation and thermospheric wind based on the IUGONET observati

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It has been well-known that geomagnetic solar quiet (Sq) variation is produced by ionospheric currents associated with dynamo process via interaction between the neutral wind and plasma in a region of the thermosphere and ionosphere. The large-scale motion of the neutral particles is caused by heat convection due to solar irradiance and by tidal force of the sun and moon. From the Ohm's equation, the ionospheric currents which lead to the Sq variation strongly depend on ionospheric conductivity, polarization electric field and neutral wind. Then, trend in the Sq amplitude may include information on the long-term trend in the 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 % at all the stations 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. However, the research of the long-term variation of Sq amplitude by Elias et al. [2010] includes the following issues: (1) Since they used only the geomagnetic field data obtained from the three geomagnetic stations until 2001, a global signature of the long-term variation of Sq amplitude has been not clarified yet, (2) The quantitative evaluation between the Sq amplitude and sunspot number cannot be performed correctly during the solar minimum when the sunspot number is zero, and (3) they did not compare the long-term trends in the Sq amplitude and the neutral wind in the lower thermosphere and ionosphere. Then, details of physical process of the long-term Sq variation have not been understood yet. In this paper, we try to clarify quantitatively the effect of the Sq variation on the long-term trend in the neutral wind, and to construct a global picture of upper atmosphere variation associated with increasing greenhouse gas using the long-term observation data of geomagnetic field and neutral wind obtained from the ground magnetometer, MF and meteor wind radars. These observation data have been provided from the institutions participating in the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which stated in facial 2009. In the present analysis, we used solar F10.7 flux indicating the solar activity, geomagnetic field data with time resolution of 1 hour observed at Memanbetsu, Kakika and Guam. The definition of Sq amplitude is the size of the H-component variation per day when the Kp index is less than 4. As a result, the Sq amplitude observed at three stations strongly depends on 11-year solar activity, and tends to be more enhanced during the high activities (19- and 22- solar cycles) than during the low activity (20-solar cycle). In order to exclude the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 and Sq amplitude during 1957-2010, and examined the long-term trend of the deviation of the fitting curve. The deviation showed a clear tendency to increase and decrease during the periods of 1957-1992 and 1993-2010, respectively. Moreover, it should be noted that the deviation around 2010 is almost the same level as that around 1970. This is inconsistent with the result of Elias et al. [2010], who proposed that the long-term variation of Sq amplitude is caused by the ionospheric conductivities enhancement associated with the decrease of the ambient magnetic field intensity and ionospheric electron density due to cooling effect of increasing the greenhouse gas. This result suggests that the variation of the upper atmosphere associated with an extremely quiet solar activity is dominant because the 23-cycle solar activity is the smallest in the period of 1957-2010.

Keywords: Geomagnetic solar quiet variation, Magnetic field intensity, Solar activity, Ionospheric conductivity, Thermospheric wind, Upper atmosphere