1. Introduction

1.1 Geomagnetic solar daily quiet (Sq) variation and its current system

The magnitude of Sq (geomagnetic Solar daily Quiet variation), and is mainly produced by ionospheric currents, which are driven by ionospheric dynamo at the E-region altitude via interaction between neutral and ionized particles. Since the Sq amplitude strongly depends on ionospheric conductivities and neutral wind in the lower thermosphere and mesosphere, we can investigate the long-term variation of the Earth’s upper atmosphere from the trend of the Sq amplitude.

1.2 Previous works on the long-term variation of the Sq amplitude

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Recently, Elias et al. (2010) found that the Sq amplitude observed at Apia, Fredericksburg and Honolulu shows significant increasing trends for the period 1990-2001. They interpreted the Sq trends as effects on both secular variation in the ambient magnetic field intensity and upper atmospheric changes associated with global warming.

1.3 Problems of the past studies and purpose of this study

However, since Elias et al. (2010) analyzed geomagnetic field data obtained only at three stations for a short period, a global feature of the long-term Sq trends has remained unknown. They did not also perform a comparison between the Sq amplitude and neutral wind in the lower thermosphere and mesosphere. Then, the purpose of the present study is to investigate a global feature of the long-term variation in the Sq amplitude using the long-term observation data of geomagnetic field and ionospheric conductivity model. For data search and analysis of the present study, we took advantage of the IUGONET data analysis system developed by the IUGONET project.

2. Data analysis and method

2.1 Observation data used in the present analysis

2. Geomagnetic index (Kp, 1932-2012): WDC, Kyoto Univ.
3. Solar activity indices

| F10.7 flux (1947-2012): NGDC/NOAA, Sunspot number (1947-2012): SIDC (Belgium) |

2.2 Identification of quiet day and Sq amplitude

1. Definition of quiet day

The maximum of Kp index is less than 4 every day.
2. Sq amplitude

Difference between the maximum and minimum values of the daily variation of the H-component of geomagnetic field during quiet as shown in Fig. 2.

2.3 Residual amplitude of Sq fields to filter out the solar activity

In order to investigate a global feature of the long-term variation of the Sq amplitude, we performed the integrated analysis of the long-term ground-based observation data of geomagnetic field with 1h time resolution and solar F10.7 index during 1950-2011. We showed several new and important results as follows:

1. The amplitude of the Sq amplitude observed in a wide region from the north to the south poles depends strongly on 11 yr solar activity but is not linearly proportional to the magnitude of the F10.7 solar activity index.
2. The long-term variations of the residual Sq amplitude showed significant decreasing, increasing and decreasing trends for 1950-1909, 1970-1980 and 1990-2009, respectively. Only the positive trend during 1970-1990 is consistent with that previously reported by Elias et al. (2010), who proposed that the long-term increase of Sq field contributes to both the decrease of the ambient magnetic field intensity and cooling effect of the upper atmosphere due to greenhouse effect. Therefore, their interpretation of the long-term Sq trends can not always be adapted for all the periods.
3. The magnitude of the Sq trends in the high latitudes (auroral zone and polar cap) tends to be larger than that in the low-middle latitudes and equator.

The 20-year periodicity of decreasing and increasing trends of the residual Sq amplitude may suggest a characteristic period of changes in the Earth’s upper atmosphere without dependence on solar activity. In the future study, we perform the comparison analysis between the residual Sq amplitude and ionospheric conductivities derived from several upper atmospheric models (IGRF, MSIS-00, IRI-2012). We also investigated the relationship between the residual Sq amplitude and neutral wind in the lower thermosphere and mesosphere estimated from the meteor and MF radars.