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A PECULIARITY OF THE Sq VARIATION'S VARIATION WITH LATITUDE

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Abstract

Solar quiet daily variations in horizontal H component in three latitudinal ranges at high, moderate and low latitudes are compared during one year (1985). It is found that the solar quiet daily variation amplitude varies strongly with season at high latitudes, with almost complete vanishing of the variation during the winter months, and the same applies to the variation shape at middle latitudes, with smaller intensity, though. In contrast to this, almost constant amplitude and invariable shape are observed during each month of the year at 3 of 4 standard low-latitude stations, but Kakioka. In Kakioka a signature of the annual variation described above is noticed, e.g., the solar quiet daily variation amplitude vanished in 1985 in winter months.

Introduction

It is difficult to add anything new to so well examined subject as the solar quiet daily variation is. The quiet variation of the ground magnetic field owing to the day-night illumination periodicity and the magnetic pole rotation about the geodetic one presents at all latitudes manifesting signatures proper to them.

Solar quiet daily variation (Sq) is usually calculated with 1 hour resolution for a chosen month interval by averaging the diurnal courses during 5 most quiet days of this month. Although there is an opinion that, because of these five days are not equally quiet, another way might be to accept for the Sq variation a diurnal variation of magnetic field component during one most quiet day of the month [Matsushita and Campbell, 1967].

In high latitudes the equivalent current system of the solar quiet variation represents 2 vortices which might be identified with the convection vortices [Lyatsky, 1978]. Therefore the amplitude of the variation is strongly related to solar illumination conditions. Near winter solstice, when the northern polar cap is shaded, the ionosphere convection intensity is minimum and the Sq variation amplitude is minimum as well. In low latitudes the source for the Sq variation is also related to the day-night illumination periodicity, but owing not to the ionosphere convection currents immediately. Long studies have shown that the dominant role in the solar quiet daily variation forming belongs to solar and lunar tides [Matsushita and Campbell, 1967] and to the neutral winds disturbed on the sunlit side of the Earth.

However, the response of the low-latitude magnetic field to the high-latitude disturbances, especially to those negative ones, leave open the question about the ionosphere interface between high and low latitudes during quiet time as well [Lyatsky, Maltsev, 1975]. There were attempts to overlap the magnetic field line inclination problem when modeling the spreading of the Hall currents from electrojets towards lower latitudes [Denissenko and Zamay, 1989]. From this point of view the revealed 'high-latitudinal convection pattern signature, found at a very local area', is of special interest.

Analysis technique

The solar quiet daily variation shape in the present study is obtained by averaging the H component data (with 1 hour resolution) over the realizations for the days with AE<400 nT. Three latitudinal belts have been compared: low-latidudinal one, presented with Hermanus, Honolulu, Kakioka and San Juan; moderate-latitudinal one, presented with Moskow, Magadan, Victoria and St Johns; and high-latitudinal one, presented with Resolute Bay, Yellowknife, Glenlea, Fort Churchill.

Results

Below in figures 1,2 and 3 the Sq variation in H component at high-, mid- and low-latitude observatories versus number of month of the year (X-axis) and UT hour (Y-axis) is given by gray color intensity. The deviation ΔH is counted out from the mean H value of each month.

It is seen that about the winter solstice in high latitudes the Sq variation sinusoid completely vanishes at two stations and diminishes in positive value at other two stations (see Fig. 1). At mid-latitude stations the Sq variation sinusoid completely vanishes for all four of them (see Fig. 2). In summer time at every observatory a definite sinusoid of the quiet daily variation is observed. Of four low-latitude stations, the Sq variation sinusoid vanishes during winter time at Kakioka only (see Fig. 3).

Another important feature of the Sq variation annual course is the increase in period during summer time. For high-latitude observatories the peak in period falls on July-August, this is true for 3 of 4 observatories except Fort

Churchill. For mid-latitude observatories this effect is even more pronounced. For low-latitude observatories this effect as though as absent.

The sinusoid amplitude behavior is different from that of the period. For high-latitude observatories, the amplitude scale is very individual. The maximum in amplitude may occur from March through October. Maximum positive deviation from baseline is observed during July, August (FCC); July (GLN); June (RES, YKS). For mid-latitude observatories the scattering in Sq sinusoid scale vanishes, maximum positive deviation from baseline is observed during June, July (MGD); July (MOS); June, August (STJ); July (VIC). For low-latitude observatories, the Sq sinusoids also join the common range, from –30 to 20 nT. Maximum positive deviation is seen to fall to September (HER); February, March (HON); April, October (KAK); April (SJG).

The Sq sinusoid period, amplitude and positive deviation annual courses suggest that the solar illumination conditions are not single, moreover not the main, source for the Sq variation.

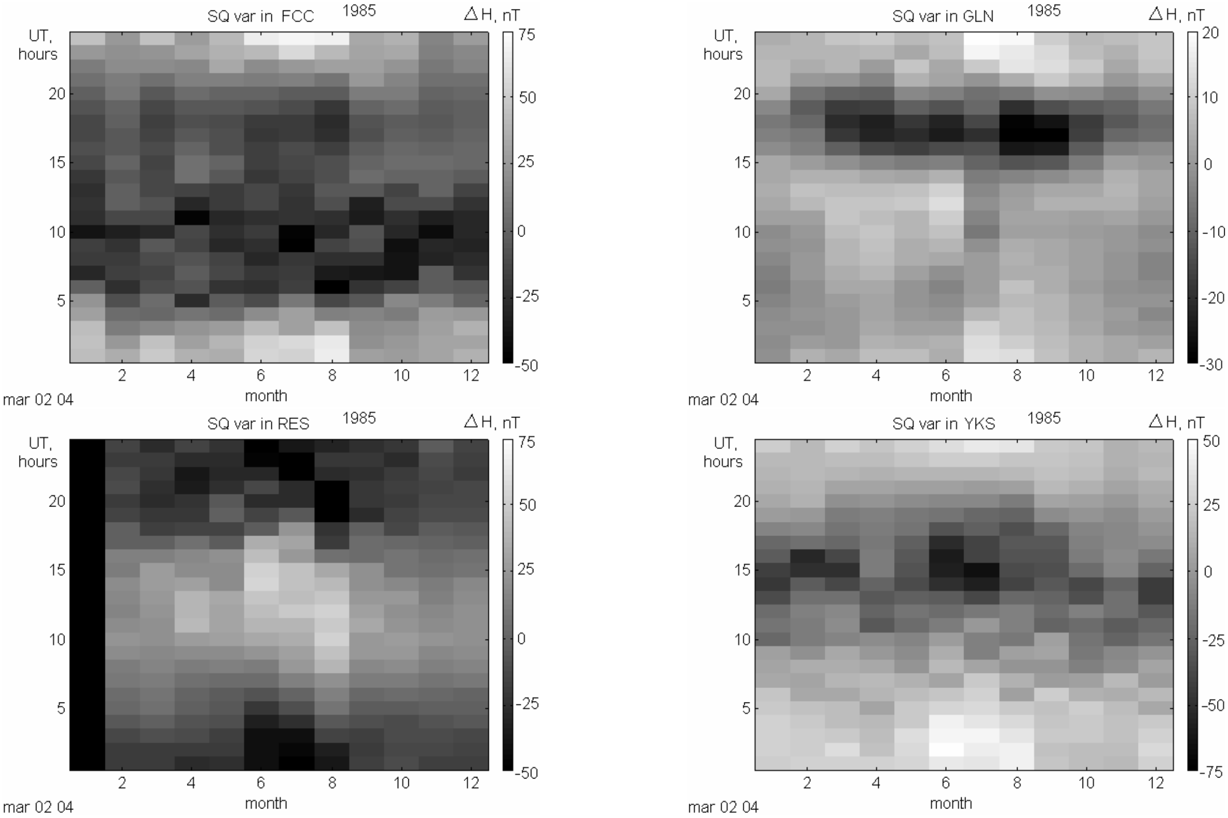

Fig.1. The solar quiet daily variation of the H component as a function of month and UT, for high-latitude observatories (code, location: °Mlat, °MLong): Fort Churchill (FCC, 68.53°, -33.88°), Glenlea (GLN, 59.19°, -33.94°), Resolute Bay (RES, 83.14°, -64.02°), Yellowknife (YKS, 69.14°, -63.44°).

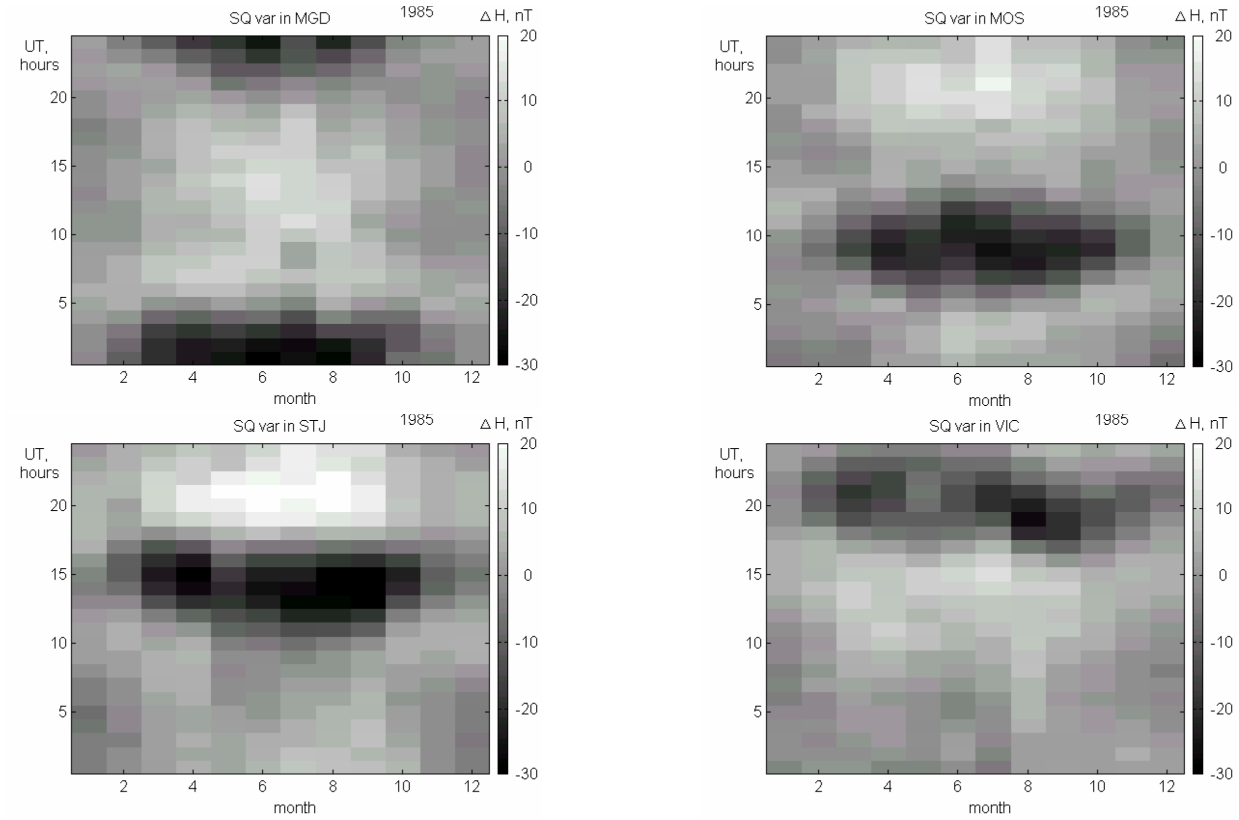

Fig.2. The solar quiet daily variation of the H component as a function of month and UT, for mid-latitude observatories (code, location: °Mlat, °MLong): Magadan (MGD, 51.28°, -147.85°), Moscow (MOS, 50.79°, 121.62°), St. Johns (STJ, 57.91°, 23.39°), Victoria (VIC, 54.33°, -64.34°).

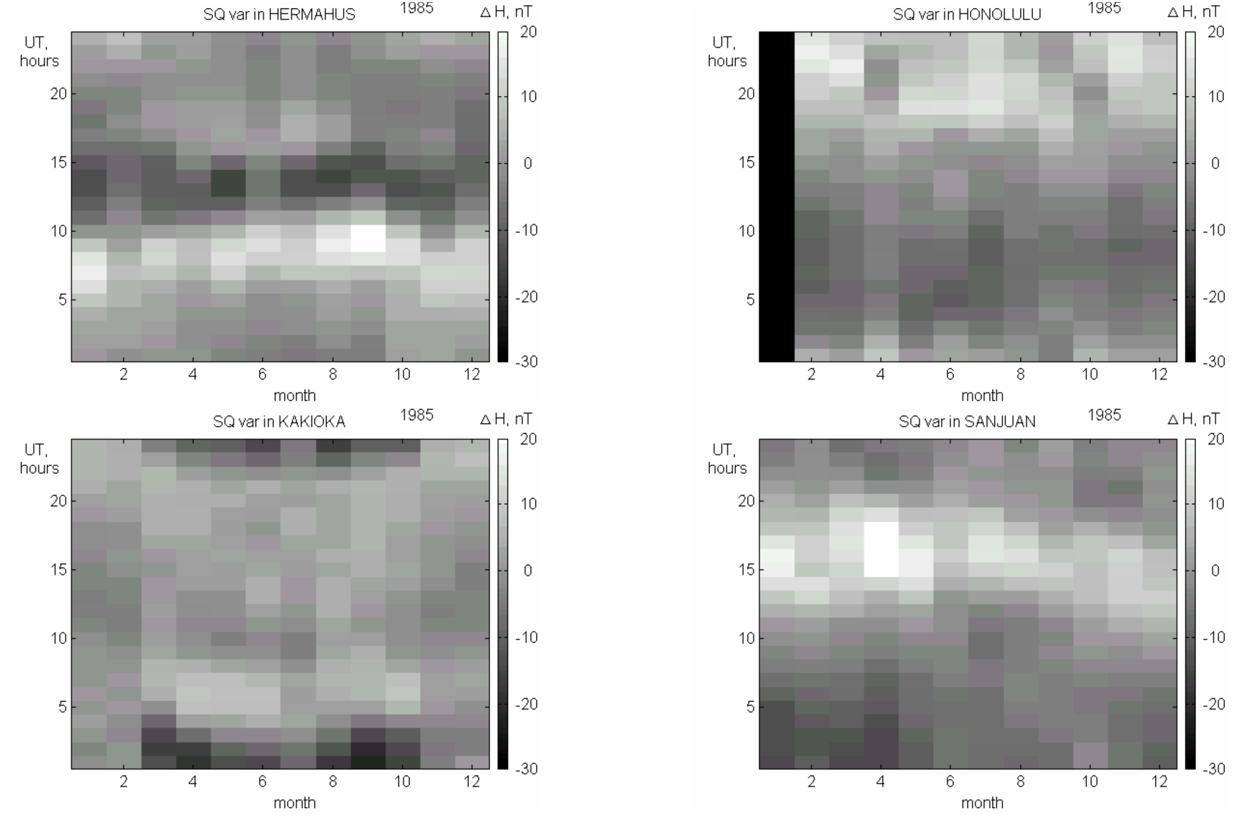

Fig. 3. The solar quiet daily variation of the H component as a function of month and UT, for 4 standard low-latitude observatories (code, location: °Mlat, °MLong): Hermanus (HER, -33.72° 82.67°), Honolulu (HON, 21.46°, -91.43°), Kakioka (KAK, 26.62°, -152.23°), San Juan (SJG, 29.36°, 5.21°).

In fig. 3 the same dependence, as in fig.1, of Sq variation versus month and UT hour for low-latitude stations is shown. It is seen that the daily variation's sinusoid retains approximately invariable in shape and amplitude for every month of the year. Only in Kakioka the variation decays about winter solstice, likely to the mid-latitude Sq variations.

To the current moment, the low-latitude Sq variation seasonal courses are obtained for year 2001. The quiet days have been determined with help of Kp index that was required during each hour to be less than 2^0. It appeared that the Sq variation is much variable in amplitude and weaker in shape. Conservation of the Sq sinusoid throughout the year 2001 is observed at Hermanus only. In Kakioka the annual variation of the Sq diurnal shape is saved, with a weak sinusoidal disturbance adding during winter months, though.

Discussion

The solar illumination conditions determine the ionosphere conductivity in high latitudes and possibly the ionosphere vorticity in low latitudes due to the atmosphere heating effects. Since the solar quiet daily variation amplitude is commonly thought as determined by the solar illumination conditions, one may expect it to have approximately invariable shape throughout the year in low and equatorial latitudes, and to vary strongly in high latitudes and in the polar cap. Sq variation at Kakioka first breaks this expectation. During 4 months the Sq sinusoid is almost invisible in 1985. Bear in mind that Kakioka is not the most distanced observatory from magnetic equator. That is the illumination conditions in it should not differ much from those at Hermanus, Honolulu or San Juan, e.g., to be typical for low-latitudes. That is the ionosphere conductivity variation above Kakioka shouldn't depend on season to a great extent, making the Sq variation to disappear.

The Sq variation vanishing during winter months at high-latitude observatories Resolute Bay and Glenlea presents, however, at Fort Churchill and Yellowknife (see their Sq variation annual courses). This suggests that the solar quiet daily variation at high latitudes is also incompletely interpreted in terms of the quiet ionosphere convection pattern alone.

The coastal effects are known to manifest themselves at shorter time scales than the solar quiet variation. [Matsushita and Campbell, 1967]. The lunar tides modifying the number of focii of the Sq field according to the lunar age are also couldn't be reasonable explanation of this effect for they should symmetrically affect the ground magnetic field at any low-latitudinal site.

Stability of the Sq variation shape appropriate to each observatory allowing to follow the amplitude decay from summer to winter time indicates that the source of the effect rotates with the observatory. Thus it might be possibly related to the local Earth conductivity and geological processes, such as the watering of rocks or soil water migration with season.

In the vicinity of the active Sun year, e.g., in 2001, the annual courses of Sq variation in low latitudes have moderately changed, especially in amplitude. This allows to suggest the solar quiet variation in low latitudes is contributed from the sources possibly dependent from the Solar activity. In present study the relationship of the Sq variation to the solar wind velocity is not considered yet. Examination of this dependence may shed light to the high-latitude convection field penetration problem down to low latitudes [Voronkov and Kuznetsov, 1989]. Penetration of ionosphere spreading currents down to middle latitudes has been reported earlier by Pudovkin and Tsvetkov [1975].

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