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SEPARATION OF THE ATMOSPHERIC GEOMAGNETIC EFFECT OF AURORAL AND RING CURRENT ORIGIN ON THE BASIS OF THEIR DIURNAL COURSE.

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ABSTRACT

The literature considers the geomagnetic effect of the equatorial neutral atmosphere a consequence of the auroral heating only, in spite of the fact that some results indicate stronger response than it is expected. Our earlier results demonstrated that the ring current is an additional energy source for the equatorial thermosphere as well. Based on the position of the humps in the LST function of the residuals — representing the different places of the enhanced energy input — an attempt is made to separate the two sources.

INTRODUCTION

The auroral heating reaches the equatorial zone by meridional winds with a 4-6 hours time delay preferably in the morning hours [1]. Its decay rate corresponds approximately to that of Kp. The ring current heating — not included into the MSIS models, but playing an important role at low latitudes according to our previous investigations [2,3,4] — has some preferred energy input sectors in LST [5]: around midnight near the equator in connection with the injection zone; around 18 hours in connection with the bulge of the plasmasphere; around noon in connection with the compositional asymmetry of the ring current [6]. The time delay corresponding to the different components may be different and the decay rate, roughly equal to that of the recovery rate of Dst, is generally slower than that of the auroral heating. The scope of the investigation was to distinguish between residual density humps of the auroral heating and excess density humps of ring current origin.

DATA AND METHOD

Thermospheric density data (ϱ) derived from the CACTUS microaccelerometer measurements [7] were used for a time interval of 1975-1977 (low solar activity). Measurements stay at our disposal for the 400-600 km height interval and for 0-40° geomagnetic latitudes. The MSIS'86=CIRA'86 model was used for comparison. At the first phase MSIS'86 residuals, i.e.

$$f=(\varrho^{CAC}-\varrho^{MSIS'86})/\varrho^{MSIS'86}$$

values have been analysed as a function of LST (a scatter around zero would correspond to a perfect model). On the basis of Dst curves 21 geomagnetic disturbances with steep descending branches have been selected. The diurnal dependence of the corresponding f-values has been investigated by the method of superposed epochs using the time of the Dst minimum as key time. Running mean curves have been plotted on consecutive 24 hours (Fig. 1) and 3 hours (Fig. 2) intervals before and after the key time. Individual f-values of the first 24 hours after key time have also been plotted as a function of LST (Fig. 3) and of Kp and Dst for every LST hour interval separately (Fig. 4). For these latter plots linear regression models were applied.

RESULTS

Looking at Fig. 1 and 2 it is obvious that the MSIS'86 model generally overestimates the density before Dst reaches its minimum value and underestimates — on the first day in particular — afterwards. The pre-storm conditions are restored after 5-6 days. The density excess is not a uniform function of LST, but five real, more or less separate humps are distinguishable:

1./ The midnight hump (LST 22-1 hours) appears 4-6 hours after the Dst minimum and disappears after 3 days. If separated according to geomagnetic latitudes, the amplitude of the hump increases towards the equator;
2./ The early morning hump (LST 2-5 hours) precedes the Dst minimum by a few hours and disappeares after 4-5 days;

3./ The morning hump (LST 6-7 hours) appears 4-6 hours after the Dst minimum and is visible only on the first day;

4./ The midday hump (LST 10-14 hours) also precedes the Dst minimum and lives at least 6 days. If separated according to geomagnetic latitudes, its amplitude increases at higher latitudes up to 40^{o};

5./ The evening hump (LST 17-21 hours) has similar behaviour to that of the early morning hump considering its appearance. Its amplitude increases, however, at higher latitudes up to 40^{o}.

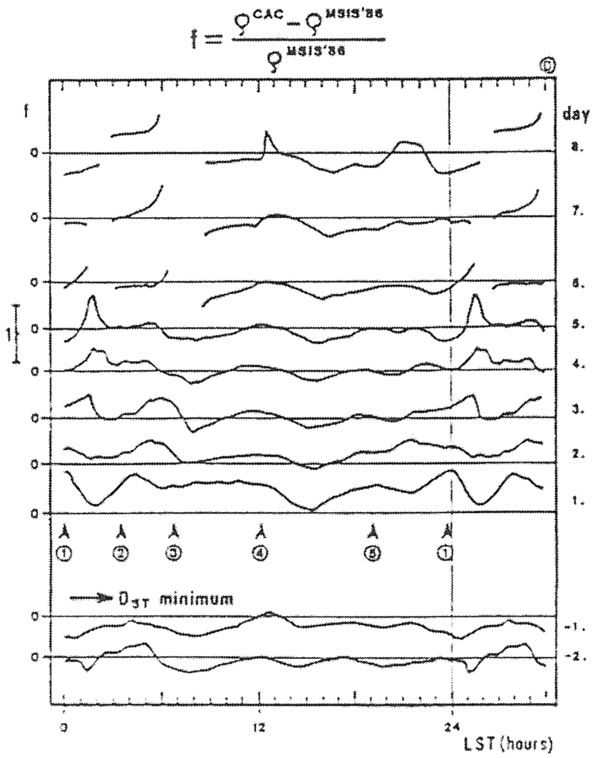

Fig. 1
Daily sequence of running mean curves of f-values as a function of LST. Dst minimum represents the starting point of the time scale for every disturbance. 21 disturbances were used in all figures.

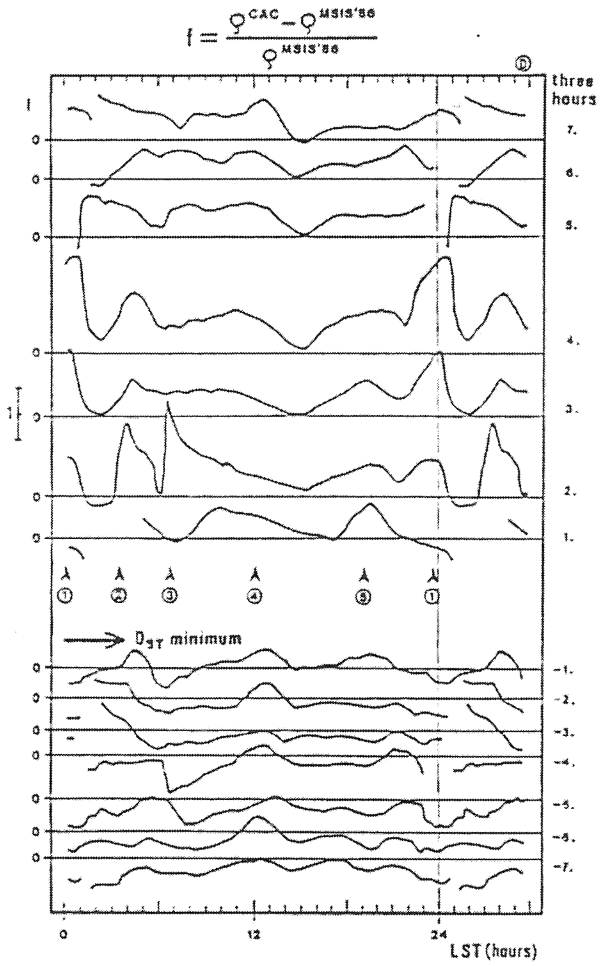

Fig. 2
The same as in Fig. 1 but with a better, 3 hours time resolution and limited to the 21 hours just preceding the geomagnetic disturbances.

The diurnal dependence of the variance of the individual f-values is conspicuous in Fig. 3. It is not a consequence of an uneven daily distribution of the f-values belonging to small and large Dst values respectively, but reveals a changing dependence of f-values on corresponding Dst and Kp values at different LST intervals (Fig. 4): e.g. the dependence on Dst is very flat in the vicinity of the midday hump. The case of the LST 4-5 and 6-7 hours maxima of the regression coefficient function (Fig. 5) deserves further attention — if the dependence is really so extremely steep as it looks like. Further investigations are needed in this respect since extreme Dst values are missing in the LST intervals in question.

CONCLUSION

The residuals of the MSIS'86 model have been analysed on an independent observational material. The behaviour of the excess density humps seems inconsistent with the character of residuals due to a probable insufficiency of the model in the description of the auroral heating effect. (The morning hump with its time delay and lifetime could be an exception, the steep dependence of f on Dst is, however, contradictory if confirmed.) Consequently we can consider the MSIS'86 model as a proper description of the auroral heating effect in the

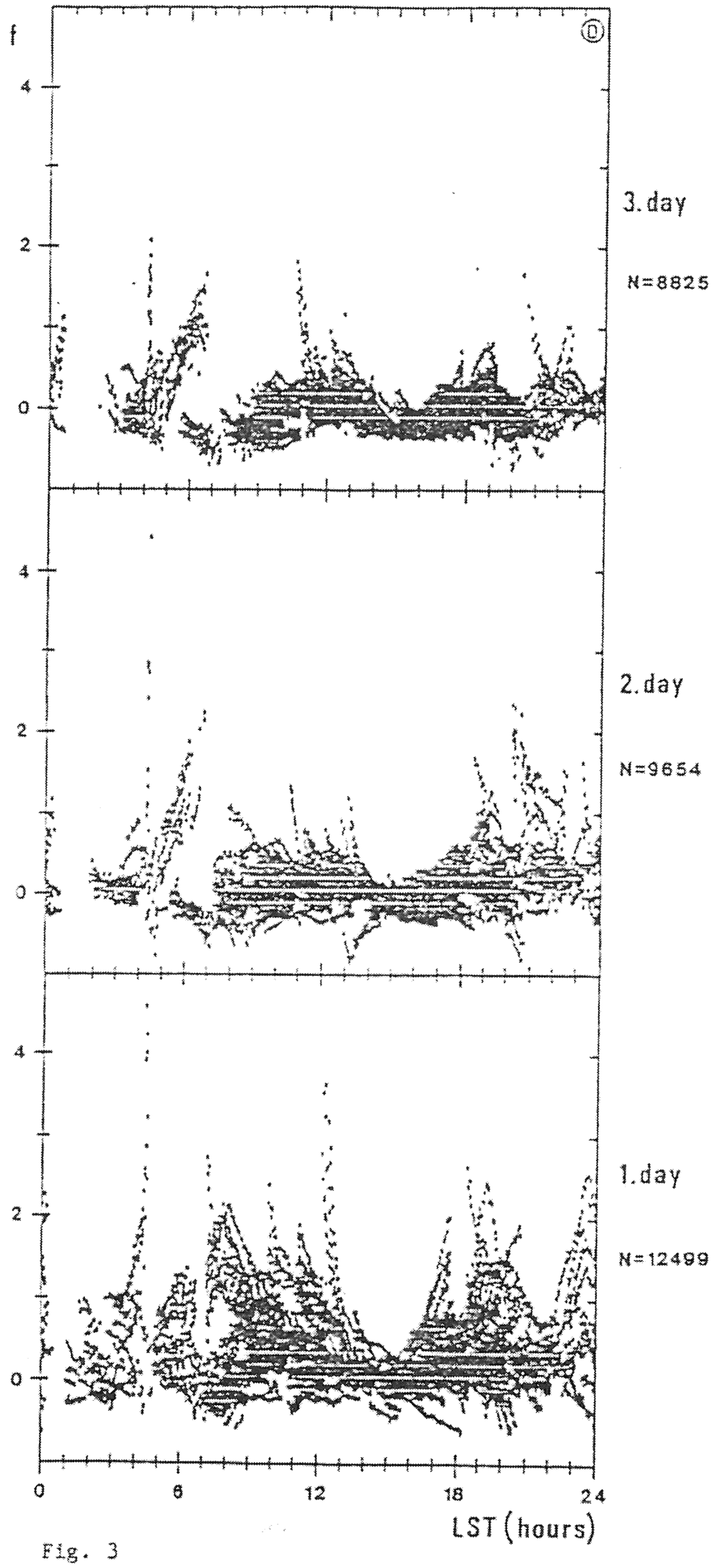

Fig. 3
Individual f-values as a function of LST determined in consecutive 24 hours after Dst minima.

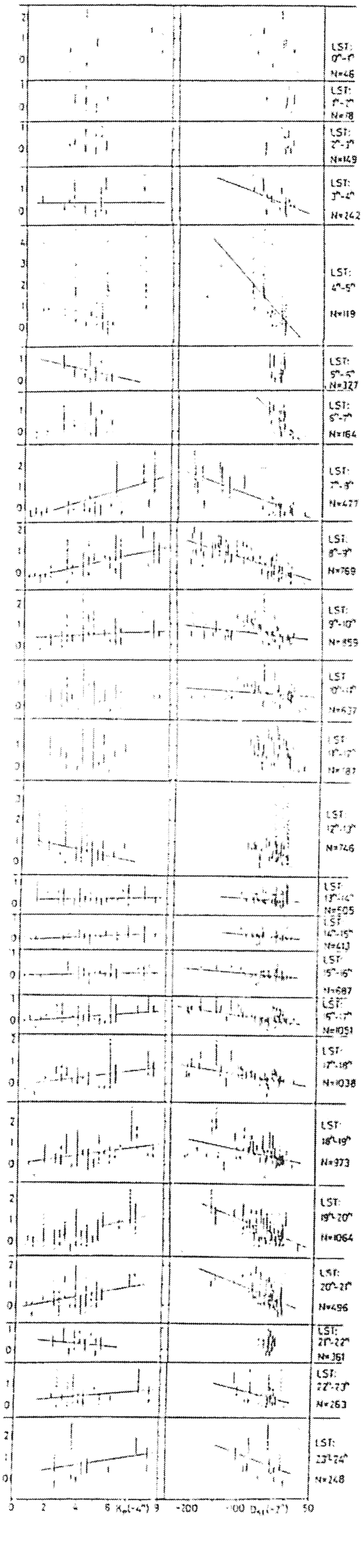

Fig. 4
Individual f-values for the first 24 hours — separated according to LST hours — are plotted as a function of Kp (left) and of Dst (right) respectively. N is the number of f-values.

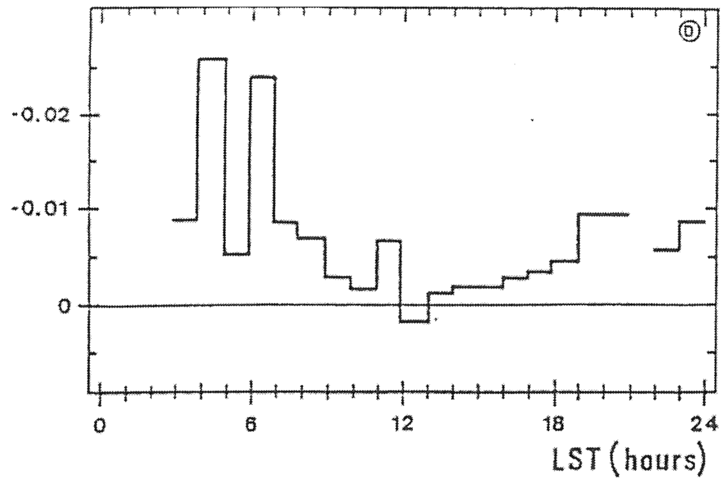

Fig. 5.
The regression coefficients of Fig. 4 as a function of LST.

equatorial zone, i.e. the residuals originate from the ring current heating. The observational characteristics of the humps are indeed not inconsistent with the characteristics to be expected if a ring current heating is present.

It can be stated as an interesting result for any model construction that the ring current heating characterized by Dst corresponds to different thermospheric density enhancements in different LST sectors (longer wave in the regression coefficient) or even in narrower LST intervals (like in LST hours 4-5 or 6-7). The probable "beam like" character of the ring current heating may constitute the physical background of the observed phenomenon producing larger density increases in certain LST sectors or intervals.

According to P. Bencze [8] the first feature is a consequence of the circumstance [6], that Dst indices represent mean values of individual low latitude measurements of the depression due to the ring current in the horizontal component of the geomagnetic field, thus its diurnal variation is eliminated. The other feature, i.e. the steep increases in the regression coefficient could be explained — in accordance with our earlier assumption [2] — at low latitudes by irregularities in the distribution of O^- ions in the ring current, at mid-latitudes by localized interactions between the plasmasphere and the ring current belt. Localized interactions can occur if the mutual position of the plasmasphere and the ring current belt changes within a short time, or plasma waves producing wave-particle interaction appear preferably at certain local times. All these considerations support that the disturbance daily variation of the geomagnetic effect with its humps is a real phenomenon and not only due to the scattering of the data.

Further investigations are planned to determine the exact contribution of auroral and of ring current heating to thermospheric density enhancements.

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REFERENCES

1. G. W. Prölss, M. Roemer, J. W. Slowey, Dissipation of solar wind energy in the Earth's upper atmosphere: the geomagnetic activity effect. Adv. Space Res. 8, (5)215-(5)216, 1988.
2. E. Illés-Almár, I. Almár, P. Bencze, A. Horváth, Investigation of the thermosphere ionosphere interaction by means of the neutral post-storm effect. Adv. Space Res. 7, (8)53-(8)57, 1987.
3. E. Illés-Almár, I. Almár, P. Bencze, A. Horváth, On a possible ring current effect in the density of the neutral upper atmosphere. Adv. Space Res. 9, (12)205-(12)208, 1989.
4. I. Almár, E. Illés-Almár, A. Horváth, Z. Kolláth, D.V. Bisikalo, T.V. Kasimenko, Improvement of the MSIS 86 and DTM thermospheric models by investigating the geomagnetic effect. Adv. Space Res. 12, (6)313-(6)316, 1992.
5. E. Illés-Almár, I. Almár, P. Bencze, A. Horváth, N. Jakowski, A. Jungstand, Similar behaviour of the thermosphere and the ionosphere in the recovery phase of geomagnetic disturbances. Adv. Space Res. 12, (6)175-(6)178, 1992.
6. P. Bencze, I. Almár, E. Illés-Almár, Ring current heating of the low latitude thermosphere connected with geomagnetic disturbances. Adv. Space Res. 13, (1)303-(1)306, 1993.
7. F. Barlier, J. Bouttes, M. Delattre, A. Olivero, P. Contensou, Experimentation on vol sur satellite d'un accelerometre de tres haute sensibilite. Compt. Rend. Acad. Sc. Paris, 281 B, 145, 1975.
8. P. Bencze, privat communication.