Mausam, (1980), **31**, 4, 535-538

551. 590. 21: 551. 510.53: 550. 386

Possible heating effect in the mesospheric 51 to 70 km altitude region over Thumba (8° N, 77° E) following geomagnetic activity

R. SESHAMANI

Indian Institute of Science, Bangalore

(*Received 28 November 1979*)

ABSTRACT. The variation in equatorial mesospheric temperatures at altitudes of 51 to 70 km during geomagnetically-active periods has been studied. A correlation analysis of rocketsonde temperature data obtained from the M-100 sounding rocket launchings at Thumba (8 deg. N, 77 deg. E) and the daily planetary geomagnetic index A_p has been carried out for a one-year period (December 1970 to December 1971).

The results of the analysis reveal a highly significant in-phase relationship between the temperatures and A_p. The 51 to 70 km layer average temperature changes in-phase, around 3 to 4 days after the A_p increase. The temperature change has been quantified by $\triangle T/\triangle A_p = 0.36°$ K (approx.) for a four-day lag between the time of A_p increase and the subsequent temperature increase.

This heating effect in the 51 to 70 km altitude region around 3 to 4 days after variations in geomagnetic activity, appears to be a part of the phenomenon of solar/geomagnetic activity — induced perturbations in the equatorial neutral atmosphere over Thumba, observed by Raja Rao *et al.* (1978). Such results would form useful inputs for modelling the neutral atmosphere over India.

1. Introduction

Relationships between variations in geomagnetic activity and subsequent changes in the neutral parameters of the upper atmosphere have been observed from analysis of satellite drag data (Marov and Alpherov 1972). At lower altitudes, in the middle atmospheric region from 30 to 100 km altitude, the atmospheric response to geomagnetic activity has been observed and reported (Seshamani 1977) from analyses of rocket data on neutral temperatures at various middle and high latitude stations.

In the present study, the response of equatorial mesospheric neutral temperatures to variations in geomagnetic activity has been studied by analysis of M-100 rocket data over Thumba (8 deg. N, 77 deg. E), over a one year period: December 1970 to December 1971.

2. Data

The temperature data were obtained by 40 μm tungsten rhenium resistance wire sensors on board the Soviet M-100 rockets launched weekly from Thumba under a joint programme of the Indian Space Research Organisation and the USSR Hydrometeorological service. 51 soundings using M-100 rockets were carried out (Narayanan 1973) during the period from December 1970 to December 1971, at Thumba, the recorded temperatures being processed for various known corrections using a standard procedure adopted at the Thumba Equatorial Rocket Launching Station (Kokin *et al.* 1970).

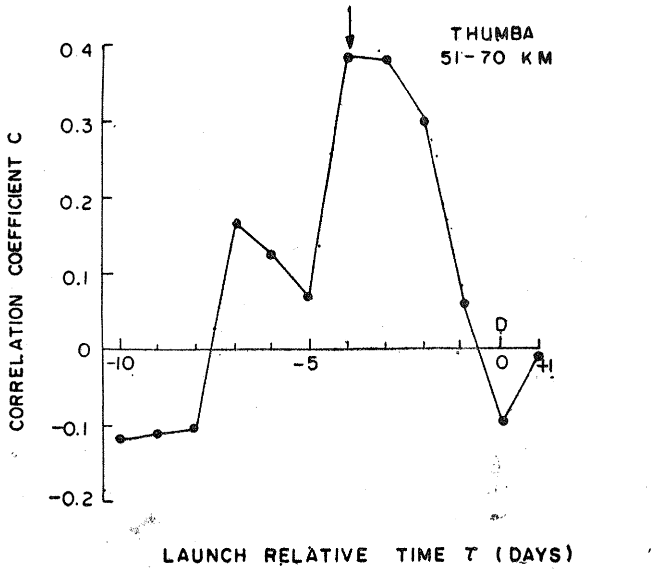

Fig. 1. Correlation coefficients of temperature *vs.* A_p at various launch relative times, for the 51 to 70 km altitude region at Thumba (8°N, 77°E)

From these soundings, a set of 43 soundings which were all in the local time range 1930-2400 hr (night time), were taken for the analysis. This feature considerably minimises the radiation correction, which is fairly large for thermistors exposed to solar electromagnetic radiation but is extremely small in the absence of incident solar radiation. The daily planetary geomagnetic index A_p was used in the analysis. Daily values of A_p for the period December 1970 to December 1971 were obtained from the *Solar-Geophysical Data Reports* (U.S. Department of Commerce 1971/1972).

A_p is essentially a mid-latitude index, being calculated from records of magnetic activity at specified magnetic observatories in the 30° to 60° latitude belt.

3. Method of analysis

The temperatures and A_p data were analysed for inter-dependent relationships by computing the Pearson's product-moment correlation coefficients C (T_m, X, L, τ) between the equatorial mesospheric temperature T_m in a given layer L and the geomagnetic index X ($X = A_p$), at a given launch relative time τ for a set of N_L soundings.

The correlation coefficients were calculated for the layers in the altitude range 51 to 70 km and launch relative times in the 12 day range D—10 to $D+1$ days, *i.e.*, 10 days before the launch day (D) to 1 day after D.

The sudent's t value $t(C)$ of each of the calculated correlation coefficients was also computed.

The linear regression coefficient $B\,(T_m, X, L, \tau) = (\triangle T_m / \triangle x)$ is then computed for the layer L and launch relative time τ.

The significance levels of the t values were calculated from standard t—tables (Federighi 1959) using the double-tailed test, as the sign of the resultant correlation coefficient at any particular layer and launch relative time was not known, a significance level of 10 per cent was considered marginally significant, while a level of 1 per cent was considered almost certainly significant.

4. Results

The correlation coefficients for the layer 51-70 km are shown in Fig. 1, plotted with respect to the launch relative time, over the period D—10 to $D+1$ days. The values were also calculated or the subsequent period upto the $D+9$ days, but no significant increase in correlation coefficients was noticed after the D day.

From the figure it can be seen that the correlation coefficient attains its maximum positive value of 0.385 on D—4 day and the correlation coefficient is significant for the next two days. The t-test shows that the peak at D—4 is significant at the 99.5 per cent level, indicating an almost certainly significant correlation. The positive correlation coefficient is indicative of a heating effect in this region, 3 to 4 days after the day of enhanced geomagnetic activity. The regression coefficient (in a linear least-squares approximation) of T_m and A_p corresponding to D—4 day has a value of 0.36.

Heating effects following 5 to 10 days after days of high geomagnetic activity characterised by A_p enhancements, have been observed (Seshamani 1976) in the 61 to 90 km region at auroral latitudes (Point Barrow, 71° N; Fort Churchill, 59° N) and at middle latitudes (Wallops Island, 38° N). Stratospheric heating effects at 30 to 35 km altitude have also been observed by Scherhag (1969) over Berlin (50° N).

The results of the present analysis seem to indicate that this effect (observed, for example by Fejer *et al.* 1971 from rocket soundings, as a heating effect in the mesosphere during geomagnetically disturbed days) is also observed at equatorial latitudes in the 51 to 70 km altitude region, 3 to 4 days after the day of enhanced A_p.

In a recent study, Raja Rao *et al.* (1978) who used K_p as the index of geomagnetic activity, have reported changes in the height of tropospheric constant-pressure surfaces following 2 to 3 days after a geomagnetically active day. Raja Rao *et al.* considered the daily sum of K_p (the 3-hourly planetary geomagnetic index) which has a one-to-one correspondence with the daily A_p index employed in the present study.

However, in an earlier study Justus and Woodrum (1973) did not find any significant response of temperatures in the 20 to 65 km altitude region over Ascension Island (8°S)—another equatorial station—after increases in the A_p index.

The mesospheric heating effect observed in the present study appears to be a part of the phenomenon of solar/geomagnetic activity induced perturbations in the equatorial neutral atmosphere over Thumba, observed by Raja Rao *et al.*

5. Conclusions

In conclusion, it can be stated that the present analysis indicates the existence of a significant heating of the 51 to 70 km altitude region over Thumba, following about 3 to 4 days after increases in the planetary geomagnetic index A_p (the strength of the relationship being given by a $\triangle T_m / \triangle A_p$ value $\simeq 0.36°$ K, in a linear least-squares approximation).

This result is significant and must be considered in studies aimed at modelling of the neutral atmosphere over Thumba and other Indian stations.

Further analysis with larger data sets and the usage of more refined regression analyses would provide a better estimate of the magnitude of these heating effects following geomagnetic activity.

Acknowledgements

The author is indebted to Professor S. Ramakrishna for his guidance and helpful comments during the course of these investigations. Thanks are also due to Professor P. R. Pisharoty and Dr. V. Narayanan for kindly providing the rocket temperature data which were obtained from the M-100 rocket soundings at Thumba, and to the referee for his comments.

References

Federight, E. T., 1959, *J. Am. Statistical Assoc.*, **54**, 683.

Fejer, B.G. *et al.*, 1971, *Space Research*, **11**, 841.

Justus, C.G. and Woodrum, A., 1973, Short and long period atmospheric variations between 25 and 200 km, NASA Report No. CR-2203.

Kokin, G.A. *et al.*, 1970, Processing of rocket data, USSR Central Aerological Observatory Report.

Marov, M. Ya and Alpherov, A.M., 1972, *Space Research*, **12**, 823.

Narayanan, V., 1973, *Ph.D. Thesis*, University of kerala.

Raja Rao, K.S., Dubey, R.C. and Patil, S.R., 1978, *Indian J. Met. Hydrol. Geophys.*, **29**, 4, 671.

Scherhag, R., 1969, *Annals of the IQSY*, **5**, 33.

Seshamani, R., 1976, *Ph.D. Thesis*, Indian Institute of Science, Bangalore.

Seshamani, R., 1977, *Space Research*, **17**, 141.

U.S. Department of Commerce 1971/72 Solar Geophysical Data, Boulder, Colorado.