ELECTRON DENSITIES AND SCALE HEIGHTS IN THE MID-LATITUDE TOPSIDE IONOSPHERE

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Summary

The diurnal and latitudinal variations of electron density and plasma scale height in the topside ionosphere during summer and winter have been calculated from Alouette I ionograms recorded at Woomera. The electron density behaviour is anomalous in that the winter night-time values are generally as large or larger than those occurring during the day. At heights near 1000 km the winter night-time values are greater than those for night-time summer. The behaviour of the scale height is very similar to that reported by others for the mid-latitude region of the northern hemisphere and implies that at night-time the transition level from O^+ to lighter ions occurs at heights of about 550 km in summer and 500 km in winter.

I. Introduction

Electron density profiles in the topside ionosphere have been calculated from some 500 Alouette I ionograms recorded at Woomera in order to study the diurnal, seasonal, and latitudinal variations of the topside ionosphere in the Australian region. The method of calculating the electron density profiles and its accuracy have been discussed elsewhere (Dyson 1967).

The Alouette I sounder (Warren 1962) is commanded on by telemetered signals from various ground stations and operates for 10 min thereafter, telemetering data back to the ground station. Approximately 33 ionograms are obtained during the operating period, and at mid-latitudes they are approximately 1° apart in latitude. Some 18 000 ionograms recorded at Woomera between September 1962 and October 1964 were available, but electron density profiles have been calculated only for those recorded at times and positions satisfying one or other of the following conditions.

(1) The sub-satellite point was within 1·5° of latitude of 40°S. geomagnetic latitude during the recording of the ionogram.

(2) The sub-satellite point was within 1·5° of latitude of either 20°, 25°, 30°, 35°, 45°, 50°, 55°, or 60°S. geomagnetic latitude during the recording of the ionogram, provided it was recorded at a time between either 0130 and 0430 hr L.M.T. or 1130 and 1430 hr L.M.T. These time intervals were chosen because they contained more records than any other three-hourly intervals that could be considered representative of night-time and daytime.

Only one ionogram was scaled for each latitude region from any one pass and, where more than one ionogram was within the latitude range, the choice was made largely on the suitability of the records for accurate scaling. Further restrictions on

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the data sample were that records must have been recorded during either June or December solstice periods and under quiet world-wide magnetic conditions ($K_p \leqslant 3^+$).

In this way the winter and summer diurnal variations of electron density and scale height at 40°S. geomagnetic latitude were obtained and also the latitudinal variations in summer and winter during the early afternoon and early morning hours.

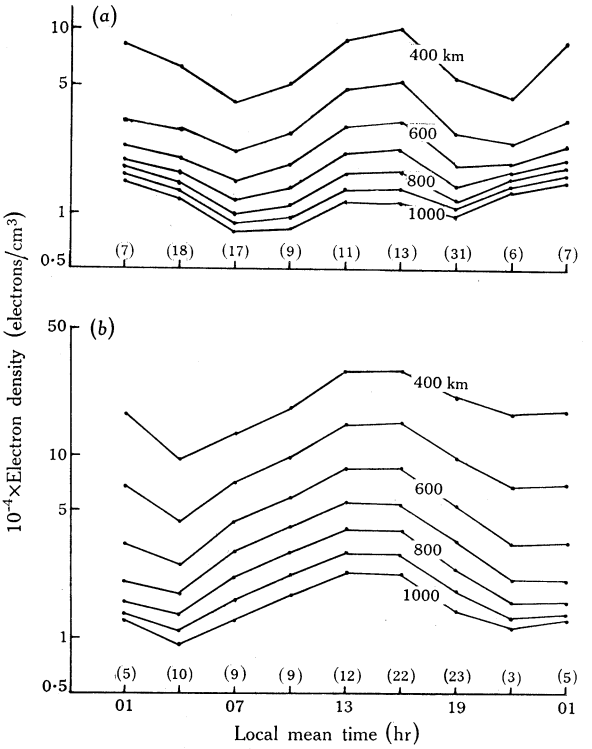

Fig. 1.—Diurnal variation of electron density in the topside ionosphere at 40°S. geomagnetic latitude: (*a*) winter; (*b*) summer.

II. Results and Discussion

The results of the analysis are shown in Figures 1–4. Figure 1 shows the diurnal variation of electron density at 40°S. geomagnetic latitude for local summer and winter, and Figure 2 shows the latitudinal variation of the electron density at 0300 and 1300 hr for both summer and winter. Figures 3 and 4 respectively show the diurnal variation of the plasma scale height at 40°S. and the latitudinal scale height variations during summer and winter at 0300 and 1300 hr. The points in these figures have been obtained by averaging over three-hourly intervals. The scatter in the values of electron density averaged to obtain each point was less than $\pm 50\%$. This seems reasonable considering that a time interval of 3 hr was used. The number of records from which each point in these figures was obtained is marked on Figures 1 and 2.

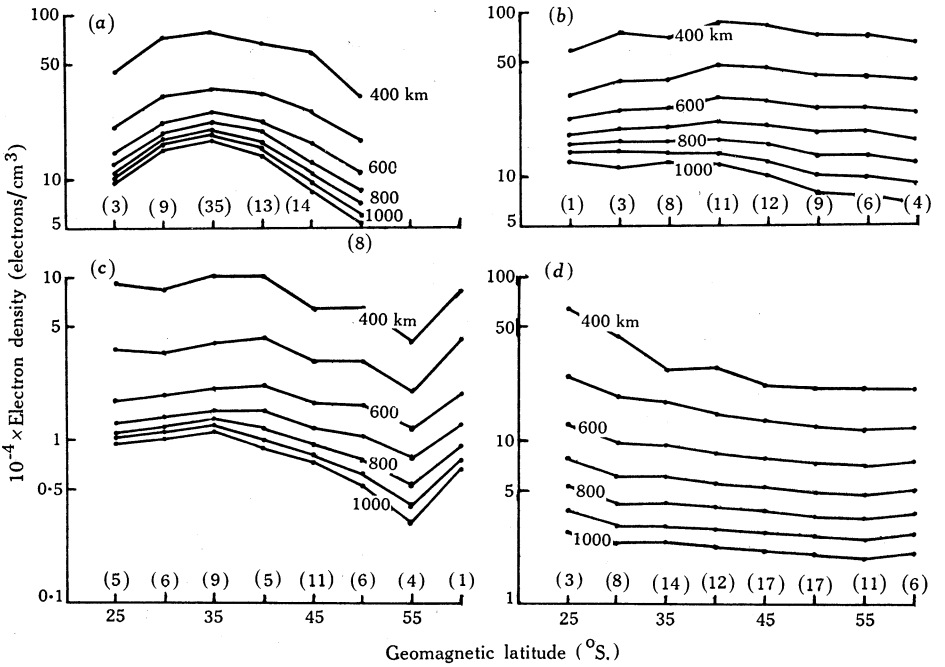

Fig. 2.—Latitudinal variation of the electron density in the topside ionosphere; for winter (*a*) 0300 L.M.T., (*b*) 1300 L.M.T. and for summer (*c*) 0300 L.M.T., (*d*) 1300 L.M.T.

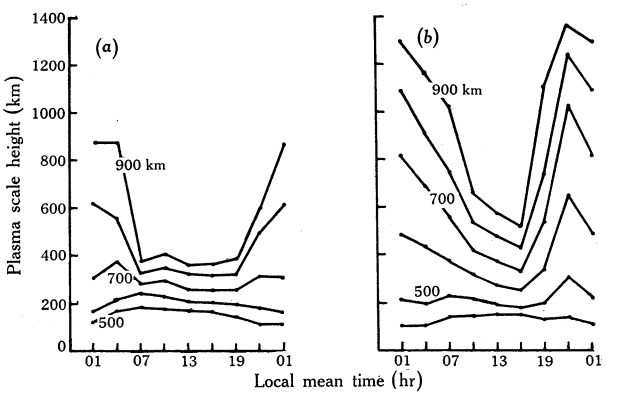

Fig. 3.—Diurnal variation of the plasma scale height in the topside ionosphere at 40°S. geomagnetic latitude: (*a*) winter; (*b*) summer.

(*a*) *Electron Density Variation*

The diurnal variations of the electron density at 40°S. (Fig. 1) show that the behaviour is considerably different from that expected for an ionized layer produced primarily as a result of photoionization by solar emissions. The main anomalies are that at night there is a maximum at midnight and that in daytime the maximum density occurs well after midday. This latter feature is widely observed in the

sub-peak ionosphere (Ratcliffe and Weekes 1960). Another anomalous feature is that the electron densities around midnight and above 700 km are higher during winter than during summer. This behaviour in the density has been observed at a height of 1000 km in the northern hemisphere (Thomas and Sader 1964). Such an anomaly

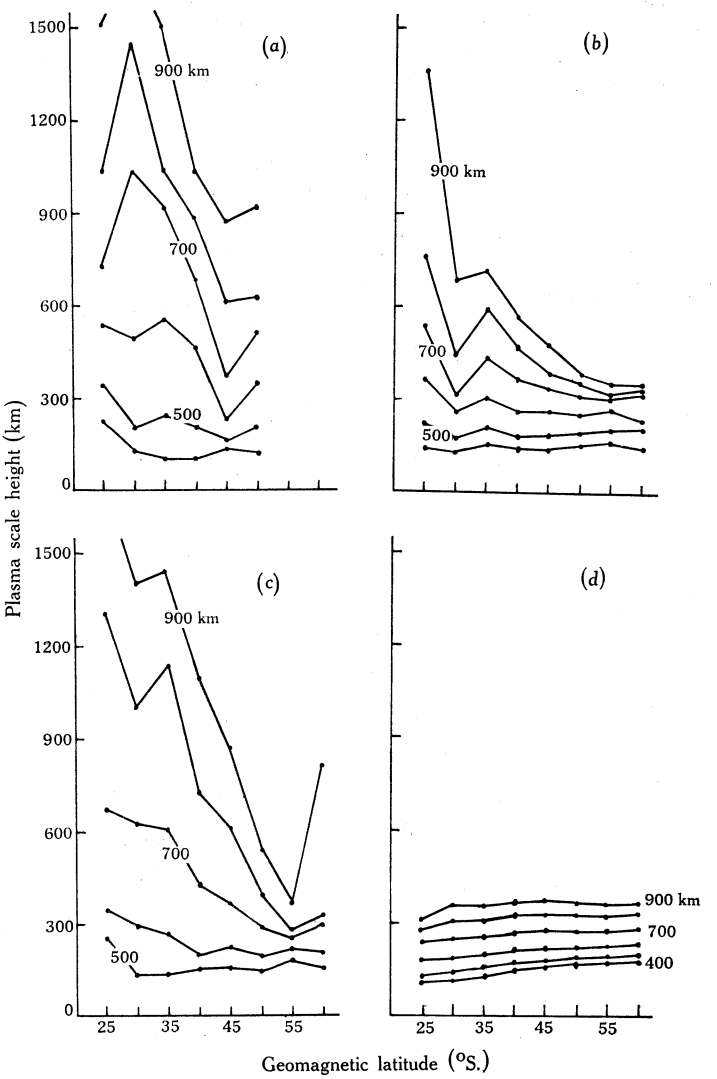

Fig. 4.—Latitudinal variation of the plasma scale height in the topside ionosphere; for winter (*a*) 0300 L.M.T., (*b*) 1300 L.M.T. and for summer (*c*) 0300 L.M.T., (*d*) 1300 L.M.T.

in the density has also been found to occur at the peak of the layer at moderate to high latitudes, particularly at sunspot maximum (Martyn 1959), but it is not observed at the layer peak in the data presented here. A further anomaly is that the winter night-time values of electron density are as large or larger than the daytime values.

An analysis for the mid-latitude northern hemisphere by Thomas, Rycroft, and Colin (1966) showed similar anomalous features.

These anomalies are also apparent in the day and night electron density variations with latitude (Fig. 2). A night-time increase in electron density in a region centred about 35°S. geomagnetic is particularly apparent during winter. During summer daytime there is a slight decrease in the electron density with increasing latitude. In winter daytime there is very little latitudinal variation.

(*b*) *Scale Height Variation*

At 40°S. geomagnetic latitude, the scale heights are larger during winter than during summer and, particularly at greater heights, the scale height increases at night (Fig. 3). Generally the scale height decreases with increasing latitude except in summer daytime, when there is little change in the scale height with latitude (Fig. 4).

From the plasma scale height values it is possible to deduce relative ion concentrations and electron and ion temperatures. Watt (1965) found that in the night-time northern hemisphere mid-latitude topside ionosphere, the transition level from O^+ to lighter ions (He^+, H^+) occurred at a height of 550 km in summer and 500 km in winter, and that 200 km below the transition level the ions are almost entirely O^+. It is probable that similar conditions exist in the southern hemisphere, since there is close agreement between the scale height observations presented here and those of Watt.

III. Acknowledgments

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IV. References

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