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Nighttime Electron Temperature at 500 km from Cosmos-900 Satellite on September 16-28, 1977

by

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Introduction

The results of electron temperature (T_e) measurements by a RF-electron temperature probe aboard the Cosmos-900 satellite for September 16-28, 1977, are given. Cosmos-900 was launched on March 30, 1977, into an almost circular (perigee 460 km, apogee 523 km) high-latitude (i = 83°) orbit. The satellite was fully stabilized with one of the axes directed along the velocity vector. T_e was measured with a plane differential RF-probe DET mounted together with a plane RPA PL-40A at the end of the velocity oriented boom. The technique of T_e measurements is given by Hirao and Oyama [1961] and Afonin et al. [1973, 1975]. A detailed description will be given elsewhere. The results below correspond to dark sections of the satellite orbits. This is because of the negative body potential of the satellite also measured by DET being lower than the lower limit of input impedance transformer ($R_{in} > 3\ 10^{10}\Omega$) linearity equal -6V.

Results

This paper is based on T_e measurement results for 36 nighttime ionosphere passes at an altitude 500 km for September 16-28, 1977. Most of the passes are given in Figure 1. The numbers on each curve are date (on the left), number of orbit (on the right) and UT, MLT and geographic longitude of the equator (in the middle). The points on the curves with values of L=5, 3, 2 and 1.5 both in the Southern and Northern Hemispheres are connected with dashed lines. All curves are aligned at L=3 in the Southern Hemisphere. The MLT values on each curve are almost constant with the exception of the ends of the passes, which occurred close to the magnetic poles (orbits 2608, 2609, 2654 and 2669). During some of the orbits the satellite passed all the specific ionospheric zones including the polar caps.

Figure 2 gives Kp and Dst values for the period of measurement. The vertical bars along the abscissa of the Figure indicate the passes under discussion. The ends of each curve in Figure 1 correspond to the shadow-light boundary intersections with the exception of orbits 2607, 2611 and 2654, the right ends of which are limited by the ends of the measurement runs.

The curves shown on the left and the lower curve on the right of Figure 1 describe T_e behavior during 24 hours on September 16, 1977, a day which was relatively quiet in accordance with Figure 2. The other curves on the right of Figure 1 were measured during a number of substorms September 19-28, 1977.

The main feature of T_e behavior on September 16 is the quiet, smooth shape of the curves. In low and middle latitudes T_e is remarkably stable and slowly rises from the Southern Hemisphere to the Northern one. For L=2, T_e values are 1200 K - 1400 K in the south and 1800 K - 2000 K in the north. In the L>2 region the T_e behavior is more complicated. There are always higher T_e values in the L=3-5 interval. Although in the lower part of Figure 1 T_e does not attain a maximum value, it starts to rise at L=2-2.5 for all passes in the Southern Hemisphere. A similar, although lower "amplitude", rise of T_e in the Northern Hemisphere is obvious on the passes which are symmetrical in L (see, for example, orbits 2600-2602). On passes 2604-2610 T_e decreases in the L=5-7 region and rises again in L>7 region, the main precipitation zone (auroral zone). As a rule, in a "gap" between the subauroral enhancement and auroral zone, T_e values are about the same as in middle latitudes before the subauroral enhancement, although they are in some passes 2-3 times greater (i.e., orbits 2608, 2610). On passes 2605, 2607, 2608 there is a polar cap depression in T_e values polarward of the auroral maxima. There are usually strong fluctuations of T_e poleward from the "gap".

On September 19 a sudden ring current intensity enhancement occurred which was not very strong (Dst=-90γ). This ring current continued until September 28 in a series of bursts. Pass 2648 occurred just before the storm and pass 2654 during the main phase of the storm. Before the storm T_e was strongly rising for L=3-5. Although the T_e is not evident from the curves it must be located at L≥5. During the main phase the T_e peak moved to L=3 and its width decreased drastically down to ΔL=0.3-0.5. On the next curve shown (pass 2669 on the next day) the T_e peak position was the same but its magnitude had increased. This increase seems to be a result of the next burst of the ring current intensity. During all the following passes when the ring current intensity was almost constant the T_e peak position was practically invariant. The start of the T_e rise was at L=2.5, and the peak width had increased. During pass 2775 an additional but lower magnitude T_e peak at L=2.2 is superimposed on the main T_e peak. This additional T_e peak is also evident on passes 2774 and 2776 (not shown in Figure 1). The lower L-values of the beginning of the T_e rise on passes 2777 and 2778 seem to be caused by this "midlatitude" peak of T_e.

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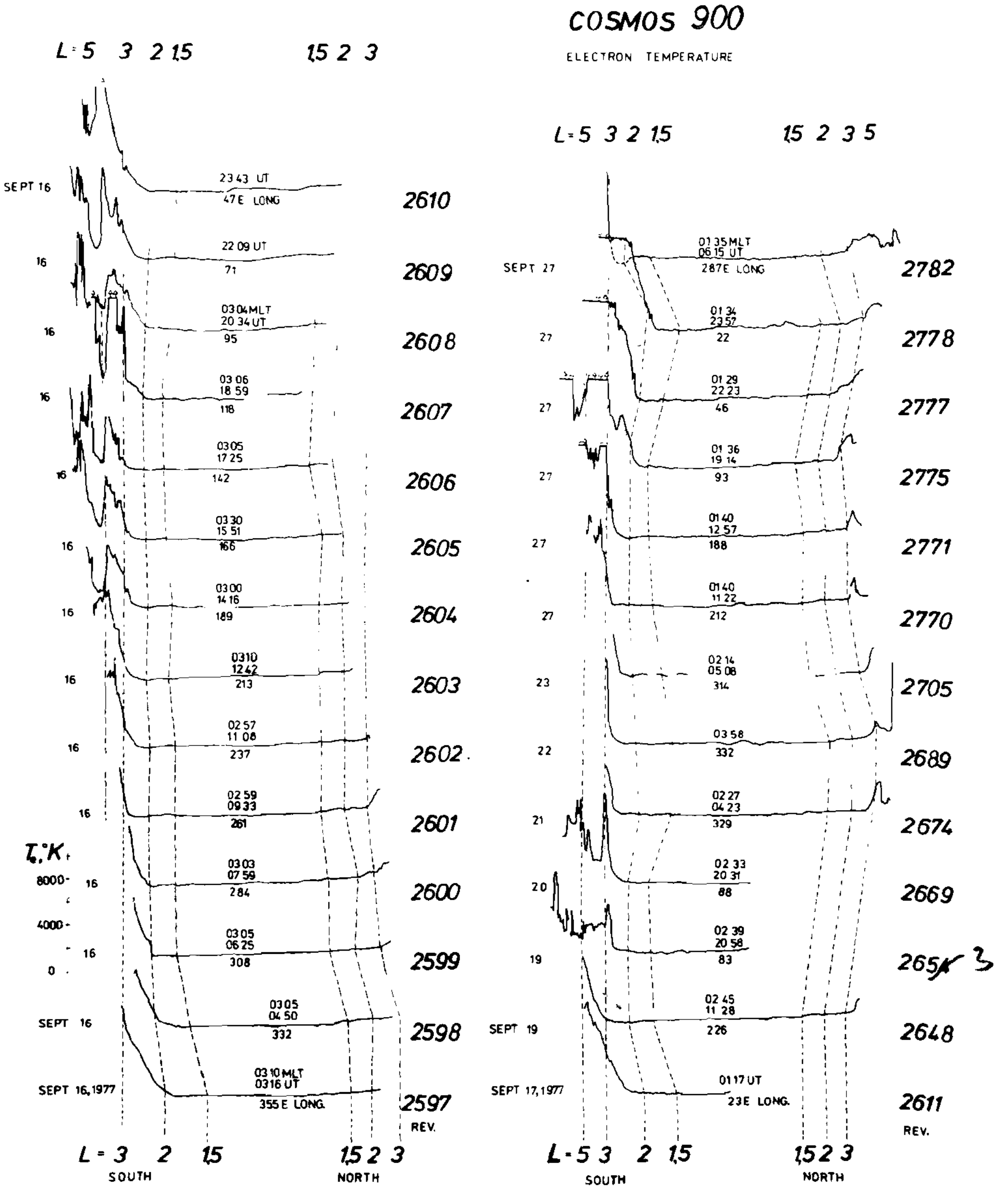

Fig. 1. T_e observed by Cosmos-900 on passes 2597-2782 from Sept. 16-27, 1977.

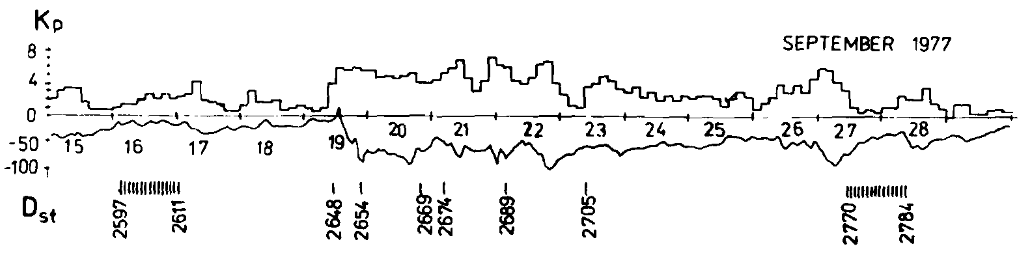

Fig. 2. Kp and Dst for Sept. 15-29, 1977 with times of passes of Cosmos-900 indicated.

Discussion

The above are the first published results on T_e from the Cosmos-900 satellite. The data must be analyzed in comparison with simultaneous data from the other experiments on the satellite, so this paper is mainly descriptive. However, the following features of T_e behavior should be noted.

The subauroral (in the region of the main ionospheric trough) T_e enhancements were observed mainly in disturbed conditions [Raitt, 1974 and Mayer and Chandra, 1975]; their presence during quiet conditions was noted [Brace and Theis, 1974 and Miller, 1970]. The subauroral T_e peaks are related to the often observed SAR-arcs in that latitude region, and the generally accepted mechanism of their occurrence is the energy transfer from the ring current particles [Rees and Roble, 1975]. The details of the mechanism are not fully understood. At least it includes ion cyclotron waves generated in the region where the ring current overlaps with the plasmasphere, the energy of which is transferred to the plasmasphere electrons through heat conduction to ionospheric electrons [Cornwall et al., 1971; Williams and Lyons, 1974; and Joselyn and Lyons, 1976].

The subauroral T_e peaks during quiet periods from the Cosmos-378 satellite and the Intercosmos-8 satellite were discussed by Afonin and Smilauer [1976] and Afonin et al. [1978], where it was shown that the peaks were observed not only in disturbed periods but almost continuously during quiet times; and that an after-effect of the isolated magnetic substorm in the plasmasphere was observed for five days. Afonin and Smilauer [1976] showed the marked role in the formation and maintenance of the subauroral T_e peaks played by the "hot zone" of the plasmasphere recently discovered by the Prognoz satellites [Gringauz and Bezrukikh, 1977]. Afonin and Smilauer [1976] also showed that the qualitative behavior and morphology of the hot zone coincide with the behavior of T_e in the ionosphere. In many papers (e.g. [Hulqvist et al., 1976]) it was shown that there is a maximum of the ion cyclotron wave growth rate in the L=2.7-4 region, i.e., in the region of overlap of the plasmasphere and the ring current. The data from Figure 1 for the quiet period (September 16) confirm this conclusion [Afonin and Smilauer, 1976] of the almost continuous presence of the subauroral T_e peaks, and support the ion cyclotron interaction of the ring current and the plasmasphere as the main cause of the subauroral T_e peaks. Figure 3 shows the simultaneously measured T_e and n_i values for pass 2654 during the maximum phase of the September 19, 1977 substorm; n_i was measured with the plane RPA PL-40A mounted close to the DET sensor on the same boom. Figure 3 shows that the position and the shape of the T_e peak correspond to the trough in n_i. Poleward of the trough and the T_e peak, the T_e values are about a factor of two higher than on the equatorward side and are strongly fluctuating. Poleward of the T_e peak this two-fold increase agrees with n_i increase as seen in Figure 3. The n_i values also strongly fluctuate in the region. This is where intense precipitation of the energetic particles seems to occur in the region.

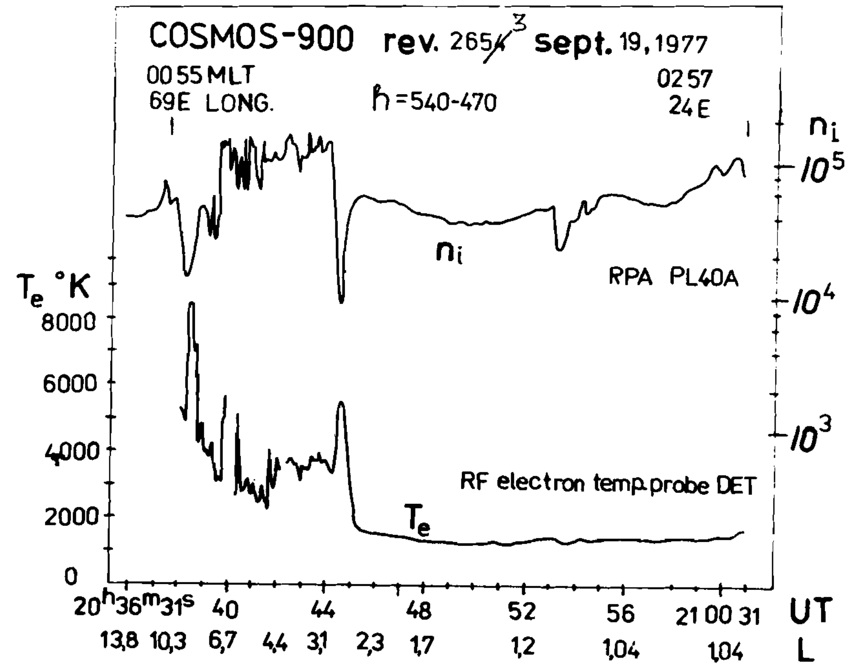

Fig. 3. T_e and n_i for Cosmos-900 pass 2654 during Sept. 19, 1977 substorm.

Without giving the details let us note that particular attention should be paid to the obvious "amplitude" asymmetry north-south during the period under discussion, and to the above midlatitude T_e enhancements at L=2.2. Relative to the former it should be noted that at the times of the T_e enhancement observations, the solar zenith angles were always greater than 110°; the magnetically conjugate heating cannot be responsible for the observed difference.

The midlatitude T_e enhancements were observed on the ESRO-1A, Explorer-31 and ISIS-2 satellites [Brace et al., 1974]. This phenomenon was specially considered by Smilauer and Afonin [1976] for the Intercosmos-14 data; **the anisotropy of T_e was also measured** on the satellite. According to Smilauer and Afonin [1976], during January 11 - February 2, 1976 strong (more than twofold) anisotropic T_e enhancments were observed on L=1.45-2.1 and h=1600-1700 km. The "amplitude" of these enhancements decreased with time. After a gap in the satellite operation until Feb. 24, 1976, this phenomenon was not observed. The most possible reason for these midlatitude T_e enhancements according to Smilauer and Afonin [1976] is the heating by the waves with frequencies of some hundreds of Hz generated in the equatorial region of the plasmasphere.

In conclusion we want to note that this experiment is a part of the ionospheric complex of instruments aboard the Cosmos-900 satellite which was designed and flown under the guidance of Prof. K.I. Gringauz, whose continuous and fruitful assistance is greatly appreciated.

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