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Plasmasphere electron temperature structures

I. Kutiev [a,*], K.-I. Oyama [b], S. Watanabe [c], T. Abe [b], A. Kumamoto [d]

[a] Acad. G. Bonchev str., bl. 3, Sofia 1113, Bulgaria
[b] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1, Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan
[c] Department of Earth and Planetary Sciences, Hokkaido University, Sapporo 060-0810, Japan
[d] Department of Geophysics, Graduate School of Science, Tohoku University, 6-3, Aoba, Aramati, Aoba, Sendai 980-8578, Japan

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Abstract

Inspection of electron temperature (T_e) profiles obtained by the thermal electron detector instrument along 5676 individual orbits of the Akebono satellite reveal the existence of localized structures with a latitude extent of 1–3θ. The analysis was constrained to the range $2 < L < 3.2$ in the northern hemisphere within the period 1991–1997. Eighty-seven well-defined structures were selected, containing a marked increase of T_e at least 20% above the background level. The electron density (N_e) and the wave intensity at the upper hybrid resonance frequency, recorded by the plasma wave and sounder instrument on the same satellite, were also used in the analysis. It was found that N_e troughs and an increase of the electrostatic electron cyclotron harmonic waves perfectly co-located with the T_e structures. The structures were observed at altitudes above 3000 km, as 70% of them are found between 03 and 08 h magnetic local time. While the plasma inside the structures is always warmer, the plasma pressure can be either higher or lower than outside.

Keywords: Plasmasphere; Electron temperature

1. Introduction

Many groups have shown the large variability of plasmasphere electron temperatures. Balan et al. (1996a,b) found a standard deviation of 1000 K around the average electron temperature T_e, at heights above 3000 km. Similar evidence was reported by Kutiev et al. (2002). They also revealed individual profiles of measured T_e along the orbit's frequently defined localized structures with a size of a few degrees latitude. These structures, containing in most cases an increase of T_e, were observed mainly in the inner part of the plasmasphere above 3000 km.

In the present paper we analyze these T_e structures obtained with the thermal electron detector (TED) along with the data from another instrument on board the Akebono satellite, the plasma wave and sounder (PWS) instrument (Oya et al., 1990), and reveal some of their main characteristics.

2. Data

The T_e measurement obtained by the TED instrument onboard the Akebono satellite was described in Abe et al. (1990). For the present analysis we collected a data set from a limited segment of orbit paths between $L = 2$ and 3 in the northern hemisphere, covering the years 1991–1997. This region of space, bounded with a green line, is shown in Fig. 1 on the background of a contour plot of the noon T_e distribution, generated by the Akebono T_e model (Kutiev et al., 2004). We consider that the bounded zone represents the inner

* Corresponding author. Tel.: +359 2971 3025; fax: +359 2971 3005.
E-mail address: ivan.kutiev@geophys.bas.bg (I. Kutiev).

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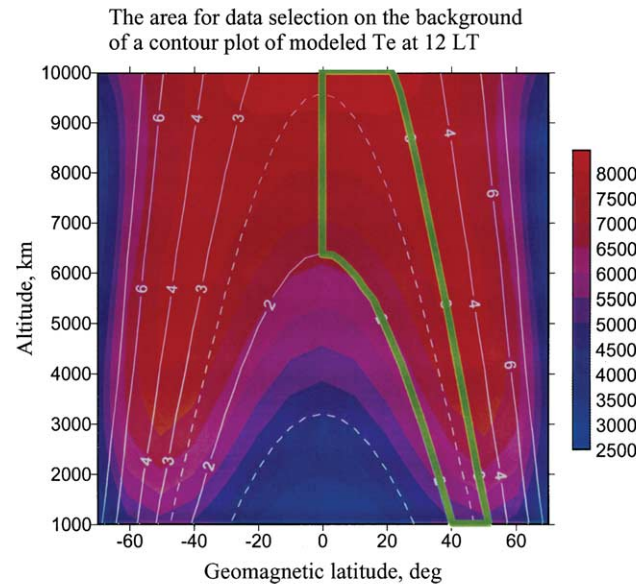

Fig. 1. The green line bounds the zone from where the T_e structures are extracted. The background is a contour plot of noon T_e distribution, generated by the Akebono T_e model.

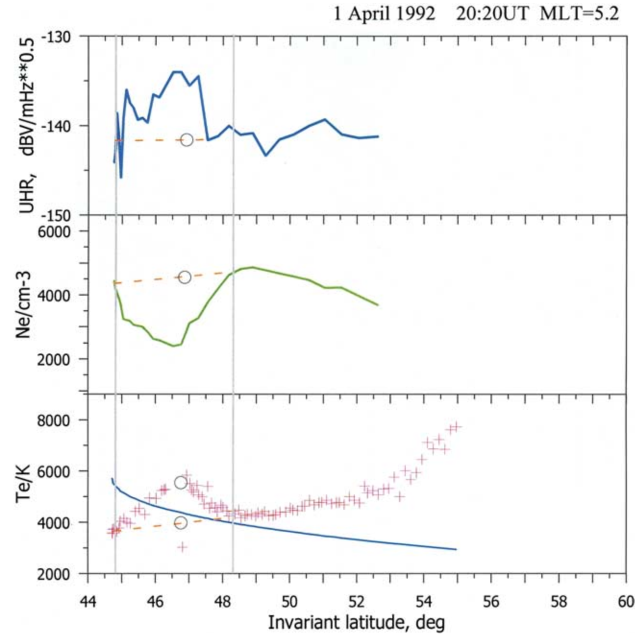

Fig. 2. T_e (red crosses, bottom), N_e (green line, middle) and UHR intensity (blue line, top), measured around 20:20 UT on 1 April 1992. The T_e structure is bounded by two vertical gray lines. The satellite altitude is shown in the bottom panel with the same scale as T_e. The brown dashed lines represent the assumed reference levels and the open circles mark the values at which the structure is evaluated.

plasmasphere conditions, outside the equatorial region. The altitude range is from 1000 to 10,000 km. The modeled contours show that T_e in the bounded zone increases with latitude at all altitudes, but does not reach, on average, the maximum of T_e crests, that project down to the main ionospheric trough. Under these constrains, we manually checked 5676 profiles for localized T_e structures. Such structures are shown by red crosses on the bottom panels of Figs. 2–4. They have a latitude width of 1–3θ ($\Delta L = 0.1$–0.3 at these latitudes) and a T_e peak that exceeds, by at least 20% the background value.

Fig. 2 shows a typical increase of T_e towards the plasmapause. As noted by Abe et al. (1990), when the plasma density decreases below 1000 cm^{-3}, the measured T_e is usually overestimated, due to the low current to the probe collectors. So, the poleward increase of T_e in Fig. 2 is partly due to the increased thermal heating and partly to the decreased plasma density in the outer plasmasphere. This uncertainty in determining T_e beyond $L = 3$ is the reason our study is limited to that L shell. From the collected data set we selected 87 cases similar to those presented in the figures.

The upper two panels in Figs. 2–4 show data recorded by the PWS instrument. The upper hybrid resonance (UHR) intensity is defined as the maximum intensity within the range 0.75 to f_{UHR}, where the UHR frequency, f_{UHR}, is determined by tracing the trend of the UHR emission in PWS spectrograms. Therefore, not only UHR but also $n + 1/2$ electron harmonic waves, or electrostatic electron cyclotron harmonic (ESCH) waves, can be included in it. N_e is determined by f_{UHR} and electron cyclotron frequency. The latter is derived from the DGRF/IGRF model (Tsyganenko et al., 1987). The top two panels represent the f_{UHR} intensity and the plasma wave N_e derived from it. It has to be noted that TED data also provides N_e. The estimated N_e, however, may include a relatively large error because determination of the space potential

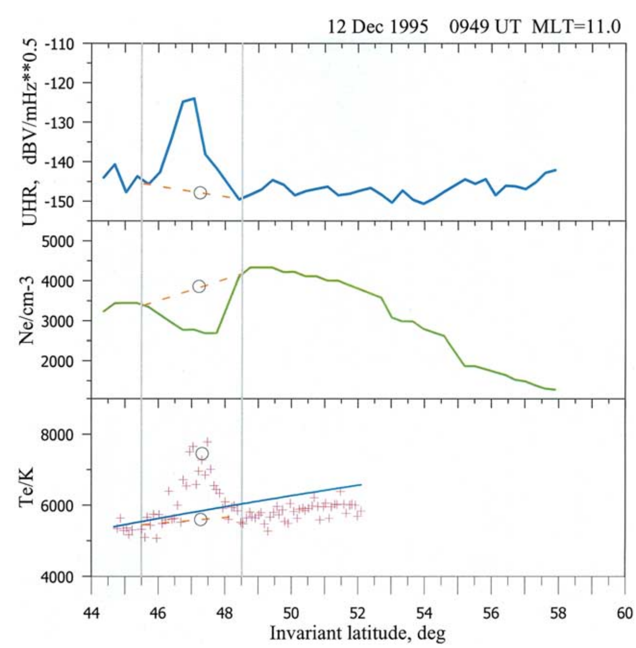

Fig. 3. The same as in Fig. 2, but for the structure observed on 12 December 1995.