COMPLEX PHOTOMETRIC, INTERFEROMETRIC AND IONOSPHERIC MEASUREMENTS IN THE SAR-ARC OBSERVATION REGION

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Data of complex optical and ionospheric measurements in the region of SAR-arc are presented. Photometric and interferometric observations were carried out at station Maimaga (Φ_C~56.5^o, Λ_C~200^o) and vertical-incidence ionospheric radio soundings were made at station Yakutsk (Φ_C~55.6^o, Λ_C~200^o) and Zhigansk (Φ_C~61.2^o,Λ_C~195^o).

The spatial position and intensity of SAR-arcs were monitored by a meridianal scanning photometer. The neutral component temperature was recorded with the help of the Fabry-Perot interferometer, having the field of view of 2^o and directed at the zenith angle of 10^o southward; the exposure time varied from 15 to 30 min. The results have shown that temperature increasing in arc correlates with the total intensity maximum . It is indicative of the relationship between the temperature and ionospheric heating in the region of SAR-arcs.

The ionospheric data of observations indicate the appearance of $F3_S$ -reflections at the time of SAR-arc observation in the vicinity of the zenith of the vertical-incidence radio sounding station. Experimental results suggest that the SAR-arc localization region is able to give rise to physical processes, typical of the polarization jet phenomenon, i.e., a rapid westward plasma drift, and by the presence of a northward directed electric field.

Introduction

The neutral gas temperature within and in the near vicinity of an SAR-arc has been measured by Roble et al. [1] and by Hernandez [2]. The temperature was determinated by measuring the Doppler broadening of the 630.0 nm emission line with a high resolution Fabry-Perot interferometer. Roble et al. [1] found no measurable temperature increase (<75 K) within the SAR-arc compared with the region outside the arc. It is was revealed an indirect evidence of Cole thermal conductivity hypothesis [3]. However, Hernandez measured a 100 K temperature increase in SAR-arc. Okano and Kim [4] measured a temperature increase of 200 K about 2.7 h after the appearance of the arc. Watanabe and Kim [5] report that the temperature enhancement within the arc is approximately 200 K and 100 K. From the above it follows that the model of thermal conductivity is required to be cleared up [5].

In paper [6] it is shown that electron temperature peaks reach T = 3000-5000 K at altitudes 400-900 km of ionosphere subauroral F-region that is typical for values T in the SAR-arc region. Electron temperature peaks are very often accompanied by narrow electron concentration trough which are explained by the local enhancement of meridianal electric field and rapid ion drifts to the west near the plasmapause ionospheric projection (polarization jet) [7,8]. The polarization jet effect on the vertical sounding ground-based ionograms is registered in the form of typical trace of $F3_s$ reflections [7].

In the present paper the SAR-arc location and intensity are compared with the ground-based interferometric and ionospheric measurements.

Photometric and interferometric measurements

It has been carried out the comparison of spatial location and intensity of SAR-arc with ground-based interferometric measurement of Doppler temperature of neutral atmosphere component and thermosphere altitudes in the st.Maimaga zenith region [9].

The neutral atmosphere temperature measurements have been carried out using Fabry-Perot interferometer with photographic registration. To decrease exposure time of interference picture the display brightness amplifier electron-optical transducer has been used [10]. The main technical features of interferometer are: the light hole diameter is 50 mm, the mirror surface reflection coefficient is 87-92%, the free spectral interval is 0.0198 nm; the registered emission is 630.0 nm; the visual angle is 2^o. The observations have been carried out at zenith angle 10^o in the southern part of firmament, the exposure time is from 15 to 30 min.

The simultaneous photometric and interferometric measurements have been carried out during five events of SAR-arc appearance (2.12.89, 3.12.89, 4.12.89, 25.02.90, 21.03.90). Fig.1 presents the spatial position of SAR-arc projection for the altitude 450 km, its intensity and temperature during the observation period December 2, 1989. Crosses show the hourly values temperature of monthly average for magnetically quiet conditions ($\Sigma Kp \leq 18$; F=188.3 is the mean value for the below-mentioned years) obtained by the measurements of night 630.0 nm emission Doppler broadening in 1980-1982 at st. Maimaga [10]. If to suppose that the undisturbanced thermosphere temperature measured by 630.0 nm line reflects exosphere temperature then one can use it for the comparison with the observed temperatures during SAR-arc existence periods. Under quiet conditions the temperature is varied little during a night and average level is 1000K.

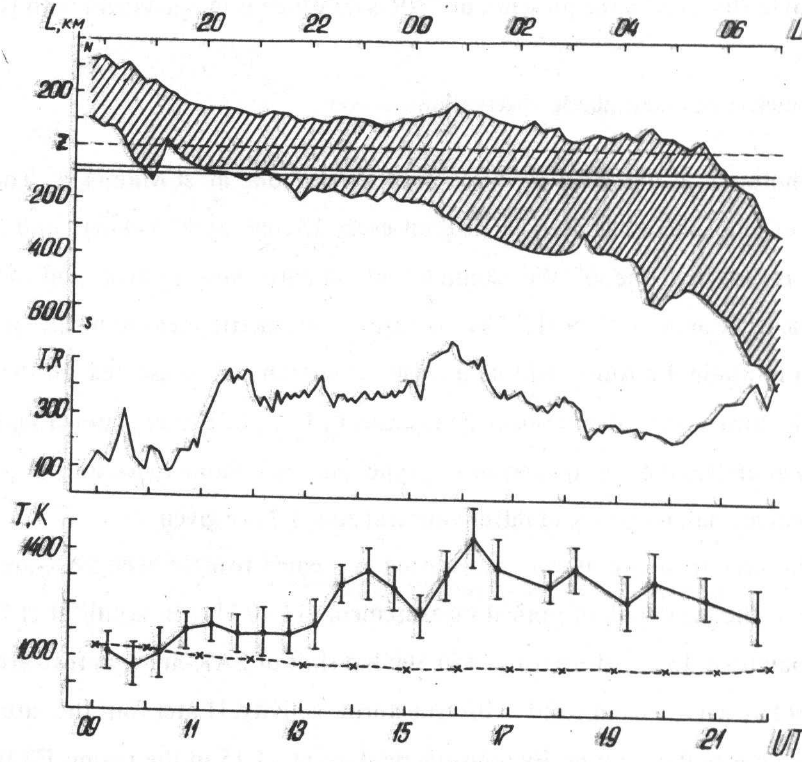

Fig.1. Projection of latitudinal position of SAR-arc relative to zenith of the st.Maimaga (Z) by photometric data (N - north, S - south, UT - universal time, LT - local time). Non-cross-hatched bend is a sky region where temperature measurements were carried out. Crosses are the hourly values of monthly average temperature under magnetoquiet conditions [10].

In the Fig.1 the SAR-arc was in the interferometer field of vision from 10.50 to 21.30 UT. About 11.30 the arc intensity increased up to 450 R and that high level remained till the end of observation. Maximum value of intensity reached 570 R. The temperature variations in SAR-arc were considerable (from 1100 to 1450 K). The average temperature in the indicated time interval was 1240 K that is approximately higher by a factor of 240 K of monthly average temperature observed under quiet conditions at SAR-arc absence. In the given case the delay between the time corresponding to the sharp intensity enhancement in the arc, (11.30) and the time of the temperature increase was observed (13.45) which was about 2 hours.

Thus, the observation results provide reasons to associate the thermosphere heating at subauroral latitudes with the presence of SAR-arcs which is in agreement with [4,5].

Photometric and ionospheric observations.

The photometric observations have been carried out at st.Maimaga, The vertical sounding of ionosphere has been carried out every 15 min. at st. Yakutsk and Zhigansk. In Fig.2 is set out one of the examples of simultaneous optical and ionospheric measurements March 5, 1989 [12]. The data of photometric measurements of SAR-arc projection latitudinal position and its intensity variations are presented. In the low part of Fig.2 the measurements of critical frequencies f_0 $F3_s$, f_0 $F2_s$ are shown and the time interval radio reflection registration of $F3_s$ type and the oblique reflections at st.Yakutsk from the equatorial boundary of diffuse auroral zone F2 are given.

The photometric observations have started in evening twilight. The SAR-arc has been registered at the beginning of optical measurement (11.20 UT) in zenith at st.Maimaga. Approximately by 13 UT there was a 150-200 km shift of SAR-arc equatorward with the airglow enhancement connected with substorm activity. Later on the arc did not practically change its location. By ionospheric data at 11.15 in the region F2 the critical reflection frequencies abruptly decreased from 6.8 to 3.8 MHz and traces of $F3_s$ - reflections appeared. From 11.30 till 13.15 there is smooth decrease of critical frequencies f_0 $F3_s$ and f_0 $F2_s$ and to the moment of appearance 13.15 on ionograms of the oblique reflections from the diffuse auroral zone. The $F3_s$ - reflection traces fuse with traces of regular reflections from the F2 region. During the rest part of night the st.Yakutsk was in the ionization trough, near its polar edge.

The detailed comparison of SAR-arc development and ionospheric measurements was considered for 23 separate events. In 18 events during SAR-arc on the vertical sounding ionograms the $F3_s$ reflections were registered. As a rule, the duration of observation time of $F3_s$ traces is considerably less of the arc existence time. At the f_0 $F2_s$ change in daily variation the critical frequency of F-region decrease, the traces of anomalous and regular reflections fuse. The critical frequencies of reflections from F region in this time are turned out to be lower of their values for undisturbed days.

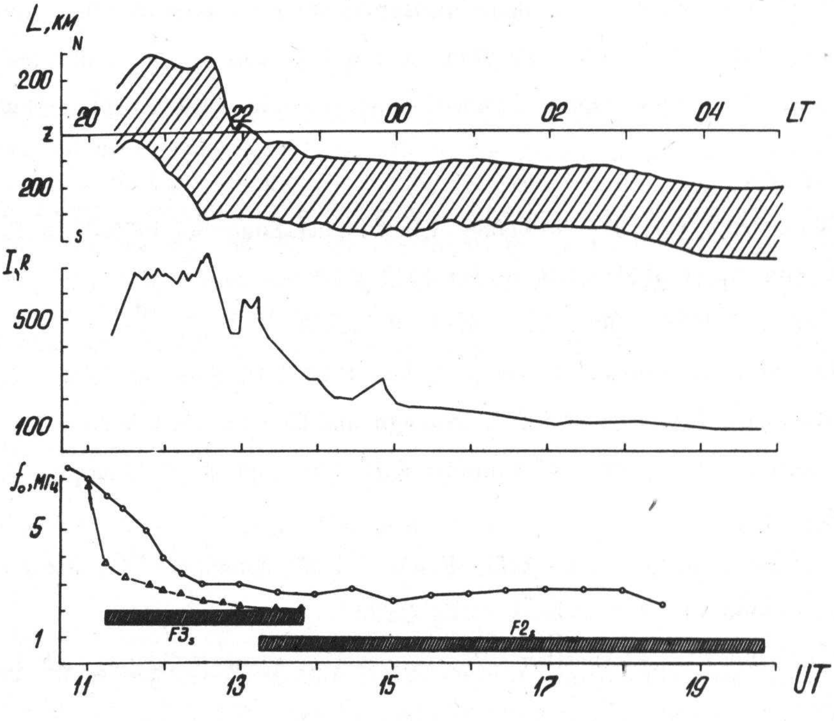

Fig. 2. The spatial projections of latitudinal position of SAR-arcs. Below there are the intensity variations of SAR-arc and the measurements of critical frequencies f_0 $F3_s$ (triangles) and f_0 $F2_s$ (small circles), cross-hatch lines - the time intervals radio reflection registration of $F3_s$ type and the oblique reflections $F2_s$ at st.Yakutsk. (05.03.89).

Conclusions

By optical and ionospheric SAR-arc measurements are obtained following results: -

1. During the observation period of SAR-arcs the thermospheric temperature noticeably rises (200-400K) both in the inside and in the vicinity of arcs.

2. Temperature of neutral component is higher in the region of SAR-arcs with higher intensity. There is a functional relation between these parameters.

The heating of thermosphere in SAR-arcs can be explained apparently, by the joint action of heat in flow from the magnetosphere along field line into the SAR-arc localization and frictional interaction of ions whose movement is caused by the electric fields of magnetospheric origin with the atmospheric neutral particles.

3. By photometric and ionospheric measurements it is shown that in the registration region of SAR-arc the radio reflections of $F3_S$ type can appear connected with the phenomena of rapid polarization jet and the presence of the electric field northward.

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