Sporadic E-layer and Powerful HF-Radio Emission

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***Abstract*—Powerful HF radio emission to the Earth's ionosphere can be a reason of complex phenomena, which leads to the generation of artificial ionospheric turbulence. One of the most important components of turbulence is artificial ionospheric irregularities with a transverse dimension from a fraction of a meter to ten or more kilometers. The investigations of their spectral and dynamic characteristics makes possible to study the instabilities properties caused by the powerful radio wave and to study the features of dynamic processes in the ionosphere, and also to determine the possible influence of artificial irregularities to the different ranges radio waves propagation. Therefore, in August 5 2010, a heating experiment was carried out at the SURA heating facilities. The experiment was carried out during evening hours. Observation of generated irregularities occurred at a distance 170 km from the SURA facility at the observatory of Kazan Federal University (near Kazan) with ionosonde Cyclone. The control system of the ionosonde was set to the fast mode of ionograms recording (1 ionogram per minute), which made it possible to observe variations in the amplitude of reflections from the sporadic E-layer (Es). These variations look like synchronous with the heating time. A possible mechanism of the observed effect is discussed.**

Keywords—ionosphere, sporadic E layer (Es), ionosonde, SURA heating facilities

I. Introduction

The study of the sporadic layer E is an important task, and information about its variations is of a large applied nature in the region of radio wave propagation up to the gigahertz range. The sporadic layer E is a plasma formation with a high electronic content and is formed at altitudes of 90-140 km. The main reason for the origin of the Es-layer is the theory of wind shear [1],[2]. Well informative investigations of Es -layers are radar observations due to high emitting powers (for example, [3]), as well as the method of partial reflections on artificial periodic irregularietis [4]. High information in the study of the Es-layer using network ionosondes can be achieved with a sufficient rate of recording ionograms [5]-[8]. Thus, in the Kazan Federal University the Cyclone ionosonde digital control system improved to record ionograms at 1 minute intervals, and the new control system began to operate from February 2010. To analyze this data flow, new forms of ionospheric sounding visualization are needed, some of these forms are presented in [8]-[10]. To visualize the ionosonde cyclone data, the summary maps of the ionosphere state (A-, H-, As-maps) [8] were developed, which allowed to detect variations of the amplitude of reflections of Es-traces in ionograms during an experiment with powerful HF radio emission with the SURA heating facility.

II. Variations of the Es-Traces Amplitudes in Ionograms

The experiment was carried out in the evening by transmitters with powers of 160 kW. Radio waves were emitted at a frequency of ~ 4.8 MHz with a repetition frequency of 15 seconds and pulse durations of 20 ms and they had an extraordinary polarization. The observation of the irregularities took place at a distance of 170 km from the SURA facility at the Observatory of Kazan Federal University with ionosonde Cyclone. When processing the ionosonde data the H- (heights map of the amplitudes maxima locations - Fig. 1.a.) and the A-map (the map of the amplitudes maxima - Fig. 1.b) were first analyzed. The H-map accurately shows the critical frequencies due to the chaotic location of the amplitude of noise relative to the height, and the A-map in addition to the critical frequencies shows amplitude variations information, but low-amplitude reflections from the layers of the ionosphere merge with industrial noises, which often blank high-amplitude useful signals (it can be seen in Fig.1.b. in the form of brown-red horizontal stripes). During the heating experiment 21:30–22:40 LT (or 1290-1360 minutes of the day), when the emission of the SURA facility was performed every two minutes with a duration of 1 minute, the A-map analysis showed sharp alternating amplification/attenuation of the amplitudes on the traces of the Es-layer. This can be seen from the enlarged fragment of the A-map in Fig.2. in the time range ~ 1290-1345 minutes. The signals of the SURA facility are noticeable as dark red lines in the frequency interval (4.5–5.2 MHz).

The detailed analisies of the described heating interval ionograms a stable trace Es is observed at an height of ~ 110 km during emmiting, as can be seen in Fig. 3 (left and right), when the emmiting is absent, the Es-trace is weaker. Namely the reflection amplitude is lower and the duration of the reflected pulses are short, i.e. looks like an almost disinteg-

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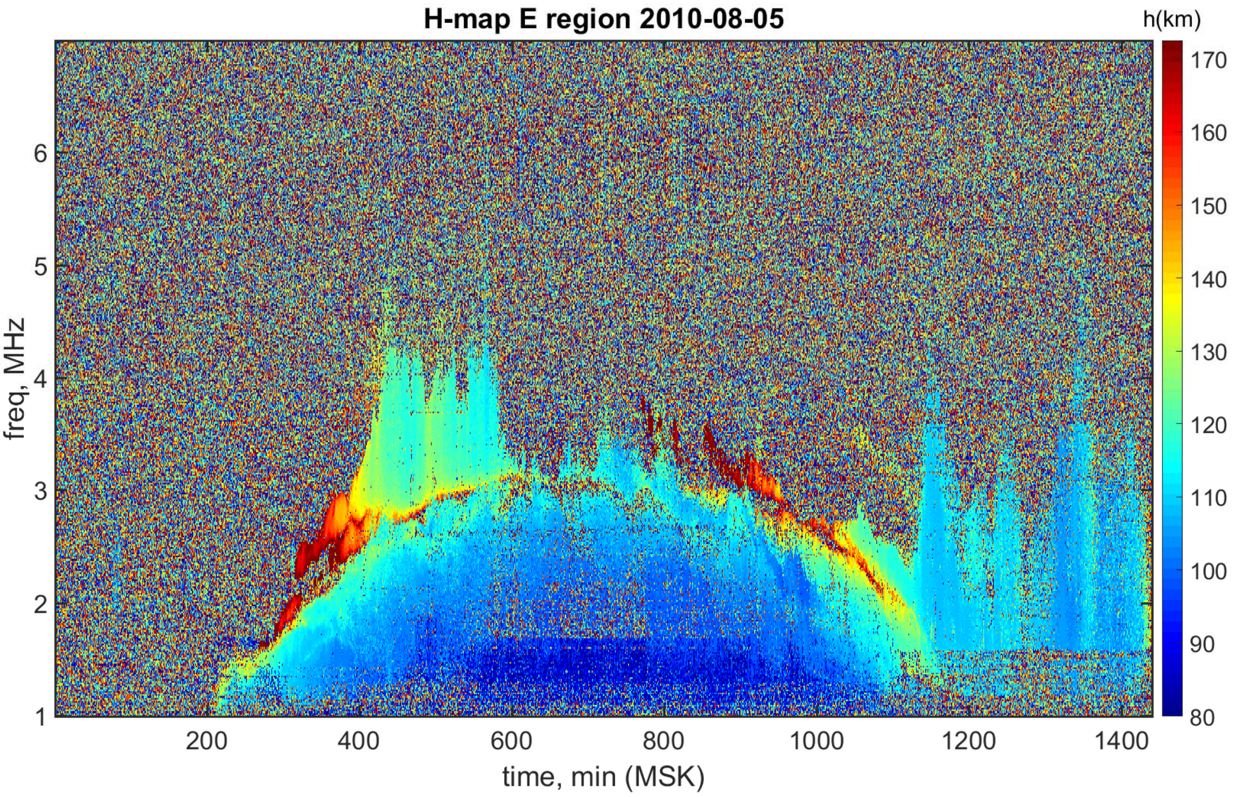
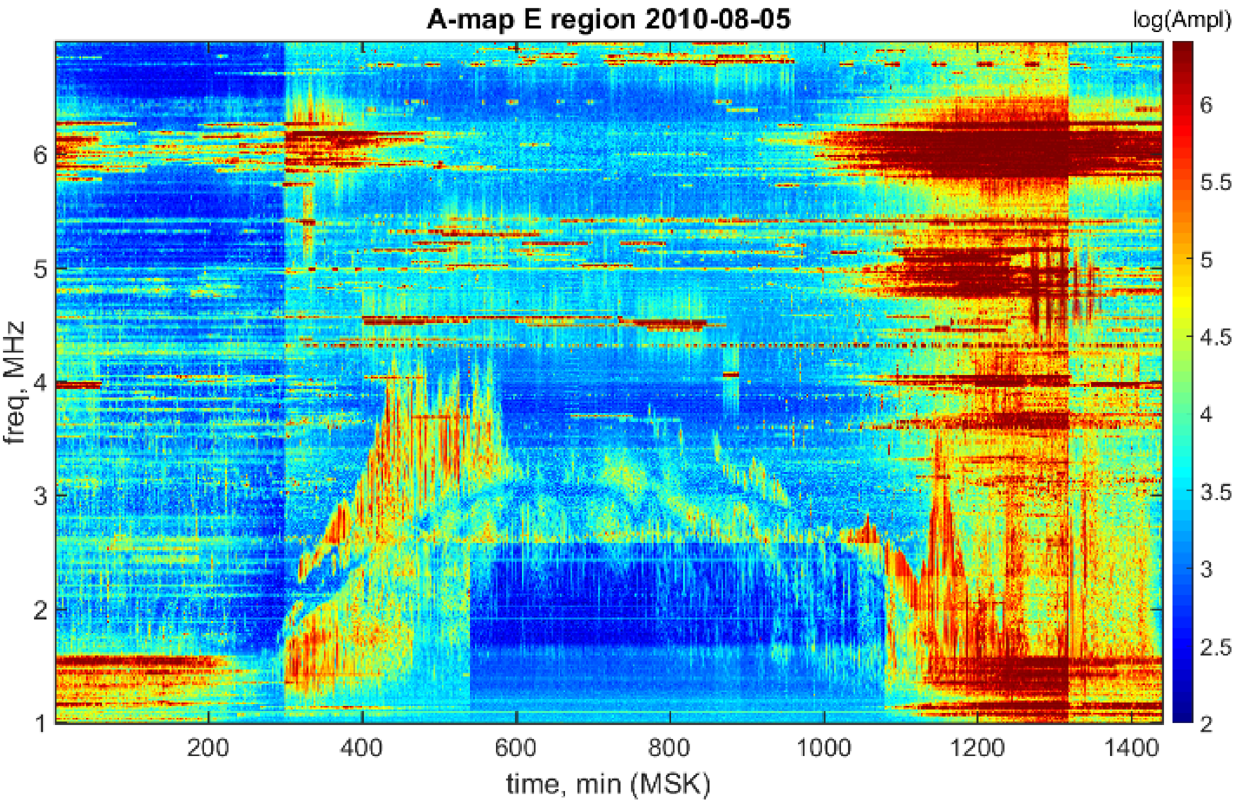


(a)



(b)

Fig. 1. a) H-map and b) A-map of the E region of the ionosphere.

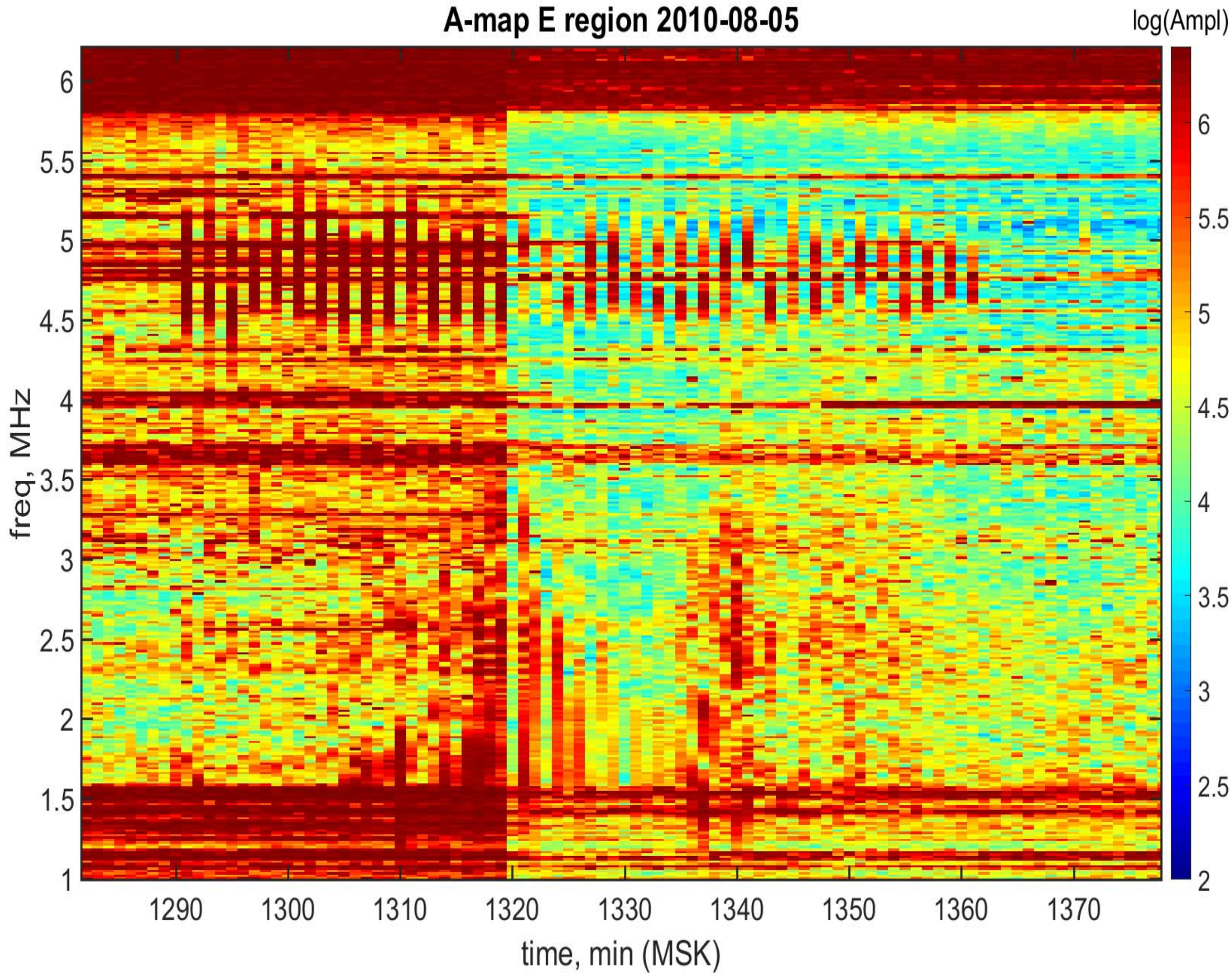


Fig. 2. Enlarged fragment of the A-map of the ionosphere E region.

rated trace (Fig. 3 - ionogram in center). Note that in this time interval, in the F layer traces , such amplitude modulation is not observed. When Es traces are diffuse (time intervals ~ 1290-1315 and ~ 1337-1360 min) such modulation of amplitudes from the ionogram to ionogram is observed in a weaker form, and outside the interval of the heating period the Es-traces ampletudes modulation is absent.

III. Conclusion

Sporadic Es layers investigations have been carrying out on for many decades, and particular interest is the influence of powerful HF radio emission to the Es-layers.

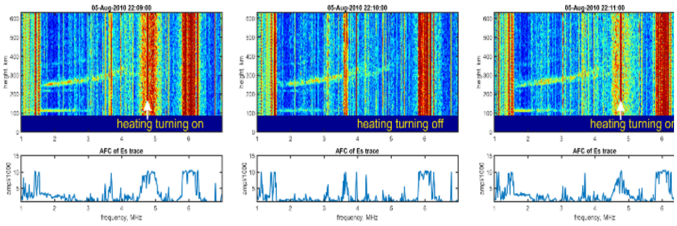


Fig. 3. An example of a sequence of ionograms showing the modulation of the amplitude of reflections from the Es-layer under the influence of high-power HF radio emission.

This work shows one of the rare features of the effect of radio emission from the SURA test facility on variations in the amplitude of reflections from the sporadic E layer during vertical sounding. This effect was detected due to the 1-minute rate of ionogram registration.

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