Transient Es-layers 2013-2014

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Abstract

The paper describes the statistical investigation of short-lived traces (look like Es), which was performed using the A, H-, and A_Σ-maps. These maps were obtained by ionogram treatment with high time resolution (1 ionogram per minute) for 2013-2014. The observed results of such Es occurrence statistics have a similar variation with some meteor showers activity peaks.

Keywords—ionosphere; ionosonde; sporadic E-layer; transient Es; meteor indused layers

1. Introduction

Ionospheric sporadic E-layer investigation is carried out for many decades with various types of instruments (ionosondes, incoherent scatter radar, rocket methods and other.). A lot of information about this layers accumulated by ionosondes measurements. Es-layers most often appear in the height range of 100-140 km and it appearance is random. Most likely such layer appear in the spring and summer months [1].

Often, from the first appearance in ionogram, the Es-layers do not have a high critical frequency, which increases over time and in the last minutes of the lifetime critical frequency decreases to the total absence of reflections. The lifetime of such "traditional" sporadic E layers varies from a few minutes to several hours.

However, some of Es-layers are little studied and have distinctive features of appearance from the "traditional" Es-layers. Such features include sudden appearance with large critical frequency, extremely short lifetime of ~ 1 (except in rare cases with lifetime up to 40 minutes), and significantly weak amplitude reflections. These layers are called transient or transitory Es [2] (example shown in Fig. 1). The name follows from the fact that the given Es is similar to the "usual" persistent Es layer and have a lot of properties look like echoes from meteor trails. Ionograms transient traces do not correspond fully to Es-layer traces or to the reflections from meteor trails. However, for definiteness, we will stick to the term of transient Es-layer, causing its resemblance with the "traditional" Es-layer in ionograms.

Distinctive characteristics of transient Es-layer is a high critical frequency (> 5 MHz) without clear features of o- and x- polarization; constant height without any frequency dispersion (cusp) in the beginning or in the end of the trace (as "l" and "f" Es-type layers).

One of the reason of the small study of this phenomenon is not sufficiently high rate of ionograms registration in network ionosondes (usually it is 1 ionogram per 15 minutes). The required rate (1 ionogram per minute) was performed in very rare cases, only for special experiments, such as, for focused relation study of transient Es-layers with meteor showers [2; 3 and references therein]. These studies showed that during strong meteor showers, the transient Es-layers are observed simultaneously in a large height range (100-250 km) and with the high occurrence frequency (1600 echoes for 14 hours) in all four widely separated Japanese ionosondes. However, in non-meteor shower time the transient Es-layers occurrence frequency is reduced (400 echoes per 88 hours) and any correlation disappear in the results of transient Es-layers observations in various ionosondes.

2. Experimental methods and equipment

To study the transient phenomena in the ionosphere from February 2010 measurements near Kazan are performed using ionosonde "Cyclone" in 1 minute mode. Therefore the opportunity studying of the transient Es statistics appear.
From a processing perspective our transient Es-trace reminds Es-trace of type f (flat), not having cusps or at the beginning or at the end. In most cases, it appears below the E-layer about 100 km, and therefore it can be referred to the type of l (low). Distinctive features of transient Es-layer is the small amplitude of the echo and short lifetime. Given the similarities of stable Es with transient Es-layers means that the specified technique for allocating Es-layers can changed.
To improve the reliability of this research the searching was in several stages of testing using all information provided by the A-, H-and A_Σ-maps (see Fig. 2), without viewing the entire stream of ionograms. Given that the researched by us trace reminds persistent Es layer, it does not require significant processing of A-maps for accounting transient Es. Because the transient Es has a short lifetime and a weak amplitude, it is not always be seen at such maps. Work with only one map can cause the skip Es-trace, and only working with three maps can reduce mistake to a minimum. Additionally, to reduce mistakes A-

and AΣ-maps were marked contrast, which greatly facilitates efforts.
In the first stage of processing the simultaneously A-, H- and AΣ- maps plotted. At the second stage the circles marked at A-, H-maps, showed signs of transient Es (at the limiting frequency). Third at the AΣ-map such Es appears like concentrated dark dot, which is a sign of its height location. For transient Es, to illustrate, the some typical points are marked with the dashed arrow at all three maps in Fig. 2 (paper sizes do not display the transient Es variations in detail so in this paper the result shown for half a day).

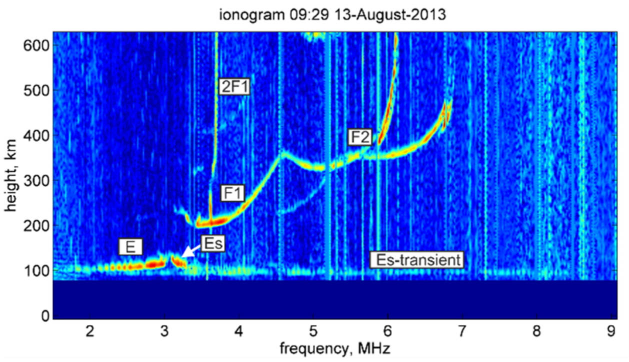

Figure 1. Example of ionogram with marking regular layers of the ionosphere and transient Es.

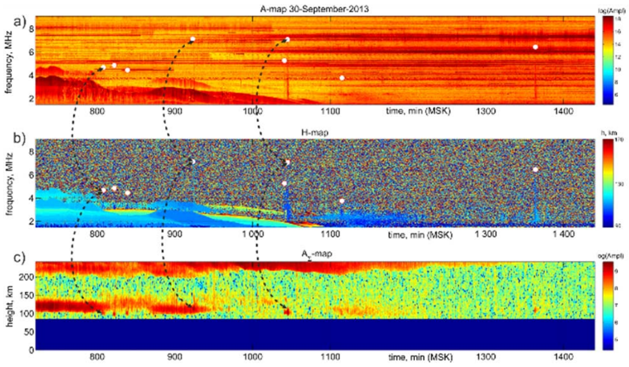

Figure 2. Example of interactive processing for transient Es allocation: a) A-map, b) H-map, c) AΣ-map. Circles marks transient Es and/or their critical frequencies. To illustrate, the arrows mark some signs of transient Es identical in all maps.

3. Data Analysis

To get the basic occurrence features of transient Es-layers the informative figure was firstly plotted in the form of dots in the day time/day number axis. The first feature of the transient Es occurrence tendency is appearence in the daytime before sunrise and after sunset (see. Figure 3 c and d). The second feature is the increase of transient Es total number of occurrences per day during peaks of known meteor showers (see. Fig. 3a and b). Annual variations of transient Es appearance frequency form a third characteristic feature. In the beginig of the year appearance has a significant minimum (from middle winter to end of spring), both for 2013 and 2014.

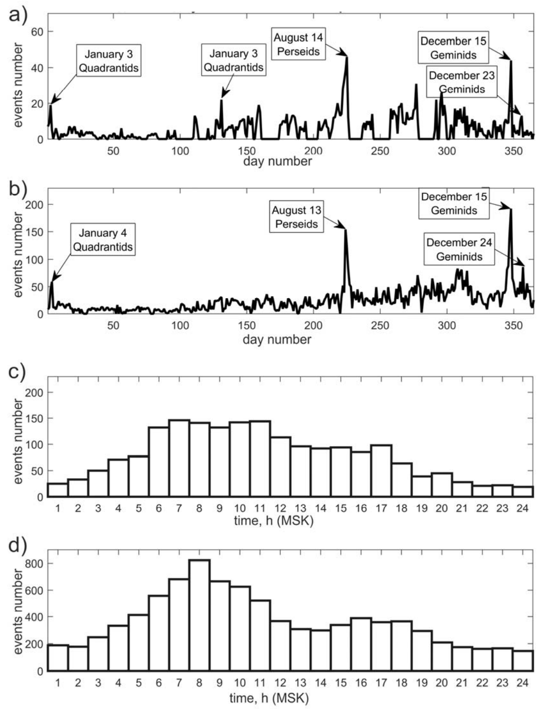

Figure 3. Transient Es-layer appearance: a) the annual variation for 2013; b) the annual variation for 2014; c) histogram of the appearances number inside day for 2013; d) histogram of the appearances number inside day for 2014.

4. Conclusions

One-minute measurements in 2013-2014 allowed revealing the events number of transient Es. Analysis of the frequency of occurrence led to the following conclusions:

1) The appearance has seasonal and diurnal dependence. It observed, the diurnal dependence has the increase in the morning hours, and seasonal dependence has a maximum in the end of summer and autumn, and a minimum in the end of winter and in the beginning of spring.

2) In the plot of the seasonal dependence are sharp peaks in January 3, April 22, August 12-13, December 14 and December 22, coinciding with the periods of maximum occurrence of strong meteor showers Quadrantids, Lyrids, Perseids, Geminids and Ursids.

3) Such peaks in seasonal and diurnal dependencies indicates that a significant part of transient Es caused by frequently appearance of meteors (of meteor showers). That are favorable factor to contribute the appearance of transient Es.

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7. References

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