PECULIARITIES OF SPORADIC E_S LAYER IN THE PERIOD OF SOLAR CYCLE ACTIVITY MAXIMUM

Kravetz R.O.[1], Galanin V.V.[2]

Institute of Radio Astronomy of National Academy of Science of Ukraine, Odessa, Ukraine
[1] *krro@ukr.net*, [2] *gvv@mail.ru*

ABSTRACT. We consider the year and a half row of observed ionosphere data from European ionosonde network DIAS in the period of 24 solar cycle activity maximum. The season changes of the mean critical frequency of sporadic E_s layer are determined. We show that the frequency of appearing of this layer in summer months is essentially exceeding it frequency of appearing in the winter ones. We compare critical frequency of E_s layer with the critical frequency of F2 layer.

Key words: ionosphere, ionogram.

The Earth ionosphere is point of issue during the many years. It caused by the fact, that ionosphere play significant role in the spreading of radio waves with various wavelengths. Particularly, due to ionosphere ability to reflect the radio waves, the decameter waves can spread for a very long distances, reaches thousands of kilometers. Herewith the firm radio communication is only possible when the reflected layer of ionosphere is stable. If this reflected layer is changes it characteristics than radio communication can grow worse and even disappear. Therefore the special services are watch for ionosphere condition, they control it current parameters and forecast the radio wave passing on the various routes.

Ionosphere play significant role also in radio astronomy, because signals of cosmic radio sources is passed through it and distorted to some degree for the expense of this. For example, this radio signals can be absorbed in ionosphere or partially reflected by it various layers, that to it turn induce the distortion of information which radio telescope received. During ionosphere disturbances, when it parameter is changes, this distortions may significantly intensify. So, further study if ionosphere is very important task.

As known, ionosphere have layer structure [3], it main layers are D, E and F. These layers are regular, because they are present in ionosphere almost always. However, in ionosphere exists also non regular layer E_s, called sporadic, because it arrival has spontaneous character. Herein, reflection ability of this layer can be very high and particularly exceed the reflect ability of all other layers. The reflect ability of every ionosphere layer is expressed by the value of it critical frequency, that represents maximum frequency of the signal which this ionosphere layer can reflect at vertical sounding.

In other words, critical frequency of sporadic E_s layer can exceed critical frequencies of all other ionosphere layers and particularly, critical frequency of the F layer. In this case the conditions of radio waves spreading in ionosphere are significantly changes, because there is arrived the additional reflected screen, which reflect signals of same and even more frequencies that the regular F layer. This can lead to an additional multibeaming in radio communication channel or to an additional refraction at the radio astronomy observations.

In some cases sporadic E_s layer can caused the blanketing effect, when it hide higher ionosphere layers. In this case, for example, the signals of cosmic radio sources may not reach the earth surface. Therefore, study of sporadic F_s layer and his peculiarities is a very important task.

Study of ionosphere and it peculiarities are in particular interest during the maximum of solar activity cycle. Nowadays the maximum of 24-th solar activity cycle is present, so the subject of further consideration is the ionosphere conditions and its peculiarities in past year and a half.

The main instrument to study the ionosphere is ionosphere station called ionosond. It represents the special radar which radiates vertically up with the frequency change from 1 to 30 MHz. The result of ionosond sounding is the ionogram, which represents the plot of reflected layer height dependence from radiated frequency. The ionograms are the initial material to get all main ionosphere parameters.

In Europe the ionosondes are united to the common system called DIAS (European Digital Upper Atmosphere Server) [1,2]. Provided by this system data allow to qualitative estimate the ionosphere state and particularly to decide the question about presence or not the ionosphere disturbances. In present work we mainly used Chilton ionosond data obtained from international data center WDC-C2.

Fig.1 show several consequent ionograms. On this ionograms we can see sporadic E_s layer arrival that looks as a straight horizontal track unlike other layers which reflecting height is changes with frequency. Time of existing of sporadic E_s layer is not big and can be from several minutes to several hours. Therefore, when considering some sequential ionograms the sporadic E_s

layer is looks as one-two ionograms that differs significantly from neighboring ones because they have straight horizontal track at 100 km height.

For study the peculiarities of sporadic E_s layer we has consider the ionograms recorded by ionosond for the last year and a half, namely for all 2012 and first half of 2013 years. Preliminary processing of ionograms consist of determine critical frequencies of all ionosphere layers and its heights. It can be made either manually or automatically by means of special software. Modern ionosondes as a rule have such software, so they provide data in text format as a time rows of critical frequencies and heights of all ionosphere layers and at the same time the initial ionograms are also accessible. Below we consider data obtained by automatic processing – autoscaling.

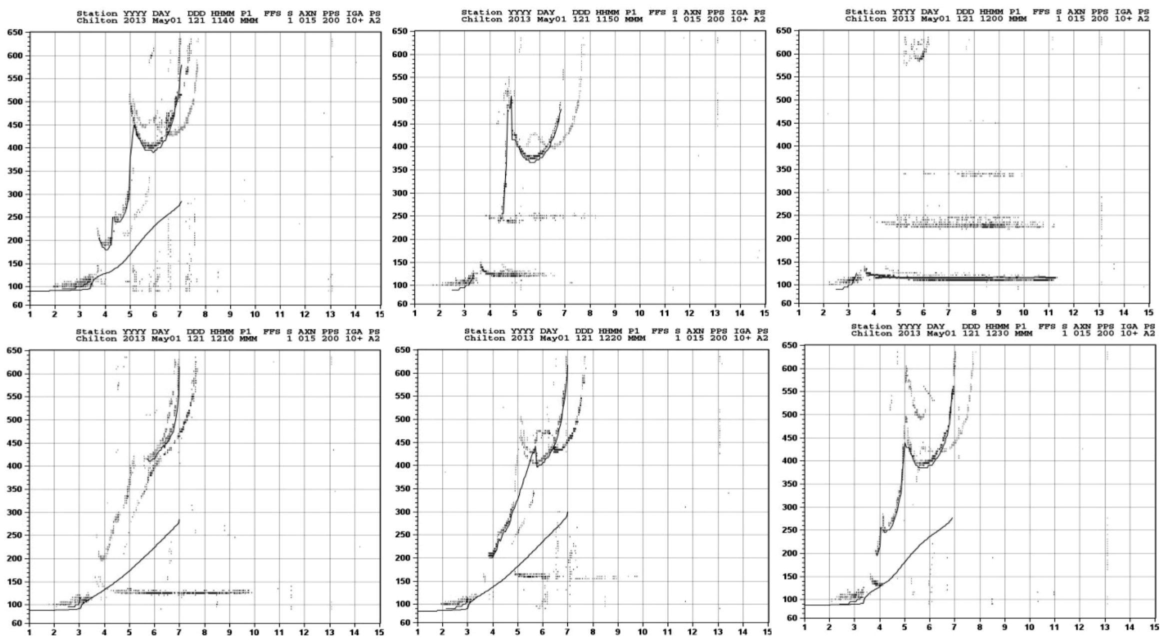

Figure 1. Arrival of the sporadic E_s layer.

Preliminary evaluation of ionosphere layers critical frequencies rows showed that generally speaking, sporadic E_s layer is regular, because it present almost every day, however it critical frequency as a rule not big. Only some separate days it critical frequency exceeds 5-7 MHz and sometimes exceeds critical frequency of the F layer. In these cases we can speak about sporadic layer itself. Fig.2 shows an example of E_s critical frequency changes for three days and F2 critical frequency for the compare. This plot shows that on the background of sporadic Es layer critical frequency regular changing there is exist some separate peaks exceeding 5-7 MHz value. Same situation is take place in other days during almost all the year.

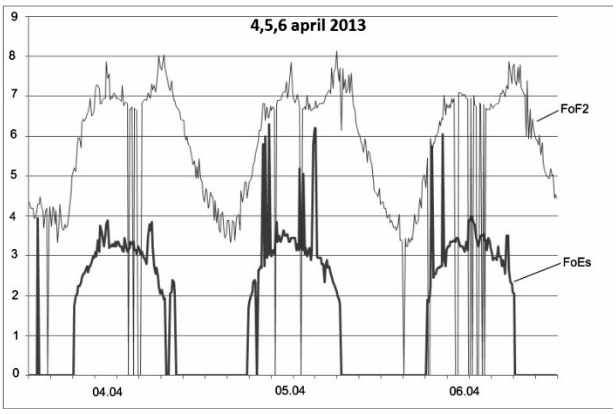

Figure 2. Critical frequencies of E_s and F2 layers.

So, time dependence of sporadic E_s layer critical frequency we can conditionally separate to some regular part which maximum value not exceed 2-3 MHz and sporadic part which maximum value can be significantly higher and even can exceed critical frequency of F2 layer.

To find the time characteristics of regular and sporadic parts we smoothed out critical frequency values of sporadic layer for one day boundaries and determine the maximum of the smoothed value for this day. This was made by the sliding mean value method for two hours time. For the same day we also had determine the maximum of non smoothed value to distinguish the sporadic part. Same manner we determined maximums of smoothed and non smoothed values of F2 layer critical frequency. These calculations was made for every day of the studied period resulting in data rows that characterizes regular and sporadic parts of E_s and F2 layers critical frequencies for a long period. These data is shows on the fig.3, where time dependencies of mentioned values for 2012 year are given, and fig.4 shows same values for the first half of 2013 year.

As it seen from this plots, regular part of sporadic E_s layer critical frequency have an expressed season dependence which consist of three periods: from January to May it grow, in summer from June to August it value practically not change and from September to December it decreased. Herein for critical frequency of F2 layer such dependence is not seen. Sporadic part of sporadic E_s layer critical frequency also has an expressed season dependence that consists in next: frequency of arrive of this layer in summer months is significantly higher than in winter ones. Here frequency of arrive was calculate as a number of times when critical frequency value exceeding F2 critical frequency.

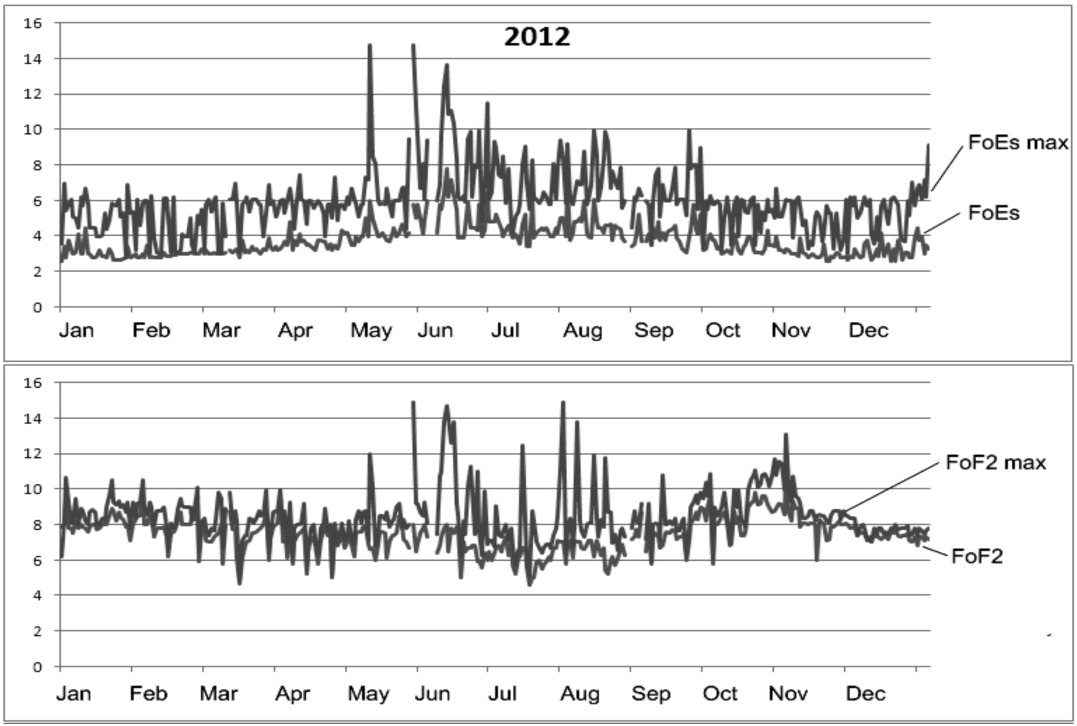

Figure 3. Maximum and smoothed values of critical frequencies in 2012 year.

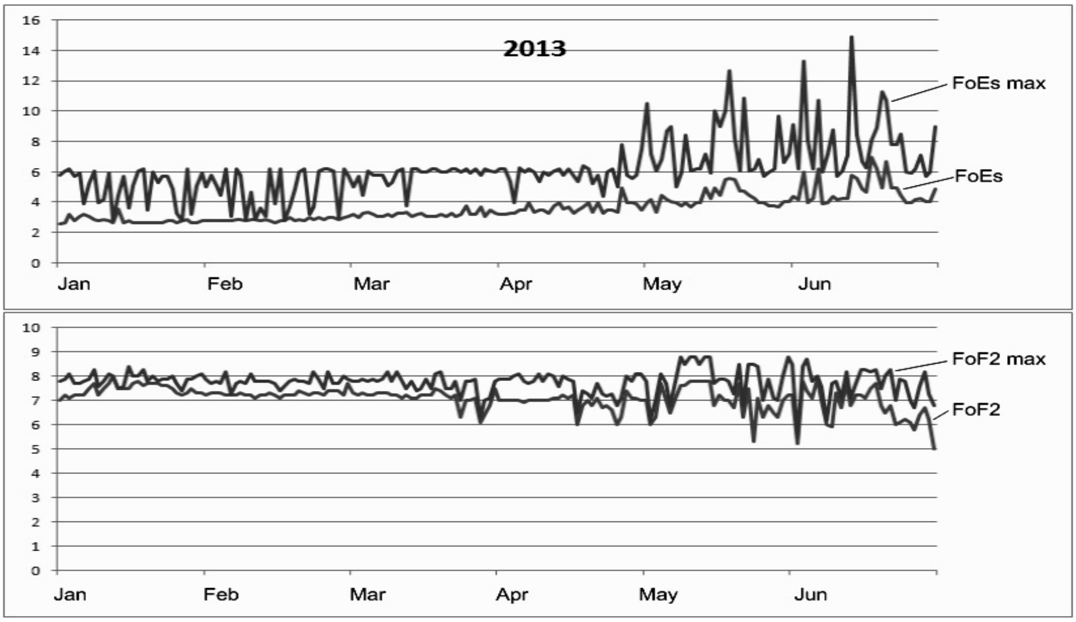

Figure 4. Maximum and smoothed values of critical frequencies in 2013 year.

These plots also show that increase of E_s layer critical frequency is accompanied by some decreasing of F2 critical frequency. This peculiarity is take place as in 2012 and in 2013 years and also on the shorter periods that can be seen on every day records of these critical frequencies.

References

1. DIAS: European Digital Upper Atmosphere Server. *http://www.iono.noa.gr/dias*.
2. Belehaki A., Cander Lj.R., Zolesi B., Bremer J., Jurén C., Stanislawska I., Dialetis D., Hatzopoulos M. DIAS Project: The establishment of a European digital upper atmosphere server, 2005, *J. Atmos. Sol-Terr. Phys.*, **67(12)**, 1092.
3. Brunelli B.E., Namgaladse A.A. *Physics of ionosphere*. M.: Nauka, 1988.