SEASONAL VARIATIONS OF IONOSPHERIC LAYER PARAMETERS DURING THE PERIOD OF MAXIMUM SOLAR ACTIVITY

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ABSTRACT. Critical frequencies of the ionospheric layers were studied using data from the European Digital Upper Atmosphere Server (DIAS) network of real-time ionosondes for 2012-2013. Some particularities of seasonal variations of these parameters were detailed.

From the moment of its discovery in the beginning of 20th century, the Earth's ionosphere has been the subject of continuous research that is caused by its leading role in the propagation of radio waves in the decameter wave band. In radio astronomy, the ionosphere represents a disturbance factor due to its distortion of signals from cosmic radio sources which are received by the ground-based radio telescopes. Therefore, the study of ionospheric characteristics, particularly ionospheric disturbances, is a crucial task indeed.

Main ionospheric parameters are measured by ionospheric stations, which are called ionosondes. In Europe, the ionosondes are united into a network called DIAS (the European Digital Upper Atmosphere Server) [1, 2]. The DIAS data are freely available and easily accessible via Internet. These data are displayed mainly as ionograms – plots of the virtual height of the reflection point in the ionosphere against frequency measured using vertical sounding. An ionogram is a display of the initial material obtained by an ionosond. Ionograms allow of determining all parameters of the ionospheric layers. The results of data processing are reported in the form of tables which are released on the web.

In this study we used data from three DIAS ionosondes, namely Athens, Chilton and Pruhonice. We also used some data from ionosondes Rome and Warszawa. These data were obtained from automatic processing (auto-scaling). It allows to get long sequences of these data, as well as to detect specific features, in particular, seasonal variations. To be specific, we used data for 2012-2013. This period is of particular interest, because it corresponds to the maximum of Solar Cycle 24.

Generally speaking, seasonal variations of ionospheric layer parameters, as well as other ionospheric characteristics, have been extensively studied and described by many authors [3]. However, availability of large amount of observation material and its accessibility allow, first, to examine previous conclusions and, secondly, refine and expand them. In particular, it is known that critical frequencies of D and E layers increase at middle latitudes during summer months and decrease in winter. The situation is opposite for the F_2 layer - the critical frequency of this layer decreases in summer months and increases in winter. We consider that it is useful to examine these conclusions and extend the range of such variations. That is the aim of this study.

As in our previous paper [4], we focus mainly on the E_s layer (sporadic E-layer) as on our opinion, it has the most significant influence on radio telescopes operating at decameter wavelength, because its critical frequency can reach very high values, and in some cases, it even exceeds the F_2 layer critical frequency. It is shown in [4] that sporadic E-layer is, generally speaking, a regular layer, because it is present practically all year long while its critical frequency does not exceed 3-4 MHz. Sometimes this value can reach 10-15 MHz and above. In such cases we can discuss the appearance of the sporadic layer itself. As such an appearance of sporadic layer is a seldom case, it is interesting to study the frequency of this phenomenon, i.e. the probability of its occurence.

Apart from the sporadic E-layer, the F_1 layer – a typical day-time phenomenon – is also of our interest. The F_1 layer particularities are also the subject of our study, because one border of this layer adjoins the sporadic E-layer while the other one is adjacent to the F_2 layer.

Figure 1 shows an example of the dependence of the E, F_1 and F_2 layers' critical frequencies on time for the interval of three days. Gaps on the plot signify the absence of corresponding layers on the ionograms.

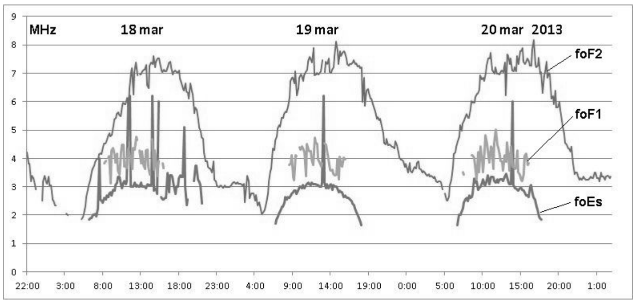

Figure 1: Critical frequencies of ionospheric layers for three days

The data for this plot were taken from the Chilton ionosonde's data-output for 18-20 March 2013. These data show typical diurnal variation of critical frequencies of these layers with maximum in the daytime around noon and minimum at night; hence, there are no signals reflected by E_s and F_1 layers at night. As can be seen on the plot, some plot points for the sporadic E-layer's critical frequency curve greatly exceed the mean values. Obviously, only these points correspond to the appearance of the sporadic layer itself, because it is presumed that this layer appears only when its critical frequency is higher than 4-5 MHz.

As it seen from Figure 1, the ionospheric layers' critical frequencies vary greatly throughout the day; thus, to determine their dependencies on time for long periods, for example for a year, the corresponding values should be averaged in some way. For the mean values we took critical frequencies averaged over 4 hours near the maximum.

Using this method we got data sequences for which a single critical frequency corresponds to one day.

Figure 2 shows time dependencies of data from the Chilton ionosonde for 2012-2013, which were processed by the indicated method. Figure 3 shows such correlation for the Pruhonice ionosonde data-output. We have got similar critical frequency-time relationships for the Athens, Rome and Warszawa ionosondes. To perform direct visual evaluation, we made further averaging of the data. In particular, using a 10-day moving average we processed data from three mentioned ionosondes. Figures 4 and 5 present the plots of these data for the Chilton and Pruhonice ionosondes, respectively. These plots show that the critical frequencies of sporadic E-layer and F_1 layer have almost similar yearly variation with maximum in July-August and minimum in January-February. Hence, the F_1 layer critical frequency almost always exceeds the critical frequency of sporadic E-layer at 0.5-1.5 MHz. The difference between maximum and minimum values is 1.5-2 MHz for the F_1 layer and 3-4 MHz for the E_s layer.

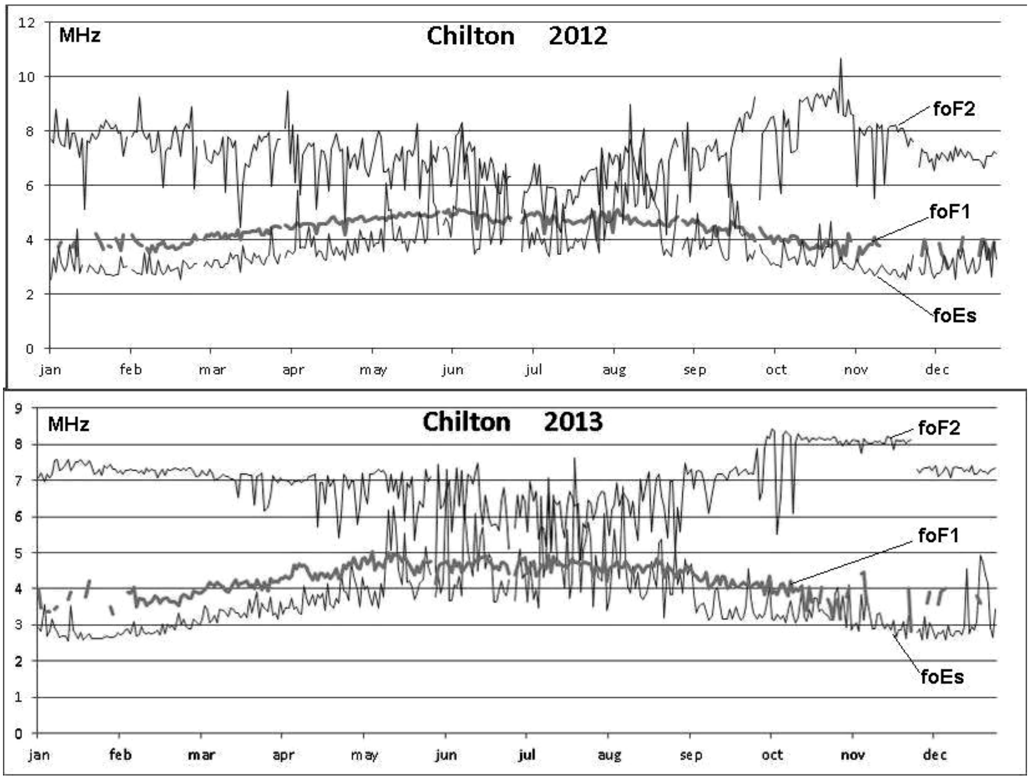

Figure 2: Critical frequencies of ionospheric layers measured by Chilton ionosonde in 2012–2013

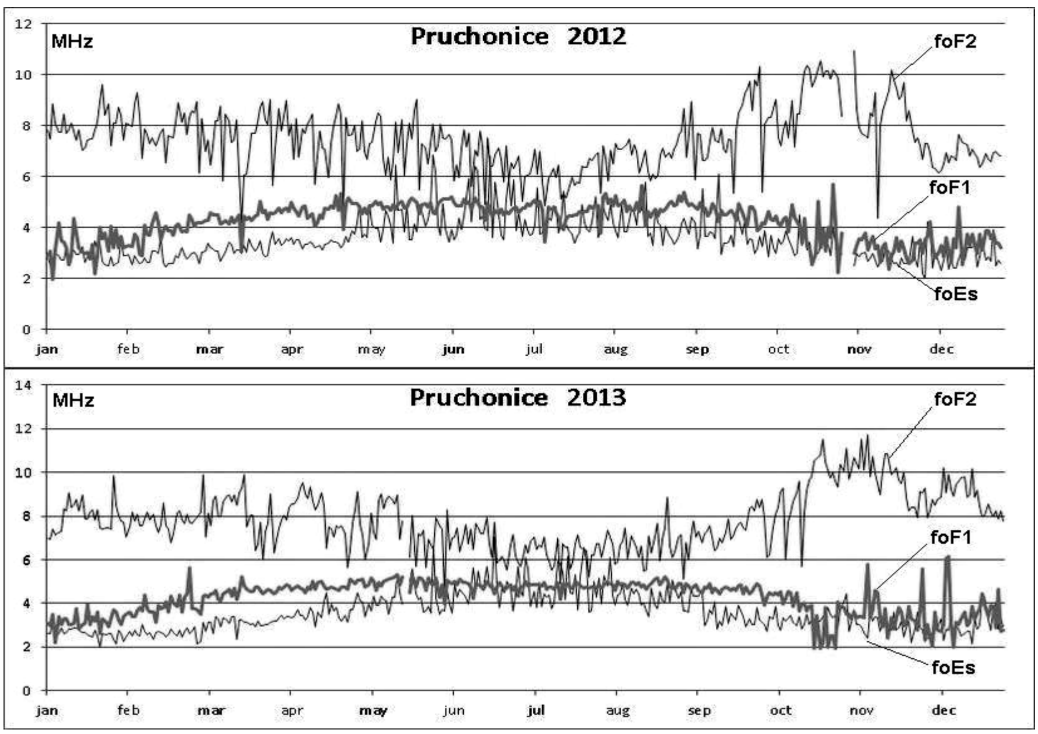

Figure 3: Critical frequencies of ionospheric layers measured by Pruchonice ionosonde in 2012–2013

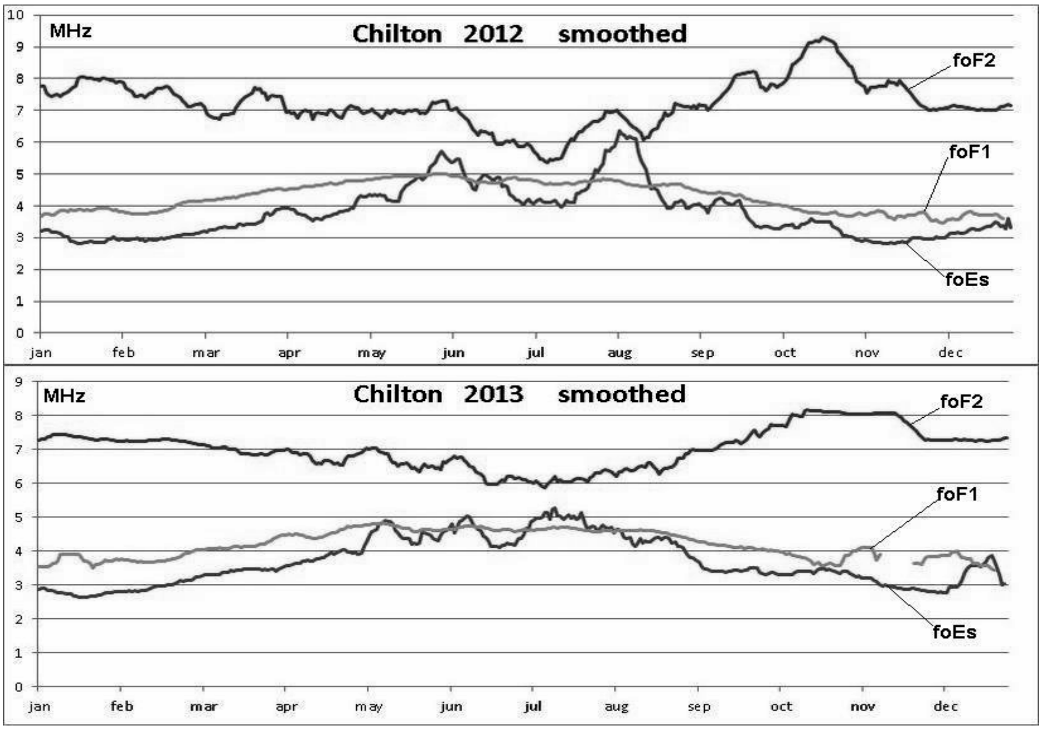

Figure 4: Critical frequencies measured by the Chilton ionosonde in 2012–2013 smoothed with a 10-day moving average

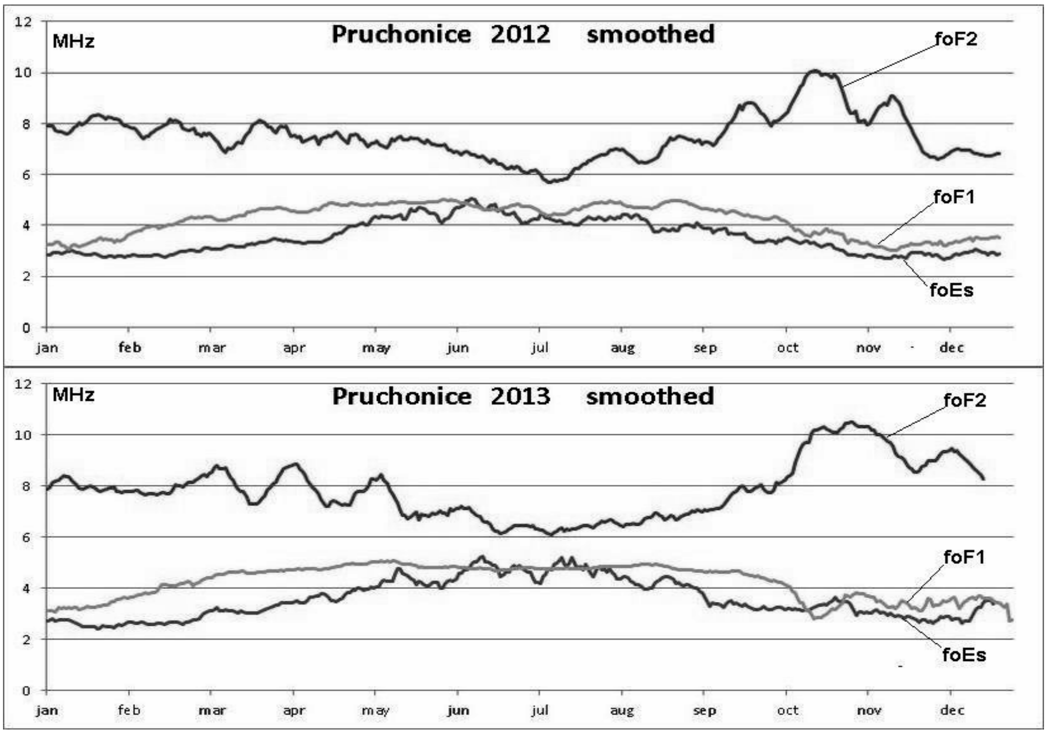

Figure 5: Critical frequencies measured by the Pruchonice ionosonde in 2012–2013 smoothed with a 10-day moving average

On the contrary, the F_2 layer critical frequency is minimum in July and maximum in November. The difference between its maximum and minimum values is 3-4 MHz.

References

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