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RESULTS OF OBSERVATIONS OF THE IONOSPHERE RESPONSE TO A PARTIAL SOLAR ECLIPSE ON 11.08.2018 ACCORDING TO DATA FROM A NETWORK OBLIQUE SOUNDING PATHS IN THE EURASIAN REGION

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INTRODUCTION

The activity of photochemical reactions decreases almost to the levels of the night ionosphere along the path of the movement of the lunar shadow in the Earth's atmosphere during a solar eclipse. The reaction of the ionosphere to a solar eclipse manifests itself mainly as a decrease in the total electron content. However, an increase in the critical frequency of the sporadic layer *Es* was observed during the solar eclipse [*Datta R. J. 1973, Geophys. Res., 78 (1), pp. 320; Chen G., Zhao Z., Yang G. et al. J. Geophys. Res., 2010115, A09325*]. The increase in the electron density in the Es layer is associated with the wind shear created by the temperature gradient during the movement of the moon's shadow.

Chimonas G. & Hines C. O. [*1970, J. Geophys. Res., (4), 875*] detected that the supersonic motion of the lunar shadow violates the thermal balance of the atmosphere and can be a source of acoustic-gravitational waves (AGW). As evidenced by numerous studies, AGW initiated by a solar eclipse have periods ranging from 20 to 60 minutes. As noted in [*Chen G., Zhao Z., Zhang Y. et al., 2011, J. Geophys. Res. 116, A09314*] gravitational waves may be responsible for the formation of wave-like structures in the sporadic layer *Es*. Due to a rather rare combination of the solar eclipse and *Es*, there is little data on the influence of the SE on the *Es* parameters. Therefore, such studies are undoubtedly relevant.

This report presents the first results of a study the effect of a solar eclipse on August 11, 2018 on the characteristics of HF signals according to oblique sounding on extended radio links.

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OVERVIEW

Partial Solar Eclipse of 2018 Aug 11

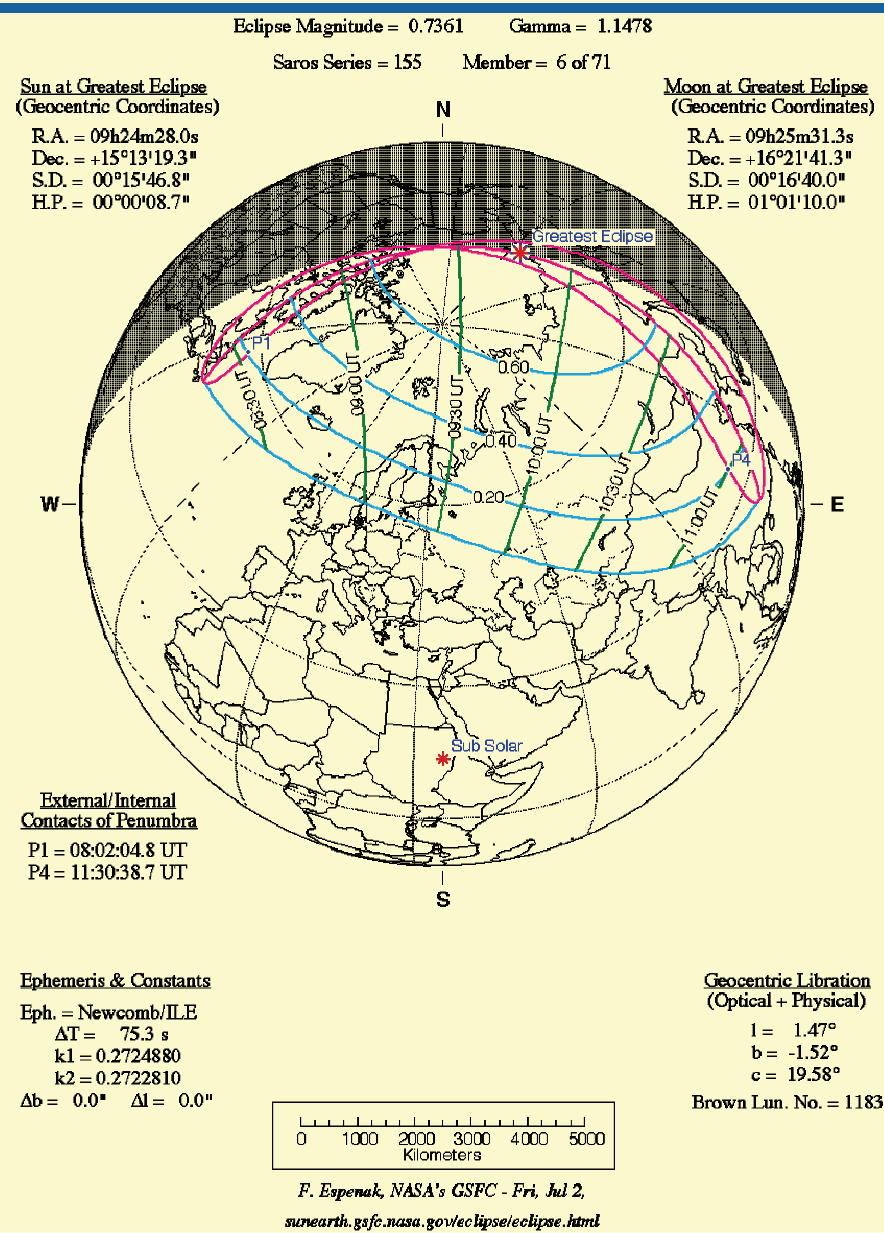
Geocentric Conjunction = 09:19:59.6 UT J.D. = 2458341.888884
Greatest Eclipse = 09:46:15.0 UT J.D. = 2458341.907118

Observations were made during August 10-12, 2018. There were control observations carried out on August 10 and 12.

The map showing the phases of the Earth's surface covering the moon with a moon shadow during a partial solar eclipse on August 11, 2018 is presented here.

In Russia, the largest phase of coverage was in the northeastern regions.

The solar eclipse took place in a calm geomagnetic environment with an index of Kp = 2-3.



To identify the response of the ionosphere to the partial solar eclipse, inclined LFM sounding was carried out on the tracks of various lengths and orientations. LFM transmitters are located in points: Lovozero, Murmansk Region (68N 35.02E), Norilsk (69.36N 88.36E), Irkutsk (51.8N 104E), Khabarovsk (47.5N 13.5E).
Next slide illustrates locations of these points on the map.

The LFM transmitters worked on a 5-minute program (Lovozero - on a 15-minute program). The receiving of chirp signals was carried out in Vasilsursk, Nizhny Novgorod Region (56.1°N; 46.1°E) and Nizhny Novgorod (56.1°N; 44.1°E).

LLC SITCOM is a base radio transceiver station (BRTRS) for diagnostics of ionospheric and high-frequency radio lines using chirp signals (see figure on this slide).

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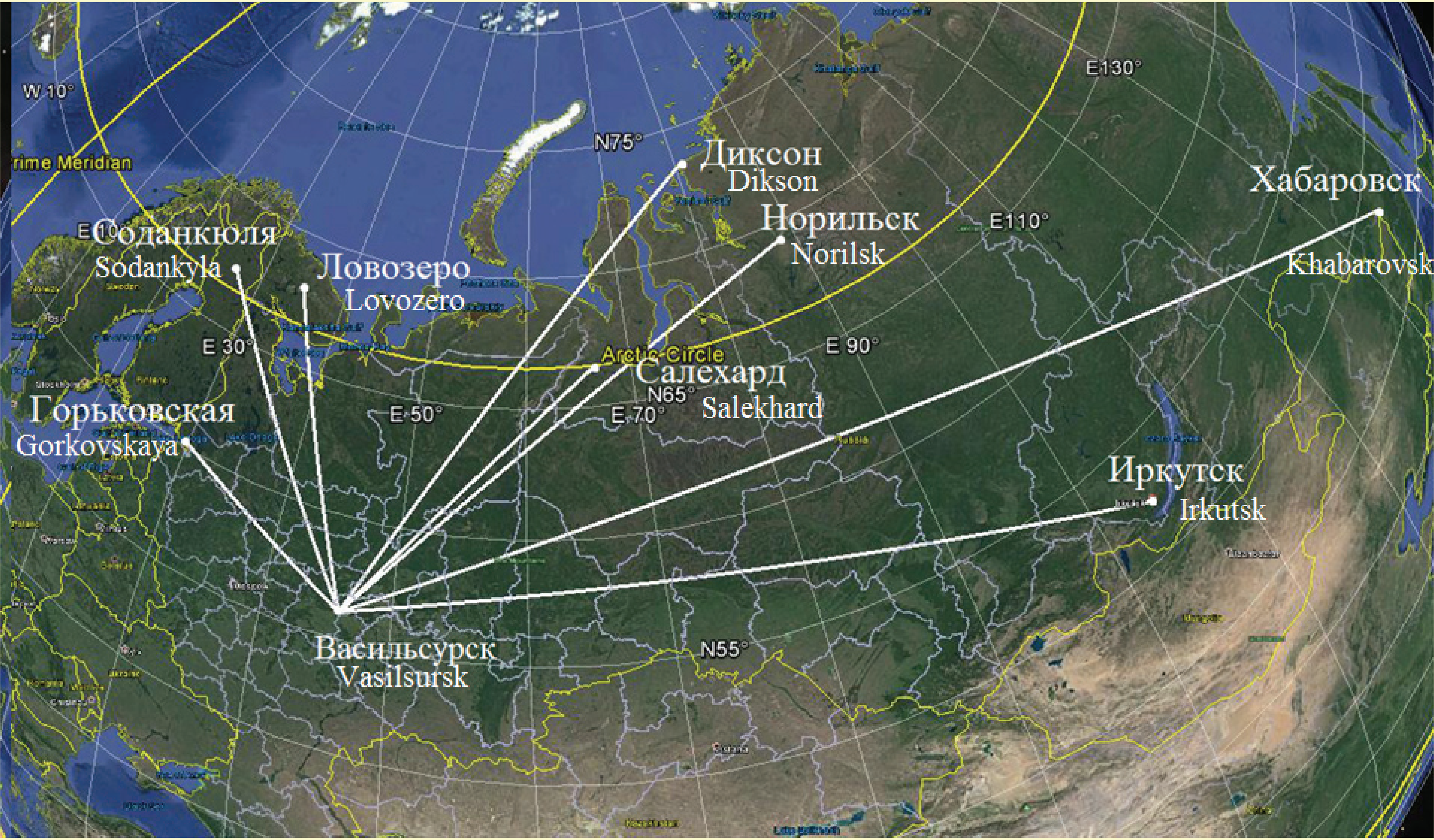

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The eclipse parameters for the midpoints of the paths for various heights in the ionosphere are given in the table. For 2-jump routes Khabarovsk - Vasilsursk the characteristics are given for the midpoints of the 1st and 2nd jumps. As can be seen from the table during the observation of the solar eclipse, the degree of coverage of the solar disk with the moon was within the range of 12–53%, depending on the orientation and length of the path.

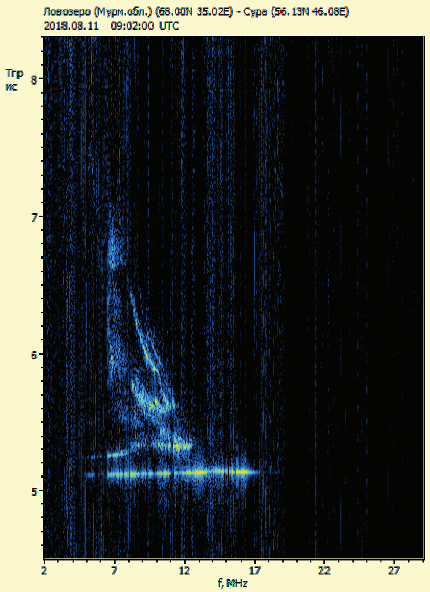
№	Track	Length, km	Coordinates midpoint	h, км	Time beginning UT	Time max phase UT	End time, UT	The degree of coverage in max. phase,%
1.	Lovozero - Vasilsursk	1440	$62^0$9'25"N $41^0$38'36"E	110 200	08:53:49 08:51:45	09:36:10 09:35:54	10:18:11 10:19:41	11.8 13.4
2.	Norilsk - Vasilsursk	2532	$64^0$14'10"N $62^0$14'58"E	200	09:01:38	09:53:21	10:43:37	27.9
3.	Irkutsk - Vasilsursk	3709	$57^0$29'44"N $76^0$41'3"E	200	09:25:04	10:15:27	11:03:32	26.8
4.	Khabarovsk - Vasilsursk	5733	1st jump $55^0$31'38"N $118^0$12'45"E 2nd jump $60^0$41'13"N $69^0$13'33"E	200 200	09:38:22 09:13:28	10:27:51. 10:04:29	11:15:00 10:53:35	53.1 26.5

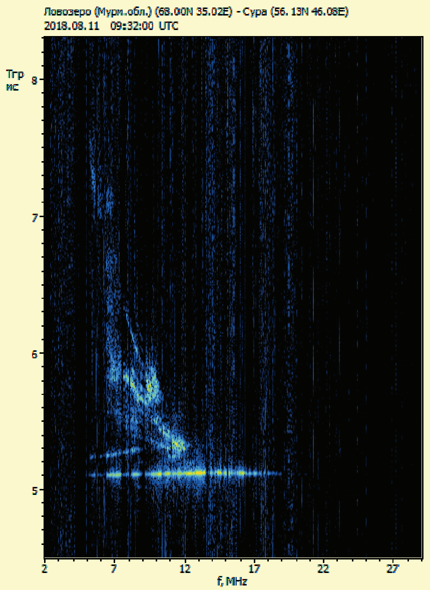
RESULTS

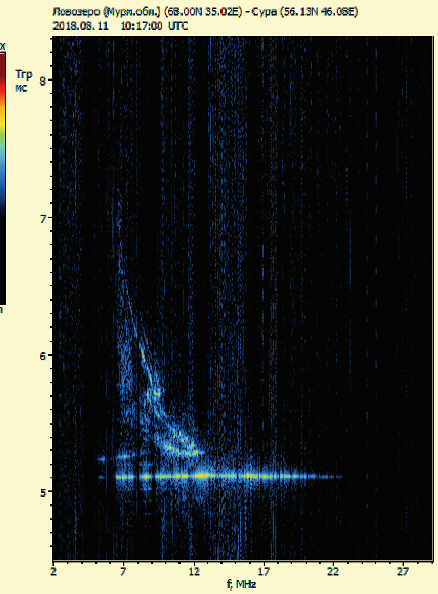
Next slides presented original recordings of HF signals according to oblique sounding on extended radio links.

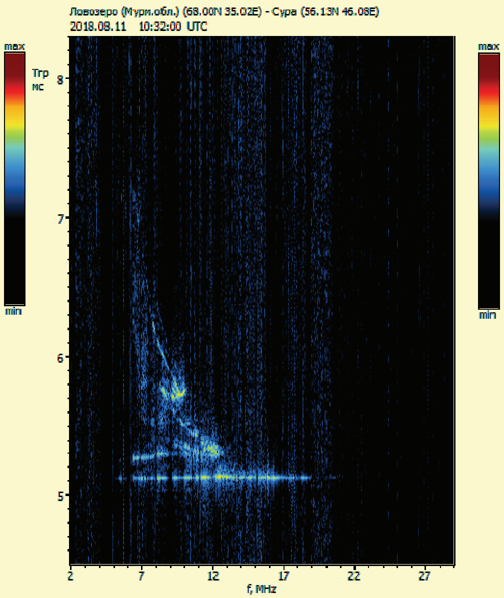
Lovozero - Vasilsursk

August 11, 2018





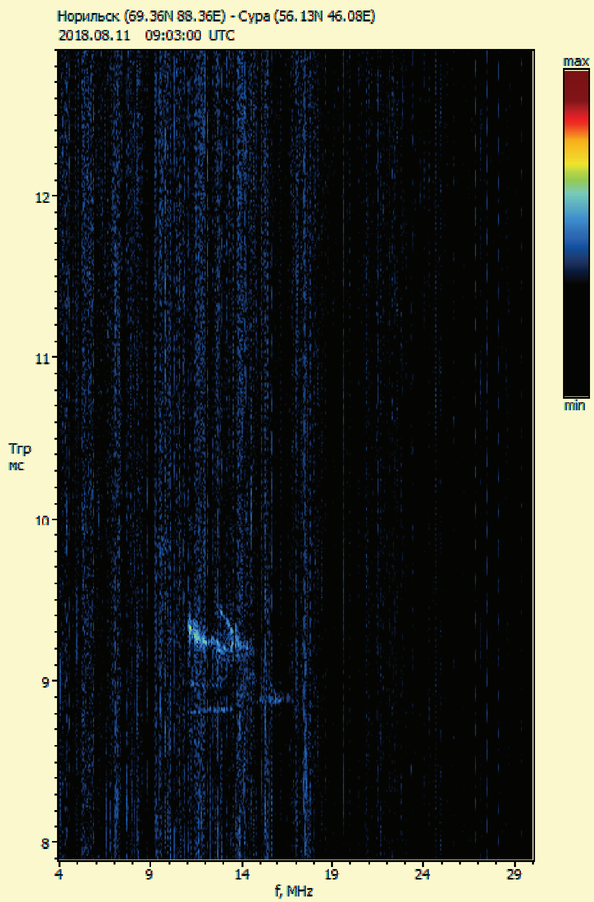




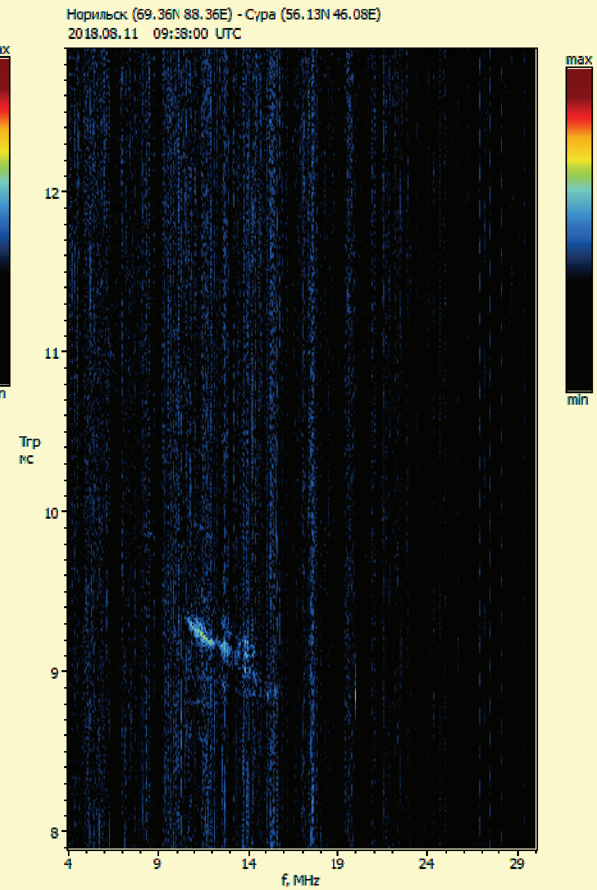
$09^{h}\,02^{m}$ $09^{h}\,32^{m}$ $10^{h}\,17^{m}$ $10^{h}\,32^{m}$ UT

Norilsk – Vasilsursk

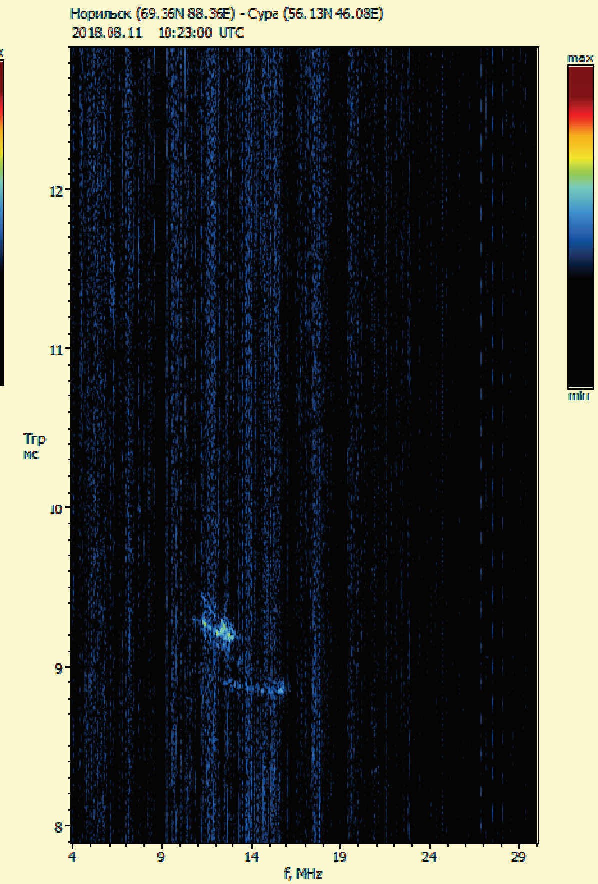
August 11, 2018



$09^h\,03^m$

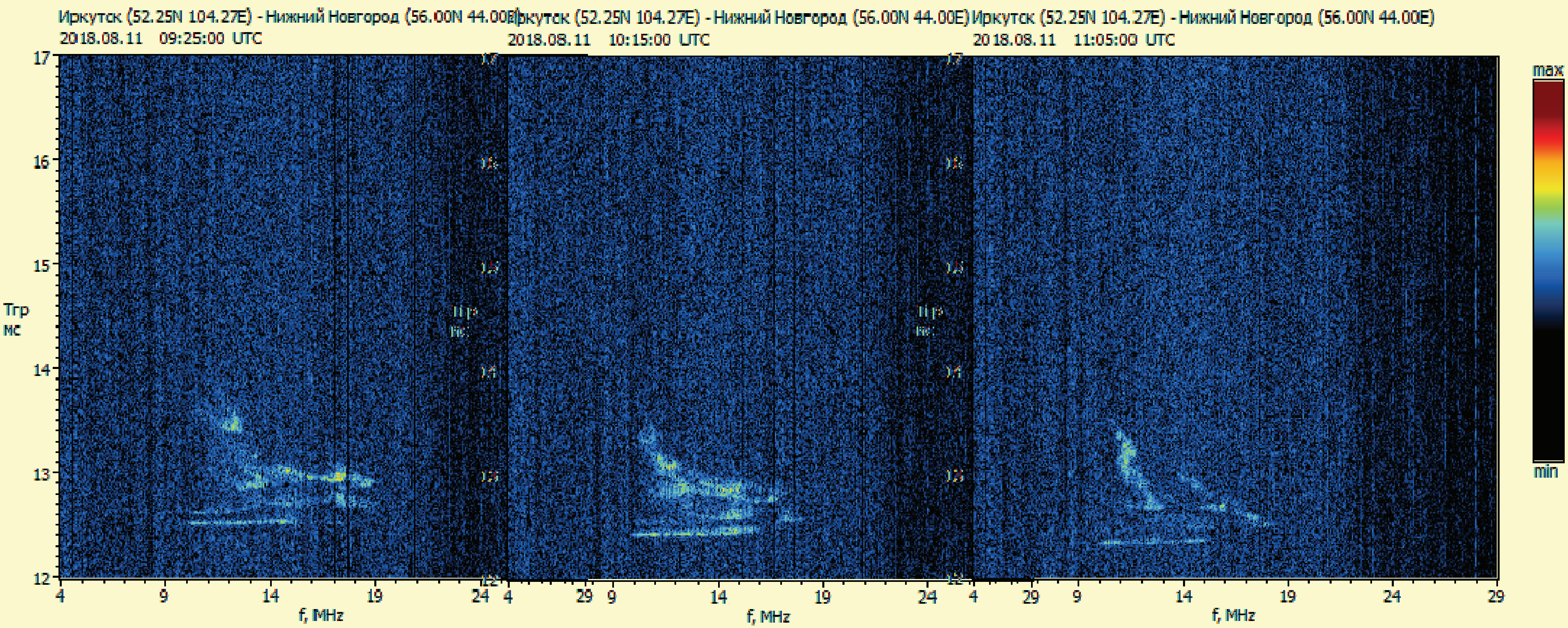


$09^h\,38^m$



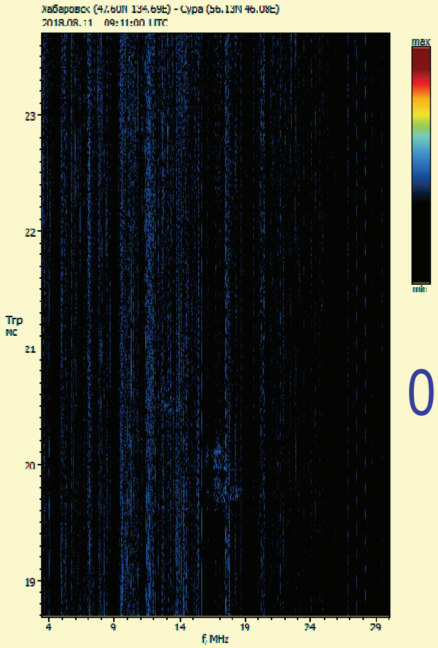
$10^h\,23^m$ UT

Irkutsk – Nizhny Novgorod
August 11, 2018

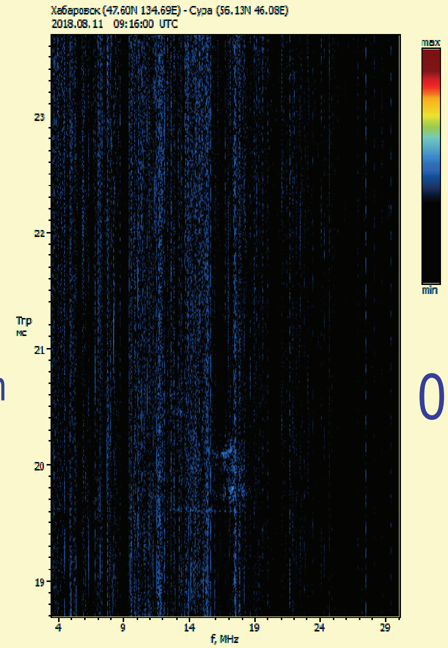


$09^h\ 25^m$ $10^h\ 15^m$ $11^h\ 05^m$ UT

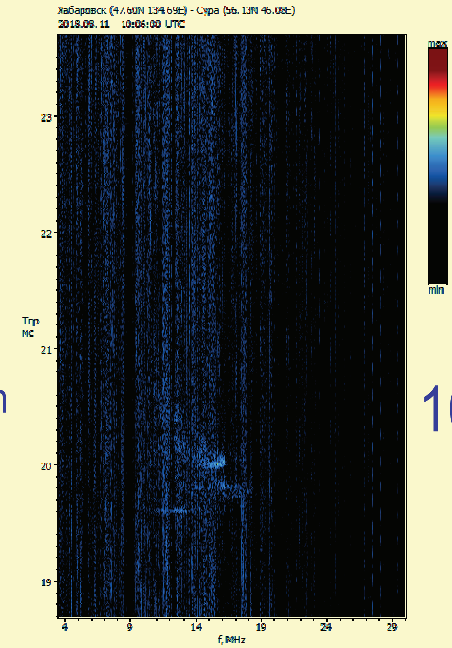
Khabarovsk – Vasilsursk August 11, 2018



$09^h\,11^m$

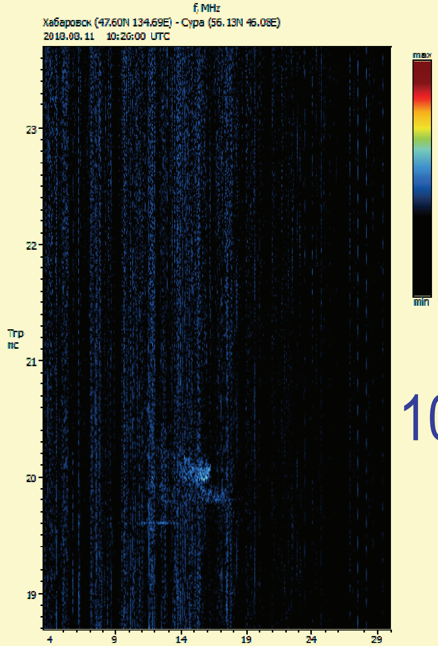


$09^h\,16^m$

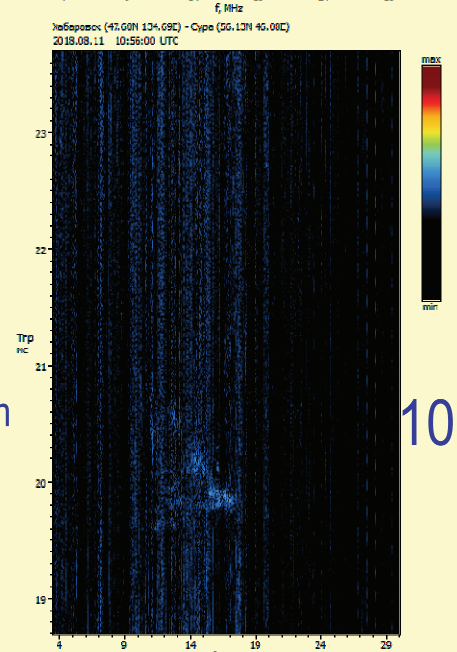


$10^h\,06^m$

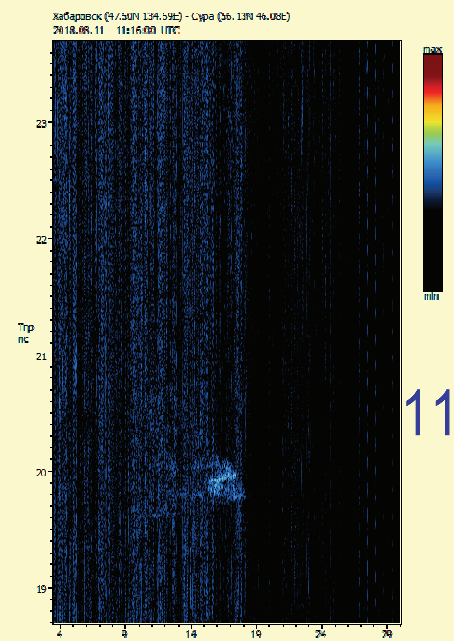
UT



$10^h\,26^m$



$10^h\,56^m$



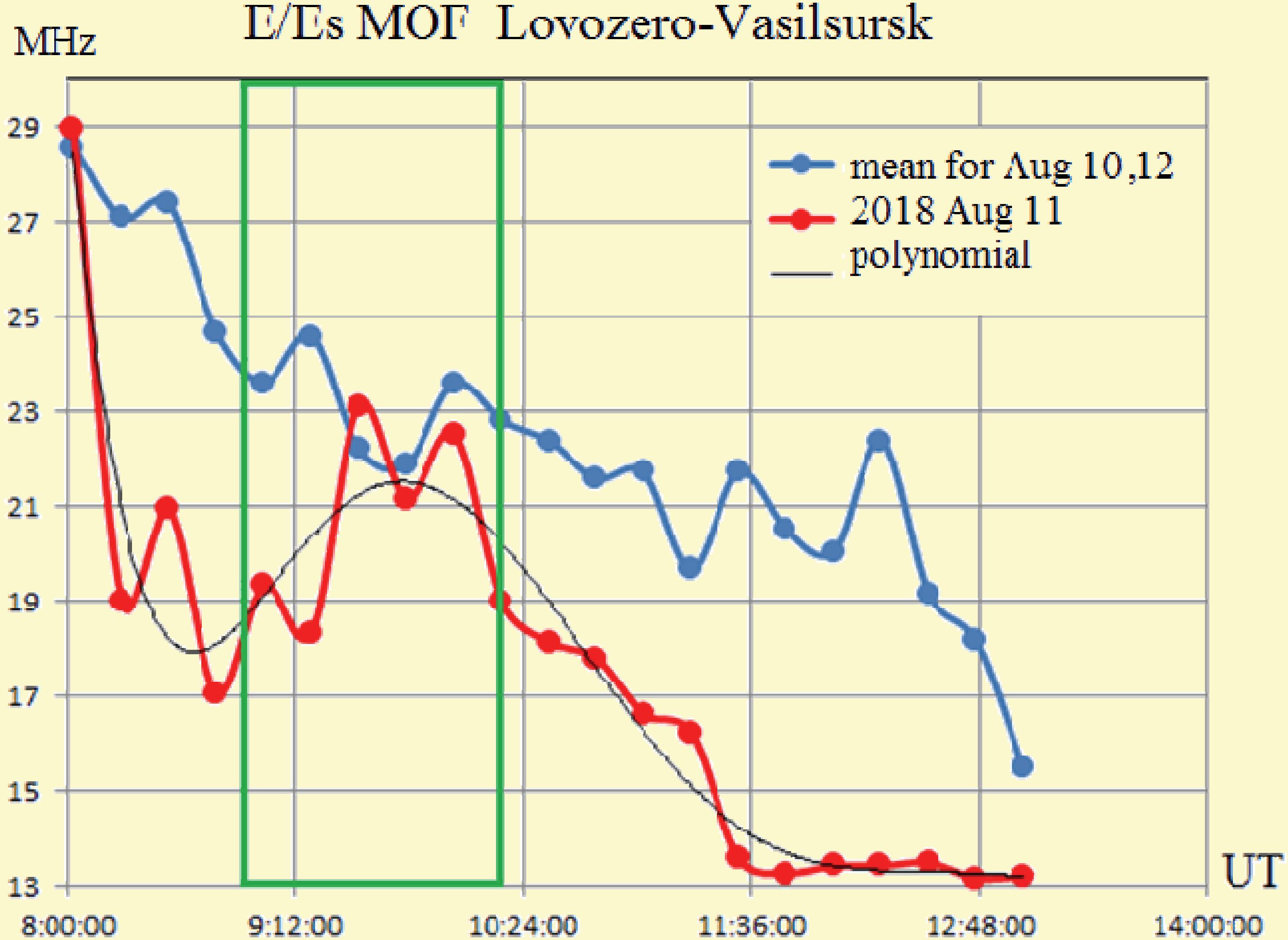
$11^h\,16^m$

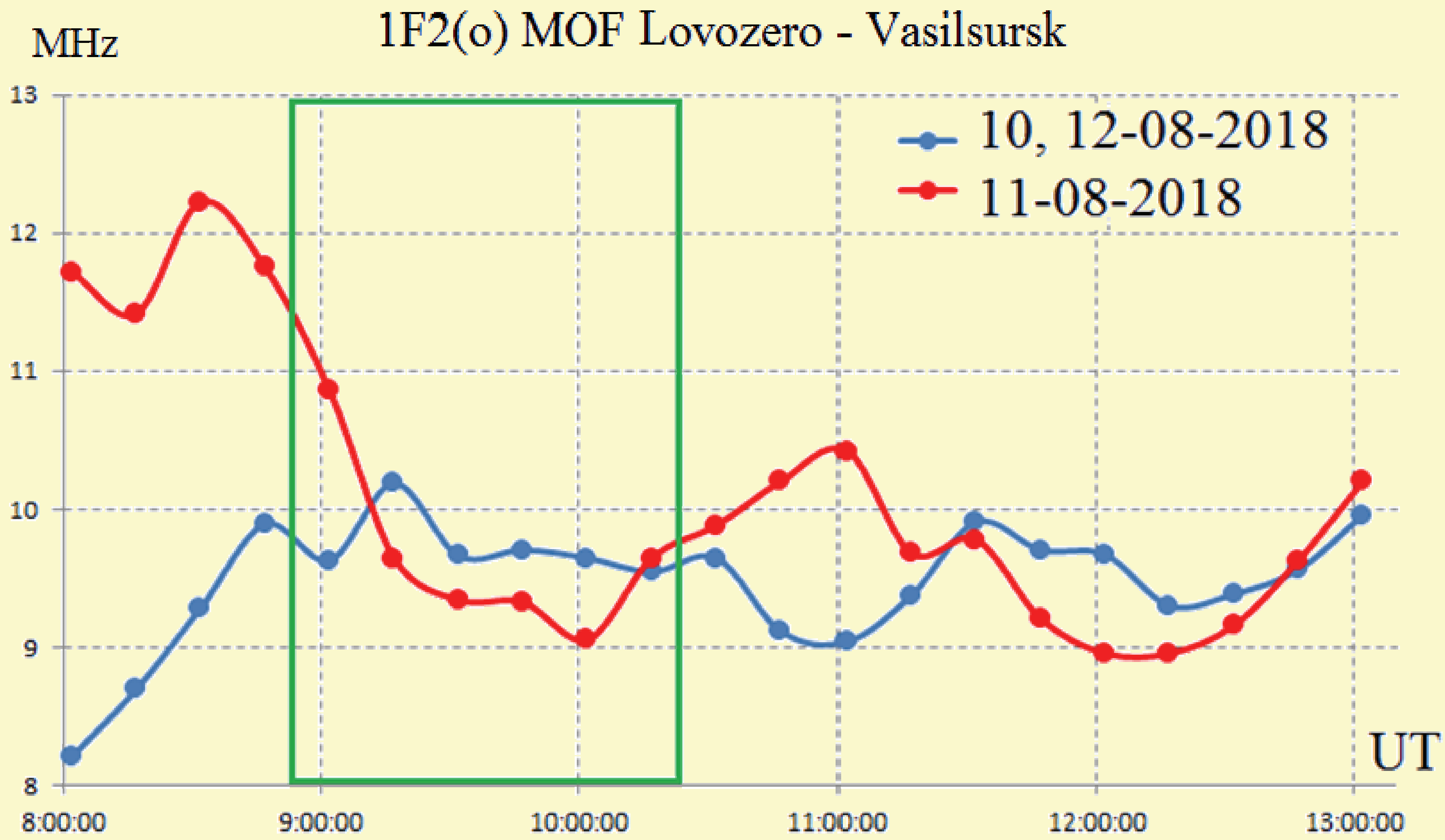
The figures below show the time dependences of the MOF for different paths and propagation modes on the day of the eclipse on August 11, 2018 and on control days on August 10 and 12, 2018. Eclipse interval for the midpoints of the sensing paths for an altitude of 200 km is highlighted in a colored rectangle (for the observations in Lovozero-Vasilsursk highway a colored rectangle highlights the eclipse interval for an altitude of 110 km).

It can be seen from the figures that on all the paths in the eclipse interval, there is a rather clear effect of a decrease in the MOF during propagation through the F-layer by 8-10% and an increase in Es MOF on the Lovozero-Vasilsursk highway by 15%.

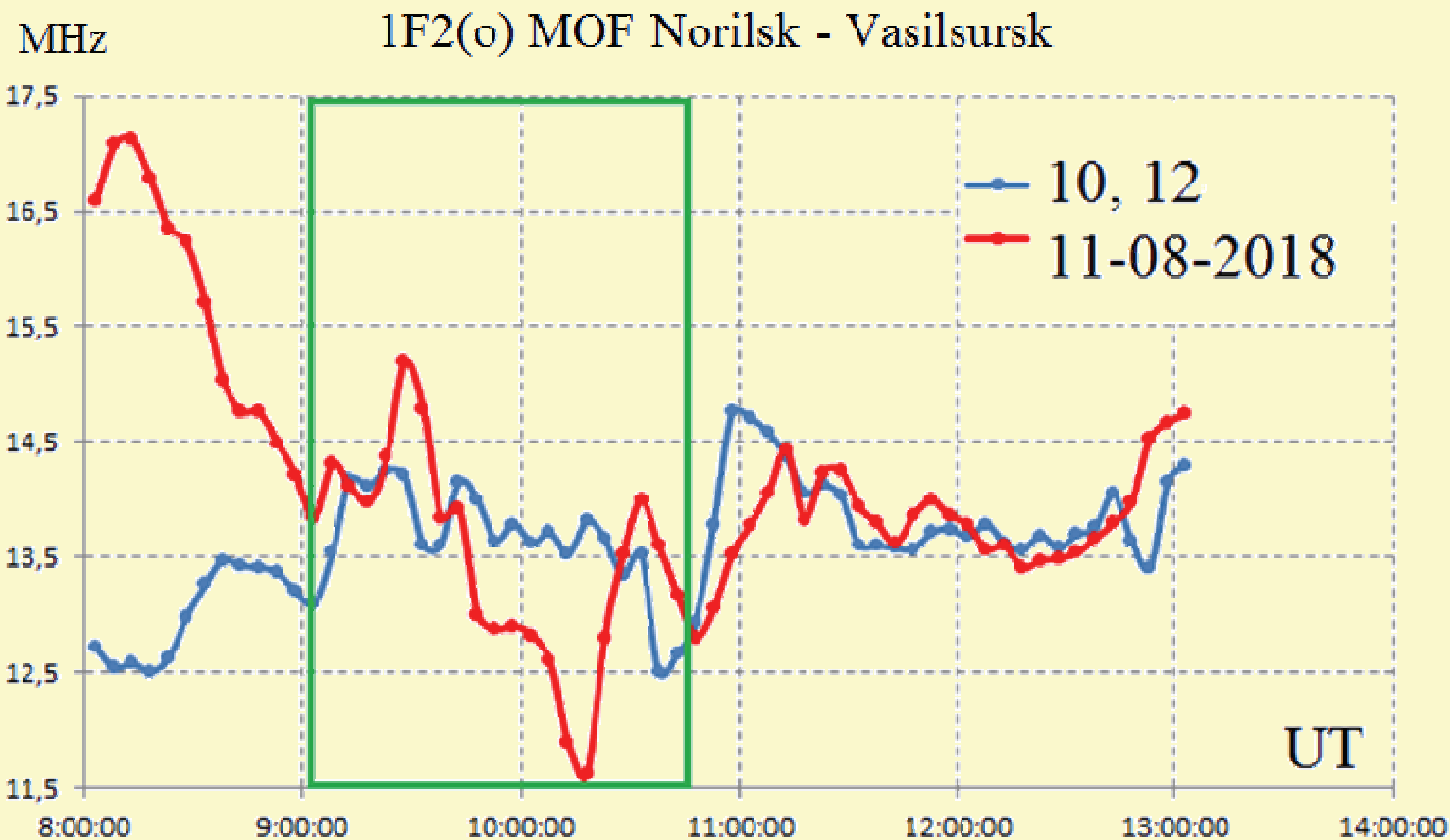
The results of oblique sounding were used to detect acoustic-gravitational waves (AGW) and their ionospheric response in the form of TID generated at the heights of the ozone layer in the stratosphere during the motion of the moon’s shadow in the Earth’s atmosphere during a solar eclipse. The clearest effect of AGW manifestation in the form of quasiperiodic variations of Es MOF and 1F MOF in the solar eclipse interval with periods of 30 and 50 minutes was observed on the Lovozero – Vasilsursk and Norilsk – Vasilsursk routes, respectively.

E/Es MOF Lovozero-Vasilsursk

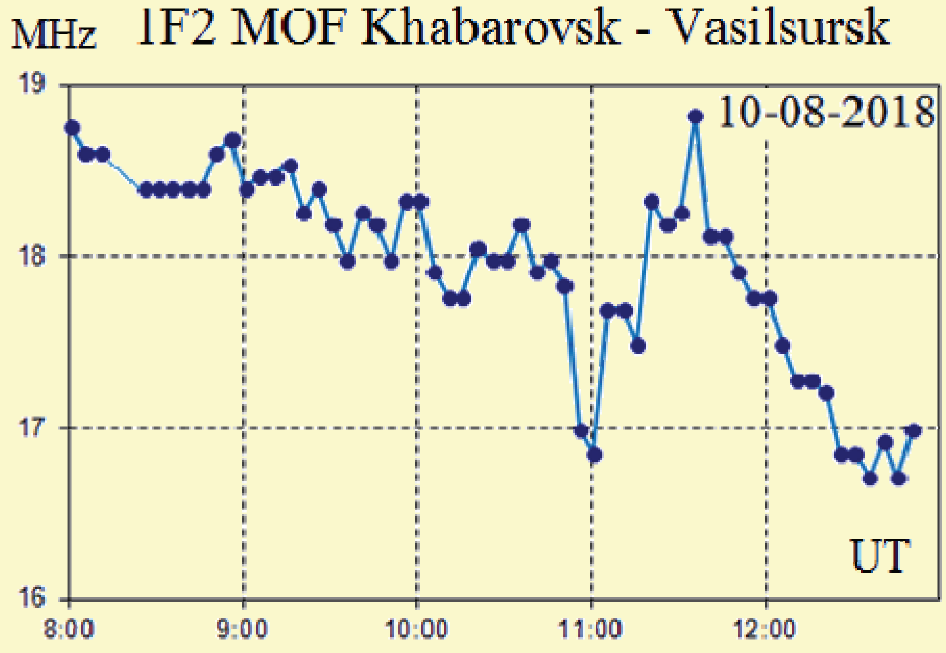


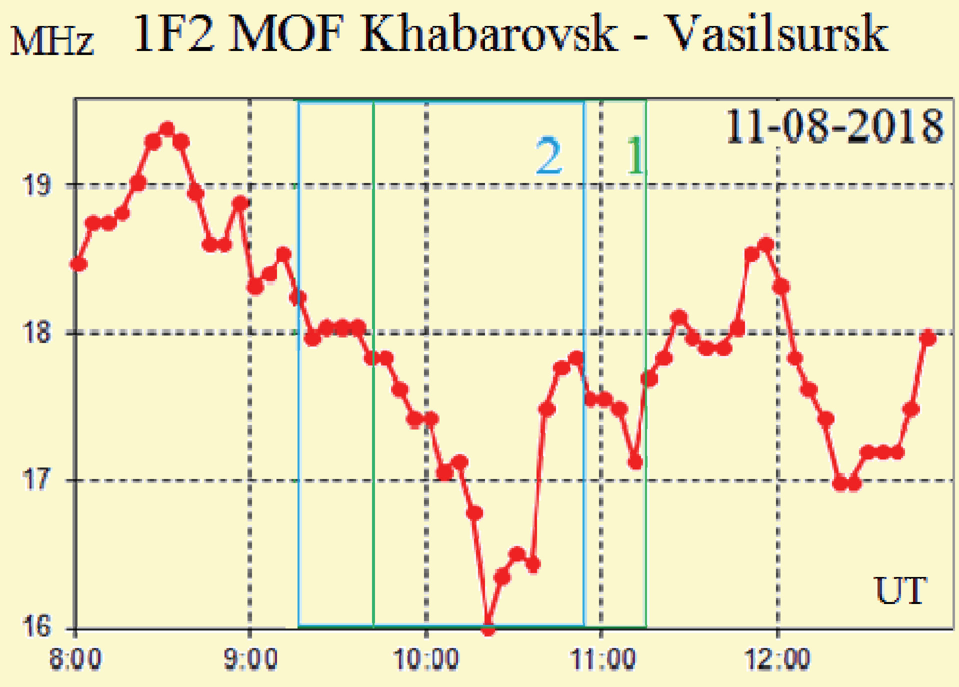


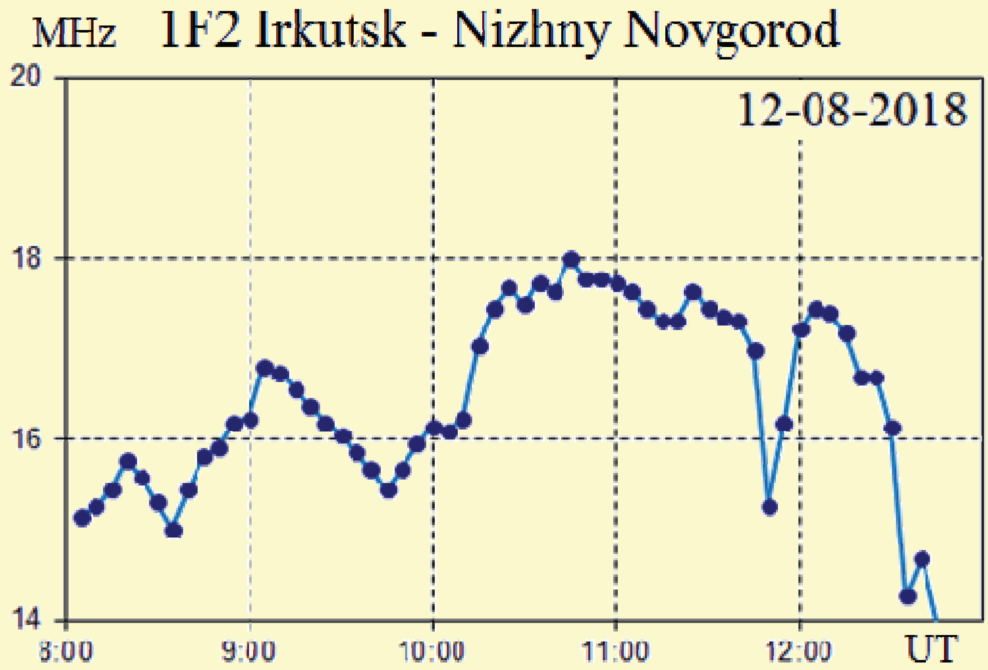
1F2(o) MOF Lovozero - Vasilsursk
MHz
13
12
11
10
9
8
10, 12-08-2018
11-08-2018
UT
8:00:00
9:00:00
10:00:00
11:00:00
12:00:00
13:00:00



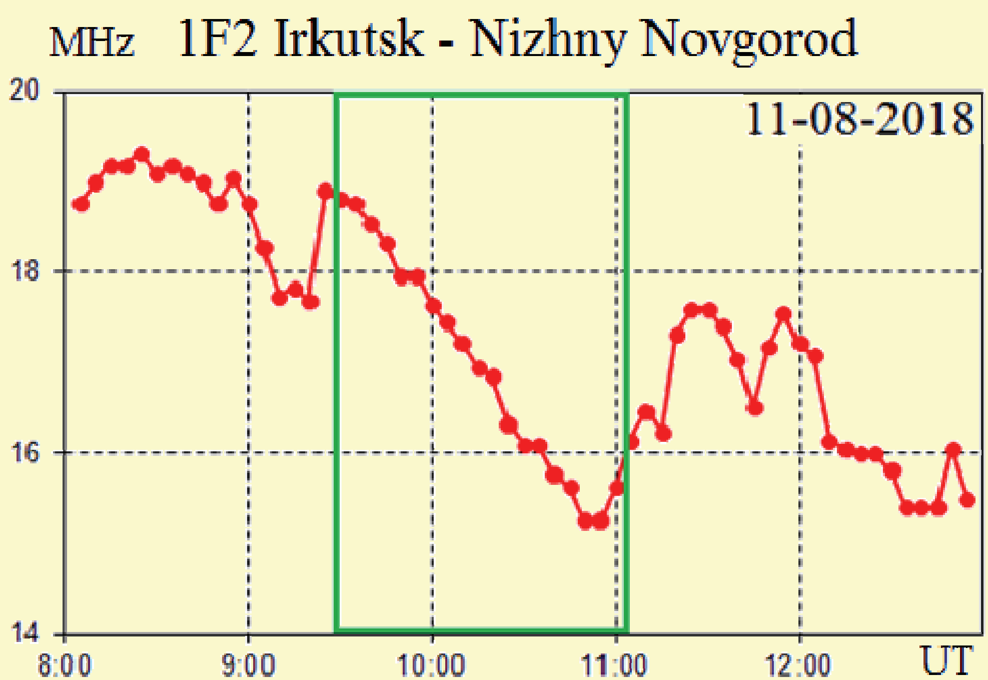
MHz
1F2(o) MOF Norilsk - Vasilsursk
17,5
16,5
15,5
14,5
13,5
12,5
11,5
10, 12
11-08-2018
UT
8:00:00
9:00:00
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00


MHz 1F2 MOF Khabarovsk - Vasilsursk
10-08-2018
19
18
17
16
8:00
9:00
10:00
11:00
12:00
UT


MHz 1F2 MOF Khabarovsk - Vasilsursk
11-08-2018
2
1
19
18
17
16
8:00
9:00
10:00
11:00
12:00
UT



MHz
1F2 Irkutsk - Nizhny Novgorod
12-08-2018
20
18
16
14
8:00
9:00
10:00
11:00
12:00
UT



MHz
1F2 Irkutsk - Nizhny Novgorod
11-08-2018
20
18
16
14
8:00
9:00
10:00
11:00
12:00
UT

Conclusions

The effect of a partial solar eclipse on August 11, 2018 on the characteristics of the ionosphere is shown.

According to the data obtained, a rather pronounced effect of a decrease in MOF by 8–10% was observed in all paths in the eclipse interval during propagation through the F layer.

It was shown an increase in Es MOF on the Lovozero – Vasilsursk highway by 15%.

Quasiperiodic variations of Es MOF and 1F MOF were observed with periods of 30 and 50 minutes, respectively, on the Lovozero - Vasilsursk and Norilsk - Vasilsursk paths, during a partial solar eclipse on August 11, 2018.