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Kotik, Dmitry; Vybornov, Fedor; Ryabov, Alex; Pershin, Alex; Yashnov, Vladimir
RRI, Higny Novgorod/ Russia

Ground based measurements of ionospheric turbulence manifestations induced by the VLF transmitter

Abstract:

The strong fluctuations of numbers of surrounding plasma parameters were reported in DEMERER satellite studies when passing above the operating VLF stations at altitudes about 700 km [Parrot 2007]. Particularly appreciable variations of electron density and quasi-static electric field (frequency range of 0–1 kHz) were detected when satellite passed the center of the disturbed region under VLF station situated near Nizhny Novgorod [Rapoport 2010]. The area of observed phenomena had the dimensions of 400-500 km in diameter and has been shifted in the magnetic zenith direction. These results provided the impetus to our efforts to detect such phenomena by ground methods. The GPS signals receiver, CADI Ionosonde (both located in 130 km to the east of the city and operating in the monitor mode) and VLF receiver for monitoring the VLF transmitter operation were used in our experiment. We have selected several magnetically quiet days in September 2014 for the analysis. The date of 2014.09.21 was especially interesting. It was observed a rather intensive VLF transmitter operation and passing of four GPS satellites between 21:00 and 24:00 LT. Rays of two satellites (G7 and G8) crossed the region of interest southward of the station, and the other two (G9 and G13) passed this area on the periphery. Comparison of the TEC registration on various routes showed qualitative differences in their behaviors. So the TEC variations for G7 and G8 satellites were maximal during the passage of the impact area and reduce when withdraw from it (by the end of the session). At the same time the amplitude of TEC variation was twice as less for the peripheral G13 satellite and even increased slightly towards the end, when the satellite approached the impact area. And quite different TEC variations curve was observed for the control day 09.23 when transmitter was out of operation. Another interesting passage was observed 09.29 when the track of the satellite crossed the center of the impact area. The TEC variation was characterized by growing of the small scale fluctuations as the satellite approach the center of the area. Operation of the VLF transmitter within 30 minutes in the evening in September 2014 resulted in the appearance of F-spread as one can see from Ionosonde data analysis. The F-spread was consistently observed during VLF transmitter operation at night. The pause up to 15 minutes in the transmitter operation does not effect on the degree of F-scattering. Our study showed the possibility of diagnosing of VLF interaction with upper ionosphere plasma by ground methods. It is obvious that it is necessary to collect statistics and add to experiment the data on signal variations from low-orbit satellites.

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