Modified MSTIDs by SURA powerful radio wave emitting

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Abstract

The first results of TEC perturbation mapping to investigate the artificial plasma perturbations caused by powerful HF radiowave emitting of the ionosphere are presented. We analyze the results of measurements made by SURA in the daytime between 14:45 and 17:30 UT on October 1, 2016 with a 15-minute emitting interval and 15-minute pause interval. To observe the ionosphere modification the dense GPS/GLONASS receiver's network was used. It was found that heating of the ionospheric plasma by powerful radio waves is able to effect on characteristics of natural TIDs, e.g. increasing their amplitude and wavelength.

1. Introduction

The recent studies of ionosphere plasma modification by powerful SURA radio emission found that TIDs with 20-60 minute periods can be induced. Registration of such plasma perturbations were carried out by Doppler radar and incoherent scattering radar [Chernogor L.F., Frolov V.L., 2012], [Chernogor L.F., Frolov V.L., 2013], [Chernogor L.F. et al., 2015]. Based on these studies some conclusions were done. The periodic SURA radiowave emitting almost always lead to TID appearance. The pumping HF radiowave period and generated TID period are similar. The most efficient regimes for TID generation are O-mode radiowaves with 15-30 minute emitting/pause intervals and effective emission power higher than 40-50 MW. Efficiency of TID generation increases while frequency of pumping radiowave and f_0F2 are close. We should note that TIDs generation studies were also held by HAARP [Pradipta et al., 2015]. Using various diagnostic methods it was shown that TIDs generation source located in the upper ionosphere and these plasma perturbations propagate from this area to the all directions.

2. Method and Results

The first results of artificial plasma perturbation observing by two-dimensional TEC perturbation maps are presented in this paper. We analyze the results of measurements made by SURA in the daytime between 15:00 and 17:30 UT on October 1, 2016 with a 15-minute emitting interval and 15-minute pause interval. The effective emission power was 70 MW and emission frequency was 4785 kHz.

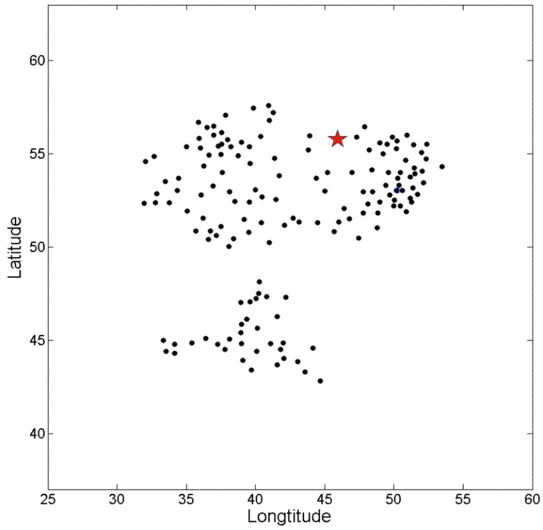

Figure 1. Location of GPS/GLONASS recievers and SURA. Dots represent the locations of the GPS/GLONASS receivers. Red start represent the location of SURA

In this study we use the data from a dense GPS / GLONASS receiver's network. More than 60 GPS / GLONASS receiving points were used. Figure 1 shows the location of SURA and GPS/GLONASS receivers. All GPS/GLONASS receivers provide the data of carrier phase and pseudo-range measurements in two frequencies (f1 = 1575.42 MHz, f2 = 1227.60 MHz for GPS receivers and f1=1602+n×0,5625 MHz , f2= 1246 MHz +n×0.4375 MHz for GLONASS receivers, there n is the number of frequency channel (n =−7,−6,−5,…0,…,6,). The data of GPS/GLONASS data are converted to two-dimensional TEC perturbation maps for TID investigation. Using of two-dimensional TEC mapping method shown by Saito et al. [1998], Tsugawa et al. [2007].

In figures 2a, 2b and 2c two-dimensional TEC perturbation maps for different ionosphere modification

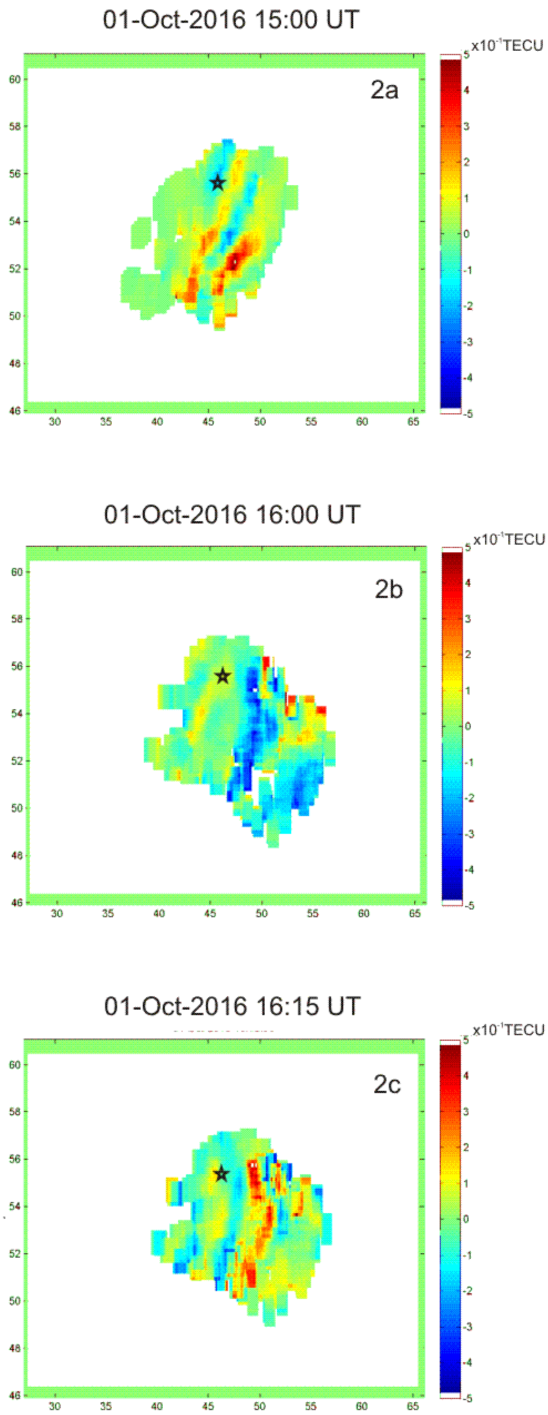

Figure 2. Two-dimensional TEC pertrubation maps during the SURA operation. 2a) Two-dimensional TEC pertrubation maps registred at 1 minute before the first emitting cycle (15:01-15:16 UT). 2b) Two-dimensional TEC pertrubation maps registred at 1 minute before the emitting cycle (16:01-16:16 UT). 2c) Two-dimensional TEC pertrubation maps registred at 14 minute of emitting cycle (16:01-16:16 UT)

cycles are shown. The presence of traveling ionosphere disturbances (TID) of natural origin before the ionosphere modification by TEC maps is observed. The lowest TID perturbation level registered before the ionosphere modification (figure 2a). At the SURA radiowave emitting time the level of TID perturbations increased (figure 2b, 2c). Also, the change in wavelength and propagation direction observed in the nearest to the SURA crest of TID.

The best cycles of ionosphere modification are 15:31 – 15:46 UT, 16:01 – 16:16 UT и 17:01 – 17:16 UT. The increased TEC perturbations are well manifested after four minutes of ionosphere modification. Four minutes after the end of ionosphere modification cycle the TEC perturbation becomes weaker, but the increased level of TEC perturbations could be observed within 15 minutes after SURA turning off. The maximum value of TID perturbations caused by SURA ionosphere modification can be estimated as 0.3-0.5 TECU and the wavelength value may increase twice (from 50-100 km to 150-200 km). The observed TID have a wavefronts longer than 600 km.

3. Conclusions

A preliminary result of the TEC perturbation mapping indicates that it is a good tool to investigate the artificial plasma perturbations caused by powerful HF radiowave emitting of ionosphere F-region. During the cycles of SURA powerful radio waves emitting, the changing of natural TID parameters (TIDs perturbation amplitude, wavelength and propagation direction) were observed. We can conclude that the presence of natural TIDs with a wavelength of 50 - 100 km can stimulate the formation of artificial TEC perturbations. The reason for such relationship remains to be determined.

4. Acknowledgements

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5. References

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