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Monitoring Space Weather with HF Passive Radar for Oblique Sounding of the Ionosphere

Yu Zheng[(1)], Qiang Guo [(2)], Leonid F. Chernogor[(3)], Konstantin P. Garmash[(3)], Victor T. Rozumenko[(3)]
(1) Qingdao University, People's Republic of China
(2) Harbin Engineering University, People's Republic of China
(3) V. N. Karazin Kharkiv National University, Kharkiv, Ukraine

Abstract

Geospace storm of 5 – 6 August, 2019 features are described, and aperiodic and quasi-periodic perturbations in the ionosphere and the geomagnetic field are studied.

1 Introduction

The objective of this work is to present data on the geospace storm and the 5 – 6 August, 2019 ionospheric and magnetic storm features. A geospace storm is a set of synergistically coupled magnetic, ionospheric, atmospheric, and electric field storms.

2 Instrumentation

The observations of magnetic storm effects were made with the magnetometer owned by the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine [1] and the V. N. Karazin Kharkiv National University fluxgate magnetometer [2]. The ionospheric storm effects were studied with the WK546 URSI code ionosonde [3] and the multi-frequency multipath (14 radio paths altogether) HF system for sounding the ionosphere at oblique incidence from the Harbin Engineering University campus [4, 5].

3 Observations

Parameters characterizing the space weather state are presented in Fig. 1. It can be seen that the geospace storm commencement occurred in the morning of 5 August, 2019, the main phase evolved in the course of 5 and 6 August, 2019, and the recovery phase proceeded during 7, 8, and 9 August, 2019.

UT variations in the geomagnetic field components are shown in Fig. 2 and Fig. 3.

UT variations in f_oE, f_oF_2, $h'E$, and $h'F_2$ are presented in Fig. 4. It can be seen that the variations on 5 August 2019 considerably differ from those on the reference day 2 August 2019.

Examples of UT variations in the Doppler spectra at 6,015 kHz along the Hwaseong to Harbin propagation path and at 9,750 kHz along the Yamata to Harbin propagation path can be seen in Fig. 5. Fig. 5 shows that the character of the variations on 5 and 6 August 2019 differs appreciably.

4 Conclusions

An increase in the basic parameters of the solar wind on 5 August 2019 resulted in the geospace storm that was observed mainly on 5 and 6 August 2019. The main phase of the magnetic storm occurred from 06:00 UT to 08:30 UT on 5 August 2019. The recovery phase persisted for no less than 4 days. The magnetic storm displayed itself in significant variations of all geomagnetic field components, in an increase by an order of magnitude in the 400 – 950-s period range. In the course of the magnetic storm, the F region experienced significant perturbations, while the E region remained essentially unchanged. The ionospheric storm appreciably affected Doppler spectra in the 5 – 10 MHz frequency range, which showed a significant spread, and the Doppler shift of frequency variations exhibited a 20 – 40-min quasi-periodicity and had temporal duration of 120 – 240 min. The quasi-periodic variations in the Doppler shift of frequency are caused by the quasi-periodic variations in the electron density whose amplitude, δ_{Na}, varied from 3% to 16%. Along one of the propagation paths, the Doppler shift of frequency amplitude attained 0.7 Hz, while δ_{Na} could attain 80 – 90%. Along the majority of the propagation paths, the ionospheric storm affected the signal amplitude insignificantly.

5 Acknowledgments

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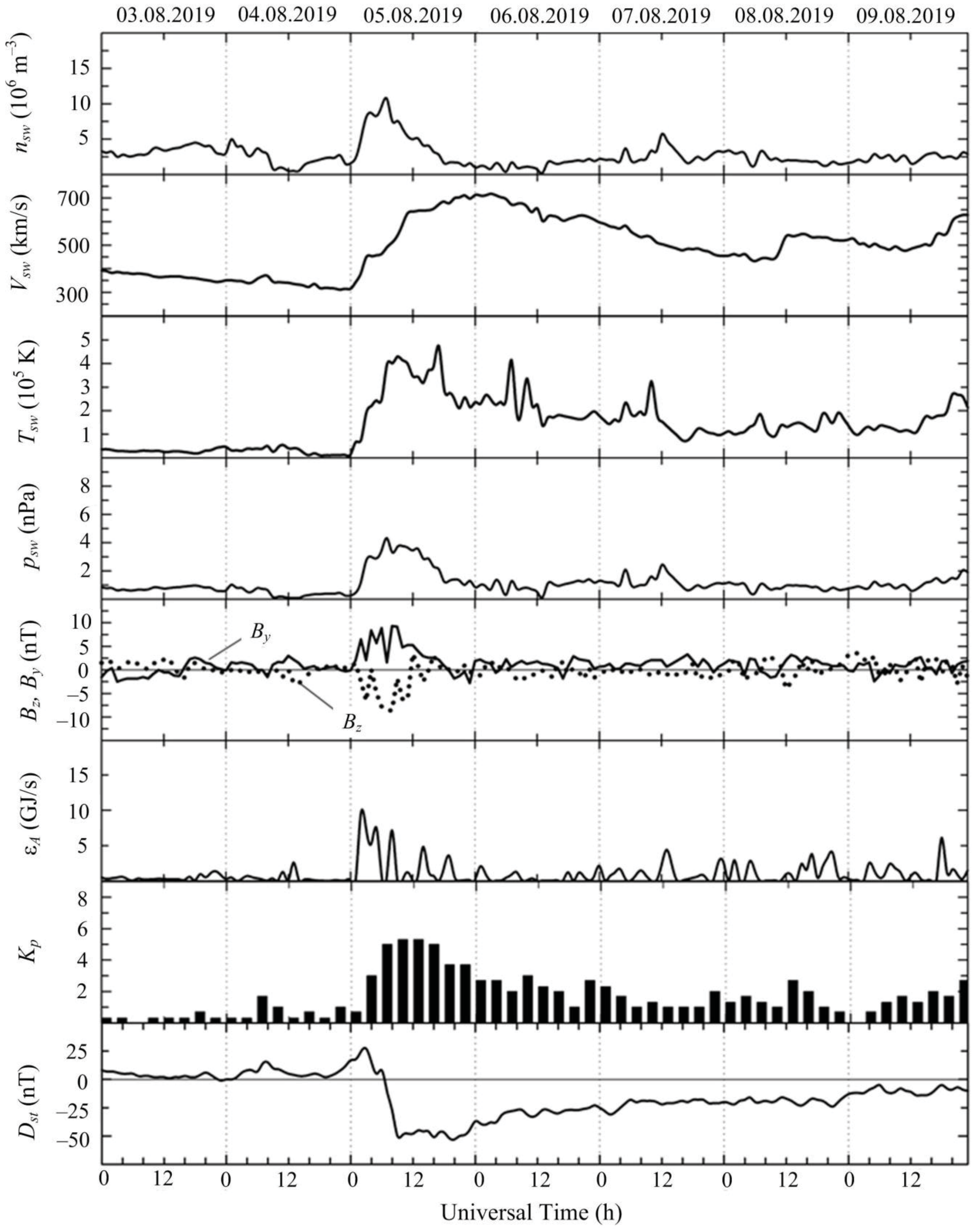

Figure 1. Space weather state. The solar wind proton density n_{sw}, solar wind bulk speed v_{sw}, solar wind ion temperature T_{sw}, calculated solar wind dynamic pressure p_{sw}, interplanetary magnetic field B_z, B_y components, calculated Akasofu's epsilon parameter ε_A, and magnetic-activity indices K_p and D_{st} for the 03 – 09 August 2019 period. The ACE and GOES Satellite data are retrieved from ftp://ftp.swpc.noaa.gov.

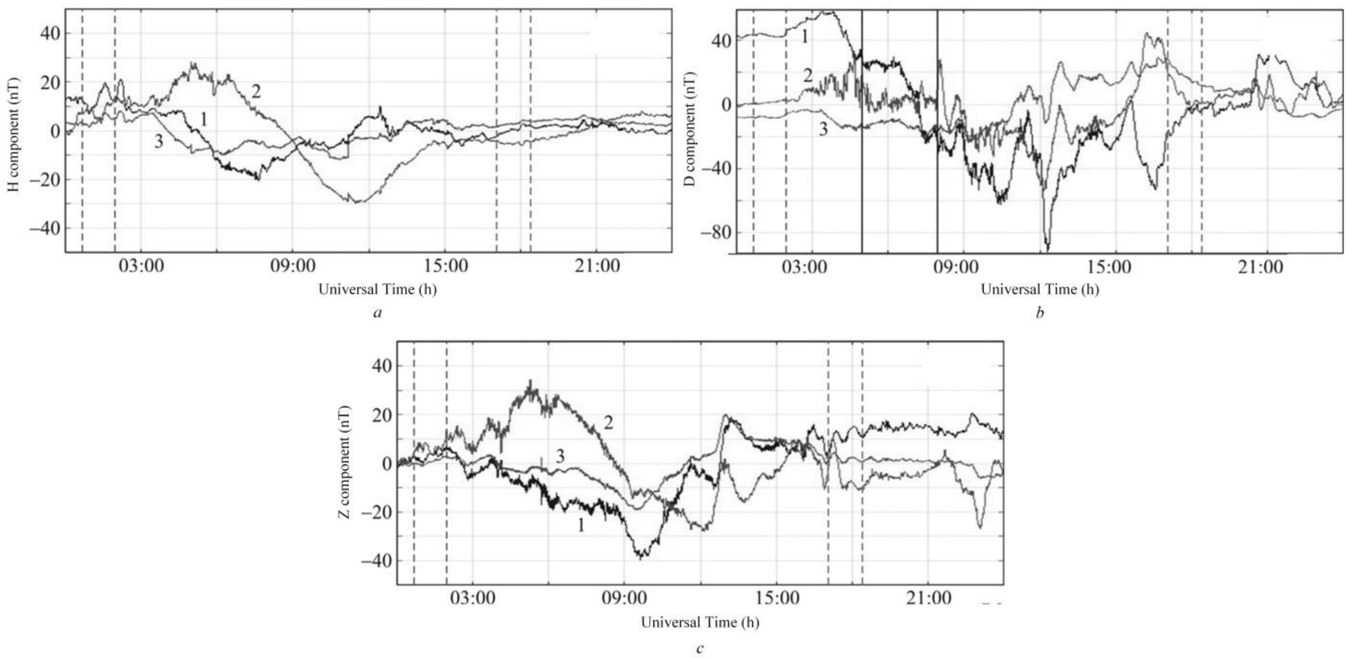

Figure 2. Universal time variations in the geomagnetic field *H*, *D*, and *Z* components for 2, 5, and 6 August 2019 (*a*, *b*, and *c* panels, respectively). The *H*, *D*, and *Z* components are denoted by 1, 2, 3, respectively [1]. The solid lines show the time interval for the occurrence of the main phase of the magnetic storm, and the dashed lines indicate the sunset and sunrise at the ground and at an altitude of 100 km.

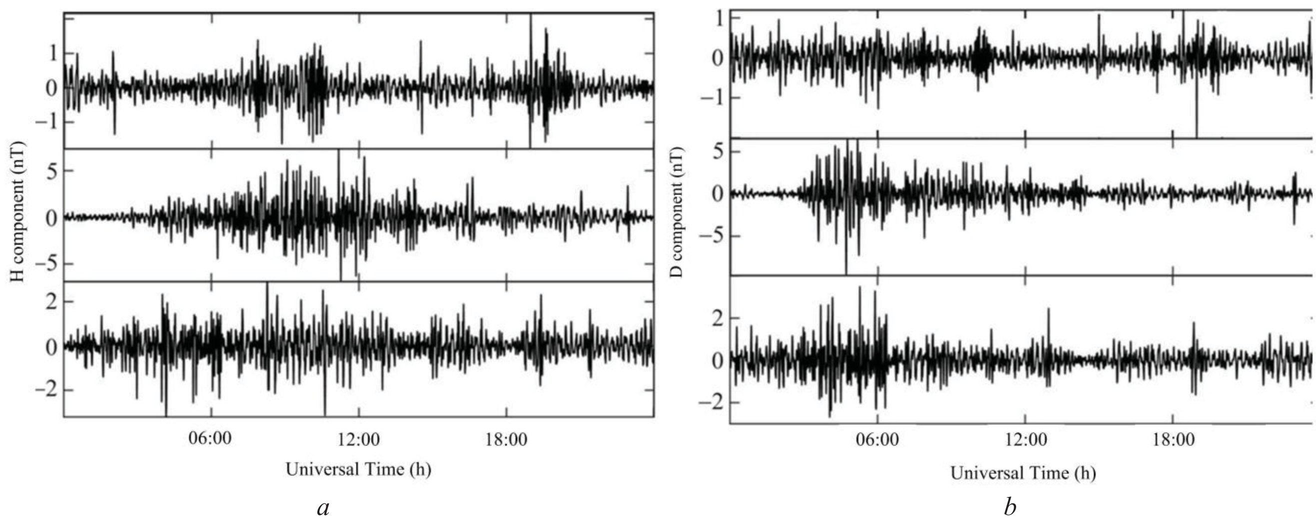

Figure 3. Universal time variations in the geomagnetic field *H* and *D* horizontal components in the 100 – 1000-s period range for 2, 5, and 6 August (panels from top to bottom).

6 References

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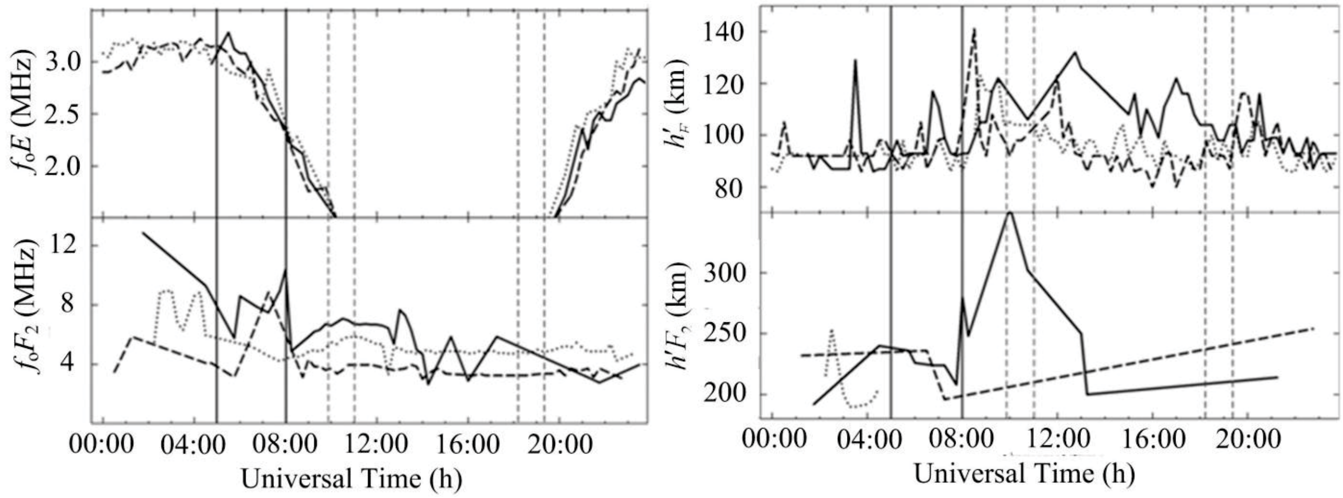
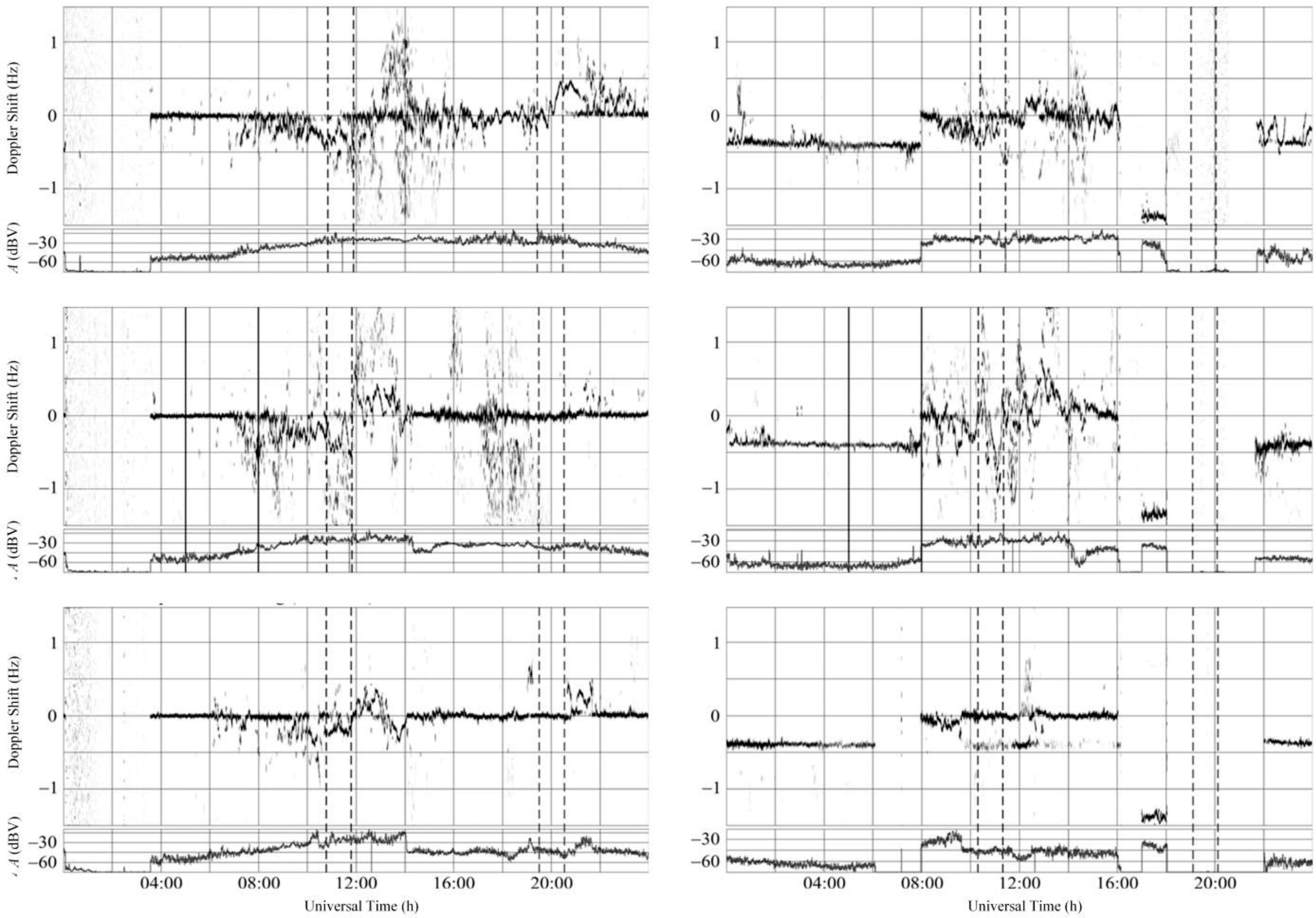


a *b*

Figure 4. Universal time dependences of f_oE and f_oF_2 (*a*) and the virtual heights $h'E$, and $h'F_2$ (*b*) for 2 (dots), 5 (solid line) and 6 (dashed line) August 2019. The vertical solid lines designate the main phase of the magnetic storm, and the vertical dashed lines show the sunset and sunrise at the ground and at an altitude of 100 km.



a *b*

Figure 5. Universal time variations in the Doppler spectra and the signal amplitude along the (*a*) Hwaseong to Harbin and (*b*) Yamata to Harbin propagation paths on 2, 5, and 6 August 2019 (panels from top to bottom). The vertical solid lines designate the main phase of the magnetic storm time interval, and the dashed lines indicate the sunset and sunrise at the ground and at an altitude of 100 km.