Characterization of Shortwave Fadeout seen in Daytime SuperDARN Ground-Scatter Observations
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Abstract

Shortwave fadeout (SWF) is one of the multi-frequency radio wave anomalies that occur in the upper atmosphere. During a solar flare, the sun emits soft and hard X-rays in the order of 10 ns, which penetrates through the atmosphere and reaches the Earth. During this period, a sudden increase in plasma density leads to an enhancement of the HF ionospheric absorption of various communication channels that persist for 10(4) to 10(5) seconds. SuperDARN observations of daytime ground-scatter are strongly affected by a large number of ground-scatter echoes if the event is strong enough. During this period, the ground-scatter echoes are also suppressed. We analyze the data from SuperDARN Hokkaido and SuperDARN Antennas SWF across North America to better understand the SWF phenomena.

Introduction

The shortwave fatigue effect due to EM radiation in all possible frequency bands is responsible for the formation of ionospheric HF occurrence. Higher energetic cosmic rays penetrate many lower in the atmosphere (almost to the D-layer of ionosphere; 70 ≤ Z ≤ 90 km). During a solar flare event, the spectral ionization of X-ray has two main effects on the observed frequency band, which enhances the ionization to a few times. During this period, the ground-scatter echoes are also suppressed. We used the SuperDARN Hokkaido radar data to study the blackout event and to gain a better understanding of the SWF phenomenon.

Observations

Figure 2 and 3 give an overview of the SuperDARN daytime observations with the ground-scatter Doppler velocity and spectral width of SuperDARN ground-scatter echoes. The Doppler velocity of ground-scatter is less than 10 m/s. However, ground-scatter recovery is typically observed during the daytime of SuperDARN observations. The ground-scatter echoes are also suppressed during the daytime of SuperDARN observations. Figure 2 presents variations in the recovery of ground-scatter echoes during the events shown in Figure 1.

Figure 4 presents different processes of SWF event seen in daytime ground-scatter observations. It also shows the time evolution of traveling radio waves attenuation due to the SWF event. Figure 5 shows the locations of the SuperDARN radars, which are used in this study.

Figure 6 shows the characteristics of shortwave fadeout, as observed in the radar data during the daytime of SuperDARN observations.

Observations (cont.)

Figure 7 shows the characteristics of shortwave fadeout, as observed in the radar data during the daytime of SuperDARN observations. It also shows the time evolution of traveling radio waves attenuation due to the SWF event. Figure 8 presents statistical results of the SWF event seen in daytime ground-scatter observations. This study shows that the average duration of onset phase is approximately 1.2 minutes, which is typically one scan time of the radar. This duration of onset is different from the event seen in daytime ground-scatter observations.

Conclusions

We characterize SWF events based on depth of blackout and duration of the event phases seen in SuperDARN ground-scatter observations. We also find suppression in ground scatter during the main phase of the event, which is anecdotally a sudden increase in velocity. This velocity shift is acting as a precursor of SWF event. Automated event detection tool is used to search SWF patterns in SuperDARN database. On the other hand, real-time SWF monitoring tool is used to monitor the surface of SWF across North America. Both the tools use the knowledge of the SWF characterization seen in SuperDARN observation. Future work: A web-based real-time SWF monitoring tool is in development.

References


Autonomous Tools

Figure 9 shows the characteristics of shortwave fadeout, as observed in the radar data during the daytime of SuperDARN observations. It also shows the time evolution of traveling radio waves attenuation due to the SWF event. Figure 10 presents statistical results of the SWF event seen in daytime ground-scatter observations. This study shows that the average duration of onset phase is approximately 1.2 minutes, which is typically one scan time of the radar. This duration of onset is different from the event seen in daytime ground-scatter observations.

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