Solar flare-induced gradient drift instability observed by SuperDARN HF radars

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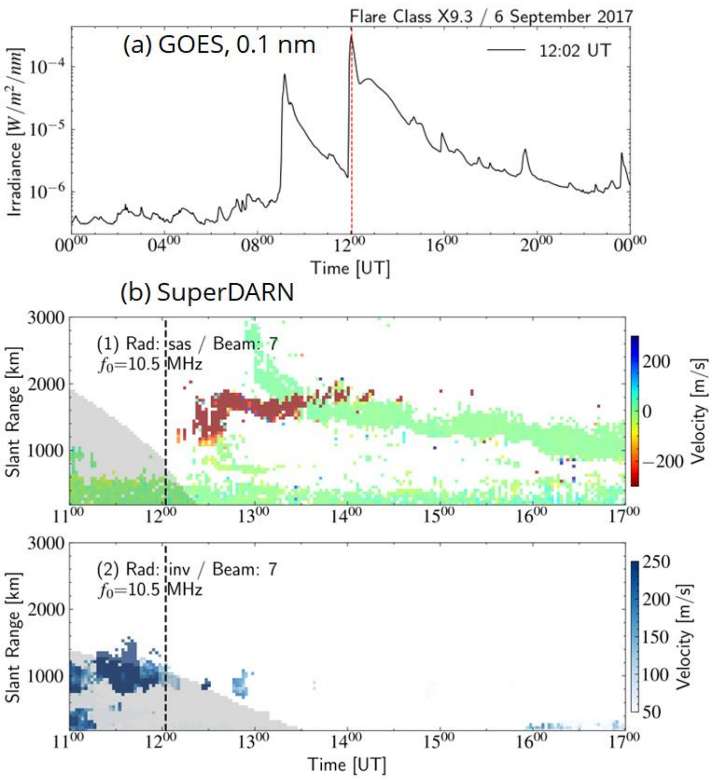

Figure 1. Solar flare irradiance and its impact on the ionosphere recorded by SuperFARN HF radars on 6 September 2017: (a) GOES flare irradiance at 0.15 nm; (b) range-time plots showing LoS Doppler velocity recorded by (b-1) Saskatoon and (b-2) Inuvik radars color coded by the color bar on left of each panel. The vertical dashed lines represent flare peak, and the gray shaded region indicates solar zenith angle greater than 90°.

A solar flare effect (SFE) is a transient disturbance in sub-auroral, middle, and low latitude dayside ionospheric currents due to changes in the ionospheric electric field and conductivity caused by flare-enhanced photoionization [1]. However, the largest X-class flares can impact current systems at auroral and polar latitudes as well. Using ground-based radars and GNSS TEC receivers located at high and middle latitudes in the North American sector, we analyzed SFE effects in response to an X9.3 flare on 6 September 2017. We found: (i) the SuperDARN radar located at Saskatoon observed a sudden appearance of irregularity backscatter near the dawn terminator quickly following the flare; (ii) the SuperDARN Inuvik radar, located in the polar cap, recorded a sudden reduction in plasma flow velocity; and (iii) several other SuperDARN radars at high and middle latitudes observed intensified irregularity backscatter near the dawn terminator persisting for several hours. We speculate that flare-enhanced density gradients intensified the conditions for the Gradient Drift Instability (GDI) at the day-night terminator, consistent with [2]. Also, the reduction in plasma flow velocity observed by the Inuvik radar was likely driven by a reduction in the efficiency of mechanical energy conversion in the dayside solar wind-magnetosphere-ionosphere (SW-M-I) interaction, also due to SFE.

References

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[2] K. Hosokawa and et al., “Characteristics of solar flare effect in the high-latitude ionosphere as observed by the SuperDARN radars,” Advances in Polar Upper Atmosphere Research, 2000.