

Diagnostics of Ionospheric Field Aligned Irregularities (FAIs) Using "Patchy" Specularly Reflected (SR) Whistler-Mode Echoes Observed on IMAGE

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Ionospheric field aligned irregularities (FAIs) are one of the key indicators of space weather. FAIs are also important from a practical standpoint because they contribute to the fading of high frequency trans-ionospheric signals, the degradation of ground to satellite communication, and uncertainties in GPS signals. In the past, FAIs were obtained mainly from the bottom and topside sounding of the ionosphere using radio waves in the HF range or from in situ satellite measurements using plasma density probes, ground-based radars, and GPS ground and satellite receivers for TEC measurements. Recently, a combination of observations from low altitude (<1000 km) satellites, ground-based radars, and GPS TEC receivers have been used to determine the altitudinal and latitudinal extent of FAIs at ionospheric heights. We present a new way to measure FAIs and their altitudinal extent using Specularly Reflected (SR) patchy whistler mode (WM) echoes observed on IMAGE. Patchy SR echoes are reflected from the Earth's ionosphere boundary at 90 km and show the absence of echoes over a range of transmitted frequencies. The patchy pattern of these echoes is attributed to the presence of 10 km or larger scale size irregularities in the ionosphere. Using the WM radio sounding method [Sonwalkar et al., JGR, 116, pp. A11211, 2011], we show that such irregularities can explain the patches in the observed echoes. We demonstrate our results with the help of patchy SR echoes observed on IMAGE on 22 Oct 2005 (altitude = 3404 km, $\lambda_m = 31.9^\circ\text{N}$, $L = 2.13$, and $MLT = 11.2$). Our preliminary raytracing results indicate that irregularities of 10-100 km scale size at 200 – 1600 km and enhancement of 50-70% along $L \sim 2.16$ explain the patchy SR echoes on 22 Oct 2005. These measurements of irregularities are consistent with those measured in the past. We discuss how patchy SR echoes can be used to study FAIs as a function of geomagnetic and solar activity. The method demonstrated here for ionospheric irregularities measurements applies to the patchy WM echoes we expect to observe on DSX. Measurements of ionospheric irregularities combined with physics-based model simulation should provide a new understanding of the physical processes and mechanisms important to generating ionospheric irregularities.

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