150-km echoes: Existence of two distinct types of equatorial echoes and the influence of solar radiation

Jorge L. Chau[1], Erhan Kudeki[2], Pablo M. Reyes[2]
[1]Leibniz Institute of Atmospheric Physics at the Rostock University, Kühlungsborn, Germany
[2]Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, IL, USA

The 150-km altitude region of the equatorial ionosphere is known to exhibit meter-scale electron density irregularities during daytime hours that scatter the VHF radar signals propagating perpendicular to the geomagnetic field in the region. We show here that VHF signals scattered from the 150-km region above the Jicamarca Radio Observatory located near Lima, Peru, exhibit two distinct types of features. In one type the Doppler spectral width increases with the echo strength and the corresponding signal-to-noise ratio (SNR). A second type of higher SNR echoes exhibits SNR-independent Doppler spectral widths narrower that those observed in the first type. This classification of the equatorial 150-km radar returns was discovered within a data set consisting of 9 days of Jicamarca observations conducted in January 2009. The low SNR echo population with SNR-dependent spectral widths is by far the dominant population --- more than 90% of the observations was of this type. While the underlying physics governing the generation of the 150-km density irregularities corresponding to these two types of echoes remains uncertain, comparisons with earlier data sets collected at Jicamarca and elsewhere is suggesting that the population of weaker SNR echoes is likely to be associated with a naturally enhanced incoherent scattering (NEIS) process while the second population with the unstable growth of field-aligned irregularities (FAI) in the electron density of the region (see Figure 1). We conjecture that small radar systems operated near the geomagnetic equator that have reported 150-km echo observations are mainly detecting the second type of FAI-related radar returns. Echoes produced by NEIS can only be seen by high sensitivity systems such as Jicamarca and possibly the Indian MST radar at Gadanki. In addition, we show and discuss the strong dependence of 150-km echoes (altitude and intensity) on solar radiation, a parameter that has been overlooked in most theories trying to explain these echoes. Figure 2 shows an example of how 150-km echoes are modified during a solar flare. It is hoped that the categorization of the 150-km returns being proposed here and the dependence on solar radiation, may lead to a better understanding of the 150-km scattering phenomena and contribute toward the resolution of the long standing mystery surrounding the generation of the 150-km irregularities in the low latitude ionosphere.

References

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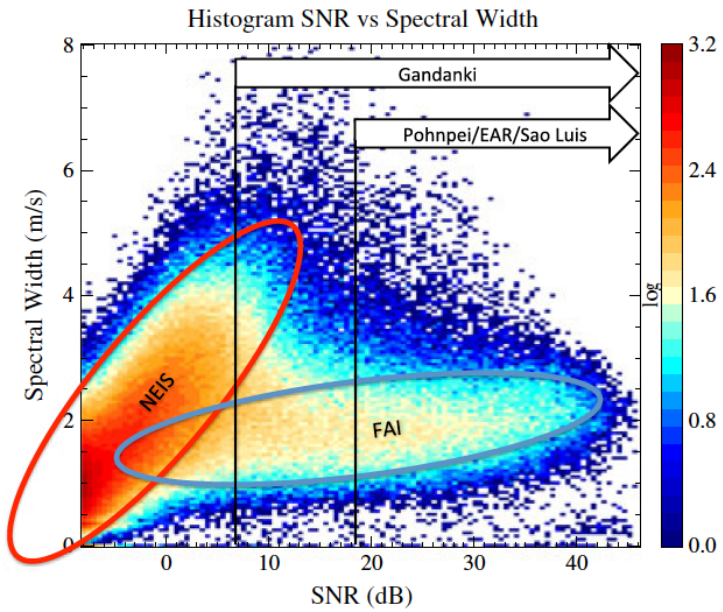

Figure 1. Two-dimensional histogram of 150 km echoes from 9 days of data in January 2009, as function of SNR and spectral width. Note that number of occurrences is given in log scale. Data with SNR greater than –8 dB have been used. Two different populations are indicated with ellipses: NEIS and FAI, respectively (from *Chau and Kudeki* [2013]).

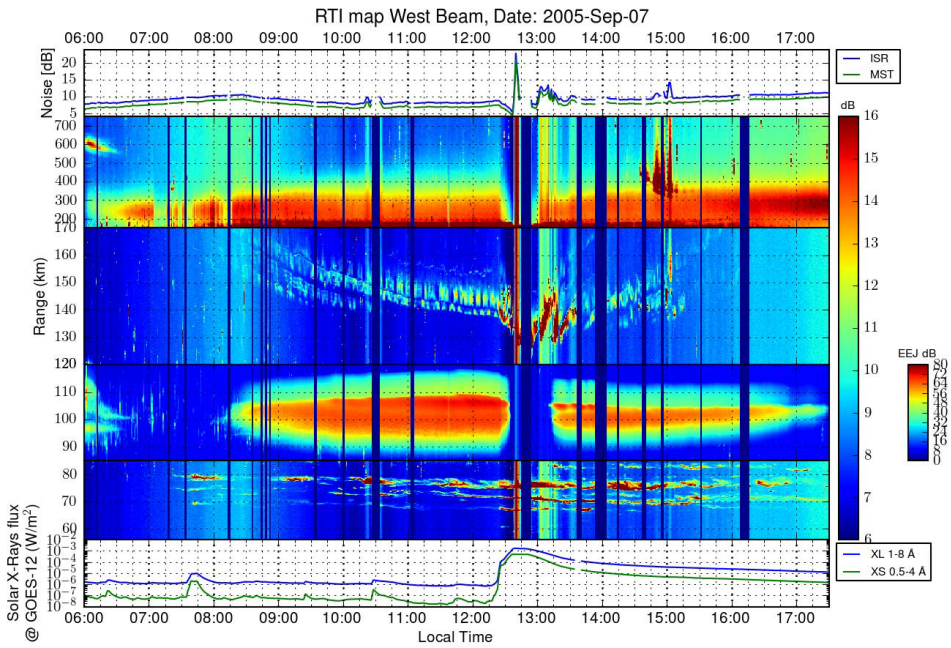

Figure 2. Range-time Intensity map of the MST and ISR regions in a 60 seconds time resolution during the X17.1 solar flare on September 7, 2005. The plot in the top shows the background noise power for each mode. Incoherent scatter, 150-km irregularities and mesospheric turbulent layers are shown with the dB range (6 to 16 dB) while the equatorial electrojet (EEJ) is shown with a larger dB range (0 to 80 dB) to notice its structure. The plot in the bottom shows the X-ray flux obtained from the GOES satellite (from *Reyes*, [2012]).