



Recent radar observations of the equatorial ionosphere at the Jicamarca Radio Observatory

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New radar configurations and techniques to probe the equatorial ionosphere have been conducted at the Jicamarca Radio Observatory (JRO) in recent years. For instance, in 2017, a special radar configuration considering a sequence of very long pulses (1 ms, 2 ms, and 4 ms pulses) was implemented.^[1] Operating the JRO transmitters to its maximum capacity, both in power and duty cycle, we conducted measurements of equatorial plasma densities reaching altitudes around 6,000 km, something that was not attempted since the sixties. In addition to the density measurements, this experiment led us to the discovery of high-altitude coherent radar echoes at altitudes around 1,500 km. These echoes were observed after midnight at topside altitudes under low solar flux conditions. Further radar campaigns were conducted in 2018 and 2019 to study the nature and characteristics of these echoes. Based on the observations, we have found that these echoes have a morphology different from the equatorial Spread F irregularities.^[2] The spectral analysis of the echoes showed sidebands at the lower hybrid resonance frequencies in plasmas. Additional studies are being conducted to understand the generation mechanism of these high-altitude coherent echoes and their relation to lower hybrid waves in the ionosphere.

In addition, radar campaigns conducted in parallel with new ionospheric instrumentation and systems deployed around the Jicamarca observatory have improved our observational capabilities. One of these systems is a multi-static HF sounding network deployed in the central part of Peru to study ionospheric radio propagation and the effects of the occurrence of equatorial Spread F. The system is composed of 3 transmitter (beacon) stations located at Ancon, Ica, and Sicaya. These stations transmit two different HF frequencies (2.72 and 3.64 MHz) and deliver a power in the order of a few watts. The transmitted CW signals are modulated using pseudorandom noise (PRN) codes, different for each station. In reception, we have six stations located at Jicamarca, Mala, Barranca, La Oroya, Huancayo, and La Merced. At these stations, we measured the signals reflected from the ionosphere for the different possible

radio links, and then estimate the virtual range for each link. Based on these virtual ranges, and applying a refraction tomography inversion approach, we estimate F-region ionospheric densities in 3D over the central coast and Andes region in Peru. These observations are used to study the conditions that preclude the occurrence of equatorial Spread-F.^[3]

In this presentation, we will describe these new radar configurations, as well as the ionospheric observations that have been conducted with them. We will also present some of the major radar upgrades that are currently being implemented at JRO. These improvements that include the implementation of an electronic beam steering system for the Jicamarca antenna and the use of solid-state medium power transmitters are going to expand the radar capabilities significantly and allow the generation of new experiments and science.

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References

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