First steps towards the implementation of a cognitive radar to study plasma instabilities near the Peruvian Andes

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A cognitive radar system is composed of three key components: 1) intelligent signal processing, which builds on radar interactions from the surrounding environment, 2) receiver feedback which is utilized by the transmitter to facilitate an intelligent response to detected signals, and 3) preservation of radar echo information contents. We describe the implementation of a VHF coherent imaging radar in Huancayo, near the Peruvian Andes to initiate continuous monitoring of the plasma structuring in the equatorial ionosphere. The new radar system will utilize cognitive sensing techniques and complement the ionospheric observations conducted by the Jicamarca incoherent scatter radar (ISR), located about 170 km to the west of Huancayo along the geomagnetic equator. The main purpose of the new system will be to obtain uninterrupted images of ionospheric structuring and drifts from Huancayo, which are only probed and sampled intermittently from Jicamarca due to the operation costs and scheduling issues of the more powerful incoherent scatter system. The proposed system will work in two stages: 1.) Classifying the occurrences observed in the atmosphere, and 2.) transmitting an optimal waveform to illuminate and process areas of interest. In this paper, we present classification techniques to correctly indentify the following geophysical equatorial echoes: Spread-F, electrojet, 150 km echoes, and meteors. These events are each categorized by signal parameters with known distributions, e.g., signal-to-noise ratio, changes in range, instantaneous frequency, periodicity, etc. In this presentation, we will provide an overview of the classification algorithm used to distinguish returns from the various equatorial phenomena. A Gaussian Mixture Model (GMM) has already been implemented to classify meteor events at mid latitudes. The same algorithm has been extended to include the Spread F, 150 km echoes, and electrojet. Previously, classifying the meteors events involved capturing whole process because of the feature selection of the GMM. With the addition of these events however, new procedures are used because the duration of the phemonema sustains for multiple hours. Therefore, classification must be made with a small fraction of the entire event. The purpose of this approach is to formalize the first step towards the cognitive radar, which can then be further extended to adjusting the waveform parameters for optimal responses.