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Simulating Ionization Layers Generated by Artificial HF Heating

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A number of recent experiments at Arecibo Observatory have demonstrated that High Frequency (HF) Heaters can excite photoelectrons in the daytime ionosphere to energies that are high enough to ionize neutral particles in the atmosphere. The ionized particles form a layer just below the typical F-layer in the ionosphere. Observations have shown that sometimes the ionized layer descend in altitude. Although, a number of potential reasons for this descent phenomenon have been suggested, the overarching mechanisms that determine when the layer does or does not descend remains unclear.

In this study, we employ a version of SAMI3/ESF to investigate the importance of the photoelectron ionization rate and the background neutral winds as potential mechanisms for the layer descent phenomenon. Previous studies have shown that the layers generated by artificial HF heating can be simulated using a coupled model of HF heating that combines an ionosphere model (SAMI3/ESF) with an HF propagation model (MoJo). We calculate, at each output time step, the path of the radio wave through the modeled ionosphere in order to determine the location of HF heating. To simulate the layer generation, an additional term has been added to the model to artificially increase photoelectron ionization at the HF heating location. Based on the simulation results, we found that the layer descent (whether it descends or not as well as the rate of the descent) is highly dependent on the photoelectron ionization rate. This is consistent with observations that have shown that the layers often descend during local morning hours when there are more photoelectrons in the ionosphere. In addition, we found that the rate of the layer descent can be modified by changing the speed and direction of the neutral winds, which indicates that the background conditions also may influence the variability that has been observed in layer descent.