

AN INVERSE-THEORETIC APPROACH TO THE OPTIMAL  
EXTRACTION OF IONOSPHERIC PARAMETERS FROM IN-  
COHERENT SCATTER RADAR MEASUREMENTS

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The extraction of altitude profiles of ionospheric plasma parameters from the incoherent scatter radar (ISR) measurements requires careful consideration of two aspects of the inversion process. The first is the range smearing effect of the radar pulse on the information from one altitude over a range of altitudes, and the second is due to the nonlinear relationship between the plasma parameters and the measured spectra. The reduction of the range smearing of the ionospheric autocorrelation function has been addressed conventionally by incorporating coding schemes in full-profile analysis whereby initial models of the altitude profiles of the plasma parameters are assumed, the theoretical autocorrelation functions (ACF's) based on these models are calculated upon the proper decoding of the imposed coding schemes, and the result is compared with the data iteratively via non-linear least squares methods to converge to an estimate that is desirably close to the constructed models. The performance of such techniques, however, is limited by the ability to specify accurate initial models for the altitude profiles of the parameters.

In this work, we present a model-free two-step technique for the estimation of ionospheric parameters with improved accuracy and reduced computational complexity. The approach is to remove the range smearing from the measurement in the first step, hence obtaining ionospheric ACF's at each altitude individually. This is accomplished by performing a set of 1-D deconvolutions for each time lag, where regularization techniques are developed and incorporated in order to ensure robustness in the presence of noise. Extraction of the plasma parameters based on the resolved ACF's forms the second step and requires non-linear least squares fitting methods. Toward this goal, simulations were performed to confirm that the transmission of a pair of amplitude modulated (AM) pulses yields more accurate deconvolution results (due to reduction in range smearing effect) and hence more accurate parameter estimation than transmitting a simple long pulse. To evaluate the performance of the method, an F-region experiment was conducted at Arecibo observatory in which two AM pulses and a long pulse were transmitted in 10-second intervals. The new technique was examined on both data sets. The results of applying the new technique to AM data show superior performance over those of the long pulse data, and also over the conventional methods currently used in Arecibo.

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