Combining ion line and plasma line measurements to study the F1 region at Arecibo

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The large sensitivity of the Arecibo incoherent scatter radar (ISR) makes it possible to measure the plasma line component of the incoherent scatter spectrum with very high precision, and high resolution in altitude and time. From these very accurate plasma line measurements it is possible to determine both the electron temperature (Te) and the electron density (Ne) as a function of altitude in the F region, independent of the ion line, with the technique of *Nicolls et al*. (Geophys. Res. Lett., 33, L18107, doi:10.1029/2006GL027222, 2006). In this paper we show a method to combine the Ne and Te parameters from the plasma line, along with ion line spectra, to measure the molecular ion composition, and the ion temperature (Ti) in the lower F region.

The accurate measurement of ionospheric parameters in the F1 region with incoherent scatter radars has been a long-standing problem. In essence, it is basically impossible to measure Ne, Te, Ti and the molecular ion fraction in the F1 region with an ISR by fitting theoretical ion line autocorrelation functions (ACFs) or spectra to the corresponding measured functions. In order to perform the measurements, additional information is needed. Traditionally this additional information has come from a model (either values or a function) of the molecular ion fraction as a function of altitude. This is the standard approach for analyzing the lower F region data at Arecibo. But as we will show, it is difficult to come up with an assumed model that can handle daily variations, especially near the transition altitude between molecular ions and atomic oxygen ions, and above.

The technique that will be discussed is only valid during the daytime, when the naturally occurring plasma line is enhanced by photoelectrons. This technique has an advantage over other methods in that it provides from the start a very accurate (and absolute) electron density measurement from the plasma line, and with the plasma line Te measurements, it allows for further guiding the fitting of the ion line data to get the remaining two parameters (Ti and the molecular ion fraction). The fitting is done height by height, without any other assumptions, which is probably not possible at any other ISR. Recent Arecibo measurements from different days and seasons will be presented.