Investigation of coding schemes for incoherent scatter radar experiments at Arecibo

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In this work, we describe the results of several new Arecibo incoherent scatter experiments utilizing amplitude modulation (AM) techniques with the goal of improvements in range resolution and statistical uncertainty in estimated parameters. Currently, the standard technique for this type of measurements at Arecibo involves simultaneous long pulse transmissions over multiple frequencies [Sulzer, 1986]. This technique has been developed to take advantage of the high signal-to-noise ratio (SNR) achievable in the F-region Arecibo measurements. This particular setting allows simultaneous measurements of plasma parameters such as electron and ion temperatures, electron density and ion composition from 160 to 680 km. The range smearing of information caused by the long pulse modulation, however, is inevitable and as such the range resolution is very coarse (about 38 km).

The new experiments involve interleaved transmissions of 300-μs long pulses and several AM codes from 60 km to 1200 km. In order to provide a ground truth for electron density measurements, transmissions of a 13-bit Barker code with 4-μs bauds were also performed as part of the experiments.

We will present the measurements along with the estimation results, which show that (with the multi-pulse coding technique as the limiting case) for a fixed integration time, the lower the ratio of the on/off portion of the code is, the lower is the statistical uncertainty in estimated parameters. This is due to the fact that amplitude modulation reduces the correlation between measured ACF lag estimates and as such increases the speed of measurements, which in turn reduces estimated parameters' uncertainty. The results also show that when the SNR is high enough, depending on the coding scheme, range resolution can be improved over the conventional long pulse modulation by up to a factor of three.