A Lightning-Based, Passive, Portable Ionospheric Sounder: The Lionosonde
USNC-URSI National Radio Science Meeting

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We present the Lionosonde, a portable, passive ionosonde that leverages the broadband emissions from lightning in the 2 to 30 MHz frequency range to produce ionograms. A Lionosonde system consists of one or more cross loop antennas, one or more Ettus Research USRP X300 software defined radios, and a single recording computer. The Lionosonde uses an algorithm to identify and isolate nearby (<200 km distant) lightning emissions and then convert these observations into a lightning ionogram (Lionogram). This algorithm, which was first described in (K. S. Obenberger, et al. Radio Sci, 53, 11, 1419–1425), uses the observed emissions above the maximum expected foF2 as an amplitude modulation (AM) waveform. It then correlates this AM waveform with each frequency bin below the maximum expected foF2 to get a time delay to any signal reflected from the ionosphere at that frequency.

This processing can be done in real time using a two second buffer of the raw 20 MSPS time series from each element. Alternatively these data can be recorded straight to disk from up to 8 separate channel inputs, where the data can be processed at a later time. During thunderstorm activity a Lionosonde can produce as many as a thousand Lionograms per hour. With dual polarization antennas, both O and X mode propagation can be isolated, and several consecutive ionograms can be averaged together to increase the signal-to-noise ratio.

With multiple elements, imaging techniques can be used to find the angle of arrival (AoA) of the reflected signal as a function of frequency. As shown in (J.B. Malins, et al. Radio Sci, 54, 11, 1129-1141) the AoA as a function of frequency can be used to infer tilts the bottomside ionosphere. We will present data from several Lionosonde systems, both with and without imaging capabilities that have been deployed to a variety of locations including New Mexico and Florida.