# The VLF Transmitter Signal as a Diagnostic of Thunderstorm-Ionosphere Coupling

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Very Low Frequency (VLF) transmitter remote sensing has long been used as a useful diagnostic for the D-region ionosphere. All it requires is a VLF radio receiver monitoring the amplitude and/or phase of a beacon signal over time. During ambient and disturbed conditions, the received signal can be compared to a theoretical model to infer ionospheric properties like electron density.

Amplitude and phase have in most cases been analyzed each as individual data streams. A clever formulation known as scattered field analysis was recently reintroduced, which combines amplitude and phase into a single measurement, and calculates the phasor of the scattered field, providing insights that would otherwise be missed by either amplitude or phase individually.

In this presentation, we describe another useful formulation that builds on that and goes step further, combining the amplitude and phase of two horizontal magnetic field channels into a single measurement: polarization ellipse. This allows insights that are not seen by examining one channel at a time.

Using this formulation, we take a new look at ionospheric disturbances from thunderstorms, including early/fast events and lightning-induced electron precipitation.