Characteristics of VLF/LF Sferics from Elve-Producing Lightning

Patrick R. Blaes and Robert A. Marshall
Stanford University, Stanford CA 94305

Lightning return strokes radiate an electromagnetic pulse (EMP) which interacts with the D-region ionosphere. The largest EMPs produce new ionization, heating, and optical emissions known as elves. Elves are at least six times more common that sprites and other transient luminous events. Though the probability that a lightning return stroke will produce an elve is correlated with the return stroke peak current, many large peak current strokes do not produce visible elves. Apart from the lightning peak current, elve production may depend on a number of other properties, including the return stroke speed, lightning altitude, and ionospheric conditions. In this work we investigate the detailed structure of lightning that gives rise to elves by analyzing the characteristics of VLF/LF lightning sferics in conjunction with optical elve observations. Lightning sferics were observed using an array of six broadband VLF/LF receivers (1 MHz sample-rate) that were installed across the state of Oklahoma. Elves were observed using two high-speed photometers pointed over the Oklahoma region with overlapping fields of view: one located at Langmuir Laboratory, NM and the other at McDonald Observatory, TX. Hundreds of elves with coincident LF sferics from the causative lightning strokes were observed during the summer months of 2013. We present data comparing the characteristics of elve-producing and non-elve producing lightning as measured by LF sferics. In addition, we compare these experimental observations with FDTD simulations of the lightning-ionosphere interaction to determine key properties of elve-producing lightning.