Lightning Energetics

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The electrical energy dissipated by a lightning stroke has been estimated using a number of techniques. Investigators have attempted to estimate the electrostatic potential difference between a negative charge region in the cloud and the ground and then multiplying the potential difference by the quantity of charge dissipated. While there are techniques for estimating the charge transferred by a lightning stoke, determining the potential difference requires vertical, electric field balloon soundings that are not generally available. An alternate approach is to determine the linear charge density deposited along the channel by the leader, calculate the energy per unit length of channel dissipated by the discharge and multiple this value by the total channel length. Again, the values needed for this calculation have not readily available.

In order to address these issues, we have developed two measurement systems: a network of electric field change meters, which we have named the Huntsville Alabama Marx Meter Array (HAMMA) and a high-speed lightning spectrometer.

With the HAMMA, we can determine where current pulses were produced during channel development, locate the charge center removed by lightning removed, determine the quantity of charge removed and in conjunction with a co-located lightning mapping array (LMA), estimate the extent of the channel. By matching waveforms produced at multiple sensor sites by the electrostatic filed change caused by leader propagation, we are able to estimate the linear charge density deposited along the channel.

With the high-speed spectrometer, acquiring up to 1 million spectra per second, we are able to time resolve many of the plasma properties of the lightning channel during the return stroke. For example, we can estimate the electron temperature, density, collision frequencies, conductivity, channel radius, and axial electric field as a function of time. The combination of the plasma properties of the channel and the estimate of linear charge density deposited along the channel enables us to calculated energy per unit length dissipated along the channel during the return stroke.

Estimates of lightning energy dissipation derived from our measurements, as well as the techniques used to arrive at these estimates will be presented and compared previous attempts to determine the energy dissipated by cloud to ground lightning