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Understanding Charge Transport by Lightning[1]

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The primary thing that a lightning flash does is move a roughly 10 C charge from one place to another. While the charge structure of a thundercloud is increasingly well understood, the actual transport of charge by a flash is crudely understood. To make progress in this area we developed a new instrument, the electric field sonde (or Esonde) which measures, at tens of kSamples/second, the vector electric field development during a lightning flash. This instrument flies into storms, allowing it to get closer than a ground-based instrument to a lightning leader. It can also sense the full vector-nature of the electric field. The measurement of E-field change in the frequency band up to 100 kHz can in principle measure how charges are transported by a lightning flash. The problem with interpreting such measurements is the "inverse problem," of mapping measured E-fields to generating charge distributions. A new technology, the lightning mapping array (LMA) now provides a 3-D, time-resolved, measurement of the location of a lightning channel in the clouds. By combining measurement of electric-field change in the clouds simultaneous with the LMA radio-frequency data on the lightning channel development, we can draw new conclusions about lightning and charge. In our first analyzed storm, we could see negative charge being deposited on the developing leader, as well as the effects of the positive charge center supplying this charge. We also reproduced by new means the findings of Krehbiel, et al. that in a multi-stroke cloud-to-ground flash, the charge for subsequent strokes draws on untapped pockets of charge ever further from the location of the cloud-to-ground channel. We are in the process of augmenting our balloon-borne Esonde and LMA with a networked array of field-change stations surrounding the Langmuir Laboratory for Atmospheric Research in central New Mexico.

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