Explaining the Spectrum of Narrow Bipolar Events with a System of Streamers

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Abstract
Narrow bipolar events (NBEs) are the sferics of a special class of thunderstorm intracloud discharges known as compact intracloud discharges (CIDs). CIDs or NBEs are of particular interest because they are the most powerful source of high frequency (HF) and very high frequency (VHF) electromagnetic radiation naturally occurring on Earth and they can initiate lightning discharges. It has recently been found, by using a broadband radio interferometer, that NBEs are caused by fast breakdown of positive polarity that propagates at a speed as high as one fifth of the speed of light (Rison et al., Nat. Commun., 7, 10721, 2016). A follow-up study using the same instrument finds that NBEs can be caused by fast breakdown of both polarities, namely negative as well as positive (e.g., Tilles et al., AE12A-03, AGU Fall Meeting, 2016).

In this talk, we report the analysis of the radio spectra of three fast breakdown events, including one fast positive breakdown event and two fast negative breakdown events, reported by Tilles et al. (2016). Data from a fast electric-field change antenna and three very high frequency antennas are analyzed to obtain the spectra from 10 kHz to 100 MHz. The results indicate both types of fast breakdown radiate more strongly in the HF and VHF bands than other types of thunderstorm discharge events, confirming that fast breakdown is the underlying process of NBEs. An approach is also developed to investigate if a system of streamers can explain the measured spectra. To produce the charge moment change of the three events, tens of million streamers are required, with each of them producing a charge moment change of 1-10 uC-m. We find that such a system of streamers can reproduce the observed spectra, providing strong support of the hypothesis of Rison et al. (2016) that fast breakdown is a system of streamers.