EGU2020-20497
https://doi.org/10.5194/egusphere-egu2020-20497
EGU General Assembly 2020

Investigating Thunderstorm HF/VHF Radio Bursts with Weak Lower Frequency Radiation

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While the spectrum of lightning electromagnetic radiation is known to peak around 5-10 kHz in the very low frequency (VLF) range, intense high frequency/very high frequency (HF/VHF) radiation can be produced by various lightning related processes. In fact, thunderstorm narrow bipolar events (NBEs), which are capable of initiating lightning, are the most powerful HF/VHF sources in nature on Earth. But even for NBEs, the spectral intensity in HF/VHF is still many orders of magnitude weaker than that of lower frequencies (Liu et al., JGR, 124, https://doi.org/10.1029/2019JD030439, 2019). HF/VHF bursts with weak VLF signals, however, can also be produced by thunderstorms. These bursts may be related to the thunderstorm precursor events noted by Rison et al. (Nat. Commun., 7, 10721, 2016) and are also found to precede a large fraction of lightning initiation (Lyu et al., JGR, 124, 2994, 2019). They are also known as continual radio frequency (CRF) radiation associated with volcanic lightning (Behnke et. al., JGR, 123, 4157, 2018).

In this talk, we report a theoretical and modeling study to investigate a physical mechanism for production of those HF/VHF bursts. The study is built on the theory developed recently concerning the radio emissions from an ensemble of streamers (Liu et al., 2019). We find an ensemble of streamer discharges that develop in random directions can produce HF/VHF radiation with intensity comparable to those all developing in a single direction, but the VLF intensity is many orders of magnitude weaker. The results of our study support the conclusions of Behnke et. al (2018) that CRF is produced in the absence of large-scale electric field, it results in insignificant charge transfer, and it is caused by streamers. In the context of the HF/VHF bursts preceding lightning initiation (Lyu et. al, 2019), our results imply that highly localized strong field regions exist in thunderstorms and streamers take place in those regions, which somehow precondition the medium for lightning initiation.