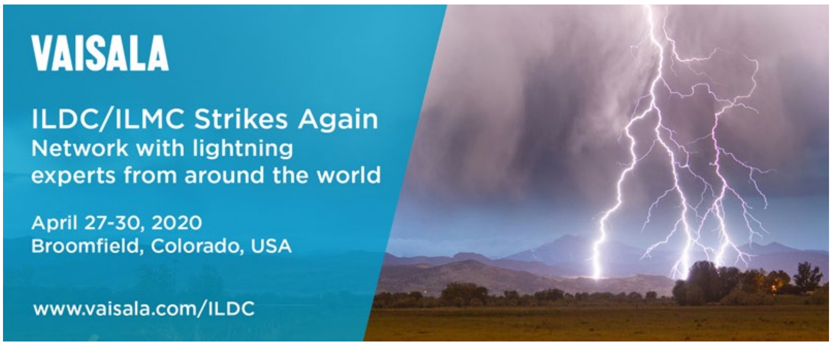

On the current and electromagnetic fields of Compact Cloud Discharges (CID)

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Abstract

Narrow Bipolar Pulses are generated by bursts of electrical activity in the cloud and these are referred to as Compact Cloud Discharges (CID) or Narrow Bipolar Events (NBE) in the current literature. These discharges usually occur in isolation without much electrical activity before or after the event, but sometimes they are observed to initiate lightning flashes. They are abundant in growing thunderstorms and mostly occur before the main electrical activity (the production of lightning flashes) sets in. They usually take place at high altitudes, at heights around 10 km or more. While CIDs are abundant in tropical thunderstorms, experimental observations show that CIDs are rare in Swedish thunderstorms.

Recently, Rison et al. [1] and Tilles et al. [2] inferred from interferometric observations that CIDs are fast streamer discharges in virgin air which do not produce conducting channels. In two recent publications [3, 4], the idea of CIDs as streamer bursts was explored to study their physical parameters.

In this paper, we have studied the features of CIDs assuming that they consist of streamer bursts without any conducting channels. results show that a typical CID may contain about 10^9 streamer heads during the time of its maximum growth. Moreover, a CID can be seen as a current front of several nanoseconds duration that travels forward with the speed of the streamers. The amplitude of this current front increases initially during the streamer growth and it decays subsequently as the streamer burst continues to propagate. Depending on the conductivity of the streamer channels, there could be a low-level current flow behind this current front which transports negative charge towards the streamer origin.

The features of the current associated with the CID are very different from those of the radiation fields that it generates. The duration of the radiation field of a CID is about 10 – 20 ms whereas the duration of the propagating current pulse associated with the CID is no more than a few nanoseconds. The peak current of a CID is the result of a multitude of small currents associated with a large number of streamers and the cumulative current that radiates at its peak could be about 10^6 A. However, the current associated with an individual streamer is no more than a few mA. Moreover, this large current is spread over an area of about several tens to several hundreds of square meters.

The study shows that the streamer model of the CID could explain the fine structure of the radiation fields present both in the electric field and electric field time derivative.

References:

1. *W. Rison, P.R. Krehbiel, M.G. Stock, H.E. Edens, X.-M. Shao, R.J. Thomas, M.A. Stanley, Y. Zhang, Observations of narrow bipolar events reveal how lightning is initiated in thunderstorms, Nat. Commun. 7:10721, 2016.*
2. *Tilles, J. N., N. Liu, M. A. Stanley, P. R. Krehbiel, W. Rison, M. G. Stock, J. R. Dwyer, R. Brown, and J. Wilson, Fast negative breakdown in thunderstorms, Nat. Commun. 10:1648, 2019.*
3. *Attanasio, A., P. R. Krehbiel, C. L. da Silva, Griffiths and Phelps Lightning Initiation Model, Revisited, J.Geophys. Res., https://doi.org/10.1029/2019JD030399,2019.*
4. *Liu, N. , J. R. Dwyer ,J. N. Tilles , M. A. Stanley , P. R. Krehbiel ,W. Rison ,R. G. Brown ,J. G. Wilson, Understanding the radio spectrum of thunderstorm narrow bipolar events, J. Geophys. Res., https://doi.org/10.1029/2019JD030439, 2019.*

Topic Areas

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