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Modeling Wideband Electromagnetic Emission of Compact Intracloud Discharges

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Wideband electromagnetic emission of compact intracloud discharge (CID) is examined in the framework of fractal approach. CID is considered as a result of electric coupling of two bipolar conducting structures, which developed relatively slowly in the regions of strong electric field at the preliminary stage of the discharge. Main stage of CID starts at the moment of electric contact of the bipolar structures and lead to fast formation of tree-like system of well-conducting channels and corresponding current system. To estimate the electromagnetic emission, tree-like current structures at the preliminary and main stages of CID are represented as a sum of linear mean component and set of numerous small-scale constituents corresponding to initial breakdowns between the neighboring cells of the discharge domain. Mean linear currents are considered as effective sources of VLF/LF emission at the both preliminary and main stages of CID. Electrostatic, induction, and radiation electric field components at different distances from CID are calculated taking into account specific features of mean currents at both stages of the discharge. It is shown that, at the preliminary stage, only electrostatic component of the mean current field can be detected, whereas at the main stage all the above components of the electric field can be observed confidently. Radiation electric field of the mean current at the main stage of CID in the far zone represents a typical narrow bipolar pulse (NBP). Dependence of NBP profile on the discharge length and current pulse velocity is analyzed. It is shown that due to bi-directional expansion of mean current the bipolar pulse remains narrow in wide range of the discharge parameters. The small-scale linear currents corresponding to formation of new conducting channels of the discharge are considered as effective sources of HF/VHF emission. Radiation electric field of whole discharge structure at any stage of CID is a sum of contributions of small-scale breakdown currents. It is shown that HF/VHF emission at the preliminary stage is negligible as compared to the emission at the main stage, when a powerful narrow burst of the high-frequency emission forms. It is shown that the burst of HF/VHF emission correlates well with the initial peak of NBP, and the spectrum of the burst corresponds well to power law with an exponent between -2 and -1. Model results are compared with satellite observations of VHF emission of CID.