

引用本文(Citation):

谭涌波, 师正, 王宁宁, 郭秀峰. 随机性与电环境特征对地闪击地点影响的数值模拟. 地球物理学报, 2012, 55(11): 3534-3541, doi: 10.6038/j.issn.0001-5733.2012.11.003

TAN Yong-Bo, SHI Zheng, WANG Ning-Ning, GUO Xiu-Feng. Numerical simulation of the effects of randomness and characteristics of electrical environment on ground strike sites of cloud-to-ground lightning. Chinese J. Geophys. (in Chinese), 2012, 55(11): 3534-3541, doi: 10.6038/j.issn.0001-5733.2012.11.003

随机性与电环境特征对地闪击地点影响的数值模拟

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Numerical simulation of the effects of randomness and characteristics of electrical environment on ground strike sites of cloud-to-ground lightning

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摘要

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摘要 本文利用已有的随机放电参数化方案,结合四次探空资料,进行了12.5 m的高分辨率二维雷暴云数值模拟实验,得到了各种雷暴云电荷结构下的地闪个例,并就地闪击地点与空间电荷、电位分布之间的相互关系进行了分析.结果表明:(1)由空间电荷唯一确定的电位分布决定了先导的传播最大趋势,而闪电传播的随机性所带来的地闪击地点的不确定范围被限制在3 km之内,利用动态聚类法迭代得出的三个击地点位置之间的差为1 km左右.(2)负地闪的初始点与击地点的位置差主要分布在0~6 km范围内,且93%的负地闪分布在0~4 km范围内,正地闪的分布相对较广,0~3 km范围内占48%,3~6 km范围内占34%,6~10 km范围内占18%.(3)正、负地闪主要产生于离地面最近的一对电荷堆之间,其起始高度越高,初始点与击地点位置差分布越广;另外,产生于三级性雷暴云电荷结构下的正地闪,其起始于上部的正电荷堆与中部主负电荷堆之间,由于下行正先导会绕过底部的次正电荷堆,因此其击地点与初始点的距离基本在6 km以上.

关键词 击地点, 电荷结构, 电位分布, 先导传播趋势, 数值模拟

Abstract: Based on the existing stochastic lightning model, combined with four sounding data, this work conducts 12.5 m resolution simulations of two-dimensional thunderstorm cloud, and gives ground flash cases under various thunderstorm cloud charge structures, and analyzes the relationship between ground strike sites and the distribution of charge structures and potential. The results show that the distribution of potential which is only defined by space charge determines the maximum spread trend of leader, while ground strike site uncertainty range is limited to 3 km because of the lightning propagation randomness, three ground strike locations are iterated with method of dynamic clustering, and the mutual distance of locations is about 1 km. The distance between the initial point and ground strike point of negative CG lightning is mainly distributed in the range of 0~6 km, and 93% negative lightning distribution in 0~4 km range, the distribution of positive CG lightning is relatively wide, 0~3 km range accounted for 48%, 3~6 km range accounted for 34%, 6~10 km accounted for 18%. CG lightning is primarily produced in a pair of charges which are close to ground. The height of lightning initiation higher and therefore larger of range of distance between the initial point and ground strike point. In addition, some positive CG lightning which are produced in the three stage of charge structure of thunderstorm cloud start between upper part of positive charge pile and middle negative charge pile. Due to the downward moving positive leader will bypass the bottom of the positive charge pile, so the distance between the initial point and ground strike site is basically above 6 km.

Keywords Ground strike site, Charge structure, Distribution of potential, Spread trend of leader, Numerical simulation

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