Contribution ID: **523** Type: **Oral**

Statistics and Propagation Modeling of Atmospheric Lightning

Wednesday 26 June 2019 17:00 (15 minutes)

A stochastic model of stepped leader propagation in downward negative lightning with inclusion of final jump process was developed. Results of stochastic gas diffusion are used to determine propagation. The model allows for large volumes of simulated lightning strikes to be evaluated quickly in the presence of complex geometries such as buildings. It enables Monte Carlo methods of arriving at probabilities of shielding failure for buildings less than 100 m in height. These probabilities were evaluated with emphasis on results for low peak return stroke current lighting propagation. A methodology for calculating the total likelihood of a shielding failure event is proposed. This method offers a superior prediction of striking probability in the form of a detailed assessment of striking probabilities specific to intervals of peak return stroke current. Used in combination with long-term predictions of lighting frequency, expectations of the number of strikes to a structure over its life or longer can be made.

Detailed sensitivity of shielding failure rates to building height, footprint area, inset protection, and aspect ratio is assessed for a sample rectangular building of 100 m by 50 m. Shielding failure rates were found to be insensitive to heights less than 30 m with a normalized error of less than 10 %. Building aspect ratio was found to have pronounced impact (up to a 36 % difference) in buildings of fixed footprint area. The extent to which protection may be inset from the building perimeter was evaluated and found to be substantial. Sensitivity to footprint area was found produce less than 10 % error and implies these results are scalable and may translate to other structures. Buildings not Faraday shielded from transient atmospheric phenomena are at risk of being struck by low current lightning. These risks of attachment to under-protected areas are simulated.

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Session Classification: 1.2 Computational Plasma Physics III

Track Classification: 1.5 Dusty Plasmas and Strongly Coupled Plasmas