URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Modelling of Lightning Return Stroke Channel above Lossy Ground in FDTD Code and Its Validation with Triggered Lightning Data

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The FDTD method has been widely used in calculations of electromagnetic fields produced by a lightning return stroke and its interaction with various systems. However, the traditional Pie-type distributed resistance (R) – inductance (L) – capacitance (C) model is no longer suitable for representing a lightning return stroke channel in the FDTD code. In this study, we propose a new type R-L-C model: a current source at the lightning channel base connecting to a series of passive R-L-C loads above the channel base. A lightning return stroke channel is divided into small segments, each segment is presented by a height-dependent R in series with an L and in parallel with a C. The current propagation and attenuation behaviors along the channel can then be simulated by tuning the R-L-C values.

With a current waveform measured during a return stroke process in a rocket-triggering lightning discharge as the current source in the model, impacts of different R-L-C values on the current propagation properties were discussed. It shows that while the R value has a significant impact on both the current propagation speed and amplitude attenuation rate along the lightning channel, the L and C values have an impact only on the profile of current propagation speed along the lightning channel.

The model was then applied to and validated with two sets of channel base current and multi-station electrical field measurements from return strokes in rocket-triggered lightning discharges. By fitting the calculated electrical fields to the measured electrical fields at different distances from the discharge, the optimal R-L-C values as a function of the lightning channel height were determined, and hence the current propagation speed and amplitude attenuation rate along the lightning channel were retrieved.

Acknowledgement. This study was supported by The Research Grant Council of Hong Kong (GRF:15215120).