32nd URSI GASS, Montreal, 19-26 August 2017

Modeling Narrow Bipolar Pulses using Numerical Solution to Fredholm Equation

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Extended Abstract

Electric field change waveforms of Narrow Bipolar Pulses (NBPs) were obtained at ten stations located in Kennedy Space Center, Florida in 2011. In this study we model NBPs using a modified transmission line model and a numerical solution to the Fredholm equation. For this work, we use a subset of NBPs previously studied for their electrical field change structures and locations compared to thunderstorm radar echo structure [1, 2]. Previous modeling of NBPs and initial breakdown pulses introduced a known mathematical current shape at an end of a modified transmission line and allowed the current to propagate along the line [3, 4]. These models use 5-7 unknown parameters depending on the modified transmission line they used. The values of the parameters were changed until the model results reasonably matched the E-change measurements at multiple locations. In this study, instead of using a mathematical model for the current pulse, we will obtain the shape of the current using E-field measurements. To achieve that, we start with the analytical equation derivate from Maxwell's Equations for the electric field generated by a vertically moving current pulse [5]. The far component of electric field will be used to generate Fredholm type 1 equation. This equation will be then numerically solved to find the channel current as a function of time. The numerically generated current will be used to obtain the predicted waveforms at different locations and compared with the measured waveforms. This new method reduces the number of unknown parameters to two and the modeled outputs were much closer to the actual measurements. We will discuss the model results and parameters we obtained for different CIDs.

References:

1. Karunarathne, S., T. C. Marshall, M. Stolzenburg, and N. Karunarathna (2016), Electrostatic field changes and durations of narrow bipolar events, J. Geophys. Res. Atmos., 121, 10,161–10,174, doi:10.1002/2016JD024789.
2. Karunarathna, N., T. C. Marshall, M. Stolzenburg, and S. Karunarathne (2015), Narrow bipolar pulse locations compared to thunderstorm radar echo structure, J. Geophys. Res. Atmos., 120, 11,690–11,706, doi:10.1002/2015JD023829.
3. Watson, S. S., and T. C. Marshall (2007), Current propagation model for a narrow bipolar pulse, Geophys. Res. Lett., 34, L04816, doi:10.1029/2006GL027426.
4. Karunarathne, S., T. C. Marshall, M. Stolzenburg, and N. Karunarathna (2014), Modeling initial breakdown pulses of CG lightning flashes, J. Geophys. Res. Atmos., 119, 9003–9019, doi:10.1002/2014JD021553.
5. Uman, M. A., D. K. McLain, and E. P. Krider (1975), The electromagnetic radiation from a finite antenna, Am. J. Phys., 43, 33–38.