On the Use of Electromagnetic Time Reversal for Lightning Location

Hamidreza Karami[(1)], Farhad Rachidi[(2)], and Marcos Rubinstein[(3)]
(1) Bu-Ali Sina University, Hamedan, Iran
(2) Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland
(3) University of Applied Sciences of Western Switzerland, Yverdon, Switzerland

Lightning is one the major sources of electromagnetic interferences. Multisensor networks known as lightning location systems (LLS) are widely used to detect and locate different types of lightning discharges (see, e.g., Cummins and Murphy, *IEEE Trans. EMC*, 51 (3), pp. 499-518, 2009). Modern LLS use different detection techniques such as the Time-of-Arrival (ToA), Magnetic Direction Finding (MDF) and interferometry. More recently, Electromagnetic Time Reversal (EMTR) has been used to develop a technique to locate lightning discharges (Mora et al., *Atmospheric Research*, 117, pp. 78-85, 2012; Lugrin et al., *IEEE Trans. EMC*, 56 (1), pp. 149-158, 2014). Lugrin et al. showed that time-of-arrival can be considered as a particular case of electromagnetic time reversal.

The application of EMTR to lightning location can be very interesting in terms of the achievable performance because, unlike the classical methods, it takes advantage of the whole waveform of the measured fields. However, as discussed in (Karami et al., *23rd International Lightning Detection Conference*, Tucson, AZ, USA, March 2014), the practical implementation of EMTR to locate lightning might not be straightforward.

In this paper, we discuss possible methods to overcome some of the practical difficulties associated with EMTR-based lightning location methods. In particular, we address the issue of the propagation of the lightning electromagnetic fields along a dissipative soil. To that end, we present numerical simulations using the FDTD (Finite-Difference Time-Domain) method to obtain fields at the Lightning Location System sensors and also to back propagate the time-reversed fields as required by the EMTR method. The simulations are used to compare the performance of different back-propagation models, comparing them to the performance obtained with the ToA technique.