Lightning Positioning in VLF Band Using CWT-EMTR

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Lightning Positioning is of great significance for lightning disaster location, lightning parameter statistics, and lightning activity law research. The lightning signal in VLF/LF frequency band has the advantages of strong signal strength and long transmission distance. At present, the lightning location system mainly works in this frequency band. Due to the limited conductivity of the ground, the electric field pulse signal of lighting return stroke has the phenomenon of dispersion, that is, the distance from the measuring station to the return point is different, and the offset of the peak value of the electric field pulse waveform is also different, which will lead to errors when using the traditional peak TOA method for positioning. Liu *et al*. [1] proposed a time-reversal approach in the frequency domain (TRFD) to improve the positioning accuracy. However, due to the wide frequency range, there are many frequency points that make calculation efficiency is not high enough.

Due to the continuous wavelet transform (CWT) method having the ability to extract the components in the local frequency band of the signal, this work combines the CWT method and EMTR method to locate the return stroke point. The main idea is as follows: select an appropriate frequency point, then obtain the wavelet waveform corresponding to the scale of the frequency point, carry out continuous wavelet transform on the electric field pulse waveform, use the transformed waveform envelope for EMTR, and automatically obtain the position of the return stroke point through the focus of the back-propagation wave. This method can effectively avoid the problem of inaccurate positioning results caused by dispersion. In order to verify the accuracy of the proposed method, the measured data of an artificially triggered lightning flash case recorded by the low-frequency lightning location system located in Huai'an, China [1] are used, Liu *et al*. [1] selected 100kHz ~ 500KHz as the analysis frequency range in TRFD method, and the upper limit of 500kHz was selected as the analysis frequency point in the proposed method, the other parameters are consistent with those in [1]. Take site 5 as an example, Figure 1(a) provides the CWT results of electric field pulse waveform at 500kHz. From the positioning results in Figure 1(b), the horizontal location errors with the proposed method and peak TOA technique are 38 and 120 m, respectively, the positioning accuracy of the proposed method is better than the peak TOA method. In addition, the location error of the proposed method is similar to that in [1] (30m), but the efficiency has greatly improved because only one frequency point is needed to calculate. This work was funded by the National Nature Science Foundation of China (No. 51977219).

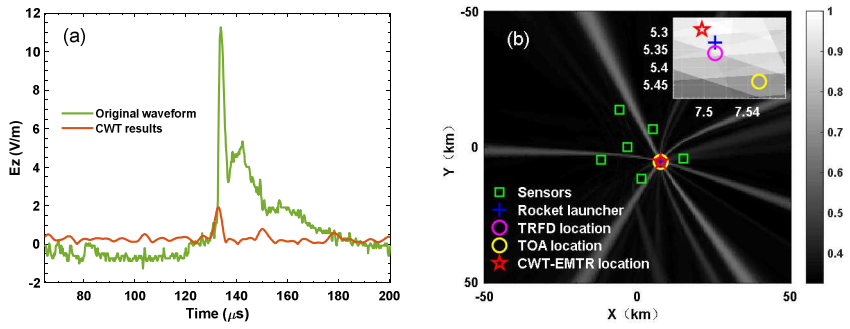

Figure 1. (a) CWT results of electric field pulse waveform at site 5 in 500kHz. (b) Positioning results.

1. Liu Bo, Shi Li-Hua, Qiu Shi, Liu Heng-Yi, Sun Zheng, Guo Yi-Fan, "Three-Dimensional Lightning Positioning in Low-Frequency Band Using Time Reversal in Frequency Domain," *IEEE Transactions on Electromagnetic Compatibility*, **62**, 3, June 2020, pp. 774-784, doi: 10.1109/TEMC.2019.2920302