

## Observations of NBEs from several thunderstorms in East China

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A narrow bipolar event (NBE) refers to a distinct class of intra-cloud discharge characterized by the most powerful RF emissions and the narrow bipolar electric field waveform in the very low frequency (VLF) /low frequency (LF) bands. Recently NBEs have received a great deal of attention as they were considered to be the most promising candidates of space-based detection of lightning. Observations of NBEs from several thunderstorms in East China were presented as follows. (1) The time for the current front to traverse the channel was estimated from the narrow bipolar pulse. For 77 NBEs, the current traversal time along the channel was shown to range between 1.7 $\mu$ s and 3.5 $\mu$ s with a mean value of 2.2 $\mu$ s. Bound by the speed of light, the upper limit on channel length of NBE was shown to be several hundreds of meters. (2) The temporal context of NBEs with ordinary lightning discharges was studied by analyzing the time sequence records of VLF/LF bandwidth electromagnetic fields associate with VHF emissions with a record length greater than 1s. When a NBE was not followed or preceded by any detectable lightning discharge signals within 100ms, it was defined as an isolated one. The percentage of isolated NBEs from four thunderstorms was 23%, 7%, 66% and 32% respectively, and others were associated with normal lightning discharges. We inferred that NBEs may produce under conditions which will favor the production of normal lightning discharges, but they are unnecessarily related to the initiation of normal lightning discharges. (3) The occurrence of NBEs with respect to the lightning activity on a thunderstorm scale was also studied. A NBE tended to occur during the relatively active stage of Cloud-to-Ground lightning activity, however, the largest NBE occurrence was unnecessarily related to the summit of Cloud-to-Ground flashes activity.

Keywords: Narrow bipolar event, narrow bipolar pulse, lightning activity