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Fine properties of trains of unusually strong preliminary breakdown pulses observed at different distances

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We analyze fine characteristics of trains of unusually strong preliminary breakdown pulses (PBPs) measured at different distances by two different receivers. Each of the observed trains of PBPs preceded a follow-up pulse (FP) which arrived with a time delay corresponding to a usually occurring return stroke (RS). However, most of the observed FPs can be identified as non-RS bipolar pulses; only in one case we observe a very weak return stroke. The amplitudes of the largest PBPs reach, on average, four times the amplitudes of the following return strokes or non-RS bipolar pulses. This could indicate an abnormally electrified storm and a high occurrence of attempted cloud-to-ground leaders.

High-resolution magnetic-field waveforms were measured at distances between 69 and 176 km from the source lightning, as it was identified by lightning detection network EUCLID. The time derivative of the magnetic field was detected with a newly designed Shielded Loop Antenna with a Versatile Integrated Amplifier (SLAVIA) and sampled at 80 MHz using a ground-based version of a broadband receiver which is being prepared for the TARANIS spacecraft. . . Electric-field waveforms were measured at distances between 258 and 377 km using a receiver sampling at 12 MHz. We use these electric field waveforms and numerically integrated magnetic field waveform records to analyze properties of the PBP trains.

Our dataset consists of 10 trains of preliminary breakdown pulses measured during one thunderstorm which occurred in Southern France in June 2013 and lasted about four hours. The lightning detection network EUCLID misclassified 4 strong preliminary breakdown pulses as cloud-to-ground RSs, in 6 other cases they were classified as intra-cloud (IC) discharges. Follow-up pulses were absent in the list provided by EUCLID (6 cases) or classified as negative cloud-to-ground (2 cases) or IC discharges (2 cases). We estimate the duration of the trains and the time between the first pulse in the train and the FP peak. We estimate the amplitude ratios of the largest PBP and the FP peaks in each individual train at different distances. We also investigate the variability in the pulse shapes belonging to the PBP trains and the fine structure of the FP waveforms. Finally, we compare the properties of the trains of unusually strong PBPs with the regular trains of PBPs preceding usual negative cloud-to-ground flashes.