Simultaneous Observations of a Winter Lightning Flash in Japan

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A winter lightning flash in Japan was simultaneously recorded with multiple instruments, including a high-speed video camera, an optical imaging system LAPOS (Lightning Attachment Process Observation System), a lightning mapping system FALMA (Fast Antenna Lightning Mapping Array), and a current measuring system. This flash lasted for about 0.34 seconds with a large horizontal extent of about 40 ×40 km. It started with a multiple-stroke positive cloud-to-ground flash that consists of two positive return strokes (RSs). The first RS was located about 3.2 km from the lightning initial location. The second RS was located about 13.2 km from the first RS with an interval of 55 ms. About 1.5 ms after the second RS, an upward positive leader (UPL) was triggered from the tip of a lightning protection tower. The UPL extended straight upward without clear branches. During the initial stage, the UPL propagated in stepped mode with an average speed of about 0.8×10^5 m/s. As it propagated to the higher altitude, the UPL became more continuous with a faster velocity of about 3.6×10^5 m/s. After the UPL propagated into the thunder cloud, a nearby leader connected to the UPL channel at about 620 m above the tower tip and initiated a strong discharge process. Further analysis indicates that this connection process is similar to the lightning large bipolar event (LBE), a special type of return stroke in winter thunderstorms. About 0.22 s after the initiation of the UPL, four negative RSs struck the same termination 5.2 km from the tower with an average interval of about 5.4 ms. The negative RS lightning channel was much curved from the view of the high-speed video camera. It seems that the occurrence of the first negative RS has little connection with the UPL but is associated with discharge processes near the lightning initiation area.

Keywords: winter lightning, multiple-stroke lightning flash, upward lightning, large bipolar event (LBE)

