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Currents and radiated E-fields of upward initiated lightning from the Gaisberg Tower in Austria

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Parameters of upward initiated lightning from tall objects are gaining increasing interest in recent years. This is a result of the installation of tall objects (wind turbines, radio towers, etc.) experiencing a high number of lightning flashes. Lightning current waveforms of flashes initiated from the Gaisberg Tower (GBT) in Austria are continuously measured since 1998. On average this radio tower (tower height 100 m) located on a small mountain (1287 m ASL) next to the city of Salzburg triggers about 60-70 flashes per year. More than 50% of the triggered flashes occurred during cold season (similar to so-called winter lightning in Japan) and more or less independent of the overall thunderstorm activity in Austria. Up to now, more than 800 flashes have been recorded by employing a 0.25 mΩ shunt at the tower top. Compared to inductive sensors, with their limited lower bandwidth, a shunt allows correct measurement of the slowly varying, low amplitude initial continuing current (ICC). ICCs are lasting for several hundreds of milliseconds and they are the main contributors to the transferred charge by a flash.
Maximum transferred charge in a single flash was 783 C and this negative flash was recorded during cold season on October15th, 2012. Contrary to observations in winter lightning in Japan, where upward initiated flashes with very large charge transfer are predominantly bipolar, at the GBT 7 out of the 10 flashes exceeding a charge transfer of 300 C were negative, 2 were positive and 1 bipolar.
Most of the flashes (93%) triggered by the GBT are of negative polarity, initiated by a positive upward propagating leader. But also positive (4%) and bipolar (3%) flashes are observed at the GBT. In case of negative lightning flashes, 45% of current records exhibit an ICC only, 23% of flashes has pulses of peak current exceeding 2 kA superimposed on the ICC, and return strokes following the ICC after a period of "no current" is observed in 32% of the events. Median peak current of return strokes (N=913) is 9.2 kA and similar to values observed in triggered lightning and to lightning location system peak current estimates for subsequent strokes in cloud-to-ground lightning. Detectability of upward flashes by typical lightning location systems strongly depends on the presence of fast rising current pulses, either as return strokes or superimposed pulses on the ICC.
In addition to the current records, corresponding vertical electric fields at close distance (170m) and far distance (about 100 km) are measured with flat-plate antennas. Upward initiated lightning often shows extensive branching and this is assumed to be the reason for the observation of rather complex overall current waveforms. In the presentation we will provide a review of the statistical analyses of the lightning parameters.
Records of the E-fields at a distance of about 100 km and radiated by the return strokes to the tower show a significantly shorter peak-to-zero time (10 μs) than typically observed in cloud-to-ground lightning (30 – 40 μs).