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Lightning Location with LINET Technology

Methodology and Performance

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Brief description of the 16-page presentation:

1. Title page
2. Positions of Geiger-Mueller counters in Southern Germany, from BfS (Bundesanstalt für Strahlenschutz). Also shown are sensor sites of the nowcast lightning detection network, and locations of lightning strokes that occurred during an anomalous recording (short-term response to radioactive bombardment) of the counters. The counters have thresholds such that long-term radiation is reported; thus, the lightning-induced responses are possible only when cascades of accelerated high-energy particles enter into the counters.
3. Parameters of strokes that occurred in coincidence with anomalous counter-recordings. It turned out that the lightning strokes touched ground very close to the anomalously responding counters.
4. Scheme for the arrangement of a large-scale lightning detection network, usedt for LINET (network designed, set up and operated by nowcast GmbH).
5. LINET detection principles: nine of the most important features of the network are enumerated, allowing for high detection efficiency, high location accuracy and measurement of total lightning (CG = cloud-to-ground strokes and IC = intra-cloud strokes).
6. Picture of the field antenna and the GPS antenna. The field antenna detects the direction of the lightning signal, though the locating procedure relies on TOA (=time-of-arrival). The GPS antenna serves as time reference.
7. Distribution of LINET sites 2011. In 2012 some additional 15 sensors are placed, mainly in Spain, Italy, France, and in several countries in northern Europe.
8. So-called field records taken 2010 during a campaign in Florida (at the NASA site KSC in Cape Canaveral), from Stolzenburg et al. (2012). The solid curves signal the static electric field; the pulses indicate discharge events during CG or IC charge neutralization. The large pulse on the left is a classical return stroke (CG). The smaller pulse labelled “UI” represents a CG stroke that is apparently different from a classical return stroke. Very significant is the observation that LINET is the only lightning location network that locates the UI; none of three Vaisala networks (NLDN in the US; CGLSS and 4DLSS operated at KSC) could report these frequently occurring events.
9. High-speed picture of the two strokes from the previous page 8. It can be seen that the UI contacts ground several km away from the return stroke. Thus, a lightning location network should be able to report events of this kind.
10. Scheme for the emission of lightning strokes in the VLF/LF regime. Occurrence of a stroke requires substantial charge neutralization current (kA) and a reasonably long channel (km); this is true also for IC strokes. LINET is the first network that measures IC strokes effectively and, thus, reports 3D total lightning solely from the VLF/LF regime.
11. LINET can also determine the emission altitude of IC strokes. 3D radar scans show good agreement between IC heights and areas of high reflectivity (taken by H. Hoeller, DLR).

12. Due to the 3D-feature of LINET a lightning storm can be visualized with discrimination of CG and IC strokes. This is helpful for the recognition of severe weather conditions, which are characterized by an increase of IC rates and IC altitudes. The graph on the left shows a weak storm, while the picture on the right is taken from a very severe thunderstorm.

13. During the campaign in Florida (see pages 8 and 9) a LINET system had been set up. One of the reasons was to compare the IC altitudes with the 3D source points observed from 4DLSS (=LDAR2). The latter network is based in VHF detection, while LINET measures only VLF/LF signals. Thus, LINET reports the real lightning strokes, while LDAR2 locates positions of small charge movements (steps) during the formation of leader channels. Source points and strokes are physically different though they are both parts of the same lightning discharge processes. The pictures show that source points and strokes are in excellent 4D-agreement, both in 3D space and in time. Interestingly, in many cases a stroke occurs before a source point can be located: this phenomenon can be understood on the assumption that the high electric fields produce run-away electrons that form a channel very fast and enable an instant lightning stroke without having prepared a channel from the above-mentioned stepped leader processes.

14. This page illustrates that LINET allows highly precise stroke locating. A convenient method to prove location accuracy is the observation of lightning strikes into towers of known position. We show results for 2 towers: the 2D-error is indeed below 100 m when the network is adjusted for site-error effects. No other VLF/LF network is able to achieve this excellent precision.

15. The high detection efficiency and the ability to report IC strokes with their emission heights allow recognition of severe weather. The example shows a fatal thunderstorm that hit a festival in Belgium on 18th August 2011 without adequate warning. LINET could see the dangerous storm development by means of a strong increase of IC rates and IC altitudes. Due to the high detection efficiency a quite reliable cell tracking is possible, allowing short-term prediction of the storm movement (nowcasting, pink areas in front of the storm, moving eastwards).

16. Time-evolution of the IC emission heights of the storm cells moving eastwards: one hour before the fatal events an increase of the rates and the altitudes indicated the particular storm development.

More information can be obtained on demand (hdbetz @ nowcast.de).