Recognition of Severe Weather by combining Dual-Polarization Radar Measurements and high-resolution 3D Lightning Data

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Thunderstorms play an important role when defining natural threats to humans. Microphysical processes in the clouds may lead to severe weather phenomena like hail or strong wind gusts at the ground. Due to the strong coupling between cloud microphysics and electrifying processes leading to lightning discharges it becomes understandable that use of 3D lightning data may be advantageous. This data source needs no filtering and exhibits excellent temporal resolution. As a consequence, one can utilize this data in real-time.
For the refinement of nowcasting purposes, it is important to resolve processes in the clouds that occur within a very short time. This condition can be met by using modern radar or lightning data from ground-based remote sensing systems, which can measure atmospheric conditions in near real-time.

Radar data allow detailed information about the spatial distribution of precipitation particles, and dual-polarisation data provide discrimination of different hydrometeors, e.g. of water and ice particles that influence charge separation and, thus, cloud electrification.

Thunderstorms necessarily produce lightning discharges. Due to strong coupling between microphysical and electrical processes, and because lightning strokes can be measured very precisely in both time and location, overlay between radar and lightning provides excellent assessment of the storm situation. The stronger the storm, the higher rises the convective core that produces and maintains the electric field leading to lightning discharges. As a consequence, intensification of the storm is accompanied by occurrence of increased number of cloud discharges, whereby a shift to higher altitudes serves as particular indicator for most severe weather.

Since 2004 a European ground-based 3D-lightning detection network is in operation that allows reporting of cloud strokes along with their emission altitudes („LINET“). Additional lightning parameters are available, which correlate with severe weather, namely total stroke rate, ratio of cloud- and cloud-to-ground strokes, discharge current amplitudes and pulse polarities. A suited analysis of these parameters allows for a realistic description of lifecycle and severity of the storm, including nowcasting with respect to evolution and expected motion of the storm cells.
Combination of data from polarization Doppler radar and lightning detection systems like LINET provides considerably improved recognition and nowcasting of thunderstorms. Examples are presented, which demonstrate the usefulness of the outlined approach.