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Lightning Measurements and its Application for Severe Storm Detection and Nowcasting

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Scientific Background and Objectives

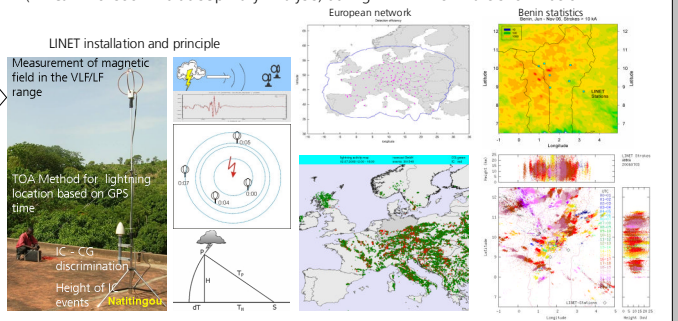
This study demonstrates some aspects of thunderstorm detection and nowcasting with relevance to the HyMeX project objectives. Lightning is closely related to thunderstorm microphysics and dynamics and, thus, connected to a variety of severe weather elements like heavy rainfall, hail, downbursts, gust fronts etc. The LINET lightning detection network offers high stroke detection efficiency and a CG/IC discrimination based on VLF/LF measurements of lightning emissions. In combination with polarimetric radar observations it is possible to infer the temporal evolution of radar-derived properties like graupel, ice, rain and hail content, doud top height, or Doppler velocity patterns in connection with lightning parameters like stroke and flash rates, CG or IC fractions, or polarity of the events.

The combined lightning-radar information is used in case studies of convection for looking at the processes associated with severe weather caused by thunderstorms. On the other hand, this information is used for tracking and nowcasting of convective cell development.



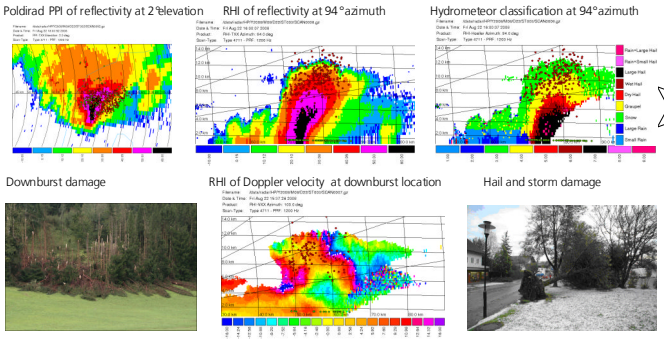
LINET - Lightning Detection Network

The LINET system measures magnetic VLF/LF emissions from lightning and is able to discriminate cloud-to-ground (CG) and intra-cloud (IC) flashes. A time of arrival (TOA) method is used for locating strokes. The operational European network consists of around 100 stations. The 6-station DLR network is deployable during campaigns. Examples from AMMA (African Monsoon Multidisciplinary Analysis) during 2006 in Benin are shown below.



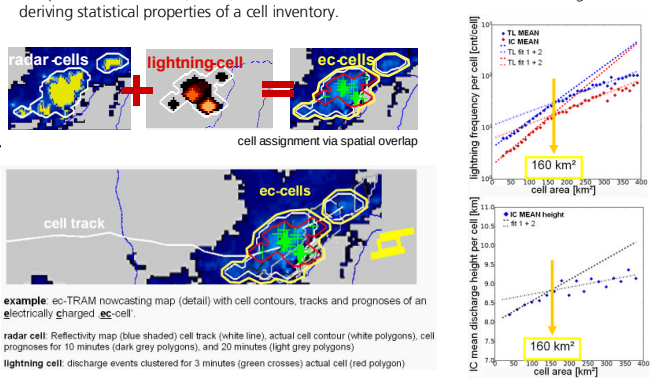
LINET and POLDIRAD

A supercell storm occurred on 22 August 2008 in Southern Germany. POLDIRAD observations show that large hail was formed in the main updraft and caused a large hailswath at the ground. LINET detected intra-cloud (IC) strokes aloft preferably in the graupel-ice region. A downburst with damaging winds occurred around 15:40 UTC when the cell had completed its first intense phase. (LINET CG – green dots, IC – red dots)



Cell Tracking and Nowcasting

The TRAM cell tracking algorithm is applied to radar (threshold of 33 dBZ) cells and lightning cells (threshold of 1 event). The combination of both cell types defines a more complete electrified cell (ec-cell). The method can either be used for cell nowcasting or for deriving statistical properties of a cell inventory.



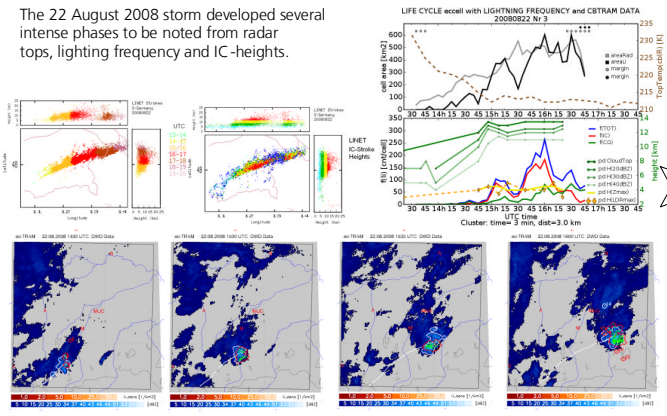
example: ec-TRAM nowcasting map (detail) with cell contours, tracks and prognoses of an **e**lectrically **c**harged **ec**-cell'.

radar cell: Reflectivity map (blue shaded) cell track (white line), actual cell contour (white polygons), cell prognoses for 10 minutes (dark grey polygons), and 20 minutes (light grey polygons)

lightning cell: discharge events clustered for 3 minutes (green crosses) actual cell (red polygon)

Cell Development

The 22 August 2008 storm developed several intense phases to be noted from radar tops, lighting frequency and IC-heights.



Summary and Conclusions

The use of combined radar-lightning information for severe storm detection and nowcasting has been demonstrated based on results of a case study of a hailstorm.

- The IC-CG discrimination is a unique feature of LINET and offers warning potential for storm intensification by increased IC stroke rates
- IC peaks were associated with increased IC heights
- IC peaks were also associated with the formation of large hail and fallout to the ground as inferred from polarimetric radar parameters and ground observations
- Strong IC peaks due to intensified storm dynamics were accompanied by downburst damages at the ground
- IC strokes predominantly occurred in the upper graupel-ice region of the storm in accordance with the non-inductive charging (NIC) mechanism by graupel-ice collisions
- Wet growth is a possible reason for IC strokes to be less frequent in the main hail core
- Thunderstorm decay is accompanied by an increase of CG rates
- Tracking of storm cells allows for following the life cycle of different kinds of storm parameters, their inter-relations and their usefulness for nowcasting and NWP
- A new thunderstorm tracker ec-TRAM (Tracking and Monitoring of electrically charged cells) has been developed in order to identify, track, and monitor thunderstorms by combining the information of independently tracked radar and lightning cells.
- The tracking procedure also allows for setting up a cell inventory which enables a statistical investigation of cell parameters and their correlations.