Life cycle analysis of convective cells for nowcasting purposes considering atmospheric environment conditions

**Overview**
The representation of the life cycle of convective cells in state-of-the-art nowcasting procedures has not reached a satisfying state yet. Spatially and temporally accurate predictions of cell intensity, area, track, and their future tendency as well as associated potential threats, desirable to know with a preferably long lead time from a warning and precaution management viewpoint, are still lacking at present (see, e.g., Wapler et al. 2017).

We plan to include information from statistical analyses of historical convective cells into nowcasting methods of DWD by combining data from the cell detection and tracking algorithm KONRAD with high-resolution model fields from operational NWP (COSMO) analyses. The objective is to develop a novel method to estimate the life cycle ‘state’ of convective cells as well as a ‘forecast function’ considering the previous cell evolution and atmospheric environmental conditions. Therefore, cell and model parameters with predictive skill have to be identified. On this basis, the method might have the potential to facilitate an improvement of on-line probabilistic predictions of cell track, intensity evolution and potential threat associated with the cells.

**Project plan**

**Cell statistics**
- Filtering
- Evolution of cell properties (area, intensity, track direction)

**Convective parameters**
- Area
- Diameter
- Maximum reflectivity

**C-band radar data**
- Nonhydorstatic analysis
- 10 m resolution

**KONRAD-2D data**
- Mean values and variances (locally and spatially)
- Discrimination?

**COSMO model analyses**
- Nonhydrostatic
- Nudging analysis
- Area = 2.8 km or
- Diameter = 7 km

**Environment statistics**

**Identification of model parameters with predictive skill**
- Multivariate Linear Regression, Principal Component Analysis, Artificial Neural Network (Machine Learning?)

**Statistics**
- Application of a suitable mathematical procedure to gain a ‘forecast function’
- Depending on a distinct set of parameters

**Including life cycle information in DWD nowcasting process**

**INPUT**
- Recent radar and KONRAD cell detection data
- Recent COSMO model forecast convective parameter fields

**OUTPUT**
- Future life cycle states of the cells

**References**

**Outlook**
- The following issues for the statistical analyses will be focused on next: 1) Generation of a filtered multi-year representative convective cell sample 2) Statistics of suitable convective COSMO model parameters during the convective events 3) Development of a mathematical procedure linking information about atmospheric environment conditions and about the previous evolution of the cells, in order to ‘predict’ single historic cell life cycles best 4) Identification of relative importance of the cell and environment parameters applied.

- Future objectives: Once a ‘machinery’ as sketched in the box above has been developed, plans for expansion include: 1) the use of multi-sensor data 2) the transfer of the machinery to a possible 3D approach 3) the use of ensemble model fields.

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**Figure 1:** Time evolution of cell area over a 3-hour sample. Each line is an average over all cells of a specific lifetime (shown in numbers). The area is only shown for events larger than 50 km² and for events larger than 50 km².

**Figure 2:** Composite mean storm Relative Helicity (3- km) fields relative to the infrared field of the hail storm track (10-year sample). (Guo et al. 2016)

- As unrealistically the life cycle model shall have to deal with, potentially destructive cells, thermodynamic parameters clearly separating between severe and non-severe cells (e.g. with respect to hail size and its associated threat) will be of special interest (e.g., Fuecker et al. 2016, Sherburn et al. 2016).
- Although not shown, a modified COSMO fields, including convective parameters and parameters chosen to possibly have predictive skill, will provide a wide variety of model data useful for the future statistical analysis.
- As an example, Kunz et al. (2016), in particular, show that Storm Relative Helicity (0-1 km) is a good proxy for distinguishing between different track lengths and hail sizes (3 km diameter 2 km) for hail producing convective cells over Germany, France and Belgium (Kunz et al. 2016).