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

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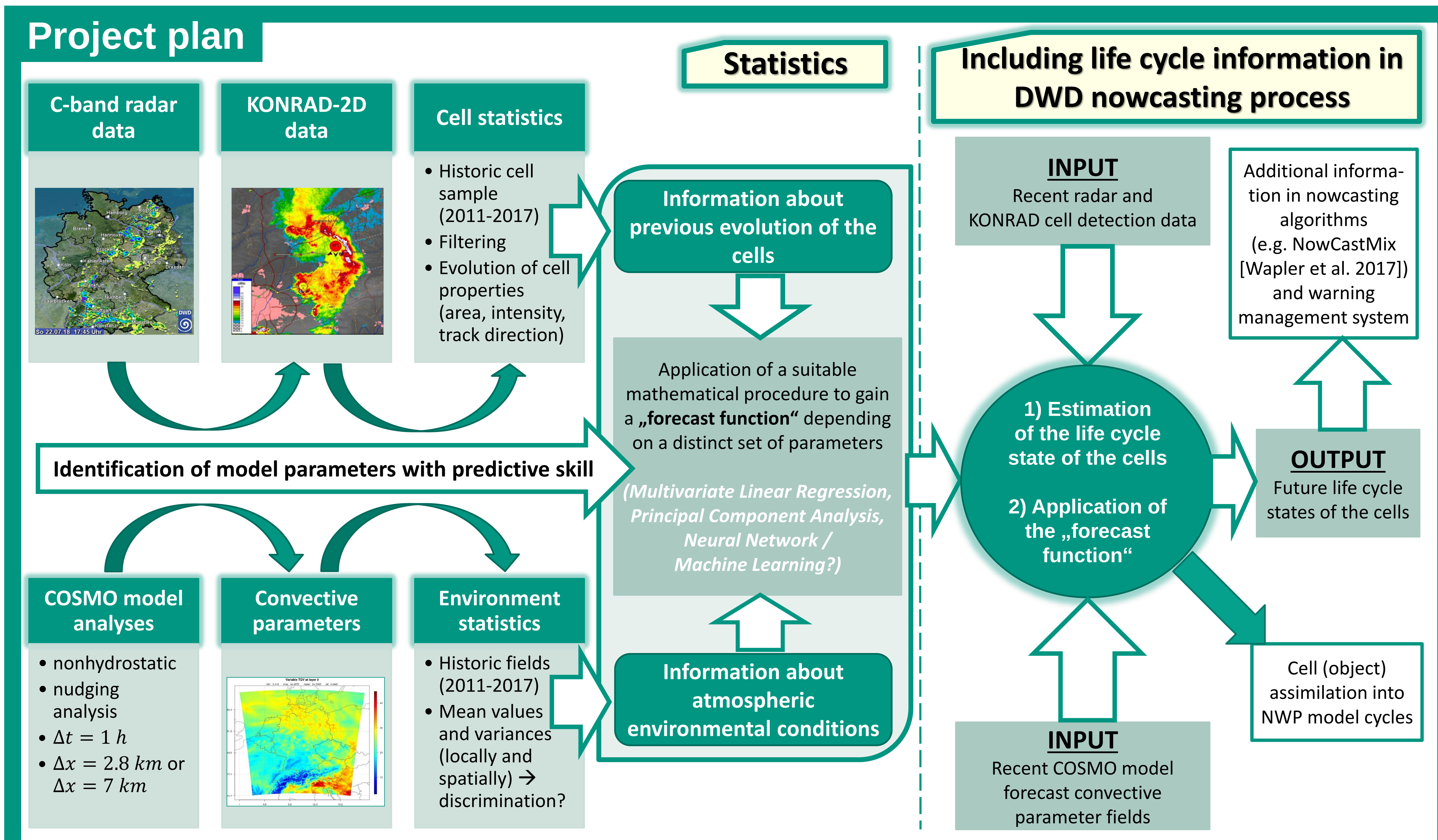
Overview

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



References

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Cell statistics

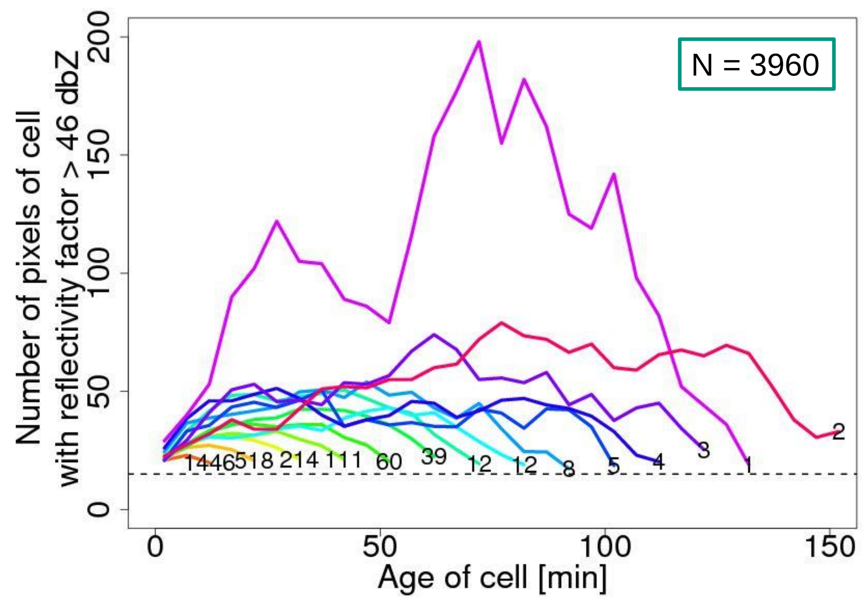

Figure 1: **Time evolution of cell area for a 3-month sample.** *Each line is an average over all cells of a specific lifetime (counts given in numbers). Lines are only drawn for every second maximum cell age. Note that the purple line with largest cell extent represents an isolated* ***hail-producing supercell*** *(locally hail diameter 2-4 cm).*

- ✓ We have developed reasonable cell **sample filters** on the basis of a **short-term convectively active time period** (27 May 2016 – 26 June 2016) using KONRAD cell detections over Germany and parts of its neighboring countries. Cells were more or less evenly distributed over the radar-covered area (not shown).
- ✓ The filters include inter alia thresholds for a minimum lifetime, unphysically tracked paths and a neighborhood criterion so as to avoid multicellular contributions – in such cases it is hardly possible to follow individual convective cores.
- ✓ **Cell area evolution** – reflected by the number of contiguous radar pixels with a reflectivity factor above 46 dBZ (*figure 1*; 3-month time period: 01 May 2016 – 31 July 2016) – seems to vary significantly with the **maximum age** of the cells.
- ✓ Inversely, it would be hard to foresee how long a cell will exactly live given a certain cell area at a certain time instance. This uncertainty could be transformed into a **probabilistic estimation** for the evolution of the cell area.

Convective parameters

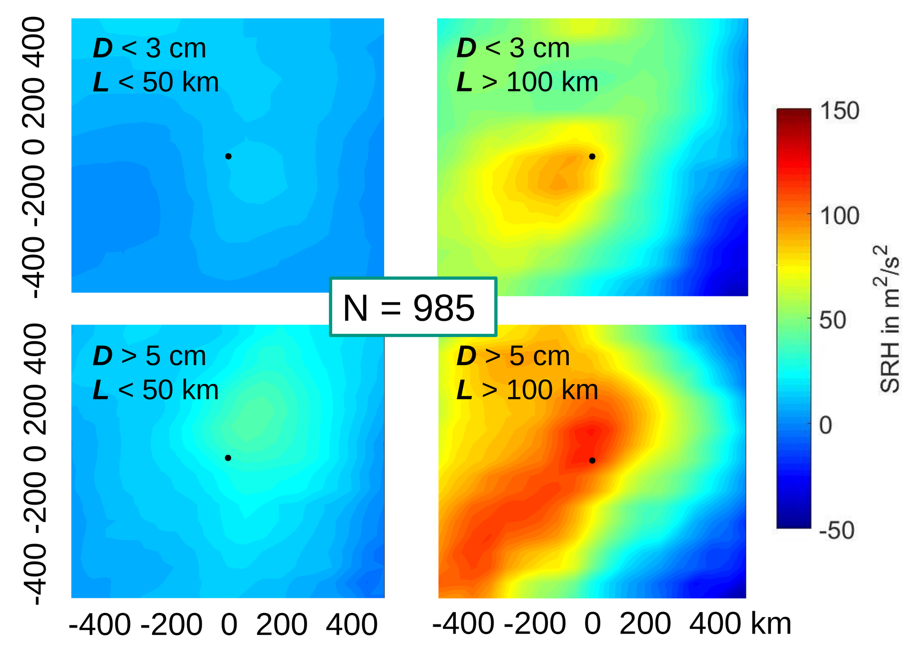

Figure 2: **Composite mean Storm Relative Helicity (0-3 km) fields relative to the midpoint of the hail storm track (10-year sample).** (Kunz et al. 2018)

- ✓ As unavoidably the life cycle module shall have to deal well with **potentially destructive cells**, (thermo)dynamic parameters clearly separating between severe and nonsevere cells (e.g. with respect to hail size and its associated threats) will be of special interest (e.g., Pucik et al. 2015, Sherburn et al. 2016).
- ✓ Already existent and newly defined COSMO fields, including convective quantities and parameters shown to possibly have predictive skill, will provide a wide variety of model data useful for the future statistical analyses.
- ✓ As an example, Kunz et al. (2018), in particular, show that **Storm Relative Helicity (0-3 km)** is a good proxy for distinguishing between different track lengths ***L*** (~ lifetime) and hail size (diameter ***D***) regimes for hail producing convective cells over Germany, France and BeNeLux (*figure 2*).

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.