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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Integrating KONRAD3D-SINFONY Ensemble Information into NowCastMIX: A Concept

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- NowCastMIX produces short-term warnings at the DWD, by automatically creating warning areas for the next 60 minutes combining various sources such as NWP and radar.
- We present a concept in which NowCastMIX combines the deterministic cell detection and tracking of KONRAD3D (K3D) with the ensemble-based approach of KONRAD3D-SINFONY (K3D-S).

SINFONY
www.dwd.de/sinfony

NowCastMIX Methodology

(a) Workflow

- Reads data of **multiple sources**
- Calculates displacement vectors
- Combines data within Fuzzy Logic
- **Clusters results** and generates warning polygons

(b) Thunderstorm Warnings

- Based on available data, potentials for heavy rain, hail and severe gusts are calculated **every 5 minutes** by a hierarchy of **fuzzy logic** sets.
- From these potentials, categorical **thunderstorm warnings** are issued.

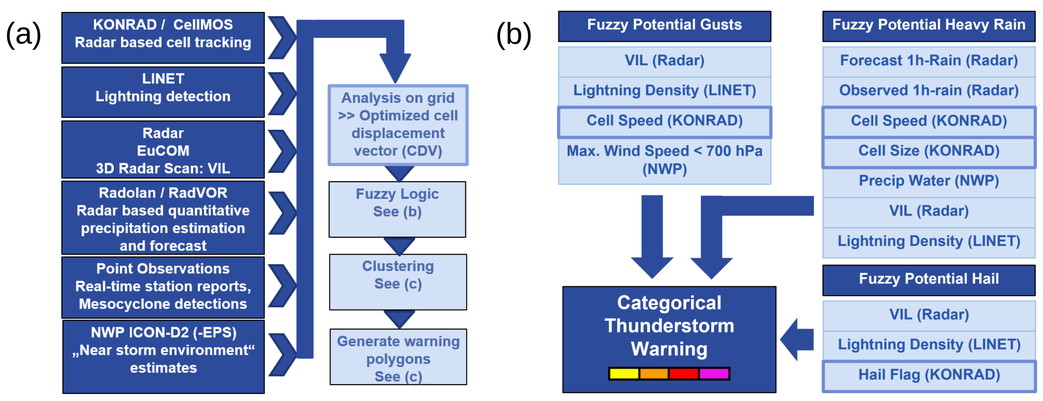

Figure 1: *Analysis* *Clusters + Warning Polygons* *Final Warning Areas*

(c) Production of Warning Polygons in NowCastMIX

- Current positions and severity of cells are analysed (colourized, left)
  - Overlapping warning zones are constructed by CDV-field (gray)
- Clustering of analysed cells allows orange categories to expand (middle)
- The final warning areas for the next 60 min mapped onto administrative districts (right)

Challenges

NowCastMIX Needs to Process More EPS Based Information

- NowCastMIX is **mainly a deterministic** product, using EPS information from NWP for precipitation estimation but not for cell creation and categorization.
- New methods must be implemented **to enhance NowCastMIX's capability to process EPS data** and to produce warning polygons based on EPS information.
- Transitioning from a single deterministic run to **20 ensemble members** will significantly **increase computational demand**, posing a challenge to fit processing within the 5-minute time window.

Forecast for Key Cell Attributes Needed

- KORNAD3D-SINFONY (K3D-S) is designed to forecast an integral variable for cell categorization, thereby **forecasting cell severity**.
- NowCastMIX requires **additional forecasted attributes** to support the current integration concept with KONRAD3D-SINFONY:
  - **Hail Flag**
  - **Cell Size**

Closer Look at Required Attributes

Polygon Cell Size (K3D) vs. Ellipse Cell Size (K3D-S)

- K3D calculates the cell size using a contour polygon, whereas K3D-SINFONY approximates cells as ellipses.
- Cell size is used by NowCastMIX for internal processing of large convective cells.
- Analysis of a K3D recalculation from 2018–2025 shows that the median **polygon-based cell size is 30% smaller** than the ellipse-based cell size.

Hail Flag Forecast

- Ongoing development aims to enable K3D-S to estimate the maximum hail flag over the lifetime of a cell.
- The HAIPI project explores machine learning–based hailstone size estimation.
- Future NowCastMIX development could use these estimates once they reach a more advanced stage.

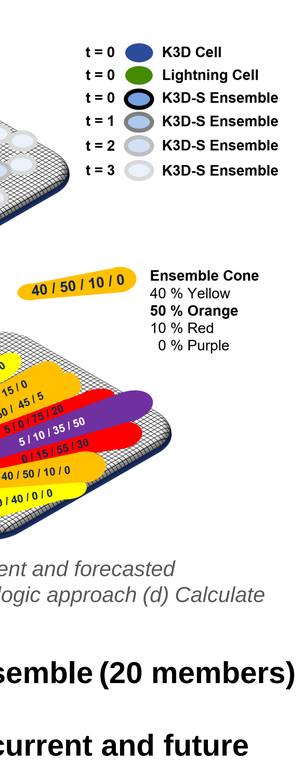

Figure 4: *K3D cell polygons closely follow corresponding cell pixels, whereas ellipses differ by design. Both match well for the yellow cell. For the red cell, the polygon area is smaller than the ellipse area.*

Concept for Integrating KONRAD3D-SINFONY Ensemble Information into the Nowcasting Guidance System NowCastMIX

Operational Product: NowCastMIX + KONRAD3D

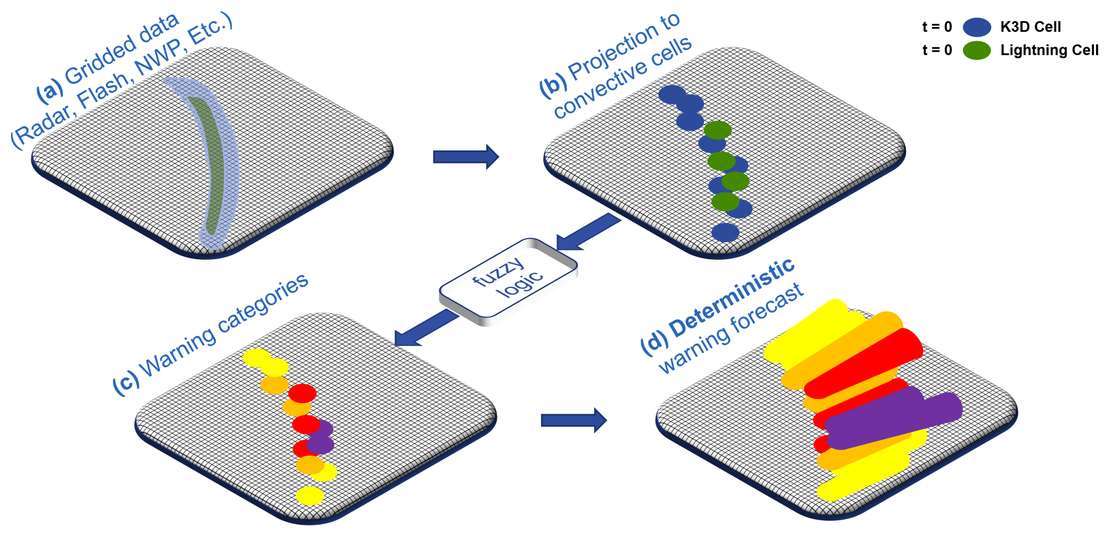

Figure 2*: (a) Gridded Radar Reflectivity (b) Detect cells based on current (t = 0) K3D cell detections (c) Categorize every cell using a fuzzy logic approach (d) Calculate warning polygons for the next hour*

- **Current** KONRAD3D **cell detections** are used to generate cells for NowCastMIX.
- Based on the detected cells, NowCastMIX applies fuzzy logic to produce a thunderstorm warning for each cell.
- Warning **cones** and clusters are **drawn for one hour**, using cell speed ($s = v \cdot t$)
- Cells detected to move faster result in larger warning polygons.
- **Deterministic** nowcasts are produced for each cone and cluster.

Ensemble Concept: NowCastMIX + KONRAD3D-SINFONY

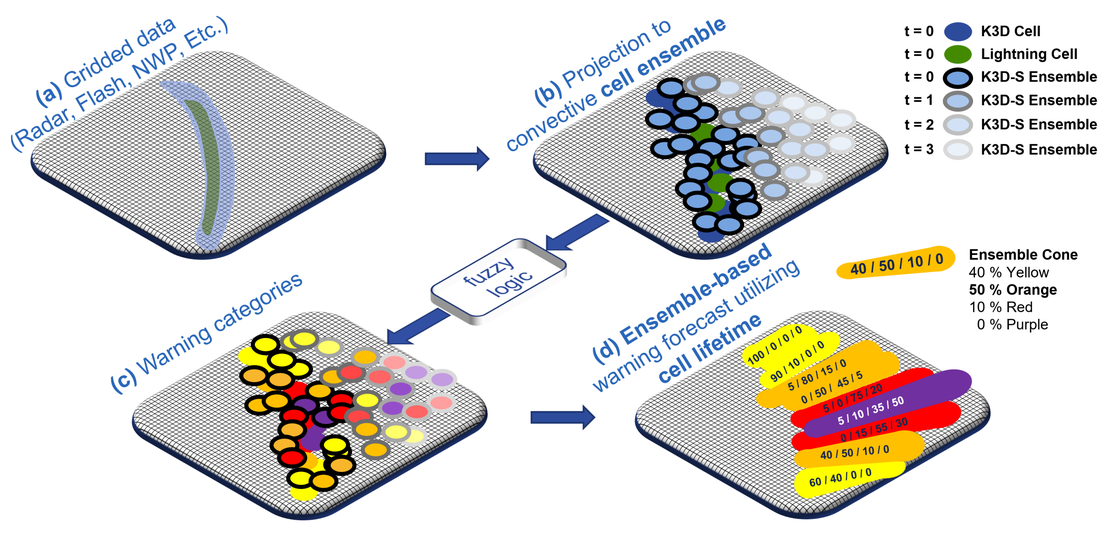

Figure 3: (*a) Gridded Radar Reflectivity (b) Detect cell ensemble, based on current and forecasted (t = 0, 5, ...120 min) K3D-SINFONY cells (c) Categorize every cell using a fuzzy logic approach (d) Calculate warning polygons based on cell lifetime of K3D-SINFONY ensemble.*

- **Current and forecasted** KONRAD3D-SINFONY **cell ensemble (20 members)** is used to generate cells for NowCastMIX.
- Warning polygons and **clusters** are drawn **utilizing the current and future cell ensemble**.
- The size of the **warning cone is determined by the cell lifetime** rather than its detected speed.
- Cells with short lifetimes (upper yellow cells) result in smaller warning polygons.
- **Probabilistic Information incorporated** in the warning cones and clusters.

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