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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Operational usage of KONRAD3D, DWD's scheme for detection, tracking, and nowcasting of convective cells

Manuel Werner, Robert Feger, Lukas Josipovic, and Tim Böhme

- ➔ **KONRAD3D is a tool for the automated detection, tracking, and nowcasting of convective cells** developed at Deutscher Wetterdienst (DWD).
- ➔ **Multi-sensor**: Uses *radar reflectivity* (primary), *lightning*, *hydrometeor classification data*, further in preparation
- ➔ **Thorough evaluation within ESSL testbed and by DWD forecasters** 2020-2022
- ➔ **Operational usage** at DWD since April 2023

Input, Output, and Implementation

Input data

- Radar reflectivity in polar coordinates from 17 operational DWD weather radars using both terrain-following near-ground scan and 10 fixed-elevation scans
- 3D-hydrometeor classification information from DWD's HYMEC algorithm
- Lightning data (LINET)

Output data

- One xml file per run every five minutes containing information about cells detected at current run and links to predecessors
- Output available ~20s after arrival of last radar sweep

Implementation

KONRAD3D

Written in c++, based on DWD's POLARA software framework

Detect and Filter I

Initial cell detection

Derivation of 2D-features in each 2D radar sweep using adaptive thresholds and formation of 3D-cells (see Figs. 1 and 2)

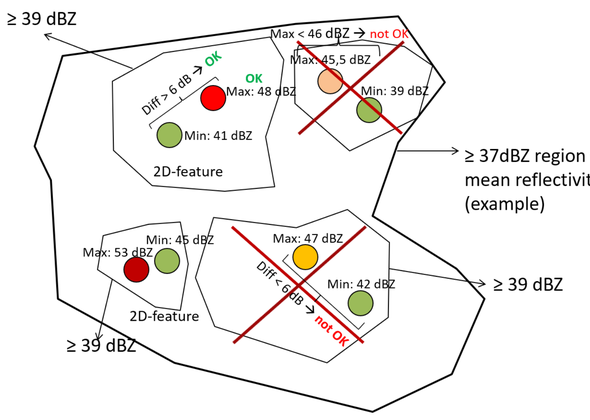


Figure 1: *Process of 2D-feature derivation: 37 dBZ region with embedded candidates for 2D-features. Candidates obtained by using mean reflectivity in 37 dBZ region as threshold. Candidates with too small maximum (< 46 dBZ) and difference between maximum and minimum value (< 6 dB) are sorted out.*

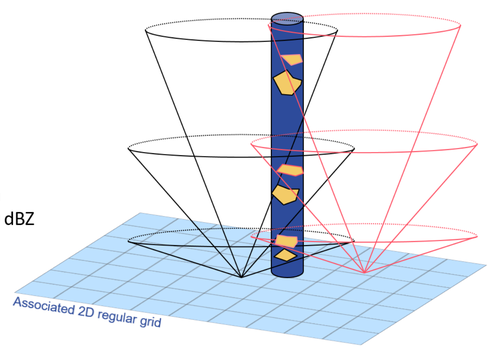


Figure 2: *2D-features (yellow) in different radar sweeps grouped together to form 3D cells.*

Cell attributes

Attribute categories: ***geometry*** *(contour polygon (Fig. 3), echo top, volume, area, etc.),* ***intensity*** *(severity level, cell based VIL, etc.),* ***hail***, ***lightning*** *(e.g. lightning jump detection),* ***tracking***, ***forecast***

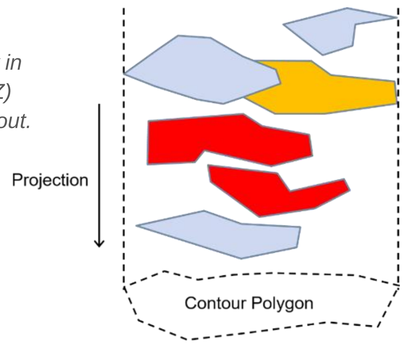
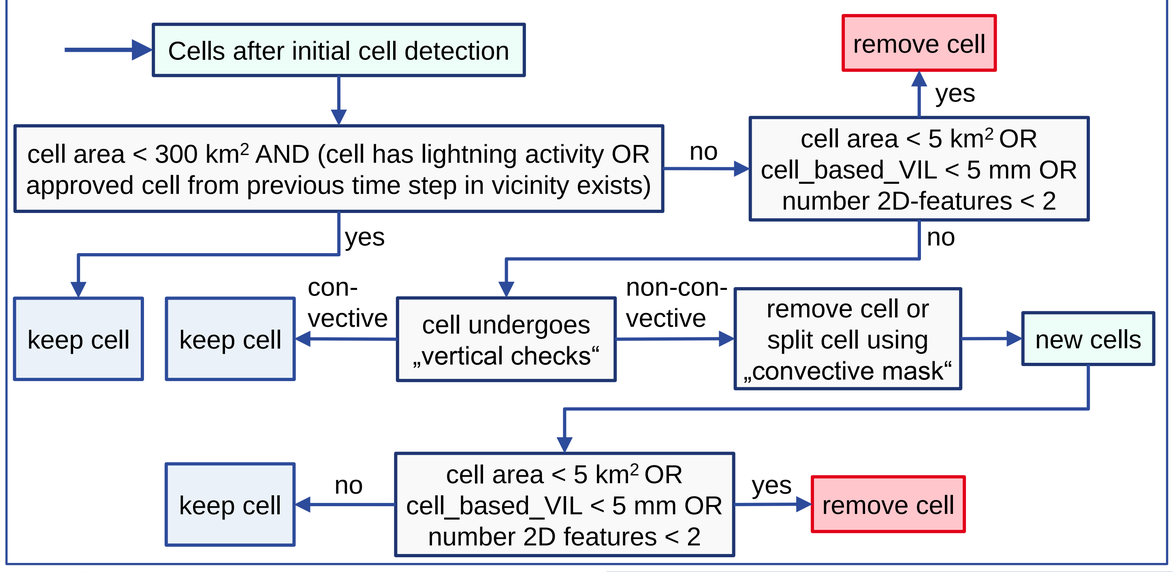


Figure 3: *Creation of the 2D contour polygon bordering the projections of the 2D-features.*

Filter scheme

- **Aims:** Suppress false alarms by clutter or stratiform heavy rain, detect at early stage, prevent gaps in cell tracks, keep all cells with lightning activity, and also keep more shallow cells in autumn, winter, and spring.
- **"Vertical Checks"**: Perform pixel-by-pixel check of sufficient vertical extent and VIL yielding a "convective mask" (cf. Figs. 4 and 5). Use "convective mask" to decide whether initial cell has to be completely removed or to extract truly convective parts. Irregular vertical coverage by radar network has to be regarded.



Detect and Filter II

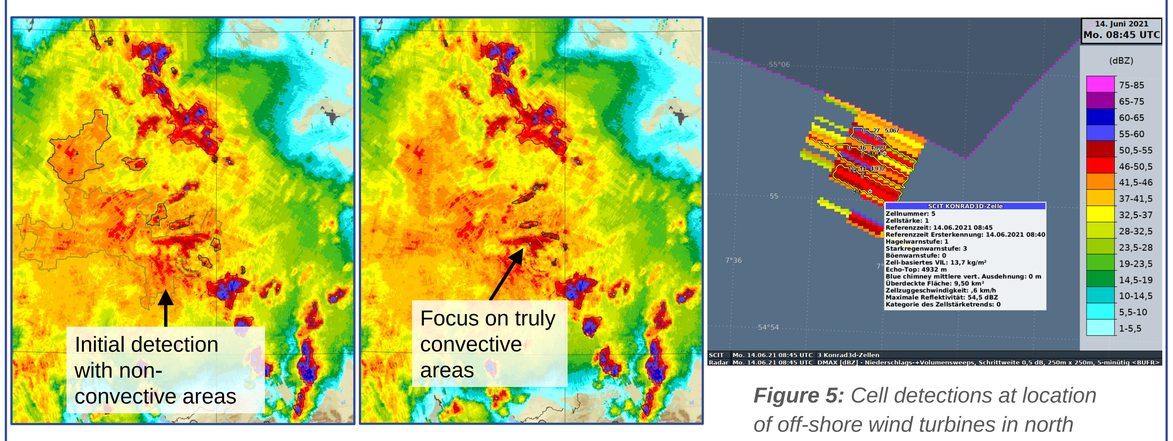


Figure 4: *Left: Without vertical checks. Huge cell occurs. Right: With vertical checks. Only truly convective areas remain.*

Figure 5: *Cell detections at location of off-shore wind turbines in north sea when filters are switched off.*

Track, Nowcast, Warn

Tracking and Nowcasting

"Hungarian Tracking" combined with Kalman filter for cell location and motion provides forecasts of cell centroid locations up to 1h forecast time with uncertainty estimates (ellipses, see Fig. 6)

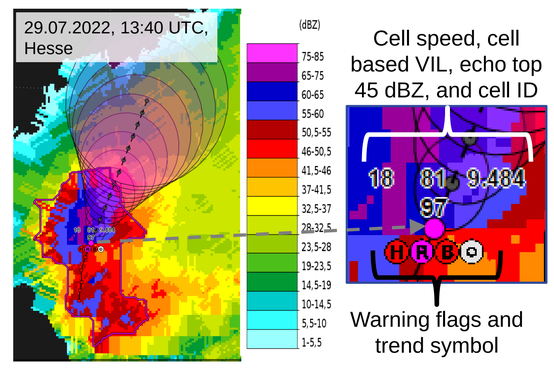


Figure 6: *Left: Example of KONRAD3D cell in meteorological workstation NinJo with contour polygon and uncertainty ellipses around forecast centroids. Right: Zoom on 2D-centroid.*

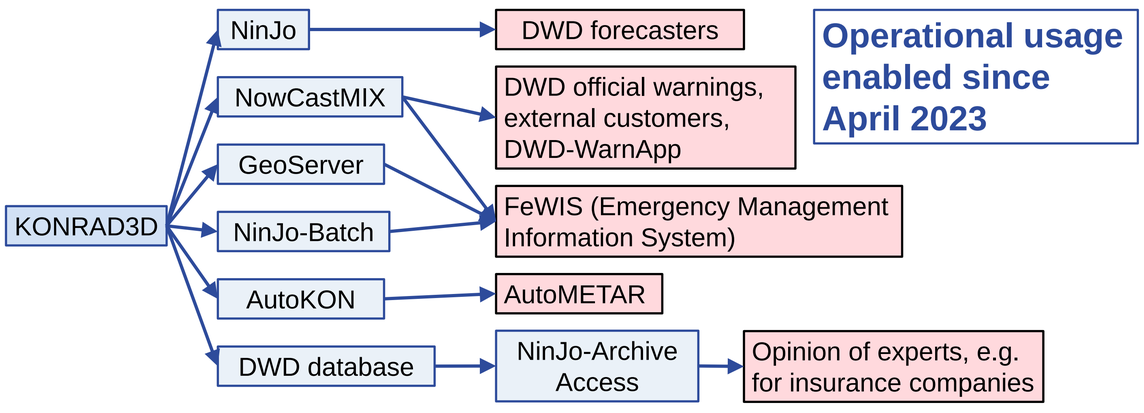
Diagnostic warning flags

- ***Hail:*** Based on DWD-HYMEC algorithm for polar radar sweeps. If *hail* or *large hail* occurs near bottom of cell (lowest 2 km), warning category 1 or 2 is set.
- ***Heavy rain:*** By rain accumulation along straight path through most intense point of cell: Thresholds 15 mm, 25 mm, 40 mm for rain amount for three warning categories.
- ***Wind gusts:*** Maximum wind gust speed estimated from echo top, cell based VIL, and cell speed inspired by *Stewart, S. R. (1991). The prediction of pulse-type thunderstorm gusts using vertically integrated liquid water content (VIL) and the cloud top penetrative downdraft mechanism. Technical Memorandum NWS SR-136, NOAA*. Thresholds 65 km/h, 105 km/h, 140 km/h for three warning categories.

Severity level

Three severity levels: ***weak***, ***moderate***, ***severe***, ***extreme***. *Obtained by combination of five attributes cell_based_VIL, volume_55 / area_55, max_reflectivity, heavy_rain_potential, cell_mass and warning flags.*

KONRAD3D in Operation



Outlook

- Fusion with DWD's **mesocyclone detection**
- Further **tuning and development of warning flags**
- Addition of attributes derived from **satellite data**
- **KONRAD3D-EPS**: **E**nsemble **P**rediction **S**ystem using ensemble Kalman-Filter
- **KONRAD3D-SINFONY**: Combination with objects derived from NWP-Rapid Update Cycle (RUC) ensemble

Remote Sensing Application Development
Contact: manuel.werner@dwd.de