

# Predicting convection with KONRAD3D-SINFONY

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KONRAD3D-SINFONY aims to predict convective cells up to 12 hours in advance. Existing thunderstorms are detected in radar observations and their evolution is nowcast while considering uncertainties through an ensemble approach. Additional, newly developing cells originate from the 21 ensemble members of the ICON-RUC (Rapid Update Cycle) NWP model. The combined KONRAD3D-SINFONY cells can be used by forecasters to issue warnings or they can contribute to future automated warnings currently under development by the RainBoW project.

## Step 1: Detecting cells with KONRAD3D

- KONRAD3D detects convective cells in radar data
- 2D features from 11 elevation sweeps are combined into 3D cells
- Cell attributes include: geometry, intensity, movement, hydrometeors, lightning
- New radar observation every 5 minutes

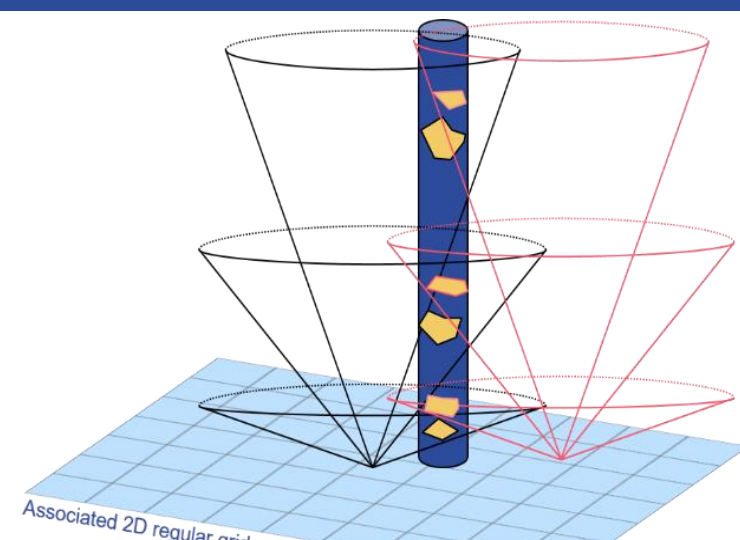


Figure 1: KONRAD3D detects 2D features (yellow) in radar sweeps and combines them into 3D cells.

## Step 2: Nowcasting with KONRAD3D-EPS

- 20 ensemble members are used to nowcast the position and intensity of detected KONRAD3D cells based on previous radar detections
- Intensity evolution causes cells to dissolve within 2 hours
- updated every 5 minutes

## Seamless INtegrated ForecastiNg sYstem

- Pilot project to integrate numerical weather prediction (NWP) and nowcasting techniques into a new ensemble-based forecasting system
- Focus on severe summertime convective events
- Forecast range up to 14 hours



## Step 5: Verifying simulated KONRAD3D cells

- Using 48 days with convection in summer 2024 (one model init per day)
- >80% of all observed cells are predicted by the RUC within 25km and +/- 5 min
- Accuracy only decreases slowly with lead time
- The average fraction of false alarm rate is ~57% at 4 hours lead time
- Rates will improve after finetuning the cell detection for model data
- Nowcasting of observed cells will improve the accuracy in the first ~2h

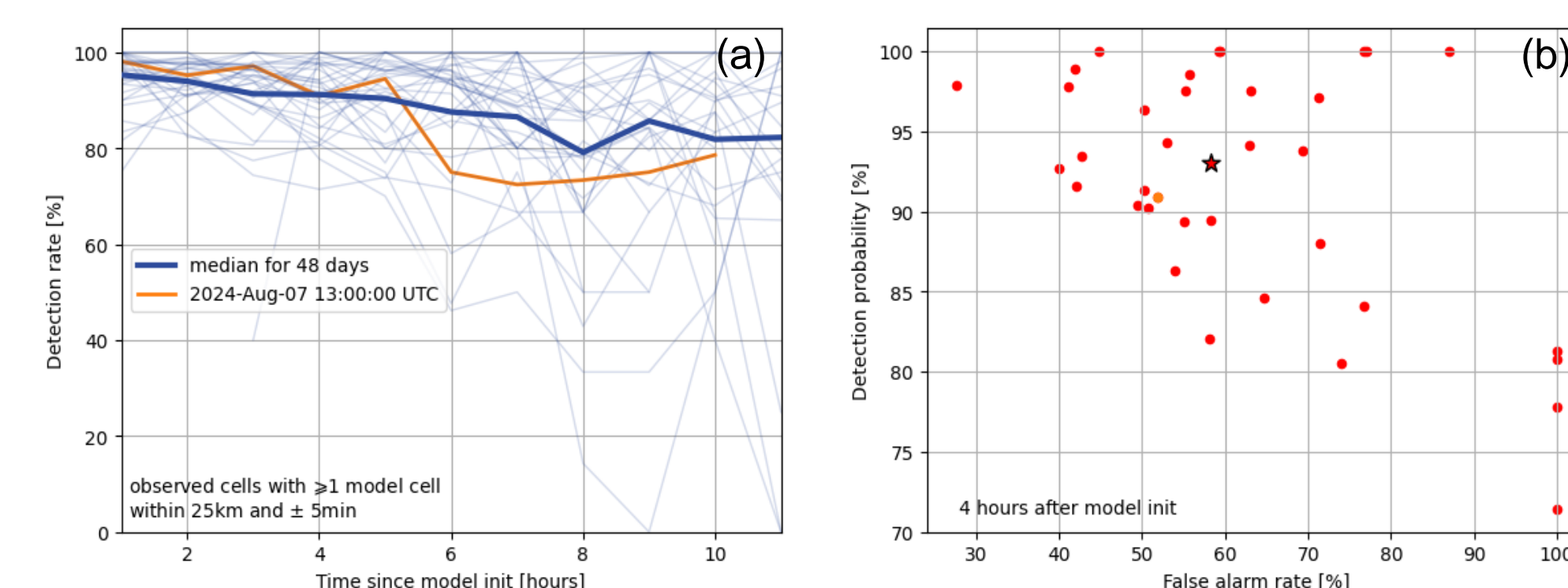
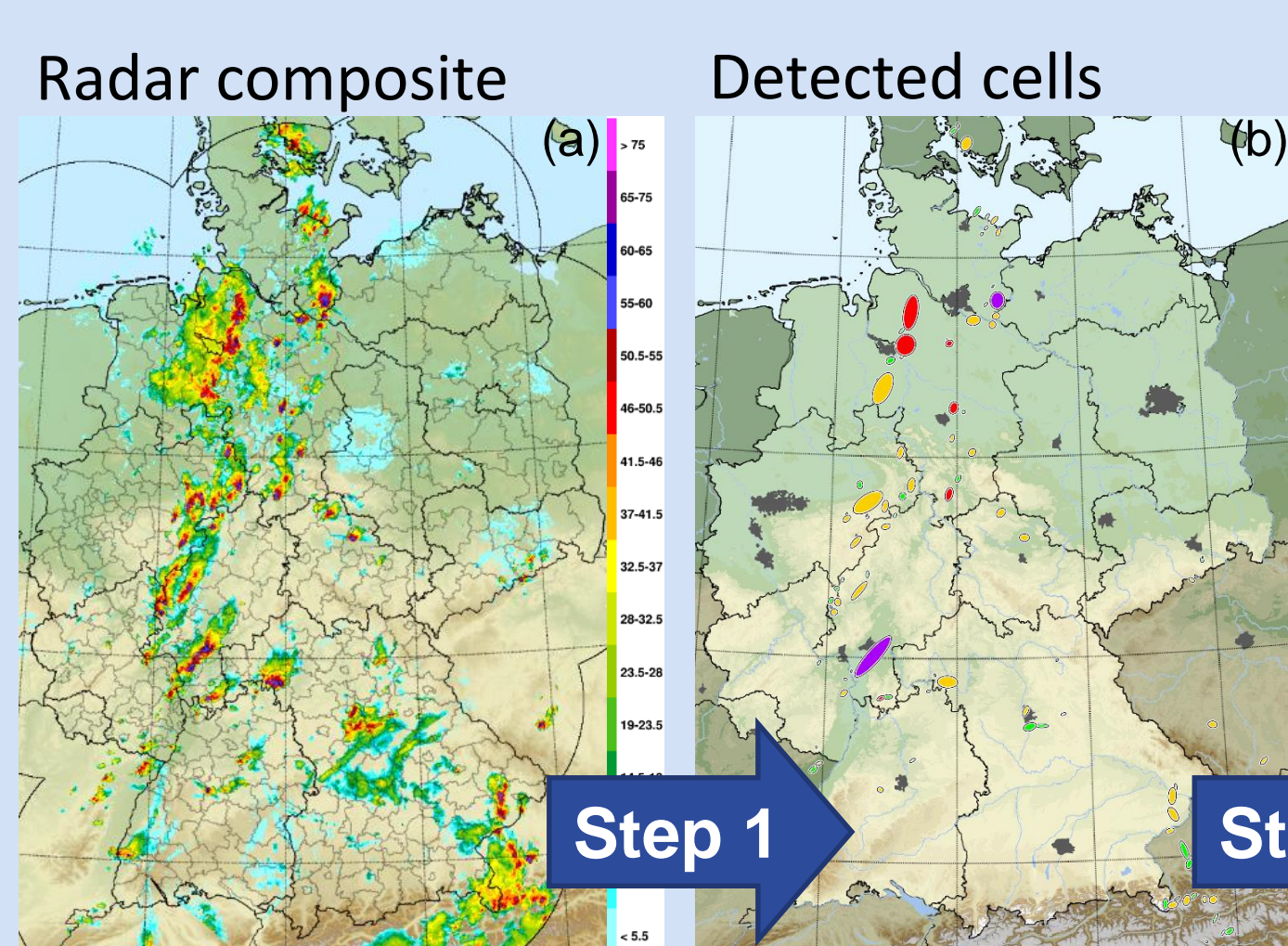


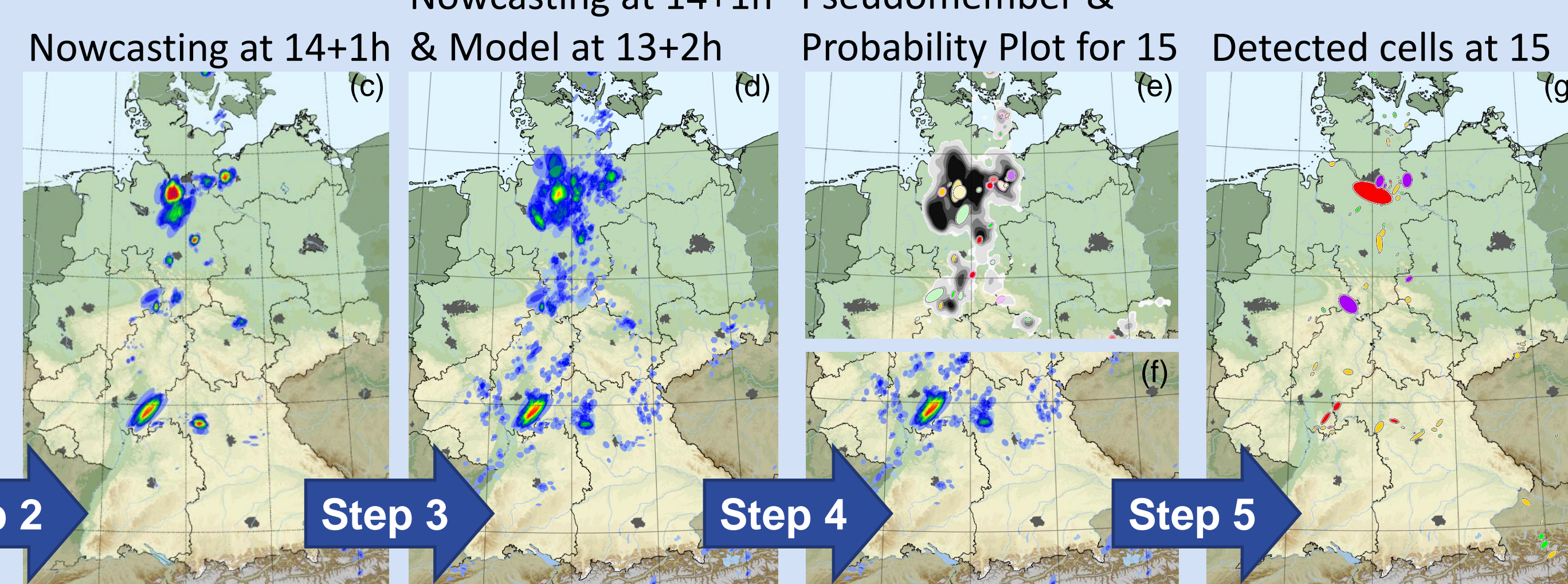
Figure 4: RUC probability to predict a cell and fraction of false alarms. Each line/dot corresponds to one day. The orange symbols show the result for 2024-Aug-07, the example case in Fig. 3. a) Fraction of correctly predicted cells versus time. b) Correct predictions and false alarm rate at 4h lead time.

## Overview: Example case 2024-Aug-07 14:00 UTC

### Observations at 14:00 UTC



### Forecast for 15:00 UTC: Nowcasting and model



### Forecast for 17:00 UTC: Model-only

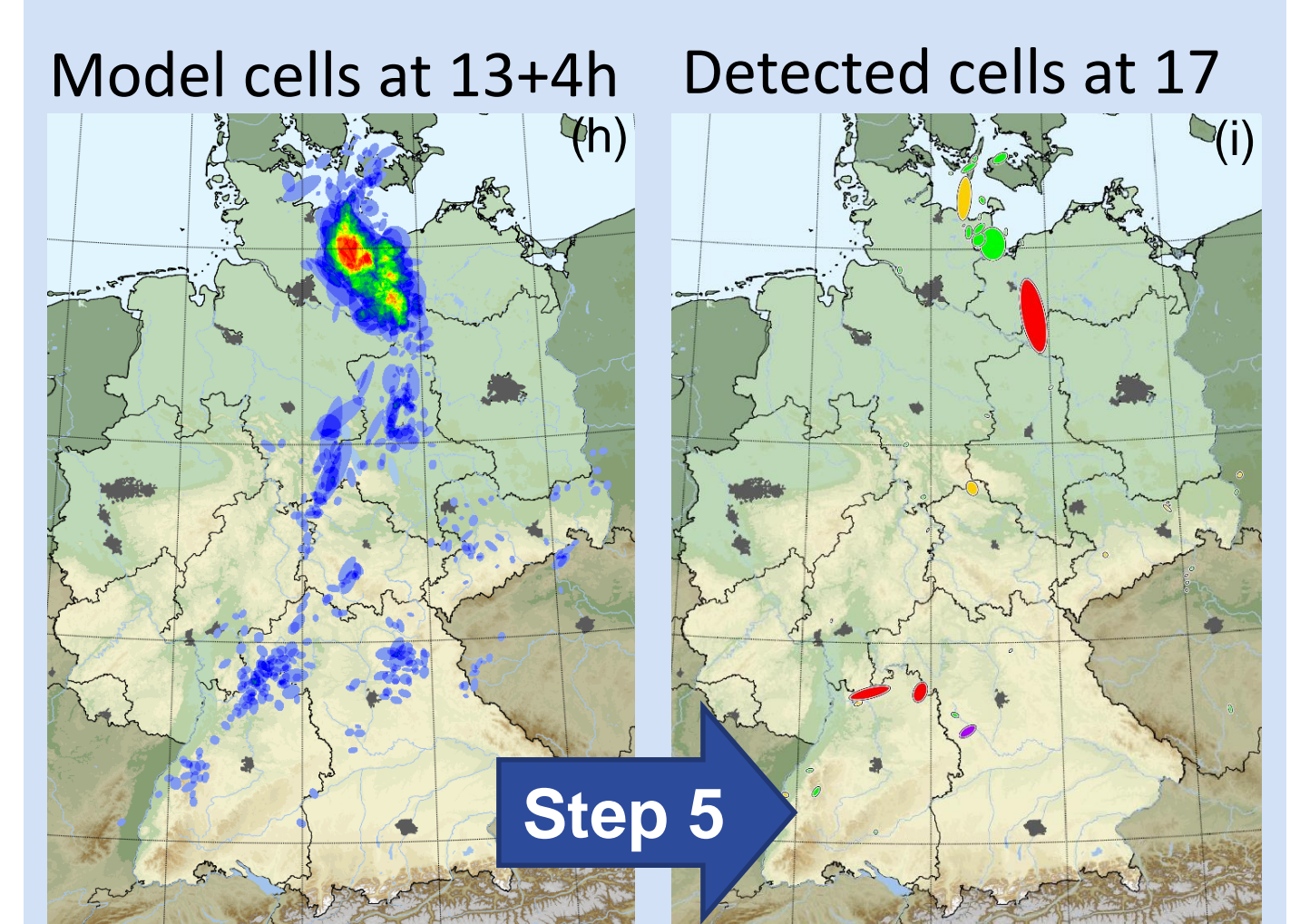


Figure 2: Steps for generating and evaluating a KONRAD3D-SINFONY forecast.

## Step 3: Adding model cells from the ICON-RUC

- KONRAD3D-SINFONY combines nowcasting and model cells into a seamless forecast
- The ICON Rapid Update Cycle runs every hour until +14h with a deterministic run and 20 ensemble members
- Model data is ~1h older than the nowcasting results due to the RUC run time
- KONRAD3D is run on simulated radar sweeps
- Challenge: Large model cells, partly due to the RUC resolution, yield too high severities
- Model cells near the current time are either matched to observed cells or discarded, if they are not similar to any real cell
- Matched cells are moved in time and space on top of observed cells (Fig. 3d)
- Most nowcasting cells dissolve within <2h and later KONRAD3D-SINFONY forecast are purely based on model data (Fig. 3h)

## Step 4: Data Products and Visualization

- Probability plots** (Fig. 2 d&f) show all nowcasting and (shifted) model cells
- Pseudomember plots** (Fig. 3) summarize the cell properties
  - Representative cells (colored ellipses) indicate the most likely cell location, size and severity
  - Black distribution indicates likely location of cells
  - Planned: popup window that shows details about individual cells, such as hail, gust or heavy rain flags

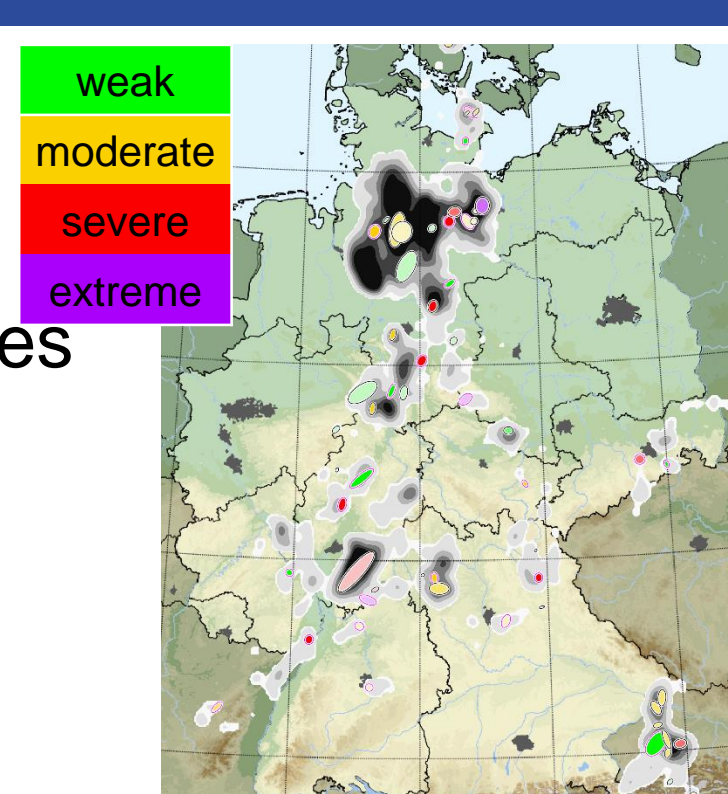


Figure 3: KONRAD3D-SINFONY Pseudomember Plot for 2024-Aug-07 15:00 UTC. 1h lead time.

## Heavy-rain event in Braunsbach on 2016-May-29

- heavy rain between 17-18 UTC increased the water level of Orlacherbach (catchment area 6.4 sqkm) which caused destruction in the village of Braunsbach
- Recalculation using today's meteorological products
- strong and extreme cells in the right location about 2h in advance
- Similarly strong cells are predicted across Southern Germany
- In this case convective cells alone not sufficient to predict flooding

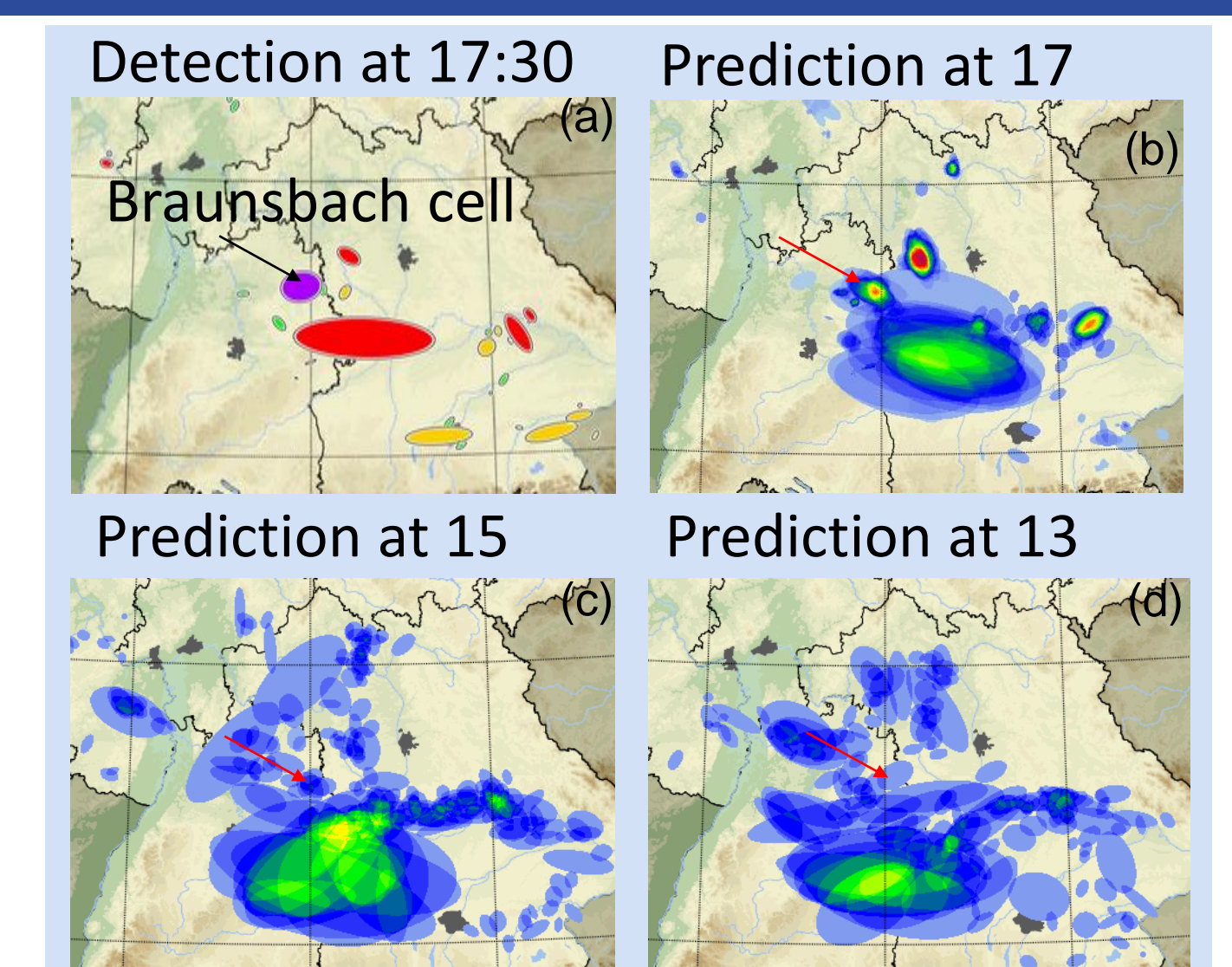


Figure 5: KONRAD3D-SINFONY predictions for 2016-May-29 17:30 UTC.

## Current status and Summary

- ICON Rapid Update Cycle and KONRAD3D are operational; KONRAD3D-SINFONY has been running in test mode since 2023
- Results under evaluation by the European Severe Storm Lab and DWD
- Currently using 2024 data to improve the predictions systematically
- Future plans: include additional cell attributes, such as lightening or hail flags
- High-quality radar data, improved nowcasting methods, and the ICON Rapid Update Cycle allow a major improvement when forecasting convective cells
- The RUC predicts large majority of cells in the correct location, but also issues some false alarms
- Further improvements expected after finetuning the product

