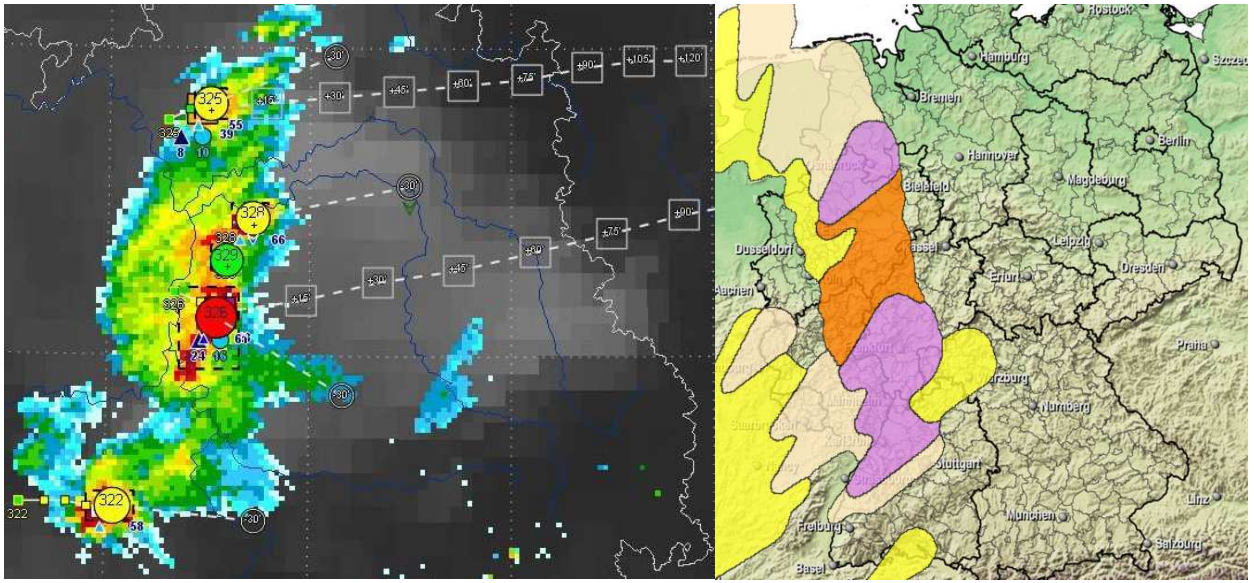
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

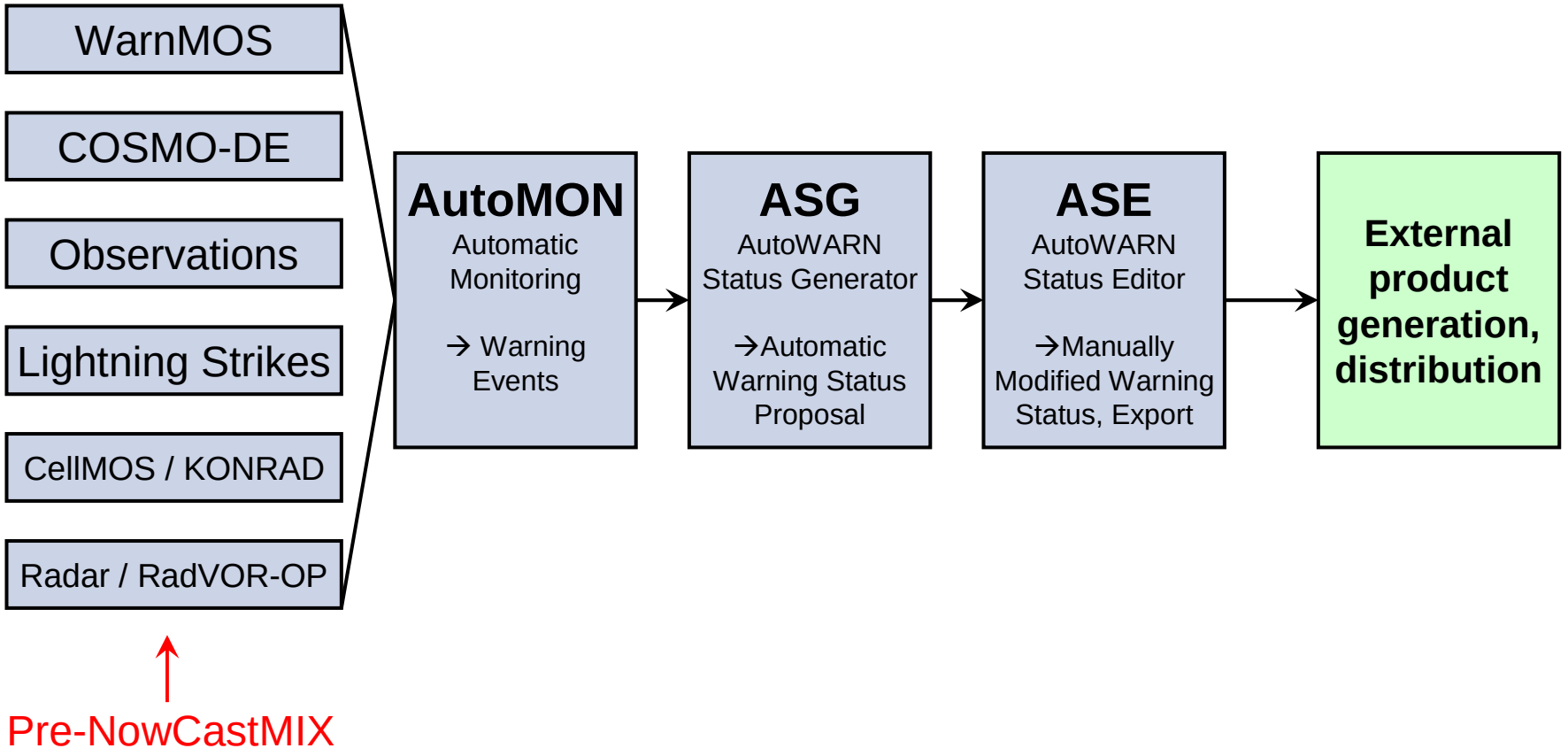


NowCastMIX

A fuzzy logic based tool for providing automatic integrated short-term warnings from continuously monitored nowcasting systems

Paul James, Deutscher Wetterdienst
EMS Meeting, Berlin, 12.09.2011

The AutoWARN (Automatic Warning) Process at the DWD



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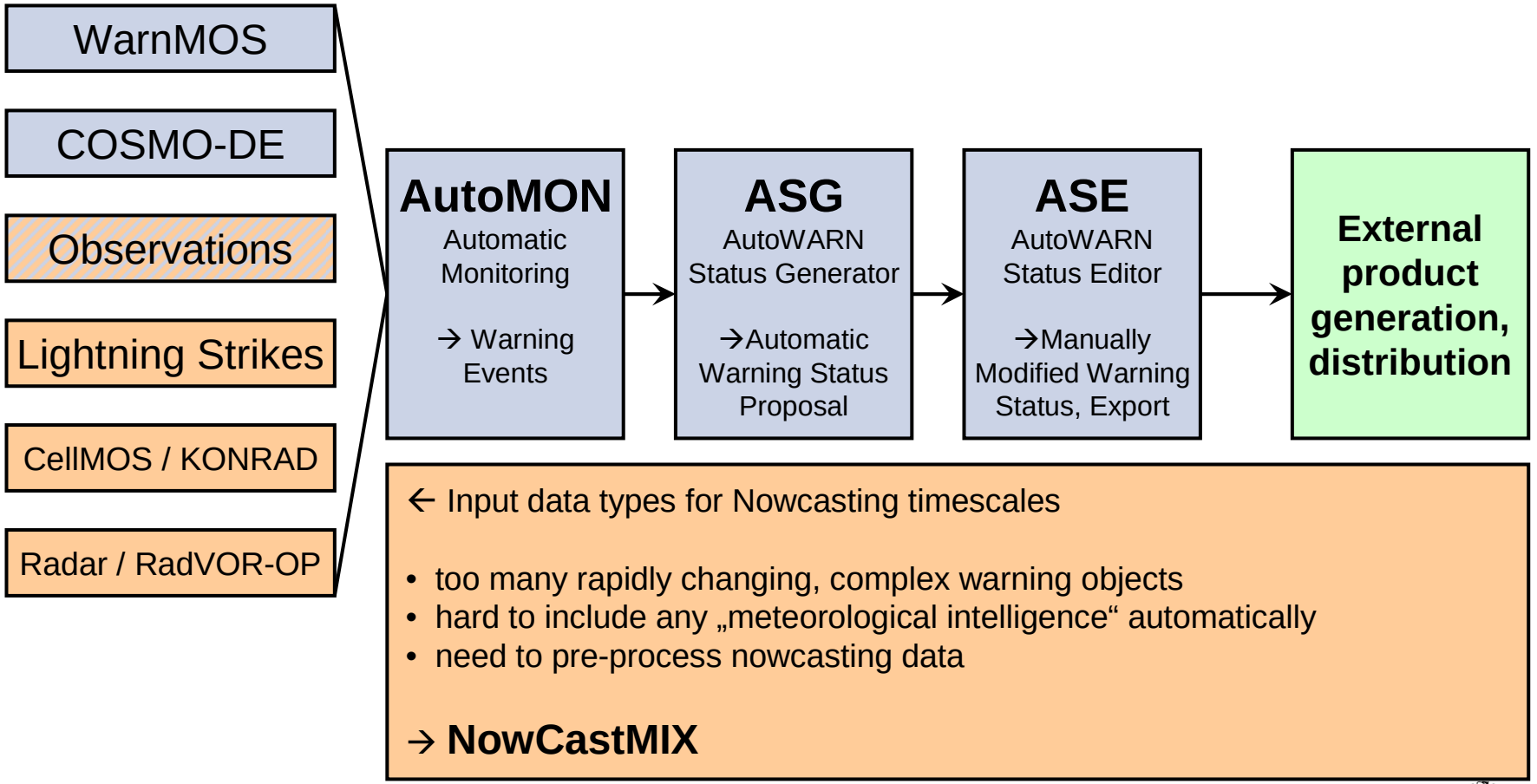

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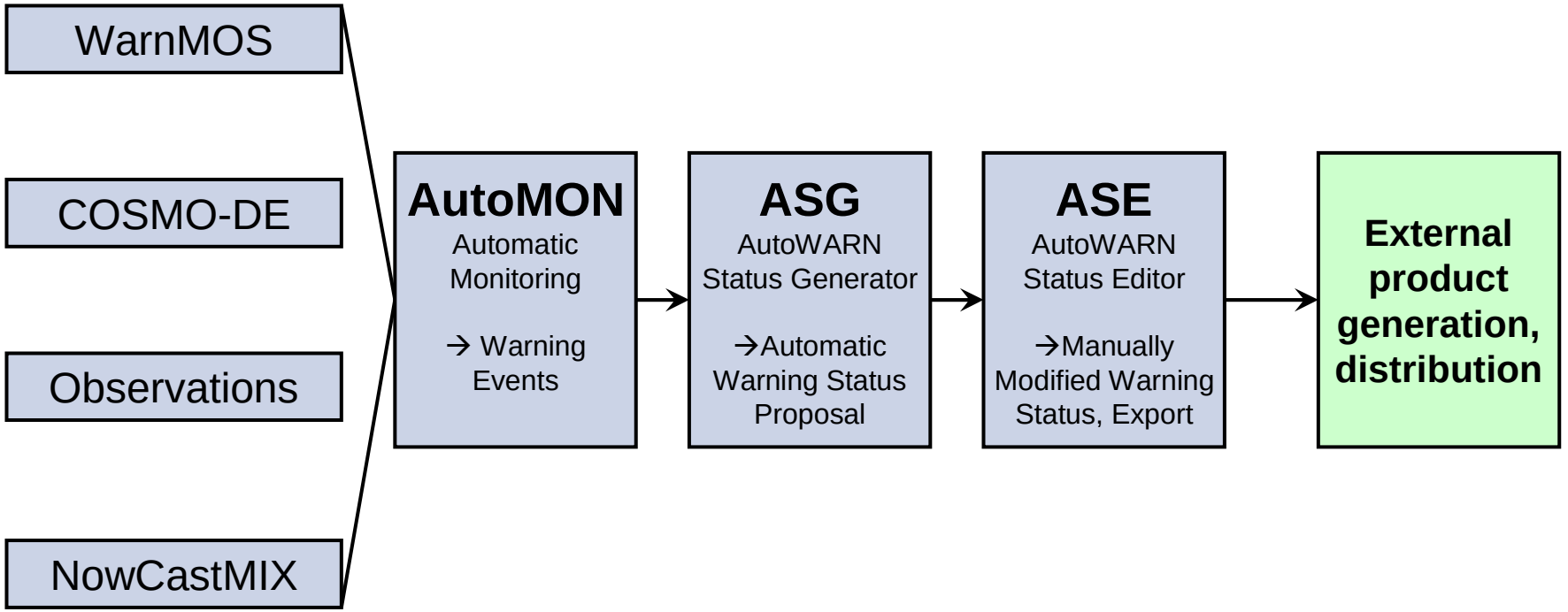
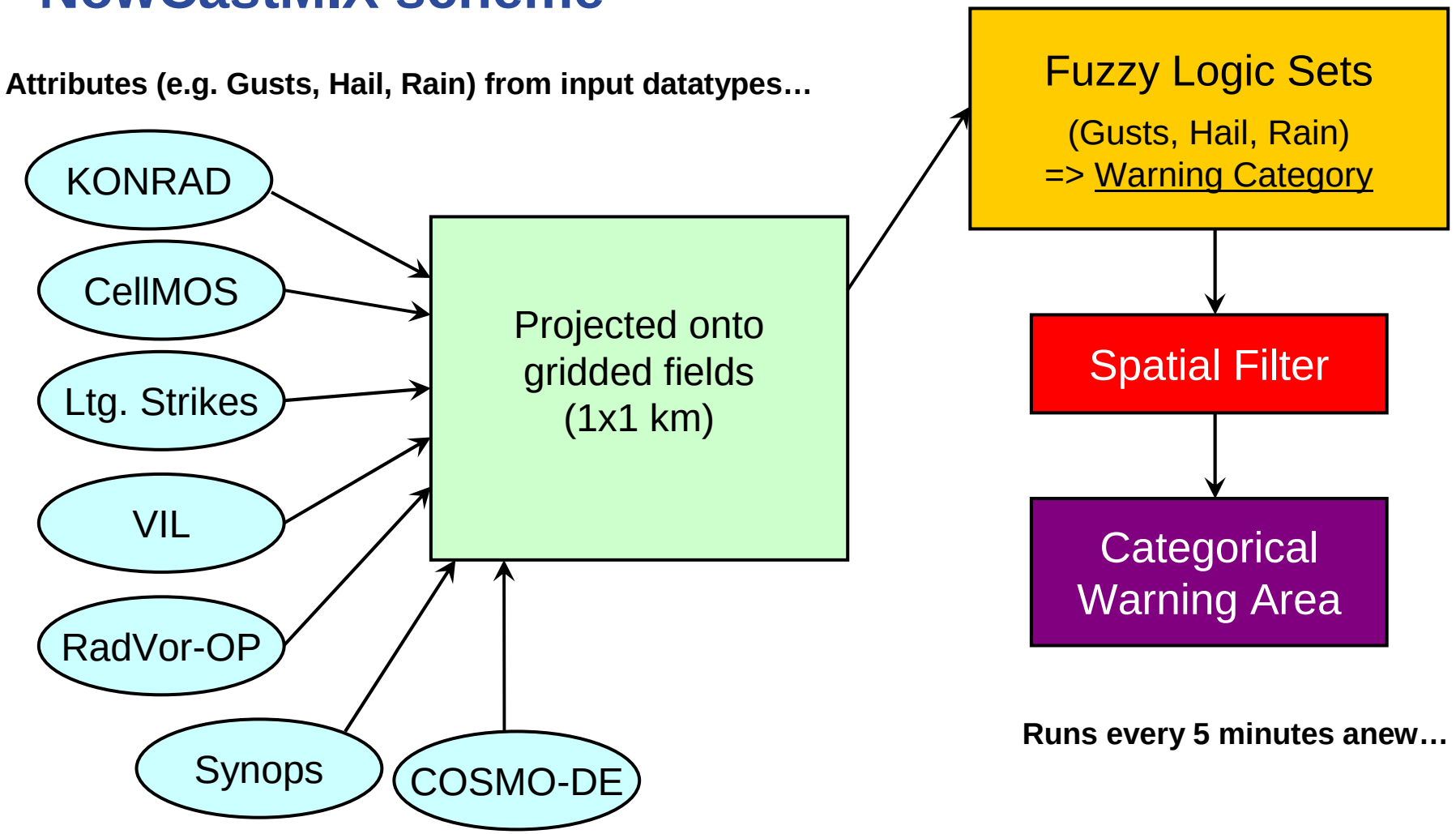


Input data types read by NowCastMIX

- **Point datasets**
  - **KONRAD** Radar-based storm cell detection with empirical tracking forecast
  - **CellMOS** Radar-based storm cell detection, tracking forecast via a MOS method
  - **NCM-Strikes** Precise Europe-wide lightning strike time-location system
  - **Synop-Reports** Observational reports of storms and/or storm attributes
- **Gridded datasets**
  - **RadVOR-OP** Radar-based analyses and forecasts of precipitation sums (1x1 km)
  - **Cell motion vectors** Estimates of speed and direction of cells in radar echoes using „Rosenow“ method (used in RadVOR-OP)
  - **COSMO-DE** Local Forecast Model. Provides estimates of background conditions for storms (Max. windspeeds 700-950 hPa, precipitable water), runs every 3 hours
  - **VIL** Vertically Integrated Water (3D Volume Radar scan), every 15 minutes

NowCastMIX scheme



Warning Events: Thunderstorms / Heavy Rain

- AutoWARN is required to predict up to 10 thunderstorm classes and 3 heavy rain classes (different ii-codes)
- The severity of the event is a function of the presence and intensity of various attributes:
  - Gusts, Heavy Rain, Hail

ii	Warning event
31	Thunderstorm with gusts to Bft. 7
33	Thunderstorm with storm-force gusts (to Bft. 10)
34	Thunderstorm with heavy rain (>10mm/h)
36	Thunderstorm with storm gusts and heavy rain
38	Thunderstorm with storm gusts, hvy. rain and hail
40	Severe Thunderstorm with hurricane-force gusts
93	Sev. Thunderstorm with extr. hvy. rain (> 25mm/h)
42	Sev. Tstorm with storm gusts and extr. hvy. rain
46	Sev. Tstorm with storm gusts, extr.hvy. rain and hail
48	Sev. Tstorm with hurricance gusts, extr. rain, hail
61	Heavy rain (10-25mm/h)
62	Extremely heavy rain (25-50mm/h)
62+	Exceptionally heavy rain (>50mm/h)

The 10 Storm and 3 Rainfall ii-codes

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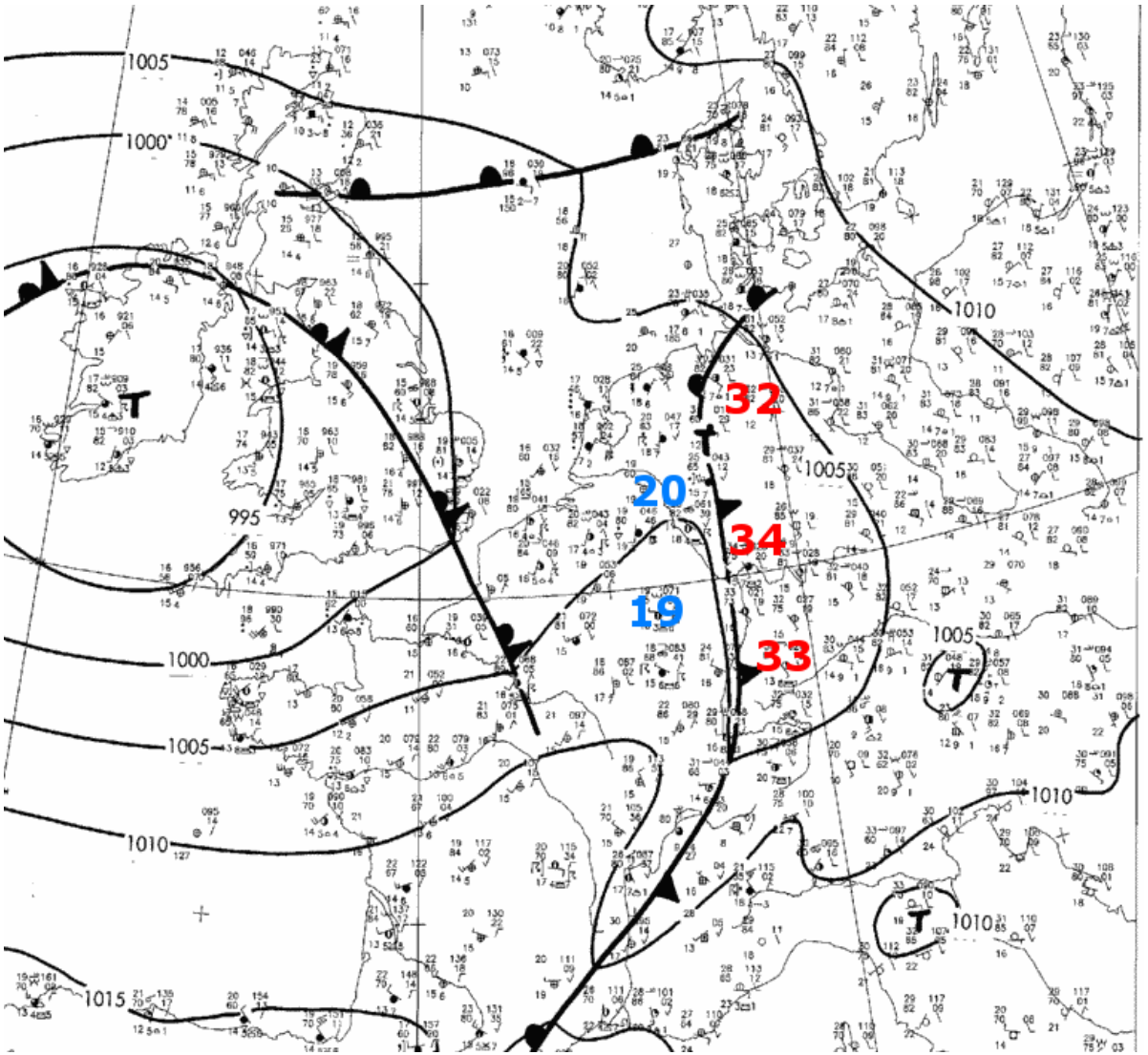
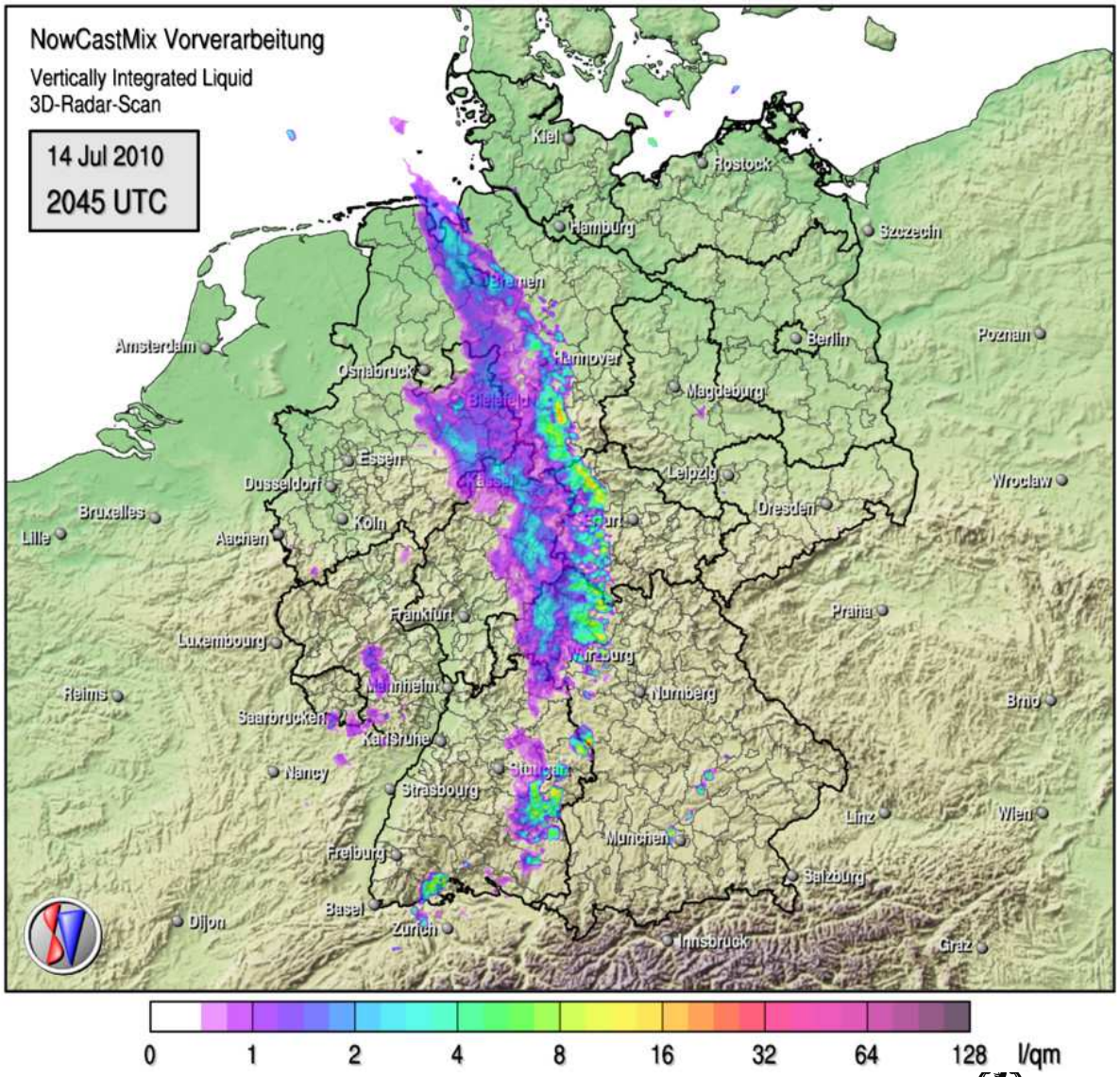
NowCastMIX Case Study

- Cold front moving eastwards
- Very hot and humid ahead of the front (up to 35 degC)
- Severe thunderstorms observed widely along the front, with hail, torrential rain and violent gusts



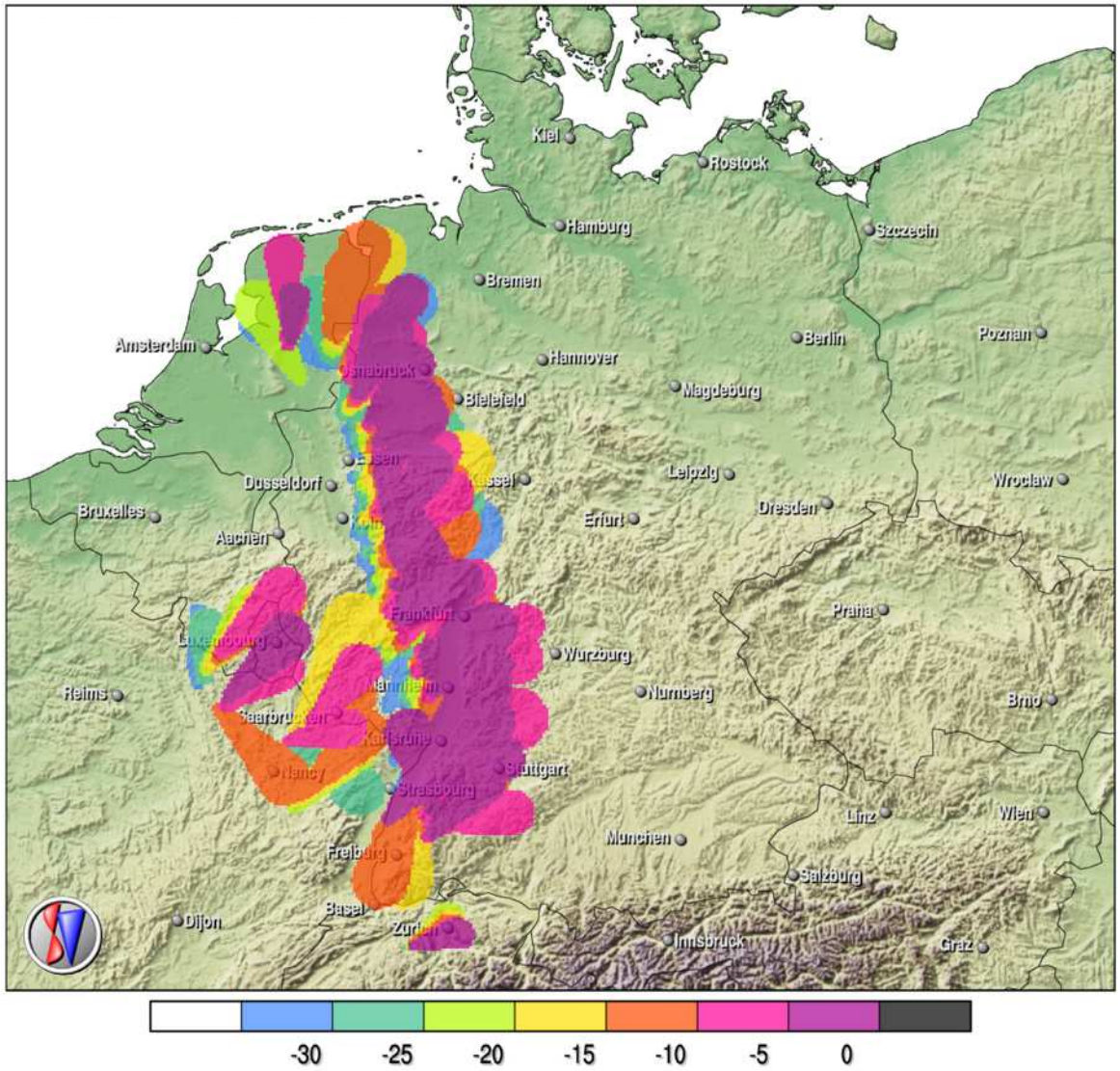
Surface Analysis
14 July 2010 18 UTC

- Vertically-integrated Liquid Water (VIL) is a product derived from 3D radar volume scans
- Currently produced from around 18 radar stations across Germany every 15 minutes
- NowCastMIX produces ist own internal VIL composite for storm severity assessment



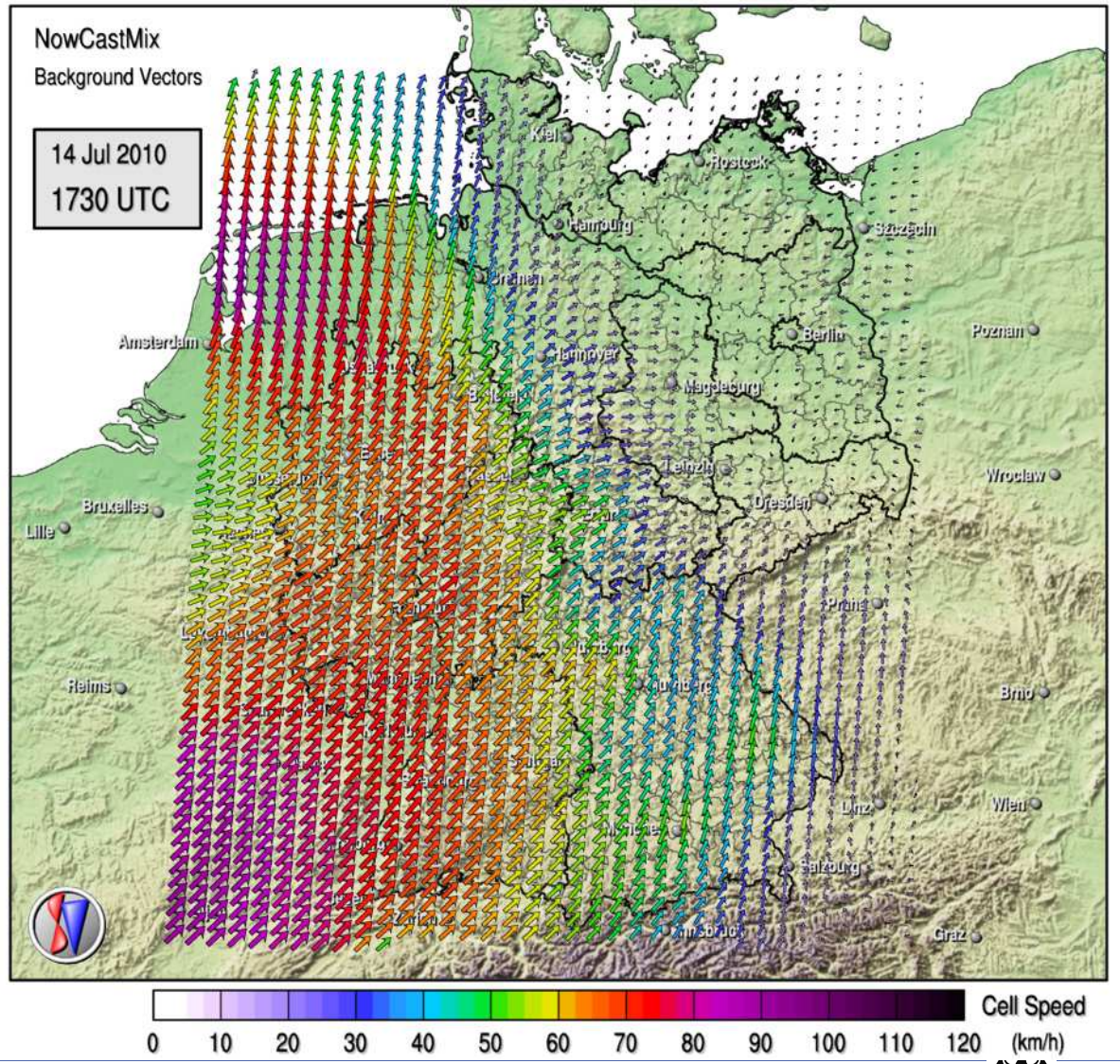
17-21 UTC, 14.07.2010
VIL (litres per m²)

- Represent each storm cell with a Cone shape, pointing in direction of motion
- Frontal movement during last 30 minutes can be seen
- But several false motion predictions are also visible (in speed and/or direction) – a problem in both KONRAD and CellMOS
- Results in a messy picture and makes automatized warnings unreliable



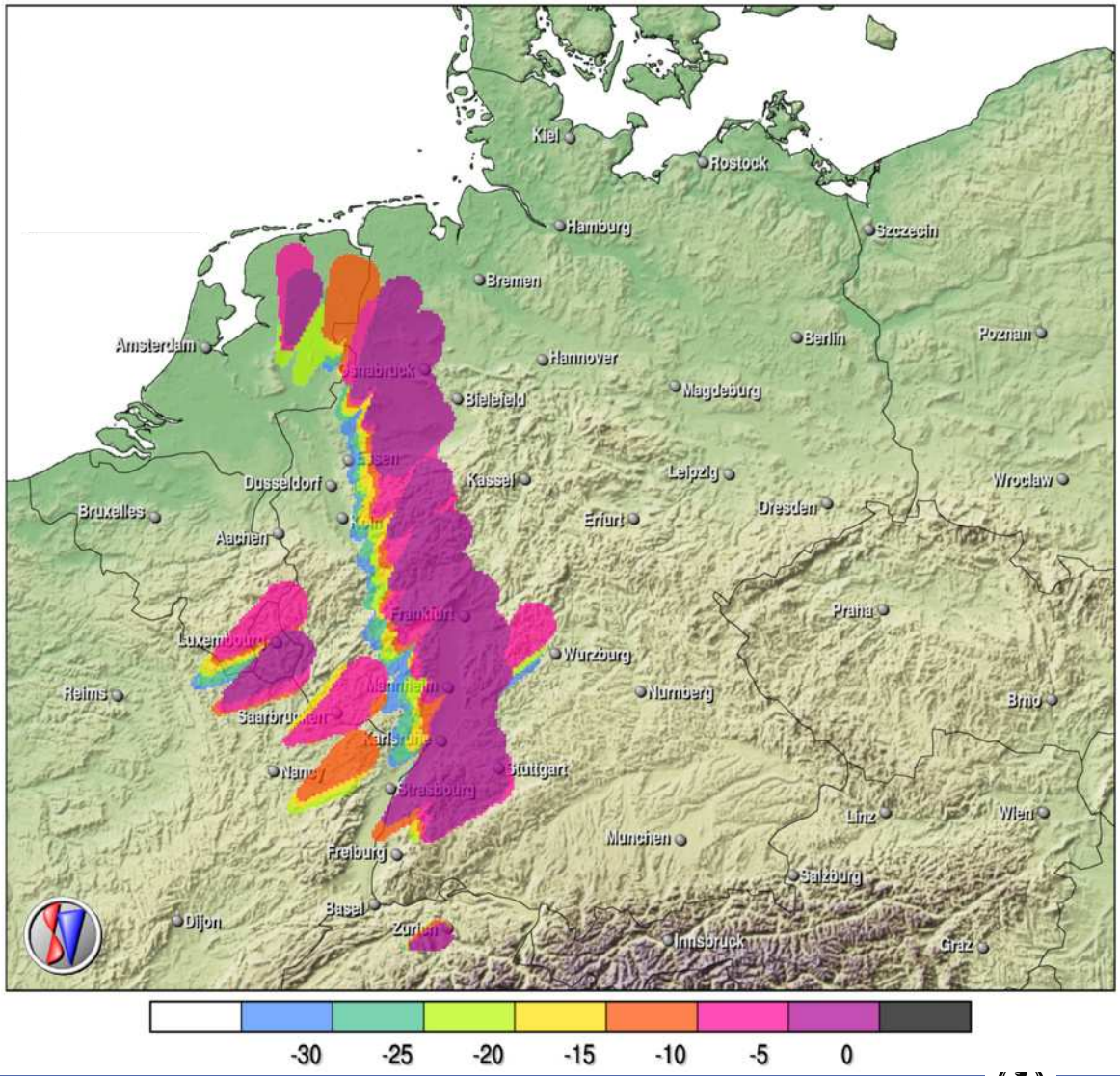
17:15 – 17:45 UTC, 14.07.2010
Storm-Warning Cones
CellMOS, KONRAD (Unfiltered)

- Require a de-noised background motion field for storm cells
- Use Rosenow-Vectors (pattern-recognition algorithm from consec. radar images)
- Combine with raw cell vectors from KONRAD / CellMOS (removing false vectors)



17:30 UTC, 14.07.2010
Cell vector field
CellMOS, KONRAD, Rosenow

- Following CVF-correction
- All cells now given local CVF properties for consistency
- Clean overview of the frontal movement
- Major improvement for the production of warning areas



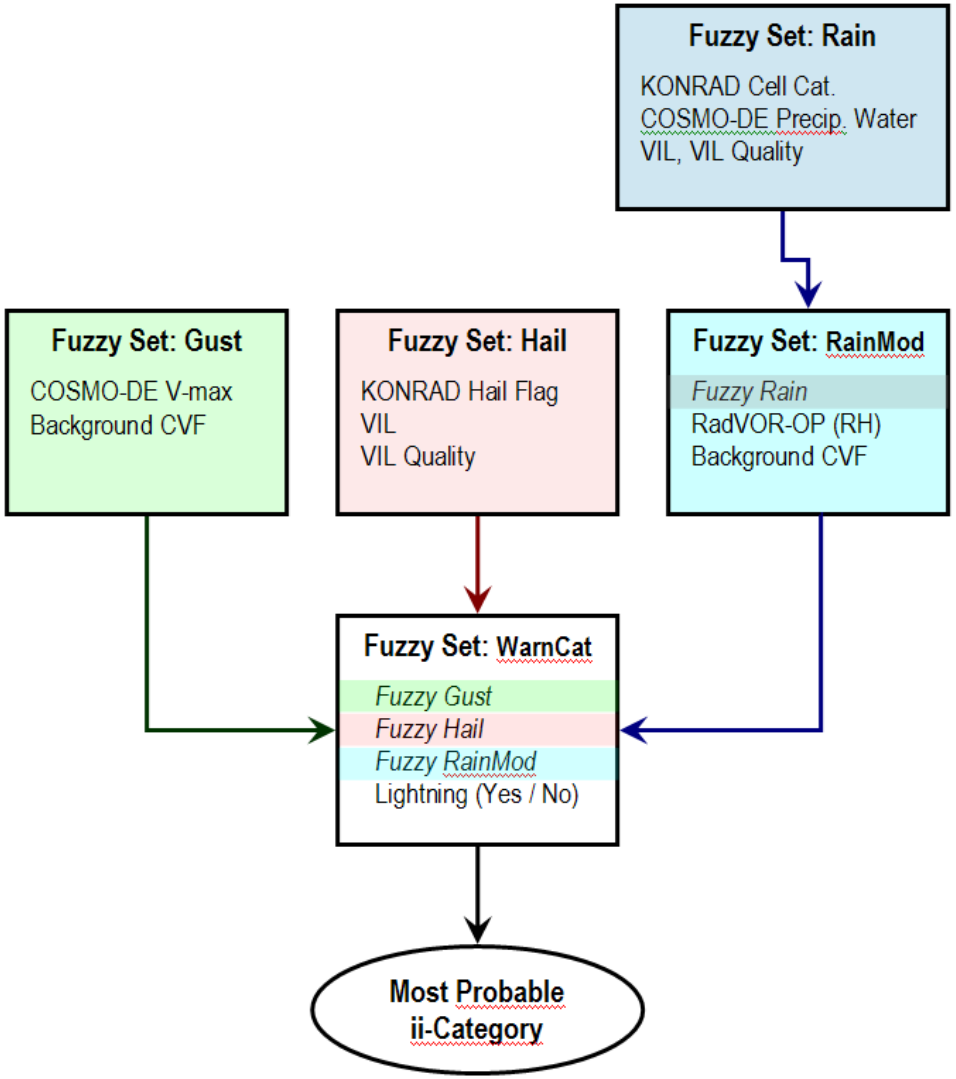
17:15 – 17:45 UTC, 14.07.2010
Storm warning cones
CellMOS, KONRAD (Corrected)

Constructing a warning field from warning cones

- Cones are created, pointing in the direction of cell motion
- 3 ways of creating a cone:
  - KONRAD-Cell (> 46 dBZ)
  - CellMOS-Cell (> 37 dBZ + Lightning Strike)
  - Lightning Strikes (at least 2 strikes in last 15 mins and within 10 km)
- Fuzzy Logic rules applied at the cell centre, using the mapped attribute fields, to estimate the storm intensity level
  - Attribute (Gusts, Hail, Heavy Rain) strength assessed as a function of the various input data types

Fuzzy Logic System

- Every cell processed, using local attribute values
- Result: A warning cone with a specific severity category

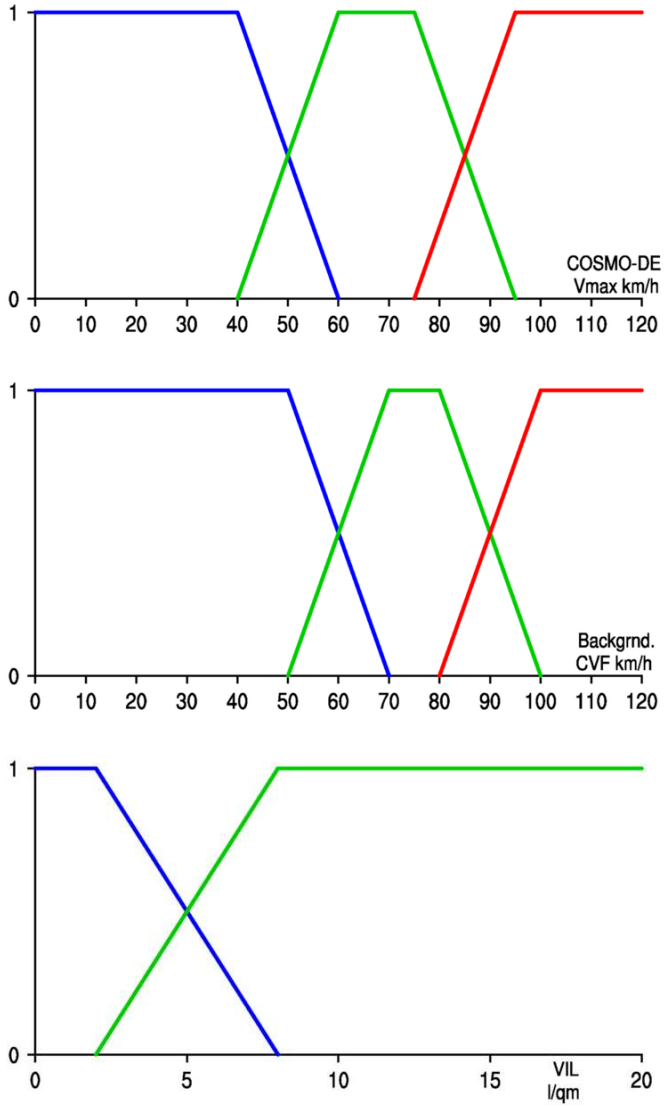


Fuzzy-Set Example (Gusts)

Strong gusts likely if

- ➔ High maximum windspeeds in the lower troposphere, e.g. 700-950 hPa (COSMO-DE)
- ➔ Rapid cell motion
- ➔ Sufficient downmixing (VIL not too small)

- ➔ Compute probabilities of all possible combinations of these functions
  - ➔ Derive an overall probability of severe gusts



Top-level Fuzzy-Set (Storm category)

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Gusts	Hail	Heavy Rain	ii
L	L	L	31
L	L	M	34
L	L	H	93
L	M	L	38
L	M	M	38
L	M	H	93
L	H	L	38
L	H	M	38
L	H	H	46
M	L	L	33
M	L	M	36
M	L	H	42
M	M	L	38
M	M	M	38
M	M	H	46
M	H	L	38
M	H	M	38
M	H	H	46
H	L	L	40
H	L	M	42
H	L	H	42
H	M	L	40
H	M	M	46
H	M	H	48
H	H	L	46
H	H	M	46
H	H	H	48

Probability or Strength

L = Low

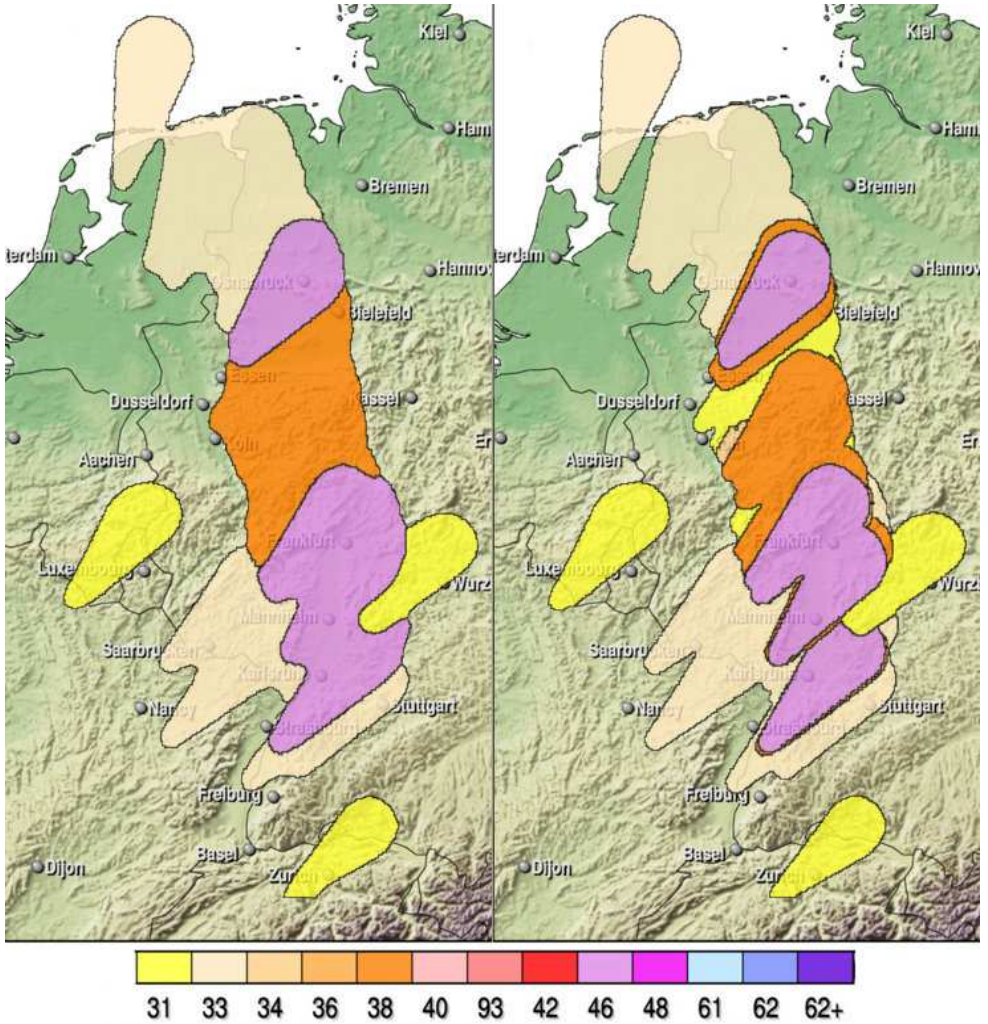
M = Medium

H = High

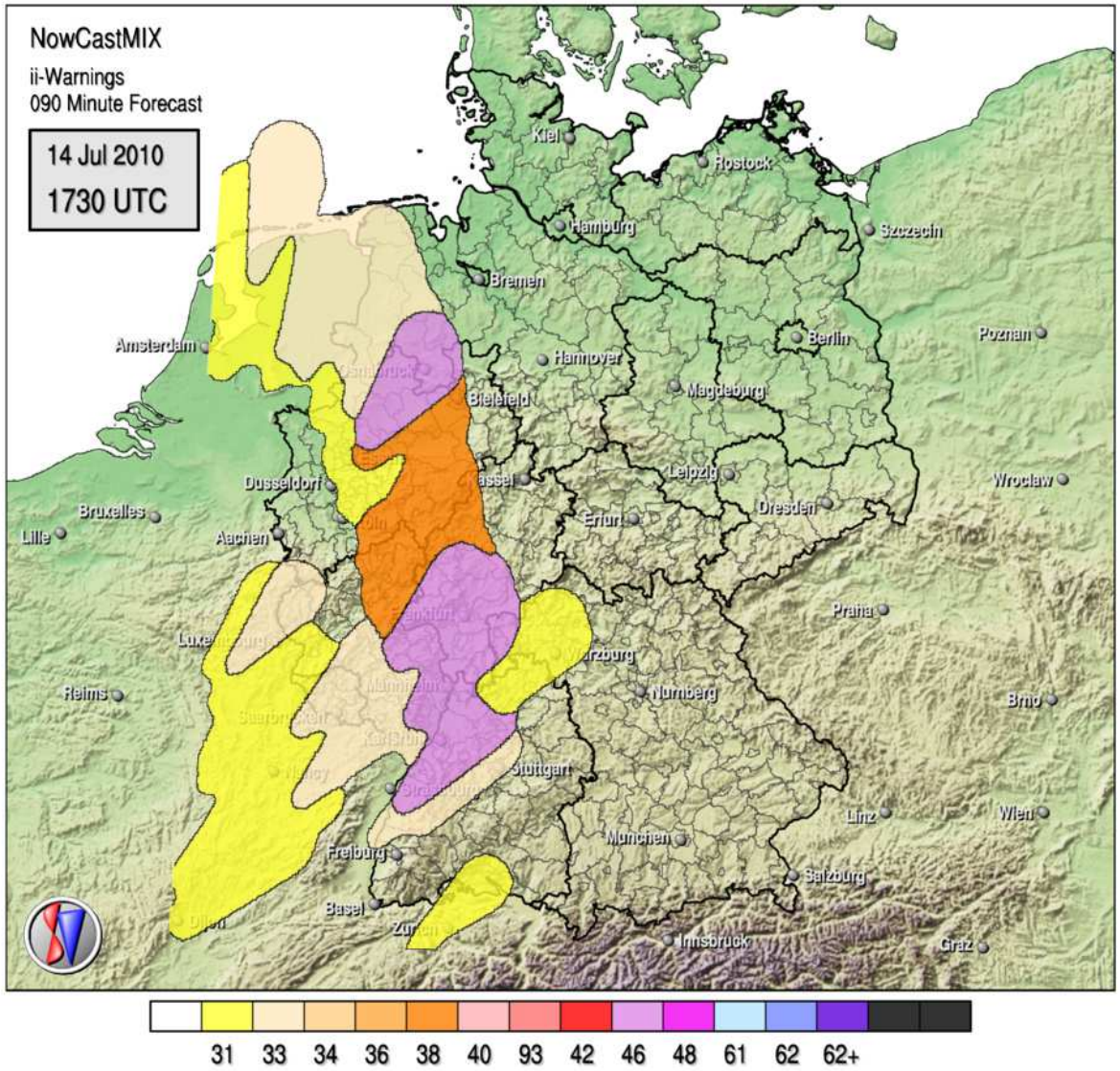
Here we take the most probable category only
(categories have no unique linear order)

Spatial Filtering

- Overlapping cones sometimes leave thin filaments
- Such shapes are ugly and have no practical physical meaning
- Remove these systematically by absorption into neighboring areas
- Apply Gaussian smoother



- Example of a NowCastMIX warning field for a 90-minute period on 14th July 2010



17:30 to 19:00 UTC, 14.07.2010

NowCastMIX Summary

- NowCastMIX is a pre-processing system for data on nowcasting timescales
  - Maps relevant data onto a 1 x 1 km grid
  - Computes an optimal storm cell motion vector field
  - Uses fuzzy logic rules to estimate storm attributes and severity levels
  - Allows meteorological intelligence to be included in the automatic process
  - Outputs fed into AutoWARN process
  - Separate NowCastMIX monitors
    - DWD-Intranet
    - NinJo Workstation environment