Deutscher Wetterdienst

Nowcast Warnings within AutoWARN –

An Automated Decision Support System for Weather Warnings at DWD

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AutoWARN Goals

AutoWARN is part of the DWD strategy 2006-2015
Headwords: *Centralization* and further *Automation* of the Weather Forecast and Warning Process.

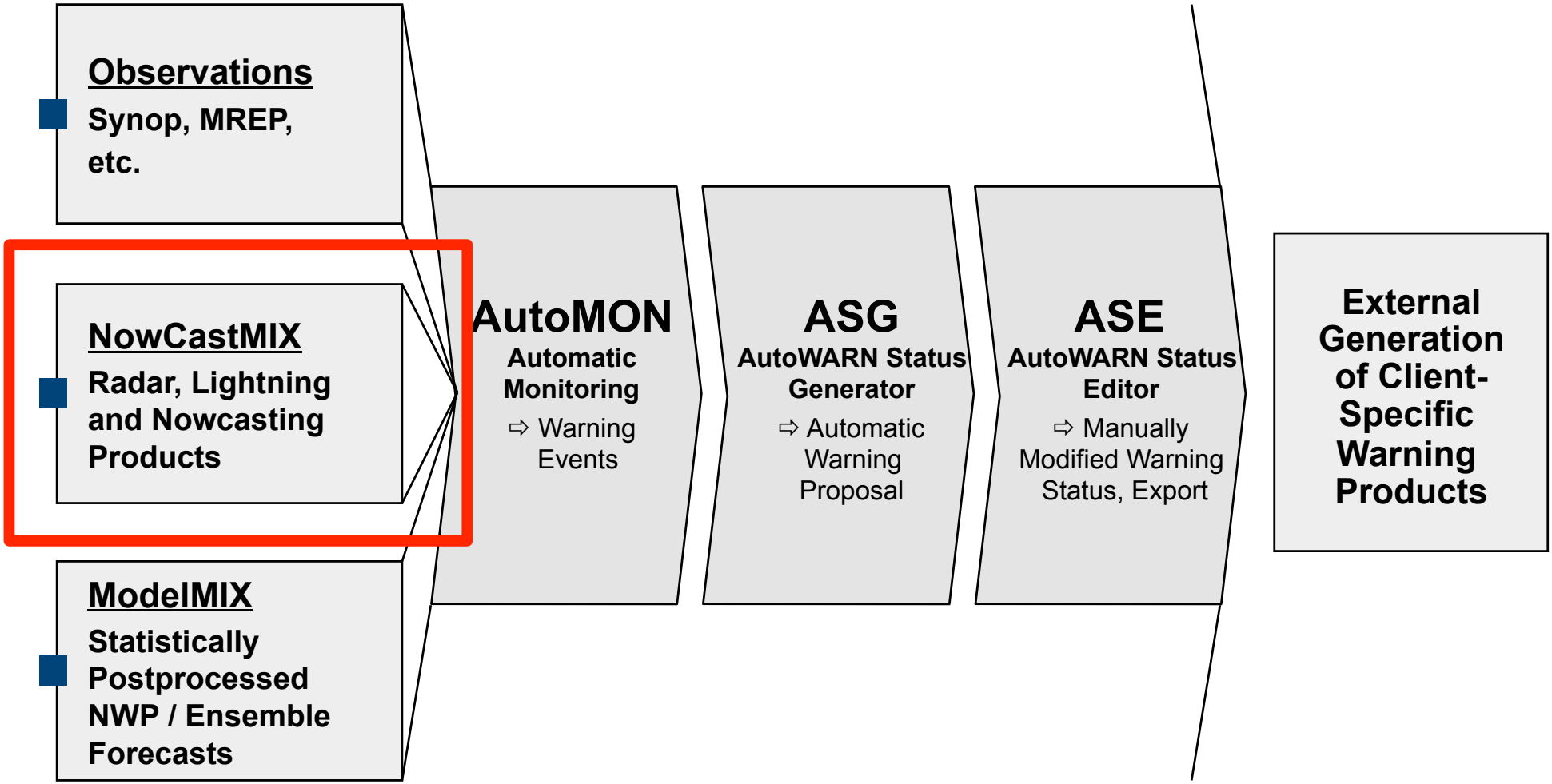
Project goals:

1. **Improvement of methods and products serving as a basis for the prediction of hazardous weather events**

2. **Integration of products in an automated decision support system with manual monitoring and decision capabilities for the forecaster**

Nowcast Warnings within AutoWARN

AutoWARN: Automatic Support of the Warning Service – Overview



NowCastMIX: A fuzzy logic based tool for providing automatic integrated warning proposals from continuously monitored nowcasting systems

NowCastMIX Input Data

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
- **COSMO-DE** Local Forecast Model. Provides estimates of background conditions for storms (max. wind speeds 700-950 hPa, precipitable water), runs every 3 hours
- **VIL** Vertically Integrated Water (3D Volume Radar scan), every 15 minutes

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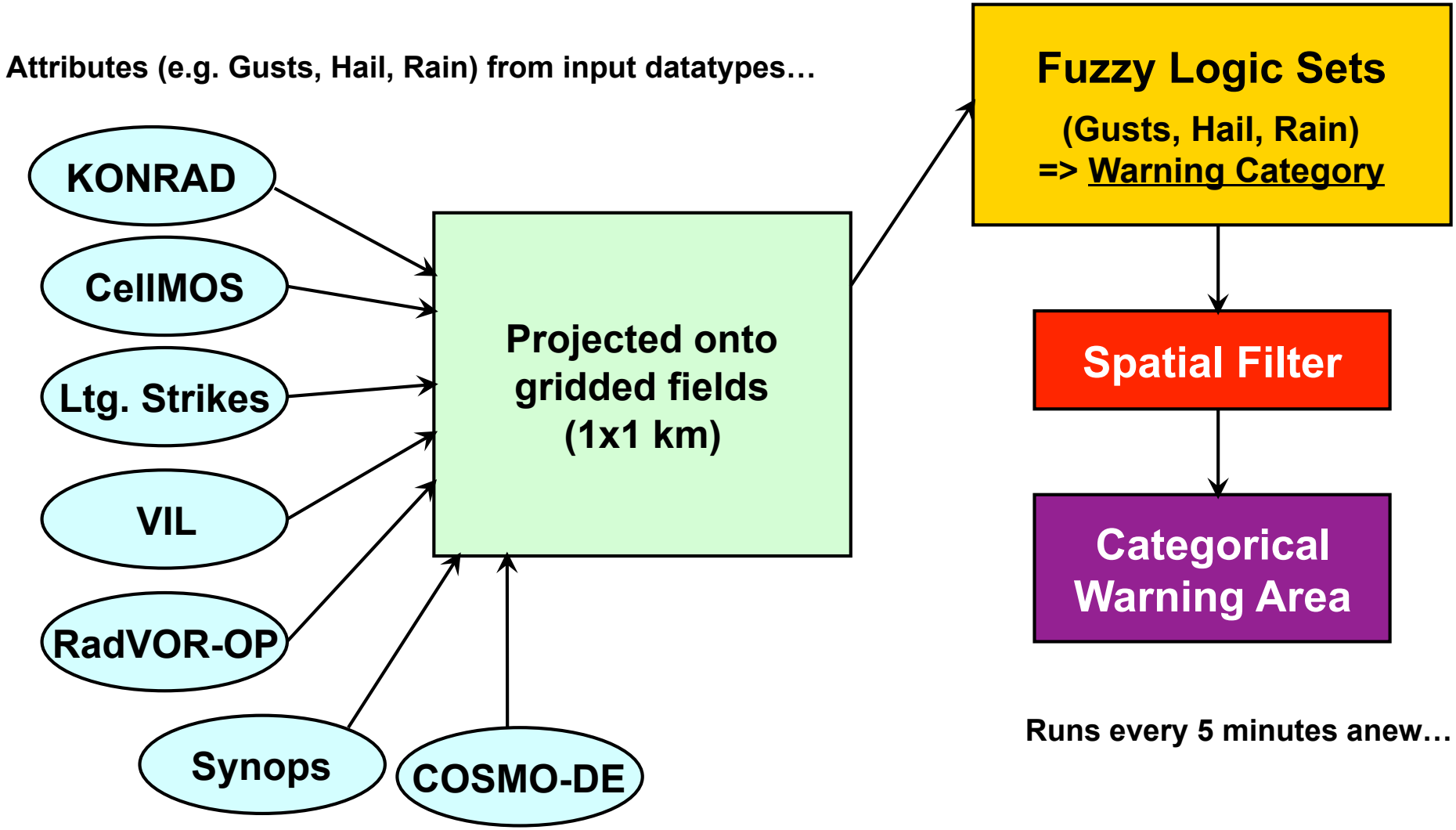
NowCastMIX: Scheme



Nowcast Warnings within AutoWARN

NowCastMIX Warning Events: Thunderstorms / Heavy Rain

- **NowCastMIX predicts up to 10 required thunderstorm classes and 3 heavy rain classes for the AutoWARN-Process**
- **The severity of the event is a function of the presence and intensity of various attributes:**
  - **Gusts, Heavy Rain, Hail**

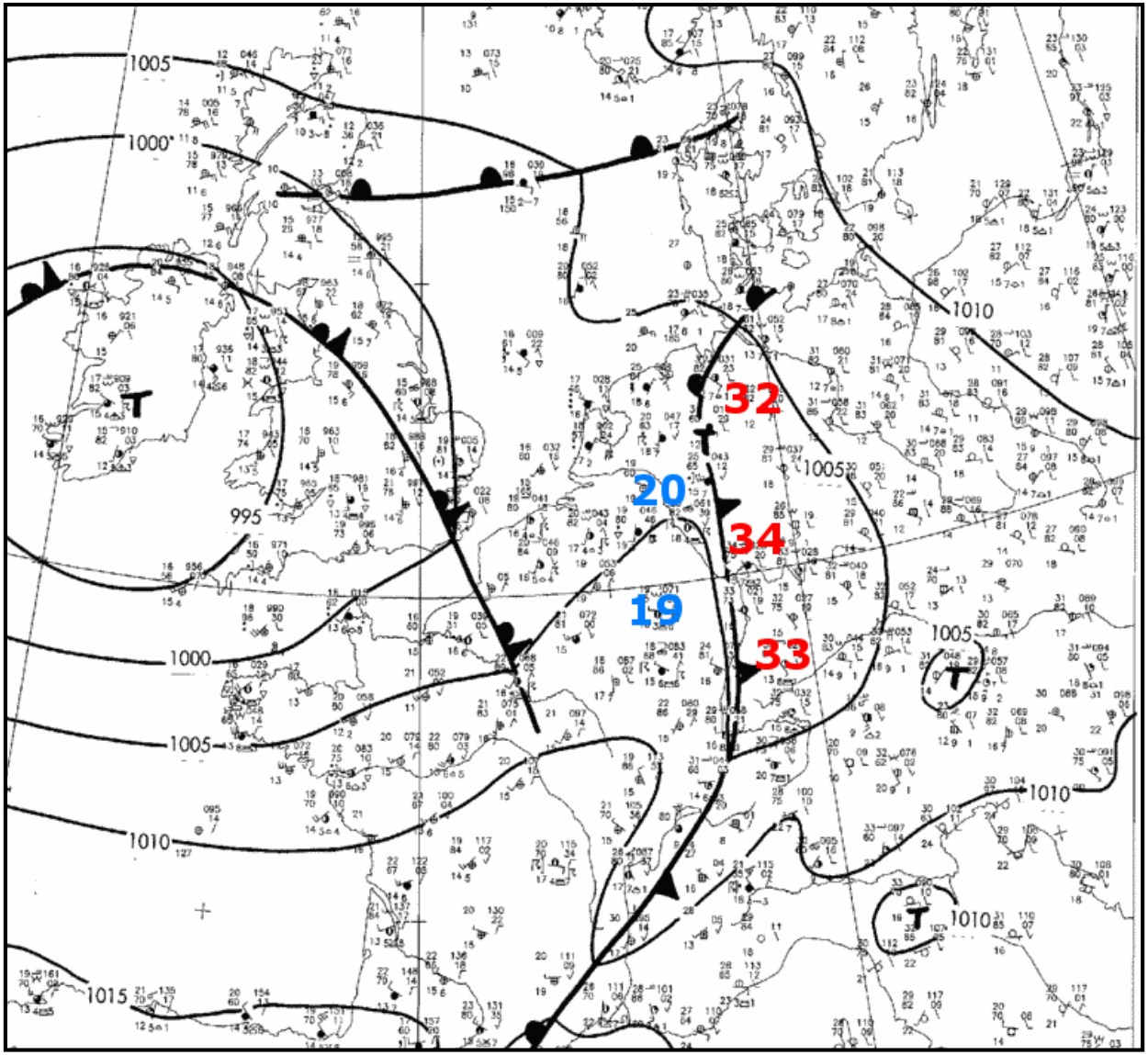
ii-code	Warning event
31	Thunderstorm with gusts to Bft. 7
33	Thunderstorm with storm-force gusts (to Bft. 10)
34	Thunderstorm with heavy rain (>10mm/h)
36	Thunderstorm with storm gusts and heavy rain
38	Thunderstorm with storm gusts, hvy. rain and hail
40	Severe Thunderstorm with hurricane-force gusts
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 warning events

Nowcast Warnings within AutoWARN

NowCastMIX Case Study: 14 July 2010 18 UTC

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

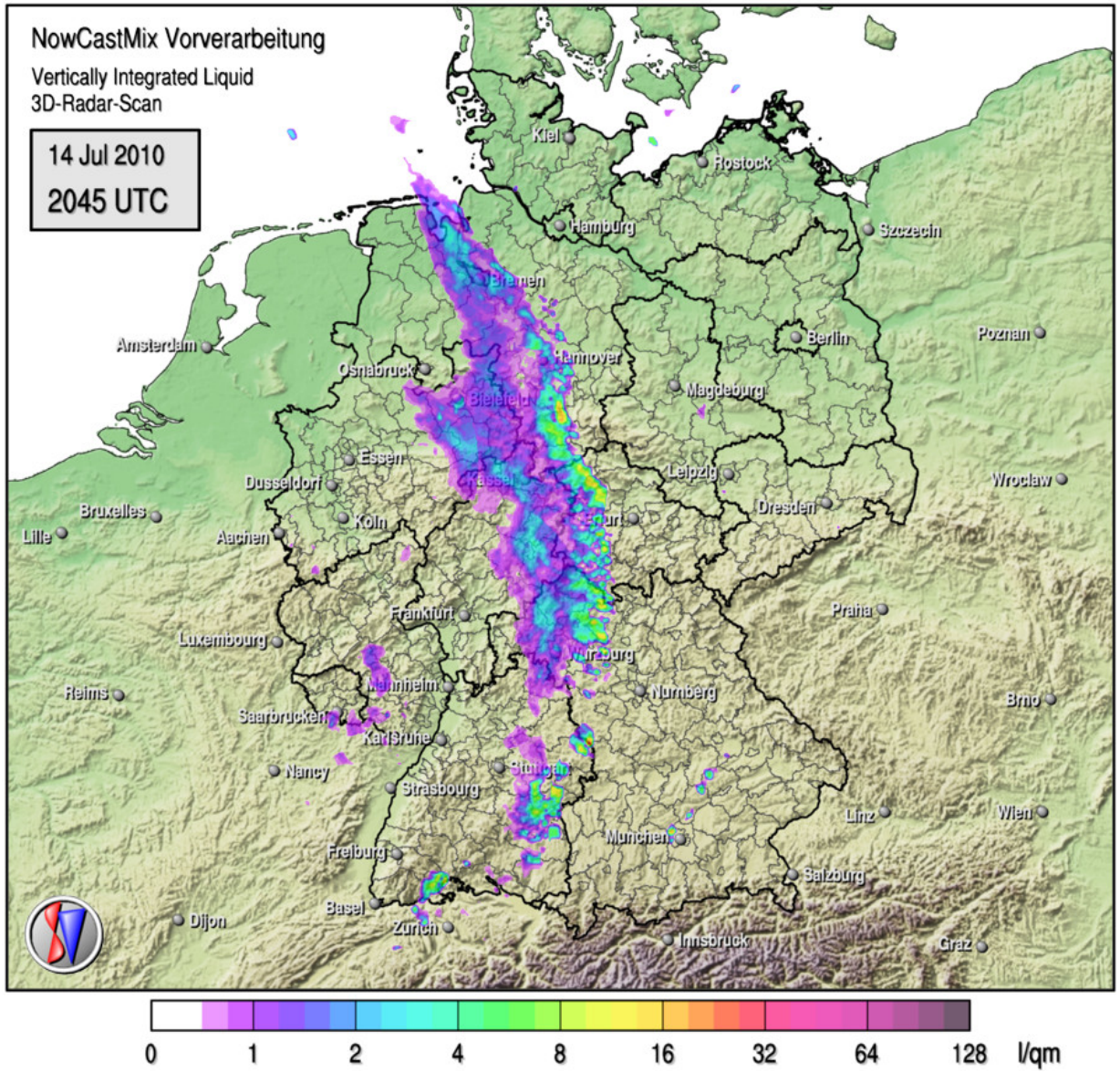


Surface Analysis
14 July 2010 18 UTC

Nowcast Warnings within AutoWARN

NowCastMIX Case Study: 14 July 2010

- **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**

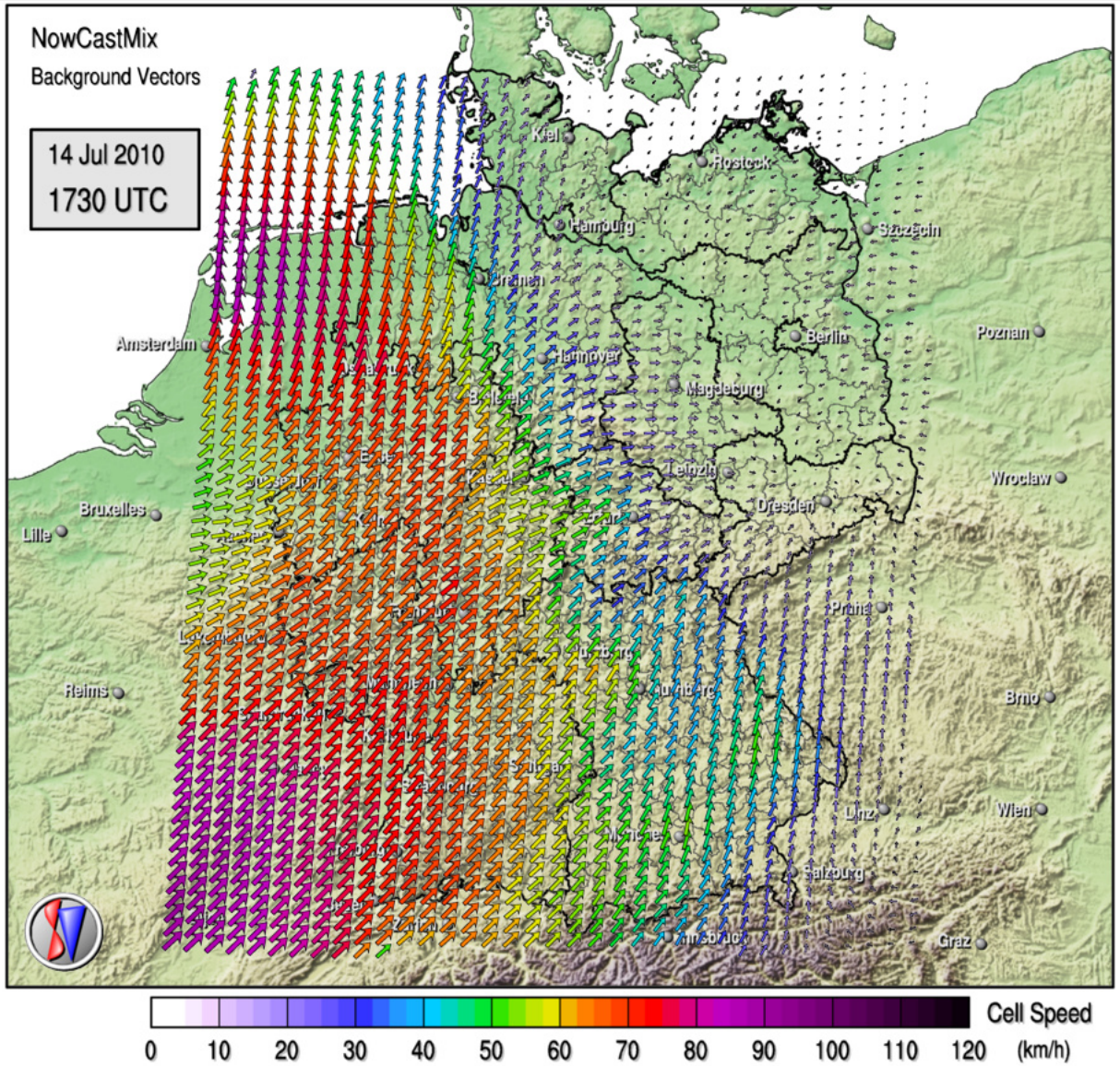


17-21 UTC, 14.07.2010
VIL (litres per m²)

Nowcast Warnings within AutoWARN

NowCastMIX Case Study: 14 July 2010

- De-noised background motion field for storm cells
- Use pattern-recognition algorithm from consec. radar images (Rosenow-Vectors)
- Combine with raw cell vectors from KONRAD / CellMOS detection and tracking systems (removing false vectors)



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

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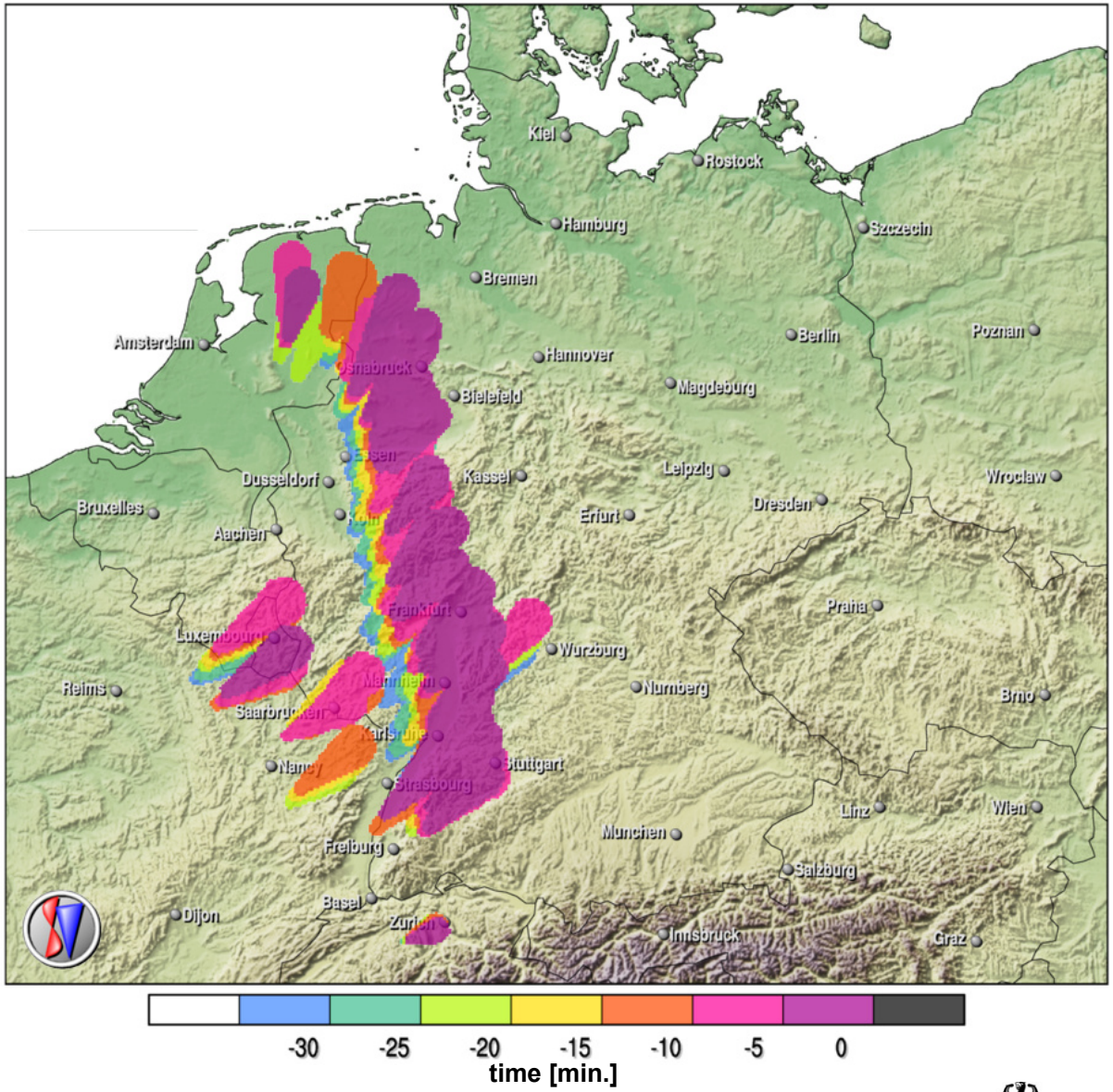
NowCastMIX Case Study: 14 July 2010

- Represent each storm cell detected by CellMOS and KONRAD with a cone shape, pointing in direction of motion
- Cell speed and direction have been corrected using optimal storm cell motion vector field from de-noised background motion fields
- Clean overview of the frontal movement
- Major improvement for the production of warning areas



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

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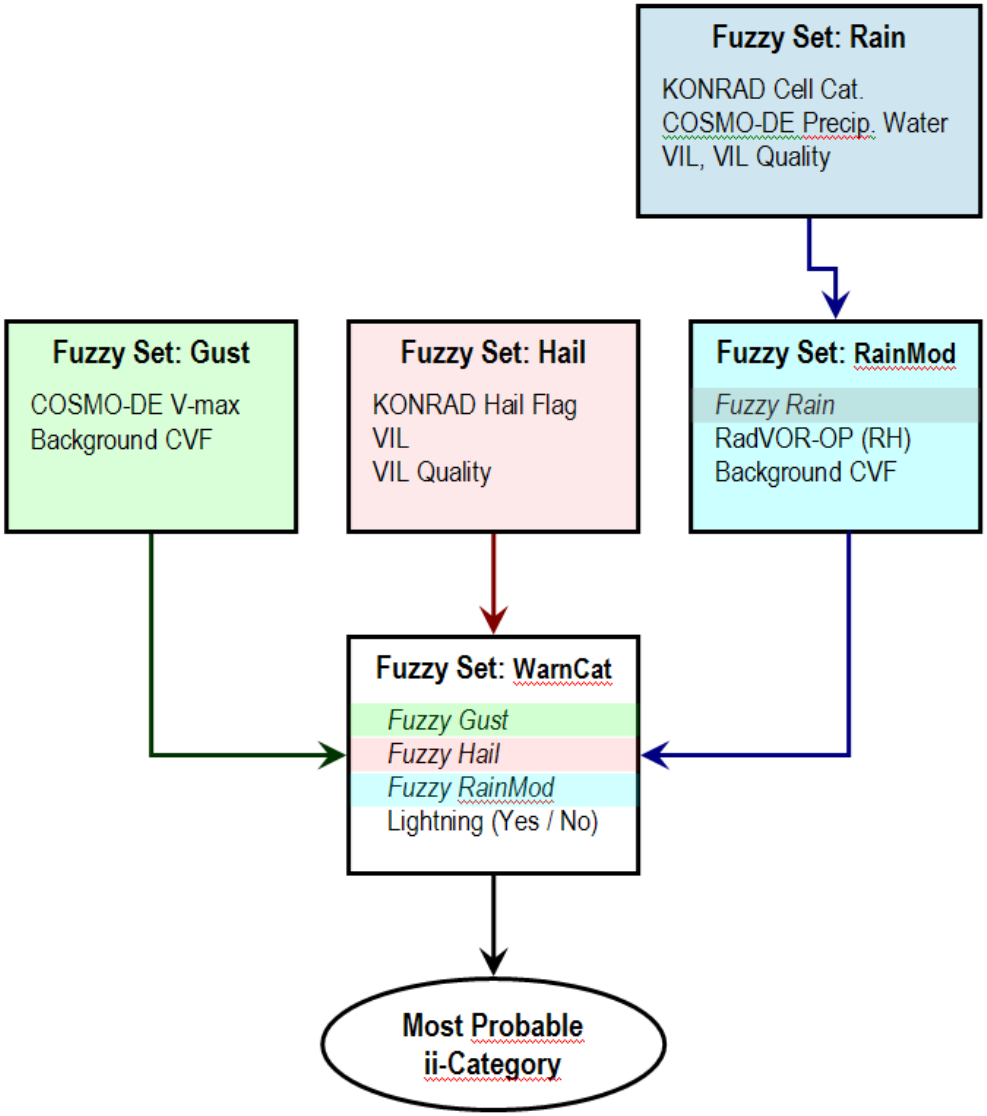
NowCastMIX: Fuzzy Logic System

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



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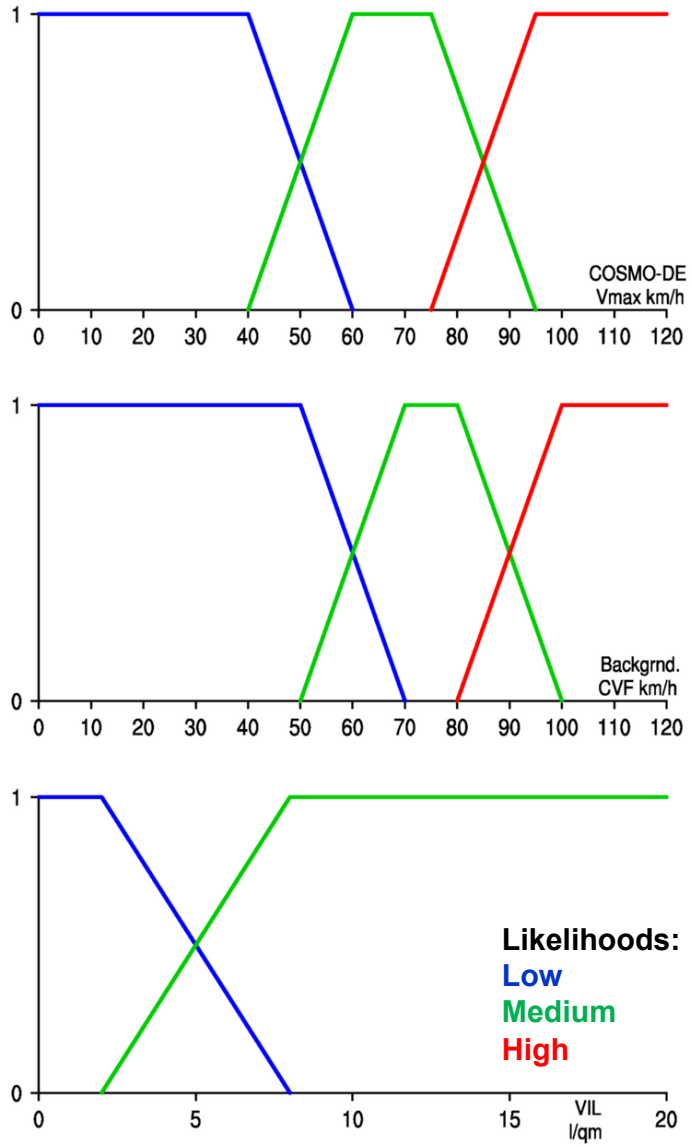
NowCastMIX: Fuzzy-Set Example (Gusts)

Strong gusts likely if

- **High maximum wind speeds 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**

Done for all 13 types of thunderstorm and rainfall warning events (big table)



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NowCastMIX: Top-level Fuzzy-Set (Storm category)

Gusts	Hail	Heavy Rain	ii-code
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

Probability or Strength

L = Low

M = Medium

H = High

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

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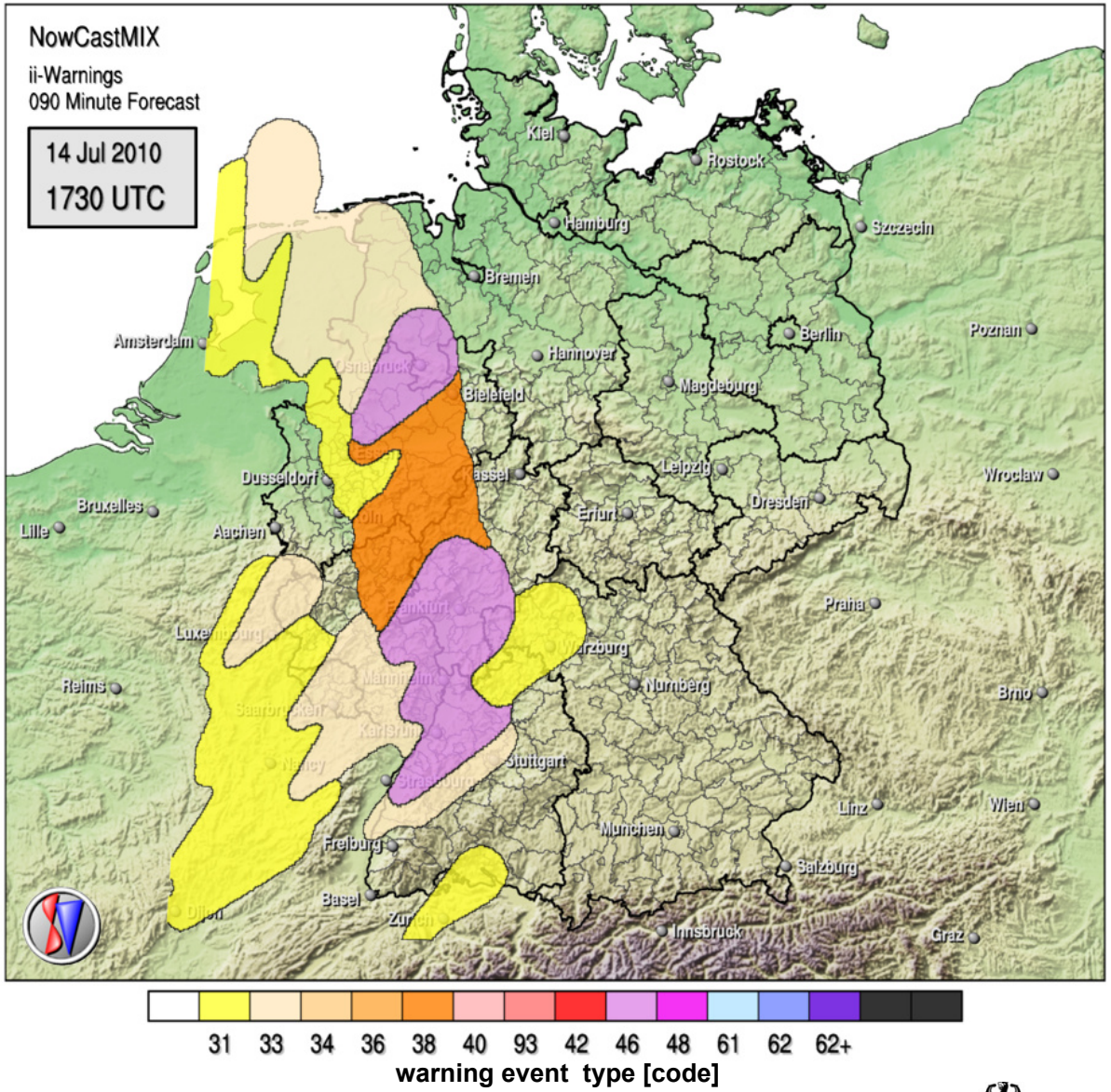
NowCastMIX: Spatial Filtering

- Remove thin filaments 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

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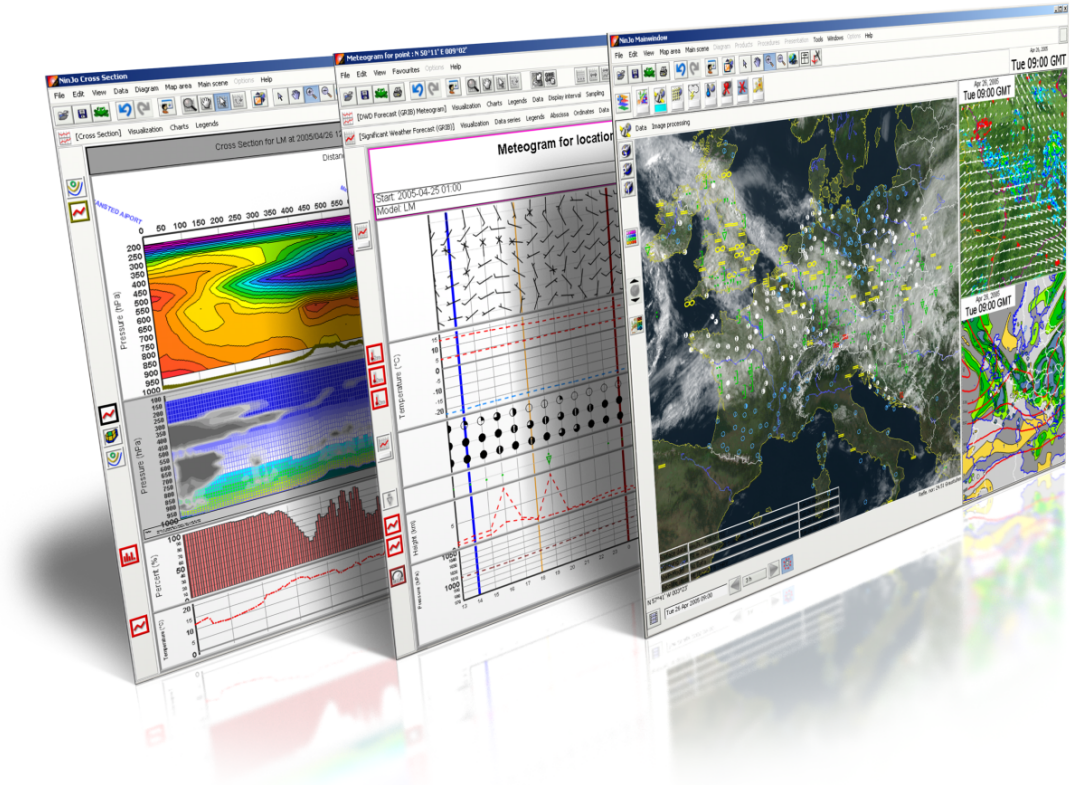
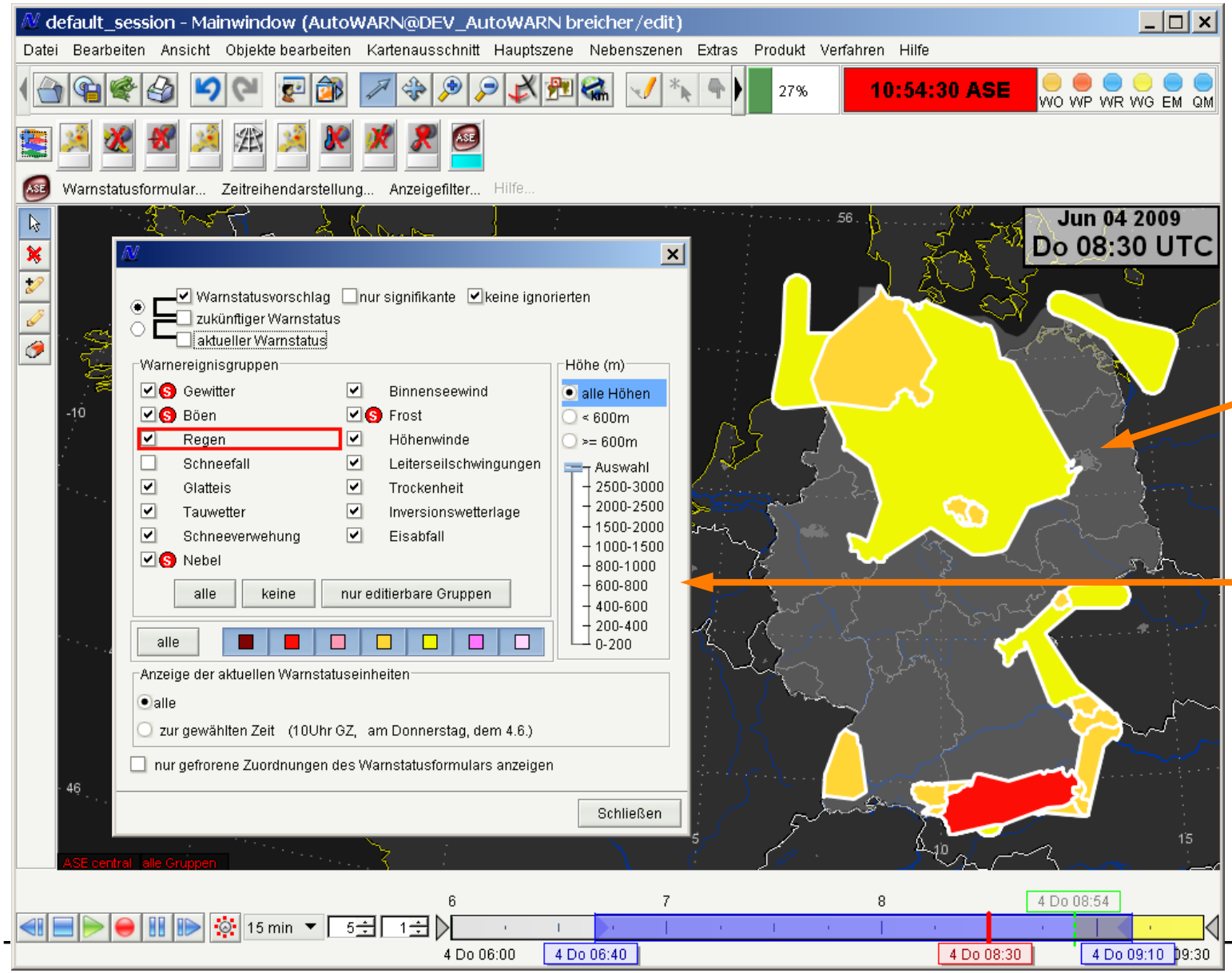
AutoWARN within the Meteorological Workstation System NinJo



- Meteorological Workstation NinJo provides a unified environment to support the entire meteorological process
- Joint project between Weather Services from Germany, Switzerland, Denmark, Canada, and German Military Service

Nowcast Warnings within AutoWARN

AutoWARN Status Editor (ASE) in NinJo: Manual Modification



Automatic Warning Status Proposal

Filtering

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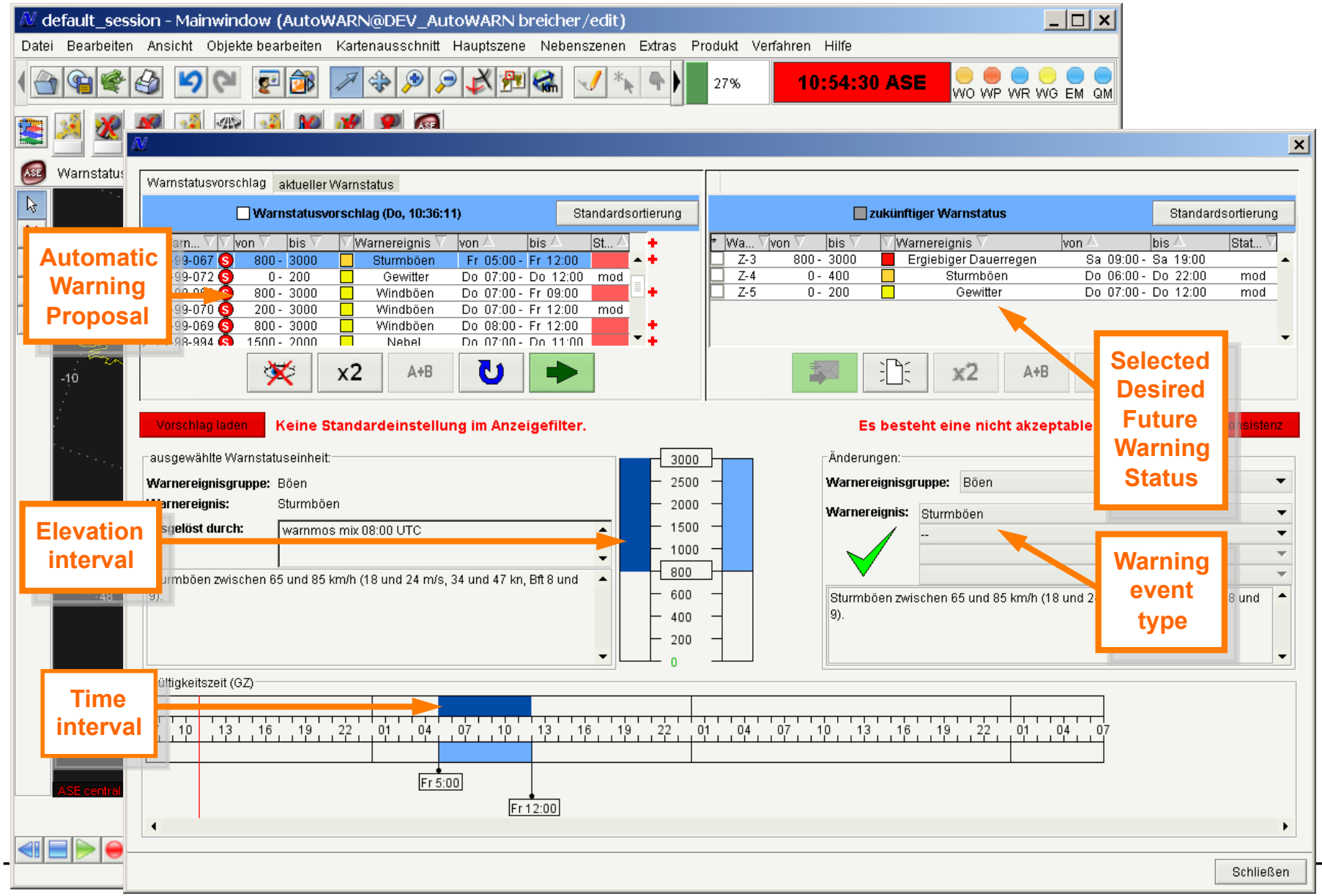
AutoWARN Status Editor (ASE) in NinJo: Warning Status Form

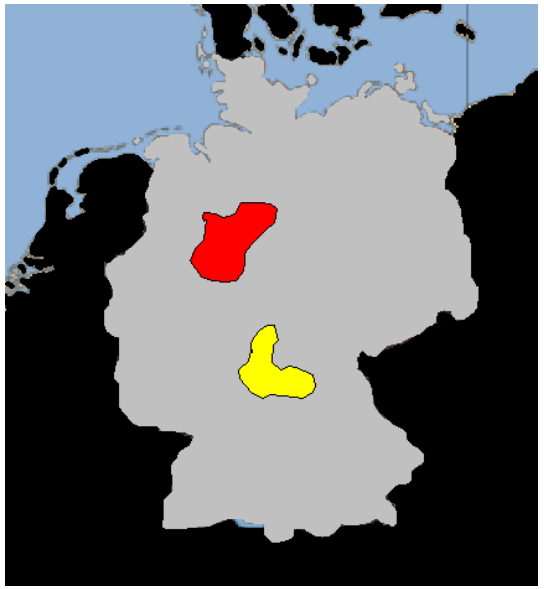


Nowcast Warnings within AutoWARN

Products of AutoWARN

- **AutoWARN automatically generates warning proposals**
  - from observations, NowCastMIX and ModelMIX pre-processing systems
  - for 27 DWD warning events plus approx. 20 combined warning criteria (some warning events like fog or locally clear ice regularly need manual intervention by the forecaster, this is part of the AutoWARN concept)
  - on a free polygon basis (free “warning status units” in space and time, not restricted to districts, etc.)
  - time range from nowcasting up to 72 hours

AutoWARN warning status
(all warning criteria, 0...72 hours)



- **Client-specific warning products are finally generated within external module (PVW)**

Summary

NowCastMIX is a fuzzy logic based pre-processing system for data on nowcasting timescales

- Uses fuzzy logic rules to estimate storm attributes and severity levels
- Computes optimal storm cell motion vector fields
- Provides meteorologically preprocessed output on 1x1 km grid

NowCastMIX is integrated into the automated decision support system AutoWARN with manual monitoring and decision capabilities for the forecaster

- Currently, system is pre-operational. Operational release in 2012 (Meteorological Workstation NinJo 1.4, including external module PVW for final client warning products)