

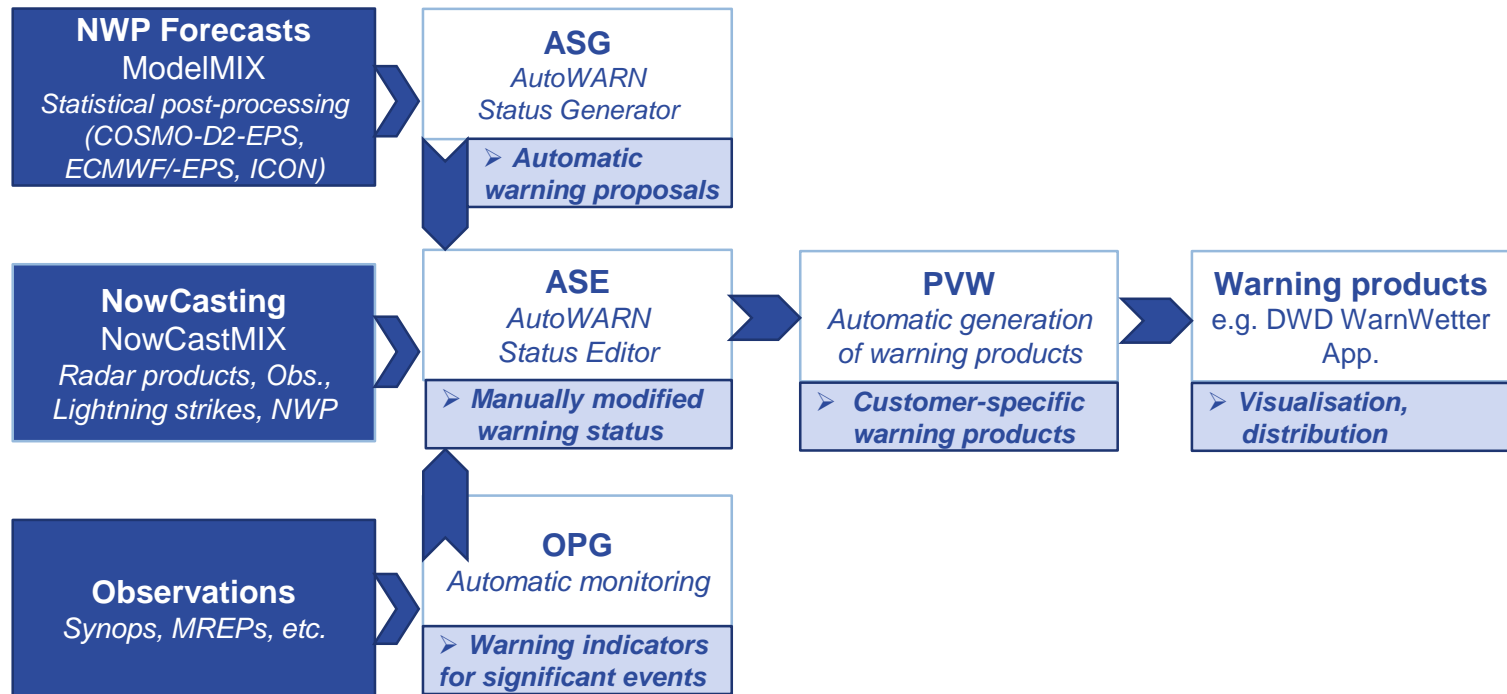
## NowCastMIX

Automatic integrated warnings for severe weather  
on nowcasting timescales at Deutscher Wetterdienst

Paul James, Bernhard Reichert and Dirk Heizenreder (DWD, Offenbach, Germany)

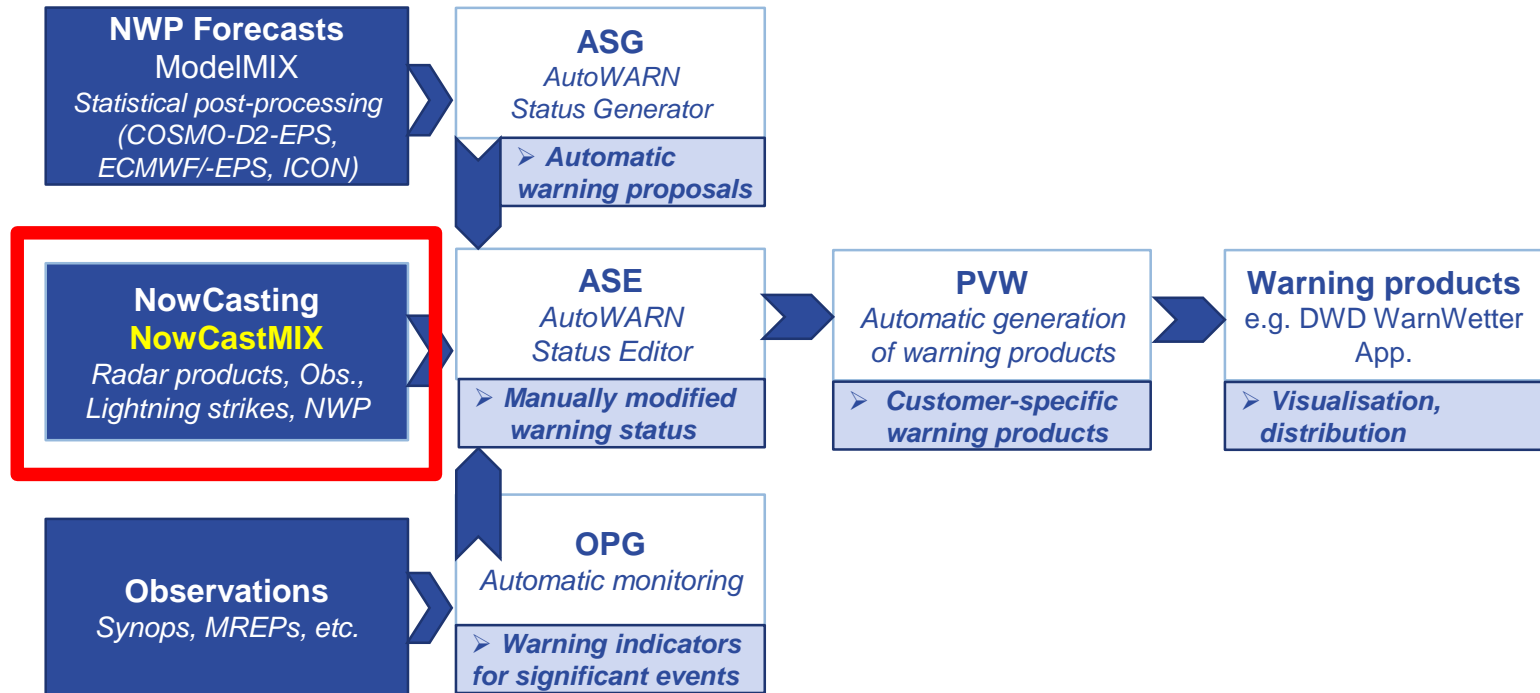
EMS Conference, Copenhagen, Session OSA1.3, 10.9.2019

NowCastMIX is a core component of the AutoWARN process at DWD...

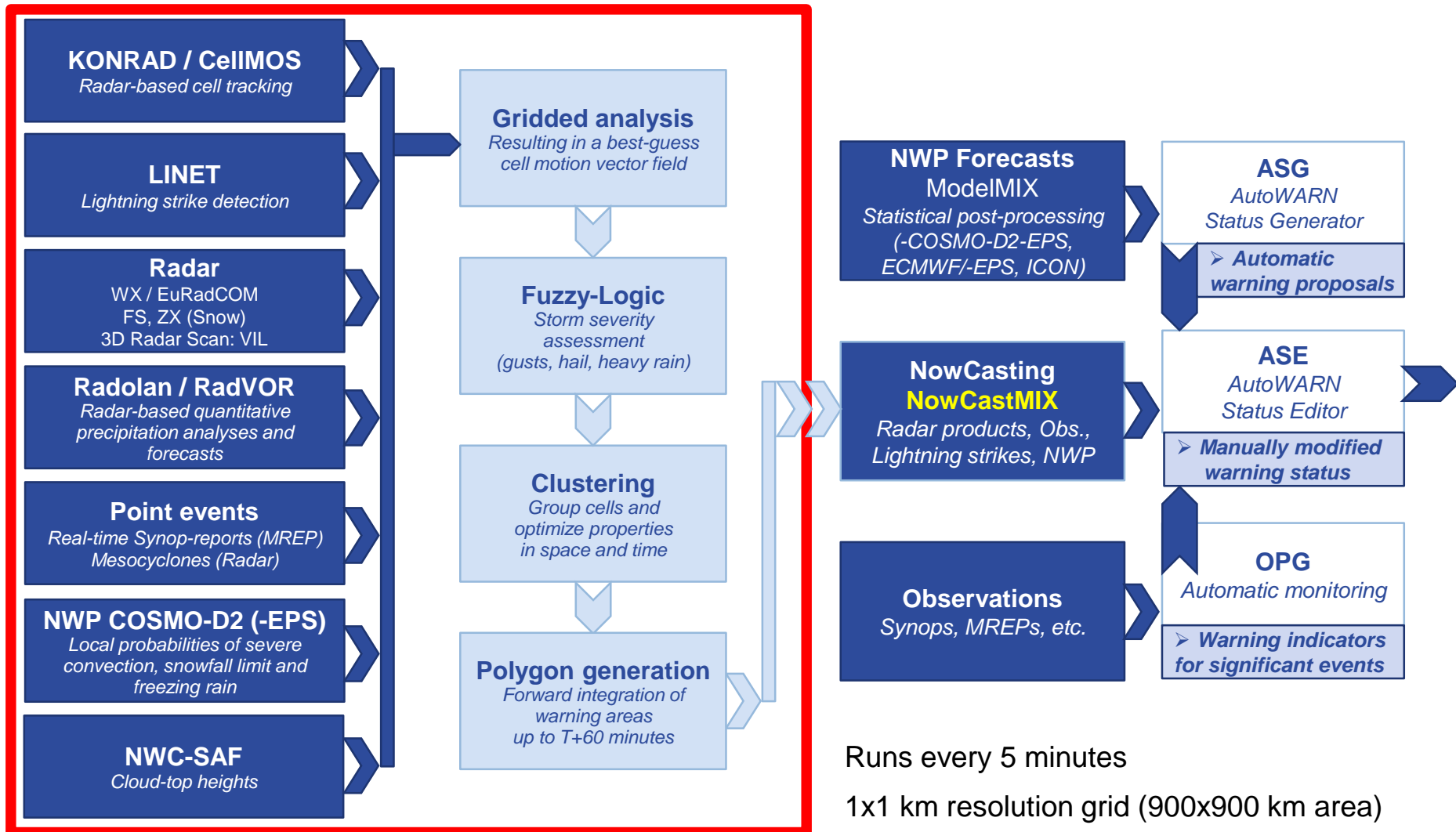


The AutoWARN process monitors several systems automatically for potential warning situations on different time scales.

Warning polygons are sent to duty meteorologists for possible modification before products are generated.



**NowCastMIX** integrates all data from the various nowcasting systems to produce a consistent, optimized set of warnings on nowcasting timescales



Runs every 5 minutes

1x1 km resolution grid (900x900 km area)

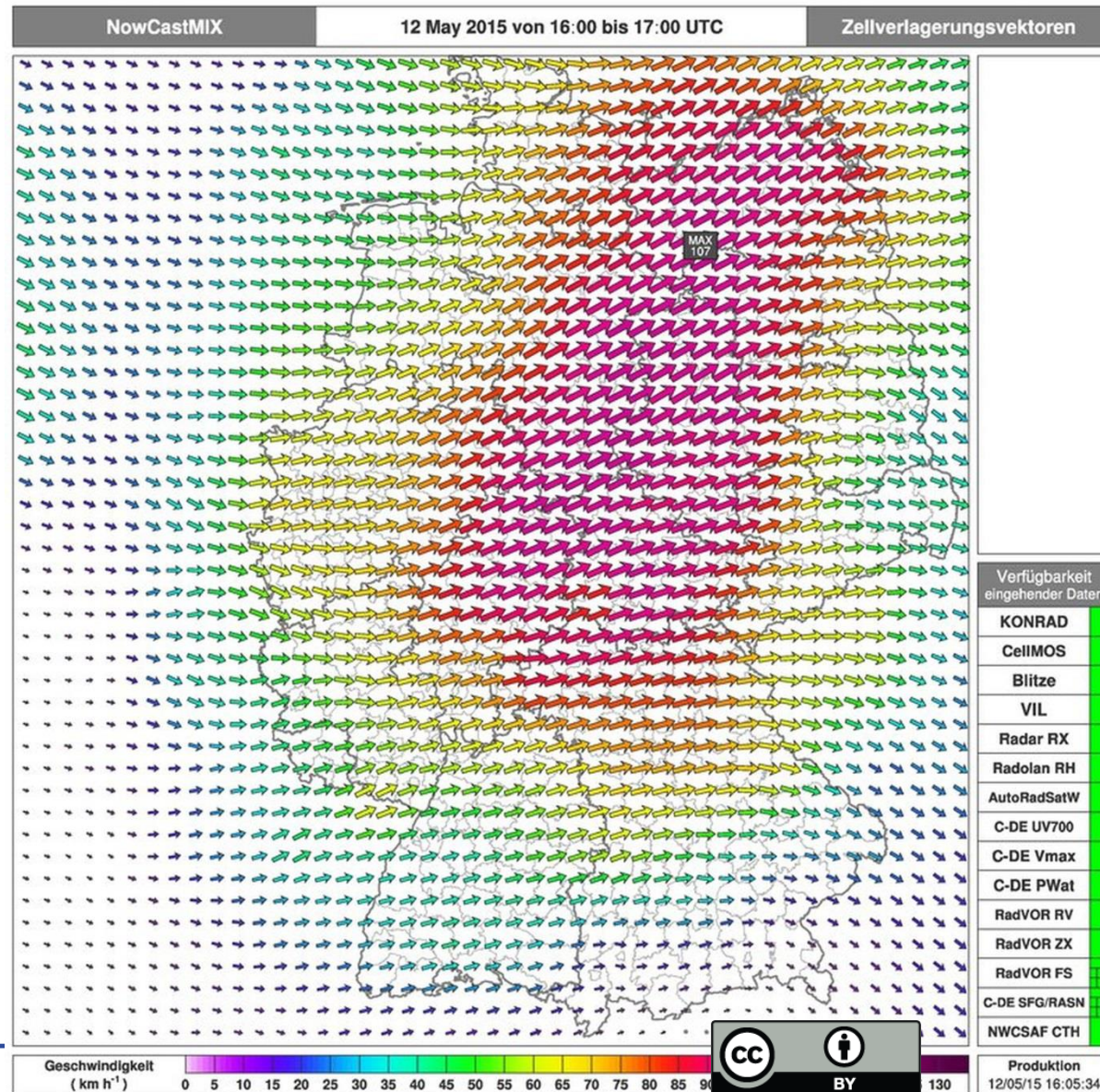
Output in CAP format (XML) for AutoWARN



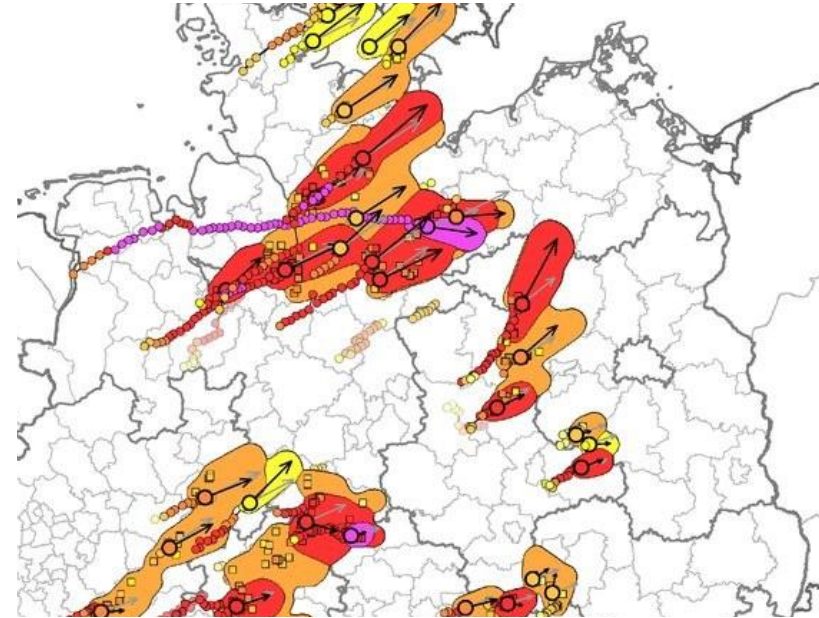
→ Initial cell motion vector field (CVF) is constructed using the following sources:

- Pattern-Matching of radar echoes in consecutive images -> motion vectors
- Explicit tracking vectors\* (**KONRAD**)
- MOS-based statistical tracking vectors\* (**CellIMOS**)

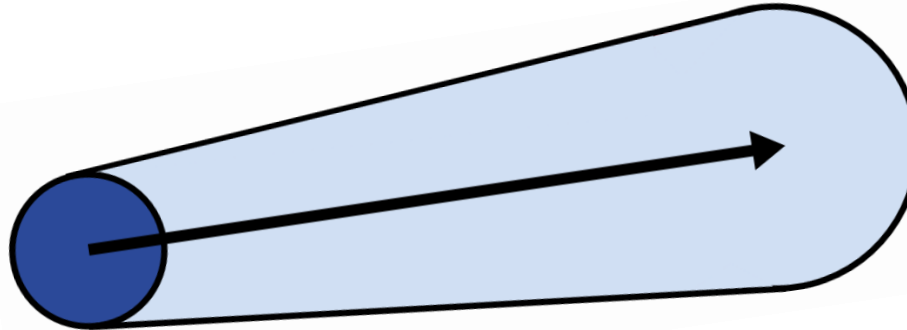
(\*mapped with a Gaussian distribution)



- NowCastMIX's initial cell motion vectors are optimized but spatially smooth
- Explicit cell tracking, introduced in 2017, strongly improves forecast tracks for anomalously moving cells, e. g. “right-moving” supercells
- Tracking combines KONRAD, CellMOS and lightning strikes into trackable objects, based on DBSCAN ensemble clustering
- Tracking vectors calculated from the last six timesteps
  - New tracks start with the standard cell motion vector field for greater stability



**Supercell near Hamburg, 28 August 2016**  
**This severe right-mover was successfully tracked for over 10 hours!**



- Warning cones are created, opening up in the direction of cell motion
- Initial radius = 7.5 km, Expansion angle =  $5^\circ$ , total length = 60 min
- 3 triggers for creating a cone:
  - [ KONRAD Cell ] OR [ CellMOS Cell ] OR [ Lightning Strike AND VIL>1mm ]
- Fuzzy Logic applied at the cell centre to estimate storm severity
  - Attribute strength (Gusts, Hail, Rain) as a function of input data



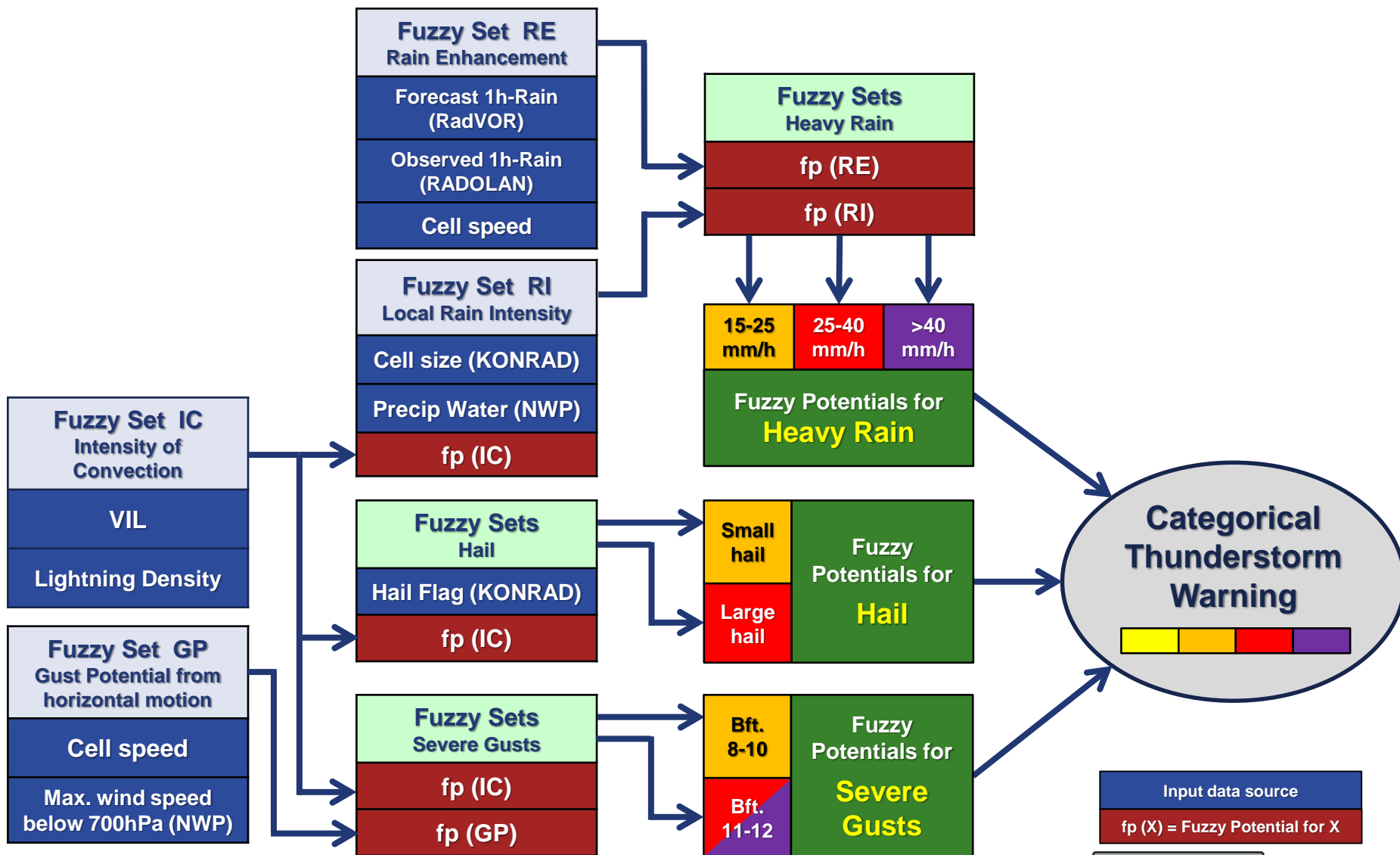
### Warning events: Thunderstorms / Rain

- Different warning events are given an „ii“-Code (e.g. „31“)
- 10 thunderstorm and 3 torrential rain event types need to be monitored in AutoWARN
  - The thunderstorm severity depends on the presence of these attributes:
  - Severe Gusts, Torrential Rain, Hail
  - Determined via fuzzy logic hierarchy

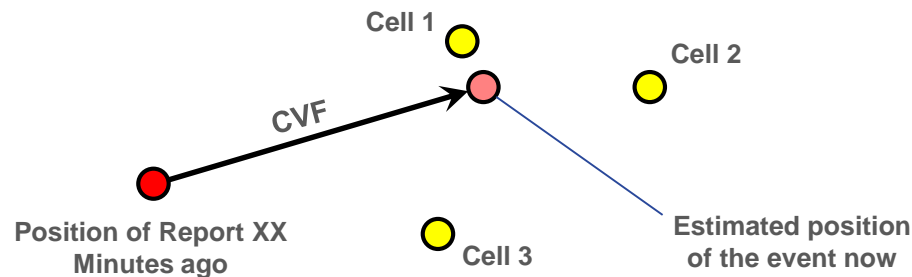
ii	Gusts Bft.	Rain mm/h	Hail
31	≤ 7	<15	
33	≤ 10	<15	
34	≤ 7	15-25	
36	≤ 10	15-25	
38	≤ 10	15-25	✓
40	≤ 12+	<15	
42	≤ 9	25-40	
46	≤ 10	25-40	✓
95	≤ 9	>40	✓
48	≤ 12+	25-40	✓
61	-	15-25	-
62	-	25-40	-
66	-	>40	-

The 10 Thunderstorm and 3 Torrential rain events





- In some cases automatic systems may underestimate storm severity
- To reduce this risk NowCastMIX monitors real-time synoptic station reports:
  - Recent gust speeds, hail occurrence and rainfall totals
- Doppler-radar mesocyclone detections (severe rotational gusts) also monitored



- Current location of event estimated using cell motion field
- Estimate probabilities for nearby cells causing the event, based on their positions and fuzzy-logic attributes
  - Here, cell 1 is chosen as the most likely candidate
- Raise the severity level for this cell, if necessary

→ Optimal warnings need to find a **balance** between:

### Precision / Accuracy

**+** Realistic, strictly correct

**-** Complex, over detailed and rapidly changing warnings. Hard for duty meteorologists to assess and process. Hard for customers to understand and assimilate

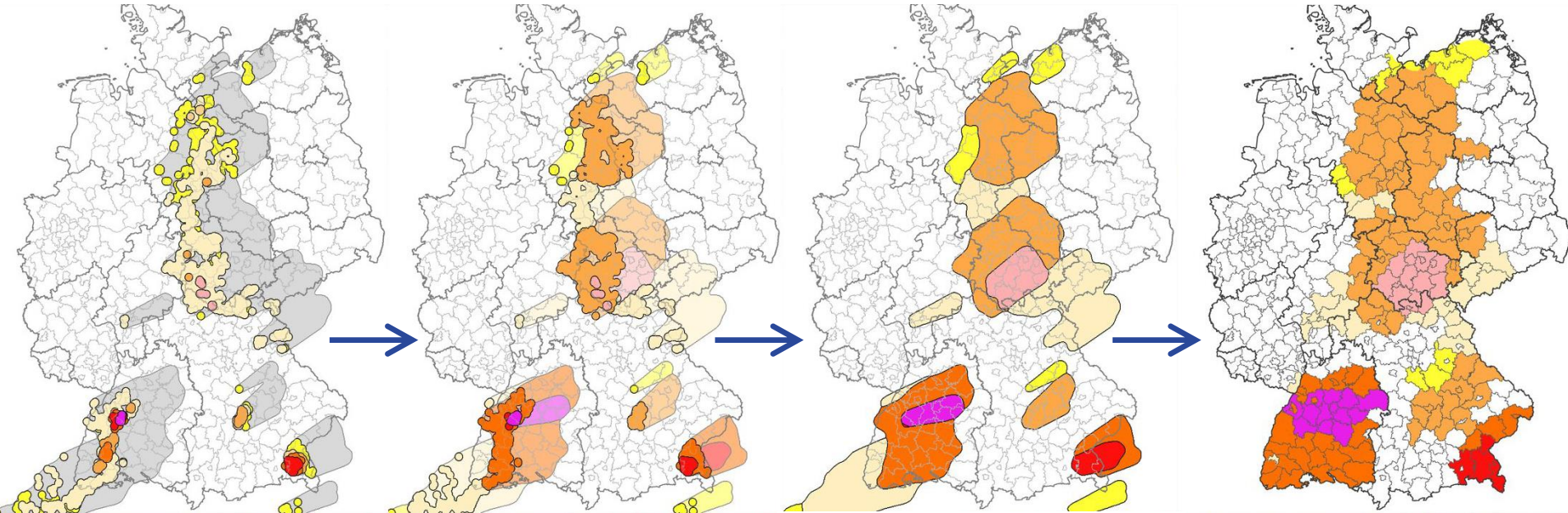
### Workability / Usefulness

**+** Smoother in space and time. Easier to process for the duty meteorologists, easier for customers to assimilate.

**-** Locally less precise, some details may be left out. Greater danger of systematic biases (e.g. over warning)

- In nowcasting you cannot have both at the same time!
- NowCastMIX would tend by nature to be over-precise
- An optimal balance is approached via a **clustering** method
  - Based on the DBSCAN algorithm within an adaptive clustering ensemble

14:15 to 15:15 UTC, 22.06.2011



**Analysis\*, warning areas**  
\* 20 minute time window

**Clusters, warning polygons**  
(Expansion of moderate severity regions, high severity events remain tightly focussed on severe cells)

**Warning proposals for the next 60 minutes for AutoWARN**

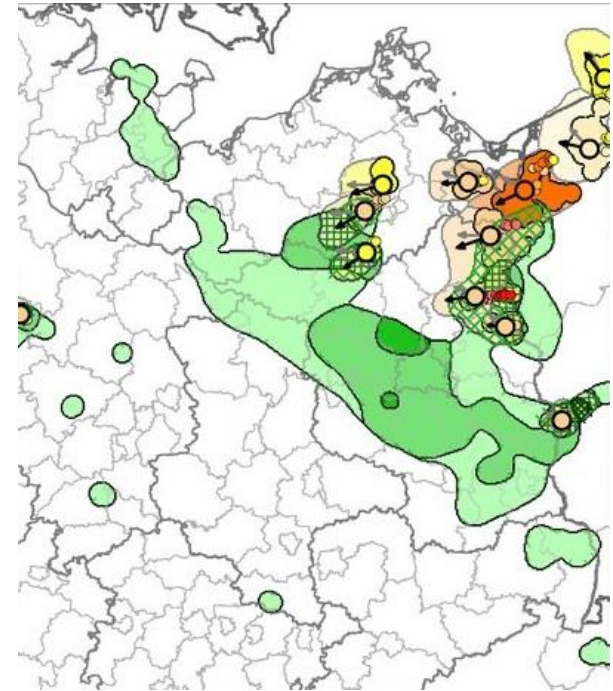
**Possible subsequent mapping onto administrative regions (illustrative example)**



# NowCastMIX Extensions

## Longer timescale heavy rainfall warnings

- NowCastMIX generates warnings for heavy rain as well as for thunderstorms
- Prolonged heavy rainfall over several hours can be very dangerous, even if the individual hourly totals are themselves not especially large
- Heavy rain warnings can be generated for the extended time range of up to 6 hours
- Based on the following datasets
  - Recent hourly rainfall radar estimates (calibrated QPE)
  - Rainfall forecasts for the first forecast hour (QPF)
  - COSMO-D2-EPS precipitation forecasts for the next few hours
  - NWP / Nowcasting blend



**Berlin floods, 29 June 2017**  
**NowCastMIX thunderstorm tracks/warnings with heavy rain warning areas (green shades)**

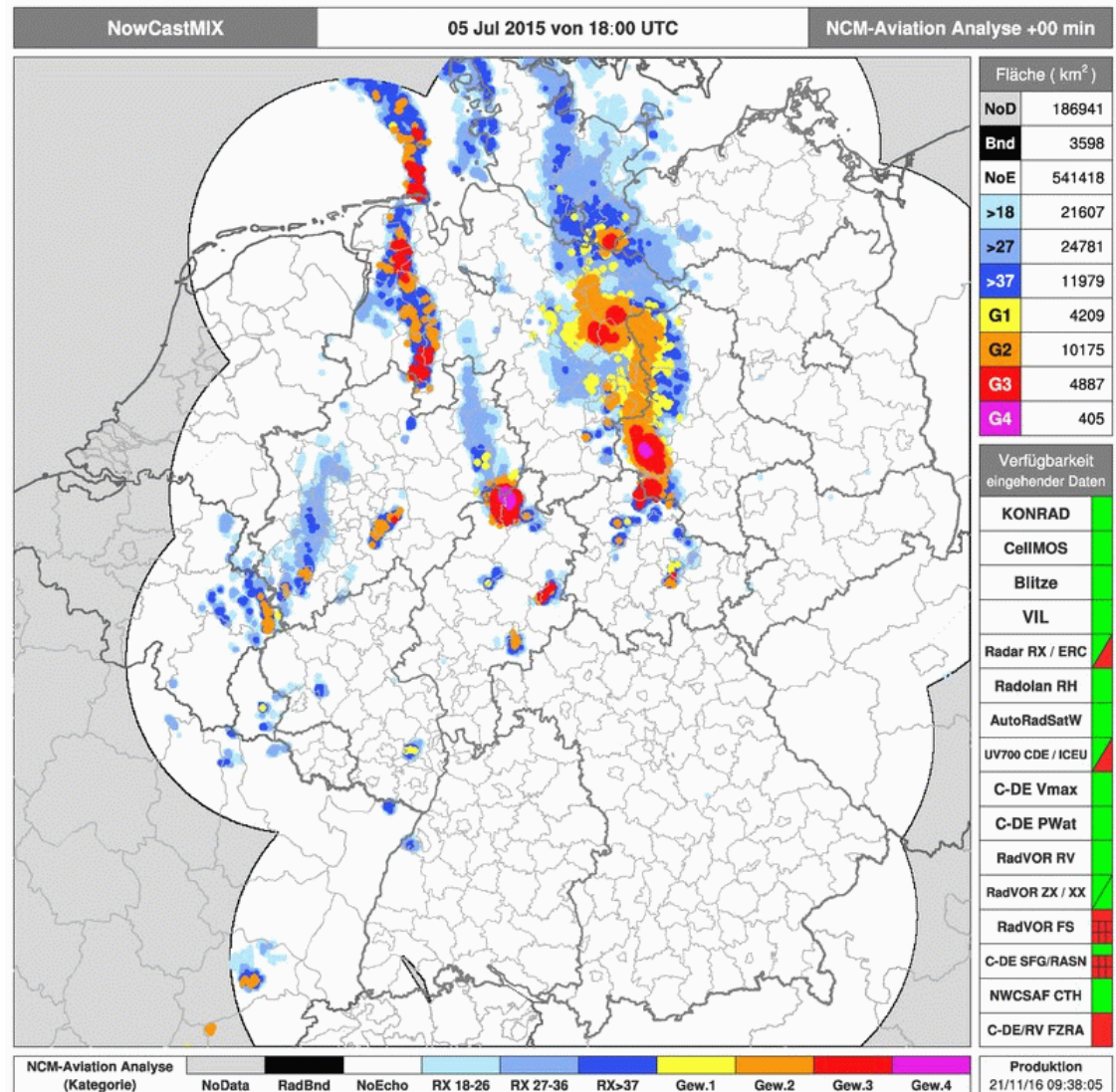
# NowCastMIX Extensions

## NCM-Aviation – Nowcasting for civil aviation

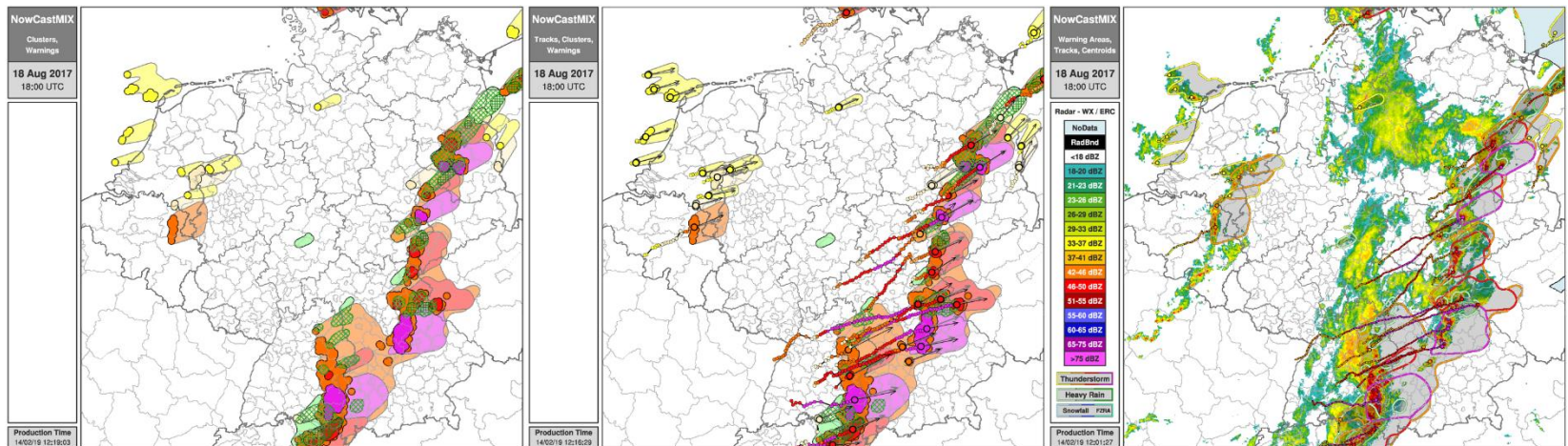
Deutscher Wetterdienst  
Wetter und Klima aus einer Hand



- High resolution radar data combined with lightning data and cell tracks in a further fuzzy logic based product for the German Flight Safety Authority (DFS)
- Simplified output on 1x1 km grid
  - 4 basic thunderstorm levels, plus heavy rain > 37 dBZ
- Linear extrapolation for forecasts up to T+60min
- Real time data displayed as part of a “Meteorological Airport Briefing”-Portal



- NowCastMIX also delivers warning polygons to the DWD WarnWetter App
- Similar to the AutoWARN proposals, but simplified
  - 4 thunderstorm classes (yellow, orange, red and violet)
  - Includes heavy rain, snowfall and freezing rain, but no clustering or temporal smoothing
  - Direct, automatic warnings
- DWD has been designated a “Regional Specialized Meteorological Centre (RSMC) for Nowcasting” by the WMO
- NowCastMIX warnings now available on the DWD internet pages via its RSMC offerings





- NowCastMIX has run continually since 2011
  - Has become an essential nowcasting component for DWD's warning services
  - Has produced a highly valuable and complete analysis of thunderstorm events over the whole of Germany for an eight year period.
  - Includes winter nowcasting of snowfall and freezing rain (in development)
- Improvements in the near future
  - Include of a broader suite of NWP model data, in particular including **Ensemble** data from COSMO-D2-EPS
    - Ensemble probabilities for severe convection
    - Real-time analyses of the synoptic situation and local air mass properties
      - Refine clustering technique to optimise warning proposals
      - Optimise choice of initial warning category and length of warnings
  - Replace various input radar products with new, improved data from DWD's POLARA system (KONRAD3D, Optical flow vectors, Hydrometeor classification)



**Thanks for your attention !**