European Conference on Severe Storms
Scandic Marina Conference Centre
Helsinki, Finland
6th June 2013

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

NowCastMIX - Automatic integrated warnings from continuously monitored systems based on a fuzzy-logic approach

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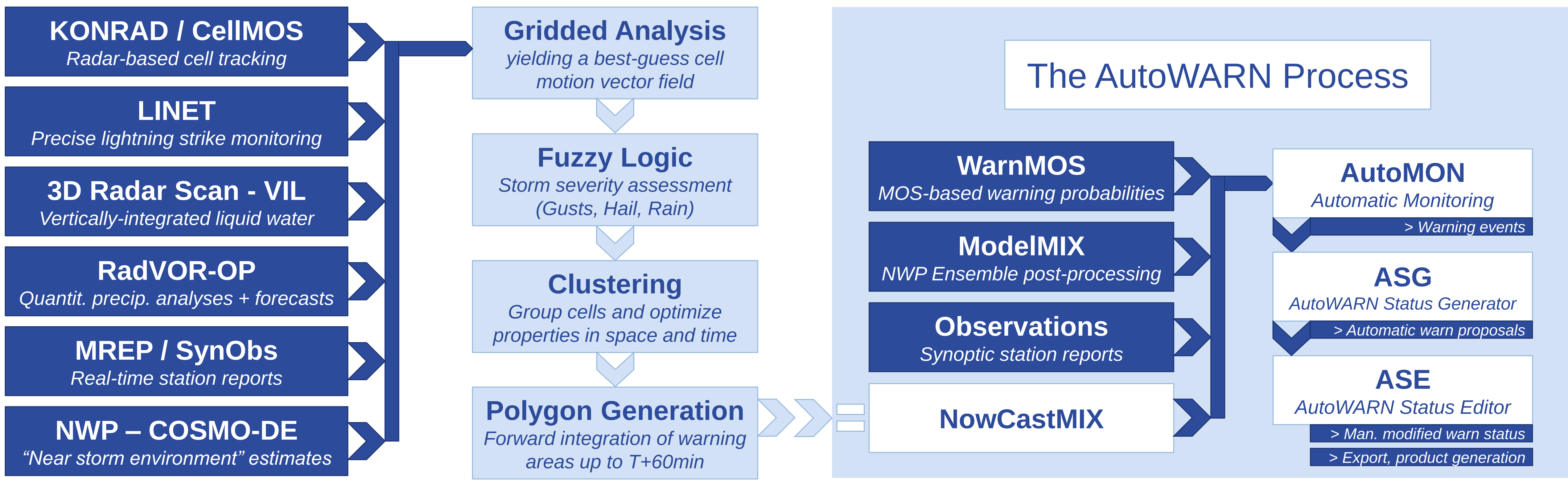


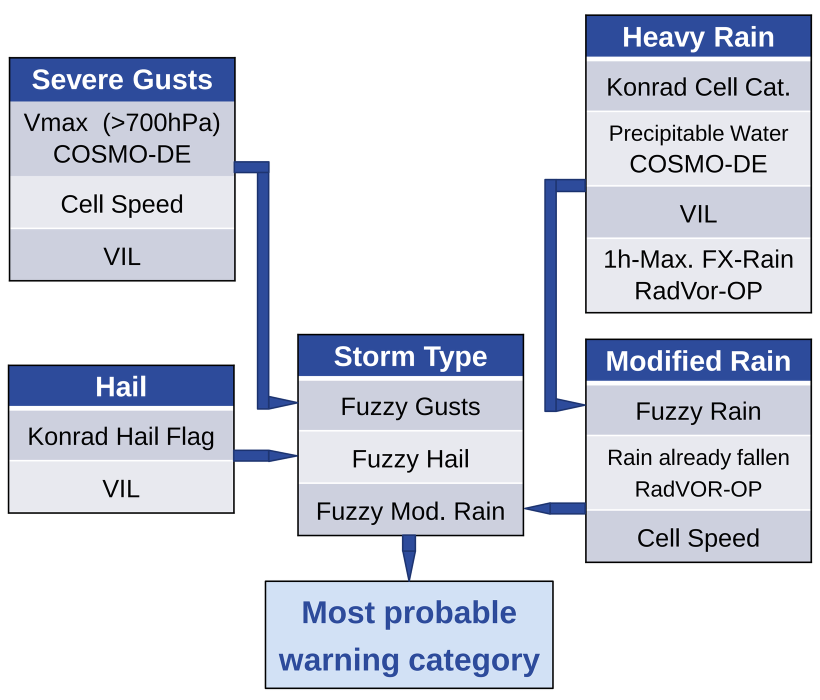
The DWD's AutoWARN system integrates various meteorological data and products in a warning decision support process, generating real-time warning proposals for assessment and possible modification by duty forecasters before dissemination to customers. On nowcasting timescales, several systems (above) are continuously monitored to capture quickly developing mesoscale events. To help the forecasters manage this large volume of rapidly changing data, NowCastMIX processes it into an integrated grid-based analysis, providing an optimal warning solution with a rapid 5-minute update cycle. NowCastMIX thus delivers an on-going real-time synthesis of the input data to provide consolidated sets of most-probable short-term forecasts across the whole of Germany.

Convective Storm Warning Levels

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	
94	≤ 9	25-40	
46	≤ 10	25-40	✓
48	≤ 12+	25-40	✓
95	≤ 9	>40	✓
61	-	15-25	-
62	-	25-40	-
66	-	>40	-

The 10 thunderstorm and 3 torrential rain warning levels in NowCastMIX, showing their typical attributes

Fuzzy Logic Sets

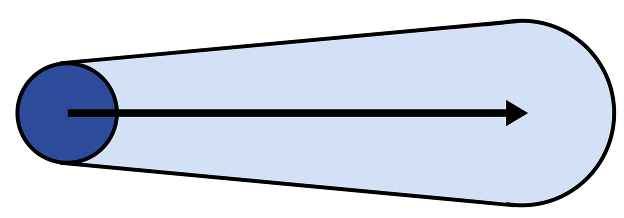


A hierarchy of fuzzy logic sets are applied at the location of each cell centre. These assess the probabilities of each storm attribute and then calculate the most appropriate warning category.

Cell Vector Field

A core aspect of NowCastMIX is the construction of an optimal cell motion vector field. This is used to sharpen the analysis of the various input data to a common single time point and provides the basis for integrating warning regions forwards in time. Linear motion vectors are provided by the cell tracking systems KONRAD and CellMOS. These are mapped onto a grid using a Gaussian decay function and combined with an areal precipitation vector field based on a radar-image-matching algorithm in the RadVor-OP system. The final motion vector field is further optimised by the iterative removal of erroneous tracks which occur from time to time in the raw KONRAD or CellMOS outputs.

Warning Cone Creation

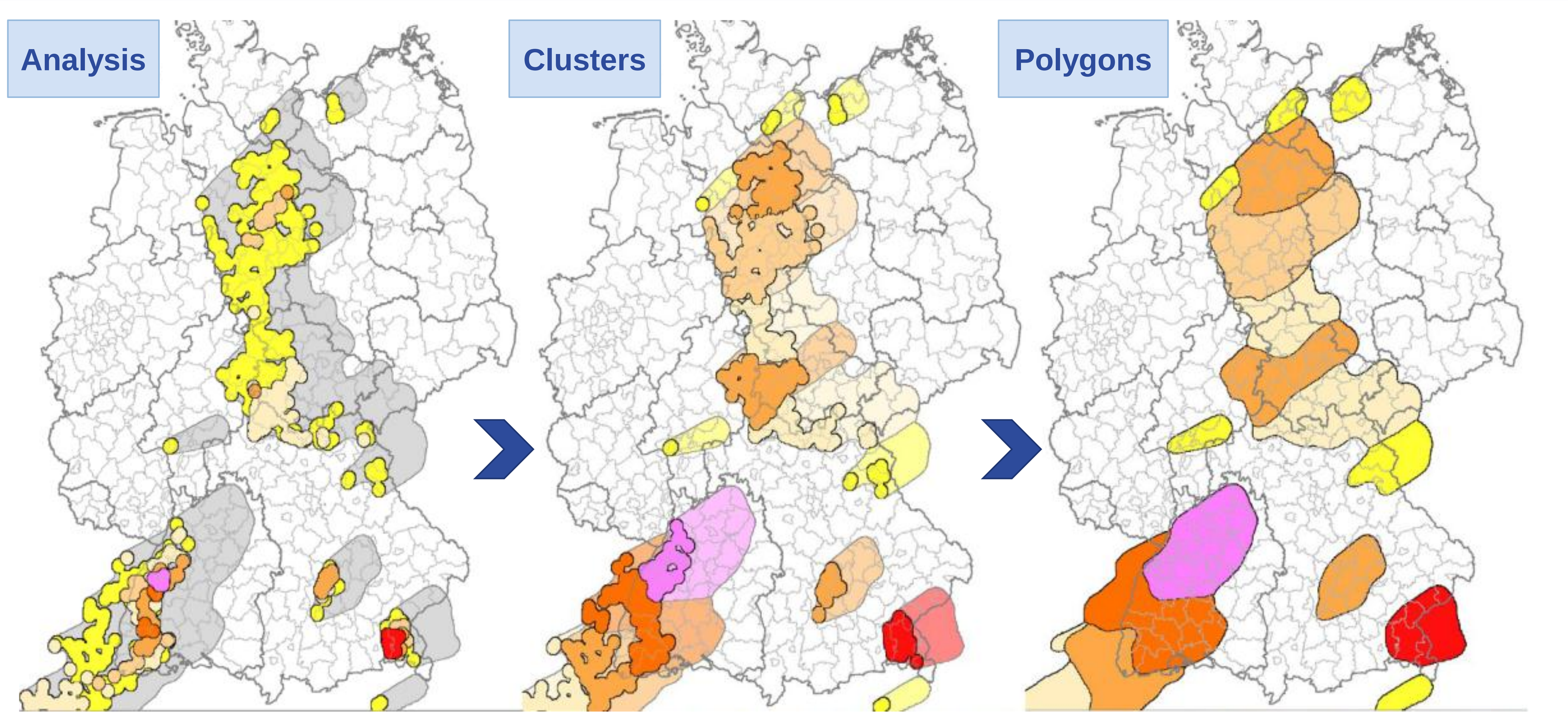


To create a warning region, covering the next 60 minutes, 10km-radius circles (blue) are plotted at the identified radar-tracked cells or lightning strikes located elsewhere. A cone is then formed in the direction of cell motion, ending at the expected distance reached after 60 minutes. The cone's spread represents the inherent uncertainty in speed and direction. The storm severity level at the cell centre is given to the whole cone, while in overlapping segments, where several cells exist near each other, higher severities are given preference.

Adaptive Clustering Ensemble (ACE)

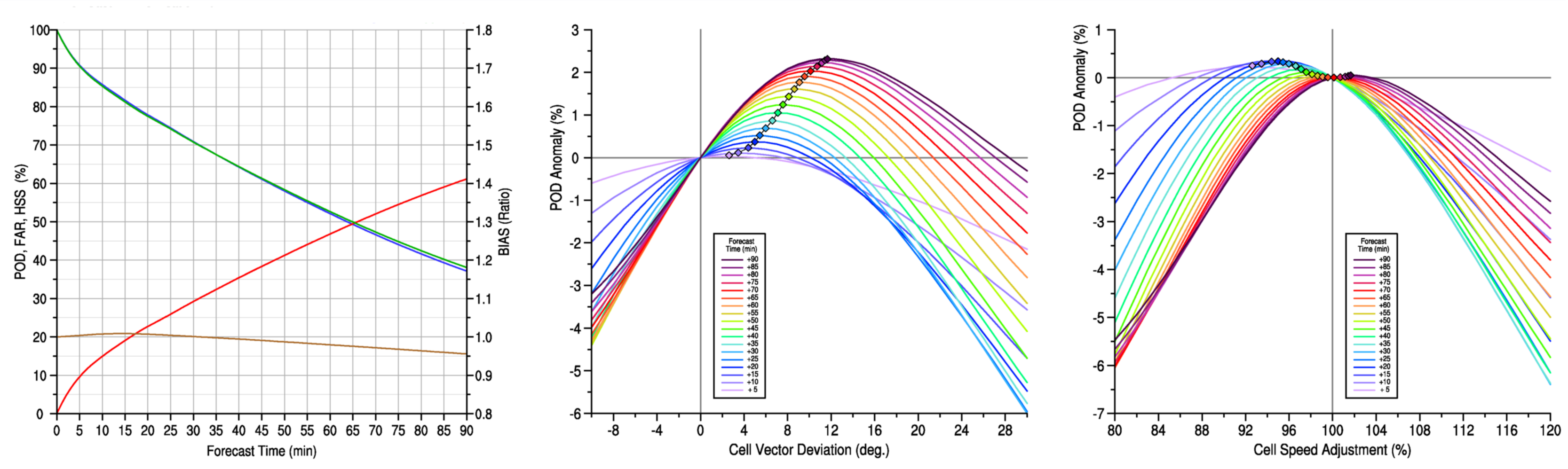
NowCastMIX's sharp cell analyses can lead to rapid temporal fluctuations in the warnings, making the task difficult for the duty forecasters. An optimal balance of accuracy and usability is achieved with spatial clustering. Cells belonging to a cluster are all given the highest severity level found there during the last 20 min., calming the fluctuations. To ensure that the clusters themselves are temporally stable, a large ensemble of clusterings is performed, using random fluctuations of the cell centre positions. The clustering which best resembles that used 5 minutes earlier is chosen. The method of random positioning is itself successively adapted for rapid convergence to an optimum as the ensemble progresses.

From analysis of cells to final warning polygons



An analysis of storm cell locations and fuzzy-logic based severity types is performed over a 20 minute time window. The cells are then spatially clustered using the ACE method. Finally, the background cell vector field is used to plot warning cones from each cell in the direction of motion to cover the next 60 minutes. The resulting areas are spatially filtered to produce the final warning polygons sent on to AutoWARN.

Verification



POD, FAR, HSS, BIAS vs. forecast time for projected warning segments against future analyses.

Variation of the POD for different forecast times vs. systematically biased cell motion vector directions.

Variation of the POD for different forecast times vs. systematically biased cell motion vector speeds.

The quality of NowCastMIX forecast warning areas has been verified against its own analyses across Germany for the entire convective seasons of 2011 and 2012. While the POD falls with increasing forecast time, as one would expect, the highest relative mean POD is achieved with a systematic rightward bias of the cell motion vectors of around 9°, indicating that new cells often form to the right of existing trajectories due to the relative motion of the large-scale troughs in which they are embedded. On the other hand, the speed of the cell vectors already appears to be close to an optimum.

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