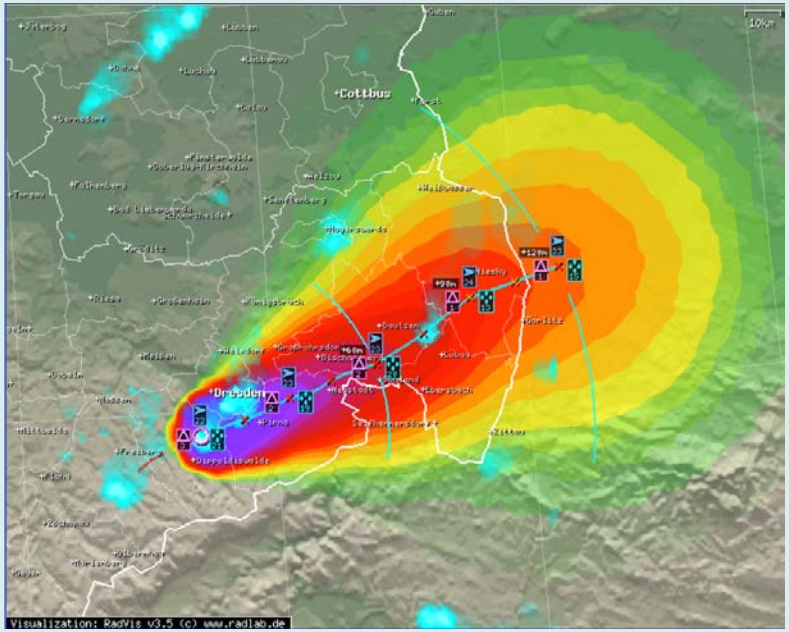
Hail protection – simply automatic

Automatic Hail Detection and Forecasting with MSwr-CellMOS



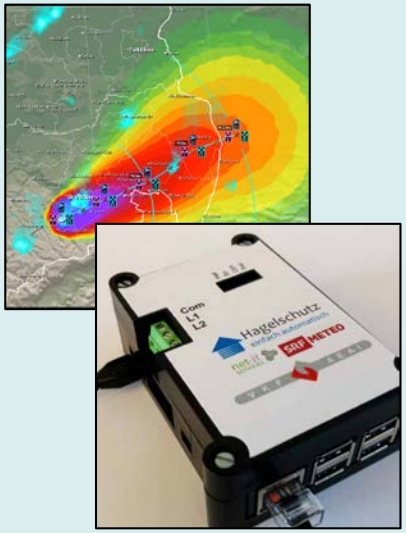
Klaus Knüpffer, Jan Hoffmann

Content

Adoption of MSwr-CellMOS for Hail Alarm in Switzerland

Hail…

Protection...



Simply automatic!

Contributors

METEO SERVICE

GEOMETIX SCIENCE & SOLUTIONS

SRF

net·it services

Hagelschutz einfach automatisch

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1.1 The 90‘s: MOS (Model Output Statistics) for Standard weather elements

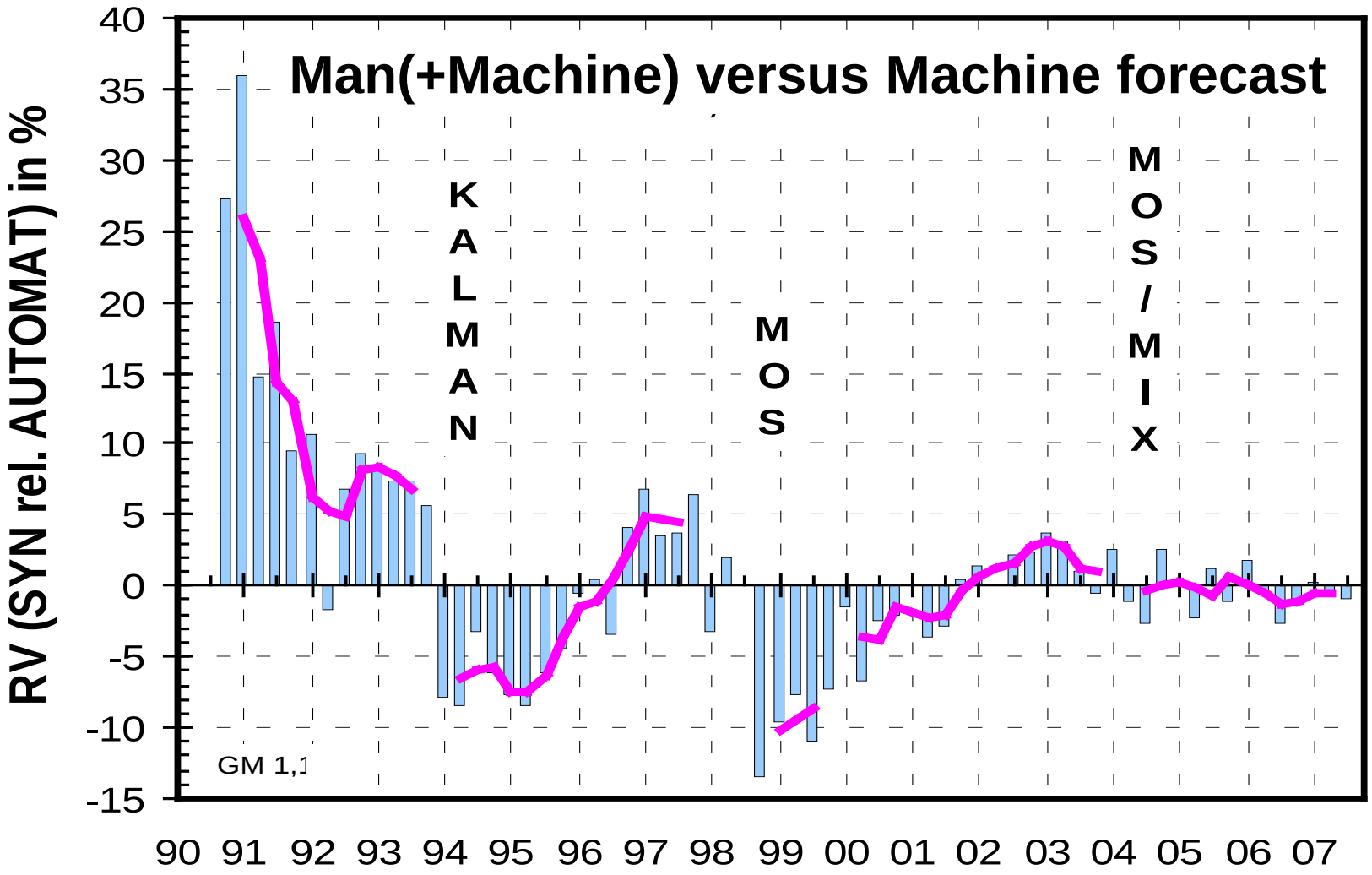
1.2 The 00‘s: NowCast-MOS

1.3 Recently: MSwr-CellMOS – the basis for automatic hail detection and forecasting

1.3.1 MSwr-CellMOS (DWD)
1.3.2 MSwr-CellMOS (SRF/VKF)

1.1 MOS from the 90's on: Verification results

- Man(+Machine) versus Machine forecasts
- RV (MOS, DMO) = 50%


Man(+Machine) versus Machine forecast
RV (SYN rel. AUTOMAT) in %
40
35
30
25
20
15
10
5
0
-5
-10
-15
KALMAN
MOS
MOS/MIX
GM 1,1
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

RV(MOS,DMO) = 50% - What does it mean?

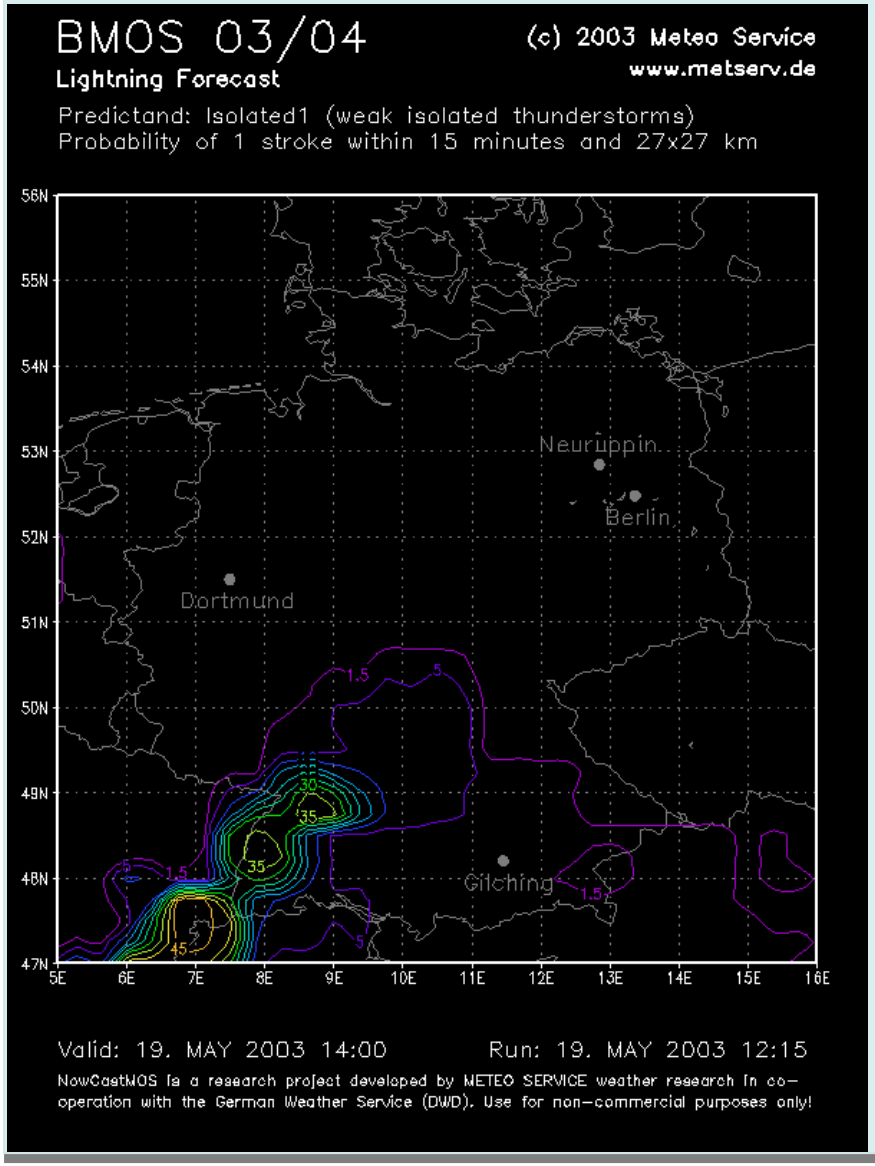
- The sum of squared forecasts errors of MOS forecasts is half the sum of squared forecast errors of Direct Model Output (DMO) forecasts
- A MOS forecast of the year 1997 had the same accuracy as a model forecast of the year 2017
- A 3-day-ahead MOS forecast has the same accuracy as a 1-day-ahead DMO forecast - no matter what the resolution is

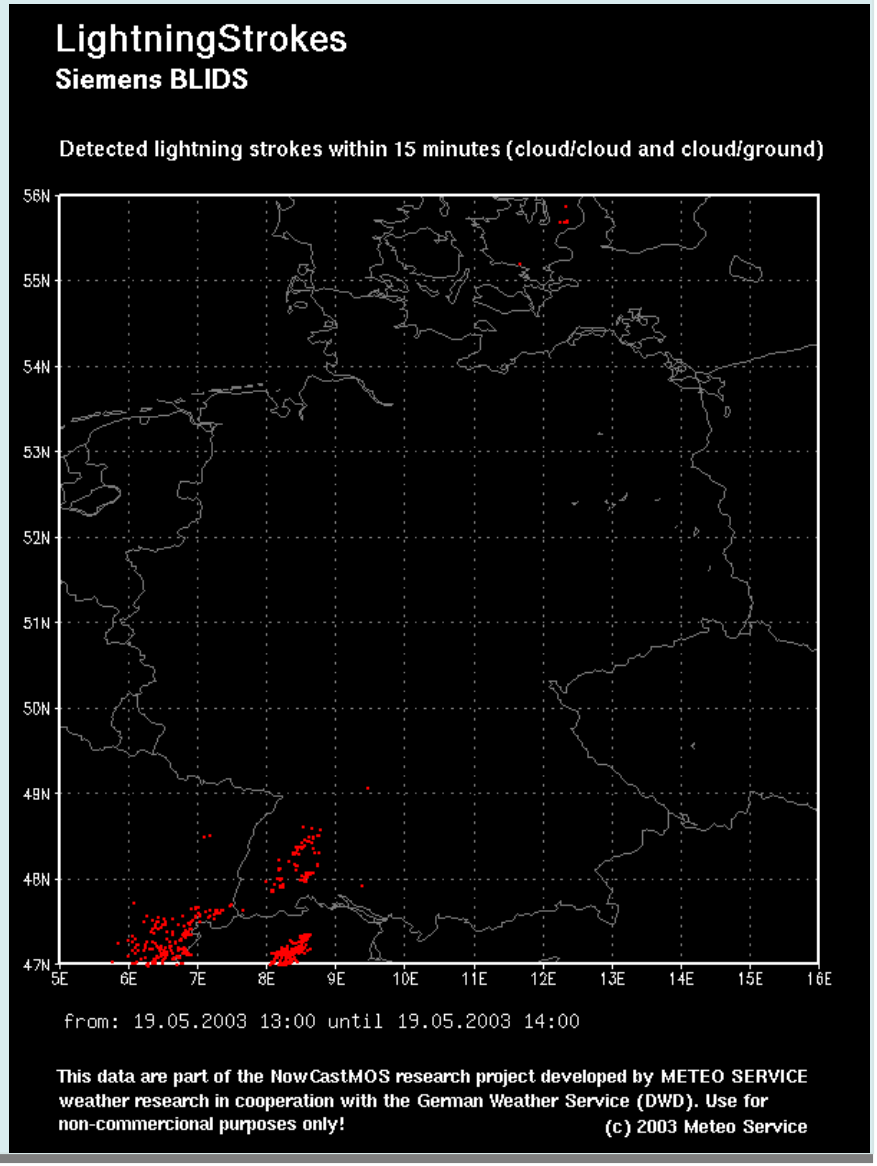
„Probability is the language of the forecaster“
(Chuck Doswell)

MOS produces Probabilities in two ways:

- **Explicitly: By pre-defining probabilistic predictands like probability of Hail**
- **Implicitly: By predicting a non-probabilistic element (e.g. T2m but also wind vector components) and its absolute forecasting error. From these two all probabilities can be calculated with normal (or other) distribution assumption.**

1.2 The 00's: NowCast-MOS





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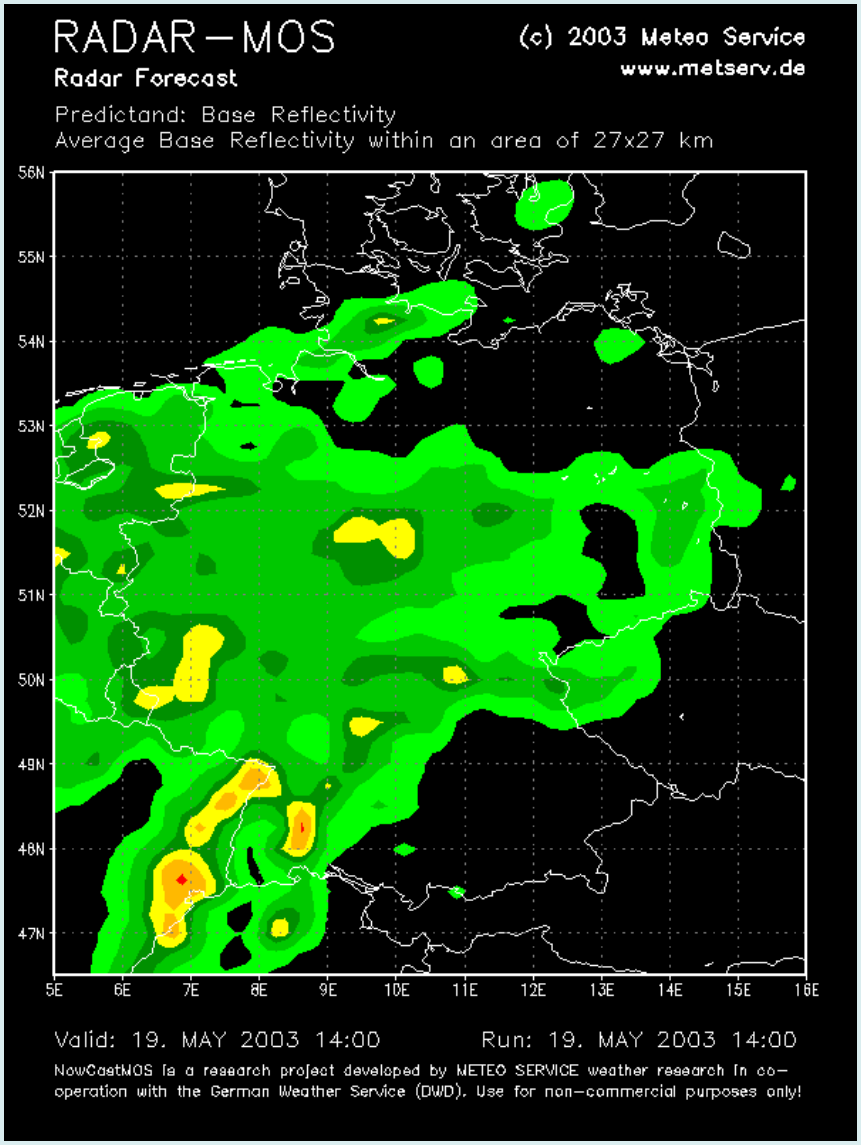

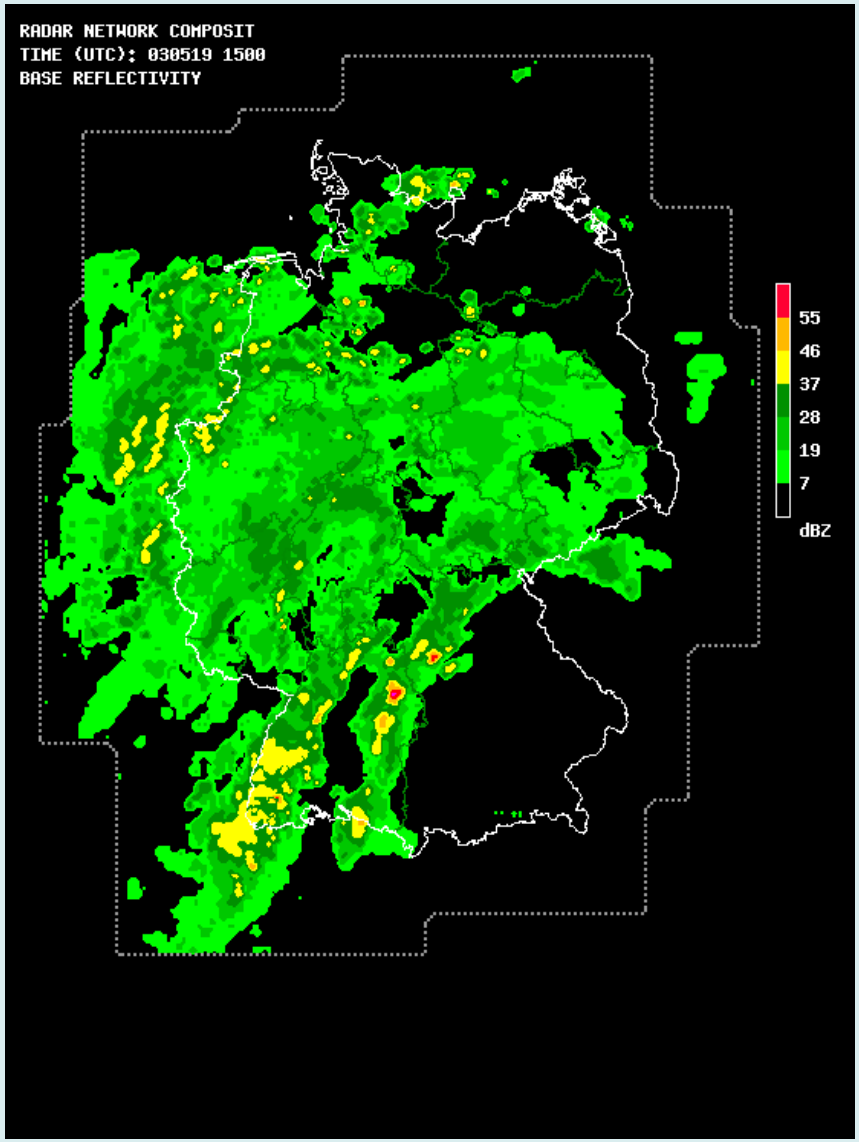

19 – 21 April 2017, University of Bern, Switzerland
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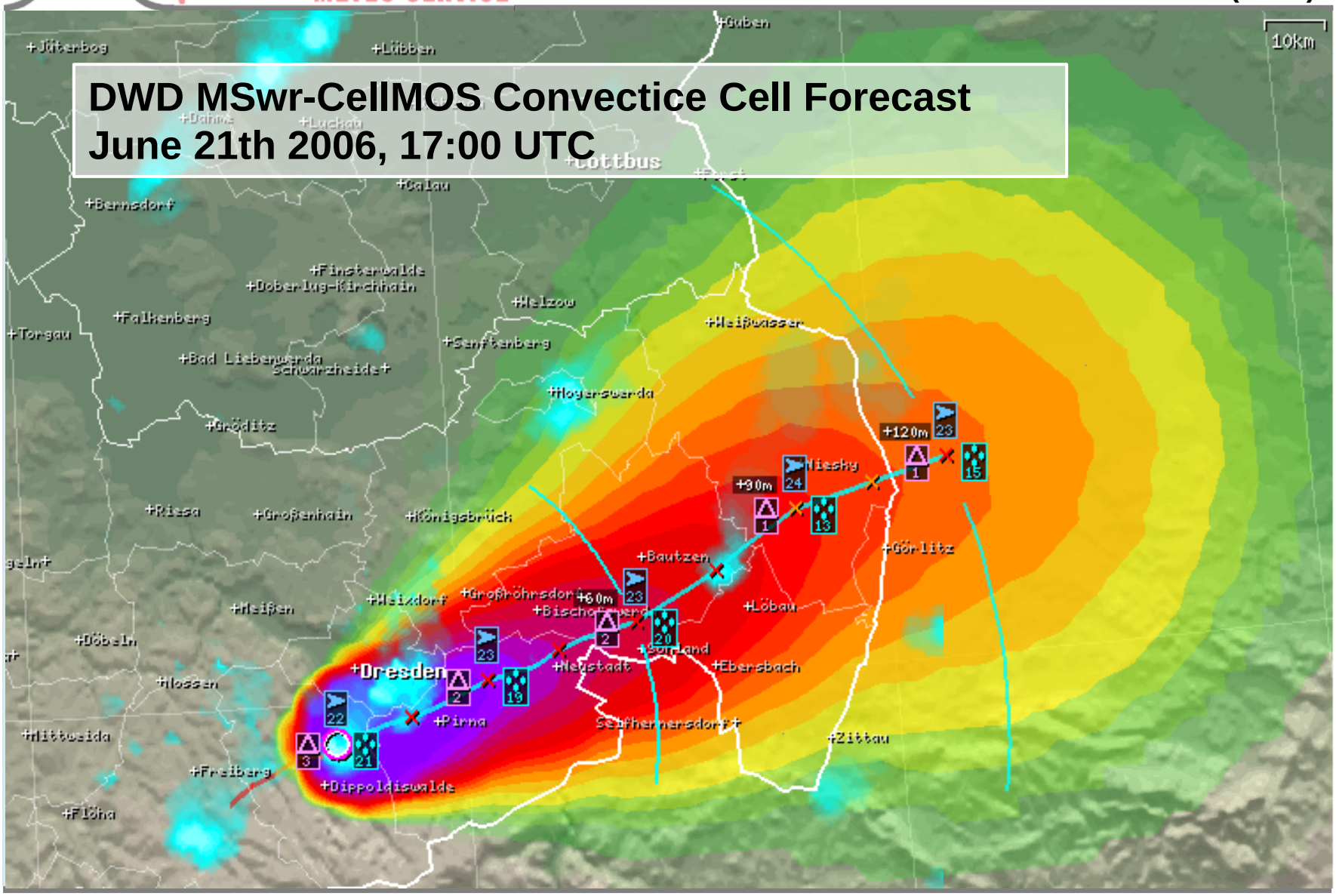
Derived Predictands from radar and lightning

- Movement (U, V, derived from cell detection)
- Absolute Errors of Movement U, V
- Hail Size / Probabilities
  - "classic": DWD MSwr-CellMOS
  - Waldvogel
  - SHI / MEHS / POSH
- Total precipitation
- Maximum estimated wind gust
- Lightning stroke rate

Forecasting

- Statistical forecasts are made for all individual detected cells
- Second step is calculation of field data derived from the cell forecasts using a Gaussian approach (assumption: cell properties and forecast location errors behave nearly like Gaussian distributions over space)


DWD MSwr-CellMOS Convectice Cell Forecast
June 21th 2006, 17:00 UTC
10km
+Jüterbog
+Lübben
+Guben
+Cottbus
+Calau
+Bernsdorf
+Finsterwalde
+Doberlug-Kirchhain
+Falkenberg
+Torgau
+Bad Liebenwerda
Schwarzheide+
+Hoyerswerda
+Weißwasser
+Senftenberg
+Weltzow
+Gröditz
+Riesa
+Großenhain
+Königsbrück
+Bautzen
+Görlitz
+Löbau
+Meißen
+Döbeln
+Dresden
+Pirna
+Neustadt
+Ebersbach
+Sebnitz
+Zittau
+Freiberg
+Dippoldiswalde
+Mittweida
+Flöha
+120m
+90m
+60m
Nieshy

Gaussian field distribution derived from cell forecasts

- **σ_shape (Gaussian shape) of the Cell:**

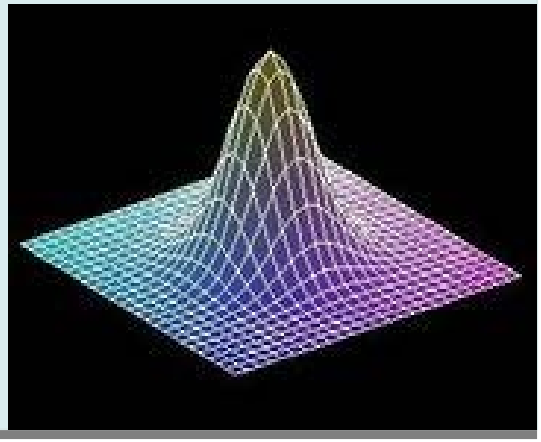
  expected value = predictand value minus environmental field value
  sigma(shape) derived from cell size and
  standard deviation = radius of 61% of expected value

- **σ_position (forecast error of cell position):**

  derived from forecast of error of trajectory

Convolution of σ_shape und σ_position:

- **σ_total** $= \sqrt{\sigma\_shape^2 + \sigma\_position^2}$

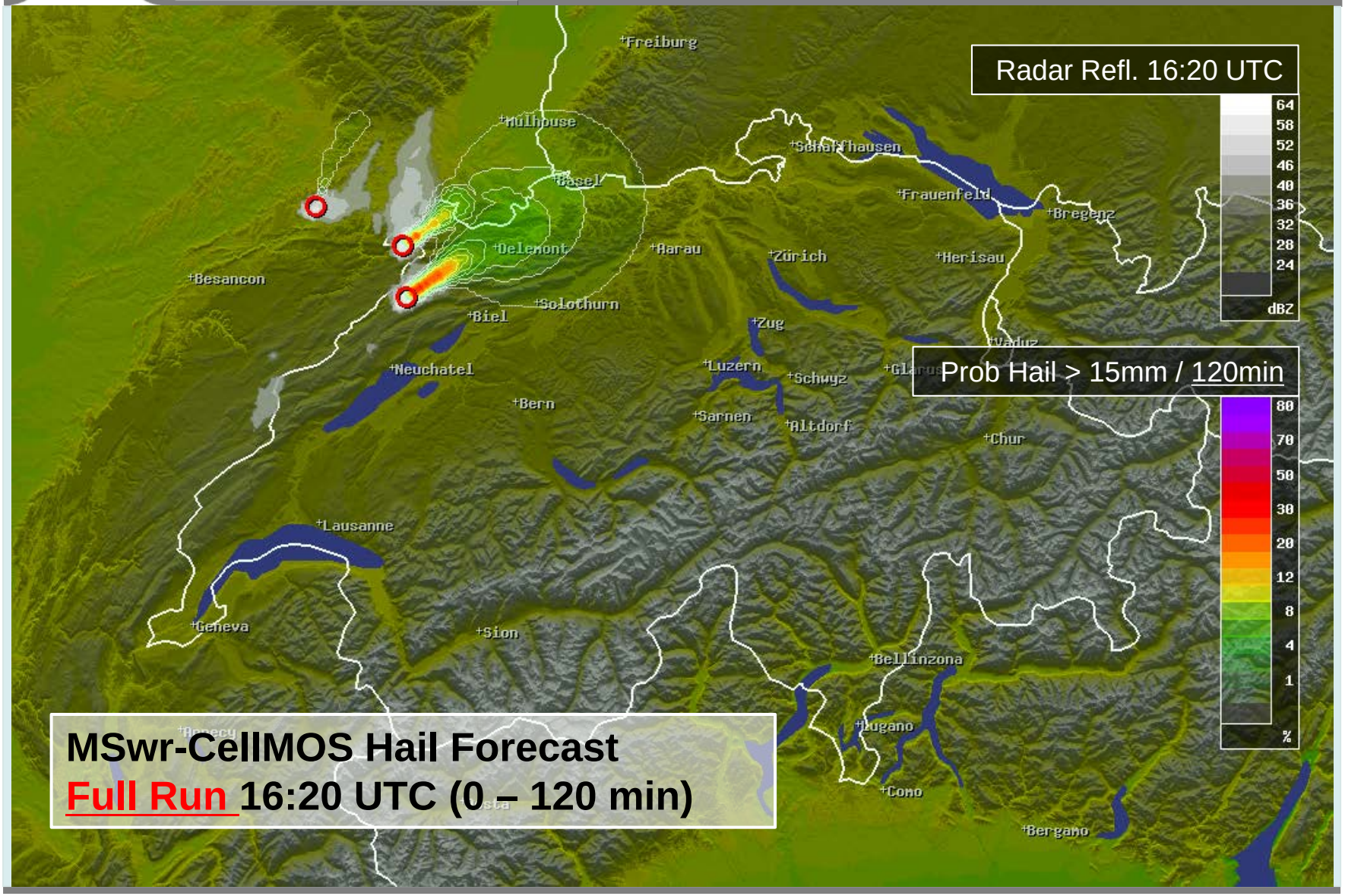


Adoption of MSwr-CellMOS for Hail Alarm in Switzerland

Case example
May 10th 2016, Canton: Jura

Image source: www.20min.ch

2 Probabilistic Hail Forecasts for Hail Alarm Switzerland



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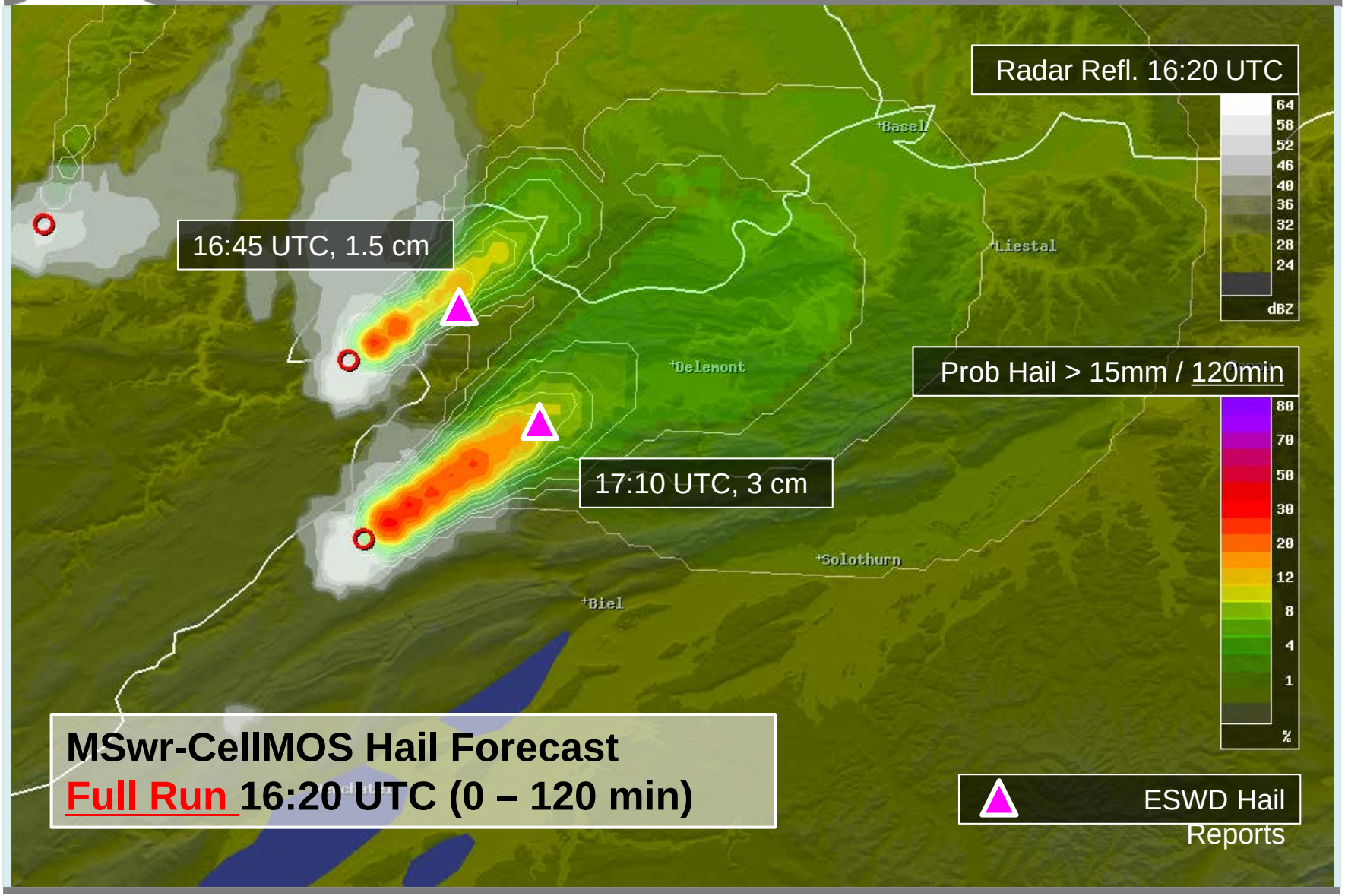

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Hagelschutz
einfach automatisch

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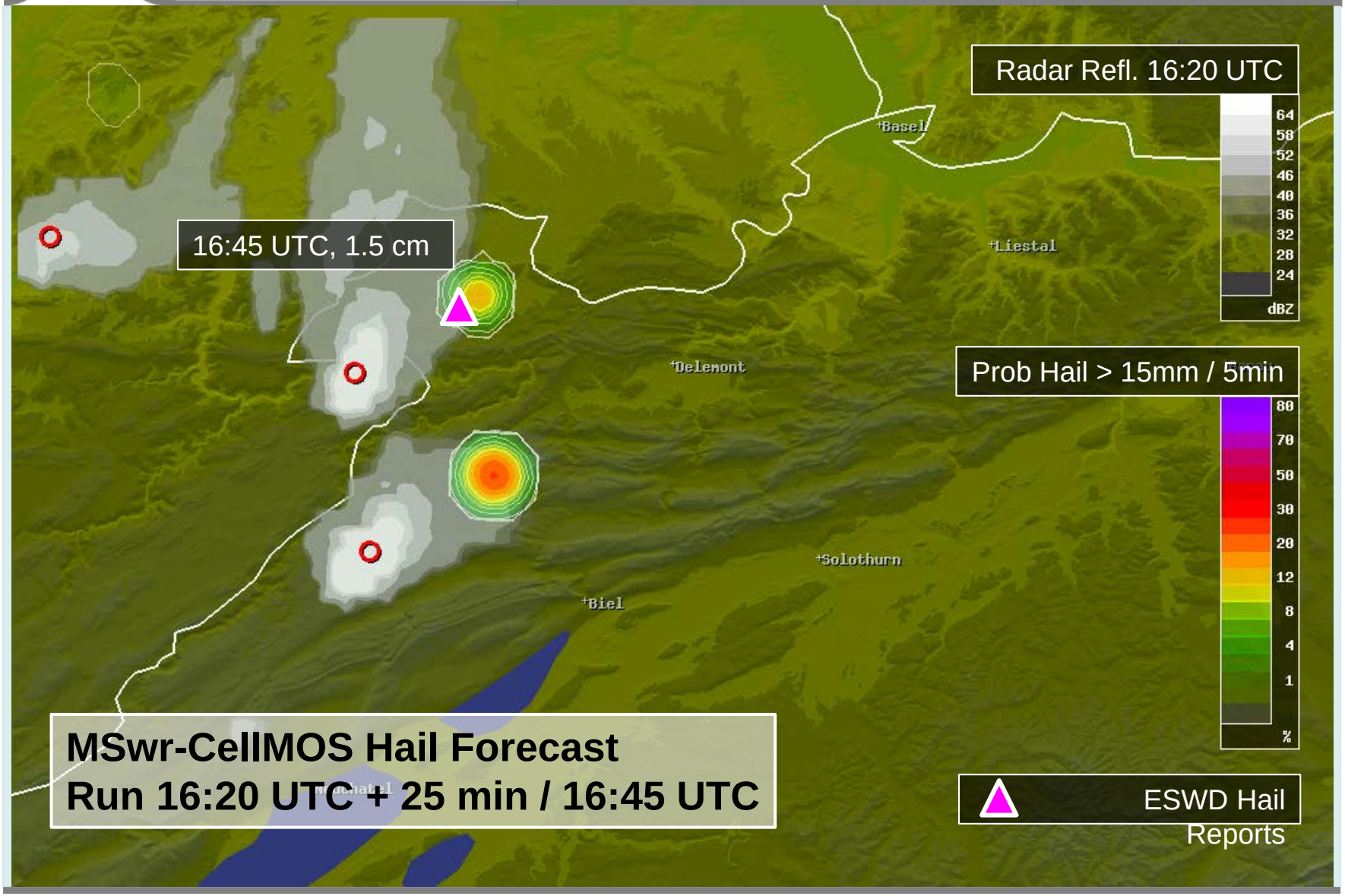

2 Probabilistic Hail Forecasts for Hail Alarm Switzerland

Radar Refl. 16:20 UTC

64
58
52
46
40
36
32
28
24
dBZ

Basel

Liestal

Delemont

17:10 UTC, 3 cm

Prob Hail > 15mm / 5min

80
70
50
30
20
12
8
4
1
%

Solothurn

Biel

MSwr-CellMOS Hail Forecast
Run 16:20 UTC + 45 min / 17:05 UTC

ESWD Hail Reports

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Optimized decision making based on Hail probabilities

Rule: If predicted hail probability exceeds the cost-loss ratio then action has to be taken:

Cost: loss of living quality due to moving external venetian blinds up

Loss: expected damage if Hail occurs.

Formula: IF (Prob_Hail>15mm > Threshold)
THEN (move external venetian blinds up)
(with Threshold = Cost / Loss)

Current Threshold is 5% and subject of discussions

Verification is very difficult:

- sparse observation data
- comparative verification with other providers impossible
- comparative verification against persistency of the observation possible
- verification possible for selected single cases with verified observations, e.g. from ESWD

Verification SFCMOS vs. observation persistency

Element: Probability of Hail Size > 15mm

Lead Time	Mean Obs	Mean Fc	Bias Fc	RMSE Fc	RV (Fc,P)	Cases /Mio	RMSE Pers
0	10.78	10.78	1.00	0.00	0.00	0.33	0.00
5	2.40	2.24	0.93	6.27	35.40	1.50	7.80
10	1.70	1.66	0.98	6.50	34.59	2.12	8.03
15	1.20	1.25	1.04	5.86	32.56	2.99	7.14
20	0.80	0.98	1.22	4.94	30.82	4.49	5.94
25	0.53	0.78	1.47	4.11	29.30	6.76	4.88
30	0.36	0.66	1.84	3.42	28.11	10.00	4.03

Outlook

- **Missing conceptual piece in MSwr-CellMOS: „Life cycle“ of convective cells: Forecast of „birth“ and „death“**

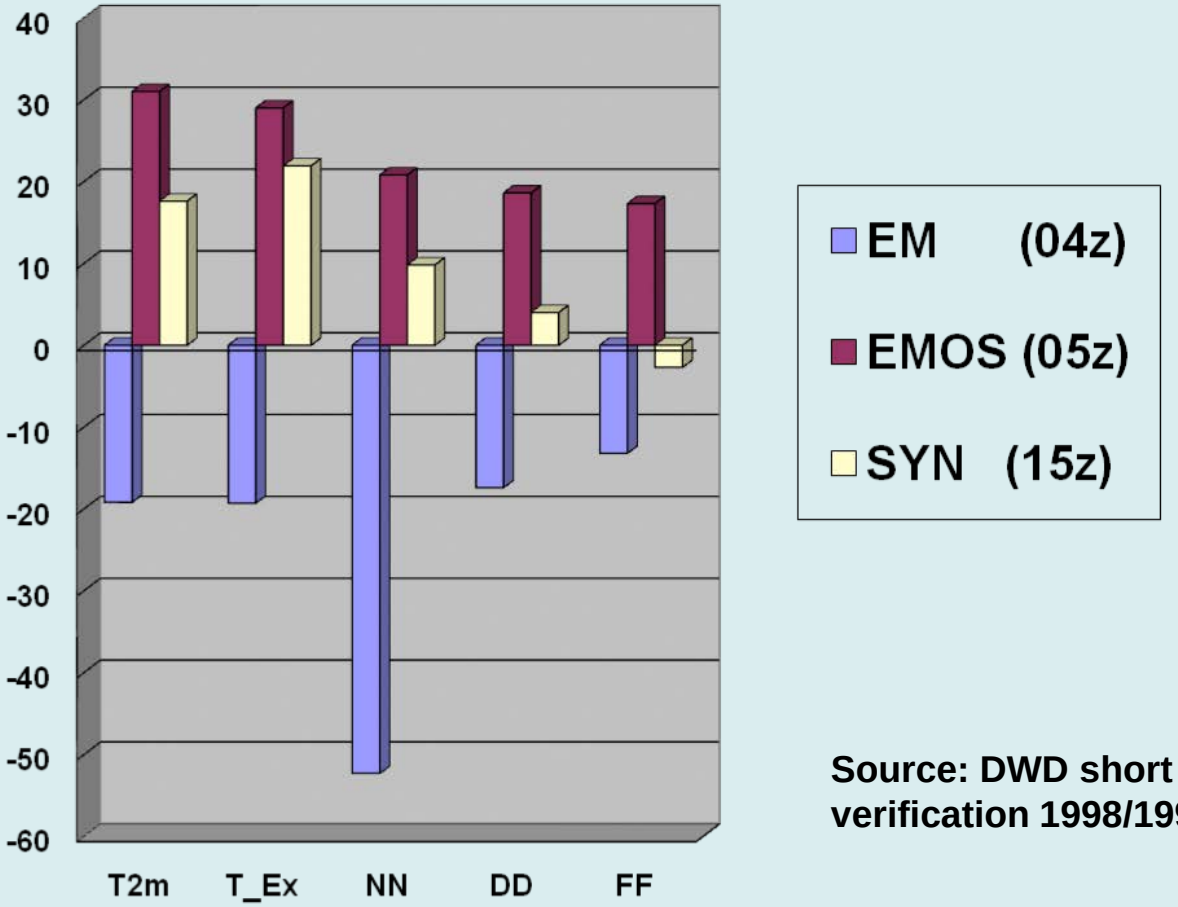
- **Improvement of hail analysis by using full volumetric radar data and polarimetric precipitation type radar data as predictand input possible**

Thank you for your attention!

Contributors

Introduction of MOS at DWD

RV of different methods vs. reference Kalman filter (neutral axis) in %



Source: DWD short term verification 1998/1999