Hail protection – simply automatic
Automatic Hail Detection and Forecasting with MSwr-CellMOS

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0 Introduction

1 History of the project „Automatic Hail Detection and Forecasting“

2 Probabilistic Hail Forecasts for Hail Alarm in Switzerland

3 Verification

4 Outlook
Adoption of MSwr-CellMOS for Hail Alarm in Switzerland

Hail... Protection... Simply automatic!

Contributors

- METEO SERVICE
- SRF
- GEOMETIX
- net-it services
- Hagelschutz
- VKF
1. History „Automatic Hail Detection and Forecasting“

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

1.2 The 00’s: NowCast-MOS

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

   1.3.1 MSwr-CellIMOS (DWD)
   1.3.2 MSwr-CellIMOS (SRF/VKF)
1.1 MOS from the 90's on: Verification results

- Man(+Machine) versus Machine forecasts

- RV (MOS, DMO) = 50%
1.1 MOS from the 90's on

Man(+Machine) versus Machine forecast

RV (SYN rel. AUTOMAT) in %

GM 1,1

DWD, Kurzfrist

K A L M A N M O S / M O X
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
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

BMOS 03/04
Lightning Forecast
Predictand: Isolated1 (weak isolated thunderstorms)
Probability of 1 stroke within 15 minutes and 27x27 km

Valid: 19. MAY 2003 14:00
Run: 19. MAY 2003 12:15

LightningStrokes
Siemens BLIDS
Detected lightning strokes within 15 minutes (cloud/cloud and cloud/ground)

from: 19.05.2003 13:00 until 19.05.2003 14:00

(c) 2003 Meteo Service
1.2 The 00's: NowCast-MOS

RADAR-MOS
Radar Forecast
Predictand: Base Reflectivity
Average Base Reflectivity within an area of 27x27 km

Valid: 19. MAY 2003 14:00
Run: 19. MAY 2003 14:00

NowCast-MOS is a research project developed by METEO SERVICE weather research in cooperation with the German Weather Service (DWD). Use for non-commercial purposes only.
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
Gaussian field distribution derived from cell forecasts

• $\sigma_{\text{shape}}$ (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

• $\sigma_{\text{position}}$ (forecast error of cell position):
  
  derived from forecast of error of trajectory

Convolution of $\sigma_{\text{shape}}$ und $\sigma_{\text{position}}$:

• $\sigma_{\text{total}} = \sqrt{\sigma_{\text{shape}}^2 + \sigma_{\text{position}}^2}$
Adoption of MSwr-CellMOS for Hail Alarm in Switzerland

Case example
May 10th 2016, Canton: Jura

Image source: www.20min.ch
2nd European Hail Workshop: Hail protection – simply automatic

19 – 21 April 2017, University of Bern, Switzerland

Dipl.-Met. Klaus Knüpffer (METEO SERVICE weather research GmbH)
Dr. Dipl.-Met. Jan Hoffmann (Geometix GmbH Science & Solutions)

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2 Probabilistic Hail Forecasts for Hail Alarm Switzerland

MSwr-CellIMOS Hail Forecast
Full Run 16:20 UTC (0 – 120 min)
2nd European Hail Workshop: Hail protection – simply automatic

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2 Probabilistic Hail Forecasts for Hail Alarm Switzerland

MSwr-CellMOS Hail Forecast
Full Run 16:20 UTC (0 – 120 min)

Radar Refl. 16:20 UTC

16:45 UTC, 1.5 cm

Prob Hail > 15mm / 120min

17:10 UTC, 3 cm

ESWD Hail Reports
2 Probabilistic Hail Forecasts for Hail Alarm Switzerland

MSwr-CellMOS Hail Forecast
Run 16:20 UTC + 25 min / 16:45 UTC

Radar Refl. 16:20 UTC
Prob Hail > 15mm / 5min
ESWD Hail Reports
2 Probabilistic Hail Forecasts for Hail Alarm Switzerland

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

Prob Hail > 15mm / 5min
17:10 UTC, 3 cm

Radar Refl. 16:20 UTC

ESWD Hail Reports
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**

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<th>Mean Fc</th>
<th>Bias Fc</th>
<th>RMSE Fc</th>
<th>RV (Fc,P)</th>
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<th>RMSE Pers</th>
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Outlook


- 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
1.1 MOS from the 90’s on

Introduction of MOS at DWD

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

Source: DWD short term verification 1998/1999