Radar-based Hail Statistics Over Belgium 2003-2012

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1. Introduction

In this study the Probability of Hail (POH) estimated by the operational hail detection algorithm is used to derive statistics on the occurrence of hail events the ten years period 2003 - 2012. In addition to the operational POH algorithm, the probability of severe hail is estimated using the Severe Hail Index (SHI) algorithm introduced by Witt et. al. (1998). The Probability of Severe Hail (POSH) and the Maximum Expected Size of Hail (MESH), derived from the SHI algorithm allows producing statistics on the severity of hail storms over Belgium.

2. Observations

For the best vertical coverage ten-elevation scan of the Wideumont radar was used. With this scan reflectivity data from 10 elevation angles between 0.5° and 17.5° are collected every 15 minutes .

Both algorithms POH and SHI combine the reflectivity data of single-polarization radar with the historical temperature profiles, obtained by dynamical downscaling of the ERA-Interim re-analysis.

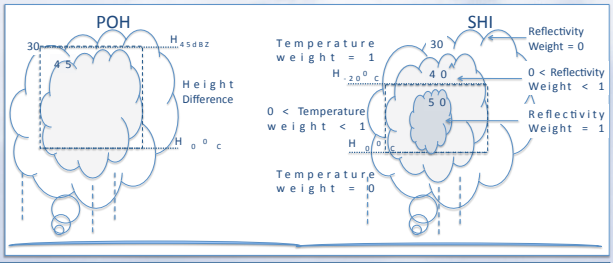
3. Hail detection algorithms

3.1 Probability of Hail (POH) is in linear relation with the height difference between 0-isotherm and the highest point where a reflectivity value ≥ 45 dBZ was measured: $POH = 0.319 + 0.133\,(H_{45\,dBZ} - H_{0\text{-}isotherm})$.
(Holleman, 2001)

3.2 Severe Hail Index (SHI) is calculated by vertical integration of the product of the hail kinetic energy $E(Z(h))$ with the temperature-based function $W_T(h)$ and a reflectivity-based function $W(Z(h))$:

$$SHI = 0.1 \int_0^{H^T} W(Z(h))\, W_T(h)\, E(Z(h))\, dh,$$

where $Z(h)$ is reflectivity at the height h and H^T is the highest point were a reflectivity ≥ 40 dBZ is measured.
Maximum Expected Size of Hail (MESH) is derived as: $MESH = 2.54\,(SHI)^{0.5}$.
Probability of Severe Hail (POSH) is given by: $POSH = 29\,\ln(SHI/WT) + 50$,
where $WT = 57.5\,H_0 - 121$ is a warning threshold.



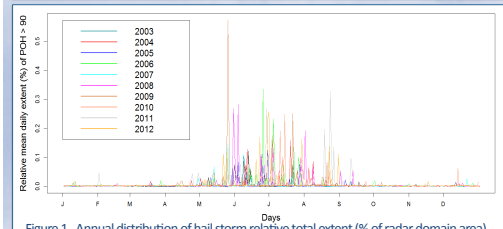


Figure 1. Annual distribution of hail storm relative total extent (% of radar domain area).

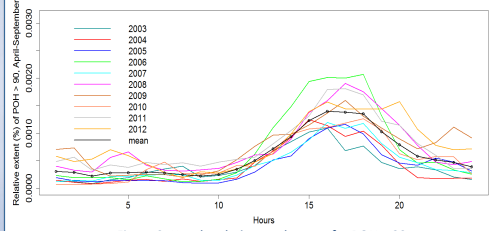


Figure 2: Hourly relative total extent for **POH > 90.**

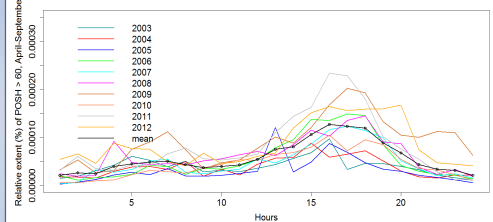


Figure 3. Hourly relative total extent for **POSH > 60**.

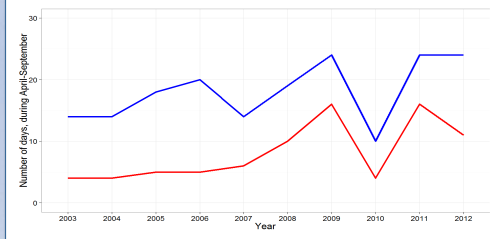


Figure 4. Total number of hail days per HS with **POH > 90** (blue) and **POSH > 60** (red).

4. Preliminary Results

From Fig. 1 it is clear that the Hail-Season (HS) for Belgium lasts from April to September. Based on this conclusion a further statistical analysis in Fig. 2-6 are made for the HS. Hail day is counted if at least 1/1000 part of pixels (≈180 km²) in the daily maximum is detected as hail.

Fig. 2 and Fig. 3 show diurnal distribution of averaged percentage over HS of the radar range area satisfying (POH>90) and (POSH>60) criteria for the POH and SHI algorithms correspondently. The mean over ten HS's curve shows a maximum between 16:00 and 18:00 UTC for both methods of hail detection.

The total number of severe hail-days in HS per year detected by POSH (red) and detected by POH (blue) algorithm can be found in Fig. 4.

The distributions of the number of hail days per month with hail and severe hail (≥ 20 mm in diameter) within the HS is shown in Fig. 5 and Fig. 6. The mean in 10 HS's number of hail days per month (in black) shows maximum in June for hail detected by POH and in May for severe hail detected by SHI algorithm.

The spatial analysis as on Fig. 7, requires inclusion of some additional quality information. That will allow to exclude artifacts related to scanning geometry and non-weather targets (ground echoes, airplanes and interferences) from the statistical analysis.

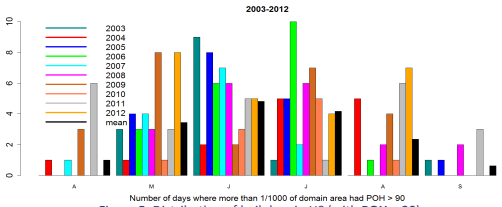


Figure 5: Distribution of hail days in HS (with **POH > 90**).

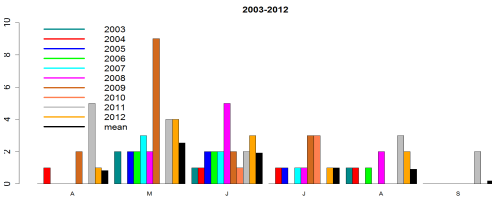


Figure 6: Distribution of severe hail days in HS (with **POSH > 60**).

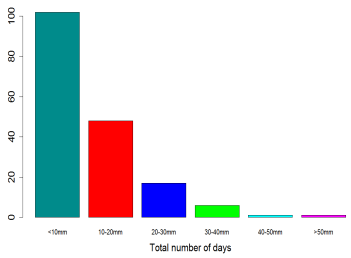


Figure 8. MESH distribution of hail days 2003 – 2012.

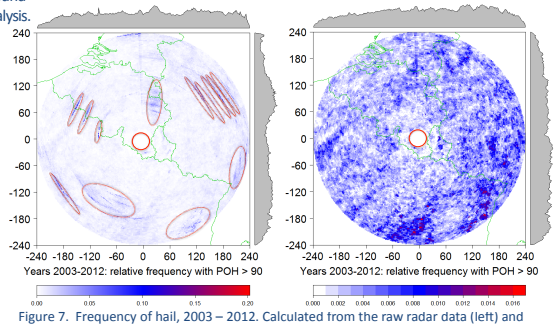


Figure 7. Frequency of hail, 2003 – 2012. Calculated from the raw radar data (left) and with partially removed artifacts (right)

5. Conclusions

From the preliminary analysis of the single-polarization C-band Wideumont radar data of years 2003-2012 can be concluded that:

1) hail storms with the largest spatial extension are most often detected by both algorithms around 16:00 – 18:00 UTC;
2) most hail storms occur in the period between April and September;
3) hail is highly sporadic event and for each month the number of hail days varies dramatically from one year to another;
4) in total at least one out of four hail events is severe and this proportion varies from year to year;
5) hail stones of ≥ 30mm in the diameter are rare (Fig. 8);
6) in average hail storms more often occur in June, but the severe hail is frequently detected in May;
7) for a better spatial statistical analysis a drastic quality control of the radar data is required.

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