MES.P10

Quality aspect related to radar-based hail detection

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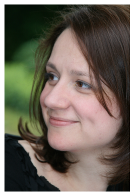

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1. Detection of hail in radar data

Two hail detection algorithms:
Waldvogel's type algorithm with Probability Of Hail (POH) product output

$$POH = 0.319 + 0.133(ETOP_{45} - H_0)$$

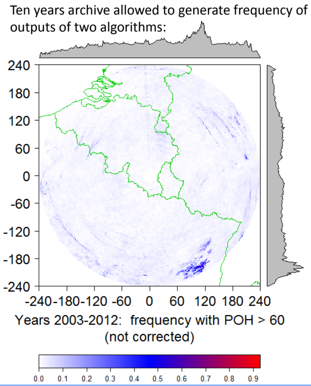
Witt's algorithm with Probability Of Severe Hail (POSH) product output

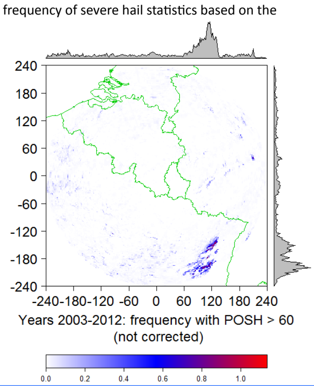
$$E = 5 * 10^{-6} 10^{0.084Z} W(Z) \qquad SHI = 0.1 \int_{H_0}^{H_T} W_T(H) E dH \qquad POSH = 29 \ln\left(\frac{SHI}{WT}\right) + 50$$

$$W(Z) = \begin{cases} 0, & Z \le 40dBZ \\ \frac{(Z-40)}{(50-40)} & 40 < Z < 50 \\ 1 & Z \ge 50dBZ \end{cases} \qquad W_T(H) = \begin{cases} 0, & H \le H_0 \\ \frac{(H-H_0)}{(H_{m20}-H_0)} & H_0 < H < H_{m20} \\ 1 & H \ge H_{m20} \end{cases}$$

where H_0 is the height of 0°C isotherm and the H_{m20} is the height of -20°C isotherm.

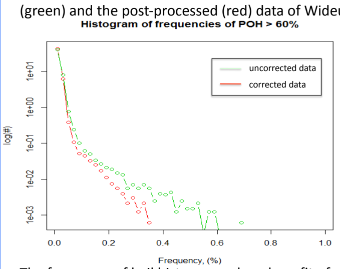
10 years archive:
The algorithms were applied on **10 years** (2003-2012) raw volumetric data from Wideumont's radar: C-band (5.62 GHz) weather radar, 10 elevation scan data (0.5°-17.5°), maximum range 240 km, 500 m resolution in range and 1° in azimuth.
After verification against reports of hail at the ground the threshold of 60% was selected for both POH and POSH products. It delivers similar high detection rates (>80%) for both POH and POSH products.
Ten years archive allowed to generate frequency of hail and frequency of severe hail statistics based on the outputs of two algorithms:

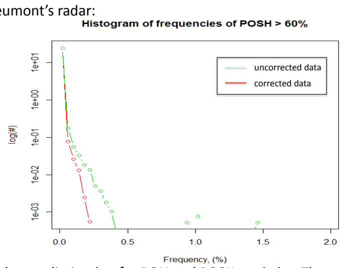




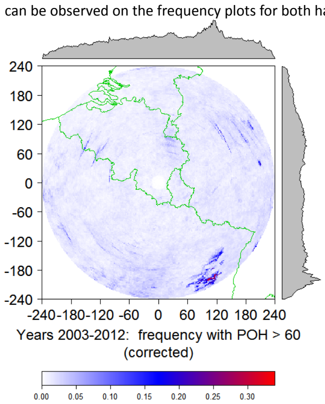
2. Impact of clutter correction on hail statistics

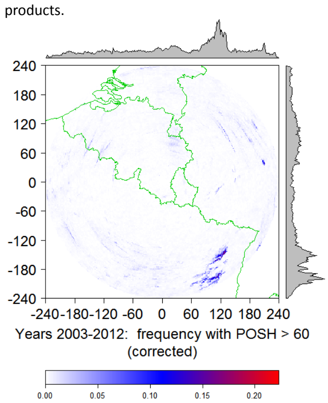
Post-processing correction for clutter removal were applied on the raw radar data. The corrections include: 1) a texture-based technique (Gabella and Notarpietro, 2002), 2) satellite observations of cloud-free areas (Goudenhoofdt, 2006), 3) a vertical profile algorithm (Steiner and Amith, 202) and (Berenguer et al., 2006).
Let us compare frequency histograms of hail (POH) and severe hail (POSH) calculated from the raw (green) and the post-processed (red) data of Wideumont's radar:





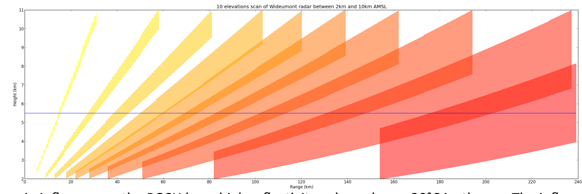
The frequency of hail histograms show benefit of clutter elimination for POH and POSH statistics. The unrealistic frequencies are reduced in both statistics. The impact of the clutter removal corrections can be observed on the frequency plots for both hail products.





3. Influence of scanning geometry

The scan with the best volume coverage has 10 elevations at angles of:
0.5°, 1.2°, 1.9°, 2.6°, 3.3°, 4.0°, 4.9°, 6.5°, 9.4° and 17.5°.
In the calculation of POH product we are analyzing only the part of the scan that is located between height of 0°C isotherm and the echo top 45 dBZ height. In the figure below you can observe scanning geometry of the part of the scan between the mean height of 0°C isotherm (~ 2 km AMSL based on 2003-2012 ALARO NWP model data) and 11 km AMSL level taken as mean tropopause height over Belgium.

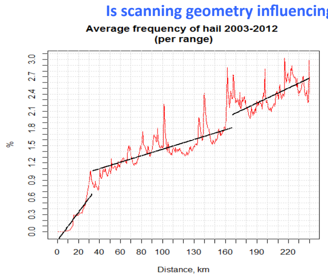


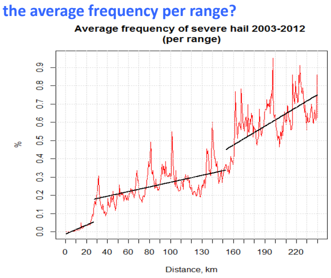
The main influence on the POSH have high reflectivity values above -20°C isotherm. The influence of high reflectivity values located between 0°C isotherm and -20°C isotherm linearly increases with the height (see the $W_T(H)$). The mean -20°C isotherm height based on the 2003-2012 ALARO NWP model data is shown on the figure above as 5.5 km AMSL level.

Are 10 elevations enough for the same quality of hail products everywhere?

The average frequencies of hail as a function of range for the POH and POSH products are definitely influenced by the height of the high reflectivity measurements. Another influencing factor is the vertical and sampling resolution of the reflectivity measurements. The POSH product depends more on the resolution, than the POH product due to the weighted integration of flux of hail kinetic energy *E*.

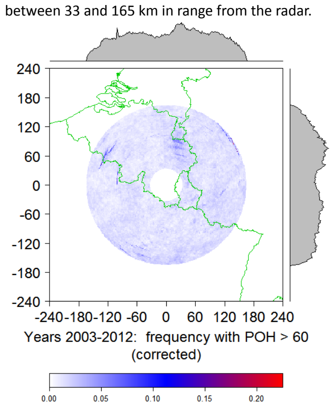
Is scanning geometry influencing the average frequency per range?

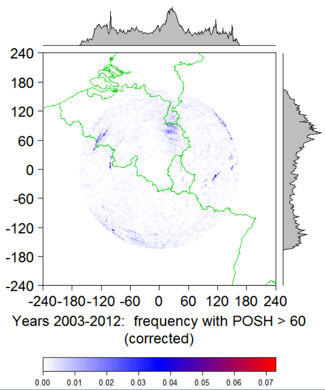




What is the optimal range interval?

The structural change analysis of the average frequency as a function of range of hail (POH) and severe hail (POSH) shows two structural breaks in both sets. The two breaks of the POH are at 33 km and 166.5 km range from the radar. The analysis of POSH data gives breaks at 27 km and 165 km. Hence the optimal range interval for the statistical analysis of hail product of Wideumont's radar is between 33 and 165 km in range from the radar.





4. Quality analysis of hail statistics

Application of the post-processing correction on the raw radar data for clutter removal reduced the mean frequency of hail over a full range from 1.53 % (not corrected) to 1.39 % (corrected). For the frequency of severe hail the reduction is from 0.25 % (not corrected) to 0.16 % (corrected) and the impact of the clutter removal post processing correction is higher.
The mean frequency of hail based on corrected radar data calculated on the optimal range interval (33 km - 165 km) is 1.37 % and the mean frequency of severe hail is 0.12 %. It means that application of quality control reduces mean frequency of severe hail by a factor of two.

References

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