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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Towards a radar- and observation-based hailstorm data set for Germany

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Hailstorms are a major threat, causing significant economical damages and losses to e.g. buildings, automobiles or agriculture land. For a detailed investigation of the impact of hail events, a spatial high-resolution climate data set of hail is needed. We are combining radar data and different kinds of hail reports, e.g. ground observation or agricultural insurance data, to generate a reliable hail event data set for Germany. Compared with only station-based investigations, radar data increase the spatial representativity of the ground-based hail reports and gain additional information in regions where observational data are rare. To ensure the applicability of the radar data for the analysis, a number of detection methods are applied to filter artefacts. In this study hail events are selected with a two-path criterion for the summer half-years of the period 2002 - 2011.

Radar Data Pre-Processing

As input we used a 2D – reflectivity product (DX) measured by a lowermost but terrain-following precip scan with a high temporal (5 min) and spatial (1°×1 km) resolution. Often, radar data are infiltrated by non-meteorological signals. To use them for climatological purposes weather radar data have to pass a pre-processing.

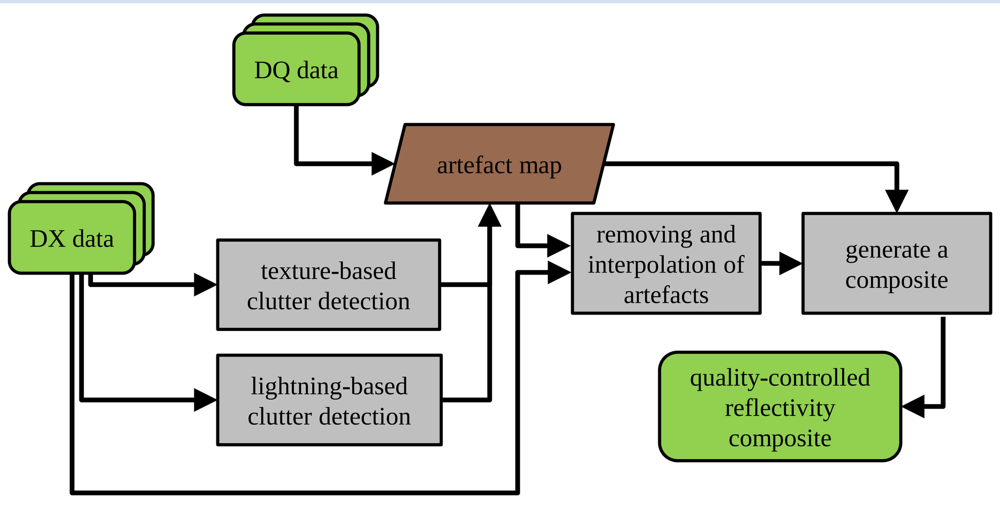

Figure 2: Schematic workflow of radar data preprocessing.

In detail, the following artefact detection and correction methods are applied:

- Information from DWD algorithms (RadarQS) about stationary and dynamic clutter as well as spokes and rings, corrupt images and German Pancake
- A two-step texture-based clutter filter by Gabella & Notarpietro (2002)
- A plausibility check of signals higher than 55 dBZ against flash data

Values marked as artefacts are replaced by interpolated values. Quality-controlled reflectivity data from all radar stations are transformed to a 1 km × 1 km Gauss Krueger grid and combined to a 5-min-composite. Finally the maximum values for each grid point from the 288 records of a day are determined.

Criterion for Hail Events

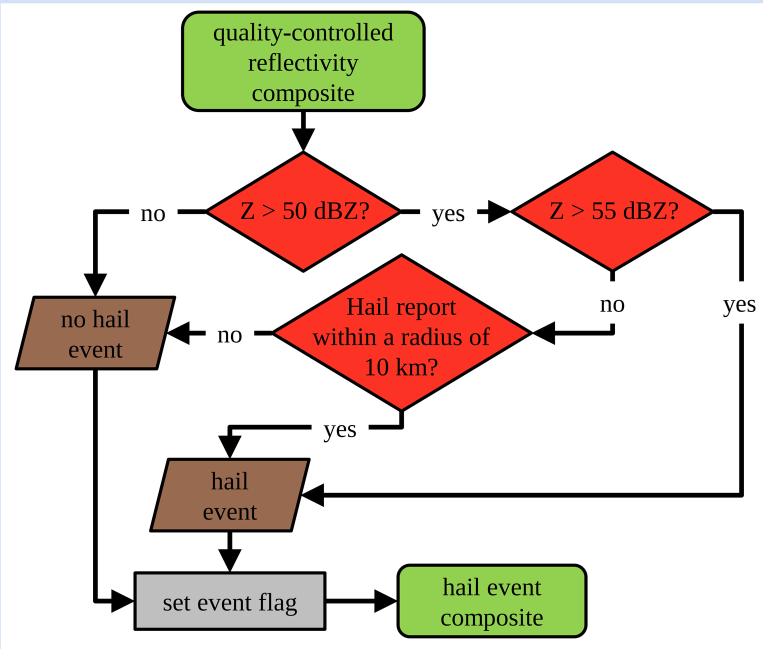

Figure 3: Selection workflow of the hail criterion.

A grid point is marked as a “hail event”:

- if the threshold of 50 dBZ is exceeded and there is a hail report within a radius of 10 km or
- if the threshold of 55 dBZ is exceeded.

Hail Reports

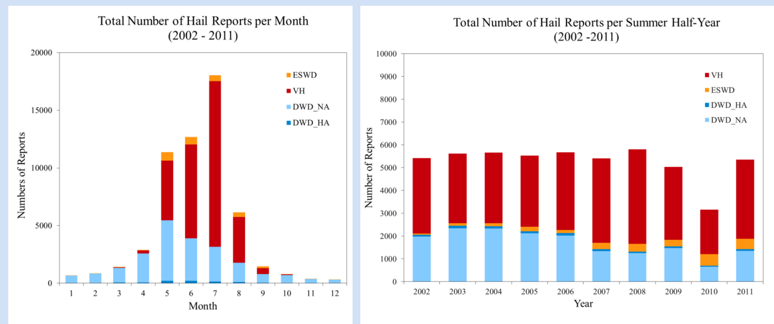

Figure 1: Temporal distribution of hail reports.
left: annual, right: per summer half-year 2002 – 2011

In addition to weather radar data we used 56 546 hail reports from different sources:

- DWD professional observation
- DWD volunteer observers
- ESWD volunteer observers
- Agricultural insurance loss data

About 92% of all hail reports describe events during the summer half-year (April – September).

Case Example: 23 August 2011 in the Western Part of Germany near the Border to the Netherlands

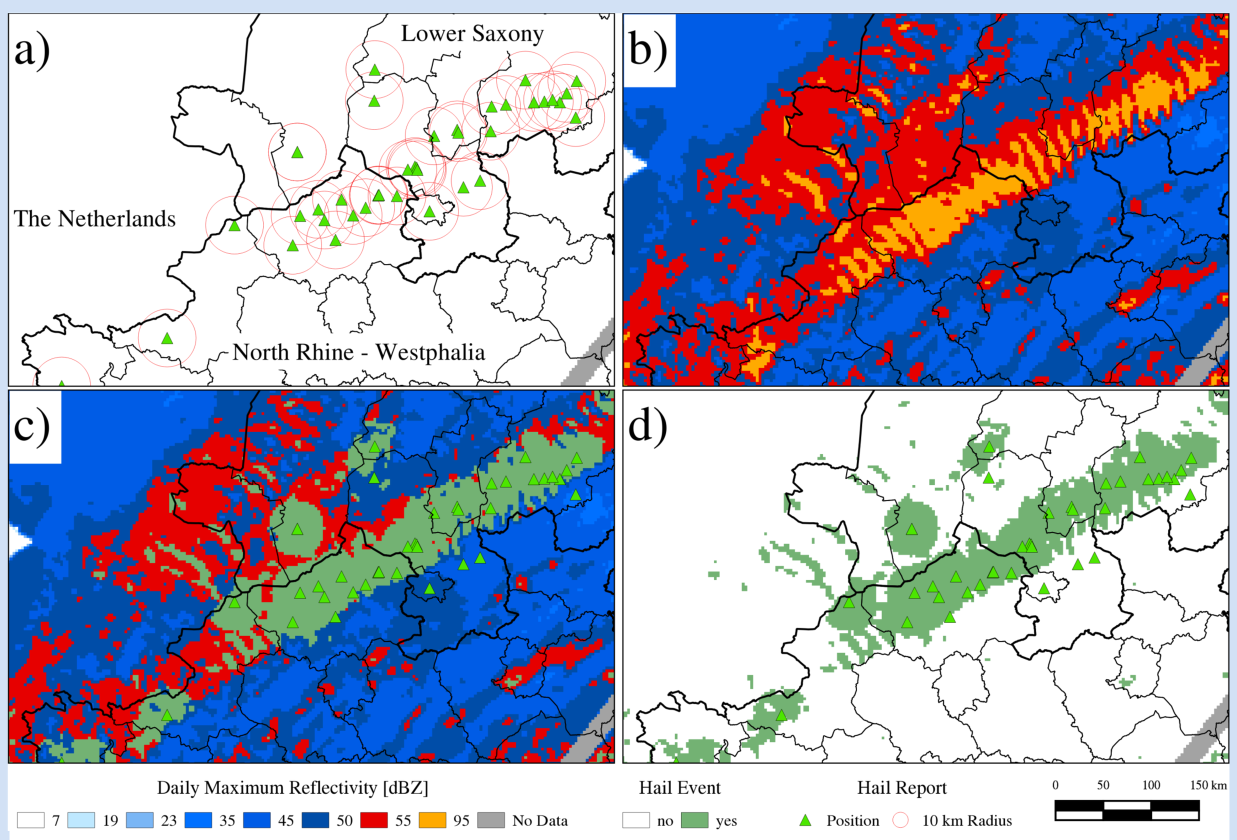

Figure 4: Example for selection by the hail criterion. The Figure shows the situation on 23 August 2011 in the border area between the Netherlands in the west and the two German federal states Lower Saxony in the north and North Rhine-Westphalia in the south.

After radar data pre-processing (Fig. 2), all grid points are analyzed for hail events for each day during the summer half-years (April–September) in the investigation period 2002–2011. Hail reports help to distinguish hail events and non-hail events in case of small hail (50 – 55 dBZ). Fig. 4 summarizes the selection process in a case example:

a. Location of the reports (triangles) of 23 August 2011. The red circles mark the 10 km radius
b. Maximum radar reflectivity of the day in dBZ. The exceedances of the 50-dBZ- threshold are marked red and of the 55-dBZ- threshold are marked orange
c. Selection by the hail criterion (see Fig. 3). Detected hail events are marked green
d. Areas, which are considered for the decadal climatology, are marked green.

The daily results were accumulated into a 10-year record of the annual average number of hail days per square kilometer (Fig. 5).

Results

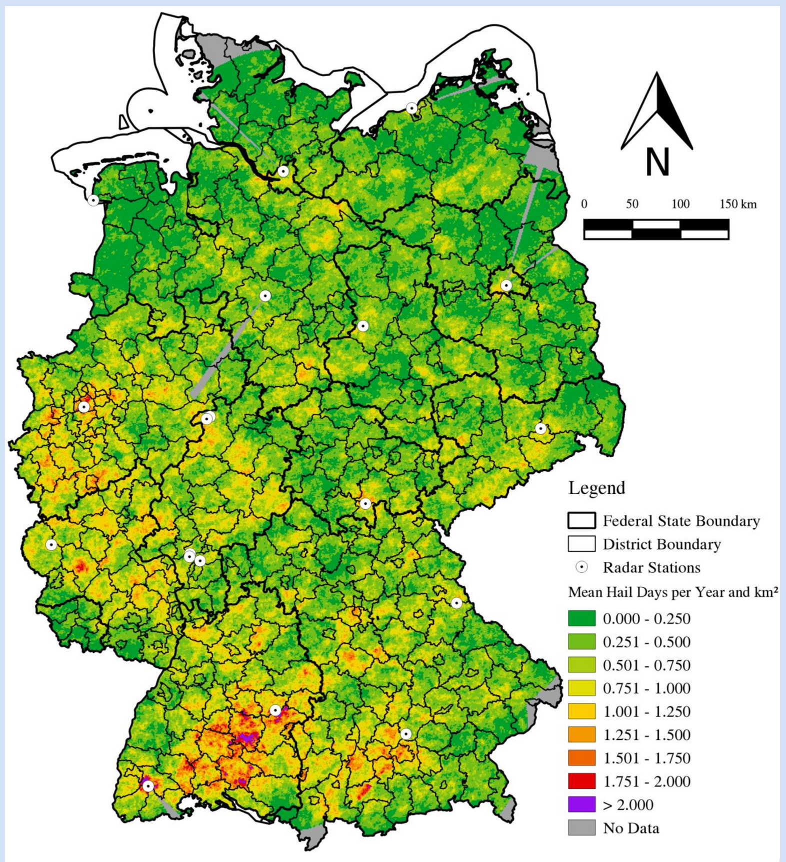

Figure 5: Average number of hail days per year and square kilometer during the summer half-year (April–September) in the investigation period 2002–2011.

The resulting hail frequency map shows an increase in the average number of hail days per year from north to south (Fig. 5). In particular, hailstorms occure less frequently in the Central North German Plain and the Mecklenburg Coastal Lowland, whereas the highest number of hail days occurs mostly in the uplands of the Black Forest and the Swabian Jura, but also in the Rhenish Massif, the Alpine Foreland and the Lower Rhine Plain. Moreover, the Feldberg region in the Southern Black Forest shows the highest number of hail days per year.

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