ZDR-Column Detection in Switzerland

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Motivation & Goals

- Information on the presence of differential reflectivity columns (so called ZDR-Columns) is known to improve nowcasting of hail and thunderstorm intensification, particularly in the US. In Europe however (and particularly in Switzerland), ZDR-columns have not yet been thoroughly investigated and little is known of their potential for nowcasting.
- The main goal of this work is to conduct a verification and sensitivity analysis of the MeteoSwiss ZDR-column detection algorithm.

Data & Methods

Data

- Dual-polarization radar data from the Swiss Weather Radar Network
  →Polar data for reprocessing ZDR-column products
  →Cartesian products: Probability of Hail (POH), Maximum estimated severe hail size (MESHS), maximum reflectivity (ZMAX or ZH)

Methods

- 5 Hailstorm case studies
- Verification of the correctness of the ZDR-Column-Detection Algorithm by manually reconstructing detected ZDR-Columns (location & height) using range-height indicators (RHIs) and detecting potential improvement options
- Sensitivity Analysis and Introduction of a maximum reflectivity (ZMAX)-threshold
  →filtering out detection-related and radar-related artefactual ZDR-columns
  →thresholds: ZH = 25-45 dBZ, ZDR=0.74-1.0 dB

MeteoSwiss ZDR-Column Detection Algorithm

- ZDR-values ≥ 1dB
- Radar visibility (50-200km) & quality-checked data
- Composite product of all 5 dual-polarization radars of the Swiss Weather Radar Network

Results

- The ZDR-Column Detection Algorithm **detects the ZDR-Columns correctly in location & height in roughly 72% of the investigated cases**. (→Fig. 1**)**
- 20.5% of the ZDR-Columns could not be verified mainly due to column height underestimation
- False ZDR-Column Detection through Three-Body Scattering was found
- Some ZDR-columns precede cell-detection (TRT-thunderstorm tracking algorithm)
- ZDR = 1.0dB more plausible ZDR-column heights as widely reported in literature
  →lower values likely lead to the detection of less relevant droplet sizes (→Fig. 3)
- **ZDR = 1.0dB + ZH=40 dBZ** potential indicator of hail cells, but shortens potential lead time
  →Fig. 2
- **ZDR = 1.0dB + ZH=25 dBZ** longer potential lead times, more ZDR-columns not related to a later thunderstorm evolution

Conclusions & Outlook

The MeteoSwiss ZDR-Column Detection Algorithm detects the ZDR-Columns in most cases correctly. The introduction of a ZMAX-threshold confines the detection of artefactual ZDR-columns. Different thresholds may be used (still under investigation):

- Good relation and potential for hail cell detection (ZMAX= 40 dBZ, ZDR = 1.0 dB)
- Better (potential) lead times with lower ZH-thresholds

Further studies could focus on the relation between ZDR-column heights and hail sizes, verifying ZDR-column occurrences with crowd-sourced hail reports. It could further be included as additional predictor for hailstorms in ML-models. A further refinement with ZDR-threshold tests in the range of 1-2 dB and ZH-thresholds of 15-25dBZ is suggested.

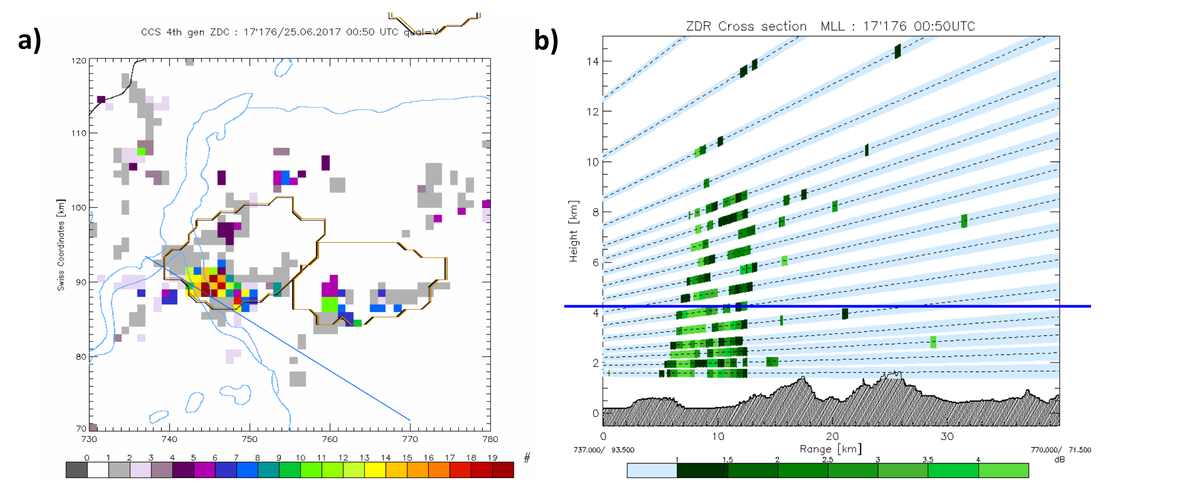

Fig. 1: Hailcell near Lago di Como, 25.06.2017, 00:50 UTC. a) Product of the MeteoSwiss ZDR-Column Detection Algorithm. ZDR-column heights are shown in 200m steps (e.g. 10 = 2km height). The blue line shows the position of the cross-section. **b)** Differential reflectivity cross-section, radar station Monte-Lema. The blue line indicates the 0°C-height level.

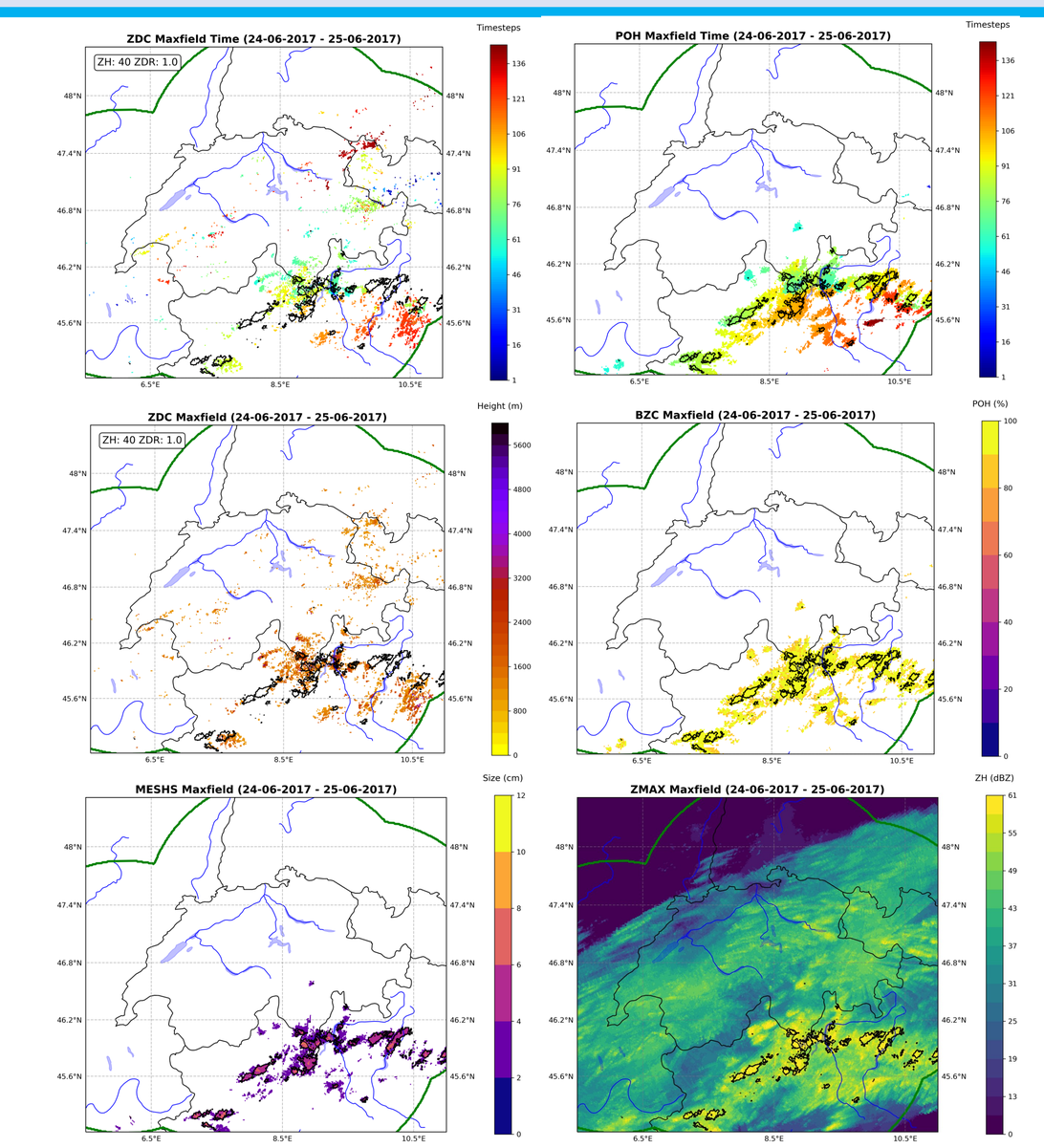

Fig. 2: Relationships between Maxfields of ZDR-columns, POH (≥ 80%), MESHS (≥ 2cm) and ZMAX over a convective period of 12h centered around the casestudy of 25th June 2017 with a threshold combination of ZDR=1.0 dB and ZH=40 dBZ. Black contours show MESHS >=4cm.

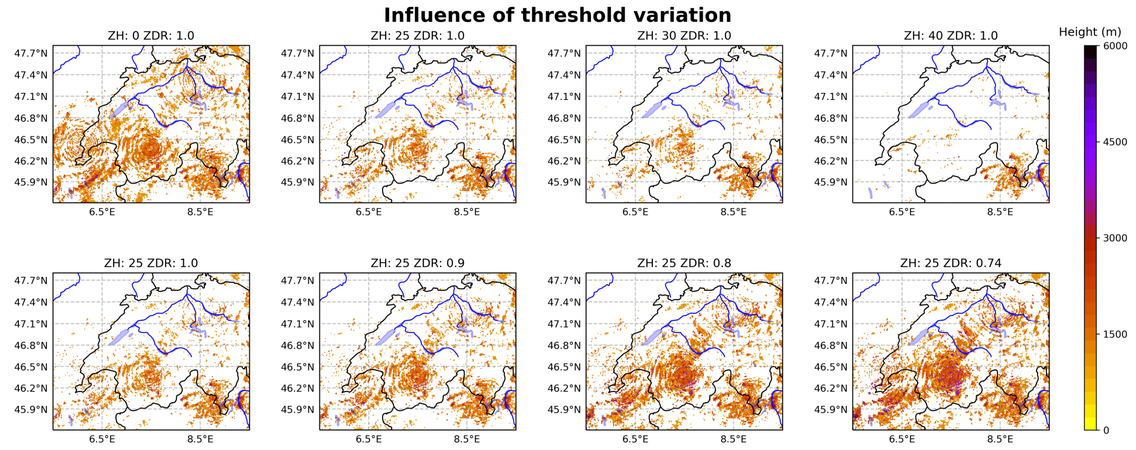

Fig. 3: The influence of varying ZDR and ZH-thresholds in a region where no POH ≥ 80% was detected (see Fig. 2, Maxfields for the same period shown here). With lower ZDR-thresholds, the ZDR-column heights increase in height to extreme heights (>4500m) especially close to the radar sites. A higher ZH-threshold leads to a higher restriction towards more severe cells.

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