ZDR-Column Detection in Switzerland
Christoph von Matt1, Hélène Barras1,3, Marco Boscacci4, Jordi Figueras i Ventura4, Alessandro Hering5, Marco Gabella6, Olivia Martius2,3, Urs Germann4
1 Institute of Geography, University of Bern, Bern, Switzerland
2 Oeschger Center for Climate Change Research, University of Bern, Bern, Switzerland
3 Mobfill Lab for Natural Risks, University of Bern, Bern, Switzerland
4 MeteoSwiss, Division for Radar, Satellite and Nowcasting, Locarno-Monti, Switzerland

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 Storm case studies
- Verification of the correctness of the ZDR-Column-Detection Algorithm by manually reconstructing detected ZDR-Colums (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=0-7.4 dB

MeteoSwiss ZDR-Column Detection Algorithm
- ZDR-values ≥1 dB
- 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-colums precede cell detection (TRT-thunderstorm tracking algorithm)
- ZDR = 1.0 dB more plausible ZDR-column heights as widely reported in literature
- Lower values likely lead to the detection of less important droplet sizes (Fig. 3)
- ZDR = 1.0 dB + 2H=40 dBZ potential indicator of hail cells, but shorter potential lead time
- ZDR = 1.0 dB + 2H=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 time with lower ZH-thresholds
- Further studies could focus on the relation between ZDR-column heights and hail sizes, verifying ZDR-column occurrences with curtain-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.

References


Available in https://www.meteoswiss.admin.ch/content/dam/meteoswiss/de/Messwesen/Messsysteme/Radar/Radar.pdf

Fits, C., Ryzhkov, A., 2011. ZDR columns as qualitative tool for hail growth and downdraft evolution – Presented at the 7th Conference on Severe Local Storms, pp. 9.


Fig. 1: Hallcell 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 ~ 24m 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 values (~450m) especially close to the radar sites. A higher ZH-threshold leads to a higher restriction towards more severe cells.