P13.14 IMPROVEMENTS OF POLARIMETRIC RADAR ECHO CLASSIFICATIONS

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1. INTRODUCTION

A two-step radar echo classification is applied on polarimetric radar data:

- A pre-classification between meteorological and non-meteorological echoes: “Nexrad” (Schuur et al, 2003) or “MeteoFrance” (Gourley et al, 2007)
- For the meteorological echoes, a hydrometeor classification: “Nexrad Warm Season” or “Nexrad Cold Season” (Schuur et al, 2003), or “BMRC” (Keenan, 2003)

All algorithms use a fuzzy logic scheme, where “Not classified” is the output if none of the classes exceed a configurable minimum combined “weight”. For the hydrometeor classification, temperature information is usually given as a constraint to avoid gros mis-classification.

The algorithms have been applied to data of various case studies. As a result, the problems shown in the following section became evident.

2. LIMITATIONS OF THE INITIAL ALGORITHMS

Initially, the various radar echo classification algorithms have been applied on range gate basis, i.e. a pre-classification and classification has been performed for the sample data (reflectivity and polarimetric quantities) of each particular range gate of the polar radar volumes. Due to random signal fluctuation and occasionally due to extreme scattering phenomena (e.g. Mie effects for large particles at small wavelength), significant mis-classification has occurred.

2.1 Mis-classification of the melting layer

In two case studies, the algorithms have been applied on data sampled in stratiform precipitation with a well-established bright band signature in the reflectivity and the polarimetric radar data. One case study was observed with a Selex-SI Meteor 50DX X-Band radar (Borgmann et al, 2007), the other one with a Selex-SI METEOR 500 CDP C-Band radar.

Fig. 1 shows observed RHI scan data of the first case study (near Torino, Italy; X-Band data; data © ARPA): The melting layer is clearly visible by enhanced reflectivity and differential reflectivity, and by reduced polarimetric correlation. The figure also shows the application of the “Nexrad” pre-classifiaction: Large areas of the melting layer are mis-classified as biological scatter and partially as ground clutter.

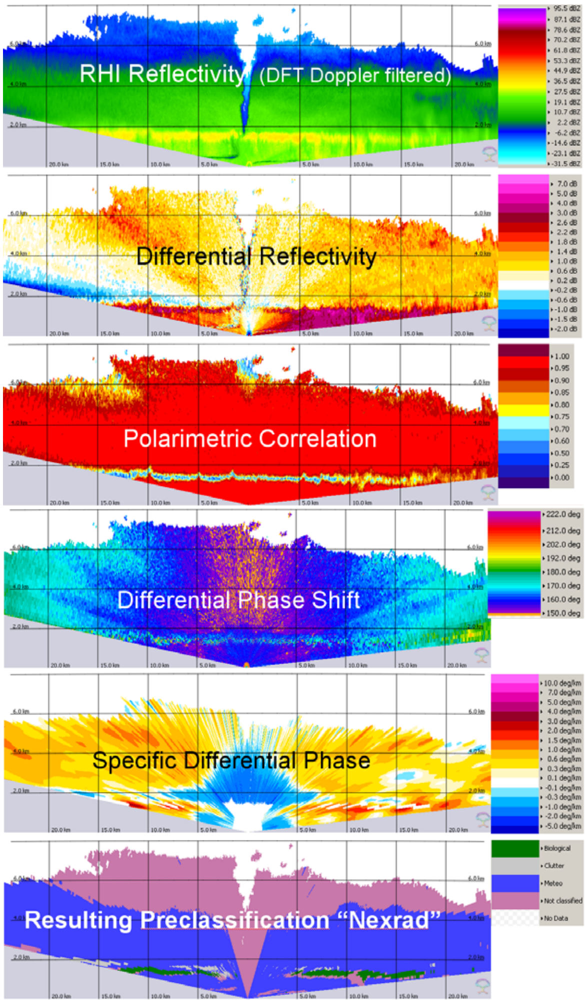

Figure 1: RHI-Scan of X-Band radar data (04-May-2007, 08:13 UTC; near Torino, Italy; data © ARPA) in statiform precipitation, and application of the “Nexrad” pre-classification.

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Fig. 2 shows the results after application of the hydrometeor classification step: Partially, liquid phase classification remain well above the melting layer, even though temperature information was given as a constraint to the fuzzy logic algorithms.

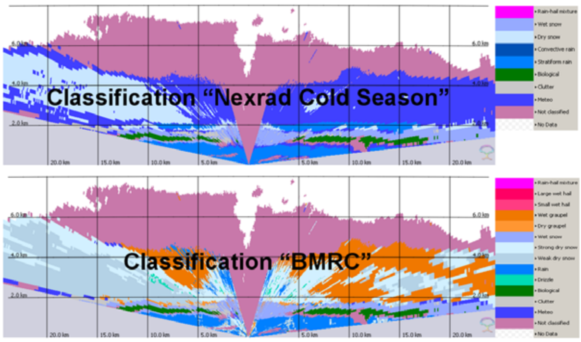

Figure 2: Application of the "Nexrad Cold Season" and "BMRC" hydrometeor classifications on the data of Fig. 1.

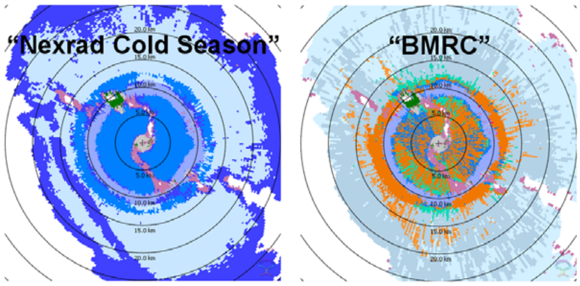

Figure 3: Application of the "Nexrad Cold Season" and "BMRC" hydrometeor classifications on data from a C-Band radar, sampled in stratiform precipitation (Neuss, Germany; 28-Apr-2008, 15:45 UTC).

Fig. 3 shows similar results for another case study of stratiform precipitation. These data have been observed with an C-band radar. In that 10-deg PPI scan, The melting layer appears as a ring at about 10 km distance. As for the X-band data, liquid phase echoes are resulting above the malting layer (i.e. at distances larger than about 10 km).

2.2 *Mis-classification of hail*

Fig. 4 shows C-Band radar data from a case study with a severe hail storm in Neuss, Germany (data from 30-May-2008, 03:45 UTC), which produced hail stones up to 5 cm. The polarimetric data exhibit hail signatures at about 15 km NW of the radar (indicated by circles): relatively low differential reflectivity and polarimetric correlation.

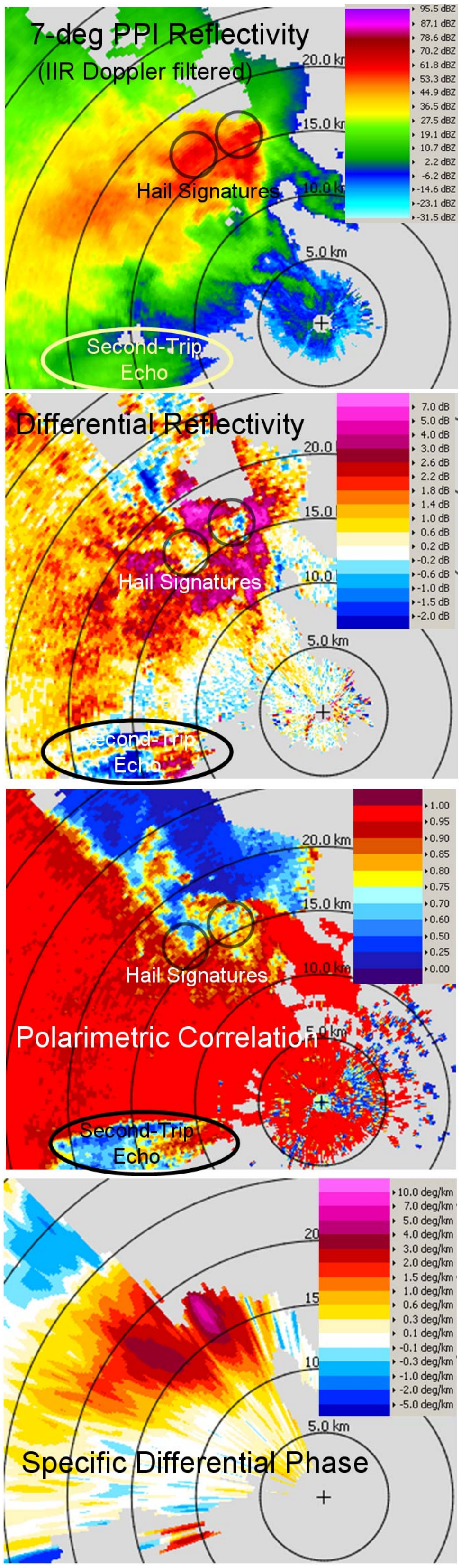

Figure 4: C-Band radar data from a hail storm (Neuss, Germany; 30-May-2008, 03:45 UTC). Data are from a 7-deg PPI scan.

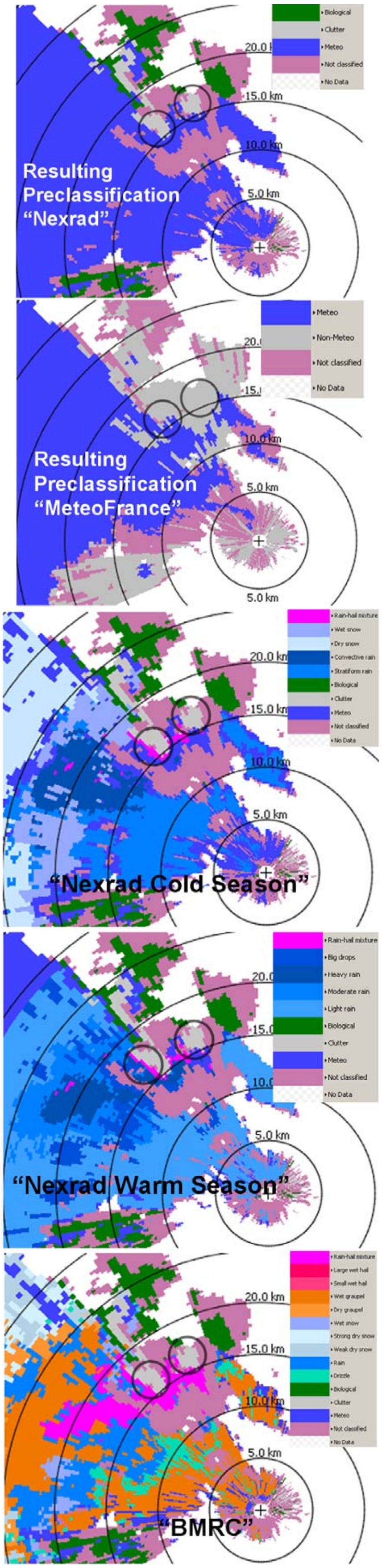

Figure 5: Results of the radar echo classifications applied on the data of Fig. 4.

Figure 5 shows the results of all pre-classification and hydrometeor classification algorithms on the data of Fig. 4: the hail cores are mis-classified as non-meteorological echoes. Furthermore, some areas above the melting layer (which is at about 25 km distance for this 7-deg PPI scan) are classified as liquid phase.

3. SOLUTION

To avoid mis-classifications as shown in the previous section, various steps have been added to the echo classification algorithms:

- Vertical plausibility check for non-meteo echoes: non-meteorological echoes are not allowed above meteorological echoes (but “clutter in the lowest slice and meteo above” remains valid as a common scenario)
- Vertical plausibility check for precipitation: Liquid-phase echoes are not allowed above solid-phase echoes. This step needs careful consideration with respect to mix-phase echoes like melting snow or rain-hail mix. Also, a careful consideration of hail and graupel, which are solid phase but may occur at quite high temperature, is necessary.
- No side-lobe clutter is allowed for high reflectivity. For instance, a 60-dBZ echo at an antenna angle 5 deg from ground cannot be clutter but must be a meteorological echo.

For the vertical checks, special care has to be taken on tilted phenomena, e.g. a tilted hail shaft. Additionally, for 3D polar scans, the time difference between subsequent elevation slices may cause artificial tilting due to fast-moving echoes. As a consequence, the vertical plausibility checks have to be extended to 2D plausibility checks (horizontal and vertical dimension).

Finally, to remove isolated mis-classifications due to random signal fluctuation, optional 2D processing steps can be applied:

- 2D smoothing of Fuzzy Logic weights before the de-fuzzification step
- 2D segregation of Echo Classification results

4. RESULTS

4.1 Results for stratiform precipitation

Application of the improved radar echo classification algorithms of the data of the case study with stratiform precipitation (cf. section 2.1) results in the displays shown in Fig. 6. Compared to Figs. 2 and 3,

- the melting layer is now correctly classified as meteorological echo,
- no liquid phase classification remain above the melting layer.

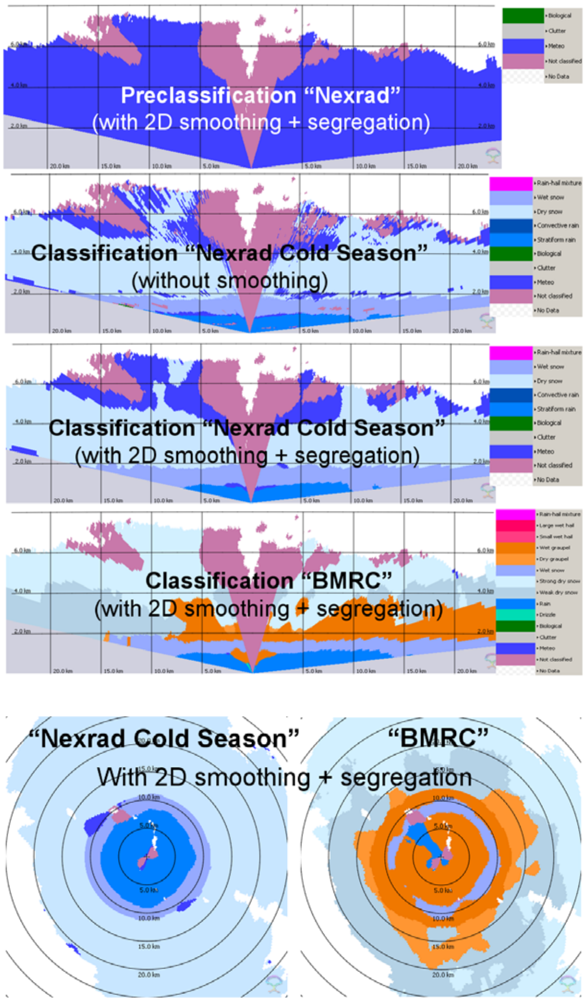

Figure 6: Improved radar echo classifications for stratiform precipitation. Same data as in Figs. 1 to 3.

4.2 Results for the hail storm case

Application of the improved radar echo classification algorithms of the hail storm data (cf. section 2.2) results in the displays shown in Fig. 7. Compared to Figs. 5, the hail cores are now identified as meteorological echoes and classified correctly as hail or rain-hail mix. Furthermore, no liquid-phase classifications remain above the melting layer.

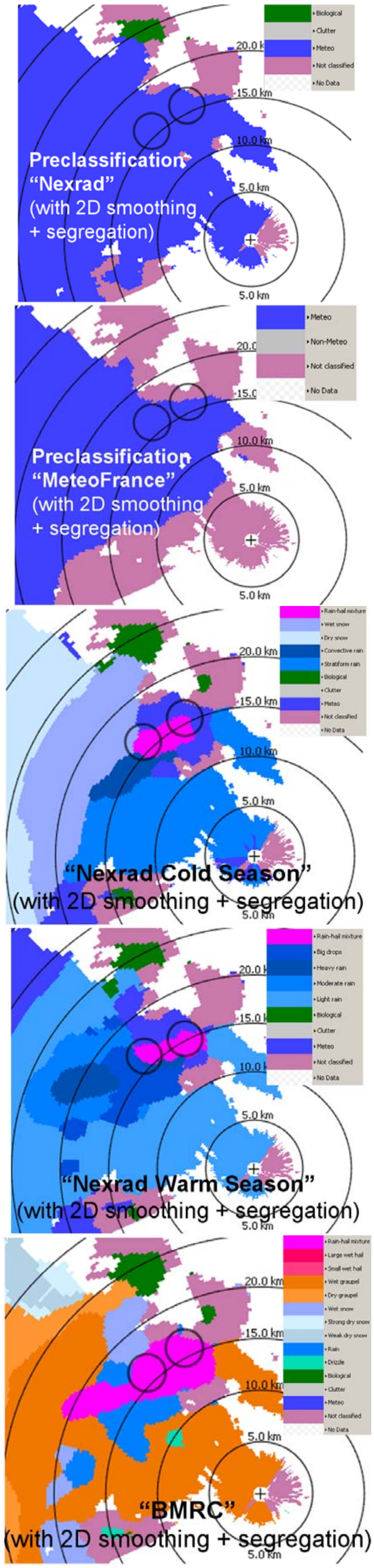

Figure 7: Improved radar echo classifications for the hail storm case. Same data as in Figs. 4 and 5.

5. CONCLUSIONS

- Echo classification on range gate data only is error prone
- Vertical plausibility checks improve classification results significantly
- Plausibility checks may need to be extended to 2D check
- 2D smoothing and segregation avoid isolated remaining mis-classifications and avoid small-scale classification variability between “similar” types

→ Echo classification algorithms require 2D data analyses

6. REFERENCES

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