

Motivation

Dual-polarization (dual-pol) weather radars enable the estimation of both precipitation quantity and hydrometeor type. This study identifies the optimal precipitation type classification method for Belgium’s C-band radar network.

Method 1: BMRC

The Australian Bureau of Meteorology Research Center (BMRC) uses 1D-membership functions and a fuzzy logic approach based on [2].

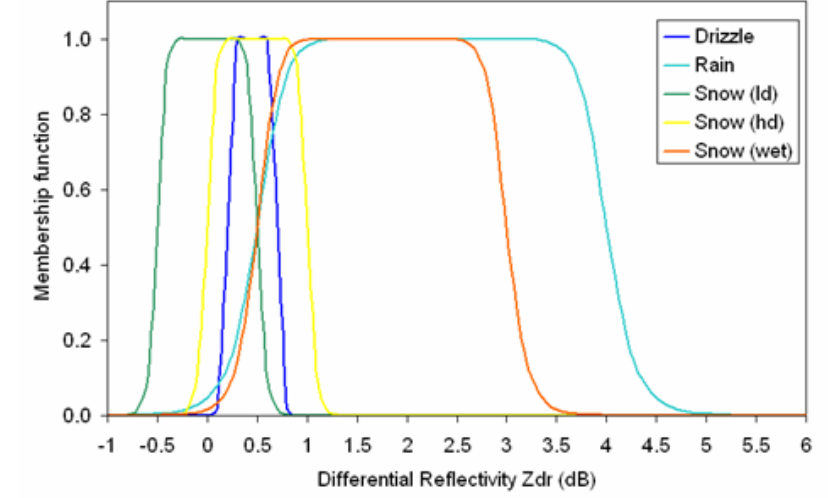


Image from: Bringl, Thural, Hannesen: Dual-Polarization Weather Radar Handbook: An Overview of Dual-Polarization Weather Radar: Theory and applications, 2nd edition

Method 2: Dolan

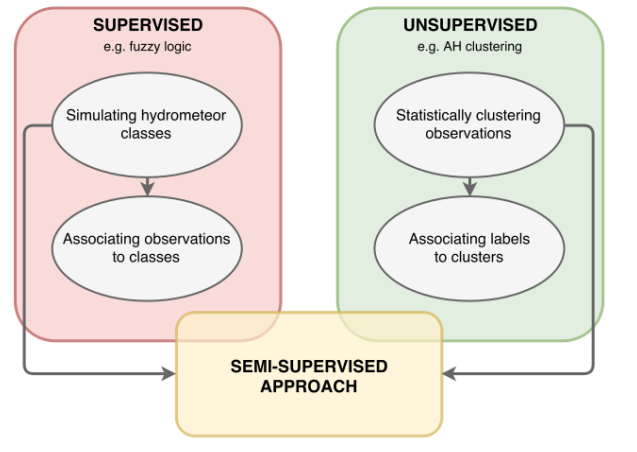
Dolan’s method [3] also uses a 1D fuzzy logic classification method for C-band radars.

	Z_{dr}			Z_{dr}			K_{dp}			ρ_{hv}			Temperature		
	m	s	d	m	s	d	m	s	d	m	s	d	m	s	d
Drizzle	175	20	100	0.46	0.46	0.0	0.01	0.01	2.0	1.0	0.015	3.0	400	410	500
Rain	70	10	100	2.3	2.7	0.0	5.5	5.5	100	1.0	0.025	3.0	400	510	500
Ice crystals	120	10	100	1.0	1.1	7.0	-0.008	0.3	1.0	0.95	0.07	3.0	250	260	150
Aggregates	200	10	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300	300	250
Wet snow	210	10	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.5	5.0
High-velocity	44.5	10	100	1.6	1.2	3.0	1.9	1.9	5.0	1.0	0.04	2.0	-25	200	2.0
Low-velocity	37.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.08	3.0	1.0	0.025	1.0	-300	25.0
Hail	62.5	14.3	10.0	0.14	0.56	0.0	0.6	3.5	6.0	0.97	0.1	3.0	0.0	100.0	5.0
Vertical	57.6	8.2	10.0	4.4	1.9	4.0	3.4	3.3	6.0	0.99	0.03	3.0	440	21.0	20.0
aligned ice	-1.0	25.0	20.0	-0.90	0.9	0.0	-0.75	0.75	30.0	0.95	0.022	3.0	-300	50.0	25.0

Parameters of beta-membership functions to separate the 10 different precipitation types.
Table A2, Dolan et al. (2013) [3]

Method 3: Basic

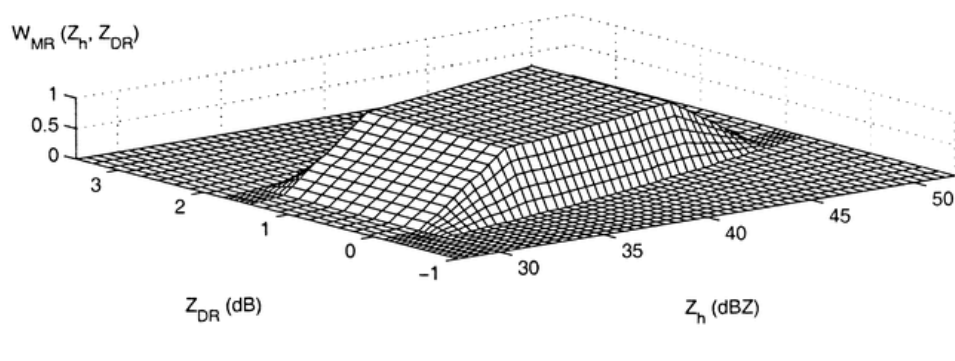
The semi-supervised classification algorithm of Basic [4] separates 9 precipitation types. It is used with default C-band centroids in this work.



Scheme of the semi-supervised algorithm. Basic et al., Fig. 1.

Method 4: Wradlib

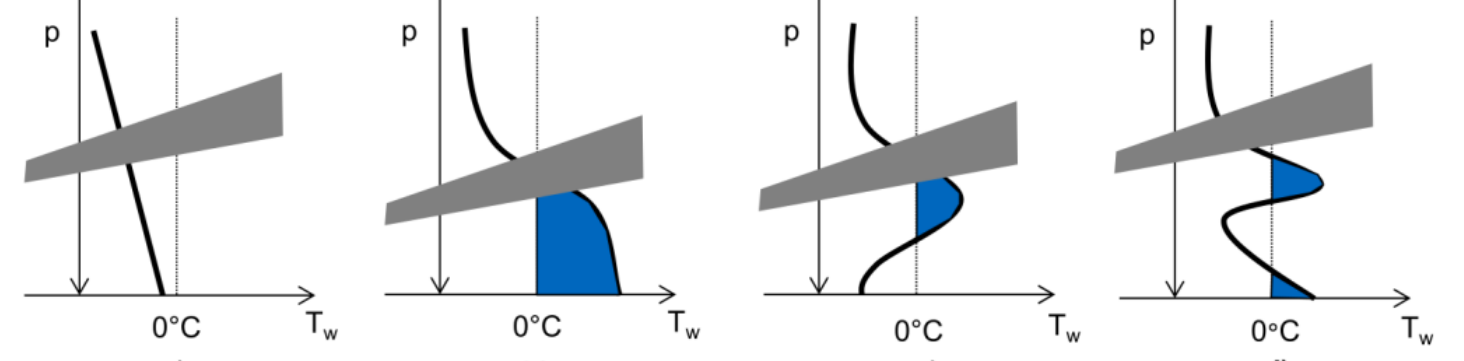
A 2D membership function approach based on [5], [6] as implemented in the wradlib Python library [7].



Two-dimensional weighting function for moderate rain, WMR(2h, ZDR), over the space Zdr, Zdr, Zdr. Zrn et al. [6], Fig. 1.

Ground transition

The dual-pol methods identify precipitation types at the altitude of the radar beam. The transition towards the ground uses the method of Steinert et al. (2021) [8] with vertical temperature profiles and pressure from RMI’s numerical weather prediction model ALARO.



Temperature vertical profiles (black) and melting area (blue) below the radar beam (gray). Steinert et al., Fig. 6.

Validation

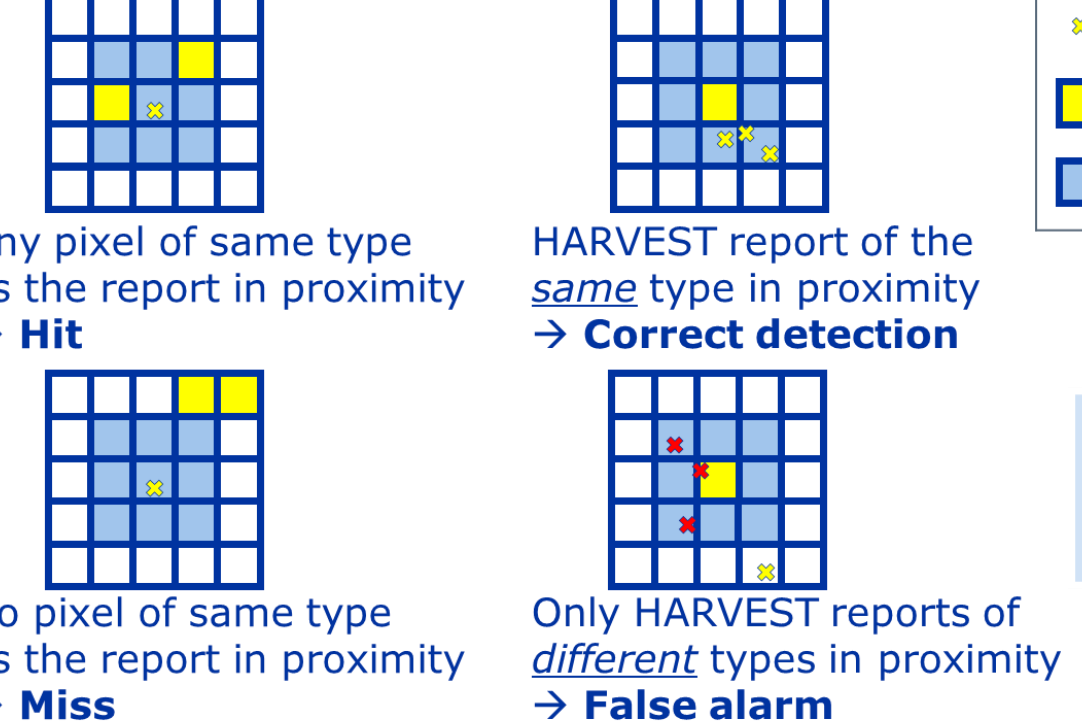
Benchmark: INCA-BE

The INCA-BE deterministic nowcasting system [1] includes an analysis of 5 precipitation types at the ground, provided on a 1km grid.

Ground truth: HARVEST reports

Weather reports are received from users via the RMI app. The raw reports are checked for plausibility, clustered in space (1km) and time (5min) to reduce ambiguity, and matched to the 1km dual-pol precipitation type grids.

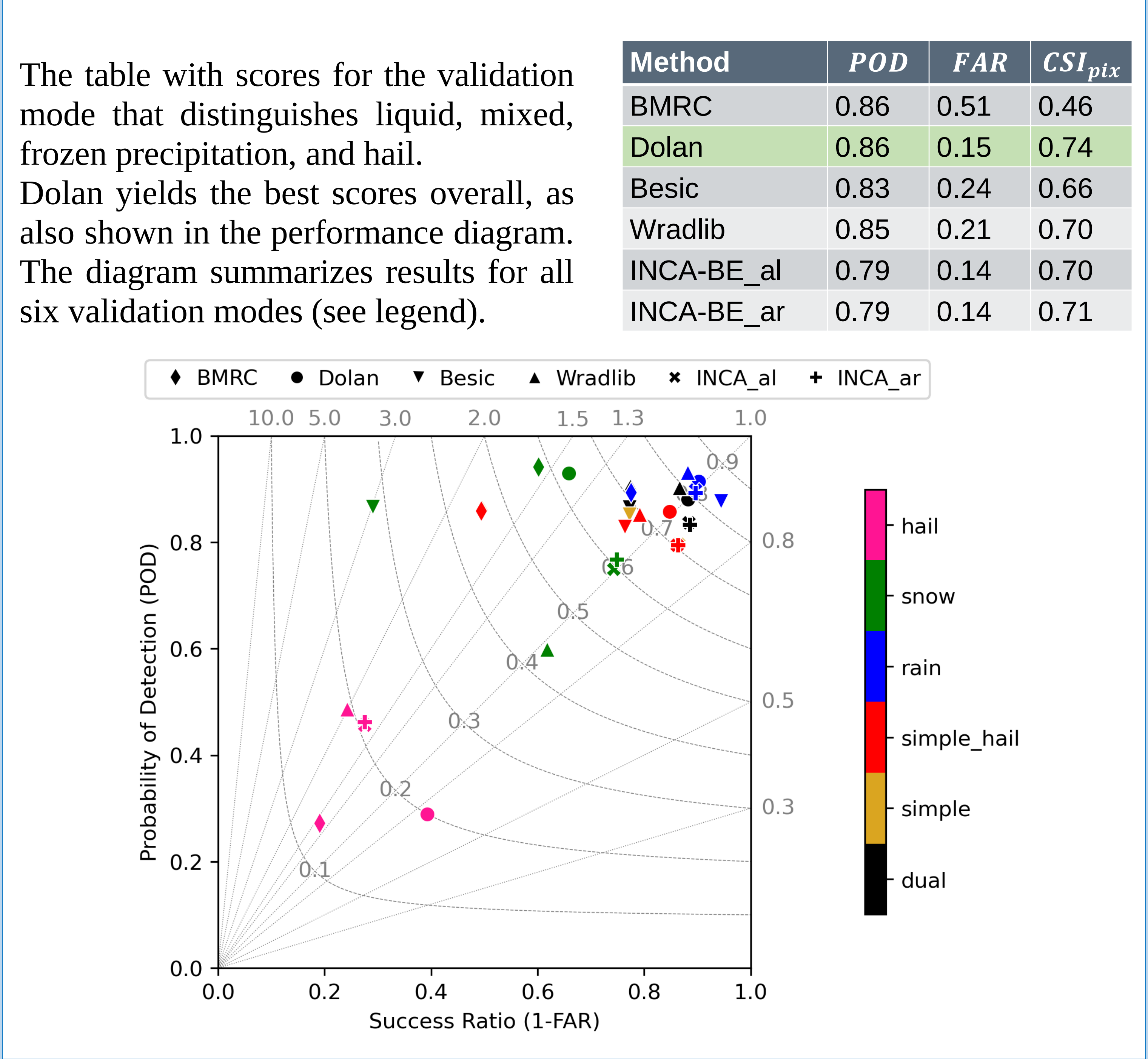
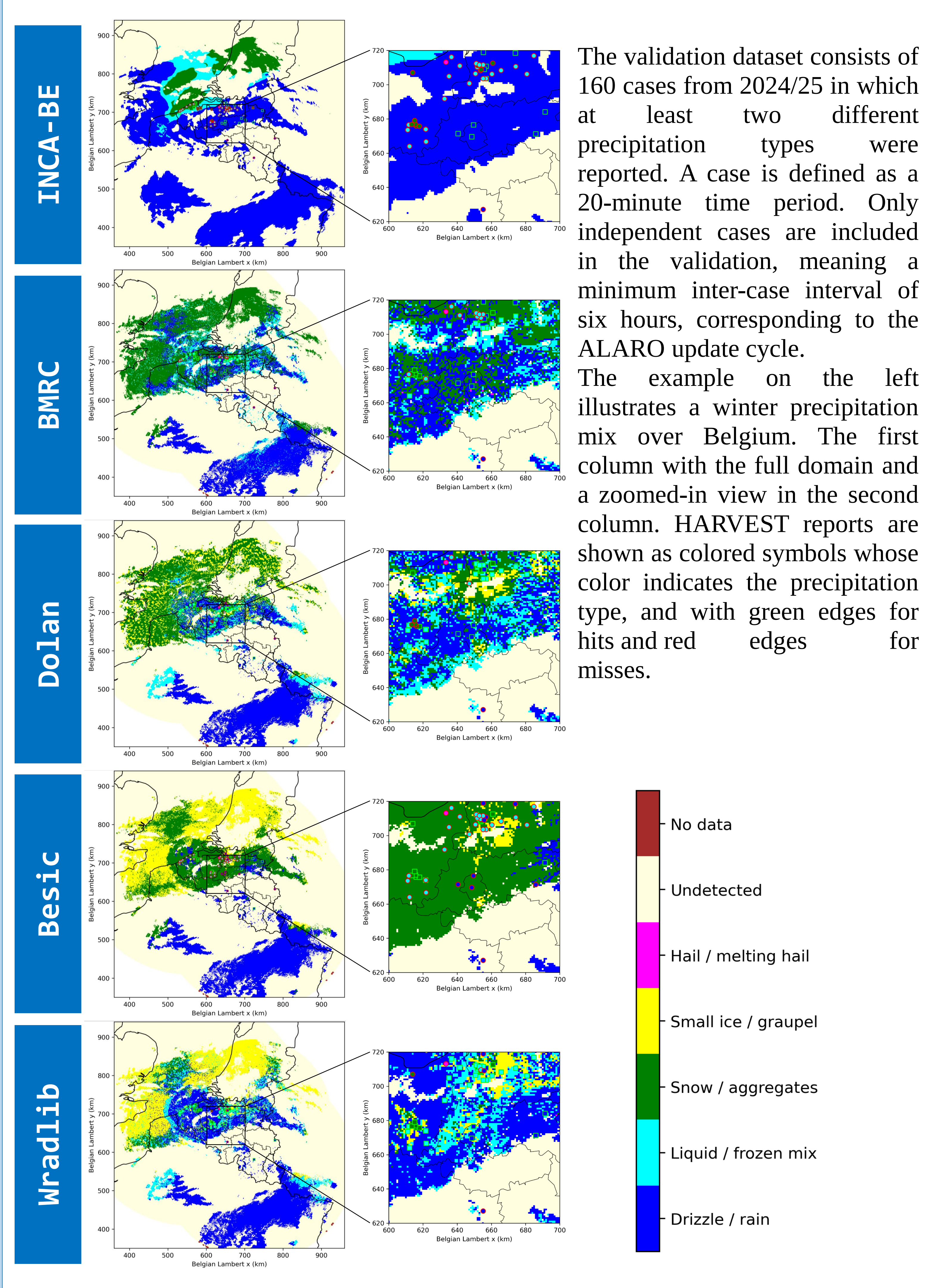
Example for 3x3 pixel matching → defines the proximity for finding matches



Reported	Yes	No
Predicted		
Yes	Hits	False alarms
No	Misses	Correct no

Example: 10/02/2025 1500UTC

Statistic and Scores



Acknowledgements

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References

[1] INCA-BE technical report: <https://zenodo.org/record/5798952>

[2] Keenan et al. (2003): Aust. Met. Mag. Hydrometeor 52 (2003) 23-31

[3] Dolan et al. (2013): doi: 10.1175/JAMC-D-12-0275.1

[4] Basic et al. (2016): doi: 10.5194/amt-9-4425-2016

[5] Straka et al. (2000): doi: 10.1175/1520-0450(2000)039<1341:BHCAQU>2.0.CO;2

[6] Zrníc et al. (2001): doi: 10.1175/1520-0426(2001)018<0892:TAPFAC>2.0.CO;2

[7] Wradlib hydrometeor classification: https://docs.wradlib.org/en/latest/notebooks/classify/2d_hmc.html

[8] Steinert et al. (2021): doi: 10.1175/WAF-D-20-0232.1

