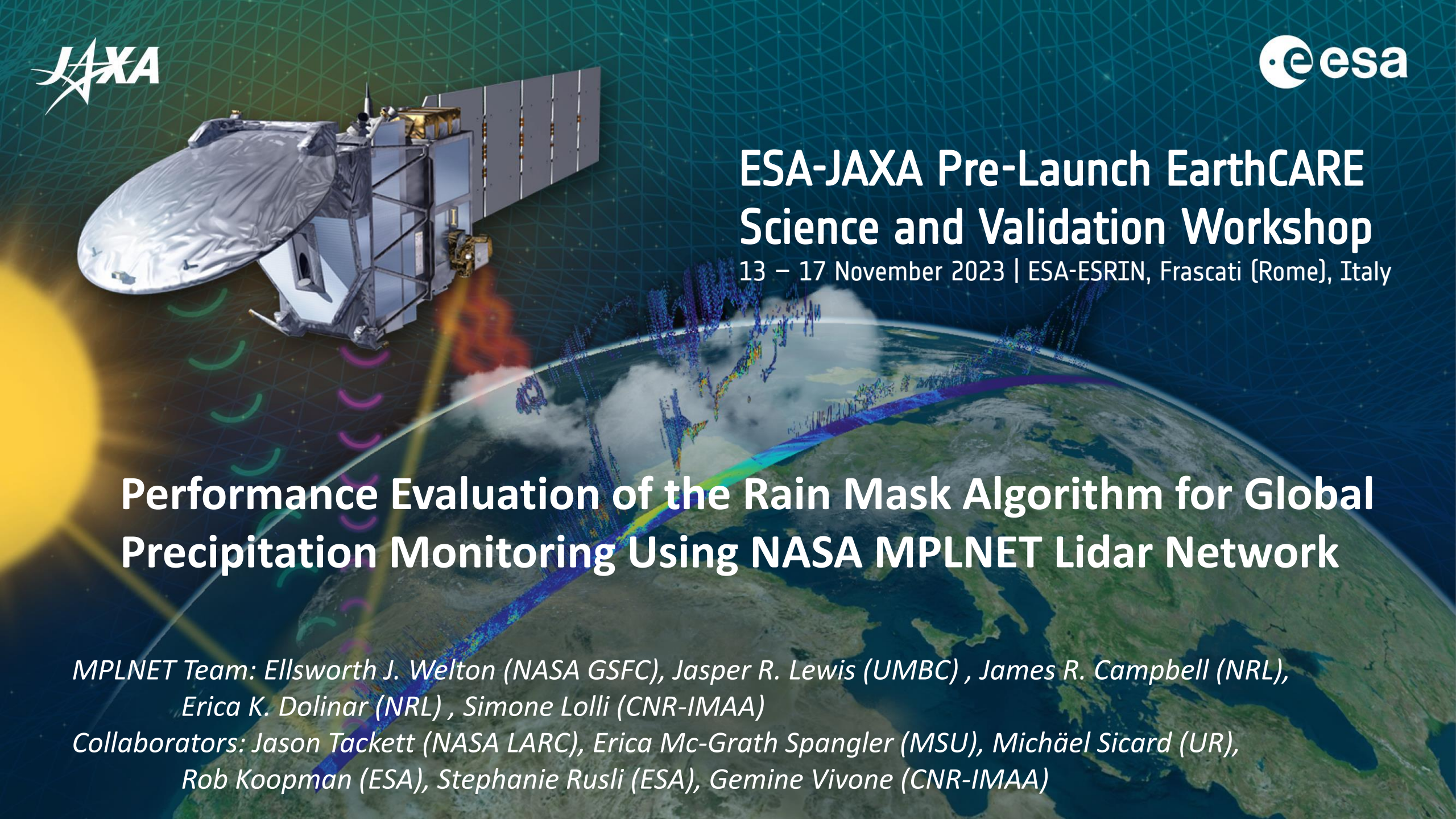

ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Performance Evaluation of the Rain Mask Algorithm for Global Precipitation Monitoring Using NASA MPLNET Lidar Network

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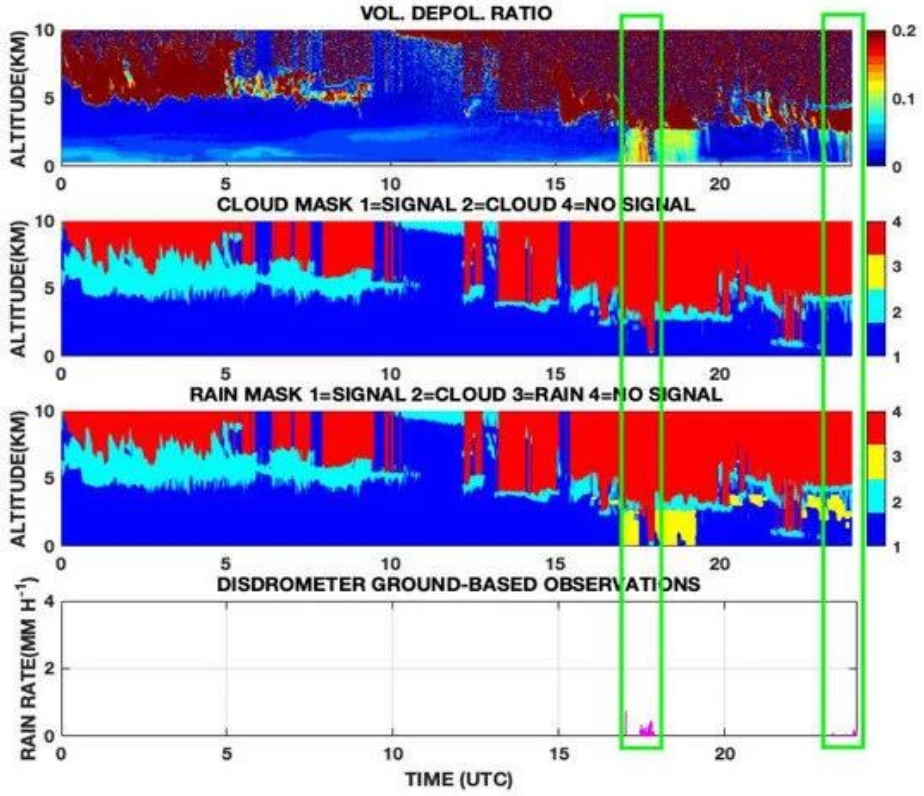
Rain Masking Algorithm (RMA)

- We present the results of testing the rain mask algorithm, developed for potential use in the NASA MPLNET lidar network over a period of several years.
- The rain mask algorithm aims to detect precipitation events from lidar measurements of the volume depolarization ratio (VDR) under cloud base.
- The algorithm will help in validating satellite cloud profiling radar observations of the European Space Agency EarthCARE mission.



EarthCARE-MPLNET Cal/Val NNH20ZDA001N-EUSPI

Intercomparison

- The Rain Masking Algorithm using lidar observations as input, categorically outputs a rain or no-rain mask which has 60-seconds temporal resolution.
- Data is then aggregated into 60-minute bins for comparison.
- The intercomparison is carried out considering a co-located disdrometer as reference. The protocol involves transforming the disdrometer rainfall intensity at a 60-second resolution, aggregated into a 60-minutes bin,. into two classes: **class 1 for "rain" and class 0 for "no-rain".**
- Data where lidar data are completely attenuated, or where the algorithm indicates that the precipitation does not reach the ground, are excluded
- For a bin, to be accepted for comparison, it must have **rain detected for a minimum of five minutes within sixty minutes period.**

Intercomparison Protocol

- Two MPLNET sites: Goddard Space Flight Center (GSFC), USA and Universitat Politecnica de Catalunya (UPC), Spain.

- Intercomparison based on categorically distinguishing between **rain** and **no-rain events** using different statistical variables such as accuracy, error, sensitivity, specificity, precision, false positive rate, F1-score, Matthews Correlation Coefficient, and Kappa

- **Database Homogenization**: no rain events occur more frequently than rain events, the database is normalized to include an equal distribution of both types, with 50% rain events and 50% no rain events. The no rain events are **randomly selected** to match the number of rain events.

- Precipitation not reaching the ground is not considered in the intercomparison

Statistics

Disdrometer Actual Class \ RMA Predicted Class	Positive	Negative	
Positive	True Positive (TP)	False Negative (FN) Type II Error	**Sensitivity** $\frac{TP}{(TP+FN)}$
Negative	False Positive (FP) Type I Error	True Negative (TN)	**Specificity** $\frac{TN}{(TN+FP)}$
	Precision $\frac{TP}{(TP+FP)}$	**Negative Predictive Value** $\frac{TN}{(TN+FN)}$	**Accuracy** $\frac{TP+TN}{(TP+TN+FP+FN)}$

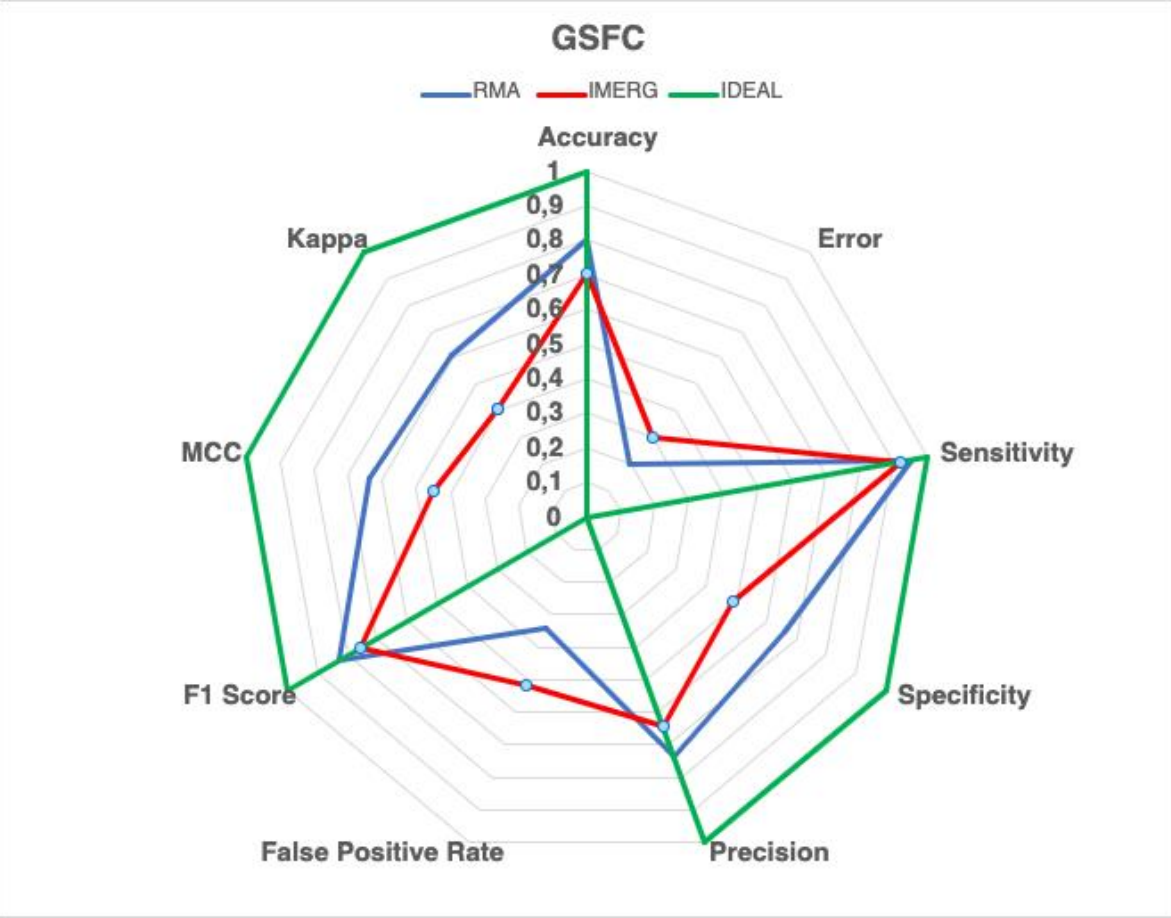
$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP+FP)(TP+FN)(TN+FP)(TN+FN)}}$$

FPR: the false positive rate measures the ratio of false positives within the negative samples

Specificity: When it's actually no-rain, how often does it predicts no-rain?

MCC takes into account all four values in the confusion matrix, and *a high value (close to 1) means that both classes are predicted well*, even if one class is disproportionately under- (or over-) represented.

Intercomparison at NASA Goddard Space Flight Center
GSFC; 38.99N; 76.84W; 55 m a.s.l., Feb 2020-May 2022, 398 rain events



The accuracy is 0.81. RMA correctly detects around 81% of rain events.

The rain mask algorithm has a high sensitivity of 0.96, accurately recognizing 96% of occurrences.

The F1-score of 0.82,
the Matthews Correlation Coefficient of 0.62, and the Kappa coefficient of 0.58 provide balanced measures of the algorithm's overall performance.

Intercomparison at NASA Goddard Space Flight Center
GSFC; 38.99N; 76.84W; 55 m a.s.l., Feb 2020-May 2022, 398 rain events

RMA

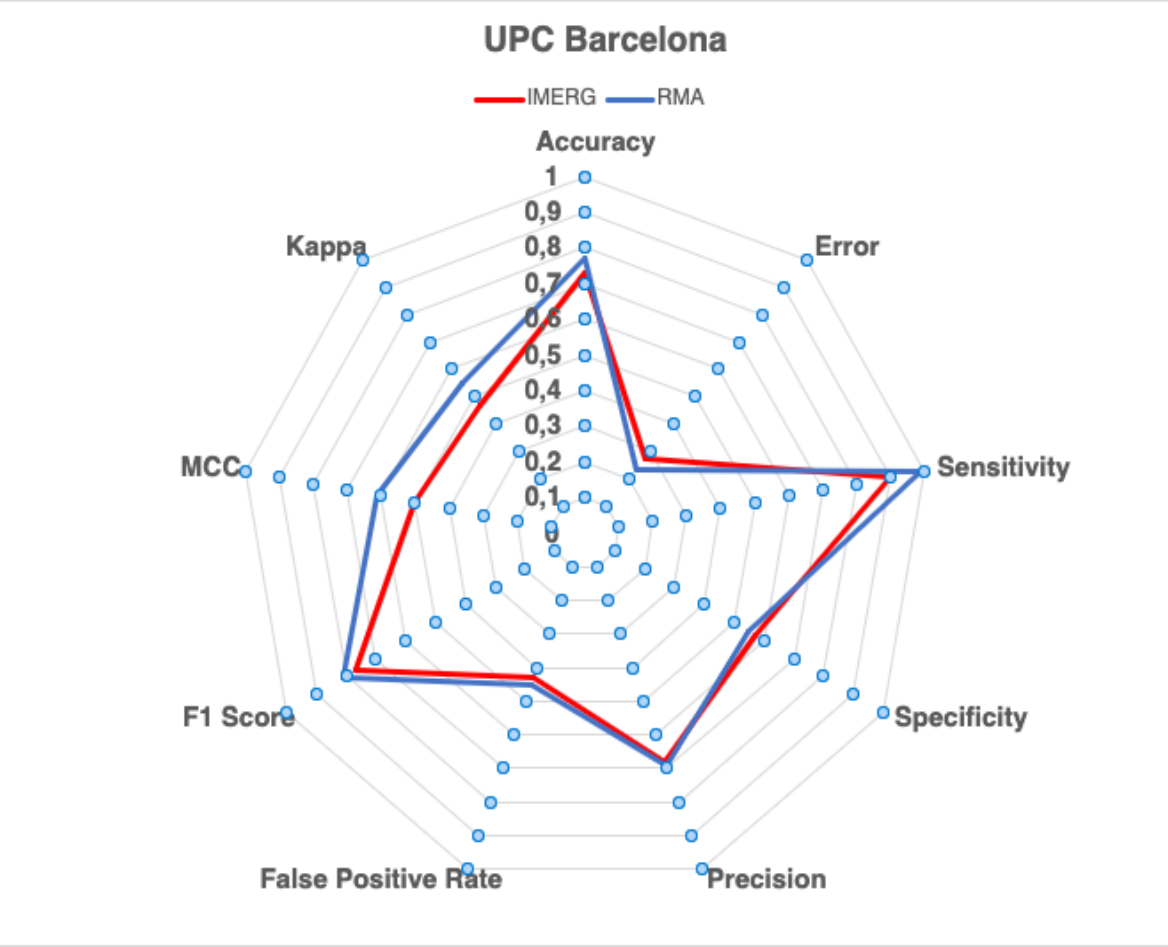
Disdrometer	No Rain	Rain	Total
No Rain	378(92.46%)	20(7.54%)	398
Rain	136(34.17%)	262(65.83%)	398
Total	504	292	796

IMERG

Disdrometer	No Rain	Rain	Total
No Rain	361(90.70%)	37(10.30%)	398
Rain	205(51.51%)	193(48.49%)	398
Total	566	230	796

Intercomparison at Universitat Politecnica de Catalunya, Barcelona Spain

UPC; 41.38N 2.11E, 125 m a. s. l., 2019-2020, 519 rain events



RMA correctly detects around 78% of rain events

RMA exceptional sensitivity of 0.99, Specificity of 0.55 indicates moderate performance in correctly identifying no-rain events.

Precision is 0.70, good level in predicting positive rain events.

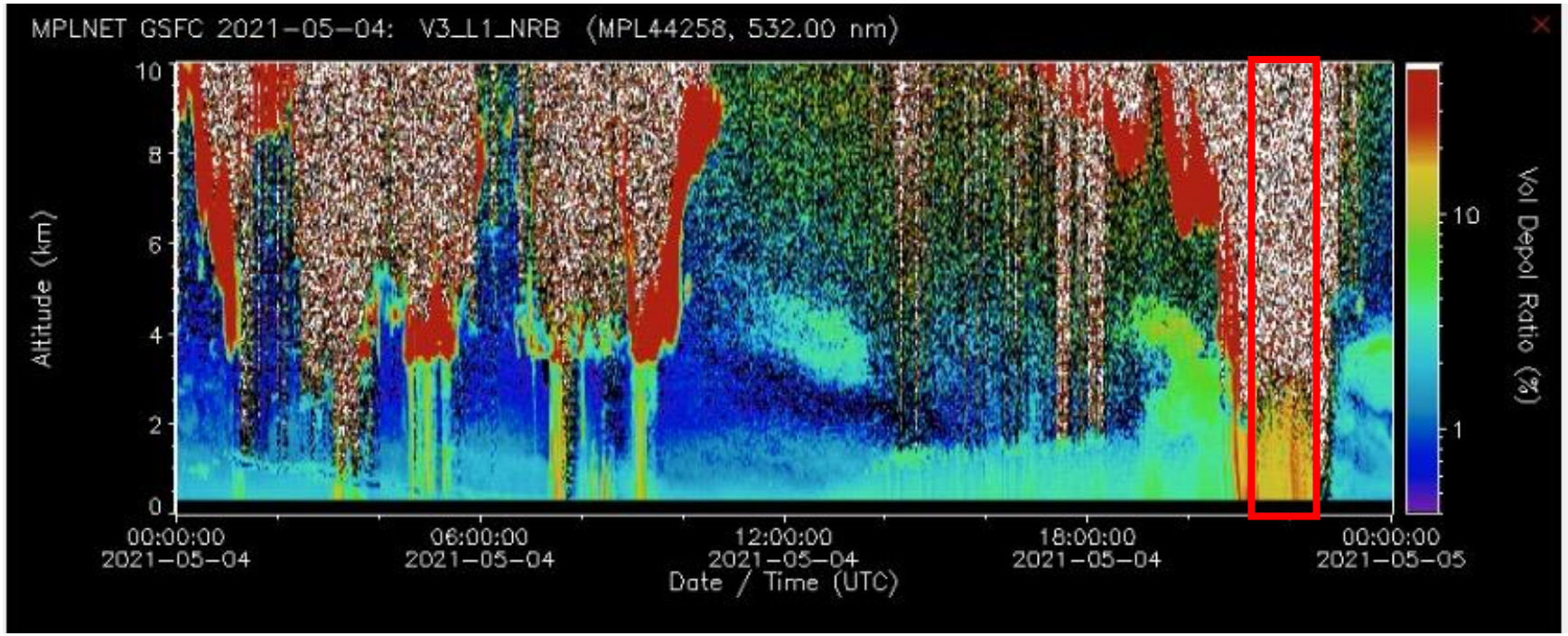
The F1-score of 0.81, the MCC of 0.60, and the Kappa coefficient of 0.55 provide balanced measures of the algorithm's overall performance.

Intercomparison at Universitat Politecnica de Catalunya, Barcelona Spain

UPC; 41.38N 2.11E, 125 m a. s. l., 2019-2020, 519 rain events

		MPLNET		
		No Rain	Rain	Total
Disdrometer	No Rain	512(98.60%)	7(1.34%)	519
	Rain	232(44.70%)	287(55.30%)	519
	Total	751	294	1038

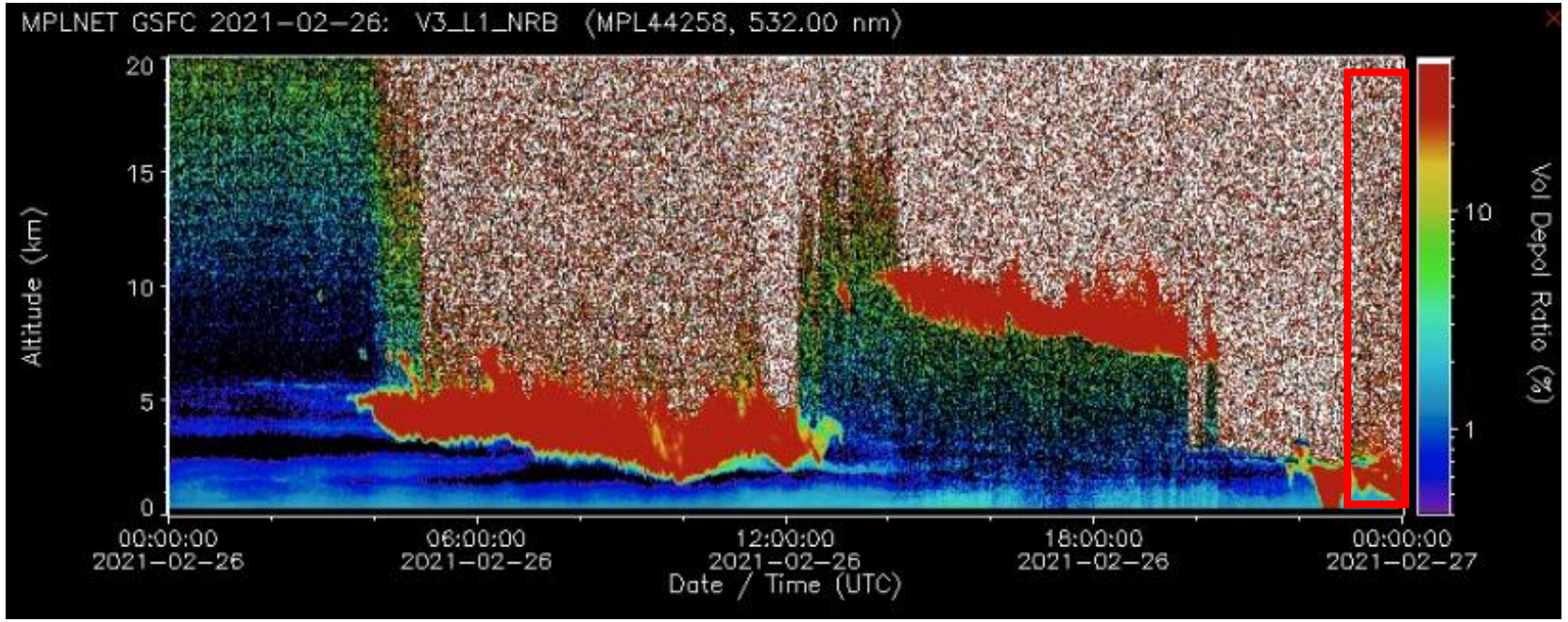
Cases in Disagreement at GSFC



04 May 2021

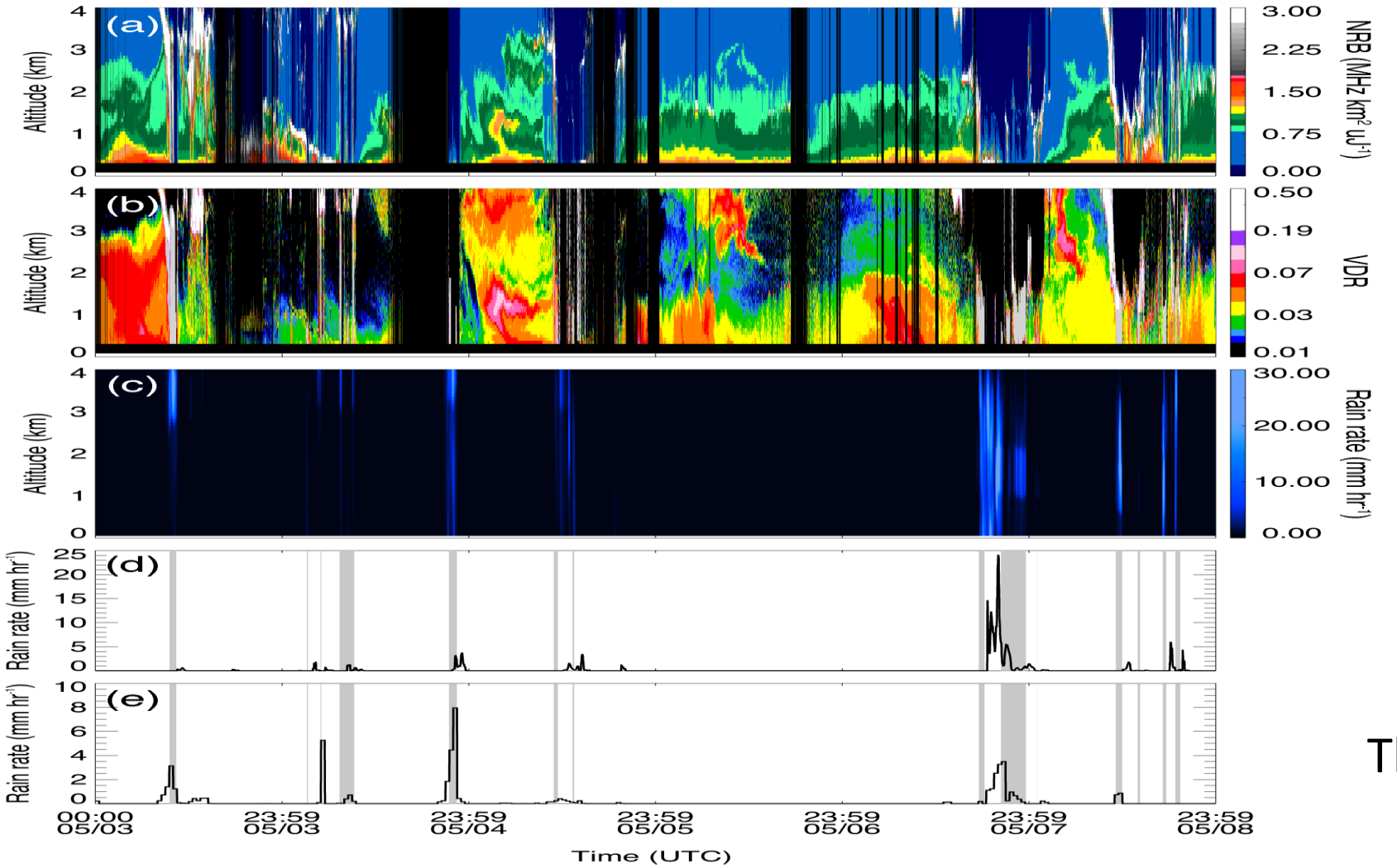
Time	MPLNET(2=1 min precip.)	Disdrometer(mm/hr)
21-22	112	0

Cases in Disagreement at GSFC



26 Feb 2021

Time	MPLNET(2=1 min precip.)	Disdrometer (mm/hr)	IMERG(mm/hr)
23-24	0	1.13	1.045



May 2021 at GSFC
The range of rain events detectable by the RMA (sub 1 to > 20-mm/hr based on Disdrometer).

RMA (and MRR) often appear to detect rain slightly ahead of the Disdrometer.

Thanks for your attention!