Research and development of a precipitation estimation methodology using INtergrateD RAinfall measurements platform for agriculture (INDRA)

INTERCOMPARISON OF OPERATIONAL PRECIPITATION PRODUCTS IN VIETNAM

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The INDRA Project

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Italian partners

Department of Physics and Astronomy, University of Bologna
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MEEO
Meteorological Environmental Earth Observation

Vietnamese partners

University of Engineering and Technology, Vietnam National University Hanoi (VNU UET)

Aero Meteorology Observatory (AMO)
Vietnam Meteorological and Hydrological Administration (VNMHA)

Hanoi University of Science, Vietnam National University Hanoi (VNU HUS)

Le Quy Don Technical University (LQDTU)

Goal of this work:

Define a baseline reference framework
for the forthcoming development of new algorithms
for near real-time rainfall detection

How:

Through the **inter-comparison** and cross-validation
of all the rain products available to-date in Vietnam

8 data sources (for now)

On the **ground**:

- Automatic weather stations (AWS): tipping bucket raingauges
- Ground weather radars (rain product by JMA)

From satellites on a **geostationary orbit**:

- FengYun-4A rain product (algorithm unknown to us)
- Geo-Kompsat-2A rain product (data available from March 25, 2020)

From satellites on a **polar orbit** (2 overpasses per day):

- GPM- DPR (dual frequency precipitation radar)

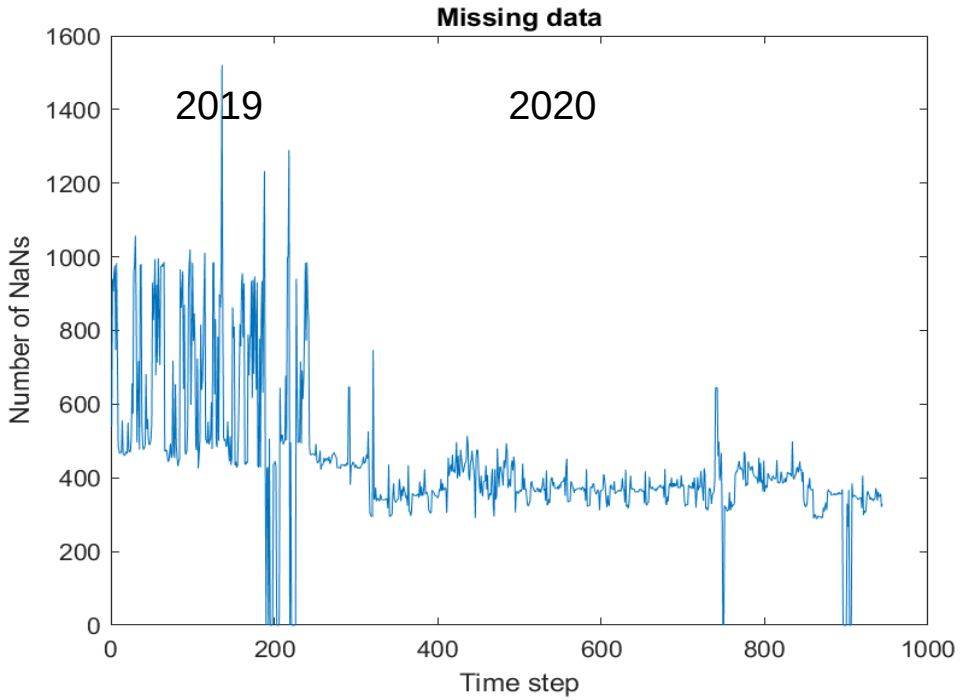
Multi satellite (both polar and geostationary):

- IMERG Early Run
- IMERG Final Run (ground calibrated)

Model reanalysis:

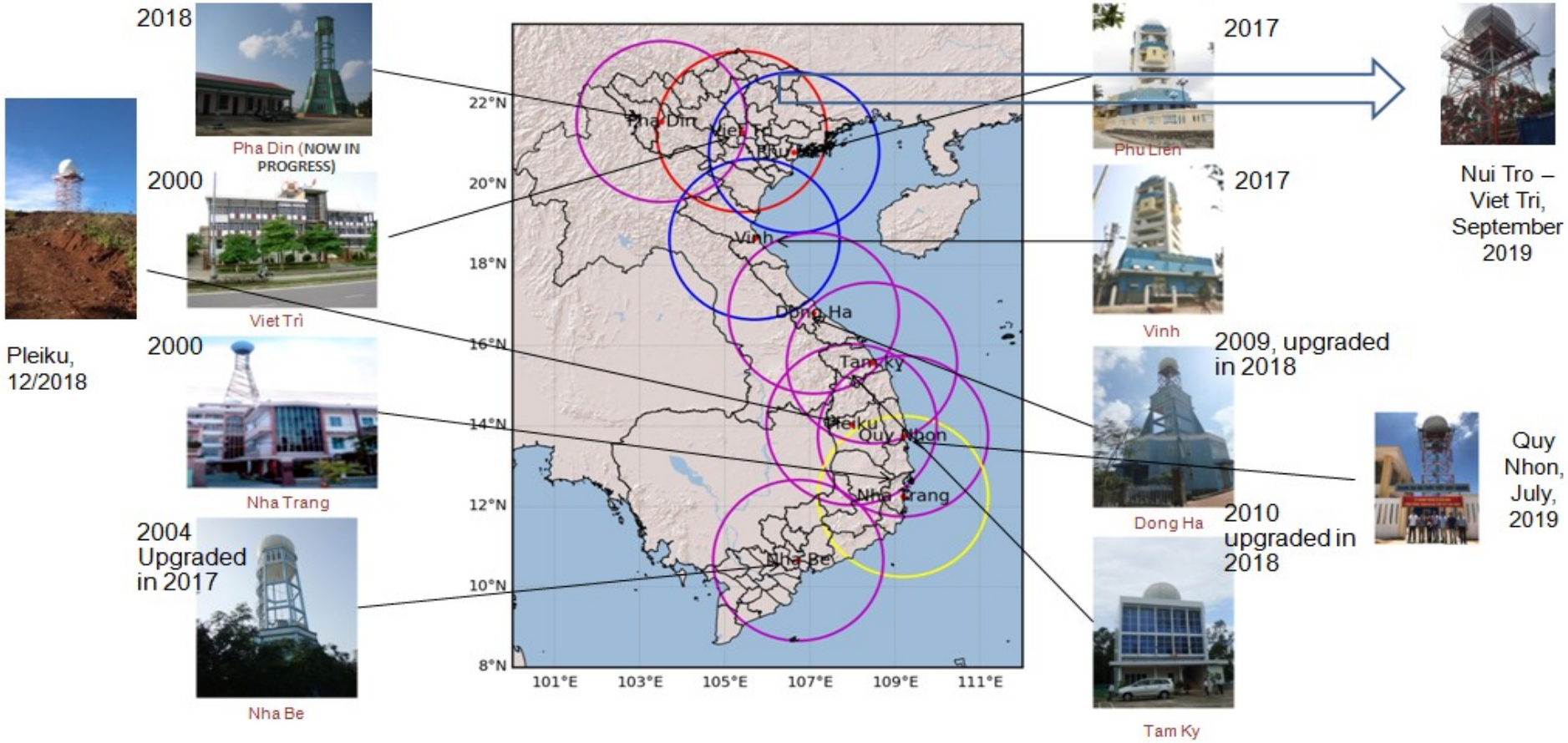
- ERA5-Land (by ECMWF)

Rain gauges (AWS)



2 years (2019-2020), **hourly** data (mm)
around 1600 stations (not always active)

Weather radars



Good coverage of Vietnam mainland territory

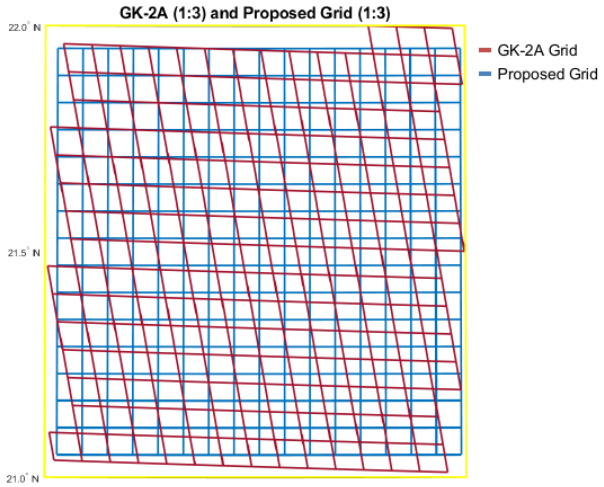
Rain product provided by JMA: **1 hour x 1 km²** resolution

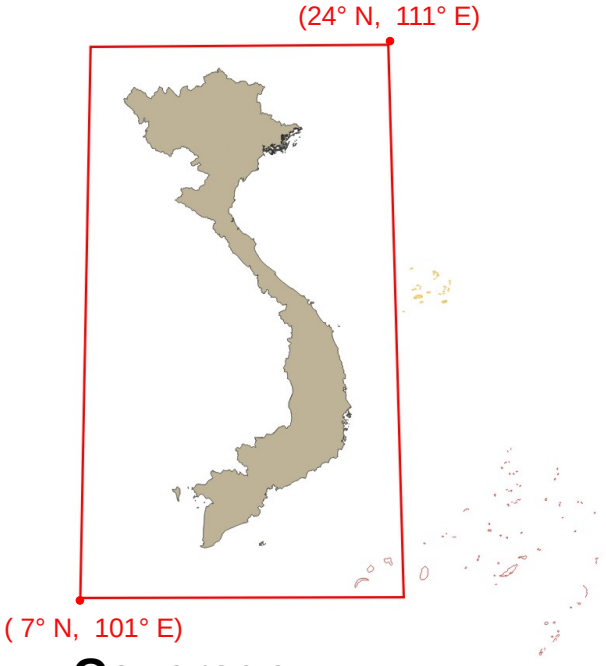
Satellite products

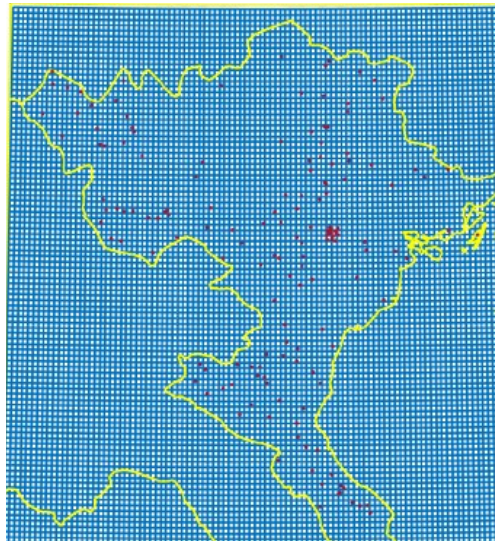
Name	Period	Grid	Temporal sampling	Coverage	Source	Latency
GPM-DPR	2014-present	5 km	~1 overpass/day	250km swath (global)	DPR	1 day
FENGYUN-4A	2017-present	4 km (nadir)	1h, 3h, 6h	Disk	AGRI	Near real-time (NRT)
GEO-KOMPSAT-2A	2018-present	2 to 4 km	10 minutes	Disk	IR+DPR	Near real-time (NRT)
IMERG Early Run	2000-present	0.1°x0.1°	30 minutes	60°N-60°S	GPM sensors+IR	4 hours
IMERG Final Run	2000-present	0.1°x0.1°	30 minutes	60°N-60°S	GPM sensors+IR+rain gauge	3.5 months

Shared frame for data intercomparison: a high-resolution **0.02° lat-lon grid**

851 rows x 501 columns = 426.351 cells







Resolution:
Comparable with the available satellite products

Coverage:
Vietnam mainland

This is a zoom over the northern Vietnam (Hanoi) to see the actual grid size (around **2km x 2 km**)

Time period and resolution

39 days from August to November of 2019 and 2020 (tropical cyclones season)

- Everything is aggregated to **1 hour** (average rain rate)

1 array of rain gauge measurements

1 radar map

2 IMERG Early Run layers

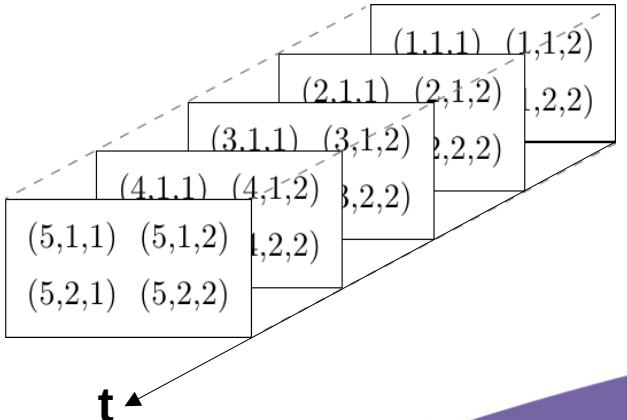
2 IMERG Final Run layers

1 FengYun-4A rain products

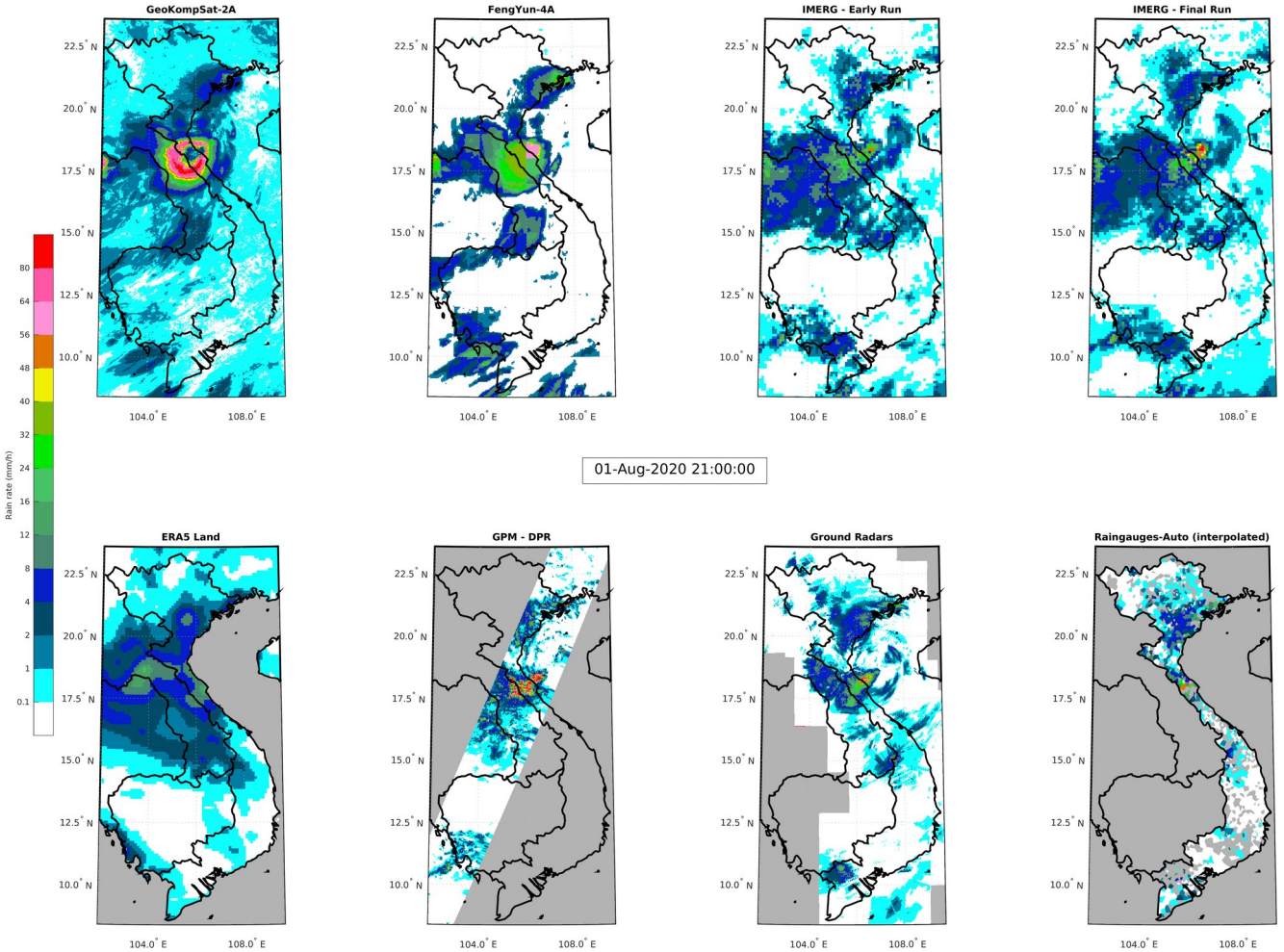
6 Geo-Kompsat-2A rain products

1 GPM-DPR swath line (when present)

1 set of **2D matrices**, then stacked in time (3D)



First result: a common framework

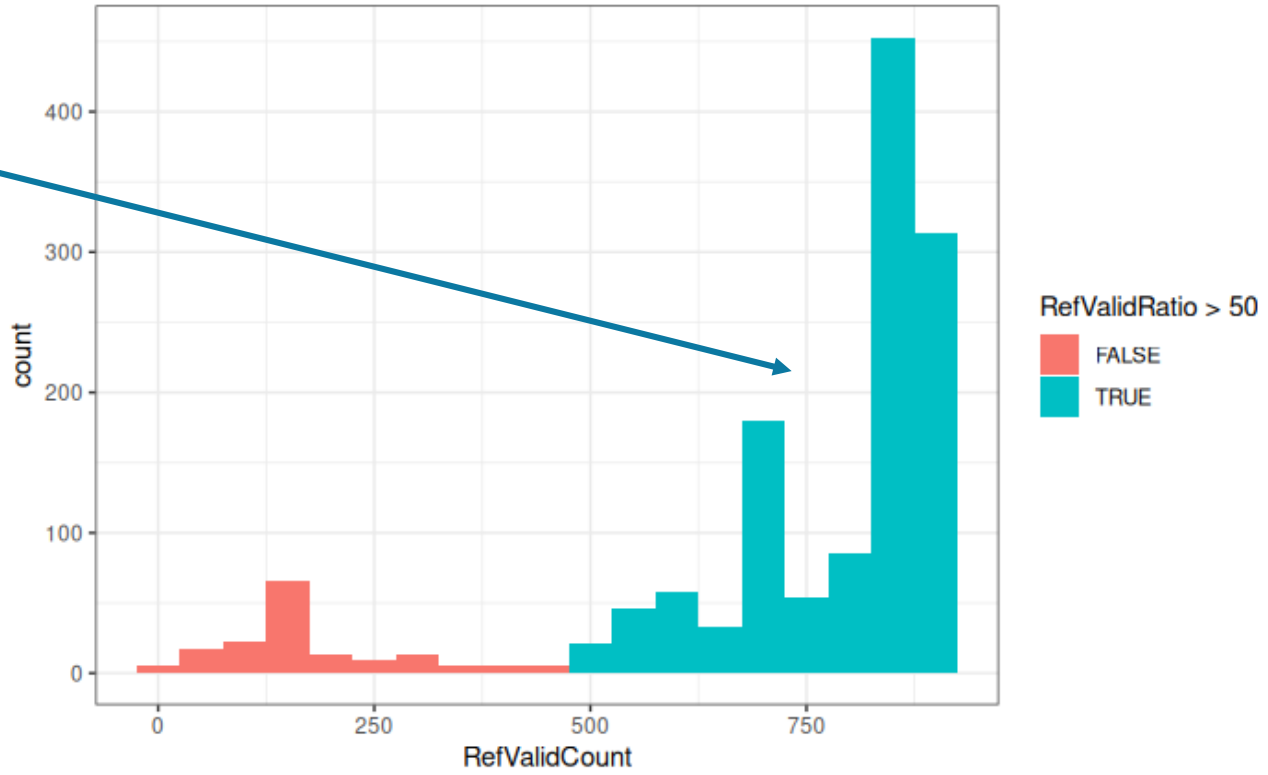


Data from very different sensors are rendered over the same grid with a unified time resolution: inter-comparisons are now possible.

Data availability

- Most of the AWS are active more than 80% of the time

- Pixels with the nearest AWS active for less than 50% of the total time are rejected



Total	Valid	Excluded
1394	1233	161

Data availability

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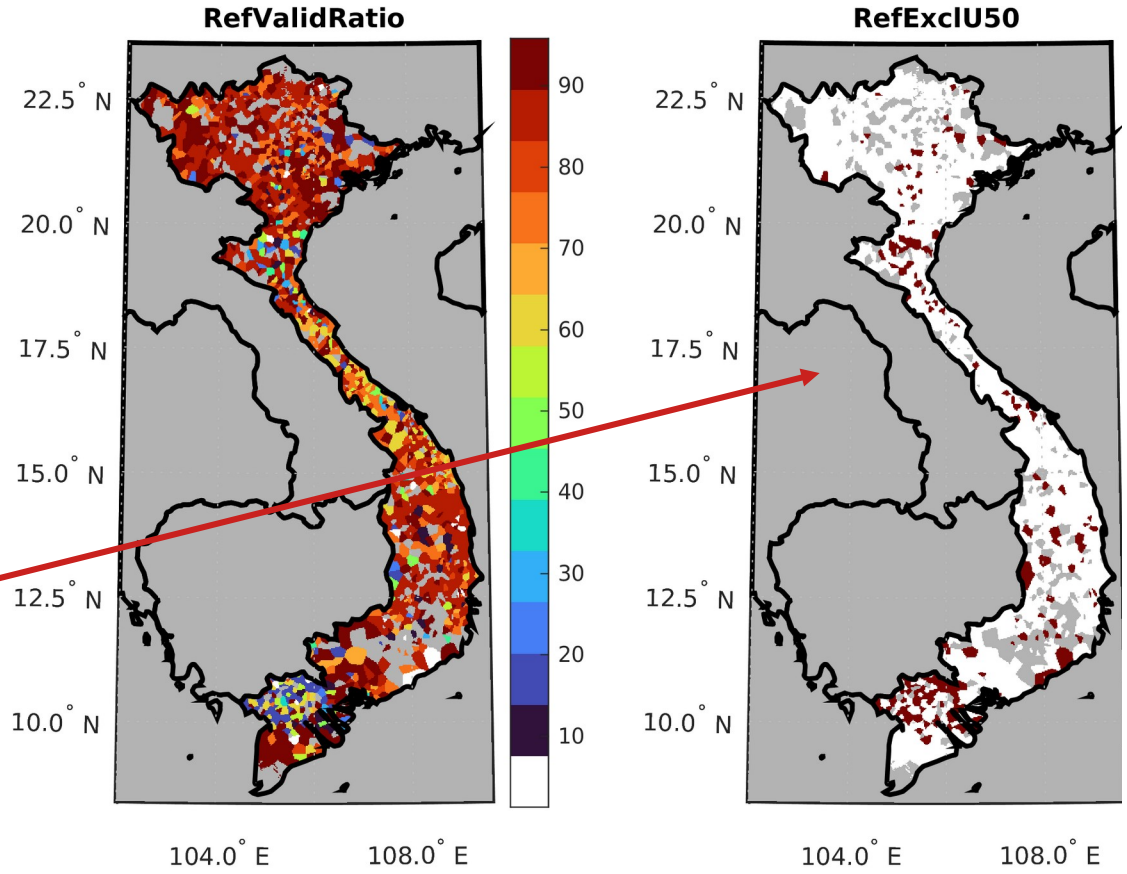
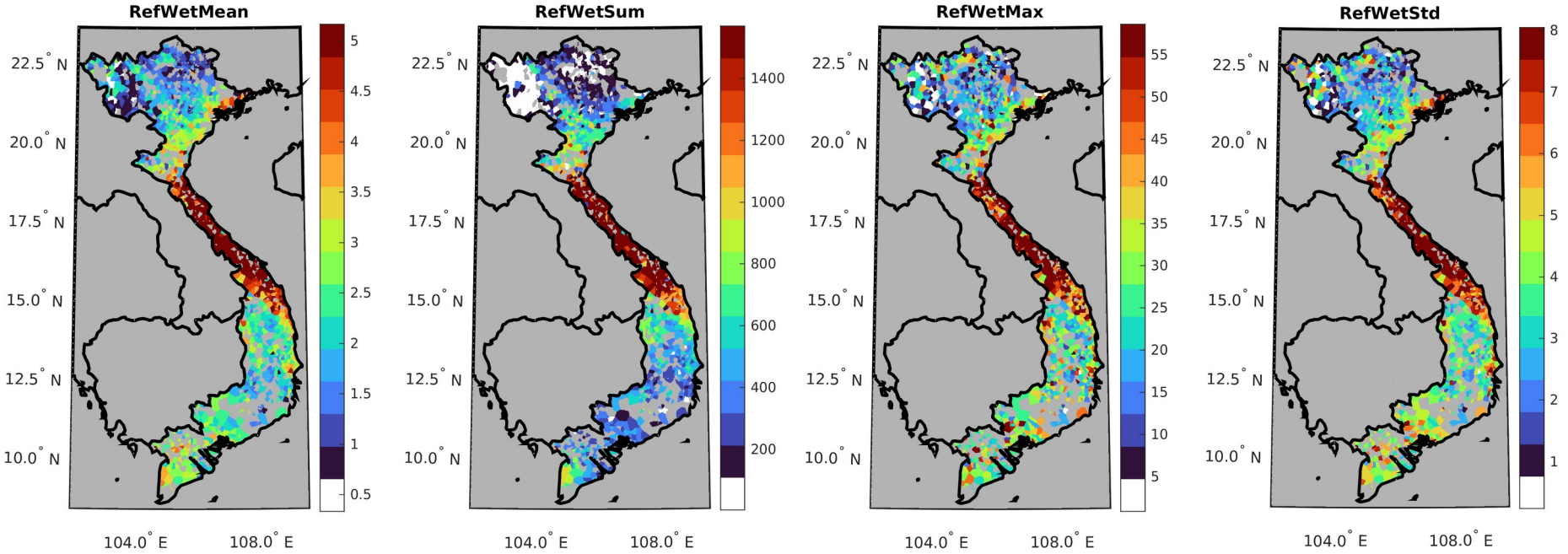
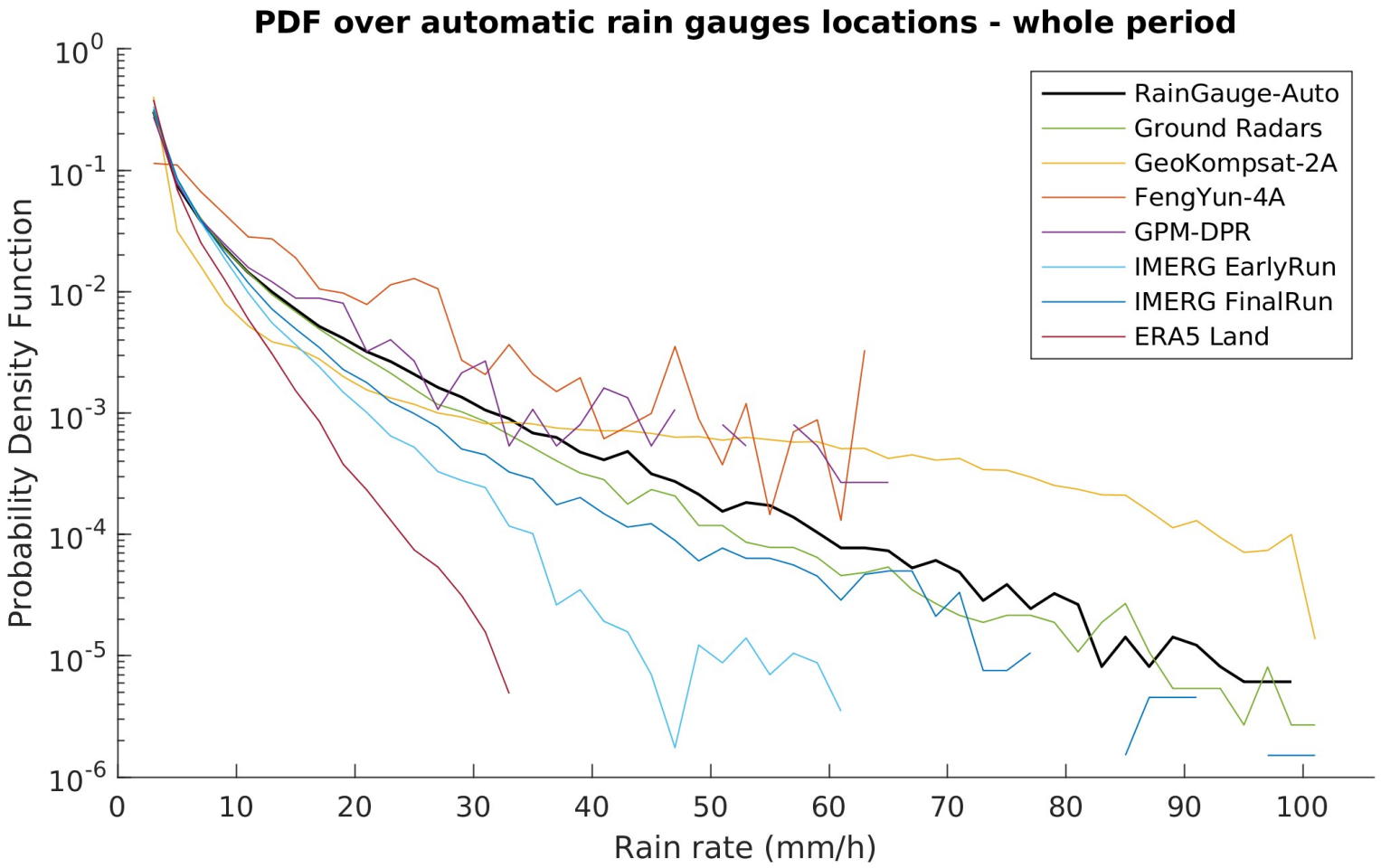


Rain gauges reference

The reference shows a strong **regional signal**: most of the rain is measured in the central part of Vietnam, while northern and north-western mountains are the driest area.



Probability Density Functions



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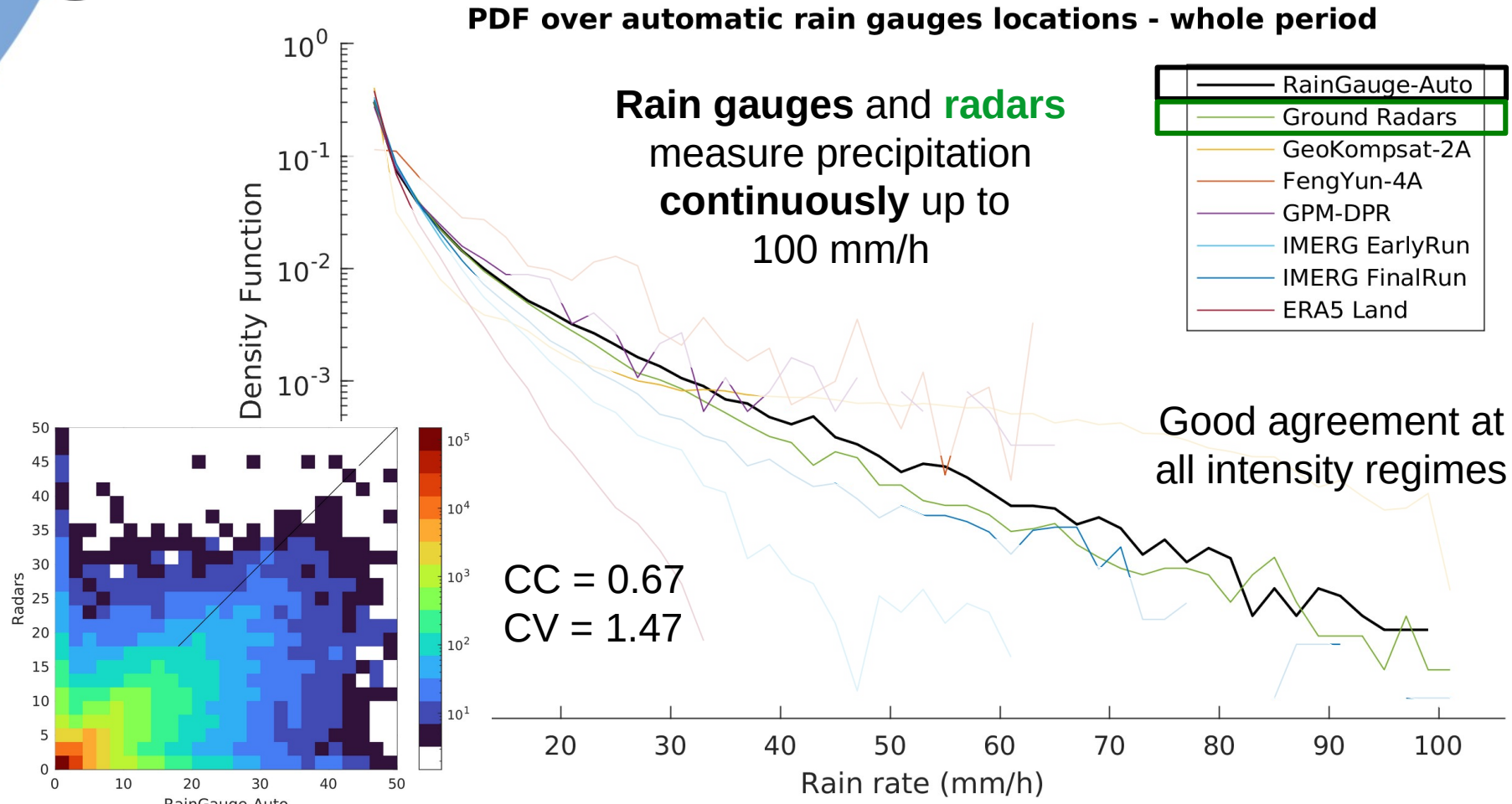

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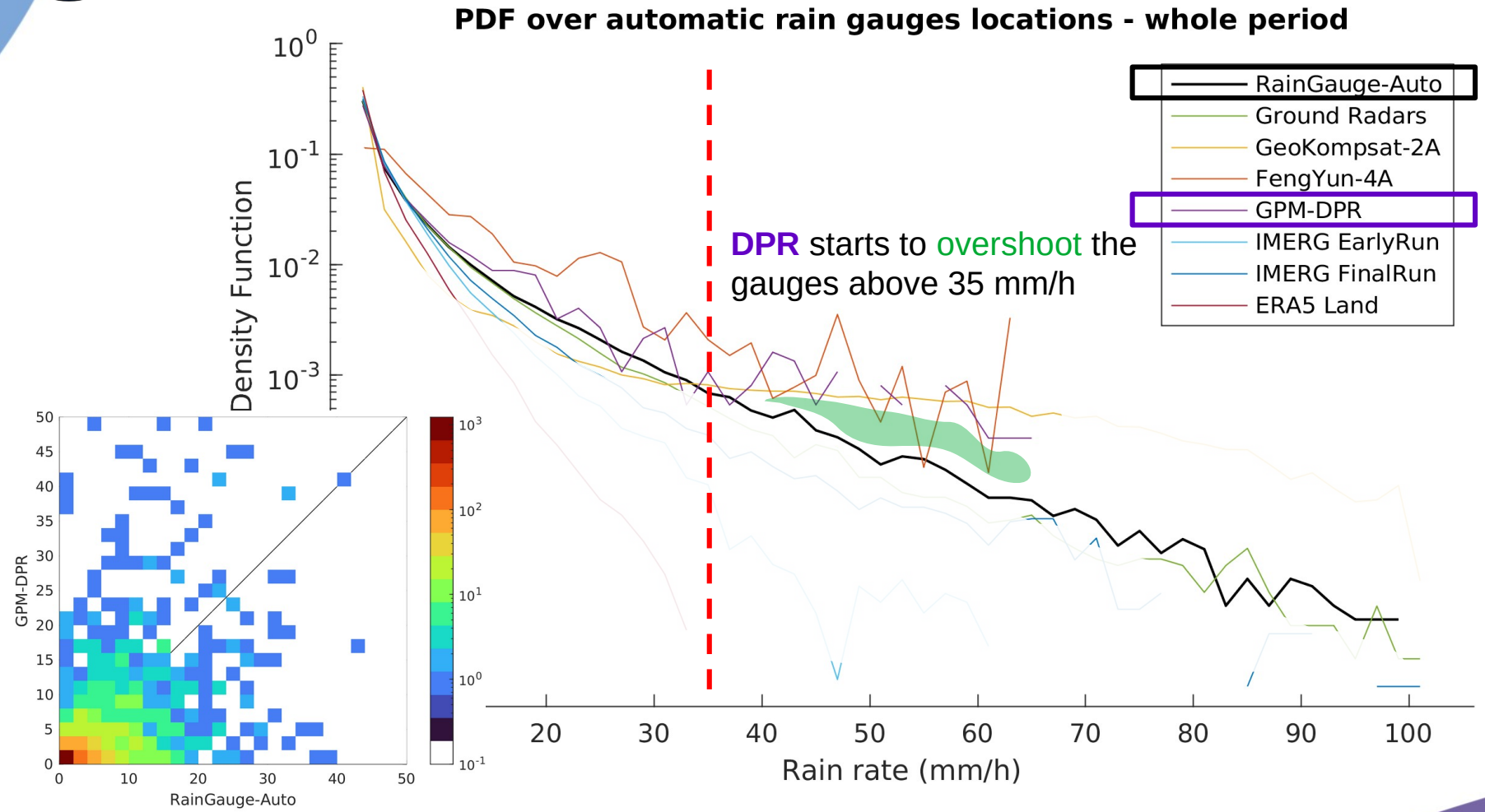

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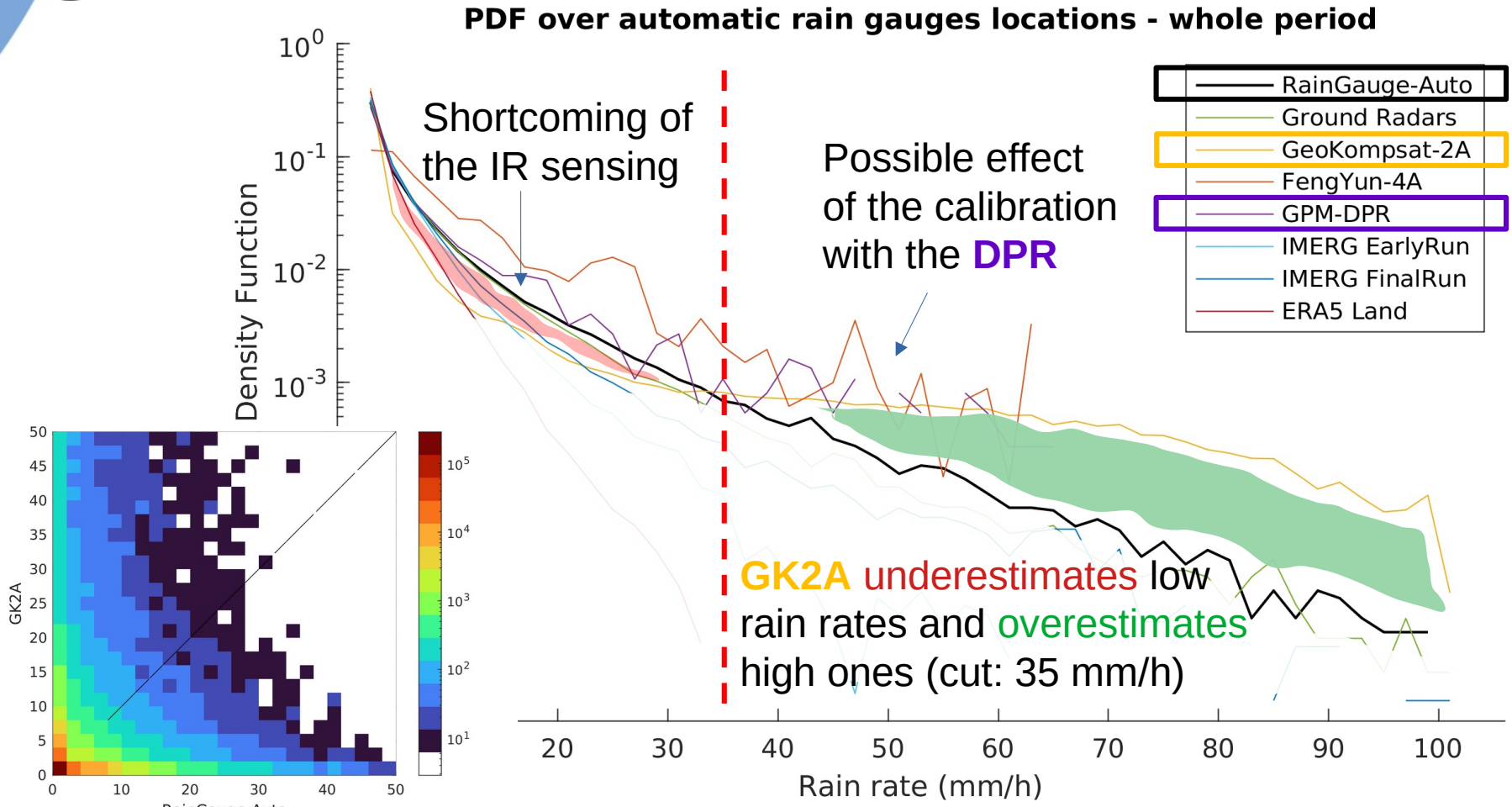
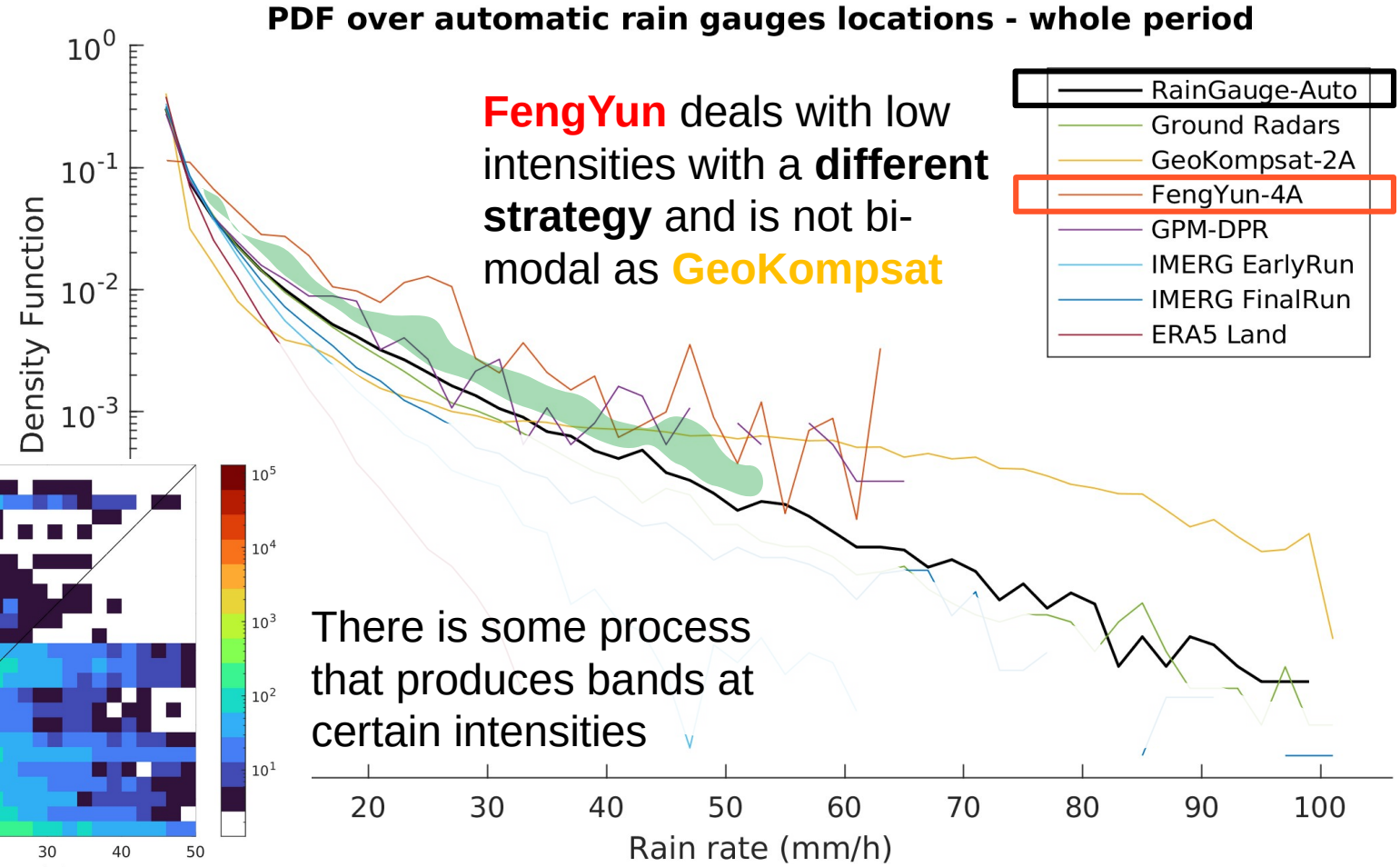
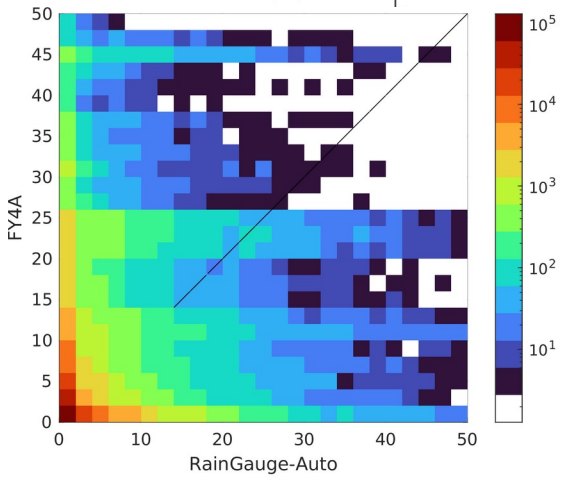


Probability Density Functions





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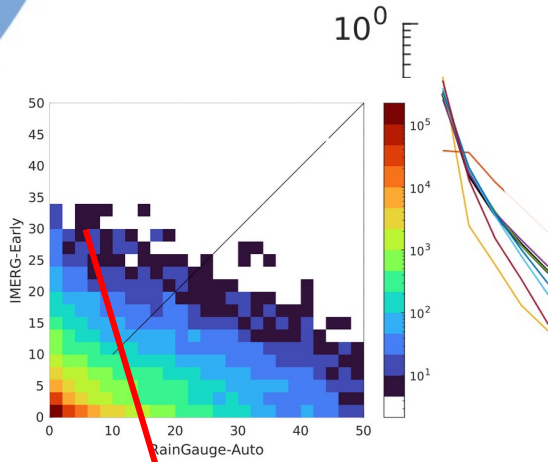
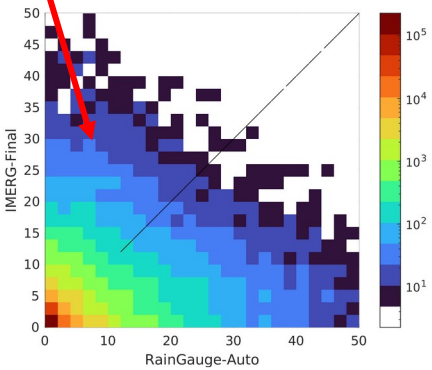
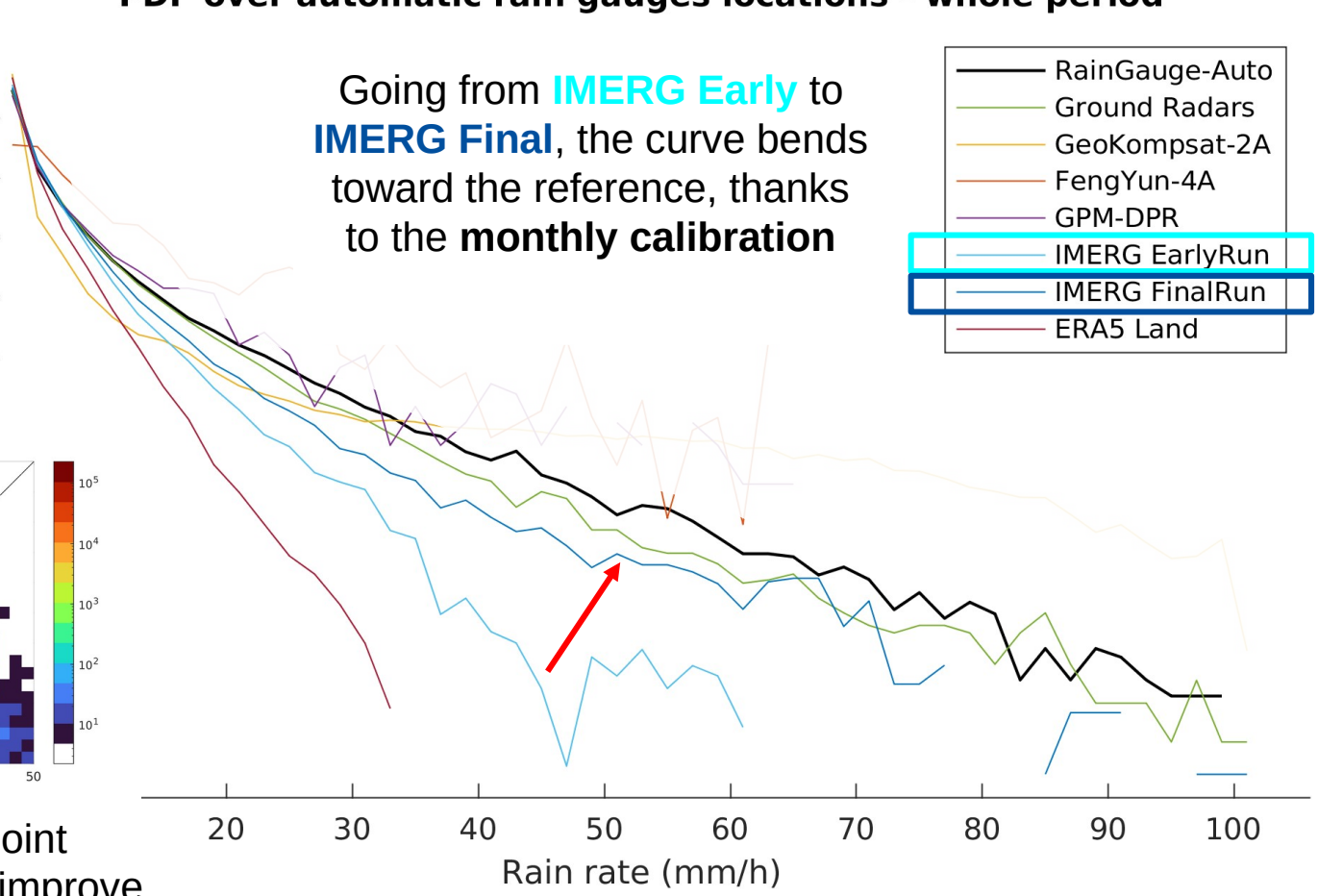
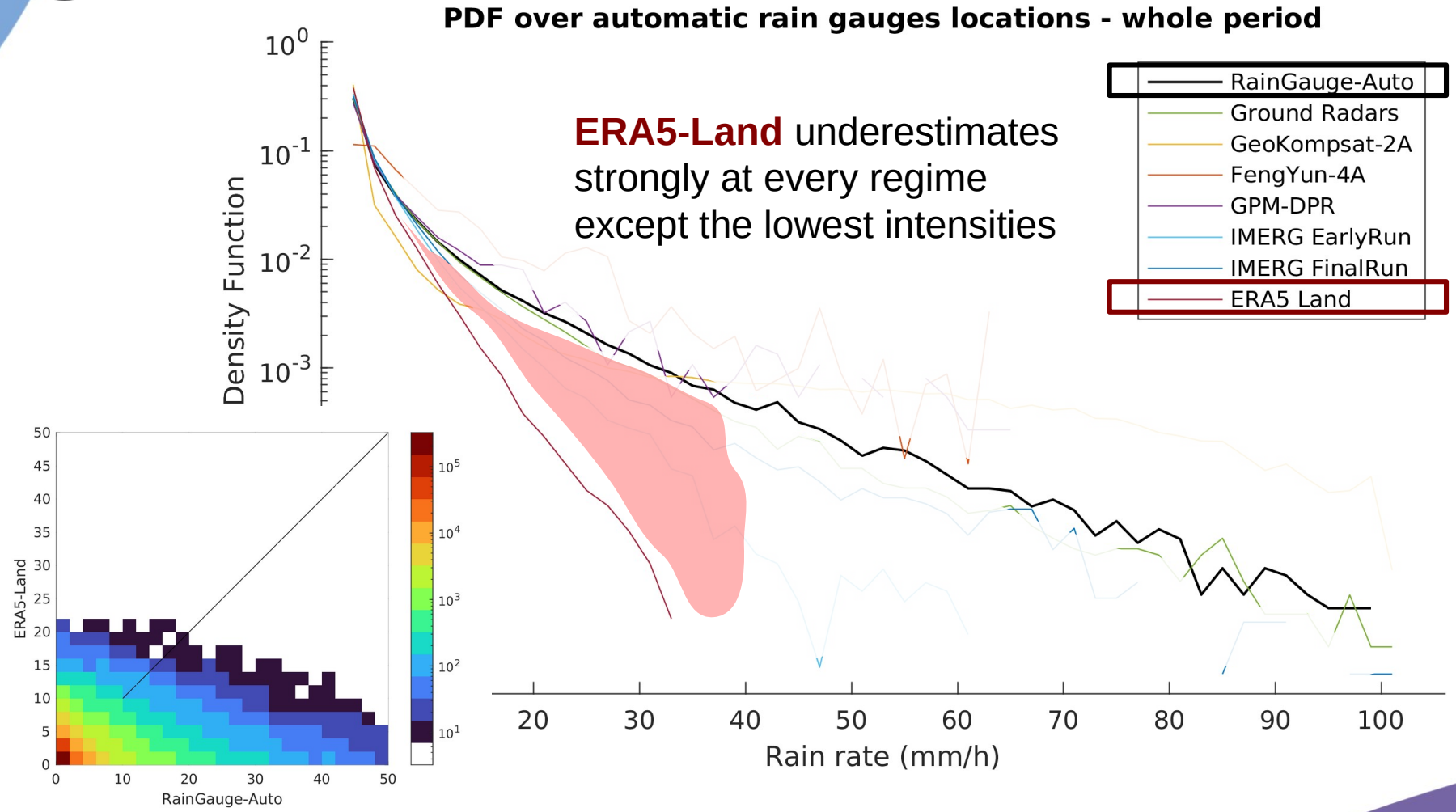




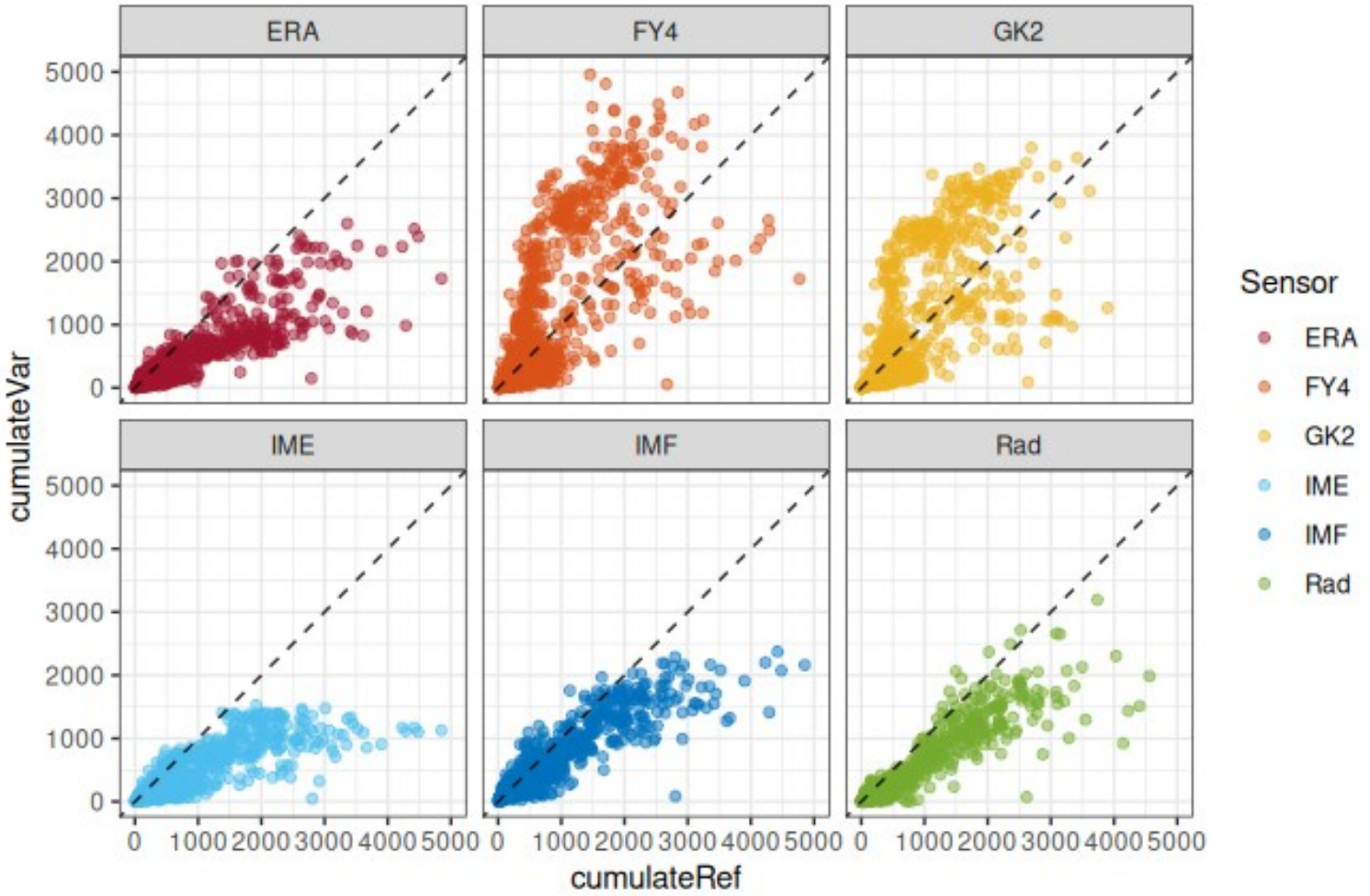
But the point by point **correlation** does not improve



Probability Density Functions



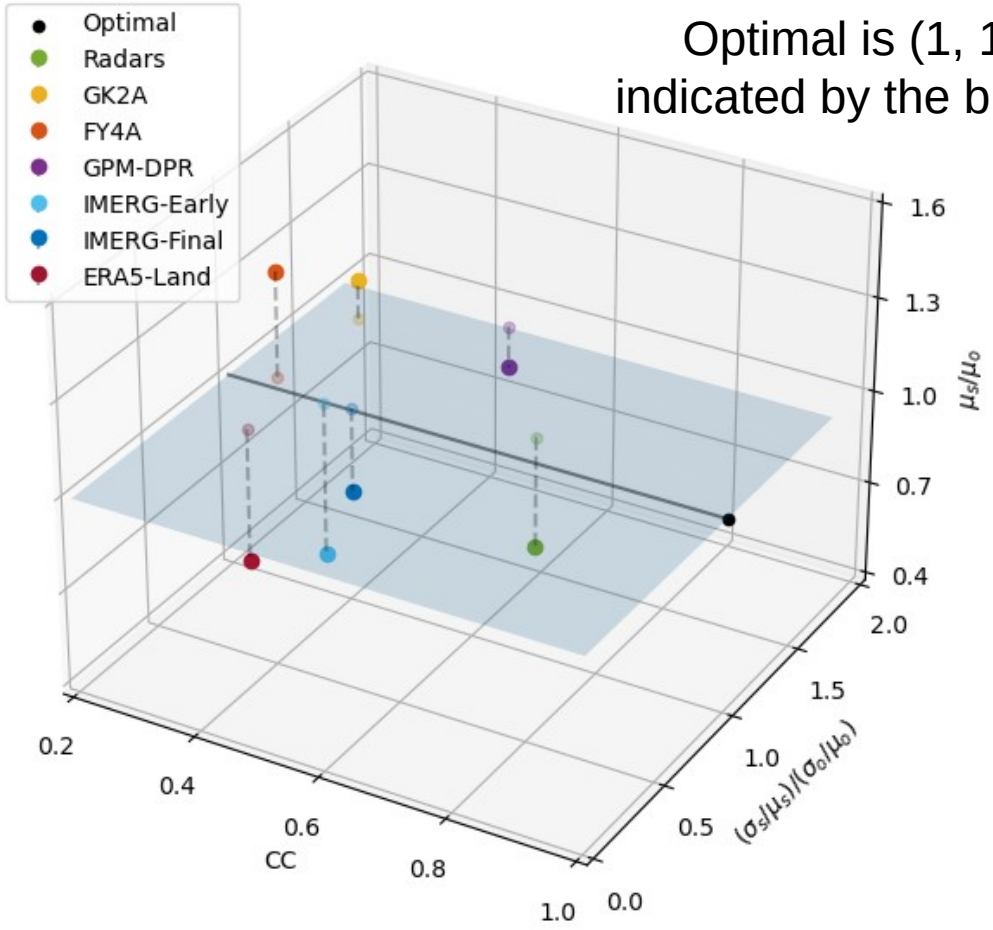
Total rain accumulation per grid cell (mm)



Continuous scores

Product	CC	CV	ME	MAE	p50
Radars	**0.67**	**1.47**	-0.36	**0.58**	0.75
GK2A	0.27	*3.31*	**0.13**	1.38	0.40
FY4A	*0.26*	2.87	0.34	*1.46*	0.69
GPM-DPR	0.47	2.24	-0.14	0.79	**0.77**
IMERG-Early	0.36	1.83	*-0.49*	0.87	0.54
IMERG-Final	0.40	1.85	-0.27	0.88	0.53
ERA5-Land	0.31	1.84	-0.43	0.85	*0.28*

KGE metric



Optimal is (1, 1, 1), indicated by the black dot

KGE is 1 minus the euclidean distance from (1, 1, 1)

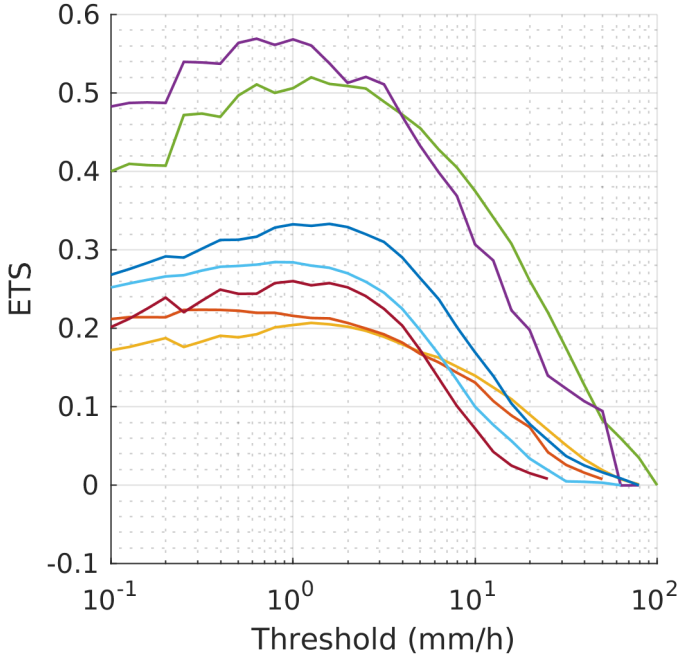
Product	**KGE***
Radars	**0.49**
GK2A	0.06
FY4A	0.19
GPM-DPR	*0.02*
IMERG-Early	0.19
IMERG-Final	0.34
ERA5-Land	0.13

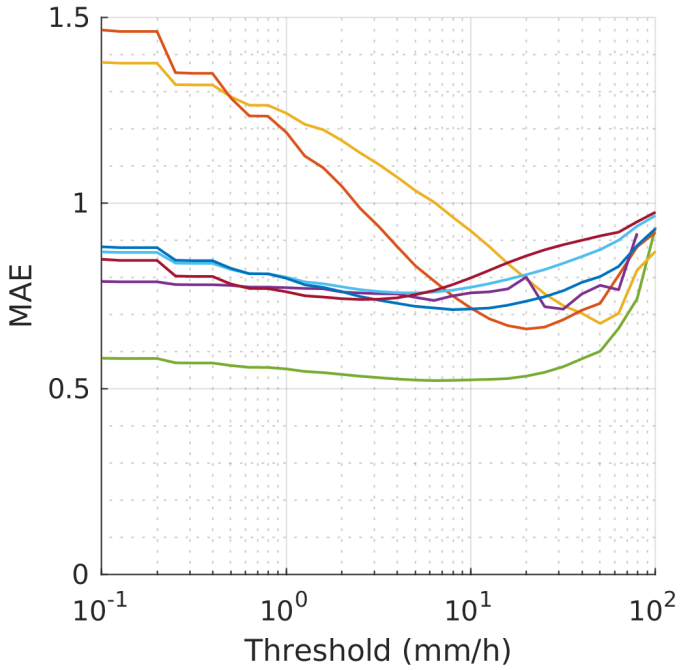
Categorical scores

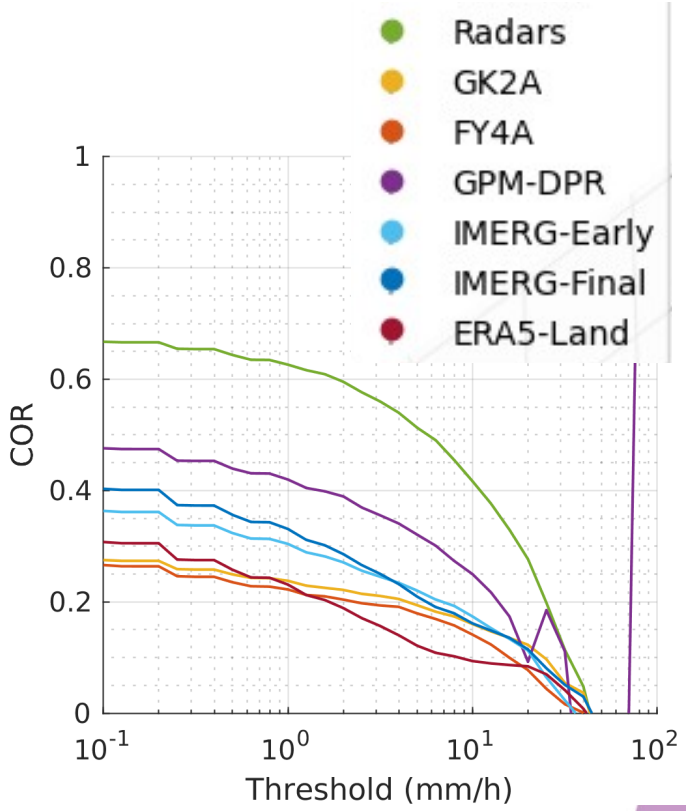
RAIN/NO RAIN THRESHOLD: 0.2 mm/h

Product	POD	FAR	BIAS	CSI	ETS
Radars	0.60	0.22	0.77	0.51	0.41
GK2A	0.70	*0.56*	1.60	0.37	*0.19*
FY4A	*0.43*	0.43	0.74	*0.32*	0.21
GPM-DPR	0.66	**0.17**	0.80	**0.58**	**0.49**
IMERG-Early	0.56	0.44	**1.00**	0.39	0.27
IMERG-Final	0.64	0.44	1.15	0.43	0.29
ERA5-Land	**0.81**	0.55	*1.80*	0.41	0.24

Variable rainrate threshold







Conclusions

Given the results we presented, we believe that a reliable near real-time algorithm in Vietnam should be based mainly on ground radars, while other data sources should be exploited to overcome radars' quantitative shortcomings (in this case: underestimation).

Ongoing development:

- Single event scale
- Regional scale (and topography)
- Radars as Reference

Next objectives:

- Near real-time regional algorithm
- Machine learning

The INDRA Project

Thank you!