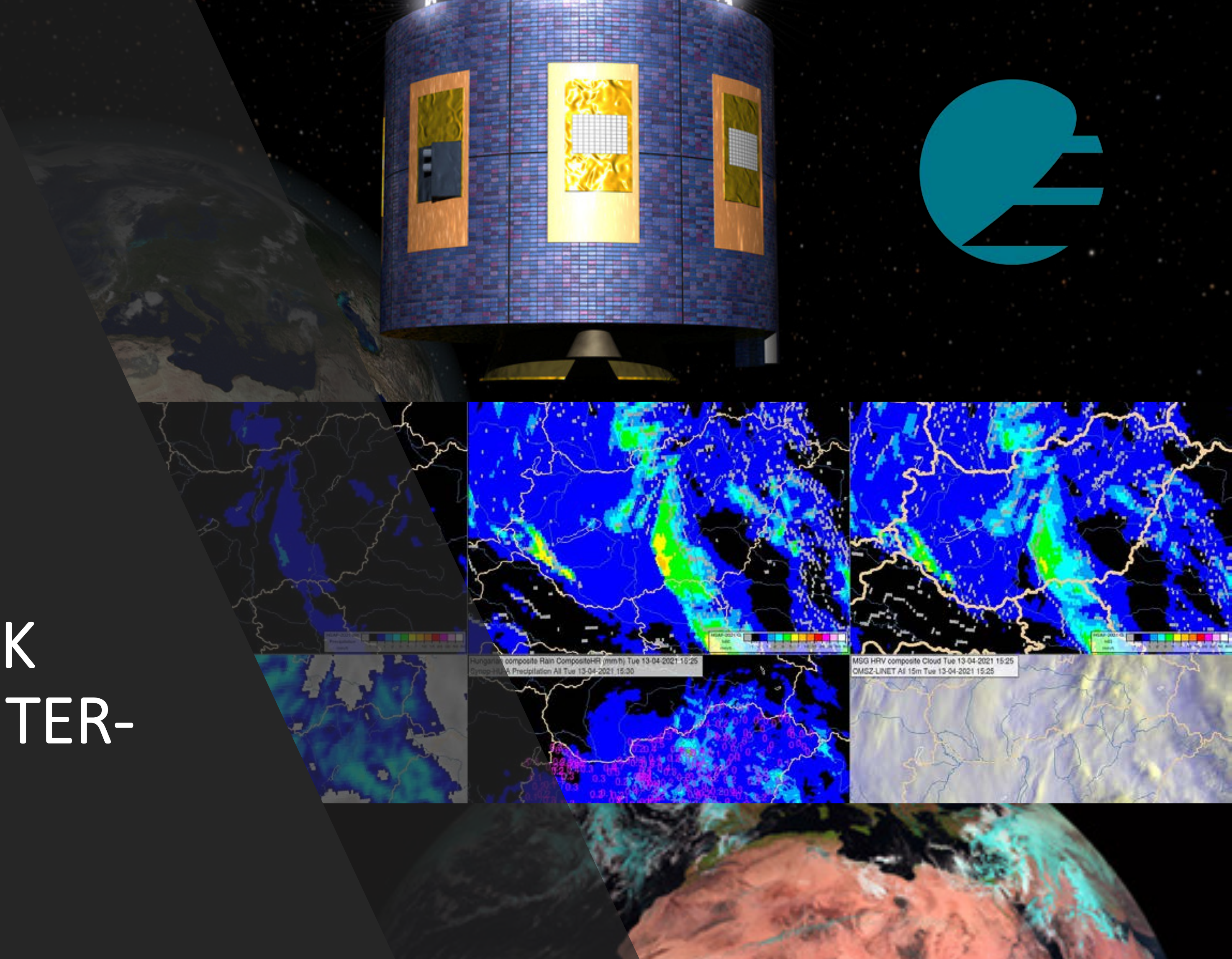
5th H SAF

USER WORKSHOP,

24-28 January 2022

SEVIRI-BASED H SAF PRODUCTS FOR NEAR REAL TIME PRECIPITATION ESTIMATES OVER FULL DISK AREA: VALIDATION AND INTER-COMPARISON ANALYSIS



PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Marco Petracca, Alessandra Mascitelli, Jan Kanak,
Ľuboslav Okon, Marta Dioszeghy, Pierre Baguis, Eram Artinyan,
Bozena Lapeta, Ahmet Öztopal, Peter Krahe, Federico Porcù and Silvia Puca
AND ALL PRECIPITATION PRODUCTS VALIDATION GROUP

Overview

- Precipitation Product Validation Group (PPVG)
- SEVIRI-based products
  - H60, H61, H63 and H90
- References and Methods
  - Ground Data (GRD, Rain gauges and radars) Validation
  - DPR (2A-DPR-NS) Comparison
  - GPCC and GLDAS (global networks) – Triple Collocation (TC)
- Quality Assessment RESULTS
  - H60 (vs GRD and vs DPR)
  - H61 (vs GRD and by TC)
  - Inter-comparison results (SEVIRI IODC vs 0° -based products)
- Conclusions

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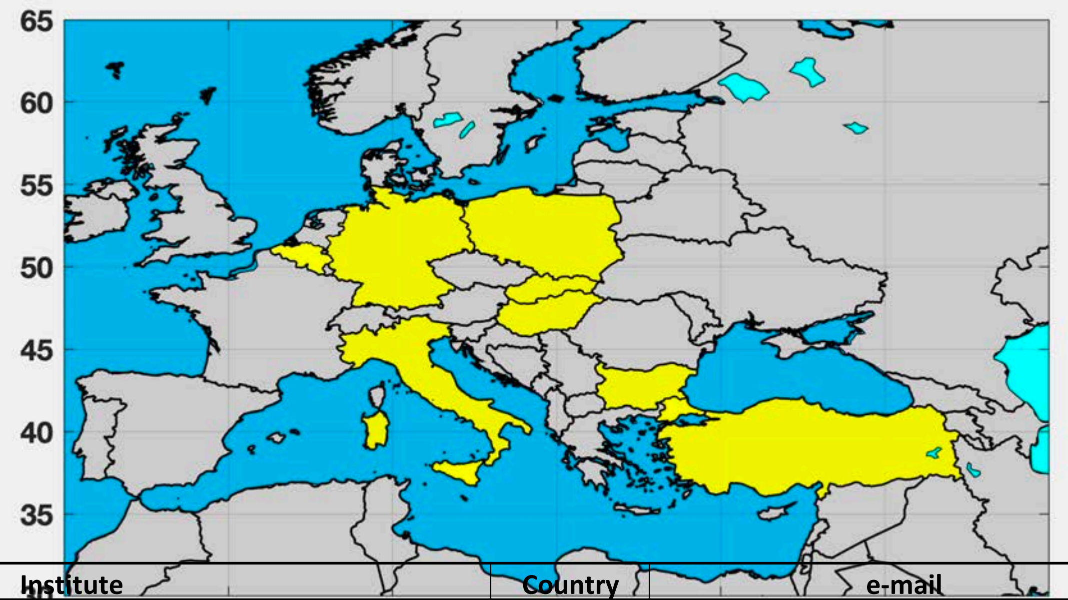
Precipitation Product Validation Group (PPVG)

The **PPVG** is composed of experts from the National Meteorological and Hydrological Institutes of **8 European countries**.

Quality-checked ground data are used for quality assessment of precipitation products, following the same methodology.



Country	Institutes
Belgium	RMI
Bulgaria	NIMH
Germany	BfG
Hungary	OMSZ
Italy	DPC, UniBo
Poland	IMWM
Slovakia	SHMU
Turkey	ITU, METU,TSMS

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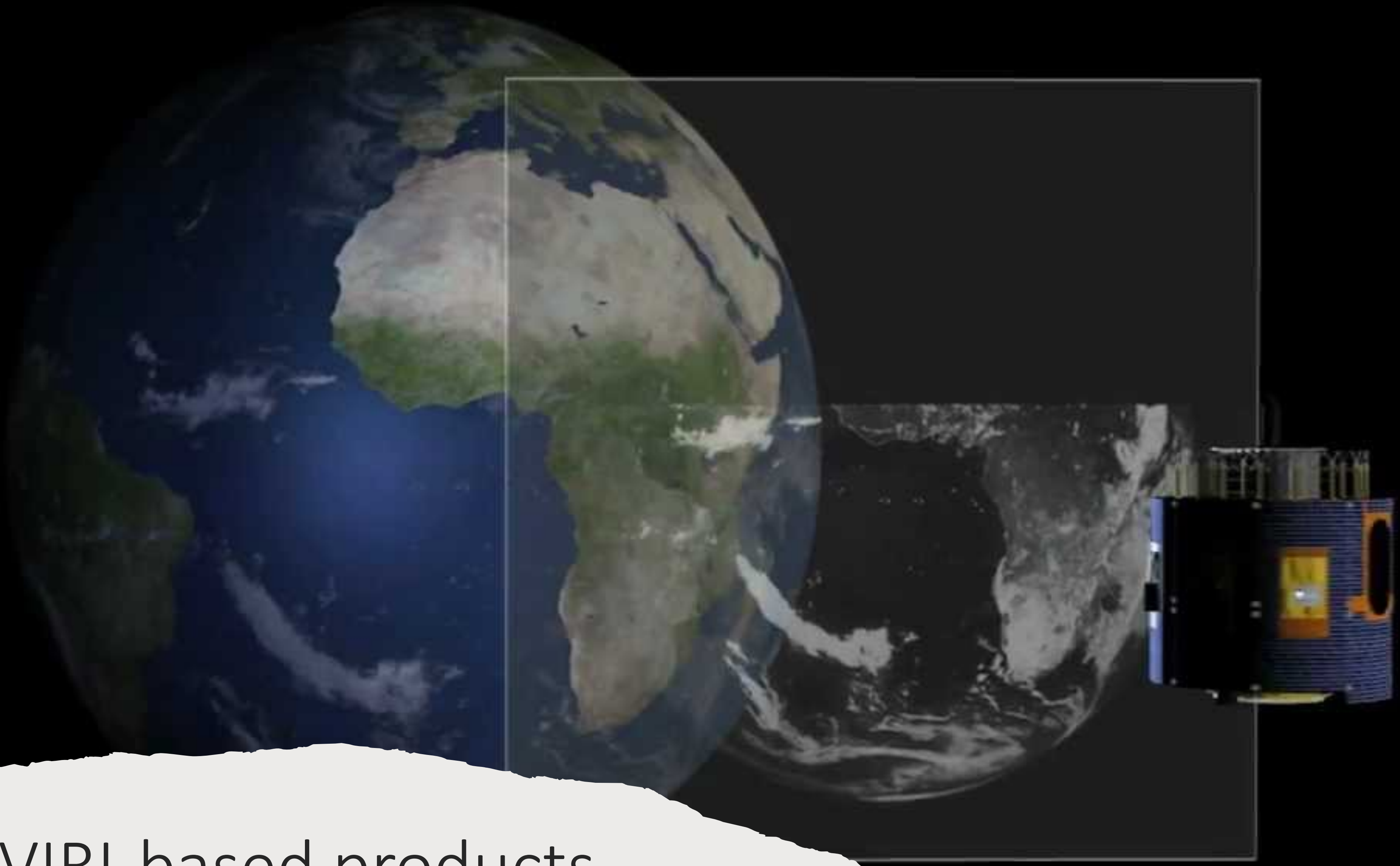
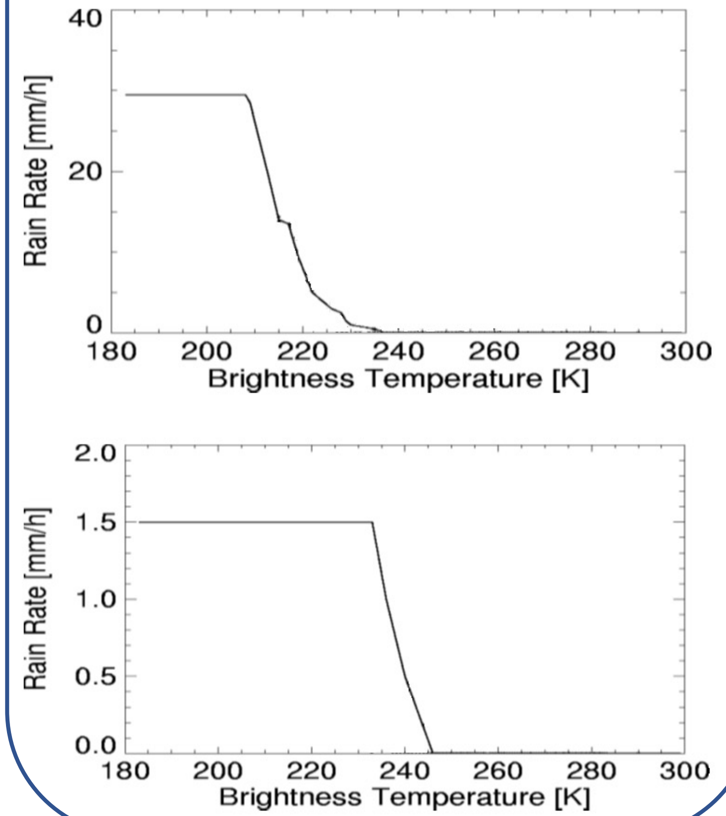
EUMETSAT H SAF



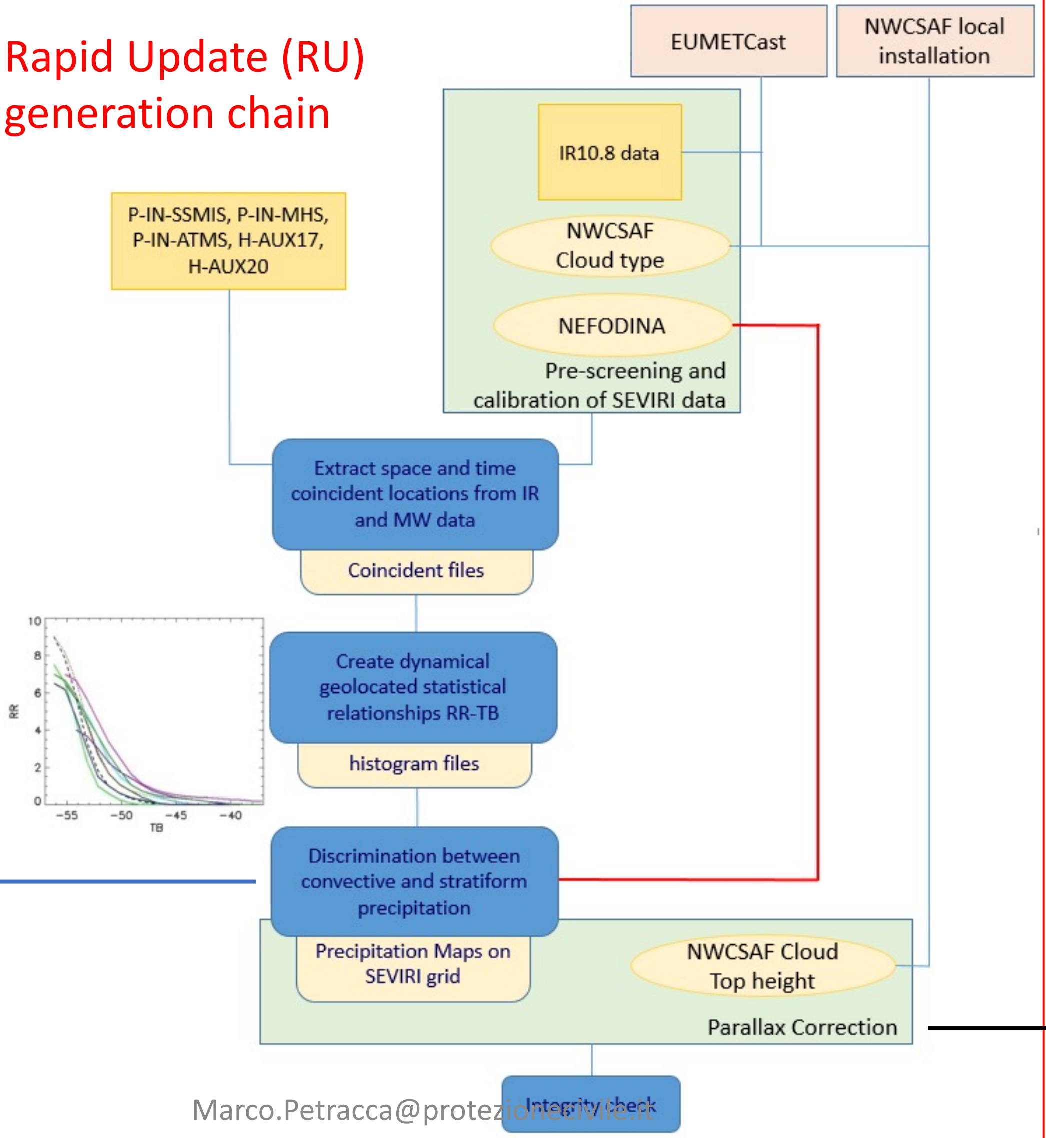
H SAF SEVIRI-based products

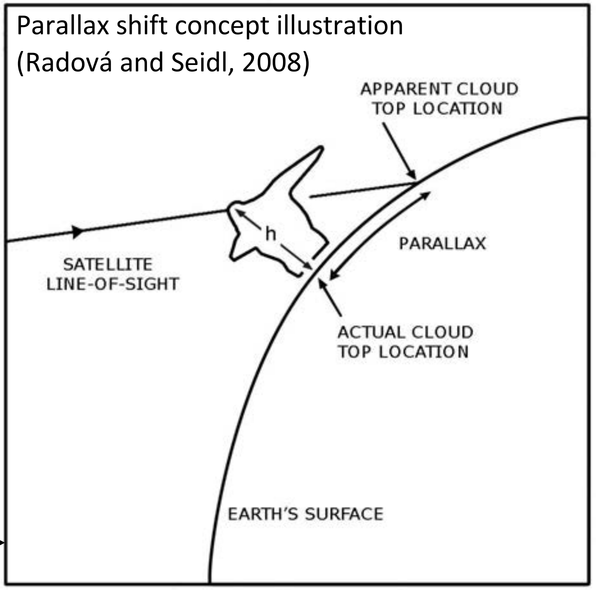
Instantaneous rain rate retrieval algorithm

Rain rate vs brightness temperature: typical averaged relationships for convective (above) and frontal (below) precipitation



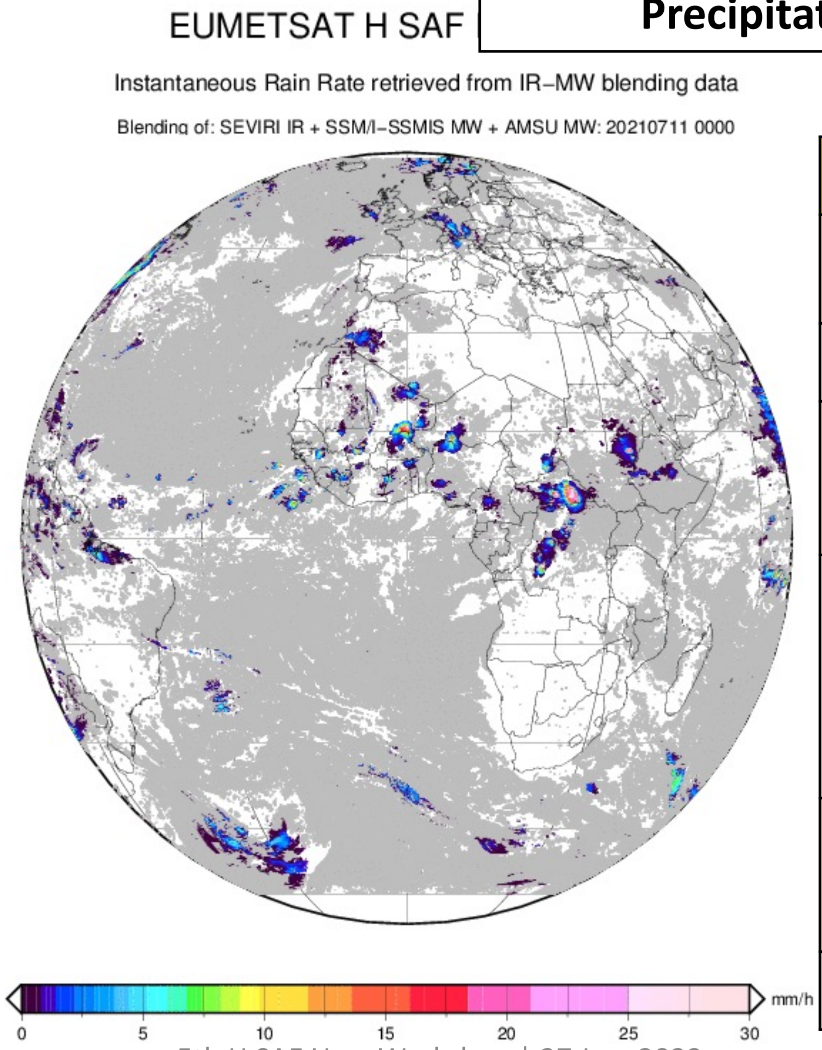
Rapid Update (RU) generation chain





H60 (P-IN-SEVIRI-PMW) and H63 (P-IN-SEVIRI_E) products

Precipitation rate at ground by GEO/IR supported by LEO/MW



Main features	
Coverage	MSG Full-disk area
Cycle	15 minutes
Spatial Resolution	3 Km s.s.p. ~8 km over Europe
Timeliness	Within 5 minutes from the end of acquisition
Dissemination	EUMETCast and HSAF (*)
Formats	NetCDF

H60 and H63 ’s domain

0°

41.5°E

(*) As soon as they become «pre operational»

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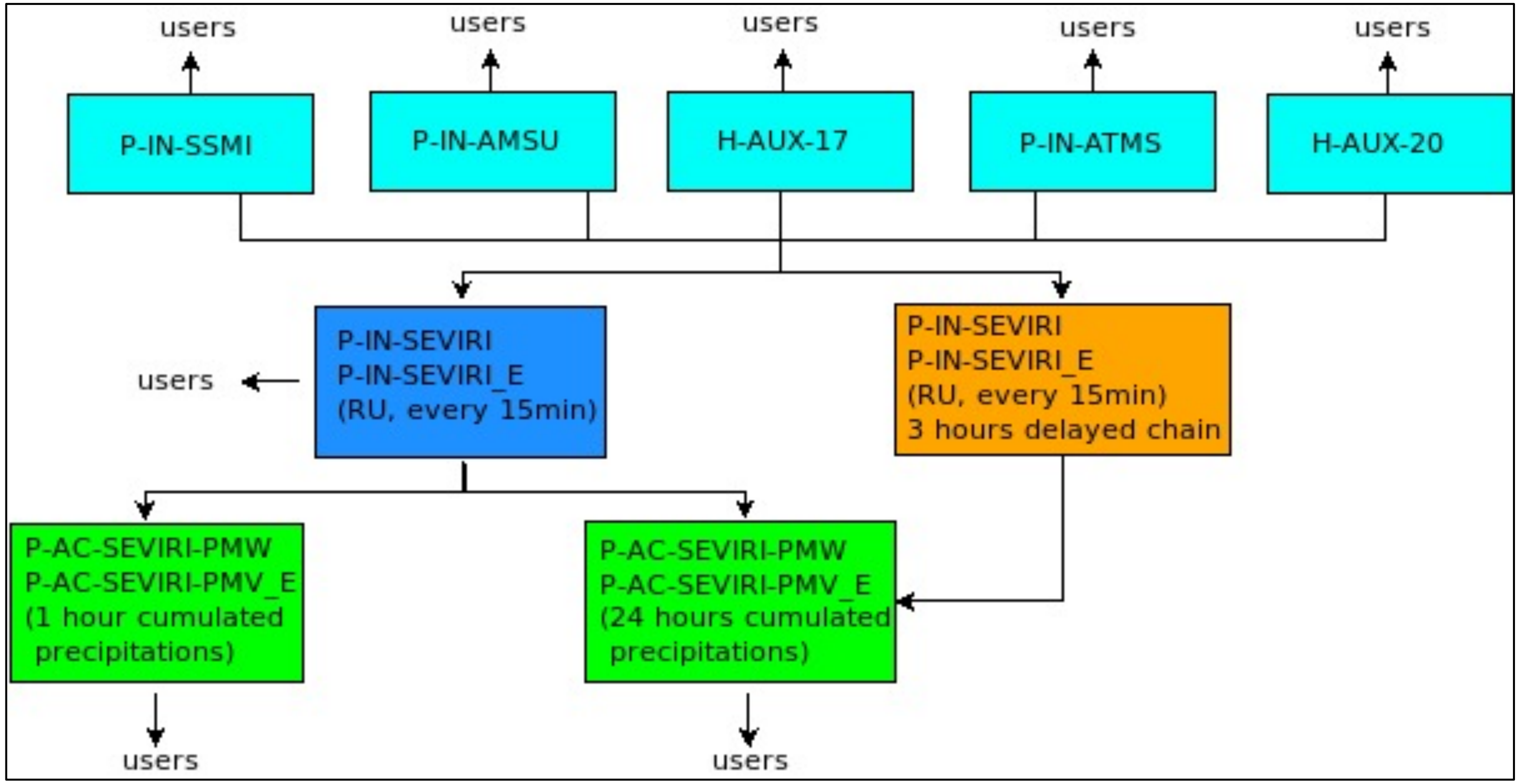
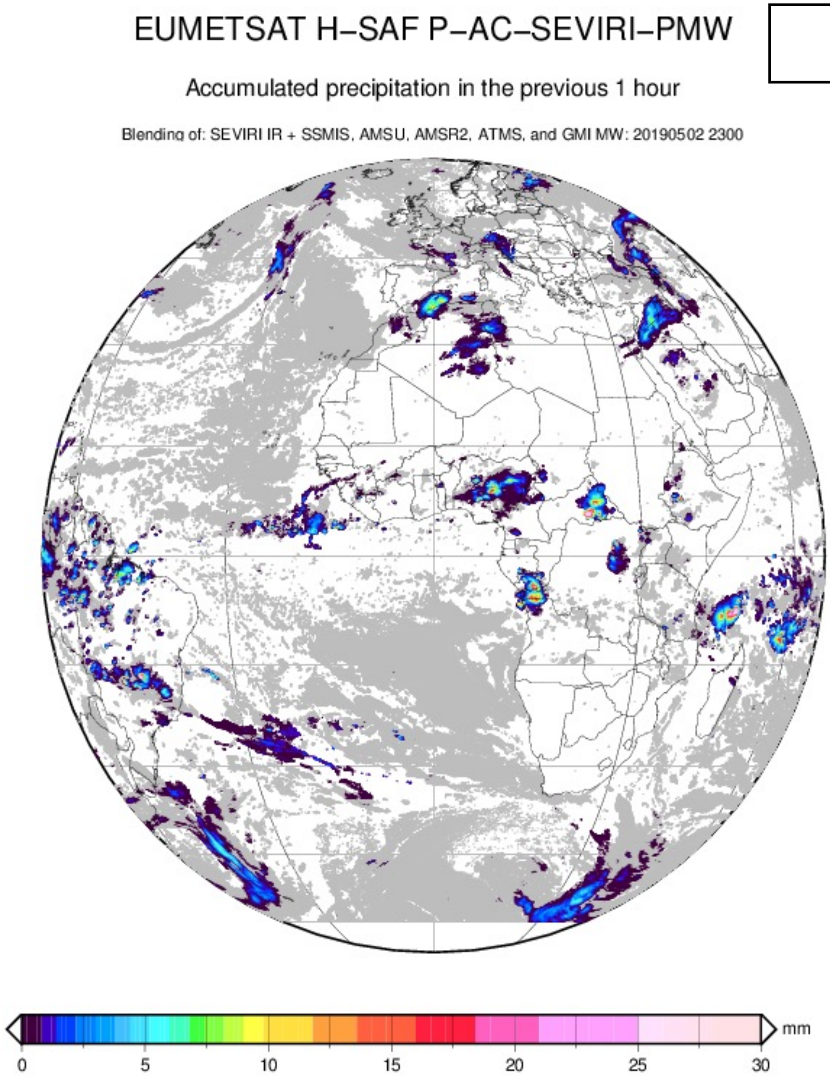
Cumulated SEVIRI-based products



SEVIRI-MSG based instantaneous and cumulated precipitation products chains architecture.

H61 (P-AC-SEVIRI-PMW) and H90 (P-AC-SEVIRI_E) products



Accumulated ground precipitation

Main features	
Coverage	MSG Full-disk area
Cycle	**1 hour**
Spatial Resolution	3 Km s.s.p. ~8 km over Europe
Timeliness	Within 5 minutes from the end of acquisition
Dissemination	EUMETCast and HSAF (*)
Formats	NetCDF

H61 and H90 's domain

0°

41.5°E

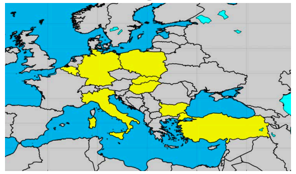
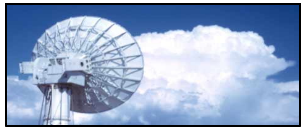
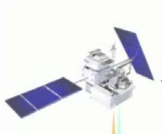
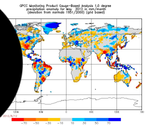
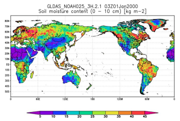
(*) As soon as they become «pre operational»

References & Methods

QA Methodologies and Reference data

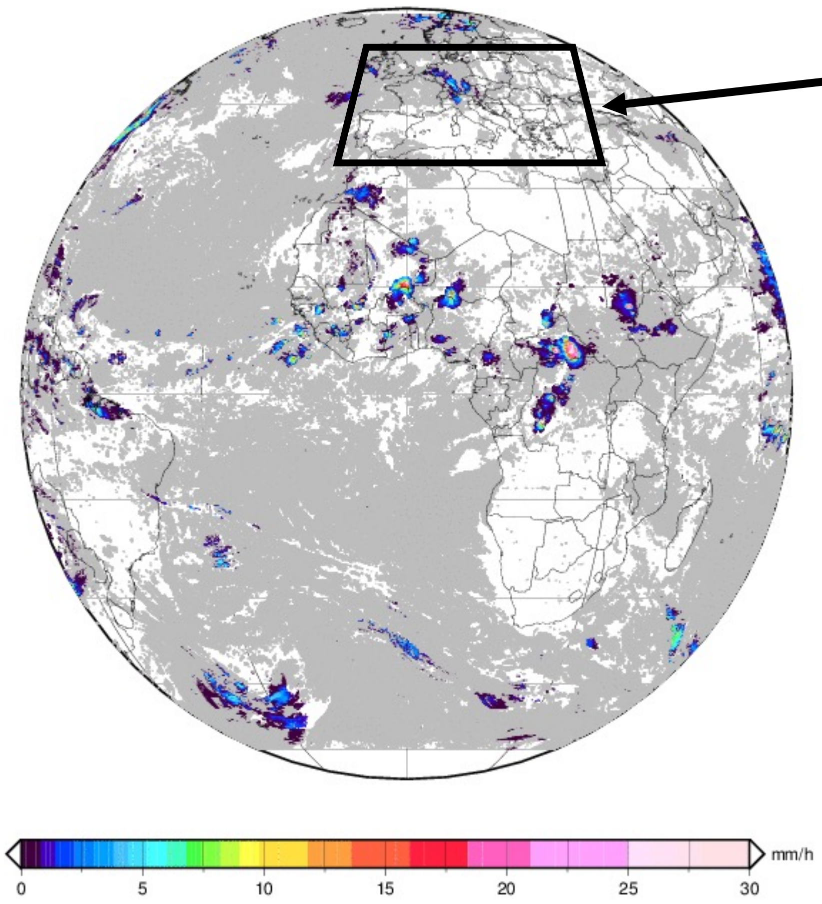
Precipitation Products

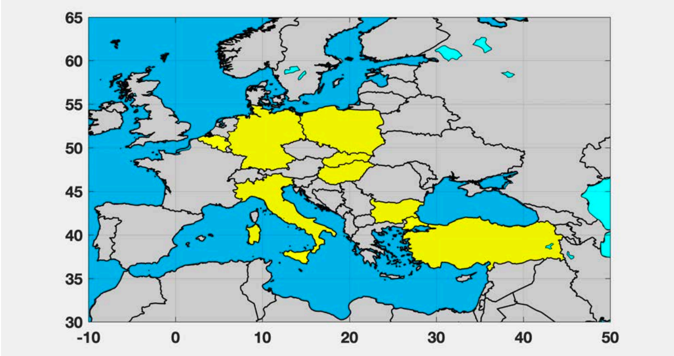
Area

	Instantaneous 	**Accumulated** 
European 	1 Unique Common Code *Ground (Radars and Raingauges)*  	
Full Disk or Global 	2 Comparison Code *DPR – GPM-CO* 	3 Triple Collocation *GPCC & GLDAS*  

1 2 3

Validation over Europe



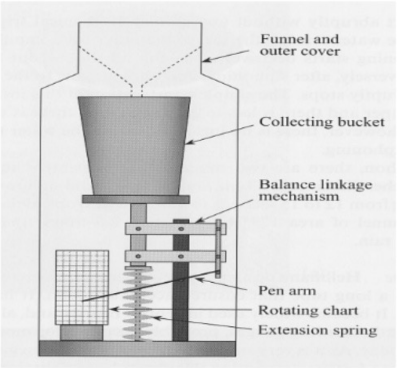


European ground data:
radars and **raingauges**

European ground data: raingauges

Most of the gauges used in the National networks by the validation Groups are of the **tipping bucket type**, which is the most common device used worldwide to have continuous, point-like rain rate measurement. The German network, and a part of the Bulgarian network, as an example, are equipped by precipitation **weighing gauges**, that allow continuous precipitation (both solid and liquid) measurements with higher accuracy.

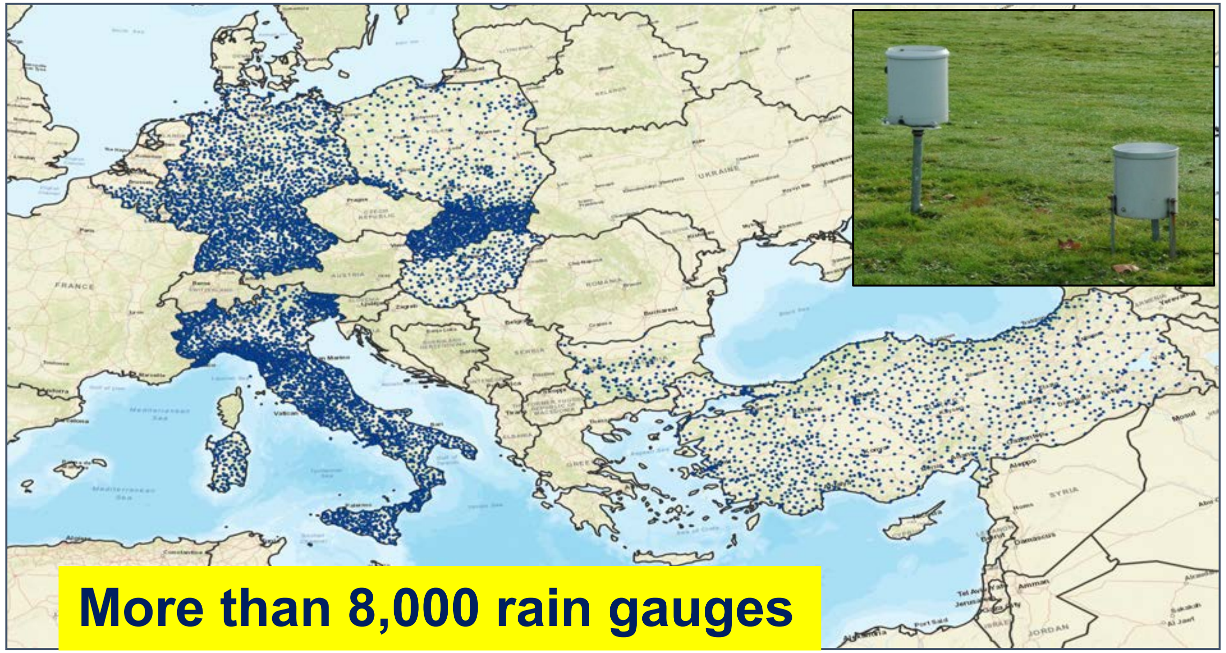
WEIGHING BUCKET TYPE



Minimum detectable rain
≥ 0.1 mm

Typical time resolution
1 hour

Available output format
ASCII



Country	Total number of gauges (*)	Average minimum distance (km)
Belgium	92	15.2
Bulgaria	123	25.2
Germany	2299	12.9
Hungary	270	17.0
Italy	2934	11.3
Poland	540	24.0
Slovakia	911	13.6
Turkey	1235	26.5
TOTAL	**8404**	

(*) The number of available data may vary daily by approximately 10% depending on the availability of the networks.

European ground data: radars

Minimum detectable rain rate
≥ 0.01 mm/h

Time resolution
5 – 60 minutes

Output formats
HDF5, NetCDF, …

Country	Total number of radar	Average minimum distance (km)
Belgium	1	-
Bulgaria	-	-
Germany	16	163
Hungary	4	190
Italy	22	141
Poland	8	186
Slovakia	4	137
Turkey	16	253
TOTAL	**71**	

Institutes involved in the PPVG declared the system are kept in a relatively good status and all of them apply some correction factors in their processing chain of radar data. Only the radar data which passes the Quality Check of the owner Institute are used by the PPVG for validation activities.

Validation methodology over Europe

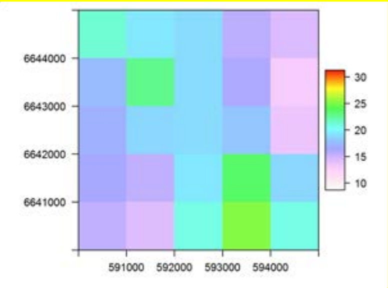
1. GROUND DATA

Quality check and filtering

Spatial interpolation (GRISO)

2. TEMPORAL-SPATIAL MATCHING

Upscaling to the product grid



<- the validation is performed over the satellite grid to evaluate the satellite product as it is released.

3. STATISTICAL (CONTINUOUS AND MULTI-CATEGORICAL) SCORES

Precipitatior

- Light [0.25≤R
- Moderate [1.0≤ R
- Heavy [R
- All [R

Surface types:

- Sea
- Land
- Coast
- Overall

Time intervals:

- Monthly
- Seasonal
- Yearly

Precipitation phases:

- Liquid
- Solid
- Mixed
- All

This comparison methodology is performed by the **Unique Common Code (UCC)** for all (8) participating countries (PPVG)

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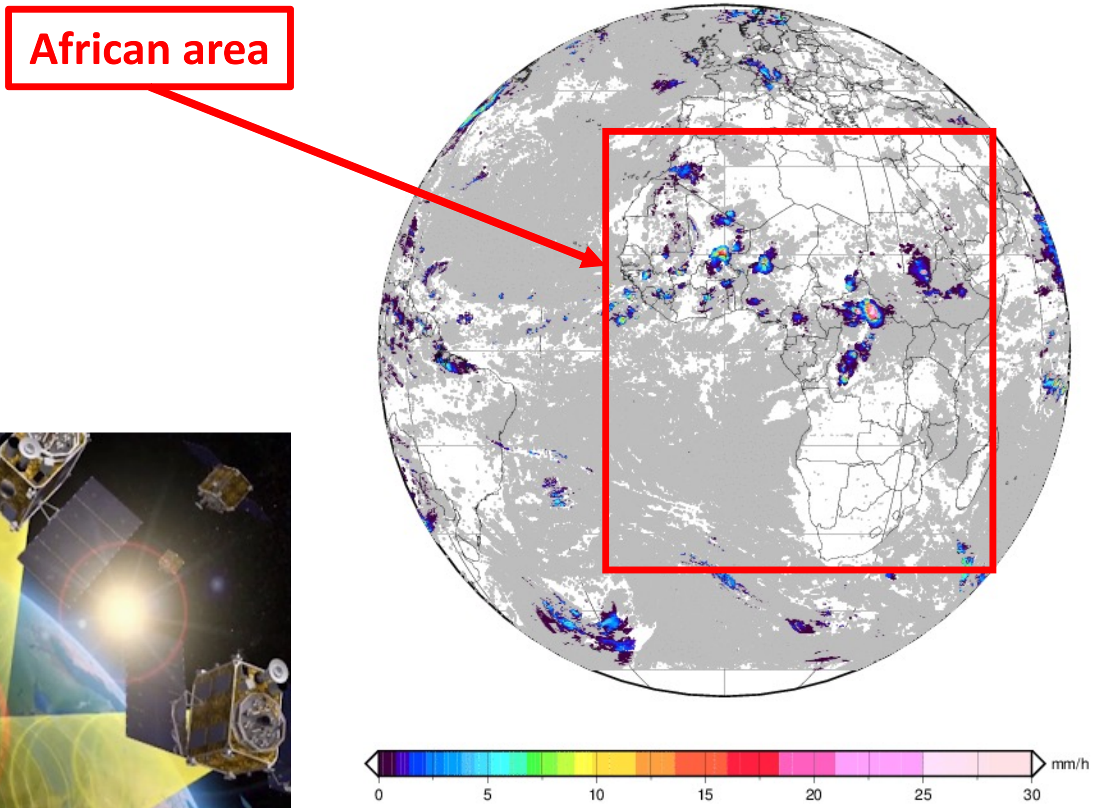
Comparison over Africa

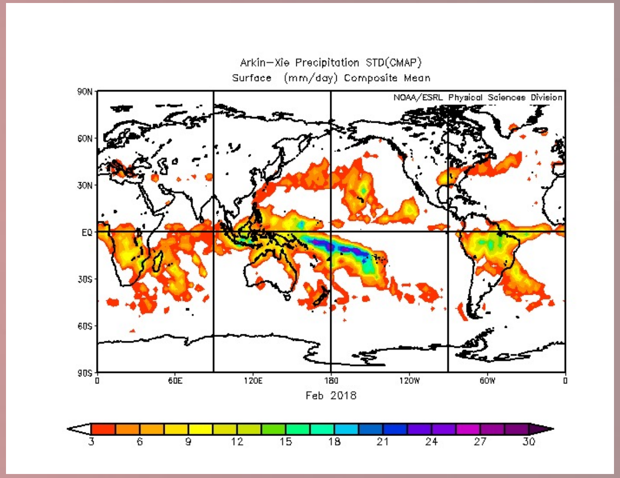


Satellites

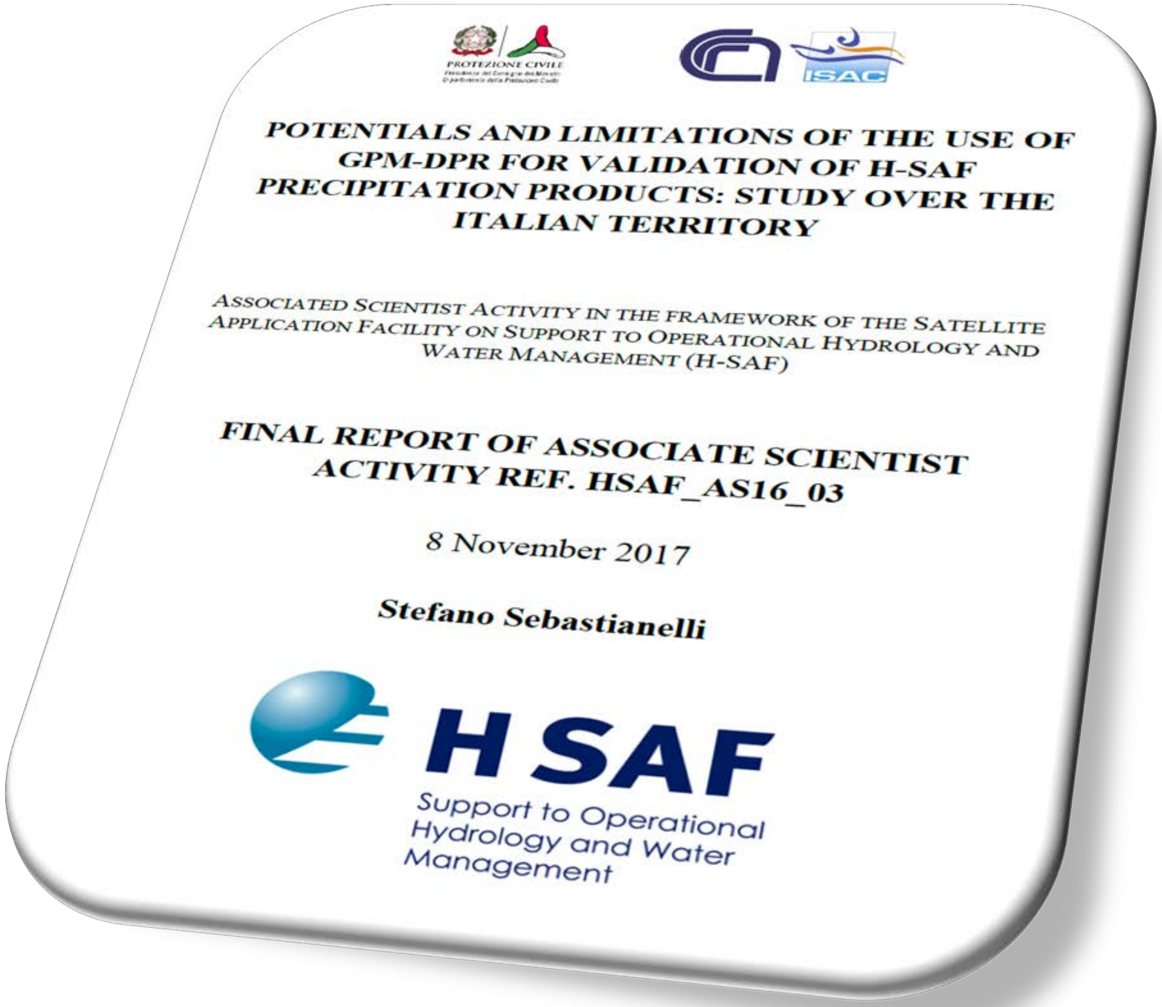
Reference ground data:
radars and/or **raingauges**

Available precipitation data over Africa

- ❑ Few gauges, very few weather radars
- ❑ Non-homogeneous extension over the whole Africa
- ❑ Daily or monthly data and not (or few) hourly or sub-hourly data
- ❑ Precipitation datasets not independent by the products to be validated
- ❑ Data mainly over land areas



Associate Scientist activity result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ISAC

POTENTIALS AND LIMITATIONS OF THE USE OF GPM-DPR FOR VALIDATION OF H-SAF PRECIPITATION PRODUCTS: STUDY OVER THE ITALIAN TERRITORY

ASSOCIATED SCIENTIST ACTIVITY IN THE FRAMEWORK OF THE SATELLITE APPLICATION FACILITY ON SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT (H-SAF)

FINAL REPORT OF ASSOCIATE SCIENTIST ACTIVITY REF. HSAF_AS16_03

8 November 2017

Stefano Sebastianelli

H SAF

Support to Operational Hydrology and Water Management

«…it can be establish that 2A-DPR NS V05 *can be used to verify the* H03 (P-IN-SEVIRI) *rainfall estimations where the ground radars are not available, as is the case for most of the African territory. This is more true for light to moderate precipitation, whereas for heavy precipitation* DPR *products should be used with more caution, due to the underestimation of* DPR *with respect the reference and to the scarce data of heavy precipitation sampled by the ground-based radars.»*

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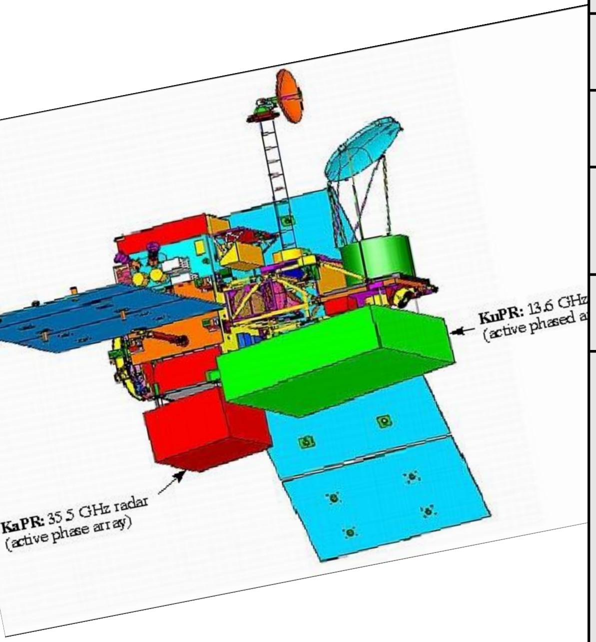
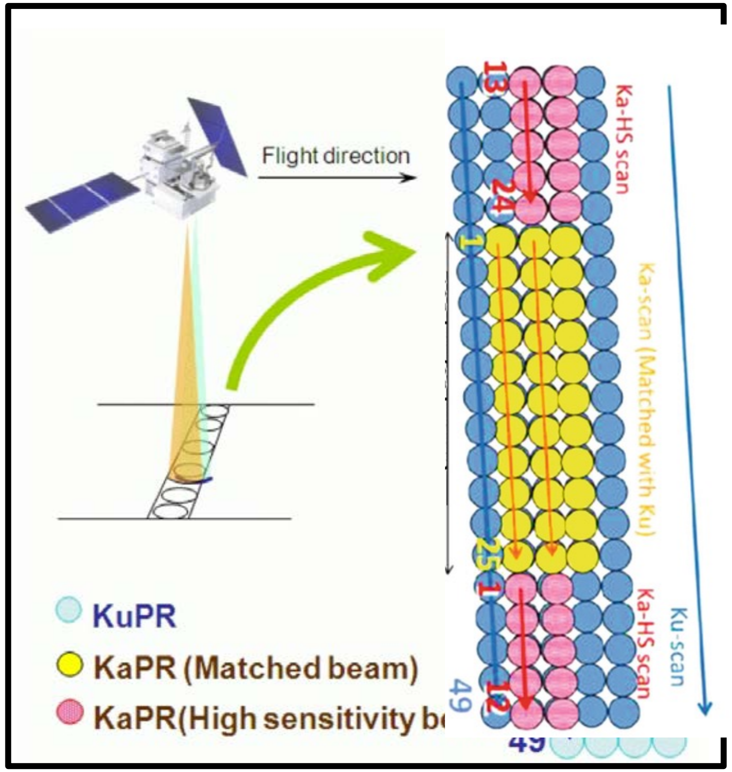
Dual-frequency Precipitation Radar (DPR)



Features	KuPR	KaPR
Frequency	13.6 GHz	35.5 GHz
Swath Width	245 km	120 km
Spatial Resolution	5.2 km (Nadir @ 407 km)	
Beam Width	0.71° (Center Beam)	
Beam Number	**49 Normal Scan, NS**	49: **25 in matched beams (MS)** + **24 in high-sensitivity scans (HS)**
Min. measur. RR	**0.5 mm/h**	0.2 mm/h
Cross T. Scan Angle	±17°	±8.5°

2 product types (K-band only / Combined [DPR] Product)



3 Scan modes (NS, MS and HS)

prEs
Precipitation Estimated on Surface

Comparison methodology over Africa

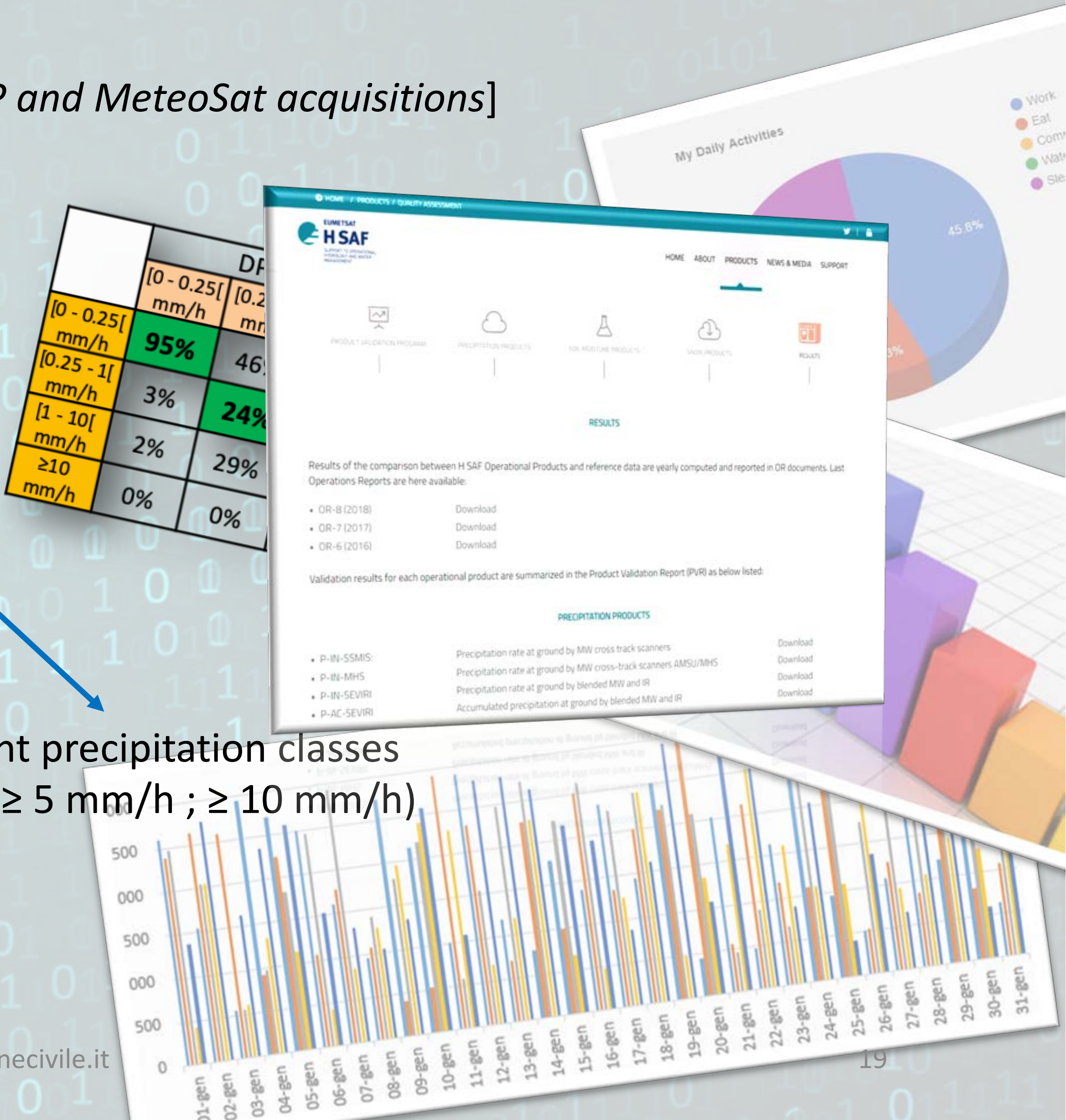
- ✓ Intersection [*temporal and spatial GPM vs NOAA/METOP and MeteoSat acquisitions*]
- ✓ Downscaling [*regular grid 0.5°*]
- ✓ Comparison [*pixel-based*]
- ✓ Results

Statistical scores
(events, monthly, seasonal, yearly)

For different geographical areas
(Africa, Europe, Ocean)

For different surface types
(sea, land, coast)

For different precipitation classes
(≥ 1 mm/h; ≥ 5 mm/h ; ≥ 10 mm/h)



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TC methodology

Underlying the triple collocation technique is the linear additive error model between the measurement systems and the unknown truth:

$$X = \alpha + \beta T + \varepsilon \qquad (1)$$

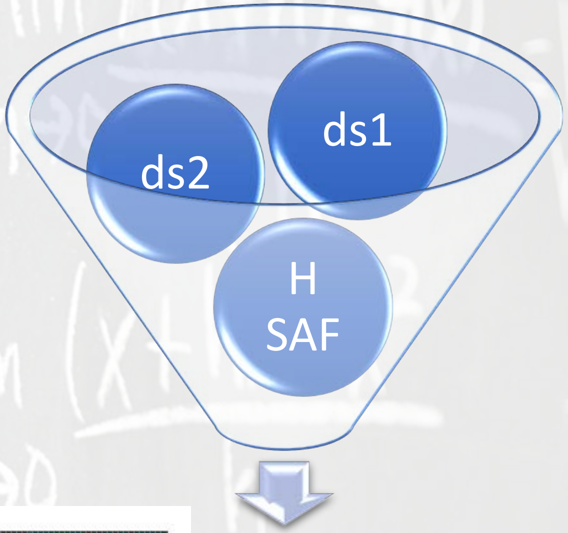
where X is a daily accumulated rainfall product, T is the true rainfall, α and β are additive and multiplicative biases, respectively, and ε is the zero-mean random error.

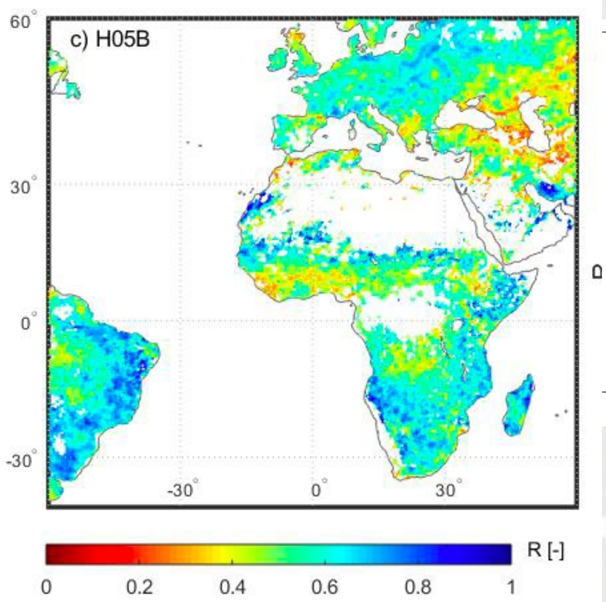
The extended triple collocation (hereafter referred to as TC) approach (McColl et al., 2014) can be applied to estimate the correlation (R) of a measurement system to the unknown truth. Given three gridded daily rainfall products (X, Y and Z) that linearly relate to the true daily rainfall intensity as described in (1), the correlation between X and the unknown truth T can be estimated as

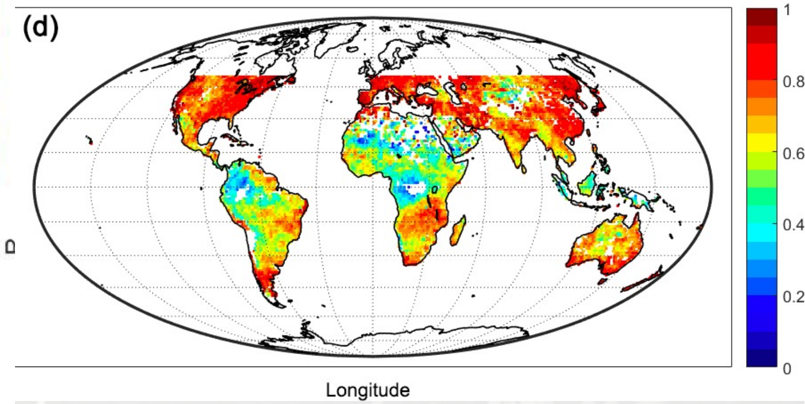
$$R_X = \sqrt{\frac{\sigma_{XY}\sigma_{XZ}}{\sigma_X^2\sigma_{YZ}}} \qquad (2)$$

where $\sigma_{XY}$is the covariance of X and Y, etc., and σ_X^2 is the variance of X. For further details please refer to McColl et al. (2014). In addition to the linearity assumption, TC also requires: 1) mutually independent error impacting X, Y and Z; 2) errors that are uncorrelated to T (i.e. error orthogonality); and 3) the stationarity of signal and error statistics (i.e., homoscedasticity) (Gruber *et al*. 2016a; Draper *et al*. 2013; Zwieback *et al*. 2012).

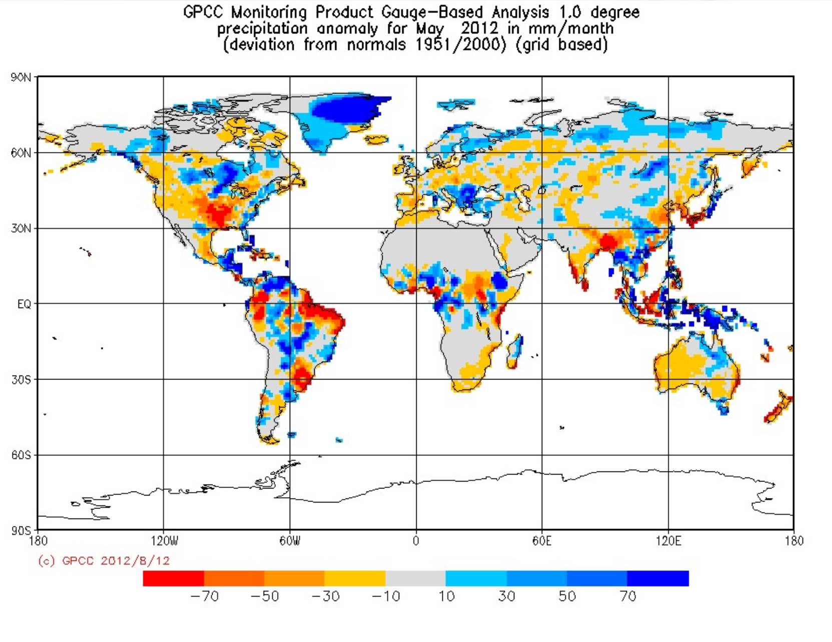
Due to the linearity assumption expressed in (1), we applied TC only at pixels where significant ($p = 0.05$) levels of mutual correlation exist between the members of the triplet. To ensure the stationarity of signal and error statistics (see above), a common practice is to remove seasonal signals from the raw time-series prior to application of TC (e.g., Chen et al., 2017; Gruber *et al*. 2016a; Su and Ryu, 2015). However, because of the intermittent nature of precipitation, no-rain days are an important category of observation and should not be artificially altered into non-zero anomaly values. Therefore, raw daily rainfall time-series were used here in the TC and QC analyses.

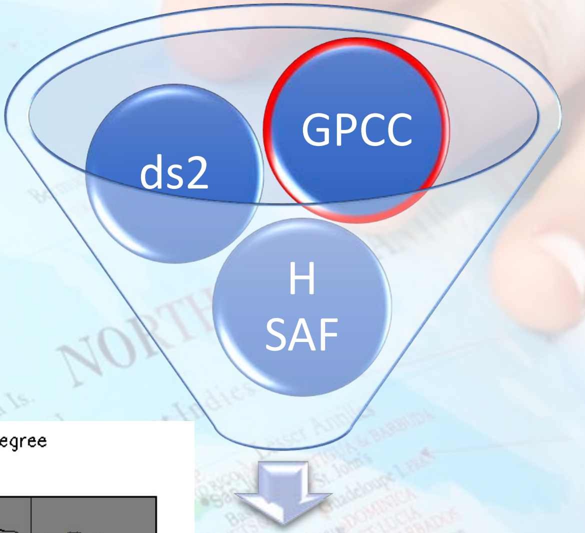


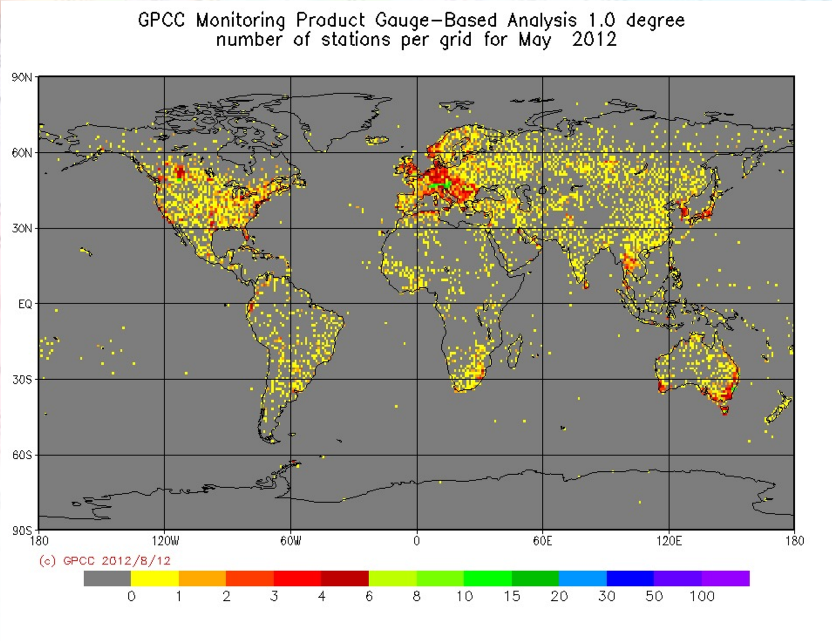




TC Global Reference
1) GPCC



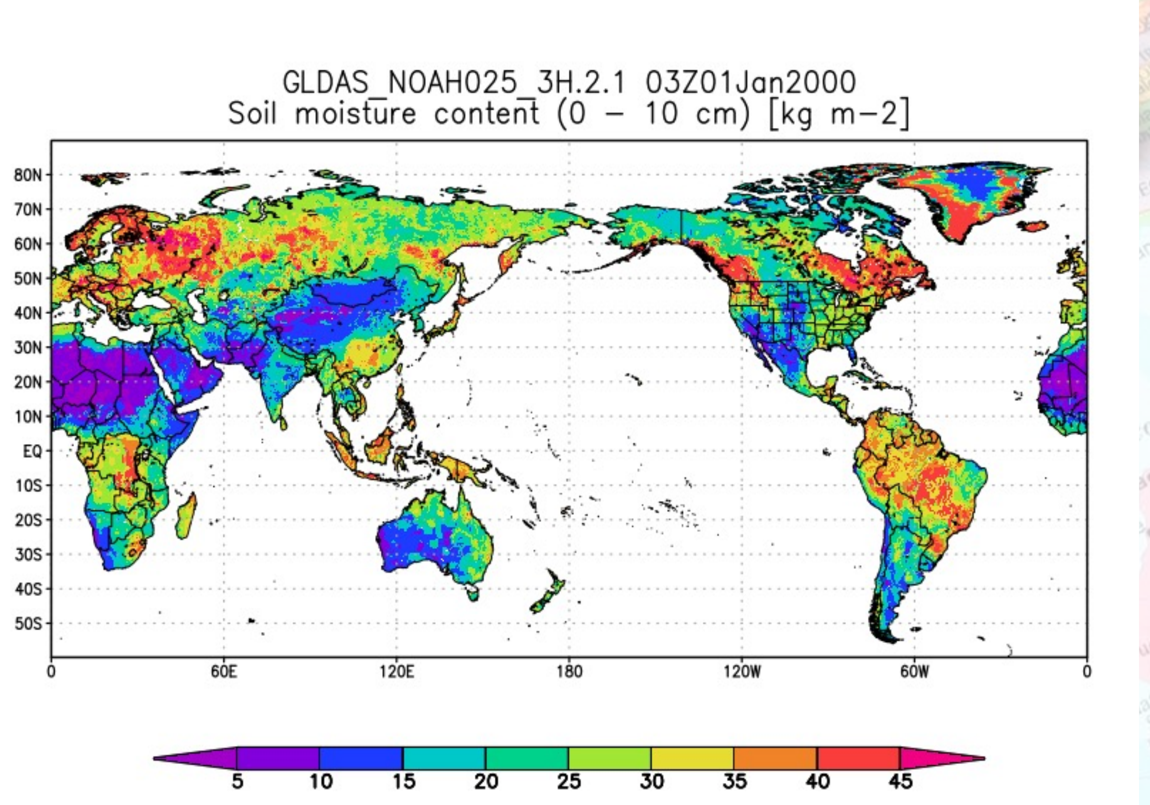




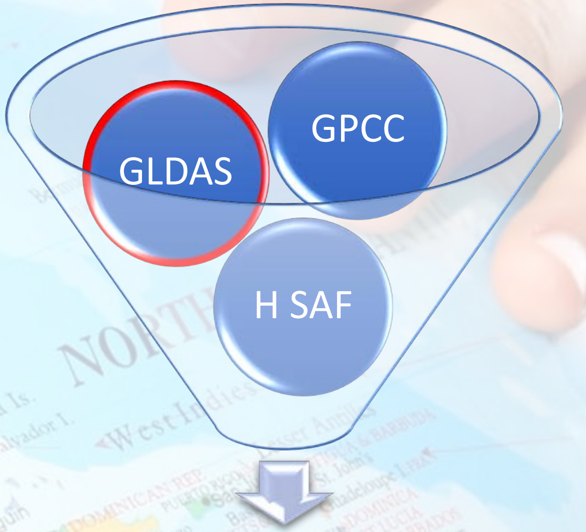
https://climatedataguide.ucar.edu/climate-data/gpcc-global-precipitation-climatology-centre

TC Global Reference
2) GLDAS

GLDAS-2.1 is forced with a combination of model and observation data from 2000 to present



GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1 (GLDAS_NOAH025_3H)



Shortname:	GLDAS_NOAH025_3H
Longname:	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1
DOI:	10.5067/E7TYRXPJKWOQ
Version:	2.1
Format:	netCDF
Spatial Coverage:	-180.0,-60.0,180.0,90.0
Temporal Coverage:	2000-01-01 to 2021-09-01
File Size:	19 MB per file
Data Resolution	
Spatial:	0.25 ° x 0.25 °
Temporal:	3 hours

https://ldas.gsfc.nasa.gov/gldas

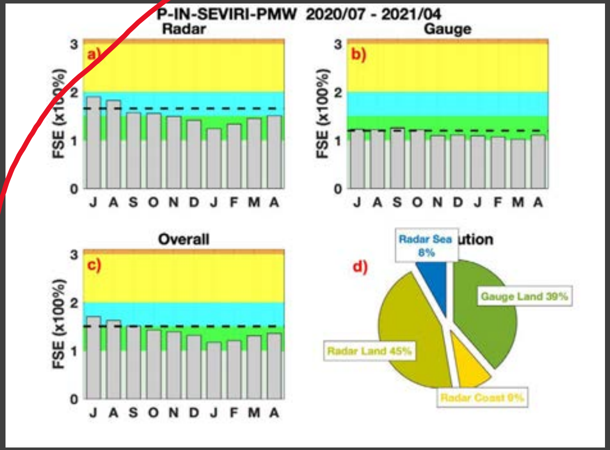
«Rain precipitation rate» variable

Quality Assessment Results

Quality Assessment: H60

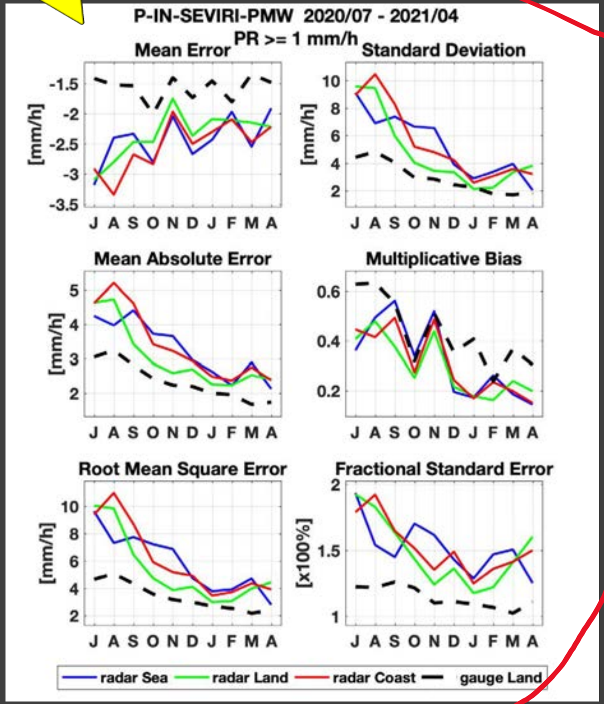
with respect to ground data

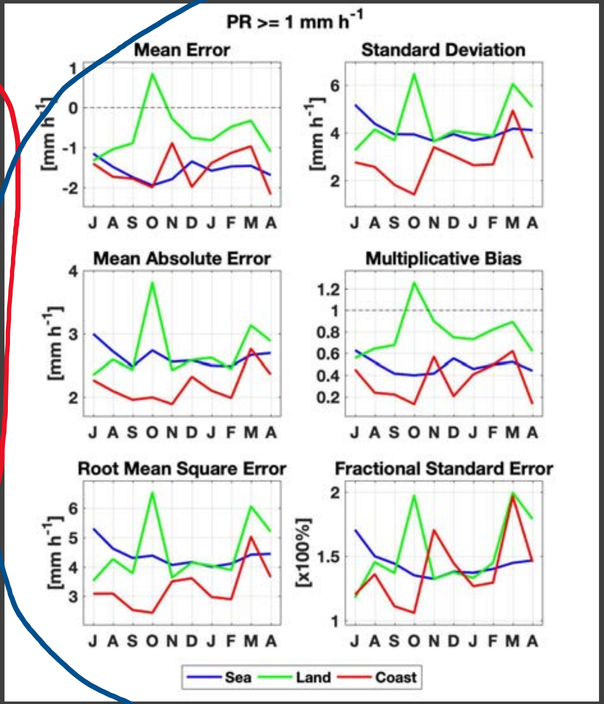
with respect to DPR

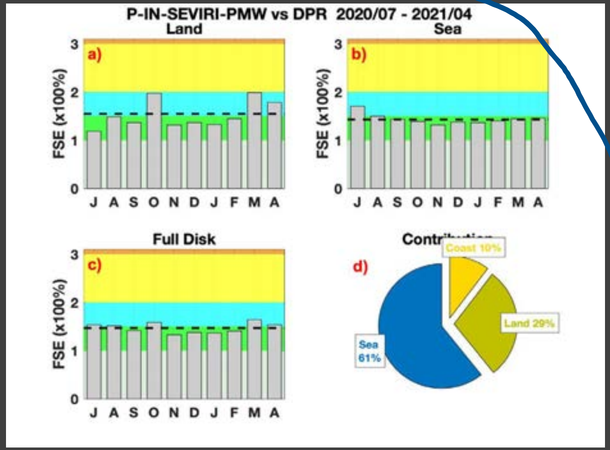


Overall				
Multi-Categorical Statistics				
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	90%	70%	54%	32%
[0.25 - 1[mm/h	6%	15%	18%	12%
[1 - 10[mm/h	4%	15%	28%	46%
≥10 mm/h	0%	0%	1%	10%

Table 24: Multi-categorical table for product H60– Overall validation.
The precipitation classes along the columns (rows) are relative to ground (satellite) precipitation.







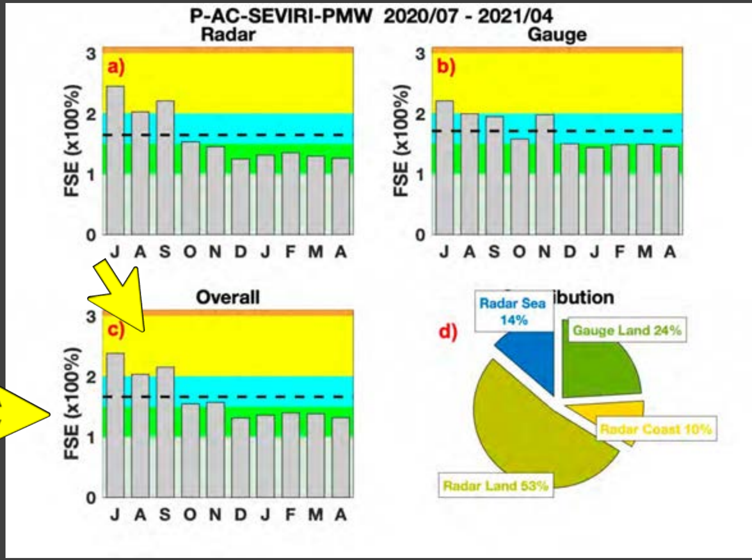
Overall - Full Disk				
Multi-Categorical Statistics				
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	98%	82%	53%	20%
[0.25 - 1[mm/h	1%	9%	16%	11%
[1 - 10[mm/h	1%	9%	28%	48%
≥10 mm/h	0%	0%	2%	20%

Table 27: Multi-categorical table for product H60 over the MSG full disk area.
The precipitation classes along the columns (rows) are relative to DPR-NS (H60) precipitation.

Quality Assessment: H61

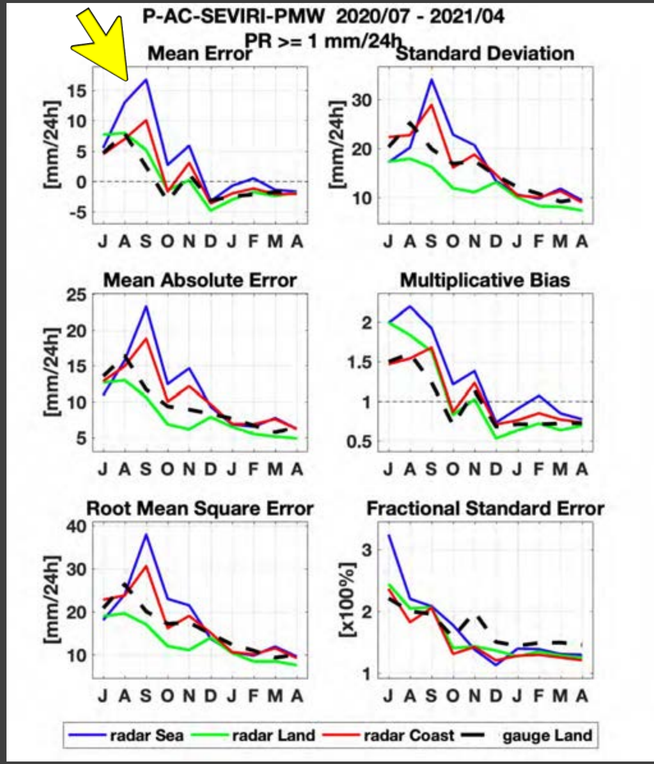
ground data

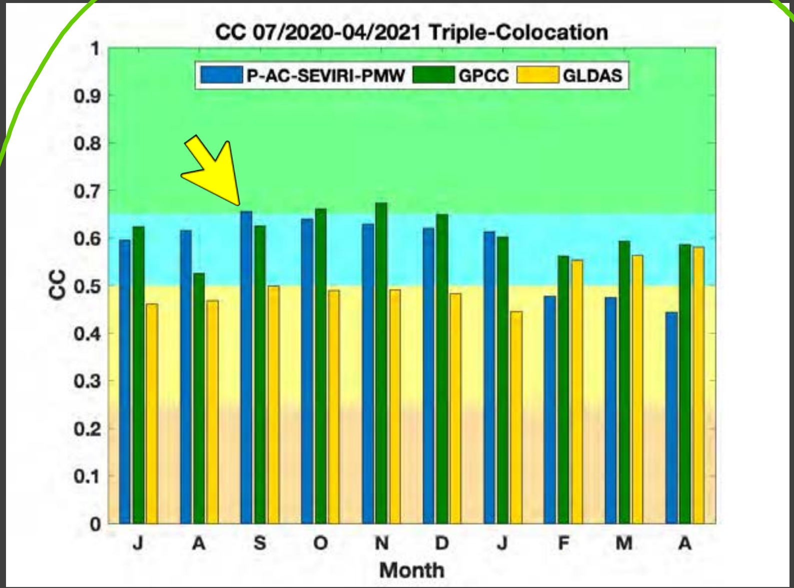
TC



Overall			
Multi-Categorical Statistics			
	< 1 mm/day	[1 - 10[mm/day	≥10 mm/day
< 1 mm/day	75%	38%	17%
[1 - 10[mm/day	21%	41%	34%
≥10 mm/day	4%	21%	49%

Table 27: Multi-categorical table for product H61 – Overall validation. The precipitation classes along the columns (rows) are relative to ground (satellite) precipitation.





P-AC-SEVIRI-PMW vs GLDAS	< 1 mm/24h	[1 - 10[mm/24h	≥10 mm/24h
< 1 mm/24h	86%	54%	26%
[1 - 10[mm/24h	10%	27%	22%
≥10 mm/24h	4%	19%	52%

Table 29: Multi-categorical table for product P-AC-SEVIRI-PMW versus GLDAS over 24h – Overall FD validation. The precipitation classes along the columns (rows) are relative to GLDAS (H SAF) precipitation.

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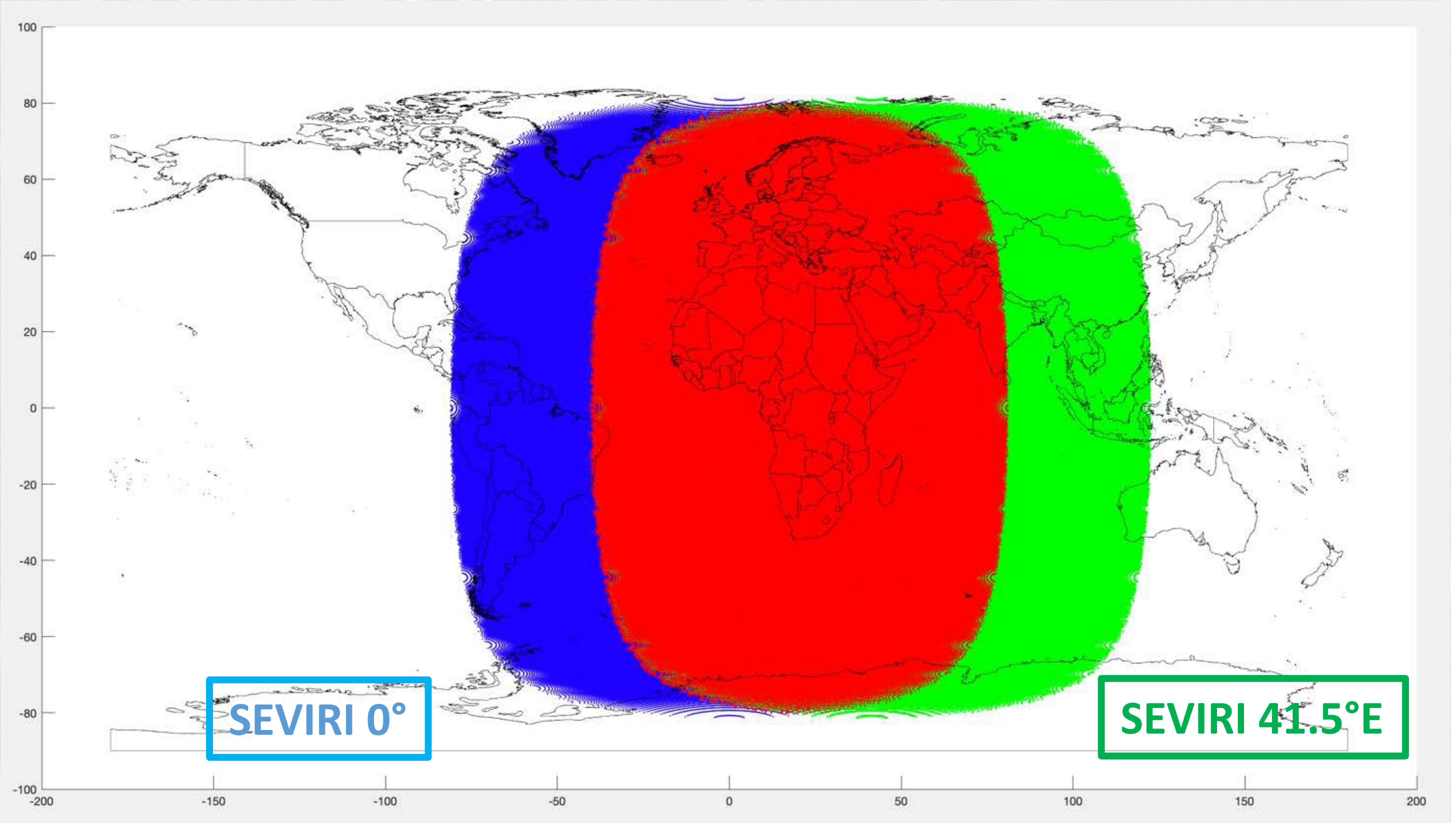
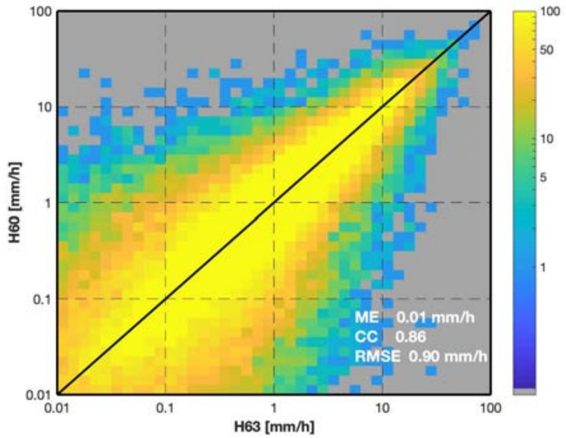
Inter-comparison



Coverage areas for H60/H61 (blue) and H63/H90 (green) products.
Overlapped area is highlighted in red.

Inter-comparison H63-H60 results

H63 vs H60		
≥0.25 mm/h	POD	0.81
	FAR	0.25
	MISS	0.19
	CSI	0.63
≥1 mm/h	POD	0.78
	FAR	0.25
	MISS	0.22
	CSI	0.62



H63 vs H60				
Multi-Categorical Statistics				
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	97%	35%	9%	1%
[0.25 - 1[mm/h	3%	44%	15%	1%
[1 - 10[mm/h	0%	21%	73%	37%
≥10 mm/h	0%	0%	3%	61%

Table 31: Multi-categorical table for product H63 in comparison with product H60 over the overlapped area. The precipitation classes along the columns (rows) are relative to H60 (H63) precipitation.

H63 vs H60	≥0 mm/h
Num H63 [#]	313,662,875
Num H60 [#]	313,662,858
ME [mm/h]	0.01
STD [mm/h]	0.90
MAE [mm/h]	0.17
MB [-]	1.02
CC [-]	0.86
RMSE [mm/h]	0.90

Table 29: Comparison scores between H63 and H60

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Inter-comparison H90-H61 results

H90 vs H61		
≥0.25 mm/24h	POD	0.92
	FAR	0.13
	MISS	0.08
	CSI	0.81
≥10 mm/24h	POD	0.86
	FAR	0.16
	MISS	0.14
	CSI	0.74

H90 vs H61	≥0 mm/24h
Num H90 [#]	181,241,159
Num H61 [#]	181,241,611
ME [mm/24h]	-0.50
STD [mm/24h]	8.92
MAE [mm/24h]	2.69
MB [-]	0.96
CC [-]	0.92

H90 vs H61			
Multi-Categorical Statistics			
	< 1 mm/24h	[1 - 10[mm/24h	≥10 mm/24h
< 1 mm/24h	96%	14%	1%
[1 - 10[mm/24h	3%	74%	13%
≥10 mm/24h	0%	12%	86%

Table 35: Multi-categorical table for product H90 in comparison with product H61 over the overlapped area. The precipitation classes along the columns (rows) are relative to H61 (H90) precipitation.

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Final Quality Assessment Results

in

ac

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

H60	Annual average of FSE (%)							
Precipitation Class	Requirement (FSE %)			Radar (Land)	Radar (Sea)	Radar (Coast)	Gauge (Land)	OVERALL
	thresh	target	optimal					
≥ 1 mm/h	200	150	100	171	158	162	120	150

Table 25: Product requirement and compliance analysis for product H60

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

H61 vs Ground	Annual average of FSE (%)							
Precipitation Class	Requirement (FSE %)			Radar (Land)	Radar (Sea)	Radar (Coast)	Gauge (Land)	OVERALL
	thresh	target	optimal					
≥ 1 mm/day	200	150	100	168	163	152	171	166

Table 28: Product requirement and compliance analysis for product H61

H63 vs H60	≥0 mm/h
Num H63 [#]	313,662,875
Num H60 [#]	313,662,858
ME [mm/h]	0.01
STD [mm/h]	0.90
MAE [mm/h]	0.17
MB [-]	1.02
CC [-]	0.86
RMSE [mm/h]	0.90

Table 29: Comparison scores between H63 and H60

H90 vs H61	≥0 mm/24h
Num H90 [#]	181,241,159
Num H61 [#]	181,241,611
ME [mm/24h]	-0.50
STD [mm/24h]	8.92
MAE [mm/24h]	2.69
MB [-]	0.96
CC [-]	0.92
RMSE [mm/24h]	8.95

Table 33: Comparison scores between H90 and H61

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

H60 vs DPR	Annual average of FSE (%)						
Precipitation Class	Requirement (FSE %)			Land	Sea	Coast	OVERALL
	thresh	target	optimal				
≥ 1 mm/h	200	150	100	154	143	154	147

Table 28: Product requirement and compliance analysis for H60 in comparison with DPR-NS product.

P-AC-SEVIRI-PMW by TC methodology	Annual average of CC			
Precipitation Class	Requirement (CC)			OVERALL
	thresh	target	optimal	
≥ 0 mm/24h	0.50	0.65	0.80	0.58

Table 32: UR and compliance analysis for P-AC-SEVIRI-PMW (24h) product over FD area by TC methodology.

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Conclusions

H60 (P-IN-SEVIRI-PMW) and partly also H61 (P-AC-SEVIRI) tend to slightly underestimate rainfall, especially compared to the low intensities observed by ground data

H63 and H90 are in **strong agreement** with H60 and H61 products, respectively

H60, H61, H63 e H90 will be **very soon H SAF operational products** (by end of February 2022)
They will be distributed via EUMETCAST or through the H SAF website

All results here shown (and more) are observable/downloadable on Validation reports

Every 15 minutes these products provide (in NRT) an estimate of the **instantaneous (and accumulated) precipitation** over more than half of the globe!

these products are unique among all available international products!

Thank you for your attention !

http://h-saf.eumetsat.int/

Question?

Contact us!

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