H SAF Precipitation Products Validation activities

Marco Petracca, Silvia Puca, Michal Kasina, and
Quality Assessment Cluster and Hydro Validation Cluster

Validation activities

Validation activities play a relevant role towards the end-users of the products.

There are two main requirements according to the specific use of the products:

• **the direct use by human operators monitoring in real time** the Hydrological **situation** for taking decision as regard Operations by Civil protection Agencies and by various institutes which have in charge the real time Hydrological monitoring of the environment;

• **the direct use by Hydrological numerical models** to provide run off information for near real time monitoring and off line studies.

In order to accomplish such requirements, dedicated clusters were designed to elaborate the direct end-user quality assessment service:

Quality Monitoring and Assessment Cluster (Q.A.)

Hydrological Validation Cluster (H.V.)

Marco.Petracca@protezionecivile.it

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Quality Monitoring and Assessment Cluster

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Objectives:

- **to monitor the progress in product quality** as further development evaluating statistical scores and case study analysis on the base of comparison between satellite products and ground data;
- **to provide validation service to end-users** publishing on the H SAF web-page the statistical scores evaluated and the case studies analysed;
- **to investigate the H SAF product impact in end-user applications** for emergency management, precipitation event alerts, street monitoring, water balance evaluation, etc.

Product quality assessment

User Promotion

Tool development

Hydrologists, meteorologists, and *precipitation, snow and soil moisture ground data experts*, coming from experts from the National Meteorological and Hydrological Institutes of **Austria (ZAMG), Belgium (IRM), Bulgaria (NIMH), Finland (FMI), France (Meteo France), Germany (BfG), Hungary (OMSZ), Italy (ITAF MET, DPC, UniBo, CNR-IRPI, CIMA), Poland (IMWM), Slovakia (SHMU), and Turkey (ITU, METU, AU)**. **ECMWF** takes also part of the cluster.

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Precipitation Product Validation Group (PPVG)

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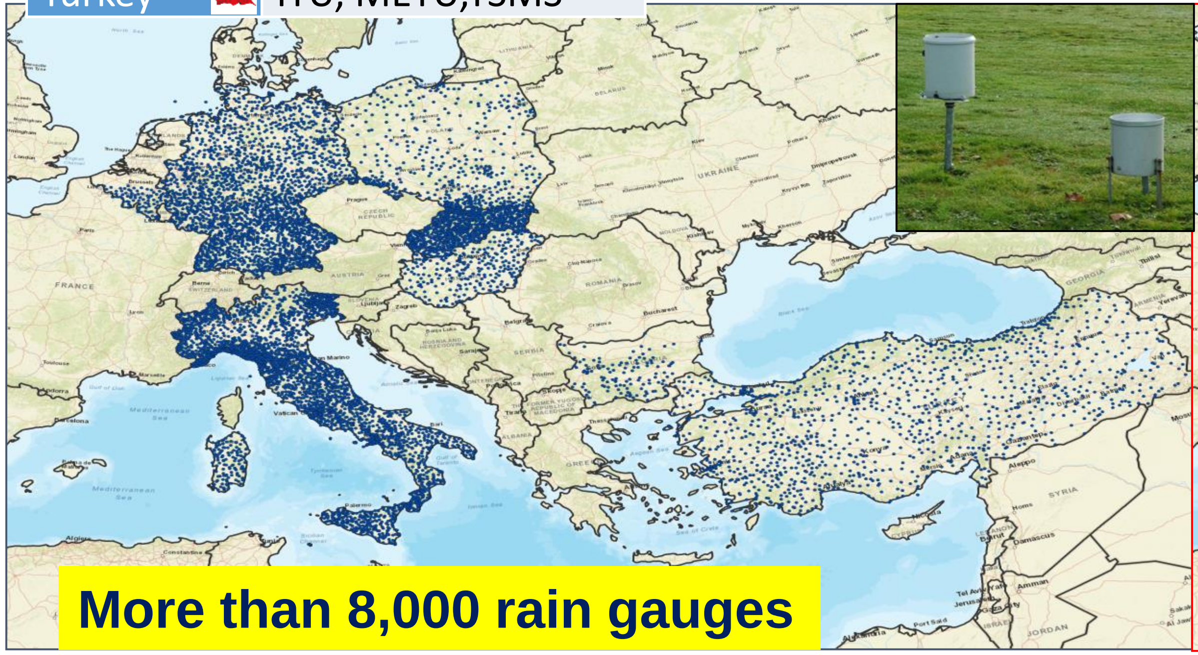
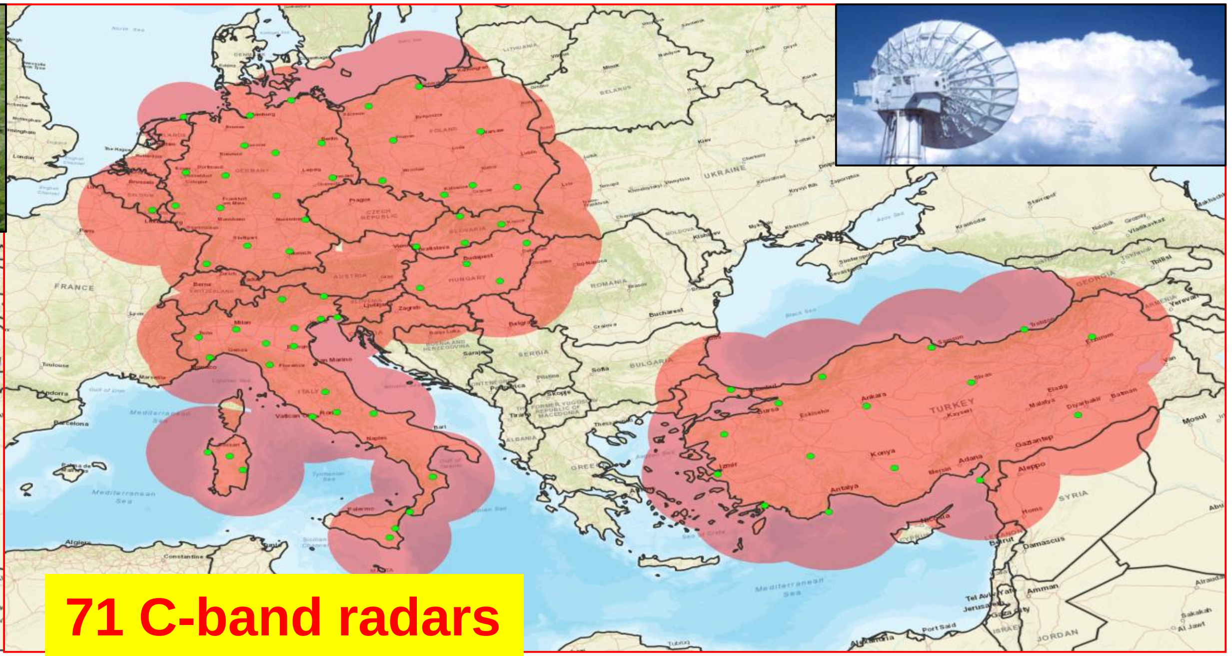
Country	Institutes
Belgium	IRM
Bulgaria	NIMH
Germany	BfG
Hungary	OMSZ
Italy	DPC, UniBo
Poland	IMWM
Slovakia	SHMU
Turkey	ITU, METU,TSMS

The *Precipitation Product Validation Group* (**PPVG**) is composed of experts from the National Meteorological and Hydrological Institutes of **8 European countries** under the coordination of the Italian Civil Protection Department. The PPVG uses both **rain gauge** and **radar** data for quality assessment of precipitation products, following the same protocol related to quality control , spatial interpolation, up scaling technique, verification method.



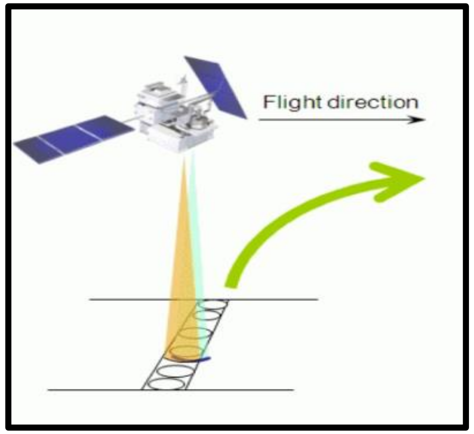


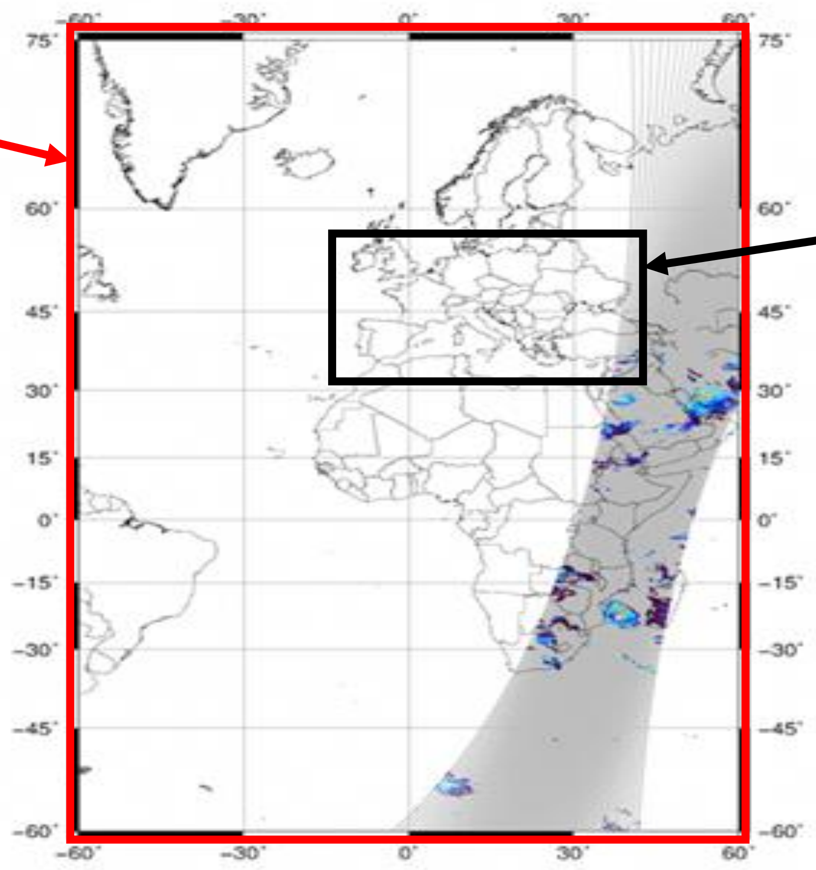
Precipitation products area coverage

MSG Full Disk area

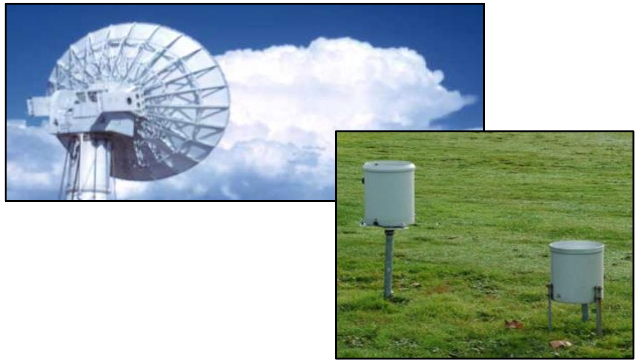
Global (or hemispherical) precipitation products

DPR (**D**ual-frequency **P**recipitation **R**adar) onboard of **GPM-CO** satellite

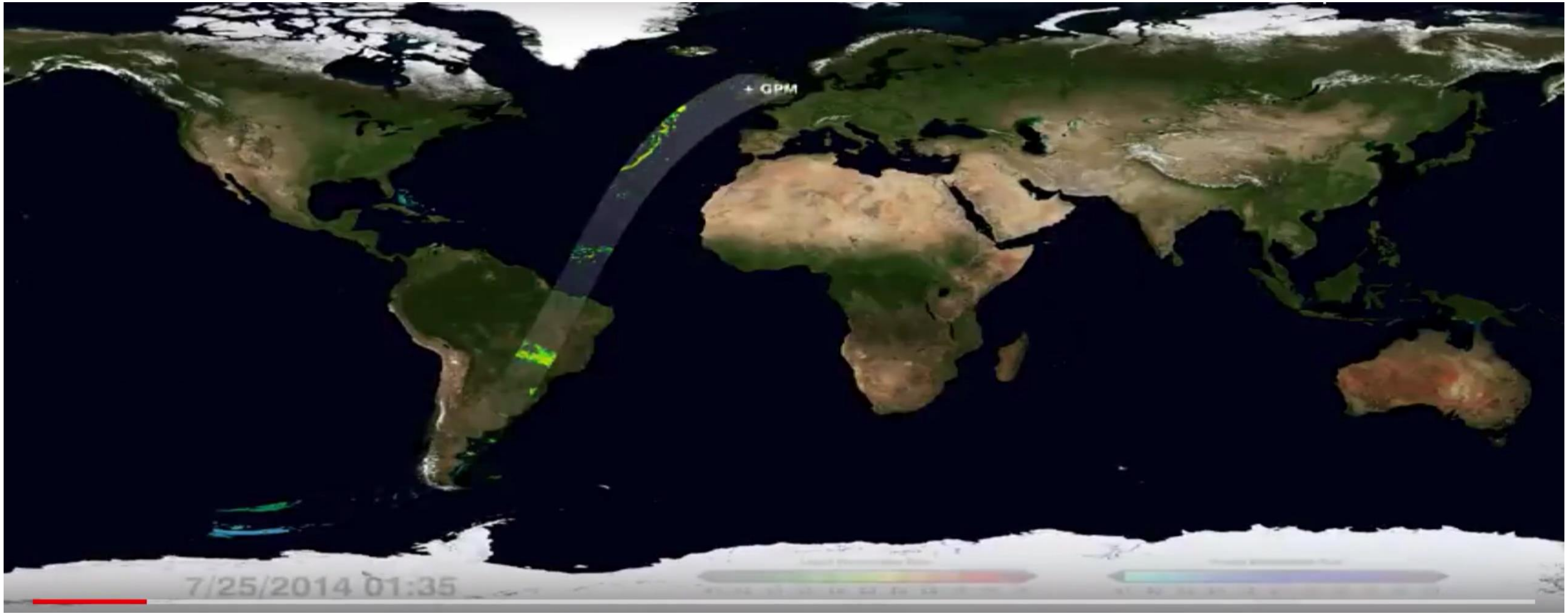




National ground data: **radars** and **raingauges**



Temporal and spatial intersection (GPM vs NOAA/METOP/Fxx and SEVIRI



Marco.Petracca@protezionecivile.it

Q.A. Methodology

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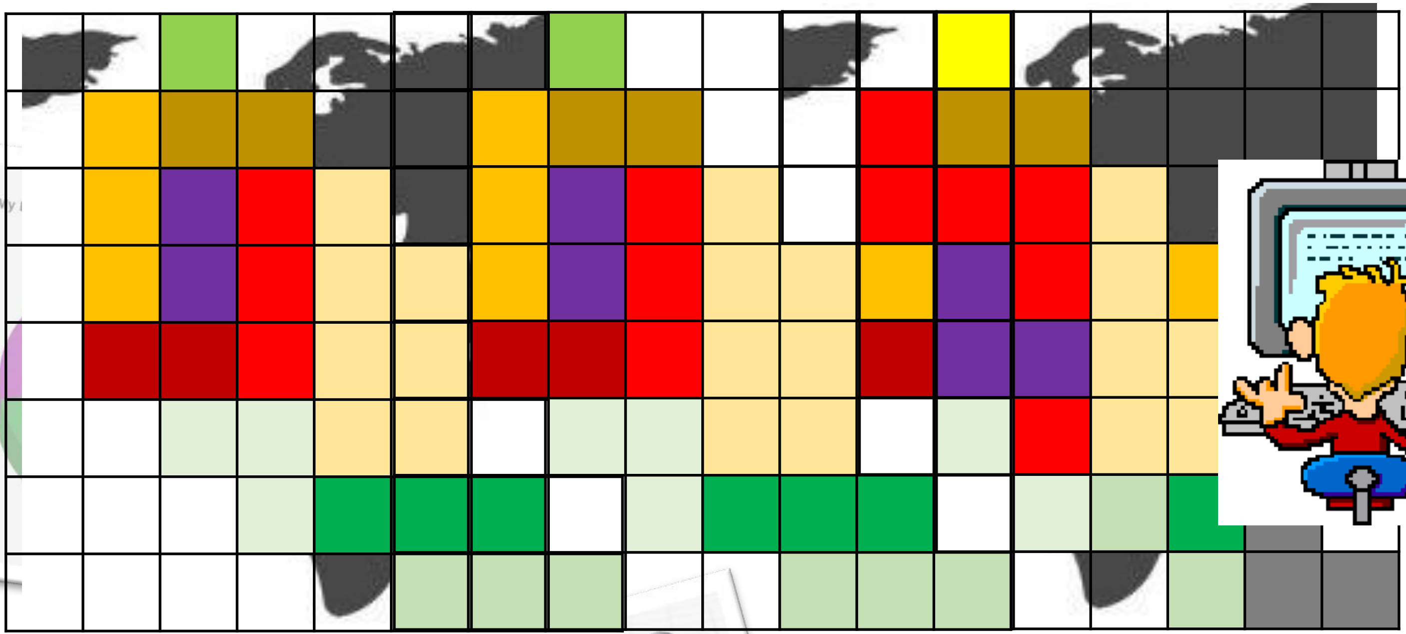
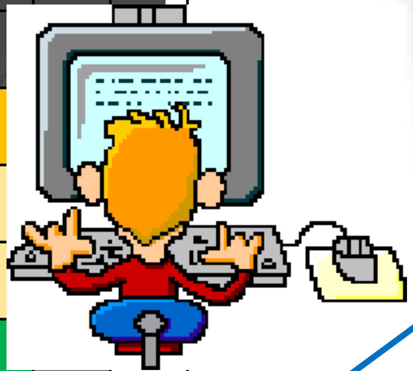


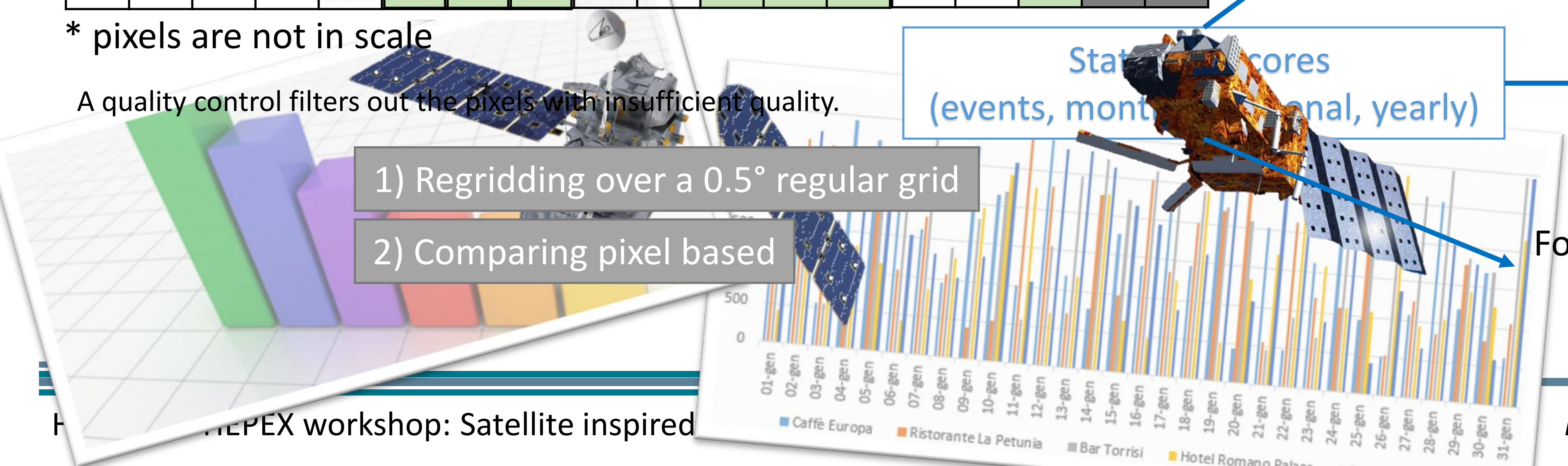
* pixels are not in scale

A quality control filters out the pixels with insufficient quality.



	DPR Pr. classes			
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	**95%**	46%	12%	1%
[0.25 - 1[mm/h	3%	**24%**	15%	2%
[1 - 10[mm/h	2%	29%	**68%**	60%
≥10 mm/h	0%	0%	4%	**38%**

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



Stat... ...cores
(events, mont... ...nal, yearly)

1) Regridding over a 0.5° regular grid

2) Comparing pixel based

For different surface types
(sea, land, coast)

For different geographical areas
(Africa, Europe, Ocean)

Marco.Petracca@protezionecivile.it

Hydrological Validation Cluster

The purpose is to assess the benefits of the novel HSAF satellite-derived data on practical hydrological applications and to improve products and their usability in operational hydrology

- Product **quality assessment** and their continuous monitoring by product validation (evaluation) with the usage of hydrological rainfall-runoff models,
- Research into possibility of **HSAF products application in operational hydrology**
- **Training activities**, stimulating the use of satellite products in hydrology and water management

Product quality assessment

Usability of products and its improvement

Promotion of products

 Marco.Petracca@protezionecivile.it

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H.V. participants

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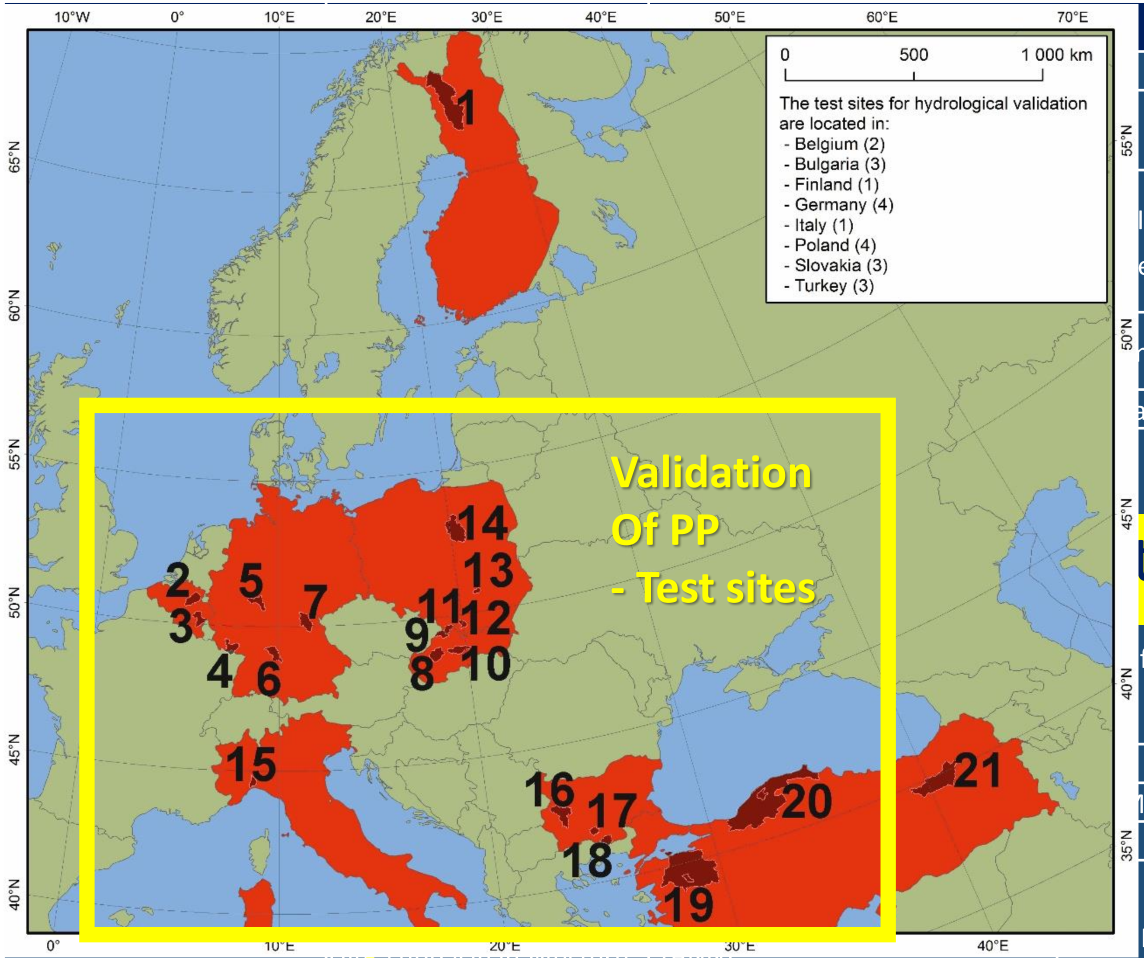

IM
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ff models
odel)
MS

8) Turkey (ITU, ITU)	Olus subbasin in Western Black Sea Basin	(ANN)
	Upper Euphrates	SRM (Snowmelt Runoff Model), HBV, data driven model

Members, test sites, models

ESKISEHIR TECHNICAL UNIVERSITY
Department of Civil Engineering

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H.V. Methodology

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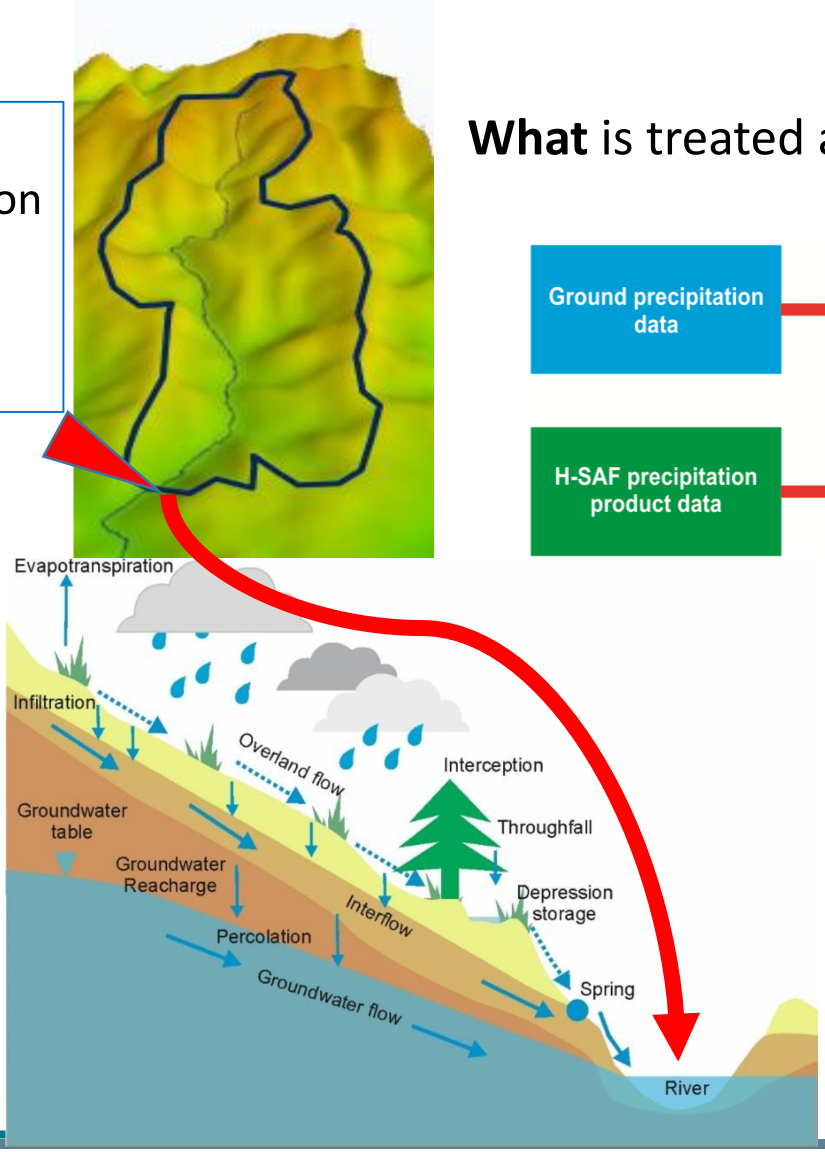
In 'standard' hydrovalidation methodology there is an assumption that only '**observed runoff**' is treated as a '**ground truth**' or '**reference data**'.

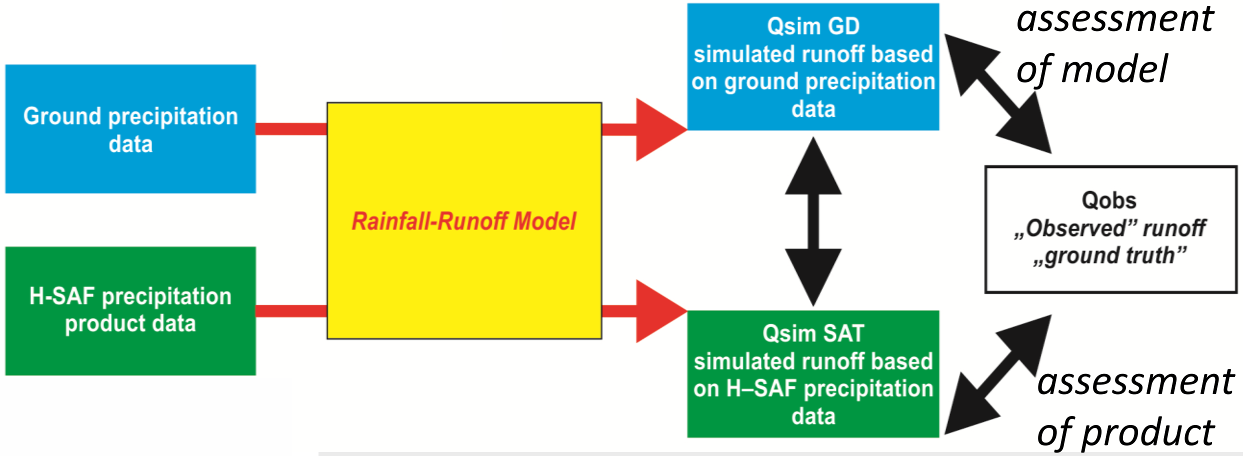
It should be noted that H–SAF products hydrovalidation is based on comparisons between **runoff** simulated from a product data and:

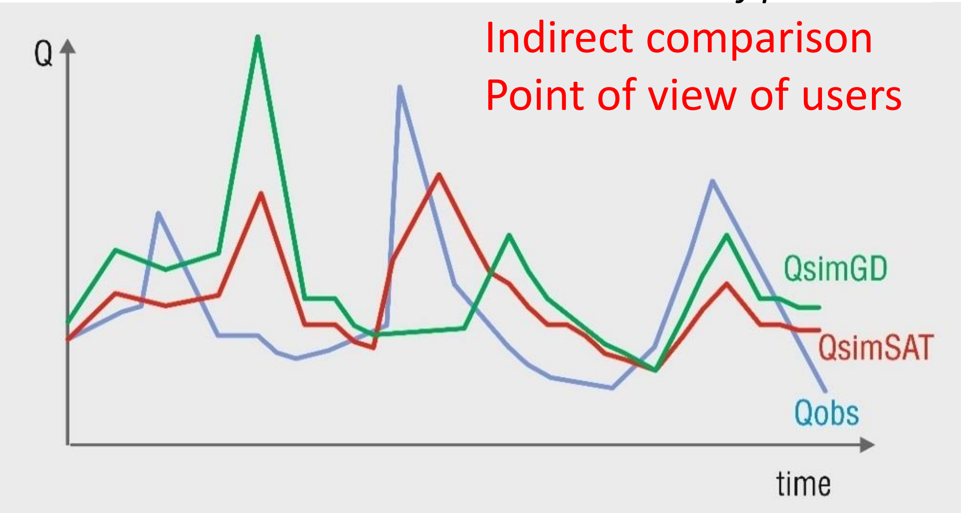
a) observed catchment runoff,

b) runoff simulated from ground precipitation data.



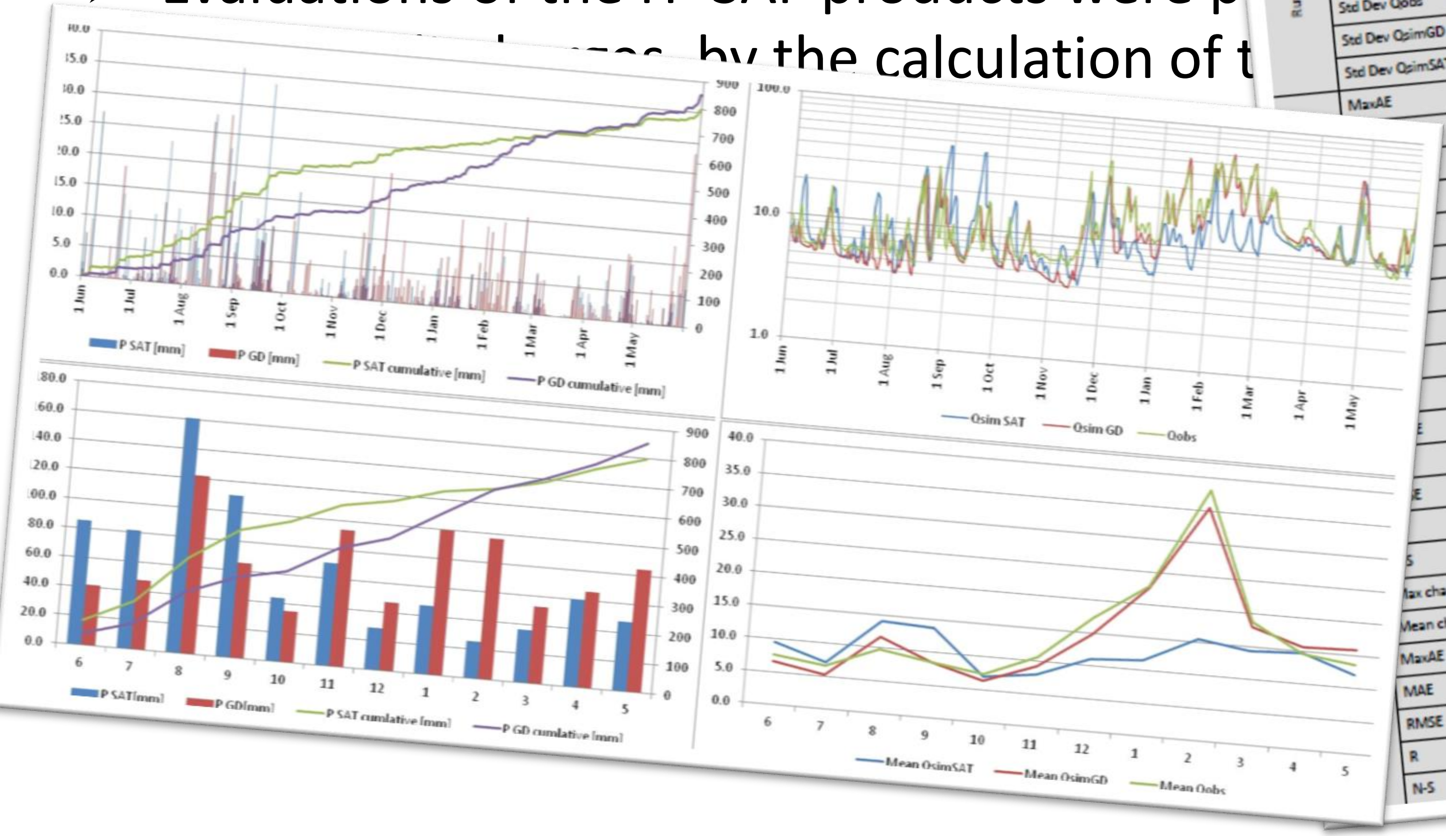
What is treated as a **"ground truth"** or **"reference data"?**





H.V. Methodology Results

- Results for **each month** and for the **whole**
- Evaluations of the H–SAF products were p
  … by the calculation of t



Month	Score	6	7	8	9	10	11	12	1	2	3	4	5	Whole Period
Product	SAT	64,700	202,800	134,000	28,800	104,500	41,100	15,000	32,300	11,600	12,900	46,500	16,500	710,700
	GD	52,100	184,400	112,500	43,800	88,900	48,500	84,400	93,100	25,500	66,100	46,700	22,700	868,700
Runoff	Mean Qobs	7,733	17,216	12,632	9,850	17,373	14,653	27,726	27,742	13,721	16,165	19,097	6,006	15,876
	Mean QsimGD	9,744	24,399	14,935	9,318	11,468	9,122	17,376	27,882	13,589	13,964	17,635	7,462	14,787
	Mean QsimSAT	10,167	27,600	17,665	8,787	13,061	8,393	5,600	12,729	12,993	9,484	15,530	7,019	12,433
	Std Dev Qobs	2,291	14,412	3,403	2,726	8,913	4,453	19,036	14,034	3,087	9,032	20,099	1,353	12,504
	Std Dev QsimGD	2,436	20,652	3,390	1,230	4,739	1,548	10,279	14,424	2,695	7,371	16,596	1,602	11,329
	Std Dev QsimSAT	2,311	19,282	5,429	1,507	5,297	0,623	1,073	2,367	2,883	2,170	12,385	1,528	9,102
	MaxAE	6,400	35,000	18,400	11,400	38,400	18,600	66,900	35,758	11,000	39,700	29,600	1,600	66,900
		2,760	13,119	6,258	2,337	6,391	6,260	22,126	15,013	1,721	6,681	5,760	1,045	7,538
		2,969	16,524	7,632	3,369	10,098	7,489	29,365	19,680	2,822	10,643	9,426	1,154	12,917
		0,718	0,735	0,190	-0,106	0,226	0,493	-0,530	0,531	0,569	0,392	0,961	0,931	0,368
		-0,737	-0,358	-4,198	-0,581	-0,326	-1,926	-1,459	-1,032	0,133	-0,435	0,772	0,248	-0,070
		6,424	33,204	8,831	9,285	22,783	13,819	31,384	6,641	4,825	7,624	13,062	2,276	33,204
		2,372	9,154	2,698	1,837	5,905	5,531	10,350	1,999	1,267	2,751	2,512	1,456	4,018
		2,717	12,691	3,475	2,594	7,485	6,276	13,614	2,681	1,698	3,653	3,950	1,578	6,562
		0,693	0,875	0,697	0,339	0,947	0,952	0,989	0,982	0,831	0,955	0,998	0,926	0,857
		-0,454	0,199	-0,078	0,063	0,271	-1,055	0,471	0,962	0,686	0,831	0,960	-0,406	0,724
	E	2,341	45,780	18,140	2,895	15,617	4,781	35,516	39,346	6,175	38,019	18,532	1,031	45,780
		0,427	7,706	5,600	0,547	4,570	0,996	11,781	15,157	0,606	4,480	3,348	0,444	4,708
	E	0,675	12,259	7,303	0,946	6,209	1,603	15,923	20,128	1,381	8,523	5,897	0,488	9,275
		0,976	0,821	-0,175	0,849	0,265	0,351	-0,538	0,473	0,899	0,147	0,967	0,992	0,633
	S	0,921	0,636	-3,795	0,387	-0,774	-0,109	-1,480	-1,012	0,728	-0,382	0,869	0,904	0,328
	ax change	0,141	0,299	0,404	0,242	0,385	0,135	4,538	3,027	1,000	2,565	0,550	0,087	4,538
	Mean change	0,061	0,138	0,160	0,133	0,198	0,054	1,516	1,212	0,302	0,206	0,116	0,037	0,348
	MaxAE	12,800	43,300	19,500	9,500	15,300	16,500	11,600	12,200	8,600	20,700	12,700	6,200	43,300
	MAE	1,840	5,194	4,623	1,107	2,974	1,200	2,374	2,077	0,904	1,994	2,047	0,903	2,289
	RMSE	4,049	10,548	7,030	2,359	4,649	3,259	3,989	3,386	2,107	5,272	4,244	1,749	4,993
	R	0,616	0,457	0,283	0,827	0,544	0,437	0,611	0,663	0,418	0,471	0,285	0,126	0,464
	N-S	0,339	-0,240	-0,122	-0,626	-0,277	-0,647	-34,631	-3,798	-5,359	-29,905	-0,323	-1,355	-0,209

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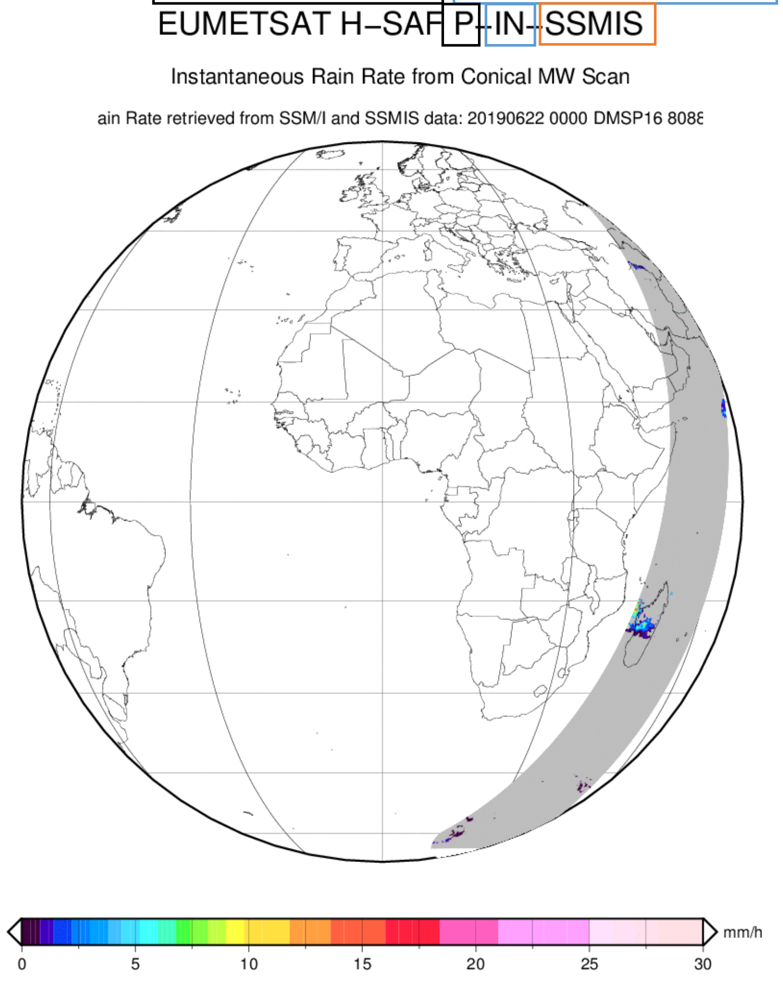
PROTEZIONE CIVILE

MW PP results

H01 new rel.

Main features	
Coverage	Strips of ~1400Km swath
Cycle	More than 6 passes/daily over Europe
Spatial Resolution	~30Km
Timeliness	150 minutes from observing time
Dissemination	EUMETCast
Formats	BUFR

Precipitation | INstantaneous | Sensor



100-150	150-200	200-300	>300

Score	≥ 1 mm/h (radar & gauge)
Overall FSE%	146% ☺
ME [mm/h]	+0.17
MAE [mm/h]	2.46
MB	1.06
CC	+0.36
RMSE [mm/h]	3.83

Between target and optimal!

Slight overestimation

	Ground ref. Pr. classes			
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	97%	60%	38%	8%
[0.25 - 1[mm/h	1%	4%	3%	3%
[1 - 10[mm/h	2%	35%	55%	57%
≥10 mm/h	0%	1%	3%	32%

No rain area well detected

Stratiform rain well observed

Validation results for period 2017/18

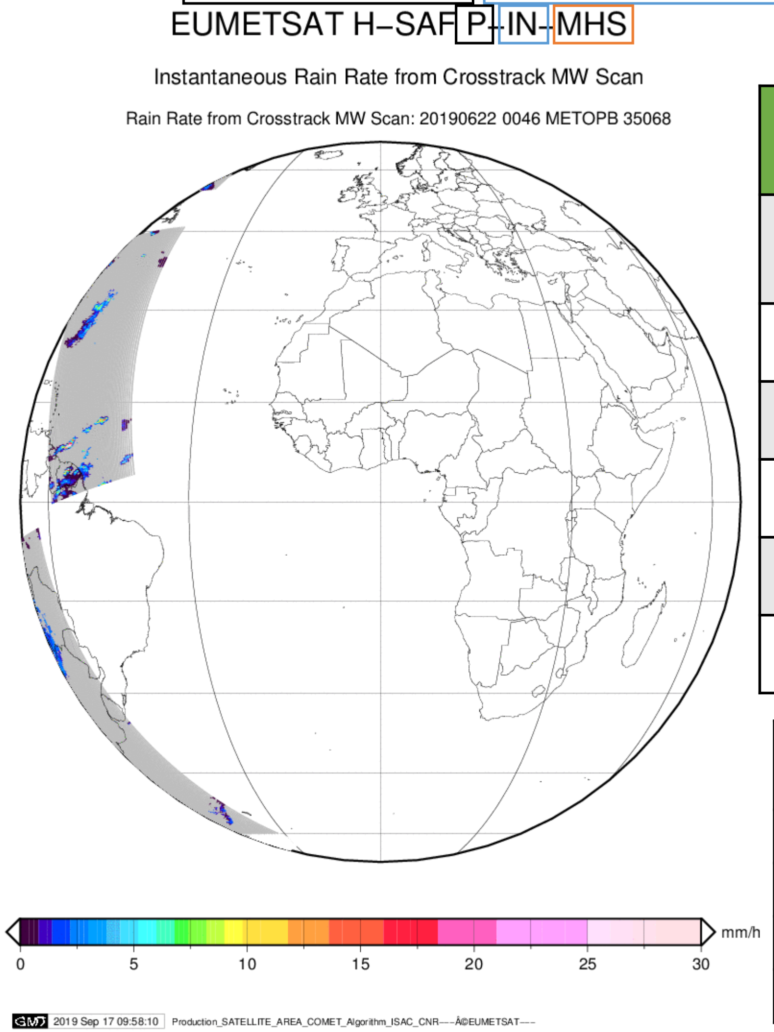
More details are reported in the Product Validation Report (available on the HSAF website).

MW PP results

H02B

Precipitation | INstantaneous | Sensor

Main features	
Coverage	Strips of ~2250Km swath
Cycle	More than 6 passes/daily over Europe
Spatial Resolution	16x16 – 26x52 km2
Timeliness	30 minutes from observing time
Dissemination	EUMETCast
Formats	BUFR



100-150	150-200	200-300	>300

Score	≥ 1 mm/h (DPR)
Overall FSE%	124% ☺
ME [mm/h]	+0.69
MAE [mm/h]	2.21
MB	1.26
CC	+0.45
RMSE [mm/h]	3.38

Between target and optimal!

Overestimation

Good correlation

	DPR Pr. classes			
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	95%	46%	12%	1%
[0.25 - 1[mm/h	3%	24%	15%	2%
[1 - 10[mm/h	2%	29%	68%	60%
≥10 mm/h	0%	0%	4%	38%

No rain area well detected

Good detection mainly for stratiform

Validation results for period 2017/18

Marco.Petracca@protezionecivile.it

MW+IR PP results

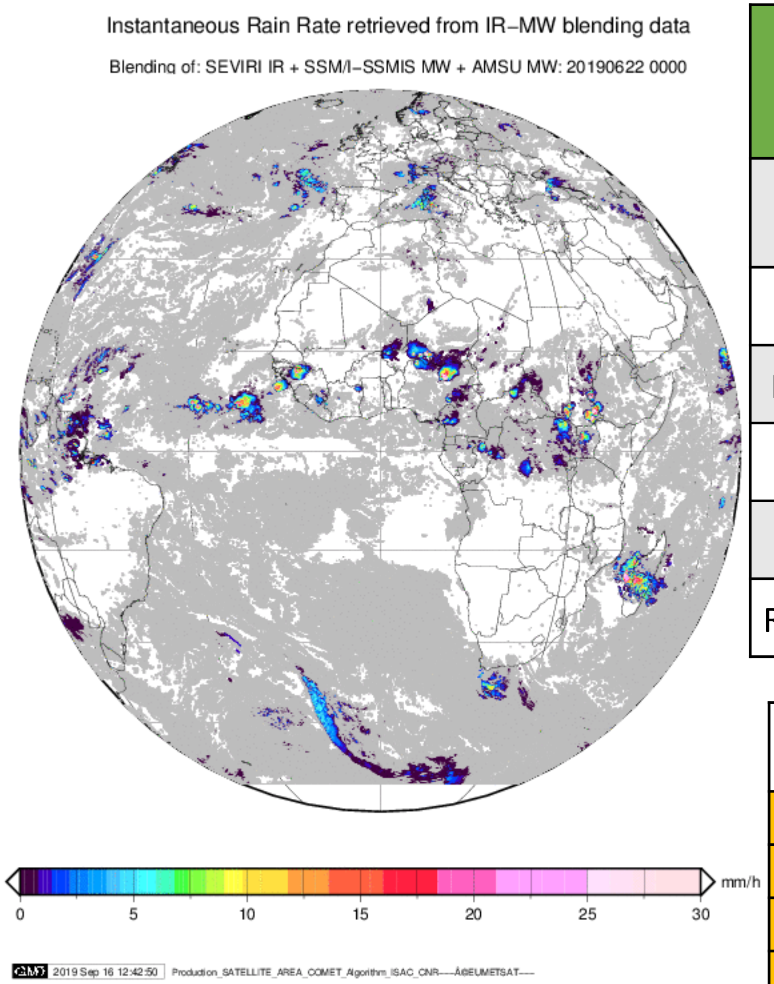
H03B

Precipitation | INstantaneous | Sensor

100-150	150-200	200-300	>300

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
Formats	GRIB-2

EUMETSAT H–SAF P-IN-SEVIRI



Score	≥ 1 mm/h (radar & gauge)
Overall FSE%	129% ☺
ME [mm/h]	-1.40
MAE [mm/h]	2.25
MB	0.47
CC	+0.19
RMSE [mm/h]	3.41

Between target and optimal!

Underestimation

Poor correlation (high time frequency?)

	Ground ref. Pr. classes			
	[0 - 0.25[mm/h	[0.25 - 1[mm/h	[1 - 10[mm/h	≥10 mm/h
[0 - 0.25[mm/h	87%	62%	49%	32%
[0.25 - 1[mm/h	7%	17%	18%	12%
[1 - 10[mm/h	6%	21%	31%	49%
≥10 mm/h	0%	0%	1%	7%

general underestimation mainly for convective rr

Validation results for period 2017/18

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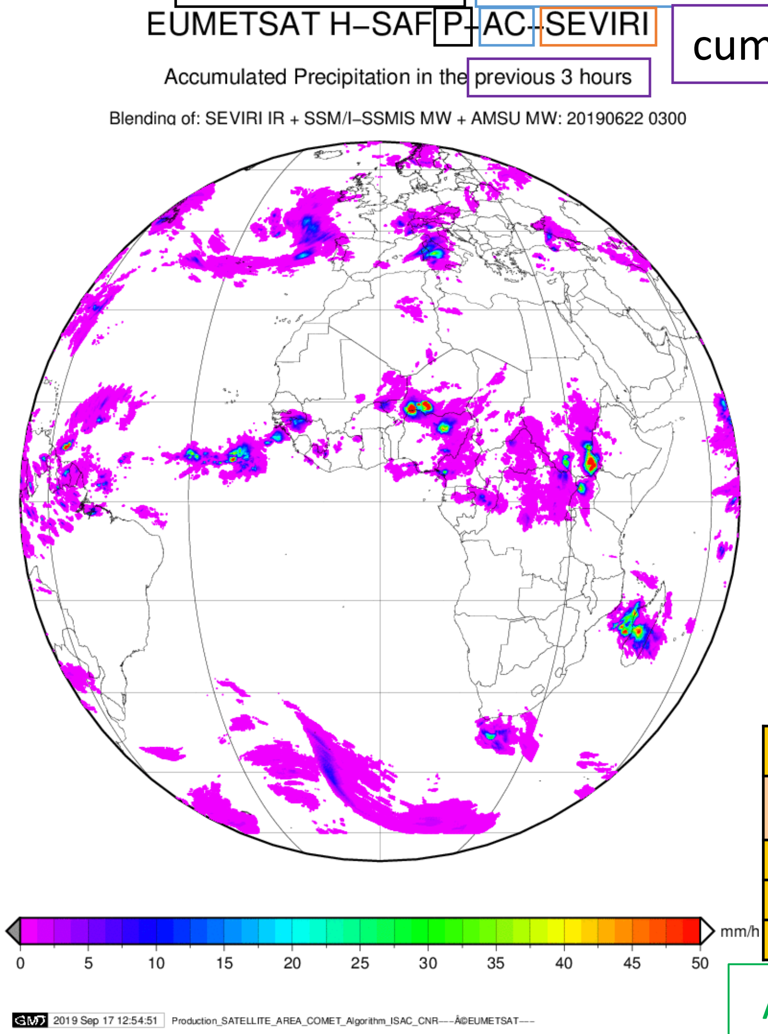
MW+IR PP results

H05B

Main features	
Coverage	MSG Full-disk area
Cycle	Every 3h
Spatial Resolution	3 Km s.s.p. ~8 km over Europe
Timeliness	Within 15 minutes after every 3h
Dissemination	EUMETCast
Formats	GRIB-2

Precipitation | ACcumulated | Sensor

Accumulation time



100-150	150-200	200-300	>300

Score	≥ 1 mm/24h (radar & gauge)
Overall FSE%	133% ☺
ME [mm/h]	-0.50
MAE [mm/h]	5.80
MB	0.93
CC	+0.40
RMSE [mm/h]	9.13

Between target and optimal!

Slight underestimation

Good correlation (24h!)

Ground ref. Pr. classes			
	< 1 mm/24h	[1 - 10[mm/24h	≥10 mm/24h
< 1 mm/24h	82%	36%	12%
[1 - 10[mm/24h	16%	48%	42%
≥10 mm/24h	2%	16%	46%

All PCs well detected, even if it is observable a slight underestimation for intense rr

Validation results for period 2017/18

EUMETSAT H SAF

H.V. General Results

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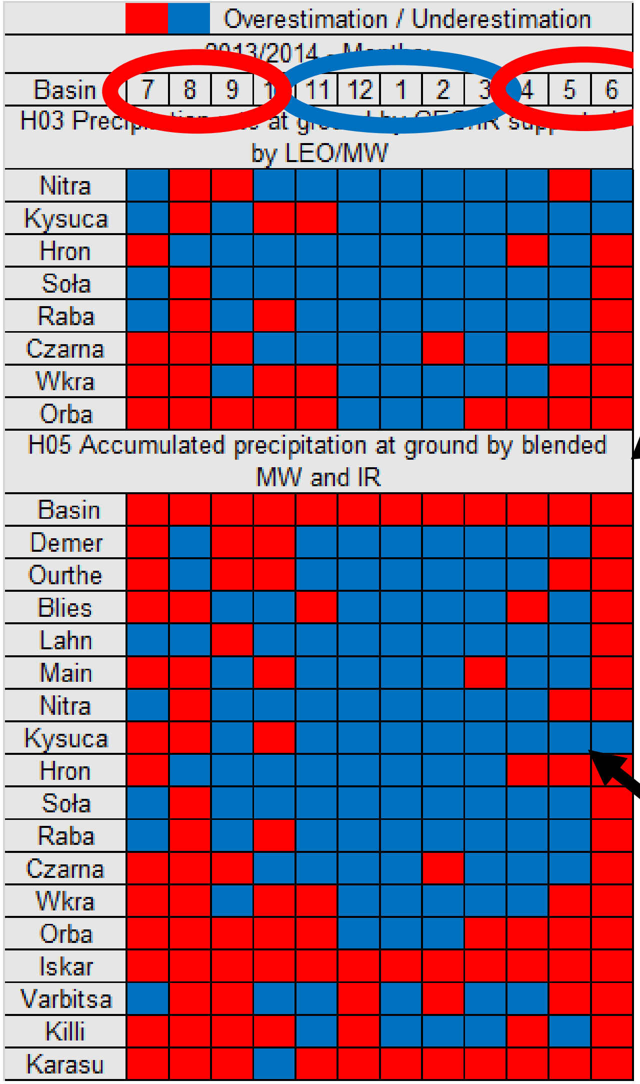
Dipartimento della Protezione Civile

Differences between mean monthly discharges derived from simulation of H-SAF products in rainfall-runoff models and "observed" discharges.
Negative values (underestimations) are marked by blue font.
The background colour of cells is related to the magnitude of differences (the smallest values are marked with green colour, large values are marked with red colour, values in between are marked with range of colours from light green, by yellow and orange, to red)



Usually SAT overestimations are observed in summer.

Underestimations are typical in winter.

Similar results are observed for **H03** and **H05** even in different validation periods.

Product	Basin	VI	VII	VIII	IX	[illegible]	XI	XII	I	II	[illegible]	IV	V	[illegible]hole [illegible]riod
H03	Blies	[illegible]	[illegible]	[illegible]	[illegible]	2.83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.83
	Blies_BCM	0.37	-1.17	-3.78	-3.96	-2.13	1.98	-4.72	10.42	3.78	20.05	4.54	5.04	2.55
	Kocher	3.04	11.12	26.32	10.59	7.59	9.88	0.20	-13.81	-49.85	-12.48	15.42	4.98	1.27
	Kocher_BCM	1.29	1.13	-1.72	-2.96	-2.99	5.39	2.98	22.27	-21.71	10.18	-1.02	-9.55	0.39
	Lahn	0.10	-0.34	7.18	2.89	-0.33	1.34	-15.07	-15.61	-31.37	-2.60	34.44	23.35	0.40
	Lahn_BCM	-0.65	-3.08	-3.23	-0.78	-2.08	0.69	-9.93	14.62	-8.23	11.03	3.42	2.79	0.42
	Main	-0.95	11.06	13.59	7.86	4.61	9.59	-26.90	-32.99	-77.36	-21.13	25.15	18.61	-5.52
	Main_BCM	-1.45	0.84	1.54	1.00	-1.42	18.61	-7.35	23.75	-7.79	12.28	10.94	2.51	4.49
	Soła	2.50	22.13	10.76	14.68	17.51	6.27	-0.09	-8.73	-16.56	-4.99	-2.57	-5.38	3.11
	Raba	0.90	6.70	2.90	3.50	7.60	1.00	-1.30	-3.30	-4.80	-2.10	0.30	-0.70	0.80
	Raków	-0.30	0.00	-0.20	-0.10	-0.30	-0.20	-0.40	-0.20	-0.70	-0.90	-0.30	-0.20	-0.30
	Mocha	0.20	0.60	0.20	0.20	-0.10	0.30	-0.10	0.00	-1.00	-1.90	-0.60	-0.20	-0.20
	Wkra	1.70	6.60	-5.90	-4.90	-6.50	2.60	-0.30	5.00	-11.80	1.90	5.30	2.00	-0.40
	Kysuca	0.30	17.10	5.50	16.20	8.00	4.00	-0.60	-5.70	-19.50	-1.00	-2.90	-2.70	1.70
	Nitra	-0.40	0.40	9.90	3.80	0.70	0.20	-0.70	-3.00	-7.40	-2.00	-1.50	0.20	0.10
	Hron	4.50	6.80	3.40	4.00	-5.90	6.50	2.00	-2.90	-29.30	-0.90	-10.30	3.40	-1.40
	Orba - Casal Cermelli	-1.90	0.80	0.00	1.30	9.90	3.20	0.20	2.00	1.50	-3.10	-3.00	-5.60	0.40
	Orba - Tiglieto	-0.90	-0.20	-0.40	-0.10	0.10	0.10	-1.10	-0.50	-4.30	-5.20	-0.70	-2.50	-1.30
H05	Blies	1.30	1.80	2.60	5.00	4.60	-0.40	-4.50	-16.80	-41.10	-19.30	-10.30	-5.00	-6.70
	Blies_BCM	0.40	-1.20	-3.80	-4.20	-2.40	0.80	-3.80	5.80	12.80	13.30	7.70	3.40	2.30
	Kocher	1.10	1.70	8.30	7.20	1.20	-2.10	-14.00	-16.30	-31.00	-6.00	4.40	1.70	-3.60
	Kocher_BCM	-0.60	-3.10	-3.40	-1.70	-2.80	-2.50	-9.40	3.70	-3.30	5.50	1.50	2.40	-1.10
	Lahn	-0.60	9.10	24.10	10.70	8.10	6.00	-0.90	-17.00	-50.90	-17.10	-7.70	-19.10	-4.40
	Lahn_BCM	-0.90	-0.20	-2.30	-3.30	-3.50	3.90	3.30	10.90	-8.30	2.30	2.90	-8.70	-0.30
	Main	-2.30	5.60	13.80	8.10	7.10	3.00	-29.60	-33.60	-73.30	-20.10	-3.10	-1.20	-10.20
	Main_BCM	-2.90	-0.60	0.70	0.60	-1.90	13.70	-7.20	6.90	3.90	5.20	10.30	1.50	2.50
	Soła 3h	1.20	21.20	9.10	14.70	16.70	3.90	0.10	-8.70	-15.20	-5.20	-2.60	-4.60	2.70
	Soa 24 h	-0.50	6.40	3.50	39.50	29.50	-6.40	-1.50	-9.40	-24.90	-3.70	-1.30	-7.70	2.10
	Raba 3 h	0.40	9.10	5.40	6.00	10.10	3.00	1.30	-1.60	-5.10	-2.10	-0.10	-0.60	2.10
	Raba 24 h	2.60	9.30	4.80	5.50	7.80	0.20	-1.50	-3.30	2.40	-0.80	-0.10	1.40	2.30
	Czarna Raków	-0.20	0.10	-0.10	0.00	-0.20	-0.10	-0.30	-0.10	-0.70	-0.80	-0.20	-0.10	-0.20
	Czarna Mocha	0.10	0.50	0.20	0.20	-0.10	0.20	-0.10	0.00	-1.00	-1.80	-0.60	-0.20	-0.20
	Wkra	1.60	6.20	-5.90	-5.10	-6.50	1.20	-0.90	4.90	-12.00	2.40	5.70	2.00	-0.50
	Kysuca	0.00	10.60	4.40	14.20	10.30	4.10	-1.40	-6.20	-23.90	-1.50	-0.90	2.30	1.20
	Nitra	-1.20	0.10	8.00	3.60	0.80	1.40	0.40	-2.30	-8.80	-2.60	-1.20	0.30	-0.10
	Hron	4.40	3.90	2.70	3.40	-5.90	3.10	1.10	-2.80	-29.40	0.10	-10.30	2.10	-2.20
	Orba - Casal Cermelli	-2.10	0.70	-0.10	3.40	-0.20	2.70	-0.30	2.00	-3.70	-6.60	-3.10	-6.20	-1.20
	Orba - Tiglieto	-0.90	-0.20	-0.40	0.30	-1.60	0.10	-1.10	-0.50	-4.80	-5.70	-0.70	-2.70	-1.50

-1.6 – underestimation (blue font)
4.9 – overestimation (black font)
MIN … MAX

Differences are much higher in summer (yellow and red highlights) than in winter and spring (green highlights).

In winter we need to take into account, that snow retention can make the results more complex…

Marco.Petracca@protezionecivile.it

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H.V. Results for period 2017/18

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Generally, the usage of PP worsened the performance of models (**statistical scores are better** for simulation on **Ground DATA**), but if density and representativeness of ground meteorological network are not sufficient or even poor, simulation based on product data can provide valuable information from a hydrological point of view – especially when information from SAT product can be merged with ground data – good example from MERGA and NEVA.

PRODUCT	BASIN	R		NS		RMSE	
		Qsim GD - Qobs	Qsim SAT - Qobs	Qsim GD - Qobs	Qsim SAT - Qobs	Qsim GD - Qobs	Qsim SAT - Qobs
H03	Blies	0,95	0,77	0,68	0,55	8,07	9,53
	Kocher	0,87	0,40	0,64	-0,13	11,08	19,73
	Lahn	0,92	0,72	0,79	0,49	9,42	14,79
	Main	0,87	0,44	0,71	0,09	11,95	21,33
	Wkra	0,89	0,85	0,76	0,66	10,81	12,91
	Stróża	0,53	0,19	0,21	-0,57	15,00	21,15
	Żywiec	0,95	0,30	0,83	-0,06	13,11	33,21
	Hron	0,87	0,86	0,74	0,71	8,27	8,76
	Kysuca	0,86	0,70	0,74	0,39	7,41	11,44
	Nitra	0,84	0,68	0,67	0,39	4,88	6,62
	Marga	0,95	0,94	0,89	0,86	16,06	18,37
	Neva	0,90	0,87	0,78	0,66	2,18	2,66
H05	Demer	0,96	0,48	0,87	-0,03	2,71	7,57
	Ourthe	0,94	0,66	0,88	0,40	7,83	17,39
	Blies	0,95	0,74	0,67	0,47	[illegible]	10,35
	Kocher	0,87	0,34	0,64	[illegible]	[illegible]	20,49
	Lahn	0,87	0,29	[illegible]	[illegible]	9,07	14,93
	Main	0,88	[illegible]	[illegible]	[illegible]	11,80	22,88
	Wkra	0,89	[illegible]	0,76	0,66	10,81	13,03
	Wkra24	[illegible]	[illegible]	0,76	0,66	10,81	12,85
	Stróża	[illegible]	0,22	0,21	-0,39	15,00	19,92
	Żywiec	0,95	0,30	0,83	-0,05	13,11	33,02
	Hron	0,87	0,88	0,74	0,74	8,27	8,34
	Kysuca	0,86	0,71	0,74	0,43	7,41	11,00
	Nitra	0,86	0,50	0,69	0,07	4,78	8,30
	Marga	0,95	0,93	0,89	0,85	16,06	18,66
	Neva	0,90	0,88	0,78	0,66	2,18	2,68
	Iskar	0,94	0,91	0,88	0,81	6,63	8,41
	Varbitsa	0,94	0,73	0,86	0,36	14,69	31,85

MERGING IMPROVES STATISTICAL SCORES

MARGA and NEVA case (ITALY)
The hydrological model does not use directly the original SAT data but a <u>derived product that properly merges the satellite data with the raingauge data</u>, Products are assimilated in a new method called <u>Modified Conditional Merging (MCM)</u>

Conclusions

- All operational PP satisfy the User Requirements (FSE% between target and optimal);
- MW PP well detect precipitation areas, mainly stratiform rr;
- SEVIRI based PP tend to underestimate.

- Observed runoff and runoff simulated with ground meteorological data agreed well;
- Overestimation are typical for warmer period (convective precipitation);
- Model simulation based on PP (usually worsened the performance of model) can provide valuable information from a hydrological point of view.

 Marco.Petracca@protezionecivile.it

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Thank you for your attention !

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

http://hsaf.meteoam.it/

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twitter

Marco.Petracca@protezionecivile.it
Silvia.Puca@protezionecivile.it
Michal.Kasina@imgw.pl