The H-SAF precipitation products and their use for severe event monitoring

Federico Porcù
Department of Physics and Astronomy – University of Bologna
Silvia Puca
Italian Civil Protection Department

outline

- Satellite Application Facility on Support to Operational Hydrology and Water Management (H-SAF);
- H-SAF Precipitation Products;
- H-SAF PP application to severe event monitoring;
- H-SAF PP validation;
- H-SAF webpage and product download.

H-SAF objectives

- ***To provide operational high quality level 2/3 products and develop new satellite products from existing and future satellites with time and space resolution to satisfy the needs of operational hydrology:***
  - precipitation (liquid, solid, rate, accumulated);
  - soil moisture (large-scale, local-scale, surface, roots region);
  - snow parameters (cover, melting conditions, water equivalent).

- ***To perform independent validation of the products for civil protection purposes (floods, landslides, avalanches), and for monitoring water resources. The activity includes:***
  - downscaling/upscaling from observed/predicted fields to basin level;
  - fusion of satellite measurements with data from radar and raingauge networks;
  - assimilation of satellite-derived products in hydrological models;
  - assessment of the impact of the satellite-derived products on hydrological applications.

H-SAF plan

H-SAF Development Phase (2005-2010), completed on August 31, 2010.

Continuous Development and Operation Phase (CDOP) (2010-2017):

- CDOP-1 (2010-2012) ended in February 2012.

  To improve algorithms and processing scheme for H-SAF area (25° N to 75° N - 25° W to 45° E) ;

- CDOP-2 March 2012 – February 2017.

  To extend algorithms and validation to Full Disk area and to new satellites.

All the products are being generated routinely for the H-SAF area on a H-SAF operational chain in NRT mode.

Products are validated by the Product Validation team and their impact in hydrology models is evaluated by the Hydrological Validation Team.

H-SAF consortium

Country	Units in the Country (responsible unit in bold)	Role in the Project
Austria	- **Zentral Anstalt für Meteorologie und Geodynamik** - Technische Univ. Wien, Inst. Photogrammetrie & Fernerkundung	Leader for soil moisture
Belgium	- **Institut Royal Météorologique**	
Bulgaria	- **National Institute of Meteorology and Hydrology**	
ECMWF	- **European Centre for Medium-range Weather Forecasts**	Contributor for "core" soil moisture
Finland	- **Finnish Meteorological Institute** - Helsinki Technical University, Laboratory of Space Technology - Finnish Environment Institute	Leader for snow parameters
France	- **Météo-France** - CNRS Centre d'Etudes Spatiales de la BIOsphere - CNRS Centre d'études des Environnem. Terrestres et Planétaires	
Germany	- **Bundesanstalt für Gewässerkunde**	
Hungary	- **Hungarian Meteorological Service**	
Italy	- **Servizio Meteorologico dell'Aeronautica** - Dipartimento Protezione Civile, Presidenza Consiglio Ministri - CNR Istituto di Scienze dell'Atmosfera e del Clima - Ferrara University, Department of Physics and Earth Sciences - CIMA Research Foundation - University of Rome "La Sapienza", Dept. of Electrical Engineering	Host + Leader for precipitation + Leader for Products Validation
Poland	- **Institute of Meteorology and Water Management**	Leader for Hydrology Validation
Slovakia	- **Slovenský Hydrometeorologický Ústav**	
Turkey	- **Turkish State Meteorological Service** - Middle East Technical University, Civil Engineering Department - Istanbul Technical University, Meteorological Department - Anadolu University	Contributor for "core" snow parameters

H-SAF soil moisture products

H SAF
Support to Operational Hydrology and Water Management

SM OBS 1 - H07	SM OBS 2 - H08	SM DAS 2 - H14	SM OBS 4 - H25
Large scale surface soil moisture by radar scatterometer	Small scale surface soil moisture by radar scatterometer	Profile Index in the roots region by scatterometer data assimilation	Metop ASCAT Soil Moisture Time Series
development	pre-operational	operational	demonstrational

Zentral Anstalt für Meteorologie und Geodynamik

Technische Univ. Wien, Inst. Photogrammetrie & Fernerkundung

European Centre for Medium-range Weather Forecasts

H-SAF snow products

H SAF
Support to Operational Hydrology and Water Management

SN OBS 1 - H10	SN OBS 2 - H11	SN OBS 3 - H12	SN OBS 4 - H13
Snow detection (snow mask) by VIS/IR radiometry	Snow status (dry/wet) by MW radiometry	Effective snow cover by VIS/IR radiometry	Snow water equivalent by MW radiometry
operational	pre-operational	pre-operational	operational

Finnish Meteorological Institute

Turkish State Meteorological Service

Middle East Technical University, Civil Engineering Department

Istanbul Technical University, Meteorological Department

H-SAF precipitation products

PP developing team

D. Biron (1), E. Cattani (2), D. Casella (2), L. De Leonibus (1), S. Dietrich, F. Di Paola(2), M. Formenton (2), S. Laviola (2), V. Levizzani (2), A. C. Marra (2), D. Melfi (1), A. Mugnai (2), G. Panegrossi (2), P. Sanò (2), F. Zauli (1).

(1) ITAF MET Service

(2) CNR-ISAC

H-SAF current precipitation products

H SAF
Support to Operational Hydrology and Water Management

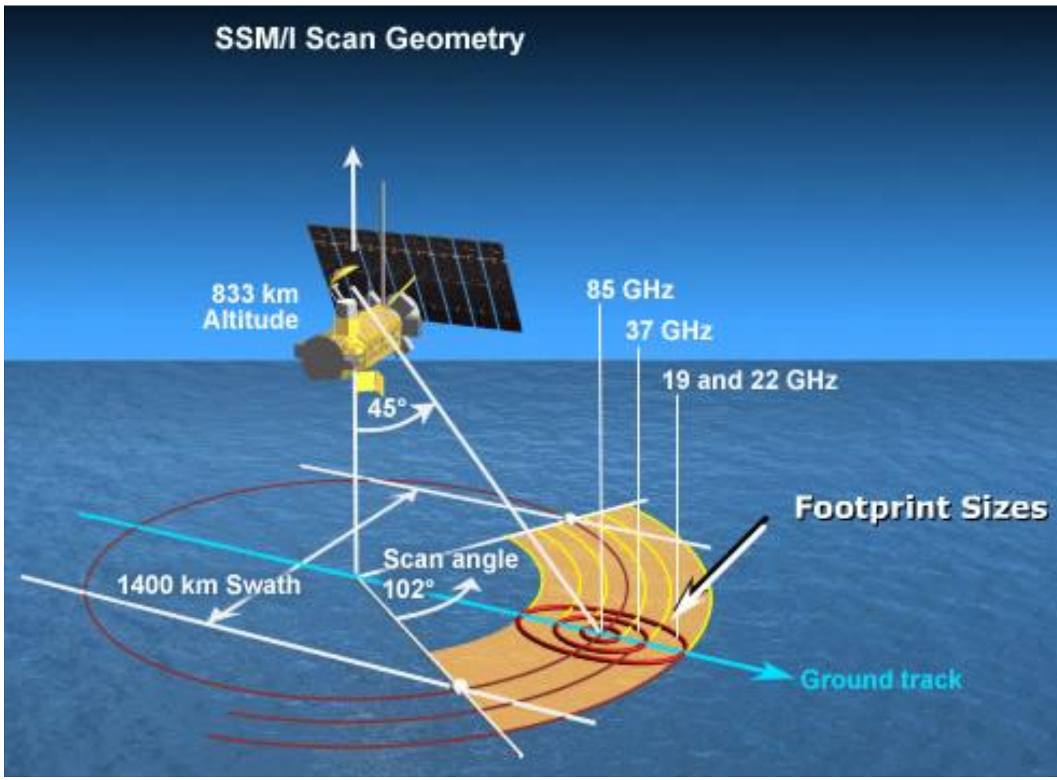
name	Product Description	Algorithm	Status
H01 **PR-OBS-1**	Precipitation rate at ground by MW conical scanners	Baesian CDRD	**Operational**
H02 **PR-OBS-2**	Precipitation rate at ground by MW cross-track scanners	Neural Network	**Operational**
H03 **PR-OBS-3**	Precipitation rate at ground by GEO/IR supported by LEO/MW	Blending	**Operational**
H04 **PR-OBS-4**	Precipitation rate at ground by LEO/MW supported by GEO/IR	Morphing	**Operational**
H05 **PR-OBS-5**	Accumulated precipitation at ground by blended MW and IR	Time integration	**Operational**
H06 **PR-OBS-6**	Blended SEVIRI Convection area / LEO MW precipitation -	Blending + NEFODINA	**Pre-operational**

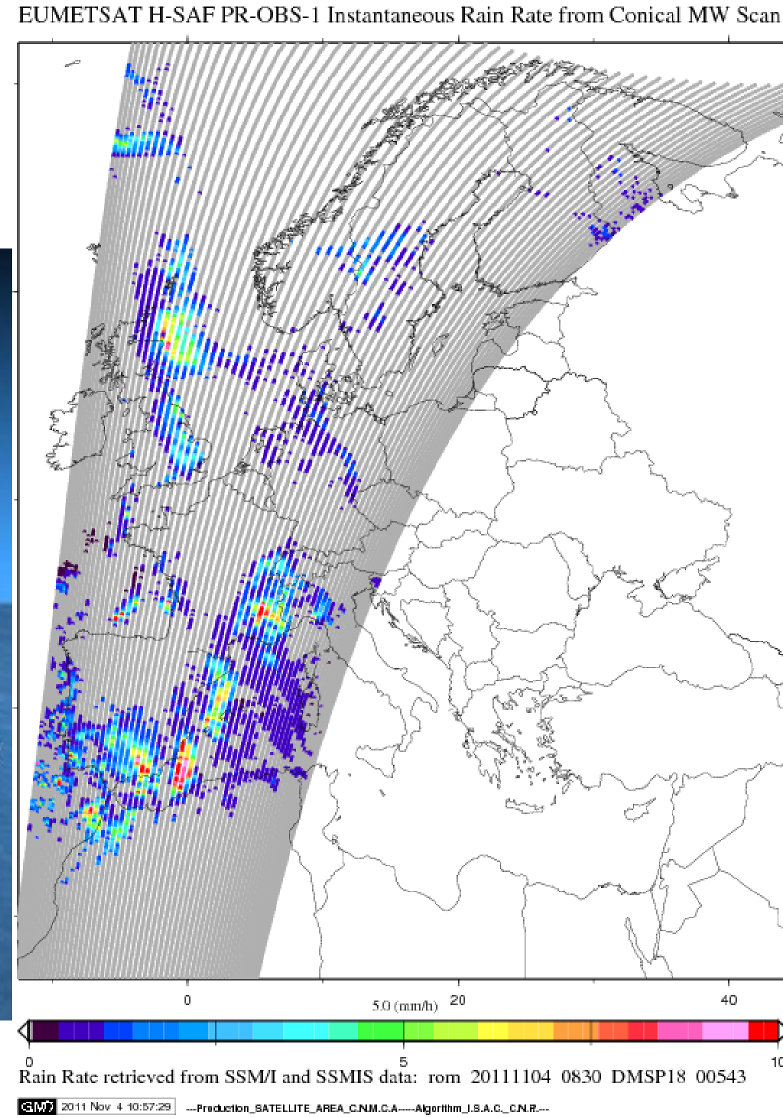
All precipitation products are generated routinely at the CNMCA, Italy
CNMCA also manages the Data service for all H-SAF products.

H-SAF precipitation product H01

H SAF
Support to Operational Hydrology and Water Management

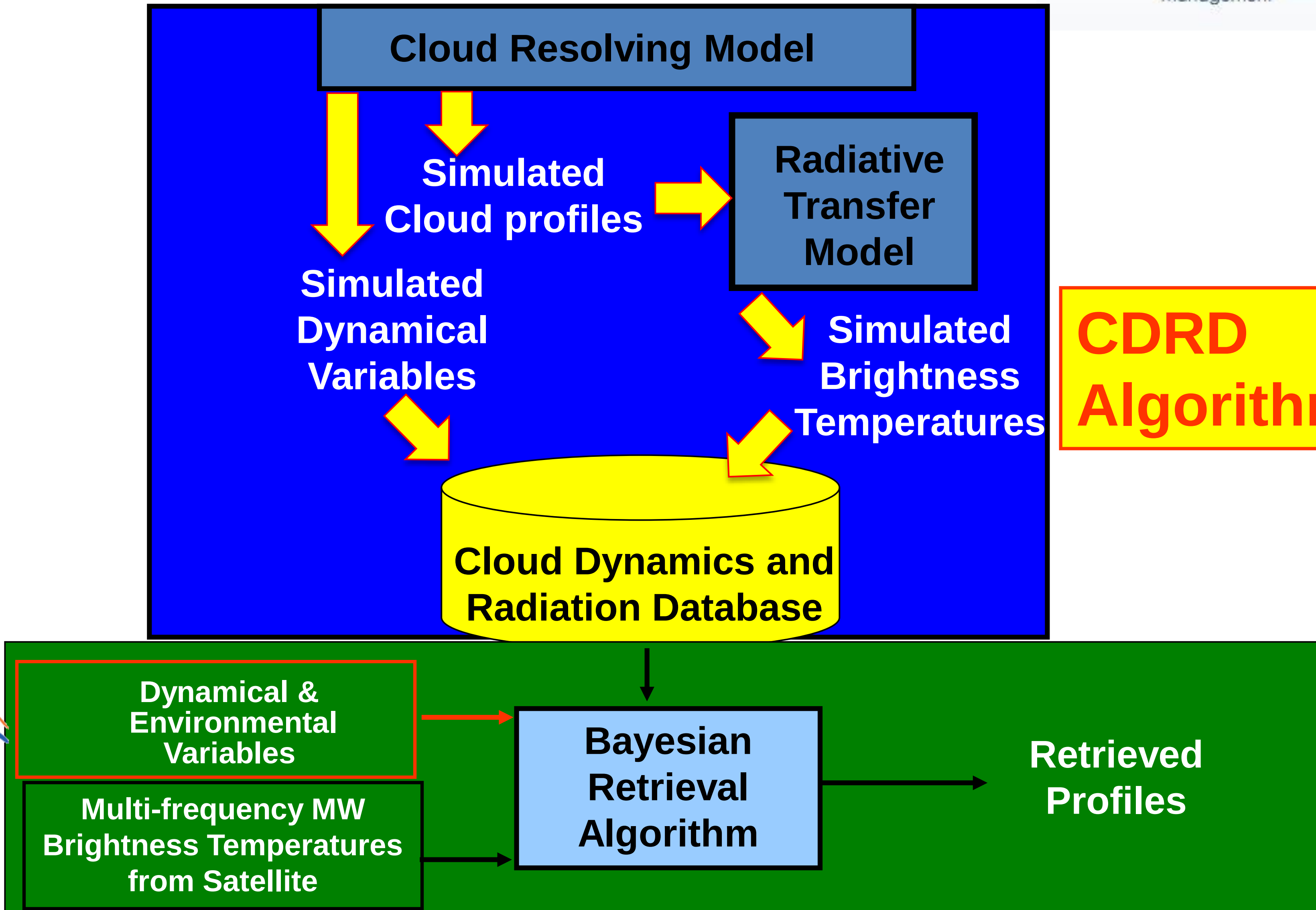
Precipitation from Microwave conical scan satellite (SSMI/S, AMSR)





ISAC

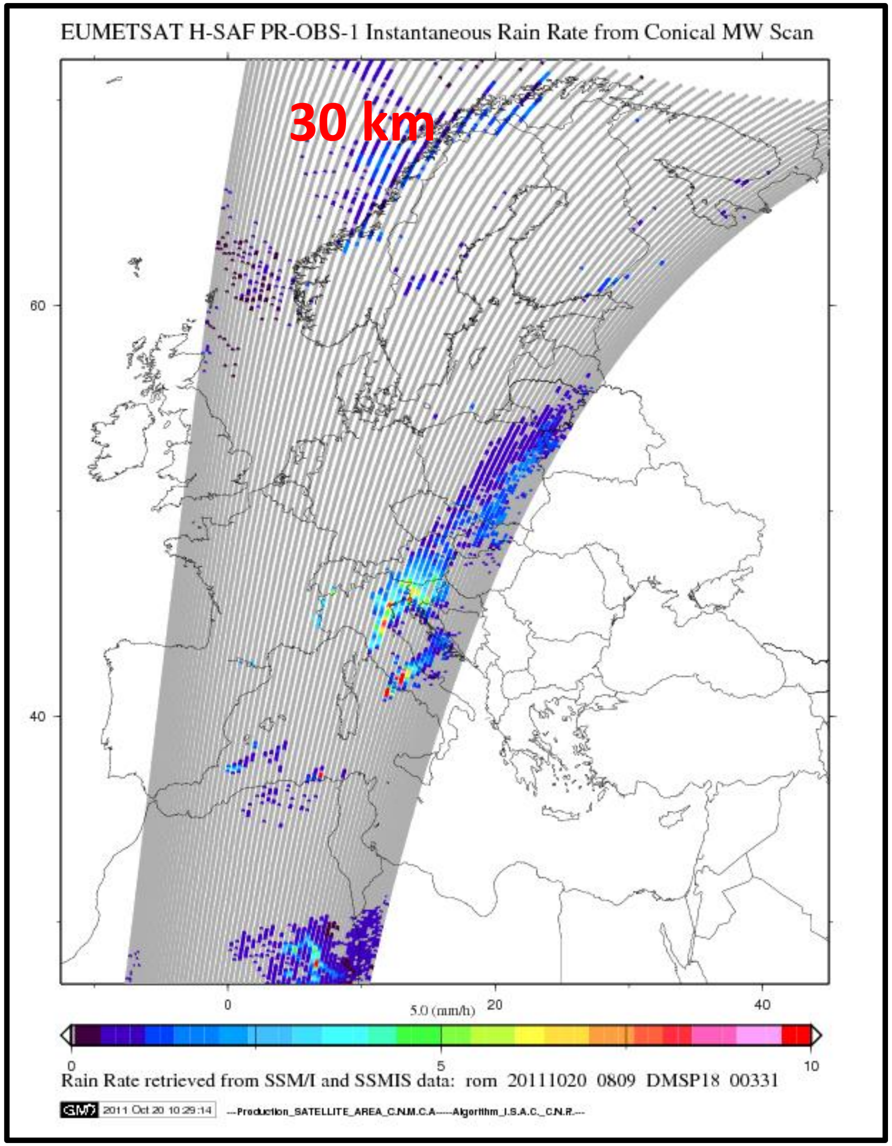
H-SAF precipitation product H01
Algorithm

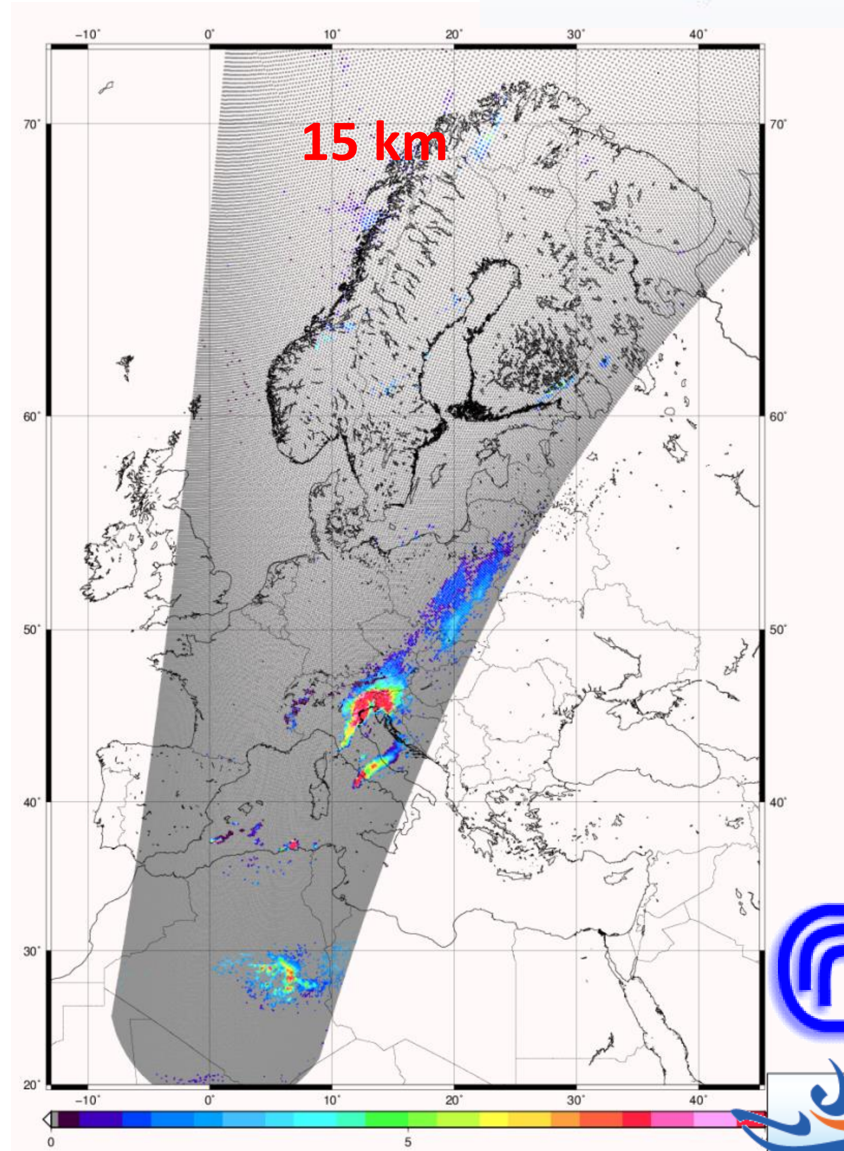


CDRD Algorithm

Sanò, P., D. Casella, A. Mugnai, G. Schiavon, E.A. Smith and G.J. Tripoli, 2013: Bayesian estimation of precipitation from space using the Cloud Dynamics and Radiation Database approach. IEEE Trans. Geosci. Remote Sens. 51, 4119–4143.

H-SAF precipitation product H01
Example (Rome flood, 20.10.2011)

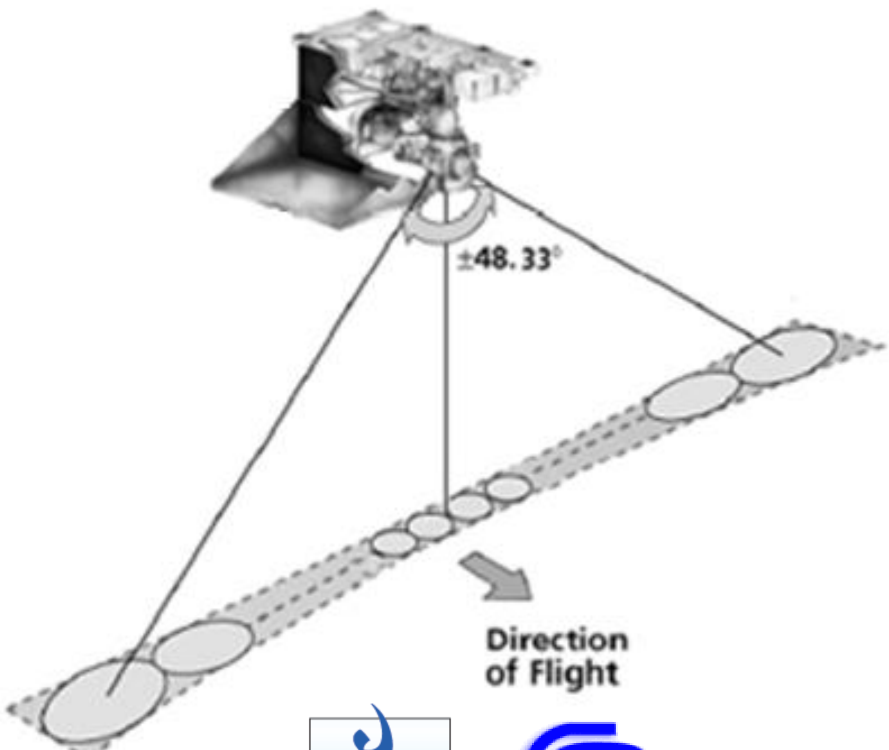


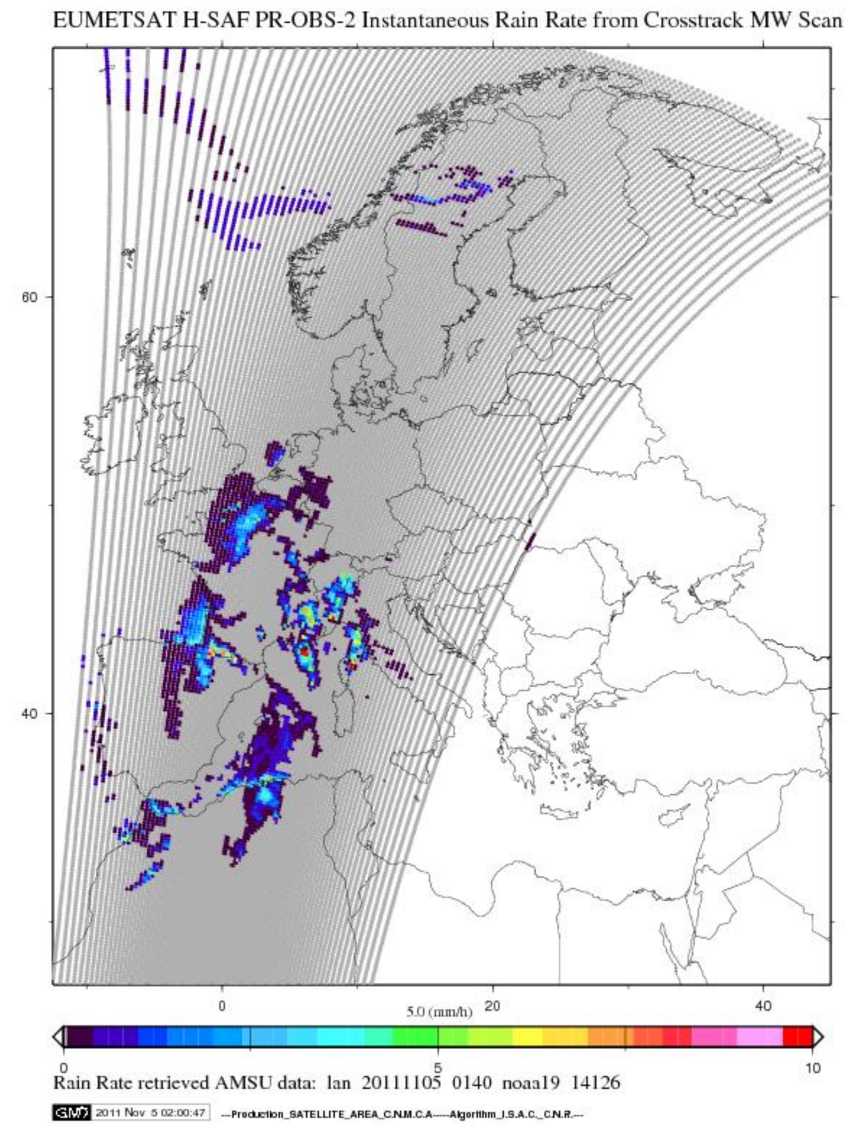


H-SAF precipitation product H02

Precipitation from Microwave cross-track scan satellite (AMSU/MHS)

AMSU-A scan geometry





H-SAF precipitation product H02 Algorithm

The CDRD approach is time-consuming for cross-track scanning radiometers. Thus, we have adopted the neural network approach trained with tested physical models, that has been proposed by Chen and Staelin (IEEE-TGRS, 41, 410-417, 2003) and Surussavadee and Staelin (IEEE-TGRS, 46, 99-108, 2008 and IEEE-TGRS, 46, 109-118, 2008).

The estimates of precipitation rates and hydrometeor water-paths were trained using a mesoscale NWP model (MM5), a two-stream radiative transfer model (TBSCAT), and electromagnetic models for ice hydrometeors.

The MM5 model has been initialized with *NCAR reanalysis* for 122 representative storms and their corresponding brightness temperatures simulated at AMSU frequencies.

New version the NNs are trained by CDRD

H-SAF precipitation product H02
Example (Rome flood, 20.10.2011)

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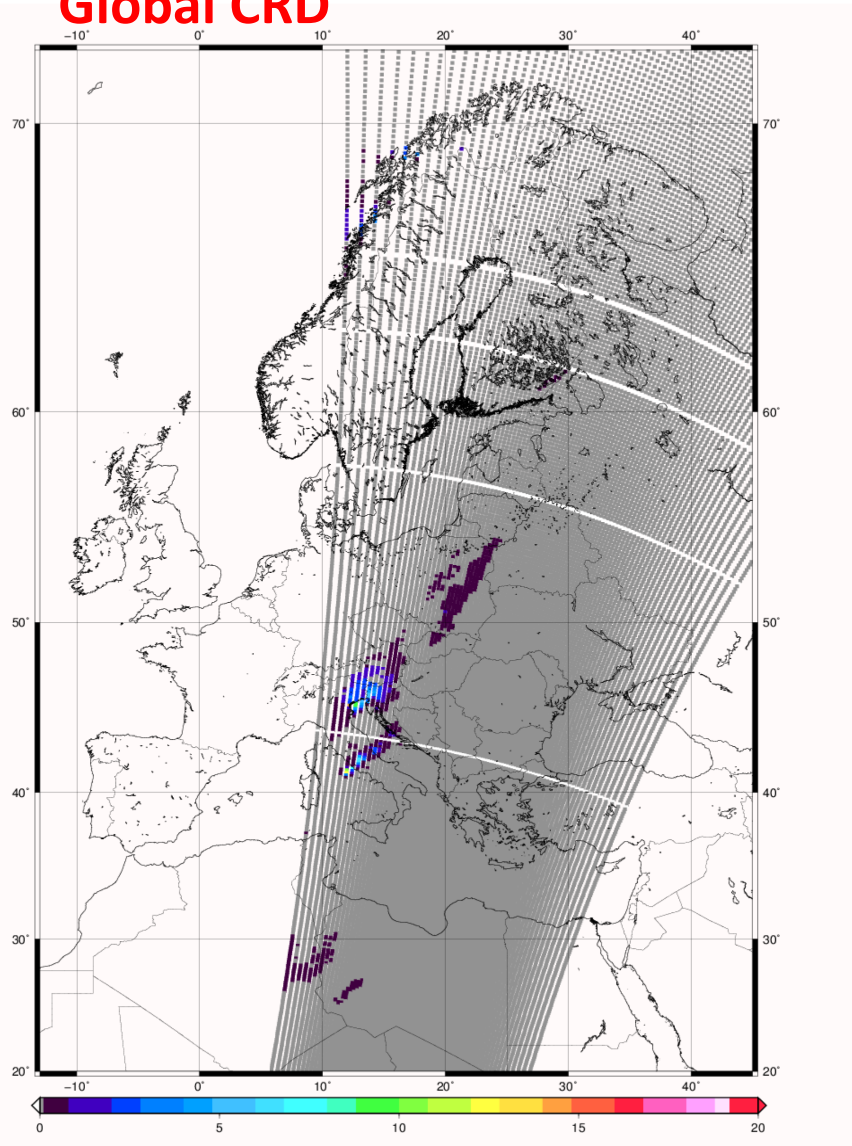
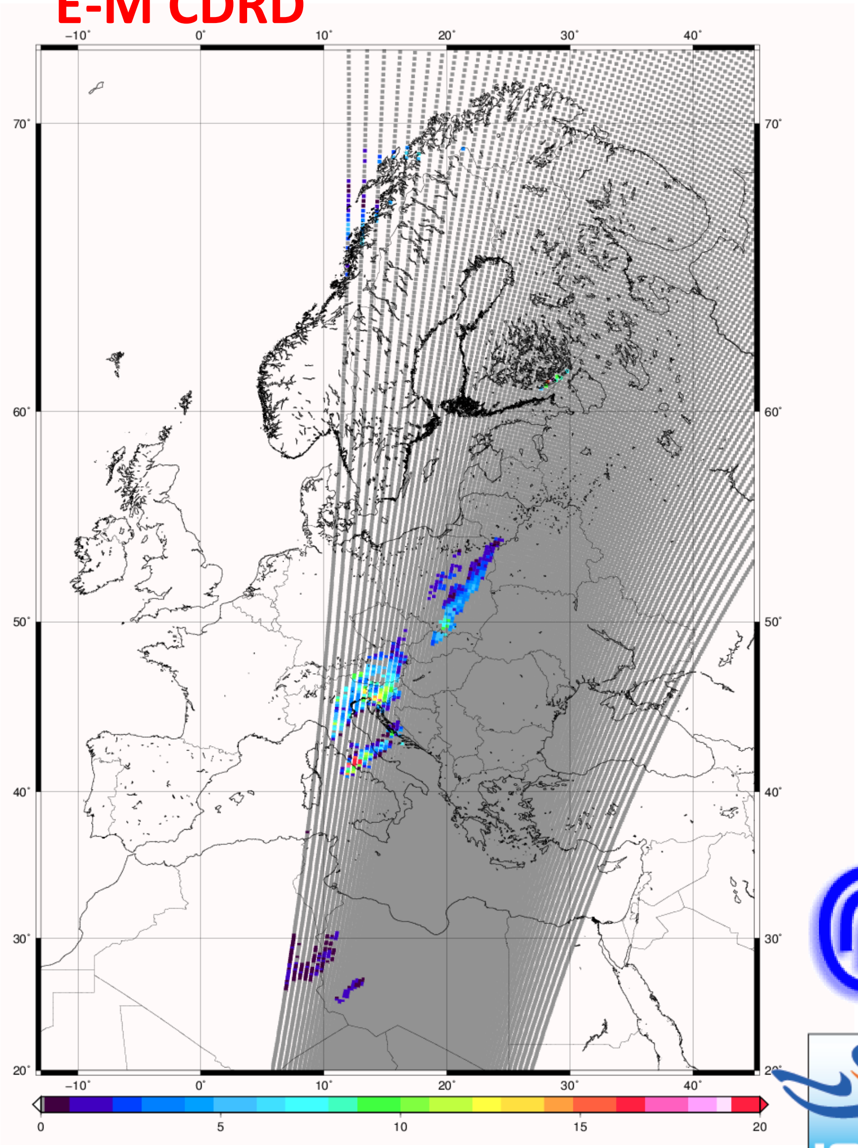
Global CRD



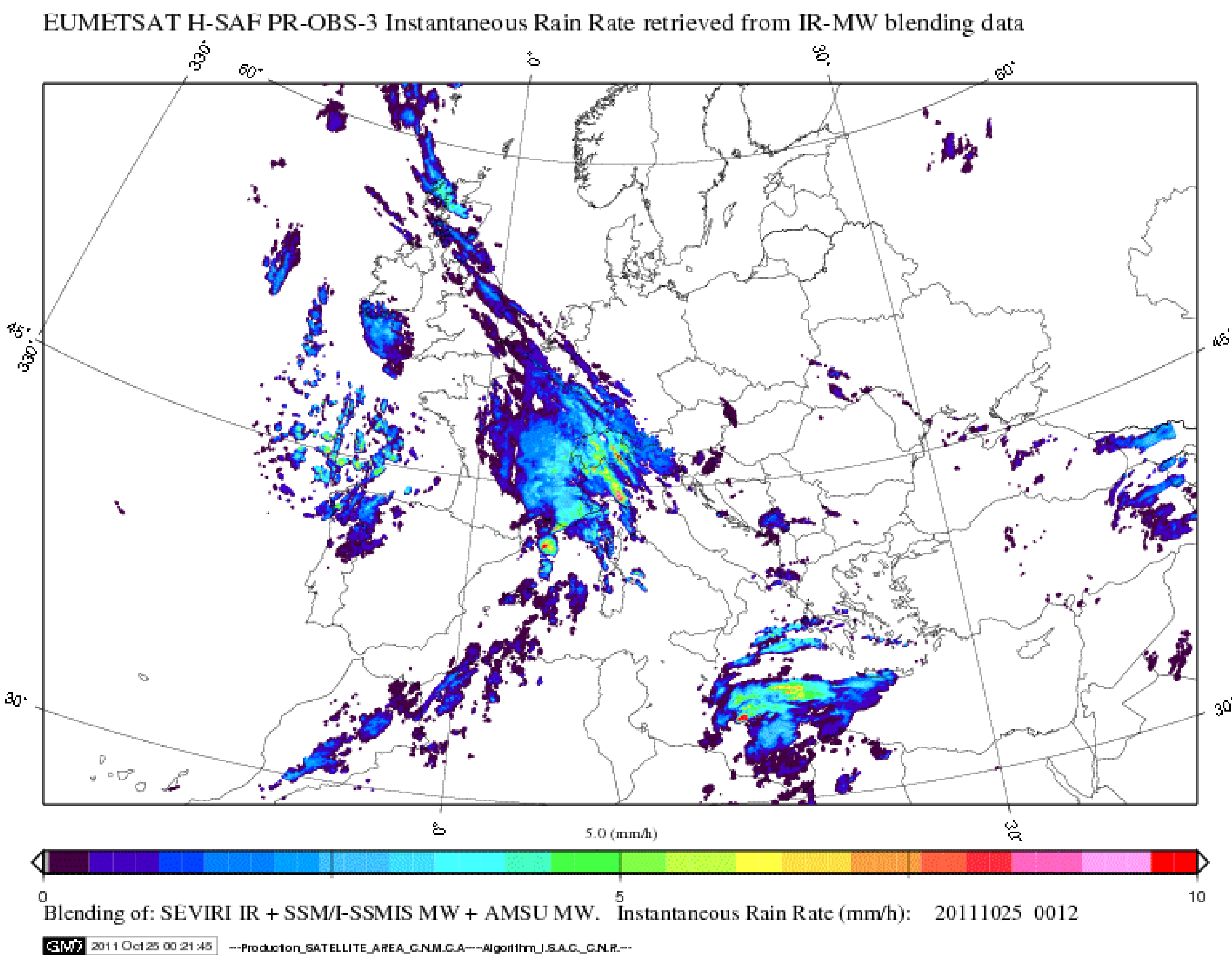
E-M CDRD



ISAC

H-SAF precipitation product H03

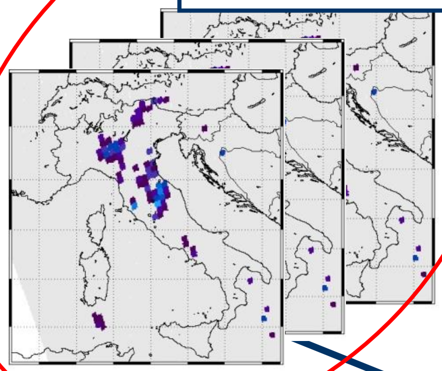
NRL Blending Algorithm & MW (SSM/I – SSMIS + AMSU/MHS) + IR (SEVIRI)



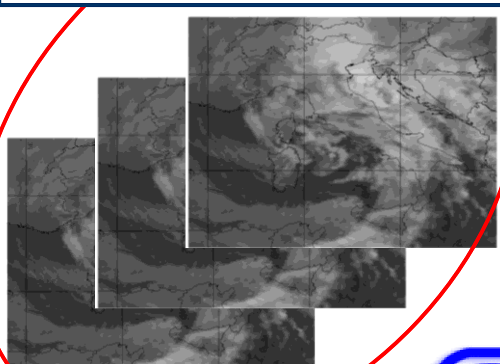
- timeliness: 15 min
- time resolution: 15 min
- space resolution: 8 km
- sampling: 5 km

H-SAF precipitation product H03 Algorithm

Rain intensity maps from PMW data

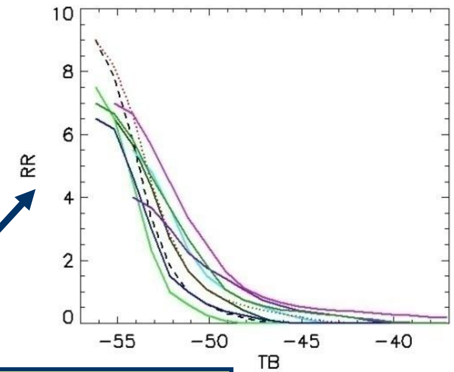


MSG- SEVIRI IR brightness temperatures at 10.8 μm



Extract space and time coincident locations from IR and MW data for each grid box

Create dynamical geolocated statistical relationships RR-T_b



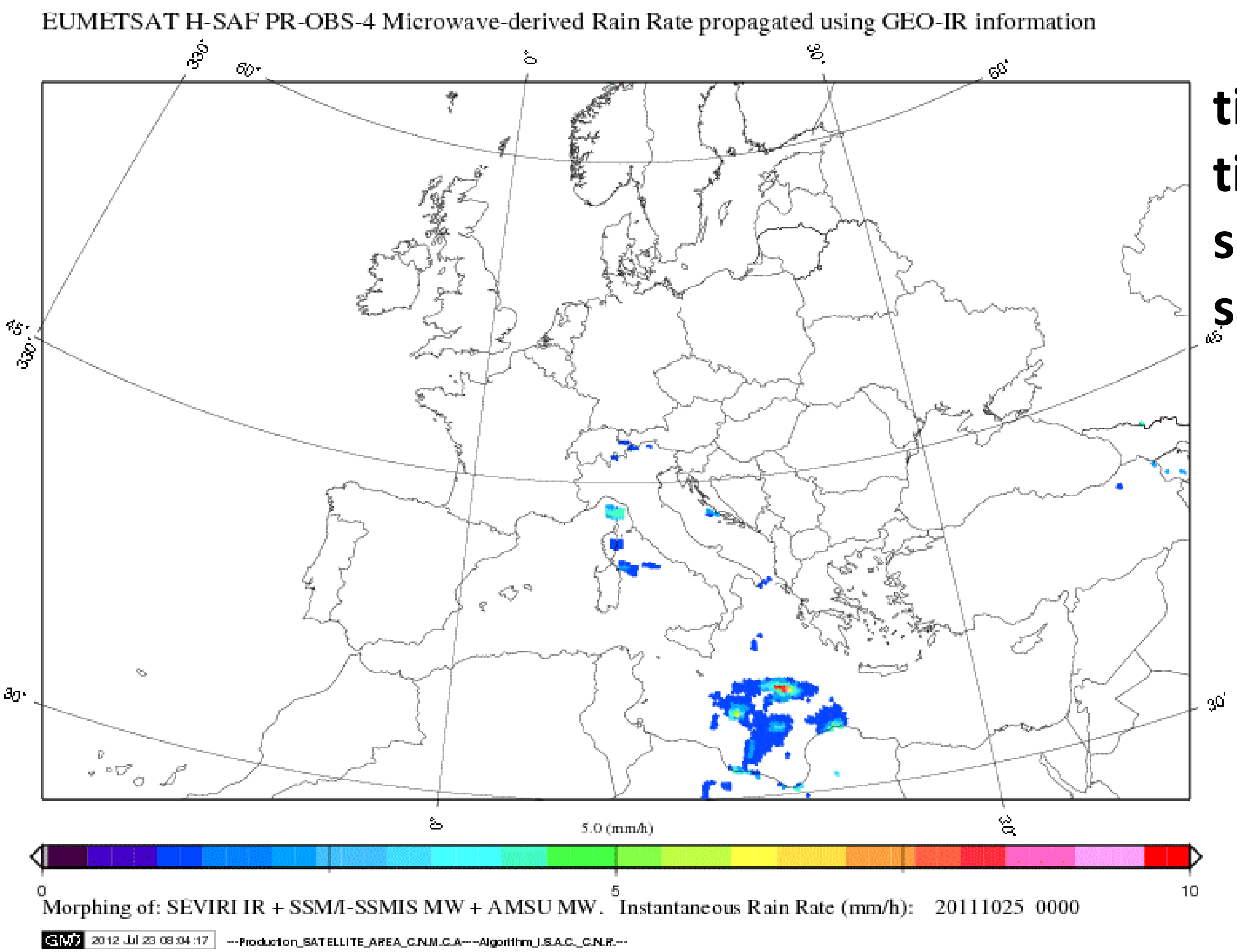
Assign RR at every IR pixel

Produce instantaneous rain intensity maps at the geostationary time/space resolution

Turk et al. 2000,
Torricella et al. 2007

H-SAF precipitation product H04

CMORPH Algorithm MW
(SSM/I – SSMIS + AMSU – MHS) + IR (SEVIRI)



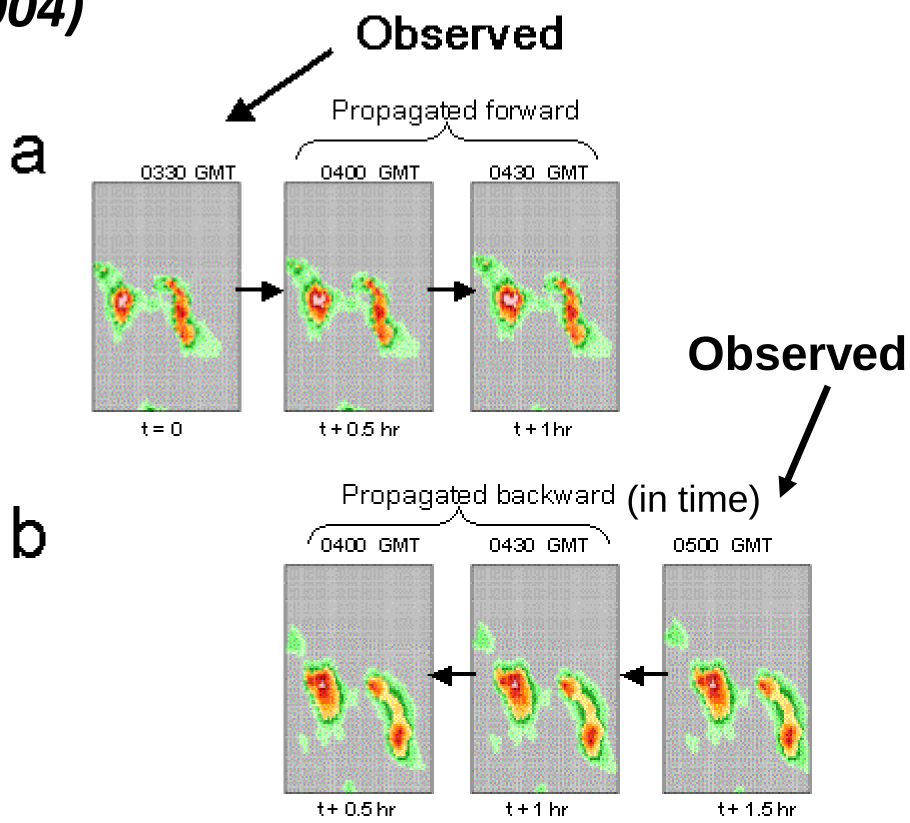
timeliness: 2 hr
time resolution: 15 min
spatial resolution: 30 km
sampling: 8 km

H-SAF precipitation product H04 Algorithm

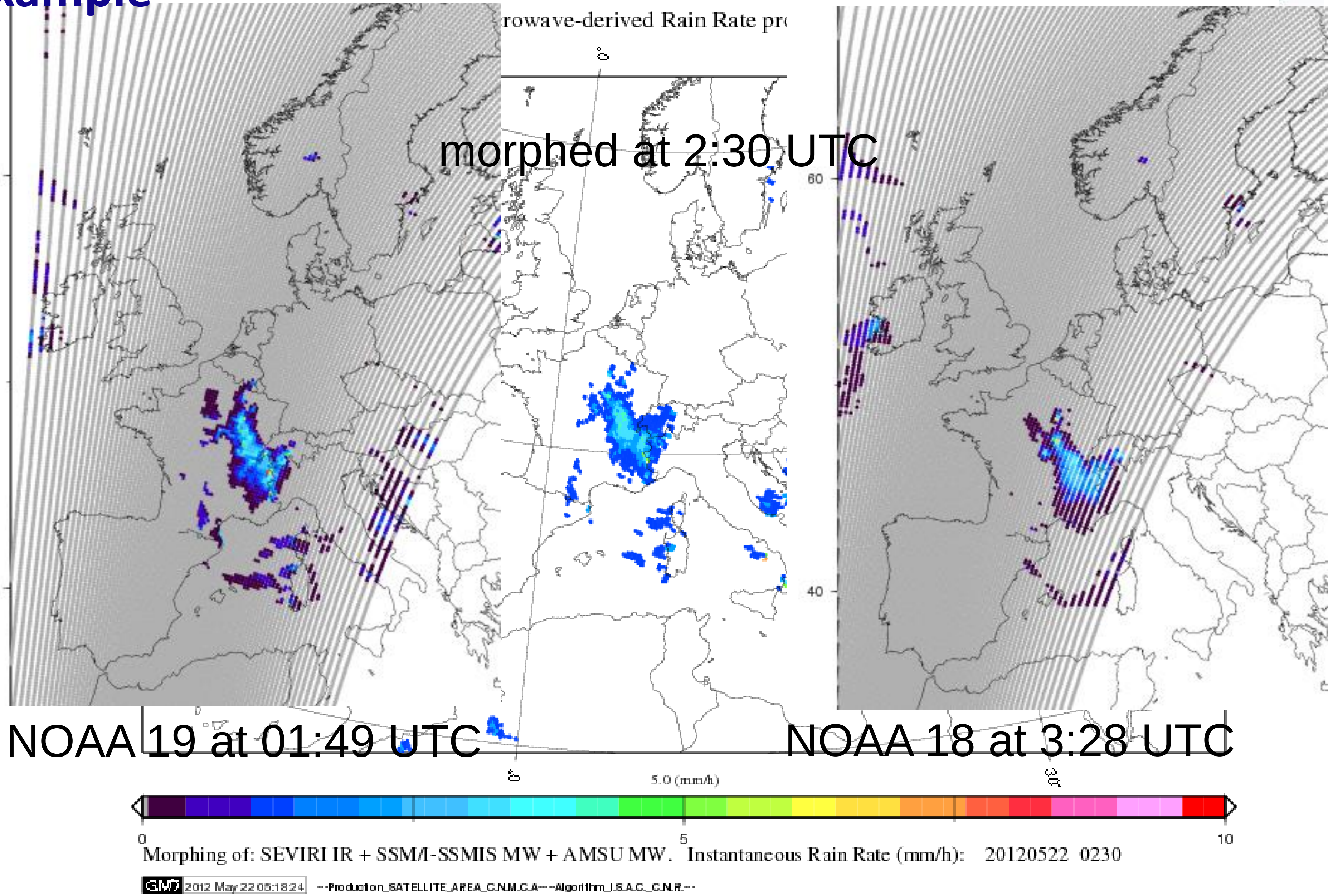
LEO + GEO Satellite Merging –

TRANSPORT METHODS

Developed by NOAA (Joyce et al. 2004)

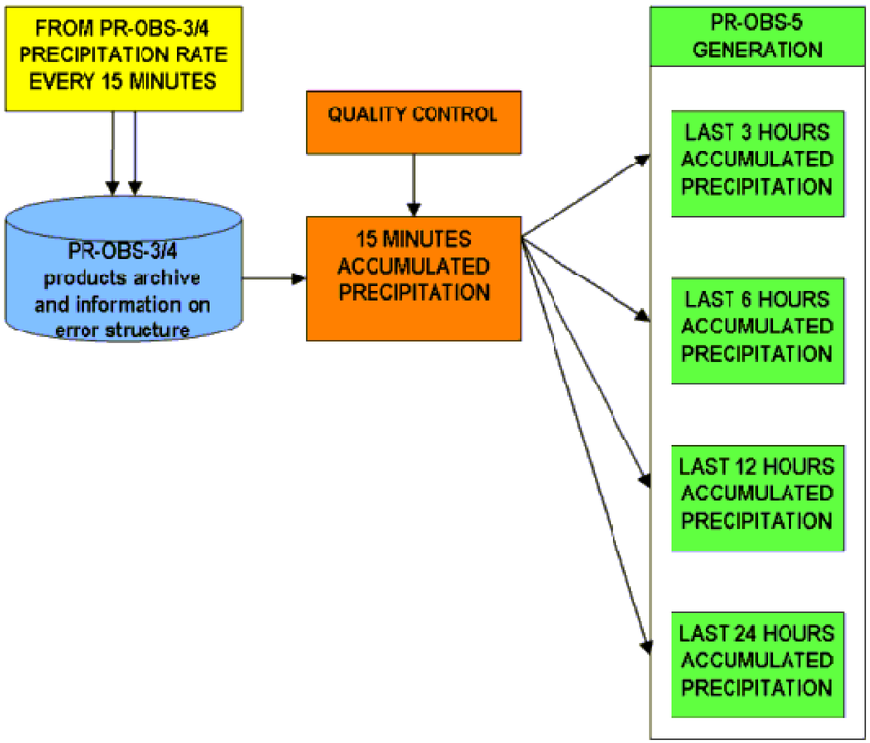


H-SAF precipitation product H04 Example



H-SAF precipitation product H05

Derived from precipitation maps generated by merging MW images from operational sun-synchronous satellites and IR images from geostationary satellites (i.e., either product **H03 or H04**).

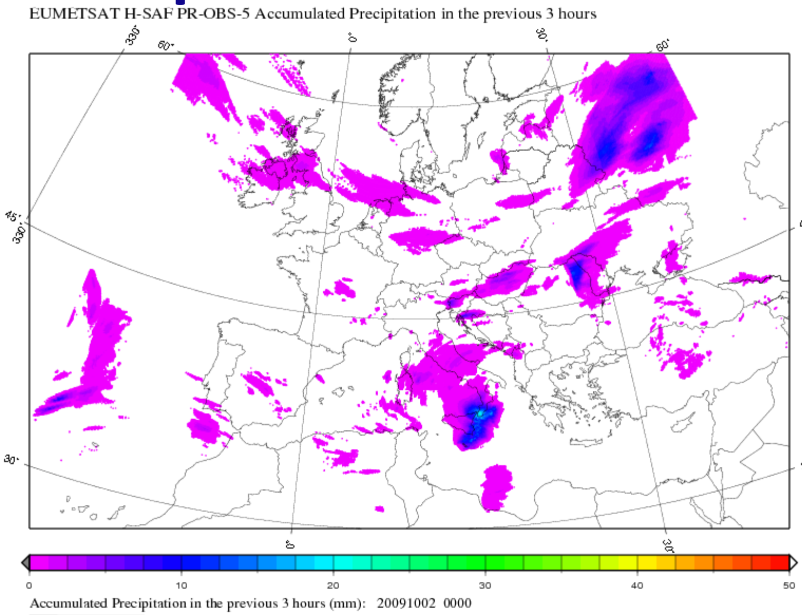


Simple time integration of product H03 (96 samples/day at 15-min intervals) over 3, 6, 12 and 24 hours.

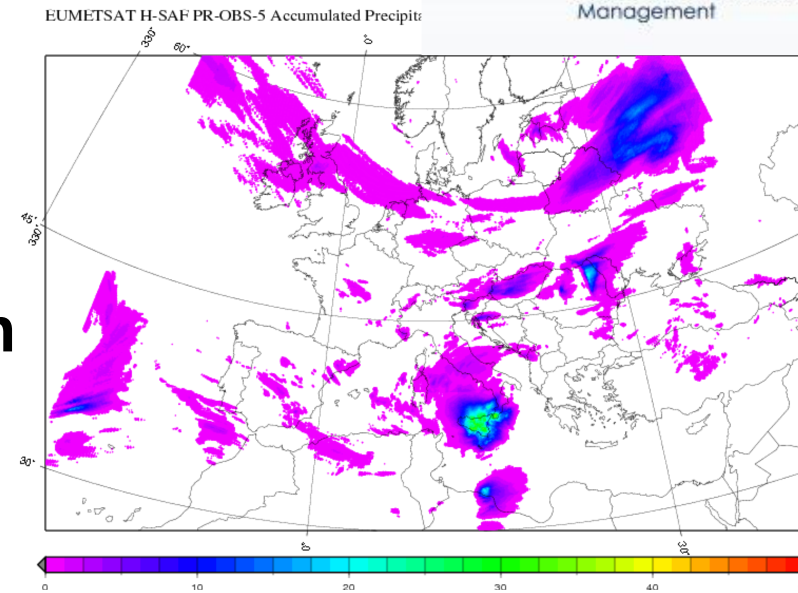
The alternative accumulated precipitation product derived by use of H04 is still not operational but it is easy to be implemented.

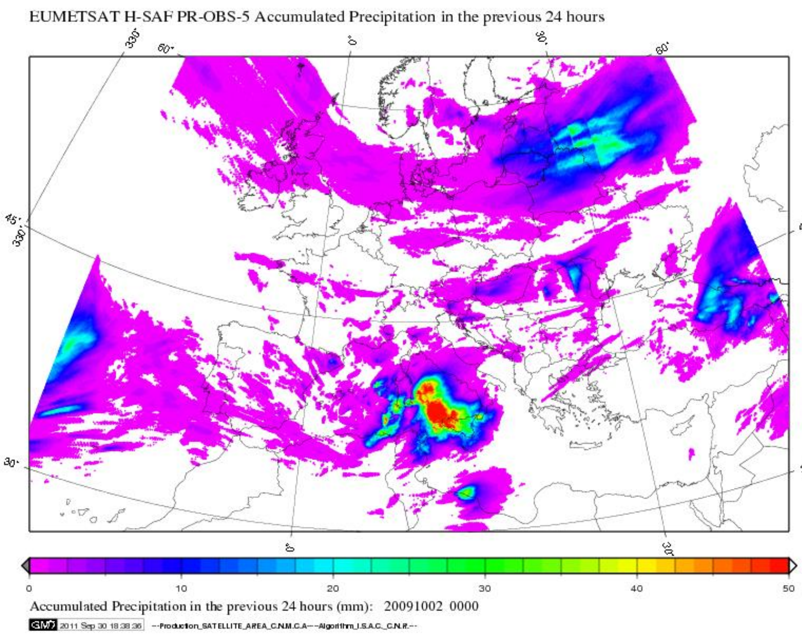
Climatological thresholds are applied on the final products to avoid outliers.

H-SAF precipitation product H05 Examples

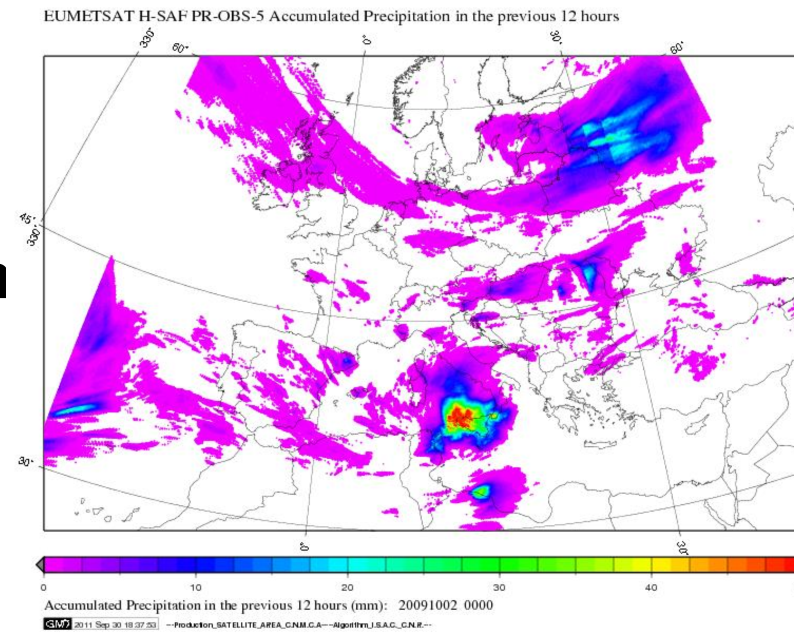


3h 6h



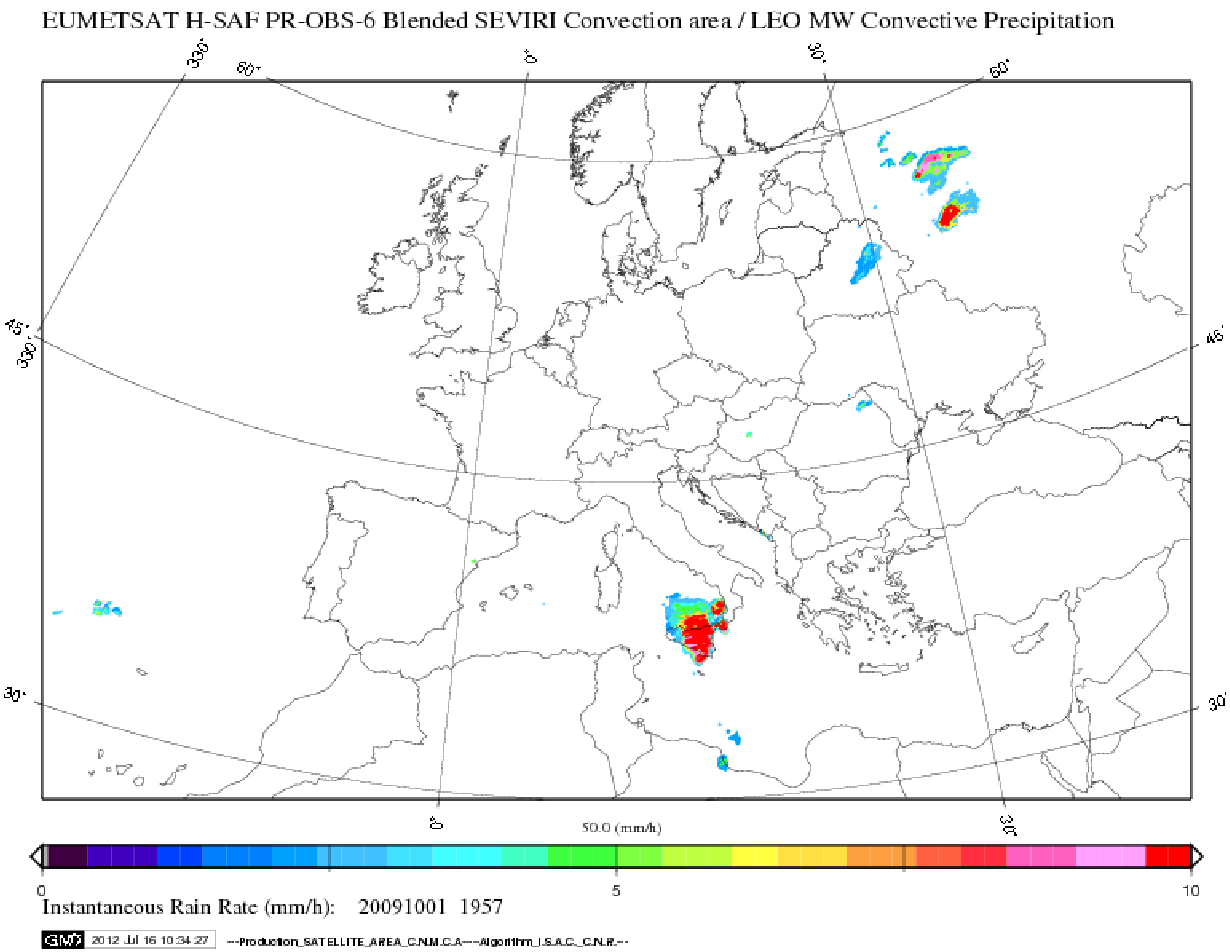


24h 12h



H-SAF precipitation product H06

Blended SEVIRI Convection area / LEO MW Convective Precipitation



timeliness: 15 min

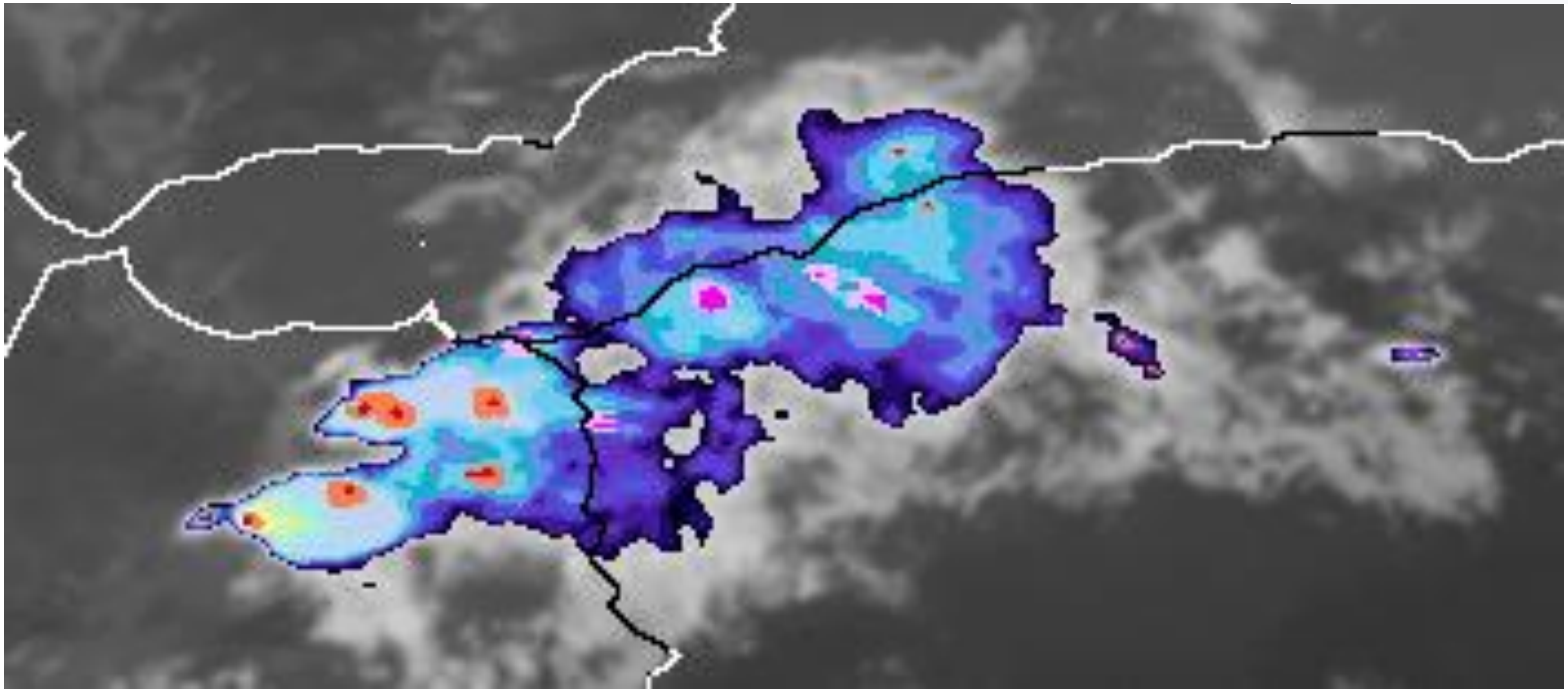
time resolution: 15 min

space resolution: 8 km

sampling: 5 km

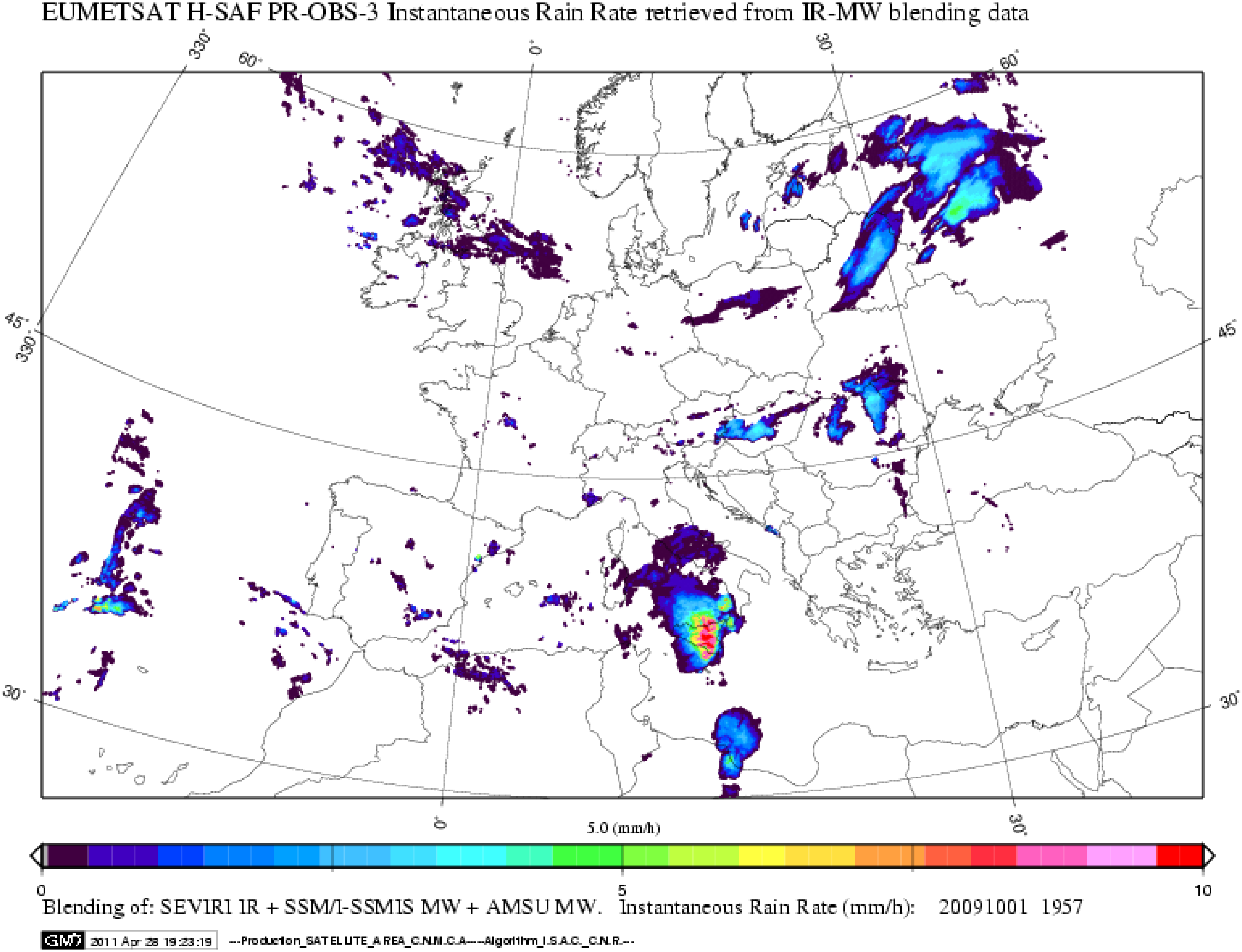
H-SAF precipitation product H06
Nefodina

H SAF
Support to Operational Hydrology and Water Management



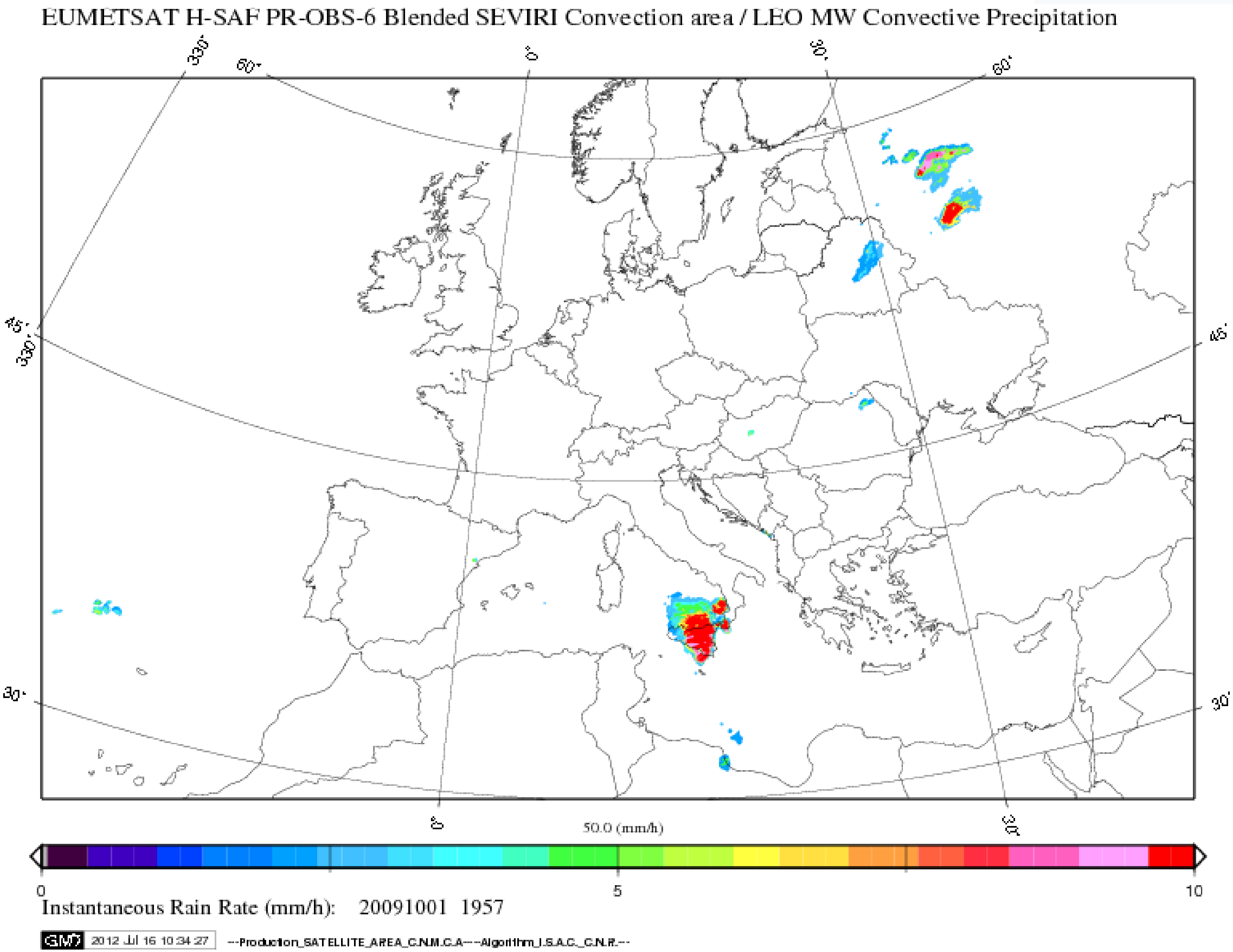
- Red shades indicate cloud tops in the growing phase
- Pink shades indicate cloud tops in the dissipation phase
- Color darkness indicates intensity

H-SAF precipitation product H03
Example



H-SAF precipitation product H06
Example

H SAF
Support to Operational Hydrology and Water Management

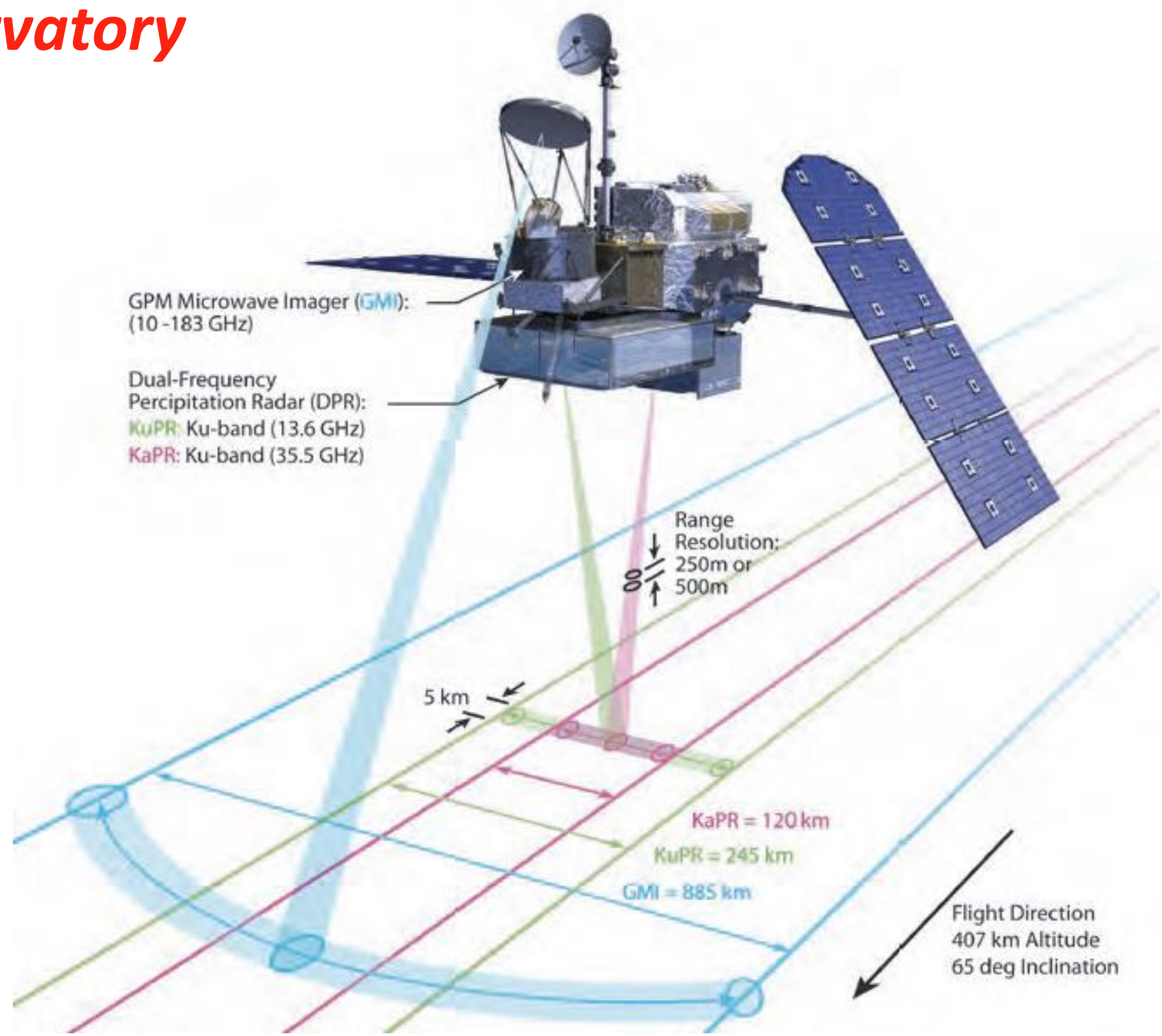


H-SAF new precipitation products

Global Precipitation Measurement

H-SAF new precipitation products

Global Precipitation Measurement Core Observatory



H-SAF new precipitation products

H19 Rainfall intensity from GMI Bayesian algorithm

- Instantaneous precipitation maps generated from GPM Microwave Imager (GMI) on board the GPM Core Observatory satellite;
- Bayesian retrieval strategy adapted to characteristics of GMI in order to provide instantaneous precipitation retrieval;

H20 Rainfall intensity from GMI Neural Network algorithm

- NN approach using Dual-frequency Precipitation Radar (DPR) on GPM Core Observatory together with GMI;
- NN algorithm trained using coincident GMI brightness temperatures measurements and DPR derived rainfall profiles;

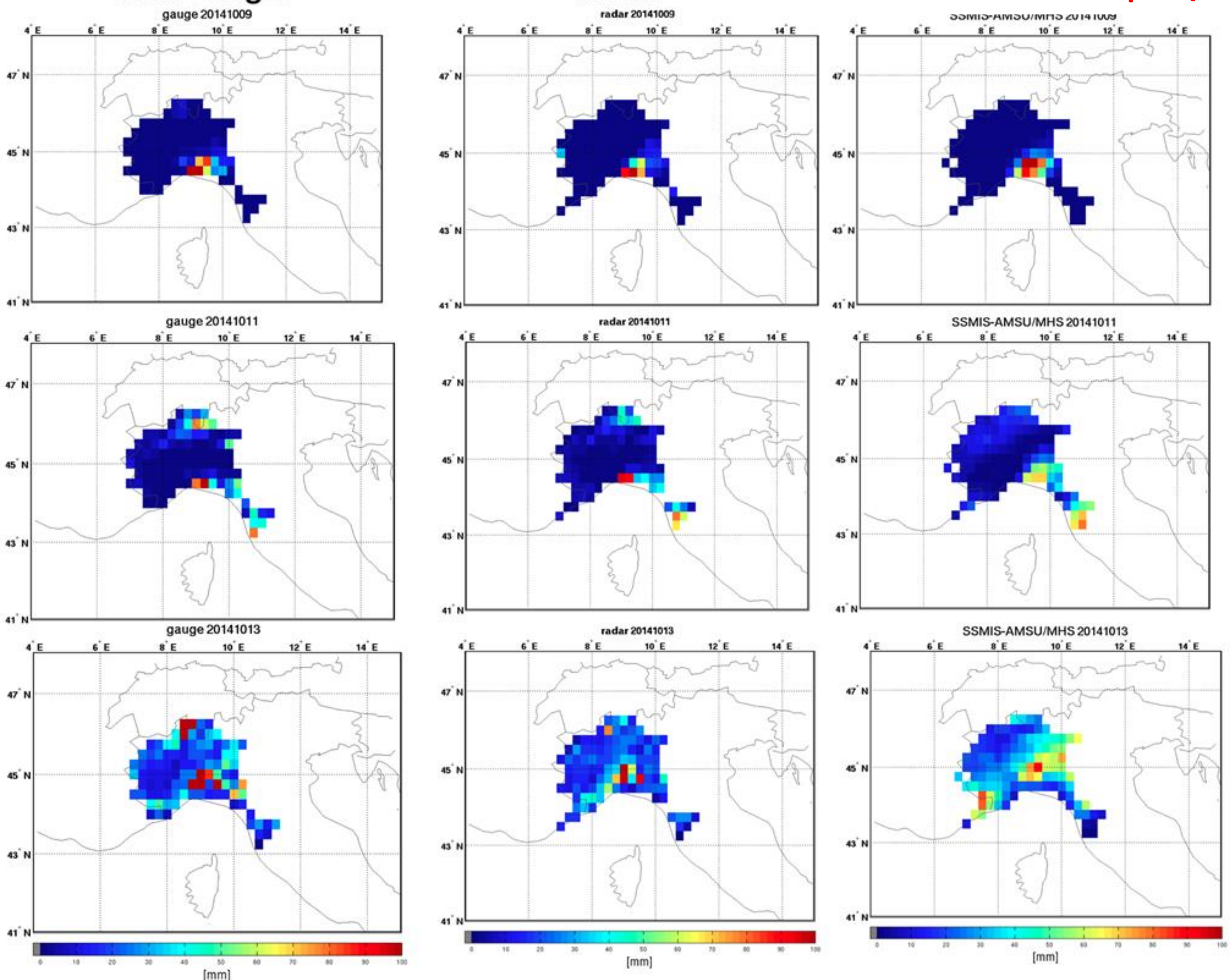
H22 Snowfall intensity

- High-frequency passive microwave algorithm producing snowfall intensity maps in NRT;
- Based on channel combinations in the window and water vapour absorption bands of AMSU-B and MHS;
- The algorithm is designed to produce its own snow cover map (wet and dry snow), but it can also use a snow map from the SAF product.

H-SAF PP to monitor severe events 9-11.10.2014, Piedmont

H SAF
Support to Operational Hydrology and Water Management

Rain Gauges **Radar** **H01 & H02 23 overpass/day**



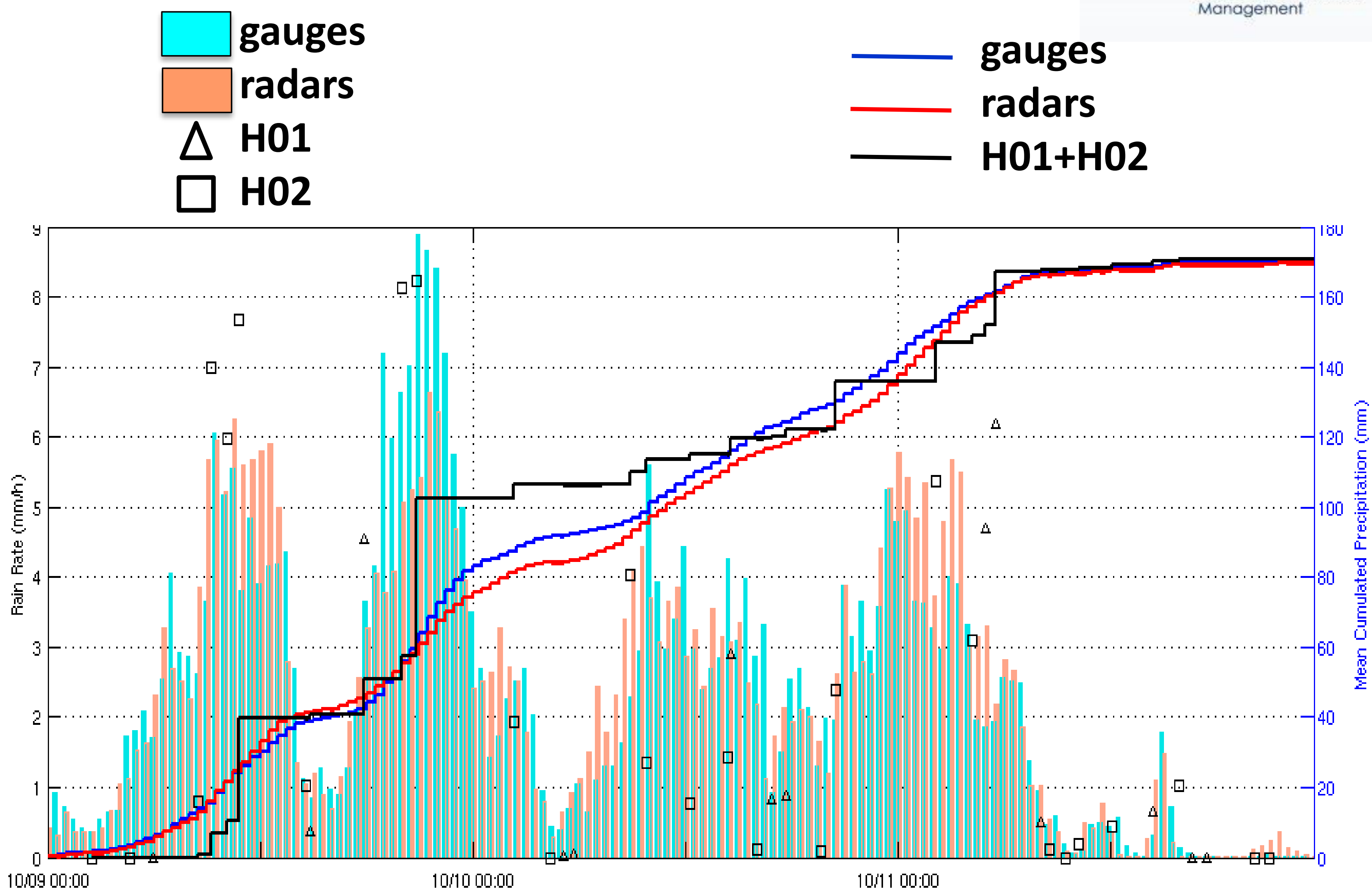
9.11

10.11

11.11

Panegrossi et al., 2016, J-STARS, in press

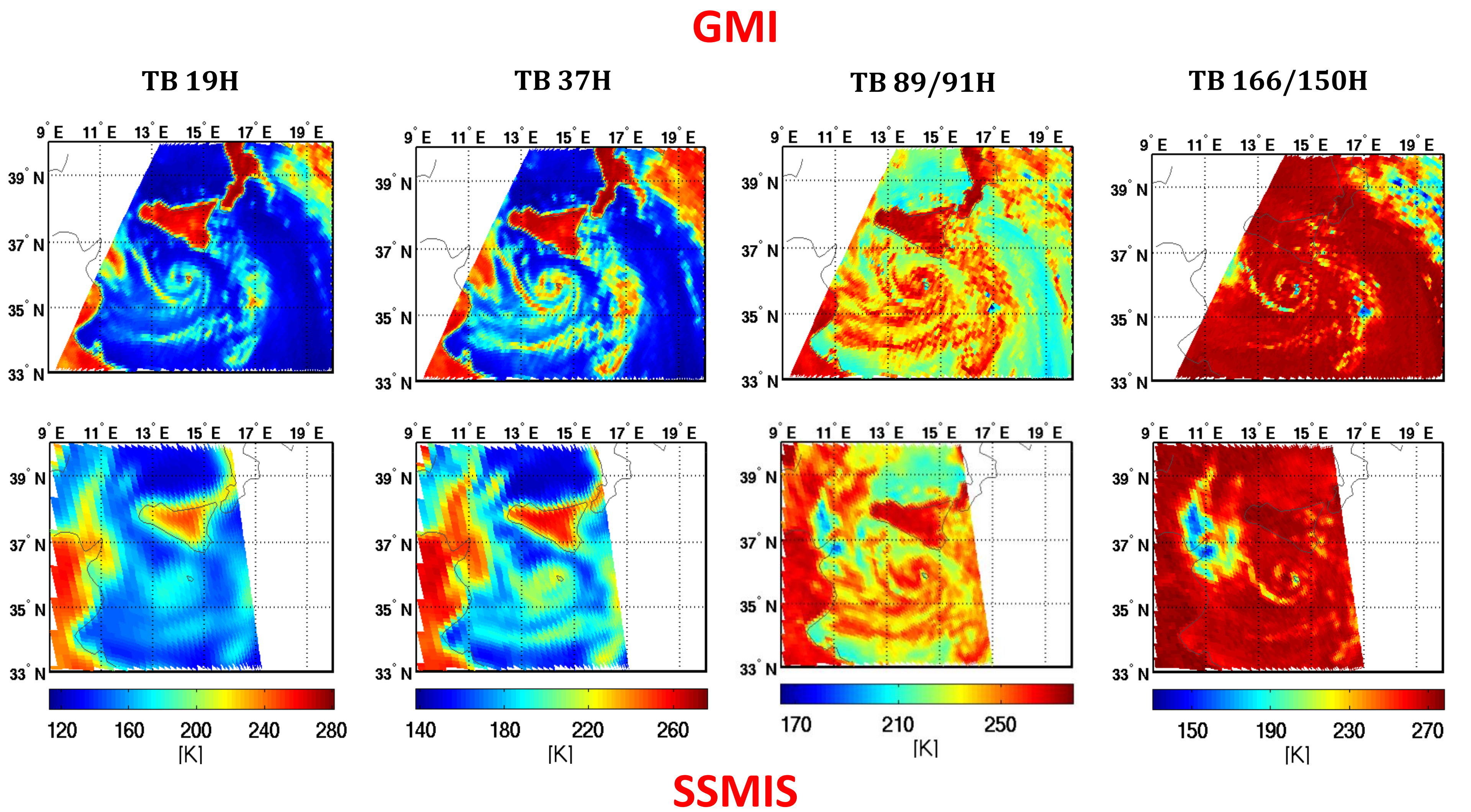
H-SAF PP to monitor severe events
9-11.10.2014, Piedmont



Panegrossi et al., 2016, J-STARS, in press

H-SAF PP to monitor severe events
7-8.11.2014 Medicane Qendresa

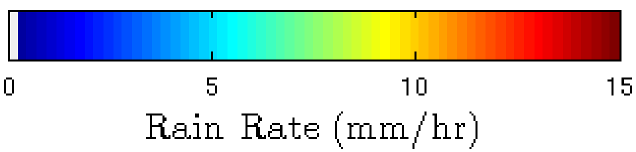
H SAF
Support to Operational Hydrology and Water Management

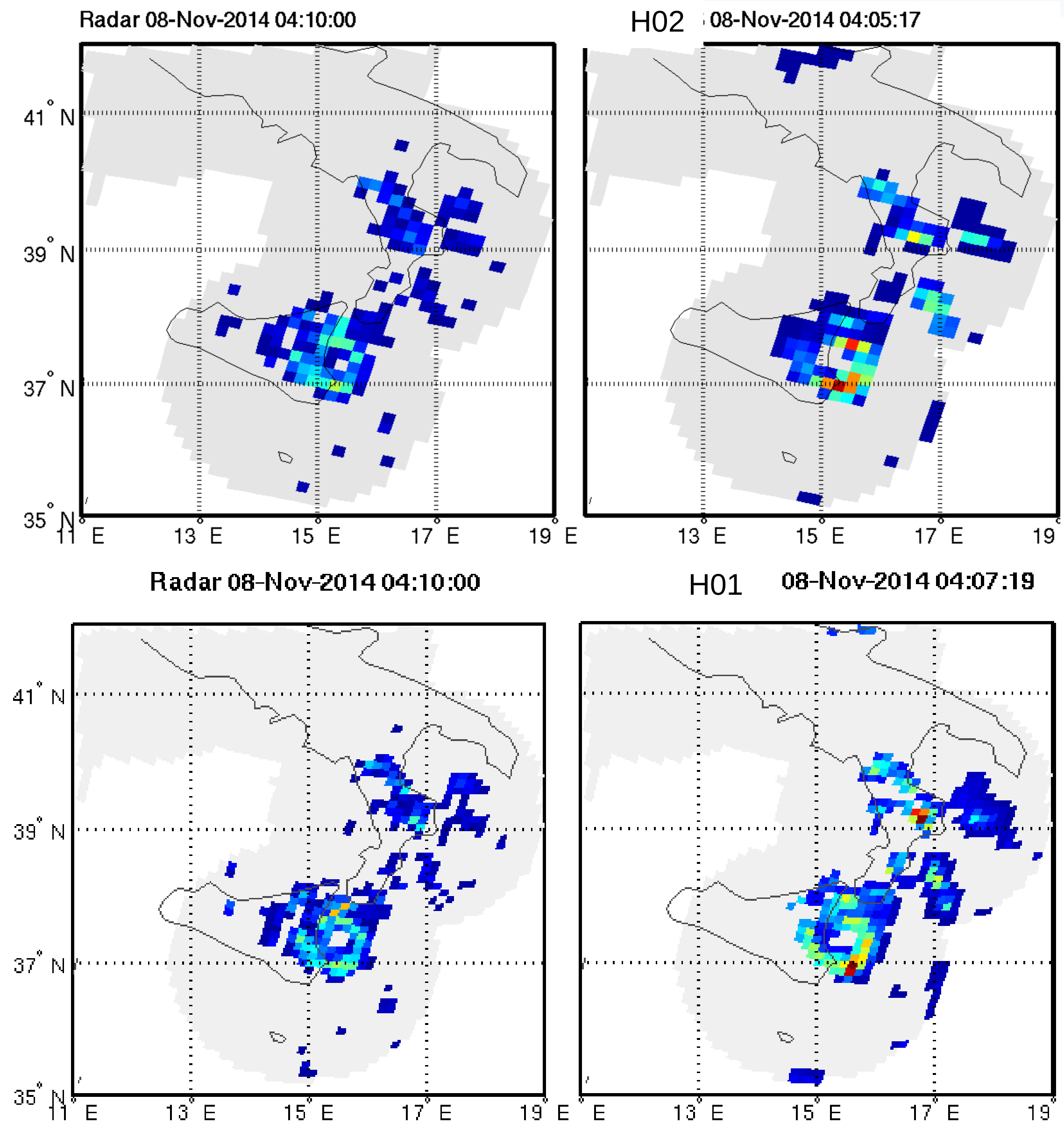


Panegrossi et al., 2016, J-STARS, in press

H-SAF PP to monitor severe events
7-8.11.2014 Medicane Qendresa

H SAF
Support to Operational Hydrology and Water Management





Panegrossi et al., 2016,
J-STARS, in press

precipitation product calibration/validation

For all products generated by the project, the product validation cluster is responsible for:

- **monitoring 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;
- **providing a validation service to end-users** publishing on the **H-SAF web-page** the statistical scores evaluated and the case studies analysed;
- **providing online quality** control to end-users generating NRT quality maps;
- **monitoring operational features** of the products as actual arrival, timeliness, intelligibility, etc..;
- **providing a ground data service** inside the project for algorithm calibration and validation activities.

PPV group

H SAF
Support to Operational

Silvia Puca (Leader)	Dipartimento Protezione Civile (DPC)	Italy
Emanuela Campione	Dipartimento Protezione Civile (DPC)	Italy
Gianfranco Vulpiani	Dipartimento Protezione Civile (DPC)	Italy
Marco Petracca	Dipartimento Protezione Civile DPC	Italy
Emmanuel Roulin	Institut Royal Météorologique (IRM)	Belgium
Pierre Baguis	Institut Royal Météorologique (IRM)	Belgium
Gergana Kozinarova	NIMH-BAS	Bulgaria
Georgy Koshinchanov	NIMH-BAS	Bulgaria
Peer Helmke	Bundesanstalt für Gewässerkunde (BfG)	Germany
Judit Kerenyi	Hungarian Meteorological Service (OMSZ)	Hungary
Federico Porcu'	Ferrara University, Department of Physics (UniFe)	Italy
Bozena Lapeta	Institute of Meteorology and Water Management (IMWM)	Poland
Rafal Iwanski	Institute of Meteorology and Water Management (IMWM)	Poland
Ján Kaňák	Slovenský Hydrometeorologický Ústav (SHMÚ)	Slovakia
Ľuboslav Okon	Slovenský Hydrometeorologický Ústav (SHMÚ)	Slovakia
Mariàn Jurasek	Slovenský Hydrometeorologický Ústav (SHMÚ)	Slovakia
Ahmet Öztopal	Istanbul Technical University (ITU)	Turkey
Ibrahim Sonmez	Turkish State Meteorological Service (TSMS)	Turkey

PPV strategy

A TWO FOLD VALIDATION STRATEGY has been defined:

- **large statistics (multi-categorical and continuous)**
  – COMMON VALIDATION

- **selected case studies**
  - SPECIFIC VALIDATION

Both components are considered complementary in assessing the accuracy of the implemented algorithms.

Large statistics help in identifying existence of **pathological behavior**, selected case studies are useful in identifying **the sources** of such behavior.

The **heterogeneity** due to climatology, land cover, orography, and type of ground observations available for each Country, is an important resource for the PPVG, but the definition and agreement on a **common validation methodology** is mandatory.

PPV strategy

the **ground reference** is represented by **radar** and **rain gauge data**;

quality filters for radar and rain gauge data are adopted;

the **precipitation products** are **evaluated on the satellite native grid.** The radar and rain gauge data were up-scaled taking into account the satellite scanning geometry and IFOV resolution of AMSU-B scan, SSMIS and SEVIRI;

multi category and **continuous statistics** are **evaluated monthly**

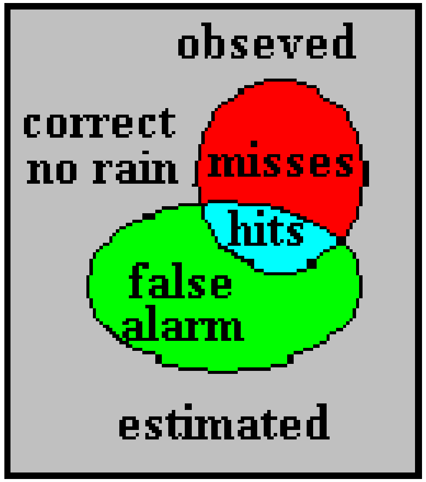
MCstatistic:

ACCURACY
POD
FAR
BIAS
ETS
OR
HSS

Cstatistic:

- **Number of points**
- **obs. Mean rainrate**
- **est. Mean rainrate**
- **obs. Maximum rainrate**
- **est. Maximum rainrate**
- **Mean error**
- **Multiplicative bias**
- **Mean absolute error**
- **Root mean square error**
- **Correlation coefficient**
- **Standard deviation**

PPV multicategorical skill scores (Nurmi, 2003)



$$POD = \frac{hits}{hits + misses} \qquad FAR = \frac{false\ alarms}{hits + false\ alarms}$$

$$ETS = \frac{hits - hits_R}{hits + misses + false\ alarms - hits_R}$$

$$hits_R = \frac{(hits + misses)(hits + false\ alarms)}{(hits + misses + false\ alarms + correct\ negatives)}$$

$$BIAS = \frac{hits + false\ alarms}{hits + misses}$$

$$HSS = \frac{\sum_{i=1}^{k} H_i - \sum_{i=1}^{k} O_i \cdot E_i}{N - \sum_{i=1}^{k} O_i \cdot E_i}$$

	FORECASTS 1	2	3	Totals
OBSERVD 1	Hit_1			O_1
2		Hit_2		O_2
3			Hit_3	O_3
Totals	F_1	F_2	F_3	

PPV continuous statistics scores

$$Mean\ error = ME = \frac{1}{N}\sum_{k=1}^{N}(sat_k - true_k)$$

$$Standard\ deviation = SD = \sqrt{\frac{1}{N}\sum_{k=1}^{N}(sat_k - true_k - ME)^2}$$

$$MeanAbsoluteError = \frac{1}{N}\sum_{k=1}^{N}|sat_k - true_k|$$

$$MultiplicativeBias = \frac{\frac{1}{N}\sum_{k=1}^{N} sat_k}{\frac{1}{N}\sum_{K=1}^{N} true_k}$$

$$Correlation\ coefficient = \rho = \frac{\sum_{k=1}^{N}(sat_k - \overline{sat})(true_k - \overline{true})}{\sqrt{\sum_{k=1}^{N}(sat_k - \overline{sat})^2 \sum_{1}^{N}(true_k - \overline{true})^2}}$$

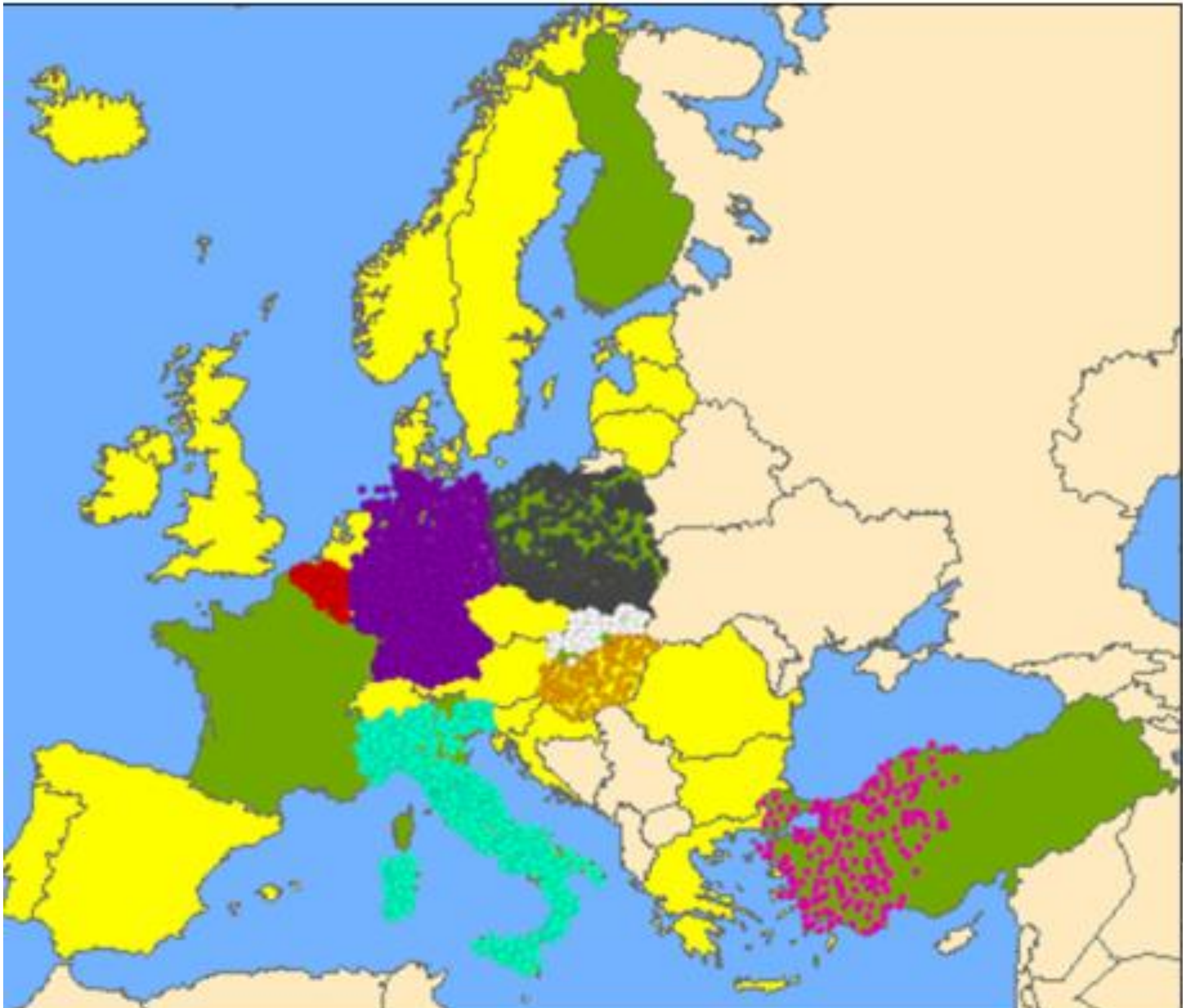
$$\overline{sat} = \frac{1}{N}\sum_{k=1}^{N} sat_k$$

$$\overline{true} = \frac{1}{N}\sum_{k=1}^{N} true_k$$

$$RMSE = RootMeanSquareError = \sqrt{\frac{1}{N}\sum_{k=1}^{N}(sat_k - true_k)^2}$$

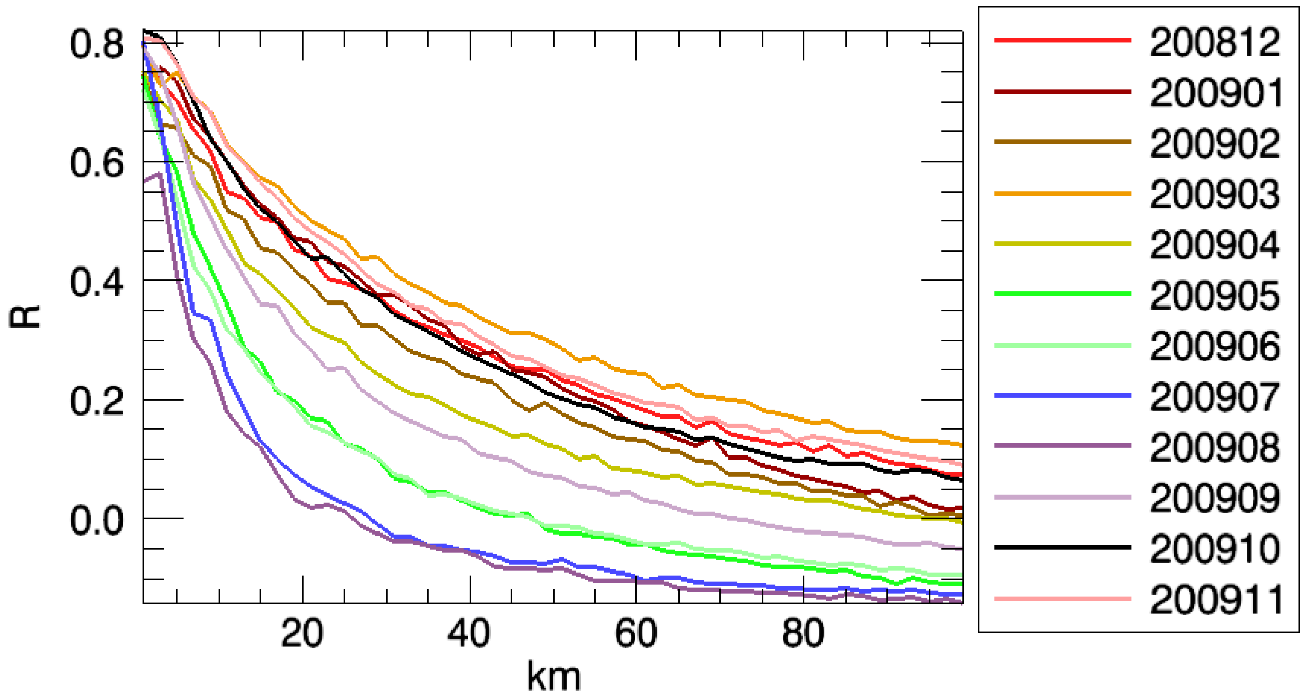
$$URD - RMSE = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\frac{(sat_k - true_k)^2}{true^2{}_k}}$$

PPV raingauge networks (~4100 stations)



PPV raingauge networks

Country	Rain gauge type (TB/W)	Minimum detectable rain rate (mm h^{-1})	Maximum detectable rain rate (mm h^{-1})	Heating system (Y/N)	Cumulation interval (min)	AMD (km)
Belgium	TB	0.1 mm	N/A	N	60	**11.2**
Bulgaria	TB/W	0.1 mm	2000	Y	60, 120	**7**
Germany	W	0.05 mm	3000	Y	60	**17**
Italy	TB	0.2 mm	N/A	Y (16%)	10 - 60	**9.5**
Poland	TB	0.1 mm	N/A	Y	10	**13.3**
Turkey	TB	0.2 mm	720	Y	1	**27**



PPV raingauges interpolation

- Point-like rain gauge measurements derive from networks with **different geographical distributions**, **densities**, **quality**. The PPVG decided to develop **a common interpolation strategy**.
- The rain gauge measurements are interpolated onto a unique 5x5 km grid.
- Three interpolation techniques have been tested: **Barnes** method (Barnes, 1964), **Ordinary Kriging** and the Random Generator of Spatial Interpolation from uncertain Observations (**GRISO**). After a sensitivity study, the PPVG to adopted the GRISO technique as common spatial interpolation of rain gauge data.
- The **GRISO** (Pignone et al., 2010) is a Kriging-based technique implemented by the CIMA-Research Foundation. The GRISO technique preserves the values observed at rain gauge location allowing for a dynamical definition of the covariance structure associated to each rain gauge by the interpolation procedure.

PPV raingauge flowchart

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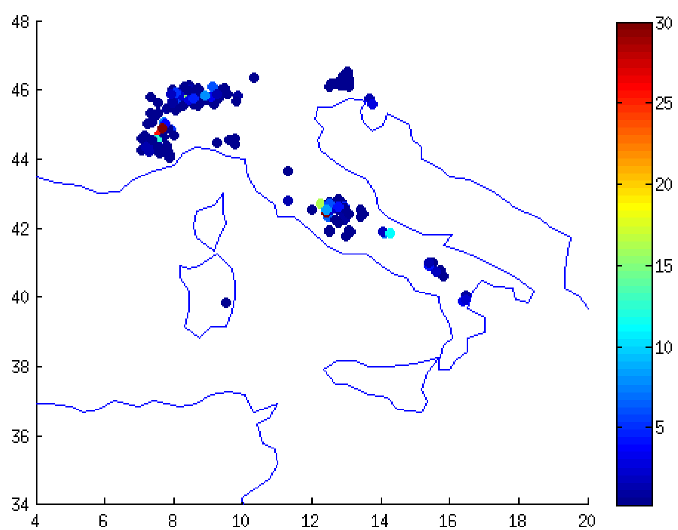
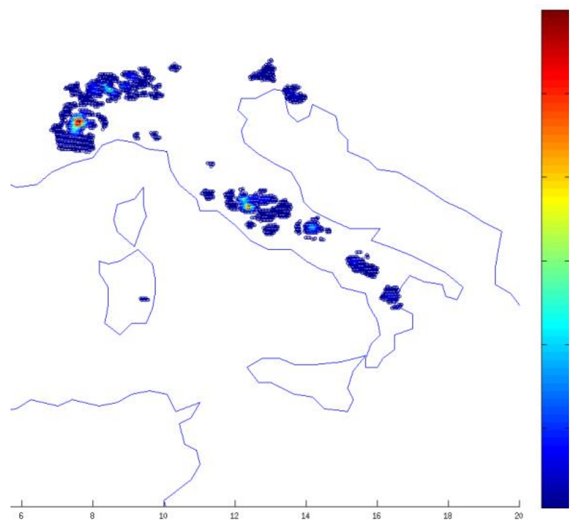
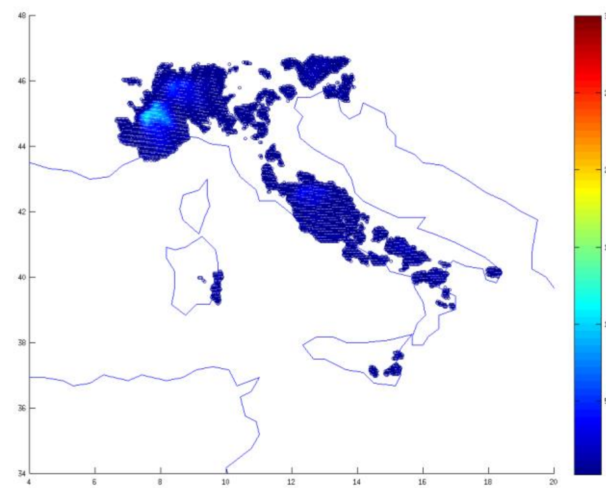
Rain gauge → Quality filter → Interpolation method ⇄ Satellite product







SEA, LAND, COAST → Precip. classes → Statistical scores

PPV radar networks (54 C-band, 1 Ka-band radars)

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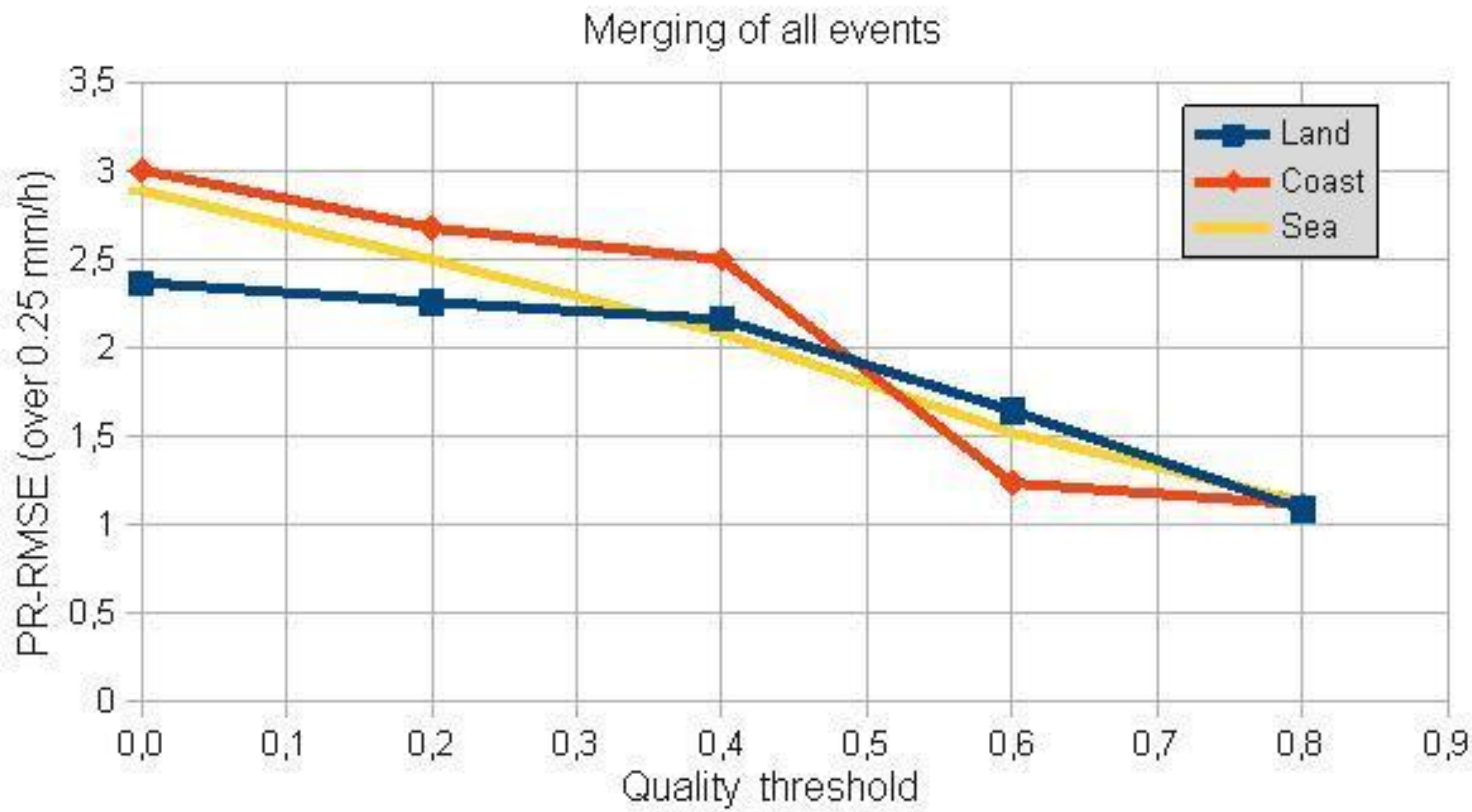
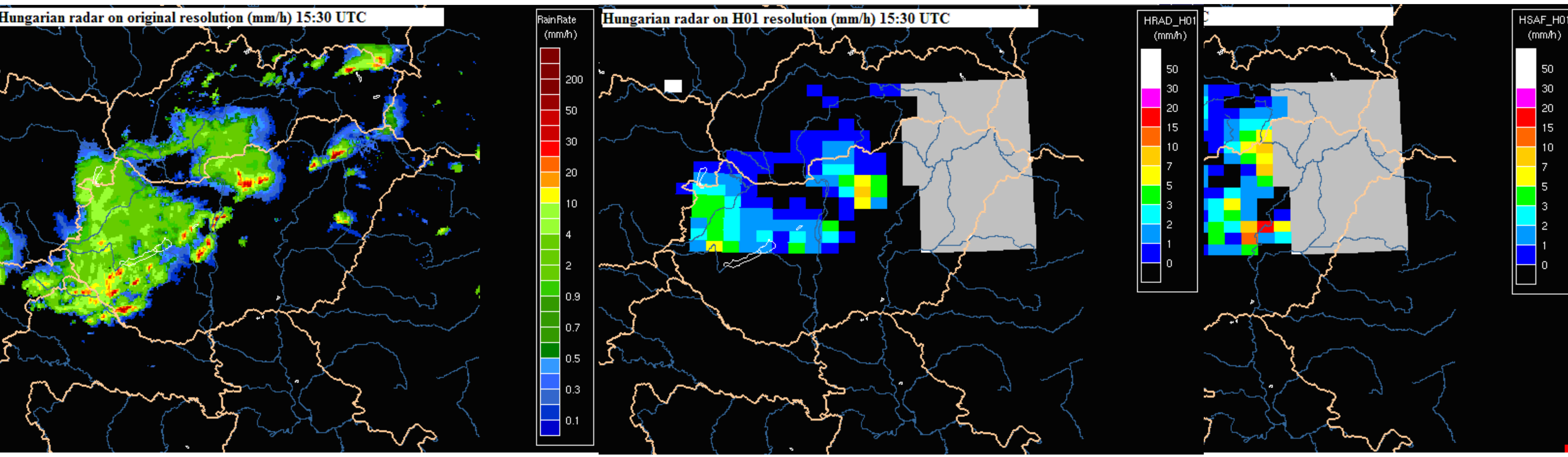
Data Sources	Radars
Instrument characteristics	Beam width ~1° , max range ~150 Km, 250m, C-band, single polarization, Doppler polarimetric
Time domain	Near real time/ case studies
Time resolution	5 min, 15 min, 30 min, 1h, 24h
Spatial distribution	Whole national territory
Number of station	53 C band +1 Ka band
Operational/ for research only	Operational
Data quality check	Permanent ground clutter removed; monitoring of electronic calibration

PPV impact of radar quality



PPV radar flowchart

Radar data → Quality filter → Radar product → Up-scaling ⇄ Satellite product



SEA, LAND, COAST → Precip. classes → Statistical scores

PPV H01 results

PR-OBS-1	RADAR						RAIN GAUGE					
	summer 2011	**autumn 2011**	**winter 11-12**	**spring 2012**	**summer 2012**	**YEAR 11-12**	**summer 2011**	**autumn 2011**	**winter 11-12**	**spring 2012**	**summer 2012**	**YEAR 11-12**
NS	74922	42927	53822	38511	24205	**234387**	38664	81411	60412	59820	12929	**253236**
NR	24331	12278	15913	15020	8556	**76098**	21734	66190	74009	51340	7054	**220327**
ME[mmh^{-1}]	0,25	0,14	0,19	0,71	0,57	**0,35**	-0,36	-0,38	-0,34	-0,03	-0,14	**-0,28**
SD[mmh^{-1}]	2,54	1,24	0,91	1,89	2,97	**1,91**	3,60	2,89	1,15	1,86	2,68	**2,13**
MAE[mmh^{-1}]	1,31	0,93	0,82	1,39	1,50	**1,18**	1,68	1,51	0,82	1,15	1,40	**1,21**
RMSE[mmh^{-1}]	2,77	1,38	1,05	2,15	3,02	**2,09**	3,63	2,92	1,21	1,88	2,69	**2,16**
MB	1,26	1,24	1,39	1,79	1,50	**1,42**	0,79	0,76	0,65	0,98	0,91	**0,78**

The validation results of the PR-OBS-1 product show:

-a yearly RMSE of around 2.1 mmh^{-1} and MAE of 1.2 mmh^{-1} obtained in comparison with both radar and rain gauge data.

-There is an overall tendency to overestimate the radar (ME equal to 0.35 mmh^{-1}) and to underestimate the rain gauge rates (ME equal to -0.28 mmh^{-1}) at European scale.

PPV H02 results

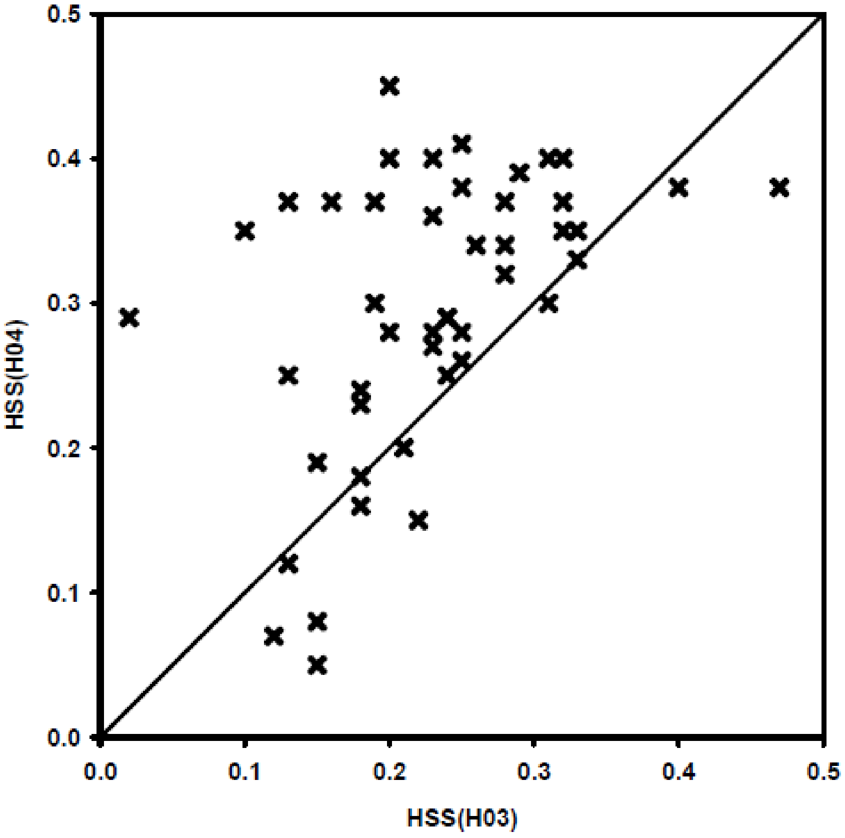
PR-OBS-2	RADAR						RAIN GAUGE					
	summer 2011	autumn 2011	winter 11-12	spring 2012	summer 2012	YEAR 11-12	summer 2011	autumn 2011	winter 11-12	spring 2012	summer 2012	YEAR 11-12
NS	59726	47990	21778	46849	38472	**214815**	18844	57596	32220	59736	13276	**181672**
NR	37779	24737	35964	33548	21673	**153701**	19727	72124	146918	88593	11315	**338677**
ME[mmh^{-1}]	-0,26	-0,36	-0,49	-0,24	-0,21	**-0,32**	-0,95	-1,08	-0,78	-0,83	-1,14	**-0,88**
SD[mmh^{-1}]	1,48	1,03	0,72	0,86	1,74	**1,13**	2,43	1,90	0,89	1,34	2,34	**1,36**
MAE[mmh^{-1}]	0,83	0,69	0,66	0,60	0,82	**0,72**	1,37	1,33	0,86	0,96	1,45	**1,04**
RMSE[mmh^{-1}]	1,53	1,09	0,90	0,92	1,65	**1,20**	2,62	2,20	1,19	1,60	2,62	**1,64**
MB	0,86	0,64	0,31	0,69	0,89	**0,66**	0,41	0,30	0,17	0,22	0,33	**0,23**

Similar results are obtained for PR-OBS-2, based on AMSU-A and AMSU-B data:

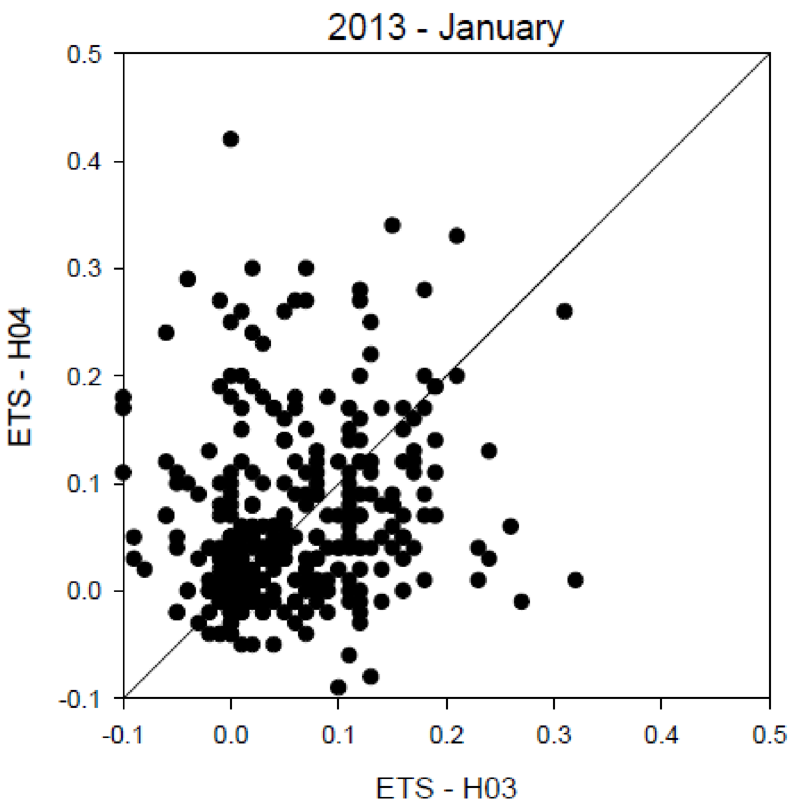
-Yearly statistical scores show better agreement with reference rain rates: RMSE is equal to 1.2 mmh^{-1} (using radar as ground reference) and 1.6 mmh^{-1} (using rain gauges as ground reference), and MAE equal to 0.7 mmh^{-1} (radar) and 1 mmh^{-1} (rain gauges).

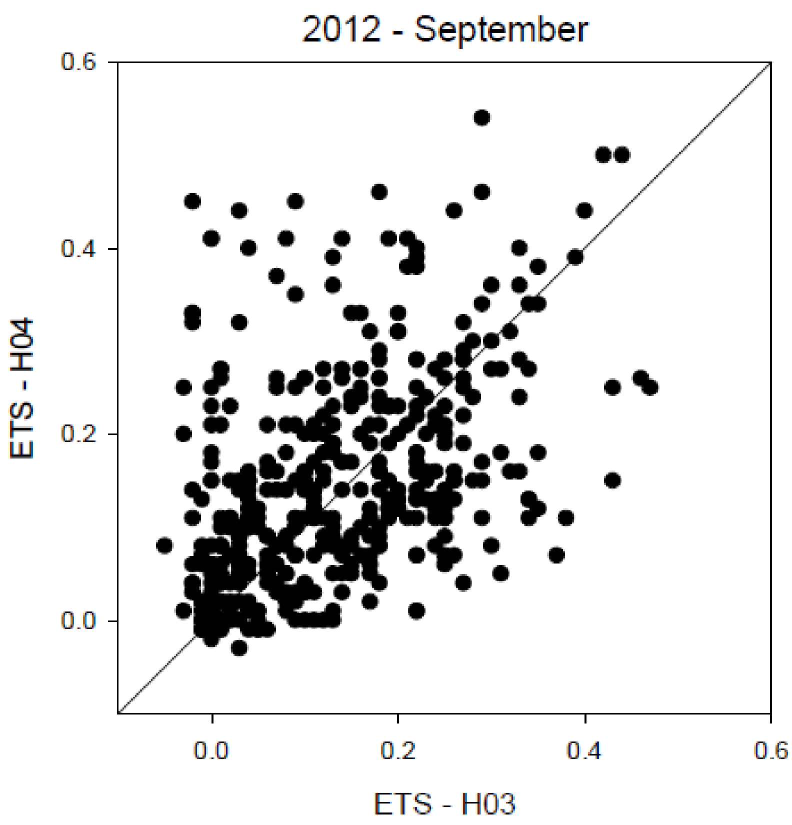
-In this case, an underestimation with respect to both radar and rain gauge precipitation fields is observed (ME lower than 0).

PPV H03/H04 comparisons 05.11.2011-06.11.2011



PPV H03/H04 comparisons monthly scale





PP hydrological validation

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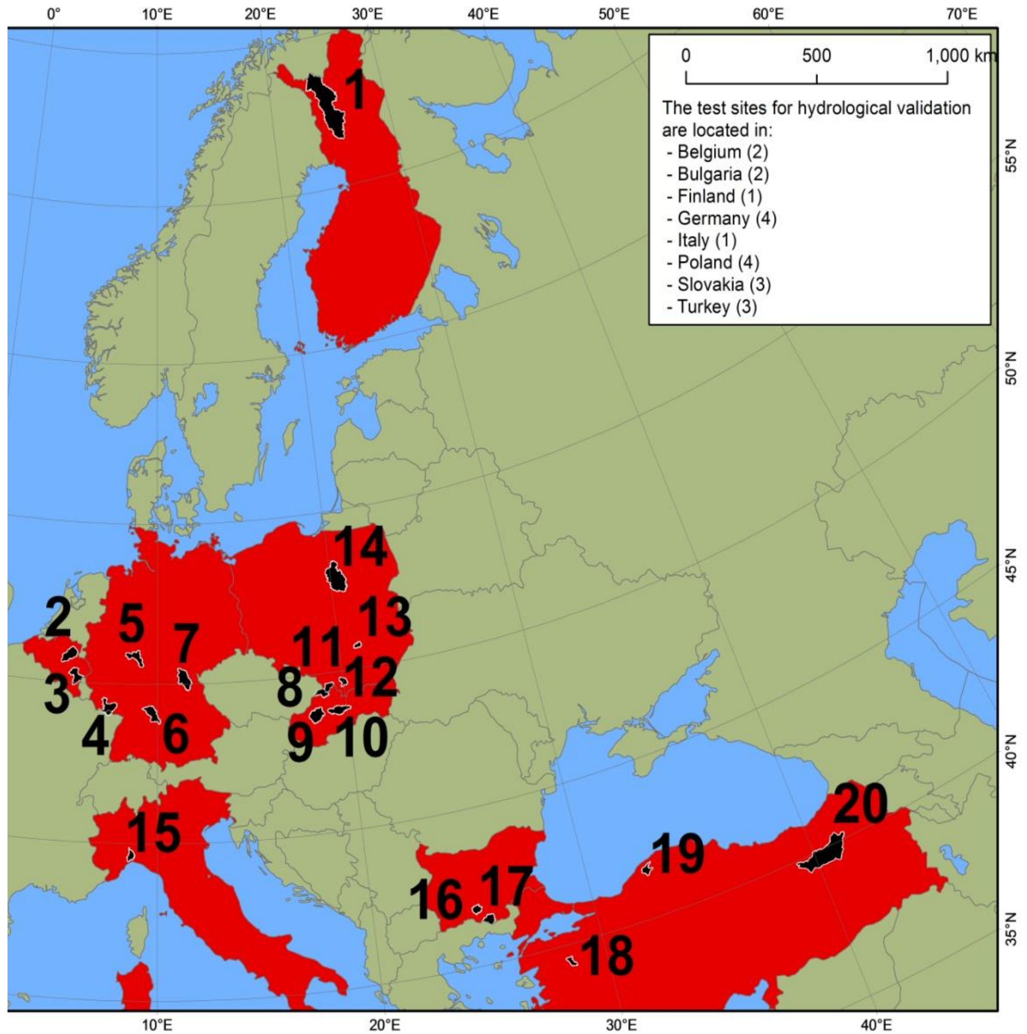
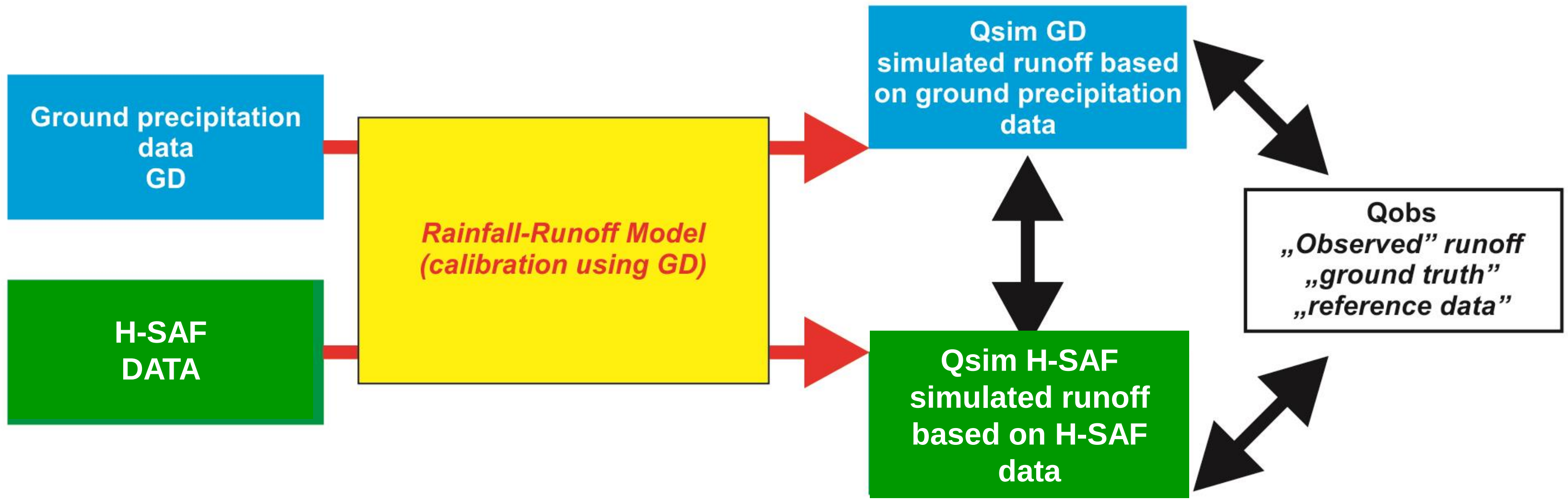
Country	Test site	Hydrological model	
Finland	Ounasjoki (no 1)	HOPS (FMI in-house developed model) version 1.3	
Belgium	Demer-Scheldt (no 2)	SCHEME (SCHEldt and model)	
	Ourthe-Meuse (no 3)		
Germany	Mosel (4), Lahn (5), Neckar (6), Main (7)	HBV	LARSIM
Slovakia	Nitra (8)	Hron-NAM	
	Kysuca (9)		
	Hron (10)	HBV	
Poland	Soła (11)	HBV	SRM (Snowmelt Runoff Model)
	Raba (12)		
	Czarna and Lagowianka (13)		
	Wkra (14)		
Italy	Orba (no 15)	Continuum Model	
Bulgaria	Chepelarska (no 16)	Isba-Modcou model	
	Varbica river (no 17)	Mike-11/NAM	
Turkey	Killi subbasin in Susurluk Basin (18)	Artificial Neural Networks (ANN)	HEC–HMS
	Ulus subbasin in Western Black Sea Basin (19)		
	Upper Euphrates (20)	SRM (Snowmelt Runoff Model)	
	Kırkgöze (20 – eastern part of the Upper Euphrates basin)	HBV	

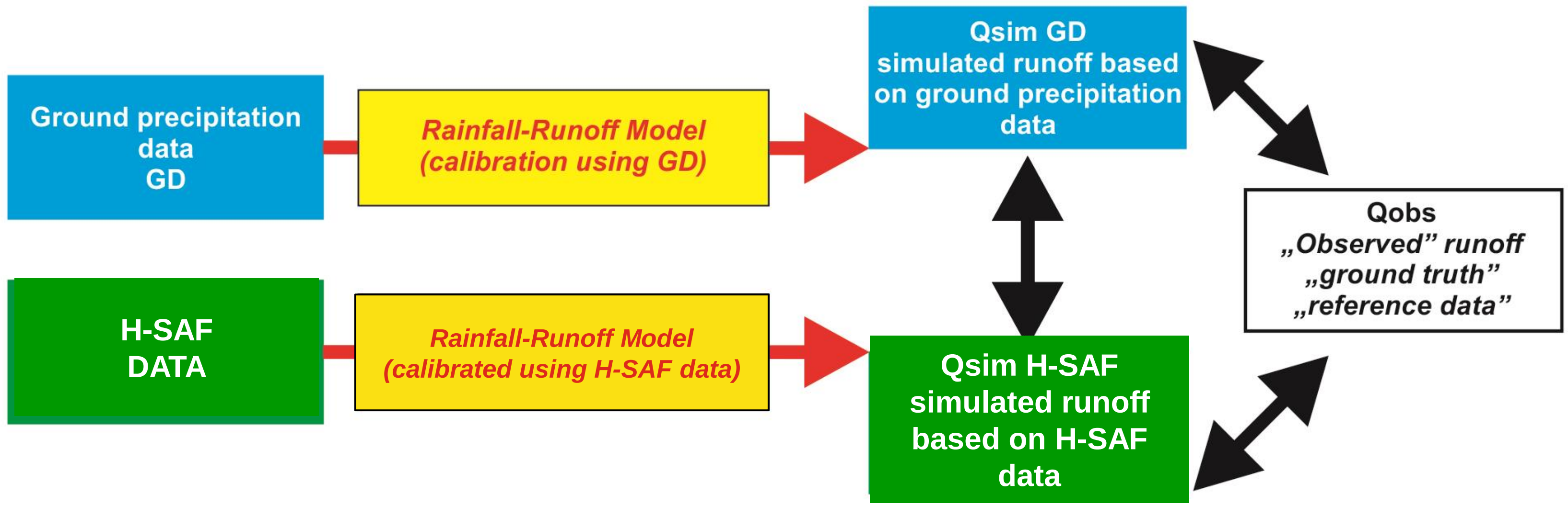


PP hydrological validation

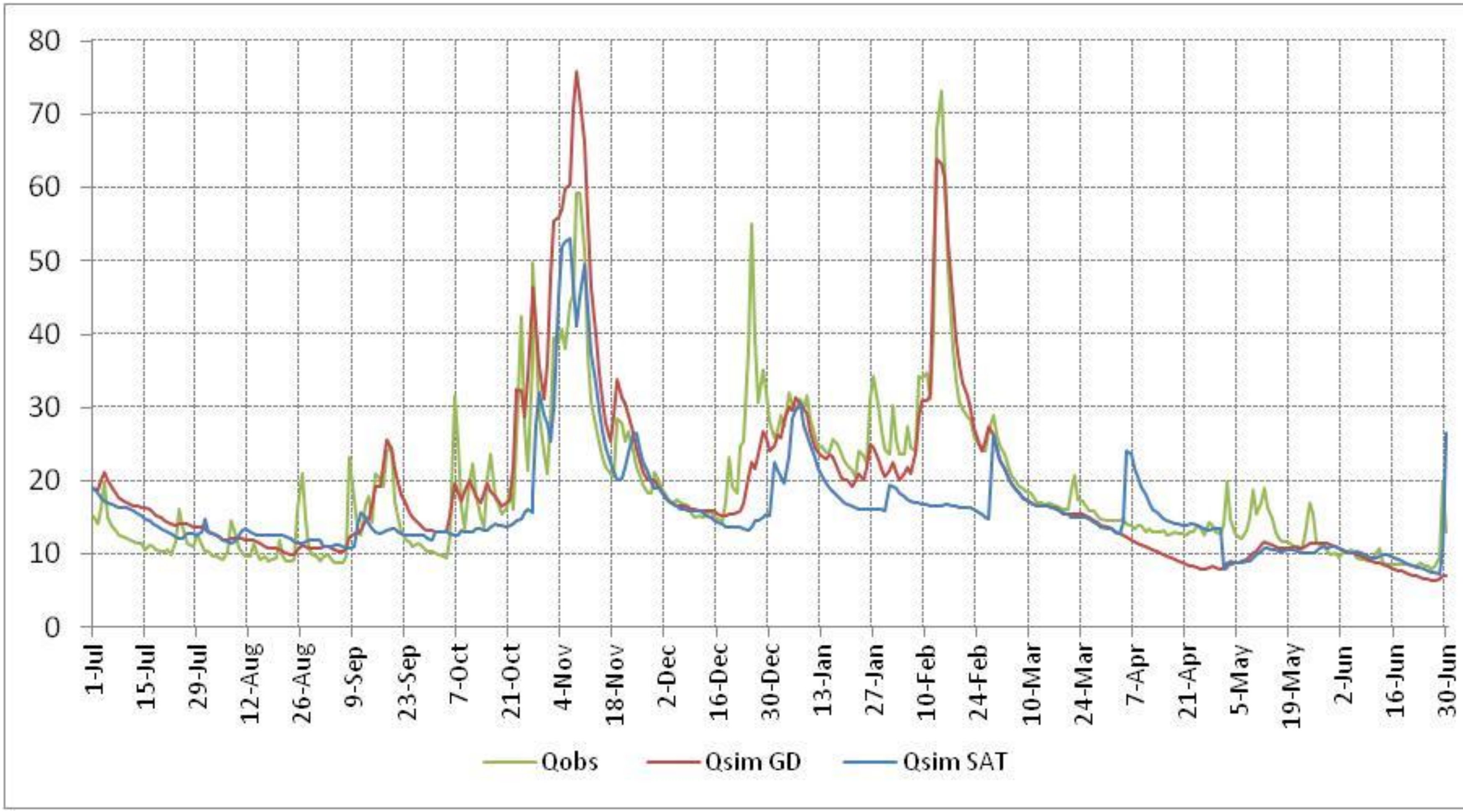
First approach



Second approach



PP hydrological validation of PR-OBS-3



PP hydrological validation: example

Characteristics		Month											
		7	8	9	10	11	12	1	2	3	4	5	6
Product	GPM	37,2	100,5	38,2	30,6	40,2	10,6	18,8	32,6	23,4	62,6	91,8	52,4
	GD	70	42,6	121,2	31,9	81,3	22,5	12,1	15,7	54,6	72,6	238,1	49,7
Runoff	Mean Qobs	7,02	2,27	4,40	2,99	7,77	7,66	4,80	5,76	7,95	7,45	23,67	2,43
	Mean QsimGD	8,31	4,15	8,55	5,84	9,02	5,84	3,94	3,84	5,49	5,28	29,44	5,64
	Mean QsimSAT	5,01	6,99	3,84	5,35	5,23	4,49	4,19	4,83	3,36	4,32	5,83	6,26
	Std Dev Qobs	7,28	0,71	3,76	2,21	6,57	5,75	2,91	2,12	8,57	4,88	39,79	1,08
	Std Dev QsimGD	6,20	0,64	5,43	2,98	5,15	2,55	0,09	0,39	3,50	1,66	54,19	2,14
	Std Dev QsimSAT	1,32	4,66	0,56	1,13	1,19	0,60	0,41	1,22	0,54	0,87	1,89	2,87
Qsim Sat - Qobs	MxAE	41,40	35,90	17,40	10,20	32,60	43,90	11,20	6,60	48,40	25,00	218,51	11,90
	MAE	3,58	4,77	2,39	2,71	4,07	3,21	1,85	1,64	4,87	3,55	18,13	3,86
	RMSE	7,43	6,60	3,72	2,92	6,77	6,53	3,06	2,24	9,73	5,72	42,53	4,51
	R	0,19	0,27	0,20	0,65	0,33	0,11	-0,15	0,35	-0,01	0,20	0,66	0,67
	E	-0,04	-86,15	0,02	-0,75	-0,06	-0,29	-0,10	-0,12	-0,29	-0,37	-0,14	-16,93
Qsim GD - Qobs	MxAE	16,00	4,10	17,80	15,00	17,20	29,20	11,40	7,10	32,00	21,50	142,97	7,30
	MAE	1,81	1,90	4,13	2,84	2,23	2,17	1,72	2,04	2,78	2,50	8,89	3,24
	RMSE	2,27	1,93	5,00	3,12	3,19	3,98	3,08	2,71	5,76	4,24	20,96	3,47
	R	0,97	0,84	0,87	0,92	0,90	0,92	-0,51	0,60	0,97	0,83	0,96	0,94
	E	0,90	-6,45	-0,77	-1,00	0,76	0,52	-0,12	-0,64	0,55	0,24	0,72	-9,62
Qsim SAT - Qsim GD	MxAE	30,60	34,80	24,70	12,10	22,50	16,80	2,50	7,70	17,50	7,20	348,40	13,30
	MAE	3,37	2,84	4,71	0,98	4,00	1,36	0,26	0,99	2,14	1,20	23,63	1,36
	RMSE	6,99	5,40	7,13	2,30	6,10	2,83	0,47	1,58	4,12	1,73	58,06	2,52
	R	0,13	0,17	0,19	0,76	0,41	0,20	0,28	0,12	0,01	0,49	0,60	0,56
	E	-0,27	-69,54	-0,73	0,41	-0,40	-0,24	-23,55	-15,52	-0,39	-0,09	-0,15	-0,39
Sensitivity	Max change	0,80	2,17	1,25	1,16	1,37	0,44	0,86	1,34	1,22	1,81	1,97	1,38
	Mean change	0,13	0,60	0,17	0,22	0,33	0,04	0,11	0,34	0,09	0,32	0,58	0,21
Product validation	MxAE	5,30	5,20	4,20	2,60	2,80	1,80	1,50	1,40	3,40	2,30	8,10	5,10
	MAE	0,10	0,15	0,17	0,06	0,13	0,04	0,04	0,07	0,08	0,12	0,32	0,12
	RMSE	0,38	0,62	0,49	0,27	0,37	0,18	0,12	0,21	0,31	0,30	0,98	0,51
	R	0,32	0,21	0,44	0,37	0,28	-0,01	0,14	0,03	0,21	0,53	0,32	0,11
	E	-3,63	-0,17	-4,63	-0,59	-2,18	-5,46	-0,58	-0,76	-1,74	-0,24	-7,05	-0,40

PP hydrological validation: remarks

- Runoff estimation **depends on many factors**, since rainfall–runoff processes are influenced not only by meteorological phenomena
- Although rainfall is usually a significant factor, a given amount and duration of rainfall may or may not affect a hydrograph, depending on the **hydrologic characteristics of the catchment**
- Usually the relationship between specific rainfall events and the resulting runoff is extremely complicated. Thus, it **is very difficult to provide clear and simple feedback** to product Developers.
- Hydrological validation can be treated as a **final validation of products** that are important for hydrological issues.

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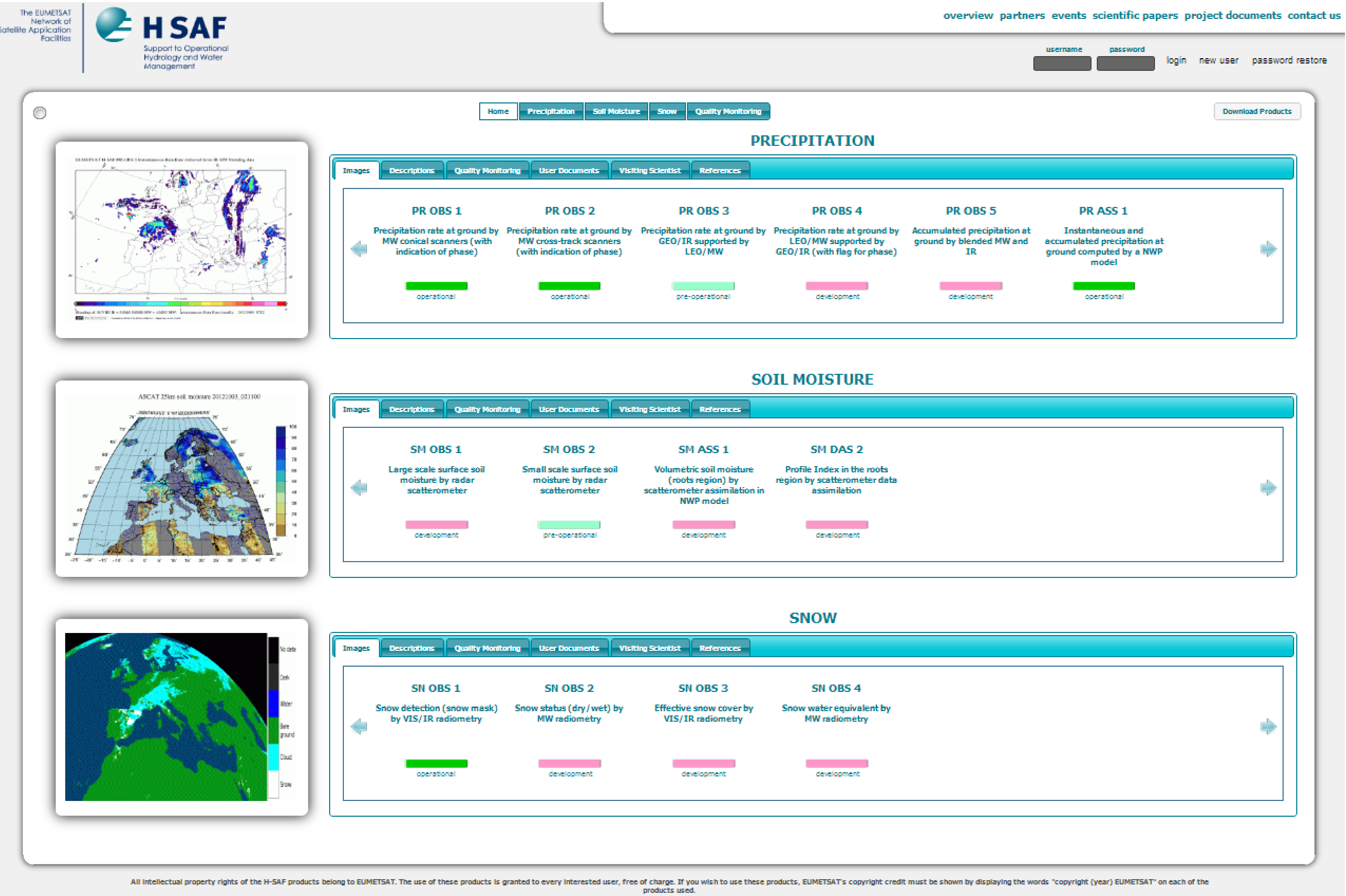

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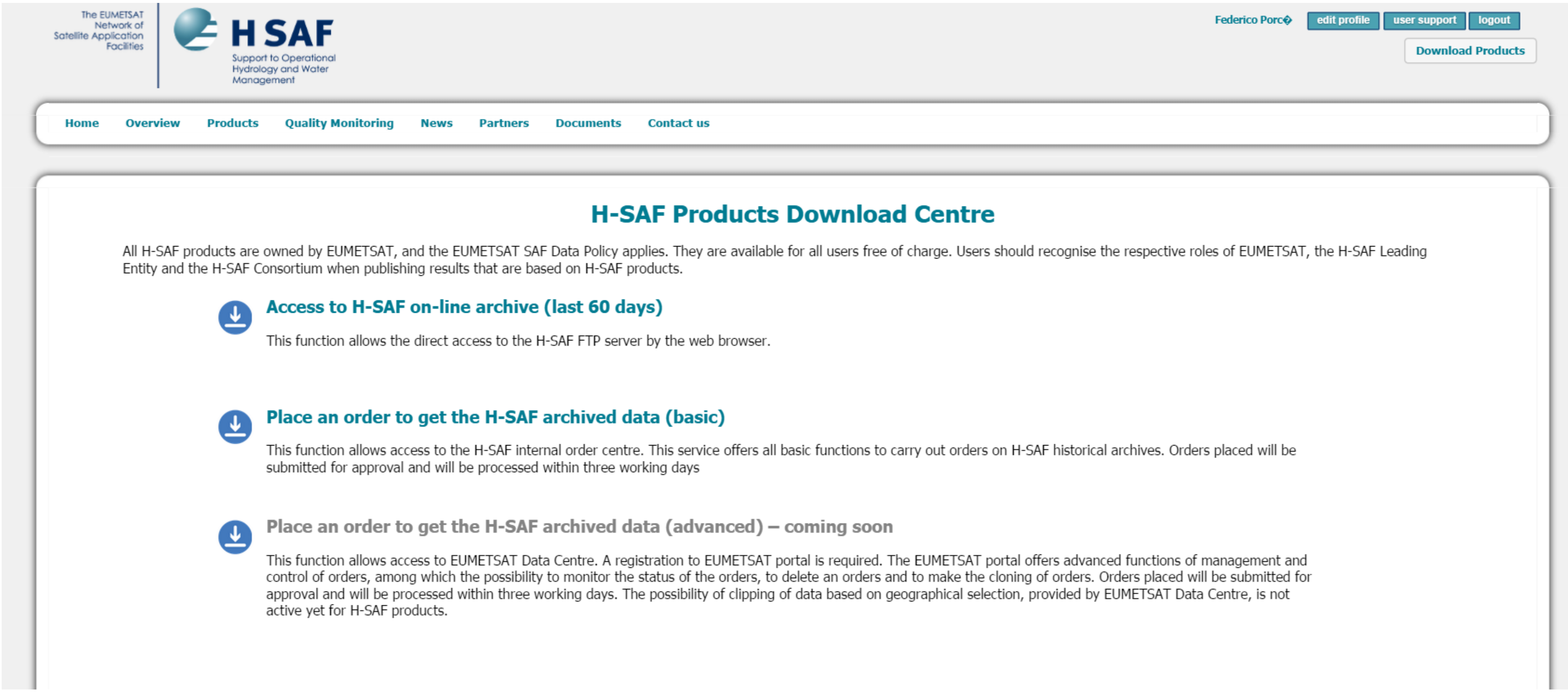

References

Barnes, S. L.: A Technique for Maximizing Details in Numerical Weather Map Analysis. J. Appl. Meteor., 3, 396–409, 1964.

Casella, D., Panegrossi, G., Sanò, P., Mugnai, A., Smith, E.A., Tripoli, G.J., Dietrich, S., Formenton, M., Di Paola, F., Leung, H. W.-Y., and Mehta, A.V.: Transitioning from CRD to CDRD in Bayesian retrieval of rainfall from satellite passive microwave measurements, Part 2: Overcoming database profile selection ambiguity by consideration of meteorological control on microphysics, IEEE Trans. Geosci. Remote Sens., 51, 4650–4671, 2013

Chen, F. W. and D. H. Staelin, 2003: AIRS/AMSU/HSB precipitation estimates, IEEE Trans. Geosci. Remote Sens., vol. 41, no. 2, pp. 410–417.

Mugnai, A., Smith, E.A., Tripoli, G.J., Bizzarri, B., Casella, D., Dietrich, S., Di Paola, F., Panegrossi, G., and Sanò, P.: CDRD and PNPR satellite passive microwave precipitation retrieval algorithms: EuroTRMM / EURAINSAT origins and H-SAF operations, Nat. Hazards Earth Syst. Sci., 13, 887–912, doi: 10.5194/nhess-13-887-2013, 2013a.

Mugnai, A., Casella, D., Cattani, E., Dietrich, S., Laviola, S., Levizzani, V., Panegrossi, G., Petracca, M., Sanò, P., Di Paola, F., Biron, D., De Leonibus, L., Melfi, D., Rosci, P., Vocino, A., Zauli, F., Puca, S., Rinollo, A., Milani, L., Porcù, F., and Gattari, F.: Precipitation products from the Hydrology SAF, Nat. Hazards Earth Syst. Sci., in press, 2013b.

Nurmi, P.: Recommendations on the verification of local weather forecasts. 11 ECMWF Tech. Memo. N. 430, 19pp, 2003.

Panegrossi, G., D. Casella, S. Dietrich, A. C. Marra, M. Petracca, P. Sanò, A. Mugnai, L. Baldini, N. Roberto, E. Adirosi, R. Cremonini, R. Bechini, G. Vulpiani, and F. Porcù, 2016, Use of the GPM constellation for monitoring heavy precipitation events over the Mediterranean region, *J-STARS, in press*

Pignone F., Rebora N., Silvestro F. and Castelli F., GRISO (Generatore Random di Interpolazioni Spaziali da Osservazioni incerte)-Piogge, Relazione delle attività del I anno inerente la Convenzione 778/2009 tra Dipartimento di Protezione Civile e Fondazione CIMA (Centro Internazionale in Monitoraggio Ambientale), report n° 272/2010, pp 353, 2010.

Puca, S., Porcù, F., Rinollo, A., Vulpiani, G., Baguis, P., Campione, E., Ertürk, A., Gabellani, S.,Iwański, R., Jurašek, M., Kańák, J., Kerényi, J., Koshinchanov, G., Kozinarova, G., Krahe, P., Łapeta, B., Lábó , E., Milani, L., Okon, Ľ., Öztopal, A., Pagliara, P., Pignone, F., Rachimow, C., Rebora, N., Roulin, E., Sönmez, İ., Toniazzo, A., Biron, D., Casella, D., Cattani, E., Dietrich, S., Laviola, S., Levizzani, V., Melfi, D., Mugnai, A., Panegrossi, G., Petracca, M., Sanò, P., Zauli, F., Rosci, P., Agosta, E., Gattari, F., and De Leonibus, L.: The validation service of the Hydrological SAF geostationary and polar satellite precipitation products, Nat. Hazards Earth Syst. Sci., 14, 871–889, 2014.

Porcù F., L. Milani and M. Petracca: On the uncertainties in validating satellite instantaneous rainfall estimates with raingauge operational network. Atmos. Res., submitted, 2013.

Rinollo, A., G. Vulpiani, S. Puca, J. Kaňák, E. Lábó, Ľ. Okon, E. Roulin, P. Baguis, E. Cattani, S. Laviola, V. Levizzani: Definition and impact of a quality index for radar-based reference measurements in the H-SAF precipitation product validation, NHESS, (submitted paper), 2013.

Sanò, P., Casella, D., Mugnai, A., Schiavon, G., Smith, E.A., and Tripoli, G.J.: Transitioning from CRD to CDRD in Bayesian retrieval of rainfall from satellite passive microwave measurements, Part 1: Algorithm description and testing, IEEE Trans. Geosci. Remote Sens., 51, 4119–4143, 2013.

Surussavadee C., and Staelin, D.H.: Satellite Retrievals of Artic and Equatorial Rain and Snowfall Rates Using Millimeter Wavelengths, IEEE T. Geosci. Remote, 47(11), 3697–3707, 2009.