H SAF precipitation products

Davide Melfi, Marco Galli, Valentina Rosati,
Stefano Dietrich, Giulia Panegrossi, Paolo Sanò,
Daniele Casella, Leo Pio D'Adderio, Anna Cinzia Marra,
Luca Brocca, Luca Ciabatta, Christian Massari, Stefania Camici,
Stefano Sebastianelli, Giorgia Salvucci.

Satellite inspired hydrology in an uncertain future:
H SAF and HEPEX workshop

ECMWF, Reading, 25-28 November 2019

EUMETSAT H SAF

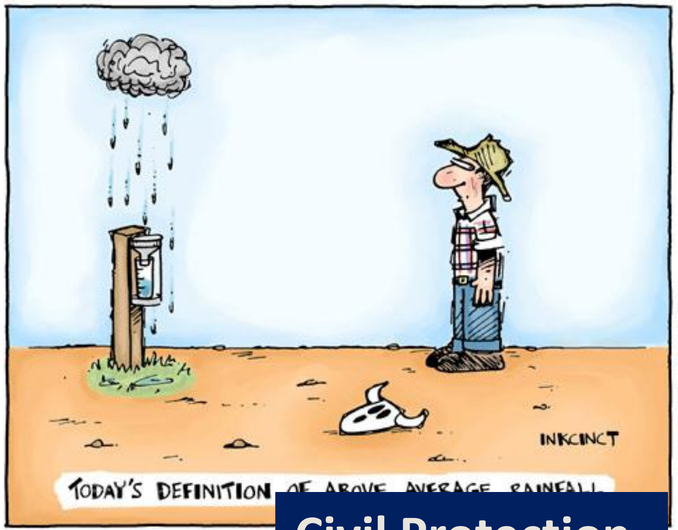
SAF NETWORK

The Satellite Application Facilities (SAFs) are a distributed network of thematic application facilities responsible for necessary research, development, and operational activities not carried out by the central facility. The SAFs are located within the National Meteorological Services (NMS) of EUMETSAT Member States, or other agreed entities linked to a user community.

SAF
The EUMETSAT Network of Satellite Application Facilities

EUMETSAT H SAF

H SAF Objectives



Civil Protection,

Risk Management,

Hydrological applications,

Nowcasting,

Hydrology and water management,

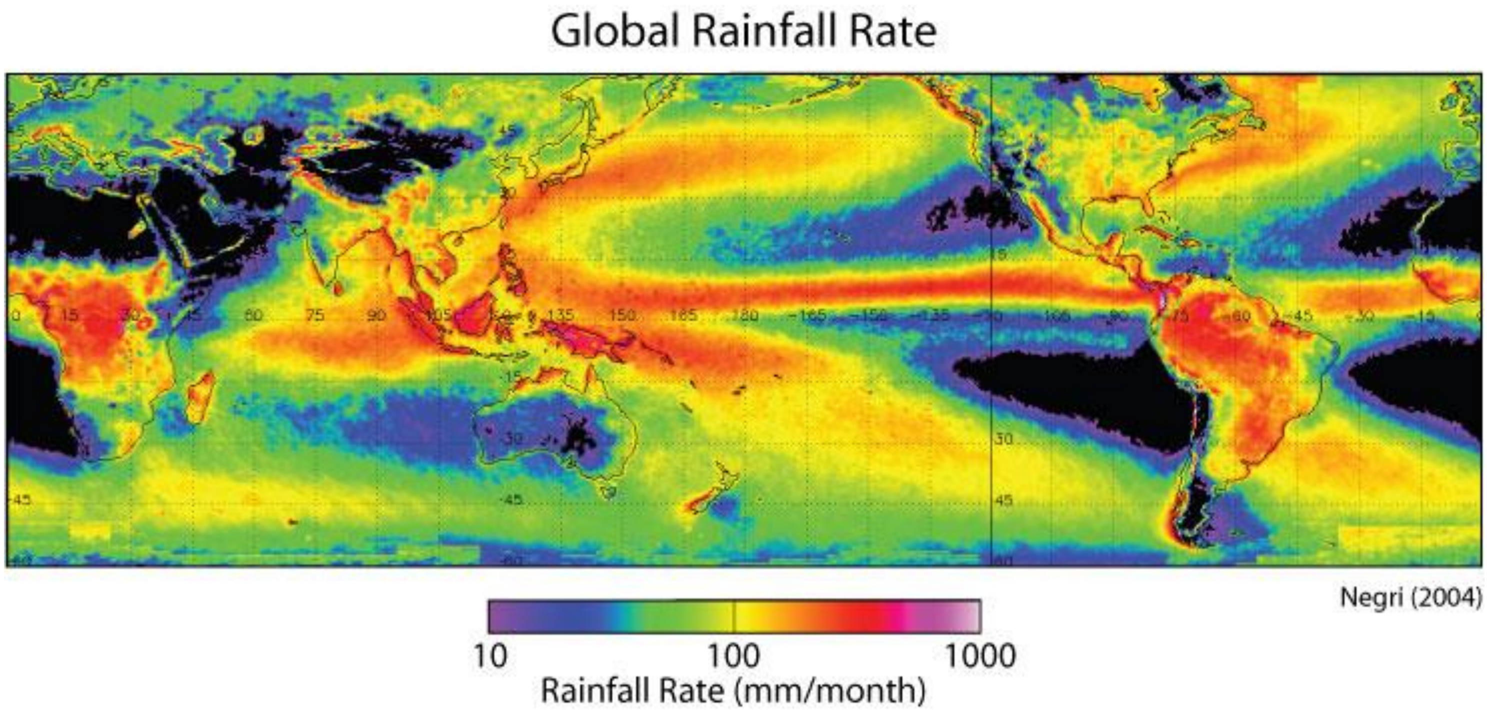
Climate,

NWP

- to provide satellite-derived products from existing and future sufficient time and space resolution to satisfy the needs of operati identified products:
  - ✓ precipitation (liquid, solid, rate, accumulated);
  - ✓ soil moisture (at large-scale, at local-scale, at surface, in the roots region);
  - ✓ snow parameters (detection, cover, melting conditions, water equivalent);
- to perform independent validation of the usefulness of the fighting against floods, landslides, avalanches, and evaluating wa activity includes:
  - ✓ downscaling/upscaling modelling from observed/retrieved fields to basin level;
  - ✓ fusion of satellite-derived measurements with data from radar and rain gauge ne
  - ✓ assimilation of satellite-derived products in hydrological models;
  - ✓ assessment of the impact of the new satellite-derived products on hydrological ap

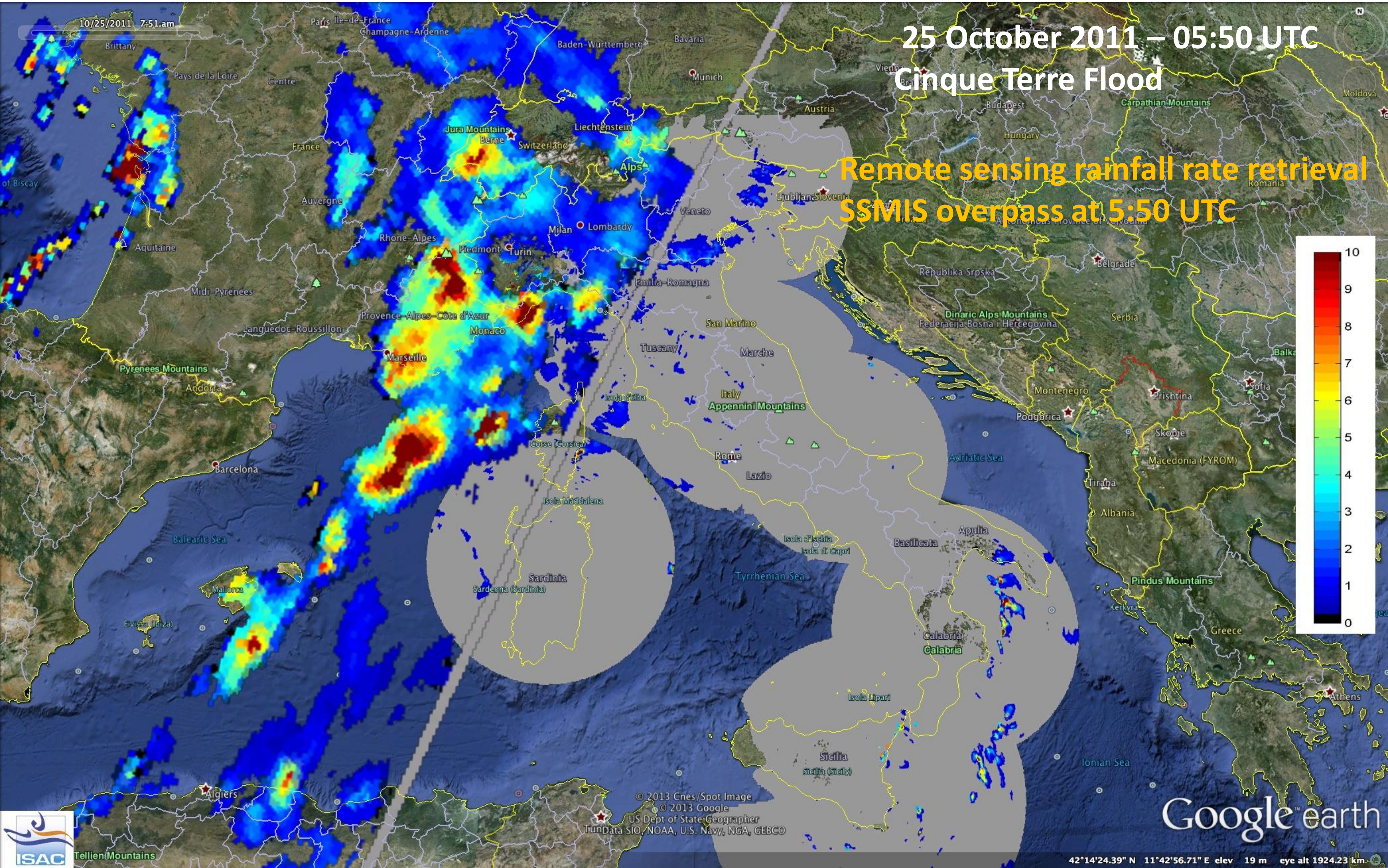
Why from space?

Meteorological satellite provide a unique opportunity for monitoring the precipitation for regions where ground measurement is limited and consistent with the accuracy required by hydrologists.



Why from Space?

Heavy Precipitation Events Monitoring: Italian Radar Network Mosaic (DPC)



H SAF Key Points

- Products are provided in **NRT**
- Their **timeliness** is compliant with the needs of operational users: some products are provided within 15 minutes from last received image
- **Operational provision**:
  - 24/7 service
  - Full operational support
- **Long term** perspective (up to 2032)
- High **accessibility**: EUMETCast dissemination, ftp direct download, orders

H SAF precipitation products: basic principles

1) **Exploitation of *all* PMW radiometers (conically and cross-track scanning) offering the most complete set of satellite based observations to retrieve surface precipitation due to the ability of MW radiation to penetrate precipitating clouds and interact with its liquid and iced hydrometeors;**

Higher confidence in:

- Identification of different types of precipitation (deep convective, convective, stratiform)
- Convective precipitation;
- Stratiform and warm rain over ocean
- Stratiform rain over land in specific environmental conditions (contrast between surface and cloud)

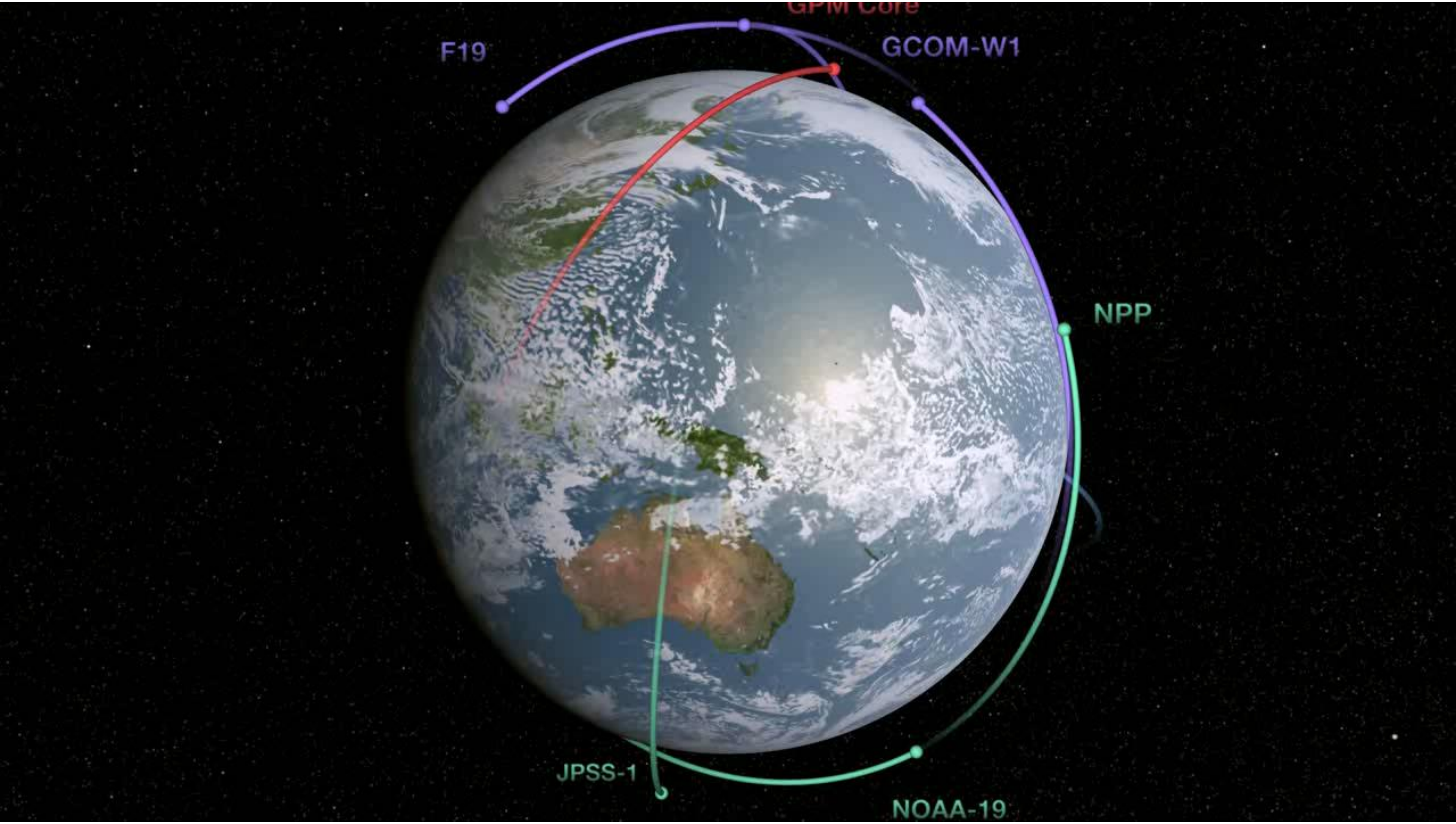
Less confidence in:

- Orographic precipitation (with warm-topped clouds);
- Light precipitation at high latitudes;
- Snowfall and/or with presence of snow/ice at the ground;
- Warm rain over land (no confidence);

2) **Combination of LEO MW estimates and GEO IR observations for near-real time precipitation monitoring and hydrological applications to benefit from physical robustness of MW and space/time resolution of IR. At very high latitudes only LEO MW observations can be used.**

Exploit Physical Robustness of LEO MW:

Exploit Space/Time Resolution of GEO IR


GPM Core
F19
GCOM-W1
NPP
JPSS-1
NOAA-19

Passive Microwave Sensor Characteristics

EUMETSAT H SAF

Constellation microwave sensor channel coverage

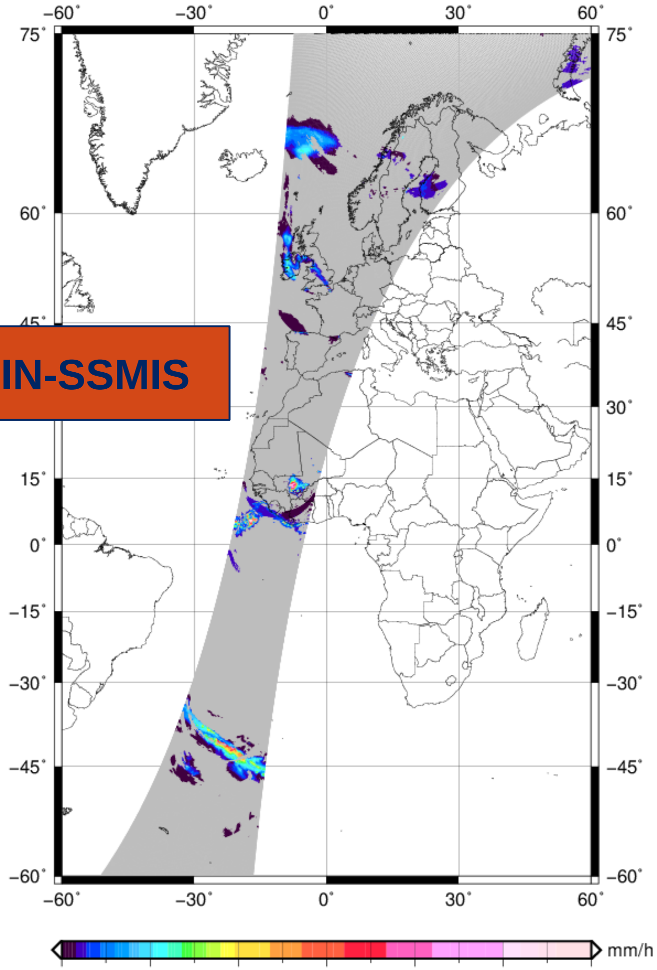
V – Vertical Polarization **H – Horizontal Polarization**

Channel	6 GHz	10 GHz	19 GHz	23 GHz	31/36 GHz	50-60 GHz	89/91 GHz	150/166 GHz	183/190 GHz
SSMIS			19.35 V/H	22.235 V	37.0 V/H	50.3-63.28 V/H	91.65 V/H	150 H	183.31H
MHS							**89**	**157**	**183.311 190.311**
AMSU-A				**23.8**	**31.4**	**50.2-58**	**89**		
AMSR-2	6.925 V/H	10.65 V/H	18.7 V/H	23.8 V/H	36.5 V/H		89.0 V/H		
GMI		10.65 V/H	18.70 V/H	23.80 V	36.50 V/H		89.0 V/H	165.5 V/H	183.31 V
ATMS				**23.8**	**31.4**	**50.3-57.29**	**87-91**	**164-167**	**183.31**

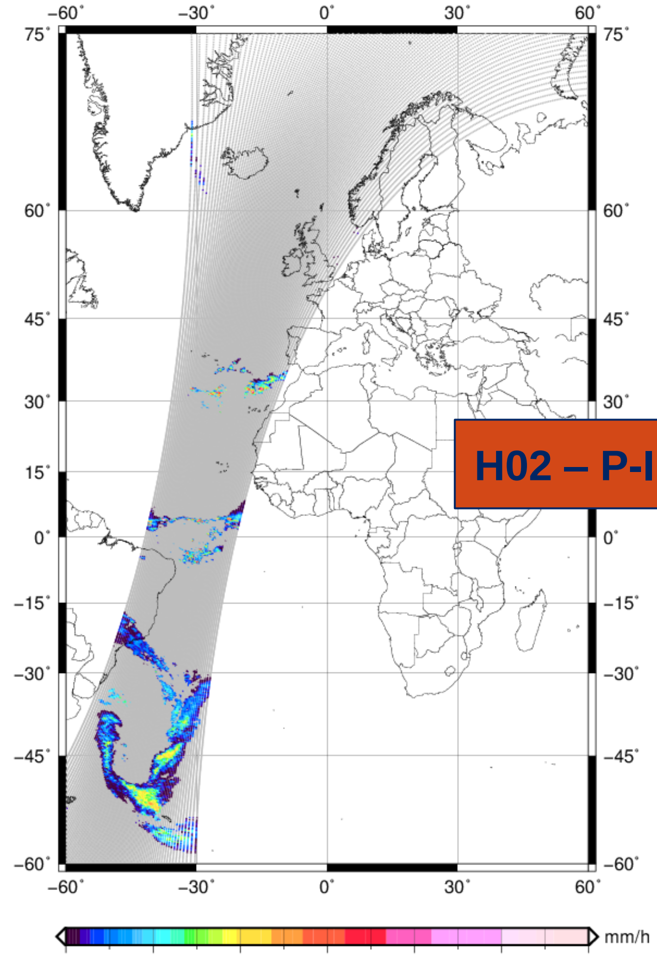
Mean Spatial Resolution (km)

Channel	6 GHz	10 GHz	19 GHz	23 GHz	31/36 GHz	50-60 GHz	89/91 GHz	150/166 GHz	183 GHz
SSMIS			**59**	**59**	**36**	**22**	**14**	**14**	**14**
MHS							**17**	**17**	**17**
AMSU-A				**48**	**48**		**48**		
AMSR-2	**56**	**38**	**21**	**24**	**12**		**5**		
GMI		**26**	**15**	**12**	**11**		**6**	**6**	**6**
ATMS				**74**	**74**	**32**	**16**	**16**	**16**

Satellite Rainfall Estimation from MicroWave instruments



H01 – P-IN-SSMIS



H02 – P-IN-MHS

- ✓ CNR-ISAC Italy: Algorithm Theoretical Basic Document for “H01 Precipitation rate at ground by MW conical scanners” .
- ✓ CNR-ISAC Italy: Algorithm Theoretical Basic Document for “H02 Precipitation rate at ground by MW cross-track scanners

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H SAF Operational Products

Precipitation Products

H01 P-IN-SSMIS	Precipitation rate at ground by MW conical scanners	Operational
H02B P-IN-MHS	Precipitation rate at ground by MW cross-track scanners	Operational
H18 P-IN-ATMS	Precipitation rate at ground by MW cross-track scanners (Suomi NPP ATMS, NOAA-20)	Operational
H03B P-IN-SEVIRI	Precipitation rate at ground by GEO/IR supported by LEO/MW	Operational
H15A P-IN-SEVIRI-CO	Blended SEVIRI Convection area / LEO MW Convective Precipitation	Pre-operational
H05B P-AC-SEVIRI	Accumulated precipitation at ground by blended MW and IR	Operational

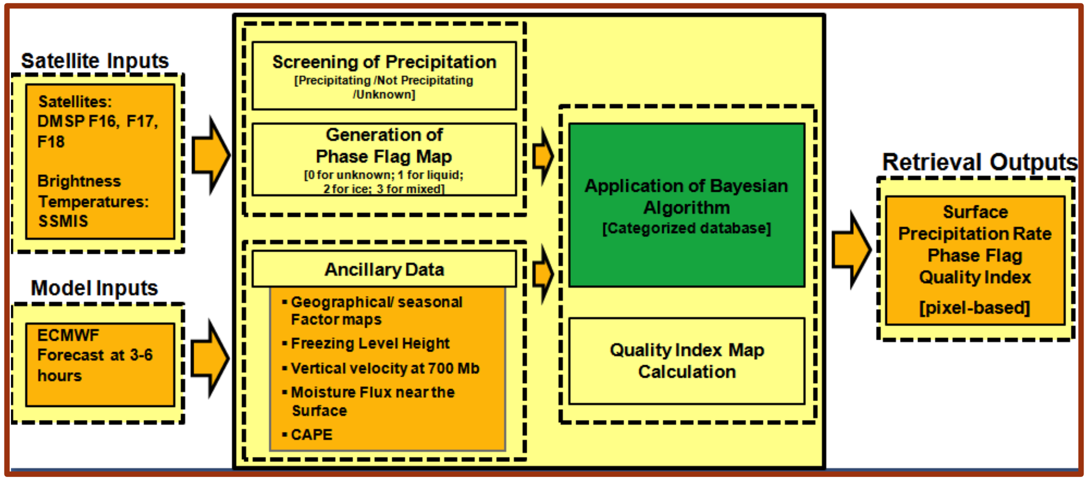
H SAF Operational Products: examples

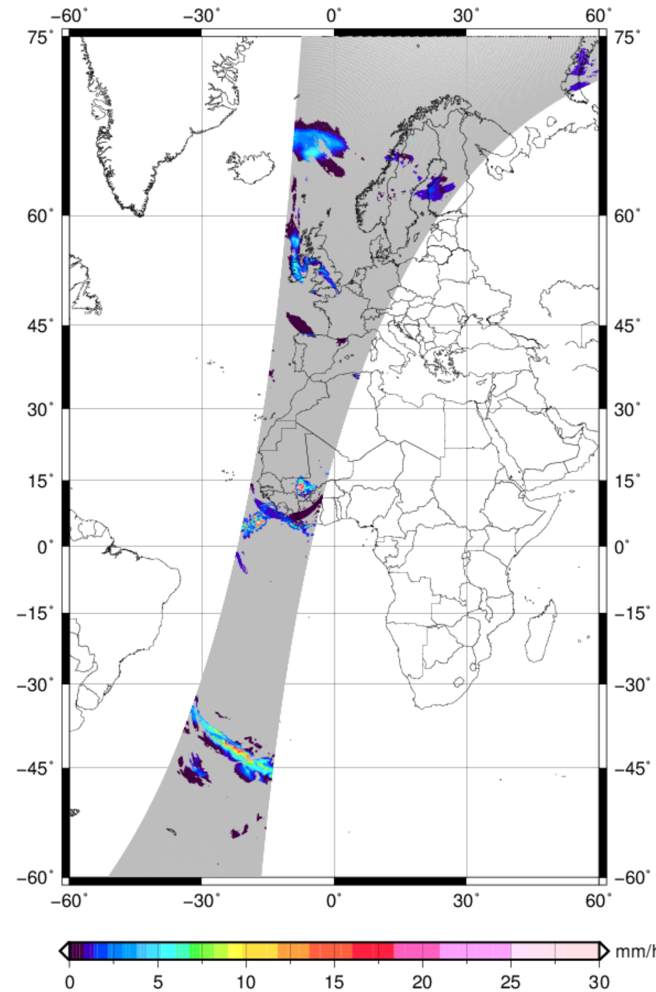
P-IN-SSMIS / H01

Cloud Dynamics and Radiation Database (CDRD)

Bayesian Algorithm for conical scanners

(Sanò et al., TGRS, 2013, Casella et al., TGRS, 2013; Smith et al., Mugnai et al., NHESS, 2013)



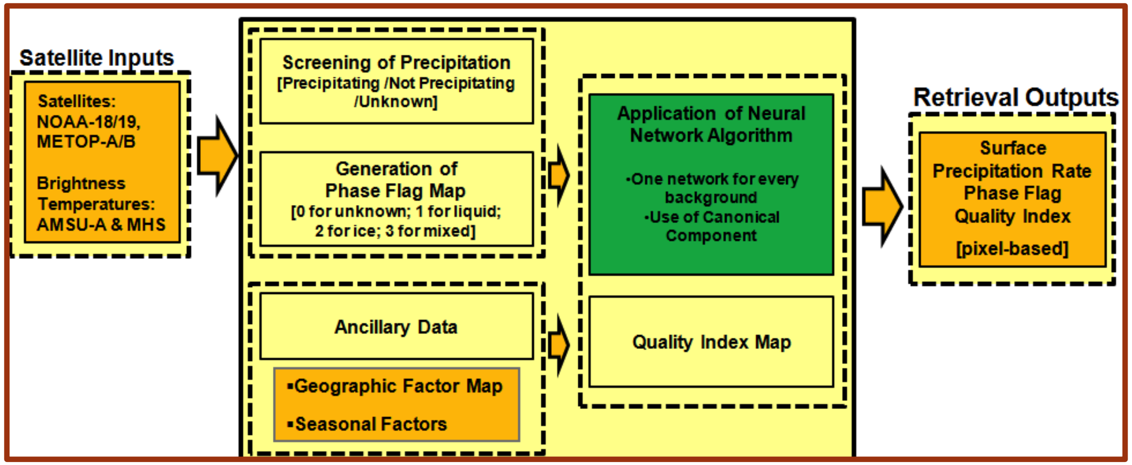


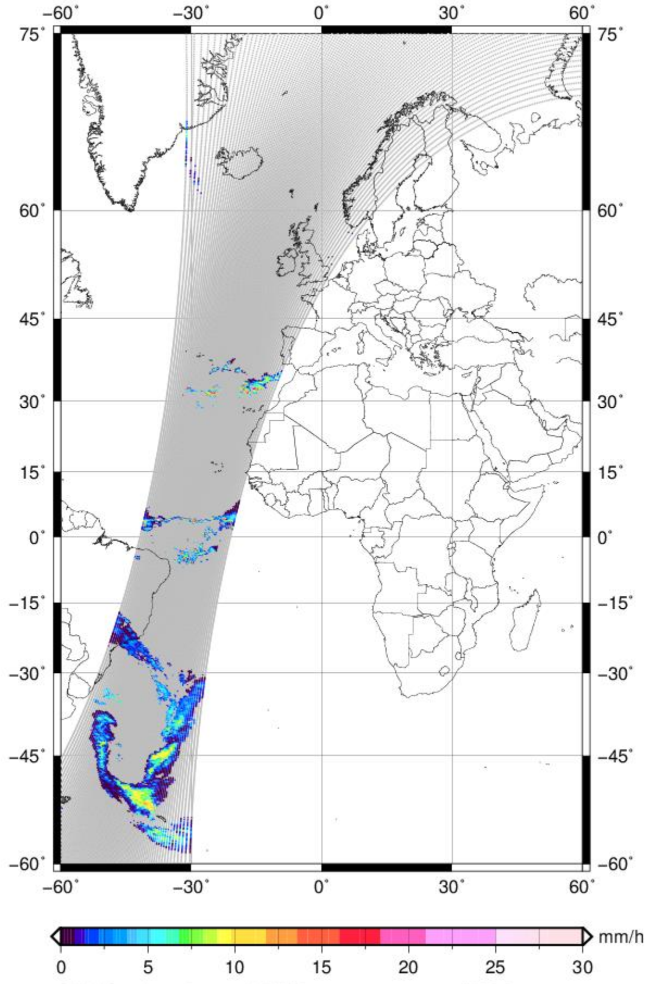
- Use of MW conical scanners (Tb) (DMSP-SSMIS);
- Physically-based Bayesian technique;
- *A synthetic a-priori* database built from cloud model generated microphysical profiles coupled to RTE model;
- Use of dynamical-thermodynamical-hydrological (DTH) model-derived variables to reduce *ambiguity* problem of retrieval solution; DTH variables from ECMWF forecast/analysis are used as additional input;
- Precipitation phase and Quality index evaluation.
- Proc. Time: < 4 min (Full disk area), Hor. Res.: ≅15 km

H SAF Operational Products: examples
P-IN-MHS / H02B.

PMW Neural-net Precipitation Retrieval (PNPR) Algorithm for cross-track scanners

(Mugnai et al., NHESS, 2013b, Sanò et al., AMT, 2014)



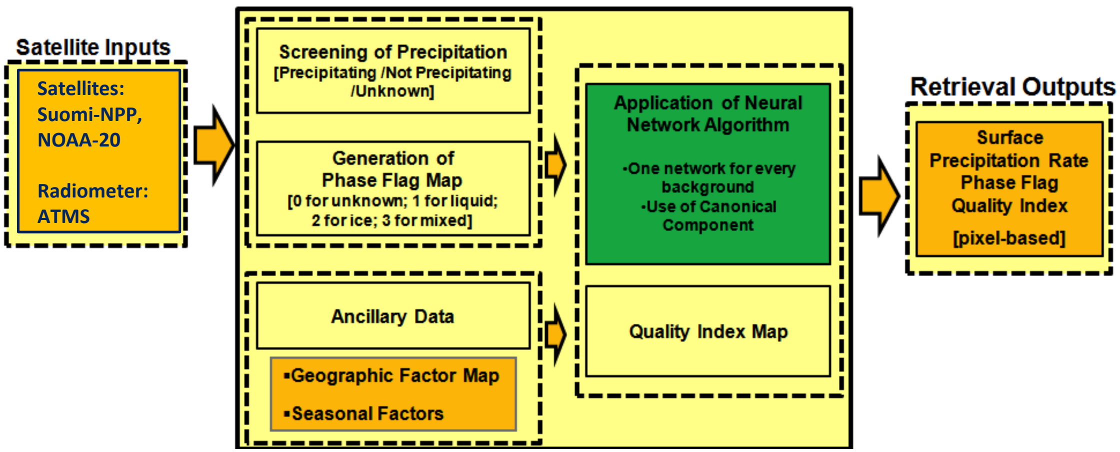


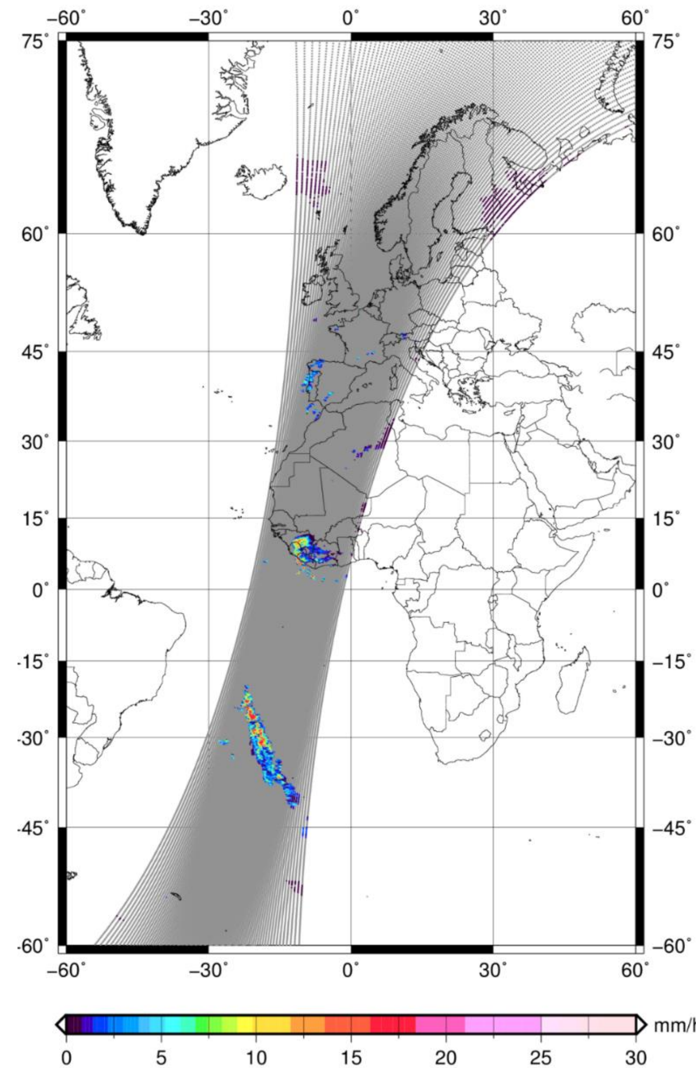
- Use of MW cross-track scanners (Tb) (NOAA and MetOp);
- Training database built from same cloud resolving simulations as CDRD;
- New optimal Artificial Neural Network (ANN) algorithm, one ANN for all surface backgrounds;
- The Full Disk Algorithm uses two ANNs (ANN-A for European Area, ANN-B for African Area) trained by the two Databases.
- Correction of MetOp-A channel [AMSU-A Channel 7 (54 GHz)] using a specific ANN.
- Input: AMSU-A/MHS channels, additional channel derived variables;
- Geographycal inputs (i.e., latitude, season, topography) used as additional input;
- Precipitation phase and Quality index evaluation
- Proc. Time: < 1 min (Full disk area), Hor. Res.: ≅16-50 km

H SAF Operational Products: examples
P-IN-ATMS / H18

PMW Neural-net Precipitation Retrieval (PNPR) Algorithm for cross-track scanners

(Sanò et al., AMT, 2015)



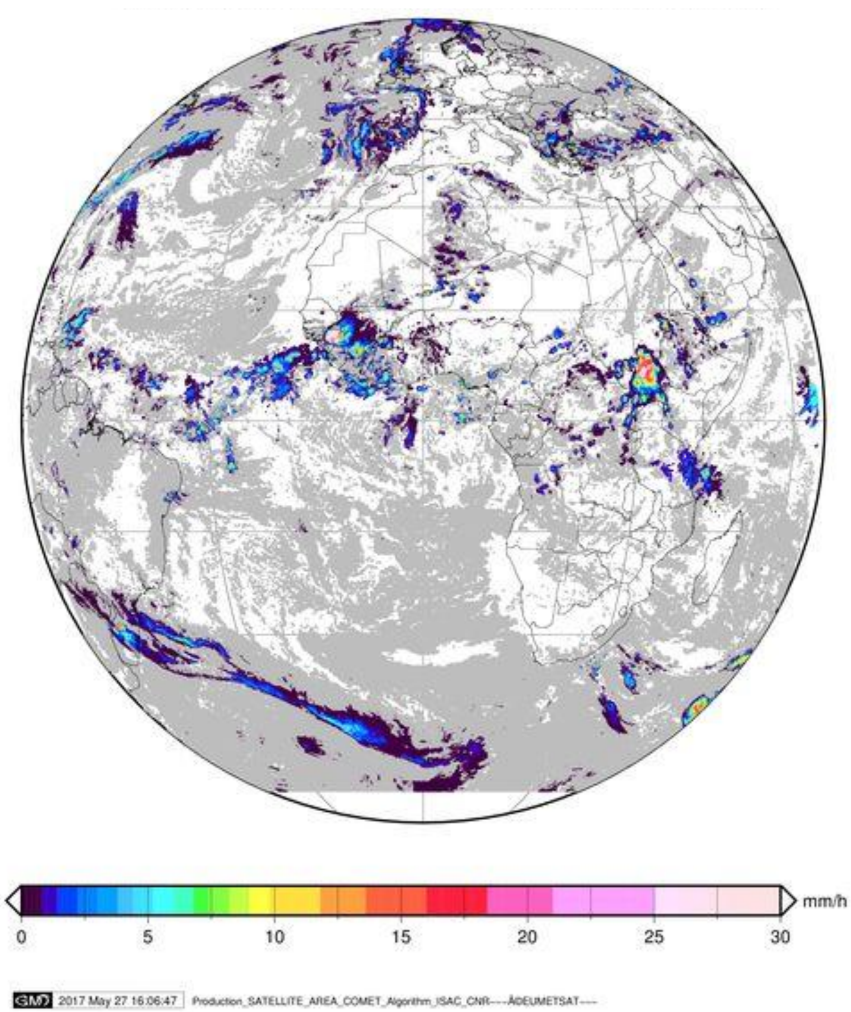


- Use of MW cross-track scanners (Tb) (Suomi NPP and NOAA-20);
- Training database built from same cloud resolving simulations as CDRD;
- Exploitation of two new ATMS channels. Combined use of the new 183±1.8 and 183±4.5 GHz channels with the previous AMSU-MHS used channels.
- New fully redesigned single ANN trained using both the European and the African databases. , One ANN for all surface backgrounds;

- Input: ATMS channels, additional channel derived variables;
- Geographycal inputs (i.e., latitude, season, topography) and model derived viables used as additional input;
- Precipitation phase and Quality index evaluation
- Proc. Time: < 1 min (Full disk area), Hor. Res.: ≅16-50 km

H SAF Operational Products: examples

P-IN-SEVIRI/H03: Multi-platform algorithm: BLENDING Technique

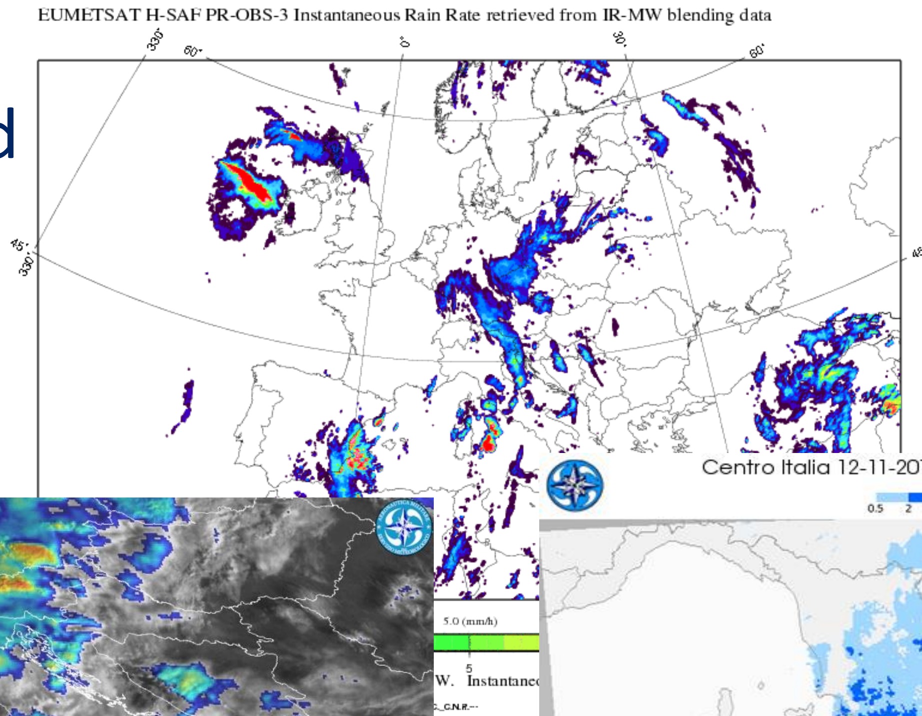


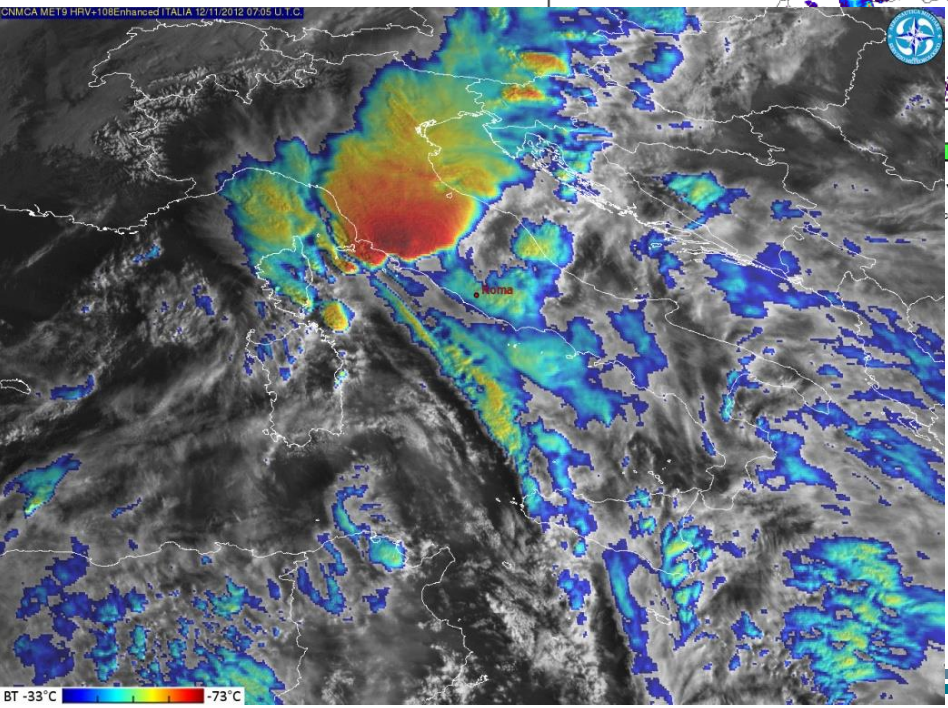
The “Rapid Update” tecnique allows to compute instantaneous rain intensities at the ground at the geostationary time-space scale (Turk et al. 2000, Torricella et al. 2007).

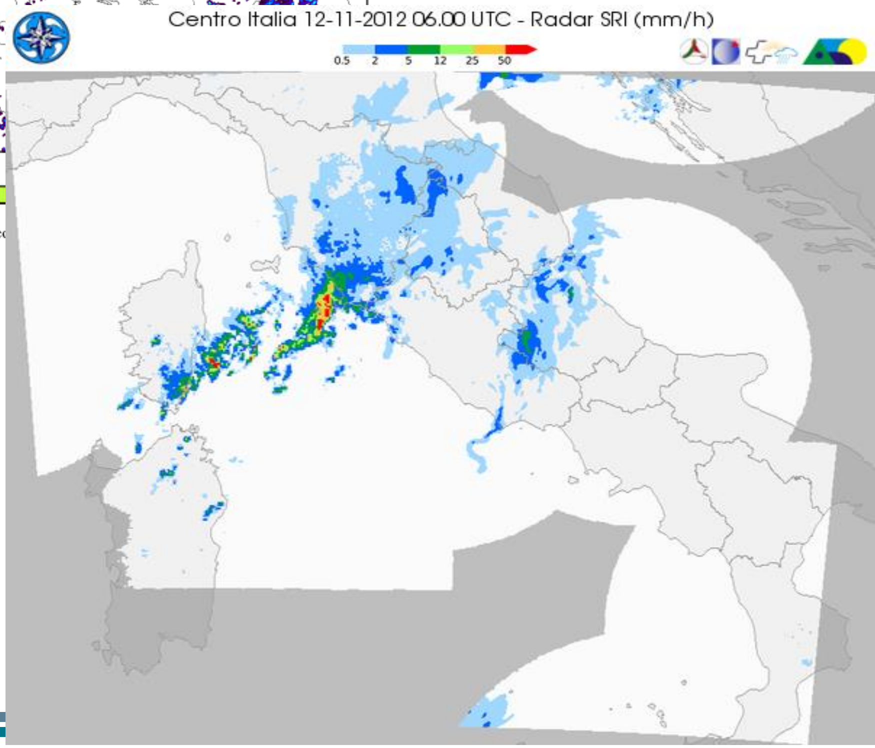
It is based on a blended MW-IR technique that correlates, by means of the statistical probability matching, brightness temperatures measured by the IR geostationary sensors and PMW-estimated precipitation rates at the ground.

Case studies

Case study: Flood event in Grosseto (Italy)



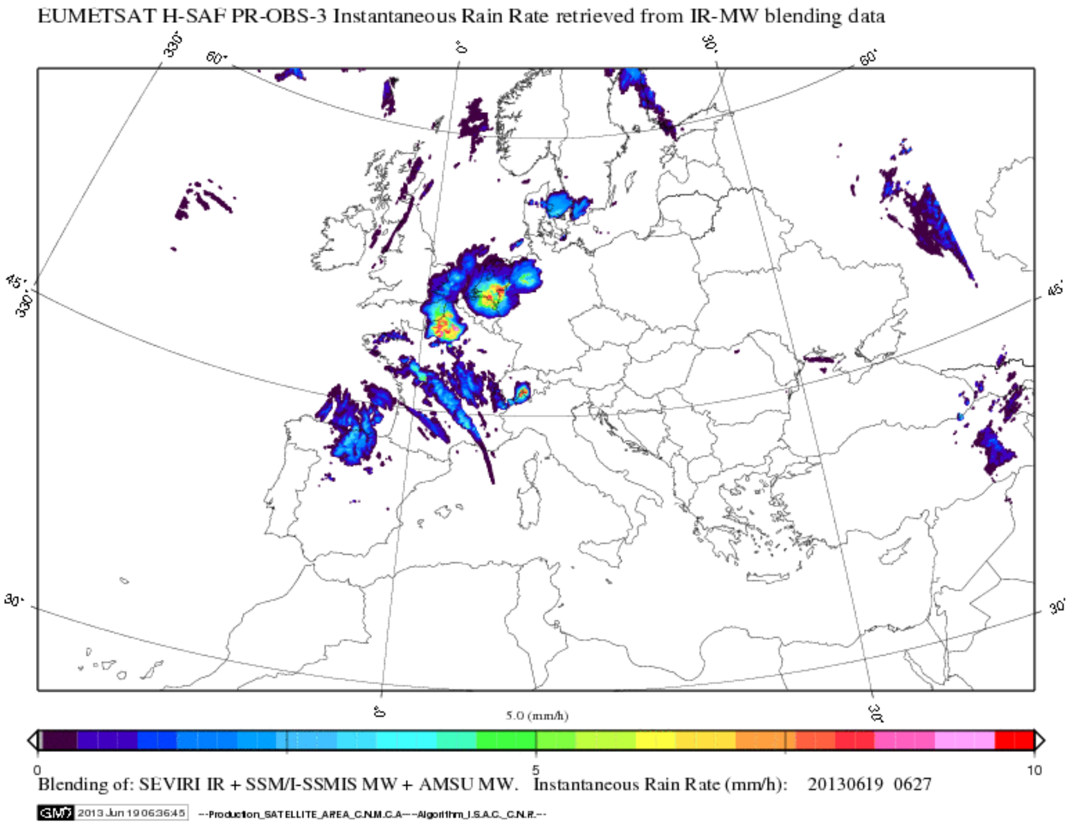




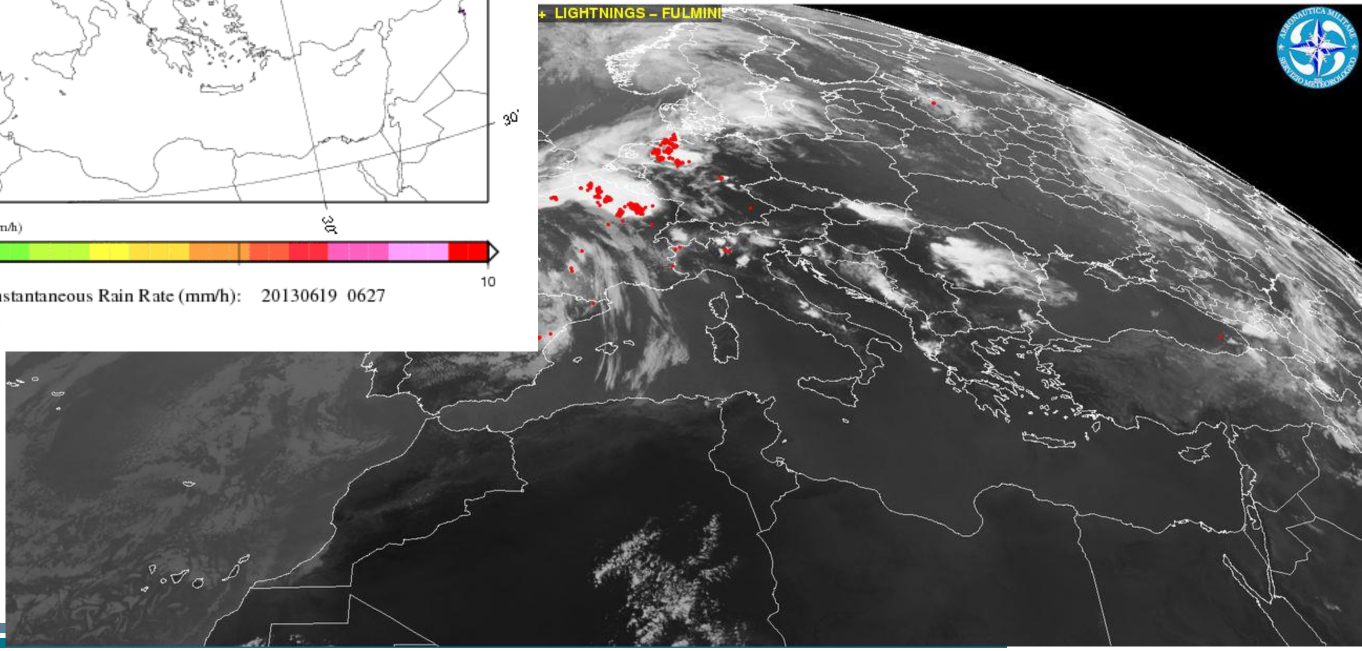
Case study: 11-12 november 2012
Grosseto

http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20121112_flood/20121112_flood.html

Case studies



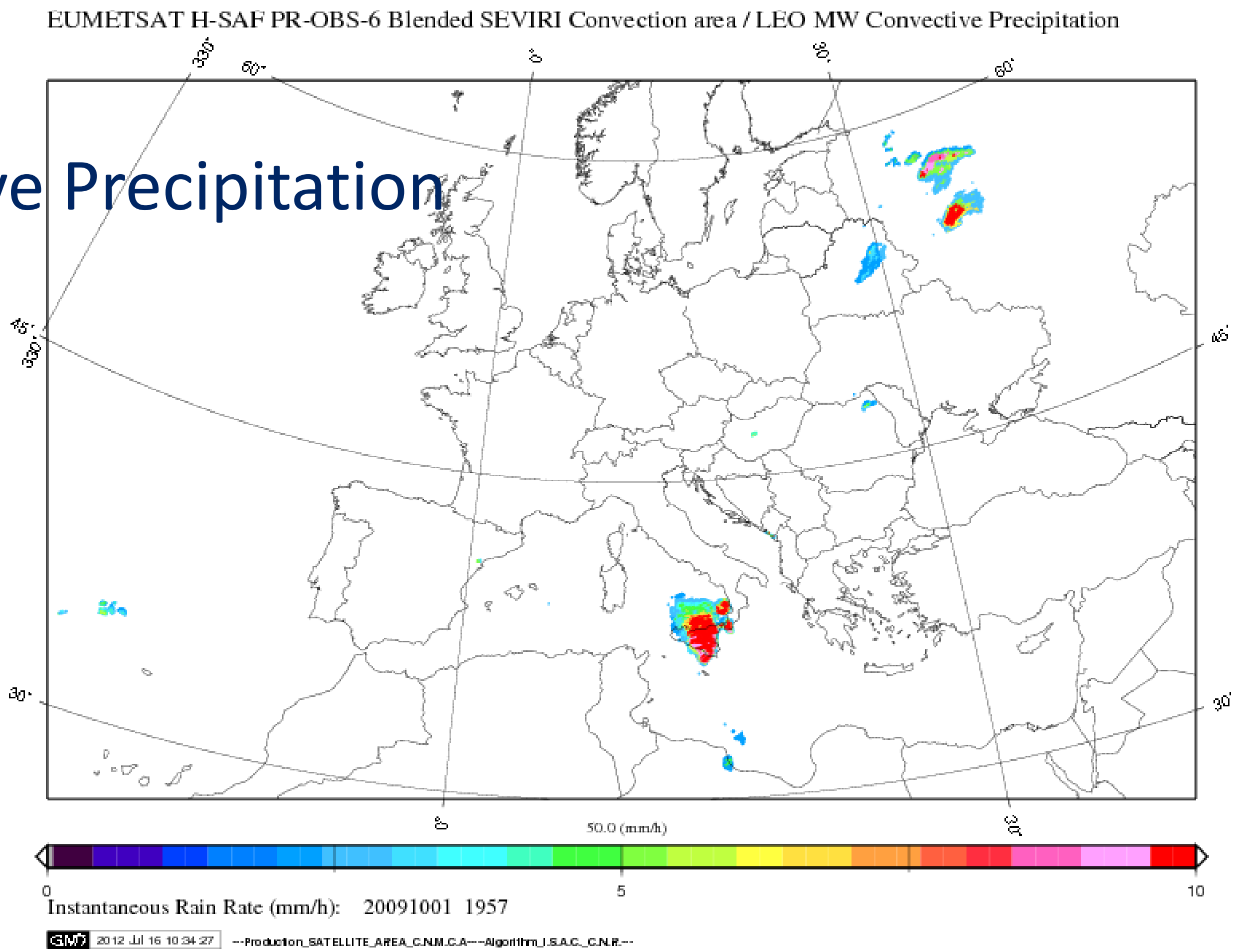
Case study: extreme precipitation event, Germany



H SAF Operational Products: examples

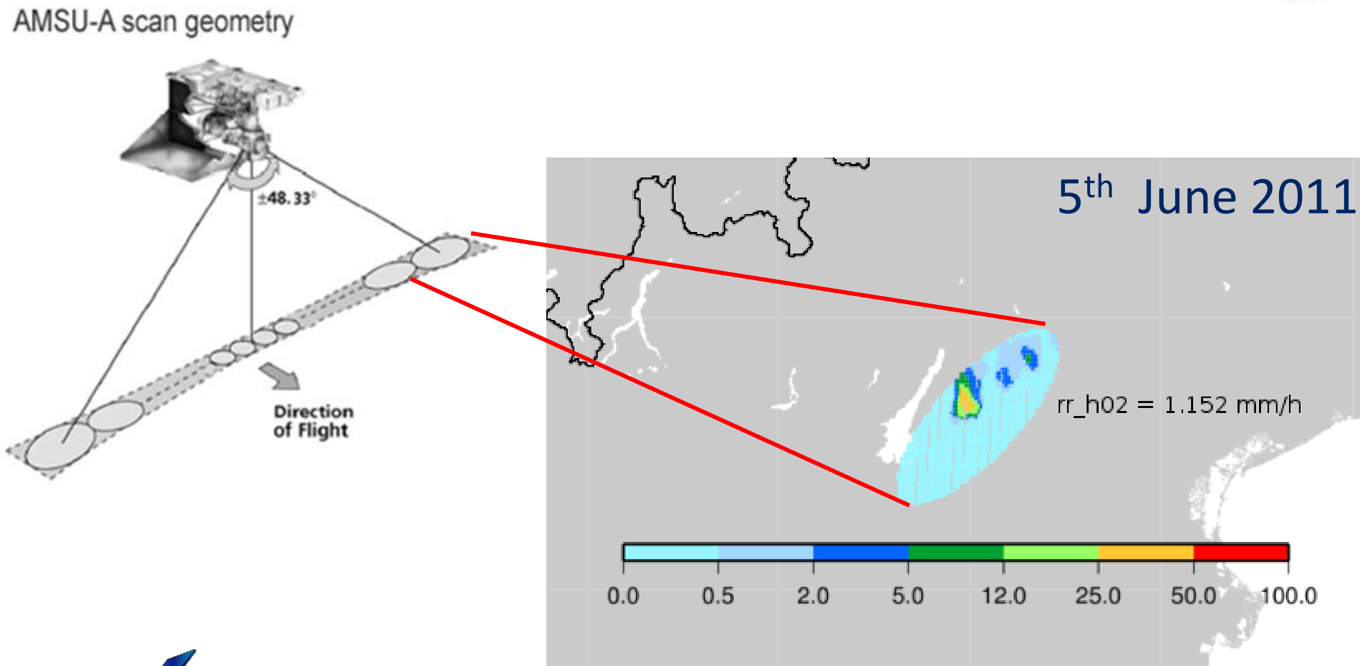
P-IN-SEVIRI-CO / H15: **BLENDING Technique + NEFODINA**

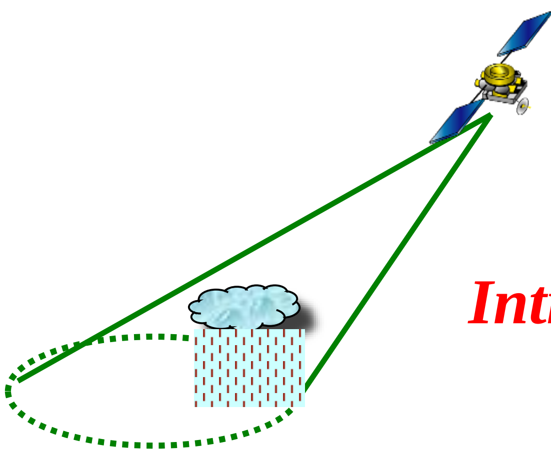
Convective Precipitation



The Satellite "Beam filling" Problem

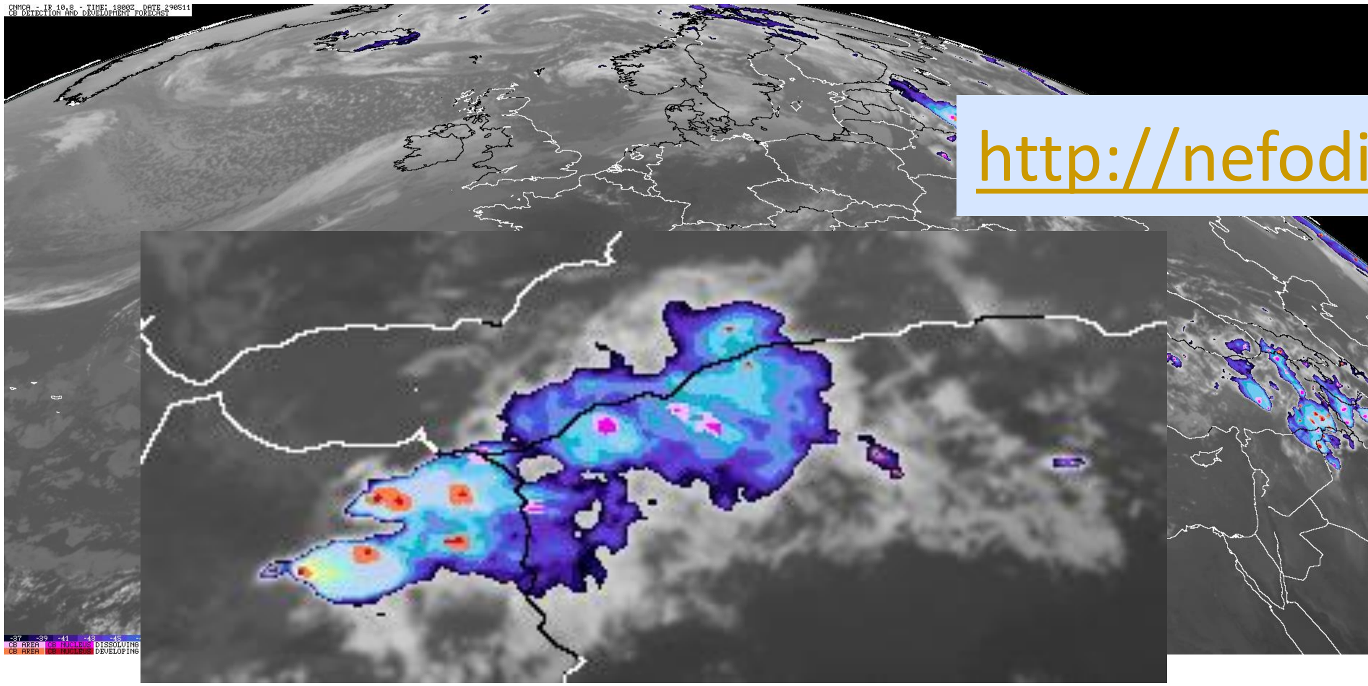
Comparison between precipitation retrieval by microwave sensor on polar satellite (AMSU) and radar.





Intrinsic Underestimation

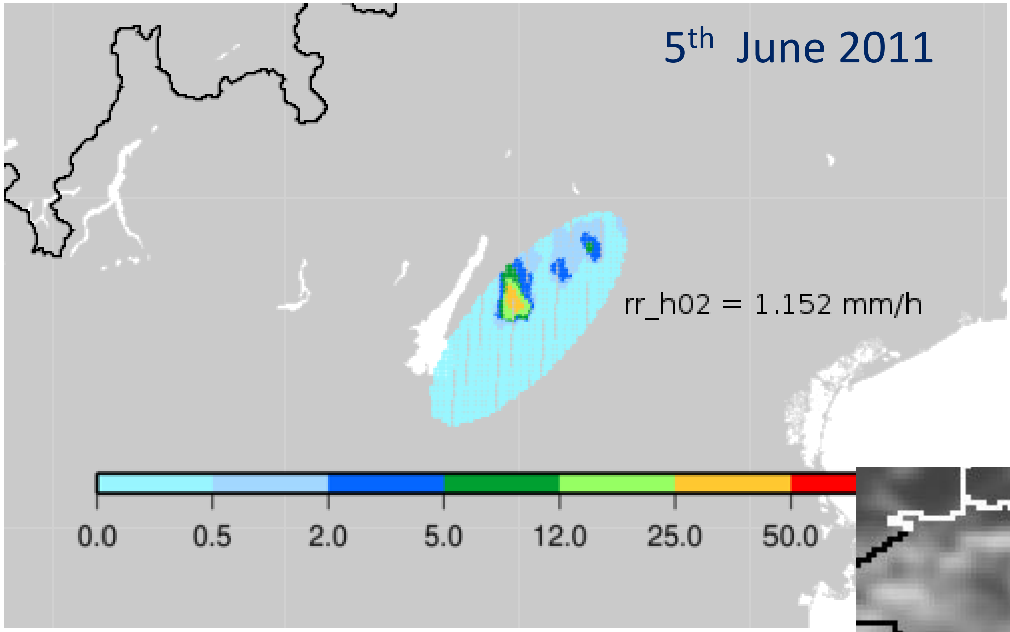
NEFODINA software



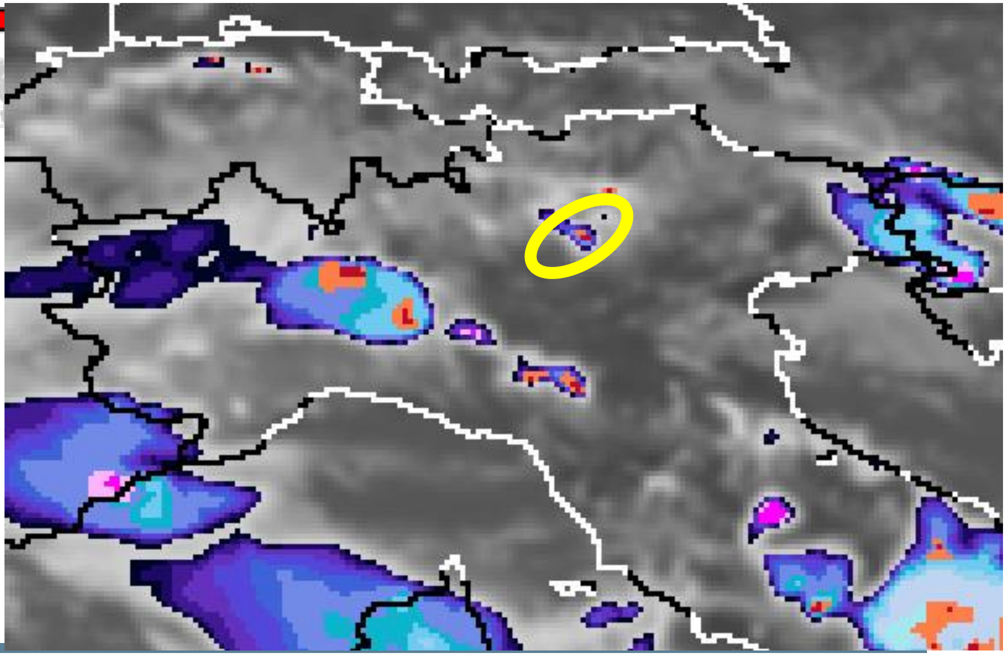
http://nefodina.meteoam.it

- With red shades are indicated the cloud top of the detected convective cell in growing phase
- With pink shades are indicated the cloud top of the detected convective cell in decreasing phase.

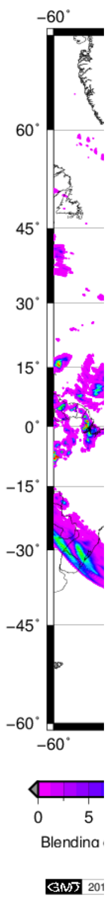
NEFODINA software

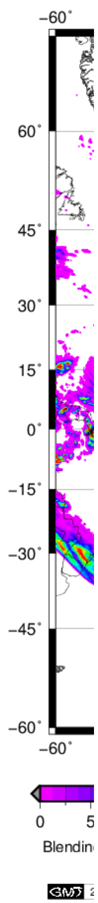


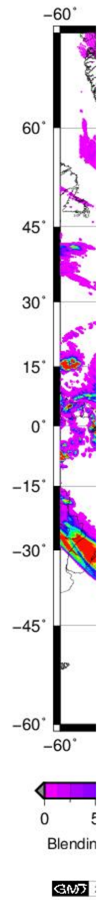
Rain redistribution based on convective cell's area

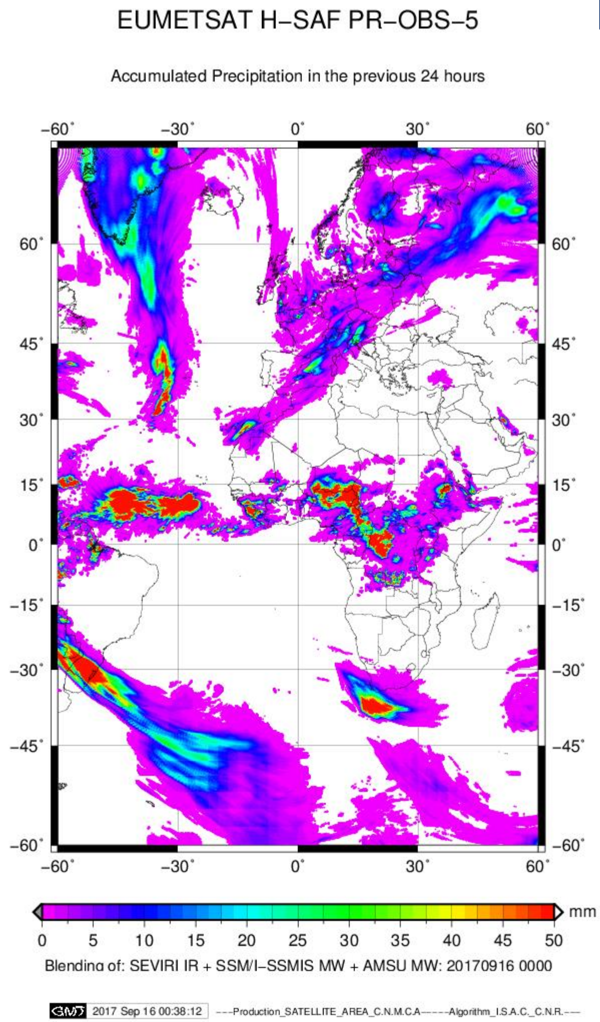


H SAF Operational Products: examples









P-AC-SEVIRI / H05

Accumulated Precipitation

Auxiliary Products

New MW based auxiliary Products

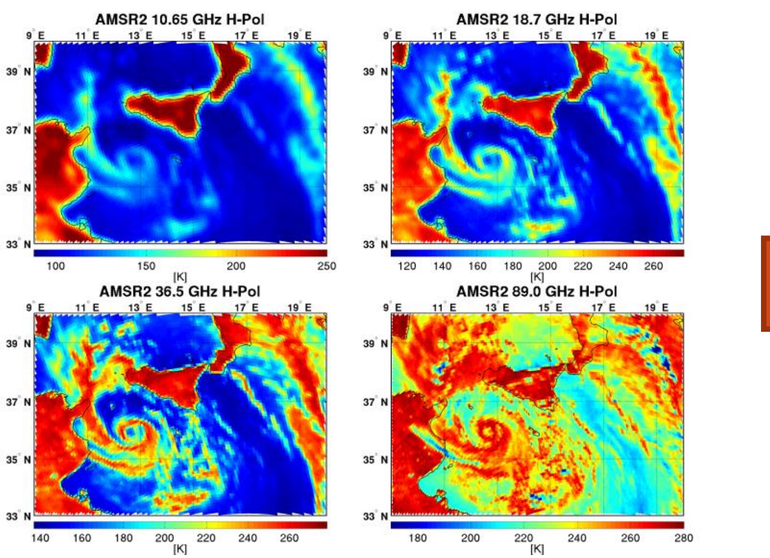
H-AUX17	Precipitation rate at ground by MW conical scanners (AMSR2)	Available via ftp
H-AUX20	Rainfall intensity from GMI (GPM - Microwave Imager)	
H-AUX23	Gridded daily mean precipitation based on PMW instantaneous precipitation rate estimates	

MW based auxiliary Products

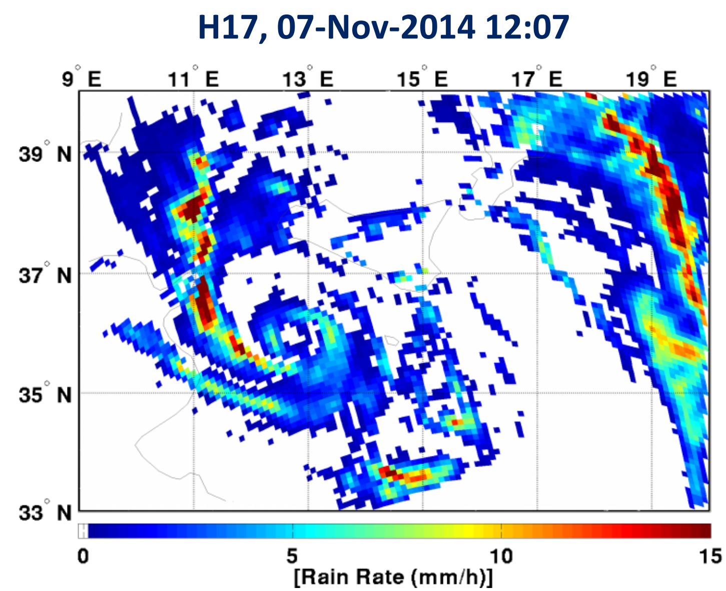
H17 H-AUX17	Precipitation rate at ground by MW conical scanners (AMSR2 - GCOM-W1 satellite)	Auxiliary

H17 is a new precipitation retrieval algorithm for AMSR2 (Casella et al., 2017) based on the Cloud Dynamics and Radiation Database (CDRD) Bayesian approach and evolution of the previous version applied to SSMIS (H01),

Medicane Qendresa, developed in the Southern Mediterranean on November 7, 2014



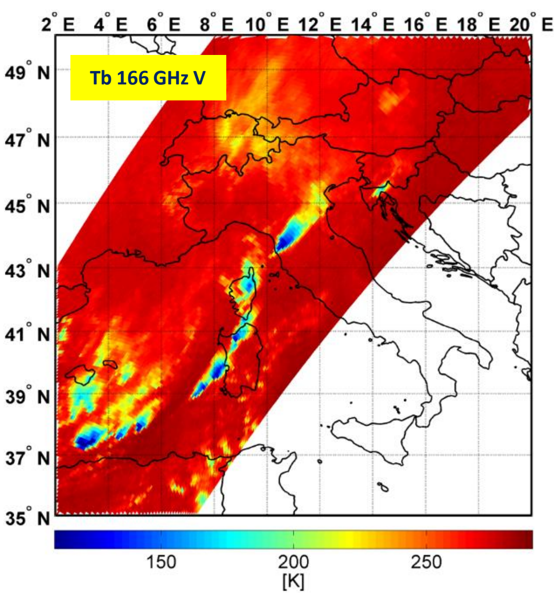
TBs in four channels from AMSR2 overpass of Medicane Qendresa on November 7, 2014 12:07 UTC.

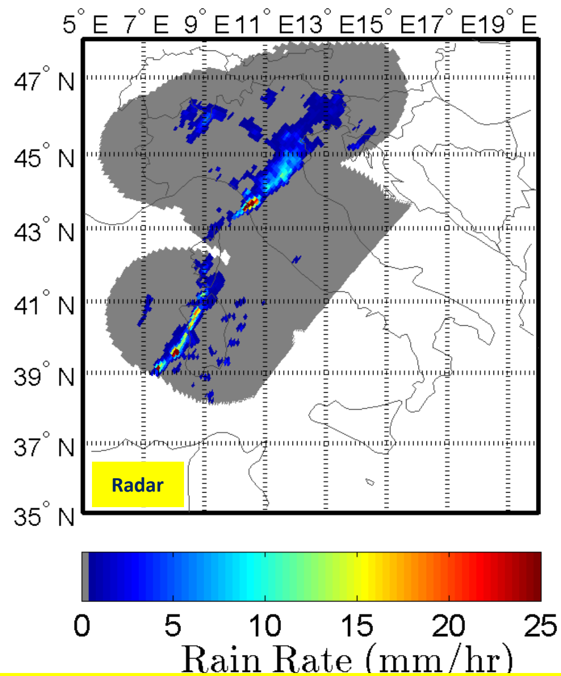


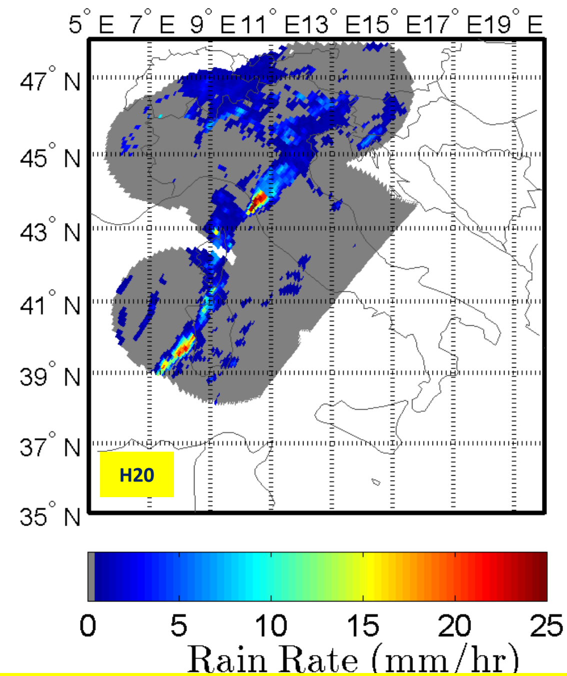
MW based auxiliary Products

H20 H-AUX20	Precipitation Rate at ground by GMI – (**GMI/DPR** Observational Dataset) (Global).	Auxiliary

Case Study 10/09/2017, 01:17 UTC, Livorno (Italy)







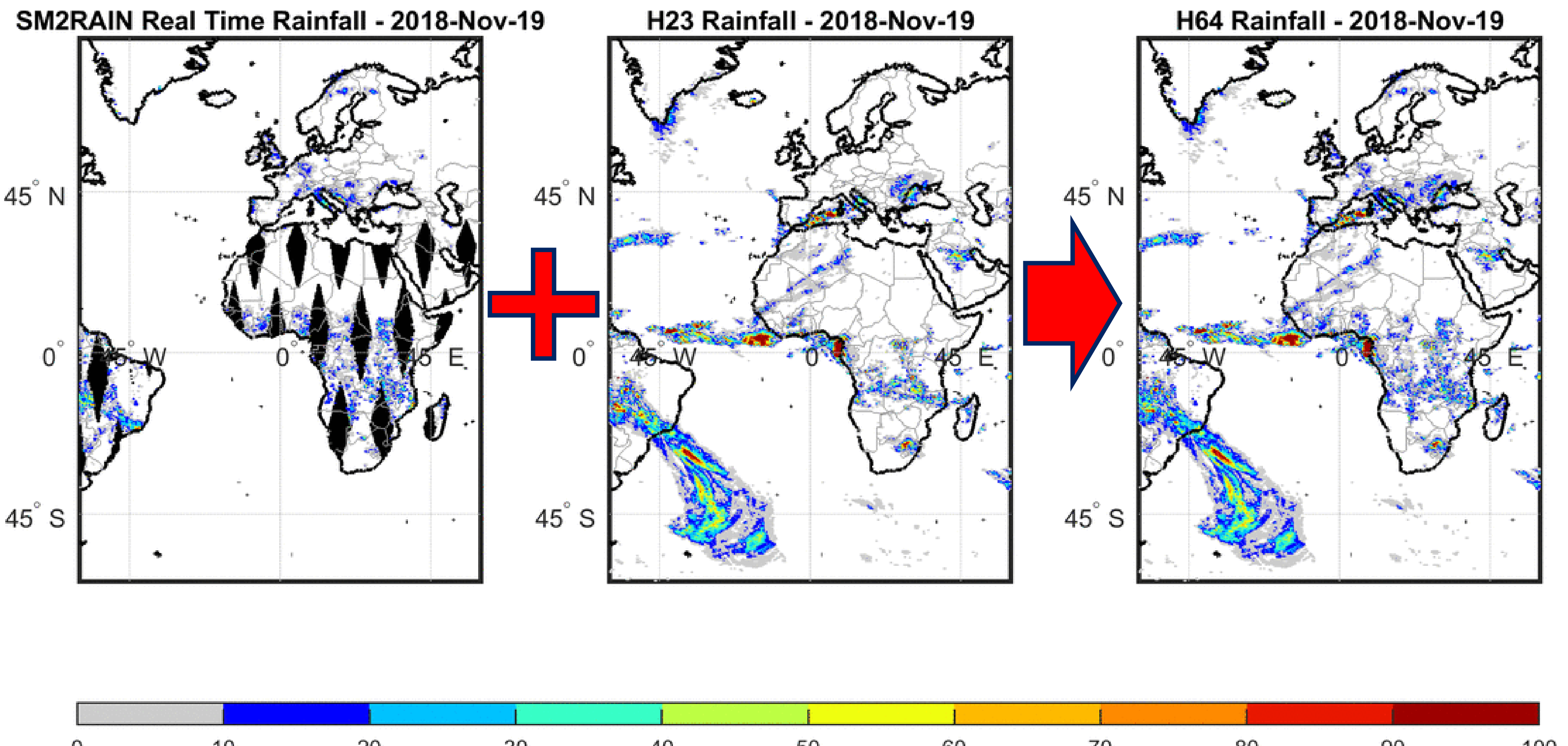
Heavy storm that struck the Tuscany

- **H20 is based on a unique ANN, trained using a large and rich observational database available from combined GPM-CO observations.**
- **It is able to retrieve precipitation over different surfaces, thanks to a careful selection of the ANN inputs to separate the precipitation signal from the noise.**
- **H20 provides surface precipitation over the GPM-CO global area, a pixel based quality index and the precipitation phase.**

In development products

Integration of Precipitation/Soil Moisture Products

H64 P-AC-SM2RAIN	Precipitation/Soil Moisture integrated product	Algorithm assessed Expected Operations 2020



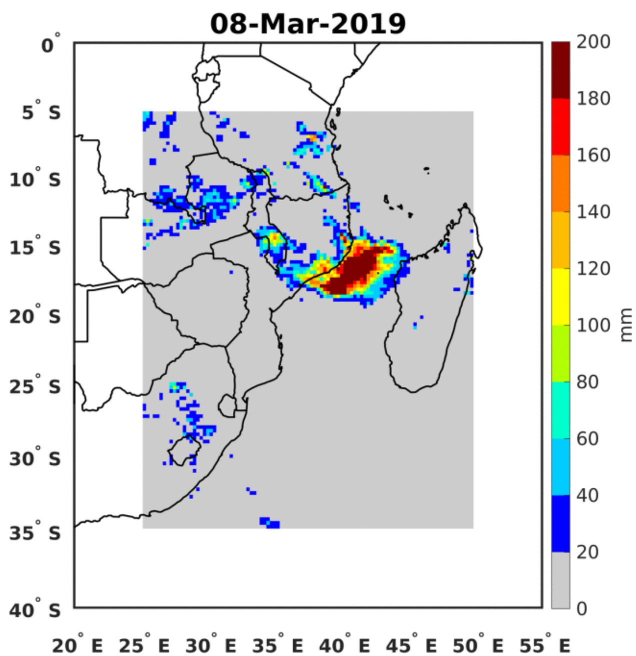
EUMETSAT H SAF

In development products

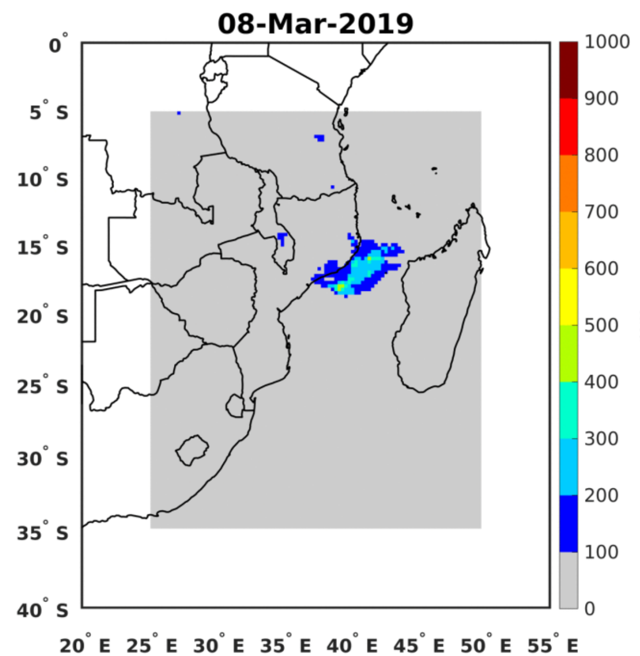
H67 P-DM-PMW-IC	Gridded 24h mean precipitation based on intercalibrated PMW precipitation rate estimates	In development

Case Study: Cyclone IDAI Mozambique 8-18 March 2019

H67



Cumulated H67 Precip.

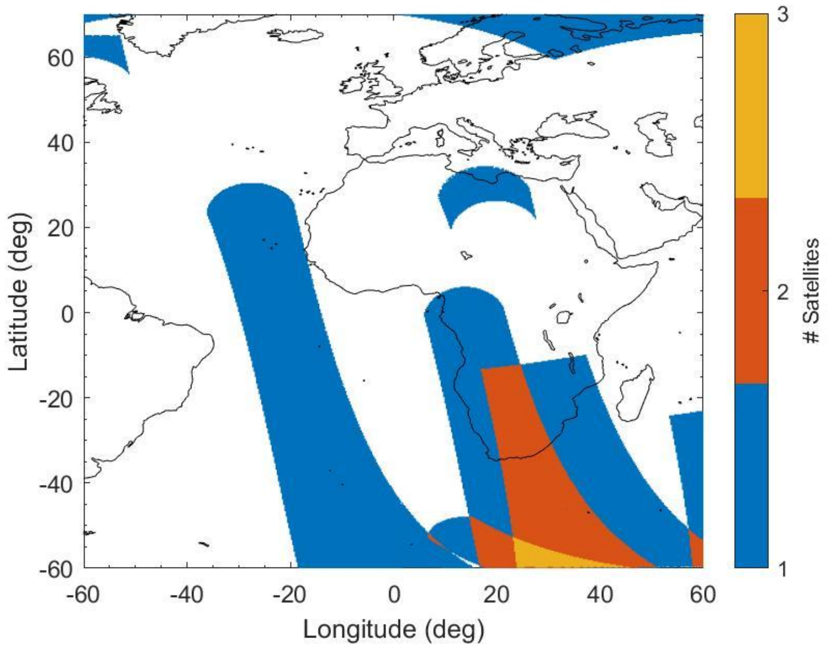


Poster ID #32
"The new H SAF H67 and H68 precipitation products"

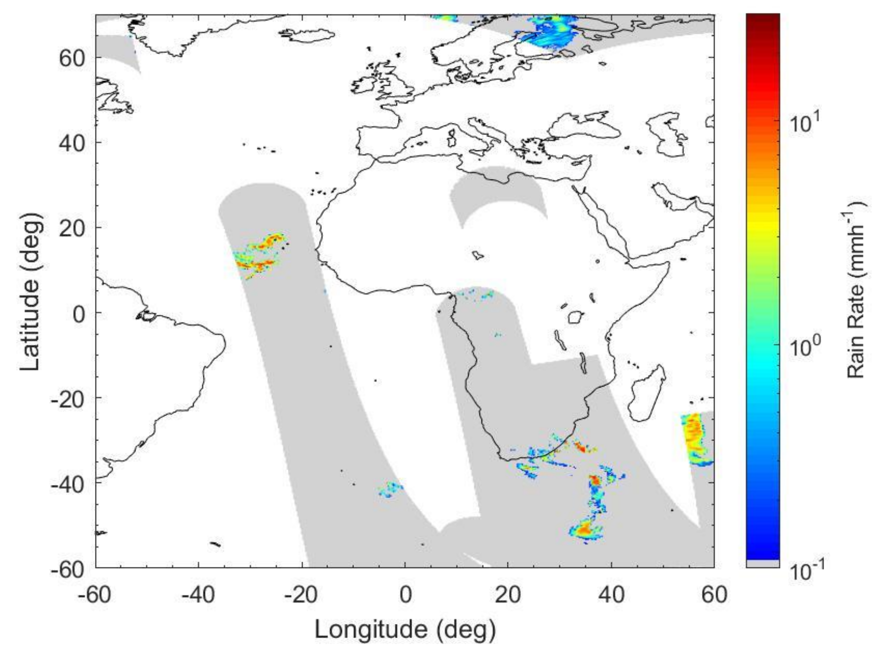
In development products

H68 P-DM-PMW-IC	Gridded half hour instantaneous precipitation based on intercalibrated PMW precipitation rate estimates	In development

20170829 17:00-17:30



20170829 17:00-17:30



Poster ID #32
"The new H SAF H67 and H68 precipitation products"

In development Products

Indian Ocean Data Coverage (IODC) Products

H63 P-IN-SEVIRI_E	Precipitation rate at ground by GEO/IR supported by LEO/MW	Algorithm assessed Expected Operations in Q1 2020
H90 P-AC-SEVIRI_E	Accumulated precipitation at ground by blended MW and IR	

EUMETSAT H SAF

In development Products

MTG-based Products

H40 P-IN-FCI	Precipitation rate at ground by GEO/IR supported by LEO/MW and MTG FCI	Algorithms assessed Expected Operations in CDOP4
H42 P-AC-FCI	Accumulated precipitation at ground by blended MW and IR and MTG FCI	
H50 P-IN-LI	Rainfall intensity from MTG LI	

EPS-SG based products

H70 P-IN-MWS	Precipitation Rate at ground by EPS-SG MWS	Expected operations in CDOP-4
H71 P-IN-MWI	Precipitation Rate at ground by EPS-SG MWI	

Recent publications

1. Sanò P., G. Panegrossi, D. Casella, A. C. Marra, L. P. D'Adderio, J.-F. Rysman, S. Dietrich, The Passive Microwave Neural Network Precipitation Retrieval (PNPR) algorithm for the Conical Scanning GMI Radiometer, Remote Sens. 10, 1122; doi:10.3390/rs10071122, 2018
2. Casella D., Casella D., L. M. Amaral, S. Dietrich, A. C. Marra, P. Sanò, and G. Panegrossi, The Cloud Dynamics and Radiation Database algorithm for AMSR2: exploitation of the GPM observational dataset for operational applications, IEEE J. of Sel. Topics in Appl. Earth Obs. and Rem. Sens. (J-STARS), 10(*8), DOI :* 10.1109/JSTARS.2017.2713485*, 2017*.
3. Ciabatta L., Marra A. C., Panegrossi G., Casella D., Sanò P., Dietrich S., Massari C., Brocca L., Daily precipitation estimation through different microwave sensors: Verification study over Italy, J. of Hydrology, 545, 436-450, DOI: http://dx.doi.org/10.1016/j.jhydrol.2016.12.057, 2017.
4. Sanò, P., Panegrossi, G., Casella, D., Marra, A. C., Di Paola, F., and Dietrich, S.: The new Passive microwave Neural network Precipitation Retrieval (PNPR) algorithm for the cross-track scanning ATMS radiometer: description and verification study over Europe and Africa using GPM and TRMM spaceborne radars, Atmos. Meas. Tech., 9, 5441-5460, doi:10.5194/amt-9-5441-2016, 2016.
5. Casella, D., Panegrossi, G., Sanò, P., Milani, L., Petracca, M., and Dietrich, S.: A novel algorithm for detection of precipitation in tropical regions using PMW radiometers, Atmos. Meas. Tech., 8, 1217-1232, doi:10.5194/amt-8-1217-2015, 2015.
6. Sanò, P., Panegrossi, G., Casella, D., Di Paola, F., Milani, L., Mugnai, A., Petracca, M., and Dietrich, S.: The Passive microwave Neural network Precipitation Retrieval (PNPR) algorithm for AMSU/MHS observations: description and application to European case studies, Atmos. Meas. Tech., 8, 837-857, DOI:10.5194/amt-8-837-2015, 2015.
7. Mugnai, A., Casella, D., Cattani, E., Dietrich, S., Laviola, S., Levizzani, V., Panegrossi, G., Sanò, P., 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., 13, 1959-1981, DOI: 10.5194/nhess-13-1959-2013, 2013.
8. 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, vol.51, no.9, pp.4650-4671, 2013, DOI: 10.1109/TGRS.2013.2258161, 2013.
9. Smith, E.A., Leung, H. W.-L., Elsner, J.B., Mehta, A.V., Tripoli, G.J., Casella, D., Dietrich, S., Mugnai, A., Panegrossi, G., and Sanò, P.: Transitioning from CRD to CDRD in Bayesian retrieval of rainfall from satellite passive microwave measurements, Part 3: Identification of optimal meteorological tags, Nat. Hazards Earth Syst. Sci., 13, 1185–1208, 2013.
10. Mugnai A., E. A. Smith, G. J. Tripoli, B. Bizzarri, D. Casella, S. Dietrich, F. Di Paola, G. Panegrossi, P. Sanò, CDRD and PNPR Satellite Passive Microwave Precipitation Retrieval Algorithms: EuroTRMM / EURAINSAT Origins and H SAF Operations, Nat. Hazards Earth Syst. Sci., 13, 887-912, 2013.

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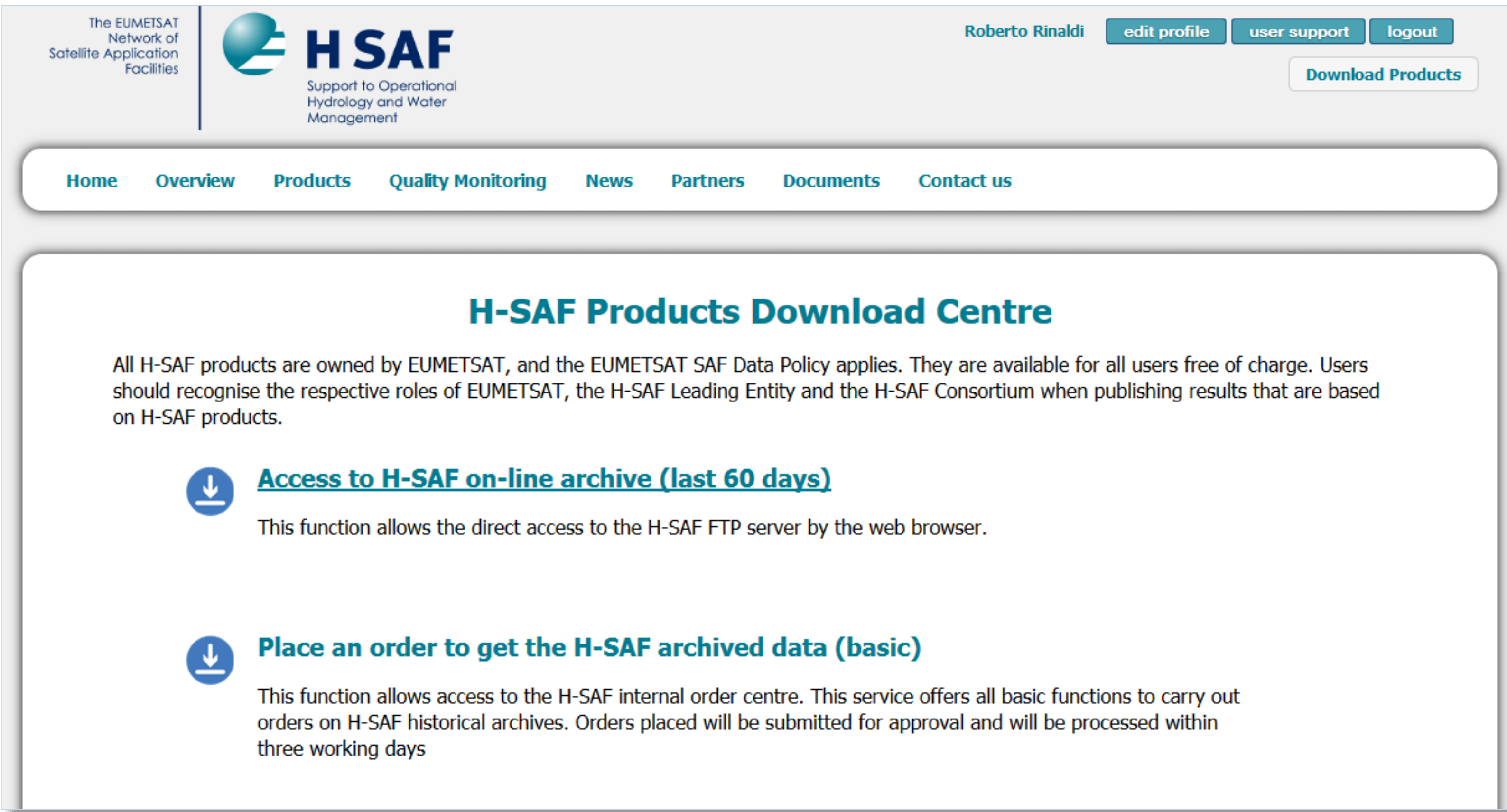

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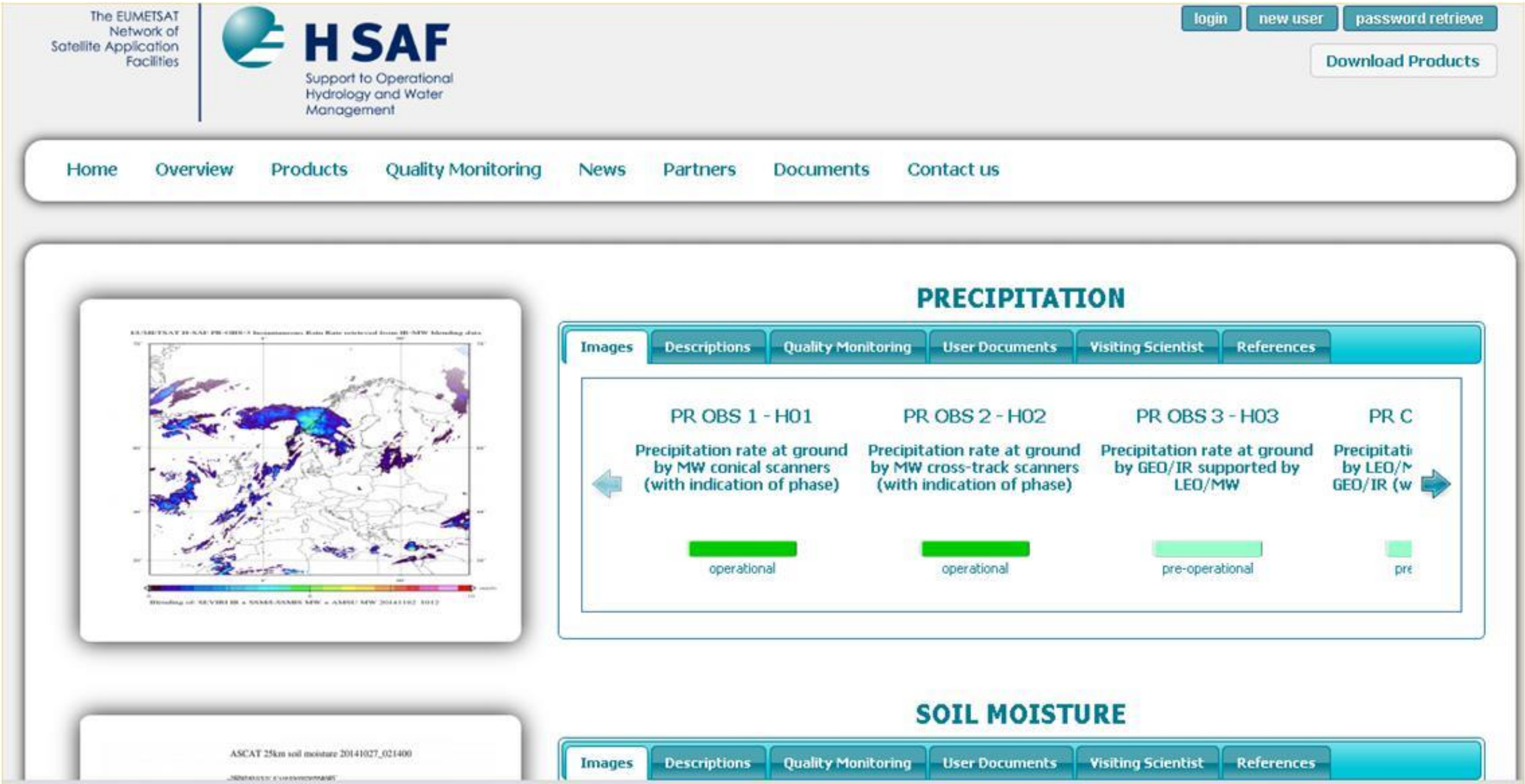

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