H68 & H67
H SAF Level 3 MW-based precipitation estimation products

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- Definition of Level 3 product
- H68 Product overview
- H68 algorithm description
- Some examples
- H67 Product overview
- H67 algorithm description
- Some examples
- Current status and future perspectives

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Definition of Level 3 product

What is a Level 3 product?

A Level 3 product is a geophysical product with spatial or/and temporal integration. Different products, orbits and type of data might be used and the product can be global or integrated over a different time interval than the original Level 1 data. These products are usually associated with larger timeliness or are processed offline.

Level 2 product

A Level 2 product is a geophysical product, derived from the corresponding Level 1 product, i.e., at the same spatial resolution/grid and generation frequency as the Level 1 product. It implies that one segment of a single orbit (or one MSG disk at one given time) is used to get a Level 2 product. These products are most of the time provided in NRT.

Level 1 product

A Level 1 product provides a calibrated-georeferenced data. EUMETSAT divides Level 1 products in: 1A georeferenced (the location of the measurements is known), 1B (data are calibrated), and 1C data are gridded (for example, MSG Level 1 data are 1C since they are gridded/calibrated data).

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H68 Overview

P-IN-PMW **(H68)** characteristics:

- Main output: instantaneous precipitation rate
- Regular grid 0.25°x0.25°
- H SAF Extended Area (60°S-75°N, 60°W-60°E)
- 30 minutes temporal resolution
- Three main modules → *Remapping* module, *Adjustment* module, *Merging* module

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Why a user should prefer H68?

1. Summarise the MW-based Level 2 precipitation rate products in a single estimation.

2. The precipitation rate estimation is given on a regular grid (wherever it is possible, i.e. over the grid-boxes covered by at least one satellite).

3. Quite good temporal resolution (30 min) and NRT product (within 4 hours with respect the considered half hour).

4. Input for future precipitation products (MTG-based precipitation products).

5. Easy output format, **NetCDF**.

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H68 Overview

Inputs

- ***Satellites***
  - ✓ DMSP F16, F17, F18
  - ✓ MetOp A-B-C, NOAA 18-19
  - ✓ GCOM-W
  - ✓ Suomi NPP, NOAA20
  - ✓ GPM CO
- ***Products***
  - ✓ H01
  - ✓ H02B
  - ✓ H18
  - ✓ H-AUX-17
  - ✓ H-AUX-20
- ***Variables***
  - ✓ Instantaneous precipitation rate (mmh^{-1})
  - ✓ Precipitation phase
  - ✓ Quality index
- ***Data format***
  - ✓ NetCDF

Data Regrid

Remapping orbital data on a regular 0.25°x0.25° by means of bilinear interpolation.

Data Adjustment

Remapped input precipitation rate data are inter-calibrated, taking as reference the GPM combined product DPR-GMI (2B-CMB-V05).

Data Merging

A merging procedure provides the optimal instantaneous precipitation rate as a function of the number, type and characteristics of satellites overpassing each grid- box. In the same way, the precipitation phase and quality index is provided for each grid-box.

Outputs

- ***Product***
  - ✓ H68
- ***Variables***
  - ✓ Instantaneous precipitation rate (mmh^{-1}) over regular grid 0.25°x0.25°
  - ✓ Phase of the precipitation
  - ✓ Quality index of the precipitation estimation
  - ✓ Number of conical and cross-track satellites overpassing each pixel in the considered half hour, and their sum
- ***Data format***
  - ✓ NetCDF

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H68 input products

Acronym (Product ID) (Instrument)	Product Description	Algorithm	Reference	Currently available satellites	Status/ Availability
P-IN-SSMIS (H01) (SSMIS)	Precipitation rate at ground by MW conical scanner SSMIS (MSG full disk)	Physically-based Bayesian (CDRD) Cloud-radiation model a priori database	Casella et al., 2013, IEEE TGRS Sanò et al., 2013 IEEE TGRS	DMSP F16/F17/F18	Operational
P-IN-MHS (H02B) (AMSU/MHS)	Precipitation rate at ground by MW cross-track scanners AMSU/MHS (MSG full disk)	Neural Network (PNPR) Cloud-radiation model training database	Sanò et al., 2015 AMT	MetOp-B/C NOAA-18/19	Operational
P-IN-ATMS (H18) (ATMS)	Precipitation rate at ground by MW cross-track scanners ATMS (MSG full disk)	Neural Network (PNPR) Cloud-radiation model training database	Sanò et al., 2016 AMT	Suomi NPP NOAA-20 (JPSS series)	Operational
P-IN-AMSR2 (H-AUX-17) (AMSR-2)	Precipitation rate at ground by MW conical scanner AMSR-2 (based on GMI/DPR Observational Dataset) ***(MSG full disk)***	Physically-based Bayesian (CDRD) GPM-based observational a priori database	Casella et al., 2017 IEEE JSTARS	GCOM W1	Auxiliary: Support to MW-only and MW/IR combined products
P-IN-GMI (H-AUX-20) (GMI)	Precipitation Rate at ground by MW conical scanner GMI – (based on GMI/DPR Observational Dataset) (***Global***)	Neural Network GPM-based observational trainig database	Sanò et al., 2018, Rem. Sens.	GPM	Auxiliary: Support to MW-only and MW/IR combined products

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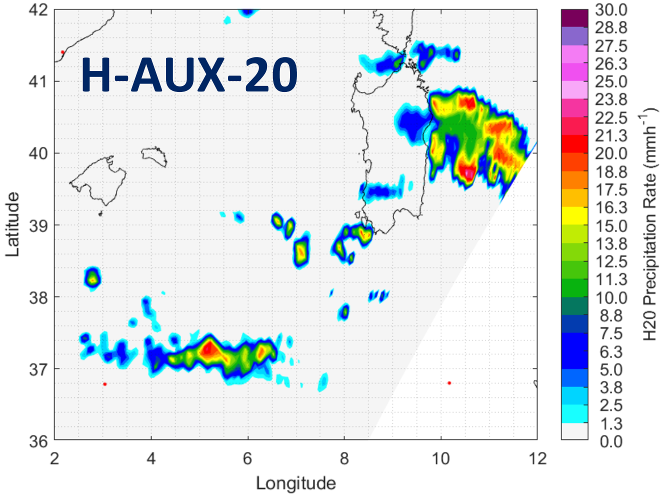
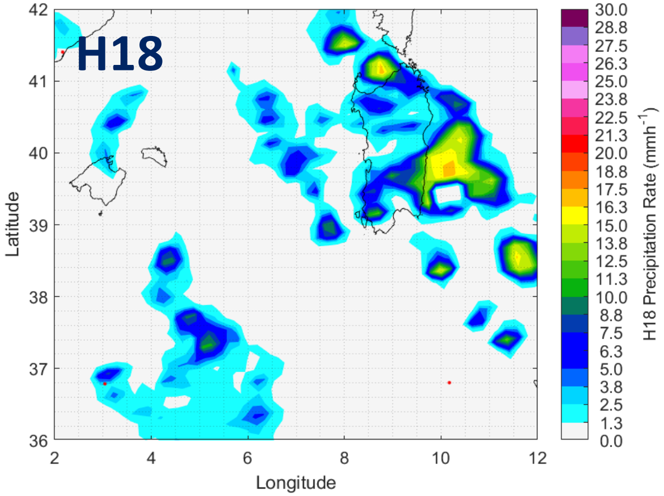
H68 Algorithm Description

Remapping Module

- The remapping module works on the orbital data of the H68's input products (i.e. H01, H02B, H18, H-AUX-17 and H-AUX-20.

- It is based on bilinear interpolation (*Remapbil* function of CDO).

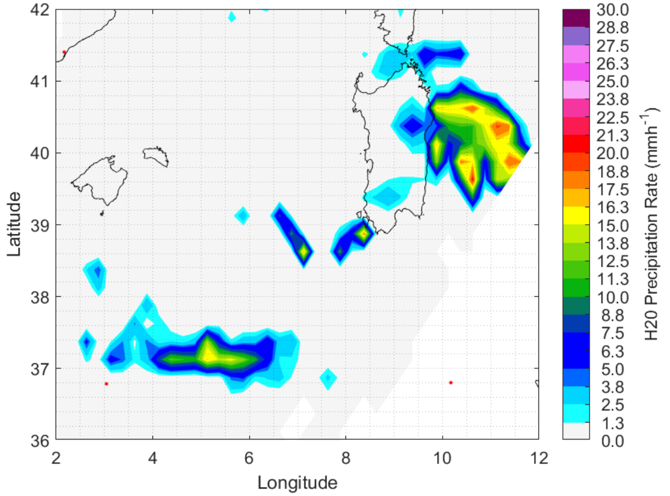


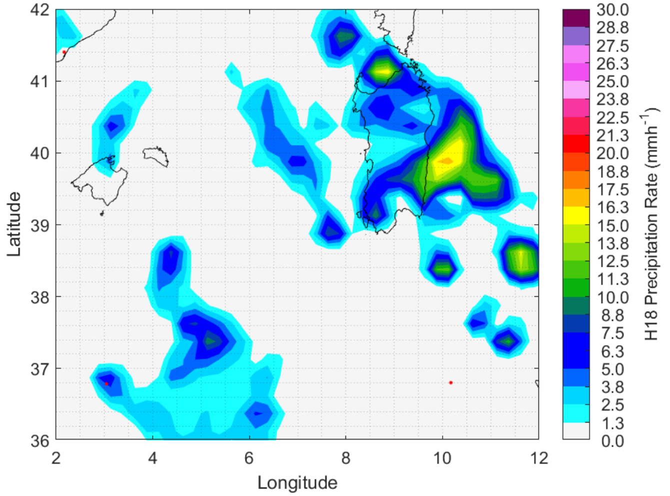


28 Nov 2020 17:30 UTC

From orbital resolution to 0.25°x0.25° regular grid.

28 Nov 2020 12:30 UTC





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Adjustment **Module**

- The adjustment module runs just after the remapping module.
- Its aim is both to improve the coherence and decrease the discrepancies among the H68's input products.

Power Law

$$PR_{adj} = a \cdot PR^{b}$$

- The power law is applied to each H68 input product (i.e. H01, H02B, H18, H-AUX-17, and H-AUX-20)
- Reference: 5 years (2014-2018) of coincident measurements between every H68 input product and the 2B-CMB combined precipitation rate product (that is taken as reference).

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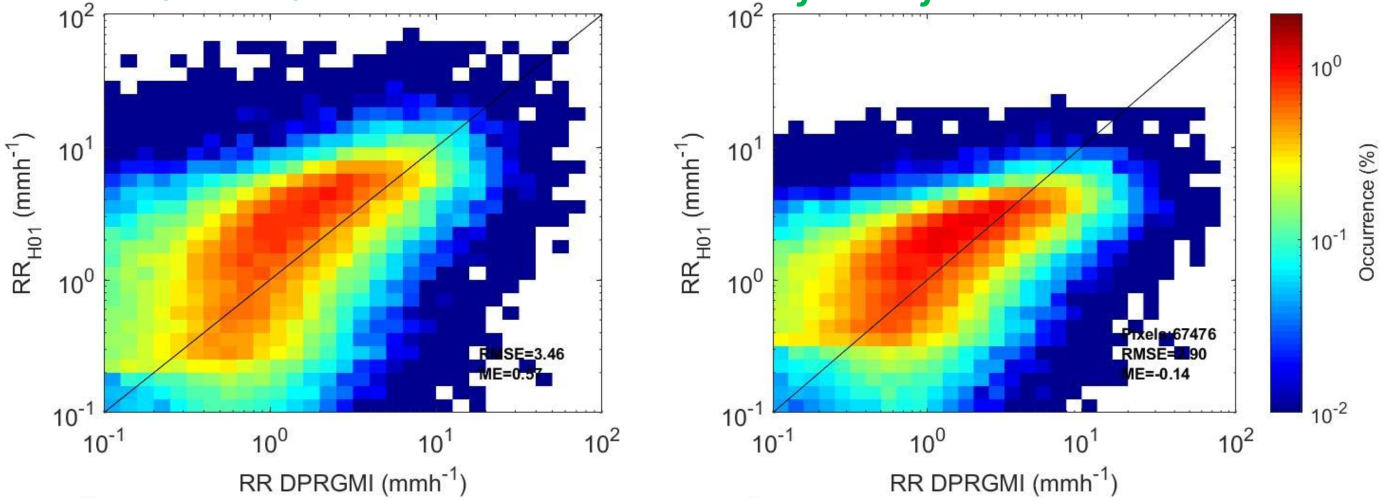
H68 Algorithm Description

How the Power Law is derived?

- The 2B-CMB precipitation rate product is upscaled through bilinear interpolation (the same of remapping module) on the same 0.25°x0.25° regular grid of the H68 input products.
- 5 years of coincident measurements between the gridded H68 input products and 2B-CMB precipitation rate product are matched up.

Before Adjustment module — *After Adjustment module*



- More samples on the one-to-one line.
- Lost of overestimation at low 2B-CMB precipitation rate.
- RMSE: 3.46 → 2.90 mmh^{-1}.

What is the 2B-CMB precipitation rate product? Why the 2B-CMB?

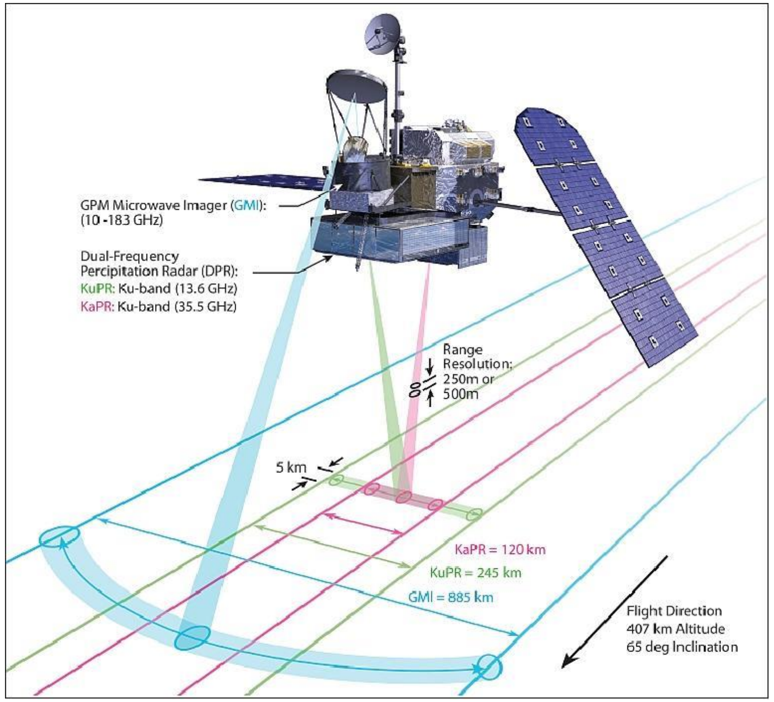
- The 2B-CMB combines the information from active and passive MW sensors on board of Core Observatory (CO) of Global Precipitation Measurement (GPM) mission.

DPR: Dual-frequency Precipitation Radar

- Ku- and Ka-band radar.
- 3D retrieval of precipitation structure.
- 5 km spatial resolution.

GMI: GPM Microwave Imager

- Conical scanning radiometer.
- 13 different MW channels.
- Spatial resolution ranging from 6x4 km^2 to 31x19 km^2 as a function of channel frequency



The most advanced active and passive MW sensors on board of LEO satellites

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Merging Module

- The merging module runs after the adjustment module and performs an ensemble mean of all the data produced by H01, H02B, H18, H-AUX-17, and H-AUX-20 in the previous 30 minutes, and remapped at 0.25°x0.25° and adjusted.
- It consists of three main steps:

1. A ranking is derived for each satellite type, i.e. one for conical and one for cross-track scanning satellites. The ranking takes into account the characteristics of the sensors and the pixel-based quality flag associated.

Conical Satellites	Cross-track Satellites
1. H-AUX-20 (GMI)	1. H18 (ATMS-NPP)
2. H-AUX-17 (AMSR2)	2. H18 (ATMS-NOAA20)
3. H01 (F17)	3. H02B (MHS-MetOp B)
4. H01 (F18)	4. H02B (MHS-NOAA18)**
5. H01 (F16)	5. H02B (MHS-NOAA19)
	6. H02B (MHS-MetOp A)
	7. H02B (MHS MetOp C)

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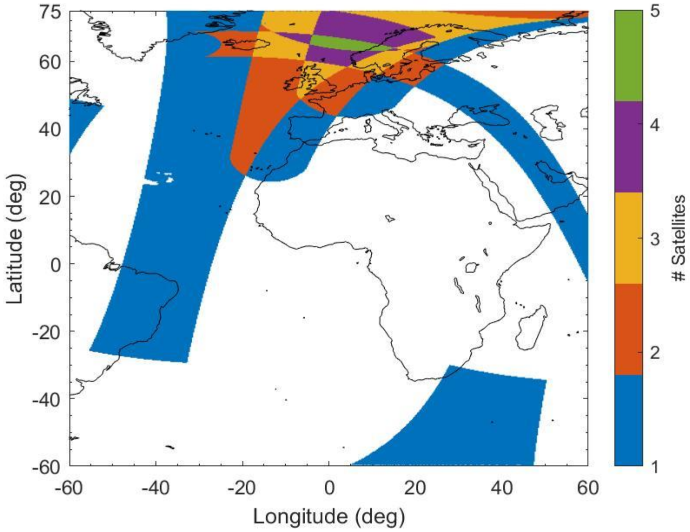
H68 Algorithm Description

Merging Module

2. The MW precipitation products (i.e. H01, H02B, H18, H-AUX-17, and H-AUX-20) are sorted according to the rankings of table in the previous slide.
3. The two best MW precipitation products (one for conical and one for cross-track, if available, following then the rankings in the table) are averaged to provide the "optimal" instantaneous precipitation estimate for each grid-box. In the same way, the quality index and the precipitation phase are provided.

Let's see an example



- The number of satellites overpassing the covered grid-boxes ranges between 1 and 5 in this case.
- 1 satellite: precipitation rate from the corresponding product.
- 2 satellites:
  - Both conical: precipitation rate from the best ranked.
  - Both cross-track: precipitation rate from the best ranked.
  - One of each: precipitation rate from their average.
- 3+ satellites: more and more possible combinations.

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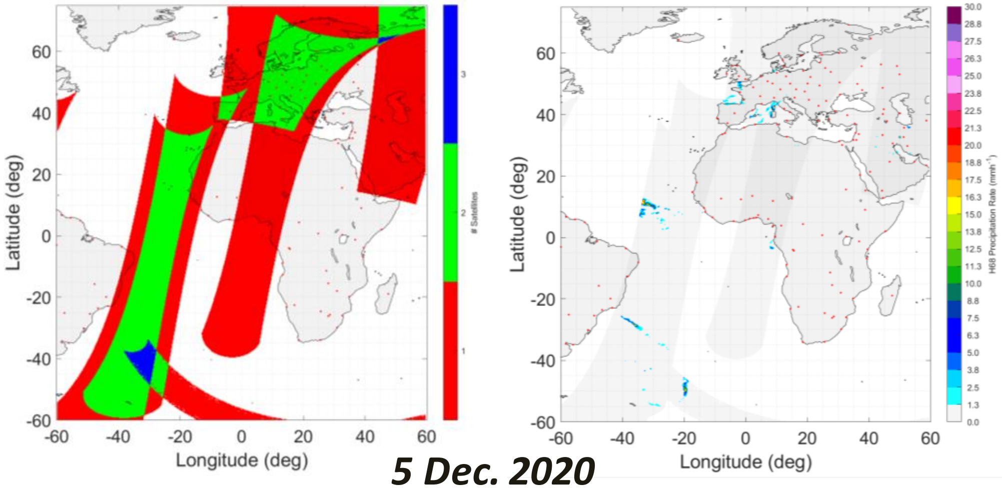
H68 – Some examples

Total Count **Precipitation Rate**

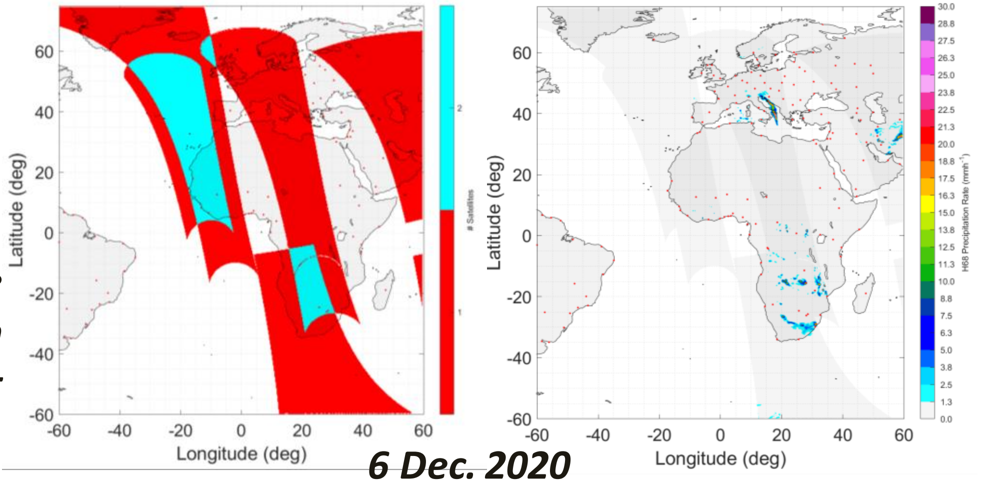


Half hour useful to understand the satellites overlapping

5 Dec. 2020
06:00-06:30 UTC

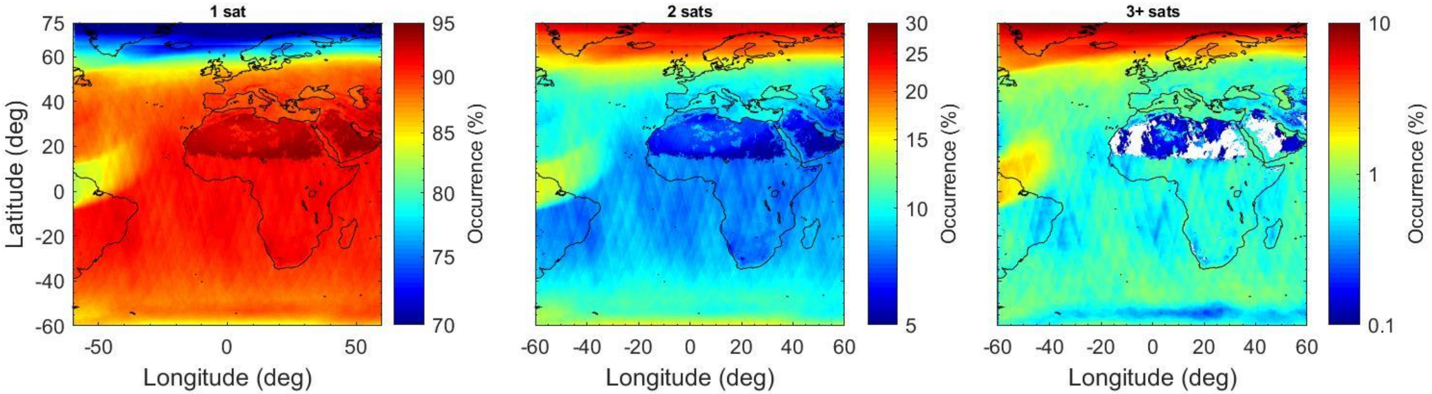
Half hour more interesting from precipitative point of view

Total Count **Precipitation Rate**



6 Dec. 2020
17:00-17:30 UTC

Some statistics



- Mean probability to have only one, two and three or more satellite overpasses in each grid-box in 30 minutes.
- Only overpasses relative to valid Level 2 products are considered.

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H67 Overview

P-DM-PMW (**H67**) characteristics:

- Main output: 24-h mean precipitation rate
- Regular grid 0.25°x0.25°
- H SAF Extended Area (60°S-75°N, 60°W-60°E)
- 4 runs per day (00, 06, 12, 18 UTC)
- One main module → *Ensemble Mean* module

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EUMETSAT H SAF

H67 Overview

Inputs

- ***Satellites***
  - ✓ DMSP F16, F17, F18
  - ✓ MetOp A-B-C, NOAA 18-19
  - ✓ GCOM-W
  - ✓ Suomi NPP e NOAA20
  - ✓ GPM CO
- ***Product***
  - ✓ H68
- ***Variables***
  - ✓ Half-hour instantaneous precipitation rate (mmh^{-1})
  - ✓ Number of conical and cross-track satellites overpassing each pixel in the considered half hour, and their sum
- ***Data format***
  - ✓ NetCDF

Data Mean

Ensemble mean of the gridded half-hour instantaneous precipitation rate.

Outputs

- ***Product***
  - ✓ H67
- ***Variables***
  - ✓ 24 hours mean precipitation rate (mmh^{-1}) over regular grid 0.25°x0.25°
  - ✓ 24 hours maximum precipitation rate (mmh^{-1}) over regular grid 0.25°x0.25°
  - ✓ Total number of half hour intervals covered by at least one satellite overpassing each grid-box in 24 hours
  - ✓ 3-hourly number of half hour intervals covered by at least one satellite overpass
  - ✓ Quality index
- ***Data format***
  - ✓ NetCDF

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H67 Algorithm Description

Ensemble Module

- It runs four times per day to produce the mean precipitation rate relative to the previous 24 hours.
- It averages the valid precipitation rate estimates out of the 48 half-hourly outputs produced by H68 over 24 hours.

$$PR_{H67} = \frac{\sum_{i=1}^{n} PR_{H68}}{n}$$

Additional Outputs

- 24 hours maximum precipitation rate.
- Total and 3-hours number of half hours covered at least by one satellite.
- Quality index: it takes into account:
  - the number of useful half hours
  - the latitude of the grid-box
  - the position of each satellite/product based on the ranking provided in the H68 algorithm

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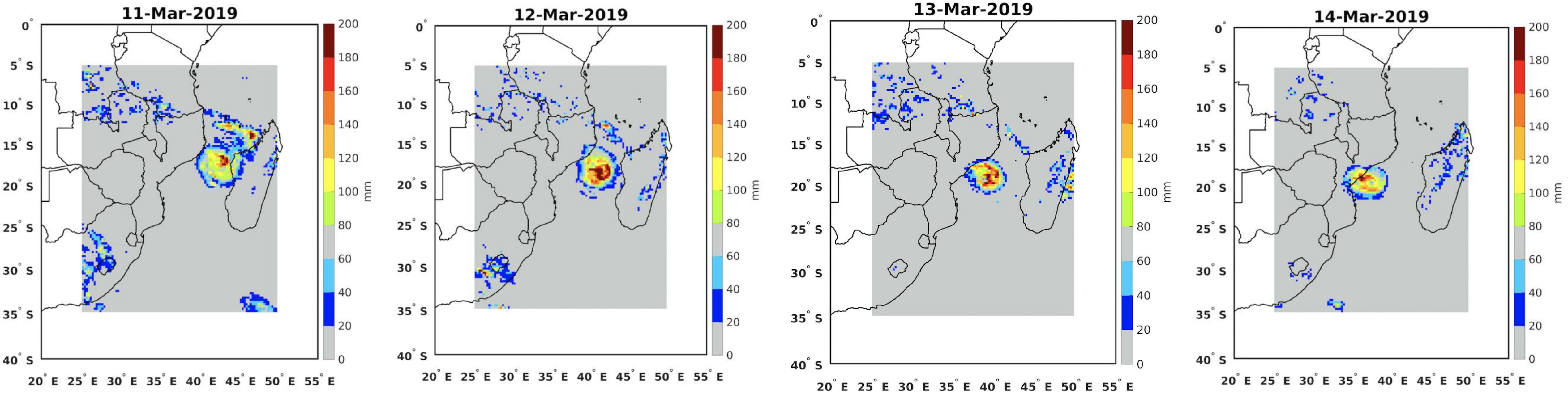
H67 – Some examples

- ***H67 is particularly recommended to monitor long lasting precipitation events.***
- ***Cyclone Idai occurred on Mozambique Channel between March 10 and March 18, 2019.***
- ***Daily evolution of accumulated precipitation.***



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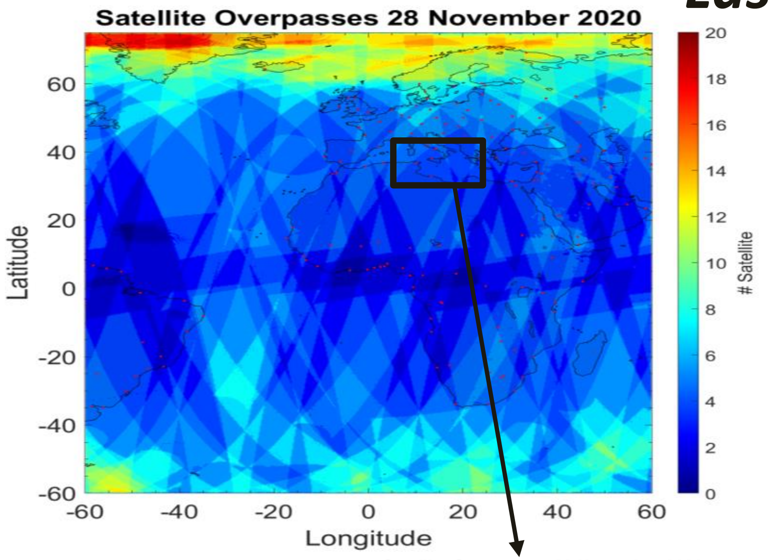
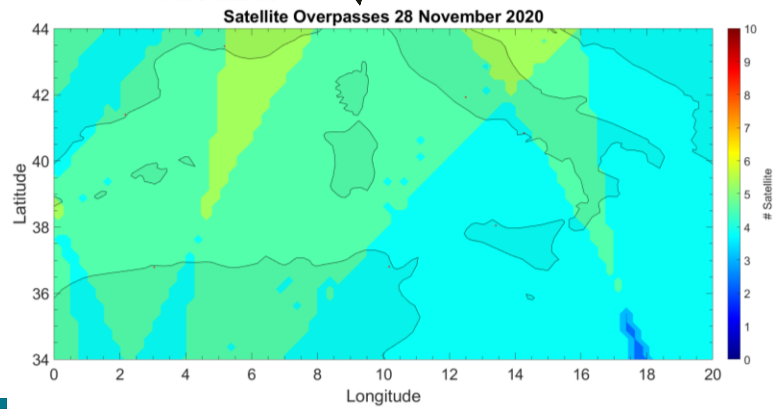
H67 – Some examples

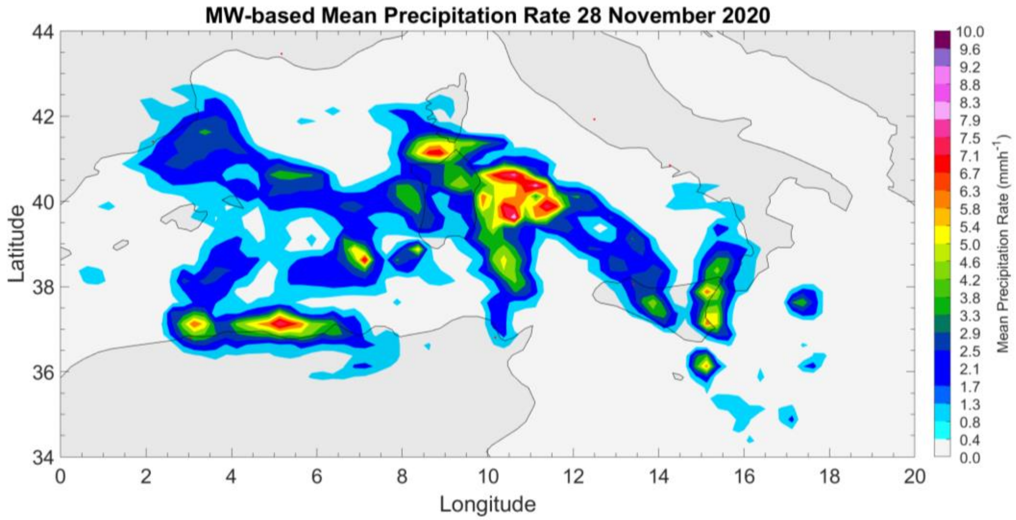
Flash flood occurred in Sardinia Last 28 November

Total Count

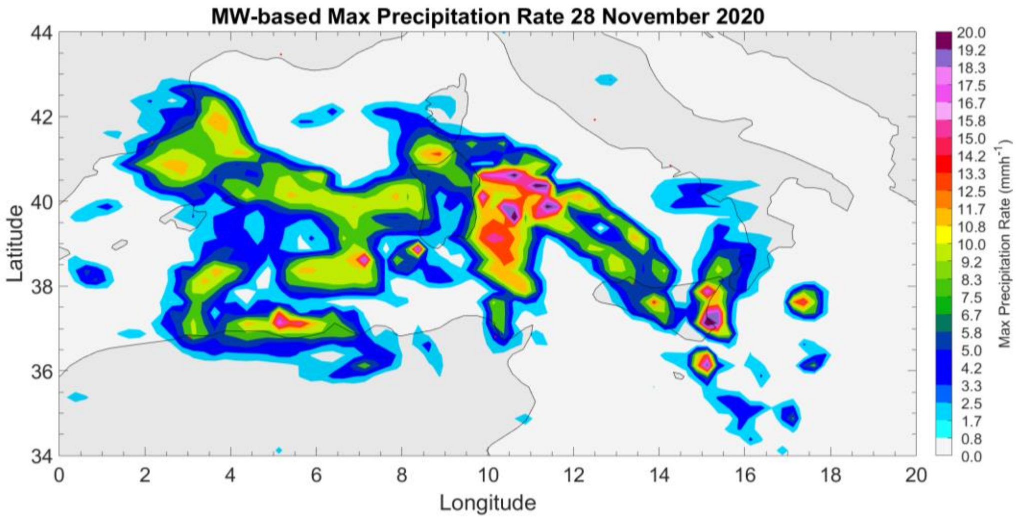




Mean Precipitation Rate



Max Precipitation Rate



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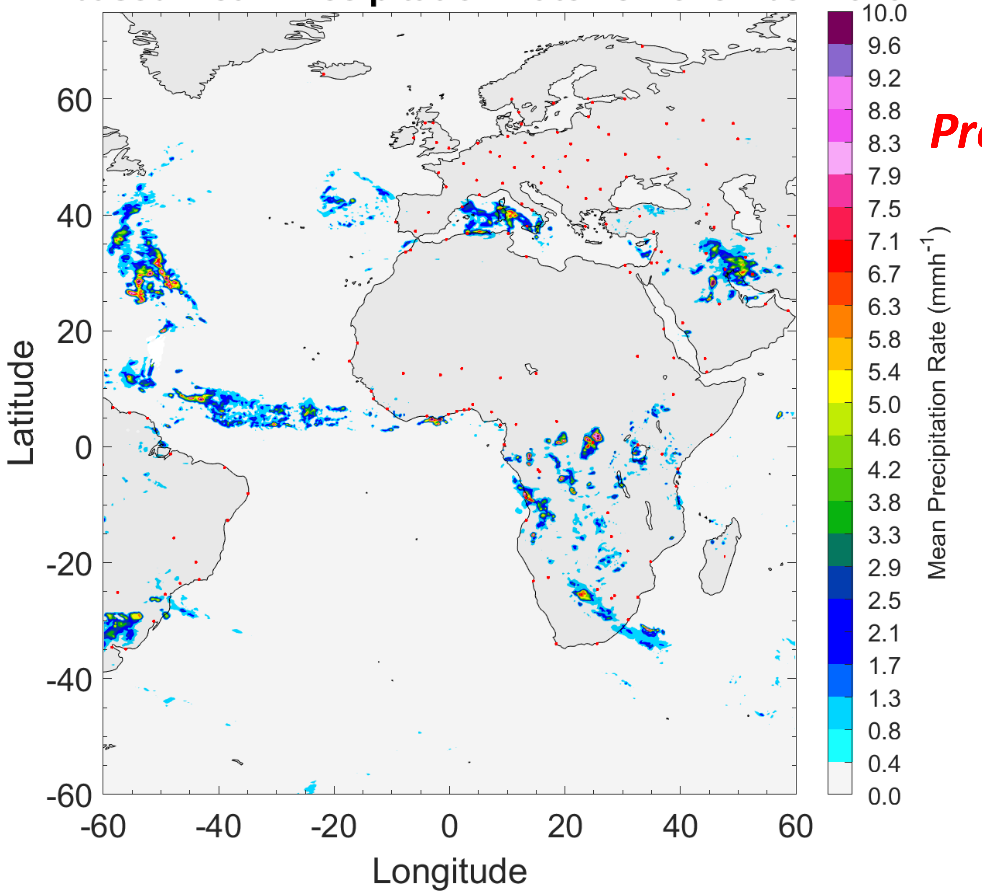
H67 – Some examples

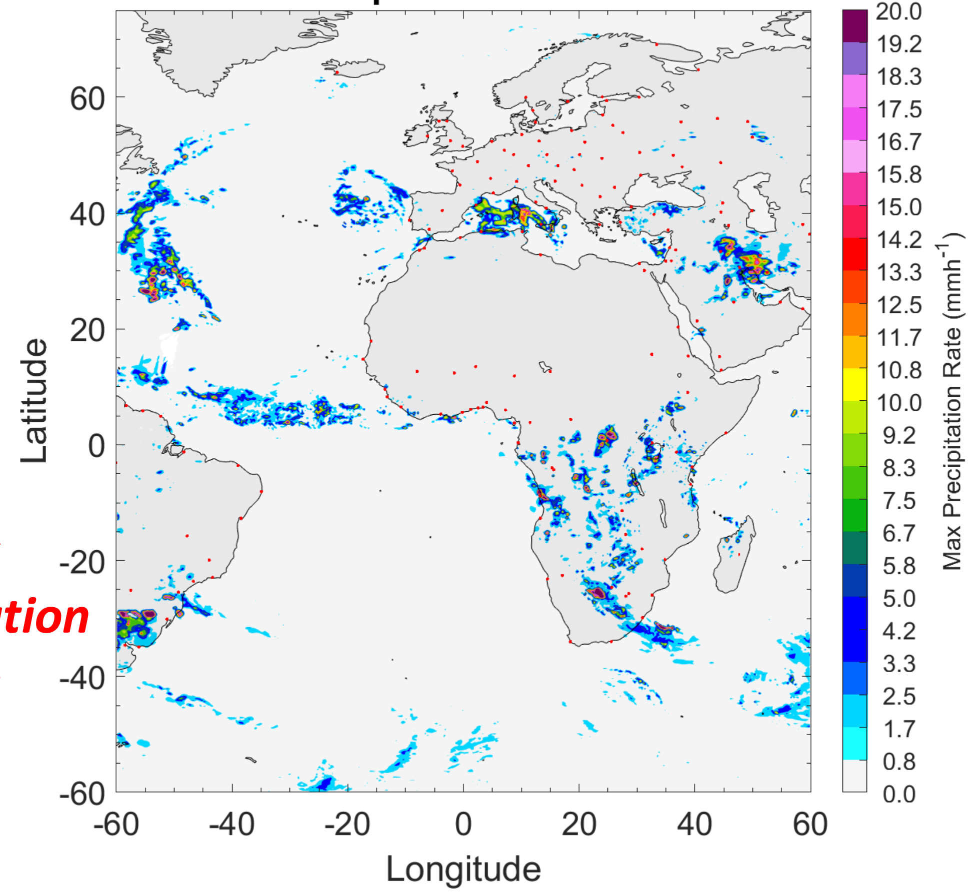
This is the precipitation estimation over the whole H SAF area for the same period

MW-based Mean Precipitation Rate 28 November 2020



Mean Precipitation Rate

MW-based Max Precipitation Rate 28 November 2020



Max Precipitation Rate

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H68 & H67 Current Status

Are H68 & H67 operational?

- Not yet.
- They are both in ***PRE-OPERATIONAL*** mode.
- It is expected to became operational in Spring/Summer 2021

- They are under EUMETSAT review process.
- Algorithm Theoretical Basis Document (ATBD) → ***Approved***
- Operational Readiness Review (ORR) → ***Spring 2021***

- *It is possible to have data of both H68 & H67 upon request.*
- We are testing H68 and H67 for some case studies.

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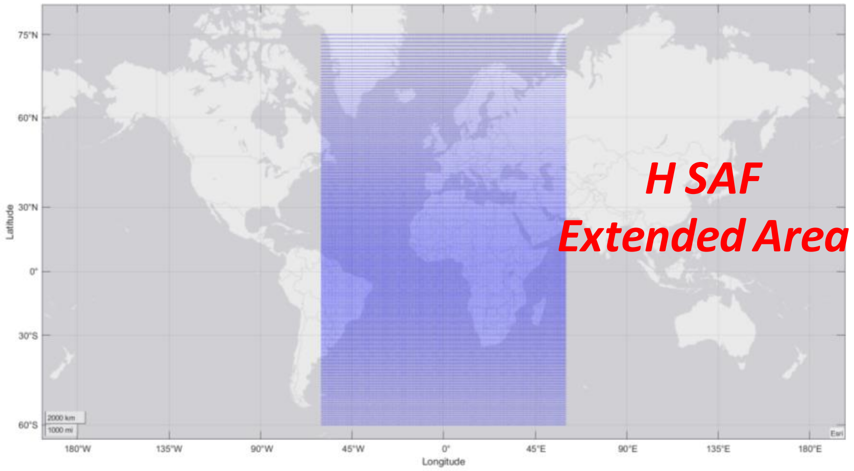
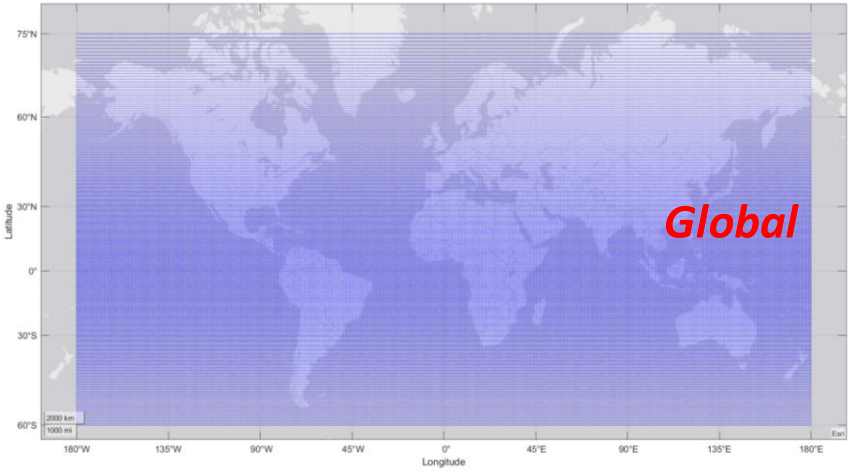
H68 & H67 Future Perspectives

What will be the evolution of H68 & H67?

1. Extension from *H SAF Extended Area* to *Global*.
2. H68 will be in input to the next day-2 MTG-based product (H45) based on Machine Learning approach (CDOP-4).
3. H67 will be in input to the Precipitation/Soil Moisture integrated product (H64). → Afternoon Session 13:00 UTC
4. The upcoming global Level 2 MW precipitation products (including EPS-SG products) will be integrated in the H68 algorithm (and, consequently, in H67).





Conical Scanning

Sensor	Satellite
MWI/ICI/MWS	**EPS-SG-B1** 2024-2045
	EPS-SG-B2 2024-2045
	EPS-SG-B3 2024-2045
AMSR-3	**GOSAT-GW** 2023-2030

Cross-track Scanning

Sensor	Satellite
ATMS	**JPSS-2** 2022-2029
	JPSS-3 2026-2033
	JPSS-4 2031-2038

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References

- 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
- 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.
- 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.
- 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.
- 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.
- P. Sanò, D. Casella, A. Mugnai, G. Schiavon, E. A. Smith and G. J. Tripoli, "Transitioning From CRD to CDRD in Bayesian Retrieval of Rainfall From Satellite Passive Microwave Measurements: Part 1. Algorithm Description and Testing," in IEEE Transactions on Geoscience and Remote Sensing, vol. 51, no. 7, pp. 4119-4143, July 2013, doi: 10.1109/TGRS.2012.2227332.

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Thanks for your attention!

For more questions and information

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