

	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 1/14</p>
---	--	---

EUMETSAT Satellite Application Facility on
Support to Operational Hydrology and Water Management





Product User Manual (PUM) **for product H61B, H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E** **Precipitation rate at ground by GEO/IR supported by LEO/MW**

Reference Number:	SAF/HSAF/PUM-61-90
Issue/Revision Index:	1.0
Last Change:	5 aug 2021

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P- AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 2/14
--	--	--



DOCUMENT CHANGE RECORD

Issue / Revision	Date	Description
1.0	05 aug 2021	First release for ORR
1.1	16 Feb. 2022	Reviewed by ORR
1.2		

 	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 3/14</p>
---	--	---

INDEX

1	Purpose of the document.....	5
2	Introduction to P-AC-SEVIRI-PMW/P-AC-SEVIRI_E products	5
2.1	Principle of sensing	5
2.2	Status of satellites and instruments	6
2.3	Highlights of the algorithm	7
2.4	Architecture of the product generation chain	8
2.5	Product coverage and appearance	8
3	Product operational characteristics	10
3.1	Horizontal resolution and sampling.....	10
3.2	Generation frequency	10
3.3	Timeliness	10
3.4	Accuracy	10
4	Product availability	11
4.1	Terms of Use	11
4.2	General Information	11
4.3	Formats and codes.....	12
4.4	Description of the files	12
4.5	Latitude and Longitude generation	14



 	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 4/14</p>
---	--	---

List of Tables

Table 1 Current status of satellites potentially utilised for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E	7
Table 2 - Multi-categorical table for product H61B – Overall validation. The precipitation classes along the columns (rows) are relative to ground (satellite) precipitation.	11
Table 3 - Multi-categorical table for product H90 in comparison with product H61 over the overlapped area. The precipitation classes along the columns (rows) are relative to H61B (H90) precipitation. 11	
Table 4 Summary instructions for accessing P-AC-SEVIRI-PMW and P-AC-SEVIRI_E data	13

List of Figures

Figure 1 P-AC-SEVIRI-PMW coverage and P-AC-SEVIRI_E coverage (from left to right, respectively).	6
Figure 2 Flow chart of generation chain.	8
Figure 3 product examples, left P-AC-SEVIRI-PMW, right P-AC-SEVIRI_E product, day 2 July 2021, time 09:00 UTC.	9

 	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 5/14</p>
---	--	---

1 Purpose of the document

Product User Manuals are available for each (pre)-operational H-SAF product, for open users, and also for demonstrational products, as necessary for *beta-users*.

Each PUM contains:


- Product introduction: principle of sensing, Satellites utilized, Instrument(s) description, Highlights of the algorithm, Architecture of the products generation chain, Product coverage and appearance;
- Main product operational characteristics: Horizontal resolution and sampling, Observing cycle and time sampling, Timeliness;
- Overview of the product validation activity: Validation strategy, Global statistics, Product characterisation;
- Basic information on product availability: Access modes, Description of the code, Description of the file structure.

2 Introduction to P-AC-SEVIRI-PMW/P-AC-SEVIRI_E products

2.1 Principle of sensing

P-AC-SEVIRI-PMW and P-AC-SEVIRI_E products are based on rainfall measurements as retrieved by blending LEO MW-derived precipitation rate measurements and GEO IR imagery. Their input data are P-IN-SEVIRI-PMW for P-AC-SEVIRI-PMW and P-IN-SEVIRI_E for P-AC-SEVIRI_E; thus, the algorithm provide a Level 3 accumulated (providing hourly the 1 hour accumulated precipitation and every six hours the 24 hour accumulated precipitation) precipitation product based on the exploitation of all available cross-track and conically scanning passive microwave radiometers, equipped with precipitation sensing channels, on board Low Earth Orbit (LEO) satellites orbiting around the globe.

Covered areas are the same as P-IN-SEVIRI-PMW and P-IN-SEVIRI_E products (figure 1).

	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 6/14</p>
---	--	---

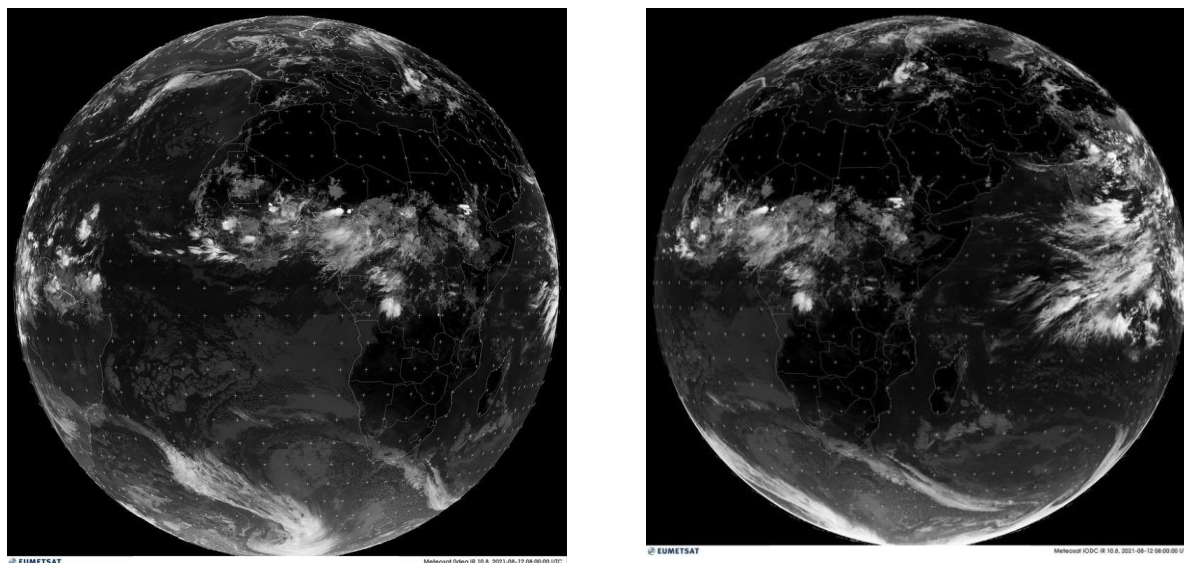




Figure 1 P-AC-SEVIRI-PMW coverage and P-AC-SEVIRI_E coverage (from left to right, respectively).

2.2 Status of satellites and instruments

The current status of the satellites possibly to be utilised for P-AC-SEVIRI-PMW and P-AC-SEVIRI_E is same as P-IN-SEVIRI-PMW and P-IN-SEVIRI_E products and it is shown in **Table 1**.

Satellite	Launch	End of service	Height	Equator Crossing Time (ECT)	Status	Instruments for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E
DMSP-F16	18 Oct 2003	2019 extended	850 km	06:20 am	Operation	SSMIS
DMSP-F17	04 Nov 2006	≥2021	850 km	06:40 am	Operation	SSMIS
DMSP-F18	18 Oct 2009	≥2021	850 km	04:50 am	Operation	SSMIS
MetOp B	17 Sep 2012	expected 2024	827 km	09:30 am	Operation	AMSU-A, MHS
MetOp C	7 Nov 2018	expected 2027	817 Km	09:30 am	Operation	AMSU-A, MHS
NPP	28 Oct 2011	≥2021	833 km	01:25 pm	Operation	ATMS
NOAA-20	18 Nov 2017	expected 2024	834 Km	01:25 pm	Operation	ATMS
GCOM-W1	18 May 2012	2020, extended	700 km	01:30 pm	Operation	AMSR2
GPM	27 Feb 2014	expected 2027	407 Km	Inclination 65 °	Operation	GMI
Satellite	Launch	End of service	Height	Lon SSP	Status	Instruments for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E
Meteosat-11	15 Jul 2015	expected 2033	GEO	0°	Operational	SEVIRI
Meteosat-10	5 Jul 2012	expected 2030	GEO	9.5° E	Operational	SEVIRI

 	<p align="center">Product User Manual -</p> <p align="center">PUM-H61-90</p> <p align="center">(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 7/14</p>
---	--	---

Satellite	Launch	End of service	Height	Equator Crossing Time (ECT)	Status	Instruments for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E
Meteosat-9	22 Dec 2005	expected 2025	GEO	3.5° E	Operational	SEVIRI
Meteosat-8	28 Aug 2002	expected 2022	GEO	41.5° E	Operational	SEVIRI

Table 1 Current status of satellites potentially utilised for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E

All mentioned sensors data, in table 1, are not directly used in the P-AC-SEVIRI-PMW and P-AC-SEVIRI_E generation chain, being products derived from P-IN-SEVIRI-PMW and P-IN-SEVIRI_E. Description can be found in ATBD of P-IN-SEVIRI-PMW and P-IN-SEVIRI_E.

2.3 Highlights of the algorithm

P-AC-SEVIRI-PMW product has been proposed as a Level 3 precipitation product, providing hourly the 1 hour accumulated precipitation and every six hours (at 00, 06, 12 and 18 UTC) the 24 hour accumulated precipitation. The accumulated precipitation rate is obtained from the H SAF product P-IN-SEVIRI-PMW instantaneous precipitation rate based on inter-calibrated Level 2 PMW instantaneous precipitation rate estimates blended with 10.8 μ m channel from SEVIRI instrument.

P-AC-SEVIRI-PMW product is an evolution of P-AC-SEVIRI product; compared to this last product, P-AC-SEVIRI-PMW considers all the available MW precipitation estimations, it provides a different treatment of convective clouds and the output is parallax corrected.

For its characteristics, the product can be well exploited for hydrological applications and for data assimilation in hydrological models and it can be easily compared to global rainfall gridded datasets (i.e., GPCP).


The P-AC-SEVIRI-PMW algorithm mainly consists of one module:

- integration module.

The basic operational algorithms for computing the cumulated precipitation relies on the assumption that:

- instantaneous derivative (the retrieved rain rate) is constant along the integration period;
- spatial resolution will be kept constant, no upscaling is performed along time integration of highest space time resolution rain rate products (IR+MW);
- one value is considered for tentative accuracy (i.e. 30 %) regardless the integration period.

Algorithm details are described in ATBD-H61B-H90.

 <p>The EUMETSAT Network of Satellite Application Facilities</p> <p>HSAF Support to Operational Hydrology and Water Management</p>	<p>Product User Manual -</p> <p>PUM-H61-90</p> <p>(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 8/14</p>
--	---	---

2.4 Architecture of the product generation chain

The architecture of the P-AC-SEVIRI-PMW and P-AC-SEVIRI_E product generation chain is shown in figure 2. With cyan colour are depicted the HSAF level 1 product based on MW instrument; H-AUX-17 and H-AUX-20 are auxiliary products based respectively on AMSR2 and GMI instrument.

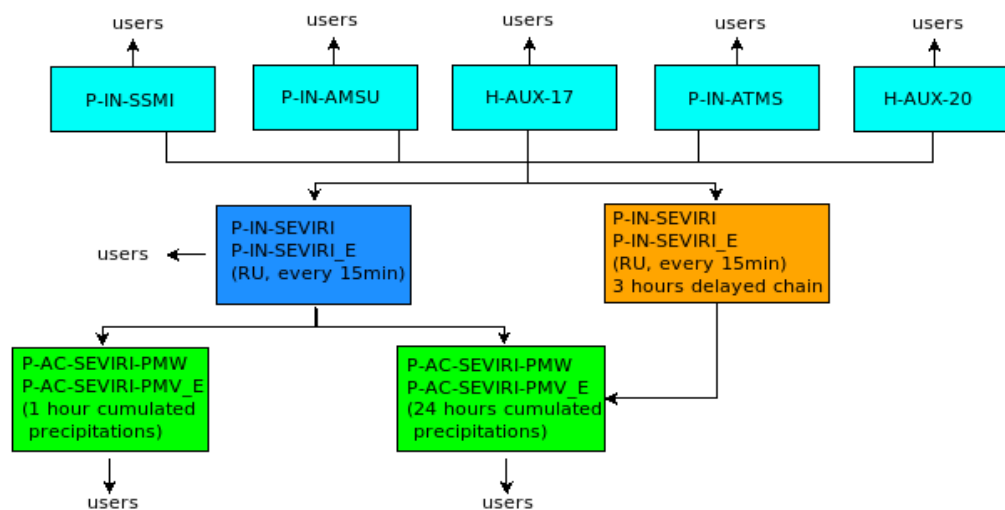


Figure 2 Flow chart of generation chain.

Final products with parallax correction are subjected to an integrity check.

The integrity check algorithm's tasks concern a series of checks performed on the output. First step is size control of output file, if less than a fixed threshold the output is moved in a failure folder.



Second control is based on identification of how many zero-value, NaN-value and rainy pixels are present in the file. These values are also compared with average values achieved by statistics over one month dataset and eventually a warning is generated.

Statistical studies are in work progress to determine the reference characteristics under which to decide whether a product should be discarded or not.

Integrity check algorithm produces a warning, recorded on log file.

2.5 Product coverage and appearance

Since data are delivered coded (in NetCDF) as values in grid points of known coordinates (those of the SEVIRI pixels), the product can be plotted in any projection of user's choice. The example of product

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P- AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 9/14
--	--	--

shown in figure 3 is in the projection actually used in the png files on the web site, *rectangular stereography centred on 42°N, 10°E*. In figure 3 is shown P-AC-SEVIRI-PMW product with 1 hour cumulated precipitation.

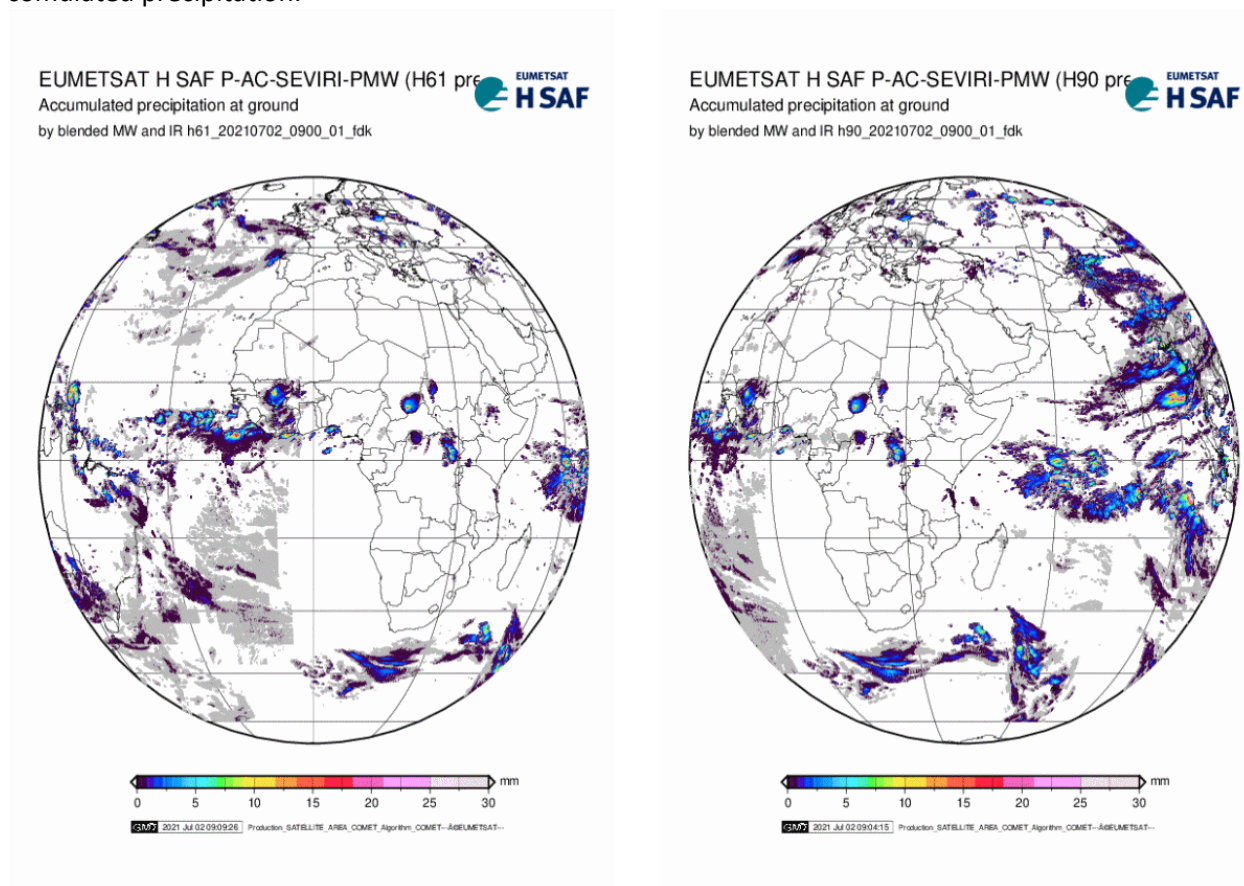




Figure 3 product examples, left P-AC-SEVIRI-PMW, right P-AC-SEVIRI_E product, day 2 July 2021, time 09:00 UTC.

As highlighted in their own PUM, P-IN-SEVIRI-PMW and P-IN-SEVIRI_E could show discontinuities at the edge of the 2.5°x2.5° in latitude and longitude box used by the algorithm to create geo-located statistical relationships between GEO and LEO products; obviously these discontinuities could be present and even more accentuated in P-AC-SEVIRI-PMW and P-AC-SEVIRI_E.

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P- AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 10/14
--	--	---

3 Product operational characteristics

3.1 Horizontal resolution and sampling

The horizontal resolution (Δx). The SEVIRI instantaneous field of view (IFOV) is 4.8 km at nadir, and it degrades moving away from nadir, becoming about 8 km over Europe. The sampling distance at the sub-satellite point is ~ 3 km. Conclusion:

- resolution $\Delta x \sim$ from 4.8 to 8 km - sampling distance: ~ 3 km at the sub-satellite point.

3.2 Generation frequency

The generation frequency is the reference time interval for calculating the cumulated precipitation. Two generation frequencies are provided: an hourly frequency for the 1 hour accumulated precipitation product, and a six hour frequency for the 24 hours accumulated precipitation.

3.3 Timeliness

The timeliness is usually defined as the time difference between end of image acquisition at satellite level and output data reception time at the end-user. Within H-SAF this definition has been adopted once the specification of EUMETCast as the main dissemination; it includes the time needed by the SAF to process the data, generate a L2 product, disseminate it to the EUMETSAT and the time for dissemination to the end users.



timeliness $\delta \sim 30$ min.

3.4 Accuracy

The accuracy, is evaluated *a-posteriori* by means of the validation activity performed with Triple Collocation methodology over Full Disk area and ground-data pixel-based comparison over Europe area.

Accuracy of H61B product ranges between threshold and target using both methodologies. Analysis highlights as H61B product shows a (negative) mean bias very close to zero, relatively high probability of detection of the precipitation, but a general trend to underestimate all precipitation classes, mainly higher accumulated classes. The inter-comparison between H61B and H90 products highlights the strong relationship between them. The very close to zero bias (-0.5 mm/24h), the very high correlation (0.92) and the excellent detection of areas with the same accumulated precipitation confirm the equality of the two products based on SEVIRI sensors, independent of their different position in longitude (0° vs 41.5° E).

The multi-categorical statistics are shown in the tables below (Tab. 2 for H61B and Tab. 3 for H90). In each table, the first column indicates the precipitation classes of the satellite product, while along the columns are reported the ground precipitation classes.

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P- AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 11/14
--	--	---

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

Table 2 - Multi-categorical table for product H61B – Overall validation. The precipitation classes along the columns (rows) are relative to ground (satellite) precipitation.

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

Table 3 - Multi-categorical table for product H90 in comparison with product H61 over the overlapped area. The precipitation classes along the columns (rows) are relative to H61B (H90) precipitation.



4 Product availability

4.1 Terms of Use

All H-SAF products are owned by EUMETSAT, and the EUMETSAT SAF Data Policy applies. All intellectual property rights of the H-SAF products belong to EUMETSAT. The use of these products is granted to every interested user, free of charge. If you wish to use these products, EUMETSAT's copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" on each of the products used.

4.2 General Information

To access the H-SAF products the user must register at the H-SAF Official Web Portal <http://hsaf.meteoam.it/> from which it is possible to access to the “H-SAF Product Download Centre”, which allows users to access data as described here following.

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 12/14
--	--	---

- 1) Access to data produced in the last 60 days must be made by the Official H-SAF FTP server <ftp://ftphsaf.meteoam.it> (to obtain user and password, please submit registration form on H-SAF Official Web Portal or contact the help desk at us_hsaf@meteoam.it) and via EUMETCAST, a multi-service dissemination system based on standard Digital Video Broadcast (DVB) technology (for more information <http://www.eumetsat.int/>).
- 2) Request for data older than 60 days can be done using the form request in the web site <https://hsaf.meteoam.it/>. The orders placed will be submitted for approval and will be delivered within three working days.

Finally, quick-looks of the latest about 20 maps can be viewed as PNG images or as an animated slideshow on the H-SAF Web Portal.

4.3 Formats and codes



Two type of files are provided for P-AC-SEVIRI-PMW/P-AC-SEVIRI_E:

- the digital data, coded in NetCDF
- the image-like maps, coded in PNG

4.4 Description of the files

P-IN-SEVIRI-PMW and P-IN-SEVIRI_E products are also identified as H60 and H63. The table 2 below shows the detailed information to access the product using the H-SAF FTP server (<ftp://ftphsaf.meteoam.it>).

P-AC-SEVIRI-PMW and P-AC-SEVIRI_E Data	
Repository root directory	ftp://ftphsaf.meteoam.it/products/h61 and ftp://ftphsaf.meteoam.it/products/h90
Sub-repository	/h61_cur_mon_data , /h90_cur_mon_data / (data of last 60 days)
File name	h61_yyyymmdd_hhMM_fdk.nc.gz and h90_yyyymmdd_hhMM_fdk.nc.gz Namespace description <ul style="list-style-type: none"> • yyyymmdd: year, month, day • hhMM: hour and minute Suffix for Digital Data: “.nc.gz” (compressed NetCDF file)
Examples	ftp://ftphsaf.meteoam.it/products/h61/h61_cur_mon_data/h61_20210601_1300_01_fdk.nc.gz ftp://ftphsaf.meteoam.it/products/h90/h90_cur_mon_data/h90_20210601_1300_01_fdk.nc.gz
P-AC-SEVIRI-PMW and P-AC-SEVIRI_E Image Data	

  HSAF Support to Operational Hydrology and Water Management	Product User Manual - PUM-H61-90 (Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)	Doc.No: SAF/HSAF/PUM-61-90 Issue/Revision Index: Date: 05 aug 2021 Page: 13/14
--	--	---

Repository root directory	ftp://ftphsaf.meteoam.it/products/h61 and ftp://ftphsaf.meteoam.it/products/h90
Sub-repository	/h61_cur_mon_png/ , /h90_cur_mon_png/ (data of last 60 days)
File name	h60_yyyymmdd_hhMM_fdk.png and h63_yyyymmdd_hhMM_fdk.png Namespace description: same as for nc.gz files Suffix for Image Data: “.png” (image data file)
Examples	ftp://ftphsaf.meteoam.it/products/h61/h61_cur_mon_png/h61_20210601_1300_01_fdk.png ftp://ftphsaf.meteoam.it/products/h61/h61_cur_mon_png/h61_20210601_1300_01_fdk.png

Table 4 Summary instructions for accessing P-AC-SEVIRI-PMW and P-AC-SEVIRI_E data

An example of nc file is shown; there are 2 variables float, rainfall rate and pixel quality index. In parallax correction section mode-on indicates that correction is occurred and data were sufficient for correction. Sometimes it happens that the CTTN data is not enough to apply the correction, in that case mode_off will be in parallax_correction section.

dimensions:

yc = 3712;

xc = 3712;

variables:

double acc_rr(xc=3712, yc=3712);

:long_name = "accumulated_precipitation_(combined_microwave-IR)_estimate";

:units = "mm";

:coordinates = "lon lat";

:_ChunkSizes = 619U, 619U; // uint

double qind(xc=3712, yc=3712);

:long_name = "pixel_quality_index";

:range = "[0 100]";

:coordinates = "lon lat";

:_ChunkSizes = 619U, 619U; // uint

// global attributes:

:hsaf61_algorithm_version = "2.0";

:parallax_correction = "Mode_on";



:sub-satellite_longitude = " 0.0f";

:satellite_altitude = "35785831";

:satellite_altitude_unit = "m";

:r_eq = "6378.169000";

:r_eq_unit = "Km";

 	<p>Product User Manual -</p> <p>PUM-H61-90</p> <p>(Product H61/H90 – P-AC-SEVIRI-PMW/P-AC-SEVIRI_E)</p>	<p>Doc.No: SAF/HSAF/PUM-61-90</p> <p>Issue/Revision Index:</p> <p>Date: 05 aug 2021</p> <p>Page: 14/14</p>
---	---	--

```
:r_pol = "6356.583800";
:r_pol_unit = "Km";
:cgms_projection = "+proj=geos +coff=1856.000000 +cfac=13642337.000000 +loff=1856.000000
+lfac=13642337.000000 +spp= 0.000000 +r_eq=6378.169000 +r_pol=6356.583800 +h=42164.000000";
:gdal_projection = "+proj=geos +a=6378169.000000 +b=6356583.800000 +lon_0= 0.000000 +h=35785831.000000
+sweep=y";
:accumulation_time = "01";
:accumulation_time_unit = "hours";
:end_of_accumulation_time = "20210601T13:00Z";
}
```

4.5 Latitude and Longitude generation

Geographic latitude and longitude coordinates are not present within the NetCDF files, but the metadata contain all parameters to calculate them.

In ftp://ftphsaf.meteoam.it/products/utilities/matlab_code/ files and code are available to simplify and speed up the calculation.

The files **lat_lon_0.nc** and **lat_lon_41.nc** include latitude and longitude in float variables, to be appended to the **.nc** files using **ncks** utility.

The matlab codes are utilities to calculate latitude and longitude directly by reading the metadata of NetCDF file. The code is fast and effective, usually faster than running **ncks** utility. Since Meteosat-9 is expected to move over Indian Ocean by 2022, the code gives higher flexibility than fixed **.nc** files. The code currently works on Matlab version 2019b.