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



Product User Manual (PUM) **for product H60B, H63/P-IN-SEVIRI-PMW, P-IN-SEVIRI_E**



Precipitation rate at ground by GEO/IR supported by LEO/MW

Reference Number:	SAF/HSAF/PUM-60-63
Issue/Revision Index:	1.0
Last Change:	5 Aug. 2021

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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		

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1 Purpose of the document

Product User Manuals are available for each (pre)-operational H-SAF product for open users and 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 products P-IN-SEVIRI-PMW and P-IN-SEVIRI_E

2.1 Principle of sensing

P-IN-SEVIRI-PMW and P-IN-SEVIRI_E (precipitation rate at ground by GEO/IR supported by LEO/MW) are based on the IR images from the SEVIRI instrument on-board Meteosat Second Generation (MSG) satellites blended with all the available precipitation MW estimates (PMW). There is no difference in the algorithm used for these products (even if the availability of PMW could be different); they differ only in the geographical coverage. The spatial coverage of P-IN-SEVIRI-PMW product includes the H SAF area (Europe and Mediterranean basin), Africa and Southern Atlantic Ocean, while the spatial coverage of the P-IN-SEVIRI_E product corresponds to the MSG IODC Full Disk and it includes the Mediterranean basin, Africa, Middle East, and Indian Ocean. Both products are provided on the MSG SEVIRI grid, at the 15-min imaging rate of SEVIRI, and the spatial resolution is consistent with the SEVIRI pixel (3 km at nadir).

The processing method adopted for both products is called “Rapid Update” (RU). Following this technique, the precipitation estimates are obtained by combining IR GEO equivalent blackbody temperatures (TB) at 10.8 μm with rain rates (RR) from Precipitation Micro-Wave (PMW) measurements. Algorithm, described in sect.3.2, is based on a collection of time and space overlapping of both GEO IR imagers and Low Earth Orbit (LEO) PMW sensors (actually SSMIS, MHS, AMSR-2, ATMS, and GMI) overpasses. Such a collection consists of a look up table of geolocated relationships of rain rate vs TB, updated as soon as new overlapping GEO IR and LEO PMW overpasses (i.e. products P-IN-

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SSMIS, P-IN-MHS, P-IN-ATMS, H-AUX-17, etc.) are available (Mugnai et al., 2013b, Casella et al., 2013, Sanò et al., 2013, Sanò et al., 2015, Sanò et al., 2016, Casella et al., 2017).

Precipitation estimation of both P-IN-SEVIRI-PMW and P-IN-SEVIRI_E products is based on the heritage of P-IN-SEVIRI (H03B) rain retrieval and P-IN-SEVIRI-CO (H15B), being the latter specific for convective clouds only. Indeed, H60B production chain identifies convective areas and computes a different RR-TB relationship by distinguish between convective and stratiform clouds (see Sect. 3 for more details). The convective areas are identified with the automatic tool for nowcasting applications NEFODINA (Melfi et al., 2012) explained in Sect. 3.3, which runs at COMet (Centro Operativo per la Meteorologia).

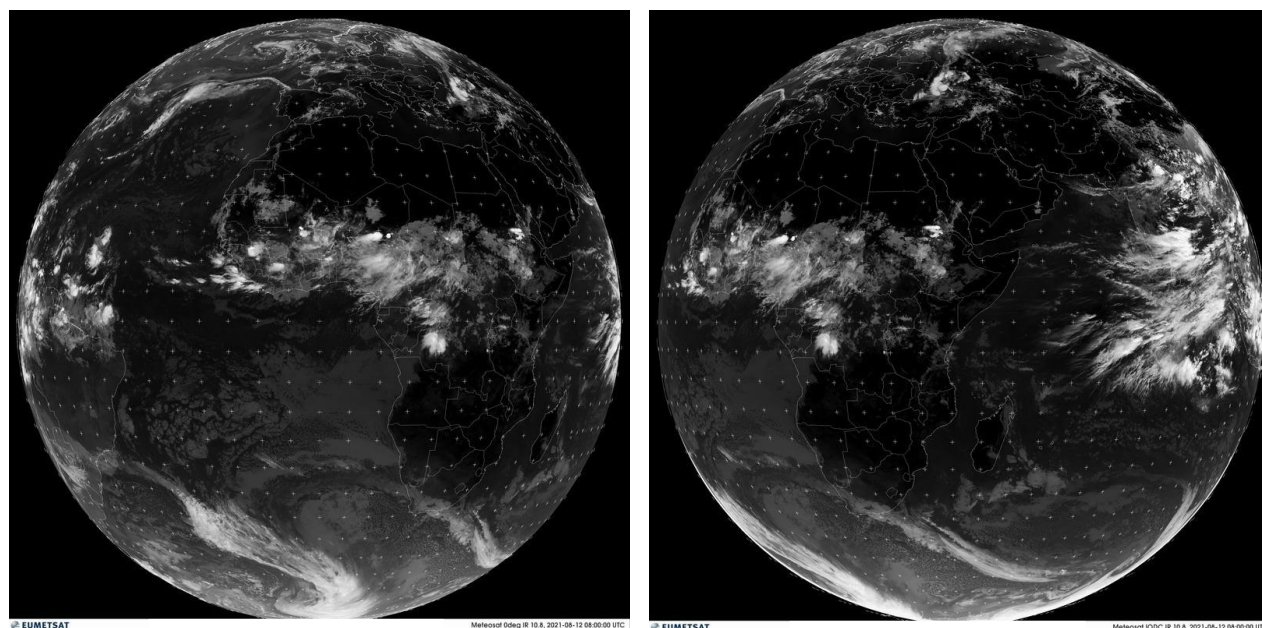




Figure 1 P-IN-SEVIRI-PMW (left) coverage and P-IN-SEVIRI_E (right) coverage P-IN-SEVIRI-PMW (left) coverage and P-IN-SEVIRI_E (right) coverage

2.2 Status of satellites and instruments

The current status of the satellites possibly to be utilised for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E is shown in **Table 01**. These products do not retrieve precipitation from MW sensors, but MW-derived precipitation data come from SSMIS (utilised by P-IN-SSMIS), MHS (utilised by P-IN-MHS), AMSR2 (utilised by PR-OBS-17), ATMS (utilised by P-IN-ATMS) and GMI (utilised by PR-OBS-20).

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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
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



SSMIS, MHS, ATMS, AMSR and GMI are not directly entered in the P-IN-SEVIRI-PMW and P-IN-SEVIRI_E generation chain, thus are not described here. Descriptions of their algorithms can be found in the relative Product User Manuals.

2.3 Highlights of the algorithm

The baseline algorithm for P-IN-SEVIRI-PMW and P-IN-SEVIRI_E processing is described in ATBD. Only essential elements are highlighted here.

P-IN-SEVIRI-PMW and P-IN-SEVIRI_E implement different way to calculate stratiform and convective precipitations.

Rainy pixel of PMW radiometer orbital grid is processed differently depending on whether rainfall is convective or stratiform. The choice of one or the other case depends on the convection file obtained by combining the information deriving from both the NEFODINA SW output and the SEVIRI-MSG file containing the Channel 9 (10.8 μm) TB (K). When a PMW radiometer's file is selected, a cycle is

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performed on the number of pixels, searching the coincidence between TB from IR radiometer and rainfall estimates from PMW radiometer based on both the geographical coordinates and time.

When the coincidence has been found, firstly, the number of pixels of SEVIRI-MSG belonging to the selected PMW radiometer's one is identified. Therefore, if more than one pixel of the SEVIRI grid has been found, those referring to convective rain are counted (according to the NEFODINA software).

In that case, a factor f is calculated depending on both the overall area of the convective pixels and their number in the following way:

$$f = \frac{N^2}{A}$$

where N is the number of SEVIRI-MSG pixels and A is overall convective area in the PMR radiometer one. Then, f is utilized to correct the PMW radiometer's rainfall estimates, being the latter multiplied by the factor. However, PMW radiometer's estimates are corrected for convective case only if f is greater or equal than 1 (Antonelli P. 2007 : "Refinement and operational implementation of a rain rate algorithm based on AMSU/MHS and rain gauge data over H-SAF area").

If none of the SEVIRI pixels related to the same PMW IFOV is labelled as convective, the rain is considered as produced by stratiform clouds and the rainfall estimation is not corrected with the proposed method.



The processing is done by the Rapid-Update algorithm, using NEFODINA data if available.

The main inputs to the RU procedure are:

- geo-located equivalent blackbody temperatures (T_{BB}) observed by the GEO platform;
- rain-rate maps that, in principle, can arise from any satellite-based MW data and algorithm;
- observation geometry (satellite zenith angle).

The package can be subdivided into four main parts, namely:

- 1) pre-processing: preparation and pre-processing of GEO data; ingest of rain rate maps at the LEO space-time resolution. To allow for the proper initialization of the statistical relationships the input data must be collected for a time window that start several hours before the study period. According to the present constellation of MW-equipped satellites, the parameter MAXHOURS is currently set to 24 h;
- 2) co-location: co-located GEO and LEO observations are collected for the selected study area and accumulated from newest to oldest;
- 3) set-up of geo-located statistical relationships applying the probability matching technique;

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- 4) assign rain rate to each GEO pixel: production of rain-rate maps at the GEO space-time resolution.

It should be highlighted that the statistical relationship mentioned at point 3 are calculated in 2.5°x2.5° in latitude and longitude, for this reason it could be happened to see discontinuities at the edge of these box due to possible different co-locations.

NEFODINA consists of seven main modules:

- cloud-cluster detection;
- selection of all the potential COs inside the cloud cluster using a varying threshold method in the IR imagery;
- continuity test between the objects detected in the last two slots;
- discrimination of the objects as already detected or first detections;
- calculation of CO parameters in the IR, WV1 and WV2 imagery;
- identification of active COs using dynamic thresholds applied to IR, WV1 and WV2 features depending on the parental relationship results;
- evaluation of their convective phase.

Once the rain rate has been estimated in each pixel of the SEVIRI grid a methodology to correct the parallax error is applied. Parallax correction is needed to best detect the high cloud top features in satellite imagery having an impact on the satellite-derived products. Parallax effect depends on the cloud top height, the geographical location of the cloud on the ground, and the position of the satellite. The algorithm processes as input both the RR estimates from PMW radiometer and the cloud top temperature and height (CTTH).

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2.4 Architecture of the products generation chain

The architecture of the P-IN-SEVIRI-PMW and P-IN-SEVIRI_E product generation chain is shown in figure below.

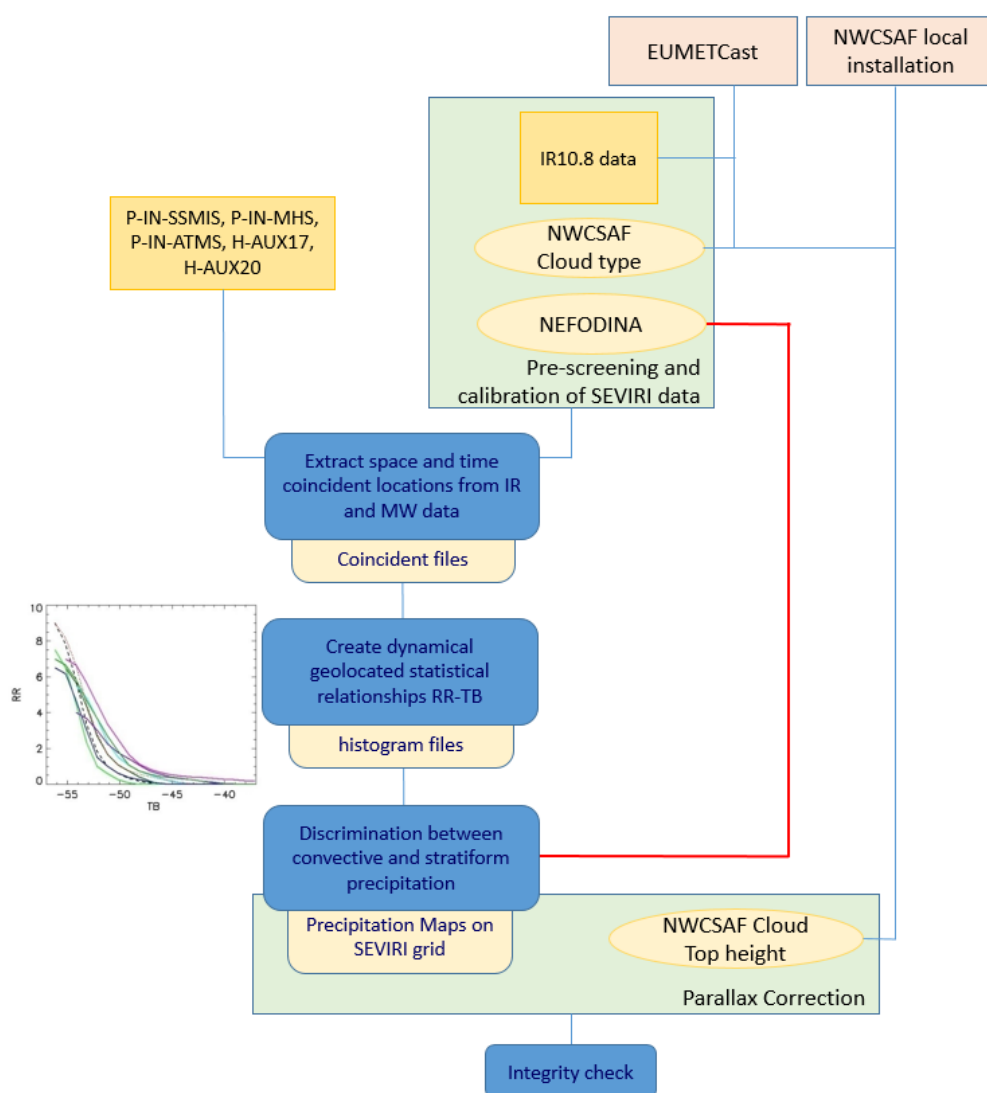




Figure 2 Flow chart of generation chain

Since LEO data have a delayed availability, the procedure in near real time cannot run with all relevant data. To allow the chain for having these data, the procedure is repeated three hours later.

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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

Figure 3 shows the SEVIRI images in the P-IN-SEVIRI-PMW product processing area (Meteosat at 0 degrees) and in the P-IN-SEVIRI_E product area (Meteosat at 41.5 degrees). The input area includes 3712 rows x 3712 columns.

Since data in NetCDF format, 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.

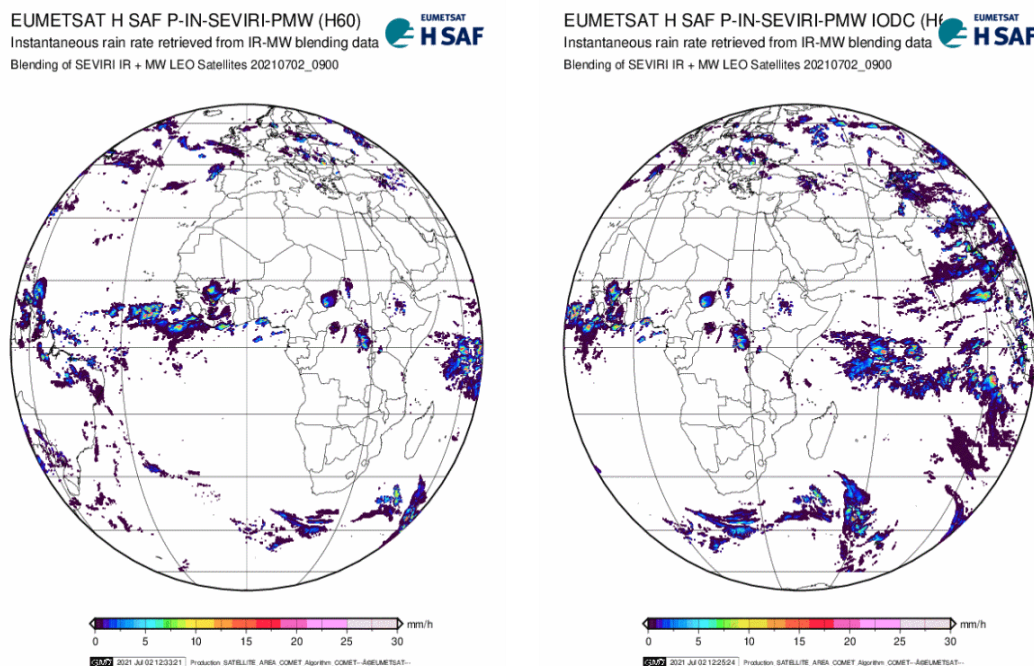




Figure 3 product examples, left P-IN-SEVIRI-PMW, right P-IN-SEVIRI_E, day 2 July 2021, time 09:00 UTC.

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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 Observing cycle and time sampling

The observing cycle (Δt). It is defined as the average time interval between two measurements over the same area. In the case of P-IN-SEVIRI-PMW the product is generated soon after each SEVIRI new acquisition. Thus:

- observing cycle $\Delta t = 15$ min - sampling time: 15 min.

3.3 Timeliness

The timeliness (δ).

- a. timeliness $\delta \sim 15$ min.

3.4 Accuracy

The accuracy is evaluated *a-posteriori* by means of the validation activity. See the related PVR (Product Validation Report) for details.

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 <https://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.

- 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-

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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-IN-SEVIRI-PMW and P-IN-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 H60B and H63. The table 3 below shows the detailed information to access the product using the H-SAF FTP server (<ftp://ftphsaf.meteoam.it>).

P-IN-SEVIRI-PMW and P-IN-SEVIRI_E Data	
Repository root directory	ftp://ftphsaf.meteoam.it/products/h60 and ftp://ftphsaf.meteoam.it/products/h63
Sub-repository	/h60_cur_mon_data/ , /h63_cur_mon_data/ (data of last 60 days)
File name	h60_yyyymmdd_hhMM_fdk.nc.gz and h63_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/h60/h60B_cur_mon_data/h60_20210528_0915_fdk.nc.gz z ftp://ftphsaf.meteoam.it/products/h63/h63_cur_mon_data/h63_20210528_0915_fdk.nc.gz
P-IN-SEVIRI-PMW and P-IN-SEVIRI_E Image Data	

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Repository root directory	ftp://ftphsaf.meteoam.it/products/h60 and ftp://ftphsaf.meteoam.it/products/h63
Sub-repository	/h60_cur_mon.png/ , /h63_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/h60/h60_cur_mon_data/h60_20210528_0915_fdk.png ftp://ftphsaf.meteoam.it/products/h63/h63_cur_mon_data/h63_20210528_0915_fdk.png

Table 2 Summary instructions for accessing P-IN-SEVIRI-PMW and P-IN-SEVIRI_E data

An example of NetCDF file metadata is shown; there are two 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 CTH data is not enough to apply the correction, in that case mode_off will be in parallax_correction section.

```

dimensions:
y = 3712;
x = 3712;
variables:
float rr(x=3712, y=3712);
:units = "mm/h";
:long_name = "rain rate";
:coordinates = "lon lat";
:_ChunkSizes = 928U, 928U; // uint

```

```



float qind(x=3712, y=3712);
:range = "[0 100]";
:long_name = "pixel quality index";
:coordinates = "lon lat";
:_ChunkSizes = 928U, 928U; // uint

```

```

// global attributes:
:hsaf60_algorithm_version = "2.0";
:parallax_correction = "Mode_on";
:satellite_identifier = "MSG4";
:sub-satellite_longitude = " 0.0f";
:satellite_altitude = "35785831";
:satellite_altitude_unit = "m";
:r_eq = "6378.169000";

```

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```
:r_eq_unit = "Km";
: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";
}
```

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.