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

Algorithm Theoretical Baseline Document (ATBD) for product H15A – PR-OBS-6A

Blended SEVIRI Convection area/ LEO MW Convective Precipitation

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DOCUMENT CHANGE RECORD

Issue / Revision	Date	Description
1.0	16/05/2011	Version prepared for PCR
1.1	30/09/2011	Baselined, acknowledging PCR Review Board comments: • Table of accuracies added (section 2.3) • Availability of the Algorithm description updated (section 4) • Applicable Document List added
1.2	10/3/2015	Updated version prepared as reference for ORR1 Part 5

Algorithm Theoretical Baseline Document ATBD-15A
Product PR-OBS-6A
Blended SEVIRI Convection area/ LEO MW Convective Precipitation

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Acronyms

AMSU	Advanced Microwave Sounding Unit (on NOAA and MetOp)
AMSU-A	Advanced Microwave Sounding Unit - A (on NOAA and MetOp)
AMSU-B	Advanced Microwave Sounding Unit - B (on NOAA up to 17)
ATDD	Algorithms Theoretical Definition Document
AU	Anadolu University (in Turkey)
BfG	Bundesanstalt für Gewässerkunde (in Germany)
CAF	Central Application Facility (of EUMETSAT)
CDOP	Continuous Development-Operations Phase
CESBIO	Centre d'Etudes Spatiales de la BIOsphere (of CNRS, in France)
CM-SAF	SAF on Climate Monitoring
CNMCA	Centro Nazionale di Meteorologia e Climatologia Aeronautica (in Italy)
CNR	Consiglio Nazionale delle Ricerche (of Italy)
CNRS	Centre Nationale de la Recherche Scientifique (of France)
DMSP	Defense Meteorological Satellite Program
DPC	Dipartimento Protezione Civile (of Italy)
EARS	EUMETSAT Advanced Retransmission Service
ECMWF	European Centre for Medium-range Weather Forecasts
EDC	EUMETSAT Data Centre, previously known as U-MARF
EUM	Short for EUMETSAT
EUMETCast	EUMETSAT's Broadcast System for Environmental Data
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FMI	Finnish Meteorological Institute
FTP	File Transfer Protocol
GEO	Geostationary Earth Orbit
GRAS-SAF	SAF on GRAS Meteorology
HDF	Hierarchical Data Format
HRV	High Resolution Visible (one SEVIRI channel)
H-SAF	SAF on Support to Operational Hydrology and Water Management
IDL©	Interactive Data Language
IFOV	Instantaneous Field Of View
IMWM	Institute of Meteorology and Water Management (in Poland)
IPF	Institut für Photogrammetrie und Fernerkundung (of TU-Wien, in Austria)
IPWG	International Precipitation Working Group
IR	Infra Red
IRM	Institut Royal Météorologique (of Belgium) (alternative of RMI)
ISAC	Istituto di Scienze dell'Atmosfera e del Clima (of CNR, Italy)
ITU	İstanbul Technical University (in Turkey)
LATMOS	Laboratoire Atmosphères, Milieux, Observations Spatiales (of CNRS, in France)
LEO	Low Earth Orbit
LSA-SAF	SAF on Land Surface Analysis
Météo France	National Meteorological Service of France
METU	Middle East Technical University (in Turkey)
MHS	Microwave Humidity Sounder (on NOAA 18 and 19, and on MetOp)
MSG	Meteosat Second Generation (Meteosat 8, 9, 10, 11)
MVIRI	Meteosat Visible and Infra Red Imager (on Meteosat up to 7)
MW	Micro Wave
NESDIS	National Environmental Satellite, Data and Information Services
NMA	National Meteorological Administration (of Romania)
NOAA	National Oceanic and Atmospheric Administration (Agency and satellite)
NWC-SAF	SAF in support to Nowcasting & Very Short Range Forecasting
NWP	Numerical Weather Prediction
NWP-SAF	SAF on Numerical Weather Prediction
O3M-SAF	SAF on Ozone and Atmospheric Chemistry Monitoring
OMSZ	Hungarian Meteorological Service
ORR	Operations Readiness Review
OSI-SAF	SAF on Ocean and Sea Ice
PDF	Probability Density Function

PEHRPP	Pilot Evaluation of High Resolution Precipitation Products
Pixel	Picture element
PMW	Passive Micro-Wave
PP	Project Plan
PR	Precipitation Radar (on TRMM)
PUM	Product User Manual
PVR	Product Validation Report
RMI	Royal Meteorological Institute (of Belgium) (alternative of IRM)
RR	Rain Rate
RU	Rapid Update
SAF	Satellite Application Facility
SEVIRI	Spinning Enhanced Visible and Infra-Red Imager (on Meteosat from 8 onwards)
SHMÚ	Slovak Hydro-Meteorological Institute
SSM/I	Special Sensor Microwave / Imager (on DMSP up to F-15)
SSMIS	Special Sensor Microwave Imager/Sounder (on DMSP starting with S-16)
SYKE	Suomen ympäristökeskus (Finnish Environment Institute)
T_{BB}	Equivalent Blackbody Temperature (used for IR)
TKK	Teknillinen korkeakoulu (Helsinki University of Technology)
TMI	TRMM Microwave Imager (on TRMM)
TRMM	Tropical Rainfall Measuring Mission UKMO
TSMS	Turkish State Meteorological Service
TU-Wien	Technische Universität Wien (in Austria)
U-MARF	Unified Meteorological Archive and Retrieval Facility
UniFe	University of Ferrara (in Italy)
URD	User Requirements Document
UTC	Universal Coordinated Time
VIS	Visible
ZAMG	Zentralanstalt für Meteorologie und Geodynamik (of Austria)

1 Introduction to product H15A - PR-OBS-6A

1.1 Sensing principle

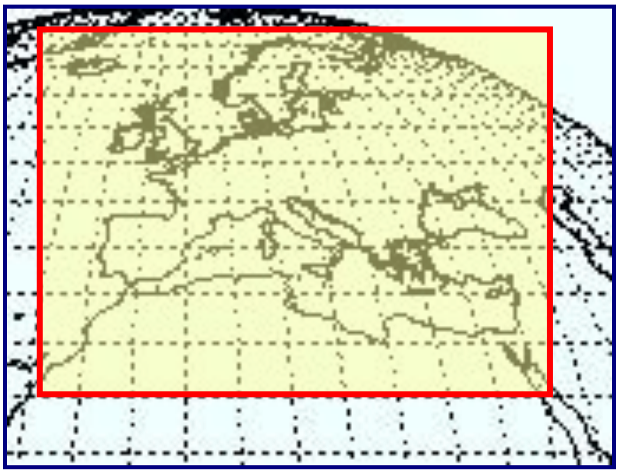


Fig. 03 - The H-SAF required coverage in the Meteosat projection.

Product PR-OBS-6A (Blended SEVIRI Convection area/ LEO MW Convective Precipitation) is based on the SEVIRI instrument onboard Meteosat Second Generation satellites. The whole H-SAF area is covered (see ***Fig. 03***), but the resolution degrades with increasing latitude.. An objective analysis of the equivalent blackbody temperatures (T_{BB}) is implemented to detect the convective structures of cloudy areas, by means of NEFODINA, an automatic tool running at CNMCA dedicated to now-casting applications. A map of convective clouds is performed to combine precipitation fields from MW channels. The product is generated accordingly SEVIRI acquisition time plus a delay of few minutes. The delay is in the range of 3 to 5 minutes with a potential maximum of 10, after end of reception of whole disk SEVIRI data at CNMCA. Processing duration is principally dominated by convection identification algorithm. The more is HSAF area affected by convection areas the more is processing time to analyze the whole scene. The SEVIRI channels utilised for convective area identification are 6.2, 7.3 and 10.8 μm. The calibration of T_{BB} in terms of precipitation rate by means of MW measurements, as reconstructed in PR-OBS-1 and PR-OBS-2A, implies the existence of good correlation between behaviour of T_{BB} and precipitation rate in case of convection phenomena. PR-OBS-6 assigns precipitation to SEVIRI pixels after the convection filtering via an algorithm that remap PR-OBS-1 and PR-OBS-2A estimation, in reason of the dynamical behaviour of clouds, to a new rain field. Being connected only with convective systems this rain fields is no more only a lookup of latest SEVIRI acquisition but has inside the capacity to diagnose clouds, individuating ones vertically changing, and to prolong rain precipitation in the dissipating phase of convection systems,

contributing adequately to accumulated precipitation (product PR-OBS-5A). For more information, please refer to the Products User Manual (specifically, PUM-15A).

1.2 Main operational characteristics

Main operational characteristics are connected with the identification of convection and the association of MW retrieved rain rate present in the same area with only active SEVIRI pixels, this by recomposing rain intensity that the system as in input from PR-OBS-1 and PR-OBS-2A towards the only part of clouds that NEFODINA individuate in the growing, mature and dissipating convective cell. While PR-OBS-3B performs a rain lookup of SEVIRI image, without any connection to preceding SEVIRI image that permit to classify cloud status and behaviour, with PR-OBS-6A there the possibility to observe principally heavy shower of rain connected with vertical development of thunderstorm clouds.

1.3 Architecture of the products generation chain

The operational characteristics of PR-OBS-6A are discussed in PUM-15A. Here are the main highlights.

The horizontal resolution (Δx). The IFOV of SEVIRI images is 4.8 km at nadir, and degrades moving away from nadir ending at about 8 km. For this reason the PR-OBS-6A resolution is variable in the range between ~ 3 km and ~ 8 km so a sampling is made at ~ 5 km intervals, consistent with the SEVIRI pixel. Summarizing:

- resolution Δx: 3 km - ~ 8 km - sampling distance: ~ 5 km.

The *observing cycle (Δt)* is defined as the average time interval between two measurements over the same area. In the case of PR-OBS-6A the product is generated soon after each SEVIRI new acquisition, Thus:

- observing cycle Δt = 15 min - sampling time: 15 min.

The *timeliness (δ)*. For PR-OBS-6A, the time of observation is 1-5 min before each quarter of an hour, ending at the full hour. To this, ~ 5 min have to be added for acquisition through EUMETCast and ~ 5 min for processing at CNMCA, thus:

- timeliness δ ~ 15 min.

The *accuracy* is defined into phases: in the first phase, for this document, the accuracy values which have been agreed into the PRD and PRT for the product H03B are adopted:

Product	Accuracy (RMS)				Resolution Δx (km)	Cycle Δt (h)			Timeliness δ (h)		
	Unit	thresh	target	optimal		thresh	target	optimal	thresh	target	optimal
PR-OBS-6	%(>10 mm/h)	90	80	25		0.25	0.25	0.25	0.50	0.25	0.17
	%(1-10 mm/h)	120	105	50	Sampling: ~ 5 km	SEVIRI cycle			Driven by processing		
	%(<1 mm/h)	N/A	N/A	N/A	(controlled by GEO/IR pixel)	(all images processed)			(trade off with accuracy)		

Then, in the second phase, the former values will be updated considering the performance obtained by the continuous validation activity provided by the Validation Cluster and reported into the Product Validation Report PVR-15A.
The architecture of the PR-OBS-6A product generation chain is shown in the **Fig. 4**.

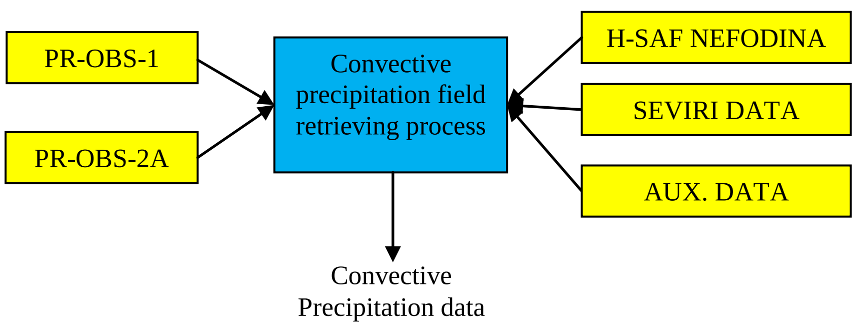


Fig. 4 PR-OBS-6A production chain architecture

The logical model above represents a schematic description of the PR-OBS-6A product chain architecture. This also represents the product context diagram by identification of inputs, outputs and application processes. It includes:

- PR-OBS-1, PR-OBS-2A, H-SAF dedicated NEFODINA data, SEVIRI raw image at 10.8 μm and auxiliary data (e.g. cloud type and cloud top height) as inputs. PR-OBS-1 microwave products are available with a delay of three hours as input of a second processing chain;
  - "Convective precipitation field retrieving process" able to decode PR-OBS-1 and PR-OBS-2A, retrieve suitable NEFODINA information, calculate the convective precipitation associated to NEFODINA Convective Objects,
  - "Convective Precipitation data" as processing output in terms of maps and encode data (GRIB2).

In the architecture of PR-OBS-6A production chain are also included (not shown in the **Fig. 4**) data archiving and dissemination functions and log of events module in order to verify the SW performance.

1.4 Product development team

Names and references of the main participants for PR-OBS-6A algorithm development and integration are listed in following table:

Centro Nazionale di Meteorologia e Climatologia Aeronautica (**CNMCA**)	Italy	Francesco Zauli (leader)	f.zauli@meteoam.it
		Davide Melfi	d.melfi@meteoam.it
		Daniele Biron	d.biron@meteoam.it
GEO-K	Italy	Matteo Picchiani	matteo.picchiani@geok.it

Table 1: Development team for product PR-OBS-6A

2 Processing concept

The PR-OBS-6A product is based on the product PR-OBS-1 and PR-OBS-2A and NEFODINA with the extended coverage shown in figure 3. The idea to match PMW map and a convective tool is based on study implemented during the Development Phase with the Visiting Scientist number 33, carried out by Antonelli P. in collaboration with CNMCA and DPC.

The fields of precipitation are retrieved directly from HSAF components, instead the convective areas are identified with NEFODINA, an automatic tool running at CNMCA dedicated to nowcasting applications. It allows the automatic detection and classification of convective cloud systems and the monitoring of their lifecycles. NEFODINA algorithm uses multispectral information from SEVIRI channels at 10.8, 6.2 and 7.3 µm in order to detect and monitor convective processes and relies on the high temporal repeat cycle of the Meteosat Second Generation (MSG) satellite. Information coming from infrared window at 10.8 µm and water vapour absorption bands (at 6.2µm and 7.3 µm) is statistically combined in NEFODINA to create an accurate detection and tracking procedure for Convective Objects (CO). Then NEFODINA moves the attention from pixels to objects (object oriented).

The algorithm classifies and groups neighbouring SEVIRI field of view that shows convective characteristics (Puca S. et al. 2003a, b, c; Puca S. et al. 2004a, b; Puca S. et al. 2005, Melfi D. 2012). Based on the hypothesis that deep convective clusters are associated with local rapid horizontal variation of cloud volume and WV content, it is possible to classify a collection of pixels as convective by looking for temporal variations in cloud top temperatures seen in IR at 10.8 μm, and for changes in WV content seen in the 6.2 μm and at 7.3 μm channels. The IR channel provides cloud top temperature and morphology, while WV channels provide information on the spatial distribution of the WV content in the neighbouring cloud-free area and above the cloud.

NEFODINA produces images that identify detected cells, their development, and their movement (**Fig. 5**). These output images are associated to ASCII files which contain quantitative information of the IR1, WV1 and WV2 channels BTs along with CO shape, slope index (spatial BT gradient), CO area and CO mean and minimum BTs.

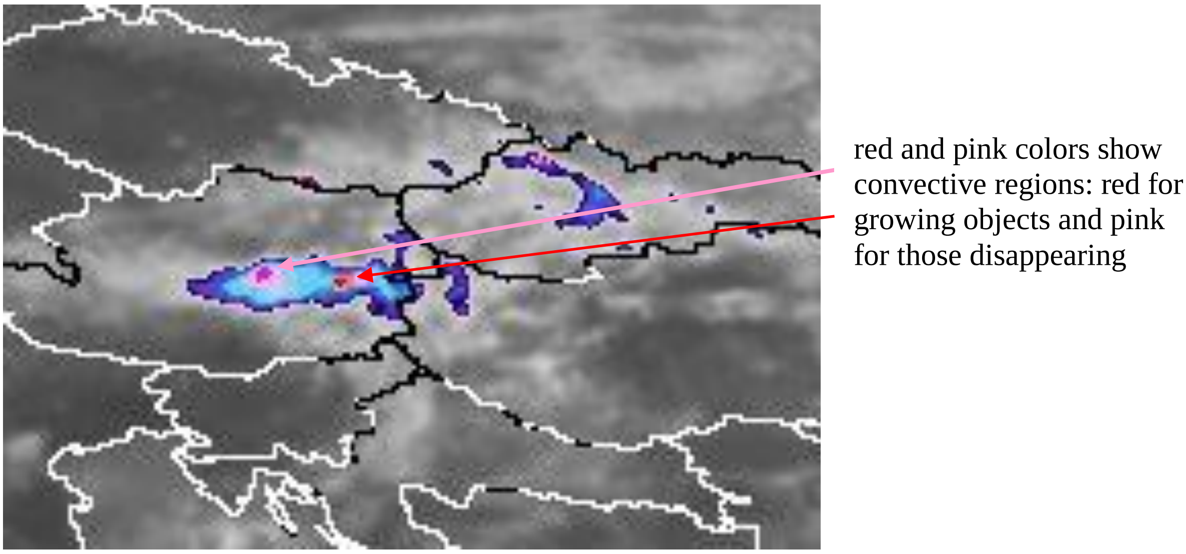


Fig. 5 Example of NEFODINA image detected objects

NEFODINA consists of seven main modules:

1. cloud-cluster detection;
2. selection of all the potential COs inside the cloud cluster using a varying threshold method in the IR1 imagery;
3. continuity test between the objects detected in the last two slots;
4. discrimination of the objects as already detected or first detections;
5. calculation of CO parameters in the IR1, WV1 and WV2 imagery;
6. identification of active COs using dynamic thresholds applied to IR1, WV1 and WV2 features depending on the parental relationship results;
7. evaluation of their convective phase.

The presence of convective objects is described in the NEFODINA textual output on the H-SAF area. The following picture (**Fig. 6**) shows an example of NEFODINA maps over the H-SAH area.

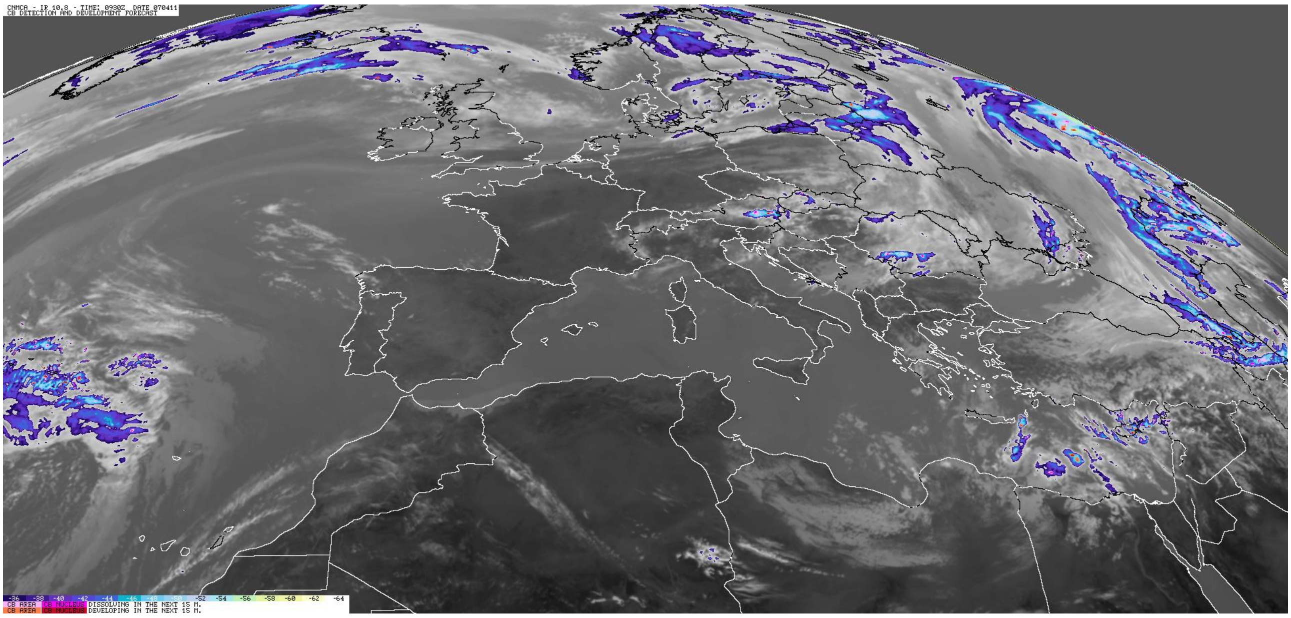


Fig. 6 Example of NEFODINA image detected objects, on the H-SAF area.

The combination of convective objects detection and precipitation fields derived from MW observation started with the Visiting Scientist n. 33 during the Development Phase: “Refinement and operational implementation of a rain rate algorithm based on AMSU/MHS and rain gauge data over H-SAF area”. In that study was combined the precipitation field retrieved from the PC algorithm developed within NWC-SAF (see Bennartz 2005) with the numerical information computed by NEFODINA.

The choice of PC algorithm was based on pre-operational software availability, the knowledge of performance characteristics over a quite large part of H-SAF area (North Europe) and that AMSU channels are more sensitive to heavy rainfall. At the start of VS activity PR-OBS-1 and PR-OBS-2A algorithms were not mature to permit the use of their outputs in the investigation for a combined MW precipitation and convection area identification. Therefore was decided to extend the PC algorithm outputs to the whole H-SAF area, in particular for testing and validation of VS algorithm over Italy. AMSU data from NOAA15,16, 17 and 18 were archived starting Feb 1st 2006. The precipitation observations from radar and rain gauges were collected for a selection of Italian convective cases and up scaling and down scaling algorithms were developed to compare precipitation ground-based observations with PC algorithm retrievals and SEVIRI products. This study has shown a relation between precipitation estimates derived by PC and NEFODINA Convective Objects. In Figure 7 a merging between rain rate from PC and Convective Objects retrieved from NEFODINA is presented.

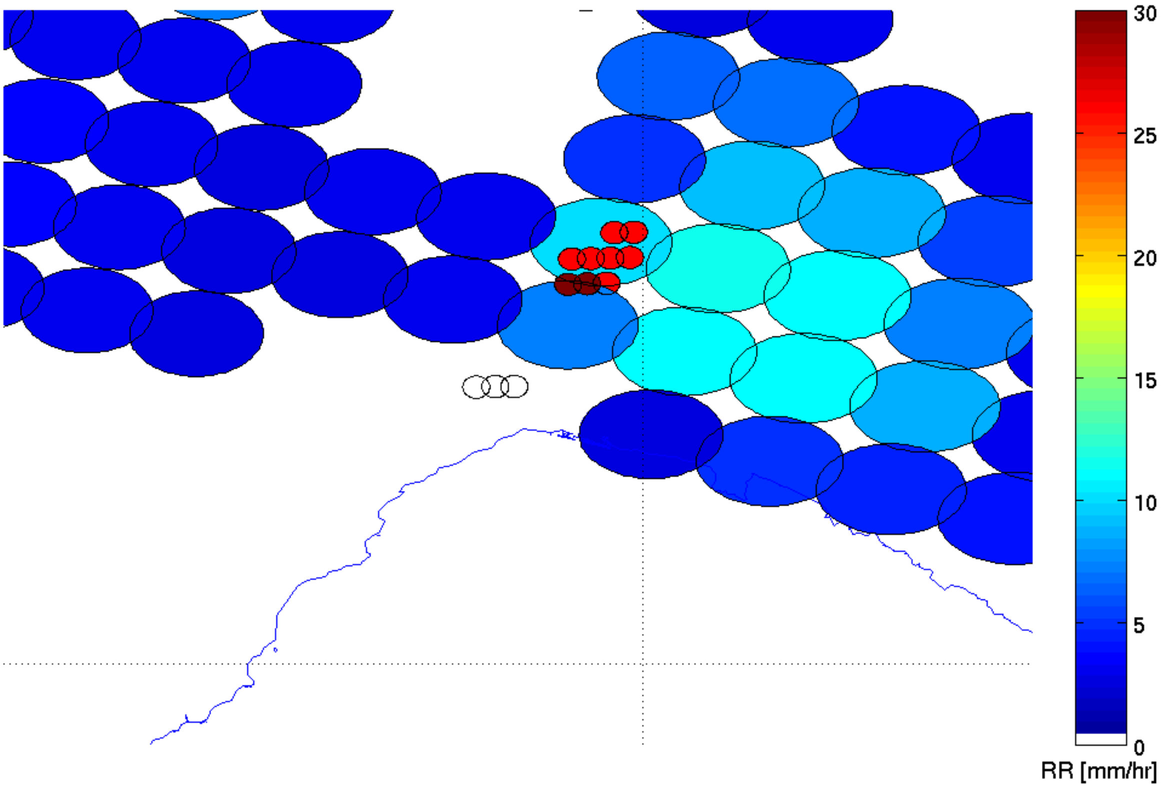


Fig. 7 PC weighted average on AMSU native grid at 01 : 52 UTC and on SEVIRI FOVs.

The co-location of Convective Objects on the precipitation fields is an explanation of methodology employed to define the convective rain. The idea is to identify the convective systems in the scene and to confine the precipitation of rainy AMSU FOV only in the portion of FOV affected by convection.
Under the assumption that most of the precipitation occurs in the highly convective region, NEFODINA provides relevant information about the distribution of precipitation within the AMSU FOV. For the case in Fig. 7 convection cell detected by NEFODINA has a mean precipitation of 47 mm/h while radar provides a value of about 42 mm/h. In this study NEFODINA was proved to be an ideal source of information to infer convective status of clouds, with information on the development stage, in coupling with a MW precipitation measurement, and VS results opened the way of merging geostationary and polar orbiting products focusing on convective systems.

3 Algorithms description

The following Sections describe the algorithms used in the various modules of the products generation chain. The degree of detail is consistent with the requirement of a manageable document. Detailed algorithm descriptions are available within the H-SAF project at the site:

***http://hsaf.meteoam.it/* ⇒ User Documents**

or sending a request to:

us_hsaf@meteoam.it

3.1 The Processing chain

The PR-OBS-6A convective precipitation field production chain starts with a new NEFODINA output on the H-SAF area, with individuated areas of convection. MW rain measurements are continuously stored in a appropriate input folder every time a new PR-OBS-1 or PR-OBS-2B is produced.
10.8 µm SEVIRI data, the same acquisition slot NEFODINA refers to, enters a filtering algorithm that leave as output only SEVIRI pixels belonging Convective Object (CO) individuated by NEFODINA with flags (growing or dissipating stages).
This new masked 10.8 µm SEVIRI image, enters a coincident algorithm that associates PR-OBS-1 or PR-OBS2B observations with SEVIRI T_{BB}, confining the precipitation of rainy MW FOV only in the portion of FOV affected by convection.
Once association of convection rain intensity and T_{BB} is computed, it is stored together with convection cell maturity stage and dimensional characteristics as a reference for similar Convective Object in the surrounding. That collection of convection rain intensity and T_{BB} couples is the reference database for assignment of rain intensity to all NEFODINA CO present in the H-SAF area, by comparison in maturity stage and cell characteristics and extrapolation in time and geographical distances, parameters that vary principally with season, latitude, orography map, land/sea mask.
The final output of the processing chain is a map in SEVIRI grid of precipitation rain rate (mm/h), encoded in GRIB2 format.
PR-OBS-1 products are available in the H-SAF operative chain at least 3 hr after the observation time. For this reason some problems may occurs in the refresh of the coincidence association of the PR-OBS-1 or PR-OBS2 observations with SEVIRI T_{BB}. Therefore to ensure that the maximum number of PR-OBS1 products are available before to compute the statistical relationships between microwave and SEVIRI data a delayed control of the availabe PR-OBS-1 is implemented in a parallel operational chain with a delay of 3 hours.

3.2 The Processing steps

PR-OBS-6 SW package comprises Fortran and Matlab programs, scripts, and include auxiliary files as seasonal and latitude configuration file, orography map, land/sea mask.

The SW inputs, are:

- PR-OBS-1.
- PR-OBS-2A.
- NEFODINA CO data.
- Auxiliary files.

The SW outputs are:

- Maps of precipitation rain rate (graphical format).
- Precipitation rain rate maps encoded in GRIB2 format.

The main functions (described in **Fig. 9**) are:

- PR-OBS-1 and PR-OBS-2A data (in BUFR format) decoding and extraction.
- NEFODINA run and data extraction (over over H-SAF area).
- Association between NEFODINA CO and MW retrieved precipitation rain rate.
- Application of calibration coefficients derived from a statistical analysis applied to a dataset on Europe areas, that will increase during the CDOP2 phase.
- Parralx correction by means of EUMETSAT - Cloud Top Height (CTH) product.
- Quality control and writing of qualiy flag (provided beside the product in the same GRIB2 file).
- Precipitation rain rate maps, both in graphical and numerical (GRIB2) format.

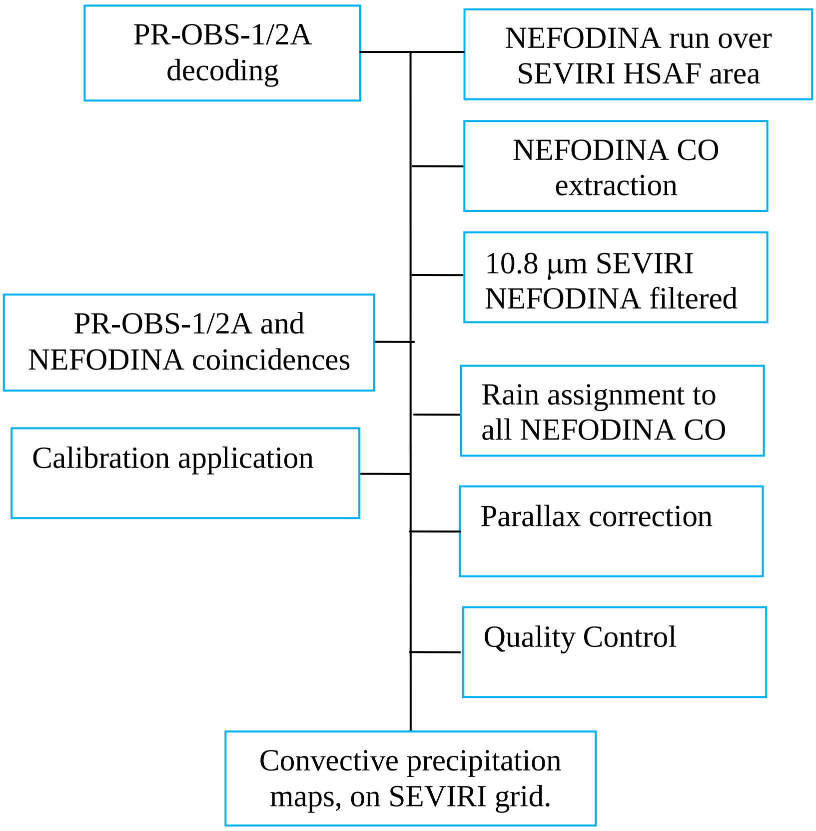


Fig. 9 SW package main functions

The steps from the decoding of PR-OBS-1/2A to the rain assignment to all NEFODINA CO, representing the PR-OBS-6A algorithm core, were already described in the previous section 3. The calibration step is achieved applying the calibration formula developed by the solution of a regularization problem aimed to minimize the difference between the PR-OBS-6A rain rates and the rain rates measured by radar on a statistically significant dataset over the HSAF area. It has been shown as the calibration step allowing to increase the performance of the PR-OBS6 algorithm.
The parallax correction is implemented using the EUMETSAT - Cloud Top Height (CTH) product figure 10) and applying the EUMETSAT formulation to reduce the parallax error on SEVIRI data.

The generation of the quality flag is based on two main aspects:

1. **Quality of the precipitation products H01 and H02A (QF_{mw}).** The quality of the product is linked to the quality of the PMW rainfall estimation input to the algorithm and it is derived from the quality of the PR-OBS-1/2B products.
2. **Monitoring the H01 and H02A flux timeliness (QF_{time}).** This factor is computed considering the time difference between the last PMW sensor overpass and the currently processing MSG slot (Δt) and it is defined as $QF_{time} = \exp(-\Delta t/t_{limit})$, With $t_{limit} = 5\text{h}$.

These two factors are weighted to obtain the quality flag of PR-OBS6B product depending on Δt:

$$QF \begin{cases} 0.5\ (QF_{time} + QF_{mw}) & \text{for } \Delta t \le t_{limit} \\ 2/3\ QF_{time} + 1/3\ QF_{mw} & \text{for } \Delta t > t_{limit} \text{ and } \Delta t \le 2\,t_{limit} \\ QF_{time} & \text{for } \Delta t > 2\,t_{limit} \text{ With } t_{limit} = 5\text{h} \end{cases}$$

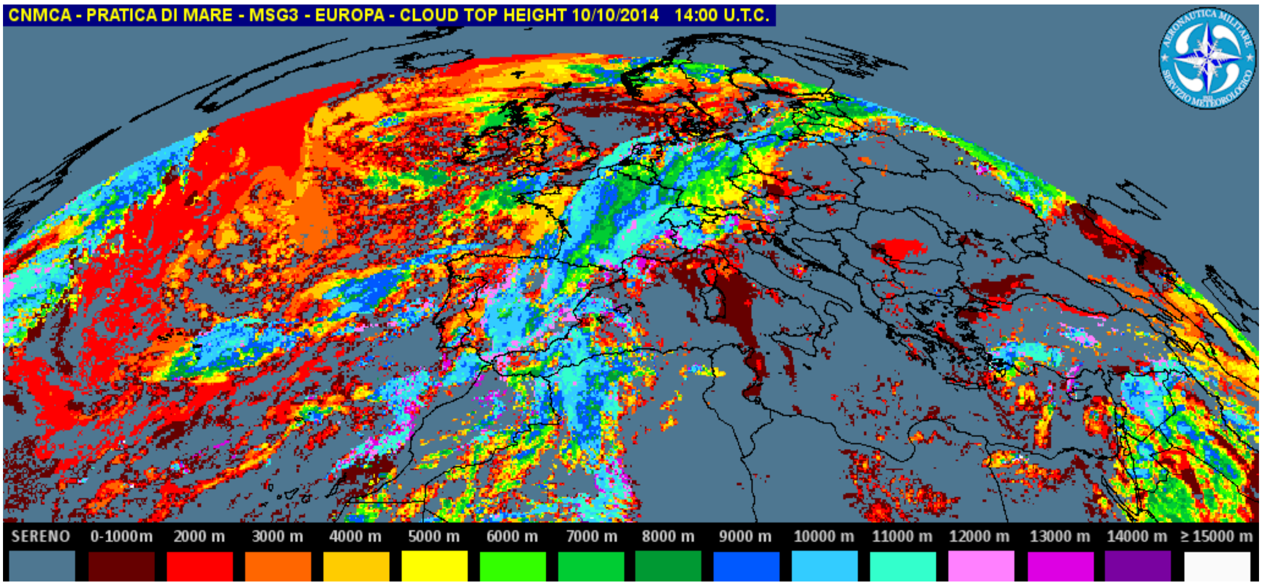


Fig. 10 Example of cloud type height product.

3.3 Further developments

Developments are foreseen with the introduction in the SAF of new products listed in table 1. In particular the product derived from the Water vapour Strong Lines at 183 GHz (183-WSL) algorithm (Laviola and Levizzani, 2009, 2011) planned as product H-21 (PR-OBS-9). The algorithm uses the five channels of the Advanced Microwave Sounding Unit-B (AMSU-B) and of the Microwave Humidity Sounder (MHS) to delineate precipitating areas and retrieve precipitation intensities based upon a radar calibration. The algorithm is designed to identify convective and stratiform rain areas on the basis of the scattering properties of the growing of ice crystals in the cold part of clouds. The growth of the ice hydrometeors as a consequence of the cloud convective vertical development uniquely and distinctively depresses the upwelling radiation at 150 GHz that combined with scattering evaluated at 89 GHz can be used to distinguish frozen cloud cores (scattering index approach). To further reinforce the robustness of the scattering index approach in the identification of cold clouds the properties of the AMSU-B/MHS opaque channels can be used to assess the altitude of cloud top and evaluate the convective development stage.

Moreover, the algorithm identifies water vapour-loaded areas as well as those sectors surrounding convective cloud system where newly developed droplets are fed into the convection.

The synergy between PR-OBS-6A and the microphysical characterization of the 183-WSL will help the identification of the convective cloud cores during their development and next evolution. Laviola et al. (2011) have shown the potential of the approach by investigating two heavy rain events over the Central Mediterranean.

Furthermore, the 183-WSL contains a module to be incorporated into the H22 (PR-OBS-10) product that discriminates between wet and dry snow cover on the ground and in perspective will address the delineation of snowfall areas and the estimate of snowfall intensity (Levizzani et al., 2011). In this sense the microphysical characterization of the 183-WSL will contribute to improve the characterization of convective clouds, especially in the cold season. The increase of Precipitation maps retrieved from new instruments (H-17 and H-18) will reduce the time difference between the last PMW sensor overpass with positive benefits on precipitation structures identification. More benefits on the performance will be waited on the CDOP-3 when an harmonization of different PMW maps will be implemented.

3.4 The Algorithm validation

To evaluate the satellite precipitation product accuracy a Validation Group has been established by the beginning of the Validation Phase in the H-SAF project. The Precipitation Product Validation team is composed of experts from the National Meteorological and Hydrological Institutes of Belgium, Bulgaria, Germany, Hungary, Italy, Poland, Slovakia, and Turkey. Hydrologists, meteorologists, and precipitation ground data experts, coming from these countries are involved in the product validation activities. The results of activities are described in a specific document Product Validation Report for each product of precipitation cluster.

The strategy of validation will be the same of H03 taking in account the results of dedicated studies performed by the working group about the convective precipitation. Some results available since the end of CDOP1 are used in the CDOP-2 to tune the product. The validation activity and reprocessing data set will continue during CDOP-2 and CDOP-3 ,. In CDOP-2 the near real time validation of the product is performed and published on the H-SAF web page.

4 Examples of PR-OBS-6A product and associated input information.

The following figure (**Fig 11**) shows the instantaneous precipitation rain rate resulting from MW scan in PR-OBS-2B for the last two time-slots available for the computation of the PR-OBS-6A product of 2015-02-02 12:12 UTC; similar maps are available from PR-OBS-1.

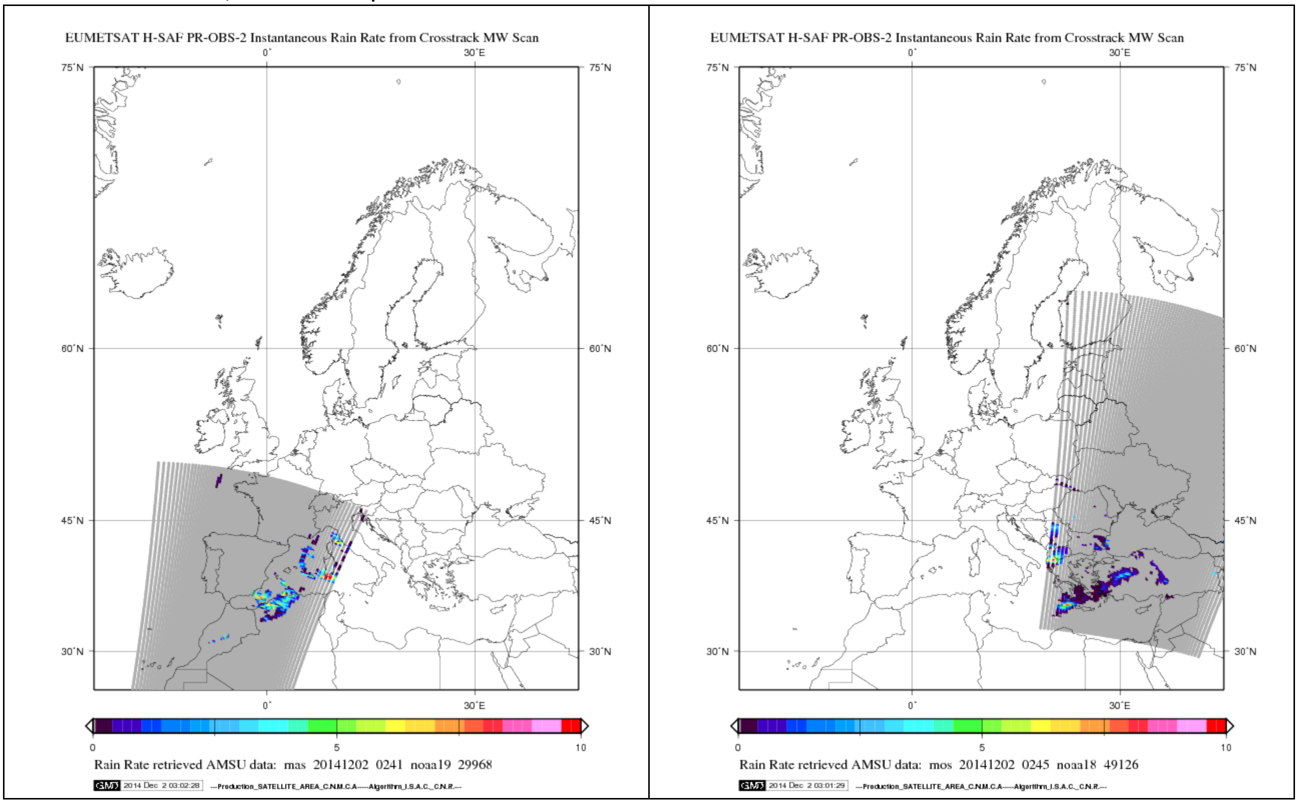


Fig. 11 PR-OBS-2B, 2014-12-02 – 02:41 and 02:45 UTC

The following figure (**Fig 12**) shows convective structures detected by NEFODINA (a subset of whole H-SAF area). Each Convective Object is associated, with its characteristics, to the figure of precipitation retrieved in PR-OBS-2. Timestamp of PR-OBS-2 and NEFODINA are close enough to correlate the two products. After collocated information convective rain rate is associated with CO characteristics, till a refresh in the database due to a new coincidence.

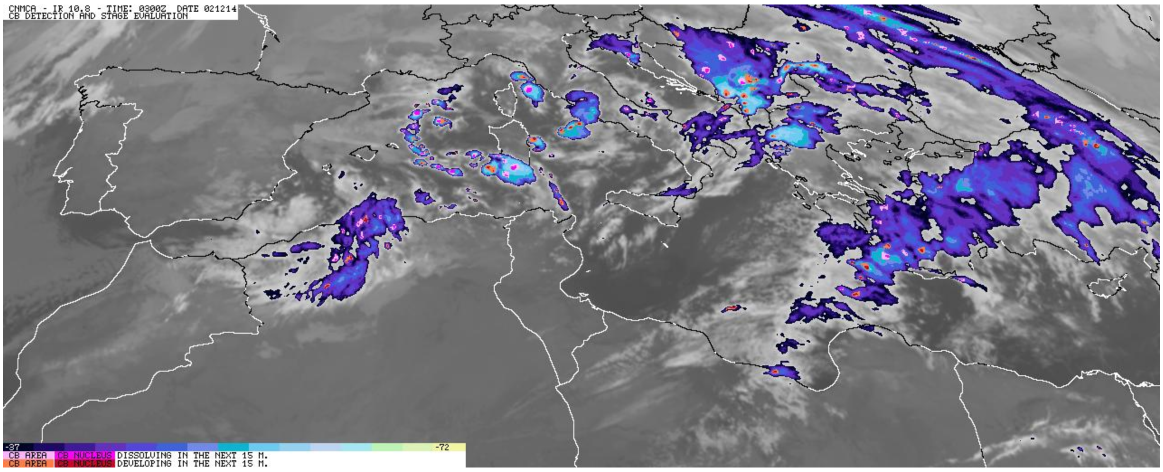


Fig. 12 NEFODINA 2014-12-02 03:00

The following figure (**Fig 13**) is an RGB colours products that help to understand the synoptical configuration over Europe, in particular the convective phenomena over the Mediterranean Sea.

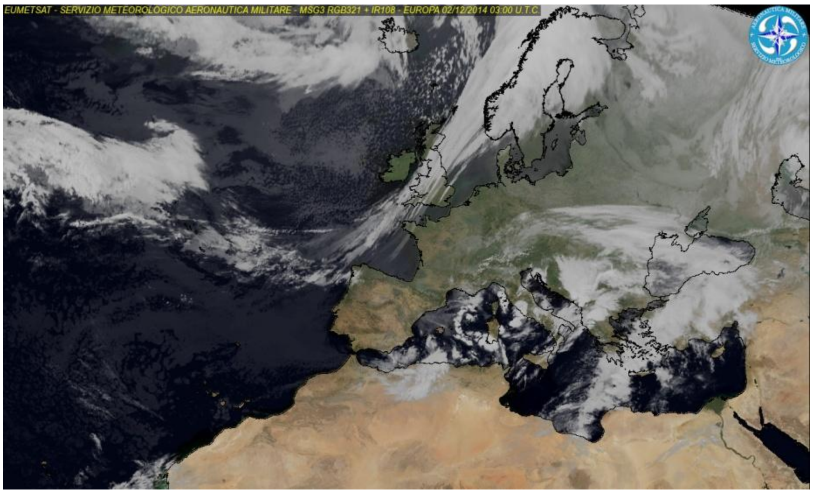


Fig. 11 RGB natural colours 2011-05-07 13:00

The associated PR-OBS-6A convective precipitation map is shown in the below figure (**Fig. 14**).

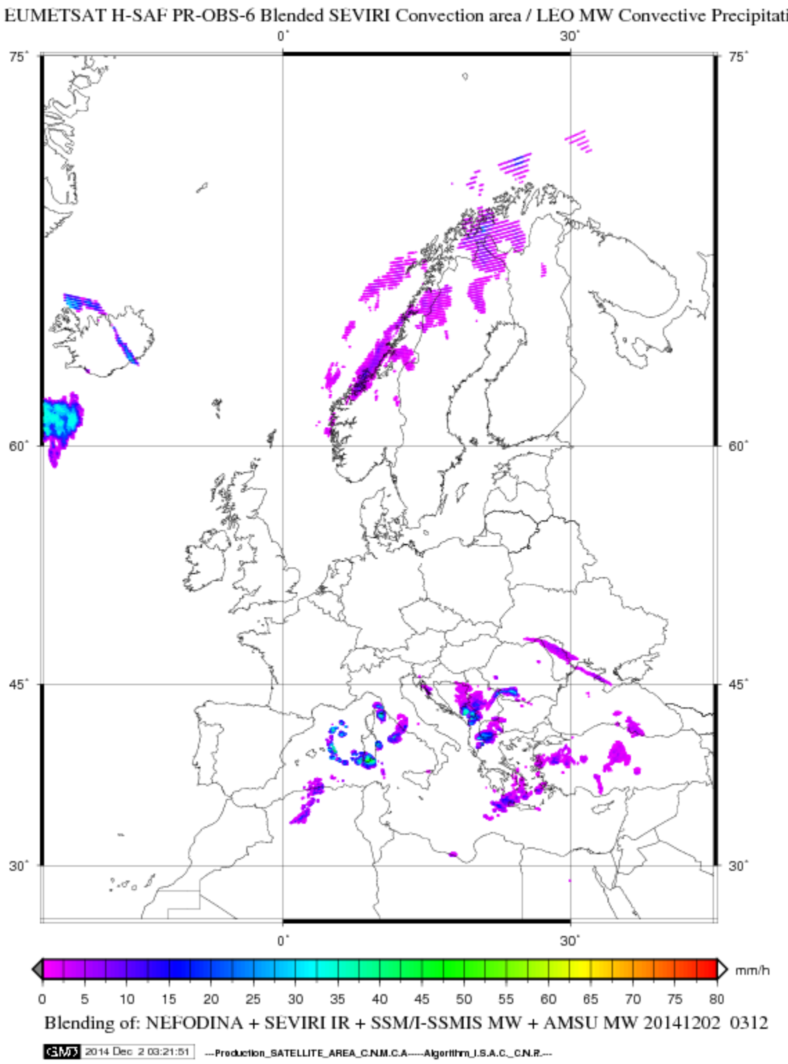


Fig. 14 PR-OBS-6A, 2014-12-02 03:12 UTC

To understand the capacity of PR-OBS-6A to better assign precipitation to convective cells, for comparison in the following figures (**Fig. 15**) PR-OBS-3A, same timestamp, and (**Fig. 16**) OPERA Radar Surface Rainfall Intensity (SRI) few minutes far (different scale bar).

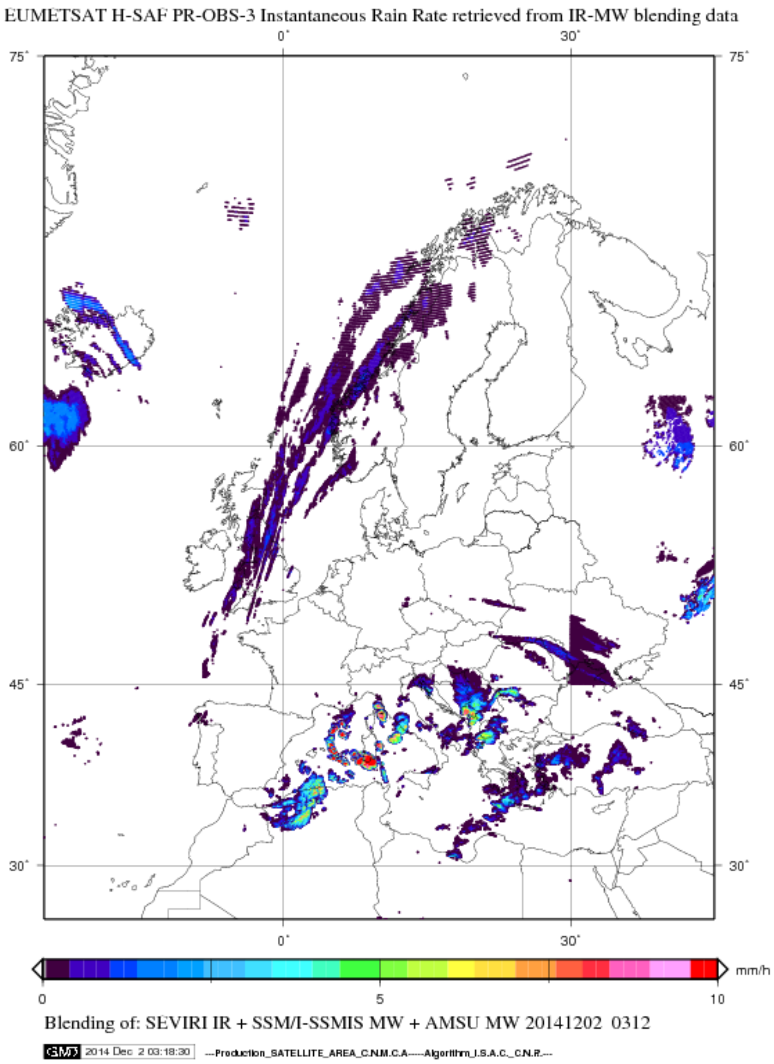
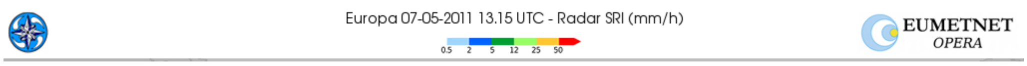


Fig. 15 PR-OBS-3A, 2014-12-02 03:12 UTC



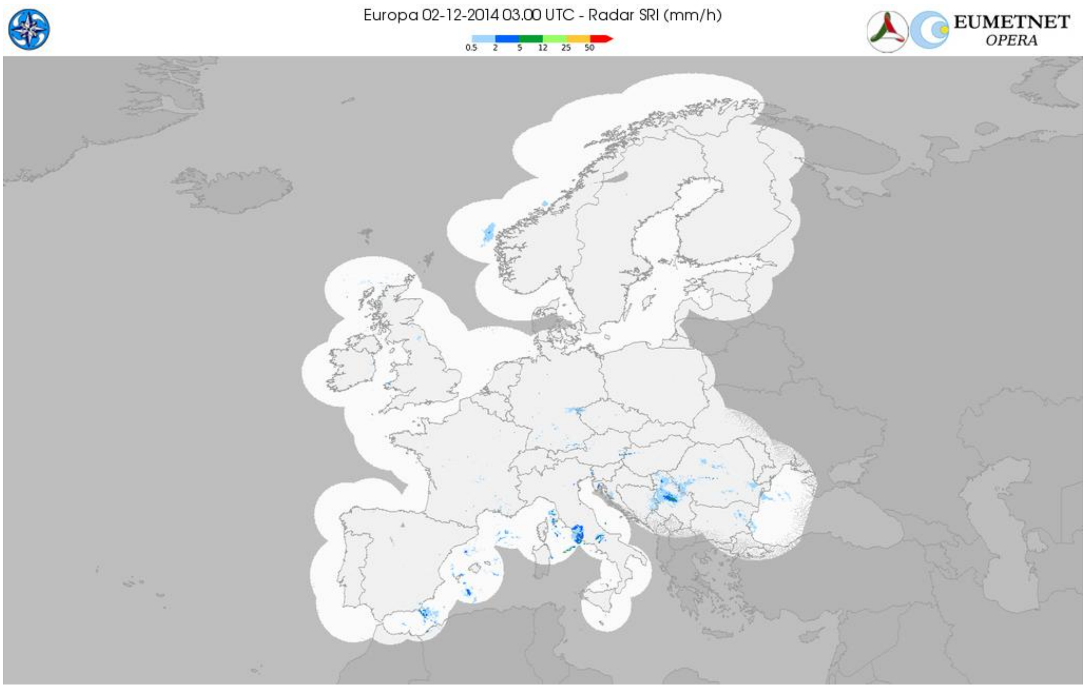


Fig. 16 OPERA Radar SRI 2011-05-07 13:15

5 Applicable Documents

Ref. SAF/HSAF/PRD ”Product Requirement Document”

6 References

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Annex 1: Introduction to H-SAF

The EUMETSAT Satellite Application Facilities

H-SAF is part of the distributed application ground segment of the "*European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)*". The application ground segment consists of a "*Central Application Facilities*" located at EUMETSAT Headquarters, and a network of eight "*Satellite Application Facilities (SAFs*)", located and managed by EUMETSAT Member States and dedicated to development and operational activities to provide satellite-derived data to support specific user communities (see Figure 17):

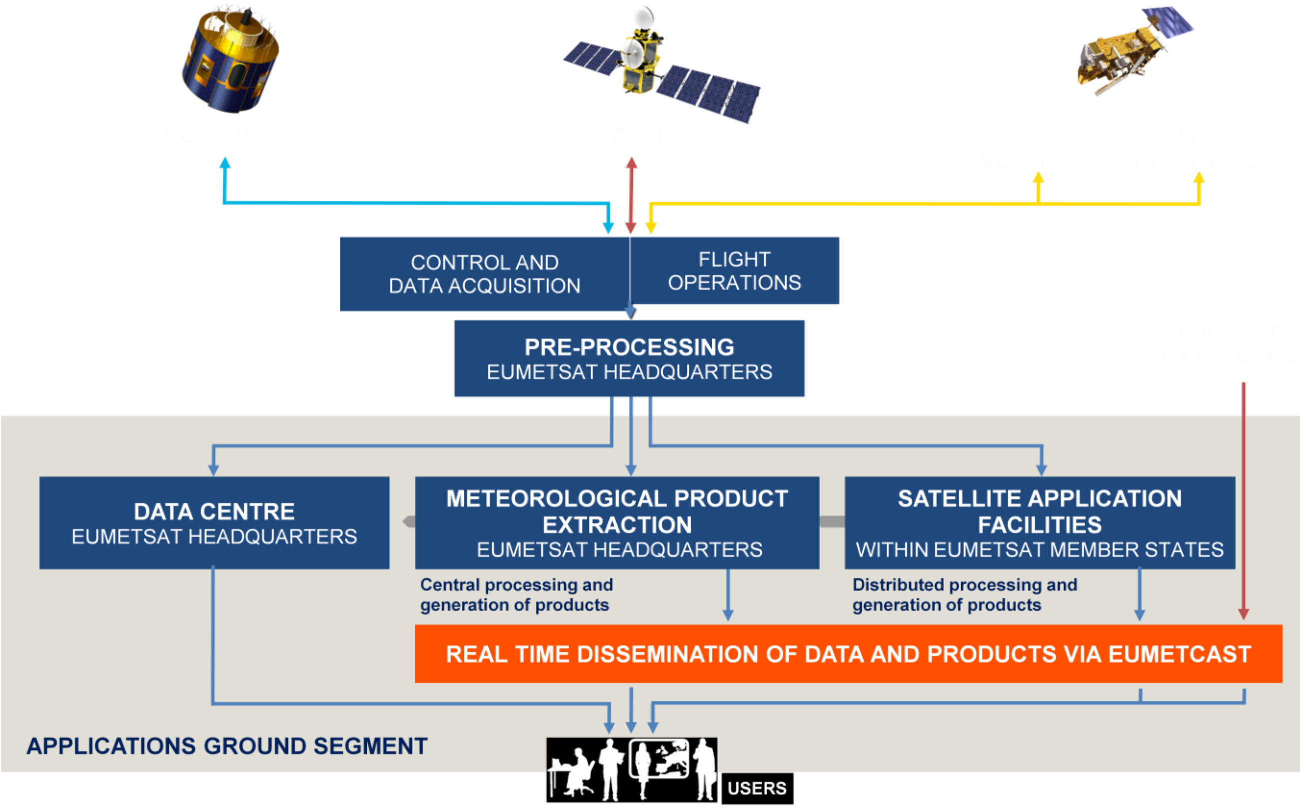

Figure 17: Conceptual scheme of the EUMETSAT Application Ground Segment

Figure, here following, depicts the composition of the EUMETSAT SAF network, with the indication of each SAF's specific theme and Leading Entity.

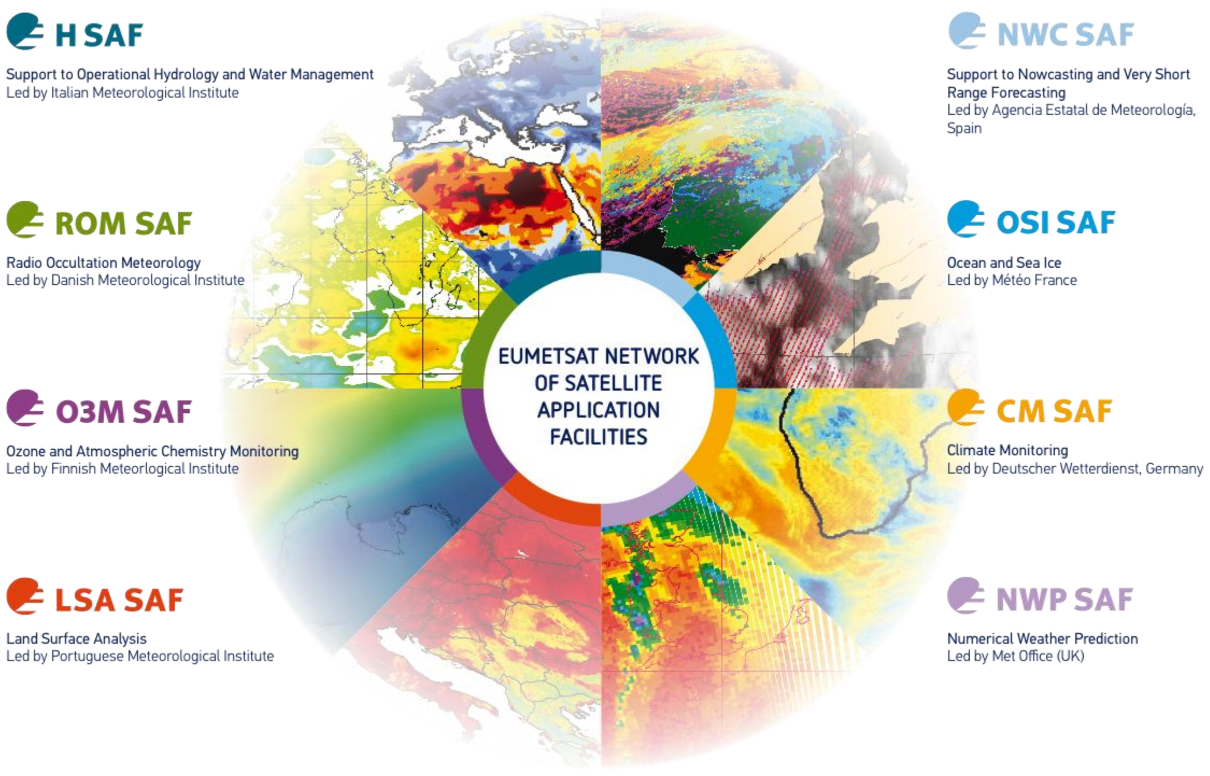

Figure 18: Current composition of the EUMETSAT SAF Network

Purpose of the H-SAF

The main objectives of H-SAF are:

a. ***to provide new satellite-derived products*** from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology, by generating, centralizing, archiving and disseminating the 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);

b. ***to perform independent validation of the usefulness of the products*** for fighting against floods, landslides, avalanches, and evaluating water resources; the activity includes:
  - downscaling/upscaling modelling from observed/predicted fields to basin level;
  - fusion of satellite-derived measurements with data from radar and raingauge networks;
  - assimilation of satellite-derived products in hydrological models;
  - assessment of the impact of the new satellite-derived products on hydrological applications.

Products / Deliveries of the H-SAF

For the full list of the Operational products delivered by H-SAF, and for details on their characteristics, please see H-SAF website hsaf.meteoam.it.

All products are available via EUMETSAT data delivery service (EUMETCast, http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/index.html), or via ftp download; they are also published in the H-SAF website hsaf.meteoam.it.

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.

System Overview

H-SAF is lead by the Italian Air Force Meteorological Service (ITAF USAM) and carried on by a consortium of 21 members from 11 countries (see website: hsaf.meteoam.it for details).

Following major areas can be distinguished within the H-SAF system context:

- Product generation area;
- Central Services area (for data archiving, dissemination, catalogue and any other centralized services);
- Validation services area which includes Quality Monitoring/Assessment and Hydrological Impact Validation.

Products generation area is composed of 5 processing centres physically deployed in 5 different countries; these are:

- for precipitation products: ITAF CNMCA (Italy);
- for soil moisture products: ZAMG (Austria), ECMWF (UK);
- for snow products: TSMS (Turkey), FMI (Finland).

Central area provides systems for archiving and dissemination; located at ITAF CNMCA (Italy), it is interfaced with the production area through a front-end, in charge of product collecting.

A central archive is aimed to the maintenance of the H-SAF products; it is also located at ITAF CNMCA.

Validation services provided by H-SAF consists of:

- Hydrovalidation of the products using models (hydrological impact assessment);
- Product validation (Quality Assessment and Monitoring).

Both services are based on country-specific activities such as impact studies (for hydrological study) or product validation and value assessment.

Hydrovalidation service is coordinated by IMWM (Poland), whilst Quality Assessment and Monitoring service is coordinated by DPC (Italy): The Services' activities are performed by experts from the national meteorological and hydrological Institutes of Austria, Belgium, Bulgaria, Finland, France, Germany, Hungary, Italy, Poland, Slovakia, Turkey, and from ECMWF.