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

Product Validation Report (PVR)
Soil Wetness Index in the roots region
Data Record

H27

Version: 0.5
Date: 07 February 2017

Revision history

Revision	Date	Author(s)	Description
0.1	10 November 2015	Clément Albergel	First draft: validation section
0.2	30 September 2016	Patricia de Rosnay	Updated version: Include sections 1,2,3, appendices, Lists of figures, tables and acronyms, updated references.
0.3	20 January 2017	Patricia de Rosnay Clement Albergel	Revised version accounting to RIDs: Editorial changes include added page numbering, updated reference list, acronyms clarified. Validation extended to the root zone using USCRN (2010-2014) and SCAN (1996-2014), Figures 3-4-5 added, Tables 4-5 added, clarified periods used for ERS 1/2 and ASCAT-A, updated references for H-TESSEL, clarified soil moisture index vs volumetric soil moisture relation, clarify usage of p-value. Clarified validation strategy, consistency with H14 validation, representativeness, diversity of soil-vegetation-atmosphere conditions. One new table added to clarify ERS1/2 and ASCAT-A products references and periods used in H27 with a new table (Table 1).
0.4	06 February 2017	Patricia de Rosnay	Clarified validation limitations
0.5	07 February 2017	Patricia de Rosnay	Fixed swapped dates in table 1 and corrected typos

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Figure A.1. Conceptual scheme of the EUMETSAT Application Ground Segment.

Figure A.2. Current composition of the EUMETSAT SAF Network.

List of Acronyms

AMI Active Microwave Instruments

ACC Anomaly Correlation Coefficient

ASCAT Advanced Scatterometer on board Metop-A

ATBD Algorithm Theoretical Baseline Document

CC Correlation Coefficient

CDOP First Continuous Development and Operations Phase

CDOP-2 Second Continuous Development and Operations Phase

ECMWF European Centre for Medium-range Weather Forecasts

EKF Extended Kalman Filter

ERS European Remote-sensing Satellite (1 and 2)

EUMETCast EUMETSAT's Broadcast System for Environment Data

EUMETSAT European Organisation for the Exploitation of Meteorological Satellites

FTP File Transfer Protocol

H-SAF SAF on Support to Operational Hydrology and Water Management

H-TESSEL Hydrology Tiled ECMWF Scheme of Surface Exchanges over Land

LDAS Land Data Assimilation System

ME Mean Error

Metop Meteorological Operational Platform

NRCS-SCAN Natural Resources Conservation Service - Soil Climate Analysis Network

PUM Product User Manual

PVR Product Validation Report

RMSD Root Mean Square Difference

SAF Satellite Application Facility

SSM Surface Soil Moisture

SD Standard Deviation

TU Wien Technische Universität Wien (Vienna University of Technology)

UTC Coordinated Universal Time

1 Executive summary

This document describes the validation of the H-SAF scatterometer root zone soil moisture product data record generation. An introduction (section 2) is followed by general overview of the H-SAF root zone data record product (section 3). The product validation is presented in section 4. Further information on the implementation of the processing chain and individual processing steps are available in the Algorithm Theoretical Basis Documents (ATBD), and information on the product format can be found in the Product User Manual (PUM).

2 Introduction

2.1 Purpose of the document

The Product Validation Report is intended to provide a description of the main product characteristics and validation activities.

2.2 Targeted audience

This document mainly targets:

1. Hydrology and water management experts,
2. Operational hydrology and numerical weather prediction communities,
3. Users of remotely sensed soil moisture for a range of application (e.g. climate modelling validation, trend analysis).

3 Presentation of the root zone soil wetness data record H27

3.1 Principle of the Product

H27 is a root zone soil moisture product retrieved from scatterometer surface soil moisture (SSM) observations. The H27 production chain uses an offline sequential based on a Land Data Assimilation System (LDAS) based on an Extended Kalman Filter (EKF) approach that follows the approach of de Rosnay et al. (2013). The EKF constitutes the central component of the H27 production chain. The H-TESSEL Land Surface Model (van den Hurk et al. 2000, van den Hurk and Viterbo 2003, Balsamo et al., 2009) is used to propagate in time and space the soil moisture information through the root zone, accounting for physiographic information (soil texture, orography), meteorological conditions and land surface processes such as for example soil evaporation and vegetation transpiration. Essentially the H27 production suite retrieves root zone soil moisture from ERS1/2 Active Microwave Instruments for 1992-2006 and ASCAT-A surface soil moisture for the period from 2007 to 2014. Table 1 below gives the details on the scatterometers SSM products used as input of the H27 production suite. As shown in Table 1 there is no overlap between ERS1/2 and ASCAT-A observations used to produce H27. In the ECMWF H27 algorithm the input scatterometer surface soil moisture products are assimilated in the H27 LDAS which propagates the scatterometer surface soil moisture information in space on the soil vertical profile and in time at a daily time scale. The main components of the data assimilation system are the Extended Kalman Filter, a land surface model and input data preprocessing. A detailed description of the ECMWF H27 LDAS algorithm can be found in the Algorithm Theoretical Baseline Document (ATBD, 2016).

H27 Period	Scatterometer SSM product used in H27		
	Sensor	Producer	Reference
04-2014 to 12-2014	ERS-1/2 AMI 50 km	TU Wien	ASCAT-A SOMO: ASCAT-A 25km sampling SSM product produced by CAF reference EO:EUM:DAT:METOP:SOMO25 (https://www.eumetsat.int/ossi/pgd/gds_metop.html)
01-2007 to 03-2014	ASCAT-A 25km sampling SSM data record	EUMETSAF-CAF	ASCAT-A 25km sampling SSM data record: Early release of H107 prototype produced by EUMETSAT CAF as a prototype of H107 (internal H-SAF product that will be released in the future)
01-1992 to 12-2006	ASCAT-A 25km sampling SSM	EUMETSAT-CAF	ERS-1/2 AMI WARP 5.5 R1.1: ERS-1/2 AMI 50km Soil moisture time series product user manual, version 0.2, TU Wien, (https://rs.geo.tuwien.ac.at/products/)

Table 1: H27 input scatterometer SSM products.

The H27 production chain also uses screen level parameters close to the surface (2-meters temperature and relative humidity) to ensure consistency of the retrieved Scatterometer root zone and the near surface observed weather conditions. The system is driven by ERA-Interim atmospheric fields (Dee et al., 2011). The H27 LDAS production suite is illustrated by Figure 1.

3.2 Main characteristics

H27 is produced on a Gaussian reduced grid at a horizontal resolution of about 16km (TL1279). It is produced on four vertical layers in the soil: surface to 7 cm, 7 cm to 28 cm, 28 cm to 100 cm, and 100 cm to 289 cm. H27 relies on a data assimilation approach that propagates the information in time and space (on the vertical dimension in the root zone). So, it enables to propagate the swath surface soil moisture scatterometer products to daily root zone soil moisture with a global coverage. H27 is a daily product valid at 00UTC. Root zone soil moisture is expressed as a liquid soil wetness index, ranging from 0 for residual soil moisture values to 1 for saturated soil moisture. It is computed in H-TESSEL using the fraction of liquid water content and the soil texture information of the model. Having the H27 product in index value of liquid soil moisture content makes it consistent with all the other ASCAT soil moisture products, that are available for the surface and which all given the information about liquid soil water index. Being independent from a specific model soil texture, it makes it flexible to be used in various areas of application or with various models.

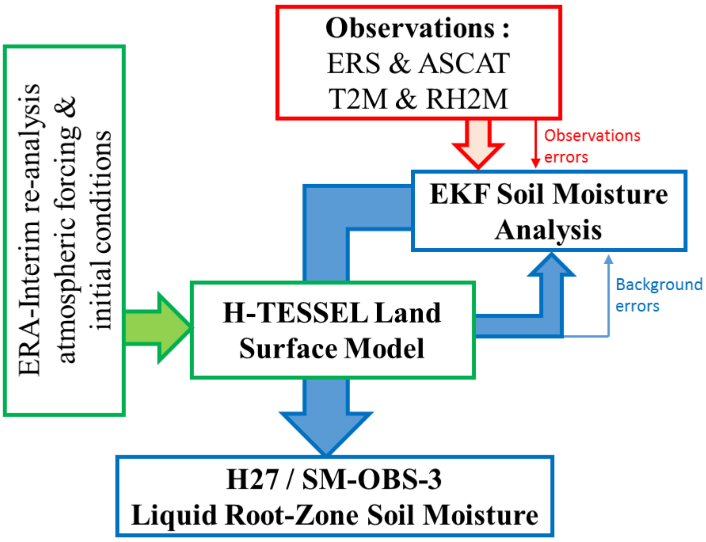

Figure 1: Illustration of the H27 root zone soil moisture production chain based on ERS 1/2 & ASCAT-A satellite derived surface soil moisture data assimilation.

4 Product Validation

4.1 Validation strategy

The H27 root zone soil wetness product is evaluated using in situ measurements of soil moisture. The validation approach is consistent with the validation used to validate the H14 product. The main challenge in validating the H27 product is related to the length of the time series that spans several decades. So, the validation proposed here relies on in situ soil moisture networks that cover a large diversity of surface and climate conditions and that have been providing observations suitable for root zone soil wetness data record validation. This sub-section gives an historic of the validation approach used for H14 in the previous H-SAF phases and in the current phase (PVR H14).

During the First and Second Continuous Development and Operations Phases (CDOP and CDOP-2), Accuracy Requirements for HSAF soil moisture products was given in volumetric unit (m^3m^{-3}) and the main score to be evaluated was the Root Mean Square Difference (RMSD), supportive scores being: the Mean Error (or bias, ME), the Standard Deviation (SD) and the Correlation Coefficient (CC). Table 2 presents the User requirements as it was for the Development Phase and CDOP (i.e. with respect to the RMSD).

Table 2: Former accuracy requirements for product SM-DAS-2 [RMSD] used during the Development phase and CDOP.

Unit	threshold	target	optimal
$m^3 \cdot m^{-3}$	0.10	0.06	0.04

The first definition of H-SAF soil moisture validation goals stems to a large extent from the efforts to build the SMOS and SMAP satellites that both aim to retrieve the absolute volumetric soil moisture content with an RMSD of 0.04 m^3m^{-3}. But considering the evolution of the literature on this topic over the last few years one can clearly see a shift in the way of how the validation of remotely sensed / modelled soil moisture data is being regarded. RMSD by itself is not sufficient, other measures such as CC are also important, and for some applications even more important than the RMSD (Entekhabi et al., 2010; Brocca et al., 2011).

Several authors have demonstrated that local measurements could be used to validate model output as well as remotely-sensed soil moisture (SM) at a different scale (e.g. Albergel et al, 2009, 2010; Rüdiger et al., 2009; Brocca et al., 2010a; 2011). However, spatial variability of SM is very high and can vary from centimetres to metres. Precipitation, evapotranspiration, soil texture, topography, vegetation and land use could either enhance or reduce the spatial variability of soil moisture depending on how it is distributed and combined with other factors (Famiglietti et al., 2008; Brocca et al., 2010b, 2012). Differences in soil properties could imply important variations in the mean and variance of soil moisture, even over small distances. Each soil moisture data set is characterized by its specific mean value, variability and dynamical range. Saleem and Salvucci (2002) and Koster et al. (2009, 2011) suggested that the true information content of modelled soil moisture does not necessarily rely on their absolute magnitudes but instead on their time variation. The latter represents the time-integrated impacts of antecedent meteorological forcing on the hydrological state of the soil system within the model.

The high spatial variability of in situ SM used for validation as well as SM data set specific characteristics suggests that the Correlation Coefficient (CC) should be the main score to be evaluated. On this basis the soil moisture products development and validation groups proposed to change the main score to evaluate the "Product Requirements" for H14 products from the RMSD to the CC. Table 3 presents the accuracy requirements are defined in the Product Requirements Document (PRD).

Table 3: Accuracy requirements for product H27 as defined in the PRD [CC]

Unit	threshold	target	optimal
Dimensionless	0.50	0.65	0.80

This implies that the main score to be evaluated is the Correlation Coefficient (CC). Supportive scores are: the Root Mean Square Difference (RMSD), Mean Error (or bias, ME). The Correlation Coefficient should be applied to normalised time-series (H14 is an index) as well as to monthly anomalies time series. Cases with significant level of correlations (pvalue < 0.05) are considered only as discussed in section 4.3. Also, a period of one year has to be considered for the evaluation.

4.2 *In situ data*

This study makes use of in situ soil moisture measurements obtained through the International Soil Moisture Network (ISMN, http://www.ipf.tuwien.ac.at/insitu/, Dorigo et al. 2011), a data hosting centre where globally-available ground-based soil moisture measurements are collected, harmonized and made available to users. In particular, the data from NRCS-SCAN (Natural Resources Conservation Service - Soil Climate Analysis Network) over the United States (159 stations), is used to validate H27 as it is available for 1997-2014 which covers most of the H27 period. For the root zone soil moisture validation, both NRCS-SCAN and USCRN (U.S. Climate Reference Network) in situ soil moisture observations are used to provide an extensive validation of H27 in the root zone from 1996 to 2014.

The NRCS-SCAN network (http://www.wcc.nrcs.usda.gov/scan/, Schaefer and Paetzold 2000) is a comprehensive, USA-wide soil moisture and climate information system designed to provide data to support natural resource assessments and conservation activities with a focus on agricultural areas in the USA. The observing network is used to monitor soil temperature and soil moisture at several depths, soil water level, air temperature, relative humidity, solar radiation, wind, precipitation and barometric pressure amongst others. NRCS-SCAN data have been used for various studies ranging from global climate modelling to agricultural studies. The vegetation cover at those sites consists of either natural fallow or short grass. Data are collected by a dielectric constant measuring devices and typically measurements are made at 5, 10, 20, 50 and 100 cm.

The U.S. Climate Reference Network National from the Oceanic and Atmospheric Administration's National Climatic Data Center (USCRN NOAA's NCDC) consists of currently 104 stations developed, deployed, managed, and maintained by the National Oceanic and Atmospheric Administration (NOAA) in the continental United States for the express purpose of detecting the national signal of climate change (Bell et al., 2013). The USCRN network covers all over the USA, from North to South and West to East (network map available in Bell et al. 2013 and at http://ismn.geo.tuwien.ac.at/networks/uscrn/). USCRN sites are sampling a variety of natural environments in addition to agricultural settings that predominate in some networks. USCRN main objective is to provide climate-science-quality measurements of air temperature and surface conditions. The stations in the network were designed to be extensible to other missions and in 2011, the USCRN team completed at each station in the conterminous United States the installation of triplicate-configuration soil moisture and soil temperature probes at 5, 10, 20, 50, and 100 cm.

In this report the validation of the H27 product is limited to the SCAN and the USCRN networks, both in the USA. Despite this geographical extent limitation, these two networks sample a large diversity of soil and vegetation types. They provide the only in situ soil moisture database that provides both surface and root soil moisture consistently for such a long period (1996-2014), and which covers most of soil texture and vegetation types (forest, crops, natural fallow, bare soil) in plains, mountainous, and coastal areas. So, although not all the Earth regions are sampled, soil moisture validation based on SCAN and USCRN networks are suitable to validate soil moisture data records both at surface and in the root zone, for a large variety of soil, vegetation, orography and climate conditions.

4.3 Data preparation and metrics

H27 is an index between 0 and 1 while in situ measurements of soil moisture are in m^3m^{-3}. To enable a fair comparison, it is then necessary to rescale the data. The 90% confidence interval was chosen to define the upper and lower values to exclude any abnormal outliers due to instrument noise using the following equations (as in Rüdiger et al., 2009; Albergel et al., 2010):

$$Int^{+}(insitu) = \mu(insitu) + 1.64\sigma(insitu)$$

$$Int^{-}(insitu) = \mu(insitu) - 1.64\sigma(insitu)$$

Where Int+ and Int- are the upper and lower 90% limits of the confidence interval, a period of one year is required for their calculation. Then a new in situ soil moisture data set is obtained using:

$$SM = \frac{SM - Int^{-}}{Int^{+} - Int^{-}}$$

SM stands for Soil Moisture. It is assumed that H27 data set do not have such outliers problem and is rescaled using the maximum and the minimum values of each individual times series considering the whole June 2013 to May 2014 period.

The comparison between the observation data and the H27 product needs to be performed, gaining the following statistical scores:

- Mean Error (ME) or Bias,
- Correlation Coefficient (CC),
- Root Mean Square Difference (RMSD), In situ data contain errors (instrumental and representativeness), so they are not considered as 'true' soil moisture. This is underlined here by using the RMS Difference terminology instead of RMS Error,
- p-value, a measure of the correlation significance should be calculated as well. It indicates the significance of the test, the 95% confidence interval should be used; configurations where the p-value is below 0.05 (i.e. the correlation is not a coincidence) have to be retained. This process has probably removed some good stations too (e.g., in areas where the model might not realistically represent soil moisture). However it also ensures that stations with nonsignificant R values can be considered suspect and are excluded from the computation of the network average metrics. It is commonly used for soil moisture validation activities against in situ as well as against model data sets (Alyaari et al., 2014 Albergel et al., 2013, Albergel et al., 2012, Gonzalez-Zamora et al., 2016).

The RMSD represents the relative error of the soil moisture dynamical range, as H27 is an index, it has no units. Hence it is possible to obtain an estimate of the error of the liquid root zone soil moisture retrieval in m^3m^{-3} by multiplication between the RMSD and the observed dynamical range (obs_max-min_max).

Usually, soil moisture time series show a strong seasonal pattern that could artificially increase the perceived agreement between satellite and in situ observations in terms of CC. Therefore, to avoid seasonal effects, time series of anomalies from a moving monthly average are also calculated (Albergel et al., 2009, 2011). The difference to the mean is calculated for a sliding window of five weeks (if there are at least five measurements in this period), and the difference is scaled to the standard deviation. For each SM estimate at day (i), a period F is defined, with F=[i-17, i+17] (corresponding to a 5-week window). If at least five measurements are available in this period of time, the average SSM value and the standard deviation are calculated. The Anomaly (Ano), dimensionless is then given by:

$$Ano(i) = \frac{SM(i) - \overline{SM(F)}}{stdev(SM(F))}$$

The anomaly transformation is used only to compute the Anomaly Correlation Coefficient (ACC) scores. All the other metrics (ME, CC, RMSD) are computed usig the H27 time series without the anomaly transformation.

More often than not, soil moisture is measured along with soil temperature. If available, a threshold of +4° degrees should be considered and soil moisture measurements below this threshold should be rejected. Also, soil temperature associated to H27 is used to filter out H27 potentially affected by frozen conditions. So, in line with the H14 validation (PVR H14), the quality of H27 is assessed for all weather conditions, except when the soil is frozen.

4.4 Validation results

The typical validation approach for model/analyses/satellite products is to compare them to the observations. Soil temperature are also observed, it permits to remove observations potentially affected by frozen condition. Daily averaged observations of surface soil moisture are used and the nearest neighbour approach has been used to collocate H27 soil moisture to that of the stations. While other networks exist NRCS-SCAN has the advantage of having stations from 1996 (note that less stations are available in the first years than in the most recent periods).

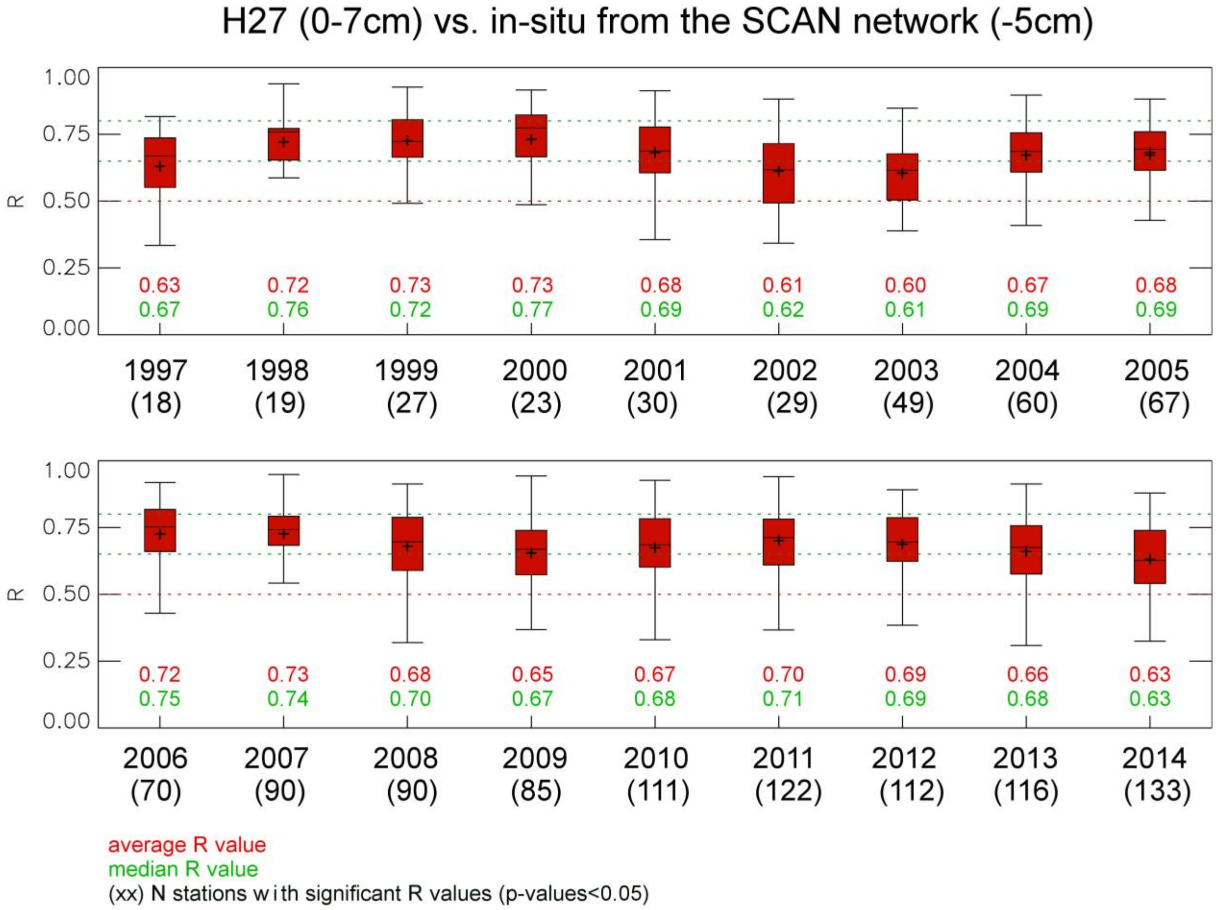

Figure 2: Evaluation results between H27soil moisture (first layer of soil, 0-7cm) and in situ observations at a depth of 5 cm for the station of the NRCS-SCAN network spanning all over the USA for each individual years between 1997 and 2014.

Table 4: Evaluation scores of H27 surface soil moisture (first layer of soil, 0-7cm) against in situ observations at a depth of 5 cm for the station of the NRCS-SCAN network spanning all over the USA for each individual years between 1997 and 2014.

Network	N stations*	Product acronym	Period	Sample	Bias (-)	RMSD (-)/[m^3m^{-3}]	CC (ACC)
SCAN	18	H27 (0-7cm)	1997	254	-0.120	0.276/0.085	0.63 (0.56)
SCAN	19	H27 (0-7cm)	1998	309	-0.117	0.244/0.073	0.72 (0.55)
SCAN	27	H27 (0-7cm)	1999	265	-0.096	0.245/0.083	0.73 (0.58)
SCAN	23	H27 (0-7cm)	2000	278	-0.078	0.223/0.071	0.73 (0.54)

SCAN	30	H27 (0-7cm)	2001	281	-0.088	0.242/0.067	0.68 (0.56)
SCAN	29	H27 (0-7cm)	2002	302	-0.112	0.273/0.084	0.61 (0.51)
SCAN	49	H27 (0-7cm)	2003	285	-0.083	0.265/0.079	0.60 (0.51)
SCAN	60	H27 (0-7cm)	2004	303	-0.071	0.224/0.067	0.67 (0.56)
SCAN	67	H27 (0-7cm)	2005	297	-0.063	0.238/0.075	0.68 (0.55)
SCAN	70	H27 (0-7cm)	2006	297	-0.056	0.215/0.067	0.72 (0.55)
SCAN	90	H27 (0-7cm)	2007	272	-0.035	0.211/0.065	0.73 (0.54)
SCAN	90	H27 (0-7cm)	2008	286	-0.051	0.223/0.070	0.68 (0.55)
SCAN	85	H27 (0-7cm)	2009	293	-0.069	0.227/0.071	0.65 (0.55)
SCAN	111	H27 (0-7cm)	2010	264	-0.077	0.238/0.078	0.67 (0.54)
SCAN	122	H27 (0-7cm)	2011	271	-0.060	0.230/0.072	0.70 (0.51)
SCAN	112	H27 (0-7cm)	2012	292	-0.065	0.230/0.068	0.69 (0.53)
SCAN	116	H27 (0-7cm)	2013	278	-0.053	0.223/0.068	0.66 (0.51)
SCAN	133	H27 (0-7cm)	2014	261	-0.025	0.223/0.065	0.63 (0.53)

* Only cases with pvalue <0.05 are considered.

Results of the surface soil wetness validation against NCRS-SCAN are illustrated by Figure 2 using the so-called boxplots for each year within 1997-2014 and scores are reported in Table 4. Figure 2 displays for each network the distribution of the R values at each stations in five numbers, they are; the median, upper quartile, lower quartile, minimum and maximum values (excluding outliers; more/less that 3/2 times of lower quartile). The box itself contains the middle 50% of the data. The upper edge (hinge) of the box indicates the 75th percentile of the data set, and the lower hinge indicates the 25th percentile. The range of the middle two quartiles is known as the inter-quartile range. Average R values are reported also (black crosses).

Results of the H27 root zone soil wetness validation using NCRS-SCAN data for 1996-2014 are presented in Figures 3, 4, 5 for 1996-2001, 2002-2007 and 2008-2014, respectively. They are summarised in Table 5.

Results of the H27 root zone soil wetness validation against the USCRN data for 2010-2014 are presented in Figure 6 and in Table 6.

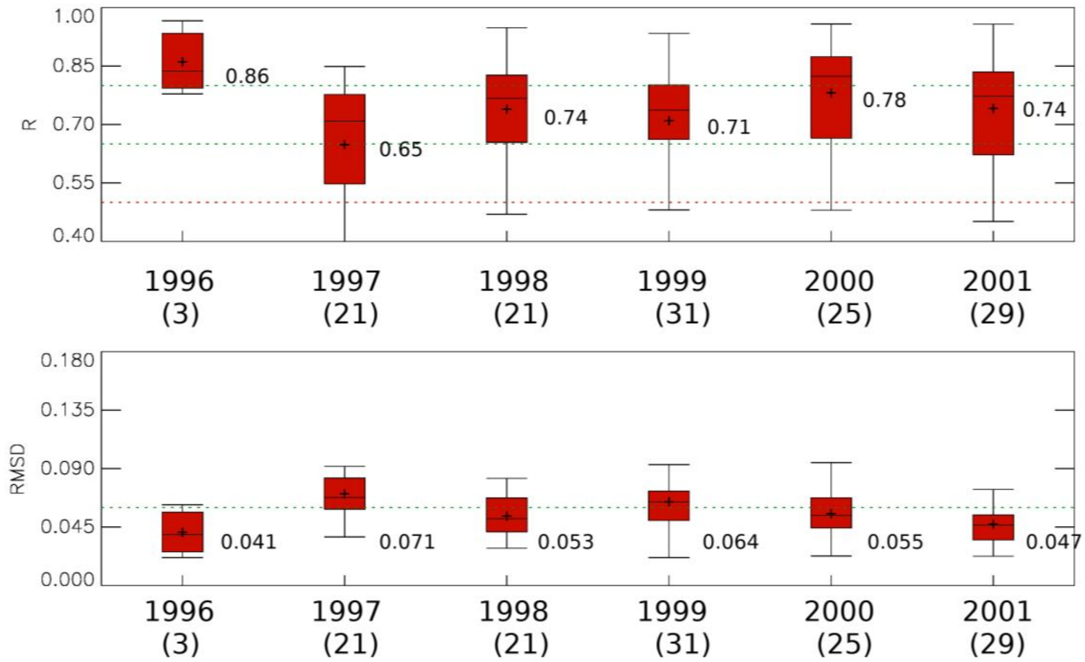

Figure 3: Evaluation results between H27root zone soil moisture (0-1m) and in situ observations at a depth of 5, 10, 20, 50 cm for the station of the NRCS-SCAN network spanning all over the USA for each individual years between 1996 and 2001.

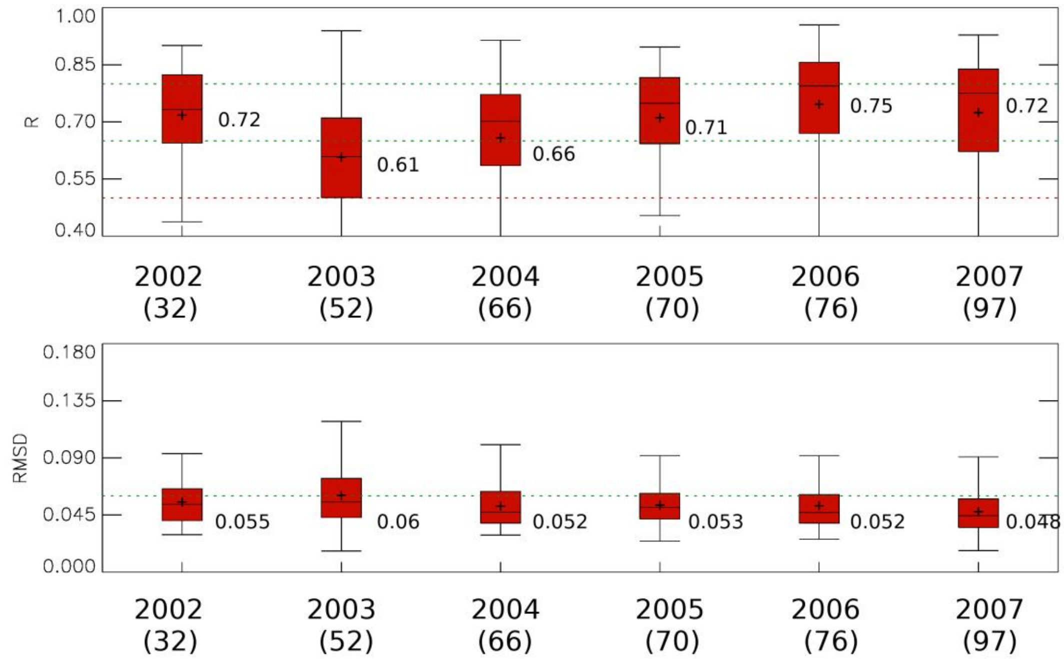

Figure 4: Same as Figure 3 (H27 root zone soil moisture evaluation against NCRS/SCAN in situ data), for 2002 and 2007.

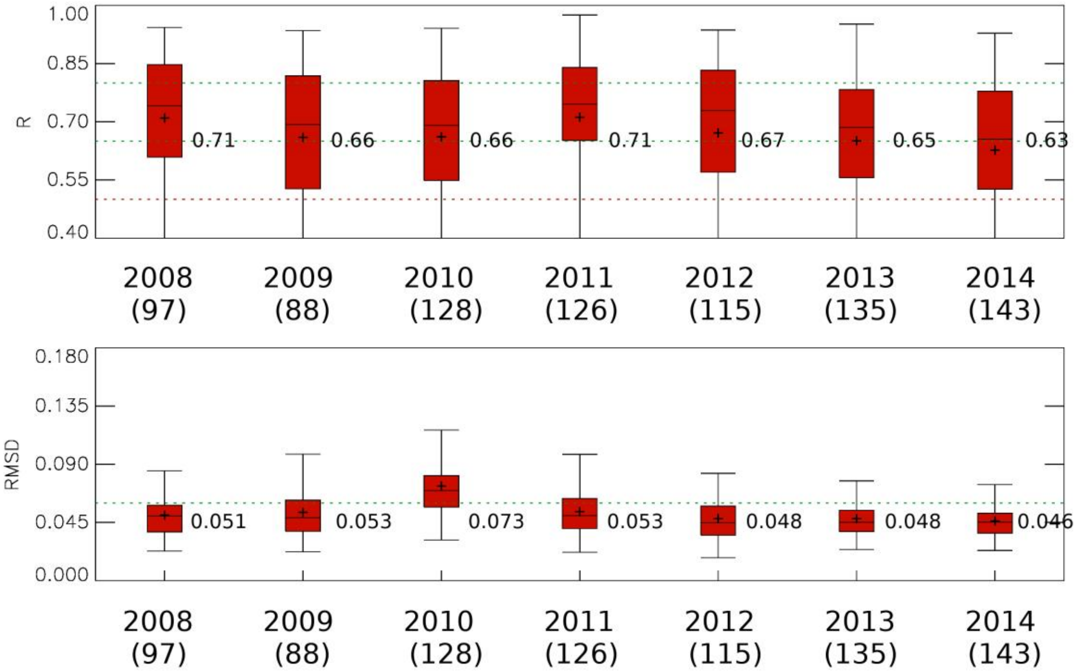

Figure 5: Same as Figure 3 (H27 root zone soil moisture evaluation against NCRS/SCAN in situ data), for 2008 and 2014.

Table 5: Evaluation scores of H27 root zone soil moisture (first three layers, 0-1m) against in situ observations at a depth of 5, 10, 20, 50 cm for the stations of the NRCS-SCAN network spanning all over the USA for each individual years between 1996 and 2014.

Network	N stations*	Product acronym	Period	RMSD m^3m^{-3}	CC
SCAN	3	H27 (0-1m)	1996	0.041	0.86
SCAN	21	H27 (0-1m)	1997	0.071	0.65
SCAN	21	H27 (0-1m)	1998	0.053	0.74
SCAN	31	H27 (0-1m)	1999	0.064	0.71
SCAN	25	H27 (0-1m)	2000	0.055	0.78
SCAN	29	H27 (0-1m)	2001	0.047	0.74
SCAN	32	H27 (0-1m)	2002	0.055	0.72
SCAN	52	H27 (0-1m)	2003	0.060	0.61
SCAN	66	H27 (0-1m)	2004	0.052	0.66
SCAN	70	H27 (0-1m)	2005	0.053	0.71
SCAN	76	H27 (0-1m)	2006	0.052	0.75
SCAN	97	H27 (0-1m)	2007	0.048	0.72
SCAN	97	H27 (0-1m)	2008	0.051	0.71
SCAN	88	H27 (0-1m)	2009	0.053	0.66
SCAN	128	H27 (0-1m)	2010	0.073	0.66
SCAN	115	H27 (0-1m)	2011	0.053	0.71
SCAN	115	H27 (0-1m)	2012	0.048	0.67
SCAN	135	H27 (0-1m)	2013	0.048	0.65

SCAN	143	H27 (0-1m)	2014	0.045	0.63

* Only cases with pvalue <0.05 are considered.

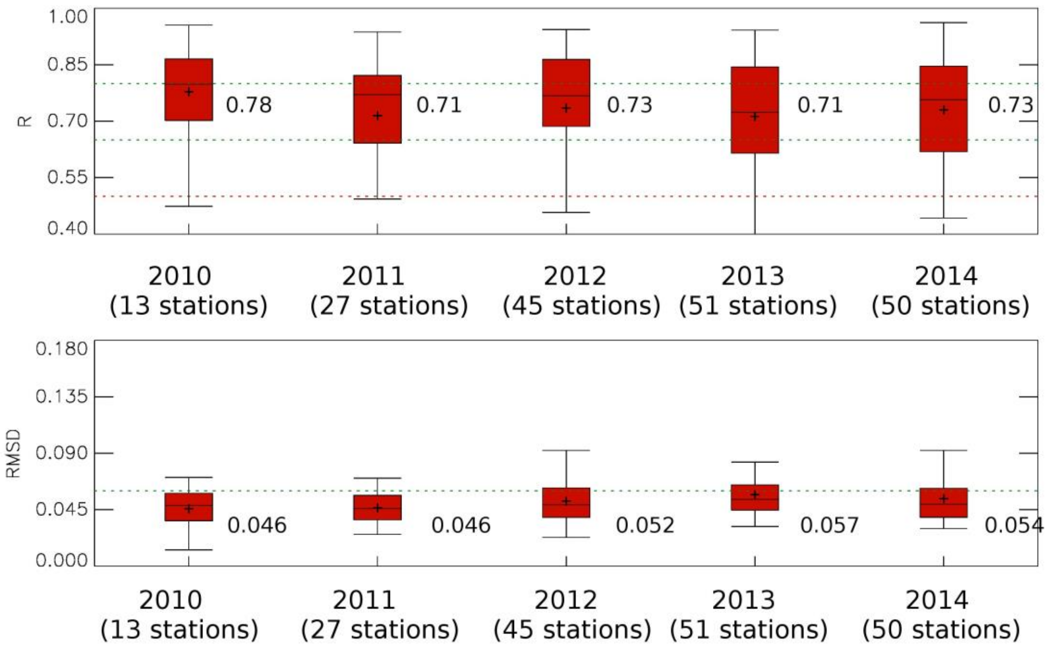

Figure 6: Evaluation results between H27root zone soil moisture (0-1m) and in situ observations at a depth of 5, 10, 20, 50 cm for the station of the USCRN network spanning all over the USA for each individual years between 2010 and 2014.

Table 6: Evaluation scores of H27 root zone soil moisture (first three layers, 0-1m) against in situ observations at a depth of 5, 10, 20, 50 cm for the stations of the NRCS-SCAN network spanning all over the USA for each individual years between 2010 and 2014.

Network	**N stations***	**Product acronym**	**Period**	**RMSD m^3m^{-3}**	**CC**
USCRN	13	H27 (0-1m)	2010	0.046	0.078
USCRN	27	H27 (0-1m)	2011	0.046	0.071
USCRN	45	H27 (0-1m)	2012	0.052	0.073
USCRN	51	H27 (0-1m)	2013	0.057	0.71
USCRN	50	H27 (0-1m)	2014	0.054	0.73

* Only cases with pvalue <0.05 are considered.

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ASCAT-A 25km sampling SSM data record: Early realease of H107 prtotype produced by EUMETSAT CAF as a prototype of H107 (internal H-SAF product that will be released in the future)

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Appendices

A. Introduction to H-SAF

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 A.1):

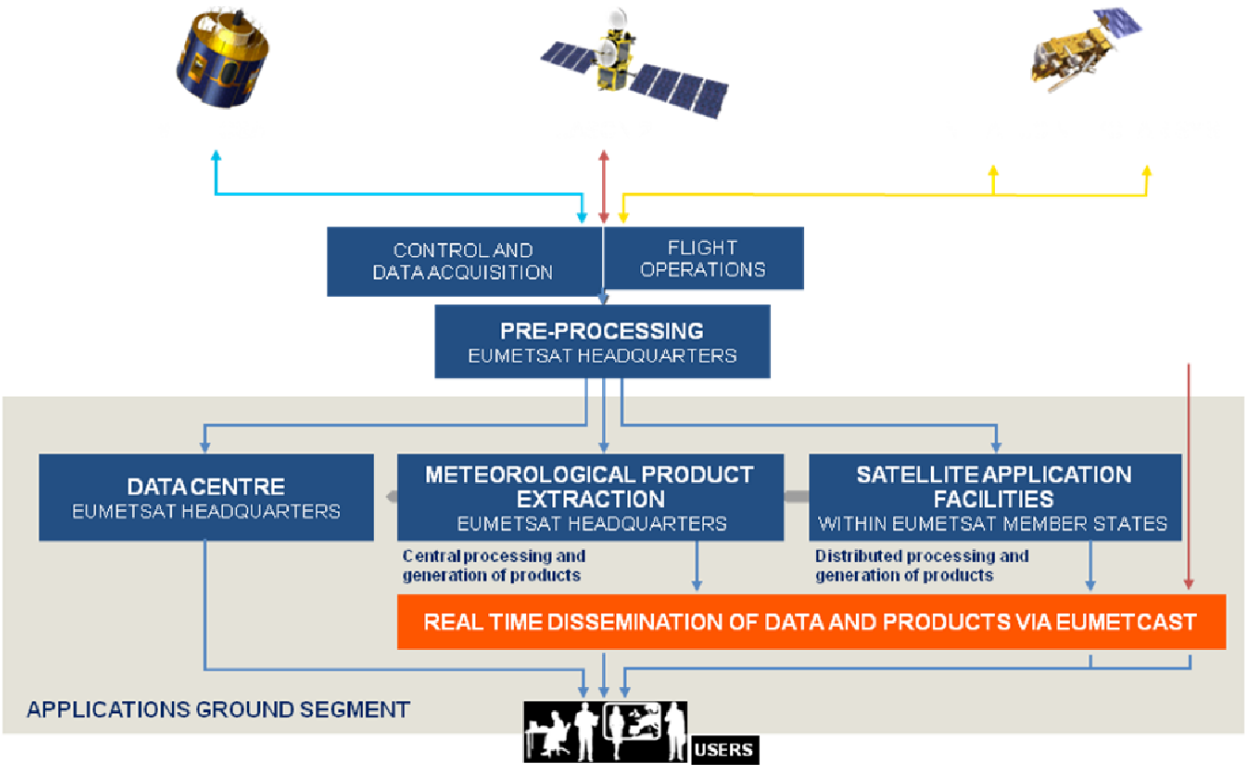

Figure A.1: Conceptual scheme of the EUMETSAT Application Ground Segment.

Figure A.2 below depicts the composition of the EUMETSAT SAF network, with the indication of each SAF's specific theme and Leading Entity.

B. 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);

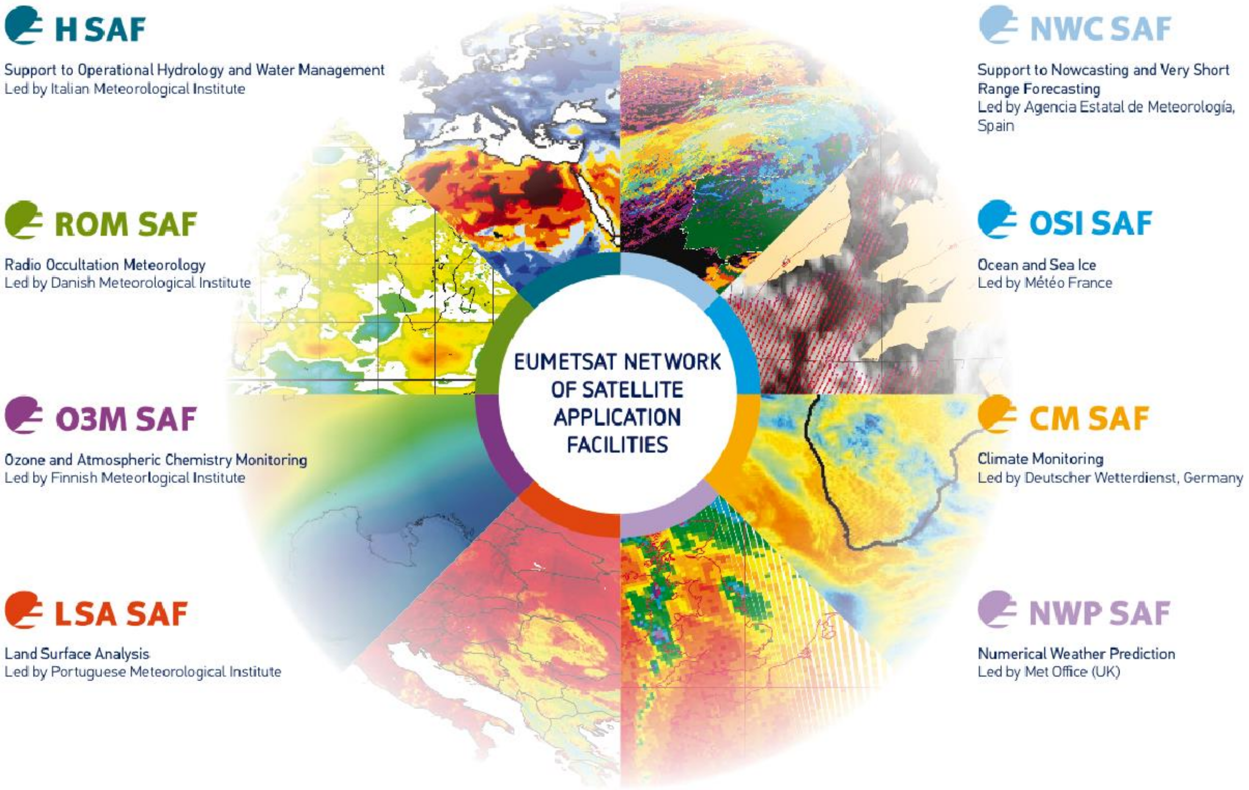

Figure A.2: Current composition of the EUMETSAT SAF Network.

- 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.

C. 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 website3 (http://hsaf.meteoam.it).

D. System Overview

H-SAF is led by the Italian Air Force Meteorological Service (ITAF MET) 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.