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Italian Department of Civil Protection

**H SAF project:  
satellite derived products for the monitoring of  
precipitation, soil moisture and snow cover**

Satellite Application Facilities

 <p><b>NWC SAF</b></p> <p>Support to Nowcasting and Very Short Range Forecasting</p> <p>Led by Agencia Estatal de Meteorología, Spain</p>	 <p><b>OSI SAF</b></p> <p>Ocean and Sea Ice</p> <p>Led by Météo France</p>	 <p><b>CM SAF</b></p> <p>Climate Monitoring</p> <p>Led by Deutscher Wetterdienst, Germany</p>	 <p><b>NWP SAF</b></p> <p>Numerical Weather Prediction</p> <p>Led by Met Office (UK)</p>
 <p><b>LSA SAF</b></p> <p>Land Surface Analysis</p> <p>Led by Portuguese Meteorological Institute</p>	 <p><b>O3M SAF</b></p> <p>Ozone and Atmospheric Chemistry Monitoring</p> <p>Led by Finnish Meteorological Institute</p>	 <p><b>ROM SAF</b></p> <p>Radio Occultation Meteorology (formerly GRAS SAF)</p> <p>Led by Danish Meteorological Institute</p>	 <p><b>H SAF</b></p> <p>Support to Operational Hydrology and Water Management</p> <p>Led by Italian Meteorological Institute</p>



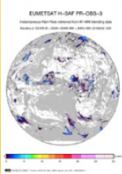
Utilising specialist expertise from the Member States, Satellite Application Facilities (SAFs) are dedicated centers of excellence for processing satellite data.

They form an integral part of the distributed EUMETSAT Application Ground Segment.

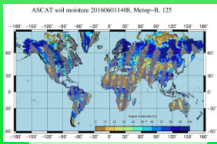
## Satellite Application Facility in Support to Operational Hydrology and Water Management

NEAR REAL  
TIME

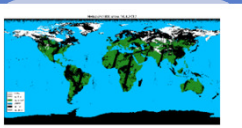
Eumetcast,  
HSAF ftp



PRECIPITATION  
rate and accumulated



SOIL MOISTURE  
surface and root mean zone



SNOW  
detection, cover, water equivalent

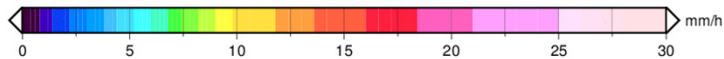
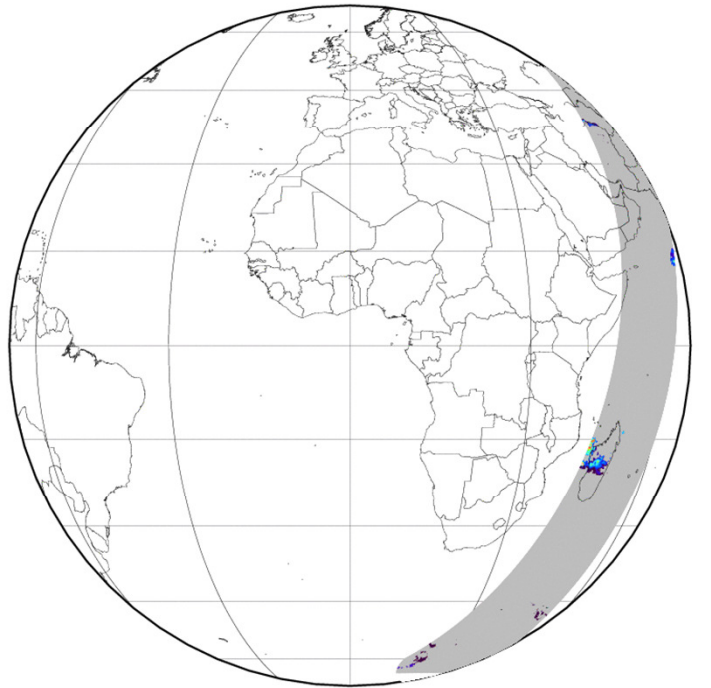
Civil Protection,  
Risk  
Management,  
Hydrological  
applications,  
Nowcasting,  
Hydrology and  
water  
management

# MW precipitation products

## EUMETSAT H-SAF P-IN-SSMIS

Instantaneous Rain Rate from Conical MW Scan

Rain Rate retrieved from SSM/I and SSMIS data: 20190622 0000 DMSP16 808E

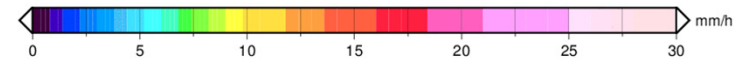
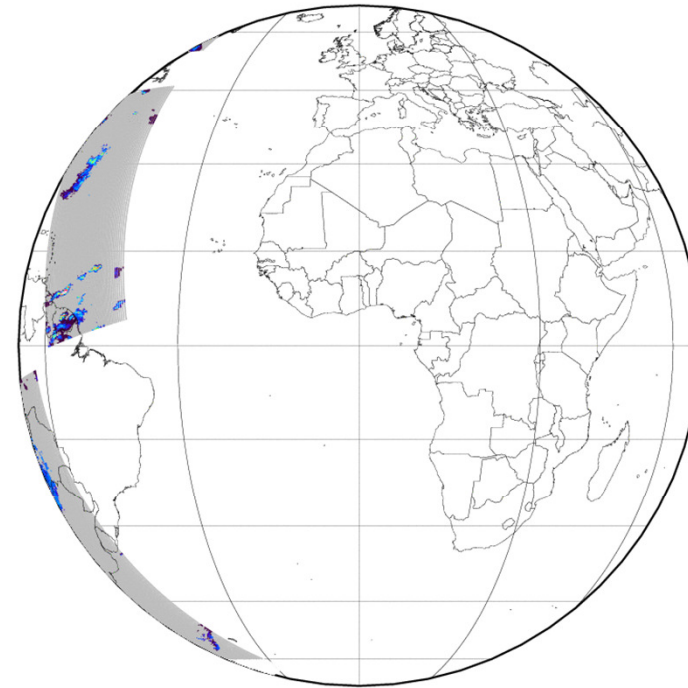


GM 2019 Sep 17 12:16:40 | Production\_SATELLITE\_AREA\_COMET\_Algorithm\_ISAC\_CNR---A@EUMETSAT---

## EUMETSAT H-SAF P-IN-MHS

Instantaneous Rain Rate from Crosstrack MW Scan

Rain Rate from Crosstrack MW Scan: 20190622 0046 METOPB 35068



GM 2019 Sep 17 09:58:10 | Production\_SATELLITE\_AREA\_COMET\_Algorithm\_ISAC\_CNR---A@EUMETSAT---

Main features
Coverage: Strips of ~1400Km swath
Cycle: More than 6 passes/daily over Europe
Spatial Resolution: ~30Km
Timeliness: 150 minutes from observing time
Dissemination: EUMETCast H SAF ftp Server
Format: BUFR

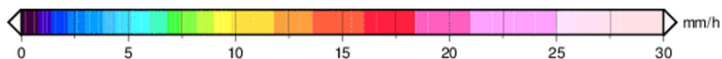
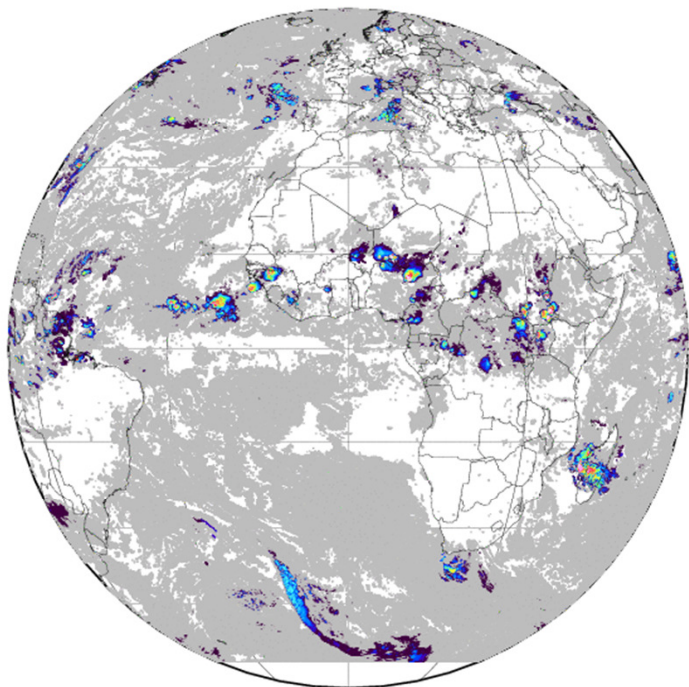
Main features
Coverage: Strips of ~2250Km swath
Cycle: More than 6 passes/daily over Europe
Spatial Resolution 16x16 - 26x52 km2
Timeliness: 30 minutes from observing time
Dissemination: EUMETCast H SAF ftp Server
Format: BUFR

# MW + IR precipitation products

## EUMETSAT H-SAF P-IN-SEVIRI

Instantaneous Rain Rate retrieved from IR-MW blending data

Blending of: SEVIRI IR + SSM/I-SSMIS MW + AMSU MW: 20190622 0000

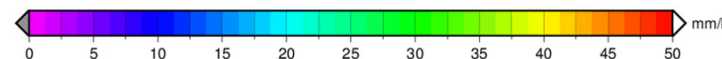
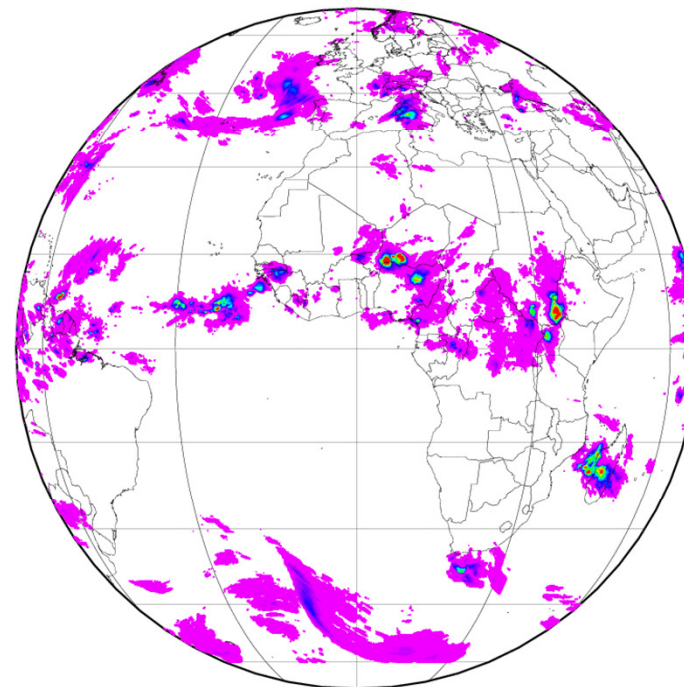


GM7 2019 Sep 16 12:42:50 | Production\_SATELLITE\_AREA\_COMET\_Algorithm\_ISAC\_CNR---ADEUMETSAT---

## EUMETSAT H-SAF P-AC-SEVIRI

Accumulated Precipitation in the previous 3 hours

Blending of: SEVIRI IR + SSM/I-SSMIS MW + AMSU MW: 20190622 0300



GM7 2019 Sep 17 12:54:51 | Production\_SATELLITE\_AREA\_COMET\_Algorithm\_ISAC\_CNR---ADEUMETSAT---

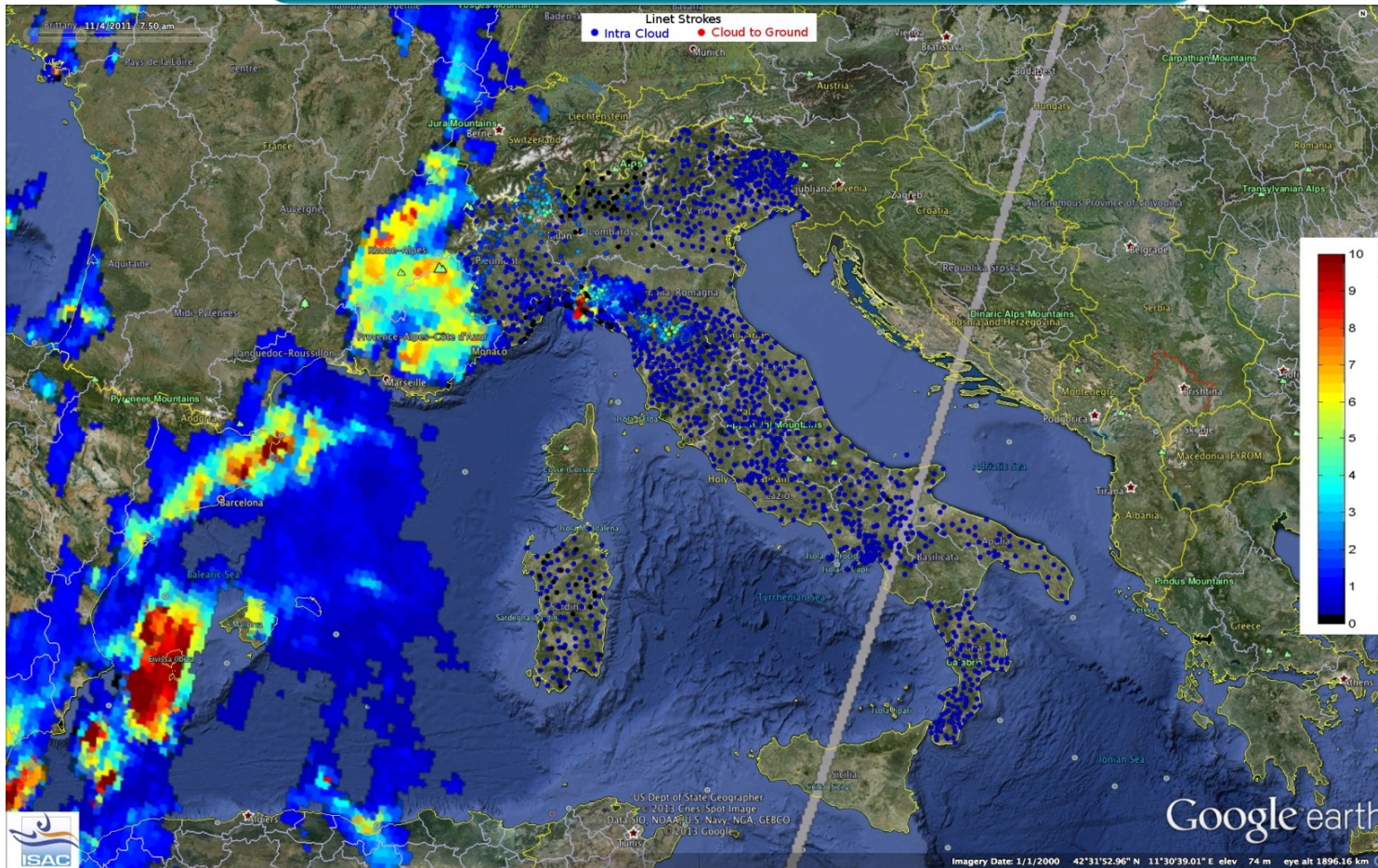
Main features
Coverage: MSG Full-disk area
Cycle: Every 15 min
Spatial Resolution: 3 Km s.s.p. ~8 km over Europe
Timelines: Within 15 minutes
Dissemination: EUMETCast H SAF ftp
Format: GRIB-2

Main features
Coverage: MSG Full-disk area
Cycle: Every 3h
Spatial Resolution: 3 Km s.s.p. ~8 km over Europe
Timelines: Within 15 minutes after every 3h
Dissemination: EUMETCast H SAF ftp
Format: GRIB-2

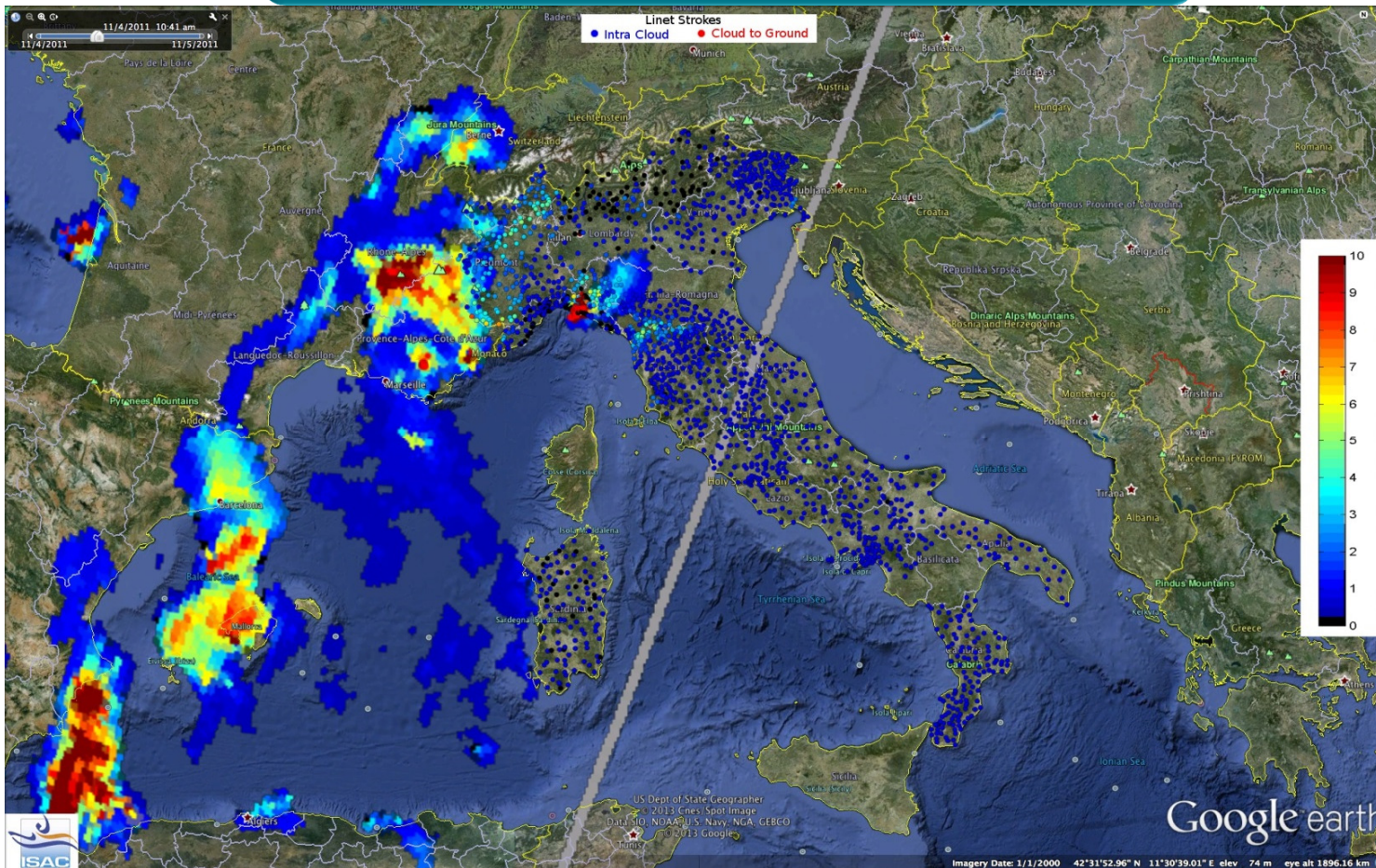
Italian case study :  
Genoa 4 November 2011



# Italian case study : Genoa 4 November 2011

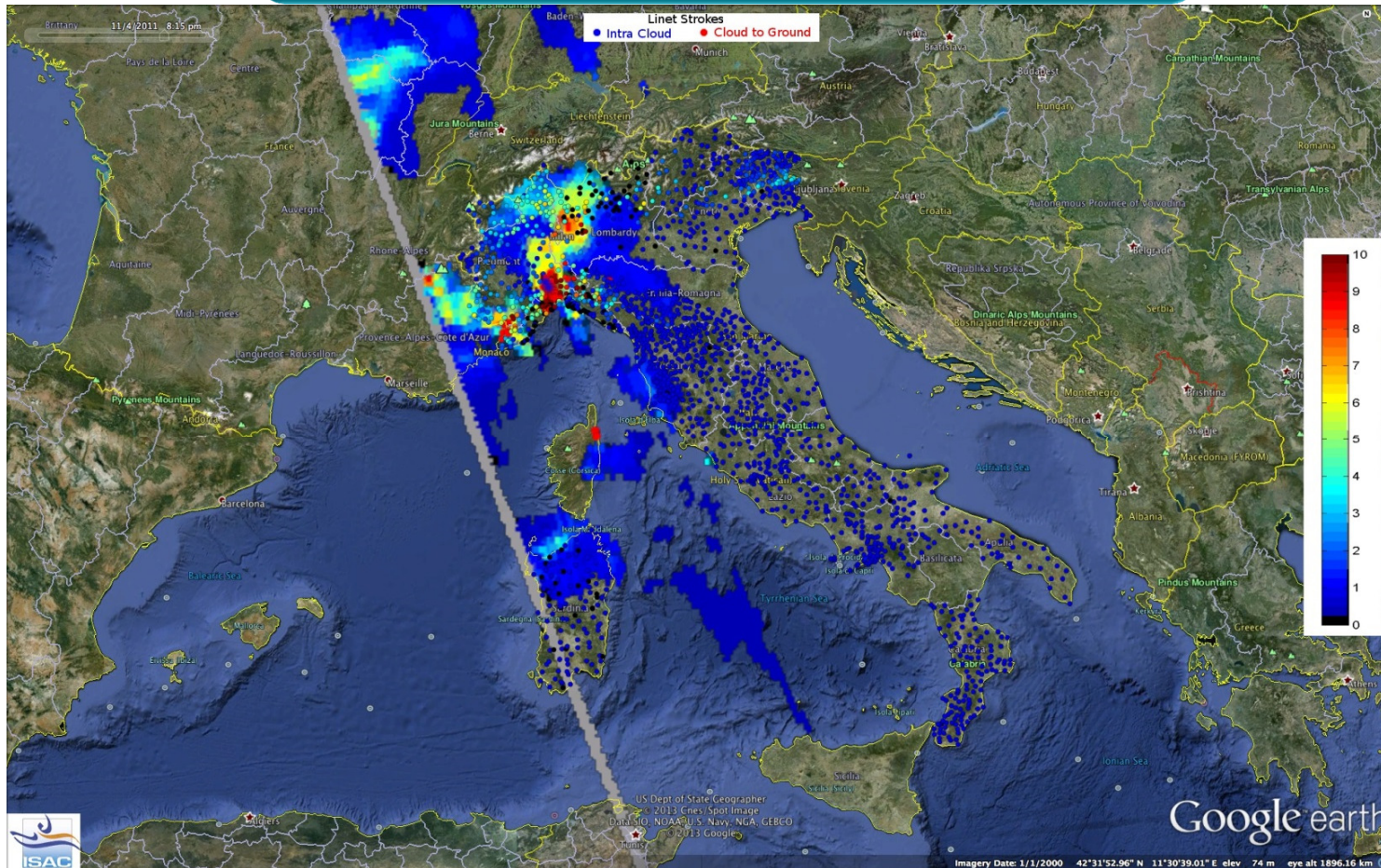


# Italian case study : Genoa 4 November 2011

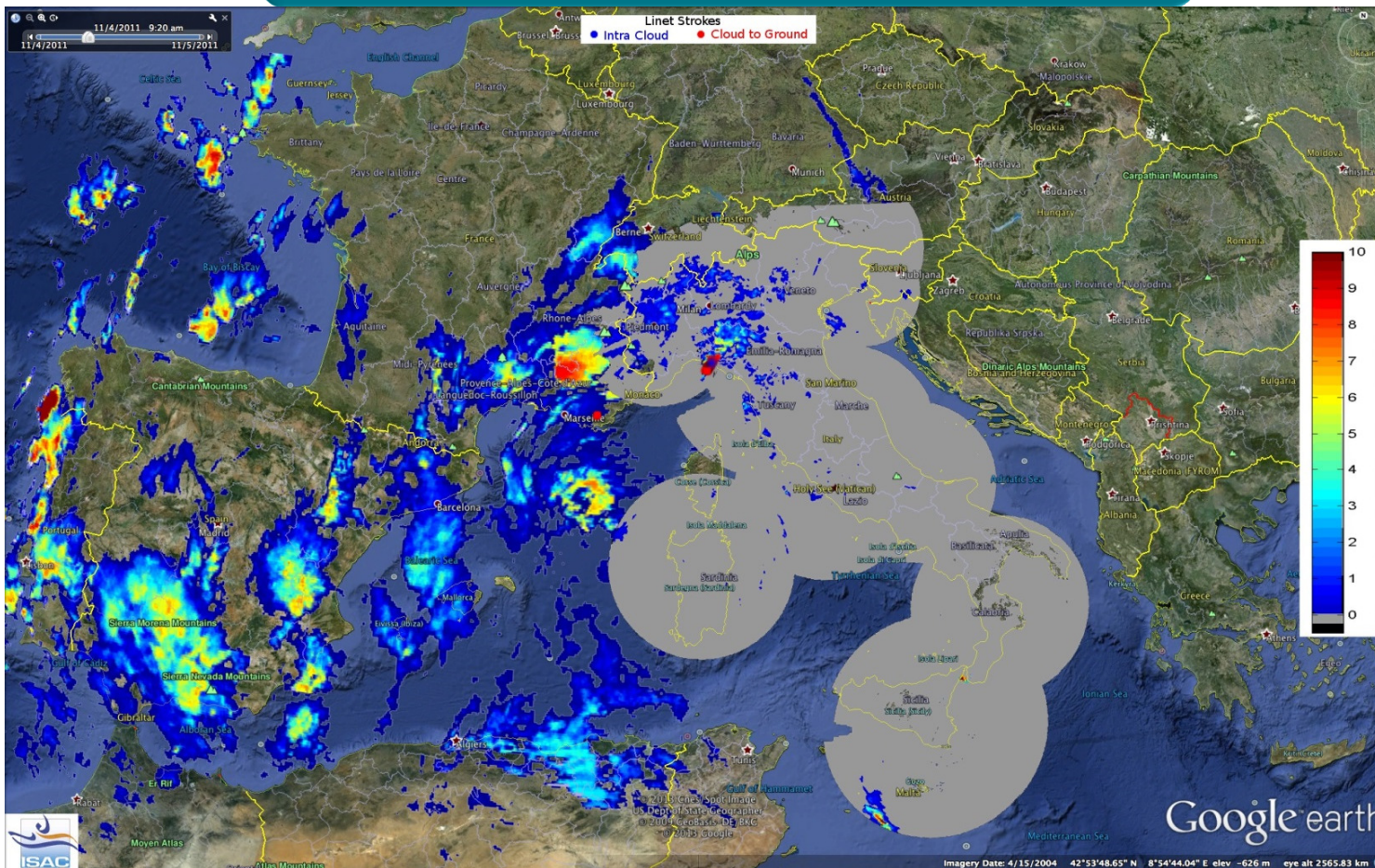




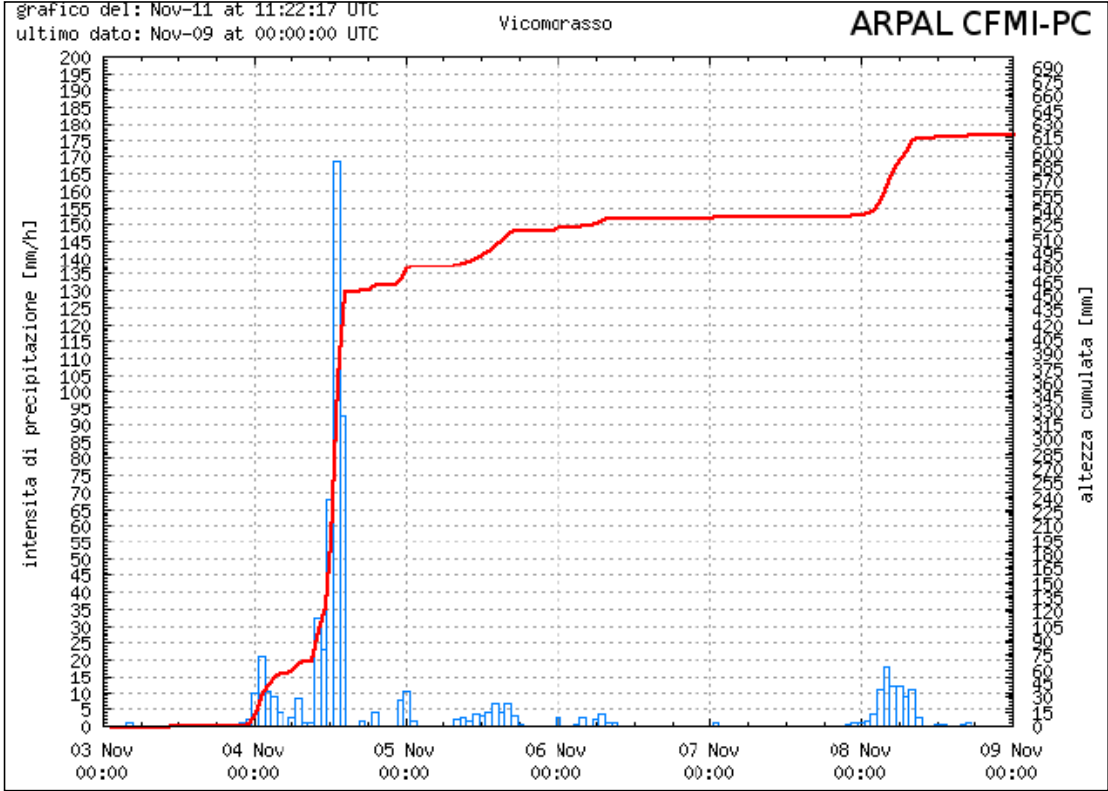
# Italian case study : Genoa 4 November 2011



# Italian case study : Genoa 4 November 2011



# Italian case study : Genoa 4 November 2011



## Precipitation Products strategy and foreseen improvements

### New PMW based Products

#### Higher temporal sampling

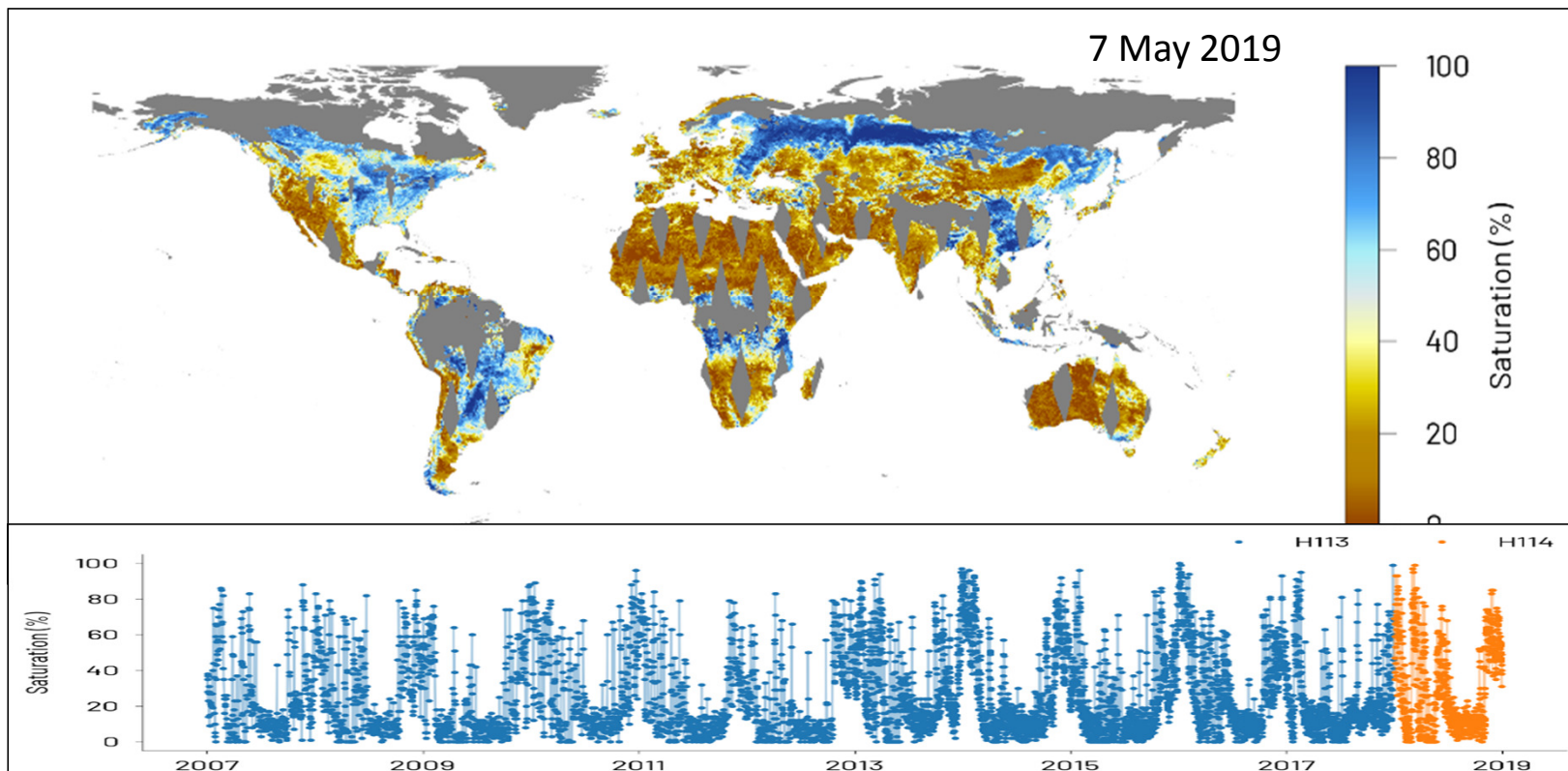
- Full exploitation of all overpasses of present and future satellites, including GPM

#### Transition to MTG

- LI

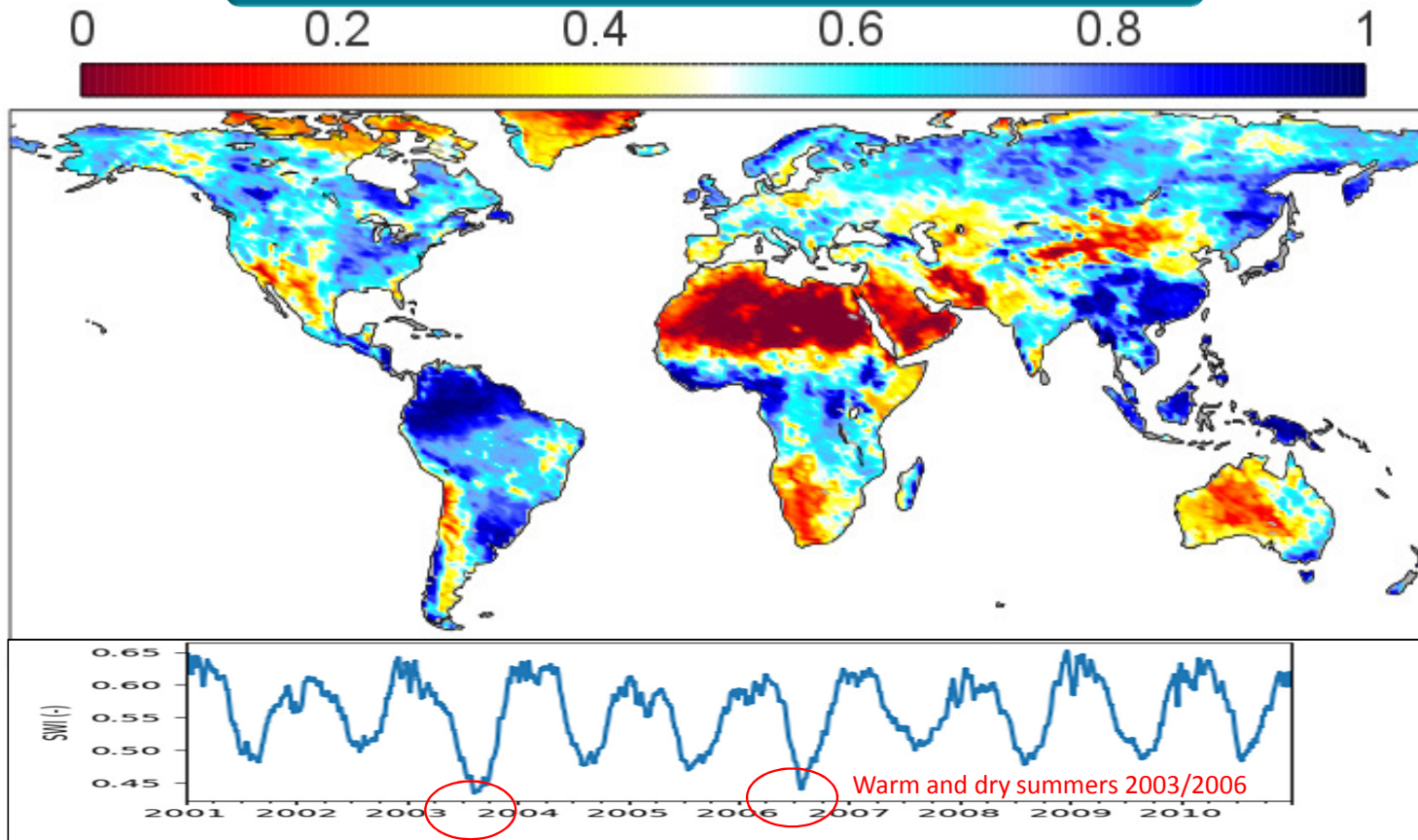
### Integration of Precipitation/Soil Moisture Products

## SURFACE SOIL MOISTURE (SSM)



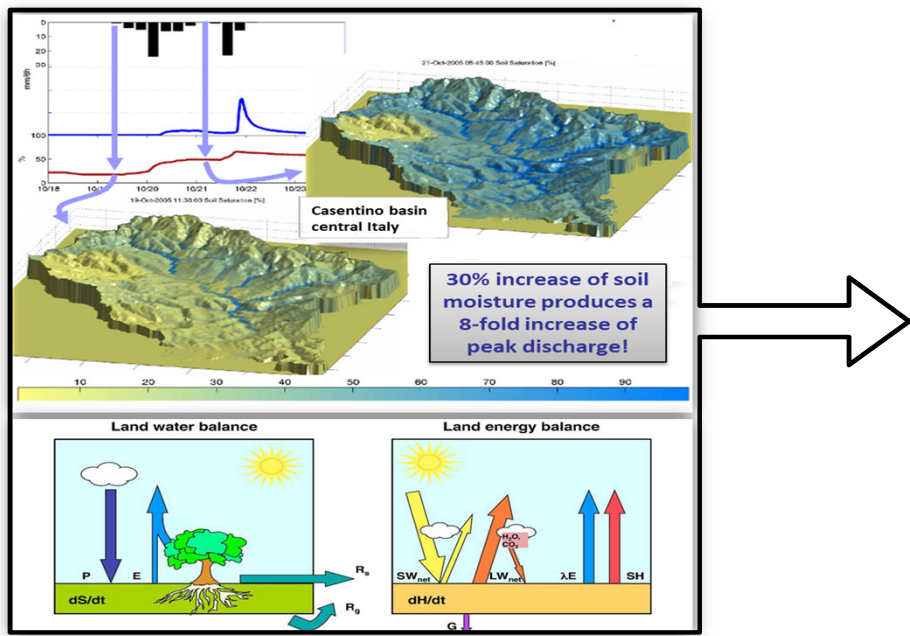
- ASCAT **Climate Data Record SSM** released every year in time series format,
- ASCAT CDR and offline extension ( 2007 /01/01- 2019/12/31)

**ROOT MEAN ZONE SOIL MOISTURE (RSM)**

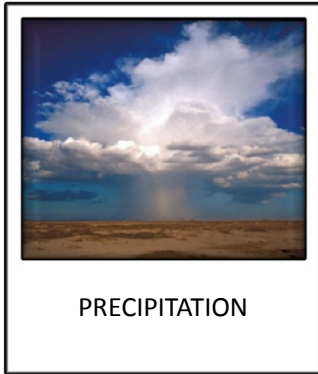


- **Global H27 CDR product** (1992-2014) and H140 (2015-2016) are produced at 16 km resolution.
- H27/H140 assimilate reprocessed ERS1/2 (1992-2006) and ASCAT-A (2007-2016) observations into an offline version of HTESSSEL forced by the ERA-Interim atmospheric reanalysis.

# SOIL MOISTURE DATA USE



DROUGHT



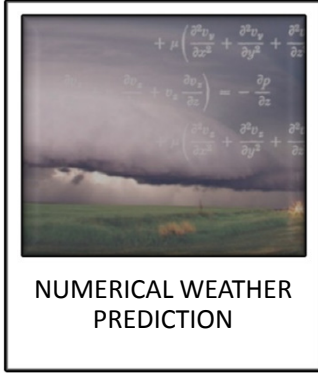
PRECIPITATION



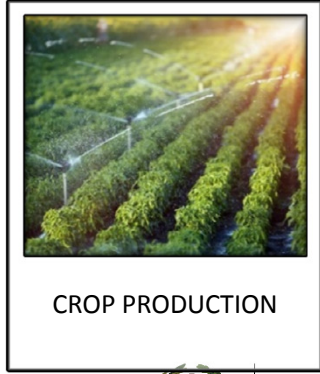
FLOODS



LANDSLIDES

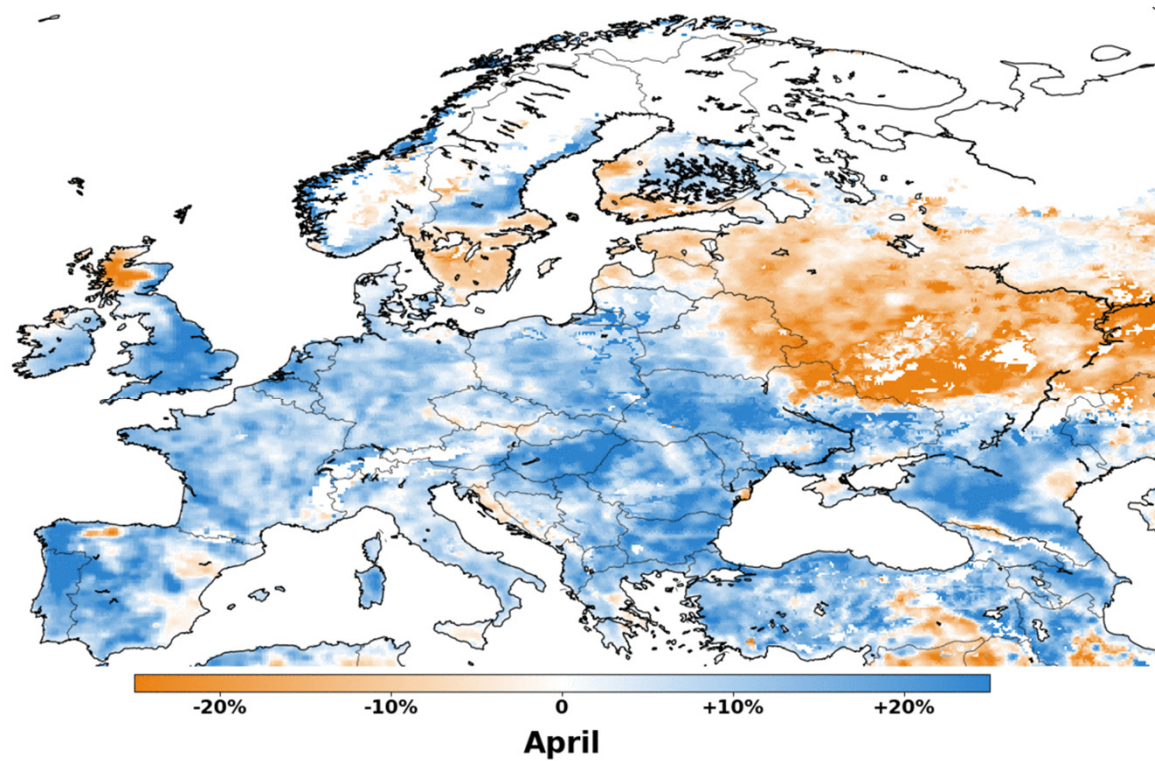


NUMERICAL WEATHER PREDICTION



CROP PRODUCTION

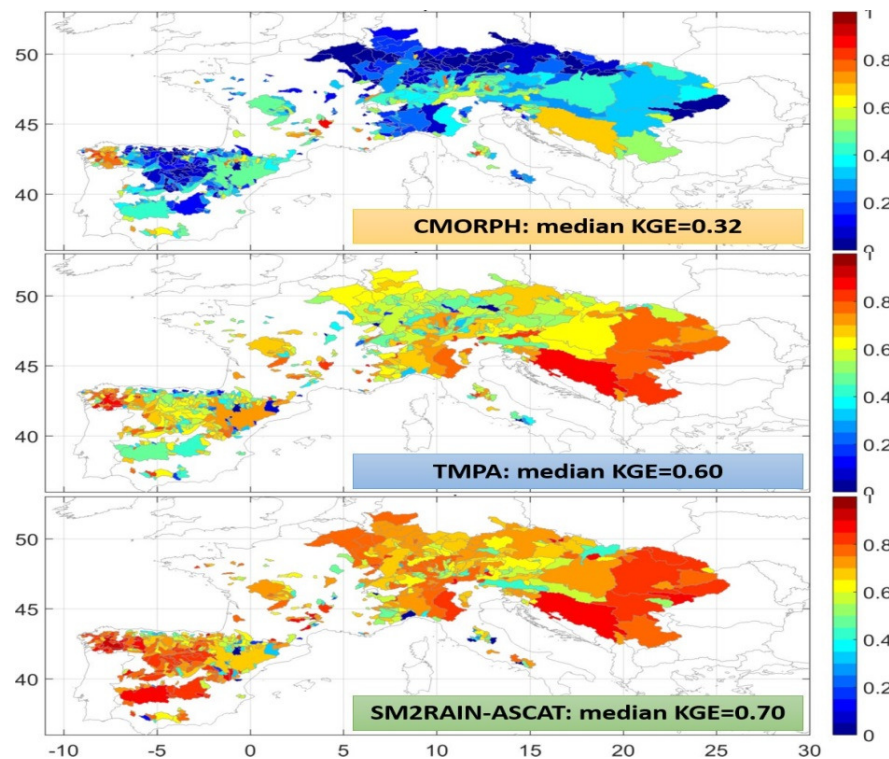
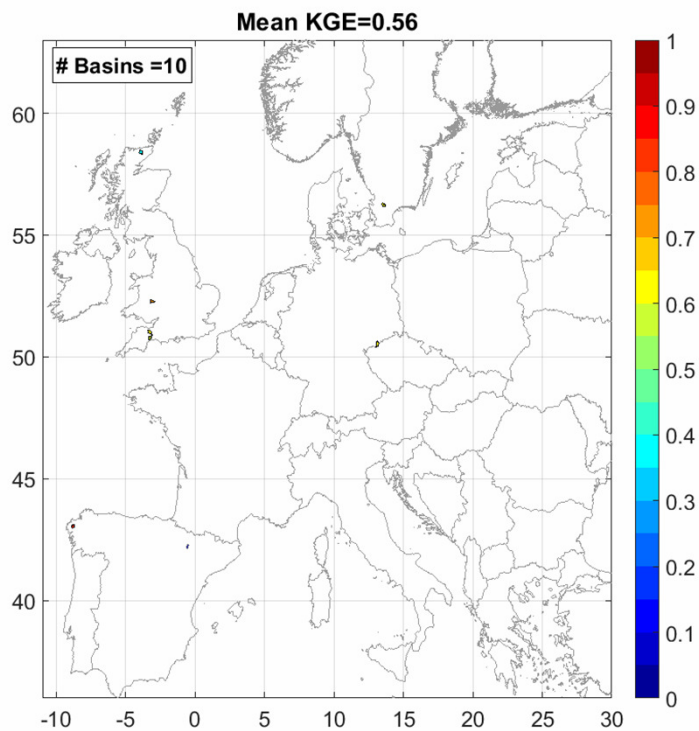
# Drought Soil Moisture Anomalies





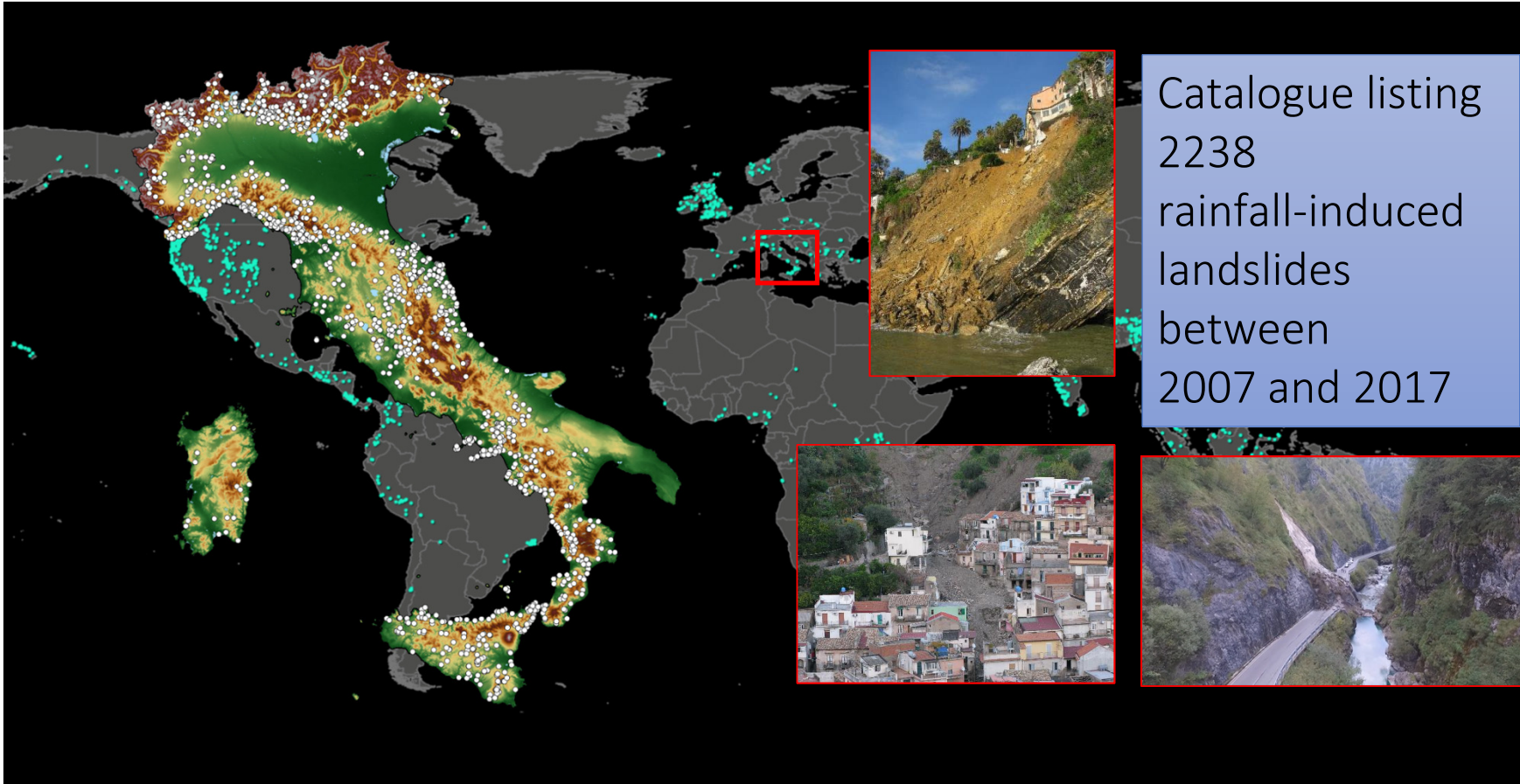
# SM2RAIN for Flood Prediction - Europe

Simulation of floods over 600 basins in Europe through SM2RAIN precipitation



Camici et al. (2018 JoH)

# SM2RAIN for Landslide - Europe



Brunetti et al. (2018 RSE)

## Soil Moisture Products strategy and foreseen improvements

### Higher resolution

- For Surface Soil Moisture

### Higher resolution

- For Root Zone Soil Moisture

### Transition to EPS-SG

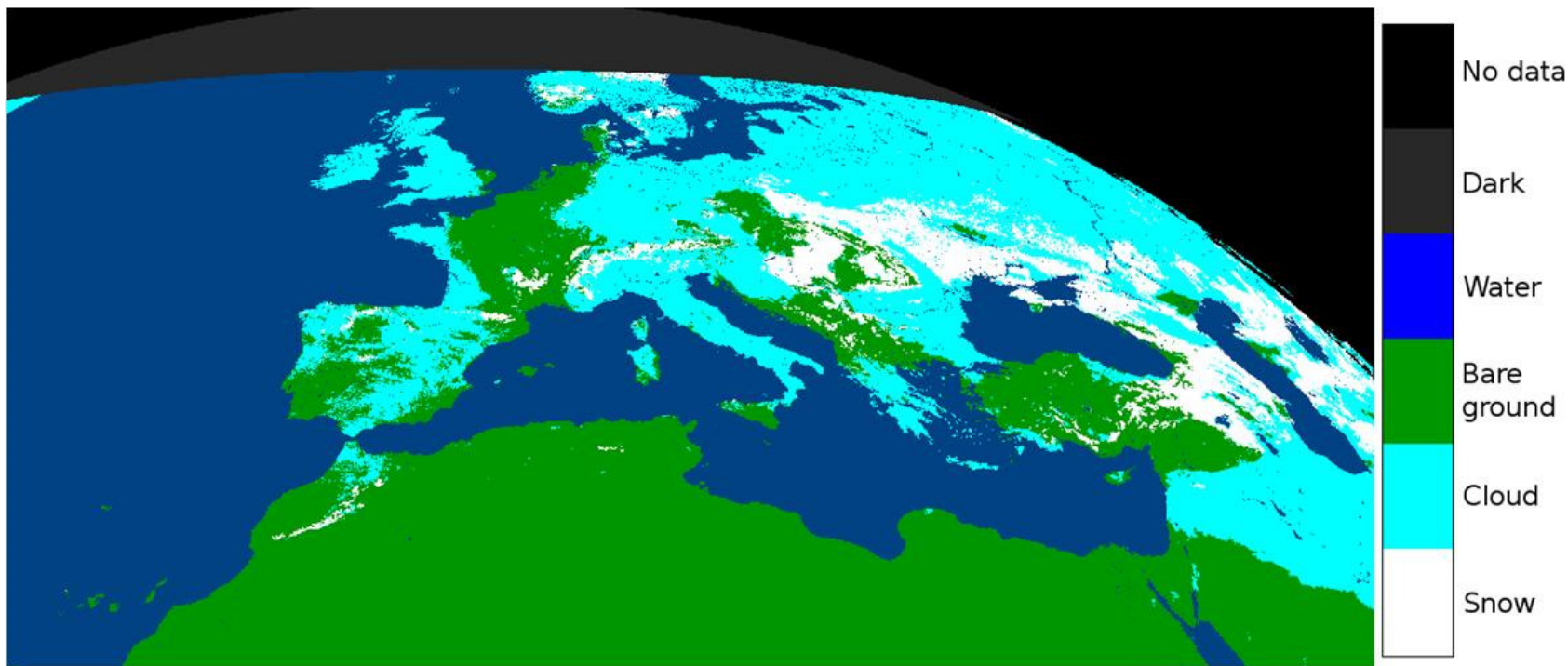
- From ASCAT to SCA, both surface and Root Zone Soil Moisture

CDOP3

CDOP4

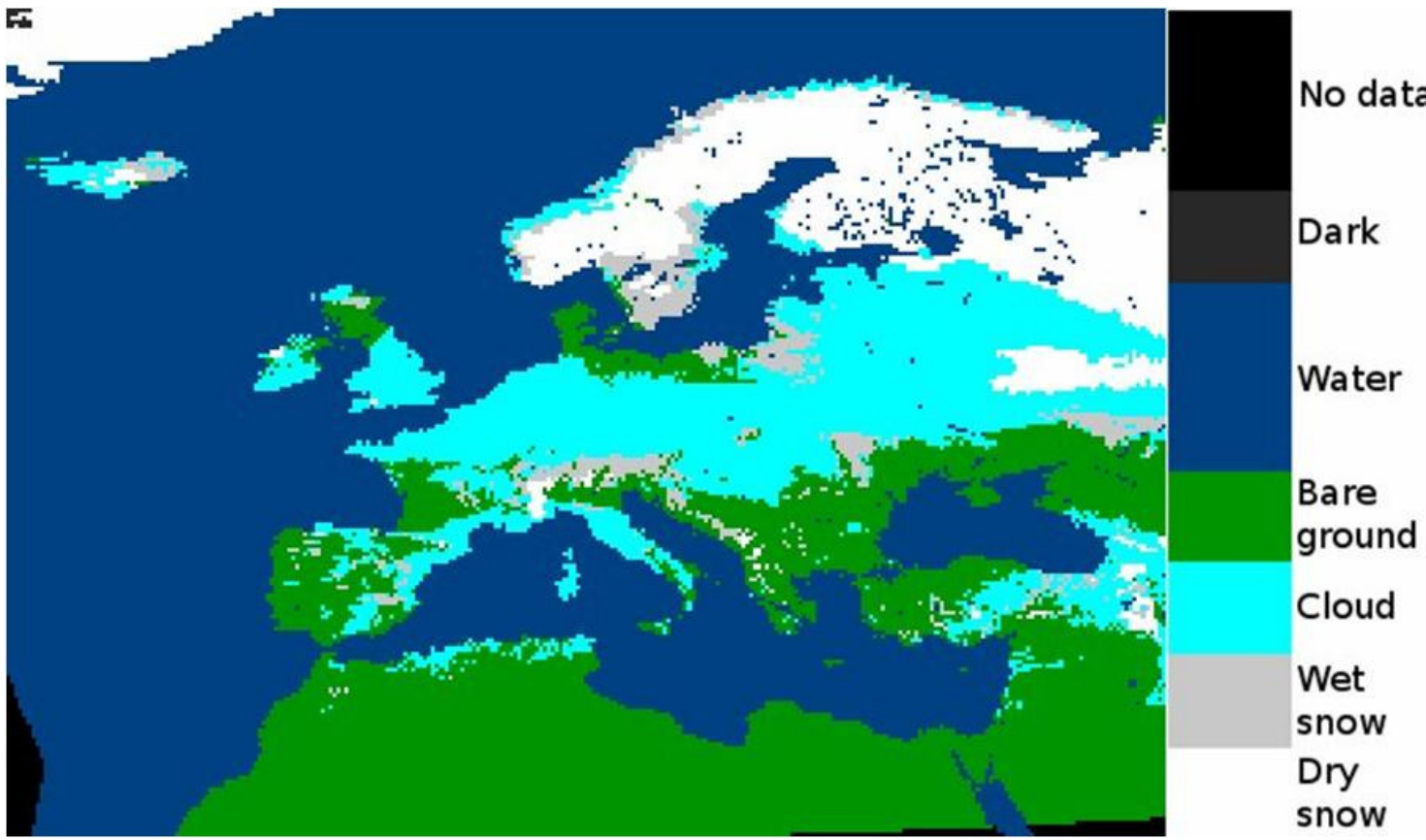
## SNOW PRODUCTS: Snow Detection by VIS/IR

- Cycle: Daily
- Coverage: Europe, Northern Africa, Middle East
- Grid/Projection: Part of Meteosat/SEVIRI 0° fulldisk, GEOS projection
- Resolution: Variable from 3 km to 10 km, depending on distance from sub-satellite point
- Formats: HDF5, PNG quicklook



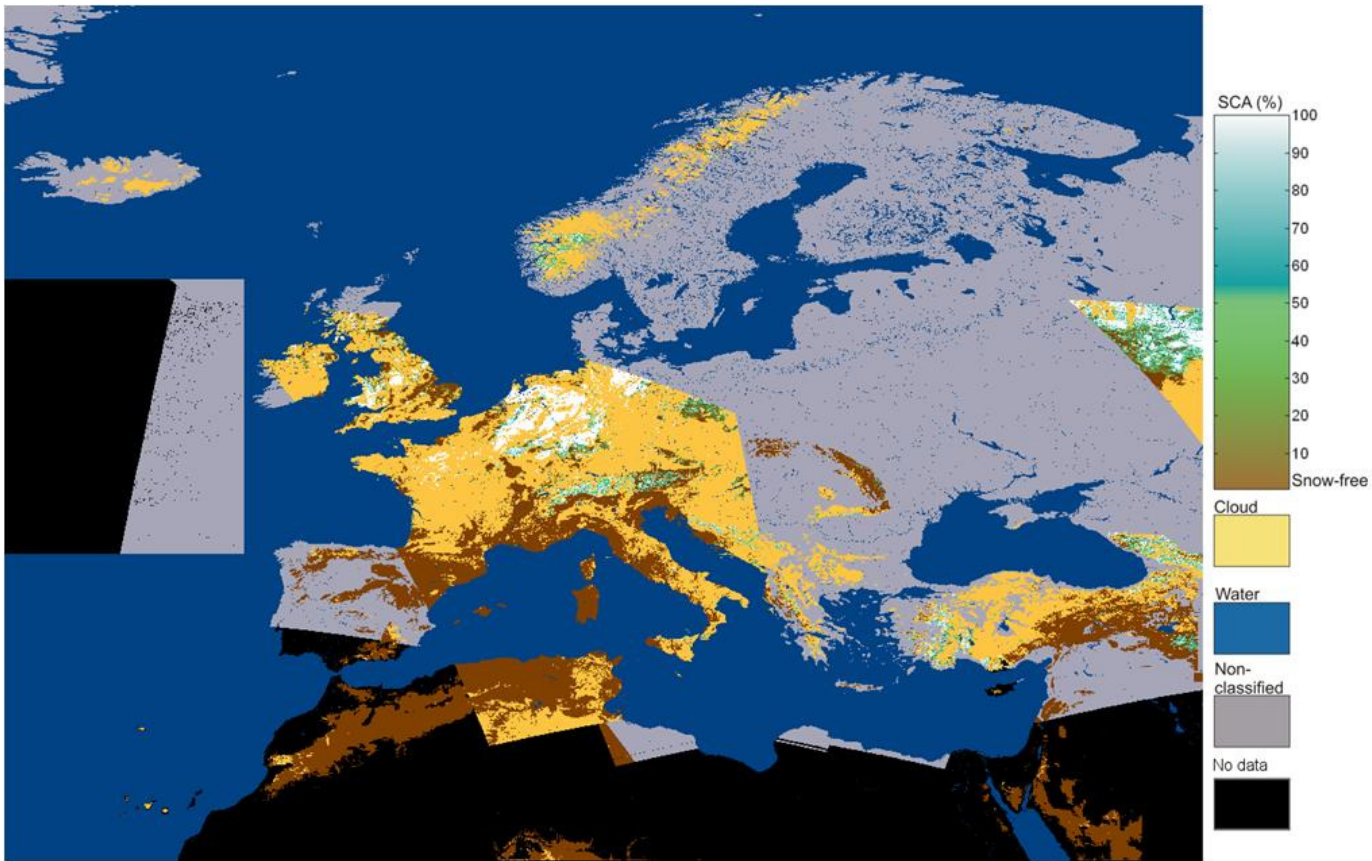
## SNOW PRODUCTS: Snow Status (Dry/Wet) by MW

- Cycle: Daily
- Coverage: 25 ° W – 45 ° E, 25 ° N – 75 ° N
- Grid/Projection: Equidistant cylindrical
- Resolution: 0.25 ° x 0.25 °
- Formats: gzip compressed GRIB2, PNG quicklook image



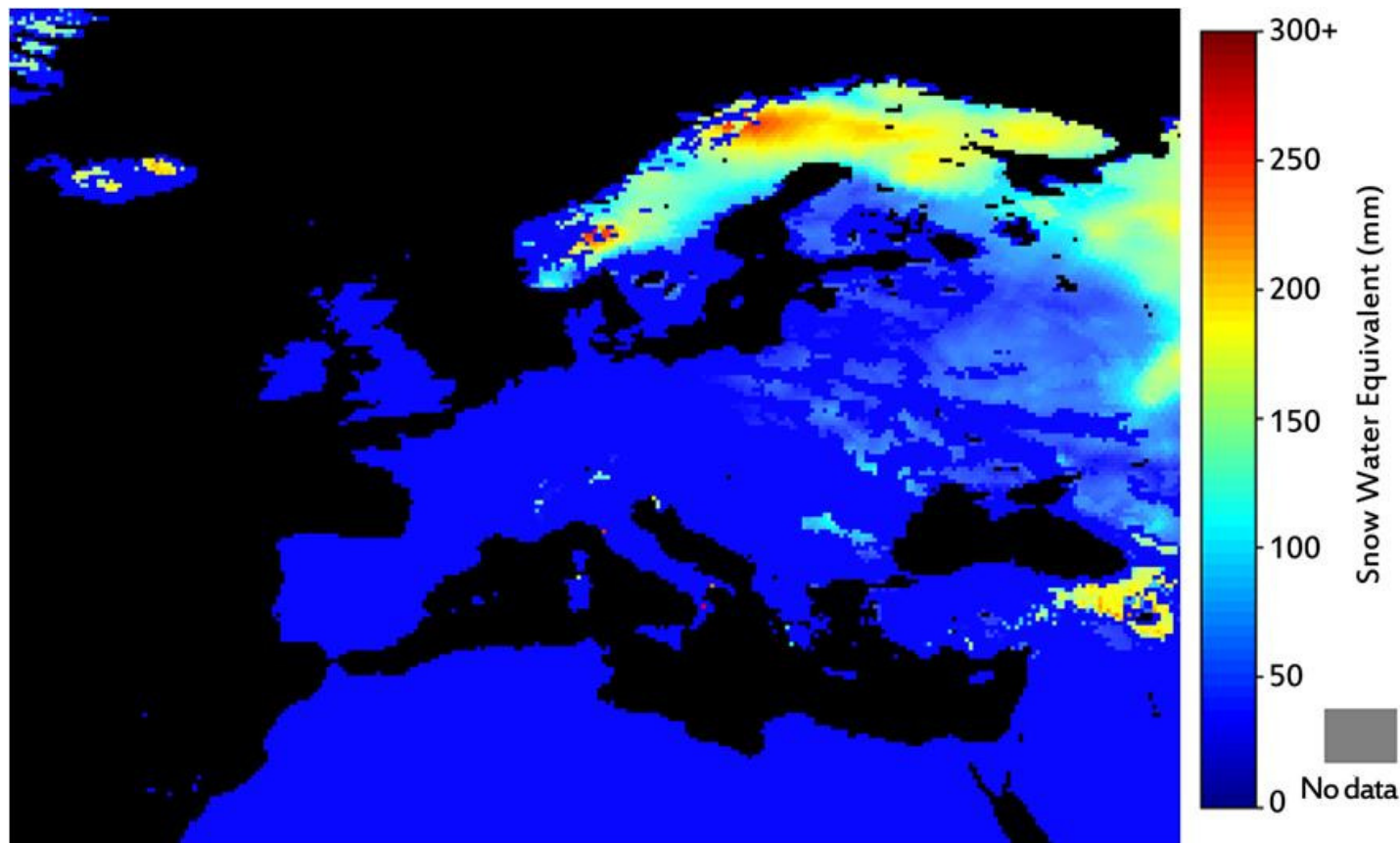
# SNOW PRODUCTS: Effective snow cover by VIS/IR

- Cycle: Daily
- Coverage: 25 ° W – 45 ° E, 25 ° N – 75 ° N
- Grid/Projection: Equidistant cylindrical
- Resolution: 0.01 ° x 0.01 °
- Formats: gzip compressed GRIB2, PNG quicklook image

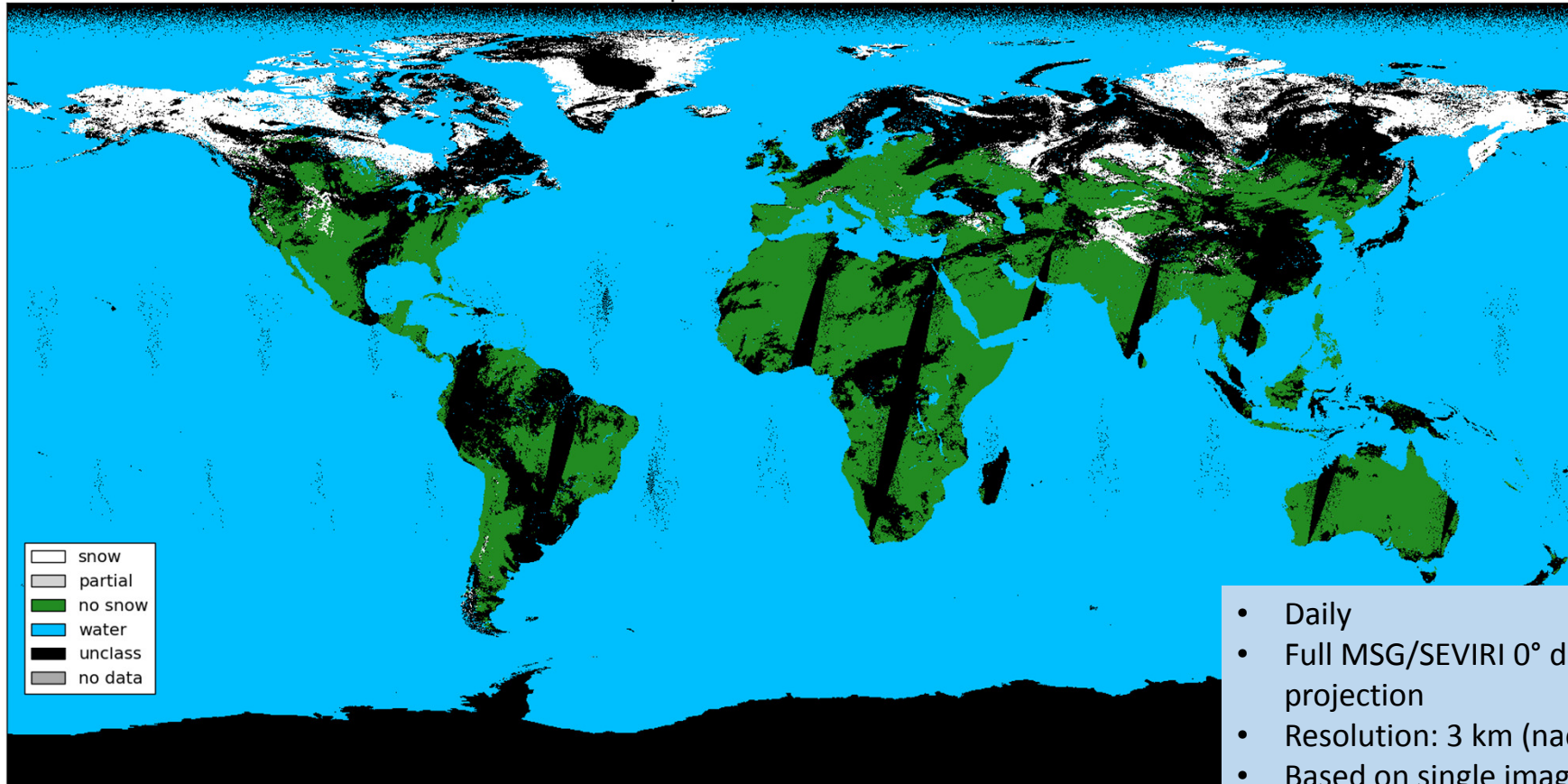


## SNOW PRODUCTS: snow water equivalent by MW

- Cycle: Daily
- Coverage: 25 ° W – 45 ° E, 25 ° N – 75 ° N
- Grid/Projection: Equidistant cylindrical
- Resolution: 0.25 ° x 0.25 °
- Formats: gzip compressed GRIB2, PNG quicklook image



## Metop/AVHRR snow extent



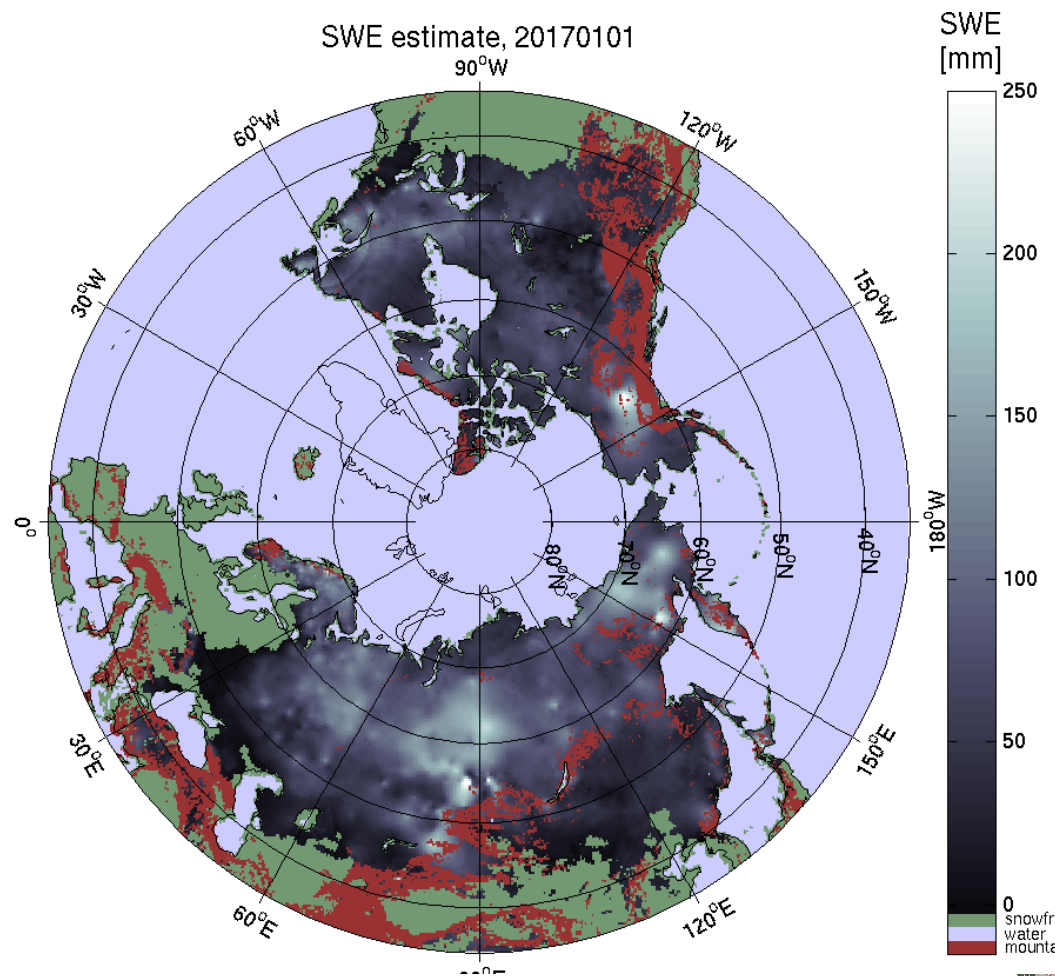
- Daily
- Full MSG/SEVIRI 0° disk, GEOS projection
- Resolution: 3 km (nadir)
- Based on single image classifications which are merged to create daily product
- Processed in the LSA SAF





## Snow products: northern hemisphere

Cycle: Daily  
Coverage: Northern Hemispherical  
Grid/Projection: "EASE-Grid" -  
Lambert's equal-area  
Resolution: 25 km x 25 km  
Formats: HDF5, PNG quicklook  
Operational status: **In development**



## Product Validation Program: Quality Control

- **to monitor the progress in product quality** as further development evaluating statistical scores and case study analysis on the base of comparison between satellite products and ground data;
- **to provide validation service to end-users** publishing on the H SAF webpage the statistical scores evaluated and the case studies analysed;
- **To investigate the H SAF product impact in end-user applications** for emergency management, precipitation event alerts, street monitoring, water balance evaluation, etc.

Product quality  
assessment

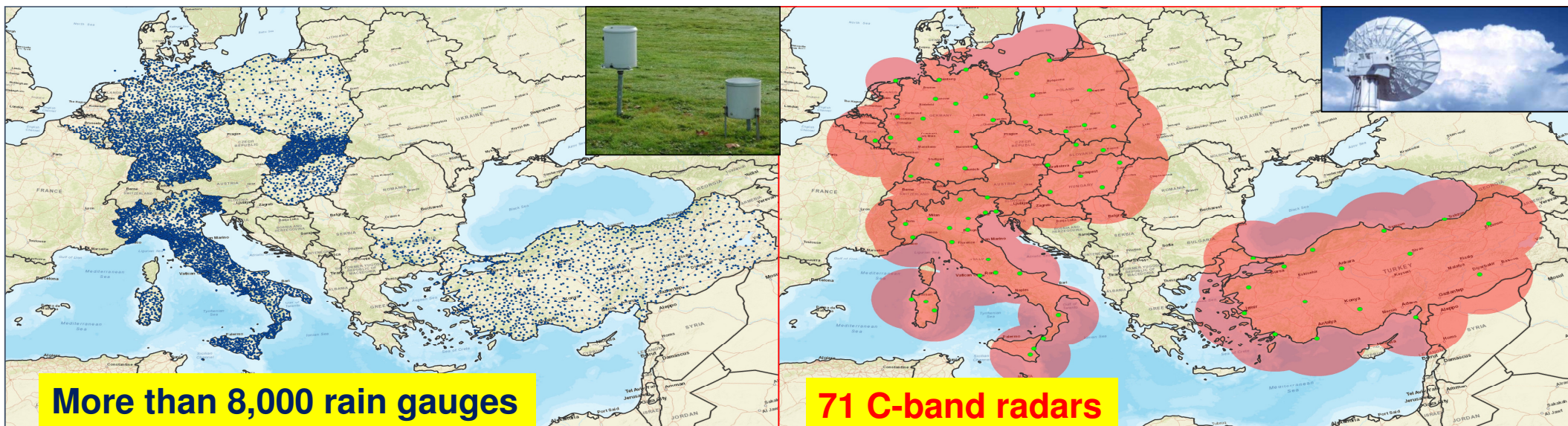
User Promotion

Tool  
development

Hydrologists, meteorologists, and precipitation, snow and soil moisture ground data experts, coming from experts from the National Meteorological and Hydrological Institutes of **Austria (ZAMG)**, **Belgium (IRM)**, **Bulgaria (NIMH)**, **Finland (FMI)**, **France (Meteo France)**, **Germany (BfG)**, **Hungary (OMSZ)**, **Italy (ITAF MET, DPC, UniBo, CNR-IRPI, CIMA)**, **Poland (IMWM)**, **Slovakia (SHMU)**, and **Turkey (ITU, METU, AU)**. ECMWF takes also part of the PVG.

## Precipitation Product Validation Group (PPVG)

The *Precipitation Product Validation Group (PPVG)* is composed of experts from the National Meteorological and Hydrological Institutes of **8 European countries** under the coordination of the Italian Civil Protection Department. The PPVG uses both **rain gauge** and **radar** data for validation of precipitation products. Following the same protocol related to :quality control , spatial interpolation up scaling technique, verification method.

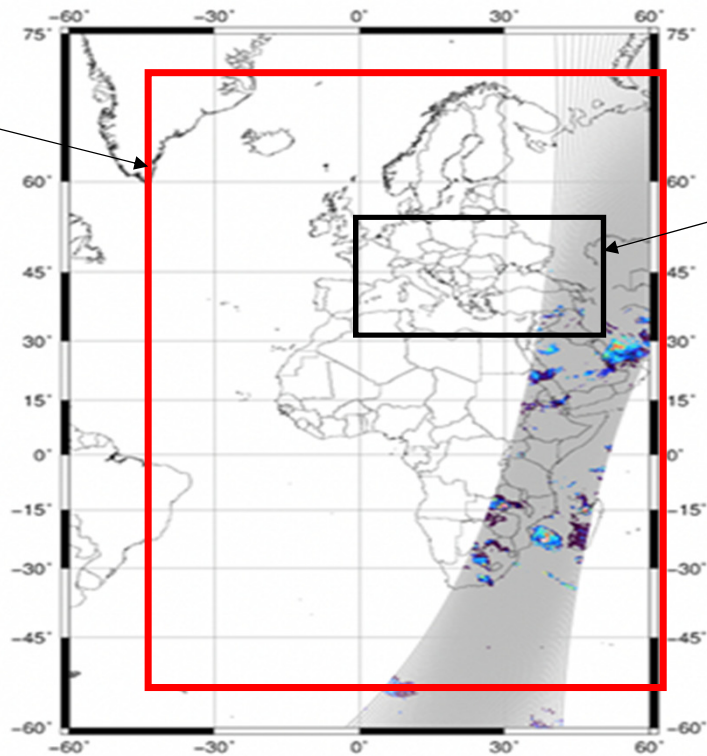
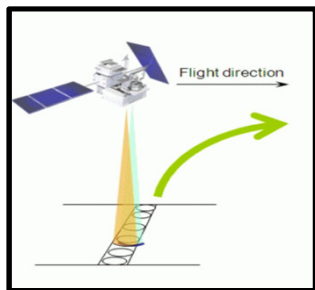


# Precipitation products area coverage

**MSG Full Disk area**

Global (or hemispherical)  
precipitation products

**DPR (Dual-frequency  
Precipitation Radar)** onboard  
of **GPM Core** satellite



**H SAF area**

National ground data:  
radars and raingauges

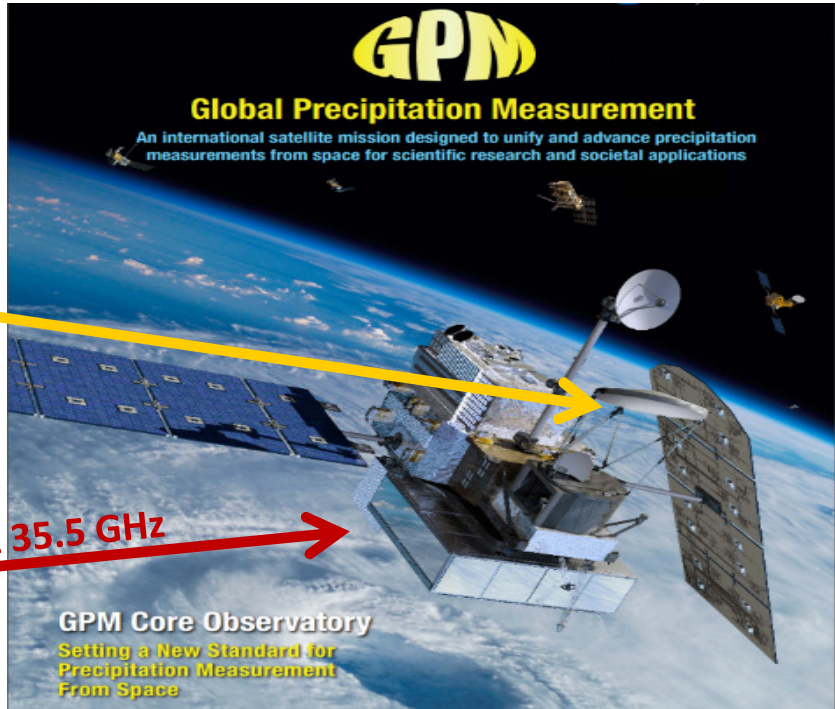


# GPM Core Observatory (Global Precipitation Measurement)

The GPM Core Observatory carries two instruments that observe precipitation (rain, snow, ice) in new ways and connect measurements to those taken on other partner satellites

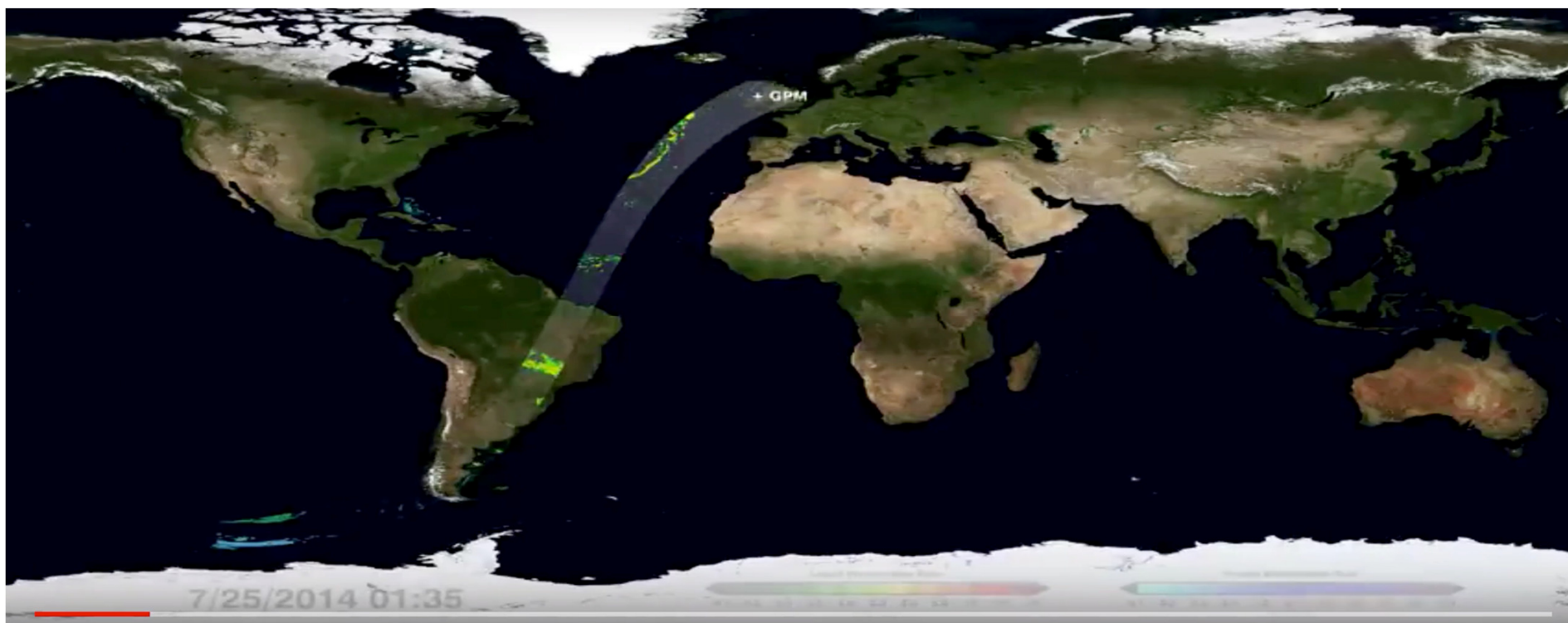
**GPM Microwave Imager (GMI): 10-183 GHz**  
13 channels that provides an integrated picture of energy emitted by precipitation, including light to heavy rain to falling snow (Ball Aerospace)

**Dual-frequency Precipitation Radar (DPR):  
Ku-Ka bands**  
Two different radar frequencies that can look at precipitation in 3-D throughout the atmospheric column (JAXA)



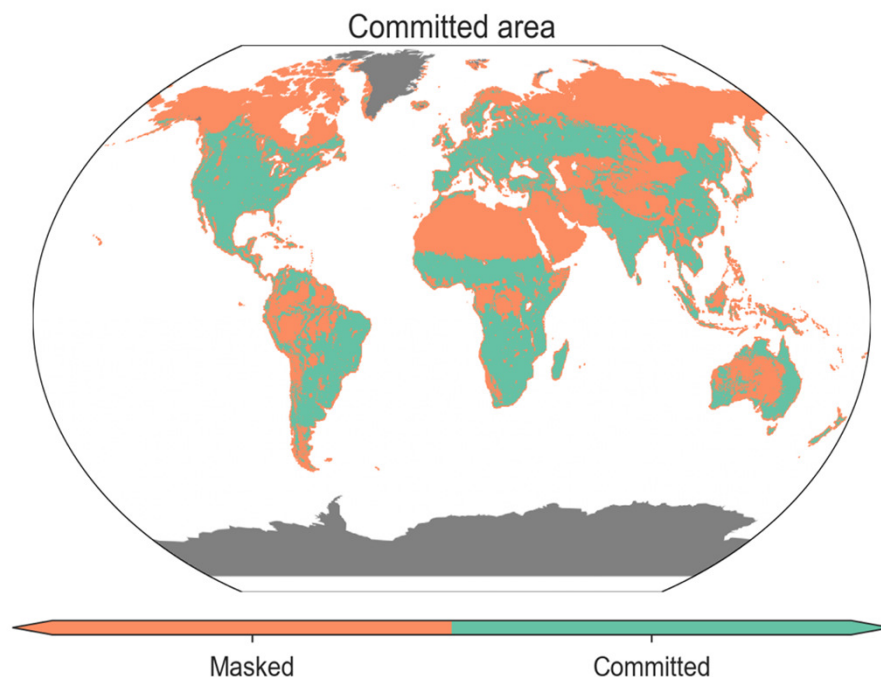
Ku band 12-18GHz; Ka band 26-40GHz;

Temporal and spatial intersection  
(GPM vs NOAA/METOP/Fxx and SEVIRI)



## Validation of the Soil Moisture products

The committed area represents a restricted geographical region with high confidence in the successful retrieval of surface soil moisture information from Metop ASCAT. The area is limited to low and moderate vegetation regimes, unfrozen and no snow cover, low to moderate topographic variations, as well as no wetlands and coastal areas.

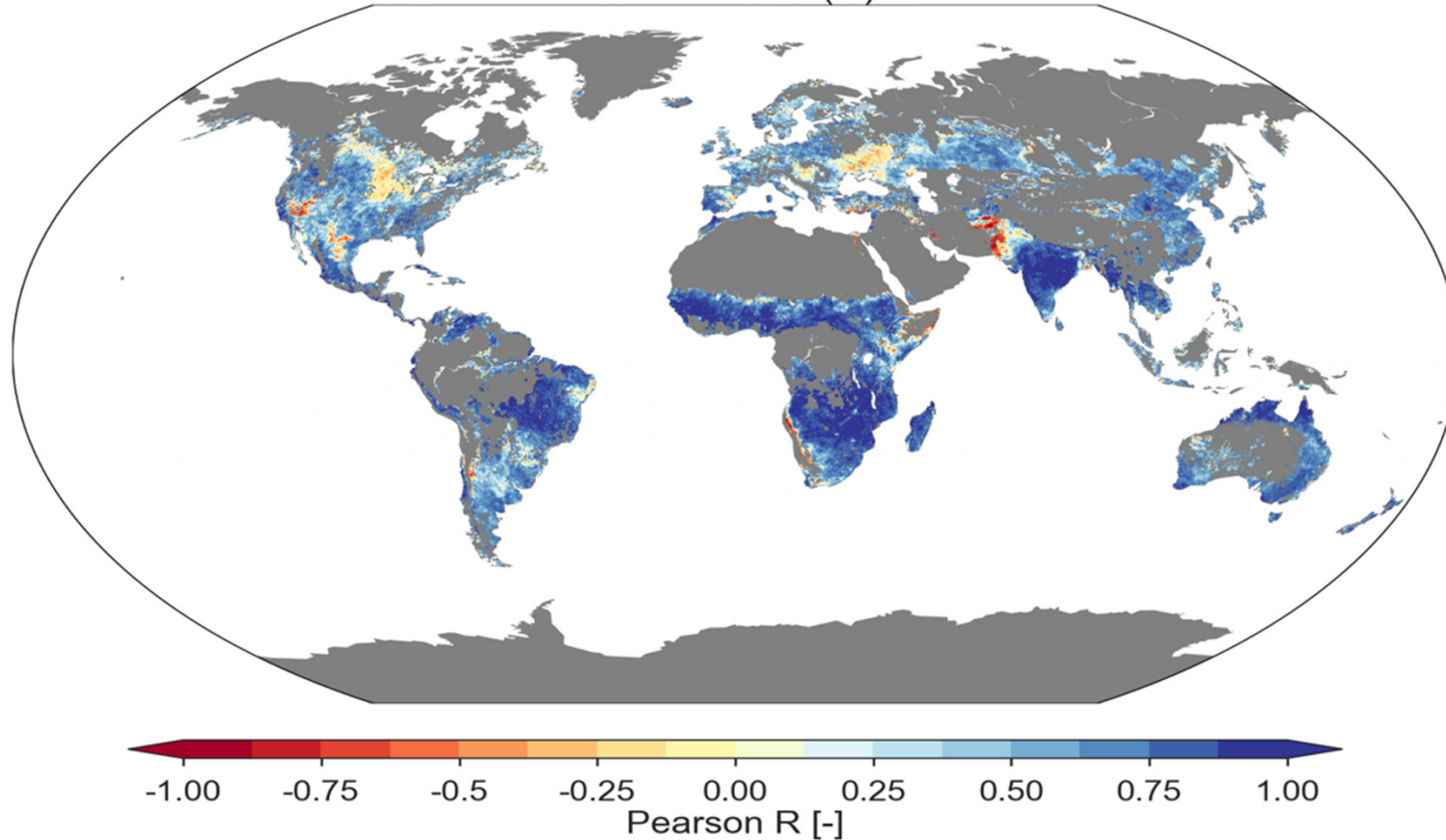


**In green the committed areas (a restricted geographical region with high confidence in the successful retrieval of surface soil moisture information from Metop ASCAT)**

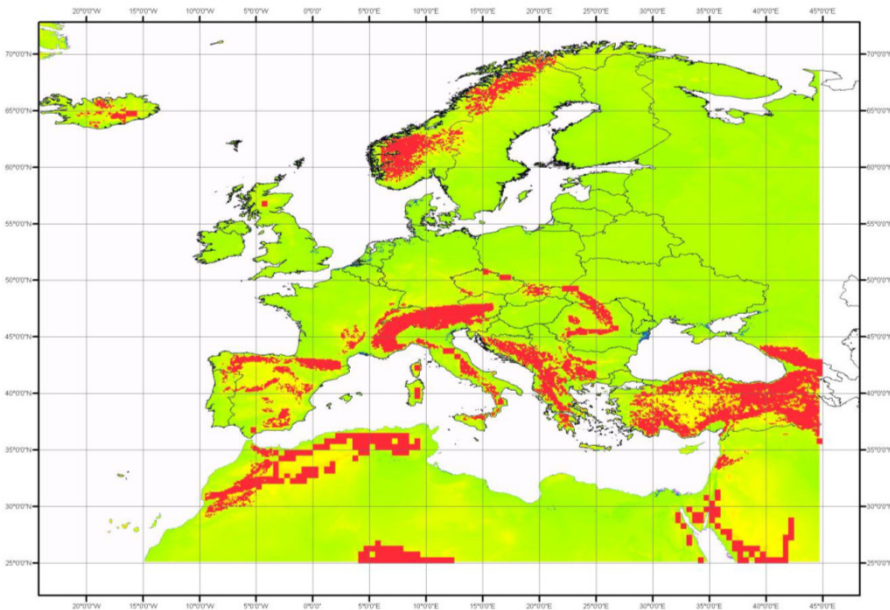


## Validation of the Soil Moisture products

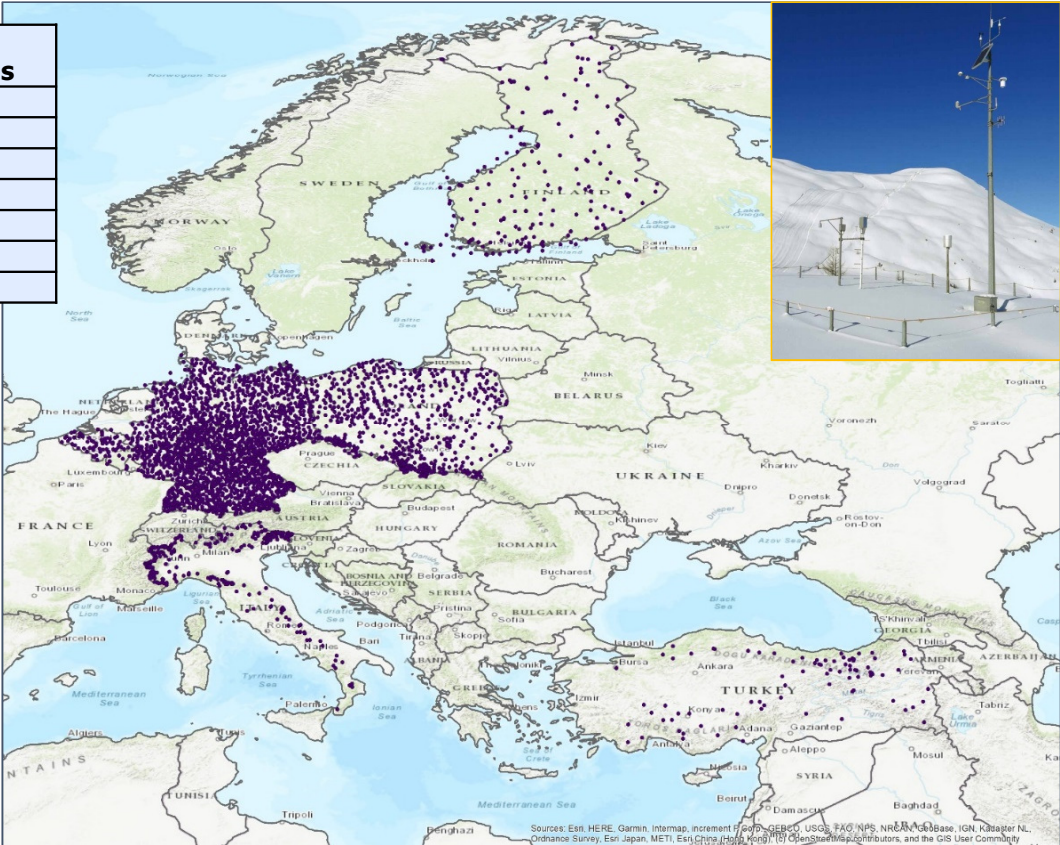
Pearson correlation coefficient (R) - Committed Area



# Validation of the Snow products vs Ground



Number of Stations
190
85
264
595
1863
84
<b>3081</b>



For Products SE-E-SEVIRI and SWE-E validation is done separately for Mountainous and Flat/Forested areas, to provide **complete error information on the product performances related to the orography.**



## The Hydrological Validation Programme

The purpose is to **assess** the benefits of the novel HSAF satellite-derived data on practical hydrological applications and to **improve** products and their usability in operational hydrology

- Product **quality assessment** and their continuous monitoring by product validation (evaluation) with the usage of hydrological rainfall-runoff models,
- Research into possibility of **HSAF products application in operational hydrology**
- **Training activities**, stimulating the use of satellite products in hydrology and water management

Product quality assessment

Usability of products and its improvement

Promotion of products

## The Hydrological Validation Programme

### The main tasks/objectives

Impact studies and hydrological validation



Product interfacing and utilization improvement

Hydrologic validation of HSAF products with the usage of rainfall-runoff models

HSAF product data assessments

Case studies

Development of tools to assimilate HSAF soil moisture and snow products to hydrological models

Tools (methods) for product correction / blended products

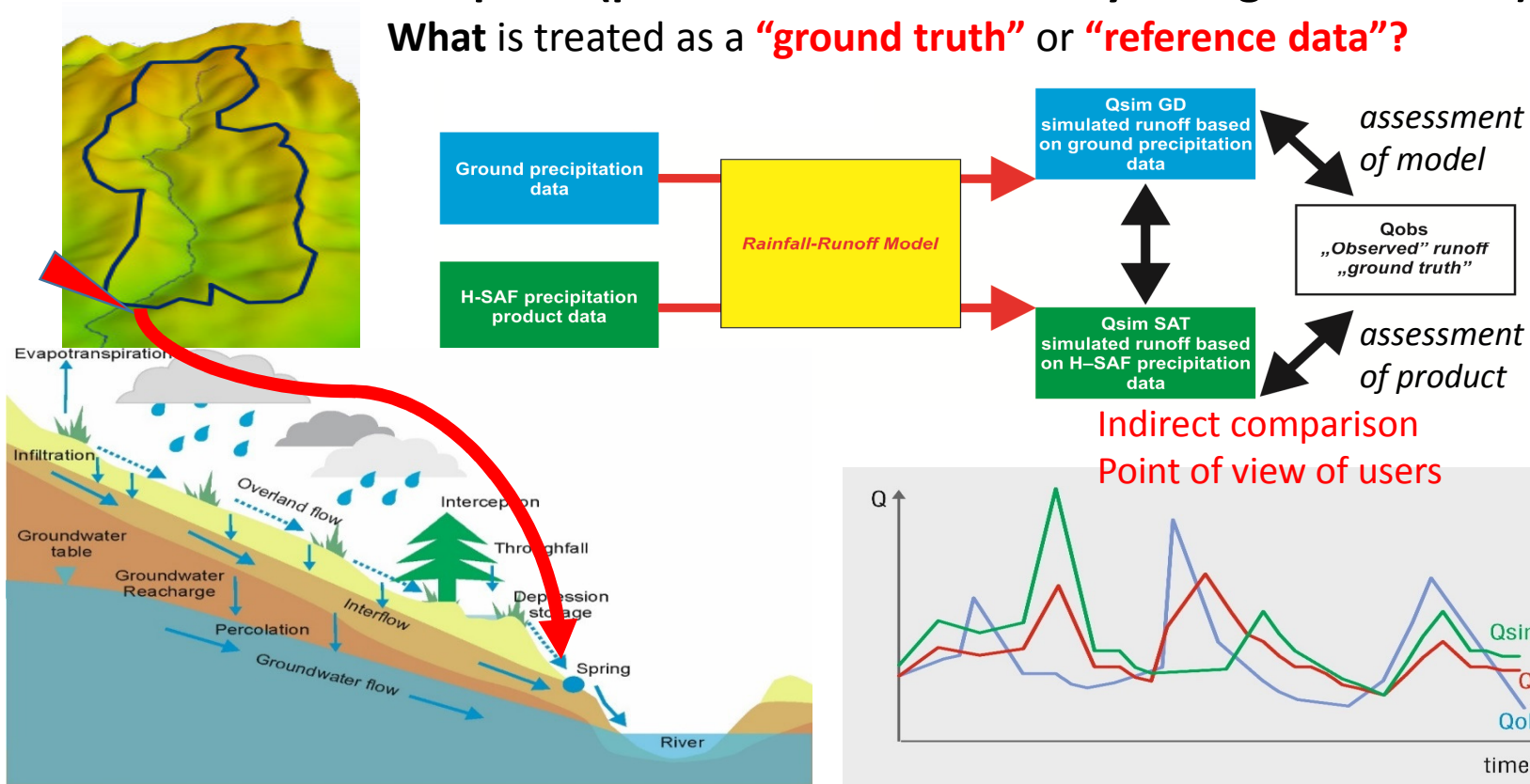
Perform the analysis of possible product utility for hydrological tasks and analysis on the improvement of HSAF products usefulness

Examples of HSAF products applications

# The Hydrological Validation Programme

## Assumption (product validation vs. hydrologic validation)

What is treated as a **“ground truth”** or **“reference data”**?



# The Hydrological Validation Programme

Country (Organization)	Test site	Hydrological model
1) Finland (FMI)	Ounasjoki	HOPS (FMI in-house developed model)
2) Belgium (RMI)	Demer-Scheldt	SCHEME (SCHEldt and model)
	Ourthe-Meuse	
3) Germany (Bfg)	Medium scale river basins of Germany e.g. Blies, Kocher, Lahn_1, Main_1	HBV (Hydrologiska Byrans Vattenbalansavdelning model)
		LARSIM (Large Area Simulation Model)
4) Slovakia (SHMU)	Nitra	Hron-NAM (Hron and Nedbør-Afstrømmings Model)
	Kysuca	
	Hron	HBV (Hydrologiska Byrans Vattenbalansavdelning model)
5) Poland (IMGW-PIB)	Medium scale river basins of Poland (mountainous, highlands, uplands)	HBV (Hydrologiska Vattenbalansavdelning)
6) Italy (CIMA, IRPI CNR, DPC)	Selected basins in Italy	Continuum Model and other rainfall-runoff models
7) Bulgaria (NIMH)	Iskar River	Artificial Neural Networks (ANN)
	Chepelarska	Mike-11/NAM (Nedbør-Afstrømmings Model)
	Varbica river	Isba-Modcou model
8) Turkey (ITU, AU)	Killi subbasin in Susurluk Basin	Artificial Neural Networks (ANN)
	Ulus subbasin in Western Black Sea Basin	
	Upper Euphrates	HEC-HMS
		SRM (Snowmelt Runoff Model), HBV, data driven model

8 countries

11 organizations



Members,  
test sites,  
models



PROTEZIONE CIVILE  
Presidenza del Consiglio dei Ministri  
Dipartimento della Protezione Civile

## SAF on Support to Operational Hydrology and Water Management

- Provide **operational** high quality level 2/3 products and develop **new satellite-derived products** to satisfy the **needs of operational hydrology**;
  - **identified products**:
    - precipitation (rate, accumulated);
    - soil moisture (at large-scale, at local-scale, at surface, in the roots region);
    - snow parameters (detection, cover, melting conditions, water equivalent);
- **independent validation**;
- **All the products have a certified Accuracy by the work of 11 countries**
- **All the 'pre-operational ' or 'operational' products are available on European, MSG Full disk and Global areas in NRT via EUMETCAST and H-SAF web page.**



<http://hsaf.meteoam.it/>

**Thank you for your  
attention !**

Contact: [Silvia.Puca@protezionecivile.it](mailto:Silvia.Puca@protezionecivile.it)