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

Silvia Puca,
H SAF Deputy Project Manager

Civil Protection Department, Italy,

Satellite Application Facilities

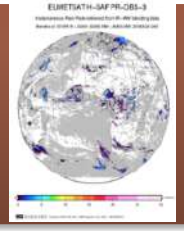
Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data. They form an integral part of the distributed **EUMETSAT** Application Ground Segment.

SAF in Support to Operational Hydrology and Water Management

NEAR REAL TIME

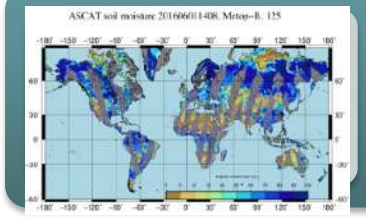
Eumetcast, H SAF ftp

Data Cube



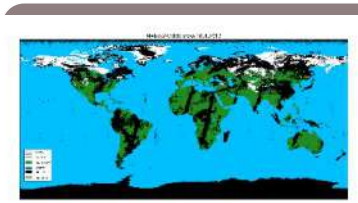
precipitation

rate and accumulated



soil moisture

surface and root mean zone



snow

cover, melting conditions,

water equivalent

Hydrological applications

Risk Management,

Nowcasting,

Hydrology and water management,

Climate,

NWP

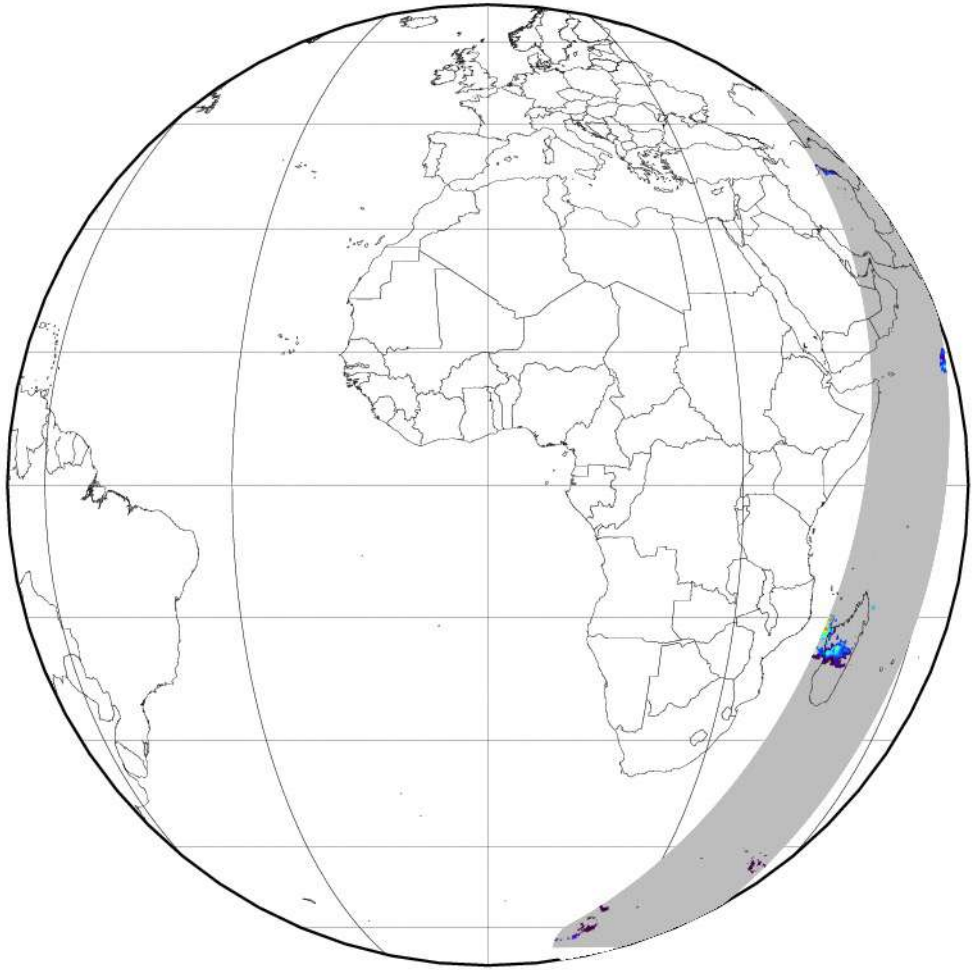
H SAF Precipitation Products: MW precipitation products

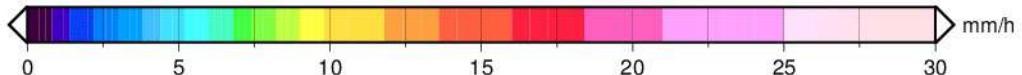
atures
Strips of ~1400Km swath
More than 6 passes/daily over Europe
~30Km
150 minutes from observing time
EUMETCast
BUFR

EUMETSAT H-SAF P-IN-SSMIS

Instantaneous Rain Rate from Conical MW Scan

ain Rate retrieved from SSM/I and SSMIS data: 20190622 0000 DMSP16 8088

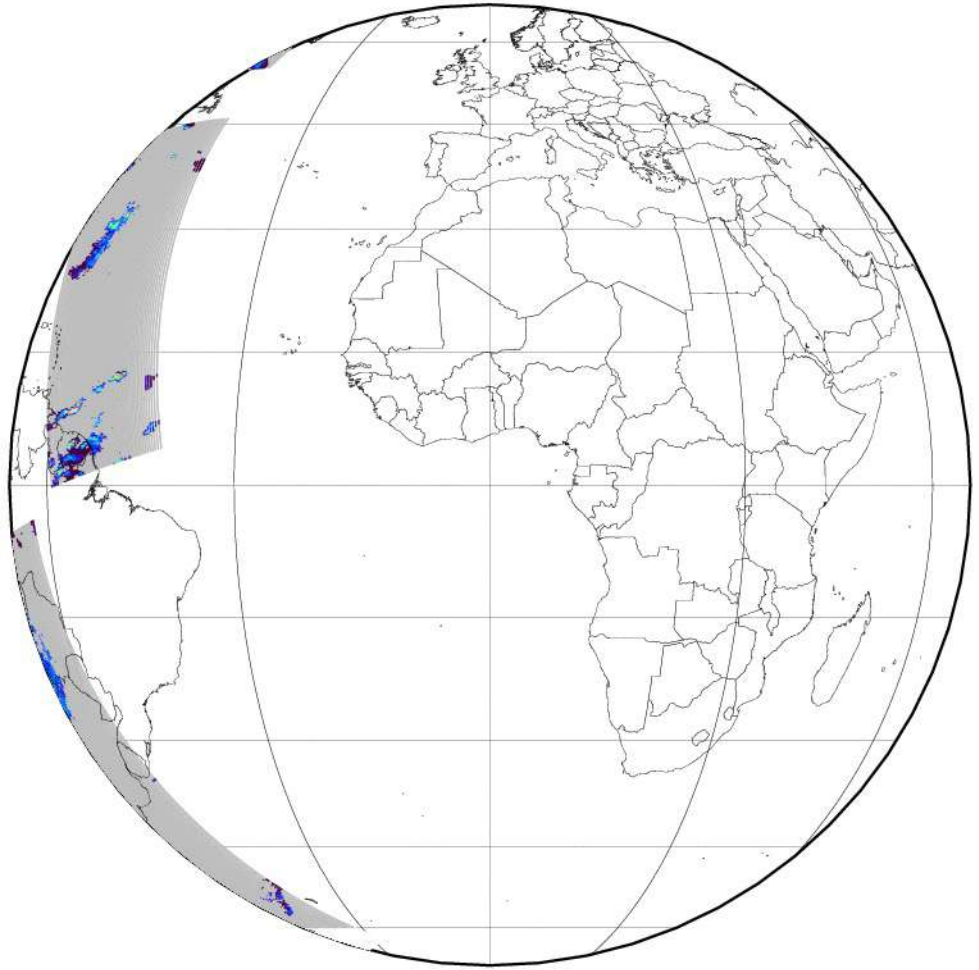


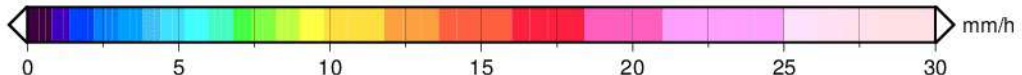


EUMETSAT H-SAF P-IN-MHS

Instantaneous Rain Rate from Crosstrack MW Scan

Rain Rate from Crosstrack MW Scan: 20190622 0046 METOPB 35068





Main features
Strips of ~2250Km swath
More than 6 passes/daily over Europe
16x16 – 26x52 km2
30 minutes from observing time
EUMETCast
BUFR

Snow Ev

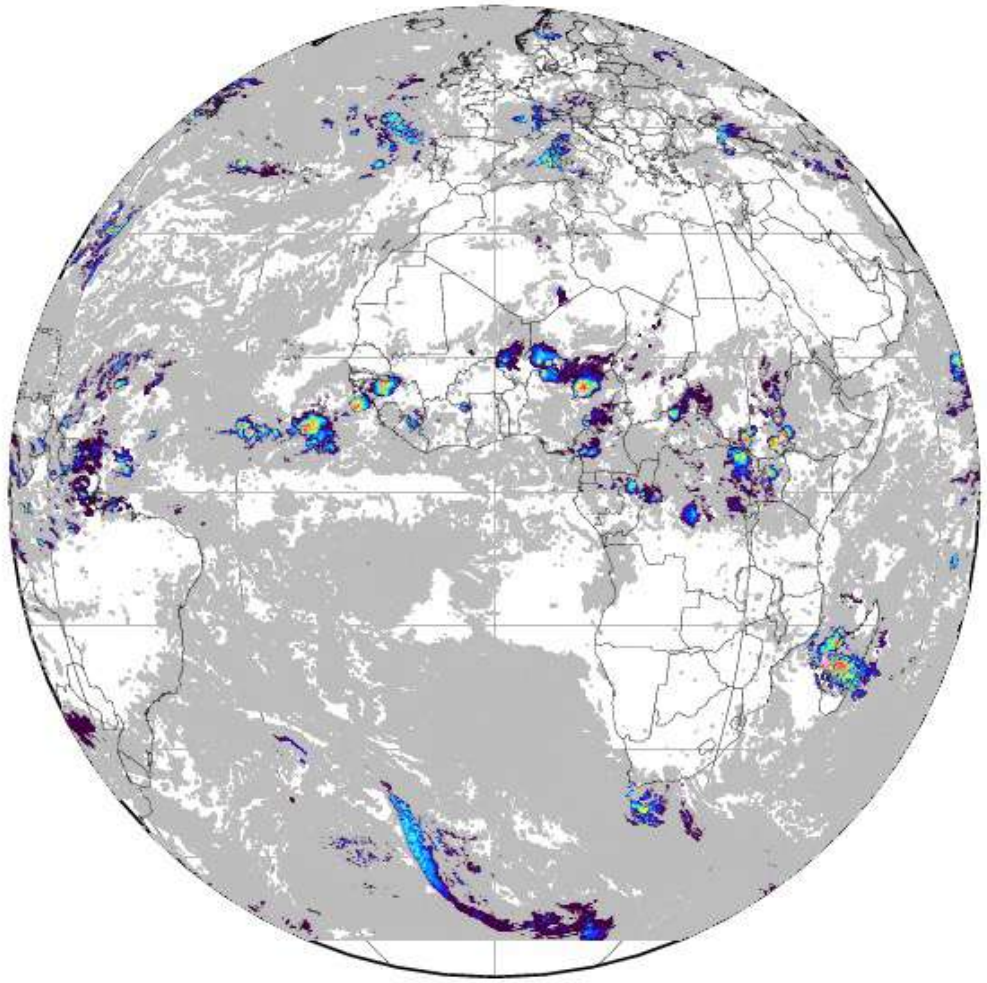
H SAF Precipitation Products: MW + IR precipitation products

Main features
MSG Full-disk area
Every 15 min
3 Km s.s.p. ~8 km over Europe
Within 15 minutes
EUMETCast
GRIB-2

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

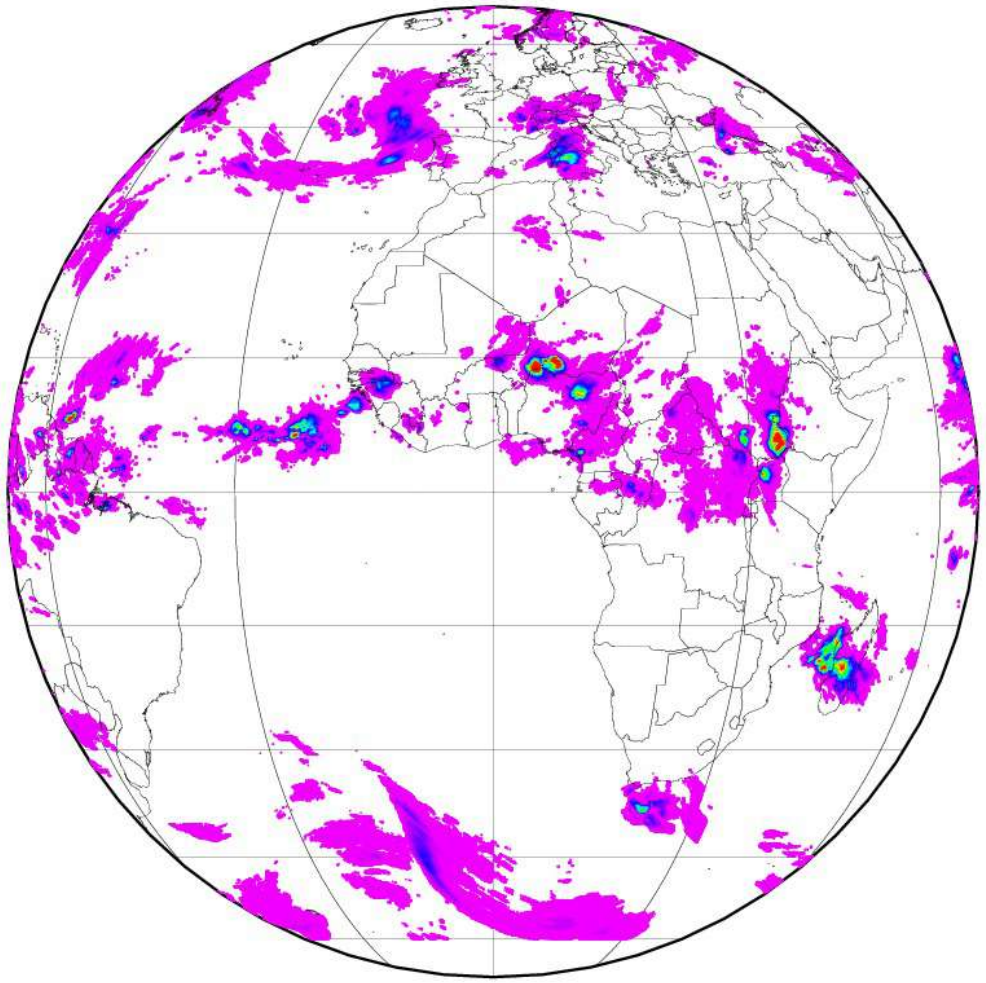


mm/h

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

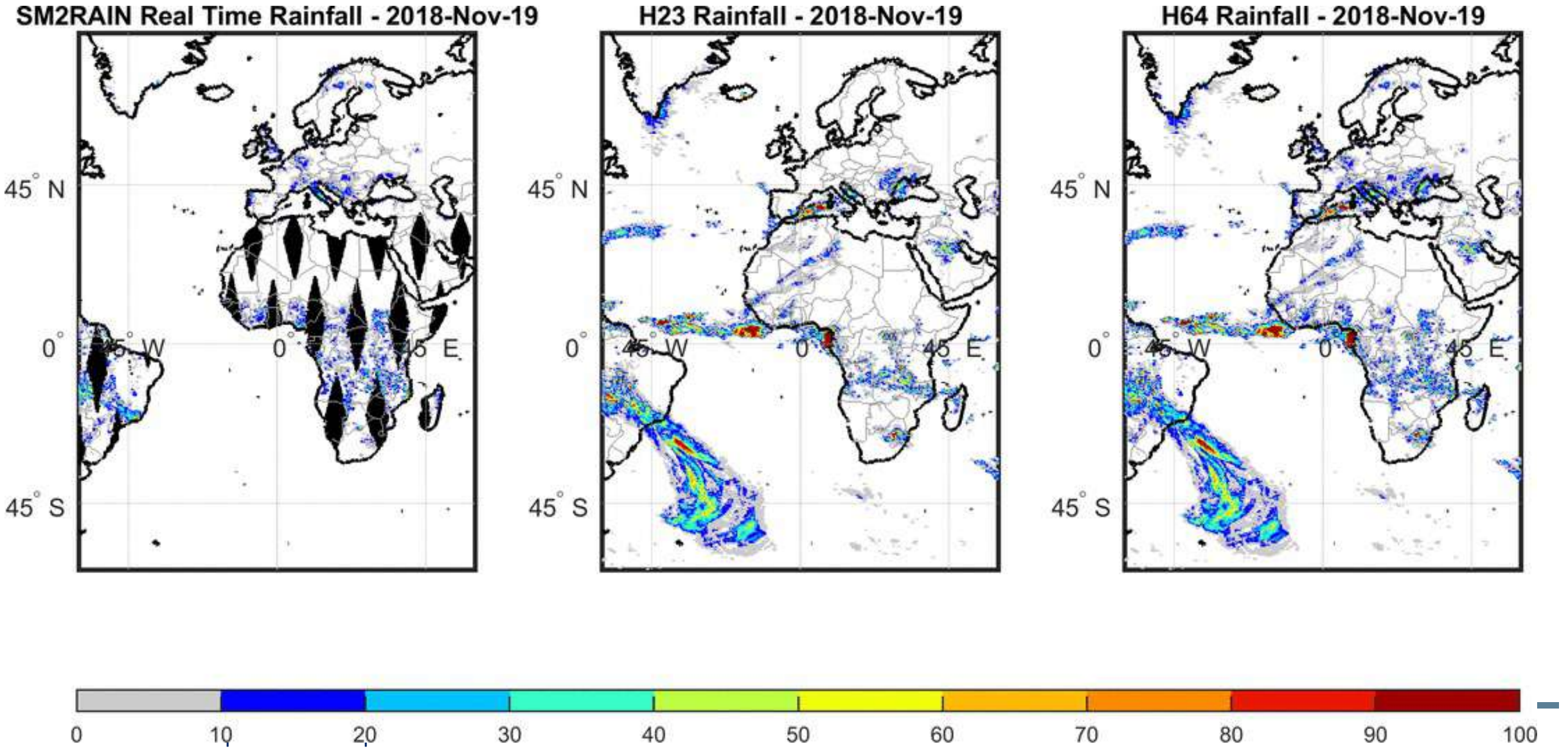


mm/h

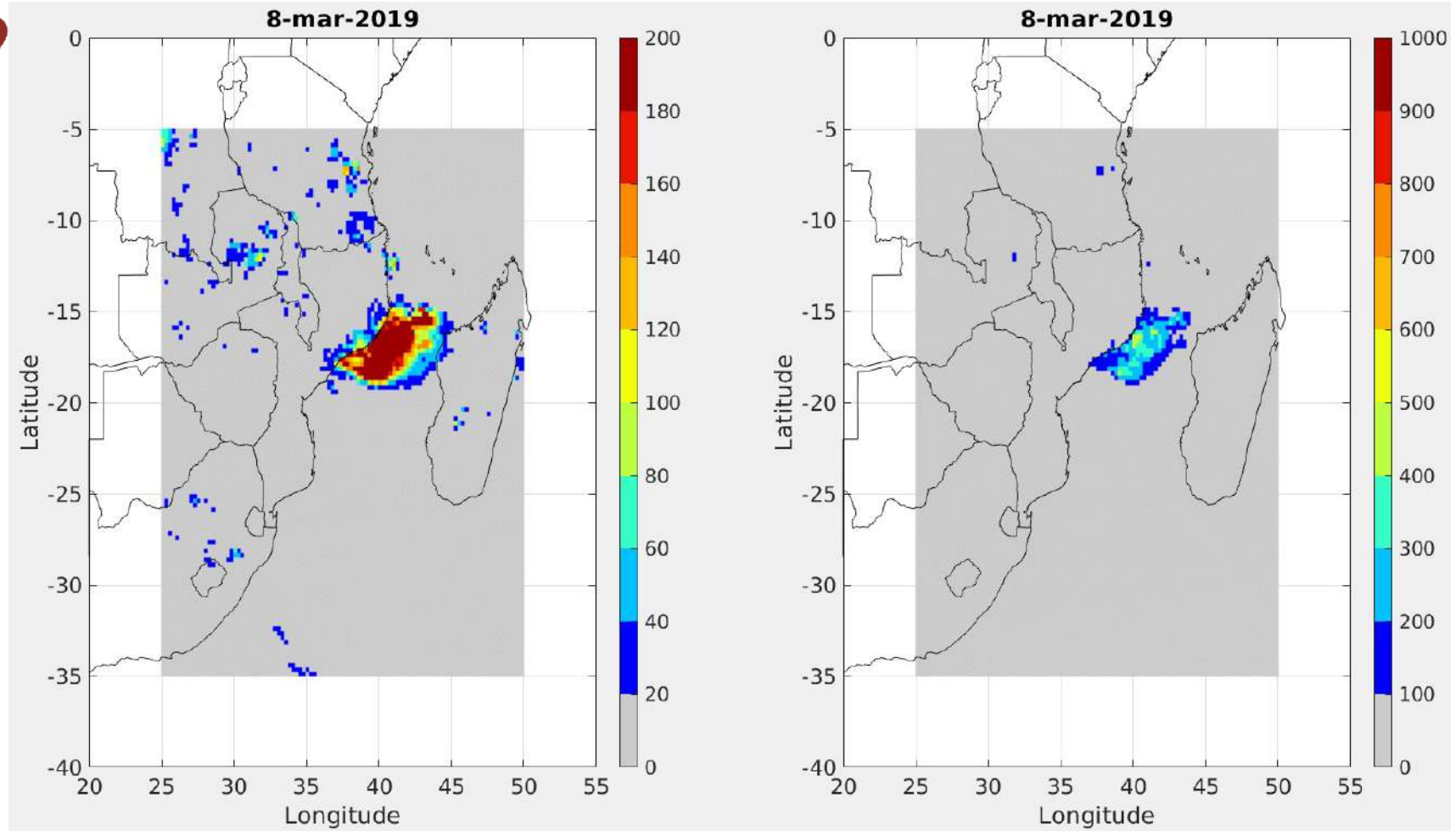
Main features
MSG Full-disk area
Every 3h
3 Km s.s.p. ~8 km over Europe
Within 15 minutes after every 3h
EUMETCast
GRIB-2

Snow Ev

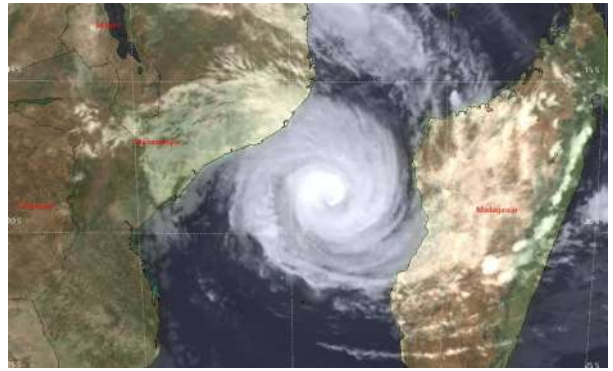
H SAF Precipitation Products: P-AC-SM2RAIN



H SAF Precipitation Product: P-AC-SM2RAIN

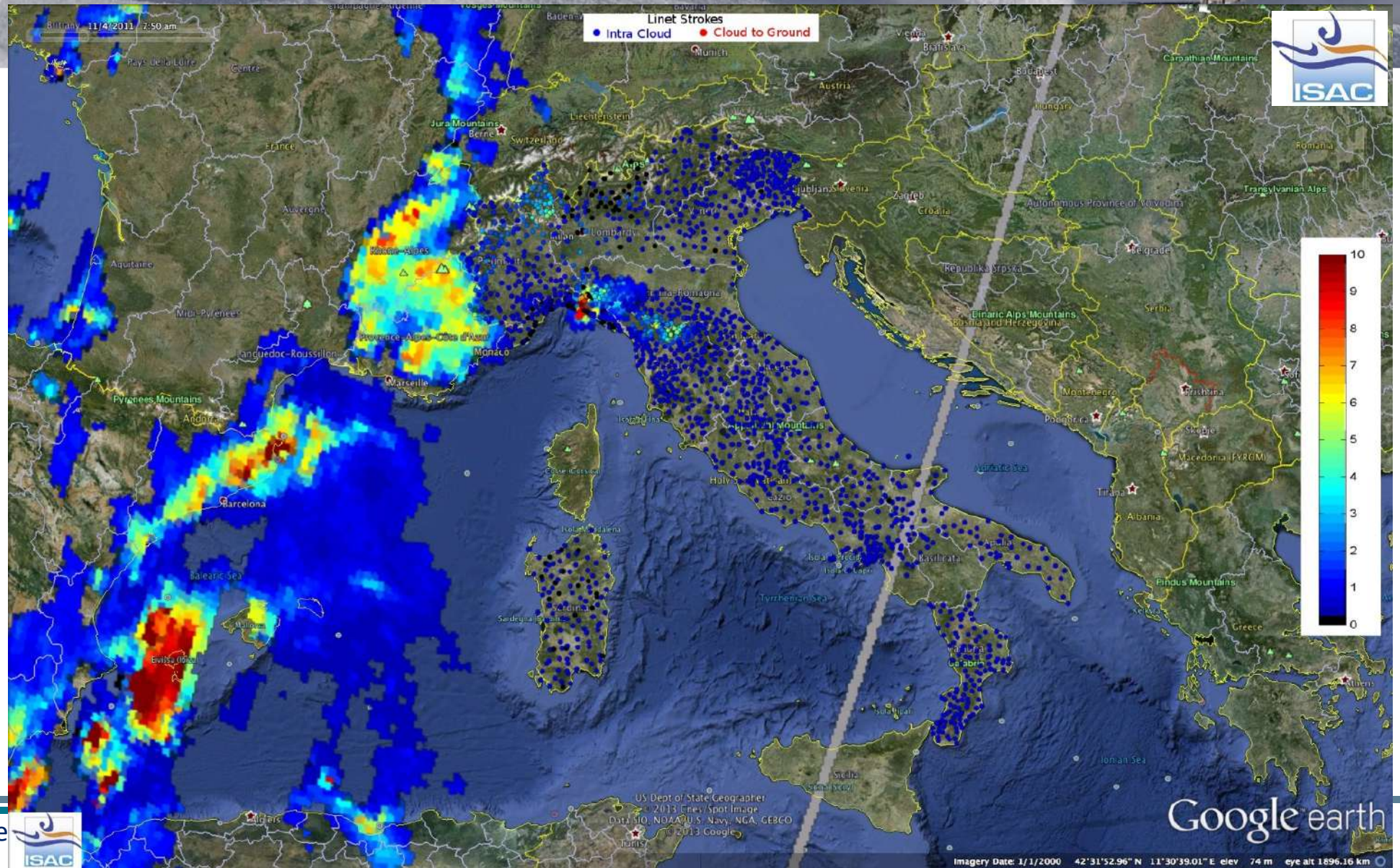


Intense Tropical Cyclone **IDAI** affected Africa causing catastrophic damage in Mozambique, Zimbabwe, and Malawi.

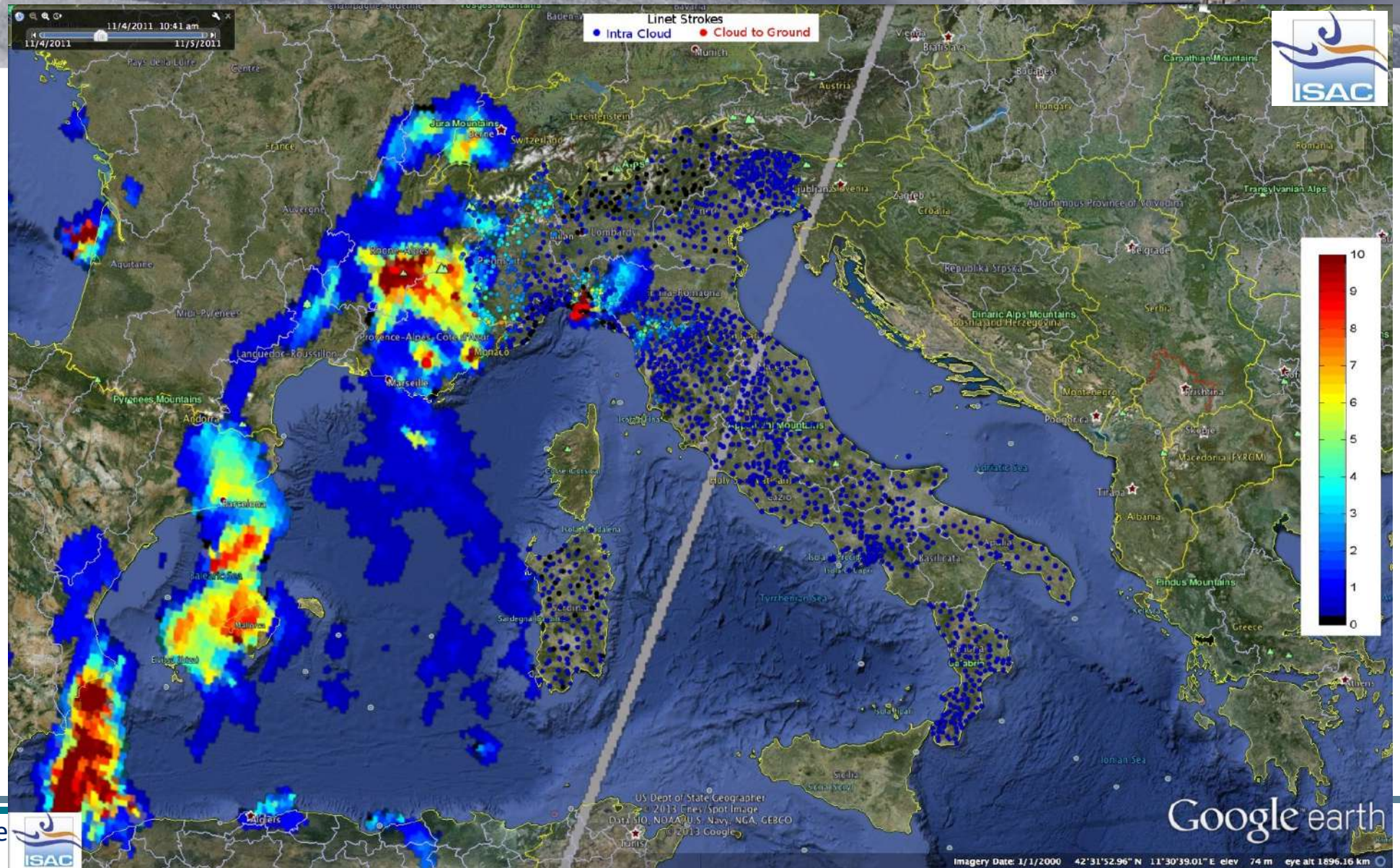


Case studies in Italy, Liguria 5 terre: 25 October and 4 November

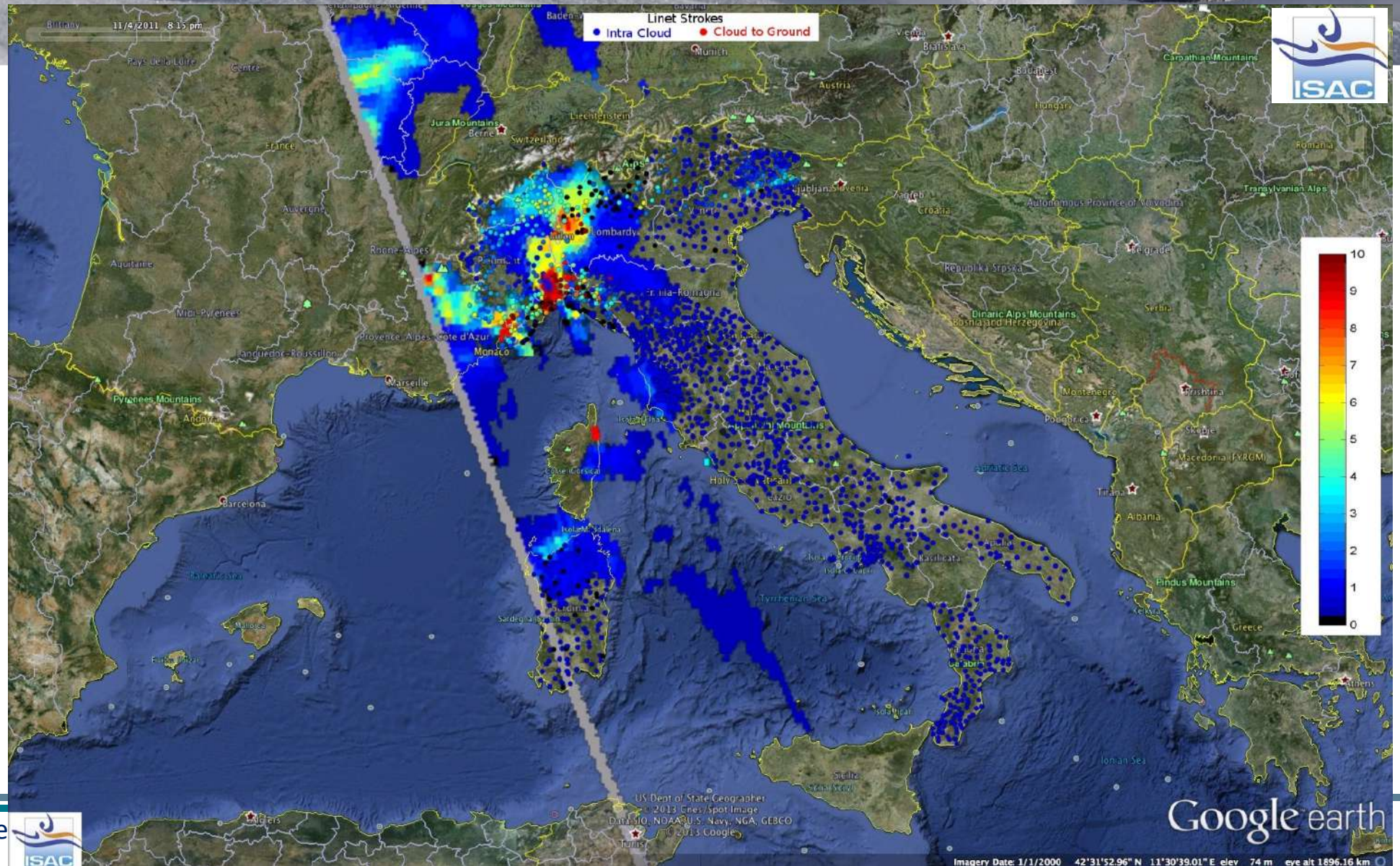
H-SAF PR-OBS-1 + Radar + Lightning + Rain gauges – time 05:50 UTC



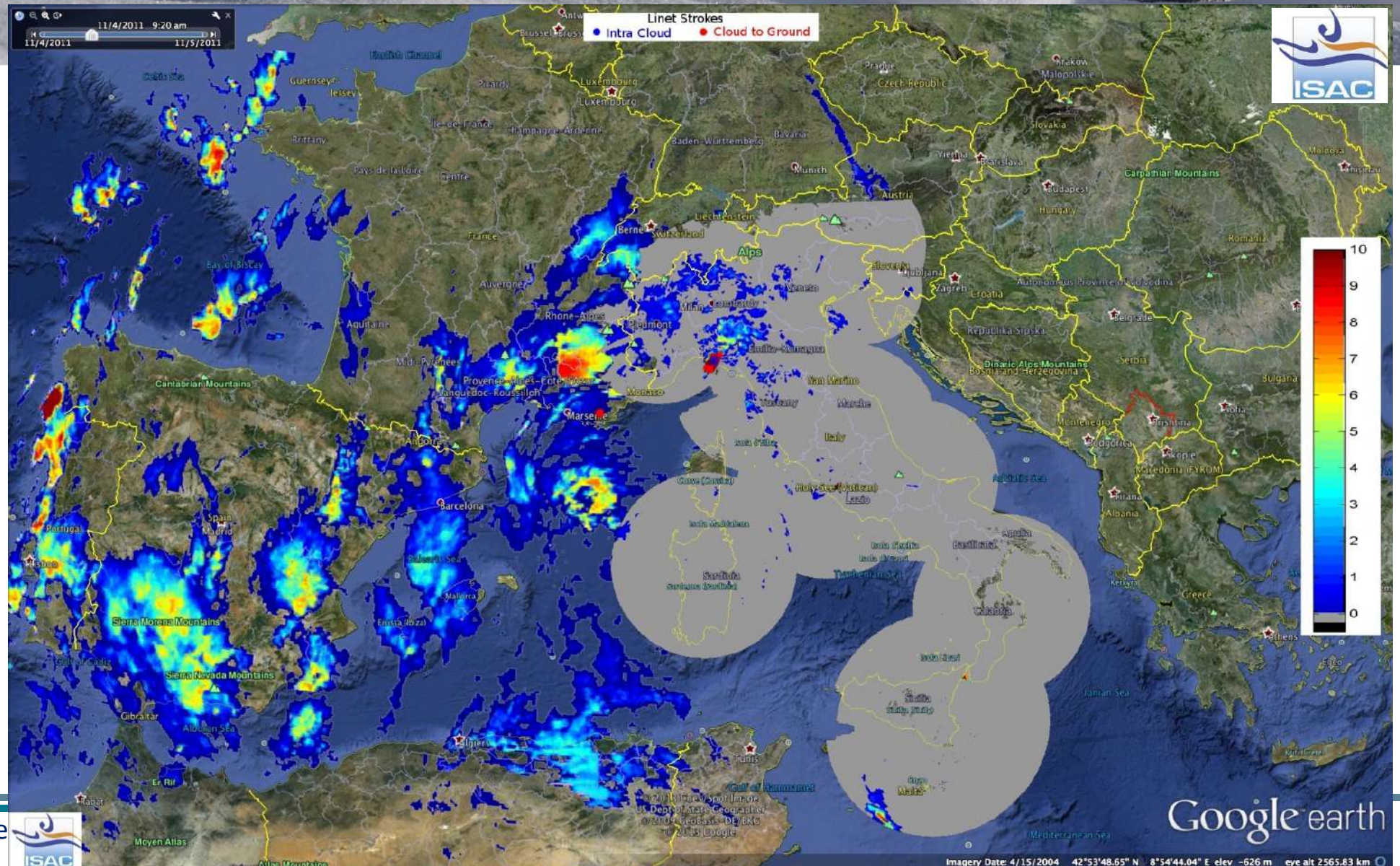
H-SAF PR-OBS-1 + Radar + Lightning + Rain gauges – time 08:50 UTC



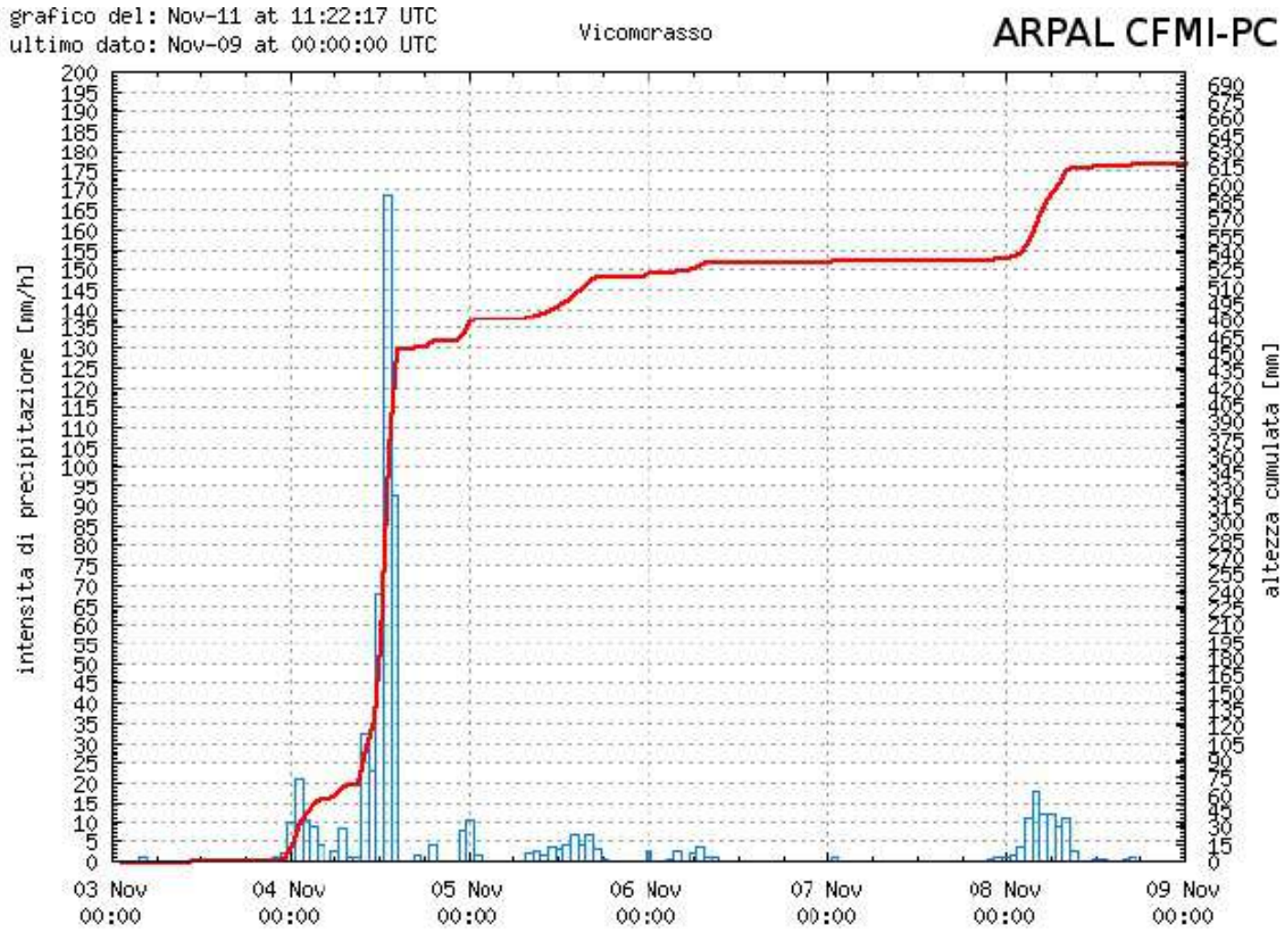
H-SAF PR-OBS-1 + Radar + Lightning + Rain gauges – time 18:15 UTC



H-SAF PR-OBS-3 + Radar + Lightning – time 07:20 UTC



Rain gauge: more than 160 mm in 1 h, more than 500 mm in 24 h



In development Precipitation products

Strategy and foreseen improvements

New PMW based Products

Higher temporal sampling

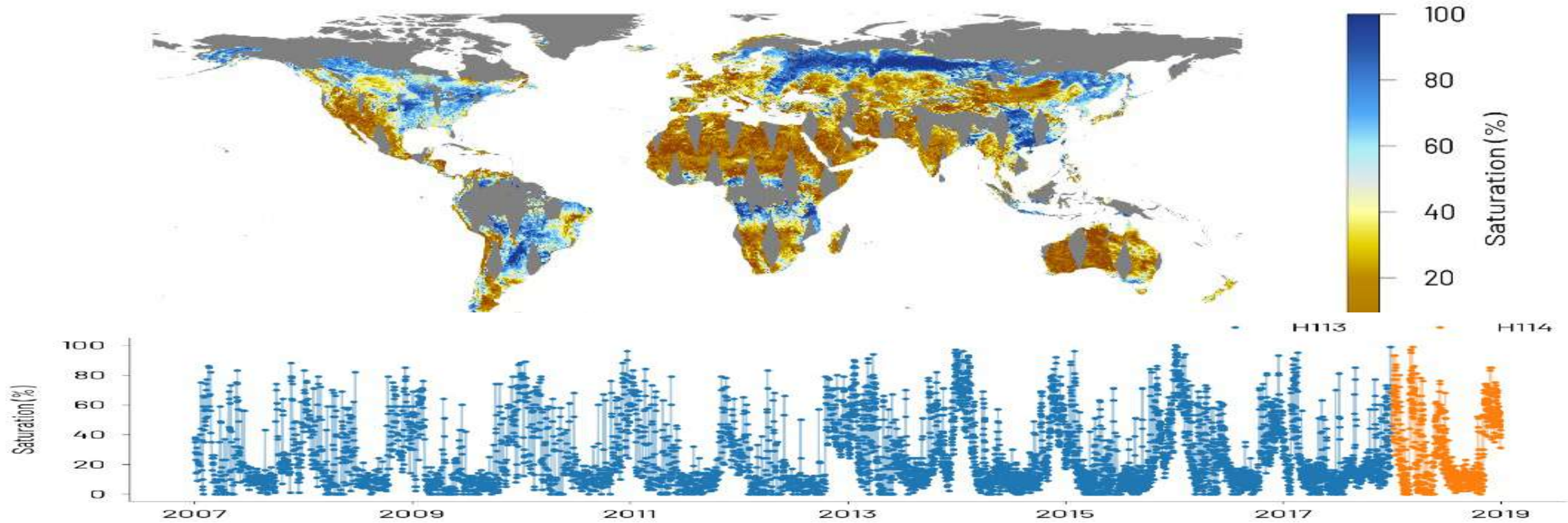
- Full exploitation of all overpasses of present and future satellites, including GPM

Transition to MTG

- LI

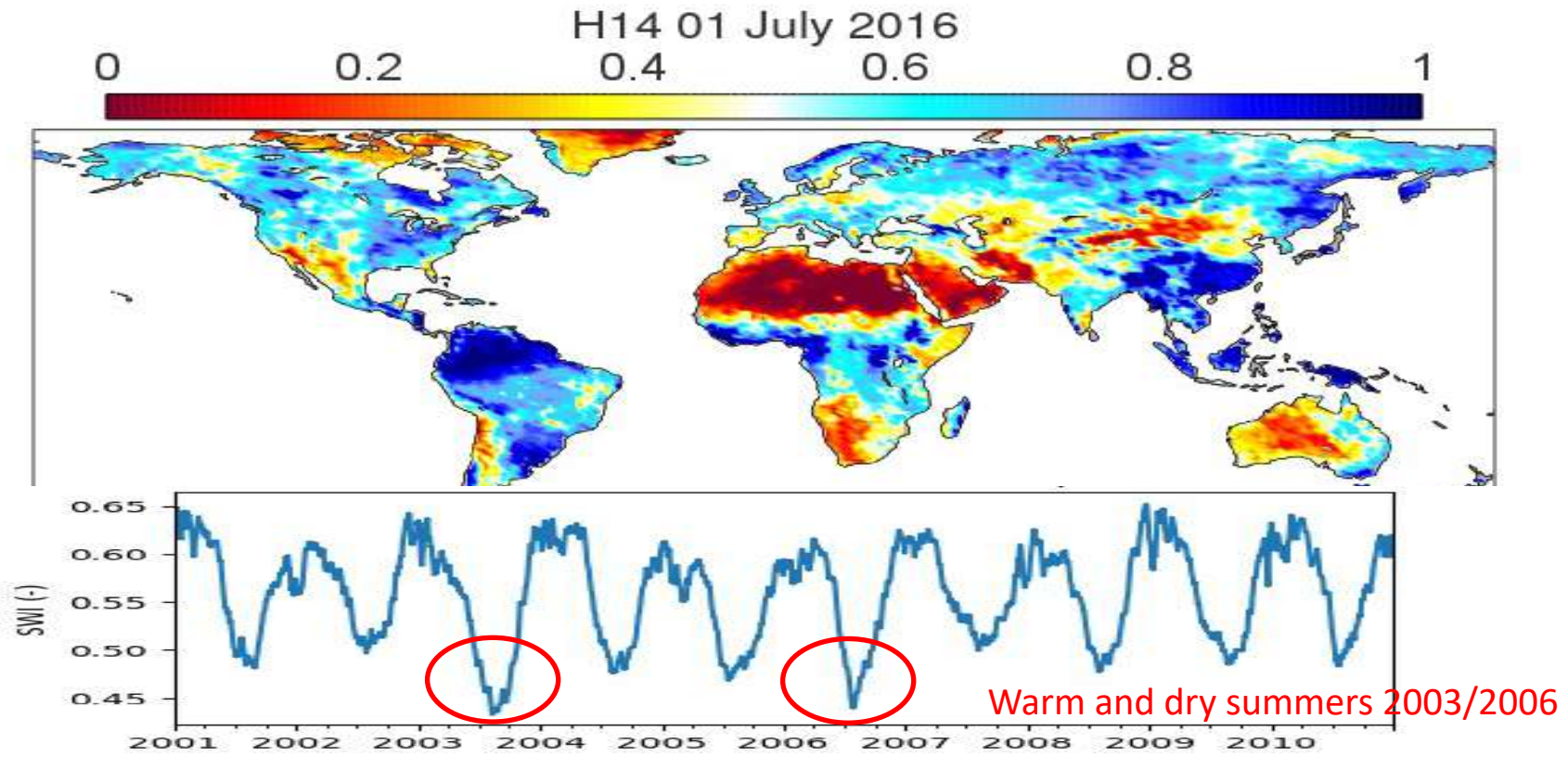
Integration of Precipitation/Soil Moisture Products

SURFACE SOIL MOISTURE (SSM)

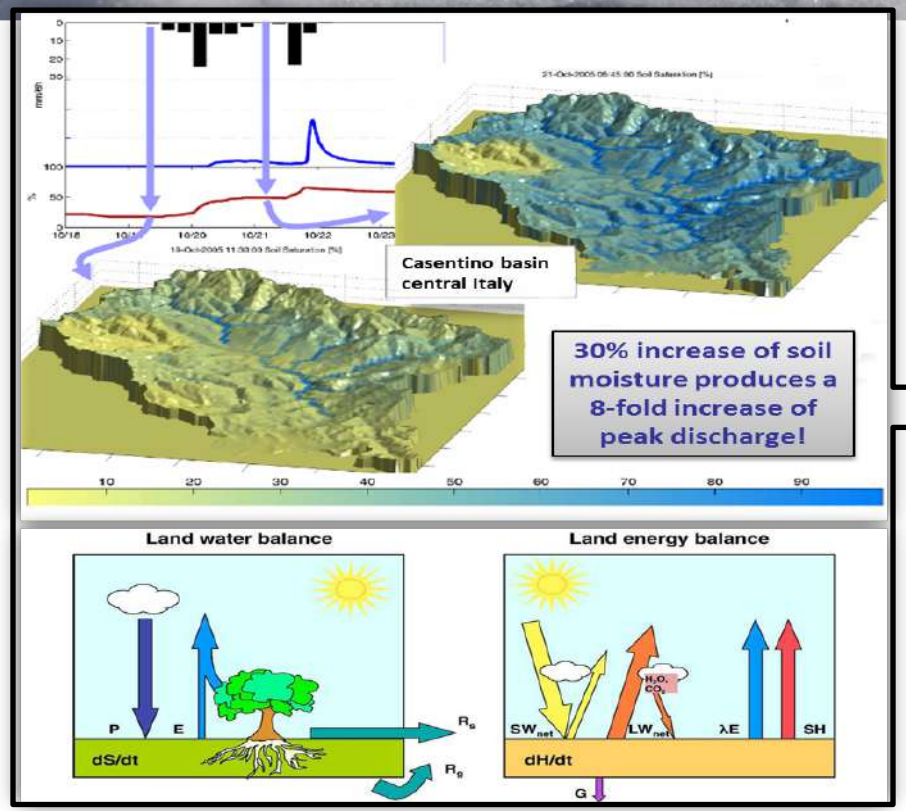


- ASCAT **Climate Data Record** SSM released every year in time series format,
- ASCAT CDR and offline extension (2007 /01/01- 2019/12/31)

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 HTESSEL forced by the ERA-Interim atmospheric reanalysis.



DROUGHT

PRECIPITATION

FLOODS

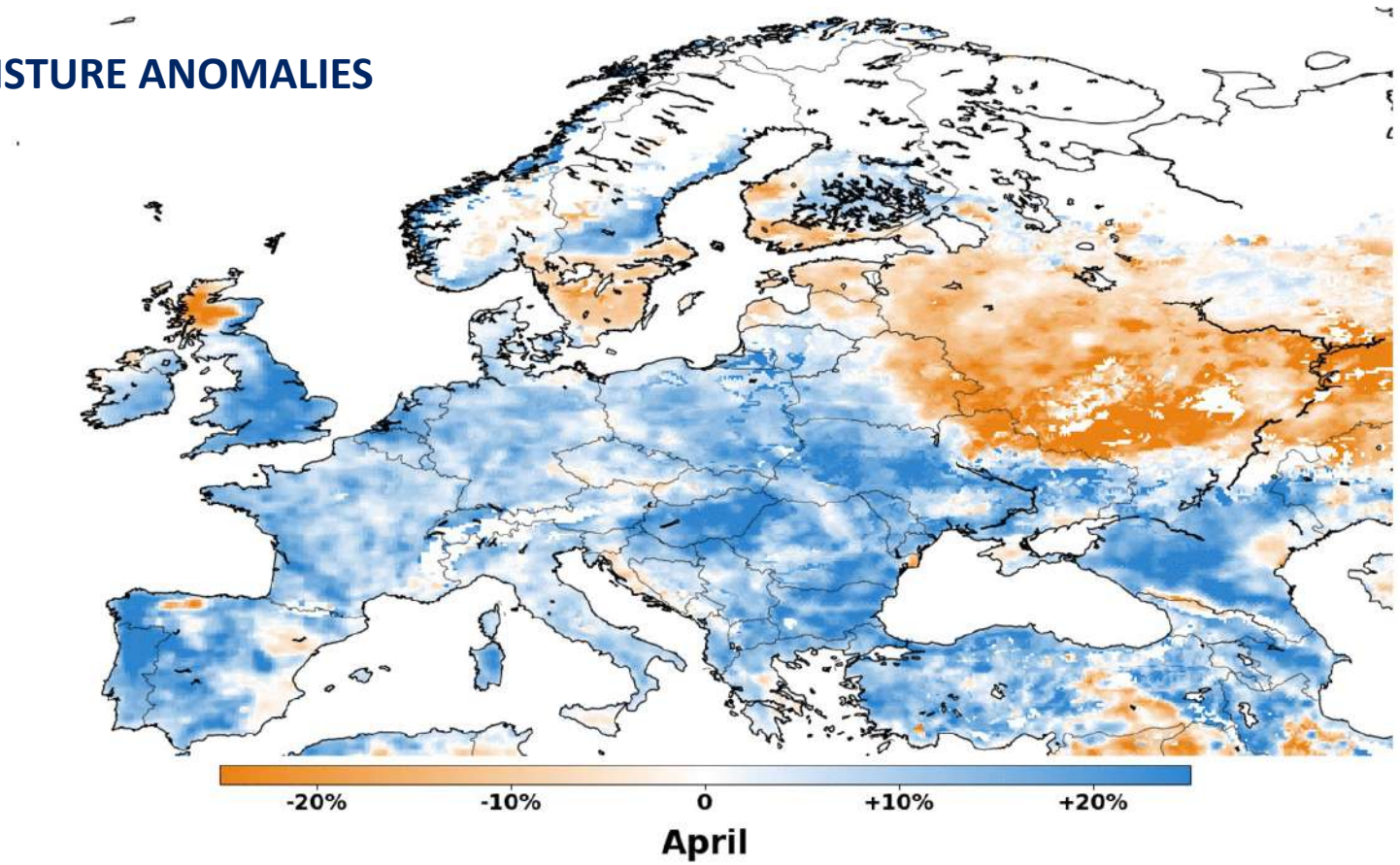
LANDSLIDES

NUMERICAL WEATHER PREDICTION

CROP PRODUCTION

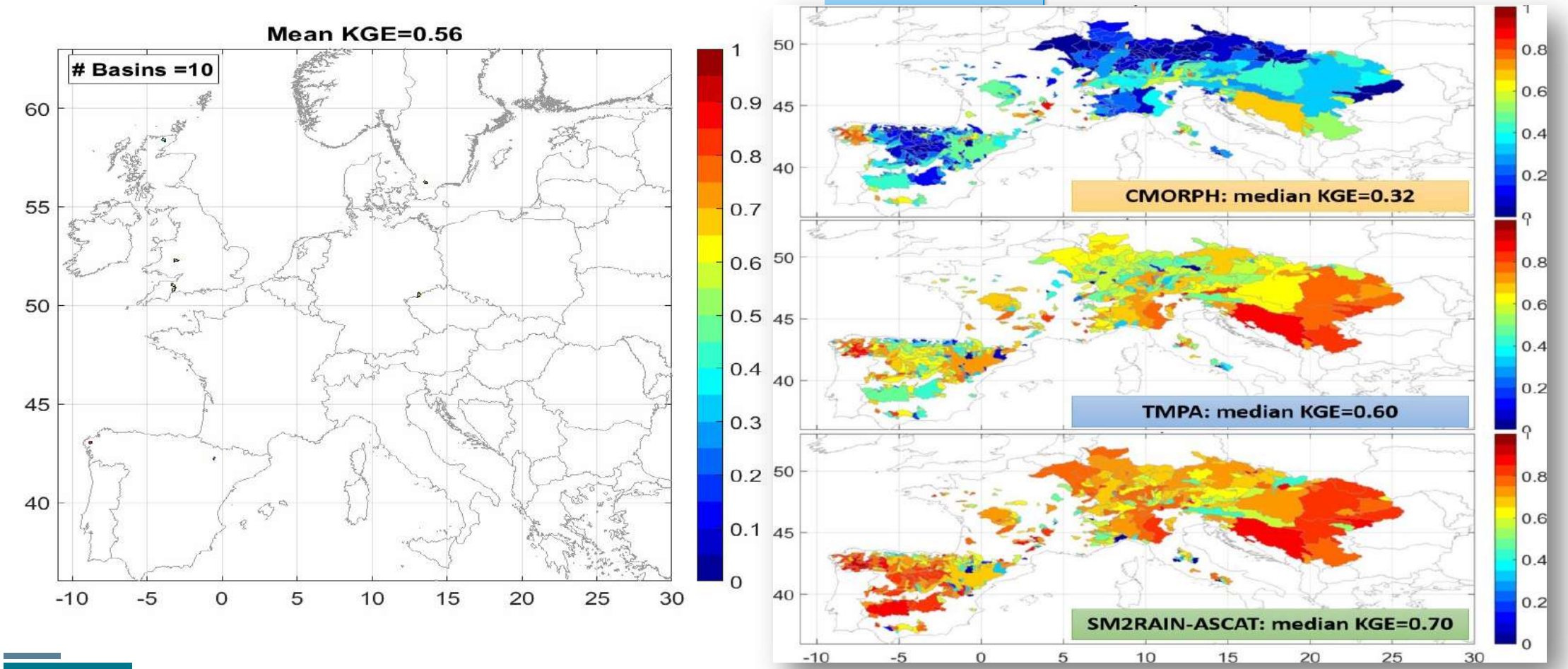
EUMETSAT H SAF

DROUGHT: SOIL MOISTURE ANOMALIES



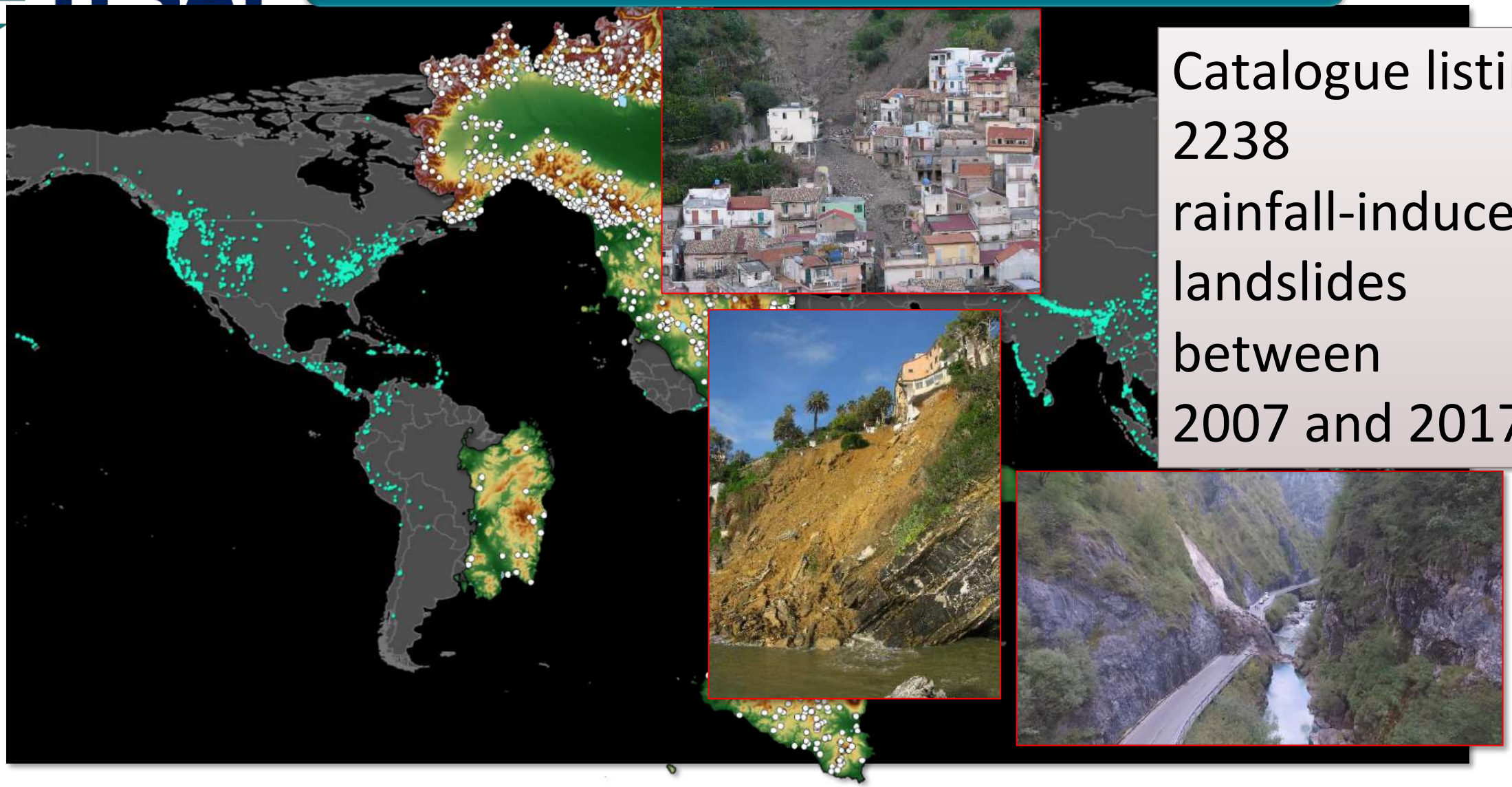
SM2RAIN for Flood Prediction - Europe

Simulation of floods over 600 basins in Europe through SM2RAIN precipitation



Camici et al. (2018 JoH)

SM2RAIN for Landslide - Europe



Catalogue listing
2238
rainfall-induced
landslides
between
2007 and 2017

Brunetti et al. (2018 RSE)

EUMETSAT H SAF

Soil Moisture products

Strategy and foreseen improvements

Higher resolution

- For Surface Soil Moisture

Higher resolution

- For Root Zone Soil Moisture

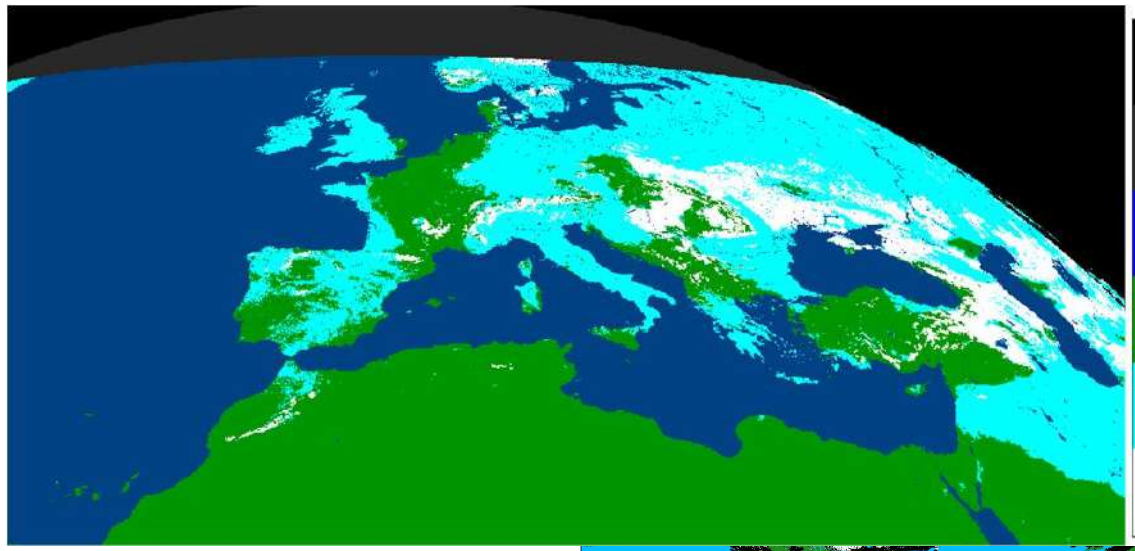
Transition to EPS-SG

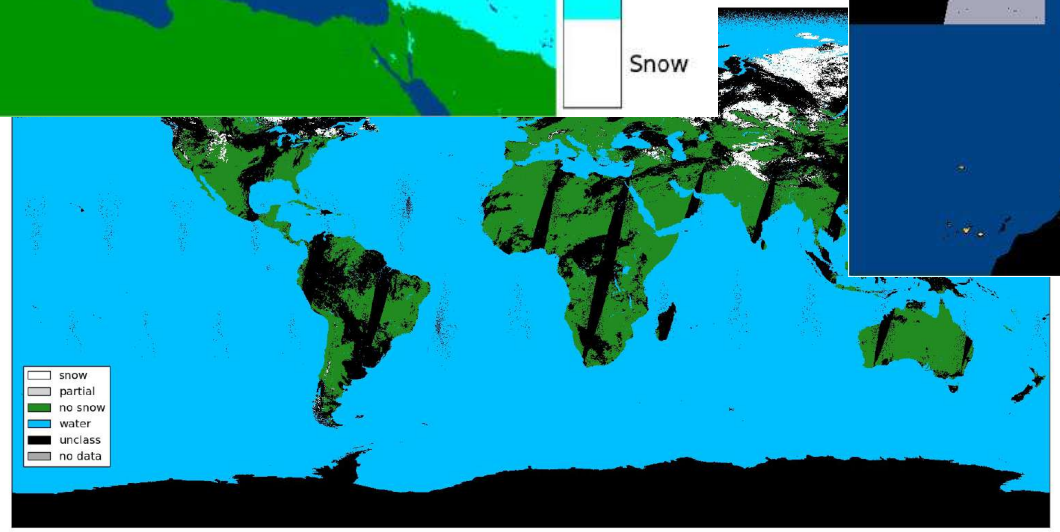
- From ASCAT to SCA, both surface and Root Zone Soil Moisture

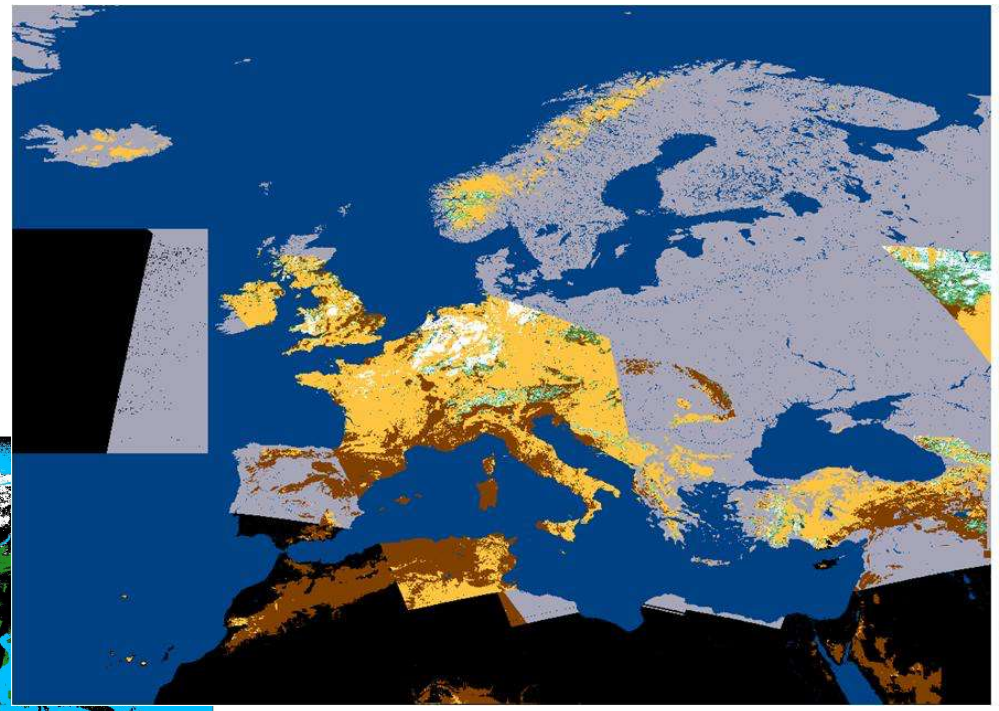
CDOP3

CDOP4

H SAF Snow products





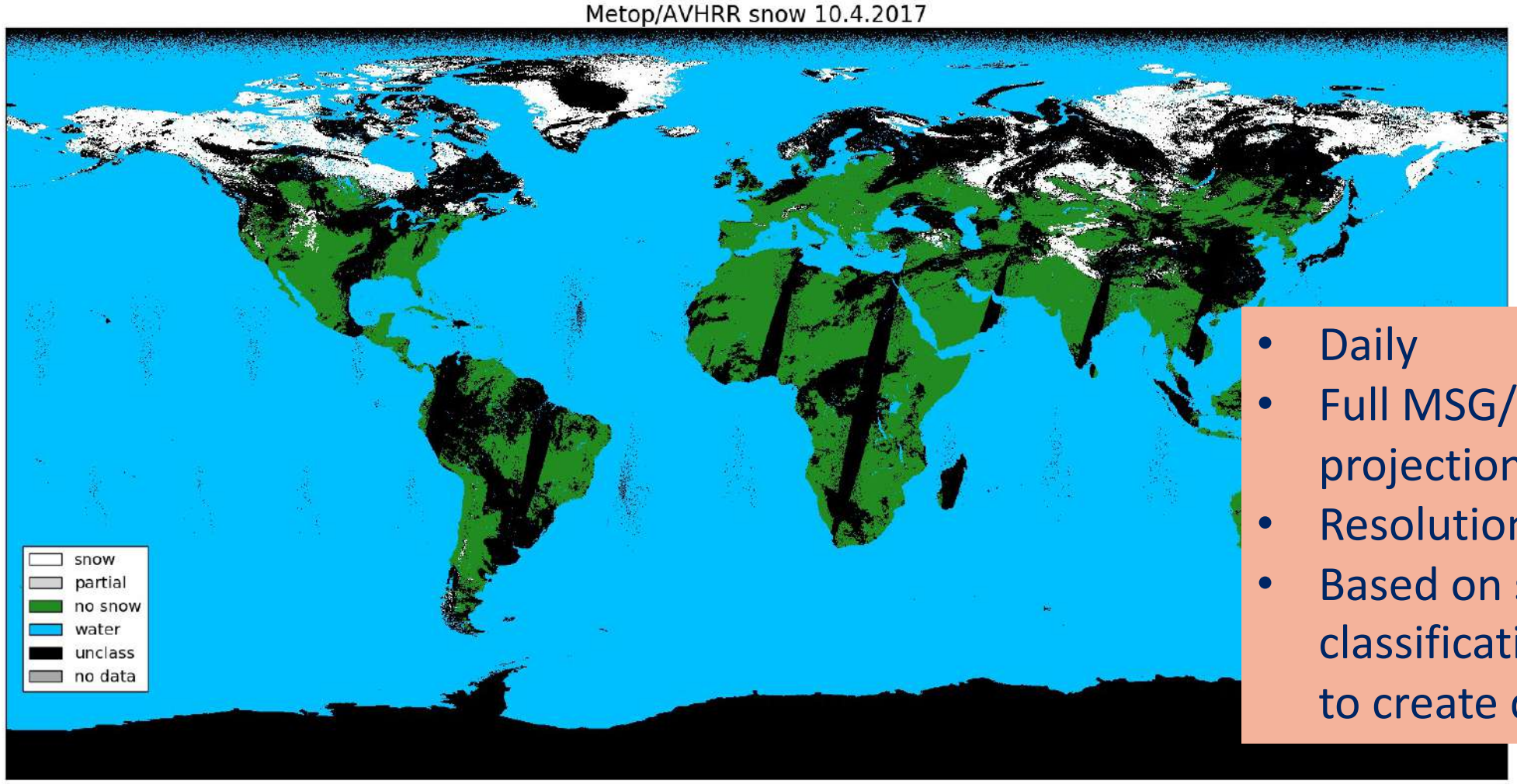


Avanzi et al: Cross-continental assessment of H-SAF snow products using Sentinel-2 Level-2 Scene Classifications (No 390)

H SAF Snow products

SE-G-AVHRR / H32

Metop/AVHRR snow extent

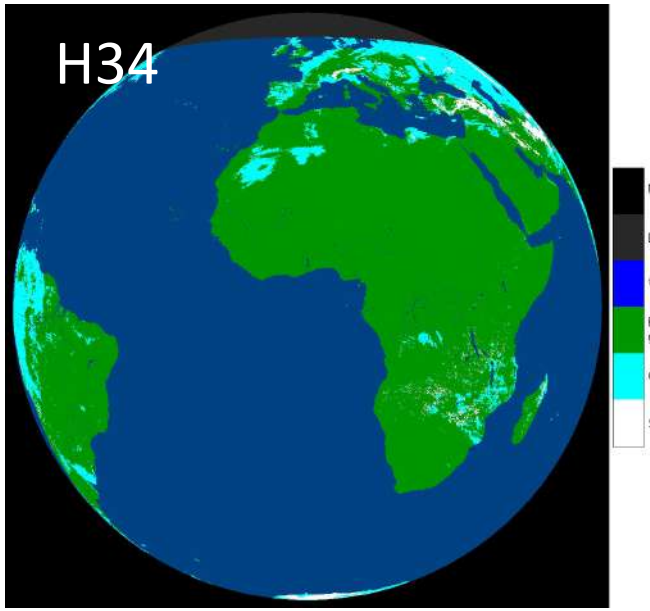


- Daily
- Full MSG/SEVIRI 0° disk, GEOS projection
- Resolution: 3 km (nadir)
- Based on single image classifications which are merged to create daily product

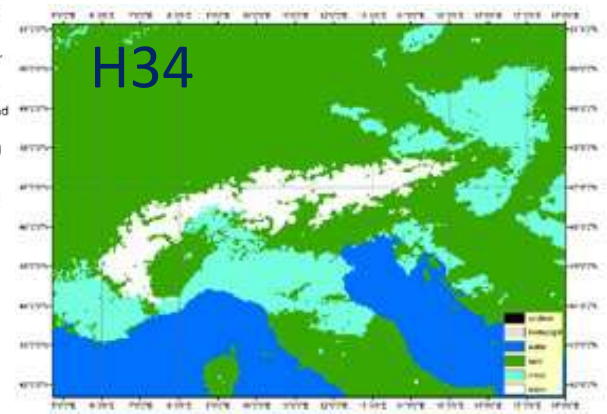
Transition to MTG from MSG

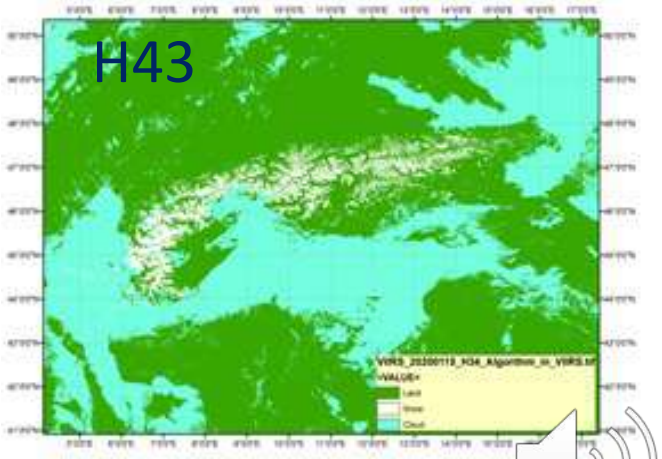
Snow extent (snow mask) by VIS/NIR of MTG FCI

Cycle: Daily
Coverage: Full MTG/FCI 0° disk, GEOS projection
Resolution: FCI pixel
Formats: HDF5, PNG quicklook
Operational status: **In development**



Better spatial and spectral resolution of MTG-FCI will give the possibility to map the snow better on complex terrain like mountainous areas





H10/H34 product (15.Jan.2020)

H SAF Snow products

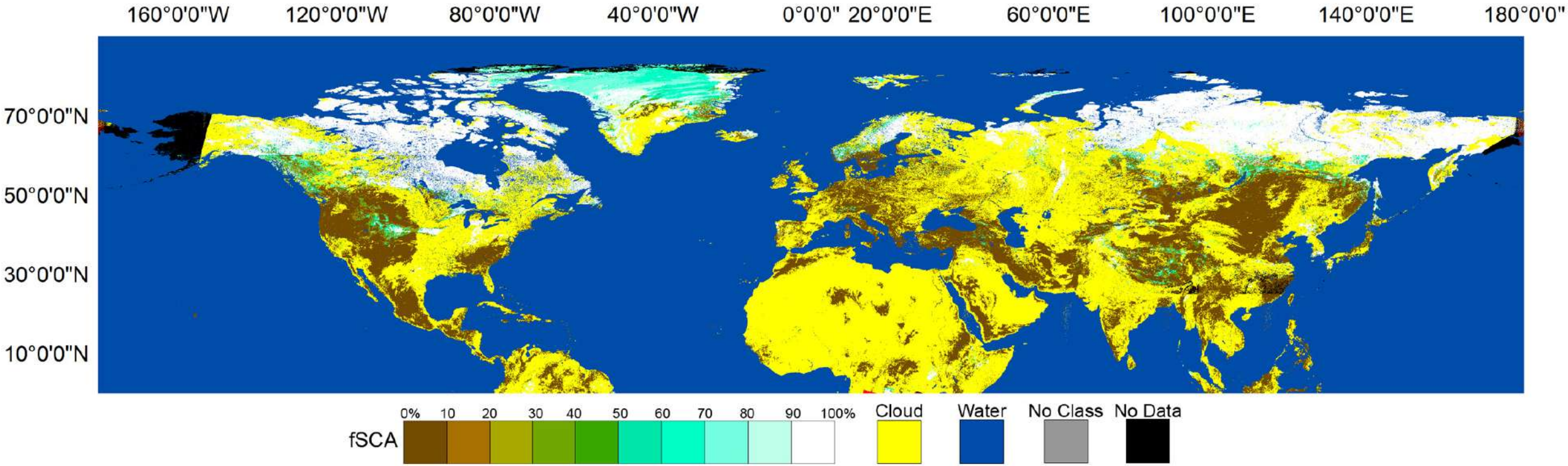
FSC-E / H12 Effective snow cover by VIS/IR

- 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

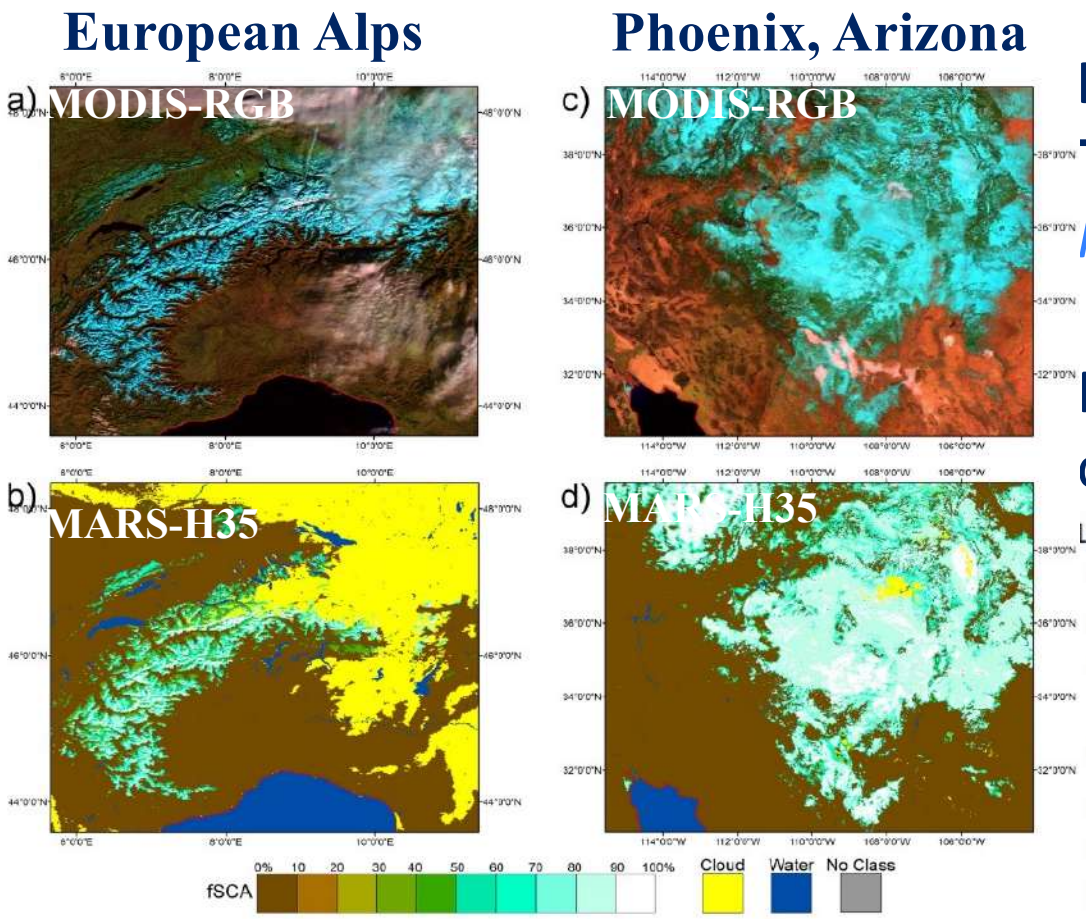
Effective snow cover in CDOP 4

Effective Snow Cover by EPS-SG METimage

Cycle: Daily
Coverage: Northern Hemisphere,
Grid/Projection: Equidistant cylindrical
Resolution: 0.01° x 0.01°
Formats: HDF5, PNG quicklook
Operational status: **In development**



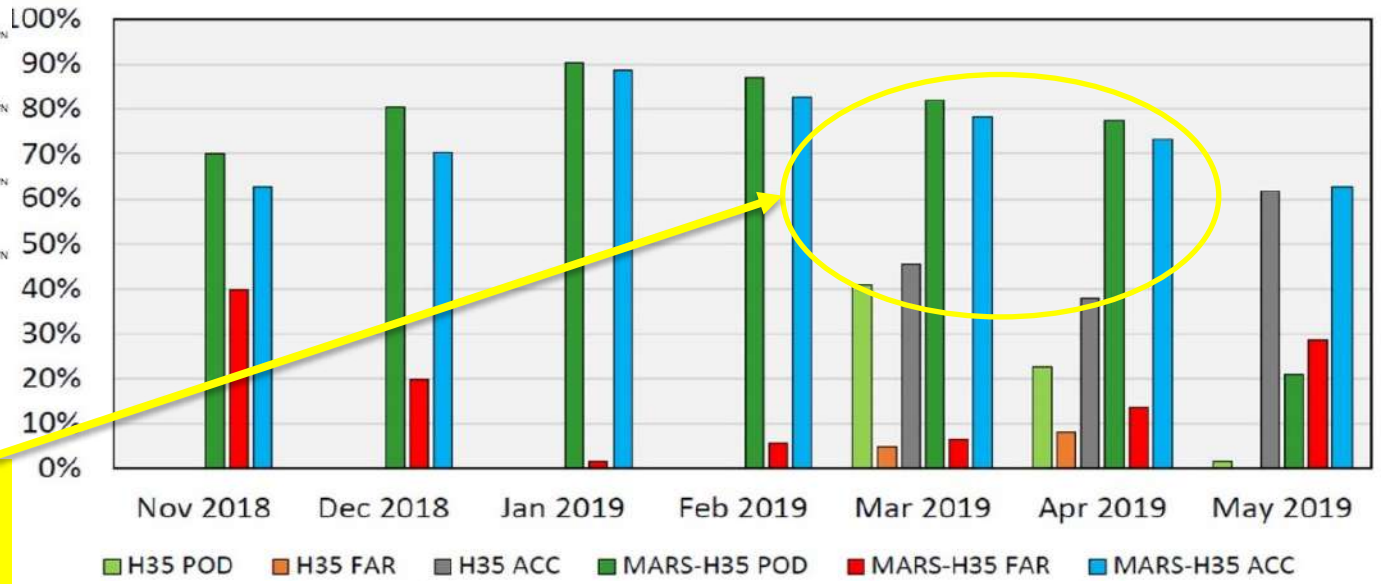
Effective snow cover by VIS/IR



Improvement on H35 by Machine Learning Techniques:

Multivariate Adaptive Regression Splines – **MARS**

Reference FSC maps are generated from binary classified Sentinel-2 images at 20 m by **Sen2Cor v2.08**:



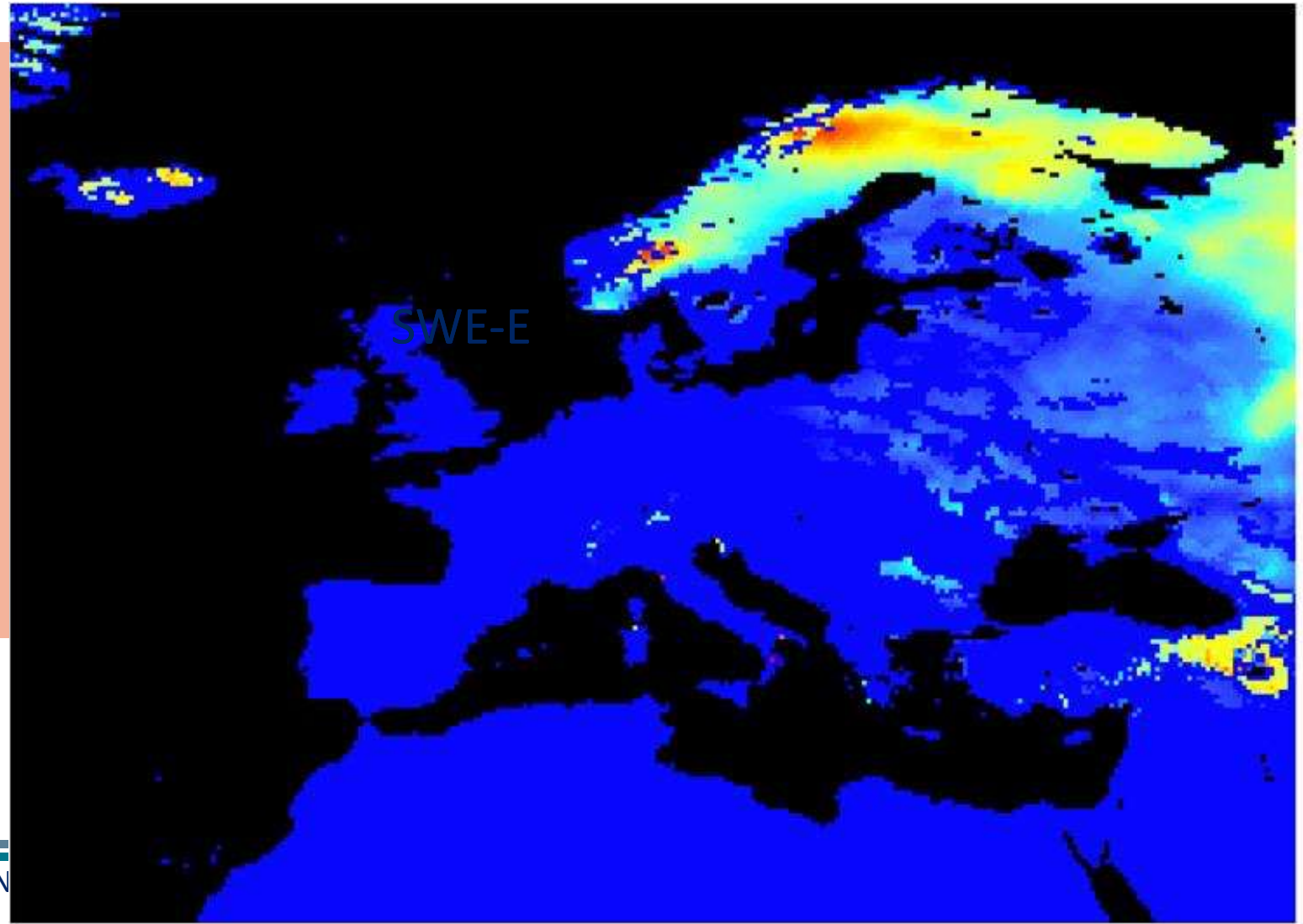
H35_MARS performance is much better than original H35 product

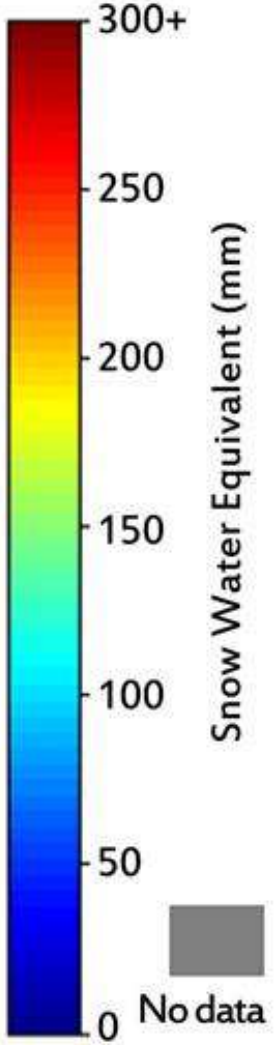
Snow water equivalent

EUMETSAT H SAF

SWE-E / H13

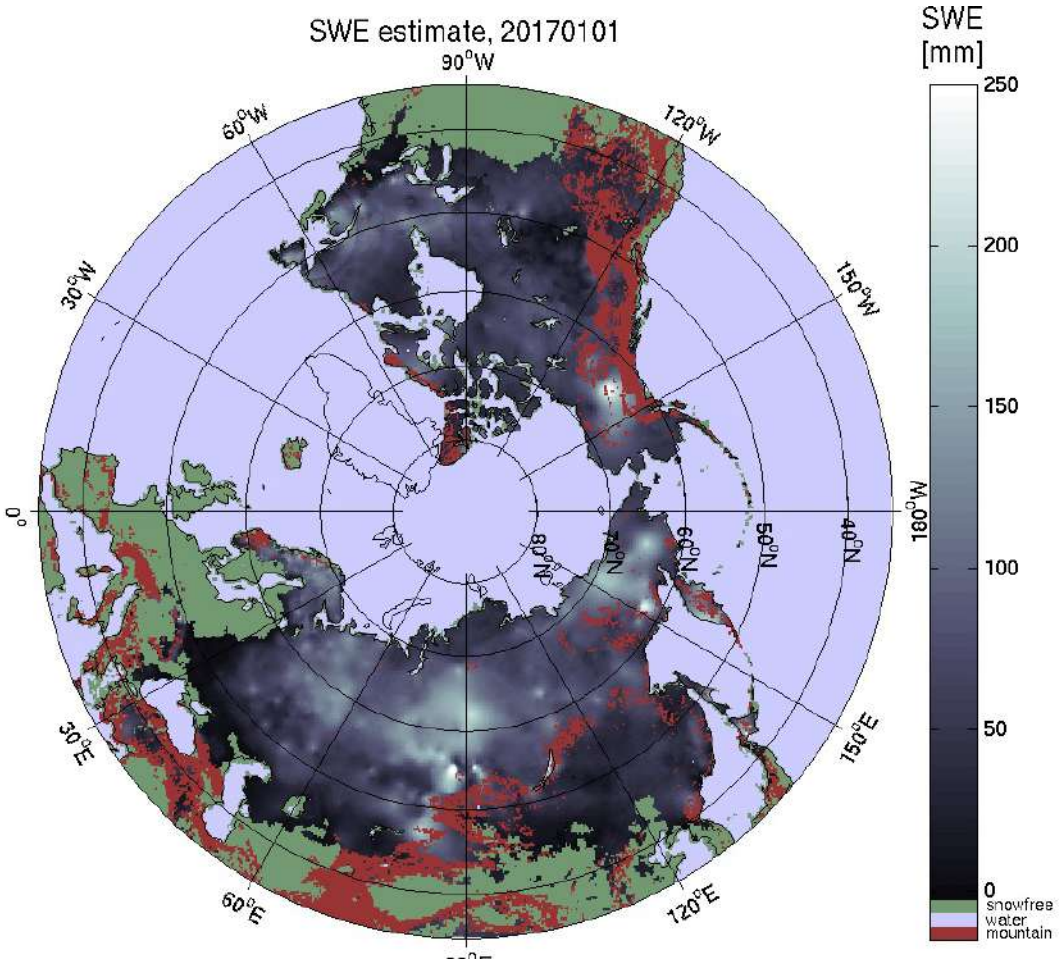
- Cycle: Daily
- Coverage: 25° W – 45°E
  25° N – 75°N
- Grid/Projection: Equidistant cylindrical
- Resolution: 0.25 ° x 0.25 °
- Formats: gzip compressed GRIB2, PNG quicklook image





H SAF Snow Water Equivalent (SWE) products in H SAF CDOP4

Cycle: Daily
Coverage: Northern Hemispherical
Grid/Projection: “EASE-Grid” - Lambert's equal-area
Resolution:5 km x 5 km
Formats: HDF5, PNG quicklook
Operational status: **In development**



H SAF Snow products in CDOP 4

Strategy and foreseen improvements – Snow Products

Enlargement to Northern Hemisphere

Transition to MTG

- From MSG

Transition to EPS-SG

- From MetImage

CDOP3

CDOP4

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 web-page 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

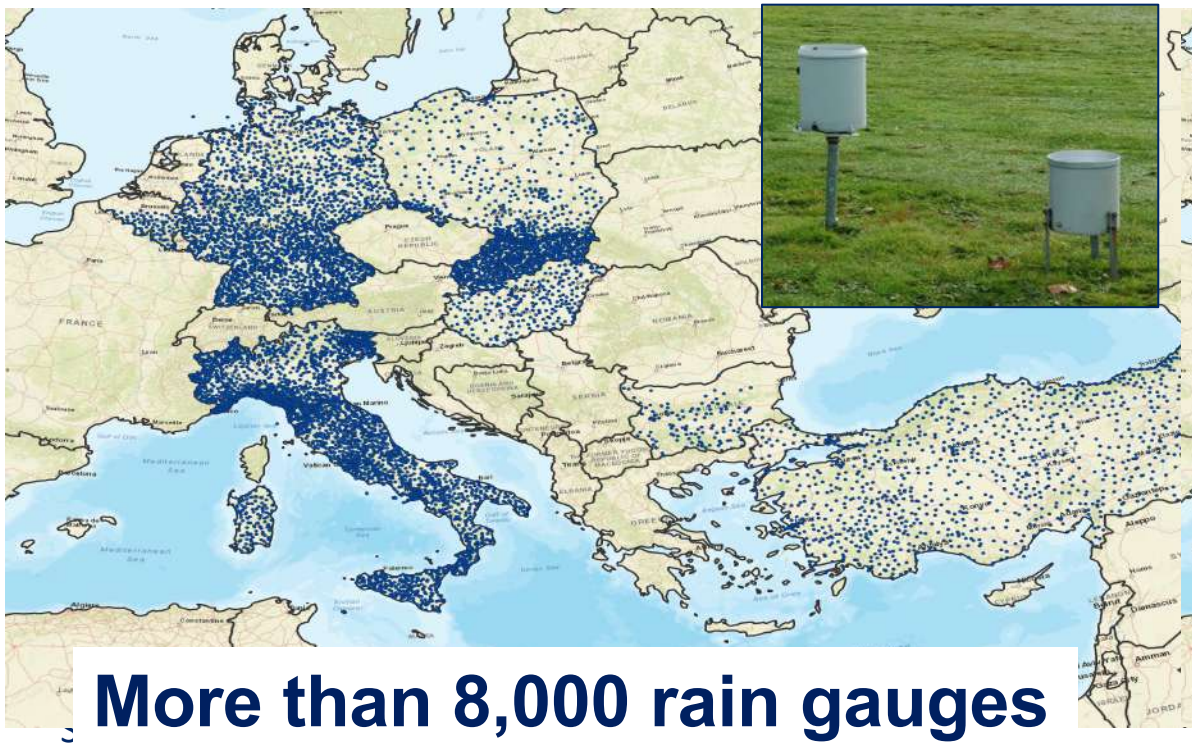
User Promotion

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.

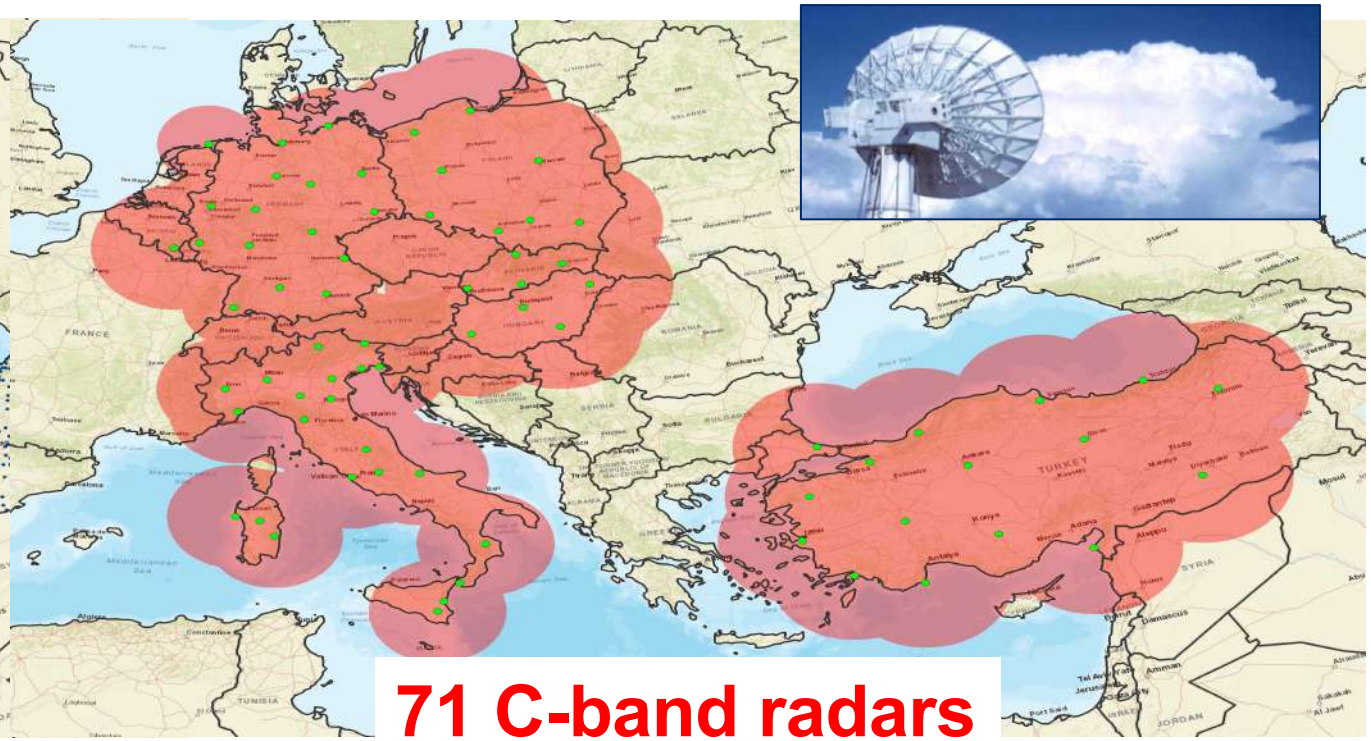
Precipitation Product Validation Group

Country	Institutes
Belgium	IRM
Bulgaria	NIMH
Germany	BfG
Hungary	OMSZ
Italy	DPC, UniBo
Poland	IMWM
Slovakia	SHMU
Turkey	ITU, METU,TSMS

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.



More than 8,000 rain gauges



71 C-band radars

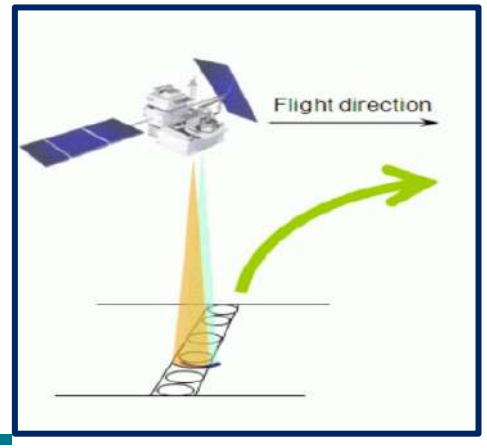
Precipitation Product:

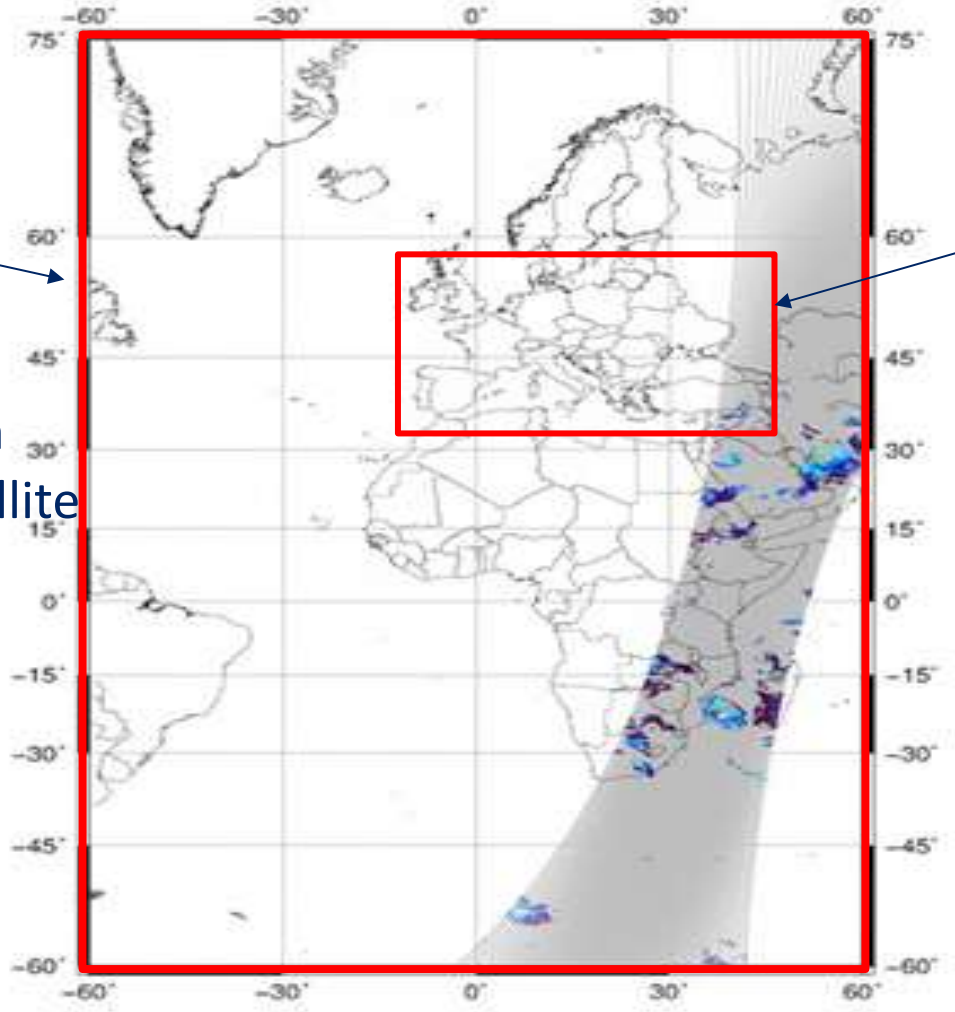
Area coverage

MSG Full Disk area

Global (or hemispherical) precipitation products

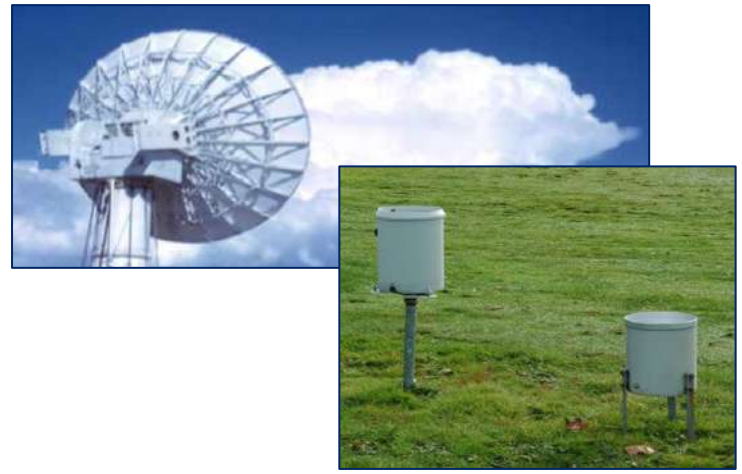
DPR (**D**ual-frequency **P**recipitation **R**adar) onboard of **GPM** Core satellite





H SAF area

National ground data: radars and raingauges



GPM Core Observatory (Global Precipitation Measurement)

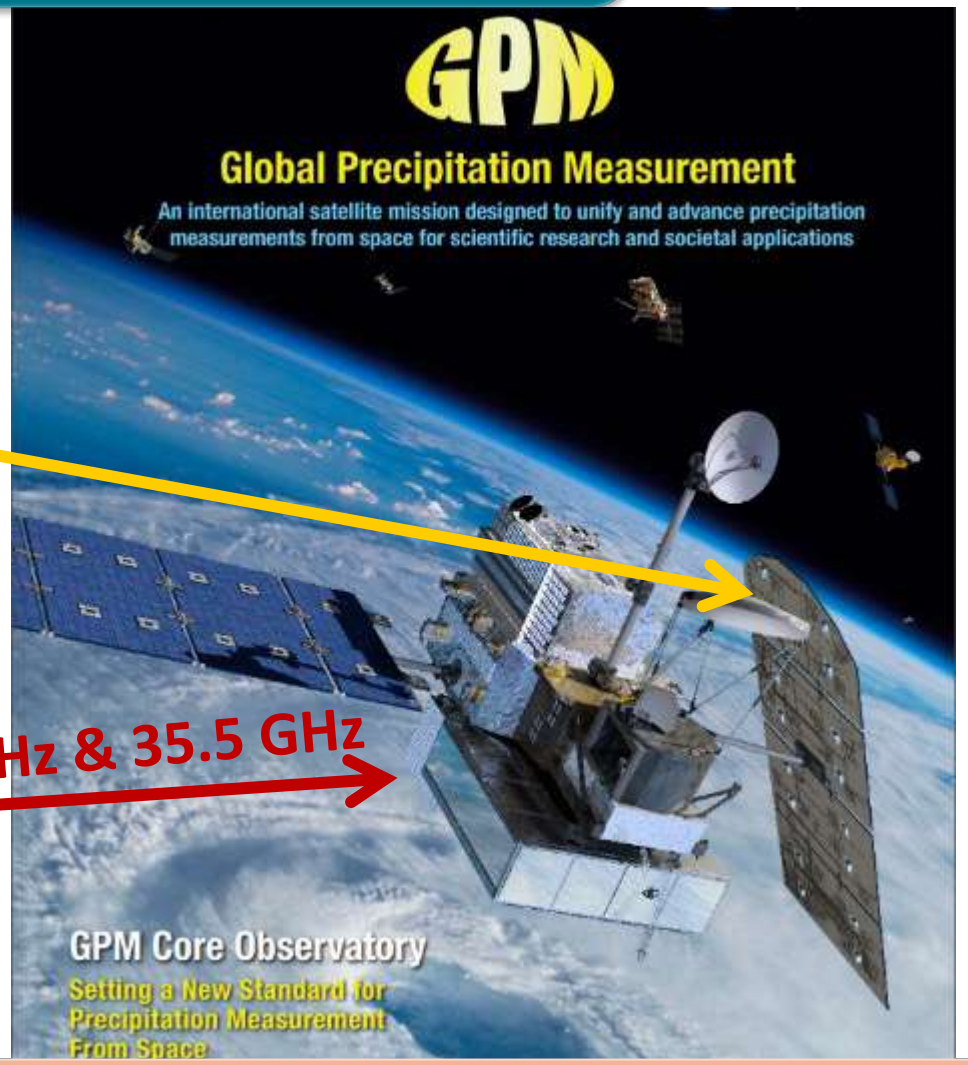
The GPM Core Observatory will carry two instruments that can view precipitation (rain, snow, ice) in new ways and connect measurements to those taken on other partner satellites

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

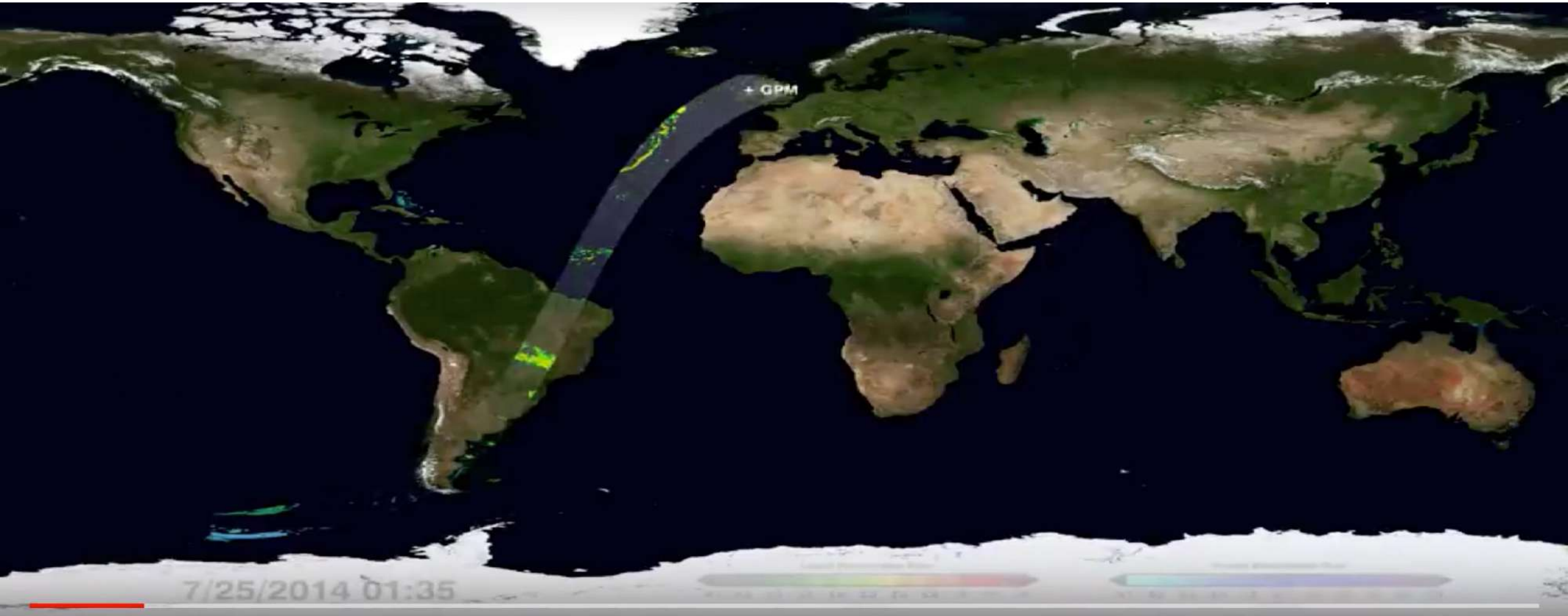
Two different radar frequencies that can look at precipitation in 3-D throughout the atmospheric column (JAXA)



13.6Hz & 35.5 GHz

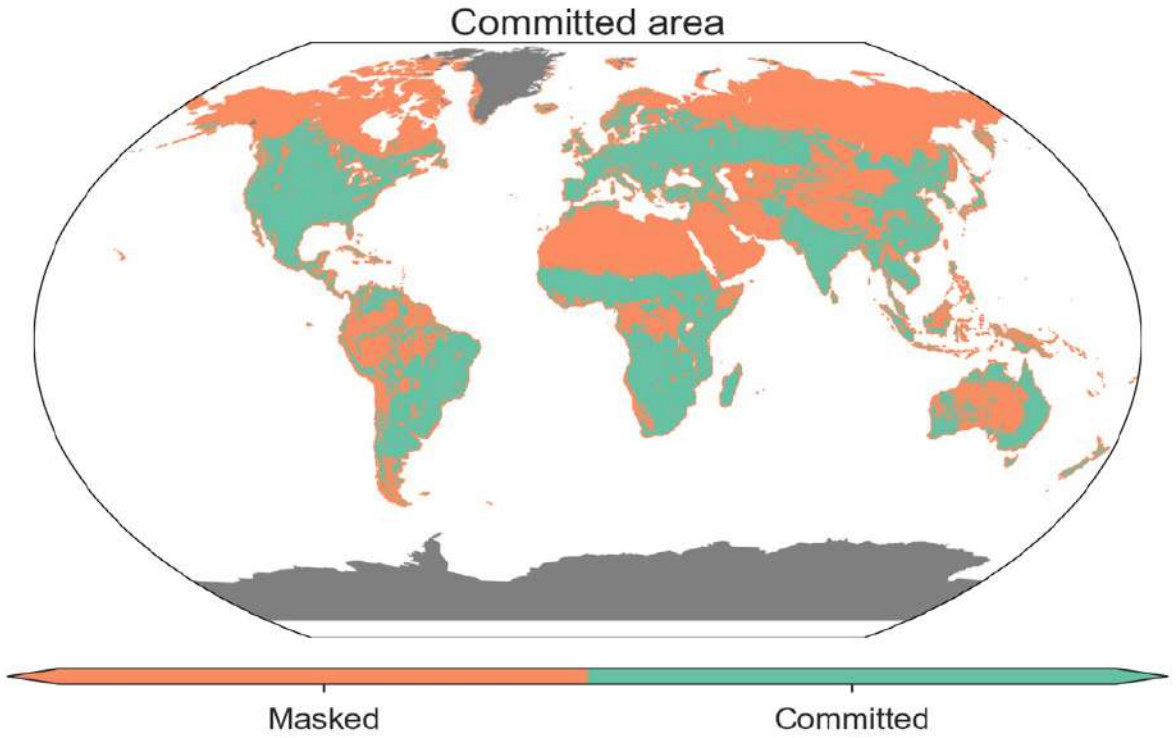
Ku band 12-18GHz; Ka band 26-40GHz;

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



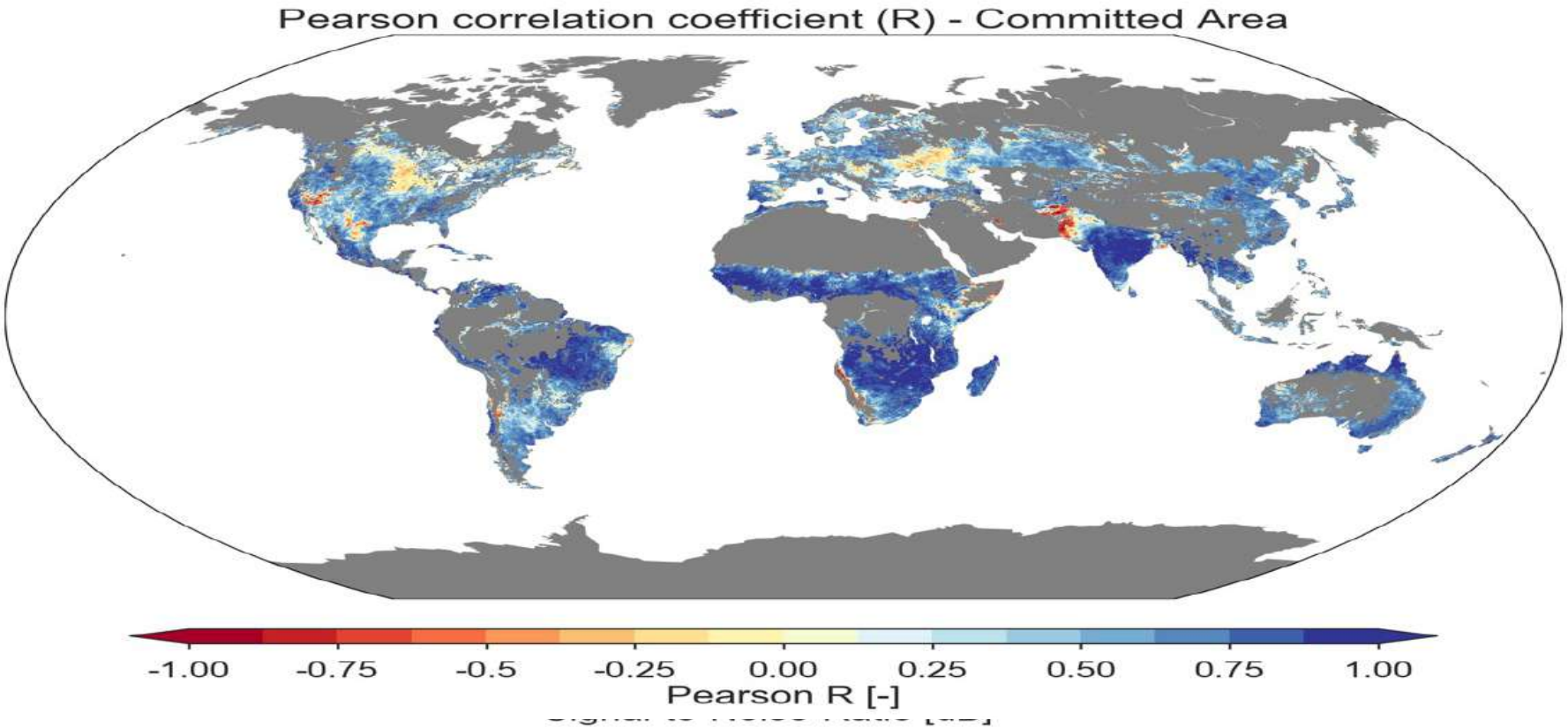
Validation of the Soil Moisture products

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



The Hydrologic 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

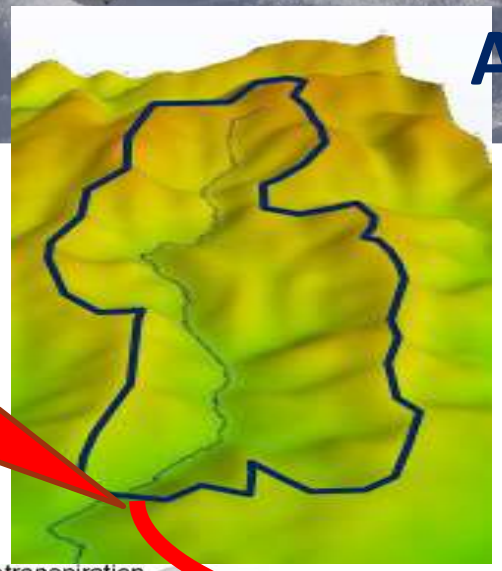
Perform the analysis of possible product utility for hydrological tasks and analysis on the improvement of HSAF products usefulness

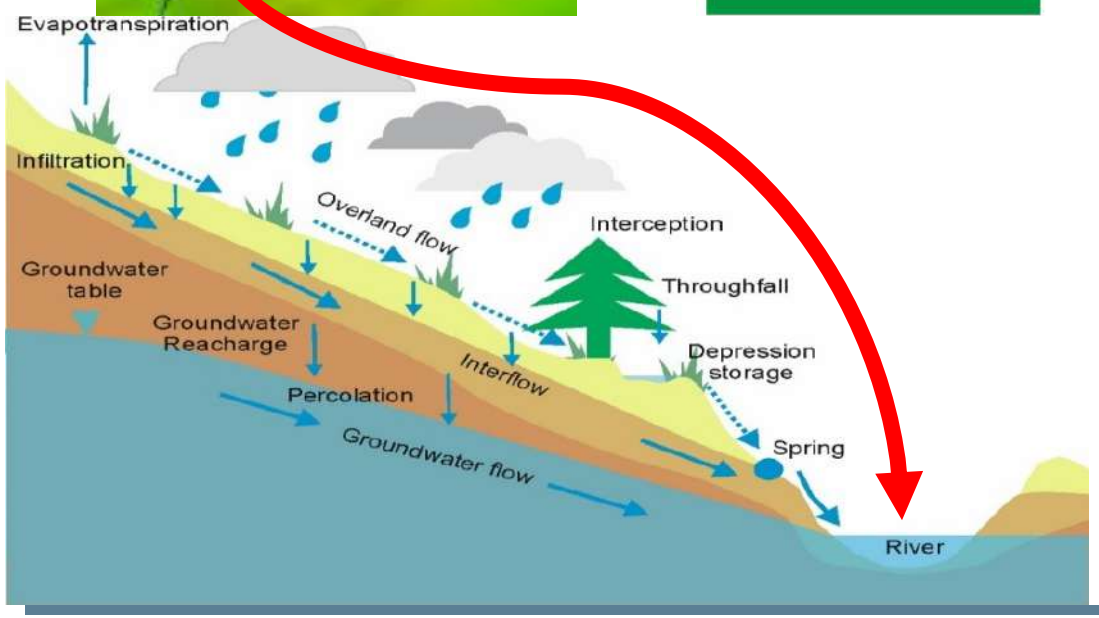
Examples of HSAF products applications

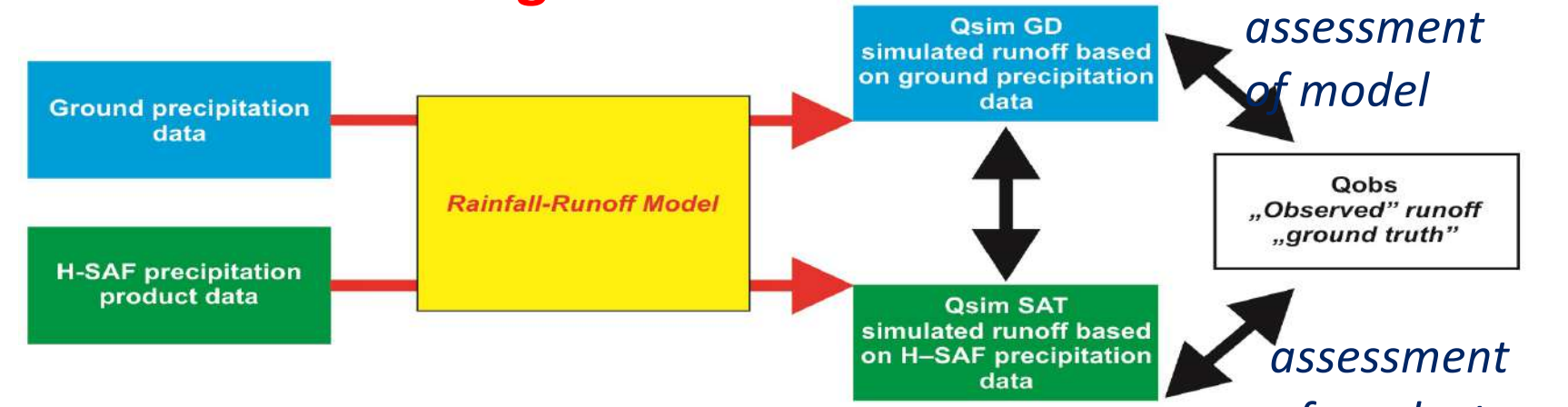
The Hydrological Validation Programme

Assumtion (product validation vs. hydrologic validation)

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

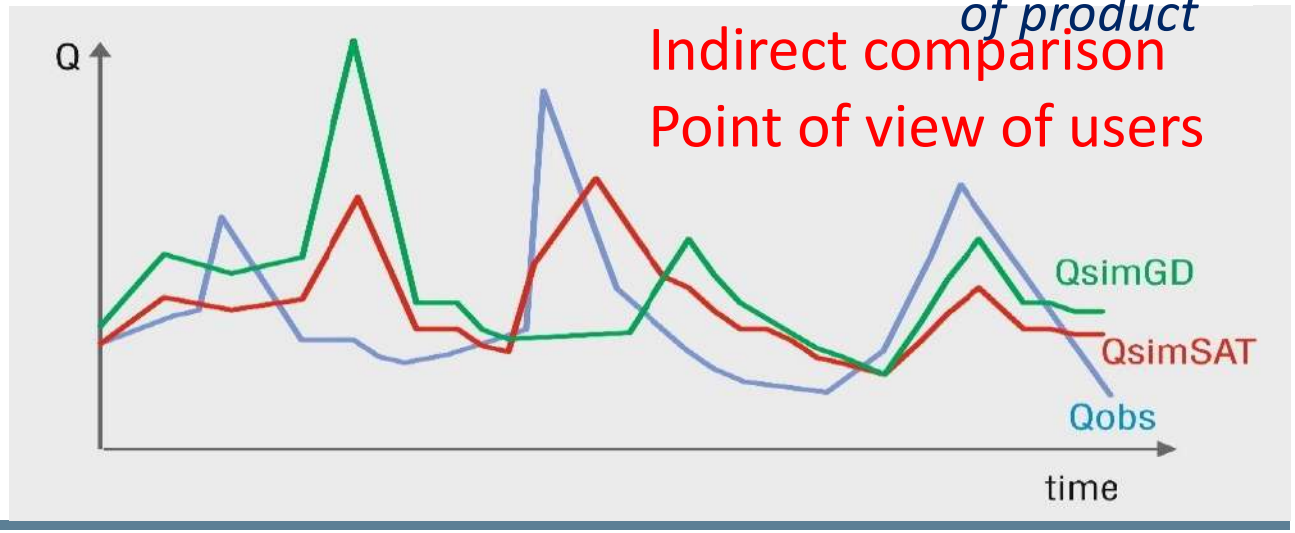






Indirect comparison

Point of view of users



The Hydrological Validation Programme

Country (Organization)	Test site	Hydrological model	
1) Finland (FMI)	Cunasjoki	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, upland, Sudety, Subcarpathian, Suprasl	HBV (Hydrologiska Byrans	
6) Italy (CIMA, IRPI CNR, DPC)	Selected basins in Italy	Continum 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)	HEC–HMS
	Ulus subbasin in Western Black Sea Basin		
	Upper Euphrates	SRM (Snowmelt Runoff Model), HBV, data driven model	

8 countries

11 organizations

Members, test sites, models

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.***

EUMETSAT H SAF

WEB PAGE

http://hsaf.meteoam.it/

EUMETSAT H SAF

Thanks for your attention !

QUESTIONS ?

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