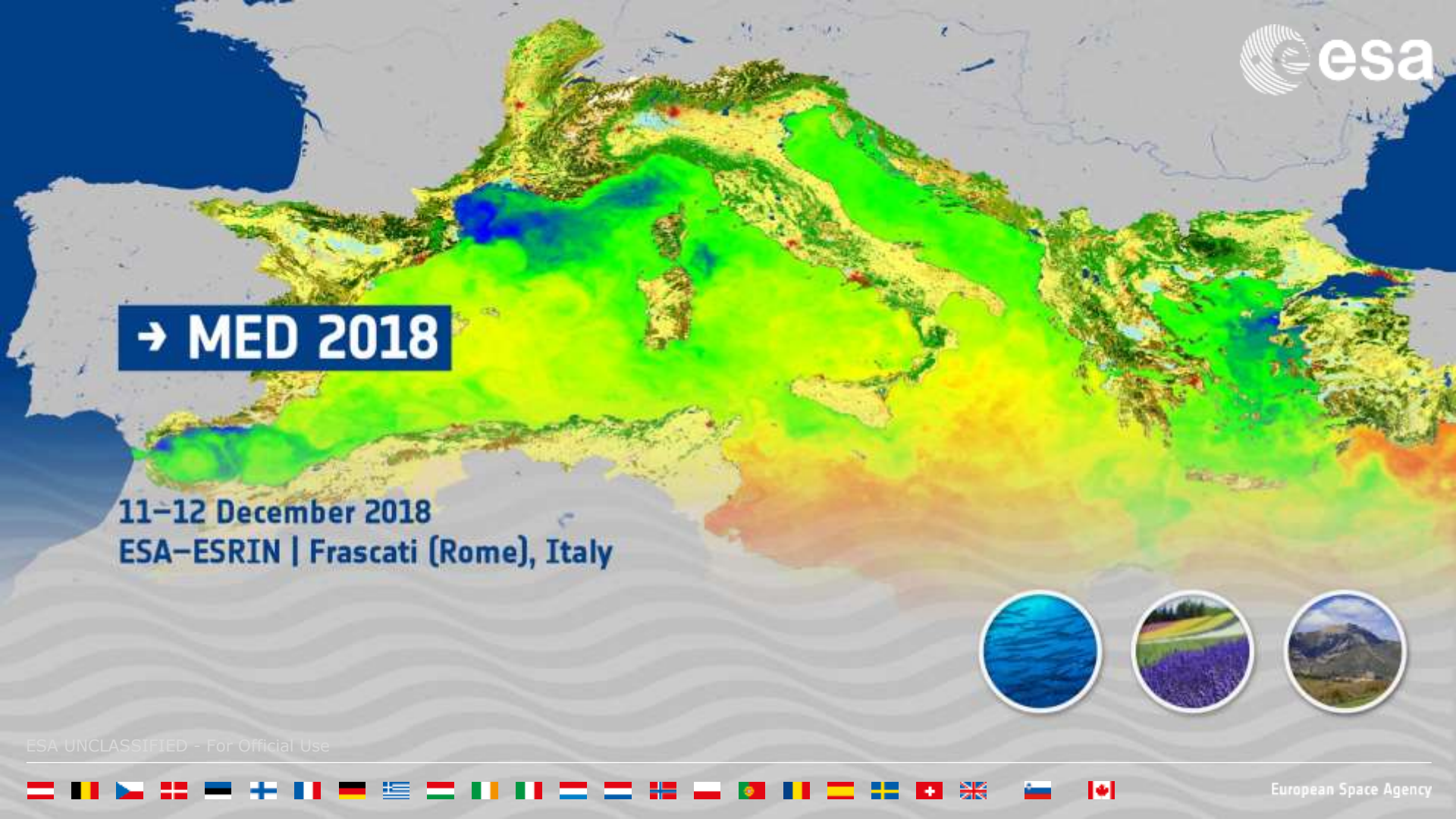


ESA UNCLASSIFIED - For Official Use

ROLE OF SATELLITE SOIL MOISTURE AND PRECIPITATION FOR HYDROMETEOROLOGICAL HAZARD PREDICTION (AND FOR AGRICULTURE) IN THE MEDITERRANEAN REGION

Luca Brocca, Stefania Camici, Luca Ciabatta,
Jacopo Dari, Paolo Filippucci, Christian Massari,
Sara Modanesi, Angelica Tarpanelli,
Maria Teresa Brunetti, Alessandro Mondini … et al!

ESA UNCLASSIFIED - For Official Use

OUTLINE

PRECIPITATION

FLOODS

LANDSLIDES

IRRIGATION

WHY IN THE MEDITERRANEAN?

- disastrous **floods** and **landslides** are much more frequent in some parts of the Mediterranean region than in the rest of Europe
  - local climate: prone to short intense bursts of **precipitation** → active convection
  - population growth: particularly high along the coasts → rapid increase in population exposed to flooding
- Hydro-meteorological events in the Mediterranean region are strongly influenced by **soil moisture** (e.g., 30% increase of soil moisture produces a 8-fold increase of peak discharge)

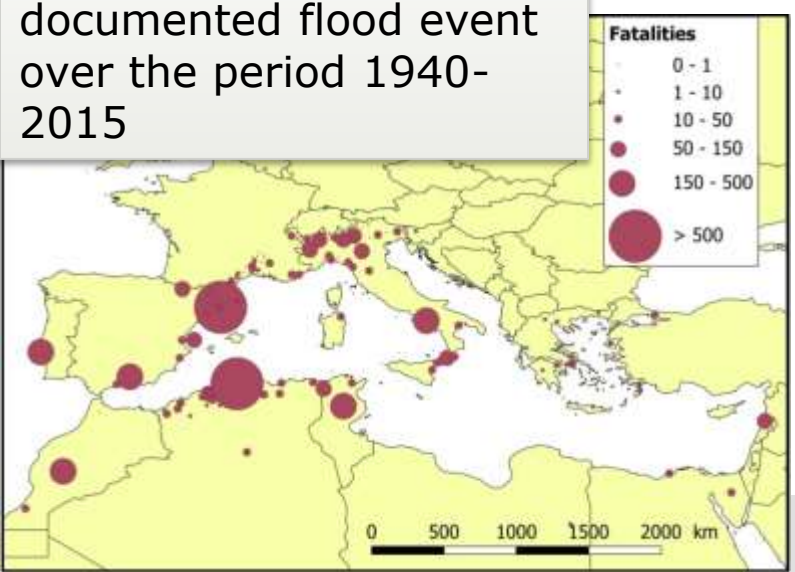
ESA UNCLASSIFIED - For Official Use

WHY IN THE MEDITERRANEAN?

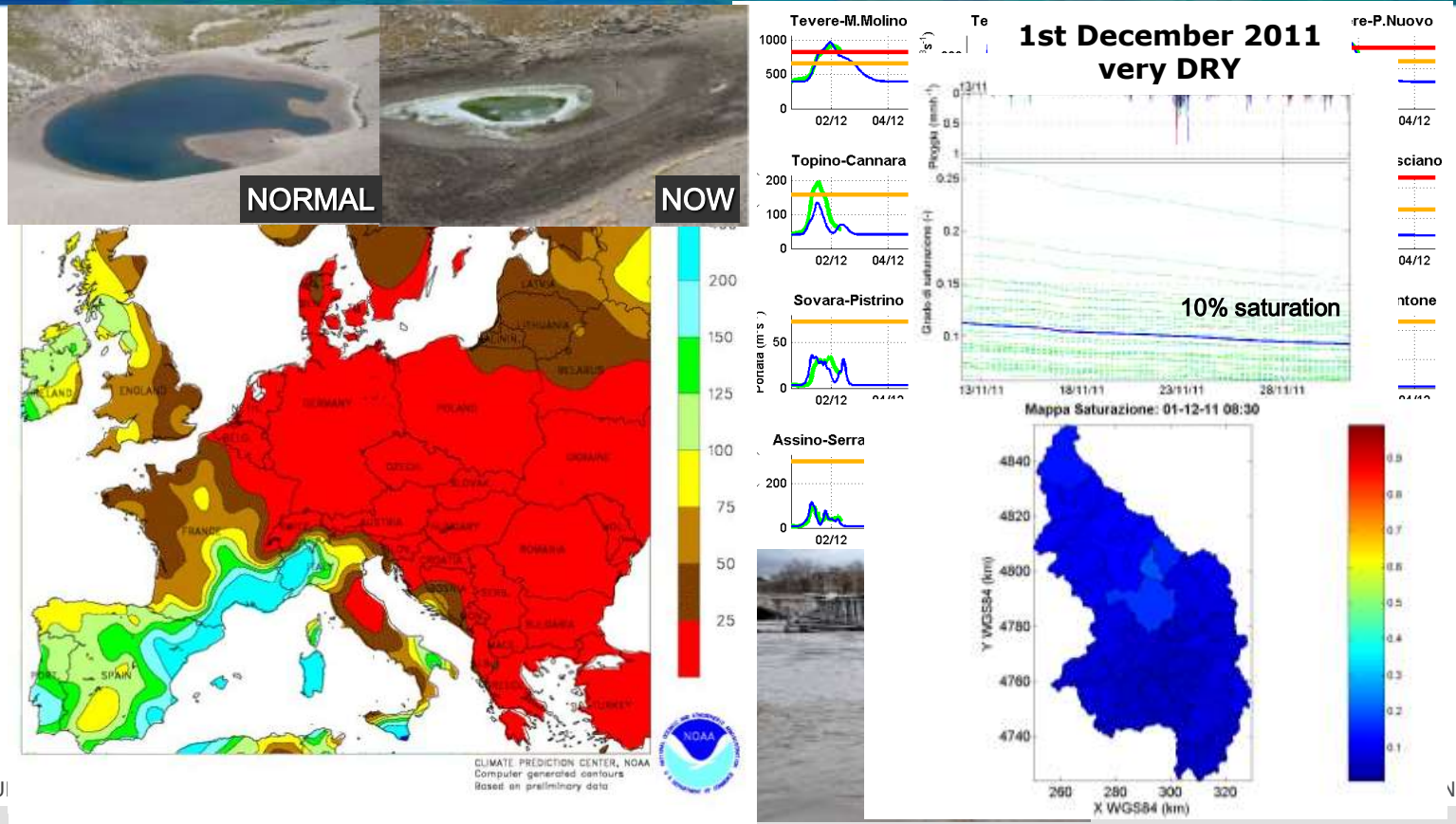
3.4. Mediterranean extreme floods and flash floods

Eric Gaume, Hydrologist, IFSTTAR, France.
Marco Borga, Hydrologist, University of Padoua, Italy.
Maria Carmen Llasat, Paleoclimatologist, University of Barcelona, Spain.
Said Maouche, Geophysicist, CRAAG, Bouzareah, Algiers, Algeria.
Michel Lang, Hydrologist, IRSTEA, France.
Michalis Diakakis, Hydrologist, University of Athens, Greece.

Number of people reported killed in each documented flood event over the period 1940-2015

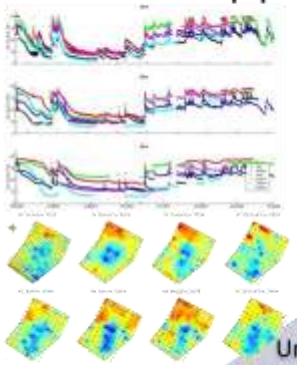


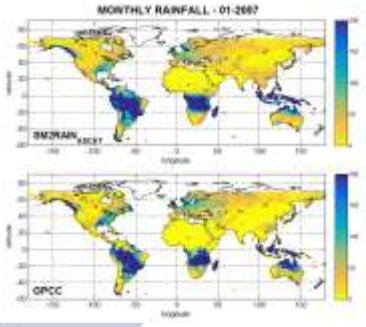
A TYPICAL EXAMPLE



A TYPICAL EXAMPLE

SOIL MOISTURE AND PRECIPITATION





Soil moisture and precipitation are the two key variables for predicting flood and landslide events

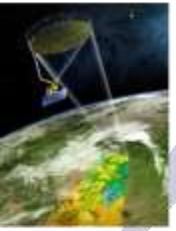
Understanding the spatial-temporal **variability** of soil moisture at different spatial scales

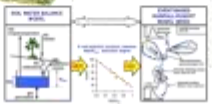
Assimilation of in situ and remote sensing soil moisture measurements for **hydrological applications**

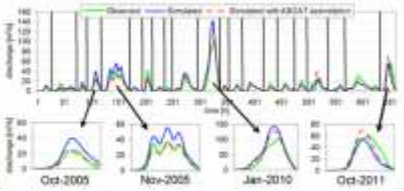
Detecting rainfall from the bottom up: using soil moisture observations for measuring rainfall (**SM2RAIN**)

Brocca, L., Ciabatta, L., Massari, C., Camici, S., Tarpanelli, A. (2017). **Soil moisture for hydrological applications: open questions and new opportunities**. *Water*, 9(2), 140.

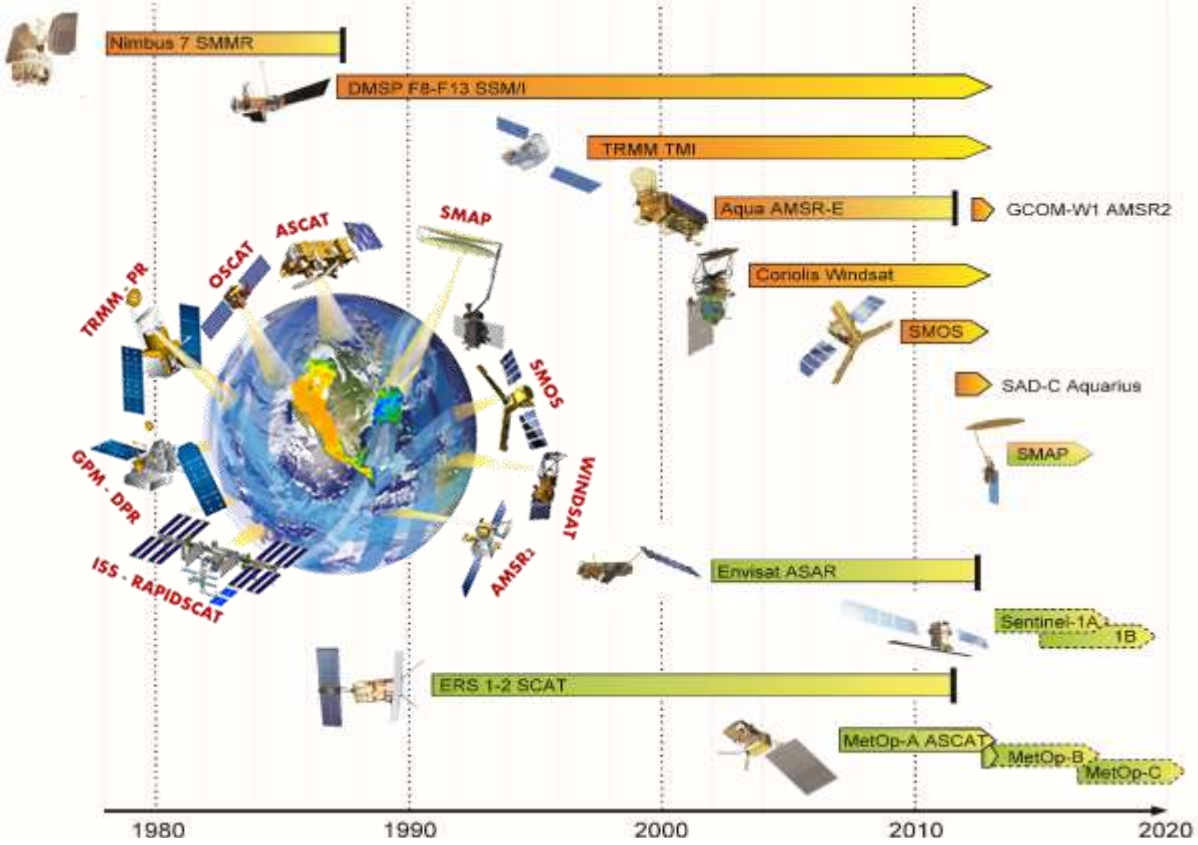
Soil moisture **monitoring** with in situ and remote sensing





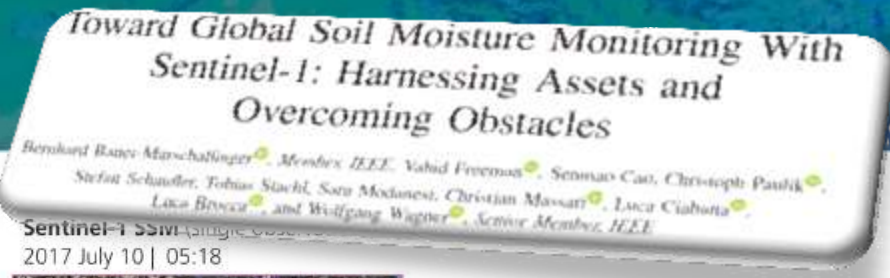


REMOTE SENSING OF SOIL MOISTURE

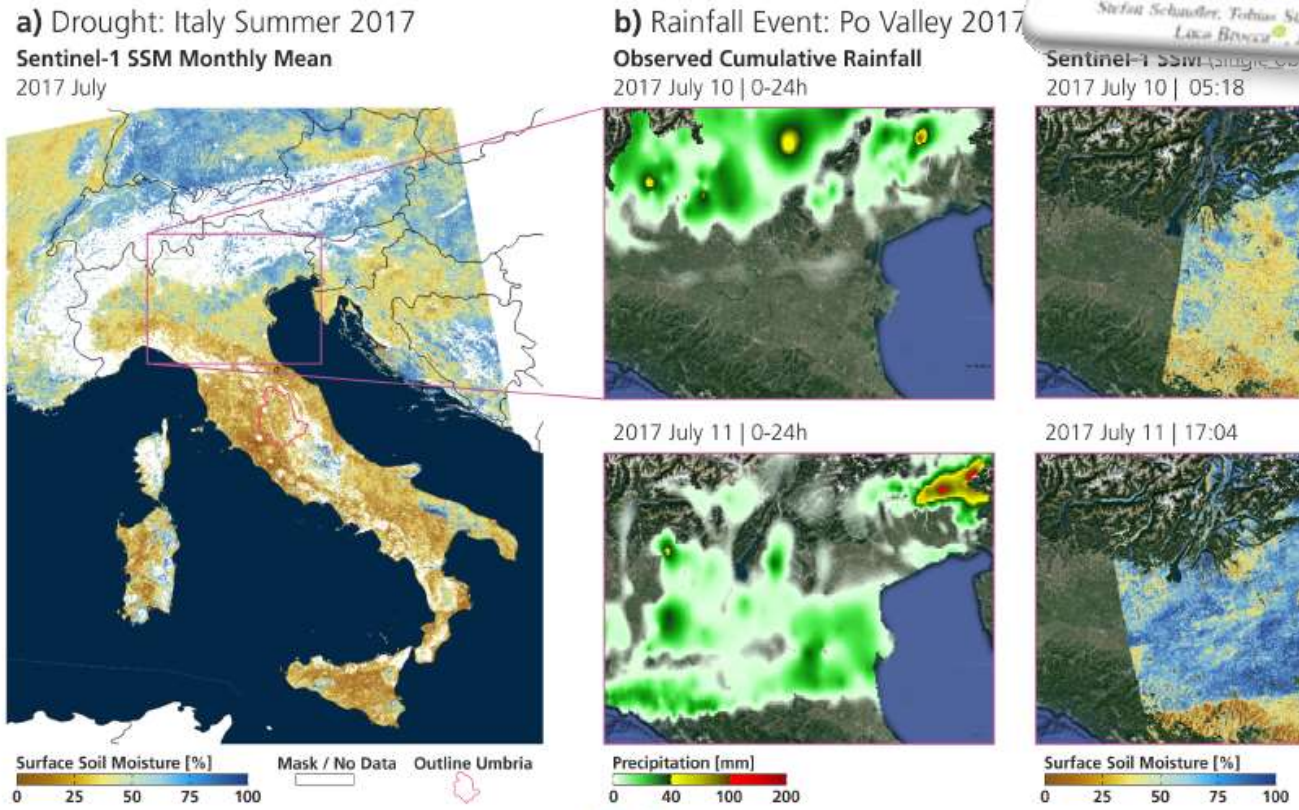


- A constellation of satellite sensors for measuring soil moisture is available
- High temporal and spatial resolution only recently:
  - Sentinel-1
  - CYGNSS
- future missions:
  - FSSCat
  - L-band SAR
  - G-CLASS (EE10)

SENTINEL-1 SOIL MOISTURE

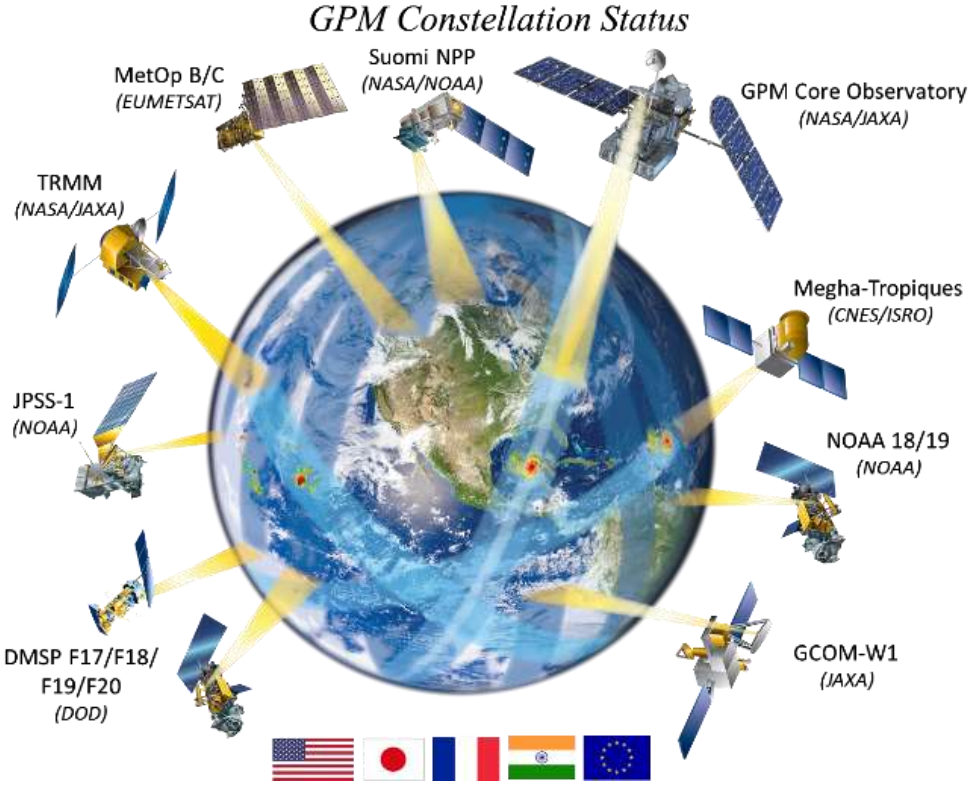

Toward Global Soil Moisture Monitoring With Sentinel-1: Harnessing Assets and Overcoming Obstacles

Bernhard Bauer-Marschallinger, Member, IEEE, Vahid Freeman, Senmao Cao, Christoph Paulik, Stefan Schaufler, Tobias Stachl, Sara Modanesi, Christian Massari, Luca Ciabatta, Luca Brocca, and Wolfgang Wagner, Senior Member, IEEE



Sentinel-1 Soil Moisture

REMOTE SENSING OF PRECIPITATION



- GPM is an international satellite mission to unify and advance precipitation measurement from space
- 10 km/0.5 hours spatial/temporal resolution
- 3 products (early, late and final run)

HOW MANY PEOPLE ARE USING SATELLITE SOIL MOISTURE AND PRECIPITATION IN OPERATION?

Matthias Drusch (ESA ESTEC): "In a meeting with 35 flood forecasting centres in Europe, I recognized that only one of them is using satellite observations…34 out 35 is not using any satellite observation!!!"

Can we use satellite soil moisture data for setting the initial conditions of flood (and landslide) modelling? Which approach?

Are satellite precipitation products accurate to simulate floods? Flash floods? Landslides?

WHAT HAS BEEN (IS BEING) DONE (2014-…)?

Past | Current

VS Activity CCI (1)
Funding: ESA
Period: 2014, 9-month
Budget: 12 K€

VS Activity H-SAF
Funding: EUMETSAT
Period: 2015, 6-month
Budget: 10 K€

VS Activity CCI (2)
Funding: ESA
Period: 2015-2016, 18-month
Budget: 40 K€

SM2RAIN in UK
Funding: CEH
Period: 2016-2017, 1-year
Budget: 15 K€

WACMOS-MED
Funding: ESA
Period: 2015-2017, 2-year
Budget: 60 K€

WACMOS-Irrigation
Funding: ESA
Period: 2017, 1-year
Budget: 70 K€

Drought in India
Funding: IWMI
Period: Jul-Dec 2017, 6-month
Budget: 10 K€

GLOBAL-SM2RAIN
Funding: EUMETSAT
Period: 2017-2019, 15 months
Budget: 100 K€

SMOS+ Rainfall
Funding: ESA
Period: 2015-2018, 3-year
Budget: 150 K€

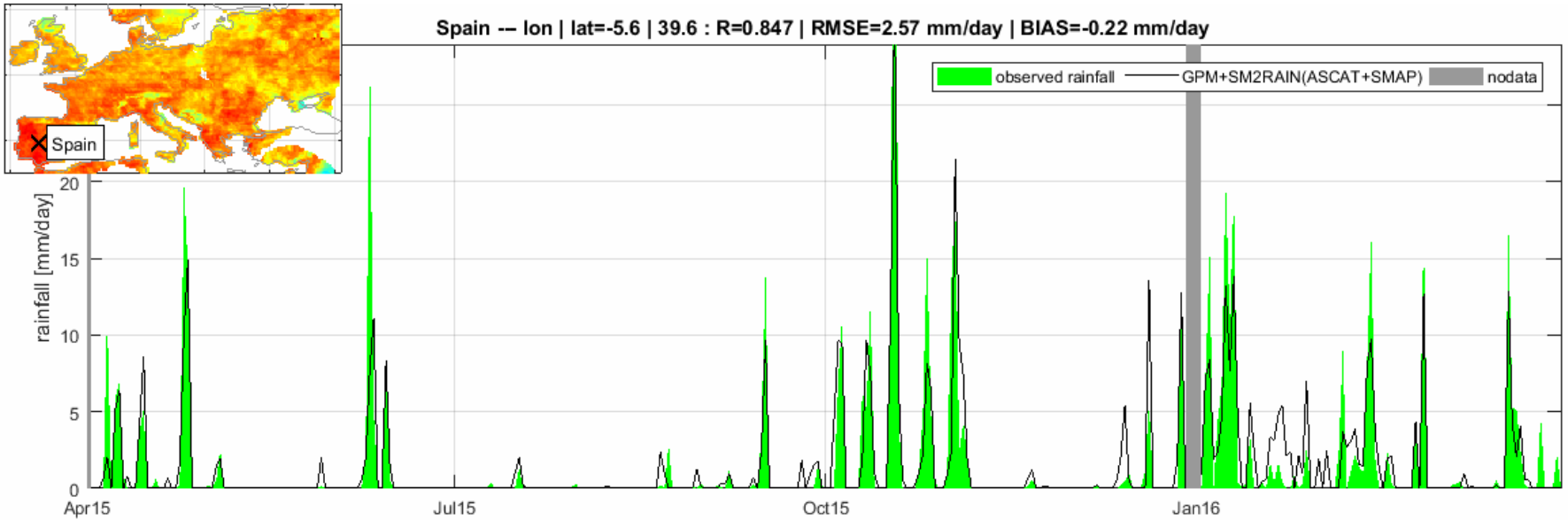
CDOP3 H-SAF project
Funding: EUMETSAT
Period: March-2017, 5-year
Budget: 150 K€

ANDROMEDA
Funding: CARIPLO
Period: March-2018, 2.5-year
Budget: 40 K€

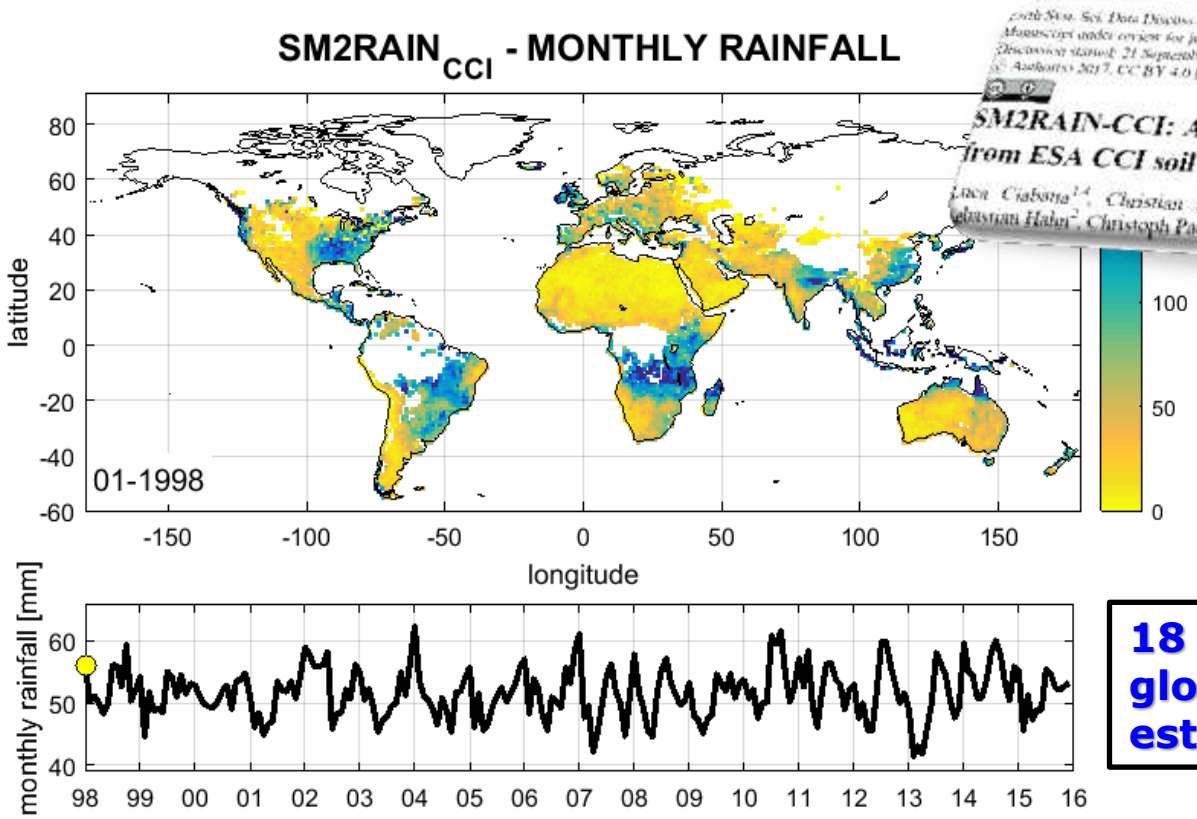
DPC
Funding: DPC
Period: 2014-ongoing, 5+-year
Budget: 350 K€

ESA SMOS+RAINFALL

The main objective of SMOS+RAINFALL project is to assess the potential of a multiple satellite soil moisture products to enhance rainfall information over land through the application of **SM2RAIN** and **PRISM** approaches



ESA CCI SOIL MOISTURE: SM2RAIN

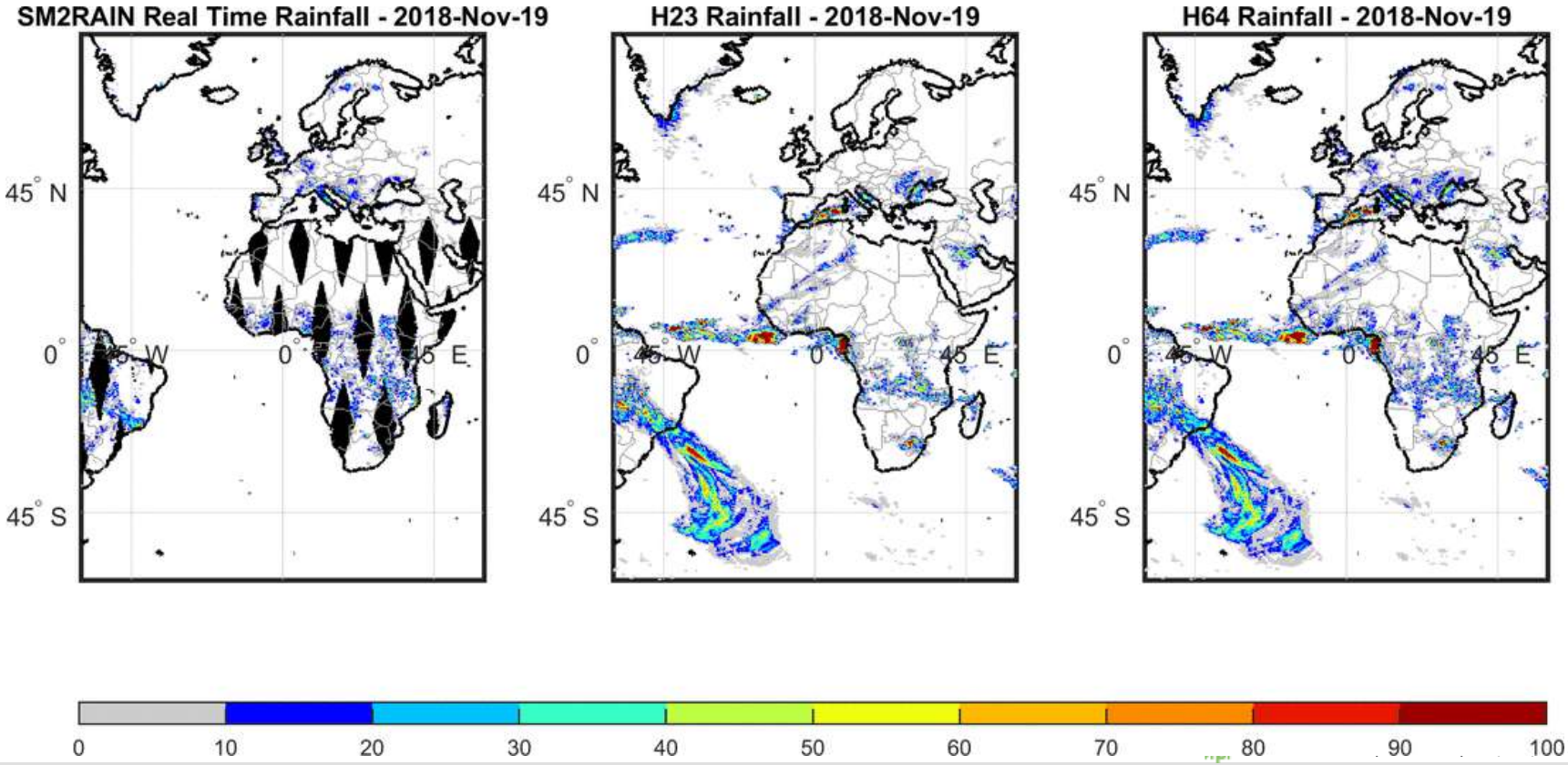


http://doi.org/10.5281/zenodo.1305021

18 years of global rainfall estimates

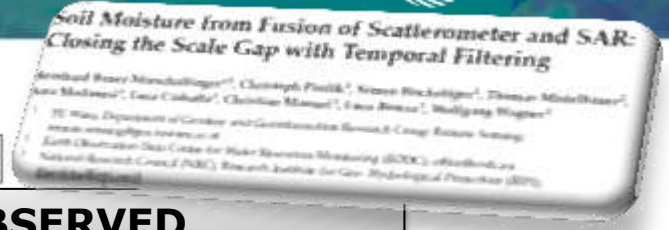
Luca Ciabatta et al.

EUMETSAT H SAF: NEAR REAL-TIME PRECIPITATION INTEGRATING SM2RAIN



Luca Ciabatta et al.

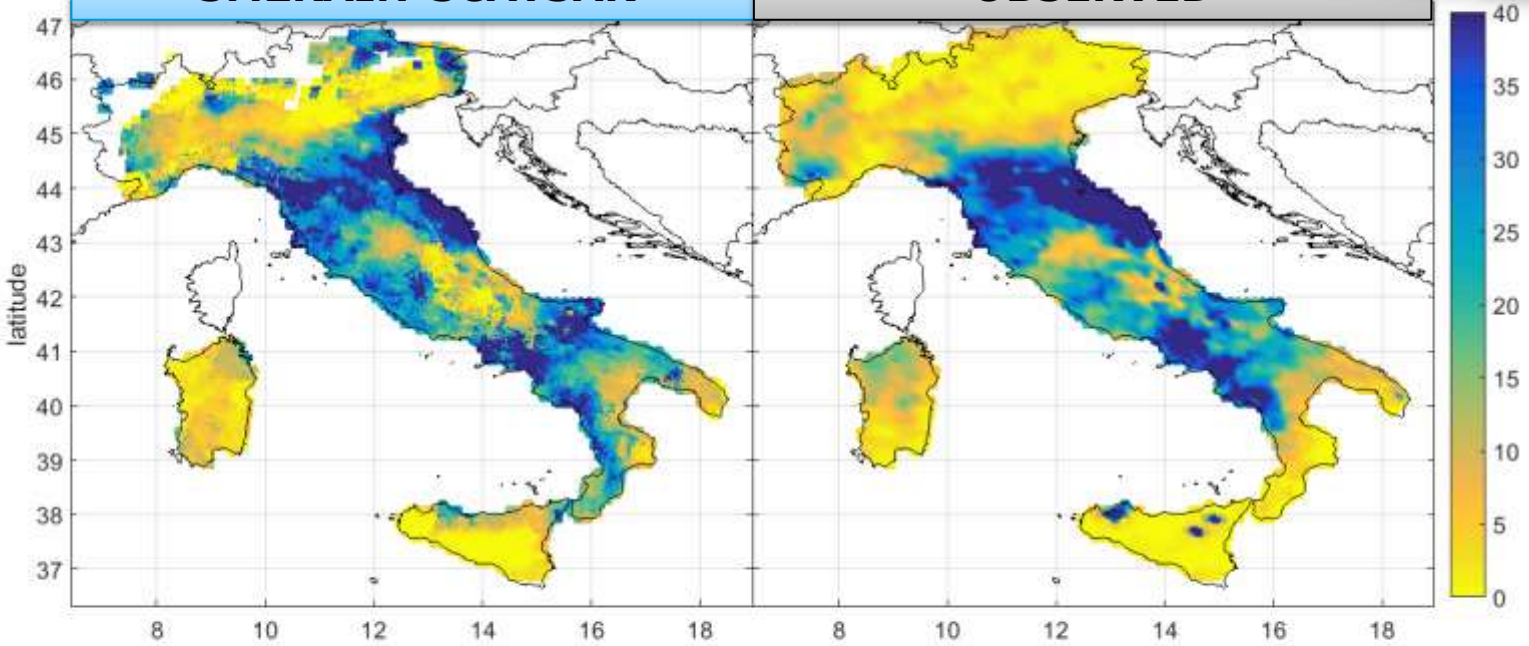
SM2RAIN-SCATSAR:
1 km PRECIPITATION FROM SPACE



From 01-04-2015 to 05-04-2015

SM2RAIN-SCATSAR | **OBSERVED**

Animation (3 months) of 5-day accumulated precipitation



Bernhard Bauer-Marschallinger et al.

SOIL MOISTURE DATA ASSIMILATION FOR IMPROVING FLOOD PREDICTION

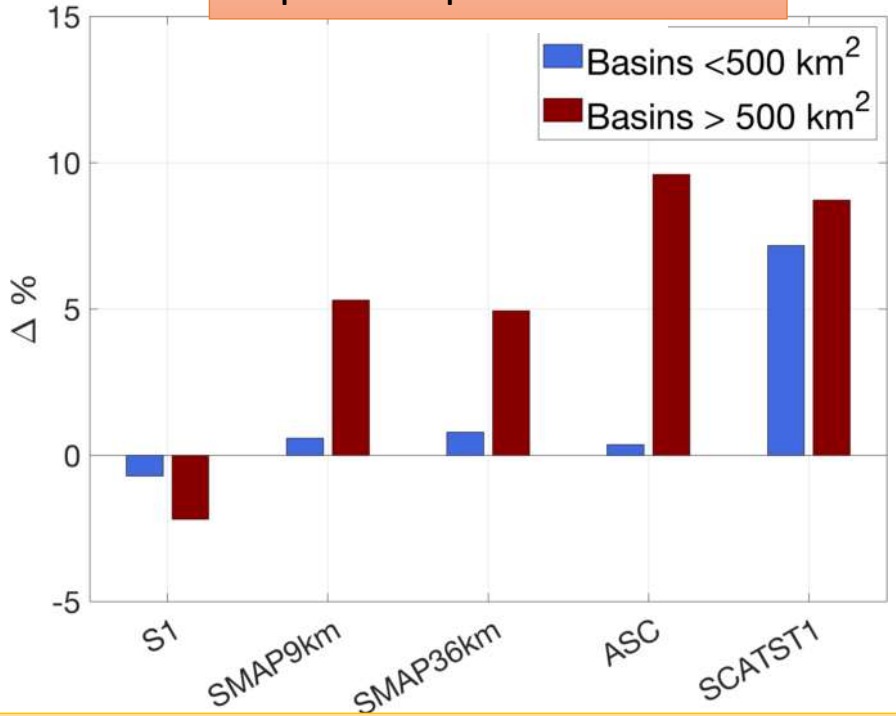
1. Will small basins benefit from the assimilation of higher spatial resolutions products?
2. How much the temporal resolution is important?
3. How much the product quality is important ?

Product	Spatial resolution	Temporal resolution
S1: Sentinel-1	1 km	3-6 days
SMAP 9km	9 km	2-3 days
SMAP 36 km	36 km	2-3 days
ASC: ASCAT	25 km	1 day
SCATST1: SCATSAR= ASCAT+Sentinel-1	1 km	1 day

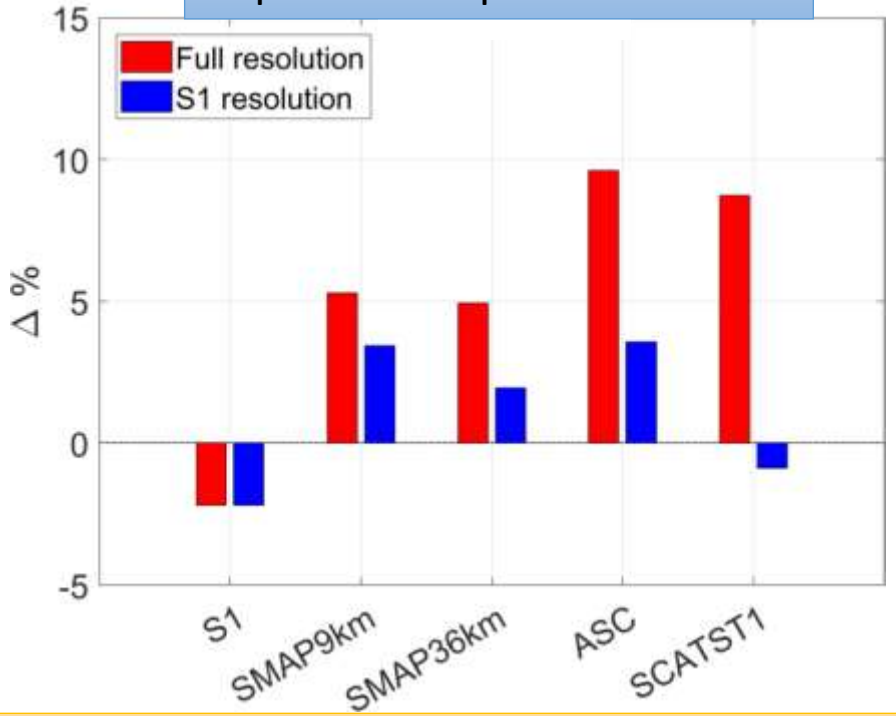
Christian Massari et al.

SOIL MOISTURE DATA ASSIMILATION FOR IMPROVING FLOOD PREDICTION

Impact of spatial resolution



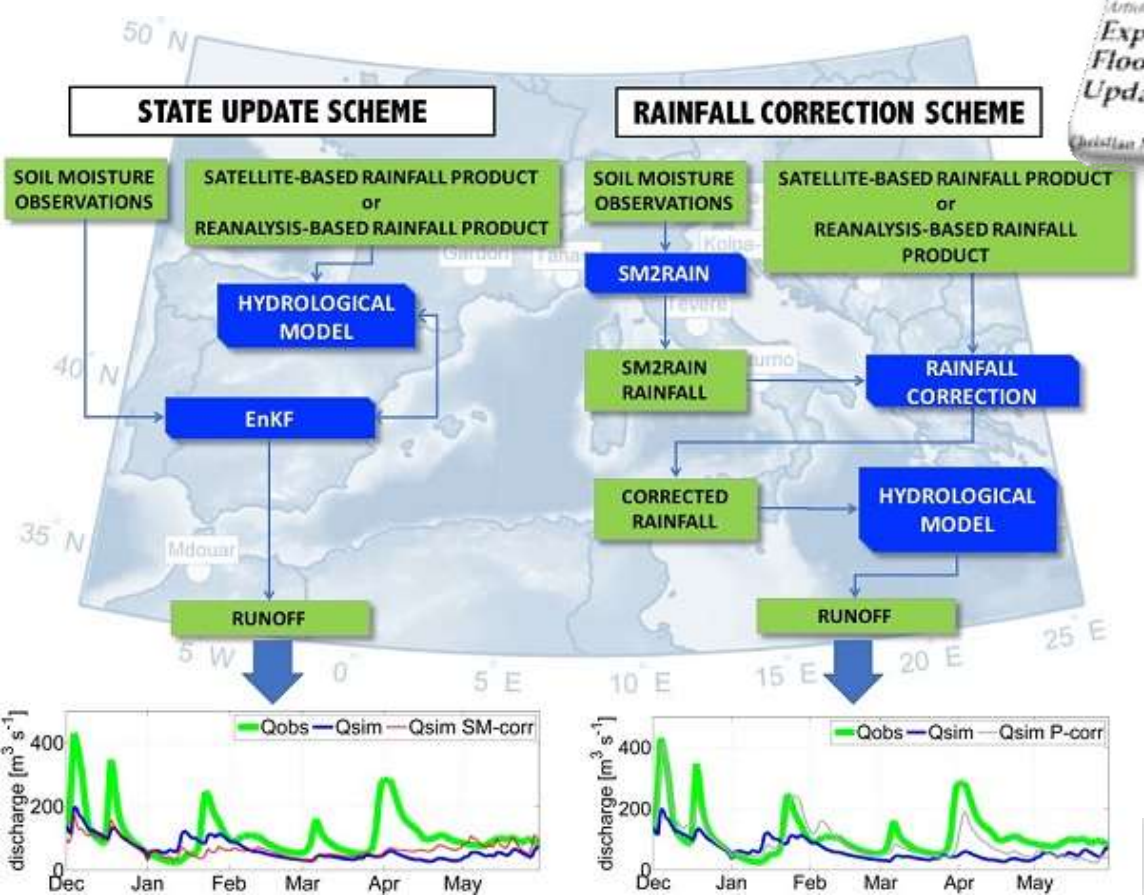
Impact of temporal resolution

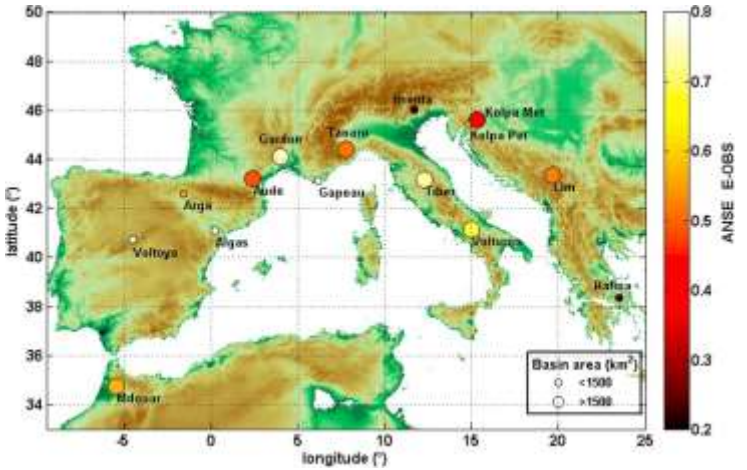


Improvement in KGE score: positive values → positive impact of satellite soil moisture assimilation

Christian Massari et al.

STATE UPDATE VERSUS RAINFALL CORRECTION

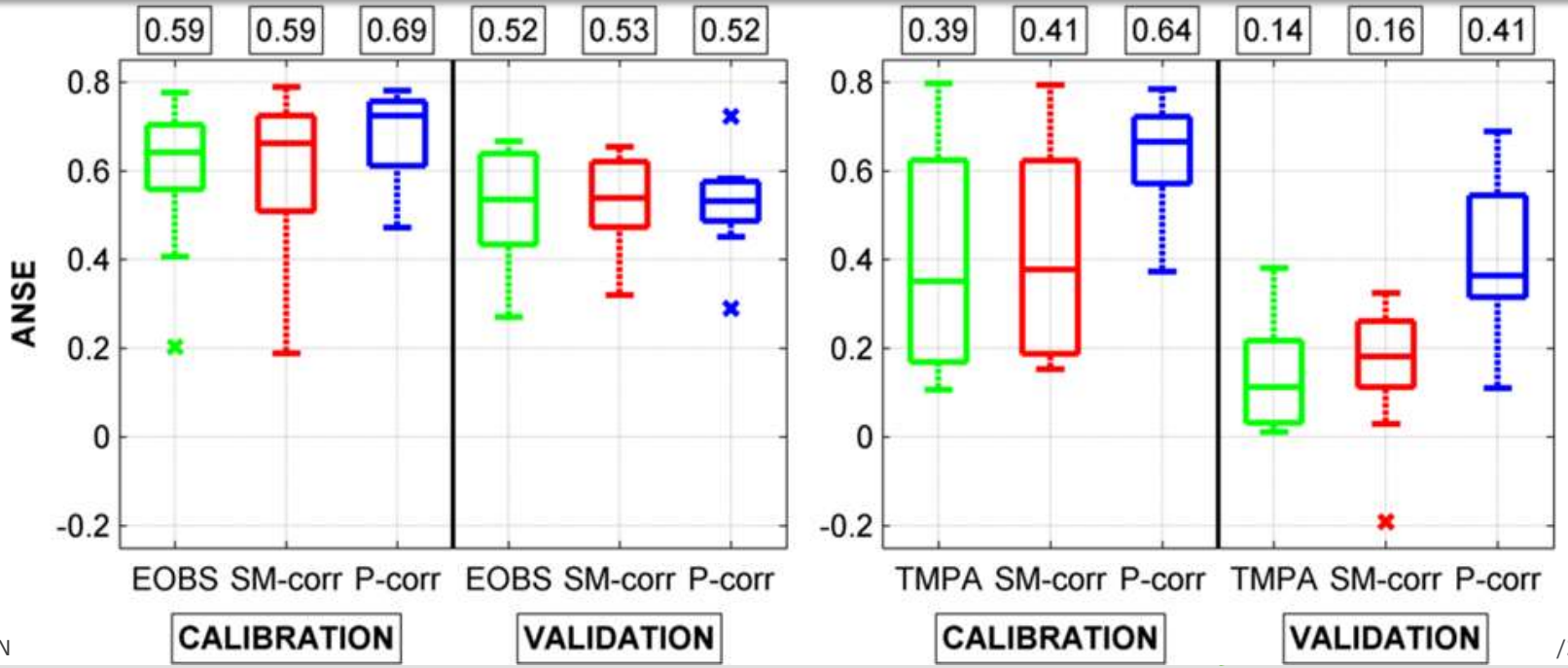




Christian Massari et al.

STATE UPDATE VERSUS RAINFALL CORRECTION

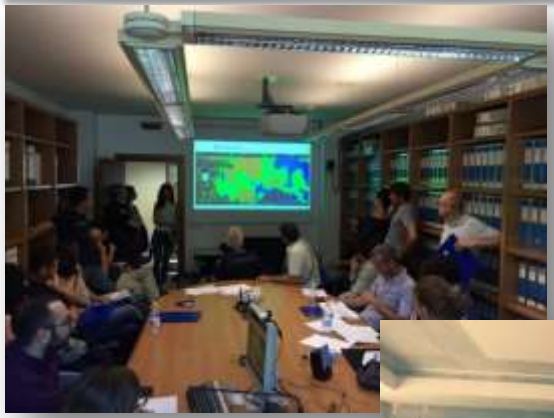
Satellite soil moisture observations can be used for improving flood modelling through data assimilation (i.e., correction of model states) or rainfall correction (i.e., through SM2RAIN). Rainfall correction has a larger, and more favorable, impact.



Christian Massari et al.

EUMETSAT H SAF: USER PROMOTION AND TRAINING

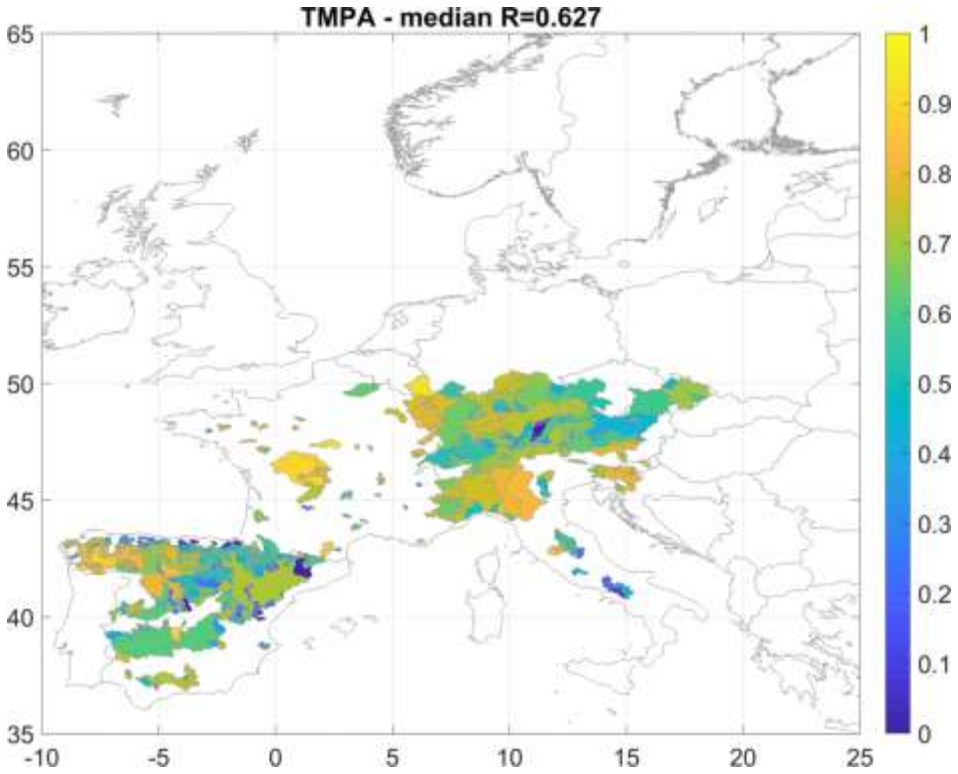
SATELLITE SOIL MOISTURE PRODUCTS FOR THE OPERATIONAL APPLICATIONS OF CIVIL PROTECTION



EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

ESA UNCLASSIFIED - For Official

ESA WACMOS-MED: FLOOD PREDICTION WITH SATELLITE PRECIPITATION



- Flood simulation through rainfall-runoff modelling over 720 basins throughout Europe
- Use of different satellite precipitation products, including SM2RAIN-derived products
- Performance assessment in comparison with in situ observations of river discharge
- Data period 2011-2014

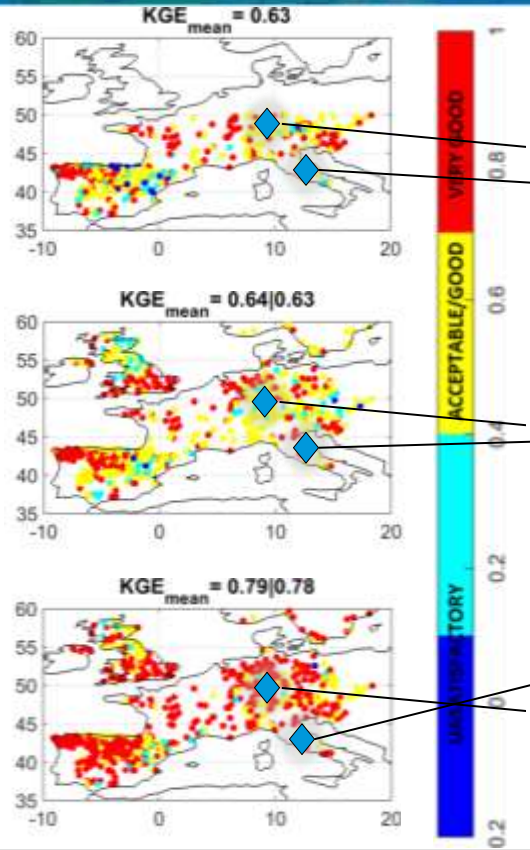
Stefania Camici et al

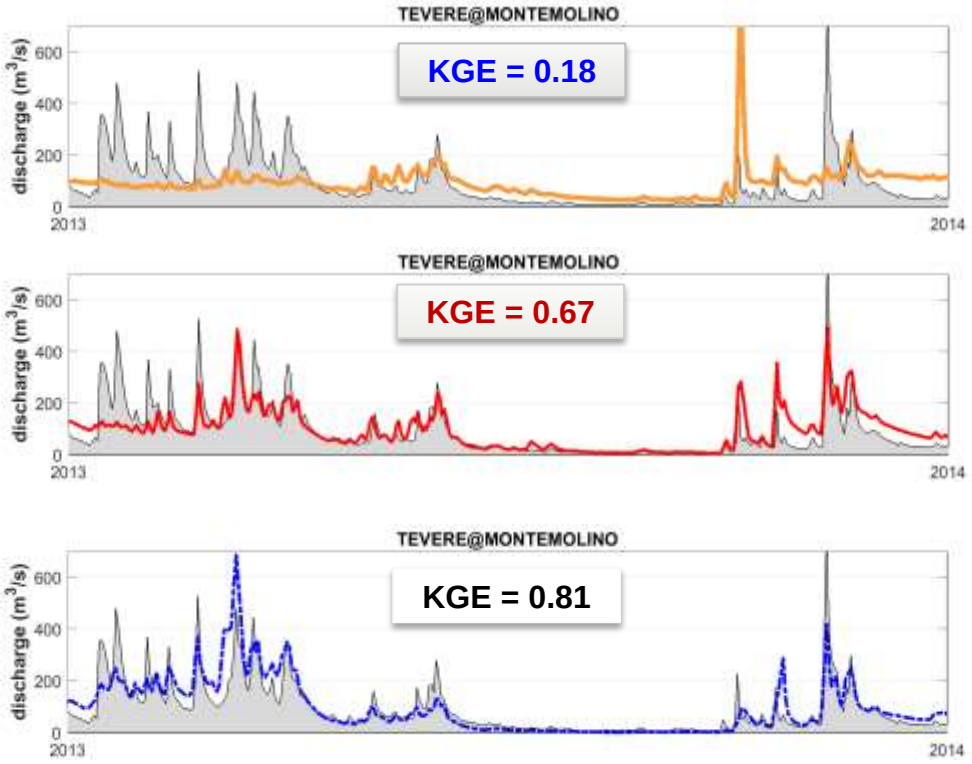
FLOOD PREDICTION WITH SATELLITE PRECIPITATION

TMPA

H SAF

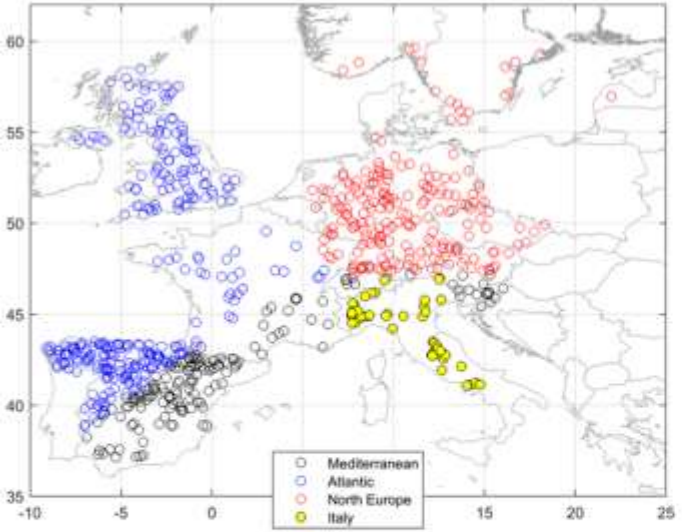
H SAF + SM2RAIN

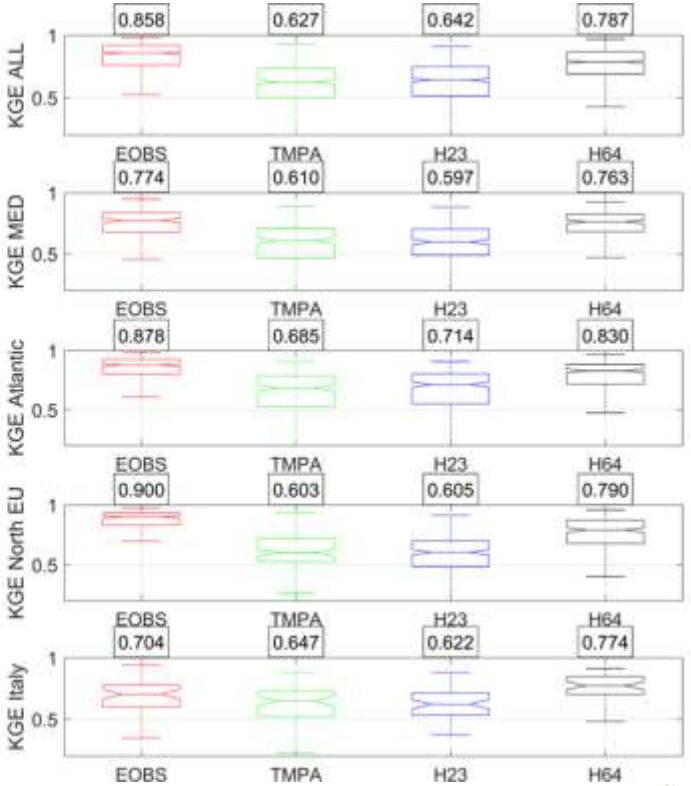




Stefania Camici et al

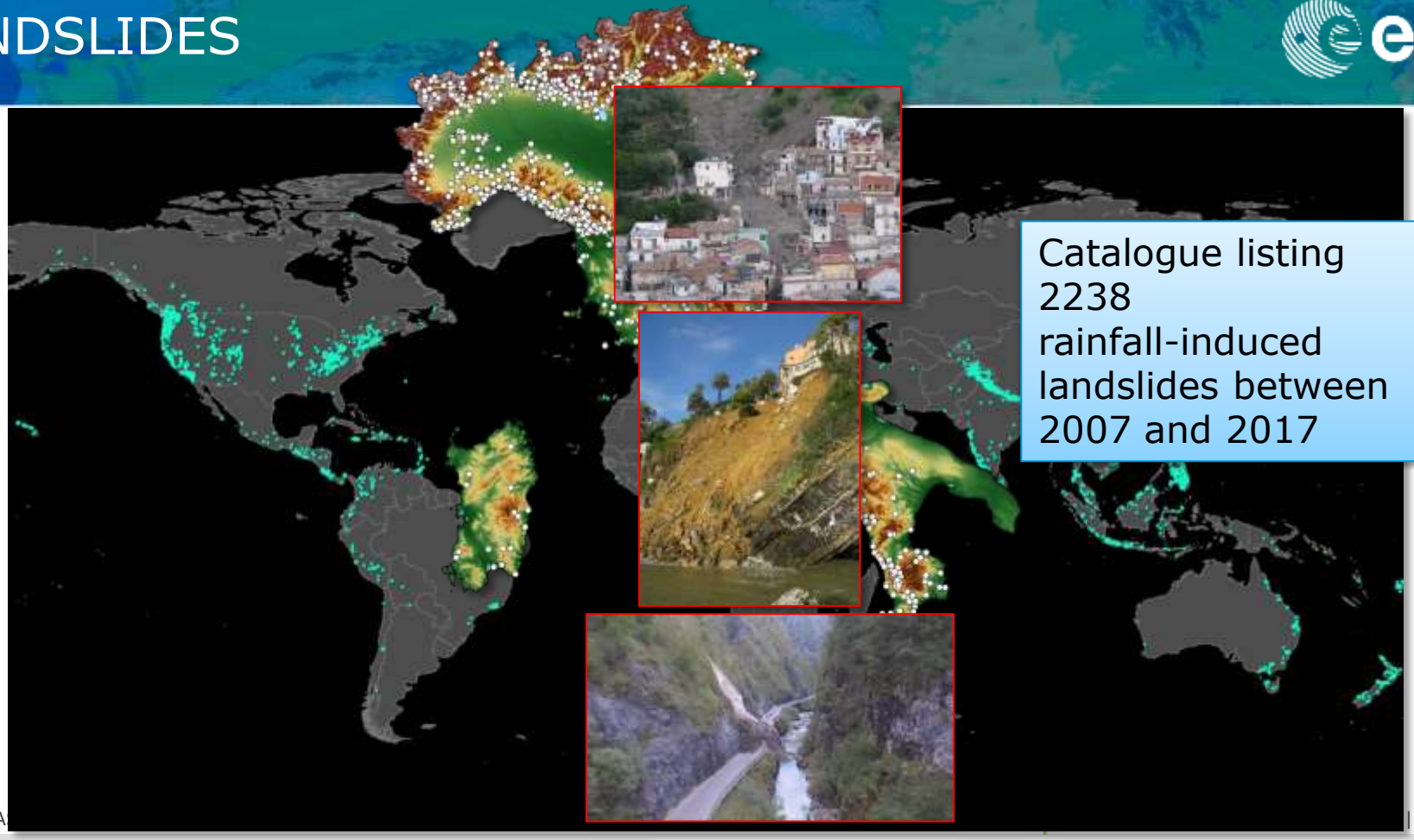
FLOOD PREDICTION WITH SATELLITE PRECIPITATION – TAKE HOME MESSAGE





Over the Mediterranean area the performance of satellite precipitation products (including SM2RAIN) are similar, and even better in Italy, than those obtained through gauge-based data

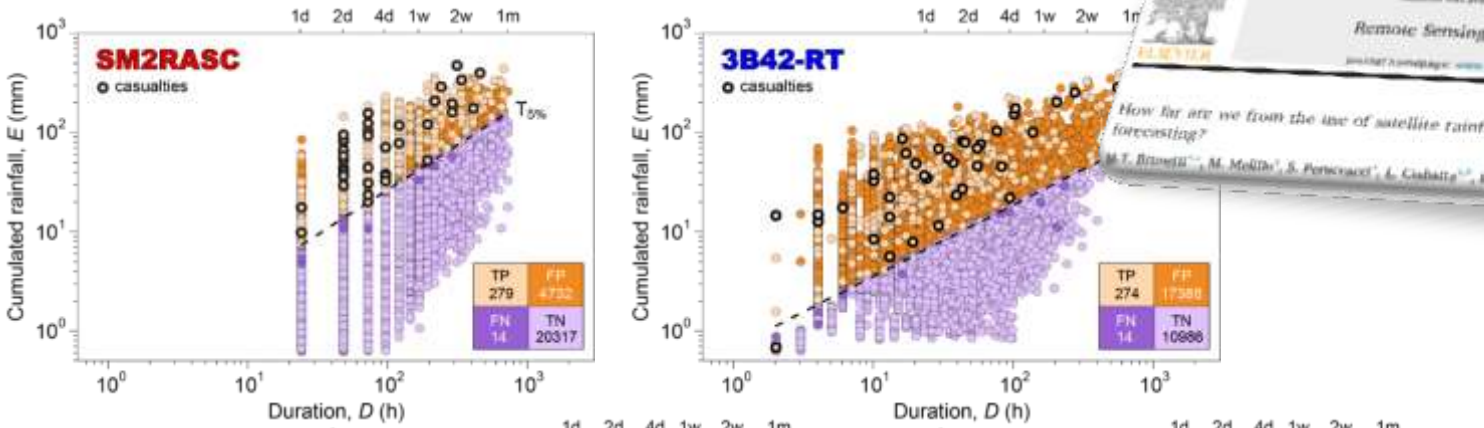
LANDSLIDES

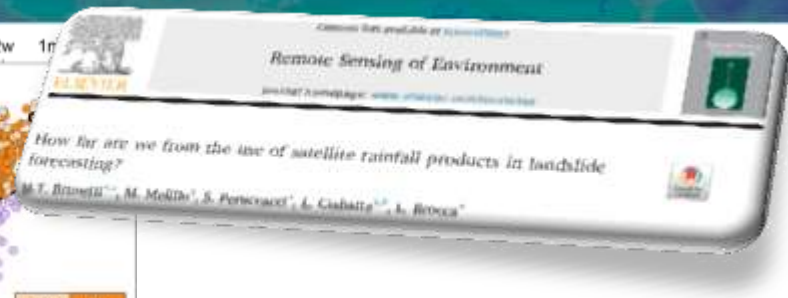


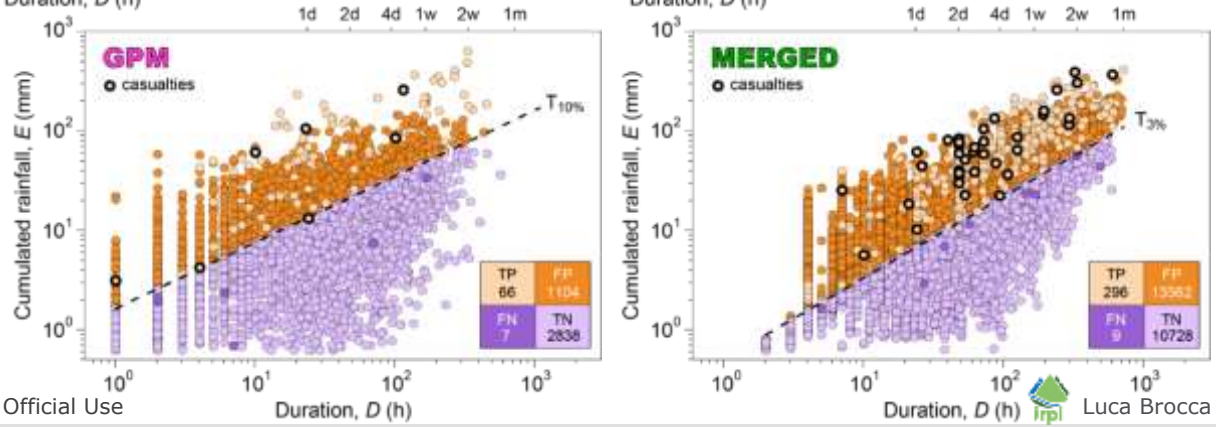
Catalogue listing 2238 rainfall-induced landslides between 2007 and 2017

Maria Teresa Brunetti, Luca Ciabatta et al.

REMOTE SENSING RAINFALL THRESHOLD

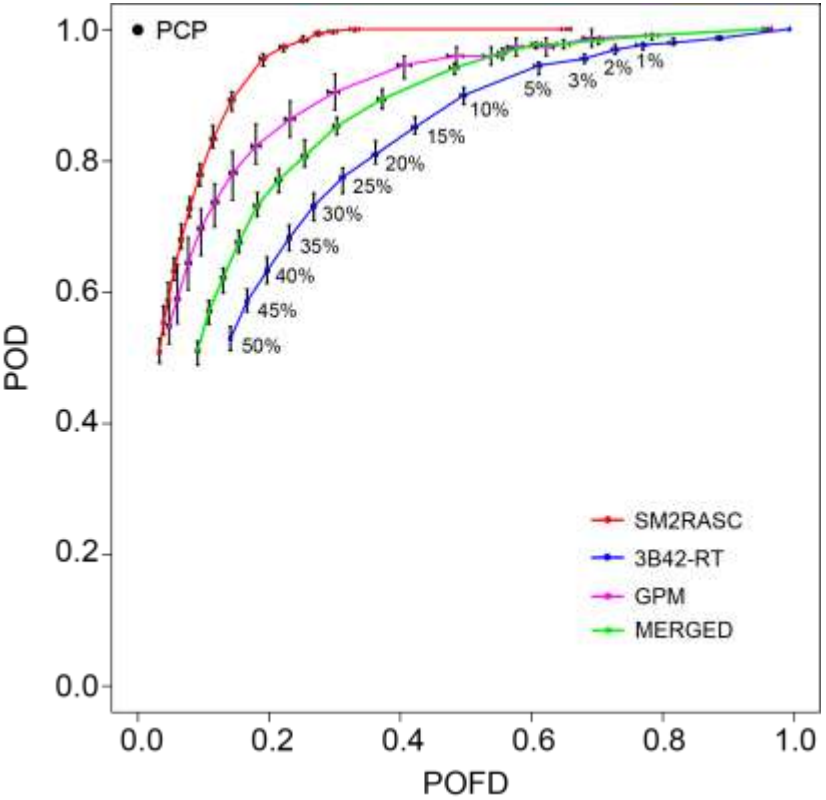




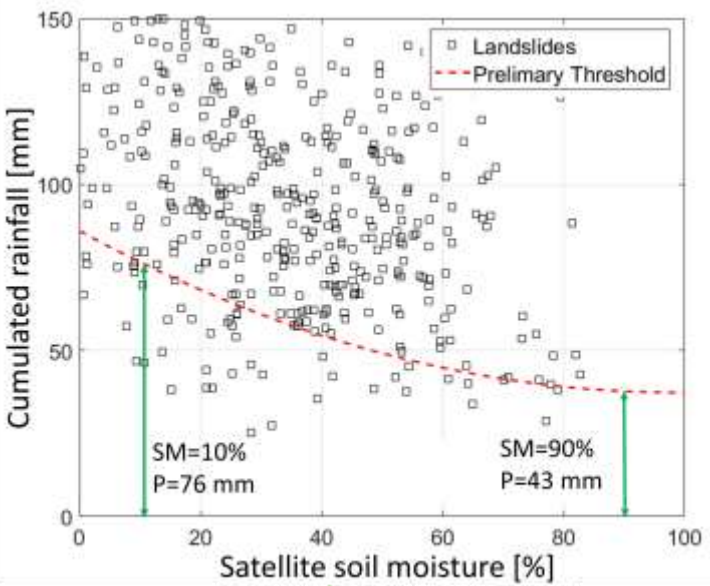


Maria Teresa Brunetti, Luca Ciabatta et al.

LANDSLIDES FORECASTING



Satellite precipitation products can be used for landslide forecasting, and should be integrated with satellite soil moisture observations



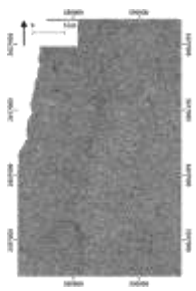
Maria Teresa Brunetti, Luca Ciabatta et al.

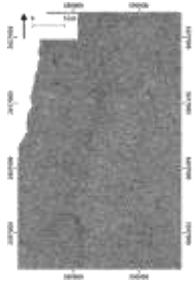
SYSTEMATIC LANDSLIDE EVENTS DETECTION & MAPPING

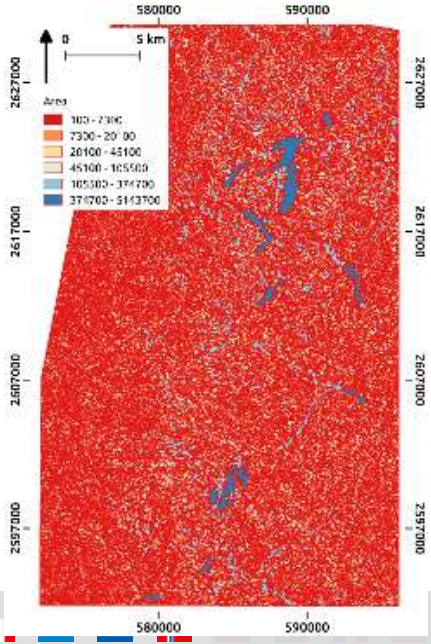
Time

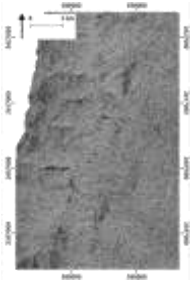
S1 S1 S1 E S1 S1 S1

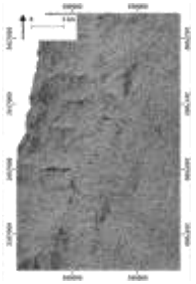
ΔS1 ΔS1 ΔS1 ΔS1 ΔS1







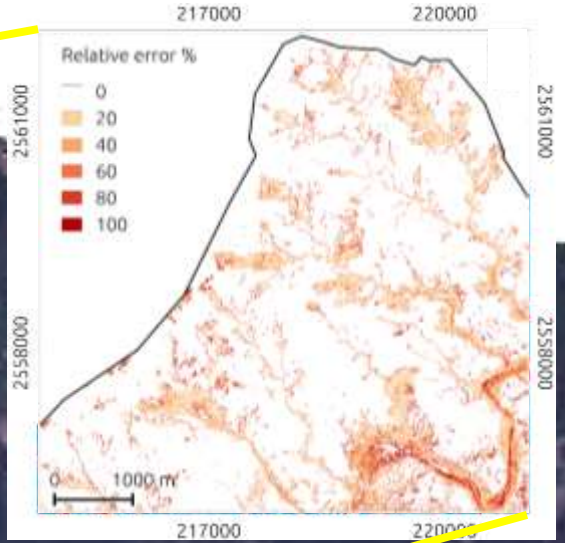




SAR

Alessandro Mondini et al.

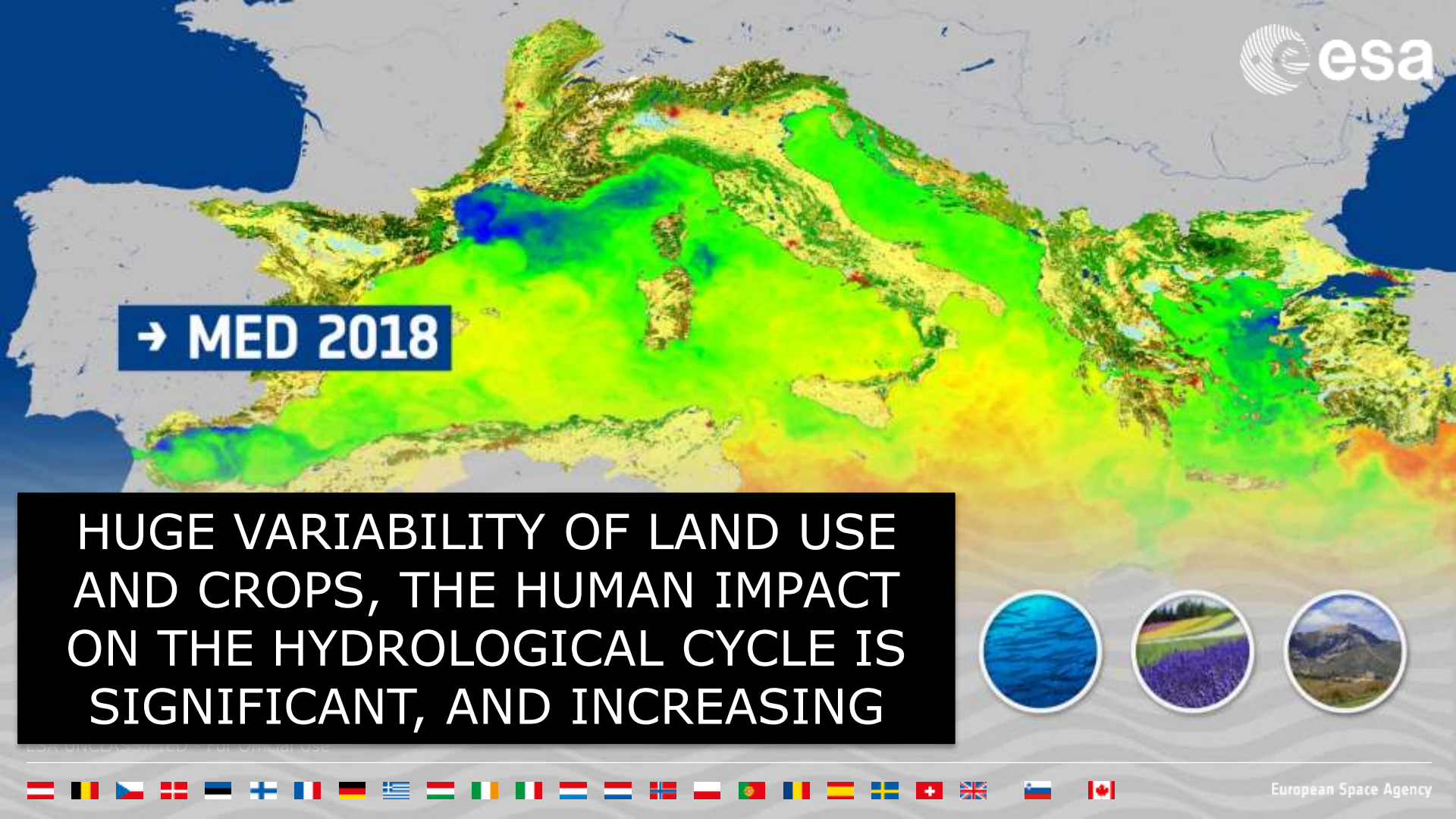
SYSTEMATIC LANDSLIDE EVENTS DETECTION & MAPPING



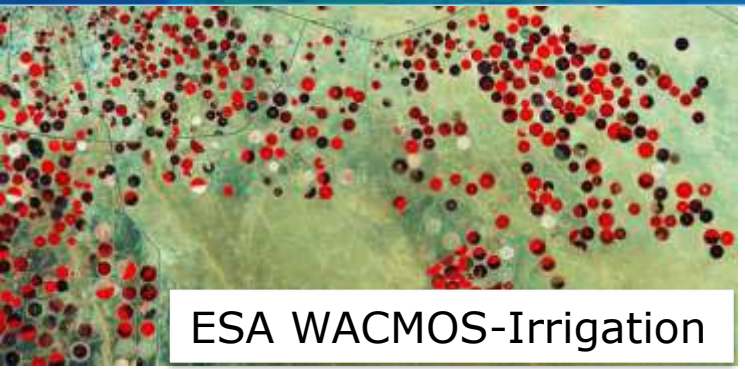
Landslide presence probability

& error estimation

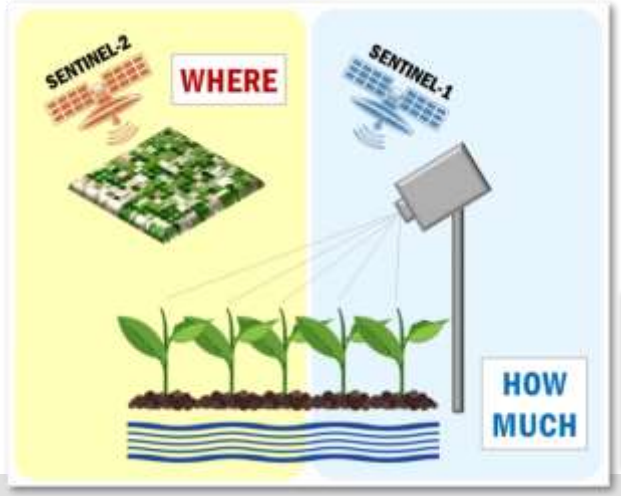
OPTICAL


esa
→ MED 2018
HUGE VARIABILITY OF LAND USE AND CROPS, THE HUMAN IMPACT ON THE HYDROLOGICAL CYCLE IS SIGNIFICANT, AND INCREASING

and IRRIGATION!



ESA WACMOS-Irrigation



Luca Brocca and the Hydrology Team
luca.brocca@irpi.cnr.it
http://hydrology.irpi.cnr.it/

IRRIGATION FROM SPACE

Sentinel1 - Italy

The high resolution of new satellite soil moisture products (e.g., Sentinel-1) may change the spatial and temporal scales at which we can observe irrigation from space

Paolo Filippucci, Angelica Tarpanelli et al.

PLAN FOR FUTURE EARTH OBSERVATION PROJECTS IN THE MEDITERRANEAN

- What is the benefit of the new high spatial resolution products (Sentinel-1, small satellites) for hydro-meteorological hazards **prediction** (**floods**, **landslides**, **drought**) ? What is the tradeoff between spatial and temporal resolution?
- What is the benefit of remote sensing for **long-term monitoring** of precipitation and soil moisture in time and space (climate changing)?
- Can we use high resolution soil moisture for quantifying **irrigation** over the Mediterranean basin? And for real-time crop monitoring addressing **water scarcity** and **food security**?
- What is the role of **in situ networks**? Should we improve the spatial coverage of soil moisture stations?
  → *Mediterranean Observatory*

WEB: http://hydrology.irpi.cnr.it/ - **EMAIL**: luca.brocca@irpi.cnr.it