PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Regione Umbria

Soil Moisture estimation from satellite data: Umbria Region early warning centre experience

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REGIONE UMBRIA

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Servizio Organizzazione e Sviluppo del Sistema di Protezione Civile
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Hsaf Soil Moisture Week 2019, 4-8 november 2019

Umbria Region (Central Italy) Civil Protection Centre - Foligno (PG)

Regione Umbria

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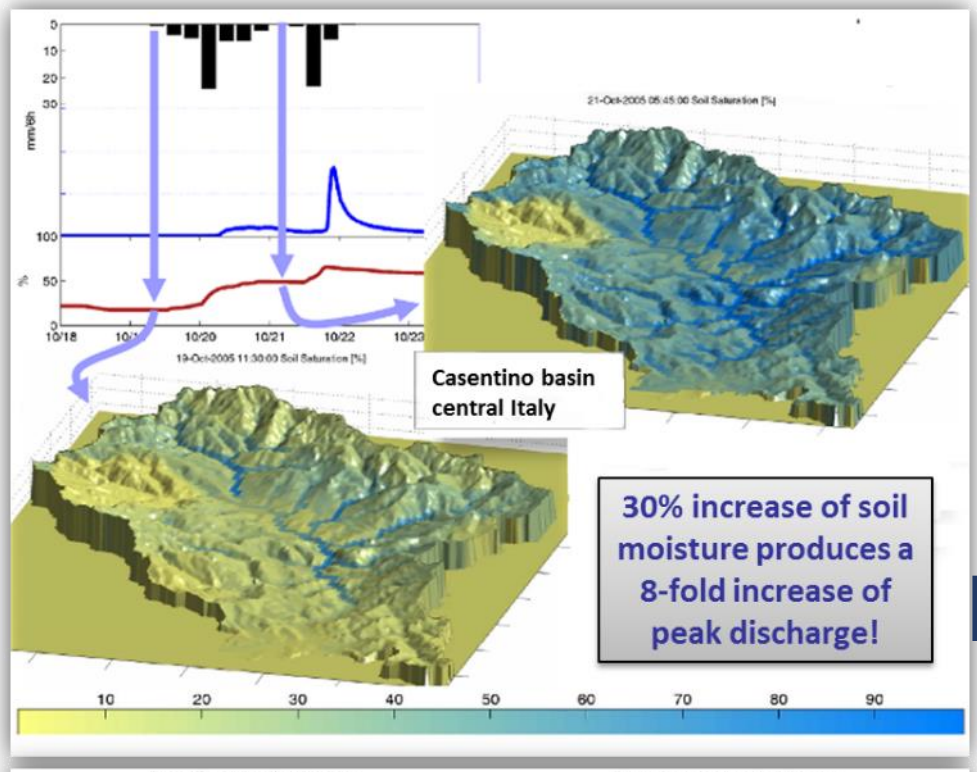
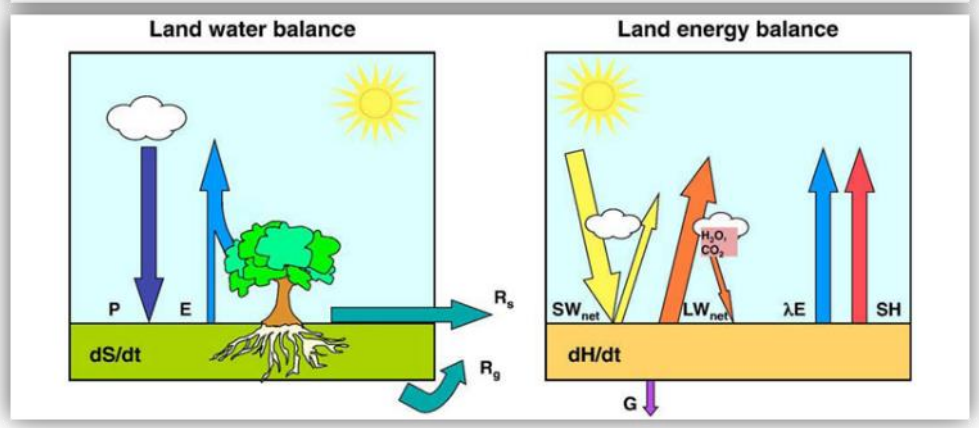
Soil Moisture for Civil Protection purposes

Regione Umbria

Why?





FLOODS

DROUGHTS

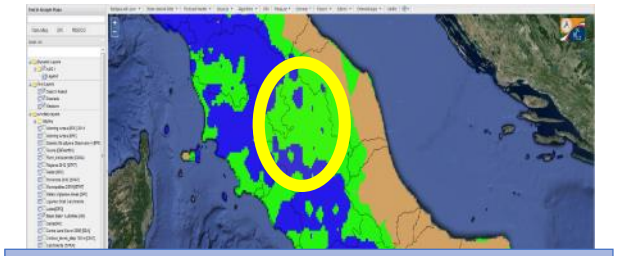
WEATHER PREDICTION

CLIMATE SYSTEM

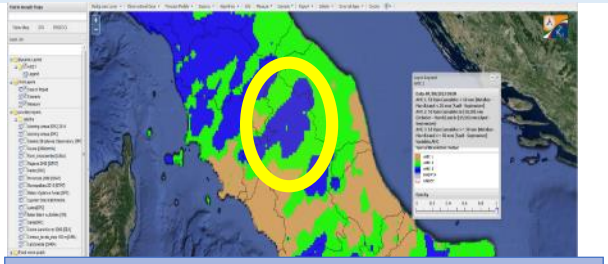
LANDSLIDES

CROP PRODUCTION

«Starting» value

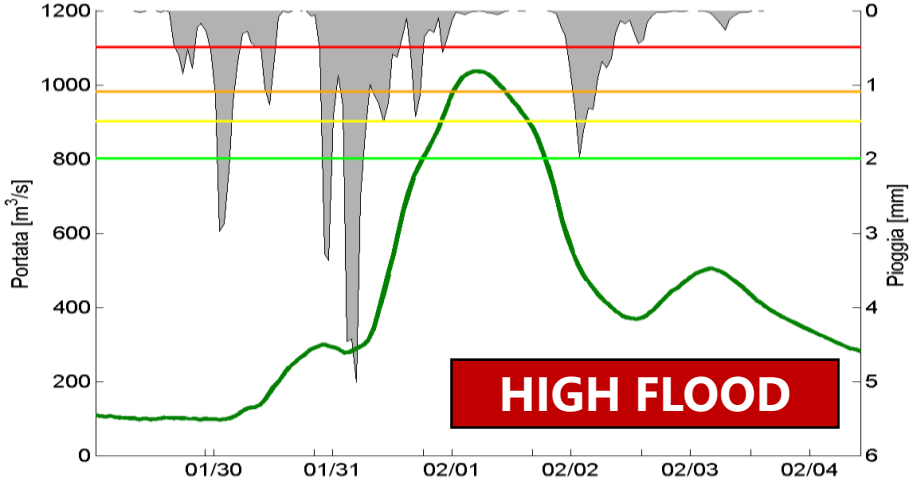


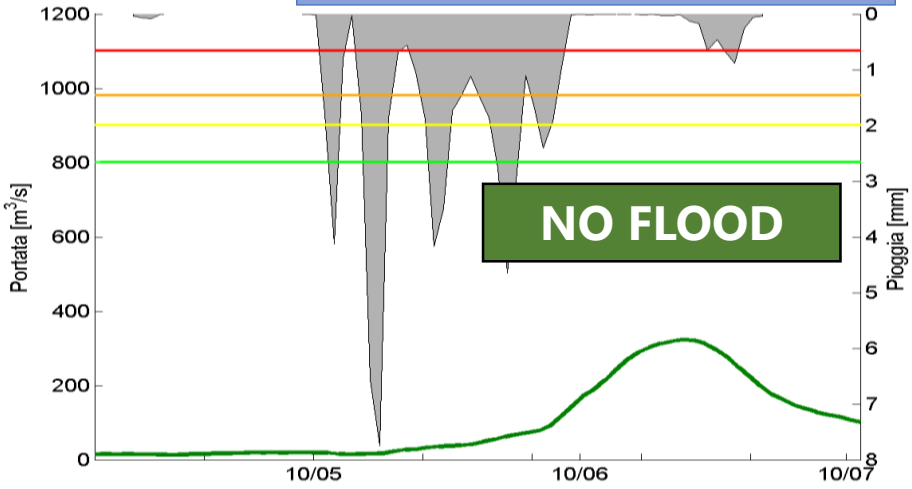
2 flood events with the same RAINFALL: **70mm/1.5 days**

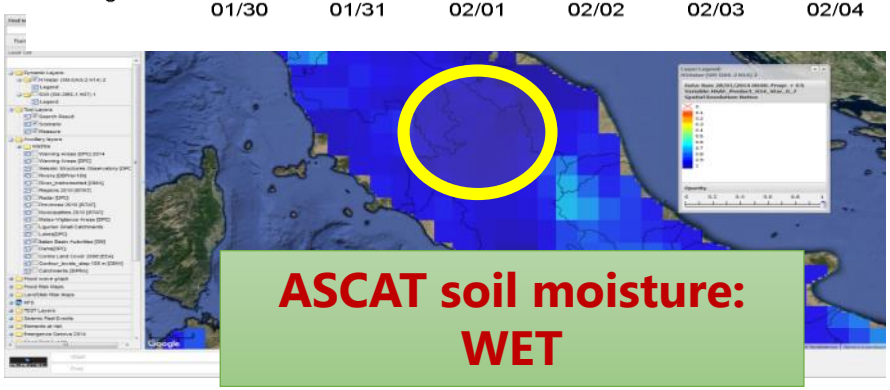


Antecedent Precipitation: MEDIUM

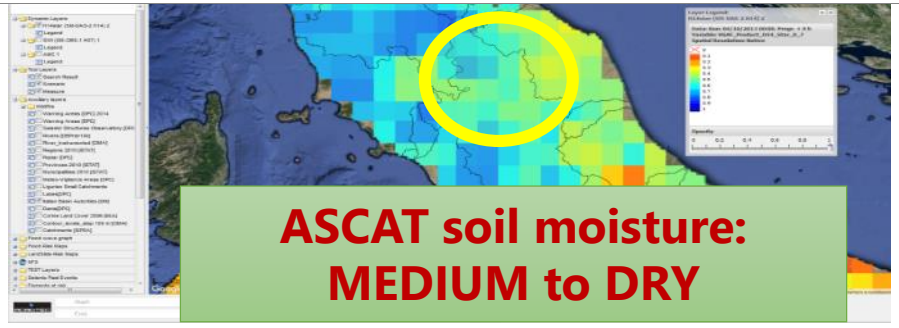
Antecedent Precipitation: MEDIUM to WET





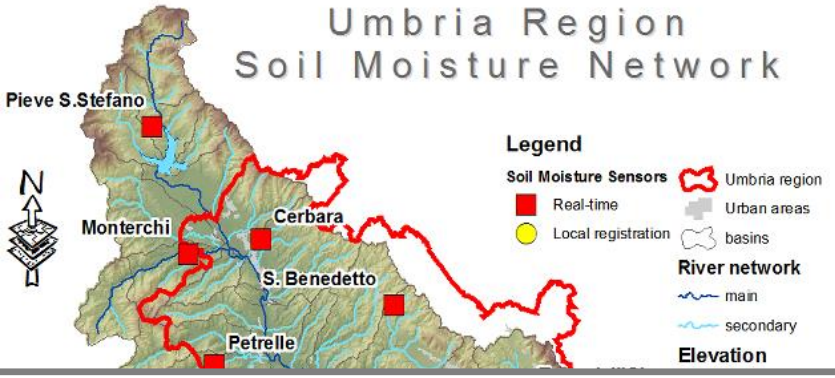


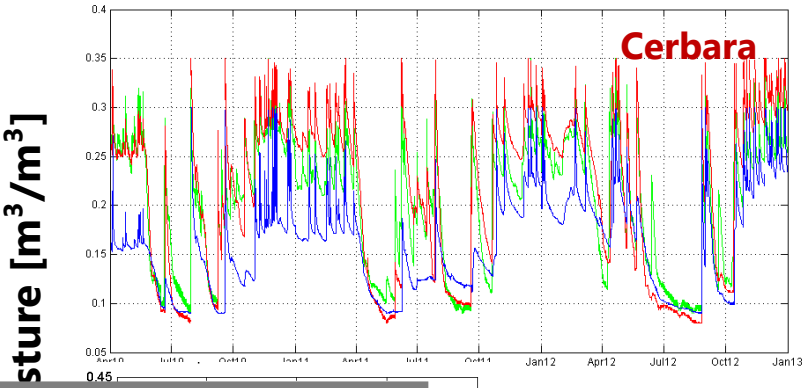
ASCAT soil moisture: WET

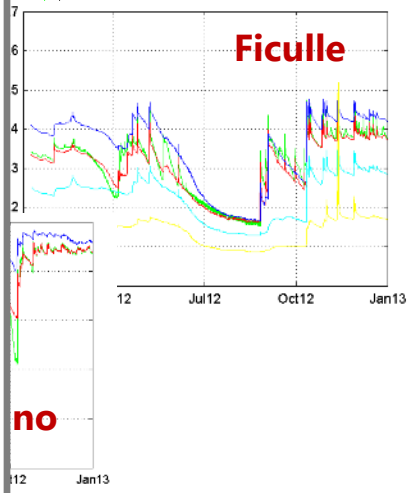


ASCAT soil moisture: MEDIUM to DRY

Umbria real time network







Welcome to the Data Hosting Facility of the

International Soil Moisture Network

Main Menu

- Home
- News
- Contributing Networks
- Satellites
- Terms and Conditions
- Download Instructions
- Participate in ISMN
- About Us
- Contact

Contributing Networks

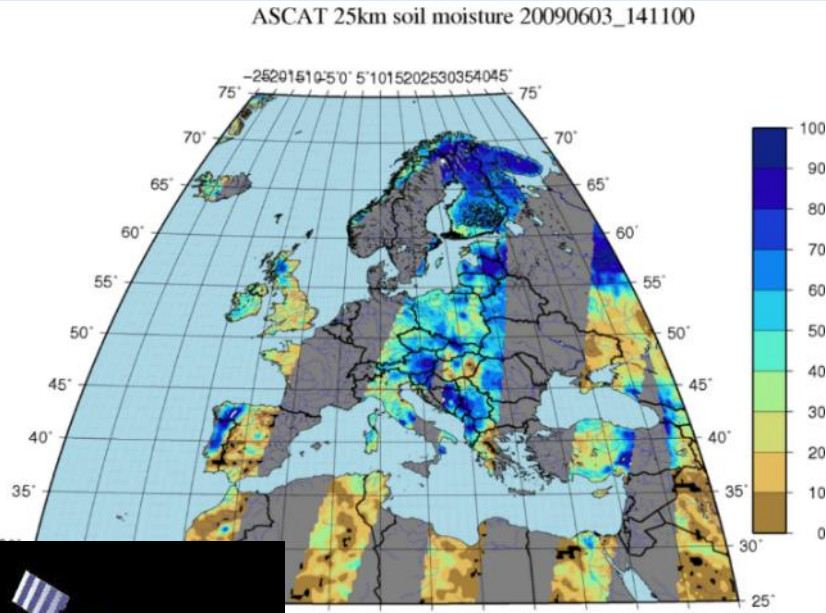
There is a growing number of in-situ soil moisture networks typically run by universities or national and regional organisations. The following networks have thankfully shared their soil moisture measurements with the *International Soil Moisture Network*.

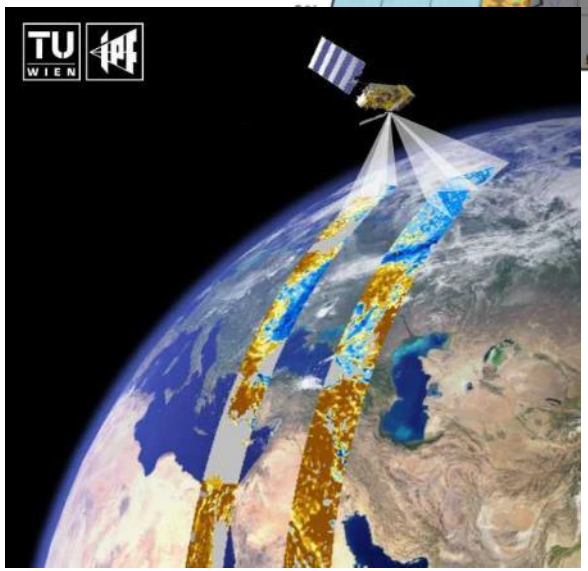
Name	Country	Stations	Website
AMMA	Benin, Niger, Mali	7	http://amma-international.org/
ARM	USA	25	http://www.arm.gov
CALABRIA	Italy	5	http://www.cfcalabria.it

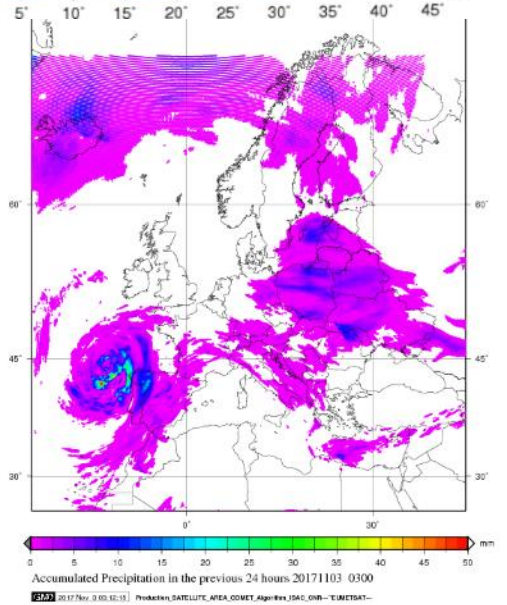
Internet | Modalità protetta: attivata

ASCAT Advanced SCATterometer

- Active
- C-band, 5.3 GHz, 5.67 cm
- VV-polarisation
- Spatial Resolution: 25/50 km
- Daily global coverage: 82 %
- Swath: 2 x 500 km
- Multi-incidence: 25 –62°
- 6 Antennas
- 3 (quasi) instantaneous independent measurements



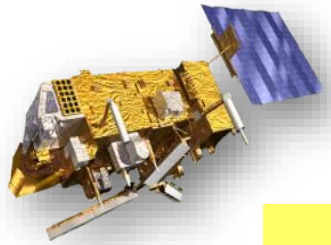




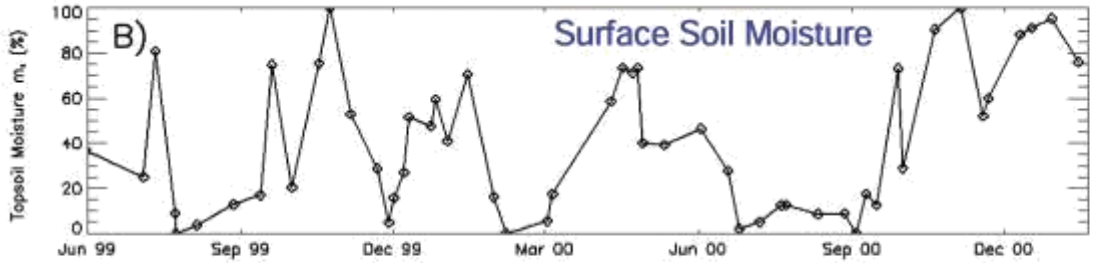
SWI Soil Water Index (filtro esponenziale)

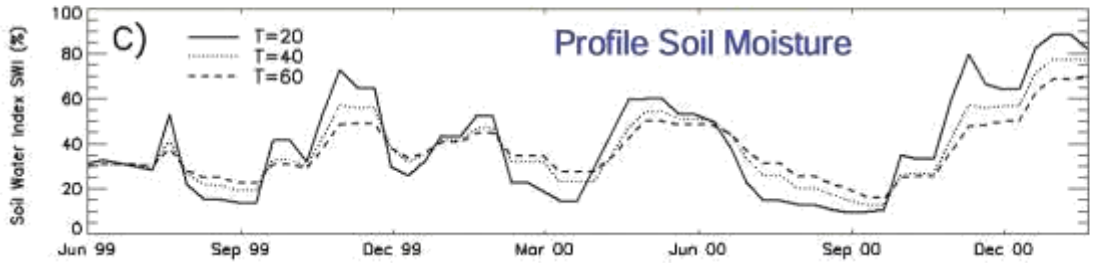
Soil water index (roots region) is obtained filtering the large scale product

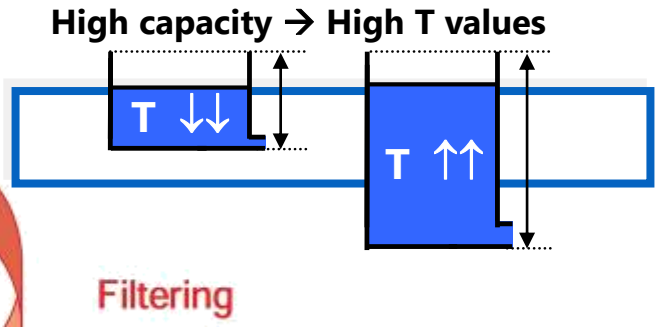
$$SWI(t) = \frac{\sum_i m_{s,t_i} \exp\left(-\frac{t - t_i}{T}\right)}{\sum_i \exp\left(-\frac{t - t_i}{T}\right)}$$



SM_ASCAT (HSAF)



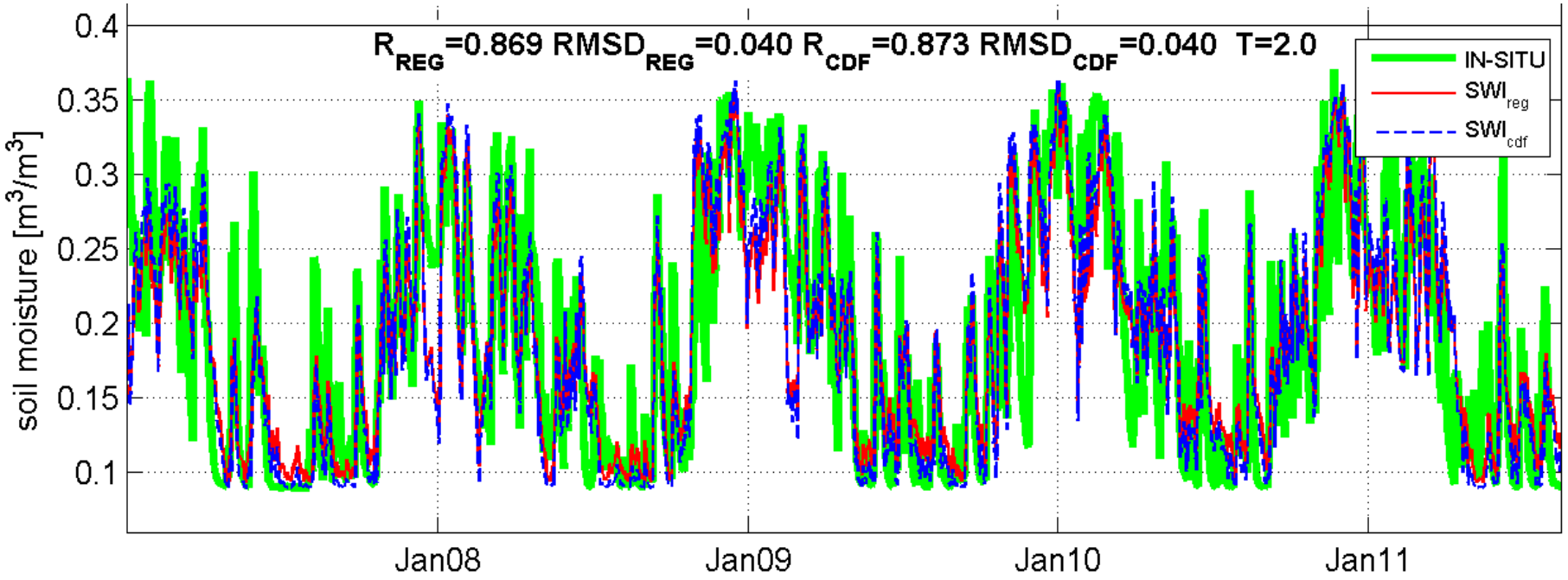




Wagner et al., 1999 (RSE)
Albergel et al., 2009 (HESS)

Validation

CENTRAL ITALY



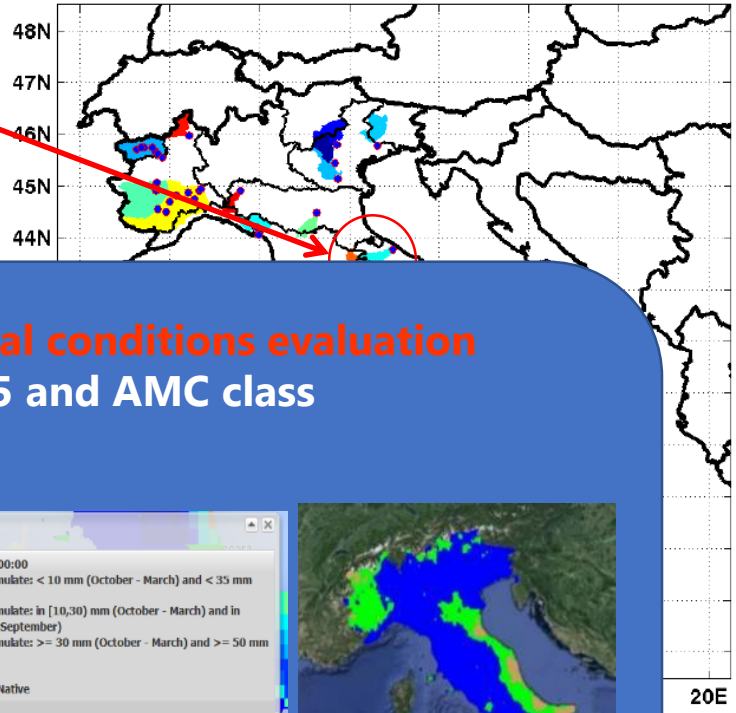
Tiber River catchment example

Regione Umbria

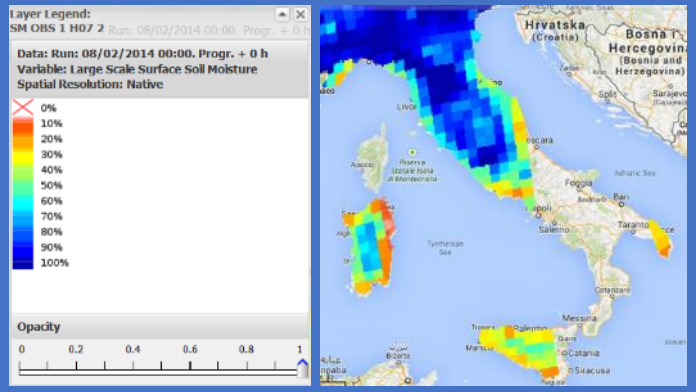
17 events : January 2010 – February 2013, Area=4815 Km^2

Input data:
Observed rainfall

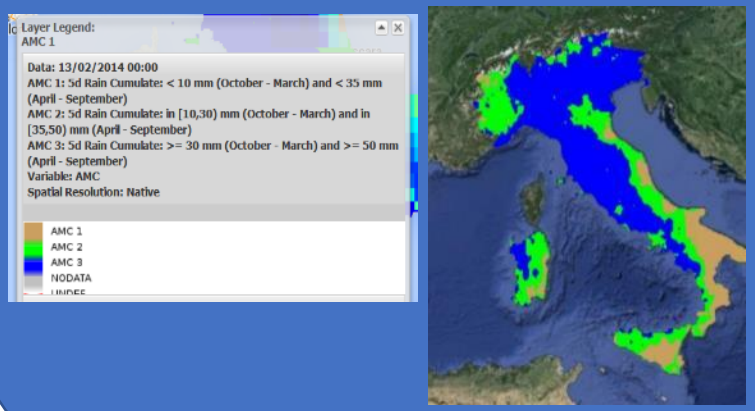
Benchmark
Discharge data at Montemolino section (Tiber river)



Initial conditions evaluation
SM_ASCAT product

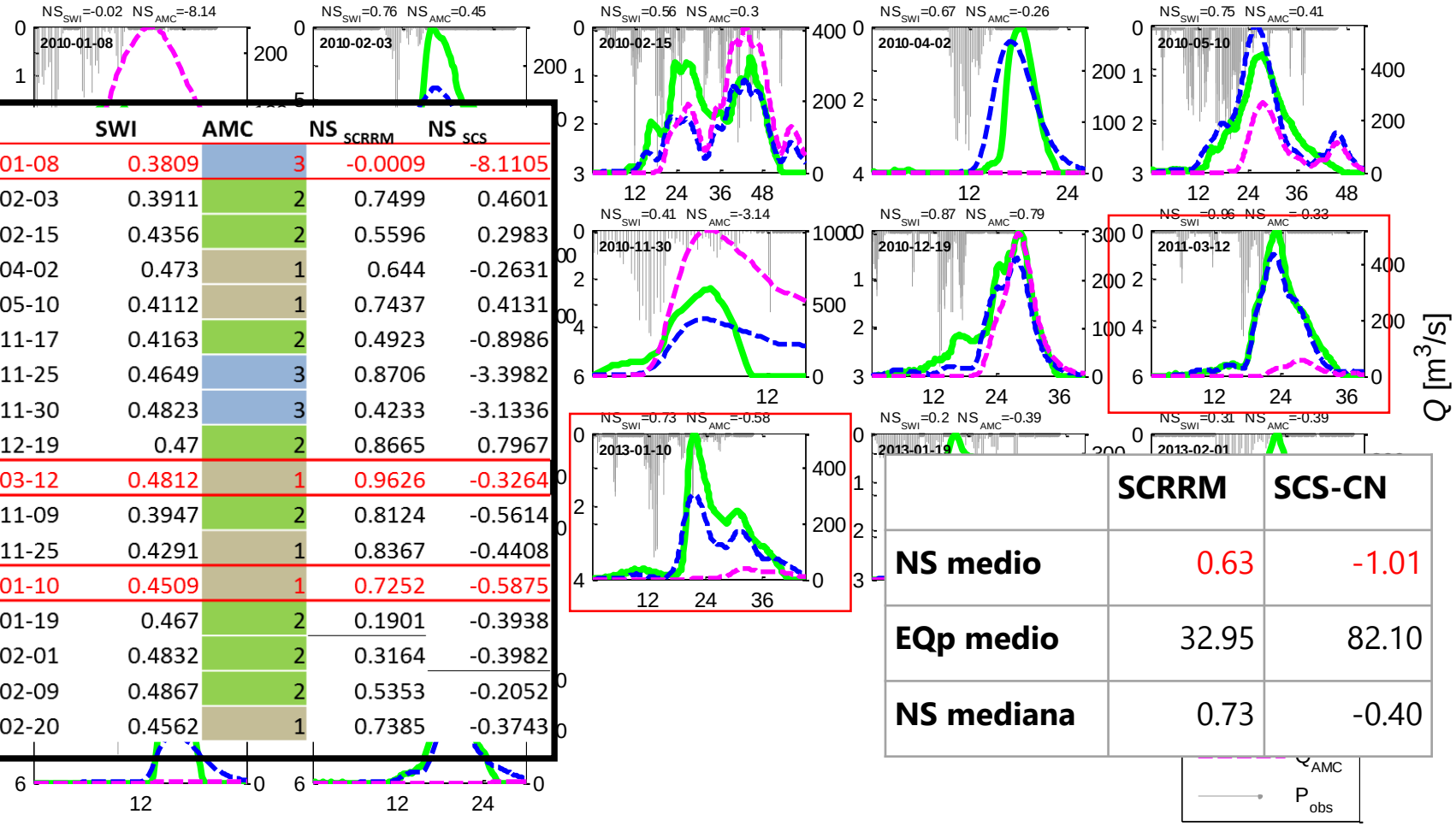


Initial conditions evaluation
API5 and AMC class



Tiber River catchment example

Regione Umbria



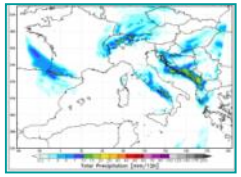
	SWI	AMC	NS SCRRM	NS SCS
2010-01-08	0.3809	3	-0.0009	-8.1105
2010-02-03	0.3911	2	0.7499	0.4601
2010-02-15	0.4356	2	0.5596	0.2983
2010-04-02	0.473	1	0.644	-0.2631
2010-05-10	0.4112	1	0.7437	0.4131
2010-11-17	0.4163	2	0.4923	-0.8986
2010-11-25	0.4649	3	0.8706	-3.3982
2010-11-30	0.4823	3	0.4233	-3.1336
2010-12-19	0.47	2	0.8665	0.7967
2011-03-12	0.4812	1	0.9626	-0.3264
2012-11-09	0.3947	2	0.8124	-0.5614
2012-11-25	0.4291	1	0.8367	-0.4408
2013-01-10	0.4509	1	0.7252	-0.5875
2013-01-19	0.467	2	0.1901	-0.3938
2013-02-01	0.4832	2	0.3164	-0.3982
2013-02-09	0.4867	2	0.5353	-0.2052
2013-02-20	0.4562	1	0.7385	-0.3743

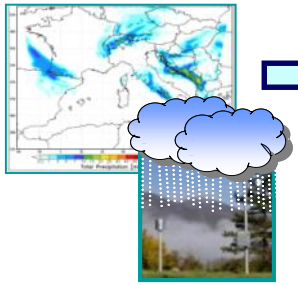
	SCRRM	SCS-CN
NS medio	0.63	-1.01
EQp medio	32.95	82.10
NS mediana	0.73	-0.40

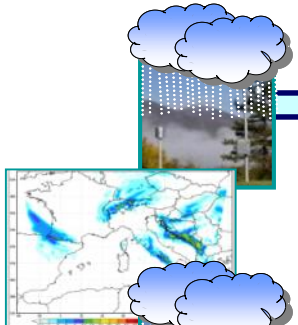
Umbria Region real time flood forecasting tools

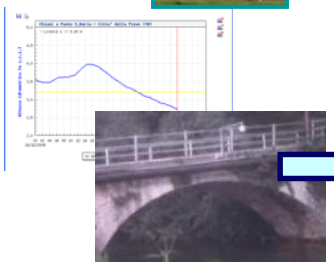
Regione Umbria

Input



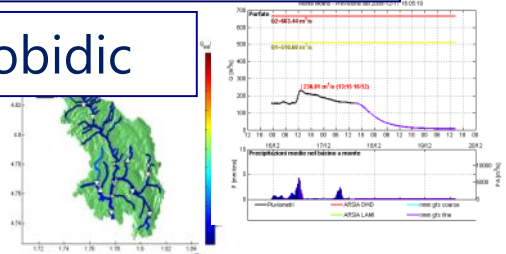




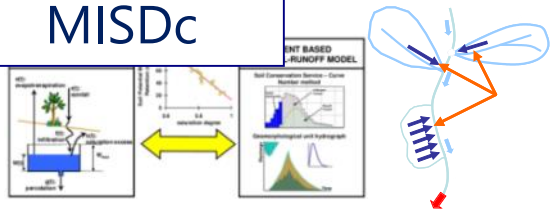


Hydrologic models

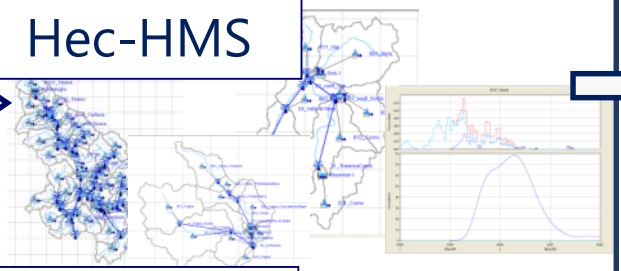
Mobidic



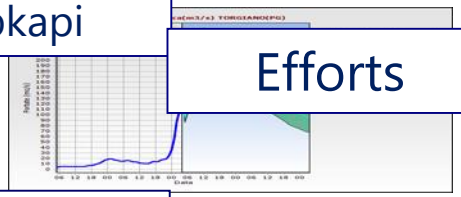
MISDc



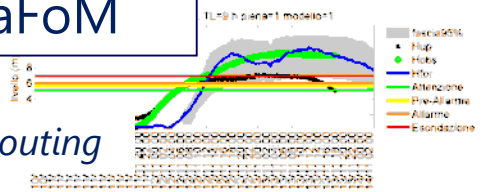
Hec-HMS



Topkapi

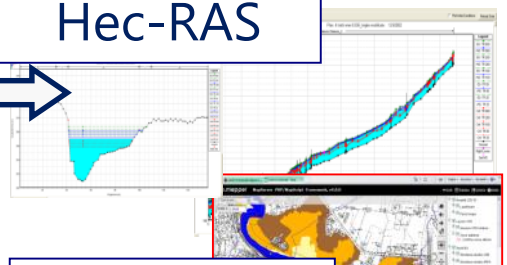


StaFoM



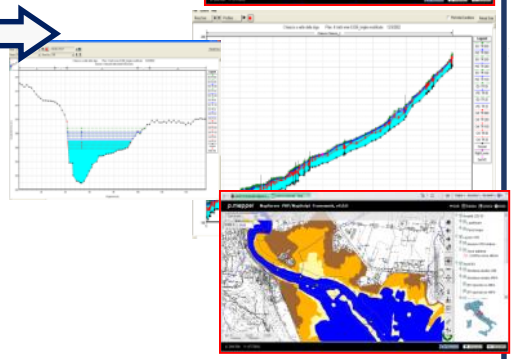
Hydraulic models

Hec-RAS

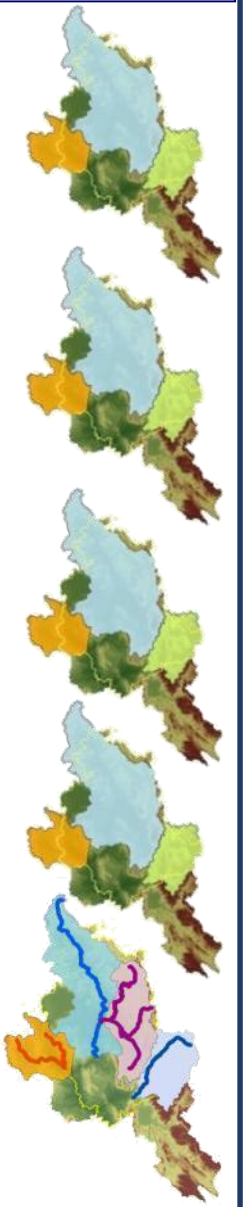


Efforts

Hec-RAS



Basins



Umbria Region real time flood forecasting tools: website

Regione Umbria

http://www.cfumbria.it/

Regione Umbria

Centro Funzionale

CENTRO FUNZIONALE DECENTRATO
DI MONITORAGGIO METEO-IDROLOGICO

Area Riservata esci »
utente Nicola Berni

MISDc_QPF

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- Privacy
- Bollettini meteo
- Previsioni meteo
- Vigilanza meteo
- Avvisi Meteo
- Criticità
- Boll. criticità
- Avviso criticità
- Adozione Avviso
- Monitoraggio evento
- Monitoraggio al suolo
- Pluviometria
- Idrometria
- Termometria

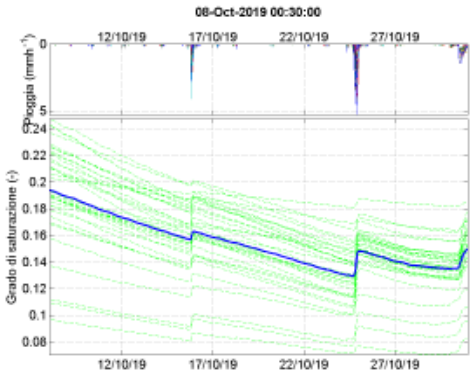
MISDc_QPF è un sistema modellistico basato sul modello MISDc (sviluppato dal CNR-IRPI di Perugia – Reparto di Idrologia) costituito da un modello di bilancio idrologico del suolo per la simulazione in continuo dell'evoluzione temporale del contenuto d'acqua accoppiato con un modello idrologico semidistribuito (MISD) per la simulazione afflussi-deflussi a scala di evento che, oltre a considerare i dati di precipitazione e temperatura registrati dalla rete di monitoraggio idrometeorologico regionale operante in tempo reale, utilizza le QPF (Quantitative Precipitation Forcast – Previsioni Quantitative di Precipitazione) provenienti dai modelli meteorologici ECMWF, COSMO-5M.

- Descrizione Modello
- Descrizione Interfaccia

Prodotti

Bacino: Tevere ▼ Modello meteo di riferimento: ECMWF ▼ Visualizza

-----**Run del** 28/10/2019 **ore** 10:29-----



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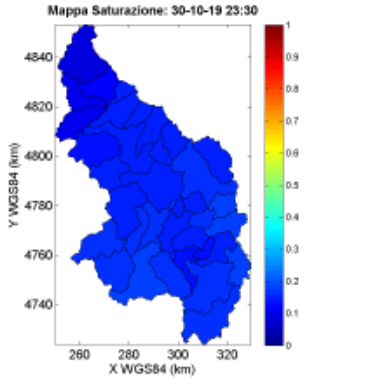
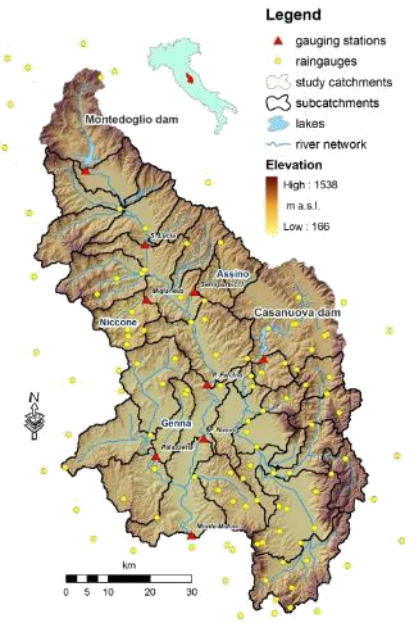
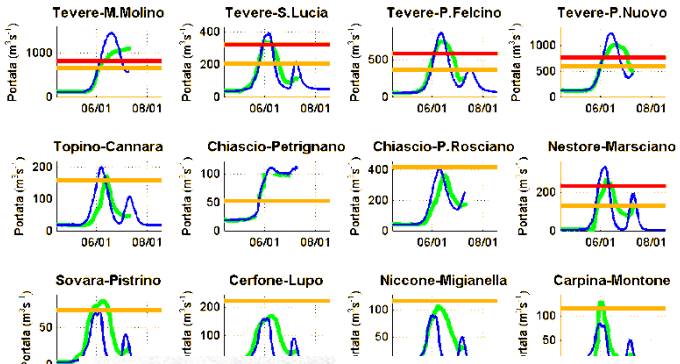


Umbria Region real time flood forecasting tools: website

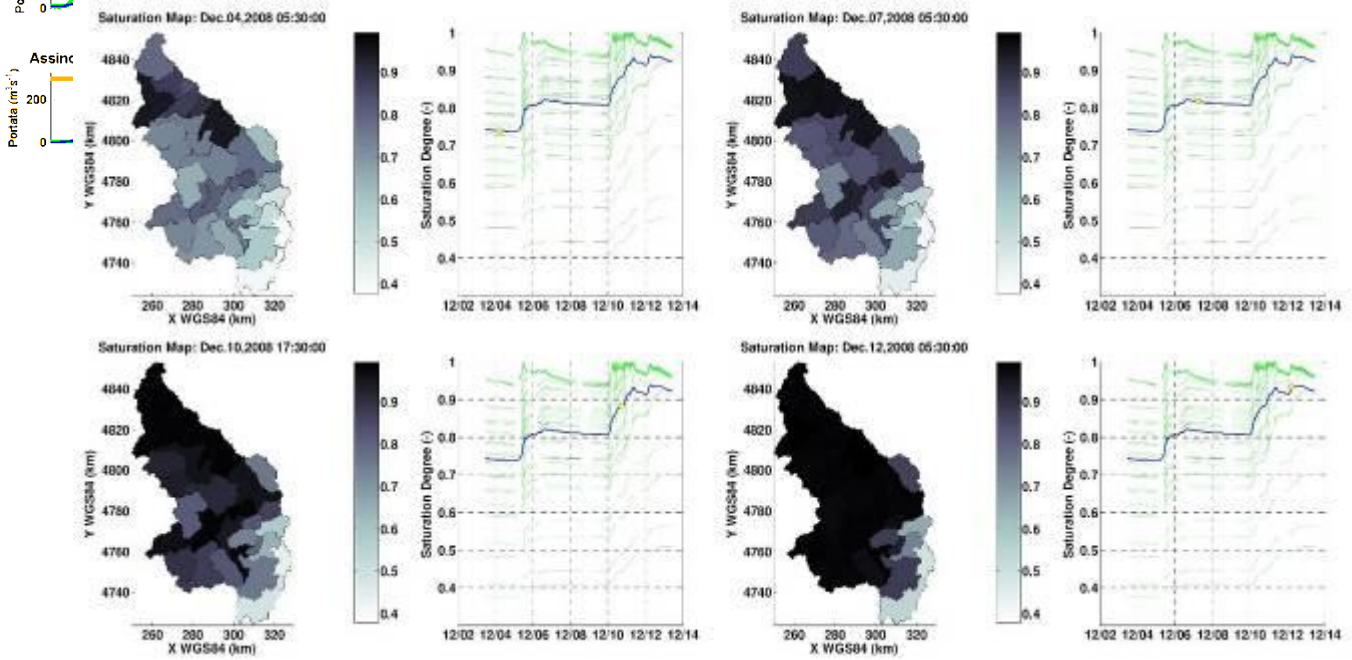
Regione Umbria



OPERATIONAL FLOOD FORECASTING SYSTEMS FOR UMBRIA REGION CIVIL PROTECTION CENTRE



http://www.cfumbria.it/

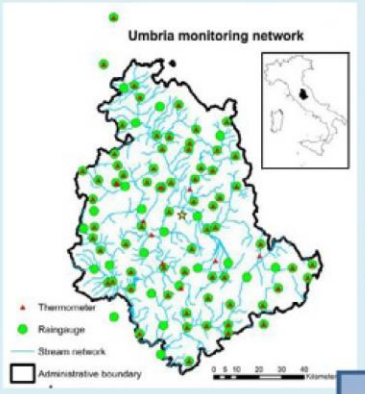


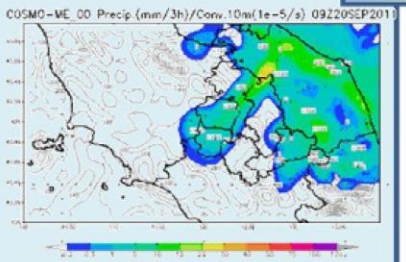
Umbria Region real time landslide forecasting tools

Regione Umbria

Rainfall and temperature

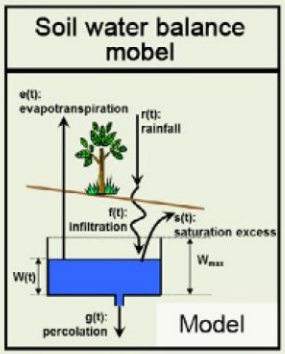
From real-time observations and numerical weather prediction modelling

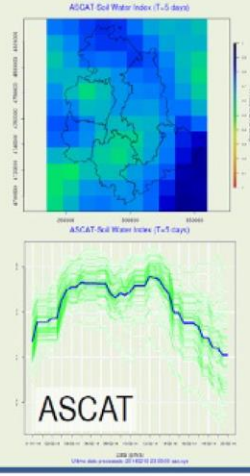




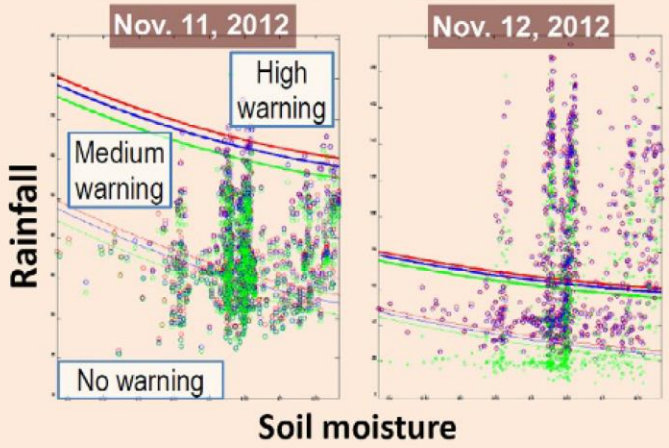
Soil moisture

From real-time in situ observations, soil water balance modelling, and satellite data (ASCAT)

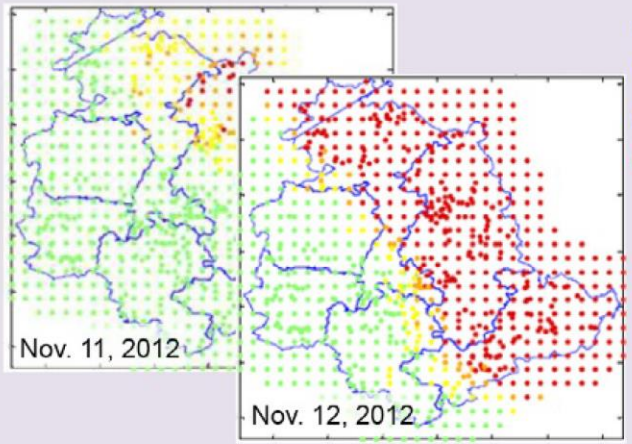




Rainfall-soil moisture thresholds



Landslide hazard maps

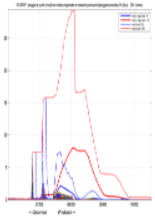


Umbria Region real time landslide forecasting tools

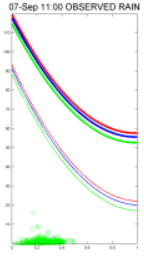
Regione Umbria

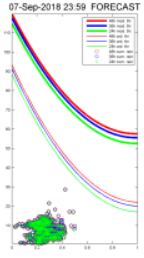
Selezionare un modello meteo:

(•) ECMWF ( ) COSMO_5M

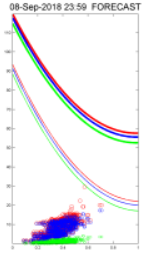


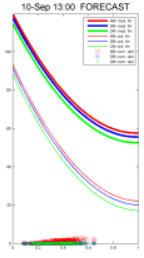
----- **Run del** 07/09/2018 **ore** 12:01 -----



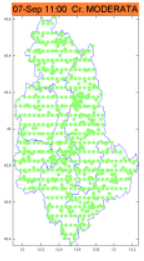


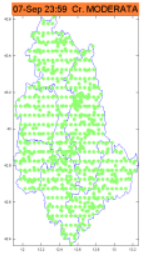
----- **Run del** 07/09/2018 **ore** 12:01 -----



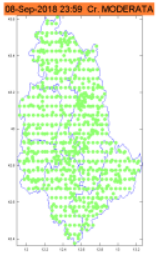


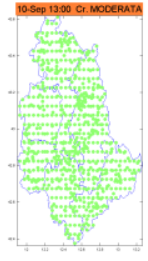
----- **Run del** 07/09/2018 **ore** 12:01 -----





----- **Run del** 07/09/2018 **ore** 12:01 -----





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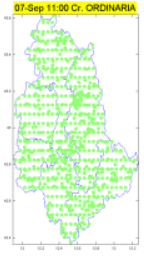

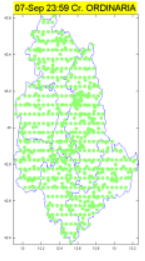

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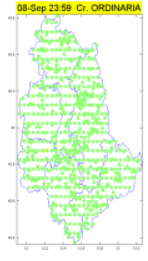
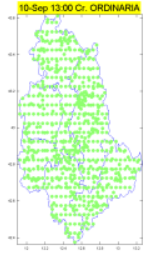
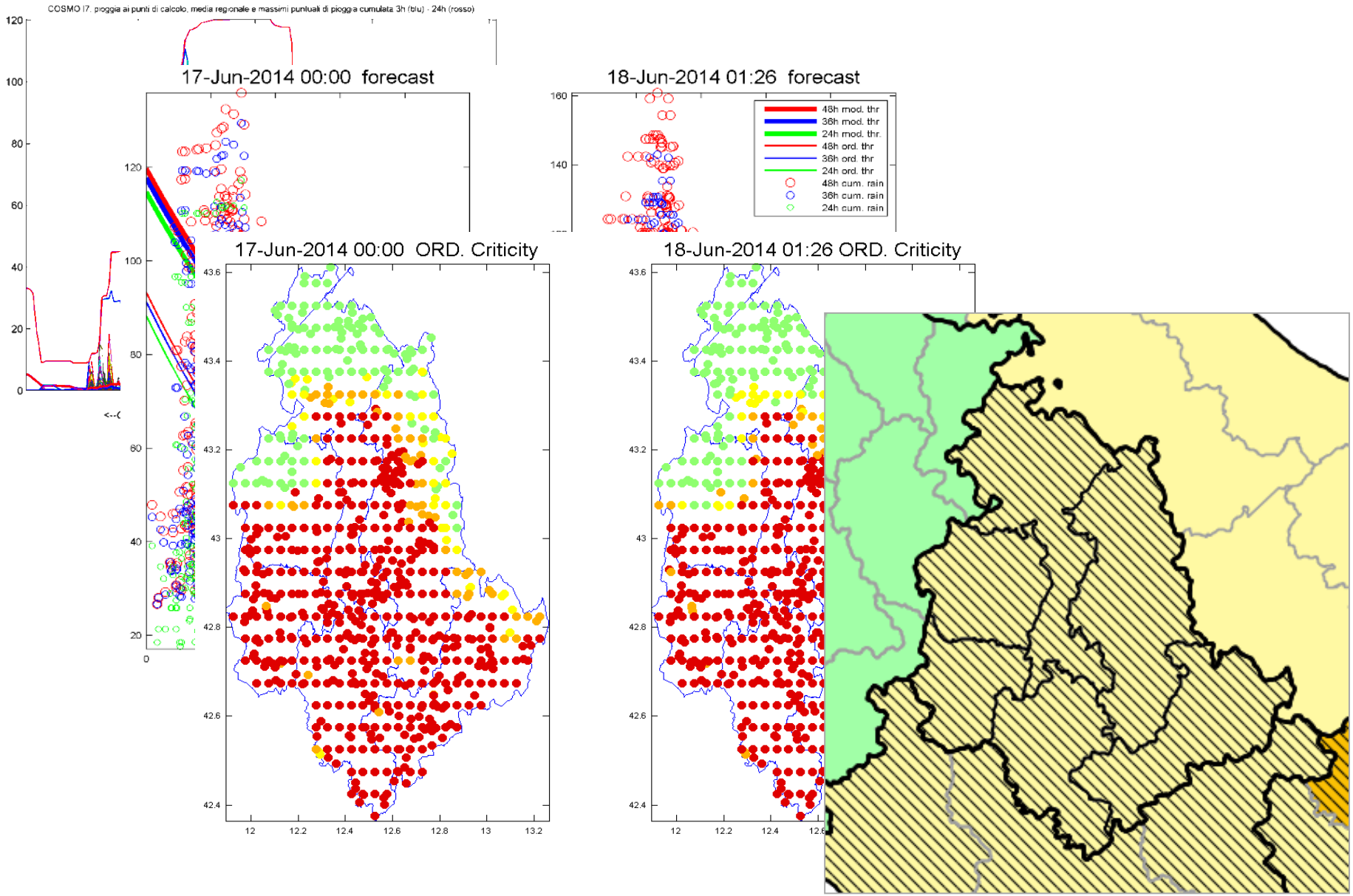




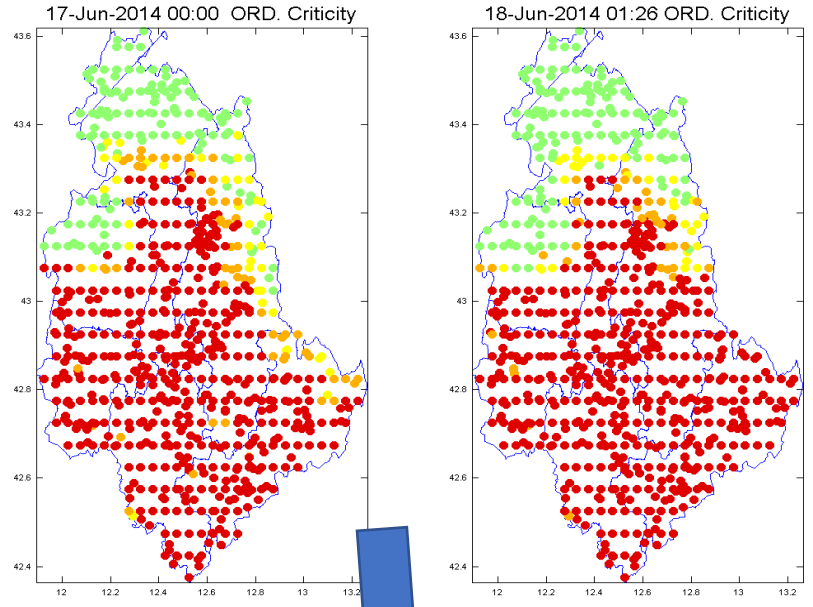
Umbria Region real time landslide forecasting tools

Regione Umbria

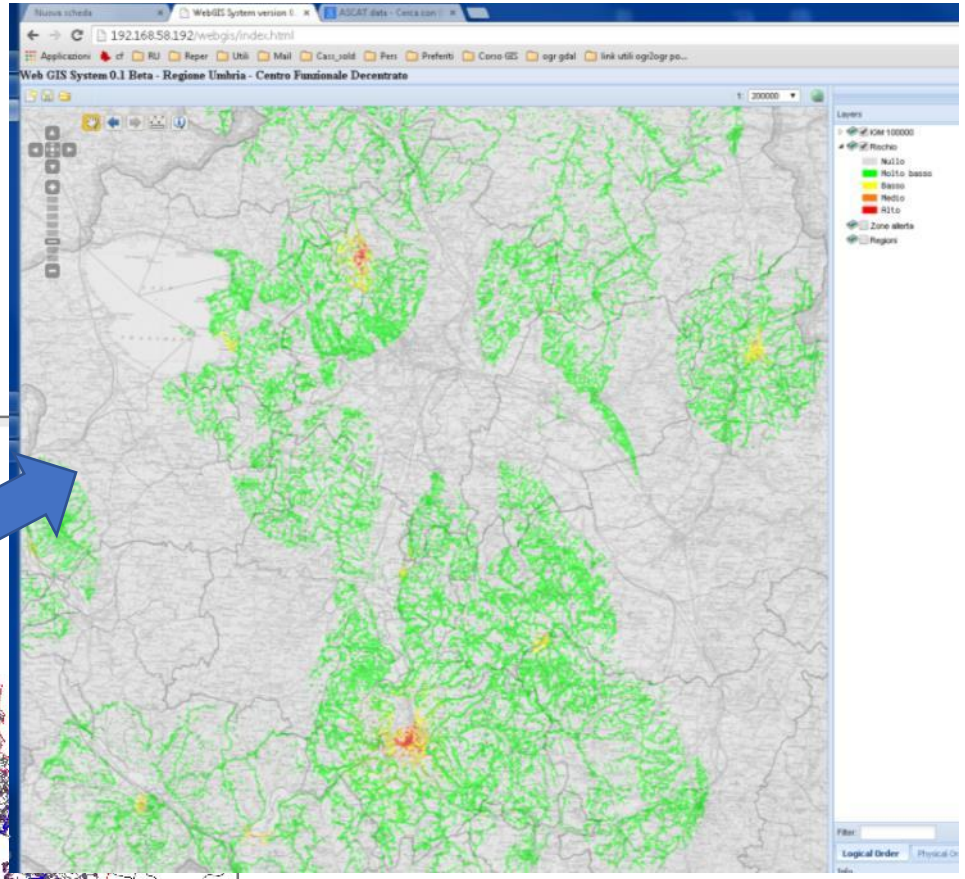


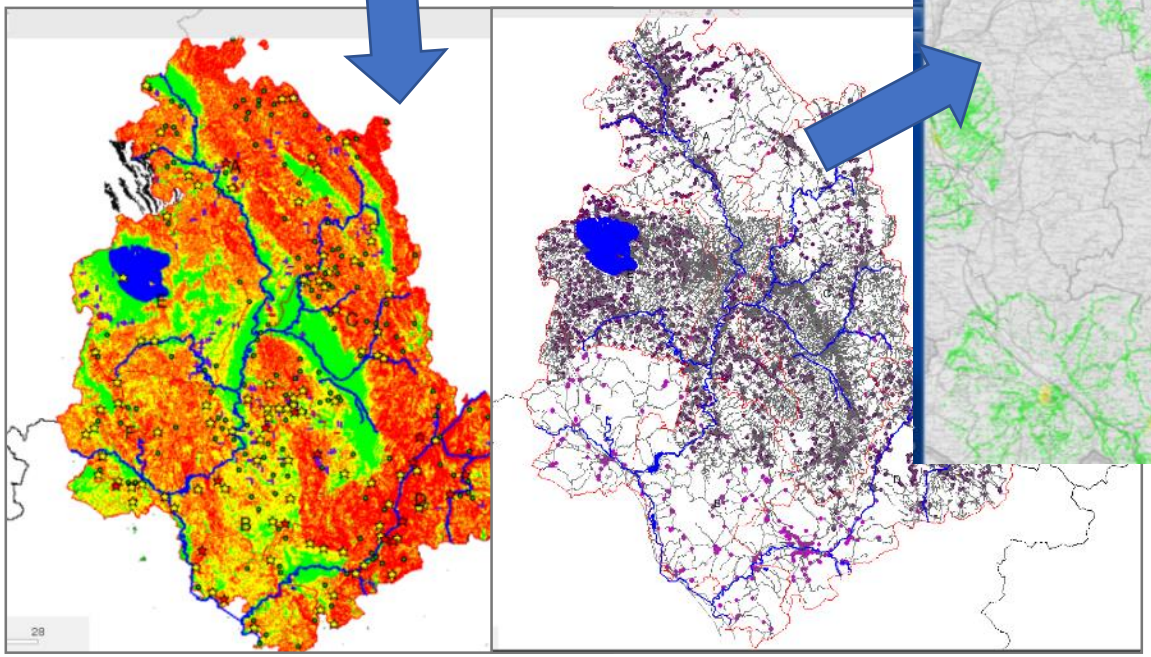
Umbria Region real time landslide forecasting tools: risk scenario

Regione Umbria



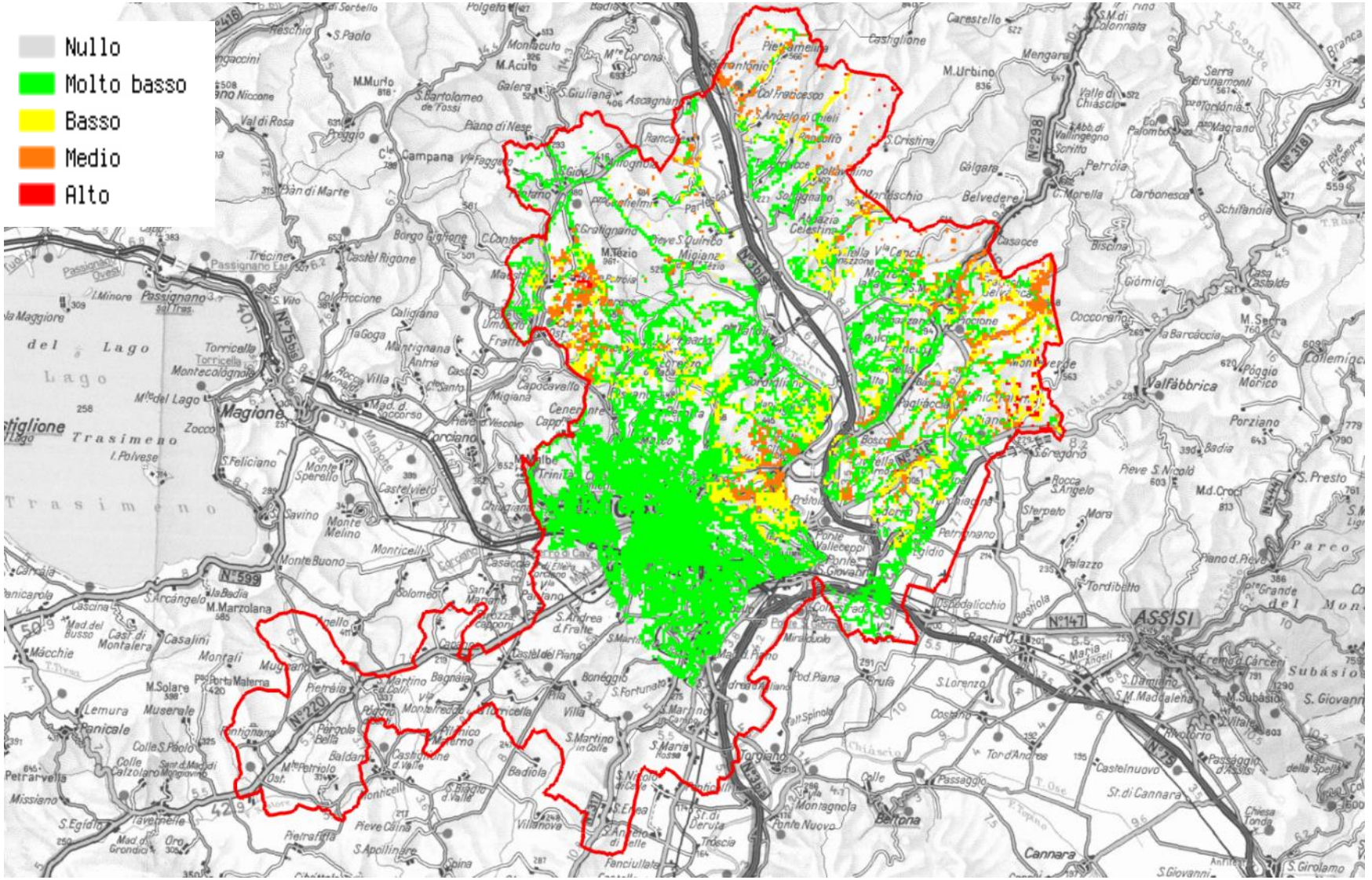
Nearly real time risk scenario production





Umbria Region real time landslide forecasting tools: risk scenario

Regione Umbria



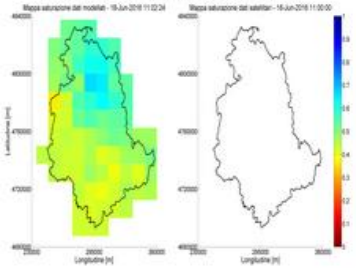
Perugia municipality scale scenario example

Umbria Region soil moisture visualization: website

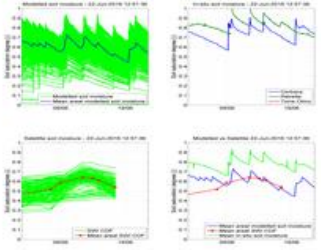
Regione Umbria

Descrizione dell'interfaccia

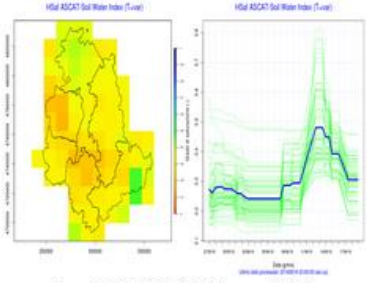
----- Run del 22/06/2016 ore 14:44 -----



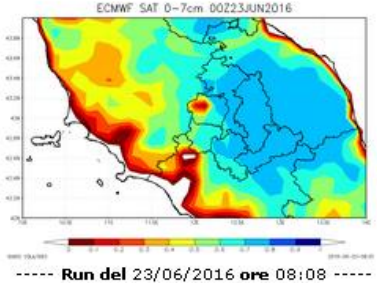
----- Run del 22/06/2016 ore 14:44 -----



----- Run del 23/06/2016 ore 08:00 -----



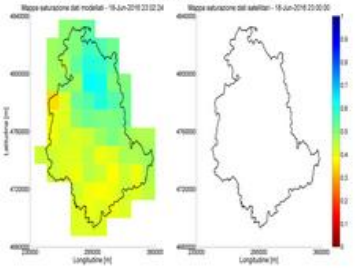
----- Run del 23/06/2016 ore 08:33 -----



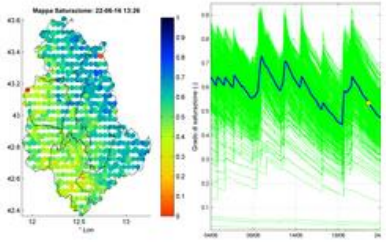
----- Run del 23/06/2016 ore 08:08 -----

Interface description

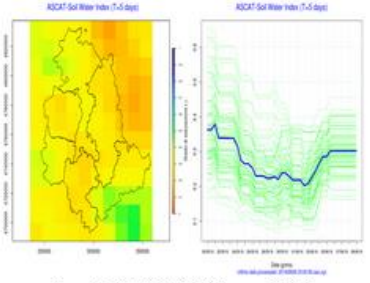
----- Run del 22/06/2016 ore 14:44 -----



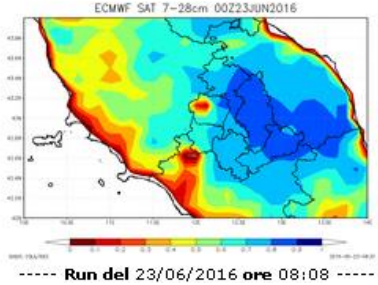
----- Run del 22/06/2016 ore 14:44 -----



----- Run del 23/06/2016 ore 06:09 -----



----- Run del 23/06/2016 ore 08:33 -----



----- Run del 23/06/2016 ore 08:08 -----

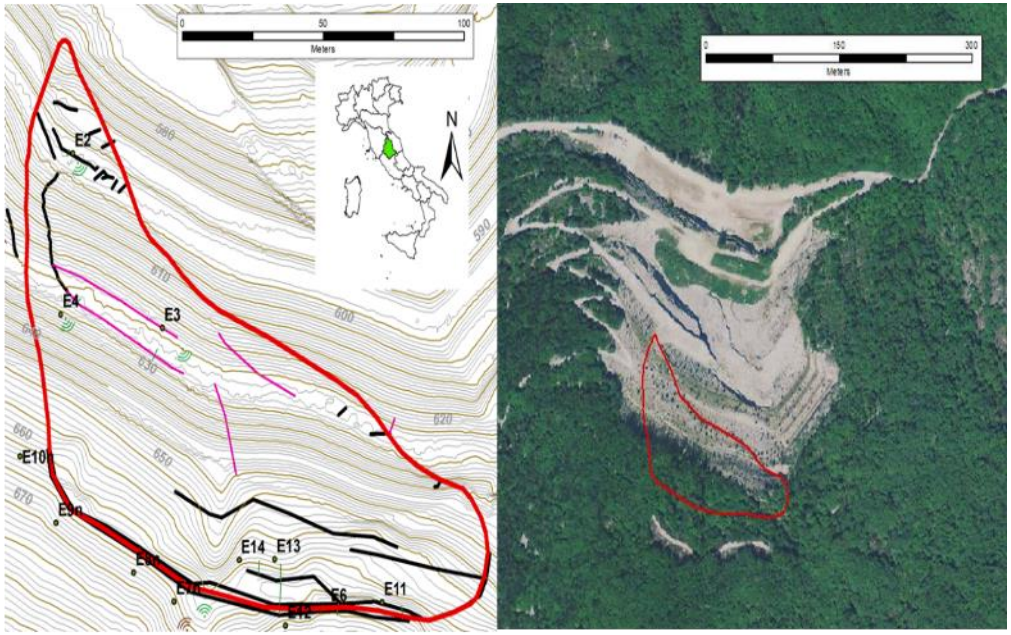
TIME VARIANT DATA

- ✓ Rainfall RT observations
- ✓ Thermometric RT observations
- ✓ Soil Moisture automatic data (ground stations)
- ✓ ASCAT satellite data:
  - ftp H-SAF project (Europe)
  - EUMETCAST service (globe)
- ✓ METEO RADAR data (National Civil Protection Dept)

PREDICTED DATA

- ✓QPF (various meteorological models)
- ✓ Predicted temperature

Torgiovannetto landslide (Assisi – PG) example

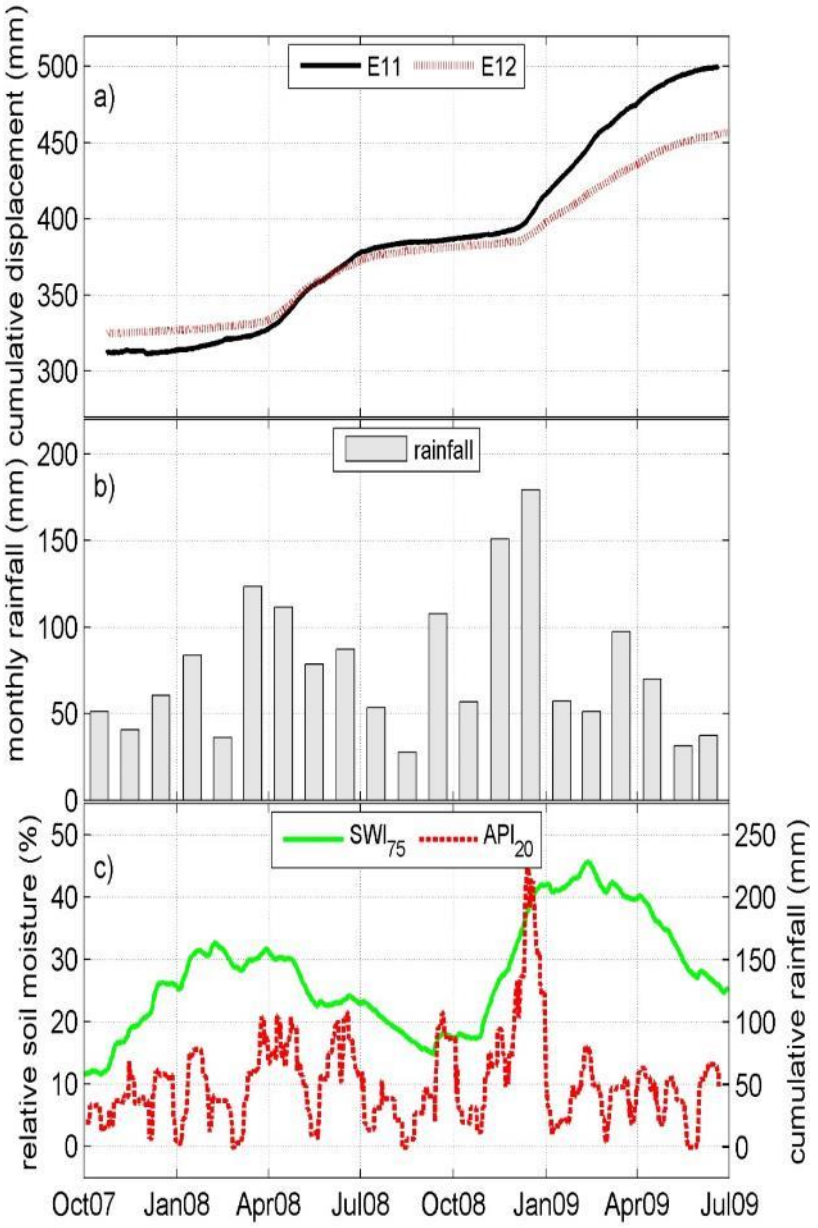


- ✓ Near Assisi
- ✓ Rock slope (abandoned stone quarry)
- ✓ First slide in 2003
- ✓ Landslide monitoring (extensometer, inclinometer)
- ✓ Meteorological monitoring (rainfall and temperature)

Torgiovannetto landslide (Assisi – PG) example

Regione Umbria

October 2007 – July 2009



Soil moisture is estimated through ASCAT and considering an Antecedent Precipitation Index

Brocca et al., 2012 (RS) – Open access

Multiple linear regression

$$d\hat{H} = \alpha + \beta \cdot P_{max\text{-}1h} + \gamma \cdot P_{tot} + \delta \cdot API_{20} + \varepsilon \cdot SWI_{75}$$

Displacements

1h max rainfall

Total rainfall

Antecedent Precipitation Index (N=20 g)

Soil Water Index (T=75 g)

1) only rainfall ($P_{max\text{-}1h}$ e P_{tot})

$$d\hat{H} = \alpha + \beta \cdot P_{max\text{-}1h} + \gamma \cdot P_{tot}$$

2) rainfall + API_{20}

$$d\hat{H} = \alpha + \beta \cdot P_{max\text{-}1h} + \gamma \cdot P_{tot} + \delta \cdot API_{20}$$

3) rainfall + SWI_{75}

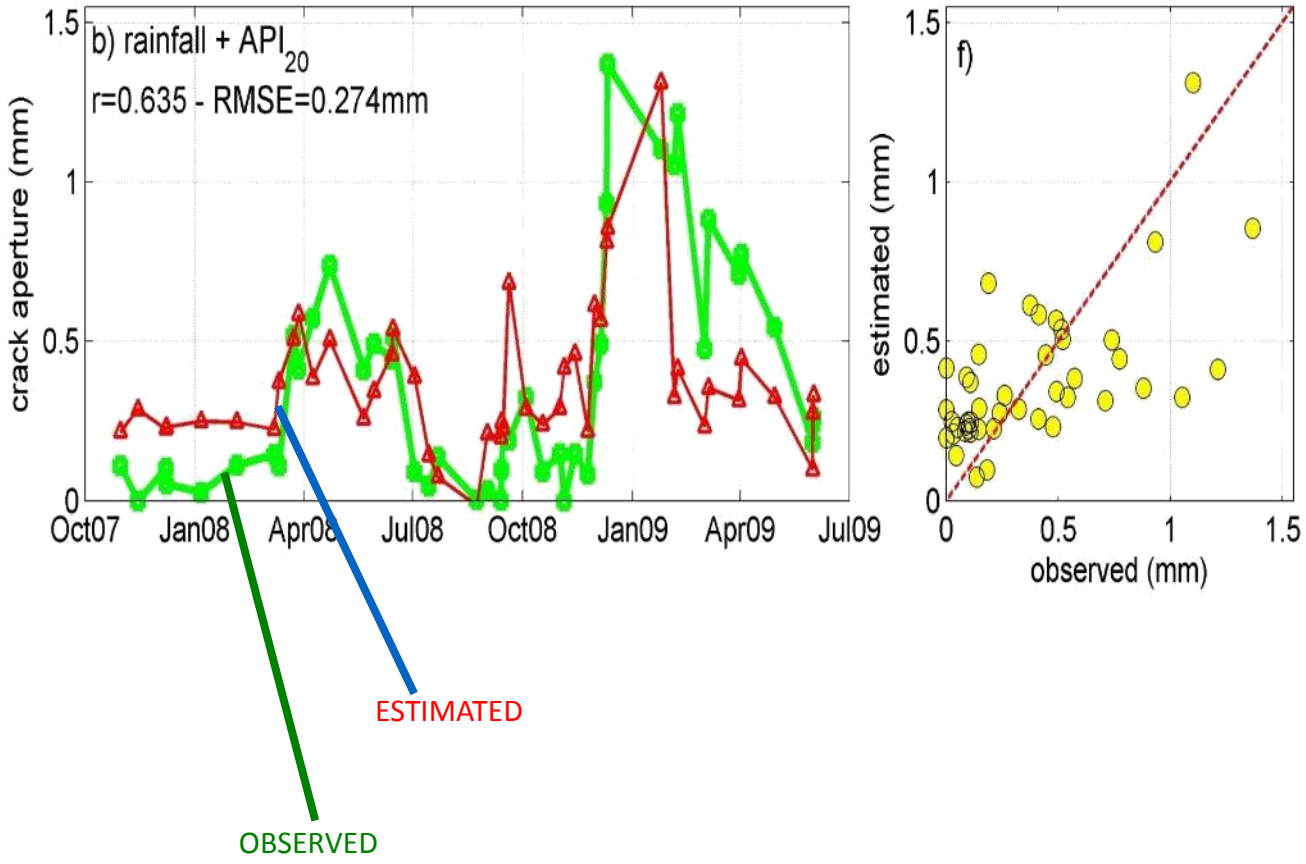
$$d\hat{H} = \alpha + \beta \cdot P_{max\text{-}1h} + \gamma \cdot P_{tot} + \varepsilon \cdot SWI_{75}$$

4) rainfall + API_{20} + SWI_{75}

$$d\hat{H} = \alpha + \beta \cdot P_{max\text{-}1h} + \gamma \cdot P_{tot} + \delta \cdot API_{20} + \varepsilon \cdot SWI_{75}$$

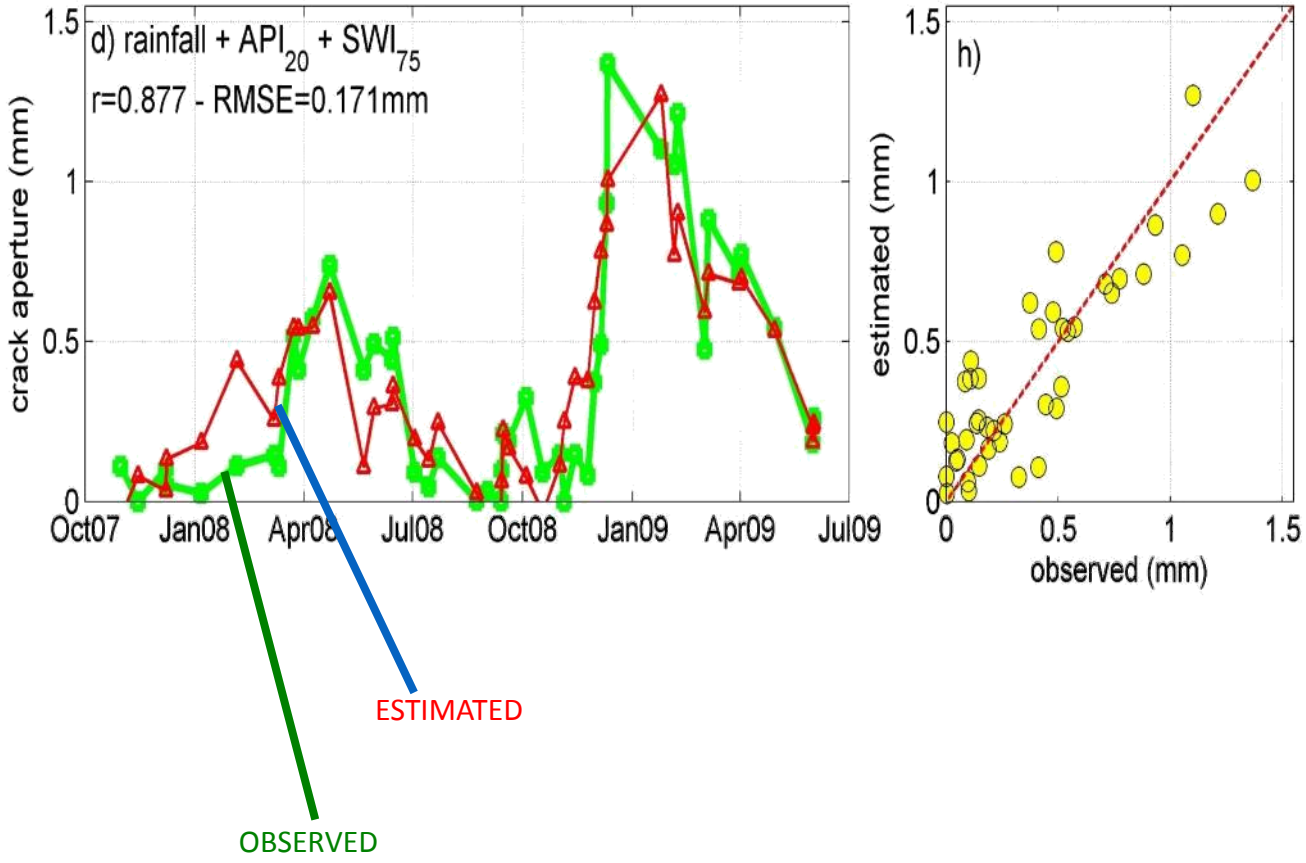
Landslide displacement prediction

2) rainfall + API_{20}



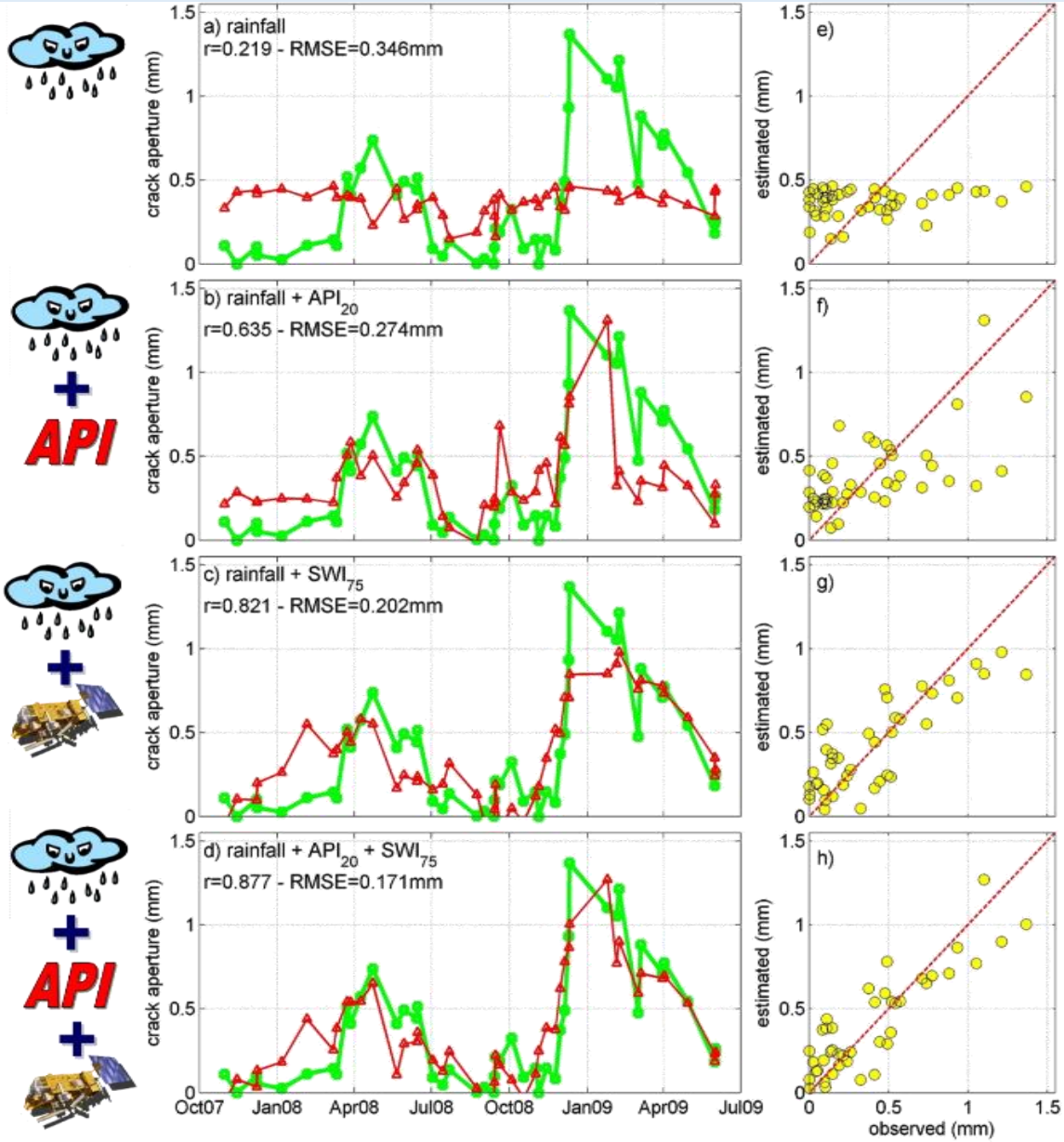
Landslide displacement prediction

4) rainfall + API_{20} + SWI_{75}



Torgiovannetto landslide (Assisi – PG) example

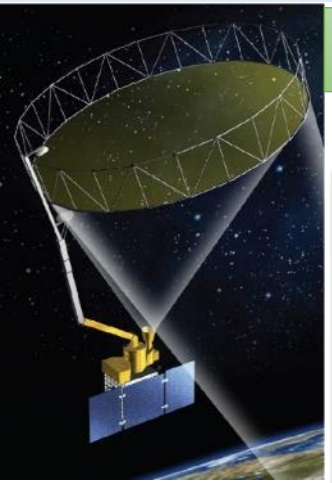
Landslide displacement prediction



FUTURE DEVELOPMENTS (IF FUNDED)

Regione Umbria

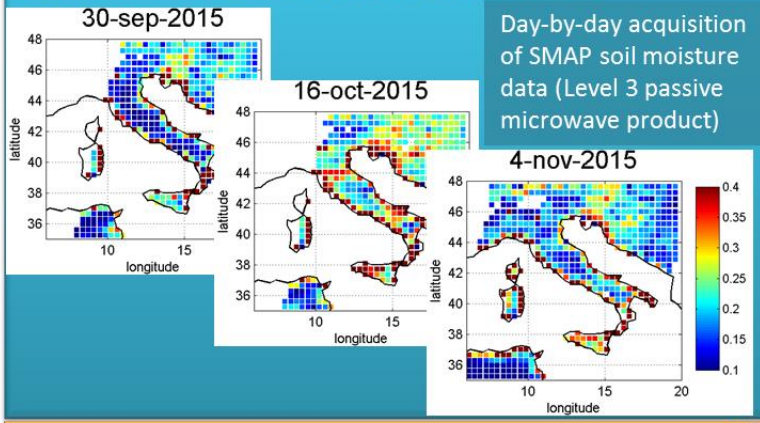
SMAP Soil Moisture Active and Passive



SMAP: Soil Moisture Active and Passive mission

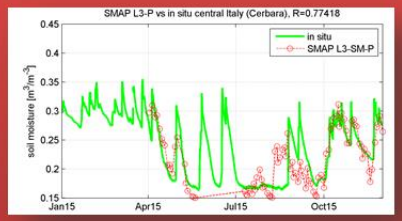
SMAP (band L, 9km resolution, 2-3 days)

1 REAL-TIME ACQUISITION OF SMAP SOIL MOISTURE DATA OVER ITALY



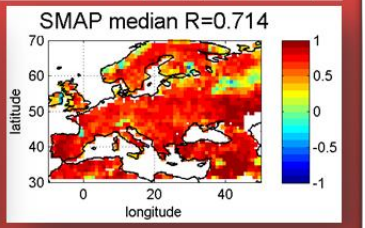
Day-by-day acquisition of SMAP soil moisture data (Level 3 passive microwave product)

2 REAL-TIME ASSESSMENT THROUGH IN SITU OBSERVATIONS



Validation with ground-based soil moisture observations (point scale)
Brocca et al. (2011)

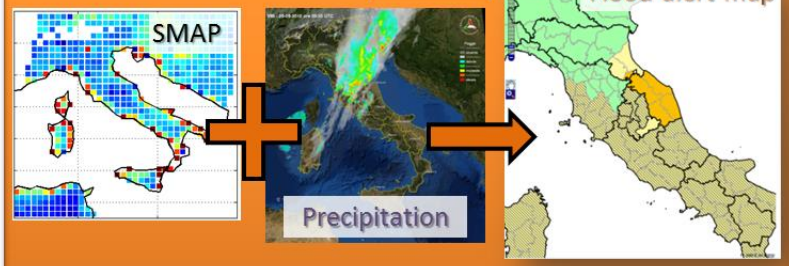
Correlation map between SMAP-derived and observed precip (Jul-Dec 2015)



Indirect validation with ground-based precipitation observations (large scale)
Brocca et al. (2014)

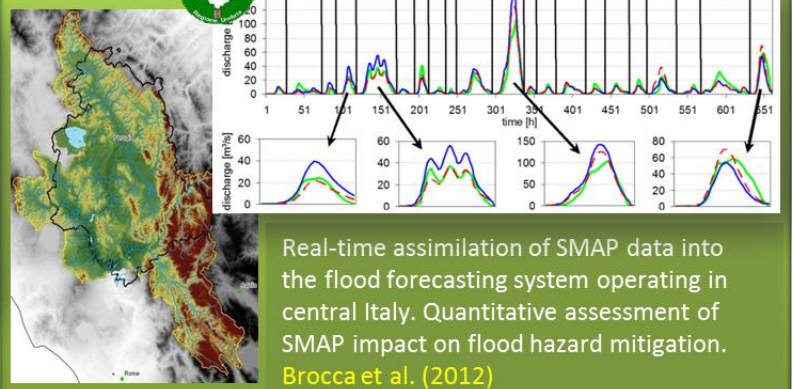
3 NATIONAL SCALE FLOOD WARNING SYSTEM

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile



Integration of SMAP soil moisture and ground-based precipitation observations for flood (and landslide) alert issuing at national scale.

4 CENTRAL ITALY FLOOD FORECASTING SYSTEM

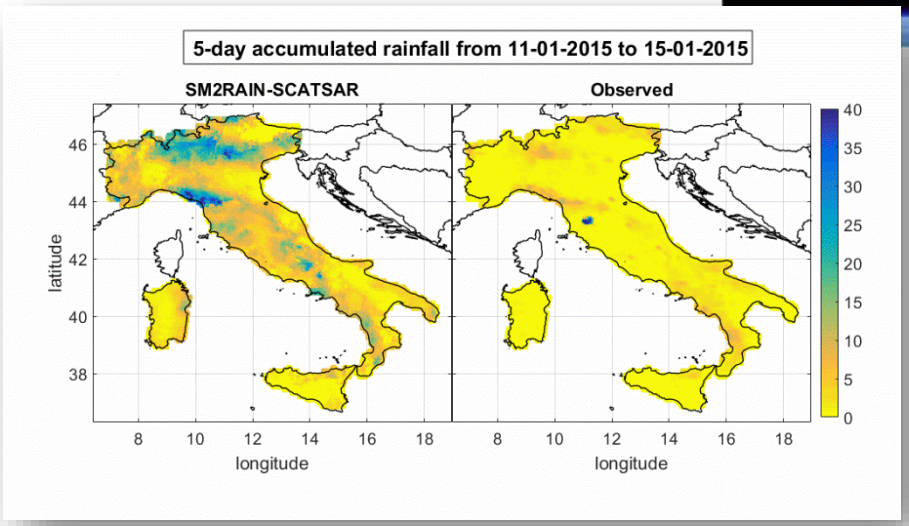


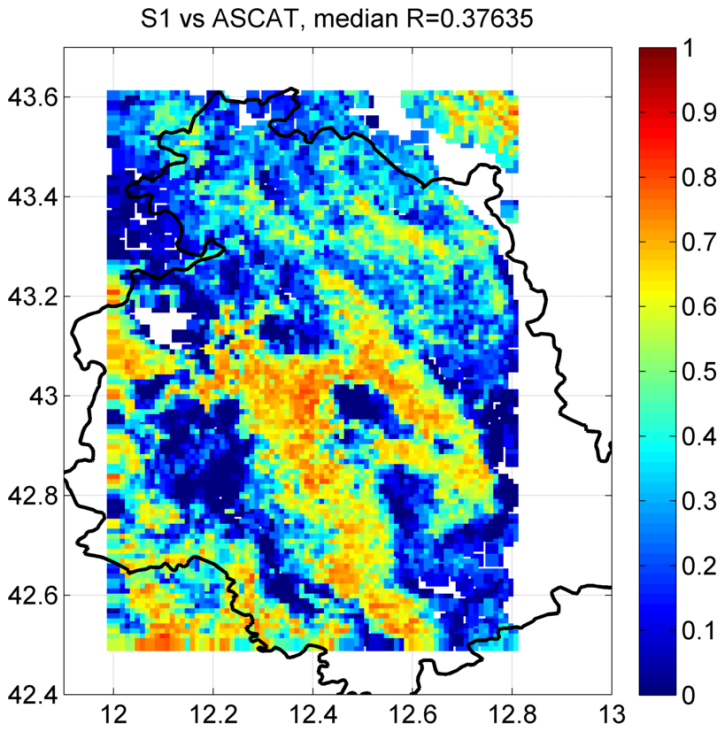
Real-time assimilation of SMAP data into the flood forecasting system operating in central Italy. Quantitative assessment of SMAP impact on flood hazard mitigation.
Brocca et al. (2012)

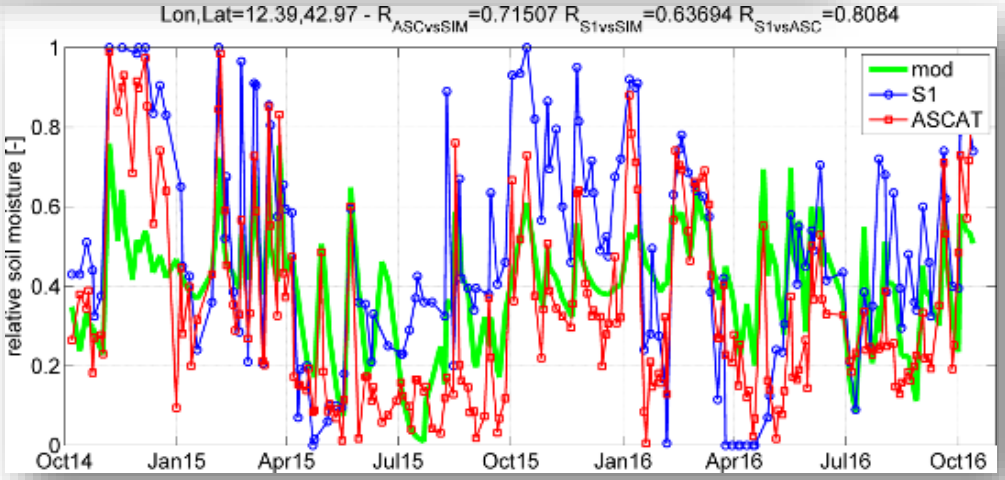
Regione Umbria

Sentinel-1

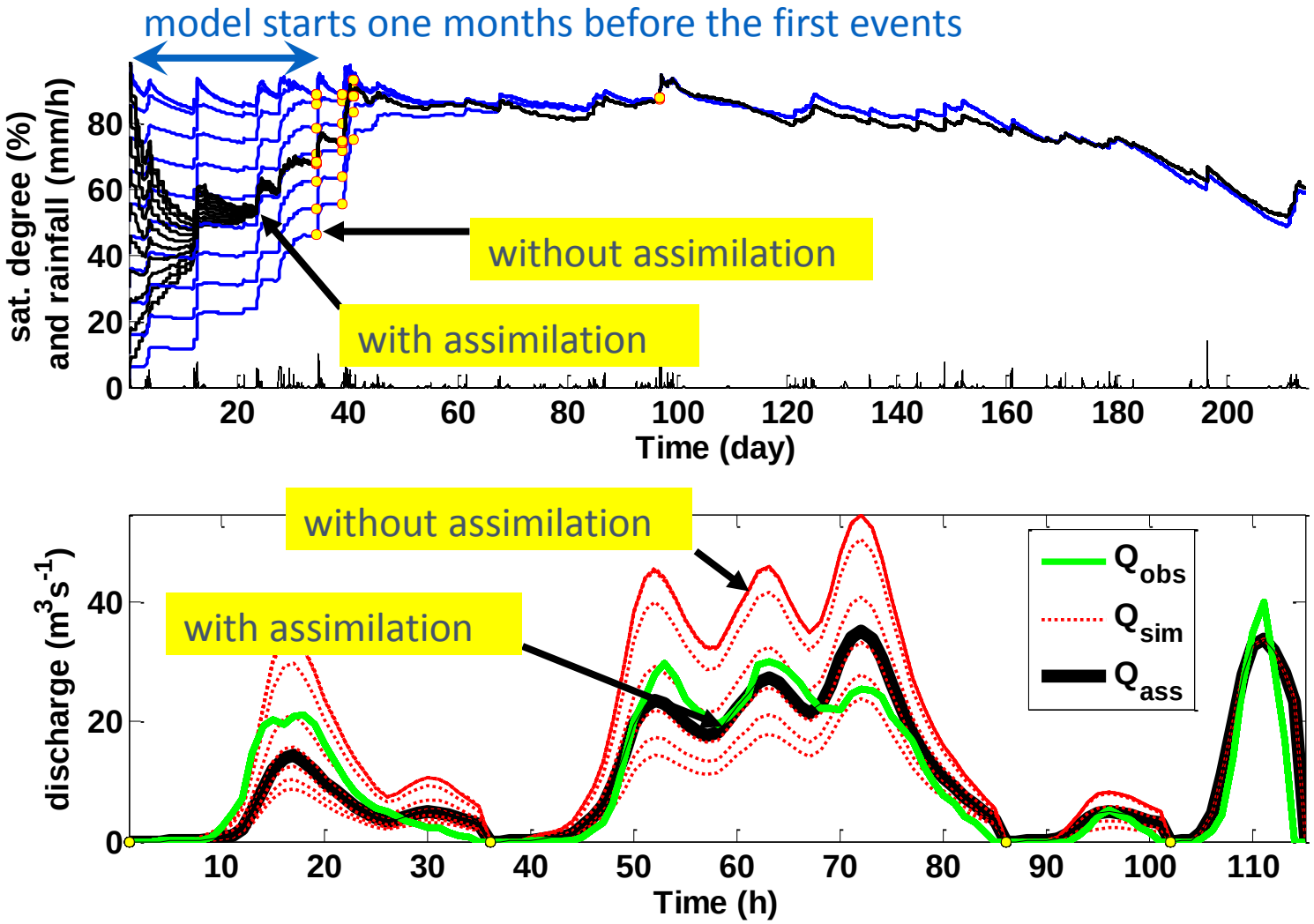
Sentinel-1
(1km, 2-3 days)







Full early warning models assimilation




Thank you for attention!
www.cfumbria.it
centrofunzionale@regione.umbria.it