

Natural hazard:  
Impact of space-borne estimates of hydrological variables in early warning systems



**Silvia Puca and Marco Petracca**  
Italian Department of Civil Protection

Defence lives and property by damage or by possible damage due to natural & technological disasters and other destructive events.





# Civil Protection Activity

Prevention



To identify needs, requirements and provide procedures & guide lines  
risk mitigation through setting up the monitoring system  
emergency plans drafting

Forecasting & Surveillance



event location  
risk assessment

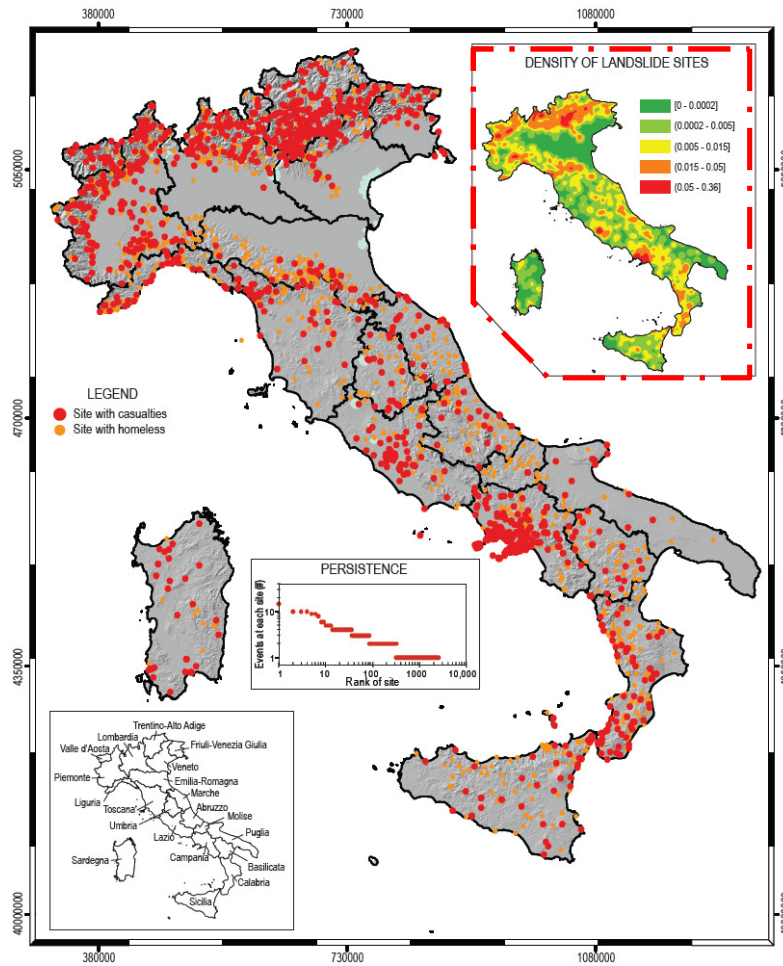
Emergency management



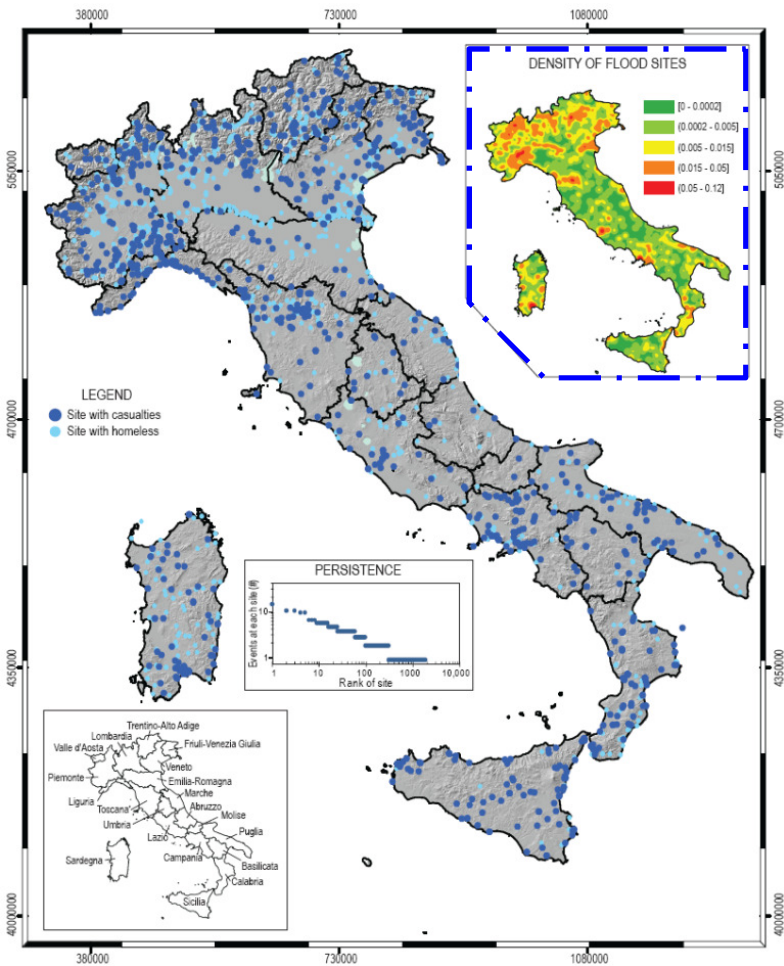
contrast actions  
aid organisation  
damage assessment



## Hydraulic and hydrogeological risk in Italy



Location of 2533 sites affected by landslide events with direct consequences to the population. Period 650-2008



Location of 1836 sites affected by floods events with direct consequences to the population. Period 590-2008



# Satellite data can provide an effective contribution to hydrological risk management? How?

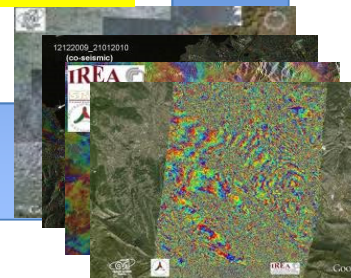


Data available  
Time latency  
Accuracy



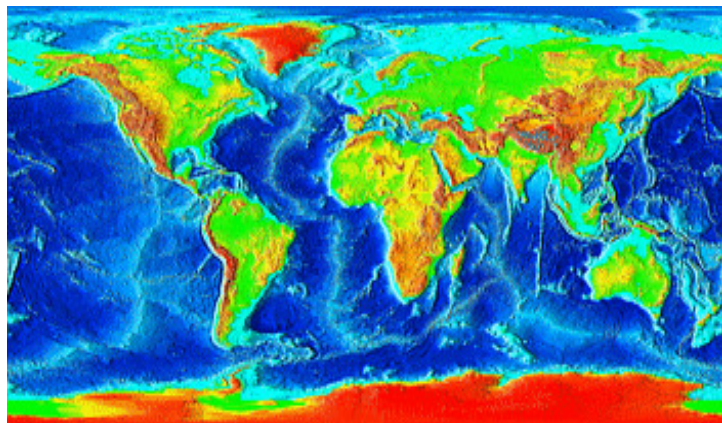
Forecasting & Surveillance

Emergency management

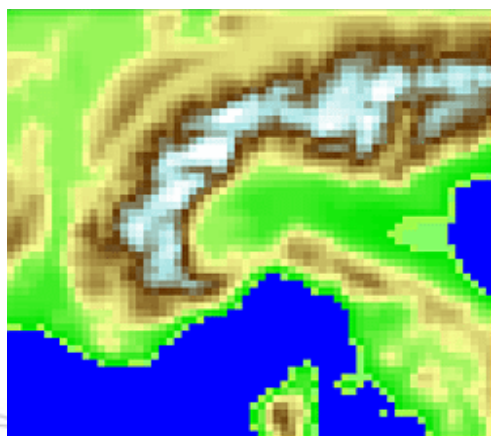


# Forecasting & Surveillance

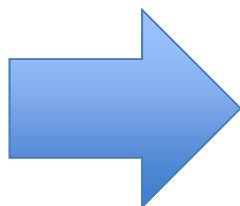
# METEO forecast



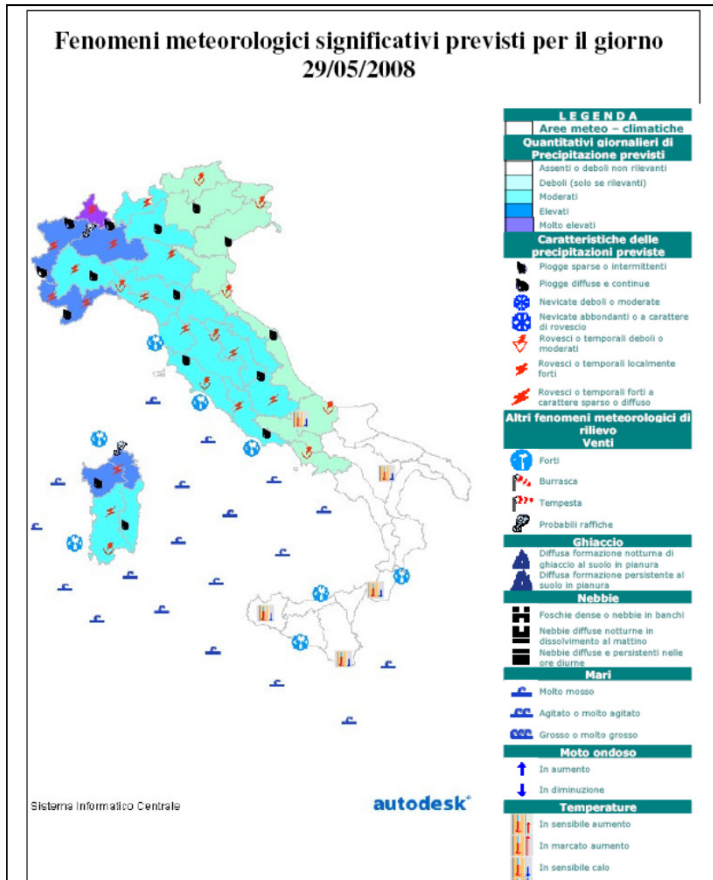
GCM-ECMWF



Local Model



**QPF**

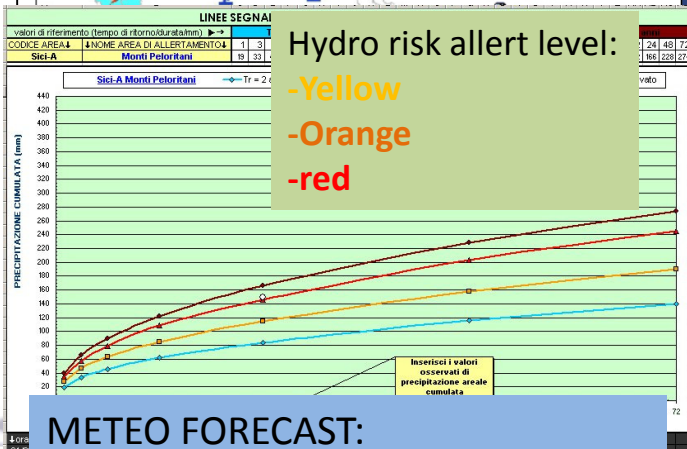
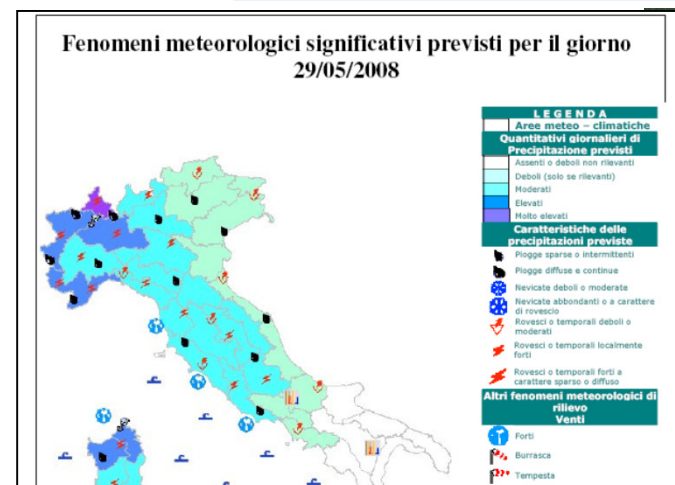


Meteorological Forecast (precipitation, thunderstorm, wind..) for 12h, 24, 36 h



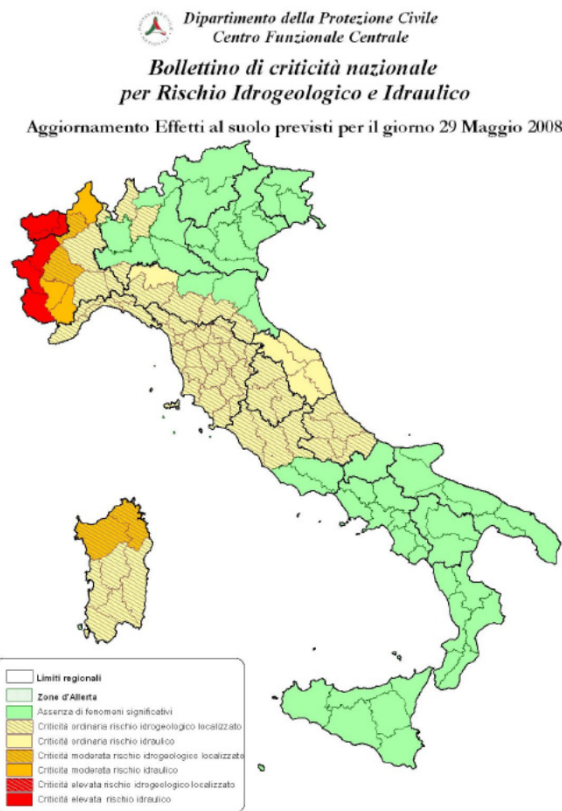
# Forecasting & Surveillance

# hydraulic and hydrological forecast



**METEO FORECAST:**  
Threshold method –return period

**ANTACEDENT CONDITION:**  
Soil Moisture Saturation



**Hydraulic and hydrogeological Forecast for 12h, 24h, 36 h**

# METEO Forecat



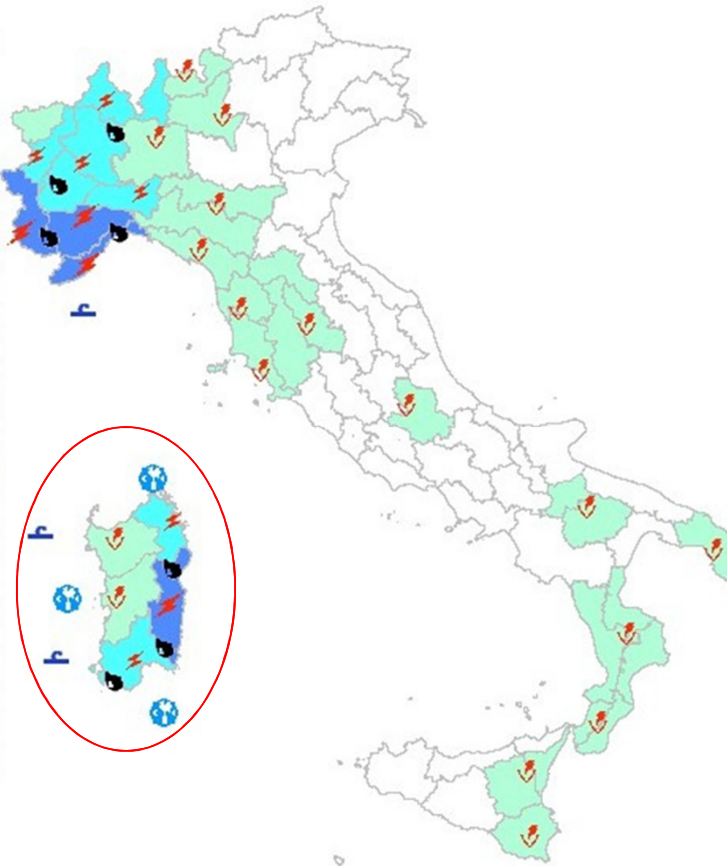
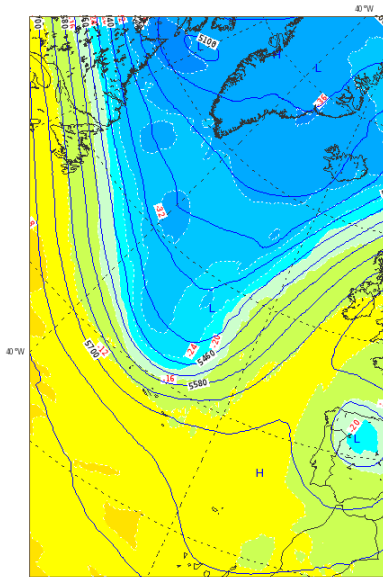
Centro Funzionale Centrale - Settore Meteo

[www.protezionecivile.gov.it](http://www.protezionecivile.gov.it)

Main low pressure ( )  
secondary shallow l



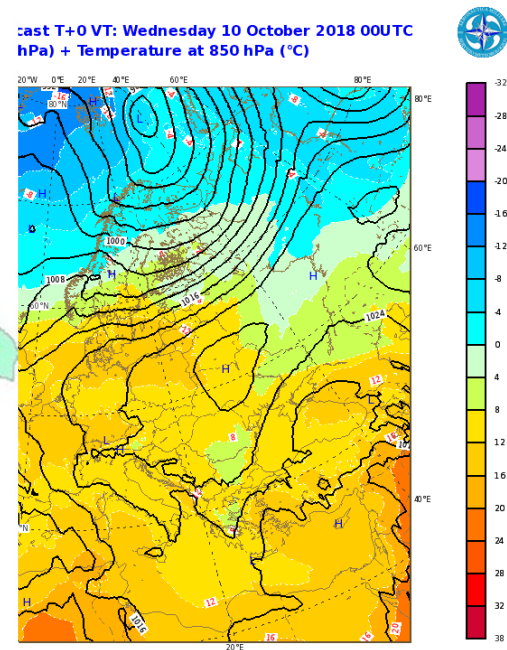
ECMWF 10 October 2018 00UTC For  
EUROATLANTIC - Geopotenti



Precipitation forecasted for 10/10/2018

noticeable signals

cast T+0 VT: Wednesday 10 October 2018 00UTC  
hPa) + Temperature at 850 hPa (°C)



ean,  
om systems (MCS)



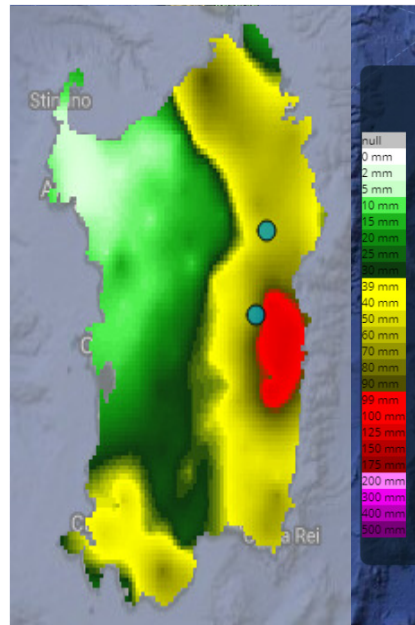


# HYDRO Forecat

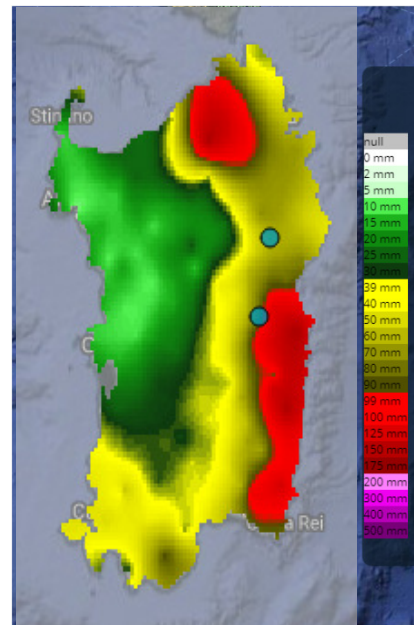
# ANTECEDENT CONDITION: SOIL MOISTURE SATURATION

www.protezionecivile.gov.it

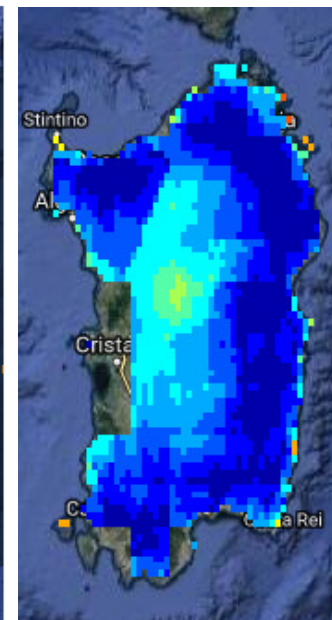
5 days rain gauge  
Dry –Wet conditions



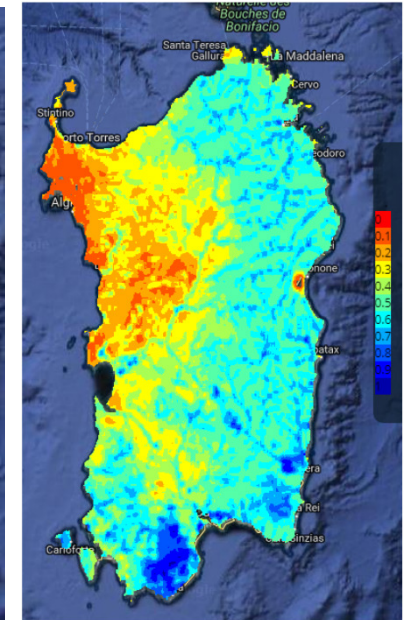
10 days rain gauge  
Dry –Wet conditions



ASCAT SM  
dry to medium conditions



MODEL SM  
medium conditions



Precipitation forecasted for 10 Oct. 2018

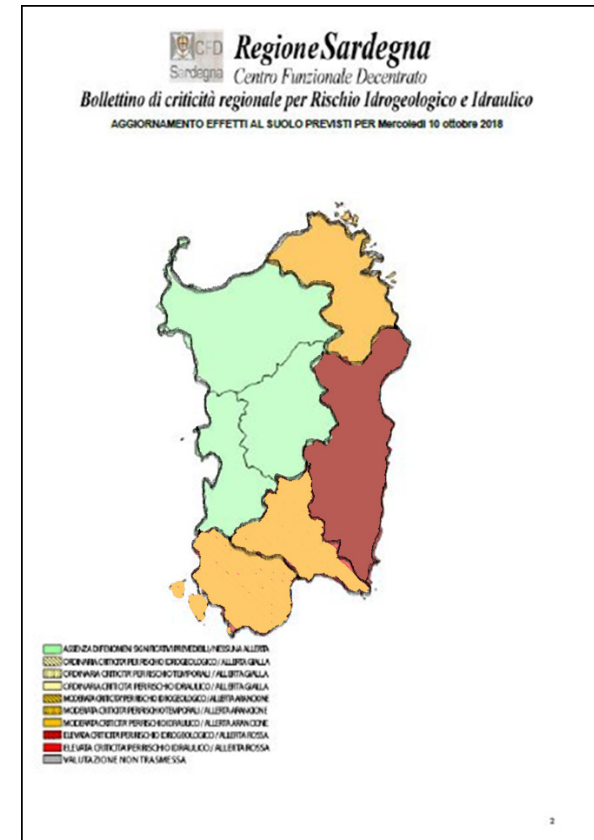
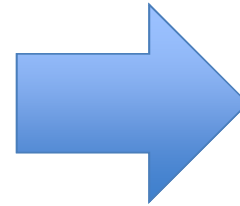
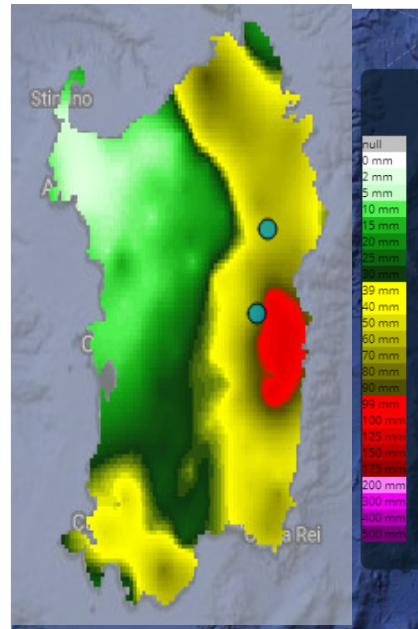
We use satellite soil moisture (plus modelling) to assess the antecedent conditions that are fundamental to provide the hydrological and hydrogeological alert. The use of multiple data sources allows us a more reliable and robust assessment of antecedent soil moisture conditions.

# HYDRO Forecat

# ANTECEDENT CONDITION: SOIL MOISTURE SATURATION

www.protezionecivile.gov.it

5 days accumulated precipitation  
Dry –Wet conditions



Precipitation forecasted for 10 Oct. 2018



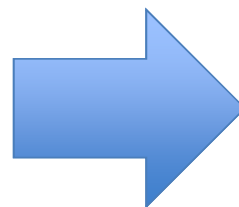
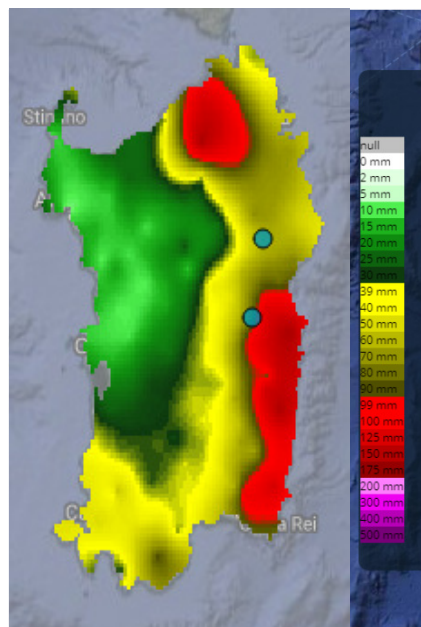


# HYDRO Forecat

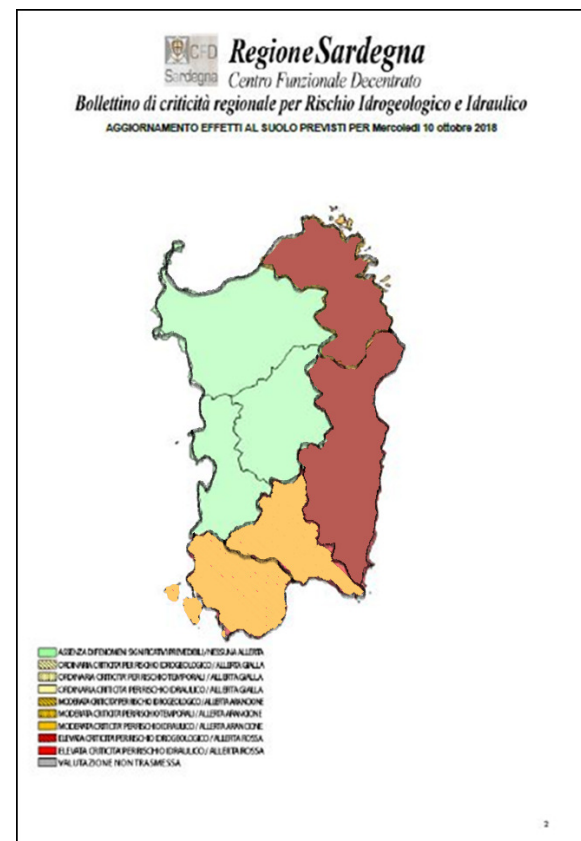
# ANTECEDENT CONDITION: SOIL MOISTURE SATURATION

www.protezionecivile.gov.it

10 days accumulated precipitation  
Dry –Wet conditions



Precipitation forecasted for 10 Oct. 2018

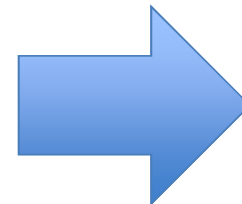
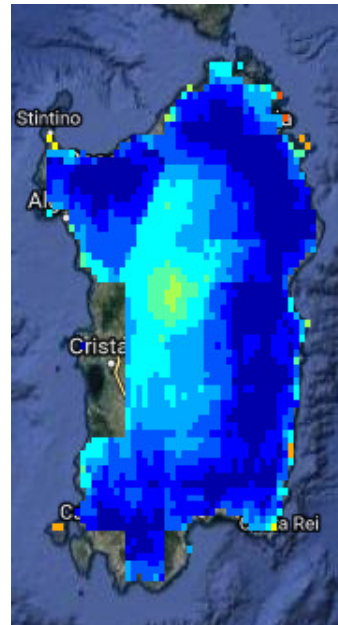


# HYDRO Forecat

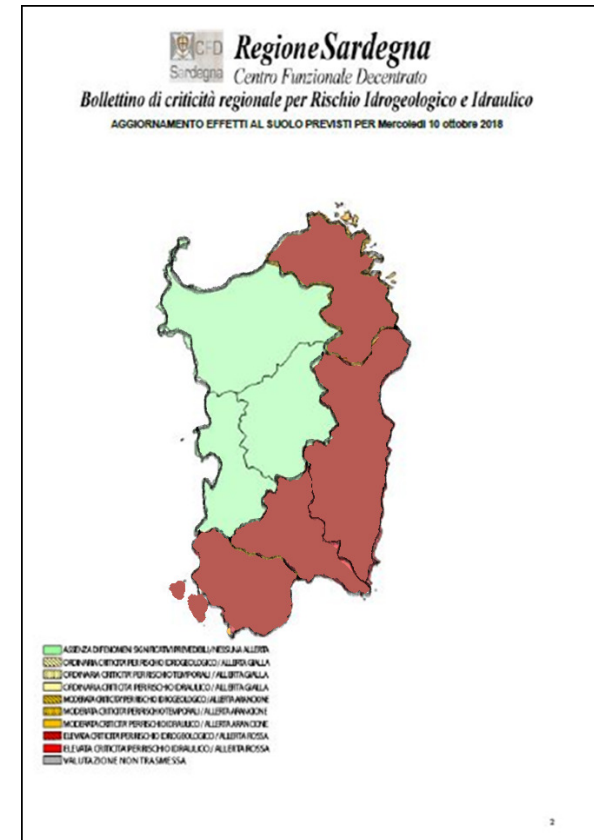
# ANTECEDENT CONDITION: SOIL MOISTURE SATURATION

www.protezionecivile.gov.it

ASCAT SM  
(09 Oct. 2019 00:00)  
dry to medium conditions



Precipitation forecasted for 10 Oct. 2018





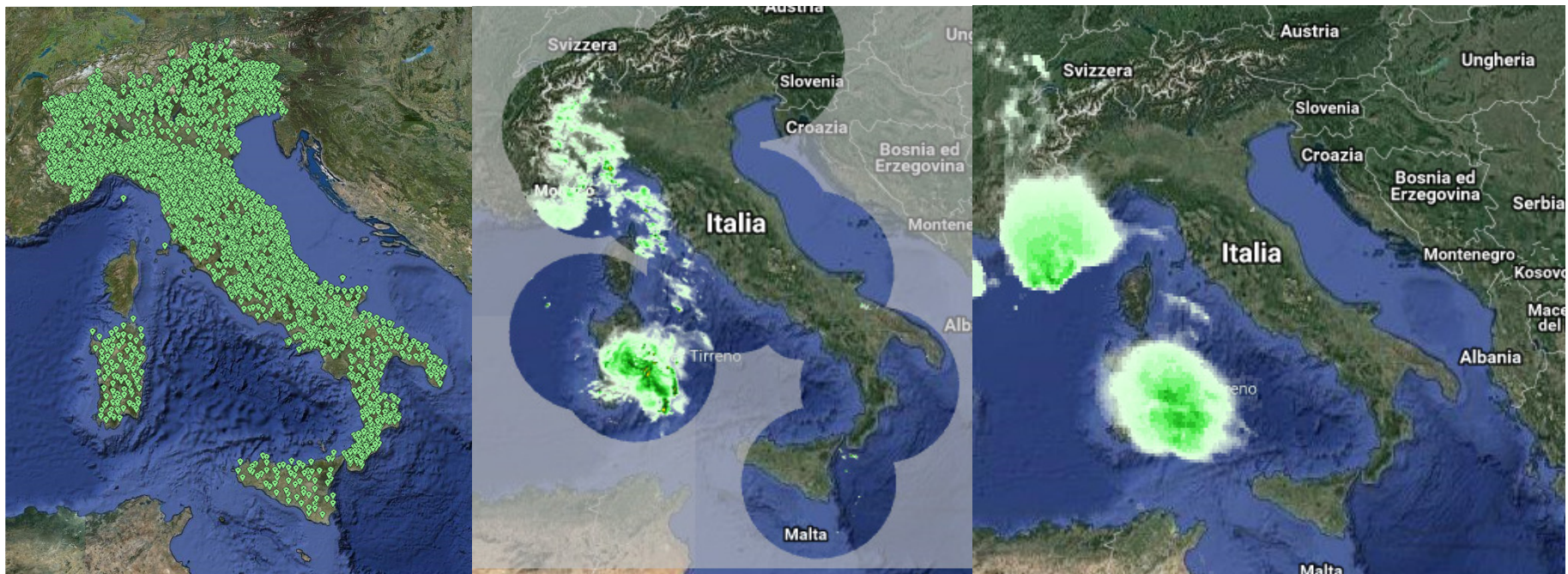


## SURVEILLANCE

## PRECIPITATION MONITORING

[www.protezionecivile.gov.it](http://www.protezionecivile.gov.it)

- Rain gauges
- radar
- satellite



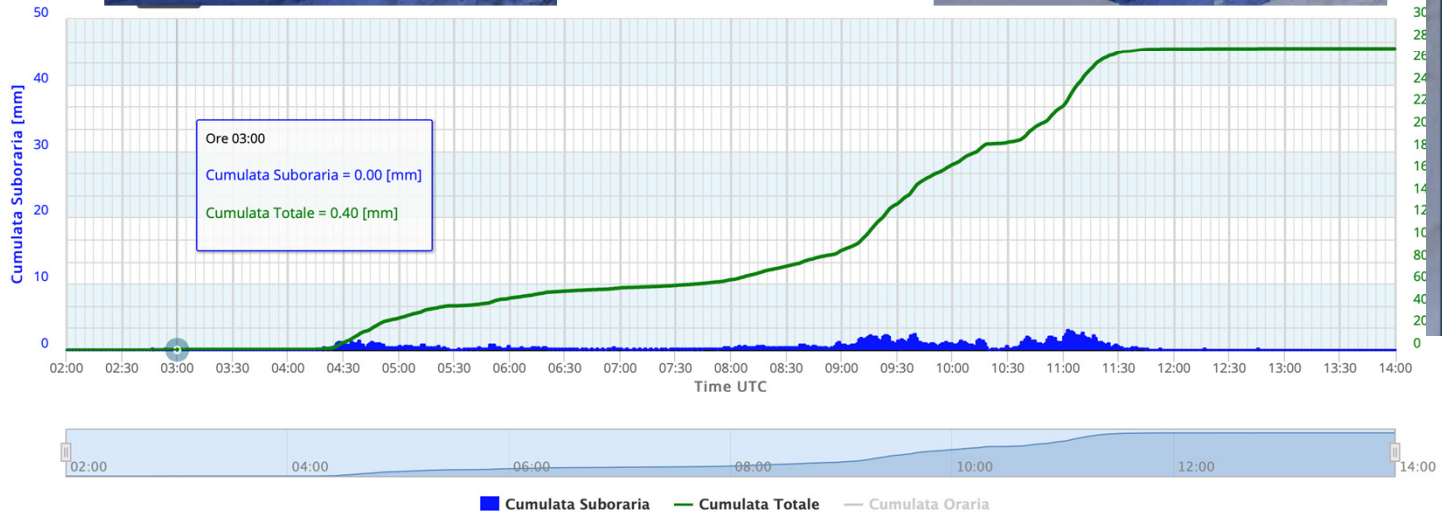
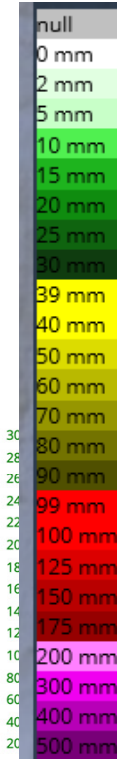
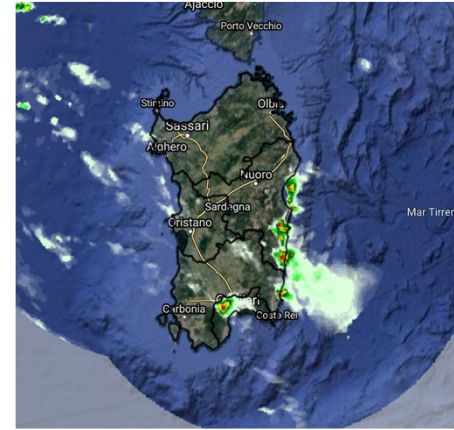
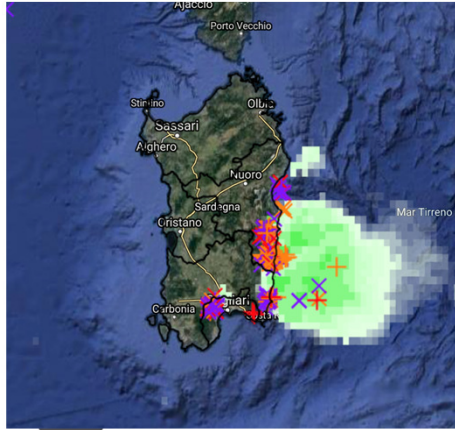


# SURVEILLANCE

(10/10/2018 03.00 UTC)

satellite-lightning

radar



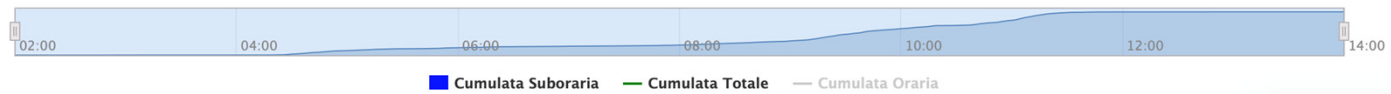
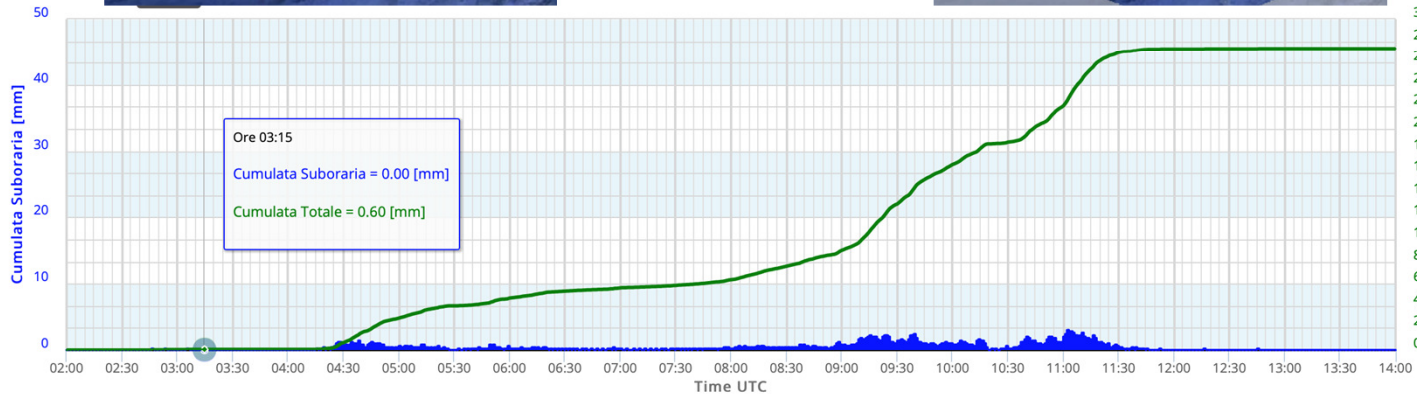
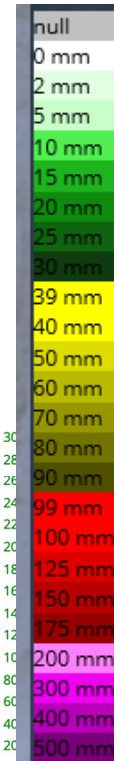
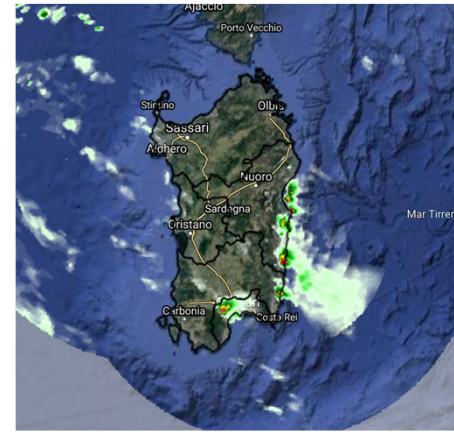
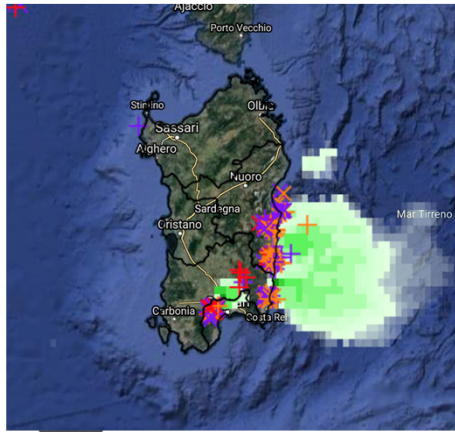


# SURVEILLANCE

(10/10/2018 03.15 UTC)

satellite-lightning

radar

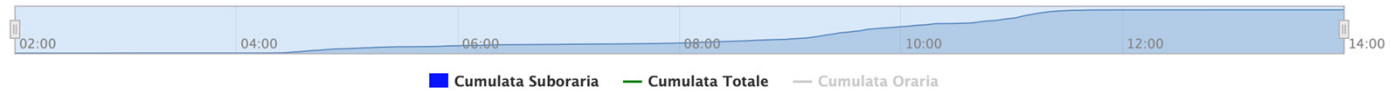
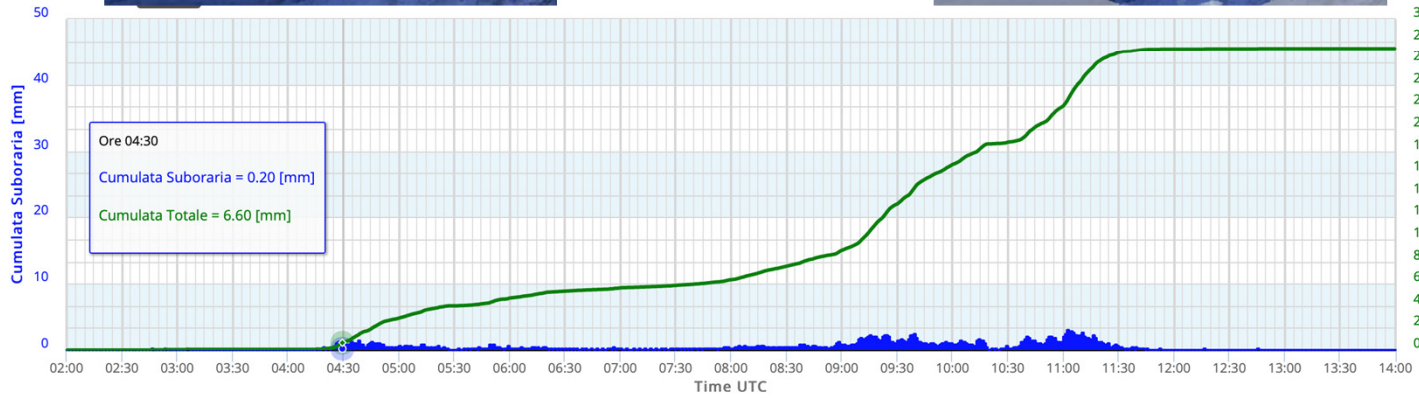
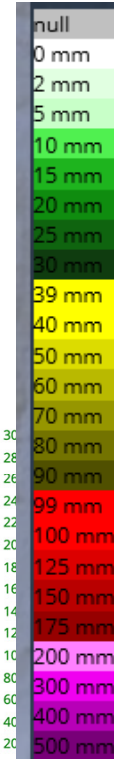
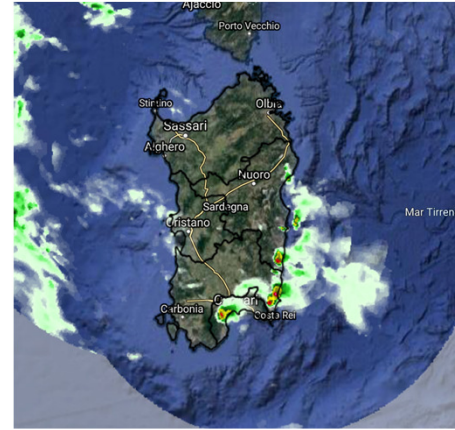
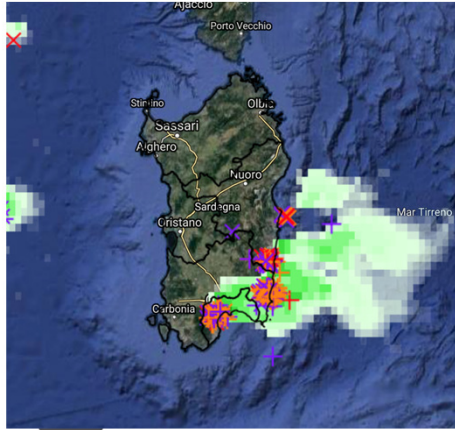


# SURVEILLANCE

(10/10/2018 04.30 UTC)

satellite-lightning

radar

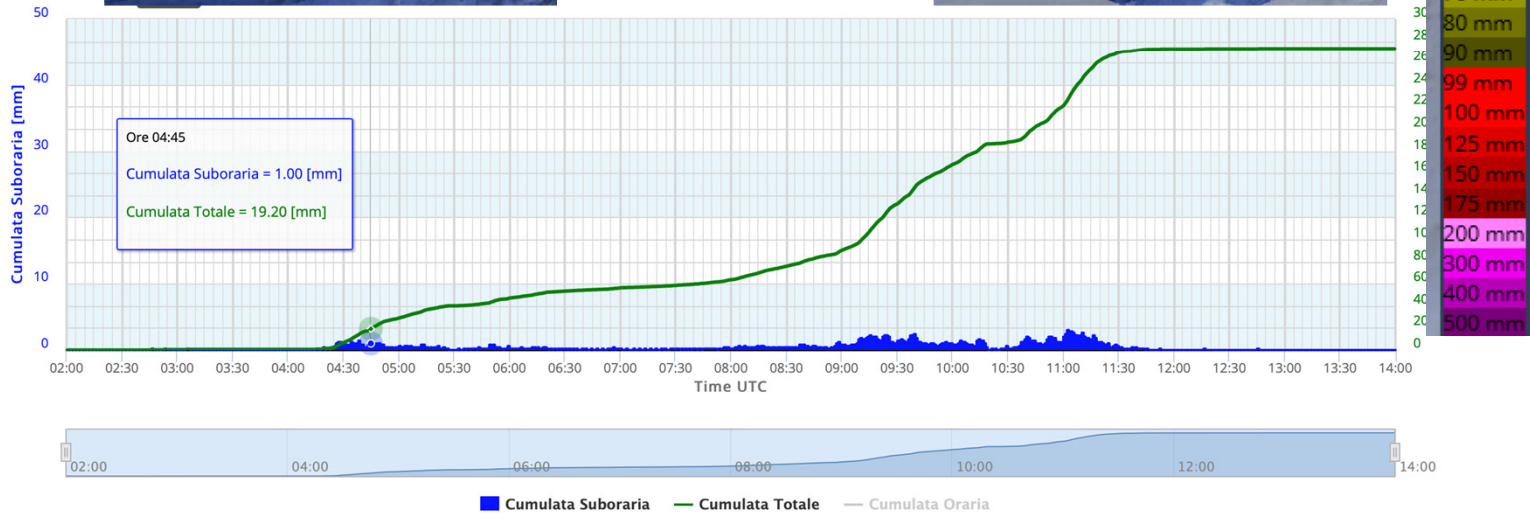
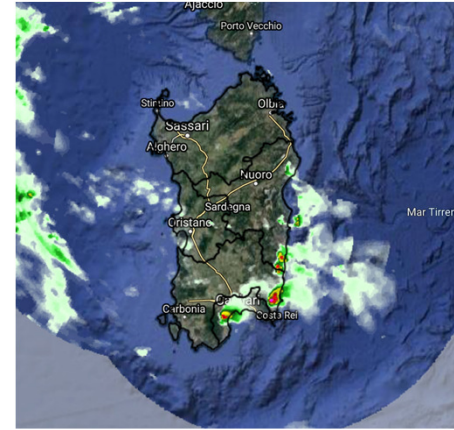
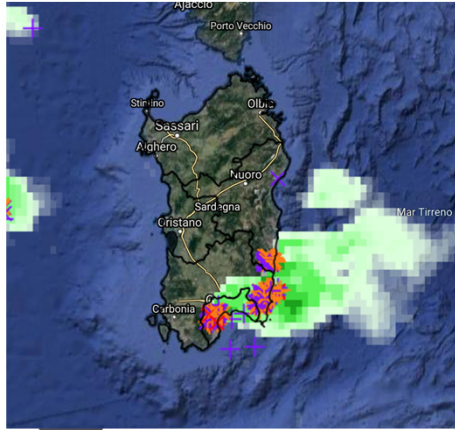


# SURVEILLANCE

(10/10/2018 04.45 UTC)

satellite-lightning

radar



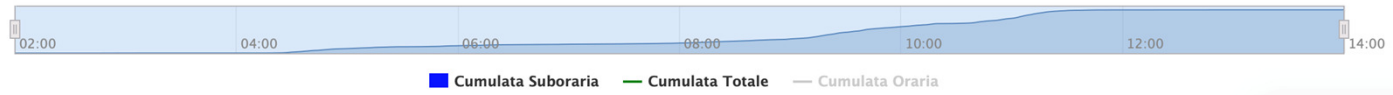
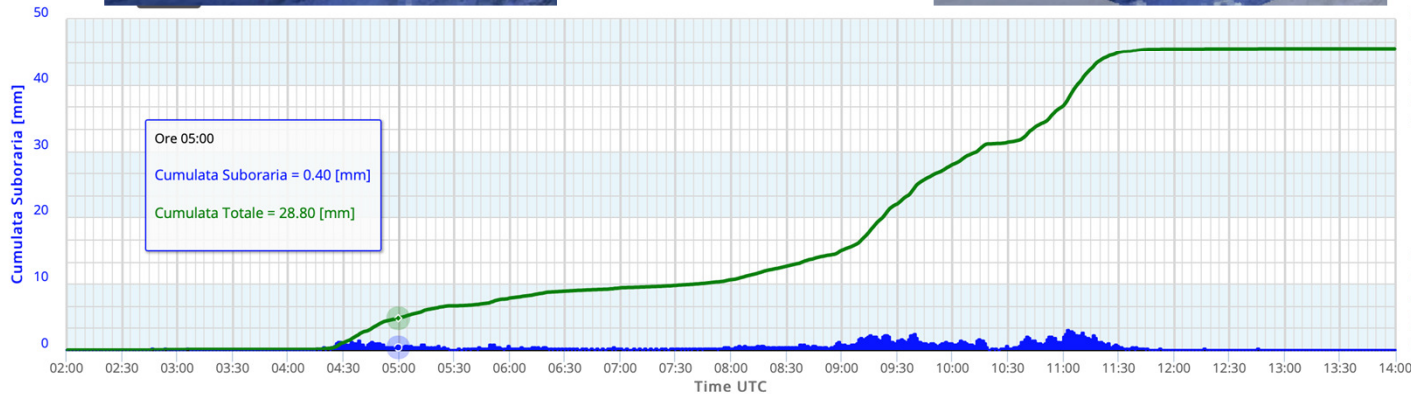
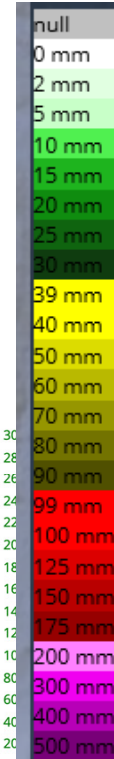
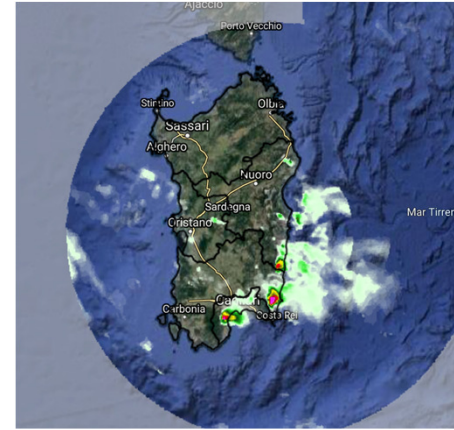
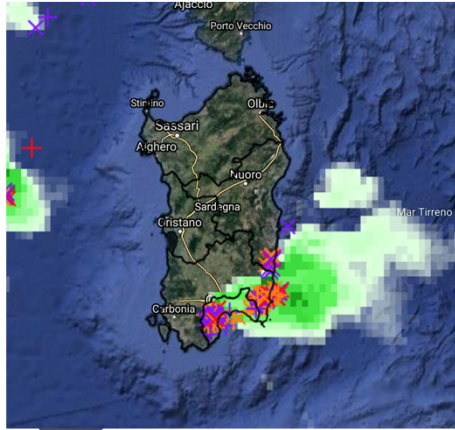


# SURVEILLANCE

(10/10/2018 05.00 UTC)

satellite-lightning

radar

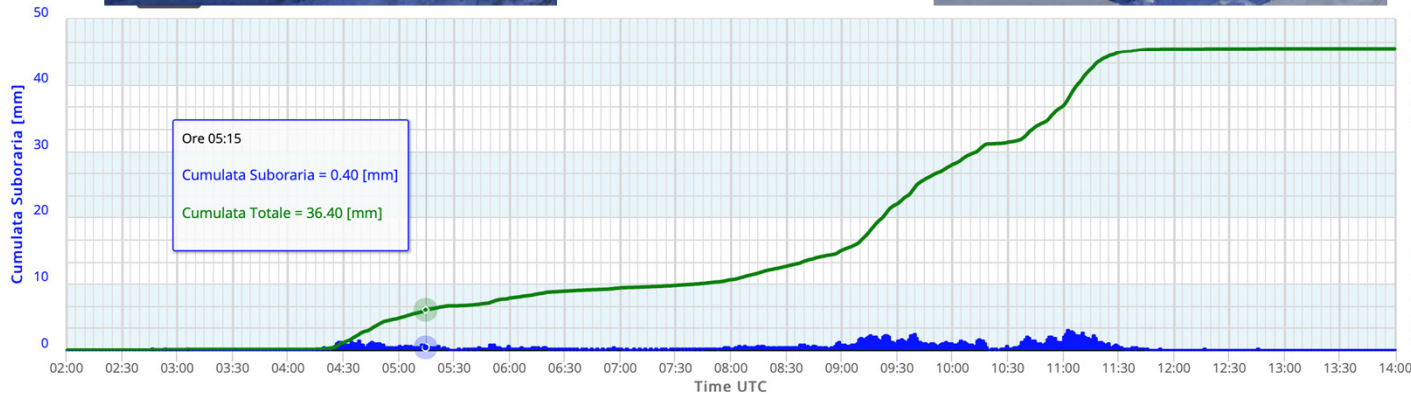
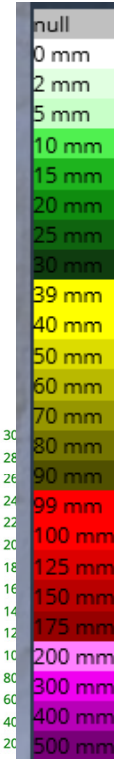
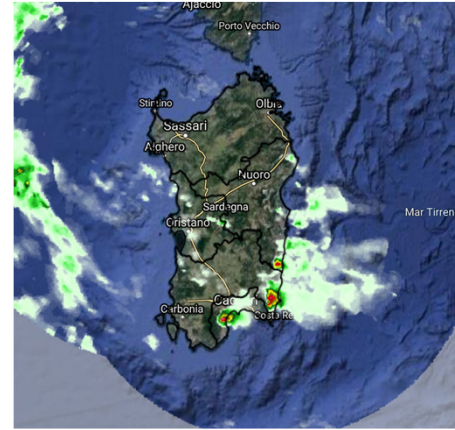
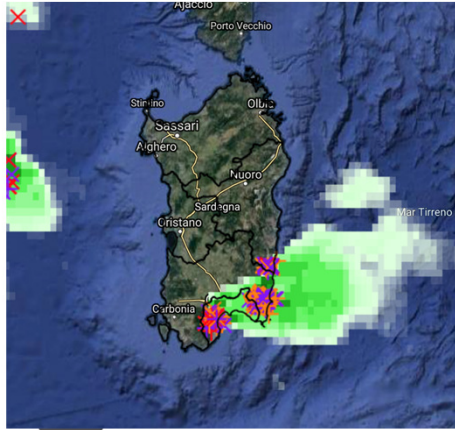


# SURVEILLANCE

(10/10/2018 05.15 UTC)

satellite-lightning

radar

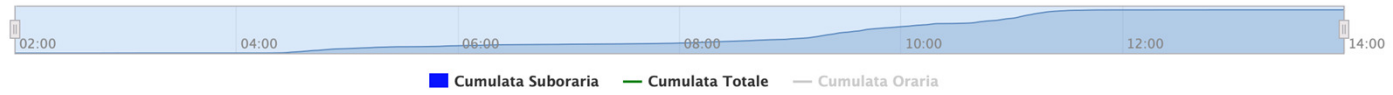
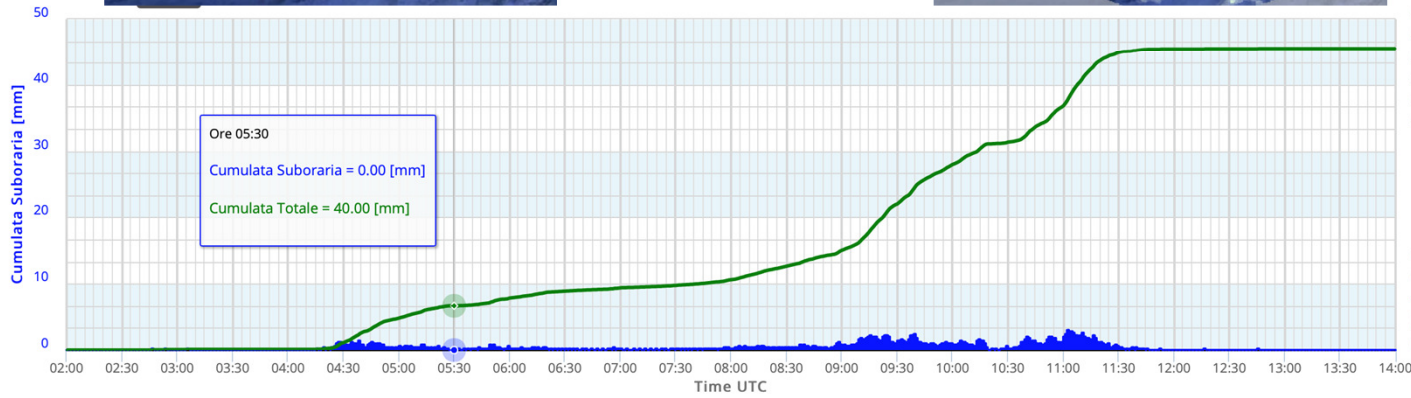
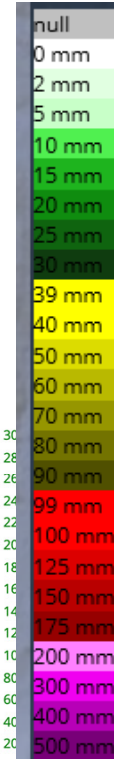
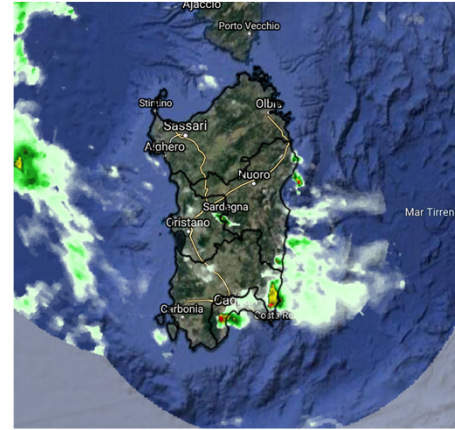
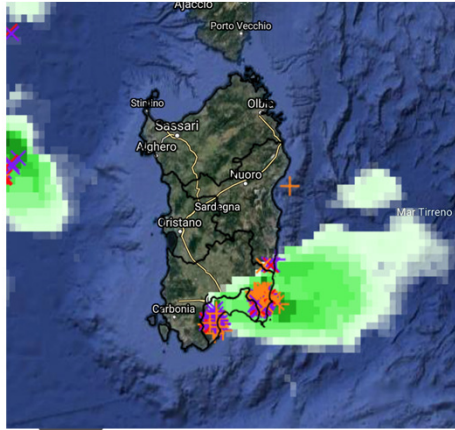


# SURVEILLANCE

(10/10/2018 05.30 UTC)

satellite-lightning

radar



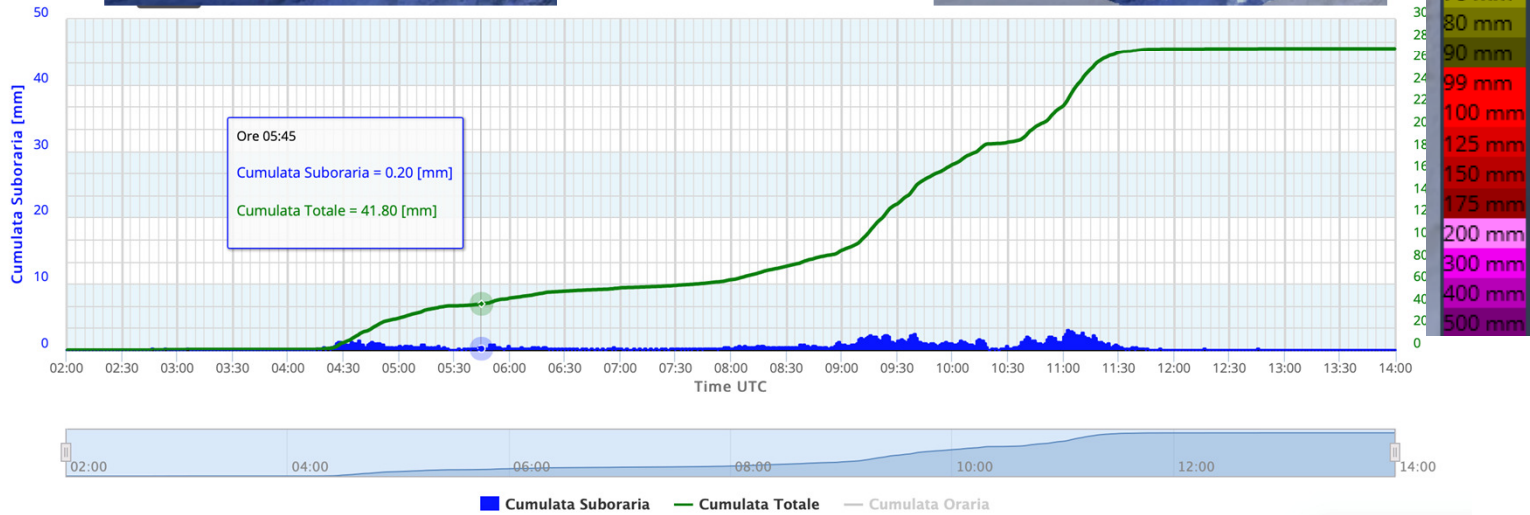
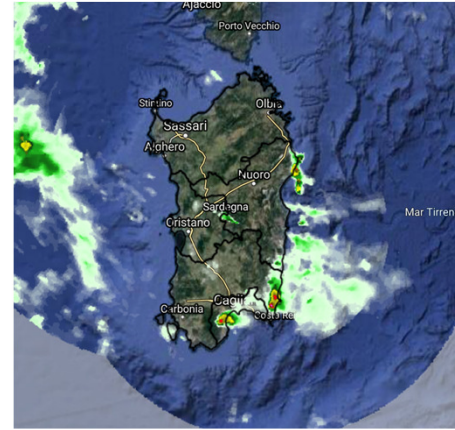
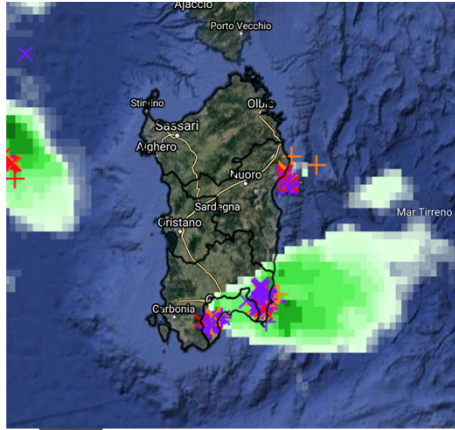


# SURVEILLANCE

(10/10/2018 05.45 UTC)

satellite-lightning

radar

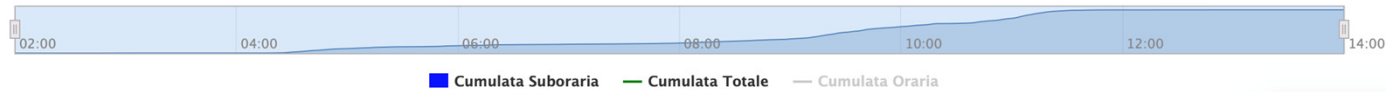
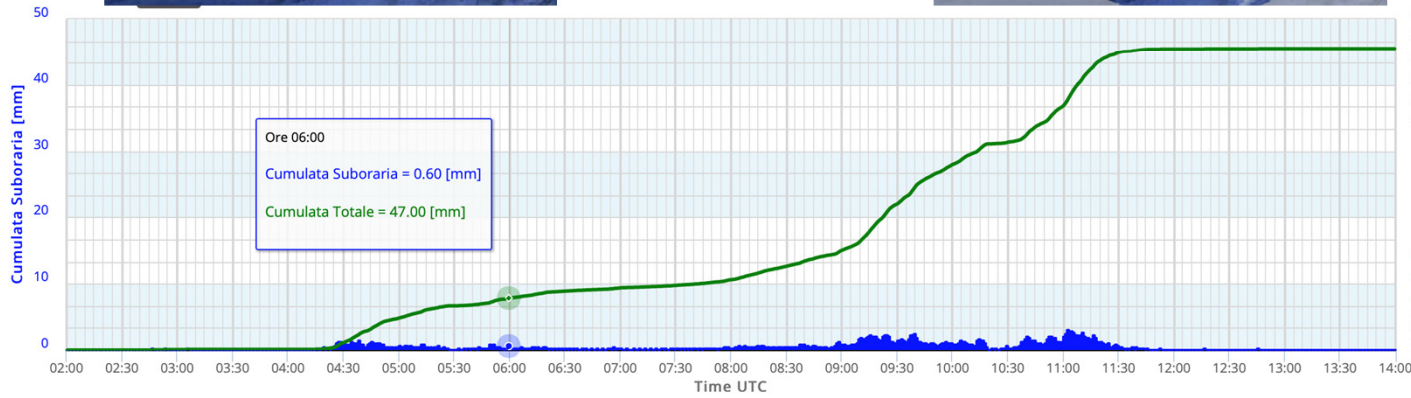
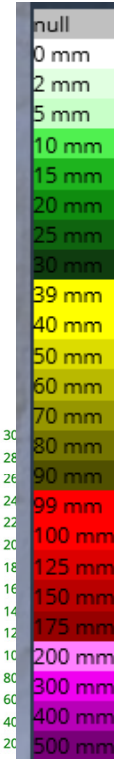
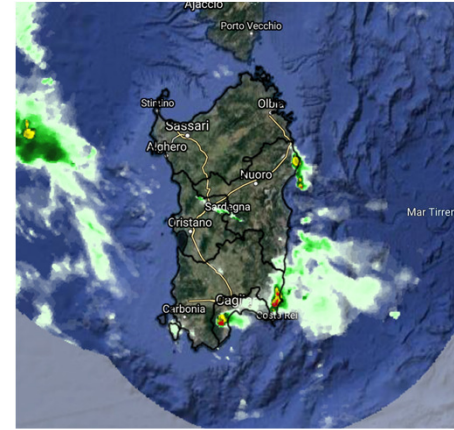
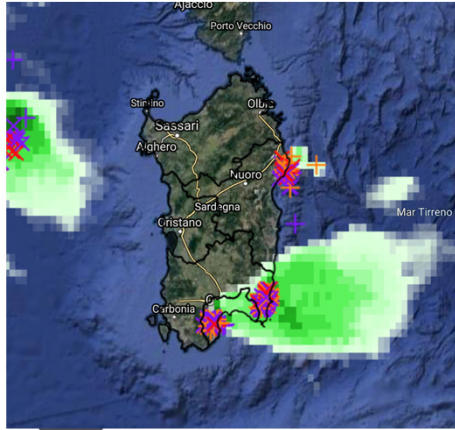


# SURVEILLANCE

(10/10/2018 06.00 UTC)

satellite-lightning

radar

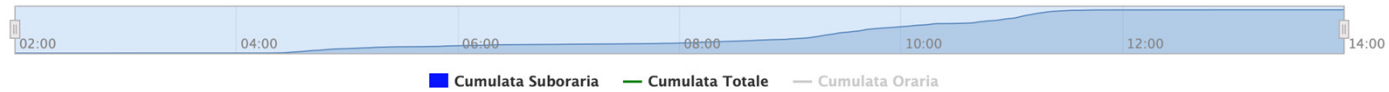
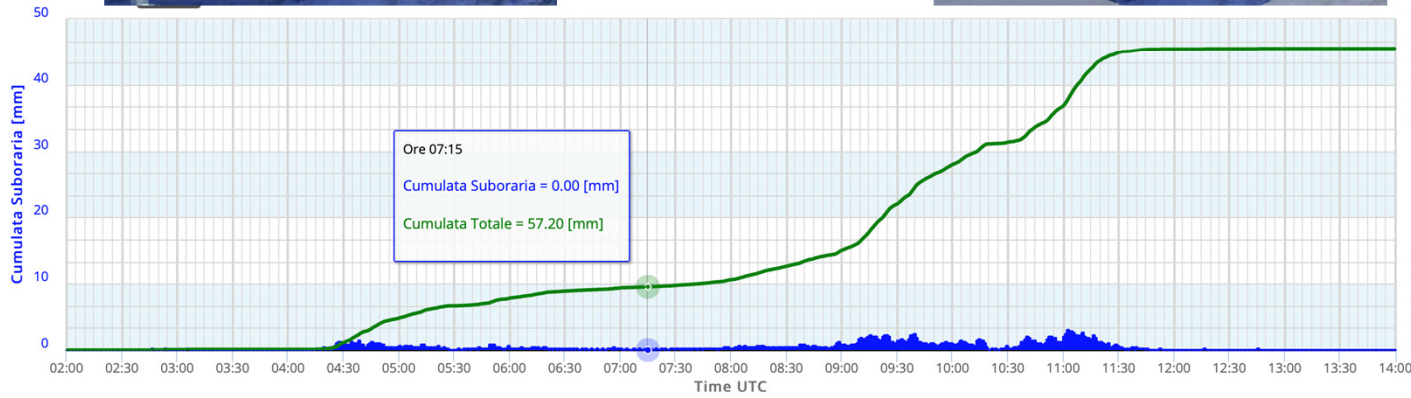
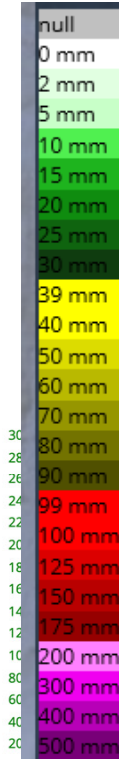
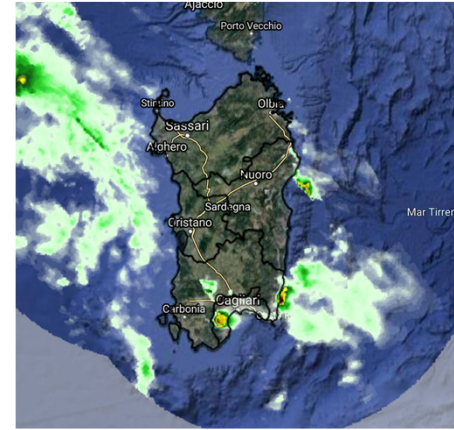
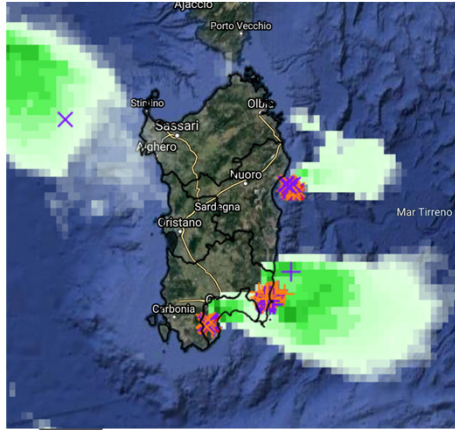


# SURVEILLANCE

(10/10/2018 07.15 UTC)

satellite-lightning

radar



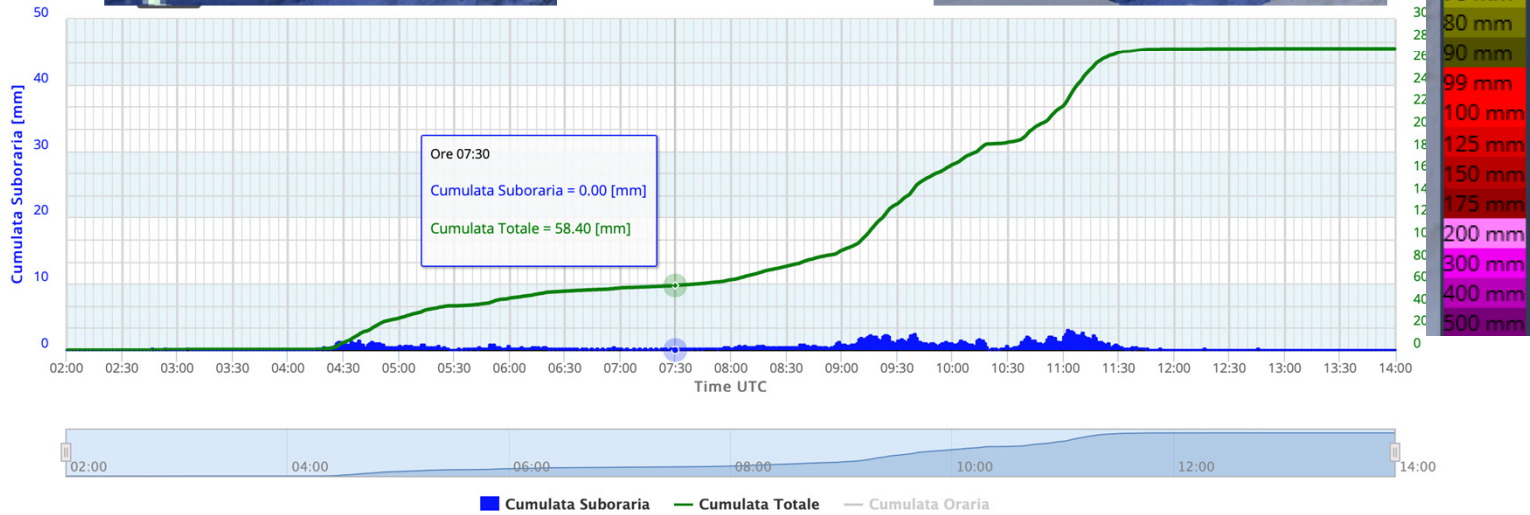
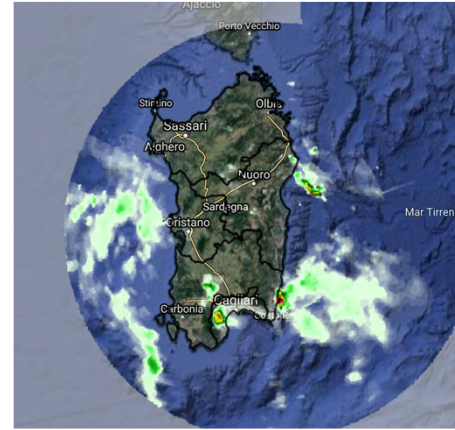
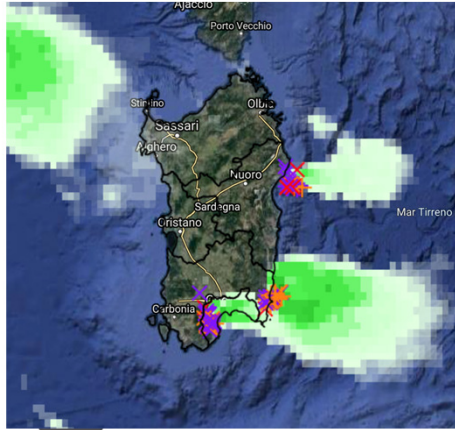


# SURVEILLANCE

(10/10/2018 07.30 UTC)

satellite-lightning

radar

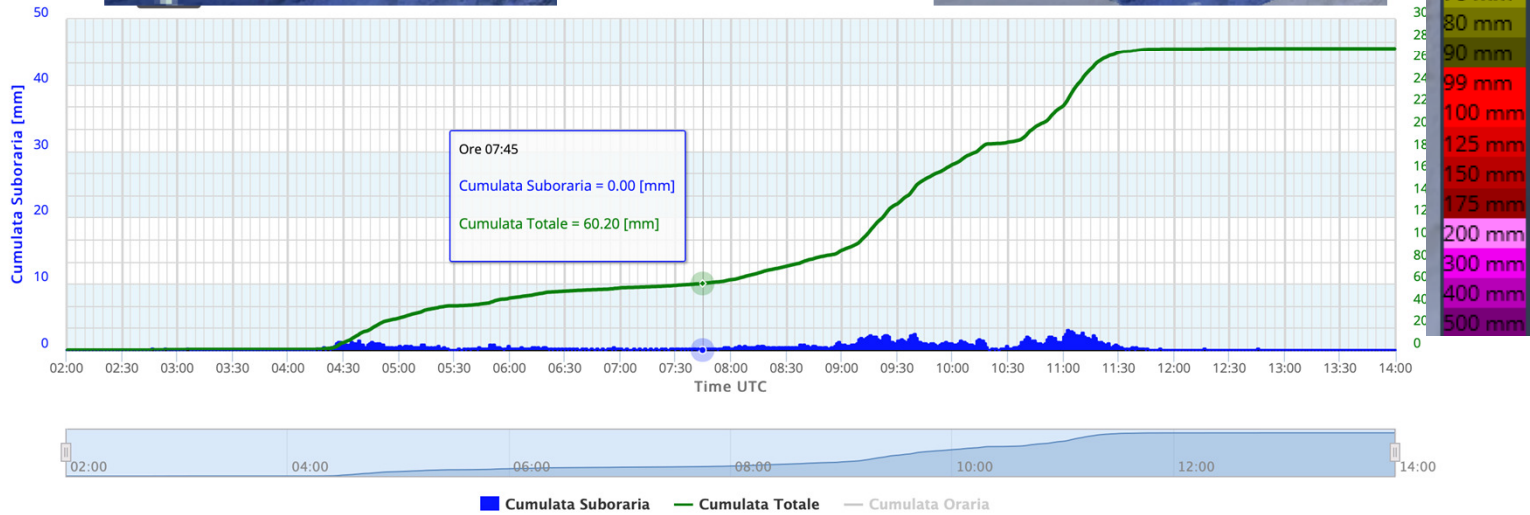
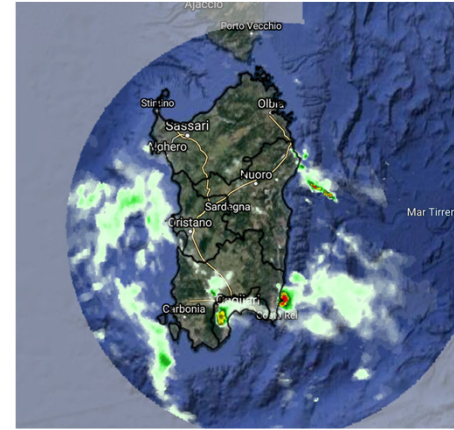
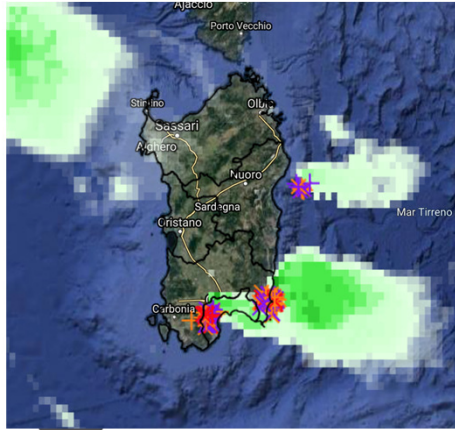


# SURVEILLANCE

(10/10/2018 07.45 UTC)

satellite-lightning

radar

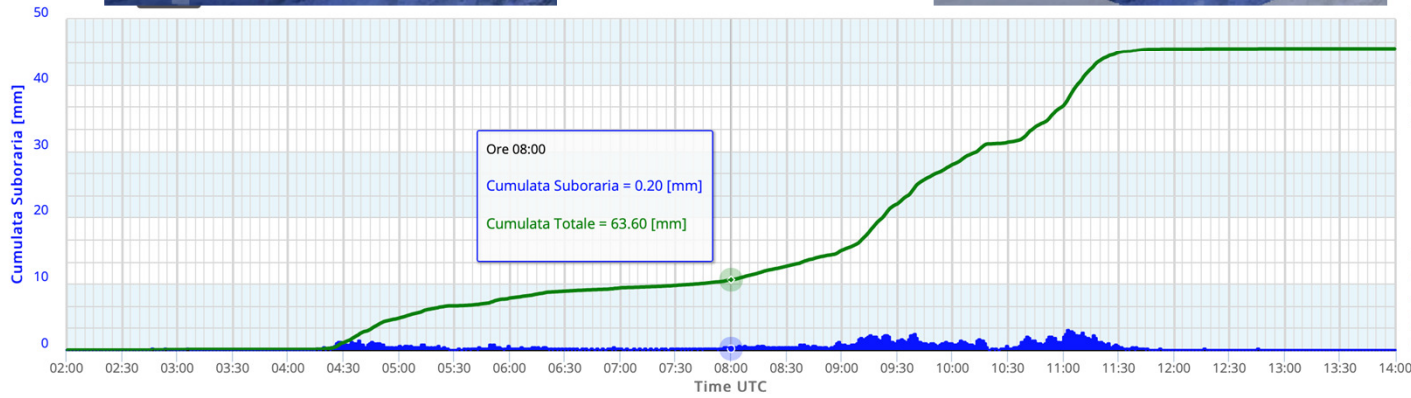
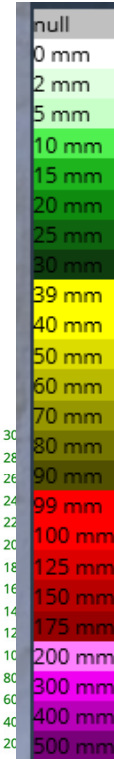
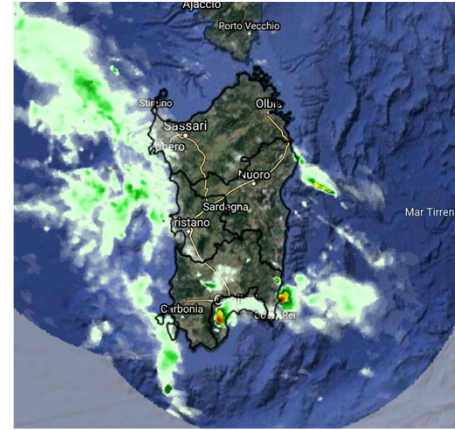
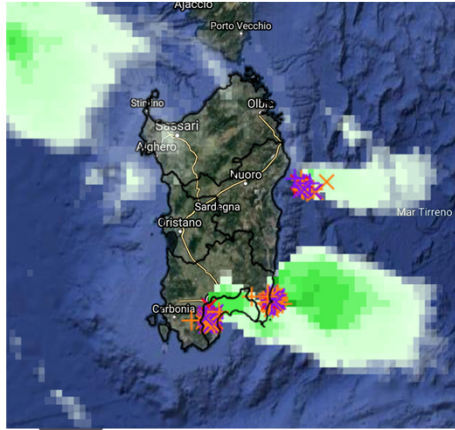


# SURVEILLANCE

(10/10/2018 08.00 UTC)

satellite-lightning

radar



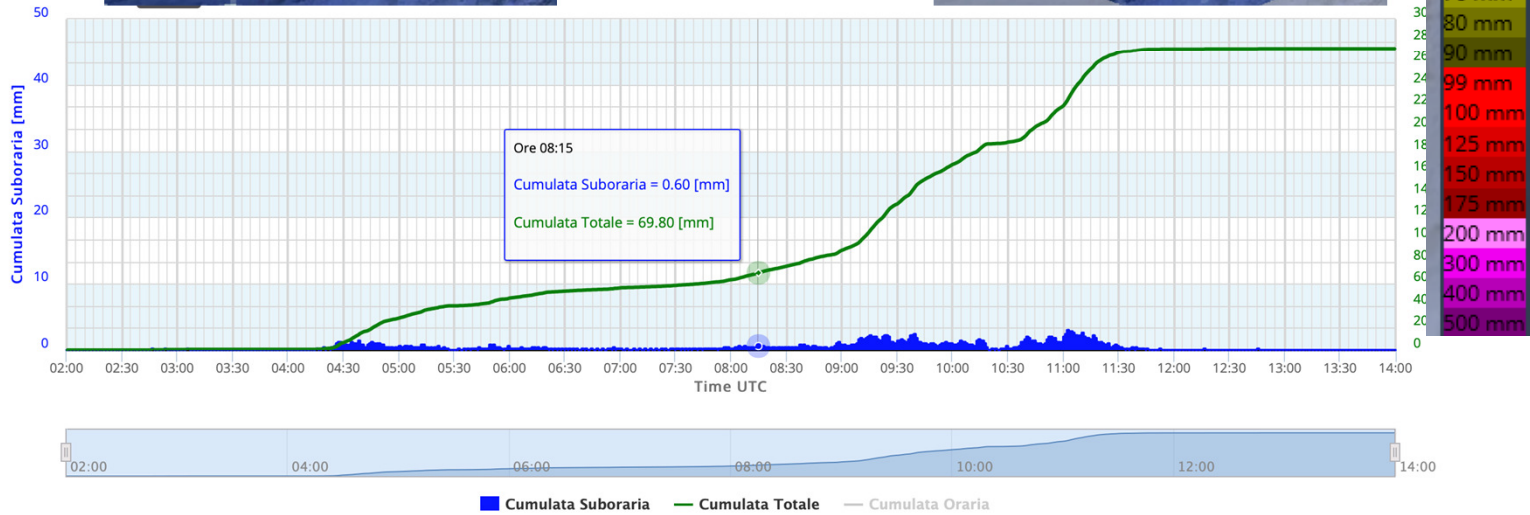
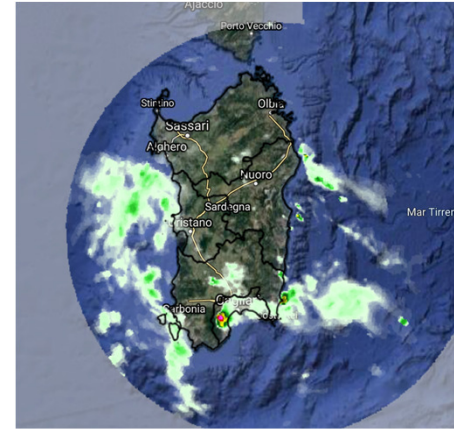
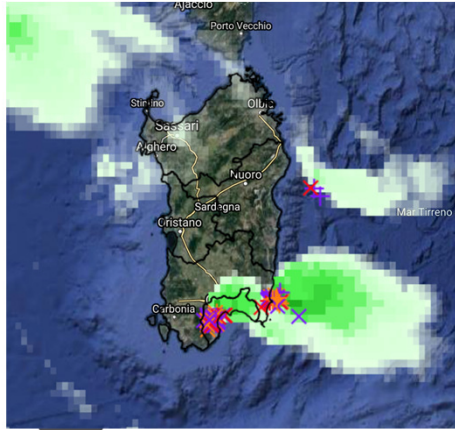


# SURVEILLANCE

(10/10/2018 08.15 UTC)

satellite-lightning

radar

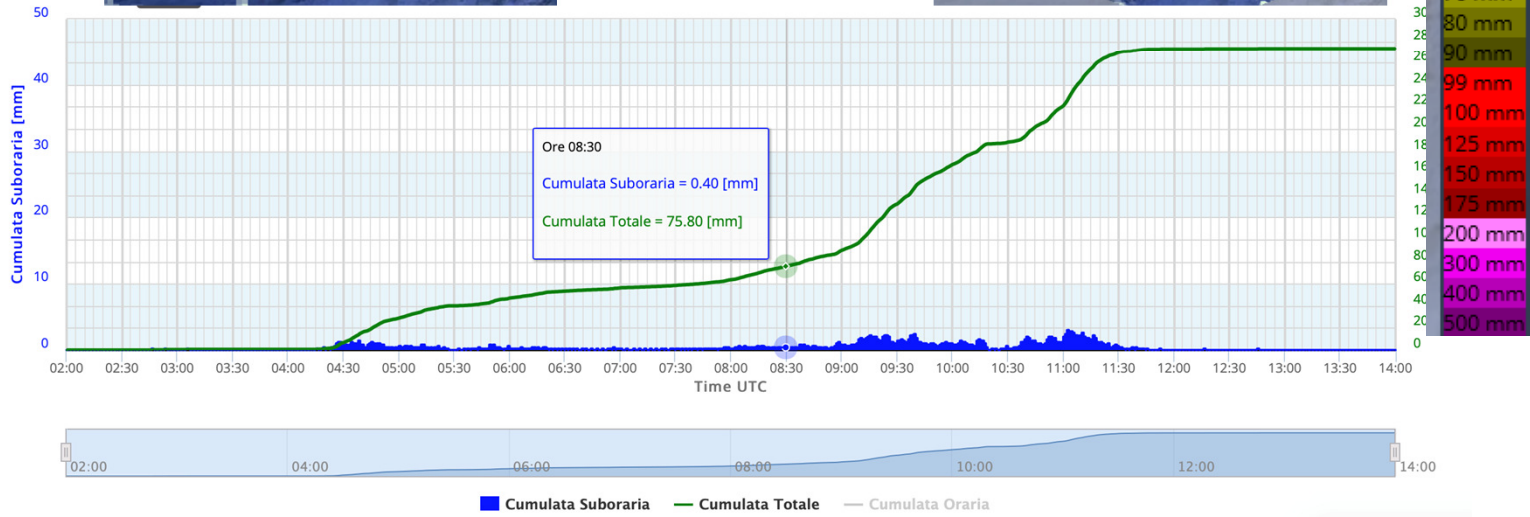
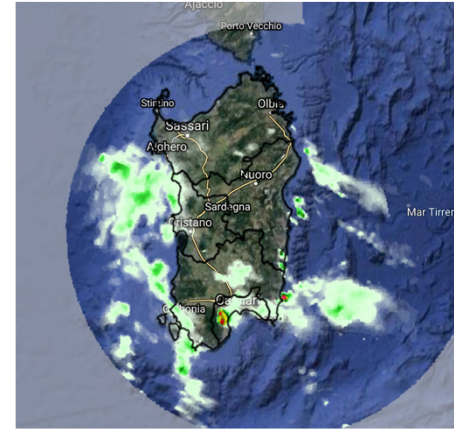
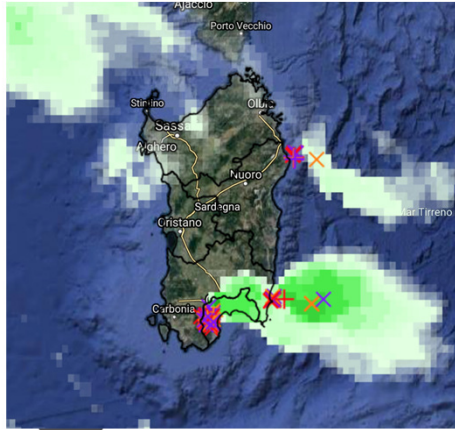


# SURVEILLANCE

(10/10/2018 08.30 UTC)

satellite-lightning

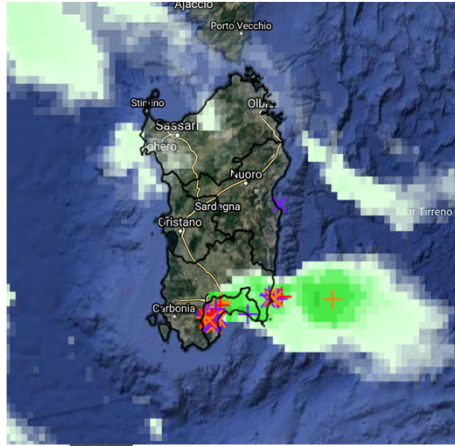
radar



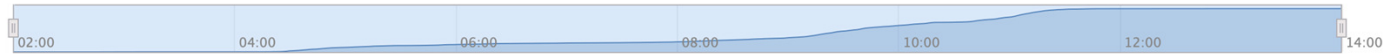
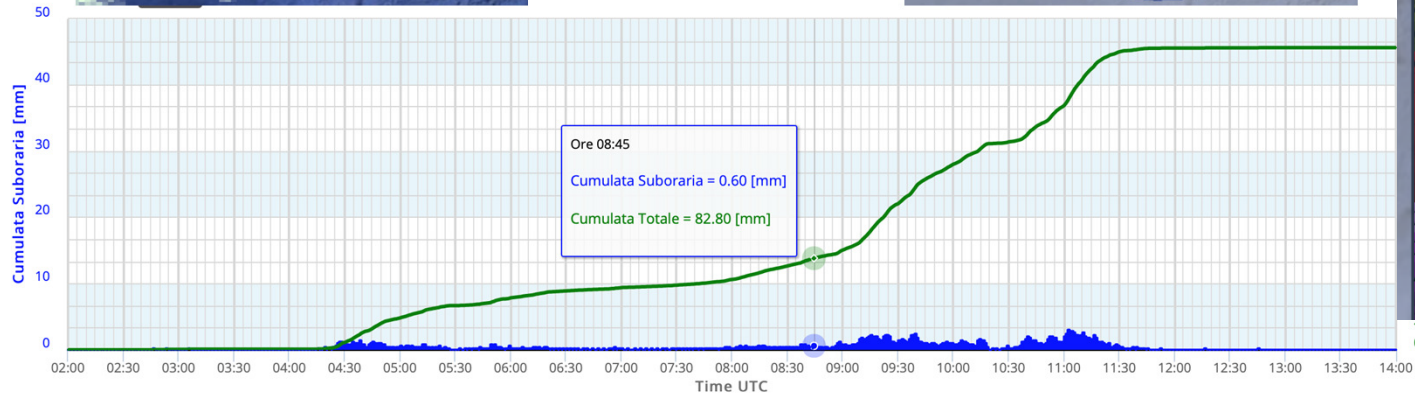
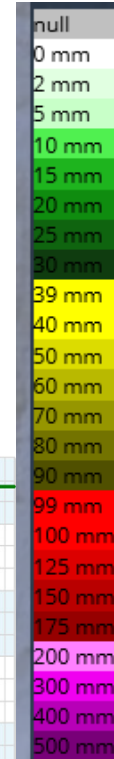
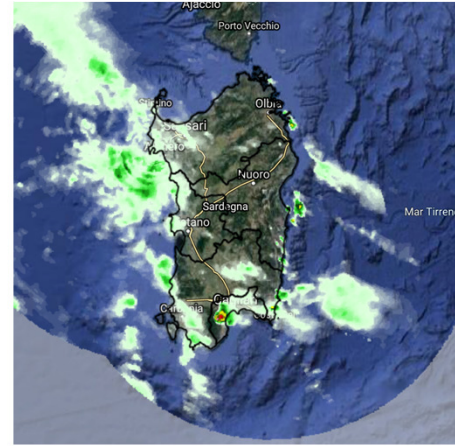
# SURVEILLANCE

(10/10/2018 08.45 UTC)

satellite-lightning



radar



■ Cumulata Suboraria — Cumulata Totale — Cumulata Oraria

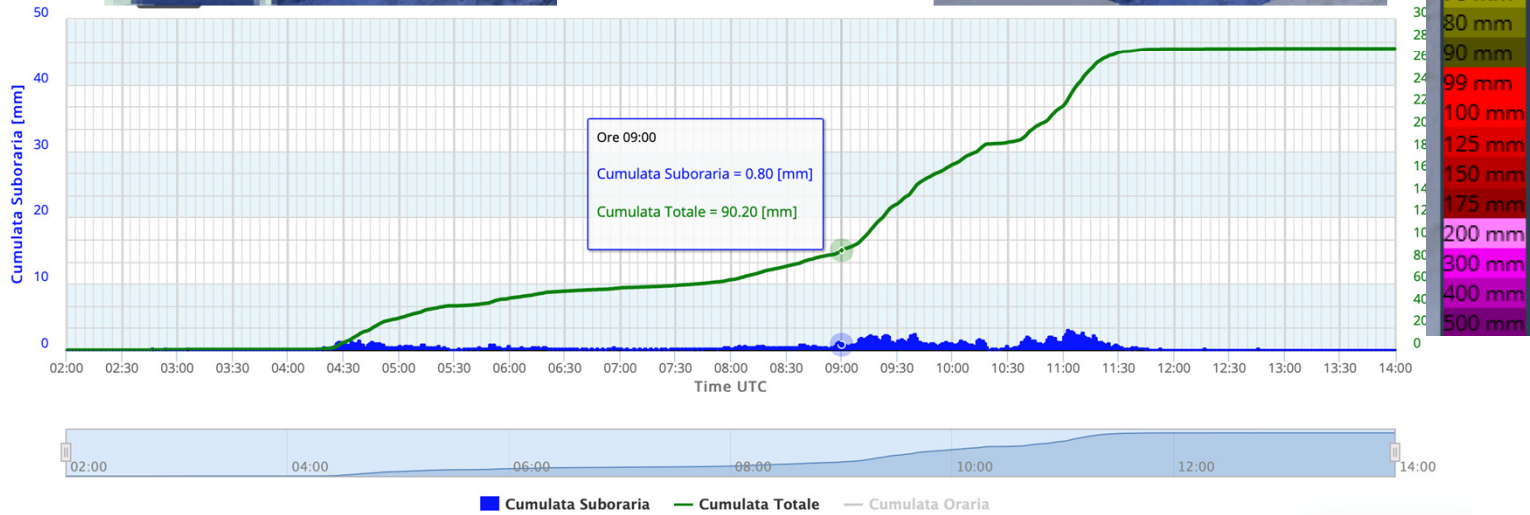
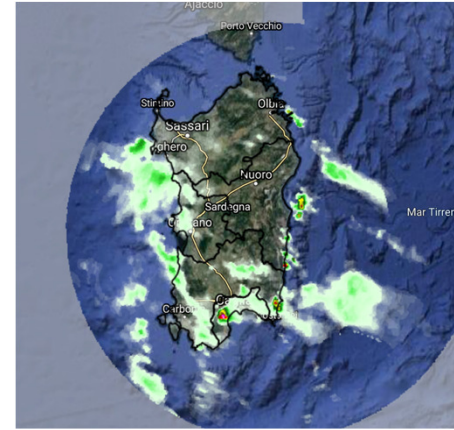
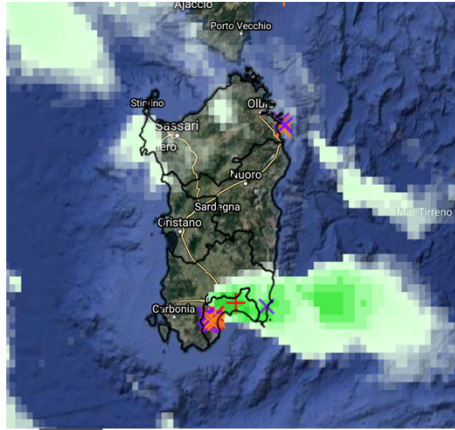


# SURVEILLANCE

(10/10/2018 09.00 UTC)

satellite-lightning

radar

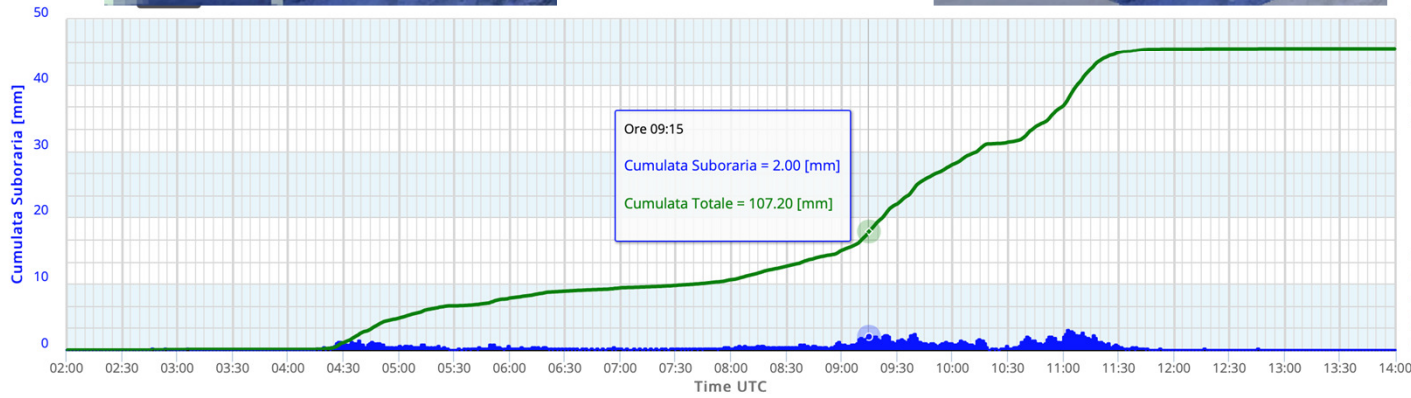
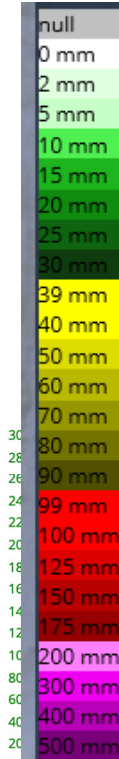
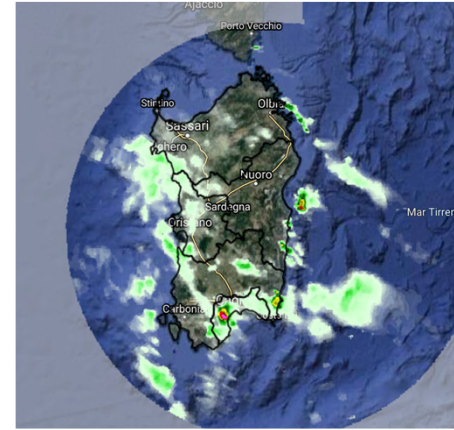
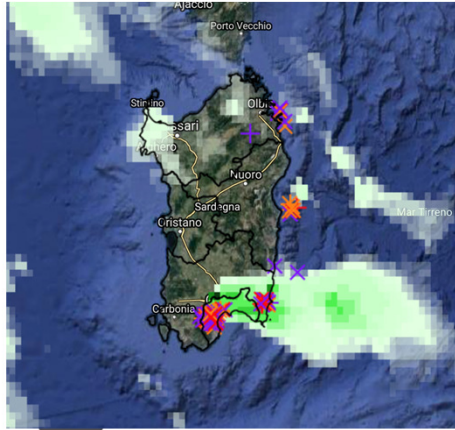


# SURVEILLANCE

(10/10/2018 09.15 UTC)

satellite-lightning

radar

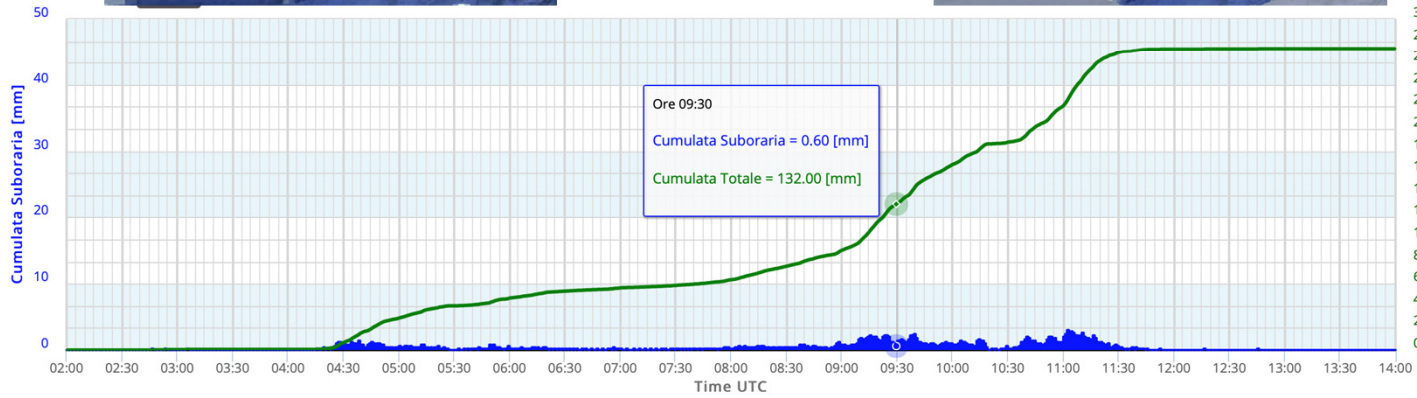
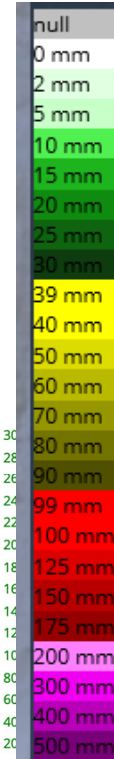
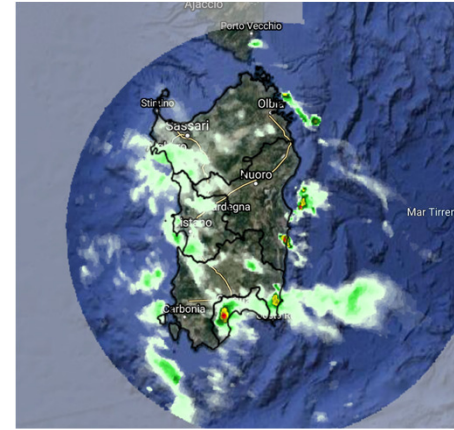
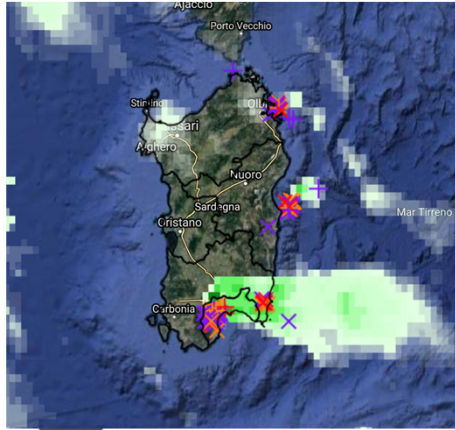


# SURVEILLANCE

(10/10/2018 09.30 UTC)

satellite-lightning

radar



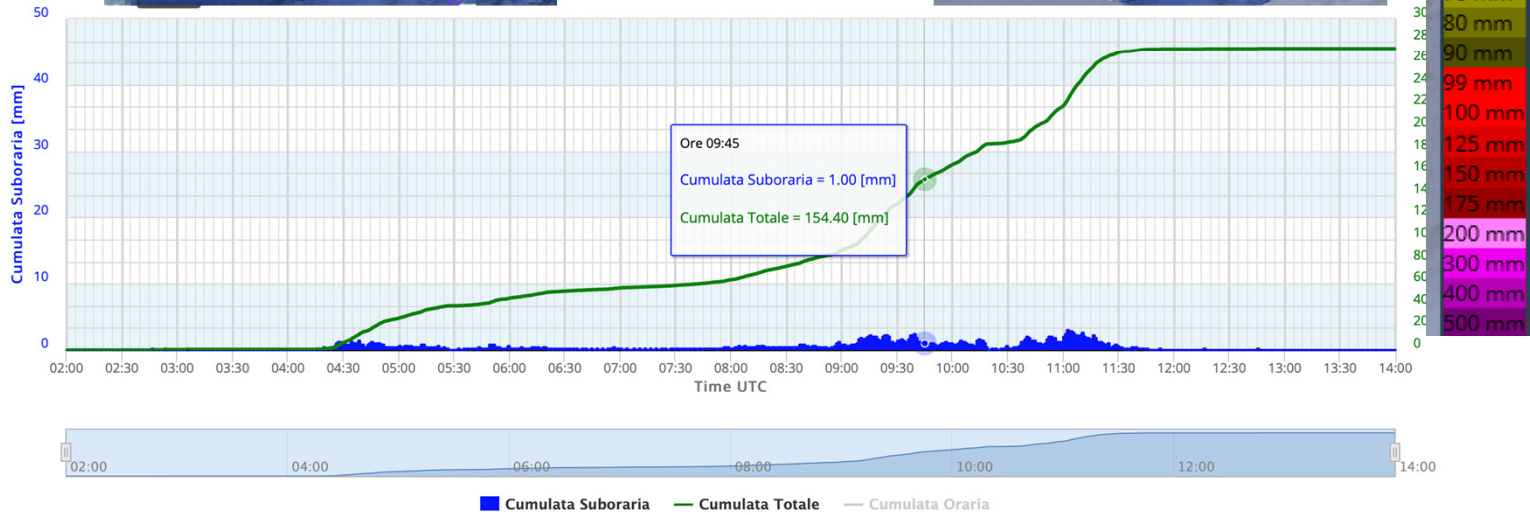
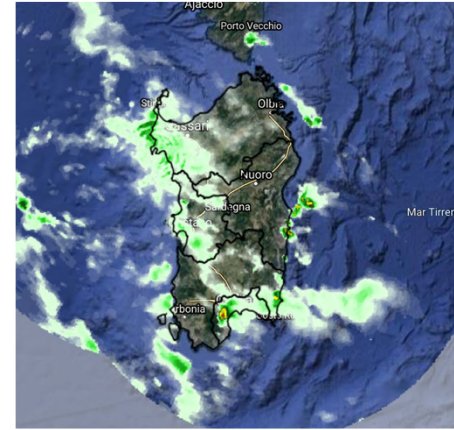
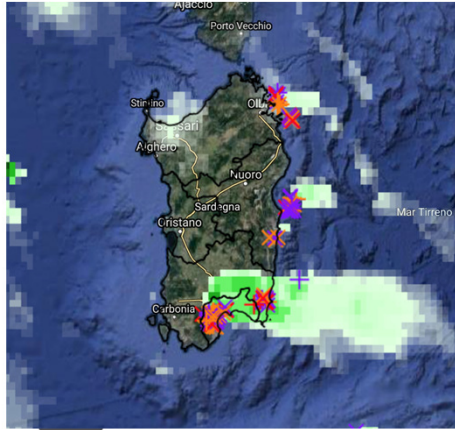


# SURVEILLANCE

(10/10/2018 09.45 UTC)

satellite-lightning

radar

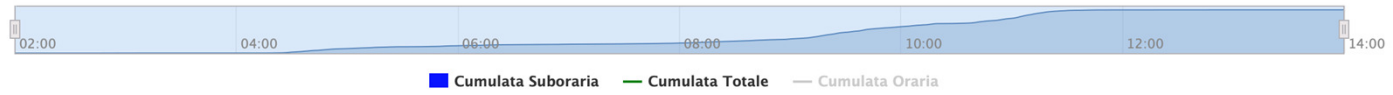
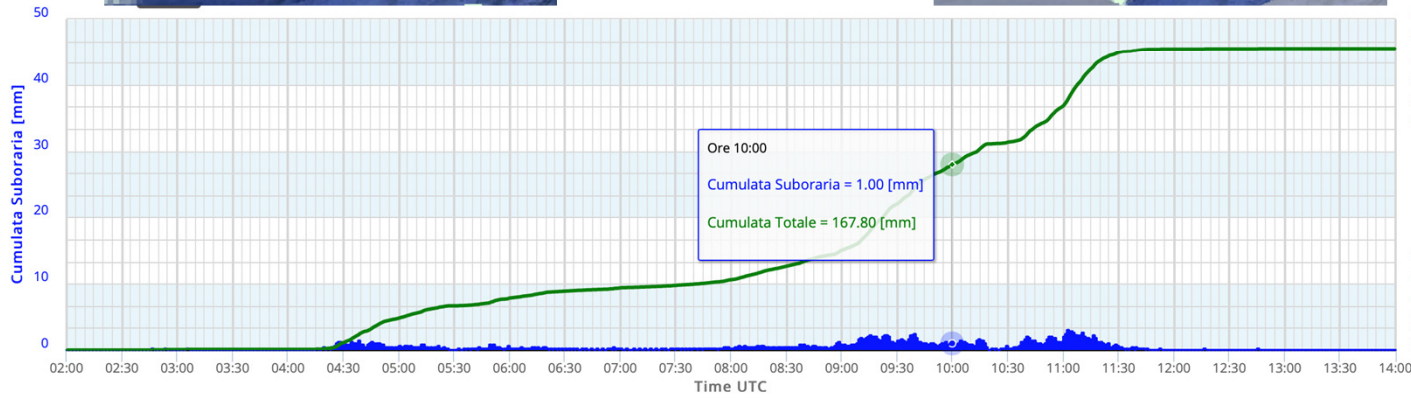
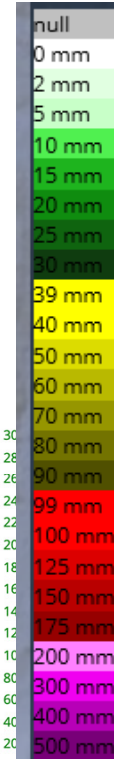
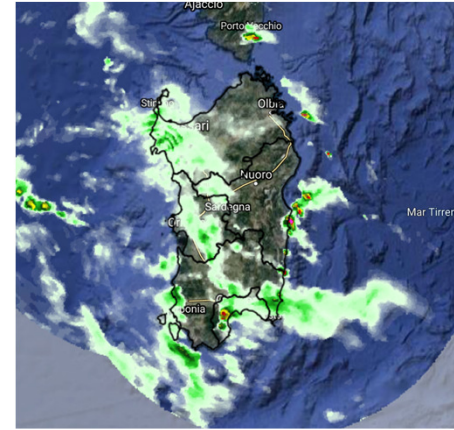
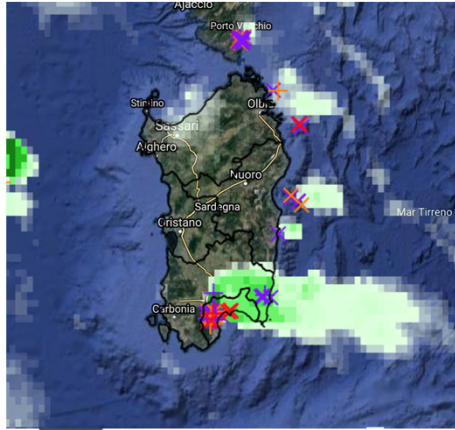


# SURVEILLANCE

(10/10/2018 10.00 UTC)

satellite-lightning

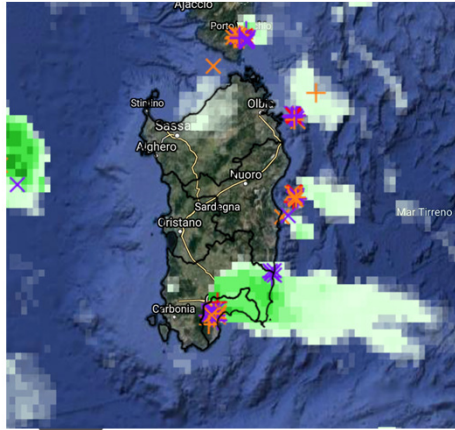
radar



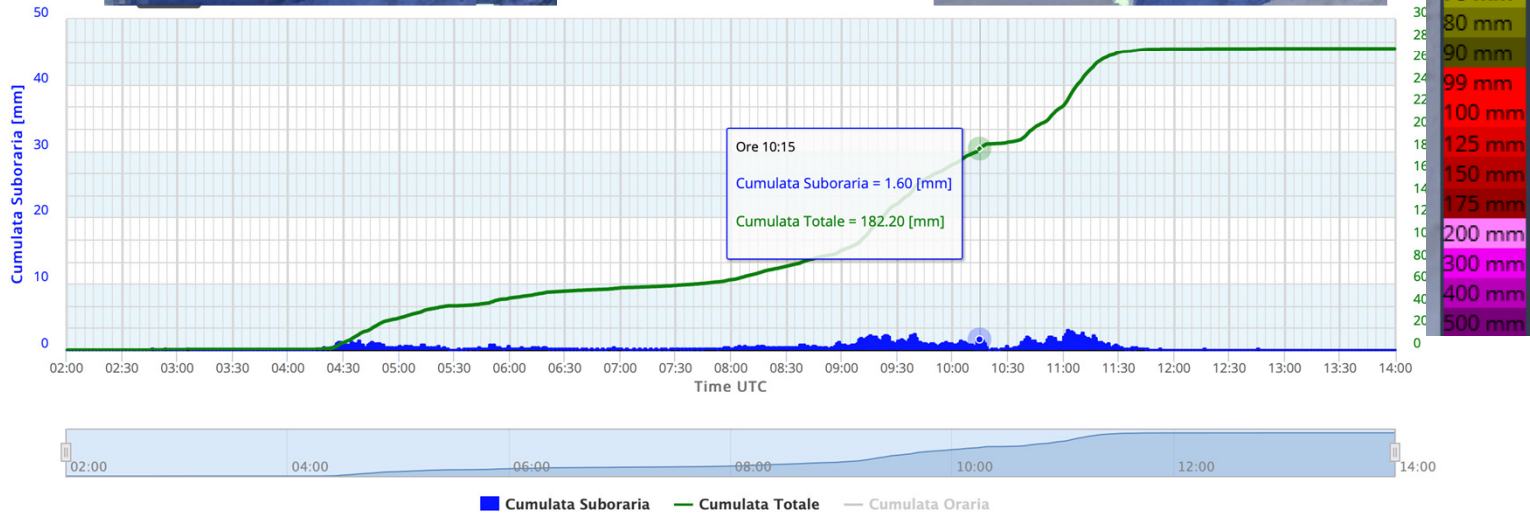
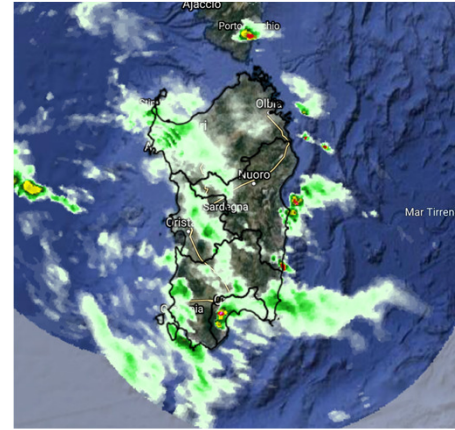
# SURVEILLANCE

(10/10/2018 10.15 UTC)

satellite-lightning



radar

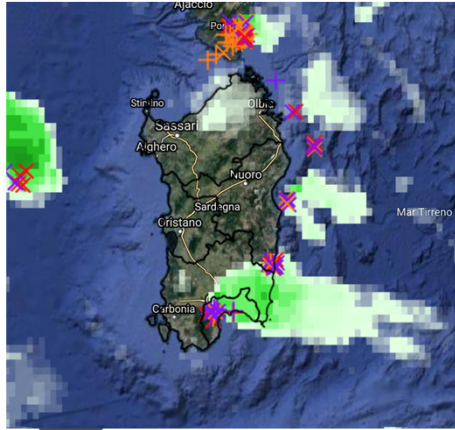




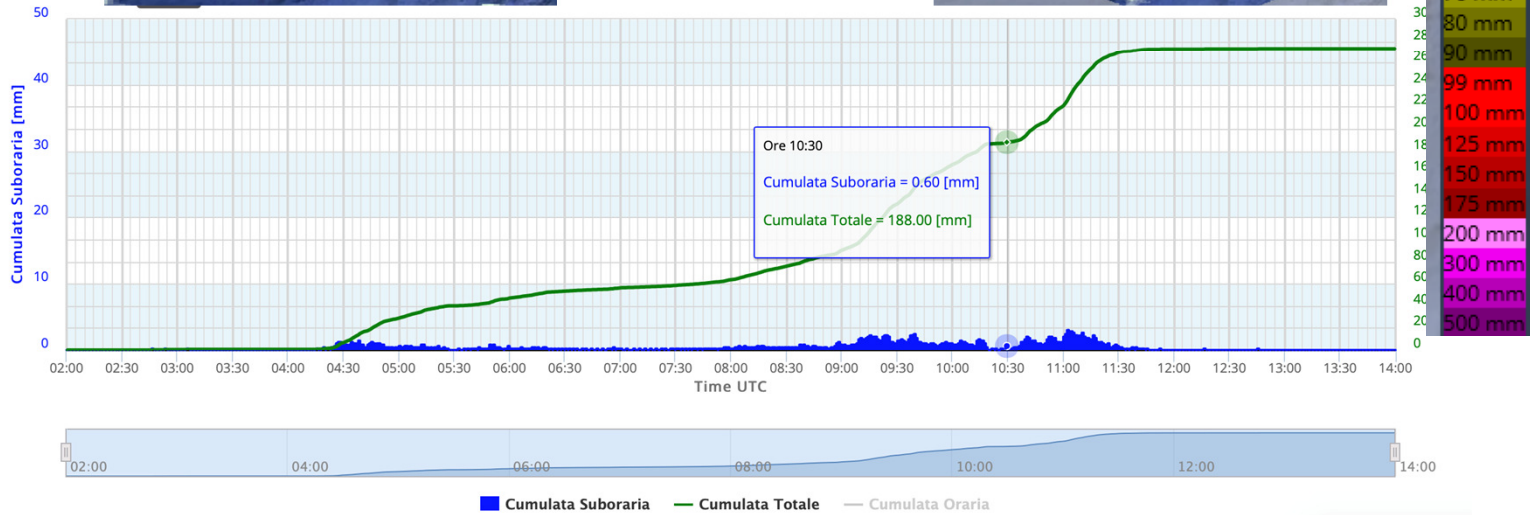
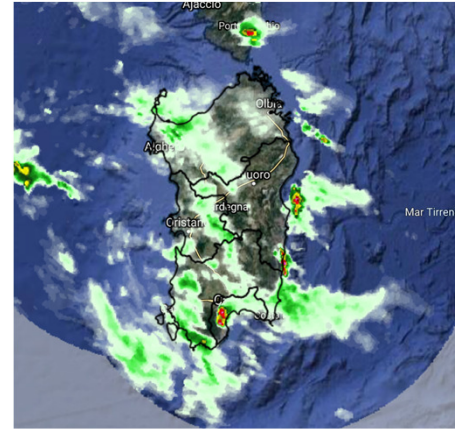
# SURVEILLANCE

(10/10/2018 10.30 UTC)

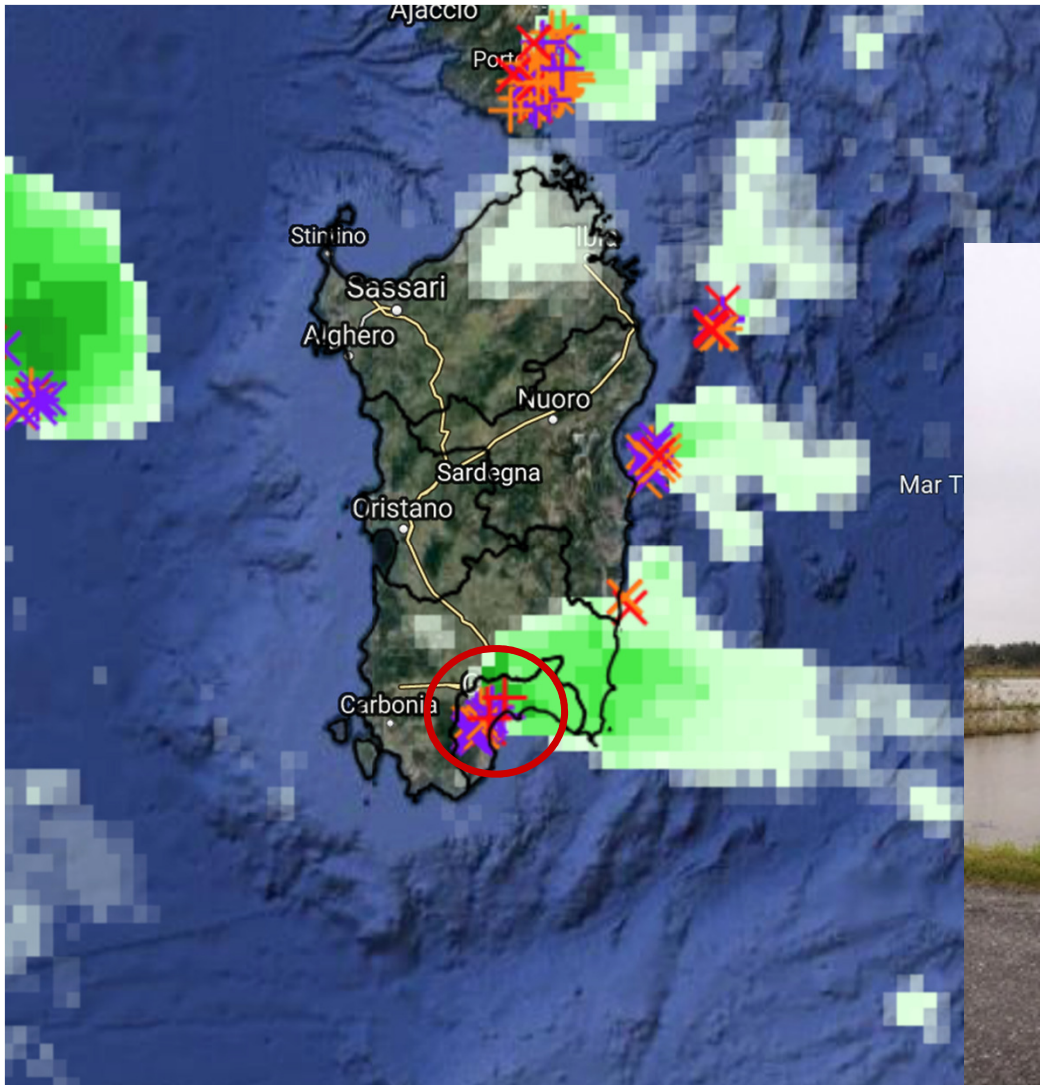
satellite-lightning



radar



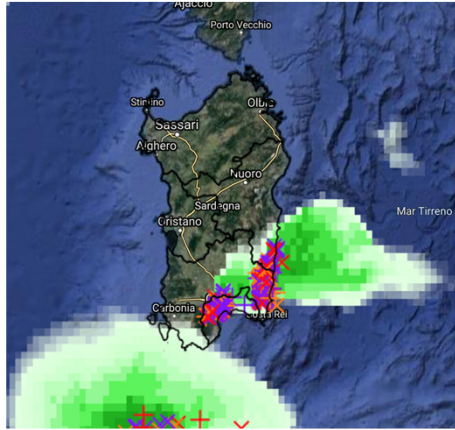
(10/10/2018 10.45 UTC)



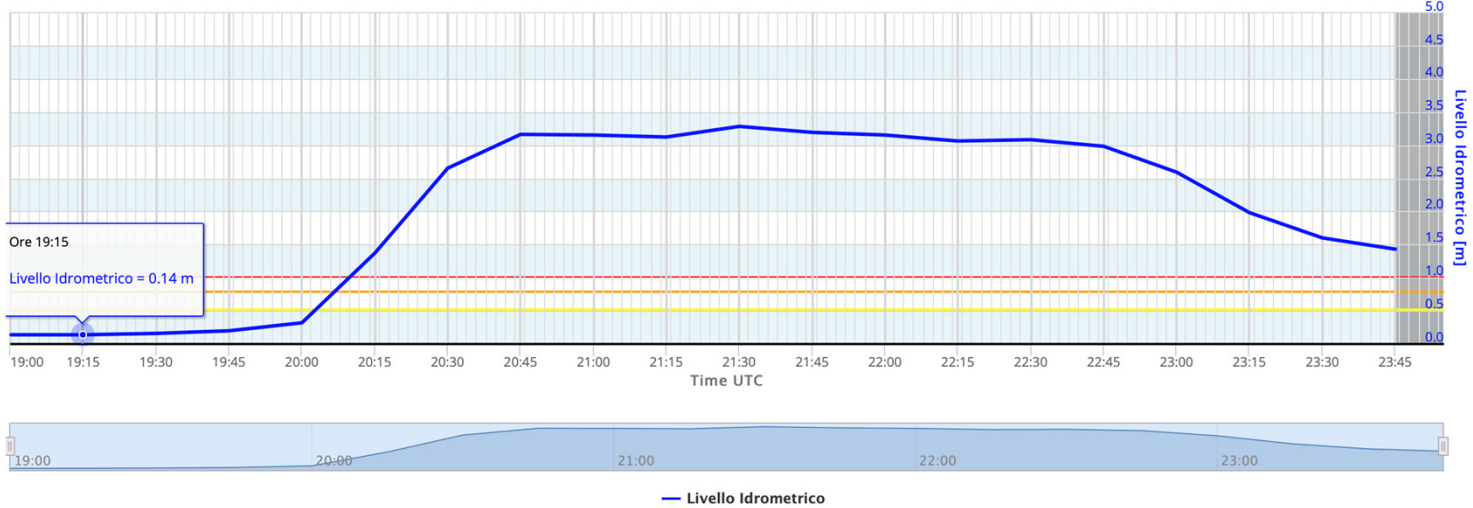
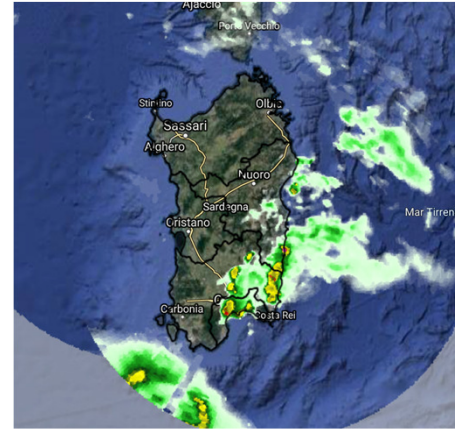
# SURVEILLANCE

(10/10/2018 19.15 UTC)

satellite-lightning



radar

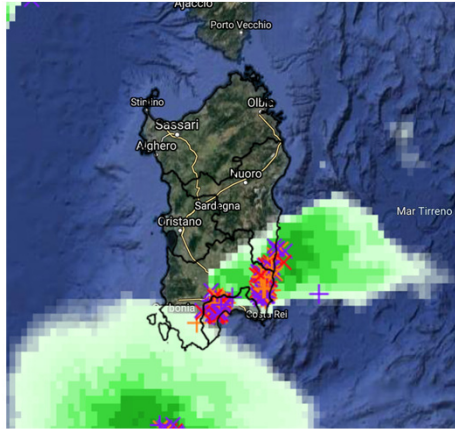




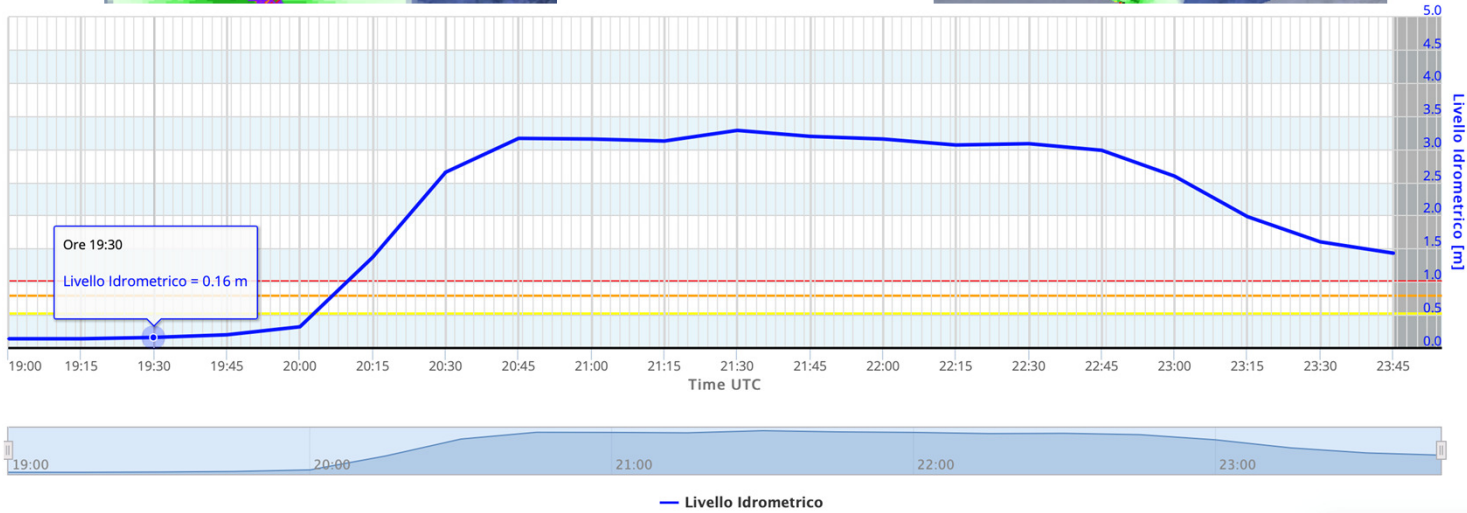
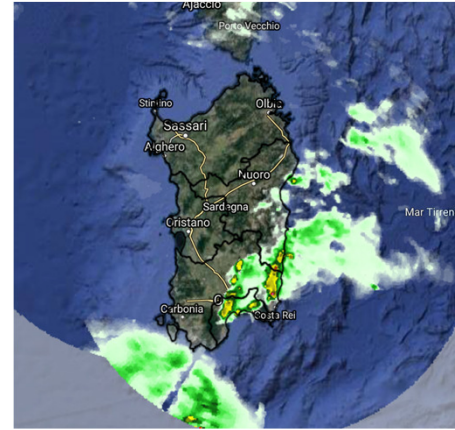
# SURVEILLANCE

(10/10/2018 19.30 UTC)

satellite-lightning



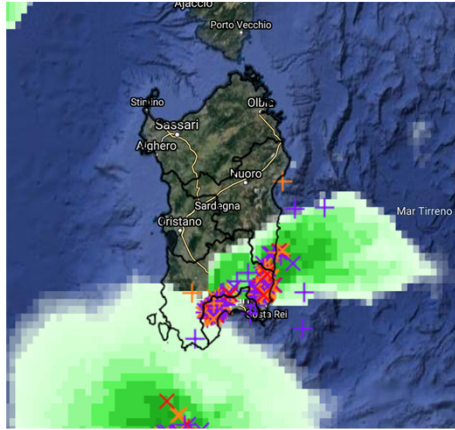
radar



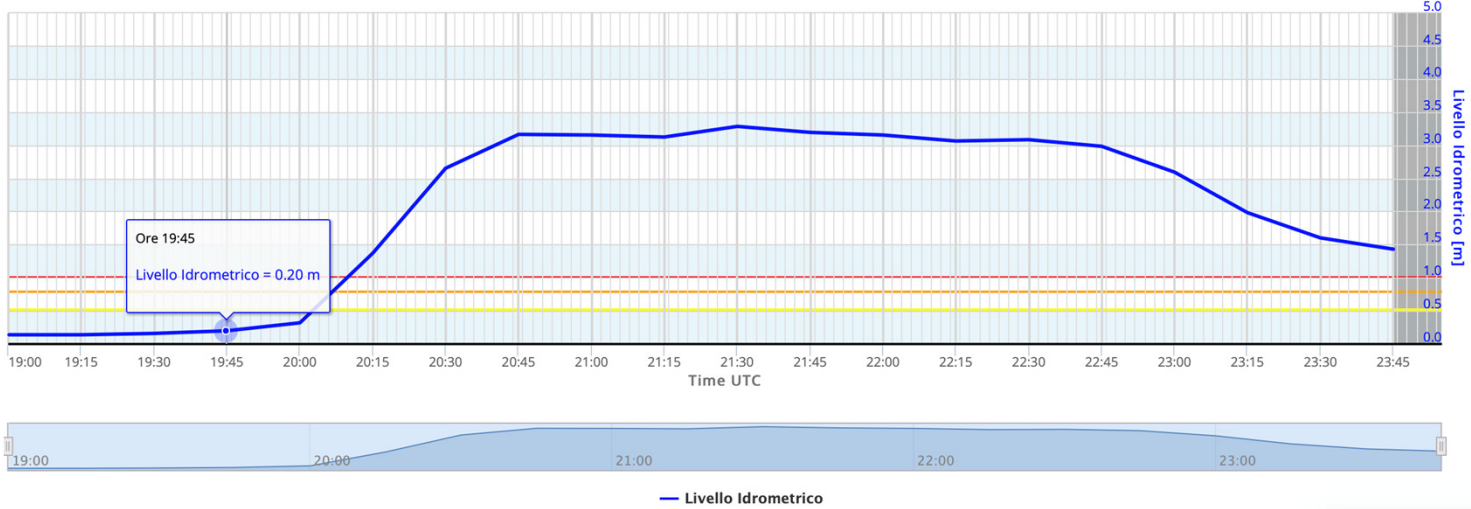
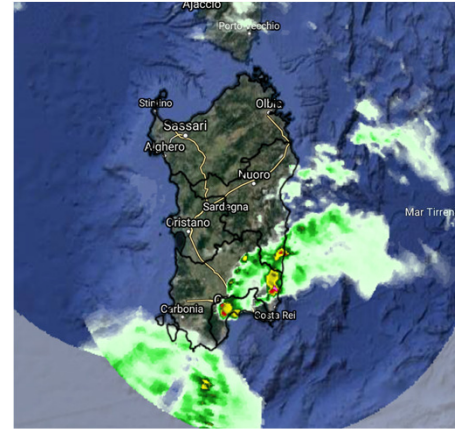
# SURVEILLANCE

(10/10/2018 19.45 UTC)

satellite-lightning



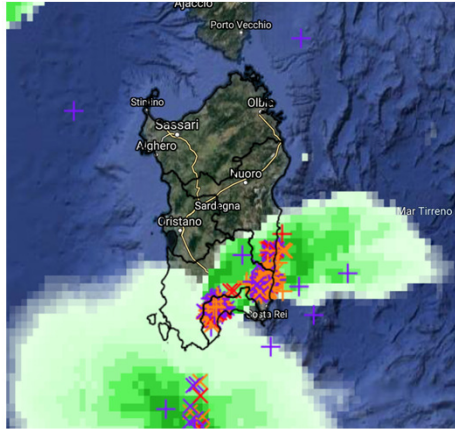
radar



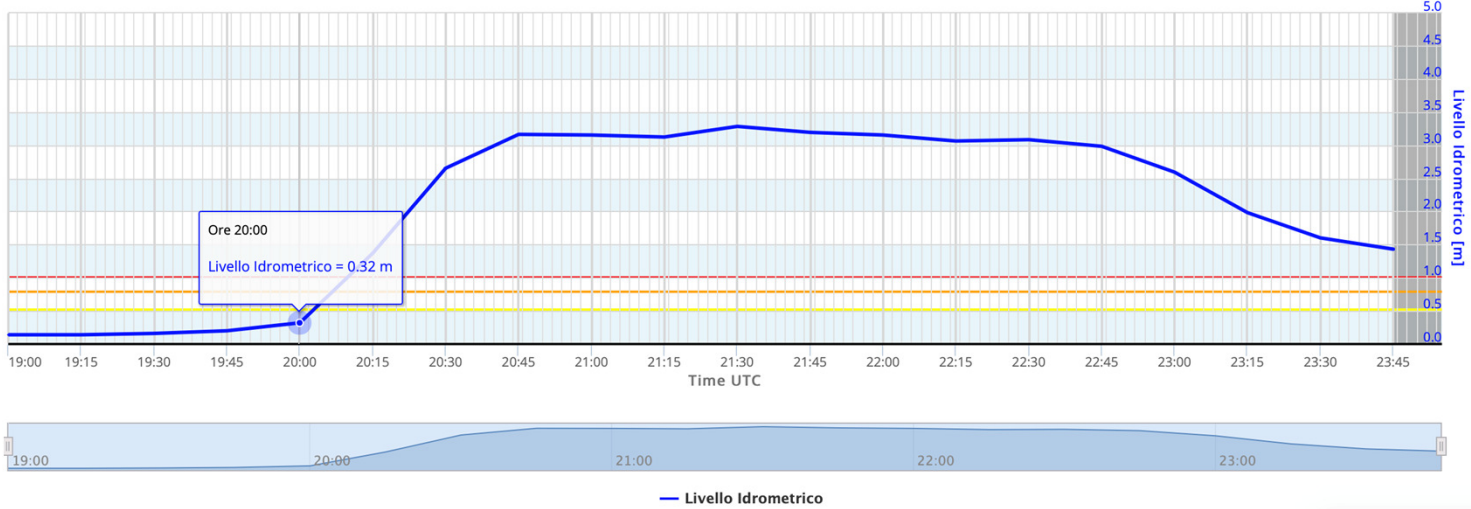
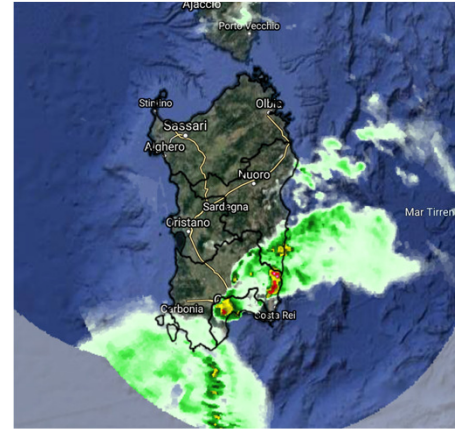
# SURVEILLANCE

(10/10/2018 20.00 UTC)

satellite-lightning



radar

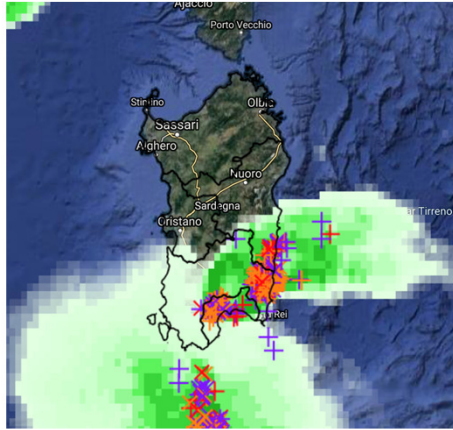




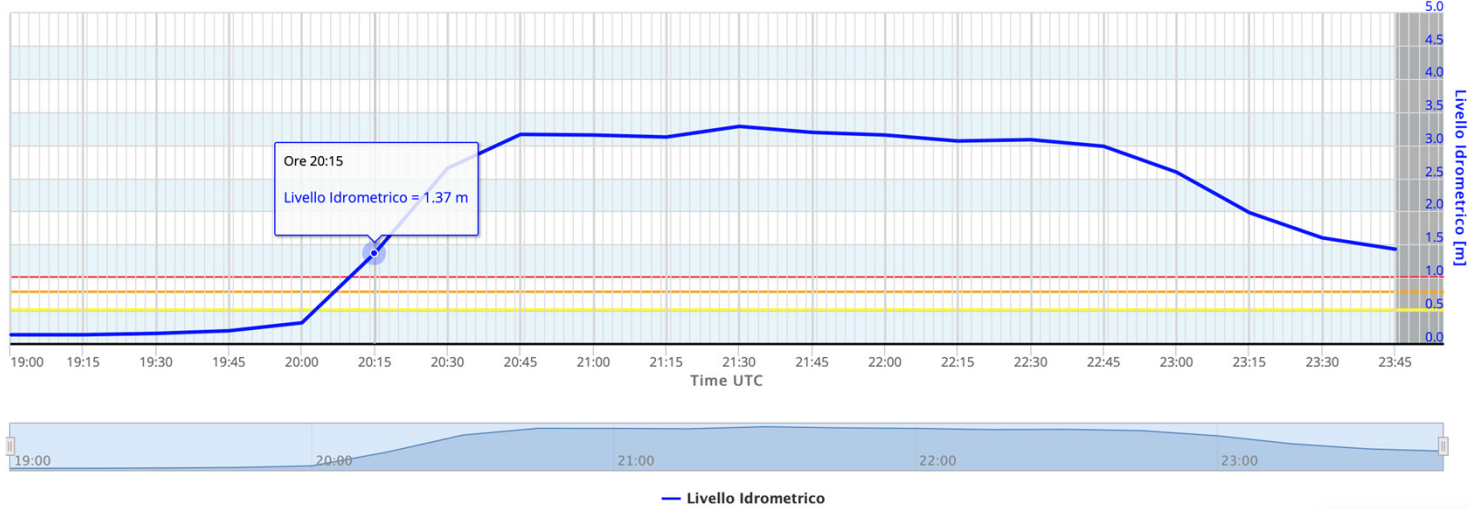
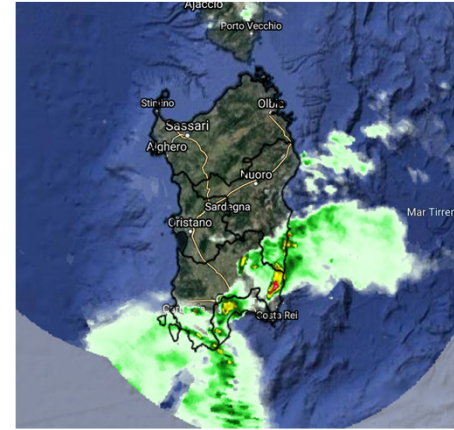
# SURVEILLANCE

(10/10/2018 20.15 UTC)

satellite-lightning



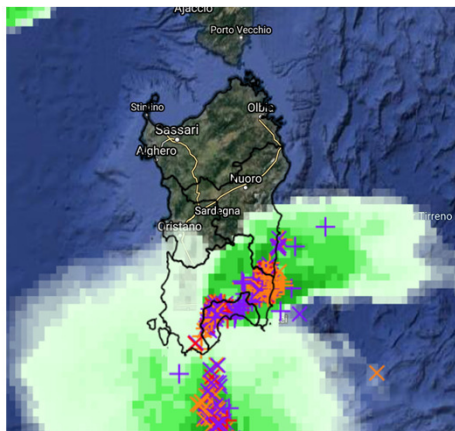
radar



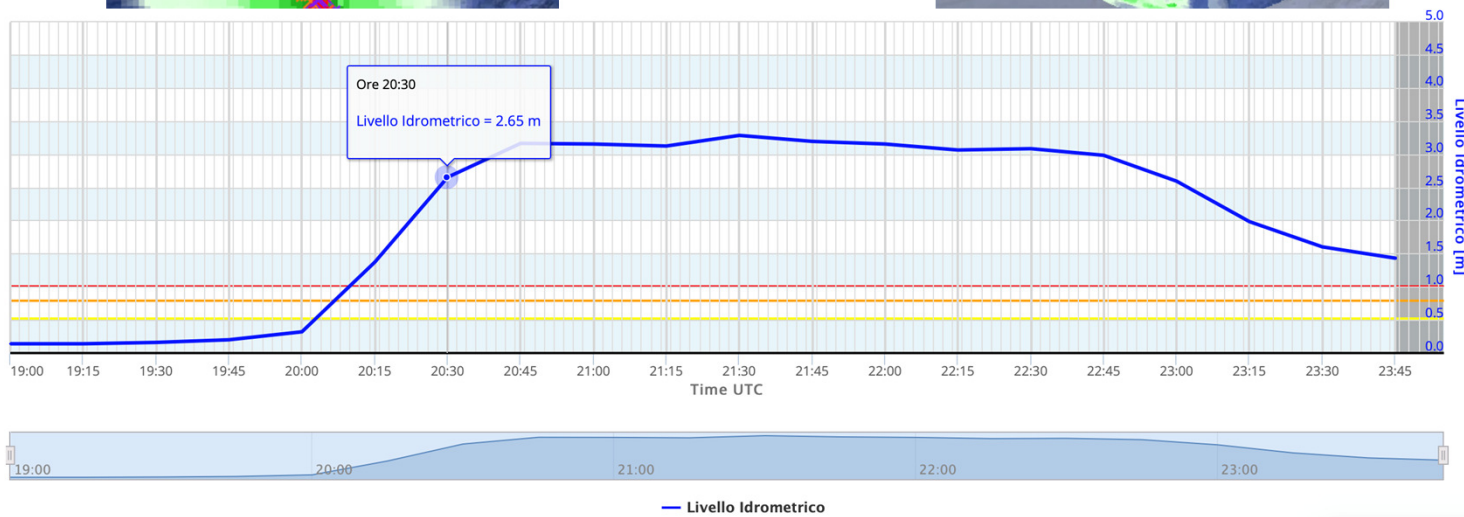
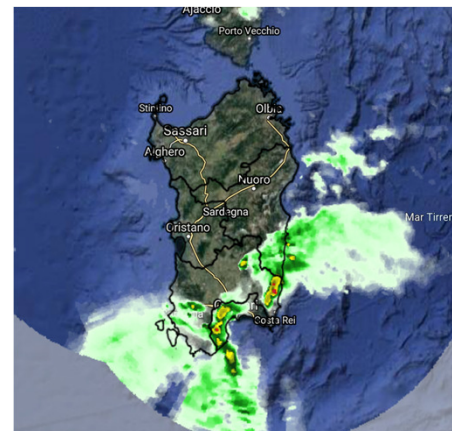
# SURVEILLANCE

(10/10/2018 20.30 UTC)

satellite-lightning



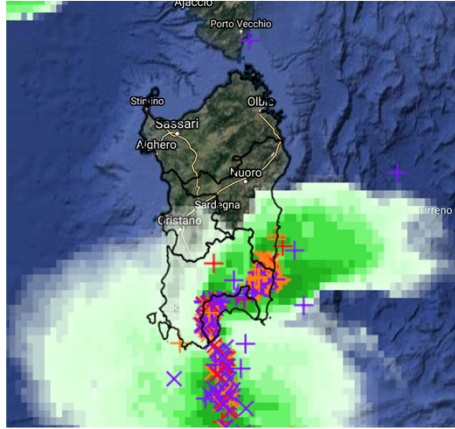
radar



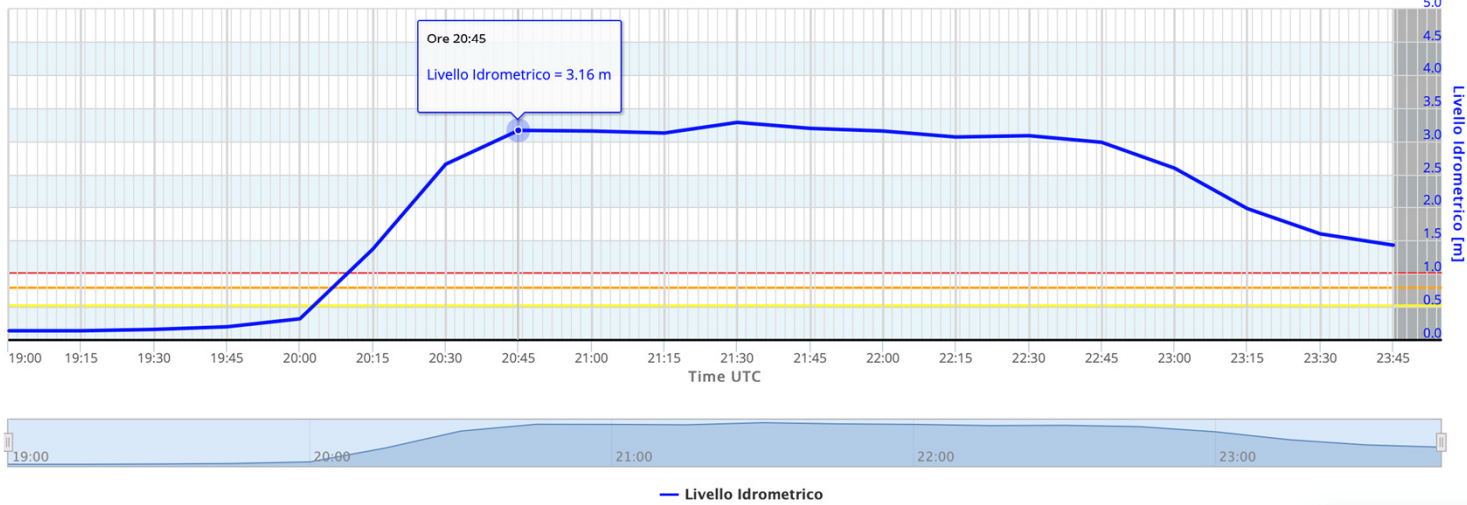
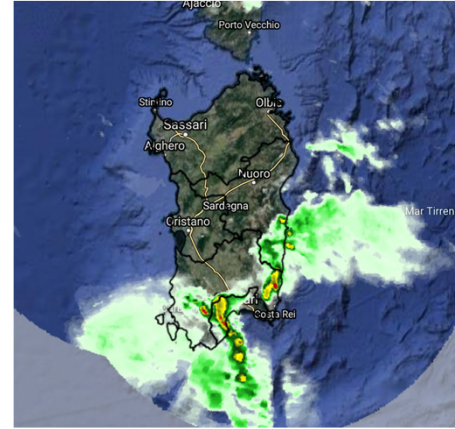
# SURVEILLANCE

(10/10/2018 20.45 UTC)

satellite-lightning



radar

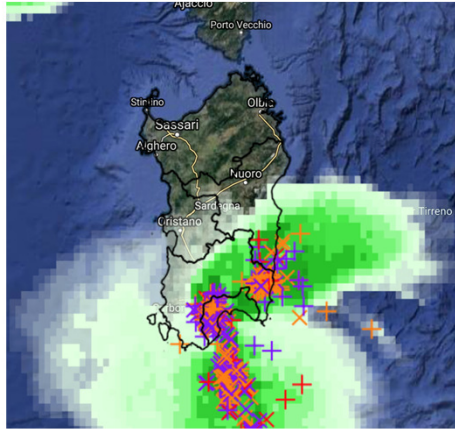




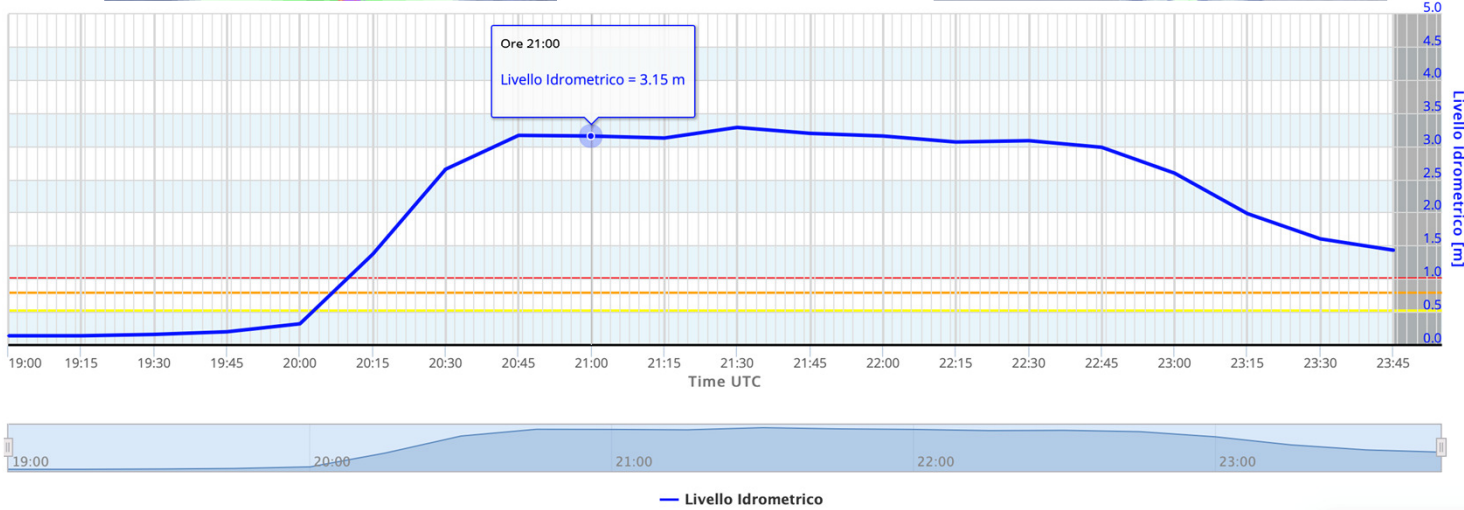
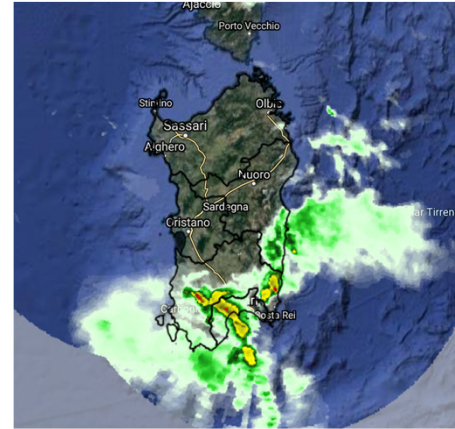
# SURVEILLANCE

(10/10/2018 21.00 UTC)

satellite-lightning



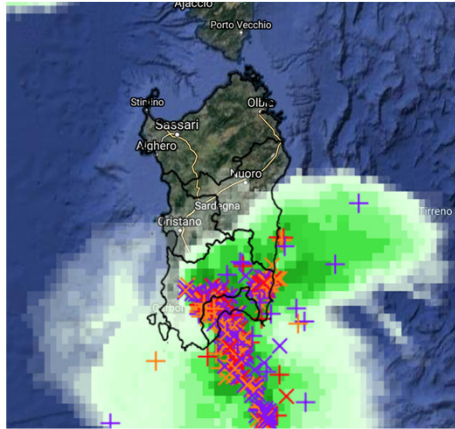
radar



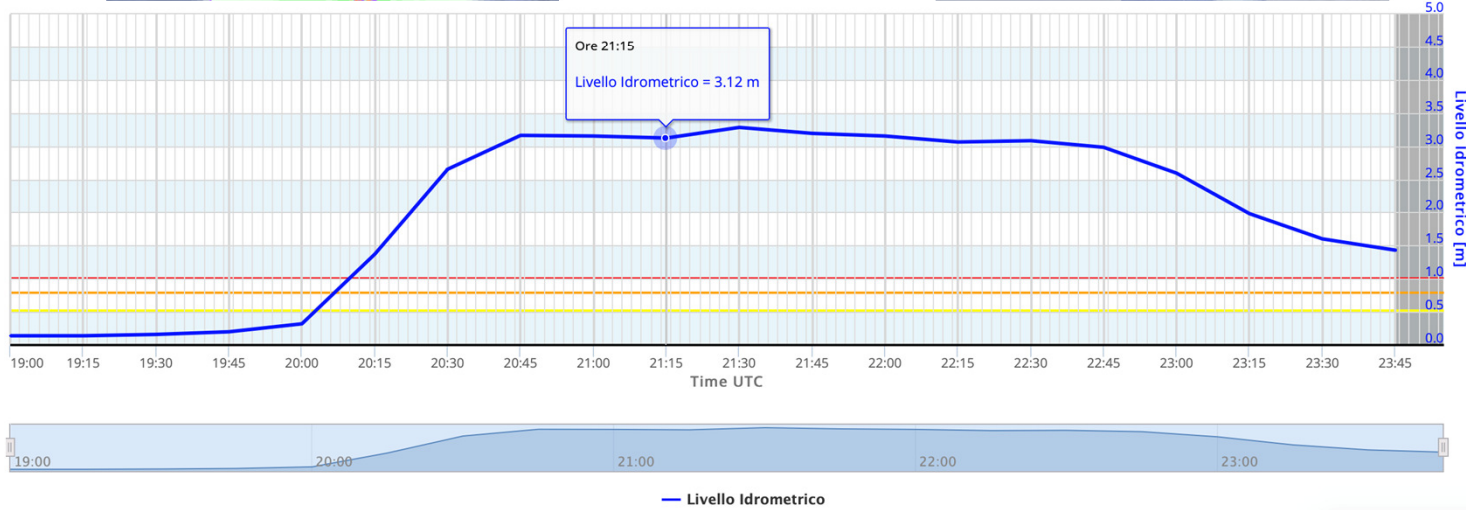
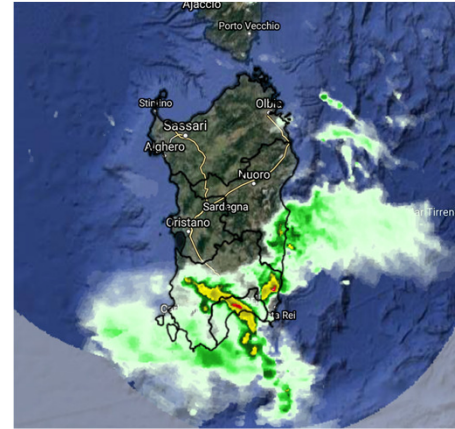
# SURVEILLANCE

(10/10/2018 21.15 UTC)

satellite-lightning



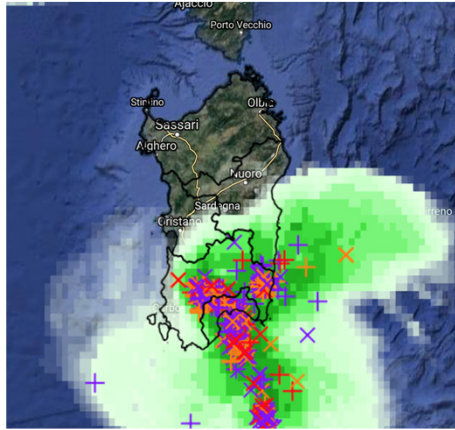
radar



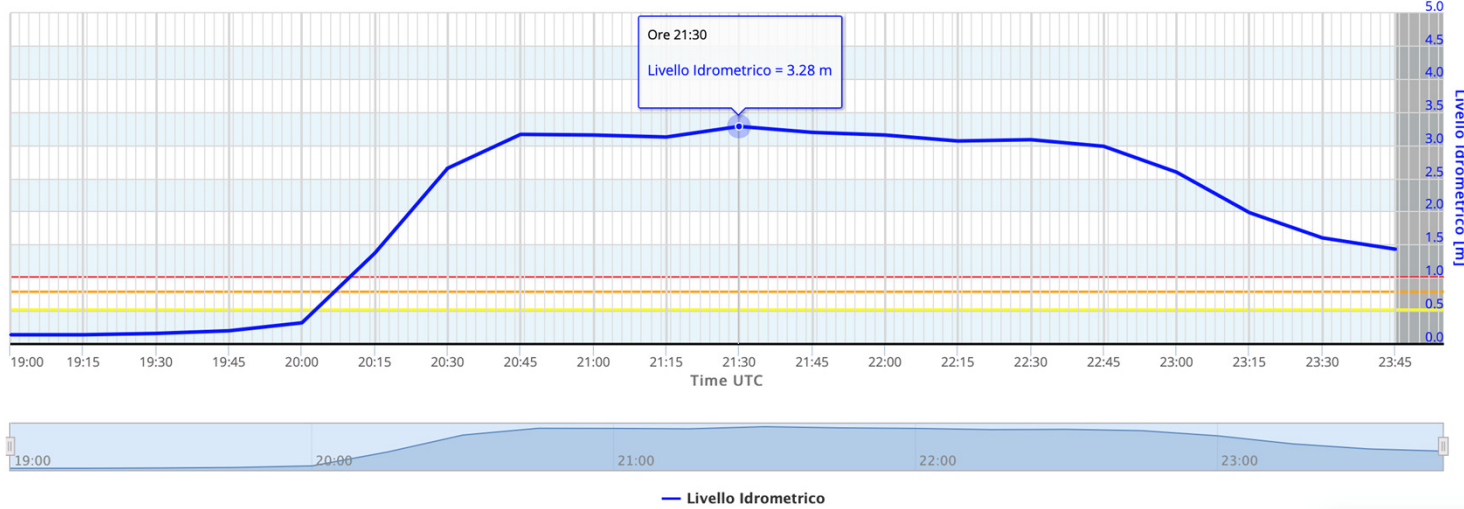
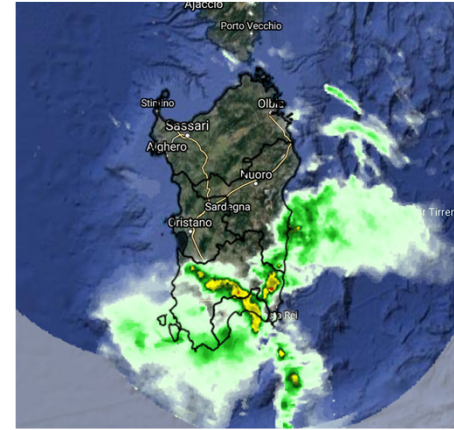
# SURVEILLANCE

(10/10/2018 21.30 UTC)

satellite-lightning



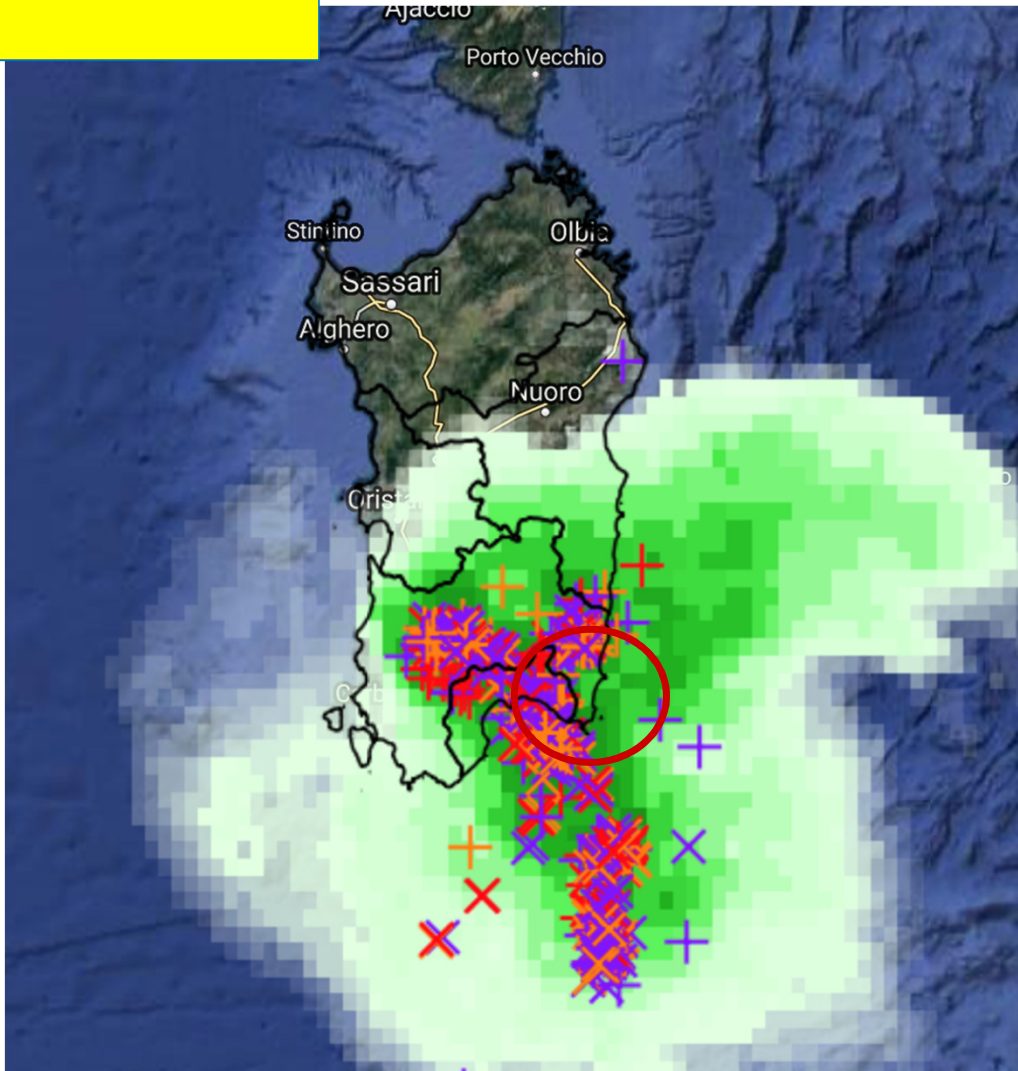
radar

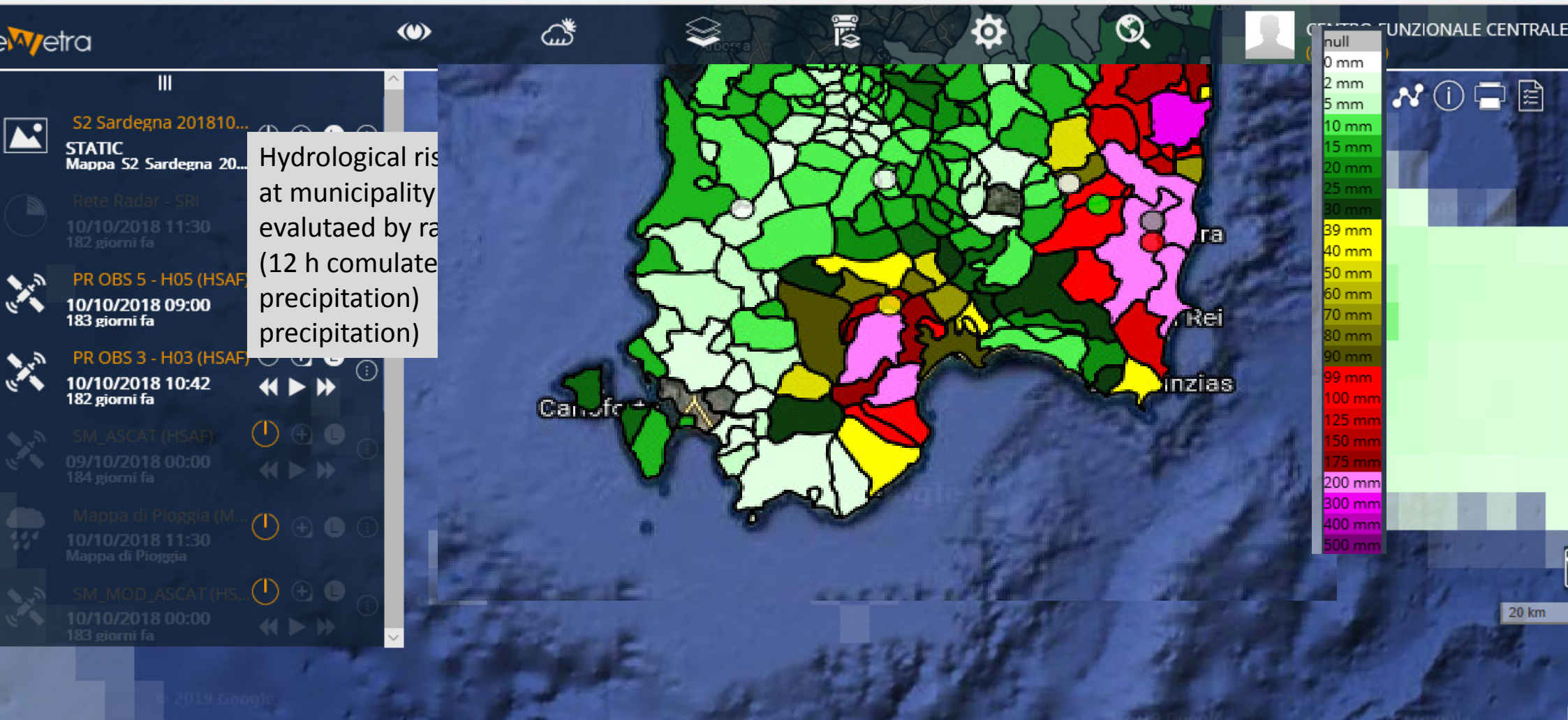




# SURVEILLANCE

(10/10/2018 21.45 UTC)



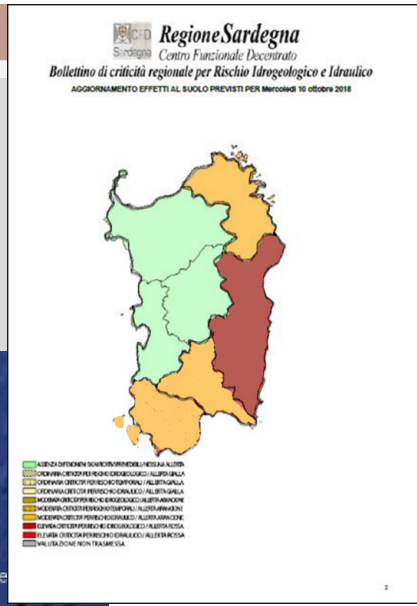
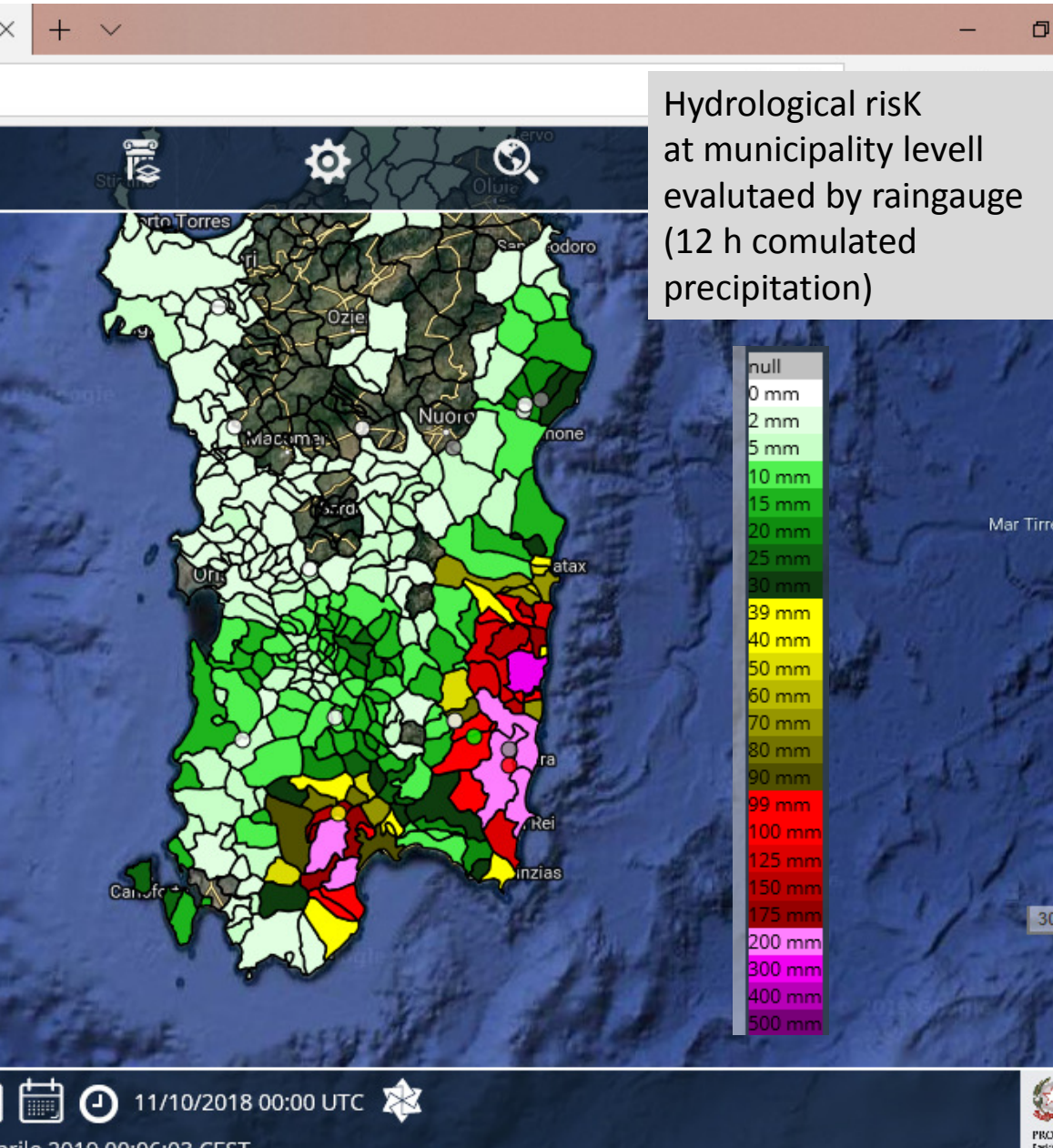


Hydrological risk at municipality evaluated by radar (12 h cumulative precipitation)

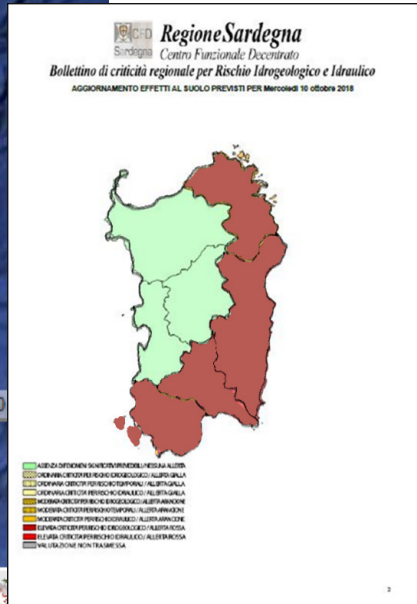
- S2 Sardegna 201810...
- STATIC Mappa S2 Sardegna 20...
- Rete Radar - SRI 10/10/2018 11:30 182 giorni fa
- PR OBS 5 - H05 (HSAF) 10/10/2018 09:00 183 giorni fa
- PR OBS 3 - H03 (HSAF) 10/10/2018 10:42 182 giorni fa
- SM\_ASCAT (HSAF) 09/10/2018 00:00 184 giorni fa
- Mappa di Poggia (M... 10/10/2018 11:30 Mappa di Poggia
- SM\_MOD\_ASCAT (HS... 10/10/2018 00:00 183 giorni fa

- null
- 0 mm
- 2 mm
- 5 mm
- 10 mm
- 15 mm
- 20 mm
- 25 mm
- 30 mm
- 39 mm
- 40 mm
- 50 mm
- 60 mm
- 70 mm
- 80 mm
- 90 mm
- 99 mm
- 100 mm
- 125 mm
- 150 mm
- 175 mm
- 200 mm
- 300 mm
- 400 mm
- 500 mm

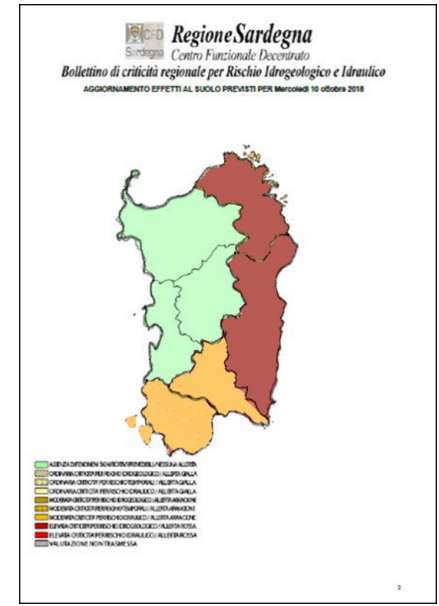




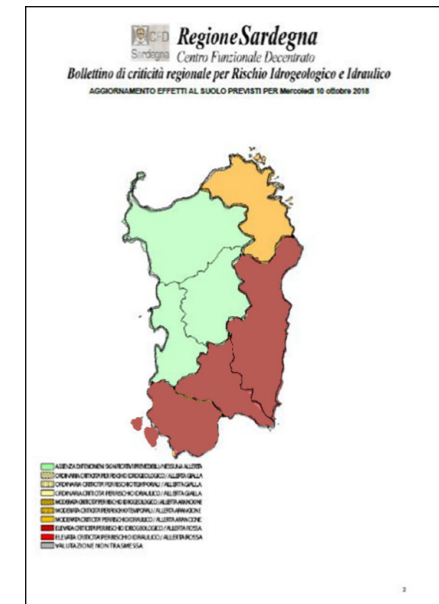
AC:5 days RG



AC:ASCAT



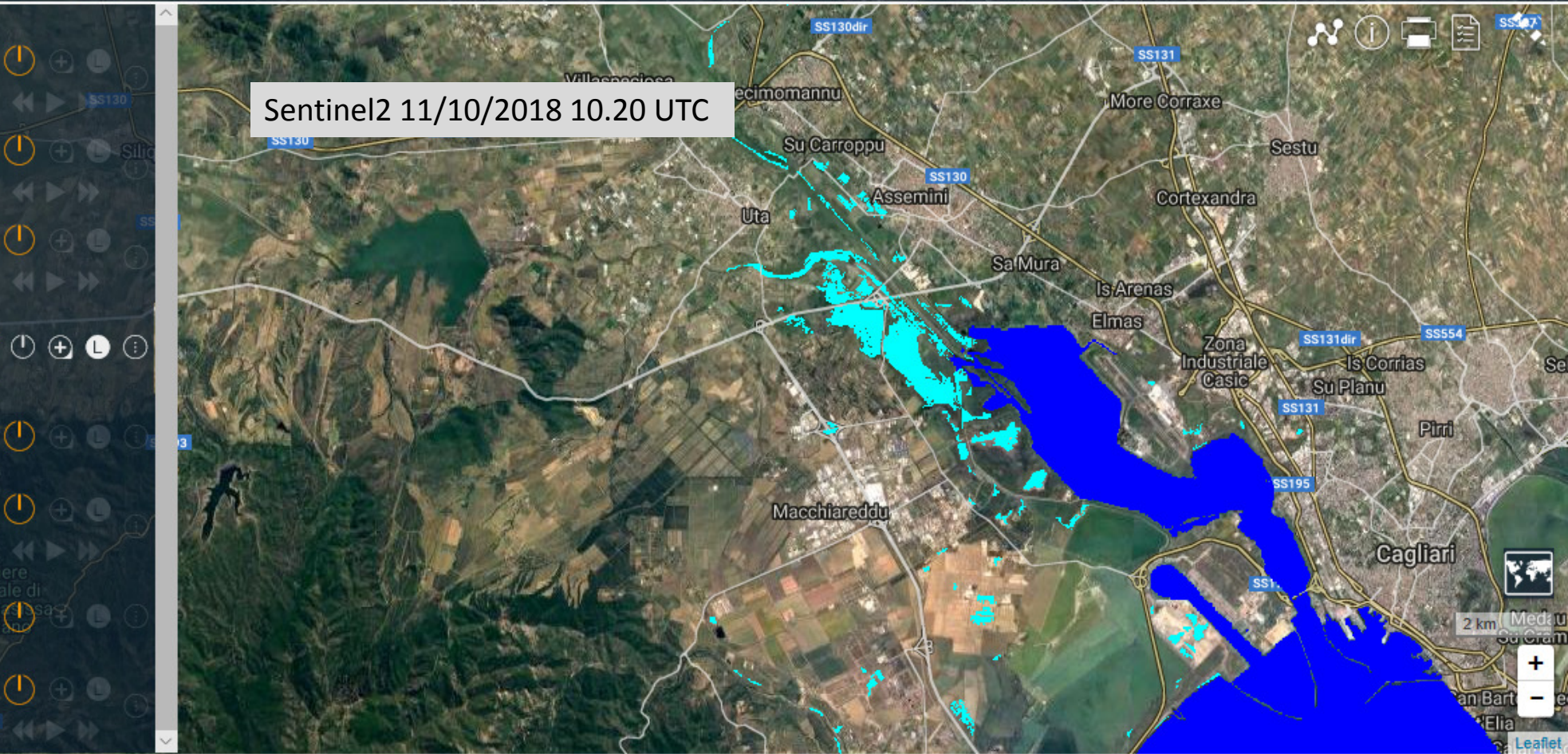
AC:10 days RG



AC:ASCAT-model



Sentinel2 11/10/2018 10.20 UTC



Vertical toolbar with navigation and zoom controls: Home, Back, Forward, Stop, Zoom In (+), Zoom Out (-), Full Screen (L), Info (i), and a series of circular icons.

08/10/2018 22:55 UTC [Calendar] [Calendar] [Clock] 10/10/2018 10:55 UTC [Compass]

mercoledì 10 aprile 2019 22:44:05 CEST







09/10/2018 06:00 UTC 10/10/2018 18:00 UTC

mercoledì 10 aprile 2019 23:48:49 CEST



## Case study conclusions

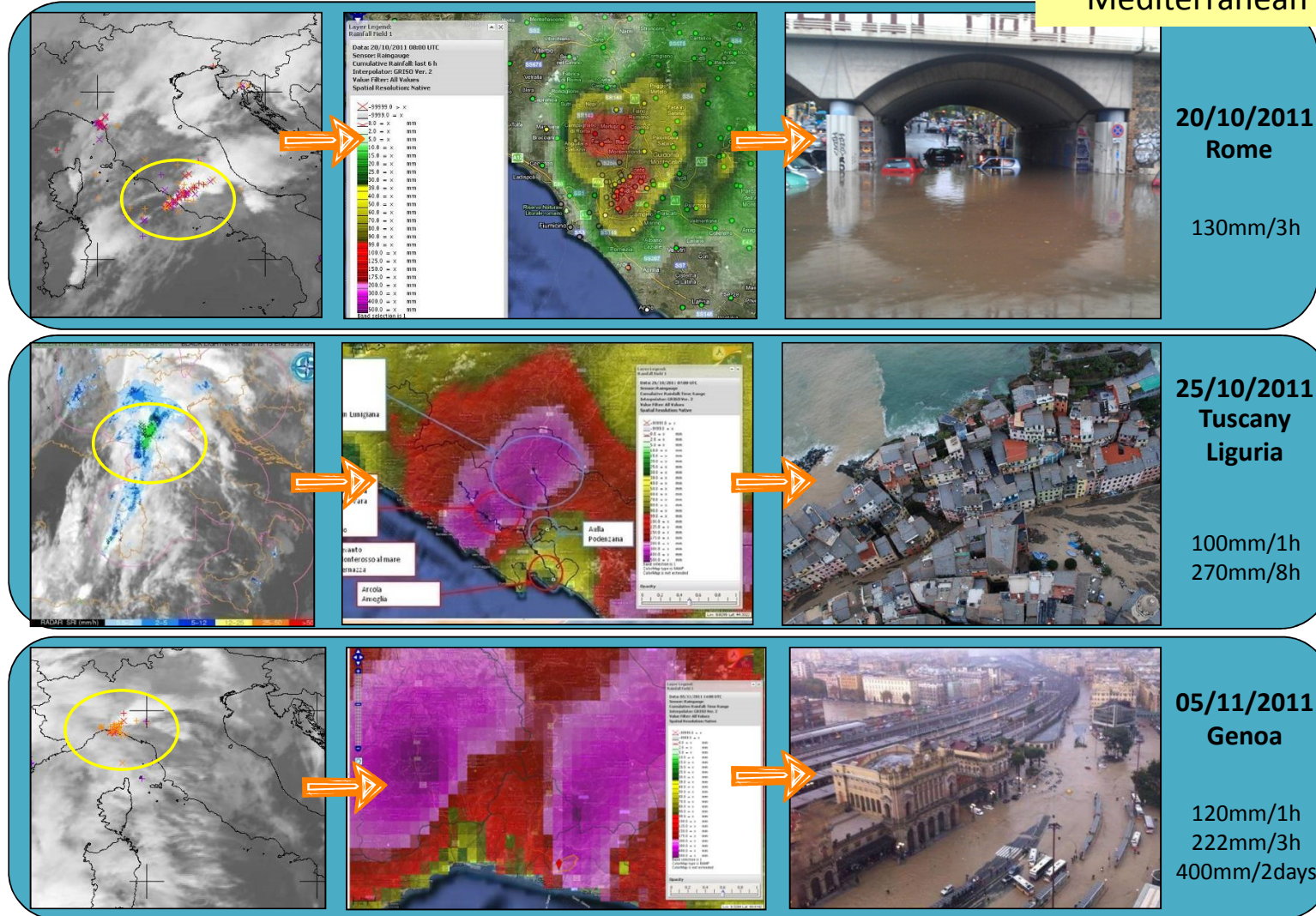
- **FORECAST:** To evaluate the antecedent conditions it is important to take into account the soil index evaluated by satellite data as ASCAT;
- **MONITORING:** The Satellite precipitation estimation derived by MW and IR data provides useful information for an hydrological risk monitoring: NRT availability (every 15 minutes) and accuracy;
- **POST-EVENT:** flood area available for the surveys by Sentinel 1 and 2.



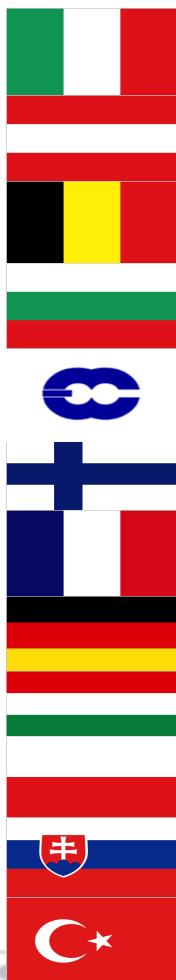


# METEO and HYDRO – events

## Mediterranean storms



## SAF on Support to Operational Hydrology and Water Management



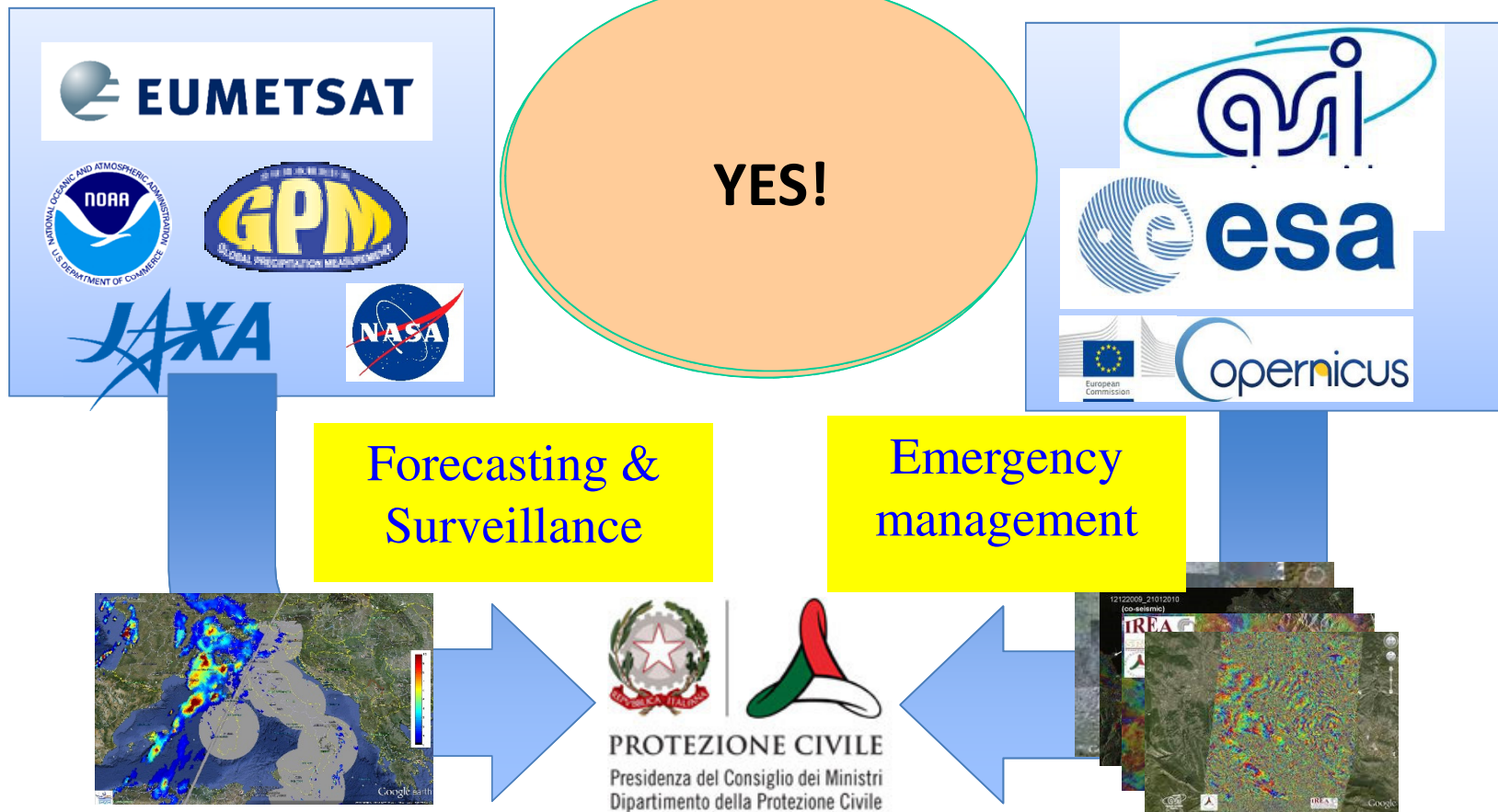
### H-SAF objectives:

### H-SAF management

- To provide **operational** high quality level 2/3 products and develop **new satellite-derived products** from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology;
  - identified products:
    - **precipitation** (liquid, solid, rate, accumulated);
    - **soil moisture** (at large-scale, at local-scale, at surface, in the roots region);
    - **snow parameters** (detection, cover, melting conditions, water equivalent);
- To perform **independent validation** of the usefulness of the new products for **civil protection purposes** (floods, landslides, etc..), and for **monitoring water resources**, and of their impact in hydrology models.

The **consortium** is composed by 12 countries: Austria, Belgium, Bulgaria, Belgium, Finland, France, Germany, Hungary, Italy, Poland, Slovakia, Turkey and ECMWF.

Satellite data can provide an effective contribution to hydrological risk management?





**Thank you for your  
attention !**

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