e-shape disaster

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1st E-SHAPE national workshop
Istanbul 7 June 2022

H2020 E-SHAPE

Geoss for Disasters in UrBan Environment Pilot 2

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Fagugli, G., Ferraris, L., Fiori, E., Gabellani, S., Masi, R., Mazzarella, V., Milelli, M., Parodi, A., Pignone, F., Puca, S. (Italian Civil Protection Deparment), Pulvirenti, L., Silvestro, F., Squicciarino, G., and Parodi, A.

EuroGEO GEO GROUP ON EARTH OBSERVATIONS Copernicus

The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852

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Introduction

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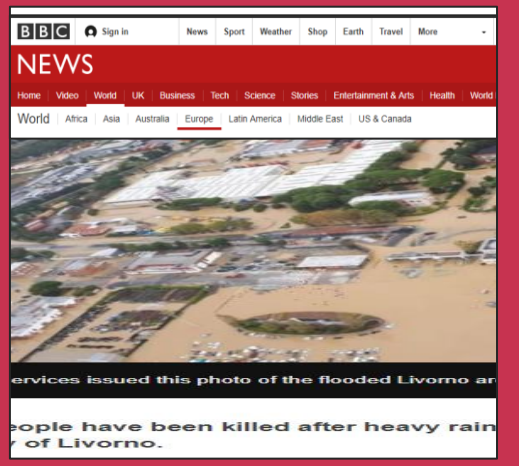

The story

Mediterranean region frequently struck by very intense hardly predictable weather events causing significant number of fatalities and socio-economic damages every year.

IPCC: The frequency of heavy rainfall events and droughts will intensify in the 21st century.

Current available tools for weather prediction and main lacks:

- Numerical Weather Prediction (NWP) models able to produce forecasts at very high resolution (km scale).
- Inaccurate representation of the initial and boundary conditions is a major source of uncertainty for weather forecasts.
- Assimilation of conventional observations cannot provide km scale description of the atmosphere.

The Pilot goals

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Objectives

Use of in-situ **Personal Weather Stations** (PWS), existing **citizen weather observatories**, **satellite observations** (Sentinel), and **low-cost sensors**, for the **enhanced hydro-meteorological** forecasting, addressing the prediction of high-impact weather events in cities, such as flash-flood, wind storms, hail storms, lightning storms, and peri urban fires.

Core Co-designers: Italian Civil Protection Department, ARPAL – Agenzia Regionale per la Protezione dell'Ambiente Ligure, Italy

Identified key users: EU decision makers, GEO Space and Security Community Activity, International organisations such as the UN

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INTRODUCTION TO MEDICANE

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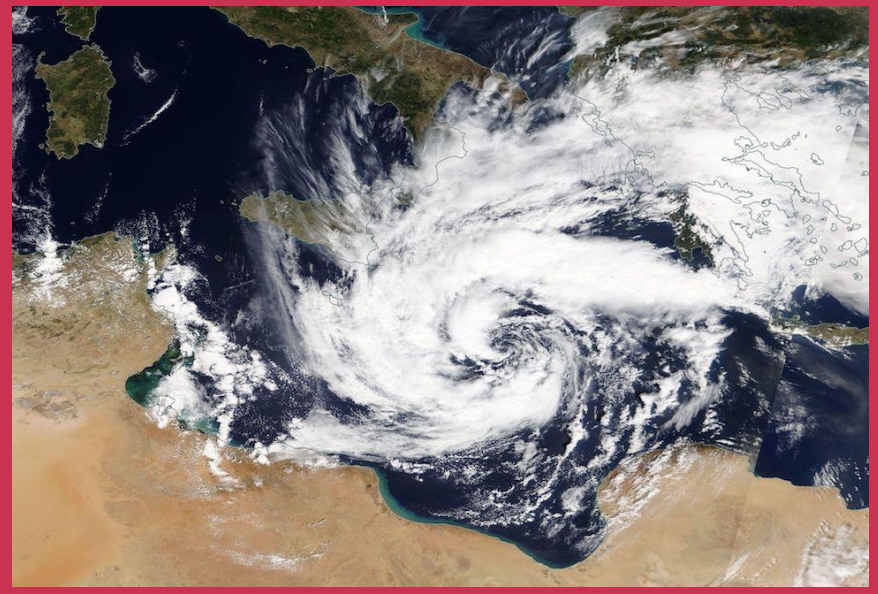

The use case

- Medicane, from Mediterranean hurricane, is a cyclone that can manifest different characteristics at different stages of its life cycle
- **Its genesis is typical of extra-tropical cyclones that are frequently observed in the middle latitudes**, but under certain conditions it can evolve into phenomena similar to hurricanes that develop in the tropical belts of the Atlantic, Pacific and Indian oceans
- Genesis is characterized by the presence of **a strong temperature difference between the upper layers of the atmosphere (colder) and those low and close to the earth's surface (warmer)**
- **Evolution into a tropical-like cyclone** occurs when there is **sufficient exchange of heat and moisture between the sea and the lower atmosphere** to **fuel the development of massive storm clouds.**

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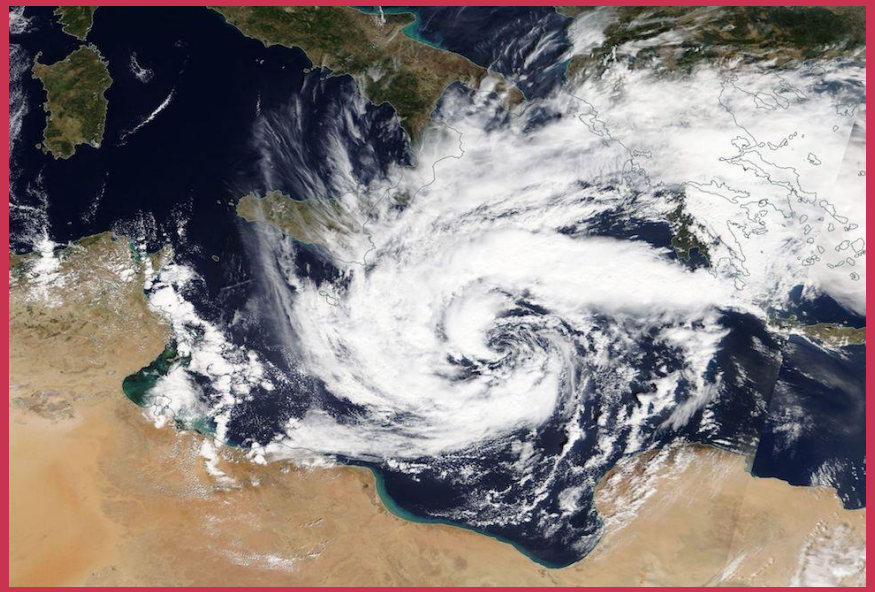
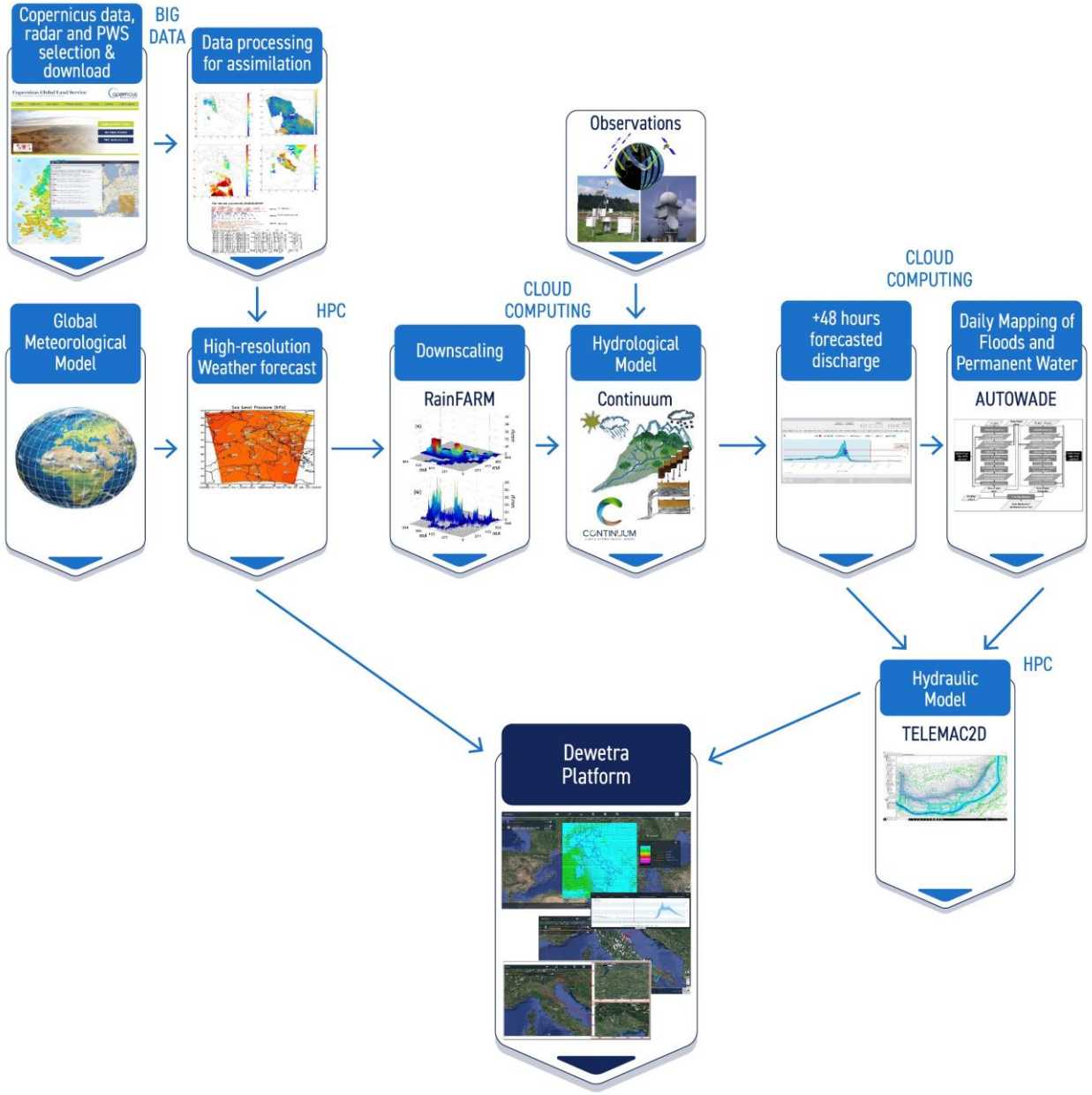
INTRODUCTION TO MEDICANE



The use case

- Medicane never reach the intensities of hurricanes of the highest category, at most they have winds comparable to category 1 hurricanes, i.e. higher than 110 km/h. For comparison, Category 5 cyclones have winds above 250 km/h
- In addition, Medicane lasts less, from 24 to 36 hours, while tropical cyclones can last even weeks
- **Several studies agree in estimating an annual incidence of around 1.5 events**, concentrated in the months between September and April. In fact, while tropical cyclones need very high water temperatures, above 26 ° C, for Medicane the formation of the vertical temperature difference in the atmosphere is decisive, which is favored in the autumn and winter season by the arrival of cold air at high altitude from the northern areas of the Atlantic.
- **Research published in 2020 in the International Journal of Climatology identified 59 events between 1979 and 2017 using ERA5 reanalyses**.

HYDRO-METEOROLOGICAL AND HYDRAULICS FORECASTING CHAIN



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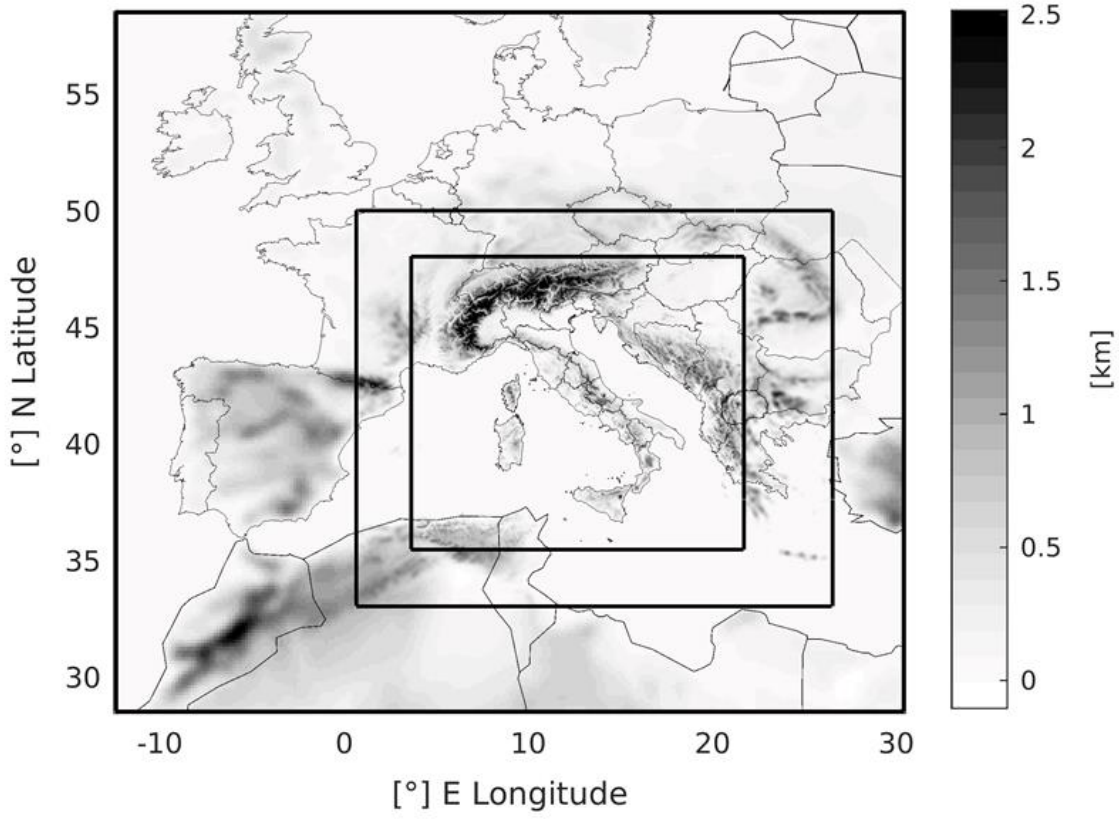
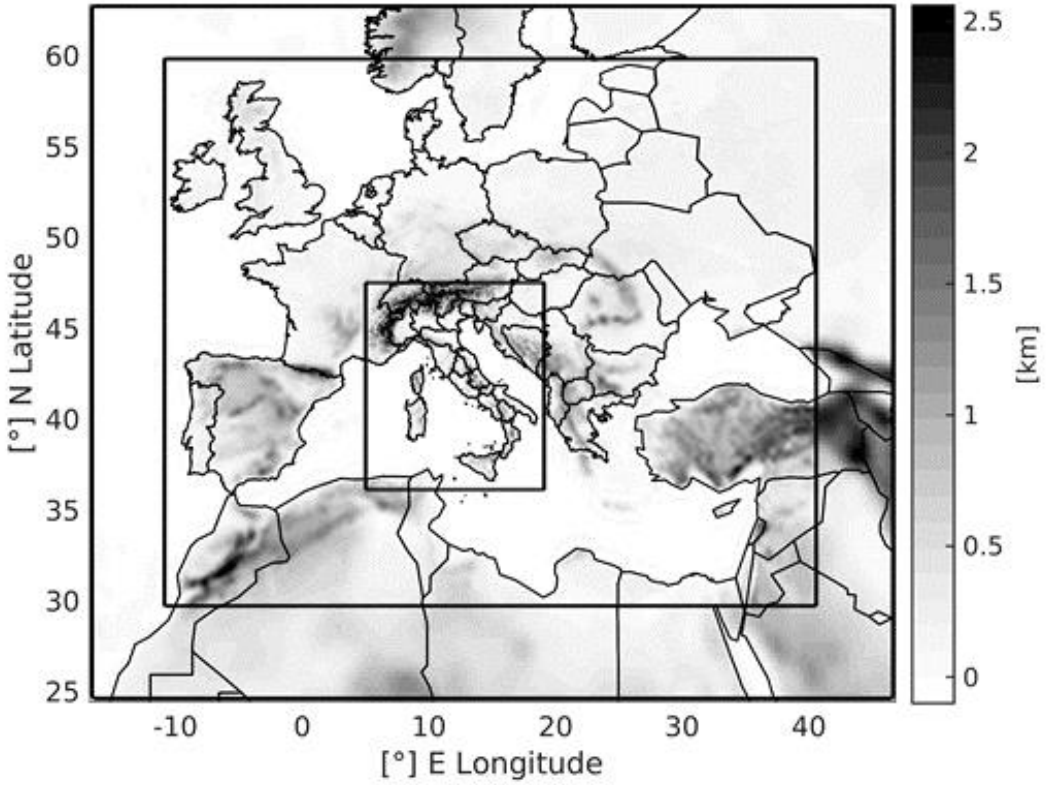
METEOROLOGICAL MODELLING

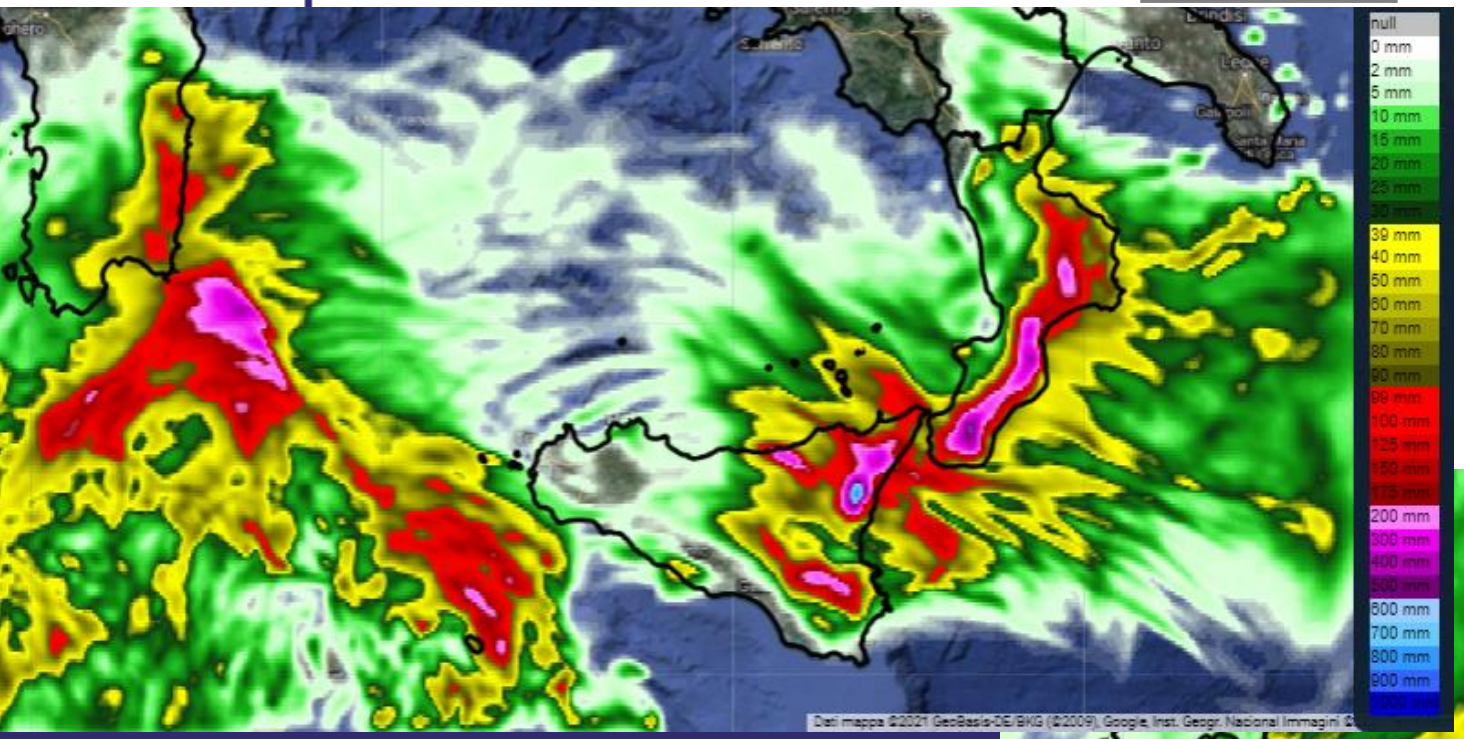
WRF-OL 1.5KM

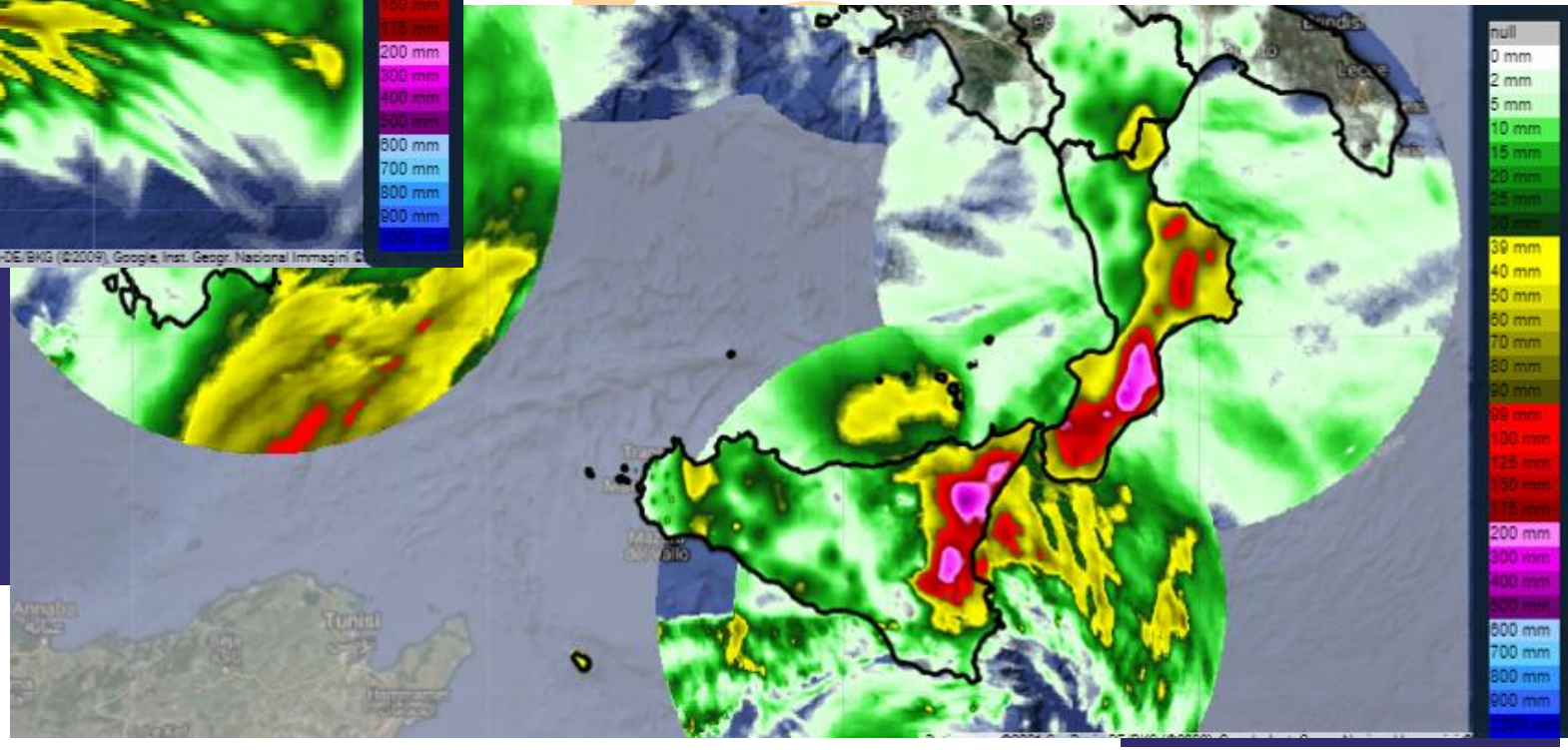


WRF-DA 2.5KM

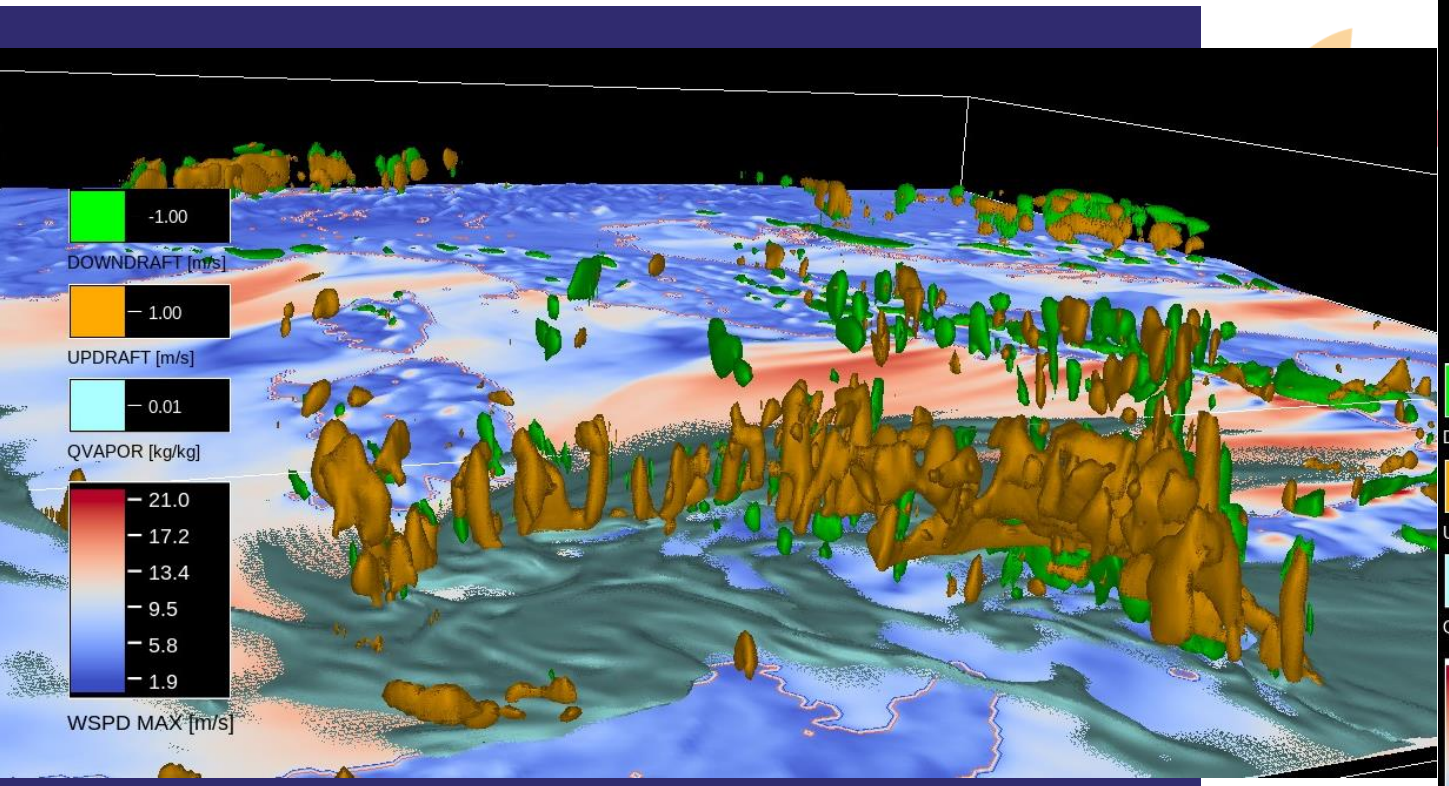


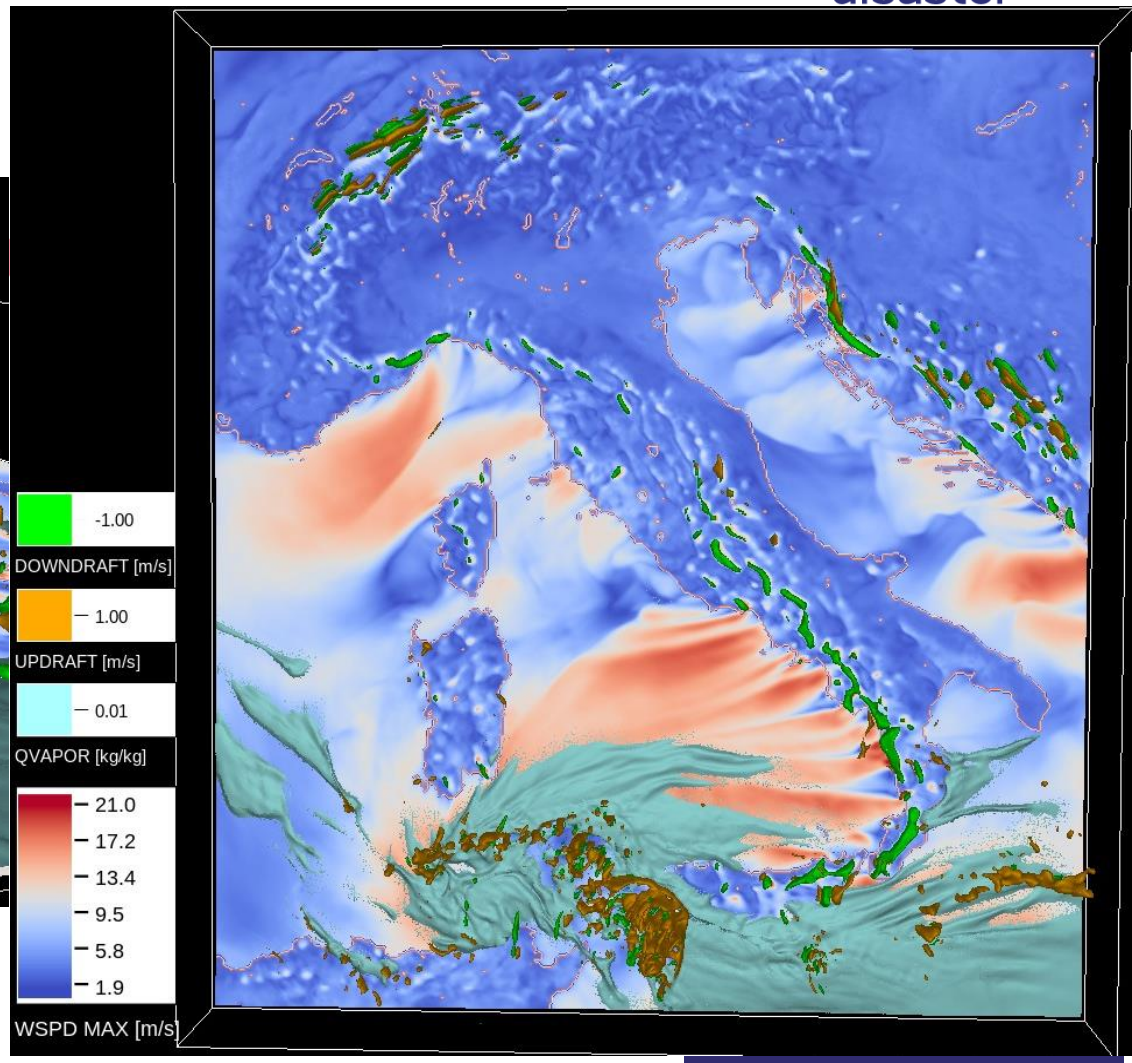
FORECAST 24-26 OCT. 2021- RADAR & PWS



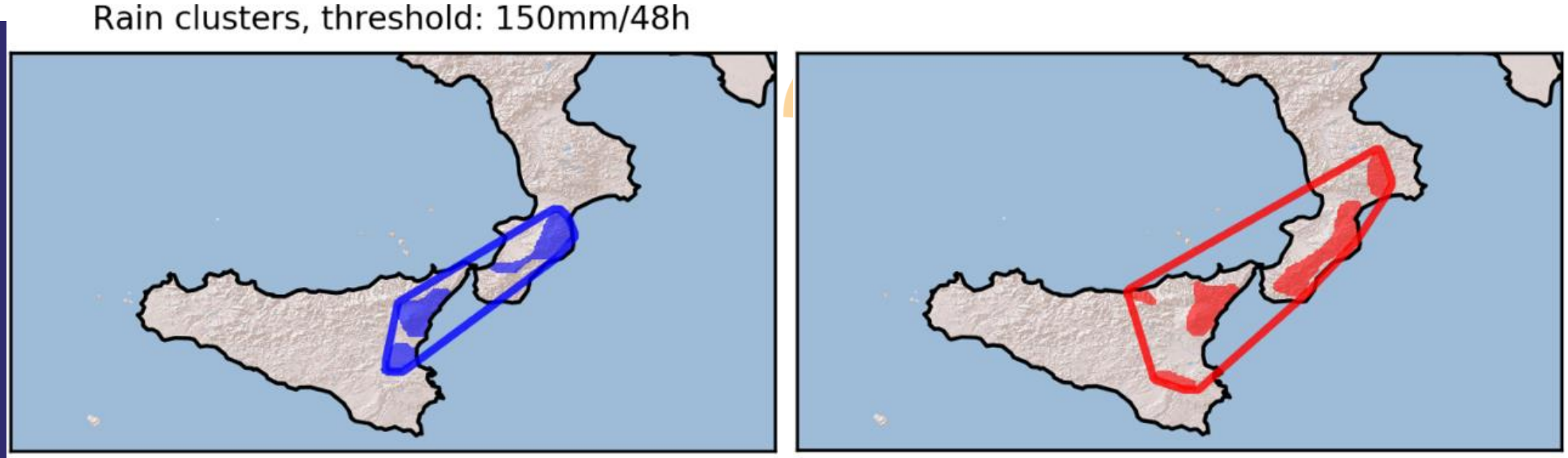


FORECAST 24-26 OCT. 2021- RADAR & PLUVIO





FORECAST 24-26 OCT. 2021- RADAR & PLUVIO VALIDATION



Cluster pair	Centroid distance	Observed area	Forecast area	Intersection area	Total interest
1	12.8km	4470km^2	9150km^2	4000km^2	0.96

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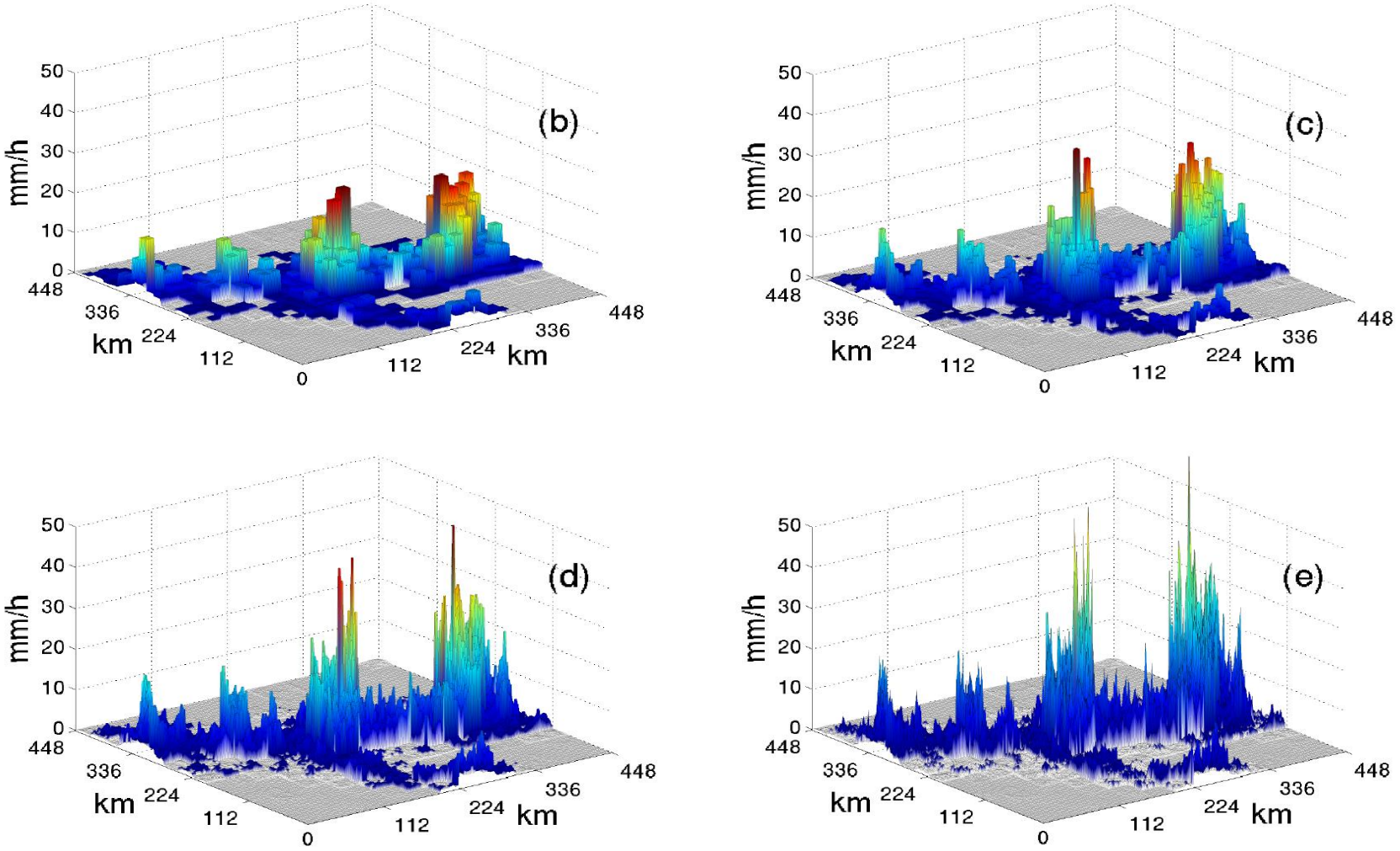
FLOOD FORECASTING CHAIN

The flood forecasting chain: RainFARM

It is a stochastic downscaling algorithm that generate an ensemble of rainfall fields with high resolution. It preserves the total volume and the spatial structure above a certain scale

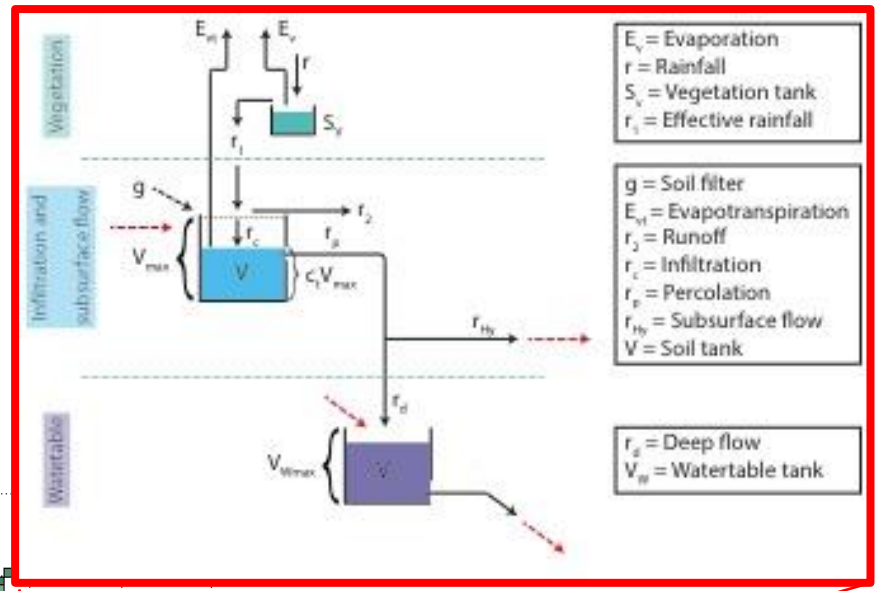


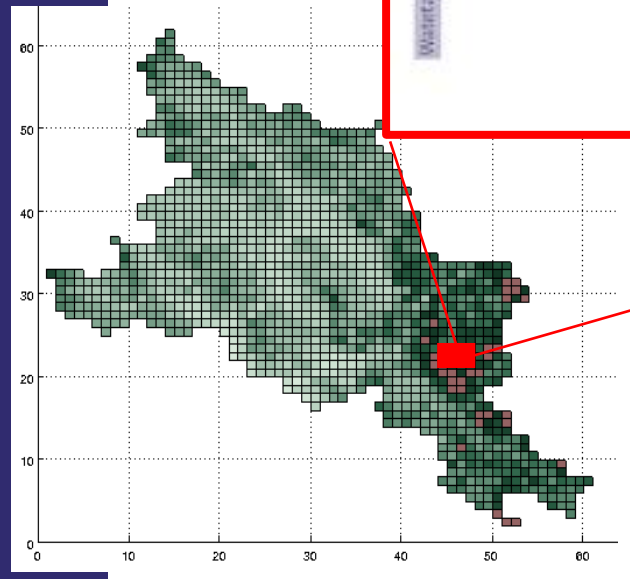
Rebora, N., Ferraris, L., von Hardenberg, J., & Provenzale, A. (2006). RainFARM: Rainfall downscaling by a filtered autoregressive model. *Journal of Hydrometeorology*, *7*(4), 724-738.

The flood forecasting chain : Continuum

MAIN CHARACTERISTICS:

- Simple but complete description of Hydrological Cycle
  - Schematization of vegetation interception and water table
  - Tank schematization of overland and channel flows
- Mass Balance and Energy Balance completely solved
- Fully Distributed
- River network derived from a DEM
- Spatial-temporal evolution of:
  - Streamflow
  - Evapotranspiration
  - Vegetation retention
  - Land Surface Temperature
  - Soil Moisture
  - Water table





The model code is open

http://continuum.cimafoundation.org

https://github.com/c-hydro/hmc-dev

- It can be **calibrated using only satellite data** (e.g. surface temperature or soil moisture). Model suitable for application in data scarce environments

Silvestro, F., Gabellani, S., Delogu, F., Rudari, R., & Boni, G. (2013). Exploiting remote sensing land surface temperature in distributed hydrological modelling: the example of the Continuum model. *Hydrology and Earth System Sciences*, *17*(1), 39.

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FLOODPROOFS FORECAST VISUALIZATION

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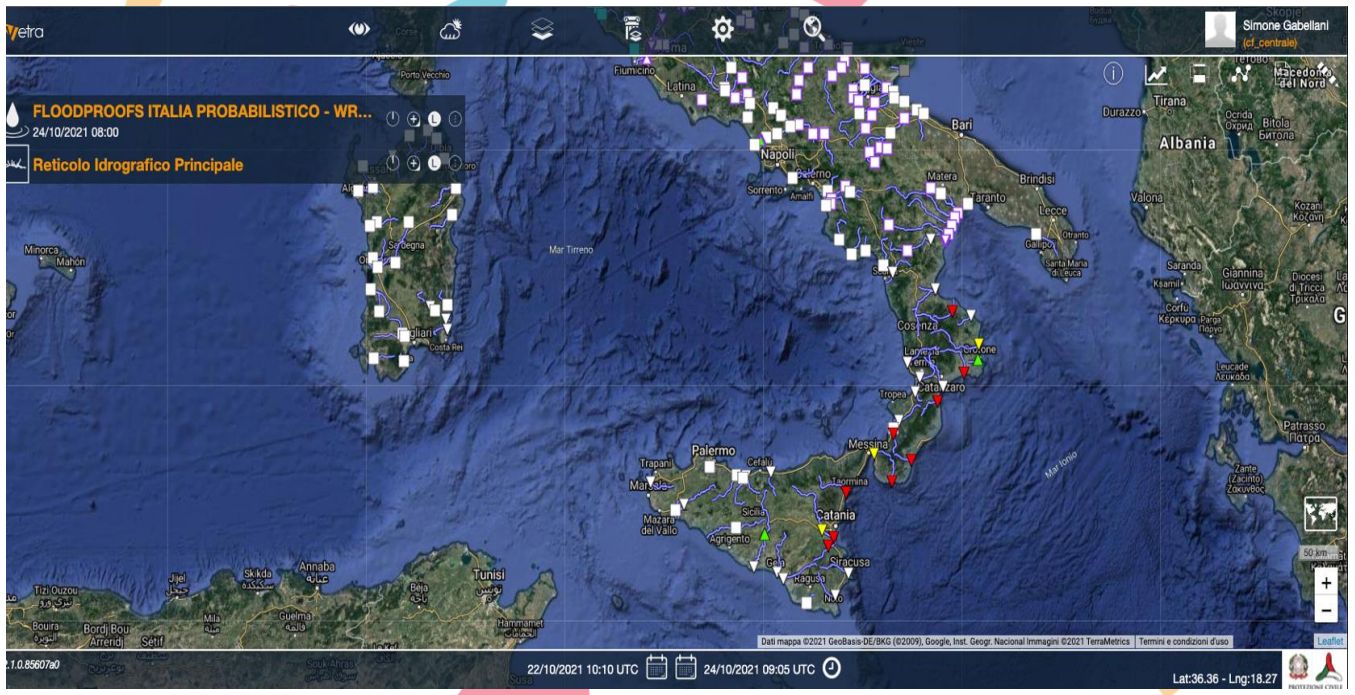
Spatial resolution: around 500 m
17 calculation domains cover the country

FLOODPROOFS FORECAST: 24 OCTOBER 09 UTC

Forecast FloodPROOFS (input WRF)
Predicted peak discharges: Calabria and Sicily



FLOODPROOFS FORECAST: 24 OCTOBER 09 UTC and 20 UTC

Forecast FloodPROOFS (input WRF)
Predicted peak discharges: Calabria and Sicily

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FLOODPROOFS

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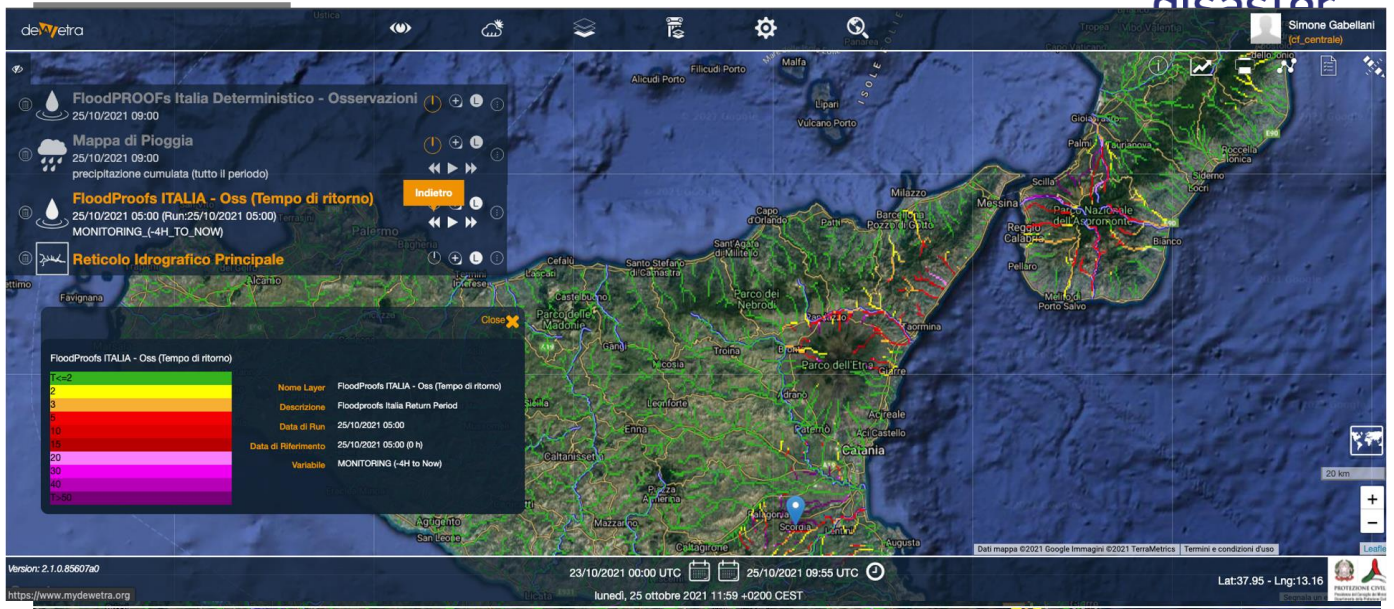
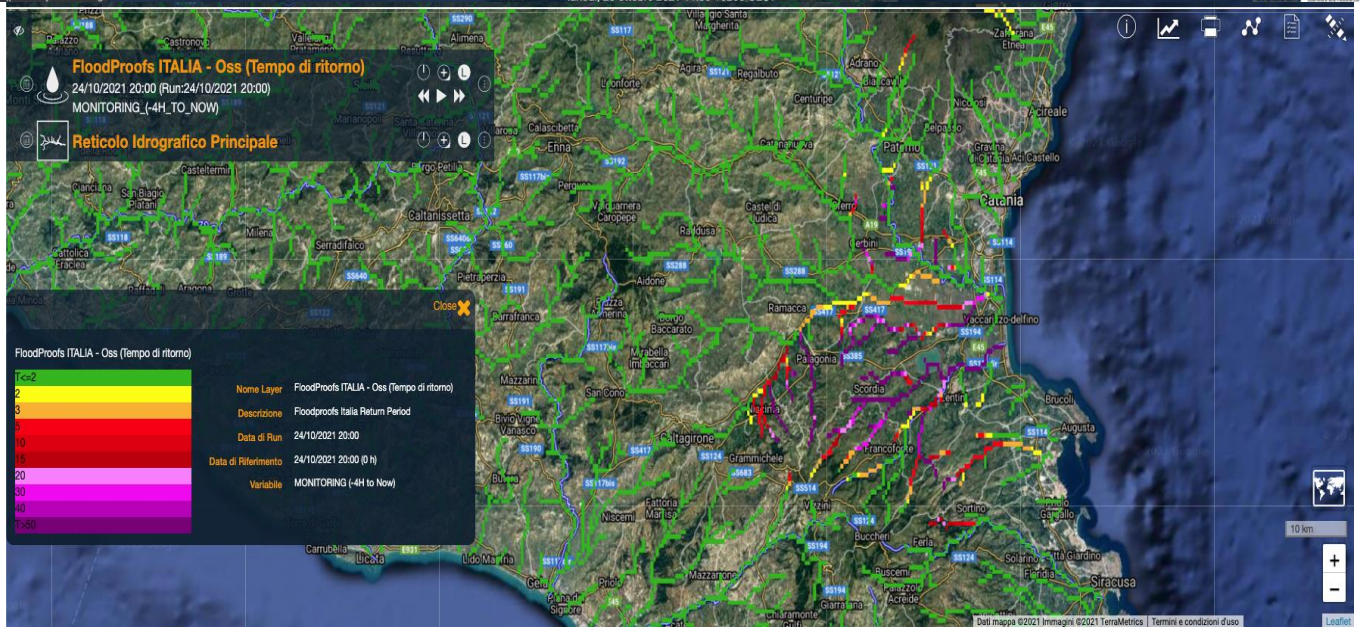
FloodPROOFS driven by meteorological observations including Soil Moisture (HSAF product) «Return time» produts (based on model climatology)

The modelling detects very well the most affected areas– Scordia, Ogliastro, piana Catania





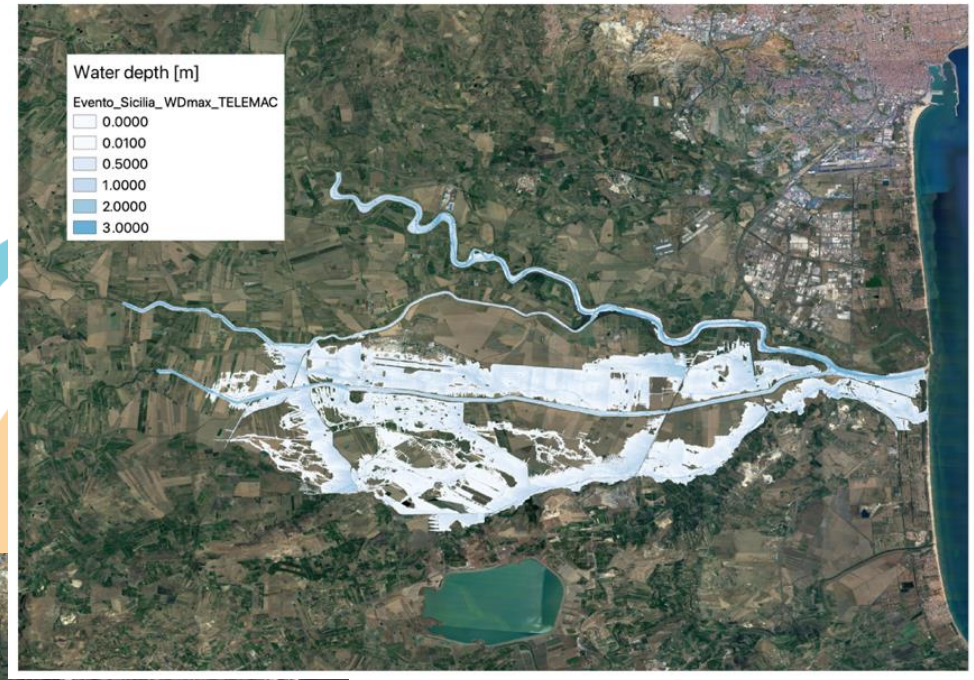
Hydraulics modeling using FloodPROOFS input

DEM 2 meters

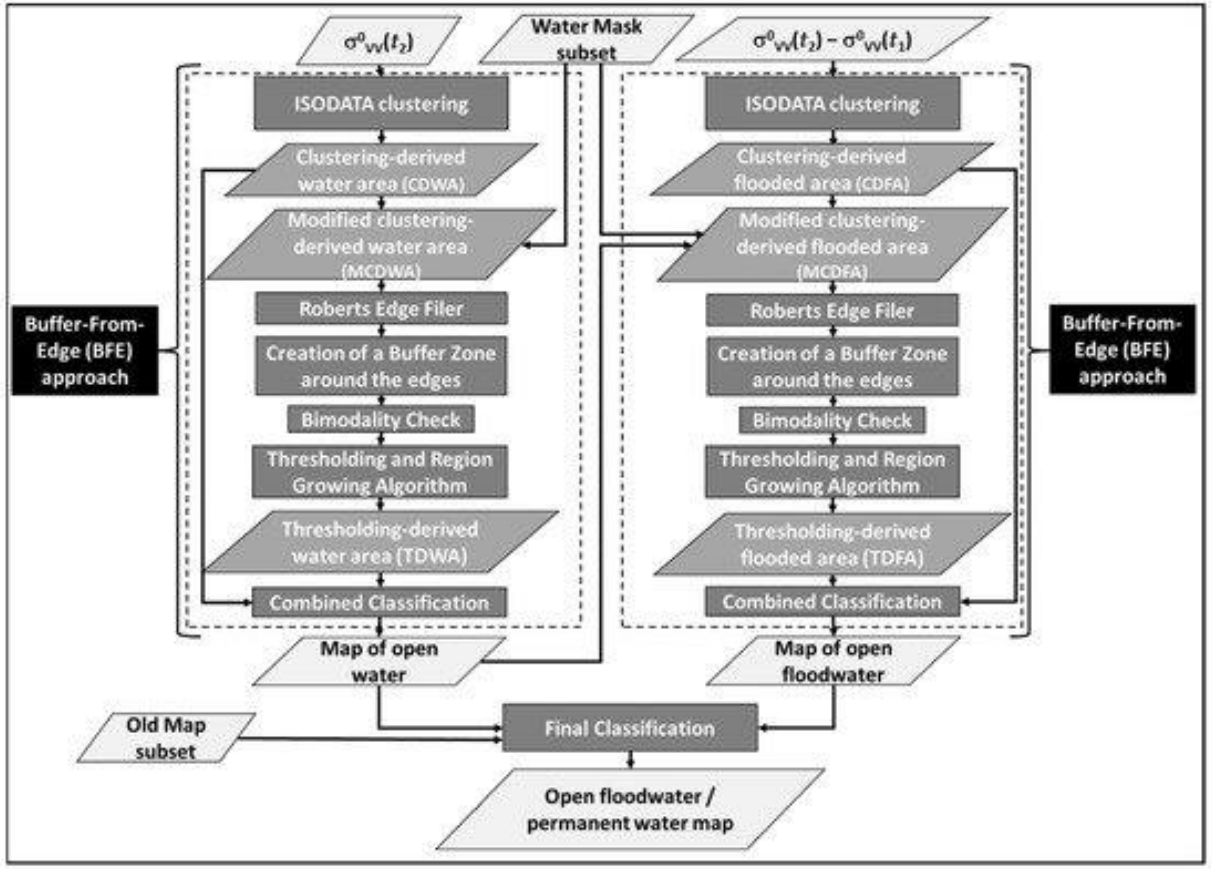
Discharge as Input: operational simulations FloodPROOFS-Italy

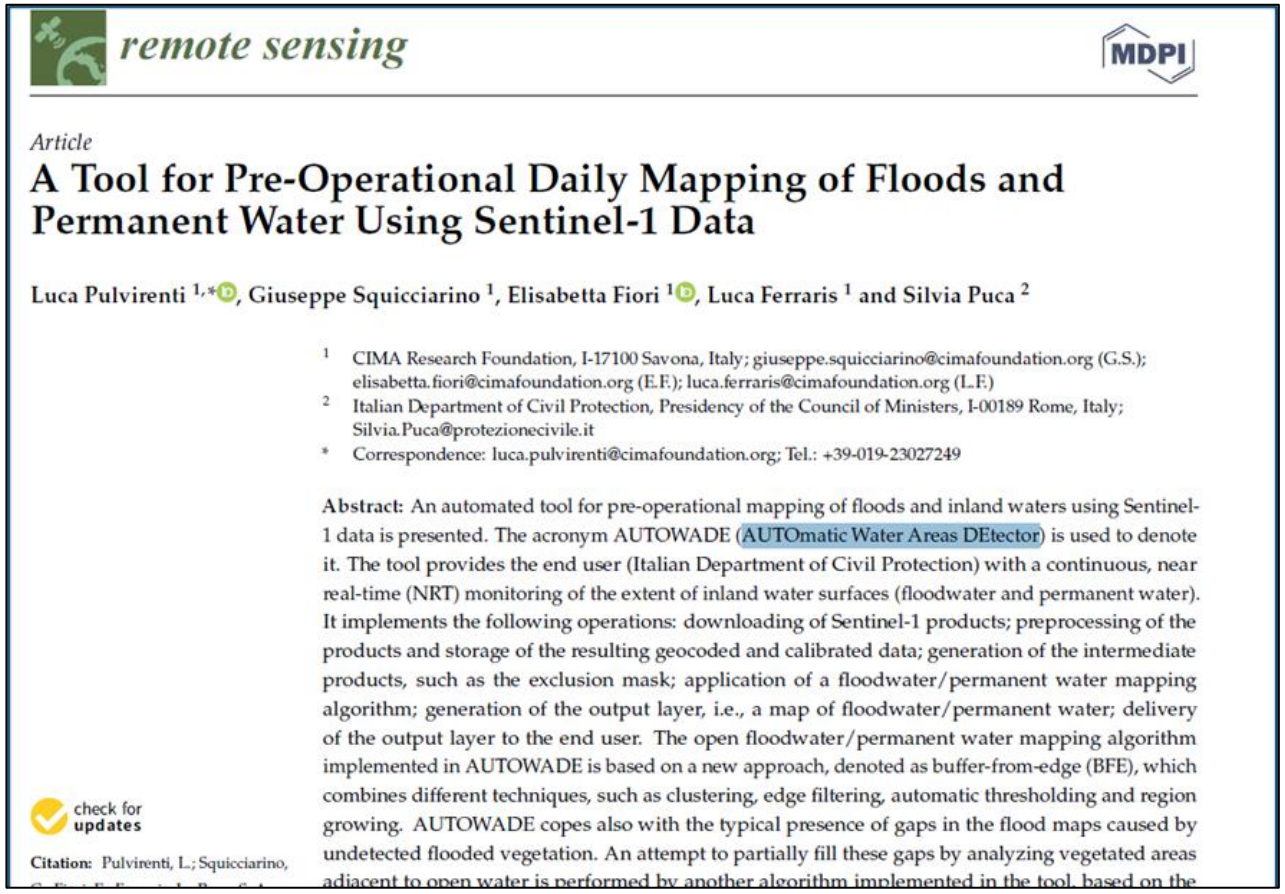
Hydraulics model: **TELEMAC2D**

Flood simulation for early assessment available on 28 October 2021 9UTC



AUTOWADE (AUTOmatic WaterAreas Detector)





remote sensing

MDPI

Article

A Tool for Pre-Operational Daily Mapping of Floods and Permanent Water Using Sentinel-1 Data

Luca Pulvirenti [1,*], Giuseppe Squicciarino [1], Elisabetta Fiori [1], Luca Ferraris [1] and Silvia Puca [2]

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[2] Italian Department of Civil Protection, Presidency of the Council of Ministers, I-00189 Rome, Italy; Silvia.Puca@protezionecivile.it
* Correspondence: luca.pulvirenti@cimafoundation.org; Tel.: +39-019-23027249

Abstract: An automated tool for pre-operational mapping of floods and inland waters using Sentinel-1 data is presented. The acronym AUTOWADE (AUTOmatic Water Areas DEtector) is used to denote it. The tool provides the end user (Italian Department of Civil Protection) with a continuous, near real-time (NRT) monitoring of the extent of inland water surfaces (floodwater and permanent water). It implements the following operations: downloading of Sentinel-1 products; preprocessing of the products and storage of the resulting geocoded and calibrated data; generation of the intermediate products, such as the exclusion mask; application of a floodwater/permanent water mapping algorithm; generation of the output layer, i.e., a map of floodwater/permanent water; delivery of the output layer to the end user. The open floodwater/permanent water mapping algorithm implemented in AUTOWADE is based on a new approach, denoted as buffer-from-edge (BFE), which combines different techniques, such as clustering, edge filtering, automatic thresholding and region growing. AUTOWADE copes also with the typical presence of gaps in the flood maps caused by undetected flooded vegetation. An attempt to partially fill these gaps by analyzing vegetated areas adjacent to open water is performed by another algorithm implemented in the tool, based on the

check for updates

Citation: Pulvirenti, L.; Squicciarino,

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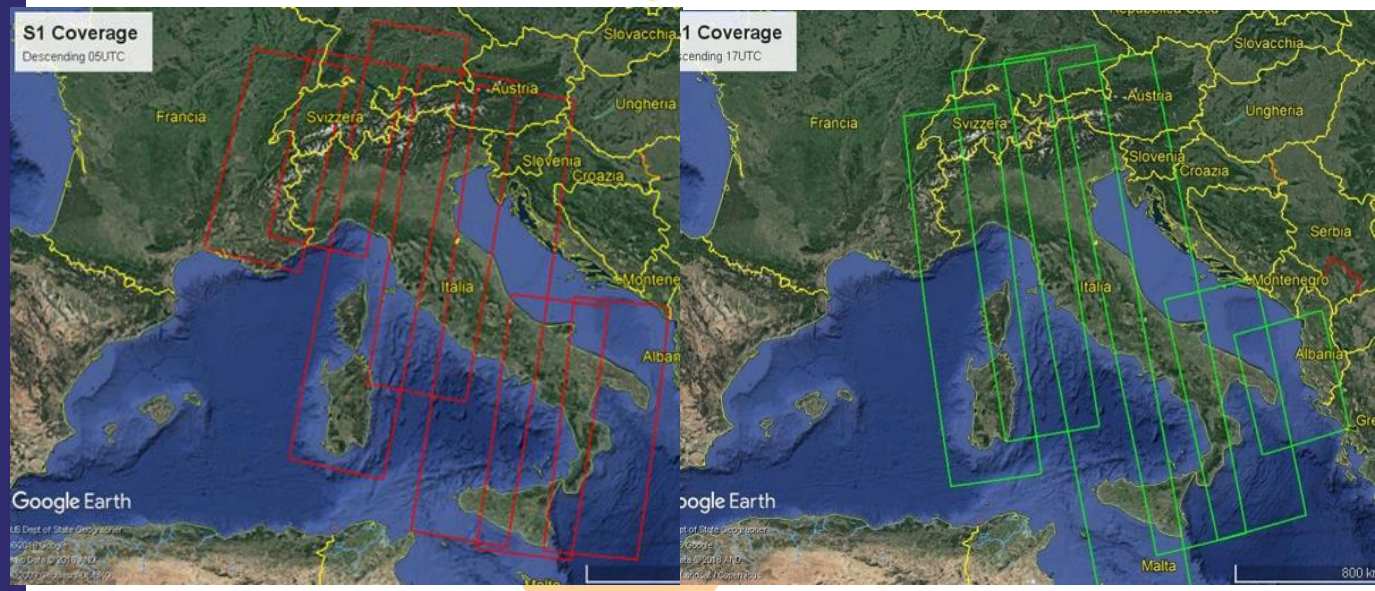
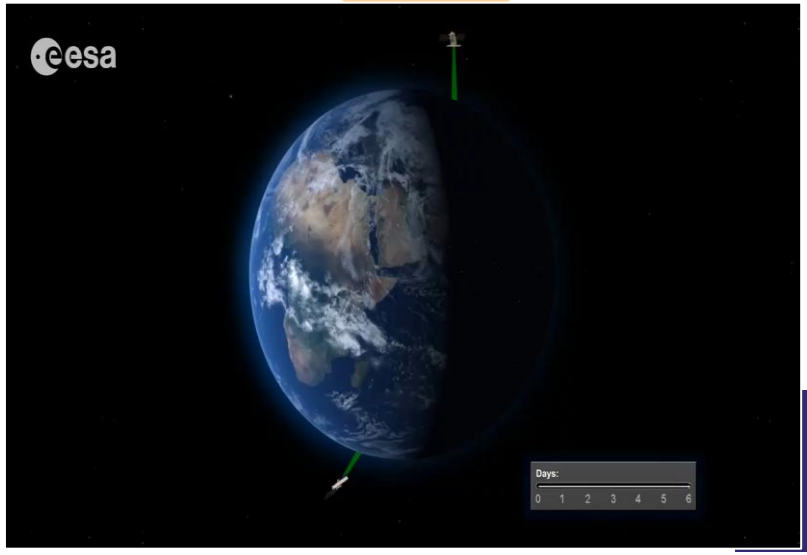
AUTOWADE (AUTOmatic WaterAreas Detector)

- Single geographical area observed every 6 days (repeat pass mode: same geometry)
- Italian territory monitoring: 7 descending and 6 ascending orbits (GRD products)
- Considering ascending and descending orbits and overlaps between adjacent orbits, the frequency of revisiting is reduced





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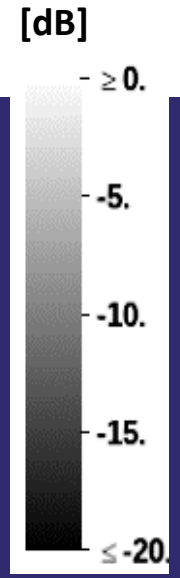
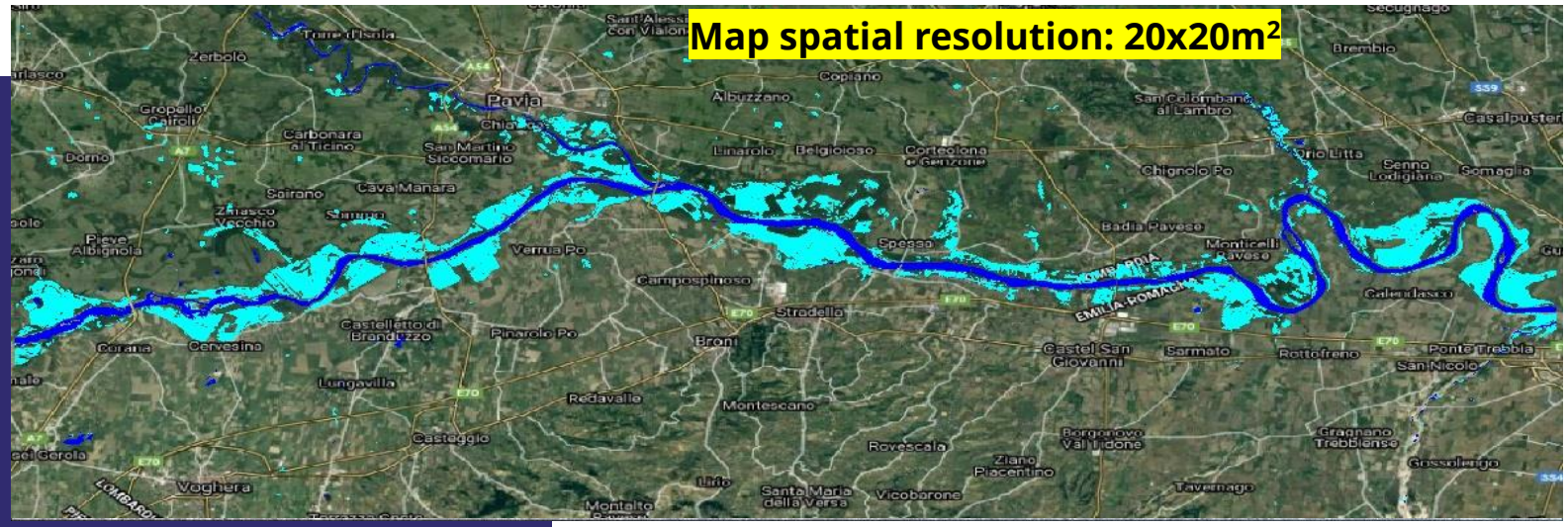
FLOOD AREAS DETECTION: HOW IT WORKS





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FLOOD AREAS DETECTION

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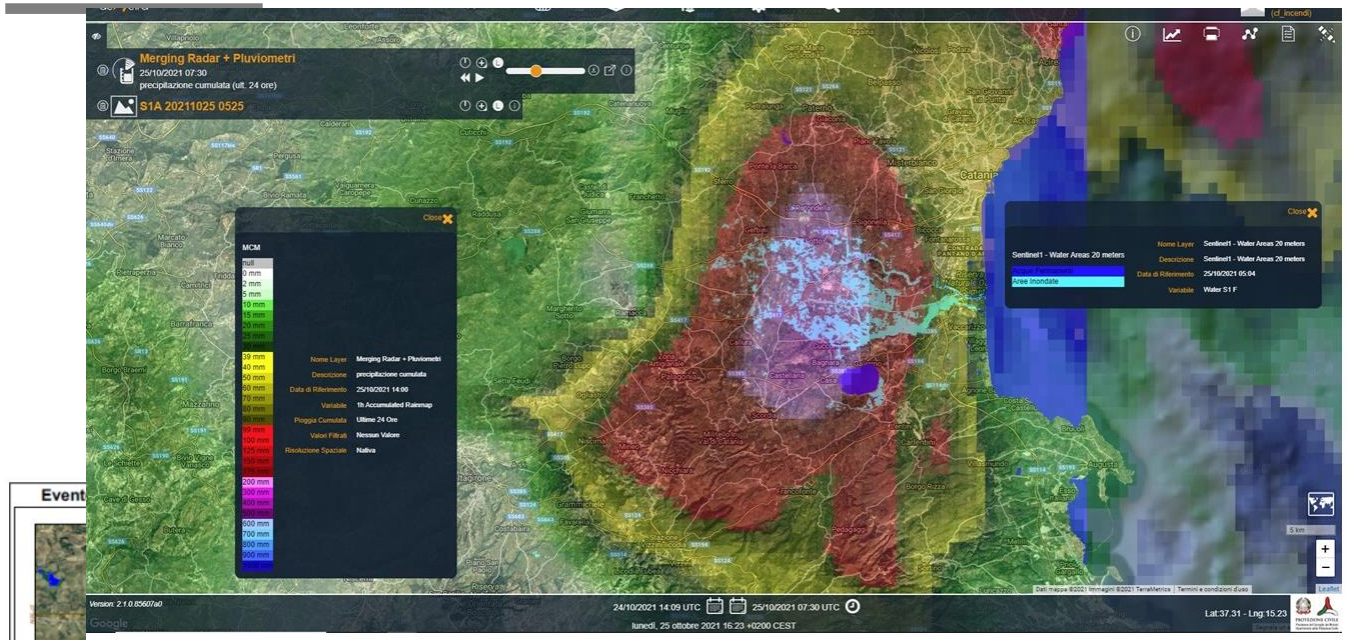
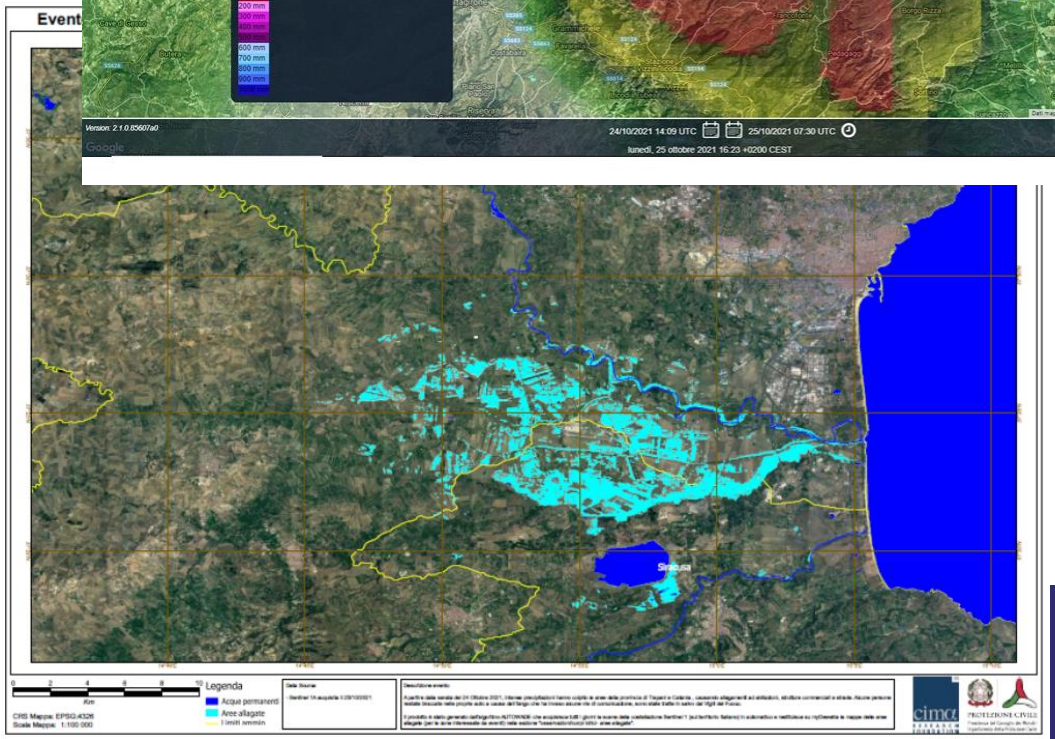
Sentinel 1 passage of 25 Oct. 5 UTC.

Flooded areas map obtained with AUTOWADE over Catania city and cumulated rainfall in the 24 hours before the acquisition time.





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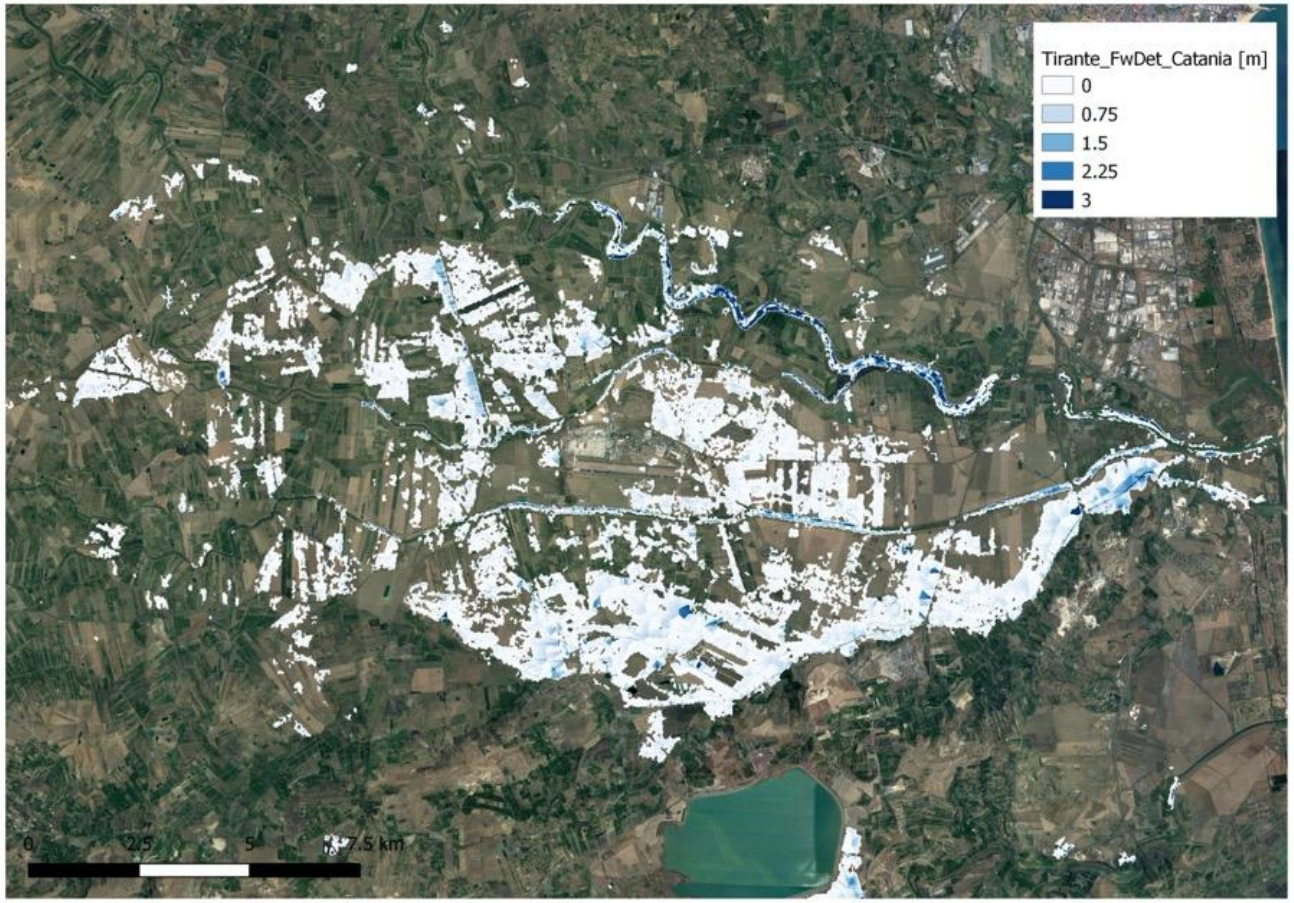
Targeted status

For the estimation of the water level the Floodwater Depth Estimation Tool (FwDET) and DEM 2 meters was used (source DEM: Sicily Region).

FwDET identifies the flooded areas water depth in each cell within a flooded domain based on its closest point located on the flooded area edge, through the use of an appropriate digital terrain model (DTM) and the flood polygons retrieved by AUTOWADE.



Cohen, S., Raney, A., Munasinghe, D., Loftis, J. D., Molthan, A., Bell, J., Rogers, L., Galantowicz, J., Brakenridge, G. R., Kettner, A. J., et al. (2019). The floodwater depth estimation tool (fwdet v2. 0) for improved remote sensing analysis of coastal flooding. Natural Hazards and Earth System Sciences, 19(9):2053–2065.

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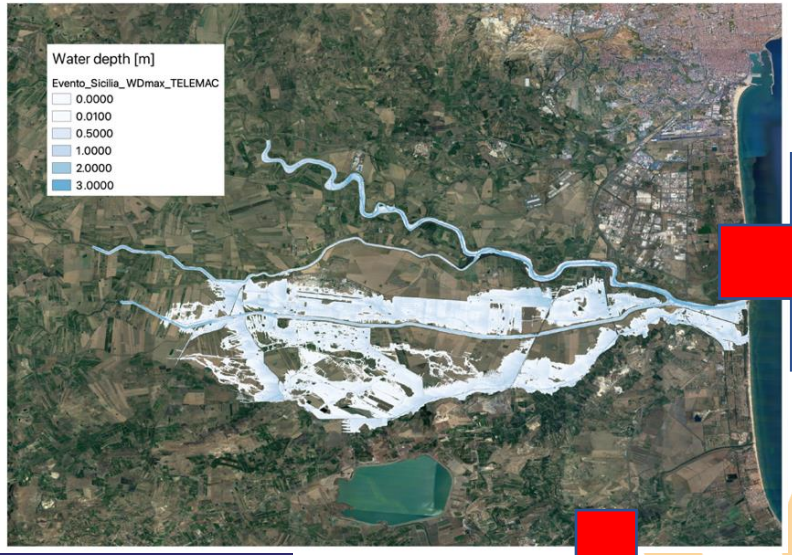
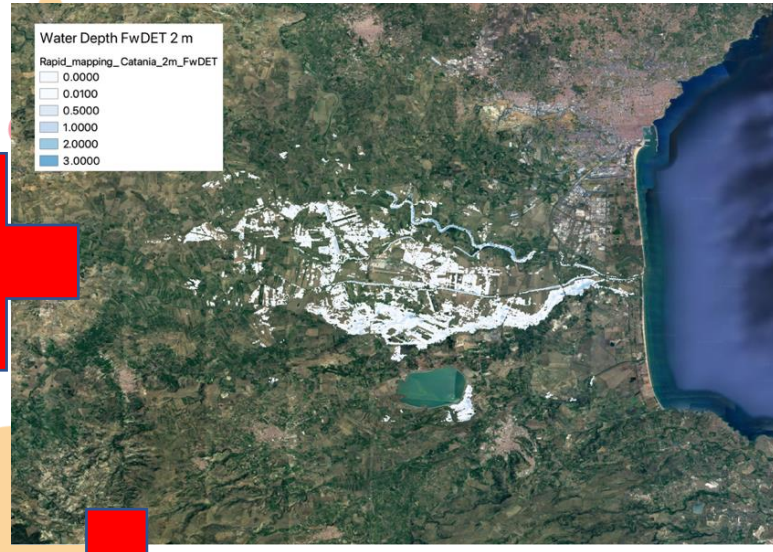
Targeted status

Overlapping of water levels estimated from

- Sentinel-1 (AUTOWADE)
- CosmoSkyMed (AUTOWADE)
- TELEMAC2D





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CONCLUSIONS

- CIMA Foundation hydro-meteorological forecasting chain, including the cloud-resolving WRF model assimilating radar data and in situ weather stations (**WRF-3DVAR**), the fully distributed hydrological model **Continuum**, the automatic system for water detection (**AUTOWADE**), and the hydraulic model **TELEMAC-2D**, has been operated in real-time to predict the weather evolution and the corresponding hydrological and hydraulic impacts of the medicane Apollo
- The WRF-3DVAR model **(available 00UTC, Oct. 24th, 2021) showed very good predictive capability** concerning the **timing and the location of most intense rainfall phenomena over Catania and Siracusa provinces in Sicily**, thus enabling also **very accurate discharge peaks and timing predictions for the creeks hydrological network peculiar of eastern Sicily**
- Based on the WRF-3DVAR model predictions, the daily run of the AUTOWADE tool, using Sentinel-1 (S1) data, was anticipated with respect to the schedule to quickly produce a flood map (S1 acquisition performed on Oct. 25th, 2021, at 5.00 UTC, **flood map produced on the same day at 13.00 UTC**). Moreover, considering that no S1 images of eastern Sicily were available during the period Oct. 26-30, 2021, an ad hoc tasking of the COSMO-SkyMed satellite constellation was performed, again based on the on the WRF-3DVAR predictions, to overcome the S1 data latency
- The resulting automated operational mapping of floods and inland waters was integrated with the subsequent execution of the hydraulic model TELEMAC-2D

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The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852