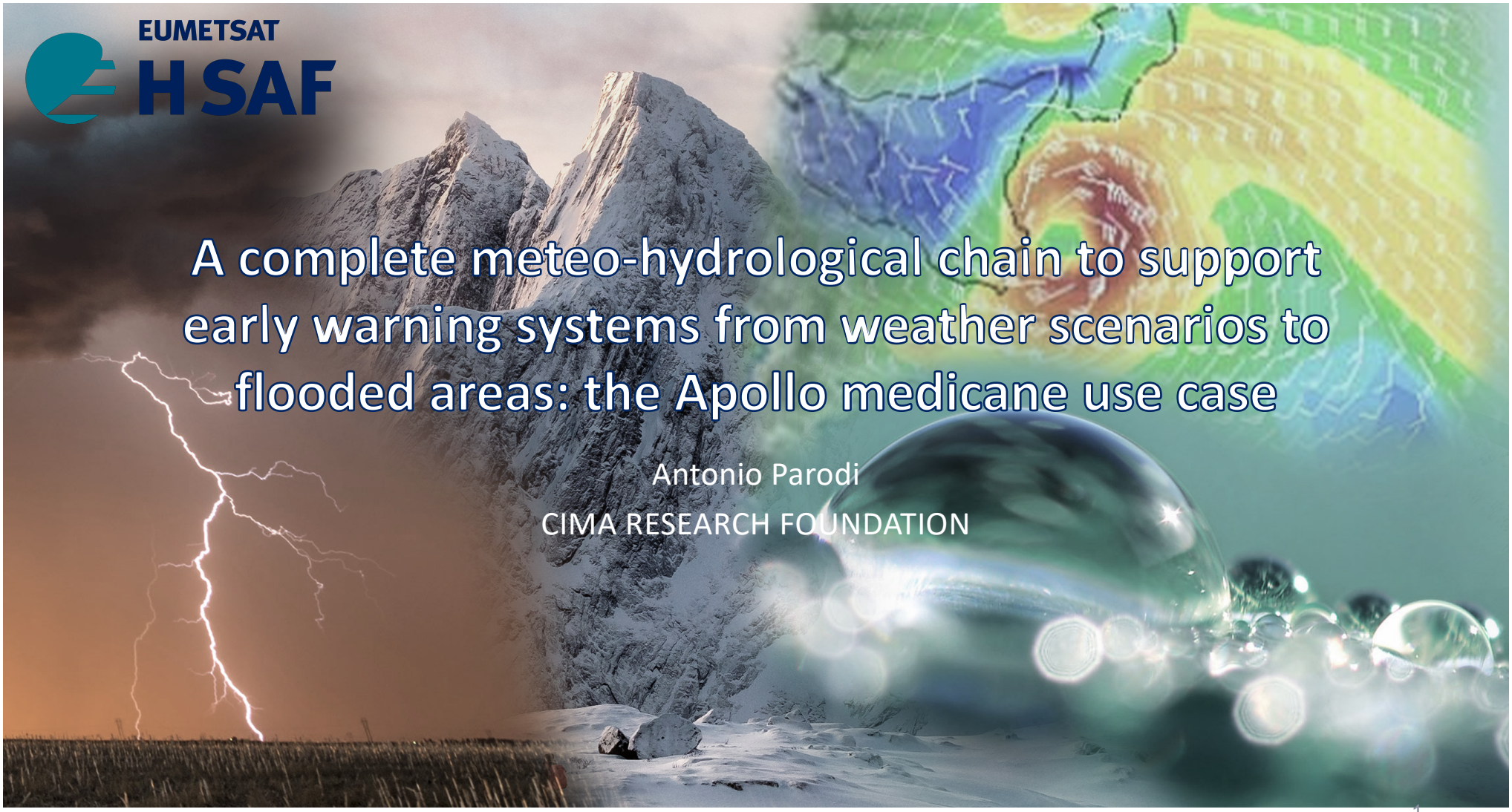


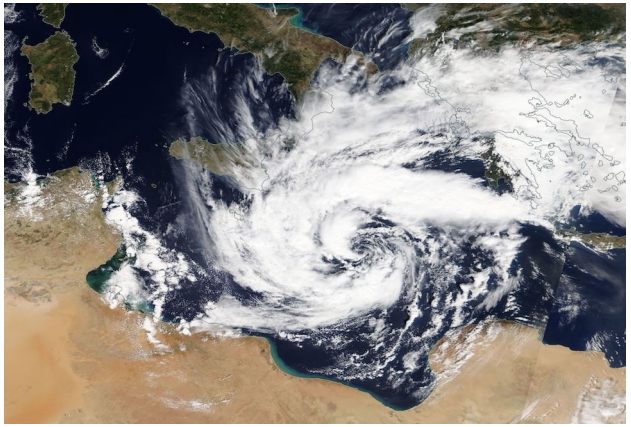
A complete meteo-hydrological chain to support early warning systems from weather scenarios to flooded areas: the Apollo medicane use case

Antonio Parodi

CIMA RESEARCH FOUNDATION

MEDICANE DEFINITION

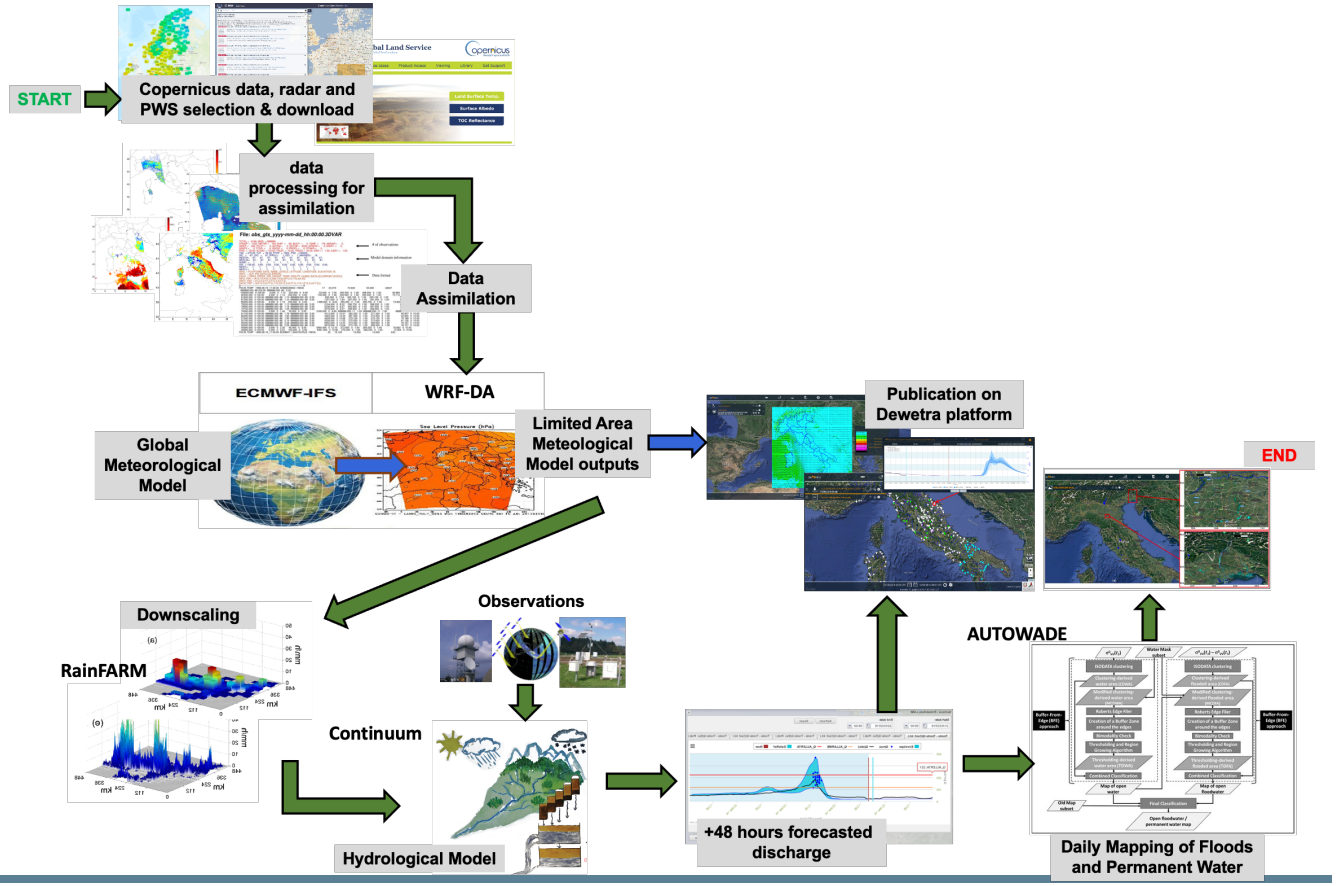
- Medicane, from Mediterranean hurricane, is a cyclone that can manifest different characteristics at different stages of its life cycle
- Its genesis is typical of extra-tropical cyclones that are frequently observed in the middle latitudes, but under certain conditions it can evolve into phenomena 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.



MEDICANE CHARACTERISTICS

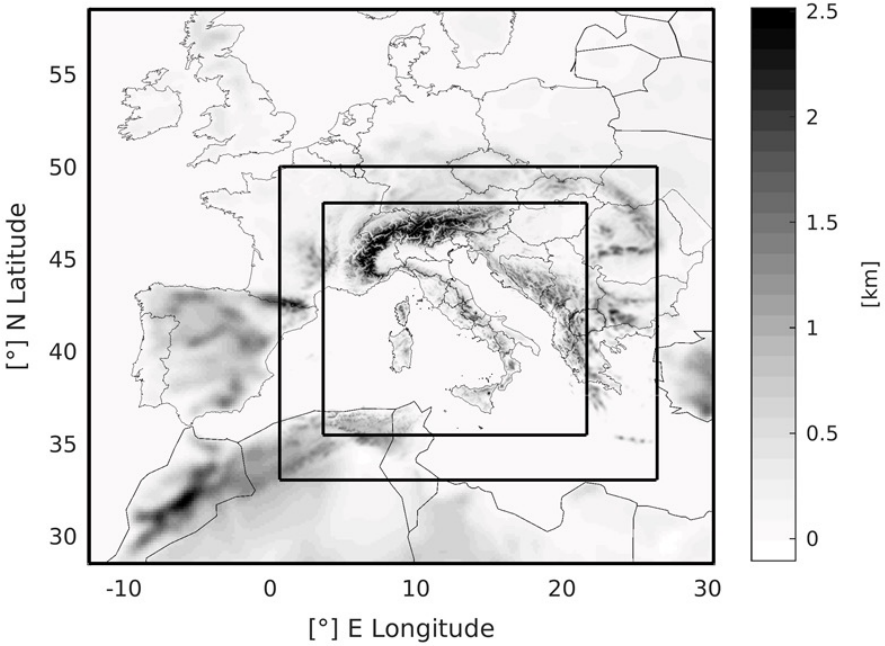
- Medicane never reach the intensities of hurricanes of the highest category, at most they have winds comparable to category 1 hurricanes, i.e. higher than 110 km/h. For comparison, Category 5 cyclones have winds above 250 km/h
- In addition, Medicane lasts less, from 24 to 36 hours, while tropical cyclones 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

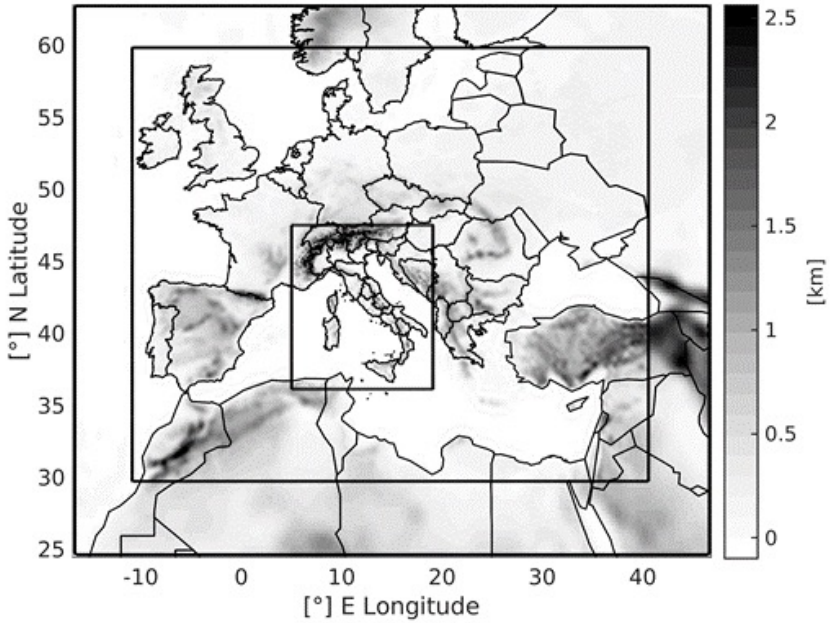


METEOROLOGICAL MODELLING @CIMA

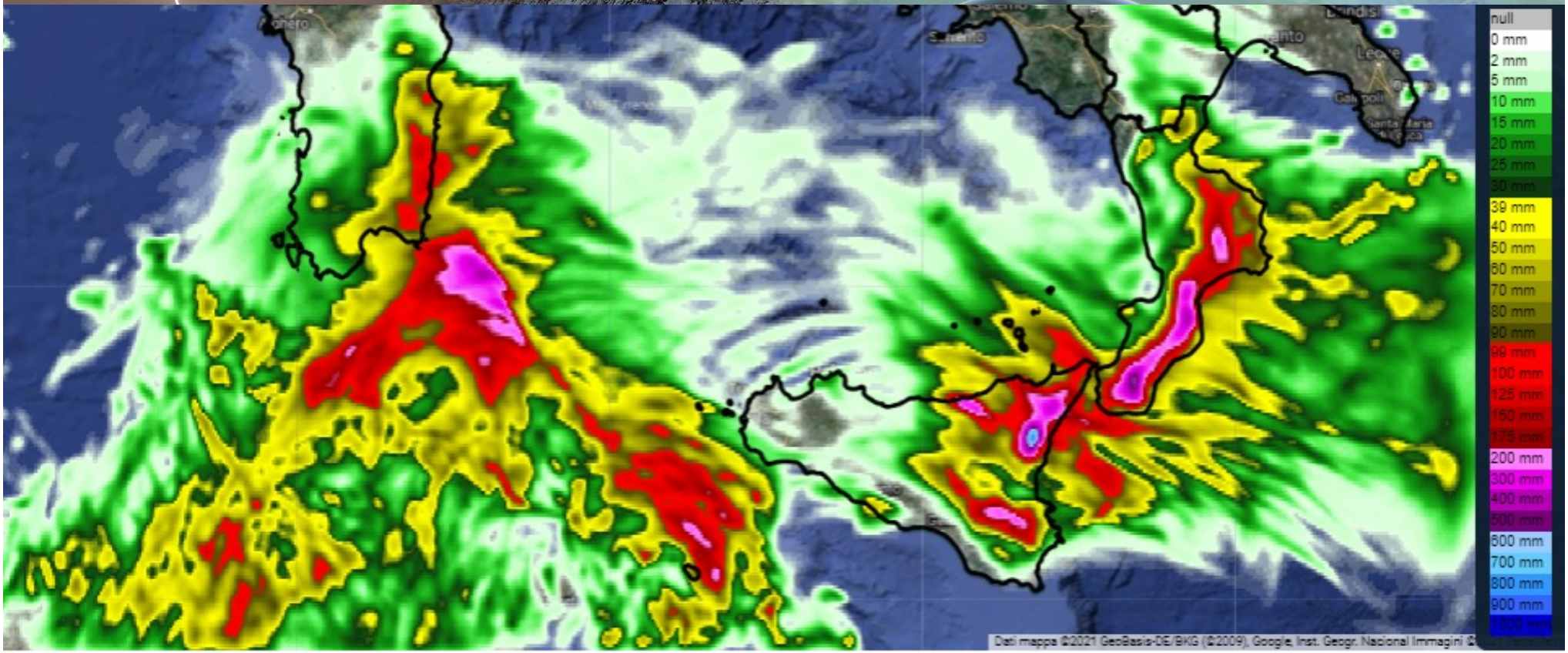
WRF-OL 1.5KM



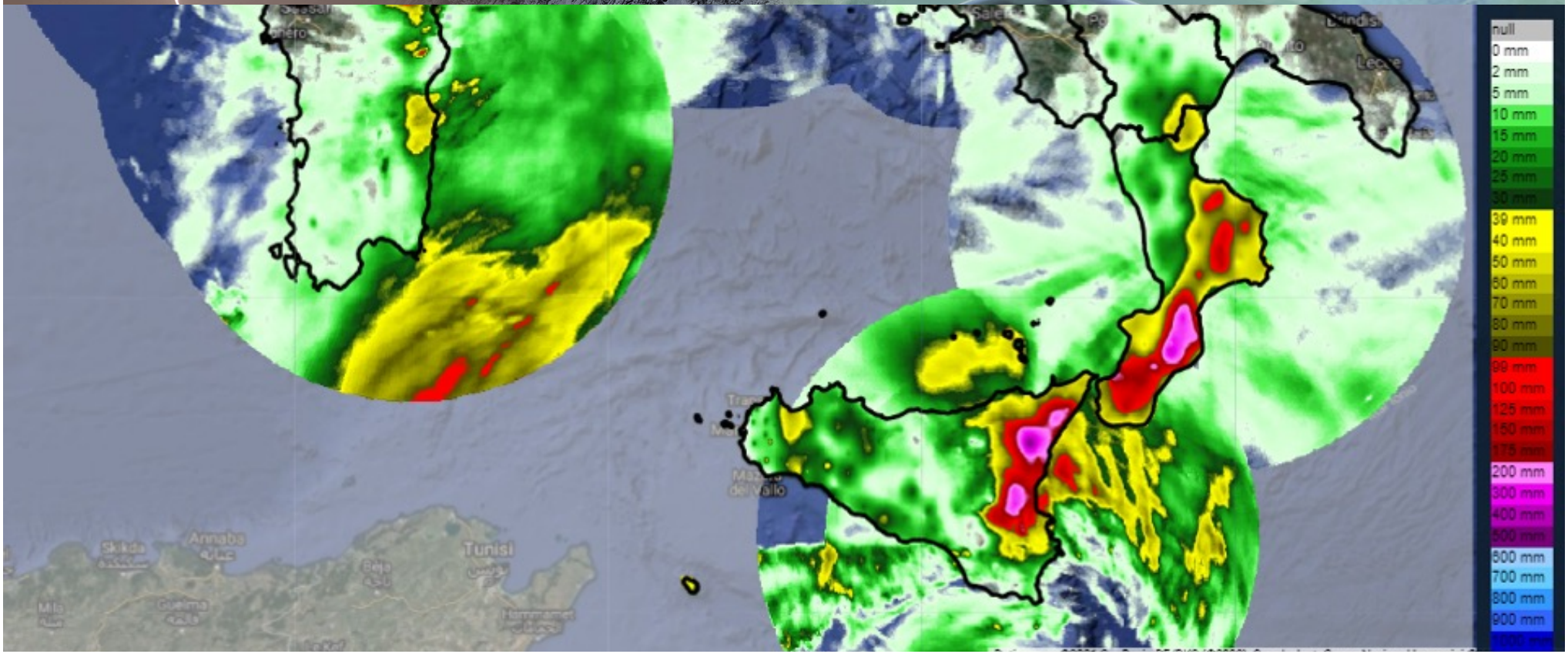
WRF-DA 2.5KM



QPF 24-26 OTTOBRE 2021- WRF-DA 2.5KM

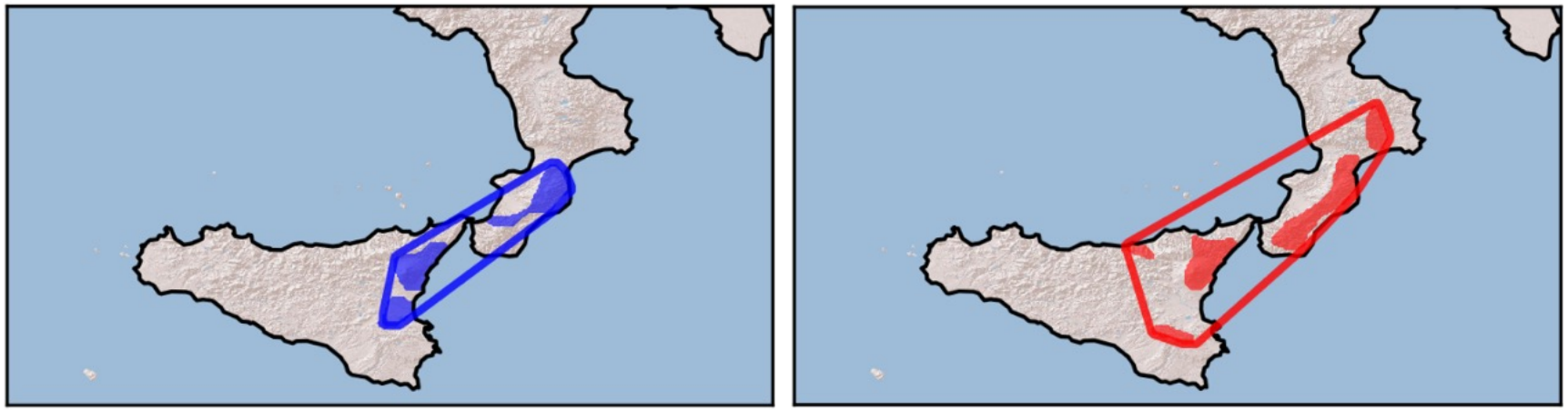


QPE 24-26 OTTOBRE 2021- RADAR & PLUVIO



MODE OBJECTS ANALYSIS

Rain clusters, threshold: 150mm/48h



Observed (blue) and forecast (red) clusters

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

FLOOD FORECASTING CHAIN

THE ITALY IMPLEMENTATION

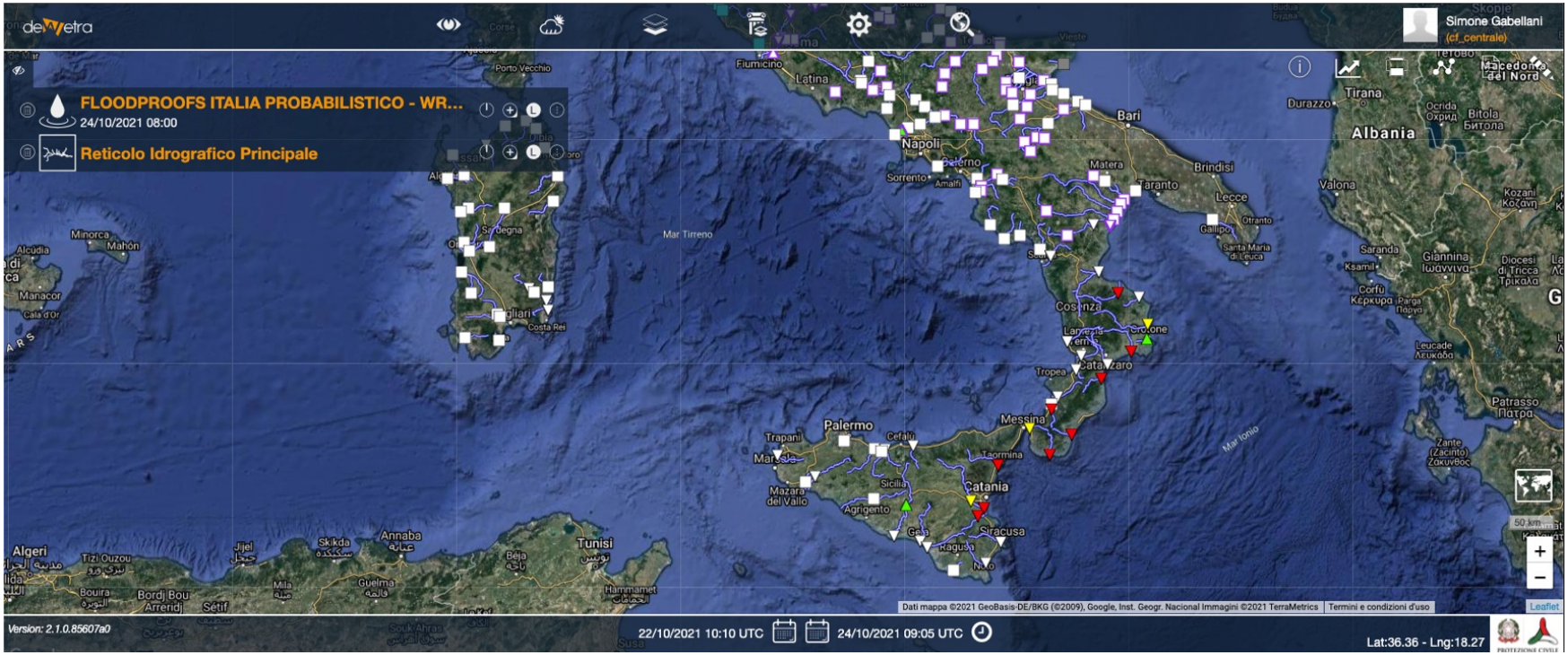
Spatial resolution: around 500 m

17 calculation domains cover the country

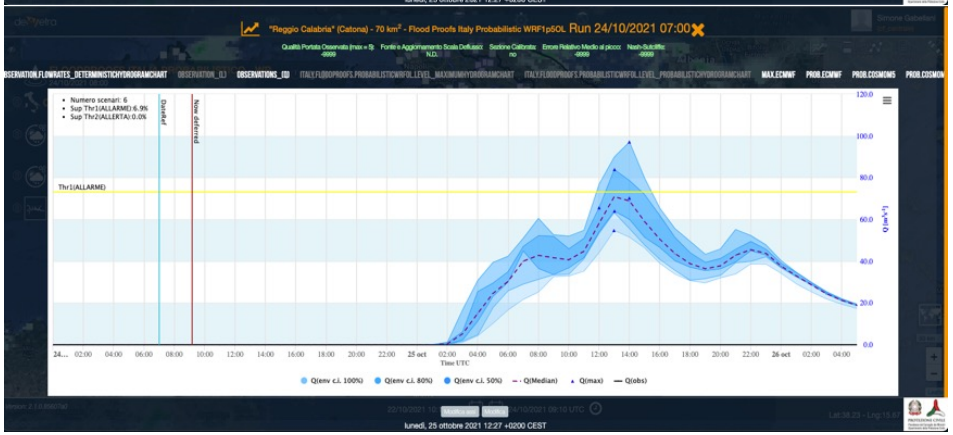
FORECAST FLOODPROOFS: 24 OCTOBER 09 UTC

Forecast FloodPROOFS (input WRF)

Predicted peak discharges: Calabria and Sicily



FORECAST FLOODPROOFS: 24 OCTOBER 09 UTC

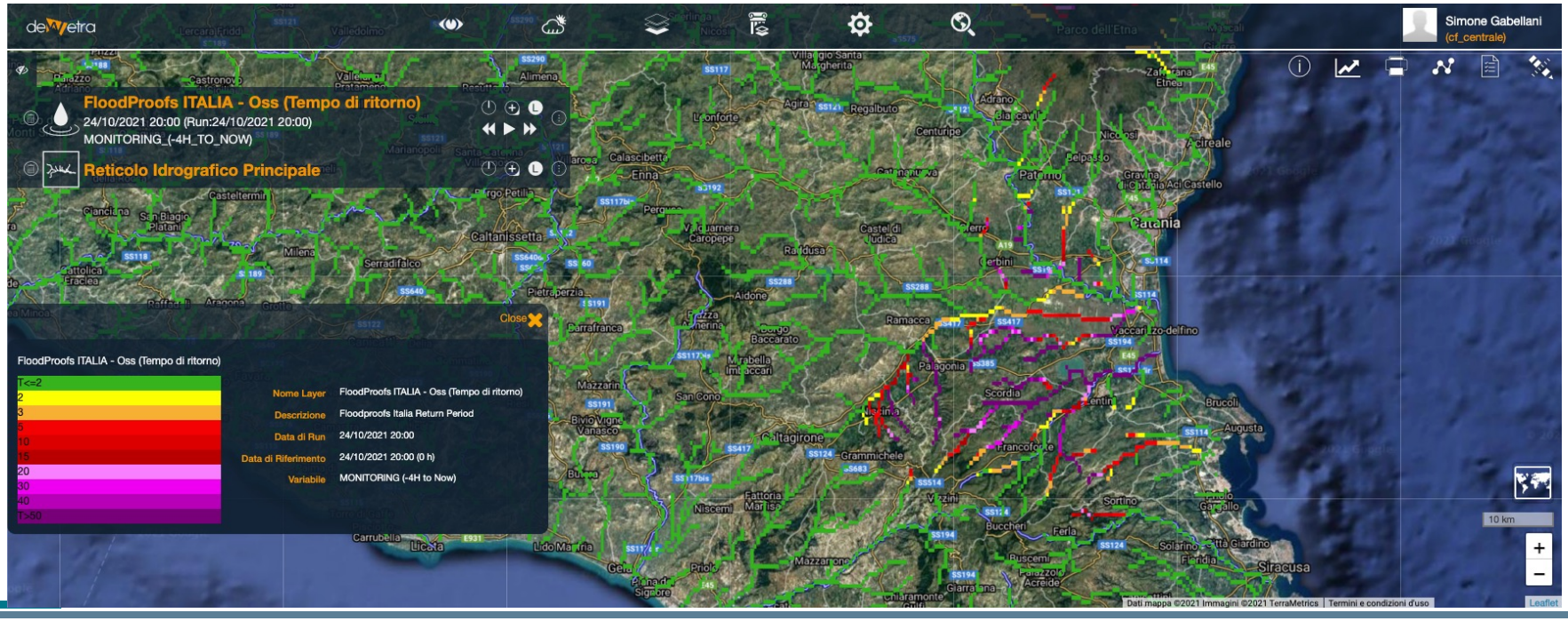


OBSERVATION DRIVEN FLOODPROOFS: 24 OCTOBER 20 UTC

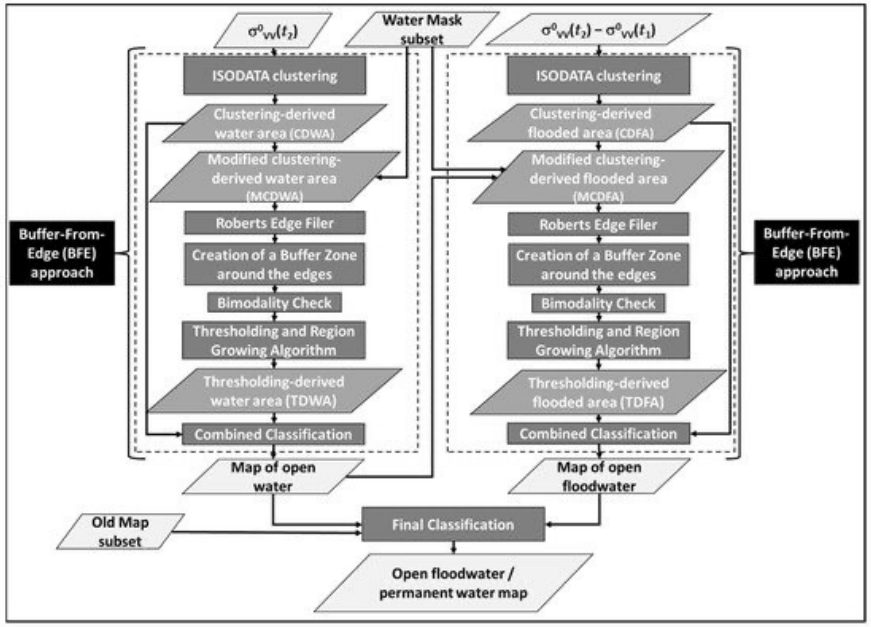
FloodPROOFS driven by meteorological observations including Soil Moisture (HSAF product)

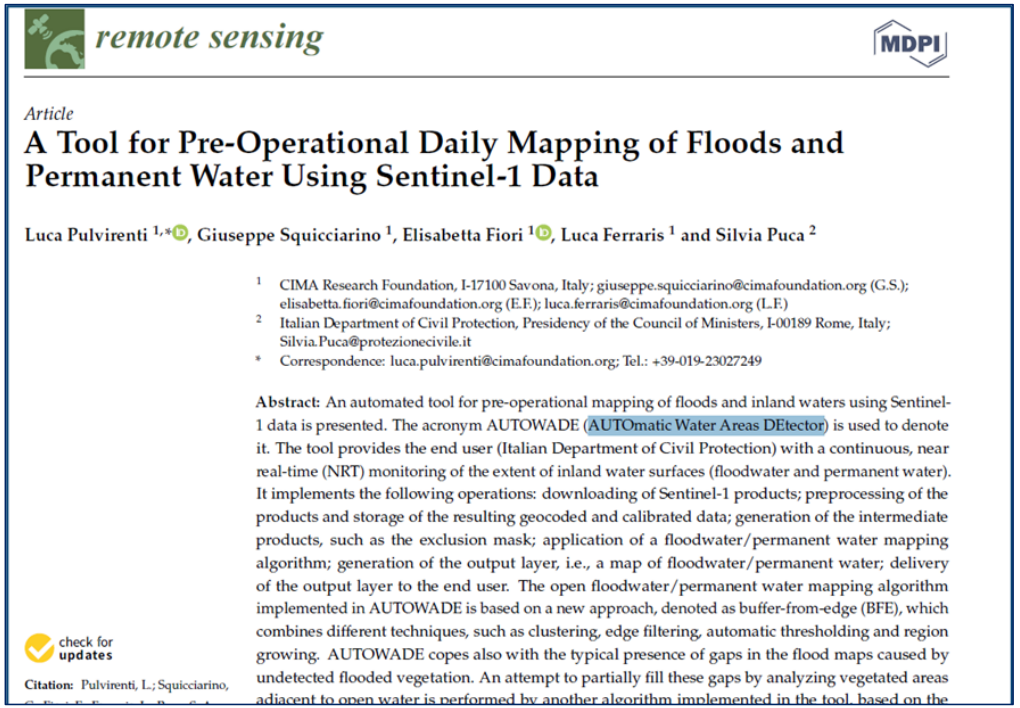
«Return time» produts (based on model climatology)

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



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]

[1] CIMA Research Foundation, I-17100 Savona, Italy; giuseppe.squicciarino@cimafoundation.org (G.S.); elisabetta.fiori@cimafoundation.org (E.F.); luca.ferraris@cimafoundation.org (L.F.)
[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

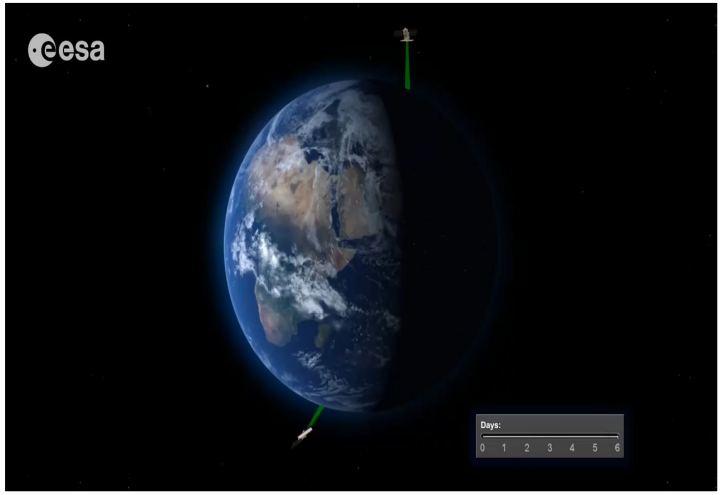
Citation: Pulvirenti, L.; Squicciarino,

SENTINEL 1 ITALY COVERAGE

- 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

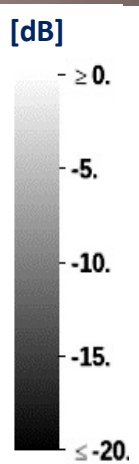
7 descending orbits – 30 frames

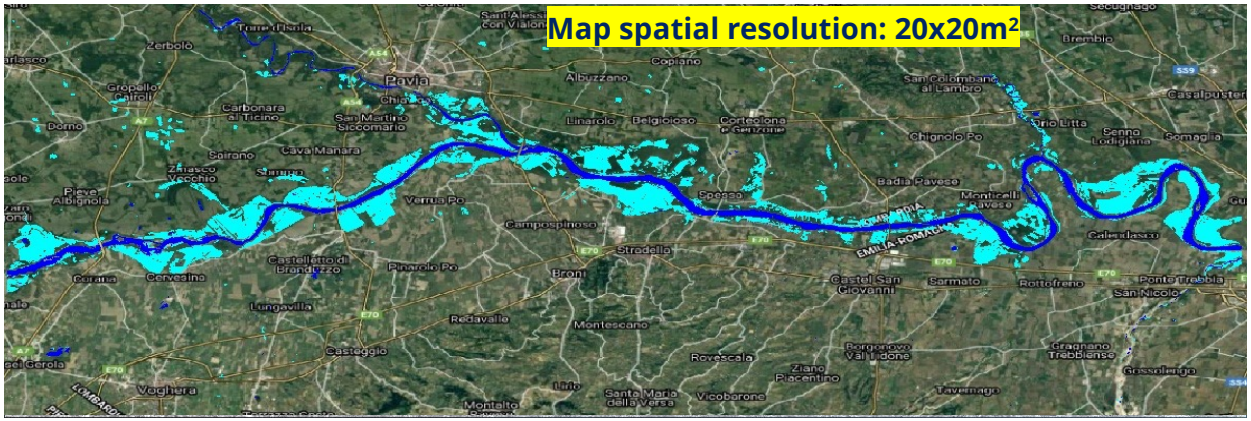
6 ascending orbits – 34 frames



COURTESY FROM ESA

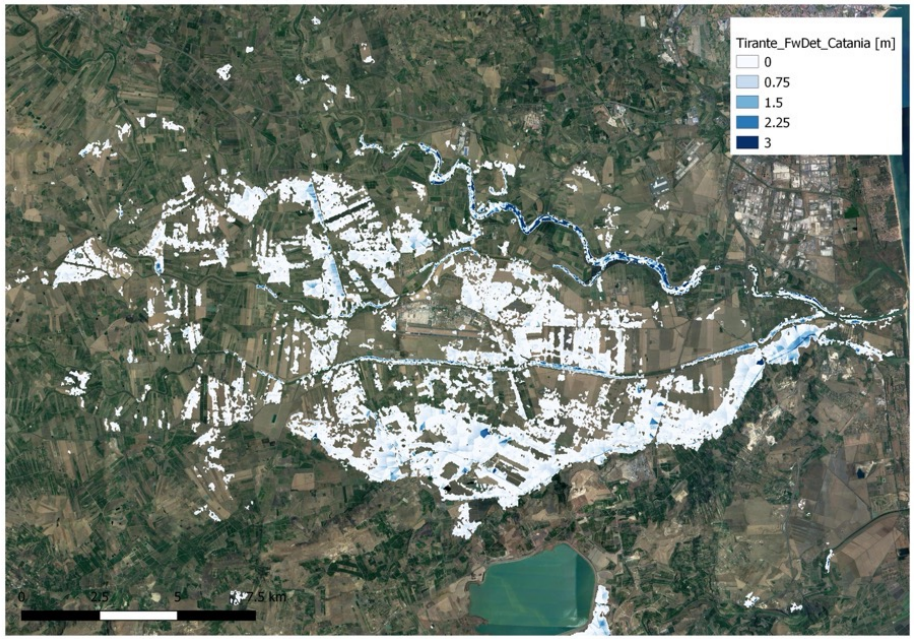
FLOOD AREAS DETECTION

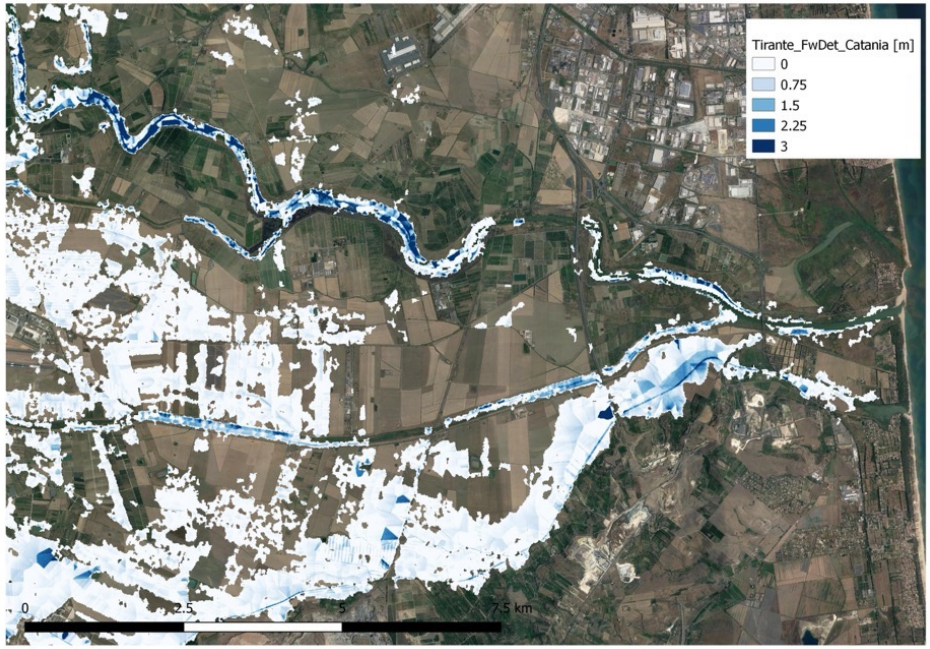




25 OCTOBER WATER DEPTH BASED ON S1 OBSERVATIONS

For the estimation of the water level the algorithm FwDET and DEM 2 meters was used (source DEM: Sicily Region)



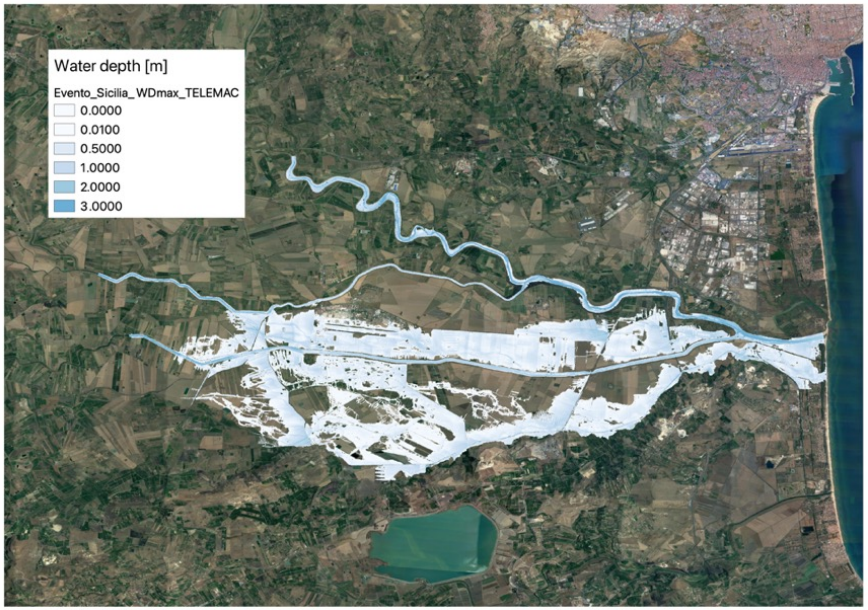


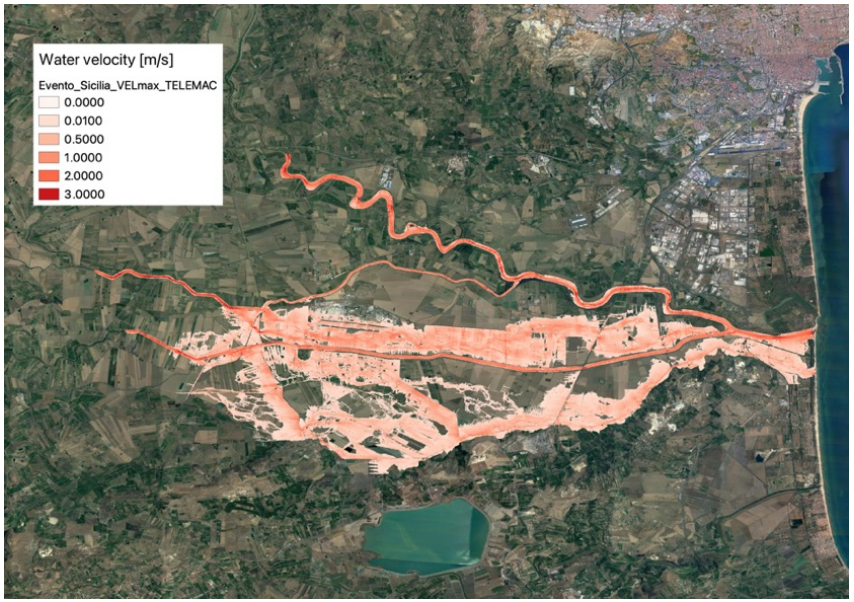
25 OCTOBER WATER DEPTH AND VELOCITY FORECAST: TELEMAC2D

DEM 2 meters

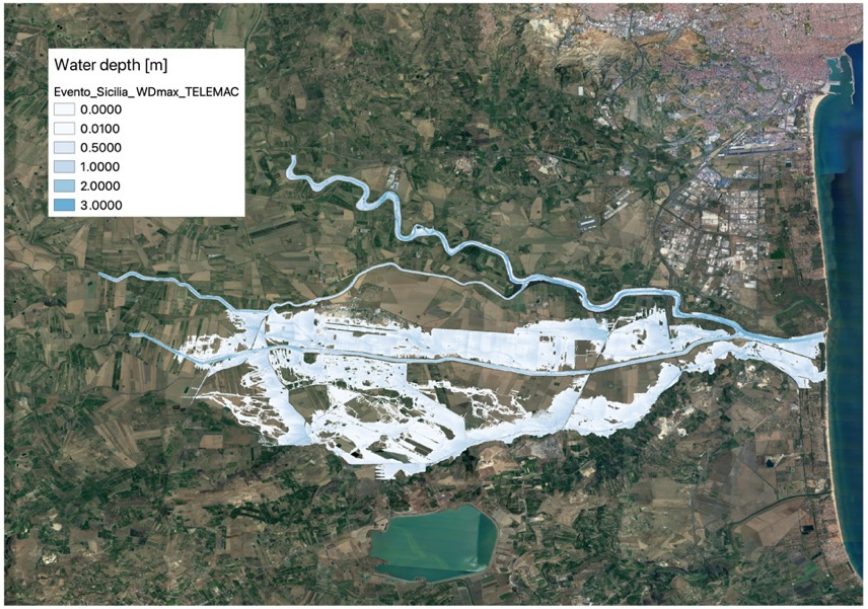
Discharge as Input: operational simulations FloodPROOFS-Italy

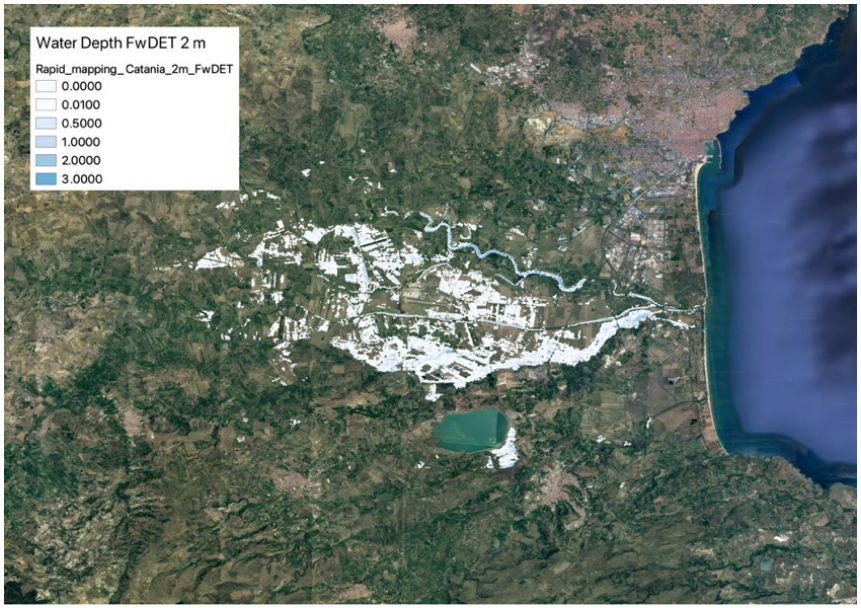
Hydraulics model: **TELEMAC2D** Forecasts available on 28 October 2021 9UTC





TELEMAC2D VS SENTINEL 1 WATER LEVELS





MERGING

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 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