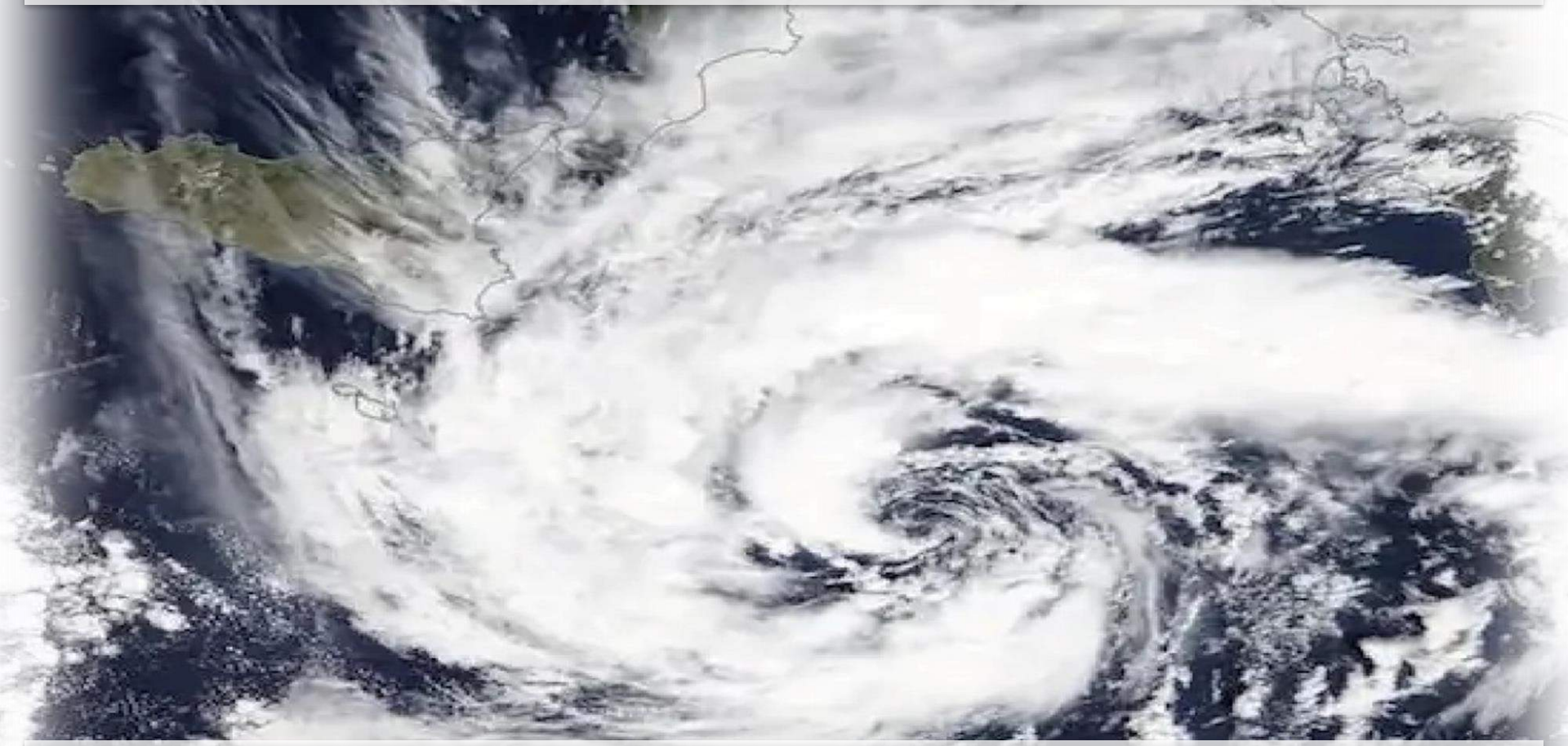
3rd MedCyclones Workshop & Training School
15 19 July 2024 | ESA-ESRIN, Frascati (Rome), Italy



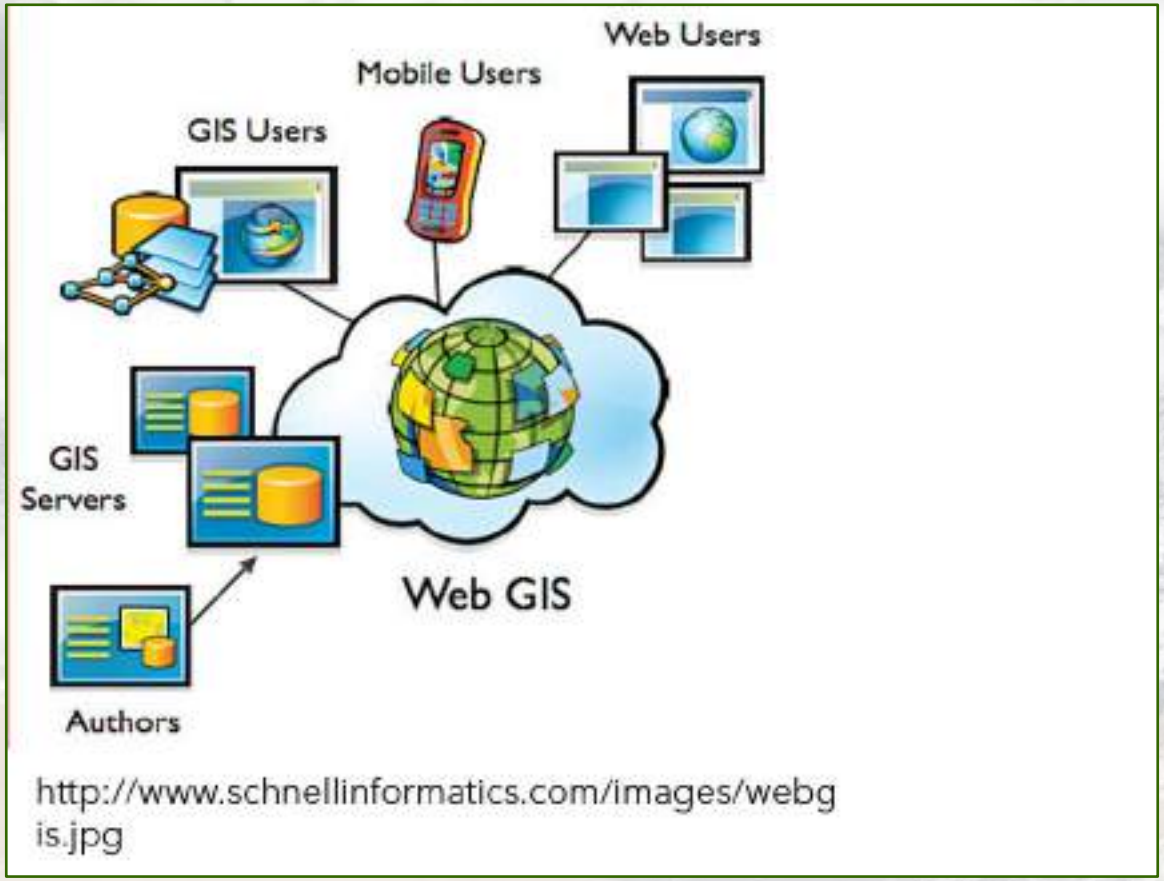
Addressing the impacts of Mediterranean cyclones by integrating a relational geodatabase in ARCHIMEDE Web-GIS platform

G. Scicchitano – University of Bari

www.archimedemedicane.it

WHAT IS A WEB-GIS

Web GIS, or Web-Based Geographic Information Systems, are GIS platforms that utilize the World Wide Web for the storage, visualization, analysis, and distribution of spatial information via the Internet. The overarching goal of this technology is to allow users to dynamically access, share, and manipulate geospatial data on the web no matter the platform or protocol.



http://www.schnellinformatics.com/images/webgis.jpg

GEOPORTALS

A geoportal is a type of web portal used to find and access geographic information (geospatial information) and associated geographic services (display, editing, analysis, etc.) via the Internet.

Geoportals are important for effective use of geographic information systems (GIS) and a key element of a spatial data infrastructure (SDI).

ARCHIMEDE Web-GIS platform

Data Collection

Creation of web map by qgis2web plugin

Web-server deployment

Processing with Q-GIS

Layers arrangement & Symbolization

PostgreSQL

Database creation

GEODATABASE DESCRIPTION

tary Material) [17]. Extratropical cyclones were selected based on their severity and their significant impact on coastal areas [33–35].

Table 1. The classification of Mediterranean tropical-like cyclones based on an intensity scale. Only extratropical cyclones with an intensity matching this table were considered in this study.

	Mediterranean Tropical Depression	Mediterranean Tropical Storm	Mediterranean Hurricane
Wind Speed (km/h)	<63	64–111	>112
MSLP (hPa)	1006–1015	994–1005	974–993

A relational database was used to store and manage the cyclone data; PostgreSQL was selected because it is an open-source database system that offers excellent support for geospatial datasets through the PostGIS extension and is also capable of integrating a variety of spatial datasets in both vector and raster forms in a web-based application. The

(1) Cyclone tracks and position derived from MSLP extracted from ERA-5 reanalysis, with tracks and positions based on every 6 h mean sea level pressure;
(2) SST differences (following the methods reported in Scardino et al. [15]) obtained from the reanalysis of CMEMS (Copernicus Marine Environment Monitoring Service) and satellite data;
(3) Wind speeds extracted from ERA-5 reanalysis, considering the eastward wind component (U wind) and the northward wind component (V wind), 10 m above the surface with an hourly temporal span;
(4) Seismic data;
(5) Old and new geomorphological data.

application through the QGIS2Web plugin. This plugin generates a simple web application containing all of the related files and resources in an organized manner, including basic

aboration of Italian inter-university PhD courses in sustainable development and climate change (PhD-SDC) (link: www.phd-sdc.it)
Coordinator: Prof. Gio

remote sensing **Kushabaha et al., 2024** MDPI

Article

ARCHIMEDE—An Innovative Web-GIS Platform for the Study of Medicanes

Alok Kushabaha [1,2], Giovanni Scardino [2,3,*], Gaetano Sabato [2], Mario Marcello Miglietta [2,4], Emmanouil Flaounas [5,6], Pietro Monforte [7], Antonella Marsico [2,3], Vincenzo De Santis [2,3], Alfio Marco Borzì [8] and Giovanni Scicchitano [2,3]

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3 Interdepartmental Research Center for Coastal Dynamics, University of Bari Aldo Moro, 70125 Bari, Italy
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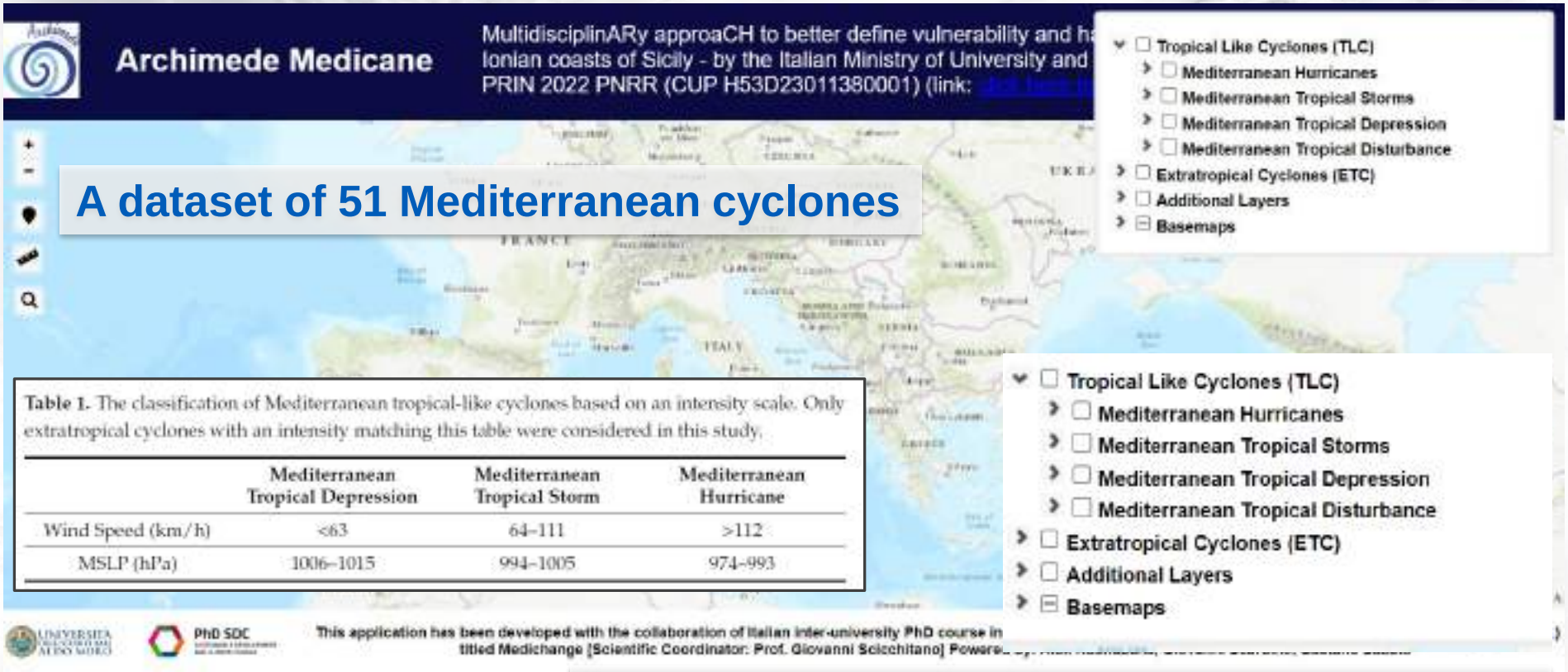
6 Institute of Oceanography, Hellenic Centre for Marine Research, P.O. Box 712, 19013 Athens, Greece
7 Department of Civil Engineering and Architecture, University of Catania, 95125 Catania, Italy; pietro.monforte@dicar.unict.it
8 Department of Biological, Geological and Environmental Sciences, University of Catania, 95129 Catania, Italy;

GEODATABASE DEVELOPMENT

The ARCHIMEDE geodatabase was initialized by separating extratropical cyclones and Mediterranean tropical-like cyclones



A dataset of 51 Mediterranean cyclones

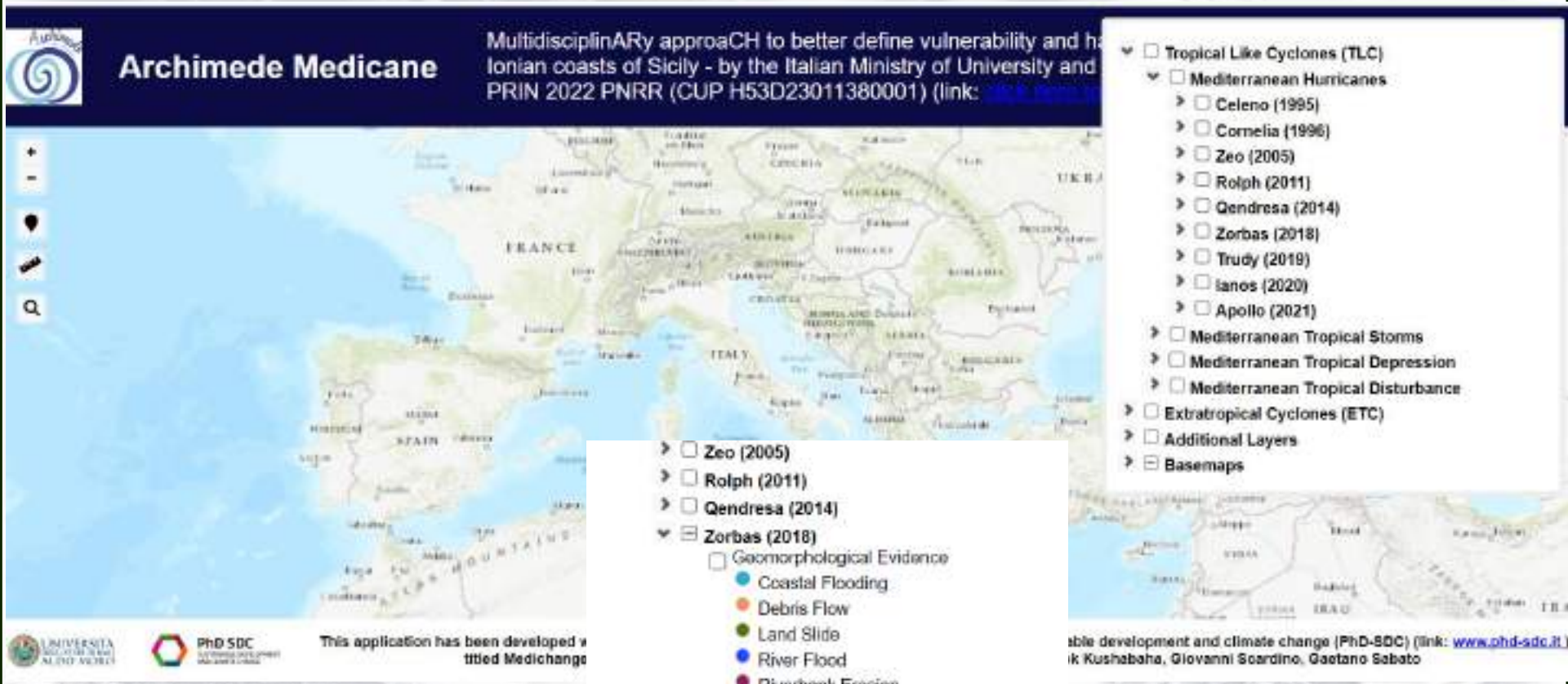
Table 1. The classification of Mediterranean tropical-like cyclones based on an intensity scale. Only extratropical cyclones with an intensity matching this table were considered in this study.

	Mediterranean Tropical Depression	Mediterranean Tropical Storm	Mediterranean Hurricane
Wind Speed (km/h)	<63	64–111	>112
MSLP (hPa)	1006–1015	994–1005	974–993

Tropical Like Cyclones (TLC)
Mediterranean Hurricanes
Mediterranean Tropical Storms
Mediterranean Tropical Depression
Mediterranean Tropical Disturbance
Extratropical Cyclones (ETC)
Additional Layers
Basemaps

Mediterranean tropical-like cyclones were categorized based on their wind speed and mean sea level pressure (MSLP), following the standards of the German Meteorological Service, which proposed an unofficial classification based on the average peak wind speed of intensity v, following the Saffir–Simpson scale for tropical cyclones

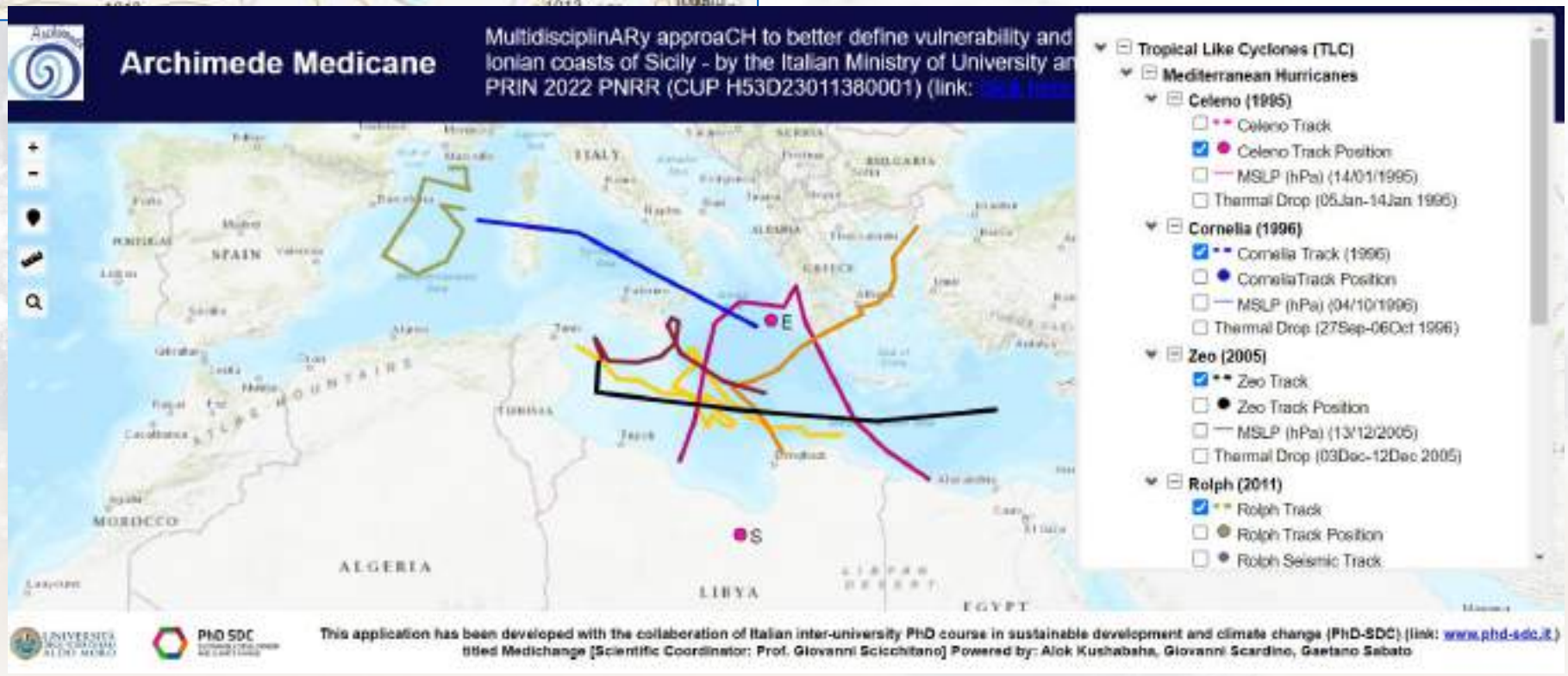
GEODATABASE STRUCTURE



GEODATABASE DEFINITION

Cyclone tracks and position derived from MSLP extracted from ERA-5 reanalysis, with tracks and positions based on every 6 h mean sea level pressure

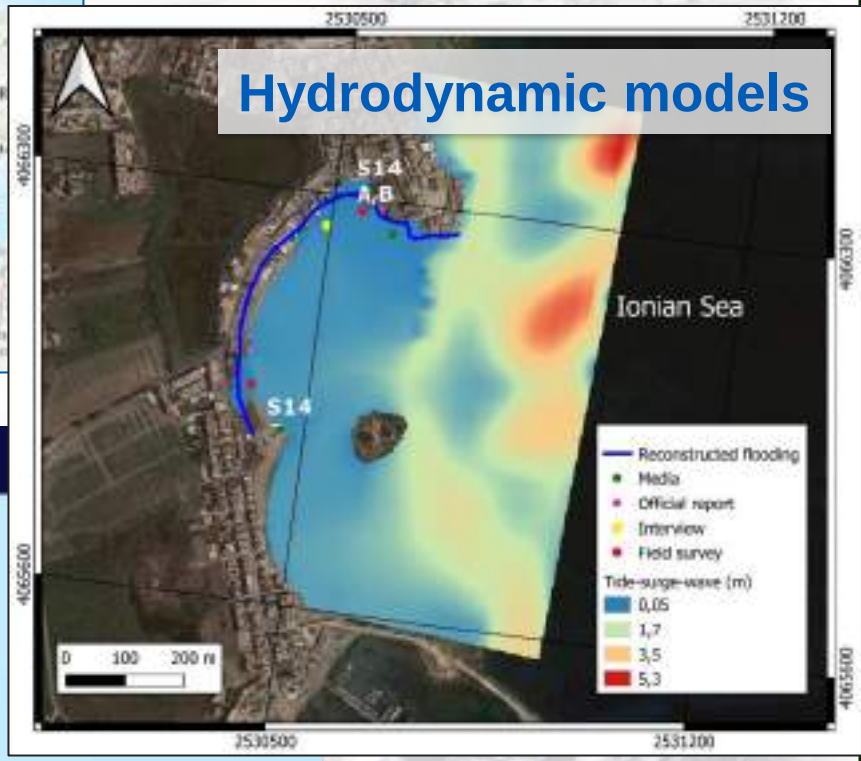
Wind speeds extracted from ERA-5 reanalysis, considering the eastward wind component (U wind) and the northward wind component (V wind), 10 m above the surface with an hourly temporal span



GEODATABASE DEFINITION

Seismic Data

Hydrodynamic models



geomorphological data

BASE MAPS

Archimede Medicane
MultidisciplinARy approaCH to better define vulnerability and hazard of MEDicanEs along the Ionian coasts of Sicily - by the Italian Ministry of University and Research (MUR) .
PRIN 2022 PNRR (CUP H53D23011380001) (link:)
ESRI World Topgraphic map
PhD SDC
This application has been developed with the collaboration of Italian inter-university PhD course in sustainable development and climate change (PhD-SDC) (link: www.phd-sdc.it.)
titled Medichange (Scientific Coordinator: Prof. Giovanni Scicchitano) Powered by: Alok Kushabaha, Giovanni Scardina, Gaetano Sabato

Archimede Medicane
MultidisciplinARy approaCH to better define vulnerability and hazard of MEDicanEs along the Ionian coasts of Sicily - by the Italian Ministry of University and Research (MUR) .
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Google Satellite
PhD SDC
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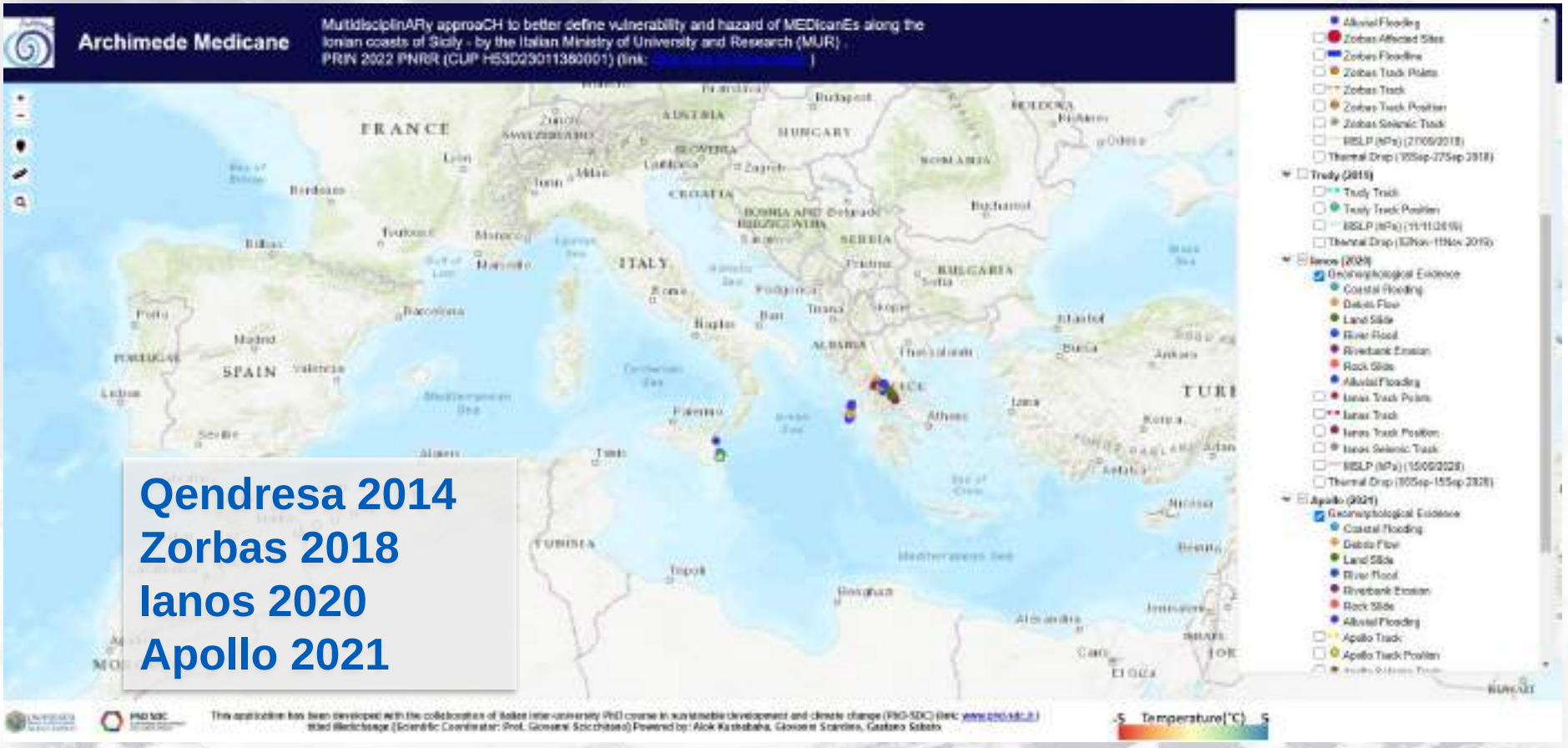
GEOMORPHOLOGICAL DATA



COASTAL GEOMORPHOLOGICAL DATA

Layer: Geomorphological Evidence

Paving slabs carried by the medicane Zorbas on the Arenella sandy coast (south-eastern Sicily).

Coastal Flooding

Zorbas 2018

sciencedirect.com/scie...01389

Layer: Zorbas Floodline

Medicane Zorbas Floodline - (2018)

Marine Geology

Comparing impact effects of common storms and Medicanes along the coast of south-eastern Sicily

Giovanni Scichitano, Giovanni Scardino, Camelo Monaco, Arcangelo Piscitelli, Maurilio Milella, Francesco De Giosa, Giuseppe Mastronuzzi

COASTAL GEOMORPHOLOGICAL DATA

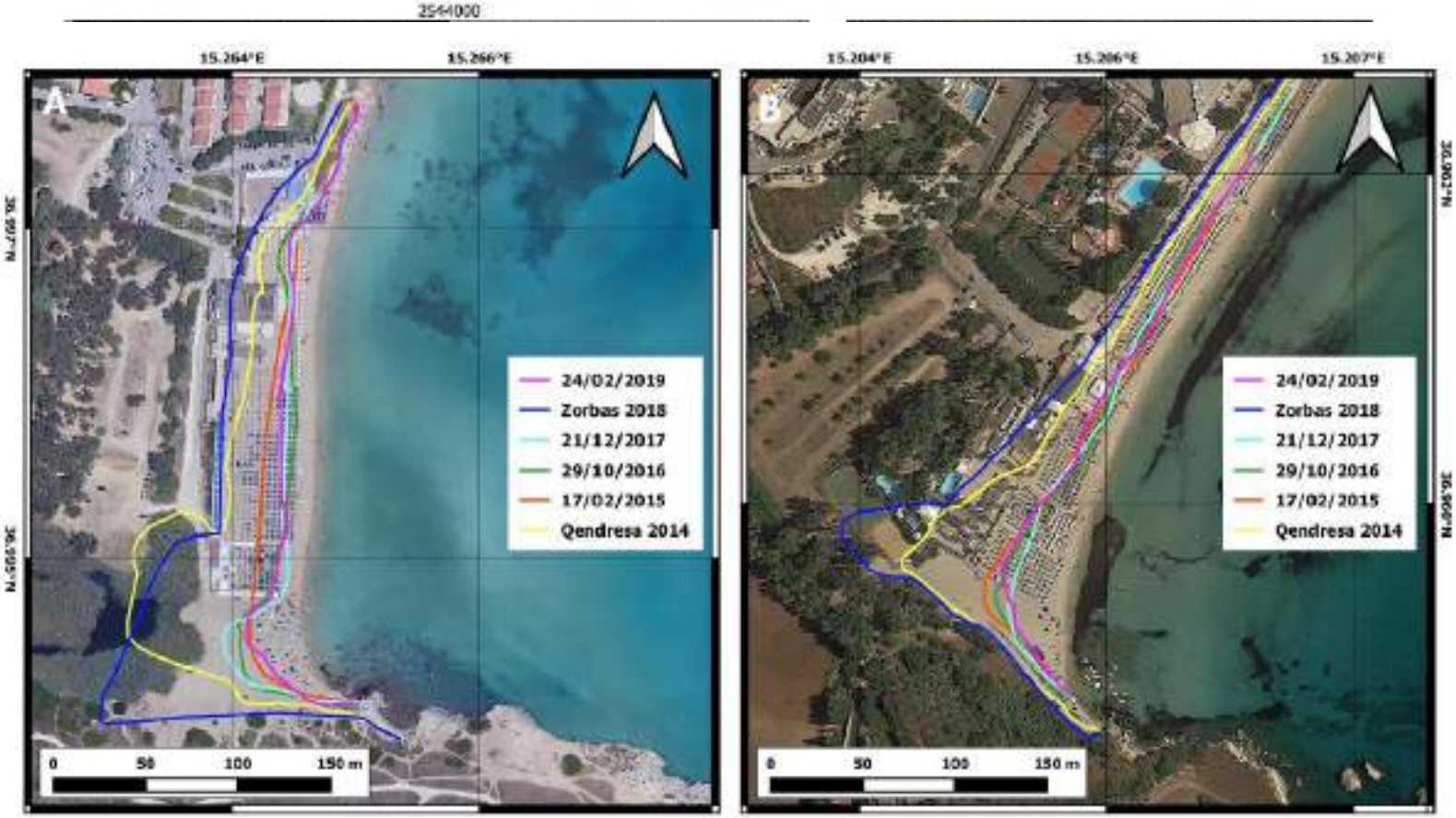


Fig. 7. Flooding limits surveyed in two specific areas during different Medicanes and storm events; A – flooding on Arenella beach (Area 3); B- flooding on Fontane Bianche (Area 5).

COASTAL GEOMORPHOLOGICAL DATA

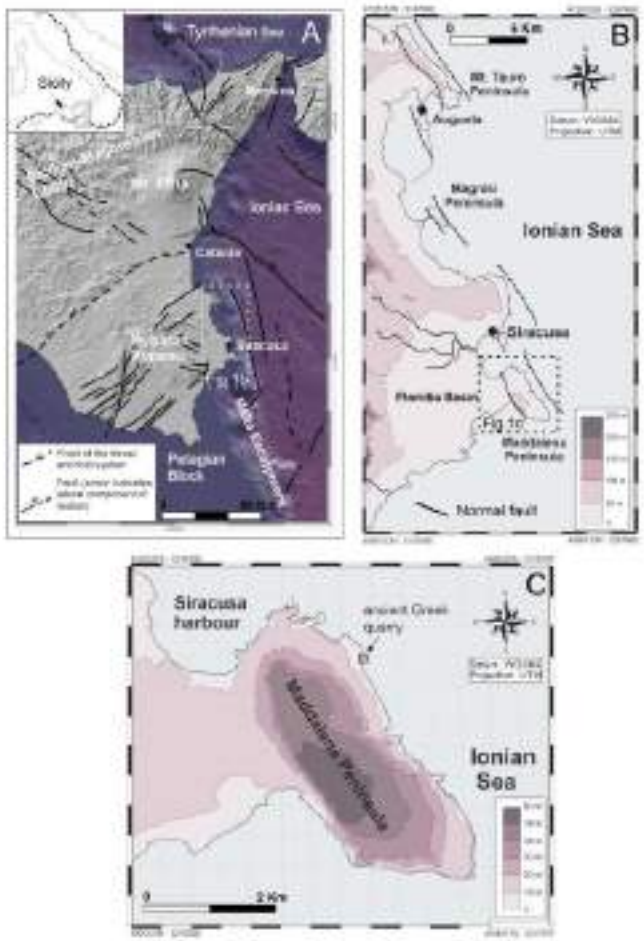


Figure 1. Geological settings of Southeastern Sicily. (A) Tectonic sketch map of the Sicilian Collision Zone in eastern Sicily (from Cultrera et al. [39], modified). (B) Position of the Maddalena Peninsula area along the Ionian coast of southeastern Sicily. (C) Morphological map of the Maddalena Peninsula showing the location of the study area (box).

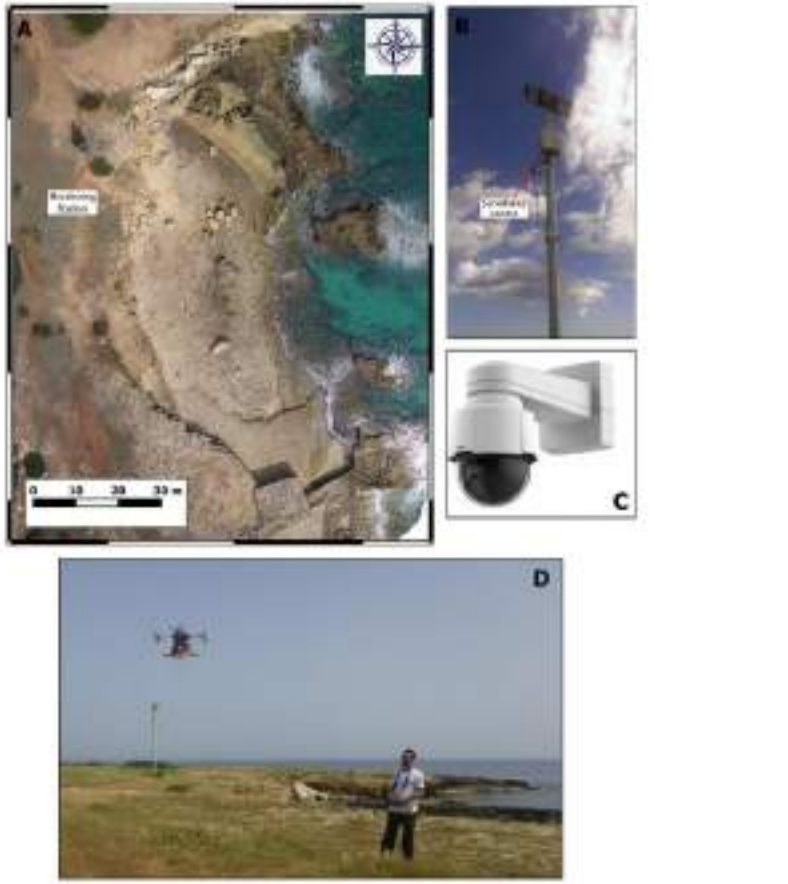


Figure 3. (A) Orthophoto (Resolution 1cm/pxl) of ancient Greek quarry located in the northern sector of the Maddalena Peninsula, the arrow shows the Monitoring Station. (B) Monitoring Station mounted on

water

MDPI

Article

The First Video Witness of Coastal Boulder Displacements Recorded during the Impact of Medicane "Zorbas" on Southeastern Sicily

COASTAL GEOMORPHOLOGICAL DATA

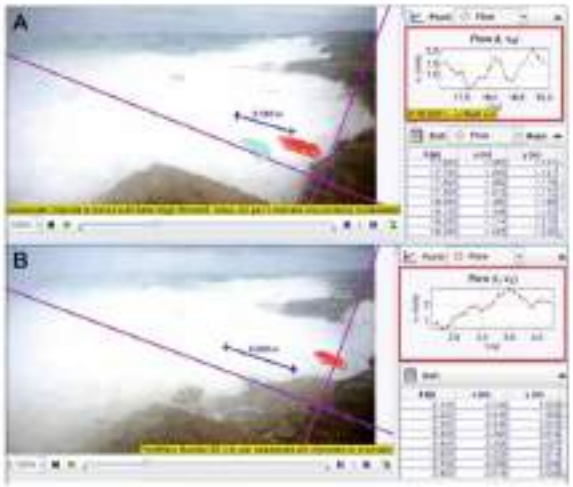


Figure 8. Editing analysis of video frames during boulder movements through Tracker software. (A) Rolling of boulder B2 at hour 15:02:00 UTC; (B) movement of boulder B3 at hour 16:16:00 UTC. In the red box diagrams are showed the flow velocity estimations marked for each frame of the video.

Table 3. Boulder detected by video-editing, selected for flow velocity comparison with hydrodynamic models.

Boulder	Instant Time (Hour UTC)	Maximum Flow Observed in the Videos (m/s)
B2	15:01:59	2.1 ± 0.42
B3	16:26:13	2.33 ± 0.5
BN	18:16:27	1.98 ± 0.11
B4	16:17:49	2.53 ± 1.34
K*	16:30:08	4 ± 2.25

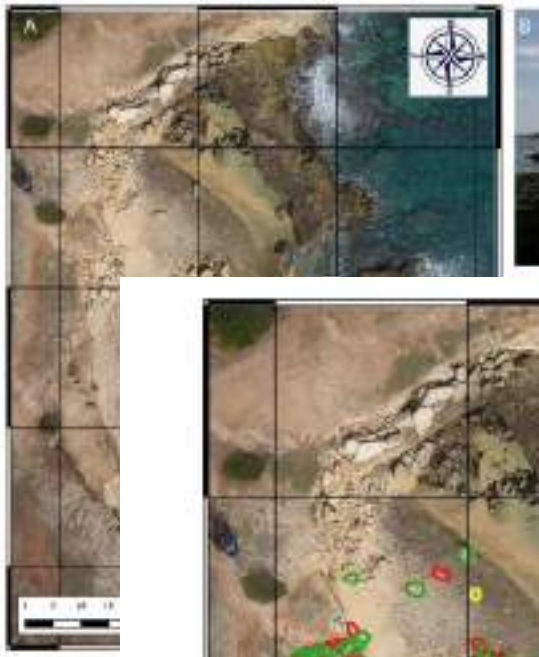


Figure 9. Bo
to 2018. (B) I
the storms.

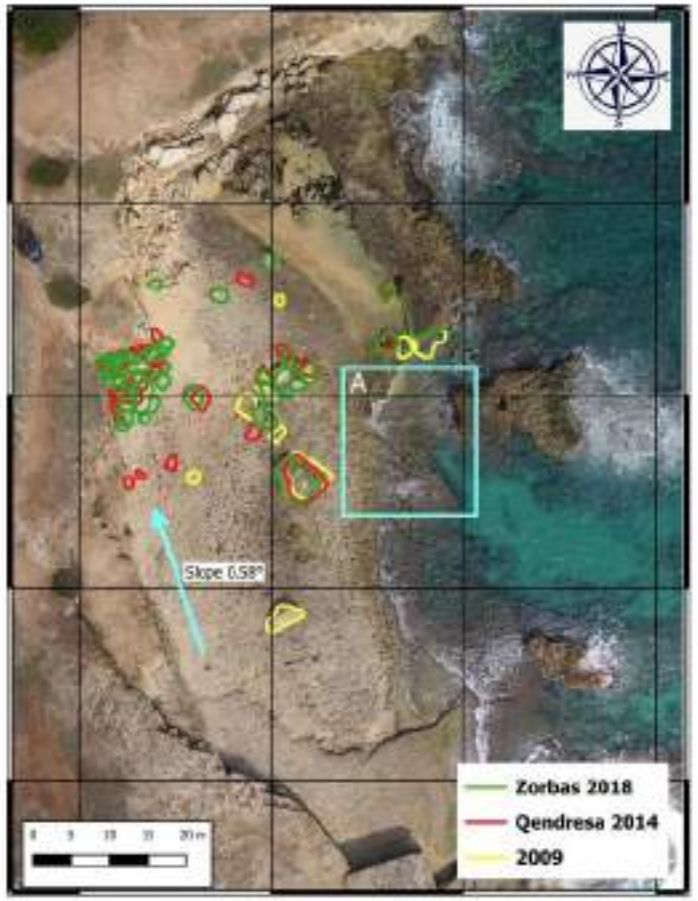


Figure 10. Boulders displaced by the impact of medicanes Qendresa and Zorbas; the rectangle marks the area where boulders have been detached from the coastline, and the arrow indicates the direction of the flow generating boulder deposit on the edge of the quarry.

COASTAL GEOMORPHOLOGICAL DATA

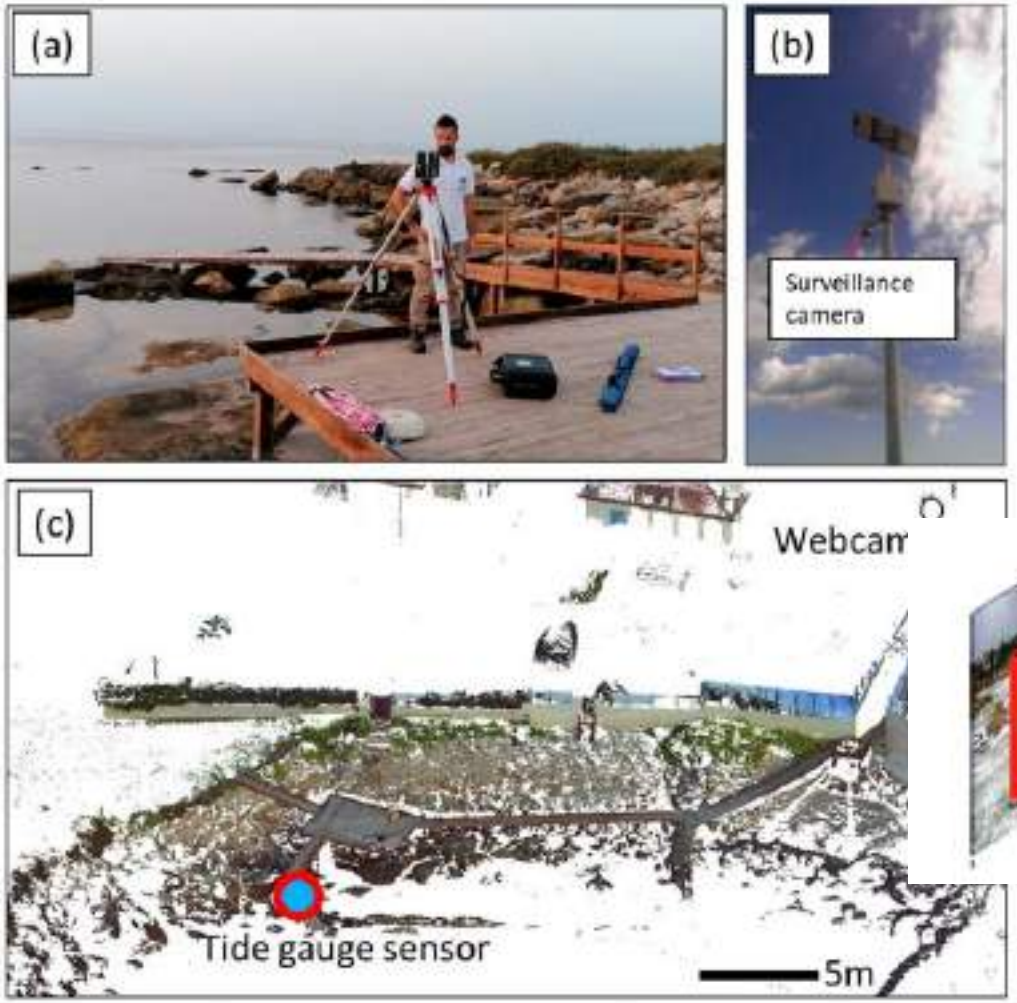
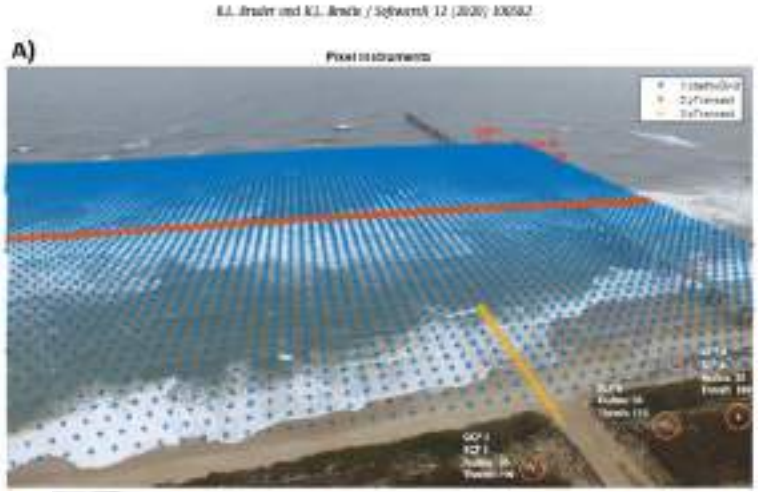
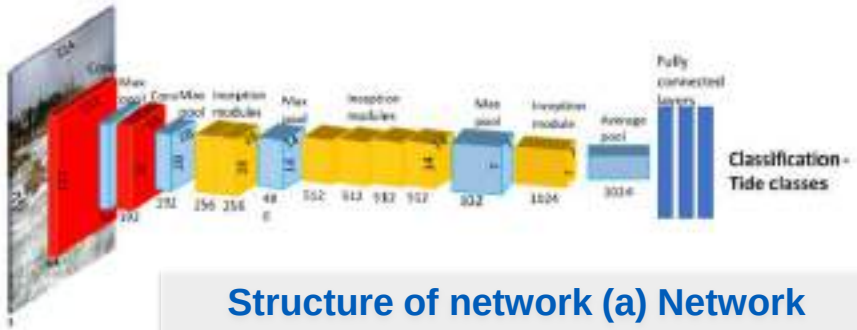


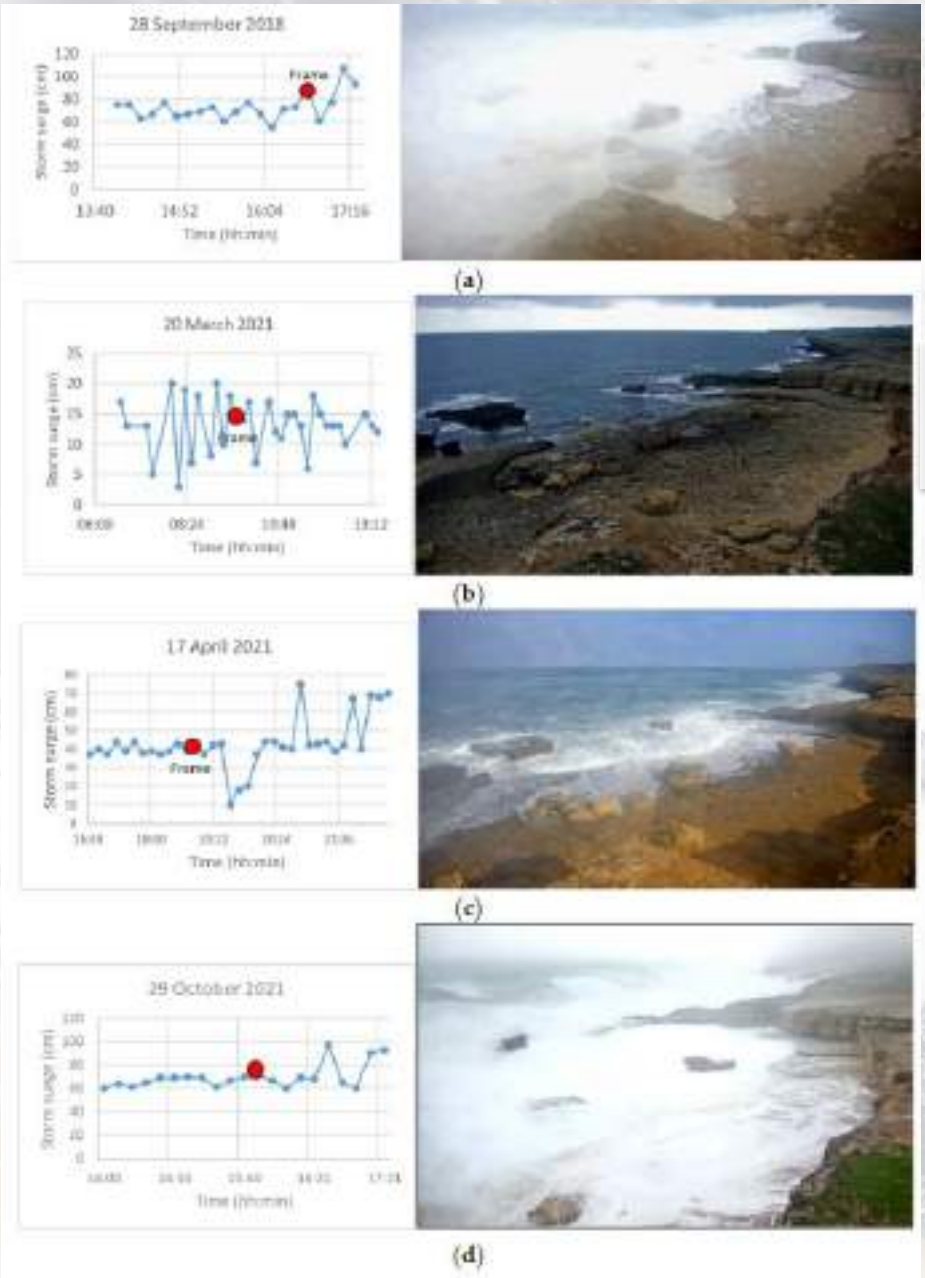
Figure 3. Topographic data: (a)-Topographic survey performed through TLS on Varco 11; (b)—surveillance camera of MPA; (c)—point clouds of TLS data of Varco 11 with ubications of the webcam and tide gauge sensor.





Structure of network (a) Network Architecture of CNN developed for assessing tidal values from video frames; (b) Inception module with dimension reductions used to decrease the computational expense (Scardino et al., 2022, Remote Sensing).

COASTAL GEOMORPHOLOGICAL DATA



Storm surge assessed through CNN during Medicane Zorbas

Storm surge assessed through CNN during storm of March 2021

Storm surge assessed through CNN during storm of April 2021.

Storm surge assessed through CNN during Medicane Ianos.

COASTAL GEOMORPHOLOGICAL DATA

The September 18-20 2020 Medicane Ianos Impact on Greece

Phase I Reconnaissance Report

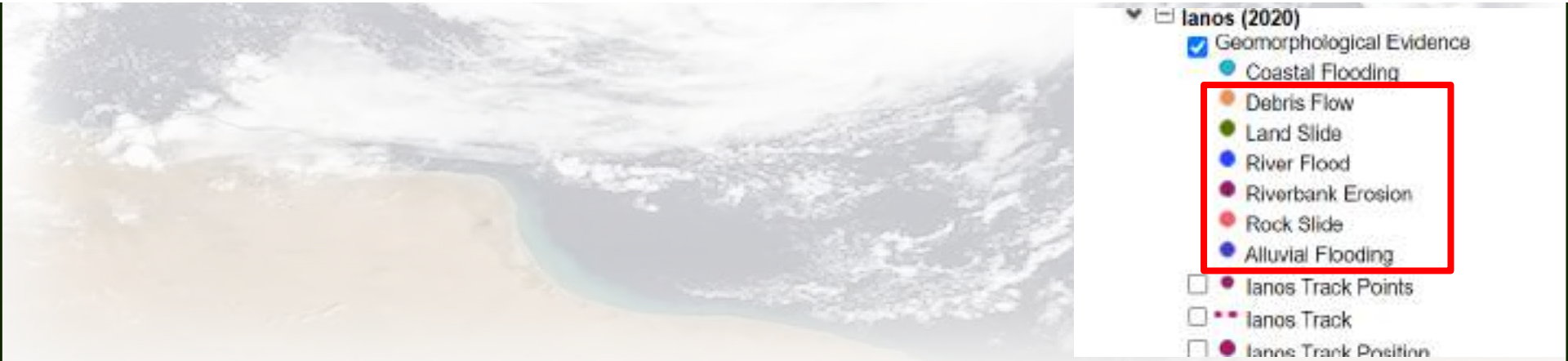
GEER

Geotechnical Extreme Events Reconnaissance Association

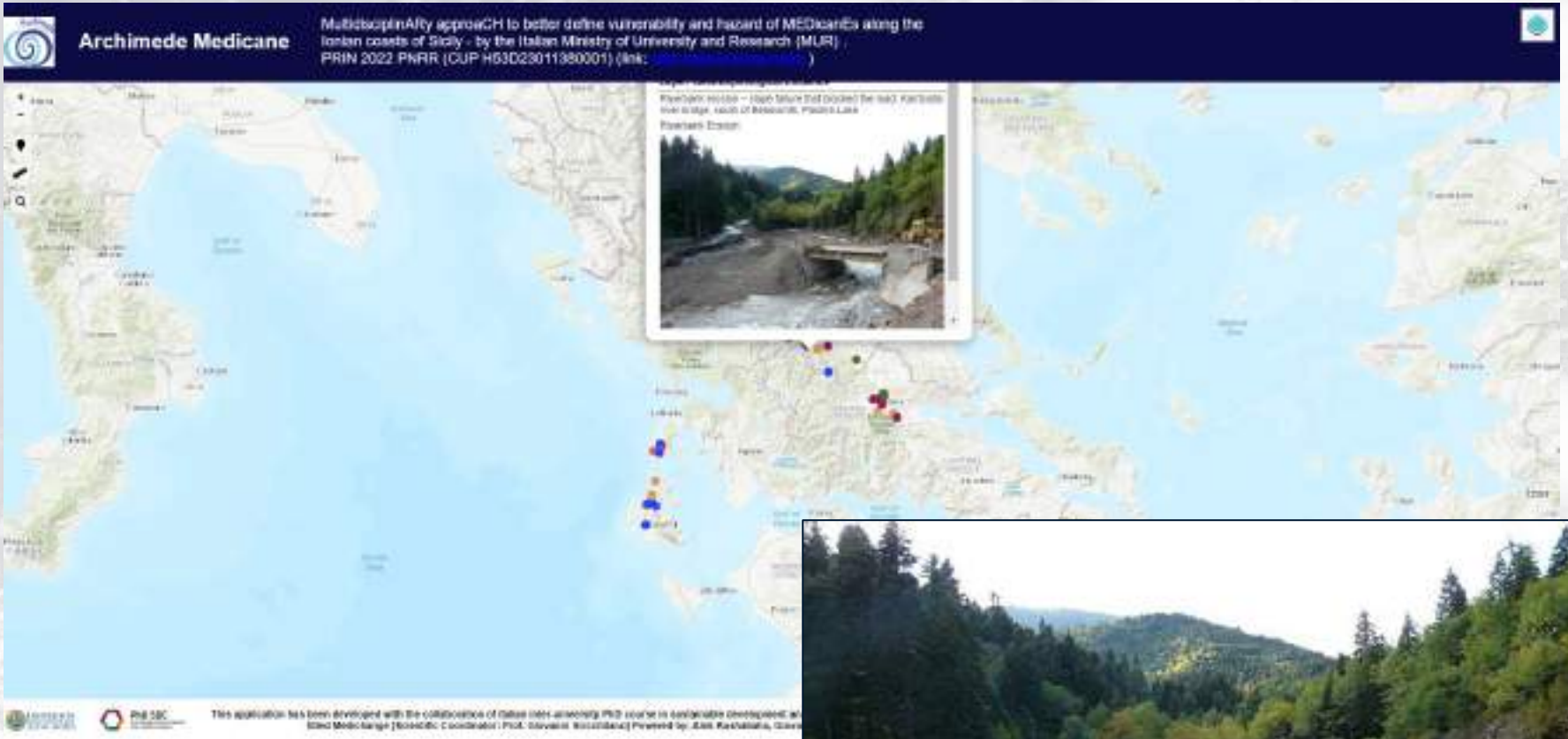
https://geerassociation.org/

Evidence of fresh rockslide sediment and debris along the steep western coastline of Lefkada island: a) pre-event photo, b) post-event photo, after Medicane Ianos

OTHER GEOMORPHOLOGICAL DATA



OTHER GEOMORPHOLOGICAL DATA



Riverbank erosion – slope failure that blocked the road during Medicane Ianos. Karitsiotis river bridge, south of Belokomiti, Plastira Lake.

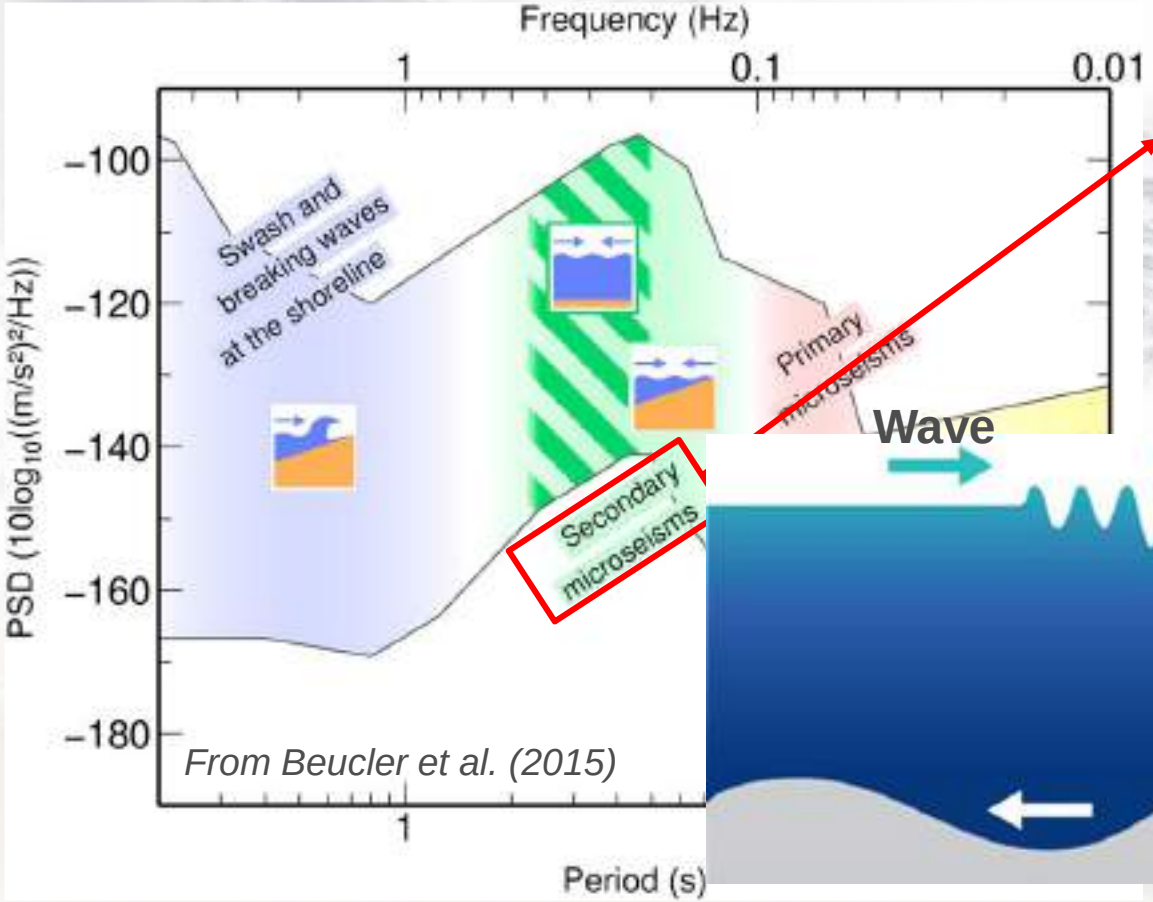
OTHER GEOMORPHOLOGICAL DATA

Manifestation of debris flow outside of Fiskardo village: a,b,c) stream incision along the debris flow track.

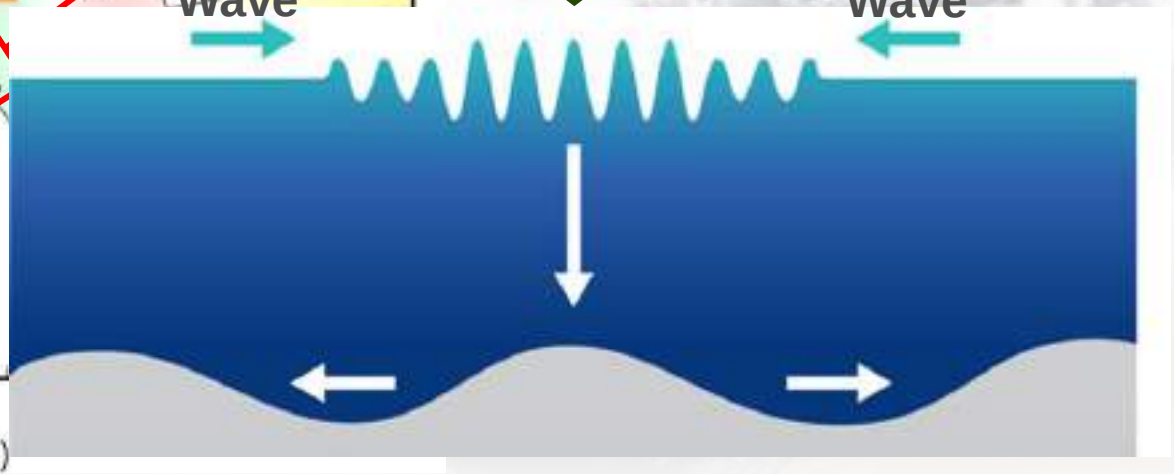
SEISMIC DATA

In geophysics, geology, civil engineering, and related disciplines, seismic noise is a generic name for a relatively persistent vibration of the ground, due to a multitude of causes, that is often a non-interpretable or unwanted component of signals recorded by seismometers.

Microseism is the most continuous and ubiquitous seismic signal on Earth, and is mostly generated by the sea - solid Earth interaction.



Secondary microseism (SM):
5-10 s (half period of ocean waves)
nonlinear interaction of waves in opposing directions
deep/shallow water
high amplitude



SEISMIC DATA

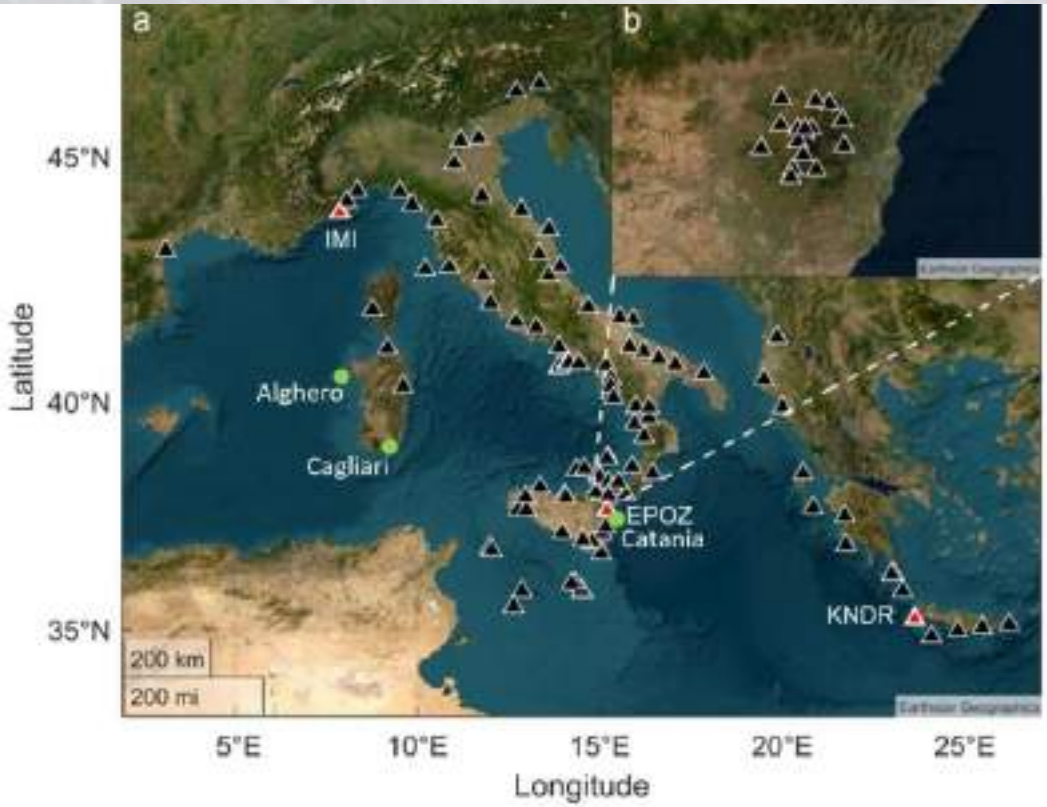


Fig. 3. Satellite image of the Mediterranean area with a selection of the broadband seismic stations available in the ORFEUS and INGV databases and used in the spectral analysis and the grid search method (a) and selection of the broadband seismic stations available in the Etna area maintained by INGV-OE (b), used in the array analysis. The red triangles indicate the stations used in the detailed analysis shown in Fig. 5 and Supplementary Figs. 3, 4, 5, 6 and 7. The green dots indicate the wave buoys used in this study. (base image source ©Earthstar Geographics).

Science of the Total Environment

Long-term analysis of microseism during extreme weather events: Medicanes and common storms in the Mediterranean Sea

seismic data recorded by

- 104 seismic stations installed along the Italian coastal areas, in the Sicily channel coastlines, in Corsica Island and along the Greek and France coastal areas (a)
- 15 seismic stations installed in Etnean area (b)

SEISMIC DATA

8 Medicanes:

- Rolf 2011 (Tyrrhenian Sea)
- Qendresa 2014 (Ionian Sea)
- Xandra 2014 (Tyrrhenian Sea)
- Trixie 2016 (Ionian Sea)
- Numa 2016 (Ionian Sea)
- Zorbas 2018 (Ionian Sea)
- Ianos 2020 (Ionian Sea)
- Apollo 2021 (Ionian Sea)

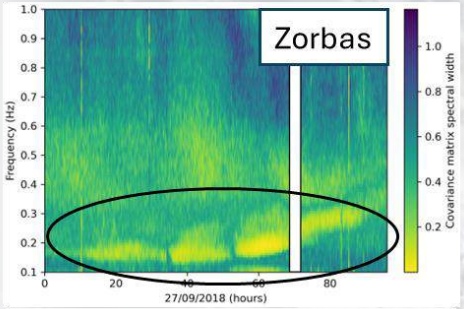
4 "common" storms that occurred in the Ionian Sea and affected the eastern Sicily coast:

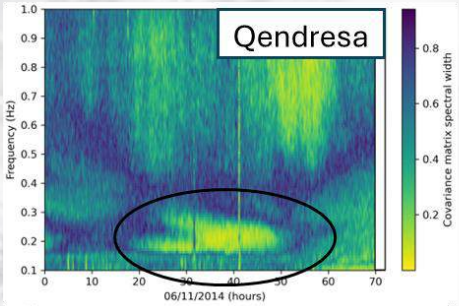
- 10–12 February 2015 (hereafter referred to as N1)
- 20–23 December 2017 (N2)
- 22–25 March 2021 (N3)
- 13–17 April 2021 (N4).

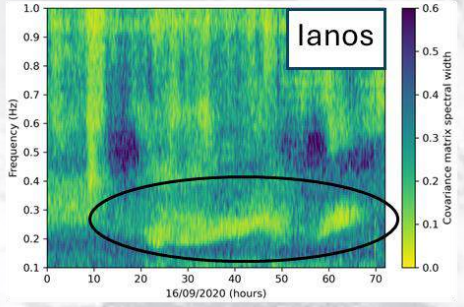
SEISMIC DATA

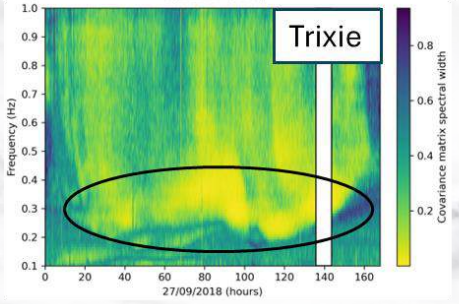
Seismic signature

Medicanes

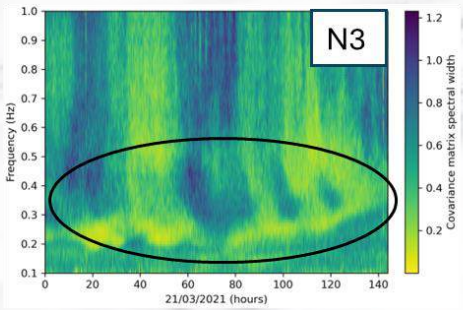


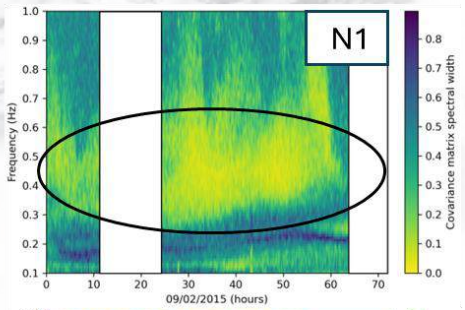


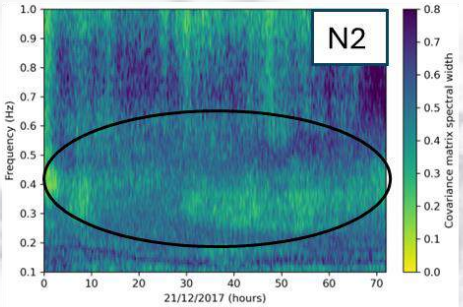


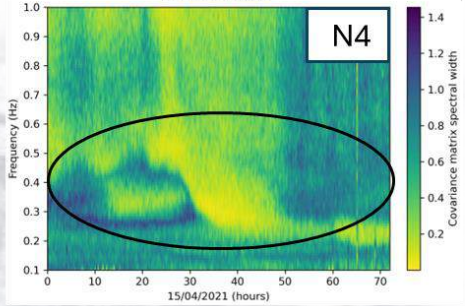


Common storms





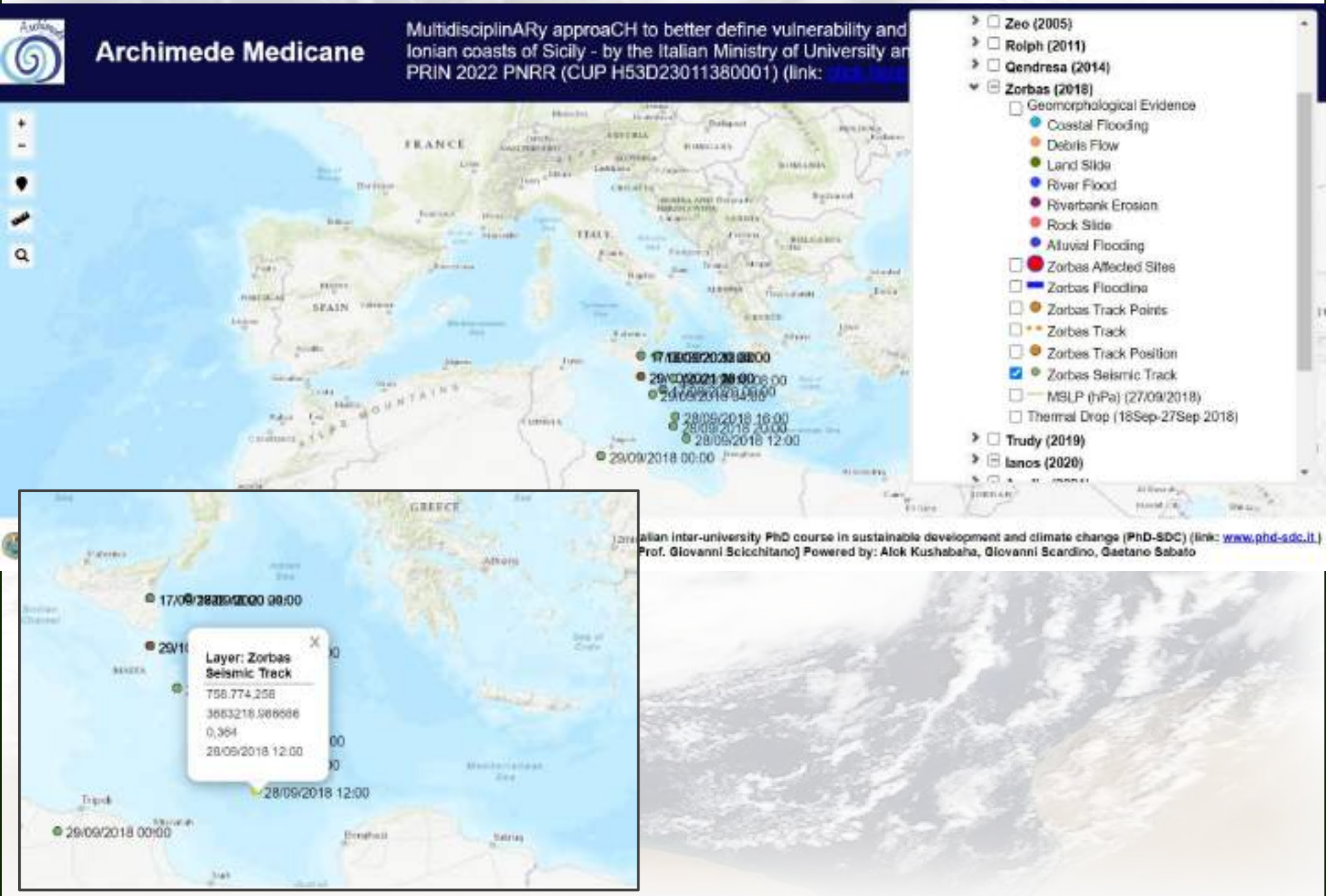




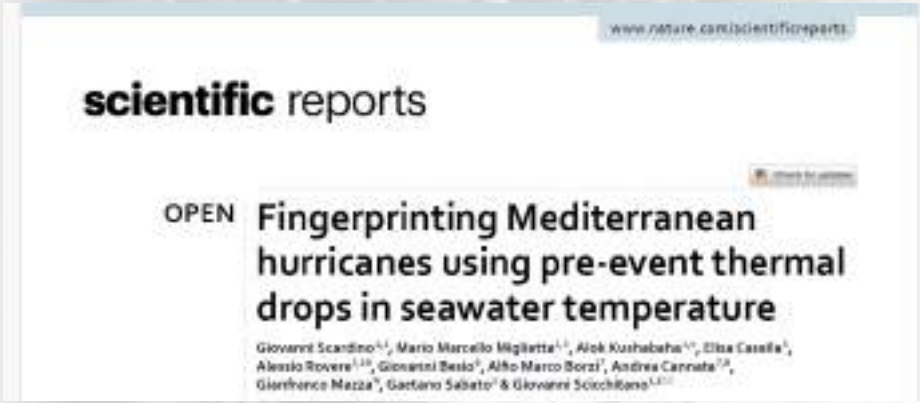
Medicanes and common storms show a different spectral content:

- all the analyzed Medicanes display well-defined microseism spectral characteristics between 0.14 and 0.35 Hz
- the common storms exhibit a wider and higher spectral content from 0.2 to 0.7 Hz

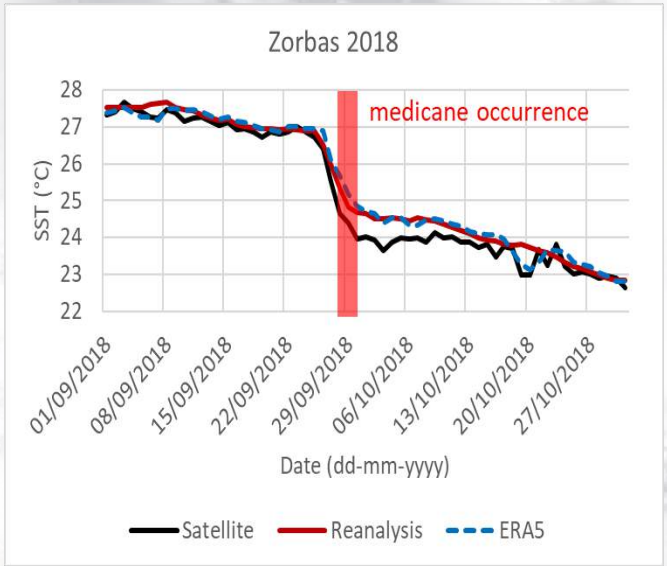
SEISMIC DATA



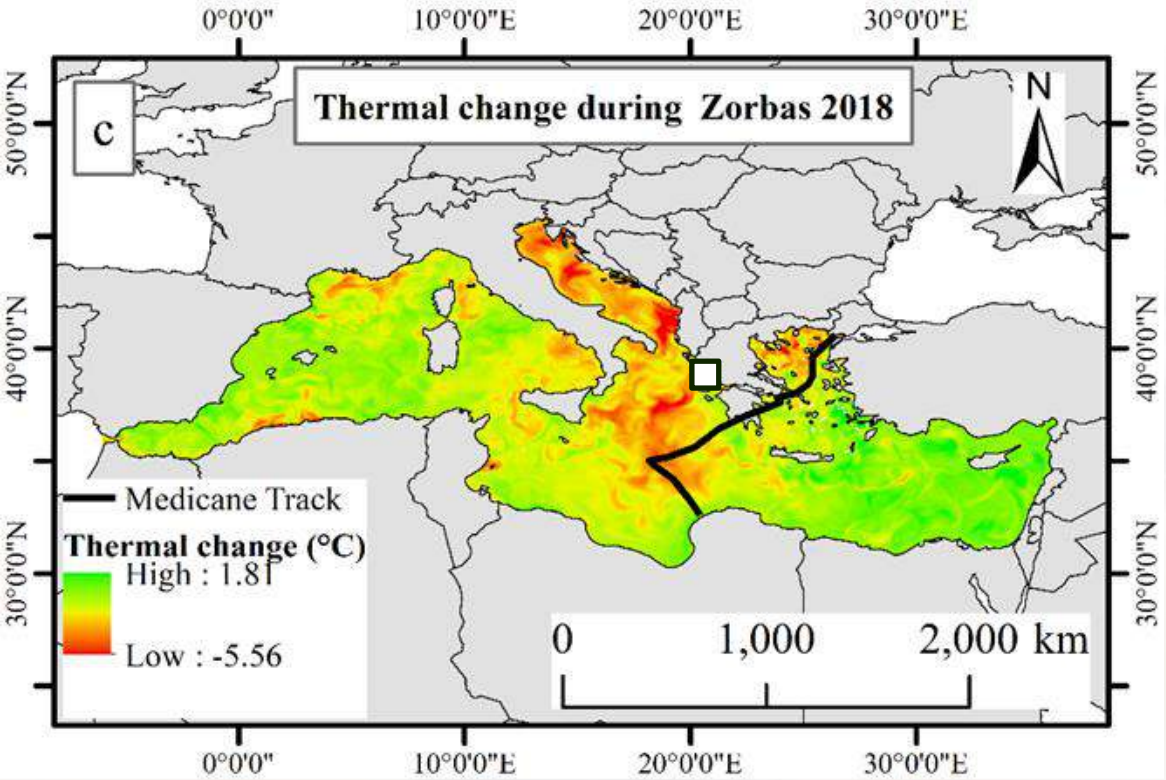
SST DIFFERENCE DATA



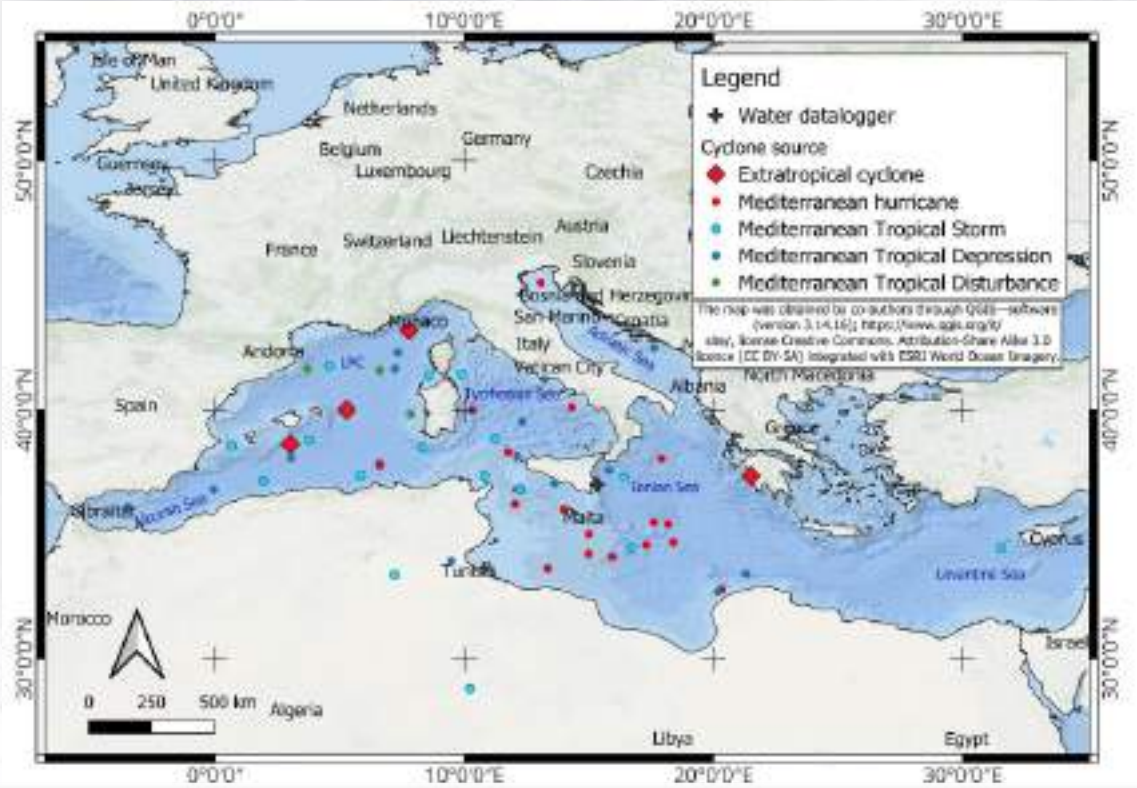
SST is suggested to be an important factor in the mature stages of cyclone development. According to Pytharoulis13 and Miglietta et al.31 high SSTs promote stronger sea surface fluxes and, consequently, stronger latent heat release due to convection needed for Mediterranean hurricane intensification.



Trend of SST recorded prior to the occurrence of Medicane Zorbas.



SST DIFFERENCE DATA



SST SST data associated with the occurrence of Mediterranean cyclones using data reanalysis and satellite observations. The "thermal drop" was defined as the difference between the SST 10 days prior to cyclone occurrence and at the end of the cyclone's lifetime. We chose to measure the SST 10 days before the event to allow us to characterize temperature drops in the environment prior to the occurrence of Mediterranean hurricanes

- Mediterranean Sea Physical Reanalysis (CMEMS MED-Currents Copernicus Marine Environment Monitoring Service (CMEMS), product available from 1987 to 2023

– European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis v5 (ERA5 from Copernicus Climate Change Service: SST values extracted from 1969 to 1985

– Satellite data observation from CMEMS Reprocessed (REP) Mediterranean (MED) dataset: available from 1982 to 2023.

– Data from the International Argo program, part of the Global Ocean Observing System

SST DIFFERENCE DATA

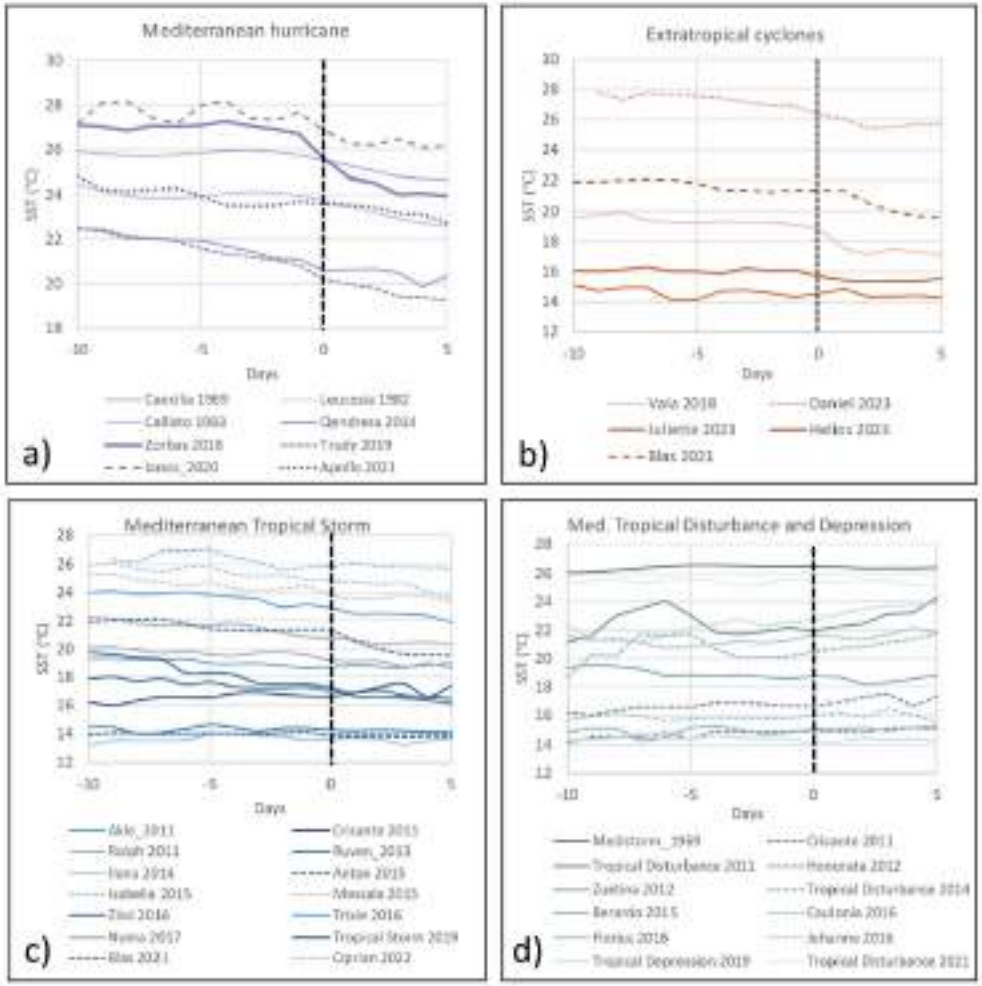


Figure 4. SST time series for cyclone events listed in Table S1. The origin of the x-axis corresponds to the beginning of the event. (a) SST time-series data for Mediterranean hurricanes; (b) SST time-series for extratropical cyclones; (c) SST time-series for the Mediterranean tropical storms; (d) SST time-series for the Mediterranean tropical depressions and Disturbances.

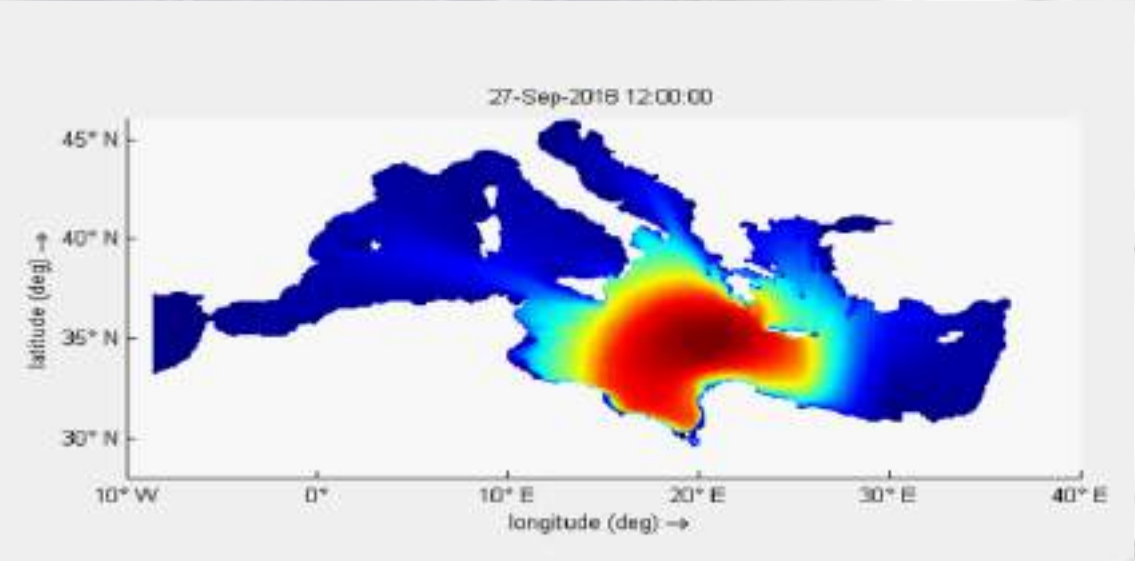
The weather systems associated with the greatest thermal drops were the Mediterranean hurricanes, with thermal drops in a range of 2–3 °C.

The most intense cyclones were characterized by a thermal drop equal to or greater than 1.6 °C

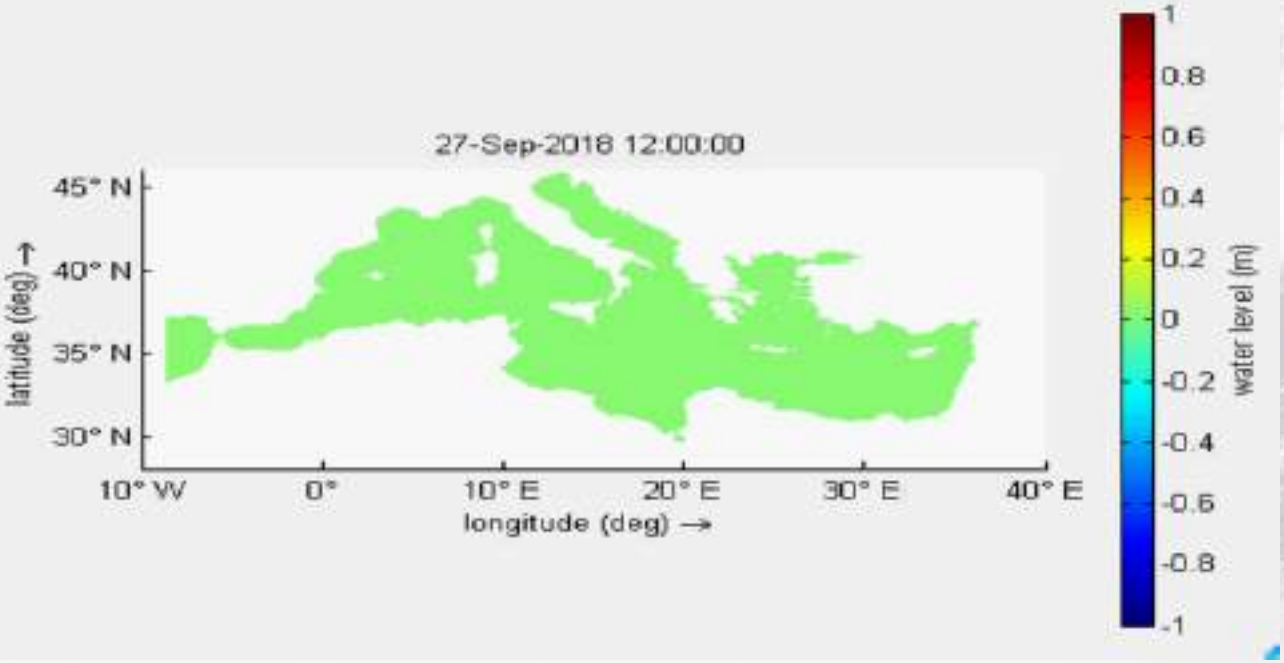
The SST time series also highlighted the onset of thermal drops a few days before the early stages of Mediterranean hurricane formation. In contrast, Mediterranean tropical storms and extra-tropical cyclones exhibited thermal drops slightly later, mostly during the early phases of the cyclone's lifetimes

Mediterranean tropical depression and disturbance events did not exhibit any significant thermal drops, and in some cases, the SST even increased during these events

HYDRODYNAMIC MODELS

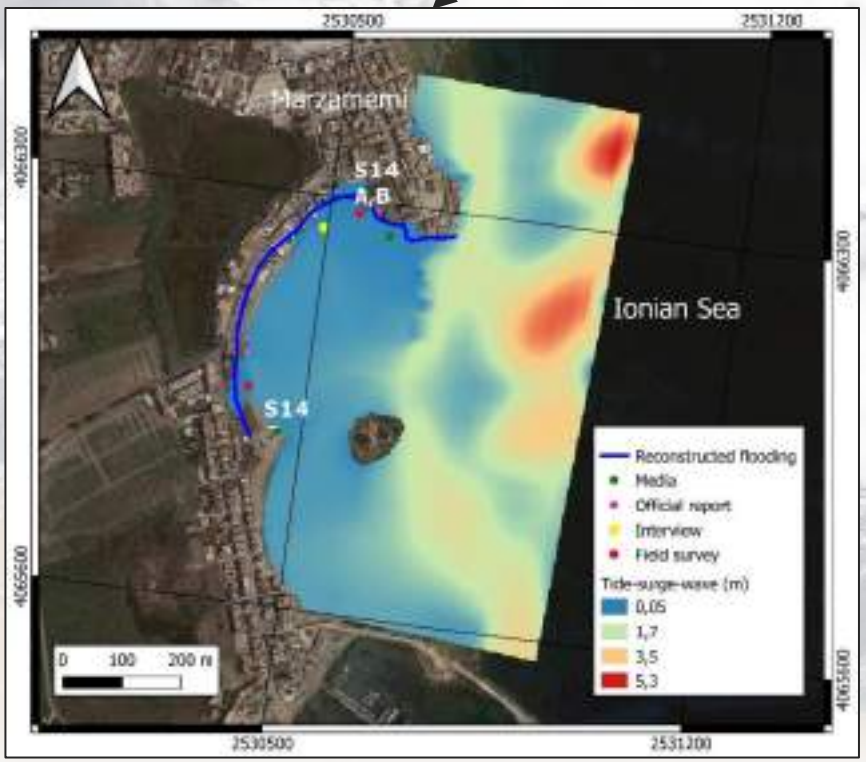


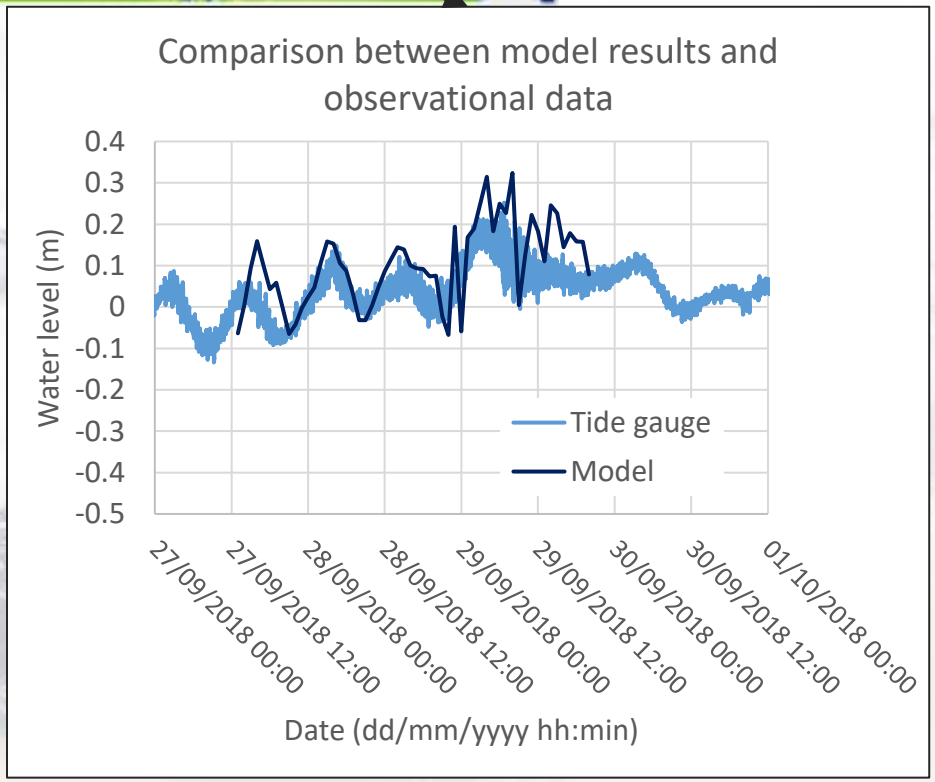
Numerical model of significant wave height performed in Delft3D WAVE for Medicane Zorbas.



Numerical model of water level performed in Delft3D FLOW for Medicane Zorbas.

HYDRODYNAMIC MODELS

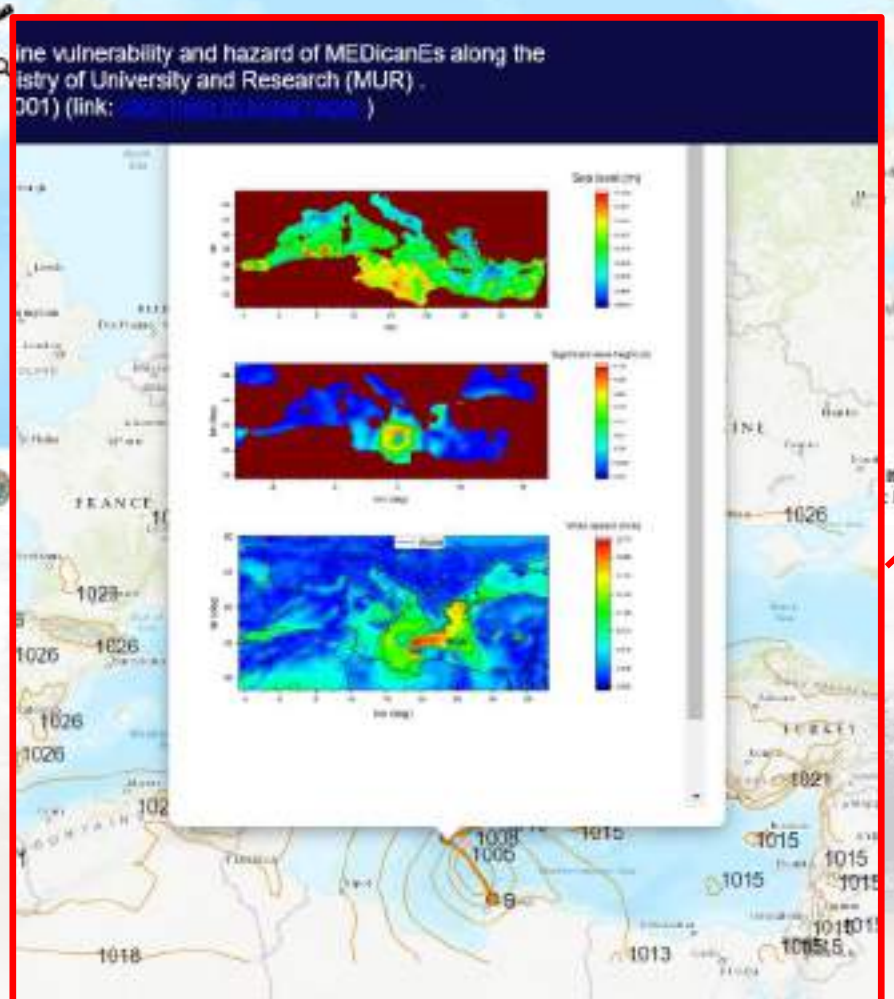




HYDRODYNAMIC MODELS

Archimede Medicane

MultidisciplinARy approaCH to better define vulnerability and hazard of MEDicanEs along the Ionian coasts of Sicily - by the Italian Ministry of University and Research (MUR) .
PRIN 2022 PNRR (CUP H53D23011380001) (link:)



talian inter-university PhD course in sustainable development and climate change (PhD-SDC) (link: www.phd-sdc.it)
: Prof. Giovanni Scicchitano] Powered by: Alok Kushabaha, Giovanni Scardino, Gaetano Sabato

FURTHER DEVELOPMENTS

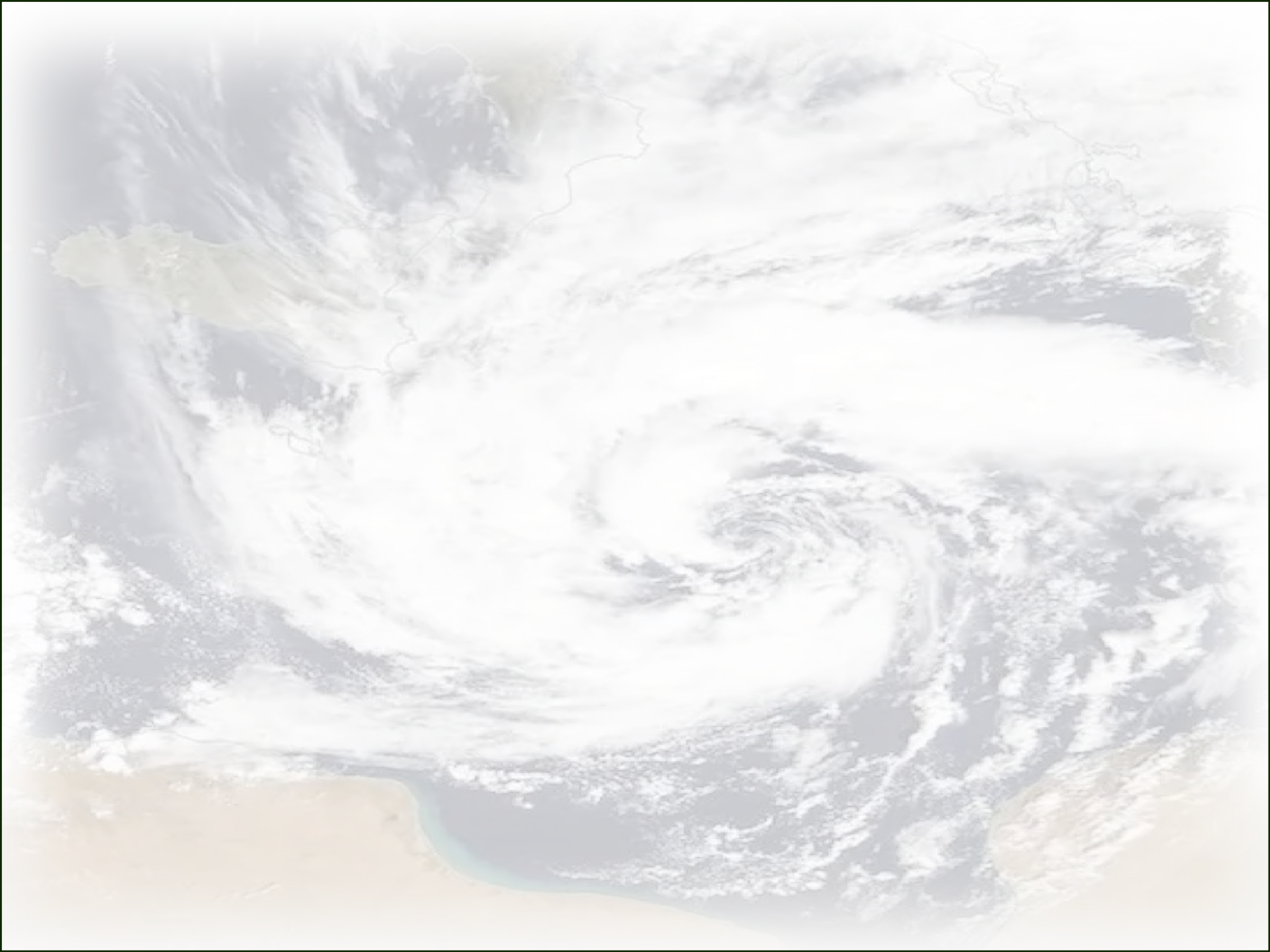
Enrichment of the Geo-database

Providing WMS service

Thanks

giovanni.scicchitano@uniba.it

www.archimedemedicane.it

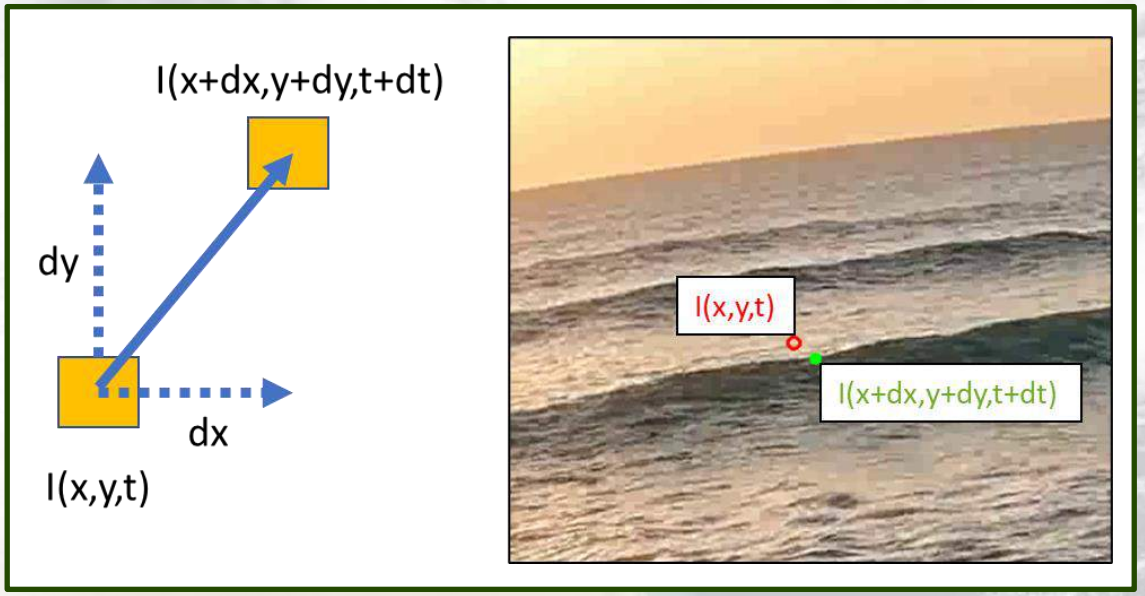


COASTAL GEOMORPHOLOGICAL DATA

IMAGE FRAME (i) → RGB to intensity → Optical Flow Farneback

IMAGE FRAME (i+1) → RGB to intensity → Optical Flow Farneback

Optical Flow Farneback → Flow vectors

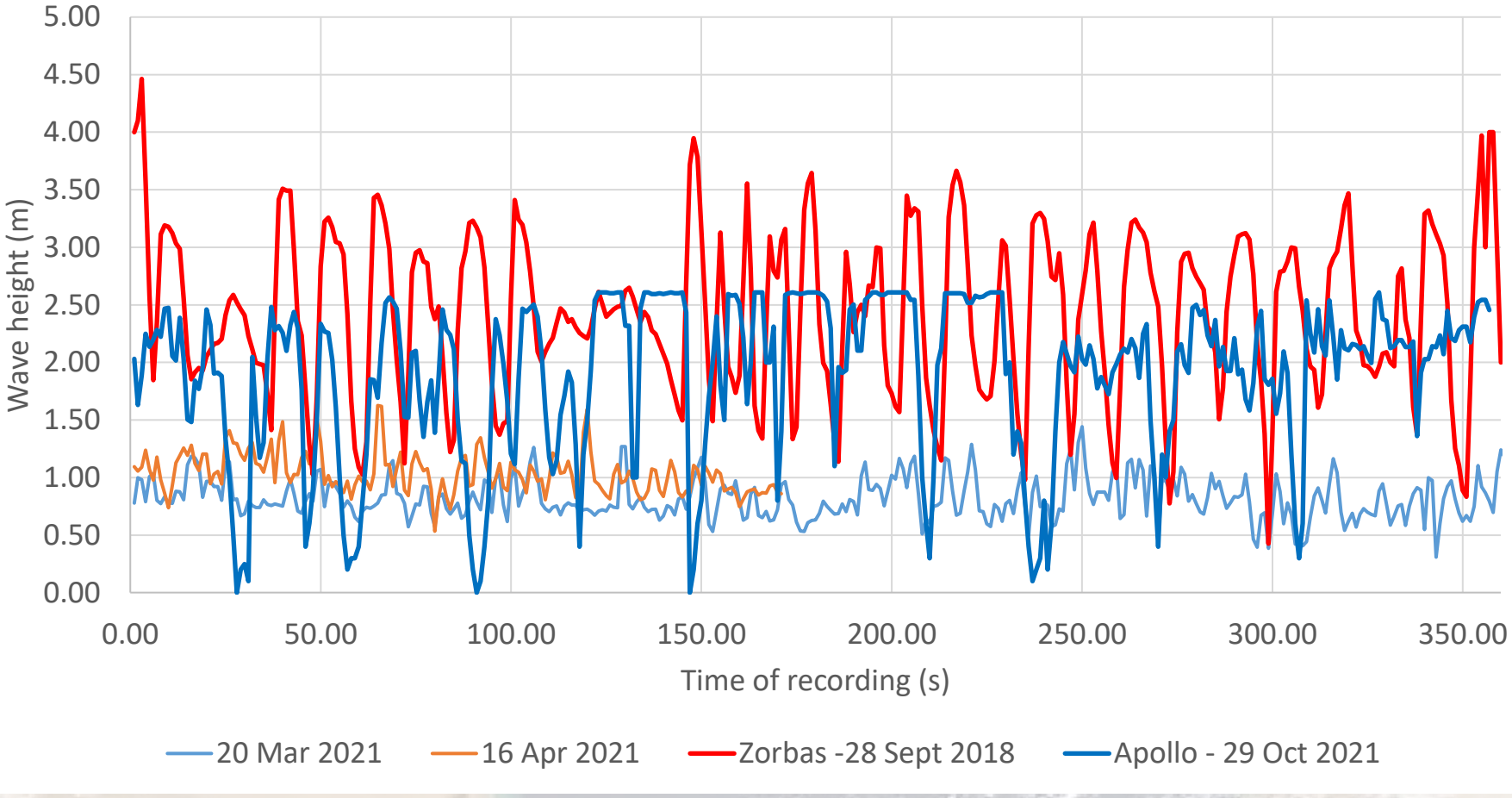


Flow vectors → WAVE PARAMETERS: Wave flow - wave height – wave period

COASTAL GEOMORPHOLOGICAL DATA

Applications of Optical Flow during the impact of Medicane Zorbas

COASTAL GEOMORPHOLOGICAL DATA



Time series of wave height assessed through Optical Flow (Scardino et al., 2022, Remote Sensing).