

FU.CO.KA project

Future scenarios in coastal karst: saltwater intrusion, loss of water resources and sinkhole development as effects of climate changes

Title of the presentation:

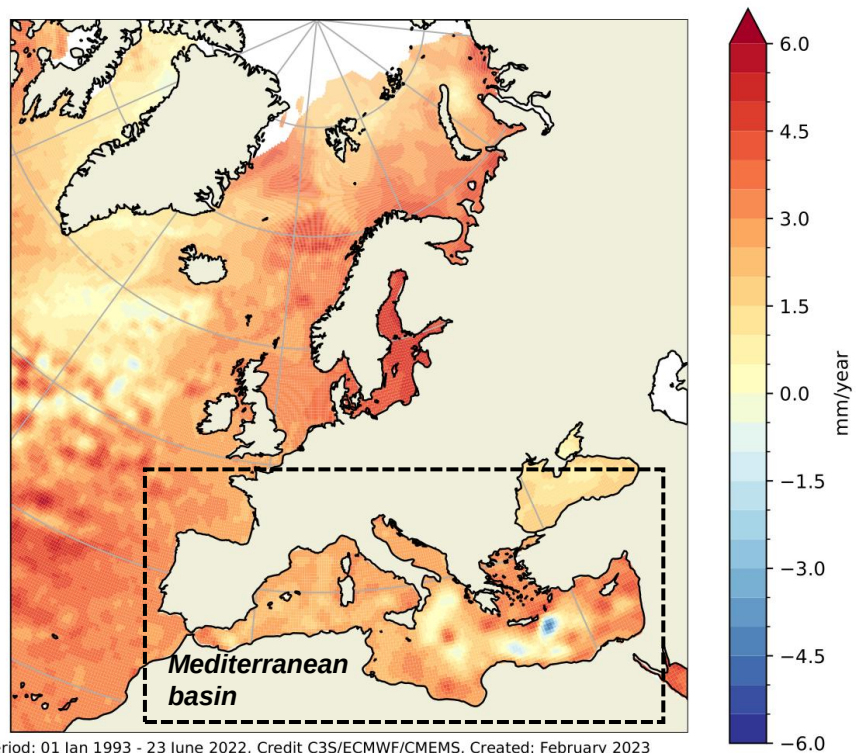
Hydrological and GIS analyses: understanding karst and groundwater processes in the study areas

University of Sannio Research Unit

Speakers: Guido Leone, Michele Ginolfi

• Introduction

The FU.CO.KA project focuses on two karst areas located along the Adriatic and Ionic coasts of Apulia, and aims to study factors and impacts of seawater intrusion



- **Climate change** is a primary driver of groundwater resource depletion and sea level rise, two processes controlling seawater intrusion.

• Introduction

The FU.CO.KA project focuses on two karst areas located along the Adriatic and Ionic coasts of Apulia, and aims to study factors and impacts of seawater intrusion



- **Climate change** is a primary driver of groundwater resource depletion and sea level rise, two processes controlling seawater intrusion.
- **Seawater intrusion** enhance affects dissolution processes of karst rocks, and thus the widening processes of **underground cavities**, eventually leading to the occurrence of **sinkhole** at the surface.

Collapse sinkholes in the proximity of the Adriatic (a) and Ionian (b) coasts (from Parise 2019, and Basso et al. 2013)

• Project Topics and Research Activities

Two of the main topics of the FU.CO.KA project are:

- Studying **climate variability** and its impacts on two karst areas of Apulia
- Mapping and analysis of surface and subsurface karst features, focusing on **sinkholes** and **underground cavities**

In relation to these two topics, the tasks of the University of Sannio Research Unit will be:

- Collecting and analyzing **hydrological** and **climate data**
- **GIS analysis** of geographic and spatial data
- Producing **thematic maps** of sinkholes, underground cavities, seawater intrusion, climate variability, etc.

• Objectives of the Presentation

The presentation deals with:

- Possible hydrological, climate, and spatial **data sources**
- **Examples of studies** carried out by the University of Sannio Research Unit concerning climate change and its impact on karst areas, groundwater hydrology, and sinkhole mapping

• Collecting Time Series

A first task is collecting time series of factors

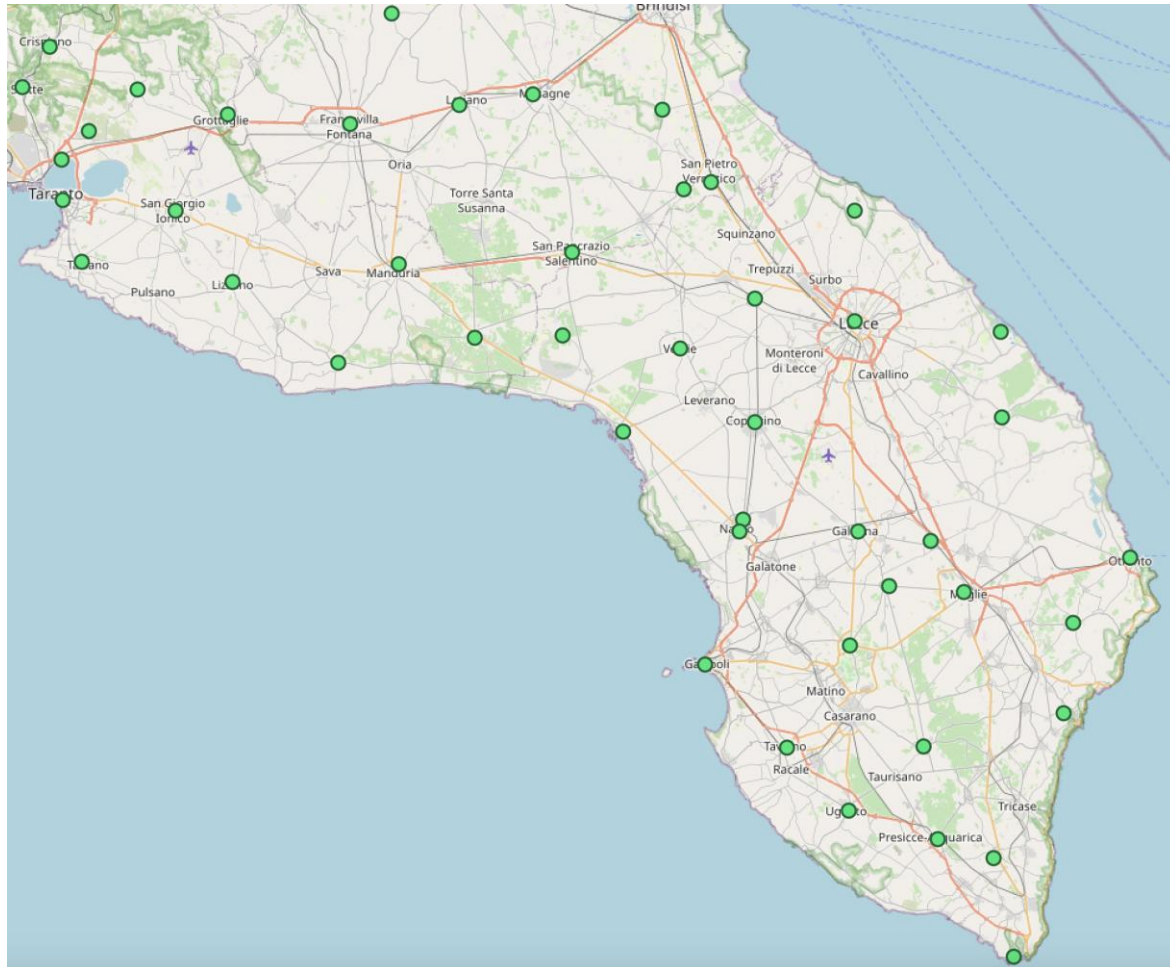
- Controlling **karst aquifer recharge** (precipitation and temperature)
- Describing **aquifer hydrological stage** (water table level)
- Controlling **seawater intrusion** (water table level, sea level)

Main problems related to collection of long-term hydro-meteorological time series:

- Identifying **data sources**
- **Spatial distribution** of measuring stations
- Time series **length, quality** and **continuity**

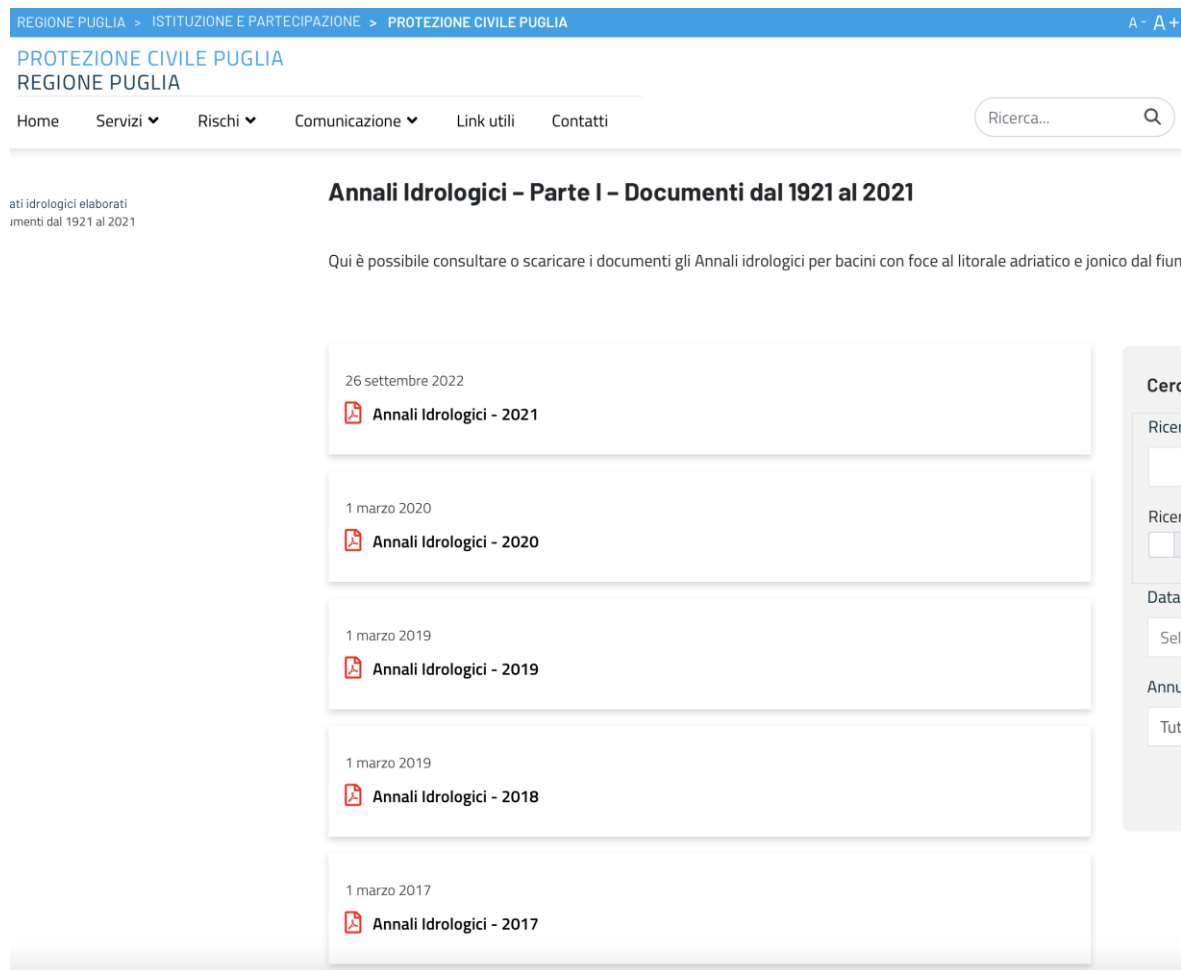
Collecting Time Series

- Currently, **meteorological stations** are managed by Protezione Civile Puglia



Map of southern Apulia showing meteorological stations of the Protezione Civile Puglia

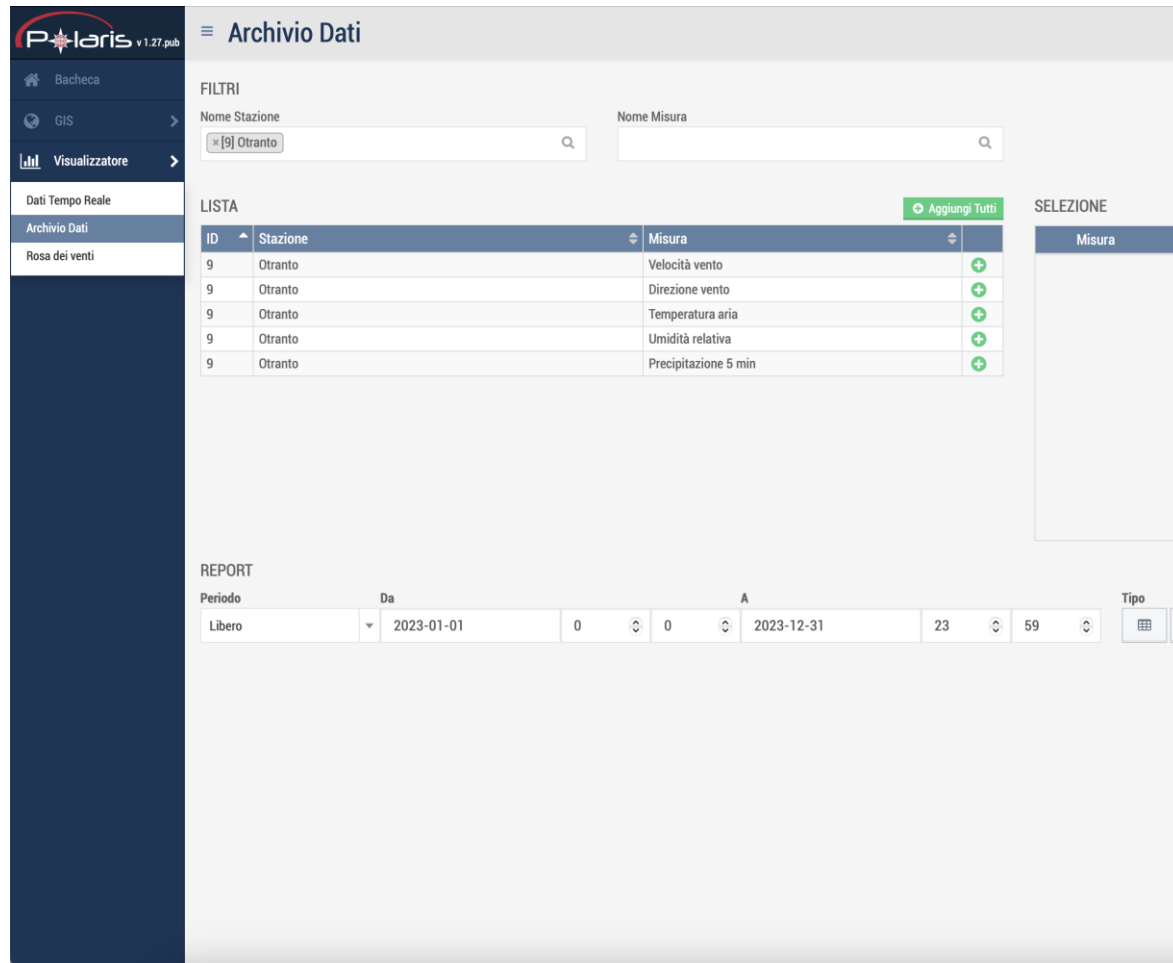
Collecting Time Series



Screenshot of the webpage of Protezione Civile Puglia

- Currently, **meteorological stations** are managed by Protezione Civile Puglia
- Data span from 1921 to 2021 are contained in **Hydrological Annals**, freely available online in PDF format

Collecting Time Series



Archivio Dati

FILTRI

Nome Stazione: [x] 9 Otranto

Nome Misura:

LISTA

ID	Stazione	Misura	
9	Otranto	Velocità vento	+
9	Otranto	Direzione vento	+
9	Otranto	Temperatura aria	+
9	Otranto	Umidità relativa	+
9	Otranto	Precipitazione 5 min	+

SELEZIONE

Misura:

REPORT

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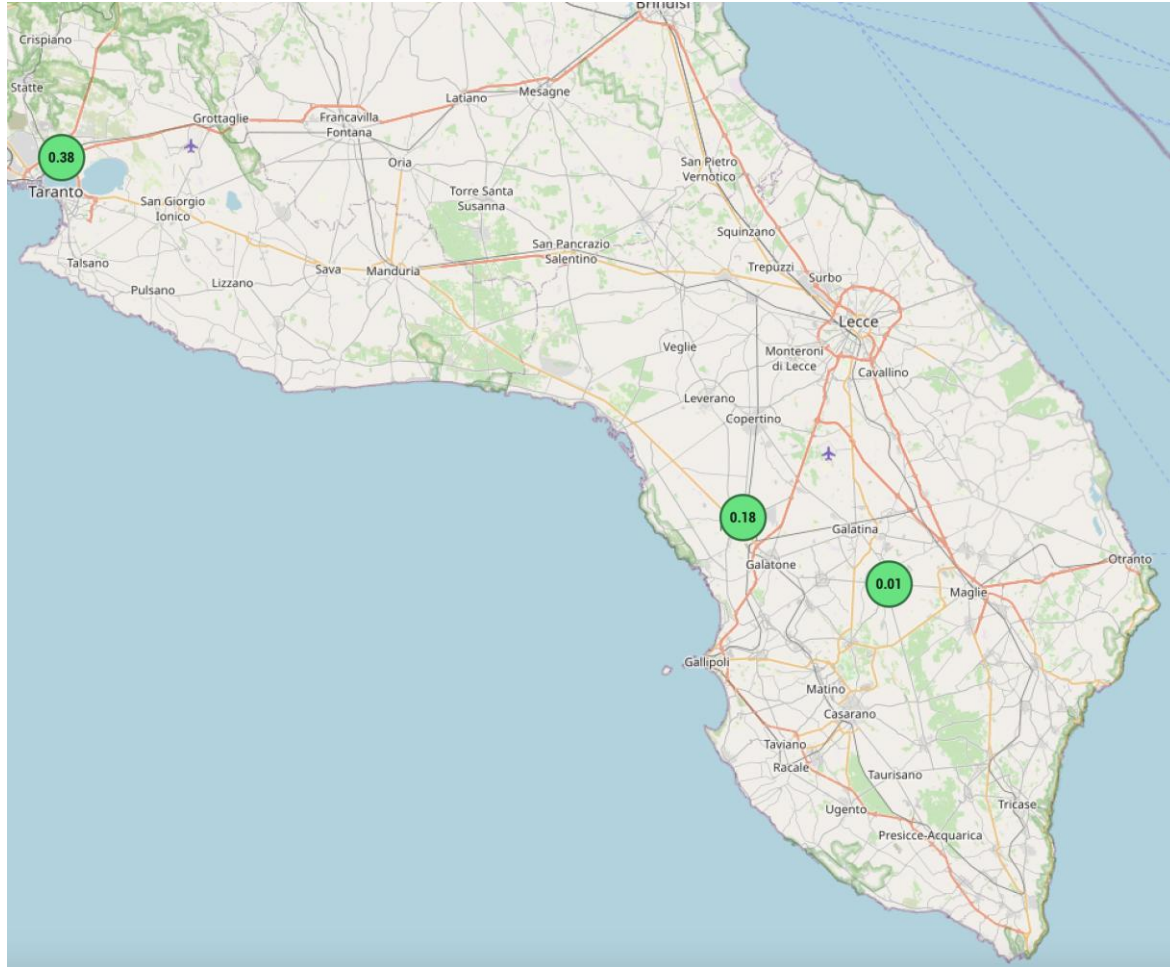
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Interactive database of the Protezione Civile Puglia

- Currently, **meteorological stations** are managed by Protezione Civile Puglia
- Data span from 1921 to 2021 are contained in **Hydrological Annals**, freely available online in PDF format
- An **interactive database** is also available



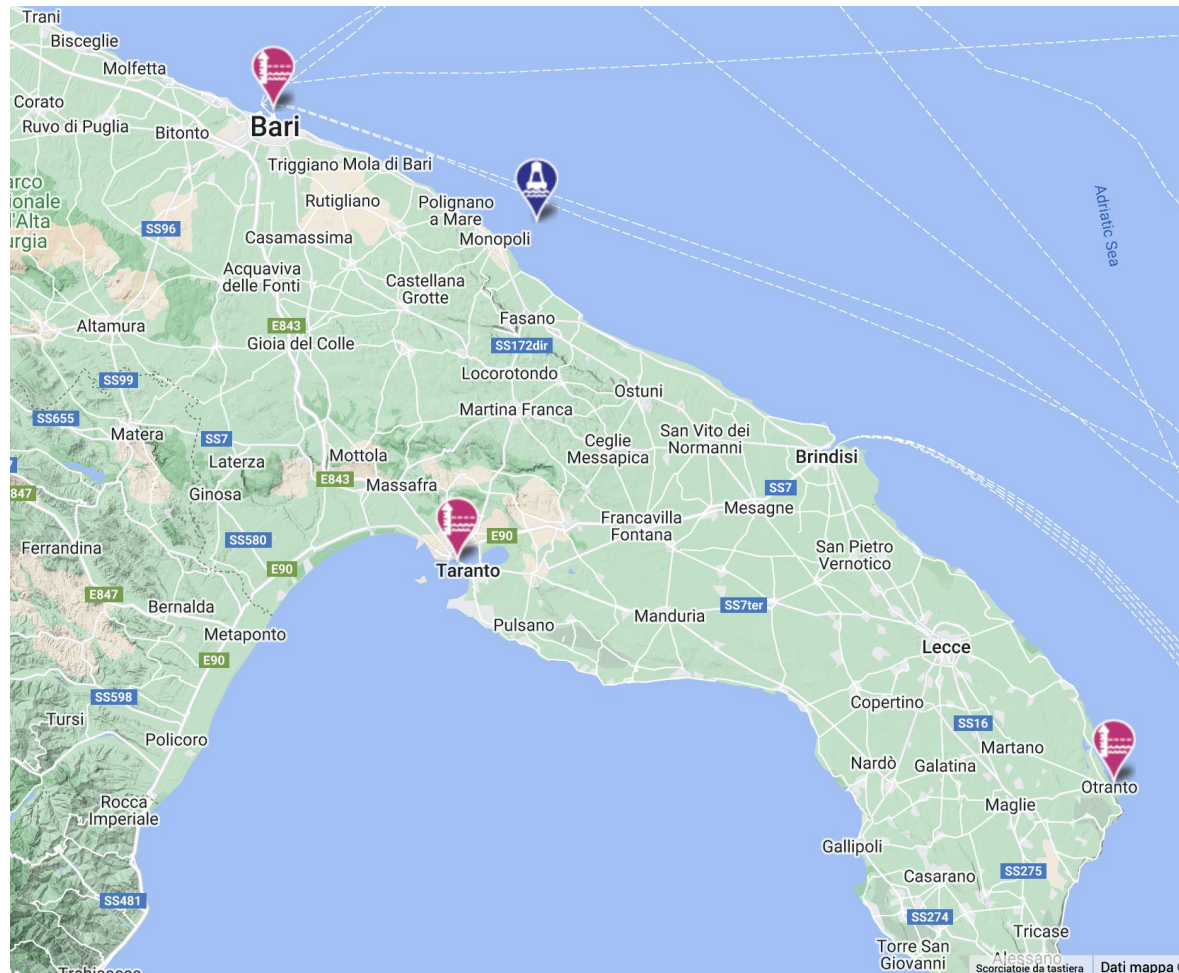
Collecting Time Series



Map of southern Apulia showing monitoring wells of the Protezione Civile Puglia

- Currently, **meteorological stations** are managed by Protezione Civile Puglia
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- An **interactive database** is also available
- **Monitoring wells** are managed by Protezione Civile Puglia. However, no well is located in the study areas. For various sites, water table levels are available up to 2002 (Hydrological Annals)

Collecting Time Series



Map of Apulia showing stations of the National Oceanographic Network

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- Data span from 1921 to 2021 are contained in **Hydrological Annals**, freely available online in PDF format
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- **Sea level data** since 1987 are provided by the stations of National Oceanographic Network managed by ISPRA

• Time Series Analysis and Hydrological Monitoring

Time series analysis involves a variety of statistical methods to quantitatively describe:

- Time series **characteristics** and **internal structure** (mean, variance, trends, randomness, autocorrelation, frequency content, etc.)
- **Degree of correlation** between variables
- **Dynamic relationships** between variables

Recently, studies have been carried out by the University of Sannio Research Units concerning:

- Relationships between **karst spring discharge** and **climate variability**, and causes of karst groundwater depletion in southern Apennine
- **Hydrological monitoring** of karst and alluvial aquifers
- Analysis of the **groundwater-surface water interaction** by time series analysis and numerical modelling

- Sinkhole in Karst Terrains

Sinkhole are closed depressions generated by two main processes:

- **Dissolution** of the karst rock operated by surface and infiltration meteoric waters



Solution sinkholes of the recharge zone of the eastern Matese karst massif (southern Apennine)

• Sinkhole in Karst Terrains

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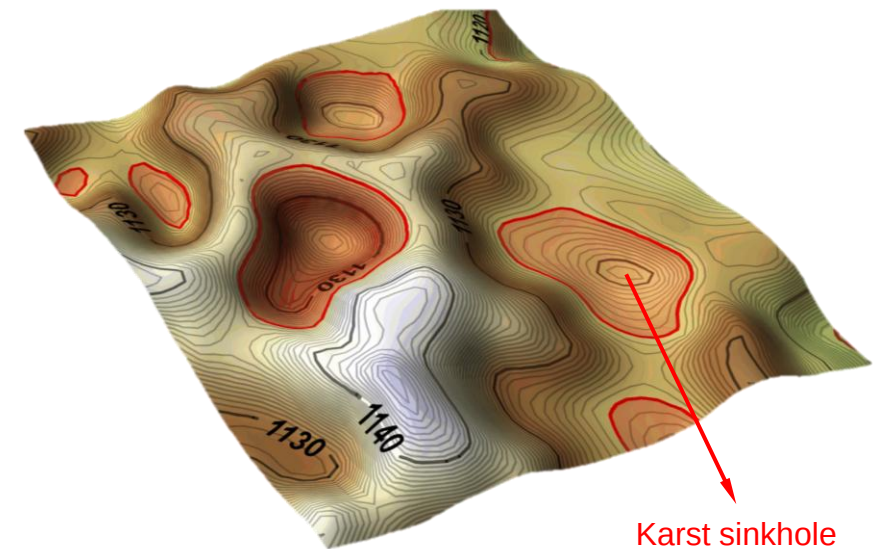
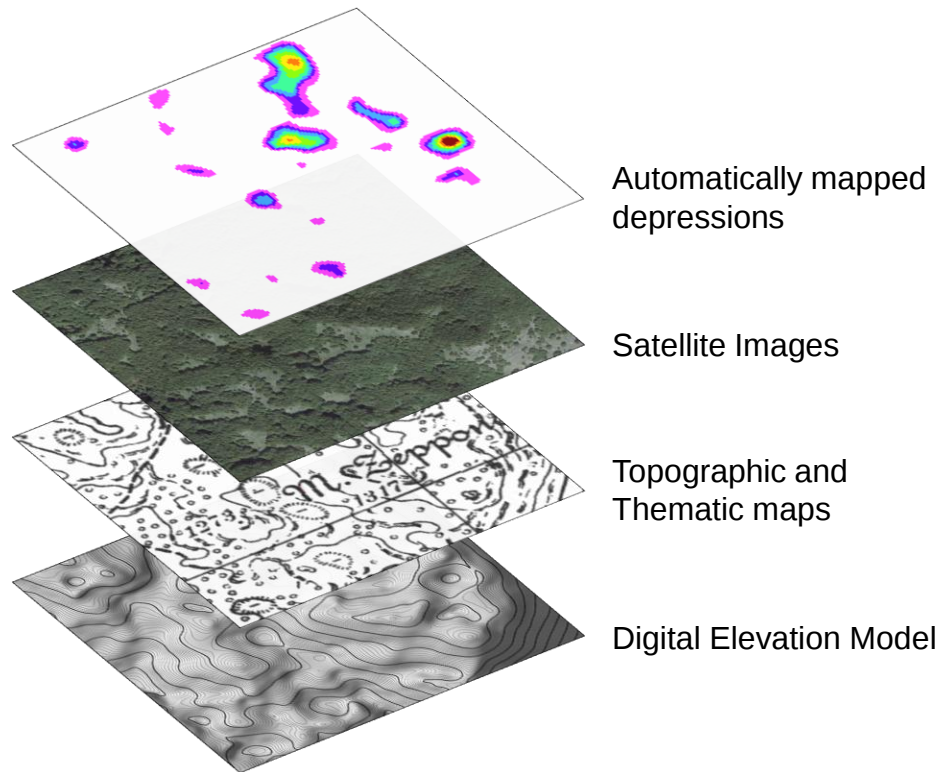
- **Dissolution** of the karst rock operated by surface and infiltration meteoric waters
- **Surface subsidence** due to internal erosion and/or deformation processes (collapse, suffusion, sagging)



Bedrock collapse sinkhole in the discharge zone of the Matese karst massif (southern Apennine)

• Sinkhole Identification and Mapping

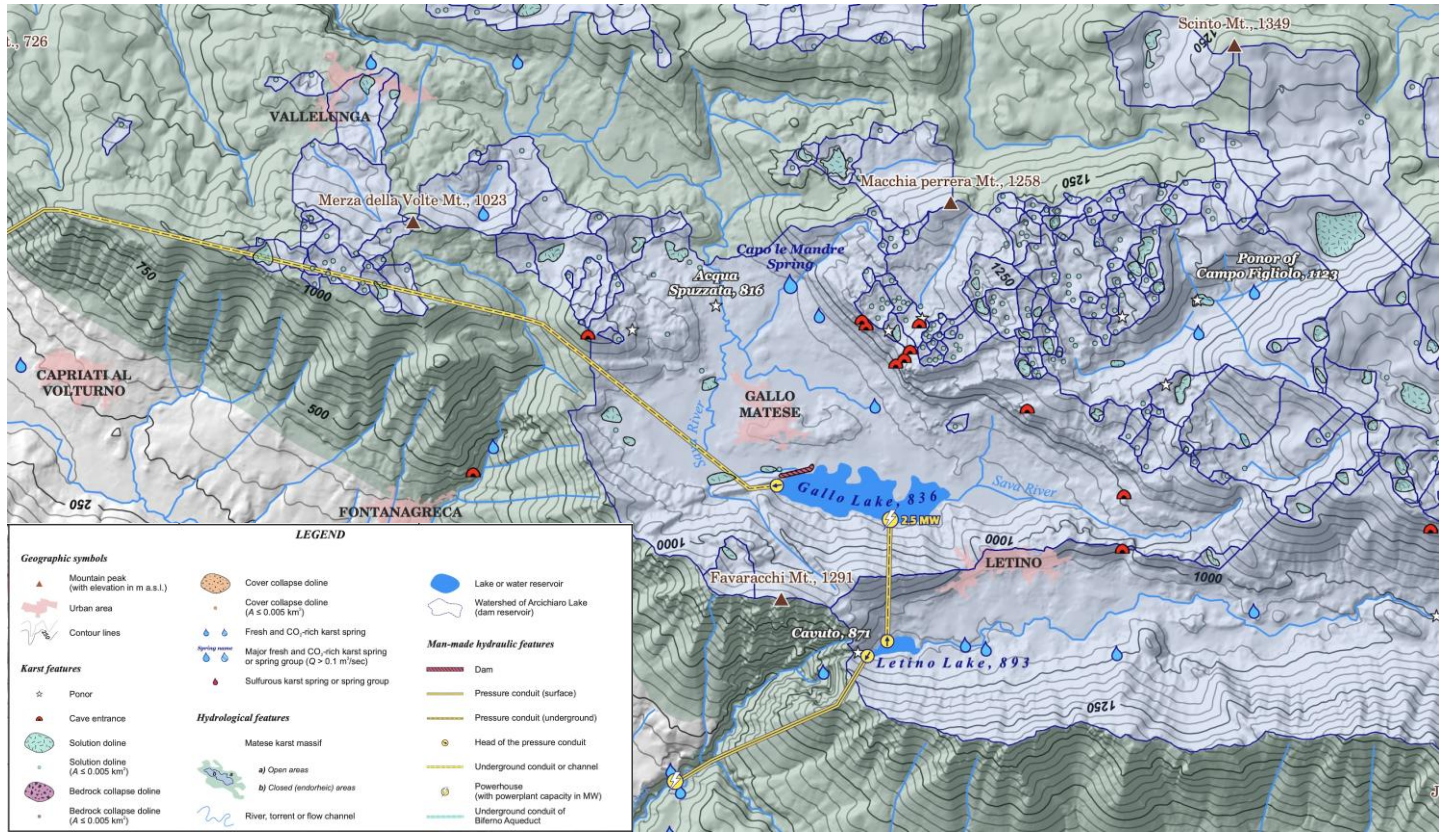
Sinkhole mapping on vast areas require analysis of DEM (**Digital Elevation Model**) using **GIS methods**, supported by visual inspection of topographic and thematic maps and satellite images



3D view of a map of sinkhole

- Recent Studies

Recently, studies have been carried out by the University of Sannio Research Units concerning sinkhole mapping:



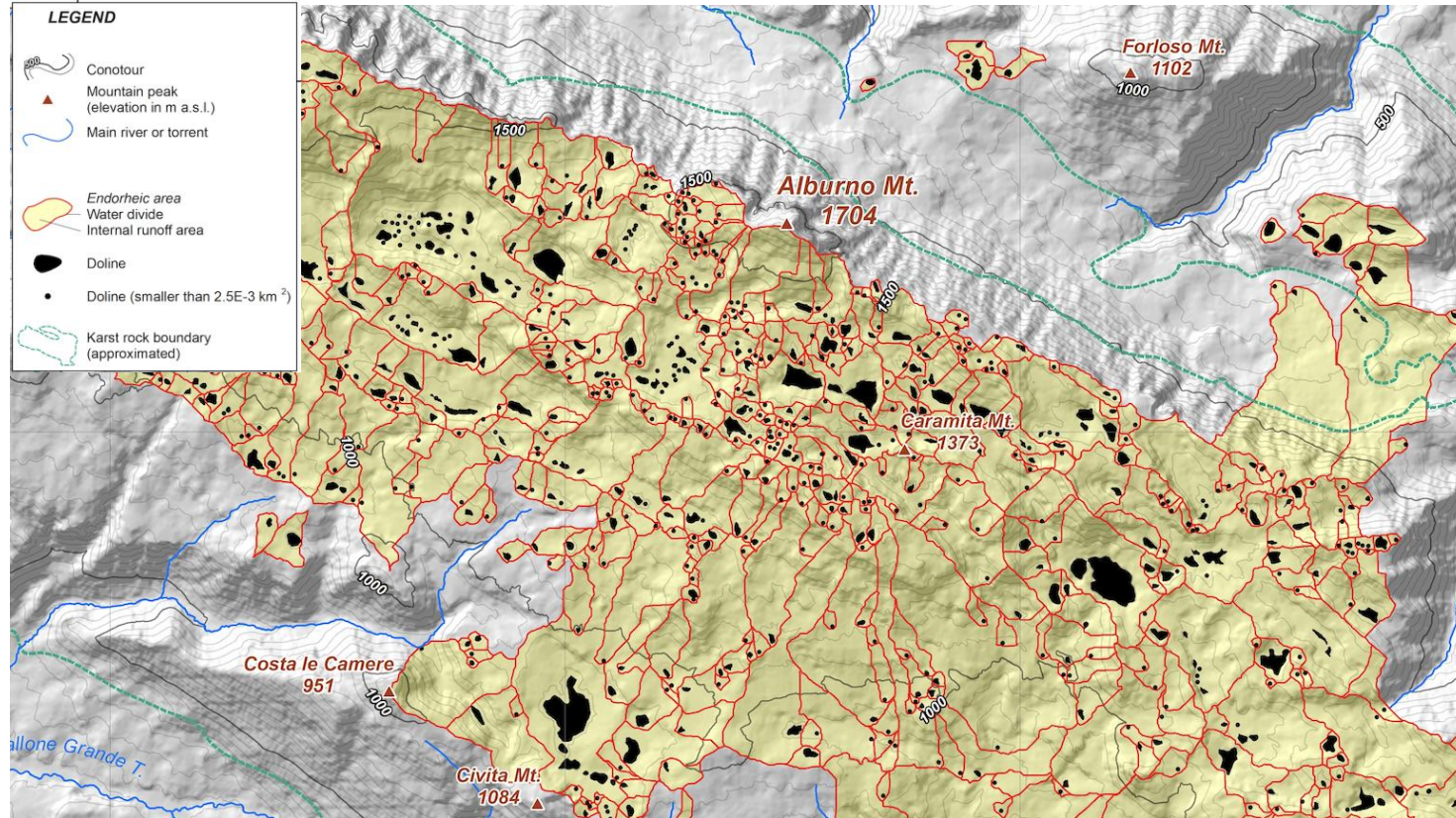
Sketch of the map of hydrological karst features of the Matese massif

- Map of sinkhole, endorheic areas, caves and ponors of the Matese karst massif

Recent Studies

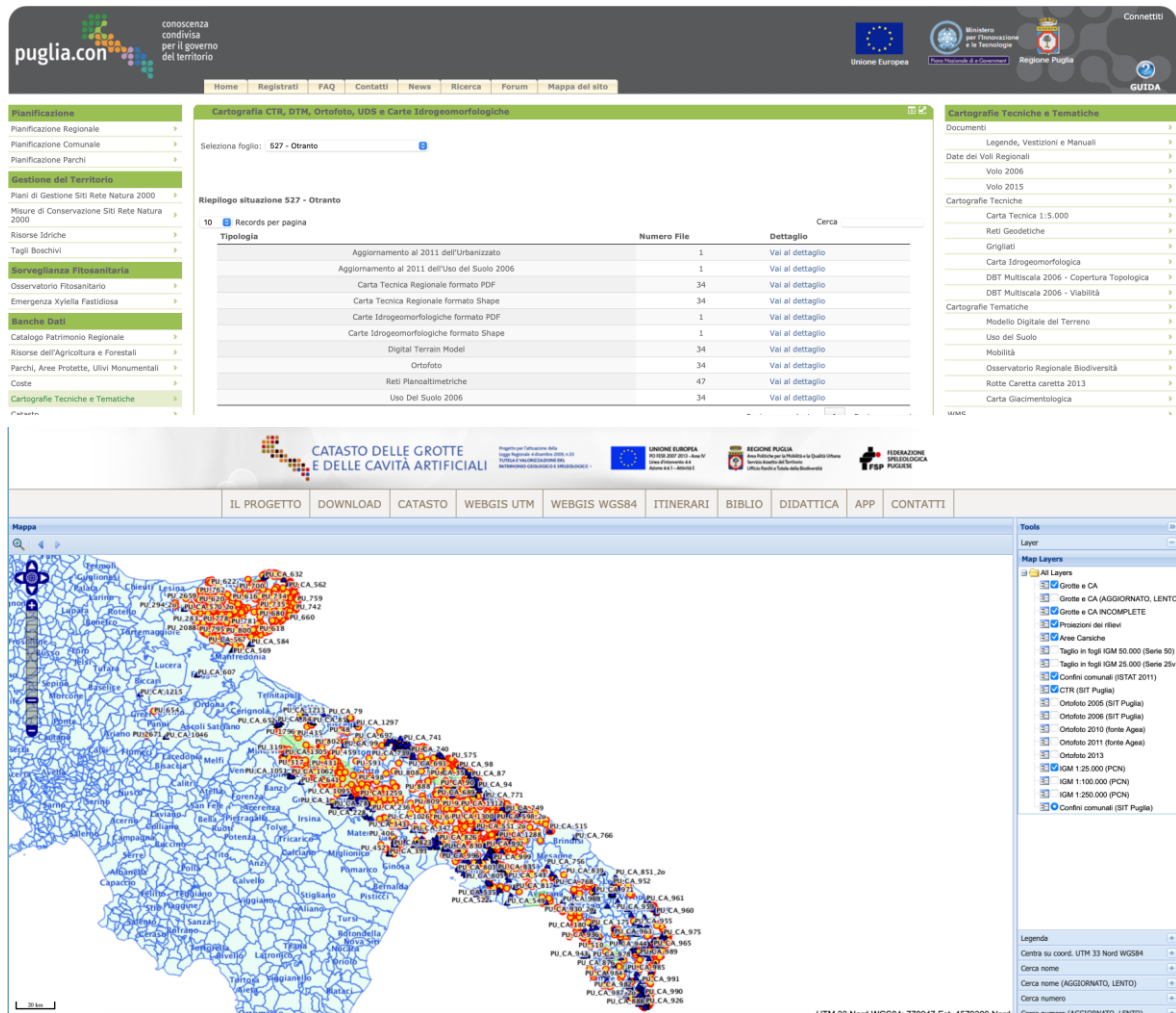
Recently, studies have been carried out by the University of Sannio Research Units concerning sinkhole mapping:

- Map of **sinkhole**, **endorheic areas**, **caves** and **ponors** of the Matese karst massif
- Map of **sinkhole** and **endorheic areas** of Alburni karst massif



Sketch of the map of hydrological karst features of the Alburni massif

Sources of Topographic and Spatial Data



Lists of available topographic and spatial data and Register Natural and Artificial Caves of Apulia

- 8-meter Digital Elevation Model (DEM), digital orthophotos, and 1:5000 Technical Regional Charts are freely available for the study area, along with multitemporal Google Earth Satellite Images
- 1- and 2-meter DEM obtained from LiDAR surveys were also acquired for the Apulia region; however, these data are not freely available
- A Register of Natural and Artificial Caves is available for the Apulia region

• Conclusions

- Further investigations are required to identify other sources of hydro-meteorological, topographic, geomorphological and spatial data
- Hydrological Annals provide time series of hydro-meteorological data up to 2021
- Currently, updated time series of water table levels appear unavailable
- Topographic and spatial data are available for the study areas; if required, these data can be employed to improve the knowledge of the study areas