

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



Finanziato dall'Unione europea NextGenerationEU



Ministero dell'Università e della Ricerca



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.

Mean annual sea level trends (mm/year) from 1993 to 2022



University of Sannio, Benevento, Italy

• 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)



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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 ٠
- Mapping and analysis of surface and subsurface karst features, focusing on sinkholes and underground cavities ٠

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

- Collecting and analyzing hydrological and climate data ٠
- GIS analysis of geographic and spatial data •
- Producing thematic maps of sinkholes, underground cavities, seawater intrusion, climate variability, etc. ٠



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



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





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

University of Sannio, Benevento, Italy

 Currently, meteorological stations are managed by Protezione Civile Puglia





Annali Idrologici – Parte I – Documenti dal 1921 al 2021

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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

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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





Map of southern Apulia showing monitoring wells 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
- 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)



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Map of Apulia showing stations of the National Oceanographic Network

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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





• Sinkhole in Karst Terrains

Sinkhole are closed depressions generated by two main processes:



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

- 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)



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



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Automatically mapped

Digital Elevation Model



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

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

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

• Sources of Topographic and Spatial Data

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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



- 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

