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Karst Aquifer Resources Availability and Quality in the Mediterranean Area – KARMA

www.karma-project.org

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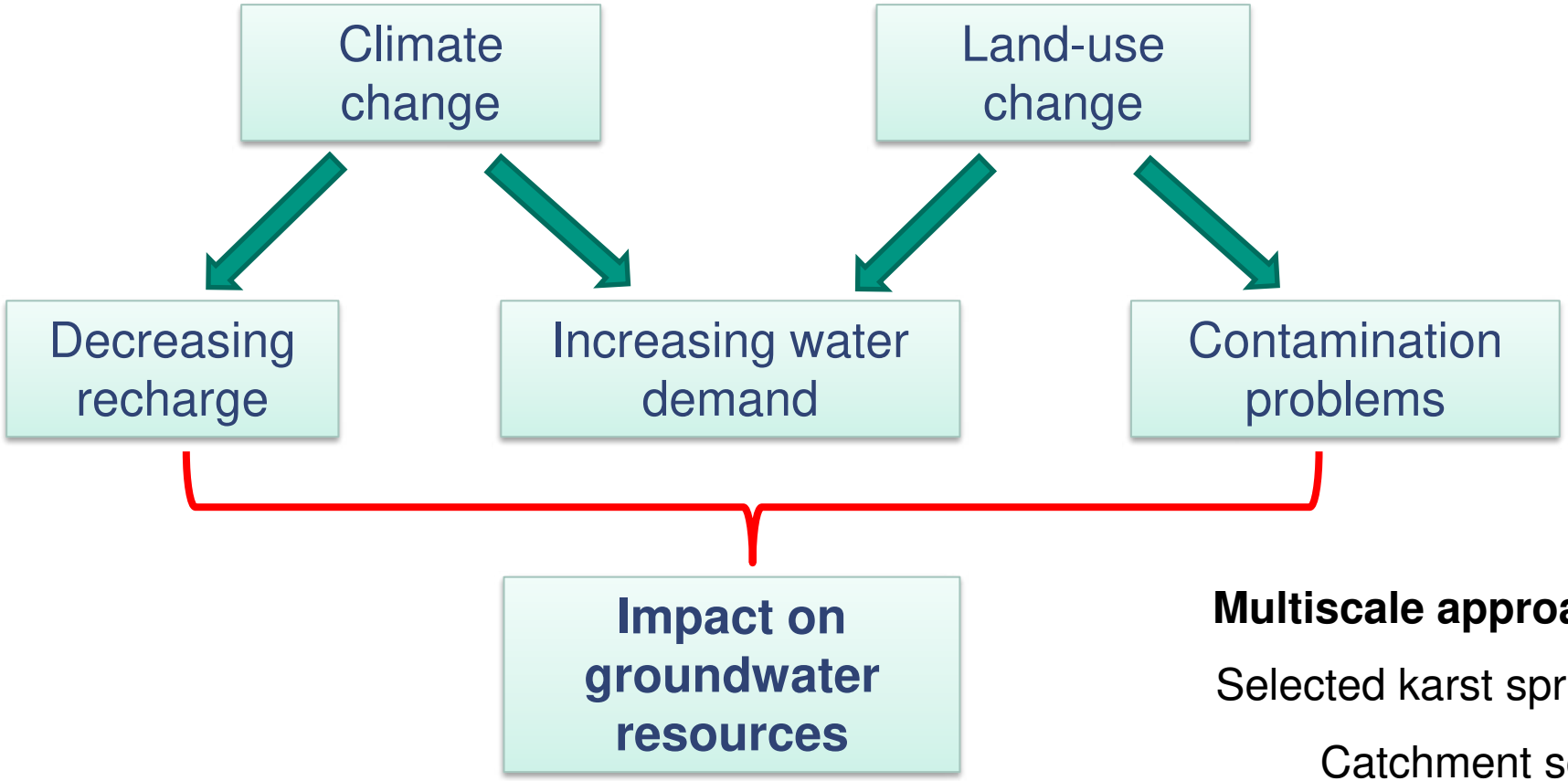
Karst Aquifer Resources availability and quality in the Mediterranean Area

The KARMA Project



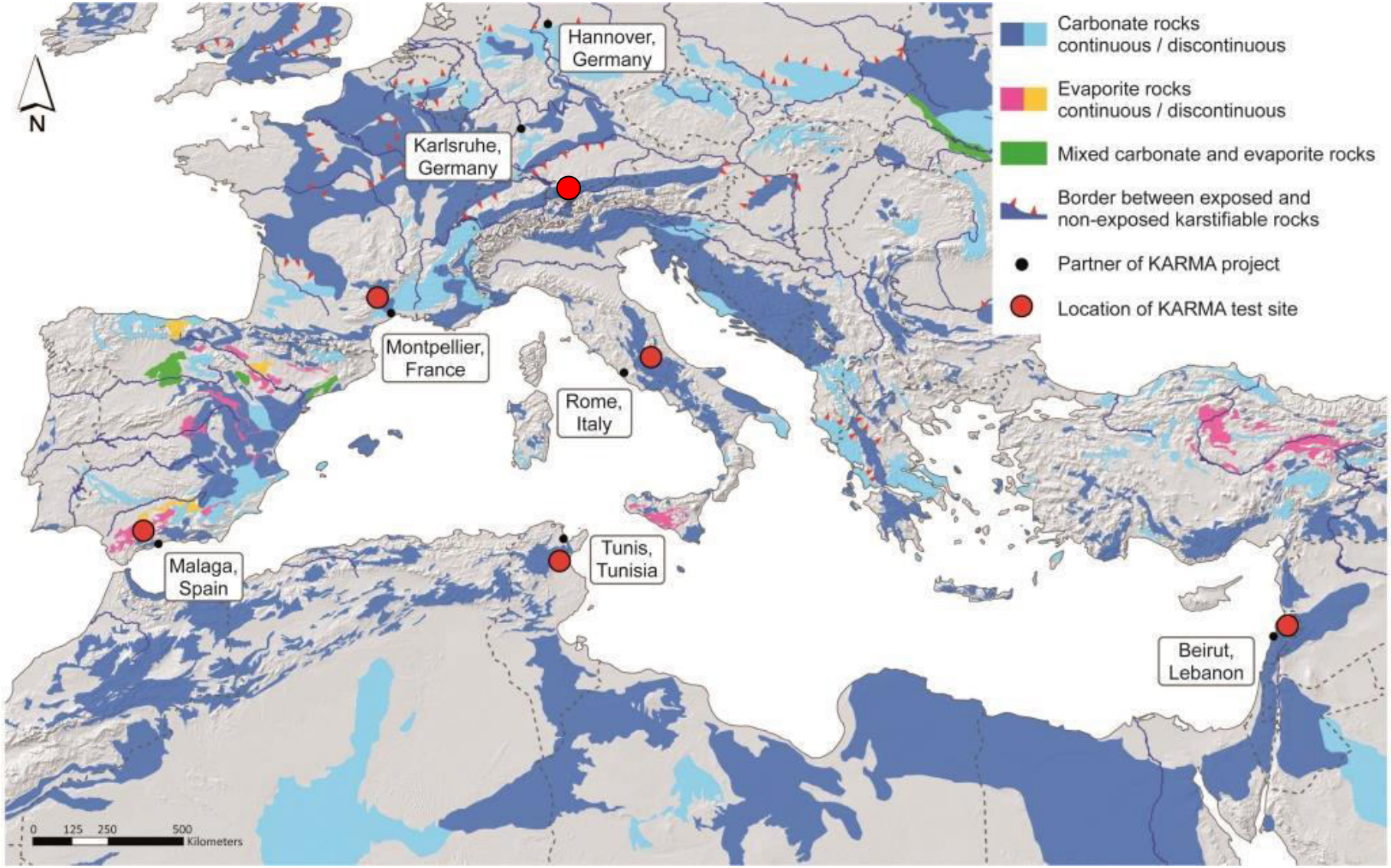
Multiscale approach:

Selected karst springs

Catchment scale

Entire Mediterranean area

KARMA partners and test sites in the Mediterranean area



Basis: WOKAM (Chen et al. & Goldscheider 2017)

Recharge assessment

- Evaluation of the water budget (recharge/discharge) for each test site,
  - Discharge monitoring at karst springs
  - Consultation and sampling of isotope data
  - Implementation and evaluation of tracer tests
  - Estimation of recharge with APLIS method and comparison with other methods

- Recharge rate higher than 50 of rainfall
- Up to 75% in aquifers or zones with mature Karst evolution

		APLIS results				Other methods		Main limitations and issues
Test site	Area (km^2)	Recharge rate (%)	Wet year (hm^3)	Dry year (hm^3)	Average year (hm^3)	Recharge rate (%)	Average year (hm^3)	
Gran Sasso	1034.4	50.6	-	-	500.65	53.97	532.72	APLIS does not take into account the snowcap contribution
	1080					53.54	546.48	
Qachqouch	55	>60	27.5	22.1	25.6	77.33	44	Original DEM and rainfall distribution map low resolution (< 5m)
East. Ronda Mt.	43.21	56.7	29.25	8.01	17.96	55.79	17.67	
						67.63	25.12	
Ubrique	26	72.84	45.49	10.14	24.47	75.66	31.4	Does not take into account the influence of the shaft
Lez	150	47 – 60	114.5	28.3	59.5	60 – 65	87.75	Original DEM presents low spatial resolution (< 5m)
Hochifen-Gottesacker	35					83	44	Resolution of the used DEM can be increased

Tracer tests

- Data from 111 tracer tests with 238 documented breakthroughs from five different field sites were compared and evaluated.
  - Qachqouch aquifer, Lebanon
  - Malaga province, Spain
  - Lez spring catchment, France
  - Hochifen-Gottesacker, Germany
  - Vitella d'Oro, Italy

Spring discharge monitoring

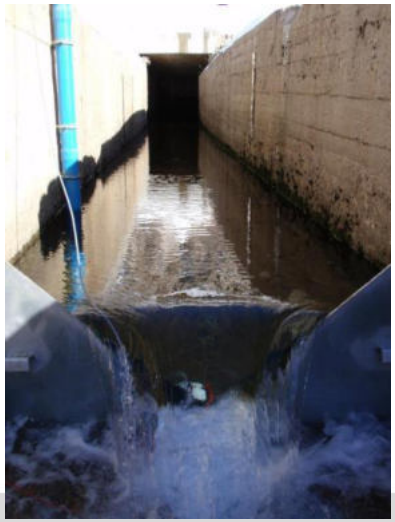
- Spring discharge measurements are conducted at all test sites by different methods
  - tracer-dilution
  - velocity-field measurement for calibration
  - pressure probes for continuous monitoring

→ Important input parameters for WP3 and WP4

Italy

Spain

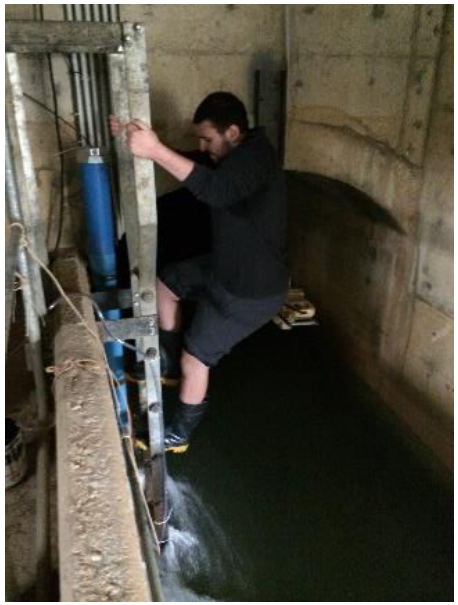
France



Lebanon

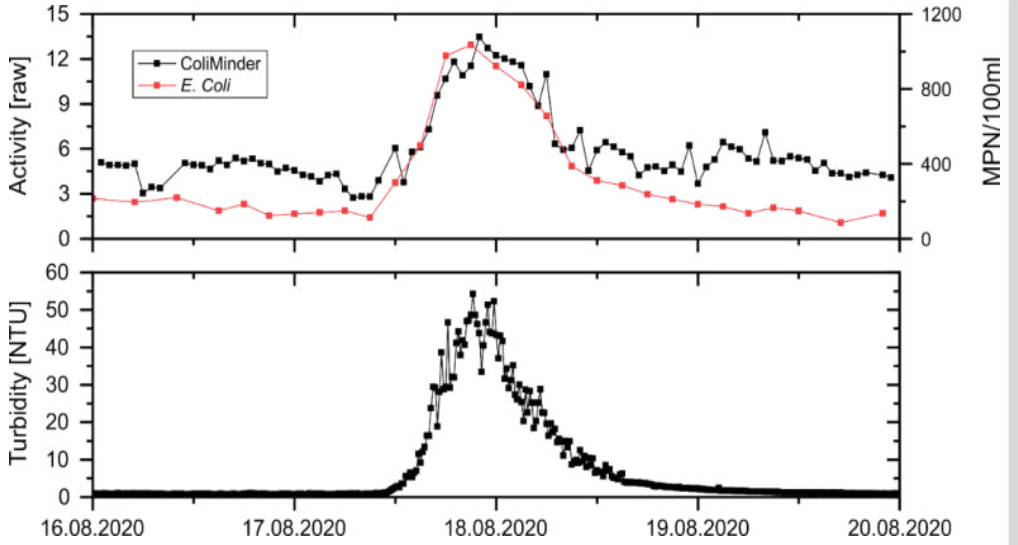
Water-quality monitoring

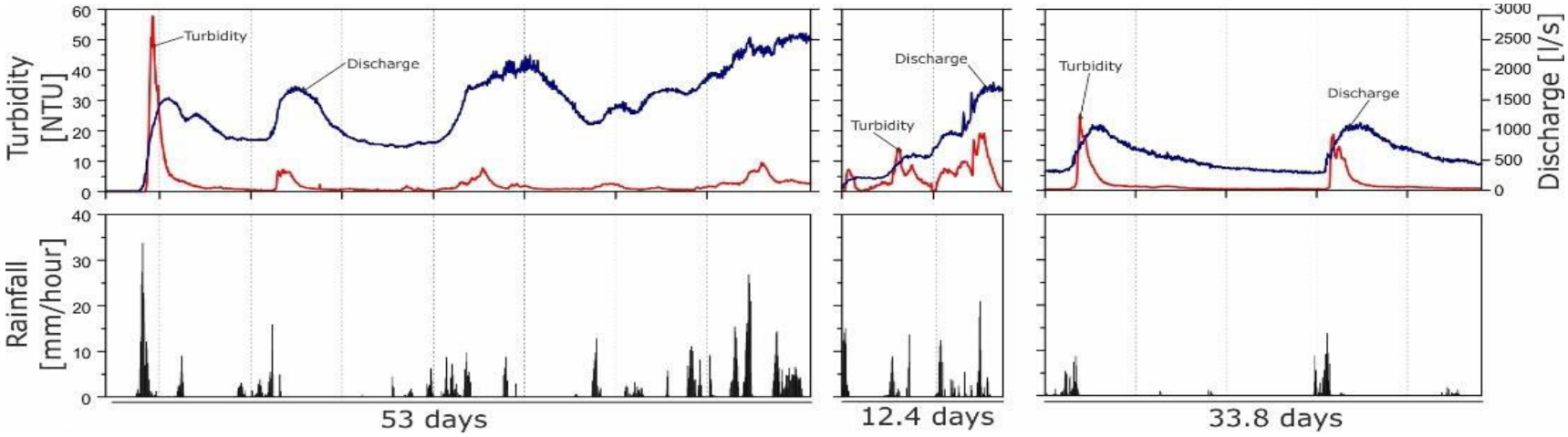
- Long-term monitoring was already in place at several test sites by specific equipment
- A large number of physical, chemical and microbial parameters that influence water quality are controlled by continuous on-site measurements and water samplings



Early-warning systems (EWS) for karst spring water contamination in 3 test sites

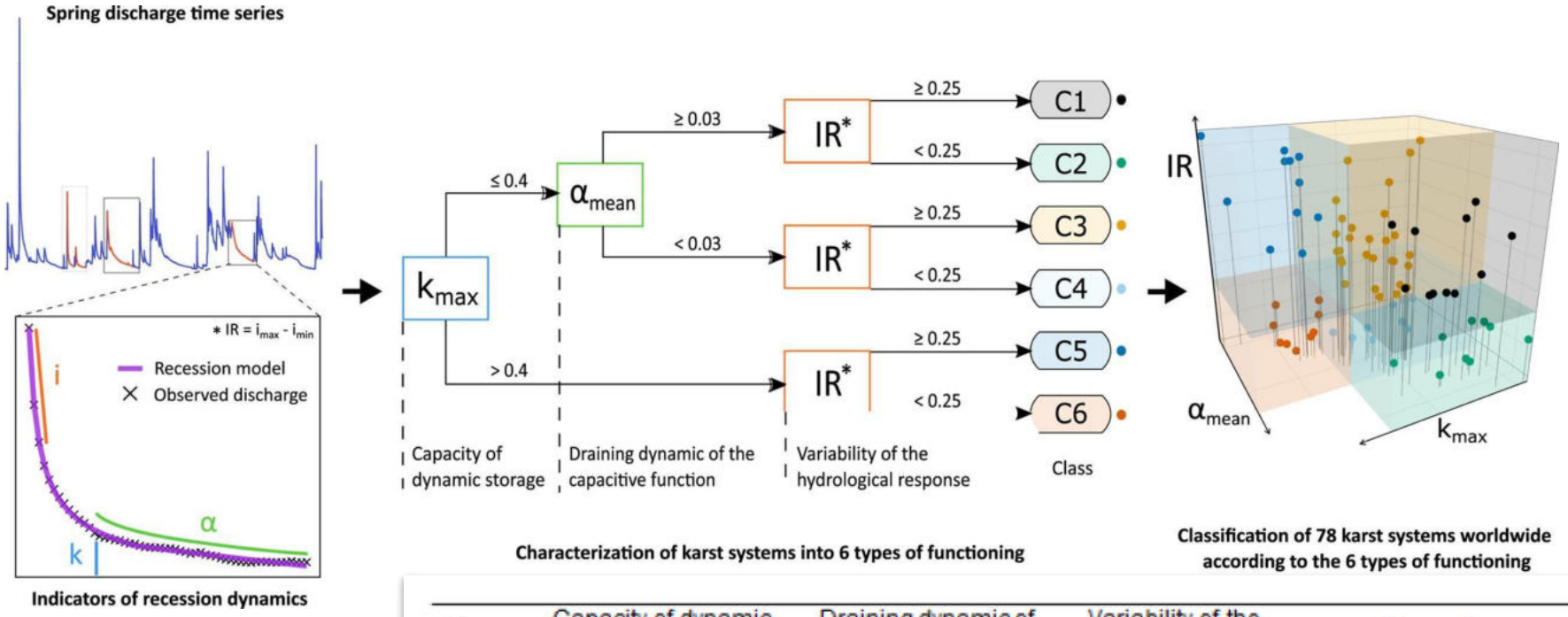
- Fluorescence-based techniques
- Particle-size distribution (PSD)
- Microbiological methods
- Trace metals analysis
- ^{222}Rn gas measurements.





Modeling and classification of karst hydrodynamic and hydro-chemical responses

- Typology consists of 6 classes accounting for 3 aspects of karst systems functioning

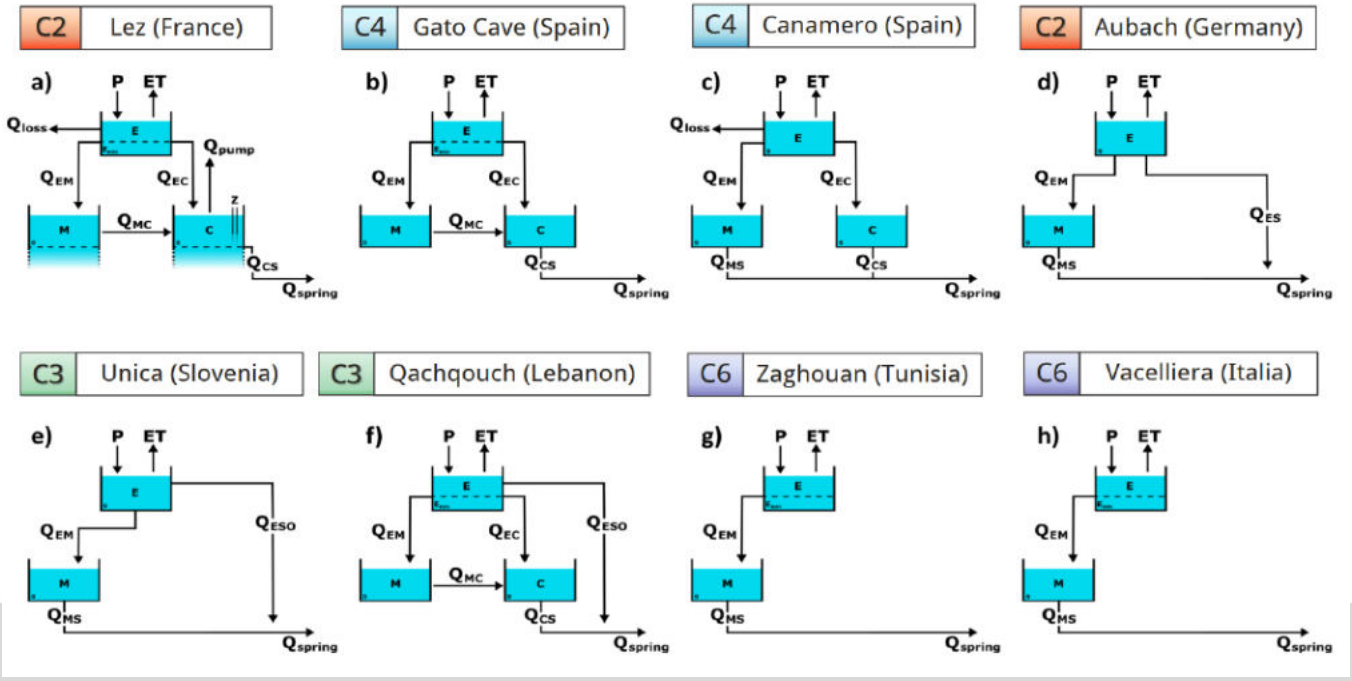


Class	Capacity of dynamic storage	Draining dynamic of the capacitive function	Variability of the hydrological response	k_{max}	$α_{mean}$	IR
C1	Very low to medium	Fast	Medium to high	≤0.4	≥0.03	≥0.25
C2	Very low to medium	Fast	Low to medium	≤0.4	≥0.03	<0.25
C3	Very low to medium	Moderate	Medium to high	≤0.4	<0.03	≥0.25
C4	Very low to medium	Moderate	Low to medium	≤0.4	<0.03	<0.25
C5	Medium to high	Moderate to slow	Medium to high	>0.4	<0.03	≥0.25
C6	Medium to high	Moderate to slow	Low to medium	>0.4	<0.03	<0.25

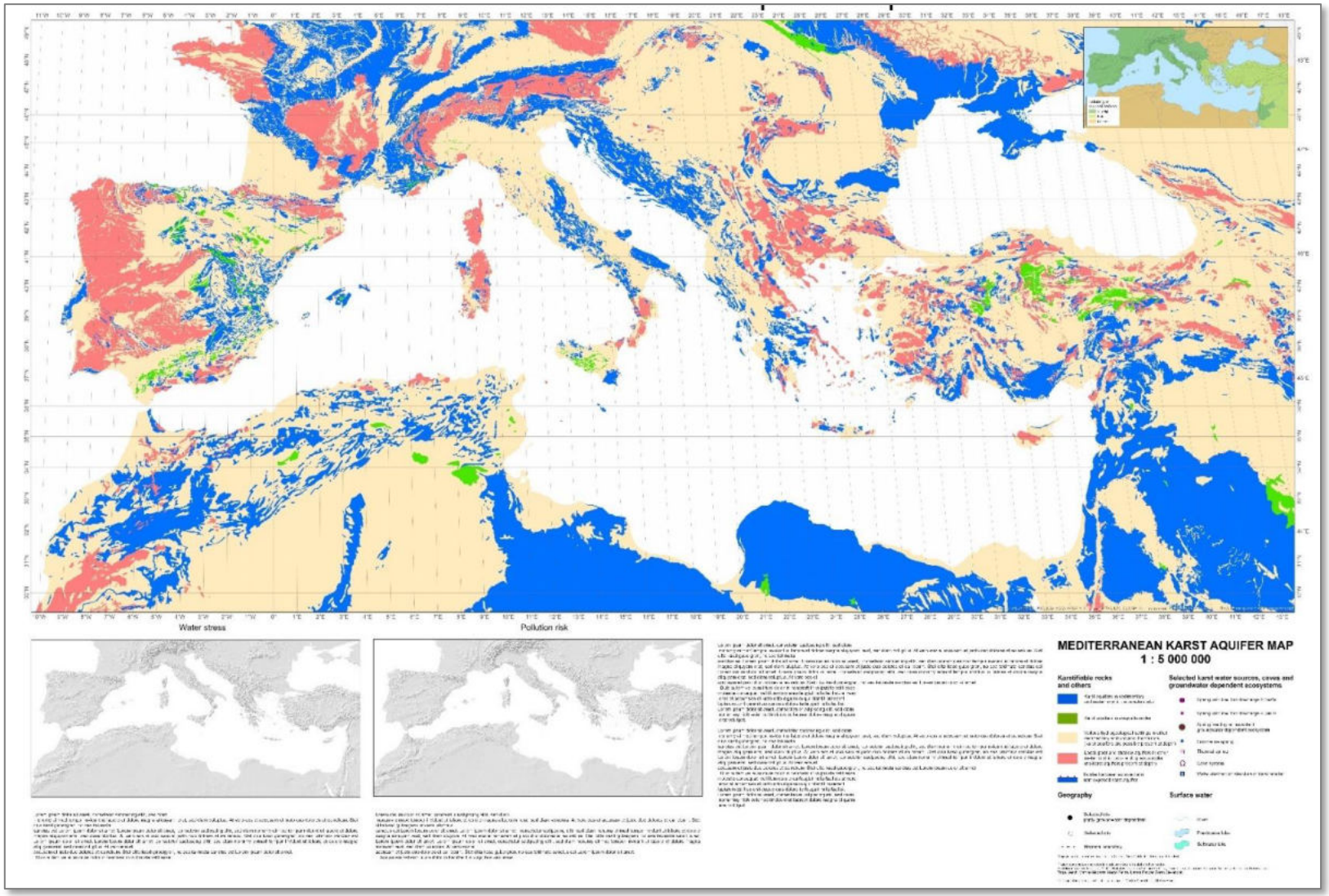
(Cinkus et al. 2021)

Lumped modeling and classification

- **C3:** High variability of hydrological functioning and moderate draining dynamic of the capacitive function: Qachqouch and Unica
- **C4:** Moderate variability of hydrological functioning: Canamero and Gato Cave
- **C6:** Very inertial and steady hydrological functioning: Vacelliera and Zaghouan
- **C2:** High variability of hydrological functioning and fast draining dynamic of the capacitive function: Lez and Aubach systems

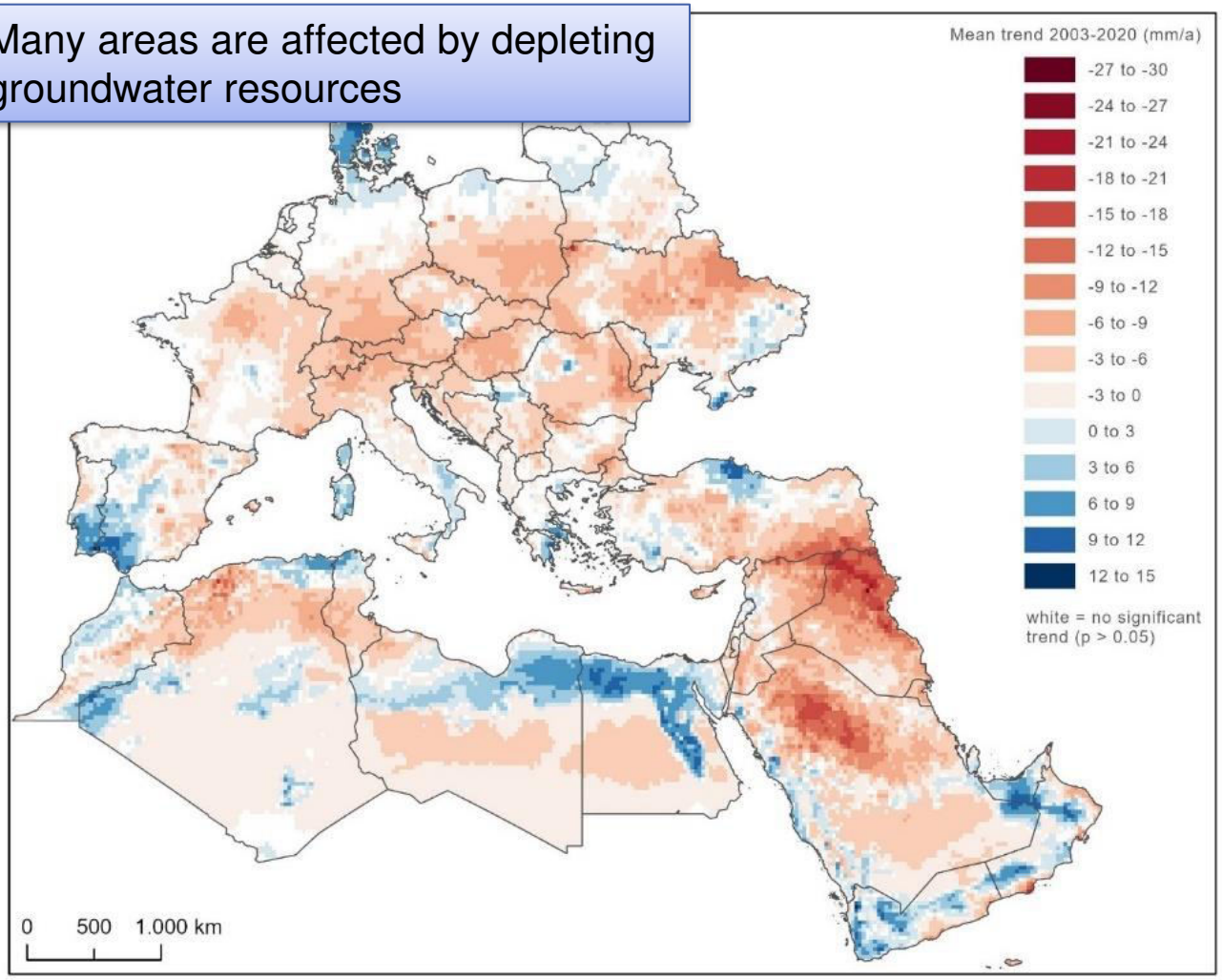


- Preparation of the **Mediterranean Karst Aquifer Map and database (MEDKAM)** based on the International Hydrogeological Map of Europe

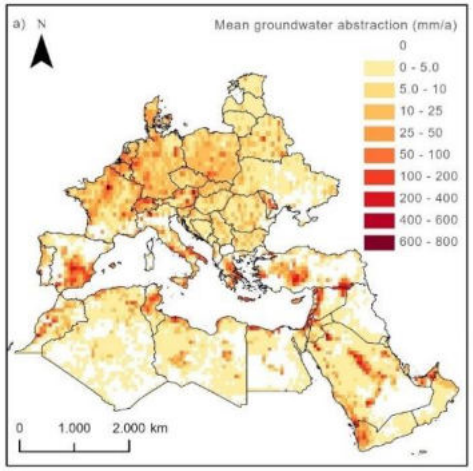


Analysis of trends in Groundwater storage using GRACE satellite data

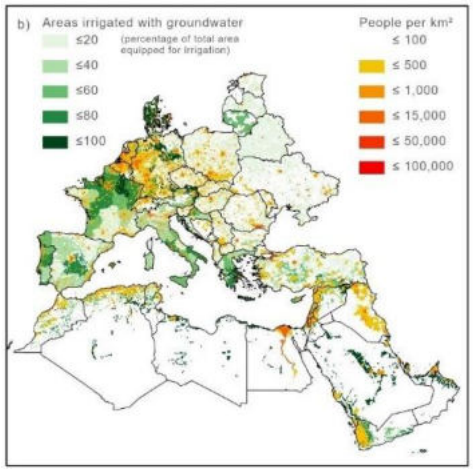
Many areas are affected by depleting groundwater resources



Trend analysis and quantification of changes in groundwater storage (GWS) in the period from 2003 to 2020



Mean groundwater abstraction (mm/a)



Areas irrigated with groundwater and population density

Karst groundwater-dependent ecosystems (KGDE)

- Data from many countries were collected:
  - West Balkan Region, Slovenia, Albania / Macedonia, Spain, Morocco, Turkey, France, Tunisia, Italy, Greece, Lebanon, Israel, Portugal
- About 120 KGDEs have been selected

Plitvice Lakes, Croatia
(photo: N. Goldscheider)

Funding / Acknowledgments

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MIUR – Ministry or Education, University and Research - Italy

National Council for Scientific Research - Lebanon (CNRS-L) - Lebanon

Ministry of Higher Education and Scientific Research (ANPR) - Tunisia