

Interreg

CENTRAL EUROPE



DEEPWATER-CE

European Union
European Regional
Development Fund

TAKING
COOPERATION
FORWARD



3rd Training of Cross Sectoral Stakeholder Group



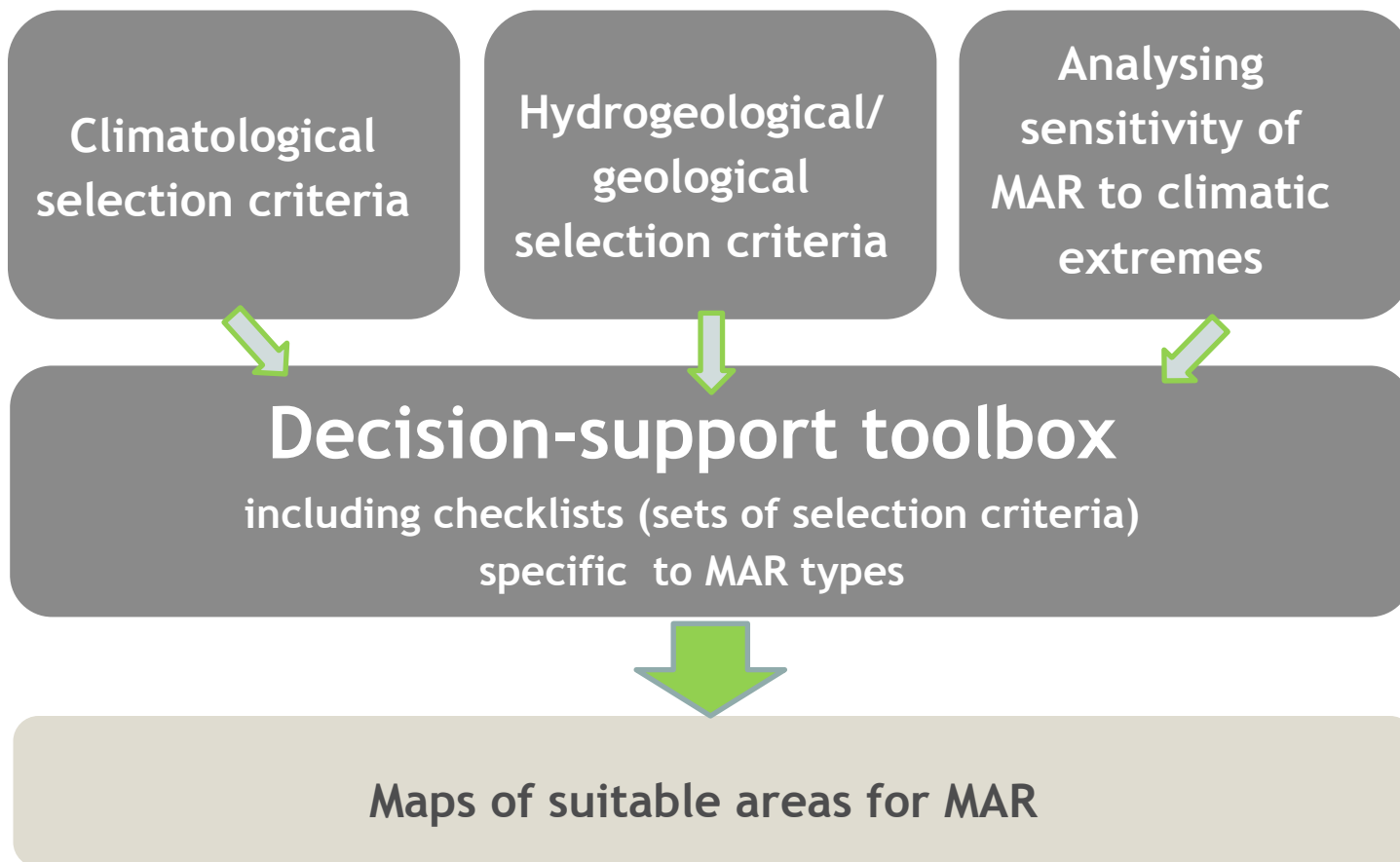
Suitability mapping of MAR in the DEEPWATER-CE project area



Arno Rein

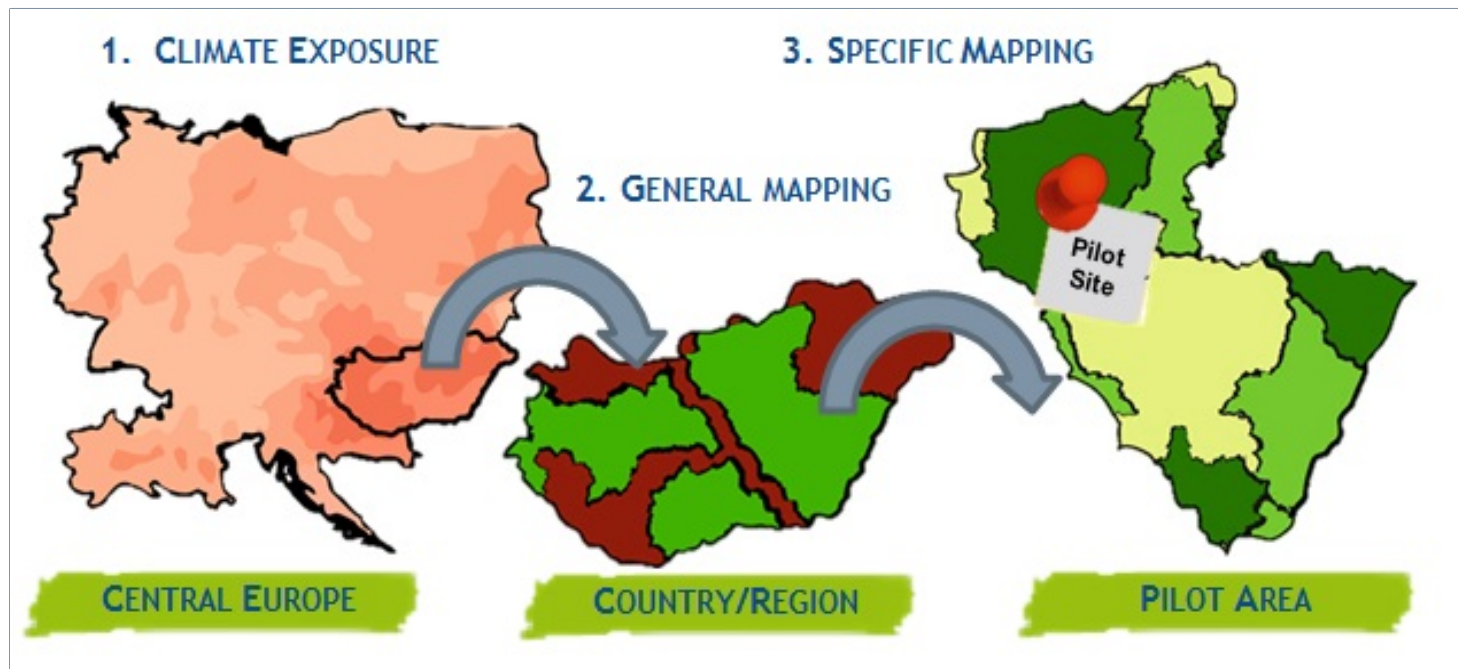
Structure of the decision-support toolbox

(topic of previous workshop, Sept 2020)



Suitability mapping

- Toolbox and methodology developed within DEEPWATER-CE project
- Applied and tested in 4 CE countries: Hungary, Slovakia, Poland, and Croatia
- Determination of specific regions where MAR is needed and feasible



Desktop study of the pilot site (as a prior/iterative step)

Aims:

- to identify the degree of difficulty of the project; assessment if the pilot site is suitable for the intended scope under application of reasonable efforts
- to give an overview on existing data for the feasibility assessment of the DEEPWATER-CE pilot site
- to developed a pilot action design plan for further steps of determining missing data for a comprehensive feasibility assessment



Desktop study of the pilot site (as a prior/iterative step)

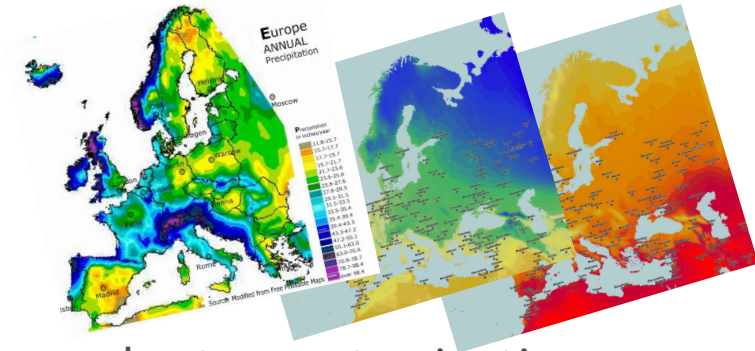
Data availability and sources

Pilot site characterization based on existing data

- Surface topography - Geomorphology
- Climatic conditions
- Land use and potential sources of surface and groundwater contamination
- Hydrology
- Geology
- Hydrogeology
- Aspects of existing infrastructure
- Regulatory limitations

Pilot action design plan (introduction of field works)

- Aims (what do you want to do and why)
- Planned geological, hydrogeological, geophysical and soil studies
- Planned numerical modelling



EXAMPLE for investigation of MAR feasibility: Study on the island of Vis, Croatia

This & following slides were provided by Matko Patekar, Croatian Geological Survey (mpatekar@hgi-cgs.hr)



- Vis - small remote island in the Adriatic Sea (89.7 km²); 55 km from the mainland
- Historical importance (4th century B.C. *Issa*); isolation during Yugoslavia
- ~4000 inhabitants
- Autonomous water supply





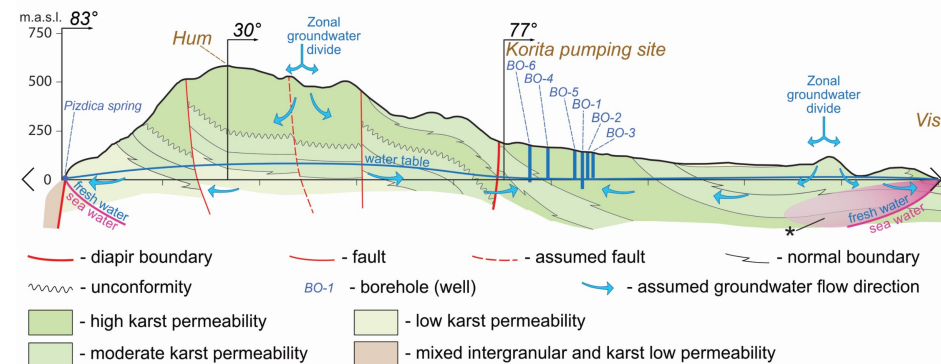
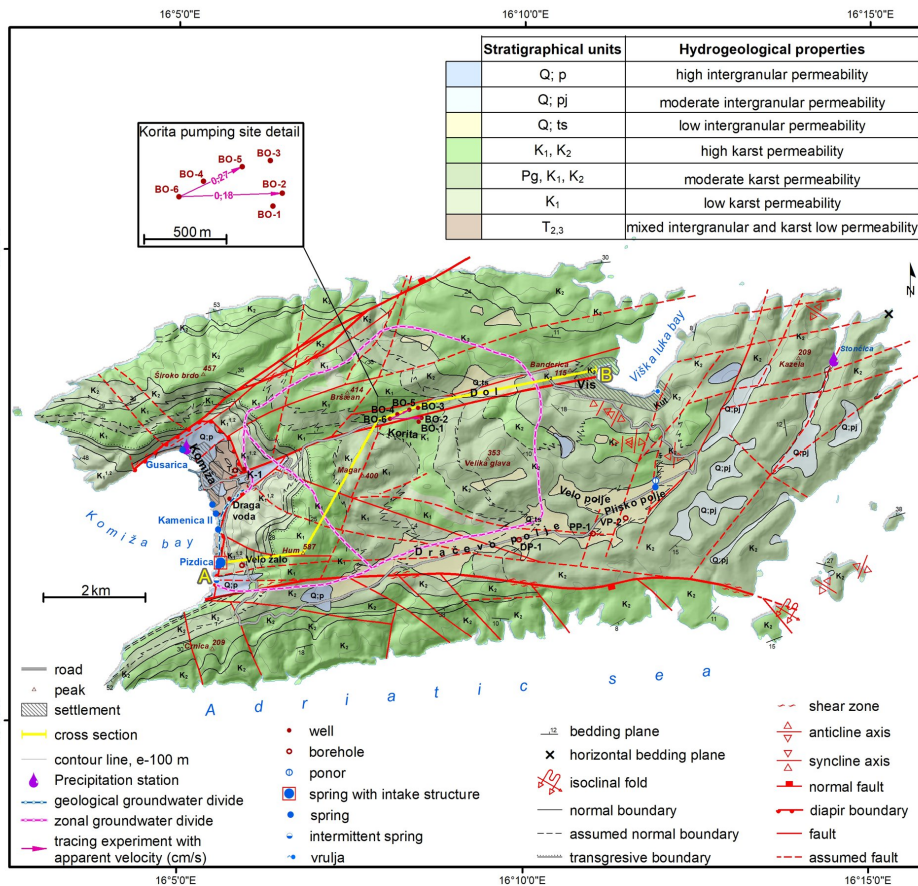
- Mediterranean climate (Csa - “olive climate”)
- 600 - 700 mm precipitation (high seasonal variability)
- Hotspot of climate change
- Increasing demand (tourism): 5x during summer!
- Occasional reductions for consumers



- *Locus typicus* of karst landforms - the Dinaric karst
- Mesozoic carbonates - **aquifers**
- Quaternary sediments and volcanic-sedimentary-evaporite complex - **barriers** to seawater intrusions



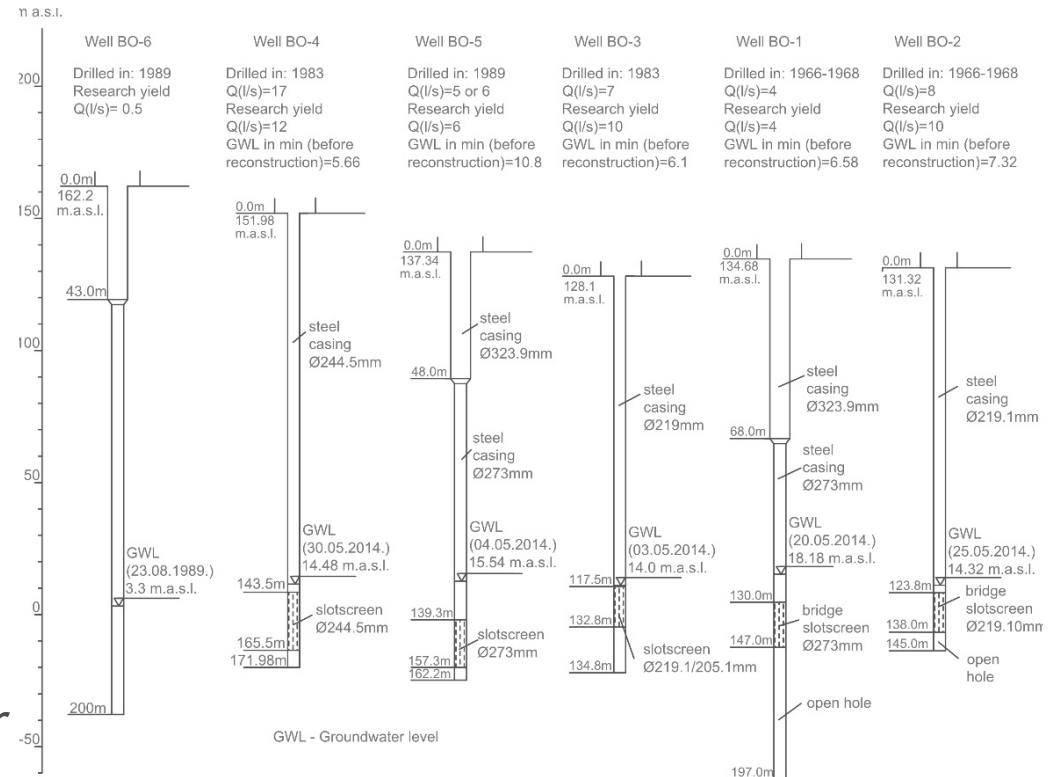
Hydrogeological map & conceptual model



Water supply - korita well field

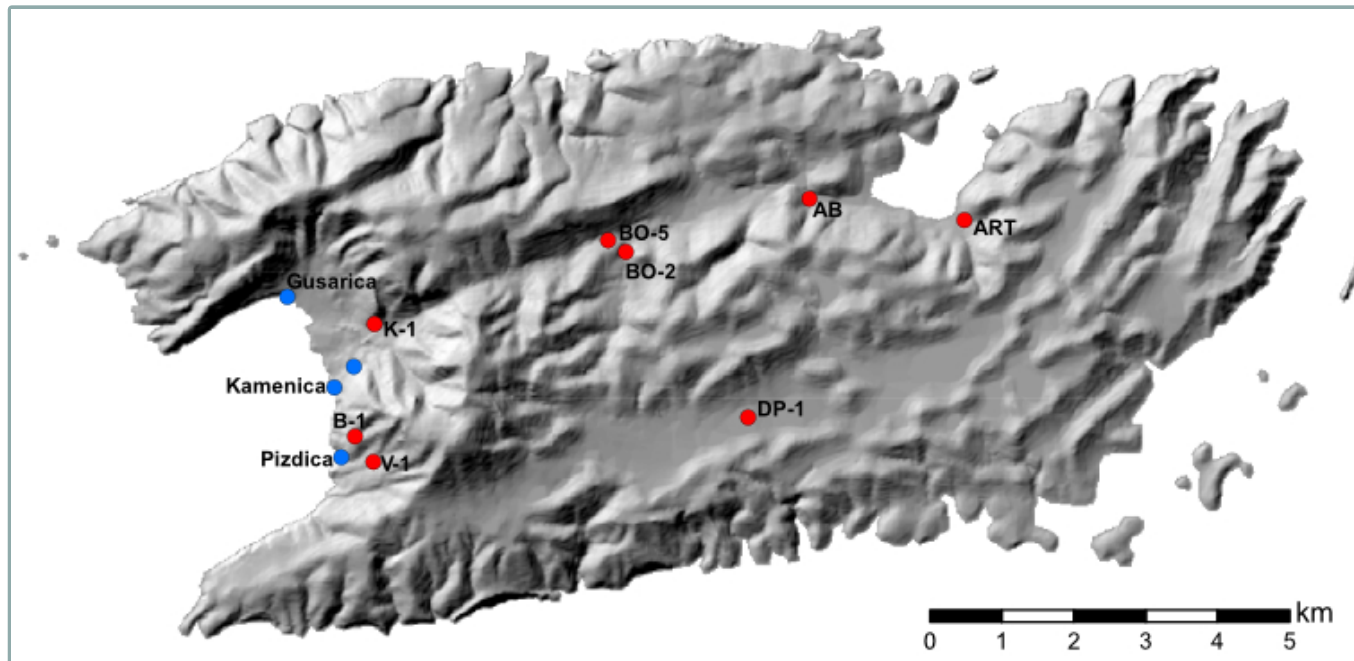


- 5 active wells (total 40 l/s)
- Potential MAR site - old river beds

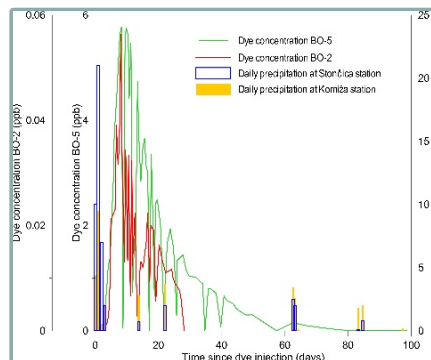


MAR investigations

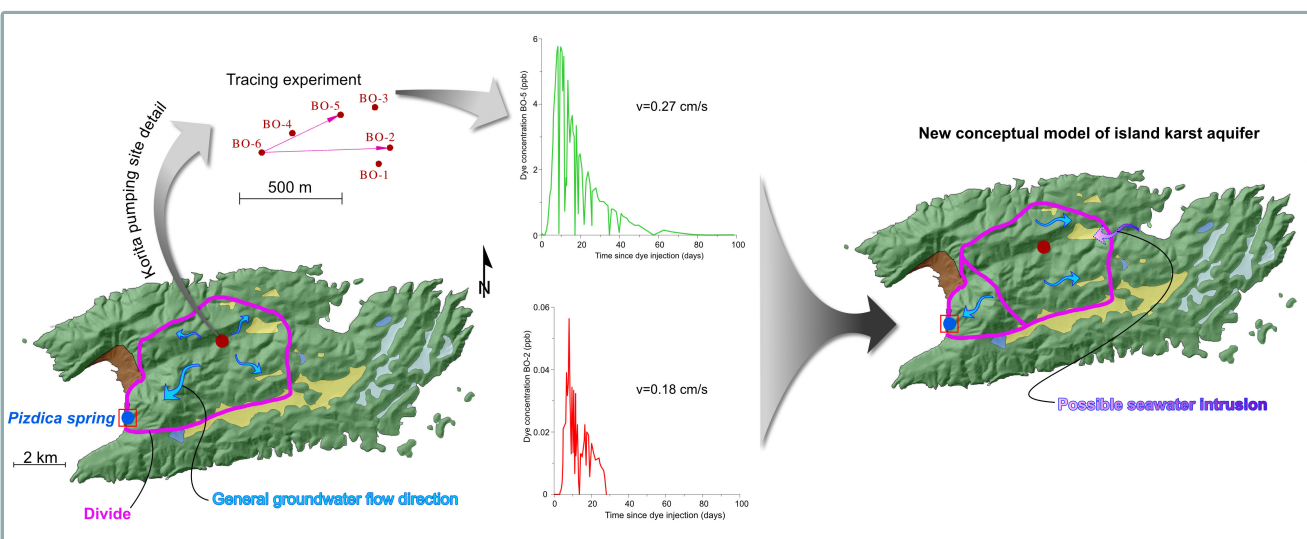
- 1st phase of multidisciplinary investigations: hydrogeology, hydrochemistry, geophysics, structural investigations, suitability mapping, climate modeling, and water balance calculation



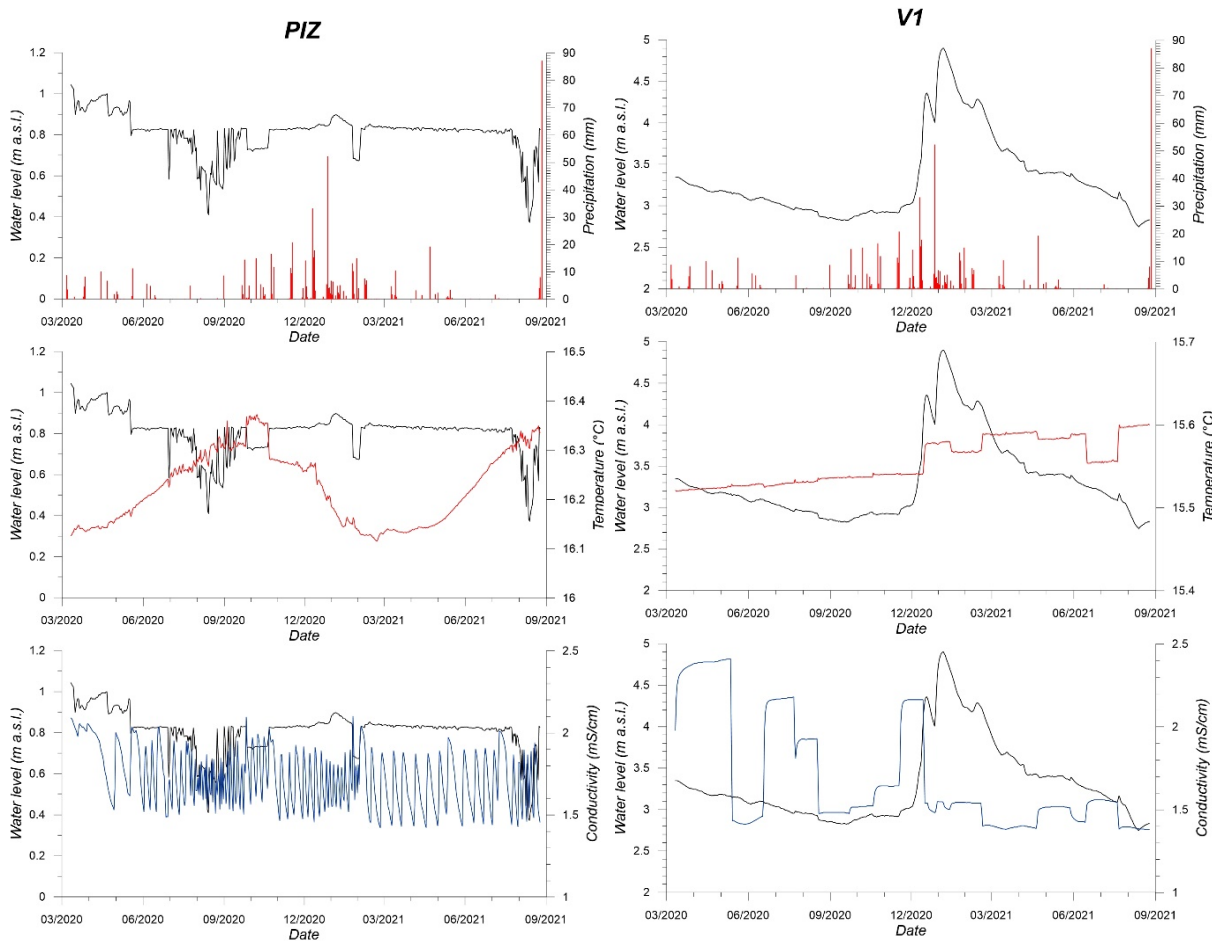
Hydrogeological investigations



- Tracer test - new conceptual model with two delineated catchments



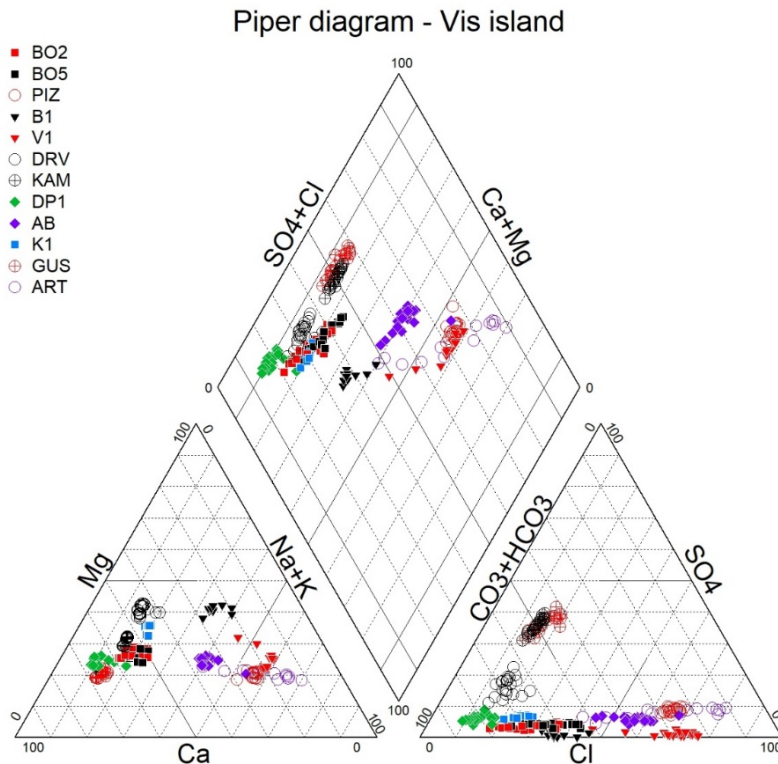
Hydrogeological investigations



- Continuous monitoring of **GW levels, temperature, and electrical conductivity**



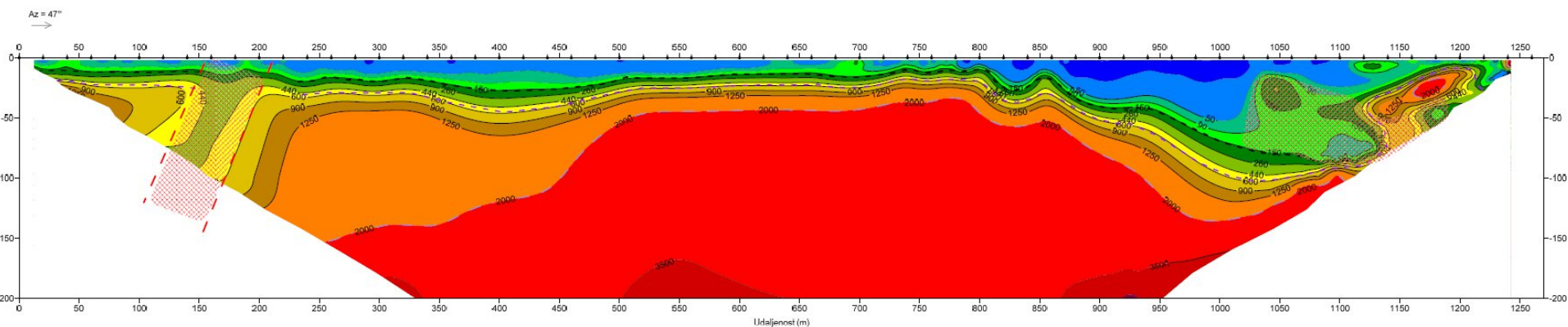
Hydrochemical investigations



- Monthly sampling for analyses of major ions and in-situ parameters
- Stable and unstable isotopes:
 - $\delta^{34}\text{S}$ from SO_4 (sulfate origin)
 - ^3H (groundwater residence time)



- Electrical resistivity tomography

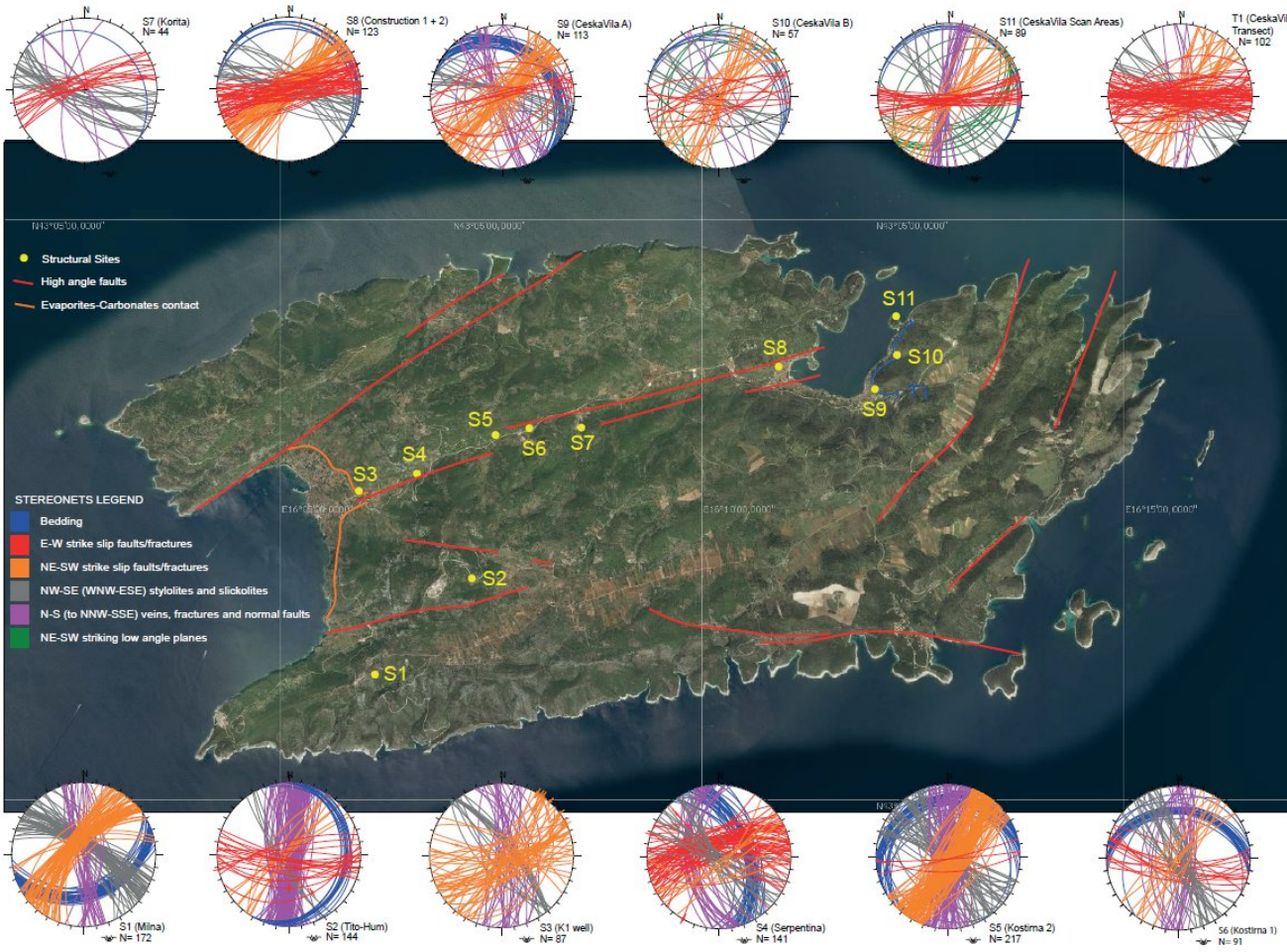


- Ongoing magnetotelluric profiling
- Interpretation of seismic profiles from regional petroleum investigations

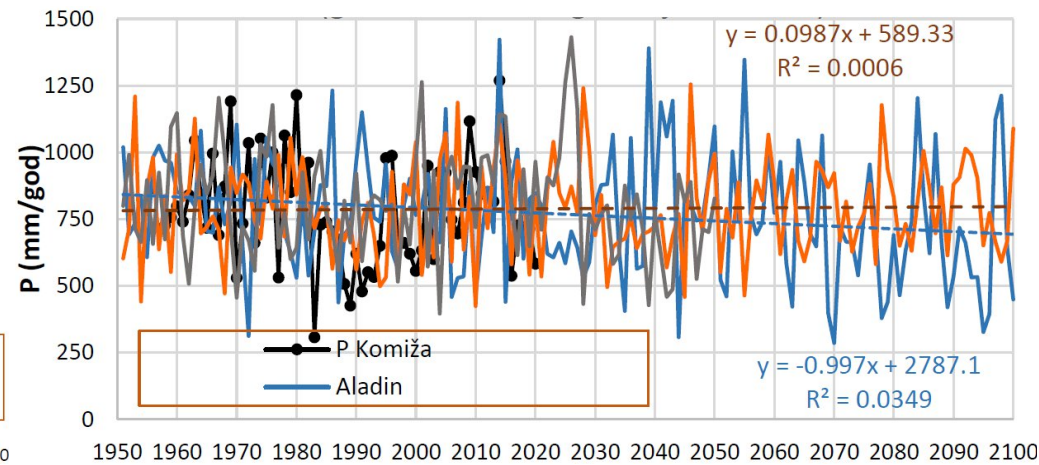
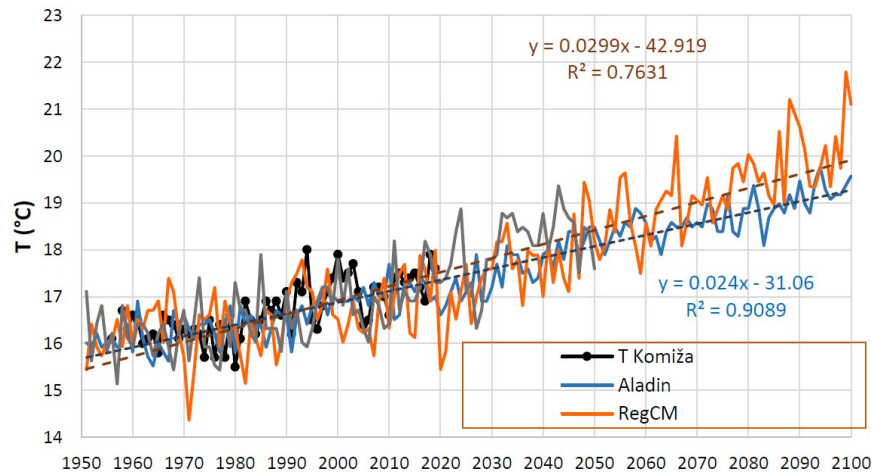


Structural investigations

- Geometrical attributes of fractures & faults



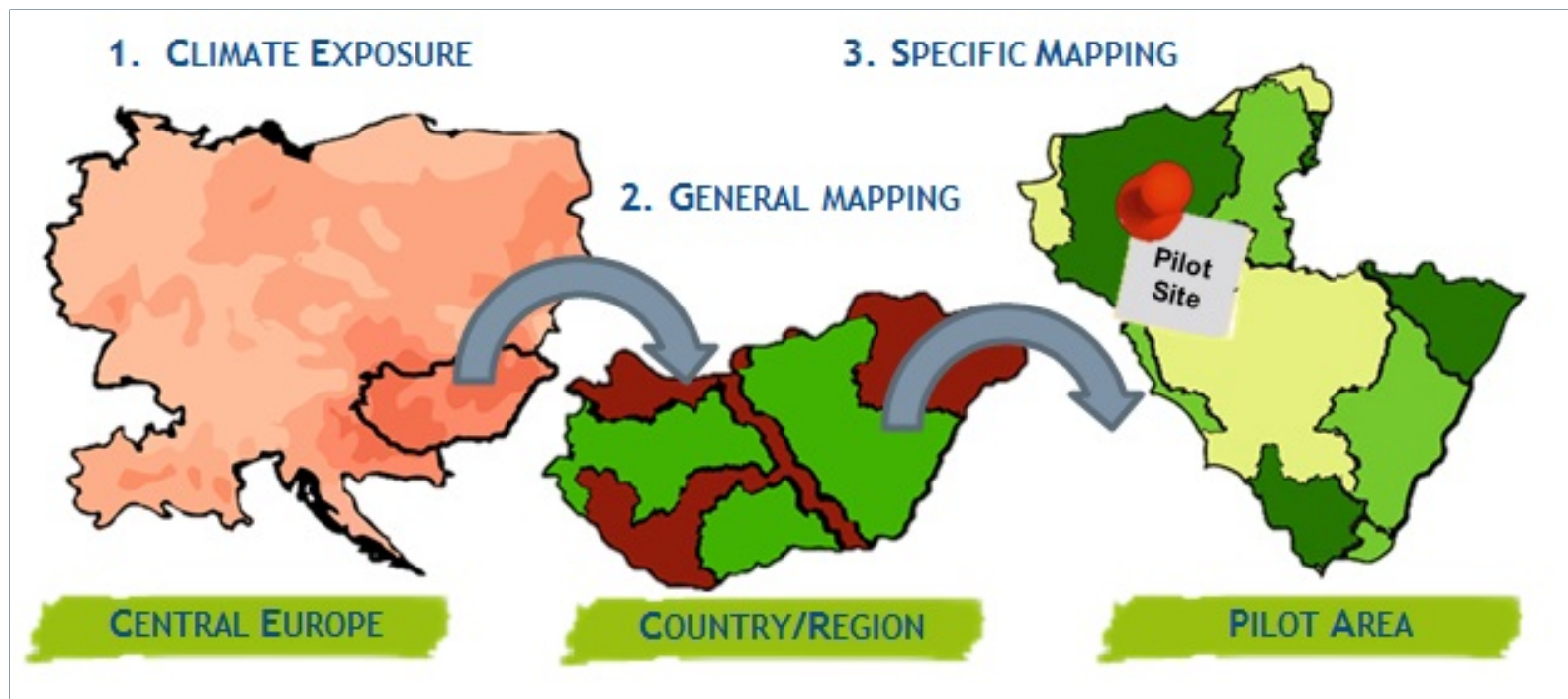
Climate models



- Regional climate models Aladin, RegCM3 and Promes
- Reduction in runoff up to 40% until 2100



Suitability mapping

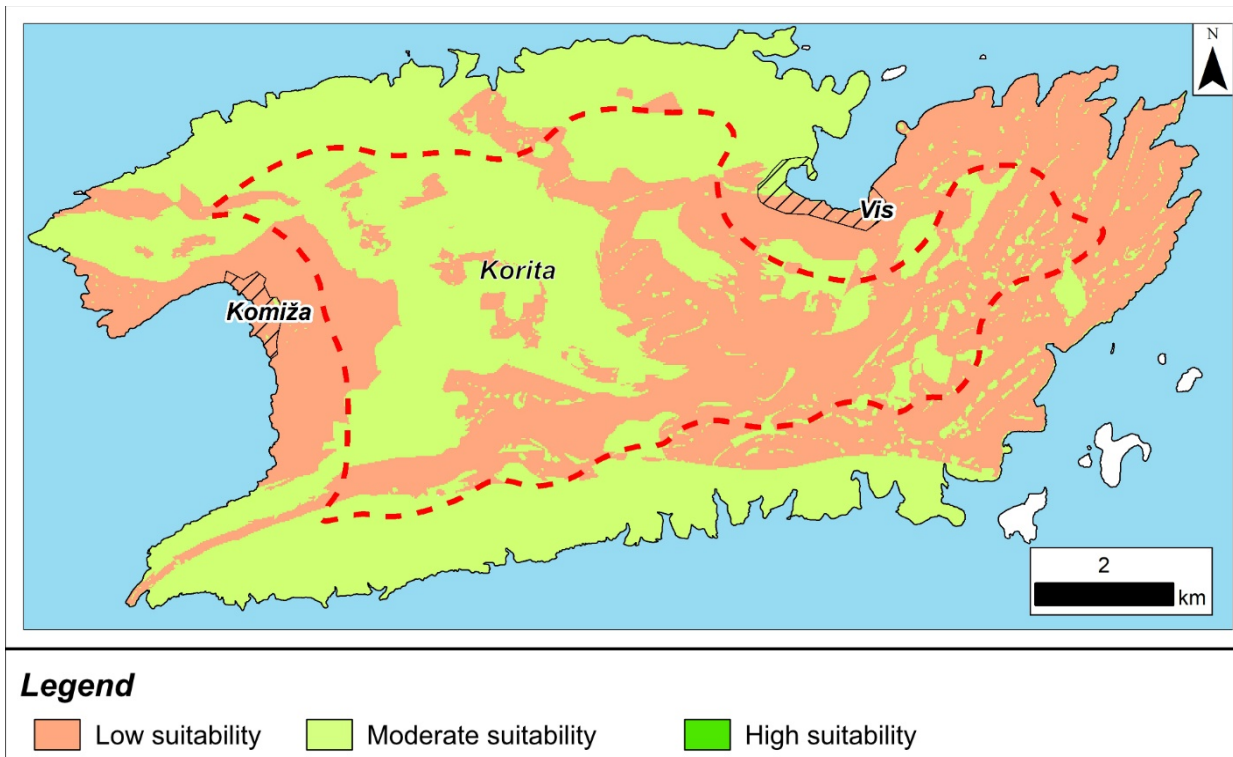


- Infiltration pond and ASR methods are investigated

Main parameter category	Name of parameter(s)	Level of suitability			Parameter weight
		Low suitability	Moderate suitability	High suitability	
Characteristics of the water source	Distance from surface water source	>1000 m	100-1000 m	0-100 m	5%
Surface characteristics	Lithology of the surface formations	low permeability sediments (e.g. sandy loam, silty sand)	moderate permeability sediments (e.g., fine sand, sand with lenses of silt or clay), moderately fractured non-karstified carbonates, igneous and metamorphic rocks	high permeability sediments (e.g. coarse sand, gravel), highly fractured and karstified carbonates	15%
	Land use	industrial or urban areas (artificial surfaces), wetlands	forests, agricultural terrains	pastures, barren land, open spaces with little or no vegetation, natural vegetation, shrub and/or herbaceous vegetation associations	3%
	Slope	>5°	3-5°	<3°	17%
Aquifer characteristics	Thickness of the aquifer	<5 m	5-70 m	>70 m	10%
	Depth of the top of the aquifer	>15 m	10-15 m	5-10 m	20%
	Lithology of the aquifer	clayey/silty sand, moderately fractured carbonate and igneous rocks	fine sand, moderately to highly fractured carbonate, volcanic and sedimentary rocks	sandy gravel, gravel, sand, alluvial sediments, highly fractured carbonates and karstic rocks	10%
	Depth of the groundwater table	>15 m	10-15 m	5-10 m	20%



Suitability mapping result



- Infiltration pond suitability map
- Korita well field – most promising location



- Despite the relatively high potential, a MAR system is unlikely to be implemented on the island of Vis in the near future:
 - ❖ big uncertainty due to the high heterogeneity of karst aquifers
 - ❖ gaps in legislation: MAR is currently not regulated nor legal to implement in Croatia
- Alternative solutions (e.g. small desalination plant, additional wells, rainwater harvesting, water re-use) are probably cheaper and safer in comparison with IP or ASR method
- Climate extremes (e.g. extremely low precipitation in the recent years) might promote small-scale MAR projects in the island communities



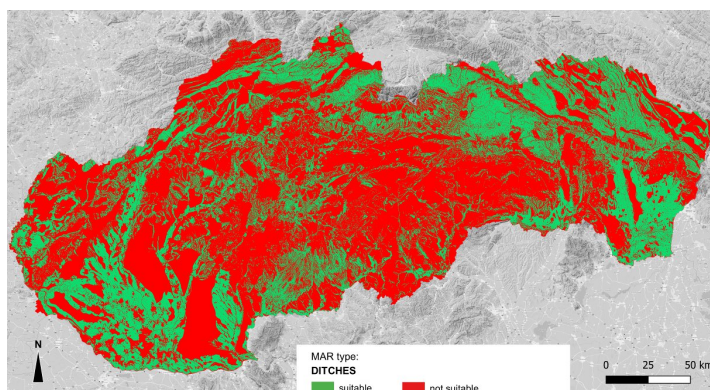
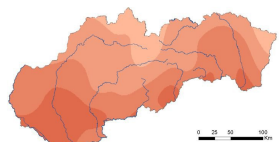
Maps of potential suitable areas for MAR

Maps are available on IGRAC map portal for DEEPWATER-CE

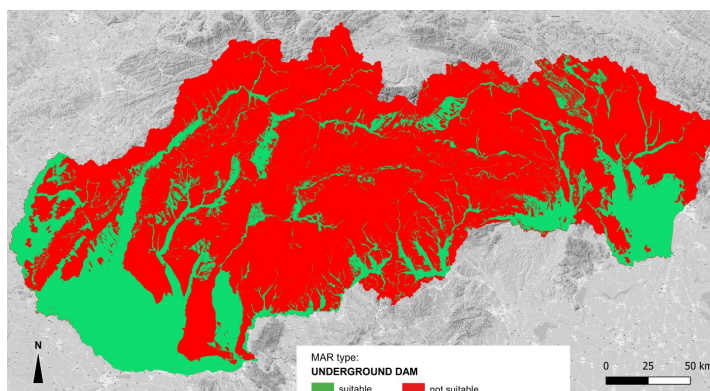
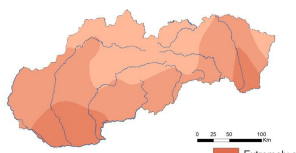
<https://ggis.un-igrac.org/maps/2171/view>

e.g. for Hungary:

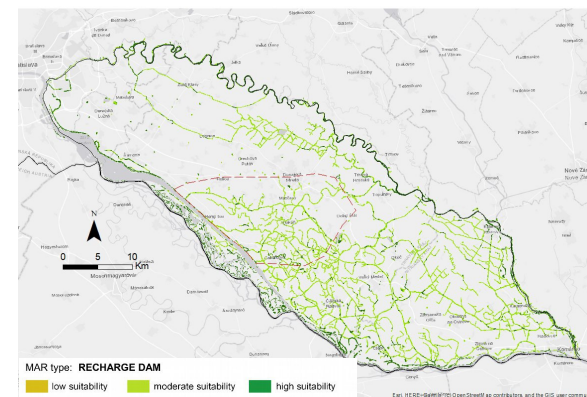
RCA4 / CNRM-CM5 / RCP4.5



RCA4 / EC-EARTH / RCP4.5



e.g. for Slovakia:



and also for Croatia and Poland



Suitability Mapping - Discussion

DINAMAR

https://ggis.un-igrac.org/layers/mar_global:marpotential_spain

IAH Working Group:

<https://recharge.iah.org/working-groups/mar-suitability-mapping>

**For discussion: what are your experiences in this field?
Where did you encounter challenges?**

Thank you for your attention

