Introducing digital information products of the four GeoERA groundwater projects for assessment and sustainable use of water resources and the subsurface in a changing climate

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on behalf of the GeoERA Groundwater TEAM

Presentation for EGU21 29.04.2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

CONTENTS

1. Groundwater in the bigger picture (EU Green Deal, UN SDGs and Planetary Boundaries)

2. GeoERA contributions to Horizon Europe

3. The four GeoERA groundwater projects and their main contributions to the GeoERA information platform / EGDI and *FAIR access to groundwater data

*Wilkinson et al., 2016. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018.

Courtesy: Christian Holmegaard Mossing /NIRAS

The European Green Deal – a high priority goal

6 ambitions of the von der Leyen Commission

1. A European Green Deal
2. An economy that works for people
3. A Europe fit for the digital age
4. Protecting our European way of life
5. A stronger Europe in the world
6. A new push for European democracy

European Commission

2020 research and innovation programme under grant agreement No 731166

GeoERA GROUNDWATER

Integrated, sustainable and just exploitation of water resources is required to meet the objectives of the ”EU Green Deal” and the UN SDGs

Sustainable management of water resources plays an important role in nearly all 17 SDG’s

Water use in Europe by economic sector, 2017

https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-3/assessment-4

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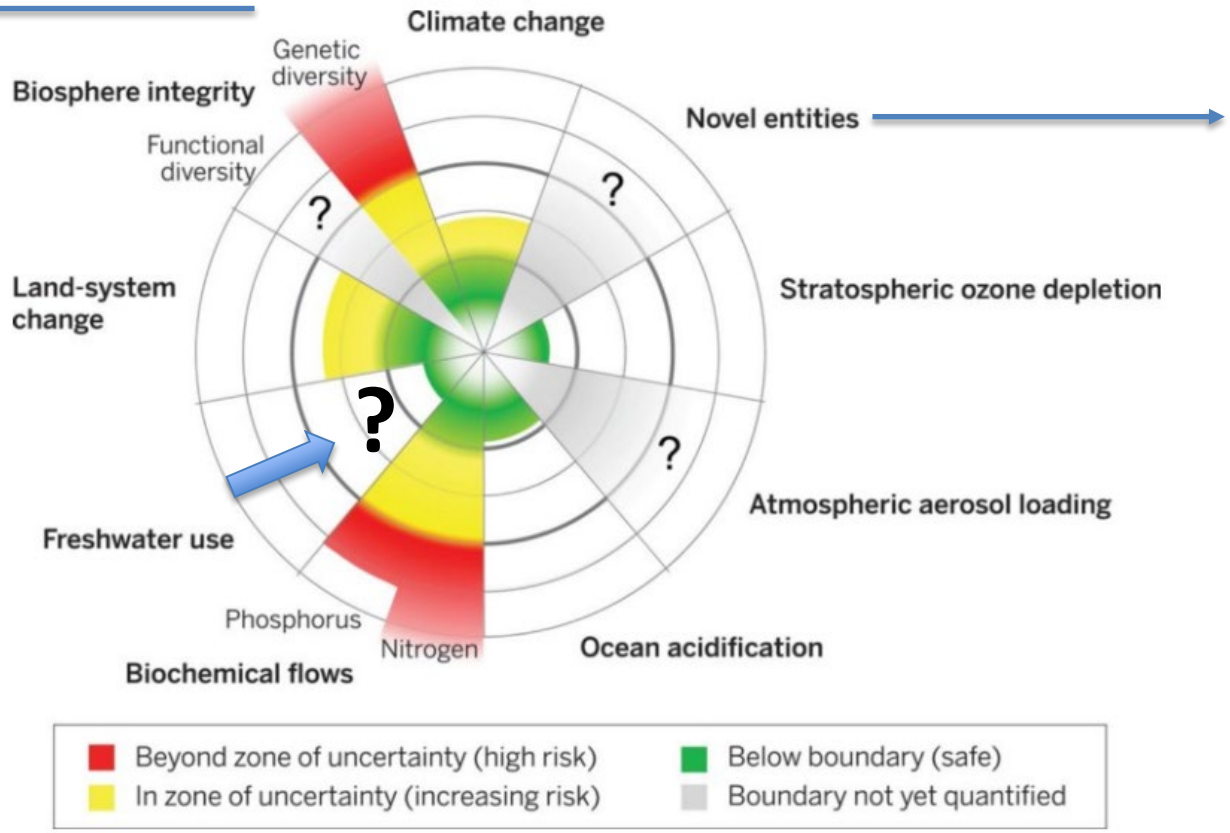
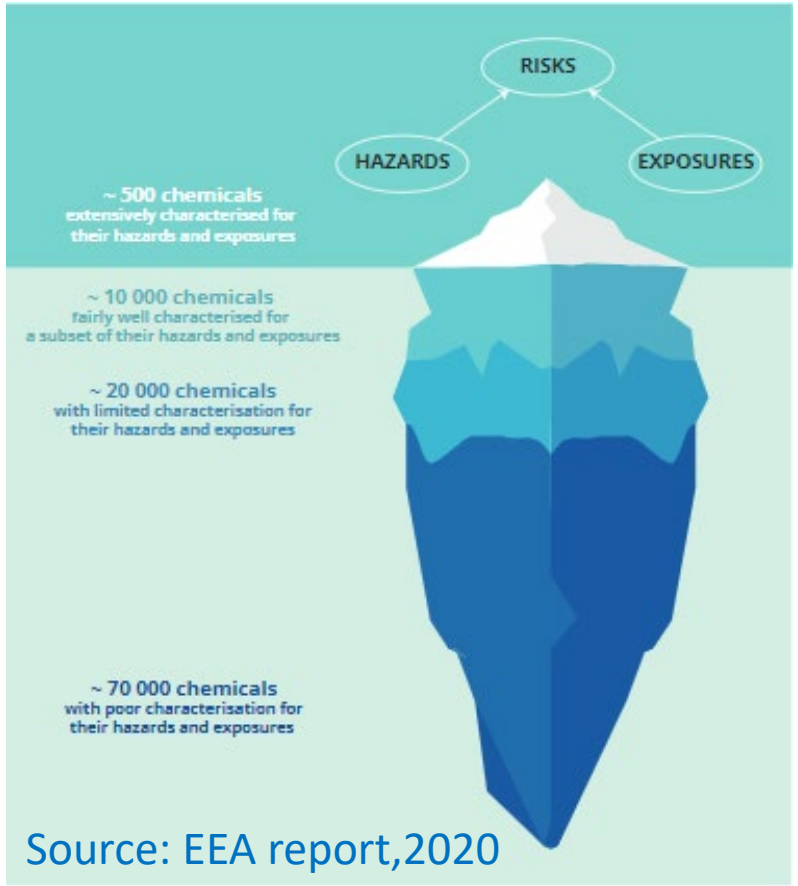
Planetary Boundaries

Groundwater quantity and quality is affecting and/or is affected by all 10 Planetary Boundaries



Steffen et al., 2015. Science 347, 1259855.



Source: EEA report,2020

https://www.eea.europa.eu/publications/soer-2020

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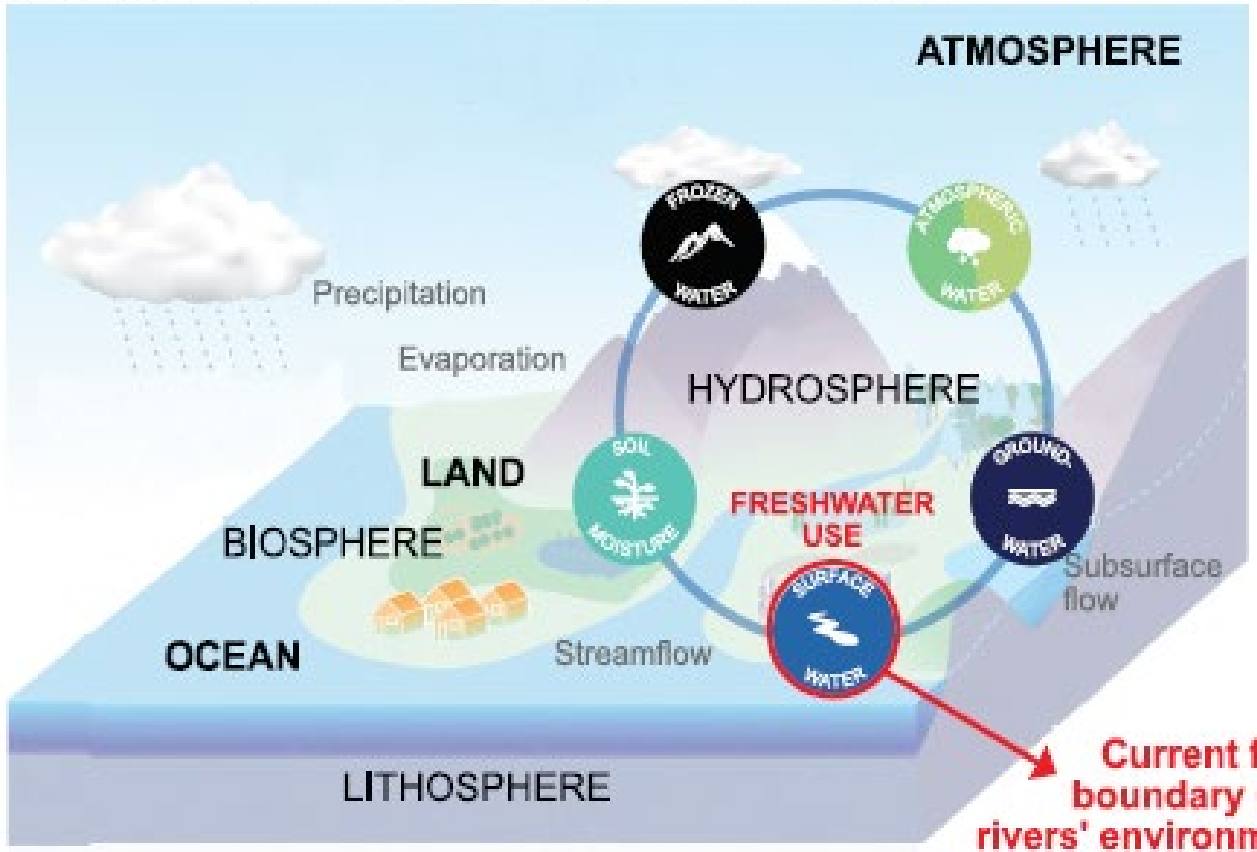
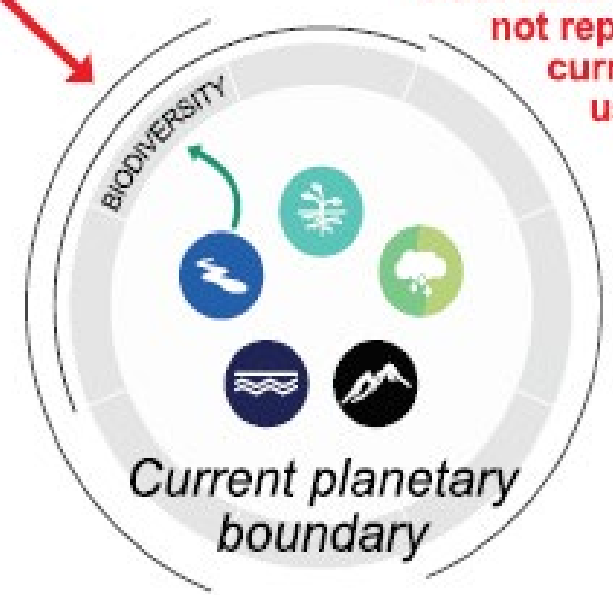
"Fresh water—the bloodstream of the biosphere—is at the center of the planetary drama of the Anthropocene. Water fluxes and stores regulate the Earth's climate and are essential for thriving aquatic and terrestrial ecosystems, as well as water, food, and energy security." (Gleeson et al., 2020).

b) Earth System components and stores of water

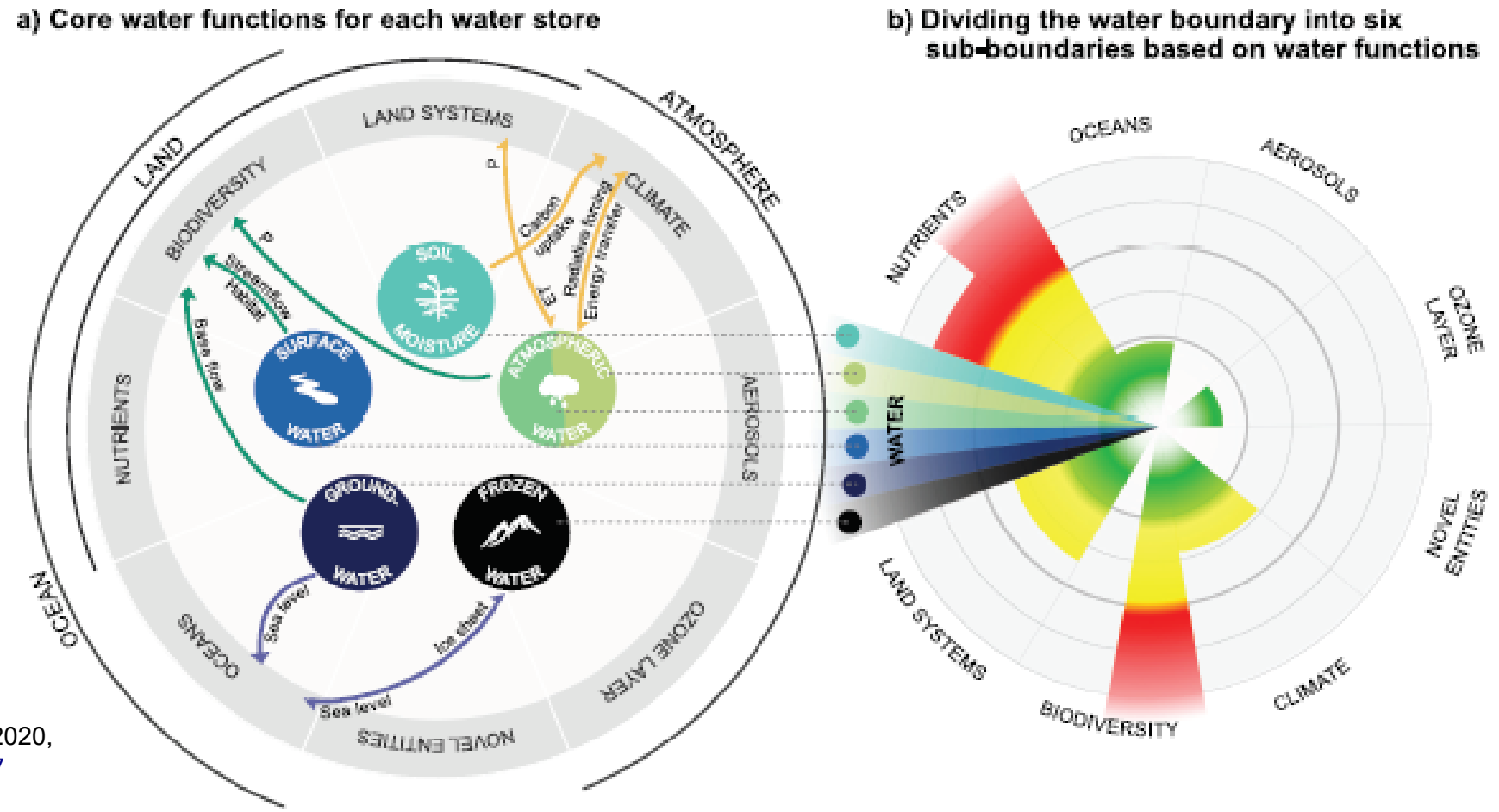




Most water functions are not represented in current freshwater use boundary

Current freshwater use planetary boundary only explicitly considers rivers' environmental flow requirements

Gleeson et al., WRR, 2020, 10.1029/2019WR024957



Gleeson et al., WRR, 2020, 10.1029/2019WR024957

c) Key aspects of each of the proposed water sub-boundaries

	ATMOSPHERIC WATER (hydroclimate)	ATMOSPHERIC WATER (hydroecology)	SOIL MOISTURE (hydroclimate)	SURFACE WATER (hydroecology)	GROUNDWATER (hydroecology)	FROZEN WATER (storage)

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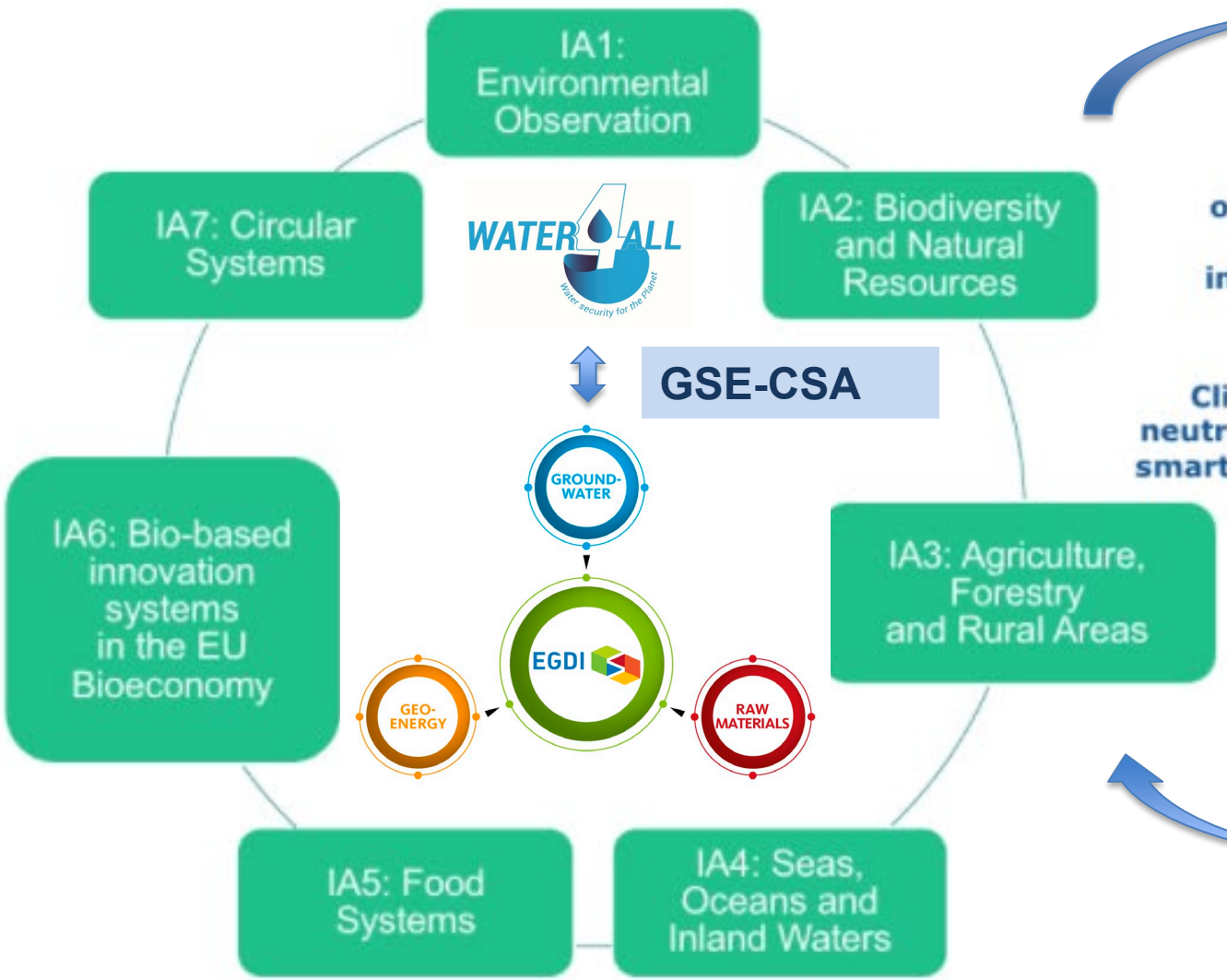
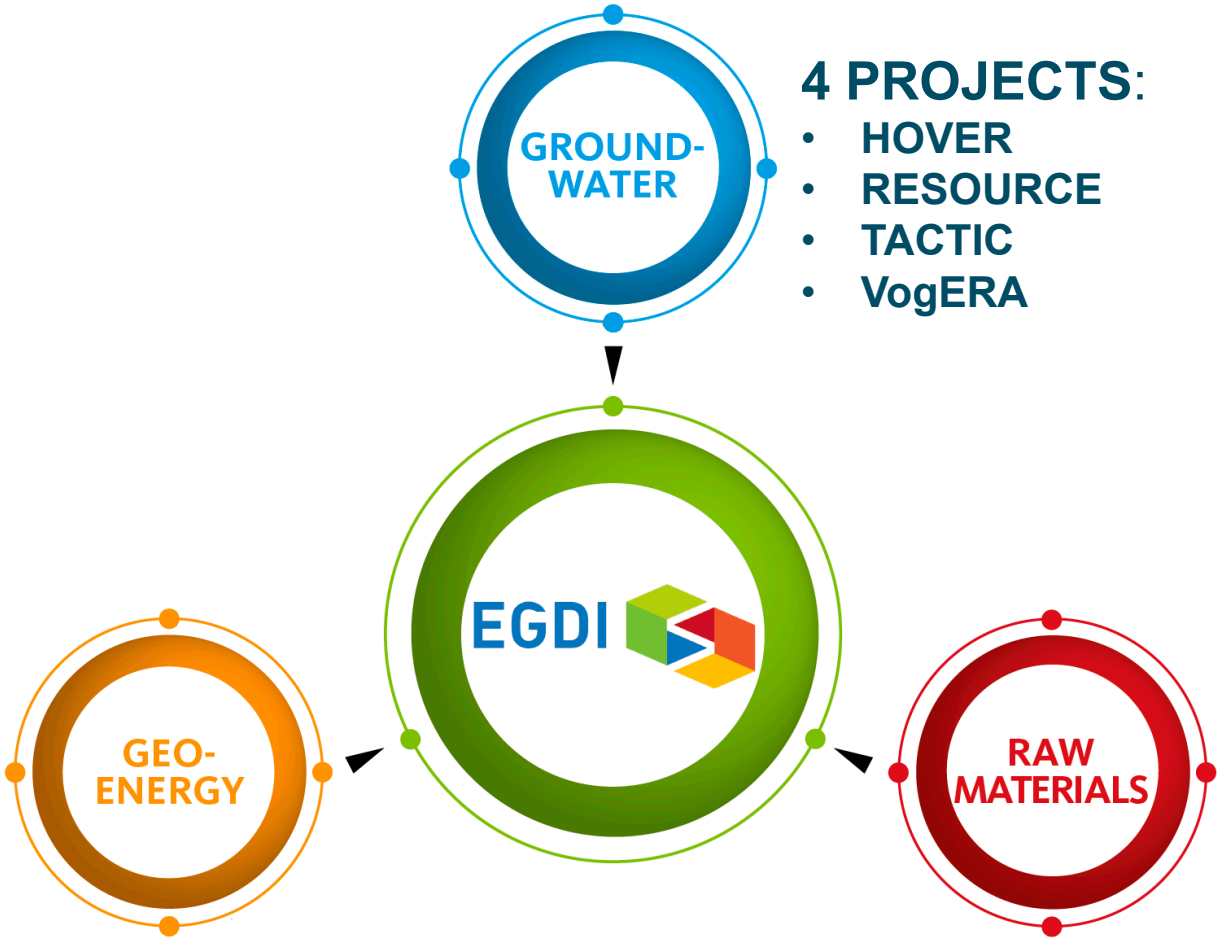
Thematic Cluster 6: Food, bioeconomy, natural resources and environment



European Commission

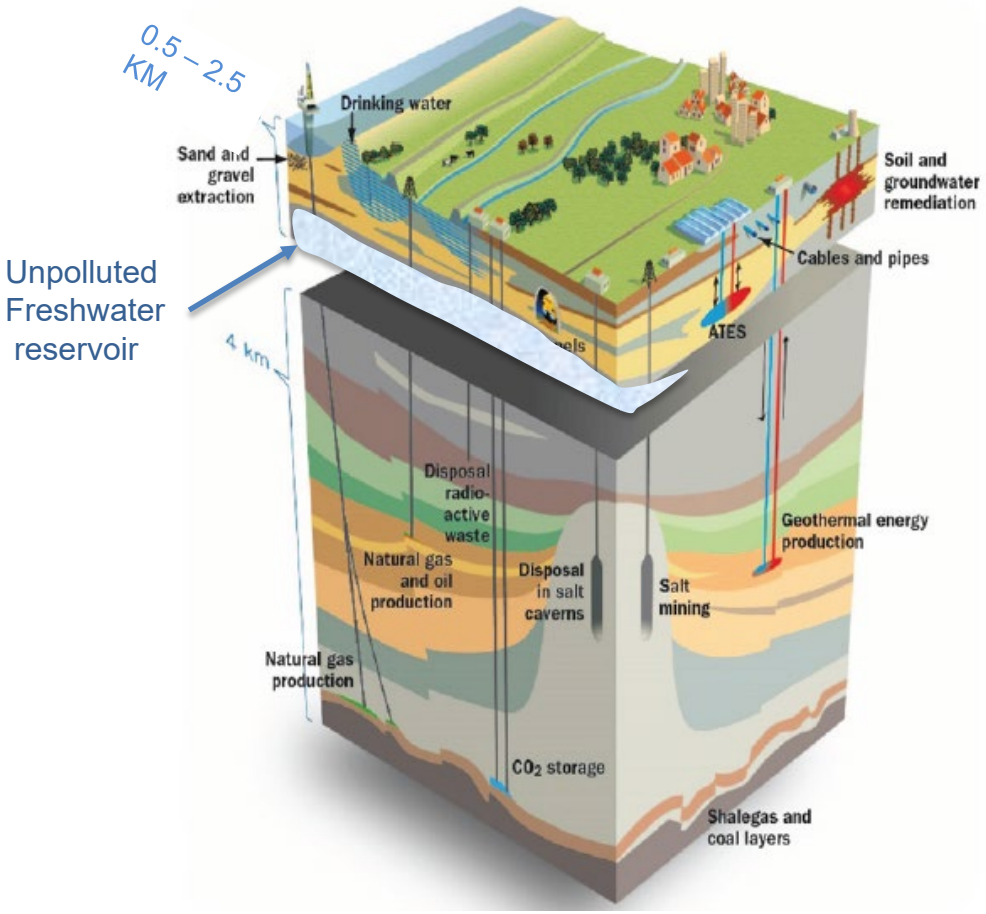
OUR MISSION:

TO CONTRIBUTE TO EU AND UN SUSTAINABILITY GOALS BY DEVELOPING A WORLD LEADING SUBSURFACE INFORMATION PLATFORM (EGDI)



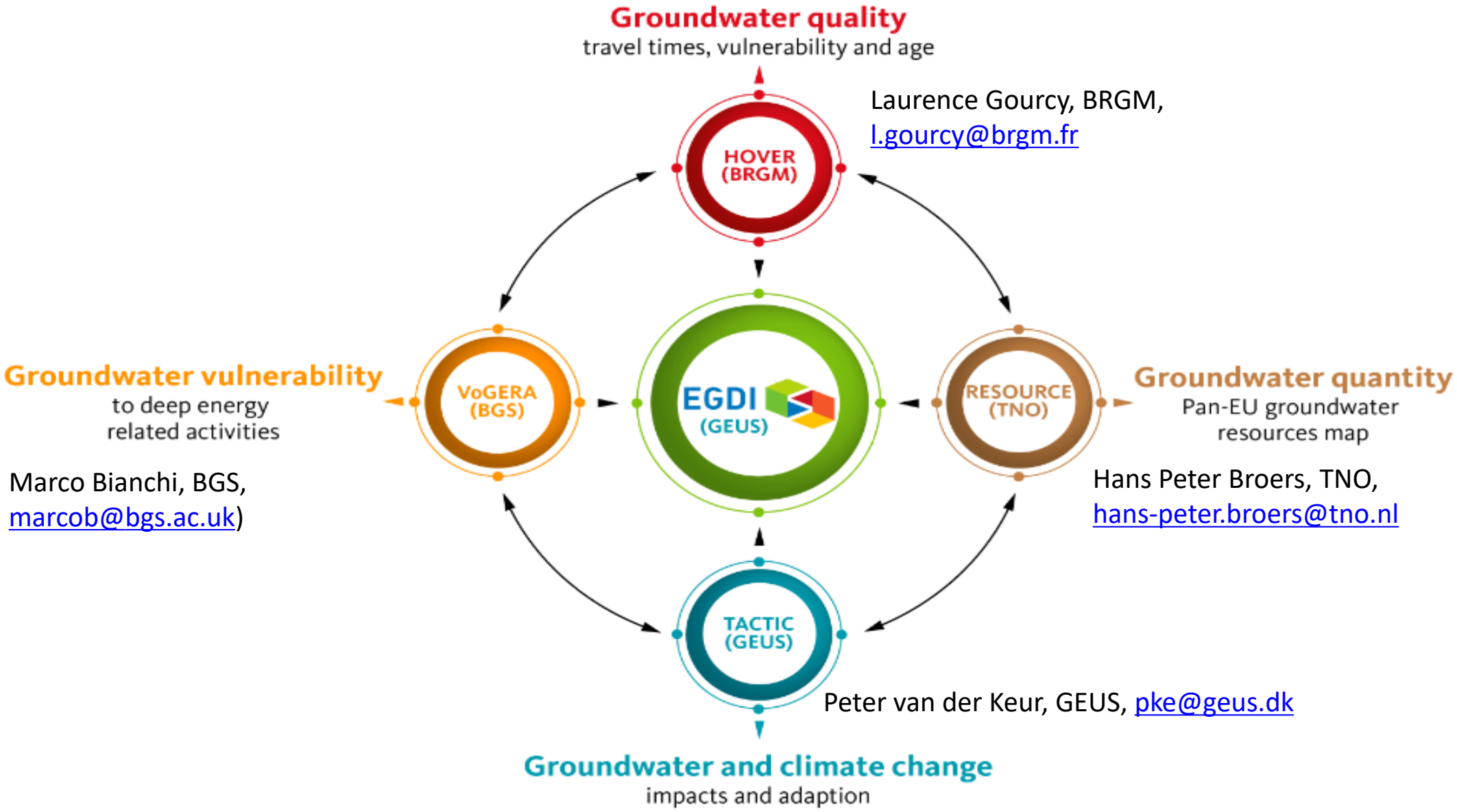
4 PROJECTS:

- **HOVER**
- **RESOURCE**
- **TACTIC**
- **VogERA**



GeoERA GROUNDWATER

The four GeoERA groundwater projects and their main contributions to EGDI:



HOVER: Hydrogeological processes and Geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems

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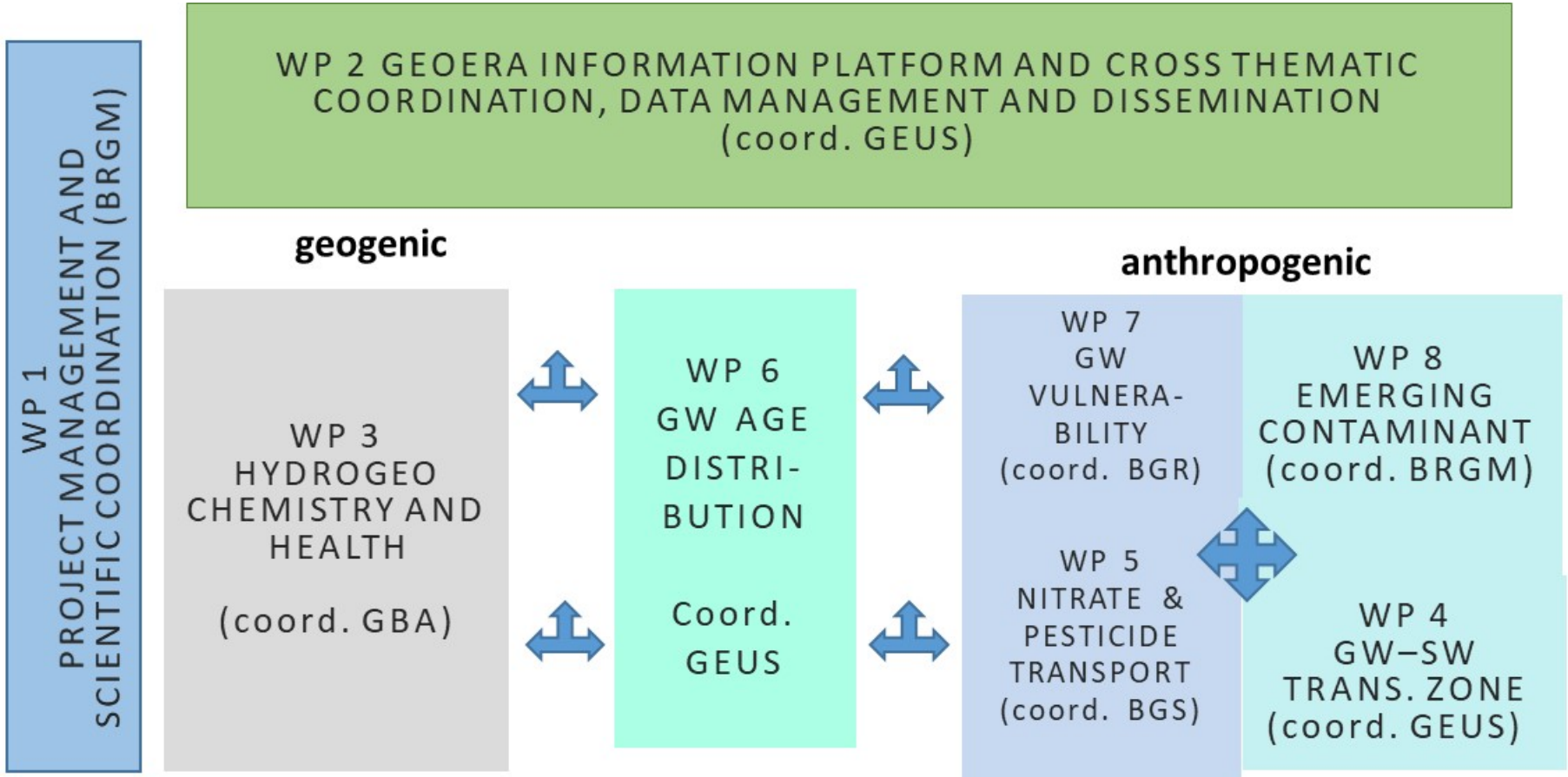
The project

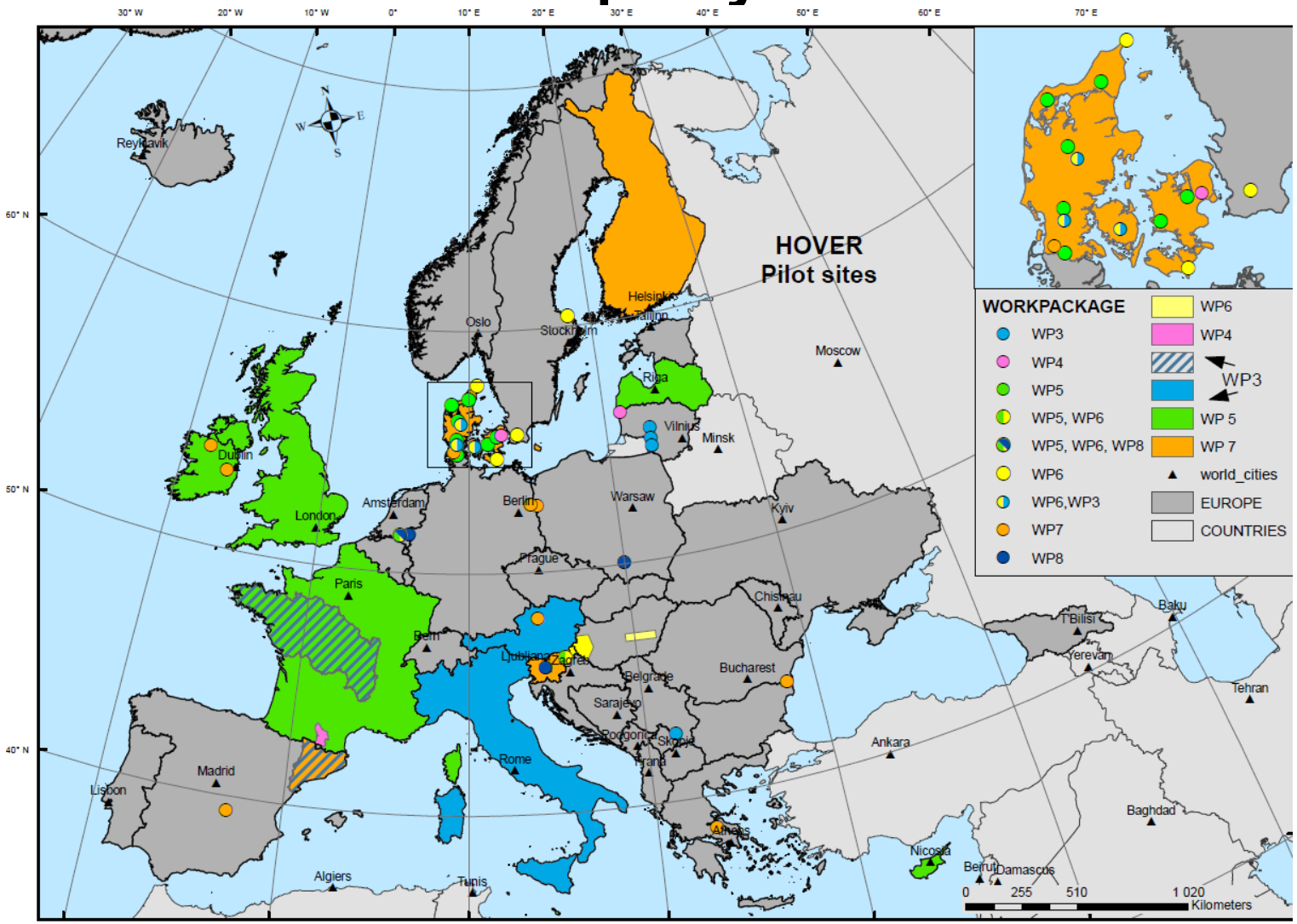

WP 1
PROJECT MANAGEMENT AND
SCIENTIFIC COORDINATION (BRGM)
WP 2 GEOERA INFORMATION PLATFORM AND CROSS THEMATIC
COORDINATION, DATA MANAGEMENT AND DISSEMINATION
(coord. GEUS)
geogenic
anthropogenic
WP 3
HYDROGEO
CHEMISTRY AND
HEALTH
(coord. GBA)
WP 6
GW AGE
DISTRI-
BUTION
Coord.
GEUS
WP 7
GW
VULNERA-
BILITY
(coord. BGR)
WP 8
EMERGING
CONTAMINANT
(coord. BRGM)
WP 5
NITRATE &
PESTICIDE
TRANSPORT
(coord. BGS)
WP 4
GW–SW
TRANS. ZONE
(coord. GEUS)

The project

32 partners

About 46 pilot sites From country to small catchment

(mid-term project – will be updated by end 2020)

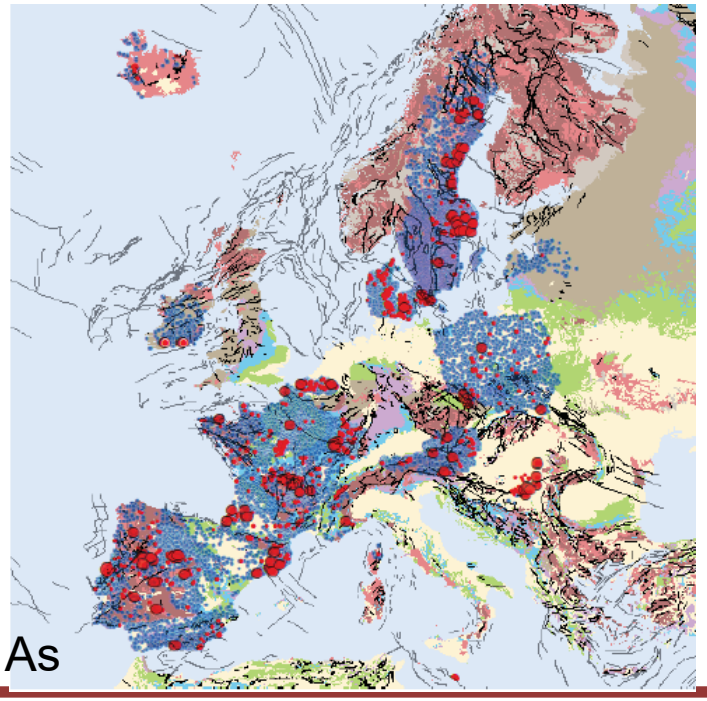


Information from pilot areas will be available to all stakeholders and the public via map viewers etc. on EGDI during 2021

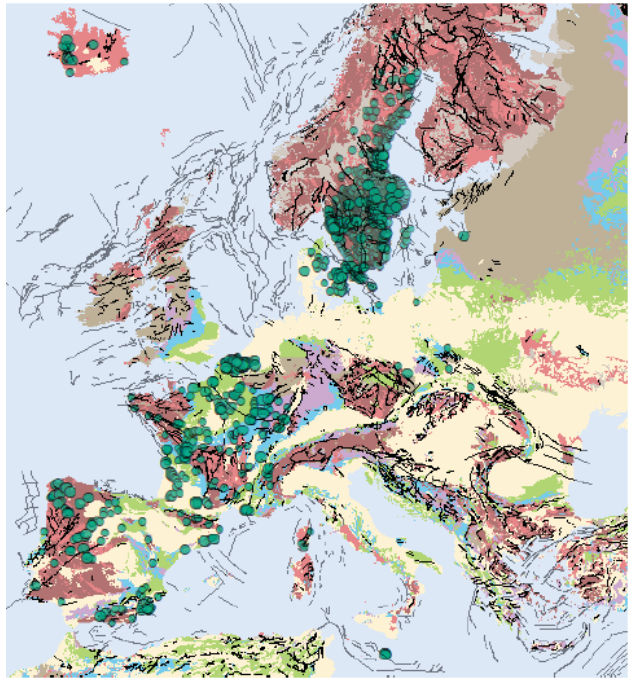
GW vulnerability is driving the project

WP3 - **Water contamination by elements of natural origin**
Origin and concentration of elements are linked to the depth and travel time of groundwater and intensity of water-rocks interactions

European exposure maps of F, As, hydrogeotoxicity indicators (HGT)



HGT As



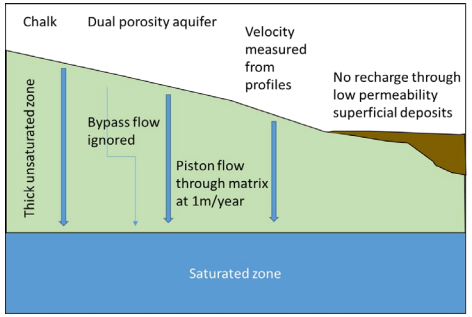
HGT F

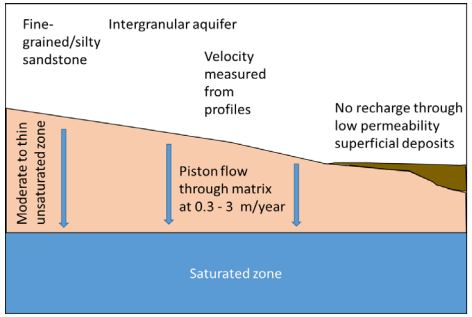
GW vulnerability is driving the project

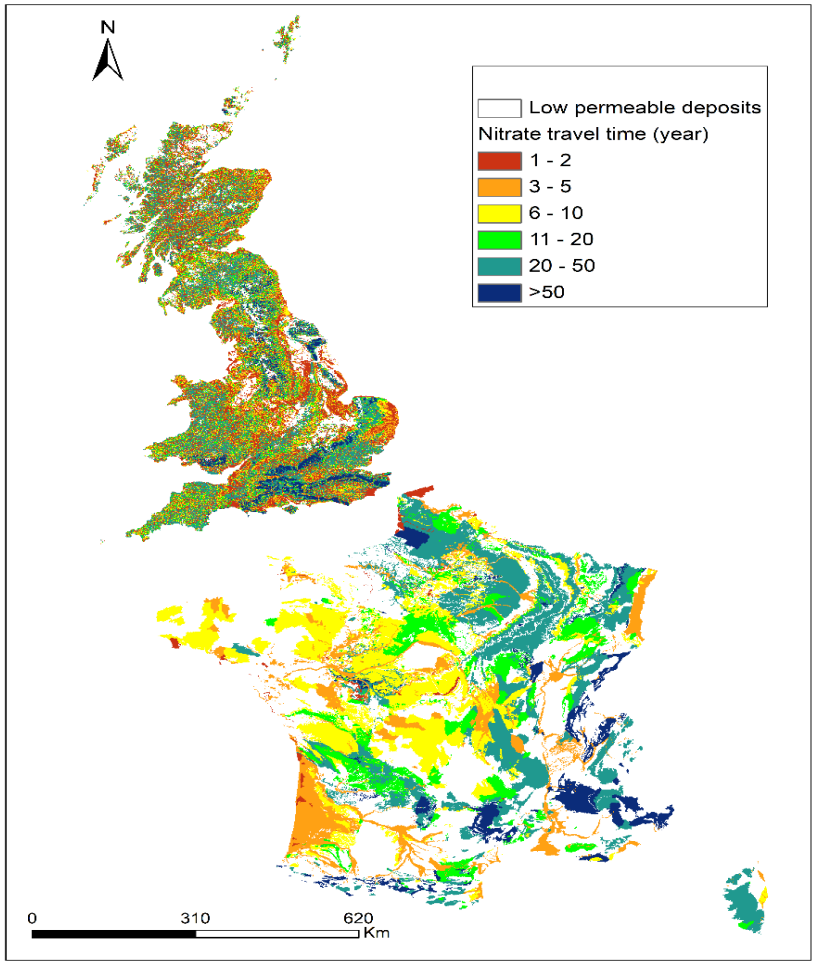
WP5 – **Nitrate and pesticides transport from soil to groundwater**

Presence of pesticides and nitrate in groundwater depend on the pressure but also on the processes that occur from soil to GW such as denitrification – upper GW levels are more vulnerable but deepest part of aquifer can reflect OLD pressures

Travel times for nitrate in the unsaturated zone



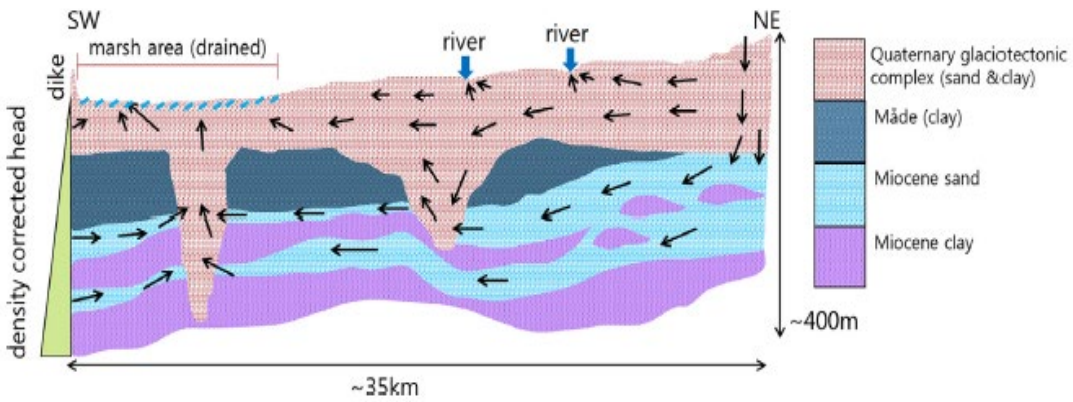


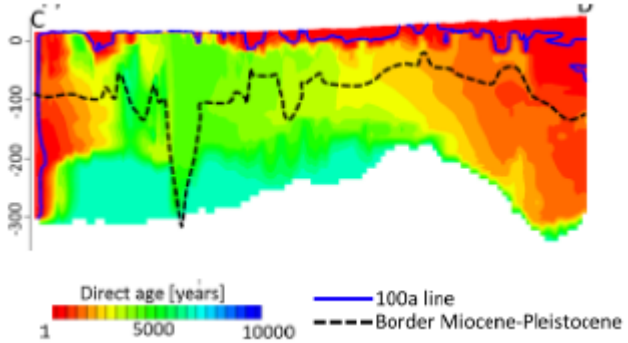


GW vulnerability is driving the project

WP6 - ***Groundwater Age DIStributions and residence times (“GADIS”)***
Linking groundwater “age”, travel time, and e.g. nitrate trend interpretation and vulnerability to pollution

Conceptual models, maps, cross-sections for pilot sites

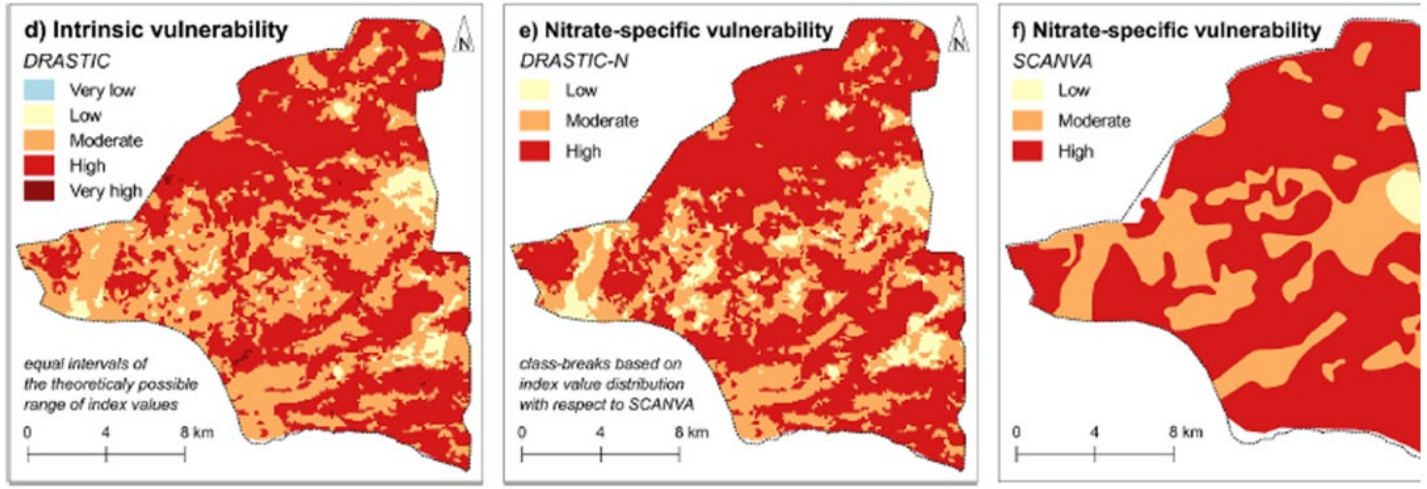




GW vulnerability is driving the project

WP7 - **Vulnerability to pollution mapping of upper aquifers**

Groundwater Vulnerability Map to Pollution (DRASTIC, COP) in pilot areas and pan-EU



Voutchkova et al. (2020)

WP8 - **Effective monitoring of emerging contaminants**

Linking the presence of emerging contaminant to the vulnerability of aquifers, groundwater age and today's pressure -> review of conditions affecting the presence of CEC

Groundwater vulnerability is driving the project

HOVER challenge – From local hydrogeological understanding to pan-EU overview helping GW management

Travel time, groundwater age, vulnerability concepts important for management :

- Protecting the areas of high vulnerability
- Linking pressure and impact taking into account lag times for contaminants travelling from soils to aquifer
- Recommend monitoring of specific contaminants depending on hydrogeological settings
- Understanding spatial distribution of geogenic and anthropogenic contaminants
- Proposing efficient programme of measures

-> links with TACTIC (vulnerability to climate change, recharge) and RESOURCE (groundwater depth/volumes) and VoGERA (vulnerability to pollution)

RESOURCE

Resources of groundwater, harmonized at cross-border and pan-European scale

RESOURCE Work packages

WP 1	Coordination
WP 2	Interaction with the IP project
WP3	Cross-border H3O-PLUS
WP 4	Cross-border TRANSFLUX
WP 5	Karst & Chalk pilots CHAKA
WP6	Pan-European map of groundwater resources

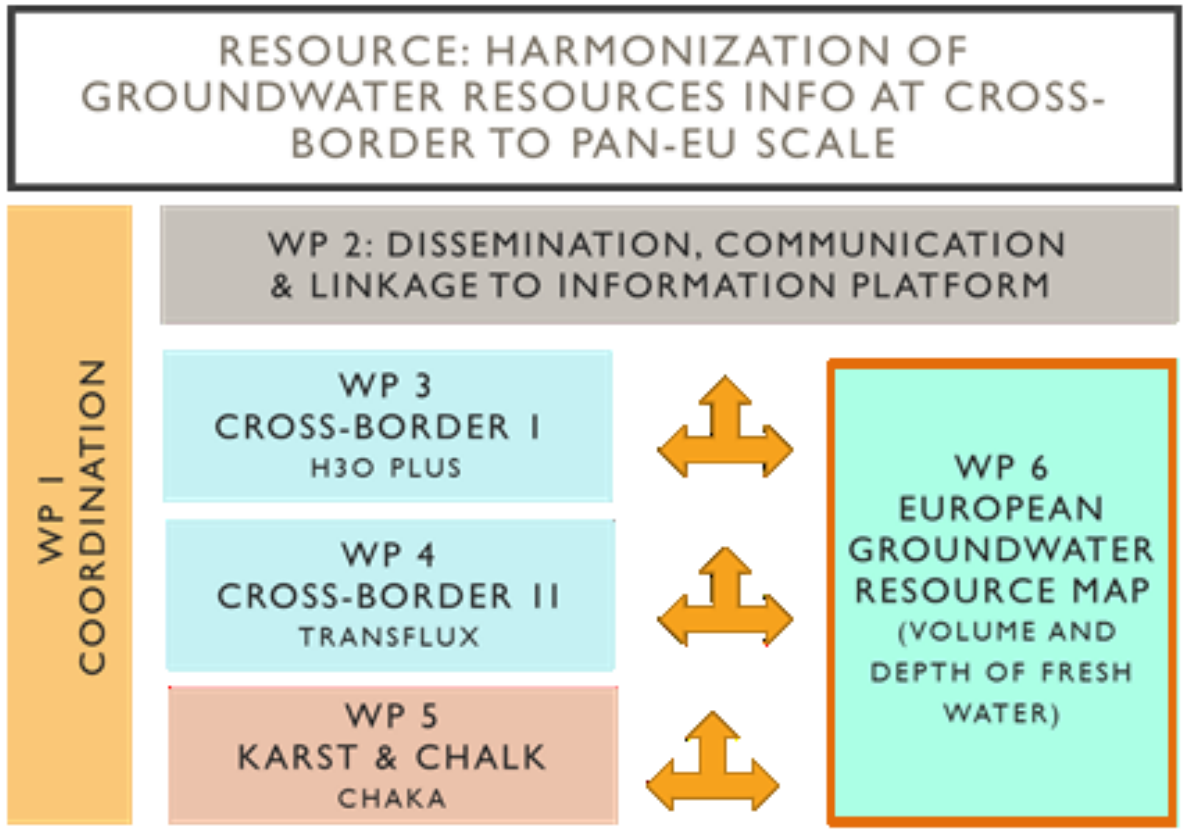
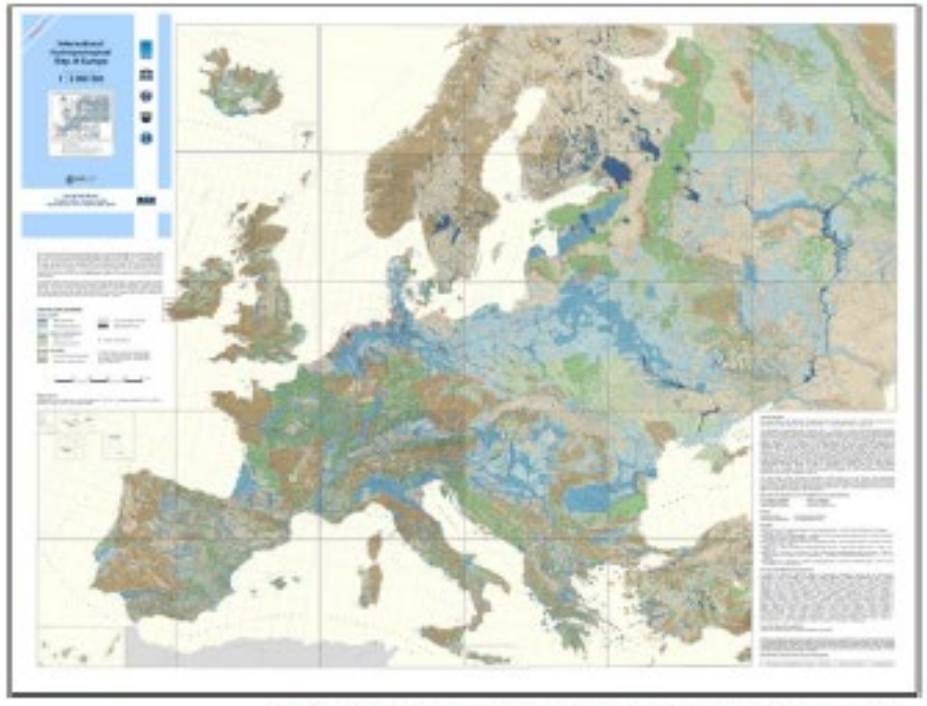


Figure 1 Overall structure of the RESOURCE project

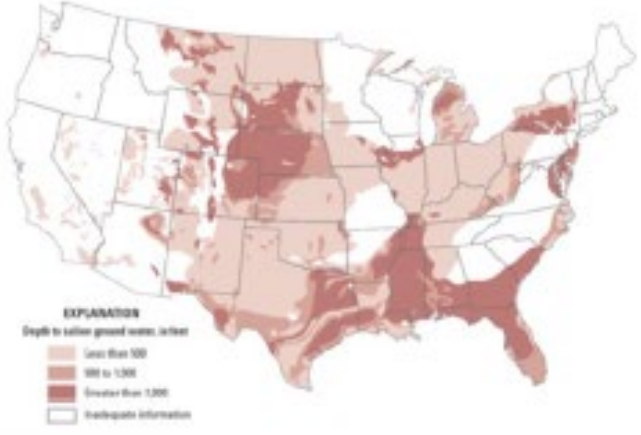
Rationale

- Harmonisation of information about groundwater resources across borders
- Towards 3D groundwater information
- Quantitative figures on volumes and depths



International Hydrogeological Map of Europe

Depth to saline groundwater



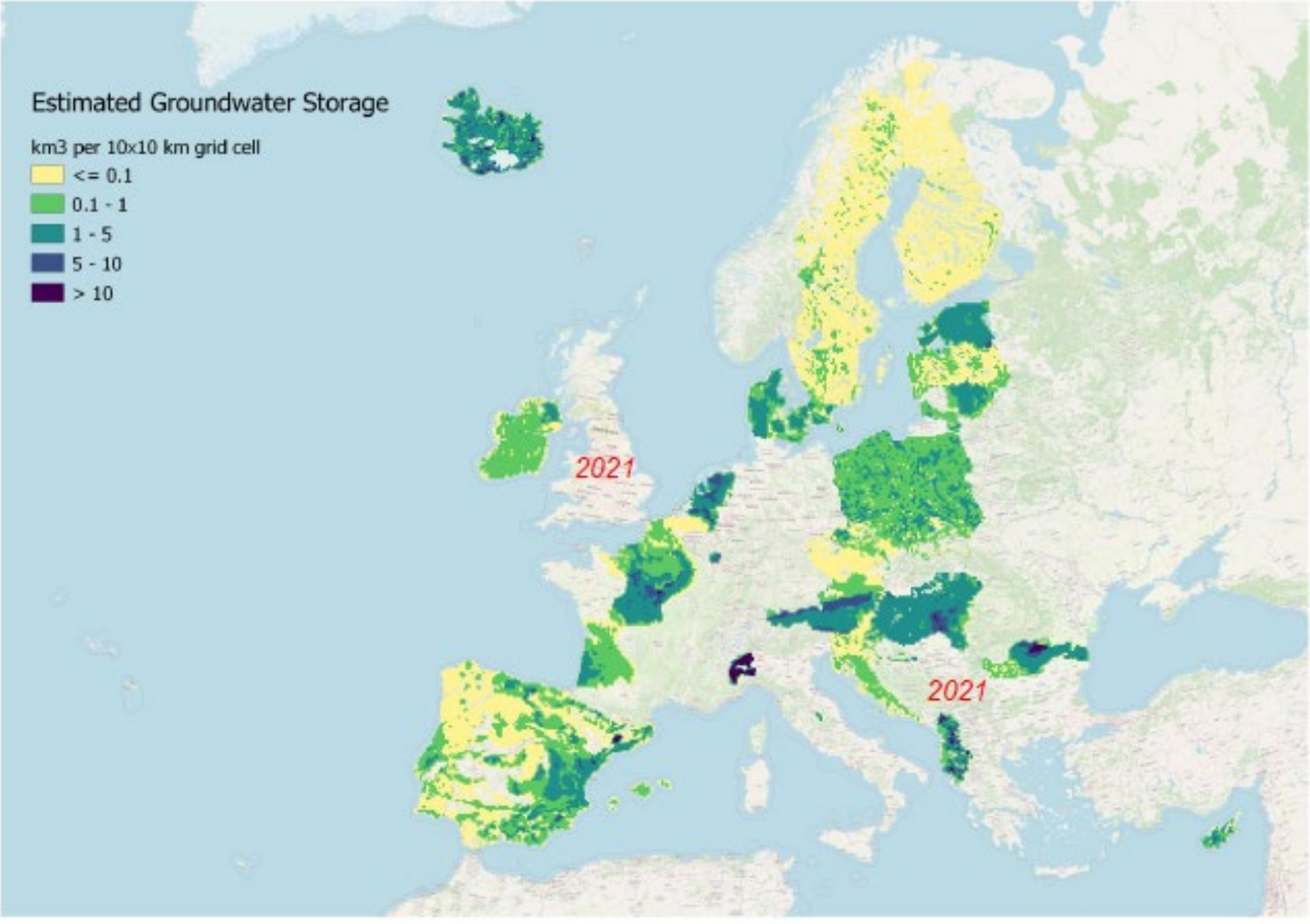
Principal aquifers

WP 6 Pan-EU map of fresh groundwater resources

- Pan-EU map of
  - Depth of the active fresh groundwater systems
  - Depths and thicknesses of aquifers and aquitards
  - Volumes of fresh water stored in aquifers
  - Towards a first estimate of the water balance of principal aquifers in Europe
- Harmonized approach !
  - Based on a 10 x 10 km grid
  - Common language and criteria

Legend

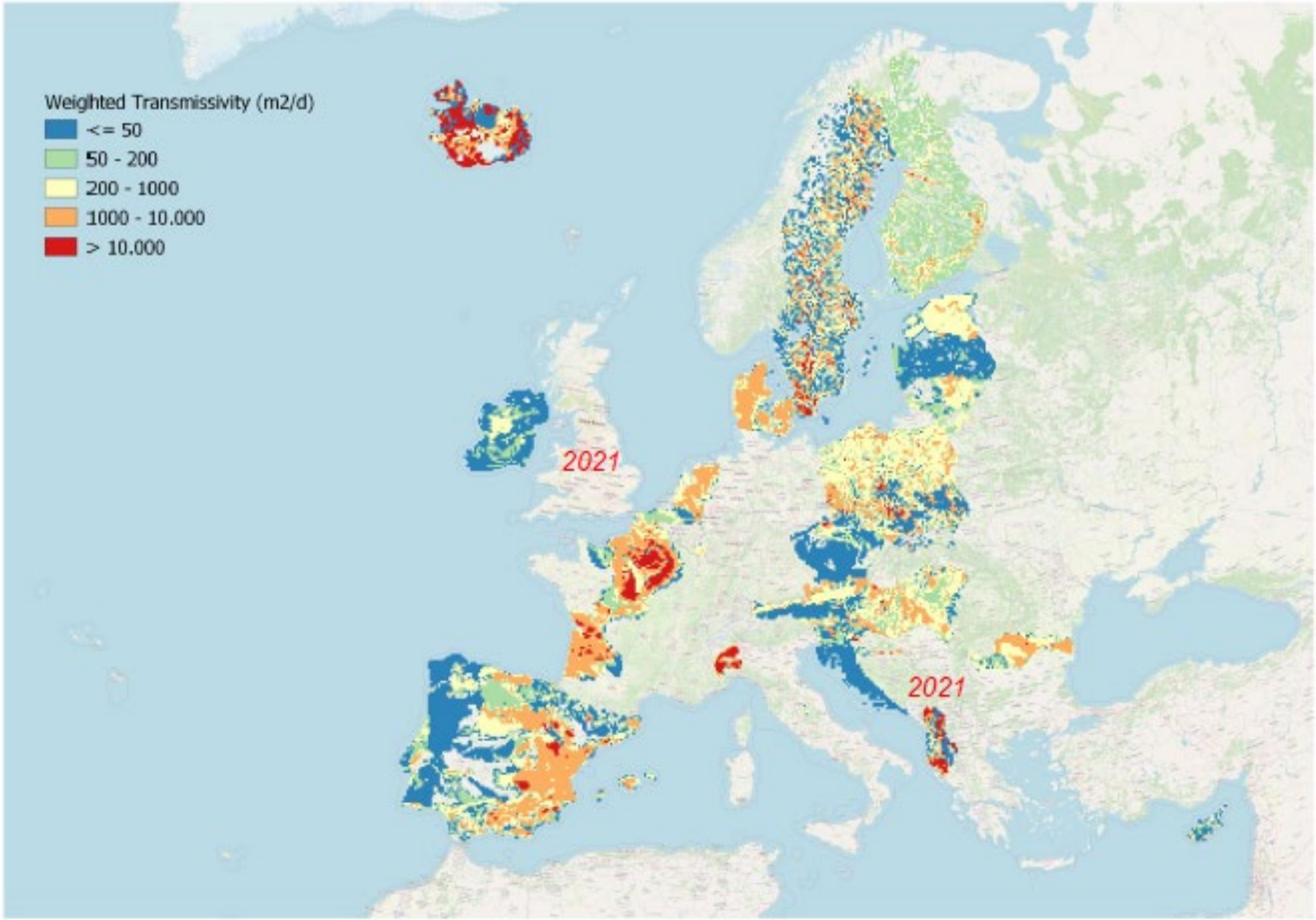
- WP6 Participant
- Regional WP6 Participant
- GeoERA partner but not WP6 participant
- Countries not part of GeoERA



Estimated Groundwater Storage

(km^3)

Serbia en UK expected 2021

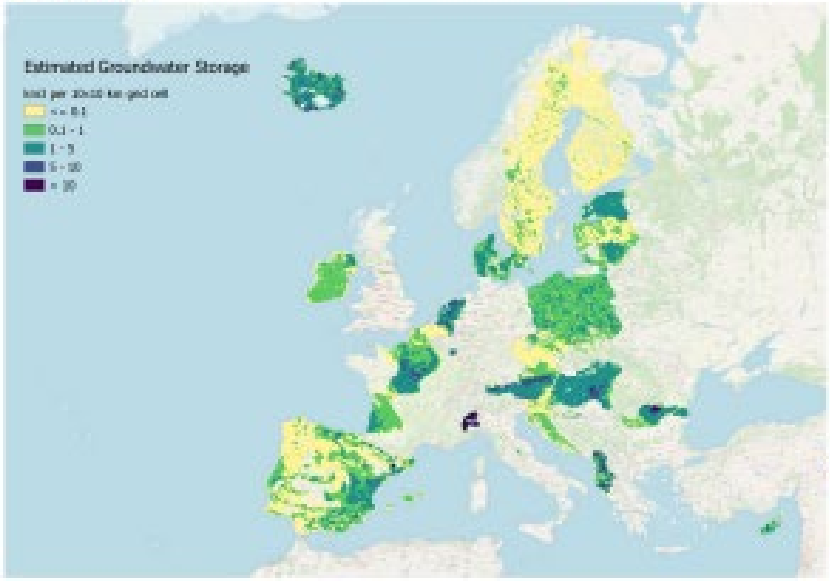


Total Transmissivity $k_h D$

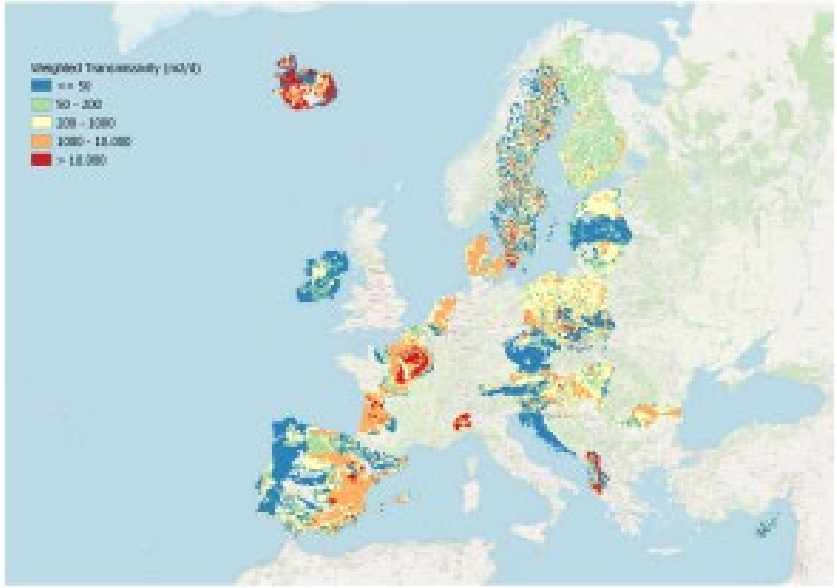
($m^2\,day^{-1}$)

GeoERA RESOURCE GROUNDWATER

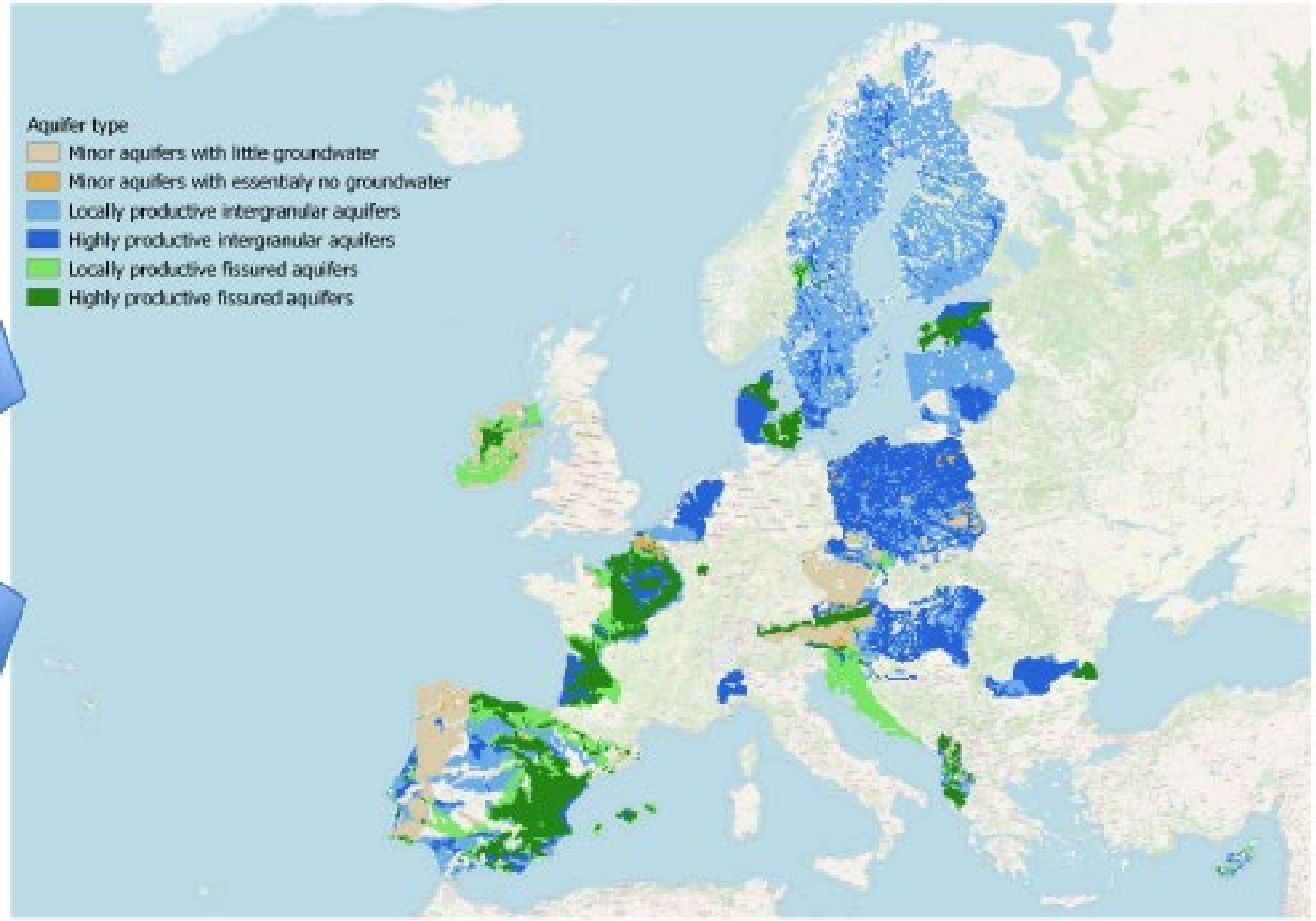
Volumes



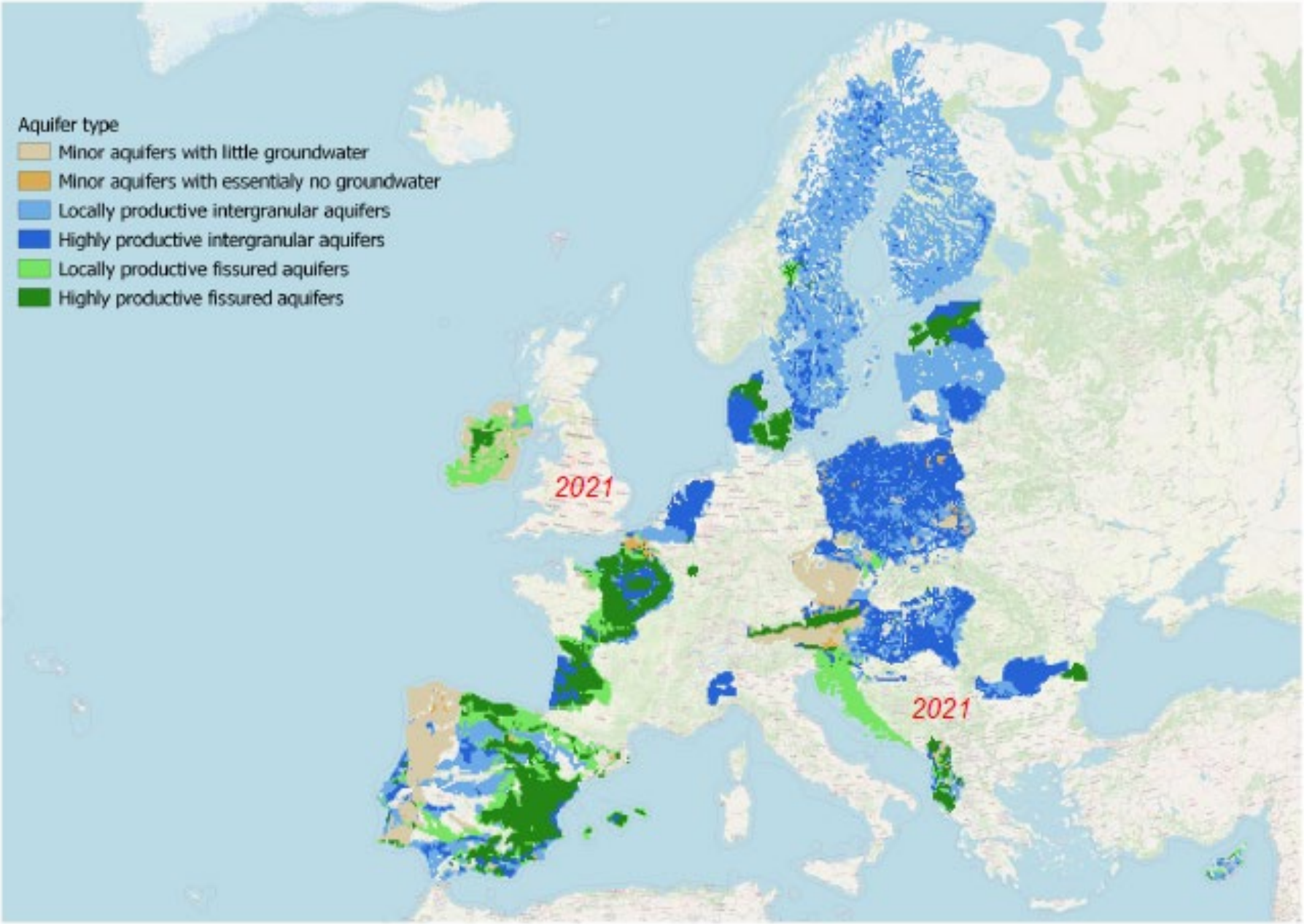
Transmissivities



Productive and minor aquifers



GeoERA RESOURCE GROUNDWATER



Aquifer types and importance

Highly productive aquifers
- Volume > 0.1 km^3 or k_hD > 200

Locally productive aquifers
- Volume < 0.1 km3 or k_hD < 200 m^2·d^{-1}

Minor aquifers with little groundwater
- Clays & marls
- Peat & raised bogs
- Glacial till
- Fissured marlstone, mudstone, shale, slate & flysch
- Fissured igneous and metamorphic rock

Minor aquifers with essentially n groundwater
- Compact igneous an rphic rock
- Anhydrite/gyp
- Mudstone ale , claystone

Criteria under evaluation

GeoERA RESOURCE GROUNDWATER

TACTIC

- Tools for Assessment of ClimaTe change ImpacT on Groundwater and Adaptation Strategies

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Climate change challenges

"…observed climate changes are already having widespread impact on ecosystems, economic sectors and human health and well-being in Europe." - European Environmental Agency

"More extreme weather conditions are anticipated…and the impact is expected to increase in the future ." - JRC

- Impacts of climate change experienced today
- Impacts expected to increase in future
- The cost is immense

➢ Improved knowledge and tools to assess climate change impact are needed to support EU policy

"Cost of climate change in Europe could reach 4 % of GDP if no policy measures are adopted" – Horizon, the EU research and innovation Magazine

"The Greatest Threat To Global Security: Climate Change Is Not Merely An Environmental Problem" – UN Security Council

TACTIC contribution

- Numerous CC studies already
- ➢ But most ignores the groundwater system
  - Impact on groundwater
  - A freshwater buffering system
  - Can enhance or dampening impacts from extreme weather events and vital for assessment of the CC impacts

TACTIC Vision

Improve **use and access** to data and knowledge acquired by the GSOs of the subsurface system in CC impact assessments and adaptation

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TACTIC impacts

Advance

Advance scientifically sound climate change impact assessments
- Local/national assessments
- Support EU policy on member state actions

Experiences varies among GSOs

Harmonise

Harmonise assessments and results – prerequisite for EU policy-making
- Common approaches
- Cross-comparison

Multiple tools and approaches available

Access

Make data and results available for future assessments and applications
- Assessments by GSOs
- Third parties "on-top" services
- New research and innovation

Data, results and knowledge currently difficult to access

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TACTIC objective and approach

TACTIC will develop an ***infra-structure among European Geological Survey Organisations*** for collaboration to advance and harmonise climate change assessments within the GSOs.

TACTIC Toolbox and guidelines

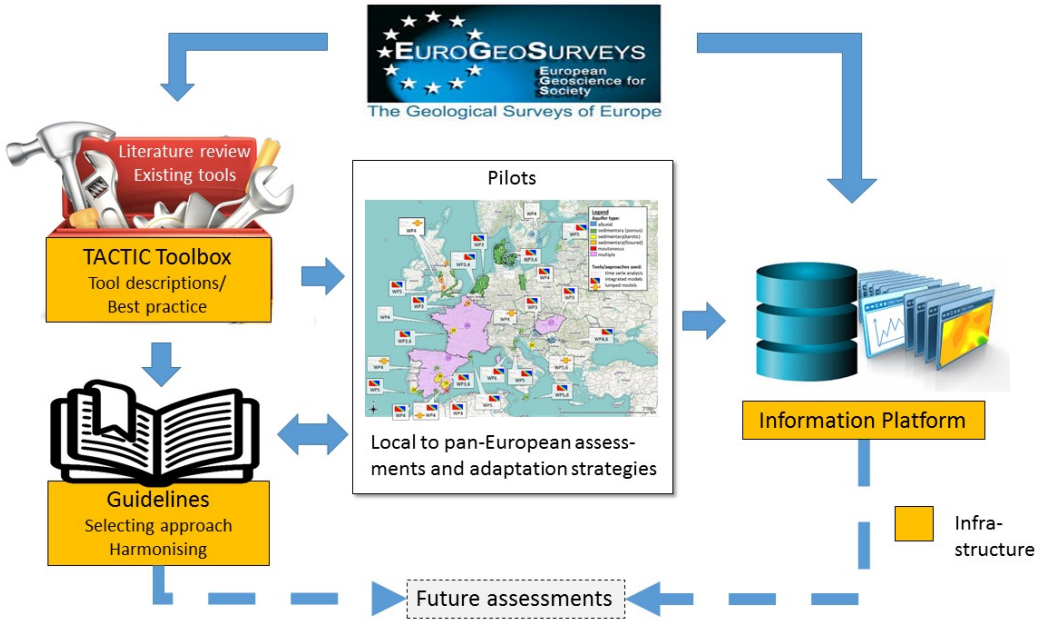
- TACTIC Toolbox
  - Identify usable tools
- Guideline
  - Selecting approach and Harmonising

Pilots

- Demonstrate in pilots (41 pilots)
- Different challenges
- Facilitating knowledge sharing

Interaction with GIP

- Collect and harmonise data
- Provide easy access to data and results in GIP



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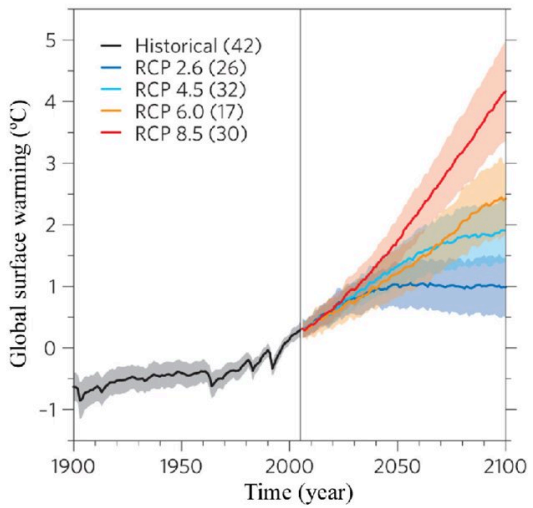
TACTIC outputs – infra structure

- Collect and develop tools and approaches
- Provide specific guidance
- Harmonise assessments
- Develop standardised TACTIC climate change scenarios
- Identify standardised outputs

Enhance and harmonise future assessments, make assessments accessible

Model ensemble
- 15 models (3 RCP x 15 GCM)
- GCM biascorrected



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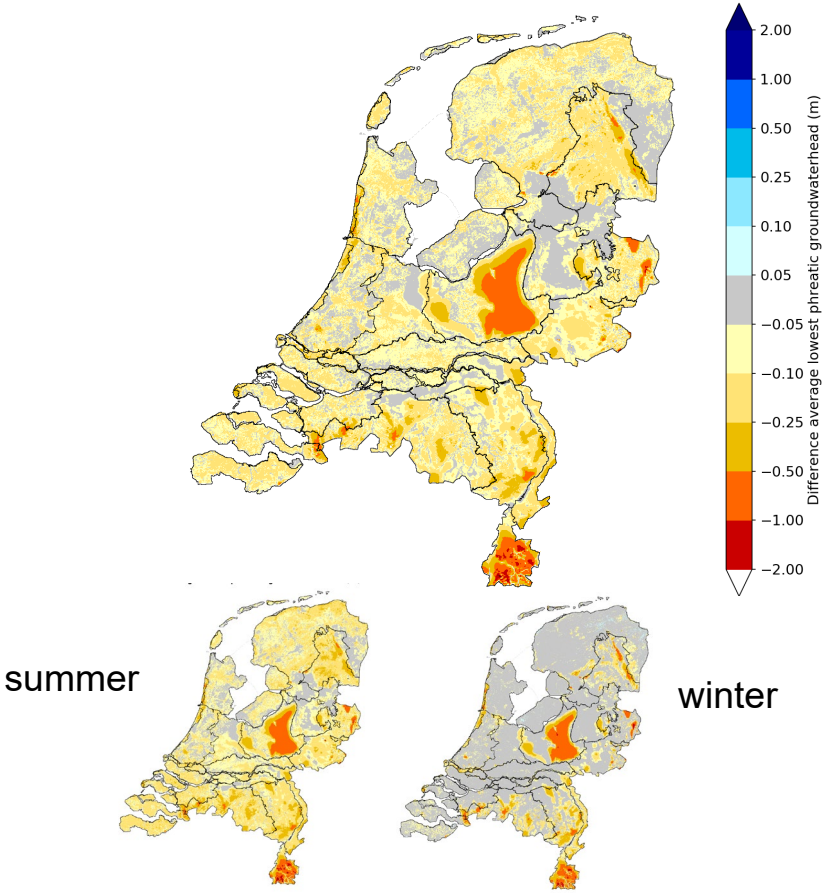
TACTIC outputs - Pilot assessments

- Assess CC impact on
  - Groundwater levels
  - Groundwater recharge
  - GW-SW interaction
  - Flood/drought
- Effect of adaptation strategies
- Pilot reports
- Collaboration with authorities and stakeholders

Pilot specific results utilized by national/ regional authorities and stakeholders

Change in groundwater heads



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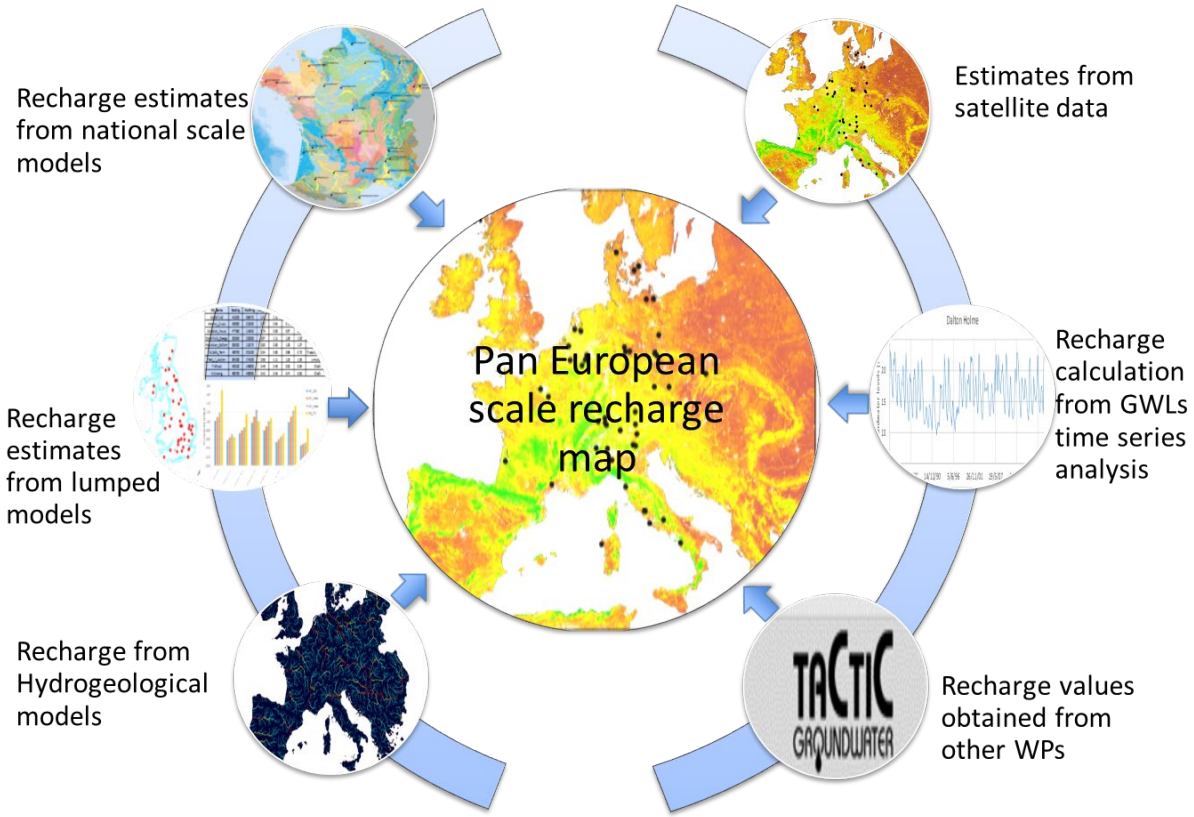
European recharge map and satellite data

Combining pilot assessments and satellite data for recharge estimate at EU-scale



Pan-EU map of groundwater recharge - combining pilot assessments and satellite data

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

The TACTIC team visiting GEUS, Copenhagen

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VoGERA

Vulnerability **O**f shallow **G**roundwater resources to deep sub-surface **E**nergy **R**elated **A**ctivities

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GeoERA GROUNDWATER

Energy related activities in the sub-surface

1. Conventional oil and gas
2. Shale gas
3. Coal bed methane
4. Geothermal (low/high enthalpy)
5. Energy and gas storage

- induce physical and chemical changes in the subsurface
- introduce new chemical substances
- cause the movement of pre-existing fluids (brine, hydrocarbons)

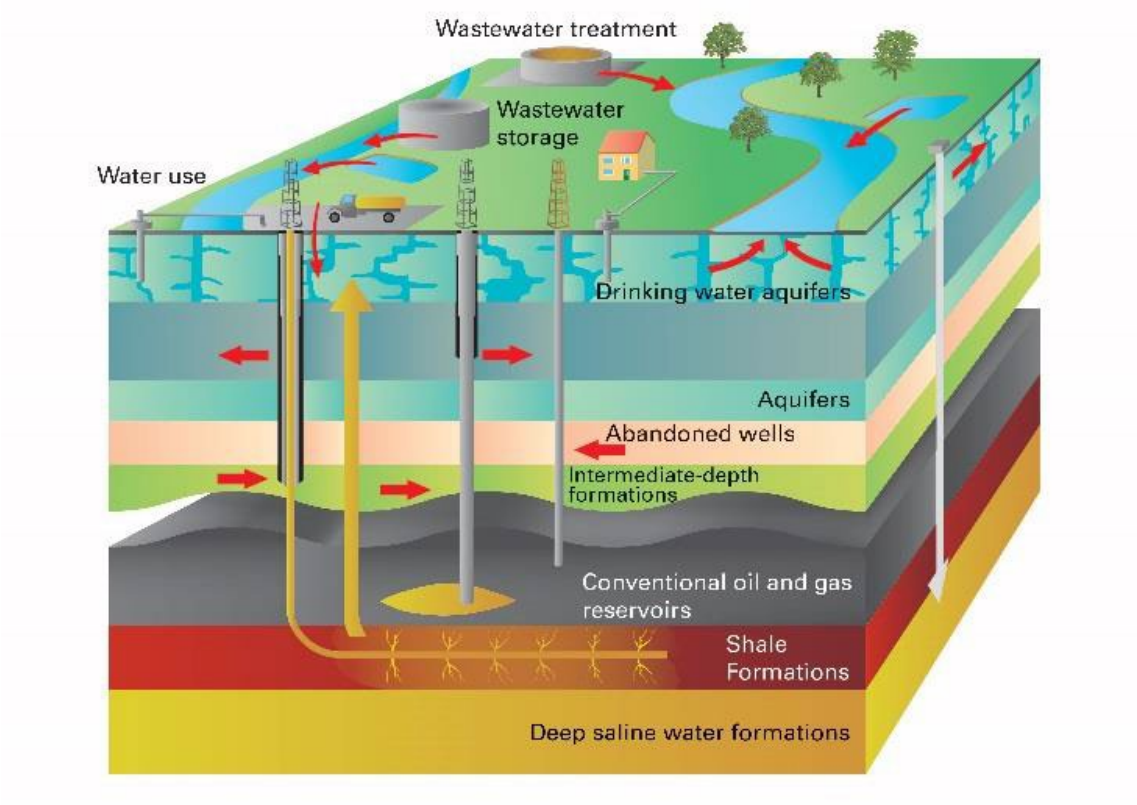
Impact on groundwater quality?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

Objective of the VoGERA project

To improve scientific understanding of the vulnerability of shallow groundwater from deep sub-surface energy-related activities.

- Protect groundwater resources
- Allow informed and responsible use of the deep sub-surface
- Develop a European-wide approach that is consistent across energy activities



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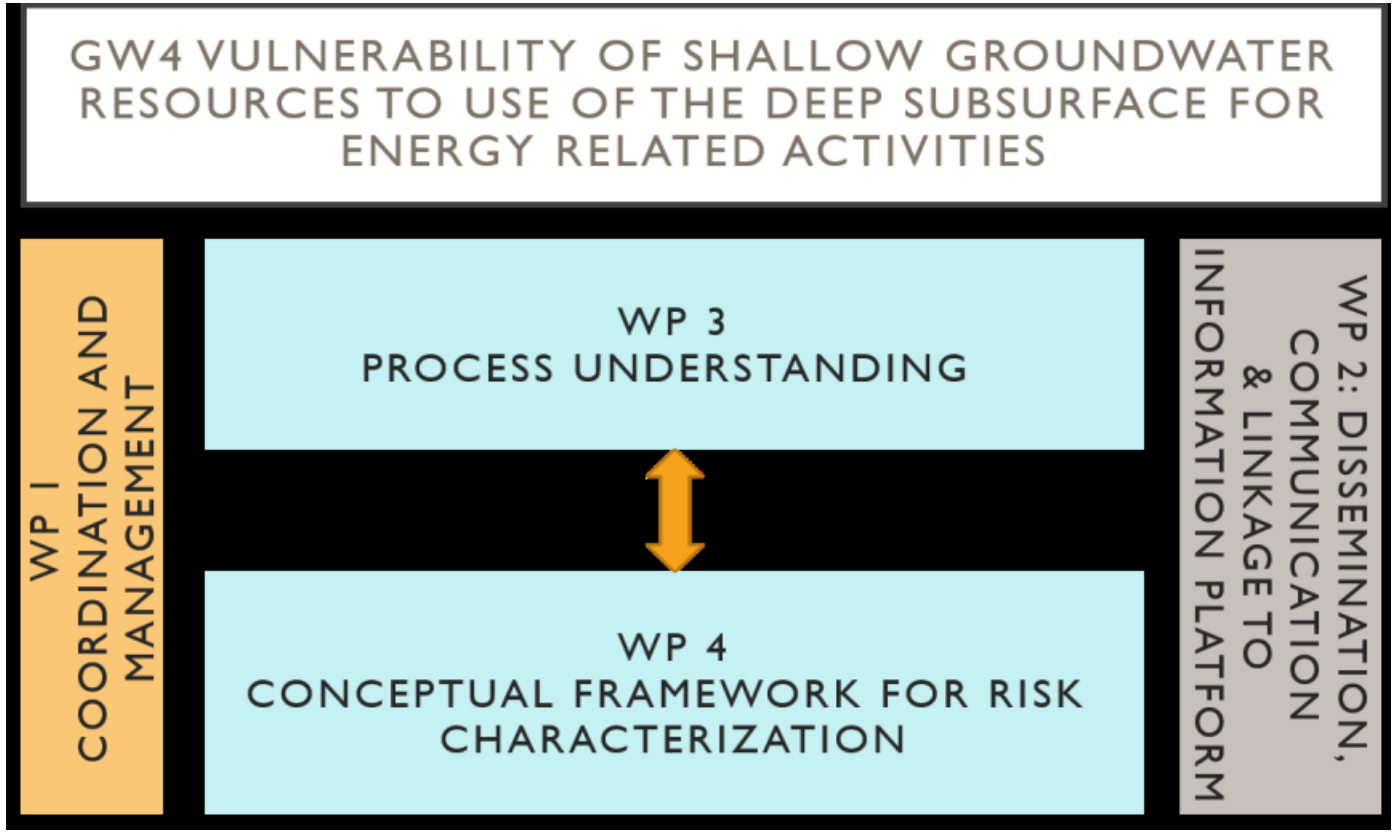
GeoERA GROUNDWATER

Project structure



6 Partners
- BGS
- TNO
- VMM
- SCK CEN
- MBFSZ
- GEUS

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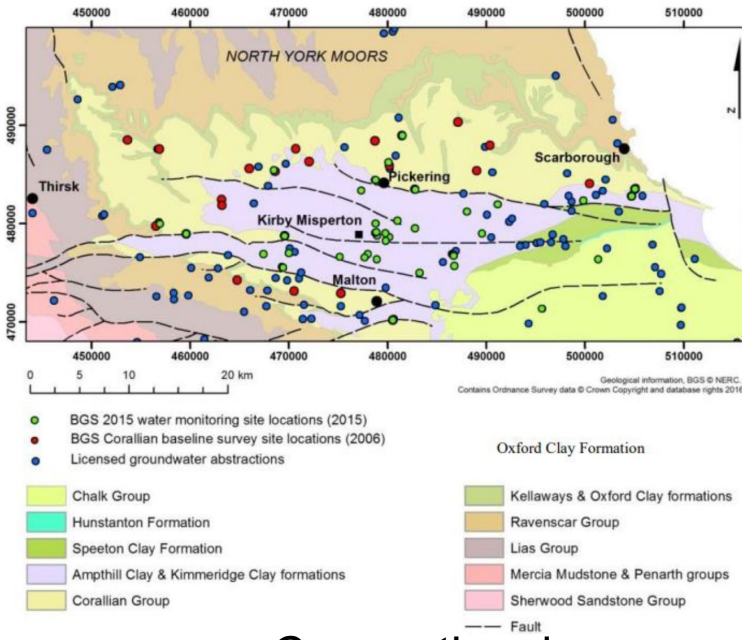
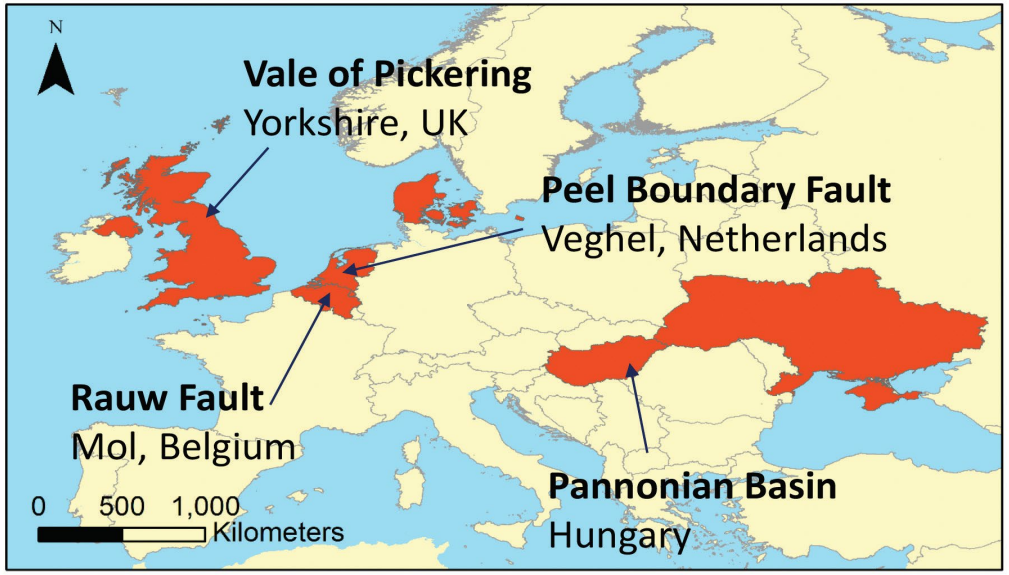
GeoERA GROUNDWATER

WP 3 – Process understanding

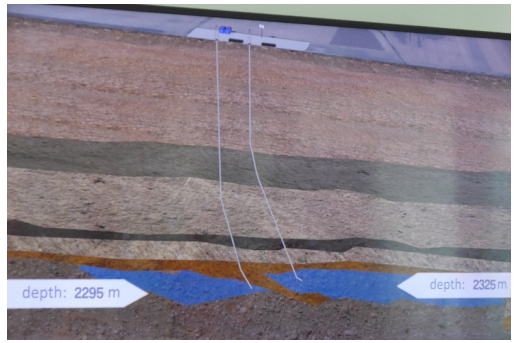
Used evidence to assess possible pathways between deep systems and shallow groundwater (e.g. fault zones, abandoned wells) at pilot locations

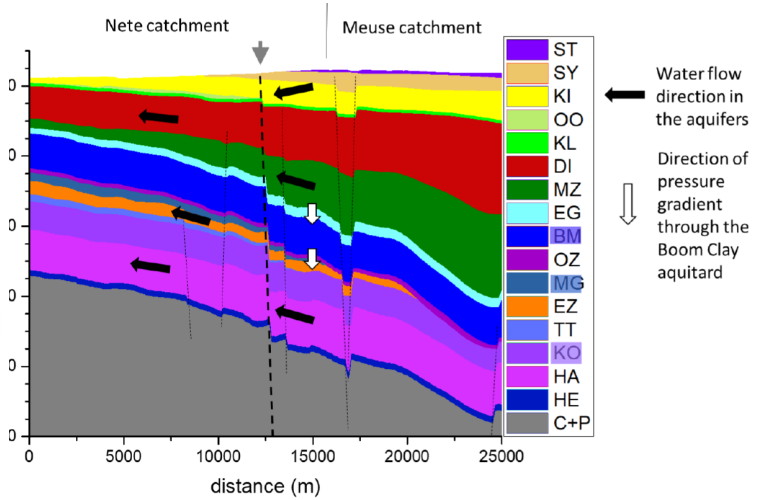


Conventional + unconventional O&G



Geothermal





Storage + Geothermal

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

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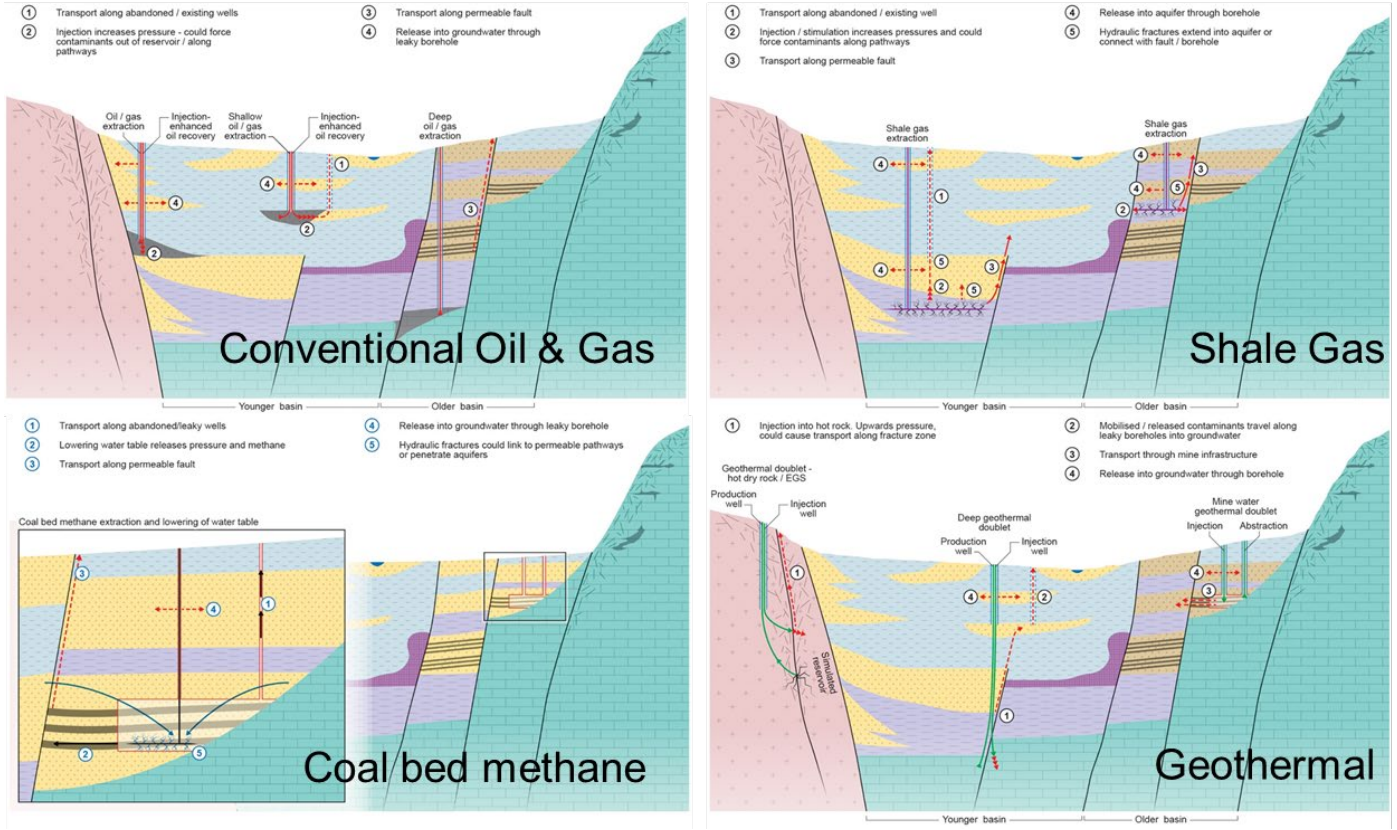
WP 4 – Conceptual framework for vulnerability characterisation



Developed a set of conceptual models for potential contaminant pathways between industrial activity in the deep sub-surface and shallow groundwater resources.

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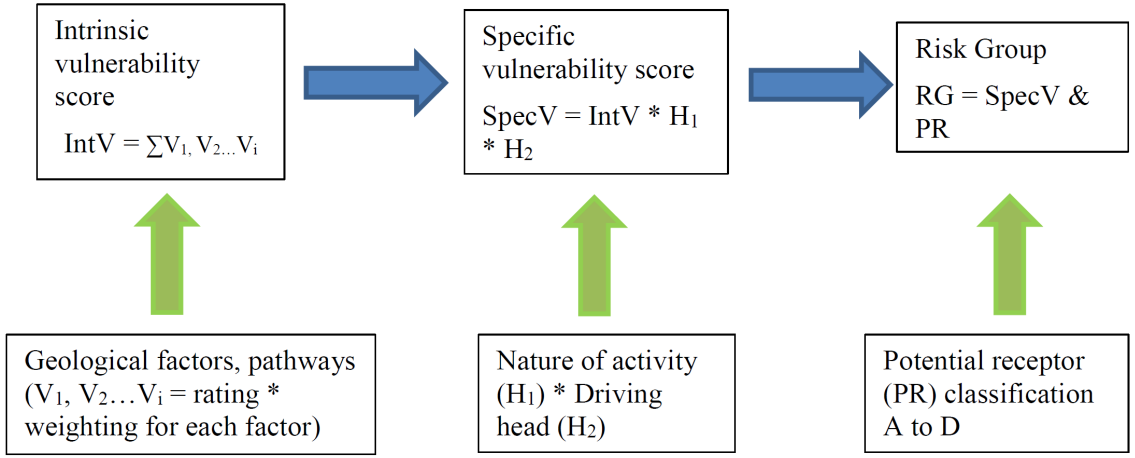
WP 4 – Conceptual framework for vulnerability characterisation

Developed a consistent screening methodology for characterizing the vulnerability of shallow groundwater from deep industrial activities

Testing ongoing at pilot sites



	Specific vulnerability score			
Potential receptor classification	< 250	250-500	500-750	>750
A	Medium/Low	Medium/High	High	High
B	Low	Medium/Low	Medium/High	High
C	Low	Low	Medium/Low	Medium/high
D	Low	Low	Low	Low

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Anticipated outcomes

- Improved understanding of groundwater vulnerability related to a range of energy related deep sub-surface activities in Europe
- Consistent approach for assessing groundwater vulnerability across Europe
- Improved sub-surface spatial planning and decision making to protect (shallow) groundwater

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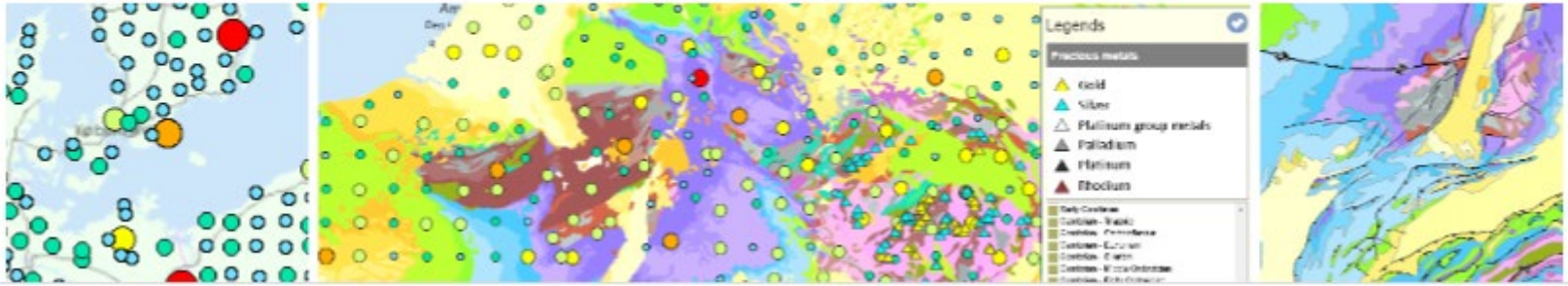
Sustainable development and use of the subsurface requires an *easy and FAIR* access to subsurface information and data –*

*FAIR = Findable, Accessible, Interoperable and Reusable
https://www.go-fair.org/fair-principles/
Wilkinson et al., 2016. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018.

EGDI

Please check out GeoERA contributions to FAIR data at the GeoERA website: https://geoera.eu/ and EGDI: http://www.europe-geology.eu/

Onshore Geology | Marine Geology | Mineral Resources | Geohazards | Energy | Soil | Groundwater | All Content | Metadata



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