

ENIGMA ITN Meeting n°5

07/02/2019, Barcelona

Coordinator's report:

Scientific & Networking 20'



I. Why ENIGMA ITN ?

II. The research objectives of the network

III. Scientific highlights of the work so far and advancement on the state-of-the-art

IV. Interactions within the network



I. Why ENIGMA ITN ?

The scientific, technological or socio-economic reasons for carrying out research in the field covered by the research





Motivations for the 2013 Jülich meeting

- **High quality field observations** are needed for testing concepts and understanding processes
- Hydrogeological field sites are **often developed independently** in each country with large investments that should be valorized by opening the infrastructures and sharing data
- They often **lack visibility** compared to historical sites (e.g. Cape Cod, MADE, Mirror lake...)
- General **lack of structuration** of the hydrological community for field infrastructures in Europe compared to other communities

17 TH MEETING - JÜLICH, 3-5 JUNE 2013

Participants

- **Geosciences Rennes (France)**: Philippe Davy, Tanguy Le Borgne, Olivier Bour, Rebecca Hochreutener, Annick Battais, Nicolas Guiheneuf, Joaquin Jimenez, Maria Klepikova, Laurent Longuevergne
- **Geosciences Montpellier (France)**: Cédric Champollion, Juliette Fabre
- **Hydras Poitiers (France)**: Jacques Bodin, Gilles Porel, Benoit Nauleau, Pascale Greco, Mathieu Le Coz
- **EMMAH Avignon/LSBB (France)**: Charles Danquigny, Naomi Mazzili
- **BRGM (France/India)**: Alexandre Boisson
- **Jülich research center (Germany)**: Jan Vanderborght, Harry Vereecken, Jan Van der Kruk, Sander Huisman
- **Bochum university (Germany)**: Andreas Englert
- **Tübingen university (Germany)**: Olaf Cirpka, Carsten Leven
- **Liège university (Belgium)**: Alain Dassargues, Frédérique Nguyen
- **Mons university (Belgium)**: Pascal Goderniaux
- **Copenhagen University (Denmark)**: Karsten Høgh Jensen
- **Bioforsk (Norway)**: Helen French
- **Neuchâtel university (Switzerland)**: Philip Brunner
- **UFZ (Germany)**: Steffen Zacharias

Oral presentations

- Forewords **Tanguy Le Borgne, Jan Vanderborght**
- **The TERENO network** Harry Vereecken
- **The H+ network of hydrogeological observatories** Philippe Davy
- **Perspectives in hydrogeological observation and experimentation** Olaf Cirpka
- **The importance of groundwater for near surface flux and state simulation** Karsten Høgh Jensen
- **Challenges and novel methods for fractured rock characterization and monitoring** Olivier Bour
- **Perspectives in groundwater contamination monitoring** Helen French
- **Interest of geodesic methods for hydrogeological investigation** Cédric Champollion
- **Integration of hydrogeological and geophysical measurements on different experimental sites** Alain Dassargues
- **New instruments for investigating the critical zone: the critex project** Laurent Longuevergne
- **Hydrological monitoring and research in TERENO** Steffen Zacharias
- Discussions on opportunities for a European network of hydrogeological observatories

Poster session

- **Krauthausen site** – Jan Vanderborght
- **Ploemeur site** – Olivier Bour
- **Lauswiesen site** – Carsten Leven / Olaf Cirpka
- **Hobbe center for hydrology** – Karsten Høgh Jensen
- **Mallorca site** – Cédric Champollion
- **Gardemoen site** – Helen French
- **Low Noise Underground Laboratory** – Charles Danquigny
- **Hermalle-sous-argenteau site** – Alain Dassargues
- **Choutupal/Hyderabad site** – Alexandre Boisson
- **Larzac site** – Cédric Champollion
- **Neuchâtel site** – Philip Brunner
- **Llobregat site** – Joaquin Jimenez
- **Characterization of a preferential flow path within a gravel aquifer using crosshole GPR Full-waveform inversion** – Anja Klotsche and Jan van der Kruk
- **Relationship between spectral induced polarization and hydraulic conductivity at the Krauthausen test site** – Andrea Treichel and Sander Huisman
- **Thermal methods for imaging fractured rocks** – Maria Klepikova
- **Fracture flow measurements at the Ploemeur site** – Andreas Englert
- **Vadose zone monitoring in fractured aquifers. Weathered granite at Ploemeur experimental site** – Joaquin Jimenez
- **A detailed conceptual model of crystalline aquifers in Southern India: focus on fracture connectivity and water levels dependency** – Nicolas Guiheneuf
- **Characterization of a heterogeneous aquifer through the integration of geological, geophysical and hydrogeological data (the Poitiers hydrogeological experimental site, France)** – Pascale Greco
- **3D numerical modeling of groundwater flow in fractured and karst aquifers from 3D seismic data. Development and calibration of the methodology in the Poitiers hydrogeological experimental site** – Pascale Greco

Field trip (Wednesday 5th June) :

Photos of the field trip: [Field trip - Jülich, 3-5 June 2013](#)



France: H+ network

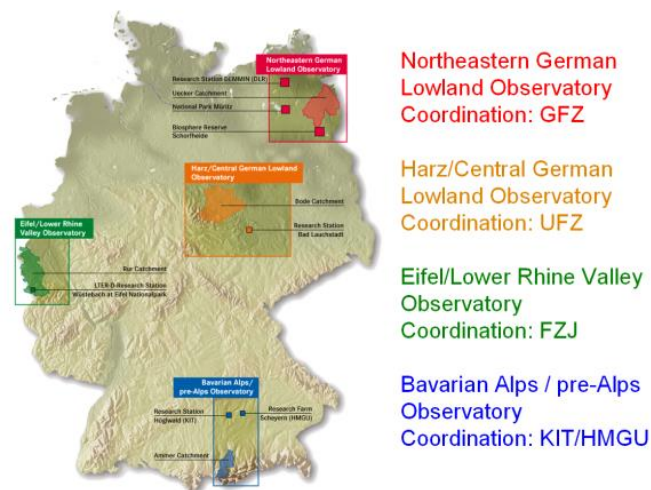


Spain: Argentona site



Germany: TERENO network

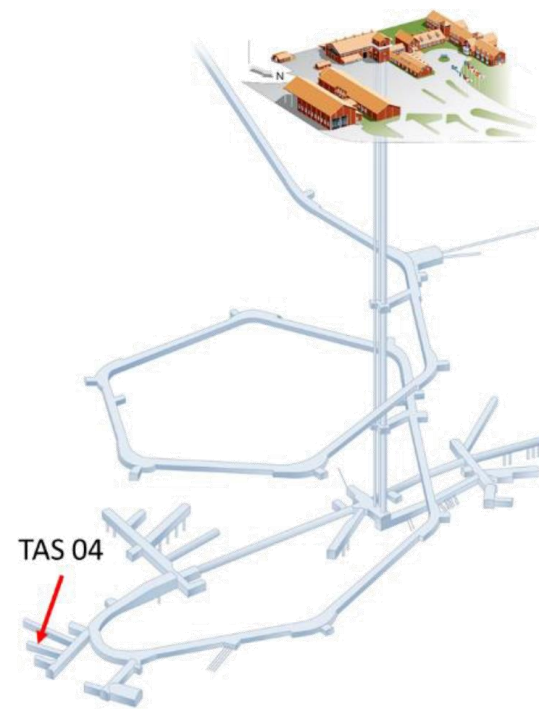
TERENO Terrestrial Environmental Observatories



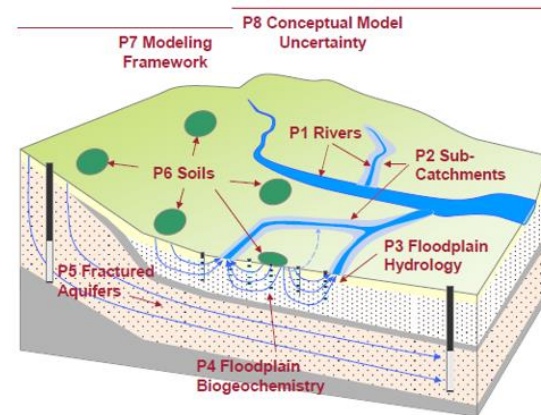
Denmark: HOBE hydrological observatory



Sweden: SKB tunnel



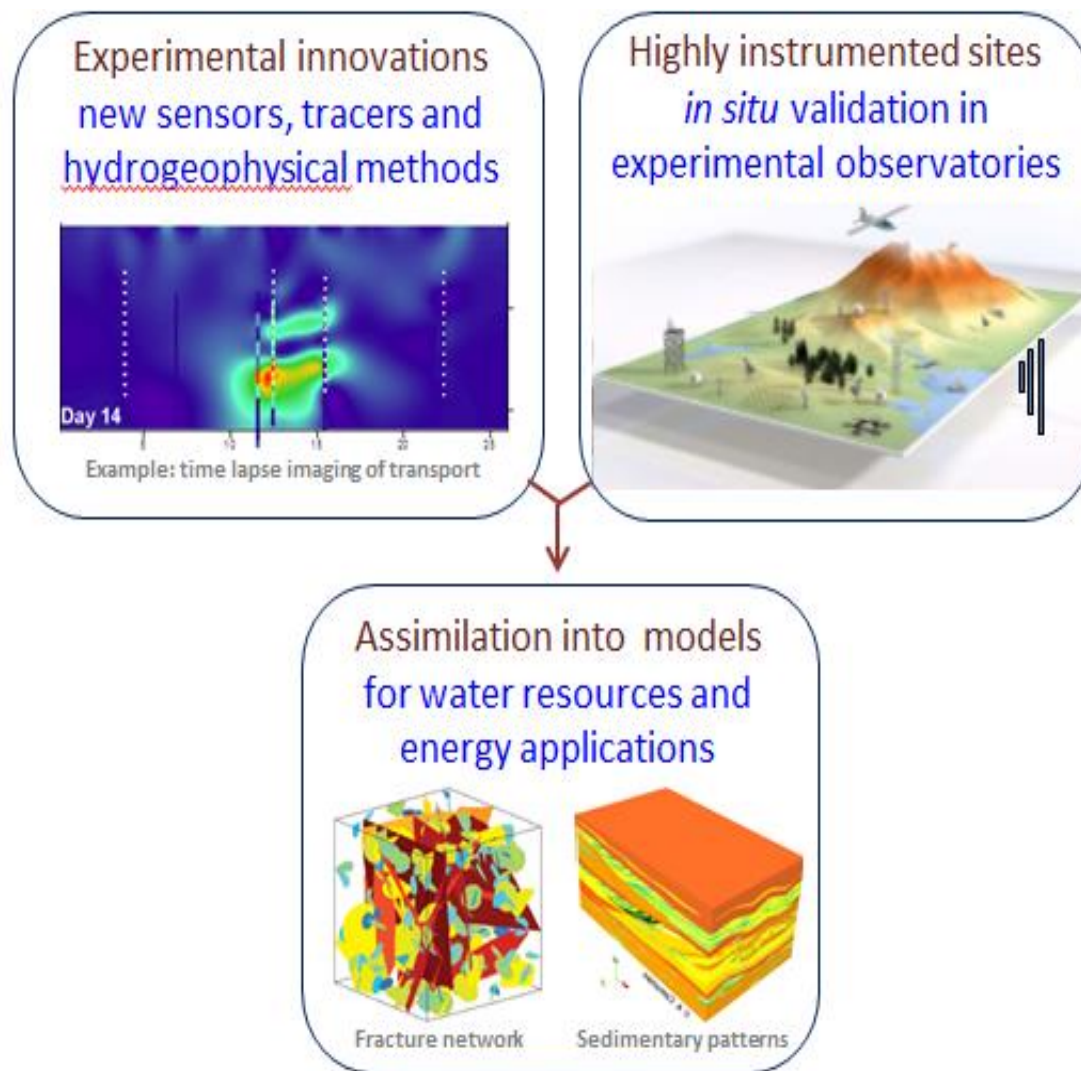
Germany: CAMPOS sites





Link between experimental sites and industrial partners

Innovative sensors and models for answering societal issues



Water resources and geothermal energy

BRGM

Geotechnik Heiligenstadt

Agencia Catalana de l'Aigua

Aquale

Hydrogeophysical tools

SILIXA

muQuans

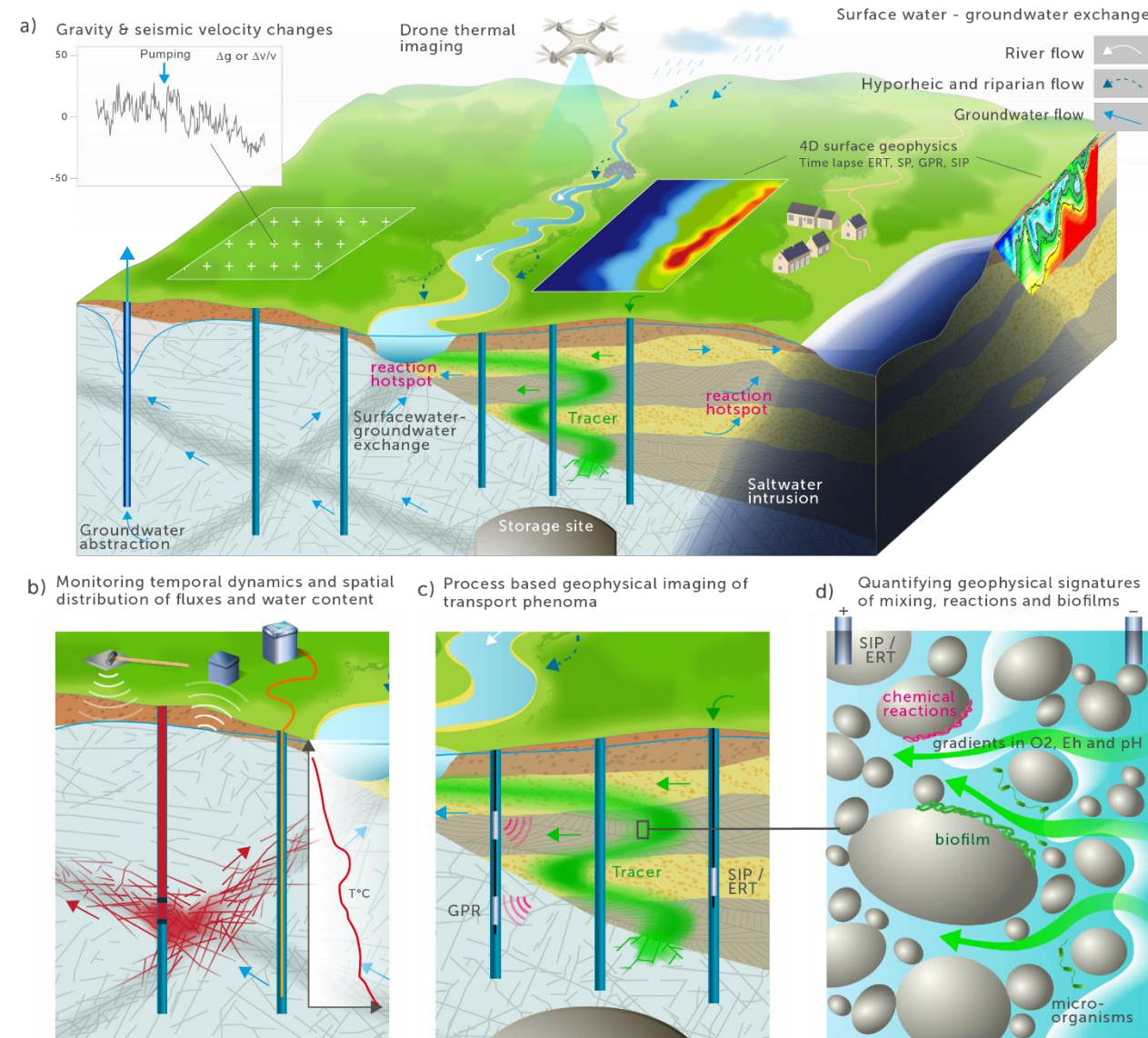
Underground waste storage

SKB

Modelling

ITASCA

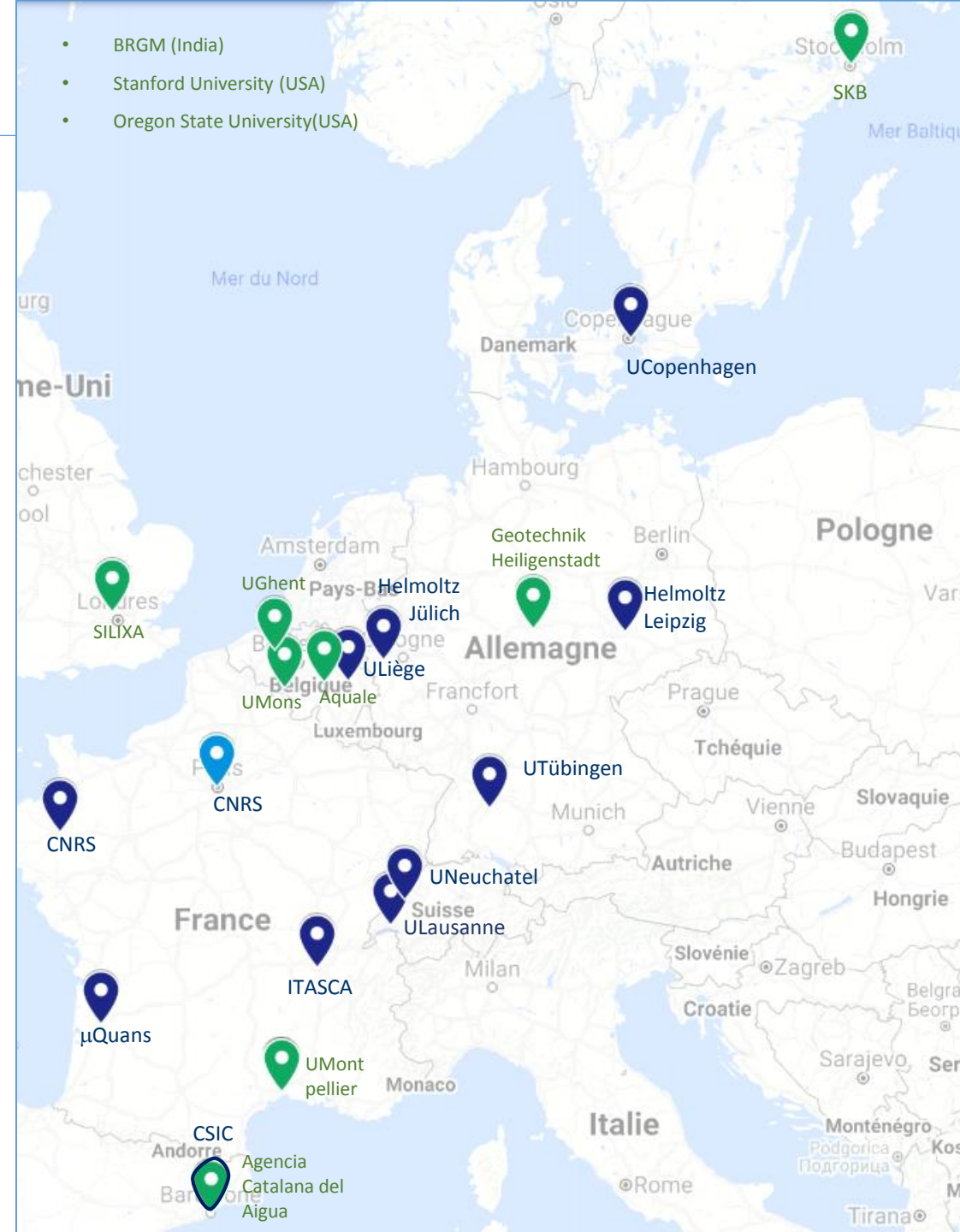
European training Network for In situ imaging of dynamic processes in heterogeneous subsurface environments





ITN Enigma

- BRGM (India)
- Stanford University (USA)
- Oregon State University(USA)



Academic

- CNRS H+: Rennes, METIS Paris (*Poitiers, Montpellier, LSBB*)
- Helmholtz TERENO: Jülich, Leipzig
- CSIC Barcelone
- University of Liège, University of Mons
- University of Ghent
- University of Tübingen
- University of Copenhagen
- University of Lausanne
- University of Neuchatel
- University of Montpellier
- BRGM (India)
- Stanford University (USA)
- Oregon State University(USA)

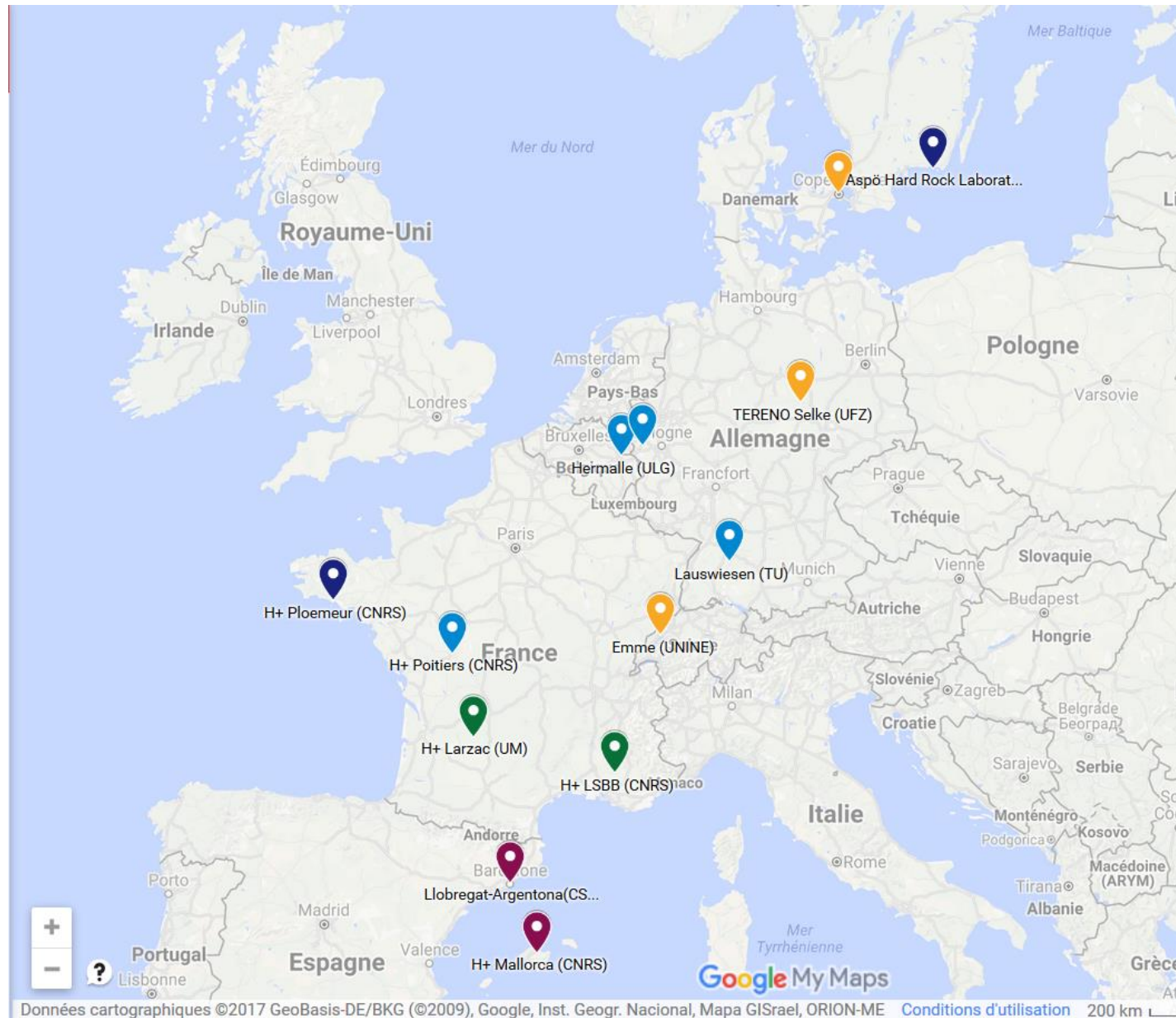
Non-academic

- μQuans, ITASCA
- SILIXA, SKB
- Geotechnik Heiligenstadt
- Aquale
- Agencia Catalana del Aigua

Enigma ITN Beneficiaries & Partners



Field Infrastructures (& H+ Hyderabad)



Field infrastructures	Unique attributes
TERENO- Krauthausen (FZJ), Hermalle (ULG), Lauswiesen (TU), H+ Poitiers (CNRS)	Hydrogeophysical test sites with high borehole density and large hydrogeophysical databases
H+ Ploemeur (CNRS) H+ Hyderabad (BRGM) Aspo Hard Rock Laboratory (SKB)	Fractured rock observatories for long term monitoring and in situ experiments
TERENO- Selke (UFZ) HOBE obs. (UCPH) Emme (UNINE)	Nested observatories in highly instrumented catchments
Llobregat-Argentona (CSIC) H+ Mallorca (CNRS)	Salt water intrusion monitoring and experimentation
H+ Larzac (UM) H+ Low Noise Lab. (CNRS)	Unsaturated zone observatories for long term monitoring and in situ experiments

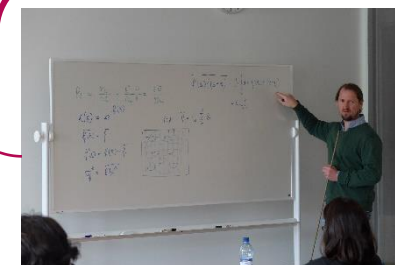
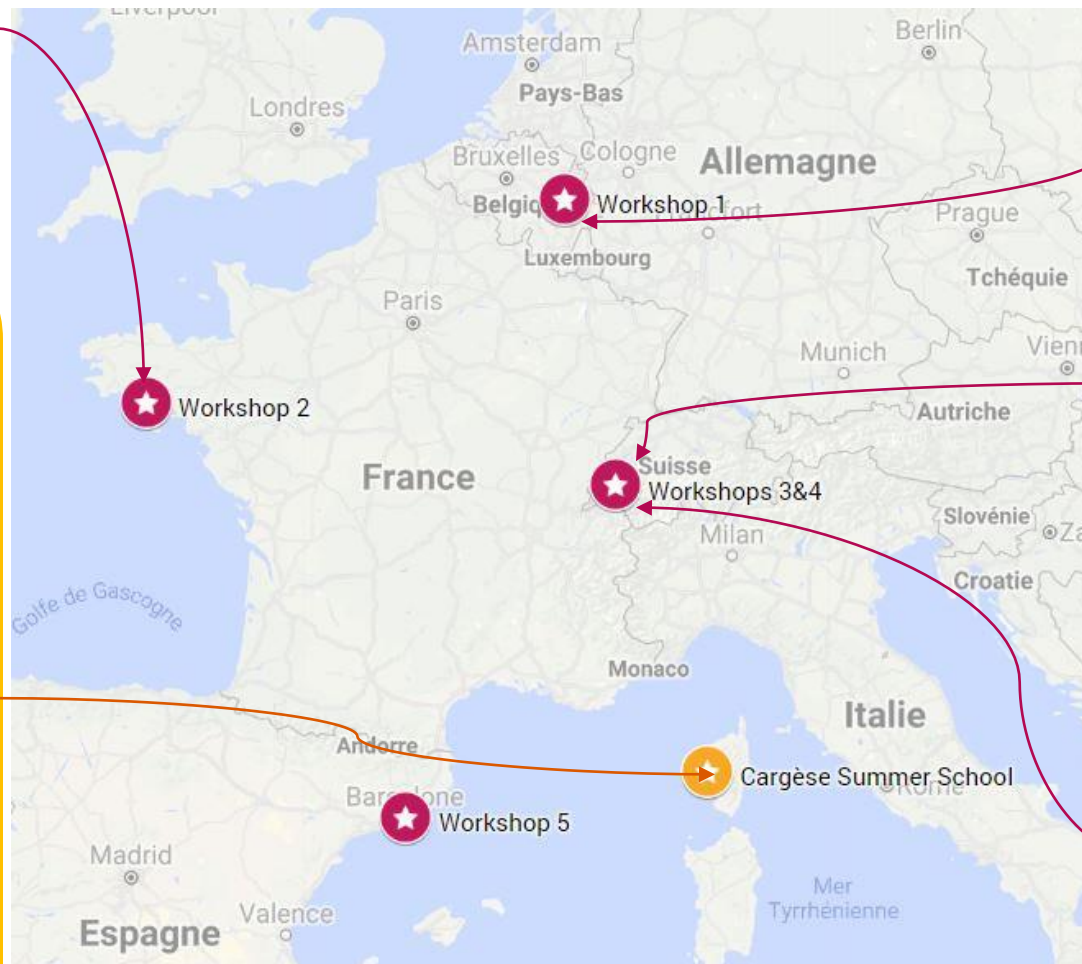
15 ESRs

- 627 (135 women) applicants from 81 countries.
- Network efforts to have a gender balance for the A candidates



15 ESRs :
5 women & 10 men

A balanced training within the network : Workshops & Summer School

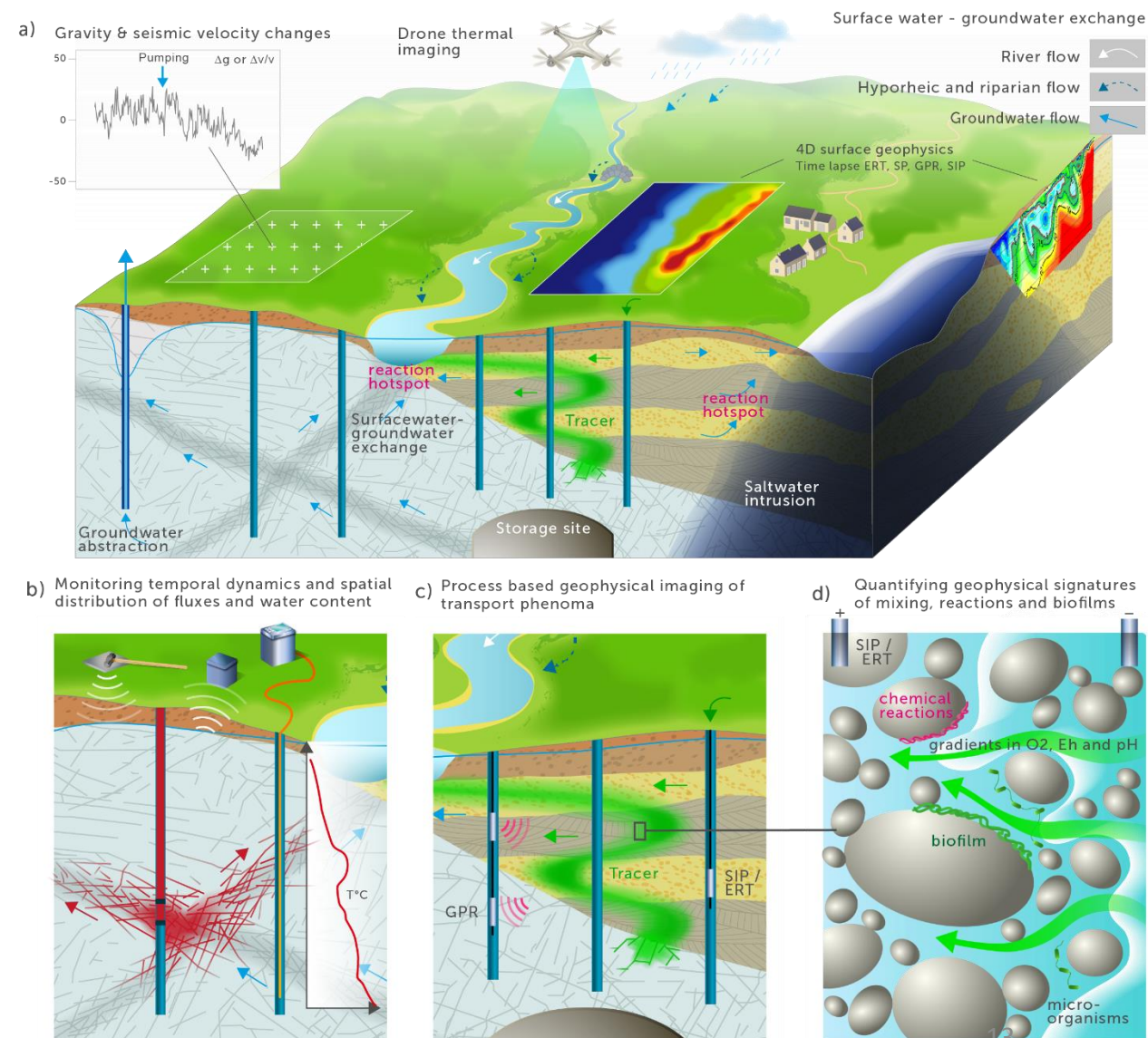


II. The research objectives of the network



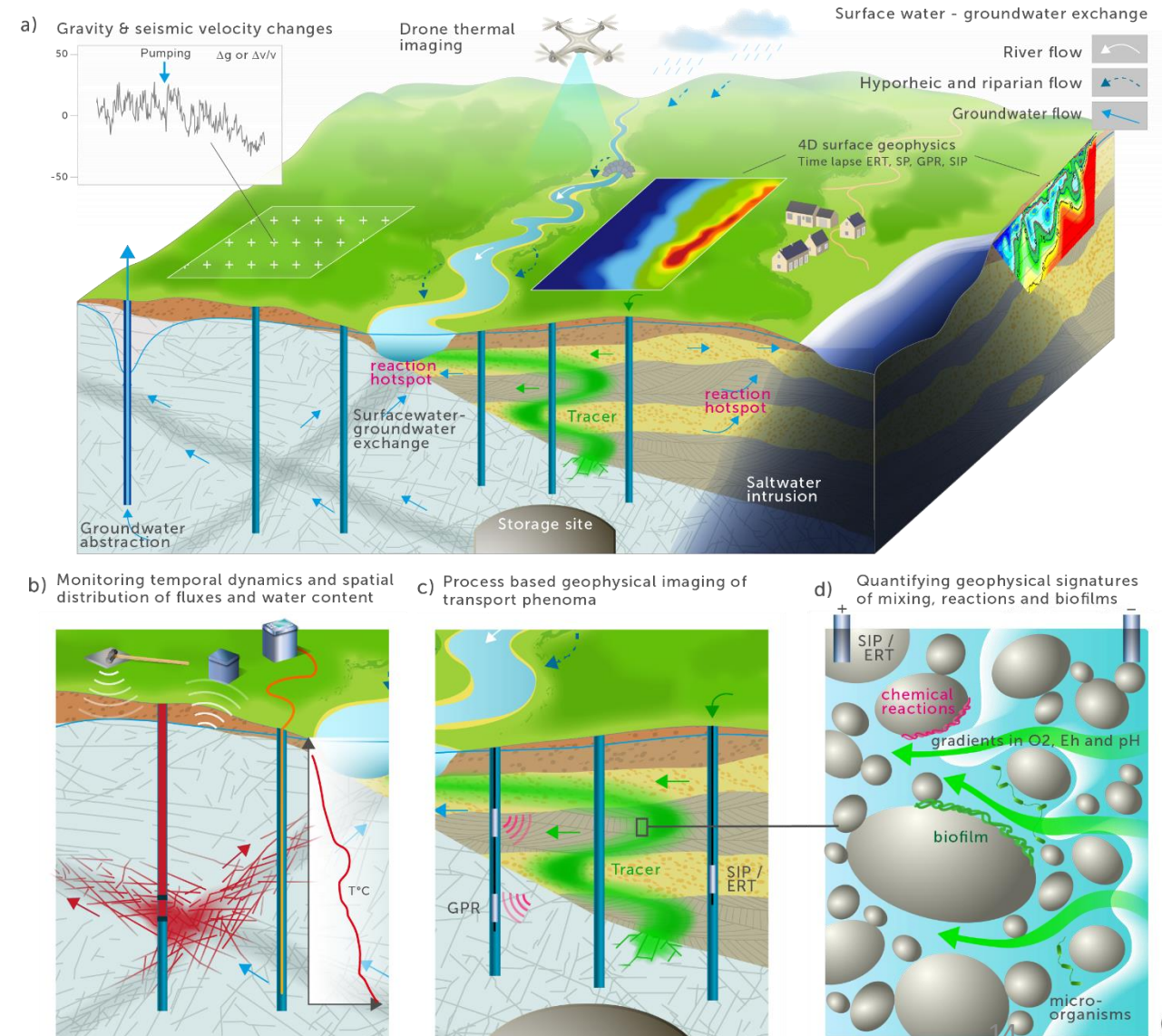
2 main scientific objectives for the ENIGMA ITN project

Scientific objectives	Adressed in workpackages
Design novel in situ experimental strategies for quantifying subsurface process dynamics by coupling innovative experimental methods and inverse modelling approaches	<ul style="list-style-type: none"> • WP3 • WP4 • WP5
Explore in-situ flow, transport and reaction processes to address current open scientific questions based on highly instrumented experimental sites where the new results, data and open source codes will be made available to academia and industry through a common on-line database	<ul style="list-style-type: none"> • WP2



2 technological objectives for the ENIGMA ITN project

Technical objectives	Adressed in workpackages
Develop and validate innovative environmental sensing techniques with the required sensitivity, as well as spatial and temporal resolution to monitor dynamic processes	<ul style="list-style-type: none"> • WP3 • WP4
Transfer the obtained knowledge of process dynamics in heterogeneous porous and fractured media to operational models for predicting the evolution of subsurface environments	<ul style="list-style-type: none"> • WP2 • WP5



III. Scientific highlights of the work so far and advancement on the state-of-the-art.





ITN Enigma



WP2: Explore coupled dynamic processes in targeted highly instrumented sites

ESR2 : Guilherme Nogueira

Flow and reactions in stream-riparian zone systems".

ESR1 Kevin De Vriendt

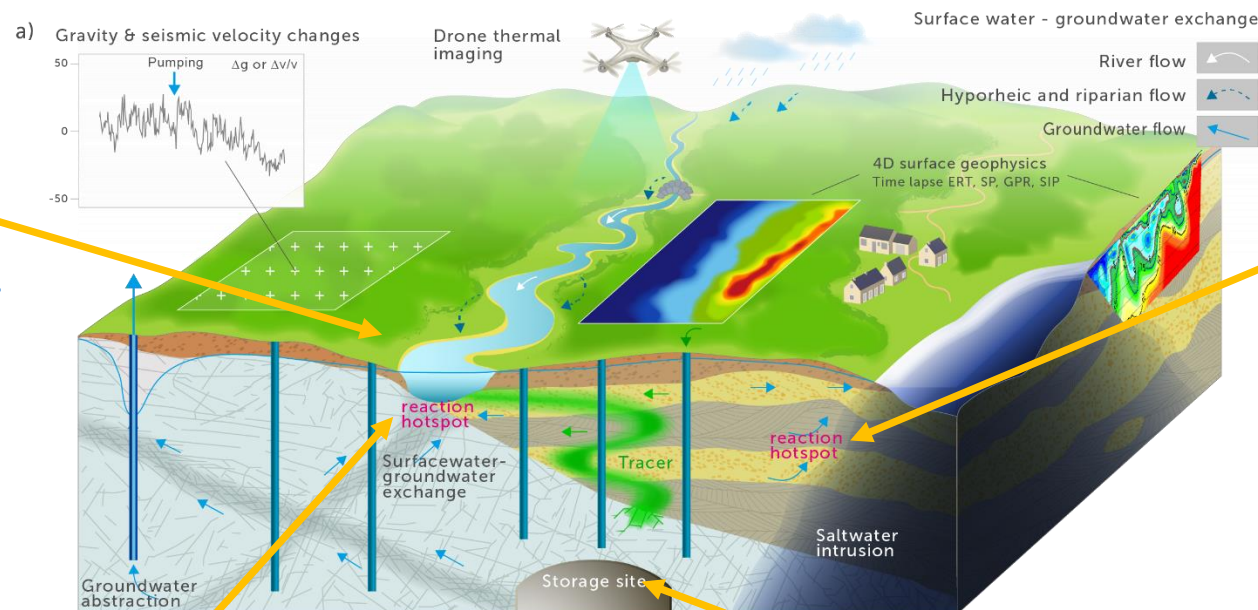
Mixing and chemical reaction hotspots in saline-freshwater mixing zones

ESR3 : Álvaro Pardo-Álvarez

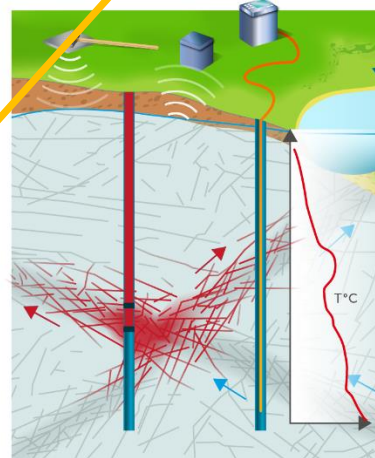
Closing the conceptual gap between the hyporheic zone and the river corridor

ESR4 : Justine Molron

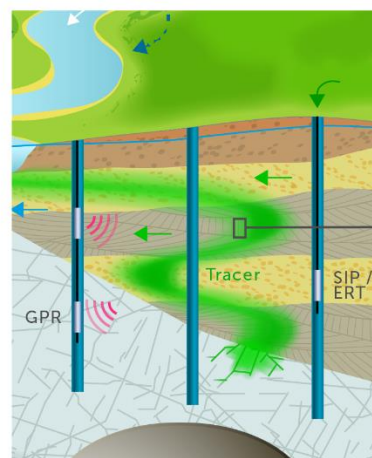
Flow and transport in fracture networks



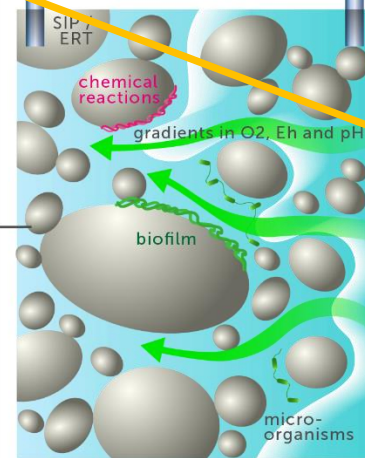
b) Monitoring temporal dynamics and spatial distribution of fluxes and water content



c) Process based geophysical imaging of transport phenomena



d) Quantifying geophysical signatures of mixing, reactions and biofilms



© Image designed by ENIGMA: European training network for in-situ imaging of dynamic processes in heterogeneous subsurface environments



ITN Enigma

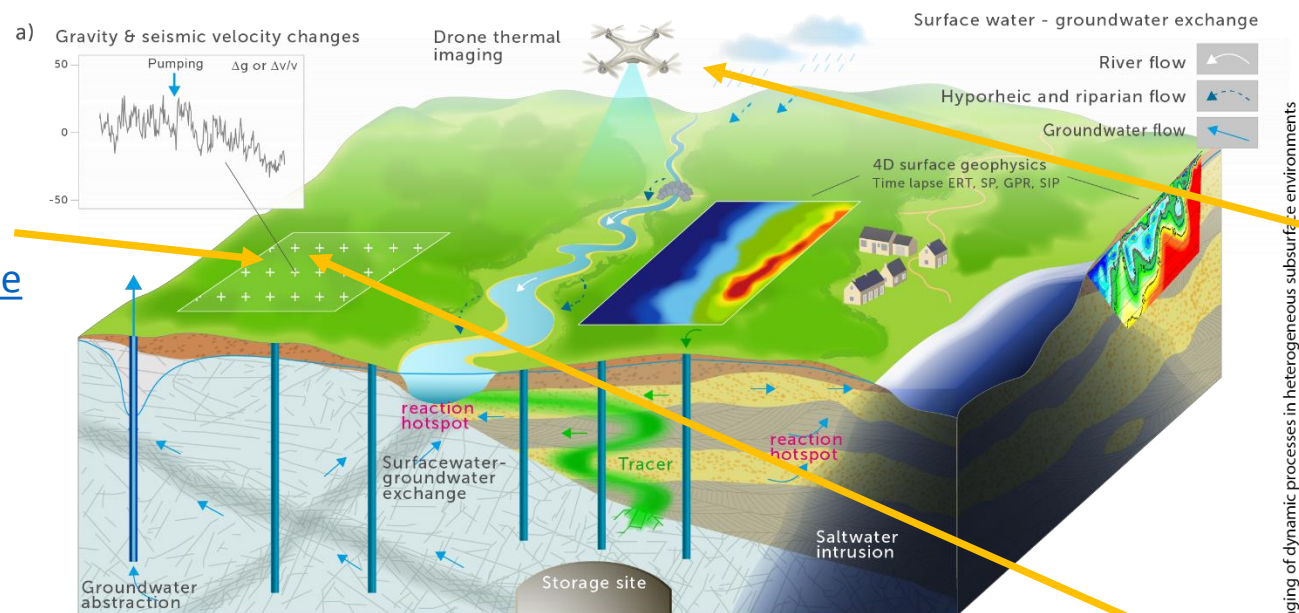


WP3: Quantify temporal changes in subsurface water content and fluxes distributions

ESR5 : Lara Blazevic



Monitoring spatio-temporal water redistribution in the subsurface



ESR7 : Joel Tirado Conde



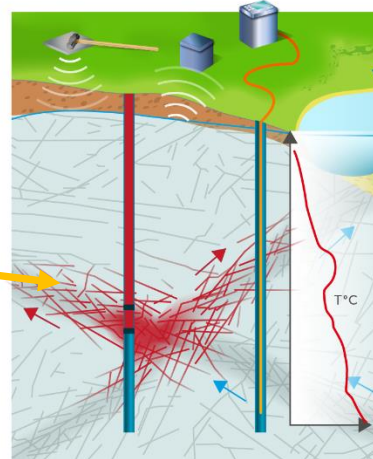
Multi-scale thermal imaging of groundwater upwelling in stream valleys

ESR6 : Behzad Pouladi

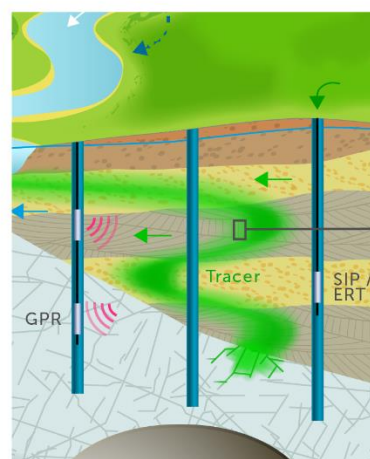


Active Fiber-Optic DTS methods to monitor subsurface flow dynamics

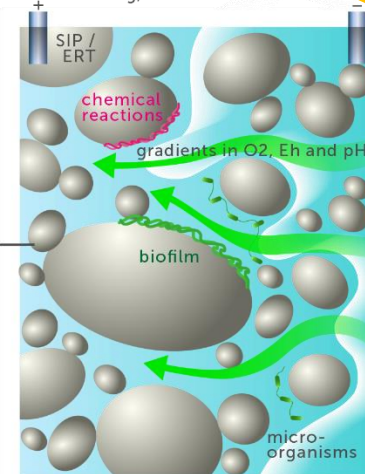
b) Monitoring temporal dynamics and spatial distribution of fluxes and water content



c) Process based geophysical imaging of transport phenomena



d) Quantifying geophysical signatures of mixing, reactions and biofilms



ESR8 : Anne-Karin Cooke



Monitoring water storage changes with a new portable absolute quantum gravimeter

Image designed by ENIGMA: European training network for in-situ imaging of dynamic processes in heterogeneous subsurface environments



ITN Enigma

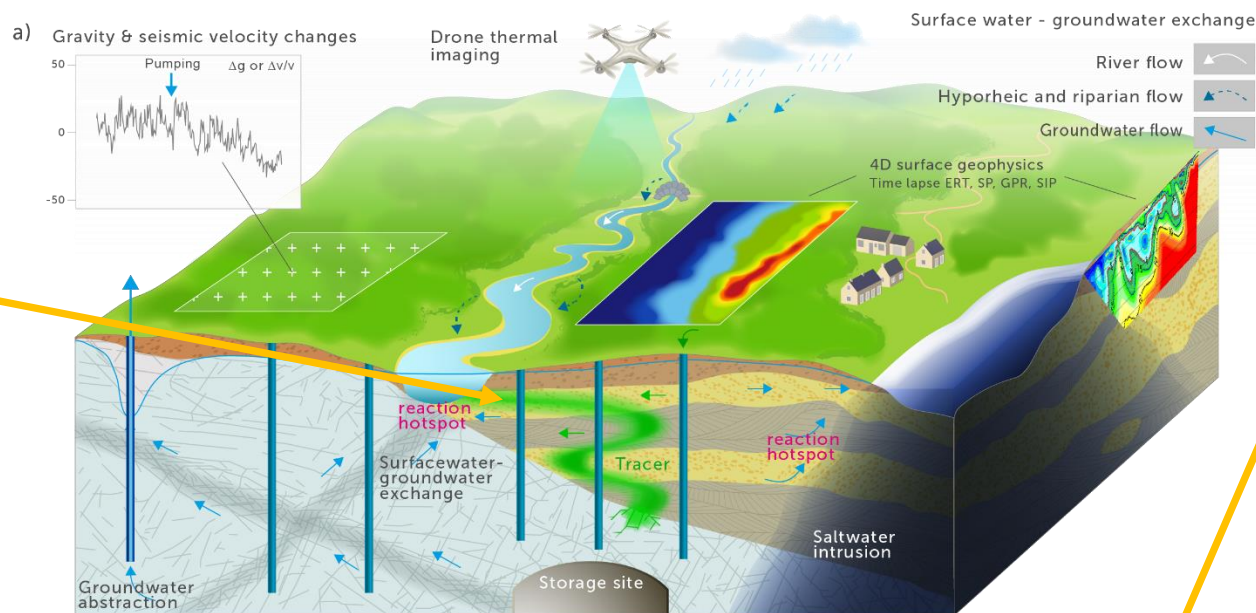


WP4: Create new methods for tracking the transport and reactivity of chemical species in subsurface

ESR11 : Richard Hoffmann



Joint heat and solute tracer test inversion for imaging preferential pathways

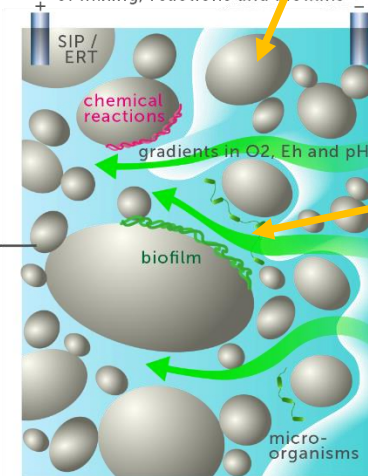
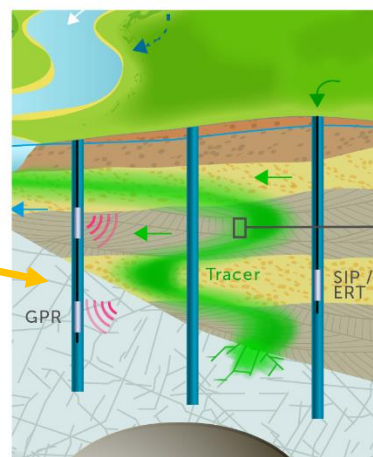
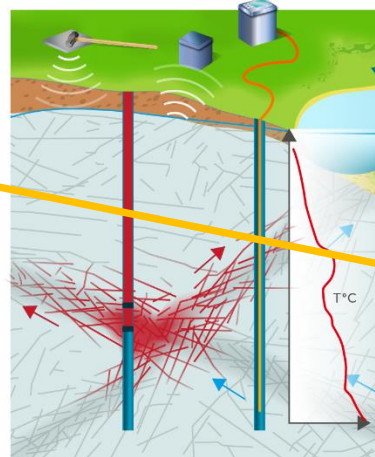


a) Gravity & seismic velocity changes

b) Monitoring temporal dynamics and spatial distribution of fluxes and water content

c) Process based geophysical imaging of transport phenomena

d) Quantifying geophysical signatures of mixing, reactions and biofilms



© Image designed by ENIGMA: European training network for in-situ imaging of dynamic processes in heterogeneous subsurface environments

ESR9 : Alejandro Fernandez Visentini



Geophysical signatures of spreading and mixing.

ESR10 : Peleg Haruzi



High resolution imaging of transport processes with GPR full-waveform inversion

ESR12 : Satoshi Izumoto

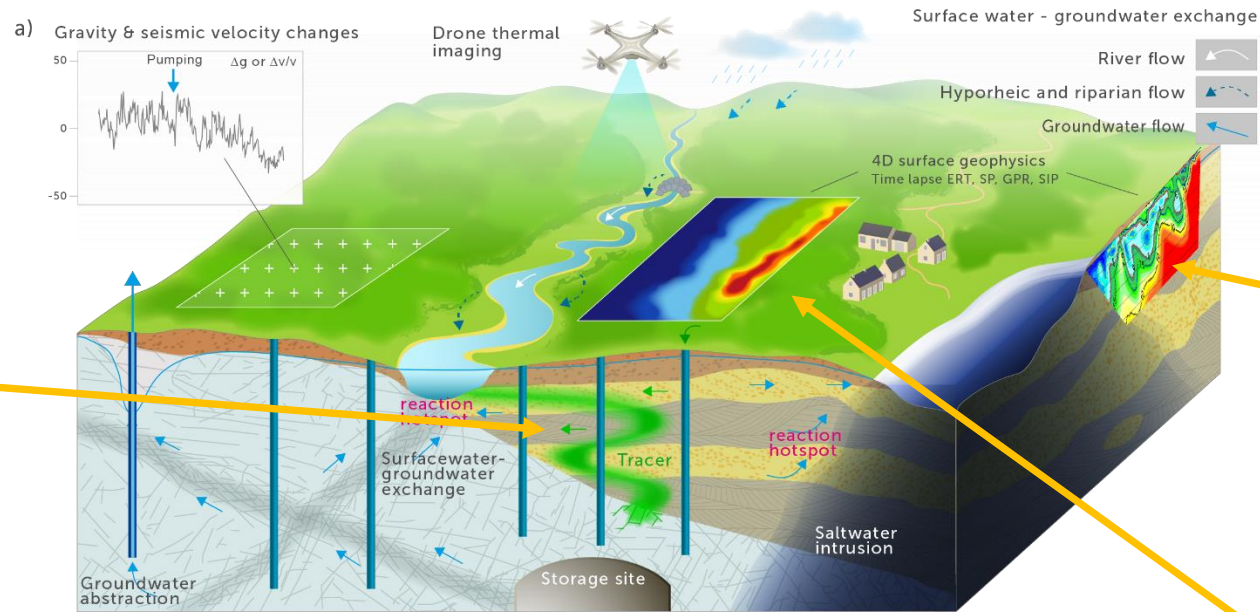


Spectral induced polarization monitoring for in-situ quantification of biochemical reactions

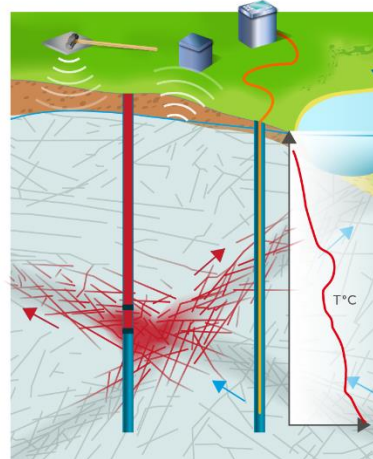
ESR13 : Veronika Rieckh



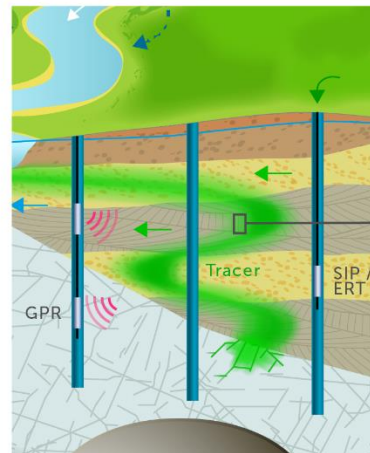
Fully coupled hydrogeophysical inversion of 3D tracer tomography using temporal moments and Ensemble Kalman Filtering



b) Monitoring temporal dynamics and spatial distribution of fluxes and water content



c) Process based geophysical imaging of transport phenomena



d) Quantifying geophysical signatures of mixing, reactions and biofilms

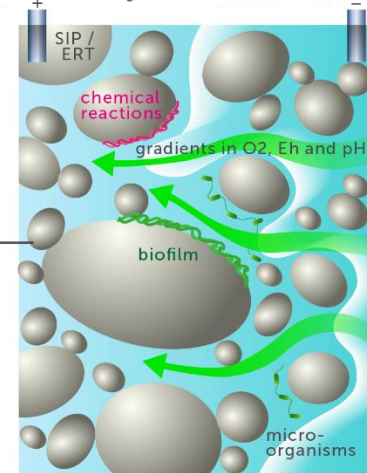


Image designed by ENIGMA: European training network for in-situ imaging of dynamic processes in heterogeneous subsurface environments

ESR14 : Andrea Palacios



Geologically constrained joint inversion of hydraulic, tracer and ERT data for process visualization

ESR15 : Jorge Lopez Alvis



Integration of dynamical hydrogeophysical data in a multiple-point geostatistical framework



Cargèse

Exploitation des eaux souterraines côtières: Comment éviter les pièges ?

Une conférence grand public sera donnée par A. Dassargues, Pr à l'Université de Liège dans l'amphithéâtre Levy, Mercredi 4 Juillet à 19h00

RENDEZ-VOUS |

Mercredi 04 juillet 2018 de 19h00 à 20h00

Institut d'Etudes Scientifiques, Cargèse, Cargèse



Some scientific deliverables already submitted :

WP5 D5.1 D12

Validated algorithms for fully coupled 3-D inversion

Lead Beneficiary:

EKUT Tübingen: Olaf A. Cirpka (Senior manager of this deliverable)

Contributors for this report:

EKUT Tübingen: Olaf A. Cirpka, Veronika Rieckh, Carsten Leven

UL Liège: Jorge Lopez Alvis

WP5 D5.2 D13

Report on joint inversion procedures for multiple and disparate datasets (soft and hard data) with realistic subsurface structure reconstruction methods

Lead Beneficiary:

UL Liège: Frederic Nguyen (Senior manager of this deliverable)

CSIC Barcelona: Andrea Palacios (ESR manager of this deliverable)

Contributors for this report:

UL Liège: Frederic Nguyen

CSIC Barcelona: Andrea Palacios

UT Tübingen: Veronika Rieckh

UL Liège: Jorge Lopez Alvis

WP3 D3.2 D7

Field test of novel techniques for quantifying water content spatial distributions and temporal fluctuations

Lead Beneficiary:

UNINE Neuchâtel: Philip Brunner (Senior manager of this deliverable)

CNRS: Lara Blazevic (ESR manager of this deliverable)

Contributors for this report:

UNINE Neuchâtel: Philip Brunner

CNRS: Lara Blazevic, Behzad Pouladi

UCPH: Joel Tirado Conde

WP3 D3.3 D8

Report: Critical assessment of emerging techniques for in situ monitoring of water content and fluxes

Lead Beneficiary:

UCPH Copenhagen: Majken Looms Zibar (Senior manager of this deliverable)

UCPH Copenhagen: Joel Tirado Conde (ESR manager of this deliverable)

Contributors for this report:

UCPH Copenhagen: Majken Looms Zibar

UCPH Copenhagen: Joel Tirado Conde (ESR 7)

CNRS: Lara Blazevic (ESR 5) and Behzad Pouladi (ESR 6)

Muquans: Anne-Karin Cooke (ESR 8)

This project has received funding from European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreement N°722028.

IV. Interactions within the network



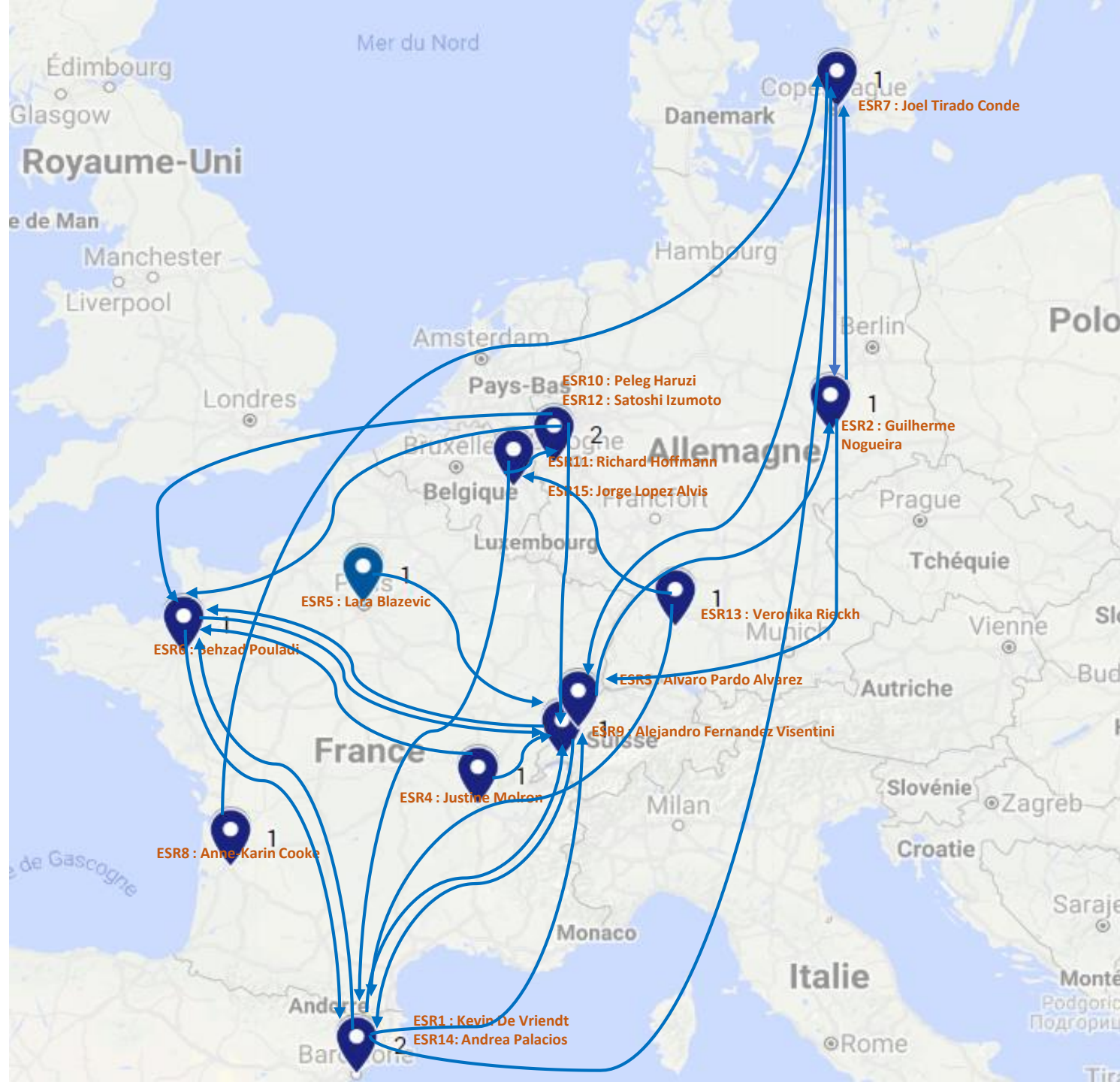


ITN Enigma



Global
interactions
through
secondments,
missions or
visits :

between the
beneficiaries

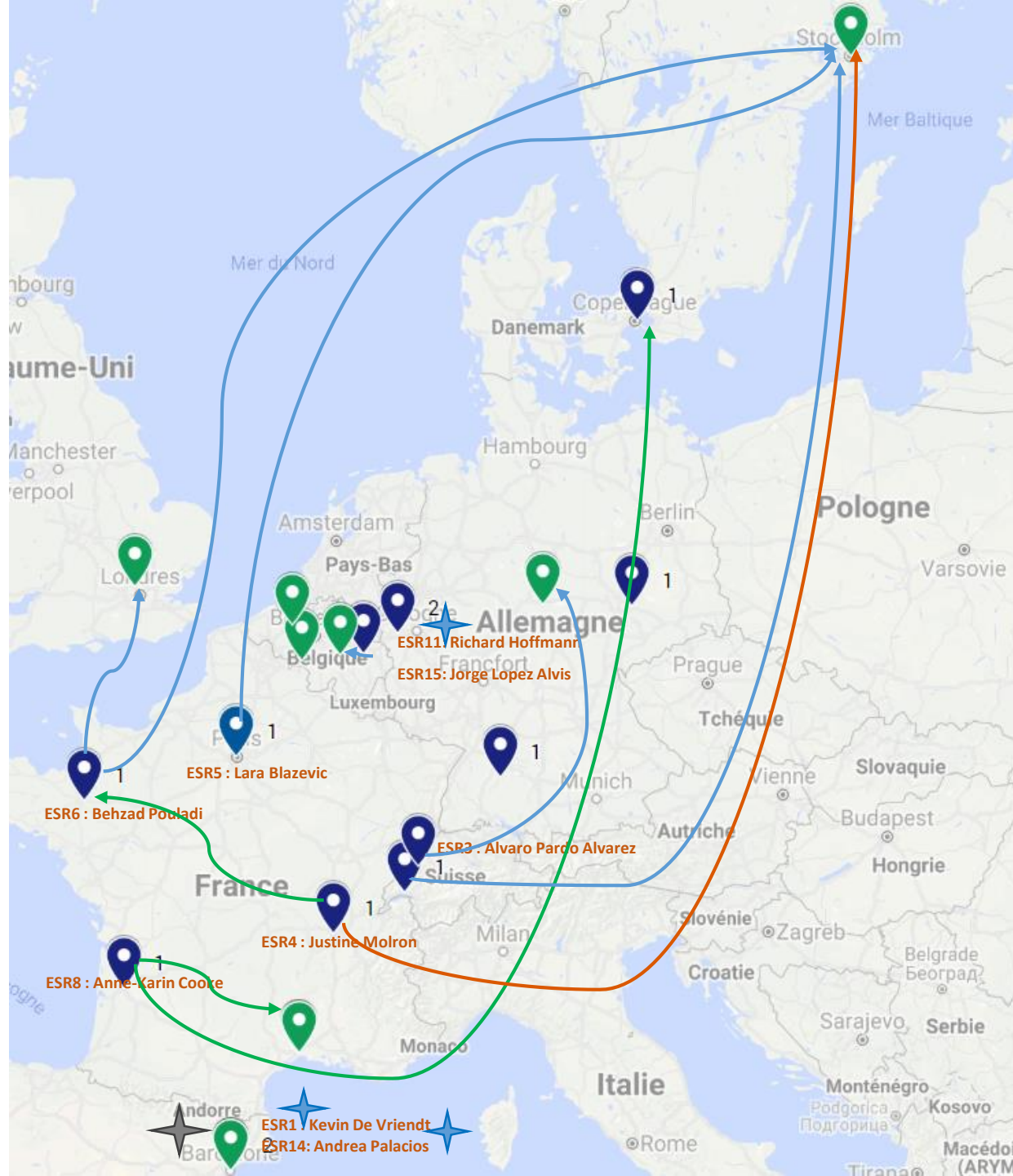


- CSIC->CNRS
CSIC->UCPH
CSIC->UNIL
- UFZ->UNINE
UFZ->UCPH
- UNINE ->UFZ
- Itasca -> CNRS
Itasca -> UNIL
- CNRS -> UNIL
CNRS ->CSIC
- UCPH->UFZ
UCPH->UNINE
- Muquans->UM
Muquans->UPCH
- UNIL->CNRS
UNIL->CSIC
- FZJ->UNIL
FZJ->CNRS
- ULG->UGhent
ULG->Umons
ULG->FZJ
ULG->CSIC
- UT->ULG
UT->CSIC



Intersector interactions through secondments, missions or visits:

- academic-> private sector/policy community
- private sector -> academic
- Within private sector
- External private -> ENIGMA ITN



- ULG – Aquale
ULG – BRGM (India)
- CSIC-ACA
- CNRS – Silixa
CNRS – SKB
- UNINE – Geoth
- Itasca – CNRS
Itasca – SKB
Researchers from CNRS and UNIL participated to the field experiments of ESR4-Itasca in SKB
- Muquans-UM
Muquans-UPCH
- Amphos 21-CSIC



ENIGMA joint experiments (done or planned)



- [Krauthausen natural gradient tracer experiment](#) (FZJ Jülich)
Leaders: Peleg Haruzi and Jan Van der Kruk
Potential Participants: ULG Liege + Guilherme Nogueira
- [Emme site pumping experiment](#) (UNINE)
Leaders: Alvaro Pardo Alvarez and Philip Brunner
Potential Participants: Joel Tirado Conde & Anne-Karin Cooke
- [Lauswiesen site forced gradient tracer experiment](#) (UFZ Leipzig)
Leaders: Veronika Rieckh and Carsten Leven
Potential Participants: Peleg Haruzi
- [SKB tracer test experiment](#)
Leaders: Justine Molron, Niklas Linde, Philippe Davy
Participants: Lara Blazevic, Behzad Pouladi, Tanguy Le Borgne, Olivier Bour
- [Argentona pumping test experiment](#) (CSIC Barcelona)
Leaders: Andrea Palacios, Jesus Carrera
Potential participants: Lara Blazevic, Kevin de Vriendt, Maria Pool, Marco Dentz
- [Surveys in one of the Danish field sites \(ERT\)](#) (UCPH)
Leaders: Andrea Palacios, plan for an inversion for temperature and its comparison and discussion with the thermal data collected by ESR7 Joel Tirado Conde



ENIGMA databases (training, projects)



- ESR11, ESR15, EPM and T. Hermans (UGhent), A. Battais (Rennes IT engineer) participated to a meeting in Rennes to create a functional database for ULG (data collected in Hermalle)
- All ESRs were trained to use the H+ database and have started to participate to discussions about the data formats and data storage in Liège (WS1) and Ploemeur (WS2).
- Campos database for UT
- Hobe/H+ database for UCPH
- SKB/H+ database
- In discussion with CSIC to create an Argenton database within the H+ database



ENIGMA plans for data storage

