WE-NEED: WatEr NEEDs, availability, quality and sustainability

POLITECNICO
MILANO 1863

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Consortium Description

WE-NEED

ACRONYM	TOPIC	Coordination	Partners
WE-NEED	**2**		
Water Needs, Availability, Quality and Sustainability		**water management; risk assessment; emerging contaminants; multiscale characterization; ecotoxicity**	

PRINCIPAL INVESTIGATOR	INSTITUTION	COUNTRY
Monica Riva	**Politecnico di Milano - Polimi**	**Italy**
Brian Berkowitz	Weizmann Institute of Science - Weizmann	Israel
Susana Loureiro	Universidade de Aveiro - UAVR	Portugal
Daniel Fernandez-Garcia	Universitat Politecnica de Catalunya - UPC	Spain

Water JPI

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Ministry of National Infrastructures, Energy and Water Resources

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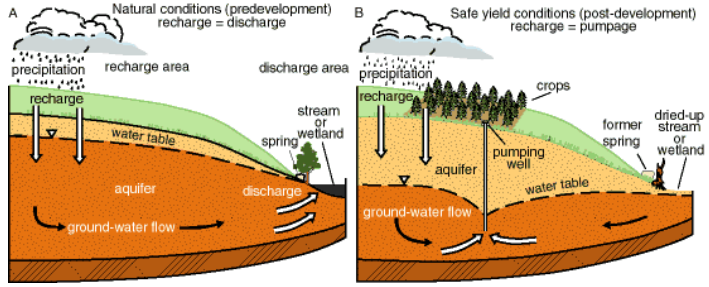
GOAL

Develop innovative management strategies to assist the sustainable use/protection of two key components of groundwater resources (Springs – Wells)

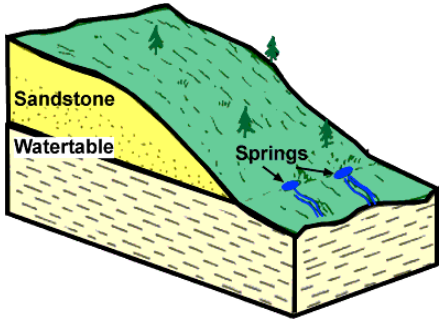


WATER QUANTITY : Over-exploitation of groundwater resources

WATER QUALITY : Regulated and emerging contaminants (pharmaceuticals, …)

KEYWORDS: Management/Protection of Groundwater Resources – Sustainability – Uncertanty Quantification - Risk Assessment - Multiscale Statistical Analysis

Relevant Study Cases - Real scenarios



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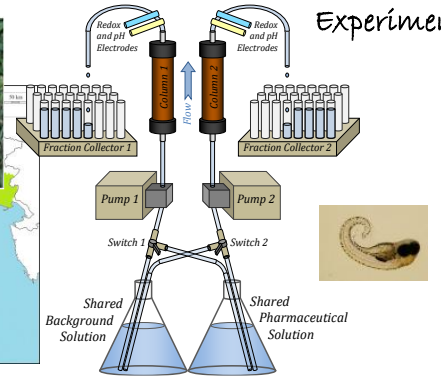
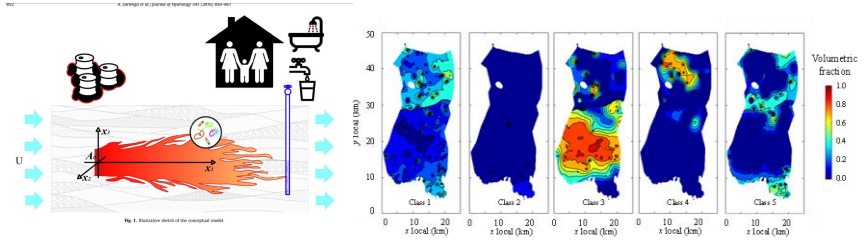
Methodology - Approach

Field observations

Experiments





Modelling under uncertainty

WATER QUANTITY
WATER QUALITY

Decision Making

1. • CHARACTERIZATION
2. • MODELING
3. • PREDICTIONS

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Methodology - Approach

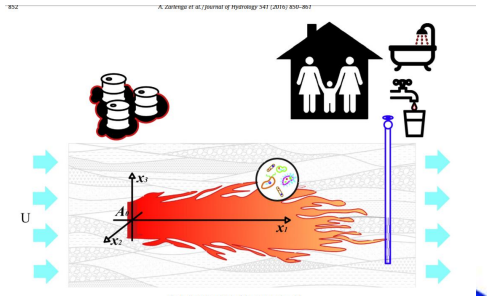
1. • **CHARACTERIZATION**
2. • MODELING
3. • PREDICTIONS

Full (Complete)

Uncertainty

Uncertainty Quantification

Decision Making



Acceptable level of Risk

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Methodology - Approach

1. • **CHARACTERIZATION**
2. • MODELING
3. • PREDICTIONS

Decision Making

Uncertainty

Formation properties (conductivity, porosity,.....)

Solute/Contaminant properties (degradation rates,.....)

Conceptual model (geomaterials' distributions, forcing terms, boundary conditions,....)

Methodology - Approach

1. • **CHARACTERIZATION**
2. • MODELING
3. • PREDICTIONS

Uncertainty

Data to reduce/control uncertainty

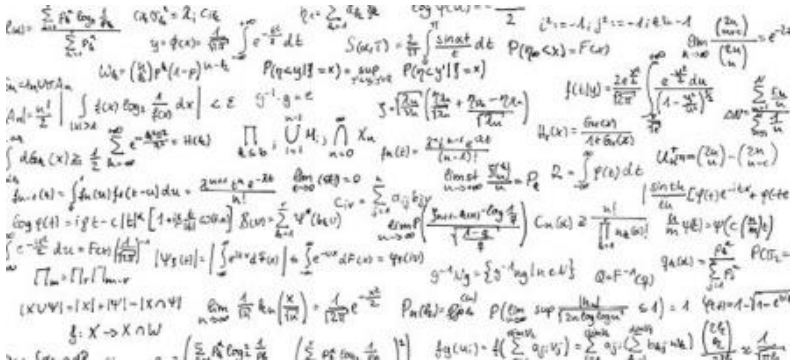
Sensitivity Analysis

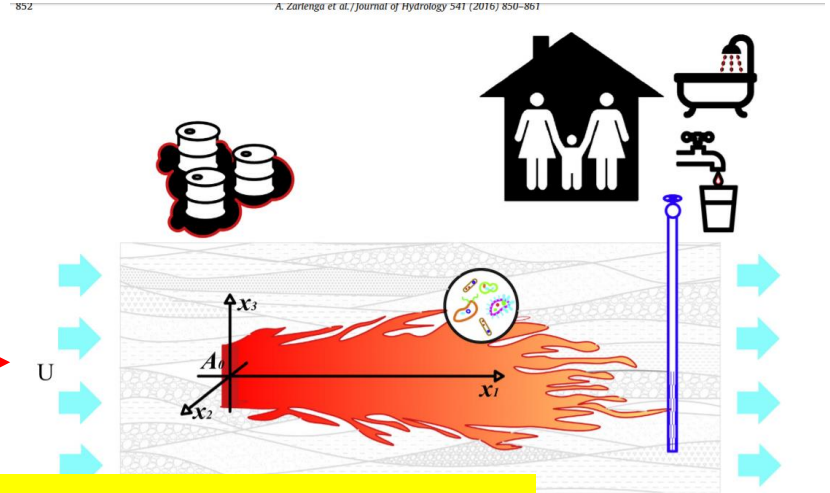
Decision Making

INPUTs

COMPLEX MODEL

OUTPUTs





It becomes challenging to understand the relationships between INPUTs and OUTPUT(s)!

INPUTs → COMPLEX MODEL → OUTPUTs

'**Sensitivity**': despite being an **intuitive** concept, it is also a **general** concept!

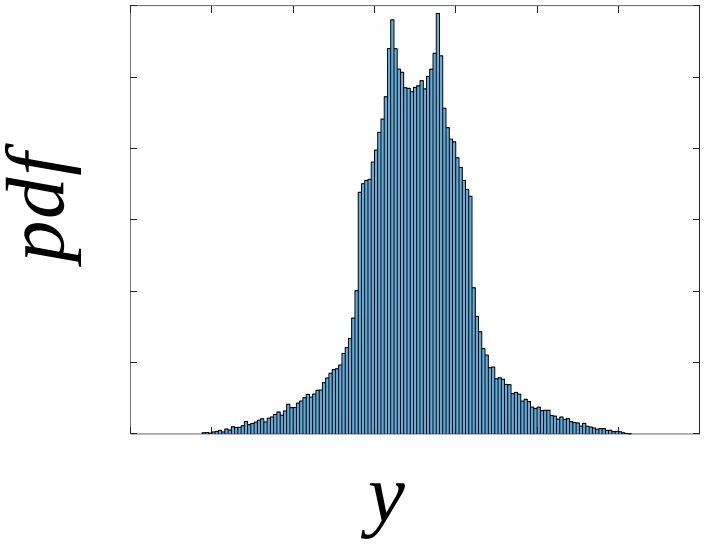
KEY QUESTIONS

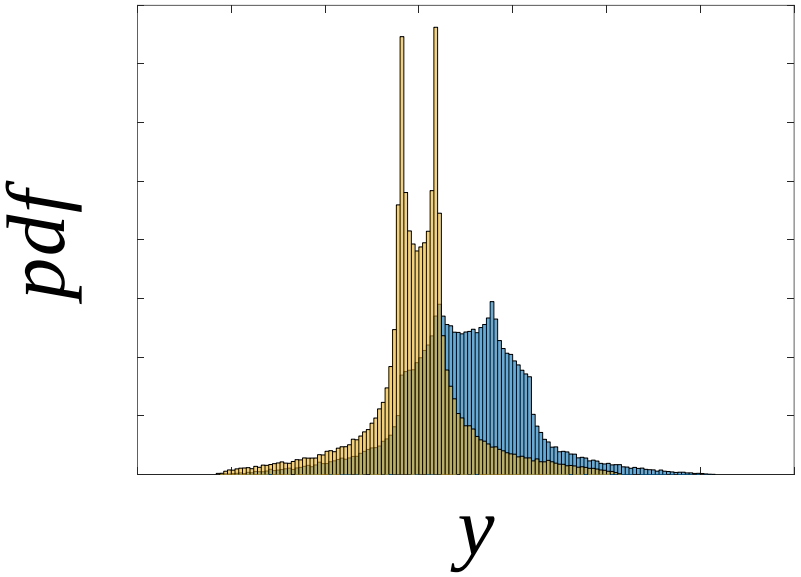
How does the ***model act***?
Which are the most ***relevant/influential*** INPUTs? Why?
Which INPUTs provide the most ***relevant contribution*** to OUTPUT(s) variability/uncertainty?
……..

Sensitivity Analysis

Sobol' Indices

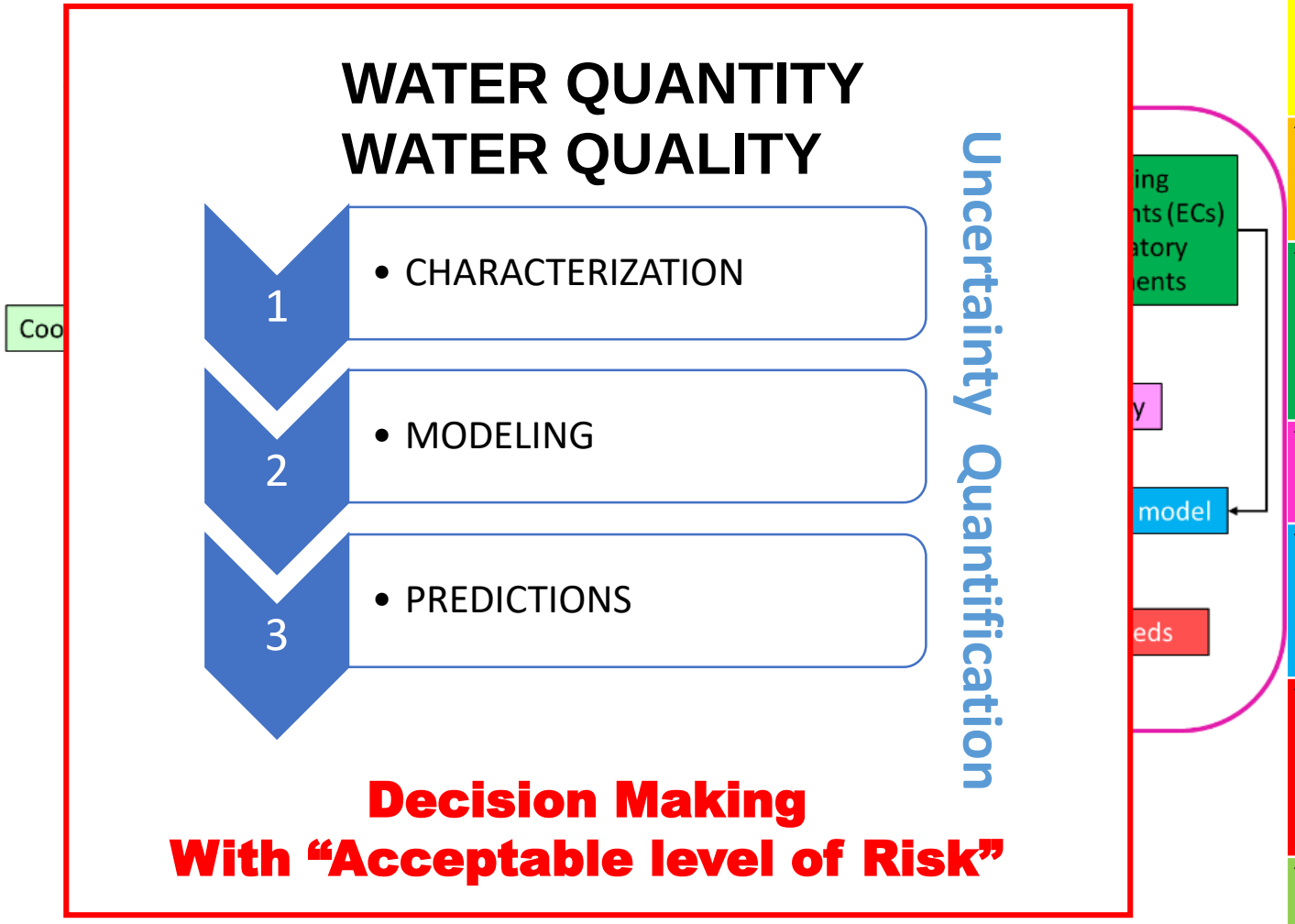
$$S_{x_i} = \frac{\mathrm{E}\left[V_y - V\left[y \mid x_i\right]\right]}{V_y}$$





New metrics!

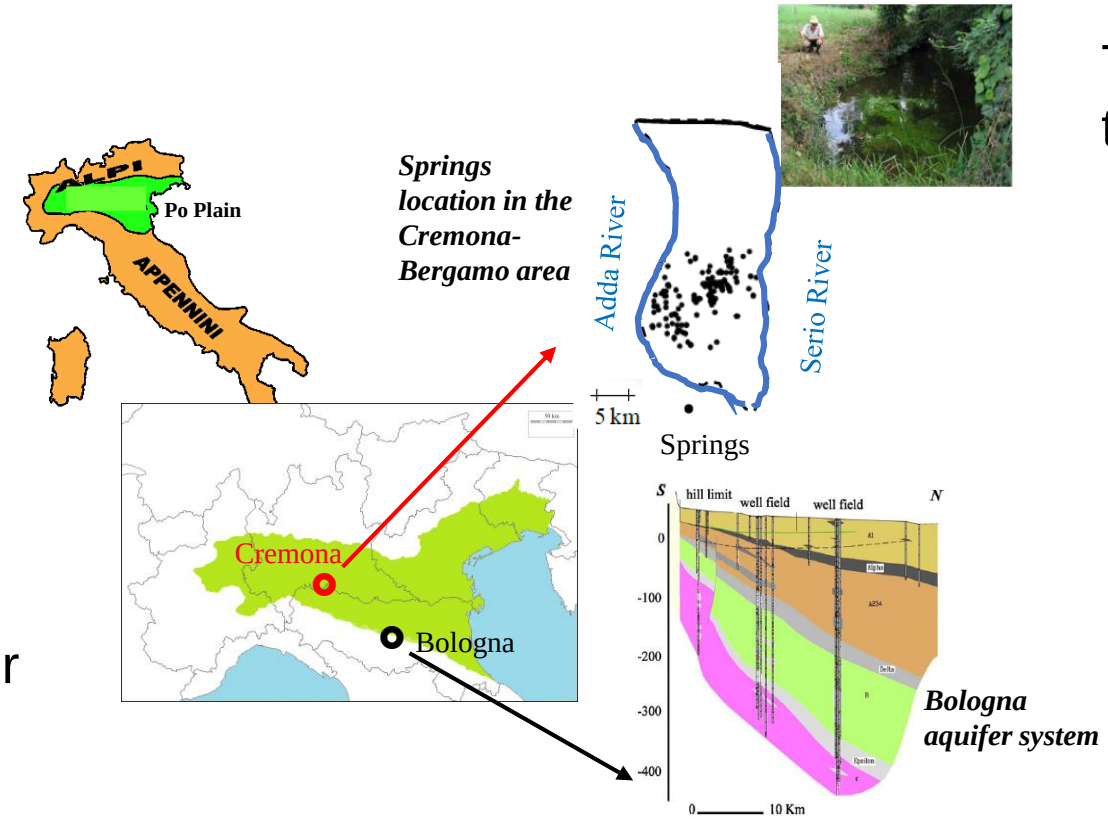
WPs



		Lead Partner	Participating Partner
WP1	Data collection and multiscale characterization	Polimi	UPC, UAVR, Weizmann
WP2	Probabilistic flow and transport modeling	UPC	Polimi, Weizmann
WP3	Fate of Emerging Contaminants (ECs) - laboratory experiments and modeling	Weizmann	UAVR
WP4	Ecotoxicology	UAVR	Weizmann
WP5	Multidisciplinary risk assessment and decision making	Polimi	UPC, UAVR, Weizmann
WP6	Dissemination of results, communication with stakeholders/general public	Polimi	UPC, UAVR, Weizmann
WP7	Project management	Polimi	UPC, UAVR, Weizmann

SITES

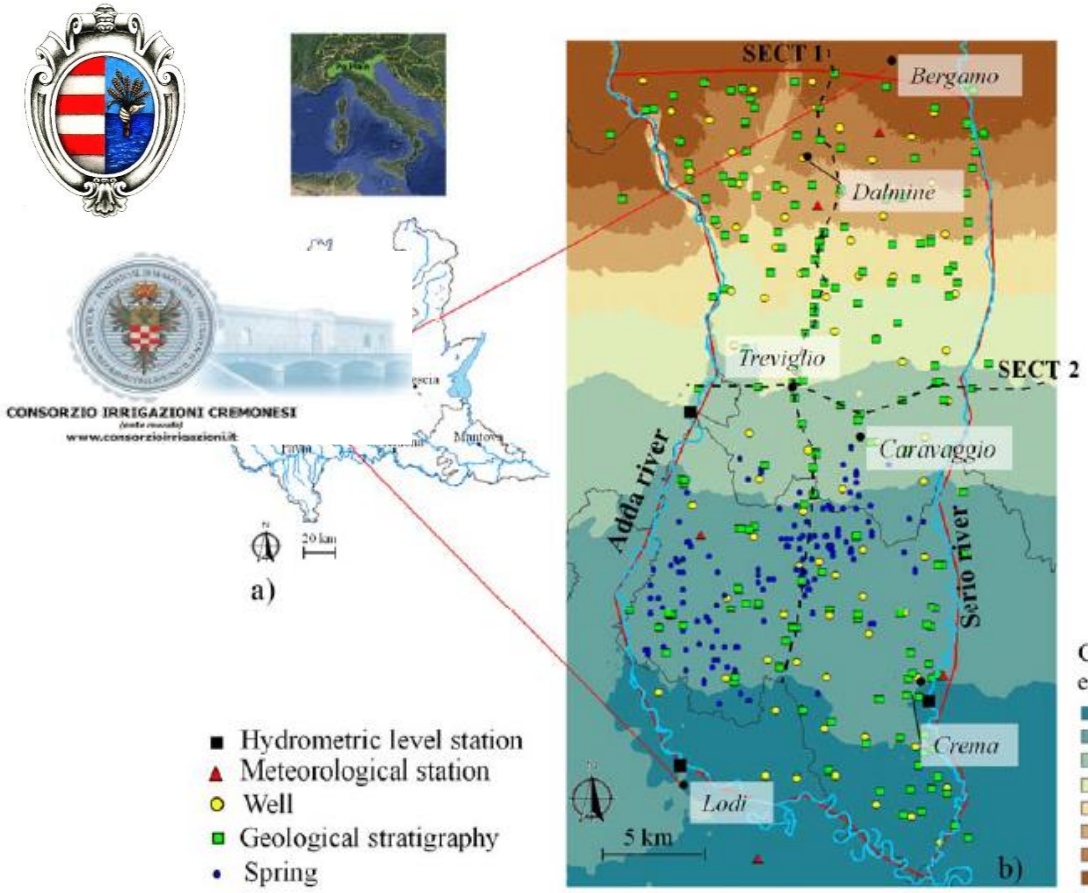
Two sites, representing different but complementary realities



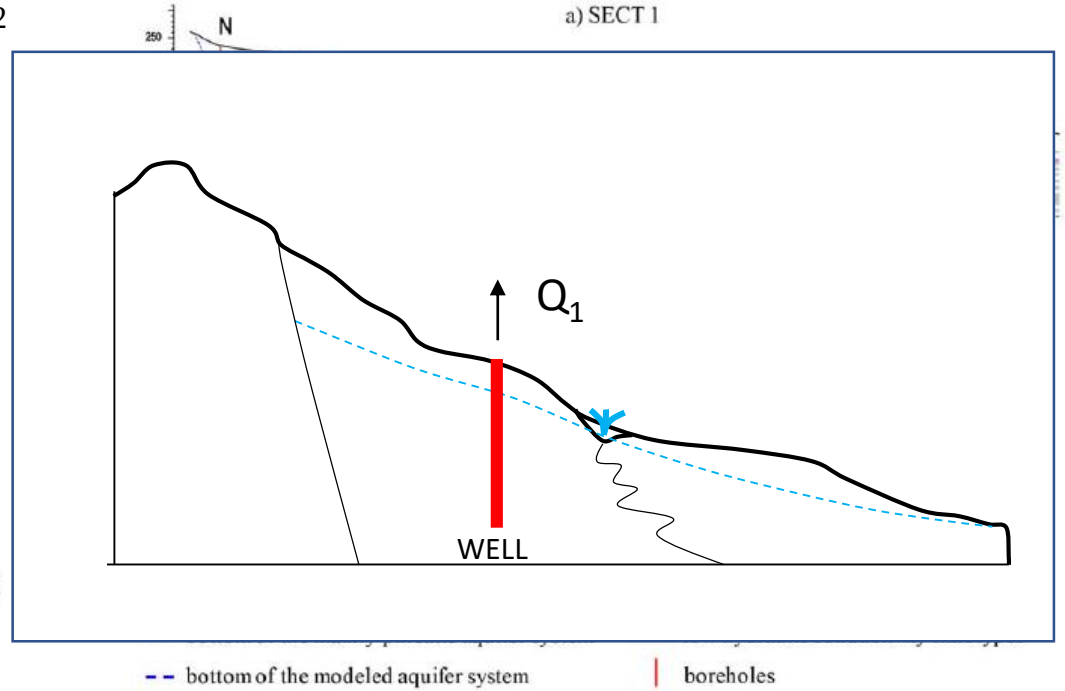
The *Cremona Aquifer* located in the so-called *Springs Belt*.

Natural high-quality water springs are the main supply to agriculture and a key environmental driver.

The *Bologna Aquifer* is a key source of water for the metropolitan area of Bologna.



785 km^2



FACIES	GEOLOGICAL MATERIAL
1	Clay and silty deposits, 37%
2	Fine Sands, Clay Sands, Silty Sands, 5%
3	Gravel, Gravel and Sand, Medium Sand, 33%
4	Compact Conglomerates, 15%
5	Fractured Conglomerates, 10%

CREMONA SITE

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Bologna Site

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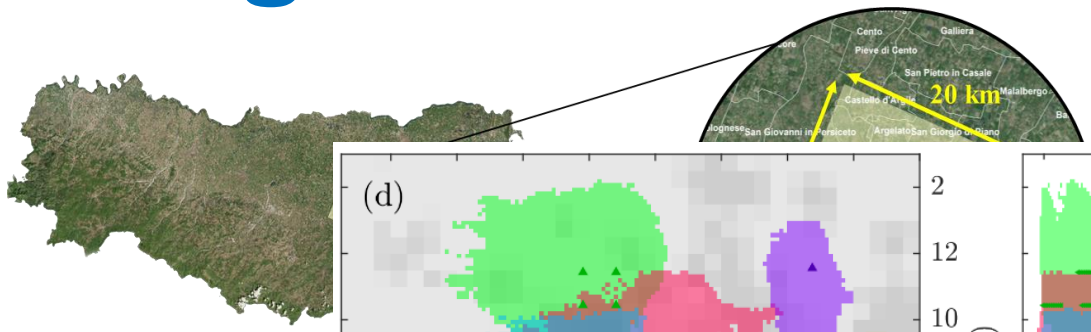
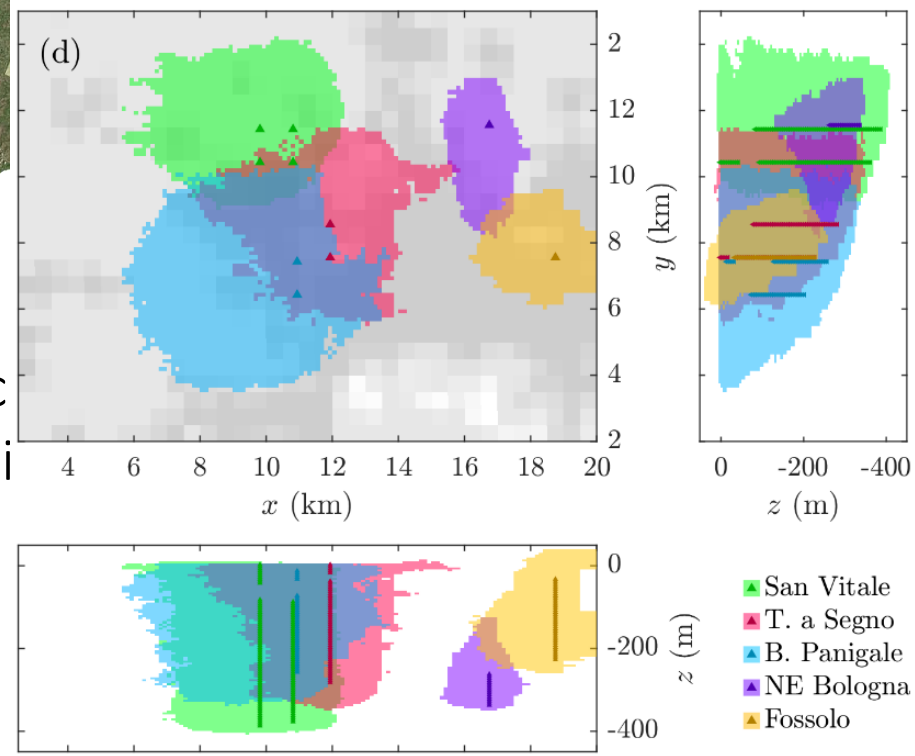
- San Vitale well field
- Borgo Panigale well field
- Tiro a Segno well field
- Study area
- Reno river
- Geological cross sections

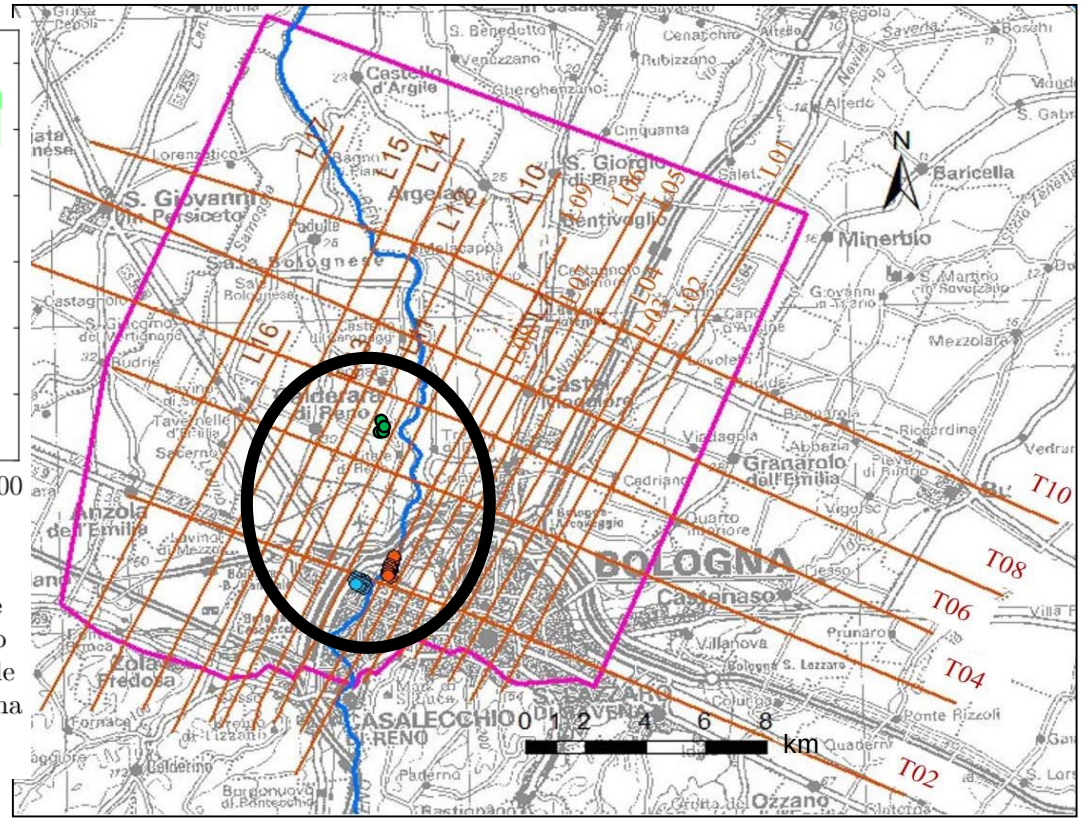


≈ 460 km²

Two geostatistic
describe the archi

Generate MC
lithological data





3D flow-transport model of the aquifer

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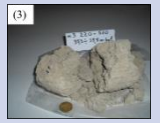
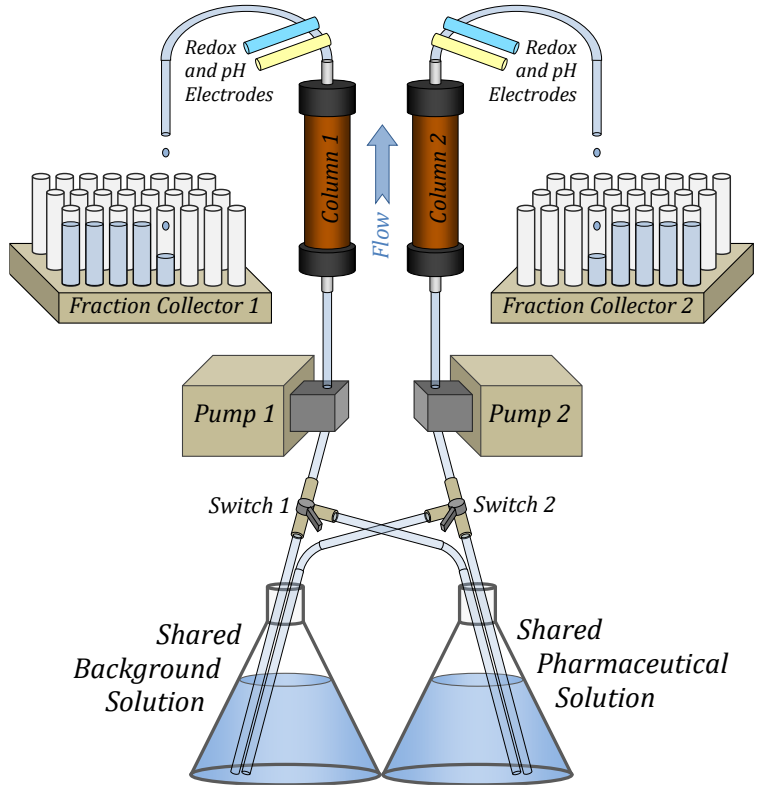
LABORATORY EXPERIMENTS

Sample	Core	Depth from ground [m]	Geological Description	
1	220-S10	51.8-52	The sample is mainly formed by sand (fluvial channel sands) with very few pebbles (maximum length 2 cm)	
2	220-S10	48.4-48.6	Sandy silt with some pebbles	
3	220-S10	35.3-35.5	Fluvial channel gravel. Heterometric gravel with grain size ranging from fine gravel (about 2 mm – the most abundant fraction) to pebbles (2-3 cm), in sandy-silt matrix	
4	220-S10	24.5-24.7	Clay and silt of alluvial plain. Fine grained material (silt)	
5	221-S6	8.3-8.6	reddish sand	
6	221-S6	15.6-16	clay	



Characterization of Aquifer porous media-Bologna site

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Assess the toxicity of groundwater samples

Assessment of toxicity of groundwater samples and potential toxicity synergisms due to multiple chemical exposure.

Ecotoxicity tests with *Daphnia magna* and *Danio rerio*, using ECs detected in Cremona and Bologna groundwater.

Anthropogenic contaminants

Composition	Bologna		Cremona	
	Concentration		Concentration	
	(mg/L)	mM	(mg/L)	mM
CaCO3	475	4.75	158.3	1.6
MgSO4	138	1.15	46.1	0.4
Ca(HCO3)2	673	4.15	224.2	1.4
NaCl	67	1.15	22.4	0.4
NaNO3	34	0.4	11.3	0.1
Humic acid (sodium salt)	5		5	5
	µg/L		µg/L	
tetrachloroethylene (PCE)	30		10.0	
NaF	75		25	
(NH4)OH	100		33.3	
H3BO3	800		266.7	

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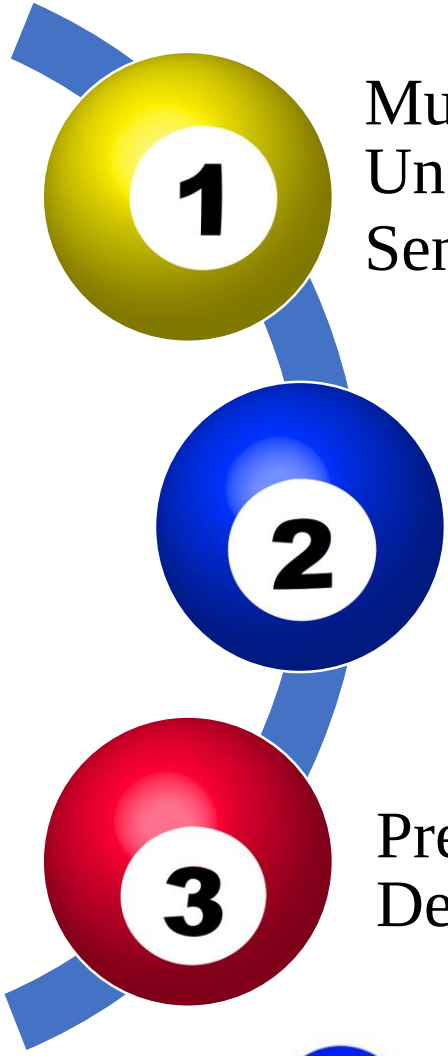

Multiple sources of uncertainty
Uncertainty Quantification –
Sensitivity Analysis

(Multi-) Modelling - Calibration

Predictions –
Decisions Under uncertainty

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Thank you

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la tua acqua, la nostra passione

Israel Water Authority

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