Innovative and Sustainable Groundwater Management in the Mediterranean

M3.1 Choice of the typology of the surrogate models to be tested in the five study cases

Acknowledgment: This project is part of the PRIMA Programme supported by the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 1923.

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DOI: 10.5281/zenodo.4756740

Project Information

Project Title	Innovative and sustainable groundwater management in the Mediterranean		
Project Acronym	InTheMED	Grant Agreement Number	1923
Program	Horizon 2020		
Type of Action	Water RIA – Research and innovation Action		
Start Data	March 1, 2020	Duration	36 months
Project Coordinator	Universitat Politècnica de València (UPV), Spain		
Consortium	Universitat Politècnica de València (UPV), Spain Helmholtz-Zentrum für Umweltforschung (UFZ), Germany Università degli Studi di Parma (UNIPR), Italy Boğaziçi Üniversitesi (BU), Turkey Centre de Recherches et des Technologies des Eaux (CERTE), Tunisie Technical University of Crete (TUC), Greece Associacao do Instituto Superior Tecnico para a Investigaçao e Desenvolvimiento (IST-ID), Portugal		

Document Information

<table>
<tr><td>Milestone Number</td><td>3.1</td><td>Milestone Name</td><td colspan="2">Choice of the typology of the surrogate models to be tested in the five study cases</td></tr>
<tr><td>Work Package number</td><td>3</td><td>Work Package Title</td><td colspan="2">Innovative Smart Modelling in the MED</td></tr>
<tr><td>Due Date</td><td>Contractual</td><td>November 1, 2020</td><td>Actual</td><td>May 13, 2021</td></tr>
<tr><td>Version Number</td><td colspan="4">1.0</td></tr>
<tr><td>Deliverable Type</td><td>report (R)</td><td>Dissemination Level</td><td colspan="2">public (PU)</td></tr>
<tr><td>Authors</td><td colspan="4">WP3</td></tr>
<tr><td>Reviewer(s)</td><td colspan="4">All</td></tr>
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Document History

Version	Date	Stage	Reviewed by
1.0	2021/05/13	Final version	All

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Glossary

BU	Boğaziçi Üniversitesi.
CERTE	Centre de Recherches et des Technologies des Eaux.
IST-ID	Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento.
MED	Mediterranean.
PU	Public.
R	Document, report.
TUC	Technical University of Crete.
UFZ	Helmholtz-Zentrum für Umweltforschung.
UNIPR	Università degli Studi di Parma.
UPV	Universitat Politècnica de València.
WP	Work Package.

1. Minutes of the Task 3.1 Meeting

The meeting was held virtually on May 7th, 2021 between 14:30 and 16:00 CET on a call by the WP3 leader with the list of attendees that follows:

Ali Saysel, Andrea Zanini, Daniele Secci, George Karatzas, Hanen Akrout, Irem Daglu, Janire Uribe Asarta, João Lino Pereira, José Jaime Gómez Hernández, Laura Molino, Leonardo Azevedo, Lobna Mansouri, Marco D'Oria, Maria Giovanna Tanda, Nadim Copty, Seifeddine Jomaa, Thouraya Mallah, Valeria Todaro, Vanessa Godoy.

Welcome by Project Coordinator and WP leader

The Project Coordinator and WP3 leader welcome everybody and introduces the topic of the meeting: *Milestone of the task 3.1: Selection of the smart model types suitable for application to groundwater systems*.

Review of the Task 3.1

The UNIPR group presented the results of the survey sent to partners in autumn 2020.

The survey (attached to these minutes) regarded the objectives of each site and the type of analyses that each partner would carry out.

Considering that, all the study sites will investigate several scenarios of climate change, Valeria Todaro presented a brief introduction on climate data and sea level rise.

The survey allowed to distinct the sites into two groups: sites with numerical models (Utiel-Requena (Spain), Tympaki (Greece), Castro Verde (Portugal), Konya (Turkey)) and without (Grombalia (Tunisia) and Mediterranean Sea region).

Moreover, regarding the sites with numerical model, in Spain, Turkey and Portugal a groundwater flow model will be developed; while in Greece a groundwater flow and transport model will be developed. In order to accomplish the objectives of these sites, WP3 leader, Andrea Zanini, showed the results obtained, on an example study case, with two types of surrogate models: artificial neural network and random forest.

Regarding the sites without numerical models, Maria Giovanna Tanda presented, as example, a linear regression approach to evaluate the effect of climate change on groundwater using standardized features such as Standardized Precipitation Index (SPI), Standardized Precipitation-Evapotranspiration Index (SPEI) and Standardized Groundwater Index (SGI).

Next actions and closing remarks

UNIPR team and all partners agreed to have one-by-one meetings in order to discuss each study case in detail.

The Project Coordinator reminded that September 30th is the deadline to submit the contribution for the mid-term report and for the mid-term financial report.

Attachments

- Results of the survey,
- Presentation of the task 3.1.

2. Survey

2.1. Survey Questions

1. Site Name:

2. Name and email of the responsible of the model/data analysis:

3. What is the purpose of the investigation?

4. Are you planning to use a numerical model to study the site?

    4.1. What is the objective of the model?

    4.2. Will you simulate flow or flow and transport?

    4.3. Is the numerical model already available?

    4.4. If the numerical model is "under construction" when it will be available?

    4.5. Which software did you use or plan to use?

    4.6. Please list some characteristics of the numerical model, such as: number of layers or grid nodes, type of aquifers (free, confined, fractured, sedimentary, karst), type of boundary conditions, hydraulic conductivity values or range, steady or transient flow, type of contaminant (organic, inorganic), type of transport (reactive, conservative). storativity, porosity, dispersivity, adsorption constants, density)?

    4.7. Do you have measurements of head and/or concentrations?

    4.8. Are the parameters known (for instance hydraulic conductivity, transmissivity, storativity, porosity, dispersivity, adsorption constants, density)?

    4.9. Do you plan to use historical time series? storativity, porosity, dispersivity, adsorption constants, density)?

    4.10. What is the objective of your analysis?

    4.11. Are you interested in piezometric and/or concentration data?

4.12. Which dataset are you considering? (hydraulic levels, rainfall, concentration data, …)

4.13. Are the historical data already available, or when will they be available?

4.14. How long is the historical dataset? Which period does it cover?

5. Have you already implemented a surrogate model?

   5.1. Which kind of model did you use?

2.2. Results

UPV

1. Hydrogeological unit 08.24 Utiel-Requena.

2. J. Jaime Gómez-Hernández (jaime@dihma.upv.es).

3. The investigation will address the overexploitation of the aquifer due to excess pumping, the hydraulic heads have experienced a consistent decline over the last 10 years after the transformation of dry vineyard farming to irrigated farming. Moreover, it will analyse different sustainable management strategies and policies to revert the quantitative status to good.

4. Yes.

   4.1. The model will be used to analyse future climate scenarios and alternative management schemes for them present and future implementation.

   4.2. Requena-Utiel aquifer does not present any contamination issue, therefore, only flow simulation will be performed.

   4.3. There is a numerical model made in 2017. Nevertheless, several field trip will be made in order to collect new data logs and then, an updated model will be built.

   4.4. It cannot be determined exactly when the updated model will be ready since field trips have not been established due to restrictions and delays caused by the situation derived from Covid-19.

4.5. The computer code MODFLOW (Harbaugh, A. W. et al., 2005) will be used to simulate flow with the support of the graphical user interface ModelMuse (Winston, R. B., 2020). Furthermore, FloPy will be used to process MODFLOW-based model, this is a Python package (van Rossum and Brake, 2009).

4.6. The design of the regular mesh is based on a horizontal discretization in square cells of 500 x 500m^2, obtaining a total of 37.719 cells, made up of 127 columns and 99 rows. Regarding the vertical discretization, the hydrological unit 08.24 Utiel-Requena is composed of three layers that rest on an impermeable bed of Keuper facies. The upper aquifer is a quaternary aquifer, free and composed of detrital materials from the alluvial of the Magro river and glacis from Utiel mountains. The lower aquifer is a Miocene aquifer divided into two systems. The upper system is a calcareous Miocene aquifer, free and composed of Pontian limestone. The lower system is a base conglomerate Miocene aquifer, it behaves as a confined or semi-confined aquifer, depending on the site and it is composed of alternating levels of conglomerates and sandstones with clayey sections and conglomerates of the tertiary formation.

The 2017 model performs the simulation during the period of time between 1940 and 2016. On the one hand, a steady or an uninfluenced regime simulation was carried out from the hydrological year 1940/41 to the hydrological year 1979/80. And on the other hand, a transient or an influenced regime simulation was performed between the hydrological years of 1980/81-2015/16, with a monthly time discretization, in order to know the effect of pumping in the aquifer storage.

As boundary conditions, lateral limits, rivers and recharge are considered. First, the lateral limits correspond to the interactions between the study aquifer and the adjacent groundwater masses. In the north, there is the Mira groundwater mass, there is a flow towards the Requena-Utiel mass of 10 hm^3/year. In the east, The Las Serranías groundwater mass is located, the interaction is variable according to the piezometry of the area. In the southeast, there is a flow discharge from Cabrillas-Malacara to Buñol-Cheste of 3 hm^3/year. In the western contour, a discharge of 1,26 hm^3/year is established towards Hoces de Cabriel. The rest of the limits are considered impermeable. Secondly, Magro and Romeroso rivers have been included in the model. The Magro river crosses the study area through the central part from the northeast to the southeast and it is the one that has the greatest influence on the aquifer. The Romeroso river is located on the western contour on the Requena-Utiel aquifer. Finally, the recharge by infiltration of precipitation is also considered.

Regions of similar hydrogeological behaviour have been defined for the hydrogeological characterization of Requena-Utiel aquifer, resulting is five different domains. In the same way, these five domains haven been thoroughly subdivided to create 25 subdomains. The value of hydraulic conductivity has a range between 0,02 and 10 m/day.

No contaminants have been detected in the groundwater of Requena-Utiel aquifer, therefore, transport simulation is not performed.

4.7. We have head measurements.

4.8. No.

4.9. Yes, hydraulic heads time series.

4.10. The objective of the analysis of the different management schemes is to determine which of them is the optimal one to guarantee the urban and agricultural supply while re-establishing the good quantitative status of the hydrological unit 08.24 Utiel-Requena, given the future climate and irrigated land use scenarios.

4.11. Piezometric data.

4.12. Hydraulic levels, rainfall and pumped water series.

4.13. Yes, historical data on hydraulic heads are already available on the internet portal of the Ministry for the Ecological Transition and the Demographic Challenge of the Government of Spain

4.14. The hydraulic heads time series covers the period of 1980-2016. However, the historical data are very scarce, some piezometers only have one monthly value recorded, nevertheless, the majority of them have data for about 15 years consecutively.

5. The surrogate model has not been implemented yet.

UFZ

1. Mediterranean Sea Region

2. Seifeddine Jomaa (seifeddine.jomaa@ufz.de)

3. Trend analysis and clustering of groundwater quality and dynamic using the long-term time's series data collected from different Mediterranean countries.

4. No

4.10. Yes

4.11. Understand the groundwater dynamic and quality in the Mediterranean region and their controlling factors using the cause-effect relationships (DPSIR framework).

4.12. Both. We are interested in historical piezometric levels and groundwater quality parameters, especially nitrate concentrations and salinity. Based on our preliminary survey, we think the concentration data are very limited and heterogeneous in space and time the Mediterranean region. If so, we will focus on some countries instead for the groundwater quality investigations (France, Spain and Greece) for detailed analyses.

4.13. All explanatory variables that can be included in the DPSIR framework for groundwater quality and dynamic will be considered.

4.14. Some are available and some are in progress. We trying to have the Mediterranean database as a dynamic process, where the data collection task will be running continuously over the course of the project. Our approaches will be tested under different database version and regions.

4.15. The length and time period of the historical data vary among the countries. When we have our first database version we will decide which time period and frequency are more appropriate for our analysis.

5. Not really. We are reviewing the most used surrogate tool for data-driven analysis. Machine learning (random forest) has shown to be a beneficial tool for this purpose. We are still investigating and no clear decision was taken yet.

   5.1. We have used Modflow for groundwater at case study scale. We did not start the modelling part for the regional scale yet. But our idea is to use a surrogate model instead of numerical model as detailed above.

TUC

1. Tympaki

2. George Karatzas, karatzas@mred.tuc.gr

3. Tympaki aquifer presents saltwater intrusion up to 2 km inland, nitrate pollution and the interaction of engineering nanoparticles and nano-pesticides with soil under different climate scenarios

4. Yes

   4.1. Salt water intrusion and nitrogen pollution

   4.2. Flow and transport

   4.3. Under construction

   4.4. Dec 2021

   4.5. FEFLOW model

   4.6. The model consists of two layers, with 3615 nodes on each layer and 6695 elements. The model of the unconfined porous (sedimentary) coastal aquifer will eventually consider all the geological properties of the formations in the region. The main concern in the region is saltwater intrusion, which will be modelled through the chloride concentration, as a conservative inorganic contaminant. The boundary conditions are of 1st type for the shoreline (hydraulic head is zero), and flux coming from inland (2nd type), fluctuating with a cosine function throughout the year, taking into account the historical data of rainfall in the region. The initial hydraulic conductivity taken from a literature review ranges from 10-2 to 10-3 m/d, but these values need to and will be further calibrated. The flow in the model is transient according to observed data time-series.

4.7. Yes, and we are still collecting

4.8. Yes, we have data for hydraulic conductivity, transmissivity, storativity, porosity, dispersivity

4.9. YES

4.10. Groundwater level space-time dynamics, salt water intrusion, climate change effects, management scenarios

4.11. piezometric and concentration data

4.12. groundwater levels, Chloride concentration

4.13. available

4.14. 1981-2020

5. YES, in terms of Kriging methodology

5.1. Kriging and Modflow

IST-ID

1. Castro Verde (Portugal)
2. João Lino Pereira joao.lino.pereira@tecnico.ulisboa.pt
3. The identification of the depth of the water table and the spatial distribution of the aquifer
4. Yes

4.1. The ability to predict the spatial distribution of the relevant rock properties for subsurface fluid flow from geophysical inversion

4.3. No, under development

4.4. We expect to have it ready (i.e., design, implementation and application in toy examples) in one year.

4.5. The development of the software application will be in MATLAB.

4.6. Unfortunately, we cannot answer yet, as we don't have all the data on our side. But we will try to create models Electrical resistivity, which will then be converted in the relevant rock properties.

4.7. Yes, we will have access to these data to calibrate the model. The data also have information about the geochemistry of the waters.

4.8. There is already a rough idea about the aquifer in terms of hydraulic conductivity and porosity. However, the models are low-resolution and we aim at improving the variability (spatial resolution of the models. The good thing about this site is the relatively high number of direct measurements.

4.9. No.

CERTE

1. Grombalia aquifer

2. Thuraya Mellah

4. No

4.9. Yes, historical and updated data

4.10. Groundwater quality index; to assess the evolution of groundwater state in different scenarios (i.e BAU, strategy of sustainable practices, remediation strategies,….)

4.11. Yes

4.12. hydraulic levels, rainfall, concentration data, …

4.13. Available in part

4.14. What is available at this moment 2011-2017

5. No

5.1. We think to use econometric model (parametric model).

BU

1. Konya Closed Basin, Turkey

2. Nadim Copty,Bogazici University, Turkey ncopty@boun.edu.tr

3. Estimate Water budget for the entire basin, Analyze the effect of different climate scenarios on water availability in the basin. The estimated water budget will be incorporated into a system dynamics model of socio-economic activity (WP4)

4. Yes

4.1. The purpose of the spatially distributed hydrologic model is to simulate the water flow through the basin.

4.2. Flow only

4.3. No, it is currently under construction

4.4. It is anticipated that the modeling task will take about 12 months until Dec 2021

4.5. MODFLOW

4.6. The model is under construction. It is anticipated that the model will be multilayer with a shallow unconfined and a deeper confined aquifer. The model will cover the entire watershed. As such the outer boundaries of the model will be no flow boundaries. The Konya basin is a closed basin with no significant water interaction with adjacent watersheds. Precipitation feeds the aquifer systems which is then extracted and used mostly for agriculture and domestic purposes. The main objective of the model is to estimate the current net recharge to the aquifer system as well as the net recharge for different climate change scenarios.

4.7. We will acquire hydraulic head data from the State Water Works. We are also planning to collect high frequency head data at selected locations.

4.8. Some transmissivity/Storativity data are available. We are currently in the process of collecting available data from the State Water Works and Published papers/reports.

4.9. No

5. No

3. Presentation of Task 3.1

WP3

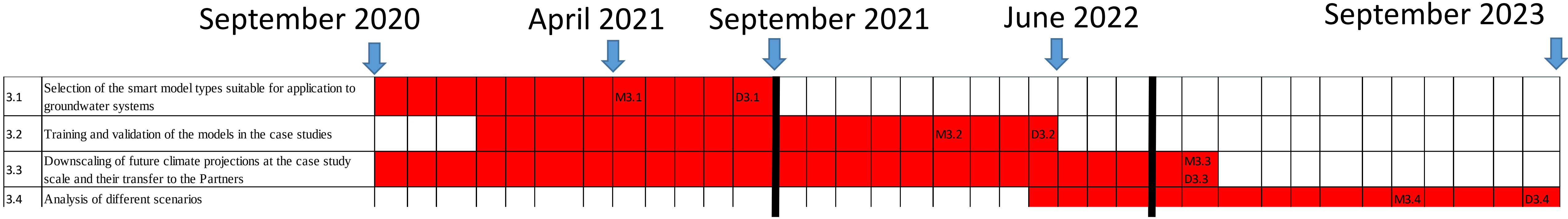
Innovative Smart Modelling in the MED

Task 3.1

Virtual meeting, May 7th, 2021

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

UNIVERSITÀ DI PARMA
DEPARTMENT OF ENGINEERING AND ARCHITECTURE



Task 3.1: Selection of the smart model types suitable for application to groundwater systems (Lead: **UPV**/ participants: All partners), (Month 1 – Month 12).

Task 3.2: Training and validation of the models in the case studies (Lead: UNIPR/ participants: UPV, UFZ, TUC, IST-ID, CERTE and BU), (Month 4 – Month 21).

Task 3.3: Downscaling of future climate projections at the case-study scale and their transfer to the Partners. (Lead: UNIPR/ participants: UPV, UFZ, TUC, IST-ID, CERTE and BU), (Month 1 – Month 26).

Task 3.4: Analysis of different scenarios. (Lead: UNIPR/ participants: UPV, TUC, IST-ID, CERTE and BU), (Month 20 – Month 36).

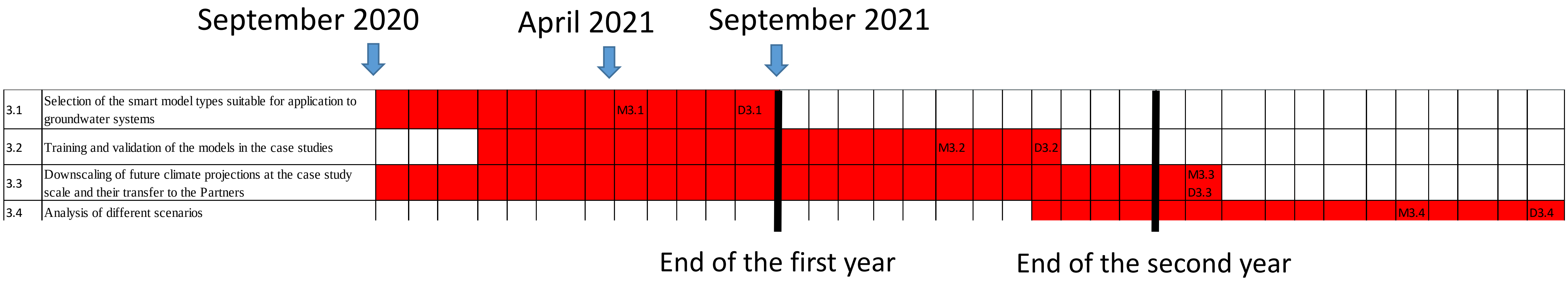
Deliverables

D3.1: Identification of the surrogate models to be applied in the case studies (M12)

D3.2: Report on surrogate models in the case studies (M21)

D3.3: Data archive containing the downscaled climate projections in the case studies (M26)

D3.4: Report on the results of the analysis of different scenarios in the case studies (M32)



Task 3.1: Selection of the smart model types suitable for application to groundwater systems (Lead: **UPV**/ participants: All partners), (Month 1 – Month 12).

Milestone: M3.1 Choice of the typology of the surrogate models to be tested in the five study (M8 - Minutes of the meeting)

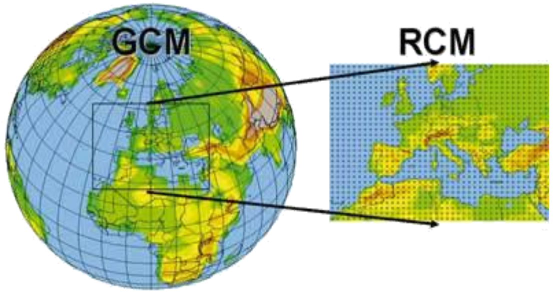
Deliverables

D3.1: Identification of the surrogate models to be applied in the case studies (M12)

Climate Change: dataset of temperature and precipitation

General Circulation Model

Resolution: 250 e 600 km



Regional Climate Model

Resolution: 10-50 km

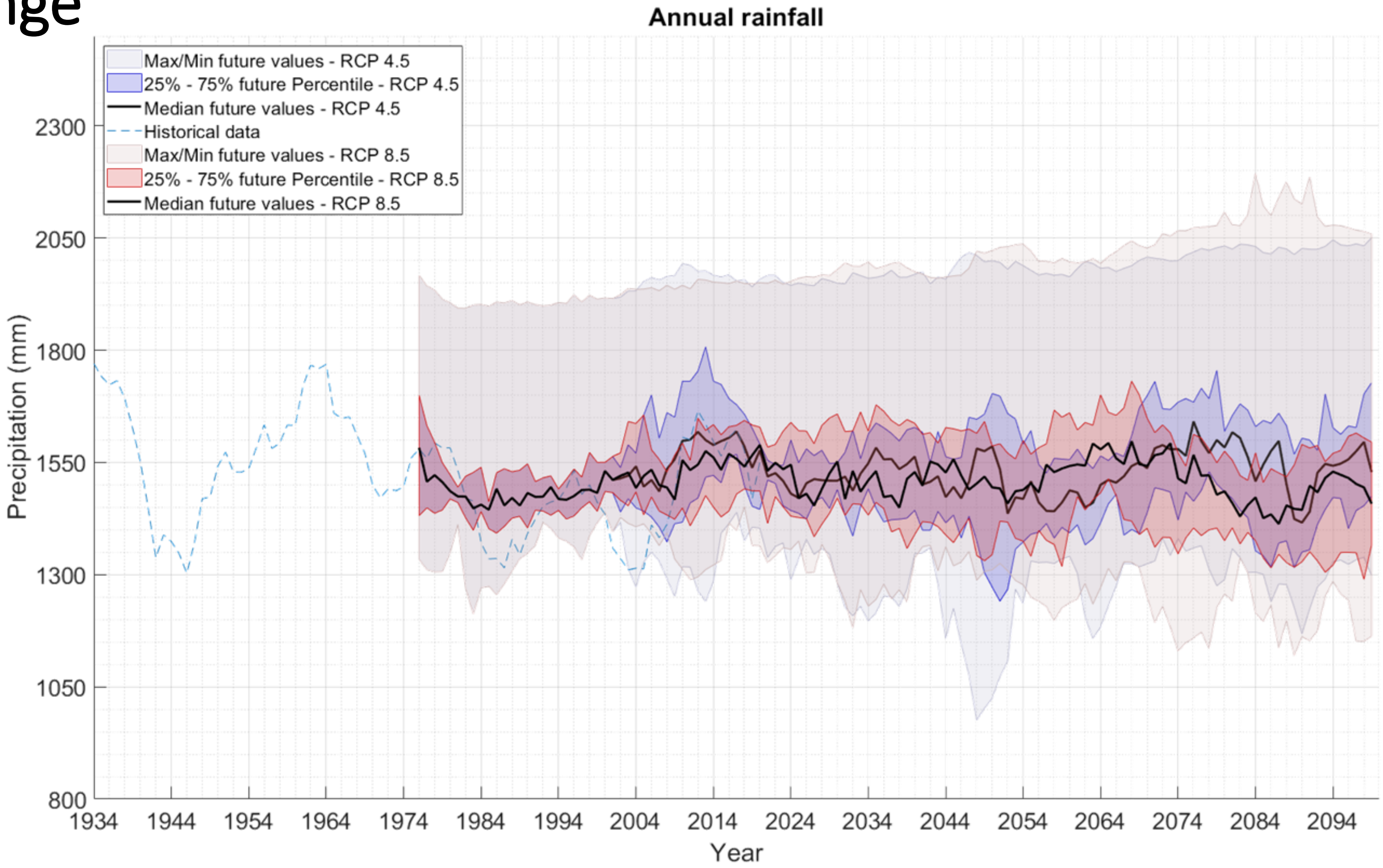
13 GCM-RCM from **EURO-CORDEX project**

RCM	GCM: CNRM-CERFACS-CNRM-CM5	ICHEC-EC-EARTH	MOHC-HadGEM2-ES	MPI-M-MPI-ESM-LR	IPSL-IPSL-CM5A-MR
CCLM	x	x	x	x	
HIRHAM5		x			
WRF331F					x
RACMO22E		x	x		
RCA4	x	x	x	x	x

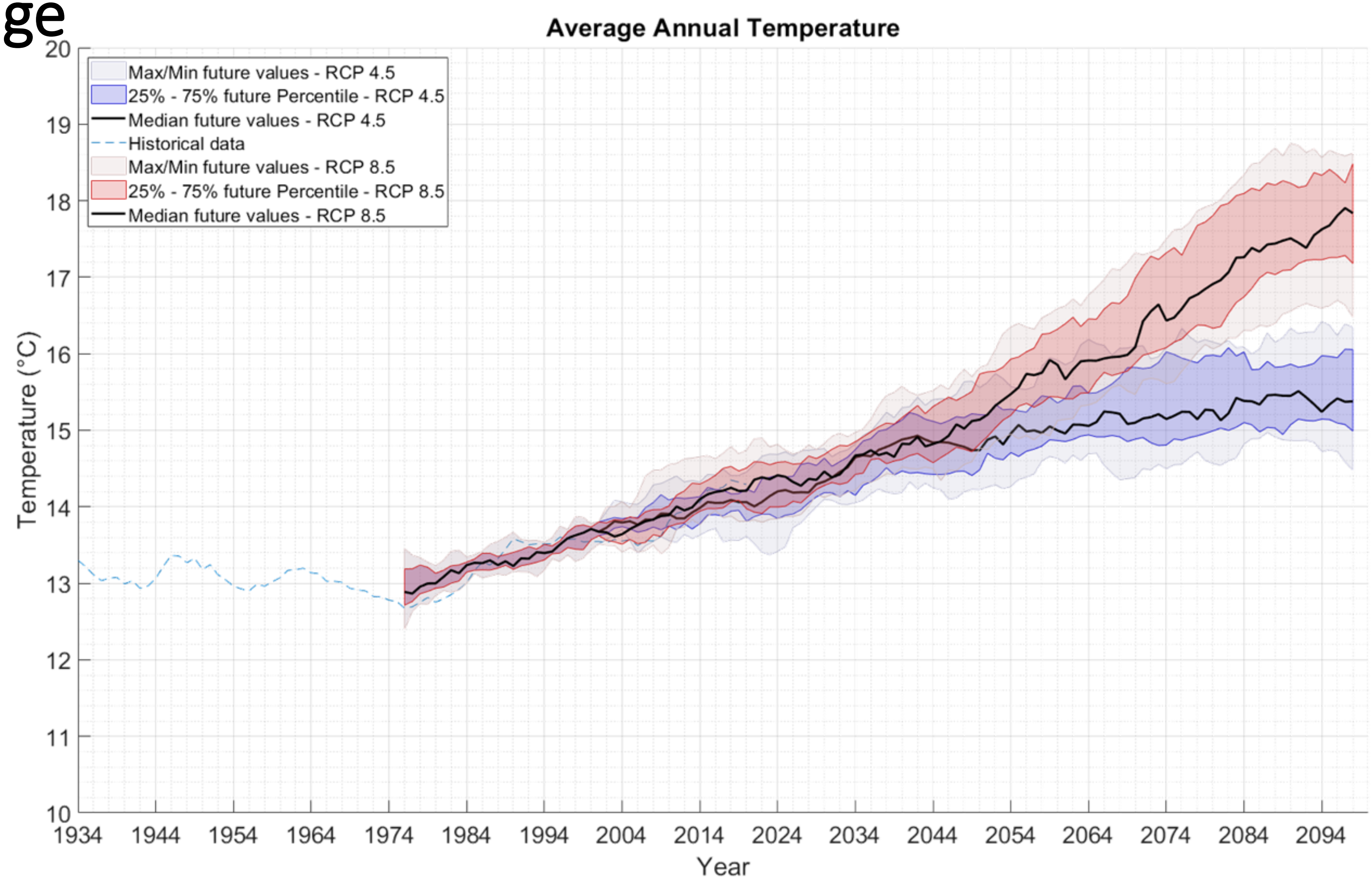
https://www.euro-cordex.net/

Emission scenarios → RCP 4.5 / RCP 8.5

Climate Change

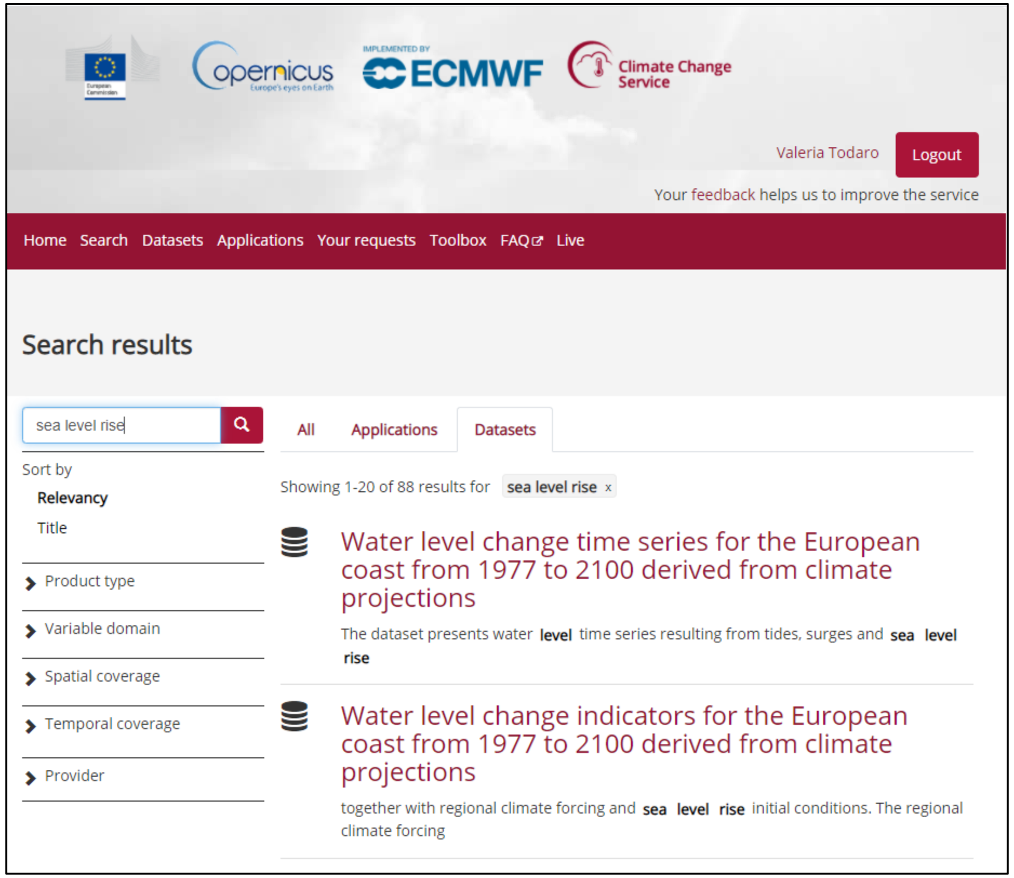


Climate Change



Climate Change: dataset of mean sea levels for saltwater intrusion

COPERNICUS CLIMATE CHANGE SERVICE



https://cds.climate.copernicus.eu

→

DATA DESCRIPTION	
Data type	Gridded
Horizontal coverage	Europe
Horizontal resolution	Coastal grid points: 0.1° Ocean grid points: 0.25°, 0.5°, and 1° within 100 km, 500 km, and >500 km of the coastline
Vertical coverage	Surface
Vertical resolution	Single level
Temporal coverage	ERA5 reanalysis: from 1979 to 2017 Historical: from 1977 to 2005 RCP8.5: from 2041 to 2070 RCP4.5: from 2071 to 2100

Regional climate forcing: an EURO-CORDEX climate model

GCM: EC-EARTH

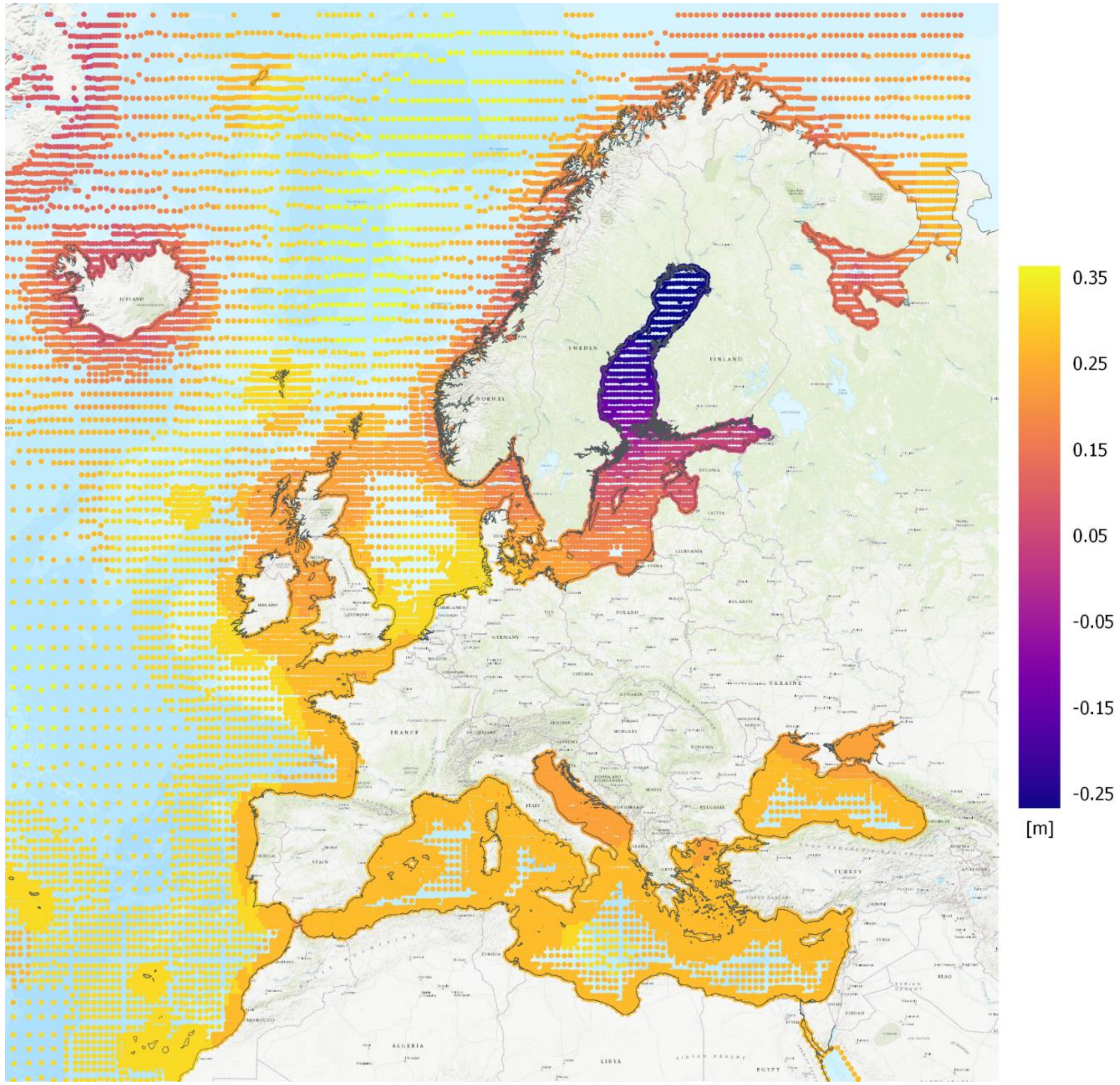
Core partners:

- SMHI, Sweden
- KNMI, The Netherlands
- DMI, Denmark
- AEMET, Spain
- Met Éireann, Ireland
- CNR-ISAC, Italy
- Instituto de Meteorologia, Portugal
- FMI, Finland

RCM: HIRAM5

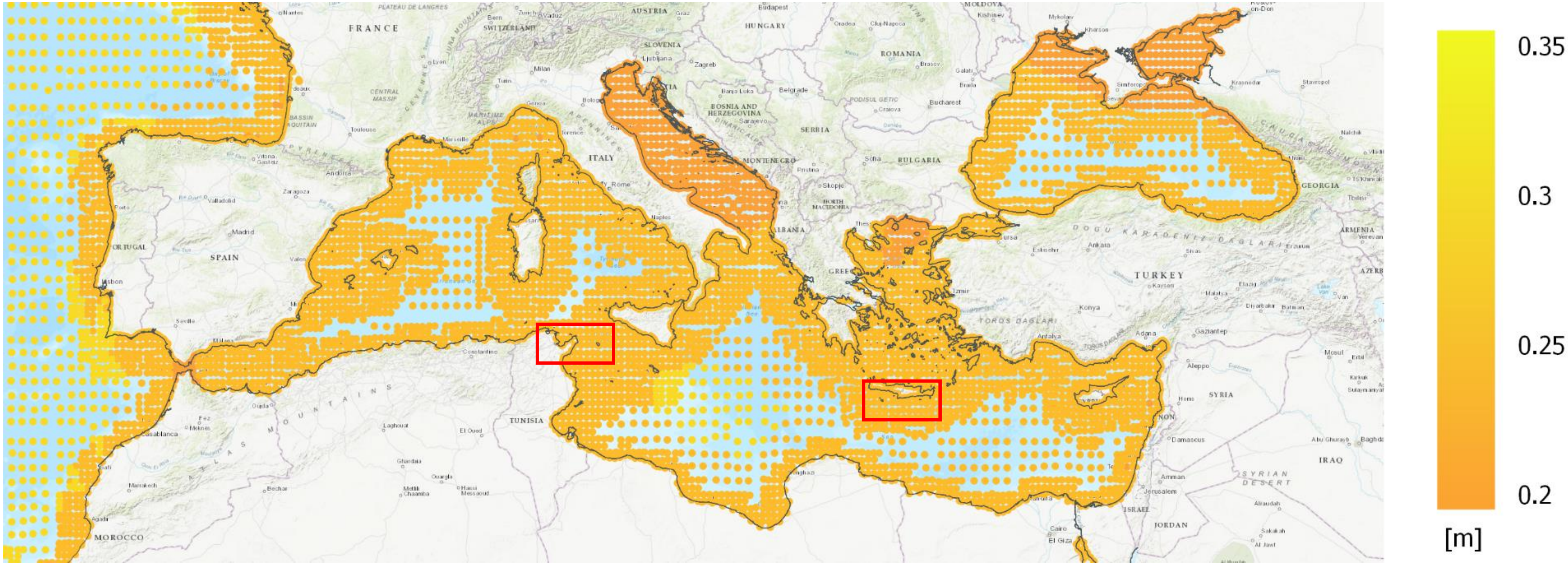
Developer:

- DNI, Denmark

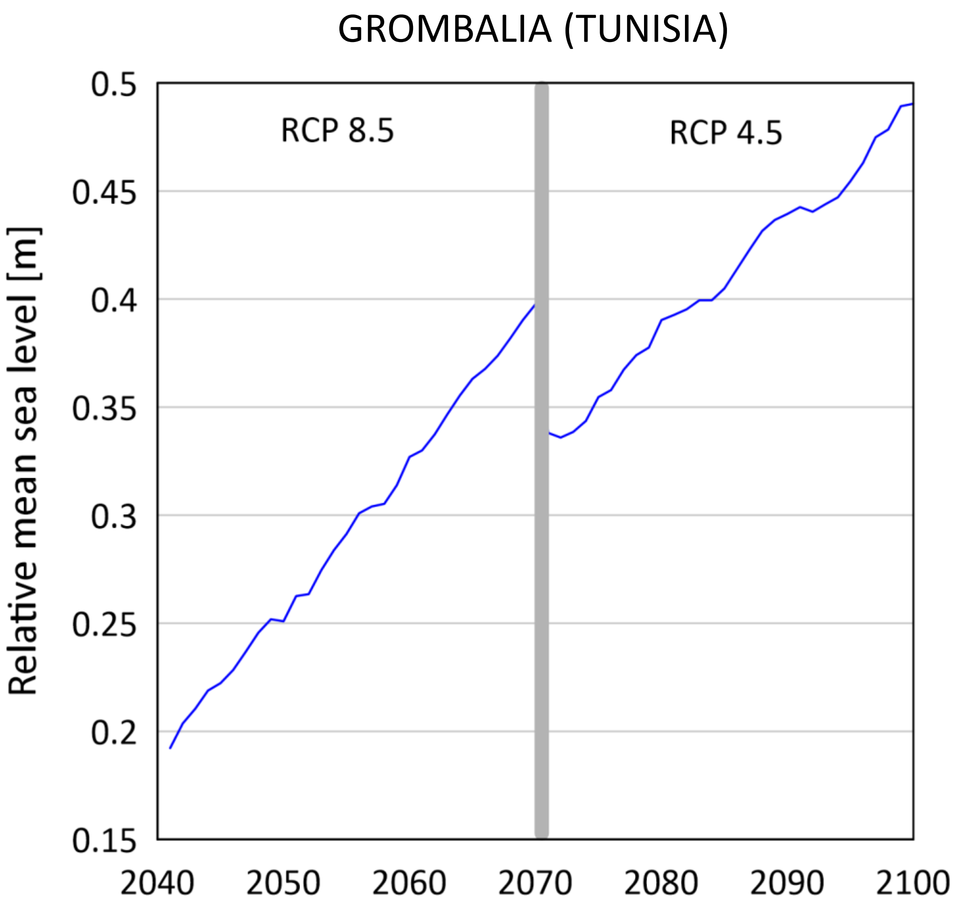


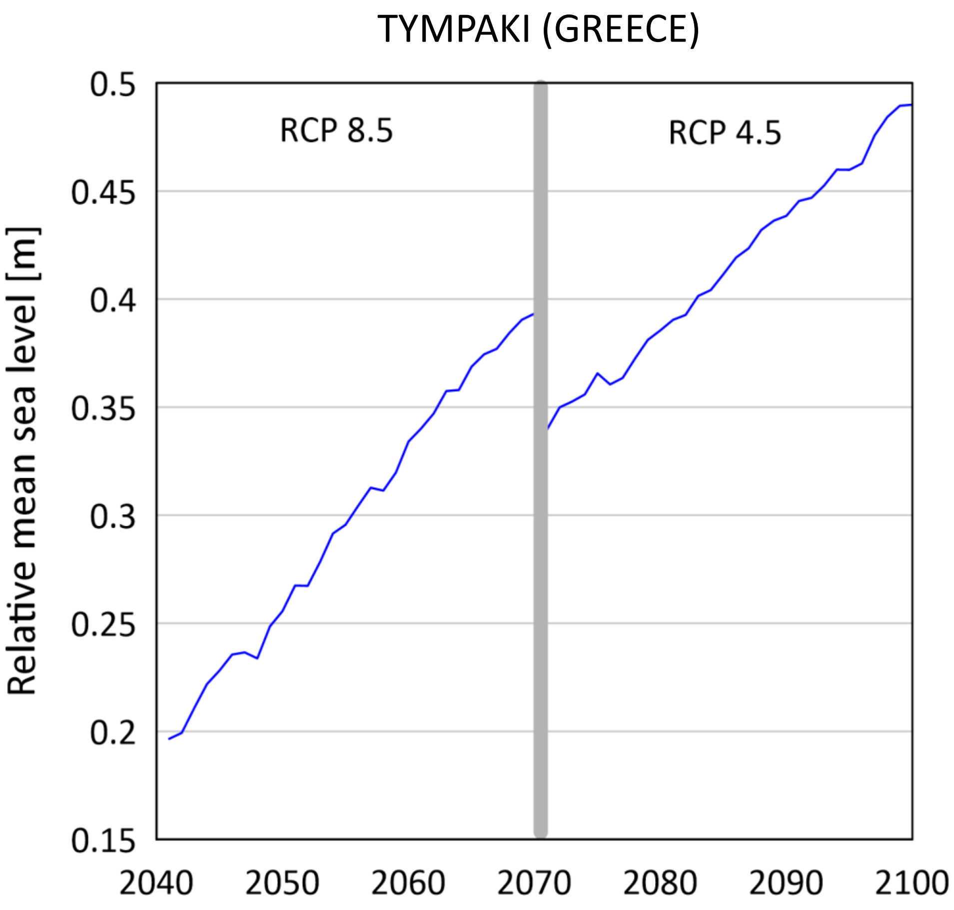
2050 mean sea level height relative to the historical mean sea level height (1985-2005)

2050 mean sea level height relative to the historical mean sea level height (1985-2005)



Mean sea level height relative to the historical mean sea level height (1985-2005)





WP3 Survey – main results

Utiel-Requena (UPV), Tympaki (TUC), Castro Verde (IST_ID), Konya (BU), have/will have numerical models

Objectives
UPV: the model will be used to analyse future climate scenarios and alternative management schemes for the present and future implementation
BU: Estimate Water budget for the entire basin, analyze the effect of different climate scenarios on water availability in the basin.
TUC: evaluation of saltwater intrusion, pollution under different climate scenarios
IST_ID: identification of the depth of the water table and the spatial distribution of the aquifer

Suggested Surrogate models
- Neural network
- Random forest

Final version of numerical models will probably be ready at the end of 2021

WP3 Survey – Groundwater flow model

Utiel-Requena (UPV), Konya (BU)

Objectives

UPV: the model will be used to analyse future climate scenarios and alternative management schemes for the present and future implementation

BU: Estimate Water budget for the entire basin, analyze the effect of different climate scenarios on water availability in the basin.

Suggested Surrogate models

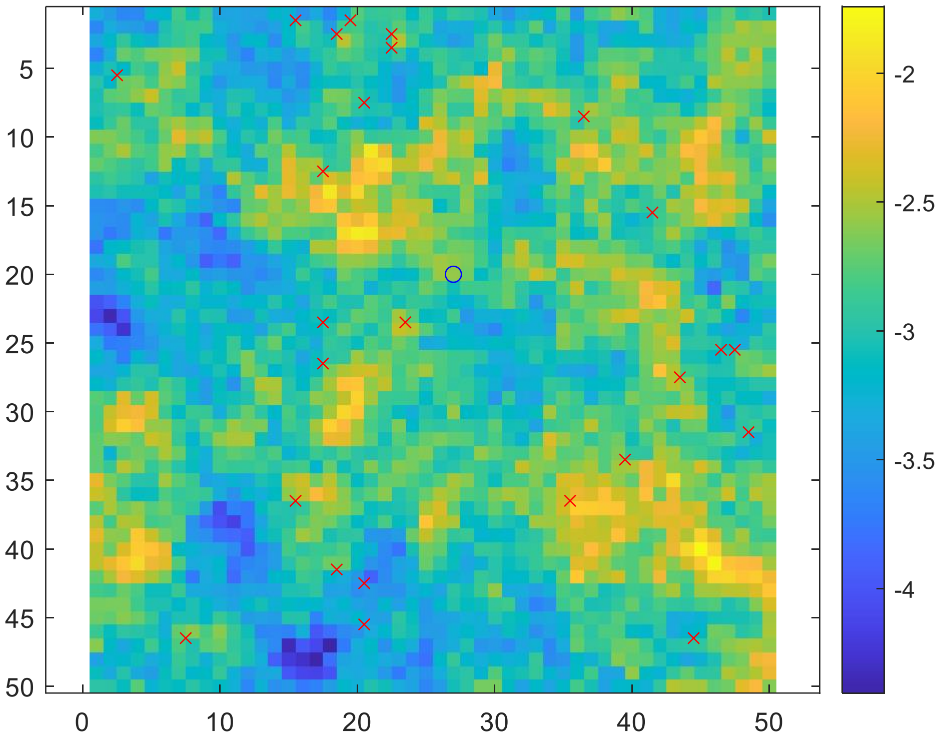
- Neural network
- Random forest

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

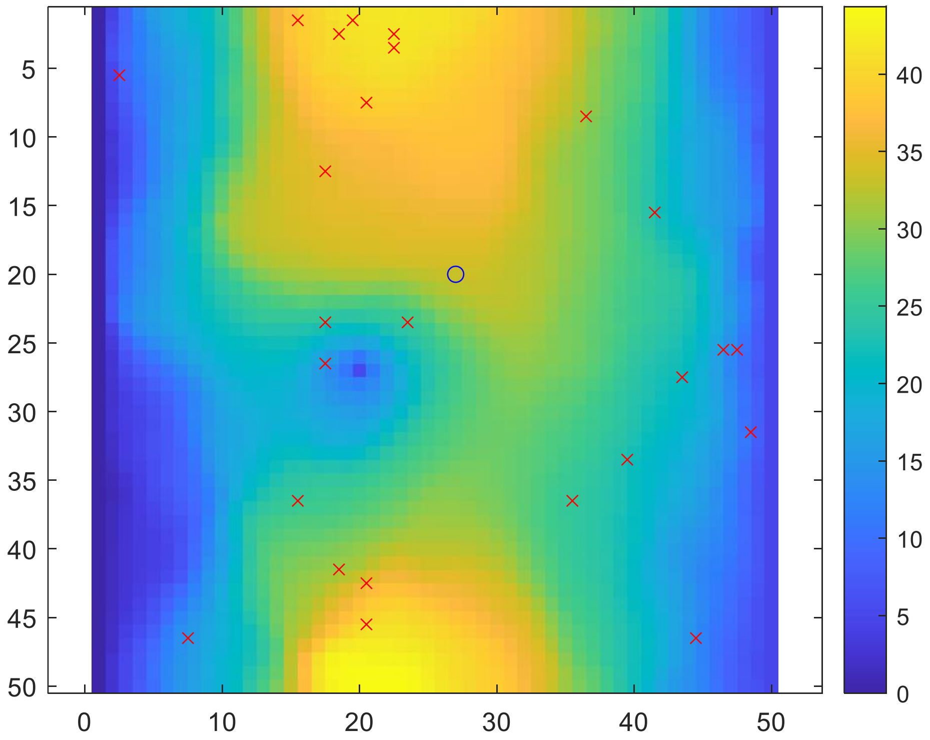
IN THE MED Innovative and Sustainable Groundwater Management in the Mediterranean

A simple example

$\sigma^2_{Y=lnT} = 1$ Y = Log_{10} T (m^2/s)



Hydraulic head (m)

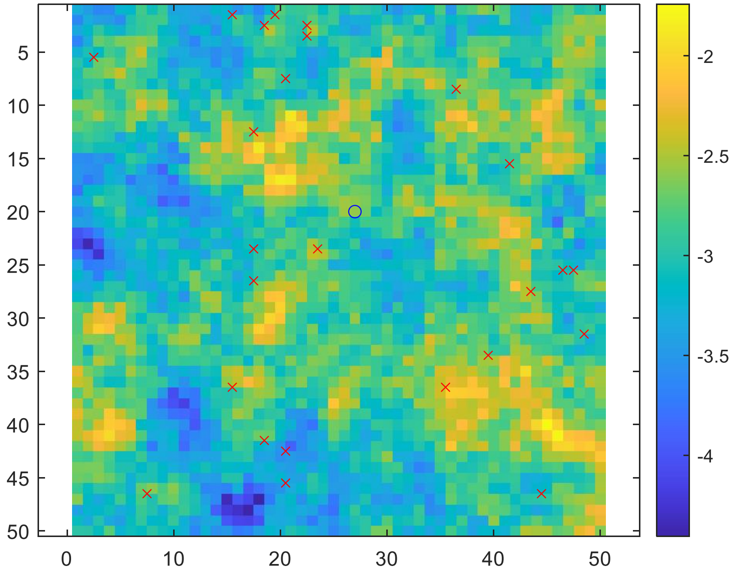


Hendricks Franssen HJ, Alcolea A, Riva M, Bakr N, van der Wiel N, Stauffer F, Guadagnini A (2009) A comparison of seven methods for the inverse modelling of groundwater flow. Application to the characterisation of well catchments. Adv Water Resour 32(6):851–872. https://doi.org/10.1016/j.adv watres.2009.02.011

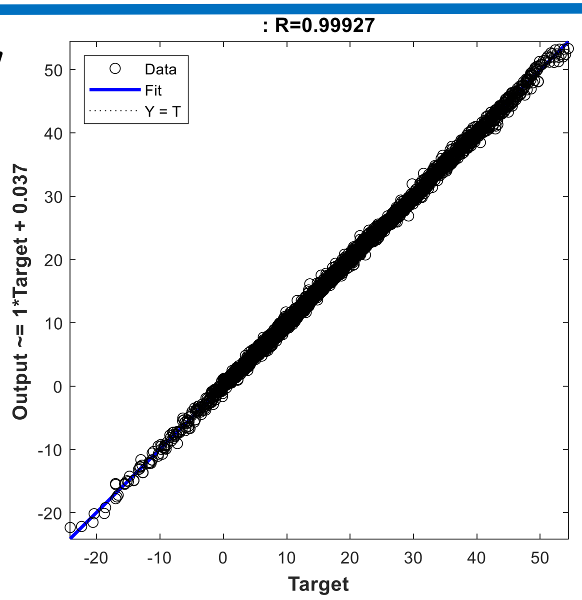
Pumping well flow rate (m^3/s): 0.02:0.005:0.095 (16 values)
Recharge rate (mm/y): 100:50:600 (11 values)
Total of 176 forward simulations
25 observations

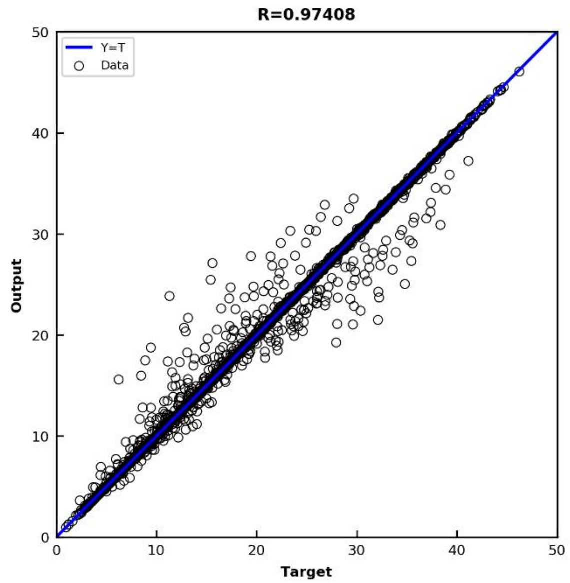
Test of ANN and Random Forest – GW Flow

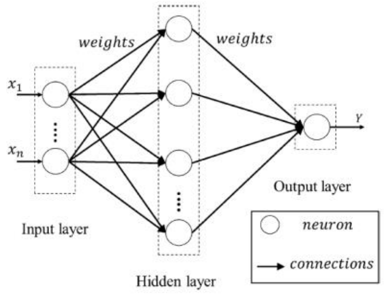
Objective: forward modeling - estimate hydraulic head at monitoring wells modifying recharge rate and/or pumping well rate.



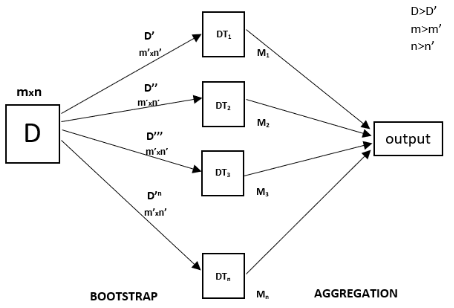
$$\sigma^2_{Y=lnT} = 1$$







Artificial Neural Network



Random Forest

WP3 Survey – Groundwater flow and transport models

Tympaki (TUC)

Objectives

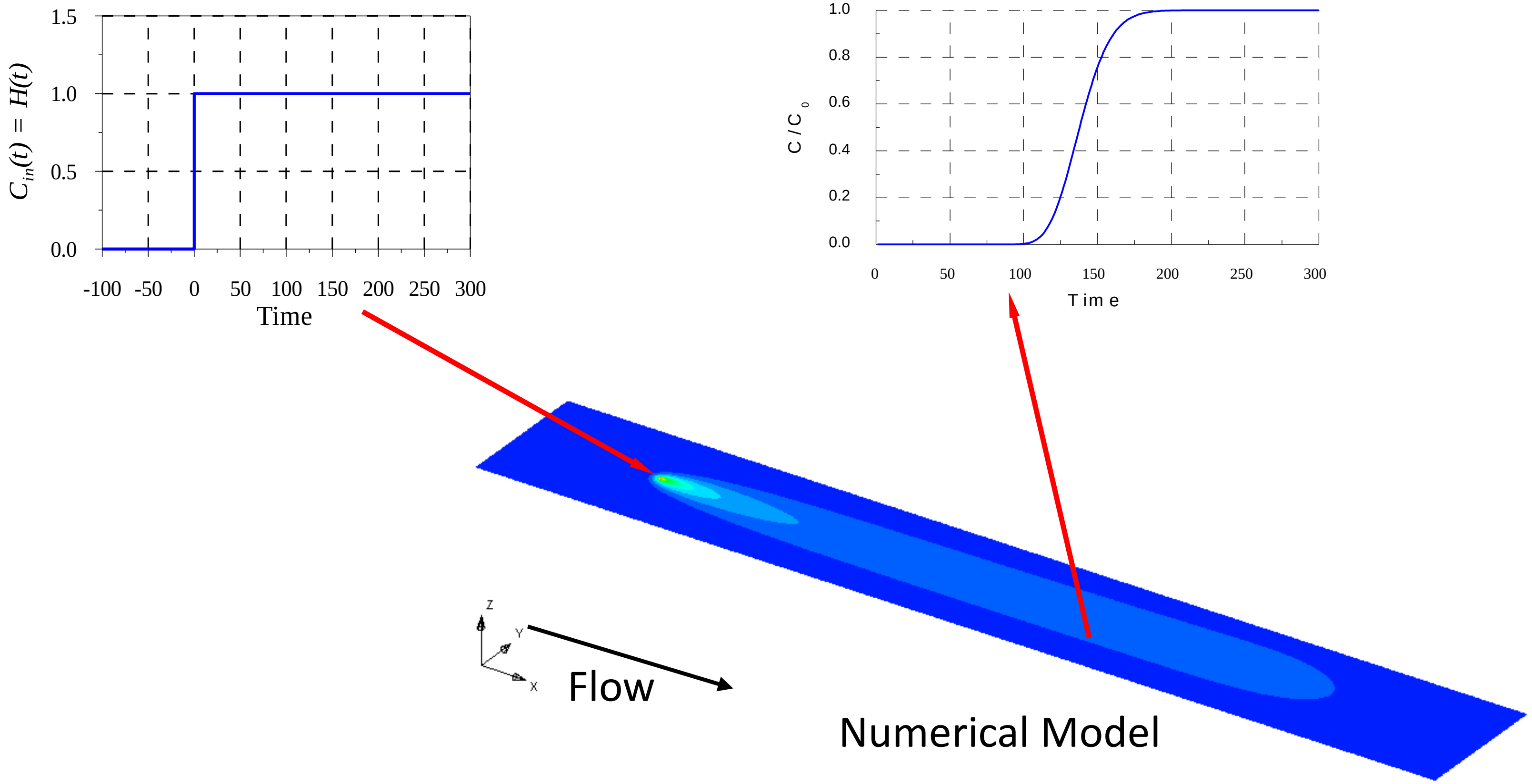
TUC: evaluation of saltwater intrusion, pollution under different climate scenarios

Suggested Surrogate models

- Neural network
- Random forest

Test of Surrogate models for GW Transport

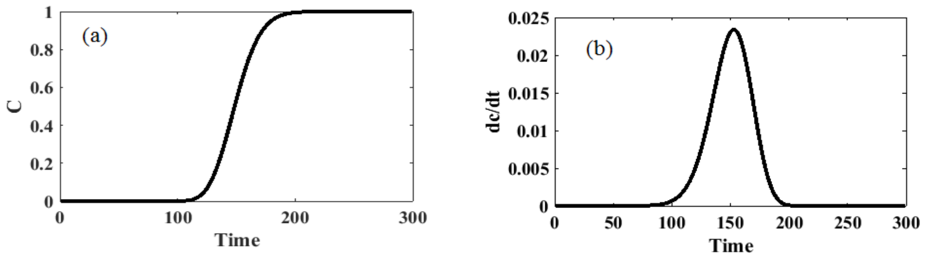
Objective: forward modeling - estimate concentration at monitoring wells modifying release history at a known contaminant source.



Transport of contaminants

For conservative non-reactive contaminants, we suggest to use the Transfer Function approach

$$C\left(\mathbf{x},t\right)=\int_0^t s\left(t-\tau\right)g(\mathbf{x},\tau)d\tau$$



$$g(\mathbf{x},t)=\frac{1}{F_0}\frac{\partial C\left(\mathbf{x},t\right)}{\partial t} \qquad t>0$$

$$\mathbf{z}=\mathbf{H}\cdot\mathbf{s}+\boldsymbol{\upsilon}$$

$$\mathbf{H}=\Delta t\cdot\begin{bmatrix} g\left(\mathbf{x}_1,T-\Delta t\right) & \dots & g\left(\mathbf{x}_1,T-n\Delta t\right) \\ g\left(\mathbf{x}_2,T-\Delta t\right) & \dots & g\left(\mathbf{x}_2,T-n\Delta t\right) \\ \dots & \dots & \dots \\ g\left(\mathbf{x}_M,T-\Delta t\right) & \dots & g\left(\mathbf{x}_M,T-n\Delta t\right) \end{bmatrix}$$

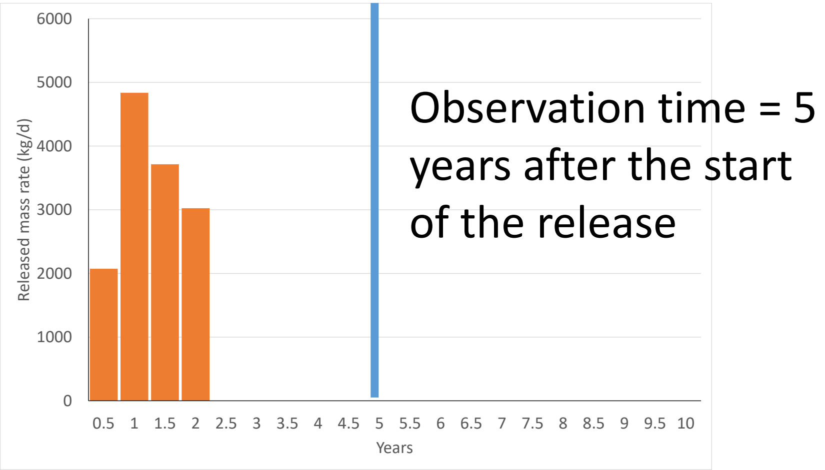
Jury, W. A. and K. Roth: Transfer Functions and Solute Movement through Soil. - Theory and Applications -. Birkhäuser Verlag, Basel, Boston, Berlin 1990; 226 Seiten, DM 65,-. ISBN 3-7643-2509-7

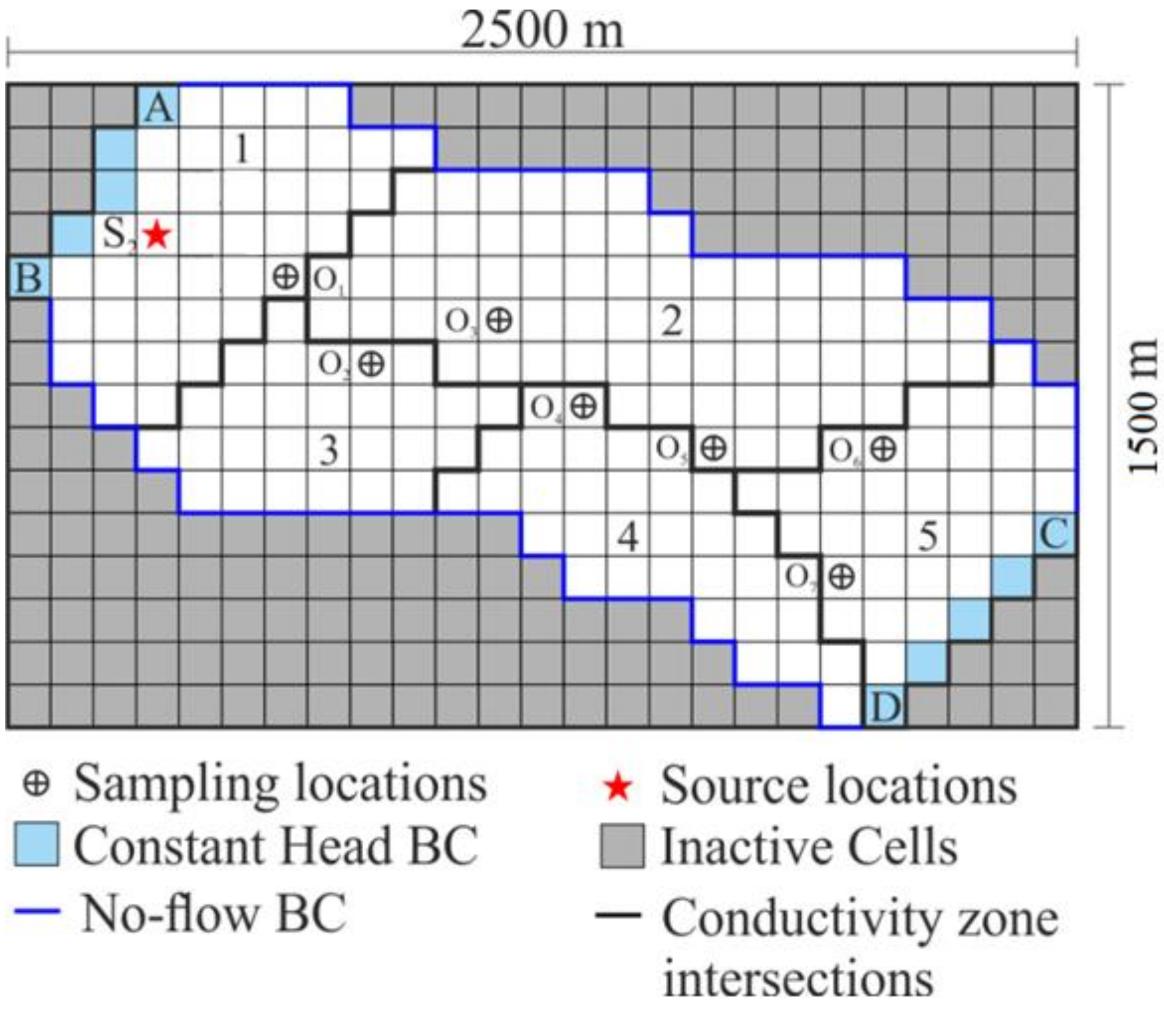
Study Case

Ayvaz, M.T. A linked simulation–optimization model for solving the unknown groundwater pollution source identification problems. *J. Contam. Hydrol.* **2010**, *117*, 46–59, doi:10.1016/j.jconhyd.2010.06.004.

Xing, Z.; Qu, R.; Zhao, Y.; Fu, Q.; Ji, Y.; Lu, W. Identifying the release history of a groundwater contaminant source based on an ensemble surrogate model. *J. Hydrol.* **2019**, *572*, 501–516, doi:10.1016/j.jhydrol.2019.03.020.

Jamshidi, A.; Samani, J.M.V.; Samani, H.M.V.; Zanini, A.; Tanda, M.G.; Mazaheri, M. Solving inverse problems of unknown contaminant source in groundwater-river integrated systems using a surrogate transport model based optimization. *Water (Switzerland)* **2020**, *12*, doi:10.3390/w12092415.

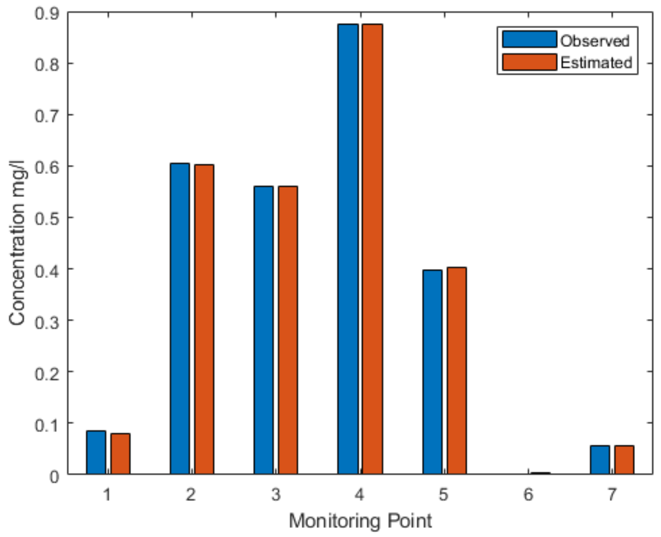




Study Case - ANN

Train simulations 256

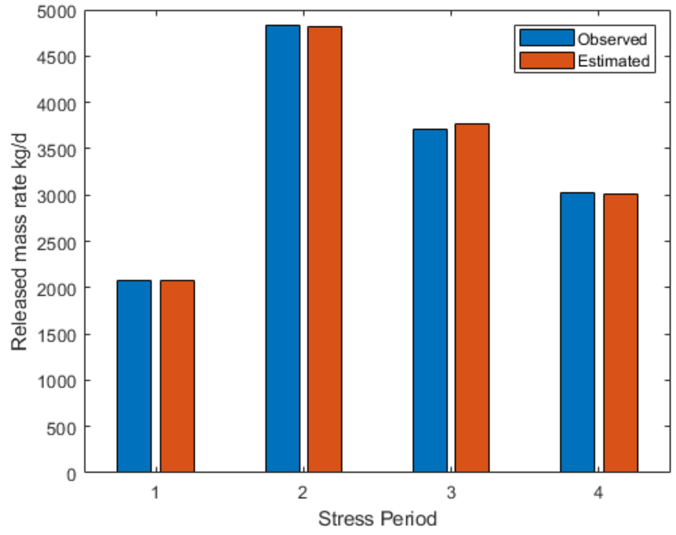
Forward problem



Observed and Estimated concentration at monitoring wells, forward simulation with one release source

Input: 4 release periods

Inverse problem



Observed and Estimated Release at known source, backward simulation (one release source)

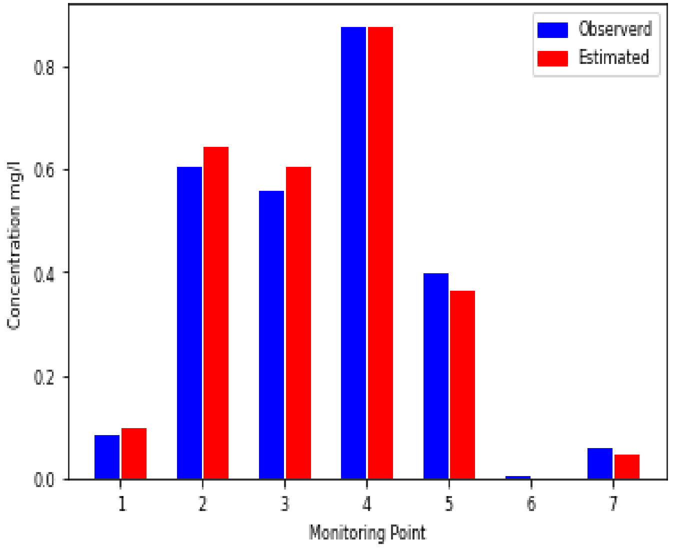
Input: 7 observations collected at MWs after five years from the start of the release

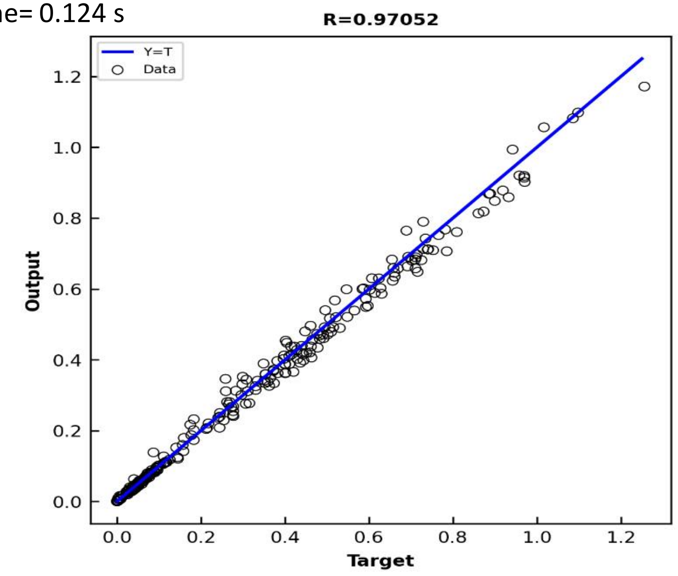
Study Case – Random Forest

Total data: 256 (Train: 217)

Forward problem

Training time= 0.124 s



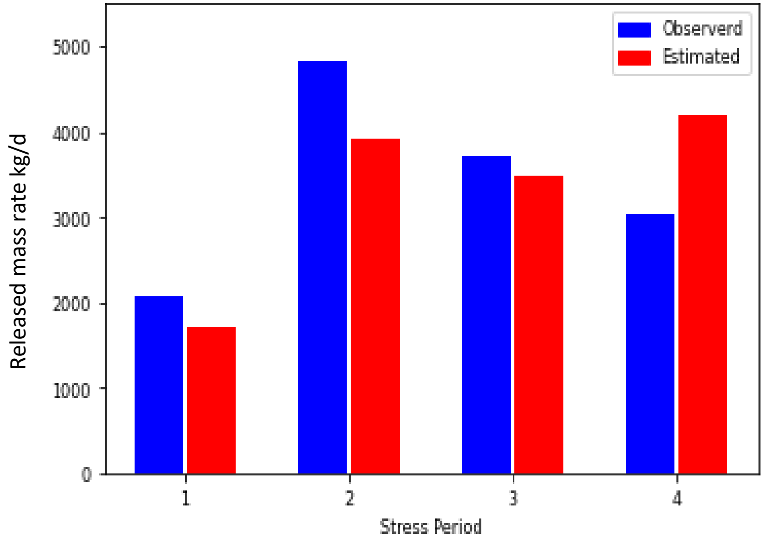


Observed and Estimated concentration at monitoring wells, forward simulation with one release source

Input: 4 release periods

Inverse problem

Training time= 0.123 s



Observed and Estimated Release at known source, backward simulation (one release source)

Input: 7 observations collected at MWs after five years from the start of the release

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Forward neural network

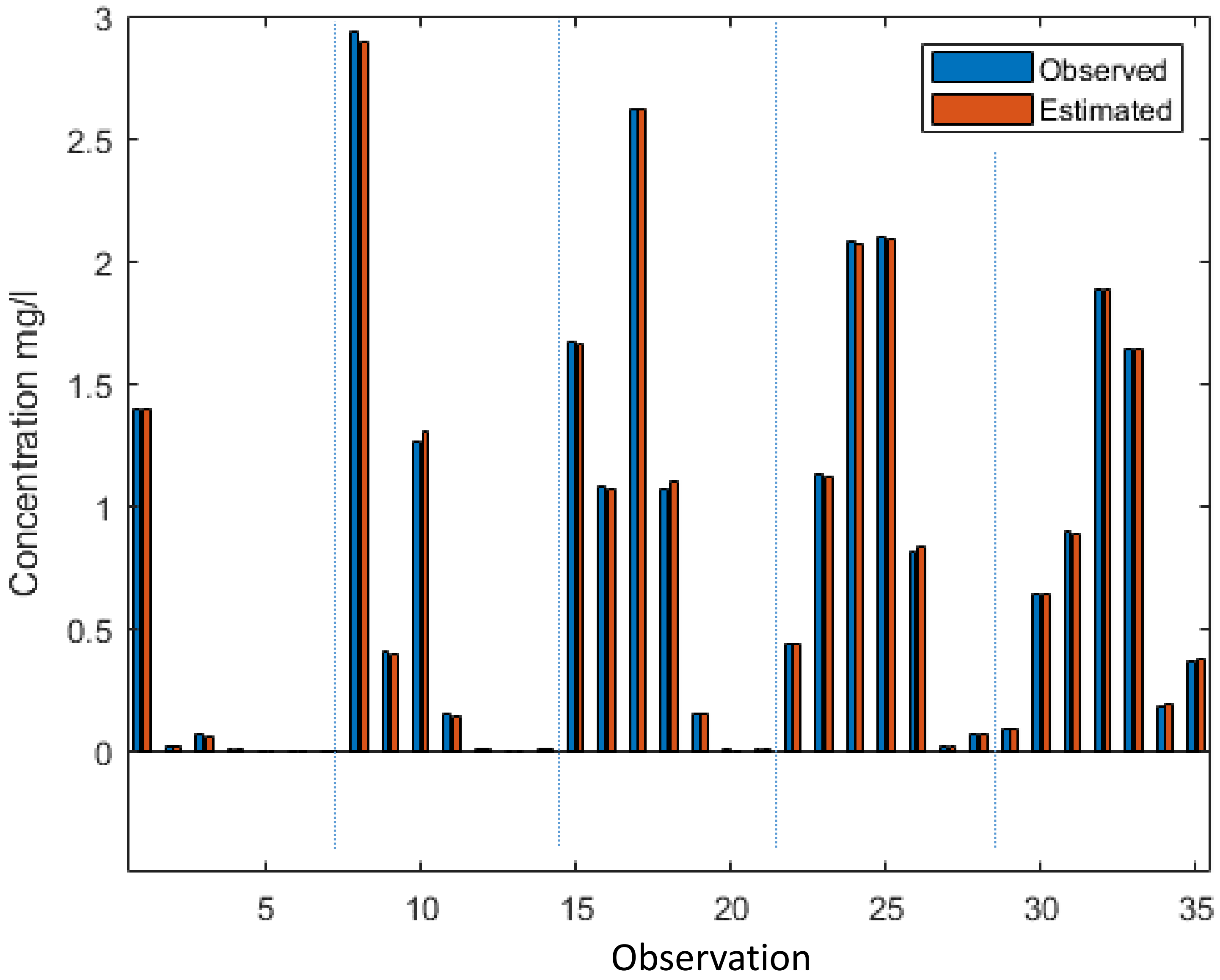
INPUT:

2 sources 4 release time for each source

OUTPUT:

7 monitoring points with 5 observations in time

35 concentration values



Train simulations ~1000

WP3 Survey – Other numerical models

Castro Verde (IST_ID)

Objectives

IST_ID: identification of the depth of the water table and the spatial distribution of the aquifer

Electrical resistivity models, then converted in the relevant rock properties

We need to discuss to evaluate the surrogate models required for this pilot site

WP3 Survey – Data analysis

Grombalia (CERTE), Mediterranean sea region (UFZ) will evaluate historical data without a numerical model

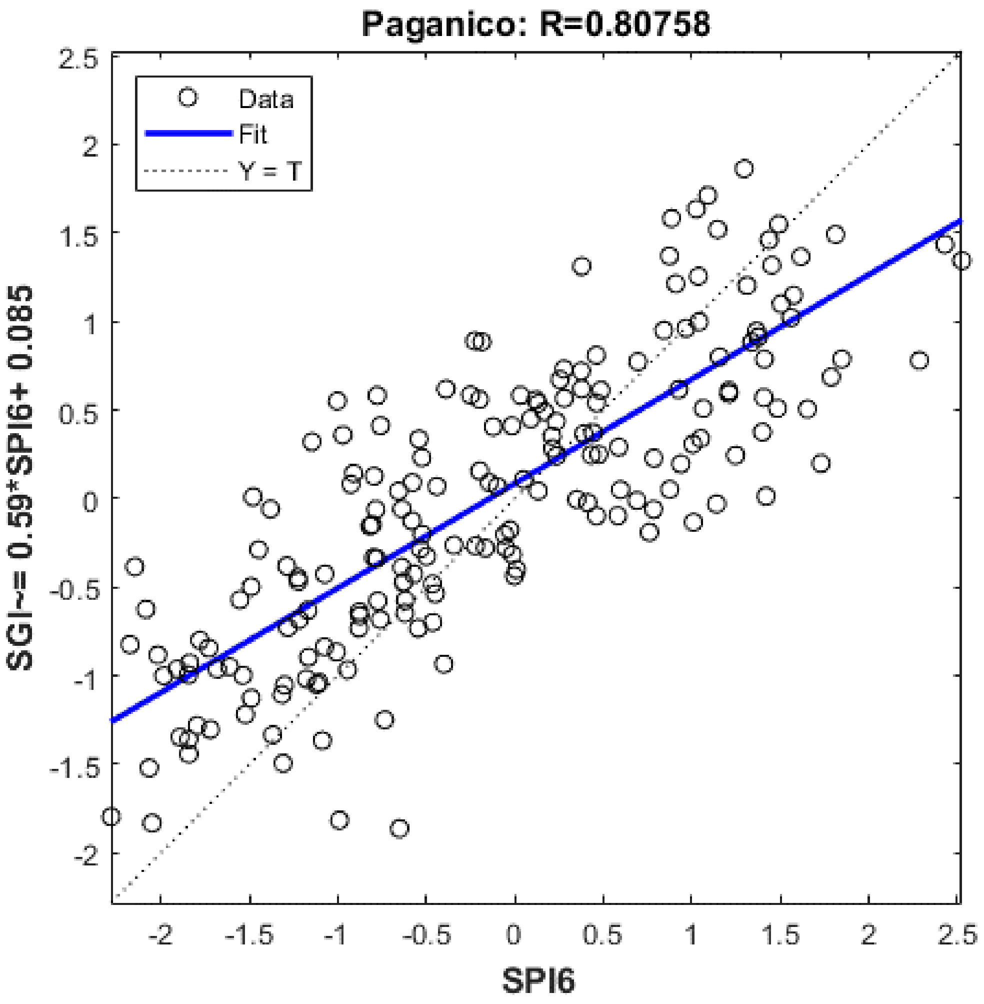
Objectives

CERTE: Groundwater quality index; to assess the evolution of groundwater state in different scenarios (i.e BAU, strategy of sustainable practices, remediation strategies,….)

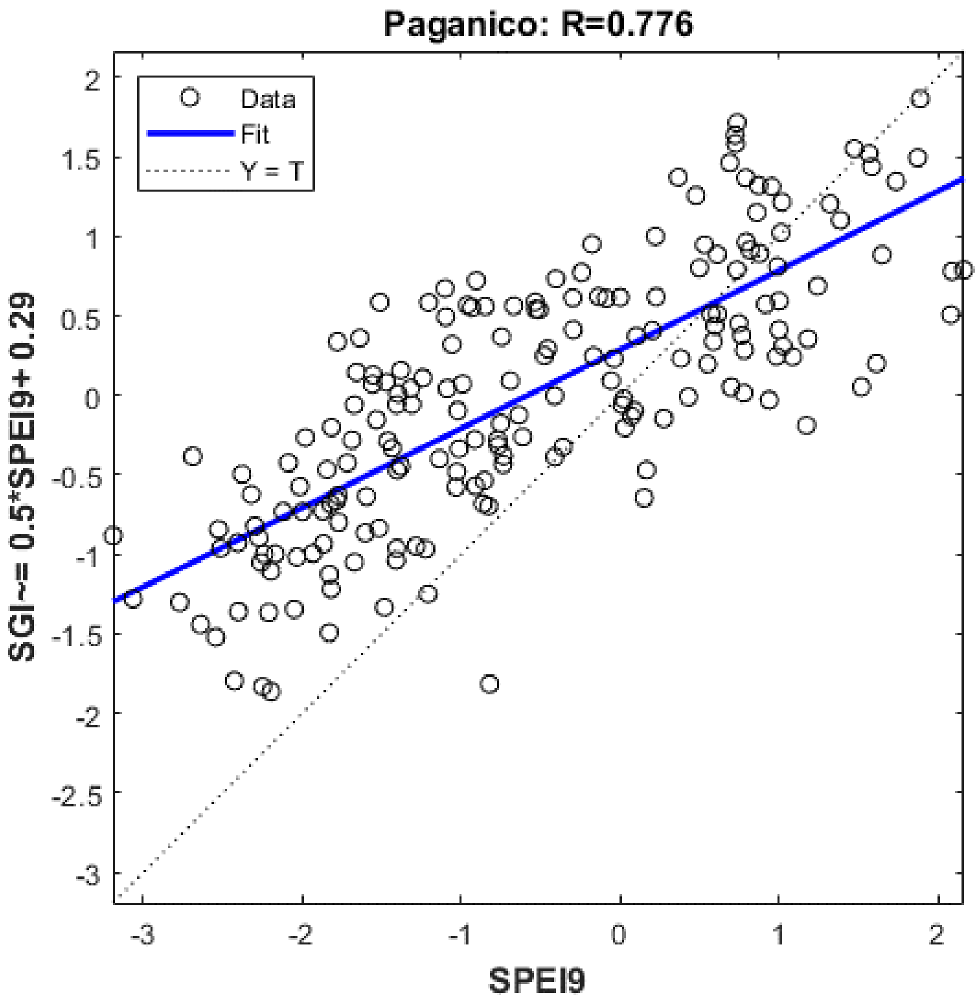
UFZ: Understand the groundwater dynamic and quality in the Mediterranean region and their controlling factors using the cause-effect relationships (DPSIR framework).

Suggested Surrogate models

- Linear models
- Neural network
- Random forest



SPI-SGI



SPEI-SGI

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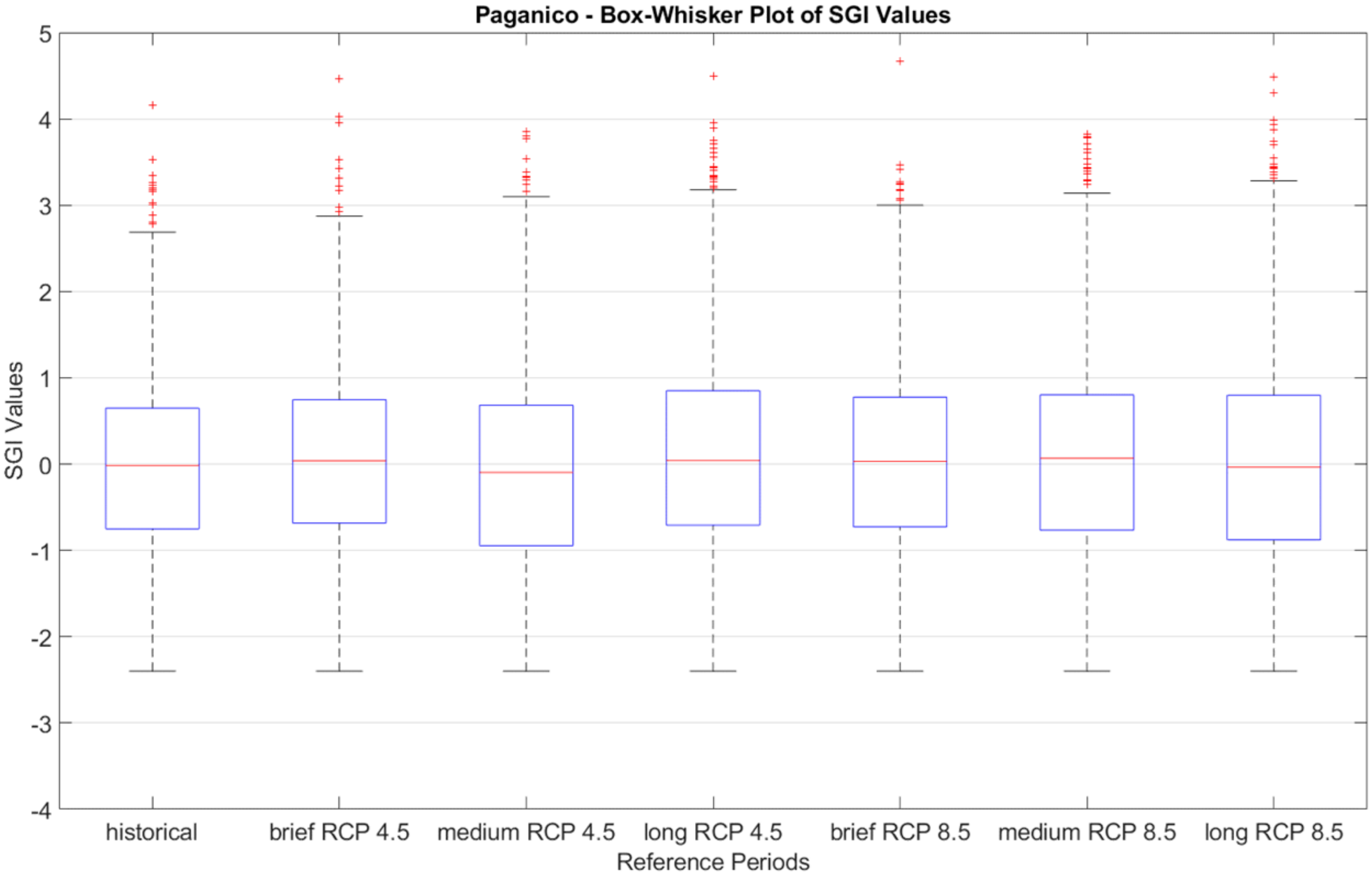
Standard Groundwater Index

Standardized Precipitation Index

SPI-SGI

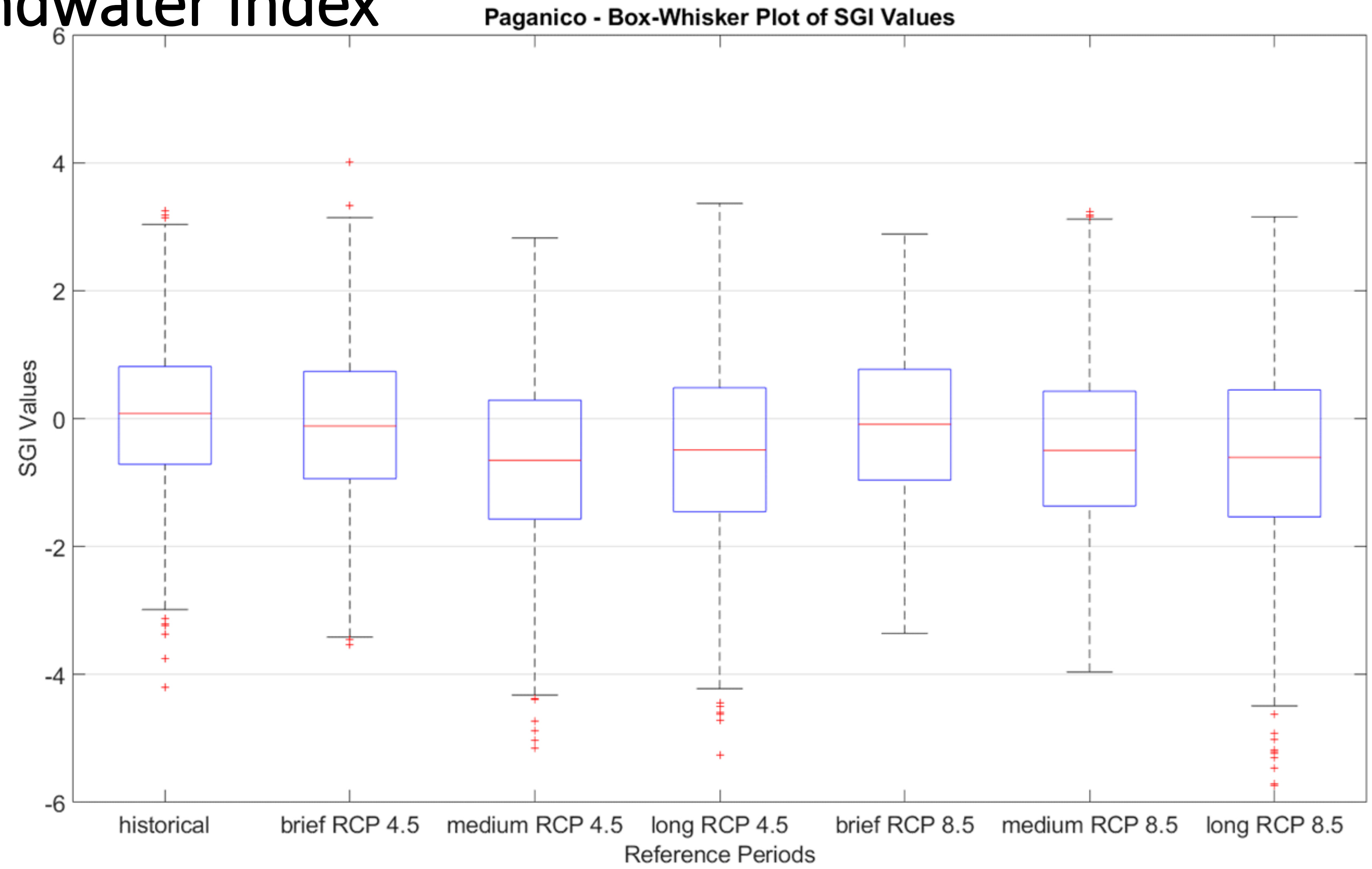


short (2006-2035), medium (2036-2065) and long term (2066-2095) period

Standard Groundwater Index

Standardized Precipitation Evapotranspiration Index

SPEI-SGI



short (2006-2035), medium (2036-2065) and long term (2066-2095) period

Future developments

One by one meeting with partners