FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

Horizon 2020
European Union funding
for Research & Innovation

ict4water.eu

The Horizon 2020 FREEWAT project: FREE and open source software tools for WATer resource management

ti | DT | DA | Sezione della protezione dell'aria dell'acqua e del suolo
Ufficio della protezione delle acque e dell'approvvigionamento idrico

Lugano, CH
September 12

University of Applied Sciences and Arts of Southern Switzerland
SUPSI

Preview

- **Introduction to the FREEWAT concept and aims**
- Tools incorporated into the FREEWAT GIS plugin
- The Ceresio Case Study (next presentation)

www.freewat.eu

FREEWAT is an ICT project for improving Water Resource Management (WRM)

MAIN EXPECTED RESULT

Open source and public domain GIS integrated modelling platform for promoting WRM by simplifying and strengthening the application of WFD, GWD and other water related Directives.

FREEWAT expected main impact →

help producing scientifically and technically sounding decision and policy making based on:

- data and innovative data analysis tools and
- including participatory approach not only in the final stage of discussion but also during the phase of scenario generation.

Concept and Motivations

1. free and open source tools, numerically based, GIS integrated, to to analyse conjunctive use of surface- and ground-water, and to boost the application of the WFD and water related Directives;

2. use effectively data provided by the extensive monitoring required by the WFD;

3. training technical staff at authorities and private companies on the use of state-of-the-art innovative software for water management;

4. including participatory approach earlier than only result discussion;

Open source characteristics of the project→

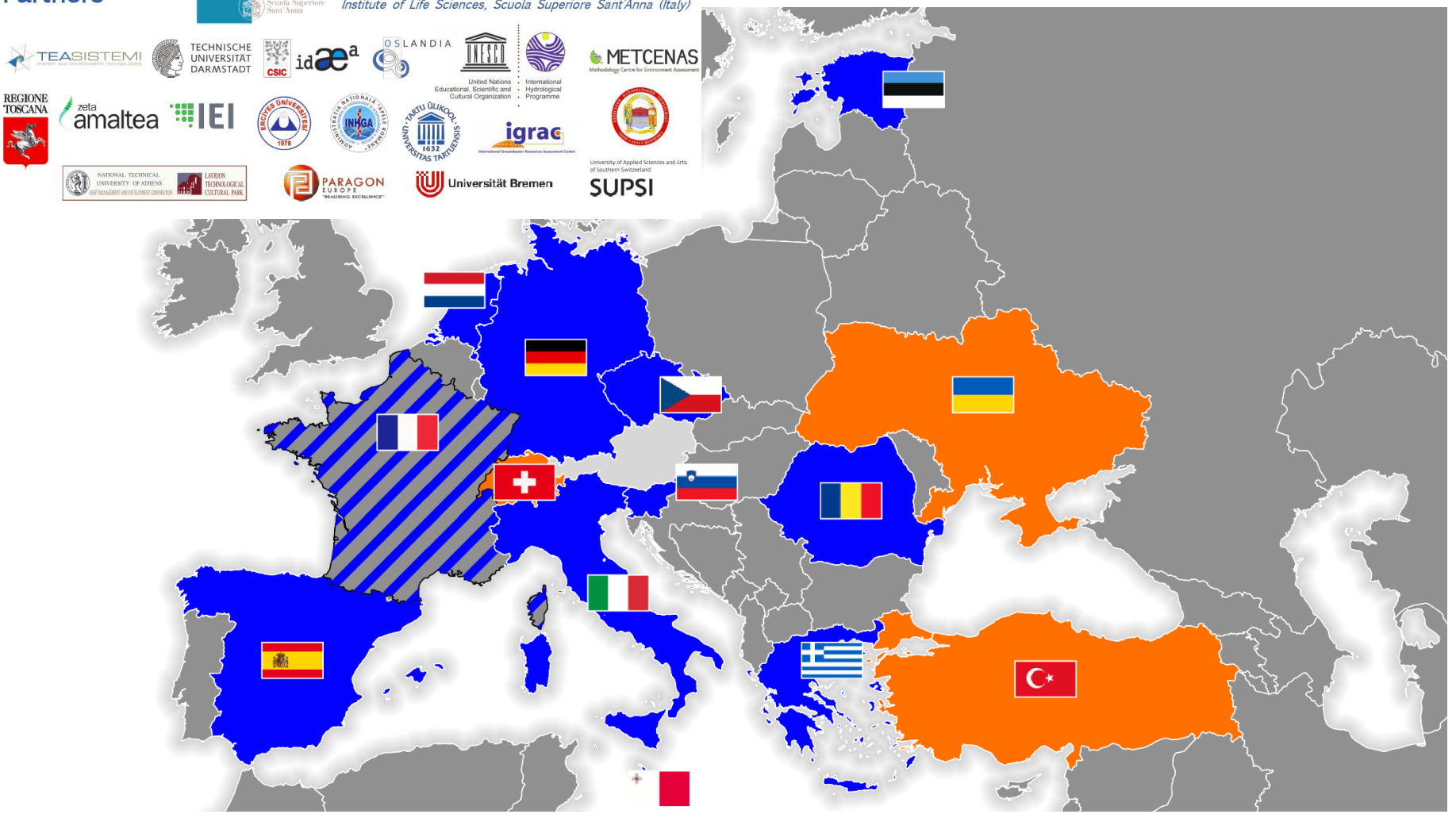
initiative "*ad includendum*" - further research institutions, private developers etc. may contribute to the project development

FREEWAT Consortium

FREEWAT

Partners

Coordination: Rudy Rossetto - r.rossetto@sssup.it
Institute of Life Sciences, Scuola Superiore Sant'Anna (Italy)



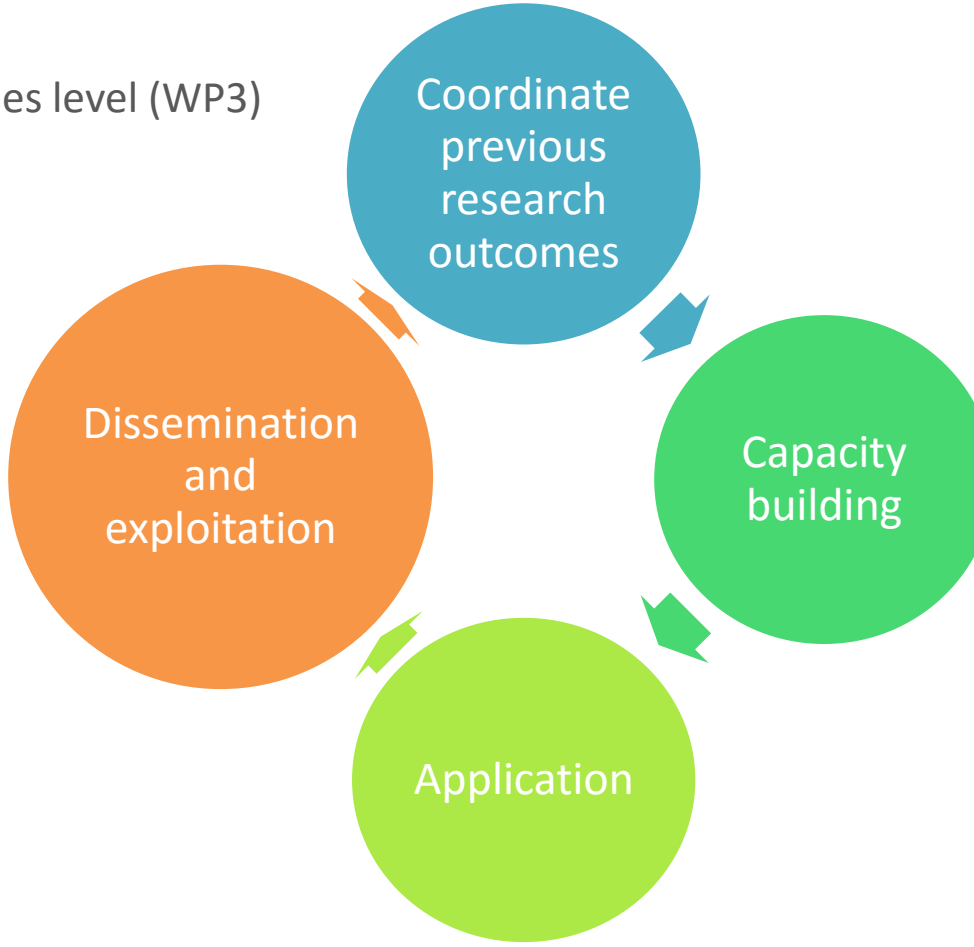
FREEWAT circular economy

SOFTWARE DEVELOPMENT AND CAPACITY BUILDING

- Building the software platform (WP2)
- Training the trainers (WP3)
- National scale training at Consortium countries level (WP3)

APPLY THE FREEWAT PLATFORM (WP4/5/6)

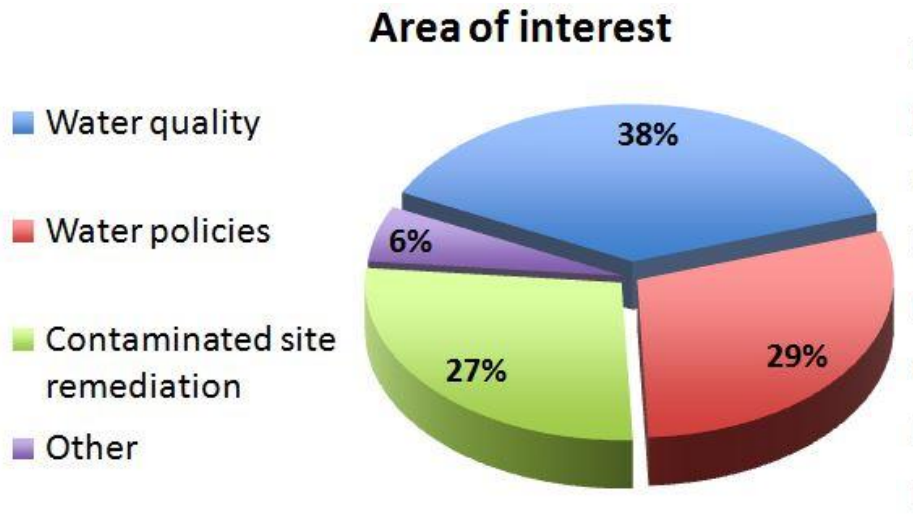
- **Postulate the problem you have to solve**;
- Gather the data;
- Discuss the data with relevant stakeholders;
- Start the model implementation;
- Involve the stakeholders during model implementation and calibration;
- Apply the model for solving your problem;
- Producing policies!

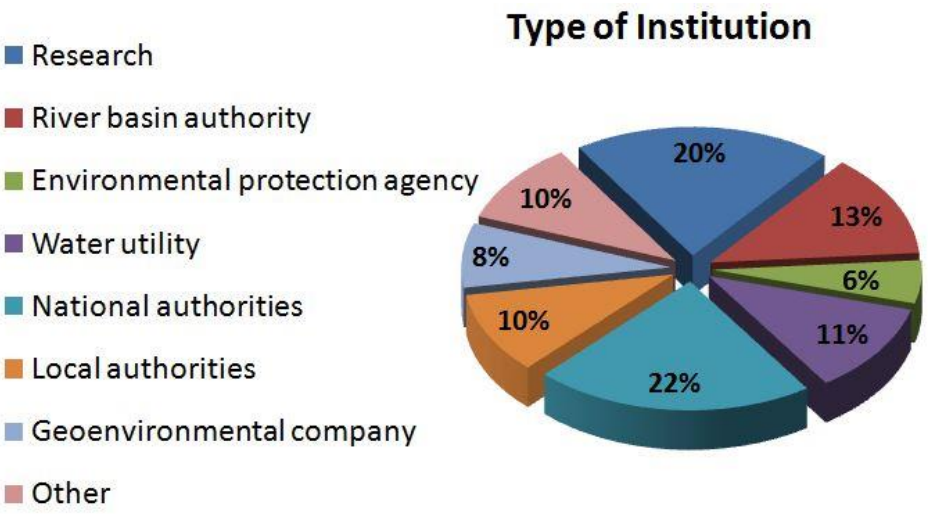


FREEWAT CAPACITY BUILDING

- Large stakeholders involvement (more than 200 stakes involved)
- Web social and professional networks

(linkedin group yet 370 followers – twitter: 256 followers @h2020freewat)

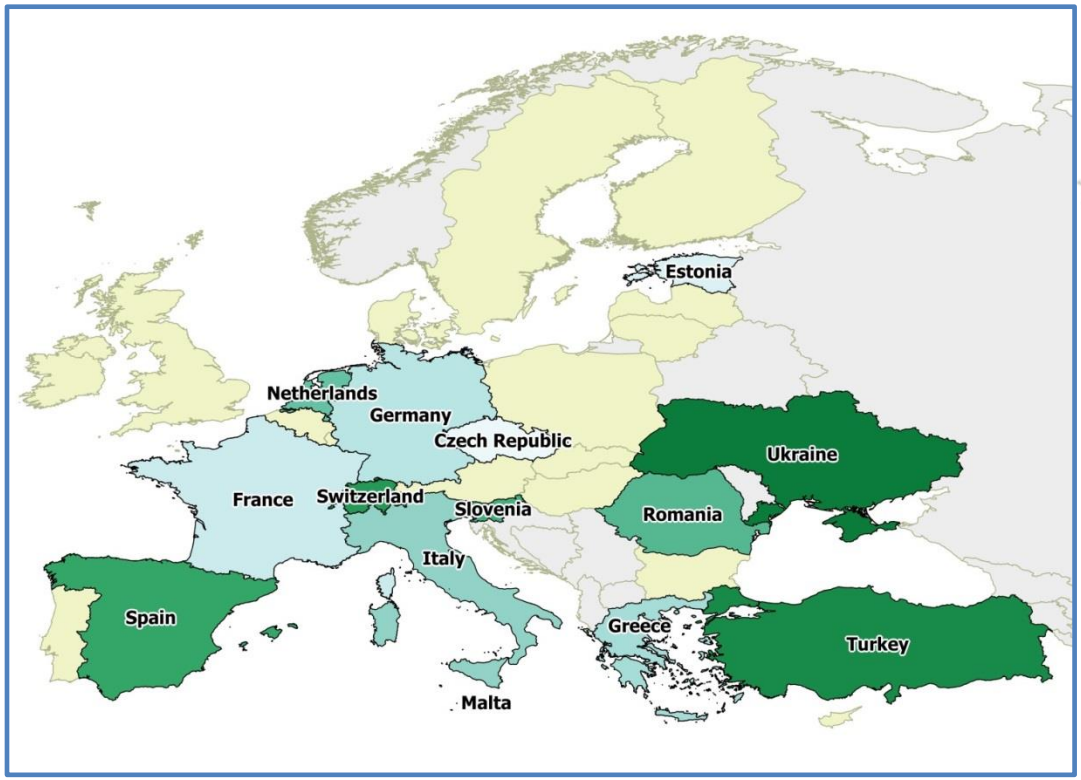




FREEWAT case studies

14 case studies:

- 8 for the application of WFD, GWD and others (EU countries) plus **1 case study in Switzerland**
- 5 devoted to rural water management: 2 EUs, Turkey, Ukraine, and Africa (through UNESCO involvement)



FREEWAT architecture

SPACE AND TIME DISTRIBUTED DATA

Observation Analysis Tool

Surface and Groundwater Flow Simulation

Calibration

Sensitivity Analysis

Parameter estimation

Water quality issues

simulation and analysis tools

Rural water management module

UPSCALING from cell results

WATER MANAGEMENT AND PLANNING MODULE

GIS AND SPATIAL DATABASE

FREEWAT PLATFORM ADVANTAGES vs. commercial simulation platform

- Unite the power of GIS geo-processing and post-processing tools in spatial data analysis to that of simulation software
- The chance for public authorities to build a high informative and dynamically growing representation of a hydrologic system (i.e. river basin) where perfoming data storage and planning analysis
- WRM modules thought for decision-making and policy applications
- No cost for licences (money can be moved to development of client tailored applications)

Preview

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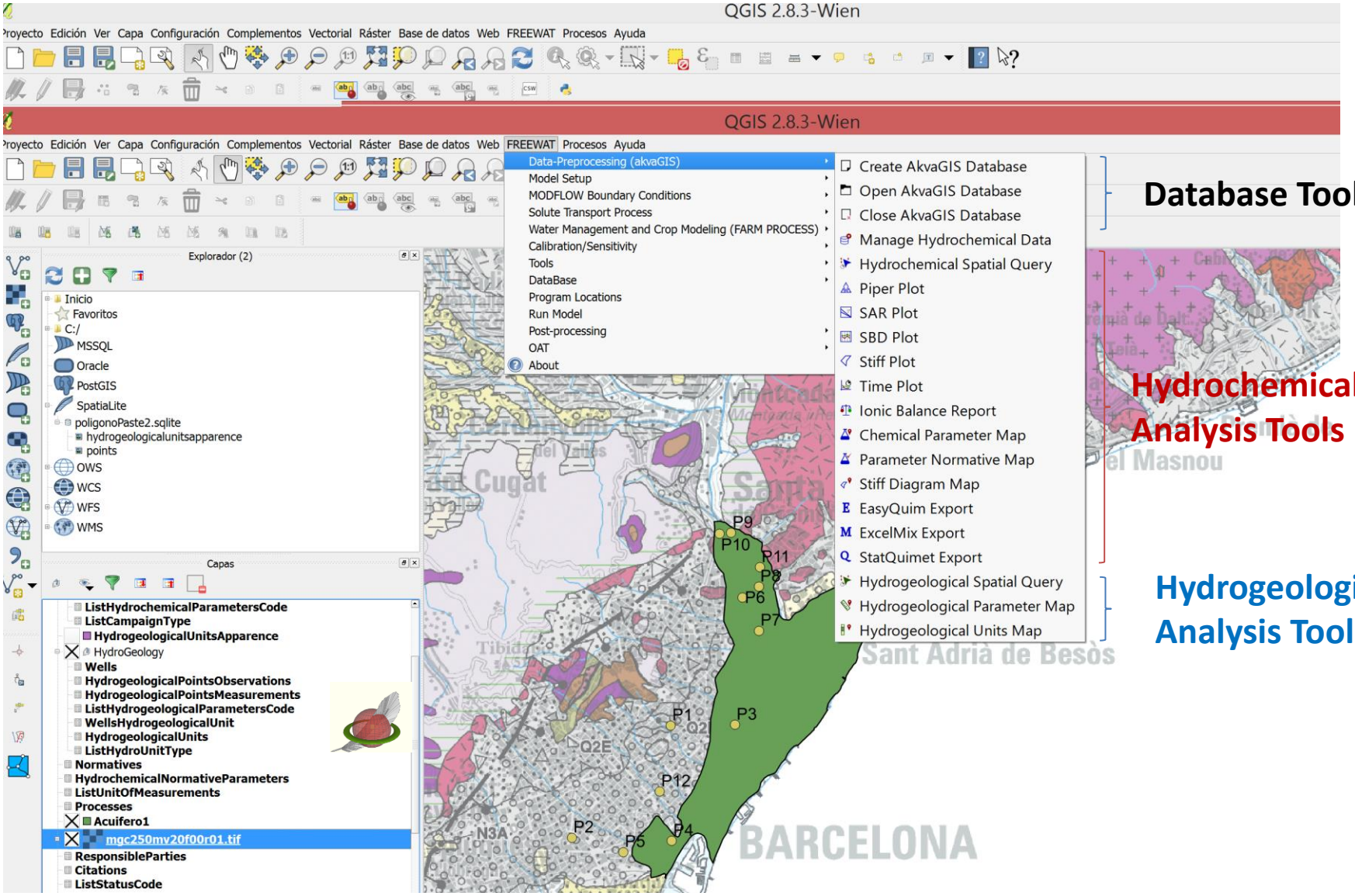
- **Tools incorporated into the FREEWAT GIS plugin**
- The Lugano Case Study (next presentation)

Pre–processing Hydrogeological Data. AkvaGIS Tools

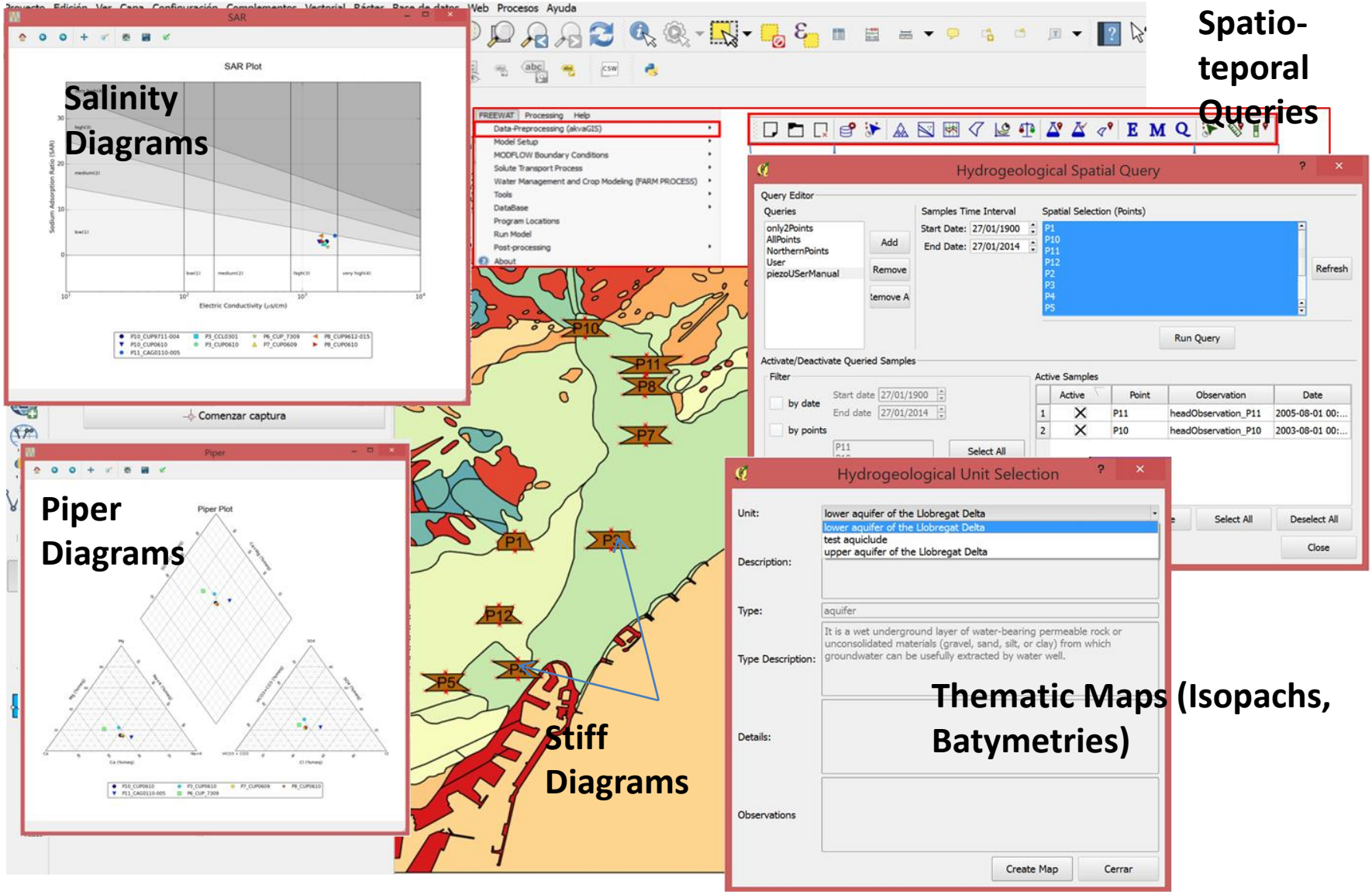


Database Tools

Hydrochemical Analysis Tools

Hydrogeological Analysis Tools

Pre–processing Hydrogeological Data. AkvaGIS Tools



OAT in a nutshell

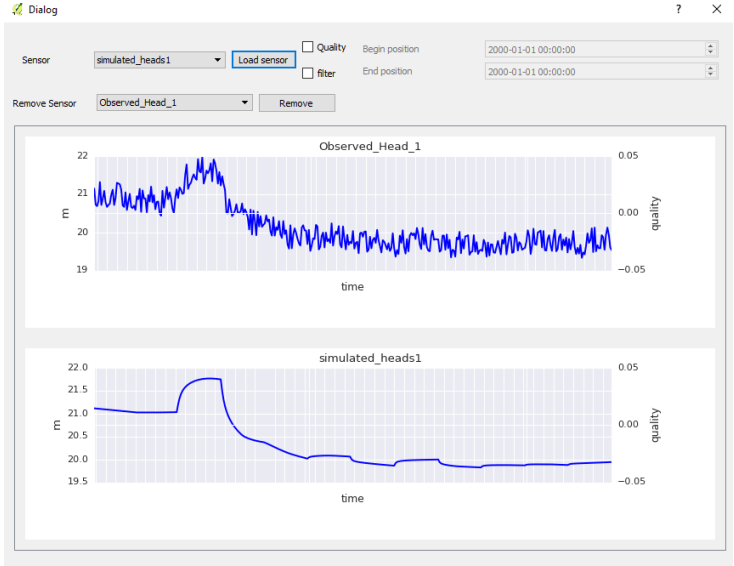
Overview

Time series are a key aspect in environmental modelling, and more and more are getting important with the increasing establishment of diffuse, online and real-time monitoring networks.

Using OAT you can upload, explore, analyse and get the maximum value out of your observations.

In particular, they are important as a means of:

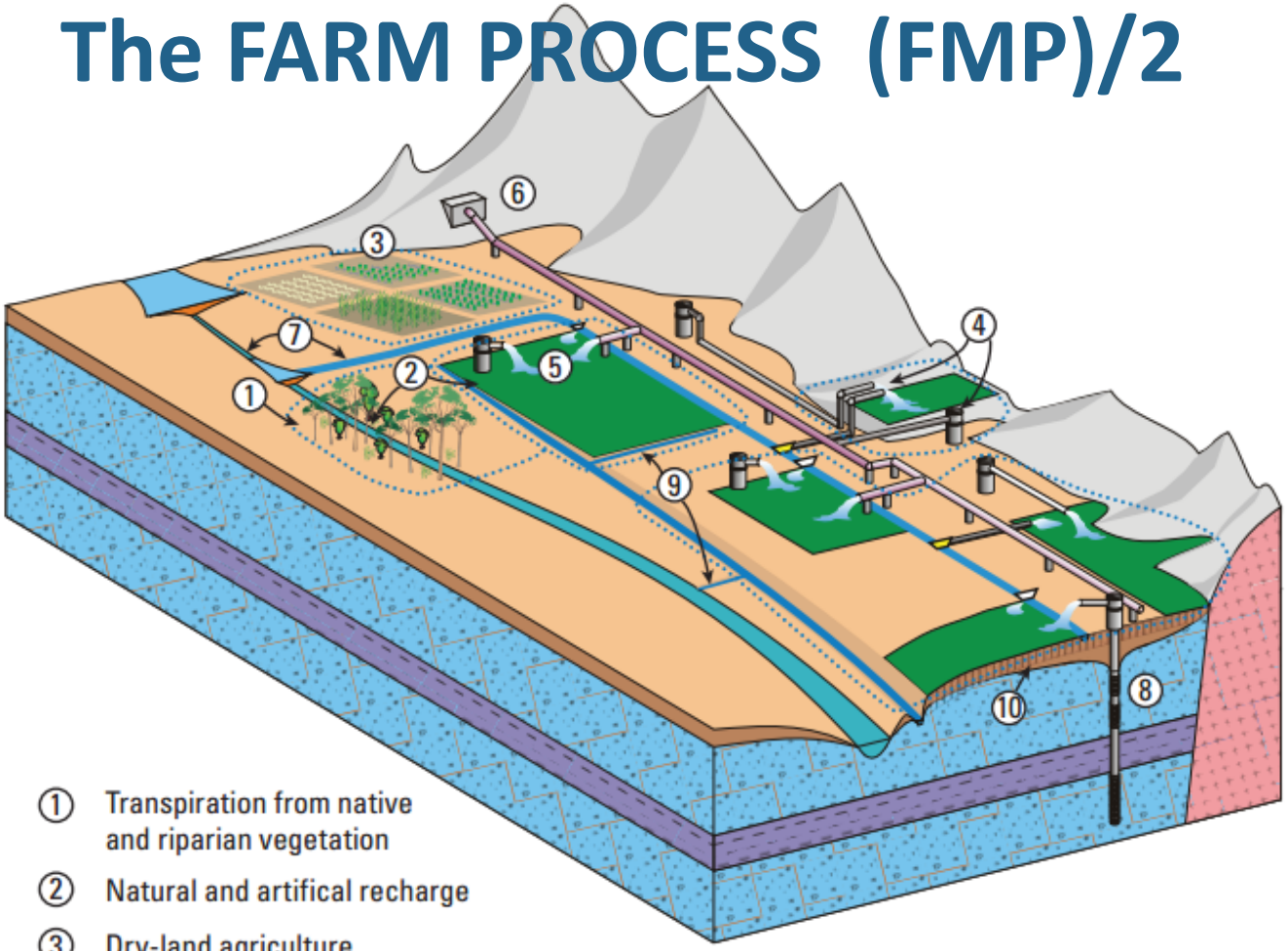
- understanding the system to be modelled and thus support the **preparation of model input data**
- verification of models results and thus help to **calibrate your model**.



The FARM PROCESS (FMP)/1

- fully-coupled, hydrologic model to dynamically estimate the integrated **supply-and-demand components of irrigated agriculture** as part of the simulation of surface and ground-water flow
- FMP includes the possibility to route water supplies towards water accounting units through surface irrigation channels.

The FARM PROCESS (FMP)/2



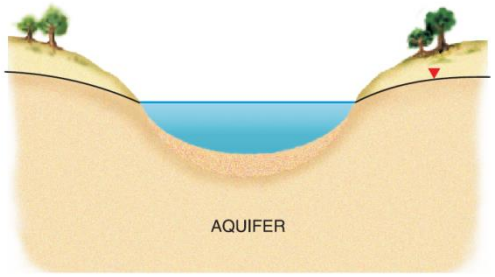
1. Transpiration from native and riparian vegetation
2. Natural and artifical recharge
3. Dry-land agriculture
4. Aquifer storage-and-recovery systems
5. Farm demand for irrigation from multiple sources of water
6. Non-routed deliveries as multiple water transfers to multiple delivery locations

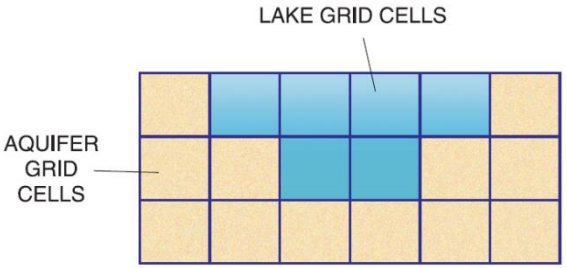
Water-accounting units

7. Routed surface-water delivery to farm from canals and rivers
8. Groundwater pumpage from single- and multi-screened/multi-aquifer irrigation and supply wells
9. Runoff and drain return flows to rivers and canals
10. Delayed artificial recharge through unsaturated zone

Lake

- A technique to describe the hydraulic interaction between a lake and the surrounding aquifer so that the effect of changes in either water body on conditions in the other can be estimated
- Can Incorporate:
  - rate of lake atmospheric recharge
  - evaporation,
  - overland runoff rate after precipitation
  - rate of any direct withdrawal





- Separate water Budget for the lakes
- Sections of the lake can dry and re-wet
- Can be integrated into the SFR package

Transport

The original version of MT3DMS solves the solute transport equation related to saturated flow (ADE- Advection, Dispersion Equation) for one or more solute components.

The following processes can be simulated:

Adsorption/desorption (linear and nonlinear, equilibrium and non equilibrium conditions)

Decay terms (first order or 0-order) to represent natural/radioactive decay and/or to estimate bio-degradation processes

Dual domain mass transfer.

It is possible to define **source/sink terms** (point-wise or area distributed)

It is possible to simulate heat transfer (by treating temperature as a particular species)

MT3DMS

MT3DMS belongs to the so-called "MODFLOW-related" codes, and it is used by a huge community of modelers, around the world, for both academic and commercial purposes.

The most frequent applications are:

- ✓ Contaminated sites characterization
- ✓ Assessment of aquifers vulnerability
- ✓ Environmental impact assessment related to pollutant sources (**existing or foreseen**), with respect to *target* objects, like water wells, rivers, etc.
- ✓ Design of site remediation strategies (hydraulic barriers, pump-and-treat, etc..), even using *bio-remediation*
- ✓ Estimating the location of a pollutant source, knowing its effect (however, this is a difficult task)

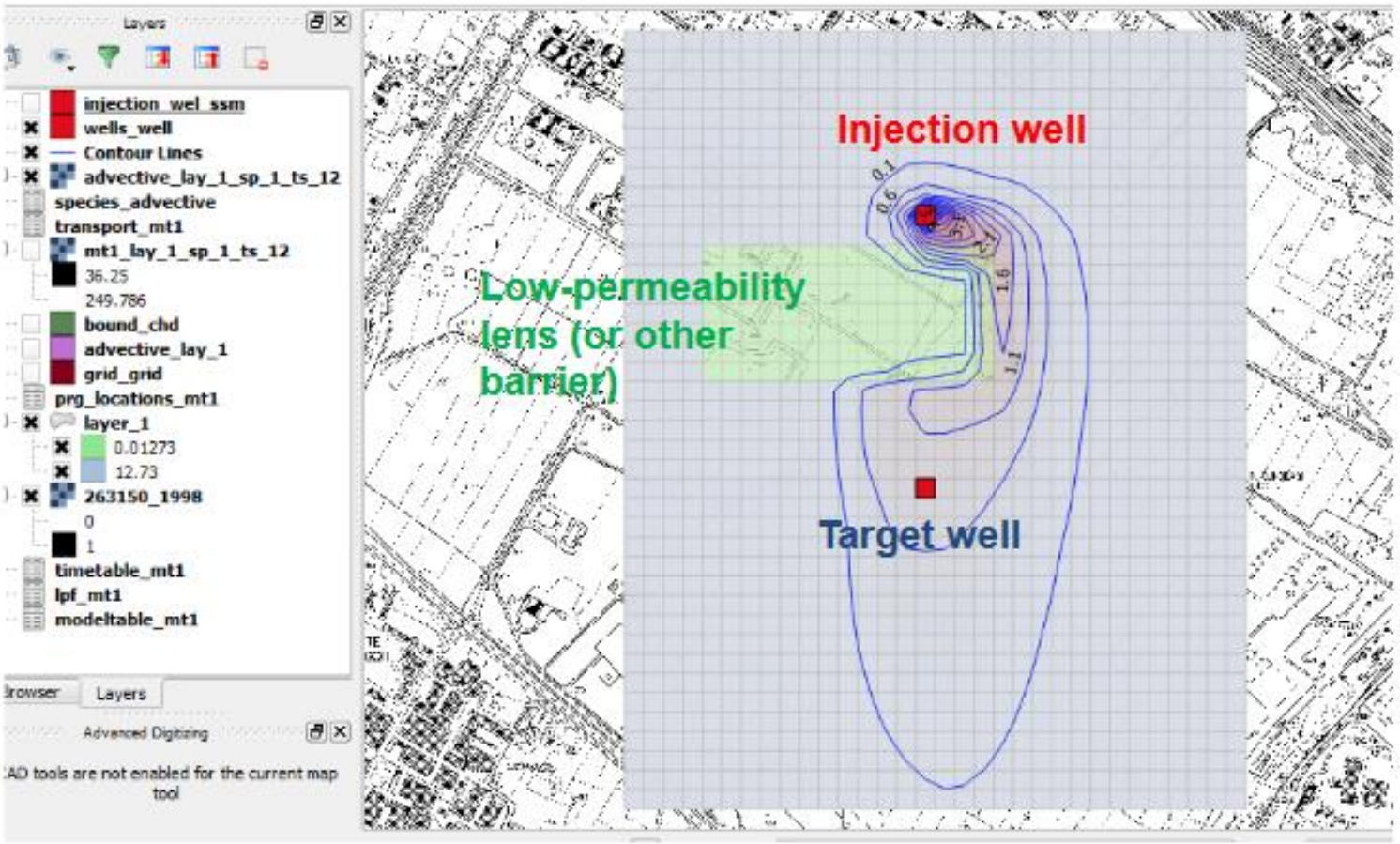
MT3DMS/2

MT3DMS has the following limitations (phenomena not addressable)

- ✓ Multi-phase flow (e.g. water + oil, water liquid + water vapor, etc.)
- ✓ Flow depending on density, temperature or viscosity (**see below!!**)
- ✓ Unsaturated flow (**see below!!**)
- ✓ Simulation of intra-species reaction (geochemical reactions). For these problems the following code can be suggested: **PHT3** (**MT3DMS/PHREEQC-based** *reactive multicomponent transport model*)

MT3DMS/3

Estimating the (**positive**!) effect of aquifer heterogeneity, with respect to the pollutant diffusion



Eventual extension:

The intergation of the new version of MT3DMS is in progress. Such a version (named **MT3DMS-USGS**) allows simulating also transport phenomena related to unsaturated flow.

- ✓ MT3DMS is coupled with flux computed by Package UZF in MODFLOW (1D simulation of vadose zone, using the *kinematic-wave approximation)*
- ✓ In FREEWAT everything is ready to host this new version: we are still waiting for the official release by USGS !!
- ✓ We are planning to include also different packages included in thsi new version, like the interesting coupling with MODFLOW Package SFR2, to simulate also the transport process occurring at the sw/gw interface (package named *SFT - Stream Flow Transport*)

Calibration/Sensitivity Analysis with UCODE

Given the model as constructed:

Sensitivity analysis

- How important is each observation to each parameter? And to all parameters?
- How important are observations to predictions?
- What new observations would be most useful to estimated parameters? To predictions?

- What parameter values produce the best fit to observations?

Calibration

Particle Tracking

MODPATH is a **particle-tracking** post-processing model that computes three-dimensional flow paths using output from groundwater-flow simulations based on MODFLOW. The particle tracking is based on simple **advection**, so it is not as accurate as MT3DMS, but is a **fast** alternative to determine flow paths.

Currently v6 is used, but a new version, ModPath OBS will be available shortly