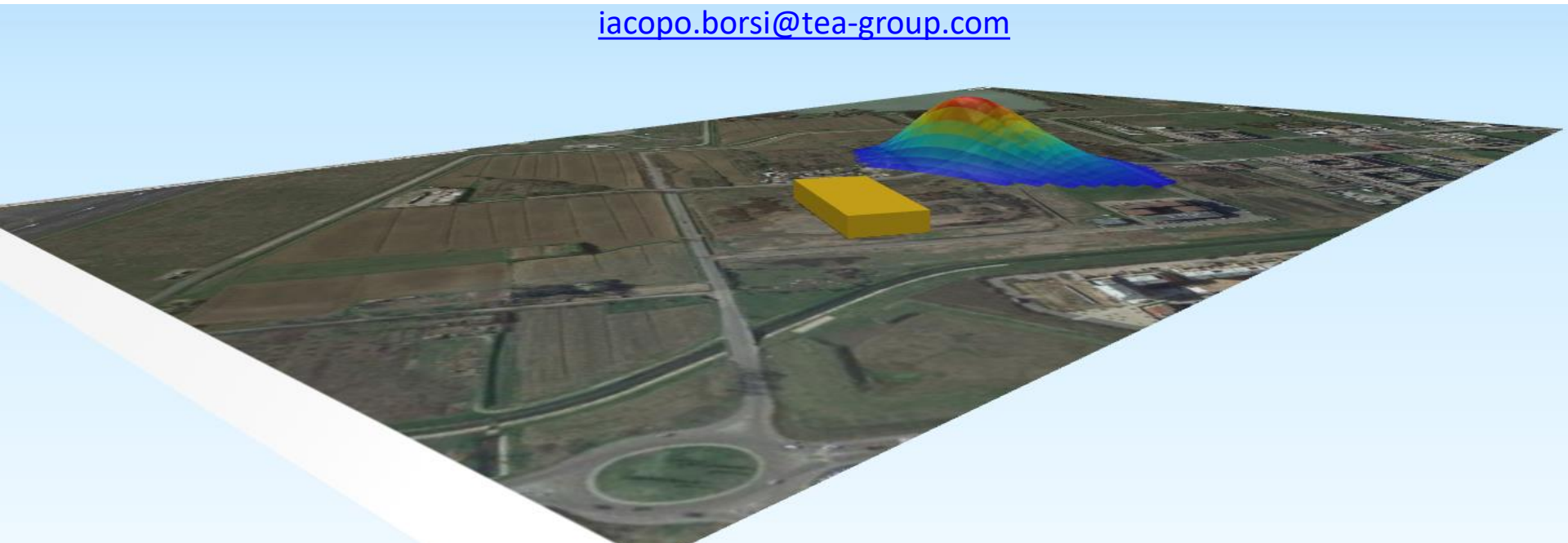# FREEWAT modeling platform: software architecture and state of development

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Outlook

❑ FREEWAT architecture

❑ Capabilities: a summary

❑ Code development: key tasks

❑ FREEWAT Community: a first attempt
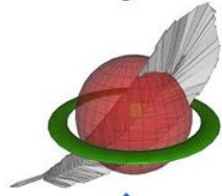
❑ Looking to the future …

FREEWAT Pillars and Conceptualization

FREEWAT is a composite plugin of QGIS, conceived as a canvas, where several simulation codes might be integrated in a unique GIS desktop. Coupling the power of GIS geo- and post-processing tools to simulation software capabilities
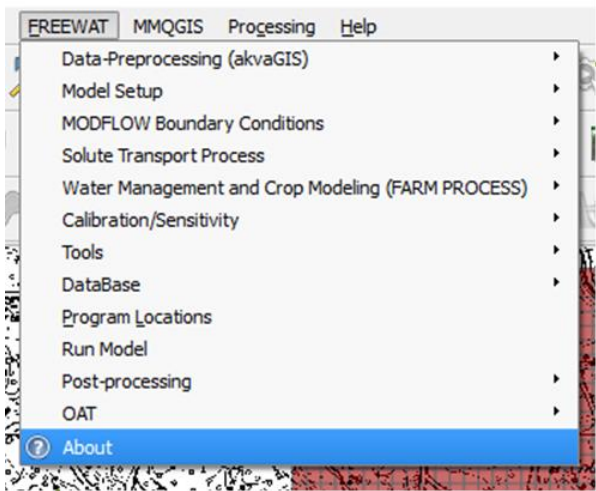
QGIS: FREEWAT's framework

QGIS
## A Free and Open Source Geographic Information System

QGIS → cross-platform, user friendly, free and open-source GIS application that provides data viewing, editing, and analysis.

It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

QGIS is the leading Open Source Desktop GIS

> ➢ A huge and worldwide community
> ➢ Several plugins available
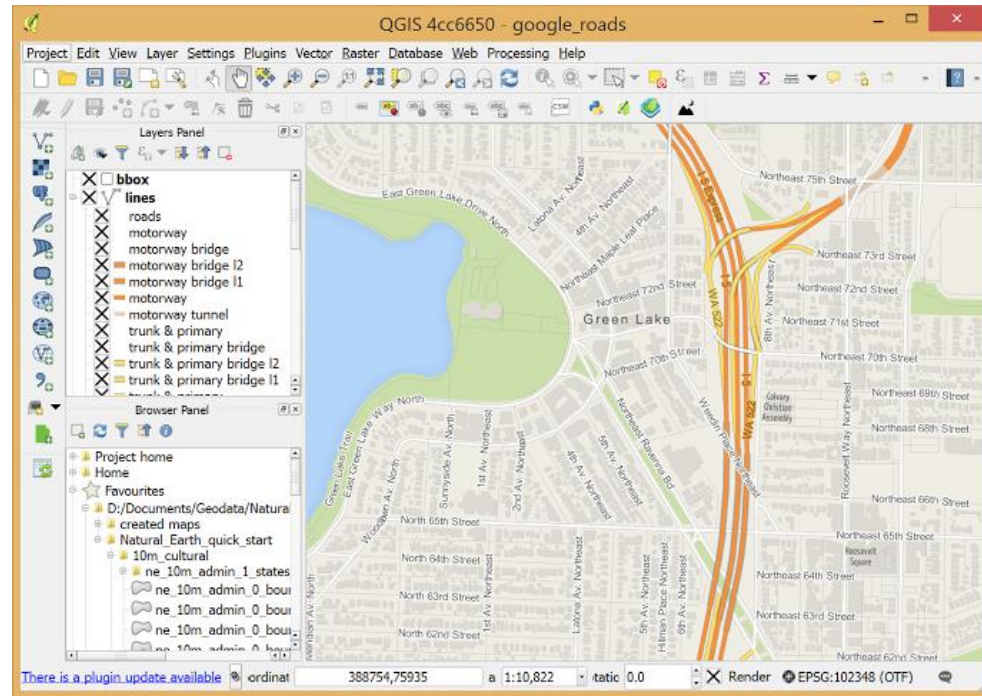
www.qgis.org

FREEWAT Capabilities:
Data pre-processing (akvaGIS)

✓ **Hydrogeological models** require the use of **a wide variety of information (hydrogeological, geological, hydrochemical, etc.)**

➢ Necessity of integrating data from **different sources** gathered with different data access techniques (boreholes, pumping tests, etc.) and **different formats**

A specific tool in FREEWAT that brings together a **spatial database** and a set of **tools** that allow us to:
Harmonize, **collect, store, manage, analyze , interpret and pre-process the hydrogeological data** in a **GIS**.

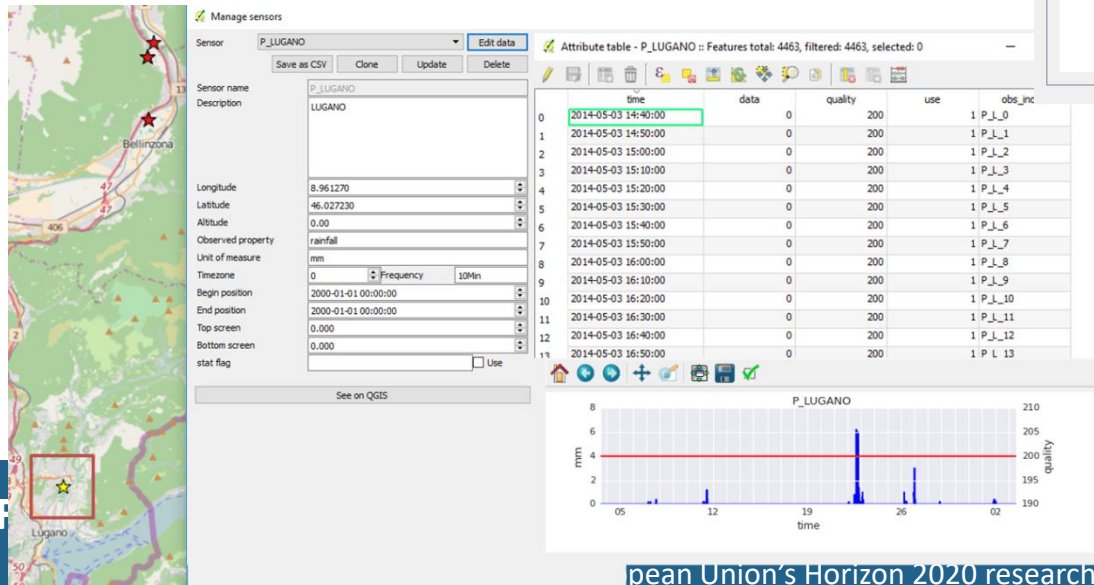**Spatial variation of the composition of the aquifer**
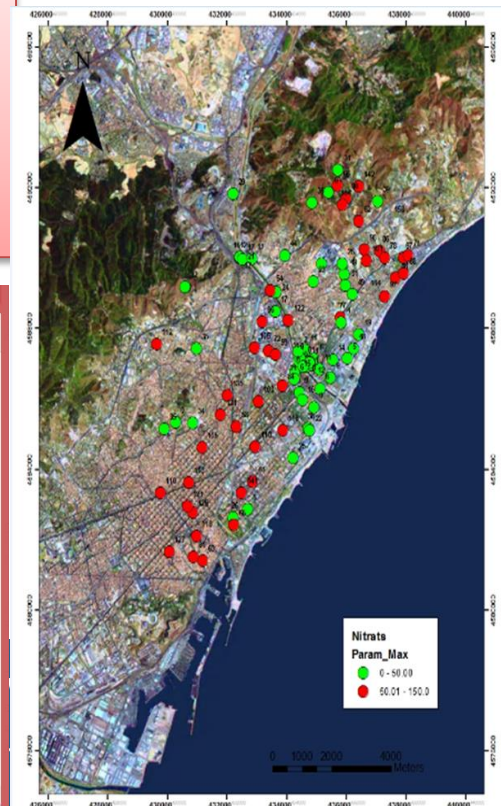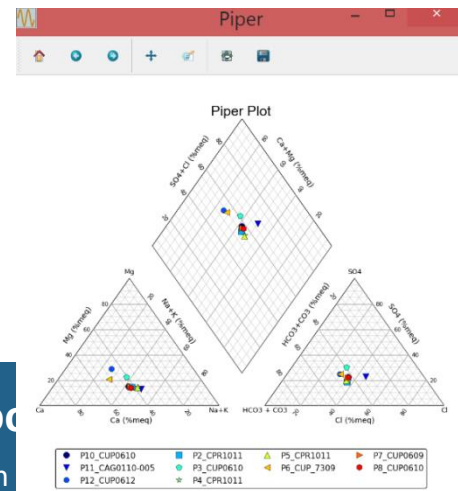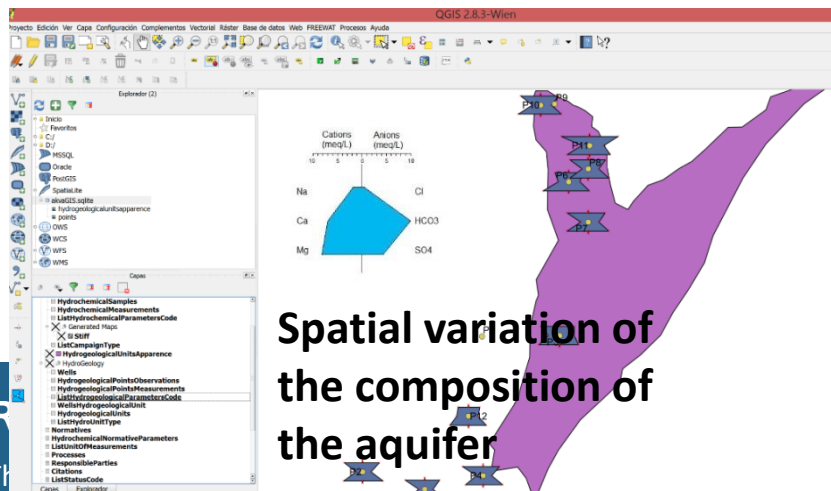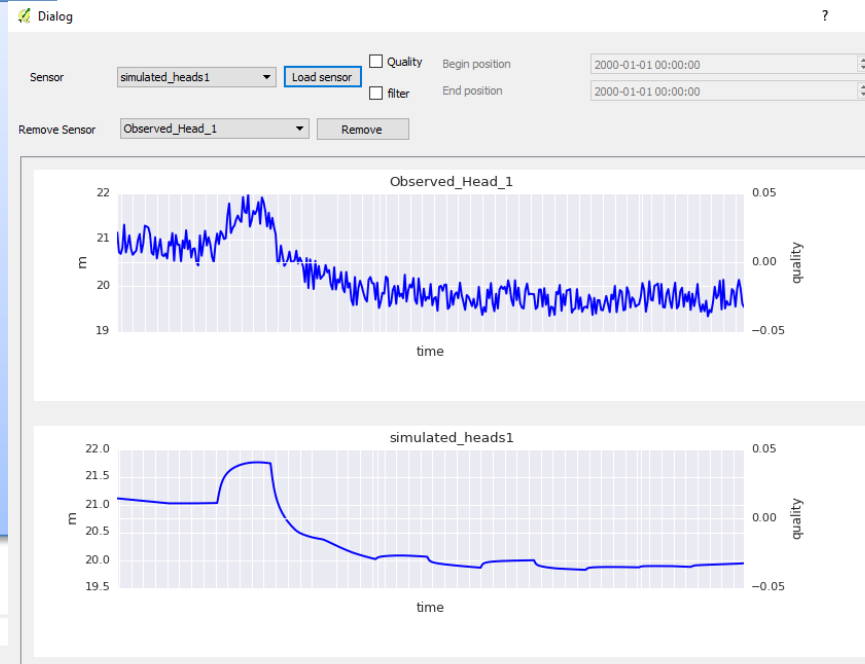
FREEWAT Capabilities:
Observations Analysis Tool (OAT)

OAT - Observations Analysis Tools

- ✓ Import sensor data
  - From Servers
  - From local files
- ✓ Manage and edit sensor data and metadata
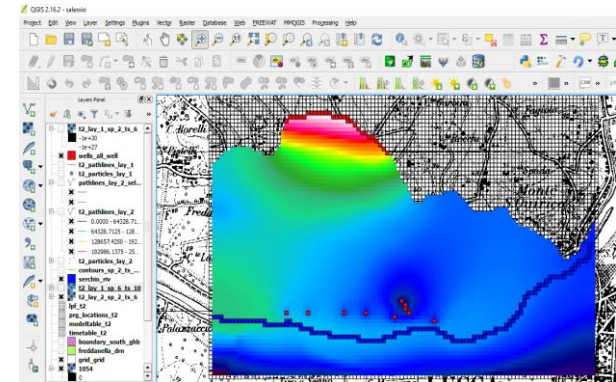- ✓ Perform various operations with data
- ✓ Display and compare sensor data

FREEWAT Capabilities:
Surface/ground-water Flow Modeling

Solving coupled surface/ground-water flow
Considering different water stresses in the model domain: wells, rivers and canals, evapo-transpiration, aquifer recharge, lakes, unsaturated zone


Getting the water budget

```
VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP   10, STRESS PERIOD   6
-----------------------------------------------------------------------------

  CUMULATIVE VOLUMES      L**3        RATES FOR THIS TIME STEP      L**3/T
  ------------------                  ------------------------

        IN:                                IN:
        ---                                ---
          STORAGE =      201311.3594          STORAGE =          12.1037
    CONSTANT HEAD =           0.0000    CONSTANT HEAD =           0.0000
            WELLS =       71220.0000            WELLS =         240.0000
           DRAINS =           0.0000           DRAINS =           0.0000
    RIVER LEAKAGE =    30683864.0000    RIVER LEAKAGE =      119135.0156
   HEAD DEP BOUNDS =          0.0000   HEAD DEP BOUNDS =          0.0000
         RECHARGE =       45662.5000         RECHARGE =           0.0000

         TOTAL IN =    31002058.0000         TOTAL IN =      119387.1172

        OUT:                               OUT:
        ----                               ----
          STORAGE =       79236.8594          STORAGE =           0.6955
    CONSTANT HEAD =           0.0000    CONSTANT HEAD =           0.0000
            WELLS =     3330000.0000            WELLS =           0.0000
           DRAINS =       67558.8047           DRAINS =         195.3501
    RIVER LEAKAGE =      280639.6250    RIVER LEAKAGE =        1137.2496
   HEAD DEP BOUNDS =    27243630.0000   HEAD DEP BOUNDS =      118034.1328
         RECHARGE =           0.0000         RECHARGE =           0.0000

        TOTAL OUT =    31001064.0000        TOTAL OUT =      119367.4297

         IN - OUT =         994.0000         IN - OUT =          19.6875

PERCENT DISCREPANCY =        0.00   PERCENT DISCREPANCY =         0.02
```
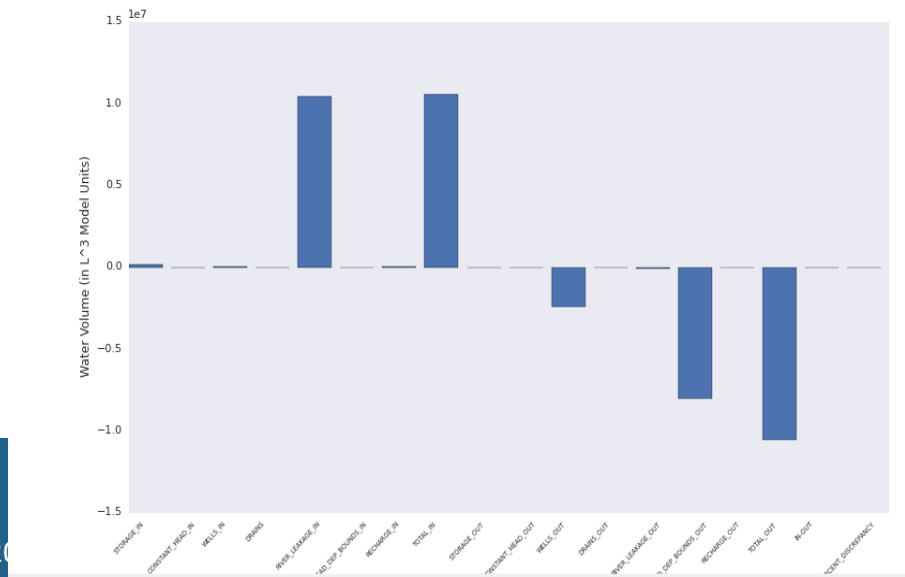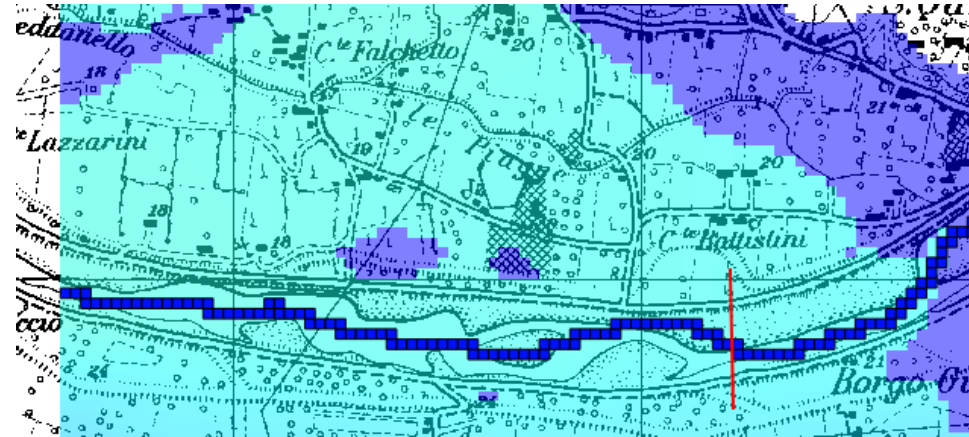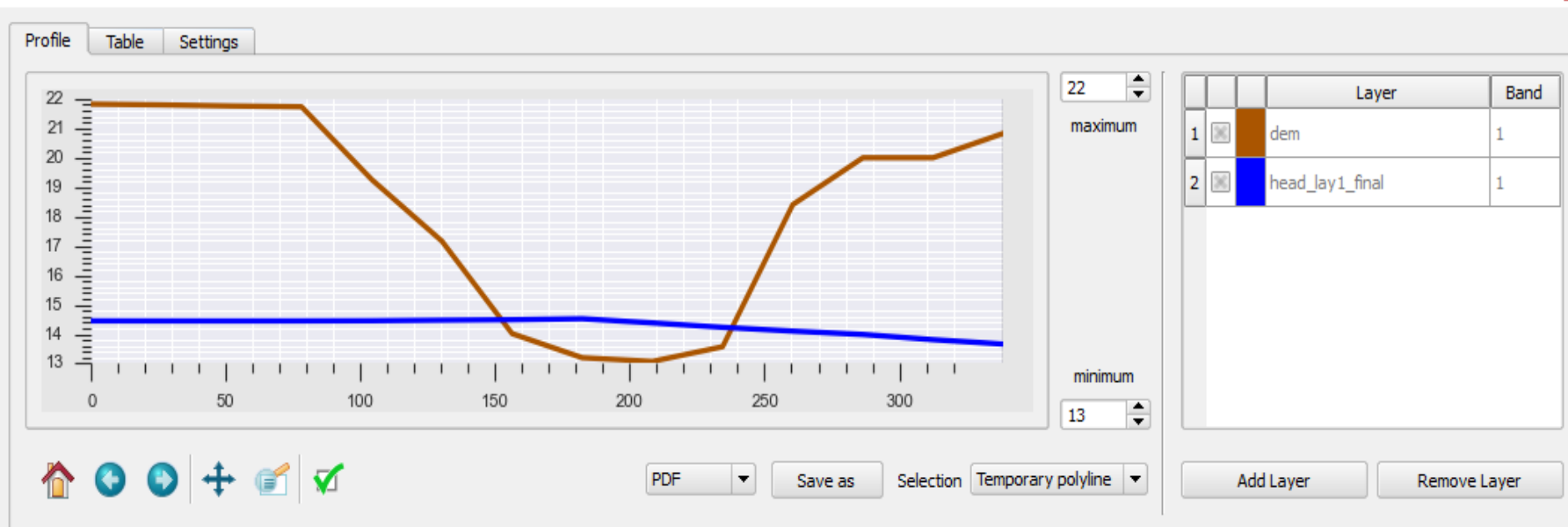
Plot cross sections using *ProfileTool*
(water table vs *terrain elevation)*
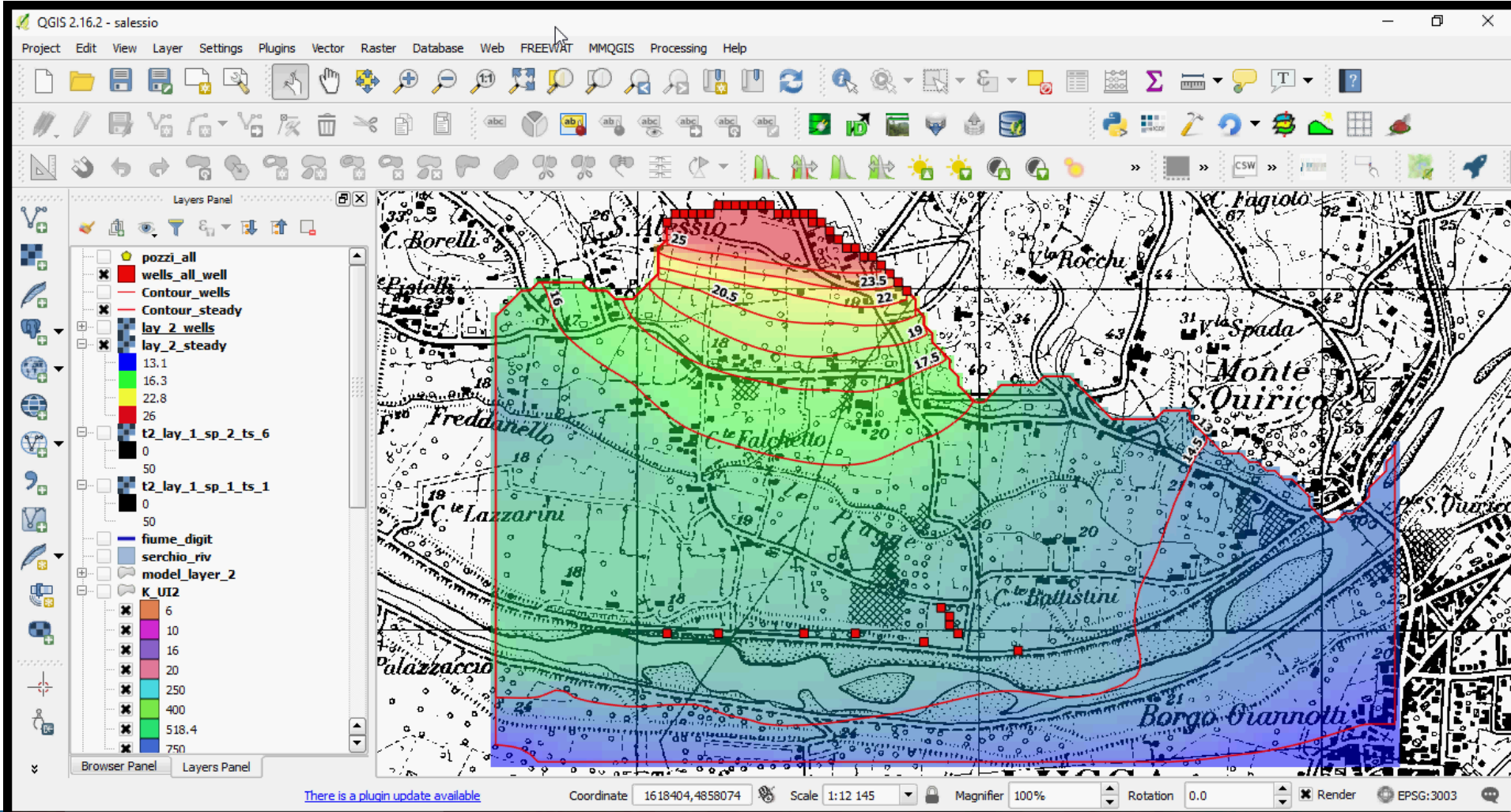
Rasterize the model outputs
(estimate the effect of pumping on the water table)

Creating well capture zones

FREEWAT Capabilities: Solute Transport

With FREEWAT the User can solve problems of groundwater contamination, to evaluate several scenarios, such as:

✓ Landfills/waste disposal

✓ Remediation of contaminated sites

✓ Salinization of coastal aquifers

FREEWAT Capabilities: Solute Transport

Solute Transport in Unsaturated Zone

❑ **USB (Unsaturated Solute Balance)**
- ✓ Computes concentration reaching the water table
- ✓ Possibility to use this result as input for MT3DMS (saturated zone)

❑ **UZT (Uns. Zone Transport) Package of the new MT3D-USGS**

MT3DMS (saturated zone)
- ✓ ADV - Advection
- ✓ DSP - Dispersion
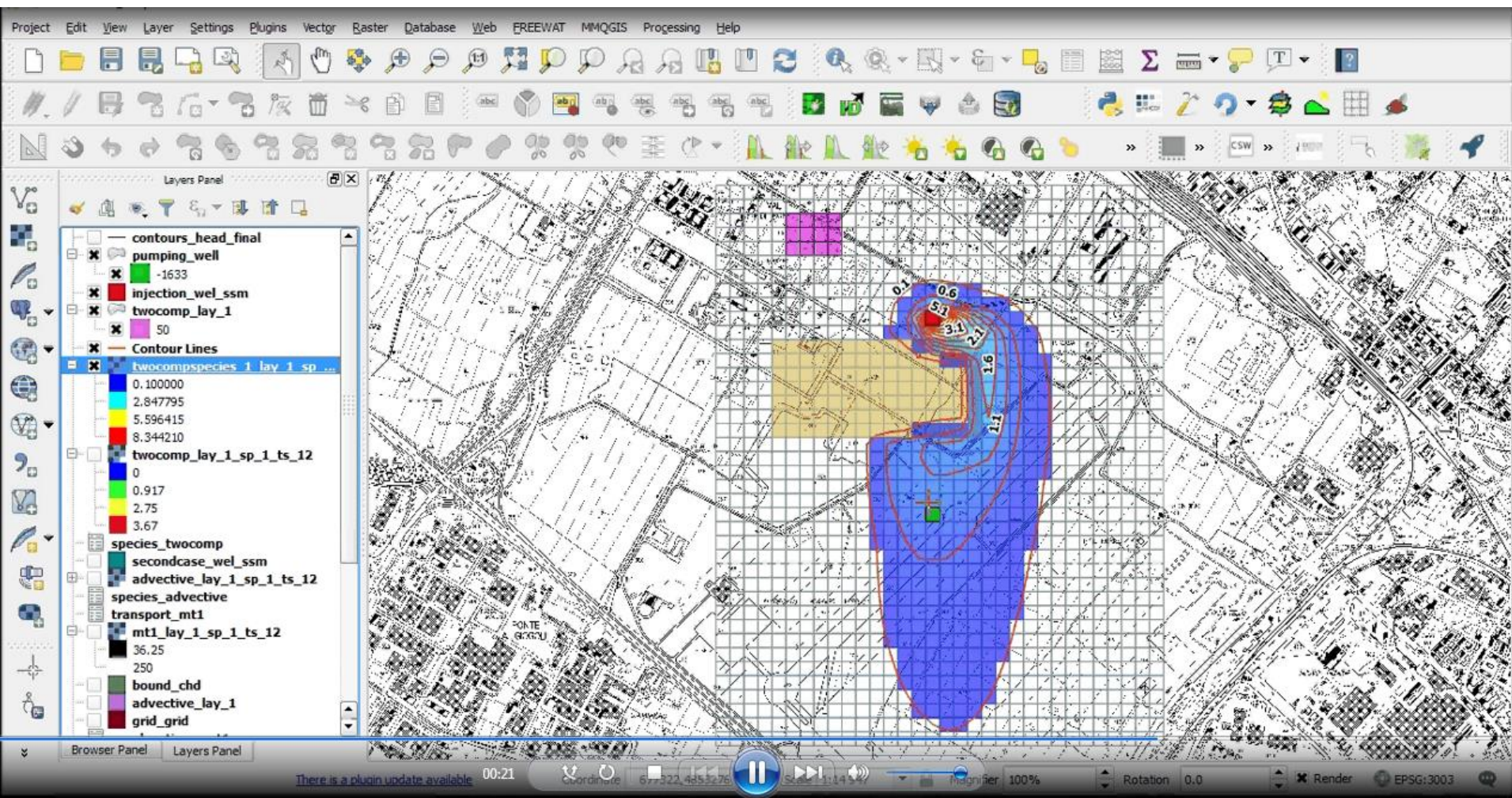- ✓ SSM – Source & Sink terms
- ✓ RCT – Reaction

SEAWAT (saturated zone)
- ✓ Density-dependent flow (VDF)
- ✓ Viscosity-dependent flow (VCF)

Visualize contamination maps

FREEWAT Capabilities:
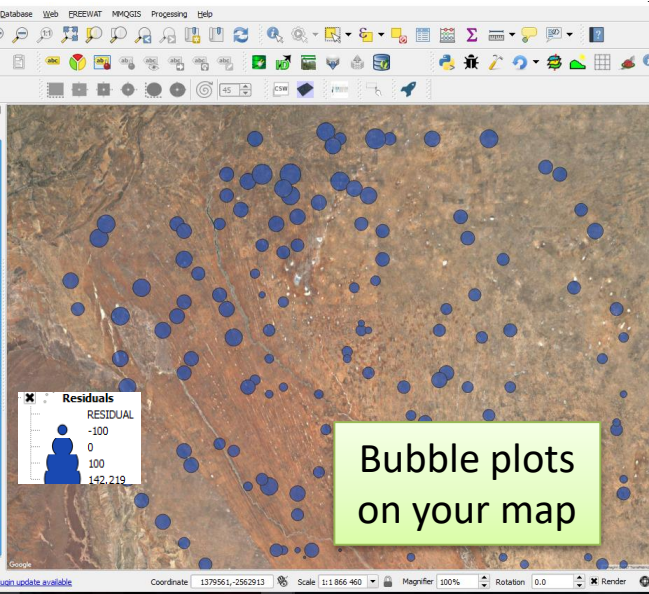# Calibration, Sensitivity analysis & Parameter estimation

✓ Comparing simulated vs observed data
✓ Evaluating the effect on the model of selected parameters (*sensitivity analysis*)
✓ Estimating the best value of selected parameters (*parameter estimation*)

Bubble plots on your map

Sensitivity diagrams

Sim. vs Obs plots
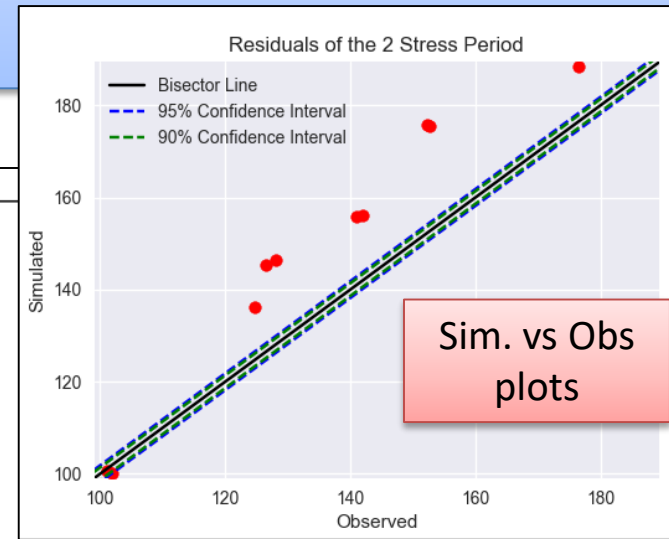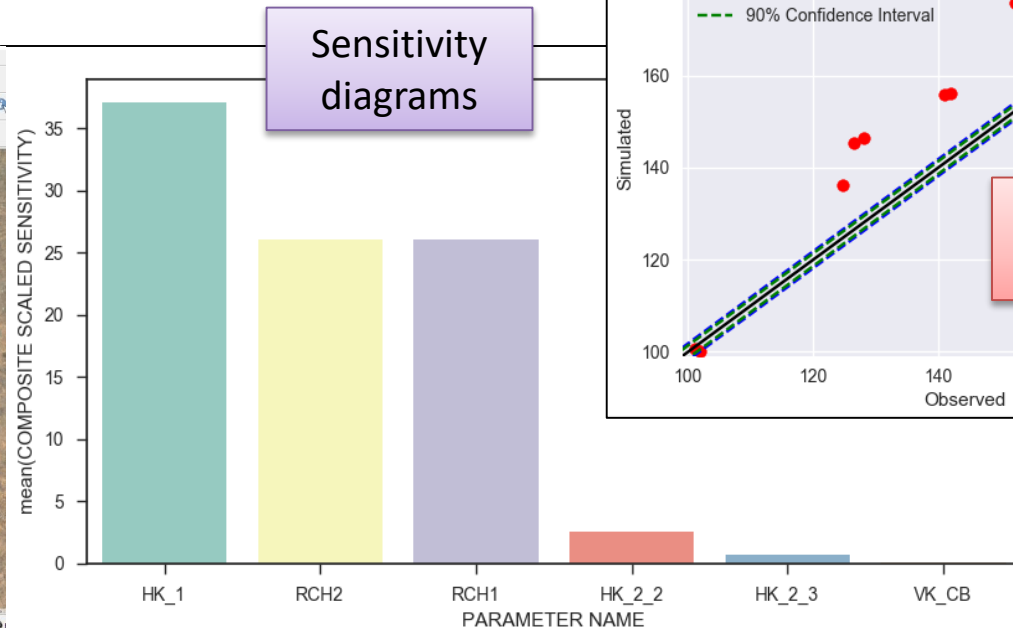
FREEWAT Capabilities:
Water Supply Management

(conjunctive use of surface/ground-water urban & rural water units)

Upscaling the model grid
- ✓ Define Water Demand Units : any "entity" consuming water
- ✓ Define in your domain the distribution of Soils and Crops

Compute the Water Demand (for each Water Unit)
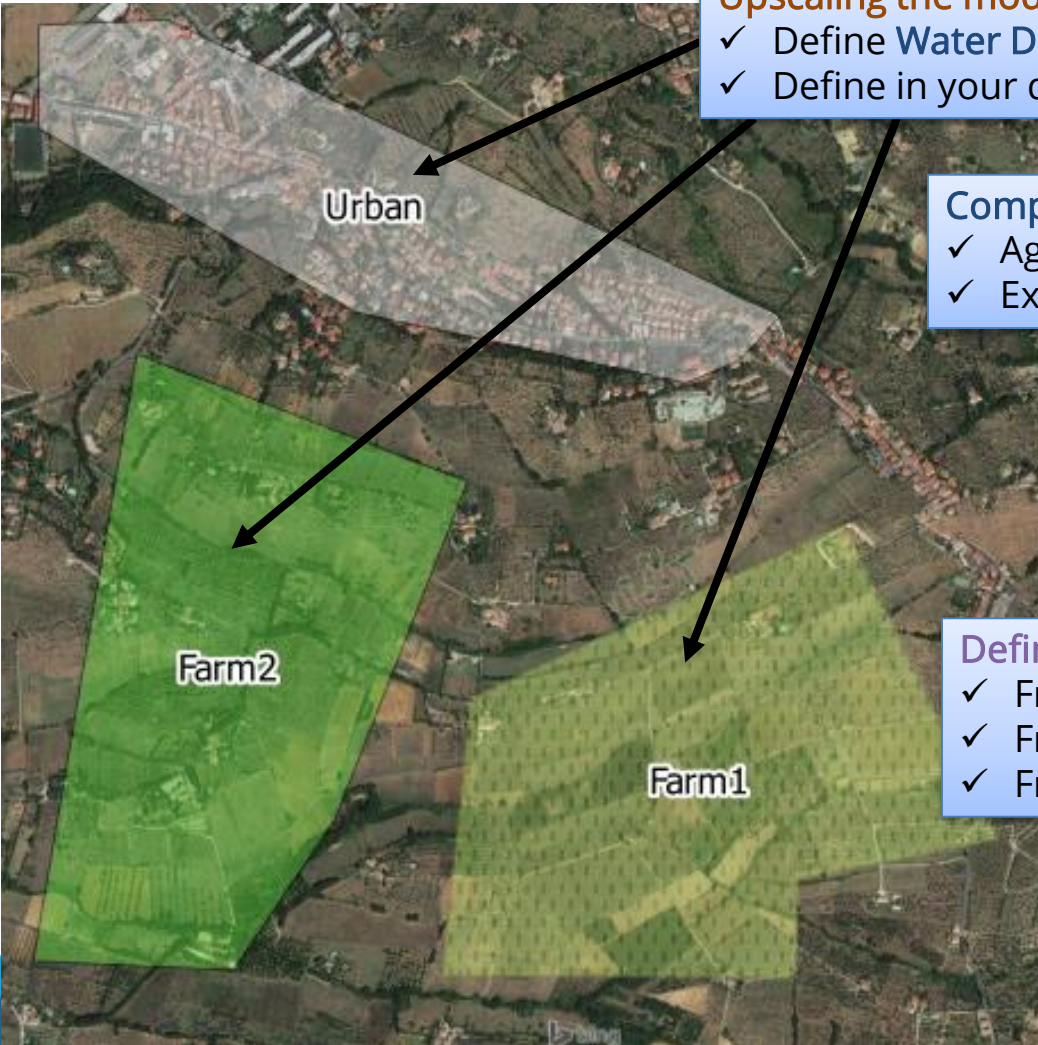- ✓ Agricultural (crops + soils)
- ✓ External (e.g. urban/domestic)

Define (potential) supply constraints: Water Rights
- ✓ Limits on Surface Water diversion
- ✓ Limits on Pumping Rate

Define the available source for Water Supply
- ✓ From **external deliveries** (also time-dependent)
- ✓ From **streams/canals**
- ✓ From **groundwater** (Pumping Wells)

Compute the Water Supply Optimization

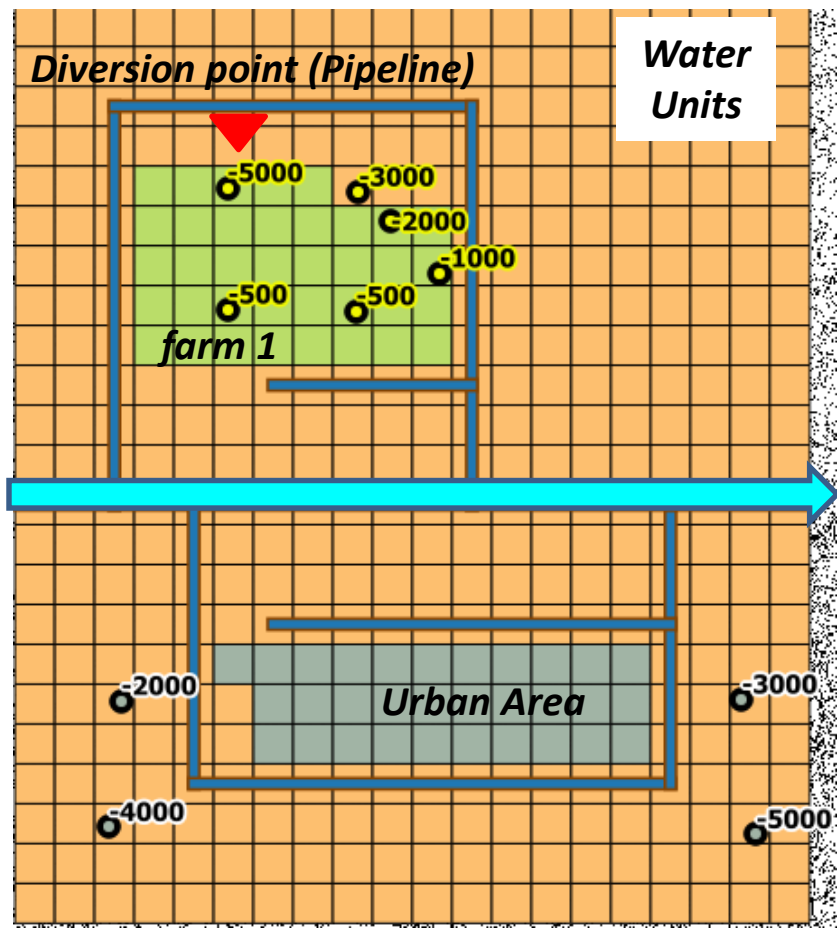# Conjunctive use of surface/ground-water
(urban & rural water units)
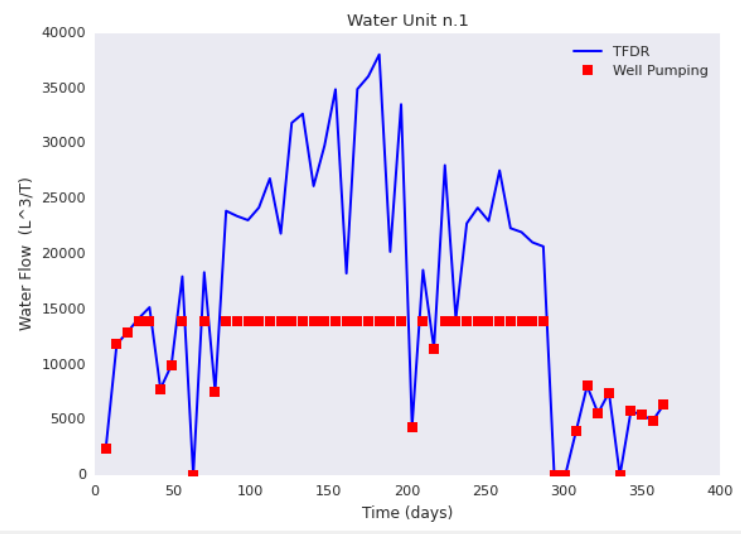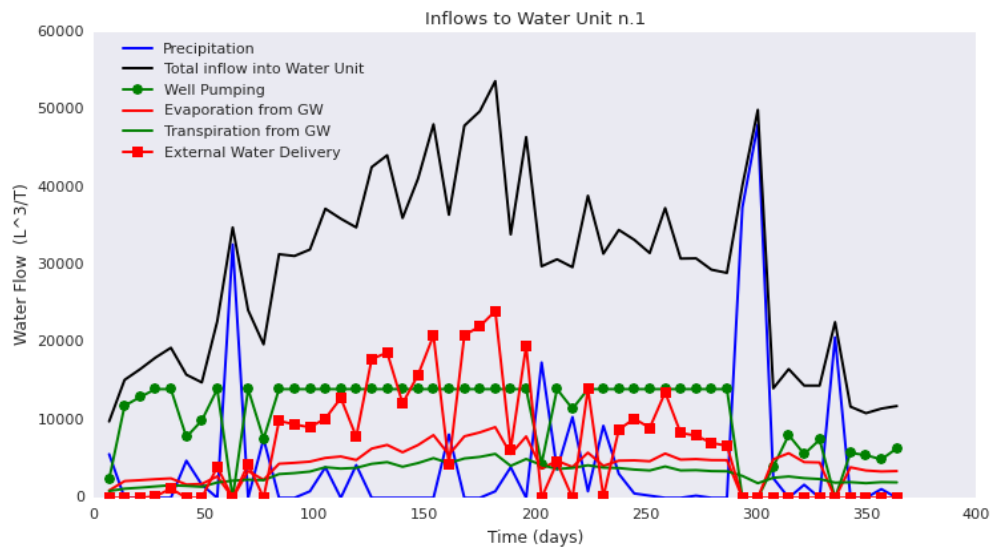
Releases history

A **Governance Agreement** and a **Release Policy** have been prepared and approved (for the after-project period)

So far: a new release every 2 months

Alpha	• November 30, 2015
Beta v.1.0	• January 31, 2016
Beta v.1.1	• April 30, 2016
Beta v.1.5	• June 30, 2016
v.0.1	• July 31, 2016
v.0.2	• Sept 30, 2016
v.0.3	• Jan 31, 2017
v.0.4	• March 31, 2017
v.0.4.1	• May 31, 2017

1ˢᵗ Public RELEASE

Testing

❑ No "structural" bug is present anymore

❑ Main tools have been extensively tested (different OS and QGIS versions): all tools included in training tutorials are stable

❑ Some (random) problems persist in the installation

❑ Some special options/capabilities has not been tested by non-developers

When the developer tests

When the quality team tests

Warning!!

When the project manager tests

When the customer tests
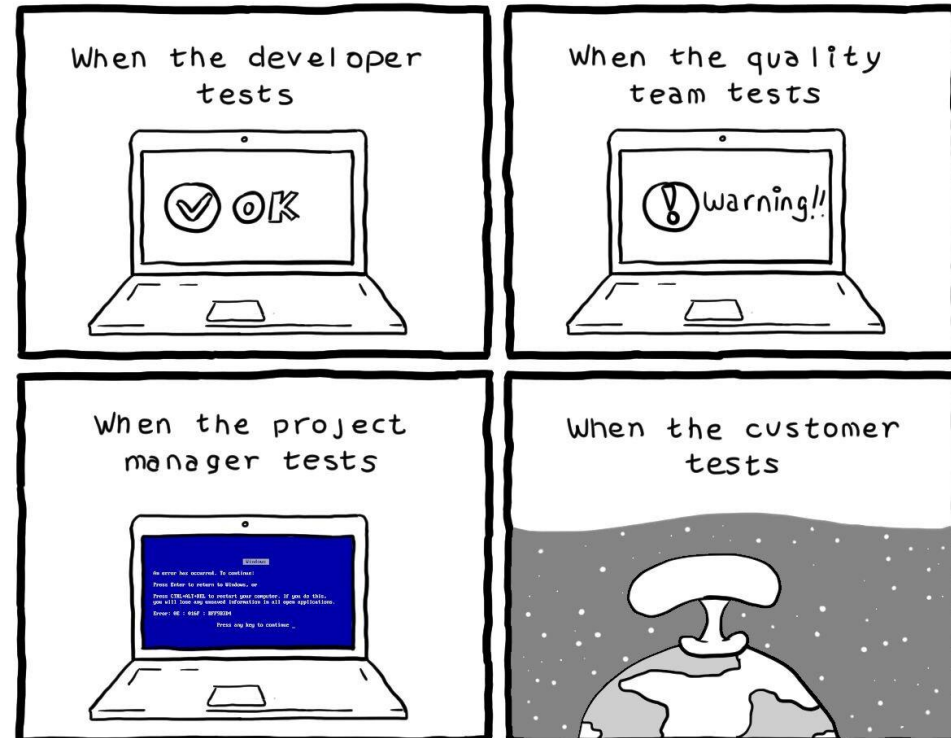
How to get FREEWAT

Starting from April 1ˢᵗ, 2017, you can free download FREEWAT:
http://www.freewat.eu/download-information

Once you have filled out the registration form (only for statistical purposes!), you get:
- *freewat* QGIS-plugin
- **User's Manuals** (6 Volumes)
- **Several tutorials** (including slides and data to run the exercise)

Registration includes you in the FREEWAT mailing list, useful to receive updates on new release, bug fixing, new tutorials, etc.
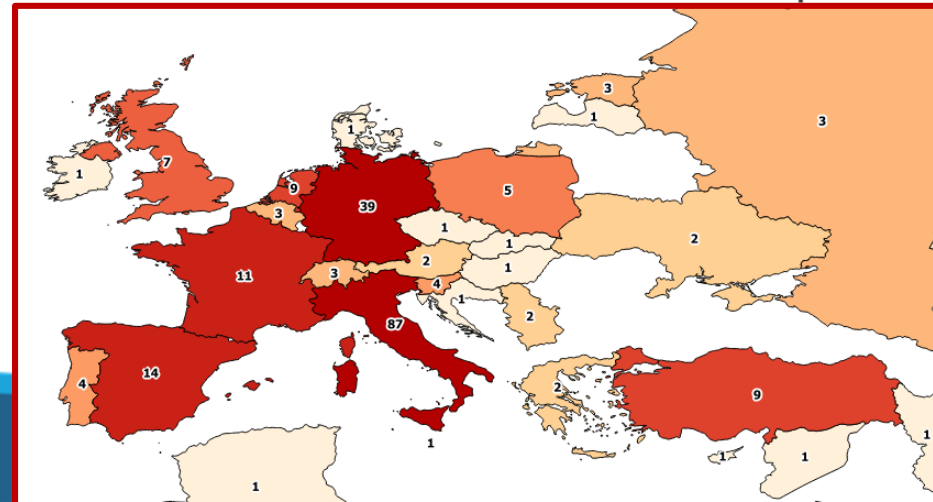
FREEWAT **downloads around the world**
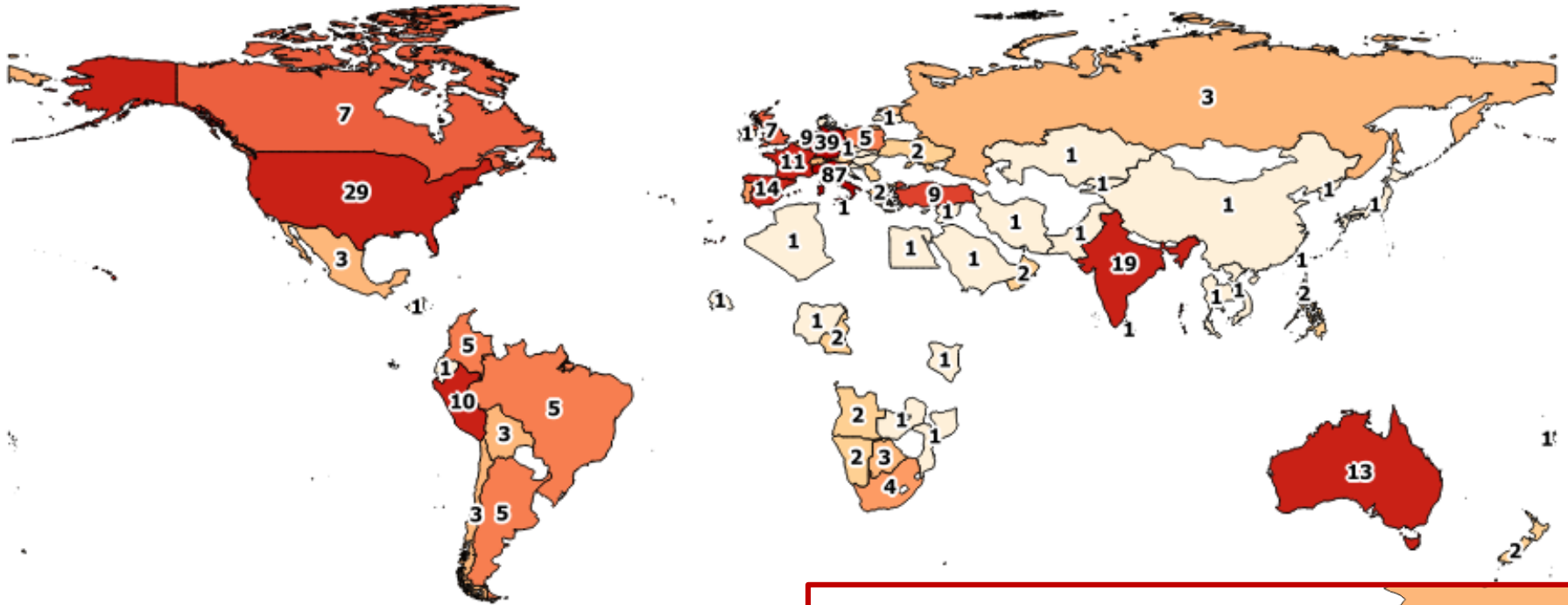
The 1st Month of FREEWAT public download
April 1 – May 1O, 2017
(~380 downloads)

FREEWAT: how to get involved

Being part of the Users' Community

To support FREEWAT application and usage, we set up a Users Google Group, to manage a shared system of Q&A

https://groups.google.com/forum/#!forum/freewat-users-group

Join the Group!!

FREEWAT: how to get involved

Keep working on development once the project ends

To support FREEWAT development, we are setting up a Developers Community

Any one interested to suggest (and develop!) enhancements and/or new capabilities is welcome!!!

If you want to join us, please write to:
iacopo.borsi@tea-group.com

and you'll get involved in FREEWAT future dev.

The future of FREEWAT

1. Official release (v.1.0) in September 2017
2. FREEWAT is being used in more and more EU projects → need the capacity to support users
3. FREEWAT 2.0 ?
4. Possible synergies?

Thank you for your attention