Project FREEWAT

FREE and open source software tools for WATer resource management

surface waters | ground water | water pollution

PROJECT DESCRIPTION

Exploitation, sustainable management and deterioration of the groundwater's quality, as well as the joint use of groundwater and surface water are issues of great importance and interest for the socio-economic development and the conservation of ecosystems. Management of these problems is closely linked, at regulatory level, to the implementation of broad, more and more cutting-edge monitoring networks which provide quantities of data that, if properly interpreted, are useful for developing efficient plans for managing groundwater resources.

Geographic information systems (GIS) allow to store, manage, analyze and display large datasets, thus facilitating the use of complex ICT (Information and Communication Technology) tools, such as hydrological numerical models, making it possible to simulate water resource distribution in time and space, taking into account anthropogenic stresses and providing information that can be readily used by decision makers.

Since GIS is a well-established technology, the use of modeling techniques is constantly spreading and in many cases the collected data is freely downloadable, the production of free and open source software tools can contribute to improve the groundwater management capacities, supporting the implementation of the water-related legislation (e.g the EU Water Framework Directive).

The H2020 FREEWAT project was conceived in this context. Its main result was the creation of a free and open source platform that integrates in QGIS different codes for the simulation of hydrological processes (including groundwater flow and interaction with surface water bodies, transport of contaminants, joint use of surface and underground waters, sensitivity analysis and estimation of the numerical model's parameters), in order to simplify the application of European directives and national water regulations.

The overall structure of the H2020 FREEWAT project is based on: i) coordination of previous national and EU funded research to create the FREEWAT platform; ii) supporting the deployment of the FREEWAT platform through specific training courses and its applications to case studies; iii) testing FREEWAT's application in an innovative participatory approach that brings together technical staff and stakeholders in designing scenarios for the proper application of water management policies; iv) communicating the activities and results of FREEWAT at international level in order to promote its application.

The development of the FREEWAT platform was supported by the result of a survey conducted in the first phase of the project to work out an evaluation grid, on the basis of which to identify the codes/ modules to be integrated into the platform itself. This was done matching the needs/ priorities related to the problems of water management with the availability of software tools to address these issues. These survey queries were distributed to 14 partners of the FREEWAT project and to different stakeholders (research institutes, governmental authorities, geo-environmental consulting firms, river basin district authorities) in EU countries and beyond. As result, priority was given to water management in rural areas (including management of agrochemical substances) and sustainable management of groundwater in terms of both quality and quantity. Further identified needs are related, directly or indirectly, to the joint use of surface and ground water, and to interactions between surface and underground water bodies. The emerged needs and priorities were then matched with the directives and related EU regulations. Therefore development of the FREEWAT platform was suited to the identified priorities.

The FREEWAT platform is now a plugin for the QGIS GIS desktop (QGIS Development Team, 2009), which brings together the mightiness of the geo-processing and post-processing tools typical of GIS softwares for spatial data analysis, and that of the

numerical models for the simulation of numerous hydrological processes (mostly benefiting from codes developed at the USGS). As such, the FREEWAT platform is designed with a modular structure, in which several codes for hydrological cycle simulation (with a prevalent focus on groundwater flow analysis) and hydrochemical processes are integrated into the QGIS desktop. Input and output data are managed via SpatiaLite spatial database (SpatiaLite Development Team, 2011). Central element of the platform's development was the use of exclusively open source codes.

OBJECTIVES

The tools currently implemented in the FREEWAT platform can be divided in two large classes. The first contains the tools for hydrochemical and hydrogeological data analysis (AkvaGIS module) and tools for data pre-processing as well as for time-series data analysis (OAT - *Observation Analysis Tool* - module). The second class consists of a series of tools for the implementation of the numerical model and mainly includes USGS MODFLOW codes, mostly dedicated to groundwater management. Available tools are detailed below.

The AkvaGIS module offers various tools for the analysis and interpretation of hydrochemical and hydrogeological data. The features of this module make it possible to prepare graphs and perform statistical analyzes on hydrochemical data for the assessment of groundwater quality, up to the interpretation of hydrogeological data and the generation of thematic maps for the construction of conceptual models.

The Observation Analysis Tool (OAT) provides the user with advanced features for an on-line and real time time-series analysis, in the perspective also of the increasing spread of monitoring networks. OAT is designed to facilitate the import, analysis and display of time-series data and the use of this data to support the construction of numerical models as well as their calibration.

Groundwater flow simulation can be performed using MODFLOW-2005 (Harbaugh, 2005), a physically based and spatially-distributed code developed by USGS. The flow associated with wells, effective recharge, evapotranspiration, drains and the surface water bodies can be simulated through specific MODFLOW packages, among which the Lake package (Merritt & Konikow, 2000) for the simulation of the lake-aquifer interaction.

On the FREEWAT platform a hydrological model can be combined with one or more solute transport models for simulating the multi-species advective-dispersive transport in the saturated zone, using MT3DMS (Zheng & Wang, 1999). Simulation of 1D solutes transport within the unsaturated zone is possible using one of the following instruments:

- USB module (Unsaturated Solute Balance) to estimate the amount of contaminant that, released to the countryside, percolates through the unsaturated area driven by a purely advective vertical flow and reaches the water table, where it constitutes a source of constant concentration for the saturated zone, where MT3DMS is applied;
- MT3D-USGS code (Bedekar et al. 2016) for the simulation of the advective-dispersive flow in the unsaturated zone.

The integration in FREEWAT of the SEAWAT code (Langevin et al. 2007) allows to simulate flows dependent on viscosity and density. This allows to simulate seawater intrusion processes or to evaluate low and medium enthalpy geothermal resources.

Management of water resources is achieved by incorporating MODFLOW-OWHM (One-Water Hydrologic Flow Model, Hanson et al., 2014), within which the Farm Process module allows to dynamically simulate the water demand and supply of the model's sub-regions in which water-demanding activities are carried out, such as those related to agriculture. In this way an integrated and combined hydrological model is obtained, which allows the estimation of possible allocations of the jointly used surface and underground waters. Management of water resources in rural areas can also take into account eventual norms on water supply regularization.

UCODE_2014 (Poeter et al. 2014) is incorporated to perform sensitivity analysis and parameters estimation, with the aim of improving model calibration, reducing the gap between hydraulic load, simulated flows and observed data. To perform this analysis different statistical data can be used in order to evaluate the model's construction and to select the parameters to be estimated using a reverse regression method based on the evaluation of a target function.

PROJECT PHASES

The project activities were implemented mainly along two axes: 1) development of the FREEWAT platform and capacity building; 2) application of the FREEWAT platform and involvement of local stakeholders (participatory approach).

1. The activities carried out during the first phase of the project concerned first of all the construction of the FREEWAT platform. The main result of this activity is a free and open source simulation platform, developed in QGIS, which integrates in a single environment pre-processing and data analysis tools, free and open source numerical codes for the simulation of hydrological processes (including the flow of groundwater and the interaction with surface water bodies, the transport of contaminants, the joint use of surface and underground waters, sensitivity analysis and estimation of the parameters of a numerical model), and post-processing tools for displaying and analyzing results. The FREEWAT platform is nothing more than a QGIS plugin, freely downloadable from the project website, **together with a complete set of 6 users' manual, 1 reference manual and tutorials with dataset** for practical exercises aimed at gaining familiarity with the platform's tools. The development of the FREEWAT platform was followed by activities of capacity building and technology transfer, aimed above all at forming the project partners on the use of the platform's tools (Training the Trainers). Each of the partners was then involved in national scale capacity building activities. This led to the training of around 1200 people from 53 countries around the world and the involvement of more than 400 institutions among research institutes, private companies and public administrations.
2. The second phase of the project concerned the application of the FREEWAT platform to 14 case studies in EU and non-EU countries, to demonstrate the effectiveness of the measures envisaged in the river basin management plans in order to improve the qualitative and quantitative status of groundwater bodies under consideration. In order to guarantee an effective communication to the decision-makers of the results obtained in each case study, an innovative participatory approach was adopted, consisting in the active involvement of local stakeholders not only in the final phase of discussion of the results, but during all the phases of application of the platform in the specific case study. For each case study a Focus Group (FG) consisting of local stakeholders (basin authorities, research bodies, environmental protection bodies, environmental associations, etc.) was set up, which took part in seven meetings with the aim of discussing the methodology to be adopted, the definition of the conceptual model and the data necessary for the specific case study. The FG also took decisions on scenarios to be simulated to test the feasibility of the planned measures. During the seven meetings participants also discussed their experiences on the use of ICT tools for groundwater management.

For each of the developed models a technical report was produced, while the models and datasets used are collected in a specific repository. Some of the implemented models have been chosen and used for operational purposes by the local authorities responsible for managing the specific water body subject of the FREEWAT platform application.

PROJECT RESULTS

The FREEWAT platform was designed to meet the needs of water management authorities and public/ private companies in building a highly informative and dynamic representation of hydrological systems, taking into account the large amount of currently available data. This with the ultimate aim to adequately support the results of scientific research promoting their widespread application, replicability and use by policy makers and water management authorities.

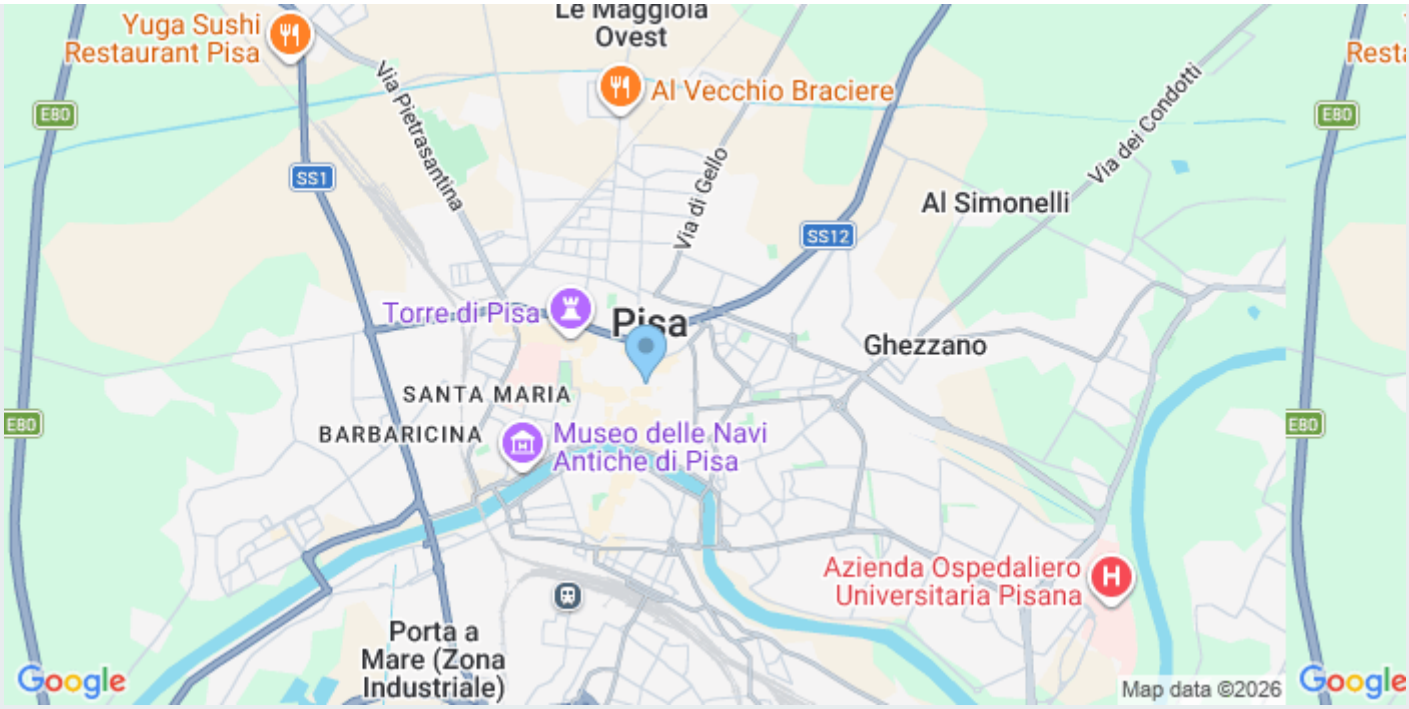
FREEWAT is now globally used by about 1000 users (with downloads done by more than 3000 people). The FREEWAT platform is currently used in university courses (degree courses, Masters, Summer Schools, etc.), dissertations, professional courses and professional activities. To date around 1500 people have been trained, directly by the members of the FREEWAT Consortium, on the use of the FREEWAT modeling tools.

FREEWAT has its website, www.freewat.eu, and is active on social media channels such as LinkedIn (approx. 770 followers), Twitter (1240 followers) and Facebook (260 followers).

Moreover FREEWAT has been awarded the 6th Mülheim Water Award.

FREEWAT has been presented in more than 60 conferences and meetings and gave rise to 16 peer-reviewed publications, all freely available and downloadable from the project's website.

The FREEWAT platform combines the power of the processing and post-processing GIS tools for spatial data analysis (including management and display of the processings' results), and that of the simulation codes. In this way it is also possible to exploit the data deriving from the monitoring activities requested by the WFD.



-

Acronym
FREEWAT

Number of reference
642224

Reference Programme
HORIZON 2020

Beneficiary Coordinator
SCUOLA SUPERIORE SANT'ANNA

Contacts
Rudy Rossetto

EU contribution
1.411.162,50

Call Year
2014

Start Year
2015

End Year
2017

Beneficiary headquarters

P.zza Martiri della Libertà
56127 Pisa PI
Italy

Region
Toscana

Description

Italia, EU, Africa, Turchia, Svizzera, Ucraina