# Development of an Earth Observation System for the management of Water resources based on SWAT

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# Presentation outline and objectives

1. Background and the European research directions
2. Description of the Earth Observation System
3. Technologies
4. Interoperability and Interfaces
5. Conclusion

# The EU research vision

The **EU is actively supporting the development of web-based and mobile applications** as promising technological tools to support citizen science.

Some initiatives:

**Copernicus** - https://www.copernicus.eu/en

Copernicus is the **European Union's Earth Observation Programme**, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers information services based on satellite Earth Observation and in situ (non-space) data.

**GEOSS** - https://www.earthobservations.org/geoss.php

GEO's Mission is to build the **Global Earth Observation System of Systems** (GEOSS). GEOSS is a set of coordinated, independent Earth observation, information and processing systems. GEOSS links these systems to strengthen the monitoring of the state of the Earth.

# SUPREME and TESTARE

These are 2 projects funded by the European ERANET MED Program and by the Sardinian Region respectively. Within these projects, one important aim is to develop **a web based Earth Observation System for the water domain based on in situ monitoring data and modelling outputs**.

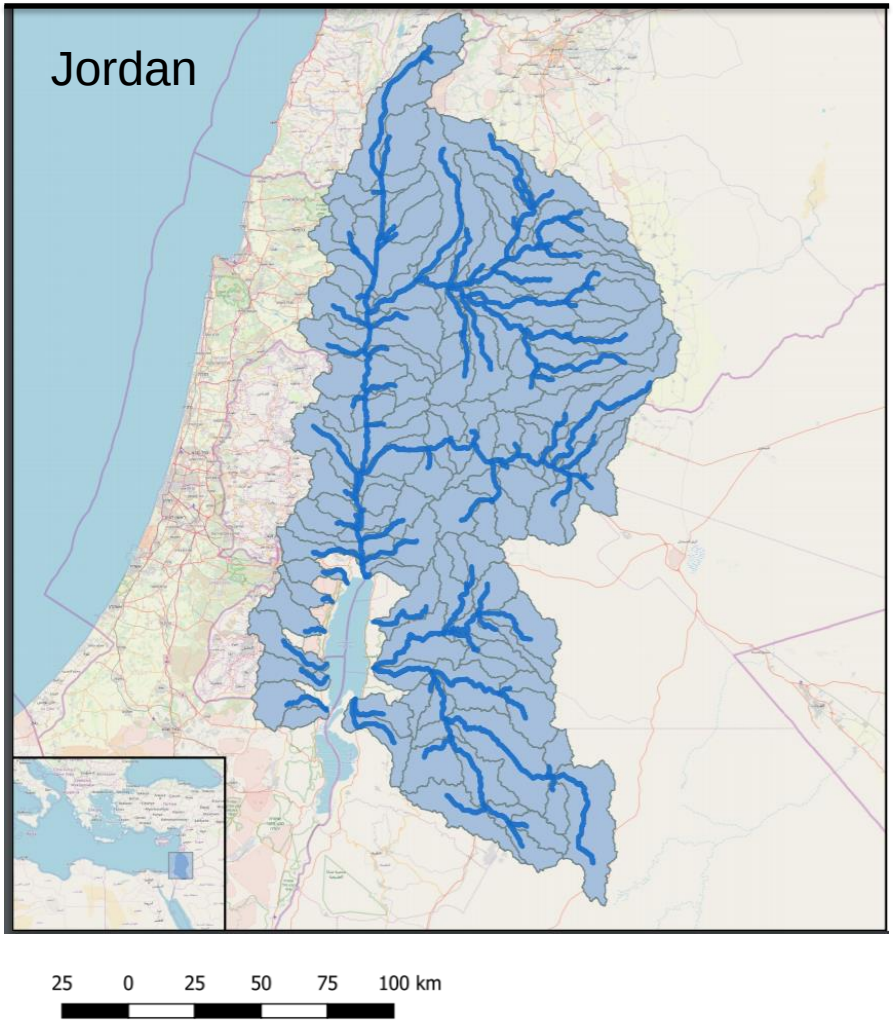
The **ODM2** data model for Measurements and Observation have been adopted and specialized to store earth observation data:

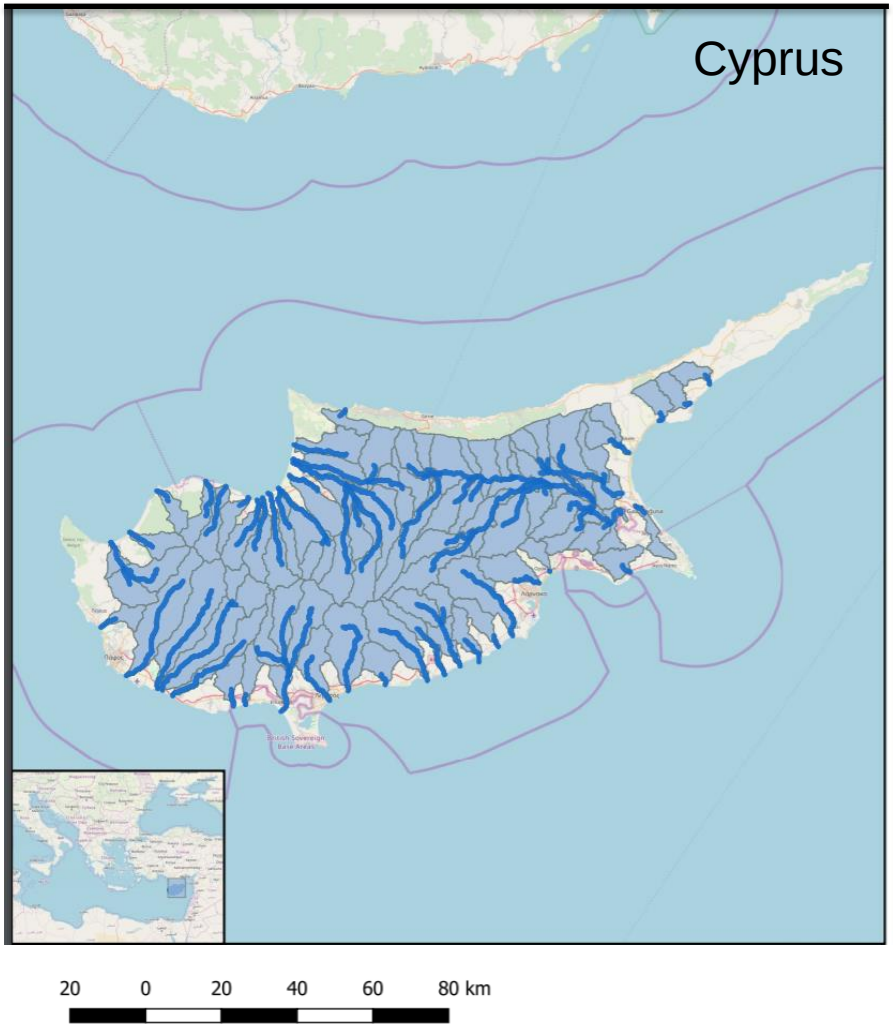
http://www.odm2.org/

SWAT has been chosen as the hydrological model and applied to study:

1. **Cyprus**
2. **Jordan**
3. Sardinia (still to be done)

# The study sites




http://acqua.crs4.it:8080/SWAT_Cyprus_HG_natural/

http://acqua.crs4.it:8080/SWAT_Jordan_MP_natural/

# Challenges and gaps

There is the need to **strengthen the connection between earth observation data both in situ and remote and modelling applications**.

Models, such as SWAT, are advanced tools to extract meaning and knowledge from Earth Observation data.

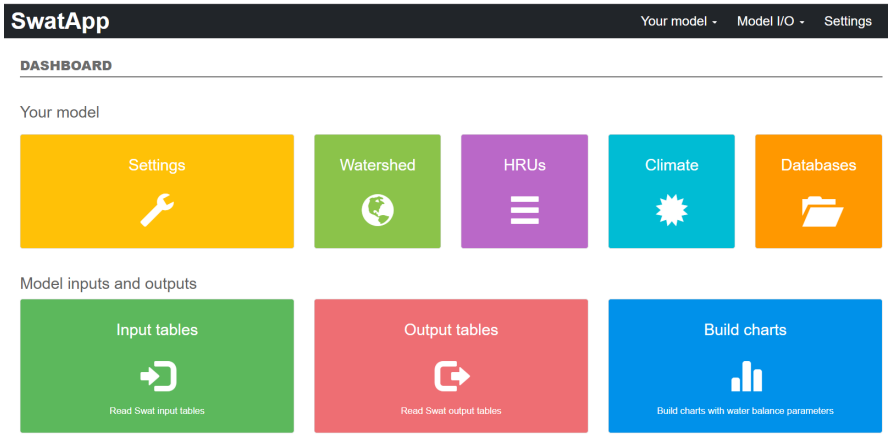
Models have also the potential to better predict transformation that natural resources undergo due to external causes (e.g. human pressures and Climate Change).

There **are still huge GAPS between Science, end users, industry and citizens**. Good science, data and knowledge must be shared (e.g. through open data, by developing web applications, by adopting interoperability standards, etc.).

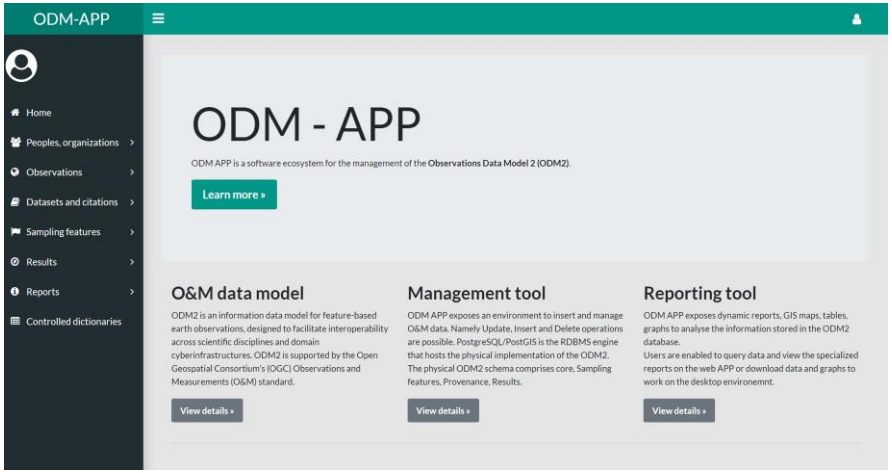
.

# **The earth Observation System** exposes currently 2 modules:

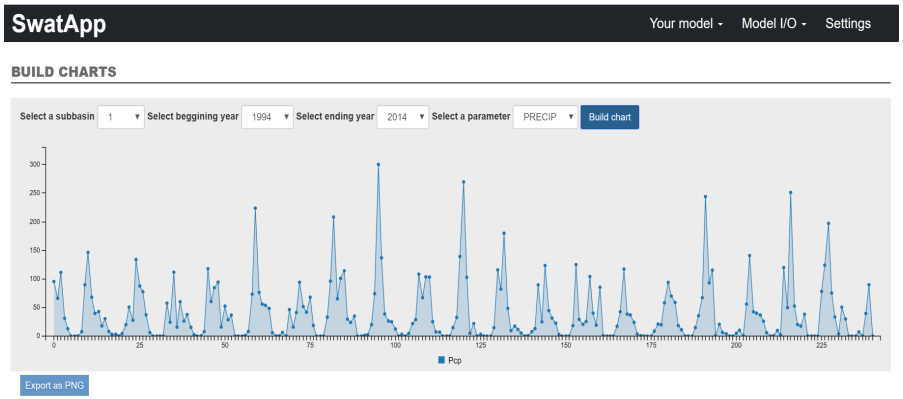
## SWAT APP to process SWAT Output




## ODM 2 APP to manage EO data




## SWAT APP digests SWAT data and expose on the WEB dynamic reports



# ODM2 APP

It exposes an environment to insert and manage Observation & Measurement (O&M) data.

**Update, Insert and Delete operations** are possible.

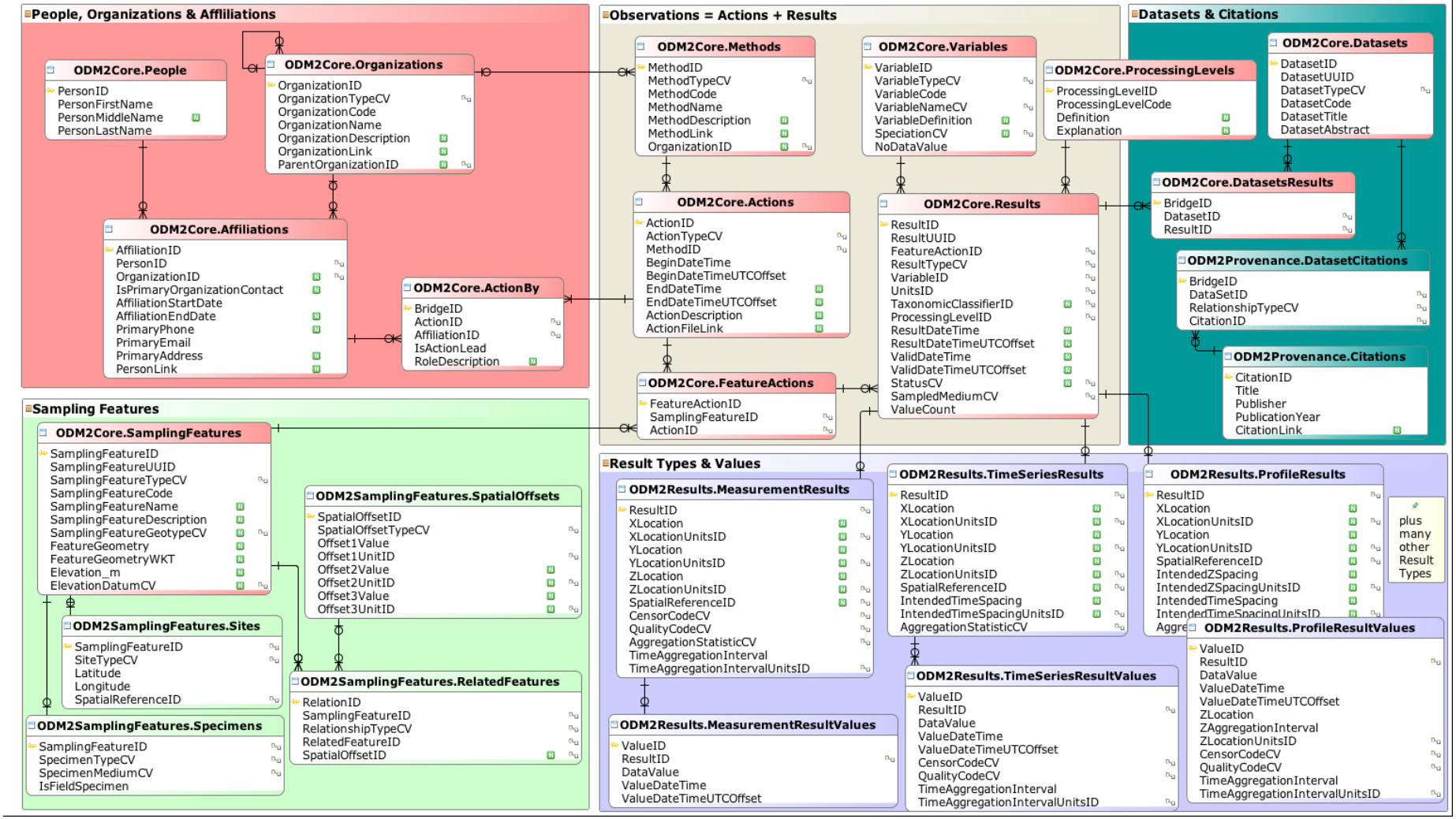
**PostgreSQL** is the RDBMS engine that hosts the physical implementation of the ODM2.

The physical ODM2 schema comprises **Core**, **Sampling Features**, **Provenance**, **Results**.

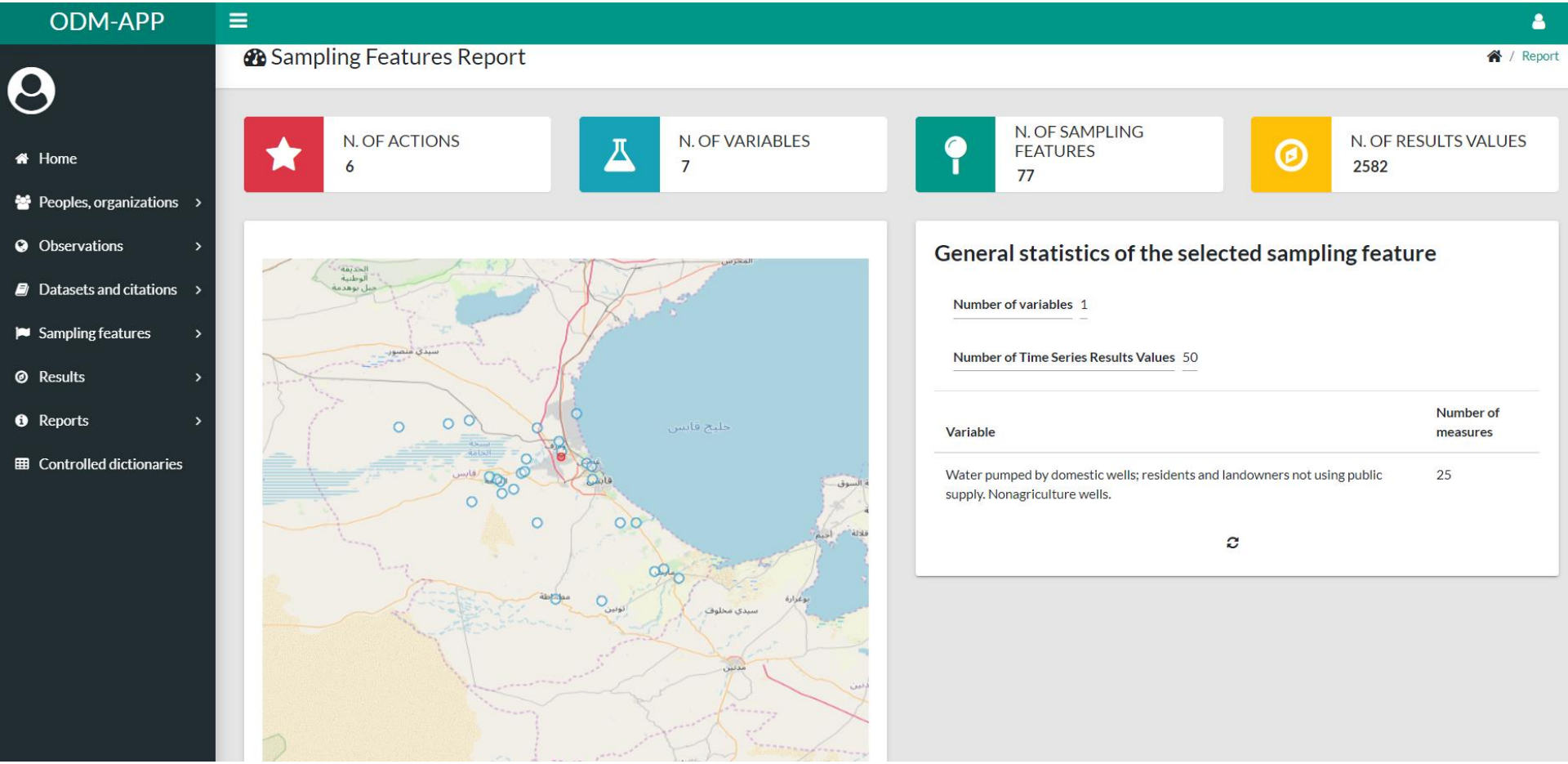
ODM2 has been specialized and extended to meet requirements of users

To view it in action:
**http://acqua.crs4.it:8080/alto/ODM2/dashboard**

# The data model



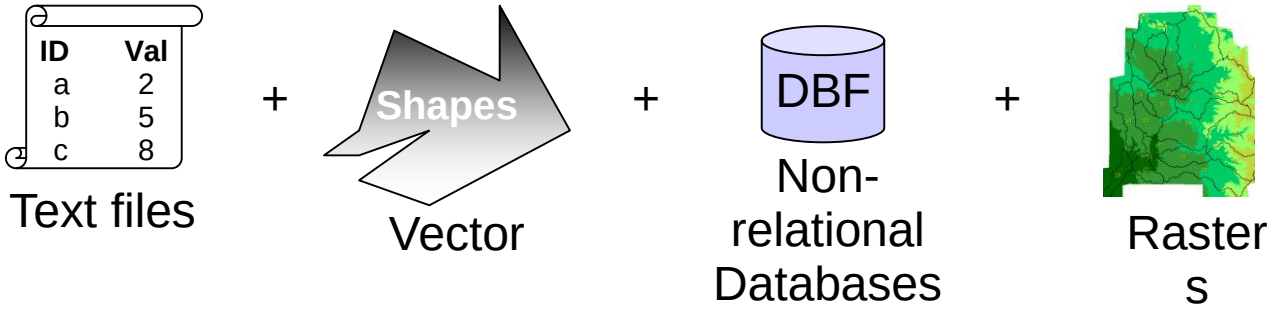
# Reports and Applications



- ✓ Enables users to expose their SWAT simulation on the web and to ease the **report production mechanism**
- ✓ Shares data, knowledge through a web based environment
- ✓ Exposes through its API **interoperability services** to foster a broader user experience
- ✓ **Bridge the gap between science and end users / citizens!** SWAT models can be viewed by anyone
- ✓ All the model-related data are organized into complex Relational DB infrastructures
- ✓ Exploit user-roles policies to define complex security and access strategies and differentiate the interfaces

# SWAT Data processing

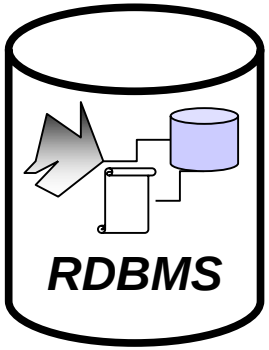
*The SWAT model uses several different data formats*




***SWAT APP needs to access data through a RDBMS***

A client-server procedure,, imports the data into relational databases on the server.

Imported data include: *output.rch, output.sub, ArcSwatDB/*.dbf, ESRI Shapefiles, etc.*

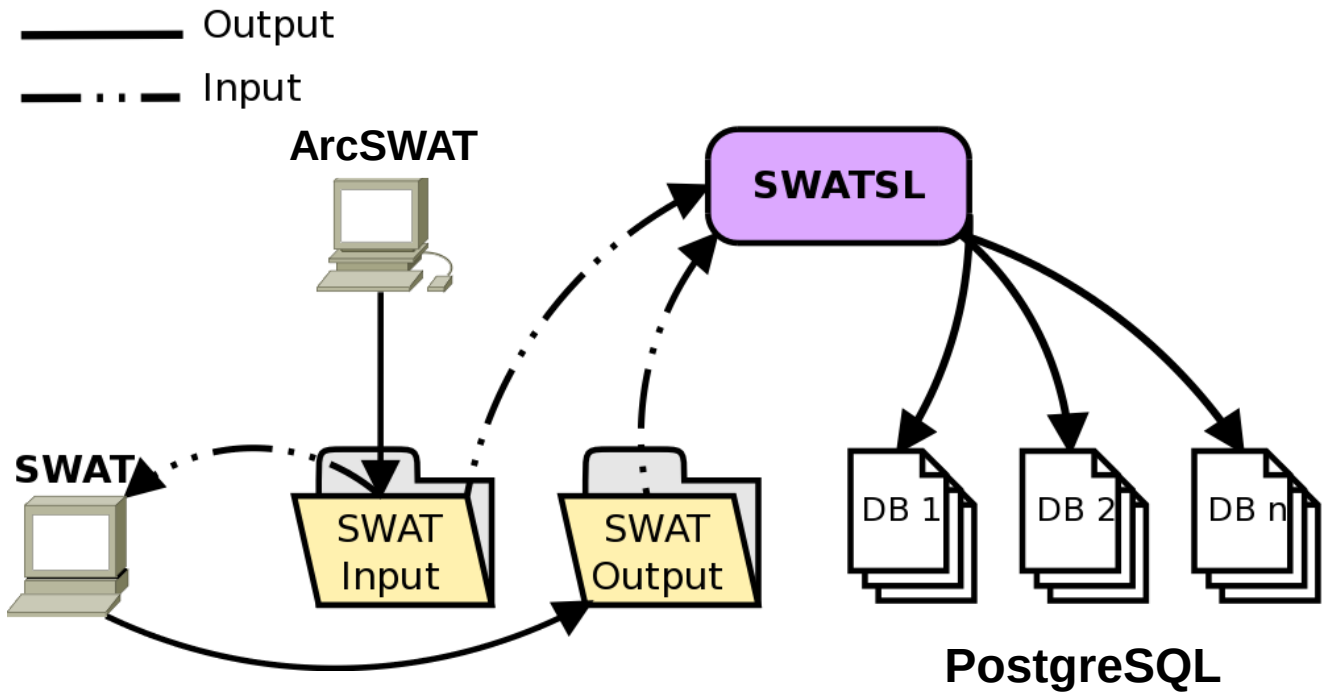



SWAT APP natively implements JDBC connections.

The PostGIS engine is used for data archiving of GIS data.

# Data flow

Each model run becomes a scenario stored in the db infrastructure



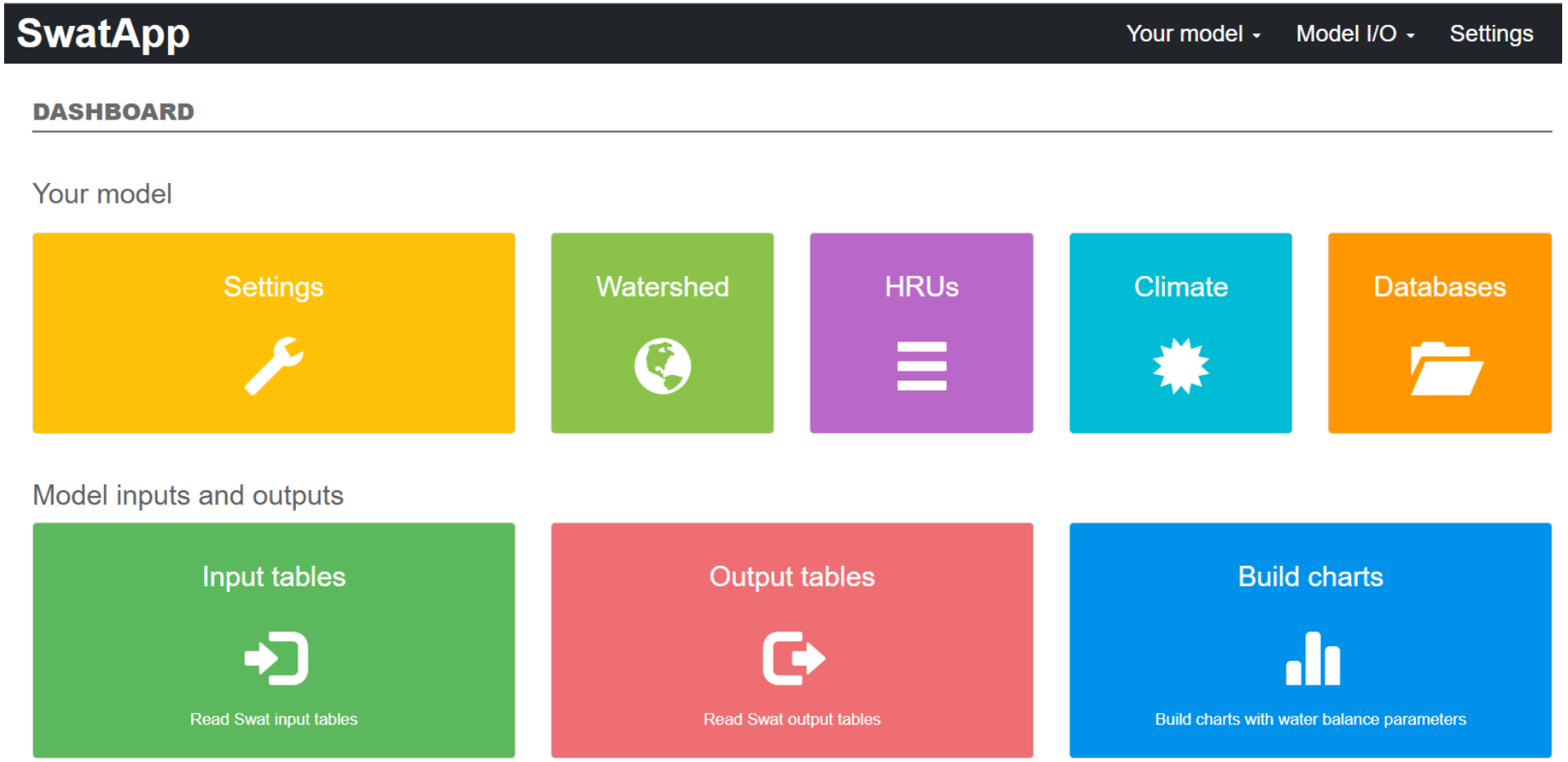
# Interoperability - API

The **SWAT APP and Alto API** are developed in the Java programming language to access and use all data and services.

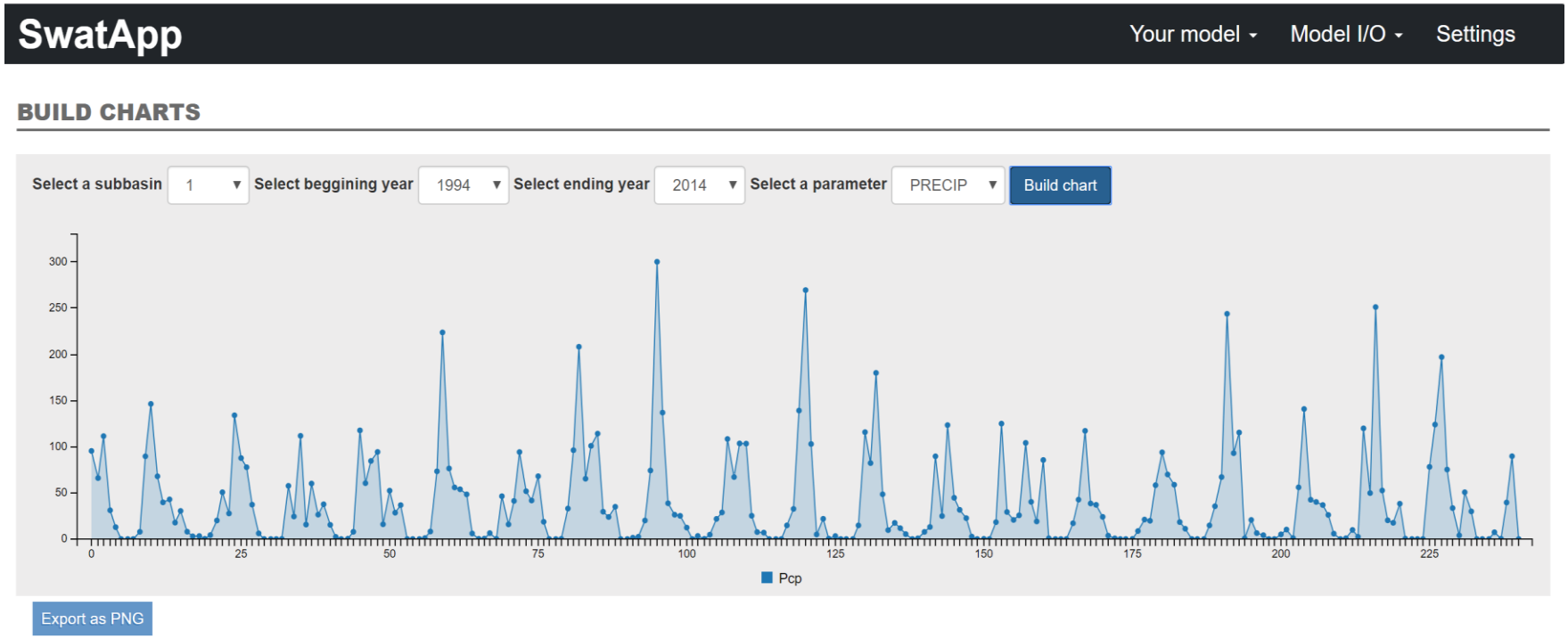
The **API** offers a uniform way of identifying and accessing to resources, and thus increasing the interoperability between applications.

The **SWAT APP and Alto** API explicitly targets needs of third party products.

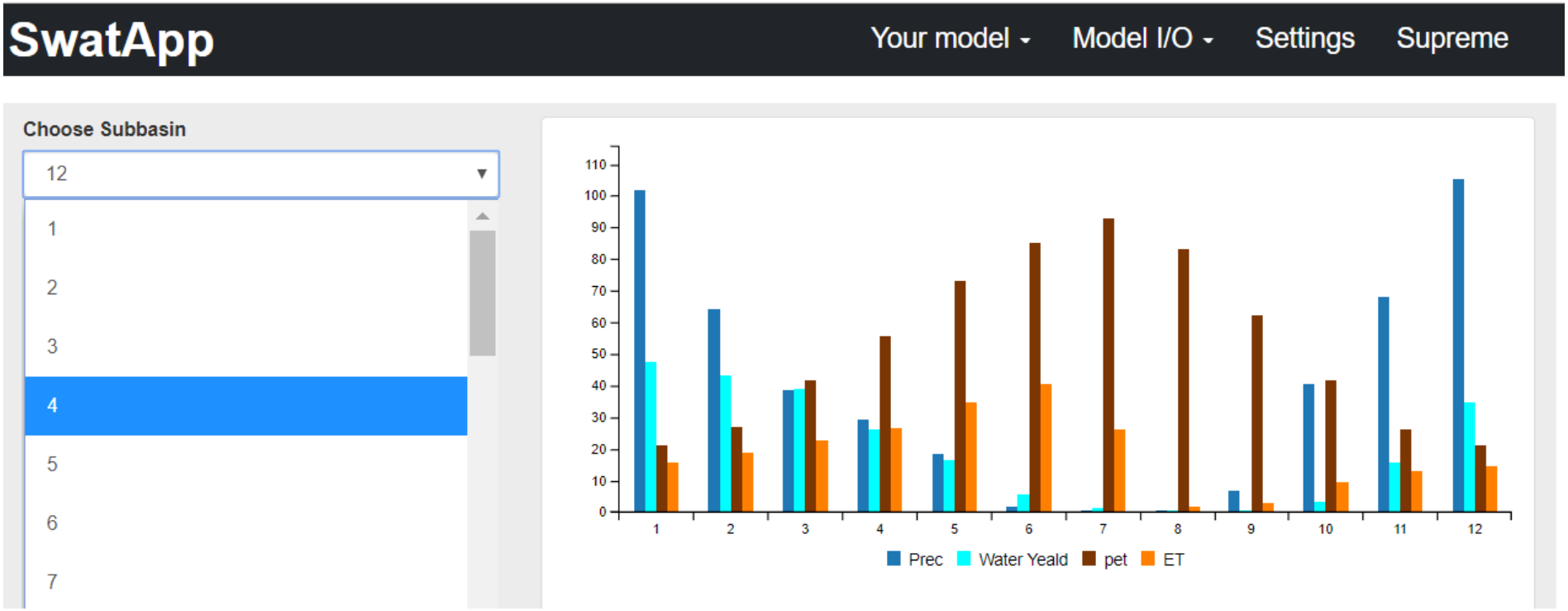
# GUIs: the Dashboard



# Example of a dynamic report: Time series Chart



# Example of a dynamic report: the water balance



# Alto Framework

Alto is a **full-stack, modular, low code development framework** to design and develop professional web information systems.

The software exposes:

- a visual user friendly web editor with a powerful GUI.
- a fast and flexible processing system for App development.
- a suite of widget engines to create complex HTML objects such as GIS maps, tables, graphs, search engines, forms, etc.
- a distributed Collaborative Working Environment where large communities can cooperatively create Web applications.

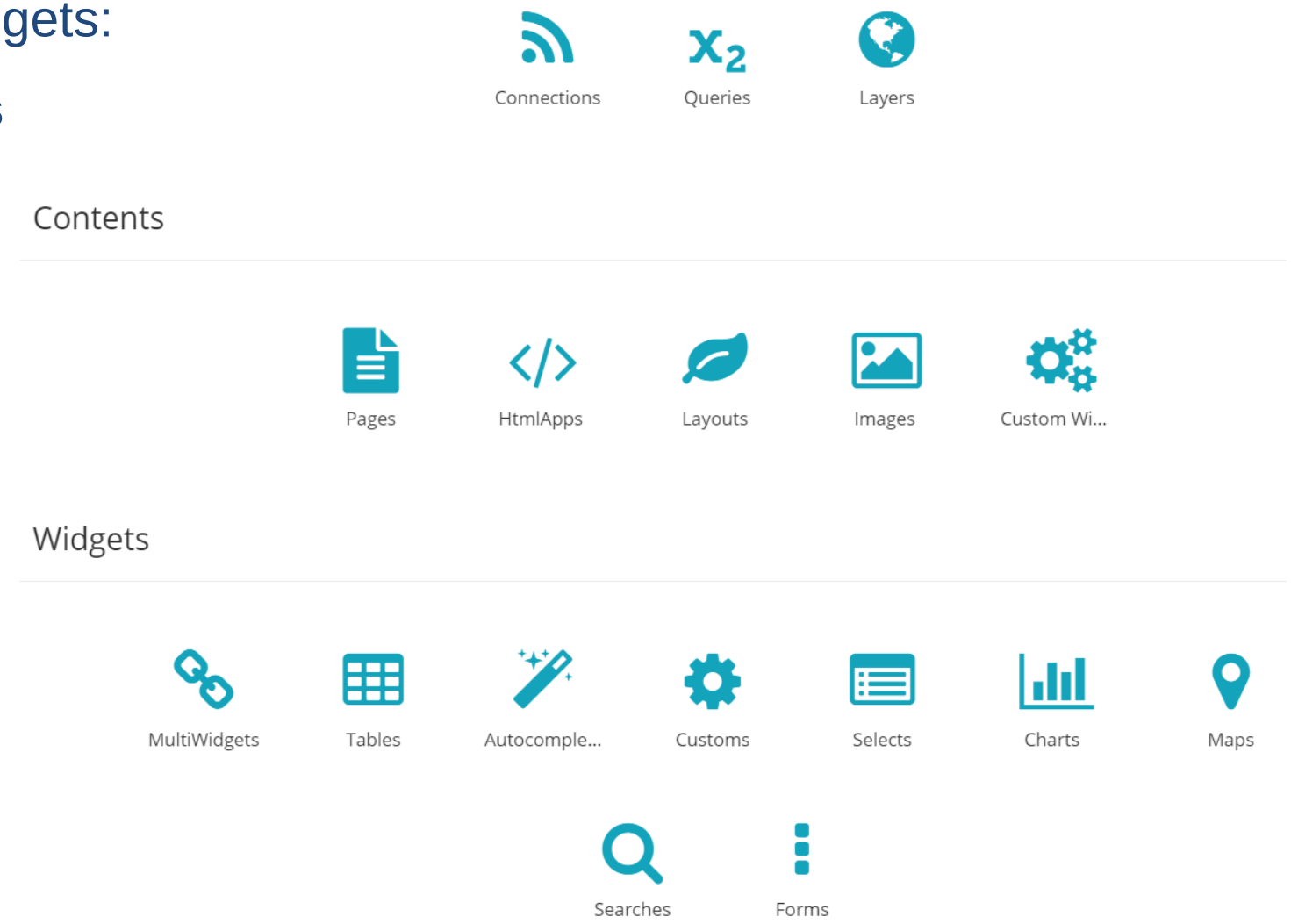
It transparently combines, in one space, technologies to access, query and process complex data infrastructures.

For the description of the framework go to: [www.altoframework.com/](www.altoframework.com/)

Through easy to use web interfaces it is possible to connect to RDBMS (e.g. Postgis, Mysql, Oracle) explore the data and shape  a variety of objects and widgets:

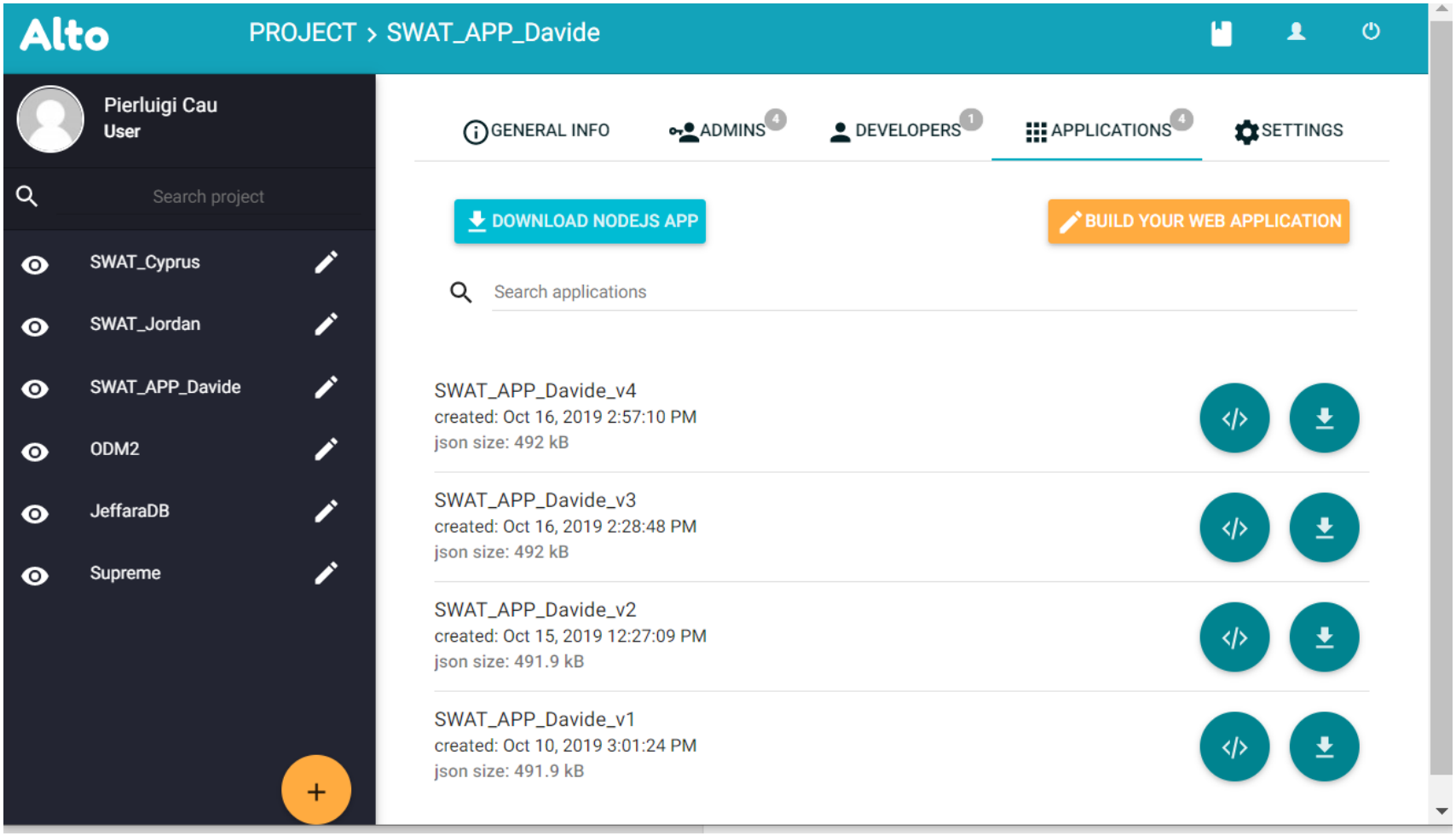
- **Connections**
- **queries**
- **charts,**
- **maps,**
- **tables,**
- **forms,**
- **dropdowns,**
- **searches,**

**etc..**



# A multi user – multi project Environment

Once ready, the application can be downloaded (as .war file) and then deployed to any tomcat / jboss webserver !



# Conclusions and future work

**ODM2 APP and SWAT APP** are web based software that can be extended to the needs.

Both APPs have been developed using the "**Alto Framework**", namely **Alto**, a development framework, for constructing spatially enabled web applications.

**ODM2 and SWAT APP + Alto** are a *problem-solving* environment *for the* **Environmental Sciences** for the integration of

- *resources for*
  - *communication*
  - *computation*
  - *data storage*
  - *visualization*
- *instrumentation*
- *human know-how*

# Conclusions and future work

**SWAT APP** works in tandem with the pre-processing **ArcSWAT**.

SWAT APP is a web interface interfaced with a **fully programmable environment in the back end** to construct spatially enabled applications on the WEB.

It has been widely tested on real case studies on available datasets: Cedrino (Italy), San Sperate (Italy), Black Sea Catchment, Cyprus, Jordan ...

*SWAT APP project is being developed at:*

**http://acqua.crs4.it:8080/alto**

*To use the system, send an email to: pierluigi.cau@gmail.com*

# Aknowledgments

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