Doctoral student : CHAKRI Achraf

- **Workpackage 2 EAUENV: "Computational modeling for water and environmental management".**
- **Supervisors : Pr. Nour-Eddine LAFTOUHI**
- **Subject title and description: Thesis**

Predictive hydrogeological modeling of the behavior of an aquifer subjected to high stress in the context of climate change: the case of central Haouz (Marrakech, Morocco)

- **Overview of the subject**

The Central Haouz aquifer is vulnerable to natural and anthropogenic changes. Surface water scarcity has had a direct impact on groundwater recharge, compounded by overexploitation by farmers and other uses.

Hydrogeological modeling consists of several stages. Before simulating hydrogeological behavior, it is essential to collect a wide range of parameters relating to the environment to be modeled (physico-chemical parameters of the water, the aquifer, and the climate), to check the statistical inventories collected, and to fill in any data gaps.

- **Subject objectives**

- Build a complete database and enter it into a GIS;
- Construction of a local geological model of the area to be modeled ;
- Modeling hydrogeological behavior in a transient context ;
- Establish predictive scenarios for the region's future water status ;
- Contribute to providing real solutions for the benefit of the region's authorities.

- **Progress report**

*** Phase 1 (In progress): preparation of model inputs**

To create the database required for hydrogeological modeling, we need to collect data on precipitation, evapotranspiration, temperature, lithology and stratigraphy, pumping tests, snow and weather conditions, and physic-chemical analyses of the water collected.

These data are used to calibrate the model and check its validity and degree of accuracy. so that it can be used for forecasting. Data collection is followed by the implementation of a GIS (Geographic Information System), which is essential for managing the spatiotemporal distribution of information. Once the GIS has been implemented, the lithological and stratigraphic model construction phase continues. For this, the litho-stratigraphic data will be structured in the form of tables, with each borehole geo-referenced and coded according to the GIS architecture. Statistical tests to verify correlation are necessary to assess data quality. The next step is the choice of interpolation algorithm, which is the most delicate as it has a major influence on the quality of the final model. A good interpolation generates a model close to reality, and vice versa.

The lithological model and the stratigraphic model are created, and the next step is to interpret these models hydrogeologically, i.e., to delineate the layers relating to aquifers and aquitards /aquicludes. At the end of this stage, the hydrogeological model is built and ready to be modeled. The inputs that the model will provide are the boundary conditions, the type of aquifer (unconfined or confined), and its 3D dimension. These data will be coupled with those entered in the GIS in order to quantify the water balance (input and output of water volume) of the aquifer studied.

MODFLOW is the U.S. Geological Survey modular finite-difference flow model, which is a computer code that solves the groundwater flow equation. The program is used by hydrogeologists to simulate the flow of groundwater through aquifers.

The chosen interfaces are modelMuse, which is a free platform, and visual Modlflow. Calibration processes will be intensively applied to ensure that the model is realistic and generates high-quality results.

* Phase 2: Field work and updating of hydrogeochemical data.

This step is necessary to ensure that the model meets the required needs. Sampling companies will be set up as work progresses to carry out physic-chemical analyses of the groundwater. Isotopy and piezometry will be carried out to assess the state of the water table and its evolution and to map areas of recharge.