Estimation of Underground Water Flows in the Shallow aquifers Using Artificial Neural Networks (ANN) in North of Algeria

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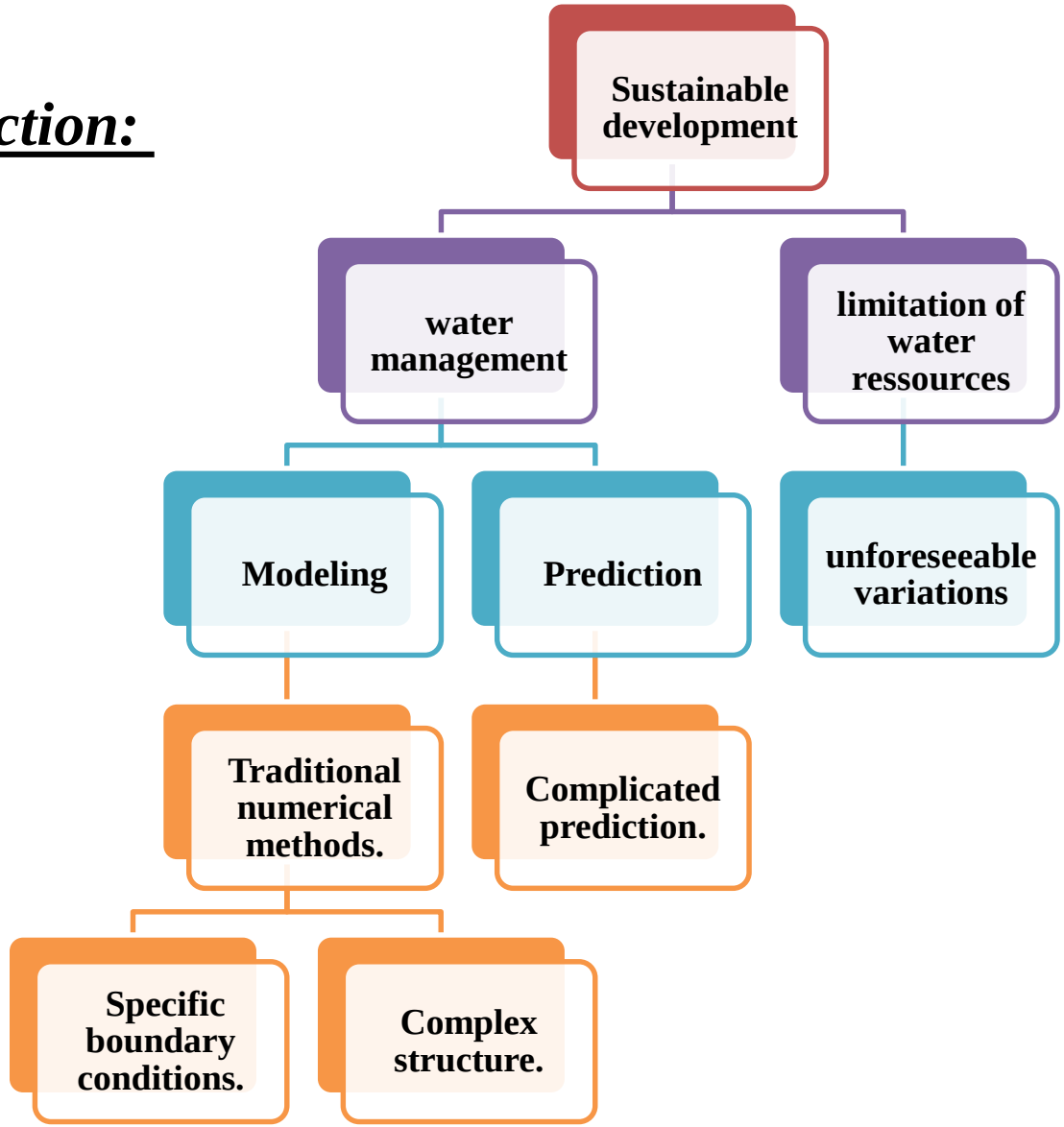
Introduction:

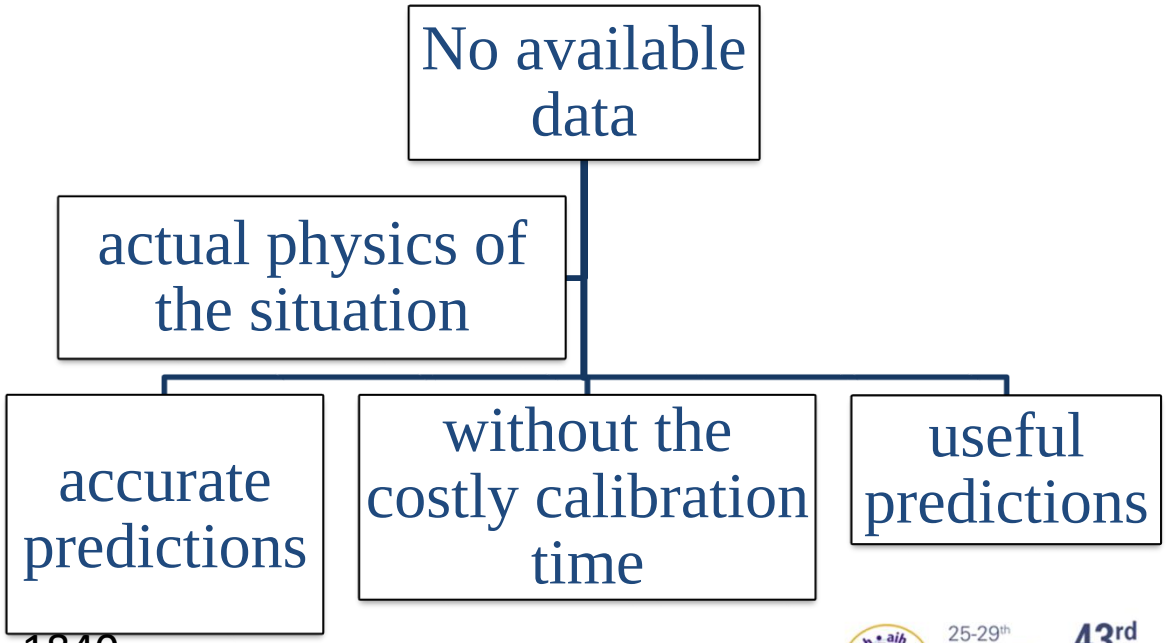


Numerical methods:

Vast and accurate data

- Spatial variations → Restricted model
- Unavailability of data → Restricted model

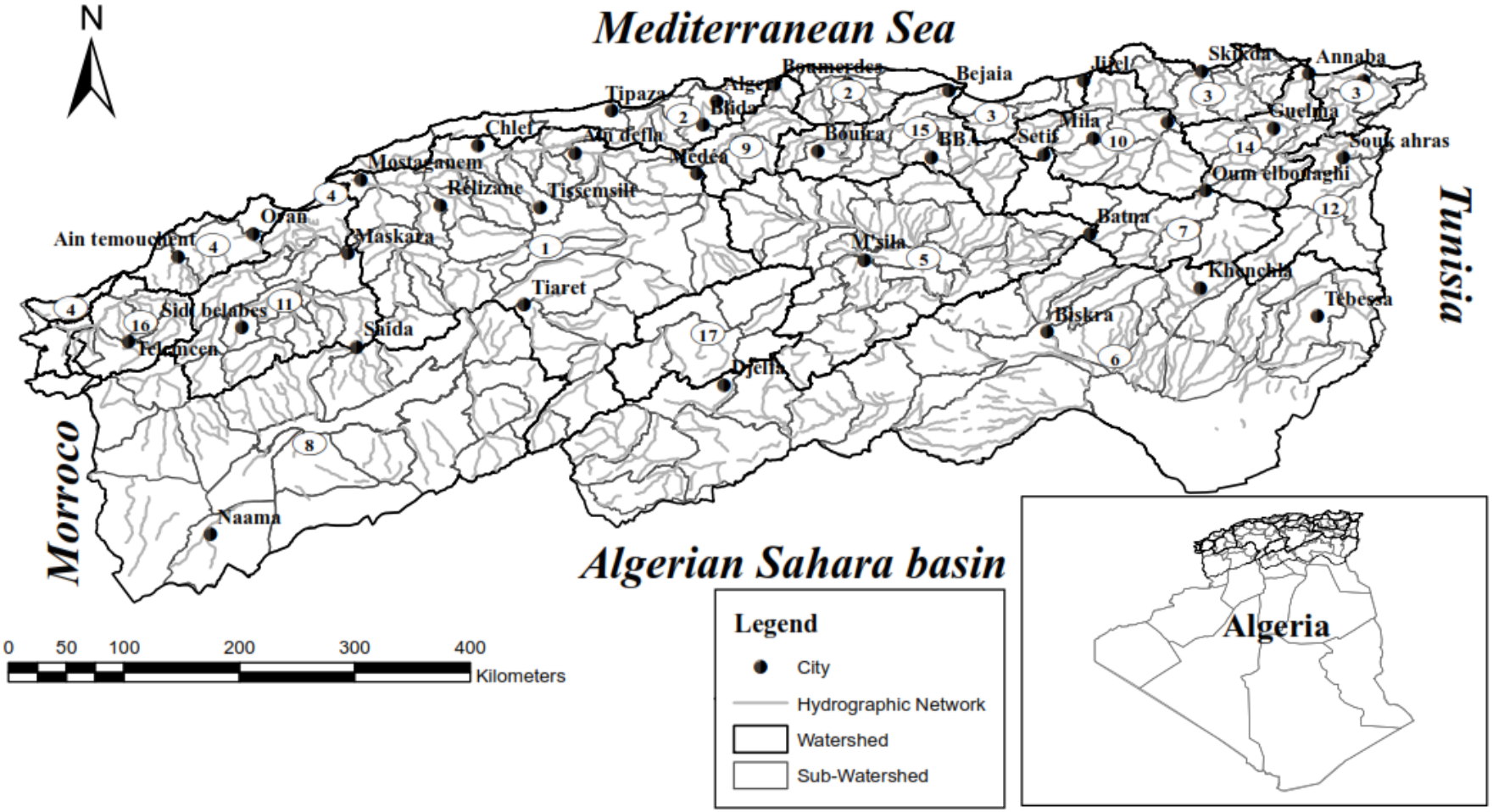
Empirical models:



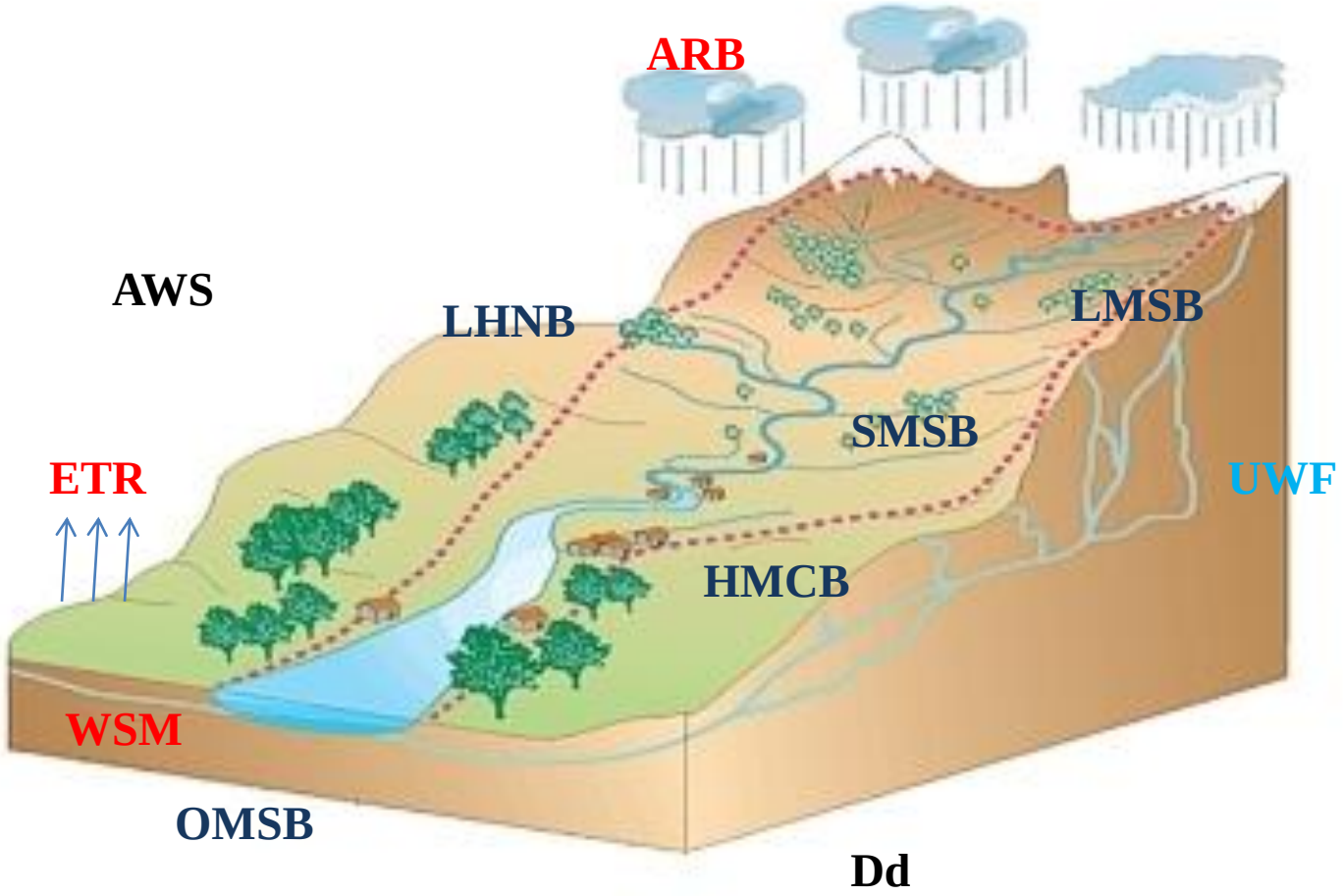
Many recent efforts have shown that when explicit information of hydrological sub-processes are not needed, such as infiltration, rainfall and runoff, an artificial neural net work (ANN) model can be more efficient and effective (Maier and Dandy, 2000).

Determining groundwater /surface-water interactions is therefore crucial in water resources planning and management.
The main factors affecting groundwater/surface water interaction are the climate factors (rainfall, evaporation demand), the surface characteristics of the basin and the underlying geological structure.

Study area and data description

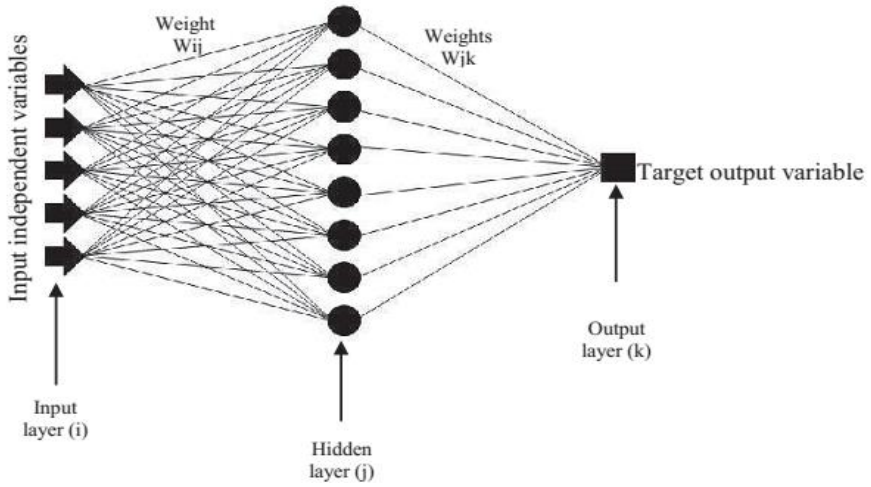


Data description



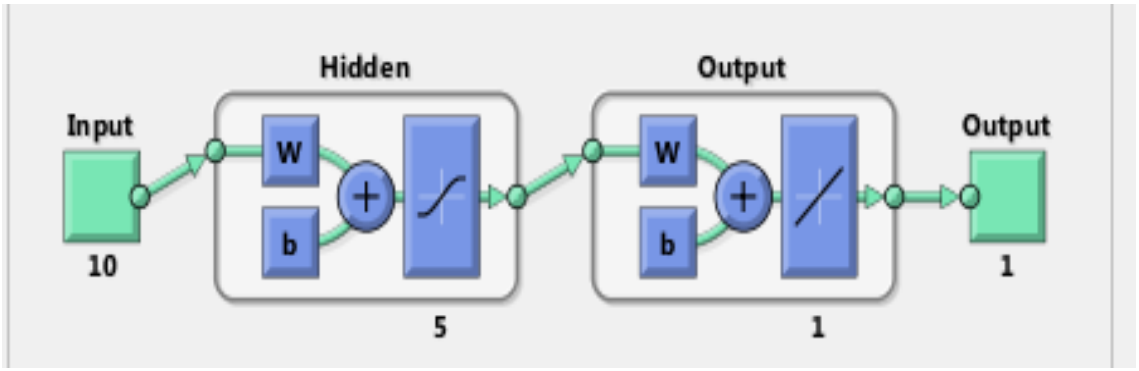
METHODOLOGY

The first critical decision is to determine the appropriate network Architecture



The network can be represented by the following compact form:

{*UWF*}= ANN [*AWS, Dd, OMSB, LMSB, SMSB, LHNB, HMCB, ARB, WSM, ETR*]



schematic diagram of neural network

A variety of verification criteria that could be used for the evaluation and inter comparison of different models:
meanabsoluteerror(MAE), root mean square error (RMSE) and coefficient of determination (R^2); expressed as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(Qi - \widehat{Q\,i}\right)^2}$$

$$R^2 = \left[\frac{\sum_{i=1}^{n}\left(Qi - \widehat{Q\,i}\right)\left(\hat{Q}\,i - \overline{\widehat{Qi}}\right)}{\sqrt{\sum_{i=1}^{n}\left(Qi - \widehat{Q\,i}\right)^2}\sqrt{\sum_{i=1}^{n}\left(\hat{Q}\,i - \overline{\widehat{Qi}}\right)^2}}\right]^2$$

Qi : is the observed Underground Water flow value

$\hat{Q}i$: is the predicted Underground Water flow value

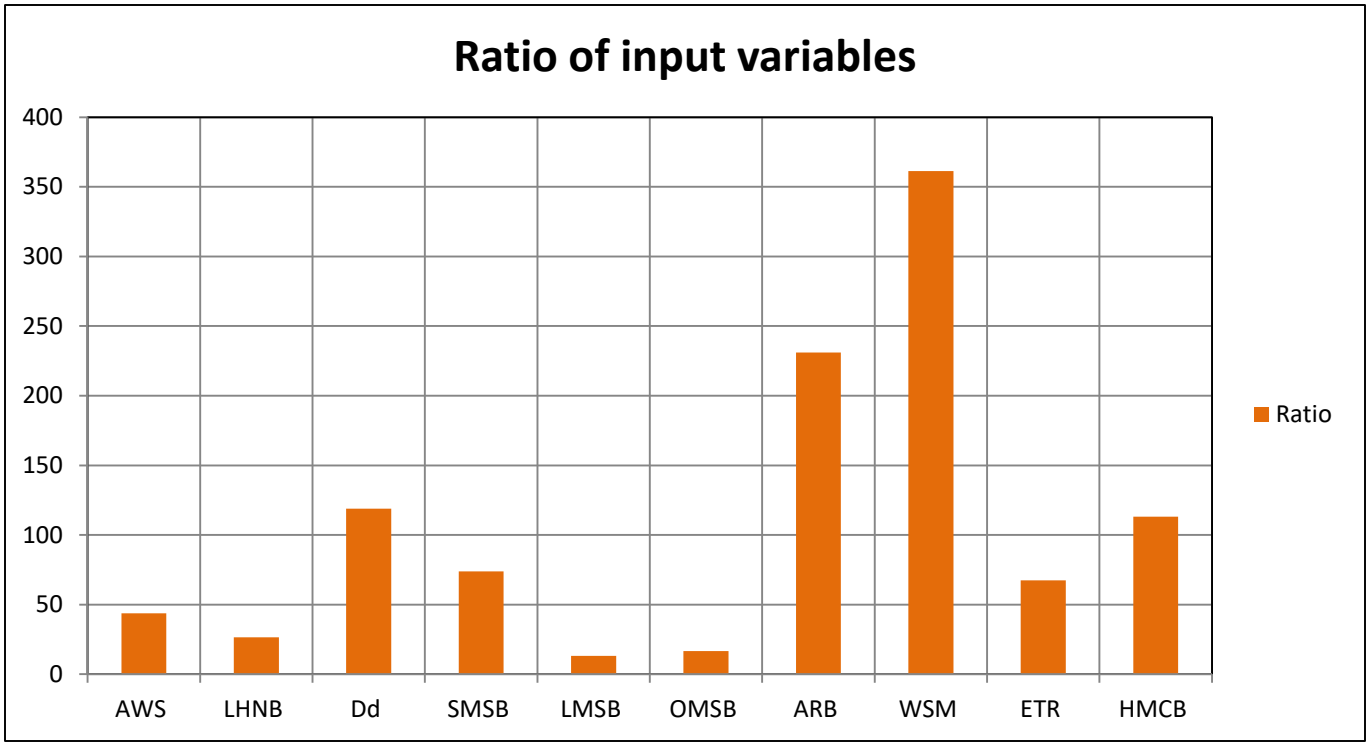
n : is the total number of data sets

RESULTS AND DISCUSSION

ANN predictions are precise; as R^2 value approaches 1 while RMSE approach zero.
The results of model are:

ANN	Training	Validation	Testing
Data Mean	18	26	44
Data S.D	16	21	53
RMSE	10^{-4}	0.01	0,01
Correlation	0,9952	0.9868	0,986

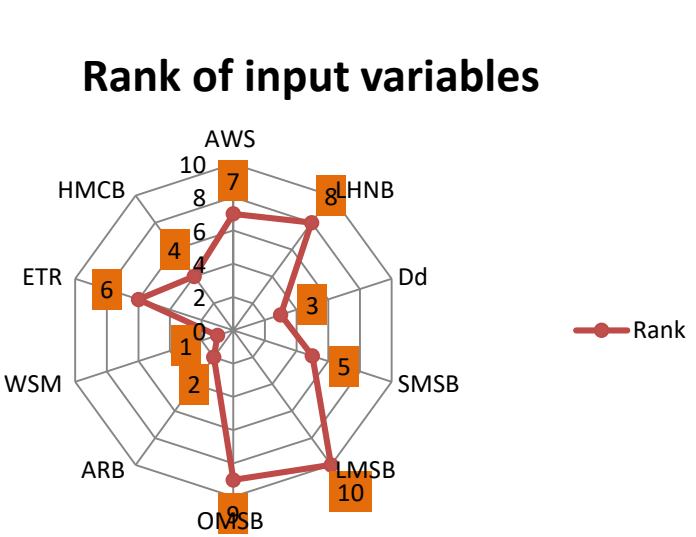
ANN models have the ability to determine which inputs are critical

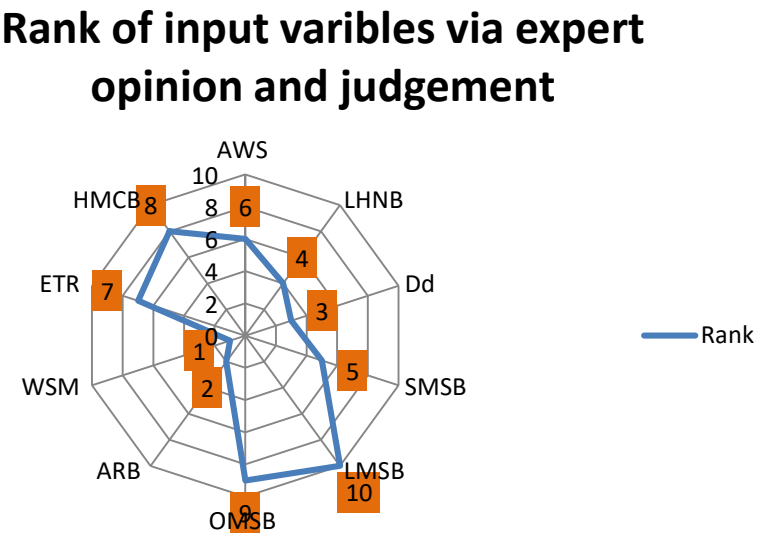


Sensitivity analysis of independent input variables

The Ratio reports the relation between the Error and the Baseline Error

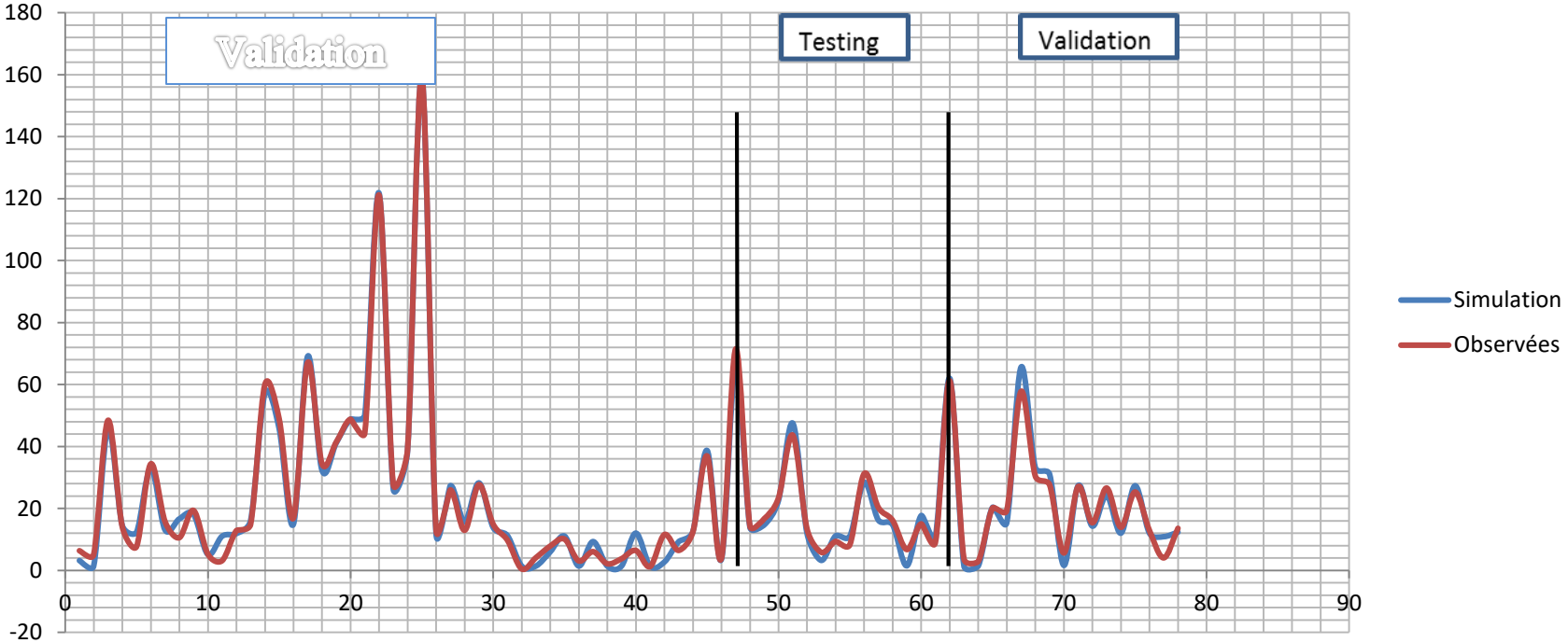
Comparison of Ranking of input variables between expert opinion and judgment and ANN model



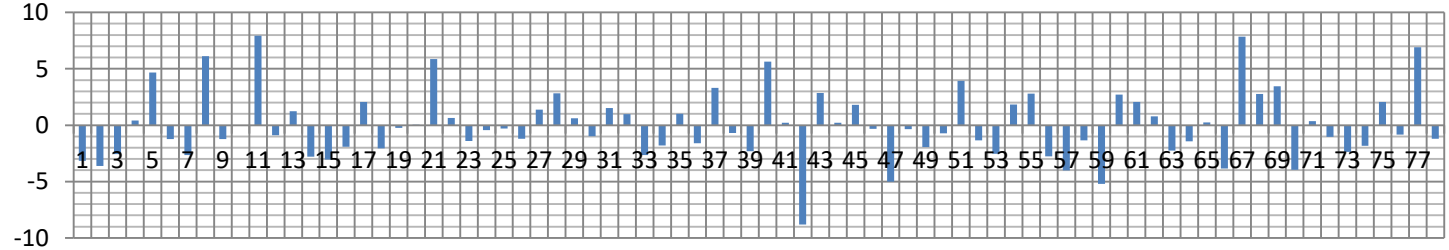


The Rank simply lists the variables in the order of their importance

Verification of results



Errors



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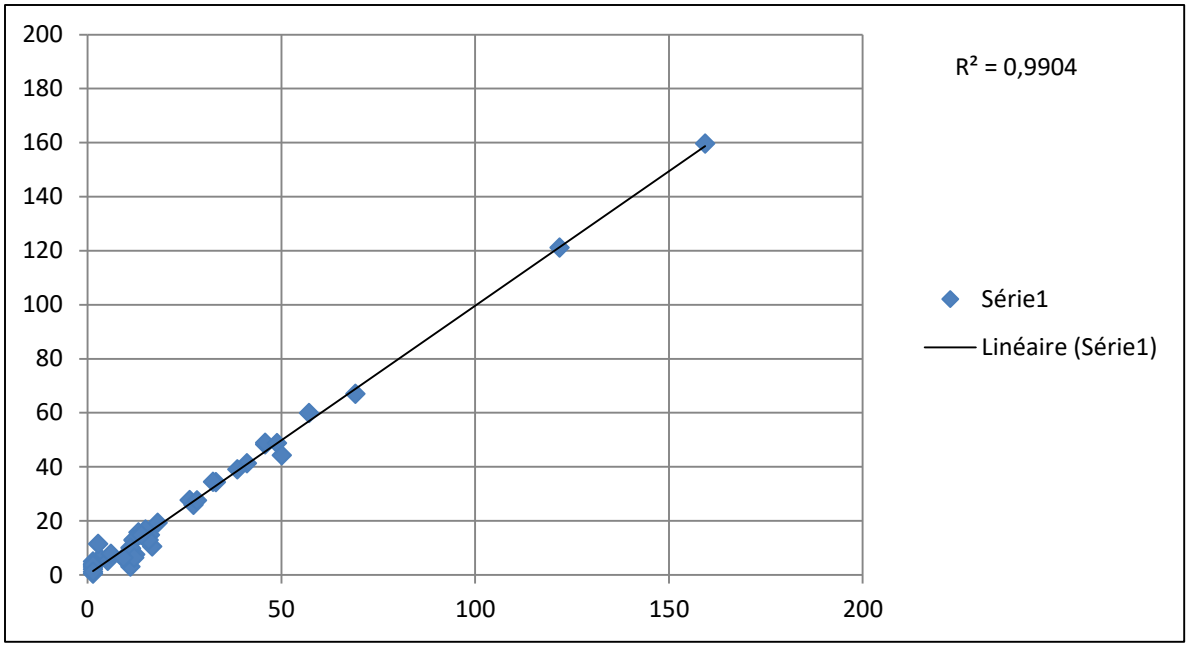
The training phase.



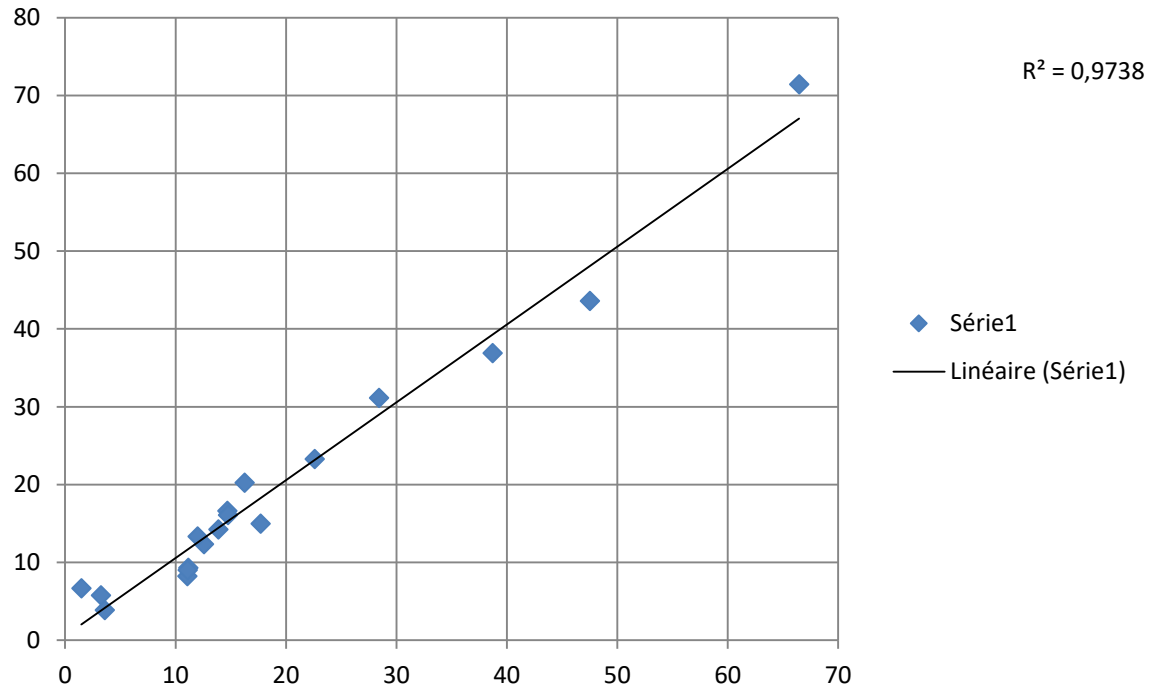
Observed and predicted annual groundwater flow for ANN models in the training phase.

R : 0,9952

R^2 *: 0,9904*

***RMSE*: 10^{-4}**

The testing phase.



Observed and predicted annual groundwater flow for ANN models in the testing phase.

R : 0,986

R^2*: 0,9738*

***RMSE*: 10^{-2}**

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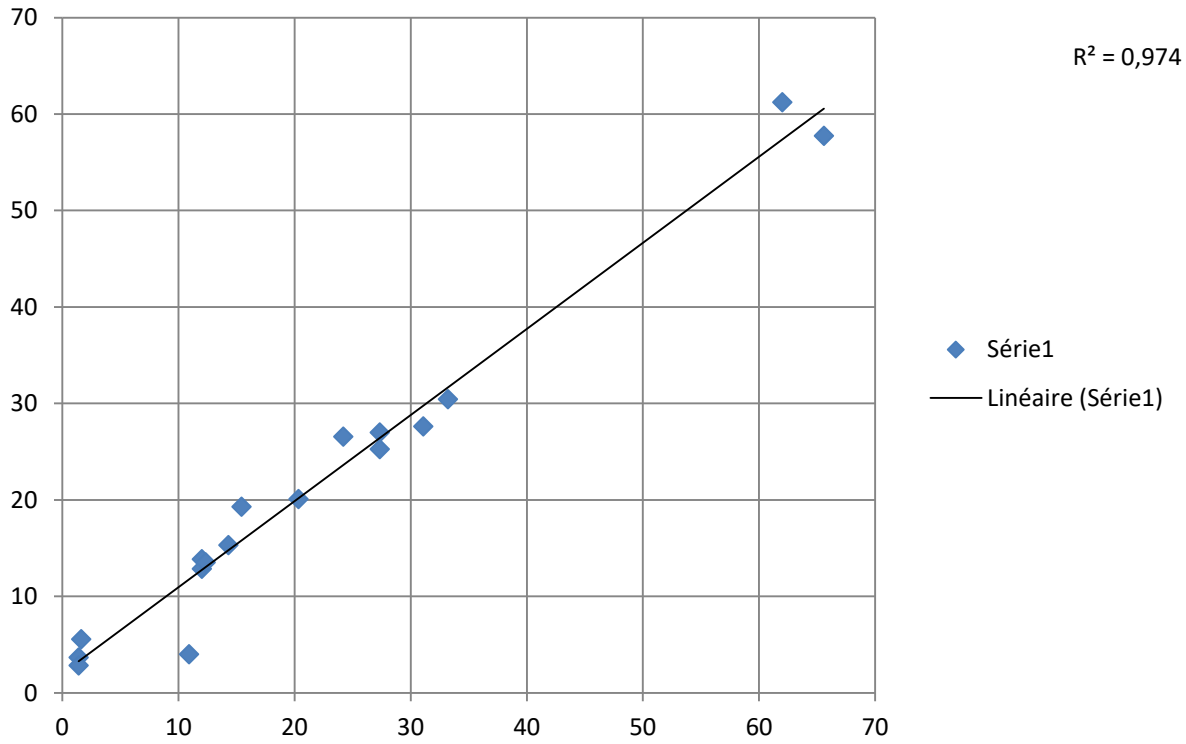
The validation phase.



Observed and predicted annual groundwater flow for ANN models in the validation phase.

R : 0,986

R^2 *: 0,974*

***RMSE:* 10^{-2}**

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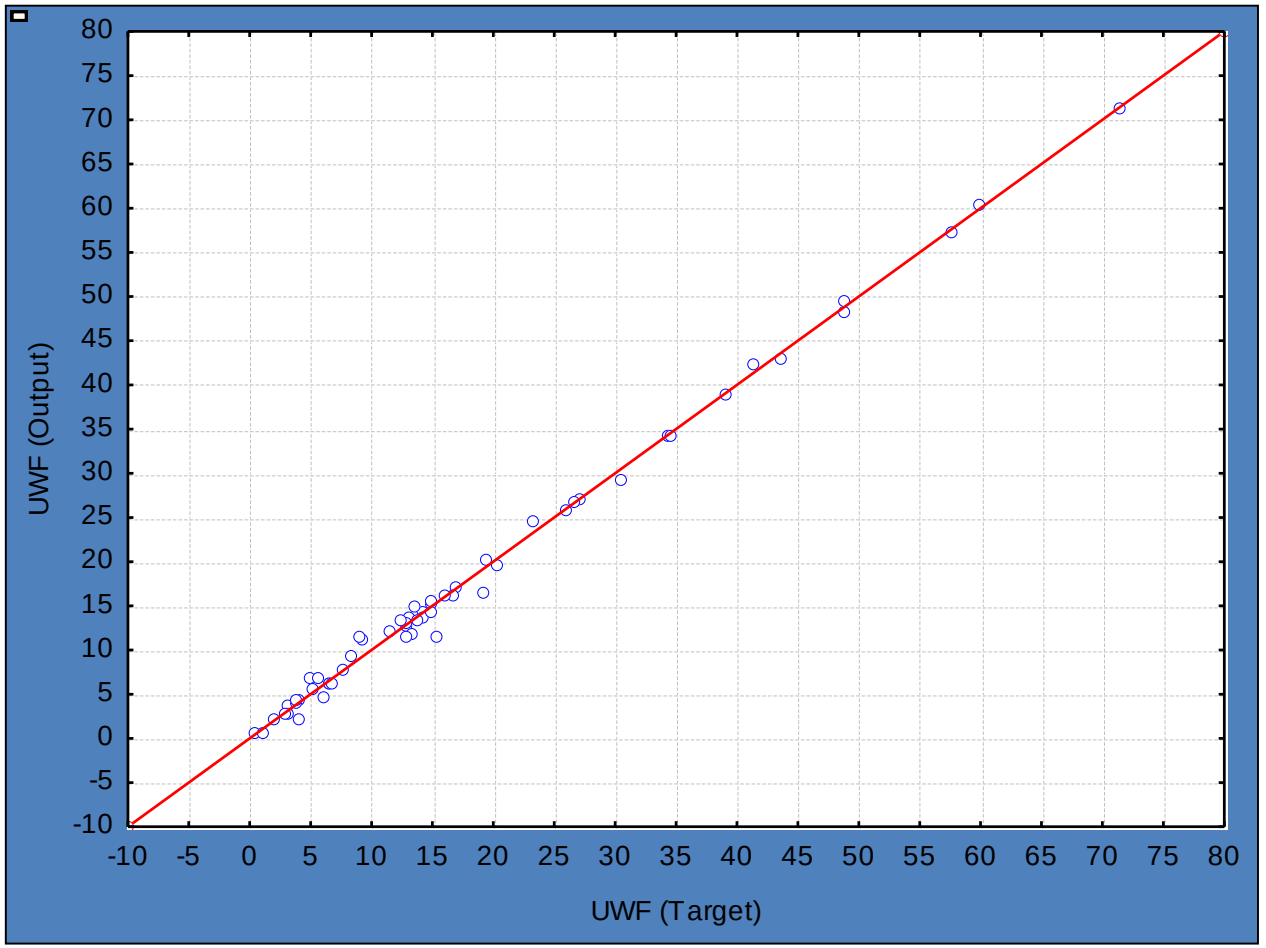

Predicted *UWF* versus Observed *UWF (*mm. y-1)

Comparison of observed and calculated results of ANN model for annual groundwater flow in shallow aquifers of northern basins of Algeria shows: the correlation coefficient higher than 99% for training, verification and testing which shows an excellent agreement between the observed and predicted underground water flow.

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CONCLUSIONS AND OUTLOOK

ANNs :

- new computational tools.
- can solving many complex problems.
- are very attractive.

ANN can determine:

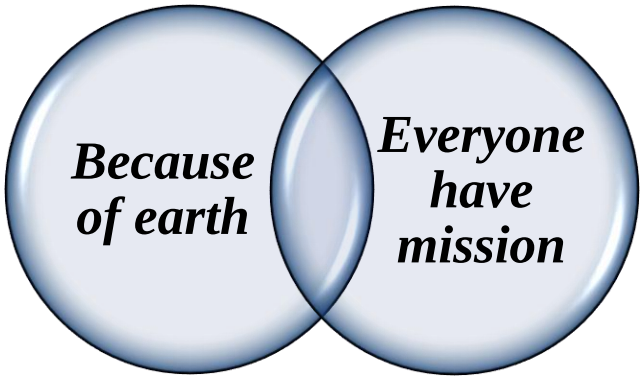
- geomorphologic factors
- climatic situation.

The model also, strengthens the Integrated Water Resources Management (IWRM) approach through addressing that the variable of Water stream flow and annual rainfall has the highest priority in UWF.

The ANN model can therefore be used as a very good tool to predict groundwater Flow in shallow aquifers of Northern basins of Algeria, using easily measurable climate data and geomorphological parameters.

ANN models are still very attractive tools to estimate UWF using limited available data, when it is not possible to apply a physically based hydrogeological model due to the unavailability of complete hydrological and hydrogeological parameters.

Thank you



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