Hydrological Modeling of the Bouregreg Watershed (Morocco) using SWAT

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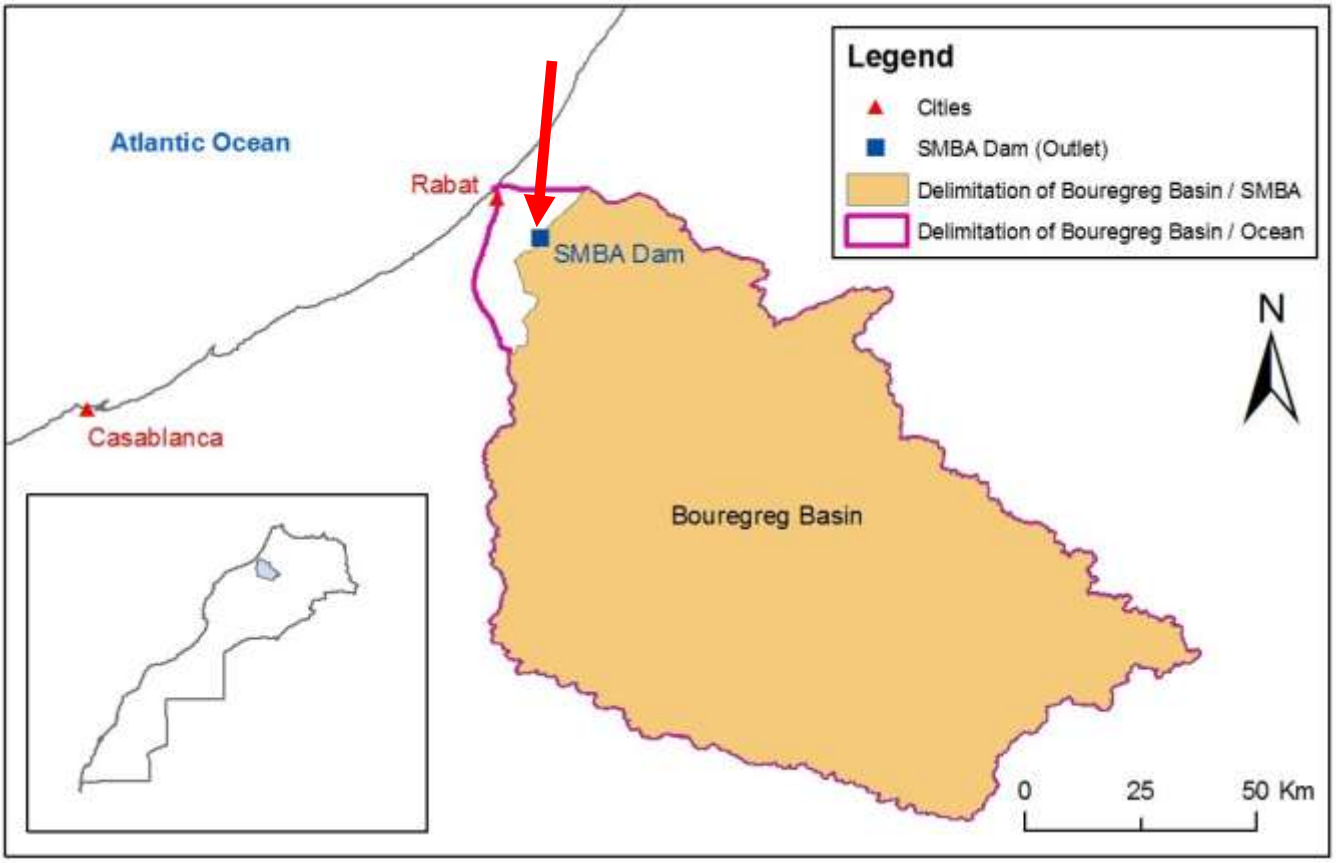
Introduction

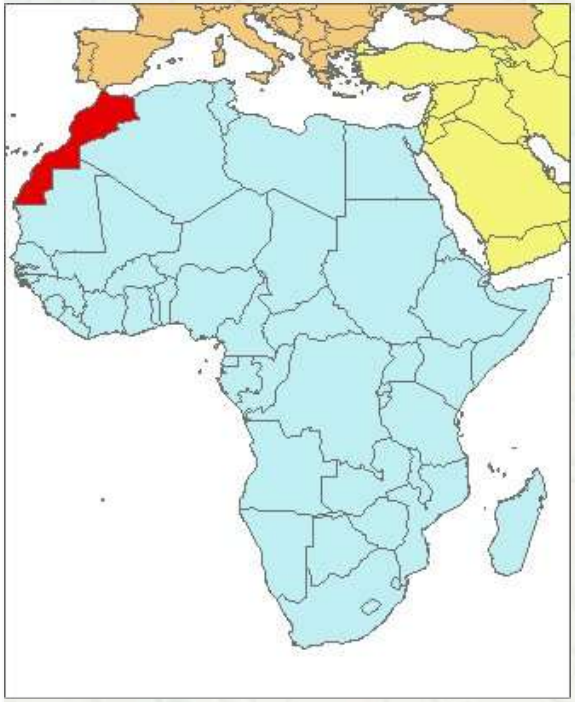
- The water is the most important natural resource
- The arid and semi-arid regions are confronting major problems related to water resources : unavailability and scarcity of fresh water, vulnerability of existing resources, irregularity of rainfall, climate change…
- Necessity to have strategy and tools to manage and assess the water resources in order to ensure an efficient use of these vital and scarce resources
- Modeling the water quantity and quality

Context of the Study

- SWAT is used worldwide to model Watersheds
- SWAT Model has never used or tested in large scale basins in Morocco
- Study the possibility and the adaptability of the model to depict the functioning of large-scale semi-arid watersheds
- Present the preliminary results obtained using SWAT to model the hydrological system of Bouregreg Watershed

Study Area





Area : 9 500 km²

Elevation : 46 m → 1630 m

Mean Annual precipitations : 425 mm

Mean temperature : 11°c (min) → 22°c (max)

Methodology

Iterations

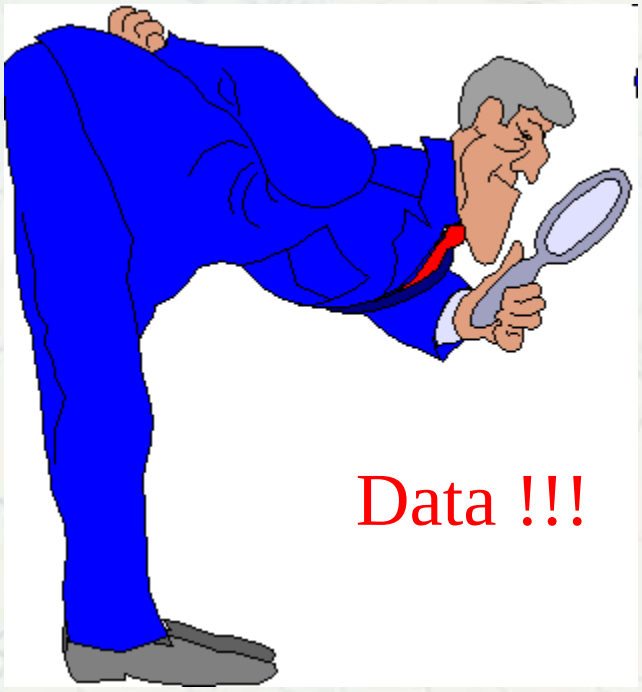
Data collect & Analysis

Model Setup

Model Calibration

Model Validation

Results Review

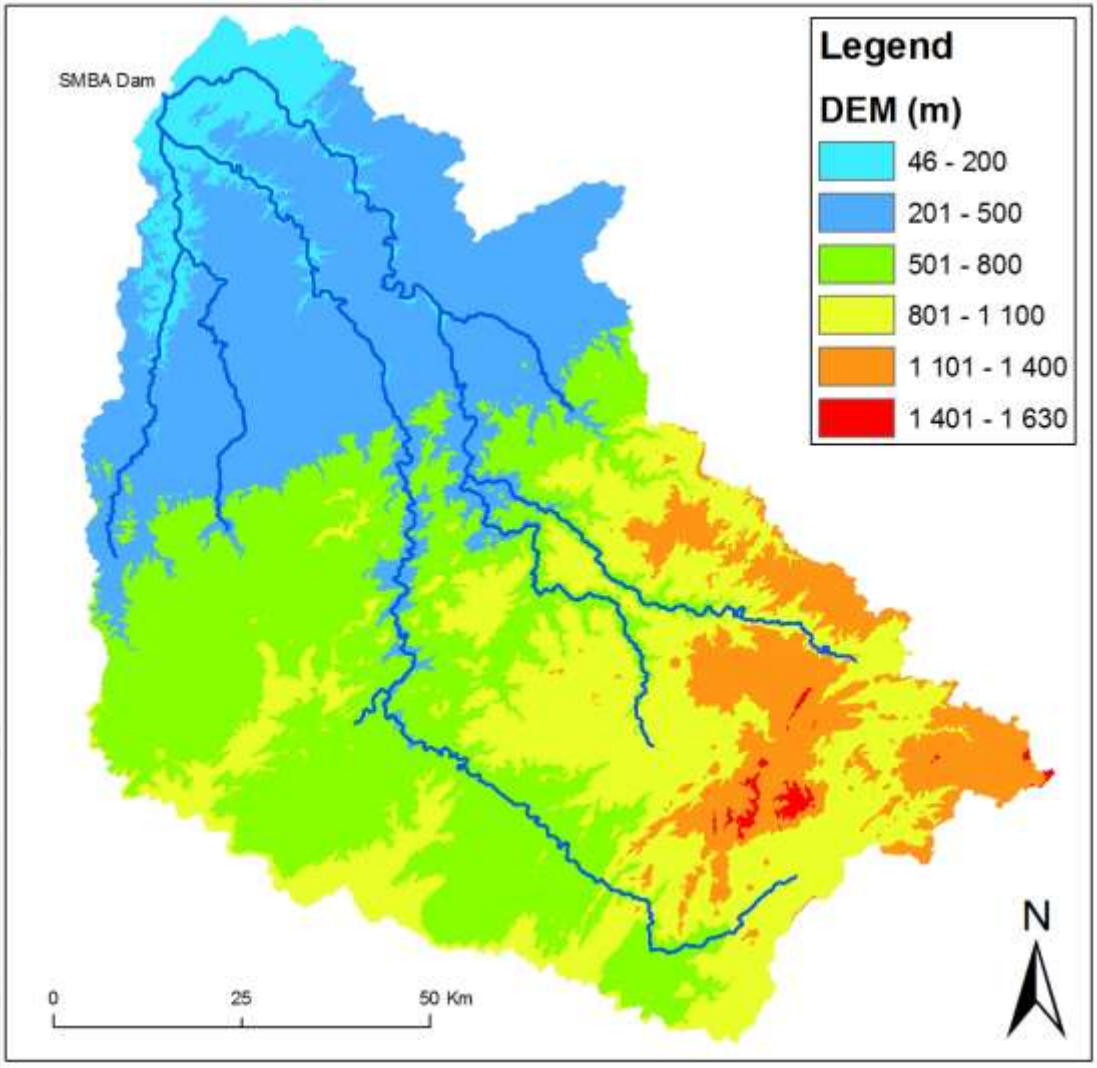


Combining available local data with global data

Data : DEM

DEM :

- GDEM-ASTER
- Resolution : 30m
- Range : 46m-1630m

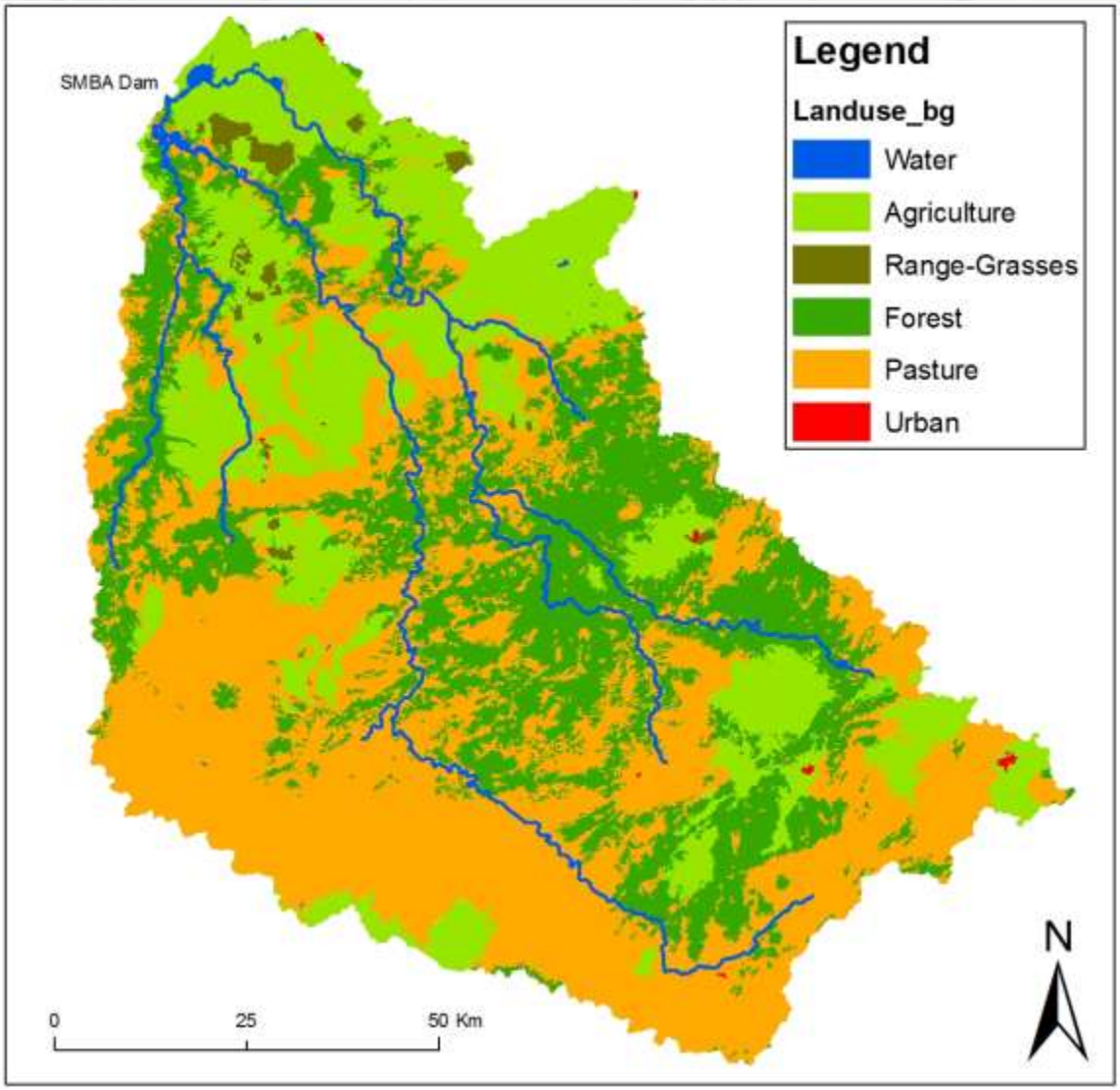


Data : Landuse

Landuse Map:

- Landsat TM Image
- Resolution : 30m
- Classification & Photo interpretation
- 6 major classes

Landuse	Area (%)
Pasture	46.4
Forest	28.4
Agriculture	23.8
Range-Grasses	0.9
Water	0.4
Urban	0.1

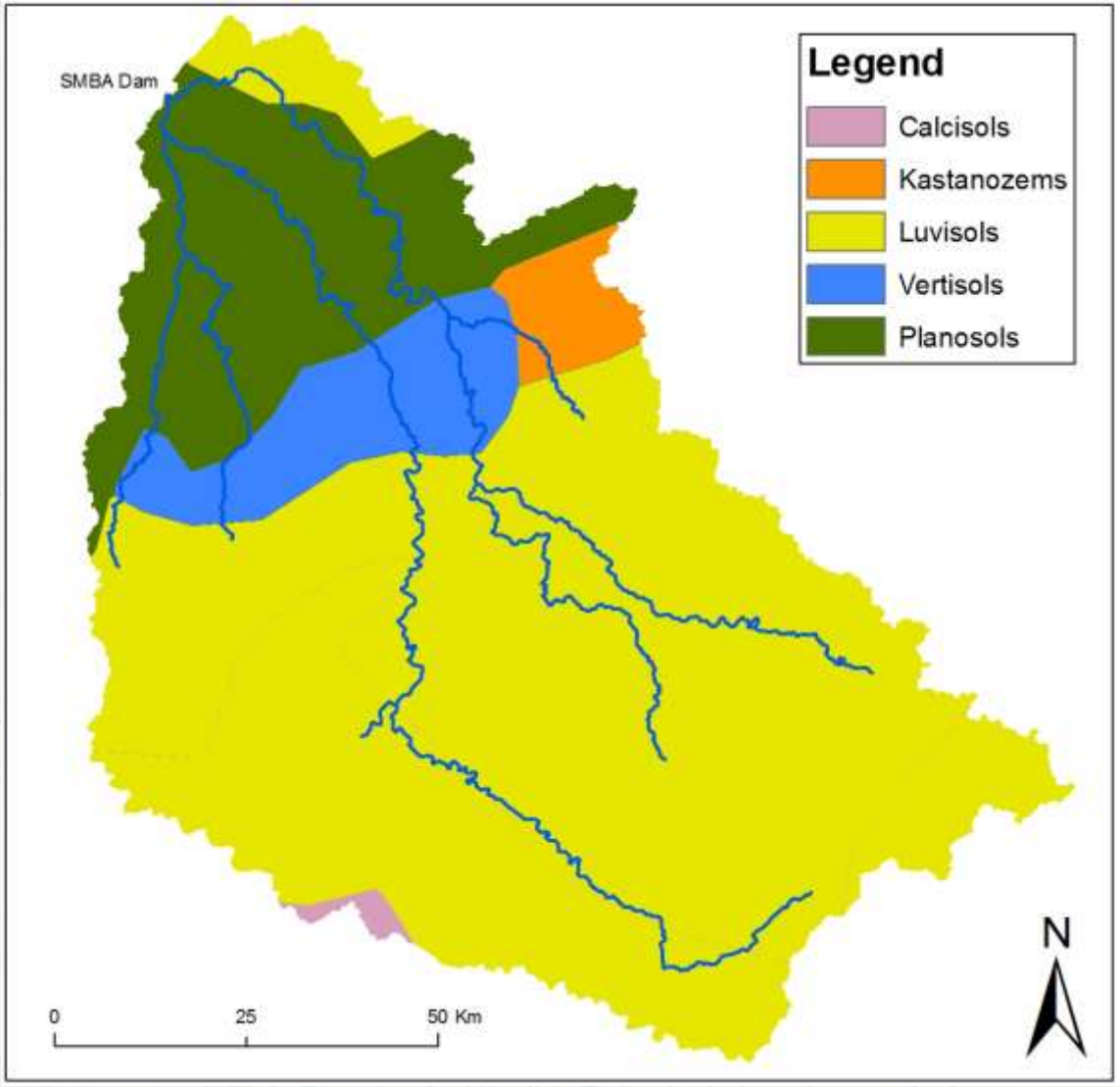


Alami and al. (2009)

Data : Soil

Soil Map:

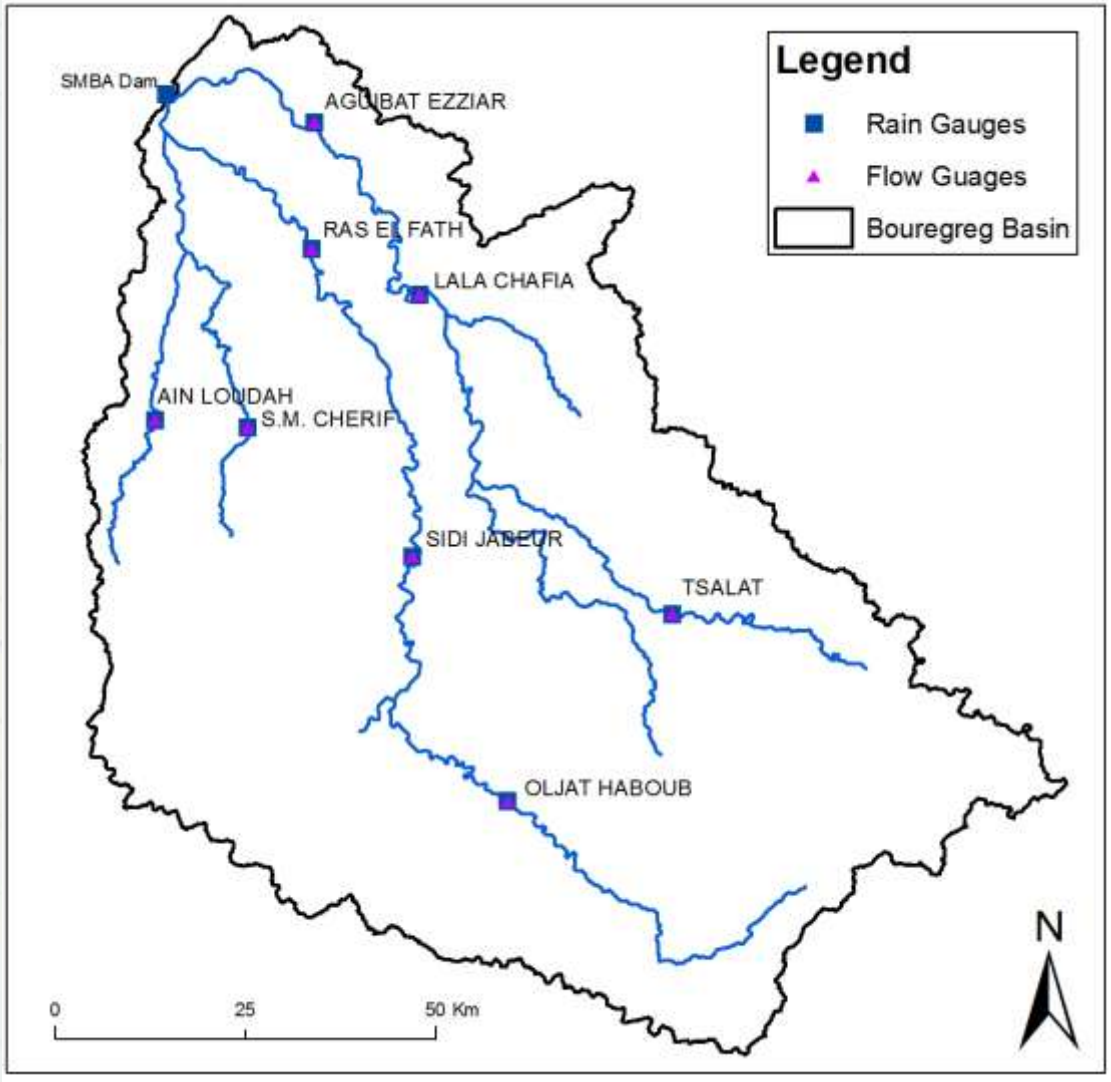
- HWSD v1.1 (FAO)
- Resolution : 30’’
- 5 major soil classes
- Dominant class : Luvisols (>60%)



Data : Precipitations / Flow

Precipitations / Flow :

- 9 Rain gages
- 8 Flow gages
- Temporal Resolution : Daily measurements



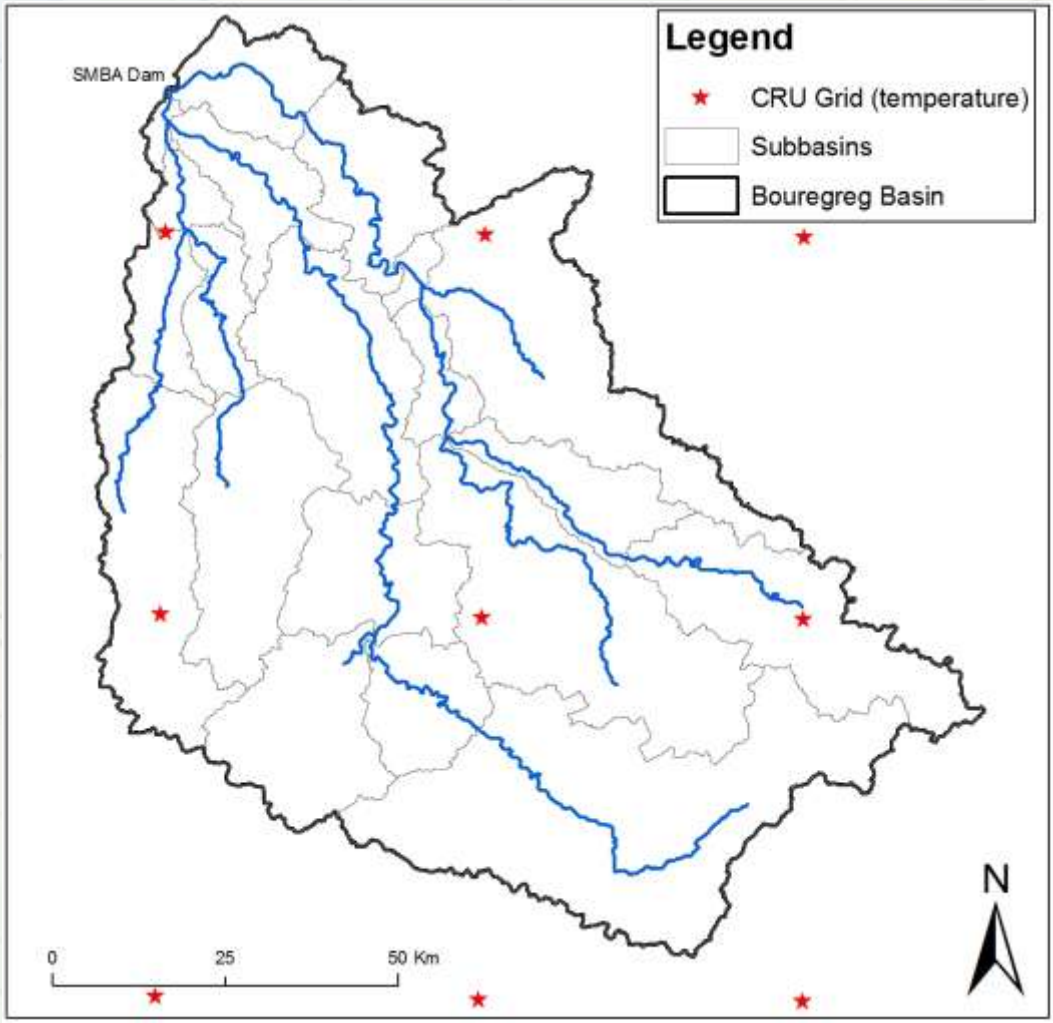
Data : Weather

Temperature (min & max):

- BADC-CRU v3.1 grid

(British Climate Research Unit)

- Spatial Resolution : 0.5°
- Temporal Resolution : Monthly
- Format : NetCDF



Model Setup & Calibration

- ArcSWAT interface (2.3.4) for SWAT2005
- Area of 300 km² was used as threshold for stream draining
- 14 subbasins (using DEM + gages)
- 164 HRUS was generated by using multiple Landuse / Soil / Slope option and threshold (10%) / exemption (urban and water)
- Weather Generator (WXGEN) was used to simulate daily Tmin & Tmax from monthly CRU Data (statistics for 30 years : 1980-2009)
- Hargreaves Method was used to estimate ETP

Model Setup & Calibration

- 10 years data were used to run and test the model (1996-2000 for calibration and 2001-2006 for validation)
- Daily and monthly output analysis
- Sensitivity analysis was done to highlight the most sensitive parameters
- Auto-calibration method (Parasol) was used to adjust the model using observation river discharge
- Evaluation of performance of the model was based on the coefficient of determination (R^2) and Nash-Sutcliffe efficiency coefficient

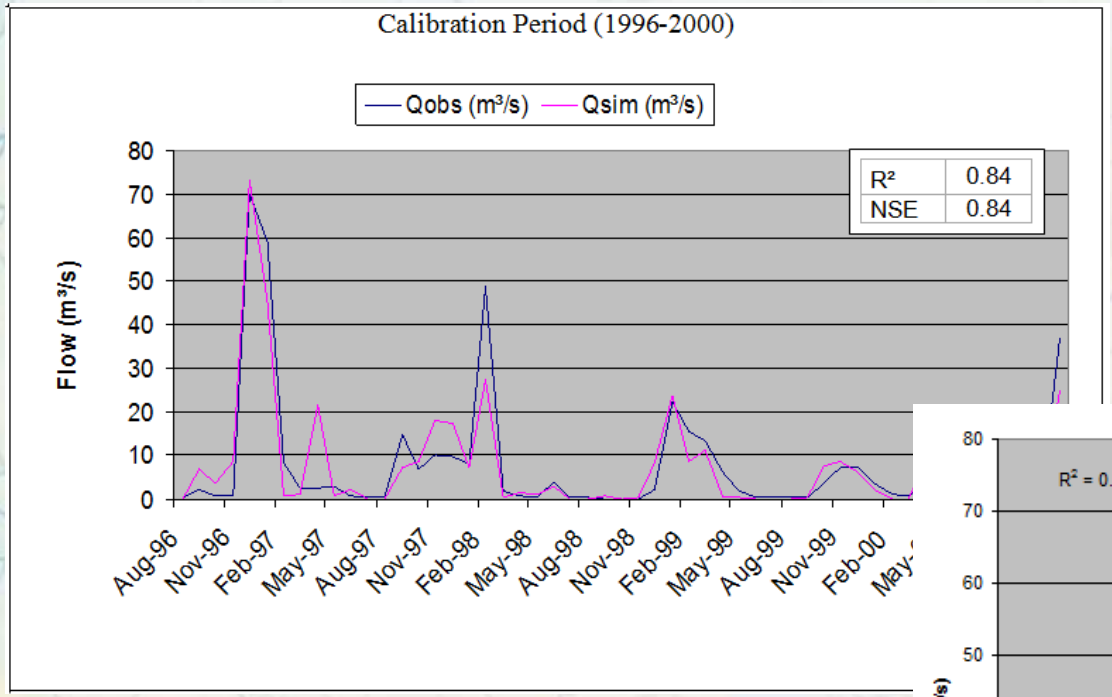
Results

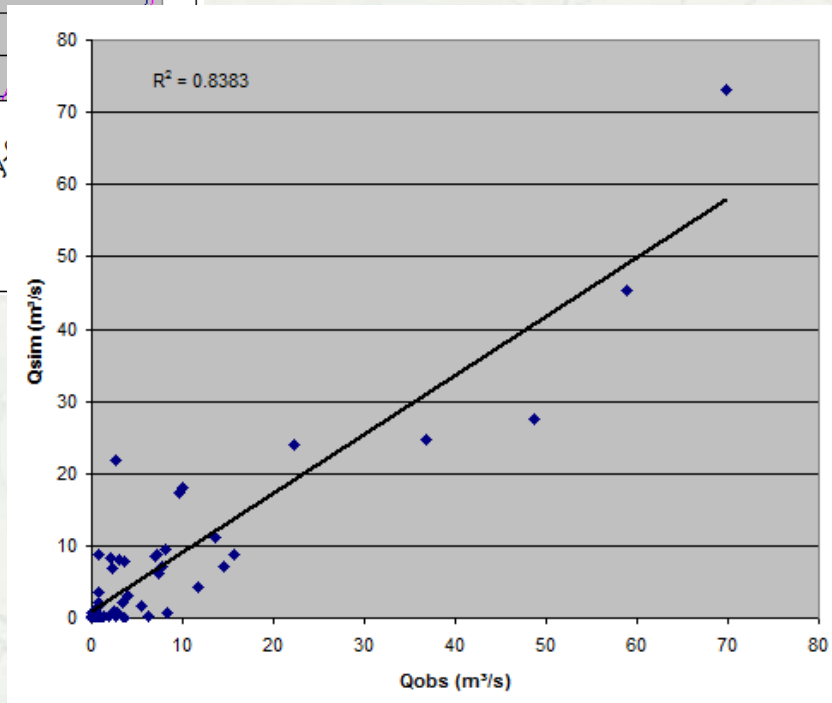
- Most sensitive parameters used to calibrate the model

1	Cn2	Moisture condition II curve number
2	Alpha_Bf	Baseflow alpha factor
3	Esco	Soil evaporation compensation factor
4	Sol_Awc	Available water capacity of the soil layer
5	Sol_Z	Depth from soil surface to bottom of layer
6	Sol_K	Saturated hydraulic conductivity of first layer
7	Gwqmn	Threshold water level in shallow aquifer for base flow
8	Revapmn	Threshold water level in shallow aquifer for revap
9	Ch_K2	Effective hydraulic conductivity of main channel
10	Ch_N2	Manning's "n" value for the main channel
11	Surlag	Surface runoff lag coefficient

Results

- Monthly Flow at The Ras El Fathia Gage





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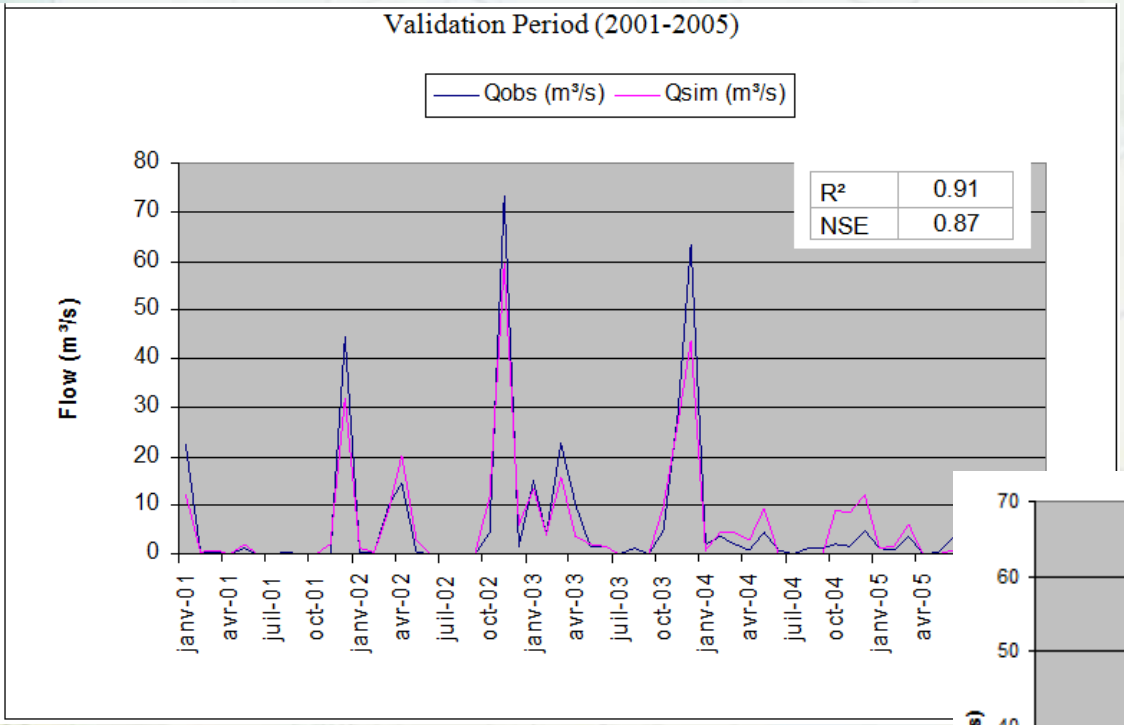
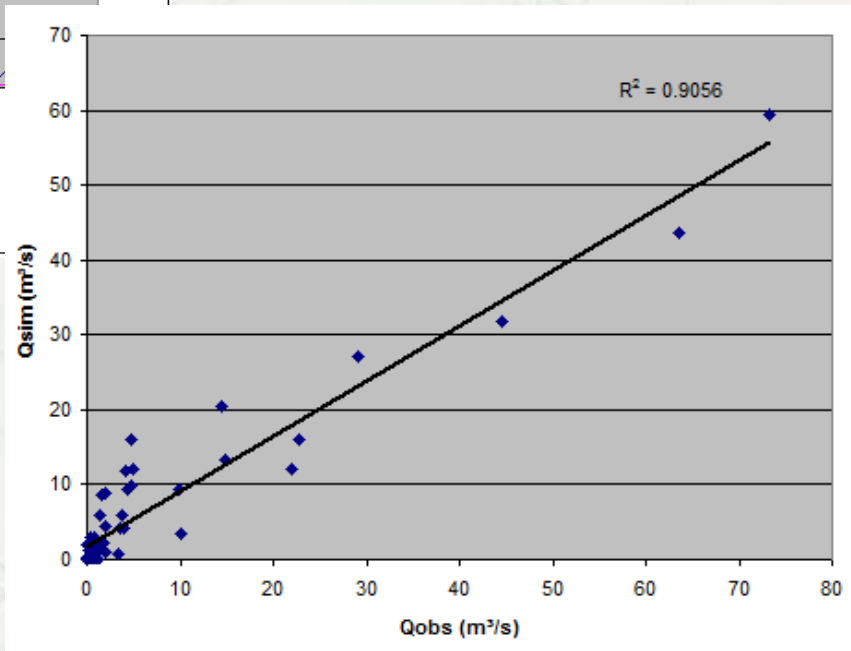
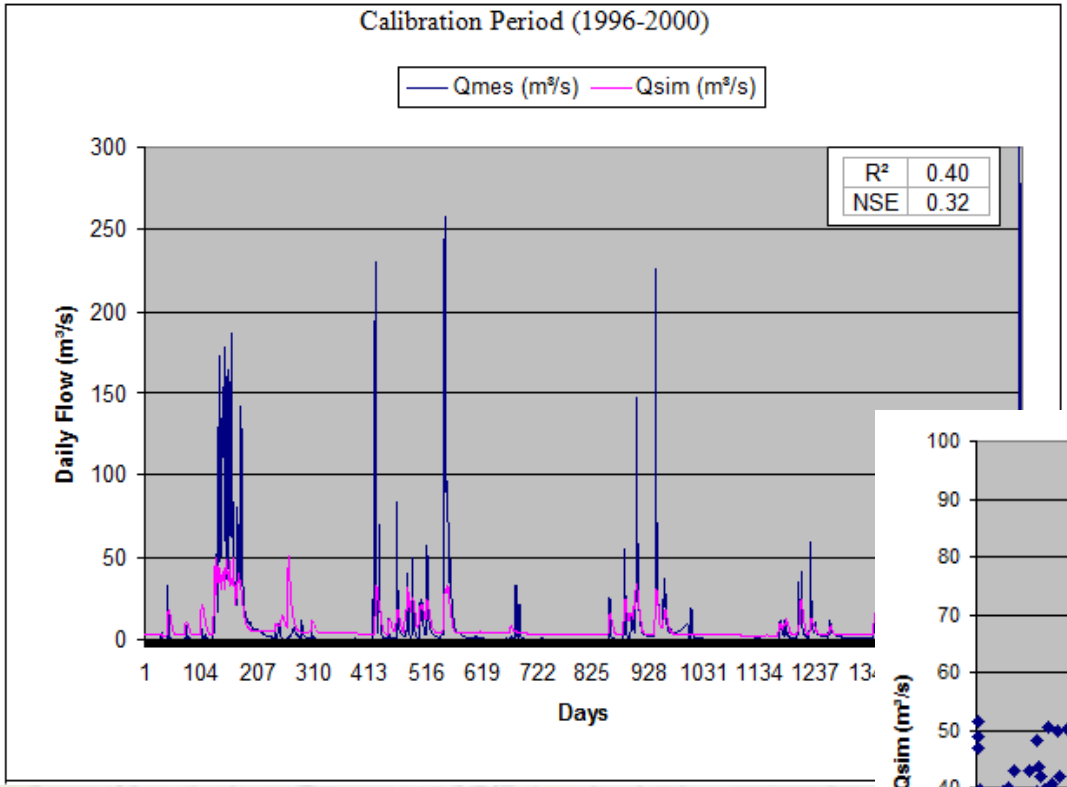
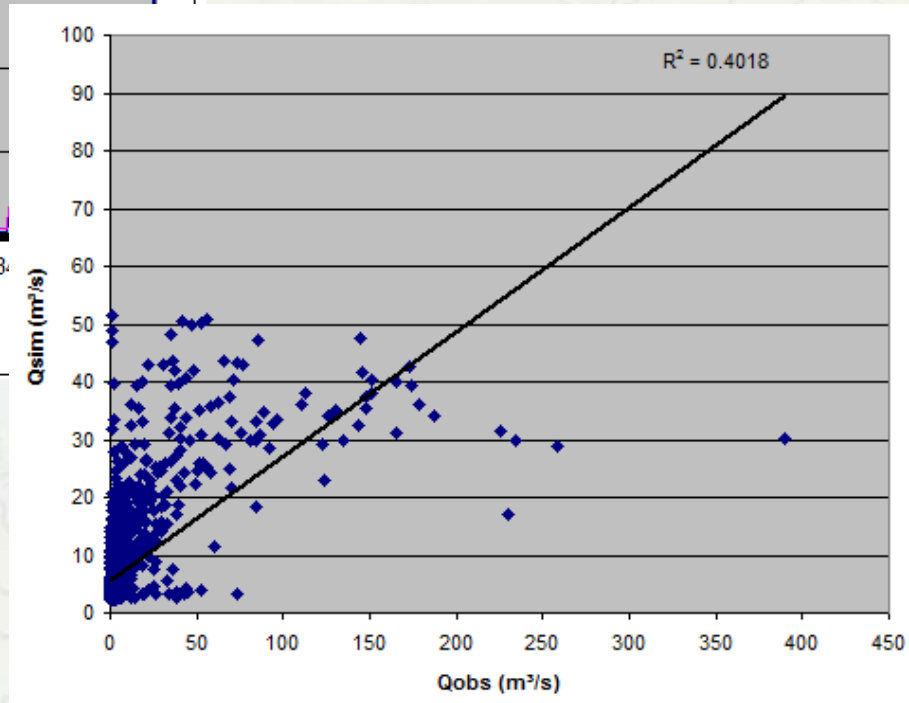




Results

- Daily Flow at The Ras El Fathia Gage





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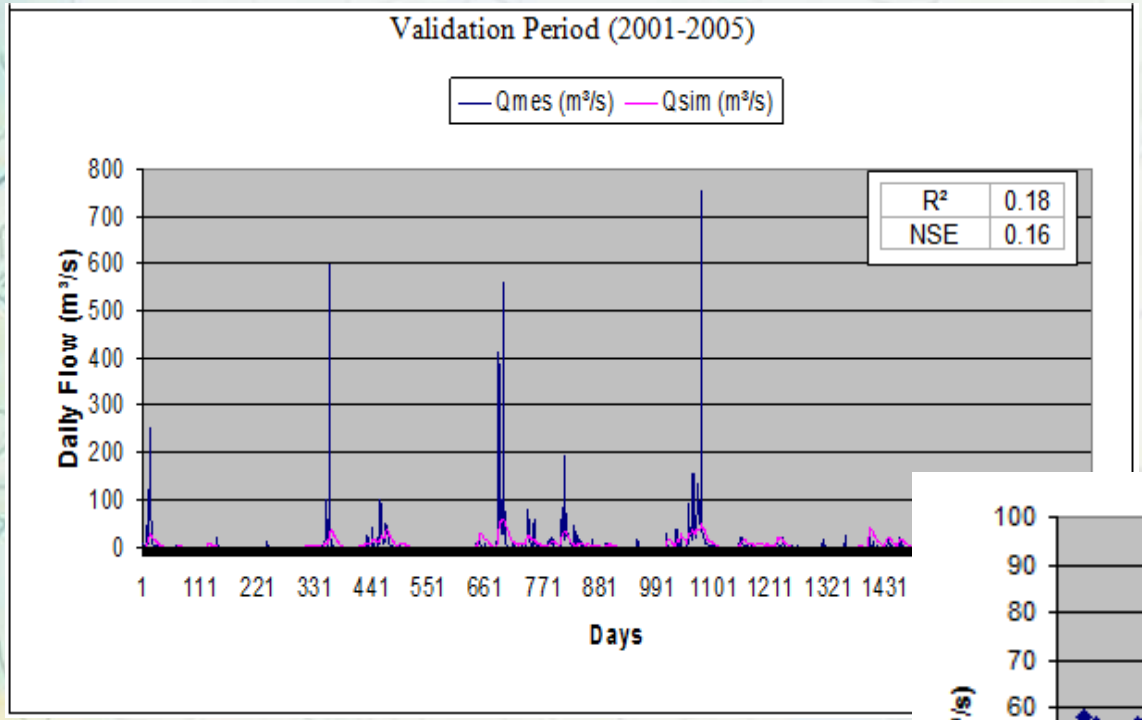
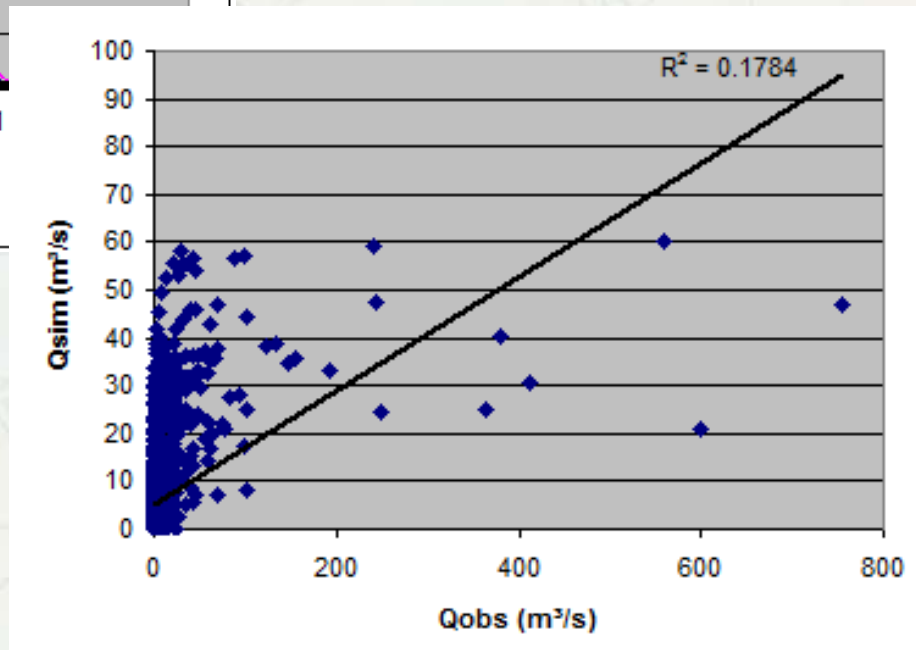
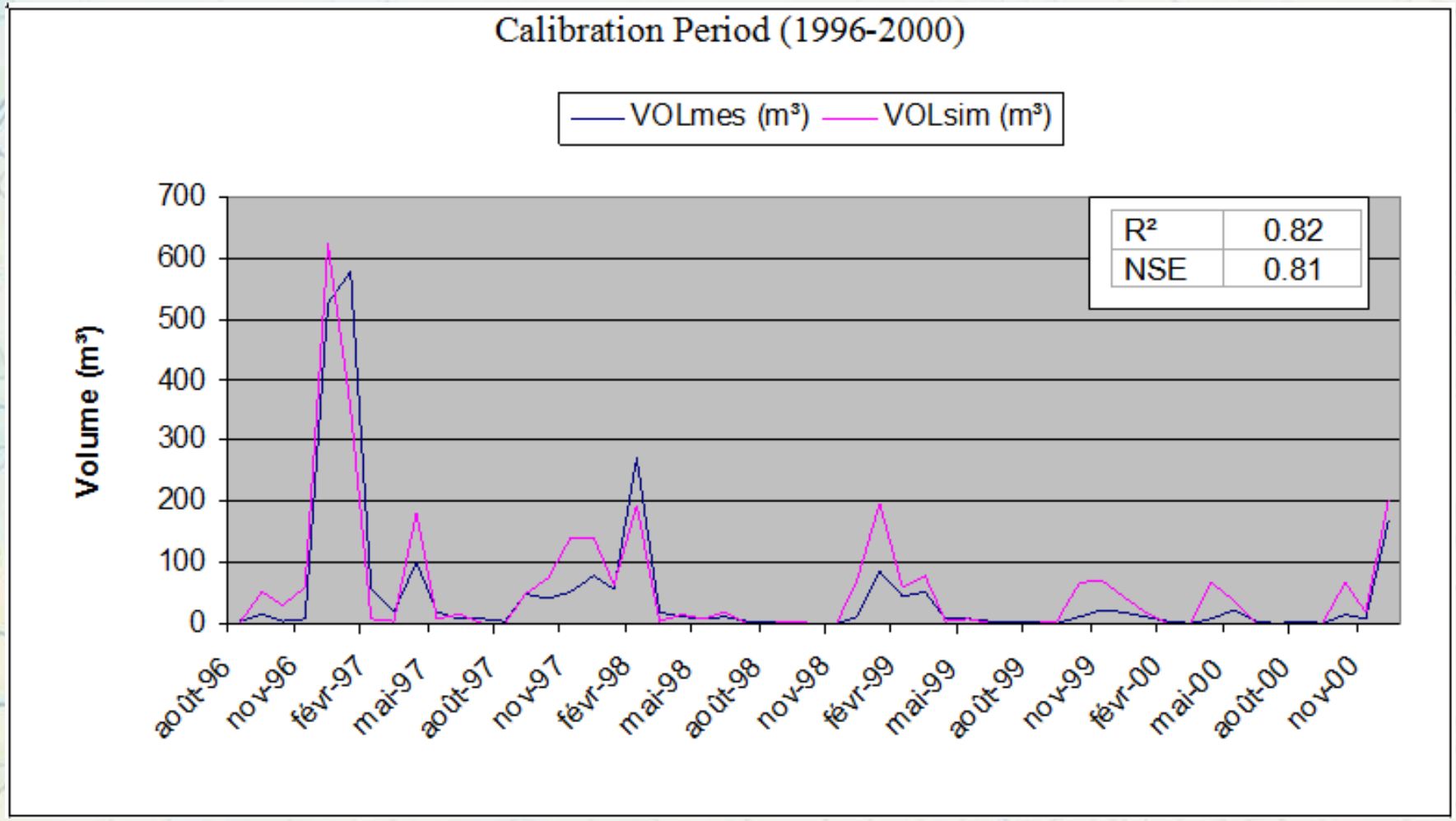




Results

- Monthly Volume entering the SMBA Dam :



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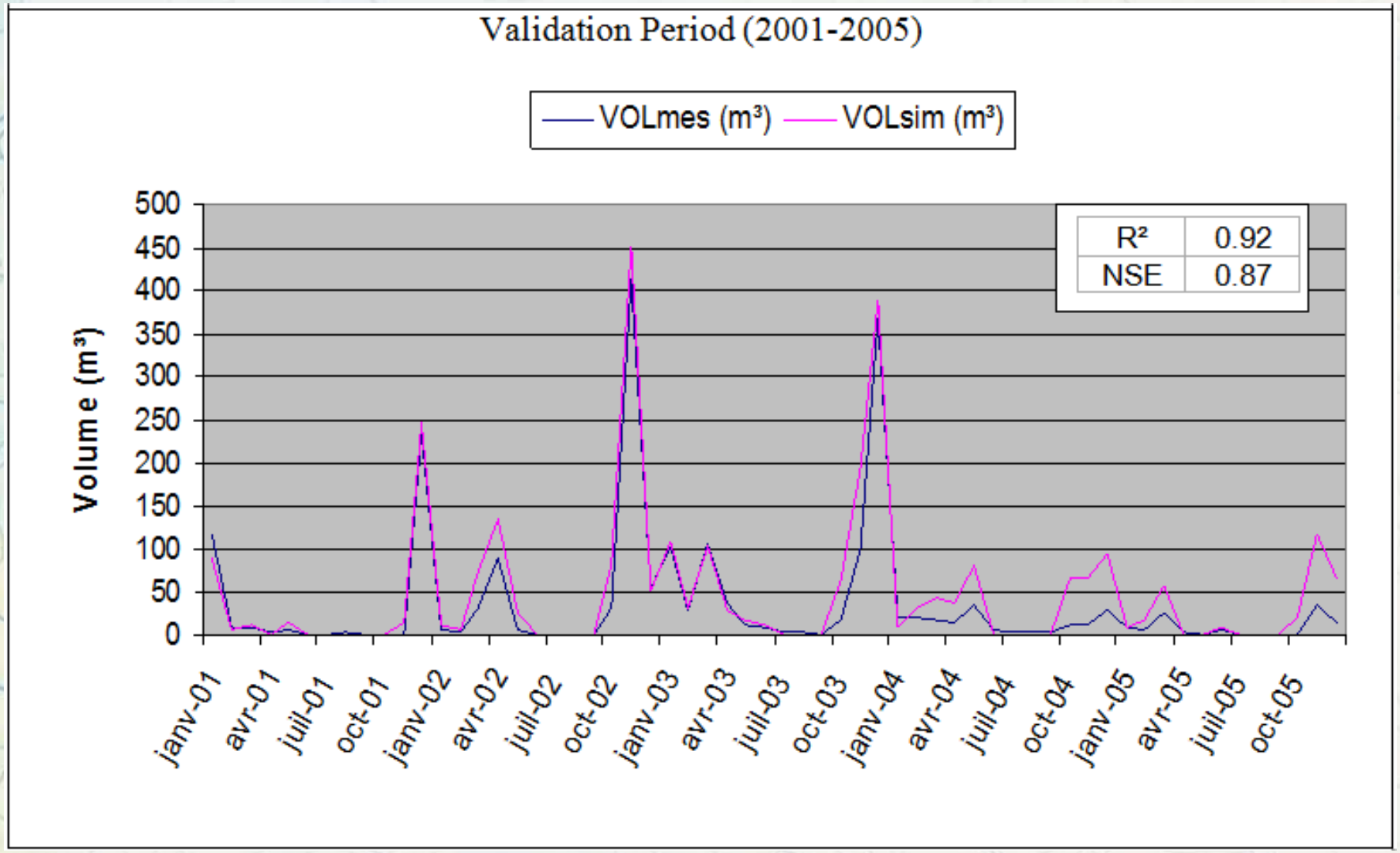

Results : Summary

- Globally, the model gives good results for the monthly time step (R^2 and NSE > 0.8) and poor results for the daily scale (R^2 and NSE < 0.3)
- The model underestimate the high monthly flow and overestimate the low monthly flow but it depicts the peaks position
- Despite that SWAT represents the peaks of daily flow it don't arrive to model the real fluctuation of the flow
- The more suspected items for the bad daily results can be : weather data, soil data, quality of gages data (April 2004-April 2005)

Conclusion

- The preliminary results obtained using SWAT to model Bouregreg Watershed show that SWAT can be used in semi-arid regions to simulate the flow and especially for the monthly time step
- Data improvements and more calibration must be done to use the model for the daily time step
- For SMBA dam, the main temporal scale management is the month. SWAT can be then used to estimate and assess loaded water volumes
- The enhancement of quality input data and calibration setup will allow us moving to nutrients modeling (Second phase of the global project)


Thanks for your Attention