A regional sensitivity analysis of a multi-variable hydrological model: A case study of a Greek catchment

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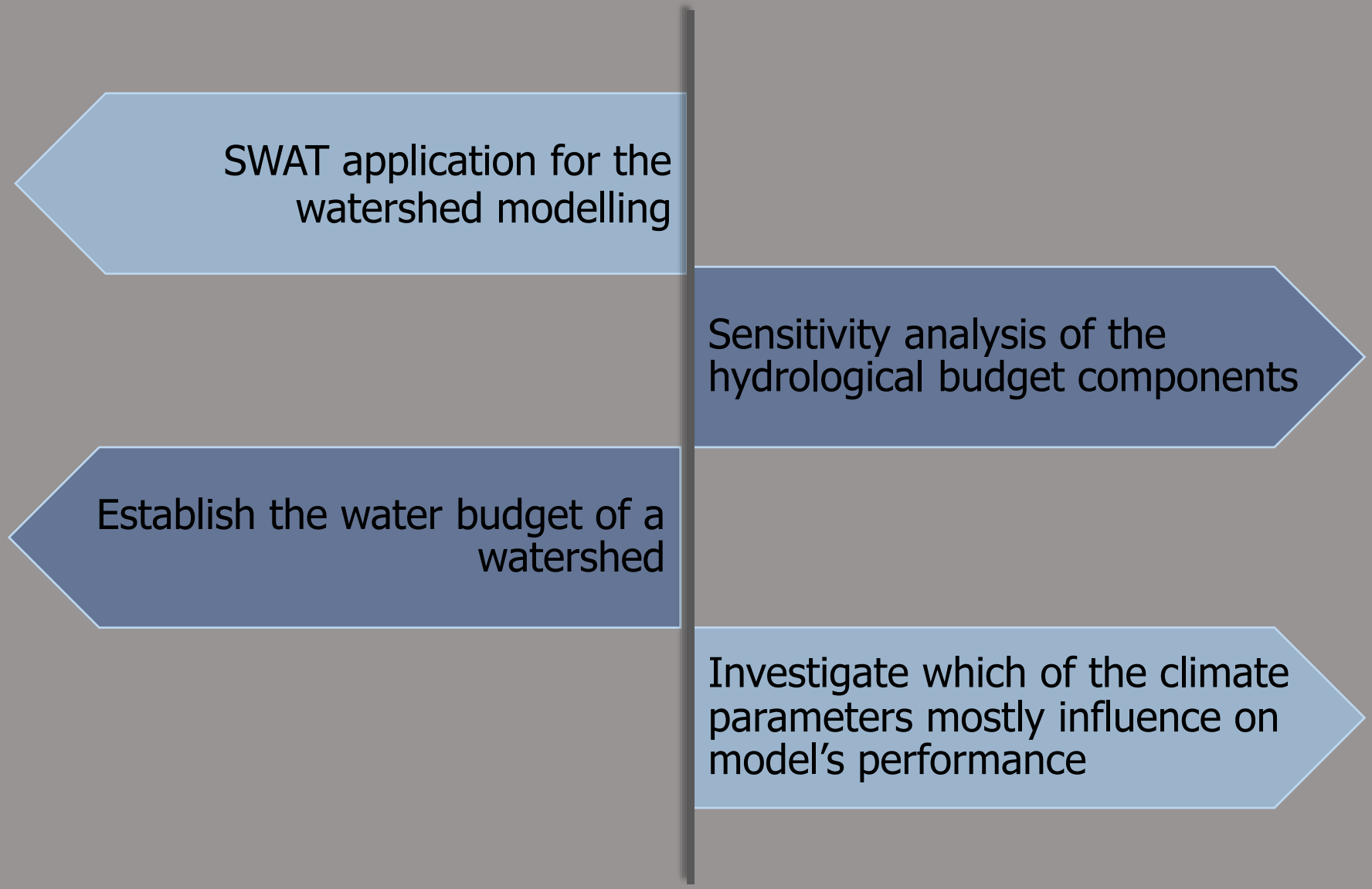
Scope


SWAT application for the watershed modelling
Sensitivity analysis of the hydrological budget components
Establish the water budget of a watershed
Investigate which of the climate parameters mostly influence on model's performance

Hydrological Modelling

- Type of model: semi-distributed and physically based model
- Capability: running on a daily time step

SWAT

- Utility: assessment the impact of the land and agricultural management practices on water, sediment and agricultural chemical yields

SWAT Structure

Input Data

- DEM
- Land Use
- Soil Data
- Climate Data: precipitation, temperature, wind speed, solar radiation, relative humidity

ArcSWAT

- Watershed delineation
- Sub-basins delineation
- Stream delineation
- HRUs definition

Model Run

- Model run
- Sensitivity analysis
- Model calibration
- Model validation

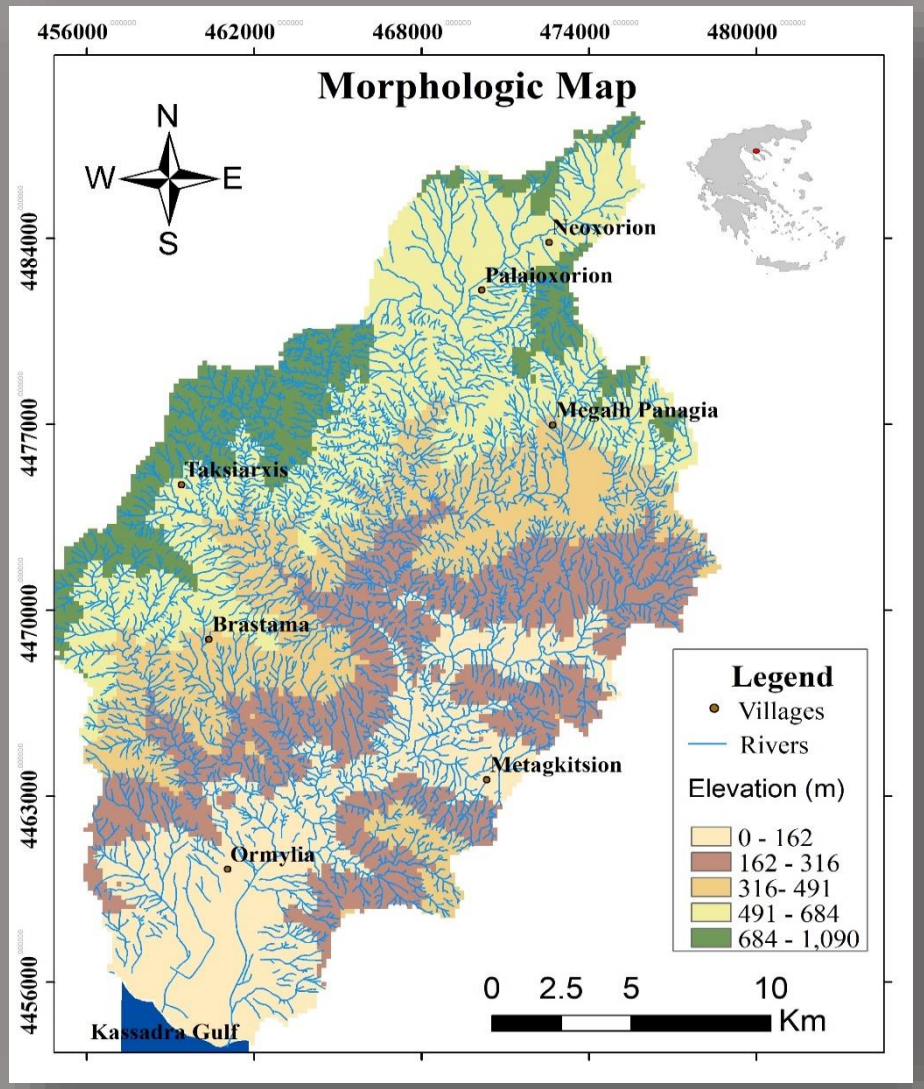
Research area

General Characteristics

Research area

General Characteristics

- The Havrias river basin is one of the most significant watershed of Halkidiki in north Greece.
- Its elevation varies between 0 m and 1090 m, covering an extent of 472 km^2, based on the GIS Analysis.
- The mean slope of the watershed is about 22%.
- The Mediterranean climate (CSa) is identified in the research area.

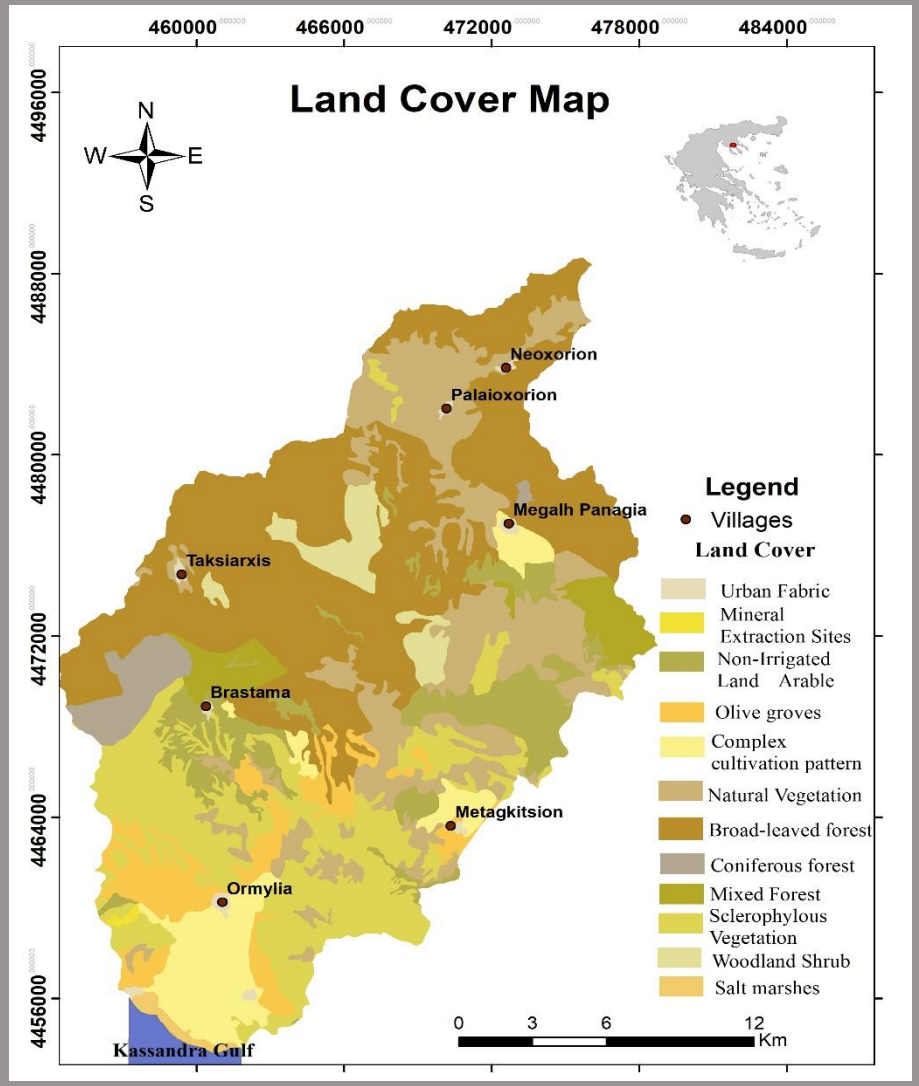


National Cadastre and Mapping Agency S.A. of Greece

Research area

Land Cover

- The agricultural land represents approximately 33% of the total area.
- The major crops are the olive groves.
- Broad-leaved, coniferous and mixed forests occupy the northern part of the watershed.



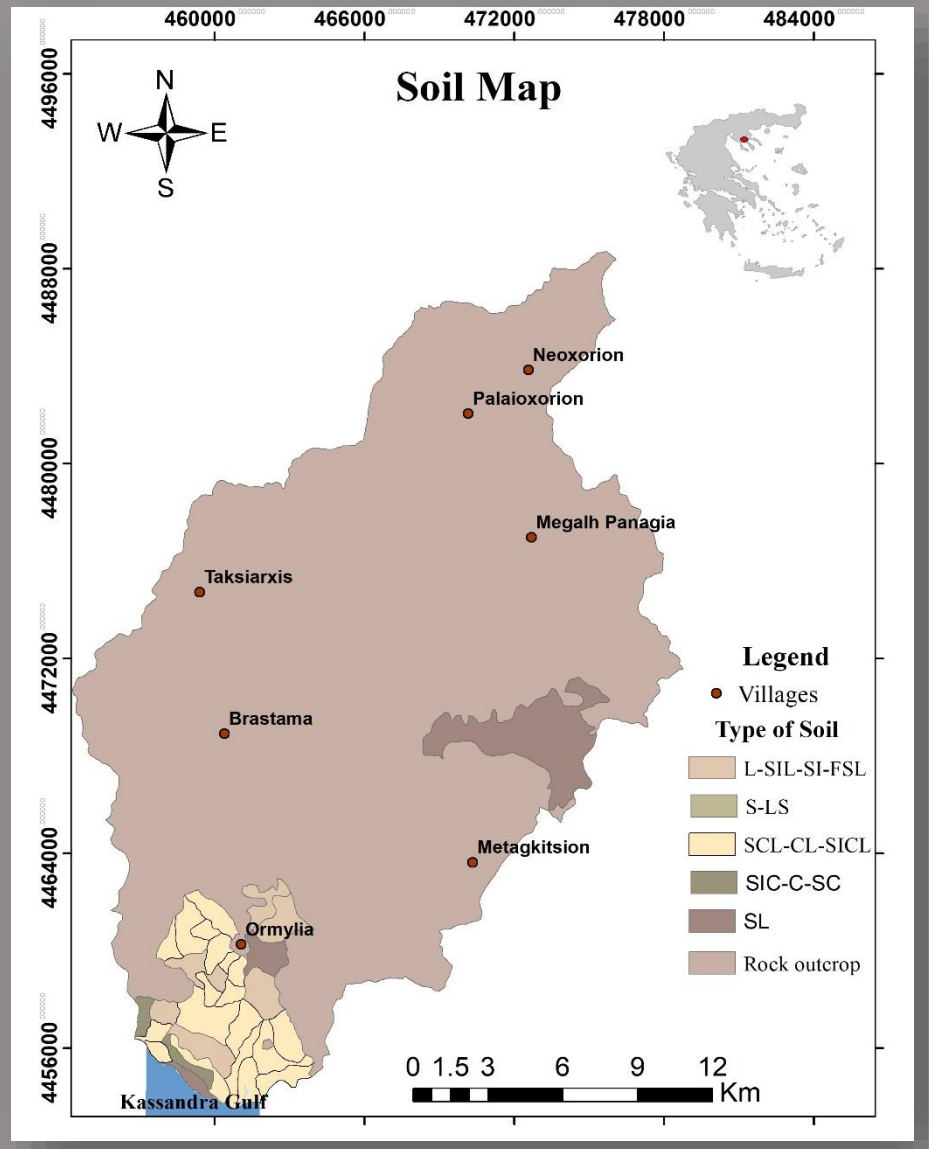
https://land.copernicus.eu/pan-european/corine-land-cover/clc-2012

Research area

Geology

- The coastal part is consisted of alluvial deposits, lacustrine and lagoon sediments, red clay and basic conglomerates series.

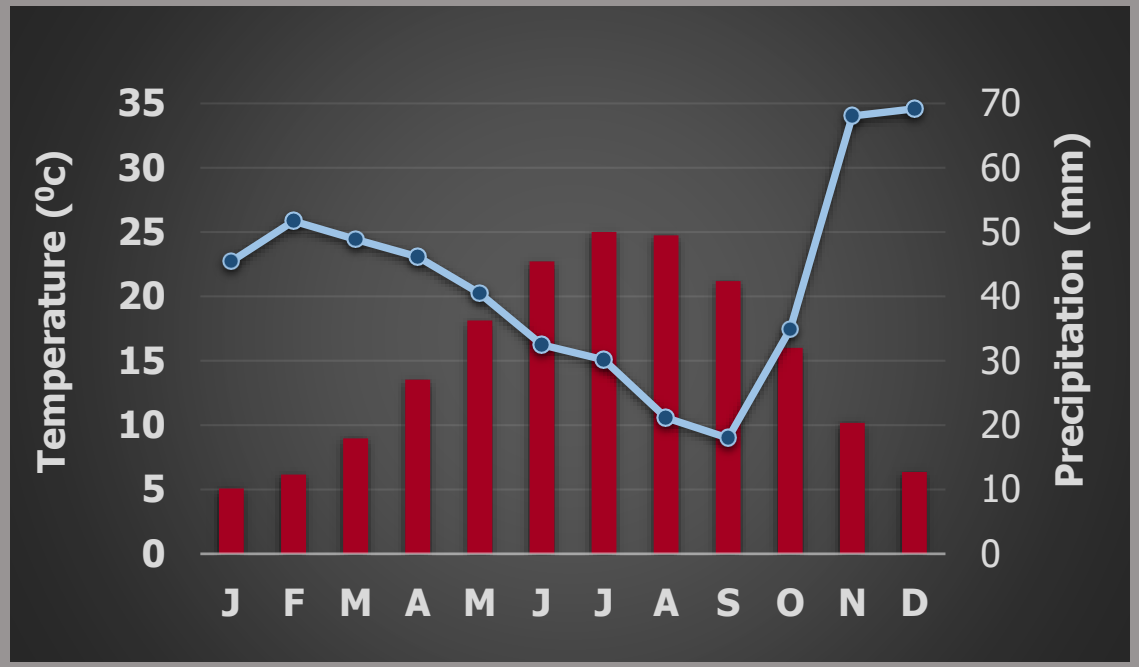
- Metasedimentary rocks, gneiss, phyllite, recrystallized limestone, gabbro, pyroxenites and dounites are encountered in the rest of the basin.



Research area

Climate Data

- The ERA-Interim daily reanalysis climate data with a spatial resolution of 12.5 km were used:
  I. precipitation
  II. maximum and minimum temperature
  III. wind speed
  IV. solar radiation
  V. dew point temperature



- Time period: 1981-2000

SWAT Application

Input Data

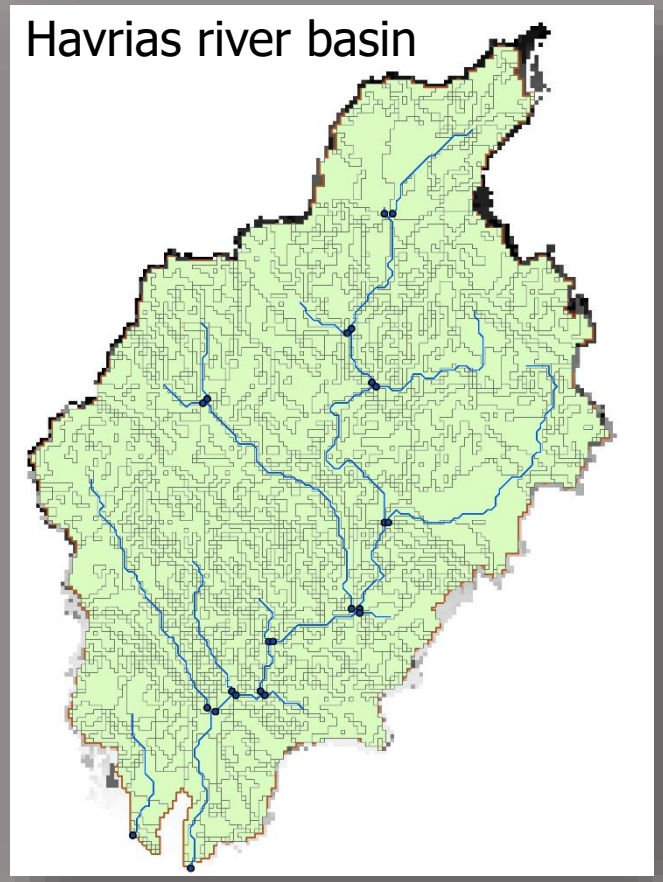
DEM

Land cover

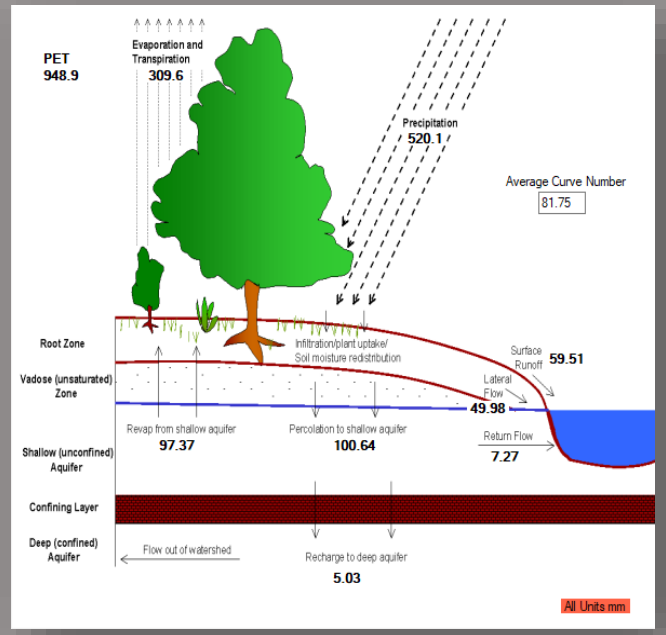
Soil data

Climate data

ArcSWAT Processing



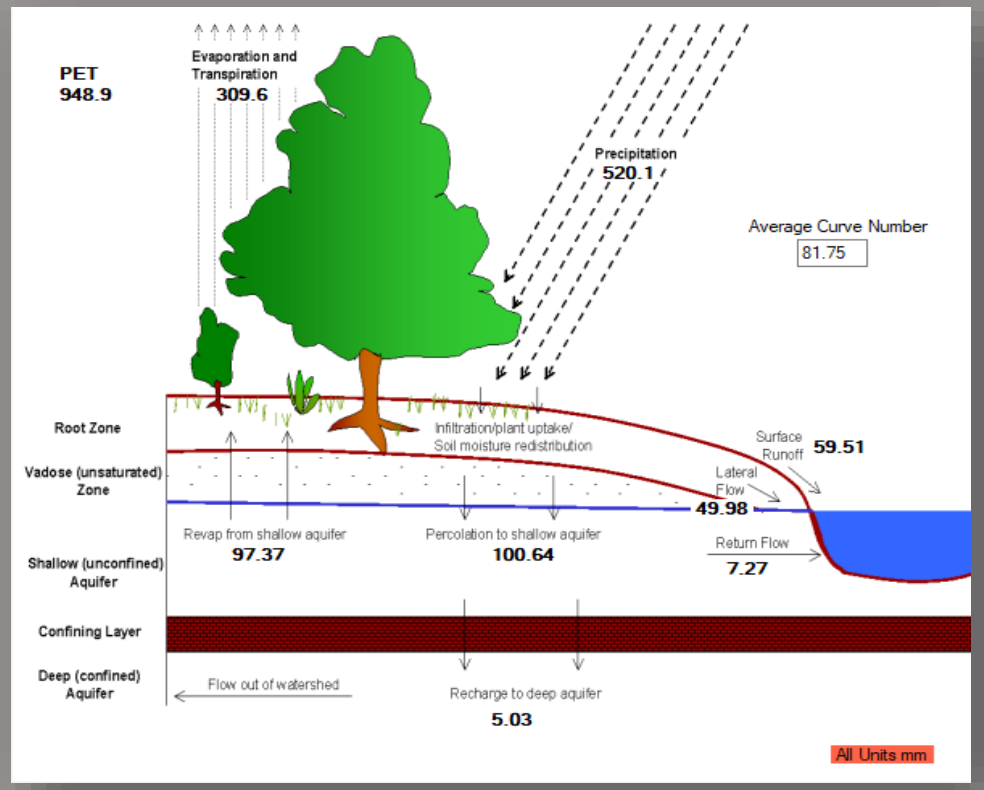
Output



SWAT Results

Based on the SWAT simulation results regarding to the period from **1981 to 2000**:

- the evapotranspiration was calculated equal to 309.6 mm, representing about the 60% of the mean annual precipitation (520.1 mm) of the Havrias river basin.
- the potential evapotranspiration was estimated equal to 949 mm.
- the percolation to shallow aquifer was estimated equal to 106.64 mm and the recharge to the deep aquifer equal to 5 mm.
- the surface runoff was computed at 59.51 mm.



The hydrological procedures of the Havrias river basin for the period 1981-2000

Sensitivity Analysis

The sensitivity of the hydrological parameters to the alteration of the climate data was analyzed by using eleven hypothetical scenarios:

Scenario	Temperature (°C)	Precipitation (%)	Wind speed (%)	Relative Humidity (%)
1	+1	0	0	0
2	+2.5	0	0	0
3	0	-5	0	0
4	0	-10	0	0
5	+2.5	0	+50	0
6	+2.5	-5	+50	0
7	+2.5	-5	+50	-25
8	+2.5	+5	+50	+10
9	0	+5	0	0
10	0	+5	0	+5
11	0	0	+50	0

Sensitivity Analysis

The following results can be drawn from the Swat simulation of the Havrias river basin under the hypothetical climate scenarios:

Scenario	Potential Evapotranspiration (mm)	Evapotranspiration (mm)	Percolation (mm)	Surface Runoff (mm)
1981-2000	949	309.6	106.6	59.5
1	979	311.3	98.6	60.2
2	1024.5	314.0	96.2	60.3
3	949.0	299.1	93.9	53.2
4	949.0	289.4	86.3	47.7
5	1219.3	332.1	84.4	56.5
6	1219.3	321.9	77.6	50.3
7	1515.6	359.4	52.9	41.9
8	1143.9	350.2	54.6	61.5
9	949.0	316.9	108.7	66.9
10	900.8	321.1	106.0	66.0
11	949	308.2	101.2	59.8

Sensitivity Analysis

The following results can be drawn from the Swat simulation of the Havrias river basin under the hypothetical climate scenarios:

- The temperature increase by 2.5 ^{o}C (Scenario 2) resulted in increase by **8%** and **1.4%** in potential evapotranspiration and in evapotranspiration, respectively. On the contrary, the percolation to the shallow aquifer and the recharge to the deep aquifer was decreased by **9.3%.**
- Reducing and increasing the precipitation, reduced and increased all the hydrological components, respectively. No changes observed in the potential evapotranspiration.
- Increasing only the wind speed (Scenario 11) resulted in slight decrease in evapotranspiration, percolation and consequently in recharge.
- The largest increases of evapotranspiration and decreases of runoff and percolation obtained when all the climate parameters (temperature, precipitation, wind speed, relative humidity) were changed.
- Scenario 7 showed an augment by **59%** and **13%** in potential evapotranspiration and evapotranspiration, respectively, whereas a decrease by 50% and 11% in percolation and hence in recharge to deep aquifer and in surface runoff, accordingly

Conclusions

- The sensitivity analysis showed that the Havrias river basin is vulnerable to the variability of the climate parameters.
- Based on the SWAT simulation results, the temperature, the precipitation and the relative humidity highly influence the hydrological budget components of the study area.
- The wind speed has negligible role in hydrological processes

Conclusions

- This paper is a preliminary research on the assessment of the sensitivity of the hydrological components to potential future climate change, laying the foundation for using the climate models outputs so as to quantify the climate change impacts on water resources.

- The couple of reliable climate and hydrological models is essential in order water managers to be able to build scenarios providing sustainability against the anticipated climate change.

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Thank you for your attention!

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