EXTENDED ABSTRACT

1. Introduction

The present postgraduate thesis constitutes an application of Geographic Information System (GIS) to the study of the water balance in a hydrological basin. A water balance model is developed having for input hydrometeorological data and output spatial data of runoff, evaportranspiration and water storage.

The basin under study is located upstream to the Kremasta Dam in Acheloos River. The ARCVIEW GIS program was employed for the application. The following figure presents the digital terrain model and the location of the basin in the Greek territory.

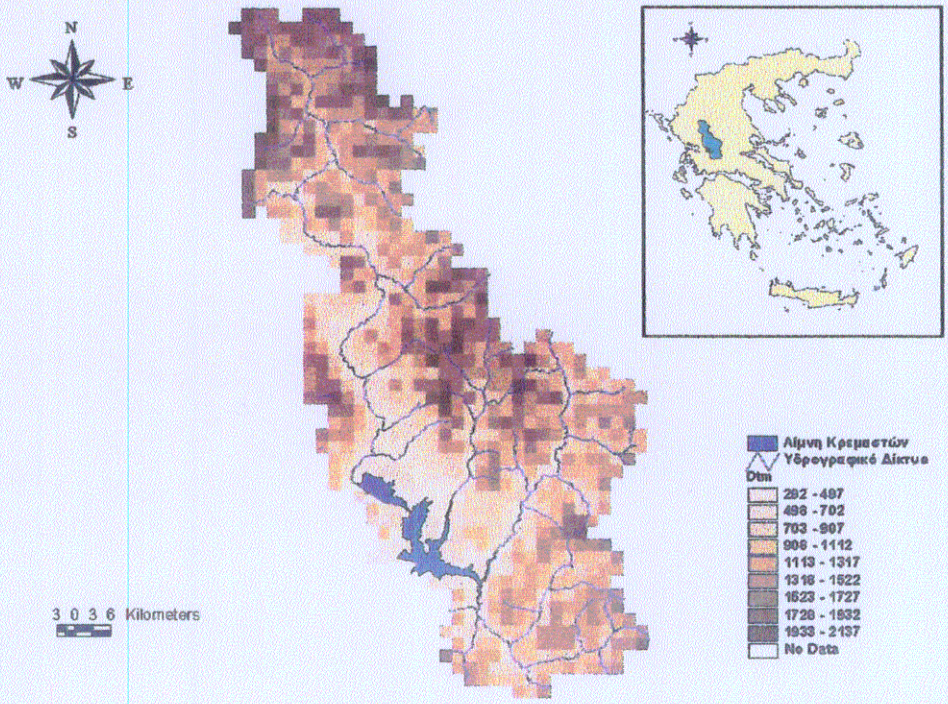

Figure 1: DEM of Kremasta Basin

The study is composed of Chapter 1 (Introduction), five Chapters (2-6), bibliography and two Annexes.

Chapter 2 consists a description of all hydrological data used.

In Chapter 3 there is a description of the ARCVIEW GIS program with emphasis to the programming language AVENUE that comes with ARCVIEW.

A detailed description of the model, operation, input variables, parameters used and output variables follows in Chapter 4. The algorithm of the model also included.

Chapter 5 contains some information about the basin. Also, a description of the application development method within ARCVIEW GIS is given, as well as the input

variables grids construction and the model algorithm for the construction of the output variable grids. The calibration and verification of the model is also accomplished here.

Chapter 6 summarizes the main points that have been presented during this study, the conclusions and suggests related future research topics.

Annexes contain all hydrometeorological data used and the programs developed for the application.

2. Literature review

A number of researchers have used water balance models to estimate hydrologic fluxes. However, there is a small number of studies that present the connection of GIS and water balance modeling (Olivera [1995], Reed et al. [1997], Pimentà [1999]).

In the Greek literature there are studies in hydrological applications that use GIS. Therefore, water balance application using GIS is an object that studied for the first time.

The water balance model developed in the present thesis, is based on an older model (Nalbantis [1992]) that modified in the present thesis.

3. Methodology

The basin was divided into cells of 4 square kilometers each and the inputs and outputs of the model were grids with the same cell size. The model is distributed as the calculations between variables take place on individual cell basis. The time step of the model is monthly.

The transformation of rainfall to runoff at the basin outlet is accomplished by successive transformations of rain in an interconnected reservoir system. A short description of these reservoirs follows:

- *R1: Reservoir of snow accumulation*

  Input: Snowfall

  Output: Snowmelt

- *R2: Reservoir of soil moisture*

  Input: Part of rain and snowmelt that percolated to the ground

  Output: Surface runoff and outflow to the next reservoir of ground water

- *R3: Reservoir of groundwater*

  Input: Part of the soil moisture reservoir storage

  Output: Outflow to the river from the groundwater reservoir storage

The input variables are:

- *Precipitation P*
- *Potential evaportranpiration Ep*
- *Average temperature Tm*
- *Maximum average daily temperature Tmax*
- *Minimum average daily temperature Tmin*

The input variables are:

- *Storage of soil moisture reservoir S*
- *Storage of groundwater reservoir G*
- *Real evaportranpiration RE*
- *Total runoff Q*

The model parameters are:

- *Imperviousness v*
- *Storage capacity of soil moisture reservoir K*
- *Recession coefficient of soil moisture κ*
- *Recession coefficient of ground water λ*

The entire application was built on the AVENUE programming language. The method that used to construct the input variables grids, the algorithm and the output variables grids is a characteristic of object oriented programming method. Important factors in the technique that followed here, are the specification of grid data and the difficulty in managing grid themes.

The thesis is completed with the calibration and verification of the model. Firstly, the lumped model was calibrated and the calibrated parameters were input in the distributed model algorithm. The values of the parameters are:

$v = 0.218$

$\kappa = 0.087$

$\lambda = 0.069$

$K = 154.02$ mm

The calibration period is 57 months and the verification period 36 months. The comparison between both lumped and distributed estimated runoff values and the available runoff values at the basin outlet for both calibration and verification period is shown in Figures 2,3 and 4.

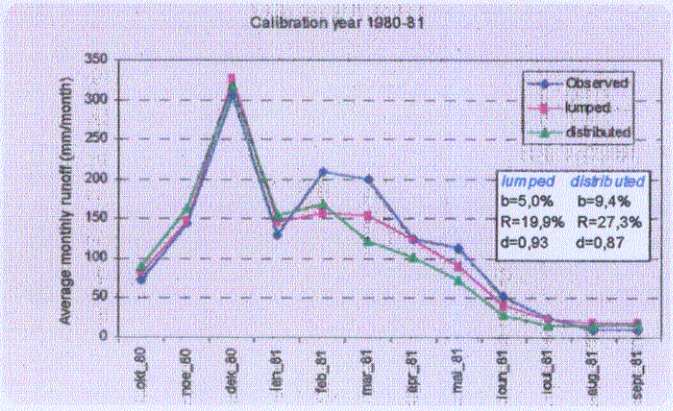

Figure 2: Calibration year 1980-81

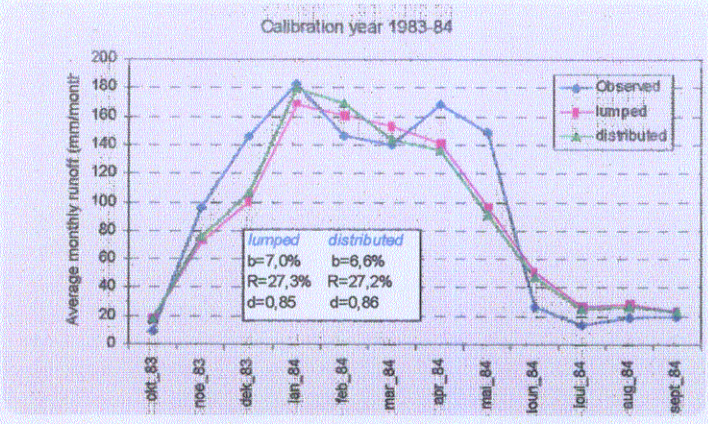

Figure 3: Calibration year 1983-84

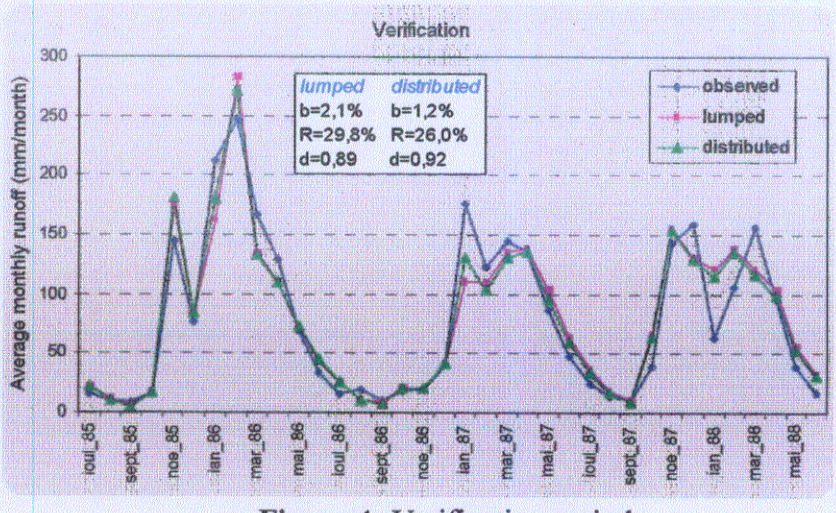

Figure 4: Verification period

4. Conclusions

- A simple distributed water balance model was developed which simulates the hydrological processes using a monthly time step. The input is hydrometeorological data and the output is spatial data of runoff, evaportranspiration and water storage in different ground levels. The development of the model was based on an object oriented programming language (AVENUE) which comes with ARCVIEW GIS program. The model was applied in a basin that lies upstream Kremasta Dam in Acheloos River.

- The model, due to its distributed character and development in a GIS environment, allows the calculation of the output variables spatial distribution. Furthermore, the output variables integration gives the monthly runoff volume along the rivers.

- The model was calibrated using runoff values available at the basin outlet. The greater part of the data was used for calibration and the smaller one for verification. The comparison between the computed and the observed values concluded that the performance of the model is very satisfactory. The model deviation for a typical calibration year was measured at 6.6% for bias, 27.3% for root mean square error and 0.86 for the determination coefficient. The respective values for the verification period were: 1.2% for bias, 26% for root mean square error and 0.92 for the determination coefficient

- As far as the computation part of the thesis is concerned, the development of the programs in AVENUE language presents advantages and disadvantages. It consists a powerful tool that automates and accelerates complicated procedures even though its processing speed is not always satisfactory. The computational demand of the program is high, due to the nature of grid data, whose management and calculations are performed on a grid cell basis.

- Grid management in ARCVIEW GIS program was satisfactory. The program was quite stable despite the large number of created grids (more than 2000 grids were created for this application's needs). The performance of the program was gradually decreased as the application execution proceeded. This fact depends on the technical characteristics of the computer system (PC) as well as the operating system (MS Windows) employed.