

HYDROLOGICAL MODELLING OF MARANHÃO AND PRACANA BASINS, A FIRST APPROACH

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Abstract

Modelling the hydrology of hydrographic basins has shown itself as a useful tool in environment management. The hydrological models can be used for multiple purposes: estimate runoff from sequences of rainfall, access stream water quality, quantify the diffuse pollution that reaches water masses such as estuaries, rivers and lakes, etc. This study has as final objective to simulate and analyse the flow, sediment transport and water quality as a function of landuse and soil type in the basins of Maranhão and Pracana. The modelling system used is SWAT, *Soil Water Assessment Tool*. In this first phase of the study the hydrodynamic calibration of the model was performed using measurements of average daily flows in five stations. The model compares well with the measurements; the annual average flows are similar and the majority of the measured flow peaks coincide with the model peaks.

Keywords: hydrological models, swat, environment management, runoff, diffuse pollution.

1 Introduction

The applicability of hydrological models for environmental issues is gaining wide support. The spatial information of processes needed for evaluate alternative watershed managements with adoption of geographic information system (GIS) technology is now becoming a usual and efficient tool, Heidenreich et al [1]. In SWAT, this approach is used: the menu interface provides a tool to identify the relative contribution of sub-watershed areas to nonpoint source pollution and to evaluate the effects of alternative land use management practices on surface and ground water quality at the watershed scale, Knox et al [2]. They can be also used to estimate river flows at ungauged sites, fill gaps in broken records or extend flow records with respect to longer records of rainfall.

The final objective of this study is to simulate and analyse the flow, sediment transport and water quality as a function of landuse and soil type. The research area is the watersheds of Maranhão and Pracana, located in Tagus basin. In this phase of the study only hydrodynamic results are shown.

2 Modelling Method

The model used is SWAT, Soil Water Assessment Tool, a watershed scale model developed by Agricultural Research Service and Texas A&M University.

The model was developed to predict the impact of land management practices, such as vegetative changes, reservoir management, groundwater withdrawals, and water transfer, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time, User's Manual SWAT [3]. SWAT can analyze large watersheds and river basins by subdividing the area into homogenous sub-watersheds. It can use a daily time step and perform continuous simulation for a 1 to 100 year period, Srinivasan et al [4]. SWAT simulates hydrology, and nutrient cycling, erosion, and sediment transport.

The hydrology component of SWAT is based on the water balance equation. A distributed Soil Conservation Services (SCS; now Natural Resources Conservation Service) curve number is generated for the computation of overland flow runoff volume, given by the standard SCS runoff equation. The curve number method is empirically based and relates runoff potential to land use and soil characteristics. The curve number method combines infiltration losses, depression storage, and interception into a potential maximum storage parameter.

Water is routed through the channel network using either the variable storage routing method or the Muskingum river routing method. Both the variable storage and Muskingum routing methods are variations of the kinematic wave model.

3 Model Application

In this study the model was applied in Maranhão and Pracana watersheds, tributaries of Tagus river, figure 1.

The basic inputs for the model are: digital elevation model, soil classification, landuse, and meteorological data.

Digital elevation models (DEM) are essential to watershed delineation and modelling because it influences the flow direction and all others hydrologic processes. The DEM was obtained from SRTM (Shuttle Radar Topography Mission). The combination of the soil and land use with meteorology data are fundamental to determine the amount of precipitation converted into effective runoff. The meteorological data needed was available from INAG (Portuguese National Water Authority) and soil and land use charts are from FAO.

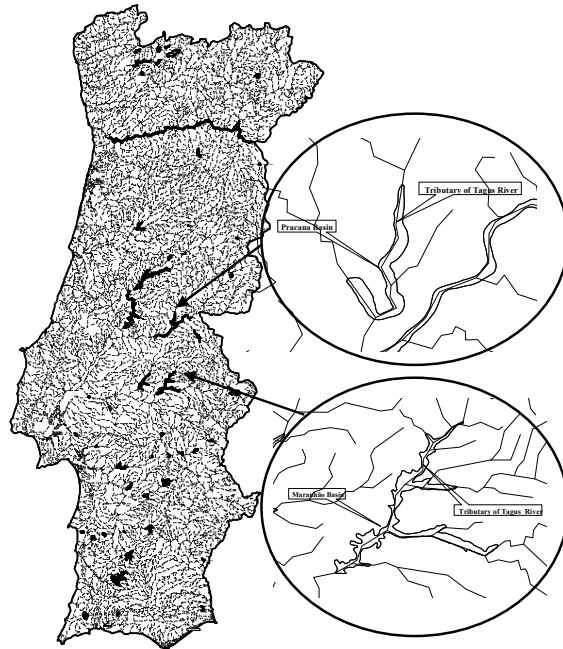


Figure 1: Localization of Maranhão and Pracana Basins

To calibrate the model there are several parameters needed to be adjusted because they influence the flow produced for each sub-watershed.

The parameter curve number distributes the amount of water entering the sub-watershed into runoff and groundwater as a function of soil type and use. The type of the soil depends generally of the fractions of clay and sand. The others soil characteristics can be obtained from using a pedologic function, K.E. Saxton et al [5]. In SWAT the soil type is used, among other things, to determine the SCS curve number. In the watersheds of Maranhão and Pracana only one type and use of soil was used. Table 1 contains the simulation conditions more appropriate for each sub-basin.

Table 1: Conditions of simulation

Sub-basin (*)	Curve Number (CN ₂)	Soil hydrologic group	Use of soil (**)
7 (Couto Andreios)	96	C	FRST
39 (Ponte Formosa)	96	C	FRST
88 (Figueira e Barros)	36	C	FRST
87 (Monforte)	95	C	FRST
78 (Pracana)	97	B	FRST

(*) Sub-basin associated to the station of measured flow

(**) FRST - Forest-mixed

The model was first used to obtain a calibrated set of parameters in each domain. With this information the model was explored to identify the main characteristics of Maranhão and Pracana hydrology.

At Maranhão watershed four flow measuring stations are available, while at Pracana only one station can be used, from INAG. These stations are chosen because they have measured flows and precipitation for the same dates.

Figures 2 to 5, show the annual measured flows and the model results for the five stations, in the same figures the values of 1/4 of the average precipitation in the upstream sub-basins are also shown. The 1/4 fraction is used since it is usually a good approximation of the flow for this systems.

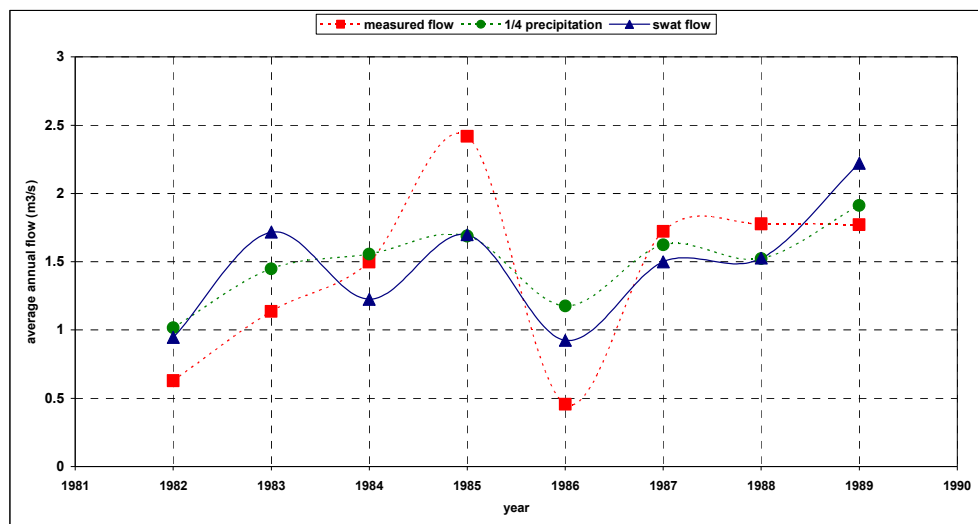


Figure 2: Couto Andreios Station - Maranhão Basin

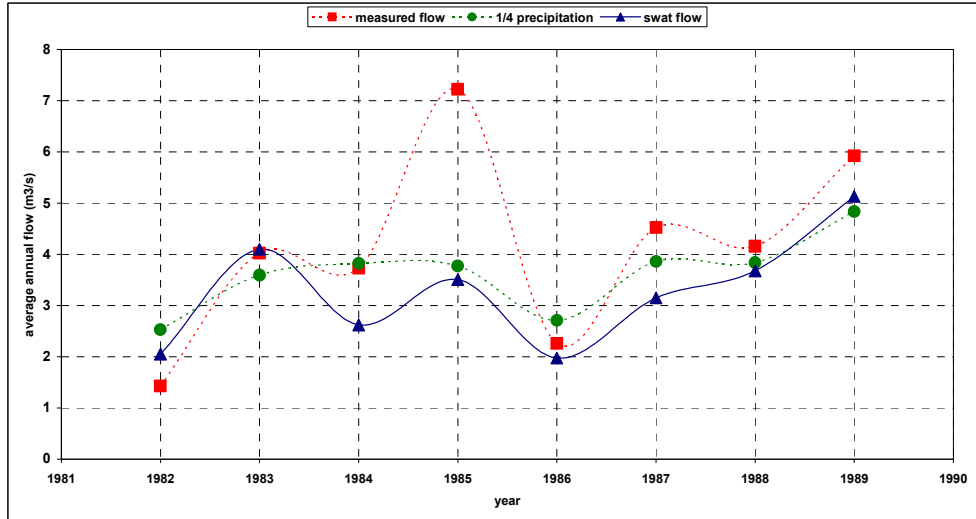


Figure 3: Ponte Formosa Station - Maranhão Basin

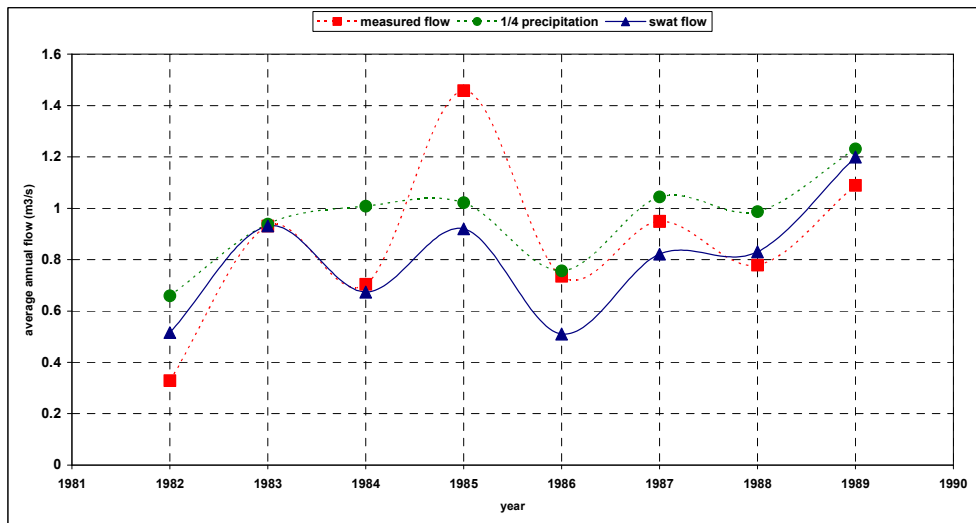


Figure 4: Monforte Station - Maranhão Basin

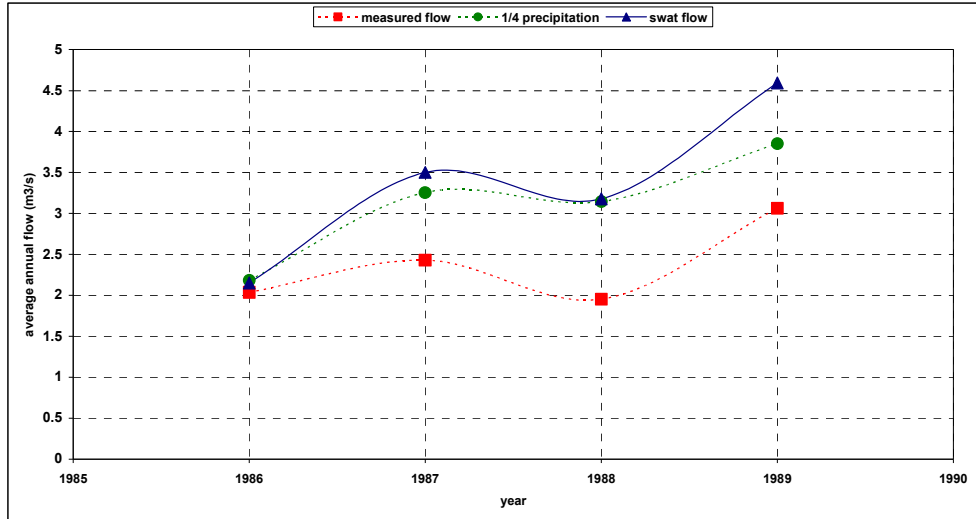


Figure 5: Figueira e Barros Station - Maranhão Basin

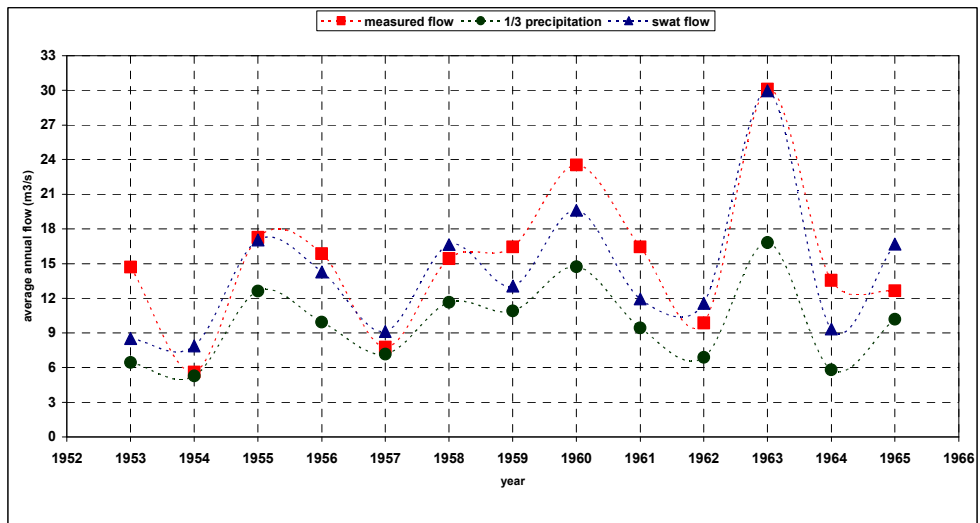
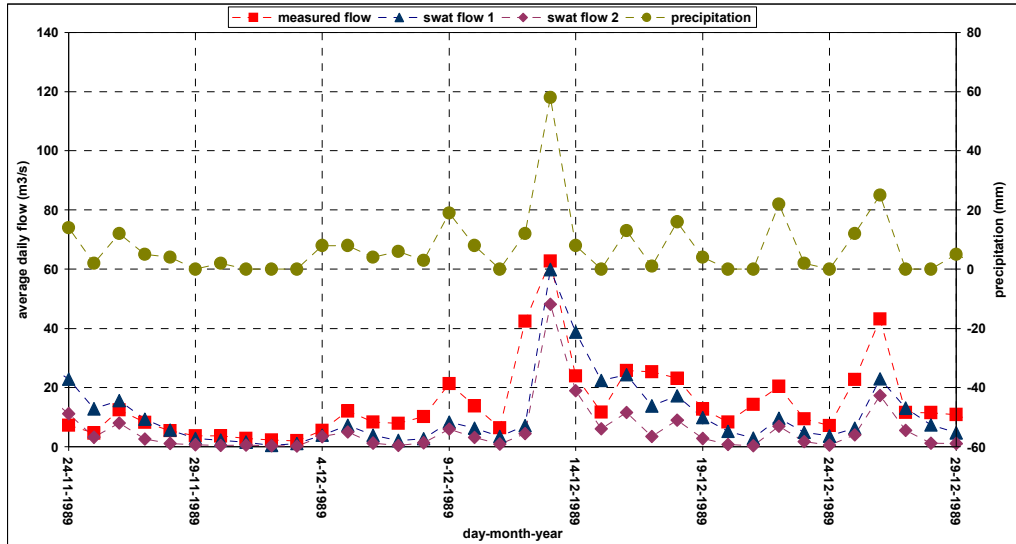


Figure 6: Almourão Station - Pracana Basin



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Figure 7: Couto Andreios Station - Maranhão Basin

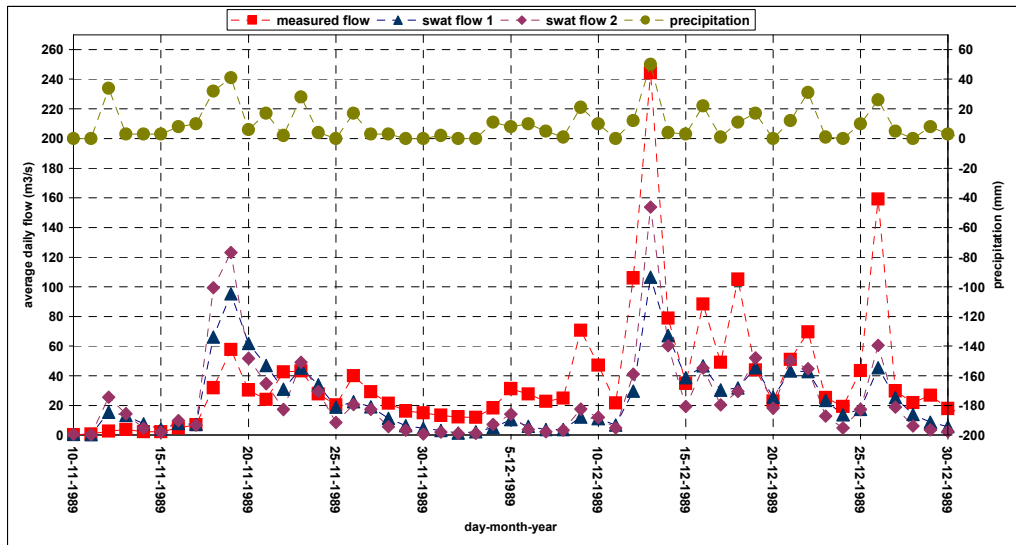


Figure 8: Ponte Formosa Station - Maranhão Basin

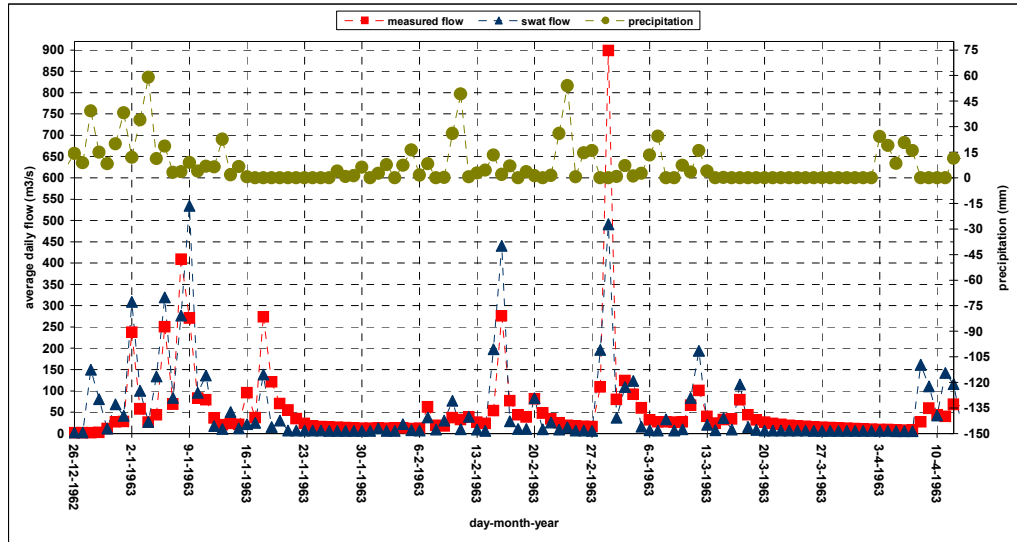


Figure 9: Almourão Station - Pracana Basin

4 Discussions of Results and Conclusions

From figures 2 to 6 it can be seen that the annual average of the measured flows approach the annual average of the model results. In 1985 (and also in 1986 for “Couto Andreios“ station), an important difference between the model and measured values can be seen. On the other hand, 1/4 precipitation results agree quite well with the model results. Several explanations to this behaviour can be advanced: the model does not consider small ponds and reservoirs that can have discharged large amounts of water in that year due to short but intense episodes of precipitation. Other explanation possible is some problem with measurements has occurred in that year.

In figures 7 to 9 it can be seen that the majority of the measured flow peaks coincide with the model peaks, showing a correct delay precipitation of about 1 day. Other aspect is that the model slightly underestimates the flow values in some cases. It can be seen that in general the modelled values compares well with the measurements.

There are several factors that contribute to these differences: only one soil type and use was considered; the water used for irrigation was also not included. This was adopted because the available data was not enough to included further refinements.

In the future the data bases for these systems will be enlarged to enable further simulations refinements.

5 Acknowledgments

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