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Sensitivity Analysis Of The Flood Forecasting With Crest Model In The Upstream Of Medjerda River (Tunisia)

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ABSTRACT

Tunisia has a dense hydrographic network in the north, whose river basins account for 81% of the national surface water potential. Oued Mejerda, which rises in Algeria, is the biggest river, with an annual water potential of around 0.8 billion m³. This region is prone to flooding events and the problem arises seriously in the upstream of Sidi Salem dam. Since these regions encompass a high socio-economic interest for the country, flood mitigation efforts are important to minimize loss of human lives and property.

To protect people and facilities on the flow of water, strategies are based on reconstruction and forecasting of floods in the short term. In this context, the axis "Flood Mapping and modeling" of the project "Improving of water resources management and adaptation to climate change - Tunisia", funded by the World Bank, coordinated by the Regional Centre for Remote Sensing of North Africa States, supported by NASA and conducted jointly by the Ministry of Agriculture, the National Centre for Cartography and Remote Sensing and the National Institute of Meteorology, aims to establish a reliable model for flood forecasting of Medjerda major hydrometric stations.

We use the hydrological model CREST (Coupled Routing and Excess Storage) to simulate the runoff and routing. This

model requires mapping data such as digital terrain model, flow direction map, storage flow map, rainfall data (TRMM satellite data), hydrometric data (flows

observed) and evapotranspiration data (NOAA satellite data).

In a first phase, a sensitivity analysis was carried on the parameters of CREST model for the flood of January 2010. This study showed that the most sensitive parameters are the parameters of the initial conditions which are the initial value of soil moisture, the initial value of interflow reservoir and the initial value of overland reservoir as well as model parameters namely the runoff coefficient of surface and the runoff coefficient of sub-surface.

In a second phase, we simulated the flow of the flood of the year 2010 and evaluate the results of CREST model using three criteria which are the Nash Sutcliffe efficiency coefficient, the relative coefficient of Bias and the correlation coefficient. The simulation of water flow resulted in a Nash coefficient of 77.77%, a coefficient for Bias of 14.87% and a correlation coefficient of 89.75%. The sensitivity study concluded that the CREST model is more sensitive to initial condition coefficients and low sensitivity to others. Decrease the values of the initial conditions has led to the reduction in flows calculated.

The results of the simulation model used to simulate water flow in the upstream part of the watershed of the Medjerda River are contributing to better floodplain management. Several tests were carried out to generate a reliable decision tool freeing increasingly climatic hazards in a country like Tunisia.

INTRODUCTION

In Tunisia, in recent years, the problems of water risks have become very common concern. Floods are the most common natural hazard in the country. Today, the problem is serious in the watershed Medjerda, especially in the plain Ghardimaou - Jendouba - Bou Salem. These floods have reminded the dangers acuity to society and environment.

Indeed, Medjerda was characterized by exceptional floods have been catastrophic for residents, in few days the river carted 940 million m³ (floods March 1973) and in a few weeks 1222 million m³ (January 2003 flood) (Zahar et al., 2007). More flood in February 2012 caused serious damage in the cities of Jendouba, Bou Salem and Medjez El Bab through overflow of the water from Medjerda and Bou Heurtma.

The present work is part of the project "Improving of water resources management and adaptation to climate change - Tunisia", is designed for a period of four years (2012-2015), funded by the World Bank, coordinated by the Regional Centre for Remote Sensing of North Africa States, supported by NASA and conducted jointly by the Ministry of Agriculture, the National Centre for Cartography and Remote Sensing and the National Institute of Meteorology.

OBJECTIVE

The purpose of this study was simulated the flow of the flood in the upstream of Medjerda River (Tunisia) and contribute to the management system and flood warning which will be managed by the Directorate General of Water Resources (DGRE) using the hydrological model CREST (Coupled Routing and Excess Storage) which is developed by the University of Oklahoma and (<http://hydro.ou.edu>) and NASA SERVIR Project Team (www.servir.net).

The CREST model was initially developed to provide real-time regional and global hydrological prediction by simultaneously running over multi-basins with relatively cost-effective computational efficiency (<http://eos.ou.edu>), however it is also very applicable for small to medium size basins at high-resolutions.

METHODS

The approach aims to analyze historical floods using data from observations and models proposed to reconstitute and to simulated the flood in our case study.

- Literature : literature review of different models of flood propagation, we will focus on adaptive models.
- Analysis of historical floods : data collection rainfall and hydrometric flood at the Medjerda river and analysis of the data quality.
- Simulation of the flood : using CREST model

CASE STUDY

This work focuses on the main stations of the river Medjerda located upstream of the Sidi Salem dam (fig.1). Medjerda is one of the main wadis Maghreb, both the length of the watercourse, the area of the watershed and the volume of water it carries. In fact, the source of this wadi is located in Algeria and whose bed is mainly on the territory of Tunisia. Its source is near Souk Ahras in Constantine Algeria, then flows east before emptying into the Mediterranean Sea (Gulf of Tunis). Flowing over 460 km including 350 in Tunisia, it is the only perennial water courses of Tunisia. It has a catchment area of about 23,700 km² of which 16,100 in Tunisia.



Figure 1 : Case study

DATA AND MODEL PARAMETERS

The CREST model is composed of modules enabling daily estimation of evapotranspiration, soil water content, flow routing, and flow generation within a cell, through the drainage network. The a priori values of the physical parameters are derived. The CREST model uses digital elevation data processed from the Shuttle Radar Topography Mission to generate flow

direction, flow accumulation, and contributing basin area.

There are 12 essential parameters in CREST model (tab.1), these parameters are derived from geomorphological characteristics from remotely sensed and in situ data.

Module	Symbol	Designation
Initials conditions	WO	Initial Value of Soil Moisture
Physicals Parameters	Ksat	the Soil saturate hydraulic conductivity
	RainFact	the multiplier on the precipitation field
	WM	The Mean Water Capacity
	B	the exponent of the variable infiltration curve
	IM	Impervious area ratio
	KE	The factor to convert the PET to local actual
	coeM	Overland runoff velocity coefficient
Conceptual Parameters	expM	overland flow speed exponent
	coeR	multiplier used to convert overland flow speed to channel flow speed
	coeS	multiplier used to convert overland flow speed to interflow flow speed
	KS	Overland reservoir Discharge Parameter
	KI	Interflow Reservoir Discharge Parameter

Table 1: CREST parameters

RESULTS

A sensitivity analysis was carried on the parameters of CREST model for the flood of January 2010. This study showed that the most sensitive parameters are the parameters of the initial conditions which are the initial value of soil moisture, the initial value of interflow reservoir and the initial value of overland reservoir (SS0) (fig.2) as well as model parameters namely the runoff coefficient of surface and the runoff coefficient of sub-surface.

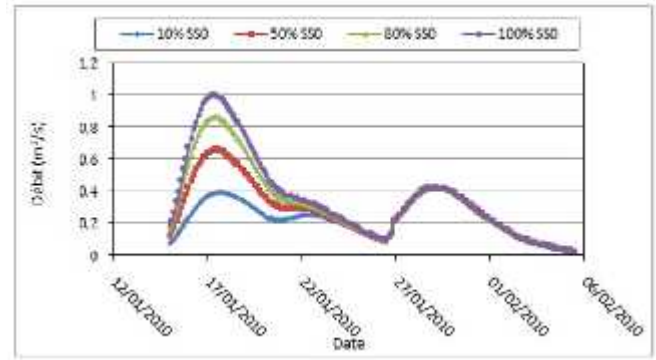


Figure 2: Sensitivity study of CREST model to the initial surface storage (SS0)

For evaluating the results of the CREST model, we use the optimization criteria which are the Nash Sutcliffe efficiency coefficient, the relative coefficient of Bias and the correlation coefficient.

Simulation of water flow with this model resulted in a Nash coefficient of 77.77%, a coefficient for Bias of 14.87% and a correlation coefficient of 89.75%. The sensitivity study concluded that the CREST model is more sensitive to initial condition coefficients and low sensitivity to others. Decrease the values of the initial conditions has led to the reduction in flows calculated.

CONCLUSION

The CREST model is examined in this study for its applicability as flood simulation for the case study of three main station of Medjerda River in Tunisia. Twenty four floods from 1973 to 2013 are analyzed for this purpose.

This model shows that the most sensitive parameters are the parameters of the initial conditions and the model parameters namely the runoff coefficient of surface and the runoff coefficient of sub-surface.

In the future, we propose to explore the SAR (Synthetic Aperture Radar) images to extract the inundated area in the Medjerda basin.

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