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Hydraulic and sediment transport simulation of Koiliaris River using the MIKE 21C model

Giasemi G. Morianou[a,*], Nektarios N. Kourgialas[a], George P. Karatzas[a], Nikolaos P. Nikolaidis[a]

[a]*School of Environmental Engineering - Technical University of Crete, Polytechneioupolis, Chania 73100, Greece*

Abstract

The objective of this work is the simulation of the water depth, flow velocity and sediment transport in the downstream part of the Koiliaris River (Crete – Greece). The two-dimensional hydraulic model MIKE 21C is used, which has been developed specifically to simulate 2D flows and morphological changes in rivers. The model is based on an orthogonal curvilinear grid and comprises two parts: (a) the hydrodynamic part which is based on the Saint-Venant equations and (b) the morphological change part for the sediment transport. The curvilinear grid and bathymetry files were generated using a very high resolution DEM (1 m x 1 m). Time series discharge data from a hydrometric station and a 2D map of initial surface water elevation were also introduced as input parameters in the hydrodynamic part of the model. Regarding the sediment transport model, field measurements of the sediment characteristics and the suspended sediment concentration were used. The model was calibrated and verified using water level field data and sediment concentration data that were collected during high and low flow discharges. Model simulation was in good agreement with field observations as indicated by a variety of statistical measures. The results of the model were 2D maps of flow velocity, water depth, sediment transport and bed level changes. Using the obtained simulation results, extreme hydrological events such as droughts or floods transporting large sediment loads, can be monitored in the study area.

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Keywords: MIKE 21C model; hydraulic simulation; river morphology; flow depth; sediment transport

* Corresponding author. Tel.: +30 28210 37793
E-mail address: giasemi.mor@gmail.com

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1. Introduction

Various numerical models have been developed for river flow simulation and sediment transport, which solve the governing equations using certain computational algorithms. These models are divided into three main categories: one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) [7]. The most widely used, one-dimensional numerical models are mostly based on finite difference and finite element methods. Different software tools, such as the HEC River Analysis System model from the US Army Corps of Engineers [10] and the MIKE 11 hydraulic model developed at the Danish Hydraulic Institute [2], have been used extensively for the dynamic 1D flow simulation in rivers. One-dimensional models, although simple to use, fail to provide detailed information regarding the flow field. In contrast, two-dimensional modelling has the advantage of flow propagation simulation with great accuracy.

The purpose of this study was to simulate river flow and sediment transport with the 2D hydraulic model MIKE 21C. The main advantage of this model is that it is based on a curvilinear (boundary-fitted) grid where the grid lines follow the bank lines [3]. The curvilinear grid makes the MIKE 21C model a suitable tool for fast and detailed simulation of river hydraulics and sediment transport. A fine curvilinear grid also requires a high analysis elevation data file of the river bed. According to Horritt et al. [5], the most significant part in two - dimensional hydraulic simulations is the bathymetry representation that is the development of an accurate geometric description for the river channel. Therefore, the last few years, remote sensing systems are used, in order to have very high resolution DEM (topographic elevation) data [1]. In this work a high accuracy DEM of a spatial resolution 1 m x 1 m is used for the bathymetry representation.

2. Study area

The Koiliaris River Basin is located 15 km east of the city of Chania in Crete. The basin extends from the White Mountains, with highest altitude 2041m above sea level, to the coastline. The watershed has a total catchment area of 130 km^2 (Fig. 1).

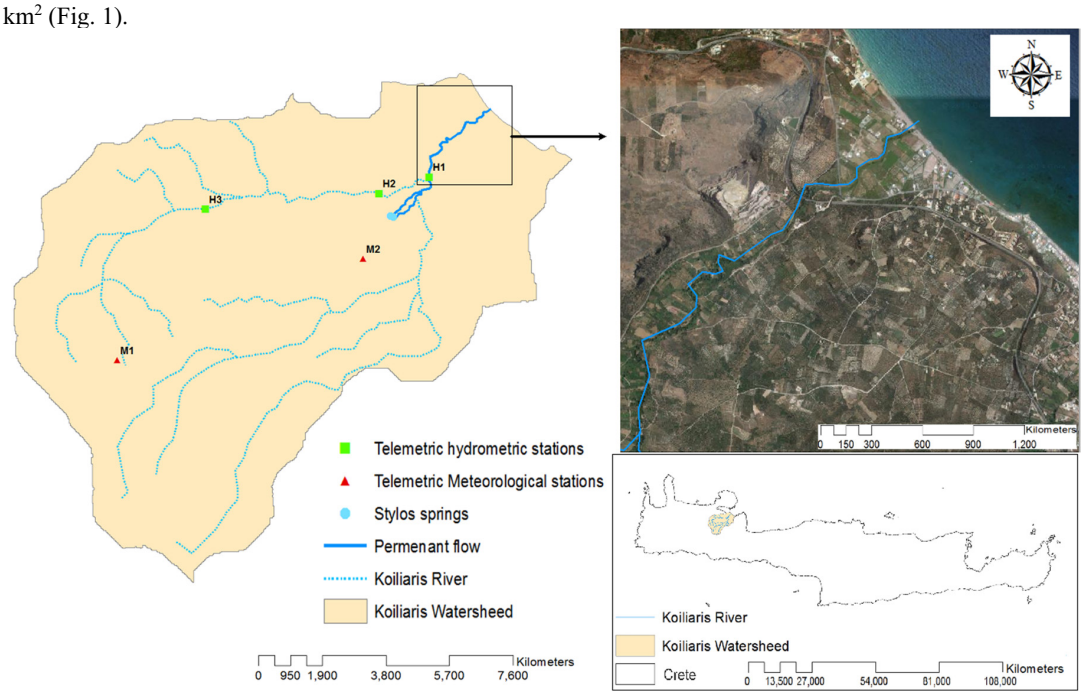

Fig. 1. Location of the Koiliaris River Basin and the downstream study area.