Development of a hydrological trans-boundary model for the Lower Jordan Valley, Israel, Palestine, Jordan

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1. INTRODUCTION

The groundwater resources of the Lower Jordan Valley and its tributaries in Israel, Palestine and Jordan are strongly limited by the semi-arid conditions. In addition, the extreme population growth intensifies the lack of available and high quality water resources in the region, where overexploitation of surface- and groundwater is usual. References are the intense drawdown of groundwater levels, the disappearance of springs and saltwater intrusions. To solve that complex issue a smart and integrated strategy to manage all available water resources (IWRM) will be developed. Such an IWRM is the aim of the multilateral SMART-project in the Lower Jordan Valley (www.iwrm-smart.org), where all water resources (groundwater, surface runoff, waste water) will be quanti- and qualitatively evaluated. One major topic of SMART is the generation of a trans-boundary numerical flow model in the scale of the Lower Jordan Valley. Different sub-projects on the local scale were necessary for the achievement of this goal. The study area of the here presented sub-project is one of the northernmost tributaries of the Lower Jordan Valley, the Wadi Al Arab (Jordan). The aim of the sub-project is to evaluate natural resources on catchment scale by combining hydrochemical and hydraulical methods to develop a high precision model. Concerning the quantification of the system, two separated models will be linked: a numerical finite element flow-model for the groundwater passage and a new developed hydrological model JAMS. The challenge of the investigation were the deployment of a conceptional groundwater model based on scarce data and adjustment of empirical equations and input parameters of JAMS onto the semiarid conditions. The results lead to a better understanding of the processes, which are important and necessary for the implementation in the trans-boundary model.

2. HYDROLOGICAL MODEL JAMS

The goal was to develop a tool for a highly accurate assessment of soil moisture balance and consequently of surface runoff and groundwater recharge. JAMS is a simplified hydrological model to calculate temporal aggregated and spatial distributed hydrological variables. Krause (2002) developed it for a humid climate zone, the challenges in the first phase of SMART were the adaption and parameterisation of JAMS onto the semiarid and arid conditions. That means basically adaptation in soil physics and vegetation conditions.

2.1 Procedure of JAMS

In JAMS the presentation and calculation of the hydrological procedures occur one-dimensional for any amount of points in space. The mentioned input data are spatially organized in hydrological response units (HRU), which lead to a spatially discriminated output. The HRU mesh builds a raster of defined scale, and therefore information of satellite images, aerial photographs and ground truth data the land covers in the catchment area of Wadi al Arab were classified. The model bases on different input parameters slope, aspect, altitude and soil type, which are determined and prepared by remote sensing techniques. The characteristics of the relief, the specific soil and the vegetation parameters define the later differentiation of the catchment into HRUs. All input parameters have to be intersected, which lead to spatially discriminated outputs (Figure 1). The resulting HRUs are the fundamental part of linkage of the hydrological and groundwater flow model.

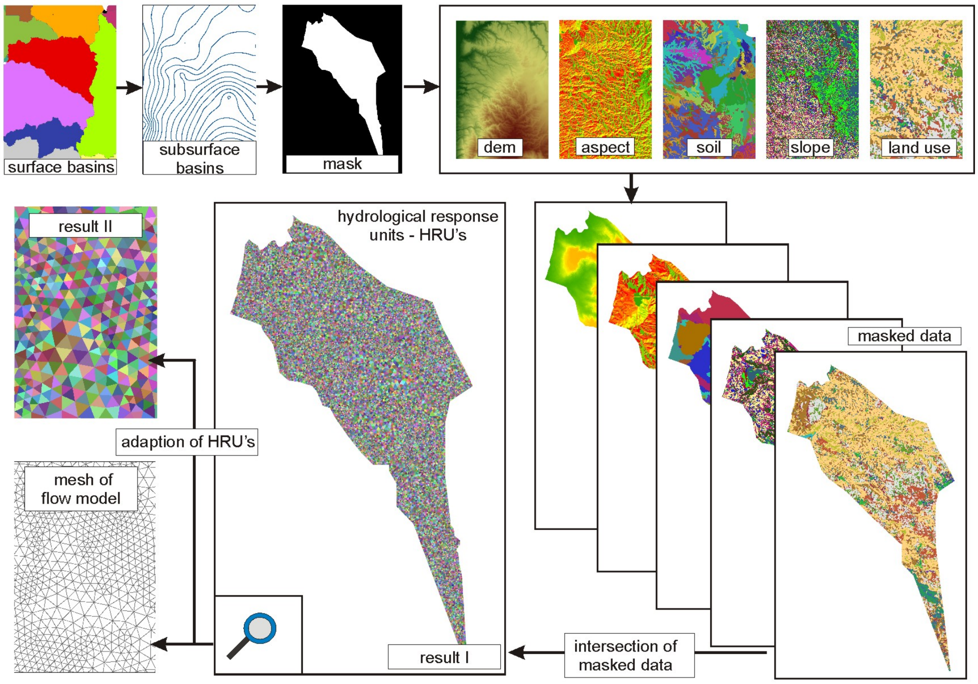

Fig.1: The intersections of the different input parameters of JAMS in combinations with the mesh of an groundwater flow model lead to the development of the HRUs.

3. RESULTS

Using climatic background information of monthly values from January 1980 until December 2008 completed the JAMS–model of Wadi al Arab. The direct measured surface runoff (WIS, 2000-2005) in the Wadi course was used to calibrate the model (Figure 2). The figure indicates that the calculated runoff, simulated by JAMS fits well to the measured runoff.

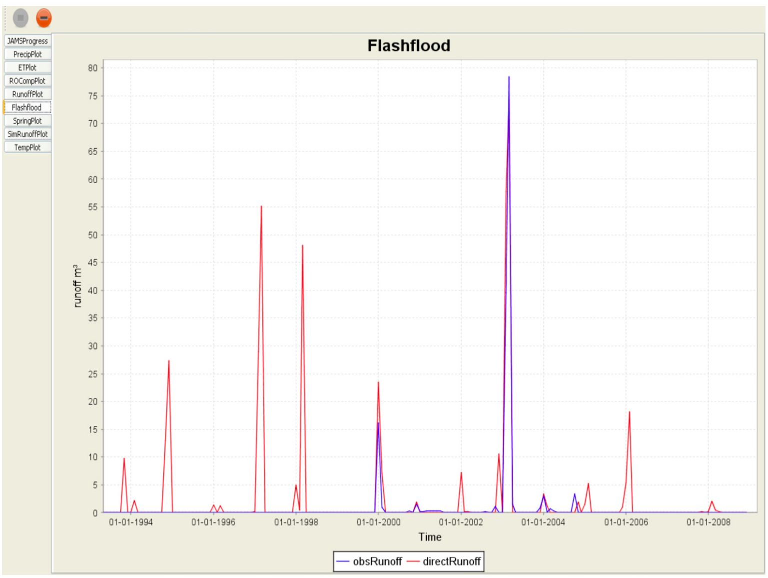

Fig.2: The result of the runoff calibration of the JAMS model of Wadi al Arab (blue observed, red simulated)

For additional validation of the model outputs, the data were compared to the groundwater (gw) recharge calculated by different methods (direct measured spring discharges, water table fluctuation and chloride mass balance methods). The simulated results of the model JAMS lead to the spatial and temporally distribution of groundwater recharge in the study area of Wadi al Arab (Figure 3).

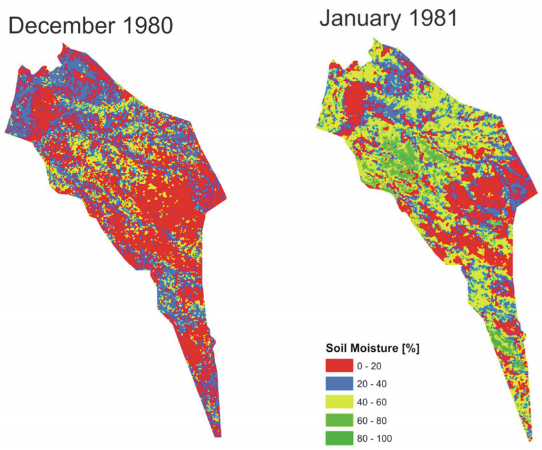

Fig.3: Spatial distribution of calculated soil moisture by JAMS in December 1980 and January 1981

Analysis of distribution of the gw recharge show, that the different input parameters of JAMS strongly control the simulated gw recharge. The Figure 4 show the minimum, maximum and mean values of gw recharge in comparison with the frequency of these parameters.

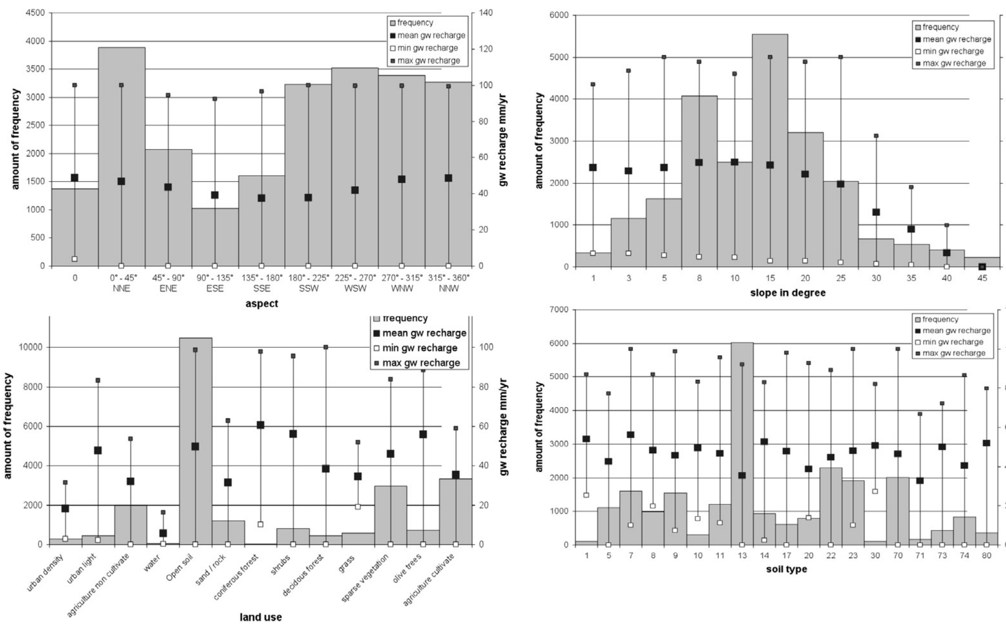

Fig.4: Analyzing of simulated gw recharge by JAMS in respect to the aspect, slope, land use and soil type

4. OUTLOOK

JAMS will linked with a groundwater flow model. The advantage is the direct comparability of the meshes of both models. The realization of linkage should be a mathematical interface between both models, which will allow a direct exchange of values.

In the second phase of SMART the hydrological model JAMS will be adapted and upscale onto the mesh of the trans-boundary model of the Lower Jordan Valley. The challenge for the development will be, that different transition zones from semiarid to arid climate conditions have to be combined in one model.

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