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Assessment of High Resolution Topography Impacts on Deterministic Distributed Hydrological Model in Extreme Rainfall-runoff Simulation

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Abstract

To represent the extreme rainfall-runoff events, the deterministic distributed hydrological modeling is gaining interest both with the increase of the computation facilities and the availability of data especially the topography inputs. The experience has demonstrated the key role of the topographic resolution within the development of the deterministic distributed hydrological models by achieving the impacts on the characteristics of the basin especially the slope distribution and the representation of the stream network. To define the suitable topography resolution applied in the deterministic distribution hydrological models is one of the key pre-processes before the modelling analysis. Thus, in this paper, the simulation results of four deterministic hydrological models with different topography resolution – 300m, 150m, 75m - for the Var basin, France (2800km^2) are analyzed in order to evaluate the influences on the simulation accuracy. The results of sensitivity analysis indicate the threshold value of the topography resolution on the model simulation with the consideration of both the sufficient accuracy and the reasonable simulation time to cover the extreme rainfall-runoff event in 1994.

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Keywords: High resolution topography, sensitivity analysis, deterministic hydrological model, extreme rainfall-runoff, Var Basin.

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1. Introduction

1.1. Deterministic distributed hydrological model

Due to the special characteristics of the extreme rainfall-runoff events (e.g. unexpected, high intensities, sudden and high damages on persons and goods, etc.), the requirements of having well-represented hydrological models to reproduce or estimate the flood disasters are rapidly increasing. In recent years, with the increase of the computation facilities, the deterministic distributed hydrological models that are based on the physical laws play a significant role in the hydrological modelling analysis. Comparing with the other kinds of models, such as empirical models or concept models, the physical deterministic distributed models have the obvious advantages in well representing the spatial variability of the system and the capacity to simulate any type of event.

In the traditional hydrological studies, with the limits of model abilities, one or less hydrological components in the hydrological cycle can be analysed deeply while others are simplified or approximated. In the physical deterministic distributed model, various hydrological processes in the hydrological cycle can be integrated considered and simulated followed partial differential equations of conversation of mess, energy and motion [1]. However, the power of the physical deterministic distributed model is as same as its weakness, as the data requirements of setting up this kind of model are relatively high. With the huge amounts of data inputs that some parameters could be over or under-estimated in the modelling set-up, the model uncertainty is increased at the same time.

The topography input as one of the main inputs of this model which directly influenced the river network and slope distribution, has significant impacts on the model simulation. One of the main factors defined the data quality is the data resolution. As we know that keeping increasing the resolution of the topography may improve the simulation results [2], but considering the geomorphology characteristics of the study area and the modelling computation time, the higher resolution topography input (e.g. 5m × 5m resolution) may not efficient in the model strategies. Hence, in this study, four topography scenarios of different resolution in Var Basin (2800km^2), France were assessed, to define the suitable inputs resolution for simulating the extreme rainfall-runoff events.

1.2. Physical behaviors of the study area

The Var catchment is located at the southeast part of France with the control area of 2800km^2 which is the largest river basin in the French Mediterranean Alps region. The elevation variation in this region is conspicuous. The basin raise from 0m above the sea level until 3100m above the sea level with the steep slope distributed along the branches located in the middle and upper area of the catchment. There are four main tributaries (Var, Estéron, Vésubie, Tinée) cross five main sub-catchments in this basin (Table 1) (Fig. 1.). The alluvial aquifer is one of the main drinking water resources for the local population. The exchange between the groundwater and surface water at the lower part of the basin is frequently [3].

Table 1. The sub-catchments and main branches in Var Basin.

Branches	Length (km)	Sub-catchments	Area (km^2)
Estéron	53.93	Estéron	446.73
Tinée	70.58	Tinée	741.96
Vésubie	48.49	Vésubie	392.36
Var	122.59	Upper Var	1082.77
		Lower Var	150.76