DEM-based Ecological Rainfall-Runoff Modelling in Mountainous Area of Hong Kong

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1.Introduction

The long-lasting alteration to the natural landscape from intensive human activities has made a great impact on the earth's water cycle. It is emerging as a prominent research topic in geographical studies (Zalewski，2000；Bonnell，2002). The current trend and future scenarios of flood risks demand accurate spatial and temporal information on the potential hazards and risks of floods (Khan *et al.*, 2011). Catchment topography is critical for modelling distributed hydrological processes (Zhou *et al.*, 2011).

The most crucial spatial data required for digital hydrological modelling are the land surface elevation, commonly represented as a digital elevation model (DEM)(Zhou and Liu, 2004; Wang and Liu, 2006). Its simple data structure, ease of implementation and the efficiency of calculation are some of the well-recognized advantages (Li *et al*., 2005). Remote sensing is the process of inferring surface parameters from measurements of the upwelling electromagnetic radiation from the land surface (Schmugge *et al.*, 2002). The current availability of high-resolution remote sensing imagery and DEM data makes it possible to integrate both technologies to advance the computation and simulation of surface water flow processes.

Hong Kong, one of the most prosperous urban areas in the world, has long been suffering from the flood and landslide disaster duo to intensive rainfall brought by eastern Asia monsoon and typhoon and its mountainous terrain. Its drainage lengths are typically short, usually less than 10 km, resulting in a great number of small watersheds with steep slopes (Helliwell and Chen, 1973). In order to better model and simulate the topographic control on the spatio-temporal distribution of rainfall-runoff processes for the prevention and reduction of the impact of short-term floods, this study attempts to develop a novel DEM-based hydrological model, which is capable of taking advantages of DEM and remote sensing by incorporating landform parameters such as slope morphology with ecological parameters derived from

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remotely-sensed images such as vegetation indices, land cover, Leave Area Index (LAI) and soil moisture. A typical small mountainous catchments in *Shek Kong*, Hong Kong is selected as the study sites (Figure 1).

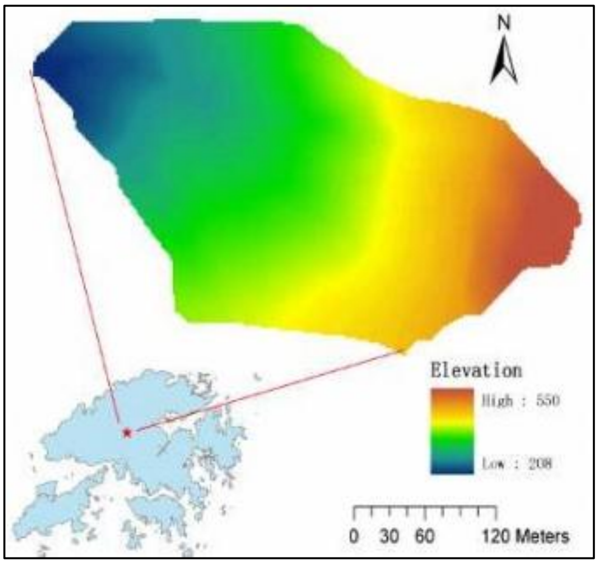

Figure 1 Study Site in Shek Kong, Hong Kong (Li, 2009)

2.Research Framework

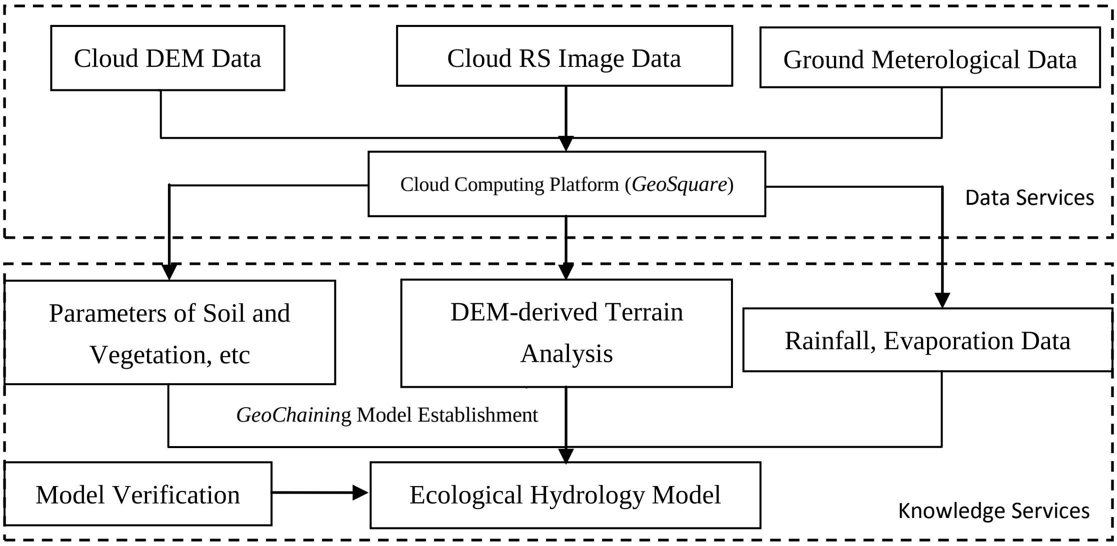

Figure 2 Research Framework

3.Key Methodologies for DEM-based Hydrological Analysis

3.1 Generalization of grid-based DEM for terrain analysis

Grid-based DEM itself is an approximation to the real-world continuous surface sampled from regular distributed elevation spots (Zhou *et al.*, 2008; Wang and Liu, 2006). Zhou and Chen (2008) have developed a compound method restructuring the surface elevation data to form a drainage-constrained TIN that is optimized to keep the important terrain features and slope morphology with the minimum number of sample points. This method has been proved of the effectiveness of generalization and ability in preserving the inherent morphological and drainage features from DEM.

3.2 Ground Parameter Acquisition from Remotely-sensed Images.

Considering the movement of water is determined by gravity and properties of the material it flows through or flows over (Gruber and Peckham, 2009), which is strongly controlled by topography, the overland flow is also profoundly influenced by the status of underlying surface (especially in Hong Kong). Schmugge *et al.* (2002) have provided a systematic investigation on the monitoring of a series of key variables of underlying surface from remote sensing which we believe are very promising in hydrology. Based on the image fusion technique for Landsat TM/ETM+ and SPOT image, we are able to develop approaches for estimating hydro-meteorological states and fluxes. Environmental variables to be monitored include:

(1) Land surface temperature (LST)

(2) Near-surface soil moisture

(3)Landscape roughness and vegetation cover

These *in-situ* variables on spatio-temporal basis are utilized to modify and further verify the DEM-based hydrological model.

4. The Implementation of Online Monitoring System

In our study, we are also investigating the possibility of establishing an online monitoring system for small catchment hydrology. Based on the geo-computation platform developed by LIESMARS, Wuhan University, the model we derived is able to register to the cloud-server in order to make it commonly available to broader communities through Internet, and the 3D visualization of the hydrological process can also be viewed.

5. Discussion & Preliminary Conclusion

An online simulation system registered in an open geo-computation platform is being developed to simulate, monitor and predict the catchment runoff in the typical vulnerable region, so that early warning system can be established to mitigate the negative impacts of natural disaster. As derived digital elevation data, particularly the grid-based Digital Elevation Models (DEM), the parameters often display noticeable uncertainties (Zhou and Liu, 2008), A high-resolution DEM does not assure higher slope and aspect accuracy. Better results may only be possible with high DEM data accuracy. In reality, where DEM data often contains errors, the accuracy of derived slope and aspect increases with lower DEM resolution. This also arouse the need to take external parameters into consider to better preserve the accuracy (here, environmental variables). Further effort can also be devoted to investigating the impacts of scale of data and analysis on establishing the hydrological model (Quattrochi and Goodchild, 1997).

The paper explores the efficacy of DEM-based hydrological model modified by environment variables derived from remotely-sensed image and ground truth data, and provide a model that is capable of representing complex hydrological processes jointly affected by terrain and landscape.The general conclusions reached by this study may be of interest to those who wishes to consider the potential of utilizing Digital Terrain Analysis (DTM) for the environmental monitoring, particularly in hydrological modelling.

6. Acknowledgement

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