THE USE OF RADAR AND HYDROLOGICAL MODELING FOR FLASH FLOOD EVALUATION AND PREDICTION

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There are many options for attempting to predict flash floods, including multiple hydrological modelling techniques using a variety of data types. This study used a lumped (NAM) and a distributed model (MIKE SHE), both using radar derived rainfall estimates, to evaluate a flash flood case study on the Hennops River, Gauteng, South Africa. The aim was to explore both models and which one, if any, accurately simulates actual river conditions. The results showed that both models effectively predicted the flash flood event and therefore lumped models are suggested for use in forecasting applications due to their low data and computing requirements whereas distributed models are suggested for flash flood risk evaluation due to their high spatial resolution.

1.INTRODUCTION

Flash floods caused by intense precipitation events are natural disasters which can be highly damaging of both life and property. They are also expected to become more frequent and intense in the future (Bronstert et al., 2002). There is much debate in the field of hydrometeorology as to the best approach to evaluating and predicting flash floods (Hapuarachchi et al., 2011). Traditionally, lumped hydrological models activated with various types of data have been used for flash flood hydrometeorology. Lumped models have their advantages in that they have low data and computing requirements but due to their lack of complexity, their usefulness for predicting flash floods is questionable. One of the more recent developments in the field of hydrology is the distributed hydrological model. Distributed models, which require a large amount of spatial data and computing power due to their high resolution, are possibly better equipped to deal with small scale hydraulic events such as flash floods.

This study evaluates both a lumped model (NAM) and a distributed model (MIKE SHE) in terms of their abilities to simulate actual flash flood conditions for a flash flood event in Gauteng, South Africa. In addition this study explores the use of radar rainfall estimates as an input into these models and whether such data is effective. This study provides insight into which model is more suitable for flash flood evaluation or prediction. It also tests whether radar data alone is sufficient for the prediction of flash floods.

2.MODELS

MIKE SHE is the distributed model used in this study. MIKE SHE is an advanced and flexible framework for modelling the hydrological cycle (McMichael., et al 2005). It includes precipitation interception ,infiltration, evapotranspiration, subsurface flow in both saturated and unsaturated zones, surface flow as well as channel flow via its integration with MIKE 11 (Refsgaard, 1997). A slightly modified version of MIKE SHE was used. The modified version has ground water turned off and is useful when the study is based on surface water and therefore a detailed simulation of ground water flow is not necessary as is the case with flash floods (Sahoo et al 2005).

NAM is the lumped conceptual rainfall runoff model that was used in this study. It was developed by Nielson and Hansen (1973). As with the distributed model MIKE SHE, NAM uses MIKE 11 for its hydraulic component (Einfalt., et al 2004). This made it good lumped model with which to compare MIKE SHE as the channel network components are the same.

3.DATA AND METHODOLOGY

The study used radar derived precipitation estimates from the S-band (2.8GHz) radar installation situated near the study site.The Marshall and Palmer (1948) relationship of $Z = 200R^{1.6}$ was be used and then biased corrected using raingauge data. Other data included river gauge data, topography, channel network, channel cross sections, land use and soil type.

The above data was then used to construct both the NAM and MIKE SHE hydrological models for a flash flood event in the study area. The runoff data from each model was then inputted into the MIKE 11 hydraulic model which gave simulated water levels along the channel network. The models were then calibrated to reach an optimum level of fit between the simulations and actual conditions. The MIKE 11 results from each model were then compared to each other as well as with actual flow.

4.RESULTS AND DISCUSSION

Figure 1 shows the NAM and MIKE SHE model simulations along with actual flow for the period of the 16th-18th January 2011. As is evident in Figure 1 the distributed model performed slightly better than the lumped model in simulating actual flow for the 72 hour period. Both models did however predict the flash flooding event.

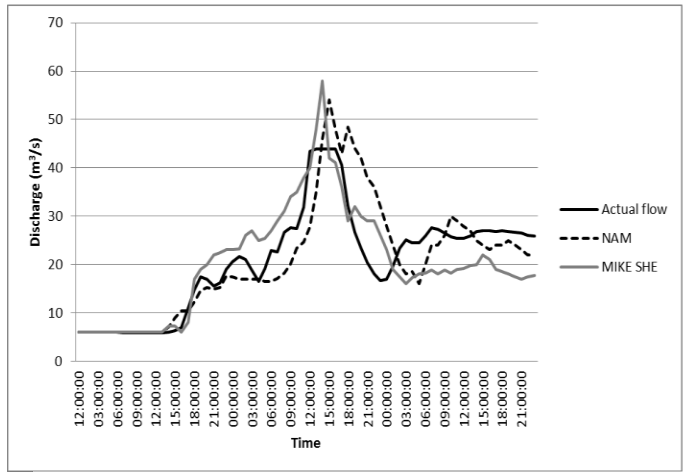

Figure 1: Discharge of Hennops river, 16-18 January 2011

The lumped model (NAM) performed well and was able to predict the flash flood using average radar rainfall estimates. Due to its low computational time and power, NAM is a viable option for use in nowcasting flash floods. Lead times could possibly be increased by using extrapolated radar rainfall estimates as well numerical weather prediction.

Due to the high computational power and time required by the distributed model, MIKE SHE is not practical for the nowcasting of flash floods. It is however useful in evaluating areas for flash flood susceptibility which could help people and industry plan their buildings and settlements outside of flood prone areas.

5.REFERENCES

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