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Integrated model for flood forecasting and river inundation in Taiwan

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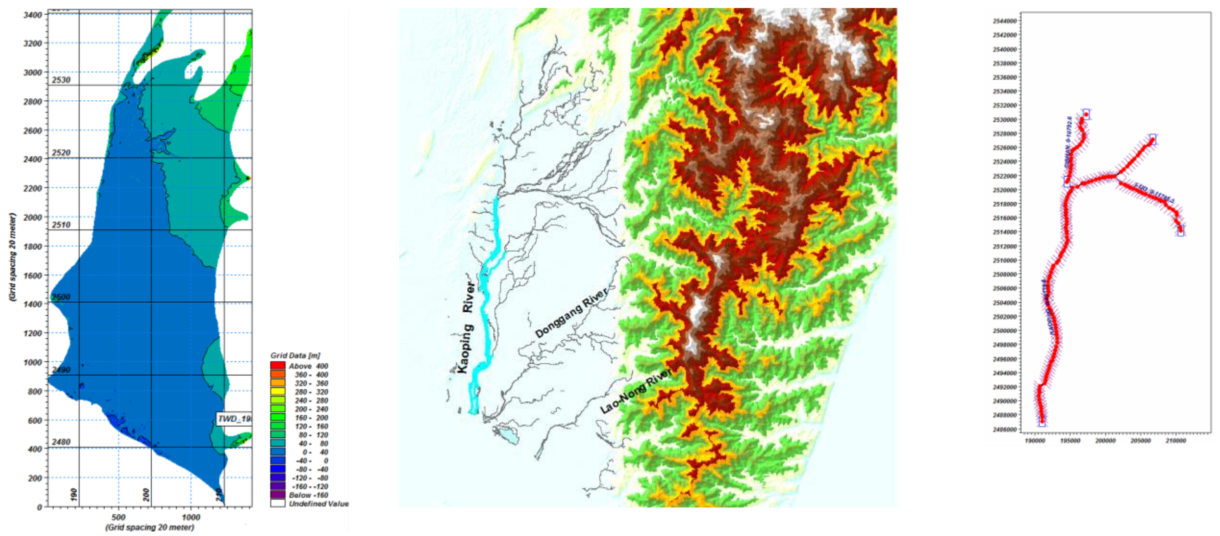
Introduction

Taiwan was hit by Typhoon Morakot in August 2009 resulting in significant damage and losses. About two-third of the counties were affected among which, Kaohsiung City and Pingtung counties located in Kaoping River basin were damaged strongly [1]. Overtopping of the Kaoping river banks due to river inundation could increase the vulnerability of these counties. Although structural measures are widely adopted for flood protection in Taiwan, the structures can only cope with flooding up to their design standards [1]. To mitigate the impact of flooding at extended scale, non-structural measures such as flood plain zoning, flood hazard mapping, flood warning, and flood forecasting have become critical options. Preparation of these measures depends on the understanding of the consequence of flooding, which can be simulated using flood inundation models, which can be accomplished by one dimensional (1D), two dimensional (2D) and coupled 1D- 2D numerical models [2]. This work presents the development of a fully coupled hydrodynamic model using MIKE Flood integrating 1D river model (MIKE11) and 2D Digital Elevation model (MIKE 21) for the Kaoping River as a case study in Taiwan [3].

Material and methodology

Cross sectional data, boundary conditions (Daily discharge data and water level, for up- and downstreams of the rivers, respectively), river network plot and initial hydrodynamic conditions (water levels) were the essential input data for the MIKE 11 model. The data in the Pingtung plain were collected by the National Taiwan University, including 99, 22 and 24 cross sections for Kaoping, Cishan and I-Lio Rivers, respectively. In the study area (1210 km^2), both Cishan and I-Lio Rivers originate from Qishan and Yanpu reaching the Kaoping River in Ligang city and making a conjunction point. Kaoping's upstream with 50 km length in the study area starts from Gaoshu and ends in Neipu by discharging into the Taiwan Strait in its downstream. The discharge and water level time series in Kaoping and Cishan Upstream reaches were provided at Da-Jin and Shan-Lin Bridge, respectively. The water level time series in the Kaoping River downstream was measured through station gauges.



(a) **(b)** **(c)**

Figure 1. (a) Bathymetry of the Pingtung plain in Taiwan, (b) Digital elevation data (c) River network layout of the three river branches Cishan, Kaoping and I-Lio

The rainfall time series data were measured at a different location of the domain area. A 2D digital elevation model (bathymetry) simulating water levels and flow variation as a reaction to different functions in rivers, lakes and coastal regions, is the only input data for setting the MIKE 21(2D) model. The calibration and validation of the MIKE 11 model were accomplished for the Manning's roughness coefficient and water levels observed in the Qishan Bridge Station, respectively. The coupling process was done via a lateral link between MIKE 11's river banks and MIKE 21's cells. The monsoon rainfall period of three months was selected for assigning flood forecasting in MIKE Flood simulation.

Results and Discussions

The data provided for 2011 to 2015 were used for simulation. The computed water level in the Cishan River upstream at the end of 2015 was selected for comparison with the measured water level at the same time series for at Qishan Bridge. The observed discharge time series data was applied to the upstream of Cishan River as inflow boundary condition and the computed water level at the end of 2015 shows a good fit with those measured at this time at the same location (Figure 2).

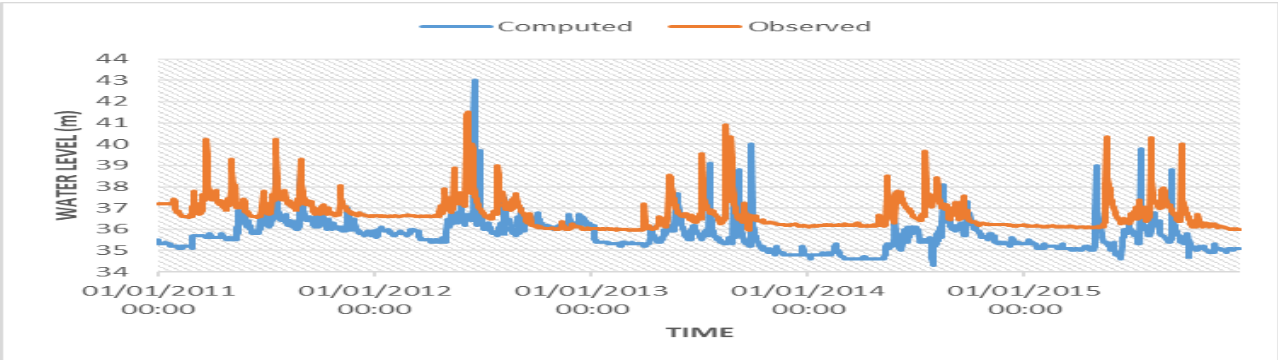


Figure 2. Validation of the computed water level data from MIKE 11 against the observed levels at Qishan Bridge

Conclusions

Based on the results from the MIKE11 model (Figure 3), Kaoping is suspectible to flooding within 13 km range from its downstream and therefore the necessary flood risk mitigation and control strategies should be mainly designed for this specific location.

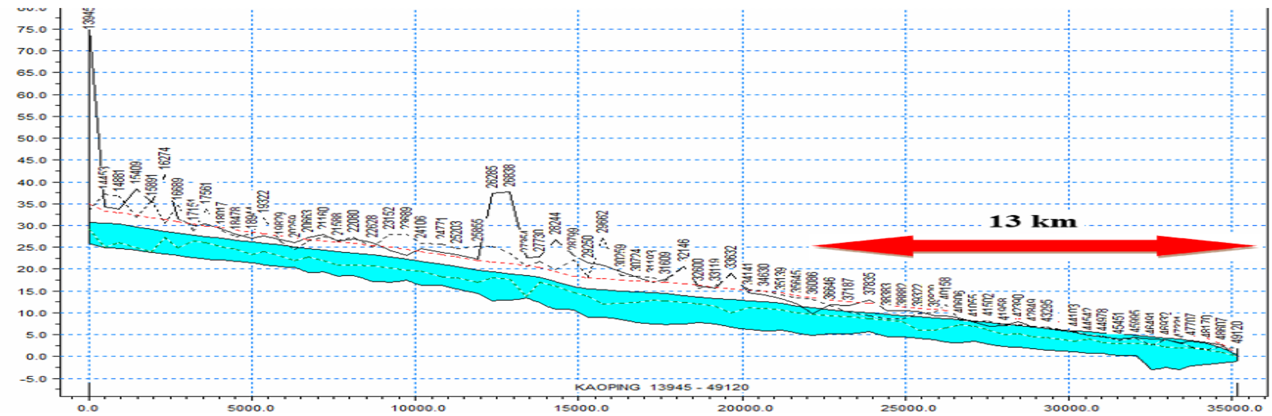


Figure 3. Water level of the Kaoping river profile in MIKE11

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