VALIDATION OF A QUASI-2D HYDRODYNAMIC RIVER FLOOD MODEL USING HISTORICAL AND ERS-SAR DERIVED FLOOD MAPS

LUIS TIMBE, PATRICK WILLEMS and JEAN BERLAMONT

Laboratory of Hydraulics, K.U. Leuven,
Kasteelpark Arenberg 40, B-3001 Leuven, Belgium,
(Tel: +32 16 321656, Fax: +32 16 321989,
e-mail: Luis.Timbe@bwk.kuleuven.be, Patrick.Willems@bwk.kuleuven.be)

There is an increasing interest in river flood modelling due to the severe flood events that occurred during the last decade in various parts of the world. This type of modelling is often performed using one-dimensional (1D) or two-dimensional (2D) hydrodynamic models to asses flood risks. Although 2D hydrodynamic models are the forefront for river flood prediction, they are constrained by the high requirements of data and computational time.

A compromise solution between a 1D and 2D model is a quasi-2D approach. In this approach the floodplains are modelled as separated river branches connected to the main river by link channels. The link channels work as weirs, allowing the water to overflow to the floodplain when the water level exceeds the river embankment or dike. The aim of the research presented in this paper was to test the quality of a quasi-2D hydrodynamic model for flood modelling along floodplains for some historical flood events.

The study was performed for the river Dender located in the south-west part of Flanders (Belgium) with a length of 50 km, and a contributing area of 708 km^2. Along the river there are eight hydraulic structures (weir/sluice combinations) to regulate the water level. Time series of hydrometric data (discharge/stage) were available at the upstream and downstream boundaries and water levels upstream/downstream of the hydraulic structures. Along the river floodplains, a high resolution DEM based on Laseraltimetry (LiDAR) was available; with a horizontal resolution of 4 m. For the river Dender, a quasi-2D model has been set-up in previous studies (Willems et al., 2001; Willems et al., 2002a,b) on the basis of the river modelling system Mike 11 (DHI, 2002).

In the first stage the potential flood risk zones for the Dender were identified based on the maps of recent floods "ROG" for Flanders which describe the maximal spatial extent of historical floods for the last 12 years (SADL, 2000). To setup the quasi-2D hydrodynamic model for the Dender a first set of floodbranches were implemented for the floodplains along the ROG regions. The cross sections for these floodbranches were extracted from the DEM.

The Mike GIS interface of DHI (2001) was used to perform flood mapping (spatial 2D-mapping of the water level simulation results in the quasi-2D model), by linking the Mike 11 results with the geographic information system ArcView. The flood mapping was done using a weighted extrapolation routine on the water levels in the calculation nodes of the hydrodynamic model results. The flood model was validated comparing the spatial extent of the floods simulated by the flood model with the ROG flood maps for

the historical flood events of December 1993 and January-February 1995. At this level coarse inaccuracies were detected and corrected when possible. The most sensitive factor in these inaccuracies was the wrong representation of the line elements in the DEM. This problem was solved in the study correcting the DEM using measured topographical elevations along river embankments, dikes, roads and railways (e.g. cross-sectional survey).

In the second phase, the model results were also compared with the flood maps derived from ERS-SAR satellite radar images (Willems et al., 2003). The comparison was made at the specific moments of the time acquisition of the images. The ERS-SAR derived flood maps have shown systematic underestimations of the flooded areas. Some problems of radar based images for detecting water bodies have been confirmed in previous studies (Horrit and Bates, 2002; Oberstadler, 1997; Smith, 1997; Willems et al., 2003) because of meteorological conditions and land cover, i.e. when the water surface in not smooth due to wind or turbulence, or due to some land cover type. Regardless of their inaccuracies ERS-SAR derived flood maps have shown to be useful complementary information for the validation and refinement of flood simulation models. They provide information on the zones along the river where some flooding occurred and an approximation of the spatial extent, together with its temporal evolution.

After detection and correction of the coarse inaccuracies, the results of the flood simulation and flood mapping appeared to be of good accuracy in comparison with the two types of historical flood information available.

REFERENCES

DHI (2001). *Mike 11 GIS Floodplain Mapping and Analysis*, User Guide Manual, Danish Hydraulic Institute, Hørsholm, Denmark.

DHI (2002). *Mike11 A microcomputer-based modelling system for rivers and channels*, User and reference manual, Danish Hydraulic Institute, Hørsholm, Denmark.

Horritt, M. S. and Bates, P. D. (2002). "Evaluation of 1D and 2D numerical models for predicting river flood inundation", *Journal of Hydrology*, Vol. 268, pp. 87-99.

Oberstadler, R., Hönsch, H. and Huth D. (1997). "Assesment of the mapping capabilities of ERS-1 SAR data for flood mapping: a case study in Germany", *Hydrological Processes*, Vol. 11, pp. 1415-1425.

SADL (2000). *Mapping of the natural and recent flooding areas in Flanders*, Report for the Ministry of the Flemish Community, Administration AMINAL, by K.U. Leuven, Division SADL, Leuven (in Dutch).

Smith, L. C. (1997). "Satellite remote sensing of river inundation area, stage, and discharge: a review", *Hydrological Processes*, Vol. 11, pp. 1427-1439.

Willems, P., Vaes, G., Berlamont, J., Cristiaens, K., Popa, D., Timbe, L. and Feyen, J. (2001). "Methodology for river flood modelling by the quasi two-dimensional approach", *Proc. World Water and Environmental Resources Congress*, Orlando.

Willems, P., Timbe, L. and Popa, D. (2002a). *Mike11 model Dender, version April 2002*, Report including the results of the research project "Implementation of the quasi 2D approach for floodplain modelling for the Mike 11 model of the river Dender" for the Flemish Ministry for Waterways and Sea Affairs (AWZ - WL Borgerhout), Report by K.U.Leuven, Hydraulics Laboratory, Leuven (in Dutch).

Willems, P., Vaes, G., Popa, D., Timbe, L. and Berlamont, J. (2002b). "Quasi 2D river

flood modeling", *River Flow 2002: International Congress on Fluvial Hydraulics*, Louvain-la-Neuve, Bousmar & Zech eds., Vol. 2, pp. 1253-1259.

Willems, P., Thompson, S. and Barbieri, M. (2003). *Flood risk and damage assessment using modelling and earth observation techniques (FAME)*, Final Report, ESA-DUP 2 Small Services Project, K.U. Leuven, Spatial Applications Division Leuven, Belgium.