Geophysical Research Abstracts, Vol. 7, 09348, 2005
SRef-ID: 1607-7962/gra/EGU05-A-09348

Modern techniques for flood risk analysis: quasi-3D simulations in a GIS environment.

P. Archambeau (1), S. Erpicum (1), B. Dewals (1,2), S. Detrembleur (1), B. Khuat Duy (1,2), M. Pirotton (1)

(1) Applied Hydrodynamics and Hydraulic Constructions (HACH), University of Liege, Belgium, (2) FNRS Research Fellow

1 Introduction

Human beings have continuously attempted to adapt their environment to their needs. However, many natural phenomena still remain challenging to control and the populations must undergo sometimes heavily damaging consequences. It is consequently essential to study these phenomena in order to assess their potential hazards. In particular, the scope of the present paper focus on floods.

The intense floods met these last years showed the importance of this phenomenon as well as its many devastating effects. Thanks to recent important breakthroughs, both in the field of conceptual and numerical modelling of complex flows and in the calculation power of computers, it is henceforth possible to study the effects of potential floods on the basis of numerical simulations, with an accuracy never reached beforehand.

The Laboratory of Applied Hydrodynamics and Hydraulic Constructions (HACH) of the University of Liege has always made this kind of study one of its core competencies, thanks to

- the development of modern and powerful modelling tools (quasi-three dimensional software for flow simulation by finite volume),
- the use of a broad range of data enabling a proper representation of the studied fields (topography, occupation of the ground...)

- the systematic validation of simulation results.

These tools are currently intensively used within the framework of a general study of the flood-prone zones of the Walloon area of Belgium, which corresponds to more than 800 km of rivers.

2 Data acquisition

In order to be able to model the phenomena of floods correctly, it is essential to have reliable and of a sufficiently high precision topographic and bathymetric data. A land survey campaign by airborne laser provided topographic data with a density of one point/m^2 and a vertical accuracy of +/- 15 cm, enabling the direct representation of each individual building.

These data are completed by bathymetric surveys taken by boats equipped with sonar probes. On the nonnavigable rivers, bathymetry is given by a series of cross sections in the main bed of the river, and then a 2D bathymetry is generated thanks to a very general process of interpolation.

Aerial photographs make it possible to compare the land surveys with reality, in particular where their interpretation is delicate (e.g. zones heavily covered with vegetation...)

Moreover, an important database of more precise information on various hydraulic structures along the rivers (e.g. dams, bridges, weirs, locks...) makes it possible to refine the data and the boundary conditions.

3 Method of calculation

Simulations have been carried out thanks to a shallow water computation software (WOLF 2D) developed for several years within the Laboratory (HACH). The equations are solved by the method of finite volume applied to a structured grid. The final results are obtained with mesh size going down to 1m, but an evolutionary grid makes it possible to start with a coarser grid and to automatically refine it during simulations in order to drastically reduce the necessary computing time. The field of calculation can reach 1 million meshes of calculation (3 million potential meshes), including 3 unknowns at each node.

Although the simulations are steady within the framework of the current study of flood-prone zones, the program WOLF 2D is also intensively exploited for the resolution of completely unsteady flows (e.g. dam breaks). Thanks to its great flexibility, the software WOLF2D can be adapted to take into account specific elements (weir...), which is an asset for a relevant representation of the real situation. It is also possible to take into account a potential sedimentary transport.

4 Calibration of the parameters and validation

Simulations of river flows require the knowledge of the friction coefficient (e.g. Manning coefficient), which is obtained through a process of calibration. This latter is made possible thanks to the acquisition of a broad set of data (discharges, water heights,...), particularly collected during flood events, as well as photographs of the flooded zones. It is possible to have the optimisation of these parameters performed automatically by means of a genetic algorithm implemented in the code WOLF 2D.

Onsite investigations by the riparian populations complement the data already available.

This whole set of information eventually allows the complete validation of the simulations. Several real cases for which sufficient data are available were successfully reproduced by WOLF software.

5 Working Interface

The entirety of the pre- and post-processing operations are carried out by means of a powerful interface, with genuine GIS capabilities, enabling:

- input operations and modifications of topography and bathymetry data,
- choices of the various parameters of simulations (boundary conditions, numerical parameters...),
- display of the results in graphic form,
- automatic generation of 2D and 3D videos
- exports of the results (direct interaction with Excel, Autocad, ...)

The integration of numerous data in a single SQL database allows a centralisation of information and a higher efficiency of the modellers.

6 Conclusion

Thanks to the development of modern and powerful working tools and along with the use of numerous and precise data, it is possible to study the problem of the risks related to floods, in a qualitative as well as quantitative way.

Efficient data acquisition methods allow a highly accurate modelling of floods : airborne laser and sonar probes are used to acquire topography and bathymetry, and numerous other sources complete this data (aerial photographs, discharge curves,. . .)

A highly effective 2D shallow water simulation software (WOLF2D) allow the computation of the flow with a fine grid resolution.

All of this data is processed thanks to a powerful interface, providing quality results which can be used to assess flood risks.

The calculation potential of the computers being in continual increase, working methods such as those used here will spread, and more and more concrete cases could be studied with an unceasingly increasing reliability.