CARPA, A PROBLEMTYPE FOR A FREE SURFACE FLOW MODELLING SOFTWARE

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Abstract. *CARPA is the natural evolution of previous problemtype Ramflood created for the Ramflood EU Project (5th Framework Programme). From the initial capabilities of the software, new features have been included, both in the hydrodynamic simulation module and in the problemtype interface, both in the pre-process and post-process. Some of the new developments include new and re-organized menus to assign new properties related with hydrological processes, bedload sediment transport and parameters associated with the problem data as a resume option or the possibility of selecting the list of results to be visualized. These improvements, based in the experience acquired after using the system to solve various real engineering problems, have increased the robustness and efficiency of the whole system.*

1 INTRODUCTION

The first problemtype for CARPA simulation code (named *Ramflood*) was developed as part of the Ramflood EU Project. The number of different applications, the interest shown by various potential end users, and the natural evolution of the software has lead to create a new problemtype called now CARPA. CARPA has been proven to be a tool of practical interest to solve fluvial dynamics, hydraulic and hydrological engineering problem.

2 ABOUT THE SIMULATION CODE

Flood propagation on natural channels is done by numerically solving the Saint Venant equations. This can be done either with a one dimensional or two dimensional approximations, the first one with less computational and information cost, the second one with more precise results when the real flow pattern does not correspond with a 1D domain. CARPA[1] uses a 1D-2D integrated finite volume high resolution numerical scheme.

The numerical is explicit and uses a domain discretization in finite volumes, which means that the results are averages within one volume (reach in 1D, mesh element in 2D) and not at sections or mesh nodes. More precisely WAF (Weight Averaged Flux) scheme is used TVD (Total Variation Diminishing) extension, which is a shock capturing explicit finite volume scheme for hyperbolic conservation laws. WAF TVD scheme can also be understood as a high resolution extension of Godunov Method with Roe Approximate Riemman Solver. This kind of modern finite volume schemes show important advantages when compared with the classic finite differences or finite element schemes that are used by most commercial packages used for one end two dimensional free surface flow modeling.

Thus, the main simulation code can be used to predict the values of hydrodynamic variables (mainly water depths and velocities) from a set of initial conditions (including that of dry domain), boundary conditions, roughness or land use properties and wind action. More recent enhances include the possibility of taking into account the precipitation as a water source and also abstractions as infiltration or evaporation, allowing for the possibility of using CARPA also as a hydrological (rainfall-runoff) model.

Apart from the hydrodynamic- hydrological model, CARPA includes a set of simple bedload sediment transport formulations (Mayer-Peter and Müller equation and Einstein-Brown equation) to evaluate bedload solid discharge and predict morphodynamic variations (erosion and sedimentation) on a granular substrate.

3 ABOUT THE PROBLEMTYPE

Thanks to the problemtype, CARPA is fully integrated in GiD. Using GiD it is possible to import geometry, define which areas are going to be studied in 2D and which in 1D, build the computational meshes, assign initial conditions, roughness, boundary conditions, hydrological and sediment transport parameters, run the simulations and visualize the results both numerically and graphically.

3.1 Preprocess

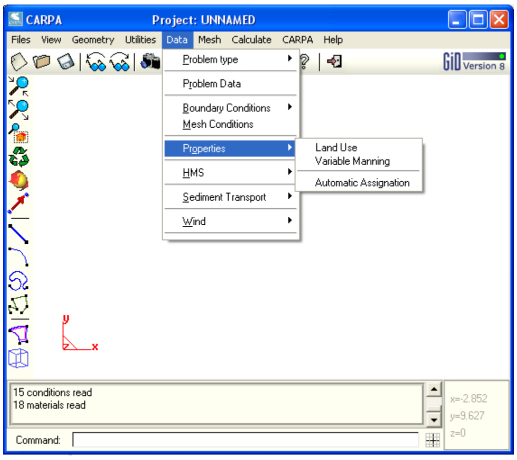

Figure 1: Screen capture of CARPA environment. Detail on menu.

The preprocess of this problemtype includes in the standard menu Data, submenus for assigning all the information required to run a simulation. Submenus are Problem Data, Boundary Conditions, Mesh Conditions, Properties, HMS, Sediment Transport and Wind. Some of these submenus have particular interest like for example, *Problem Data* where the user can select time parameters for the simulation or the type of results to be printed for postprocess; *Properties*, where the user can assign the roughness coefficient in two different ways, using the standard material window of GiD or using the automatic assignation tool that was specifically developed for CARPA[2].

Moreover, another menu was built-in to group the submenus related the specific tools created for the software. There are two groups of tools, the first is prepared to deal with DTM creation and importation[2], and the second correspond to 1D geometrical creation and management[3].

3.2 Postprocess

The results that are directly generated by CARPA are: depth and the two velocity components. However, in the post-process other results can be presented from those according with the selection done in preprocess options. CARPA problemtype also includes the possibility to present the results not in terms of hydraulic variables but in terms of hazard according to the Catalan Water Agency Criteria. This criterion classifies the flood in one point as a high hazard, moderate hazard or low hazard according to the value of depth, velocity and specific discharge.

4 APPLICATIONS

The software has been applied to solve question in a wide range of projects. As an example we presented following some representative images of studies done by CARPA.

The study of Tietar River in the south of Spain, involve the analysis of a stretch of about 53 km. Considering this dimension and other parameters was decide to apply an study 1D-2D and a important number of cross section was created from the original detailed geometry using the specific capabilities[3] that the program includes. Figure 2 shows two details of this 1D geometry visualized on top of a rendered image of the whole topography mesh.

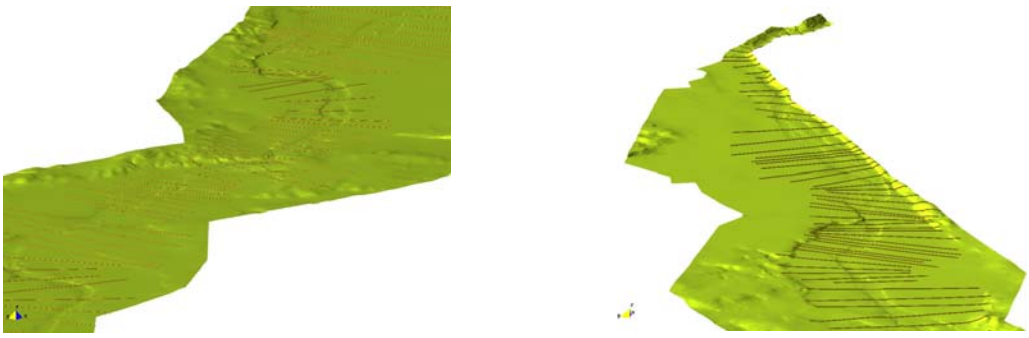

Figure 2: Tietar River, example of 1D cross sections.

Another interesting application is the case of a study of flood risks in Andorra. See Figure 3. In this case the analysis corresponds to an urban area, with the complexity that this type of topography implies. The capacity of the embanked main channel is not enough to contain the design flood, and the water spreads into the city along the streets. The geometry used for the simulation is a Triangular Irregular Network obtained from a 0.5m x 0.5m grid which, in its turn, is the result of a LIDAR (Laser Scanner) flight. The simulation mesh corresponds with the TIN geometry (structured mesh with one element per TIN triangle).

The last application corresponds to the EU founded project RAMWASS; the study site is a section of River Elbe in Germany (approximated length 5.5 km, Elbe-km 512.5-518). The River carries important quantities of sediment and remarkable amount of these sediments are contaminated so is crucial to determine qualitatively and quantitatively the erosion and sedimentation process (Figure 4).

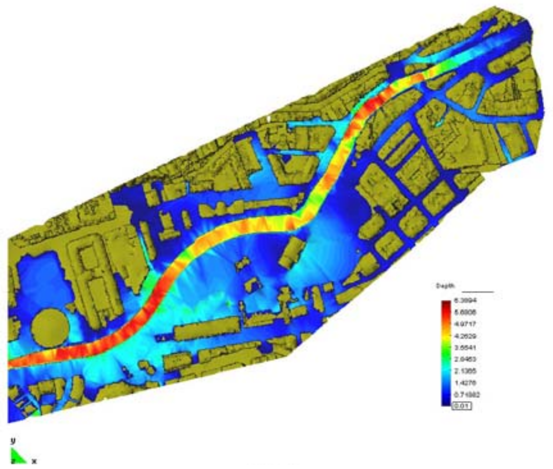

Figure 3: Andorra LaVella; water depths for a flood of 833 m3/s at the centre of the city.

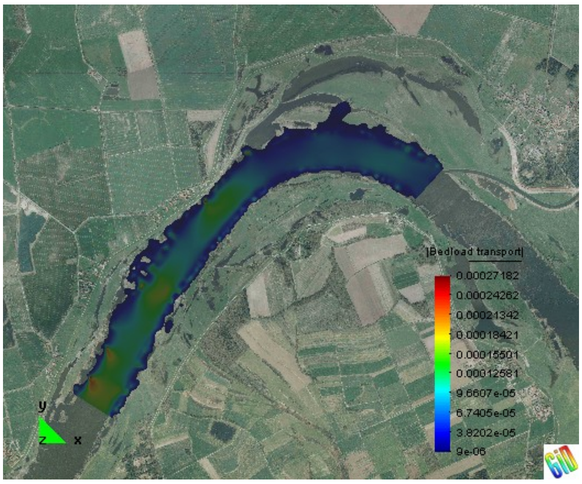

Figure 4: Elbe River; solid discharge during a flood event. Project webpage www.cimne.com/ramwass

5 CONCLUSIONS

- A new software that fully integrates GiD and CARPA was developed and registered.
- The capabilities of GiD have shown to be one of the key factors in the success of this idea.
- There have been a good acceptance of the software between the community of users and potencial users of this kind of tools. CARPA is presently used by government environmental administrations, research groups and consultancy companies.

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