From hydrodynamic modelling to urban flood risk

*Paquier, A., Irstea, UR HHLY, Villeurbanne France**

Mignot, E., LMFA, Villeurbanne, France

**Irstea, 5, rue de la Doua, CS70077,69626 Villeurbanne ; andre.paquier@irstea.fr*

Context and motivation

For a hydraulic point of view, the structure of the city is organized around some networks: the hydrographic network that includes the large rivers but also the ephemeral streams that are often distorted by urbanization, the sewage network that is mostly a hierarchized set of pipes in our French cities, the street network that usually permits the car traffic but that occasionally be flooded and will become a secondary network for water. Additionally, the urban environment includes built-up areas, themselves including buildings, walls and other obstacles to flow. If one wants to describe the flood processes inside the city, there will be a first sharing between surface flows and underground flow (mainly in the sewage network) and thus a focus about exchanges between these latter flows. Secondly, surface flow will be shared between the main flow inside the hydrographic and street networks in which the flow velocity ie relatively high and in which the flow direction is constant and equal to the direction of the stream or of the street.

Both flows in the sewage network and on the surface are complex during floods. In the pipes, the flood can lead to an excess of flow discharge with free surface alternating with pressurized conditions, the conditions being modified at each of the multiple junctions and structures of the network. On the surface, shallow flow combined with the obstacles to flow propagation lead to local changes from subcritical to supercritical flow regimes and conversely. However, this flow complexity leads to a strong variation of the hydraulic parameters (water depth, velocity, etc), which means that the exposure to flood is varying a lot. In the same way, the vulnerability to flood may vary a lot because of the type of buildings, the use of the buildings or of the streets.

Then, to define flood risk accurately, the flood hazard should be defined at a local scale. The objective of this paper aims at explaining how this latter objective can be reached.

Methodology

Because the main cause of flooding, a first step includes the estimation of the water inputs. For every potential source of flooding (rainfall, runoff, overflow), the water volumes entering the study area should be defined along the time. According to the source, various methods permit to define scenarios that are reference historical events (that have a meaning for people) or probabilistic events.

Then, hydrodynamic modelling should be performed to propagate the flow inside the urban pattern. For local estimate of flood hazard, solving 2-D shallow water equations is the preferred method. The calculation mesh can be easily adapted to the local accuracy requirements. Comparisons of calculation results with measurements on experimental set-ups permit to define the range of uncertainty of numerical results and then to extrapolate these results to real cases of urban floods.

Results

Two examples of typical situations modelled in laboratory are used to estimate the relevance of hydrodynamic modelling. One experiment represents a crossroad in which two flows are interacting. On this example, the influence of the change in flow regime is shown: not only, the water depths and velocity can be changed but the distribution of flow downstream the crossroad can be strongly modified. The second experiment represents the exchange between a street and a pipe focussing on the difficulty to evaluate the actual flow capacity of the connecting device.

2-D modelling of the 1988 flood in the Richelieu district of Nîmes was performed. Same modelling difficulties as those found analysing experimental results and additional ones linked to the various obstacles met in the urban environment (cars, trees, etc) lead to the questions:

How practitioners will take into account the uncertainty of the results of such modelling in the assessment of flood risk?

How one can use such assessment of flood risk for definition of measures either for urban planning or for emergency procedures?

Conclusion

Although flood hazard is known by people living in areas that can be flooded, the individual protection measures are often not organized or not integrated into individual behaviour. The definition of local flood hazard identifying indicators of the range of individual effects for each of the potential flood scenarios can contribute to an improvement of flood mitigation measures.