Urban water management

Overview

Urban floods are events that cause most casualties and economic losses, because these occurrences affect great number of people, properties and infrastructure. Flood events can determined by two main factors: the first one is location of the towns or cities near the river beds. The second factor is related to strong, concentrated and sudden rainfalls. In this case urban floods occur due to the lack or clogging of the sewers or due to the total lack of filtration. Due to the above facts, urban areas can face high risk of flooding in very short period of time (Fig. 1).

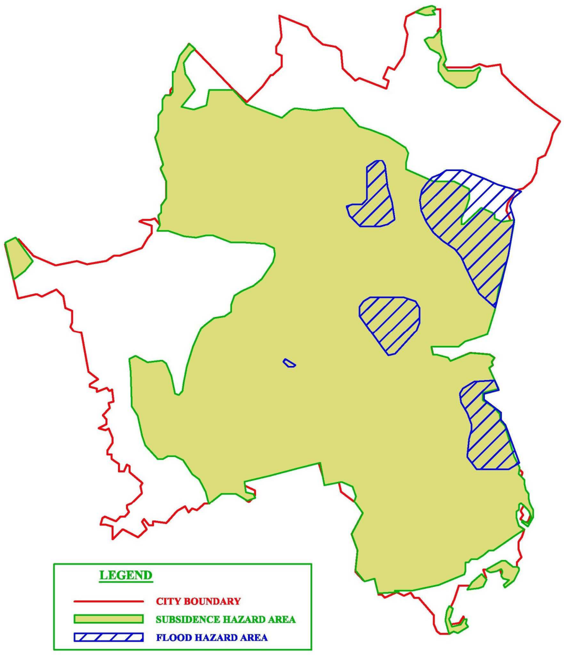

Fig. 1. Subsidence and flood hazard areas in Katowice (Poland).

In the cities and its suburbs where large part of the land is paved or covered (streets, buildings, shopping malls) rainwater runs off as much as ten times faster than on unpaved land. Since this water cannot be absorbed by the soil, it flows rapidly down the storm drains or through sewer systems, contributing to floods and often carrying debris and other pollutants to streams. Urbanization has increased the surface runoff and decreased the replenishment of underground water.

Impervious surfaces and sewers cause runoff after a rainstorm to occur more rapidly and with a greater peak flow than in non-urban conditions (Fig. 2). In turn, larger peak flows increase the frequency of floods. In general, urbanization increases flood volume, its frequency and peak value. The next result of this flushing effect can be to increase turbidity, pollutant loads, and bank erosion.

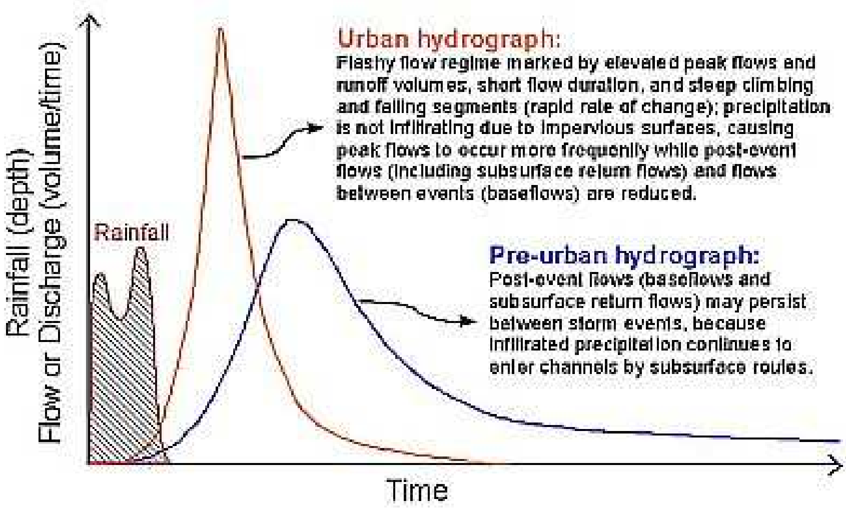

Fig. 2. The hydrological effects of urbanization (based on: Goudie, 2000).

These scenarios raise several challenges that at the moment have not been solved. All these challenges are linked to the temporary chronogram of this type of events, because of it's short lifetime from the moment when rainfall are observed (forecasted) till the moment the flood occurs.

Data usefulness

Modeling urban runoff using few rain gauges may easily lead to very high uncertainty in the simulated runoff. Use of weather radar precipitation data becomes crucial especially for urban areas:

- meteorological maps for specific domain: ground precipitation, especially heavy type, type of precipitation, wind vectors – monitoring using GIS-based tools is helpful,
- high-resolution: at least 1 km, every from 5 or 10 min to 1 hour,
- real-time and precise nowcasted data,
- built-in weather warning system nowcasting-based is desirable.

Remote sensing high-resolution data and GIS techniques

To model the urban storm water runoff processes with a high-resolution, a physically based hydrological model, with a set of non-linear partial differential equations is required. High resolution GIS data, as well as remote sensing data can be used to investigate the impact of precipitation data to urban storm water runoff. The results show (Zhang et al., 1999) the advantages of the integration of remote sensing and GIS with hydrological simulation to improve the urban hydrology. The remote sensing data and GIS complement each other; the high quality meteorological data is necessary in addition to high resolution GIS data for modeling a residential area mixed with some commercial and industrial uses. GIS tools play a central role for parameterization.

Examples of implementations

GIS-based hydrological systems

Integrated systems are to improve urban hydrologic modeling with GIS tools and remote sensing meteorological (weather radar) and catchment (satellite images) data (Fig. 3). Satellite images for a highly developed urban area are used to automatically acquire land use information. Next, a GIS derives the distributed hydrological parameters from processed satellite images. The GIS organized the input files from weather radar data for a distributed hydrological simulation.

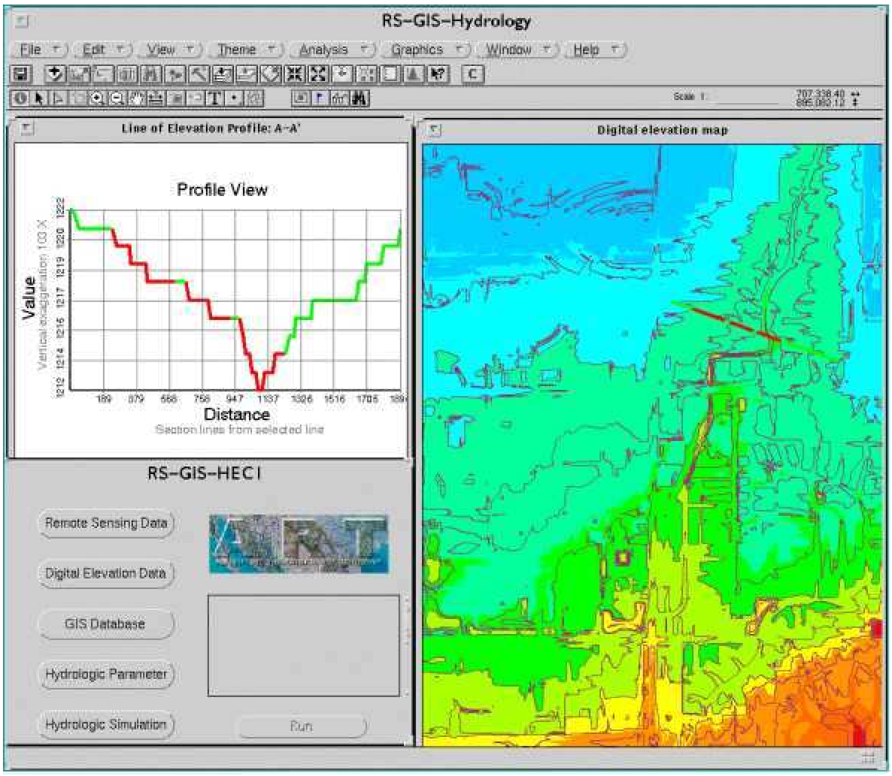

Fig. 3. Example of GIS-based software employing weather radar data to estimate urban runoff (Zhang et al., 1999).

MIKE 11 and MIKE URBAN system

MIKE 11 and MIKE URBAN are examples of a GIS-based integrated modeling platform of DHI (Denmark) for urban collection and water distribution systems (Metelka, 2006) (Fig. 4).

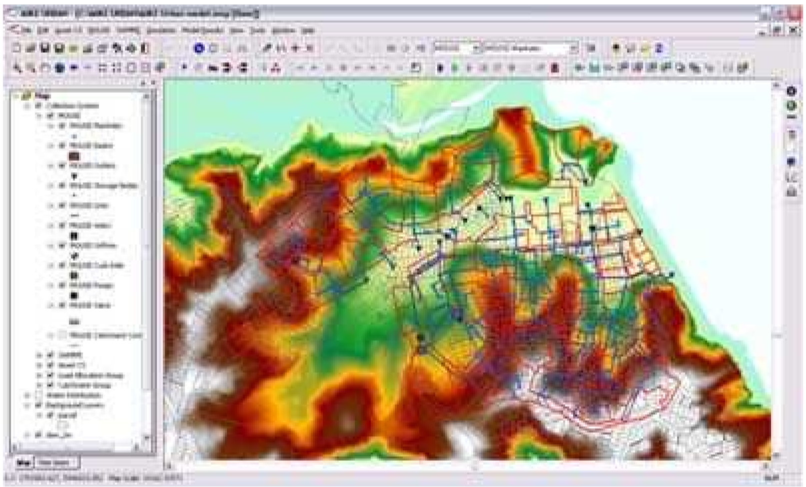

Fig. 4. GIS layers generated by MIKE URBAN software.

Expectations and contribution for effective management of heavy rain events and flooding in urban areas

The first challenge is to improve rainfall monitoring. The next is integration of forecasting and warning models based on radar surveillance with existing or reconstructed combined and separate sewerage system. The weather radar networks together with nowcasting systems allow for high-resolution measurements. Spatial resolution of precipitation data should be at least 1 km for estimates and forecasts, and temporal resolution at least 5 minutes. The data must be available in real-time so they can be used for monitoring and warning systems for urban flooding caused by heavy rain. The high resolution allows to determine specific hazard areas.

The GIS-based systems of monitoring and early warning should be developed. A revised rainfall-runoff model containing characterization of buildings, streets and storm waters overflows and temporary reservoirs should be elaborated and implemented (incorporating of man-made factors). New demands including the impact of climate change are expected to be introduced to the models. The specific conditions of land subsidence (effects of deep coal mines activity) and local impoundments have to be taken into consideration as well. Elaborated various strategies of online (real-time) control of the sewer system are expected to have also more general application.

Literature

Goudie, A. 2000. *The human impact on the natural environment*. MIT Press.

Metelka, T., 2006. Integrated urban water cycle modeling. In: P. Hlavinek et al. (Eds.). *Integrated urban water resources management*. Springer, Dordrecht 2006, 51–58.

Zhang, X., Ball, G., Guertin, P., Halper, E., and Zhang, L., 1999. Integrating GIS and remote sensing with urban hydrology. ESRI International User Conference, San Diego, KA, 26–30 July 1999.