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Development of a spatially distributed hydrological model for urban water management analysis

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Water is an extremely precious resource that needs to be protected and used in a sustainable way. Urbanization augments the pressure on the environment and often challenges maintaining good ecological conditions. Thus it is necessary to monitor and predict the impact of anthropogenic pressure on the environment. Since more than half world's population is living in cities, the research interest in urban hydrology is strongly increasing. Hydrological models are able to analyze and simulate the water cycle and are hence indispensable tools for water management. Many hydrological models have been developed to simulate specific hydrological processes, but relatively few studies try to model the complete water cycle. Moreover modelling distributed processes can be difficult, particularly in heterogeneous urban context. A new hydrological challenge is represented by an integrated water management which takes into account all water components in an urbanized area. Therefore a method describing the urban hydrological cycle is given. The goal is to produce a practical and useful tool for integrated water management in urbanized areas by extending the fully distributed physically based hydrological model WetSpa (Water and energy transfer between Soil plant and atmosphere). The methodology can be summarized as follow:
- Characterization of urban features: information acquisition and coherent model structure adaptation;
- Groundwater WetSpa extension for subsurface water analysis;
- Urban Hydraulic module to simulate water flow in artificial networks;
- Calibration and validation.

Concerning the 'characterization of urban features', the research focuses on the increased capability of remote sensing. The model has been adapted to assimilate spatially distributed imperviousness maps derived from spectral unmixing of hyperspectral images (CHRIS/Proba and airborne images) and tested on case studies. It was noticed that the model is sensitive to changes in the assumed urban imperviousness. The largest impact was observed for the peak discharges but also the base flow is sensitive to the degree of imperviousness. A new classification scheme for urban man-made objects (sealed surfaces) has been developed using field measurement data and satellite images; new land cover maps are being tested and for improving the description of urban areas and hydrological model capabilities.

The GIS pre-processor, to calculate parameter maps for model simulation, was converted to PCRaster-Python, a high level approach, easy to adapt to specific research needs and very attractive for further development.

For the groundwater module some preliminary research has been performed. MODFLOW, has been selected and we will be soon coupled with WetSpa. The link will be made with the free open source OpenMI standard interface, with the dynamic PCRaster framework or directly programmed in Python. The 'Urban hydraulic module' will be created by coupling WetSpa model with the EPA Storm Water Management Model (SWMM).

The created tool, the fully distributed WetSpa-URBAN model, could then be applied to find answers to several scientific and practical demands. It will be possible to obtain a better estimation of water fluxes for surface water as well as for groundwater, therefore, thanks to the spatially distributed nature of the model, also to produce more precise runoff hydrographs at various points in the study area. Analysis of the impact produced by expanding cities and land use change will be possible, WetSpa-URBAN model will also produce detailed characterization of infiltration and recharge. With the parameterization of the exchange between groundwater and sewer system, we will be able identify structural defect in sewer pipes.