Evaluation of nature-based solutions for storm water management with a fully distributed model in semi-urban catchment

Author(s):
Qiu, Y.; Ichiba, A.; Tchiguirinskaia, I.; Schertzer, D.

Publication date:
2019

Permanent link:
https://doi.org/10.3929/ethz-b-000347564

Evaluation of nature-based solutions for storm water management with a fully distributed model in semi-urban catchment

Y.Qiu*[1], A.Ichiba[1], I.Tchiguirinskaia[1], D.Schertzer[1]

1 Hydrology, Meteorology and Complexity, Ecole des Ponts ParisTech, Champs-sur-Marne, France

*Corresponding author: yangzi.qiu@enpc.fr

Abstract

During the last few decades, the continuing increase of impervious surfaces directly connected to grey infrastructure has caused significant increases of fast-forming runoff (Qin et al., 2013). Meanwhile, the changeable climate raises potential of extreme disasters, especially in urban areas (Lovejoy and Schertzer, 2013).

Compared to the traditional drainage system, Nature-Based Solutions (NBS) are widely considered as a sustainable approach to urban stormwater management. However, the efficiency of NBS is closely linked to their innate properties and urban environment conditions, both being a subject to the small-scale heterogeneities. Such heterogeneities are indeed difficult to assess by using the conceptual, instead of physically based, hydrological models. To better evaluate hydrological performances of different NBS across urban catchment scales, especially their capacity for storm-water management, a fully-distributed physically based model, Multi-Hydro, was developed at Ecole des Ponts ParisTech (Ichiba et al., 2017). This model was implemented on the Guyancourt semi-urban catchment of about 520 ha, southwest of Paris (France) (Neto et al., 2018). In this work, we use this catchment (Fig 1) under several scenarios of NBS implementation to evaluate the most suitable development for the area. The high resolution land cover and GIS information were carefully processed to define the area most suitable for the implementation of NBS. Several individual and combined NBS were considered, such as porous pavement, rain garden, green roof, and porous pavement combined with rain garden and green roof. These measures were implemented into Multi-Hydro and their performances were simulated using two types of rainfall data, provided by the C-band (with 1 km pixel) and X-band (with 0.25 km pixel) radars. Results were analyzed with two indicators: runoff volume and peak discharge reduction, making the comparison with the initial hydrological conditions of the catchment.

The results show that the suitable combination of NBS could reduce up to 70% the peak discharge and up to 90% the runoff volume. However, such “suitable combination of NBS” appears dependent on the whole catchment variability. The Multi-hydro model is demonstrated to be an effective model to evaluate and quantify hydrological responses of NBS, which can be used as a decision support tool to give certain insights to decision-makers.

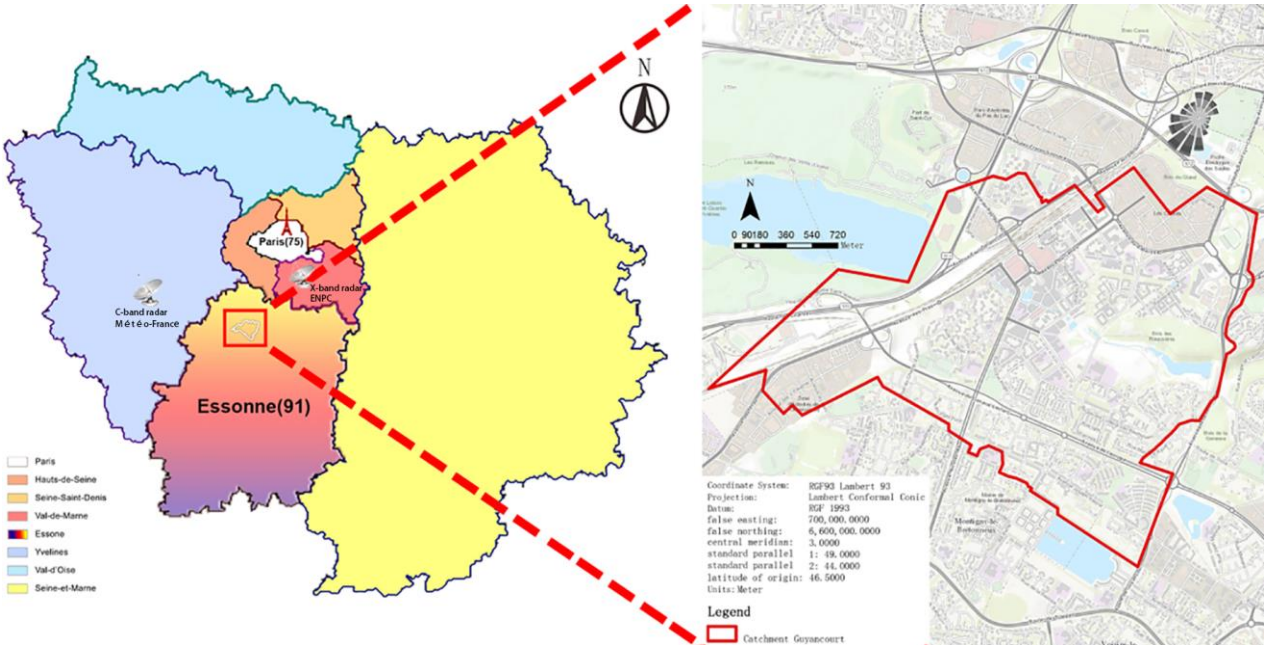

Fig 1: Study area of Guyancourt, France

References

Hua-peng Qin., Zhuo-xi Li., Guangtao Fu.(2013).The effects of low impact development on urban flooding under different rainfall characteristics. Journal of Environmental Management. 129, 577-585.

Lovejoy, S., Schertzer, D. (2013). The Weather and Climate: Emergent Laws and Multifractal Cascades. Cambridge U.K: Cambridge University Press.

Ichiba, A., Gires, A., Tchiguirinskaia, I., Schertzer, D., Bompard, P., Ten Veldhuis, M.-C. (2017). Scale effect challenges in urban hydrology highlighted with a Distributed Hydrological Model. Hydrology and Earth System Sciences (HESS).

Neto, A., Paz, I., Borges, E., I, Abdellah., Tchiguirinskaia, I., Schertzer, D. (2018) Hydrological responses to small scale rainfall variability over a semi-urban catchment using Multi-Hydro model: C-band vs. X-band radar data. EGU General Assembly, Wien.