International Association for Hydro-Environment Engineering and Research

*Hosted by*
Spain Water and IWHR, China

# 1st IAHR Young Professionals Congress

Online. 17 - 18 November 2020

# Proceedings

**Editors:** José María Carrillo | Eva Fenrich
David Ferràs | Silke Wieprecht

IAHR YPN

*Hosted by*
Spain Water
and IWHR, China

**ISBN:** 978-90-82484-6-63

International Association
for Hydro-Environment
Engineering and Research

*Hosted by*
**Spain Water and IWHR, China**

# Session 4
# Urban Drainage

*Hosted by*
**Spain Water
and IWHR, China**

Proceedings of the 1st IAHR
Young Professionals Congress
17-18 November 2020s

# DATABASE DESIGN AND GRAPH-BASED ANALYSIS FOR SWMM URBAN MODELLING

**Martín Ríos**[1,2], **Leandro D. Kazimierski**[*1,2], **Marina Lagos**[1,2], **Mariano Re**[1,2]

[1]National Institute for Water (INA), Hydraulics Laboratory, Ezeiza, Argentina
[2]School of Engineering, University of Buenos Aires (UBA), Buenos Aires, Argentina

*Correspondance : marios@fi.uba.ar

**ABSTRACT**
This work illustrates the steps on the development of a graph-based approach for the analysis of a high-resolution urban 1D hydrological-hydraulic model. The basin of San Juan - Jimenez (SJJ, Buenos Aires, Argentina) is used as a test case, where the model was previously calibrated and validated. A database with the data (.INP file) and results (.OUT file) of the EPA-SWMM model is built in PostgreSQL. The database is used to build a graph network of the hydraulic system, allowing a deeper analysis over the sub-basins of each node.

**Keywords:** hydroinformatics, urban flooding, surrogate modelling, database, graphs

## 1 INTRODUCTION

SJJ basin of 75 km$^2$ in the Metropolitan Region of Buenos Aires (RMBA) has suffered numerous heavy rainfall events usually result in urban flooding. The development of 1D High-Resolution (1DHR) urban flood model of the dual-drainage system with EPA-SWMM, calibrated and validated with direct and indirect information (Re *et al.*, 2019; Ortiz *et al.*, 2017) allowed an advanced understanding of the flood dynamics in the basin. A forecast of water levels in streams during intense rain events in the basins of the RMBA is a demand of civil protection and local governments. These needs are requested to the Hydro and Meteorological National Services to generate strategies for their development. 1DHR models developed are not suitable for short-term forecasting due to their high computational cost.

The main objective of the whole project is the development of surrogate model (Bermúdez *et al.*, 2018) using graph neural networks for real-time operation on intense precipitation events. Surrogate models aim to increase speed forecasting with minimal loss in quality. Multiple simulations of the HR model for different scenarios are going to be used as input for the training of the neural network model (Berkhahn *et al.*, 2019). In this work, the first step in this development is presented, which includes the assembly of a database and the graph implementation.

## 2 METHODOLOGY

SSJ 1DHR model has over 19.000 nodes, 25.000 links and 18.000 subcatchments which generates an output file of about 4GB. For the simulation result, EPA-SWMM outputs a binary file (.OUT file), which makes the data-extraction a complex and time consuming process. A database in PostgreSQL was built, where all the data in the output file was extracted with the *swmmtoolbox* [1] library; the data in the model file (.INP file) and the meteorological data is stored. A Python script automates the extraction and loads the data on the database using the *psycopg2* library. The motivation to implement a graph is to achieve an alternative representation of the data extracted from the EPA-SWMM and the future design of a graph neural network model. A graph consists of nodes connected by edges, where each one of this elements have attributes. This approach appears to be suitable for modeling the behaviour of a basin, adding the constraint of the water flow direction at a given

[1]https://timcera.bitbucket.io/swmmtoolbox/docsrc/index.html

time. Thus, a directed graph is build mapping analog elements between them: nodes on the graph represent the EPA-SWMM's nodes (junctions and storage units) and the directed edges on the graph represent the EPA-SWMM's links (streets, channels and conduits). The properties on the EPA-SWMM's elements such as water level, velocity, roughness, are added as attributes of the nodes and links on the graph.

## 3 RESULTS

The database reduces the access time during operation from 5 seconds, directly from the binary file, to 10 milliseconds (a 500x reduction) querying from the database; the time consuming extraction is done once and the data remain accessible through a SQL interface in a more structured way. The database has 23 tables including: model version, rainfalls registry; sub-catchments, nodes and links of the model, geometric properties and the time series outputs of the model simulations. Once the graph is built, it can also generate the corresponding sub-graphs for a node of the model at any given time (Figure 1). This sub-graphs are composed by the predecessor tree and the chosen node as outlet of the sub-basin, with aggregated data such as accumulated precipitation, mean impervious area and the area associated to the sub-basin (Table 1). This data will be useful as features for the neural network model.

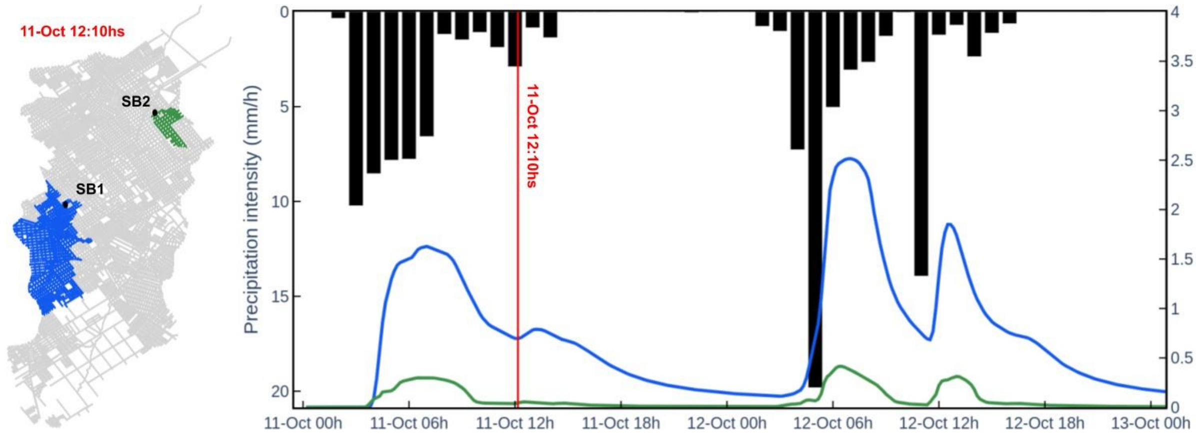


Figure 1: SSJ 1DHR model topology in grey and sub-basins associated to two nodes. Temporal series of water level and precipitation intensity every 1 hour in the two nodes with the time of analyses of the sub-basins properties in red.

Table 1: Attributes of the two sub-basins shown in Figure 1.

| | SB1 | SB2 |
|---|---|---|
| **Sub-basin Area [Ha]** | 751 | 99 |
| **Impervious Area [%]** | 47 | 68 |

## 4 CONCLUSIONS

During this work a database to manage the results of the simulation by the EPA-SWMM software was designed and implemented. Also, an exploratory analysis of the results and model performance was possible after the important reduction on access time. By querying the database, a graph of the basin for any node at any time was built, with detailed properties and variables time series. Finally, this information will be provided as input for a graph neural network which will aim to forecast water levels as a result of rainfall events.

### References

Berkhahn S., Fuchs L., Neuweiler I. (2019). An ensemble neural network model for real-time prediction of urban floods. *Journal of Hydrology 575*, 743 – 754.

Bermúdez M., Ntegeka V., Wolfs V., Willems P. (2018). Development and comparison of two fast surrogate models for urban pluvial flood simulations. *Journal of Water Resources Management 32*(8), 2801–2815.

Ortiz N., Re M., Kazimierski L. D., Garcia P. E. (2017). Characterization of the impact associated with different flood types on an urban basin (in spanish). In *CONAGUA 2017*, Volume 1. Congreso Nacional del Agua, Argentina.

Re M., Kazimierski L. D., Badano N. D. (2019). High-resolution urban flood model for risk mitigation validated with records collected by the affected community. *Journal of Flood Risk Management 12*(S2), e12524.

IAHR YPN

**Young Professionals Network**

*Hosted by*
**Spain Water and IWHR, China**

IAHR AIRH

**International Association for Hydro-Environment Engineering and Research**

*Hosted by*
**Spain Water and IWHR, China**


## IAHR Madrid Secretariat

Paseo Bajo Virgen del Puerto 3. 28005, Madrid, SPAIN

Tel: +34 913357908

## IAHR Beijing Secretariat

A-1 Fuxing Road, Haidian District, 100038, Beijing, CHINA

Tel: +86 1068781808