Faculty of Engineering

Queensland University of Technology, QUT

Students | 53257

Staff | 13249

Full-time equivalent staff | 4459

TOP 20
GLOBAL UNIVERSITY
under 50 years old
(16th) 2022 QS Top 50 Under 50

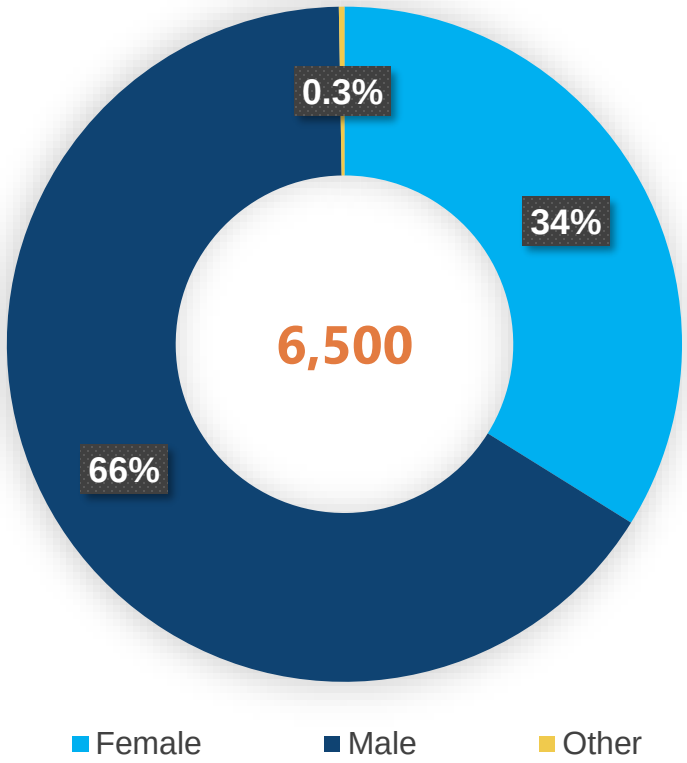
Ranked in the TOP 200
World Universities Ranking
(193rd) Times Higher Education 2022

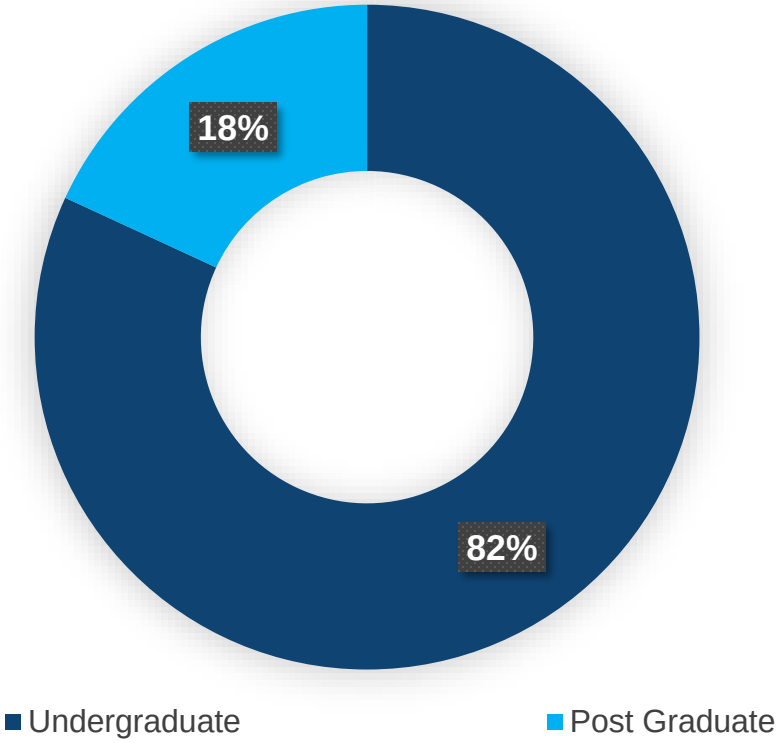
CRICOS No.00213J

Facultet za Inžinjeriju @ QUT

škole	discipline
Architecture & Built Environment	• Architecture • Interior architecture • Landscape architecture • Construction management & surveying • Urban & regional planning
Civil & Environmental Engineering	• Structural engineering • Transport engineering • Environmental engineering (Water & Geo)
Electrical Engineering & Robotics	• Robotics & autonomous systems • Power engineering • Vision & signal processing
Mechanical, Medical & Process Engineering	• Mechanical engineering • Biomedical engineering • Chemical engineering

Naši studenti





Dizajniranje gradova za odbranu od poplava

Ana Deletić

Klimatske Promene

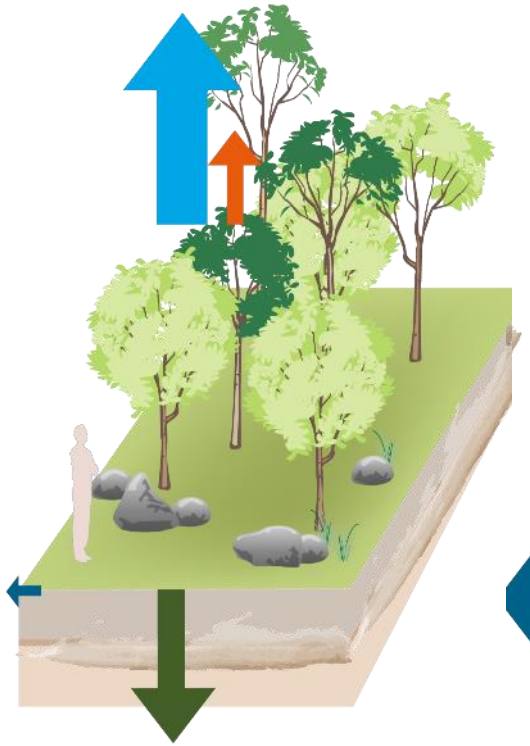
Zagadjenje

Kišni oticaji su deo problema!

Plavo-Zelena Infrastruktura – Blue Green Systems (BGS)

Kako radi BGS

Natural

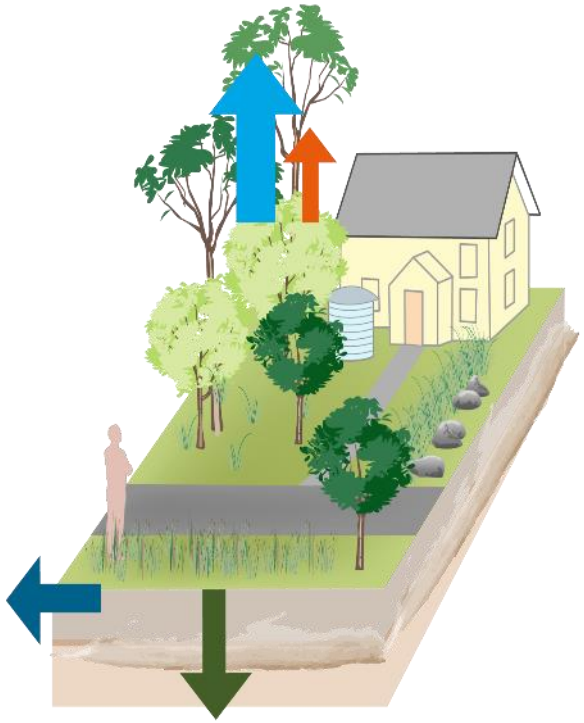


- Oko 85% padavina se izgubi
- Max 15% otekne

Urbanised

- Oko 15% padavina se izgubi
- Oko 85% otekne

Green Technology

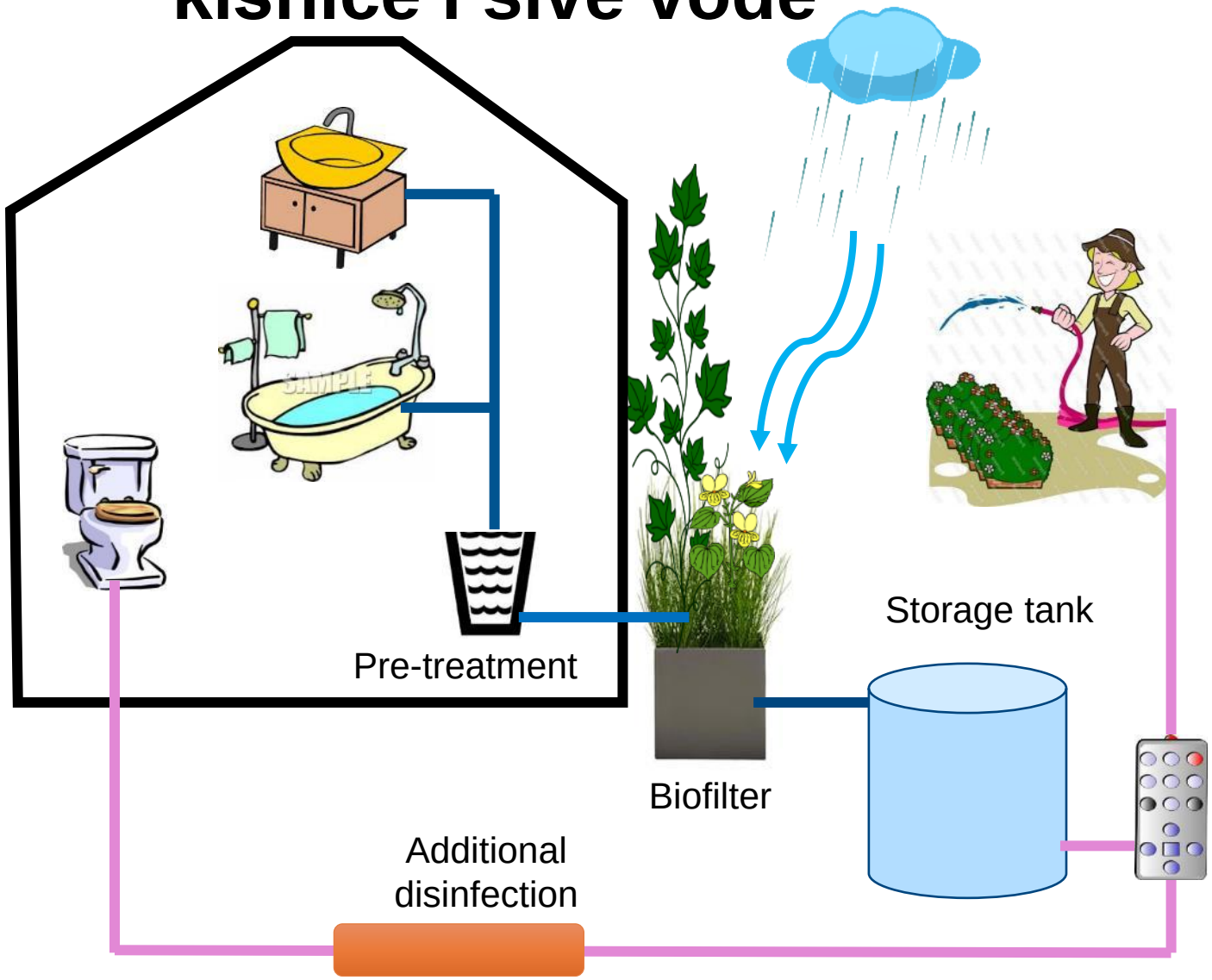


- Prikuplja, zadržava, infiltrira, precišcava, koristi

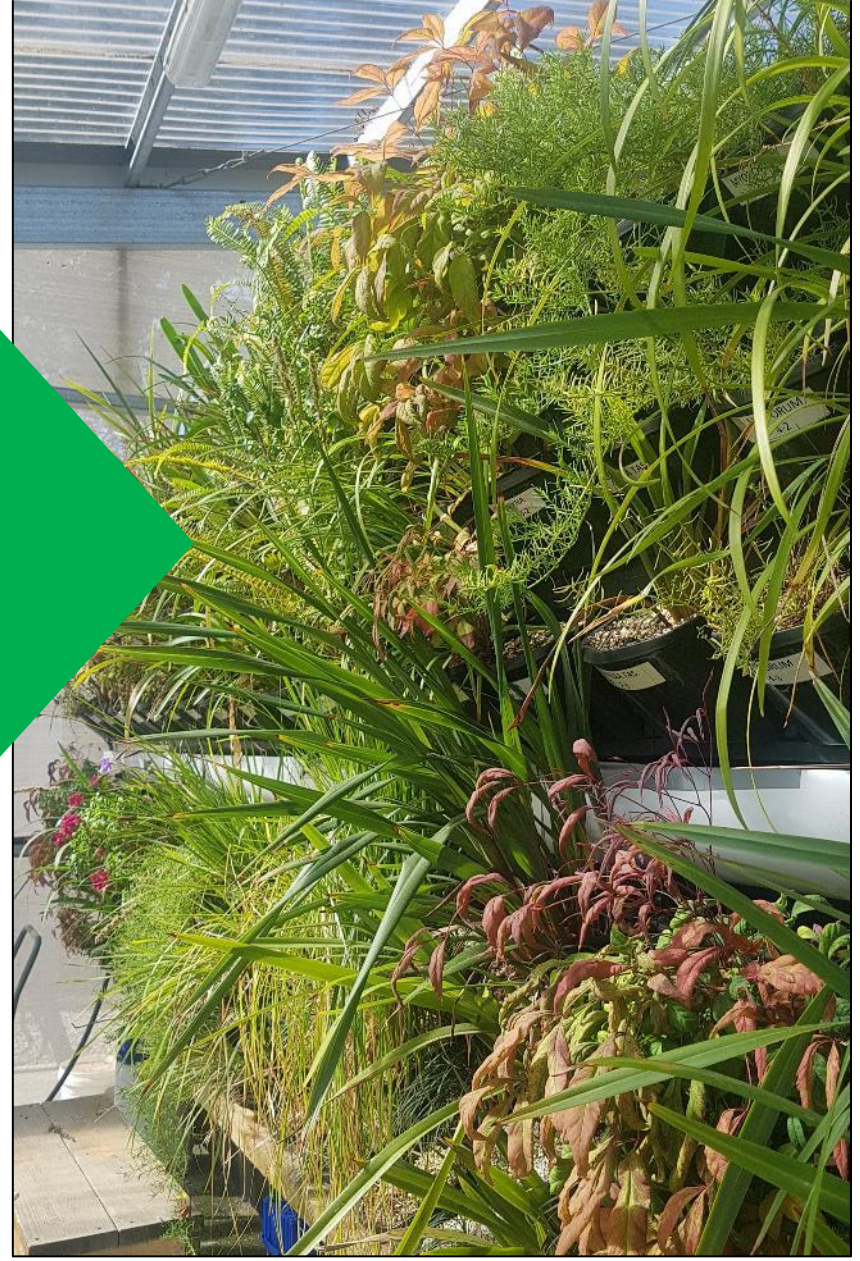
10,000 raingardens in Melbourne

Vertikalne Tehnologije

Zeleni vertikalni zid za regulaciju i prečišćavanje kišnice i sive vode

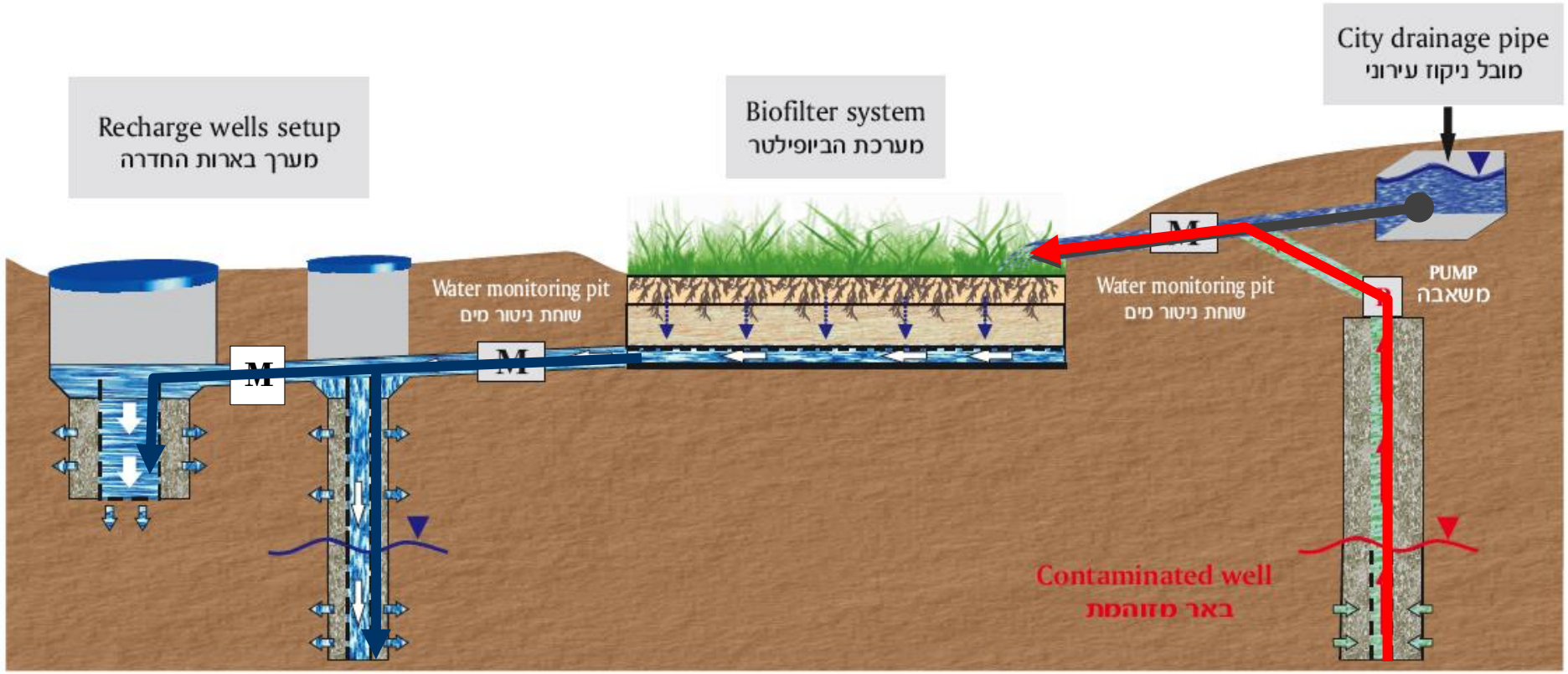


1 godina kasnije



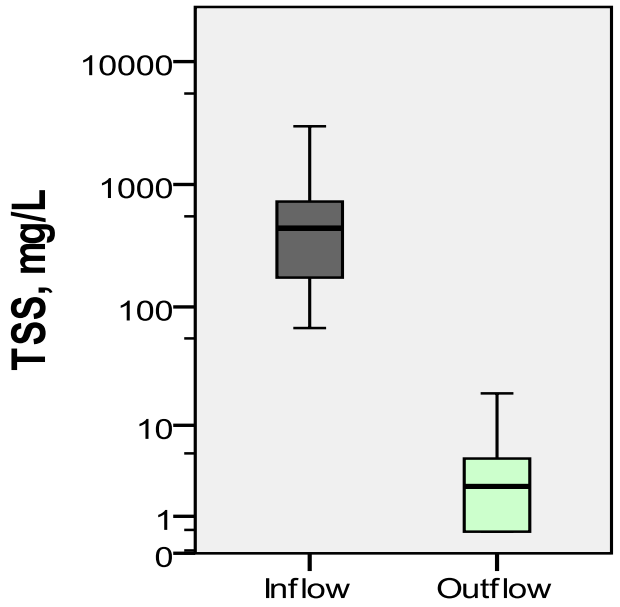
Kfar-Saba biofilter, Israel

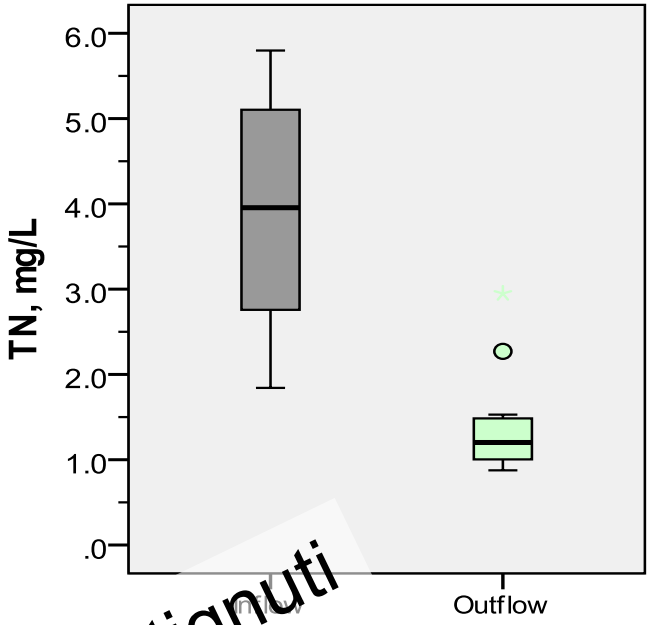
Kfar-Saba biofilter prečišćava kišnicu tokom kišnog perioda, i zagadjenu podzemnu vodu tokom sušnog

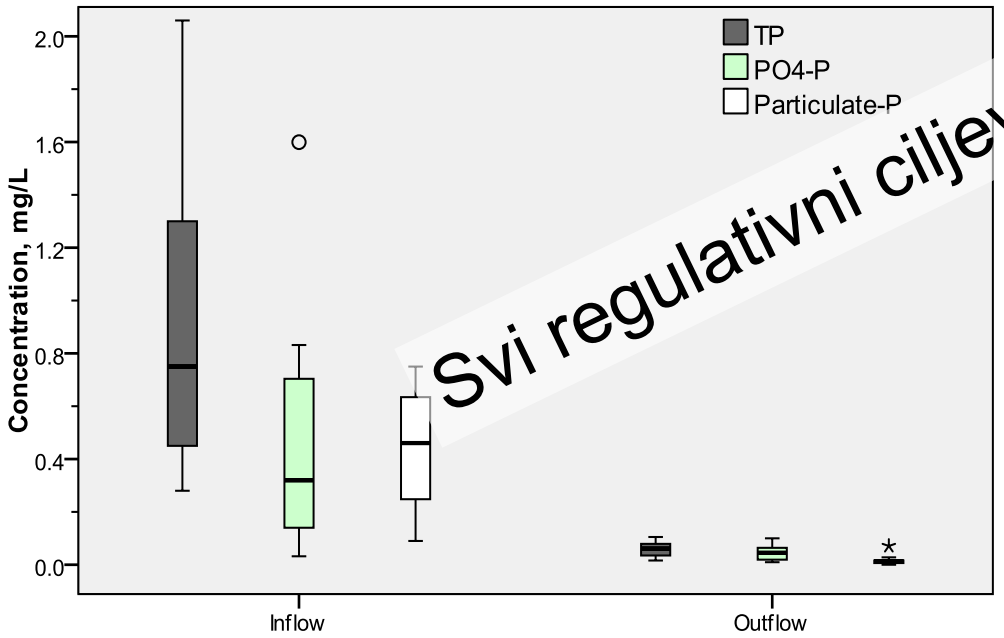


Merenja tokom dve sezone

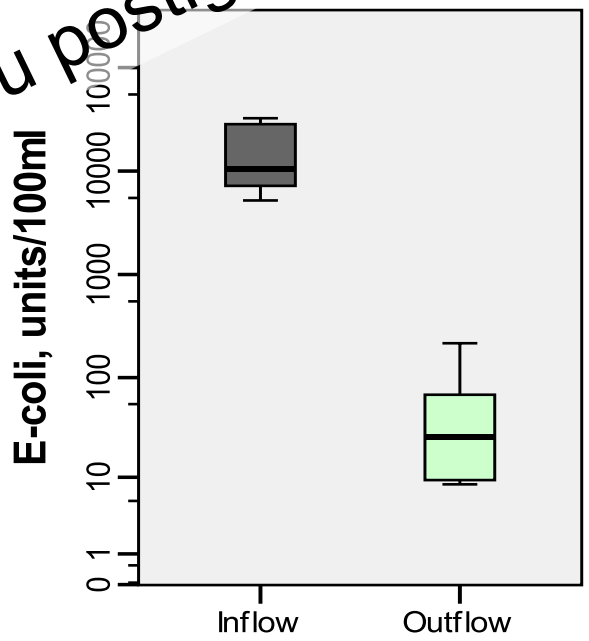
(Event Mean Concentrations)







Svi regulativni ciljevi su postignuti



Da li može BGS da se koristi za odbranu gradova od poplava?

Tradicionalno modeliranje poplava u gradovima

Design Storms
(2, 5,…, 100-yr)

DEM
pipes
…

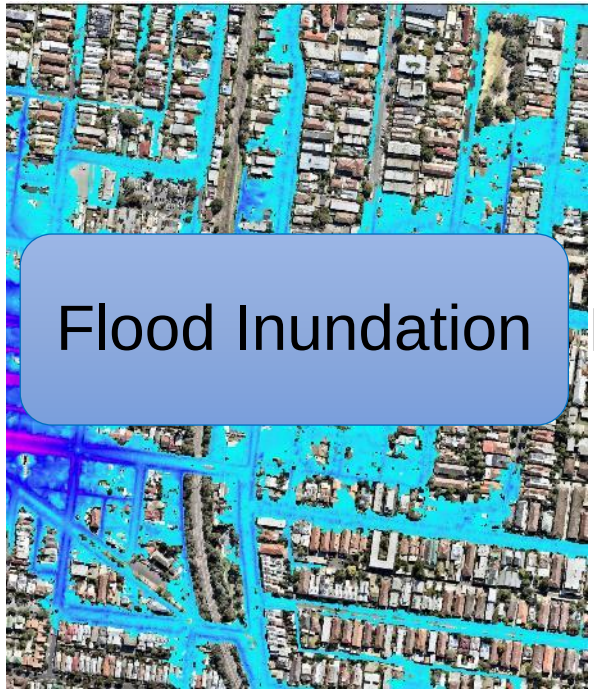
WSUD
(type, size, …)

TUFLOW

1D-2D hydrodynamic flood simulation

XP SWMM

MIKE by DHI

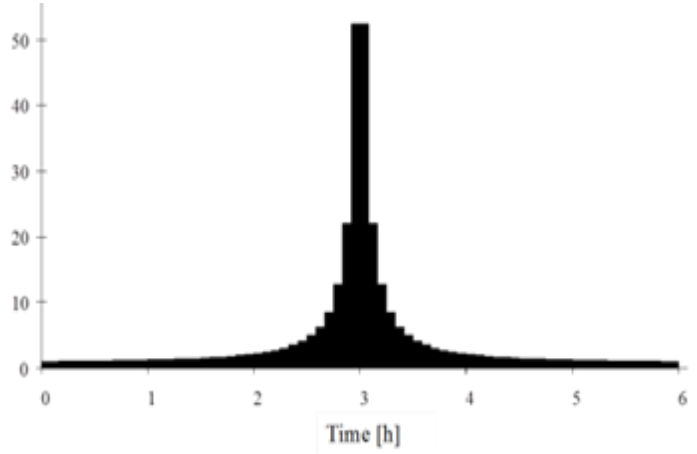


Damage Assessment
& Cost-Benefit Analysis

Da li ovo ‘radi’ za modeliranje BGS ?

- Korišćenje ‘design storms’ je problematično

- Simulacije traju jako dugo



Tradicionalni modeli ne mogu da ocene uticaj BGS sistema na poplave, jel su oni obično jako mali i veoma distribuirani

Konceptualni modeli poplava

- **Jednostavni**: Bazirani na topologiji i jednačini balansa
- **Brzi**: Simuliraju jednu kišu za samo nekoliko minuta
- **Statični**: Rezultat je mapa maksimalnih inundacija (dubina) – razvoj inundacije tokom padavina se ne simulira!

Konceptualni model poplava (1)

RUFIDAM

Contents lists available at ScienceDirect

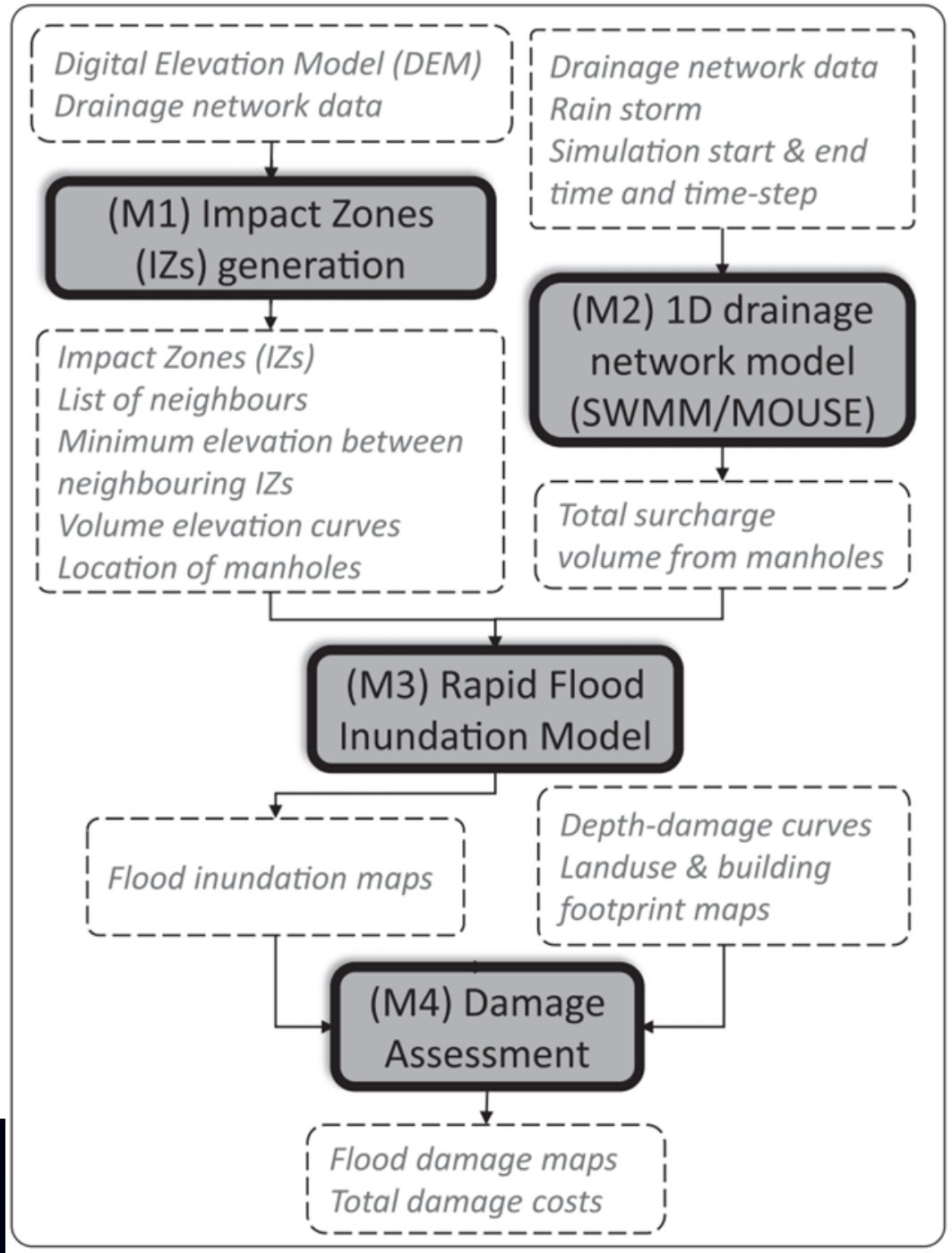
Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

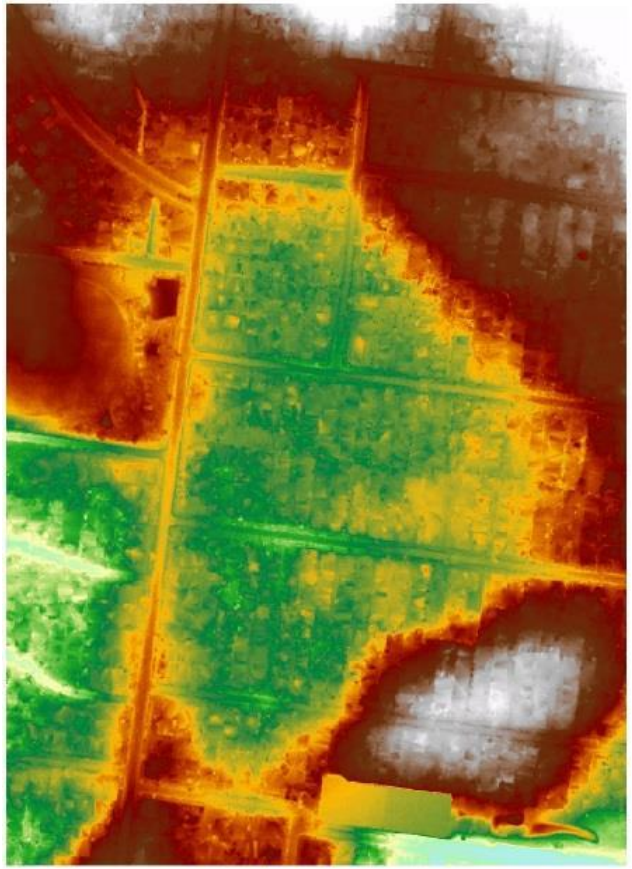
A rapid urban flood inundation and damage assessment model

Behzad Jamali[a,*], Roland Löwe[c], Peter M. Bach[a,d,e], Christian Urich[a], Karsten Arnbjerg-Nielsen[c], Ana Deletic[a,b]

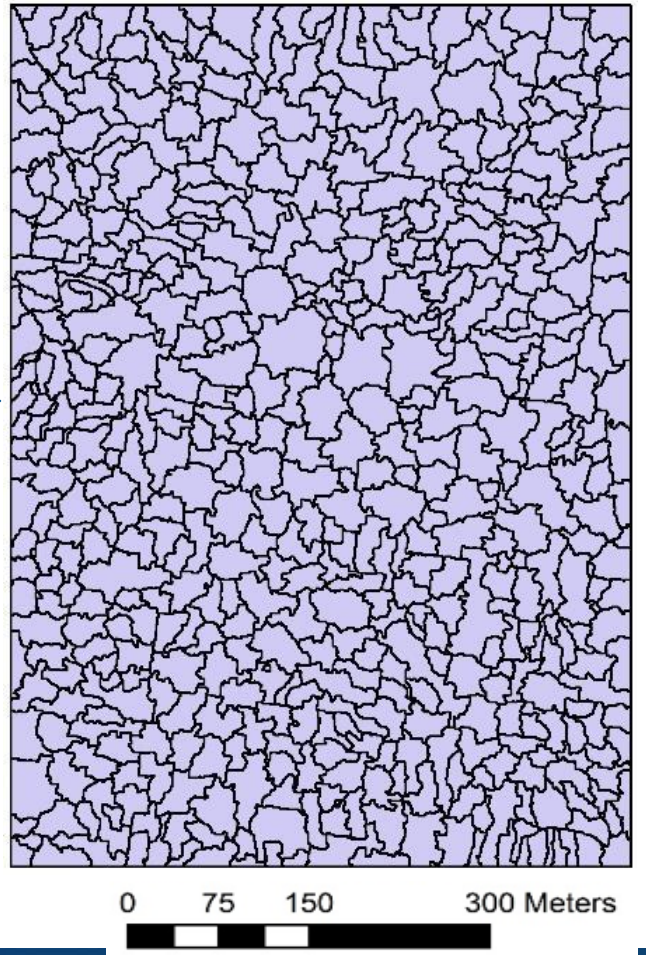


(M1) Pre-procesiranje

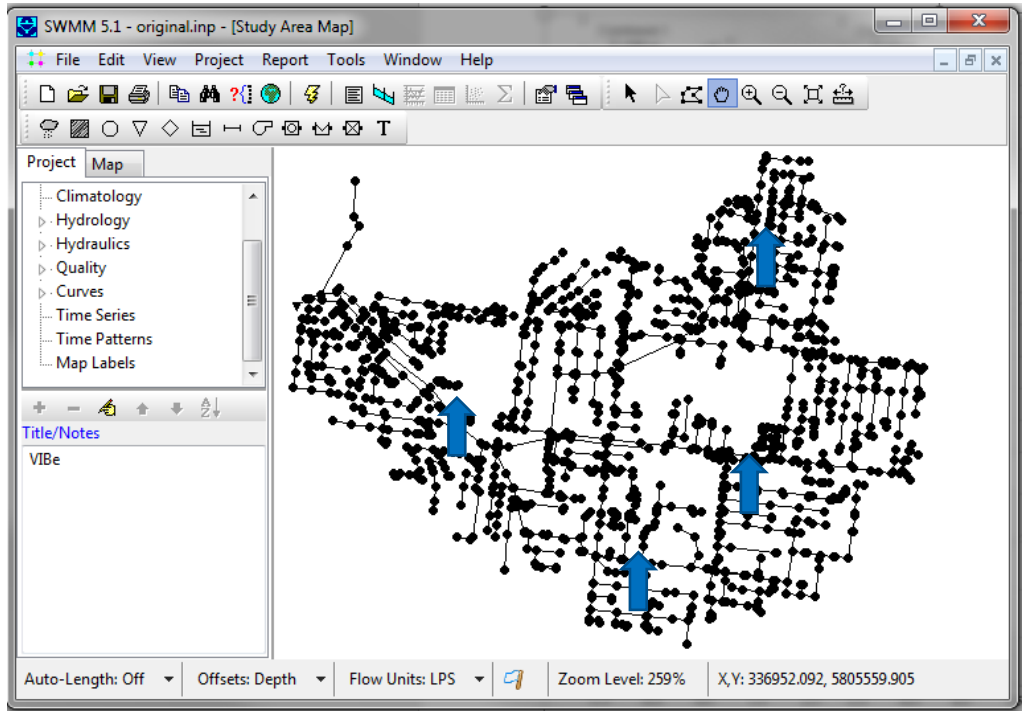
DEM



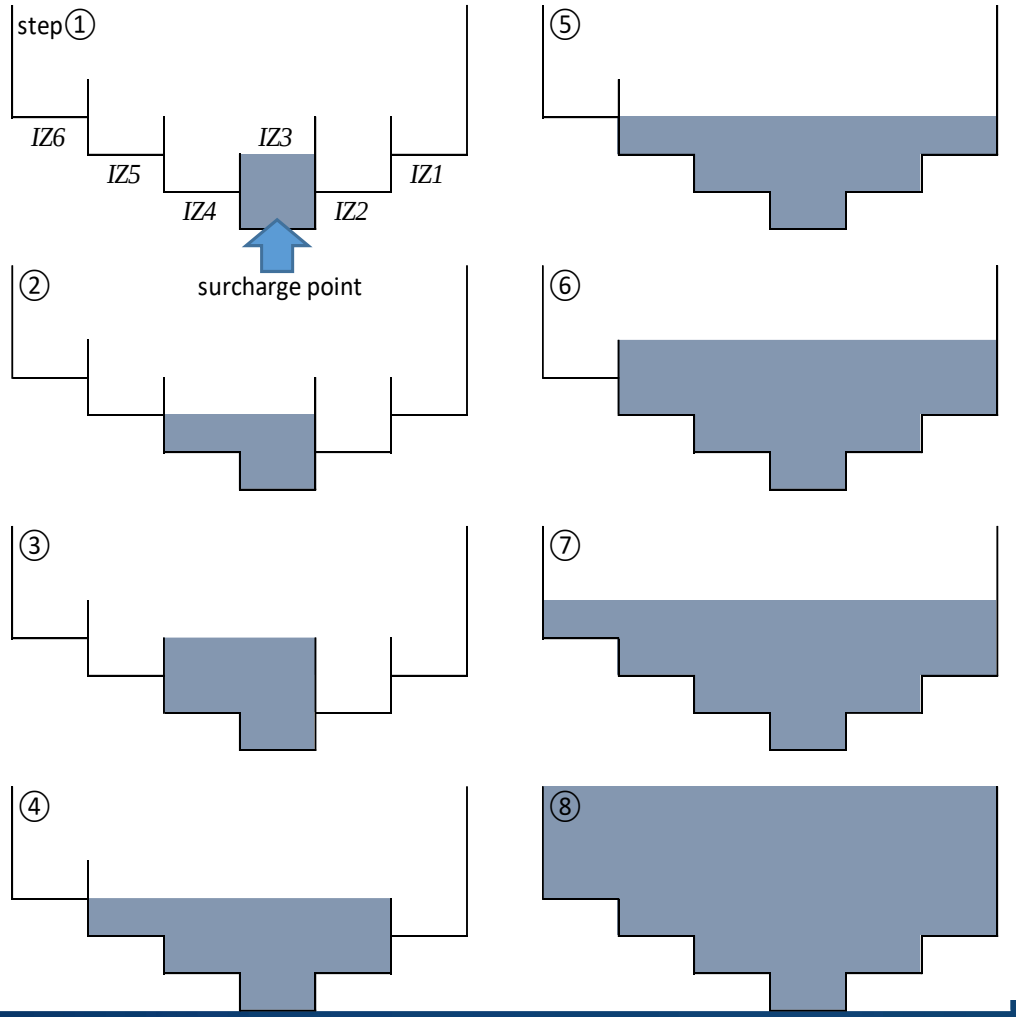
Impact Zones (IZs)



(M2) 1D model kišne kanalizacije



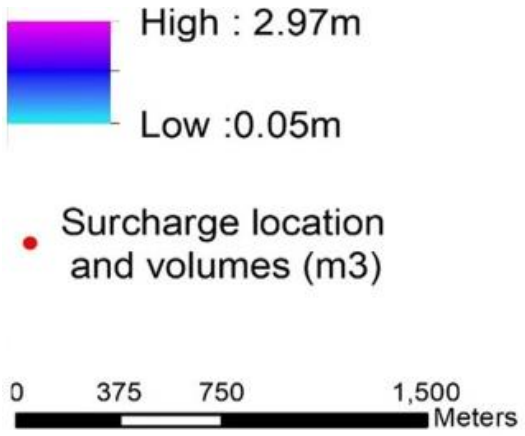
(M3) Brzi model inundacija

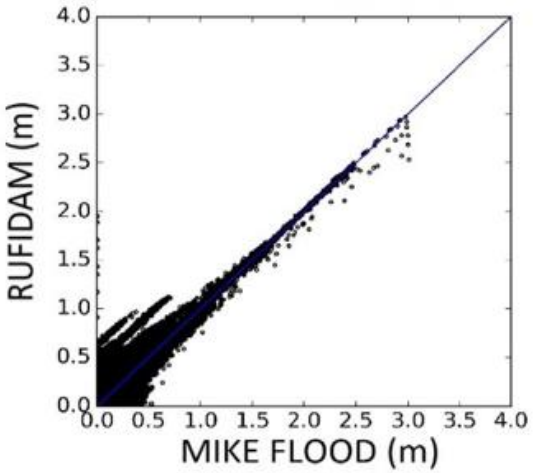


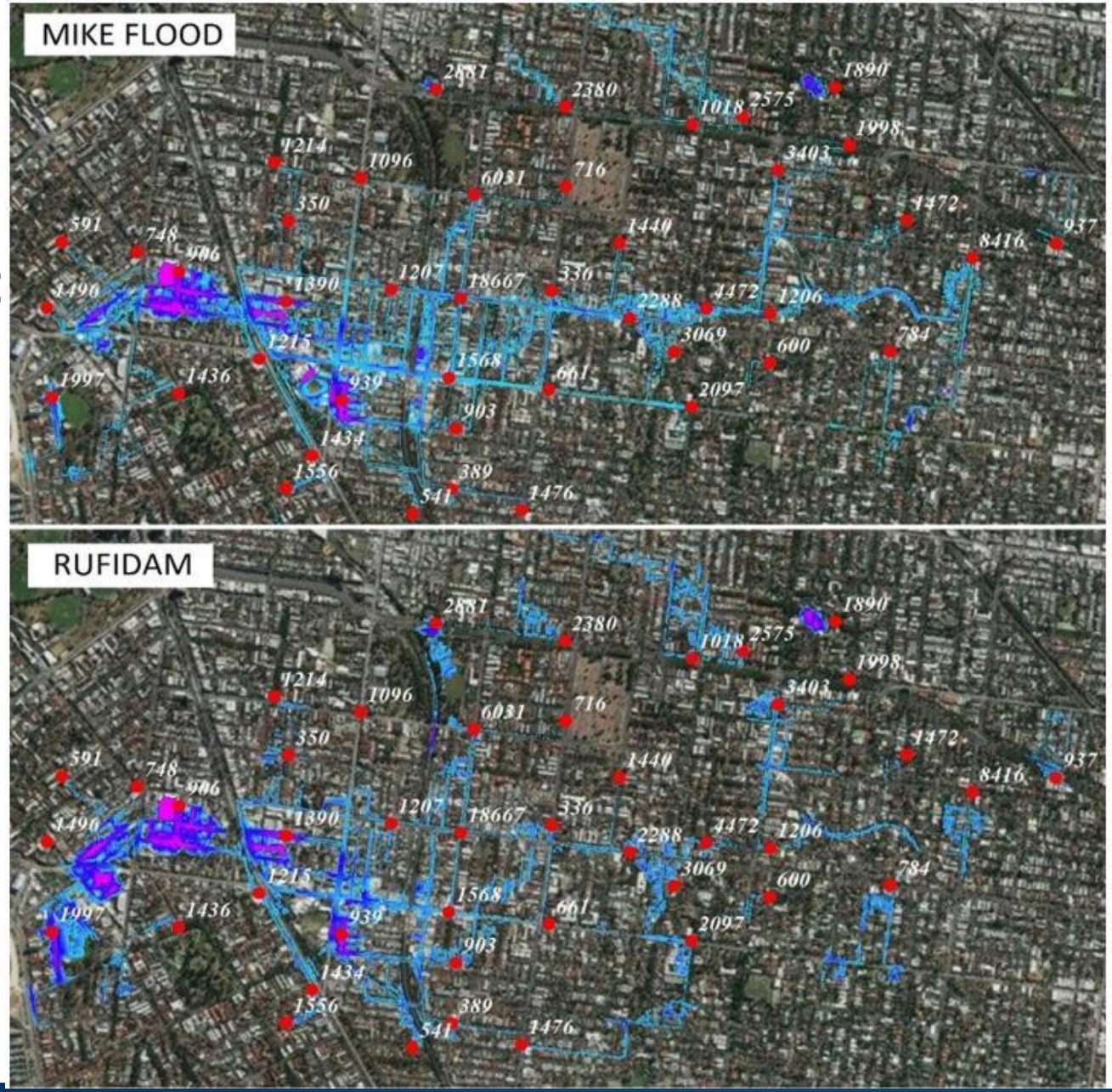
RUFIDAM

Mapa maksimalnih inundacija sa dubinama za 100-god kišu se simulira za:

- RUFIDAM - **10 min**
- 2D MIKE FLOOD - **64 hours**







Konceptualni Model Poplava (2)

Water Resources Research

RESEARCH ARTICLE
10.1029/2018WR023679

A Cellular Automata Fast Flood Evaluation (CA-ffé) Model

Behzad Jamali[1,2], Peter M. Bach[2,3,4], Luke Cunningham[5], and Ana Deletic[1]

[1]Water Research Centre, School of Civil and Environmental Engineering, University of New South Wales, Sydney, New South Wales, Australia, [2]Monash Infrastructure Research Institute, Department of Civil Engineering, Monash University, Clayton, Victoria, Australia, [3]Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland, [4]Institute of Environmental Engineering, ETH Zürich, Zürich, Switzerland, [5]Water Technology Pty Ltd, Notting Hill, Victoria, Australia

Key Points:

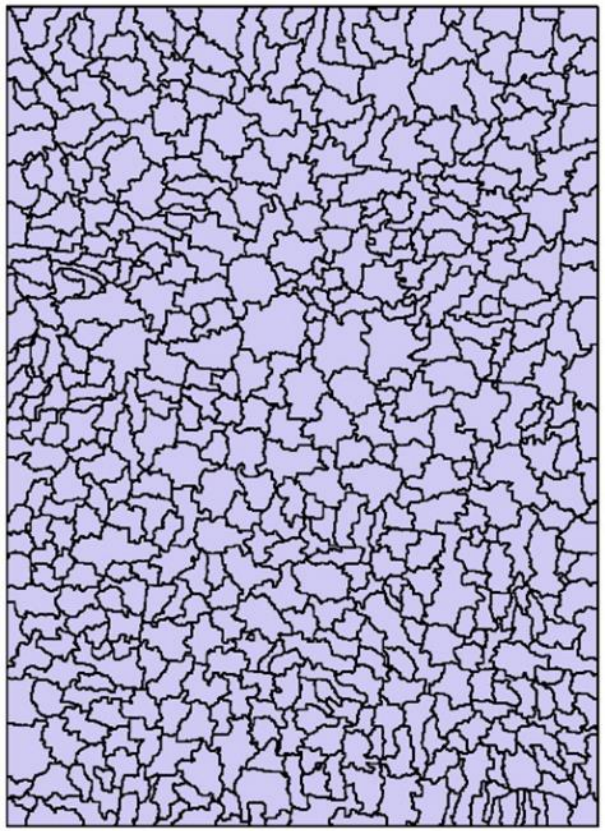
- A rapid urban flood inundation model was developed using a novel cellular automata approach and tested against detailed hydrodynamic models
- Our model successfully predicted

CA-ffé's je bolji od RUFIDAM

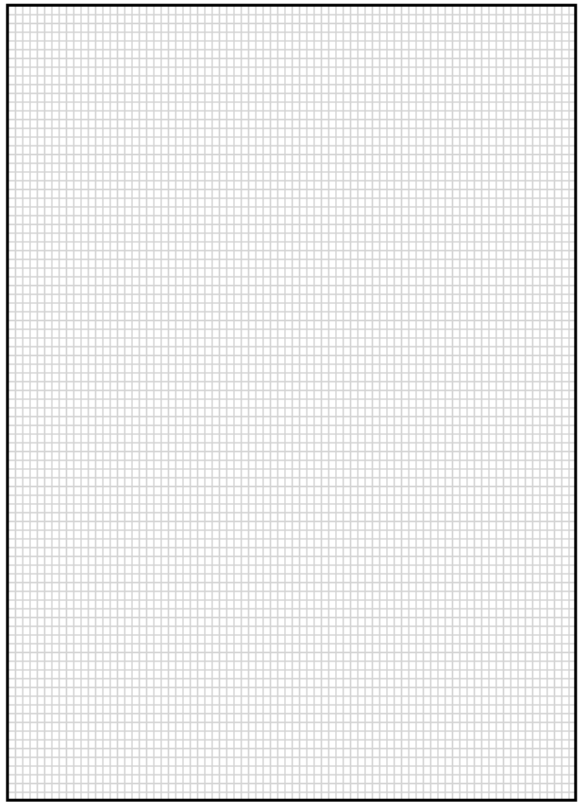
RUFIDAM

Smanjuje se vreme simuliranja, pošto nema pre-procesiranja

Impact Zones



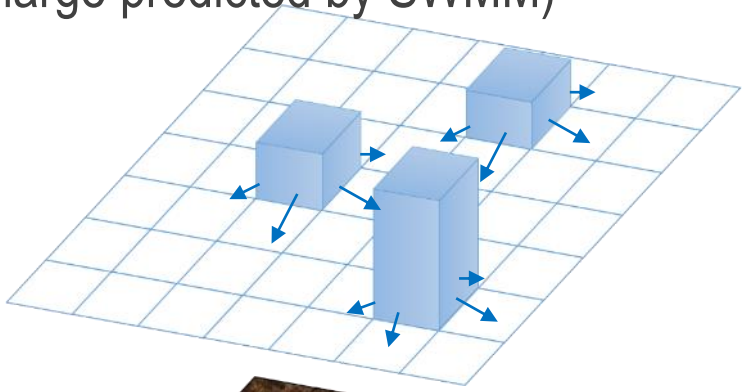
Cells

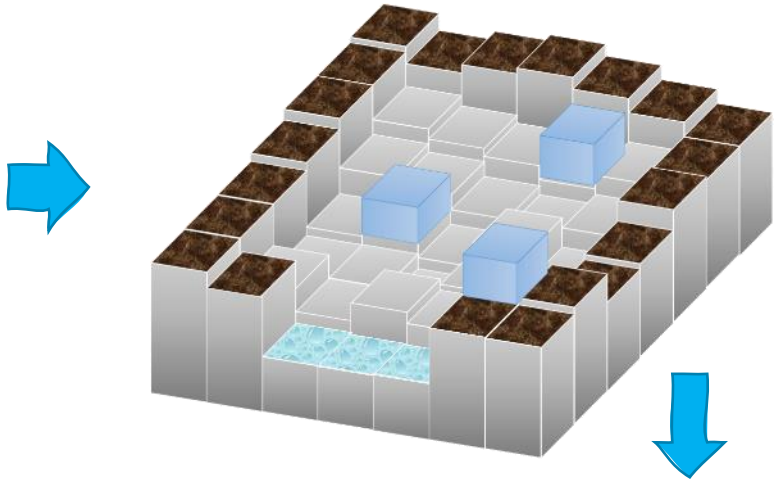


CA-ffé

Excess water volume

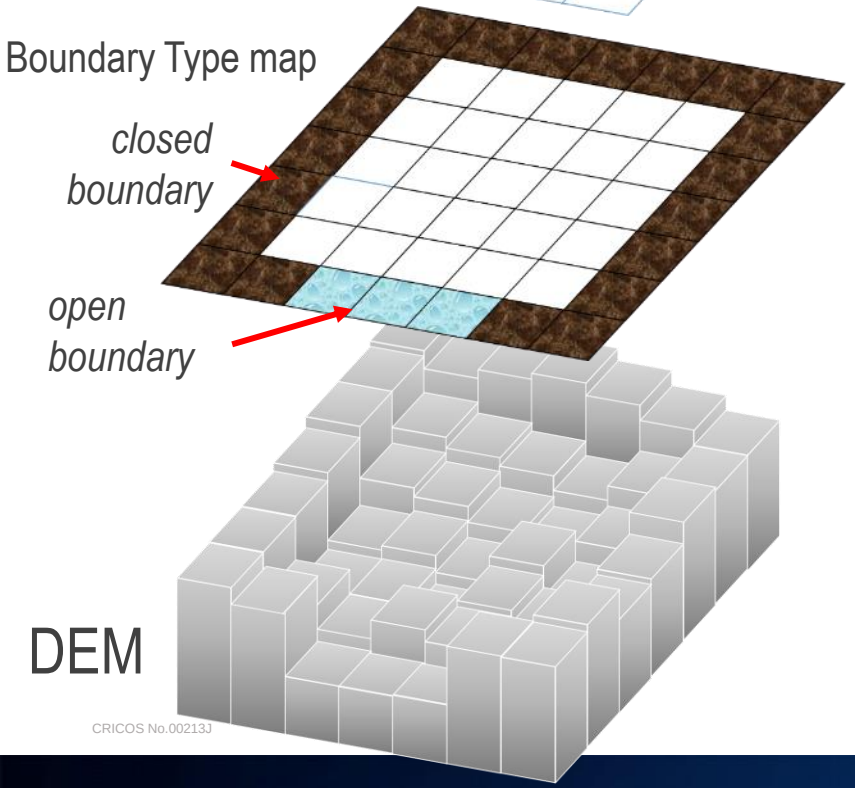
(Surcharge predicted by SWMM)

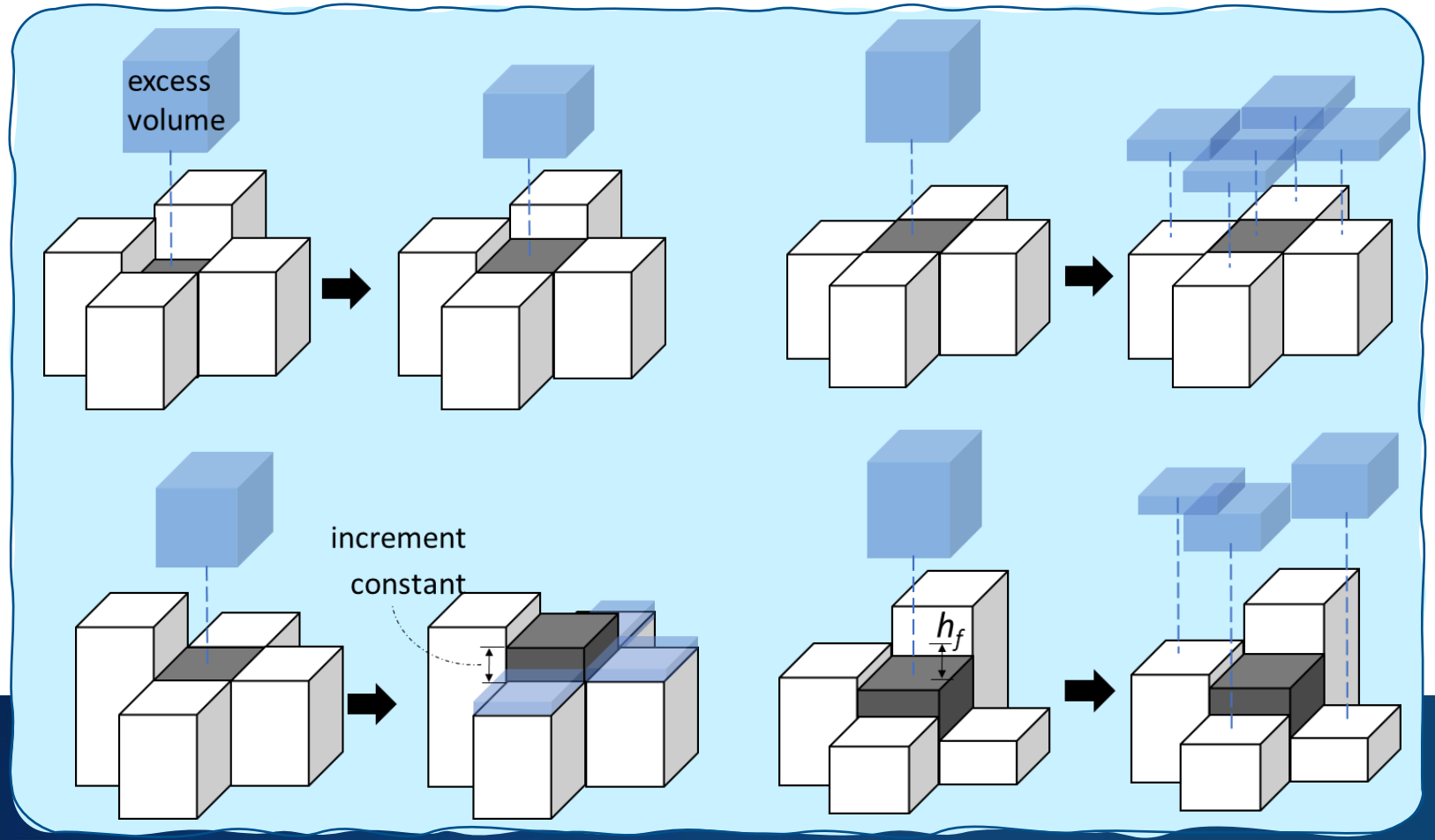




CA-ffé

Four simple CA rules to spread excess water



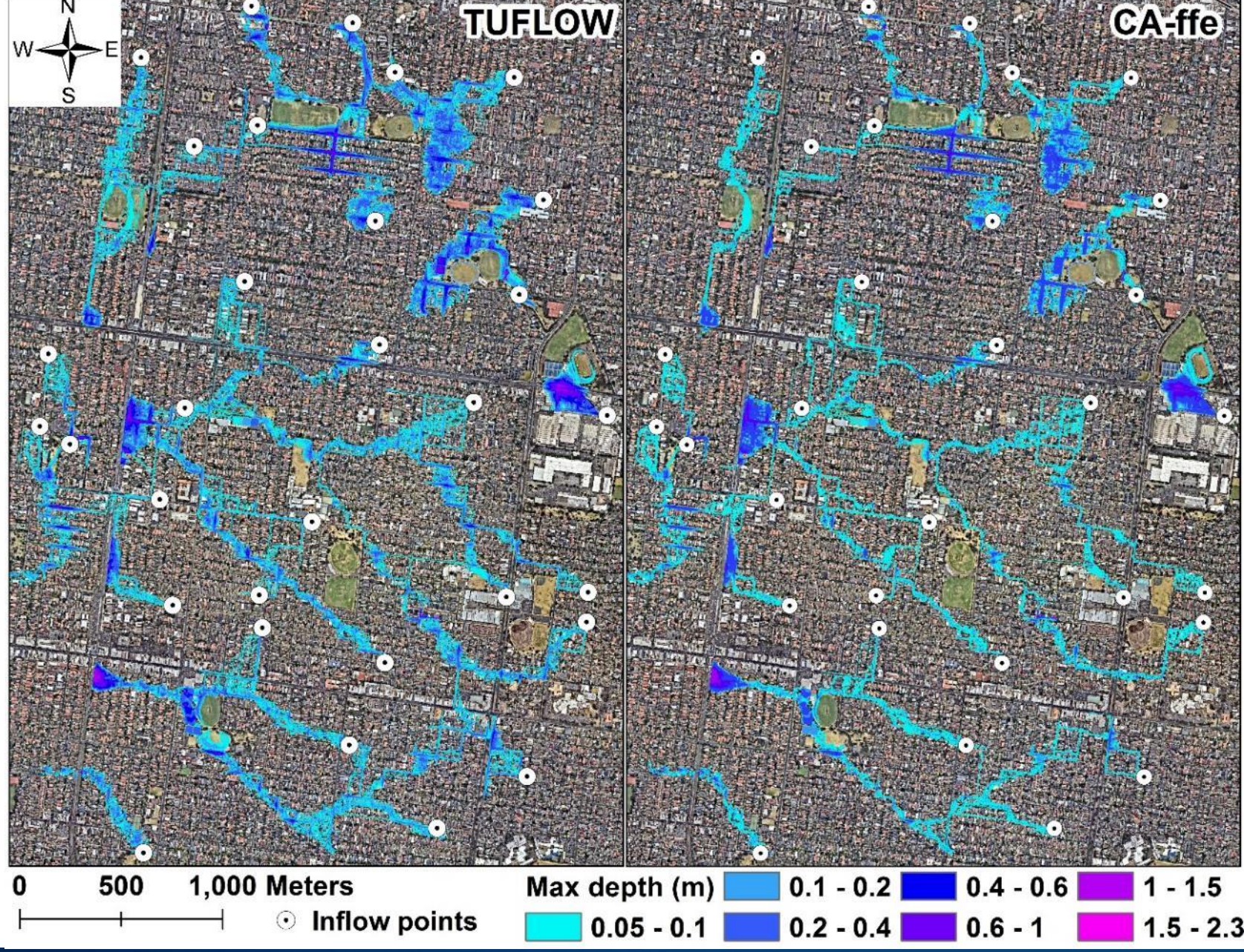


Jamali, B., et al. (2019). "A Cellular Automata Fast Flood Evaluation (CA-ffé) Model". Water Resources Research

CA-ffé

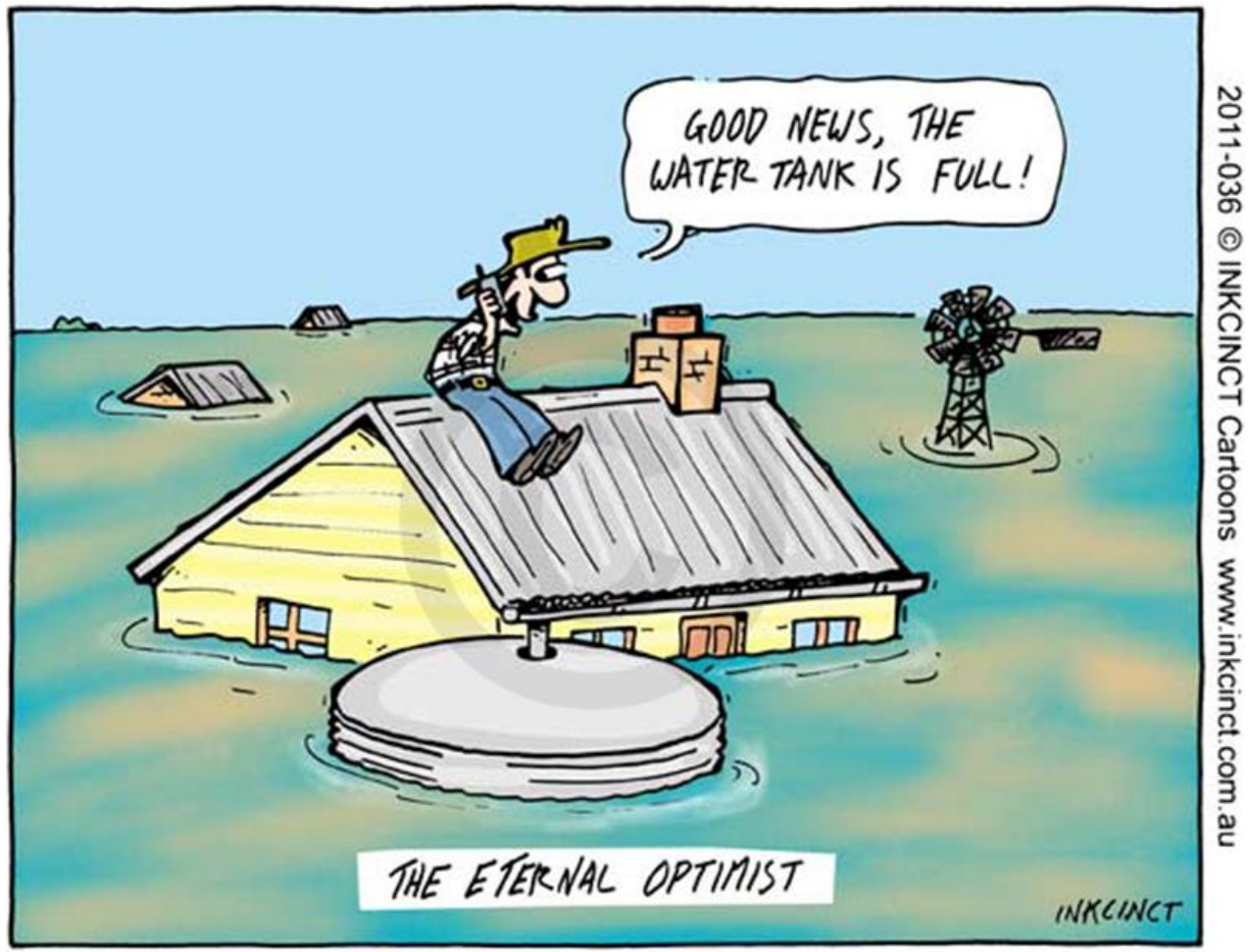
Testiran na 14.4 km^2 slivu u Melburnu:

- TUFLOW: 45 to 80 h
- CA-ffé: 8 s – 2 min



Primer:

Hvatanje i korišćenje kišnice kao mera za odbranu od poplava



M1. Tank Water Balance

Rainfall-runoff model

Stochastic water demand model

RWHTs behaviour storage model

M2. Flood hazard simulation

Rainfall events extraction

Fast Flood Inundation Modelling

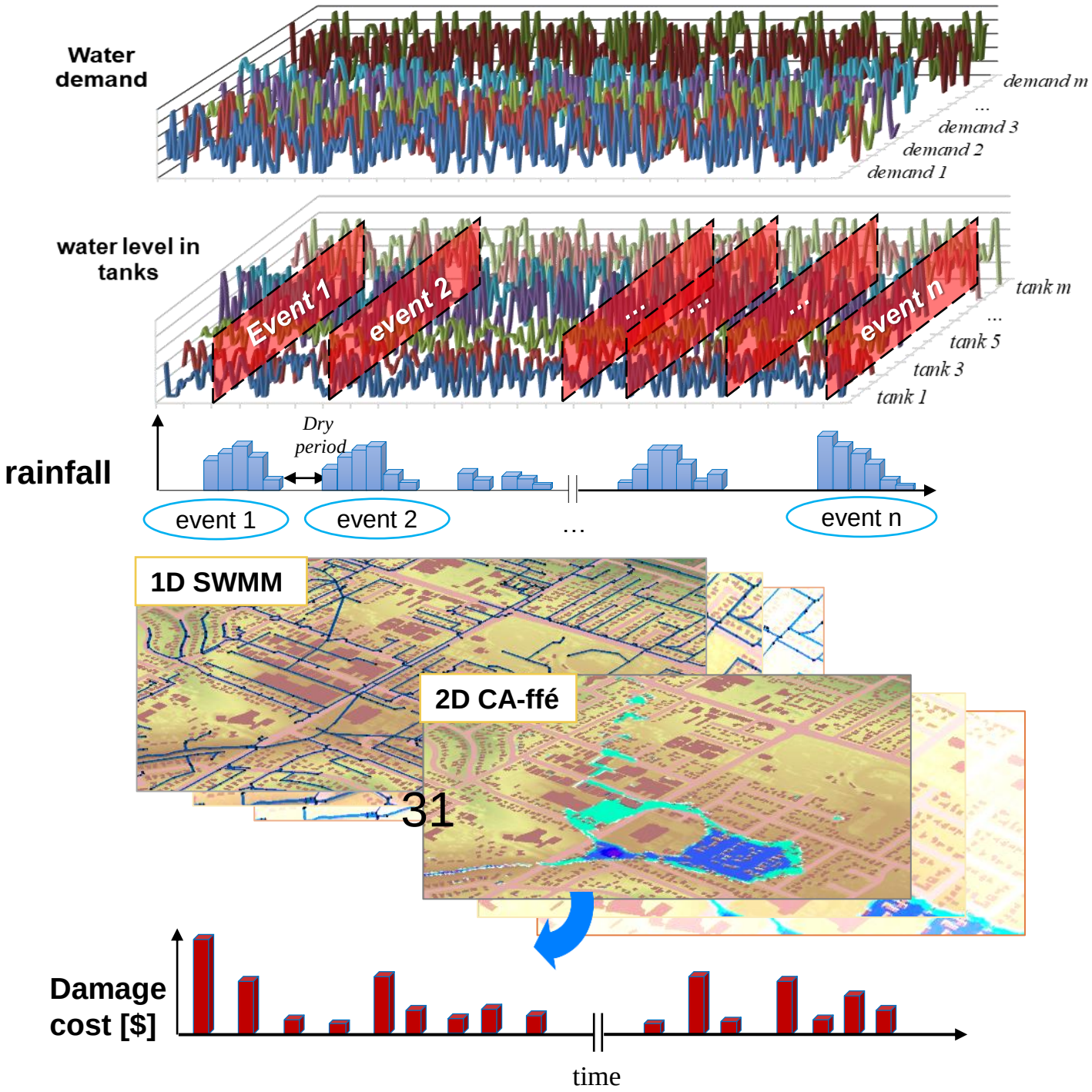
1D SWMM → CA-ffé

M3. Risk and Economic analysis

GIS-based flood damage estimation

Flood risk analysis

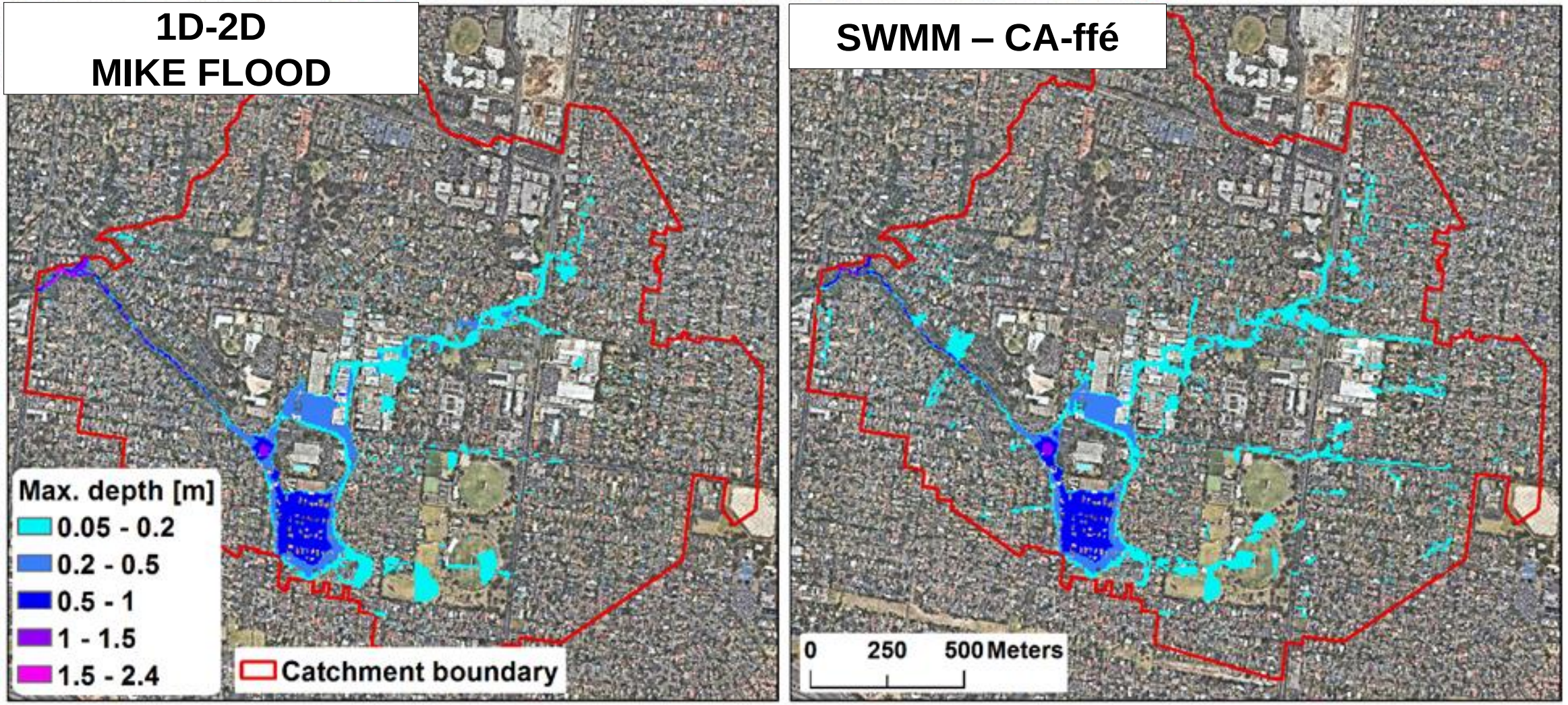
Cost Benefit Analysis



PRIMER

- Scotchman’s Creek sliv
- 270 ha
- 2400 objekata (1 mali rezervoar za svaki objekat)
- Totalna zapremina rezervoara ~9,200 m^3
- 85 godina istorijskih zapisa kiša (6 min rezolucija)

Kalibracija 2D modela

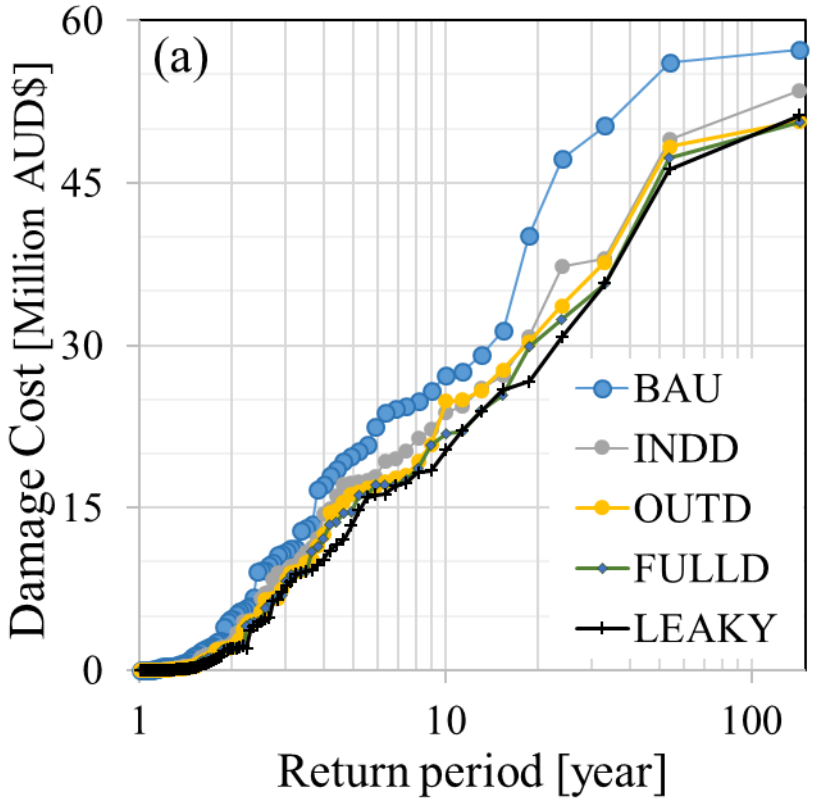


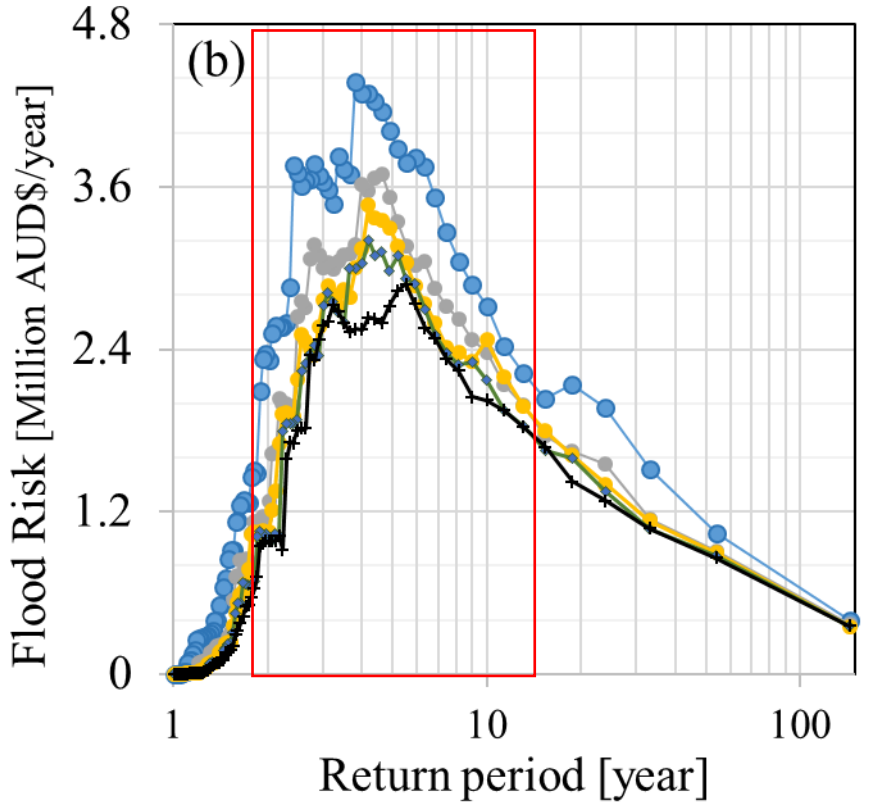
Testirani scenariji

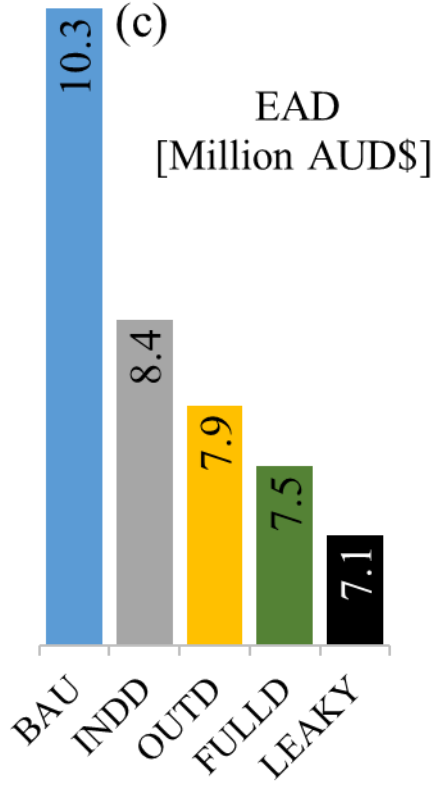
- BAU – bez rezervoara
- LEAKY – rezervoari su prazni pre kiše
- INDD – voda se koristi za toalete
- OUTD – voda se koristi za zalivanje
- FULLD – voda se za toalete i zalivanje

Analiza rizika od poplava

Šteta se smanjuje do 30%







Svi scenariji upotrebe kišnice smanjuju cenu štete

Uticaj je 2 - 10-god kiše je značajan

Limitacije

2-D model (Ca-ffe) treba da uključi dinamiku procesa.

Trenutno radimo na:

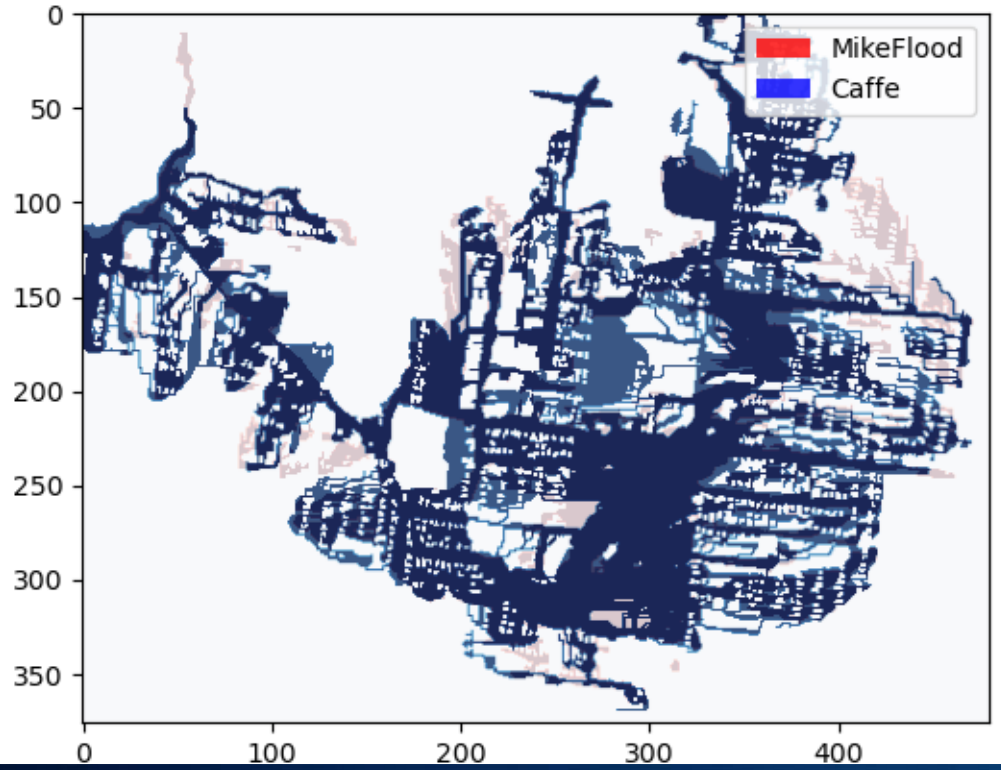
(1) Boljoj integraciji sa1D modelom kišnih cevi

(2) Uključivanju jednačine momenta u model;

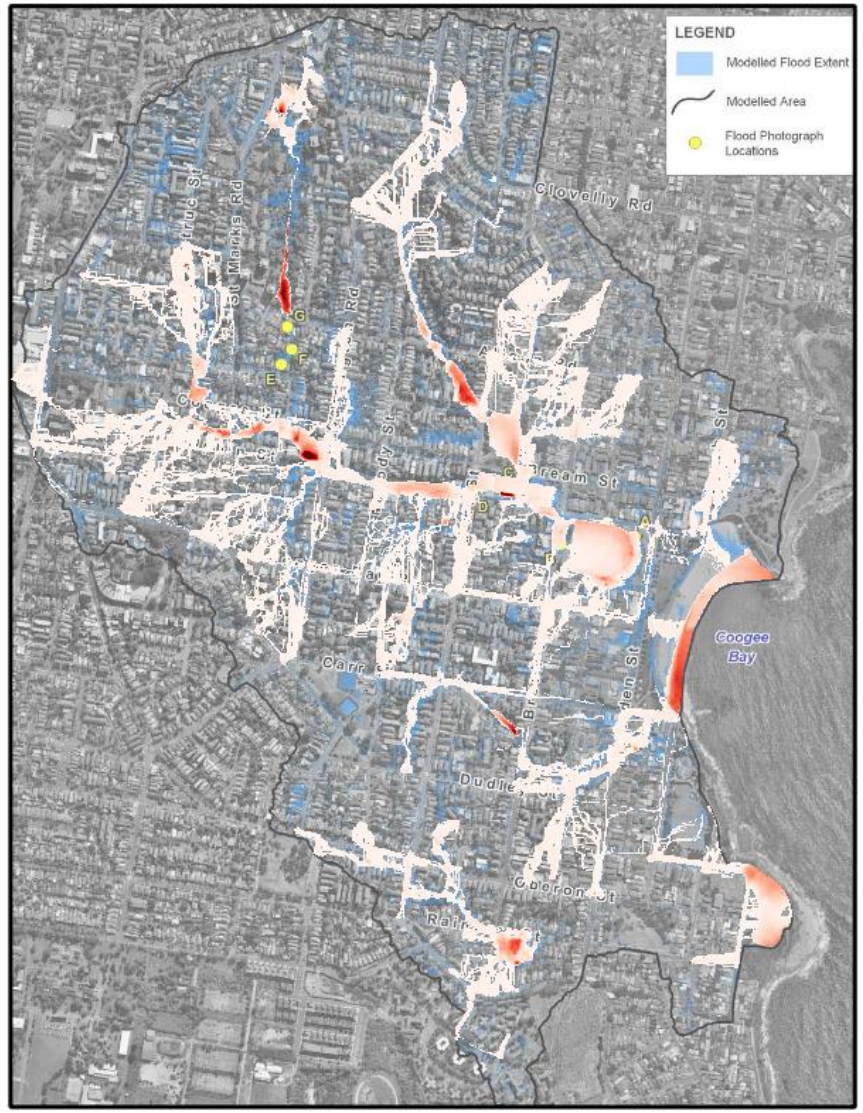
(1) Dynamic Fast Flood Model

- Simulira razvoj inundacije tokom vremena
- Povezuje 1D sa 2 D modelom u realnom vremenu

Scotchmans Creek



Coogee Bay



(2) ‘Data Driven’ Metode za rešavanje jednačine momenta

Momentum Equation (1D)

$$\frac{\partial}{\partial x}(hq^2) + \frac{\partial q}{\partial t} + gh\frac{\partial(h+z)}{\partial x} + \frac{gn^2|q|q}{h^{7/3}} = 0$$

Convective acceleration

Local acceleration

Pressure + gravity force

Friction force

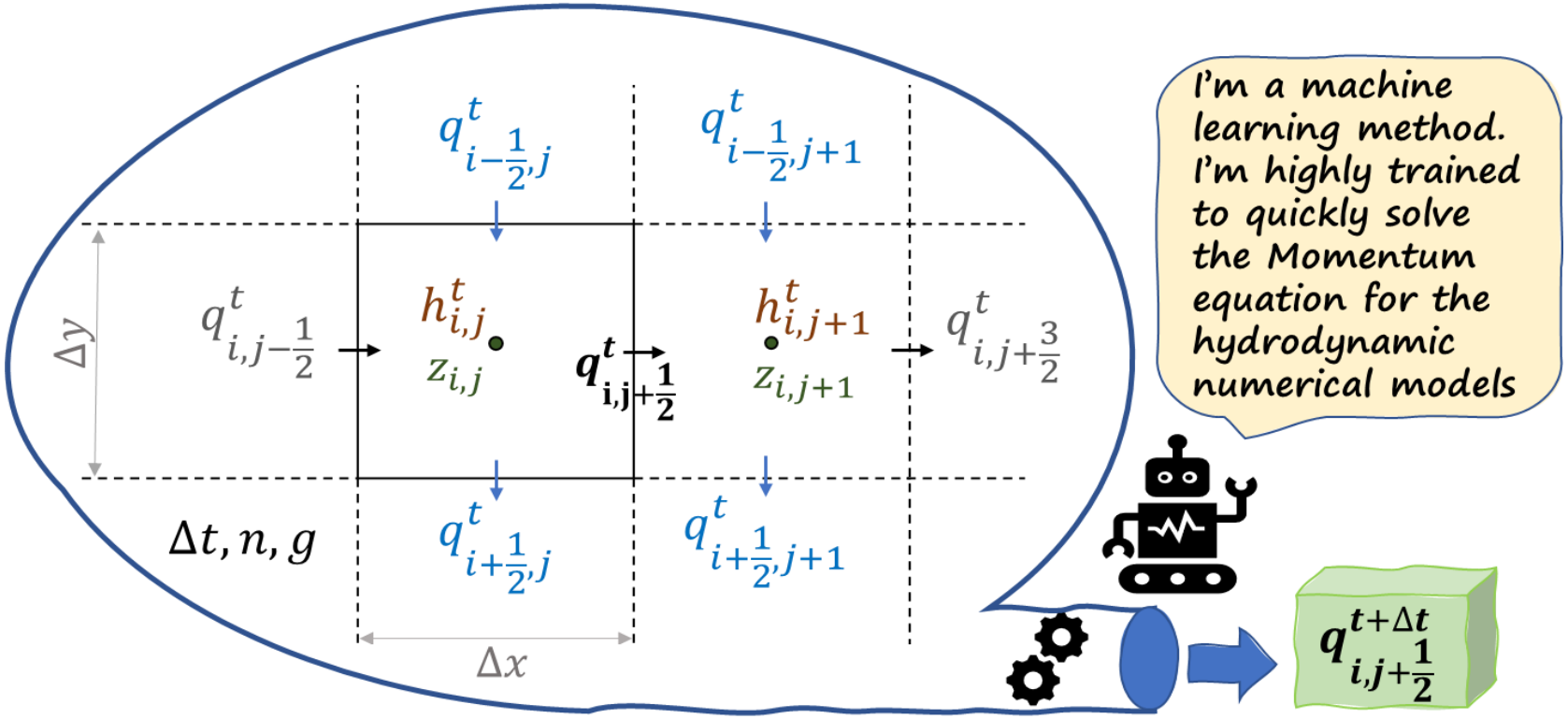
Kinematic Wave

Diffusion Wave

Local Inertial Approximation

Dynamic Wave

ML metode za rešavanje jednačine održanja momenta



Hibrid ML and Numericke metode

Received: 6 August 2020 | Revised: 21 January 2021 | Accepted: 22 January 2021

DOI: 10.1002/hyp.14064

RESEARCH ARTICLE

Hydrological Processes

Machine learning for accelerating 2D flood models: Potential and challenges

Behzad Jamali[1] | Ehsan Haghighat[2] | Aleksandar Ignjatovic[3] | João P. Leitão[4] | Ana Deletic[1,5]

Local Inertial Approximation

1.Curve fitting

$$q = \frac{a}{n} {h_f}^{\frac{5}{3}-b} S^{0.5-c}$$

Trained Manning's

$$q_{i,j+\frac{1}{2}}^{t+\Delta t} = \frac{\theta q_{i,j+\frac{1}{2}}^{t} + (1-\theta)\frac{q_{i,j-\frac{1}{2}}^{t} + q_{i,j+\frac{3}{2}}^{t}}{2} + g h_f \Delta t S}{1 + b \times g \Delta t n^2 \left\| a \times q_{i,j+\frac{1}{2}}^{t} \times h_f \right\| / ({h_f}^2 + c h_f)}$$

Trained Local Inertial

2. Artificial Neural Networks (ANNs)

$$q_{i,j+\frac{1}{2}}^{t+\Delta t} = ANN\left(q_{i,j+\frac{1}{2}}^{t}, q_{i,j-\frac{1}{2}}^{t}, q_{i,j+\frac{3}{2}}^{t}, h_f, S, q_{i+\frac{1}{2},j}^{t} + q_{i-\frac{1}{2},j}^{t} + q_{i+\frac{1}{2},j+1}^{t} + q_{i-\frac{1}{2},j+1}^{t}, \Delta t, \Delta y\right)$$

Simulation time [seconds]

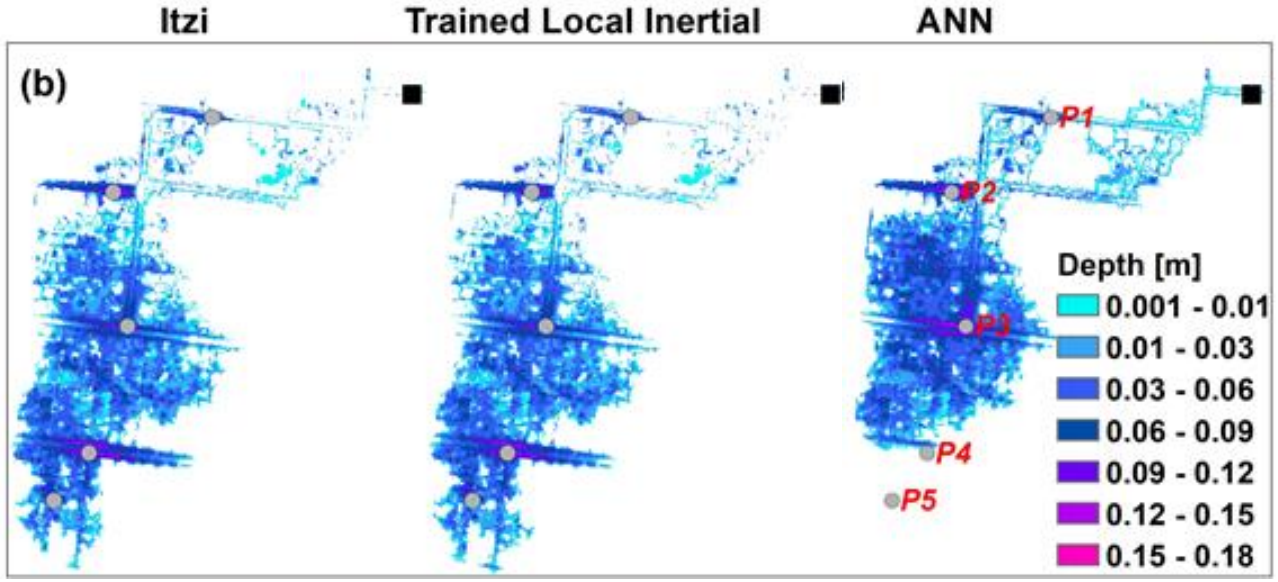
Test name	Local Inertial Model (Itzï)	Curve Fitting	ANN
T1-H1	5.3	4.7	139.4
T1-H2	5.0	4.7	108.3
T1-H3	4.4	4.0	105.0
T2-H1	5.3	4.8	130.9
T2-H2	5.1	4.7	106.8
T2-H3	5.1	4.8	86.3
T3-H4	184.5	167.8	5161.2
T4	3180	2427	Failed

Test T3-H4

Local Inertial Model

Curve Fitting

Neural Networks



~23% faster

~30X slower

Physics Informed Neural Networks

ELSEVIER

Journal of Computational Physics

Volume 378, 1 February 2019, Pages 686-707

Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations

M. Raissi [a], P. Perdikaris [b], G.E. Karniadakis [a]

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https://doi.org/10.1016/j.jcp.2018.10.045

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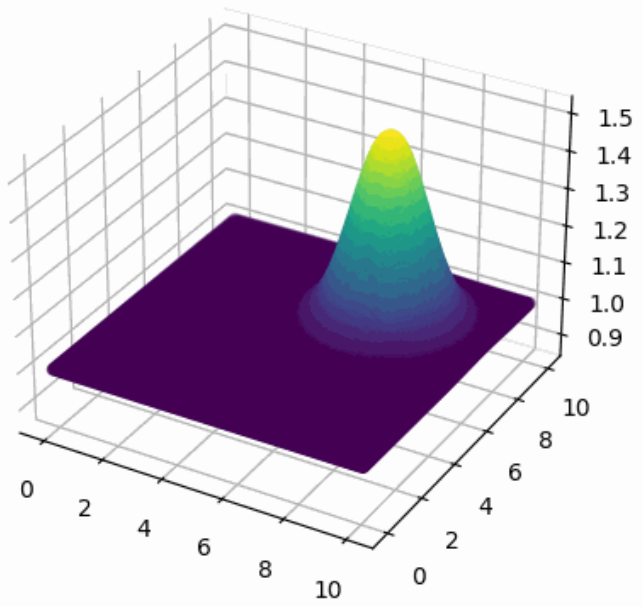
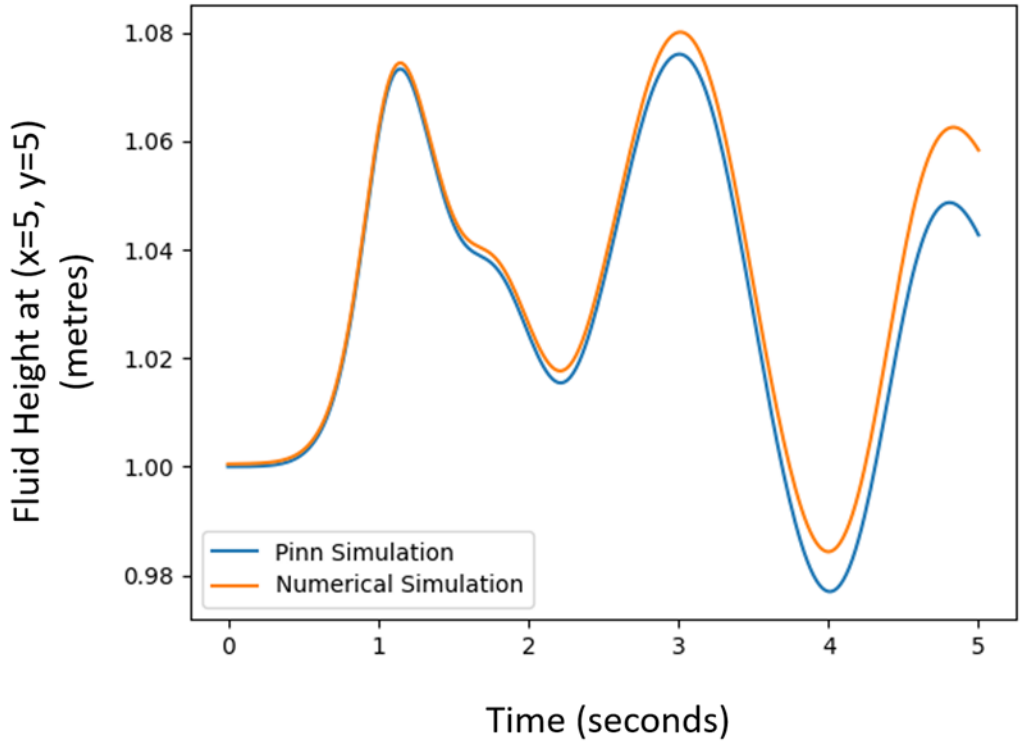
Physics Informed Neural Networks



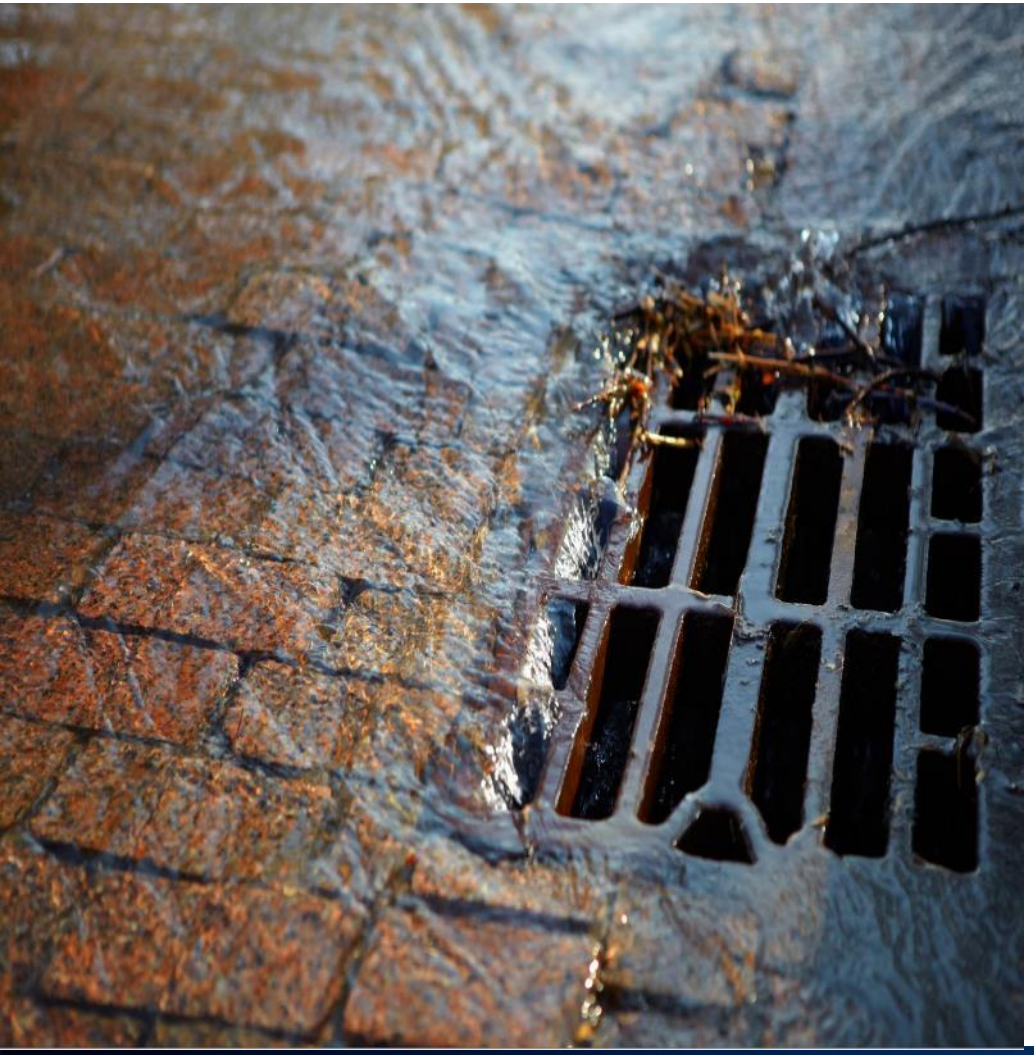
PINN Generated Simulation



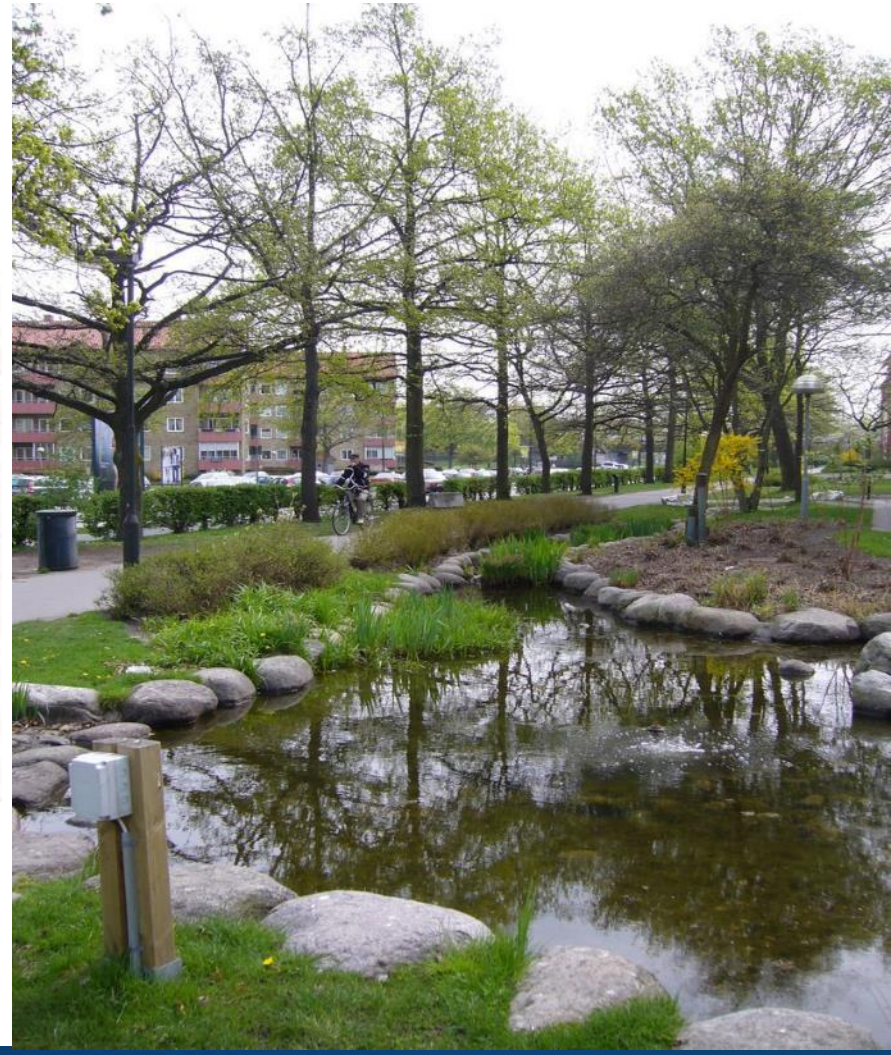
Numerically Generated Simulation

Active and attractive urban drainage systems for management of flash floods

Sivi Kanalizacioni Sistemi



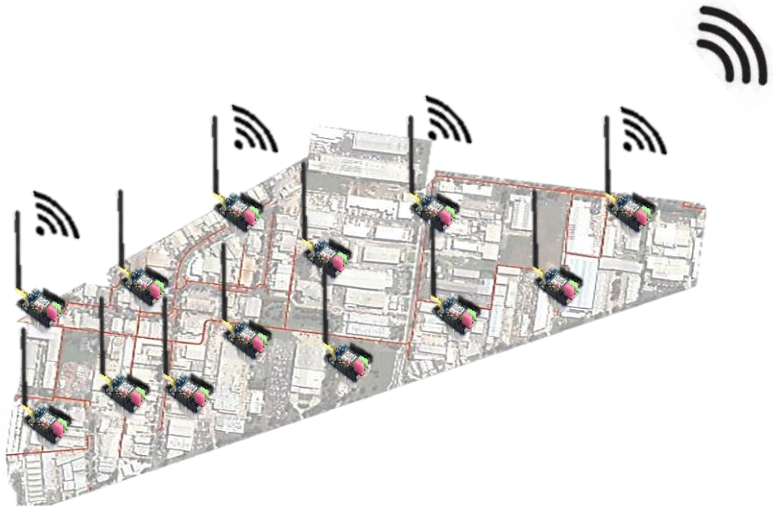
BGS



Obavezno je integrisati modele sa merenjima u realnom vremenu!

Cloud database

Online data adjustment



NextGen SENSOR ARMY

Flow detection → alarm

Old Joes Creek, Mel

Senzori su postavljeni u cevima :

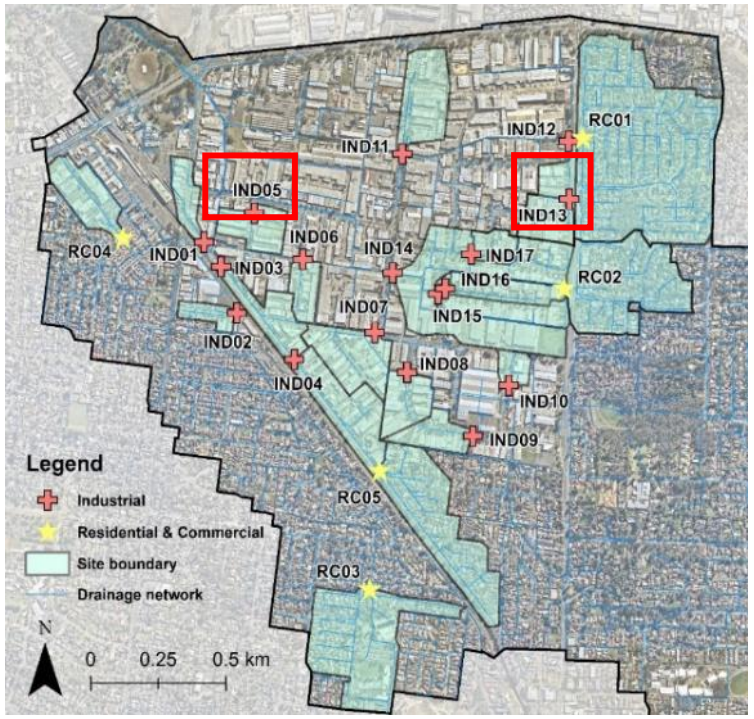
- 22 sensora za protok (17 IND + 5 R&C)
- Brza instalacija (30 min po mestu)

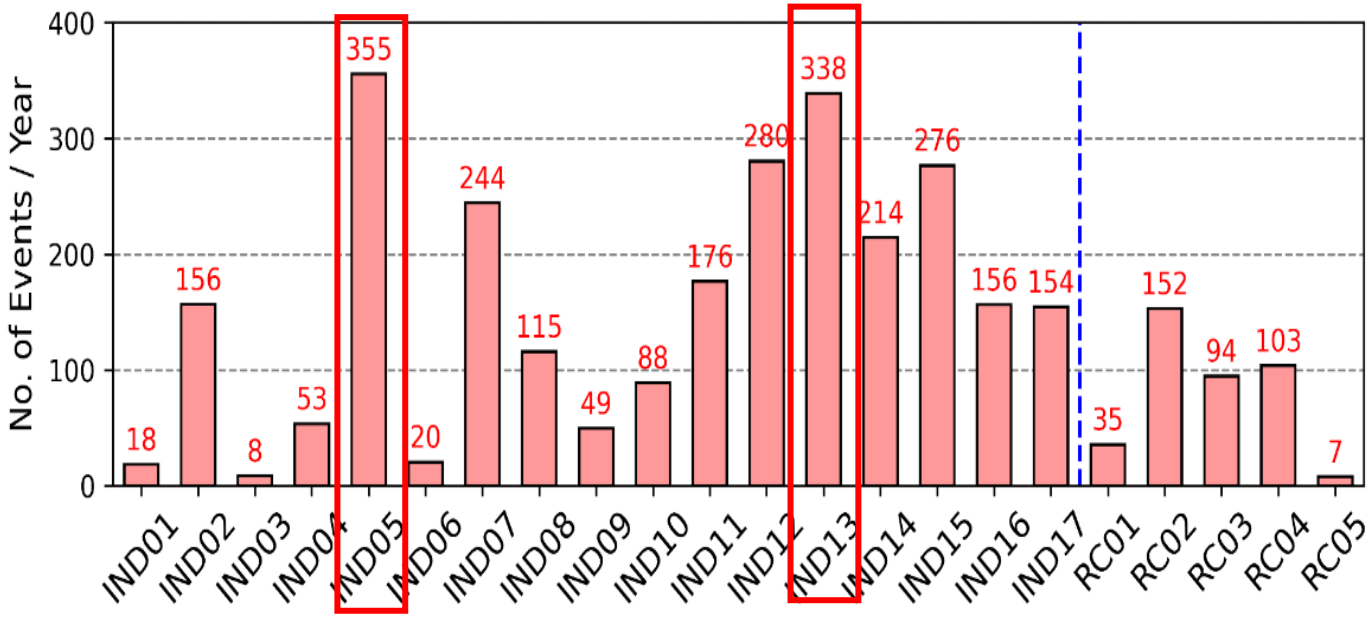
Merenja oticaja tokom suvih perioda tokom 1 godine

- IND - 160 kiša u industrijskoj zoni
- R&C - 79 kiša u stambenoj zoni

Trajanje zabeleženog protoka:

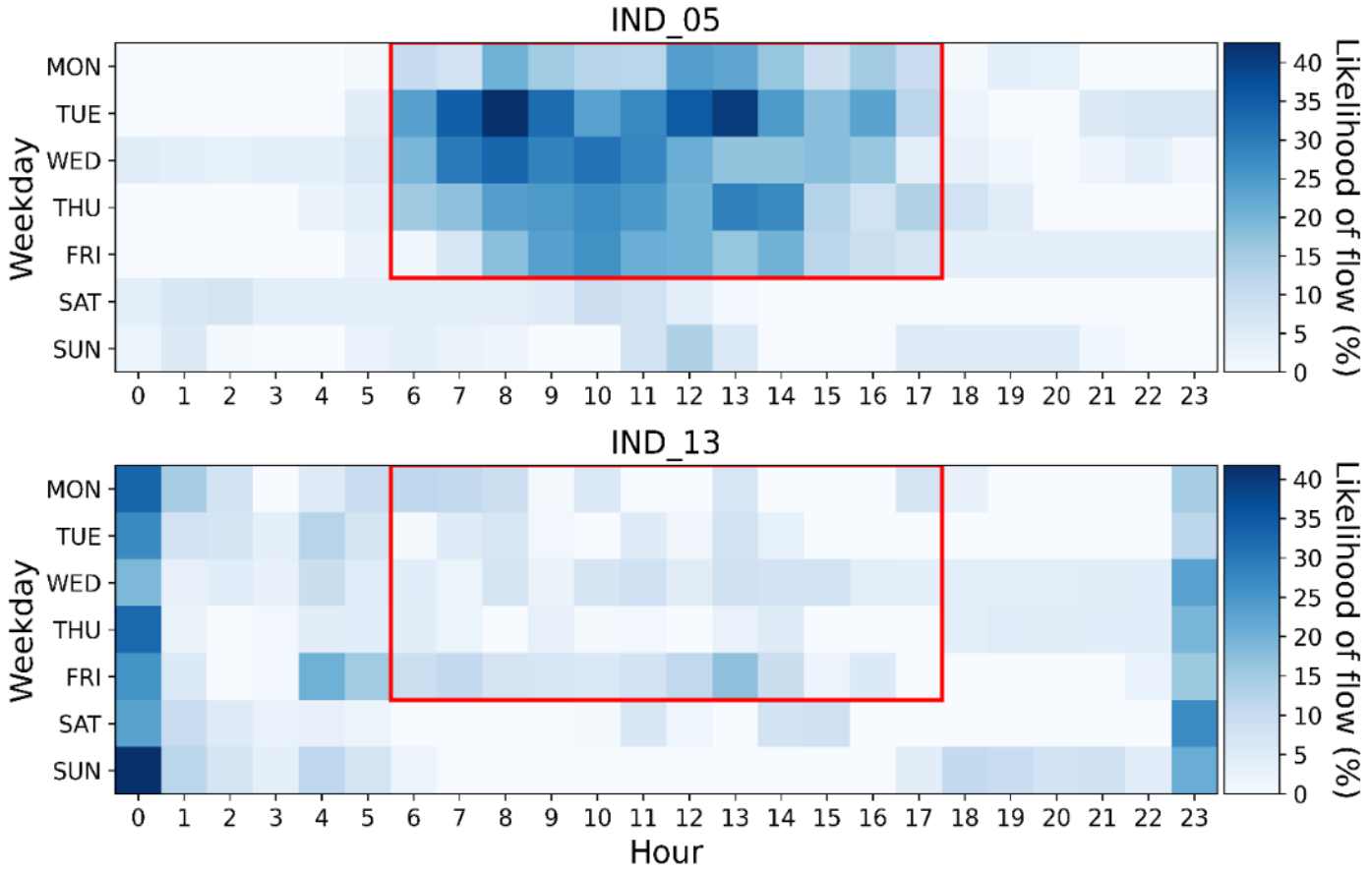
- IND – 51 min/kiši (median)
- R&C – 45 min/kiši (median)
- Otijacaji traju ispod 90 mins





Old Joes Creek, Mel

- IND05: zabeleženi oticaji su uglavnom **utorkom i sredom** ujutru i oko podne
- IND13: zabeleženi oticaji su uglavnom **nedeljom** u ponoć



→ Industrijski procesi?

Vremenska prognoza

Merenje

CA-ffé

Kontrola u realnom vremenu

+

HVALA