Drainage Network Configuration Focusing on the Flood Mitigation in Urban Catchments

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Outline

- Motivations and objectives
- Gibbs' model: A stochastic network model
- Drainage network characteristics of Seoul
- Drainage network configuration for flood mitigation
- Results and discussion

Motivations and objectives

- Topological and geomorphological characteristics of **drainage networks are essential to assess the hydrologic response of catchments.**

- **A stochastic network model** has been applied to regenerate or classify complex river net works.

- **Flood vulnerability in urban areas is increasing more and** more due to climate change a nd intense or rapid urbanization.

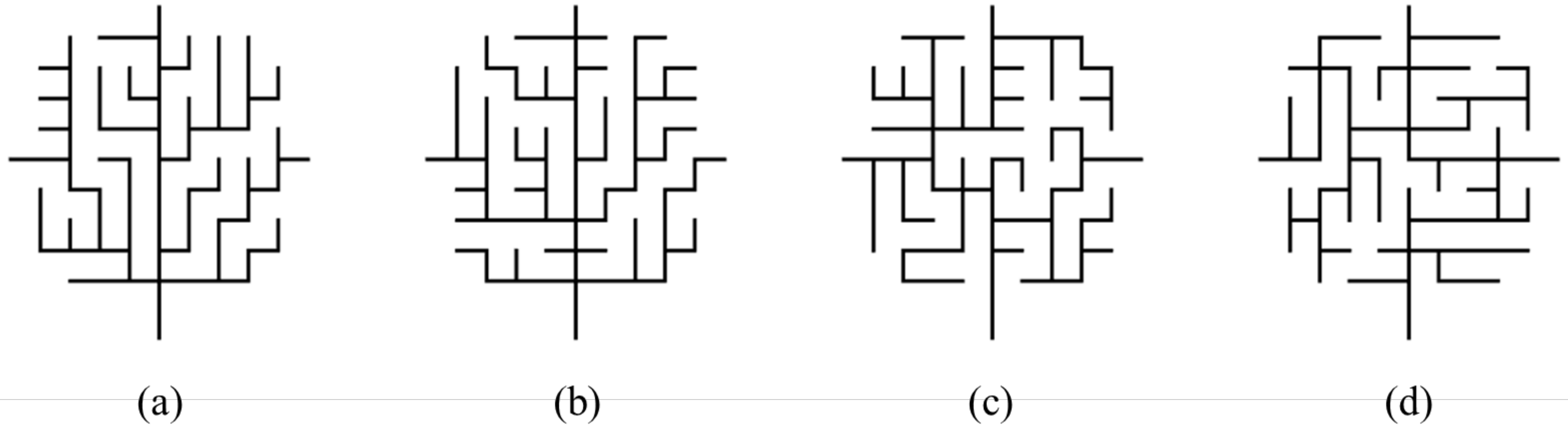
Motivations and objectives

- Various counter measures are introduced to urban catchments such as detention or retention ponds, pumping stations, levees and drainage systems to mitigate these impacts. However, **conventional and structural measures can trigger serious flood damages in case of failure due to operational problems.**

- This study aims to overcome limitation of conventional measures and focus on **sustainable drainage network configuration** that can operate persistently to prevent floods in the event of hydrologic extremes.

Gibbs' model: A stochastic network model

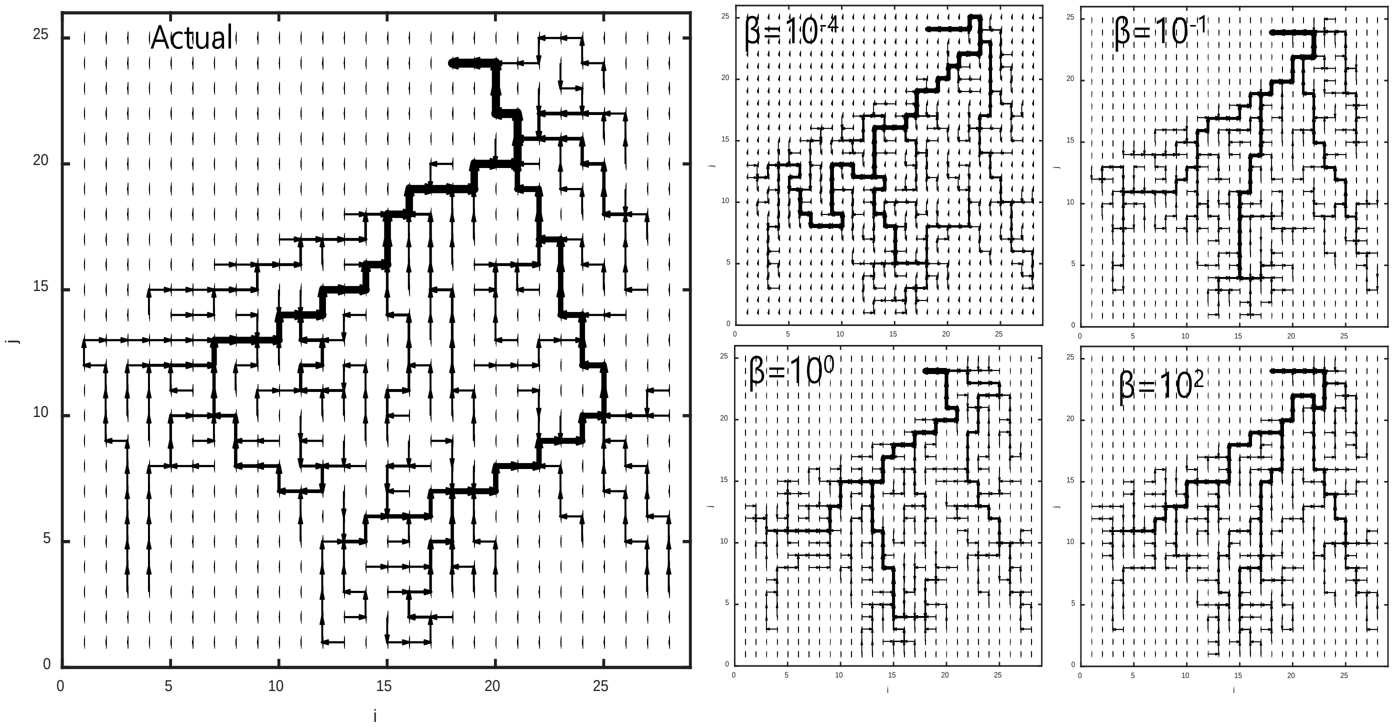
- Gibbs’ model includes both the Scheidegger model and the uniform model depending on the value of a parameter, *β*



a) The Scheidegger model, (b) Gibbs model with $\beta = 10^3$ and (c) $\beta = 10^{-4}$, and (d) the Uniform model

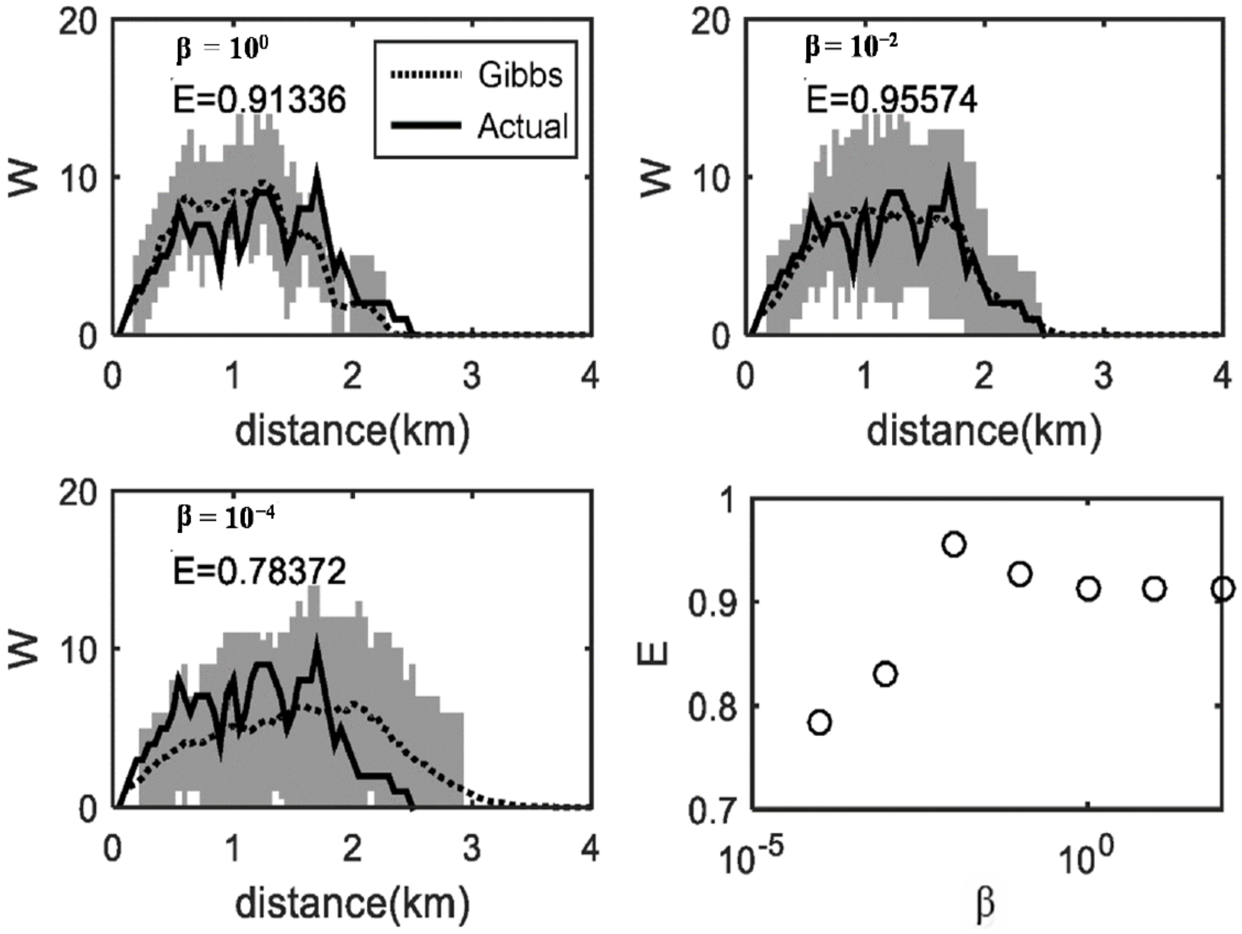
Gibbs' model: A stochastic network model

- As the value of β increases, the network becomes more an more sinuous and vice versa
- A network's value of β can be found by comparing the width function from the actual network and Gibbs' model for each value of β



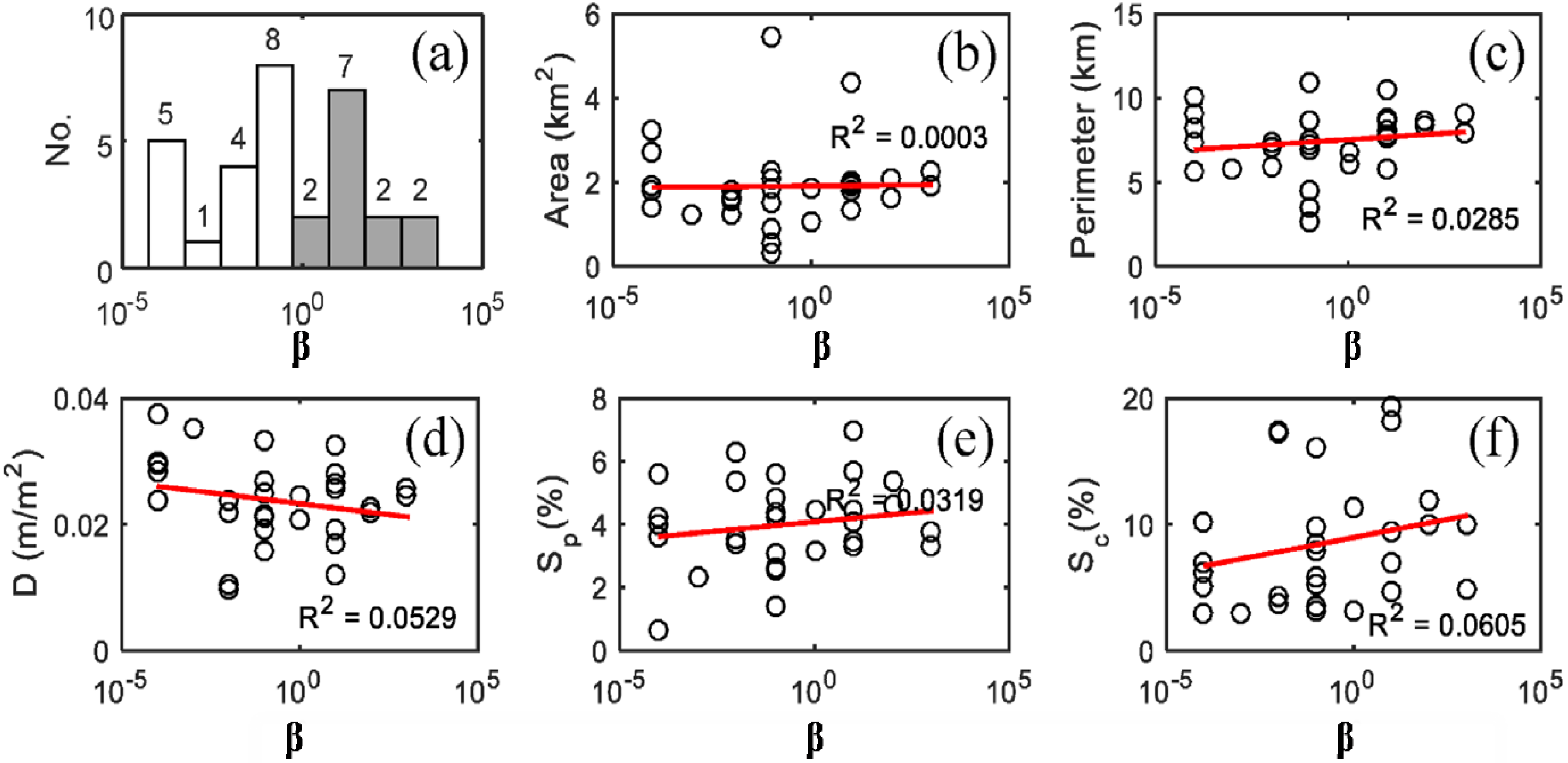
Drainage network characteristics of Seoul

- The analysis of drainage network in Seoul showed no close correlation between the network configuration and the topological characteristics of the catchment



Comparing the width function from the actual network and the Gibb's model

Drainage network characteristics of Seoul



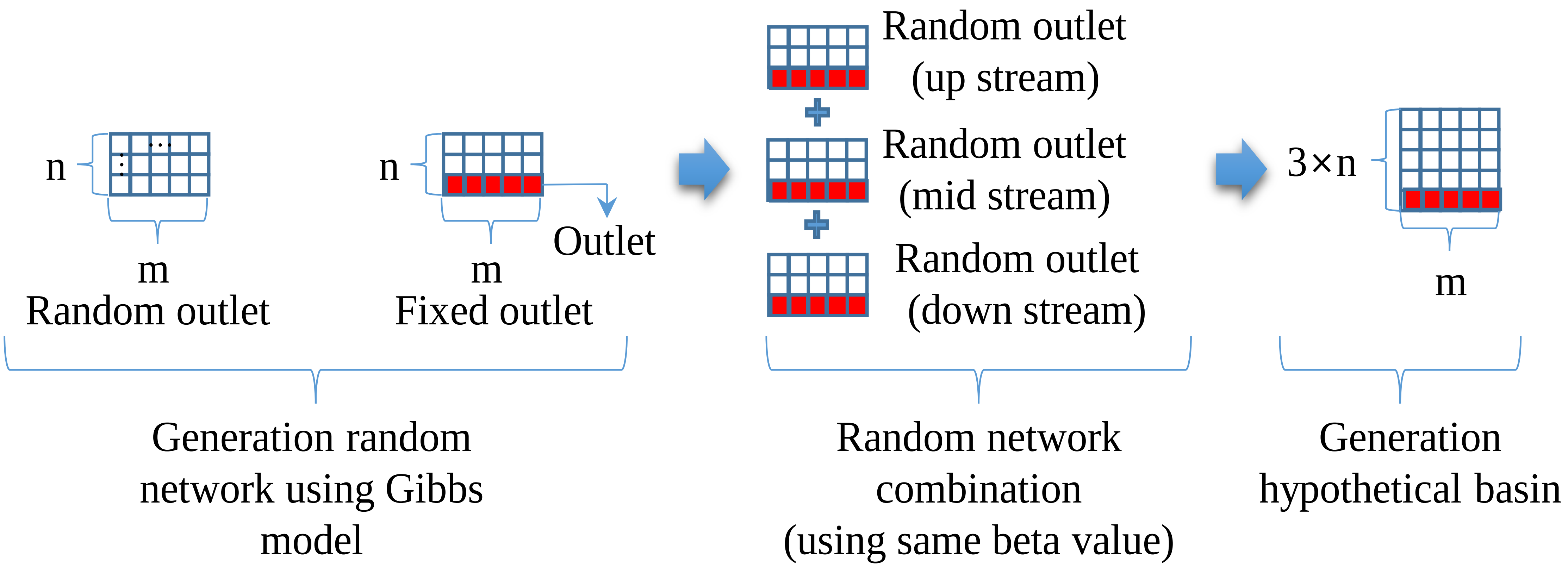
Relation between the network configuration and the topological characteristics of the catchment

Drainage network configuration for flood mitigation

Test for synthetic catchments

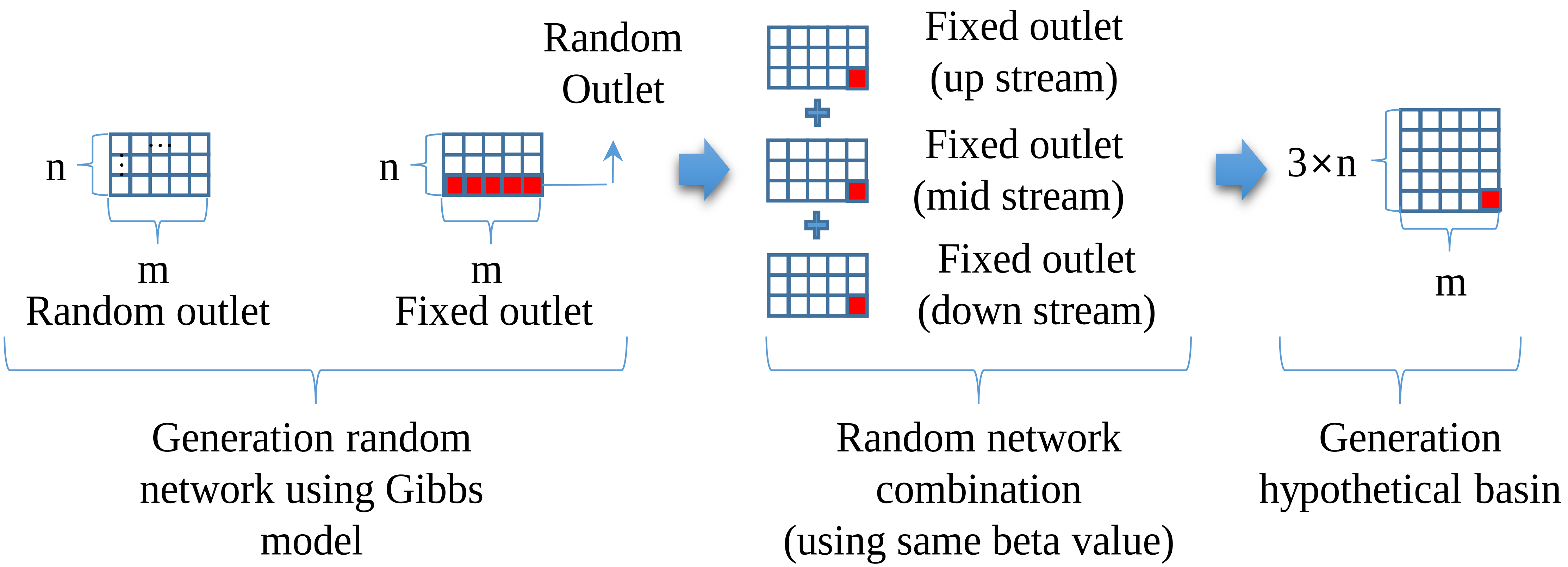
- This study adopted two types of synthetic catchments
- The first one is a square-shaped watershed (18×18), which is a combination of three 6×18 subcatchments in downstream, midstream and upstream
- The other is an elongated catchment (15×5), which is a combination of three 5×5 subcatchments in downstream, midstream and upstream

Drainage network configuration for flood mitigation



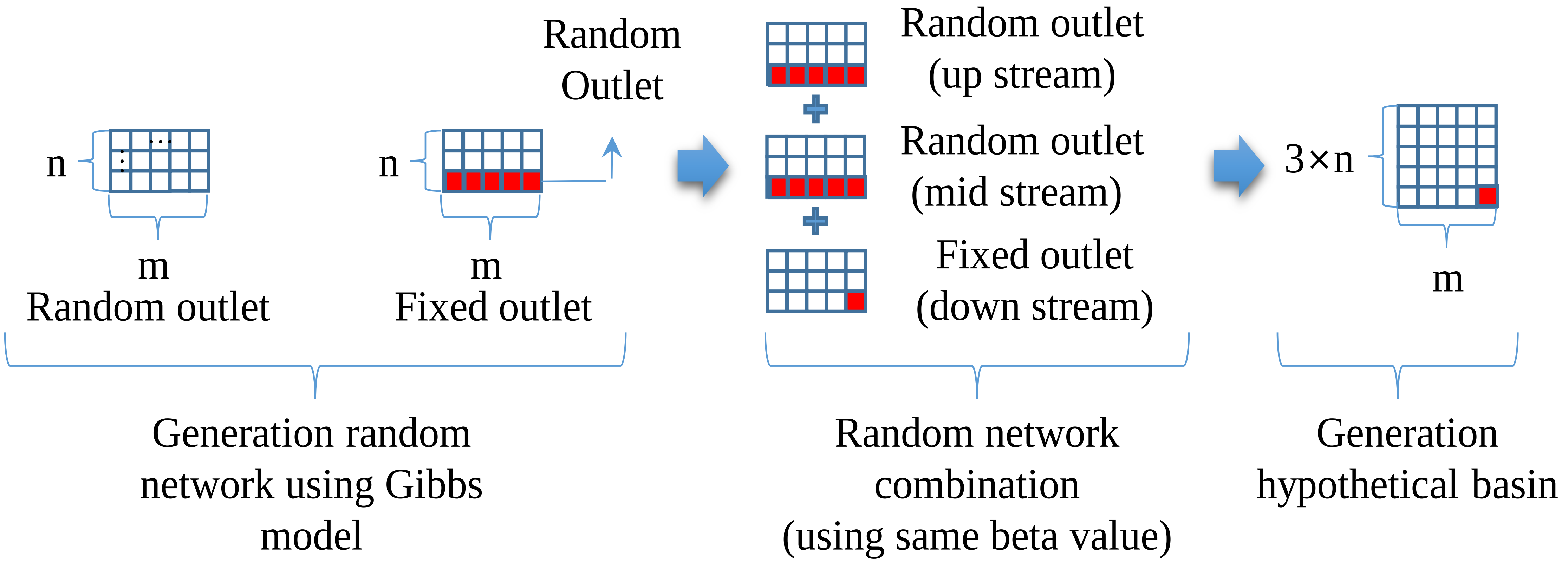
(a) Random outlet

Drainage network configuration for flood mitigation



(b) Fixed outlet

Drainage network configuration for flood mitigation

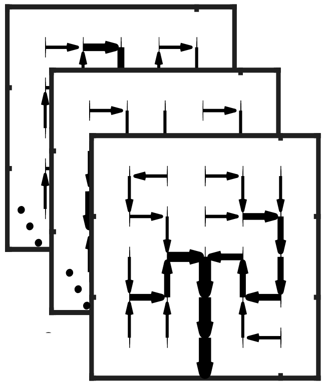


(c) Down stream Fixed outlet

Drainage network configuration for flood mitigation

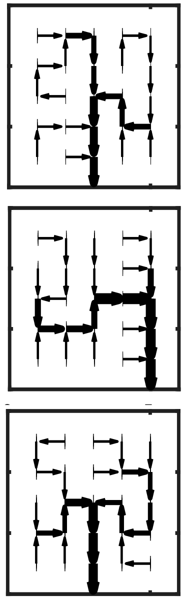
Two types of catchment geometry

5×5



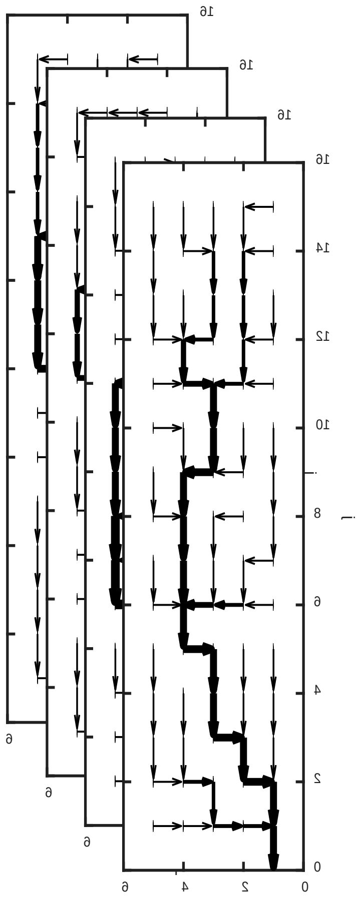
100 set

combination



15×5

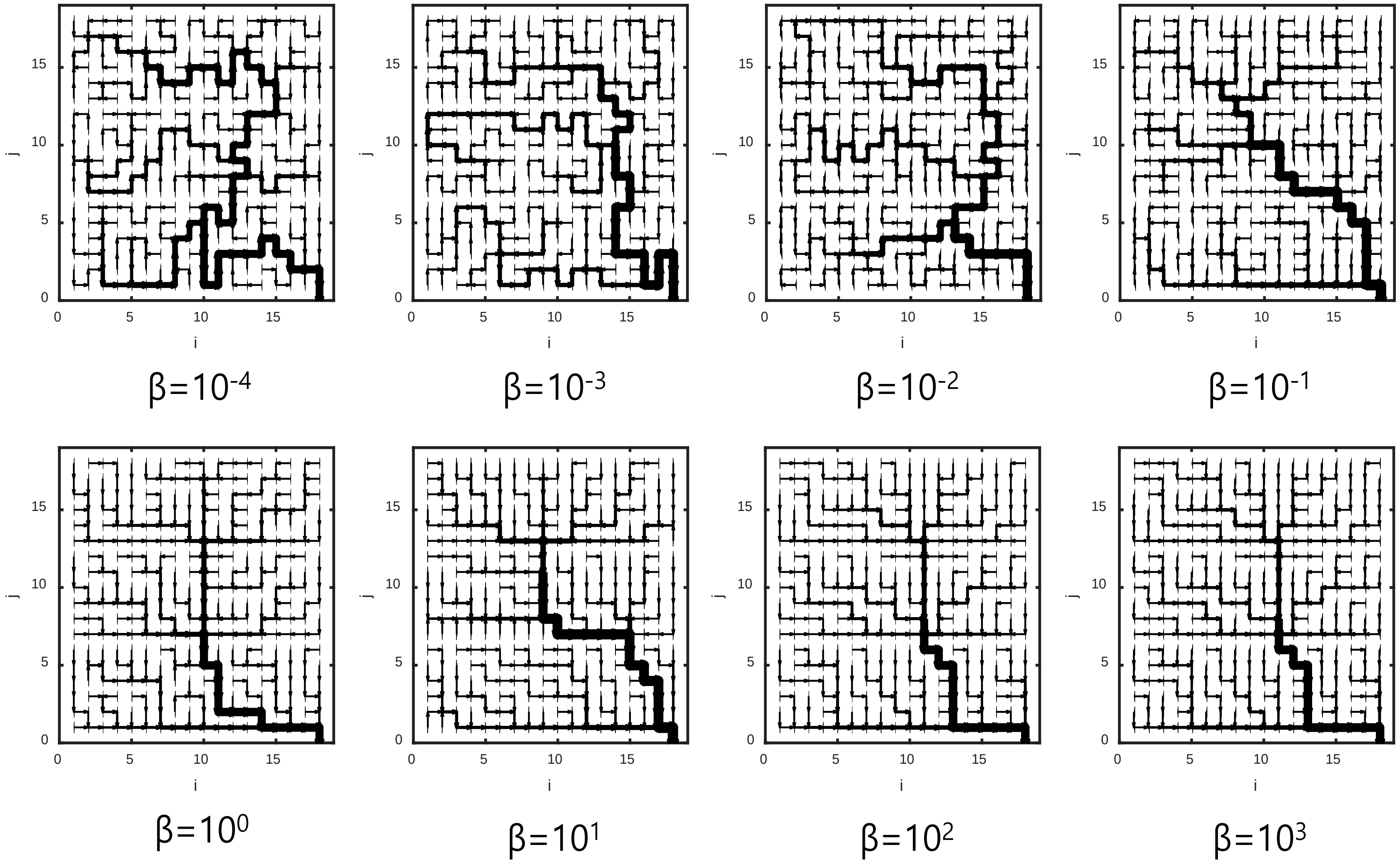
generation



15×5 size basin
161,700 set

Drainage network configuration for flood mitigation

Two types of catchment geometry



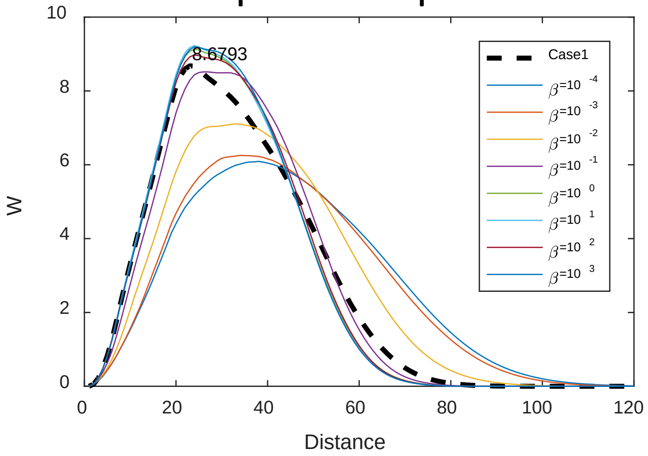
Results and discussion

Modeling summary

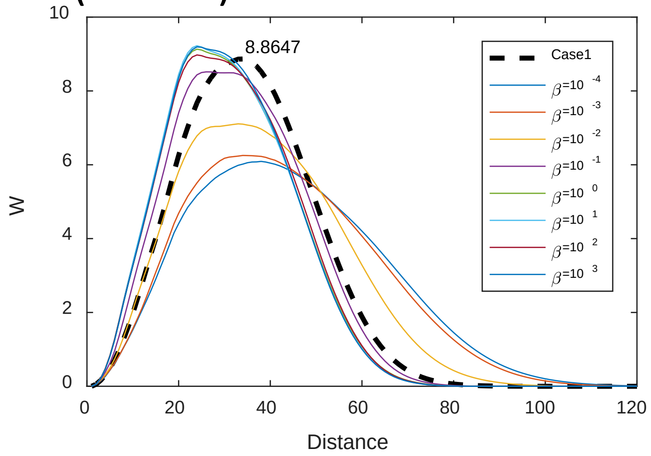
- Random outlet or fixed outlet
- Combination of three network configuration: 10^{-2}, 10^{-1}, 10^{0}
- Case 1: Network configuration increases in downstream direction “Up to Down”
- Case 2: Network configuration decreases in downstream direction “Down to Up”
- The network configuration for the entire catchment remains the same but internal network configuration changes

Results and discussion

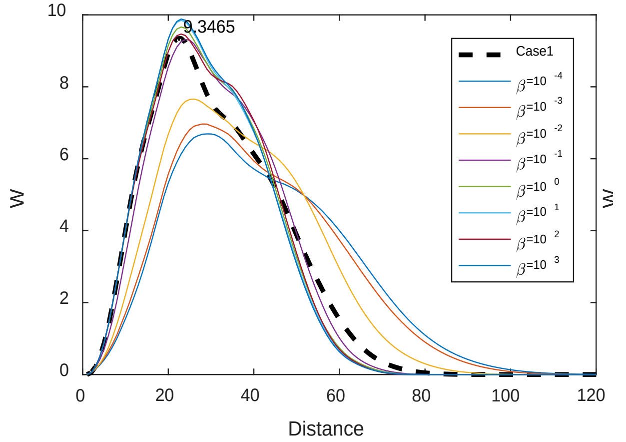
For the square-shaped watershed (18×18)



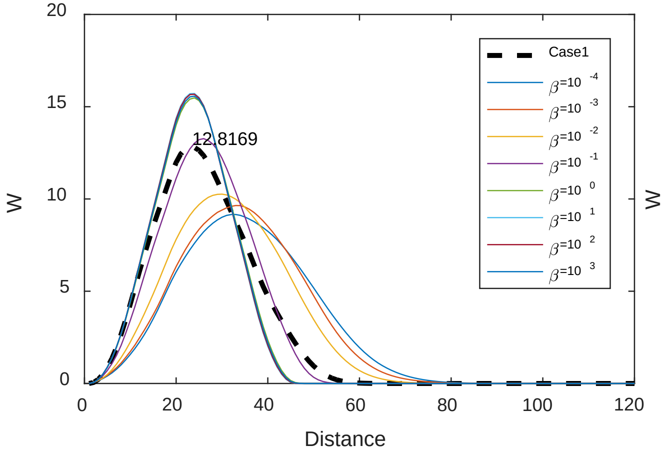
Random outlet (Up: β=10^{-2}, Mid: β=10^{-1},Down: Mid: β=10^{0})



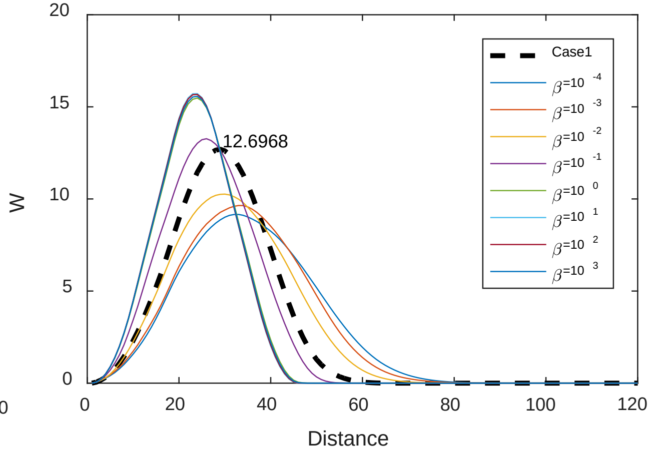
Random outlet (Up: β=10^{0}, Mid: β=10^{-1},Down: Mid: β=10^{-2})



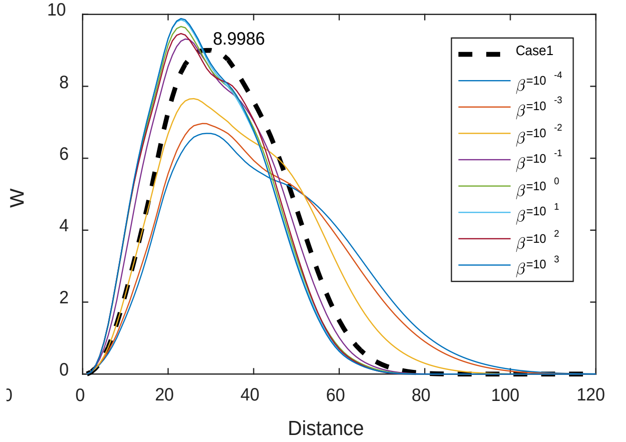
Down stream fixed outlet (Up: β=10^{-2}, Mid: β=10^{-1},Down: Mid: β=10^{0})



Fixed outlet (Up: β=10^{-2}, Mid: β=10^{-1},Down: Mid: β=10^{0})



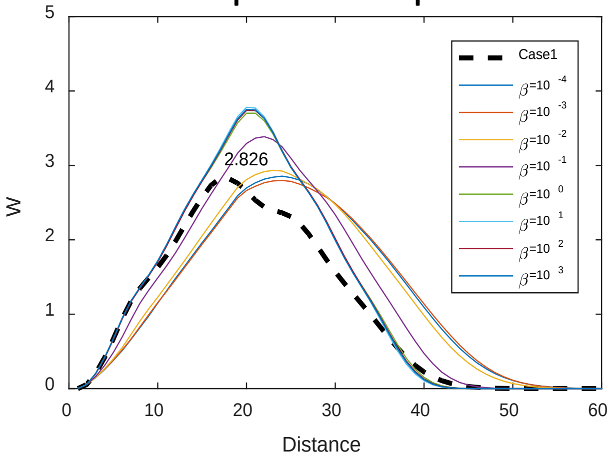
Fixed outlet (Up: β=10^{0}, Mid: β=10^{-1},Down: Mid: β=10^{-2})



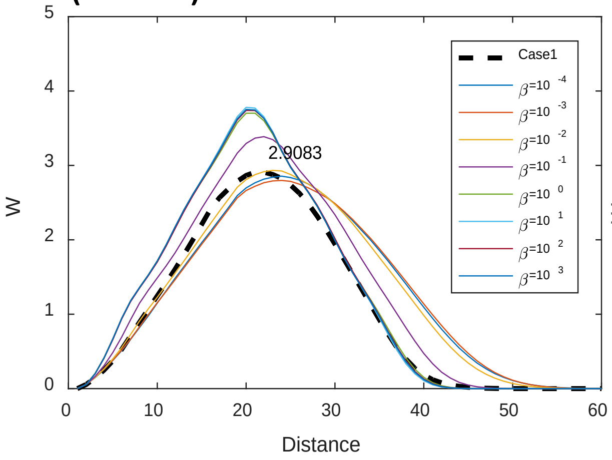
Down stream fixed outlet (Up: β=10^{0}, Mid: β=10^{-1},Down: Mid: β=10^{-2})

Results and discussion

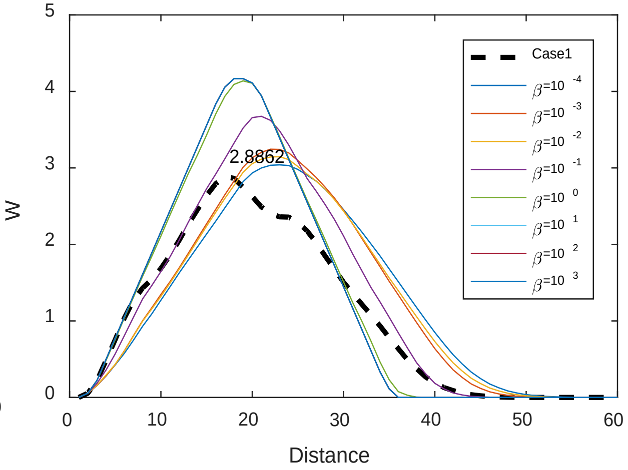
For the square-shaped watershed (5×15)



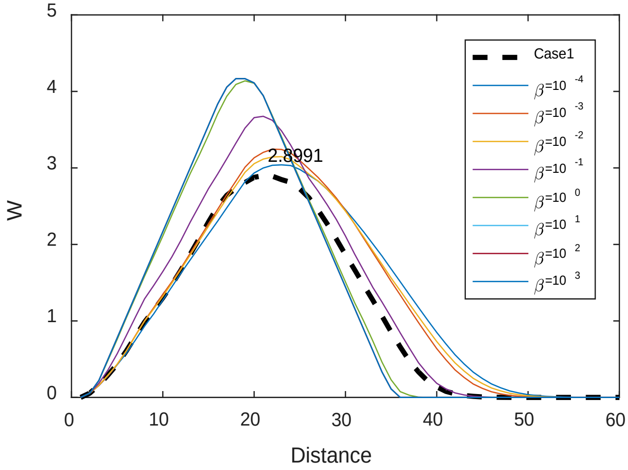
Random outlet (Up: $\beta=10^{-2}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{0}$)



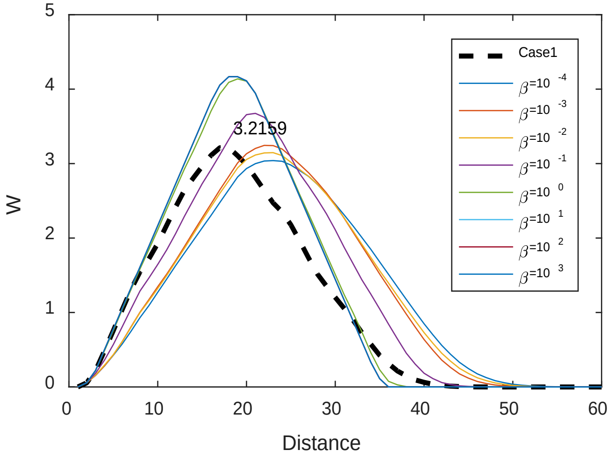
Random outlet (Up: $\beta=10^{0}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{-2}$)



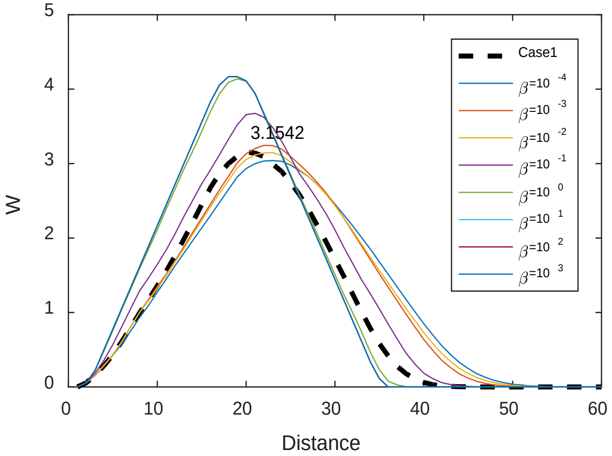
Down stream fixed outlet (Up: $\beta=10^{-2}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{0}$)



Down stream fixed outlet (Up: $\beta=10^{0}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{-2}$)



Fixed outlet (Up: $\beta=10^{-2}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{0}$)



Fixed outlet (Up: $\beta=10^{0}$, Mid: $\beta=10^{-1}$,Down: Mid: $\beta=10^{-2}$)

Results and discussion

- We expected Case 2 would show higher peak than Case 1 because the network configuration of Case 1 would bring about “disperse effect” for the flow and the peak would decrease
- However, the results were against what we expected and the peak flows for Case 1 are higher than Case 2

Results and discussion

- In all cases, the combined network configuration reduces the peak flows compared with the single network configuration of the synthetic catchment
- These results imply the importance of a drainage network layout in the design stage to reduce the flood risks in urban catchments

Thank you very much for your attention!

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