Analysis of urban inundation considering pathway of downpour-rainfall based on radar data

Analyse des inondations urbaines à partir de données radar, en prenant en compte les chemins de l'eau pour des pluies torrentielles

Hiroaki Furumai[1], Keisuke Kojima[2]

[1]The University of Tokyo, Tokyo, Japan
(furumai@env.t.u-tokyo.ac.jp)
[2]Shimizu Corporation, Tokyo, Japan
(kojima_k@shimz.co.jp)

ABSTRACT

When conducting the urban inundation analysis by distributed runoff model, it is important and desirable to give rainfall data with high resolution of space-time rainfall distribution in order to evaluate the detailed inundation situation. It is known that inundation situation is influenced by not only total rainfall volume, maximum intensity, and duration time observed by rain gauge but also distribution of localized downpour area. In this study, inundation simulation results were compared between using rain gauge data (56 precipitation stations) and using radar rainfall data (250 m mesh). The effect of pathway of downpour area was discussed from the viewpoint of inundation occurrence and its location and duration.

By using radar rainfall data with higher resolution, it is possible to evaluate the inundation analysis considering localized downpour area accurately (Fig. 1). The comparison of the results suggested that it is more useful to investigate the more detailed inundation situation using 250m mesh radar data. Since it is easy to evaluate the effect of pathway of localized downpour area with using radar rainfall data, radar data should be more effectively used for urban inundation analysis so that the changes of inundation situation and its risk could be evaluating in association with the rainfall characteristics including the pathway of localized downpour area.

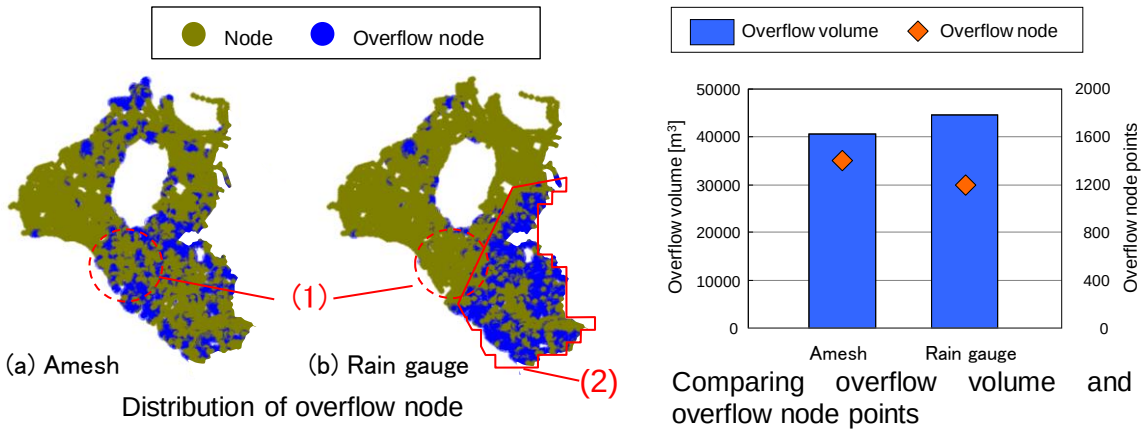


Fig. 1 Simulation of inundation situation. Distribution of overflow (left) and comparing overflow volume and overflow node points (right). (1)Results by using Amesh radar could express local inundations. (2)Results by using rain gauge data was reflect compartmented rainfall information

KEYWORDS

Downpour-rainfall, radar data, urban inundation

In what aspects does this case study:

Integrate stormwater?

Prediction of urban inundation by urban runoff simulation model using X band radar data was discussed in our case study.

Has a sustainable approach?

The outcome of this case study is useful to provide effective countermeasures for control urban inundation considering detailed rainfall distribution including localized downpour rainfall which is captures by X-band radar data. It is directed to development of sustainable urban drainage plan.

Has a multi-actor approach?

This case study was collaborative work by our university and Tokyo Metropolitan Government. We conducted model simulation using radar data, sewer pipes and networks data and Land-use type data provided by Tokyo Metropolitan Government.

Is innovative?

Radar data and model simulation are themselves not new. However, we focused on localized downpour type of rainfall which can be grasped by the high resolution radar data. Urban runoff and inundation simulation model with different pathway scenarios of heavy rainfall shows a new direction to deal with localized inundation by downpour.

Is exemplary?

This case study introduces the important step for highly accurate inundation analysis considering downpour rainfall pathway.

Is applicable to other projects?

The simulation work is applied to prediction of inundation in Tokyo. When similar data sets are available, the procedure in this study can apply to other urban area. In addition, based on this highly accurate inundation analysis, it might be used for selection of effective inundation control measures.

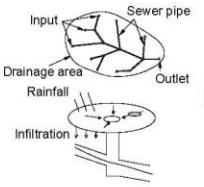
Analysis of urban inundation considering pathway of downpour-rainfall based on radar data

Analyse des inondations urbaines à partir de données radar, en prenant en compte les chemins de l'eau pour des pluies torentielles

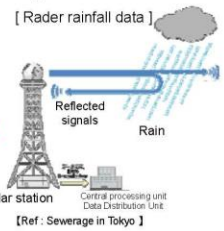
1 Background

- Advanced inundation analysis

[Distributed runoff model]



[Rader rainfall data]



【Ref : Sewerage in Tokyo 】

"Tokyo Amesh"

- X-band radar
- 250 m mesh
- 1 min. interval
- Widely used for website and mobile phone

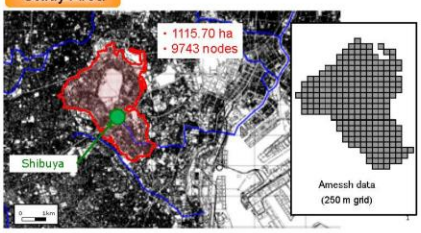
【Ref : Sewerage in Tokyo 】

Objectives

1) To compare the inundation simulation results between using rain gauge data (56 precipitation stations) and using radar rainfall data (250 m mesh).
2) To evaluate the effect of pathway of downpour area on inundation situation from the viewpoint of inundation occurrence and its location.

2 Material and Methods

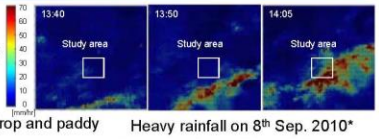
Study Area



Runoff analysis

Distributed model, InfoWorks CS (Version 10.0)

- Land-use type data
  - Pervious (⇒ Horton model)
    Railway, Green zoon, Pervious vacant space, Crop and paddy
  - Impervious (⇒ PR model)
    Roof, Road, water surface, Impervious vacant space
- Rainfall data (1 min. interval data)
  - Rainfall gauge data. (7 stations)
    Each rainfall information was given to each district subdivided by the Tiessen method.
  - Amesh data. (240 meshes)

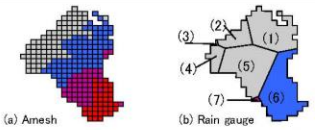


Heavy rainfall on 8th Sep. 2010*

*The transfer pathway of downpour-rainfall was from the southwest to the northwest

3 Results and discussion

- Compare to using 2 rainfall data



Total precipitation distribution on 8th Sep., 2010

Characteristics of rainfall on 8th Sep., 2010 (Amesh)

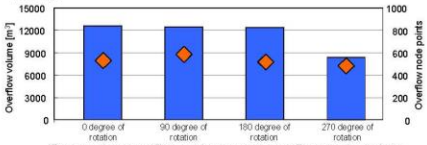
Precipitation stations	Average	Max	Min
Total precipitation [mm]	92.7	126.7	68.7
Duration time [min]	760	789	677
Rain intensity [mm/h]*		204	55

*Calculating by mm/min

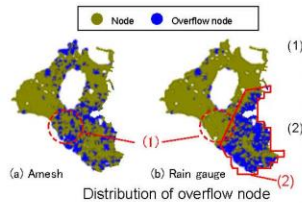
Characteristics of rainfall on 8th Sep., 2010 (Rainfall gauge)

Precipitation stations	Total precipitation [mm]	Area [ha]
(1) Shinjuku	49	233.53
(2) Yayoicho	45	99.05
(3) Wadamibashi	37	0.52
(4) Kitazawa	46	58.29
(5) Komaba	66	328.17
(6) Shibuyabashi	99	393.65
(7) Kamimeguro	103	2.49

- Compare to different rainfall transfer pathway
  - Based on actual amesh data on 8th Sep., 2010, and equalizing the total precipitation (92.7 mm) of all meshes
  - Rainfall started from the southwest to the northwest (0 degree of rotation

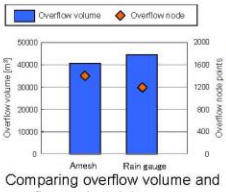


Comparing overflow volume and overflow node points

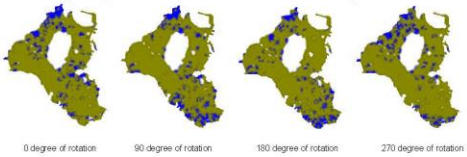


Distribution of overflow node

(1) Results by using Amesh radar could express local inundations
↓
increasing overflow nodes
(2) Results by using rain gauge data was reflect compartmented rainfall information.
↓
differences occur in overflow volume



Comparing overflow volume and overflow node points



Comparing the distribution of overflow node

Even if the total precipitation is same, inundation condition is different due to the difference of space-time distribution of rainfall event.

4 Conclusions

- It is useful for urban inundation analysis to consider occurrence of localized downpour area using radar rainfall data with higher resolution. We showed different inundation analysis results with rainfall data by rain gauge and radar.
- Since it is easy to evaluate the effect of pathway of localized downpour area with using radar rainfall data, radar data should be more effectively used for urban inundation analysis so that the changes of inundation situation and its risk could be evaluating in association with the rainfall characteristics including the pathway of localized downpour area.

Keisuke Kojima*,** and Hiroaki Furumai*

* Research Center for Water Environment Technology, School of Engineering, The University of Tokyo,
**Institute of Technology, SHIMIZU CORPORATION

Today's Work, Tomorrow's Heritage