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Discussions

Interactive comment on "Scenario-based inundation analysis of metro systems: a case study in Shanghai" *by* Hai-Min Lyu et al.

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This article proposed an approach to investigate the flood risk to metro system. This is an interesting topic for urban management to improve flood resilience of significant infrastructure. To achieve the objective, the metro system of Shanghai is studied. The authors have used SWMM software to simulate the scenario and developed an algorithm to calculate the inundation depth. The results are very useful for the metro management and decision-making for municipal government. However, the following weak points have to be addressed.

Answer: Thanks for the reviewer's positive and suggestive comments. We have revised the manuscript according to the comments point by point.

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GENERAL COMMENTS: - The equations have to be clearly referenced.

Answer: Thanks for the reviewer's comment. The Eqs. (1) to (3) have been referenced. Other equations are proposed by authors.

- A brief summary of the simulated scenario should be added to the introduction. It seems that some repeat information is provided in section to make it lengthy otherwise.

Answer: We have summarized the scenario-based inundation analysis from line 1 to line 6 in page 3.

Line 1-6 in page 3: Scenario-based inundation analysis presents inundation risk under different scenarios (Willems 2013; Naulin et al. 2013), which requires the topography, land-use, and urban drainage system data. Owing to the complex interaction between the drainage system and overland surface in urban regions, scenario-based models can only simulate inundation over a small range, e.g., less than 3 km2 (Wu et al. 2017), which limits their application. Thus, the application of scenario-based model needs to be extended to the problem of overland flow over a large scale, e.g. whole region with area over several hundred square kilometers.

SECTION 2.2 - value of r is taken as 0.45. how is this value determined?

Answer: Thanks for the reviewer's comment. The value of r is an empirical value. We refereed the related publication to determine is as 0.45. We have added the reference in context in line 11 in page 7.

Reference: Yin, J., Yu, D.P., Yin, Z.E., Liu, M., and He, Q.: Evaluating the impact and risk of pluvial flash flood on intra-urban road network: A case study in the city center of Shanghai, China. Journal of Hydrology. 537, 138-145, doi: 10.1016/j.jhydrol.2016.03.037, 2016a.

- Type of soil in the study area should also be added so as to get a clear image of the study site. This is an important point missed. Answer: Thanks for the reviewer's comment. The soil type of the study area has been added in the revised manuscript.

The study area is located in urban center, where the dense buildings exist. The blocking effects have important influence on surface flow. We have added this section from line 6 to line 25 in page 10.

Line 6-25 in page 10: The impervious parameter was determined based on the types of land use. The study area is located in urban centre, where the land use has no big changes. The existence of dense buildings in the study area makes more than 80% of the surface is impervious. Due to the existence of road pavement, subgrade and many municipal pipelines under the road, the water infiltration through road and subsurface under road is very small, which can be considered as impervious. Thus, soil infiltration and evapotranspiration have slight effects on surface runoff concentration during short-term flash flooding under rainstorm. The soil infiltration mainly depends on green land (combined by lawn, flower bed, and grove) and water body within the study area. In this aspect, the geotechnical information in Shanghai is as follows. The groundwater table is higher than 2 m below ground surface. The soil type at the depth 2 m is a mixed soil with of sand (5%), silt (55%), and clay (40%) according to Shanghai Geotechnical Investigation Code (DGJ08-37-2012). At the surface, sand content increased to 15%, so that soil has the hydraulic conductivity of 2ïĆť10-5 m/s, which is 72 mm/h; at the bottom of water body, the soil has more clay content (>50%) and less sand content (<5%) with the hydraulic conductivity of 2ïĆť10-7 m/s, which is 0.72 mm/h (Shen et al., 2015). According to the SWMM handbook, the maximum infiltration rate is determined as 72 mm/h to reflect the characteristics of green land, while the minimum value is 0.72 mm/h to reflect the characteristics of water body, since the soil under water body is saturated clay. In addition, the blocking effects of the buildings have significant influences on the surface runoff generation and concentration. Therefore, the heights of the existing buildings were extracted to modify the elevation of the calculated grids, which have crucial influence on the redistribution of rainwater during calculation.

- Do assumptions made in methodology are validated for a similar type of work at another site also?

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Answer: The proposed algorithm of surface flow spreading is based on the variation of grid elevation. Thus, the assumptions in the algorithm is suitable to simulate the spreading of rainwater in flat region. When the study area with large difference between high and low elevations, the rainwater will be converged in low region. We have added discussion from line 1 to line 3 in page 24.

Line 1-3 in page 24: The proposed algorithm is used to spreading surface flow based on the variation of the elevation in study area. Thus, the proposed approach is suitable to simulate the inundation risk in flat region.

SECTION 3.1.2 - Description showing the that calculation of width and area should be included.

Answer: Thanks for the reviewer's comment. The width and area of each subcatchment are obtained using GIS tools.

SECTION 3.2 - Step 4 in the flowchart of figure 3(b), needs to be clarified.

Answer: Thanks for the reviewer's comment. We have revised this section from line 7 to line 10 in page 11.

Line 7-10 in page 11: Fig. 3 shows the description of the spreading procedure of runoff. Fig. 3(a) illustrates the determination of grid location and spreading coefficient. Fig 3(b) is the iterative calculation of the spreading process. Firstly, grids are created with 20 m$\times$20 m meshes across the study area using GIS fishnet tools [see Fig. 3(a)]; secondly, the calculated average inundation depth is extracted from each grid [see Fig. 3(b)].

- In Result and Analysis: If using abbreviation anywhere, its full form needs to be stated at first.

Answer: Thanks for the reviewer's detailed comment. We have added full form of abbreviation in the context.

- In discussion: Bit more flooding prevention measures and tips should be added in this section. Does the type of soil have any effect on inundation depth?

Answer: Thanks for the reviewer's comment. We have added the flooding prevention measures in the section of 'Flood prevention measures'. The effects of the soil type on inundation depth have been added from line 6 to line 25 in page 10.

- Details about 50 years rainfall intensity and 100 years rainfall intensity should also be included in conclusion as the whole manuscript covers 50, 100 and 500 years rainfall intensity.

Answer: Thanks for the reviewer's comment. We have added the results of 50-year and 100-year rainfall intensity in conclusion from line 18 to line 24 in page 25.

Line 18-24 in page 25: (3) The proposed approach was used to simulate the inundation risk of the metro stations in Shanghai under 50-year, 100-year, and 500-year-scenarios. The results showed that these stations of Xinjiangwan Cheng, Yingao east, Yangshupu Road, and Longyao Road are possible to inundated. In the 50-year-rainfall intensity, these four stations are predicted to be inundated at 100 mm-depth. In the 100-year-rainfall intensity, the inundation depth of the four stations increased by 200–300 mm, whereas the inundation extent exacerbated to other central regions. In the 500-year-rainfall intensity, the largest inundation depth exceeds 300 mm, and other metro stations also undergo inundation with a depth of 100–300 mm in the central region.

The following publications may be useful for this article: - An enhanced inundation method for urban flood hazard mapping at the large catchment scale. Journal of Hydrology, 2019, 571: 873-882. - The effectiveness of low-impact development for urban inundation risk mitigation under different scenarios: a case study in Shenzhen, China. Natural Hazards and Earth System Science, 18, 2525–2536, 2018, https://doi.org/10.5194/nhess-18-2525-2018 - Modelling urban floods and drainage using SWMM and MIKE URBAN: a case study. Natural Hazards, 2016, 84(2):

749-776. - Urbanization and climate change impacts on future urban flooding in Can Tho city, Vietnam. Hydrology and Earth System Science, 17, 379-394, 2013, https://doi.org/10.5194/hess-17-379-2013

Answer: Thanks for the reviewer's suggestive comment. We have referred the following reference both in context and reference list. Theses references are helpful to this manuscript.

Reference: Zhao, G., Xu, Z.X., Pang, B., Tu, T.B., Xu, L.Y., Du, L.G.: An enhanced inundation method for urban flood hazard mapping at the large catchment scale. Journal of Hydrology. 571: 873-882, 2019. Wu, J.S., Yang, R., Song, J.: Effectiveness of low-impact development for urban inundation risk mitigation under different scenarios: a case study in Shenzhen, China. Natural Hazards and Earth System Science. 18: 2525-2018, 2018. Bisht, D.S, Chatterjee, C., Kalakoti, S., Upadhyay, P., Sahoo, M., Panda, A.: Modeling urban floods and drainage using SWMM and MIKE URBAN: a case study. Natural Hazards. 84: 749-776, 2016. Huong, H.T.L., Pathirana, A.: Urbanization and climate change impacts on future urban flooding in Can Tho city, Vietnam. Hydrology and Earth System Science, 17: 379-394, 2013.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-28/hess-2019-28-AC3-supplement.pdf

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