Response to the Reviewers Comments

Author reply to RC1 egusphere-2023-2458 (NHESS)

Paper title: Detection of flooding by overflows of the drainage network: Application to the urban area of Dakar (Senegal)

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General comments

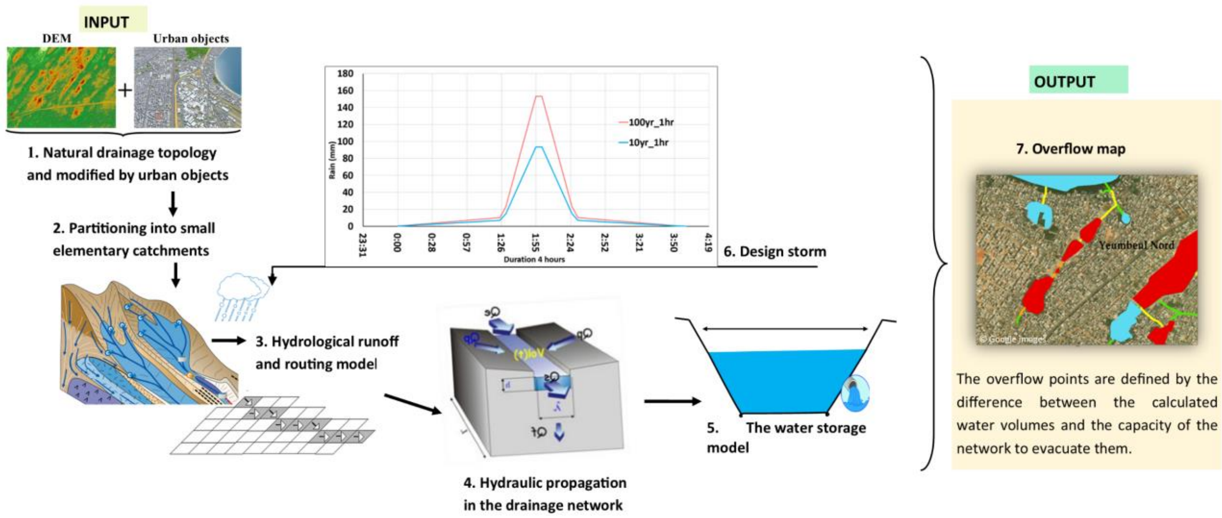
The presented study falls within the scope of NHESS. However, There are many points that should be clarified before considering the paper for publication.

We thank the reviewer for the valuable comments and appreciate the useful suggestions to improve the manuscript. In the revised manuscript, we will carefully consider the reviewer comments. Below, the reviewer comments are displayed in blue, while the author responses are shown in black. We expect these changes have improved the readability of the text and its structure.

Major Comments

1. A flow chart of the methodology should be used to present the methodology. This will help the reader to understand the proposed modeling system

A flow chart will be inserted in section 3.



2. It is not clear to me whether the drainage system (i.e. stormwater drainage network and retention basins) is constructed or it is planned. It is strange to me that the drainage network is a network of open channels of orthogonal cross section. Stormwater drainage network is usually underground and consists of pipes. If the network exists then the dimensions are set and known otherwise the dimensions of the drainage network elements (i.e. pipes and cannals) is a matter of design. The authors should clarify this issue

A more detailed description of the stormwater channel structure, retention basins, and DTM will be provided in section 2. In the study area, the drainage and stormwater storage network already exists (lines 85-87). The drainage network built by the stormwater management project (PROGEP) and its dimensions are provided in numerous technical reports of the project. In Dakar, for cost and facility of maintenance, the entire rainwater network is structured as an open-air network (canals, ditches) or sometimes an underground network (pipes, gutters). The majority of channels are surface drains and are rectangular.

3. In continuation of the previous comment, more information about the study area should be presented, e.g. climate, historical extreme rainfall and flood events, hydrology, DEM, etc.

The description of the study area will be extended to include relief, climate, and the various flood situations that have affected the city. Also, a figure showing the distribution of elevations, soil types will be added to provide a better description of the study area.

4. More information about the Kinematic Wave (KW) flow routing model should be given in Section 3.4. The governing equations of KW to be solved should be presented.

The 1D kinematic wave model will be more carefully presented in section 3.4. Below is a description :

"The hydraulic propagation velocity of flow in the unchanneled network and the channeled network (297 collectors) is computed by the 1D Kinematic Wave (KW) model (Constantindes, 1981; Miller, 1984). The KW model combines a conservation equation (Eq.):

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0$$

where Q is the flow rate (m^3/s), A is the area of the wetted section (in m^2), x is the horizontal distance (m) and t is the time (s).

with a dynamic equation, used as the Manning-Strickler formula (Eq.) :

$$\mathrm{V(t)} = \mathrm{Kr}.\sqrt{S_f}.\mathrm{Rh}^{2/3}$$

where V(t) represents the flow velocity ($m.s^{-1}$), Kr the Manning Strickler roughness coefficient ($m^{1/3}.s^{-1}$), S_f ($m.m^{-1}$) the friction slope, Rh (m) the hydraulic radius, using :

$$S_0 = S_f$$

where S_0 is the bed slope ($m.m^{-1}$) .

5. Section 3.5. Why a simple linear storage model is not used for water retention structures?

We will modify the behavior of the reservoirs as suggested by the reviewer. Adopting a linear reservoir behavior is indeed more convenient. It was done by considering that the reservoir discharge was linearly dependent on the volume in the reservoir. So section 4.3 will therefore be rewritten in that sense, and the simulations will be redone under this new basis.

6. All areas have the same soil characteristics as found in the experimental site. It would be more realistic to have a soil map of the area or CN maps to estimate the parameters of SCS rainfall abstractions (or effective rainfall) model.

A soil map, provided by the National Institute of Pedology (Senegal), will be inserted and commented on in section 2.

7. What is the basin response time (Tr)? Is it the time of concentration or the time lag? In Equation 11, please explain what is Tm (transfer time). Why Tr is not estimated by widely used common and typical equations?

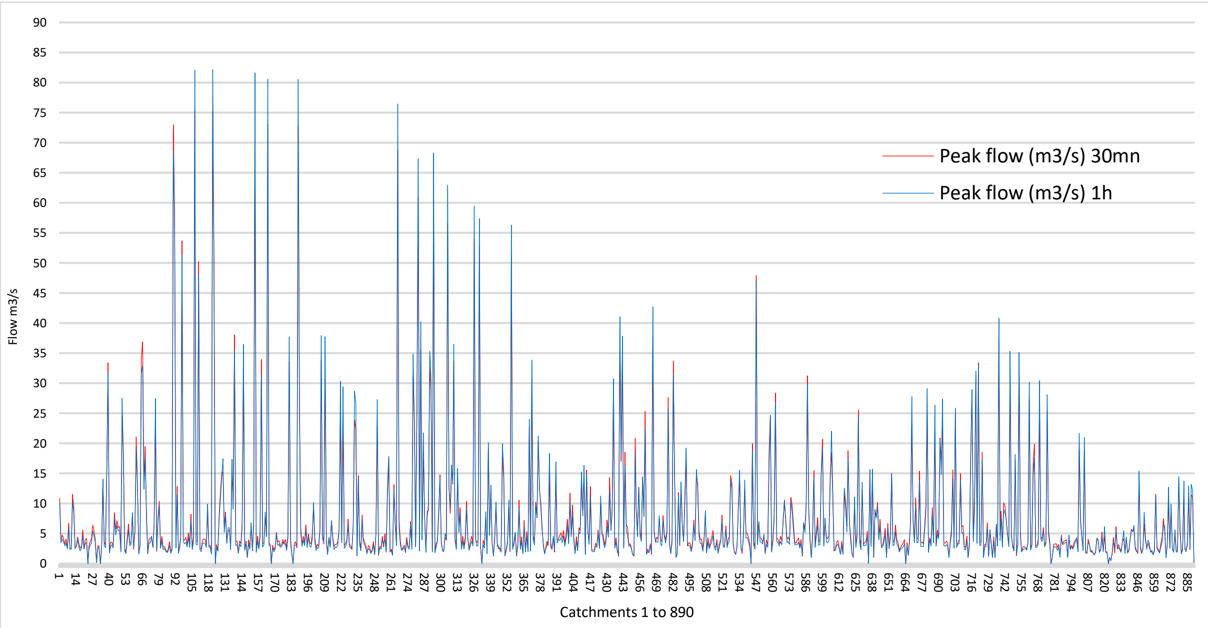
Tr is indeed a lag time, considered as the time between the center of gravity of the runoff and the center of gravity of the rainfall. The measurements of both rainfall and runoff in the experimental catchment of Fann-Mermoz led to an estimation Tr = 30 mn. As Tr can be also derived from the model under some simplified hypothesis, it allows to estimate Vo (the average velocity of the flow over the path travelled). This seems to be more reliable than empirical common equations. Section 4.1.2 will be rewritten to give more detailed explanation of the method.

8. Give the general equation of IDF curves as $i = CT^n D^{-k}$

We're going to insert a new table showing rainfall of different durations (1, 2, 4, 6, 9, 12, 24h) and different return period (10, 100 years).

9. How and why a 4-hour rainfall is selected? Is 4 hours the critical duration of a storm? Please explain.

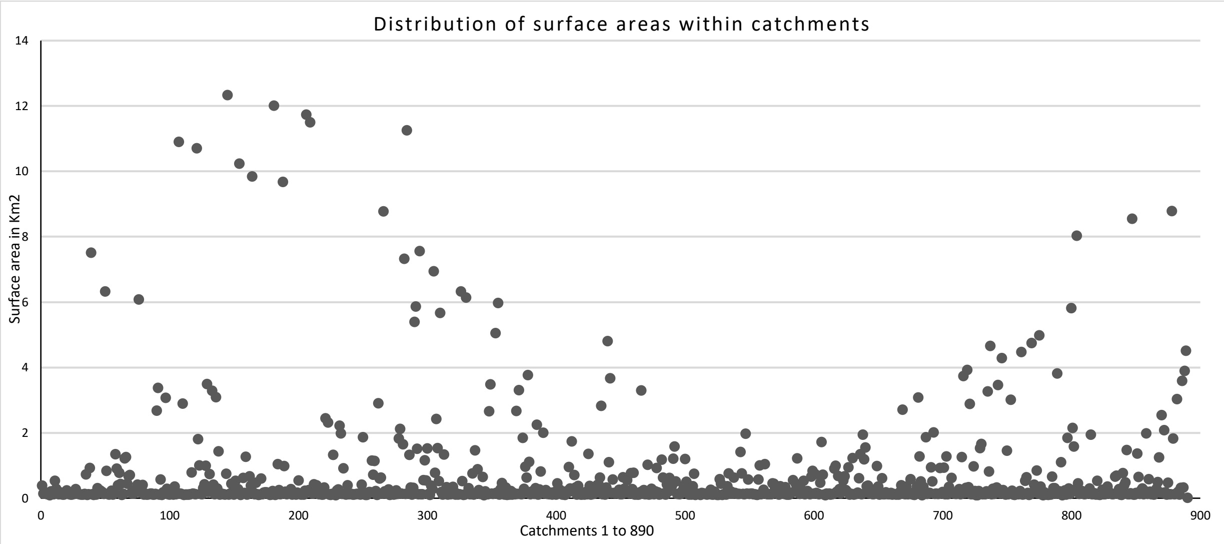
4 hours is mostly the life duration of rainstorms generally observed in African convective systems as analysed by Tadesse and Anagnostou (2010). We have applied this duration for Dakar, even though detailed local analyses are required to assess the structure of significant precipitation events. The former critical duration of rain that we extracted from the IDF provided by Sane et al. (2018) is 1 hour. For future work, possible improvements would be to choose the critical duration less than 1 hour. Integrating durations less than 1 hour has been tested using the IDF curves recently updated by Diedhiou et al. (2024) . New simulations with the model show that the project rainfall associated with a critical duration of 1 hour tends to underestimate peak flows by an average of 7% compared with the project rainfall associated with a critical duration of 30 mn, regardless of the surface area of the basins, ranging from 10 ha to 12 km^2. Furthermore, a 10 mn led to underestimate the peak flows associated to a 30 mn critical period by an average of 9%.



Comparison of peak flow between an intense rainfall of 30 minutes and 1 hour duration.

10. Why the spatial distribution of design rainfall is not considered? The same design hyetograph is applied over the study area.

The simulations were carried out on the assumption that the rainfall was uniform over all the defined catchment areas. Such hypothesis does not account for areal reduction factor, but can be adopted because most of the catchments (i.e. 94%) have small areas, less than 2 km^2. The largest catchment areas (6 to 12km^2) account for 2% and 4% out of the 890 catchment outlets which have been considered, as shown below.



11. A major drawback of the study is that the methodology has not been validated against historical flood events. The results presented are purely theoretical and could be fictional and not representative. The authors should simulate one or two events for validating the method and the modelling system.

Indeed, a key limitation of this study is the lack of validation of the simulation results, as it was pointed out in the discussion. Although it is of major importance, the validation task cannot be undertaken at the moment. However, we hope that the methodological aspects of the simulation should be of enough interest to be published. The validation task is a priority and a perspective for our future work. We added in the discussion the sentence, as follows:

"As things stand at present, it was not possible to get the necessary data for the validation of the method, which means on the one hand sub-daily rainfall data, and on the other hand flood maps for the recent events that occurred in Dakar. The imminent installation of a rain gauge radar in Dakar could help to facilitate this. Flood maps could be obtained by exploring citizen science tools (Sy et al., 2020) or ordering a high-precision satellite image to map out flooded areas."

12. Conclusions. The authors correctly write the deficiencies of the methodology but they should outlined and discussed these deficiencies earlier in the paper.

A mention of one of the limitations of the work (in particular the non-validation of the simulations) will be included in the abstract.

13. There are many awkward hydrological terms. Proper hydrological terms should be used. Some of them are indicated in the minor comments bellow.

Corrected

14. English language needs improvement. In some paragraphs, the English writing is poor.

We will carefully correct this aspect

Minor comments

***1.** There many improper hydrological terms. For example:*
a. Line 93. "…hydrological production …." Please revise to "…..flow generation…."
b. Line 97. "……injected in the model….." Please revise to "……used as input data to the model…"
c. Line 199. "…production model…" Please revise to "….hydrological model…."
d. Line 308. "…..project…" Use the term "design"
And others.

We have reviewed the terms and corrected them accordingly. We have also removed words or phrases that were repeated (lines 43-45, 51)

***2.** Equation 5. Not "si". It is "if"*

Corrected

***3.** Line 180 and elsewhere. What is the OC model? It has not been described.*

OC has been changed to KW which is the used kinematic wave model

***4.** Table 2. It is not understandable. Use the equation of reservoir level-storage volume outflow curves.*

Table 2 will be modified according the use of the linear reservoir model

References

Constantindes, C. A.: Numerical techniques for a two-dimensional kinematic overland flow model., Water SA, 7, 234–248, 1981.

Diedhiou, C. W., Panthou, G., Diatta, S., Sané, Y., Vischel, T., and Camara, M.: Simple scaling of extreme precipitation regime in Senegal, Scientific African, 23, e02034, https://doi.org/10.1016/j.sciaf.2023.e02034, 2024.

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Tadesse, A. and Anagnostou, E. N.: African convective system characteristics determined through tracking analysis, Atmospheric Research, 98, 468–477, https://doi.org/10.1016/j.atmosres.2010.08.012, 2010.