Response to the Reviewers Comments

Author reply to RC1 egusphere-2025-77 (NHESS)

Paper title: Identification of nighttime urban flood inundation extent using deep learning

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GENERAL COMMENTS

This study proposes a method for recognizing flooded urban areas by analyzing night-time images taken by urban surveillance cameras during a rainy event. The method is based on combining deep learning model (using advanced semantic segmentation techniques) with video images as a data source to effectively perform real-time urban flood recognition, which addresses common challenges in the field of research into the identification of night-time urban flooding. The proposed Model - nighttime waterlogging recognition model —NWseg - outperforms the other models tested in this study for detecting urban nighttime flooding. The ability of the models to recognize flooding on a series of night-time flood images was used as a basis for validating the experimental results. My minor and major comments are presented in the next paragraphs.

Response: Sincerely thank the reviewer for the recognition and detailed evaluation of this study. We look forward to your feedback and commit to revising the manuscript earnestly based on your specific suggestions to further enhance its scientific rigor and readability. Below, the reviewer's comments are presented in black, and the authors' responses are provided in blue.

Minor comments

- Line 22: Please add space
- Line 33: It would be interesting to add references about complex climate change
- Line 219: Please remove comma repetition
- Line 240: Please add space
- Line 317: Please add space (Check along the text)

Response: We sincerely appreciate the reviewer's careful review and valuable comments. We will fully revise the manuscript according to the suggestions, including formatting corrections, removing redundant punctuation, and adding relevant references. Additionally, we will check the entire text to ensure consistency. Thank you for your detailed feedback, which has helped improve the quality of our manuscript.

Major Comments

1. Line 44 : "… remote sensing techniques have difficulty in capturing subtle topographic changes within cities …". Can the proposed model do it?

Response: We sincerely appreciate the reviewer's valuable comments and extend our sincere apologies for any potential misunderstanding caused by our wording. In the original manuscript (Line 44), we stated that "remote sensing techniques have difficulty in capturing subtle topographic changes within cities." However, this statement was not sufficiently precise and did not fully reflect the specific limitations of remote sensing technology in urban flood monitoring.

To directly address the reviewer's inquiry and clarify the capabilities of the NWseg model, We provide the following explanations. NWseg is not designed to directly capture subtle topographic changes within urban environments. Instead, it utilizes high-resolution video images obtained from mobile phones or urban surveillance cameras, to achieve real-time and fine-grained detection of urban flood areas. Unlike remote sensing technologies that rely on satellite data, NWseg is based on near-ground imagery, offering higher spatial resolution and temporal continuity. This enables the model to effectively capture the dynamic evolution of inundation areas, particularly in nighttime scenarios. By overcoming the limitations of remote sensing techniques—such as cloud cover interference and low spatiotemporal resolution—our approach provides timely monitoring support for rapidly developing flood events. In addition, Line 44 has been revised as follows: *"Due to the limitations in temporal resolution and the impact of cloud cover and atmospheric variations, remote sensing technology struggles to timely capture the dynamic changes of urban flooding, making real-time monitoring of rapidly evolving flood events challenging."*

2. Line 70 : "… under complex weather conditions …". Let's imagine that a heavy or exceptional nighttime rainstorm caused a power cut and consequently darkness in the city. What would be the performance (flood recognition) of the proposed NWseg model?

Response: We sincerely appreciate the reviewer's thoughtful question. For flood recognition under extreme nighttime conditions, such as a heavy rainstorm causing a power outage and complete darkness, the performance of the NWseg model largely depends on the availability of image data from surveillance cameras or mobile devices. While NWseg incorporates specialized preprocessing techniques and deep learning-based enhancements to handle low-light environments, its recognition capability would be significantly affected in the absence of any light sources.

In scenarios where minimal ambient lighting is available (e.g., vehicle headlights, emergency lighting, or infrared cameras), NWseg can enhance image quality through contrast enhancement and noise reduction techniques, thereby maintaining a certain level of detection performance. We acknowledge that in cases of complete darkness with no auxiliary lighting, the model's performance would be severely limited, which is an inherent constraint of image-based flood monitoring methods.

To address the reviewer's suggestion, we will introduce a new discussion section in the revised manuscript, where we elaborate on the model's robustness and potential future improvements. We sincerely appreciate the reviewer's insightful question, which has allowed us to further refine the applicability analysis of our approach and clarify future optimization directions.

3. Line 220 : "… GPU acceleration libraries…". What are the calculation times? Compatible with real-time forecasting? Please specify. Indeed the ability to provide results quickly to facilitate decision-making is essential in urban environments, given the economic, social, and other issues at stake.

Response: We sincerely appreciate the reviewer's detailed suggestion on Line 220. In the revised manuscript, we will include a comprehensive description of the GPU acceleration libraries, clarify the model parameters of NW-seg, and specify its response speed for flood

detection. We will also confirm its capability to support real-time prediction to meet the demand for rapid decision-making in urban environments.

4. Line 274 : An important element in the characterization of a flood is its depth, velocity and extent. It is not clear to me whether the model detects only the extent or both extent, velocity, and depth.

- How does the NWseg model calculate depth? velocity?
- To what spatial scale is the model applicable (Street? District? Whole city?)

Response: We sincerely thank the reviewer for their thorough examination and valuable suggestions regarding the content in line 274. In the revised manuscript, we will modify line 274 and related sections to clarify the model's capabilities and scope of applicability in response to the reviewer's specific comments. Specifically, the NW-seg model is designed to perform semantic segmentation on nighttime surveillance images, enabling precise identification of urban flood inundation extents. Furthermore, the spatial applicability of the NW-seg model depends on the coverage of the surveillance images. In this study, the model is based on street- and small-area-level surveillance imagery, making it suitable for street or community scales rather than city-wide applications.

5. Line 329 : "… Future work will focus on reducing the model's parameters…". The various model parameters have not been detailed.

Response: We express our heartfelt gratitude to the reviewer for their meticulous review and valuable feedback on the content in line 329. In the revised manuscript, we will include a detailed presentation of the parameters of each model in the Results section, accompanied by a comparative analysis. This will provide a foundation and direction for future efforts to reduce model parameters.

6. The study should robustly integrate a discussion section providing the advantages, limitations, and improvements of the proposed model.

Response: We sincerely appreciate the reviewer's valuable suggestions regarding the discussion section. In the revised manuscript, we will add a dedicated discussion section analyzing the advantages, limitations, and future improvements of the NW-seg model. First, this study constructed a dataset of 4,000 nighttime urban flood images, addressing the lack of nighttime scene data in existing research. Using this dataset, we conducted comparative experiments between NW-seg and other mainstream segmentation models, where NW-seg demonstrated superior performance across key evaluation metrics. To further validate its real-world applicability, we conducted tests in real-world scenarios. The experimental results indicate that, compared to other models, NW-seg exhibits significant advantages in detection stability and computational efficiency, demonstrating its adaptability and robustness in diverse nighttime environments.

However, despite NW-seg's strong performance in nighttime urban flood detection, certain limitations remain. First, while the dataset covers various nighttime flooding scenarios, the number of samples under extreme low-light conditions or strong dynamic reflections is relatively limited, which may affect the model's generalization capability. Additionally, in cases of total darkness due to power outages, NW-seg's detection performance is further

constrained. Second, due to the model’s structural complexity, its computational resource requirements are relatively high, making it difficult to run efficiently on portable devices such as smartphones.

Future research will focus on optimizing the model to reduce parameter size and computational costs while maintaining detection accuracy, thereby improving its applicability in resource-limited environments. Furthermore, we plan to expand the model’s deployment scenarios, such as integrating it with edge computing or lightweight network architectures, to enhance its generalizability and practical value in real-world applications.