

Title: Reducing False Alarms in Urban Flood Detection: An Enhanced NDWI (ENDWI) with Hybrid Max Fusion on Sentinel-2 Data.

RC2: ['Comment on egusphere-2026-672'](#), Guy J.-P. Schumann, 19 Apr 2026

Note No.1: Reviewer comments in italics

Note No.2: Manuscript updates are in blue.

Note No.3: Author's clarifications in green.

Note No.4: (non-official) test results in red.

==Start

(General Comment)

This paper presents a method to process S2 flood images using an enhanced NSWI method.

The paper is well written and I have only a few comments but some of those deserve moderate to major attention.

Response:

Dear Referee,

Thank you so much for your time and encouraging feedback.

==End

==Start

(SPECIFIC COMMENTS)

- It is appreciated that the authors demonstrated the innovation presented relative to other published methods, but I feel they need to better justify why their method is preferred. Is it better accuracy, more robustness/consistency, better scaling. I feel the accuracy gained does not necessarily justify the implementation.

Response:

Dear Referee,

Thank you so much for your time and your valuable comments. The following clarifications are provided in response to your valuable suggestions:

First justification:

The proposed ENDWI is formulated as NDWI divided by the green band (i.e., $(\text{Green} - \text{NIR}) / (\text{Green} + \text{NIR}) / \text{Green}$). This design relies only on visible and near-infrared (NIR) bands, making it simple, low-cost, and easily applicable to a wide range of users, sensors, instruments, and platforms — including UAVs — without the need for hyperspectral data. ([Lines 101-108](#)).

Second justification:

The main objective of this study is to reduce false alarms in optical remote sensing imagery for detecting urban flood events using widely adopted spectral indices such as NDWI, MNDWI,

and AWEIsh. To achieve this goal, we proposed a new and simple index called ENDWI (Enhanced Normalized Difference Water Index ($ENDWI = NDWI / \text{Green band}$)), which achieved a FAR (False Alarms Rate) of approximately 10.95%. (Table 3). When compared with seven established water indices, ENDWI ranked among the top three performers (alongside AWEIsh and NDWI). (Table 1). Furthermore, we introduced a hybrid max fusion index based on ENDWI and AWEIsh, which dramatically reduced the FAR to approximately 2.99%. (Table 4). Both the proposed ENDWI and the hybrid approach successfully achieved the core objective of the study by significantly lowering false alarms according to the formulation of $FAR = FP / (TP + FP)$.

Third justification:

To assist the Otsu thresholding phase for the proposed ENDWI index assessment, we developed a custom normalization technique called Z-Split. This technique expands the narrow near-zero values (approximately ~ -0.0004 to ~ 0.0002) produced by dividing NDWI by the Green band to a wider range (approximately ~ -0.4 to ~ 0.7) (Fig. 1). The Z-Split prepares ENDWI for a more reliable Otsu separability step when necessary, and to avoid a single value after Otsu thresholding, such as values collapsing to 1-to-1 or 0-to-0 ranges that often result in a white or blank image. Although this step was developed specifically for ENDWI, we believe it holds broader potential for bipolar indices (those containing both positive and negative values) by improving contrast, class separability, and measurement accuracy. (This will be added in the revised manuscript).

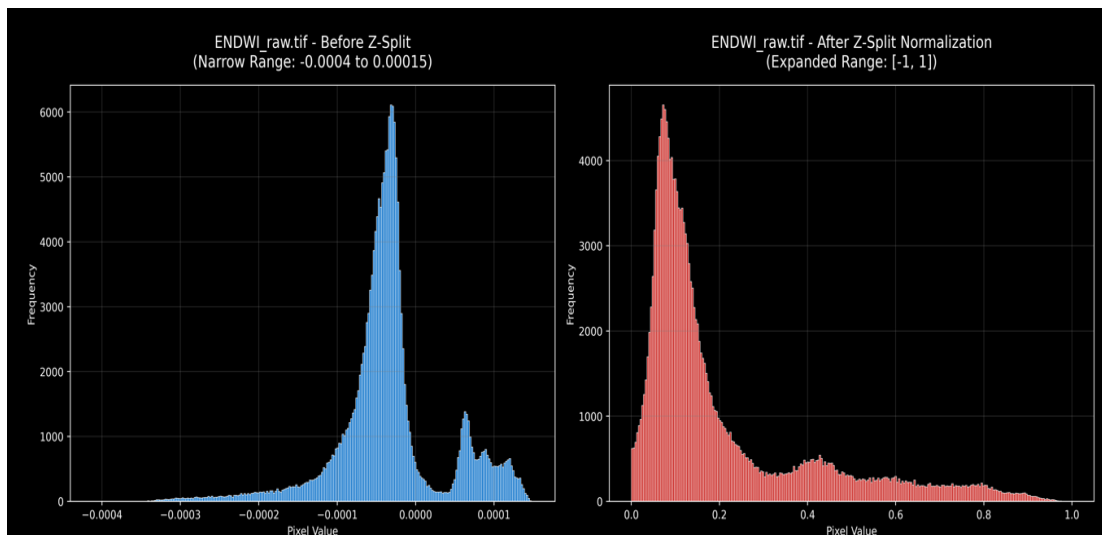


Fig 1. ENDWI Histogram Before and After Z-Split Normalization

==End

==Start

(SPECIFIC COMMENTS)

- The authors should also perform a simple cost-benefit analysis against other methods using some of the performance measures, but also computational efficiency and robustness, obtained by computing a series of different flood events.

Response:

Dear Referee,

Thank you so much for your time and your valuable comments. The following clarifications are provided in response to your valuable suggestions:

-Perhaps the most important consideration for us from the very beginning of this work was the need to demonstrate the generalizability of the proposed method across multiple flood events. Due to the lack of reliable, high-quality validation that relies on high-resolution imagery or government reports, we focused on a single well-documented flood case in this study.

-This approach is common in many highly cited previous studies. Nevertheless, we informally tested the method on several other flood events outside the main study area and observed consistently low FAR values. One of these tests was a study recently published: <https://doi.org/10.3390/rs18060895> . As shown in Figure 1, ENDWI clearly outperforms NDWI in terms of false alarm reduction on this independent event.



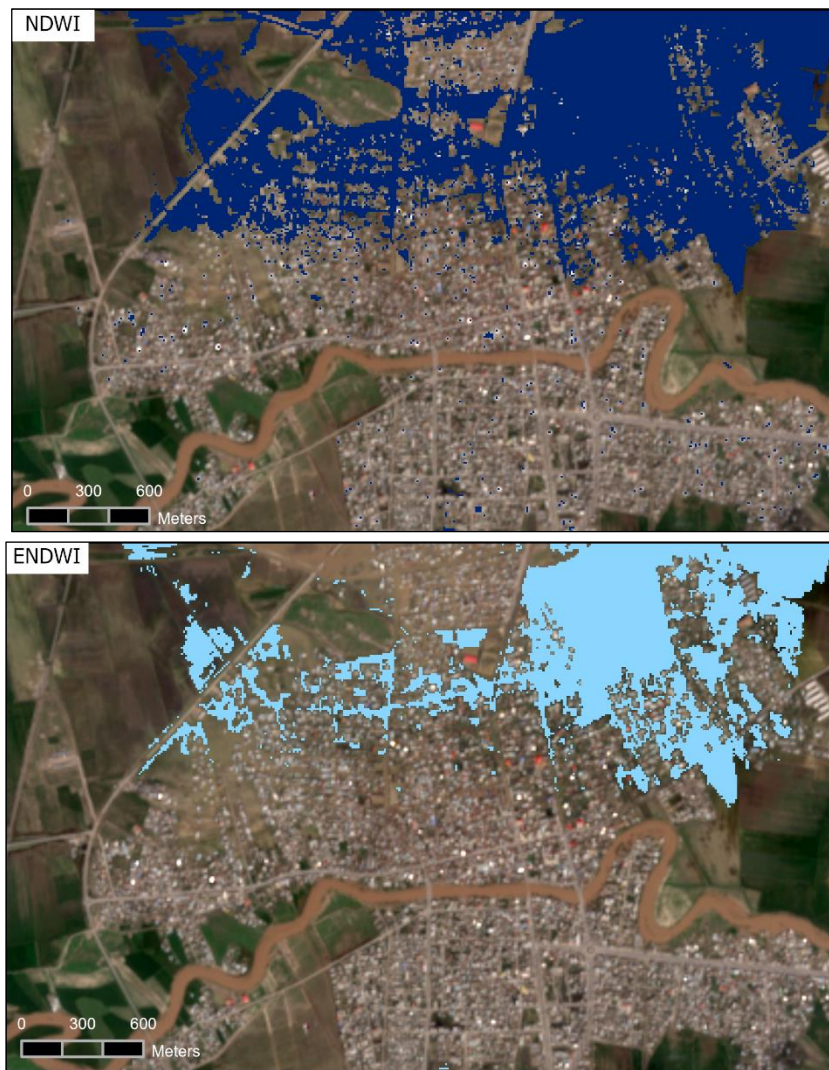


Fig. 2. Pre-flood, post-flood, NDWI, and ENDWI TIFF images illustrating the performance of ENDWI compared to NDWI in terms of False Alarm Rate (FAR). Source: <https://doi.org/10.3390/rs18060895>

-In addition, to address this limitation, we explicitly acknowledge it in the Limitations section of the manuscript and recommend in the Future Work section that subsequent studies expand the validation to include multiple flood events to further confirm the robustness and transferability of ENDWI and the hybrid approach. At the same time, to compensate for this constraint, the current study places strong emphasis on simplifying the index, effectively handling bipolar near-zero values through the proposed Z-Split normalization, systematically evaluating the most efficient spectral indices, and developing the hybrid fusion model, which achieved the maximum reduction in the false alarm rate, thereby enhancing the reliability of flood detection and supporting timely decision-making for identifying high-risk and affected areas. (Lines 493-502).

==End

References:

Ahmadi, P.; Valadan Zoej, M.J.; Mokhtarzade, M.; Kardan, N.; Ahmadi, P.; Ghaderpour, E. TLE-FEDformer: A Frequency-Domain Transformer Framework for Multi-Sensor Multi-Temporal Flood Inundation Mapping. *Remote Sens.* 2026, 18, 895. <https://doi.org/10.3390/rs18060895>