école normale supérieure paris—saclay

université PARIS-SACLAY

KAYRROS

AGENCE INNOVATION DÉFENSE

CENTRE BORELLI

Portraying the Need for Temporal Data in Flood Detection via Sentinel-1

Xavier Bou, Thibaud Ehret, Rafael Grompone, Jérémy Anger

xavier.bou_hernandez@ens-paris-saclay.fr

IEEE IGARSS 2024 July 7-12 ATHENS GREECE

Code

Paper

Context

Flooding became the most affecting natural disaster on global populations in 2020 [1], and the magnitude of flood-related losses is expected to continue to increase [2]in the future. Several flood detection methods have been proposed to provide a rapid response to such events. However, there are key main limitations in current approaches.

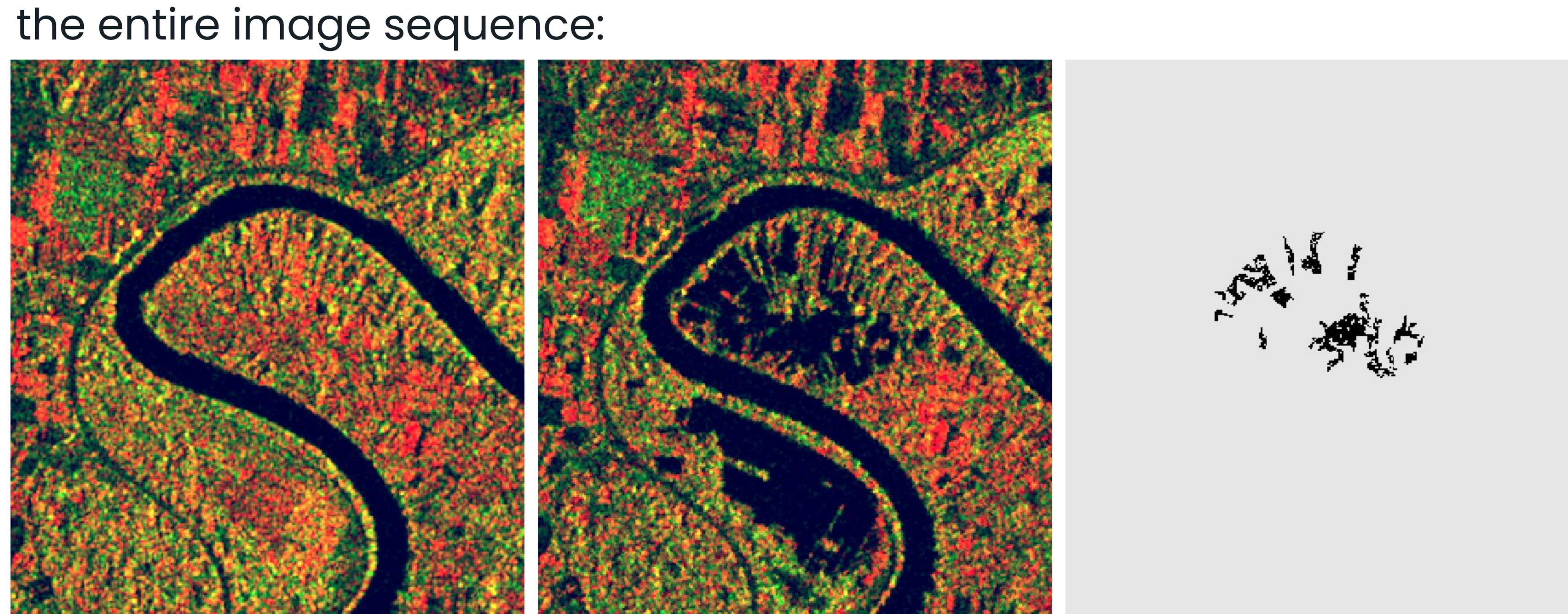
In this work, we address these limitations and illustrate the importance of temporal information to solve the flood detection problem.

Contributions

- **We illustrate the two main limitations in flood detection**: (1) minimal region variability and (2) distinguishing flooded areas from water bodies from a single image.
- **We extend the MMFlood dataset to multidate** by providing one year of Sentinel-1 observations around each flood event.
- We re-frame the flood detection task as a temporal anomaly detection problem and **provide a simple unsupervised method as a baseline for the temporal MMFlood dataset**.

Extending the MMFlood dataset

The MMFlood [3] dataset is well distributed, containing a large set of flood events. Hence, we extend it by adding the Sentinel-1 images one year before the event and one month after. To our surprise, **we notice that the definition of flooded pixels in MMFlood is inconsistent** when observing the entire image sequence:



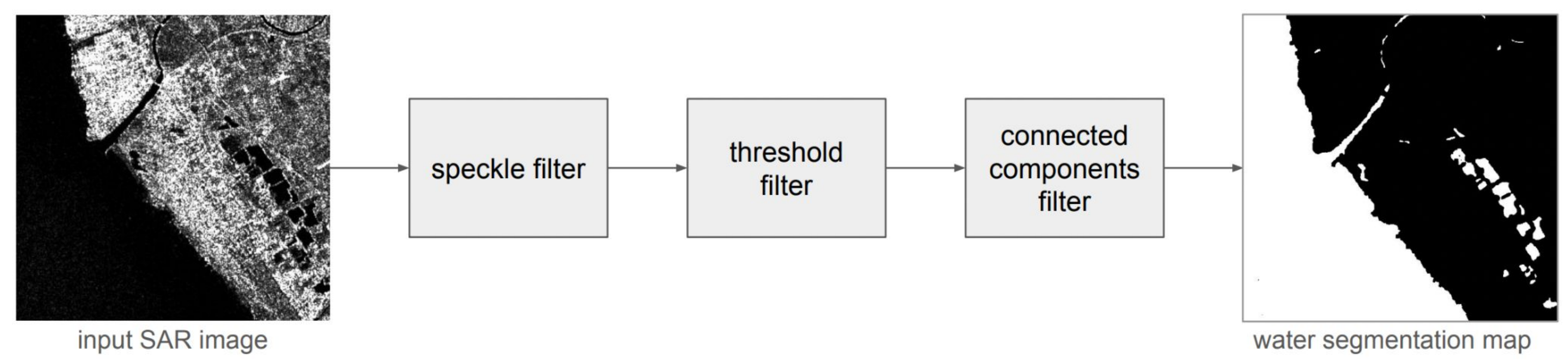
Sample from the MMFlood [3] dataset. The left image was acquired on 2019/05/10 (not part of MMFlood), the middle image is from 2019/05/16 during the flood event, and the MMFlood label on the right shows only a partial annotation of the flooded areas. **Note that from only the middle image it is not possible to infer which are the permanent water bodies, a multi-date input is essential for flood mapping**.

Unsupervised baseline

To address the inconsistencies between temporal information and annotations in MMFlood, we propose to re-frame the flood detection problem from a temporal anomaly detection point of view.

Inspired by the video change detection algorithm ViBe[4], **we develop a simple yet reasonable unsupervised method as a baseline for the temporal MMFlood dataset**, which consists in the following steps:

- **Water segmentation**: maps are first computed via denoising, thresholding and filtering by connected components:



Then, a background model is build to model the past water observations and detect flooded areas at all locations in the scene.

- **Background model**: each pixel in the scene is modeled by a collection of K previously observed water/ground events

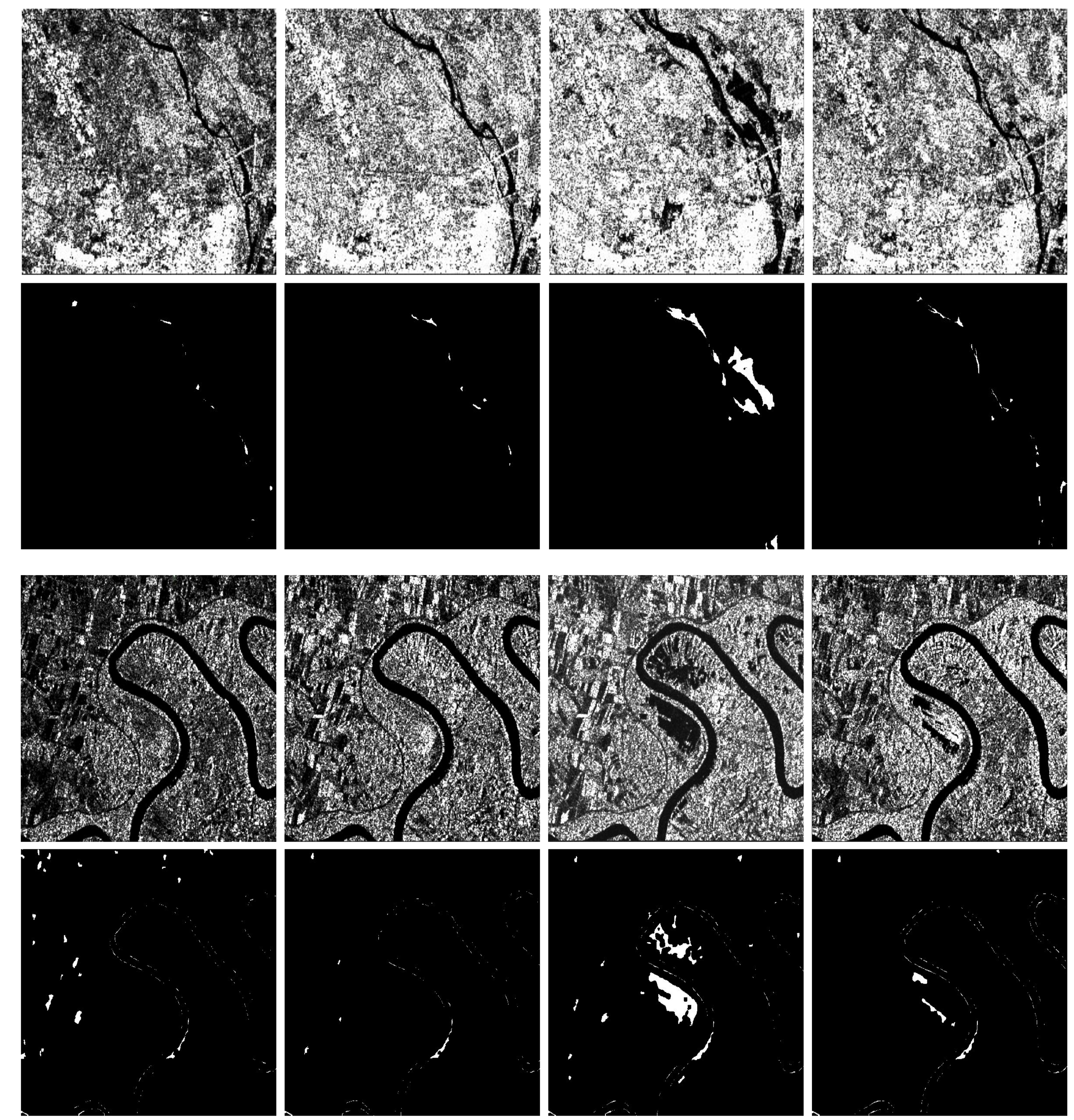
$$B(x) = \{v1, v2, \dots, vK\}$$

B(x) is initialised by assigning the temporal median across a set of initial frames to all samples at each location.

- **Flood detection**: A new observed pixel is considered a flooded pixel only if
  (1) the water segmentation process has classified it as a water event, and
  (2) less than k_{min} water events can be found in the background model at that location.

Qualitative results

Results of the proposed unsupervised method for two MMFlood scenes. Two observations prior to the event and two afterwards are shown. The top rows correspond to the input SAR images and the output segmentation maps are shown on the bottom.



References

[1] Centre for Research on the Epidemiology of Disasters (CRED) CfRotEo. "Disaster year in review 2020: Global trends and perspectives." Cred Crunch 62 (2021).
[2] Steinhausen, Max, et al. "Drivers of future fluvial flood risk change for residential buildings in Europe." Global Environmental Change 76 (2022): 102559.
[3] F. Montello *et al.* "MMFlood: A Multimodal Dataset for Flood Delineation From Satellite Imagery," in IEEE Access, vol. 10, pp. 96774-96787, 2022, doi: 10.1109/ACCESS.2022.3205419.
[4] O. Barnich, and M.V. Droogenbroeck. "ViBe: A universal background subtraction algorithm for video sequences." IEEE Transactions on Image processing 20.6 (2010): 1709-1724.
[5] C. Rambour, et al. "Flood detection in time series of optical and sar images." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 43.B2 (2020): 1343-1346.