

Dear Referee,

We sincerely thank the Editor and the referees for their constructive and insightful comments on our manuscript entitled “ A Time-Series SAR-Based Anomaly Detection Method for Simultaneous Monitoring of Large-Scale Floods and Urban Inundation ” . The comments were very helpful for improving the methodological rigor, validation strategy, and clarity of the manuscript.

All changes have been incorporated into the revised manuscript. Below, we provide a point-by-point response.

- 1. Please note that your reference list has not been compiled according to our standards. Please consider adjusting your reference list with the next revision of your manuscript. The manuscript preparation guidelines can be seen at: https://www.natural-hazards-and-earth-system-sciences.net/for_authors/manuscript_preparation.html.**

Response: Thank you for this comment. The format of the references has been revised according to the requirements of Natural Hazards and Earth System Sciences. The revised list of references is as follows:

Alvarez-Vanhard, E., Corpetti, T., and Houet, T.: UAV and satellite synergies for optical remote sensing applications: a literature review, *Sci. Remote Sensing*, 3, 100019, <https://doi.org/10.1016/j.srs.2021.100019>, 2021.

Amitrano, D., Di Martino, G., Di Simone, A., and Imperatore, P.: Flood detection with SAR: a review of techniques and datasets, *Remote Sens.*, 16, 656, <https://doi.org/10.3390/rs16040656>, 2024.

Anusha, N. and Bharathi, B.: Flood detection and flood mapping using multi-temporal synthetic aperture radar and optical data, *The Egyptian Journal of Remote Sensing and Space Science*, 23, 207 – 219, <https://doi.org/10.1016/j.ejrs.2019.01.001>, 2020.

Barredo, J. I.: Major flood disasters in Europe: 1950 – 2005, *Nat. Hazards*, 42, 125 – 148, <https://doi.org/10.1007/s11069-006-9065-2>, 2007.

Borrelli, P., Robinson, D. A., Panagos, P., Lugato, E., Yang, J. E., Alewell, C., Wuepper, D., Montanarella, L., and Ballabio, C.: Land use and climate change impacts on global soil erosion by

- water (2015 – 2070), *Proc. Natl. Acad. Sci. U. S. A.*, 117, 21994 – 22001, <https://doi.org/10.1073/pnas.2001403117>, 2020.
- Cheadle, C., Vawter, M. P., Freed, W. J., and Becker, K. G.: Analysis of microarray data using Z score transformation, *J. Mol. Diagn.*, 5, 73 – 81, [https://doi.org/10.1016/S1525-1578\(10\)60455-2](https://doi.org/10.1016/S1525-1578(10)60455-2), 2003.
- Cian, F., Marconcini, M., Ceccato, P., and Giupponi, C.: Flood depth estimation by means of high-resolution SAR images and lidar data, *Nat. Hazards Earth Syst. Sci.*, 18, 3063 – 3084, <https://doi.org/10.5194/nhess-2018-158>, 2018.
- Clement, M. A., Kilsby, C. G., and Moore, P.: Multi-temporal synthetic aperture radar flood mapping using change detection, *J. Flood Risk Manag.*, 11, 152 – 168, <https://doi.org/10.1111/jfr3.12303>, 2018.
- Cruz, H., Véstias, M., Monteiro, J., Neto, H., and Duarte, R. P.: A review of synthetic-aperture radar image formation algorithms and implementations: a computational perspective, *Remote Sens.*, 14, 1258, <https://doi.org/10.3390/rs14051258>, 2022.
- DeCarlo, L. T.: On the meaning and use of kurtosis, *Psychol. Methods*, 2, 292, <https://doi.org/10.1037/1082-989X.2.3.292>, 1997.
- DeVries, B., Huang, C., Armston, J., Huang, W., Jones, J. W., and Lang, M. W.: Rapid and robust monitoring of flood events using Sentinel-1 and Landsat data on the Google Earth Engine, *Remote Sens. Environ.*, 240, 111664, <https://doi.org/10.1016/j.rse.2020.111664>, 2020.
- Doane, D. P. and Seward, L. E.: Measuring skewness: a forgotten statistic?, *J. Stat. Educ.*, 19, <https://doi.org/10.1080/10691898.2011.11889611>, 2011.
- Du, W., Xia, Q., Cheng, B., Xu, L., Chen, Z., Zhang, X., Huang, M., and Chen, N.: Flood inundation probability estimation by integrating physical and social sensing data: case study of 2021 heavy rainfall in Henan, China, *Remote Sens.*, 16, 2734, <https://doi.org/10.3390/rs16152734>, 2024.
- Fernandez, P., Mourato, S., Moreira, M., and Pereira, L.: A new approach for computing a flood vulnerability index using cluster analysis, *Physics and Chemistry of the Earth, Parts A/B/C*, 94, 47 – 55, <https://doi.org/10.1016/j.pce.2016.04.003>, 2016.
- Geudtner, D., Torres, R., Snoeij, P., Davidson, M., and Rommen, B.: Sentinel-1 system capabilities and applications, in: *Proceedings of the 2014 IEEE Geoscience and Remote Sensing Symposium*, 1457 – 1460, <https://doi.org/10.1109/IGARSS.2014.6946711>, 2014.

- Groeneveld, R. A. and Meeden, G.: Measuring skewness and kurtosis, *Journal of the Royal Statistical Society Series D: The Statistician*, 33, 391 – 399, 1984.
- Jongman, B., Ward, P. J., and Aerts, J. C.: Global exposure to river and coastal flooding: long-term trends and changes, *Global Environmental Change*, 22, 823 – 835, <https://doi.org/10.1016/j.gloenvcha.2012.07.004>, 2012.
- Kang, W., Xiang, Y., Wang, F., Wan, L., and You, H.: Flood detection in Gaofen-3 SAR images via fully convolutional networks, *Sensors*, 18, 2915, <https://doi.org/10.3390/s18092915>, 2018.
- Kummerow, C., Simpson, J., Thiele, O., Barnes, W., Chang, A., Stocker, E., Adler, R., Hou, A., Kakar, R., and Wentz, F.: The status of the Tropical Rainfall Measuring Mission (TRMM) after two years in orbit, *J. Appl. Meteorol.*, 39, 1965 – 1982, [https://doi.org/10.1175/1520-0450\(2001\)040%3C1965:TSOTTR%3E2.0.CO;2](https://doi.org/10.1175/1520-0450(2001)040%3C1965:TSOTTR%3E2.0.CO;2), 2000.
- Kunkel, K. E.: North American trends in extreme precipitation, *Nat. Hazards*, 29, 291 – 305, <https://doi.org/10.1023/A:1023694115864>, 2003.
- Li, H., Zhao, J., Yan, B., Yue, L., and Wang, L.: Global DEMs vary from one to another: an evaluation of newly released Copernicus, NASA and AW3D30 DEM on selected terrains of China using ICESat-2 altimetry data, *Int. J. Digit. Earth*, 15, 1149 – 1168, <https://doi.org/10.1080/17538947.2022.2094002>, 2022.
- Liu, B., Li, Y., Zhang, Y., Wu, Z., Pan, Y., and Li, M.: Multi-criteria decision-making method for emergency shelter site selection considering flood risk: a case study of Zhuhai, China, *Cleaner Eng. Technol.*, 24, 100892, <https://doi.org/10.1016/j.clet.2025.100892>, 2025.
- Liu, X., Huang, Y., Xu, X., Li, X., Li, X., Ciais, P., Lin, P., Gong, K., Ziegler, A. D., and Chen, A.: High-spatiotemporal-resolution mapping of global urban change from 1985 to 2015, *Nat. Sustain.*, 3, 564 – 570, <https://doi.org/10.1038/s41893-020-0521-x>, 2020.
- Martinis, S., Kuenzer, C., Wendleder, A., Huth, J., Tuele, A., Roth, A., and Dech, S.: Comparing four operational SAR-based water and flood detection approaches, *Int. J. Remote Sens.*, 36, 3519 – 3543, <https://doi.org/10.1080/01431161.2015.1060647>, 2015.
- Martinis, S., Plank, S., and Ćwik, K.: The use of Sentinel-1 time-series data to improve flood monitoring in arid areas, *Remote Sens.*, 10, 583, <https://doi.org/10.3390/rs10040583>, 2018.

- Moreira, A., Prats-Iraola, P., Younis, M., Krieger, G., Hajnsek, I., and Papathanassiou, K. P.: A tutorial on synthetic aperture radar, *Ieee Geosci. Remote Sens. Mag.*, 1, 6 – 43, <https://doi.org/10.1109/MGRS.2013.2248301>, 2013.
- Nhangumbe, M., Nascetti, A., and Ban, Y.: Multi-temporal Sentinel-1 SAR and Sentinel-2 MSI data for flood mapping and damage assessment in Mozambique, *Isprs Int. J. Geo-Inf.*, 12, 53, <https://doi.org/10.3390/ijgi12020053>, 2023.
- Pekel, J.-F., Cottam, A., Gorelick, N., and Belward, A. S.: High-resolution mapping of global surface water and its long-term changes, *Nature*, 540, 418 – 422, <https://doi.org/10.1038/nature20584>, 2016.
- Tang, G., Clark, M. P., Papalexiou, S. M., Ma, Z., and Hong, Y.: Have satellite precipitation products improved over the last two decades? A comprehensive comparison of GPM IMERG with nine satellite and reanalysis datasets, *Remote Sens. Environ.*, 240, 111697, <https://doi.org/10.1016/j.rse.2020.111697>, 2020.
- Tellman, B., Sullivan, J. A., Kuhn, C., Kettner, A. J., Doyle, C. S., Brakenridge, G. R., Erickson, T. A., and Slayback, D. A.: Satellite imaging reveals increased proportion of population exposed to floods, *Nature*, 596, 80 – 86, <https://doi.org/10.1038/s41586-021-03695-w>, 2021.
- Tingsanchali, T.: Urban flood disaster management, *Procedia Engineering*, 32, 25 – 37, <https://doi.org/10.1016/j.proeng.2012.01.1233>, 2012.
- Torres, R., Snoeij, P., Geudtner, D., Bibby, D., Davidson, M., Attema, E., Potin, P., Rommen, B., Floury, N., and Brown, M.: GMES Sentinel-1 mission, *Remote Sens. Environ.*, 120, 9 – 24, <https://doi.org/10.1016/j.rse.2011.05.028>, 2012.
- Tripathi, G., Pandey, A. C., Parida, B. R., and Kumar, A.: Flood inundation mapping and impact assessment using multi-temporal optical and SAR satellite data: a case study of the 2017 flood in Darbhanga district, Bihar, India, *Water Resour Manage*, 34, 1871 – 1892, <https://doi.org/10.1007/s11269-020-02534-3>, 2020.
- Twele, A., Cao, W., Plank, S., and Martinis, S.: Sentinel-1-based flood mapping: a fully automated processing chain, *Int. J. Remote Sens.*, 37, 2990 – 3004, <https://doi.org/10.1080/01431161.2016.1192304>, 2016.
- Voigt, S., Giulio-Tonolo, F., Lyons, J., Kučera, J., Jones, B., Schneiderhan, T., Platzeck, G., Kaku, K., Hazarika, M. K., and Czarán, L.: Global trends in satellite-based emergency mapping, *Science*, 353, 247 – 252, <https://doi.org/10.1126/science.aad8728>, 2016.

- Voigt, S., Martinis, S., Zwenzner, H., Hahmann, T., Twele, A., and Schneiderhan, T.: Extraction of flood masks using satellite-based very-high-resolution SAR data for flood management and modeling, in: RIMAX Contributions at the 4th International Symposium on Flood Defence (ISFD4), Managing Flood Risk, Reliability & Vulnerability, Toronto, Canada, 6-8 May 2008.
- Wang, T. and Tong, C.: An analytical model of double scattering for SAR imaging of urban structures, *Optik*, 171, 484 – 491, <https://doi.org/10.1016/j.ijleo.2018.06.084>, 2018.
- Wang, Z., Qin, Y., Zhang, Q., Li, Y., Liu, J., Yuan, X., Zhao, L., Li, M., and Cao, S.: China ' s GaoFen-3 mission: a review, *Ieee Geosci. Remote Sens. Mag.*, 13, 79-115, <https://doi.org/10.1109/MGRS.2024.3523924>, 2025.
- Xu, H.: Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery, *Int. J. Remote Sens.*, 27, 3025 – 3033, <https://doi.org/10.1080/01431160600589179>, 2006.
- Zafarmomen, N., Samadi, V., and Borgomeo, E.: Spatiotemporal SWMM-LSTM surrogate modeling for efficient node-level water depth and inflow prediction in urban drainage networks, *Cambridge Prisms: Water*, 4, 4e, 1 – 35, <https://doi.org/10.1017/wat.2026.10013>, 2026.
- Zhang, J., Zhou, C., Xu, K., and Watanabe, M.: Flood disaster monitoring and evaluation in China, *Global Environmental Change Part B: Environmental Hazards*, 4, 33 – 43, <https://doi.org/10.3763/ehaz.2002.0404>, 2002.
- Zhang, M., Liu, D., Wang, S., Xiang, H., and Zhang, W.: Multisource remote sensing data-based flood monitoring and crop damage assessment: a case study on the 20 July 2021 extraordinary rainfall event in Henan, China, *Remote Sens.*, 14, 5771, <https://doi.org/10.3390/rs14225771>, 2022.
- Zhao, J., Pelich, R., Hostache, R., Matgen, P., Wagner, W., and Chini, M.: A large-scale 2005 – 2012 flood map record derived from ENVISAT-ASAR data: United Kingdom as a test case, *Remote Sens. Environ.*, 256, 112338, <https://doi.org/10.1016/j.rse.2021.112338>, 2021.
- Zhao, L., Zhang, Q., Li, Y., Qi, Y., Yuan, X., Liu, J., and Li, H.: China ' s Gaofen-3 satellite system and its application and prospect, *IEEE J. Sel. Top. Appl. Earth Observ. Remote Sens.*, 14, 11019 – 11028, <https://doi.org/10.1109/JSTARS.2021.3122304>, 2021.

2. The section “Author contributions” with the authors’ initials must be included in *.pdf manuscript with the next revision.

Response: Thank you for your comment. The author's contribution has been incorporated into the manuscript (Line 586-589). The revised author contributions are as follows:

JZ: Project lead, Study design, Data curation, Writing, Reviewing. RX: Formal analysis, Writing, Reviewing. FL: Data curation, Formal analysis, Reviewing.

3. Your *.pdf manuscript contains the Supplementary materials. Please note that supplementary material is reserved for items that cannot reasonably be included in the main text or as appendices. See more: <https://www.natural-hazards-and-earth-system-sciences.net/submission.html#assets> > Supplements. The Appendix, however, is part of the *.pdf manuscript and will be inserted as the final section. See more: <https://www.natural-hazards-and-earth-system-sciences.net/submission.html#manuscriptcomposition> > 7. With the next revision, please rename or place the supporting materials accordingly.

Response: Thank you for this comment. The supplementary materials have been removed from the manuscript.

4. The “Code and data availability” section of the manuscript: If the data are not publicly accessible (including cases where access is provided “upon request” or is missing), a clear and detailed justification must be provided. For further details, please refer to: https://publications.copernicus.org/for_authors/manuscript_preparation.html#assets → Data sets

Response: Thank you for this important comment. We agree that the explanation provided in the original “Code and data availability” section was insufficient. The database used in this study contains sensitive, site-specific ecological information. Unrestricted public disclosure of these data could expose sensitive ecological

locations and increase the risk of disturbance, inappropriate use, or other adverse impacts on the associated ecological resources. Therefore, the full database cannot be deposited in a publicly accessible repository.

The data may nevertheless be made available to qualified researchers for legitimate academic purposes upon reasonable request to the corresponding author. Each request will be evaluated based on the proposed use of the data, and access will be subject to appropriate conditions to prevent the disclosure or misuse of sensitive ecological information. The analysis code can also be provided upon reasonable request after it has been checked to ensure that it does not contain sensitive site identifiers or other information that could reveal the restricted ecological data.

Accordingly, we have revised the “Code and data availability” section to provide a more detailed justification and to clarify the conditions under which the data and code may be accessed. The revised code and data availability are as follows ([Line 576-584](#)):

Code and data availability. The database supporting this study is not publicly accessible because it contains sensitive, site-specific ecological information. Unrestricted disclosure of these data could expose sensitive ecological locations and increase the risk of disturbance, inappropriate use, or other adverse impacts on the associated ecological resources. The data may be made available by the corresponding author to qualified researchers for legitimate academic purposes upon reasonable request. Requests will be assessed based on the intended use of the data, and access will be subject to appropriate conditions to prevent the disclosure or misuse of sensitive ecological information. The codes used for the statistical analyses may also be obtained from the corresponding author upon reasonable request. Before release, the code will be checked to remove any sensitive site identifiers or other information linked to the restricted database.

5. Please add the following attribution texts to the following figure captions:

Figure 1 - Map data © Google.

Figure 6 - Sentinel-2 data courtesy of ESA Copernicus.

Figures 3, 7 - Sentinel-1 data courtesy of ESA Copernicus.

Response: Thank you for your comment. This information has been incorporated into the figure captions. The revised figure captions are as follows:

Line 100: Figure 1: The geographical location of the study area (Map data © Google). The red box represents the UAV imaging range.

Line 385: Figure 3: The influence of heavy rainfall on the strength of building areas. Sentinel-1 SAR composite processed by the authors (Sentinel-1 data courtesy of ESA Copernicus).

Line 445: Figure 6: Comparison of monitoring results in the downstream flood monitoring area of Weihui City based on the Sentinel-2 images (Sentinel-2 data courtesy of ESA Copernicus). (a), 07/26/2021, (b), 07/27/2021, (c), 07/31/2021. The blue or green areas in the picture represent the areas affected by the flood.

Line 470: Figure 7: Flood monitoring results in the building area of Weihui city based on the Sentinel-1 images and Z-score (Sentinel-1 data courtesy of ESA Copernicus). Grey indicates that the area has not been affected by the flood; red indicates that the area has been affected by the flood. The UAV imaging range is shown in Figure 1.