Researchers propose a more effective method to predict floods

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Flooded Lake House, Keswick, Cumbria, U.K. Credit: Gavin Lynn

More people are vulnerable to the effects of flooding than ever before

due to changes in climate, land use, infrastructure and population growth in recent decades. It is, therefore, crucial to accurately predict flood frequency and severity to reduce physical and economic losses.

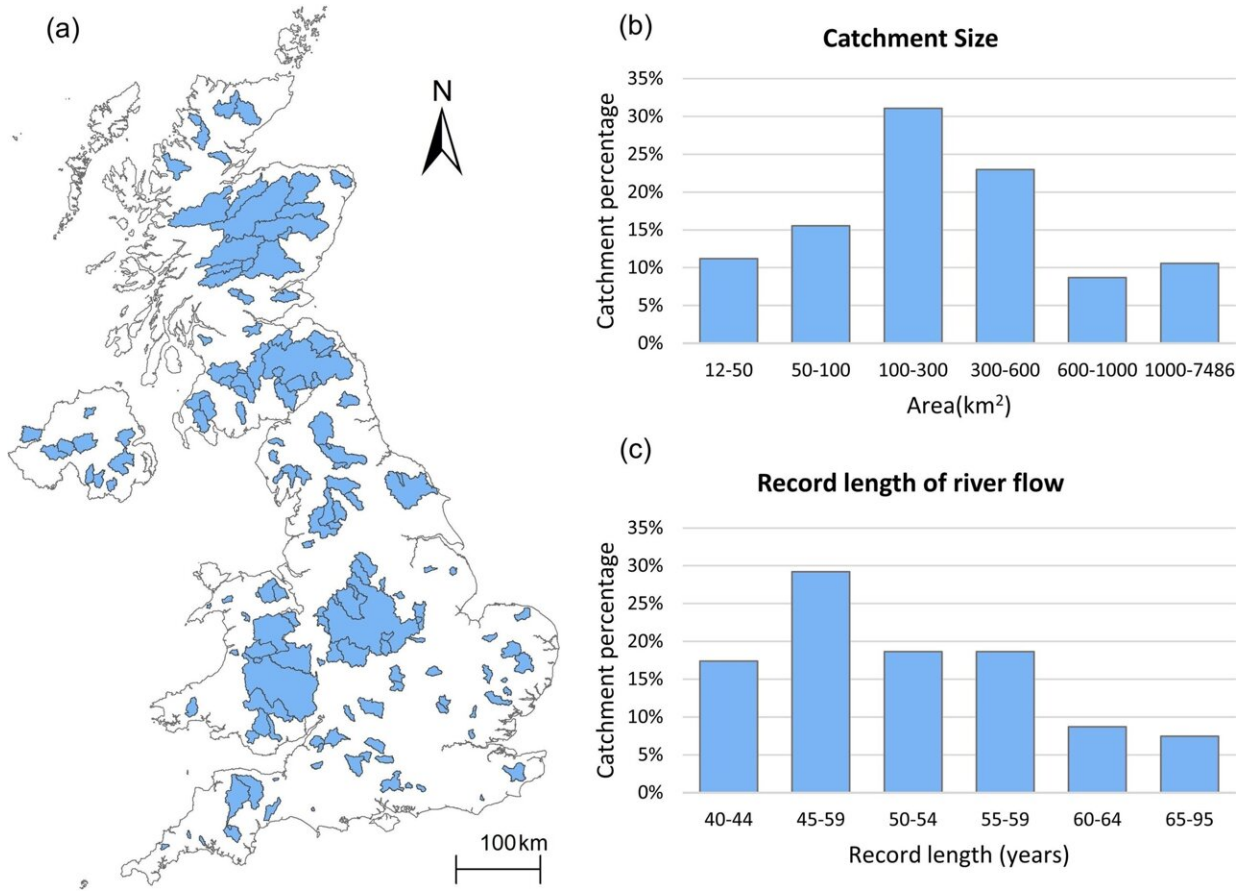
Conventional analysis of flood frequency assumes that flooding follows historic patterns, and the methods used often do not take into account changing conditions such as climate change, river regulation, and land cover variation. This creates a higher risk of underestimating the frequency and severity of floods and designing less resilient infrastructure.

In a recent study published in the *Journal of Hydrology*, researchers from Xi'an Jiaotong-Liverpool University, China; Chung-Ang University, Korea; and the University of Liverpool, U.K., proposed that an alternative method is more appropriate for analyzing flood frequency in a changing environment.

The team of researchers propose a model that is a type of nonstationary flood frequency analysis. Nonstationary models provide more reliable estimations for water-related structures and flood prevention measures as they take into account variations of factors influencing flood frequency.

Despite nonstationary flood frequency analysis now being a hot research topic, there is a lack of consensus on the most appropriate methods. The existing models are either too complicated or too expensive for engineers or hydrologists to implement in practice.

Mengzhu Chen, the first author of the paper, is a Ph.D. student at XJTLU's Department of Civil Engineering. In 2021, she published a study that used a different model of nonstationary flood frequency across the U.K. However, she found there were limitations in applying this approach to practices like engineering design and hydraulic structure design.



(a) Location of the 161 catchments used in the study (b) summary of catchment size and (c) available record length. Credit: Mengzhu Chen (Xi'an Jiaotong-Liverpool University)

"We were unable to express the model as a simple mathematical formula which made it difficult to interpret and calculate. Therefore, we wanted to find a more suitable model," Chen says.

To assess and compare different modeling techniques in the current study, the researchers analyzed historical flood data from 161 catchments across the U.K. These areas, also known as watersheds or

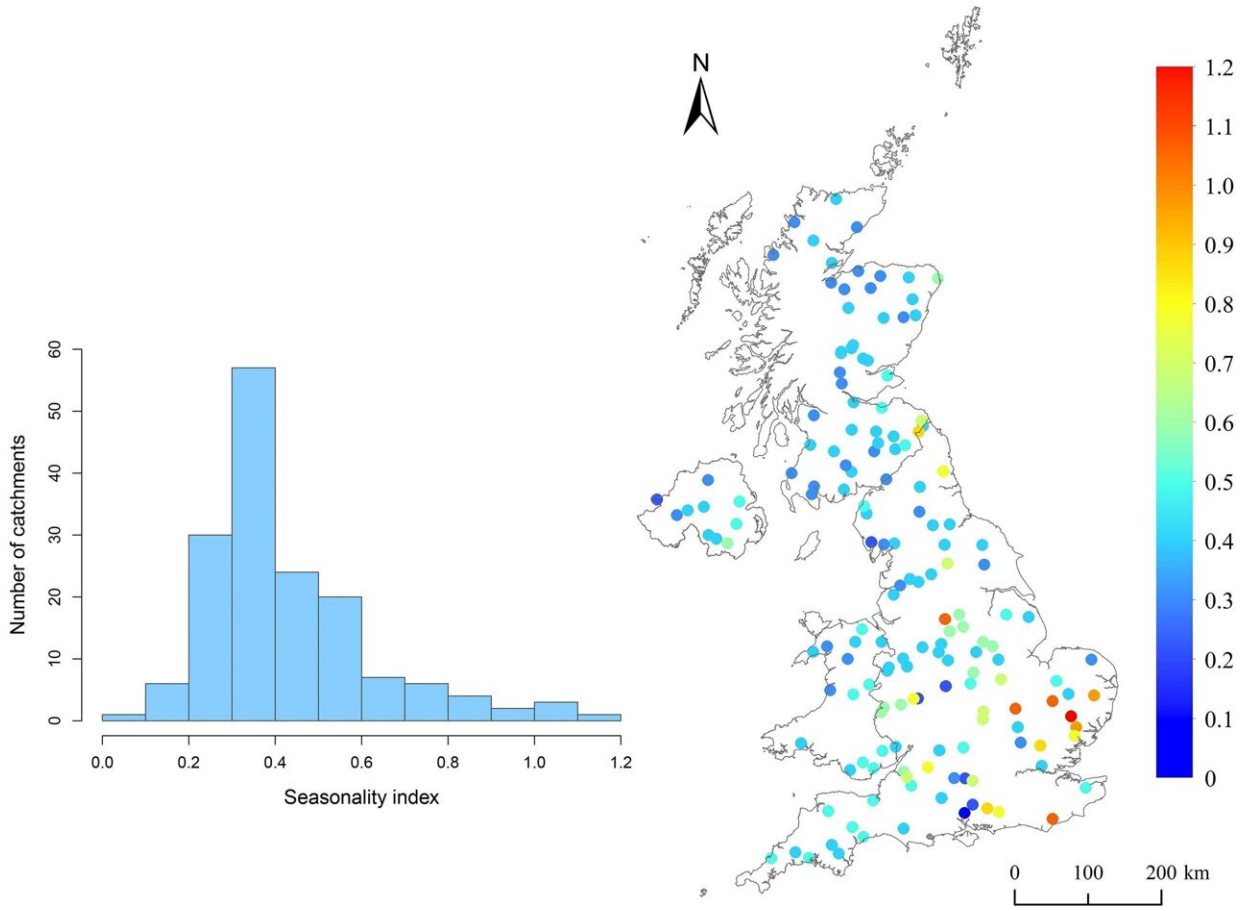
drainage basins, have natural boundaries such as ridges, hills or mountains, and all surface water drains to a common channel to form rivers or creeks.

They found that the "fractional polynomial-based regression" model is the most flexible, effective, and user-friendly among all the models. This method is an emerging tool in certain applied research areas like medical statistics and clinical research but is currently used very little in the hydrology field.

Bridging the gap

Chen says, "Currently, there is a gap between hydraulic research and practice, as most practitioners are not familiar with nonstationary models even though they have gained popularity in academia.

"The findings of our recent study provide recommendations to hydrologists and engineers to help them choose from the available analysis models.



Quantified seasonality index (seasonal flood peak variance) for the 161 catchments across the UK. The higher the index, the more significant the flood variability is in these catchments; the wet season may be wetter, and the dry season may be drier. Credit: Mengzhu Chen (Xi'an Jiaotong-Liverpool University)

"For practitioners, the fractional polynomial model we propose in our paper can be an additional valuable tool for application. It can be expressed as a mathematical formula and is more user-friendly.

"After all, the primary purpose of nonstationary flood frequency analysis is to provide estimations for the design, construction, and management

of water-related infrastructure.

"Nevertheless, there's a long way to go before nonstationary methods can be widely used in practice. A more user-friendly, straightforward, and generally agreed-upon approach for nonstationary flood frequency analysis is still worth exploring in the future," Chen says.

"We also need further investigation into the complex underlying factors influencing flood frequency to help prepare for future extreme weather events," she adds.

More information: Mengzhu Chen et al, Linear, nonlinear, parametric and nonparametric regression models for nonstationary flood frequency analysis, *Journal of Hydrology* (2022). DOI: 10.1016/j.jhydrol.2022.128772

Provided by Xi'an jiaotong-Liverpool University