New study findings could help improve flood projections

August 27 2021

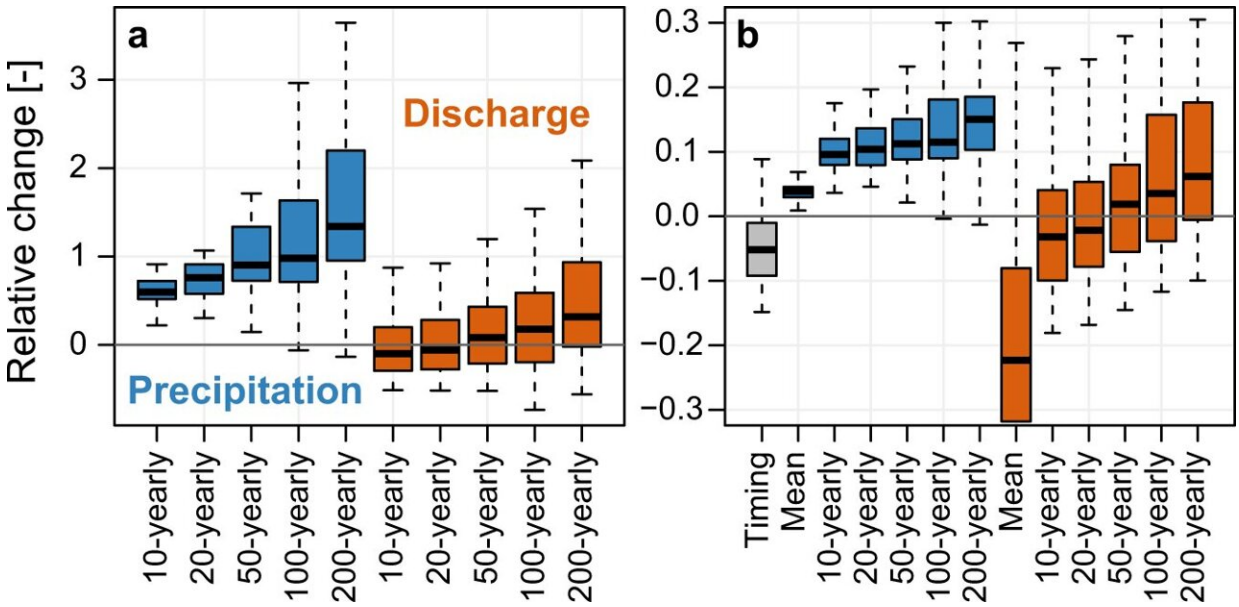

Fig. 1: Future changes in precipitation (P) and streamflow (Q) magnitudes for different levels of extremeness overall 78 catchments. Relative changes [−] in (a) event frequency and (b) peak magnitude for mean and progressively more extreme events (those with 10, 20, 50, 100, and 200 year empirical return intervals, respectively). Relative changes are computed by comparing event characteristics of a future period (2060–2099) to characteristics of a historical period (1961–2000). The gray bar in (b) shows the relative change in event timing (day of the year, negative values indicate earlier extreme event occurrence overall events). Meaning of boxplot elements: central line: median, box limits: upper and lower quartiles, upper whisker: min(max(x), Q3 + 1.5 × IQR), lower whisker: max(min(x), Q1 − 1.5 × IQR), no outliers displayed. Credit: DOI: 10.1038/s43247-021-00248-x

Climate change will lead to more and stronger floods, mainly due to the increase of more intense heavy rainfall. In order to assess how exactly flood risks and the severity of floods will change over time, it is particularly helpful to consider two different types of such extreme precipitation events: weaker and stronger ones. An international group of scientists led by Dr. Manuela Brunner from the Institute of Earth and Environmental Sciences at the University of Freiburg and Prof. Dr. Ralf Ludwig from the Ludwig-Maximilians-Universität München (LMU) have now shed light on this aspect, which has been little researched to date. They found that the weaker and at the same time more frequent extreme precipitation events (on average every 2 to 10 years) are increasing in frequency and quantity, but do not necessarily lead to flooding. In some places, climate change may even reduce the risk of flooding due to drier soils. Similarly, more severe and at the same time less frequent extreme precipitation events (on average less frequent than 50 years and as occurred in the Eifel in July 2021) are increasing in frequency and quantity, but they also generally lead to more frequent flooding. The team published the results of their study in the journal *Communications Earth & Environment*.

In some places, climate change leads to lower flood risk

"During stronger and at the same time rarer extreme precipitation events, such large amounts of rainfall hit the ground that its current condition has little influence on whether flooding will occur," explains Manuela Brunner. "Its capacity to absorb water is exhausted relatively quickly, and from then on the rain runs off over the surface, thus flooding the landscape. It's a different story for the weaker and more frequent extreme precipitation events," says Brunner. "Here, the current soil conditions are crucial. If the soil is dry, it can absorb a lot of water and the risk of flooding is low. However, if there is already high soil

moisture, flooding can occur here as well." So, as climate change causes many soils to become drier, the flood risk there may decrease for the weaker, more frequent extreme precipitation events—but not for the rare, even more severe ones.

Heavy rainfall will generally increase in Bavaria

In the specific example of Bavaria, the scientists also predict how the different extreme precipitation events there will become more numerous. Weaker precipitation events, which occurred on average every 50 years from 1961 to 2000, will occur twice as often in the period from 2060 to 2099. Stronger ones, which occurred on average about every 200 years from 1961 to 2000, will occur up to four times more frequently in the future.

"Previous studies have proven that precipitation will increase due to climate change, but the correlation between flood intensities and heavier precipitation events has not yet been sufficiently investigated. That's where we started," explains Manuela Brunner. Ralf Ludwig adds, "With the help of our unique dataset, this study provides an important building block for an urgently needed, better understanding of the very complex relationship between heavy precipitation and runoff extremes." This could also help to improve flood forecasts.

78 areas investigated

In its analysis, the team identified so-called frequency thresholds in the relationship between future precipitation increase and flood rise for the majority of the 78 headwater catchments studied in the region around the Inn, Danube and Main rivers. These site-specific values describe which extreme precipitation events, classified by their occurring frequency, are also likely to lead to devastating floods, such as the one in

July in the Eifel region.

For its study, the research team generated a large ensemble of data by coupling hydrological simulations for Bavaria with a large ensemble of simulations with a climate model for the first time. The model chain was applied to historical (1961-2000) and warmer future (2060-2099) climate conditions for 78 river basins. "The region around the headwater catchments of the Inn, Danube, and Main rivers is an area with pronounced hydrological heterogeneity. As a result, we consider a wide variety of hydroclimates, soil types, land uses and runoff pathways in our study," says Brunner.

More information: Manuela I. Brunner et al, An extremeness threshold determines the regional response of floods to changes in rainfall extremes, *Communications Earth & Environment* (2021). DOI: 10.1038/s43247-021-00248-x

Provided by Albert Ludwigs University of Freiburg

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