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The joint threat of storm surges and high discharge for the Netherlands

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The low-lying Netherlands is at risk from multiple threats of sea level rise, storm surges and extreme river discharges. Should these threats occur simultaneously, a catastrophe will be at hand. Knowledge about the likelihood of simultaneous occurrence or the so-called 'joint probability' of such threats is essential to provide guidance on legislation for dike heights, flood barrier design and water management in general.

In this study, which forms a contribution to the ECLISE project, we explore the simultaneous threats of North Sea storm surges and extreme Rhine river discharge for the current climate in a large 17-member global climate model ensemble. We use a simple approach, taking proxies of North-Northwesterly winds over the North Sea and multiple-day precipitation averaged over the Rhine for storm surge and discharge respectively, so that a sensitivity analysis is straight forward to apply. By investigating soft extremes, we circumvent the need to extrapolate the data and thereby permit the synoptic development of selected events to be inspected.

Currently the joint probability between storm surges and extreme discharge for the present climate is calculated assuming that each threat can be treated independently. This assumption is based on the negligible correlation modelled between the sea level at the coast and river discharge. But this assumption of independence lies at odds with intuitive reasoning, which would connect both high surge-driving winds and heavy precipitation with the passage of synoptic low pressure systems.

Our principle finding is that the probability of extreme surge conditions following extreme 20-day precipitation sums is around 3 times higher than that estimated from treating extreme surge and discharge probabilities as independent, as previously assumed. The presentation of the results allows the connection between the previous assumptions and intuitive reasoning to be visualised.