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The geomorphic response of river alternate bars to climate change

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Understanding the possible geomorphic trajectory of rivers on the scale of decades is crucial for a successful design of river restoration interventions, especially in the contest of a changing climate. In this contribution we focus on river alternate bars, large bedforms that appear as a repeating sequence of diagonal depositional fronts and scour holes. Downstream-migrating alternate bars can spontaneously form due to a well-known process of riverbed instability and are frequently found in channelized river reaches. We considered two study reaches of the Alpine Rhine River in Switzerland, characterized by similar hydrological and sedimentological characteristics, but different channel width. Expected hydrological changes until 2100, depending on the Representative Concentration Pathways for greenhouse gases, were evaluated by considering the recents projections from the Hydro-CH2018 project. The bar evolution was reproduced through the novel mathematical model developed by Carlin et al. (2021), which allows for simulating the temporal variability of the reach-averaged bar height in the long-term. Model's results clearly show that the expected response of the river bed strongly depends on channel conditions with respect to the relevant morphodynamics threshold for bar formation. The first reach, which is sufficiently wide to allow for a full development of migrating alternate bars, turns out to be weakly sensitive to the projected hydrological alterations. Conversely the second, narrower reach, which is currently close to the threshold conditions, is expected to experience a remarkable alteration in bar dynamics. Specifically, the average bar height is expected to significantly increase, while its variability during flood events will probably drastically reduce. Ultimately, this work reveals a noteworthy example of a more general property of near-threshold geomorphic systems, which are potentially fragile and highly susceptible to changes of their hydrological and ecological conditions, in contrast to systems that being far from threshold conditions are more likely to maintain their physical characteristics in the long term.