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Storyline simulations suggest a northward expansion of European droughts in warmer climates.

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Climate change is causing an increase in the frequency, intensity and persistence of heatwaves and droughts, as seen, for example, in Central Europe in recent years. These changes are expected to be even more severe in the future. Two factors contribute to these changes in extreme events: dynamic changes – changes in the likelihood of weather patterns – and thermodynamic changes. While the former are uncertain in future climate projections, the latter are characterized by a high signal-to-noise ratio, as there is a robust and ubiquitous rise in land-surface temperatures.

To better understand and analyze both contributions, we employ the so-called "event-based storyline approach", which involves nudging our global CMIP6 coupled climate model (AWI-CM1) towards the observed large-scale free-troposphere winds using various climate background conditions and initial states. This enables us to simulate the same weather conditions, including jet streams and blockings, in different climates: preindustrial, present, and in 2 °C, 3 °C, and 4 °C warmer worlds. This methodology provides an efficient way of making the consequences of climate change more understandable to experts and non-experts, as extreme events that are fresh in people's memory are simulated in different climates with moderate computational resources.

Our simulations successfully reproduce recent hot and dry extreme events, like the 2019 or 2022 European heatwaves and the record-breaking 2022 drought. Our experiments reveal an intensification of these extremes from preindustrial to present climates (attribution), mainly in southern Europe, with no major changes in Central and Northern Europe. However, we project that this exacerbation will expand northward in future warmer climates, leading to even more severe drought in Central Europe and the Mediterranean by the end of the century. Taking advantage of our methodology we explore the physical mechanisms helping to exacerbate these events in future warmer climates.