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Low-likelihood high-warming storylines for extremes

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Recent IPCC focused their assessment of changes in climate extremes primarily on the *likely* range and on mapping them as multi-model means. Recently, it has been argued that focusing primarily on the *likely* range potentially ignores changes in the physical climate system that are unlikely to occur but are associated with the highest risks for human and ecological systems. This is particularly the case for extremes where impacts often non-linearly depend on changes in hazards and where uncertainties are typically large both due to model response uncertainty and internal variability. Low-likelihood high-warming storylines have been proposed as a powerful tool to assess and communicate the risk associated with such future climates. However, storylines that are consistent across variables and spatial patterns is challenging.

Here, we introduce and compare different approaches for creating low-likelihood high-warming storylines for extremes based on CMIP6 models, and discuss their strengths and limitations for temperature extremes, heavy rainfall and droughts. We demonstrate that all approaches yield storylines in which changes in hot extremes, extreme rainfall and droughts strongly exceed the multi-model mean over large parts of the globe. This suggests that a focus on the likely range may indeed substantially underestimate the risk associated with changes in extremes.

We further demonstrate that the choice of the storyline approach needs to be informed by the purpose of the assessment. Pattern-scaling based storyline approaches are simple and easy to communicate and provide a reasonable first guess for extremes that are closely related to temperature changes. However, they often lead to implausible global patterns and violate physical consistency across regions and different variables. Particularly for wet and dry extremes, the models showing the largest global warming often do not show the greatest changes in extremes. Other more complex approaches have the advantage of generating storylines of globally coherent patterns of changes in extremes. Such approaches allow assessing physically consistent and spatially coherent global low-likelihood high-warming storylines of regional extremes that are suited for global risk assessment and resilience building across different sectors.