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Attributing extreme precipitation in the Black Sea region to sea surface warming

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Higher sea surface temperatures (SSTs) warm and moisten the overlying atmosphere, increasing the low-level atmospheric instability, the moisture available to precipitating systems and, hence, the potential for intense convective systems. Both the Mediterranean and Black Sea regions have seen a steady increase in summertime SSTs since the early 1980s, by over 2 K in places. This raises the question of how this SST increase has affected convective precipitation extremes in the region, and through which mechanisms any effects are manifested. In particular, the Black Sea town of Krymsk suffered an unprecedented precipitation extreme in July 2012, which may have been influenced by Black Sea warming, causing over 170 deaths.

To address this question, we adopt two distinct modelling approaches to event attribution and compare their relative merits. In the first, we use the traditional probabilistic event attribution approach involving global climate model ensembles representative of the present and a counterfactual past climate where regional SSTs have not increased. In the second, we use the conditional event attribution approach, taking the 2012 Krymsk precipitation extreme as a showcase example. Under the second approach, we carry out ensemble sensitivity experiments of the Krymsk event at convection-permitting resolution with the WRF regional model, and test the sensitivity of the event to a range of SST forcings.

Both experiments show the crucial role of recent Black Sea warming in amplifying the 2012 Krymsk precipitation extreme. In the conditional event attribution approach, though, the explicit simulation of convective processes provides detailed insight into the physical mechanisms behind the extremeness of the event, revealing the dominant role of dynamical (i.e. static stability and vertical motions) over thermodynamical (i.e. increased atmospheric moisture) changes. Additionally, the wide range of SST states tested in the regional setup, which would be infeasible under the global modelling approach, reveal that the intensity of the Krymsk event responds highly nonlinearly to Black Sea warming and suggests a role for regional SST thresholds in more intense coastal convective extremes.