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Role of Sea Surface Warming in Triggering Amplification of Coastal Rainfall Extremes

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Whether recent changes in the occurrence of meteorological extremes are attributable to a warmer climate remains a challenging question. One area where the potential for extreme summertime convective precipitation has grown recently, along with substantial sea surface temperature (SST) increase, is the Black Sea and Mediterranean (BSM) region.

To study mechanisms through which SST increase may impact BSM convective extremes, we take the July 2012 precipitation extreme near the Black Sea town of Krymsk as a recent showcase example. The event was related to a slow moving low pressure system crossing the eastern Black Sea, advecting warm and moist air towards the coast. Two waves of convection resulted in precipitation totals that dwarfed all previous events in the instrumental record, dating back to the 1930s, and over 170 deaths. The synoptic environment which led to this event is typical of that found with intense summertime precipitation in the BSM region.

We carry out ensemble sensitivity experiments over an eastern Black Sea domain with the WRF regional model, using multiply nested sub-domains, increasing to 600 m convection resolving resolution. The model's ability to reproduce the event with observed SST forcing is first verified, before a series of additional ensembles with altered SST is created. These ensembles consist of subtracting (adding) the 1982 – 2012 trend in Black Sea SST from (to) the observed 2012 SST field in 20% increments, giving a total of 11 ensembles whose SST differ from the observed field by between -100% and +100% of the warming trend.

We demonstrate that such an intense precipitation event would not have been possible without the recent Black Sea warming. The increased SST enhances low-level instability, allowing deep convection to be triggered and causing a more than 300% increase in precipitation. Additionally, a highly nonlinear precipitation response to incrementally increasing SST suggests that Black Sea SSTs have exceeded a regional tipping point. The identified physical mechanism suggests that BSM coastal regions (as well as other comparable regions) may face abrupt intensifications of convective precipitation under continued sea surface warming.