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Differing Response of Extreme Precipitation to Changing Boundary Conditions in Simulations with Parametrized and Explicit Convection

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Recent studies have shown that the representation of extreme precipitation in climate models is much more sensitive to model resolution than that of mean precipitation. With global and regional circulation models simulating both present and future climates at ever-increasing resolution, it is only a matter of time before convection resolving climate projections become the norm. In the meantime, regional climate models provide an efficient and inexpensive tool to assess what, if any, impact explicitly resolved convection may have on the representation of precipitation extremes in warmer climates with enhanced boundary forcings.

To compare the response of precipitation extremes in models with parametrized and explicitly resolved convection to changing boundary forcings, we select 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.

We carry out ensemble sensitivity experiments with a triply nested configuration of the WRF regional model, for a domain covering the eastern Black Sea. The event is simulated at 15 km, 3 km and 600 m resolution. The model's ability to reproduce the event with observed forcings is first verified, before a series of additional ensembles with altered boundary forcings, in our case sea surface temperature (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.

Aggregating all data to the 15 km grid, we compare the responses of hourly precipitation maxima to incrementally increasing SST forcing. Between the parametrized and explicit convection simulations, despite the former driving the latter, we find a notable divergence in the transition behaviour (i.e. from cold → warm SST) of hourly precipitation maxima. The improved representation of convective downdraughts in the explicit convection simulations plays a key role in inhibiting further precipitation intensity increases by cooling and drying the boundary layer, whereas precipitation intensity continues to increase in the parametrized simulations. Here, we elucidate further the mechanisms behind the differences in the parametrized and explicit responses to varying boundary forcings.