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Evidence for added value of convection-permitting models for studying changes in extreme precipitation

Edmund Meredith (1), Douglas Maraun (2), Vladimir Semenov (3,4,5), and Wonsun Park (3)

(1) Freie Universität Berlin, Meteorology, Climate Diagnostics and Extreme Meteorological Events, Berlin, Germany (edmund.meredith@met.fu-berlin.de), (2) Wegener Center for Climate and Global Change, University of Graz, Graz, Austria, (3) GEOMAR Helmholtz Centre for Ocean Research Kiel, Maritime Meteorologie, Kiel, Germany, (4) A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences, Moscow, Russia, (5) P.P. Shirshov Institute of Oceonology, Russian Academy of Sciences, Moscow, Russia

Climate model resolution can affect both the climate change signal and present-day representation of extreme precipitation. The need to parametrize convective processes raises questions about how well the response to warming of convective precipitation extremes is captured in such models. In particular, coastal precipitation extremes can be sensitive to sea surface temperature (SST) increase. Taking a recent coastal precipitation extreme as a showcase example, we explore the added value of convection-permitting models by comparing the response of the extreme precipitation to a wide range of SST forcings in an ensemble of regional climate model simulations using parametrized and explicit convection. Compared at the same spatial scale, we find that the increased local intensities of vertical motion and precipitation in the convection-permitting simulations play a crucial role in shaping a strongly nonlinear extreme precipitation response to SST increase, which is not evident when convection is parametrized. In the convection-permitting simulations, SST increase causes precipitation intensity to increase only until a threshold is reached, beyond which further SST increase does not enhance the precipitation. This flattened response results from an improved representation of convective downdrafts and near-surface cooling, which damp the further intensification of precipitation by stabilizing the lower troposphere locally and also create cold pools that cause subsequent convection to be triggered at sea, rather than by the coastal orography. These features are not well represented in the parametrized convection simulations, resulting in precipitation intensity having a much more linear response to increasing SSTs.