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Clausius-Clapeyron temperature-precipitation scaling over the UK in high-resolution climate models

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Clausius-Clapeyron (C-C) temperature-precipitation scaling relationships for extreme hourly precipitation (99th quantile) are examined in observations and a set of 12-km parameterized-convection and 1.5-km convection-permitting regional climate model (RCM) simulations, over a domain covering England and Wales for the summer months (JJA). RCM simulations have been carried out driven by ERA-interim reanalysis, and also for control (1996-2009) and future ($\sim$2100) runs driven by a 60km resolution Met Office Unified Model using the Global Atmosphere GA3.0 configuration.

Radar observations are found to give at least a 1xC-C scaling for UK hourly extreme precipitation at temperatures above 10°C. Despite sharing the same large-scale conditions, the 1.5km explicit-convection model shows very different C-C scaling relationships to the 12km model, whose C-C scaling is shown to be highly sensitive to the lateral boundary conditions – suggesting that the model physics play an important role in the scaling. In contrast, the 1.5km model shows consistent C-C scaling relationships for all present-day (ERA-interim and control) simulations and these are generally in line with observed C-C scaling relationships which sample temperatures mainly between 10°C and 20°C.

The future simulations indicate the fallacy of extrapolating present-day scaling relationships to infer extreme precipitation in a future warmer climate. All future climate simulations show a sharp decline in the scaling relationship at high-temperatures ($\sim$>20°C), which are not well sampled in the current climate. This is consistent with observational studies in other regions which have also found declines in the scaling relationship at high temperatures. This suggests that there may be an upper temperature limit to super-Clausius-Clapeyron scaling of short-duration extreme precipitation which differs dependent on ambient climate conditions in the study location.