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Unprecedented summertime daily rainfall across the UK

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The UNSEEN (UNprecedented Simulated Extremes using ENsembles) method involves using a large ensemble of initialised climate model simulations to increase the sample size of rare events. In this work we extended UNSEEN to focus on intense summertime daily rainfall events. Specifically, plausible extreme rainfall scenarios were developed to help understand potential surface water flooding impacts, and ultimately better inform flood management and resilience across the UK. To help address modelling limitations a large ensemble of simulations from two climate models were used; an initialised 25km global model that uses parametrized convection, and a dynamically downscaled 2.2km model that uses explicit convection. Climate model fidelity was assessed using a regional pooling technique based on extreme value theory. Across much of the UK both models are indistinguishable from the observations in terms of the statistical characteristics which govern the magnitude of very rare return periods. The UNSEEN analysis provides new estimates of plausible extreme return levels (i.e. 1-in-1000 year) across the UK and can reduce uncertainty in the expected frequency of very rare events by 50-70% compared to estimates using observations alone. These results enable suitable observed rainfall profiles to be uplifted to plausible extreme return levels, which can then be used within regional hydrological models to stress test surface flooding scenarios. The annual chance of unprecedented daily rainfall events in the current climate is also quantified, and found to be up to 5% (1-in-20 year return level) for many grid cells across southern parts of the UK. Finally, a significant benefit of the UNSEEN approach over purely statistical emulators is the use of dynamical climate models which allow the large-scale dynamical drivers of extreme daily summertime rainfall to be assessed.