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The influence of synoptic airflow on UK daily precipitation extremes. Observed relationships and regional climate model validation.

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Extreme precipitation is a major natural hazard in the United Kingdom. Reliable high resolution estimates of future changes in the magnitude of precipitation extremes are required for local communities to adapt to potential impacts. In this context it is crucial, how realistically regional climate models (RCMs) simulate the spatial-temporal variability of extreme precipitation. Expected changes in precipitation patterns are mainly controlled by changes in the atmospheric circulation and by an intensification of the water cycle. For a reliable projection of extreme precipitation it is therefore not sufficient to validate the simulated climatology and variability over a control period. In particular, it is important to validate the representation of the relationship between the controling large scale processes and the local precipitation extremes. Here we present a UK case stusy to exemplify a new approach to validate the representation of physical processes in climate models. First, we investigate the relationship between synoptic scale airflow and local extreme daily precipitation, measured at 689 rain gauges in the United Kingdom. To this end, we model the monthly maxima of daily precipitation using a generalised extreme value distribution (GEV), and the airflow influence using a vector generalised linear model, that links airflow strength, vorticity and direction to the GEV parameters. The relationships show pronounced spatial patterns related to the interaction between airflow, orography and the surrounding seas. On regional scales, synoptic scale airflow explains about 20% of the variability on sub-annual to decadal time scales. In a second step, the same statistical model is calibrated against a gridded precipitation data set provided by the UK Met Office and 14 ERA40 driven 25km resolution RCMs from the ENSEMBLES project. Subsequently, the parameters of the statistical models for observations and RCMs are compared with respect to a set of validation measures for spatial patterns. The results for the different RCMs are compared using Taylor diagrams. Additionally, we use this approach to validate extreme precipitation in the E-OBS data set over the UK. We show that the RCMs adequately simulate the influence of airflow strength and vorticity on precipitation extemes, but show deficits in representing the influence of airflow direction. E-OBS shows considerable biases in particular in regions of sparse data.