EGU23-13180, updated on 28 Mar 2024
https://doi.org/10.5194/egusphere-egu23-13180
EGU General Assembly 2023

Drivers of large footprints of extreme winds and rainfall and their projected future changes

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Extratropical cyclones produce extreme surface wind speeds and heavy rainfall which can individually and jointly influence impacts and potentially produce large aggregate impacts. Within this study, we assess the UKCP 12-member ensemble of local convection-permitting 2.2 km climate projections. We quantify the likelihood of cyclones producing large footprints of both extreme winds and rainfall over the UK in a control (1981-2000) and future (2061-2080, RCP8.5) climate simulation. Following this, we characterise the convective and frontal drivers of wet and windy conditions within cyclones, and identify the characteristics of cyclones, their tracks and interactions with the jet stream that contribute to the occurrence of large, combined footprints in the control and future simulations. The future simulations project an increased probability of extratropical cyclones producing extremely wet and windy conditions in the same storm, as well as an increase in the land area covered by such conditions. In both the control and future simulations, combined wet and windy extremes largely occur close to cold and warm fronts, likely due to the warm conveyor belt which produces heavy rainfall (due its ascent over the frontal boundaries) and high winds (when occurring within a region of tight pressure gradients). Cyclone composites reveal that the largest changes in joint extremes are closely located within the sector of cyclones where we expect to see the warm conveyor belt, suggesting their change arises partly through the response of this shared driver rather than being a simple consequence of increased rainfall due to thermodynamics. In further analysis, we identify favourable conditions and cyclone characteristics that lead to cyclones producing large rainfall and wind footprints over the UK.