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Forecasting Heat-Related Hazards on the UK Rail Network

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Continuous welded rails, which are used as standard on the United Kingdom railway network, are optimised to withstand a specified temperature range centred around a given "stress-free temperature" (SFT). This is the temperature at which the rail is neither in tension nor compression. Higher SFTs mean the track can withstand higher temperatures before expanding. However, too high an SFT makes the rail susceptible to brittleness and cracks in low winter temperatures. Exceeding the temperature range within which the rail is designed to operate can cause it to distort, leading to increased instances of buckling. Although rare, derailment caused by buckling can result in catastrophic consequences. Therefore, to prevent such accidents, blanket speed restrictions are currently imposed when the forecast air temperature exceeds a set threshold.

However, these blanket speed restrictions are based on the simple assumption that the rail surface temperature will be a constant value above the air temperature. This assumption is widely adopted even though observations show that rail surface temperature is not linearly correlated with air temperature. If rail surface temperatures can be accurately and reliably modelled, speeds restrictions and preventative measures can be more targeted. This is becoming increasingly important since climate change is predicted to increase the frequency of occurrence of extreme high temperatures in the United Kingdom.

Therefore, the Met Office is currently developing a new rail surface temperature model, designed to accommodate these future user requirements. This model is centred on the Joint UK Land Environment Simulator (JULES); a community model used as the land-surface component of the Met Office Unified Model (UM), but which can also be used – as we do here – as a stand-alone surface-exchange-scheme driven by forecast output from Numerical Weather Prediction (NWP) models. By adapting JULES to model the energy balance of the rail, we are able to produce forecasts of rail surface temperatures. In particular, by driving JULES with output from the Met Office regional ensemble model MOGREPS-UK, we are able to create a set of possible rail forecast outputs. Considering these in aggregate allow us to produce probabilistic forecasts of rail surface temperatures.

Output from the rail surface temperature model has been compared to observation data collected at 40 locations across Northern Ireland. Initial analysis shows the model significantly outperforms traditional forecasting methods based on linear relationships with air temperature. Additionally, producing probabilistic forecasts allows to quantify uncertainty, supporting users in moving

towards probabilistic, risk-based forecasting. This has the potential to significantly improve heat-related hazard forecasting across the UK railway network, thus improving the safety and efficiency of the network.