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Improving Regional Rainfall Forecasts using Convolutional-Neural Networks

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Traditional weather forecasting approaches utilize numerous numerical simulations and empirical models to produce a gridded estimate of rainfall, the cells of which often span multiple regions and struggle to capture extreme events. The approach presented here combines the power of modern meteorological forecasts from the ECMWF C3S seasonal forecasts service with convolutional neural networks (CNNs) to improve the forecasting of total monthly regional rainfall in the UK. The CNN is trained using mean sea-level pressure and 2m air temperature forecasts from the ECMWF C3S service using three lead-times: one month, three months and six months. The training is supervised using the equivalent true rainfall data provided by the CEH-GEAR (Centre for Ecology and Hydrology, gridded estimates of areal rainfall). The resulting predictions are then compared with the total monthly regional rainfall values calculated from the precipitation forecasts provided by the ECMWF C3S service. The results of this comparison show the new CNN model out-performs the ECMWF model across all three leadtimes. This performance is calculated using the root-mean square error between the predicted rainfall values for each region and the true values calculated from the CEH-GEAR dataset. The largest gap is found at a one month leadtime where the CNN model scores a root-mean square error (RMSE) 13% lower than the ECMWF model (RMSEs: 46.5 and 53.4 respectively), the smallest gap is found at a six month leadtime where the CNN scores an RMSE only 2.2% lower than the ECMWF model (RMSEs: 48.5 and 49.6 respectively). However, these differences are exacerbated at the extremes with the CNN producing errors 26% lower than the ECMWF model at a one-month leadtime, 19% lower at a three-month leadtime and 3% at a six-month leadtime. These results are then extended to show how the CNN made the predictions and by comparing the attribution patterns of North West and South East England we are able to show a reliance on both the mean sea-level pressure to the west of the UK and the 2m air temperature to the south west of the UK and over the European continent.