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Improving sub-seasonal forecasts by correcting missing teleconnections using ANN-based post-processing

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Sub-seasonal forecasts are challenging for numerical weather prediction (NWP) and machine learning models alike. Predicting temperature with a lead-time of two or more weeks requires a forward model to integrate multiple complex interactions, like oceanic and land surface conditions that might lead to recurrent or persistent weather patterns. The representation of the relevant interactions is imperfect in NWP models, just as our physical understanding of them. Model predictability can therefore deviate from real predictability for poorly understood reasons, hindering future progress.

This paper combines NWP with machine learning to detect and resolve such imperfect representations. We post-process ECMWF extended range forecasts of high summer temperatures in Europe with a shallow artificial neural network (ANN). Predictors are objectively selected from a large set of atmospheric, oceanic and terrestrial sources of predictability from ERA-5 and ECMWF re-forecast output. In the proposed architecture, the ANN learns to 'update' a prior ECMWF-given probability of two-meter temperature exceeding a given threshold. Due to the architecture of the network the magnitude of each correction, like increasing underestimated probabilities, can be attributed to specific predictors at initialization- or forecast-time. We interpret the circumstances in which substantial corrections are made. This reveals, e.g., that a tropical west Pacific sea surface temperature pattern is connected to high monthly average European temperature at a two-week lead-time. This teleconnection pattern is underestimated by the dynamical model and by correcting for this bias the ANN-based post-processing can thus improve forecast skill. We further find that the method does not readily increase skill when applied to other combinations of lead-time, averaging period and threshold, possibly due to non-stationarity in the data, lack of real predictability or lack of a re-forecast set of sufficient length.