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Improving Summer Precipitation Prediction in China Using Deep Learning

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Summer precipitation in China exhibits considerable spatial-temporal variation with direct social and economic impact. Yet seasonal prediction remains a long-standing challenge. The dynamical models even with a 1-month lead still shows limited forecast skill over China in summer. The present study focuses on applying deep learning to summer precipitation prediction in China. We train a convolutional neural network (CNN) on seasonal retrospective forecast from forecast centres in several European countries, and subsequently use transfer learning on reanalysis and observational data of 160 stations over China. The Pearson's correlation coefficient (PCC) and the root mean square error (RMSE) are used to evaluate the performance of precipitation forecasts. The results demonstrate that deep learning approach produces skillful forecast better than those of current state-of-the-art dynamical forecast systems and traditional statistical methods in downscaling, with PCC increasing by 0.1–0.3, at 1–3 months leads. Moreover, experiments show that the data-driven model is capable to learn the complex relationship of input atmospheric state variables from reanalysis data and precipitation from station observations, with PCC of about 0.69. Image-Occlusion technique are also performed to determine variables and spatial features of the general circulation in the Northern Hemisphere which contribute maximally to the spatial distribution of summer precipitation in China through the automatic feature representation learning, and help evaluate the weakness of dynamic models, in order to gain a better understanding of the factors that limit the capability to seasonal prediction. It suggests that deep learning is a powerful tool suitable for both seasonal prediction and for dynamical model assessment.