Use of machine learning technique in predicting ENSO and IOD

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The tropical climate variations, such as El Niño/Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) can often bring about global and regional climate extremes and ecosystem impacts. Skillful long-lead forecasts of those major year-to-year climate variations would therefore be valuable for reducing socio-economic losses. But despite decades of effort, skillful forecast of ENSO and IOD events at lead times of more than one year remains a big challenge. Here we show that a statistical forecast model employing a deep-learning approach produces skillful ENSO forecasts for lead times of up to one and a half years. To circumvent the limited amount of observational data, we first train a convolutional neural network (CNN) model by use of historical CMIP5 simulations, which is further tuned based on observational reanalysis during 1871-1973. During the validation period from 1984 to 2017, the all-season correlation skill of the Nino3.4 index of the CNN model is much higher than those of current state-of-the-art dynamical forecast systems. The CNN model is also better at predicting the detailed zonal distribution of sea surface temperature anomalies in association with different types of ENSO. In addition, the CNN model displays good skill in predicting the IOD indices, competing with the skills of dynamical models. A heat map analysis indicates that the ocean precursors selected by the CNN model for the long-lead prediction of ENSO and IOD events are consistent with existing physical understandings. Despite many caveats, the machine learning technique shows a big potential in helping improve our understanding and prediction of tropical climate.