Wavelet-Based Hybrid Deep Learning Model for Forecasting El Niño-Southern Oscillation Cycles

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The El Niño-Southern Oscillation (ENSO) is a significant climate phenomenon with far-reaching impacts on global weather patterns, ecosystems, and economies. This study aims to enhance ENSO forecasting with the Extended Reconstruction Sea Surface Temperature v5 (ERSSTv5) climate model. The M-band discrete wavelet transforms (DWT) are utilized to capture multi-scale temporal and spatial features effectively, isolating dominant ENSO-driven signals while removing noise components from the data. Long-short term memory (LSTM) autoencoders are also used to capture significant spatial and temporal patterns in sea surface temperature (SST) anomaly data. Deep learning techniques such as the convolutional neural networks (CNN) are used with non-image and image time series data. Parallel computing in various support vector regression (SVR) approximators was employed to further enhance accuracy. Results indicate that this hybrid model effectively identifies key precursors and patterns associated with El Niño events, surpassing traditional forecasting methods. The composite model achieved a hit rate of almost 0.94 in 4-month lagged forecasting of the Oceanic Niño Index (ONI) - over 170% higher than that of the model without additional techniques and equal to or superior to the current state-of-the-art. Future work will focus on evaluating the model's performance using additional reanalysis datasets and other methods of deep learning to further refine its robustness and applicability. It is proposed that wavelet-based deep learning models have potential to support achieving United Nations' '2030 Agenda for Sustainable Development's goal 13: Climate Action', as an innovation with potential in improving time series image forecasting in all fields.

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