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How to utilize deep learning to understand climate dynamics? : An ENSO example.

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Many deep learning technologies have been applied to the Earth sciences, including weather forecast, climate prediction, parameterization, resolution improvements, etc. Nonetheless, the difficulty in interpreting deep learning results still prevents their applications to studies on climate dynamics. Here, we applied a convolutional neural network to understand El Niño–Southern Oscillation (ENSO) dynamics from long-term climate model simulations. The deep learning algorithm successfully predicted ENSO events with a high correlation skill of 0.82 for a 9-month lead. For interpreting deep learning results beyond the prediction skill, we first developed a “contribution map,” which estimates how much each grid point and variable contribute to a final output variable. Furthermore, we introduced a “sensitivity,” which estimates how much the output variable is sensitively changed to the small perturbation of the input variables by showing the differences in the output variables. The contribution map clearly shows the most important precursors for El Niño and La Niña developments. In addition, the sensitivity clearly reveals nonlinear relations between the precursors and the ENSO index, which helps us understand the respective role of each precursor. Our results suggest that the contribution map and sensitivity would be beneficial for understanding other climate phenomena.