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Machine Learning Parameterization of Mature Tropical Cyclone Boundary Layer

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Tropical cyclone (TC) is among the most destructive weather phenomena on the earth, whose structure and intensity are strongly modulated by TC boundary layer. Mesoscale model used for TC research and prediction must rely on boundary layer parameterization due to low spacial resolution. These boundary layer schemes are mostly developed on field experiments under moderate wind speed. They often underestimate the influence of shear-driven rolls and turbulences. When applied under extreme condition like TC boundary layer, significant bias will be unavoidable. In this study, a novel machine learning model—one dimensional convolutional neural network (1D-CNN)—is proposed to tackle the TC boundary layer parameterization dilemma. The 1D-CNN saves about half of the learnable parameters and accomplishes a steady improvement compared to fully-connected neural network. TC large eddy simulation outputs are used as training data of 1D-CNN, which shows strong skewness in calculated turbulent fluxes. The data skewness problem is alleviated in order to reduce 1D-CNN model bias. It is shown in an offline TC boundary layer test that our proposed model, the 1D-CNN, performs significantly better than popular schemes now utilized in TC simulations. Model performance across different scales is essential to final application. It is found that the high resolution data contains the information of low resolution data but not vise versa. The model performance on the extreme data is key to final performance on the whole dataset. Training the model on the highest resolution non-extreme data plus extreme data of different resolutions can secure the robust performance across different scales.