Enhancing Wind and Solar Energy Estimation Accuracy in Malaysia through Deep Learning Techniques for Bias Correction in WRF Model Outputs

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Abstract

Accurate estimation of wind and solar energy potentials is crucial for the successful integration of renewable energy into power grids. However, traditional numerical weather prediction (NWP) models, like the Weather Research and Forecasting (WRF) model, often suffer from biases leading to inaccurate energy forecasts. This study employs deep learning (DL) techniques to address these biases in WRF model outputs, aiming to enhance wind and solar energy estimation in East and West Malaysia. Various DL techniques, including Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Convolutional Neural Networks (CNN), and Feedforward Neural Networks (FNN), were implemented. These models were trained and validated using historical weather data and ground-based measurements, focusing on improving the accuracy of wind speed and solar radiation predictions. The models' performances were evaluated based on root mean square error (RMSE), mean bias error (MBE), and mean absolute error (MAE). Results demonstrate the superior performance of CNN and FNN models over the traditional WRF approach. CNN achieved the lowest RMSE in wind estimation (0.91 in CEMACS and 0.97 in Baram), while FNN exhibited significant improvements in solar radiation prediction (RMSE of 86.86 in Baram and 99.23 in CEMACS). These results indicate the effectiveness of DL in mitigating biases in NWP models, offering a promising avenue for reliable renewable energy assessment in Malaysia. This research contributes to advancing energy forecasting techniques, thereby promoting the adoption of sustainable energy solutions amidst increasing energy demands and environmental concerns.

Early Career Scientist

NO, I am not an early career scientist.