ASIA-PACIFIC
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Improving the accuracy of solar irradiance forecasts based on Numerical Weather Prediction using variables from multiple vertical layers as machine learning inputs

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The penetration of Photovoltaic (PV) power in electricity grid is rapidly increasing. At high penetration levels, accurate solar power forecasts are indispensable in order to compensate the inherent uncertainty in solar irradiance for improving power quality and reliability, and economic integration of solar power into grid. Numerical Weather Predictions (NWPs) are physical models that predict the future state of the atmosphere on a 3-dimensional grid. Although NWP is currently the best tool for forecasting solar irradiance in few hours to several days ahead time horizon, it still exhibits substantial forecast uncertainties. Several studies have demonstrated significant improvement in solar irradiance forecasts based on NWP by applying statistical postprocessing methods using various NWP forecast variables (such as temperature, cloud cover, etc.) as machine learning inputs. However, to the authors' knowledge, these studies are largely limited to the use of forecast variables from the surface level fields. This paper investigates the value of using forecast variables from multiple vertical layers of NWP as machine learning inputs in improving the accuracy of solar irradiance forecasts. Moreover, the effects of postprocessing on the NWP models with different spatio-temporal resolution – Global Forecast System (GFS), regional (ACCESS-R) and city (ACCESS-C) scale mesoscale models of the Australian Community Climate and Earth-System Simulator (ACCESS) model, are studied across different climatic locations in Australia. Functional Analysis of Variance (FANOVA) shows that the importance of NWP variables varies greatly across different climatic locations. More importantly, it is shown that in addition to the variables from surface level fields, including NWP variables from vertical layers as machine learning inputs provides further improved accuracy of solar irradiance forecasts.