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Precipitable water vapor fusion of MODIS and ERA5 based on convolutional neural network

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Precipitable water vapor (PWV) is a key parameter of the global climate system and the hydrologic cycle. Accurately sensing PWV is of significant importance to understanding the process of global climate change and the hydrologic cycle as well as improving severe weather forecasting. Currently, PWV can be measured and retrieved with various techniques of different accuracies as well as spatial and temporal resolutions, while PWV products still show diverse limitations. In this study, we aim to achieve PWV estimates of high accuracy and resolutions by fusing PWV values derived from the moderate resolution imaging spectroradiometer (MODIS), the fifth generation of the European Centre for Medium-Range Forecasts (ECMWF) global reanalyzes (ERA5) and Global Navigation Satellite System (GNSS) through a convolutional neural network (CNN). Specifically, a CNN-based PWV fusion model which is capable of extracting and fusing information from input features is established to improve the accuracy and spatial resolution of PWV. The region is focused on the west coast of America and the experimental duration lasts for the whole year of 2020. The fused PWV values reveal good agreement with the GNSS PWV values taken as the references, showing the mean absolute error (MAE) of 0.54-0.65 mm and the root mean square error (RMSE) of 0.73-0.90 mm. Compared to MODIS PWV estimates, the fused PWV demonstrates significant improvement in accuracy, with the MAE and RMSE reduced by 79.4% and 76.8%. Meanwhile, they are also superior to the ERA5 PWV, revealing decreases of 35.3% in RMSE and 33.7% in MAE, respectively. Furthermore, the PWV estimates derived from the fusion model are less affected by seasonal variations in terms of accuracy and can provide more detailed and reasonable spatial variation features. The fused PWV values retrieved from the proposed approach contribute to exploiting the full potential of MODIS and ERA5 products and offer promising potential for meteorological applications.