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A Geographic Information System Mapping Method for Creating Improved Satellite Solar Radiation Dataset Over Qatar

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Abstract : The future of solar energy in Qatar is evolving steadily. Hence, high-quality spatial solar radiation data is of the uttermost requirement for any planning and commissioning of solar technology. Generally, two types of solar radiation data are available: satellite data and ground observations. Satellite solar radiation data is developed by the physical and statistical model. Ground data is collected by solar radiation measurement stations. The ground data is of high quality. However, they are limited to distributed point locations with the high cost of installation and maintenance for the ground stations. On the other hand, satellite solar radiation data is continuous and available throughout geographical locations, but they are relatively less accurate than ground data. To utilize the advantage of both data, a product has been developed here which provides spatial continuity and higher accuracy than any of the data alone. The popular satellite databases: National Solar radiation Data Base, NSRDB (PSM V3 model, spatial resolution: 4 km) is chosen here for merging with ground-measured solar radiation measurement in Qatar. The spatial distribution of ground solar radiation measurement stations is comprehensive in Qatar, with a network of 13 ground stations. The monthly average of the daily total Global Horizontal Irradiation (GHI) component from ground and satellite data is used for error analysis. The normalized root means square error (NRMSE) values of 3.31%, 6.53%, and 6.63% for October, November, and December 2019 were observed respectively when comparing in-situ and NSRDB data. The method is based on the Empirical Bayesian Kriging Regression Prediction model available in ArcGIS, ESRI. The workflow of the algorithm is based on the combination of regression and kriging methods. A regression model (OLS, ordinary least square) is fitted between the ground and NSBRD data points. A semi-variogram is fitted into the experimental semi-variogram obtained from the residuals. The kriging residuals obtained after fitting the semi-variogram model were added to NSRBD data predicted values obtained from the regression model to obtain the final predicted values. The NRMSE values obtained after merging are respectively 1.84%, 1.28%, and 1.81% for October, November, and December 2019. One more explanatory variable, that is the ground elevation, has been incorporated in the regression and kriging methods to reduce the error and to provide higher spatial resolution (30 m). The final GHI maps have been created after merging, and NRMSE values of 1.24%, 1.28%, and 1.28% have been observed for October, November, and December 2019, respectively. The proposed merging method has proven as a highly accurate method. An additional method is also proposed here to generate calibrated maps by using regression and kriging model and further to use the calibrated model to generate solar radiation maps from the explanatory variable only when not enough historical ground data is available for long-term analysis. The NRMSE values obtained after the comparison of the calibrated maps with ground data are 5.60% and 5.31% for November and December 2019 month respectively.

Keywords : global horizontal irradiation, GIS, empirical bayesian kriging regression prediction, NSRDB
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