Evaluation of direct normal irradiance via cloud optical depth from third-generation geostationary meteorological satellites in the USA

07. Data and products for emerging services

Thursday, October 3rd 2024 11:30 - 11:45 Room 13

Mathieu Turpin[1] , Sébastien Marchal[1] , Nicolas Sébastien[1] , Nicolas Schmutz[1]

[1] Reuniwatt

The evaluation of Direct Normal Irradiance (DNI) is essential for the solar energy sector. Satellite-based estimations present numerous advantages over ground-based measurements, including rapid and cost-effective deployment without the necessity for hardware installation, no operational and maintenance requirements for sensors, and effective identification of malfunctions through comparisons between meter-measured production and satellite-derived estimations. In this work, we compare two estimation models of Cloud Optical Depth (COD) to infer the DNI from the third-generation geostationary meteorological satellite GOES-16 (75.2?E) in the USA. The first model is based on COD from the “Satellite Application Facility on support to NoWCasting and very short-range forecasting” (SAFNWC) version 2018.1. The algorithm is based on a multispectral threshold technique applied to each pixel of the satellite image and uses Numerical Weather Prediction (NWP) input data for surface temperature and total atmospheric water vapour content. These data are only accessible for the full disk scan every 10 minutes with a spatial resolution of 2 km and are only available if the solar zenith angle is lower than 70?. The second model is based on Daytime Cloud Optical and Microphysical Properties (DCOMP) and Nighttime Cloud Optical and Microphysical Properties (NCOMP) provided by National Oceanic and Atmospheric Administration (NOAA). The algorithm uses both visible and near-infrared bands during the day and a combination of infrared bands for nighttime detection. Unlike NWCSAF, data are available day and night regardless of the position of the Sun. In addition, these data are accessible for the Contiguous U.S (CONUS) scan which covers an area of 3000 km x 5000 km over the USA and Mexico every 5 minutes with a spatial resolution of 2 km, therefore twice as frequently. Both models use a Cloud Mask (CMA) product to delineate all cloud-free pixels in a satellite scene with a high confidence, then DNI is forced to the value obtained by the McClear clear sky model when CMA indicates "cloud free". Otherwise, the COD is combined with the clear sky model to compute the effective DNI. Moreover, the circumsolar radiation is considered to avoid underestimation of the forward scattered radiation in DNI when compared to ground observations. The model outputs are compared to quality-checked 10-minute solar radiation measurements from one Baseline Radiation Monitoring Center (BSRN) station and five Measurement and Instrumentation Data Center (MIDC) stations located in the USA over the period 2021-04-01 and 2022-03-31. These networks measure the Global Horizontal Irradiance (GHI), Diffuse Horizontal Irradiance (DHI) and DNI. Only data where the DNI measurement is larger than 25 W/m² is kept for the study. The results are expressed for all available measurement data in terms of relative Root Mean Square Error (RMSE), RMSE Skill Score, Mean Absolute Error (MAE), MAE Skill Score, and Mean Bias Error (MBE). Metrics are normalized by the average of measurements. We conclude that taking into account circumsolar radiation improves the quality of the DNI estimates from both models. Moreover, the NOAA model performs better than the NWCSAF model with an average RMSE of 38.3% and

42.4% respectively, and an average MAE of 24.1% and 25.0% respectively.