ASSESSMENT OF THE SPATIOTEMPORAL VARIABILITY OF SURFACE OF GLOBAL HORIZONTAL IRRADIANCE USING HIGH-RESOLUTION SATELLITE DATA ABD GROUND BASED MEASUREMENTS

Salamalikis V.[1], Tzoumanikas P.[1], Argiriou A. A.[1] and Kazantzidis A.[1*]

[1] Laboratory of Atmospheric Physics, Department of Physics, University of Patras, Patras GR 26504, Greece

***corresponding author e-mail: akaza@upatras.gr**

Summary

The accurate description of surface solar irradiance (SSI) is of crucial concern for assessing the efficiency of alternative energy sources. Satellite-derived information provides the main resource for deriving historical data and short-term solar radiation forecasts with coarse spatial and temporal resolution. The uncertainties of atmospheric quantities (clouds, aerosols, water vapor, etc.) can be translated to SSI uncertainties reaching 5%-10% for a coarse spatial grid and temporal interval. Those induced errors increase for finer temporal and spatial resolutions. In this study, the global component of SSI, namely GHI, is calculated at 15-min using atmospheric inputs from the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) onboard the Meteosat Second Generation satellite. Daily GHI integrals are compared against ground-based observations and those provided by the Copernicus Atmospheric Service (CAMS) reanalysis project. Furthermore, site-adaptation methods are applied to adjust the biases of the satellite and the model-derived solar irradiances using as skill-reference the ground-based measurements.

Keywords: Global Horizontal Irradiance, solar satellite resource, CAMS, site-adaptation methodologies

1. Data and Methodology

Data from the MSG satellite are used to retrieve the CCI (cloud clearness index), which is defined as the ratio of irradiance under real conditions and the corresponding one considering cloud-free atmospheres. This cloud parameter is further multiplied with the clear sky GHI values to calculate the solar irradiance reaching the surface while the clear sky GHI is simulated using the SBDART model (Ricchiazzi et al. 1998) of the LibRadtran radiative transfer package. The overall methodology, as well as the data sources, are given in detail in Nikitidou et al. (2015). Following the spatiotemporal resolution of the MSG-SEVIRI instrument, GHI is modeled at a 0.05° grid and a 15-min temporal step. Also, daily GHI is gathered from CAMS (http://www.soda-pro.com/web-services/radiation/cams-radiation-service). Satellite-derived and CAMS GHI are statistically verified against ground-based measurements from the radiometric station of Patras, Greece. The radiometric station is equipped with Kipp&Zonen CM-type pyranometer recording GHI at a 1-min step with the corresponding standard deviation. The statistical verification of the simulated GHI is also followed by the application of bias-correction algorithms for the reduction of systematic and dispersion biases. Here, the Least-Squares Linear (LIN) correction and the Empirical Quantile Mapping (EQM) approaches are evaluated for the site-adaptation of simulated GHI (Polo et al., 2020).

2. Results

This section includes the statistical verification of the simulated global horizontal irradiances against ground-based observations in Patras for the year 2012. The upper three panels of Figure 1 correspond to CAMS-RAD GHI, while the lower panels are for the MSG-derived GHI. Regarding the initial simulated GHI, GHI from MSG inputs simulates with high accuracy, the ground GHI daily integrals with an average underestimation of -0.25 kWh m^{-2} and low dispersion error (RMSE=0.54 kWh m^{-2}). On the other side, CAMS GHI is significantly dispersed (RMSE=1.29 kWh m^{-2}), also providing low systematic bias. The correlation coefficient for CAMS and MSG-derived GHI is high, exceeding 0.85. The site-adaptation procedures correct the modeled irradiances expressing almost similar results. The linear regression slopes are very close to the identical line and the error metrics are lower than in the uncorrected case. For both GHI products, the LIN correction acts better giving lower errors than the EQM method, increasing also the linear association between the modeled and the observed GHI ($R>0.9$).

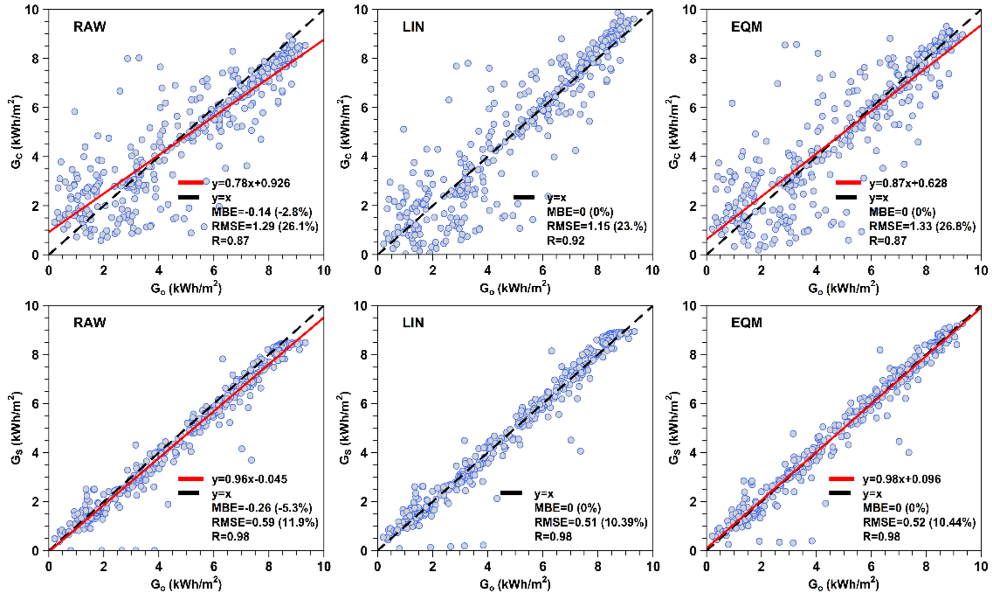

Fig. 1: Scatterplots between the measured and the modeled (bias-corrected) GHI. The upper panels correspond to modeled GHI from CAMS-RAD product, and the lower panels the simulated GHI based on the satellite-resource from MSG-SEVIRI. The values in the parentheses correspond to relative error metrics using as skill reference the ground-measured GHI. The subscripts o, C and S indicate the observed, CAMS, and MSG-derived GHI.

The Taylor plot in Figure 2 indicates that the LIN method corrects better the simulated GHI since the distance from the horizontal axes is lower for LIN cases (green circle and triangle for CAMS and satellite-derived GHI). Also, the right panel in Figure 2 shows that the error-distributions are concentrated around zero, especially for the satellite-derived GHI, explaining the efficiency of LIN to correct the simulated GHI. The accurate performance of MSG-derived GHI (blue and red lines) explained with strongly zero-peaked distributions and a small number of GHI absolute discrepancies above 1 kWh m^{-2}.

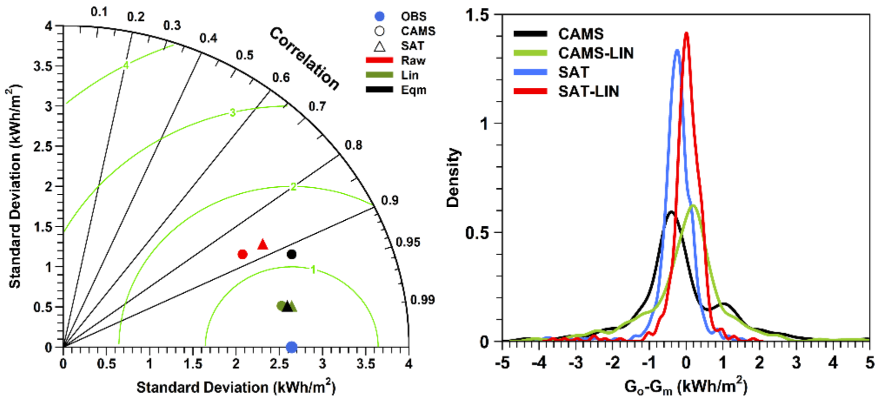

Fig. 2: Taylor Diagram for the modeled and the satellite-derived GHI (left panel) and statistical distribution of the GHI differences between the initial and the linear-corrected GHI simulations (right panel)

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4. References

Ricchiazzi, P., Yang, S., Gautier, C., Sowle, D., 1998. SBDART: A Research and Teaching Software Tool for Plane-Parallel Radiative Transfer in the Earth's Atmosphere. Bull. Am. Meteorol. Soc. 79, 2101–2114

Nikitidou, E., Kazantzidis, A., Tzoumanikas, P., Salamalikis, V., Bais, A. F, 2015. Retrieval of surface solar irradiance, based on satellite-derived cloud information, in Greece. Energy 90 (1), 776-783.

Polo, J., Fernández-Peruchena, C., Salamalikis, V., Mazorra-Aguiar, L., Turpin, M., Martín-Pomares, L., Kazantzidis, A., Blanc, P., Remund, J., 2020. Benchmarking on improvement and site-adaptation techniques for modeled solar radiation datasets. Sol. Energy 201, 469-479.