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Comparison of NASA-POWER surface solar UVA irradiance with ground-based measurements in Argentina

F. Orte[1,2, a)], F. Carmona[2,3], A. Lusi[1,2], E. Wolfram[2,4,5], E. Luccini[6,7], F. Nollas[4], R. D'Elia[2], J. Pallotta[1].

[1]*DEILAP-UNIDEF (CITEDEF-CONICET), Villa Martelli, Buenos Aires, Argentina*
[2]*Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina*
[3]*Instituto de Hidrología de Llanuras (IHLLA), Univ. Nacional del Centro de la Prov. de Bs As, Tandil, Argentina*
[4]*Servicio Meteorológico Nacional (SMN), Buenos Aires, Argentina*
[5]*Facultad Regional Buenos Aires, Universidad Tecnológica Nacional, Buenos Aires, Argentina*
[6]*CONICET-CEPROCOR, Sede Santa María de Punilla, Córdoba, Argentina*
[7]*Facultad de Química e Ingeniería del Rosario, Pontificia Universidad Católica Argentina, Rosario, Argentina.*

[a)] *Corresponding author: pfacundo.orte@gmail.com*

Abstract. High-quality ground-based measurement is the most reliable technique for obtaining local surface solar irradiances and it is crucial to validate satellite retrievals. Within the framework of the SAVER-Net Project (2013-2018), ground-based instruments for solar UVA (315-400 nm) irradiance measurement at horizontal plane have been installed at 7 sites along Argentina from ~26ºS to ~52ºS (Orte et al., 2022). In this work, daily averages of surface solar UVA irradiance from NASA's Prediction of Worldwide Energy Resources (NASA-POWER; power.larc.nasa.gov) are compared against UVA ground-based measurements an the 7 SAVER-Net sites. All sites present high correlation, with two stations showing coefficient of determination (R^2) of 0.89 and the others above 0.96, and generalized low values of MAE and RMSE.

INTRODUCTION

Surface UV (280-400 nm) solar radiation is mainly associated with its biological consequences and damage on materials. The UVA portion (315-400nm) is weakly attenuated by the atmosphere, and it is estimated that more than 90% of the amount that reaches the top of the atmosphere also reaches the Earth's surface [1-2]. The exposure of humans to UVA radiation is associated with photo aging and wrinkling. It can penetrate to the deeper layers of the skin and damage both DNA and the proteins that repair DNA damage causing cell death and malignant transformation of skin cells [1, 3-4].

On the other hand, some studies suggest a relationship of the amount of surface UVA with changes in plant morphology, photosynthesis and chemical mechanisms, among other effects [5-6].

In spite of the importance to measure and evaluate the irradiance in the UVA band and their consequences due to the exposure, it is observed [2] that there are not many reports on the UVA waveband if we compare with those reporting validation analysis or evaluate the erythemal UV [e.g. 7], or even of those related with the ozone amount monitoring [e. g. 8-10].

With the aim to contribute to the quantification of the UVA surface solar radiation, a ground-based network for solar radiation has been deployed in Argentina between 2013 and 2018 in 8 sites, including UVA (315-400 nm) radiometers (except for Tandil) [11]. The Saver-Net network covers a latitudinal range from ~26 to ~52°S. The southernmost sites are deployed in high latitudes of the Southern Hemisphere, which is a latitude range with a scarcity of continental areas and, therefore, with lack of ground-based measurements. This fact highlights the need to reinforce observation from the ground and the importance of validating satellite information with high quality measurements in these latitudes.

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Although well-calibrated and well-maintained ground-based measurements are the most reliable technique for obtaining surface solar irradiance in a specific site, it are usually limited in number at only certain locations due mainly to the cost of these facilities and the requirement of skilled human resources to operate and maintain it, which is crucial to provide high-quality information. In this sense, satellite-based measurements validated with ground-based instrumentation provide a valuable option to evaluate the solar radiation in long-term and global bases, mainly in regions with lack of ground-based measurements. Therefore, combining satellite and terrestrial information is useful to accurately evaluate the solar radiation on the surface in global bases.

In this work, daily averages of surface solar UVA irradiance from NASA's Prediction of Worldwide Energy Resources ($DUVA_{NP}$) (NASA-POWER; power.larc.nasa.gov) are compared against UVA ground-based measurements ($DUVA_{GB}$) in Argentina.

DATASETS AND METHODOLOGY

Study Area and Ground-based Measurements

The $DUVA_{GB}$ were obtained in 7 sites of SAVER-Net along Argentina from measurements of YES UVA-1 radiometers, except for Tucumán and Córdoba which have installed radiometers Kipp&Zonen serie UV-S-A-T. Table 1 includes the location, instrument, and period considered in the comparisons. The first two years since the installation of each instrument are taken into account as a strategy to minimize the effect of the ground-based instrument degradation. In addition, a quality test over the one-minute database has been performed using the clearness index for the UVA range. The days with data showing an unusual behavior have been separated and visually analyzed to ensure the quality of the database.

TABLE 1. Details of the UVA Radiometers, location, and period of the measurement included in the comparison

Station City (Province)	Location (altitude)	Instruments	Period
Tucumán (Tucumán)	26.79ºS, 65.21ºW (456 m a.s.l.)	K&Z UV-S-A-T	15/11/2017 – 17/12/2018
Pilar (Córdoba)	31.68ºS, 63.87ºW (330 m a.s.l.)	K&Z UV-S-A-T	1/11/2017 – 1/11/2019
Villa Martelli (Buenos Aires)	34.58ºS, 58.48ºW (25 m a.s.l.)	YES UVA	31/8/2014 – 30/8/2016
Neuquén (Neuquén)	38.95ºS, 68.14ºW (270 m a.s.l.)	YES UVA	14/12/2016 - 14/12/2018
Bariloche (Río Negro)	41.15ºS, 71.16ºW (846 m a.s.l.)	YES UVA	16/3/2016 – 22/2/2018
Comodoro Rivadavia (Chubut)	45.78ºS, 67.50ºW (43 m a.s.l.)	YES UVA	19/1/2016 –2/10/2017
Río Gallegos (Santa Cruz)	51.60ºS, 69.32ºW (15 m a.s.l.)	YES UVA	15/9/2014 – 14/9/2016

NASA-POWER solar irradiation data

We evaluate $DUVA_{NP}$ data provided by the NASA-POWER project. Specifically, here we use the "CERES SYN1deg All-Sky Surface UVA" product, Edition 4A. $DUVA_{NP}$ data were downloaded from the web site https://power.larc.nasa.gov (last access ago. 16, 2021) on a 1°× 1° latitude and longitude for the pixels that include the location of each ground-based Saver-Net station.

Comparison methodology

The $DUVA_{NP}$ data is compared with the ground-based measurements $DUVA_{GB}$ in 7 sites of SAVER-Net network in Argentina to evaluate the satellite product in each site. The one-minute ground-based database was daily averaged to obtain the $DUVA_{GB}$. Only days with more than 1400 minutes of acquisition of the ground-based measurements were considered for the comparison, which represent more than 97% of the whole day.

The correspondence between satellite and ground-based measurement were based on a linear regression analysis. The determination coefficient (R^2), the root mean squared error (RMSE), and mean absolute error (MAE) were analyzed.

RESULTS

Figure 1 presents the scatter plot between $DUVA_{NP}$ and $DUVA_{GB}$ together with the corresponding linear regression analysis for each site. Table 2 summarizes the metrics of the comparison. It shows that Neuquén (NQN), Comodoro Rivadavia (CR), and Río Gallegos (RG) present the best performance with minimum values of RMSE and MAE and high correlation, accounting with a coefficient of determination R^2 above 0.96. Pilar (CBA) and Villa Martelli (VM) show the highest values of RMSE and MAE but a good correlation, which reflect high relative bias with respect the others sites but low dispersion.

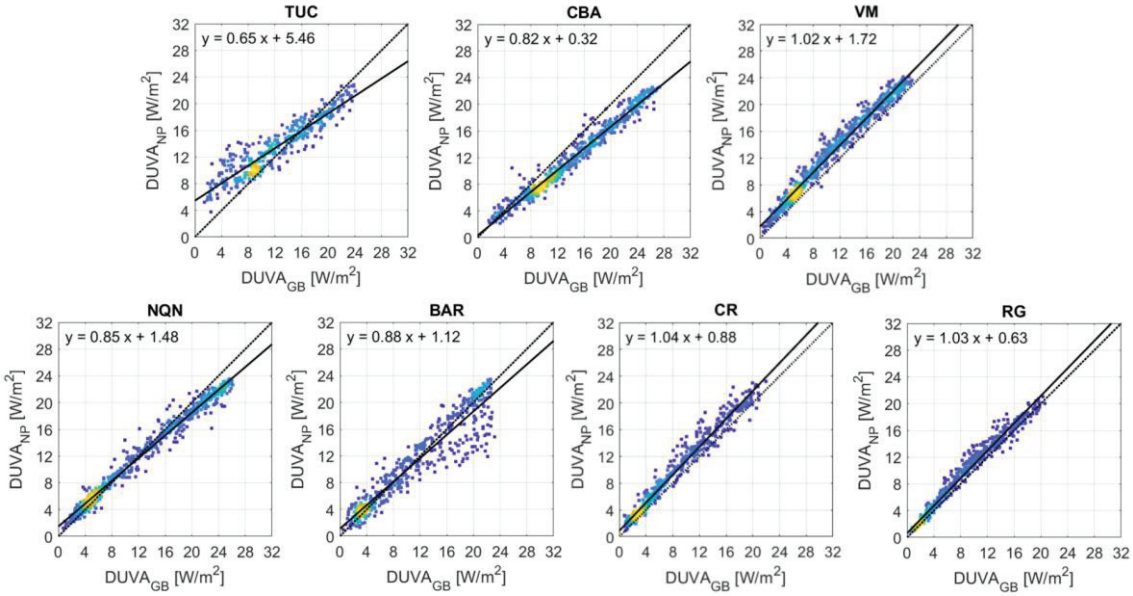

FIGURE 1. Scatter plot of the daily global solar irradiation NASA POWER data versus Ground based measurements, linear regression (black line) and 1:1 line (black dotted line) for each station

TABLE 2. Metrics of NASA POWER – Ground Based DUVA Analysis. N: number of pairs compared. R^2: determination coefficient. RMSE: root mean squared error; MAE: mean absolute error

Site	N	R^2	RMSE (W/m^2)	MAE (W/m^2)
Tucumán (TUC)	390	0.86	2.83	2.20
Pilar (CBA)	618	0.97	2.78	2.45
Villa Martelli (VM)	677	0.97	2.13	1.90
Neuquén (NQN)	690	0.98	1.54	1.20
Bariloche (BAR)	508	0.89	2.33	1.61
Comodoro Rivadavia (CR)	612	0.97	1.60	1.30
Río Gallegos (RG)	619	0.98	1.21	0.91

The worst agreements were found for Bariloche (BAR) and Tucumán (TUC). These results are in agreement with those found by Orte et al. (2021) [12] for GHI wavelength range, who suggested that the lower agreement between satellite and ground based measurements in these two sites is mainly attributed to the deviation of the atmospheric and ground characterization from the 1 × 1 degree grid box mean characterization which is used in the satellite retrieval products, due to the high variability of the input parameters (elevation, surface albedo, cloudiness, among others) into the pixel.

CONCLUSION

This work presents a comparison of the daily average surface solar UVA irradiance from NASA-POWER with ground-based observation of UVA irradiance in 7 sites of the Saver-Net solar radiation network installed in Argentina.

In general, the results reflect good correspondence in all the sites. The greatest differences found for Bariloche and Tucuman are attributed to the fact that the mean characterization used for the satellite retrievals into the pixel appears to deviate from the punctual situation. Orte et al. (2021) obtained similar results for total solar irradiance using independent instrumentation, which reinforce the conclusion obtained in this work for the UVA waveband.

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