VALIDATION OF THE METEONORM SATELLITE IRRADIATION DATASET

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ABSTRACT: Global irradiation is the main source for photovoltaic (PV) energy production. The knowledge of the incoming solar short-wave irradiation is of major importance for the planning, monitoring and operation of solar energy power plants and grid operations. In this paper we present a validation of the newly developed Meteonorm Satellite Irradiation (MNSI) dataset for Europe, Middle East and Africa. Uncertainties of 12-25% relative RMSE for hourly values has been found.
Keywords: solar resources, irradiation data, satellite data

1 INTRODUCTION

Global irradiation is the main source for photovoltaic (PV) energy production. A large number of PV power plants produce a significant amount of power penetrating into the electrical grid under sunny conditions. Therefore the knowledge of the incoming solar short-wave irradiation is of major importance for the planning, monitoring and operation of solar energy power plants and grid operations.

Ground station measurements from national weather services still provide the most accurate data for global irradiation. They represent the ground truth, which is the relevant parameter for solar energy applications. However, the network of the measurement stations is not dense enough to cover an entire area in sufficient spatial resolution. In this context, satellites have become a valuable source for solar irradiation data, in particular in areas with sparse distribution of meteorological stations. Satellite images from weather satellites have a horizontal grid resolution of a few km^2. Beside the availability of high resolution gridded time series, the rapid update of satellite images every 15 minutes in real time allows to retrieve information of the actual cloud state. This allows the use for monitoring and nowcasting applications [1], [2].

In this paper we present a validation of the newly developed Meteonorm Satellite Irradiation (MNSI) Dataset for Europe, Middle East and Africa. It is based on satellite images from Meteosat Second Generation (MSG). The dataset was compiled combining the Heliosat method [3, 4] applied to the visible channels 1 (VIS06) and 12 (HRV) with a multichannel retrieval for snow cover detection. Irradiation values from the HRV channel images are calculated on a 1/40 degree grid (Figure 1), those from the VIS06 channel on a 1/16 degree grid (Figure 2). The spatial extension is from 66°N to 66°S and 66°W to 66°E. A regionalized statistical regression approach integrating ground measurements is adopted for bias correction and uncertainty reduction. The dataset covers a time period from 2006 onwards and is updated in real-time.

The dataset is compared to reference ground measurement stations from the Baseline Surface Radiation Network BSRN [5] (http://bsrn.awi.de/). These stations are not included in the statistical bias correction.

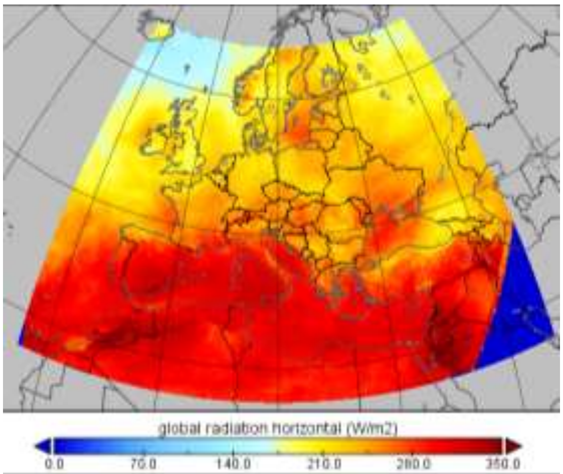

Figure 1: Global horizontal irradiance for May 2017 showing the area covered by the high resolution visual (HRV) channel.

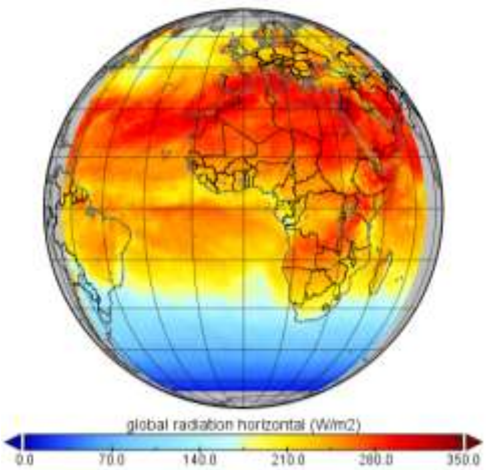

Figure 2: Global horizontal irradiance for May 2017 showing the area covered by the full disk VIS06 channel.

2 METHOD

We validate the satellite dataset by a comparison to reference ground stations from the BSRN. The recommended quality checks [6] have been applied to the BSRN data.

2.1 Validation sites

Table I and Figure 3 shows the list of the validation sites. Eleven sites were used, where nine are located in

Europe from Spain up to Estonia and two are located in the southern part of Africa.

Figure 3: Maps showing the location of the validation sites (top: Europe / bottom: Southern Africa)

Table I: List of the validation sites including the period of data used to validate.

Abbr.	Name	Latitude [°]	Longitude [°]	Period
CAB	Cabauw	51.9711	4.9267	2006-2017
CAR	Carpentras	44.0830	5.0590	2006-2017
CAM	Camborne	50.2167	-5.3167	2006-2017
CNR	Cener	42.8160	-1.6010	2009-2017
LIN	Lindenberg	52.2100	14.1220	2006-2017
LER	Lerwick	60.1389	-1.1847	2006-2017
TOR	Toravere	58.2540	26.4620	2006-2017
PAY	Payerne	46.8150	6.9440	2007-2013
PAL	Palaiseau	48.7130	2.2080	2006-2017
GOB	Gobabeb	-23.5614	15.0420	2013-2017
DAA	De Aar	-30.6667	23.9930	2015-2017

2.2 Validation procedure

The following procedure has been applied to validate the dataset.

- The dataset is validated on a per station basis.
- Hourly and daily values are validated separately.
- The statistical measures bias and rmse are calculated in absolute and relative values. The relative value was gained by division of the absolute value with the average measured value.
- Only daytime values are used for the comparison. We defined daytime when GHI (Global horizontal irradiance) is above 10 W/m^2.

3 RESULTS

Figure 4 and Figure 5 are showing exemplary scatter plots of hourly and daily value comparisons of satellite versus ground data for the location of Carpentras. RMSE is 14.8% for hourly and 9.1% for daily values, which is a relative improvement of 38% in RMSE by averaging to daily values. Figure 6 (hourly values) and Figure 7 (daily values) show absolute and relative values of the statistical measures for all sites. Sites below 55°N show a RMSE of 60-70 W/m^2 or 12-25% relative RMSE. Higher latitude sites show larger uncertainties. RMSE of daily values are in the range of 9-16% for the sites below 55°N. This is a relative reduction of 30-40%.

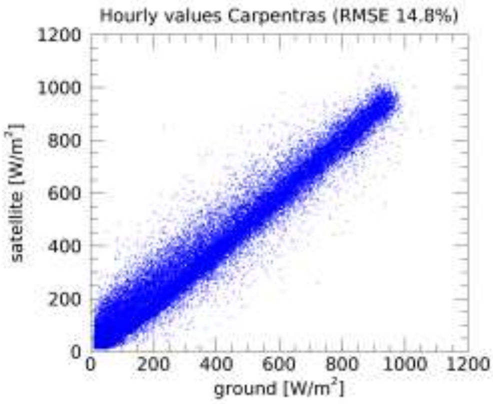

Figure 4: Scatter plot of hourly values of GHI for Carpentras (FR). Relative RMSE is 14.8% for this location.

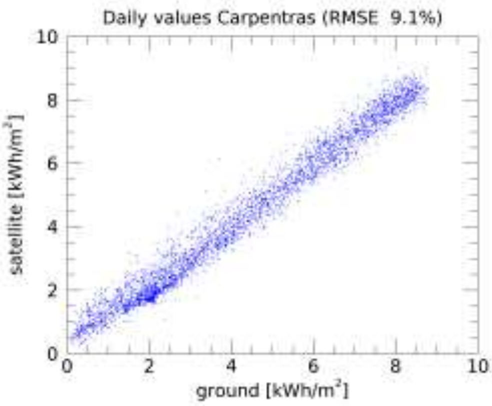

Figure 5: Scatter plot of daily values of GHI for Carpentras (FR). Relative RMSE is 9.1% for this location.

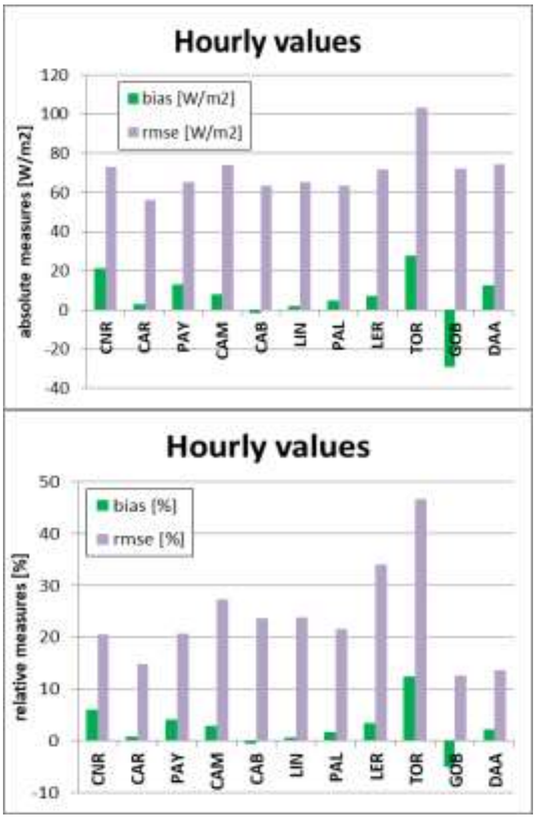

Figure 6: Statistical measures of hourly values per station (green: bias, violet: rmse). Absolute values in top Figure and relative values at the bottom Figure.

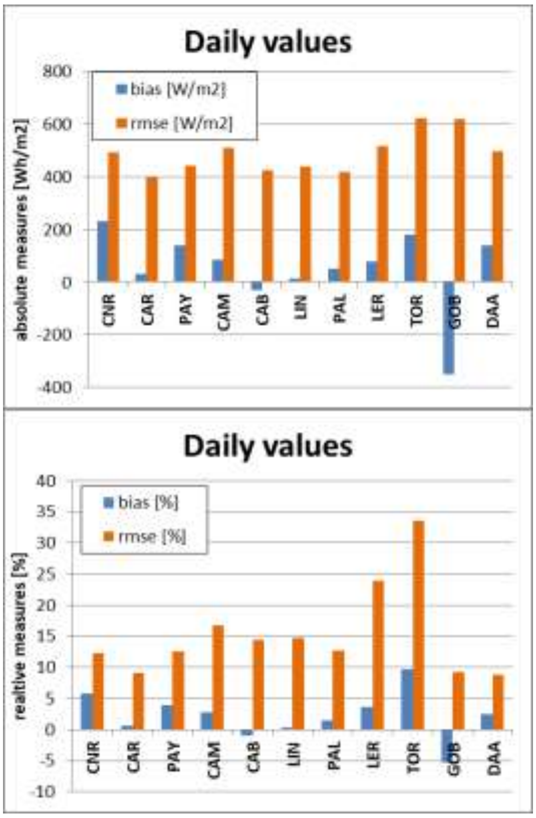

Figure 7: Statistical measures of daily values per station (blue: bias, orange: rmse). Absolute values in top Figure and relative values at the bottom Figure.

4 AVAILABILITY

The dataset is available through the climate database software tool Meteonorm in version 7.3 (www.meteonorm.com).

5 CONCLUSION

We presented the validation of the newly compiled Meteonorm Satellite Irradiation (MNSI) Dataset for Europe and Africa. A representative number of eleven stations, nine across Europe and two in the Southern part of Africa, from the BSRN network served as reference for the validation. A RMSE of 60-70 W/m^2 for hourly values has been found. This is in the order of 20% for the temperate zone in Europe and around 13% for the sunny African sites. Larger uncertainties were found in high latitude sites above 55°N in Northern Europe. Aggregating hourly to daily values reduces the uncertainty. Errors are smoothed out. The gain in relative RMSE is in the order of 30-40%.

6 REFERENCES

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6 ACKNOWLEDGEMENTS

Thanks to the World Radiation Monitoring Center (https://bsrn.awi.de/) for providing the data from the BSRN station network.