

IRRADIANCE MAPS APPLIED FOR THE PERFORMANCE ASSESSMENT OF PV SYSTEMS - A CASE STUDY FOR THE GERMAN FEDERAL STATE OF SAXONY

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OBJECTIVE

For the check of the annual or month by month energy yield of a PV system, methods based on irradiance maps published by weather services or others are in use.

To assess the validity of these products for this task, a case study for the region of the German federal state of Saxony has been performed using irradiance data from different data source for the year 2005. A comparison of satellite-derived hourly irradiance data with ground measurements on a monthly and annual scale has been done.

Maps of the annual radiation sums have been inter-compared for additional information on the spatial structure of the radiation field.

An assessment of the end use accuracy of the irradiance data has been done by checking a set of monthly energy yield data of well-running grid-connected PV systems.

DATA USED

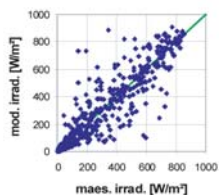
Hourly time series from ground and satellite-derived horizontal global irradiance data:

- Ground data from the stations Chemnitz, Dresden, and Zinnwald operated by the German Weather Service (DWD). These data are supported by measurements from the agrar-meteorological net (result are not presented on this poster).
- Irradiances for the same location derived by the Heliosat method using Meteosat-7 and Meteosat-8 data.

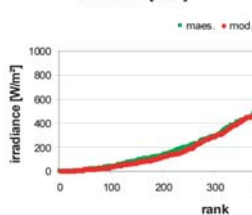
Maps of annual radiations sums from the following data provider:

- DWD, a mixed product of satellite-derived irradiance values and ground measurements.
- CM-SAF, a product of the Climate Monitoring Satellite Application Facility derived from satellite data only, Meteosat-8 and NOAA/ AVHRR data.
- Oldenburg Univ., derived from Meteosat-7 satellite data by the Heliosat method.
- Oldenburg Univ., derived from Meteosat-8 satellite data by an improved Heliosat method.

ACCURACY OF IRRADIANCE DATA



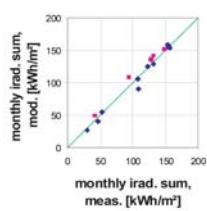
Example: hourly horizontal irradiance measured at the DWD station of Dresden for the month of July, 2005 compared to modelled Heliosat/ Meteosat-8 data.
rMBE=1%



Cumulative distribution of measured (green) and modeled irradiance data (same data set as figure above) presented here as plot of the irradiance values sorted by magnitude. The coincide indicates that the probability distribution of the data is well matched.

	Chemnitz	Zinnwald	Dresden
Measured radiation sum;	1130 kWh/m ²	1013 kWh/m ²	1101 kWh/m ²
Heliosat/ Meteosat 7	rMBE -4.0%	rMBE -4.1%	rMBE -3.1%
Heliosat/ Meteosat 8	rMBE -2.6%	rMBE 0.2%	rMBE -1.6%

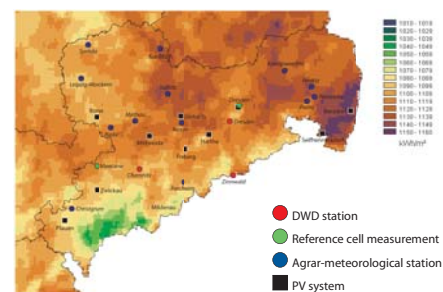
Example: annual irradiance sums at 3 DWD ground stations compared to Heliosat results from Meteosat-7 and Meteosat-8 data.



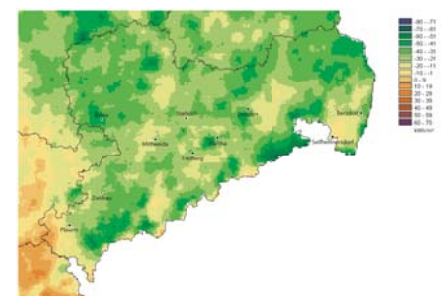
Example: monthly irradiance on the inclined surface (30°) at two PV systems in Meerane and Dresden. Comparison of reference cell measurements to Heliosat/ Meteosat-8 results.

INTER-COMPARISON OF IRRADIANCE MAPS

Map of the 2005 annual radiation sum covering the German federal state of Saxony. The map is derived from Meteosat-8 data by the Heliosat method. Circles indicate radiation-measuring ground stations. Black squares locate the investigated PV systems.



Difference between the annual DWD irradiance map and the Meteosat-8/ Heliosat (see above). Mean deviation is 6%. The DWD map shows higher values.



Mutual inter-comparison of the different irradiance maps. The mean and root mean square differences of the annual radiation sum given by pairs of radiation maps.

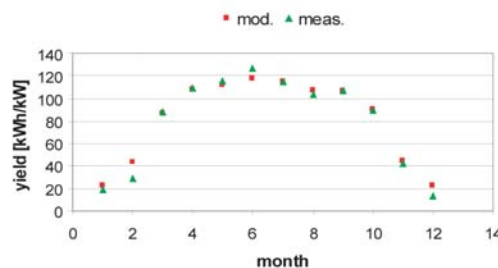
Maps intercompared	mean difference [%]	root mean square dif. [%]
H/M7- H/M8	-0.4	1.2
DWD- H/M8	2.2	2.5
CMSAF- H/M8	2.8	3.4
DWD-H/M7	2.7	3.0
CMSAF-H/M7	3.2	3.8
CMSAF-DWD	0.5	1.7

CHECK OF ENERGY PRODUCTION

	modeled yield [kWh/kW]	measured yield [kWh/kW]	rel. error [%]
Location			
Borna	928	998	-7.0
Seithennersdorf	926	930	-0.4
Starbach	942	930	1.3
Hartha	976	957	1.9
Zwickau	906	957	-5.3
Plauen	921	850	8.4
Bertzdorf	1040	964	7.9
Freiberg	906	977	-7.3
Mittweida	912	958	-4.7
Dresden	966	989	-2.3

Accuracy of the estimated energy yields. Heliosat/ Meteosat-8 results to assess the system's yield via the PVSAT-2 procedure. Only data sheet information have been used as simulation input for the PV systems.

Modeled and measured annual yield of 10 PV systems in Saxony (1-92 kWp).



Example: monthly energy yields of a PV system at Hartha.
rMBE: 1.1 %

RESUMÉ

This investigation has shown that procedures to gain satellite-derived irradiance values may end up with maps showing annual errors in the same order of magnitude as the accuracy of ground based measurements. This finding holds for both, horizontal irradiances and irradiances on tilted planes. A reliable ranking of the different satellite-derived data calls more extended sets of independent, high quality ground data.

Looking to the end use accuracy of the modeled data for the assessment of the yield of grid-connected PV-systems, the following may be stated:

- despite the fact that individual hourly data may show remarkably higher errors, the annual yield is given within error margins of +/- 9%, a figure partly effected by accuracy of the system characterisation (for some systems this figure may be down to the range of 2%). Ensemble yields may be given with errors close to 1%.
- both modeled and measured data proved, that yields in the range of 950 kWh/kW were reached in 2005.

This information on the achievable accuracy of the model data has to be taken into account when applying the irradiance data for estimations of the expected long-term yield of PV systems - together with estimates of the long-term variability of the radiation resource, increasing the uncertainty of the estimates.