Documentation - EnMetSOL

Satellite Data – Available Regions at Oldenburg University

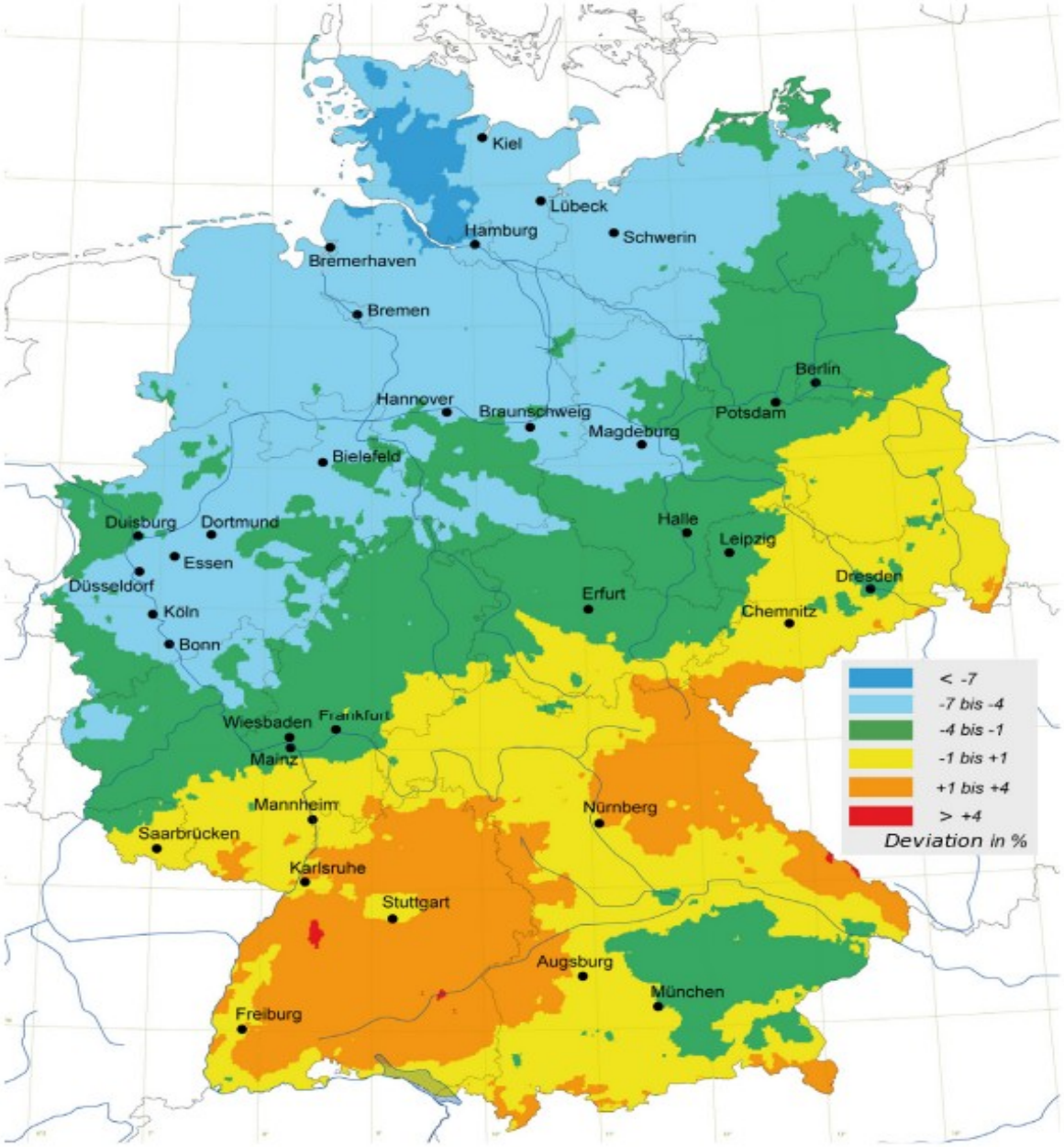
Energy Meteorology Group
Department of Energy and Semiconductor Research
Faculty of Physics
Carl von Ossietzky University of Oldenburg

Dr. A. Hammer

Date 2016-03-14

Inhaltsverzeichnis

Introduction....3
Irradiance from satellite imagery....4
References....6
Data Archive at University of Oldenburg....7



Global horizontal irradiance sum: Deviation of the year 2012 from the longterm average (2005-2011) for Germany. Source: University of Oldenburg and Meteocontrol, Sonne Wind & Wärme 4/2013.

Introduction

At University of Oldenburg satellite images are used for short term forecasting of solar irradiance and photovoltaic power. These forecasts are used by clients for intraday energy trading.
Satellite derived irradiance data are also available as timeseries and maps. Both are routinely used for site assessment and monitoring of photovoltaic systems by meteocontrol GmbH.

These data are based on the cloud index which is calculated from satellite images of both Meteosat generations (Meteosat First Generation MFG and Meteosat Second Generation MSG).
Moreover, GOES East data is calculated in near real time for the Continental United States.
The use of MTSAT and Himawari 8 for regions in the Pacific Ocean like Japan and Australia is in preparation.

University of Oldenburg satellite image archive – overview

Area	Satellite	Position	Period	Resolution at sub satellite point	Images per hour
Europe	MFG	0°E	1995-2005	2.5*2.5km^2	2
Europe	MSG	0°E	2005-today	1.0*1.0km^2	4
India, Arabia	MFG-EAST	53°E	2011-2015	2.5*2.5km^2	2
USA	GOES-EAST	75°W	2012-today	1.75*1.0km^2	4

Irradiance from satellite imagery

The Heliosat method is a technique of determining the global radiation at the ground by using data from a geostationary satellite, see [1,2]. We use this method in combination with a clear sky model to calculate global horizontal irradiance GHI, diffuse horizontal irradiance DHI and direct normal irradiance DNI.

Heliosat method

The key parameter of the Heliosat method is the cloud index n, which is taken from the satellite measurements and related to the transmissivity of the atmosphere via

$$k^* = 1 - n,$$

where the transmissivity is expressed by the clear sky index k* defined as the ratio of global irradiance and clear sky irradiance:

$$k^* = Ig / Iclear.$$

The clear sky irradiance must be known for each site.

Clear sky models

The clearsky case is determined by the atmospheric turbidity.

For GHI the Clearsky model of Dumortier [3] can be used with two alternative turbidity data sets:

- Satellight zones with yearly pattern of Bourges [4]
- high resolution data base of Remund (MeteonormHR) [5]

The SOLIS clear sky model [6] uses the radiative transfer model libRadtran [7] to calculate input parameters for a fitting function called the modified Lambert–Beer (MLB) relation. For this, only two radiative transfer calculations are needed for a given atmospheric state to get the irradiance for a full day. Until 2015 we used climatologies with monthly averages of AOD [8] and water vapour content [9] as input parameters for SOLIS and get DNI and GHI as output. Since 2015, within the project PVKLIMA, we use daily values of MACC aerosol, water vapor and ozone.

The cloudy sky

For the Dumortier Clearsky Model a diffuse fraction model [10] is used to calculate the all sky diffuse horizontal irradiance. In a second step DNI is calculated from the difference GHI-DHI.

A beam fraction model [11] is used to calculate the DNI for all sky conditions with the SOLIS model. This enables a more direct route to calculate DNI.

Data base of satellite images

For the following regions time series of GHI and DNI can be calculated:

- Europe (starting from 1995 up to today)
- Canary Islands (starting from 1995 up to today)
- some regions in Middle East, North and South Africa.
- India and Arabian Peninsula (2011-2015)
- Continental US (starting from 2012 up to today)

The regions covered by the satellite image archive are illustrated below.

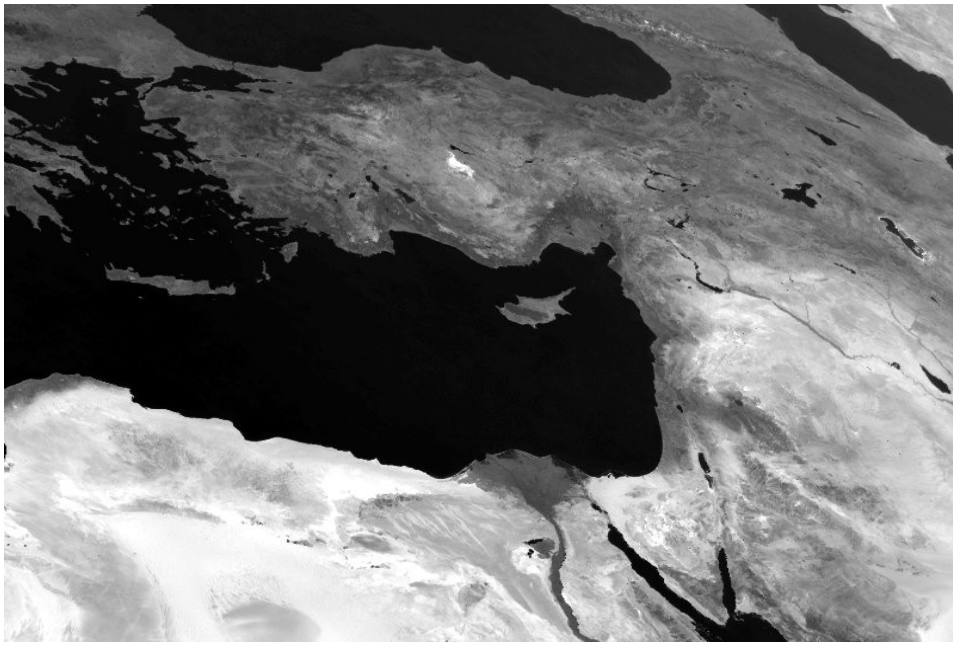
Validation

Within the IEA task „Solar Resource Management“ independent validations of the EnMetSol database have been performed. Ineichen [12] used data from 18 sites, including up to eight years of ground measurements. The relative mean bias deviation resulted in −0.8%, and the standard deviation was 17% for GHI. Guyemard [13] found that EnMetSol DNI data with climatological aerosol data as input showed similar deviations as the other data bases. With a correction of DNI clearsky irradiance with actual aerosol optical depth instead of climatological values a much better performance has been achieved.

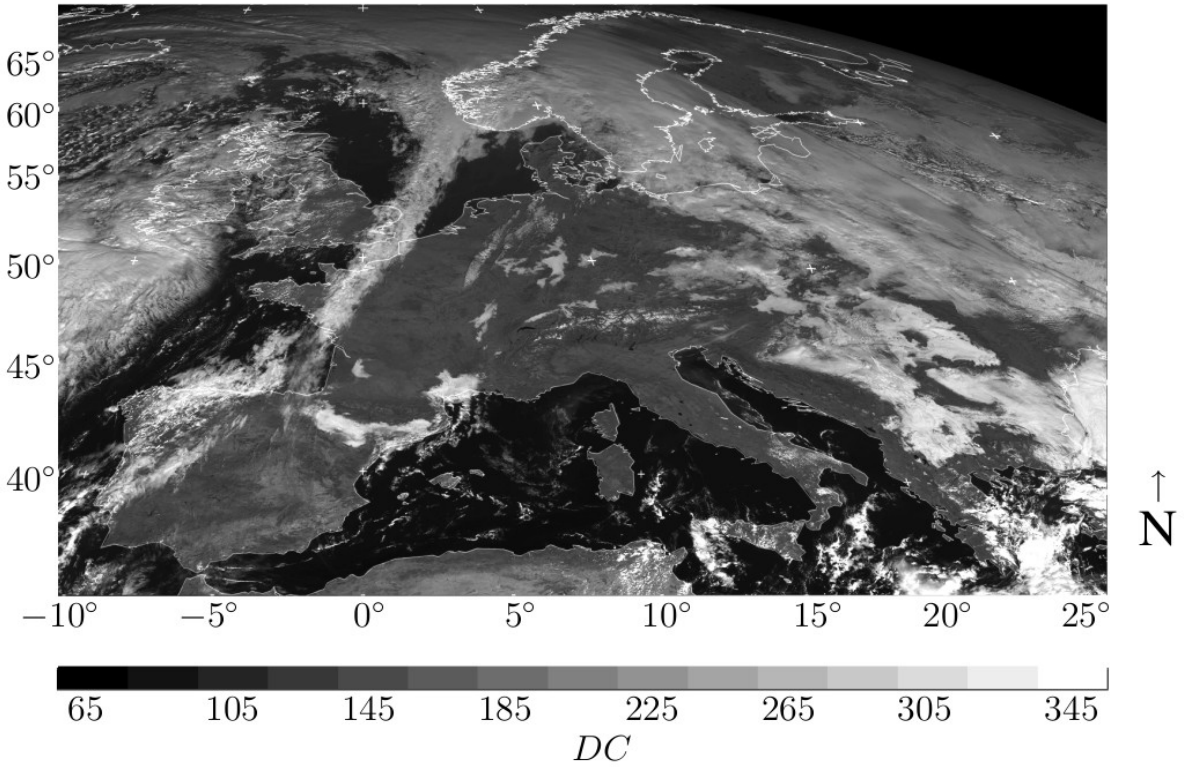
The validation at the 5 sites Cologne (DEU), Ancona (IT), Tempe (USA), Thuwal (SAU) and Chennai (IND) is performed within the project PVKLIMA with actual MACC aerosol input.

Data Archive at University of Oldenburg

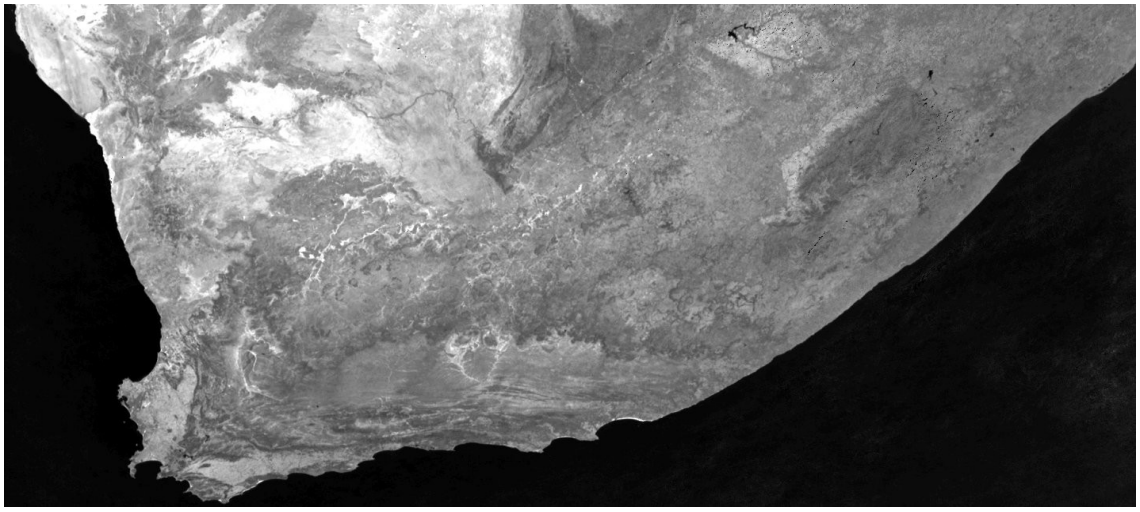
MFG: Mediterranean Sea, 1995-2005, 2.5*2.5km^2 resolution at sub satellite point, 2 images per hour



MSG: Crete, Turkey, Israel, 2005-today, 1.0*1.0km^2 resolution at sub satellite point, 4 images per hour

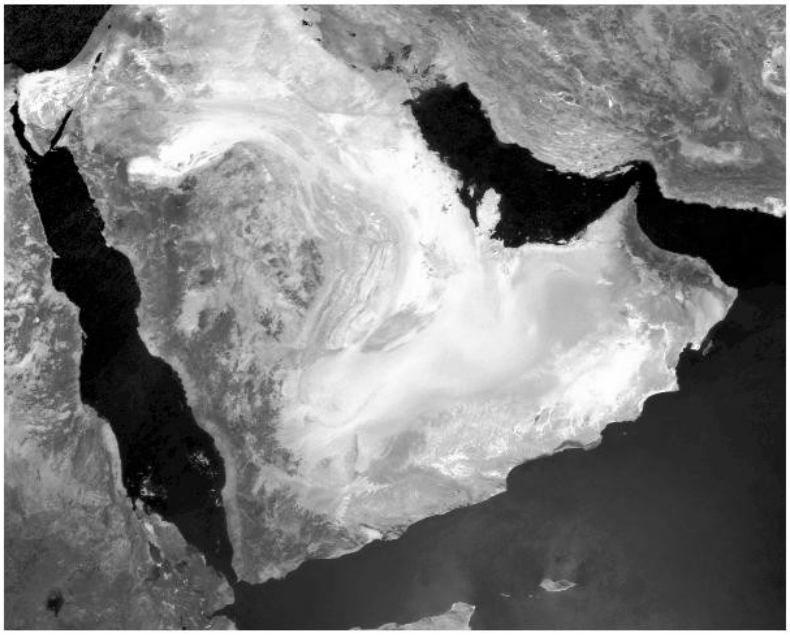


MSG HR-VIS image for Europe 2014-11-01, 1100 UTC. Digital counts are depicted with enhanced contrast. Image data are archived from 2005 until today, 1.0*1.0km^2 resolution at sub satellite point, 4 images per hour. Before 2005 this region was scanned by MFG with a resolution of 2.5*2.5km^2 resolution twice per hour.

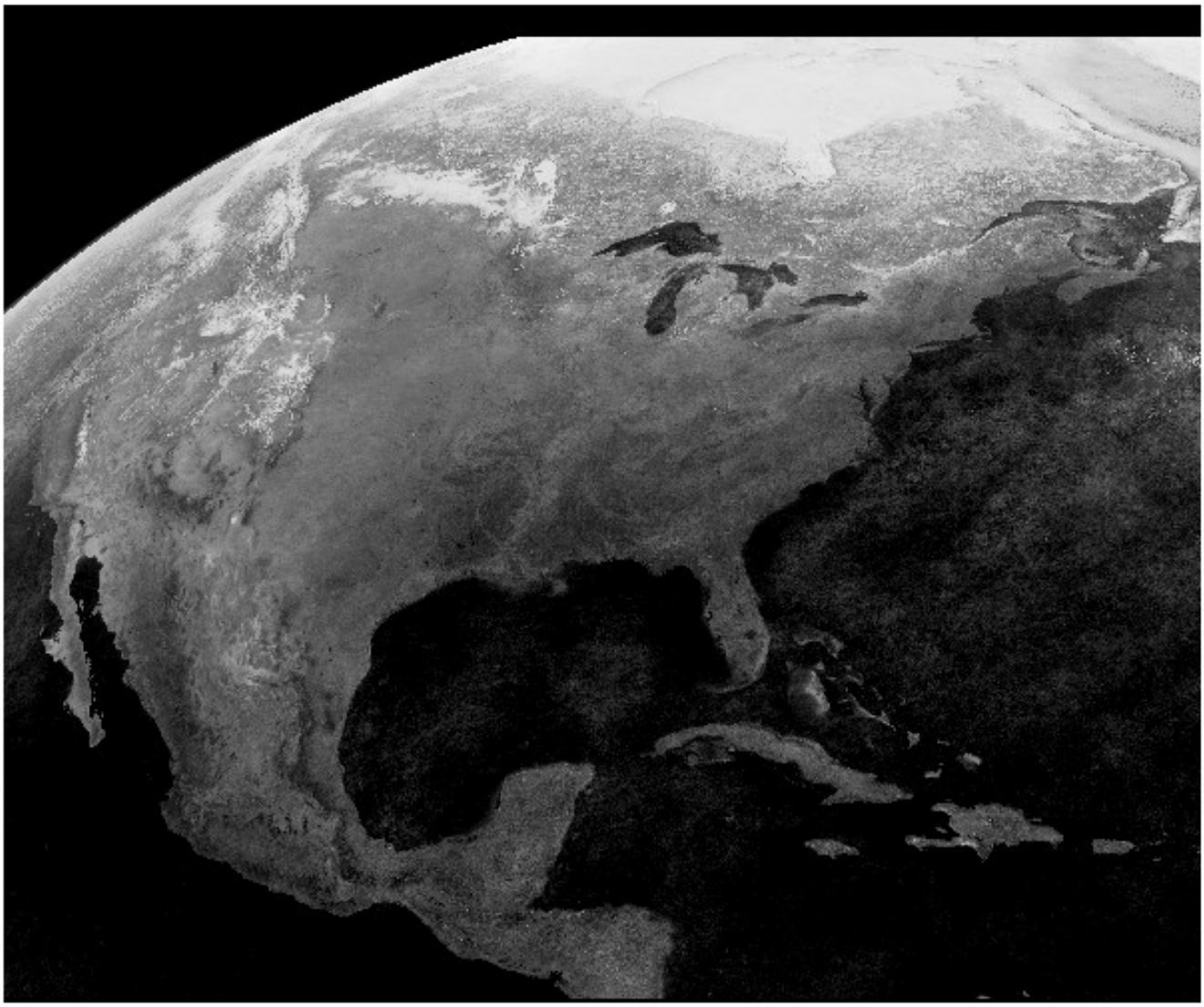


MSG: South Africa, 2005-2009, 1.0*1.0km^2 resolution at sub satellite point, 4 images per hour

MFG-East: India, 2011-2015, 2.5*2.5km^2 resolution at sub satellite point, 2 images per hour



MFG-East: Arabian Peninsula, 2011-2015, 2.5*2.5km^2 resolution at sub satellite point, 2 images per hour



GOEAS-EAST: Continental USA, 2005 until today, 1.75*1.0km^2 resolution at sub satellite point, 4 images per hour

References

[1] Beyer HG, Costanzo C, Heinemann D (1996): Modications of the Heliosat procedure for irradiance estimates from satellite data. Solar Energy 56, 207–212.

[2] Hammer A, Heinemann D, Hoyer C, Kuhlemann R, Lorenz E, Müller R, Beyer HG (2003): Solar energy assessment using remote sensing technologies. Remote Sensing of Environment, 86, 423–432.

[3] Fontoynont M et al. (1998): Satellight: A WWW server which provides high quality daylight and solar radiation data for Western and Central Europe. 9th Conference on Satellite Meteorology and Oceanography, 434–437.

[4] Dumortier D (1998): The Satellite model of turbidity variations in Europe. Technical Report

[5] Remund J (2009): Aerosol optical depth and Linke turbidity climatology, Description for final report of IEA SHC Task 36, Meteotest Bern

[6] Müller RW, Dagestad KF, Ineichen P, Schroedter M, Cros S, Dumortier D, Kuhlemann R, Olseth JA, Piernavieja C, Reise C, Wald L, Heinemann D (2004): Rethinking satellite based solar irradiance modelling - The SOLIS clear-sky module. Remote Sensing of the Environment, Volume 91, Issue 2, 160-174

[7] Mayer B and Kylling A (2005): Technical Note: The libRadtran software package for radiative transfer calculations: Description and examples of use. Atmos. Chem. Phys., 5:1855-1877, 2005

[8] Kinne S et al. (2005): An AeroCom Initial Assessment – Optical Properties in Aerosol Component Modules of Global Models. In: Atmospheric Chemistry and Physics Discussions, 5, 8285-8330.

[9] Kalnay E et al. (1996): The NMC/NCAR 40-year reanalysis project. Bull. Am. Meteorol. Soc. 77 (3), 437–472.

[10] Lorenz E (2007): Improved diffuse radiation model, MSG. Report for the EC-project PVSAT-2: Intelligent Performance Check of PV System Operation Based on Satellite Data, NNE5-2001-0571, Deliverable D4.2b, Univ. Oldenburg

[11] Hammer A, Lorenz E, Kemper A, Heinemann D, Beyer HG, Schumann K, Schwandt M (2009): 'Direct normal irradiance for CSP based on satellite images of Meteosat Second Generation', SolarPACES 2009, Berlin

[12] Ineichen, P. (2013): 'Long Term Satellite Hourly, Daily and Monthly Global, Beam and Diffuse Irradiance Validation. Interannual Variability Analysis'; IEA Report; University of Geneva: Geneva, Switzerland.

[13] Gueymard, Christian A. (2011): 'Uncertainties in modeled direct irradiance around the Sahara as affected by aerosols: are current datasets of bankable quality?.' *Journal of Solar Energy Engineering* 133(3), 031024.