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A Review of the Existing Solar Irradiation Databases

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Abstract:
Huge gains in the form of time and cost savings, increased productivity and efficiency will be obtained by designers and researchers of solar technology systems if relevant information is available and easily accessible for every site in the world. The Internet has played a major role in making this information available to users through various online databases for solar radiation. However, often times many of the available databases do not meet actual users 'needs. In general most users prefer hourly or daily irradiation data with a spatial resolution of a maximum of 20km, but unfortunately the number of ground measuring station around the globe are too small to attain such accuracy. The accessibility is also made poor by the complexity of the data which comes from various storage standards, units, ways of expressing time etc. in the databases. Moreover, users often face difficulties in selecting the database that meet their needs for a particular time and location. This paper provides a comprehensive review of the available online databases with the information that they provide and their advantages and disadvantages. Demonstrations are also shown for the applicability of one online design software called HELIOSCOPE. Recommendations and proposals for future work were given to address the discrepancies between users' needs and the available databases.

Keywords: Solar Radiation database, HELIOSCOPE software.

1. INTRODUCTION

Solar radiation data is of high importance in the feasibility studies, design and operation of solar energy conversion systems. It can also be used as input to the design of green buildings, biomass production, crop forecast etc.

Huge gains in the form of time and cost savings, increased productivity and efficiency will be obtained by designers and researchers of solar technology systems if relevant information is available and easily accessible for every site in the world.

Conventional methods to obtain solar irradiation data include weather stations, solar radiation models, and field measurements.

The Internet has also played a major role in making radiation information available to users through various online databases for solar radiation.

However, often times many of the available databases do not meet actual users 'needs.

In general most users prefer hourly or daily irradiation data with a spatial resolution of a maximum of 20km, but unfortunately the number of ground measuring station around the globe are too small to attain such accuracy.

Numerous meteorological databases that are derivatives of different spatial resolutions, time periods with different time intervals are available online.

System designers are usually left with a dilemma on choosing the best database to use and most of the time they have limited information on the types and quality of commonly used meteorological databases.

Moreover, the accessibility is made poor by the complexity of the data which comes from various storage standards, units, ways of expressing time etc. in the databases.

2. METEOROLOGICAL DATABASES

A number of meteorological databases are presently available, and most of them provide varying and unique quality of data.

They also however vary inmethodology, input data, covered area, time intervals and their spatial resolution.

This section provides a basic overview of the available meteorological databases based on previous reviews [1], [2], [3].

National networks have been used to measure solar radiation for several decades.

This collected data can be processed in research programs and other institutions to come up with reliable networks with heterogeneous spatial coverage and national solar atlases [4].

Ground measuring stations are randomly distributed all over the Globe and the availability of investor grade solar radiation data is limited in some areas.

There are more ground solar radiation resource assessment stations in India and Germany than there are in the entire Africa. A summary of ground stations is indicated in Table 1

Table.1. Summary of ground based databases

DATABASE BASED ON GROUND STATION	AREA	NUMBER OF STATIONS	PERIOD	TIME RESOLUTION
World Radiation Data Center (WRDC)	Global	1195 [9]	1964-2004 unevenly distributed[3]	Daily, hourly sums of instantaneous values unevenly distributed[3]
Global Energy Balance Archive (GEBA)	Global	1600 [10]	Unevenly distributed [11]	Monthly averages[9], [11]
Baseline Surface Radiation Network (BSRN)	Global	46	1994- onwards, unevenly distributed	1 - 5 min [12]
International Daylight Measurement Program (IDMP)	Global	48	1990- onwards, unevenly distributed	1 - 5 min[3]
National Solar Radiation Database (NSRD)	USA	1454[13]	1991-2005[13]	Hourly averages[13]
Deutscher Wetterdienst (DWD)	Germany.	112	unevenly distributed.	Hourly averages
Solar Radiation Resource Assessment (NIWE)	India	121[14]	2011 onwards evenly distributed	1 minute data[14]

Solar radiation measurements from NASA satellites provide the only source that is truly global in coverage. Table 2 gives a brief overview of some of the commonly used satellite databases with their specifications.

Table.2. Overview of the satellite-based databases

NAME	DATA INPUTS	AREA	PERIOD	TIME RESOLUTION	SPRATICAL RESOLUTION	TIME SERIES	PARAMETERS
3TIER	Meteosat 5,7,9 GOES, GSM	Europe, Africa, Asia	1999-2009	1-hourly	3km x 3km	Hourly, daily, monthly average	G,D,DNI
EnMetSol (Univ of Oldenburg)	Meteosat	Europe, Africa[16]	1995 onwards	15-min/ 1hourly	(3x7)km (1x3)km	Real 15 min 1 hourly data	G,D,DNI spectra
Focus solar	Meteosat 9 GOES, MTSAT	Europe, Africa, USA, Mexico Asia, Australia	2005-2009 1998-2008 2007-2008	15 min	2km x 2km	Real 15 minute Daily or monthly average	G,DNI
HelioClim-1 (Mines ParisTech-Armines)	Meteosat 2,3,4,5	Europe, Africa	1985-2005	daily	20km x 20km	Daily average	G, DNI
HelioClim-3 (Mines ParisTech-Armines)	Meteosat 8,9	Europe, Africa	2004 onwards	15- min	5km x 5km	Real time 15-min data	G, DNI
NASA SSE Release 6.0	GEWEX/SRB 3	Global[15]	1983-2005	3-hourly	100km x 100km [16]	Daily average	G,D,DNI, Clouds
Satel-Light (ENTPE)	Meteosat 5,6,7	Europe	1996-2000	30-minute	5km x 7km[16]	Real 30-min Data	G,B,D, illuminance
SolarAnywhere (Clean Power Research)	GOES-EAST-WEST	U.S.A	1988 onwards	1-hourly	10km x 10km	Hourly, daily , monthly average	G,DNI
SolarGIS (GeoModel Solar)	Meteosat 9		2004 onwards	15 min	5km x 5km	Hourly, daily , monthly average	G,D,DNI
Solemi (D.L.R)	Meteosat 5&7	Europe, Africa, Asia	1991-2005 1999-2006	1 hourly	2.5km x 2.5km	Monthly, yearly, multi-annual average	G,DNI

Data is available in near-real time for daily averages and for 3 hour intervals. At least 19 geostationary weather satellites have been launched by various countries that help in capturing satellite images that are a very good source for the development of meteorological data. The main benefits of using satellite data is that it provides spatial-continuous and time continuous data with invariant uncertainty. The generally accepted notion however, is that ground measured data is more accurate than satellite-based data. If the distance from a ground station measurement exceeds close to 70 km for daily data estimations, satellite based estimates have to, be preferable[5]. Several available and most used solar radiation databases are a result of data analysis and integration (e.g. Meteonorm). The main idea behind reanalysis is to use developed mathematical models to predict future trends in solar radiation based on the available measured historical data. Most of these databases usually combine the historical ground measured data satellite images to predict future trends to a high accuracy. The future and current projects based on reanalysis are summarised in [6]. Besides the basic solar radiation databases, software models such as SAM and Hilioscope merge databases and software models. The Meteonorm database has a global coverage of data from more than 8000 ground based weather stations and five geostationary satellites. It is based mainly on the 8000 ground stations and makes an interpolation based on these ground stations. If a ground station is not available within 300 km, data from the geostationary satellites (period 2000-2009) is used instead. Satellite and ground based data is combined for use if the nearest station is at least than 50 km away and this gives better estimates [7]. Table 4 entails a summary of such derived and system integrated databases.

Table.3. Summary of Derived and System Integrating Databases

DERIVED DATABASE AND SYSTEM INTERGRATING DATA	DATA INPUTS	AREA	PERIOD	TIME RESOL UTION	SPRATIC AL RESOLU TION	SIMMUL ATION OF TIME SERIES	PARAME TERS
EMP Climate (Mines ParisTech-Armines)	Satellite data and reanalysis	global	1990-2004	Monthly average	10km x 10km	monthly average	G
ERA- Interim (ECWMF)	reanalysis	global	1989-onwards	4 analyses per day	80km x 80km	Daily ,monthly average	G
NCEP/NCAR (ESRL)	reanalysis	global	1948 onwards	4 analyses per day	250km x 250km	Daily ,monthly average	G
ESRA (Mines ParisTech-Armines)	586 meteo stations + satellite data	Europe	1081-1990	monthly average	10km x 10km	Simulated daily profile	G, D, B
Meteonorm 6.1 (Meteotest)	1422 meteo stations + satellite data	world	1981-2000 Unevenly distributed	monthly average	interpolatio n	Simulated daily profile based on monthly average	G,D,B Interim shadowing
PVGIS (Joint Reserch Center)	566 meteo stations	Europe, Africa	1981-1990	monthly average	1km x 1km 2km x 2 km	Simulated daily profile from monthly average	G,D,B Interim shadowing

Solar systems design software such as System Advisor Model (SAM) used to make performance predictions and cost of energy estimates for grid connected power projects using the computer models developed by NREL, Sandia National Laboratories, University of Wisconsin and other organizations. SAM software automatically downloads radiation data from NREL National Solar Radiation Database [8].

3. HELIOSCOPE

HelioScope is online software developed by Folsom Labs. It is an advanced PV system design tool that integrates system layout and performance modelling to simplify the process of engineering and selling solar projects. Helioscope uses online data from Google Maps to locate the area to perform the design.

3.2 Design of a Solar Rooftop for Harare Institute of Technology Library: A rooftop solar design for the Harare Institute of Technology dining was carried out. The motive behind this exercise was that the Harare Institute of Technology experiences a lot of electricity power cuts. Hence a rooftop solar can help to mitigate the problem. The dining rooftop was selected because it has a larger area which is free from shading and it is centrally located relative to other buildings. The module and wiring layout is as shown below:

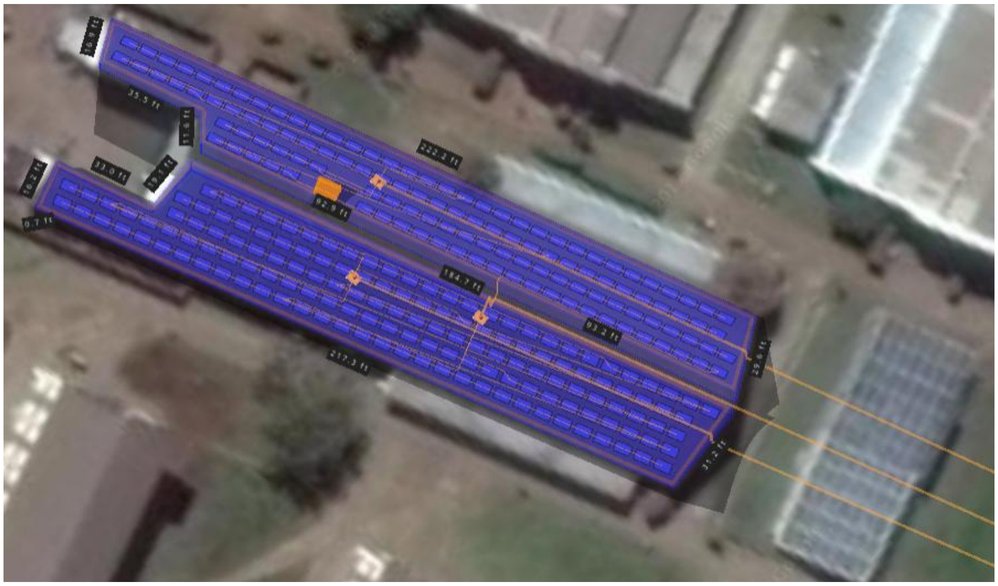
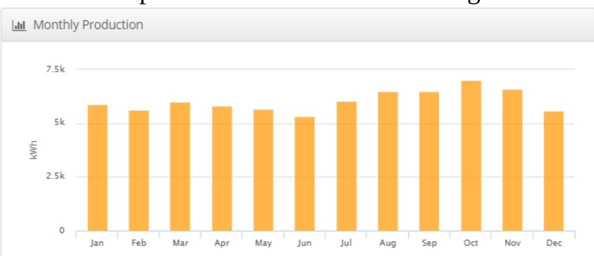


Figure.1. Module Layout

Keep-outs are specified to describe which areas must not be covered with modules, this can assist in specialized design. After the layout, HelioScope will perform its shading analysis. With this method, one can do a complete site assessment and design without setting foot on the actual property. This saves considerable travel time and expense. Helioscope will simulate and produce a detailed report as shown in figure below:



Hide table

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	168.1	164.3	164.3	8,605.6	5,874.4
February	155.5	152.7	152.6	7,991.9	5,643.3
March	168.8	164.4	164.4	8,601.9	6,000.7
April	154.8	150.2	150.2	7,848.4	5,799.6
May	146.5	142.4	142.3	7,408.9	5,643.9
June	133.4	129.7	129.5	6,721.4	5,326.7
July	151.6	146.9	146.8	7,633.7	6,023.1
August	174.7	168.8	168.7	8,828.1	6,472.5
September	183.8	178.0	178.0	9,332.2	6,479.0
October	199.0	193.3	193.3	10,146.2	7,012.1
November	194.4	189.4	189.4	9,946.4	6,601.7
December	162.5	158.5	158.4	8,306.8	5,605.1

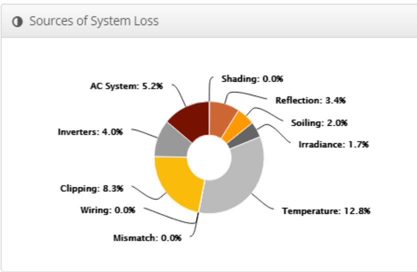


Figure.2.Simulated monthly production results and module losses

Helioscope will produce a summary of the annual production report as shown below:

System Metrics — PDF — CSV

Design	HIT ROOFTOP DESIGN
Module DC Nameplate	56.1 kW
Inverter AC Nameplate	61.2 kW Load Ratio: 0.92
Annual Production	72.48 MWh
Performance Ratio	66.6%
kWh/kWp	1,292.0
Weather Dataset	TMY, 10km Grid, meteonorm/nrel medium resolution (meteonorm)
Simulator Version	325be25859-a84469ab09-82b734056f-eb09a05cf5
Shade Report	View Shade Report

Project Location

Figure.3. Annual production report

The advantage of using Helioscope is the fact that it is online, so people can work from any place that has a net connection. It is very user friendly interface and it does the report is quite simple and to the point. It has a huge and up to date database of modules and inverters. Moreover it has a regular webinars to train professionals how to use the software and design systems. The disadvantages are that it is costly and unless the location can be found on google map one cannot simulate/proceed further. In India many locations are not marked well in Google maps, hence it can be very difficult to find the exact location.

4. CONCLUSIONS

From the above review it can be noted that the best source of irradiation data for solar systems design is the measured data as compared to satellite and modelled data. Due to the unavailability of the measured data in some areas reanalysis and modelling based on historical data satellite data and developed models are used to give predictions of future irradiation trends for the analysis of the performance of solar systems. The solar radiation estimates are the backbone for the prediction of output of solar photovoltaic and thermal systems. If the actual yield of a power plant varies by larger margins as compared to the estimated production using forecasting data, this could mean very large financial implications to the company when it fails to meet it power supply obligations to the grid. This is the major reason why trusted investor grade information is preferred by most people. The most commonly and most accessible databases however on most third party software is based a combination of both the ground and satellite based data to try and give data that is reliable.

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