SolarGIS data validation for China

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SOLARGIS SOLAR RESOURCE DATA

Solar resource determines how much electricity will be generated from solar power plants. By making an analysis on the different solar components it is possible to understand the potential and performance of solar power plants:

Global Horizontal Irradiance/Irradiation (GHI) is the sum of diffuse and direct components and it is often considered as a climate reference as it enables to compare individual sites or regions.

Direct Normal Irradiance/Irradiation (DNI) is the component that directly reaches the surface, and is relevant for solar thermal power plants (CSP) and photovoltaic concentrating technologies (CPV).

Diffuse Horizontal Irradiance/Irradiation (DIF) is the part of the irradiation that is scattered by the atmosphere. Higher values of DIF/GHI ratio represent: less stable weather, higher occurrence of clouds, higher atmospheric pollution or higher water vapour

Global Tilted Irradiance/Irradiation (GTI), is sum of direct and diffuse solar radiation falling at a tilted surface. Unlike horizontal surface, the tilted surface also receives small amount of ground-reflected radiation. It determines performance characteristics of the PV technology.

While solar irradiance refers to solar power (instantaneous energy) falling on a unit area per unit time [W/m^2], solar irradiation is the amount of solar energy falling on a unit area over a stated time interval [Wh/m2 or kWh/m^2].

Tab. 1: Solar resource parameters provided by SolarGIS database

Parameter	Acronym
Global Horizontal Irradiance/Irradiation	GHI
Direct Normal Irradiance/irradiation	DNI
Diffuse Horizontal Irradiance/Irradiation	DIF
Global Tilted Irradiance/Irradiation	GTI

Geographic distribution of long-term annual sums of solar irradiation values across different latitudes can be represented in maps.

Besides solar resource, SolarGIS provides meteorological data derived from meteorological models: air temperature, wind speed, wind direction, relative humidity and atmospheric pressure.

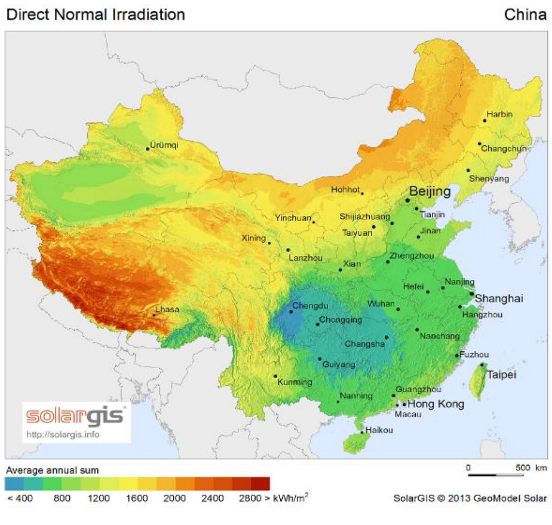

Fig. 1: Long term annual sum of DNI.

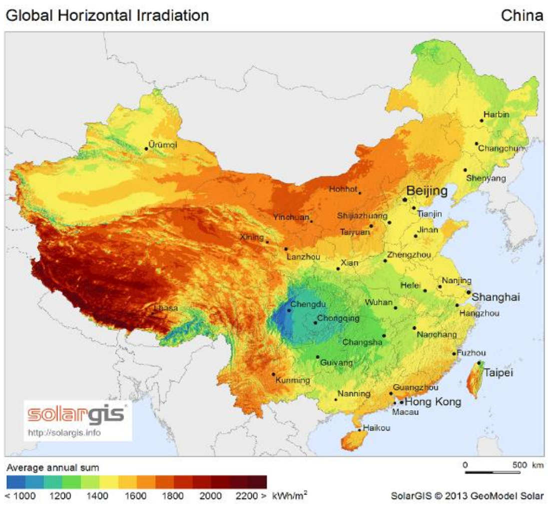

Fig. 2: Long term annual sum of GHI.

Present geographical availability of solar resource data can be seen in the map below. Solar resource data is available for almost any location between 60°N and 50°S latitudes in 250 metres resolution.

Temporal coverage of the data varies by region and depends on the history and features of each particular satellite mission. Presently we have been processing data from several satellite missions, thus covering almost the entire world.

Tab. 2: Features of SolarGIS solar resource data

Techincal characteristic	Description
Approx. grid resolution	~250 m Up to ~90 m for some regions
Spatial coverage	Global from 60°N to 50°S
Time representation	Since 1994/1999/2007 depending on the region
Time step	Original 15/30 minutes depending on the region. Aggregated into hourly, daily, monthly values

Due to coverage of different satellites, SolarGIS data in the territory of China has different characteristics depending of the location. Data is always delivered according to the best expert assessment and quality criteria.

Fig. 3: Current time representation of SolarGIS database in China

VALIDATION SITES FOR CHINA AND SURROUNDING REGIONS

Solar data accuracy from the SolarGIS database has been compared to high-quality ground measurements from an extensive number of stations worldwide. Validation statistics for China till now is limited and we use for comparison also other ground measurements from neighbour countries like Japan, South Korea and Taiwan. The comparison shows very good fit which is in accordance to accuracy expectations of SolarGIS database.

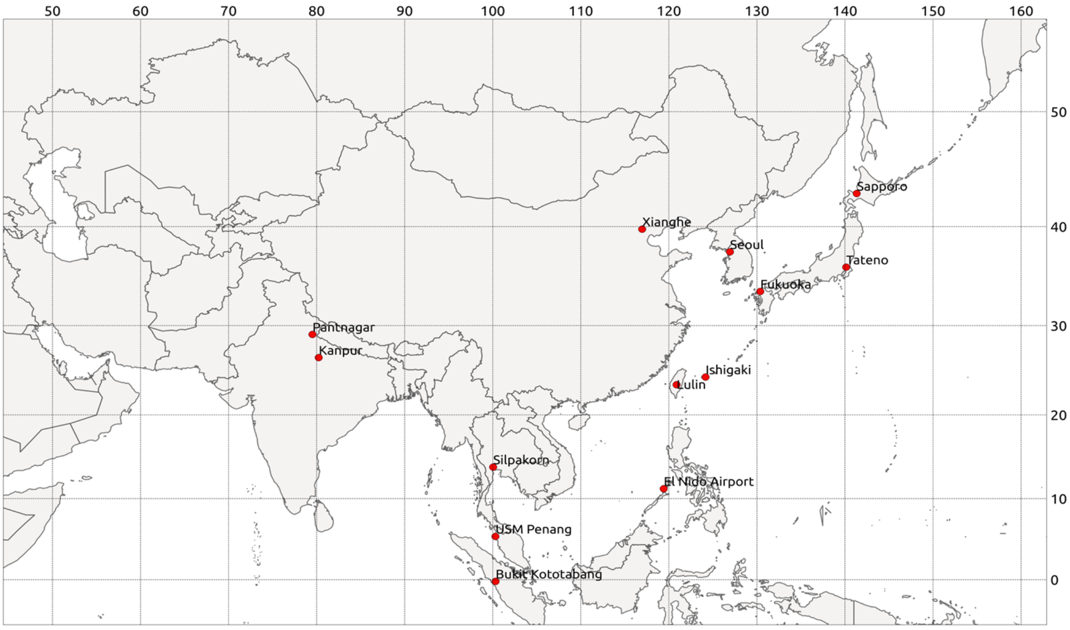

Fig. 4: Map of validation sites close to China

Tab. 3: Validation sites close to China

Site name	Country	Code	Lat	Lon	Source
Sapporo	Japan	JP	43.060	141.328	BSRN
Xianghe	China	CN	39.754	116.962	BSRN
Yonsei University, Seoul	South Korea	KR	37.564	126.935	SOLARFLUX
Tateno, Tsukuba	Japan	JP	36.050	140.133	BSRN
Fukuoka	Japan	JP	33.582	130.375	BSRN
Pantnagar	India	IN	29.046	79.521	SolRadNet
Kanpur	India	IN	26.513	80.232	SolRadNet
Ishigaki	Japan	JP	24.337	124.163	BSRN
Lulin	Taiwan	TW	23.469	120.874	SOLARFLUX
Silpakorn	Thailand	TH	13.819	100.041	SOLARFLUX
El Nido Airport	Philippines	PH	11.205	119.413	SOLARFLUX
USM Penang	Malaysia	MY	5.358	100.302	SOLARFLUX
Bukit Kototabang	Indonesia	ID	-0.202	100.318	WRDC, GAW

Tab. 4: Validation statistics for GHI values

Site name	Data pairs	MBD [W/m2]	rMBD [%]	rRMSDh [%]	rRMSDd [%]	rRMSDm [%]
Sapporo	9996	-4	-1.4	29.1	17.1	3.4
Xianghe	14891	-3	-1.0	19.9	14.5	3.9
Yonsei University, Seoul	2651	0	0.1	19.7	9.9	3.3
Tateno, Tsukuba	27734	0	-0.1	20.4	10.7	2.4
Fukuoka	9978	1	0.2	24.0	13.6	3.2
Pantnagar	616	-6	-1.5	17.3	11.3	2.5
Kanpur	12999	-9	-2.0	14.7	8.2	2.8
Ishigaki	10141	-5	-1.3	24.2	14.3	2.3
Lulin	11985	38	10.5	43.7	27.0	15.1
Silpakorn	7308	-9	-1.9	23.6	12.2	5.0
El Nido Airport	686	-13	-3.1	26.4	10.7	5.7
USM Penang	942	-11	-2.8	29.4	10.8	3.0
Bukit Kototabang	22593	2	0.6	31.6	14.8	2.5

Tab. 5: Validation statistics for DNI values

Site name	Data pairs	MBD [W/m2]	rMBD [%]	rRMSDh [%]	rRMSDd [%]	rRMSDm [%]
Sapporo	7602	5	1.4	53.4	33.8	7.0
Xianghe	12880	6	1.9	45.0	36.4	5.9
Tateno, Tsukuba	27702	-2	-0.7	39.4	22.4	3.4
Fukuoka	7788	-15	-4.4	40.3	25.7	8.2
Ishigaki	7770	2	0.7	43.7	25.7	4.9
Bukit Kototabang	15301	19	8.9	72.6	42.1	11.0

INTERPRETATION OF RESULTS

For objective evaluation, the model has been evaluated only with quality-controlled data measured using high standard and professionally maintained instruments. After comparison with more than 200 stations globally, a consistent distribution of bias has been observed for SolarGIS. For sites closer to the territory of China, these results are confirmed.

Uncertainty of SolarGIS GHI and DNI yearly summaries for 80% of observations is within the range of ±4% and ±8% (±5% and ±10% for 90% of observations), respectively. In complex geographies and extreme cases, uncertainty of GHI and DNI yearly summaries can be as high as ±8% and ±15%, respectively.

Regions where higher uncertainty can be expected (higher than ±4% for yearly GHI and higher than ±8% for DNI): high latitudes (approx. above 50°), high mountains (e.g. Lulin site), regions with regular snow and ice coverage, high-reflectance deserts, urbanized and industrialized areas, regions with high and dynamically changing concentrations of atmospheric aerosols, coastal zone (approx. up to 15 km from water) and countries in humid tropical climate.

The results can be transformed into uncertainty at different probability scenarios assuming a normal distribution. An average of biases close to zero has been observed, which means that there is no systematic tendency to overestimate or underestimate (distribution is symmetrically centered). The low standard deviation of bias (3%) shows a narrow probability distribution, i.e. P90 value (value exceeded in the 90% of the cases) closer to the P50 (most expected value).

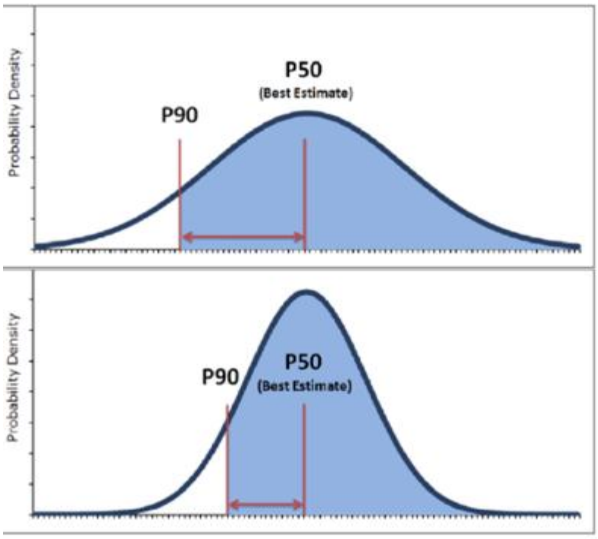

Fig. 5: P50 and P90 values represented in the probability distribution

Tab. 6: Description of validation statistics used

Acronym	Statistic	Description
MBD	Mean Bias Deviation or Bias	Systematic model deviation for each site
RMSD	Root Mean Square Deviation	Spread of deviation of values for each site
AVG MBD	Average of bias	Tendency to overestimate or to underestimate the measured values
SD MBD	Standard deviation of bias values	Range of deviation of the model estimates assuming normal distribution or errors

ADDITIONAL READINGS

[1] Šúri M., Cebecauer T., 2015. Uncertainty of satellite-based solar resource data. Presented at ISES Webinar on Solar Resource Data Applications for Utility Planning and Operations, 23 Feb 2015.

[2] Šúri M., Cebecauer T., 2014. Satellite-based solar resource data: Model validation statistics versus user's uncertainty. ASES SOLAR 2014 Conference, San Francisco, 7-9 July 2014.

[3] Perez R., Cebecauer T., Šúri M., 2013. Semi-Empirical Satellite Models. In Kleissl J. (ed.) Solar Energy Forecasting and Resource Assessment. Academic press.

[4] Ineichen, P., 2013. Long Term Satellite Global, Beam and Diffuse Irradiance Validation. Energy Procedia, Volume 48, 2014, Pages 1586–1596

[5] More about SolarGIS data calculation methodology at http://solargis.info/doc/methods

ABOUT

Background on GeoModel Solar

Primary business of GeoModel Solar is in providing support to the site qualification, planning, financing and operation of solar energy systems. We are committed to increase efficiency and reliability of solar technology by expert consultancy and access to our databases and customer-oriented services.

The Company builds on 25 years of expertise in geoinformatics and environmental modelling, and 14 years in solar energy and photovoltaics. We strive for development and operation of new generation high-resolution quality-assessed global databases with focus on solar resource and energy-related weather parameters. We are developing simulation, management and control tools, map products, and services for fast access to high quality information needed for system planning, performance assessment, forecasting and management of distributed power generation. Members of the team have long-term experience in R&D and are active in the activities of International Energy Agency, Solar Heating and Cooling Program, Task 46 Solar Resource Assessment and Forecasting.

GeoModel Solar operates a set of online services, integrated within SolarGIS® information system, which includes data, maps, software, and geoinformation services for solar energy.

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