Online apps for solar prospecting: New challenges and industry needs

All-in-one app for pre-feasibility of solar plants

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apps.solargis.com

New generation of Solargis online apps

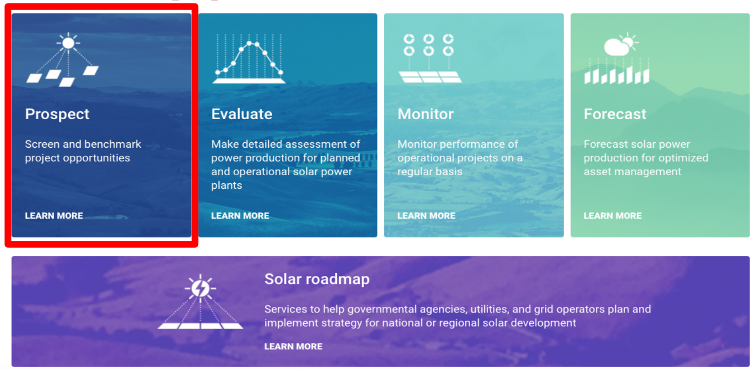
Why industry needs new prospecting tool?

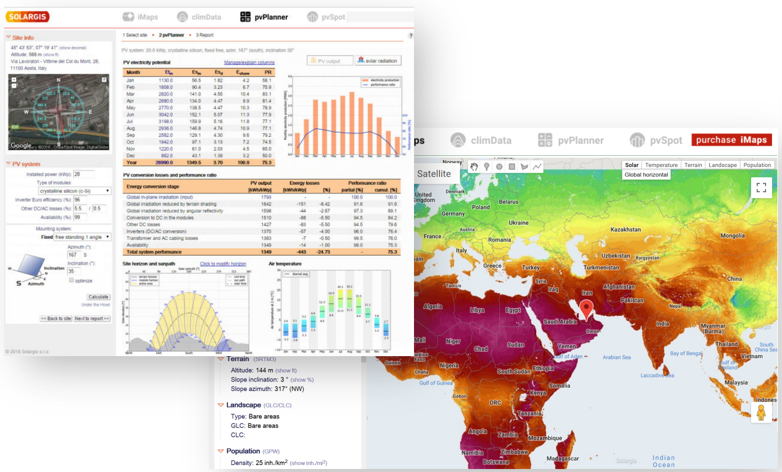
- PV becoming global
- Less known environments – high uncertainty
- Environmental risk assessment
- Prospecting multiple projects shared between multiple project partners

How Prospect addresses these needs?

- All basic environmental info in one place
- High accuracy solar resource database
- Reduced uncertainty
- Results available in few clicks
- Sharing projects

New generation of Solargis online apps





iMaps (interactive maps) & pvPlanner are integrated with new features:
more data, new PV simulation tool, economy calculator, site management and sharing tool, new reports, compare tool, collaborative work.

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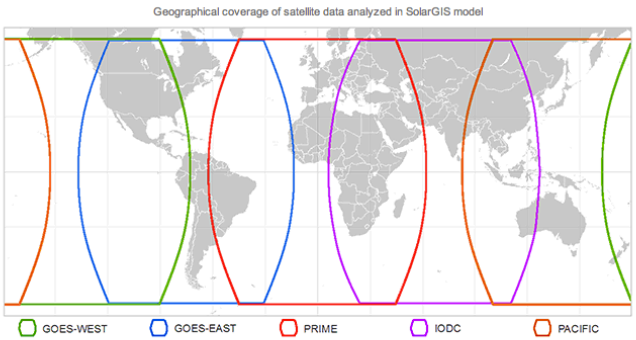
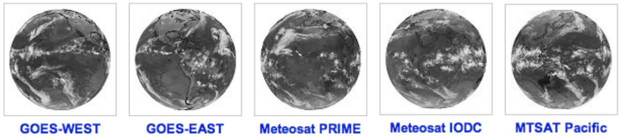
Prospect
Solar radiation database

Prospect – underlaying radiation database

Modelling **cloud attenuation** from geostationary satellites

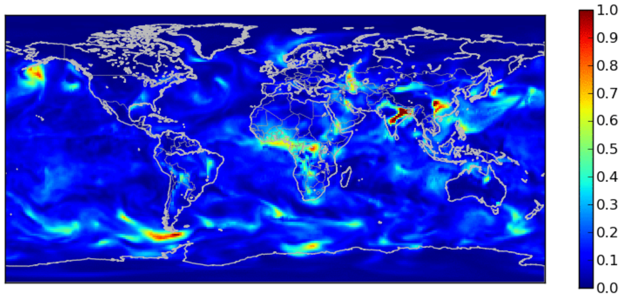
- From 1994/1999/2007 to the end of 2018
- Time resolution 10, 15 and 30 minutes
- Native grid resolution approx. 2 to 7 km





Modelling **clear-sky (cloudless) atmospheric conditions**:

- Aerosols and water vapour from global models: MERRA-2, CFSR, CFSv2, GFS, MACC-II, CAMS
- Digital Elevation Model SRTM-3



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Volume of data increases

	GB/day	TB/year	Active
Meteosat MFG (IODC)	*0.6 GB*	*0.3 TB*	*No*
Meteosat MSG	7.2 GB	2.6 TB	Yes (2x PRIME, IODC)
GOES West	12.5 GB	4.5 TB	Yes
GOES East	*12.5 GB*	*4.5 TB*	*No*
GOES-R(S)	50 GB	18 TB	Yes
MTSAT	*2.6 GB*	*0.9 TB*	*No*
HIMAWARI 8	80 GB	30 TB	Yes
Meteosat MTG, HIMAWARI 9	+	+	No, but soon…

Source: SolarGIS

- Increasing spatial resolution (Himawari 8 and GOES-R: 0.5-2.0 km)
- Higher data frequency (Himawari 8: 10 min., GOES-R 15 min)
- More spectral channels (Himawari 8, GOES-R: 16 channels)
- Redesign of HW infrastructure and storage
- Optimization of management software performance

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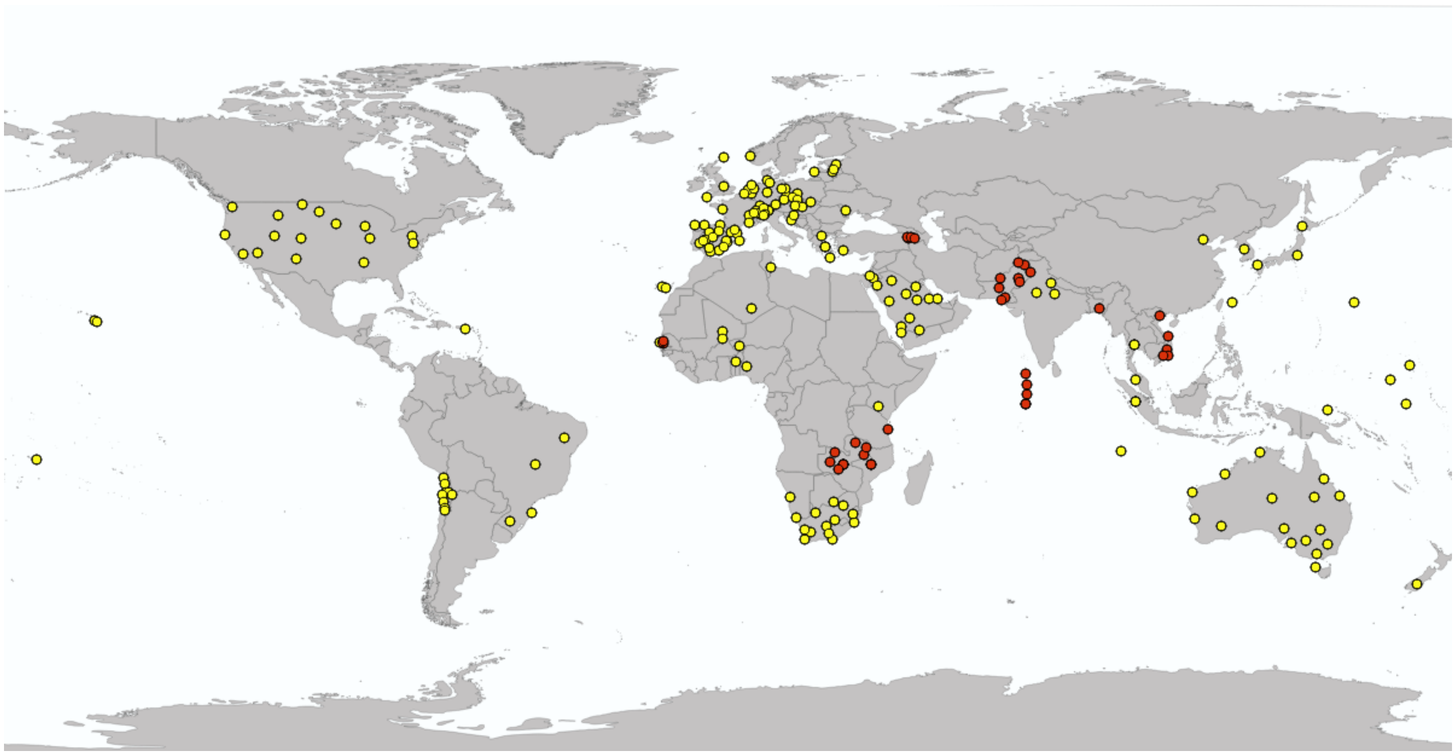
Solargis worldwide database validation
Public validation sites – support from the World Bank

Solar meteorological stations with high quality measurements
Red color shows meteo sites supported by the World Bank since 2015



This information may not be complete

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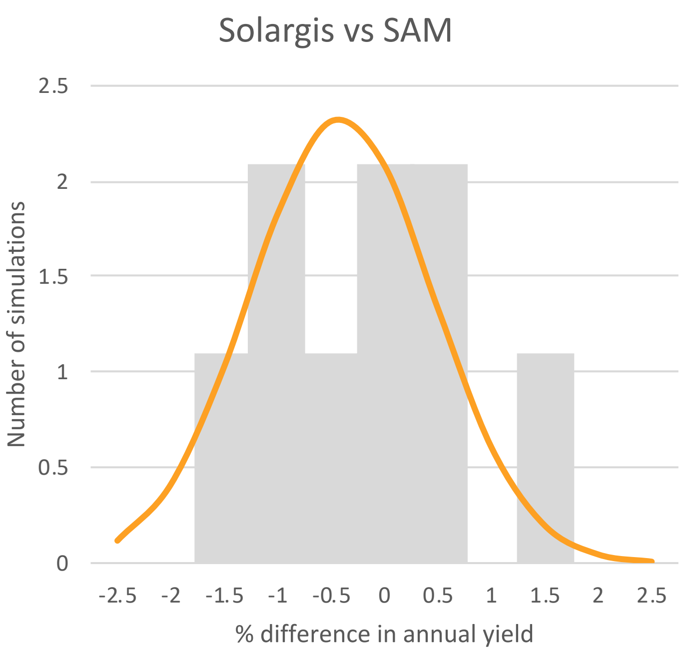
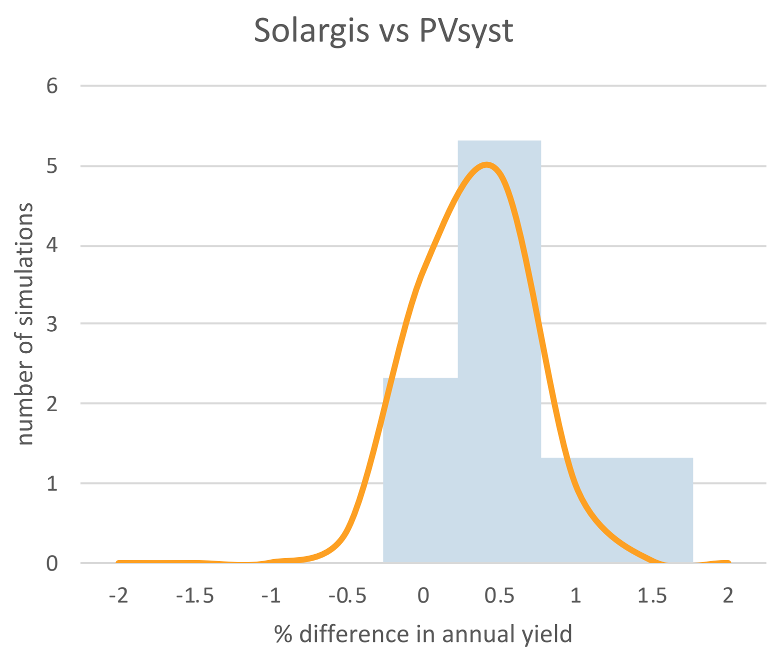
Extensive validation with existing PV software packages: pvSyst, SAM

Simulation results: Solargis vs NREL SAM vs PVsyst

	Solargis vs SAM	Solargis vs PVsyst
Mean energy yield difference simulation at 9 locations	-0.41% ± 0.86%	0.33% ± 0.36%

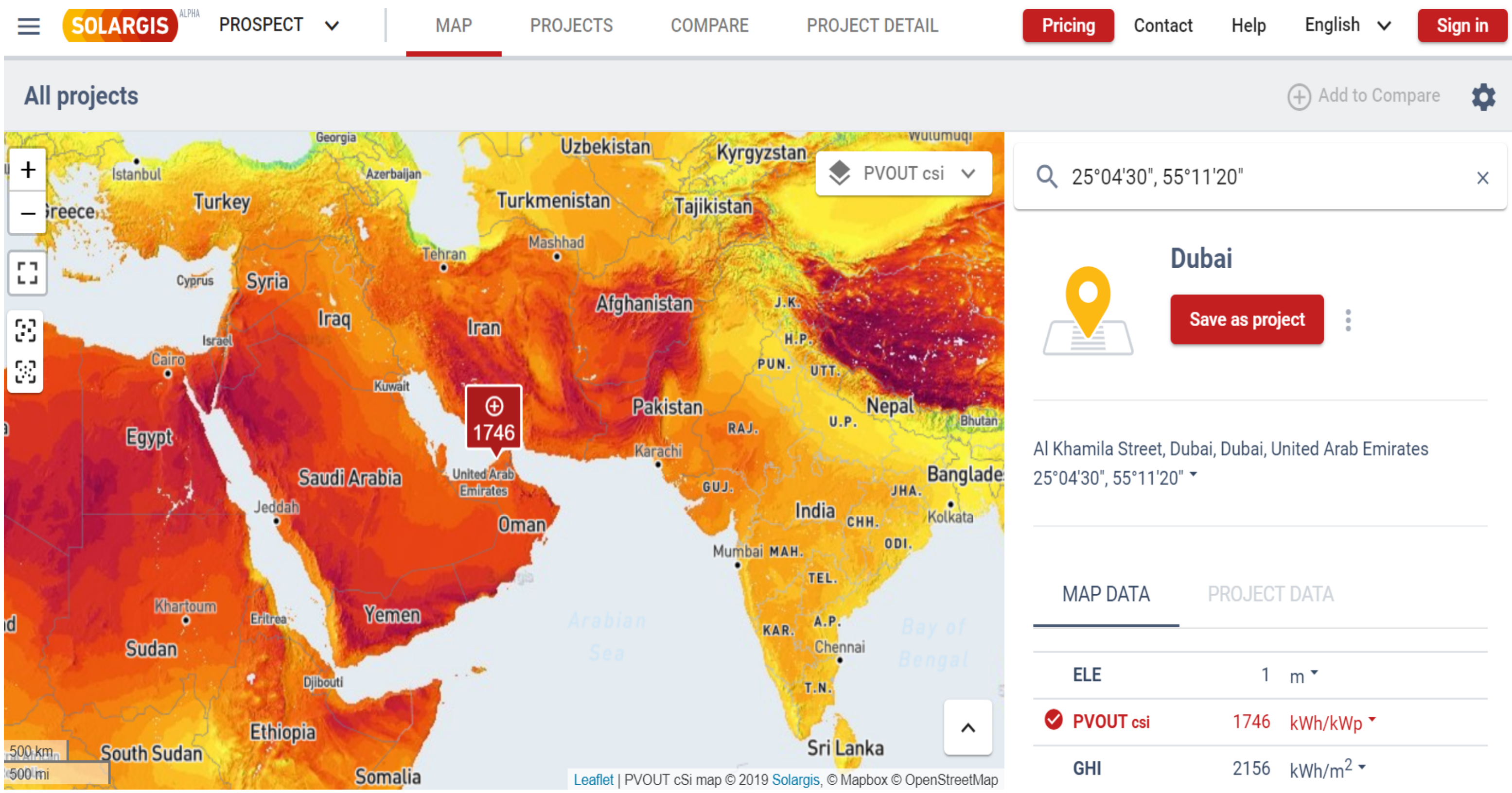




New features in Prospect online application

Interactive maps

Prospect offers 250-m grid resolution data for exploration of solar climate and for reliable PV energy assessment



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New maps

Data reveal striking geographical variability

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More meteorological parameters

Prospect shows 20+ solar meteo and enviro parameters that are critical for preliminary assessment of PV power plants worldwide

Global tilted irradiation at optimum angle
Yearly average
2345 kWh/m²

Air temperature
Yearly average
28.3 °C

The most important project-specific meteorological parameter that determines solar electricity production is solar radiation, which fuels a PV power system. Power production is also influenced by air temperature. Other meteorological parameters also affect the performance, availability and ageing of a PV system.

Solar radiation and meteorological parameters

	GHI kWh/m²	DNI kWh/m²	DIF kWh/m²	D2G	GTI opta kWh/m²	ALB	TEMP °C	WS m/s	RH %	PWAT kg/m²	PREC mm	CDD degree days	HDD degree days
Jan	128	150	48	0.38	172	0.24	20.5	3.9	61	17	19	79	1
Feb	140	141	54	0.38	173	0.25	21.4	4.2	59	18	28	98	1
Mar	181	158	72	0.40	202	0.26	23.8	4.3	57	18	26	179	0
Apr	201	158	81	0.41	204	0.27	27.6	4.0	52	19	7	288	0
May	232	184	91	0.39	218	0.27	31.5	4.1	51	19	0	419	0
Jun	223	164	95	0.43	203	0.27	33.4	3.9	53	22	0	461	0
Jul	210	128	107	0.51	195	0.27	34.9	3.9	51	32	1	525	0
Aug	209	144	97	0.47	205	0.27	35.2	3.8	47	32	0	533	0
Sep	195	163	78	0.40	210	0.27	32.8	3.6	51	25	0	444	0
Oct	177	182	62	0.35	213	0.27	30.0	3.3	53	21	1	372	0
Nov	137	159	48	0.35	181	0.25	26.1	3.6	55	21	5	243	0
Dec	123	150	45	0.37	169	0.23	22.4	3.7	59	18	20	138	0
Yearly	**2156**	**1883**	**879**	**0.41**	**2345**	**0.26**	**28.3**	**3.9**	**54**	**22**	**107**	**3778**	**2**

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New primary source of meteorological parameters

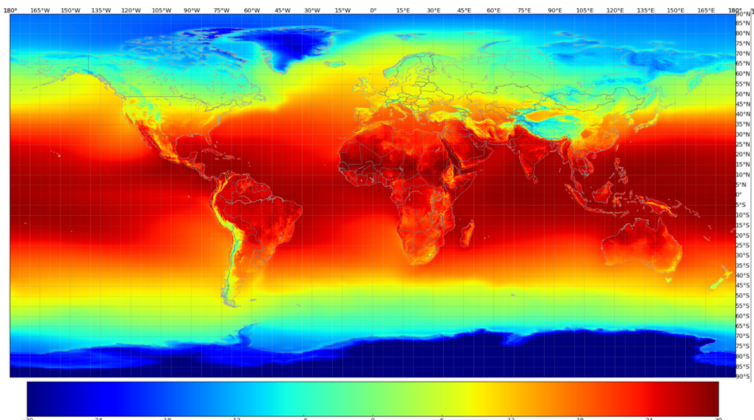
Current data source

MERRA-2 Modern-Era Retrospective Analysis for Research and Applications, Version 2

CFSR NCEP Climate Forecast System Reanalysis [1979 - 2010]

1994-2010 2011 -yesterday

MERRA2 resolution: 0.5^{o} x 0.5^{o}
CFSv2 resolution: 0.2^{o} x 0.2^{o}



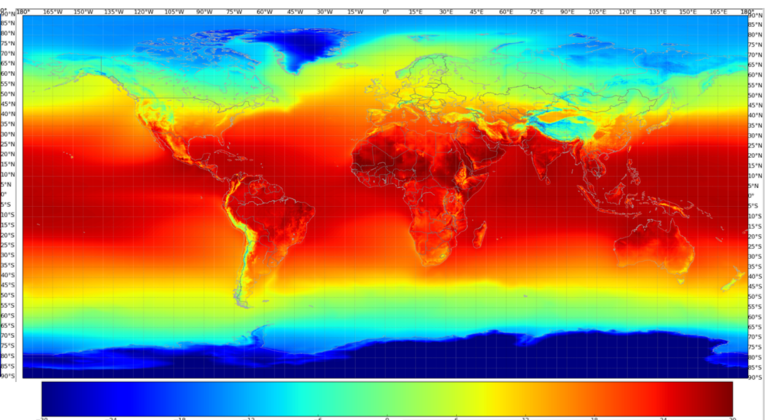
Upcoming data source

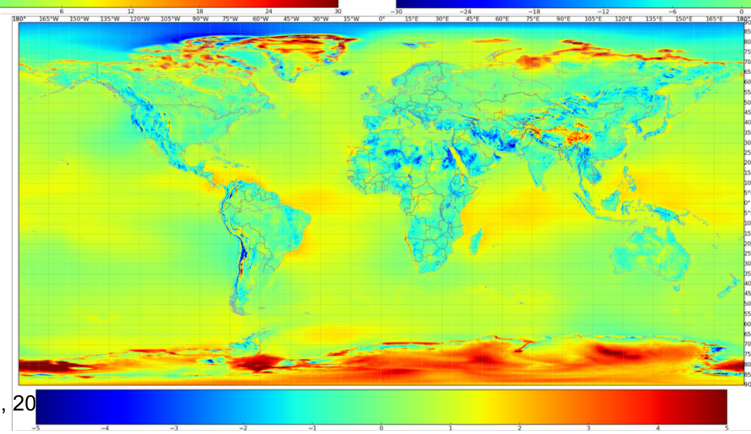
ERA5

CFSR NCEP Climate Forecast System Reanalysis [1979 - 2010]

1994-2019 Last 3 months

ERA5 resolution: 0.25^{o} x 0.25^{o}
CFSv2 resolution: 0.2^{o} x 0.2^{o}





Difference

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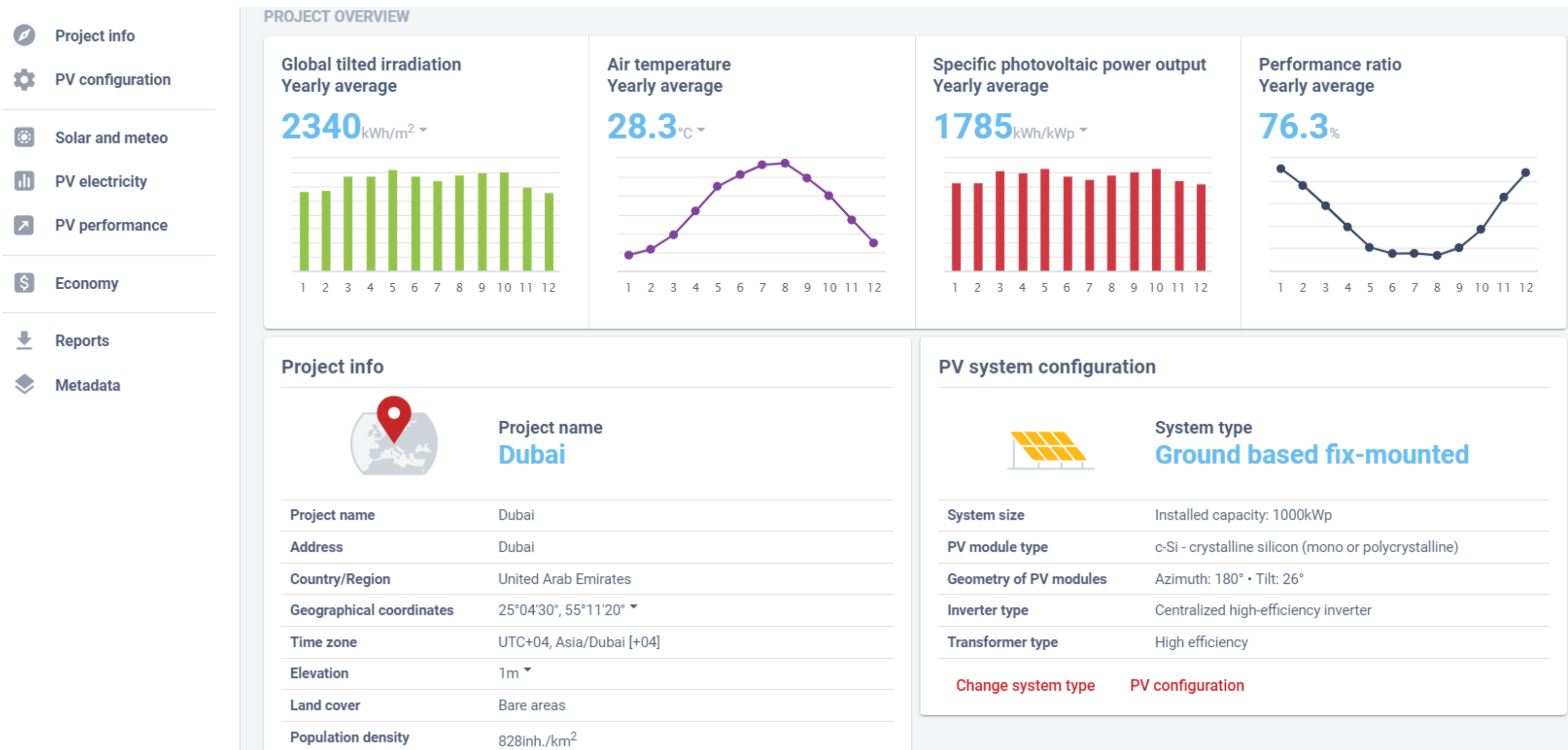
Introductory information for any project

Pre-feasibility assessment can be further evaluated in any design software, by Solargis time series and TMY data, consistently and in a full detail



User interface and reports in multiple languages

User interface and reports in English, Spanish and Mandarin Chinese

Contactar Ayuda Español

English

Español ✓

中文

Información del proyecto

Configuración FV

Solar y meteo

Electricidad FV

Estadísticas mensuales

Perfiles horarios

Rendimiento FV

Economía

Informes

Metadatos

Resumen

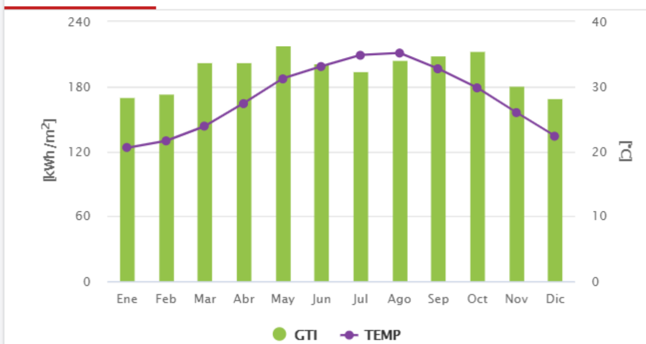
Producción fotovoltaica específica
Promedio anual
1785 kWh/kWp

Producción fotovoltaica total
Promedio anual
1784683 kWh

Potencial teórico de generación eléctrica fotovoltaica

Mes	GTI kWh/m²	PVOUT specific kWh/kWp	PVOUT total kWh	PR %
Ene	171	138	138335	81.1
Feb	174	138	138085	79.6
Mar	203	158	157747	77.8
Abr	203	154	153895	75.9
May	218	161	161294	74.1
Jun	202	149	148518	73.5
Jul	194	143	142861	73.5
Ago	205	150	150079	73.4
Sep	209	155	154738	74.0
Oct	213	161	161144	75.7
Nov	180	142	141708	78.5
Dic	169	136	136279	80.7
Anual	**2340**	**1785**	**1784683**	**76.3**

GTI+TEMP PVOUT TOTAL PVOUT SPECIFIC+PR



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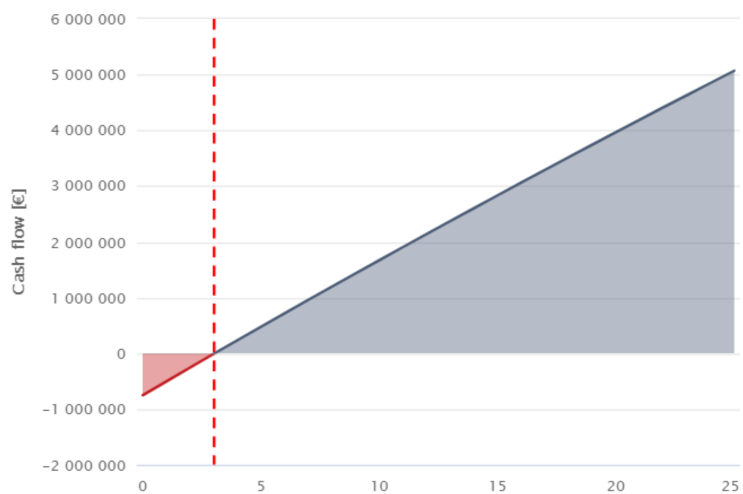
Economy calculator

Payback, return on investment, levelized cost of electricity for any PV configuration

PV system economy

Simple payback	Return on investment	Leveled cost of energy
3.0 years	3.90	0.03 $

Simple payback



Economic indicators

End of year		0	5	10	15	
Resource generation	kWh	1,784,683	1,735,262	1,692,312	1,650,425	1,609,
Cost saved	$		0	0	0	
Energy to the grid	kWh		1,735,262	1,692,312	1,650,425	1,609,
Revenue generated	$		260,289.26	253,846.78	247,563.75	241,43
Annual cash flow	$		242,789.26	236,346.78	230,063.75	223,93
Total cash flow	$	-750,000	477,092.07	1,671,646.34	2,834,468.17	3,966,3

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Collaborative work & Management of portfolios

In Prospect app, teams can collaborate on projects. Organize projects using tags, share them and manage permissions.

Users

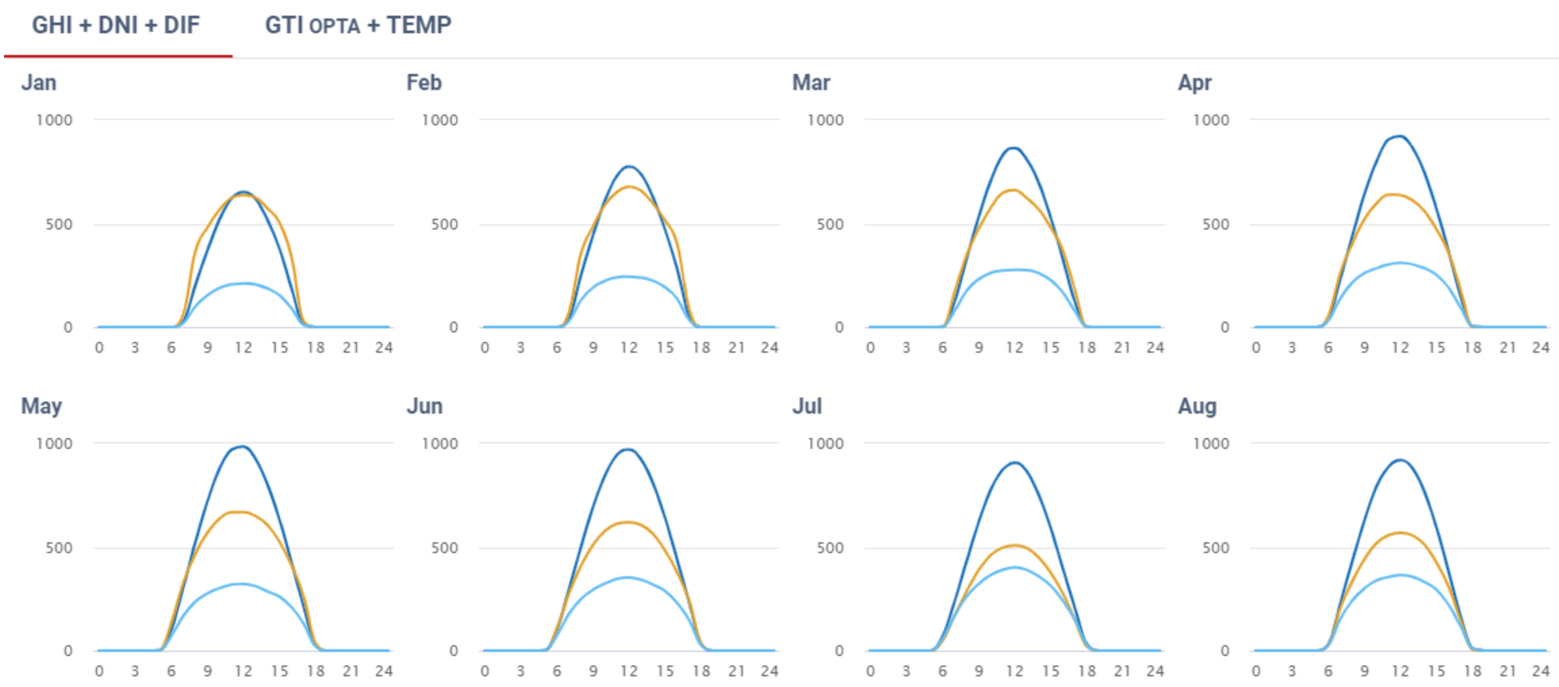
Name	Email	System role	Status	
Martin Ďuriš	martin.duris@solargis.com	Admin	Active	Delete
Branislav Cief	branislav.cief@solargis.com	Admin	Active	Delete
Daniel Chrkavy	daniel.chrkavy@solargis.com	Admin	Active	Delete
– –	marcel.suri@solargis.com	Admin	Active	Delete
Shihying Lin	shihying.lin@solargis.com	Admin	Active	Delete
Tomas Cebecauer	tomas.cebecauer@solargis.com	Admin	Active	Delete
daniel ranusa	daniel.ranusa@solargis.com	Admin	Active	Delete
		Admin	Active	Delete
Nada Suriova	nada.suriova@solargis.com	Admin	Active	Delete

More detailed solar analytics and comparison

Data output aggregated as:

- Long-term yearly and monthly averages
- Average hourly profiles for each month

… to better understand the PV electricity potential and PV performance.



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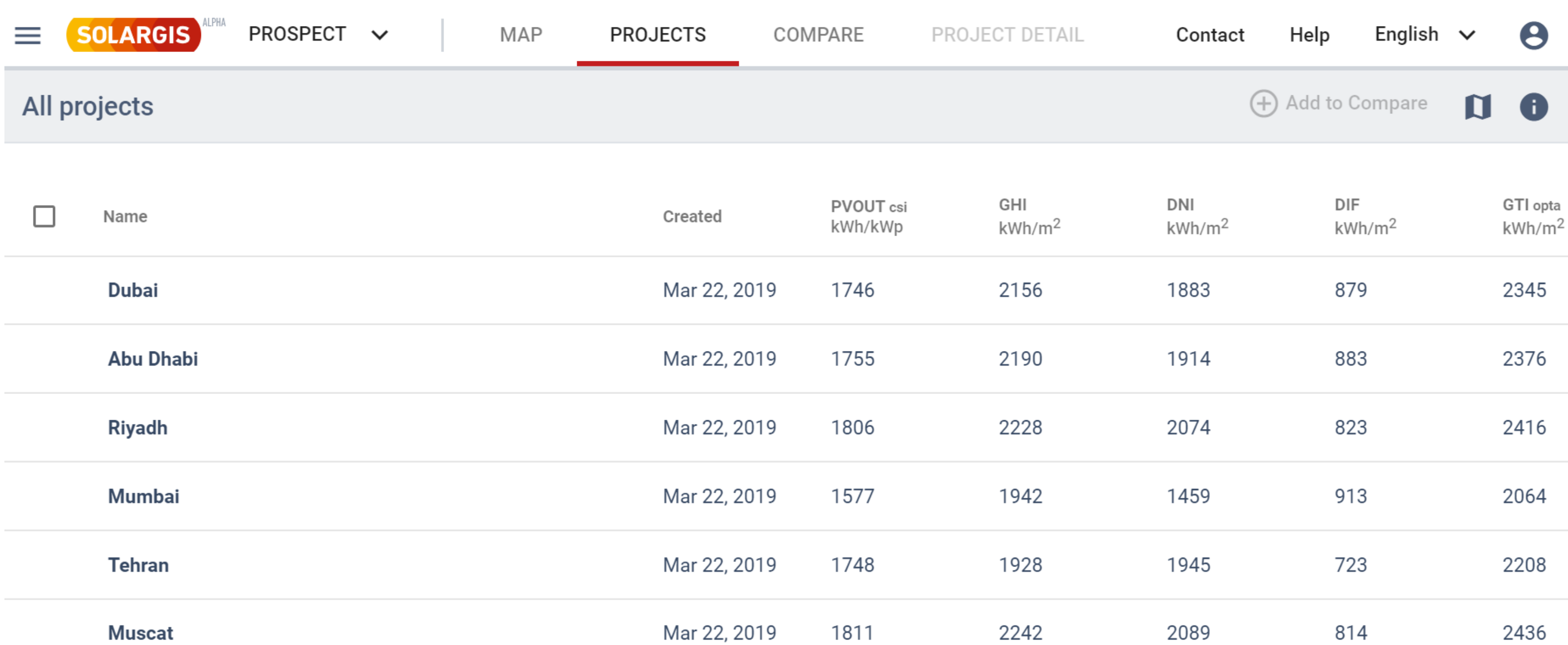
Global and most accurate data

Solargis data has been recognized as the most accurate by independent studies and confirmed in thousands of large-scale PV commercial projects, worldwide.

Accurate information consulted in the pre-feasibility stage prevents disappointment in the solar project development and operation



Name	Created	PVOUT csi kWh/kWp	GHI kWh/m^2	DNI kWh/m^2	DIF kWh/m^2	GTI opta kWh/m^2
Dubai	Mar 22, 2019	1746	2156	1883	879	2345
Abu Dhabi	Mar 22, 2019	1755	2190	1914	883	2376
Riyadh	Mar 22, 2019	1806	2228	2074	823	2416
Mumbai	Mar 22, 2019	1577	1942	1459	913	2064
Tehran	Mar 22, 2019	1748	1928	1945	723	2208
Muscat	Mar 22, 2019	1811	2242	2089	814	2436

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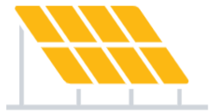
Advanced online PV simulator

New PV simulation tool based on the latest scientific developments and new concepts which consider all critical technical details of the PV power plant.

Pre-defined PV configurations for an easier system set-up.

- ○ **Rooftop small**
  Photovoltaic system mounted on a tilted roof of a residen...
- ○ **Rooftop large flat roof**
  Photovoltaic system mounted on a large horizontal roof o...
- ○ **Rooftop large tilted roof**
  Photovoltaic system mounted on a large tilted roof of a c...
- ○ **Building integrated**
  Photovoltaic system integrated into a facade or roof of a r...
- ◉ **Ground based fix-mounted**
  Large-scale commercial photovoltaic system mounted on ...
- ○ **Tracker with 1 horizontal axis**
  Tracker with one horizontal axis North-South bound. Rotat...
- ○ **No PV System**
  Only solar and meteorological parameters are calculated. ...



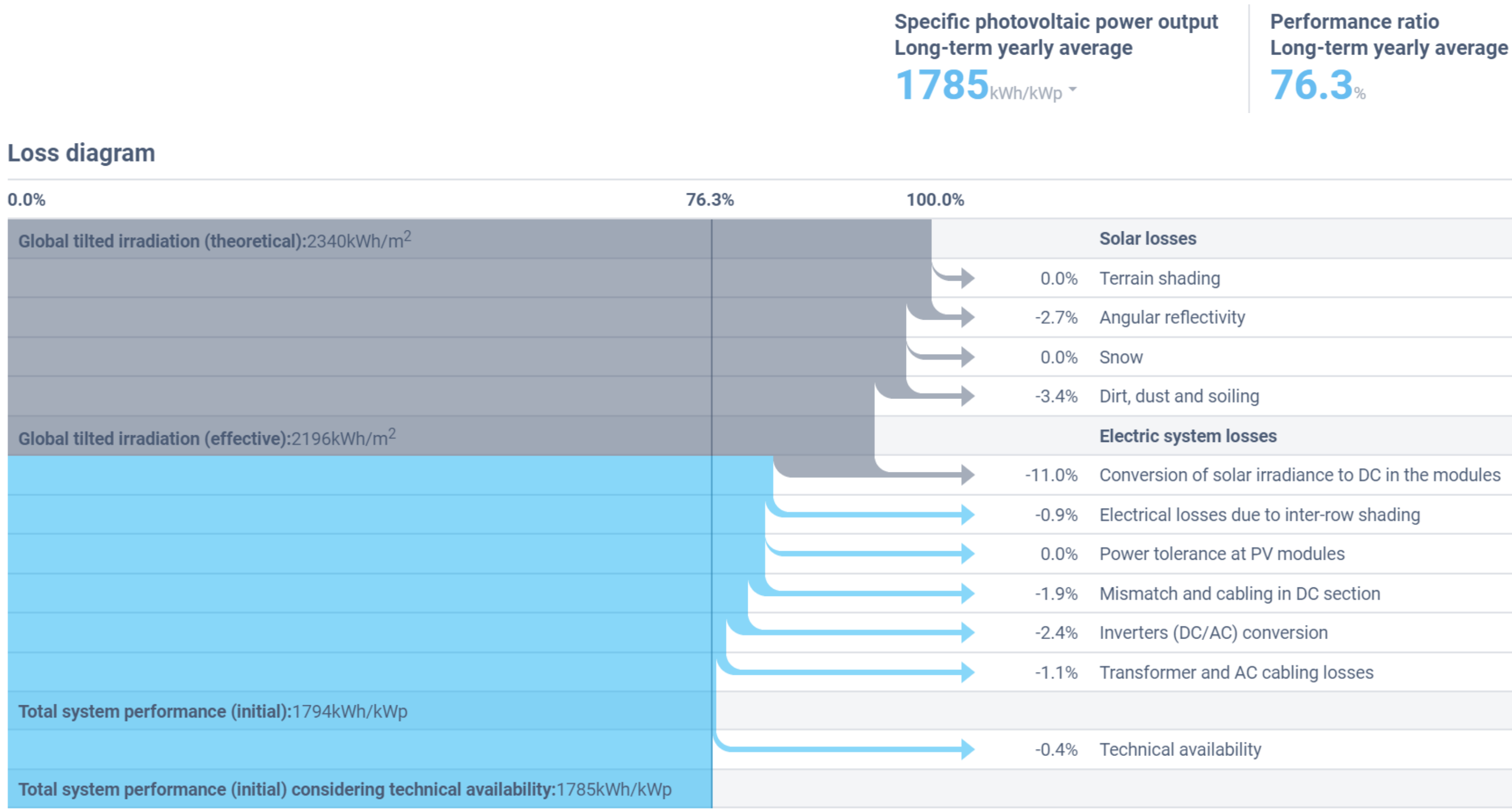
Ground based fix-mounted

Large-scale commercial photovoltaic system mounted on leveled ground. Azimuth and tilt of PV modules are homogeneous, usually facing towards the Equator and inclined at the optimum tilt to maximize yearly energy yield. The modules are fix-mounted on tilted structures aligned in rows. During low-sun angles, they may be partially shaded by preceding rows. The modules are well ventilated. This type of PV system is connected to a medium- or high-voltage grid through an inverter and distribution transformer, and an additional transformer may also be used. No electricity storage is considered.

System size	Installed capacity: 1000kWp
PV module type	c-Si - crystalline silicon (mono or polycrystalline)
Geometry of PV modules	Azimuth: 180° • Tilt: 26°
Row spacing	2.5
Inverter type	Centralized high-efficiency inverter
Transformer type	High efficiency
Snow and soiling losses at PV modules	Yearly average soiling losses 3.5 % • Yearly average snow losses 0.0 %
Cabling losses	DC cabling 2 % • DC mismatch 0.3 % • AC cabling 0.5 %
System availability	99.5 %

PV system losses

Detailed shading calculation and analysis of all system losses.



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Outputs: monthly or hourly averages

Solargis Prospect delivers outputs as long-term averaged monthly & hourly data

GHI DNI TEMP

Global horizontal irradiation Wh/m^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1	-	-	-	-	-	-	-	-	-	-	-	-
1 - 2	-	-	-	-	-	-	-	-	-	-	-	-
2 - 3	-	-	-	-	-	-	-	-	-	-	-	-
3 - 4	-	-	-	-	-	-	-	-	-	-	-	-
4 - 5	-	-	-	-	-	-	-	-	-	-	-	-
5 - 6	-	-	-	-	1	2	-	-	-	-	-	-
6 - 7	-	-	1	41	101	101	69	31	28	13	1	-
7 - 8	29	42	125	232	308	298	239	229	227	184	112	33
8 - 9	203	252	332	441	525	502	433	432	441	406	313	231
9 - 10	370	444	532	641	720	694	621	628	644	604	488	397
10 - 11	520	614	707	798	878	847	777	791	804	755	622	535
11 - 12	621	731	831	905	970	946	873	887	899	841	703	617
12 - 13	652	775	865	922	985	971	907	920	919	845	701	630
13 - 14	620	738	809	867	927	923	866	881	857	771	634	579
14 - 15	517	625	696	745	801	807	751	766	726	634	511	474
15 - 16	377	469	526	570	631	640	591	594	541	446	344	322
16 - 17	187	282	329	367	426	438	397	385	327	215	136	129
17 - 18	14	52	123	148	214	233	205	169	82	16	1	1
18 - 19	-	-	2	4	26	32	31	11	1	-	-	-
19 - 20	-	-	-	-	-	-	-	-	-	-	-	-
20 - 21	-	-	-	-	-	-	-	-	-	-	-	-
21 - 22	-	-	-	-	-	-	-	-	-	-	-	-
22 - 23	-	-	-	-	-	-	-	-	-	-	-	-
23 - 24	-	-	-	-	-	-	-	-	-	-	-	-
Sum	**4111**	**5024**	**5879**	**6681**	**7513**	**7433**	**6762**	**6724**	**6495**	**5729**	**4566**	**3949**

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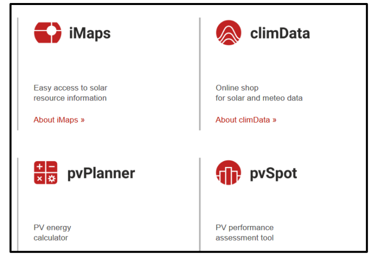
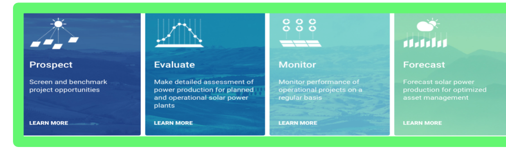
Old and new Solargis tools
Changes in PV simulation

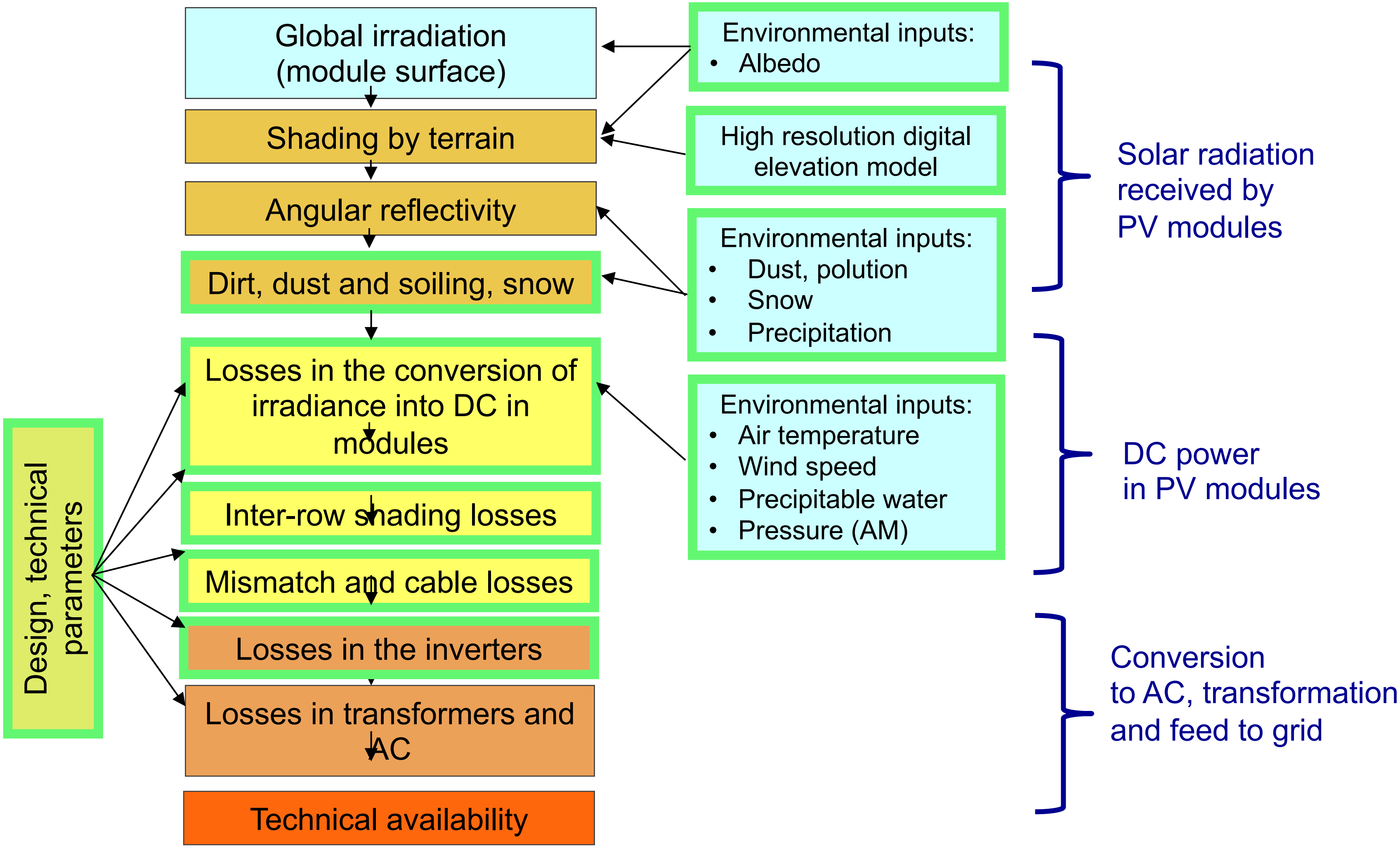
Old and new Solargis tools

Simulator elements added / modified



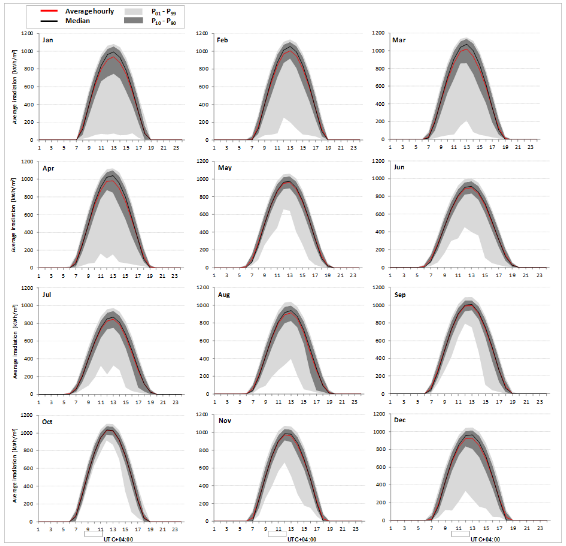


Simplified PV simulation chain

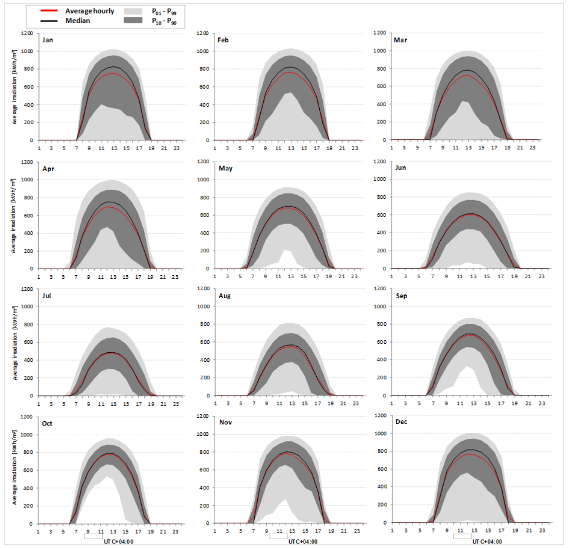


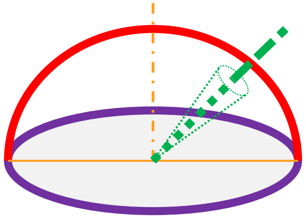
Aggregated solar radiation data

GHI

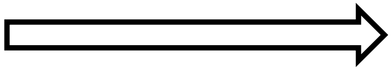


DNI

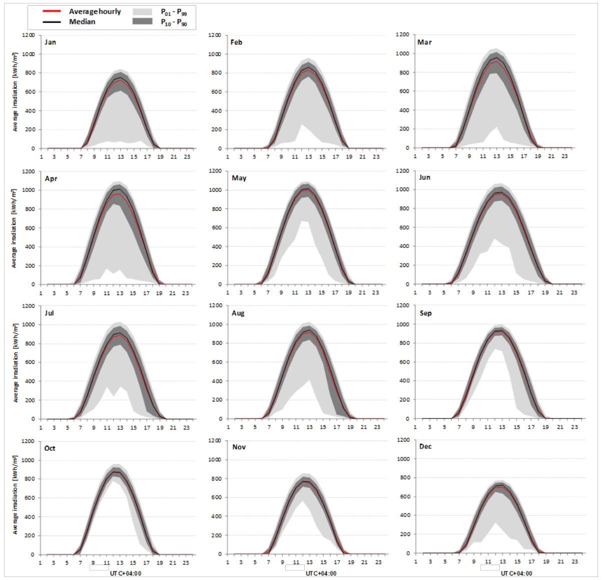




R. Perez transposition model



GTI



Global dataset of 7 percentile DNI and GHI „days" per month, 15-min data time step

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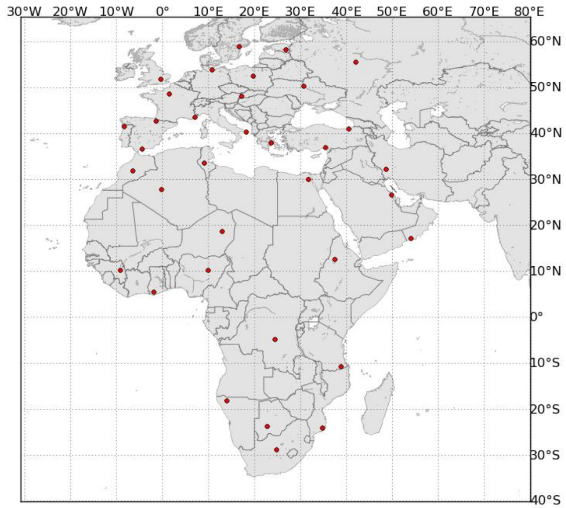
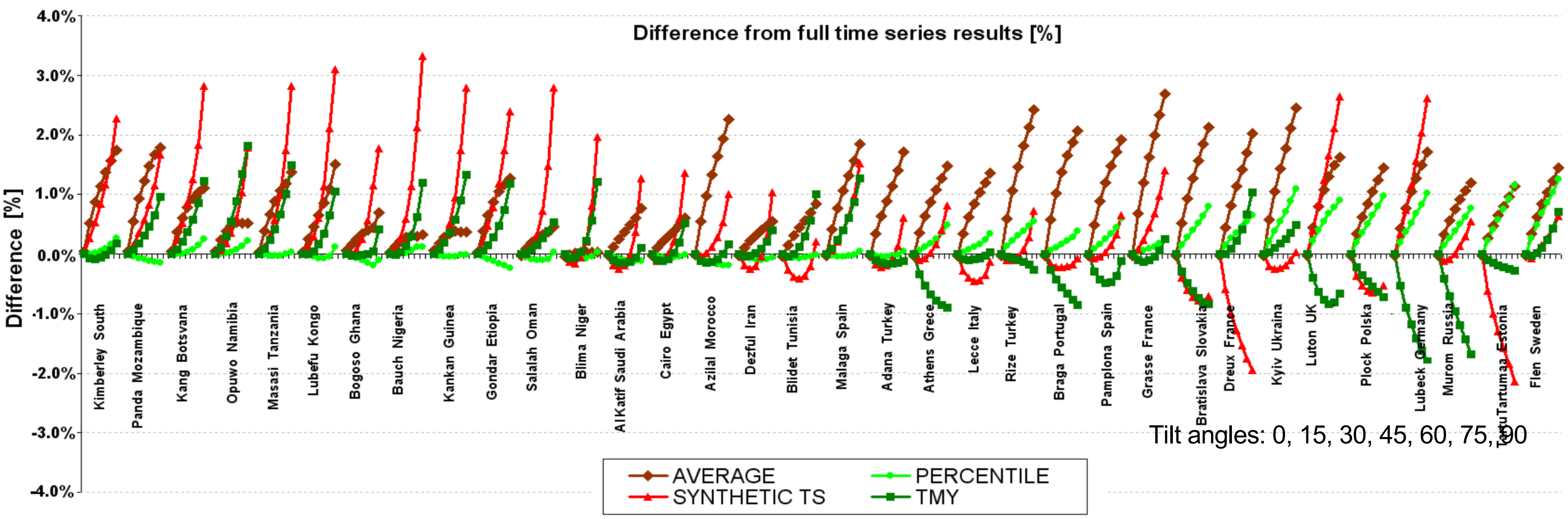
Aggregated solar radiation data





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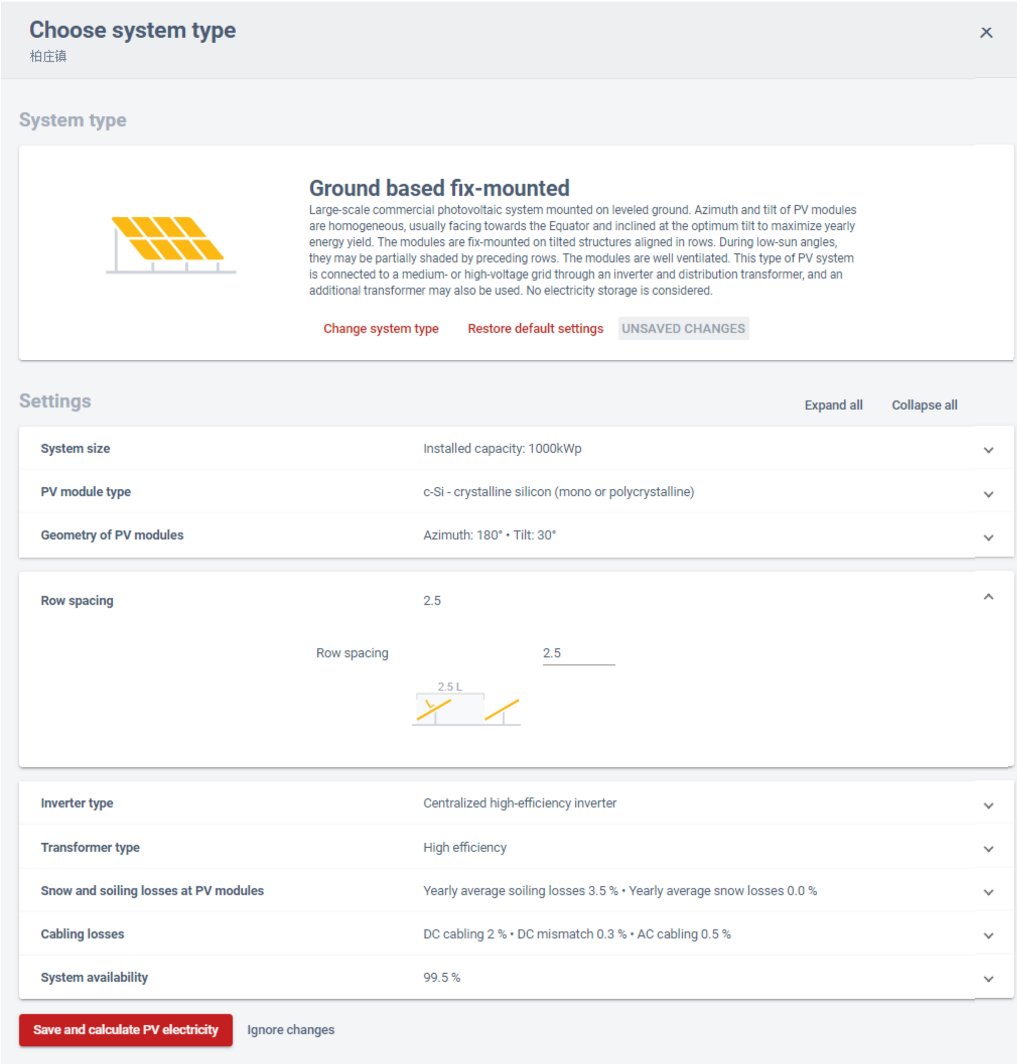
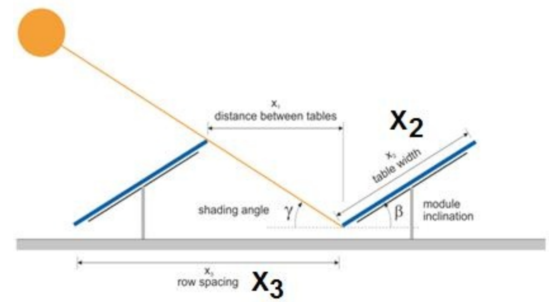
Detailed inter-row shading analysis





Fix mounted systems

- direct and diffuse shading
- per cell simulation
- varius strings layouts
- modules orientation V and H
- mono and bifacial modules

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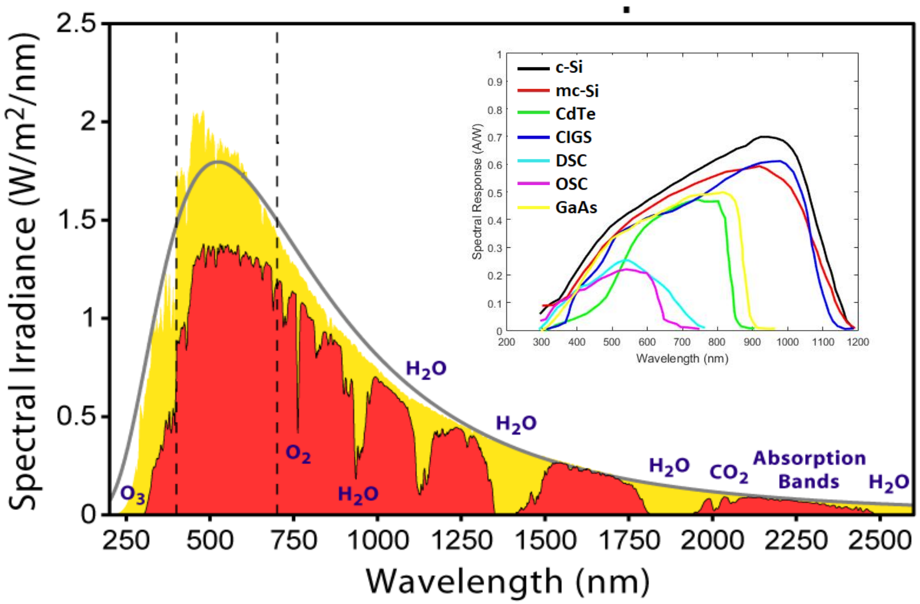
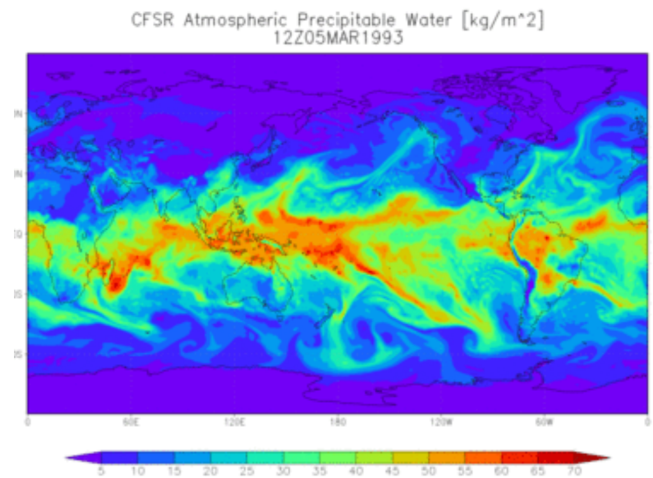
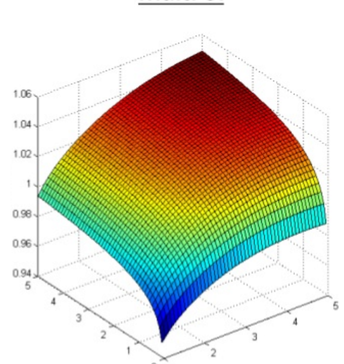
Combined AM and PWAT correction



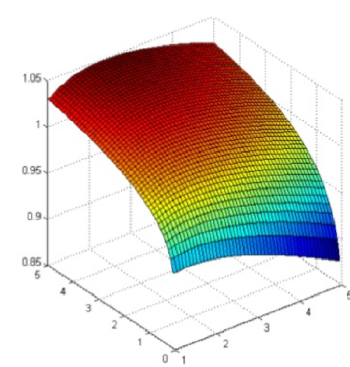


$$M = b_0 + b_1 \cdot AM_a + b_2 \cdot p_{wat} + b_3 \cdot \sqrt{AM_a} + b_4 \cdot \sqrt{p_{wat}} + b_5 \cdot \frac{AM_a}{\sqrt{p_{wat}}}$$

Multi-Si



CdTe



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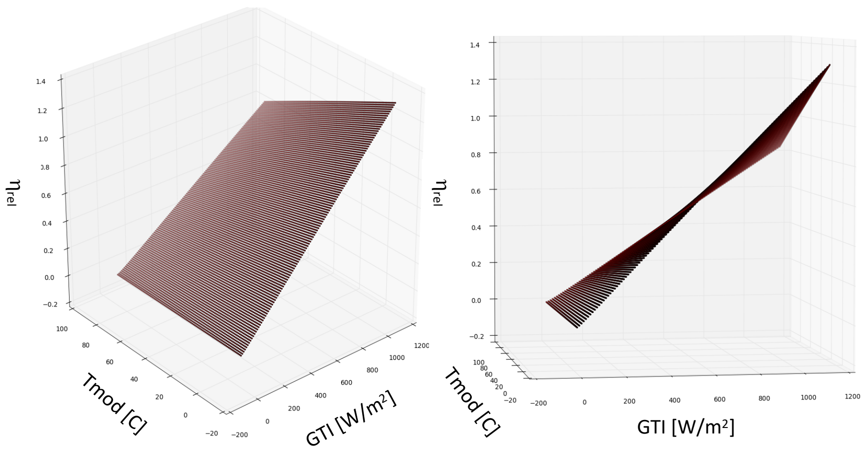
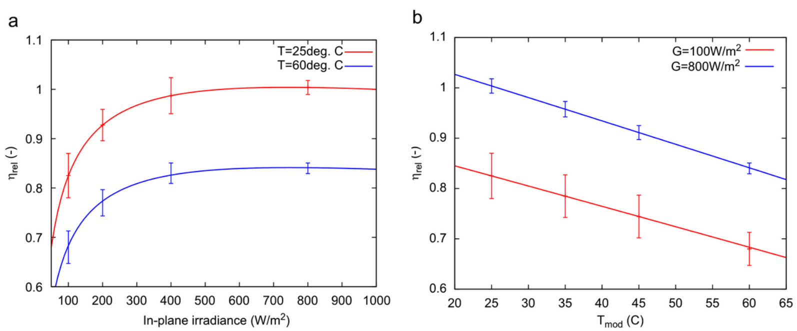
Change in PV simulation chain





A power-rating (performance surface) model developed by Huld T. **ESTI Laboratory**
based on King L. PV array model Sandia National Laboratories

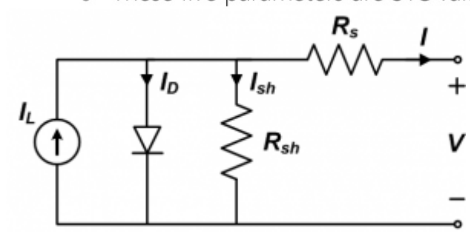
IEC-61853 Module Model

Recall: single diode models consist of two parts:

- The nonlinear I-V curve equation defined by parameters: a, I_L, I_o, R_s, R_{sh}

$$I = I_L - I_o\left(\exp\left[\frac{V + IR_s}{a}\right] - 1\right) - \frac{V + IR_s}{R_{sh}}$$

- These five parameters are STC values (@ 1000 W/m² & 25 C)



Single diode model

PVPerformance MODELING COLLABORATIVE

The **De Soto model**, also known as the five-parameter model, uses the following equations to express each of the five primary parameters as a function of cell temperature and irradiance :

- $I_L = \frac{S}{S_{ref}}\frac{M}{M_{ref}}\left[I_{L,ref} + \alpha_{Isc}\left(T_c - T_{c,ref}\right)\right]$
- $I_0 = I_{0,ref}\left(\frac{T_c}{T_{c,ref}}\right)^3 \exp\left[\frac{1}{k}\left(\frac{E_g\left(T_{ref}\right)}{T_{ref}} - \frac{E_g\left(T_c\right)}{T_c}\right)\right]$
- $E_g\left(T_c\right) = E_g\left(T_{ref}\right)\left[1 - 0.0002677\left(T_c - T_{ref}\right)\right]$
- $R_s = \text{constant}$
- $R_{sh} = R_{sh,ref}\frac{S_{ref}}{S}$
- $n = \text{constant}$

Evolution of inverter model complexity

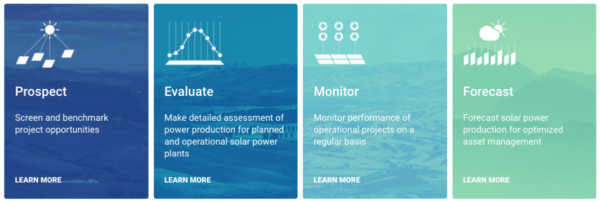
Euro Efficiency

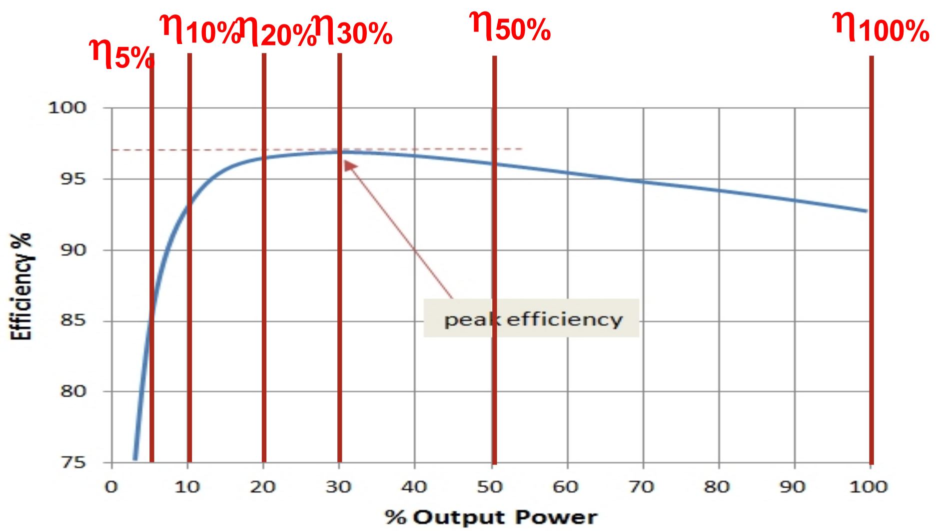
Efficiency curve

Sandia empirical model

pvPlanner
iMaps
pvSpot
climData

climData
pvSpot





Euro Efficiency – weighted efficiency

$\eta_{EU} = (3 \cdot \eta_{5\%} + 6 \cdot \eta_{10\%} + 13 \cdot \eta_{20\%} + 10 \cdot \eta_{30\%} + 48 \cdot \eta_{50\%} + 20 \cdot \eta_{100\%}) / 100$

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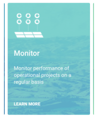
Further developments

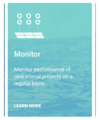
PV simulator development roadmap

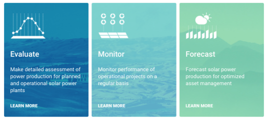
Detailed PV power plant configuration available through API
PV simulator is independent of input data

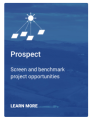
It works with:



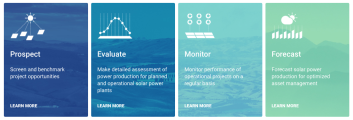
- Modelled or measured data, site-adapted data



- Sny time-step 1, 5, 10, 15, 30, 60 min
- Timeseries, 

 statistical data (percentiles) 

Supports all most popular mounting scenarios
(mono and bifacial, fix and trackers)



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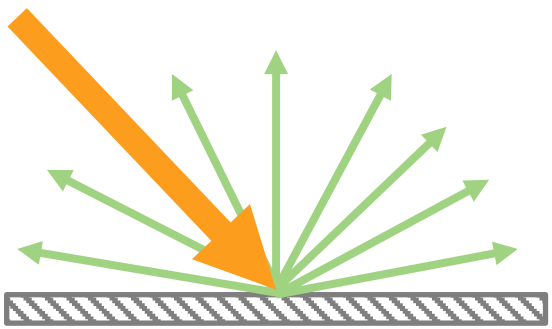
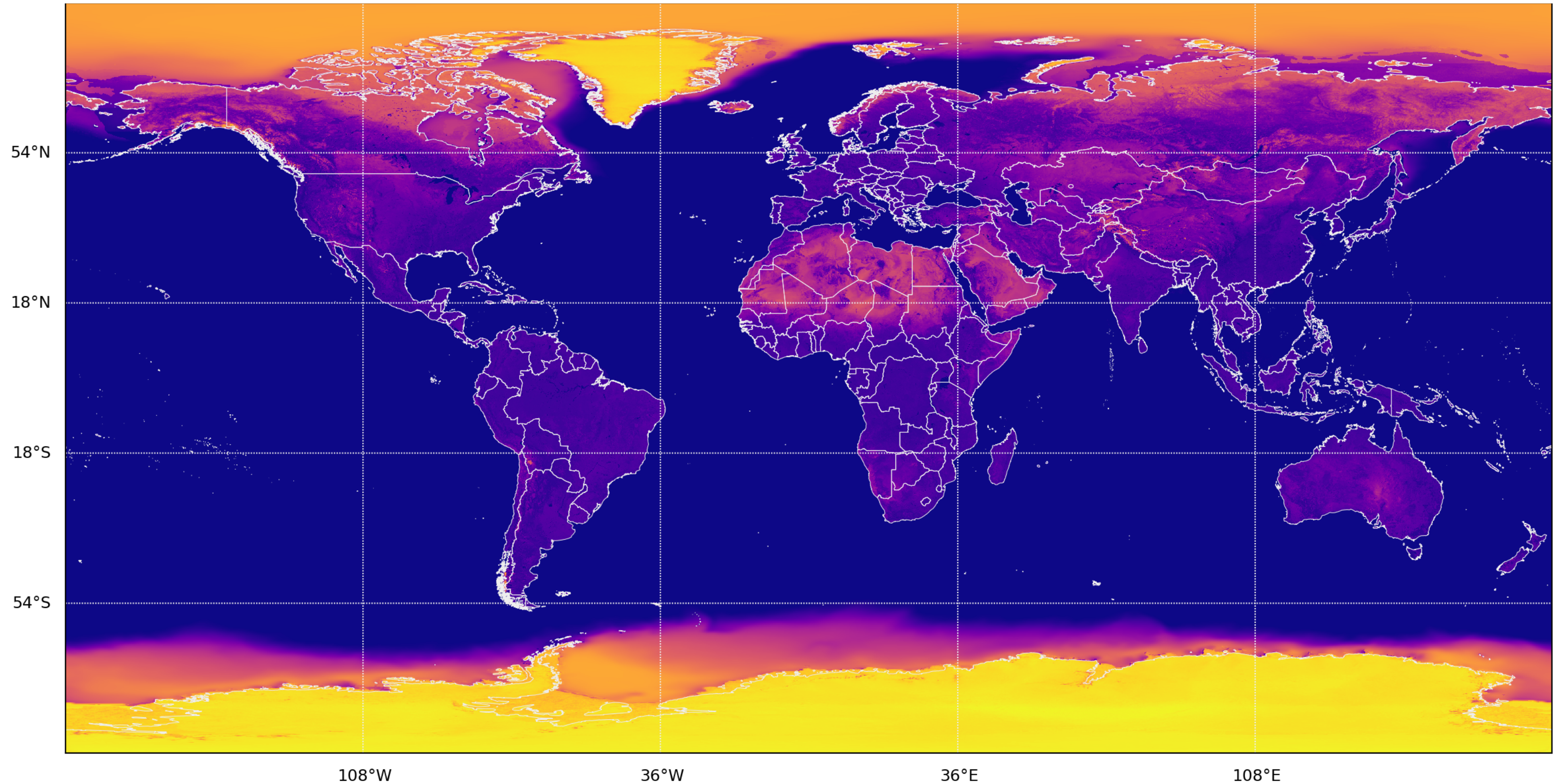
Ground albedo





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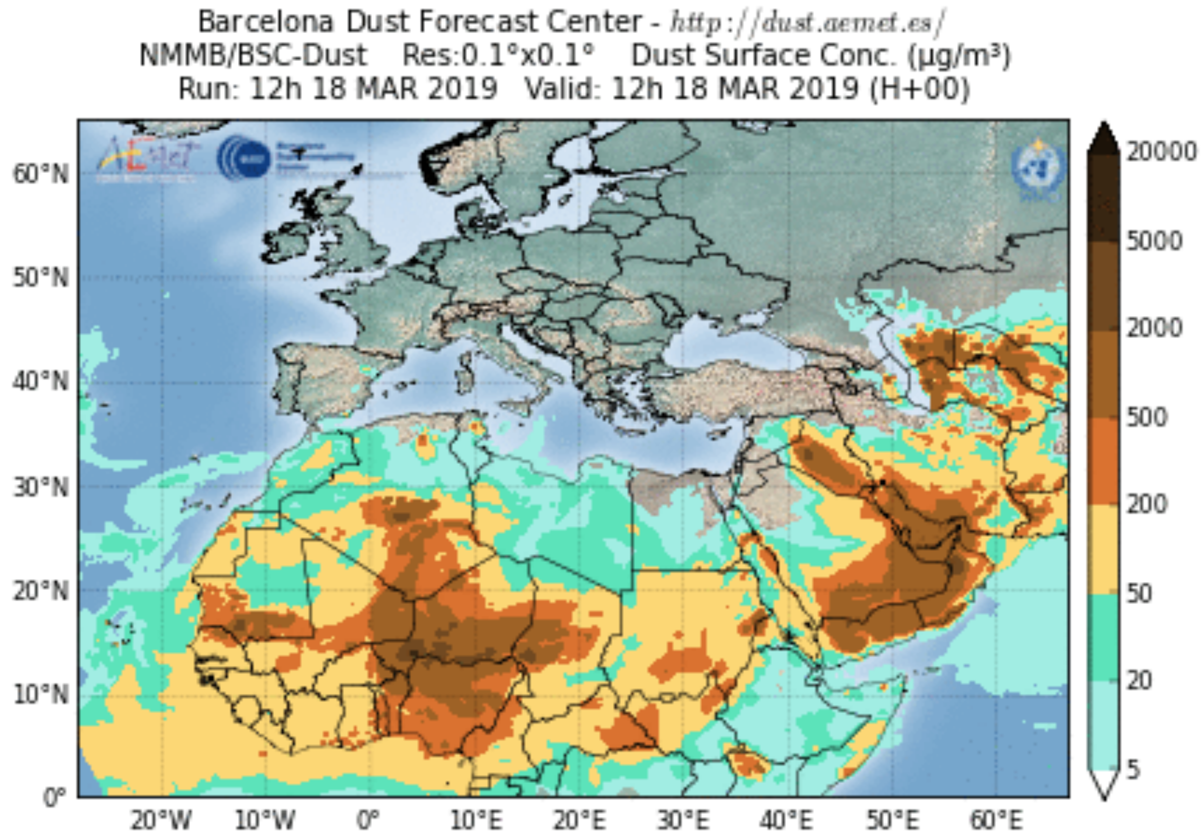
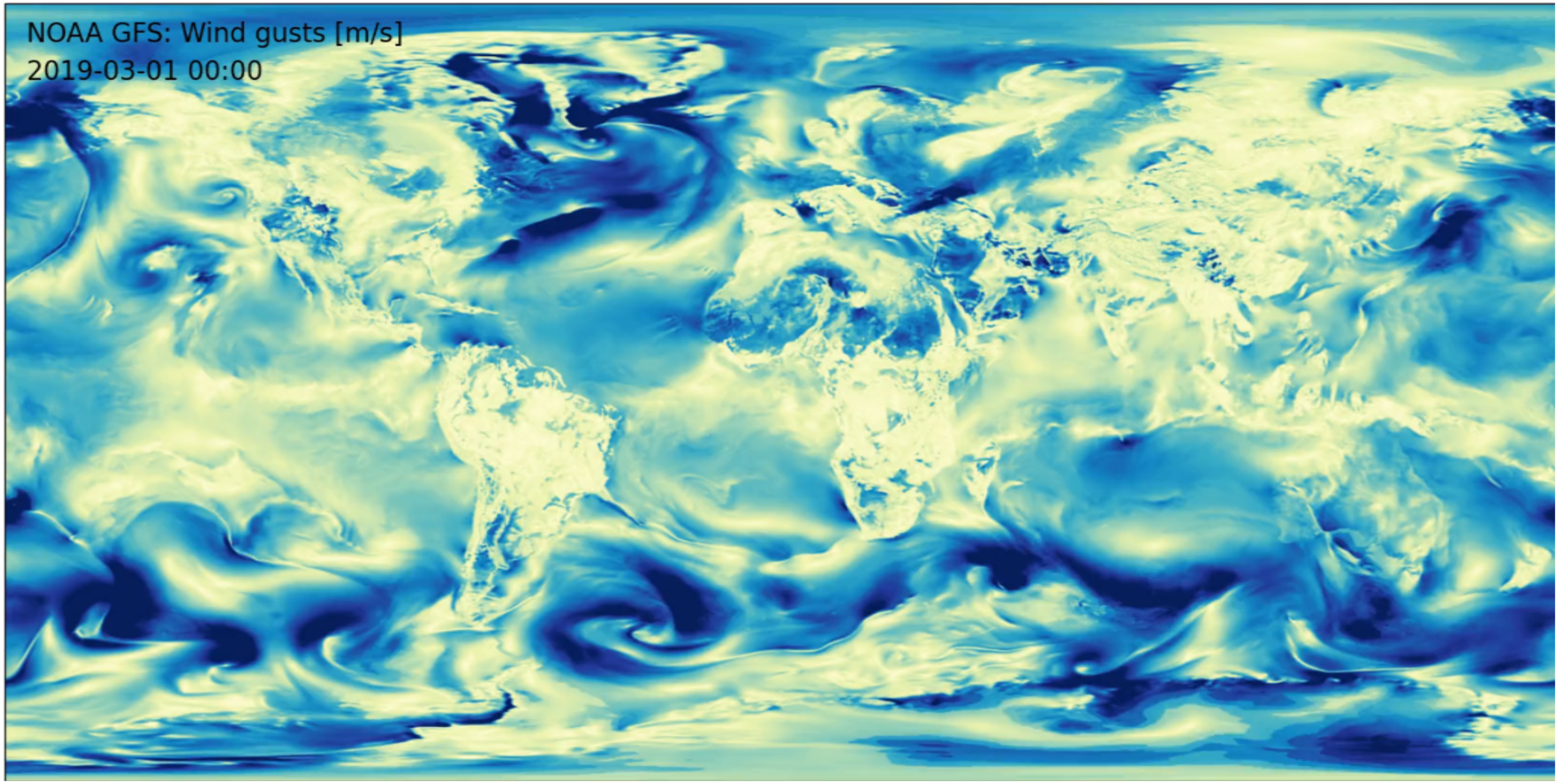
NMMB/BSC-Dust model: history and forecast



Latest dust forecast for Northern Africa, Middle East and Europe

Model reproduces significantly well daily variability and seasonal geographical distribution of dust optical depth over Northern Africa, Middle East and Europe

Maximum wind gusts: history and forecast



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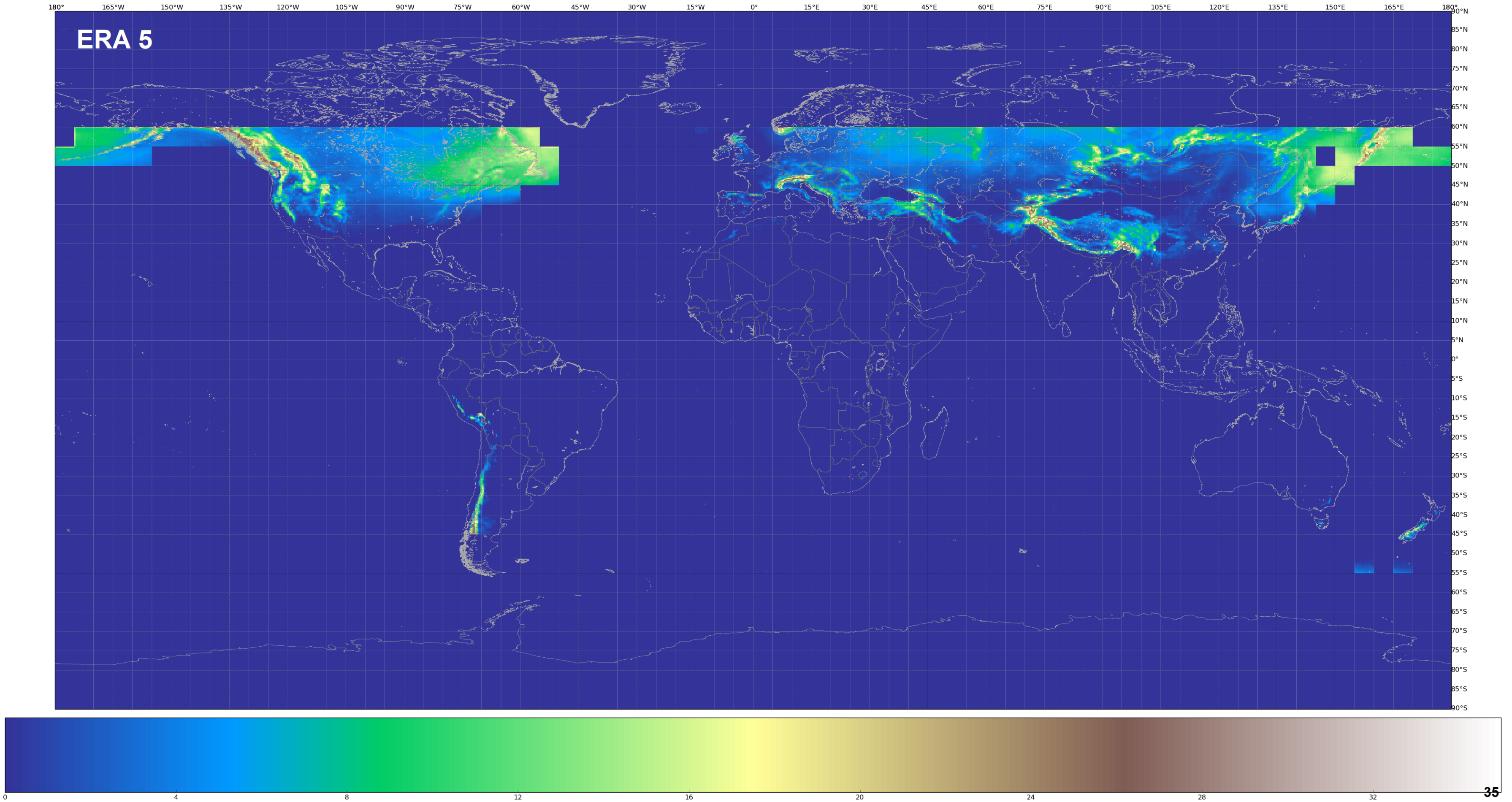
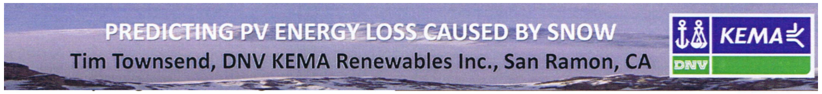
Snow losses – history and forecast





$$\text{Monthly Loss, \%} = C_1 \times Se' \times \cos^2(T) \times GIT \times RH / T_A^2 / POA^{0.67}$$

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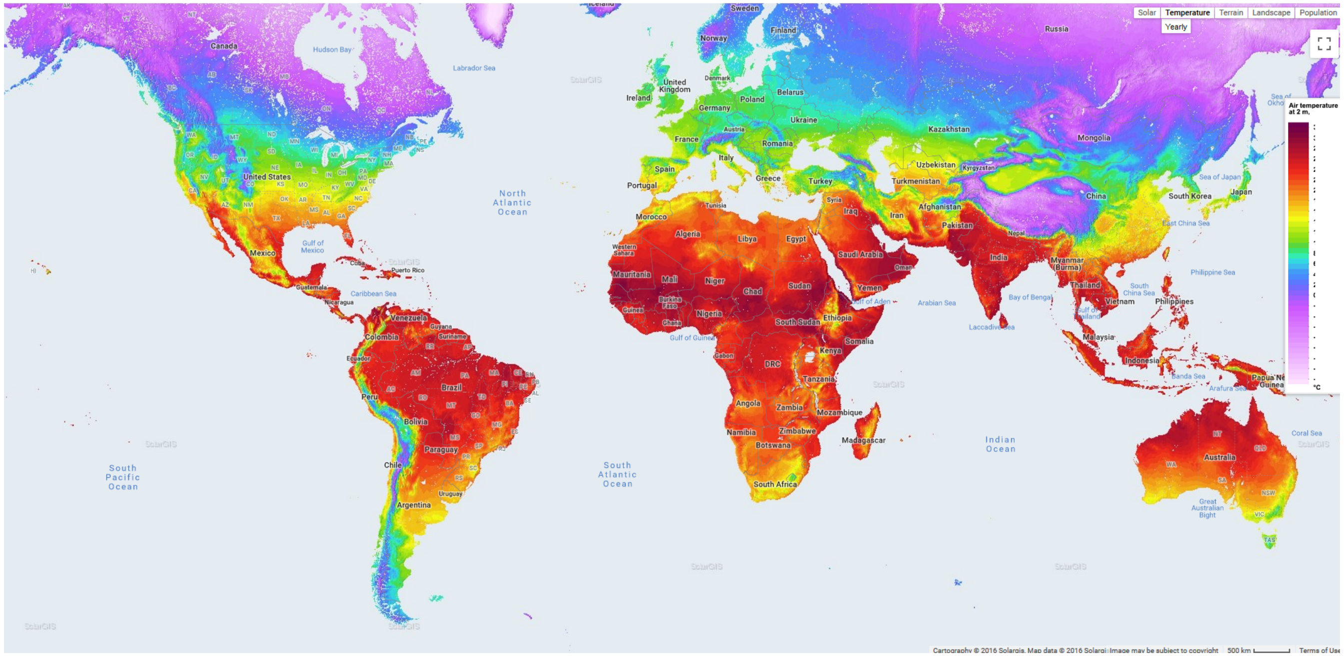
PV system sizing – minimum temperature

IEC
International Electrotechnical Commission

IEC 62548:2016

Photovoltaic (PV) arrays - Design requirements



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Thank you!

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