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Estimating Algerian Solar Potential Using Solar-Med-Atlas Data Source

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***Abstract*— A solar assessment has been established in this work. Database made available by "Solar Atlas for the Mediterranean" portal was used. In our case a large part of the national territory was covered, a sample grouping together a total of 78 sites was considered. Radiometric parameters such as, global irradiation received on horizontal plane and direct normal irradiation parameters, air temperature were treated. Thanks to the availability of measured data regarding 6 sites across the country, we were able to compare data given by Solar-Med-Atlas to those measured by the Algerian weather office (ONM). Results have shown that data from Solar-Med-Atlas are in good agreement with measured data. Finally, solar maps were produced thanks to the use of SURFER® software, through Kriging interpolation method. The results show a great potential for most parts, especially in the southern part of the country. This confirm results of previous studies which were undertaken. The great availability of solar potential led recently to a large deployment of photovoltaic (PV) solar plants across the country.**

***Keywords*— Solar Radiation, Solar-Med-Atlas, Annual and monthly averages**

I. Introduction

Many studies dealing with solar radiation evaluation have been conducted in recent years [1-10]. These contributions confirmed the availability of a great solar potential in Algeria. The availability of large quantities of solar energy in the region means that solar energy could be considered as a potential source of energy for different applications in the form of individual photovoltaic solar modules or concentrating systems (CSP) for example. In 2011, the Algerian government has launched an ambitious programme dedicated for renewable energies; this programme was updated recently, where the capacity of the photovoltaic (PV) solar plant was increased to 13.575 MW, which represent more than 60% of the total capacity [11].

However, a precise solar assessment is crucial before any implementation of a solar energy system. This assessment must take into consideration the daily and seasonal variations, solar radiation and load profile. It is based upon measured data, where available. Unfortunately, only few stations perform recordings of solar radiation in a country such as Algeria where it is necessary to have hundreds of radiometric stations.

Several databases have been made accessible to public recently, among them we can cite European PVGIS system [12], RETScreen® [13], where monthly radiometric data are available, with good precision.

In this work, Solar-Med-Atlas Data Source was used in order to evaluate solar potential in Algeria. Monthly global irradiation received on horizontal plane, direct normal irradiation and diurnal air temperature are available on the portal [14].

Data treatment was achieved for seventy eight (78) locations across the country. Meanwhile confrontation to measured data for six (06) locations where data are available was done. Results shown good fitting for almost all cases. In addition, we were able to plot out solar maps with a fair precision. They were established thanks to SURFER® software using Kriging method.

II. Data Source

In this work, data obtained from the "Solar Atlas for the Mediterranean" are used as the main source Solar Atlas for the Mediterranean (Solar-Med-Atlas),it is a project supported by International Climate Initiative of the Germany Ministry of Environment Nature Conservation and Nuclear Safety. It was developed by a consortium which includes European research centers such as the German Aerospace Center (DLR)

The project uses a serial data with high resolution (1km), on long term period for 20 years (1991-2010). It covers Syria, Jordan, Israel, Lebanon, Egypt, Libya, Tunisia, Algeria, Morocco, Palestine National Authority, Mauretania and Turkey The resource data are based on Earth Observation satellite data, based on published and transparent methodologies and the data were validated with existing ground measurements in the region.

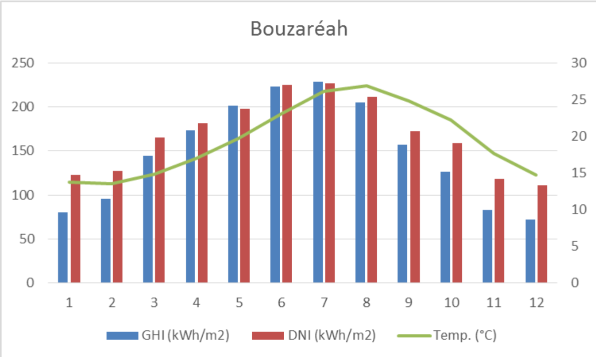
In our study, 78 locations across the country were considered. Data are made available online, concerning the global irradiation received on horizontal plane (GHI), direct normal irradiance (DNI) diurnal air temperature. Annual and monthly averages were used in this work

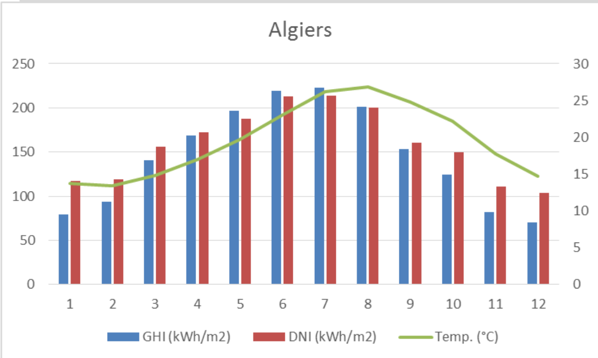
In table 1, are reported the considered sites with their geographical coordinates and the annual average of the considered parameters.

TABLE 1. GEOGRAPHICAL COORDINATES AND RADIOMETRIC DATA (ANNUAL AVERAGE)

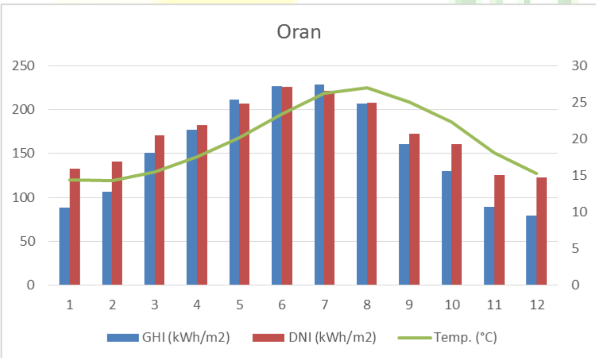
	Site	Lat. (deg.)	Lon (deg.)	Alt. (m)	GHI (kWh/ m²)	DNI (kWh /m²)
1	Collo	37.00	6.60	9	1687	1782
2	Annaba	36.93	7.75	3	1716	1854
3	Dellys	36.88	3.93	8	1736	1903
4	Skikda	36.87	6.92	2	1732	1920
5	Jijel	36.82	5.75	8	1730	1925
6	Bouzaréah	36.77	3.01	345	1789	2018
7	Alger	36.75	3.07	25	1756	1905
8	Béjaïa	36.75	5.05	2	1681	1820
9	Tizi Ouzou	36.72	4.05	188	1728	1889
10	Bouharoun	36.62	2.65	5	1778	1991
11	Tènes	36.50	1.32	17	1788	1981
12	Blida	36.48	2.83	326	1705	1861
13	Aïn Bessam	3640	3.72	748	1808	2062
14	Bouira	36.37	3.90	555	1799	1990
15	Constantine	36.37	6.65	693	1766	1946
16	Miliana	3632	2.23	715	1894	2230
17	Guelma	36.28	7.52	227	1713	1848
18	Médéa	36.28	2.77	1030	1866	2117
19	Souk Ahras	3627	7.95	680	1806	1992
20	Sétif	36.20	5.42	1007	1911	2234
21	Chettia	36.17	1.23	202	1826	2032
22	Chlef	36.15	1.33	143	1834	2041
23	B.B.Arreridj	36.07	4.75	928	1908	2189
24	Mostaganem	36.02	0.13	137	1871	2147
25	Oum El Bouaghi	35.87	7.12	889	1833	2044
26	Arzew	35.82	-0.35	3	1846	2075
27	Relizane	35.73	0.57	95	1849	2066
28	Oran	35.70	-0.63	90	1854	2071
29	M'sila	35.68	4.55	441	1865	2068
30	Batna	35.57	6.17	822	1919	2215
31	Aïn Oussera	35.45	2.90	17	1909	2154
32	Khenchela	35.43	7.15	83	1941	2262
33	Tébessa	35.42	8.10	821	1835	2029
34	Mascara	35.40	0.13	511	1880	2123
35	Barika	35.38	5.28	460	1861	2014
36	Tiaret	35.37	1.32	977	1923	2208
37	Béni Saf	35.30	-1.37	68	1865	2112
38	Ksar Chellala	35.22	2.32	800	1909	2169
39	Boussaâda	35.22	4.18	461	1907	2135
40	Sidi Bel Abbes	35.20	-0.63	475	1897	2127
41	Hassi Bahbah	35.08	3.03	802	1934	2199
42	Tlemcen	34.88	-1.32	810	1877	2110
43	Maghnia	34.85	-1.73	427	1907	2162
44	Ain Deheb	34.85	1.55	1107	1985	2296
45	Saïda	34.83	0.15	750	1886	2103
46	Biskra	34.83	5.75	82	1900	2076
47	Djelfa	34.67	3.25	1180	1971	2279
48	El Kheiter	34.13	0.07	1000	2008	2286
49	Aflou	34.10	2.10	1080	2054	2432
50	El M'ghaïr	33.93	5.93	204	1815	1757
51	Laghouat	33.80	2.87	767	1984	2231
52	Méchria	33.55	-0.28	1149	2054	2386
53	Naama	33.43	-0.90	1166	2066	2397
54	El Oued	33.37	6.85	64	1960	2100
55	Touggourt	33.10	6.08	87	1964	2129
56	Hassi R'mel	32.93	3.27	764	2030	2263
57	El A.Sidi.Cheikh	32.90	0.53	842	2047	2317
58	El Guerrara	32.78	4.50	339	1989	2161
59	Ain Sefra	32.75	-0.57	1058	2032	2290
60	Ghardaïa	32.48	3.67	468	2052	2310
61	El Bayadh	32.35	0.60	1305	2067	2320
62	Ouargla	31.95	5.33	144	2029	2238
63	Bechar	31.62	-2.22	809	2095	2402
64	El Golea	30.60	2.88	397	2113	2362
65	Hassi Messaoud	30.42	5.40	142	2059	2196
66	Béni Abbes	30.13	-2.17	550	2064	2202
67	Timimoun	29.26	0.23	312	2104	2274
68	In Aménas	28.05	9.58	561	2162	2348
69	Adrar	27.97	-0.18	279	2135	2272
70	Tindouf	27.68	-8.13	443	2207	2458
71	In Salah	27.20	2.48	268	2163	2325
72	Aoulef	26.98	1.07	290	2178	2344
73	Illizi	26.52	8.47	559	2214	2439
74	Reggane	2528	-1.52	225	2152	2206
75	Djanet	24.55	9.48	968	2325	2650
76	B. B. Mokhtar	23.77	-090	397	2168	2189
77	Tamanrasset	22.78	5.53	1362	2373	2723
78	In Guezzam	19.57	5.77	400	2266	2276

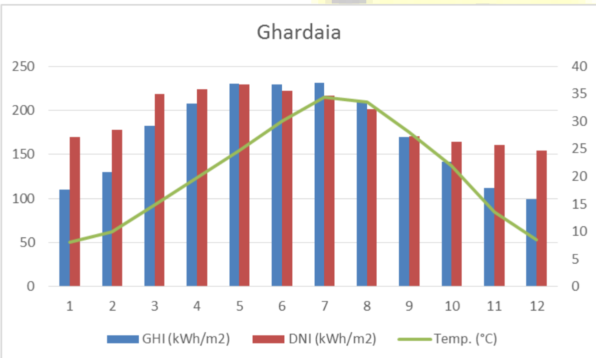
Monthly data of selected sites are reported in figure 1. Selection was based on the availability at our level of recorded data. These data will be used in order to make a confrontation with those given by the "Solar-Med-Atlas" data source.

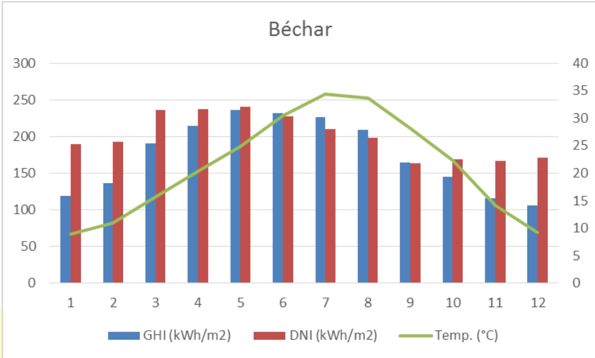




III. PAGE STYLE







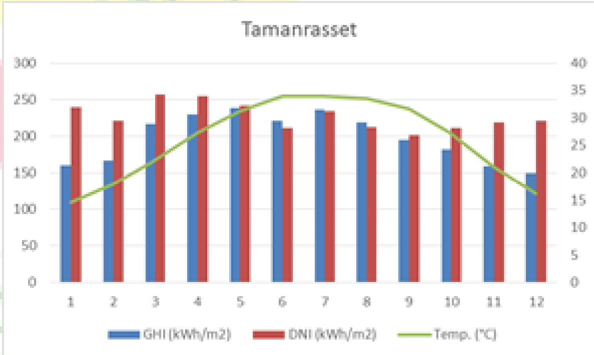


Fig.1 Evolution of monthly averages of Global Horizontal Irradiation. Direct Normal Irradiation and air temperature for selected sites

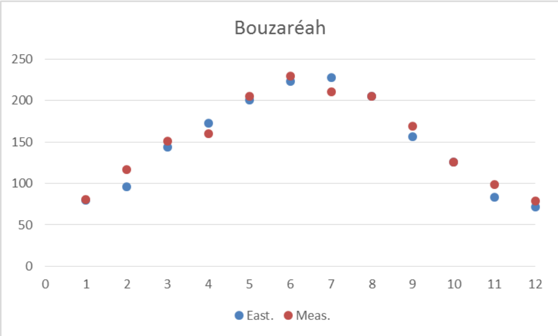
III. MODEL CONFRONTATION

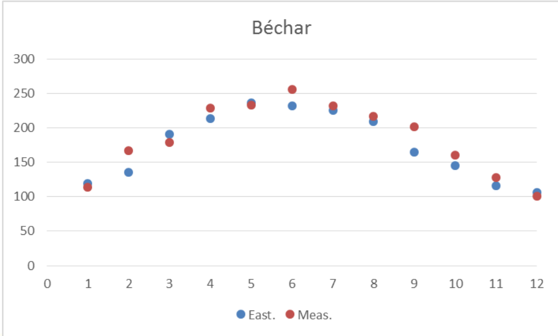
Due to lack of data, recordings from six (06) sites were used in our case. In figure2, are plotted measured data by the National office of Meteorology (ONM, Algeria), versus those estimated by “Solar-Med-Atlas” tool. Furthermore, a basic relation allowing the calculation of the relative error (e_r), was used. The relation is given as follows:

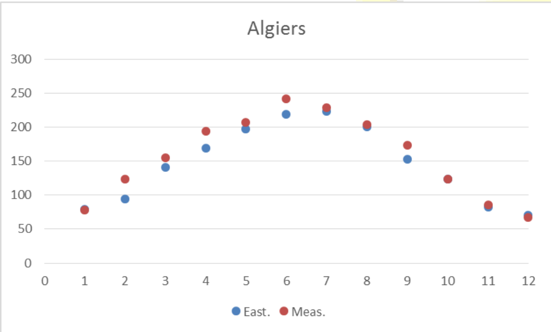
$$e_r(\%) = 100 \times \left|\frac{G_{est} - G_{meas}}{G_{meas}}\right| \quad (1)$$

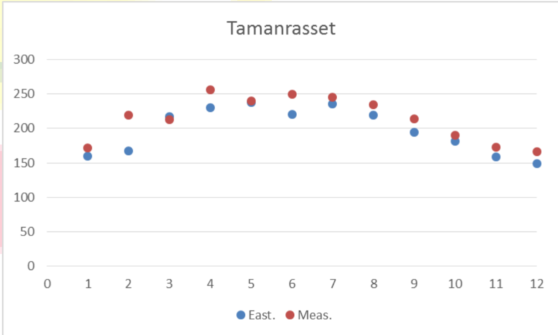
G_{est}: is the global solar irradiation given by the model

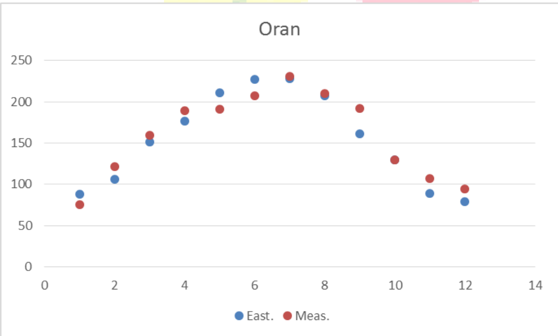
G_{meas}: is the measured global solar irradiation by ONM











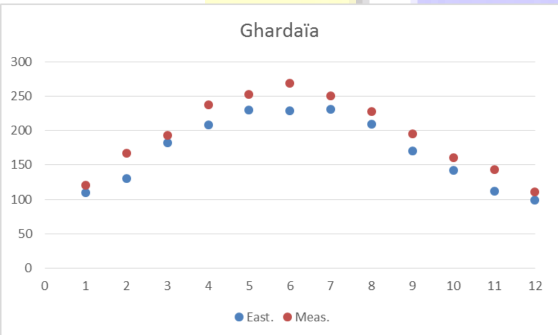


Fig.2 Evolution of monthly averages of Global Horizontal Irradiation. (Measured Vs Estimated)

In table 2, Are given results for the relative error, were calculation was performed for the six (06) available sites.

We can remark that data obtained from “Solar-Med-Atlas” database fits well with the measured ones, the results are almost the same for the 6 sites. The maximum error was obtained for the site of Algiers with a value approaching 25% for the month of February. However, the model was able to give the exact value for the month of October for Bouzaréah site.

	Jan	Feb	Mar	Apr	May	Jun
Bouzaréah	1.0	18.5	4.9	8.1	2.3	3.0
Algiers	0.5	24.5	9.3	12.7	4.7	9.6
Oran	16.8	12.8	5.4	6.3	10.2	9.3
Ghardaïa	9.1	22.8	6.0	12.4	9.1	15.0
Béchar	4.1	19.0	6.8	6.3	1.2	9.4
Tamanrasset	7.0	24.4	1.9	10.4	0.9	11.4

	Jul	Aug	Sep	Oct	Nov	Dec
Bouzaréah	8.1	0.1	7.0	0.0	16.0	9.1
Algiers	2.3	1.3	12.0	0.2	4.5	4.7
Oran	1.2	1.6	16.3	0.2	17.0	16.2
Ghardaïa	7.9	7.7	12.8	11.8	21.9	10.9
Béchar	2.6	3.7	18.4	9.6	9.0	5.1
Tamanrasset	3.9	6.5	9.0	4.2	8.2	10.6

IV. Solar Cartography

Solar maps representing GHI and DNI parameters were established. It concerns the whole country. This task was possible thanks to SURFER ® software, with the use of Kriging method.

In Figure 3a. and 3b., are shown a sample of maps representing the yearly solar potential. As we can see in the map, the southern region of the country receive a greater solar potential than other regions.

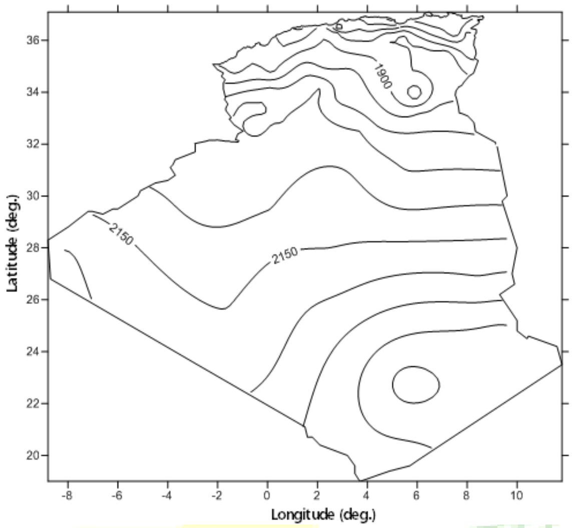


Fig. 3.a: Yearly average direct normal solar irradiance (kWh/m2).

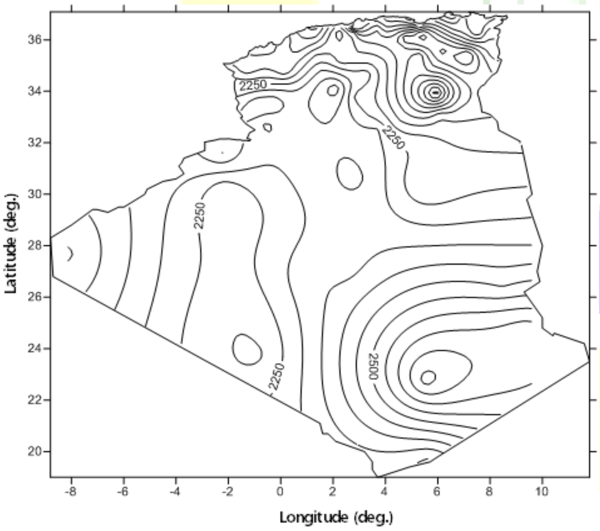


Fig. 3.b: Yearly average global solar irradiance received on normal plane (kWh/m2).

V. Conclusion

Using radiometric database that was made available on the «Solar Atlas for the Mediterranean» portal helped us to give our contribution to the evaluation of Algerian solar potential. Confrontation between the data we used to those measured has given good results in almost all cases. Furthermore, this work consolidates studies that preceded it, including the production of solar maps of Algeria with an acceptable accuracy. We can also confirm the availability of a huge solar potential in the country, which remains one of the most important in the region as stated by many studies.

This step for the assessment of solar energy potential remains necessary. This kind of study must be done before any installation of solar systems, including PV and concentrating solar power (CSP).

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